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PLANNING AS A TRANSFORMATIVE ACTION IN AN AGE OF PLANETARY CRISIS

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Track 1

POSTGROWTH URBANISM

From abandonment to critical conception: post-growth policies for the resilience of deindustrialised areas. The case-studies of Ile-de-Nantes and Docks-de-Seine in France

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Abstract
The appearance of the notion of sustainable development in the 1980's constituted an important step in the procedures of urban planning as its structuring elements referred to questions like growth and its limits. Considering the inequal development of urban areas in the Global North and Global South, especially places that were left neglected for several years such as deindustrialised areas, the paper tries to explore the ways through which deindustrialised areas could be developed in order to sustain both ecological balance and social equity. The choice of the case studies, the projects Ile-de-Nantes and Docks-de-Seine in France, was based on the necessity to critically think existing growth theories and concepts for the development of deindustrialised areas based on the reduction of their environmental footprint.

Key words: post-growth policies; social and environmental balance; deindustrialised areas; socio-economic inequalities, France

Introduction

The appearance of the notion of sustainable development in the 1980's and the publication of the Brundtland report constituted an important step in the procedures of urban planning of the late 20th century, especially for deindustrialised cities (Devillers, 2010). Its multifaceted nature, result of the diversity of intellectual filiations that preceded it (humanist, economist, ecologist), shows, according to some researchers like Passet, a reconciliation between limitless growth and environmental and social barriers (Passet, 1978). We can distinguish from the origins of this notion its structuring elements such as growth and its limits, conservation and preservation, as well as the place and role of natural and artificial capital in economic development procedures (UN, 1987).

A historical analysis of the issue of sustainable development carried out by Bertrand Zuindeau and Franck-Dominique Vivien in 2001 allows us to reflect on the spatial dimension of sustainable development and its role in transforming urban areas beyond modern policies of urban growth. The two authors distinguish in the intellectual framework of the concept two approaches:

- a global approach that focuses on the interactions between the environment and the economy on a global scale and
- a local approach which insists on the local characteristics (environmental, economic, cultural) for the spatial implementation of sustainable development at the local level (Vivien and Zuindeau, 2001).

It can be underlined, therefore, that even if previous works, particularly from the 1960s and 1970s, such as the Green Paper of European Commission, present a global approach to the concept of sustainable development (EU, 1990), linked to international concerns on the protection of the environment, there is also a local approach addressed particularly in reports on sustainable cities and sustainable neighbourhoods (Aalborg Charter) (EU, 1994).

The question of application of sustainable development policies at territorial level brings out the different apprehensions of space related to urban development (particularly economic). The space can take the form either of a support space, for example a space that facilitates the installation of production activities in a given territory (for example low taxes), or of a space - resource, that is to say a space that attracts the installation of production activities thanks to its natural and artificial resources (Bastié and Dézert, 1980).

It should be emphasised that there are no general rules that can function as key formulas for the implementation of sustainable development at territorial level. On the contrary, in studies of the application of sustainable development policies at territorial level, several researchers note that there are difficulties and limits in generalising local approaches and results issued from local experiences (Godard,1996). In addition, we can note that the local dimension of sustainable development, especially in small scale projects at neighbourhood level,

consists rather of a tool mobilised by local actors in order to promote mutual learning, with the collaboration of inhabitants, technicians and local elected officials for the planning of sustainable neighbourhoods.

The principles of sustainable development policies are often quite vague, particularly with regard to the simultaneous implementation of the global issues set out at the United Nations Conference on Environment and Development in 1992 in Rio de Janeiro, as these principles do not articulate with the reality of the territories (Theys, 2000). Today there are very few approaches that allow the operational implementation of the goals of sustainable development as they appeared in Agenda 21. The one that can be noted is that of the environmental footprint. This concept makes it possible to show the capacities of ecosystems to resist the pressures of human activities (Matuštík, Kočí, 2021). It mostly refers to the environmental dimension of sustainable development. However, it can be an important tool for analysing the limits of modern modes of urban growth as cities expand towards their surrounding areas and exploit their natural resources (Valderrama and al, 2024).

The difficulty of defining priorities by local authorities on the implementation of sustainable development policies both at territorial level and in public action shows the dual nature of the concept which refers, as we have already seen, at two scales: global and local (Vivien and Zuindeau, 2001). Cyria Emelianoff and Jacques Theys underline in their analysis for the sustainable city, that a sustainable city must first contribute to the solution of major global problems. This is not only a question of conflict of priorities, but of the profound difficulty in articulating several obviously different representations of territory and political action (Emelianoff and Theys, 2001). We can see that there is a dissociation between the two scales of the concept (global and local) which underlines the importance of the management of the interfaces between the two.

In regard to the subject of the scale of implementation of sustainable development policies, it is important to refer to the work of the French Institute for the Environment which highlights two aspects of the concept:

- What is sustainable on one scale may not be at another
- In problem solving there is no optimal scale in itself, there are only scales that are more useful than others for answering very specific questions (IFEN, 1999).

It is therefore obvious that there is no optimal scale of intervention. On the contrary, we can observe that there are several scales which articulate, and which must be studied in relation to their specificities and their complementarities (Eames and Abedowale, 2002). However, it should be noted that even if the implementation of sustainable development policies at different territorial scales does not allow us to talk about global sustainable development objectives, there are elements in sustainable urban development projects that reinforce the hope of a territorial implementation of sustainable development on a global scale in the future (the exemplarity of sustainable development projects at territorial level, the cooperation between the actors involved in sustainable development urban projects, the awareness of local actors around the notion of sustainable development) (Emelianoff, 2007).

By considering the inequal development of urban areas, especially those that were left neglected for several years such as deindustrialised areas which are characterised by high levels of air, water and soil pollution, the paper tries to answer the question of which ways lead to the sustainable development of deindustrialised areas in order to sustain both ecological balance and social equity. Issues related to the implementation of sustainable development policies at territorial level, the actors involved in these procedures, the different levels of decision making as well as the complementarity of these policies (at regional, municipal and neighbourhood level) are among the key points for the development of urban areas that were left neglected for several years. The purpose of the research is to critically question the appearance of new planning policies for deindustrialised areas which are considered innovative and inscribed in the sustainable development framework, such as the creation of sustainable neighbourhoods and participatory design, based on their capacity to foster regenerative relationships between society and the environment. Sustainable neighbourhoods (écoquartiers in the French context) are a form of urban design projects that try to implement environmental policies at territorial level while proposing social housing for the low-income inhabitants and participatory design actions for the involvement of inhabitants in decisions related to the form and functions of their living environments (Hamdan and al, 2021, Ministère de l'aménagement du territoire et de la décentralisation, 2024). However this type of projects seem to be rather ambitious as they are trying to respond to environmental questions that cannot be handled at local

level (for example air and water pollution) (Dessouky and al, 2023) while citizen engagement and participatory design usually refer to experimentations at neighbourhood level and not to the elaboration of concrete solutions that could be applied at different governance levels (regional, municipal) (Allen, Queen, 2018).

Methodology

The research method used was the descriptive-analytic. The descriptive method was used in order to define post-growth policies and tools for the development of deindustrialised areas and relate them to previous studies in areas facing significant socio-economic inequalities. Our main hypothesis is that the development of deindustrialised areas in a sustainable way that focuses on their particular characteristics, internal dynamics and external opportunities should be the basis for the development of such areas which struggle with the effects of deindustrialisation (socio-economic and environmental difficulties) and gentrification due to the interest for their planning by private and public investors. In several cases the former industrial cities have a significant urban past reflected on the architecture of industrial buildings such as factories and houses of industrial workers and the organisation of spaces around industrial units. At the same time, there is still present on these areas their social structure, which dates back to their industrial era, through the form of associations gathering former industrial workers and local inhabitants. These associations are interested in preserving the local character of their areas, both its tangible form (buildings and neighbourhoods) and intangible (inhabitants' relationships, areas for the low- and middle-class households), thus creating the conditions for social sustainability (Katapidi, 2023).

Deindustrialised areas, inside or outside of cities limits, face significant economic and social difficulties due to deindustrialisation, or to the closure of local enterprises, and seem to bear the effects of this negative context as they do not have sufficient funds for their environmental protection and economic development (Schindler and al, 2023). The former industrial lands are heavily polluted and struggle with economic recession. In certain cases, we observe waste in these areas either domestic or resulting from industrial activities whose presence in these areas deteriorates the existing environmental degradation, while contractors, investors and local authorities show a particular interest to build them in order to boost their local economy and those of neighbouring cities who also face social and economic difficulties. In this context the development of deindustrialised areas in a sustainable way that takes into consideration the needs of the local population and proposes economic activities in accordance with the restauration of the natural environment, offers a second life to places that were underdeveloped and neglected for several years due to socio-economic problems. Our hypothesis is that the development of neglected deindustrialised areas in a sustainable way and their subsequent integration into the regional and municipal economic channels fabric is not only a measure towards environmental and economic sustainability and resilience, but it can also serve as a measure to solve social conflicts as underdeveloped deindustrialised areas are places that gather activities of regional and municipal interest such as research hubs, tourism and cultural facilities.

Another point to underline in contemporary practices for the development of deindustrialised areas, related to technological innovations and to the need to reduce cities' environmental footprint, is the planning of these areas according to specific standards (international and national) that seems to give answers to the global dimension of sustainable development such as the reduction of carbon emissions and energy demands for cooling and heating housing units (Power, 2018). Policies such as the design of passive houses, the collection and reuse of grey water in domestic activities and the re-design of polluted former industrial lands as parks are presented as strategies for the creation of sustainable neighbourhoods (Ministère de l'aménagement du territoire et de la décentralisation, 2024). However, it is important to see whether these high-cost policies in areas historically gathering low and middle-class households are acceptable by the local population. Taking this into consideration, our third hypothesis is that the development of deindustrialised areas through the creation of sustainable neighbourhoods could act as a measure for sustainability and resilience, when these areas are developed for all (both for the local population and for new inhabitants), take into consideration the local socio-economic context (thus do not propose high-cost policies) and restore the polluted natural environment in order to bring environmental sustainability.

The analytic method was used in order to identify first the particular socio-economic characteristics of the two case studies, the relationship between the built and the natural environment as well as technical innovations which seem to foster social and environmental balance. At the same time, we took interviews with local actors (inhabitants' associations, former industrial workers associations, environmental associations, researchers, teams of architects and urban planners working on the two sustainable neighbourhood projects, local elected officials) in order to study the implementation of inclusive and equitable territorial policies which aim to foster a circular economy model than a one that exploits ecosystems. In second place based on the findings of the field research we tried to verify our initial hypotheses in order to see which policies lead to the sustainable transformation of deindustrialised areas and take into consideration the local social, economic, environmental and cultural characteristics. The research proposes an experimental approach in order to investigate the policies and tools which potentially could tackle socio-economic inequalities and reshape planning policies in deindustrialised areas. A critical point is to underline policies that seem to align with community needs, especially at neighbourhood level and which could be generalised at the level of the city. This approach (bottom-up) helps to better identify and understand cities' future in a resilient and inclusive way, as it is possible to study whether the goal of growth concerns all inhabitants, including marginalised groups, or is targeted at a limited number of people.

The analysis of the findings of the field research focuses on policies at municipal and regional level such as: 1) the revalorisation and reuse of significant buildings and neighbourhoods dating on the industrial era as a form of reminiscence of the tangible heritage, 2) the creation of community ties through the preservation of intangible heritage and the presence of active inhabitants' associations in the areas, 3) the restauration of the natural resources polluted during the industrial era of the two cities and environmental policies for reducing environmental footprint as well as 4) the development of economic activities in accordance with the local needs in order to boost municipal and regional economy as a means to reduce local unemployment rate and to lead to economic resilience and sustainability.

In our analysis of the policies that lead to the sustainable development of the two former industrial areas we took into consideration existing power dynamics of the two cities (Nantes and Saint-Ouen), their surrounding areas as well as of the regions of Loire-Atlantique and Ile-de-France in which administratively are part the cities of Nantes and Saint-Ouen. It is important to mention that both of the two regions are characterised by their industrial past with industrial activities related to energy production and shipbuilding while their deindustrialisation seems to had a different impact on the two cities as Ile-de-France, where Saint-Ouen is located, is the most developed region at national level (French) and its economy is also based on other activities such as tourism, culture, research and national administration. At the same time the funding of the two redevelopment projects in Nantes and Saint-Ouen (EU funds, public-private partnership) poses challenges regarding their growth urban planning policies as private investors (we can see it in the case study of Saint-Ouen) are more interested in economically profitable activities (office and administration buildings) and avoid taking measures for the good living conditions of the local low-income households such as the construction of social housing. A final point of our analysis is based on the political decisions taken at municipal and regional level on environmental, social and economic issues which are usually related to the political party that is affiliated the majority. While socialist and ecological parties are more interested in questions related to social cohesion and environmental protection, right and liberal parties are interested in the economic development of their areas leading in several cases in the gentrification of these spaces.

The case studies: the sustainable neighbourhood Docks-de-Seine in the city of Saint-Ouen and the industrial reconversion project Ile-de-Nantes in the city of Nantes

The choice of the case studies was based on the necessity to critically think and reshape existing growth theories and concepts for the development of deindustrialised areas based on the reduction of their environmental footprint. On one hand we have the case study of the Docks-de-Seine in Saint-Ouen, a sustainable neighbourhood project located at the north part of the Ile-de-France region not far from Paris (Figure 1). The neighbourhood was constructed on a deindustrialised brownfield by focusing on bringing eco-social balance. The project covers an area of about 100 hectares. Saint-Ouen's population in 2017 was approximately 90,000 inhabitants (INSEE a, 2018). Saint-Ouen, which is known for its industrial activities since the nineteenth century, faced a significant population decline in the late 1980s due to the departure of local industries in the periphery of the city.

Figure 1. Saint-Ouen's location on the map of France. The city is located in the Seine-Saint-Denis department in the north suburbs of Paris. The city and the Docks-de-Seine district are connected by bus and metro to Paris, thus attracting new inhabitants and enterprises who search for lower rents outside the French capital. Source: Varvara Toura

Saint-Ouen's industrial history is linked to the Docks-de-Seine district, where the city's railway station was built in 1856. The two main sectors were those of energy production and waste treatment (Figure 2). Saint-Ouen became an industrial city as a result of the infrastructure and equipment installed in the Docks-de-Seine district, where a water station was established in 1830 and a railway network in 1856. The two infrastructures created the conditions for the city's industrial development due to the good access of the site (APUR, 2006). However, this concentration of infrastructures will prevent the city from developing towards the Seine River. Only two streets of the city crossed the area of the Docks and had access to the river quay, rue Ardouin and rue des Bateliers. In the northern part of the site, a plot of 26 hectares was purchased in 1917 by the Thomson-Houston company. On the strip of land directly along the Seine, a facility was created in 1862 (Département de la Seine, Direction des affaires départementales, 1902). The departure of Total (2003) and Alstom (2004) industries from the Docks district marked the beginning of a city's renewal program for central districts, as large zones alongside the Seine River were left inactive.

Figure 2. The Docks-de-Seine district during its industrial era in 1964. The industrial activities never ceased to exist in Saint-Ouen. There are still present on the site of Docks industries related to the production of electricity and waste treatment posing restrictions to sustainable development projects in the city such as the sustainable neighbourhood project of Docks-de-Seine. Source: Historical archives of the city of Saint-Ouen

Saint-Ouen's policies towards the city's development after its industrial era focused on the sustainable reconversion of the city's urban voids and the preservation of local industrial heritage. They were established in 2000 as a measure inscribed within the regional policies of Ile-de-France region for the redevelopment of its peripheral areas. A representative project for the reconversion of industrial urban suburbs in a sustainable way is the sustainable neighbourhood project of the former industrial site Docks-de-Seine initiated in 2005. The

Docks-de-Seine project contributed to reverse Saint-Ouen's population decline that followed the closure of local industries in the late 1990s. The design team selected for the development of the project of Docks-de-Seine was the team lead by the architect Makan Rafatdjou (2005-present) while the project was planned since its beginning as a sustainable neighbourhood (écoquartier in French) focusing on the environmental dimension of the project. In the French context the écoquartiers projects receive a label from the French Ministry of Environment as projects inscribed in the field of sustainable development. We should mention that this label does not include public funds for the project but is rather an honorary title increasing the competition between architects and urban planners working on these projects.

On the other hand, we have the case study of Ile-de-Nantes, a reconversion project located in the city of Nantes at the west of France which is constructed in a deindustrialised zone (Figure 3). Compared to the first case study, in the case of Ile-de-Nantes we have a big, deindustrialised area, where an important role plays the planning and development of sustainable neighbourhoods during the third phase of the project (2017-present). The main purpose of the project was the transformation of a deindustrialised area in a sustainable way which reconciles the natural environment while revitalising the local economic and social tissue. The project covers an area of about 337 hectares. Nantes' population in 2017 was approximately 300,000 inhabitants (INSEE b, 2018).

Figure 3. Nantes' location on the map of France. The city is located in the Loire-Atlantique region at the west of France. Despite deindustrialisation Nantes' population increased after 1990 due to the development of activities based on culture, tourism and research. The city is connected by intercity buses and train to the main French cities including Paris. Source: Varvara Toura

At the beginning of the nineteenth century, industrial activities became the driving force of Nantes economy, succeeding the early manufactories of the eighteenth century. Shipowners and merchants invested in the industrial sector, particularly benefiting from European maritime trade (Guépin and Bonamy, 1835). The two areas for factory establishments were the banks of the Loire and the Erdre River. By the end of the nineteenth century, other productions emerged alongside metallurgy: sugar refineries, chemicals, and fertilizers. Companies like Amieux and Saupiquet thrived between the two wars, relying on vegetable and horticultural products or the processing of fish from the entire Brittany region. During the period of the World War I, the growing industry was that of military production as well as the construction or reconstruction of the military and civilian fleet (Bois, 1977). Till World War I, factories from all branches in the city employed over 27,000 workers. In the 1950s, reconstruction allowed a revival of the main sectors: shipbuilding (Figure 4), metallurgy, and agri-food. In the seventies, the concentration of businesses accelerated. The largest factories established themselves on the outskirts in new activity zones.

Figure 4. The Dubigeon shipbuilding industry in Nantes during its industrial era. Nantes' industrial era ended in the 1980s when shipbuilding industries located inside the city's limits moved to the neighbouring city of Saint-Nazaire. The significant industrial heritage of the city and especially shipbuilding infrastructure and equipment was part of the reconversion policies of the site of Ile-de-Nantes as they were restored and reconverted into museums and cultural spaces. Source: Musée des hommes et des techniques de Nantes

Nantes's policies towards city's development and preservation of local industrial heritage within the context of sustainable development were developed in the 1990s as part of a municipal plan for the revitalisation of urban voids. A representative project of these policies is the reconversion project of the former industrial site Ile-de-Nantes. The project is developed in three different phases since 2000 with three different design teams focusing on the sustainable development of the area by combining modern economic and environmental policies alongside citizen engagement in the urban design process as measures to preserve the local industrial heritage and to transform the deindustrialised site. These policies' primary objective was to reverse the significant population decline that the city faced after the closure of local industries in the late 1980s. The first selected design team was the team lead by the architect Alexandre Chemetoff (2000-2010) focusing on the inscription of industrial heritage in the new urban planning of Ile-de-Nantes. The next two teams started to reflect on the issue of sustainable development of the deindustrialised site through its connection with Nantes' city centre (team Marcel Smets and Anne Mie Depuyt, 2010-2017) and the creation of green-blue corridors in the site of Ile-de-Nantes alongside the planning of sustainable neighbourhoods (team Shorter and Osty, 2017-present).

Outcomes-Results

The study of the regions of Ile-de-France and Loire-Atlantique, of the cities of Saint-Ouen and Nantes and the projects of transformation of deindustrialised spaces in these cities especially the Docks-de-Seine and Ile-de-Nantes projects revealed different strategies and policies for the post-growth development of the above areas. In the case study of Docks-de-Seine the project is inscribed within the perimeter of Grand Paris, a project of transformations of former industrial cities of the Ile-de-France region based on environmental, economic and social policies, while at the same time the former industrial cities (les banlieues) are connected to Paris with a new urban railway network (Grand-Paris Express). The close proximity of the Docks-de-Seine site to the Olympic Village of 2024 Olympic Games (Seine-Denis) and the active industrial units within its perimeter make both the project of the sustainable neighbourhood Docks-de-Seine and the urban transformations inside the city of Saint-Ouen important for the development of the region of Ile-de-France as the area is considered as an energy pole providing activities of regional interest. Even though the project of Docks-de-Seine is labelled by the French Ministry of Environment as an écoquartier the planning and construction of the project are not funded by national funds, but from a public-private partnership between the Region of Ile-de-France, the Municipality of Saint-Ouen and private investors such as Nextcity, an urban development company, posing challenges regarding the social dimension of the project as the private investor is interested in profitable economic activities like office buildings and not on the preservation of the local industrial heritage and the construction of social housing for the low-income households.

At regional level the Regional Counsil is in favour of the project since its beginning, while the construction of the main building of the Ile-de-France region on the site of the Docks underline the importance of the site for the regional development. On the contrary at municipal level since the beginning of the project, the Municipal Counsil was led by three different political parties (communists, liberals, socialists) showing a different interest for the main axes of the project (environmental and social for communists and socialists, environmental and economic for the liberals).

In the case study of Ile-de-Nantes the project is located inside the city limits in proximity with Nantes historical and economic centre. Due to Nantes former socialist Mayor Jean-Marc Ayrault (who later became Prime Minister of France under the presidency of François Hollande) and his ambition to make Nantes an attractive destination for new inhabitants, tourists and public and private investors the deindustrialised area of Ile-de-Nantes, an island in the Loire River, was developed in the 1990s as part of a bigger project of urban transformations inside the city. The project was developed in three phases led by different design teams focusing since the beginning on issues related to post-growth development theories such as the social parameter of the project (a project for all), the environmental justice in a polluted industrial land and the boost of the local economy based on the internal strengths of the city of Nantes (local industrial heritage). Even though industrial activities have moved to areas outside the city of Nantes, especially the thriving shipbuilding activity who has moved in the city of Saint-Nazaire, the strategy for the development of Nantes reached to reduce the local unemployment rate through economic activities such as research labs and universities built on the site of Ile-de-Nantes, industrial museums and monuments found particularly on the Ile-de-Nantes site, as well as office and commercial activities. Inside the region of Loire-Atlantique the city of Nantes is developed as a large French city of the west side of the country while the political continuity at municipal level since the 1990s (Nantes Municipal Counsil is led by the socialist party) creates the conditions for the development of the city according to the same economic, environmental and social policies. Unlike the project of Docks-de-Seine, the Ile-de-Nantes project was funded by European Union Funds from 2000 to 2010 while the rest of the second development phase of the project and the third phase are funded by public-private funds deriving from the Region of Loire-Atlantique, the Municipality of Nantes and private investors. It is important to mention that despite the fact that the sustainable development dimension was discussed as a pillar of the project since 2000 (restauration of the natural environment of the Ile-de-Nantes and connection to the city centre of the city), this dimension of the project is more evident in the current third phase of the project with the planning and construction of sustainable neighbourhoods inside the perimeter of the project, which are also labelled écoquartier by the French Ministry of Environment.

Concerning policies for the revalorisation and reuse of significant buildings and neighbourhoods dating on the industrial era in order to inscribe the local tangible heritage within the post-growth development model (development based on local resources) the two cities followed a different strategy. In Saint-Ouen and the Docks-de-Seine site there are still active industrial units dating from the industrial era as industrial activities never ceased to exist. Due to the abandonment of several districts of the city after the closure of a certain number of local factories and to the focus on the economic regeneration of Saint-Ouen, important industrial buildings such as le garage à bennes (a space for stocking merchandise) were demolished in favour of the construction of office and commercial buildings. After 2005 and the beginning of the sustainable neighbourhood project of Docks-de-Seine we note policies for the preservation of the local industrial heritage in correspondence with the national (French) and regional framework for the conservation and restauration of historical buildings. We can note the reuse and transformation of the Halle Alstom into a recreation and office space (Figure 5) and the inscription of the gardens of the formal industrial workers on the plan of the main park of the Docks.

Figure 5. La Halle Alstom on the site of the Docks-de-Seine. A former office building of the industrial complex of Alstom, the building was transformed into an office and recreation space. Source: Varvara Toura

In Nantes and the Ile-de-Nantes site there aren't active industrial units. Even though the abandonment of several districts of the island led to the demolition of buildings dated on the industrial era such as houses of the industrial workers, the activism at city level from scholars like Jean-Louis Kerouanton and associations working on the urban and industrial heritage of Nantes created the conditions, despite oppositions at the Municipal Counsil, for the preservation and reuse of industrial heritage. These policies in favour of the preservation of the local heritage are in correspondence with the national (French) and regional framework for the conservation and restauration of historical buildings. In the shipbuilding sector at the west of the island buildings and equipment from the industrial era are still present on the site and are transformed into industrial museums, city's landmarks and recreation spaces (Figure 6).

Figure 6. Industrial building from the Dubigeon complex. The Dubigeon complex included a space for shipbuilding activities as well as office buildings and warehouses that are nowadays transformed into recreation spaces. Source: Varvara Toura

As we have previously mentioned, an important dimension of post-growth policies in the processes of transformations of former industrial cities into sustainable cities concerns the social dimension of these processes and particularly the creation of community ties between the citizens and the presence of active inhabitants' associations in the areas (development based on co-planning and co-decision). In the analysis of interviews with local elected officials and local inhabitants' associations we noted differences in the two case studies resulting from the local political and associative context. In the case study of Saint-Ouen and the Docks-de-Seine project after the deindustrialisation era many former industrial workers left the city as gentrification

processes appeared (rents' increase, construction of office and administrative buildings). The new inhabitants who were installed in the city and on the site of the Docks were young people trying to benefit from the presence of social housing in the Docks-de-Seine project and the lower housing rents compared to the Parisian housing rents. Both the region of Ile-de-France and the municipality of Saint-Ouen were favorable in the creation of inhabitants' associations working on issues like environmental protection and preservation of the local heritage. The association Mon Voisin les Docks is among the first in Saint-Ouen working with the local authorities on issues related to the quality of life on the Docks and the maintenance of the local natural resources such as the River Seine and the main park of the Docks (Figure 7).

Figure 7. Public meeting between local elected officials and inhabitants' associations in Saint-Ouen. The meeting was held in order to discuss changes in the planning of the sustainable neighbourhood Docks-de-Seine. Source: Municipality of Saint-Ouen

In the case study of Nantes and the Ile-de-Nantes project, despite the appearance of gentrification processes after the deindustrialisation era (rents' increase, construction of office buildings) the local inhabitants did not leave the city of Nantes and the Ile-de-Nantes site. With the support of the municipality of Nantes and the region of Loire-Atlantique many associations were created by local scholars and former industrial workers who were interested in the preservation and promotion of the local urban and industrial heritage. A local way of city planning focusing on the principles of co-decision and co-design was developed inside the city (l'urbanisme à la nantaise) and was used in all phases of the project of Ile-de-Nantes with the participation of local elected officials, inhabitants' associations, scholars and the teams of architects and urban planners working on the project. Public meetings, workshops and seminars were used as a means to boost citizens involvement in the processes of decision making on issues such as environmental protection, preservation and reuse of industrial heritage and design of houses and public spaces (Figure 8).

Figure 8. Workshop on the second phase of the project of Ile-de-Nantes. Local elected officials, inhabitants' associations and the team of architects and urban planners that led the project during this phase participated in the workshop. Source: Municipality of Nantes

An important parameter in the development policies of deindustrialised areas is the restauration of the natural resources polluted during the industrial era and environmental policies for reducing environmental footprint as a measure for bringing ecological and social justice to areas facing serious environmental and social difficulties

(development based on eco-social integrity). In the case study of Saint-Ouen and the Docks-de-Seine project environmental policies are inscribed in the regional environmental plan for the preservation of local natural resources such as the Seine River while inside the city are created blue and green corridors for the protection of important green spaces such as public spaces and small forests (Figure 9). The polluted industrial area inside the site of the Docks was re-designed and transformed into the main park of the neighbourhood, where vegetation acts as a natural filter in order to clean the water inside the park. Even though the project of Docks-de-Seine as an écoquartier is based on ecological and energy criteria there are doubts about its eco-social dimension as the maintenance of green public spaces of the neighbourhood and the use of smart buildings are expensive measures that do not fit with the industrial character of the city.

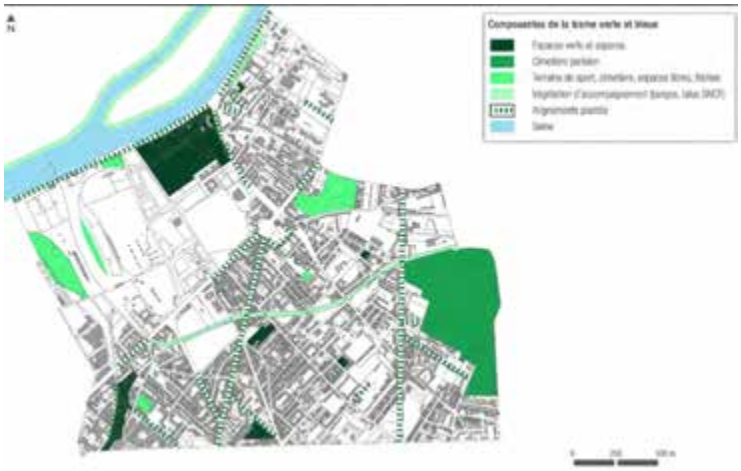

Figure 9. Blue and green corridors inside the city of Saint-Ouen. The development of blue and green infrastructures helps to restore the polluted former industrial lands. Source: Municipality of Saint-Ouen

In the case study of Nantes and the Ile-de-Nantes project environmental policies are inscribed both in the regional environmental plan for the preservation of local natural resources such as the Loire and Erdre River while the city of Nantes developed a plan for the revitalisation of the city based on green public spaces and mobility by bicycle and foot. The polluted industrial spaces inside the Ile-de-Nantes are re-designed and transformed into public spaces (parks) using vegetation as a filter for the polluted water while in the current third phase of the project the leading design team (Shorter and Osty) proposed the creation of green and blue corridors inside the island that will connect it with the public spaces of the city centre (Figure 10). As in the previous case study we should note that the planning and construction of écoquartiers on the site of Ile-de-Nantes focus on ecological and energy criteria but there are doubts about the high cost of such measures that do not fit with eco-social integrity.

Figure 10. Blue and green corridors inside the Ile-de-Nantes project. The development of blue and green infrastructures helps to restore the polluted former industrial lands and connect them to the public spaces of the city centre of Nantes. Source: Varvara Toura

Another point for the growth of deindustrialised areas in post-growth theories is related to the development of economic activities in accordance with the local needs in order to boost the municipal and regional economy as a means to reduce local unemployment rate and to lead to economic resilience and sustainability (economic development based on the local and social characteristics). In the case study of Saint-Ouen and the Docks-de-Seine project at regional level the local economy is based on existing industrial activities together with the construction of office and administrative buildings. At municipal level Saint-Ouen tries to develop its local economy based on activities related to culture and tourism using the former industrial buildings as places to host cultural and educational events (Figure 11). Even though industrial activities play a key role in the economic development strategies for the project of Docks-de-Seine, they are harmonised with the other economic activities while maintaining the industrial character of the city which seems to be gentrified as a result of the installation of office and administrative buildings.

Figure 11. Industrial, cultural and tourism activities on the site of the Docks-de-Seine. While industrial activities continue to exist in Saint-Ouen the city focuses on its industrial past as a source of development of economic activities based on local needs. Source: Varvara Toura

In the case study of Nantes and the Ile-de-Nantes project at regional level the local economy is based on industrial activities in neighbouring cities of Nantes such as Saint-Nazaire while the city of Nantes is developed as the big urban centre of the region where office and administrative buildings are found together with commercial, educational and cultural activities. At municipal level Nantes tries to develop its local economy based on activities related to culture and tourism using the former industrial buildings as places to host cultural and educational events (Figure 12). Even though the restauration and reuse of industrial buildings brings tourists to the area and together with office and administrative buildings creates gentrification conditions inside the former industrial city, they play a key role in the economic development strategies for the project of Ile-de-Nantes and maintain the industrial character of the city as they are also used by local associations of scholars, citizens and former industrial workers.

Figure 12. Educational, cultural and recreation activities in the site of Ile-de-Nantes. Even though industrial activities do not exist inside Nantes the city focuses on its industrial past as a source of development of economic activities based on local needs. Source: Varvara Toura

Discussion

The study of two real-world cases revealed the necessity to consider planning in deindustrialised areas in an interdisciplinary way that brings together members of academia, industry and local actors in order to reshape cities through bottom-up strategies while promoting eco-social integrity. The development of deindustrialised areas in the context of post-growth theories should be based on their particular characteristics, especially their tangible and intangible industrial heritage. Traces of the industrial past such as buildings, neighbourhoods, infrastructure and equipment could be restored and reused as museums, cultural spaces, research hubs and universities in order to promote the local history and boost the local economy through activities related to culture, education and tourism. Local associations of citizens and former industrial workers work on the issue of preservation of industrial heritage and in several cases reverse regional and municipal policies to demolish industrial buildings in order to built contemporary office buildings. The intangible industrial heritage relies on these social ties and on the preservation of the social character of these areas where mainly live low- and middle-class households. The funding of the projects of transformation of deindustrialised areas and especially the planning of sustainable neighbourhoods seems to attract the interest of private investors who are more interested in the development of tertiary activities that in several cases lead to the gentrification of these areas. For this reason, it is important to be developed at national, regional and municipal level policies to reverse gentrification such as a minimum number of social housing in the sustainable neighbourhoods.

Another point to consider from the above analysis for the development of sustainable conditions in former industrial areas are the policies for the environmental protection of these areas alongside the restauration of the polluted natural resources. These policies should be inscribed at a larger context (national, regional, municipal) referring to the global dimension of sustainable development in order to respond to issues such as cities' environmental footprint and reduction of gas emissions. At the same time environmental policies at neighbourhood level that are part of the development program of sustainable neighbourhoods (for example the creation of small and big public spaces such as parks) should be in accordance with the regional and municipal strategic plan for environmental protection in order to propose solutions that would not only benefit certain cities' districts but rather the entire city and region. These environmental policies should be combined with economic activities in accordance with the local communities needs (for example the creation of schools, hospitals and small shops) in order to bring ecological and social justice to areas that suffer from high unemployment rates and pollution due to being neglected for several years after their deindustrialisation. These economic activities could serve as a means to solve social conflicts as underdeveloped deindustrialised areas are places that gather activities of regional and municipal interest such as research hubs, tourism and cultural facilities.

Finally, the last point to consider are the technological innovations of the sustainable neighbourhoods' programs that are presented by politicians (in the French context by the French Ministry of Environment) and contractors as measures that bring social, economic and environmental sustainability and resilience in underdeveloped deindustrialised areas. The development of écoquartiers in France is based on certain policies and measures (Charte Ecoquartier) common for all projects of this category which mainly focus on the reduction of carbon emissions and energy demands for cooling and heating housing units. In certain cases, the cost of this policies is really high thus preventing cities to develop other local policies such as education and health care which are particularly important in areas historically gathering low and middle-class households. Technological innovations of the sustainable neighbourhoods' projects in underdeveloped urban areas such as the design of passive houses, the collection and reuse of grey water in domestic activities and the re-design and transformation of polluted lands into parks should receive national and international funding as they are part of global policies against global warming and climate change. At the same time these innovative policies should be developed for all cities' inhabitants, take into consideration the local socio-economic context (especially the difficulties related to unemployment) and restore the polluted natural environment in order to bring environmental, social and economic sustainability.

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Planning the Great Acceleration: Contributions of planning theory, ideology, and implementation to planetary transformation and social-ecological decline

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Abstract
In the years and decades following WWII, global energy and resource consumption were unleased on a hitherto unseen scale. The fields of earth system science, history, and planetary health continue to grapple with the causes and consequences of this 'Great Acceleration' – a proposed entry point into the Anthropocene. This paper takes its cue from recent trends in research that are 'globalizing' perspectives on the processes of suburbanization and the distinct suburbanisms these processes produce. We explore spatial and temporal scale as necessary, conjoint lenses for articulating key contributions of planning to the Great Acceleration. Taking Prince George, British Columbia, Canada as an illustrative case, we draw on archival sources and spatial analysis of historical subdivision data. These streams of analysis allow us to track and explicate how dominant planning theories were deployed between 1946 and 1981 to both rationalize and accommodate urban expansion within British Columbia's northern capital.

Keywords: Planning; Garden City; Neighbourhood Unit; Great Acceleration; Urban Development

Introduction

Across North America, the mass adoption of the suburban spatial order in the mid-twentieth century emerged in the shadow of the industrial city. While suburban settlement existed alongside the earliest cities for the wealthy and their households, urban planners at the turn of the twentieth century began to focus on the working classes as a group that should also benefit from new notions of health and order (Mumford 1961). Concepts of order, health and separation drew their power from the unprecedented mobility of labour, dispossession, tenements, and disease that had characterized the industrial cities of the late 19th Century. Ideas shaping suburban place-making emphasized orderliness, familiarity, cleanliness, health and prosperity. The separation of uses – notably domestic from industrial – and the intentional development of distinct neighbourhoods as social units became fundamental to the developing profession of planning (Aalen 1992; Grant1997; March 2004; Talen 2017; Ulmer 2018).

Across North America, auto-centric suburbs grew in the decades after the Second World War through the promulgation of a development model Filion (2015) describes as *dispersed suburbanism*. Economic growth, population growth, and household consumptivity interacted to create the culture of suburbia; planners rationalized it, cities marketed it. In Prince George, British Columbia, Canada, most of the city was developed during this period. The impacts of the growth ideology that was forged in this period are still visible in the city's present struggles to advance sustainable development around goals like decarbonization and protection of urban biodiversity. This same growth ideology is also visible in the role the City and the Province played in post WWII planning, land development, and land acquisition, as well as the resource consumptive spatial structure these processes contributed to.

Taking Prince George as an illustrative case, this article charts a historical context elucidating at a local level how dispersed suburbanism became North American cities' primary contribution to what environmental historians John McNeil and Peter Engelke have called the Great Acceleration. In the decades following 1945, accelerating energy and resource consumption became the most powerful influence on global ecology, and the entry into what is increasingly accepted as the human-induced epoch of the Anthropocene (McNeil and Engelke 2014; Steffen et al. 2015). Our goal in this paper is to examine the use of physical planning concepts that entrenched dispersed suburbanism in the structure of Prince George during a period (1946-1981) of rapid post-war growth[1]. By doing so we strengthen an empirical evidence base illustrating how the planning profession helped condition present day global challenges during the peak of the Great Acceleration.

In the post-1945 period, models of neighbourhood design in Prince George (and hundreds of other cities) borrowed from Clarence Perry's neighbourhood unit and Howard's garden city concepts. These concepts had been developed a half century before as ideal forms for work, family, and leisure (March 2004; Patricios 2002).

1 Between 1951 and 1966, the population of Prince George, British Columbia quintupled from 4,703 to 24,471 and then almost tripled by 1981 to a population of 67,559 (BC Stats 2012)

In Prince George and elsewhere, they were translated into the auto-centric spatial patterns of growth and consumption that continue to structure the city and its consequent socio-ecological impacts. In the case of the colonial settlement of Prince George, a future city began as a small number of places competing for centrality. Beyond the scope of this paper, Curry and Llewellyn (1999) review how, in the early decades of the 20th Century, the Grand Trunk Pacific Railway inserted itself and its City Beautiful inspired plan into a struggle between two existing settlement areas (Central Fort George and South Fort George) to attract development. Vogt and Gamble (2010) further problematize this struggle, illustrating a host of coercive tactics the railway deployed to secure the acquisition of property to accommodate their plan on lands wrested from the Lheildi T'enneh First Nation's Indian reserve allotment.

As the Province and resource industries sought to capitalize on the natural resources of the region, aspirations of growth following the Second World War drove the City to secure its place as the regional service centre for resource development. In British Columbia (BC), as elsewhere, there was a massive expansion of highway infrastructure and rapid investment in automobiles (Bradley 2017). Using archival sources and historical land development data, we highlight the role planners and planning thought played in shaping land consumption, growth, and automobile dependence in Prince George. Before doing so, we review two norms of spatial order that were used to rationalize auto-centric growth and design in Prince George and elsewhere. We then present first steps that entrenched a post WWII growth ideology in Prince George's planning regime before exploring the 'big picture' of boundary expansion by the City over the period. We end by examining how the spatial norms of the neighbourhood unit and garden city were deployed to extend and accommodate (both spatially and temporally) this growth ideology.

The suburban spatial order as designed and as built

Two norms of suburban spatial order were formative in realizing the spatial structure of Prince George today. Perry's neighbourhood unit shaped new neighbourhoods built between 1954 and 1981, and Howard's garden city helped to both shape and rationalize a multi-centric sprawling layout underlying planning strategies from the 1970's onward. Both concepts share many of the assumptions/certainties/ideologies of suburbia, although they operate at different scales. In the Prince George context, they were also applied at different periods through the work of different planners, as we discuss later.

The garden city concept was first presented by Ebenezer Howard in his 1898 book *To-morrow: A Peaceful Path to Real Reform.* The impact of the garden city concept on planning and urban development is well recognized, although it is worth noting that its implementation has strayed considerably from the original vision (Aalen 1992; Clark 2003; Hardy 1992; Lewis 2015; March 2004; Ulmer 2018). Influenced by reformist thinking, Howard was primarily concerned with social ideals; the spatial organization of the garden city being somewhat secondary (March 2004; Ward 1992). These social ideals included *inter alia* the collective ownership of land, reinvestment of profits from land conversion to support robust public services, and promotion of a healthy relationship between residents and their natural surroundings (Hardy 1992; Lewis 2015; Ulmer 2018).

Due in part to the growing involvement of a business class less interested in social reforms, the physical features of the garden city concept began to take priority as early as the planning for the first garden city at Letchworth (Ward 1992). Howard was a director for Letchworth but was marginalized early in the project over conflicts with other directors. As Clark (2003) describes, Howard's vision of a city created for its potential residents clashed with obligations others held toward project shareholders. Famously, the physical aspects of the first garden city were also not left for Howard to decide and were instead vested with the architects Barry Parker and Raymond Unwin (Lewis 2015; Livesey 2016; March 2004). Tensions between social goals and environmental design and quality persisted, and Aalen (1992, 28) provides a concise, if not biting, summary of the extent to which spatial planning prevailed: "[I]t is the practical dimensions of [Howard's] work that have been emphasized, while the vital socio-political ideals were barely understood, much less put into effect".

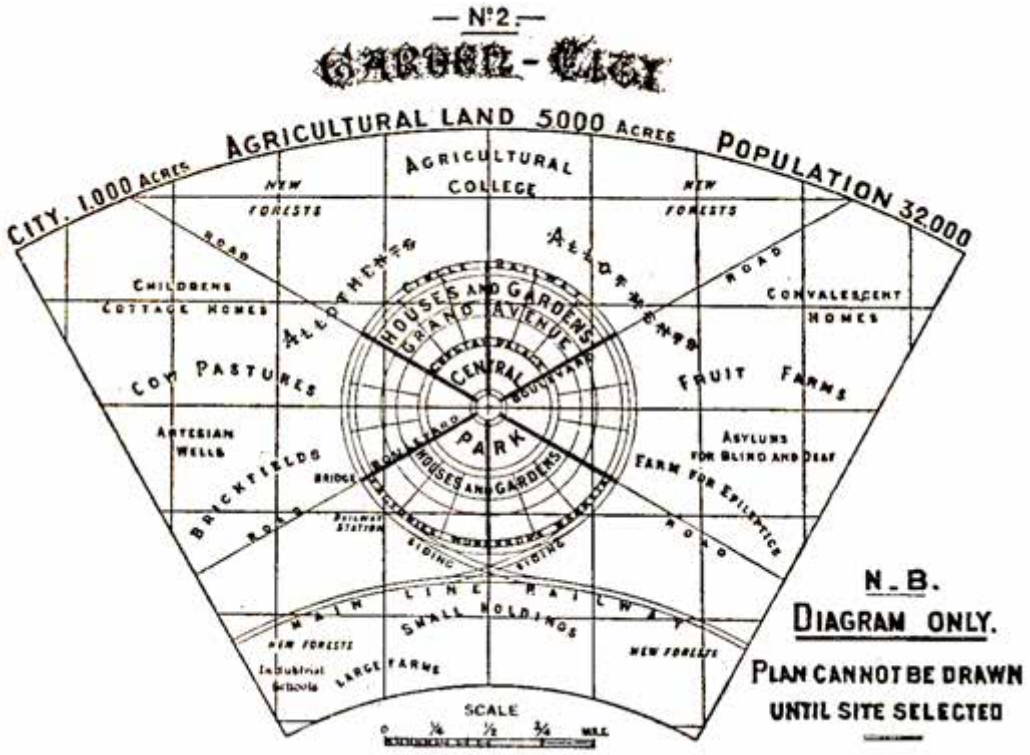

Figure 1: Garden city diagram (Source: Public Domain Wikimedia Commons).

As the garden city diagram in Figure 1 illustrates, the design of the garden city sought to connect the population to healthier natural surroundings while repopulating rural areas to ease the burden of London's population growth (Rockey 1983; March 2004). Fully realized, a 'social city' was to be a network of small scale, decentralized garden cities, each with a central settlement node housing up to twice the population of surrounding nodes. Each garden city in this network was to hold 30,000 residents in its core and 2,000 more in surrounding agricultural estates (Hardy 1992; Ward 1992). The rural agricultural landscape accommodating the network of settlements was to contribute to the livelihoods of garden city residents, a revitalized rural economy, and the sustenance needs of a growing region. Along with tree-lined streets and the provision of public gardens and parks within the settlement boundary, at the edge of the city an agricultural belt provided a space for recreation and a fixed boundary to contain outward growth of the urban area (Aalen 1992; Clark 2003).

Ogilvy (1968) discusses the implementation of the garden city concept as an aspiration to create self-contained communities. Self-containment in Ogilvy's view referred to the provision of a full suite of urban functions (e.g., employment, affordable housing, commerce, etc.) within a defined area, but also the ability for residents to pursue all aspects of a fulfilled life within the community boundary. Accordingly, land use across the wards that were defined in Howard's graphic of a circular city with six intersecting boulevards was to be carefully balanced through zoning. Public services and opportunities for commerce were afforded in a core area, surrounded by concentric belts of residential land that culminated in an outer ring of industrial use connected by a rail corridor (Aalens 1992). The relatively small scale of the garden city meant that residents would have access to the rural landscape and the clean air, pastoral views, and moral healthfulness and simplicity it was understood to provide (Ogilvy 1968).

The second norm of spatial order relevant to understanding post-WWII growth in Prince George is Clarence Perry's neighbourhood unit. The neighbourhood unit concept is typically attributed to Clarence Perry, with its most recognized form emerging in 1929 as part of New York City's regional planning process (Patricios, 2002). Although affixed within the planning cannon, both Talen (2017) and Johnson (2002) challenge the veracity of this story, recounting evidence that formulations substantially akin to Perry's concept were submitted to a design competition hosted by the City Club of Chicago in 1912.

Indeed, Johnson (2002) discusses in detail architect William E. Drummond's entry to this competition, labelled *Neighbourhood Unit*, and goes on to argue that Perry's formulation over a decade later was an appropriation of this original work.

Despite the more varied origins of the neighbourhood unit concept than are sometimes recognized, there is little doubt that Perry popularized contemporary ideas about neighbourhood planning in use by scholars and practitioners at the time (Talen 2017). As Mumford (1954, 262) notes, Perry's work "had a dramatic value in crystallizing many diffuse efforts". These efforts were influenced by social reformers like John Dewey and Robert Park and included a push to plan cities on a neighbourhood scale to address crowding, sanitation, and corruption in the industrial city. Neighbourliness, community, and safety became pillars in the foundation of new physical formulations of neighbourhood structure and function, while principles of scientific management became a counterpoint to a perceived ineffectiveness and immorality within the waning city beautiful movement (Banerjee & Baer 1984; Grant 1997).

The neighbourhood unit would become a ubiquitous model for realizing planned residential environments en masse, seeking to reinforce in physical form sociological theories of neighbourhood and community connection and identity. This included work from Roderick McKenzie identifying two *essential ingredients* of a neighbourhood: geographic proximity to a defining object and the intimate association of people living in proximity to one another. More centrally, Perry's formulation drew on Charles H. Cooley's description of a *primary group*. The primary group was a network of face-to-face interactions and exchanges among family, children, and close relations that served as a heart of a community and informed most directly one's social world and ideals (Banerjee & Baer 1984).

As a model for spatial planning, Perry's neighbourhood unit was designed to fulfill the functional needs of education, commerce, security, and identity for a population of 1000 families, or 5000 people (Grant 1997; Talen 2017). In addition to a *size* that would be defined by a population large enough to support a school, arterial roads formed *boundaries* that would direct vehicular traffic around (rather than through) the neighbourhood. An interior *open space* network served the need for recreational park space, and *institutional sites* like a school anchored the centre of the neighbourhood unit. Finally, *local shops* provided opportunities for commerce on the periphery at major transportation intersections; intentionally sited away from an *internal street system* designed to further dissuade through traffic (Banerjee & Baer 1984).

In addition to following clearly defined spatial prescriptions, neighbourhood units were to be linked together in a cellular design to plan for large areas with relative ease and efficiency (Johnson 2002). Although often understood through the motivation to provide self-containment, each neighbourhood unit can also be viewed as part of the broader function of a designed urban system that resists a centralization of urban services that might hollow out recreation, shopping, and educational opportunities at a neighbourhood level. As Mumford (1954) notes, the function of neighbourhood planning was met with a mix of welcome acceptance, and open critique regarding the potential reproduction of racial, cultural, and economic segregation. Indeed, as Erickson and Highsmith (2018, 12) document, Perry acknowledged that the use of his neighbourhood formula would likely reproduce homogenous grouping processes, "speaking more favourably than critically of separation" and the role of homogeneity as a foundations for shared community consciousness.

As Table 1 below summarizes, the garden city and neighbourhood unit are fundamental spatial concepts whose norms were translated into automobile-oriented neighbourhoods across North America. This includes a tremendous influence in accommodating growth and consumptivity in Prince George during the period of the Great Acceleration, as we now explore.

Table 1: Norms of spatial order.

	Spatial Norms as Designed	
	Garden City	*Neighbourhood Unit*
Origin	1898	1929
Tradition	Social reform	Scientific rationality
Scale	Metropolitan / organism	Neighbourhood / cell
Role of neighbourhoods	Social/educational/arts	Domestic community around a school
Pedestrian walkability	Walkable city proximate to rural landscape	Access to services within neighbourhood walking catchment
Spatial relationships	residents and nature/residents and work/services and education	residents and school/neighbourhood services
	Spatial Norms as Built	
	Garden City	*Neighbourhood Unit*
Concept + automobility	Residential-use suburbs with some services connected by highways to work and to city	Residential-use neighbourhoods without throughways and schools at the centre
Rationale	Multicentric growth and development	Scientific rationality and development
Scale	Metropolitan and suburb	Neighbourhood
Role of neighbourhoods	Residential with services	Physical community around a school
Pedestrian walkability	Access to nature	Walking routes to schools

First steps toward a post WWII growth ideology in Prince George

In Prince George, municipal policy relating urban form to growth came into place immediately following the close of the Second World War. By June of 1946, City Council approved a plan and associated zoning policy prepared by J.H. Doughty-Davies, a civil engineer with the Regional Planning Division of the Bureau of Post-war Rehabilitation and Reconstruction (Prince George Citizen, 1946). The vision of the plan was "[t]o provide healthful, safe and satisfying living environments for all individuals and families" (Doughty-Davies, 1946, 1). In this vision, Doughty-Davies reflected at a local level contemporary discourse surrounding the spatial norms of the garden city and neighbourhood unit. At a broader scale, with a population[2] of less than 5,000 at the time, his newly produced vision and supporting ideas about zoning also meshed well with a desire on the part of Provincial leaders and resource companies to capitalize on the opportunities to expand resource development and extraction in the northern half of the Province (Markey et al. 2008).

As part of the Provincial support for land privatization, the Province undertook surveys and had defined a grid of lots and road allowances in Prince George. The spatial pattern proposed was consistent with both the land layouts done by surveyors and the Crown in the period from 1875-1946, as well as the use of the grid to expedite land development in rail communities across Western Canada (Gilpin 1992; Leonard 1984). Originally, most of the lands that came to make up Prince George had been converted from Provincial to private title for agricultural development in large blocks, but some of these lands the Province had already subdivided in parcel grid. Significant areas west of the original Central Fort George settlement area would ultimately be built out according to prescriptions of the neighbourhood unit (instead of the Province's grid), but the aspirations for urban expansion were clear.

The Province's role in planning Prince George was part of a clear growth ideology evolving around the vision for the city in the postwar period. Prince George's 1946 community plan and its zoning policies were justified on

2 Rutherdale (1994) reports population data for Prince George from the 1961 Census. In 1941, the population was 2,027, and in 1951 the population was 4,703.

what Doughty-Davies (1946) described as two *important considerations*. The first was accommodating growth to a minimum population of 8,000 people. The second was accommodating, through the design of the city, the expectation that Prince George would become a freight and service hub for northern BC. This vision for a northern hub placed Prince George at the centre of not only an east-west train corridor connecting Prince Rupert to Winnipeg and Chicago, but also on a north-south axis that relied increasingly on a nascent highway network (Bradley, 2017). Reflecting on experiences from the United States, Doughty-Davies (1946, 1) described the need to allow for "[w]hat would have been regarded as monstrous vehicles and loads a few years ago".

Prince George's function as a freight and service hub for the north was rationalized in the 1946 community plan in numerous ways. A street plan called for designs that would minimize the use of right angle turns, as well as the strategic acquisition of lots along the east side of a main artery (Vancouver Street) to accommodate a widening of the street to 100'. Along with a zoning plan (see Figure 3) that established six land use designations, the community plan leveraged the rhetoric of community safety and the logic of separation to create the discursive and ultimately physical space for growth in freight and service functions. Notably, the Doughty-Davies discussed the importance of open space to afford children's play, relating preferred sites to the provision of safe family areas located away from high volume traffic corridors. While Doughty-Davies policies and vision spoke to the preferred structure and function of a future city, the most important role of his plan was to reinforce a growth ideology that would become a throughline for planning in Prince George for decades.

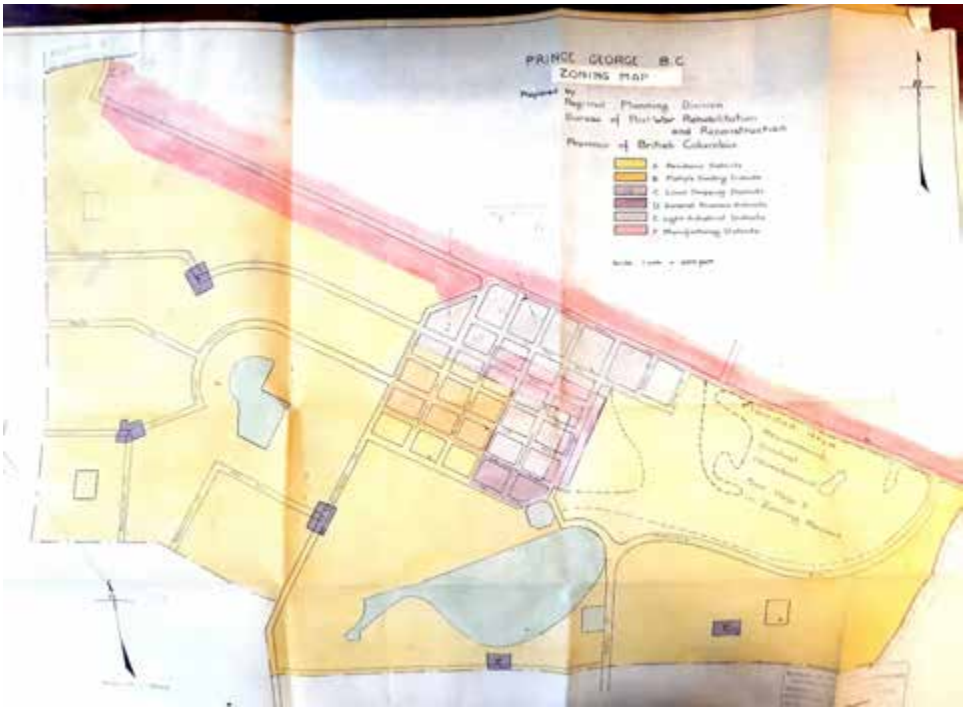

Figure 2: 1946 zoning map for the City of Prince George (Source: Northern BC Archives).

An era of boundary expansions in British Columbia's northern capital

Bolstered by the growth of a regional resource economy and its increasing function as a service hub for northern BC, a vision for post WWII urban expansion in Prince George would be largely realized by end of the 1970s. During this time, the City was an active partner with the Province in expanding its settlement boundaries. The Provincial postwar land policy for urban growth emphasized expanding the boundaries of municipal jurisdiction, and the City of Prince George seized this opportunity to grow the land area under its control.

The map shown as Figure 4 below identifies boundary expansions beginning in 1953 and ending in 1979, illustrating the extent and pattern of annexation of land into the city. The area shown in the 1946 zoning plan (see Figure 3 above) falls within central grey area depicted in Figure 4 below. Through the 1950's two boundary expansions added 1508.2 ha of land and water extending west and southwest from the area discussed by Doughty-Davies only a few years earlier in 1946.

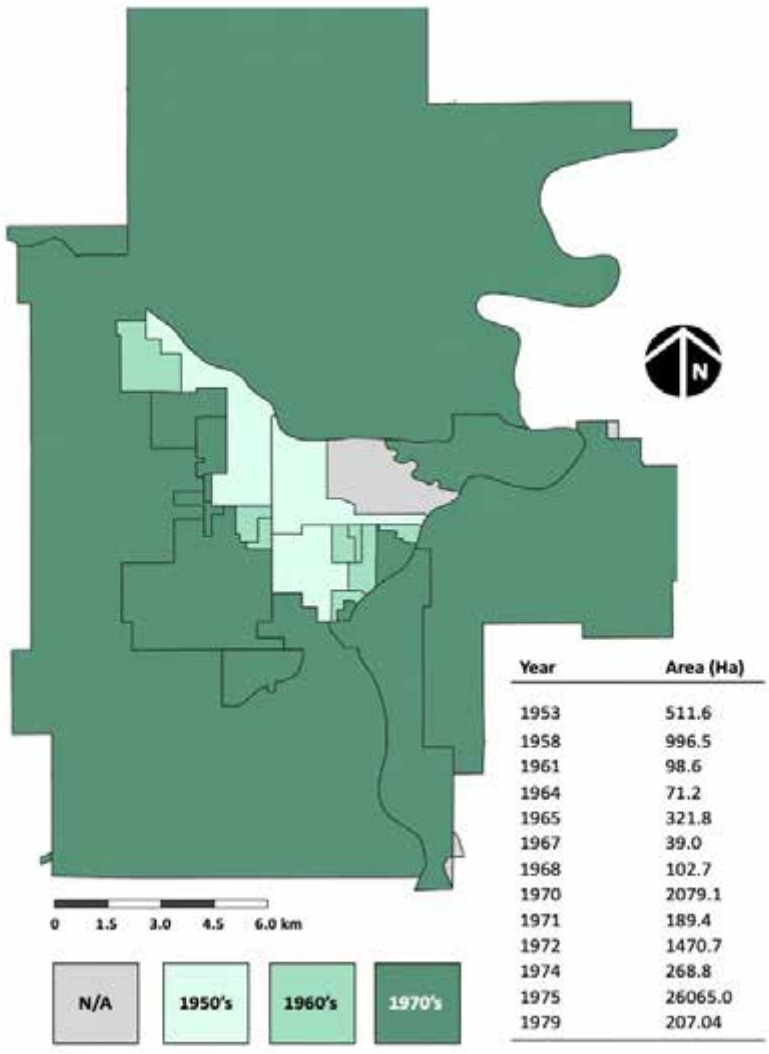

Figure 3: Boundary expansions between 1946 and 1981 in the City of Prince George (Source: City of Prince George OpenData Portal – created by lead author).

In the first boundary expansion in 1953, the City acquired responsibility for the financing and provision of utility services in the new area, placing a direct financial constraint on potential future development. Before the second boundary expansion, the City had negotiated with the Province an ownership transfer of 25% of the remaining Crown land in the expanded area (Trick 1988). While this transfer did not take place until the land met the conditions of use under Land Act regulation (BC Department of Lands, Forests, and Water 1974, 18), through this negotiation the City accessed important new tools to finance the infrastructure required to support ongoing expansion. Ultimately the City became a land developer and regulator. Each boundary expansion from 1958 onward resulted in the potential for the City to develop and sell parcels. Over the next decade an additional eleven boundary expansions would bring 26,698.3 ha of land into their jurisdiction.

As Meligrana (2003) discusses, land annexations in BC during the post-WWII period placed greater importance on the social contract with local communities than concerns for a coordinated planning vision for the spatial or governance arrangements of the province's growing regions. Up until the mid-1970s, annexation required support from a majority of landowners in the area to be annexed, but by the mid 1970s this shifted to a majority support of residents in the incorporated and unincorporated areas.

Building out Prince George's neighbourhood units

With land and financial inputs for the expansion of Prince George supported through annexation and novel financing pathways, a growing city required a spatial norm to plan for, attract, and accommodate settlers in an expanding regional resource economy. In Prince George, the neighbourhood unit served this need. Prescriptions associated with the neighbourhood unit were present in the local policy discourse as early as Doughty-Davies' 1946 community plan. While not in full or by name, Doughty-Davies drew on rhetoric familiar to the neighbourhood unit. He discussed safety at some length to support proposed siting for children's play areas within their neighbourhoods such that "no child has to go more than one quarter of a mile nor cross a main traffic street to reach it" (Doughty-Davies 1946, 3). Consistent with the scientific rationality of the neighbourhood unit, he also singled out standards for the appropriate provision of school services. Allowing for an average ratio of adults to children appropriate to the period and an expected population of 8,000 people, each child was to be afforded 100 square feet of play space proximate to their school.

Early nods to the neighbourhood unit notwithstanding, full implementation of this spatial norm would lag the sequence of boundary expansions that began in 1953. By applying the planning elements[3] summarized by Banerjee and Baer (1984) to openGIS data for Prince George's street network and zoning data (and cross referencing these against land use plans from 1969 and 1978), we identify twelve neighbourhoods that were substantially or fully built out according to the neighbourhood unit (see supplementary material). A review of all registered plans of subdivision and strata plans within these areas of the city shows the implementation of neighbourhood units through land development began between 1956 and 1960 and persisted through 1981 (BC LTSA, 2022).

The implementation of the neighbourhood unit accommodated the growth of Prince George's built-up area as the city expanded in all directions, often with new developments leapfrogging into recently incorporated areas of the city. From 1956 to 1981, over 5000 new residential parcels were established within areas that would be built out according to neighbourhood unit principles. The pace of subdivision into these residential areas peaked from 1971-1975, ultimately comprising 16.2% of the City's total parcel fabric (see Table 2).

While we were interested in the possible role the City played in processes of place branding that are increasingly scrutinized within the field of placemaking (see for instance Masuda & Bookman 2018), available archival sources revealed little evidence of this function. One caveat to this is a promotional brochure produced by the City in 1970 (City of Prince George 1970). The document features the city's high rate of growth and its industries, projecting this state into the future. For each of the main resource industries including forestry, forest products, and mining and minerals, the document paints a bright future. The emphasis is almost completely on economic prosperity and business growth, with almost no mention of the city as a place to live, with one notable exception. Affordable serviced lots available in "planned neighbourhood units".

Illustrative of the aspirations for further growth and development, the footprint of Prince George as built according to the neighbourhood unit ultimately could have been much larger if not for the fact that population growth and land subdivision began to subside by the early 1980s. As dispersed as Prince George's built-up area became, a 1978 land use plan includes a far more extensive network of arterial and collector roads expanding into the urban-rural interface (Schaber 1978). Reflective of Perry's concept, outlying areas in Prince George were to comprise neighbourhoods identified on the land use plan by a proposed set of intersecting arterial roads and a symbol representing a school at the centre of each newly bounded area.

3 Banerjee and Baer (1984) identify a combination of the following elements as characteristic of the implementation of the neighbourhood unit: *size, boundaries, open space, institutional sites, local shops, internal street networks.*

Table 2: Land subdivision within Prince George's completed neighbourhood units.

Date Range	Parcels Created	*Proportion of Parcels Created	*Area Subdivided (Ha)
1956 - 1960	312	1.0%	41.77
1961 - 1965	607	1.9%	79.88
1966 - 1970	1231	3.8%	150.60
1971 - 1975	2161	6.6%	219.46
1976 - 1981	963	2.9%	124.72

* Proportions based on total number of active parcels in City of Prince George open GIS parcel fabric layer as of June 2022. Total land and water area calculated from City of Prince George open GIS boundary layer.

Rationalizing continued growth through a garden city master plan

The post WWII growth ideology that was built in part through Doughty-Davies 1946 community plan and subsequent land transactions between the City and Province intersected with the neighbourhood unit concept as early as a the 1950s. It would be two decades later that garden city planning would play a similar role. Led by Chander Suri, then Director of Planning for the Regional District of Fraser Fort George, a Proposed Master Plan from 1971 documents a planning concept for accommodating future growth across the landscape increasing within the City's jurisdiction (see Figure 4). Reflective of Howard's vision of town and country harmony, Suri drew on surveys of the local population to support a vision that "will take advantage of the natural character of the area by combining both rural and urban elements to create urban units within rural settings" (Suri 1971, 3). To actualize this vision, the concept identified the city as a *centre of urbanity* housing a population of 175,000 to 200,000, and a network of three *satellite towns* ranging in size in size from 50,000 to 90,000 people.

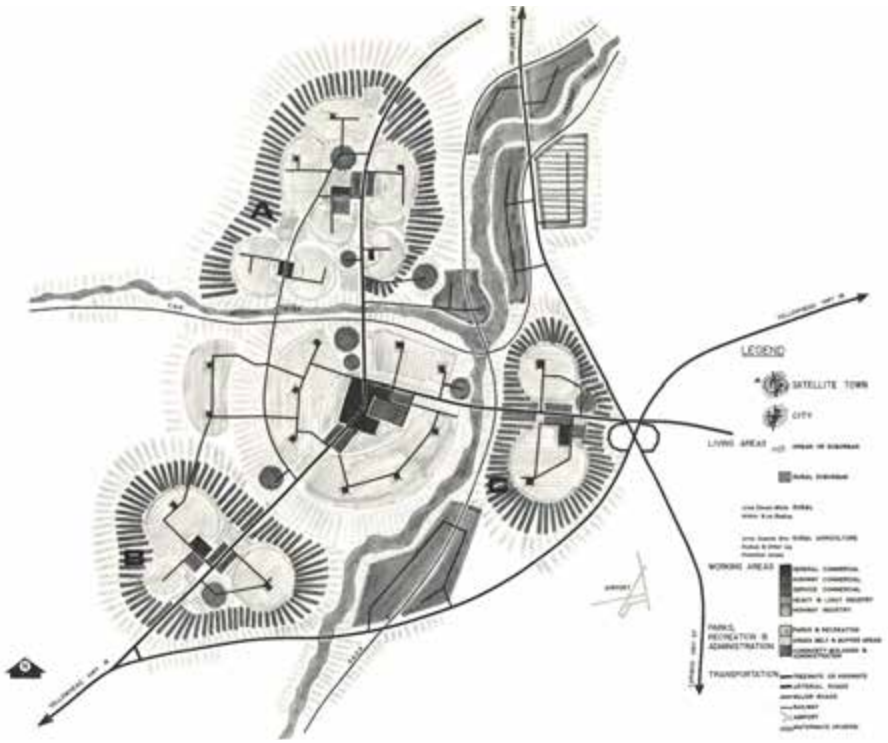

Figure 4: Greater Prince George Planning Concept from 1971 Proposed Master Plan (Source: Regional District of Fraser Fort George – Reproduced with permission)

The pace of population growth present in the two decades following the close of the Second World War would falter and ultimately stagnate by the early 1980s, but continued expectations and aspirations for growth are evident throughout the Suri plan. While focused on a detailed set of objectives and policies for building out satellite town A north of the city's original urban core, Suri articulated a broader vision for the Greater Prince George area. This vision drew directly on many of the garden city's spatial prescriptions. *The city* and each *satellite town* were to be surrounded by a green belt, with additional separation provided by the Nechako and Fraser Rivers in the case of satellite town A and C.

Within Suri's vision Greenways were to play a role as *containment areas*, while simultaneously supporting values like intensive recreation and engagement of citizens in forest reserve management. Although falling short of the collective ownership Howard envisioned (Hardy 1992; Lewis 2014; Ulmer 2018), the goal to create forest reserves managed with direct input from local citizenry sought to capture aspirations to secure an enduring public good through spatial planning and land management. The plan articulates this as the need to foster "a spirit of participation and appreciation by the local people toward preservation and management of the forest resources in the region" (Suri 1975, 25).

In addition to the function of the greenway system, an open space hierarchy was developed in response to trends in mobility, income, population, and leisure time. The sequence of open spaces would afford connection to nature, including pedestrian access from homes to private green spaces, playgrounds, local parks, and town parks. Access to regional parks was to require a vehicle. Like Doughty-Davies standards for youth play areas, planning standards for green space provision left questions of environmental quality and human health and well-being unexamined, focusing instead on quantitative relationships between population and land provision.[4]

Set within the context of two decades of economic and population growth and an era where planning thought was increasingly permissive toward growth (Chapin 2012; Filion 2009), it is perhaps not surprising that Suri would contribute to an ongoing growth ideology. Although the Proposed Master Plan and supporting summary do not address the use of common practices to address uncertainty, like building multiple scenarios with varying assumptions, Prince George's garden city concept was informed by a population projection signaling continuous, vigorous growth. Within the boundaries of the contemporary City, projections estimated population growth from 32,629 in 1971 to 150,460 in 2001. Within each of the surrounding electoral areas, population growth ranging from 21,509 to 118,670 was projected over the same period. Based on this expected growth, the planning concept for Greater Prince George depicted in Figure 4 was developed to "accommodate a population of over ½ million people (580,000)" (Suri 1975 29).

To create a plan for meeting the demand for services and consumption of such a rapidly growing population, Suri again turned to garden city principles to develop a networked hierarchy of commercial urban functions. A *downtown or central core* was to meet the specialized shopping needs of 100,000 to 250,000 people, with direct transportation connections to three outlying satellite towns. In turn, each satellite town would be serviced by three connected commercial districts: a *town centre* with at least 225,000 ft^2 of commercial space; a *town sub-centre* providing 95,000 ft^2 of space for *convenience goods and services*; and a *neighbourhood centre* of 32,000 ft^2 of space meeting *day to day* shopping needs and minor personal services (Suri 1971).

Conclusion

On May 20th, 1975, Prince George City Council was presented with a range of options for future growth. Of the four options presented, "Council approved the option of **growth in all directions"** (Suri 1975, 1 - **emphasis added**). Far from unique, this decision was one of myriad made during the decades following the Second World War that contributed to the transformation of cities across North America.

4 The open space standards in the Proposed Master Plan were related to population. Regional Parks – 2.5 to 13 acres per 1000 people; Town Parks – 2.5 to 4.5 acres per 1000 people; Community Parks – 1.5 to 2.5 acres per 1000 people; Golf Courses – 18 holes per 40,000 people; Neighbourhood Parks – 2 acres per 1000 people.

Driven by similar growth ideologies and growing affluence sparked by a massive rise in consumer goods ranging from household appliances to automobiles, cities sprawled outwards to accommodate booming populations (Belisle 2011; Bradley 2017; Filion et al., 2016; Owram 1997). Described by Filion (2015) as *dispersed suburbanism*, the postwar development pattern that accommodated this growth committed North American cities to an urban form and function dominated by low-density development, functional land-use specialization, separation of activities, and auto-dominated forms of mobility.

The negative human health (e.g., sedentary lifestyles) and environmental (e.g., greenhouse gas production) consequences that were embedded in North America's post WWII urban landscape are now well established (Chapin 2012; Girardet 2020; Rees 2018), but are often understood within a limited historical context, especially in Canada's urban north. Under the banners of resilience, sustainable development, and new urbanism (among many others), the planning profession continues to mobilize a response to address its contribution to growing global environmental issues like climate change and biodiversity loss. To succeed in this endeavour, the profession must not only advance new spatial norms for sustainable urban development. It must also take stock of the historical forces that coalesced during the period of the Great Acceleration that continue to shape present social-ecological crises (Castree 2017; O'Brien & Lousley 2017).

This research contributes to this necessary stock take by examining how planning thought, planning practitioners, development processes, and financial mechanisms coalesced from 1946 to 1981 to realize the resource consumptive urban expansion of Prince George, BC. Like a growing number of scholars (see de Baro 2022 for a recent example), we sought to situate the local and regional processes of urban planning and land development in closer proximity to global scale discourses about the Anthropocene and Great Acceleration. We did so by examining how the spatial norms of the garden city and neighbourhood unit were converted between 1946 and 1981 to facilitate growth and automobility.

Like other cities in western Canada, most of the growth in the city of Prince George took place while the spatial norms of the garden city and neighbourhood unit were dominant. The influence of other norms, namely the application city beautiful and the urban grid, have been placed within a historical context in northern cities like Prince George (Leonard 1984; Sedgwick 2010). Much of this scholarship examines the establishment of early settlements near the turn of the century, and our focus on post WWII urban planning in BC's northern capital offers new insights into the multiple waves of planning thought that were deployed to build the urban north.

Although nascent, the pattern of land annexation and the roles of the City and Province in these processes represents potential evidence of the type of urban growth coalition dynamics heavily scrutinized in metropolitan contexts, but understudied in the urban north. Further study is required to better understand these dynamics, but the present examination of Prince George helps us to understand the extent to which planning thought could lend itself to – or was mobilized in support of – a growth ideology. In this case, planners helped to promote growth, to rationalize growth, and to invest in growth. At the height of the Great Acceleration, City Council adopted a policy of unconstrained expansion within its available boundary and an urban structure designed to support a population that has yet to arrive over 50 years later.

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Deprivation Analysis in Turkey and Its Provinces: Insights for Post-Growth Urbanism

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Abstract
This paper presents a multidimensional deprivation assessment across Turkey's 81 provinces by adapting the English Indices of Deprivation (EID) to national data. It builds a Turkish Composite Deprivation Index (TCDI) using 2023 statistics from TURKSTAT, covering seven domains: income, employment, education, health, crime and social distress, housing access, and the living environment. By weighting and scaling each indicator, the study allows meaningful comparison between provinces. The results highlight a persistent east–west divide, with places like Şanlıurfa, Ağrı, and Şırnak facing deeper disadvantage. The index offers a practical lens for spotting regional gaps and guiding fairer resource allocation. It also contributes to post-growth urbanism discussions by calling attention to the structural roots of inequality and the need for more grounded, socially responsive planning.

Keywords: Deprivation Index, Deprivation Index of Turkey, Index of Multiple Deprivation, Regional Disparities, Spatial Inequality.

Introduction

This research applies English Indices of Deprivation (EID) to national data to provide a holistic evaluation of deprivation across Turkey's 81 provinces. Based on TURKSTAT data for 2023, it constructs a Turkish Composite Deprivation Index (TCDI) consisting of seven fields: income, work, health, education, social distress and crime, access to housing, and living conditions. Analysis enables comparison of provinces on a balanced basis through balancing and scaling all variables. According to the findings, there exists a long-standing east-west gap, with provinces like Şanlıurfa, Ağrı, and Şırnak being underprivileged ones. The index can be an effective instrument to find areas of inconsistency between regions and prepare for more balanced allocation of resources. By bringing to mind the structural sources of inequality and the necessity for more embedded, socially oriented development, it also helps contribute to post-growth urbanism discussions.

Such indices allow decision-makers to design financial strategies and interventions more effectively. The overarching goal of this study is fourfold: (1) to identify provinces that require more focused development strategies, (2) to generate a province-level deprivation map for Turkey that encourages a more transparent and goal-oriented planning culture among regional authorities, (3) to promote the use of systematic, data-driven evaluation tools for policy design, and (4) to emphasise the value of using official TURKSTAT data in place of survey-based samples that may be subject to bias or limited accuracy.

As this study relies on relative comparisons, the ranking of provinces is contextual—not absolute. That is, a province ranked highest in deprivation is more deprived compared to others but may not be deprived in an absolute sense. If updated regularly, the map can foster a feedback loop of improvement and accountability among provinces. It also offers a multi-layered spatial representation of how Turkish provinces relate to one another in terms of development gaps.

The central research question is as follows: What would the spatial pattern of deprivation across Turkey's provinces look like if current TURKSTAT data were structured according to the English Indices of Deprivation (EID)? Answering this requires translating nationally available datasets into domain-specific indicators, applying a multi-criterion weighted sum method, and visualising the output to better understand inter-provincial disparities.

Conceptual Framework

The study's limitations stem primarily from differences between the data used in the English Indices of Deprivation (EID) and those provided by TURKSTAT. The EID framework comprises seven domains: income, employment, education, health and disability, crime, barriers to housing and services, and the living environment.

Each domain is supported by a set of published indicators and combined using defined weights to produce domain-specific scores. These are then aggregated into an overall deprivation index.

Deprivation, as defined in this study, is a multi-dimensional condition encompassing economic insufficiency, limited access to public services, and poor living standards (Payne & Abel, 2012). At the municipal, regional, and national levels, spatial disparities have long been identified using deprivation indices. Turkey's official statistics are produced in large part by TURKSTAT (Türkiye İstatistik Kurumu). It gathers information on a variety of subjects from homes, people, and organizations and releases it on a regular basis. For this study, TURKSTAT's online database was the primary source, providing province-level data which was extracted, filtered, and assessed according to each domain. Due to the lack of a one-to-one match between English and Turkish data, alternative indicators were chosen that closely reflect the meaning and function of the original ones. Due to the fact that this directly affects both domain-level and overall deprivation outcomes, it was imperative that all indicators chosen were in good alignment with the domains they represent.

The Provincial Well-Being Index, which covered 11 dimensions and 41 variables, was first released by TURKSTAT in 2015. Although comprehensive, it integrated both objective measures and subjective survey responses. Similarly, Çağlar (2020) recalculated the index using updated sources but retained some foundational aspects. These earlier efforts leaned towards general well-being and were partially based on dated or self-reported data. In contrast, this study focuses solely on deprivation and relies only on objective and current indicators. These distinctions make direct comparisons challenging.

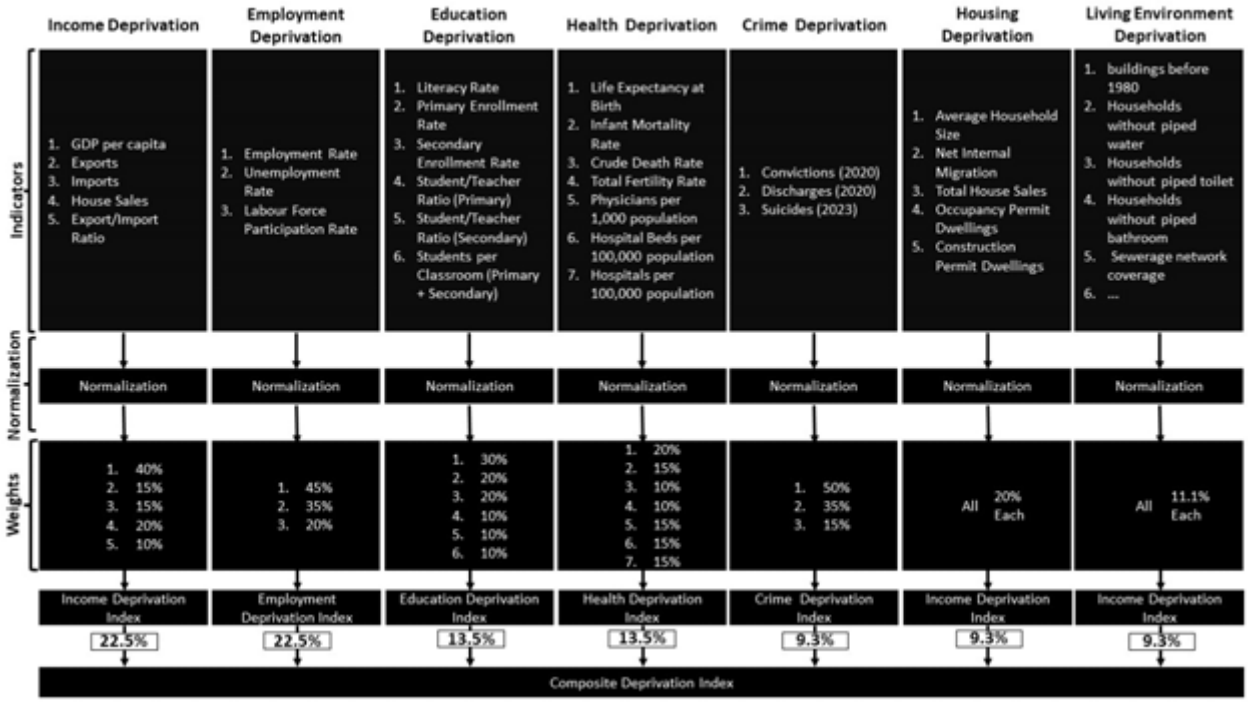

Figure 1. Framework for constructing the Turkish Composite Deprivation Index (TCDI), showing indicator selection, normalization, weighting, and aggregation into domain and composite indices across seven deprivation domains.

Income Deprivation

Captured through GDP per capita, trade volume (exports and imports), and housing market data—providing insights into regional economic capacity and household income levels. The goal of this analysis is to develop a province-level Income Deprivation Index (IDI) for Turkey by combining multiple economic indicators. The index is designed to reflect spatial disparities in economic wellbeing and to rank provinces from most to least deprived. All data used are official province-level statistics published by the Turkish Statistical Institute (TURKSTAT) for the year 2023, including:

Gross Domestic Product (GDP) per capita, Exports, Imports, Number of house sales, and Export/Import Ratio (calculated), see table 1. The reason of choosing the year 2023 is the limitations of GDP indicator's data in 2024 and 2025.

Table 1. Income Deprivation indicators and description

Indicator	Description
GDP per capita	Reflects the economic output and income potential per person.
Exports	Proxy for production capacity and global market integration.
Imports	Reflects consumption capacity but with mixed implications.
House Sales	Indicates internal economic activity and individual asset access.
Export/Import Ratio	Captures trade balance and economic self-sufficiency.

To allow meaningful comparison across different units and magnitudes, each indicator was normalized to a 0–1 scale using Min-Max scaling. This ensures that all indicators contribute proportionately to the index, regardless of their original scales, see equation (1). Higher exports usually reflect stronger economic activity, production capacity, and international market integration. It indicates more job opportunities and better industrial output thus reduces deprivation. High Imports, on the other hand, can reflect a healthy consumer market and purchasing power but if overly high relative to exports, they might indicate dependency or trade imbalance. For province-level analysis, high imports often align with urbanized, economically vibrant areas (like Istanbul or Kocaeli) so they can reduce deprivation in that context. Since the income index is based on the assumption that Higher GDP, exports, imports, and house sales equals to lower deprivation, then imports and exports have a negative contribution to deprivation in a sense.

$$Normalized_i = (X_i - X_{min}) / (X_{max} - X_{min})$$

Export/Import ratio as a separate indicator to reflect economic balance were calculated where a higher ratio (>1) indicates stronger export performance relative to imports (positive economic balance) and a lower ratio (<1) may suggest dependency on imports or a weaker production/export base. The Income Deprivation Index has been recalculated to include the Export/Import Ratio as a fifth indicator. Following the inclusion of the Export/Import Ratio, the top 5 provinces had the largest increases in rank: Hatay (46 → 30), Kırşehir (38 → 23), Tunceli (49 → 35), Edirne (50 → 38), and Zonguldak (47 → 28). These provinces have strong export/import ratios relative to their overall economic scale. Including this economic balance improves their standing, reflecting greater economic resilience or self-sufficiency. On other hand, Gümüşhane (6 → 74), Giresun (16 → 70), Rize (26 → 68), Ardahan (28 → 69), Şırnak (20 → 51). These provinces likely had low export/import ratios, suggesting weak export performance or high import reliance, this disproportionately affected their overall economic balance in the updated index.

Table 2. Income domain indicators and their weights

Indicator	Weight
GDP per capita	40%
Exports	15%
Export/Import Ratio	15%
House Sales	20%
Imports	10%

$$IDI_{(i)} = 1 - \Big(0.40 \times Normalized\ GDP\ per\ capita_i + 0.15 \times Normalized\ Exports_i + 0.15 \times Normalized \frac{Export}{Import} Ratio_i + 0.20 \times Normalized\ House\ Sales_i + 0.10 \times Normalized\ Imports_i\Big)$$

The top 5 provinces that improved most in rank after applying the custom weights are Giresun, Şırnak, Rize, Trabzon and Gümüşhane. The top 5 provinces that dropped the most in rank after applying the custom weights are Kırıkkale, Çanakkale, Zonguldak, Bolu and Düzce. These provinces likely benefited more from equal-weighted indicators (especially imports or exports) than the new GDP-dominant index. Each province received a final IDI score and was ranked from most deprived (Rank 1) to least deprived (Rank 81). The ranking directly corresponds to the descending order of the IDI score. According to the results, Gümüşhane, Hakkari, Kırıkkale, Şanlıurfa, and Edirne are the top 5 most deprived provinces. High degrees of economic deprivation were indicated by these provinces' consistently low GDP, export volume, housing activity, and economic balance numbers.

The regions of İstanbul, Ankara, Kocaeli, İzmir, and Bursa are the top five least deprived. These provinces displayed strong economic performance and trade balance, thus scoring lowest on the deprivation index.

Figure 2 illustrates the clear regional separation between the western and eastern regions in Turkey's income deprivation distribution. The eastern and northeastern provinces of the nation are the most economically deprived areas, which are represented by the darkest tones. Deprivation scores are high in provinces like Hakkari, Şırnak, Ağrı, Bitlis, and Gümüşhane. The provinces like Yozgat, Çorum, and Tokat also has a secondary cluster of high-income deprivation.

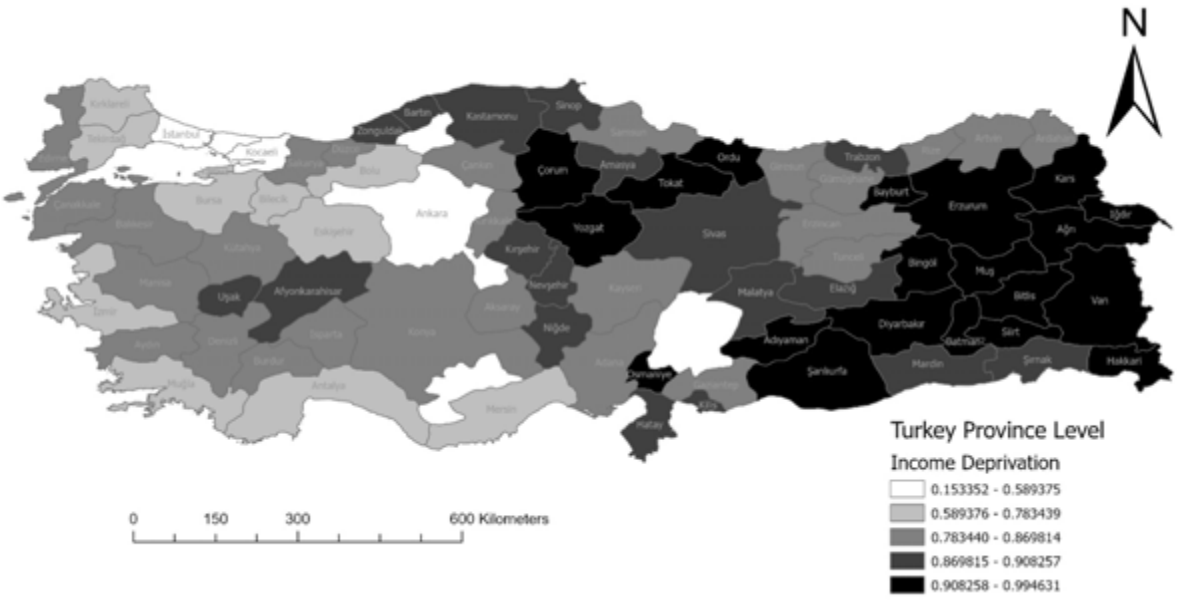

Figure 2. Income Deprivation Index by province in Turkey. Darker shades represent higher levels of income-related deprivation.

The coastal provinces of the Aegean and Mediterranean also have lower income deprivation ratings, most likely as a result of their diverse economic bases and tourism-driven economies. Despite being close to more affluent neighbors, some western interior provinces, such Afyonkarahisar and Uşak, have greater levels of deprivation, exhibiting an outlier pattern. This points to sectoral constraints impeding wider regional convergence or localized economic stagnation. Because of their varied economic bases and tourism-driven economies, the coastal provinces of the Mediterranean and Aegean also have lower income deprivation scores.

Some western interior provinces, including Afyonkarahisar and Uşak, have higher levels of deprivation while being near more prosperous neighbors; this is an outlier trend. This suggests either localized economic stagnation or sectoral restrictions preventing broader regional convergence.

Employment Deprivation

Employment Rate (the proportion of the working-age population that is employed), unemployment rate (the proportion of the labor force that is unemployed), and labor force participation rate (the proportion of the working-age population that is either employed or actively seeking employment) were chosen as indicators to aggregate the data for the Employment Deprivation Domain. These metrics offer a thorough summary of employment-related metrics for every Turkish province. Although the information provided is adequate to begin examining job deprivation, a more complete picture may be obtained by include other measures such as income inequality, gender inequalities, young unemployment, and informal work. But due to the limitations of data provided by TURKSTAT, which is the main focus of data in this study, the employment deprivation domain indicators are employment Rate, unemployment Rate, and labour Force Participation Rate. All data used are official province-level statistics published by the Turkish Statistical Institute (TURKSTAT) for the year 2023.

Table 3. Weights of employment domain indicators and their impact direction

Indicator	Weight	Impact Direction	Reasoning
Employment Rate	45%	Higher = Less Deprivation	Strongest predictor of economic inclusion
Unemployment Rate	35%	Higher = More Deprivation	Reflects labor exclusion and economic strain
Labour Force Participation Rate	20%	Higher = Less Deprivation	Signals labor market engagement, indirect

$$EDI_{(i)} = (1 - Normalized\ Employment\ Rate_i) \times 0.45 + (Normalized\ Unemployment\ Rate_i) \times 0.35 + (1 - Normalized\ Labour\ Force\ Participation\ Rate_i) \times 0.20$$

According to the job Deprivation Index, the provinces of Hakkari, Van, Diyarbakır, Hatay, and Şırnak have the worst job conditions in Turkey. The provinces have significant unemployment rates—23.3% for Hakkari and 19.1% for Van—and a consistently low employment rate, which ranges from 35.9% to 38.5%. Labour force participation is comparatively low in the provinces, particularly in Diyarbakır (40.8%) and Şırnak (42.5%). These factors, being interdependent, cause the deprivation scores to be higher, indicating low participation in formal labor markets and high economic vulnerability in these areas. At the other end of the scale, the least deprived in terms of employment are Ardahan, Tekirdağ, Antalya, Bartın, and Zonguldak. These provinces all have significantly higher employment rates—up to 58.2% in Ardahan—and relatively low unemployment rates, i.e., 5.8% for Ardahan and Balıkesir. Labour force participation is also high, especially in Ardahan (61.7%) and Tekirdağ (60.6%), indicating higher participation in the labour force. These positive figures in the three indicators reflect lower deprivation scores and place these provinces in the first rank of the employment well-being, see table (4).

Table 4. Top and least 5 deprived provinces, employment domain

Top 5 Most Deprived Provinces					
Rank	**Province**	**Employment Rate (%)**	**Unemployment Rate (%)**	**Labour Force Participation Rate (%)**	**EDI Score**
1	Hakkari	38.2	23.3	49.9	0.848
2	Van	38.5	19.1	47.5	0.783
3	Diyarbakır	35.9	11.9	40.8	0.757
4	Hatay	38.0	15.6	45.1	0.748
5	Şırnak	36.9	13.1	42.5	0.745
Top 5 Least Deprived Provinces					
Rank	**Province**	**Employment Rate (%)**	**Unemployment Rate (%)**	**Labour Force Participation Rate (%)**	**EDI Score**
81	Ardahan	58.2	5.8	61.7	0.199
80	Tekirdağ	56.2	7.3	60.6	0.244
79	Antalya	55.1	7.4	59.5	0.253
78	Bartın	50.7	8.1	55.2	0.259
77	Zonguldak	46.9	11.0	52.7	0.268

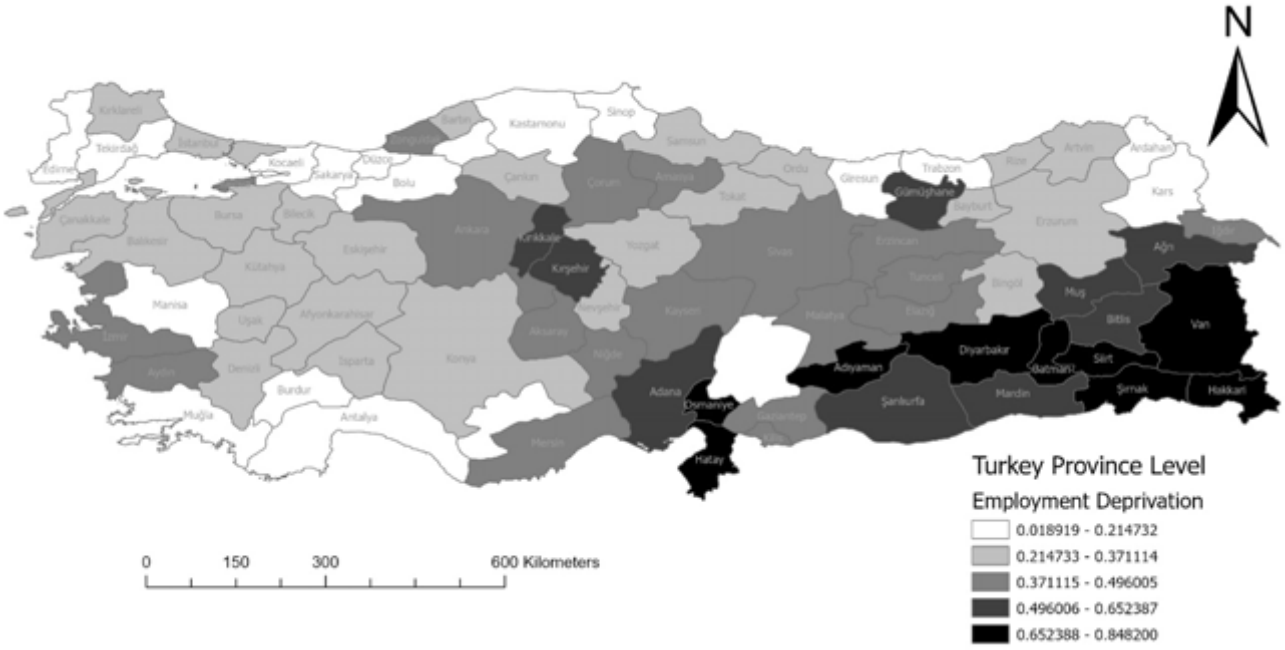

Figure 3. Employment Deprivation Index by province in Turkey. Darker shades represent higher levels of employment-related deprivation.

Education, Skills, and Training Deprivation Index (EDDI)
Quantified in terms of mean years of schooling, education attainment levels, and gender parity indices—indices of inequalities in access and attainment. The Education, Skills, and Training Deprivation domain measures geographical inequalities in access to education and educational attainment between Turkey's provinces. The domain is a key driver of long-term deprivation as educational attainment is strongly linked with labor market prospects, earnings levels, and general well-being. Statistics for this category are taken directly from the Turkish Statistical Institute (TURKSTAT) and include the following measures: literacy rate (%), primary and secondary school enrollment rate (net), student/teacher ratio for primary and secondary schools, and average number of students

per class. These measures are employed as proxies for both educational attainment and quality of educational facilities. All data used in this analysis are up to date as of 2023, and they provide temporal homogeneity for the province-level comparison.

In order to build a weighted Education, Skills, and Training Deprivation Index (EDDI), policy usefulness, data quality, and the influence of each indicator on education deprivation should be taken into account carefully. Literacy and enrollment are assigned 70% of the overall weight since they are direct indicators of the availability of and returns on education. Pupil/teacher and pupil/classroom ratios influence quality but are less direct and thus given a combined total of 30%. This allows output (literacy) and access (enrollment) to be emphasized, while infrastructural and resource indicators nevertheless weigh heavily on the deprivation index.

Table 5. Education domain indicators, impact direction and justification.

Indicator	Weight (%)	Impact Direction	Justification
Literacy Rate	30%	Higher = Less Deprivation	Literacy is the most fundamental education outcome. It reflects access to and success in basic education and influences employability and lifelong learning.
Primary Enrollment Rate (Net)	20%	Higher = Less Deprivation	Ensures foundational education access.
Secondary Enrollment Rate (Net)	20%	Higher = Less Deprivation	Indicates retention and progression in the education system. A key step toward skills training.
Student/Teacher Ratio (Primary)	10%	Lower = Less Deprivation	A proxy for learning quality. Lower ratios suggest better teacher attention and classroom interaction.
Student/Teacher Ratio (Secondary)	10%	Lower = Less Deprivation	Similarly important for quality education at later stages. Often varies more between regions due to specialization needs.
Students per Classroom (Primary + Secondary)	10%	Lower = Less Deprivation	Reflects school infrastructure and overcrowding, which affect learning conditions.

Min-Max scaling was used to normalize the chosen indicators so that they could be compared across various scales and units. The following were then weighted according to policy impact and relevance: literacy rate (30%), secondary school enrollment rate (20%), primary school enrollment rate (15%), secondary school student/teacher ratio (15%), primary school student/teacher ratio (10%), and pupils per classroom (10%). While larger classroom densities and student-teacher ratios suggest difficulties with educational accessibility and quality, higher enrollment and literacy rates suggest less disadvantage. The resulting Education Deprivation Index (EDDI) aggregates these weighted, normalized values to rank provinces from most to least deprived. This composite score captures both infrastructure strain and educational inclusion, revealing stark contrasts between regions in terms of educational opportunity and equity.

$$
\begin{aligned}
EDDI_{(i)} = {} & (1 - Normalized\ Literacy\ Rate_i) \times 0.25 + (1 \\
& - Normalized\ Primary\ Enrollment\ Rate_i) \times 0.20 + (1 \\
& - Normalized\ Secondary\ Enrollment\ Rate_i) \times 0.20 \\
& + Normalized\ Student/Teacher\ Ratio\ (Primary)_i \times 0.10 \\
& + Normalized\ Student/Teacher\ Ratio\ (Secondary)_i \times 0.10 \\
& + Normalized\ Students\ per\ Classroom_i \times 0.15
\end{aligned}
$$

Table 6. Top 5 most deprived, education domain.

Top 5 Most Deprived Provinces - Education Domain								
Rank	Province	Literacy Rate	Primary Enrollment Rate	Secondary Enrollment Rate	Student/Teacher Ratio (Primary)	Student/ Teacher Ratio (Secondary)	Students per Classroom	EDDI
1	Şanlıurfa	94.13	96.06	87.2	29	19	32	0.67
2	Mardin	93.76	95.39	88.74	21	15	25	0.53
3	Gümüşhane	96.92	81.61	76.78	13	9	13	0.51
4	Şırnak	95.11	94.37	86.14	21	15	22	0.49
5	Diyarbakır	94.97	96.17	90.35	20	15	29	0.47

Its eastern and southeastern provinces—Şırnak, Ağrı, Şanlıurfa, Muş, and Bitlis—are the five poorest in the nation. With a low secondary school enrollment rate of 86.14%, a low literacy rate of 94.85%, and a high student-teacher ratio of 21 primary and 16 secondary students per instructor, Şırnak has the lowest degree of deprivation. Comparably, Ağrı and Muş present alarming data, indicating severe infrastructure pressure with literacy rates ranging from 94.13% to 94.62% and average class sizes exceeding 30 pupils. Across all measures, the least disadvantaged provinces—Eskişehir, Rize, Trabzon, İzmir, and Ankara—show better educational achievement. With a literacy rate of 98.56%, enrollment rates for primary and secondary education above 95%, and a low average of 15 pupils per class, Eskişehir, the 81st (least disadvantaged) school, stands out. Similarly, Trabzon and Rize have low student-teacher ratios (usually less than 13 kids per teacher in primary school) and excellent literacy and enrollment rates.

Table 7. Top 5 least deprived, education domain.

Top 5 Least Deprived Provinces - Education Domain								
Rank	Province	Literacy Rate	Primary Enrollment Rate	Secondary Enrollment Rate	Student/ Teacher Ratio (Primary)	Student/ Teacher Ratio (Secondary)	Students per Classroom	EDDI
80	Edirne	98.13	95.06	92.91	13	11	16	0.1205
79	Muğla	98.79	94.76	92.43	14	11	19	0.1271
78	Balıkesir	98.43	95.01	93.19	15	11	18	0.1309
77	Amasya	97.76	95.26	93.3	13	11	16	0.1311

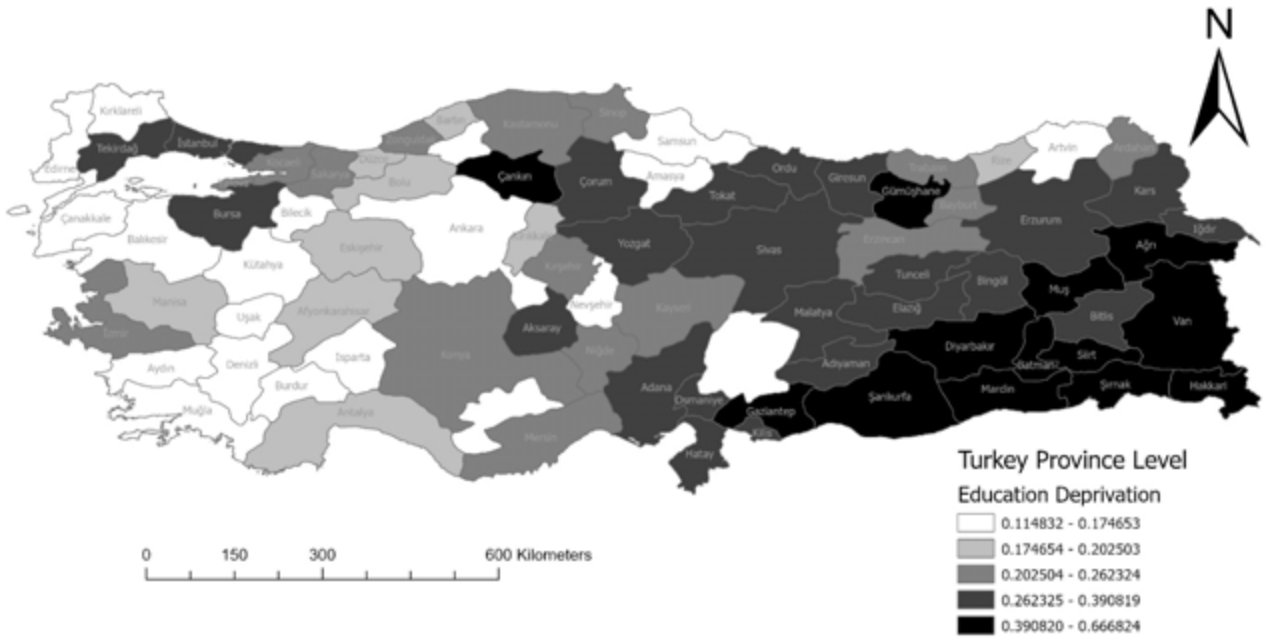

Figure 4. Education Deprivation Index by province in Turkey. Darker shades represent higher levels of education-related deprivation.

Health Deprivation

Across Turkey's 81 provinces, the Health Deprivation domain assesses regional differences in health outcomes and access to necessary medical treatments. Although some were formally published in early 2024–2025, this domain employs a set of indicators that are only taken from official 2023 datasets released by the Turkish Statistical Institute (TURKSTAT). The indicators that were selected include life expectancy at birth, hospital beds per 100,000 population, hospitals per 100,000 population, number of physicians per 1,000 population, infant mortality rate, crude death rate, and total fertility rate.

When taken as a whole, these indicators provide a comprehensive view of health-related deprivation at the provincial level by reflecting both infrastructural capacity (such as the availability of hospitals, beds, and medical professionals) and outcome-based health status (such as life expectancy, mortality, and fertility).

Each health indicator was normalized using Min-Max scaling, which converts results to a specified range between 0 and 1, in order to guarantee comparability and understandable aggregate. By doing this, the impact of several scales and measurement units is removed, enabling each indicator to make a proportionate contribution to the composite index. In order to ensure that higher normalized scores consistently reflect poorer deprivation, an inversion was used before weighting for indicators—specifically, Infant Mortality Rate, Crude Death Rate, and Total Fertility Rate—where larger values indicate worse health outcomes. By matching all indicators with the direction of well-being (greater is better), this guarantees conceptual clarity across the domain.

Even though it is less accurate, the crude death rate is useful for estimating regional mortality burdens, especially in older populations. In order to account for population dynamics and reproductive health, which can either alleviate or strain service demand, the total fertility rate was incorporated. Hospital beds per 100,000 people and hospitals per 100,000 people are used as stand-ins for the capacity and spatial distribution of medical institutions. The crude death rate is helpful for evaluating regional mortality burdens, particularly in elderly populations, despite its lower accuracy. The total fertility rate was included to take into consideration population dynamics and reproductive health, which can either reduce or increase service demand. Medical facilities' capacity and spatial distribution are represented as hospital beds per 100,000 people and hospitals per 100,000 people.

Each signal was given a unique weight according to how directly it affected health outcomes. Because it captures the combined impact of several health variables, life expectancy was given the greatest weight (20%). Because they have a significant impact on child survival and service access, respectively, the infant mortality rate (15%) and the number of physicians per 1,000 (15%) were also given priority. In order to recognize their importance and take into consideration potential demographic confounders, the crude death rate and total fertility rate were assigned somewhat lower weights (10% each). To represent their combined significance in healthcare system capacity, the three infrastructure indicators—physicians, beds, and hospitals per capita—were assigned equal weights (15 percent each), as shown in Table (7).

Table 8. Health domain indicators, weight, impact direction and justification.

Indicator	Weight (%)	Impact Direction	Justification
Life Expectancy at Birth	20	Higher = Less Deprivation	Captures overall longevity and long-term health outcomes; highly comprehensive.
Infant Mortality Rate	15	Higher = More Deprivation	Sensitive to maternal and infant care quality; reflects healthcare system performance.
Crude Death Rate	10	Higher = More Deprivation	Indicates general mortality burden; relevant in aging or high-risk regions.
Total Fertility Rate	10	Higher = More Deprivation	Reflects reproductive health and demographic pressure on health systems.
Physicians per 1,000 population	15	Higher = Less Deprivation	Measures accessibility to healthcare professionals and service availability.
Hospital Beds per 100,000 population	15	Higher = Less Deprivation	Indicates treatment capacity and readiness for inpatient care and emergencies.
Hospitals per 100,000 population	15	Higher = Less Deprivation	Represents infrastructure spread and geographic accessibility to services.

Adıyaman and Kilis both show low life expectancy (78.7 and 76.1 years), limited healthcare infrastructure (1–2 hospitals per 100,000), and high infant mortality and fertility rates—placing them at a disadvantage under a weighting scheme that emphasizes access and outcomes. Ağrı's placement is primarily driven by its low number of physicians, below-average life expectancy, and elevated fertility (2.20), which suggest regional service gaps despite a relatively low crude death rate. Under a weighting method that prioritizes access and results, Adıyaman and Kilis are at a disadvantage due to their short life expectancy (78.7 and 76.1 years), insufficient healthcare infrastructure (1–2 hospitals per 100,000), and high infant mortality and fertility rates. The main reasons for Ağrı's placing are its low physician population, below-average life expectancy, and high fertility rate (2.20), all of which point to regional service deficiencies even if the crude mortality rate is quite low.

$$
\begin{aligned}
HDI_{(i)} = {} & (1 - Normalized\ Life\ Expectancy_{(i)}) \times 0.20 \\
& + (Normalized\ Infant\ Mortality\ Rate_{(i)}) \times 0.15 \\
& + (Normalized\ Crude\ Death\ Rate_{(i)}) \times 0.10 \\
& + (Normalized\ Total\ Fertility\ Rate_{(i)}) \times 0.10 \\
& + (1 - Normalized\ Physicians\ per\ 1{,}000_{(i)}) \times 0.15 \\
& + (1 - Normalized\ Hospital\ Beds\ per\ 100{,}000_{(i)}) \times 0.15 \\
& + (1 - Normalized\ Hospitals\ per\ 100{,}000_{(i)}) \times 0.15
\end{aligned}
$$

Conversely, the five least health-deprived provinces—Tunceli, Ankara, Bolu, Isparta, and Trabzon—excelled across almost all indicators. Tunceli, the least deprived, reported the highest life expectancy (80.8 years), low infant mortality (6.4), and above-average health infrastructure, including 3 physicians per 1,000 population. Given the 20% weight assigned to life expectancy, this significantly contributed to its favorable index score. Ankara, as the capital, benefits from extensive healthcare coverage with 4 physicians per 1,000, 431 hospital beds per 100,000, and high life expectancy (79.2 years)—outperforming most provinces on service availability. Bolu, with 3 physicians per 1,000 and 425 hospital beds per 100,000, compensates for slightly less favorable fertility rates

by ranking strongly in infrastructure. Similarly, Isparta's high physician density, favorable infant mortality, and relatively low fertility help it score well despite a modest crude death rate. Last but not least, Trabzon regularly performs well on all metrics, including balanced health care delivery and an above-average life expectancy (79.0 years), which supports its classification as the least impoverished group (see table).

Top 5 Most Deprived Provinces - Health Domain		
Rank	**Province**	**HDI**
1	Şanlıurfa	0.801657
2	Hatay	0.72846
3	Adıyaman	0.726333
4	Kilis	0.685363
5	Ağrı	0.683439
Top 5 Least Deprived Provinces - Health Domain		
Rank	**Province**	**HDI**
81	Trabzon	0.35297
80	Isparta	0.338067
79	Bolu	0.304313
78	Ankara	0.297139
77	Tunceli	0.292462

The Health Deprivation map reveals a stark concentration of health-related challenges in the southeastern provinces of Turkey, where the darkest tones indicate the highest levels of deprivation. Provinces such as Şanlıurfa, Hatay, Adıyaman, Kilis, and Ağrı are among the most deprived, consistently reflecting poor outcomes across key health indicators—including high infant mortality rates, low life expectancy, limited access to physicians, and inadequate healthcare infrastructure such as hospital beds and treatment facilities. This southeastern cluster, extending into neighboring provinces like Mardin, Şırnak, and Van, highlights a persistent structural deficit in both health service delivery and health outcomes.

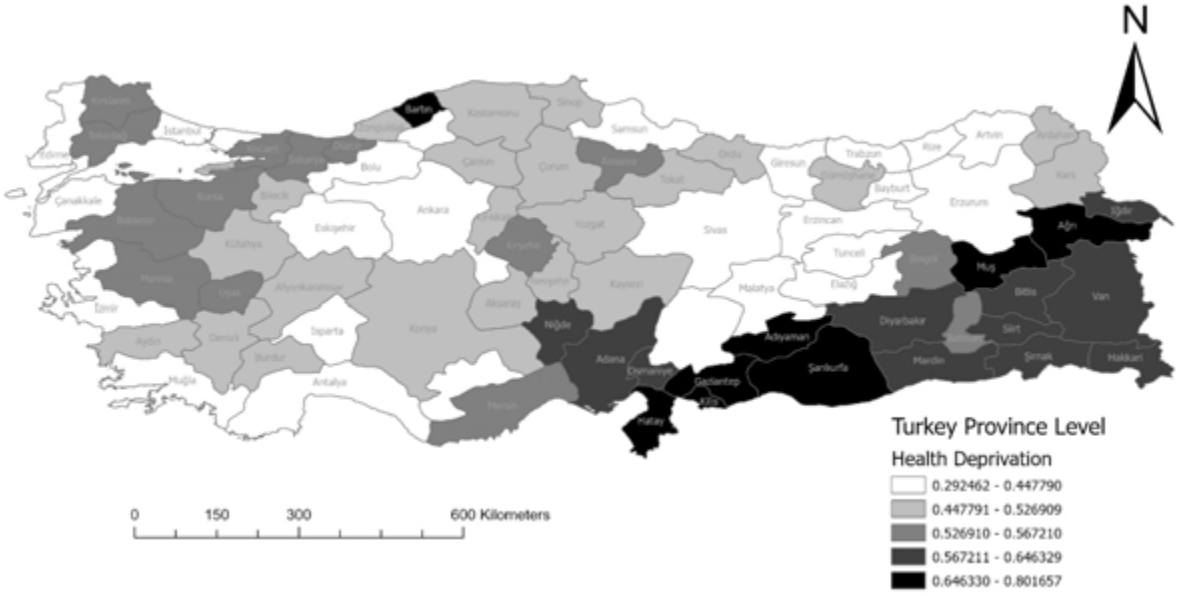

Figure 5. Health Deprivation Index by province in Turkey. Darker shades represent higher levels of health-related deprivation.

In contrast, provinces with the lowest levels of health deprivation—depicted in the lightest shades—are largely located in the central and northern parts of the country. Provinces such as Ankara, Eskişehir, Bolu, and Trabzon perform strongly across both health outcome and infrastructure metrics. These regions benefit from higher physician-to-population ratios, better hospital access, and lower mortality indicators, contributing to their favorable deprivation scores. Notably, Bartın appears as an outlier in the highest deprivation class despite its relatively peripheral location in the western Black Sea region.

Crime and Social Distress Deprivation

The Crime and Social Distress Deprivation domain evaluates regional disparities in criminal activity, justice system, and extreme social distress across Turkey's provinces. This domain integrates three core indicators: (1) the number of convicts received by penal institutions based on the province where the crime was committed, (2) the number of convicts discharged from prisons by province, and (3) the number of suicides reported per province. All data were obtained from the Turkish Statistical Institute (TURKSTAT) and correspond to the most recent available years—2020 for crime-related indicators and 2023 for suicides. These indicators jointly reflect both direct criminal activity and broader social instability. While the inclusion of suicides—legally not a crime—is conceptually distinct, it serves as a proxy for psychological and socio-economic distress. For this reason, the domain name was expanded to "Crime and Social Distress" to more accurately reflect the indicators used.

A major limitation of this domain is the scope and recency of publicly available data. Unlike economic or health indicators updated annually, crime and justice statistics from TURKSTAT are more limited in coverage and often lagged. Consequently, this domain relies on 2020 prison records and the 2023 suicide dataset, which, while still useful, may not fully capture current trends in crime or institutional burden. Nonetheless, the available indicators provide meaningful insights into spatial patterns of deprivation linked to criminality, recidivism, and societal breakdown.

Each indicator was normalized using Min-Max scaling, allowing for comparability across different magnitudes and measurement units. Since all indicators represent negative outcomes (i.e., higher values suggest worse conditions), no inversion was necessary during normalization.

To construct a composite Crime and Social Distress Deprivation Index (CSDDI), weights were assigned based on each indicator's conceptual importance. The number of convictions was assigned the highest weight (50%) as it directly measures criminal acts reported and processed through the legal system. Discharges from prison received a moderate weight (35%), representing the burden on penal institutions and potential recidivism in provinces with high release rates. Suicides were included with a lower weight (15%), acknowledging their indirect but critical connection to social distress and deprivation without equating them to crime. The final CSDDI was calculated by aggregating the weighted normalized scores of the three indicators for each province. Provinces were then ranked from most to least deprived based on their CSDDI scores. The five least deprived provinces in the Crime and Social Distress Deprivation Index—Bayburt, Tunceli, Gümüşhane, Ardahan, and Çankırı—are characterized by relatively low values across all three indicators, resulting in the lowest composite deprivation scores nationwide.

Table 9. crime domain indicators, weight, impat direction and justification.

Indicator	Weight (%)	Impact Direction	Justification
Convictions (2020)	50	Higher = More Deprivation	Represents direct measure of criminal offenses by location of crime; highest indicator of crime burden.
Discharges (2020)	35	Higher = More Deprivation	Reflects the burden on the penal system and potential re-entry of convicts into society; moderately weighted.
Suicides (2023)	15	Higher = More Deprivation	Acts as a proxy for extreme psychological and societal distress; included to capture broader deprivation but with lower weight as it is not legally categorized as a crime.

$$CSDDI_{(i)} = (Normalized\ Convictions_{(i)} \times 0.50) + (Normalized\ Discharges_{(i)} \times 0.35) + (Normalized\ Suicides_{(i)} \times 0.15)$$

Table 10 Top 5most and least deprived, crime domain.

Top 5 Most Deprived Provinces - CSDDI		
Rank	**Province**	**CSDDI**
1	İstanbul	1
2	İzmir	0.478677
3	Ankara	0.35499
4	Antalya	0.302759
5	Bursa	0.217504
Top 5 Least Deprived Provinces - CSDDI		
Rank	**Province**	**CSDDI**
82	Bayburt	0.003241
81	Tunceli	0.005252
80	Gümüşhane	0.006778
79	Ardahan	0.007452
78	Çankırı	0.009148

The Crime and Social Distress Deprivation map reveals a distinctive spatial distribution that diverges from the patterns seen in other deprivation domains. High levels of deprivation—indicated by the darkest shades—are most concentrated in major metropolitan and industrialized provinces, including İstanbul, Ankara, İzmir, Bursa, and Konya. These areas exhibit elevated levels of recorded convictions, prison discharges, and suicide rates, reflecting the complex interplay between urban density, socio-economic stressors, and institutional burden.

This urban-centric deprivation pattern suggests that crime and social distress are more acute in larger cities where population pressure, income inequality, and systemic strain may contribute to higher incidences of criminal behavior and psychosocial distress. It also underscores the challenge of balancing urban prosperity with inclusive safety and well-being.

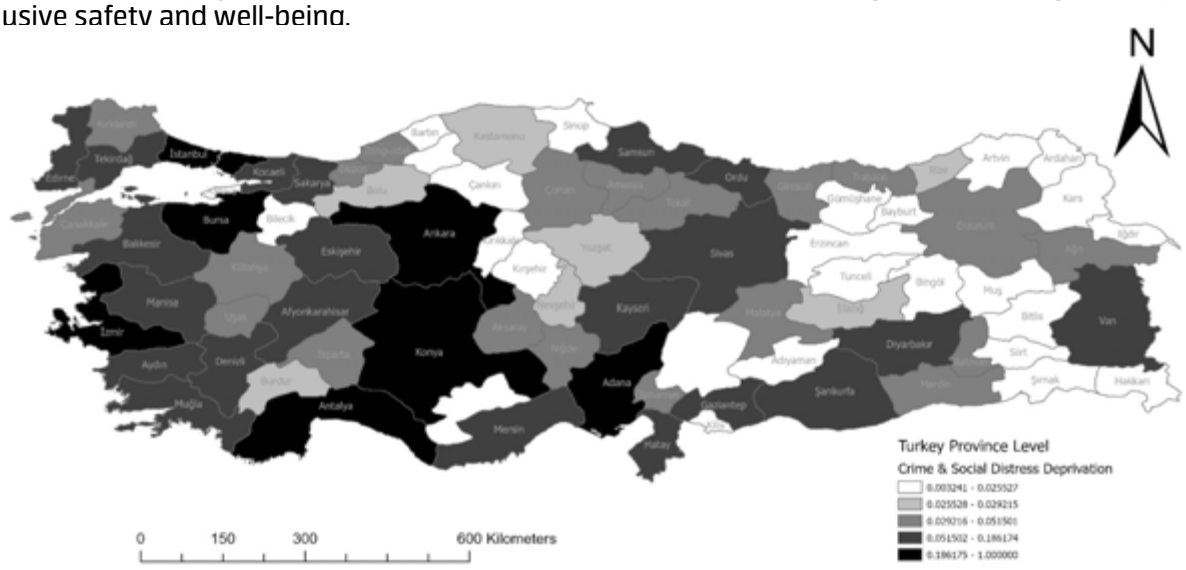

Figure 6. Crime Deprivation Index by province in Turkey. Darker shades represent higher levels of crime-related deprivation.

In contrast, the least deprived provinces are located predominantly in the northeastern and eastern parts of the country, particularly in Bartın, Ardahan, Bayburt, Tunceli, and Gümüşhane. These provinces are characterized by relatively low recorded crime rates and minimal prison system throughput. The lighter shades in these regions suggest more stable social environments with lower institutional crime burdens and fewer indicators of extreme distress.

A notable pattern is the relatively moderate-to-low levels of deprivation observed in many southeastern provinces such as Şırnak, Hakkari, and Mardin. Despite high deprivation in economic and education domains, these provinces report lower crime and social distress scores, possibly due to underreporting, demographic factors, or differing social dynamics compared to urban centers.

Barriers to Housing Deprivation

The Barriers to Housing Deprivation domain assesses spatial inequality in housing accessibility, adequacy, and supply pressure across Turkey's 81 provinces. The indicators selected aim to capture both demand-side pressures and supply-side limitations using datasets published by the Turkish Statistical Institute (TURKSTAT) for the year 2023. The final set of indicators includes average household size, internal migration (population inflow), total house sales per province, occupancy permit dwellings, construction permit dwellings. Each indicator reflects a specific challenge: larger household size implies overcrowding or under-housing; internal migration increases demand on existing stock, and high housing sales can indicate market stress or reduced affordability. On the supply side, low occupancy or construction permit approvals point to limited available or future housing stock.

This dual-perspective approach captures the tension between housing demand growth and infrastructure lag, which often results in barriers to decent housing access.

Table 11. Housing domain indicators, weight, impact direction and justification

Indicator	Weight (%)	Impact Direction	Justification
Average Household Size (2023)	20	Higher = More Deprivation	Larger household sizes often indicate overcrowding and limited housing access, especially in low-income areas.
Net Internal Migration (2023)	20	Higher = More Deprivation	High levels of in-migration increase pressure on local housing supply, leading to accessibility and affordability challenges.
Total House Sales (2023)	20	Higher = More Deprivation	Elevated housing sales may reflect overheating markets, pricing out low- and middle-income populations.
Occupancy Permit Dwellings (2023)	20	Lower = More Deprivation (inverted)	Low numbers of occupancy permits signal insufficient current housing stock; values were inverted to reflect deprivation.
Construction Permit Dwellings (2023)	20	Lower = More Deprivation (inverted)	Low issuance of construction permits indicates limited future housing provision and development; values were inverted.

$$HDI_{(i)} = (Normalized\ Household\ Size_{(i)} \times 0.20) + (Normalized\ In - Migration_{(i)} \times 0.20) + (Normalized\ Housing\ Sales_{(i)} \times 0.2) + (Normalized\ Occupancy\ Permits_{(i)} \times 0.2) + (Normalized\ Construction\ Permits_{(i)} \times 0.2)$$

The top five most deprived provinces in the HDI ranking—Şanlıurfa, Kilis, Gaziantep, İstanbul, and Mardin—demonstrated consistently high scores across multiple indicators. Şanlıurfa, ranked as the most deprived, reported both a high average household size (6.34) and a significant number of in-migrants (33,373), paired with low construction (2,696) and occupancy permits (1,685), signaling infrastructure lag amid growing demand. Kilis followed with one of the smallest housing stocks in terms of permits (384 occupancy, 245 construction) despite recording substantial in-migration (7,383), contributing to its elevated deprivation score. Gaziantep ranked third due to intense market activity—housing sales (45,139) and internal migration (39,412) were both among the highest nationally—combined with a household size above 5, stressing capacity. İstanbul and Mardin completed the top five, both reflecting extreme population pressure. İstanbul reported the highest internal migration (271,169) and house sales (240,145), while Mardin recorded high household size (5.69) and relatively low new housing provision (1,602 construction permits), reinforcing the supply-demand imbalance.

Table 12. Top 5 most and least deprived, housing domain.

Top 5 Most Deprived Provinces - HDI		
Rank	**Province**	**HDI**
1	Şırnak	0.63357
2	Kırşehir	0.627328
3	Siirt	0.586963
4	Şanlıurfa	0.5814
5	Diyarbakır	0.577848
Top 5 Least Deprived Provinces - HDI		
Rank	**Province**	**HDI**
81	İstanbul	0.264585
80	Balıkesir	0.385355
79	İzmir	0.390831
78	Çanakkale	0.396982
77	Ankara	0.408613

Conversely, the five least deprived provinces—Bartın, Karabük, Amasya, Eskişehir, and Kırklareli—ranked lowest in HDI due to a more favorable balance of demographic pressure and housing provision. Bartın and Karabük, ranked 81st and 80th respectively, had among the lowest household sizes (2.91 and 2.93), low in-migration figures (2,206 and 2,640), and modest but adequate housing permit numbers. Amasya showed moderate performance across all indicators with no extremes, which kept its deprivation low. Eskişehir and Kırklareli also maintained moderate household sizes (2.98 and 3.03) and managed a balance between sales activity and new construction, avoiding the housing market volatility seen in more deprived provinces.

The spatial distribution of housing deprivation in Turkey shows a strong concentration of high-deprivation scores across the southeastern and eastern provinces, as well as parts of Central Anatolia. Provinces such as Şırnak, Hakkari, Mardin, Adıyaman, and Gaziantep appear in the darkest shades, indicating the highest levels of deprivation. These areas are characterized by a combination of high household density, strong internal migration pressures, and insufficient housing stock as reflected by low occupancy and construction permit volumes. A secondary axis of high deprivation extends through central provinces such as Yozgat, Kırşehir, and Aksaray, where structural housing shortages and limited urban expansion contribute to constrained housing access. These provinces highlight inland challenges that differ from those found in high-growth coastal or metropolitan regions.

Unexpectedly, some industrialized or otherwise economically stronger provinces, such as Kocaeli and Antalya, also appear in the highest deprivation class. This likely reflects intense demand-side pressures—such as high internal migration and elevated housing sales—that outpace available housing supply, creating affordability and accessibility barriers. Their inclusion in this category underscores the fact that housing deprivation is not solely a function of poverty or underdevelopment but can also stem from overheating urban markets. Conversely, the least deprived provinces—represented in the lightest tones—are found in the western and northwestern regions, including Bartın, Kırklareli, and Çanakkale. These areas maintain a more balanced housing dynamic, with moderate population pressures and relatively sufficient housing stock. Similarly, select provinces in Central Anatolia and the Black Sea region—such as Çankırı and Gümüşhane—register low housing deprivation, likely due to lower in-migration rates and slower urban growth.

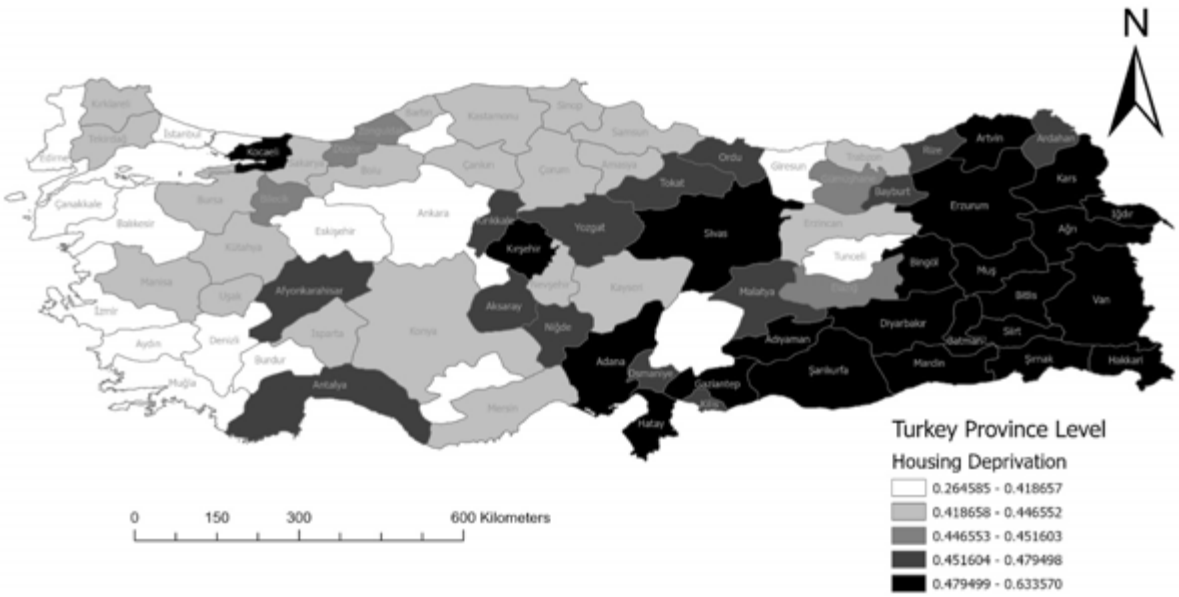

Figure 7. Housing Deprivation Index by province in Turkey. Darker shades represent higher levels of housing-related deprivation.

Living Environment Deprivation

The Living Environment Deprivation domain evaluates disparities in environmental quality, municipal infrastructure, and housing safety across Turkey's 81 provinces. This domain relies on indicators derived from official datasets provided by the Turkish Statistical Institute (TURKSTAT), reflecting both service provision and exposure to environmental or infrastructural risks. The selected indicators include traffic accident counts, the proportion of municipal populations served by sewerage networks, drinking water supply, drinking water treatment, and wastewater treatment plants, as well as the rate of electricity connections and the number of cars per 1,000 people. Additionally, three household-level indicators were incorporated: the proportion of housing stock built in or before 1980, and the share of households lacking access to piped water, toilets, or bathrooms. These indicators together offer a comprehensive view of the physical and infrastructural living conditions at the provincial level.

Each of these variables reflects a distinct dimension of deprivation. Traffic accident counts serve as a proxy for urban stress and road safety risks, while the proportions of municipal service coverage highlight regional disparities in basic infrastructure. The electricity connection rate indicates access to essential utilities, and car ownership serves as a loose proxy for mobility and transport accessibility. The absence of piped water, toilet, or bathroom facilities within dwellings reflects deeply embedded housing inadequacies that affect dignity and hygiene. Finally, the percentage of buildings constructed before 1980 acts as a proxy for outdated and potentially unsafe housing stock, particularly relevant in a country with considerable earthquake vulnerability.

To ensure comparability, all indicators were normalized using Min-Max scaling, rescaling their values between 0 and 1. For indicators where a higher raw value indicated better living conditions—such as sewerage access or water network coverage—values were inverted so that higher normalized scores consistently represented worse conditions. This allowed for a unified interpretation of deprivation across the dataset. Each indicator was assigned an equal weight of approximately 11.1%, reflecting a balanced approach to measuring deprivation across infrastructure, environmental health, and safety. The final Living Environment Deprivation Index (LEDI) for each province was calculated as the sum of all weighted normalized indicators, where higher LEDI values correspond to greater environmental deprivation.

$$LEDI_{(i)} = (\sum Normalized\ Weighted\ Indicators_{(i)}) \times 0.111$$

Table 13. Living environment domain indicator, weight, impact direction and justification.

Indicator	Weight (%)	Impact Direction	Justification
Proportion of buildings built before 1980	11.1	Higher = More Deprivation	Acts as a proxy for outdated or potentially unsafe housing, especially in earthquake-prone regions.
Households without piped water (%)	11.1	Higher = More Deprivation	Reflects inadequate access to basic in-home water infrastructure, indicating serious deprivation.
Households without toilet (%)	11.1	Higher = More Deprivation	Signals severe sanitation deprivation, affecting both dignity and public health outcomes.
Households without bathroom (%)	11.1	Higher = More Deprivation	Indicates fundamental infrastructure deficiency within the home environment.
Sewerage network coverage (%)	11.1	Lower = More Deprivation	Captures disparities in urban sanitation infrastructure and its public health implications.
Drinking water network coverage (%)	11.1	Lower = More Deprivation	Reflects accessibility of clean, piped water supply—a critical public health and welfare concern.
Water treatment plant coverage (%)	11.1	Lower = More Deprivation	Represents the quality of water service provision and regional health safeguards.
Wastewater treatment plant coverage (%)	11.1	Lower = More Deprivation	Addresses environmental and hygiene quality through wastewater management capacity.
Electricity subscription coverage (%)	11.1	Lower = More Deprivation	Measures access to electricity, a basic necessity in modern living; lower variation, but essential.
Cars per 1,000 people	11.1	Lower = More Deprivation	Used as a proxy for economic status and transport infrastructure; limited mobility can signal isolation.
Traffic accident count	11.1	Higher = More Deprivation	Indicates infrastructural stress and safety risks in the physical environment.

The five most environmentally deprived provinces—Ağrı, Şırnak, Iğdır, Ardahan, and Van—consistently scored poorly across multiple indicators. Ağrı reported one of the highest proportions of households living in buildings constructed before 1980, combined with significant percentages of homes lacking basic facilities such as piped water, toilets, and bathrooms. Similarly, Şırnak showed poor infrastructure coverage, including low rates of access to treated water and sewerage networks, alongside elevated deprivation in household-level sanitation access. Iğdır and Ardahan both exhibited critical deficiencies in basic in-home utilities and sanitation facilities, with Ardahan standing out for an exceptionally high share of households without bathrooms. These provinces also reported very low levels of car ownership per 1,000 people and limited access to wastewater and drinking water treatment systems. Van's placement was mainly driven by aging housing stock and lower than average environmental infrastructure scores, especially in treated water services, which compounded its LEDI value.

Table 14. Top 5 most and least deprived, living environment domain.

Top 5 Most Deprived Provinces - LEDI		
Rank	**Province**	**HDI**
1	Ardahan	0.597509
2	Iğdır	0.543384
3	Mardin	0.502147
4	Kars	0.458331
5	Sinop	0.434612
Top 5 Least Deprived Provinces - LEDI		
Rank	**Province**	**HDI**
5	İstanbul	0.099773
4	Yalova	0.129202
3	Kocaeli	0.132782
2	Eskişehir	0.141178
1	Ankara	0.152081

On the other hand, the five least deprived provinces—Ankara, Eskişehir, Kocaeli, Yalova, and İstanbul—ranked best due to strong performance across nearly all environmental indicators. Ankara and İstanbul, as major metropolitan areas, benefit from near-universal coverage of electricity, sewerage, water networks, and water treatment systems, along with high car ownership rates. Eskişehir also performed well, particularly in its urban infrastructure and low proportion of households lacking piped water or toilets. Kocaeli and Yalova demonstrated similarly high levels of access to urban services and modern housing stock, with minimal percentages of households in buildings built before 1980 and strong access to treated water and sanitation. These provinces consistently reported lower rates of deprivation in both household and municipal indicators, which is reflected in their low LEDI scores.

The Living Environment Deprivation map demonstrates a predominantly peripheral distribution of environmental and infrastructural challenges across Turkey. The most deprived provinces—represented in the darkest shades—are concentrated in the eastern and southeastern regions, particularly Ardahan, Iğdır, Muş, Mardin, and Şanlıurfa. These provinces face multiple deficits in basic infrastructure and environmental conditions, including aging housing stock, low access to sewerage systems, untreated water, and limited utility coverage such as piped water and electricity. This high-deprivation pattern also extends to select northern provinces such as Çankırı, Kastamonu, and Sinop, highlighting that environmental deprivation is not limited to socioeconomically underdeveloped regions but may also reflect insufficient investment in infrastructure maintenance or modernization in less urbanized northern areas.

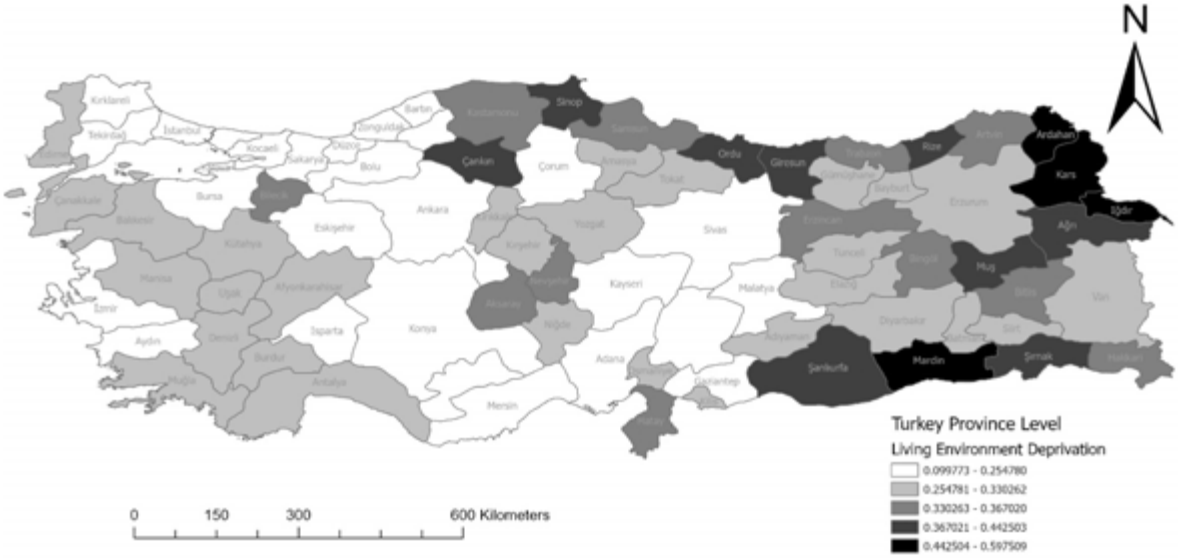

Figure 8. Living environment Deprivation Index by province in Turkey. Darker shades represent higher levels of living environment-related deprivation.

In contrast, the least deprived provinces are concentrated in the west and central-west of the country. Regions like Ankara, Eskişehir, Kocaeli, and Muğla show strong environmental conditions, marked by high access to treated water, electricity, modern housing, and municipal services. These provinces also benefit from better waste and water management systems, higher vehicle ownership, and stronger disaster-resilient infrastructure. Interestingly, several mid-performing provinces across Central Anatolia and the Aegean—such as Afyonkarahisar, Kütahya, and Aydın—display moderate levels of deprivation, indicating a relative balance between infrastructure availability and environmental pressure. These regions may have adequate municipal services but still face challenges related to older housing stock or regional population growth.

Turkish Composite Deprivation Index

The Turkish Composite Deprivation Index (TCDI) offers a multidimensional evaluation of regional deprivation across Turkey's 81 provinces. It combines seven domain-specific indices: Income, Employment, Education, Health, Crime and Social Distress, Barriers to Housing, and Living Environment. Each domain reflects a distinct dimension of socioeconomic well-being and infrastructure access, capturing both individual and structural determinants of deprivation. Weights for each domain were assigned in alignment with the English Indices of Deprivation (EID) model, emphasizing economic and labor-related domains more heavily. Specifically, Income and Employment domains each account for 22.5% of the overall index, Education and Health domains for 13.5% each, and the remaining three domains—Crime, Housing Barriers, and Living Environment—each contribute 9.3%. These weights were applied to the normalized domain scores for each province, producing a final composite index value (TCDI) and associated rank, where higher values correspond to greater deprivation.

The five most deprived provinces—Şanlıurfa, Ağrı, Şırnak, Mardin, and Iğdır—consistently exhibited high deprivation across multiple domains. Şanlıurfa, which ranked first overall, recorded elevated deprivation in health (rank 1), education (rank 1), housing (rank 4), and crime (rank 5), reflecting multidimensional structural disadvantage. Ağrı followed with top-five placements in education, health, and environmental deprivation. Şırnak also scored among the highest in deprivation across health, education, and employment, underscoring persistent developmental challenges. Mardin and Iğdır demonstrated widespread infrastructure gaps, particularly in environment and housing domains, alongside socioeconomic stress reflected in employment and crime data.

In contrast, the least deprived provinces—Istanbul, Ankara, Kocaeli, Tekirdağ, and Eskişehir—ranked consistently low on the deprivation scale due to strong performance across all seven domains. Istanbul and Ankara benefit from high income levels, extensive infrastructure, and service access, though Istanbul shows slight vulnerability in crime-related indicators. Kocaeli and Tekirdağ exhibit robust labor market and industrial metrics, with strong

educational and health outcomes. Eskişehir rounds out the least deprived group with uniformly favorable indicators across education, environment, and health, reinforcing its long-standing reputation as a well-performing mid-sized urban province.

The spatial pattern of the Composite Deprivation Index (CDI) map provides a holistic view of multidimensional deprivation across Turkey's provinces, combining all seven individual domains. The highest levels of overall deprivation—marked in the darkest shades—are concentrated in the southeastern and eastern provinces, notably Şanlıurfa, Hakkari, Şırnak, Mardin, and Ağrı. These provinces consistently scored high on multiple domain-specific indices, particularly income, education, health, and housing deprivation. Their composite scores reflect persistent structural disadvantages and underscore the cumulative effect of overlapping deprivation. This core high-deprivation zone extends westward through a belt of central and inner Anatolian provinces such as Adıyaman, Osmaniye, Niğde, and Aksaray, suggesting that deprivation is not confined to the geographical periphery but also affects provinces with constrained development trajectories and limited access to diversified economic opportunities.

Conversely, the lowest levels of composite deprivation—shown in the lightest shades—are predominantly found in the northwestern and western regions, particularly in provinces such as İstanbul, Ankara, Kocaeli, Eskişehir, and Muğla. These areas benefit from strong economic performance, well-established infrastructure, high service provision, and better education and health outcomes. Their consistently low scores across most domains place them at the opposite end of the deprivation spectrum. A noticeable mid-deprivation band cuts through western Central Anatolia and parts of the Mediterranean and Aegean regions, encompassing provinces like Afyonkarahisar, Manisa, and Denizli. While not as severely deprived as the southeastern regions, these provinces face challenges in select domains such as employment, education, or housing, which prevent them from ranking among the least deprived.

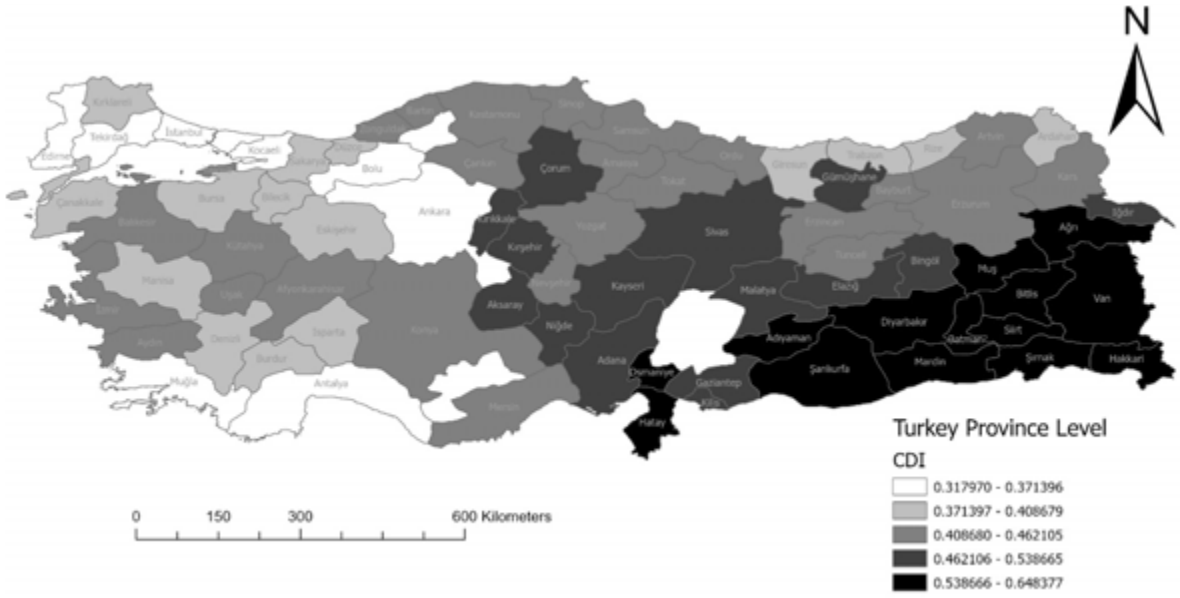

Figure 9. Turkish Composite Deprivation Index by province. Darker shades represent higher levels of composite deprivation.

Conclusion

This study presents a comprehensive, province-level analysis of multidimensional deprivation in Turkey, combining seven distinct domains—Income, Employment, Education, Health, Crime and Social Distress, Housing, and Living Environment—into a single Composite Deprivation Index (CDI). By leveraging the most recent TURKSTAT datasets and adapting the English Indices of Deprivation framework, the analysis provides a nuanced understanding of regional inequalities and spatial disparities in socio-economic and infrastructural well-being.

The results reveal a persistent and deeply embedded east–west divide, with the southeastern and eastern provinces consistently ranking among the most deprived across multiple domains. Provinces such as Şanlıurfa, Ağrı, Şırnak, and Mardin exhibit high composite deprivation scores, reflecting structural disadvantages in access to income, employment, quality education, and health services. Conversely, the least deprived provinces—including İstanbul, Ankara, Kocaeli, and Eskişehir—benefit from strong economic performance, developed infrastructure, and broader access to essential services.

It is highly recommended to agree on a specific mechanism for data collection, combination and agreement on weightings that reflect deprivation indicators that are specific to Turkey. It is also highly recommended to conduct this research at a constant annual rate in order to easily track changes in the development of the Turkish provinces and the sustainability of the spirit of competition among decision-makers in the Turkish provinces.

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Toward New Circular Urban Economies: Regeneration Models for the Ecological Transition of Cities. European Cases and Initiatives.

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Abstract
In response to climate change, cities must be reimagined as living organisms with sustainable urban metabolisms that efficiently manage flows. This article reviews scientific literature, policy reports, and European research to examine urban regeneration projects through the circular transition lens. It proposes new urban planning scenarios based on circular flows of both material and immaterial resources. Introducing the concept of Circular Urban Economy, the paper offers an alternative perspective in the circular cities debate by integrating circularity, nature-based solutions, climate change, well-being, and urban development to promote ecological sustainability and social equity. It explores urban transition processes grounded in regenerative design principles, emphasizing nature's role and local resource recirculation to transform degraded urban areas into ecosystems that enhance biodiversity and improve the well-being of citizens.

Keywords
Circular design; regenerative design; urban metabolism; critical urban space; ecosystem service.

Introduction

The circular economy is an increasingly emerging concept in the field of urban studies that seeks to create a more sustainable and efficient system for resource management. Contemporary cities guarantee high levels of functionality in many areas: from housing to transport, from educational to healthcare services, from employment to cultural opportunities. However, in order to provide such levels of efficiency, urban areas have been designed and built with considerable levels of sophistication, both in terms of materials and technology, making them hypertrophic and energy-intensive metabolisms that produce huge amounts of waste in the form of solid waste, water and air pollution. This factor contributes to increasing the fragility of urban areas, increasing vulnerability, reducing resilience to the effects of global warming and accelerating processes related to biodiversity loss. Ultimately, urban metabolism considers cities as complex systems that consume resources and produce waste.

During the 20th and 21st centuries, global CO2 emissions have increased from around 5 Gt to over 37 Gt per year (IEA, 2025). However, the absorption capacity of terrestrial and ocean ecosystems is limited to 19 Gt of CO2 per year, corresponding to the carbon budget available to the planet (Friedlingstein et al., 2023). Current environmental policies are consistent with a trajectory that could lead to a temperature increase of more than 3°C by the end of the century, exceeding the targets set by the Paris Agreement (IPCC, 2021). This scenario is associated with serious risks to biodiversity and human health (IPCC, 2021). (Fig.1)

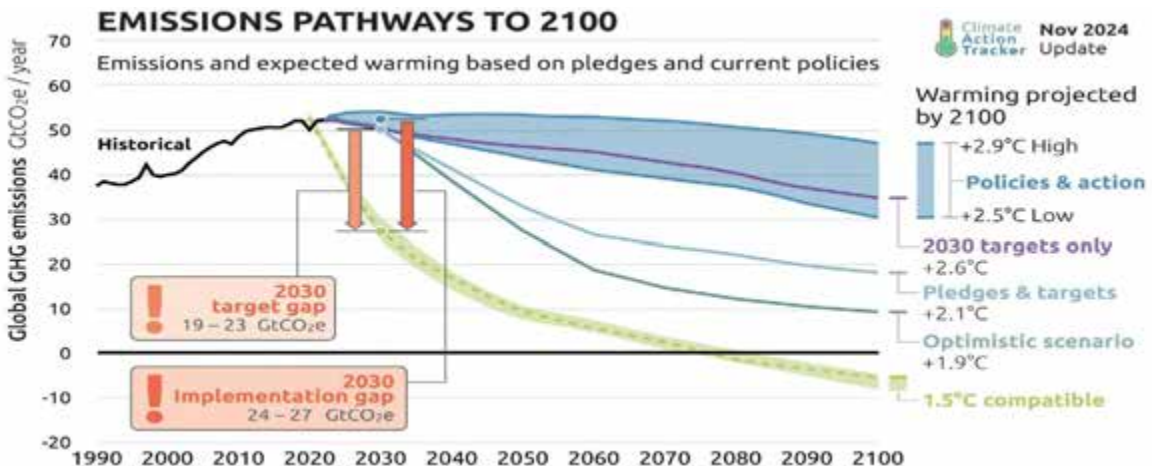

Fig. 1 – Global policies and pledges effects on greenhouse gas emissions and warming scenarios (Source: Climate Action Tracker, 2024)

Human actions have significantly altered 77% of the Earth's surface (IPBES, 2019), exploiting nature and its resources at a rate 1.75 times faster than the planet's ecosystems are able to regenerate (GFN, 2020; SCBD, 2020). The (distorted) use of natural resources is the main cause of air, water and soil pollution; waste, on the other hand, is tangible evidence of the degradation and waste that characterise the era in which we are living, the Wasteocene: an era marked by the continuous production of people, communities and places of waste, a global landfill that we must dismantle (Armiero M., 2021).

In this scenario, cities are a critical part of this mechanism as they consume 70% of the world's energy (UN-Habitat, 2022), use 75% of natural resources (Mancuso, 2023), emit 75% of CO2 into the atmosphere and produce 70% of waste (Luqman et al., 2023). In urban contexts, the linear management of resources (water, food, materials, energy) represents a development model that is no longer sustainable, as it contributes significantly to aggravating environmental problems such as resource depletion, ecosystem degradation, biodiversity crisis and loss of natural capital.

The climate crisis now requires a profound rethinking of the way we approach architecture. The year 2024 represented a critical threshold: the planet recorded its highest ever temperatures, far exceeding the +1.5°C limit set by the 2016 Paris Agreement. In just two years, global warming has accelerated to such an extent that even the most advanced scientific models are being called into question.

Until now, architecture has tried to respond through mitigation strategies, aiming to reduce the environmental impact of buildings. But this is no longer enough. The time has come to shift the focus from the goal of limiting damage to the urgent need to adapt. Adaptation means radically rethinking architectural design, imagining solutions capable of addressing the profound transformations already underway (Ratti C., 2025).

Conventional construction systems require a global flow of materials that are often untraceable. They depend on externalised and hidden spaces: copper mines, aluminium production sludge basins, and cement clinker calcination plants. The production and transport of materials require so much fossil fuel energy that the construction sector is responsible for 37% of global CO2 emissions (UNEP, 2022).

The concept of externalities was introduced in 1920 by British economist Arthur Pigou in his book "The Economics of Welfare" to describe the indirect costs that fall on individuals and territories not directly involved in the production of a good. This definition includes all the unaccounted consequences of production processes: emissions, waste, by-products and environmental impacts. Construction, in particular, is one of the sectors that generates the most externalities: every time we build, extracting resources, consuming energy, marginalising local skills and producing pollution, we contribute to a profound imbalance between the buildings we construct and the territories we transform. Taken together, these dynamics are the main cause of the environmental crisis. (Fig. 2)

Fig. 2 – Material extraction (Source: UNEP, Global Resources Outlook 2024).

Therefore, the built environment is a key lever for exploring how we can collectively engage in imagining a sustainable future. In an era marked by multiple crises, the ecological transition can no longer rely exclusively on established rules and methods: new, creative and interdisciplinary approaches are needed. Everyone's collaboration is essential. Only by integrating the social, economic and ecological dimensions can we initiate a truly circular, regenerative and sustainable transformation of our built environment.

It is possible to decouple economic growth from resource use and the environmental impacts it causes. This goal can be achieved by replacing prevailing linear growth models with regenerative and circular models for the preservation and enrichment of urban ecosystems and biodiversity. To combat climate change and reverse the current linear development model, we need to reconvert our production and consumption systems with appropriate economic, social, political and technological changes that go beyond conservation and restoration practices, towards a paradigm shift in the way we produce, use and reuse products and resources (IPBES, 2019) moving from an anthropocentric to an ecosophical vision that shifts the focus from humans to the ecosphere, integrating environmental, social and mental ecology to create communities integrated with nature.

Residues. From discarding to upcycling to reimagine cities as living organisms
"Nature produces no waste, no externalities. Every material flow is internalized in a continuous cycle. What if architecture followed the same logic? How can we balance the economies of construction with the ecologies of production?

Every time we construct a space, we deconstruct another (often in remote geographies across the planet). Buildings and the environment are therefore closely connected through a material link, and it is the responsibility of architects and planners to ensure that this link is positive." (Internalities: Architectures for Territorial Equilibrium, Spanish Pavilion at the Venice Architecture Biennale.)

Urban sites are complex, layered entities that are constantly evolving (Dovey, 2010). They can be described as an assembly of material things, flows and spatial connections that coexist. The relational understanding of sites also extends to the fact that every urban space contains a past, a present and a future (Hvattum, 2010), which means that they are dense, layered accumulations formed over time.

The challenges of circularity in urban areas call for a regeneration of cities based on circular design that brings about economic, social and environmental transformation without increasing the consumption of new resources and reducing the impact on the environment. Urban areas are characterised by a significant concentration of

material resources that accumulate over time (Gorgolewski, 2019) and, as the volume of built cities is expected to double by 2060, it is clear that the circular model will have to play a crucial role in cities in order to achieve the European Union's target of a zero-emission building stock by 2050. In order to meet these requirements and bring about a real paradigm shift in line with the principles of environmental sustainability and resource circularity, the design and management phases of interventions and the identification of the main urban challenges related to circularity play a central role (Atanasova et al., 2021;).

A fundamental aspect of this transition is understanding the key principles of the circular economy outlined by the Ellen MacArthur Foundation (EMAF, 2021) (Fig. 3):

- The first principle, "Eliminate waste and pollution", focuses on the goal of eliminating waste and pollution from the design stage onwards. This approach is not limited to managing waste at the end of the production cycle, but is based on intelligent design that prevents the creation of waste and minimises externalities. In this sense, energy efficiency, responsible use of resources and reduction of polluting emissions become an integral part of the economic system, contributing to the construction of a more equitable, resilient model that respects the ecological limits of the planet.

- The second principle, "Circulate products and materials (at their highest value)", is to keep resources in use for as long as possible. This promotes strategies such as reuse, repair, reconditioning and recycling. In this way, the aim is to improve efficiency in the extraction of new natural resources, optimise energy use and reduce losses within the system.

- The third principle, "Regenerate nature", concerns the need to regenerate the urban environment by integrating it with nature. This will ensure the long-term provision of essential ecosystem services such as clean water supply, climate regulation, soil fertility and biodiversity protection.

FIGURE 1 **THE CIRCULAR ECONOMY PLAYS A CRUCIAL ROLE IN BENDING THE CURVE ON BIODIVERSITY LOSS**

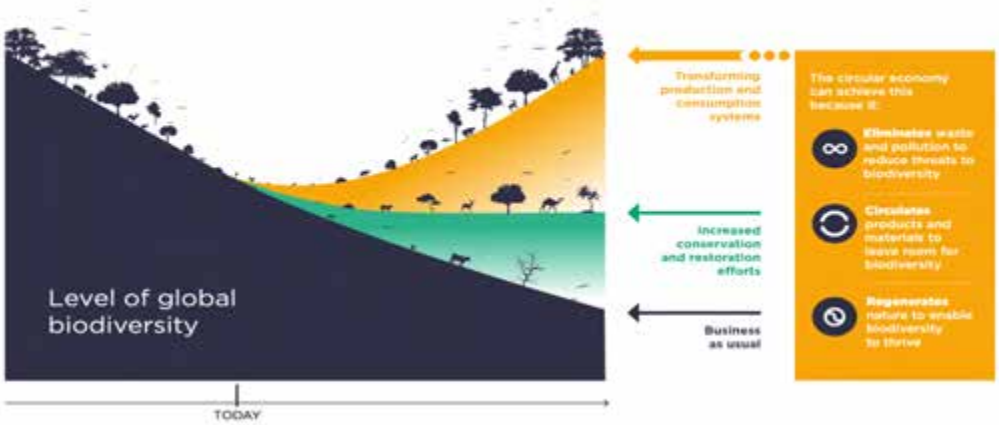

Fig. 3 - The three basic principles of the circular economy to contrast biodiversity loss (Source: Ellen MacArthur Foundation, 2021)

Resource-intensive urban lifestyles have made cities big, rich, and diverse stores of raw materials, which constantly depend on flows of goods and services to keep them running. Green and fair urban spaces can only happen if we take action that deals with urban areas as places of unsustainable consumption and socio-economic inequality at the same time. This is why urban communities characterised by regenerative design and development are desirable, as they aim to improve urban liveability while reducing the environmental footprint of cities by closing material cycles (Girardet, 2015). Increasingly circular urban economies are the means, and regenerative urban planning is the goal.

In this sense, the design of the built environment plays a decisive role, as it affects not only the quality of urban life but also society's long-term contribution to resilience to anthropogenic climate change and the depletion of

natural resources. Therefore, in order to respond effectively to the principles of the circular economy, a radical rethinking of the design and management of urban infrastructure is necessary.

At the urban level, society is transforming. As a result, there is a need to adapt the availability of spaces and buildings to new requirements. The urban regeneration process must necessarily take these changes into account, seeking to find appropriate solutions for each phase of the city's transformation. Research programmes and planning tools must recognise the vital role of cities and urban areas in the use of global economic resources, as they account for the vast majority of global consumption. This consumption puts considerable pressure on the environment, which is why the Circular Urban Economy (CUE) aims to support cities in becoming more resource-efficient and reducing their impact on the planet. The CUE encourages cities to implement circular measures that address socio-economic inequalities, promote social cohesion and improve access to urban resources, services and green spaces.

The introduction of Nature-based Solutions (NbS) in cities for resource management and to contribute holistically to the three principles of the circular economy leads to the reshaping of existing linear management into circular management. NbS play an important role in "keeping resources in use", mainly through the recovery and reuse of water and nutrients, and by giving new life to waste materials generated by other local production chains. In particular, their multifunctionality opens up a wide range of implementation possibilities: from transforming their outputs so that they fit into the value chain, to absorbing waste from other production chains to create an integrative urban supply chain.

Starting from the assumption that urban areas must be understood and addressed in relation to their use of resources and their socio-economic preconditions, the CUE aims to support the planning and design of urban places characterised by regenerative urbanism: by this term we mean liveable and green communities that are supported by circular flows of resources. Circularity should not be the ultimate goal, but rather a tool for creating healthier, more inclusive and regenerative urban communities that rely on closed material cycles to reduce their environmental footprint. We imagine cities and urban areas with restored natural resource cycles that support a high quality of life for their inhabitants, creating a transformative push towards healthy, attractive and green urban spaces. Through regenerative urban planning, we must think of cities characterised by restored natural resource cycles that support a high quality of life for their inhabitants.

The role of European policies in the circular transition: the New European Bauhaus Facility 2025-2027

In recent years, the concept of urban regeneration has evolved to become increasingly multidimensional and strategic in response to the growing complexity of urban transformation phenomena. The Urban Agenda for the EU (2023) frames urban regeneration as an integrated vision and action aimed at combating urban decay through economic, social, environmental and physical interventions, with the goal of sustainably improving the economic conditions and quality of life of residents. At the global level, UN-Habitat (2022) proposes a complementary interpretation, emphasising the participatory, inclusive and resilient nature of the process, which aims to transform declining urban areas into sustainable communities that are attentive to human well-being, social cohesion and adaptation to climate change. These definitions converge in recognising urban regeneration not only as a set of physical interventions, but as an integrated and sustainability-oriented process capable of responding to contemporary challenges related to ecological transition, spatial justice and social cohesion.

The urgency for Europe to take a leading role in global environmental governance and sustainable innovation has never been more evident. Given its significant historical carbon footprint, Europe now faces a dual and significant responsibility. Not only have European countries played a predominant role in the intensive consumption of planetary resources in the past, but in many cases they continue to do so at a rate that remains unsustainable (Dm, 2024).

Throughout Europe, profound transformations are taking place that affect both human and non-human communities. The idea that places are dynamic entities in constant flux (Dovey, 2010) is confirmed by the current reality.

In many areas, these changes are occurring particularly rapidly: buildings, infrastructure and public spaces are being rapidly constructed, modified, demolished or redeveloped. These processes have a significant impact on resident communities, as well as on future communities that will inhabit these territories.

In this context, the transition to a more circular, regenerative and systemic conception of the built environment requires a profound rethinking of decision-making practices. An integrated approach is needed that takes into account the three fundamental dimensions of sustainability: economic, environmental and social (Grupe Larsen, 2024). To effectively guide these transformations, it is crucial to activate profound levers of change capable of affecting systems at their roots. An effective green transition requires the construction of shared and imaginative visions of the future. Collective approaches to planning and storytelling are therefore essential, promoting new ways of thinking and acting in our living spaces, within societies and economies. In this perspective, it is essential to develop innovative languages, methods and tools that avoid the reproduction of unsustainable models, while promoting imagination, hope and creativity as transformative resources (Moore, 2023).

Many cities are experimenting with strategies for sustainable development and circular use of resources. A significant example of this is the "European Circular Cities Declaration", which aims to support the circular transition of municipalities, offer a shared vision of "circular cities", highlight the challenges of creating a closed-loop economy, and build a community of local authorities that share experiences, challenges and achievements. Trends show a growing number of circular initiatives at European level in support of cities and an increase in the adoption of strategies and action plans to guide the circular transition. Similarly, awareness-raising programmes on circularity for citizens and European instruments are also particularly important. In this regard, the New European Bauhaus (NEB) represents a fundamental pact as it supports actions for healthier and more resource-efficient urban environments with a particular focus on air, water, nature, biodiversity, waste and the circular economy.

The NEB is an initiative of the European Commission that aims to transform the European Green Deal into tangible change on the ground, improving everyday life through sustainable solutions for the built environment and lifestyles. It combines sustainability with good design, inclusiveness, accessibility and affordability, while respecting the diversity of places, cultural heritage and European cultures. (EC 2023). The New European Bauhaus Facility 2025-2027 (EC, 2025) is a European Commission tool designed to accelerate the transformation of neighbourhoods through sustainable and inclusive design, focusing on promoting innovation, circularity and the use of biological materials. By prioritising the use of circular economy principles and resource-efficient materials, the NEB contributes to the Clean Industrial Deal's goal of reducing carbon emissions and improving the sustainability of industrial processes. By embedding its vision in local and regional contexts, the NEB aims to bring Europe closer to its inhabitants, strengthening ties and bridging disparities to create prosperous and inclusive communities. The Tool addresses the transformation of the built environment at the neighbourhood scale, understood as complete systems where people live, socialise and find services. The main objectives are:

- Transforming places with communities by enhancing public spaces and buildings and empowering local communities through greater involvement.
- Promoting a sustainable, circular and regenerative European building ecosystem that is inclusive, accessible, affordable, resilient and promotes health and well-being. It focuses on innovation in materials, products and methods and seeks to make the built environment and materials more adaptable and reusable.
- Developing new business and financing models to rethink the way projects are conceived, planned, executed and invested in.

The tool invites cities to use planning strategies aimed at rethinking urban metabolisms to support both ecological balance and social equity by promoting regenerative relationships between society and the environment. These are the themes of the second objective of the NEB Facility, which promotes projects and strategies to make neighbourhoods more sustainable, circular, accessible and regenerative, improving their climate resilience through the restoration of nature and biodiversity. It will do so by helping to rethink the way we design, build and use the spaces around us. Particular attention will be paid to the reuse of existing infrastructure and materials and to renovation. New technologies will also be explored to optimise construction methods and the resources used and reduce costs, while ensuring user-centred and place-based solutions that take into account cultural heritage, local and vernacular knowledge, reflect local cultural identity and meet people's needs. It will take a

more systemic and holistic approach to neighbourhoods, looking at energy or mobility systems, for example. Under this specific objective, the NEB Instrument will promote environments where nature can thrive, helping to restore biodiversity, reduce pollution and improve the health and well-being of all living beings. The choices and actions implemented by European strategies (Fig. 4) should serve as concrete and replicable examples, helping to set benchmarks for collective action in the fight against climate change and environmental degradation.

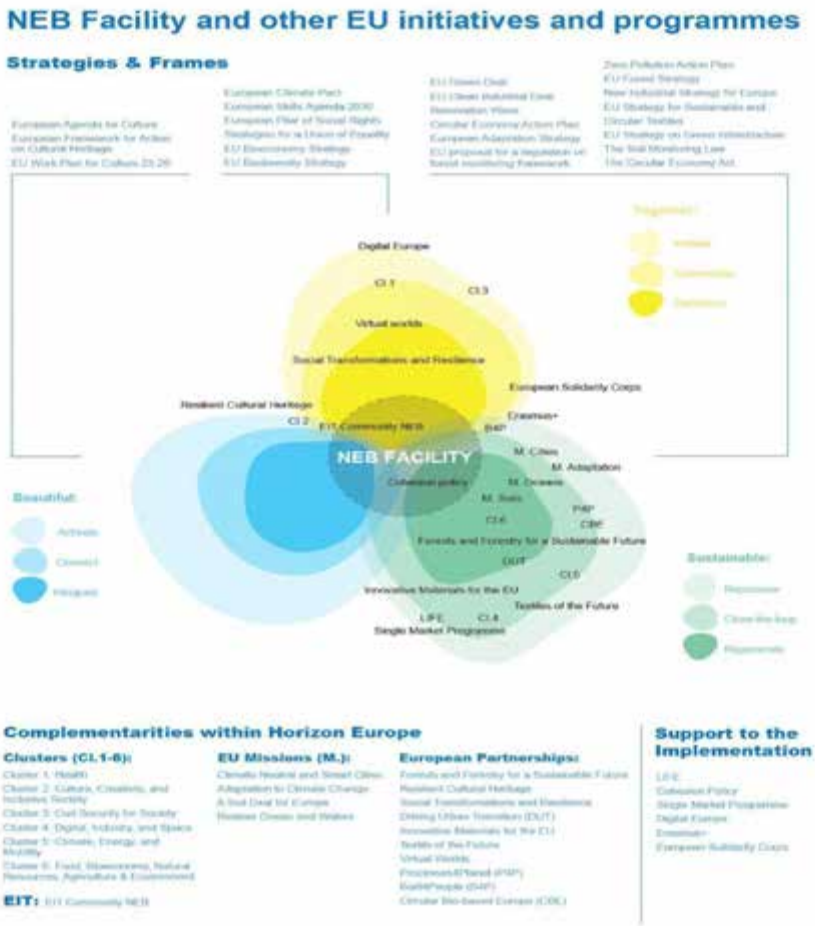

Fig. 4 - European Programmes and initiatives that support New European Bauhaus (Source: New European Bauhaus Facility 2025-2027)

European experiences in regenerating existing abandoned spaces through circular economy processes.
In order to address the various urban challenges and prepare cities for new development based on the recovery, reuse and recycling of materials and resources, starting from the design phase, but also in the management and maintenance phases, it is essential to adopt a holistic and systemic approach that carefully assesses flows. An initial survey of scientific literature, urban governance and European policy guidelines has highlighted the importance of promoting a systemic and innovative architectural model capable of contextualising individual interventions within a broad framework of transformation, taking into account the complexity of urban contexts. Although all urban challenges related to the circular economy can make a concrete contribution in the field of architecture, those related to the recovery of the built environment and construction waste and the protection and enrichment of urban ecosystems and biodiversity are of particular interest for the future urban development of cities as they deal, on the one hand, with waste from construction and demolition work and, on the other, with the transformation of impermeable urban surfaces into resilient and biodiverse natural infrastructure systems (IPBES, 2019; EC, 2020). and, on the other hand, the transformation of impermeable urban surfaces into resilient and biodiverse natural infrastructure systems (IPBES, 2019; EC, 2020). In order to identify some significant strategies,

solutions and tools adopted in experiments to regenerate existing abandoned spaces through circular economy processes, a survey of case studies was carried out (Table 1 shows the most relevant projects) according to four fundamental axes for decarbonisation: waste, materials, inclusion and biodiversity.

(1) The built environment as a resource mine. The Waste axis focuses on optimising the use of resources in urban areas, which are seen as complex systems containing buildings, infrastructure, technologies and material flows. This approach promotes interventions aimed at extending the useful life of resources through maintenance, renovation and repair activities, in order to interrupt linear flows and reduce waste production, thus increasing the efficiency of urban resource use. The built environment represents a resource of materials for the transformation of buildings and open space, offering great opportunities for circularity. In this sense, the design of the built environment plays a decisive role as it affects not only the quality of urban life but also society's long-term contribution to resilience to anthropogenic climate change and the depletion of natural resources. Therefore, in order to respond effectively to the principles of the circular economy, a radical rethinking of the design and management of urban infrastructure is necessary. In this regard, urban mining offers the opportunity to reshape our cities by converting waste into valuable resources.

(2) Circularity as an enabling tool for the transition of urban resources. The Materials axis analyses the value chains of natural and regenerative materials. In the case studies analysed, circularity is not conceived as an end goal, but rather as a set of tools for developing more resilient, inclusive and regenerative urban communities, characterised by closed material cycles that contribute to reducing environmental impact. The approach is based on closing material cycles, reducing environmental impact and restoring vitality to urban ecosystems, benefiting the quality of life of inhabitants. Conventional construction systems require a global flow of materials that are often untraceable. The transition to materials produced using regenerative methods allows for the use of materials or the production of resources with low greenhouse gas emissions, promoting biodiversity and the climate and avoiding damage to ecosystems (Filho et al., 2021).

(3) Social cohesion and integration of socio-economic dimensions in circular approaches. The Inclusion axis recognises the crucial importance of social dynamics in pursuing a circular economy. Therefore, measures aimed at mitigating socio-economic inequalities, promoting social cohesion and ensuring equitable access to resources, services and urban green spaces are encouraged. Urban areas are also considered privileged contexts for the application of new urban design principles geared towards inclusive regeneration.

(4) Towards regenerative urban planning: The Biodiversity axis promotes the adoption of regenerative design principles aimed at restoring natural resource cycles and creating sustainable, inclusive urban spaces capable of improving quality of life. This approach aims to generate green, resilient and socially cohesive urban environments capable of responding effectively to contemporary environmental and social challenges. Contributing to paradigm shifts in urban planning, design and architecture towards a biocentric perspective, in which urban areas and communities are further integrated into nature for a sustainable socio-ecological balance across urban-rural gradients.Table 1: most relevant experiments to regenerate existing abandoned spaces through circular economy processes analised.

Table 1: most relevant experiments to regenerate existing abandoned spaces through circular economy processes analised.

Project	Description	Axes				Pillars of the circular economy
		Was.	Mat.	Incl.	Biod.	
Kopfbau Halle 118 (Winterthur, Switzerland)	A concrete example of the recovery of an abandoned building is represented by the work carried out by the Swiss architecture firm Bauburo in situ and its partner company Zirkular, which, with the K118 pilot project, demonstrated how urban mining can be integrated into a modern building context, promoting the adoption of sustainable and circular practices. This case study highlights how, through innovative design and the use of recycled materials, it is possible to reduce the environmental impact of construction while maintaining the high quality and functionality of buildings.	•	•	•		Recovery of abandoned infrastructure Maximisation of the use Reversed planning process Reuse of materials Design for disassembly Strengthening community development Promoting social cohesion
Frank Areal (Basel, Switzerland)	Franck Areal, a new centre for social innovation, circularity and art, is a place where new connections are created: a centre for contemporary and urban dance, inclusive and cultural projects for young people, gastronomy and nightlife, as well as a space for regenerative and circular economy projects and an intergenerational housing project built with recycled construction materials and innovative energy technologies.	•	•	•		Recovery of abandoned infrastructure Maximisation of the use Reversed planning process Reuse of materials Strengthening community development Promoting social cohesion
La Ferme du Rail (Paris, France)	Located in the dense urban fabric of Paris's 19th arrondissement, on Rue de l'Ourcq, the urban farm and green oasis La Ferme du Rail provides an excellent example of possible circular approaches to the regeneration, reuse, protection and conservation of urban space for biodiversity through the active involvement of stakeholders. Developed over four years, this block creates an oasis of circular urban economy: it promotes a value chain that combines commercial activities with social and cooperative initiatives that benefit those who live there.	•	•	•	•	Recovery of abandoned infrastructure Maximisation of the use Reuse of materials Experimentation with natural solutions Urban renaturalisation Strengthening community development Promoting social cohesion

LUMEN - Laboratorio Urbano Mensola (Florence, Italy)	This is a culturally-based urban regeneration project that redevelops municipal real estate, creates social interaction in an abandoned public space and aims to create a new cultural hub next to the newly created Mensola Park. LUMEN's mission is to create a space where people can independently build opportunities to actively participate in their community. Through participation and individual empowerment, LUMEN is committed to promoting creativity, civic engagement and urban regeneration, encouraging the creation of an environment in which every individual can contribute to positive change.	•		•	•	Recovery of abandoned infrastructure Management of disused public properties Maximisation of the use Temporary and flexible use of space Reuse of materials Urban renaturalisation Strengthening community development Promoting social cohesion
Buiksloterham (AmsterdamNetherlands)	Buiksloterham is a typical post-industrial district, just a short ferry from the center of Amsterdam. The development of Buiksloterham as a living lab for circularity has led to a significant strengthening of the local economy and a transformation of what could previously have been deemed 'unusable land' into a thriving neighbourhood. Currently, Buiksloterham is undergoing transformation from an industrial area to a mixed living and working area. With local stakeholders, Metabolic developed a set of interventions for improving the current situation through waste minimization, high levels of source separation, and improved recycling techniques.	•	•	•	•	Recovery of abandoned infrastructure Maximisation of the use Reuse of materials Promoting responsible consumption Urban renaturalisation Optimise water use Strengthening community development Promoting social cohesion
Bluecity (Rotterdam, Netherlands)	Since 2015, BlueCity has developed from a vacant swimming pool into a circular economy hub for the city and region. In 2025, BlueCity is a model city for the circular and blue economy and home to 55 entrepreneurs. It is a meeting place for pioneers and enterprising minds, where they develop a framework for action, whether to grow their impact, live a zero waste life, or develop a future-proof material. BlueCity's mission is to accelerate the transition from the linear to the circular economy through entrepreneurship. BlueCity is designed as a prototype circular city to be replicated on a large scale.	•	•	•	•	Recovery of abandoned infrastructure Maximisation of the use Develop a future-proof material Experimentation with natural solutions Optimise water use Strengthening community development Supporting entrepreneurs with knowledge about circular economy

Oosteroever Circulair District (Oostend, Belgium)	For the Oosteroever site, a comprehensive hypothesis for a circular district was developed, addressing all key dimensions: materials, water, biodiversity, and programme. The proposal emphasises the importance of systems research and the creation of an urban planning model to support the economic transition of the area. This approach aims to avoid fragmented developments lacking mutual interaction. Furthermore, sustainable solutions require an integrated strategy at the scale of the entire district.	•	•	•	•	Recovery of abandoned infrastructure Reuse of materials Promoting responsible consumption Urban renaturalisation Optimise water use Strengthening community development Promoting social cohesion
Darwin Eco-system (Bordeaux, France)	Darwin aims to regenerate an abandoned urban space while promoting a social, green and creative economy. It is a place where new models are explored to reconcile economy and ecology, based on cooperative and sharing principles. The initiative focused on the preservation and renovation of the original buildings while providing workspace for over 100 enterprises and (social and cultural) associations, as well as co-working facilities. The ecological transition is an important theme in the redevelopment of the area, both in the renovation of buildings and in the wider activities developed. The area has for example become a living lab for new (urban) farming techniques like aquaponics and micro-gardening.	•	•	•	•	Recovery of abandoned infrastructure Promoting responsible consumption Develop a future-proof material Experimentation with natural solutions Strengthening community development Promoting social cohesion

Strategies for circular urban regeneration. Systemic processes for the cities of the future.

We already have everything we need. The point is not to continue producing, but to learn to read what exists more carefully, to recognise its latent value and reactivate it. The built environment is not an exhausted resource, but a reservoir of potential: every building, every material used has a residual value that can be regenerated. This approach opens up a new aesthetic of architecture, in which reuse is not only an environmental necessity, but also a design language capable of expressing beauty, memory and innovation. From a systemic perspective, architecture takes on the role of mediator between ecologies and economies, becoming an active tool in decarbonisation and the reactivation of local economies. The transition from a linear to a circular model requires a profound transformation of design methodologies: it is not just a matter of changing materials, but of radically rethinking processes, value metrics and decision-making models. We must move beyond the logic of initial cost to embrace a holistic view of value throughout the entire life cycle of the work.

We are accustomed to considering demolition and disposal as inevitable stages of the building cycle. But today it is possible to overturn this paradigm: designing architecture and neighbourhoods that generate minimal waste, facilitating disassembly, reuse and recovery of materials. This means intervening not only on the built environment, but also on design habits, supply chains and regulatory tools, in order to build urban contexts that reduce waste production and maximise regeneration.

Circular urban regeneration is based on a compact, biodiverse and zero-land approach, where the useful life of buildings and materials is extended through reuse strategies and the use of materials produced according to regenerative criteria (EMAF, 2021).

The urban transformation projects analysed aim to promote and accelerate progress towards inclusive, regenerative and transformative urban futures and highlight the importance of collaborative efforts between policymakers, urban planners, environmentalists and communities to implement effective strategies to preserve and restore urban biodiversity. Based on the results obtained through the analysis of the state of the art and the observation of case studies, it emerges that the main strategies for circular transition through the creation of interacting and replicable models concern:

- Recovery of critical or abandoned infrastructure or urban areas;
- Maximisation of the use of existing building heritage through models of sharing and flexible use of space;
- Reversed planning process: form follows availability, the project develops constantly as the search for components progresses;
- Adaptive reuse of materials from existing infrastructure, through a detailed analysis of residual and reusable materials;
- Mapping of local surpluses, in collaboration with companies and local networks for the reuse of resources within projects;
- New internal balance of relations between ecologies and economies;
- Experimentation with natural solutions to increase the presence of urban greenery, promote biodiversity and create resilient ecological infrastructure;
- Dematerialising public space infrastructure and focusing on nature as infrastructure;
- Promoting social cohesion and a participatory approach ensuring that urban regeneration aligns with the needs and characteristics of local populations;
- Strengthening community development and civic awareness.

Measuring the effectiveness of the projects analysed is the priority challenge that requires constant refinement of tools, continuous updating and improvement of results, and progressive deepening of evaluation methods, in awareness of the complexity and variability of reference parameters and the need to build a system for predicting effects throughout the entire life cycle for a regenerative and accessible urban system by design. The experiences studied show that the circular transition, with a view to climate neutrality, lays the foundations for an innovative vision of regenerative intervention, which aims to eliminate the concept of waste and refuse in the short to medium term (8-10 years, according to the European average) and invests, over the longer useful life phase, the entire range of material and immaterial resources in a perpetual self-sufficient cyclical process of decommissioning and regeneration.

Urban space can be configured as a regenerative ecosystem, guided by a zero waste approach that involves all resource flows, from design to management. Designing according to the useful life cycle of elements allows for the creation of self-sufficient and adaptive environments capable of resiliently addressing environmental, economic and social challenges. Circular design radically reformulates the relationship between construction and materials, focusing on the continuity of value over time and space. Reuse is no longer just a technical practice, but an evolving architectural narrative, where even buildings that can no longer be recovered become urban quarries, rich in materials that, as part of the existing heritage, acquire a cultural and environmental value greater than that of virgin materials.

CUE therefore proposes itself as an integrated, adaptive design model rooted in the territories, capable of generating environmental, social and economic value from what already exists. An approach based on proximity, nature and the enhancement of local resources, towards more equitable, resilient and regenerative cities.

If we look at this type of approach, NbS can be seen as a concrete application of the principles of circularity on an urban and architectural scale, through the mimicry of natural processes and the closure of ecological cycles (EEA, 2021). Artificial wetlands, vegetated channels, detention and infiltration basins, rain gardens, bioswales, renaturalised riparian strips and many other solutions act as decentralised biophysical systems, capable of filtering, storing and returning water to the natural hydrological cycle. These systems reduce pollutant loads,

mitigate flow peaks and recover resources (such as nutrients and biomass), in line with circular strategies for wastewater recovery (Li et al., 2020; EEA, 2021). NbS applied in urban areas to buildings and open spaces support the metabolic efficiency of urban systems, reducing energy consumption for cooling, greenhouse gas emissions and promoting passive ecosystem service flows (Pauleit et al., 2017). These results contribute directly to a circular reconfiguration of urban infrastructure without consuming new land (Pomponi & Moncaster, 2016).

Practices aimed at regenerating degraded soils increase carbon sequestration, improve soil fertility and promote biodiversity in urban and peri-urban areas. Such approaches are consistent with the principles of the circular bioeconomy, as they transform organic waste into productive inputs, contributing to the restoration of ecosystem functionality and increasing resource productivity in the long term (Lal, 2020; IUCN, 2020).

The integration of NbS into the theoretical and operational frameworks of the circular economy is not merely functional, but systemic. Both approaches emphasise resource cyclicality, multifunctionality and decentralisation, opposing linear and sectoral development models. The adaptive and feedback-based nature of NbS reflects the cyclical flows inherent in circular systems, reinforcing the need for their integration into sustainable territorial development strategies (Fischer & Newig, 2016; Kirchherr et al., 2017).

Fig.5 - 'Structure and flow' channels (efficiency) and 'network and exchange' (resilience) within a mycelial system (Source: National Institutes of Health)

The long-term future of our materials economy is regenerative. This transition requires a deep understanding of the impacts of systems, avoiding further degeneration of global biodiversity and land through green growth. Therefore, to imagine a post-capitalist future, it is important to promote circular, green and inclusive governance models. The CUE theme, through a proactive approach, encourages cities to implement circular measures that address socio-economic inequalities, promote social cohesion and improve access to urban resources, services and green and blue spaces. For this reason, new government tools must deepen urban transition processes according to the principles of regenerative design, strengthening the role of nature and the recycling of local resources to transform degraded urban areas into ecosystems that enhance biodiversity, combat climate change and improve the well-being and health of citizens.

Conclusions

The regeneration of degraded urban spaces according to the principles of the circular economy represents an urgent challenge but also a strategic opportunity to radically rethink our relationship with the built environment. The hegemony of the extractive economy over design culture has consolidated production chains so effective that they block the possibility of considering pre-existing materials on site as a valuable resource, improperly reducing them to waste. A paradigm shift, on the other hand, invites us to view these materials as a new form of urban stratification, an urban and anthropogenic mine from which to draw in order to promote infinite andregenerative production cycles. From this perspective, architecture should no longer be an act of replacement but a process of transformation, supporting a creative rebirth of our relationship with the built environment through an approach that prioritises reuse, regeneration and reintegration of materials on site, rather than demolition and disposal.

The adaptive reuse and regeneration of existing urban resources are the foundations of a new culture of urban renewal, which should guide all city operational plans according to the principles of "zero volume" and "no net land take". Unused or underused spaces represent a strategic potential for activating targeted urban policies

and strategies capable of responding sustainably to contemporary needs. It is therefore essential that local administrators recognise the social, economic and environmental impact that these places can generate and equip themselves with appropriate visions and tools to rethink urban planning logic in a regenerative and circular way. The temporary activation of abandoned buildings and areas can trigger participatory processes of active citizenship and local activism, offering citizens concrete tools to contribute to urban development. If systematised, this approach can lead to a more inclusive and resilient urban transformation.

The transition to regenerative cities therefore requires deep integration between spatial innovation, social inclusion and the protection of urban biodiversity. This is not simply a matter of adding up good practices, but of a structural change in the vision of the city: from an entity that consumes land and resources to an integrated ecosystem capable of self-regeneration. The promotion of biocentric planning, which reintegrates the built environment with natural processes, is one of the most effective levers for a just ecological transition.

For these changes to be effective and scalable, it is necessary to build a model consisting of policies, financial instruments, design regulations and collaborative mechanisms. The simultaneous development of tools such as material registers and passports, together with the creation of alliances between public and private actors and local communities, is essential to enable a truly circular institutional urban economy.

Through the implementation of the CUE, the goal is to create a cohesive ecosystem that not only anticipates future needs but also collectively guides the transition of cities towards systemic, equitable and transformative governance models capable of internally rebalancing the relationship between ecologies and economies.

The paradigm shift presented in the paper is not easy, but it is necessary and requires a joint effort that cannot be postponed and can provide policymakers with the tools and knowledge needed to expand related interventions in other urban contexts.

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Post-growth Redefinition of Urban Textures: The Changing Faces of Human Scale through Eminonu and Maslak Central Business Areas in Istanbul

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Abstract
As cities move beyond growth-driven models, the relationship between urban texture and human scale becomes essential for designing people-centered environments. Historically, economic expansion has produced dense, vehicle-oriented urban forms, often at the expense of spatial intimacy and human comfort. This paper explores how contrasting urban forms along Istanbul's Central Business District axis—Eminonu and Maslak—reveal the impacts of urban morphology on social experience. Through spatial analysis of building height, street width, and enclosure, the study highlights how Eminonu fosters walkability, social interaction, and a sense of place, while Maslak reflects the spatial fragmentation of growth-focused development. The paper proposes a post-growth urban framework grounded in human-scale design, advocating for inclusive, livable, and resilient cities shaped by morphological balance rather than expansion.

Keywords: post-growth urbanism, human scale, morphology, central business area, Istanbul

Introduction

Urban growth has long been equated with progress, prosperity, and modernity (Harvey, 2005). However, this growth has also led to social alienation, spatial fragmentation, and environmental degradation, prompting increasing criticism of the traditional growth-driven urbanism model (Sachs, 2015). In response, post-growth urbanism has emerged as a critical framework that not only questions the relentless pursuit of growth but also calls for a fundamental reorientation of urban development priorities. Rather than focusing on quantitative metrics such as GDP, urban sprawl, and consumption, post-growth urbanism emphasizes spatial quality, ecological integrity, and the well-being of individuals and communities (Latouche, 2009; Raworth, 2017; D'Alisa, Demaria & Kallis, 2015). This shift invites a profound rethinking of urban design, with a focus on creating environments that are both sustainable and human-centered, fostering more inclusive, resilient, and livable cities (Sennett, 2018; Gehl, 2010).

Central to this rethinking is the concept of the human scale, which underscores the importance of designing urban spaces in alignment with human needs and experiences. It promotes environments that are accessible, navigable, and conducive to social interaction (Gehl, 2010; Sennett, 2018). Human scale extends beyond physical size and proportion; it embodies an experiential and social relationship between urban form and the human body, encouraging legibility, comfort, and inclusivity (Gehl, 2010). Scholars such as Lynch (1981) and Alexander (1977) argue that human-scale environments enhance coherence, orientation, and meaningful engagement among inhabitants. Within the post-growth paradigm, the human scale is not merely a design guideline but a vital lens for evaluating the inclusivity, accessibility, and resilience of urban life (Carmona et al., 2003; Sennett, 2018). Urban spaces shaped through this lens foster a deeper sense of connection, both to place and to community, thereby strengthening social cohesion and overall well-being.

The human-centered approach is also closely linked to urban texture, understood as the spatial arrangement of streets, buildings, and open spaces. Urban texture includes the voids and patterns that shape everyday urban experiences (Mehaffy, Porta & Romice, 2010). Dense and layered urban textures support walkability, spatial intimacy, and mixed land uses, thereby nurturing vibrant social life and a heightened sense of place (Jacobs, 1961; Gehl, 2010). In contrast, growth-oriented design often prioritizes car infrastructure and high-rise, functionally segregated development. These conditions disrupt the spatial continuity and social cohesion essential for livable environments and tend to alienate individuals from their surroundings (Gehl, 2010). The relevance of this discussion becomes particularly evident in metropolitan cities like Istanbul, which embodies both historical continuity and rapid modernization.

Istanbul's Central Business District (CBD) axis, stretching from the organically developed historic texture of Eminonu to the modern district of Maslak, presents a striking contrast in spatial and experiential perspective (Keyder, 1999; Aksoy & Robins, 2011). These two business districts, which differ physically and functionally, have been selected as case areas due to their distinctive urban forms. While Eminonu maintains a dense, fine-grained

structure that promotes pedestrian activity, visual coherence, and spontaneous social exchange, Maslak reflects the spatial consequences of late 20th-century neoliberal urbanism, characterized by fragmentation, vertical expansion, and a loss of public life (Erkip, 2000). The contrast between these two commercial districts highlights how different urban textures can significantly influence both physical space and social dynamics, particularly in terms of post-growth urbanism and human scale.

This paper investigates how the contrasting urban forms of Eminonu and Maslak shape not only the physical space but also the social experience and sense of place, qualities essential to post-growth urban environments (Carmona et al., 2003; Gehl, 2010). Adopting a comparative morphological approach, the study focuses on three key indicators: street width, building height, and street enclosure. These parameters are analyzed not only in formal terms but also as spatial conditions that influence human comfort, inclusivity, and the vitality of urban life. By bridging morphological analysis with post-growth theory, this paper aims to contribute to contemporary urban debates on how spatial form can support human-centered, sustainable, and socially inclusive futures (Latouche, 2009; Raworth, 2017).

Spatial Development of Istanbul's Central Business District (CBD) Axis

The urban development of Istanbul's CBD axis has been crucial to the city's history, characterized by changes influenced by urban planning and socio-economic conditions (Göksu & Pilehvarian, 2019). Understanding this formation is essential for contextualizing the historical background of the selected case areas, as the axis reflects significant changes from the city's traditional commercial core to its contemporary business districts.

In the 1950s, Istanbul's commercial center was the Eminonu area of the Historical Peninsula, functioning as the main trading location of the city for the import, export, and sale of many commodities (Göksu & Pilehvarian, 2019). From 1956 to 1958, a significant development in the city's planning was going on with the construction of Barbaros Boulevard, which connects Beşiktaş to Zincirlikuyu. This development served as a pivotal axis for the spread of the city's primary commercial centers into other regions. This shift marked the beginning of a new phase for Istanbul's CBD, which would later see the rise of modern commercial areas beyond the historical core (Çelik, 1993). In the late 1960s, the city subsidized skyscraper construction in Maslak, the city's development area. This development signaled a notable transition towards vertical development and modernity.

In the 1970s, the evolution of the city's commercial landscape continued to grow, as the merging of the Taksim-Şişli-Büyükdere axis and the Mecidiyeköy-Gayrettepe axis facilitated the northern region of Istanbul's development as an extension of the Historical Peninsula's commercial center (Kubat et al., 2012). The simultaneous reduction of military zones in the northern part of the city, especially in the Sarıyer district, resulted in a cluster of multi-storey projects in Maslak after the 1970s. These improvements positioned the area as a modern business district, highlighting vertical expansion. This period also experienced a notable transformation in commercial architecture, as enterprises progressively preferred contemporary office buildings to maintain market competitiveness (Kıray, 1998).

During the 1990s and early 2000s, the evolution of Maslak coincided with the expansion of the entire CBD axis, characterized by the establishment of industrial zones, business hubs, and upscale residential districts. In this period, initiatives were undertaken to maintain the identity of the 'Old City' in the Historical Peninsula, transforming it into a tourism and commerce-focused district (Aydemir, 2019) (Figure 1).

In the present day, Eminonu and Maslak represent two critical points along Istanbul's CBD axis, embodying different historical backgrounds, urban textures, and planning paradigms. While Eminonu, located in the Historical Peninsula, has served as the city's core commercial and cultural hub for centuries, its dense streets maintain a strong connection to human activities and daily life (Tüfekçi, 2017). In contrast, Maslak, which spatially developed in the second half of the 20th century, symbolizes Istanbul's modern expansion, characterized by vertical growth, office spaces, and infrastructural integration (Karaca, 2020). The comparison of these two business district areas illustrates the broader tension between preserving historical urban character and accommodating contemporary economic and spatial demands.

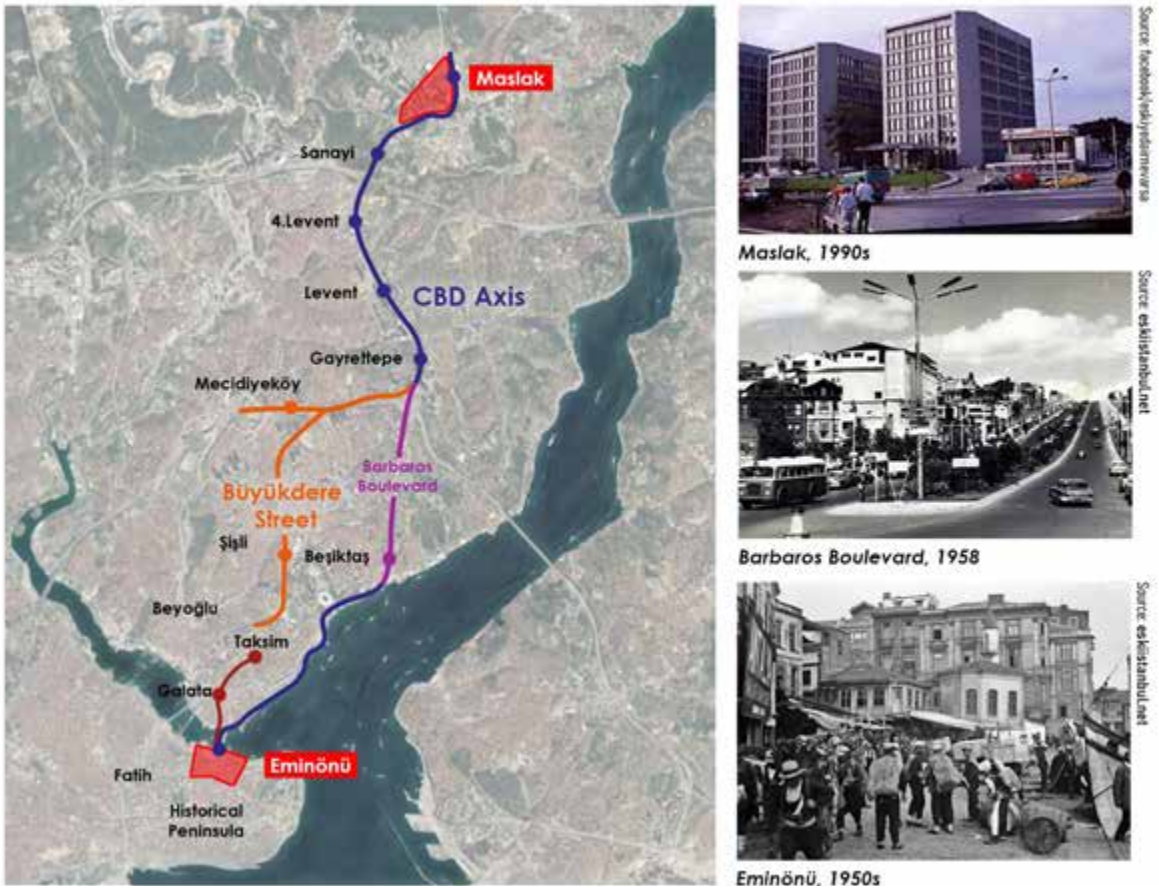

Figure 1. Development of Istanbul's Central Business District (CBD) Axis

Morphological Comparison of Eminonu and Maslak Case Areas

This section systematically analyzes the morphological characteristics of Eminonu and Maslak through essential spatial parameters, seeking to explain how distinct planning approaches, particularly those shaped by human scale and post-growth thinking, have influenced their urban forms. By contrasting these two areas, the analysis highlights the spatial implications of different urban development models, one based on historical continuity and social proximity, the other on modern economic imperatives, and raises critical thinking about how cities can transition to post-growth futures that prioritize human well-being over expansion.

Environmental Relations

Eminöonu serves as a highly connected urban node, influenced by its historical layers and dense transportation networks. Surrounded by significant areas including Golden Horn, Vezneciler, Sirkeci, and Unkapanı-Vefa, it acts as a central connection in Istanbul's urban texture. Three major streets and two iconic bridges (Galata and Haliç) provide strong east-west and trans-Golden Horn connectivity, connecting the district to both old and modern city regions. Eminonu's multimodal infrastructure, which includes the M2 metro, the T1 and T5 tram lines, and a rearranged bus network, improves its accessibility and spatial planning. Its maritime function strengthens both intercontinental and local links, with eight ferry lines anchored in Istanbul's water-based transportation. Green and cultural icons, including Gülhane Park and Istanbul University's Beyazıt Campus, contribute to the city's environmental and historical identity. Overall, Eminonu illustrates environmental urban integration by combining natural, infrastructure, and socio-cultural systems into a multilayered urban network (Figure 2).

Maslak, on the other hand, is a vast northern district defined by its strategic placement along Büyükdere Street, a major urban axis that connects it to the surrounding districts. The M2 metro line connects Maslak directly to Eminonu, increasing its connectivity to Istanbul's transportation network. Istanbul Technical University's Ayazaga Campus is a significant educational and research construct in the region. The Atatürk Auto Industrial Zone reflects

the district's industrial background, however, it is currently facing issues as a result of urbanization. Maslak is a dynamic urban neighborhood where transportation, sectoral clusters, and changing land uses all contribute to its position in the city (Figure 2).

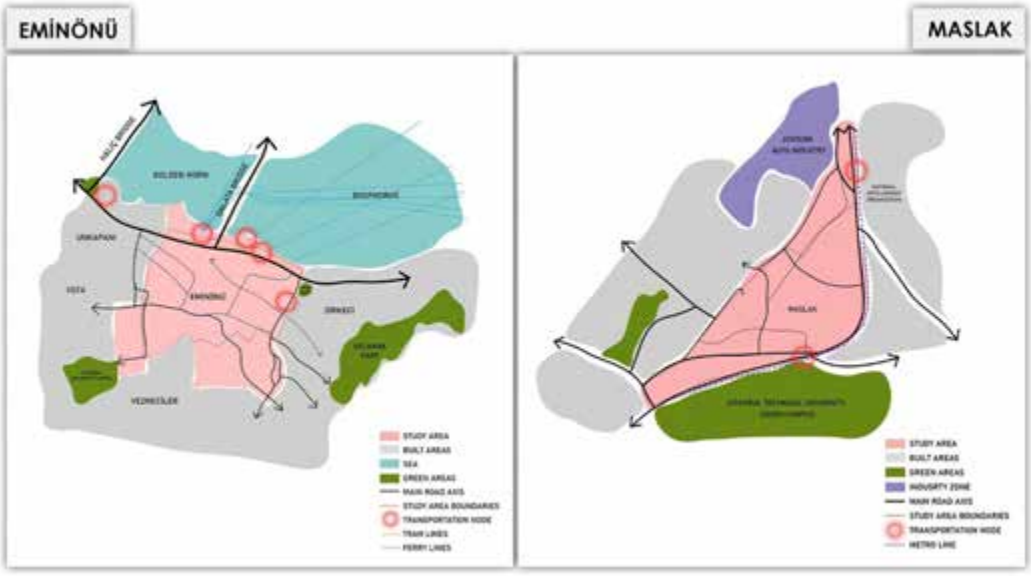

Figure 2. Environmental Relations Analyses of Eminonu and Maslak Areas

Eminonu demonstrates environmental integration through historical continuity and multimodal connectivity, whereas Maslak stands out with its vibrant and modern sector of commerce. Together, they represent distinct urban processes at various spatial scales.

Land Use

Eminonu exhibits a more complicated and layered land use pattern within a smaller space. In addition to its primary commercial purpose, Eminonu incorporates a diverse range of uses, including tourism, religious facilities, public services, and technical infrastructure. This multifunctional structure is integrated into a historical urban texture, where dense building stock and fine-grained parcelization allow for the cohabitation of many activities within walking distance. In contrast to Maslak's single mosque, Eminonu has a high concentration of mosques and religious institutions (Figure 3).

Maslak is a large-scale, contemporary business district, with land use primarily monofunctional. Commercial activity is primarily centered in high-rise office buildings and luxury plazas, with little integration of different land use functions. While the region has designated green spaces and a single religious facility, the general land use composition is simplified to support business and corporate services, representing a planned and vertical urban structure common in modern development models (Figure 3).

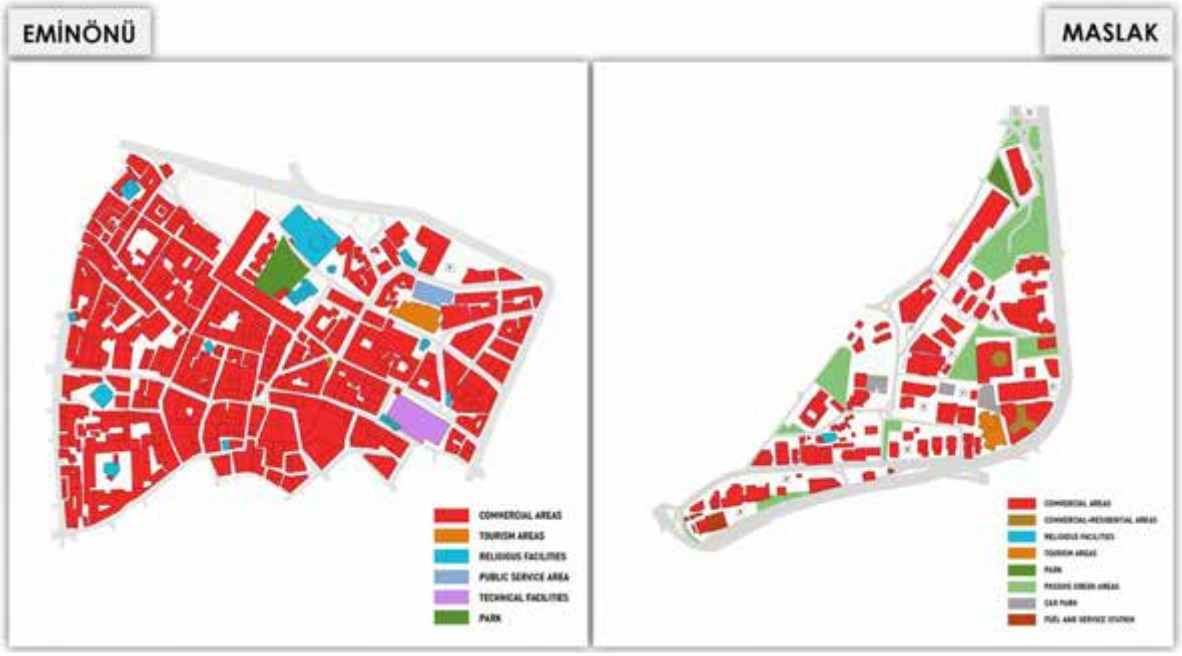

Figure 3. Land Use Analyses of Eminonu and Maslak Areas

Eminonu represents a tight, historically evolved, and multipurpose urban center, whereas Maslak displays a planned, monofunctional, and geographically large business area because of modern commercial demands.

Figure-Ground

Eminonu is characterized by a dense and closely knit urban texture in which buildings are primarily linked, resulting in continuous street frontages and enclosed block constructions. This creates a figure-ground connection in which architectural forms dominate, leaving open spaces fragmented, small in scale, and irregularly distributed. The built environment's compactness helps to create a readable and well-defined street network, with restricted yet coherent circulation paths that have evolved organically over time (Figure 4).

In contrast, Maslak's figure-ground composition is more dispersed and broken. Buildings are typically independent, standing alone on larger building blocks and surrounded by open space. This division causes a lack of continuity of the urban texture, resulting in a less coherent streetscape. Maslak's open spaces are larger in scale and more evenly distributed. The road network is also less prominent, with wider but more scattered roadways (Figure 4).

Eminonu and Maslak provide two distinct urban morphologies defined by spatial organization, construction patterns, and open space distribution. While both areas have open spaces, the scale, distribution, and connection of built and unbuilt environments differ significantly, reflecting the underlying urban logic.

Figure 4. Figure-Ground Analyses of Eminonu and Maslak Areas

Urban Elements

Eminonu offers a layered urban experience through Kevin Lynch's elements, which are paths, edges, districts, nodes, and landmarks. Its narrow, continuous streets create a dense pedestrian network shaped by the organic structure of the area. Districts in the area blend commerce, religion, tourism, and public services, forming micro-zones rooted in historical-commercial uses. Numerous nodes, such as squares and marketplaces, serve as vibrant social anchors. Historical landmarks such as mosques, bazaars, and monuments stand out in the area. The landscape in the area is concentrated in the middle parts of the building blocks (Figure 5).

Maslak reflects a modern, functionally pre-zoned urban model. Broad, vehicle-oriented streets form a legible but less human-scaled path system. Edges like Büyükdere Street act as rigid physical boundaries. Nodes are fewer and primarily serve functional roles, like plazas at business buildings' entries. Landmarks are mostly high-rise office buildings, offering visibility through scale rather than historical or cultural significance. The landscape is concentrated in the idle spaces (Figure 5).

Eminonu and Maslak represent two contrasting urban typologies. Eminonu's organic, fine-grained structure fosters a rich and immersive urban experience grounded in historical continuity and human-scale complexity. Maslak, in contrast, embodies a modern, planned environment focused on function, scale, and accessibility. Analyzing these two areas through Lynch's framework highlights the spatial, social, and experiential divides between traditional and contemporary urban forms.

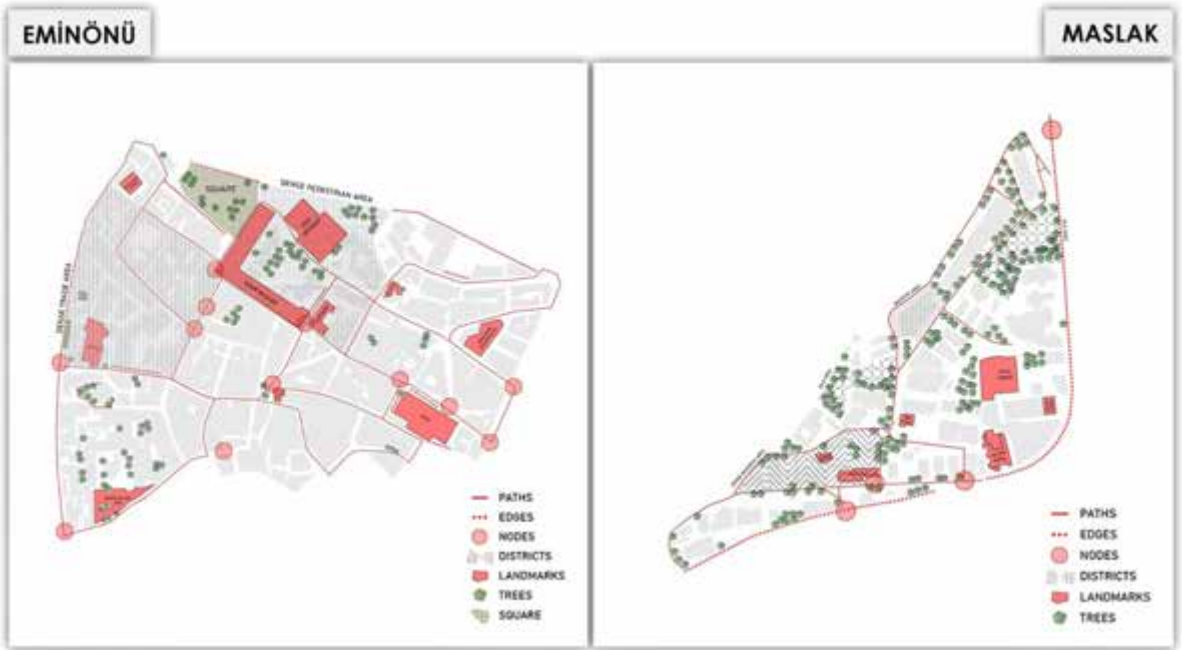

Figure 5. Urban Elements Analyses of Eminonu and Maslak Areas

Street Width

Eminonu's historic urban texture creates a narrower and enclosed street network, which includes mostly streets measuring 2 to 3.9 meters. This compactness brings buildings closer together, making visible boundaries, and encouraging and prioritizing pedestrian activity. These narrow paths promote intimacy, social connection, and accessibility. The built environment encourages walking, with street life smoothly transitioning between commerce, culture, and daily activities (Figure 6).

In Maslak, the rarest street width range in the area is 2 to 3.9 meters. The area is defined by wider streets, primarily designed to accommodate vehicular traffic. The scale of streets and buildings reflects a modernist planning approach, prioritizing efficiency, car access, and the separation of functions. This leads to a spatial environment that often overwhelms the pedestrian, where distances are longer, street crossings are broader, and public life is more dispersed. The human scale in Maslak is diminished by the verticality of high-rise buildings and the vastness of road corridors, creating an experience that feels more formal, distant, and controlled (Figure 6).

Street width in both of these areas has a significant impact not only on physical accessibility but also on urban behavior, daily rhythms, and perceived relationships between human and place. Eminonu aligns with human-scaled, walkable characteristics, while Maslak represents a more vehicle-oriented, large-scale urban paradigm.

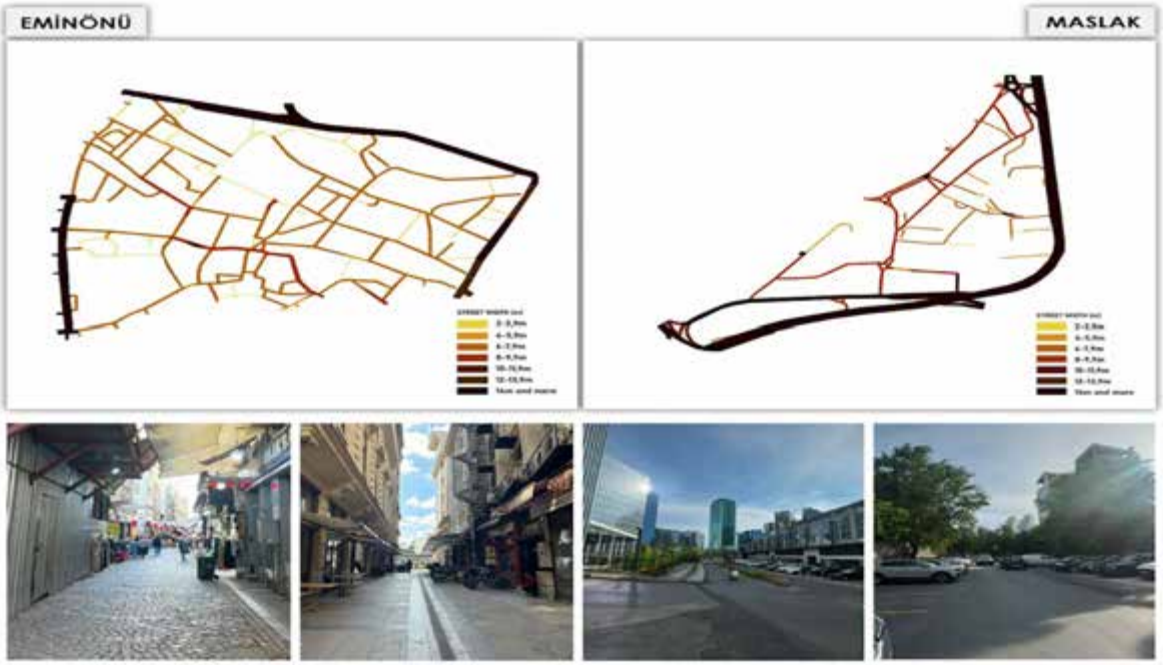

Figure 6. Street Width Analyses of Eminonu and Maslak Areas

Building Height

Eminonu represents a historically evolved urban texture defined by human-scale interactions, walkability, and spatial intimacy. Its mid-rise building stock, typically 3 to 4 storeys, supports a consistent skyline aligned with a dense street network and enclosed blocks. The compact figure-ground relationship fosters direct connections between buildings and public space, creating a layered, legible environment. Streets, squares, and built forms transition organically, shaped by centuries of incremental development. The gradual east-west height transition enhances visual harmony. Eminonu's form prioritizes connectivity, enclosure, and architectural coherence rooted in tradition and urban memory (Figure 7).

Maslak, in contrast, illustrates a modern, planned business district defined by verticality and fragmented urban form. With a wide range of building heights, from low-rises to skyscrapers, often in isolated clusters, the skyline is less cohesive in the area. Buildings are typically separated and surrounded by open space, reducing spatial continuity and pedestrian permeability. The wide roads and scattered paths prioritize vehicles, while nodes and landmarks serve functional roles rather than creating social or spatial anchors. Maslak emphasizes visibility and economic identity, but often at the cost of accessibility and urban richness (Figure 7).

The contrast between Eminonu and Maslak reveals two opposing urban models—one shaped by organic growth and human-scale design, the other by modern planning and functional zoning. Eminonu offers a compact, coherent, and pedestrian-oriented space fostering interaction and place identity. Maslak reflects contemporary urbanism focused on visibility, zoning, and monumentality, often with limited cohesion. These differences impact how space is used and experienced. Future planning can draw from both approaches, combining the experiential richness of traditional districts with the flexibility and efficiency of modern development to create more inclusive and resilient urban environments.

Figure 7. Building Height Analyses of Eminonu and Maslak Areas

Street Enclosure

Street enclosure is crucial for defining the quality of pedestrian space and influencing how individuals perceive and navigate the urban landscape. This understanding is essential for creating pedestrian-friendly environments that promote walking and social engagement (Gehl, 2011). Moreover, studies on street enclosures may assist with decisions on street design, land use planning, and public space development, leading to more vibrant and livable urban environments (Whyte, 1988). The ratio of enclosure, defined as the spatial relationship between building height and street width (Ewing & Handy, 2009), varies notably between these areas, leading to different levels of urban intimacy and openness.

Eminonu is an example of a historically complex urban setting where street enclosure is a key factor in shaping the experience of pedestrians and the character of the space. Narrow streets with mid-rise buildings, which are usually three to four stories high, interact closely to produce the area's high enclosure ratio. The average ratio in the area is 1:1 and above. This implies the field has great and high placemaking potential. Because of the intimacy and continuity created by this spatial arrangement, pedestrians can fully immerse themselves in the constructed environment. Because of its distinct boundaries and well-defined paths, the enclosure at Eminonu helps people feel safe and oriented. However, in some areas, particularly where large and continuous facades are on the narrow streets, this intensity can become overwhelming, resulting in a sense of spatial compression or visual overload (Figure 8).

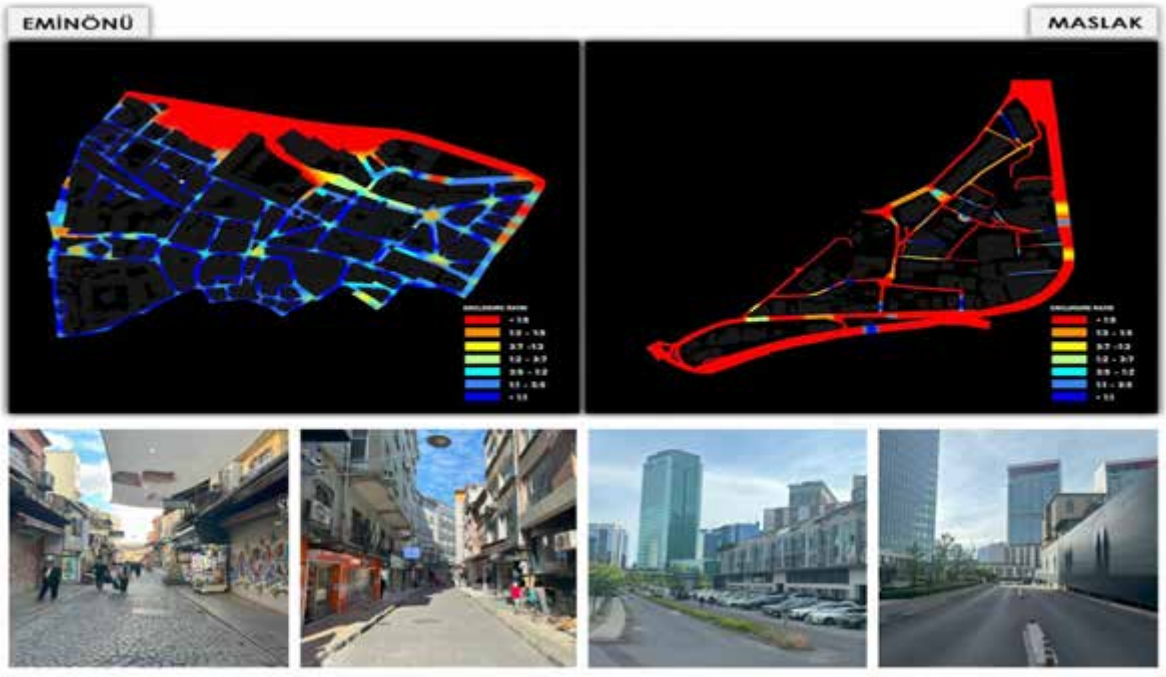

Figure 8. Street Enclosure Analyses of Eminonu and Maslak

Maslak, on the other hand, exemplifies a modern urban paradigm focusing on openness and visual permeability over its built environment. The area's street enclosure ratios are significantly lower, due to wide paths, large building setbacks, and a variety of building heights, which frequently range from low-rises to skyscrapers. As a result, many of Maslak's streets are large and exposed, which decreases the sense of place. It is observed that the prevailing ratio in the area is 1:5 and lower. This means that there is a weak and low placemaking potential in the field. Pedestrians feel disconnected from the surrounding built space, as large-scale shapes and dispersed layouts undermine the interaction between buildings and the streets. While certain parts of the area are pedestrian-centered and have more defined proportions, the area is predominantly car-oriented and fragmented (Figure 8).

Eminonu and Maslak demonstrate how street enclosure shapes urban atmosphere and user experience. Eminönü's narrow, well-defined streets foster pedestrian comfort, social interaction, and spatial coherence rooted in historical patterns. Maslak, shaped by zoning and large-scale planning, prioritizes openness and visibility but often lacks human-scale engagement. While both areas vary internally, Eminonu offers a more cohesive and emotionally resonant public realm. These contrasts highlight the role of proportion, enclosure, and building-street relationships in creating inclusive and walkable urban spaces.

The Erosion of Human Scale in Vertical Growth

The shift from historical, human-scaled urban textures to vertically extended business districts in the case areas brings out the broader phenomenon of losing human proportions in modern cities. This phenomenon, exemplified by the different development patterns in Istanbul's Eminonu and Maslak districts, demonstrates the physical and social effects of promoting vertical growth above intimate proportions, which encourages human comfort and social interaction.

Historically, urban settings like Eminonu evolved organically, with thick urban textures, building heights, and street widths that strongly resemble human proportions. These types of areas encourage walking, stimulate spontaneous social interactions, and maintain a strong feeling of place (Gehl, 2010; Jacobs, 1961). The length of streets and buildings' heights creates an enclosure that visually and physically connects people to their surroundings, promoting direction and social cohesiveness (Lynch, 1981). These features, according to Lynch (1981), are critical for legibility and psychological comfort among urban dwellers.

Maslak, on the other hand, illustrates the late twentieth-century trend toward vertical expansion and sprawling office buildings, which has radically transformed urban shape and distorted human scale. High-rise skyscrapers on large building blocks can disrupt urban continuity and limit spatial intimacy (Erkip, 2000; Kıray, 1998). This type of growth emphasizes economic efficiency while excluding pedestrian experience and reducing potential for dynamic street life (Montgomery, 1998).

The vertical expansion concept, while representing modernization and economic advancement, frequently creates spatial conditions that are alienating human interactions. Higher structures cause microclimatic effects such as wind tunnels and large shadows, which reduce outdoor comfort (Solecki et al., 2004). Furthermore, greater scale and spacing between buildings reduce the intelligibility and cohesion of urban environments, complicating navigation and lowering the sense of safety (Carmona et al., 2003).

Modern central business districts around the world have followed a similar trajectory, with a focus on automobile-oriented infrastructure and high-density vertical building (Graham and Healey, 1999). The resulting urban surroundings frequently fail to support cities' social functions, such as communal activities and cultural expression (Whyte 1980). The challenge of post-growth urbanism is to balance the needs of economic progress with the preservation and restoration of human dimensions. This includes reconsidering zoning restrictions, promoting mid-rise, mixed-use complexes, and emphasizing pedestrian-friendly street networks (Dovey, 2016). Cities can establish environments that are not only economically productive but also socially inclusive and environmentally sustainable by focusing on morphological balance and spatial quality rather than just height and density (Alexander, 1977; Gehl, 2010).

Pathways to Human-Centric Urbanism

In response to the alienating effects of vertical urban growth and the loss of human scale, urban theorists and practitioners have increasingly argued for a return to human-centric principles in urban planning. Human-centric urbanism focuses on spatial, social, and sensory elements that improve daily life. This strategy challenges growth-driven paradigms and instead promotes inclusivity, livability, and sustainability—core principles shared by post-growth urbanism (Latouche, 2009; D'Alisa et al., 2015).

Rescaling cities is an important step toward human-centric urbanism. This entails reactivating human-scale spatial proportions and ensuring that buildings, streets, and public spaces promote pedestrian mobility and interaction between individuals. According to Jan Gehl (2010), designing for "the human dimension" necessitates an awareness of people's physiological and psychological capabilities—how far we can see, walk, and gather comfortably. Mid-rise, mixed-use complexes, fine-grained urban blocks, and narrow streets with busy frontages are practical alternatives to the spatial fragmentation created by megastructures and superblocks (Carmona et al., 2003).

Another critical pathway is reclaiming and reactivating public space. The quality, accessibility, and programming of public spaces significantly shape the social life of cities. William H. Whyte (1980) famously demonstrated how small design choices, like movable chairs, sun exposure, or food kiosks, can foster spontaneous social engagement. In contemporary urban discourse, reclaiming public space also involves confronting its commodification and promoting spatial justice, ensuring that all social groups, especially those marginalized, have the right to the city (Lefebvre, 1996; Mitchell, 2003).

Another crucial approach is to reclaim and reactivate public spaces. The quality, accessibility, and management of public places all have significant effects on urban social life. William H. Whyte (1980) notably illustrated how minor design elements, such as movable seats, sun exposure, and food kiosks, can encourage spontaneous social contact. In modern urban discourse, reclaiming public space entails opposing its commodification and advocating spatial justice, ensuring that all social groups, particularly those oppressed, have the right to the city (Lefebvre, 1996; Mitchell, 2003).

Redefining the criteria for creating sustainable, safe, and pedestrian-friendly environments is required to promote human-scale concepts. Dominant planning paradigms frequently use growth measures like GDP or square meters of developed land to judge success. In contrast, post-growth urbanism emphasizes criteria like well-being, accessibility, ecological balance, and social equality (Raworth, 2017; Banister, 2008).

This paradigm change highlights the need for new planning tools and evaluative frameworks that value quality over quantity and focus on long-term resilience.

Human-centric urbanism is not a nostalgic return to pre-modern cities, but rather a forward-thinking synthesis of social, ecological, and morphological understanding. It acknowledges the city as a living organism that must be created with compassion, humility, and common sense. While the pressures of global capitalism and population expansion persist, rethinking cities at the human scale opens up new avenues for urban justice and sustainability.

Conclusion

As urban societies face the limitations of growth-driven planning approaches, the demand for spatial strategies based on human scale and experiential enrichment becomes more essential. This study indicated that the contrasting morphological layouts of Eminonu and Maslak—two different commercial hubs along Istanbul's CBD axis—provide important insights into the effects of urban form on social life, environmental integration, and pedestrian experience.

Eminonu, with its organically evolved, fine-grained urban fabric, exemplifies the enduring value of human-scale environments. Its compact street network, moderate building heights, and dense land use pattern foster a spatial intimacy that supports walkability, spontaneous social interaction, and emotional attachment to place. These characteristics align with Gehl's (2010) advocacy for "life between buildings," as well as Lynch's (1981) argument that spatial legibility and coherence enhance urban dwellers' psychological comfort. Eminonu's success in maintaining a functional and inclusive urban landscape is also a testament to the resilience of historical urban textures, where the layering of functions and diversity of uses encourage multisensory engagement and community-oriented life (Jacobs, 1961; Pallasmaa, 2005).

In contrast, Maslak demonstrates the effects of vertical expansion patterns that favor economic efficiency over physical scale. Its spatial configuration, which includes large vehicle roadways, detached towers, and monofunctional zoning, shows a modernist planning tradition that frequently ignores the human scale (Erkip, 2000; Montgomery, 1998). Although Maslak represents Istanbul's global integration and neoliberal urban agenda (Aksoy & Robins, 2011), its fragmented urban texture, reduced pedestrian connectivity, and lack of social anchors highlight the limitations of a development model that prioritizes expansion over spatial quality (Graham & Healey, 1999; Fainstein, 2010).

This study's comparative morphological analysis focuses on street width, building height, figure-ground interactions, and street enclosure (Figure 9). Eminonu's high enclosure ratios and narrow streets generate a rhythm of spatial interaction and intimacy that encourages informal interactions and promotes a sense of place (Gehl, 2010; Carmona et al., 2003). In contrast, Maslak's low enclosure ratios and building setbacks add to spatial alienation and weaken the cognitive connection with the built environment (Alexander, 1977; Whyte, 1980).

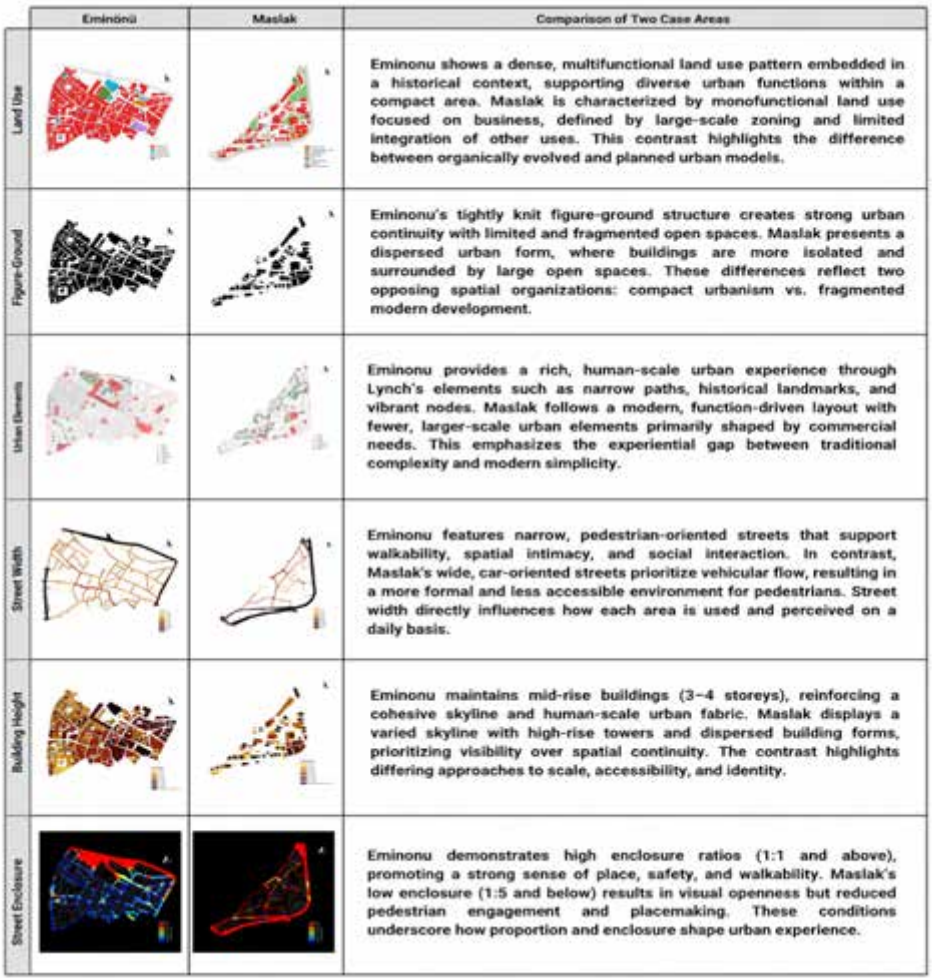

Figure 9. Comparison of Two Case Areas

From a post-growth urbanism viewpoint, these insights highlight the need to shift planning objectives away from verticality and toward ecological integrity, social inclusion, and spatial justice (Latouche, 2009; Raworth, 2017). The human scale is more than just a throwback to ancient urban forms; it is an essential design guideline for creating places that promote well-being, accessibility, and resilience. As Dovey (2016) points out, geographical complexity and morphological variation are critical for adaptive, habitable cities in a post-growth period.

The legislative consequences of this study suggest that future urban development in Istanbul and other metropolitan locations should not aim to imitate the vertical expansion of places like Maslak without critical thinking. Instead, a hybrid planning approach that draws on the morphological complexity of historical cores like Eminonu while adapting to modern infrastructure and economic needs could result in a more balanced and humane urban future. This would entail encouraging mid-rise, mixed-use projects, improving pedestrian infrastructure, preserving cultural assets, and implementing participatory design methods incorporating local knowledge (Sanoff, 2000; Healey, 1997).

Finally, reestablishing human scale in urban design entails redefining progress rather than opposing it. A city that is readable, inclusive, walkable, and emotionally engaging is more likely to be socially cohesive and environmentally responsible.

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Alto Medio Sannio inner area between marginality, latent place knowledge and territorial heritage

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Abstract
The paper examines some results from the ongoing PRIN (Research Project of Significant National Interest) "RE-PLACE. Reframing the Place-Based Approach through Cultural Ecosystem Services of "inner areas," aimed at strengthening local communities' role in building "place knowledge". Among the three Italian inner areas addressed in the PRIN (Alta Marmilla and Gennargentu-Mandrolisai in Sardinia, Alto Medio Sannio in Molise, Madonie in Sicily), it focuses on the case study of Alto Medio Sannio, also assessing the effectiveness/ineffectiveness of tools used to date to overcome gaps and poor integration of these contexts. Particular attention is given to a current topic in these areas: the transhumance routes ("tratturi"), considered here as generating elements of a rich territorial heritage to be valorized and reproduced through autonomous local development practices.

Keywords
Inner areas, autonomous local development, territorial heritage, tratturi

Introduction

This contribution regards a reflection on the planning of the so-called inner areas, in which depopulation, emigration, social and productive rarefaction, abandonment of the land, are distinctive phenomena. Shaping a new role for inner areas requires forms of community and the arising of new subjectivities that rely on forms of direct democracy (Magnaghi, 2020), reconstructing the places of living and promoting the synergic connection between local economies (Bruni, Zamagni, 2015).

In particular, we analyse the first results of the ongoing PRIN (Research Project of Significant National Interest) "RE-PLACE. REframing PLace-based Approach through the Cultural Ecosystem services of inner areas"[1]. It aims to strengthen the role of local communities in building "place knowledge" and territorial heritage also through the innovative lens of Cultural Ecosystem Services (CES), which represent non-material and/or socio-ecological benefits that people gain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, aesthetic experiences, and cultural and educational values (Chan *et al.*, 2012; Andersson *et al.*, 2015).

The project investigates three Italian inner areas (Alta Marmilla and Gennargentu-Mandrolisai in Sardinia, Alto Medio Sannio in Molise, Madonie in Sicily) and promotes a multi-scalar approach, based on a co-evolutionary perspective on the interplay between human settlement and the environment. It is oriented to understand and maximise the resilience of marginalised territories, to build alliances and collaborative processes and to promote place-making developed by communities.

In detail, the contribution focuses on the case study of Alto Medio Sannio inner area, made up of 33 small municipalities (many of which with less than 1,000 inhabitants) between the Molise provinces of Isernia and Campobasso, some of which border the Abruzzo region. The research path is designed to support the expression of the autonomous local development practices based on the continuous reproduction of territorial heritage. It

1 The PRIN "RE-PLACE", funded by the Italian Ministry of University and Research, is coordinated by the Research Unit of the University of Cagliari (PI prof. Anna Maria Colavitti), and involves the Research Units of the University of Palermo (Associated PI prof. Annalisa Giampino) and of the University of Molise (Associated PI prof. Luciano De Bonis) to which all the authors are affiliated.

is intended to capture the critical issues of some ongoing experiences in the area which are aimed at reducing the fragility of marginalised contexts, also identifying the ineffectiveness of the tools that until today have perpetuated the gap and the poor integration of these contexts.

First of all (see section 1), we position our research within the EU "place-based" approach, which in the Italian context is fully articulated through the SNAI (National Strategy for Inner Areas). However, our approach diverges significantly from the EU and national frameworks by embracing a self-organising paradigm. This paradigm is rooted in some key findings from resilience studies within ecological and socio-ecological disciplines, as well as the fundamental concept of territorial heritage, a cornerstone of the Italian territorialist school.

Then (see sections 2 and 3), in alignment with the objectives of the PRIN "RE-PLACE", we identify the key components of the territorial heritage within the study area, combining the non-sectoral nature of the territorialist approach to heritage with the notion of Cultural Ecosystem Service. Emphasising the critical role of CES in environmental planning, we additionally outline the envisaged participatory mapping activities in the area, designed to progressively and self-organisingly shape appropriate actions for the preservation and enhancement of territorial heritage.

Finally (see section 4), we dedicate particular attention to a very popular and current topic in these areas: the "tratturi system" (territorial system of sheep tracks), ancient transhumance routes which today are considered important elements of the heritage to be valorised. These elements, from a multifunctional perspective, are considered by us to be latent resources for self-sustainable development that takes into account the benefits that ecosystems provide to the inhabitants of the area.

1. Inner Areas between marginality, fragility and resilience

The Territorial Agenda 2030 (Aa.Vv., 2020) emphasises the importance of the "place-based" concept (De Bonis, 2021). However, unlike the term territorial cohesion, it does not offer a clear or explicit definition. It is reasonable and logical to infer (De Bonis, 2021) that the interpretation of "place-based" frequently mentioned in the Territorial Agenda aligns with the framework developed by Barca (2009) for the EU and thoroughly taken up in the EU's place-based approach (Barca *et al.*, 2012). This approach highlights the critical role of a place's social, cultural, and institutional characteristics while also acknowledging the need for external political interventions. The latter aim to address underutilized endogenous potential and social exclusion caused by the unwillingness or incapacity of local elites. In essence, it incorporates top-down measures as a vital component of territorial cohesion policies (De Bonis, 2021), in order to overcome internal barriers that obstruct territorial development and innovation processes (Barca, 2009).

The National Strategy for Inner Areas (SNAI in Italian), established in 2013 at the conclusion of Barca's tenure as Italy's Minister for Territorial Cohesion, is inherently a direct extension of the EU's place-based approach, which Barca himself pioneered in 2009. As a result, it also incorporates the use of top-down initiatives. Moreover, its primary objective is to recognise the vulnerability of places and communities while enhancing the delivery of essential citizenship services to address depopulation effectively (Lucatelli *et al.*, 2022).

Beyond an "indirect" limitation — which aligns with the same "deficiency" Ugo Giusti (1938) identified in the INEA research on the depopulation of Italian mountain areas — namely the attempt to address the anorexia of peripheral regions without simultaneously tackling the bulimia of central areas (Giacchè, 2019:41) — we believe that a more "direct" evaluation of the Strategy is needed. Specifically, this pertains to the effectiveness of the partially top-down, place-based approach of the SNAI to areas considered as "fragile" (De Bonis, 2021).

It is clear, however, that in order to conduct a more direct assessment, we first need a reference definition of "fragility". The latter is often regarded as the opposite of resilience, in turn a term which, although belonging to a relatively defined semantic field, assumes markedly different meanings depending on the context in which it is applied. In an ecological or socio-ecological context, resilience, as defined by Holling (1973), refers to the ability of a system to persist by absorbing changes and disturbances while maintaining consistent relationships between populations or state variables.

With specific reference to socio-ecological systems, resilience refers to the system's ability to absorb disturbances, adapt, and reorganise while undergoing change, ensuring it retains its core functions, structure, identity, and feedback mechanisms (Walker *et al.*, 2004).

Considering that we are discussing territorial systems, which we align with socio-ecological systems (SES) (De Bonis 2023a; De Bonis, Ottaviano 2024a), precisely to specific subsets of social systems where certain interdependent relationships among humans are mediated through interactions with non-human entities (Anderies *et al.*, 2004), we regard the previously mentioned definitions of resilience as equally applicable to territorial SES. Highlighting that the potential fragility (lack of resilience) of the latter, as with all SES, can be particularly critical due to their state of "perpetual dynamism" and "continuous adaptation" (Gunderson, Holling, 2002), driven by the complex interactions between the human species and the environment that define them (De Bonis, 2021). With specific reference to such a criticality, it is also worth highlighting that Gunderson (2000) associates resilience with an emergent property of ecosystems, stemming from their self-organising behaviours over time.

In other words, the more territorial SES exhibit self-organisation, the more they behave in a "non-fragile" way. We can consequently posit that the effectiveness and relevance of policies concerning these systems can be assessed by their ability to promote and enhance the emergence of self-organising properties within such systems (De Bonis, 2021).

Without hastily concluding that the SNAI is entirely ineffective in reducing the fragility of the territorial systems it targets — which is one of its primary goals — it can nonetheless also be asserted that its risk of ineffectiveness increases significantly when its inherent top-down component becomes dominant (De Bonis, 2021).

In contrast, such a risk tends to disappear within the territorialist approach, due to its focus on the concept of territorial heritage. This heritage is understood as the result of long-term co-evolutionary processes involving a wide range of social actors and their interactions with the environment (Magnaghi, 2017). It includes not only the particularly significant portion of resources that constitute it, and also embraces the socio-cultural environment, the *milieu* (Dematteis, Governa, 2005), as well as productive knowledge, the arts, and more (Magnaghi, 1998).

2. Territorial heritage and CES

The process of reconstituting virtuous co-evolutionary relationships between communities and environments is necessarily linked to a more general reconsideration of the way of understanding the relationality between the human and non-human components of socio-ecological systems.

The recent trend towards forms of "ecologically oriented" economy brings with it utilitarian and extractivist visions of non-human biological and biophysical elements, which materialise in market approaches (pure or in some way assimilable to them) to the relationship between human societies and ecological systems (De Bonis, Ottaviano, 2024b).

Among the objectives of the "RE-PLACE" research project is the identification of elements of territorial heritage through tools other than those that guide market approaches in order to be able to use them as a key to critically reading the actions and governance planned for these territories within the National Strategy for Internal Areas. The ultimate aim is to outline new approaches to a new shared knowledge of Inner Areas, capable of enabling processes of territorial reproduction of systems.

The "RE-PLACE" project, through a range of territorial and ethnographic analysis methods, analyses the different "knowledges of place" and territorial heritage as a key factor for local development of the subjects (local communities, inhabitants, local associations, public actors, etc.), allowing to explore territorial heritage as a key factor for local development from different points of view.

The non-sectoral nature that is the foundation of the territorialist approach to heritage can also be profitably integrated by the notion of Cultural Ecosystem Service.

As a paradigmatic class of service, Cultural Ecosystem Services have emerged as a concept around which researchers and policy makers can understand ecosystems in terms of their life-enriching and life-affirming

contributions to human well-being, and represent a salient example of how culture is more generally accepted as an important "variable" in the work of environmental managers and planners (Satterfield *et al.*, 2013 in Fish *et al.* 2016). The idea that the ecosystem approach can improve and innovate traditional methods of planning collective services is gaining consensus in the scientific debate. The introduction of new performance criteria in terms of ecological-environmental, social and cultural supply would allow us to evaluate the multiple benefits that ecosystem components and urban biodiversity can bring to local communities (Colavitti *et al.* 2024).

CES can be a source of "deep attachment" in communities (Chan *et al.* 2012) and access points for public engagement and concern in environmental issues, thus helping to build broader public support for ecosystem protection (Daniel *et al.*, 2012 in Fish *et al.* 2016) and, potentially, to support those processes of reconstitution of co-evolutionary relationships between communities and environments based on virtuous forms of relationality. Moreover, recognising the intrinsic link between territorial heritage and the concept of cultural landscape as provided by UNESCO[2], but overcoming the UNESCO exclusive focus on the "outstanding universal value" (De Bonis *et al.* 2024), it can be considered that, among the benefits that ecosystems generate for human societies, their cultural value cannot be ignored, even in the dimension of «ecosystems' contributions to the non-material benefits (e.g. capabilities and experiences) that arise from human-ecosystems relationships» (Chan *et al.*, 2012:9).

Although their value in the assessment of ecosystem services is generally less recognised, it should be noted that while «locally degraded provisioning and regulating services may be substituted by socio-economic means (e.g. drinking water from a polluted well can be replaced by bottled water), [...] the cultural values of an ecosystem or a landscape are irreplaceable» (Plieninger *et al.*, 2013:118).

Some authors (Plieninger *et al.*, 2013) argue that definitions of most categories of cultural services are vague, and it is therefore difficult to rigorously establish significant relationships between ecosystem structures and functions and the satisfaction of human needs and wants (Daniel *et al.*, 2012 in Plieninger *et al.*, 2013), having to also consider that cultural services do not represent purely ecological phenomena, but rather are the outcome of complex and dynamic relationships between ecosystems and humans in landscapes over long time spans (Fagerholm *et al.*, 2012 in Plieninger *et al.*, 2013).

According to Plieninger (2013), a greater awareness of cultural ecosystem services can be relevant for nature conservation and sustainable land management — and therefore to support those territorial reproductive processes based on virtuous co-evolutionary relationships between local communities and the environment, the importance of which we have underlined — because they are directly experienced and intuitively appreciated by people, unlike what often happens with regulation and support services (Daniel *et al.*, 2012; Schaich *et al.*, 2010), and because they are generally enjoyed in "packages", thus potentially helping to overcome the tendency to design in relation to single ecosystem services.

The "RE-PLACE" project aims to fill some of the gaps identified in the literature through a participatory mapping of the entire range of cultural ecosystem services perceived by local populations in the inner areas under study[3]. The challenge is to understand whether CES can be integrated into the planning processes of inner areas through the active involvement of settled communities that have developed an "adaptive resilience" (Davoudi, 2012) towards a context of progressive abandonment and who with their daily practices reinvent these spaces through a co-evolutionary nature-culture process.

The "RE-PLACE" project then aims to investigate, analyse and map informal local development practices promoted by inhabitants. The ongoing results derive from a combination of mapping exercises, semi-structured interviews and questionnaires, also analysed with statistical and GIS-based techniques. On the one hand, we are advancing the detailed definition of the investigation tools for the Alto Medio Sannio area, on the other we are

2 Particularly the "continuing landscape" where evolutionary processes remain ongoing, while simultaneously displaying significant material evidence of their historical development over time (UNESCO, 1992).

3 Mapping CES requires connecting local communities' perceptions of place. This goal can be achieved by collecting data from interviews and mapping conducted on representative samples of the settled community. CES mapping has been extensively studied in recent years. However, methodologies for spatial analysis of CES are still weak due to problems related to data quality and evaluation, which make it difficult to accurately determine their catchment area (Colavitti et al. 2024).

experimenting with the investigation tools refined on the basis of prior experiences. Notably, in the workshops in Sorgono (Sardinia, Gennargentu-Mandrolisai area), where in March 2025 the entire RE-PLACE research group convened with the local communities. By posing targeted questions rooted in the CES framework a community map was created, where each participant identified the places he considered most significant.

Similarly, through some questions that are starting to be submitted to the communities of Alto Medio Sannio, the aim is to build over time a patrimonial base to understand which actions can be activated for the self-sustainable development of the territory.

3. Alto Medio Sannio, the hinge of biodiversity

Figure 1 - The Verrino Valley afrom a viewpoint in Agnone. Ph. Francesca Giangrande, 2024.

Alto Medio Sannio is the largest inner area in Molise. It extends in the central-northern sector of the Molise Region, south of the provinces of Chieti and L'Aquila and is made up of 33 municipalities[4] belonging to the two provinces of Campobasso and Isernia, with Agnone as the lead municipality of the area. The Alto Medio Sannio area has a total population of 28,835 inhabitants (2023) with a population density of 30.62 inhabitants/km^2. The most populous municipalities are Agnone (4,679 inhab.), Frosolone (2,830 inhab.) and Trivento (4,360 inhab.), while the smallest one — not only of the area but of the whole Molise — is Castelverrino with only 98 inhabitants. The area is affected by significant demographic problems: population data by Istat indicate that between 1994 and 2023, the area has overall lost 28.1% of its resident population, presenting an average annual decrease rate of

4 For the province of Campobasso, the municipalities of Castelbottaccio, Duronia, Lucito, Molise, Montefalcone nel Sannio, Montemitro, Roccavivara, Salcito, San Biase, Sant'Angelo Limosano, Torella del Sannio, Trivento are included; for the province of Isernia the municipalities of Agnone, Bagnoli del Trigno, Belmonte del Sannio, Capracotta, Carovilli, Castel del Giudice, Castelverrino, Chiauci, Civitanova del Sannio, Frosolone, Macchiagodena, Pescolanciano, Pescopennataro, Pietrabbondante, Poggio Sannita, Roccasicura, San Pietro Avellana, Sant'Angelo del Pesco, Sant'Elena Sannita, Sessano del Molise, Vastogirardi are included. In the programming cycle 2021-2027, compared to the cycle 2014-2020, the composition of the area has changed as it has seen the municipalities of Civitacampomarano, Limosano, Montagano, Petrella Tifernina, San Felice del Molise leave and those of Molise, Montemitro, Sant'Angelo Limosano, San Biase, Torella del Sannio join.

1.1%. During the period above, the municipalities that recorded a greater average annual loss are San Biase (with -58.7% in 29 years) and Castelbottaccio (with -56.3%). People aged over 80 represent 11.4% of the total residents of the Area, while those under 14 represent 9.3%. The high presence of the population over 80 clearly photographs the incidence of aging within the area.

The lowest percentage is in Pescolanciano (8.6%) while the highest is in Castelbottaccio (23.2%). Demographic data also confirm that the Municipalities of Agnone, Frosolone and Trivento, in addition to having the largest number of residents, have an economic and social dynamism that makes them the major centers providing district services.

Alto Medio Sannio is a naturalistic and historical "hinge" territory between the Sannio Collinare (hilly) and the Abruzzo Apennines with great potential for territorial development offered by a landscape rich in biodiversity and the presence of historical values. It goes from 300 m of sinuous panoramas drawn by the Trigno river up to the 1,730 m of Monte Campo. As part of an historical-cultural heritage, the area features several remains of the Samnite territorial civilisation , first of all the Italic site of Pietrabbondante. Furthermore, there is a rich museum heritage, almost a single still visible trace of what has crossed the territory for years, and the cultural events are also numerous. Certainly, to date, a weakness that emerges from the analysis is that there is a poor recognition and valorisation of the aforementioned territorial heritage.This area also presents geomorphological and hydrogeological degradation despite having good agricultural potential demonstrated by current production.

It is a fact that this territory has undergone, like most of the Italian inner areas, a process of marginalisation that has lasted more than a century with all the consequences that this entails (delayed development, reduction in the use of the very rich natural-cultural heritage, reduction in job opportunities, de-anthropisation, partial reduction of cultural identity). The depopulation of young people and families and the consequent process of population aging, associated with low population density, determines a strong impact on the fixed costs for the provision of services and infrastructures. The Alto Medio Sannio Area Strategy (fund FESR and FSE+ programming cycle of 2014-2020) focused on welfare interventions; however, it emerges that this policy have little effect on reducing fragility if it does not take into account some specific local experiences – current or latent – of heritage valorisation, which demonstrate the virtual capacity to create favourable conditions for the generation of CES and self-organising processes of more intimate and strong interconnection between local communities and territorial resources (Ottaviano, De Bonis, 2023), for a process of land care, which however lack a systemic vision. What could this vision be?

4. The system of sheep tracks ("tratturi")

Figure 2 - Shepherd on the Lucera-Castel di Sangro sheep track in the municipality of Pescolanciano. Ph. Francesca Giangrande, 2024.

As regards the deepening of this contribution with respect to the whole of the territorial heritage and the CES, a relevant sub-theme that is emerging from the mapping is that of the system sheep tracks ("tratturi"), recognised and perceived by the people who live in the cultural landscape of the Alto Medio Sannio as territorial elements that can potentially provide intangible cultural benefits. The network of so-called "tratturi" constituted the link for the summer-winter movement of flocks that moved from mountain pastures to those in the plains and vice versa, making the economy of the Abruzzo-Molise Apennines interdependent and complementary with that of the Apulian plain.

Plausibly, transhumance was the generator, or one of the main co-generators of the territorial, and therefore also landscape, structure of Mediterranean Europe (De Bonis, 2023b). The civilisation of transhumance allowed the development of agriculture, trade and craftsmanship, which flourished in the area. In Agnone, for example, the copper tradition was carried on for centuries, linked above all to the presence of the rivers, which lasted from the Middle Ages until 1970, the year in which the San Quirico Ramera (artisanal copper company) was closed. In 1400 there was a coppersmith for every three houses, dense workshops that reached 171 in 1700, and as many as 8 foundries that employed over 500 people. Today the only remaining trace of this activity is the Ramera Gerbasi in Agnone, where the seventh generation works the copper; a symptom that craftsmanship is little appreciated among young people who, for various reasons, no longer dedicate themselves to this profession. The survival of Ramera Gerbasi is paradoxically linked to the digital world, since they have a strong connection to the foreign import-export market. A similar fate has befallen agriculture, where it is even more difficult to innovate; this sector still has a high relevance but has difficulty in reconverting and raising the quality of products and/or innovating in well-defined sectors (including supply chain sectors).

Forestry is also at risk from modern and contemporary development processes in inner areas. In general, a co-evolutionary approach between human settlement and environment, aimed at understanding and maximising the resilience of inner and marginalised territories, has diminished and weakened. Let's observe this phenomenon from a particular point of view: the system of "tratturi".

In environmental and naturalistic terms, the system of sheep tracks is inserted within two other elements of the landscape of significant importance such as agricultural crops and woods. For centuries, the transhumance routes have represented the only infrastructures for communication and economic and social exchange between populations, so much so that some more recent inhabited centres still show their dependence on the course of the sheep tracks. This ecosystem is a unique and rare example of the strong bond between traditions, people and territory (Cicoira, 2016). The infrastructures of the transhumance landscapes do not coincide with the wider set of transhumance landscapes, to which they primarily belong; in addition to the infrastructural elements, landscapes also include further elements of the built environment – like taverns, fountains, churches (Meini *et al.*, 2018), but also small urban agglomerations, watering holes, boundary markers and milestones built along the network (Di Martino *et. al.*, 2006) – and above all they are constituted by the agro-forestry and settlement structures co-generated by the transhumant practice, well beyond the lands directly occupied by it (De Bonis, 2023b). The castles in Molise, for example, are arranged orthogonally to the path of the tratturi, with major centres supported along the ridge path of the reliefs emerging between the two main watercourses (Trigno and Biferno) and with the smaller centres (of promontory) arranged in clusters, in a geologically and morphologically suitable position but reachable from the first (Cerasoli, Cordoni, 1998 in De Bonis, 2023b). This is a settlement structure that can simultaneously take into account the constraints imposed by the need to easily reach the tratturi on the one hand, and the need to place the settlements in sufficiently safe areas on the other (Cerasoli, Cordoni, 1998 in De Bonis, 2023b).

Summarizing the history of the evolution of the tratturi, it has to be said that the Romans were the first to institutionalise transhumance (Meini *et al.*, 2018 in De Bonis 2023b), by imposing the payment of a certain fee to the tax authorities. But the phenomenon of transhumance, and the territorial civilisation connected to it, has much more distant origins; according to Salmon (1967 in De Bonis 2023b) the *calles* that crossed Roman Sannio were not only used in pre-Roman times by the Samnites and the Sabellian peoples of central Italy, who in the winter months drove their animals (especially sheep) long distances towards the pastures of the plains, but they also date back to the Iron Age if not the Bronze Age, as archaeology has demonstrated. It is highly probable that the basis of the tratturi development was a model of seasonal nomadism of human groups which, already in the prehistoric phase, they had exploited those characteristics to activate a "hunting nomadism", which

would later transform into pastoral nomadism, due to the progressive climate warming that determined the vegetation transformation of valley and mountain environments starting from 15,000 years ago (Minelli, 2015 in De Bonis 2023b). On the other hand, it is certain that, after the acquisition of large portions of *ager publicus* by the Romans following the Samnite, Pyrrhic and Punic wars, pastoral activities in Samnium increased in comparison to agricultural ones. At the "price" however of having to pay from then on for the use of pastures that were previously freely available (De Bonis, 2023b). The Normans, after the early medieval pause caused by the barbarian invasions, contributed to the flourishing rebirth of pastoral activity, generally recreating political unity and re-establishing the necessary conditions of security (Meini *et al.*, 2018 in De Bonis 2023b). The Angevin rulers established the so-called Dogana della Mena delle pecore, with significant contextual expansions of the pastures, with the aim of stabilising and increasing the tax revenue that derived from it (Musto, 1964:10 in De Bonis, 2023b). The institutionalization process reached its peak with Alfonso V of Aragon, until 1806 when the Dogana was suppressed with the law promulgated by G. Buonaparte of dissolution of all the constraints and easements of the Tavoliere (De Bonis, 2023b).

The pasture was then closely linked to the culture of transhumance and denigrated specially in the era of the affirmation of private property, as reported by the historical scholar Mattia Iorillo (2025)[5] that stated that the construction of a strongly negative imaginary of the transhumant world was imposed with the spirit of the Enlightenment, which has produced the demonisation of civic uses, of common lands and obviously of those tratturi, which with their spatial transversality were natural enemies of private property, of field closures and agricultural rationality. Thus, although transhumance continued in other forms even after the Second World War, the breaking of the routes of the "sheep kingdom" decreed a marginalisation of territories ancestrally suited to that type of exploitation. First with the Bourbons, with the Fascism (with the battle for grain and the construction of a "very rural" Molise) then, until the modernisation processes a secular world, cultural and natural together, was broken. And also, as Potito d'Arcangelo noted, the "cosmovision" of the transhumant shepherd modeled on the "phasic movement of natural cycles and movements along the sheep tracks", in return, it gave it "the ability to leave a mark, to transform places profoundly". Herein lies, once again, the most emblematic and real character of the tratturo throughout the modern age and on the borders of contemporaneity. Its contextual nature, of evolution and transformation in an environmental continuity made up of human and animal relationships. Those that practically disappeared at the dawn of the twentieth century, leaving the great void of Molise (Iorillo, 2025).

The Alto Medio Sannio area is crossed by the Celano-Foggia, Castel di Sangro-Lucera, Sant'Andrea-Biferno-Ateleta "tratturi", and by the Pescolanciano-Sprondasino-Castel del Giudice "tratturello". As described in the Wide Area Environmental Landscape Plan of Alto Molise, the landscape is characterised by roads, fortifications, villages, hill areas whose environmental characteristics are determined by different groups of houses and agricultural agglomerations, by the land division, by the compromised hydrogeological situation and by the network determined by the torrential channels, and from the intensive use of cultural and natural resources of the territory concentrated in the municipalities of Agnone, Belmonte del Sannio, Poggio Sannita, Castelverrino.

Since, as previously mentioned, one of the objectives of the "RE-PLACE" project is the analysis of the ways in which SNAI has been implemented in the study areas, also with specific reference to its relations with planning and governance, an in-depth study was carried out regarding actions and tools that have as their object the sub-theme of the "tratturi" system. We have therefore taken into consideration a current area planning tool that is considered complementary and synergic to the Alto Medio Sannio Area Strategy, *i.e.* the project "Sviluppo turistico lungo i tratturi - recupero e valorizzazione del percorso tratturale; incentivazione e potenziamento dell'offerta turistica" (Tourism development along the sheep tracks - recovery and enhancement of the sheep track; promotion and enhancement of the tourist offer) foreseen in the "Contratto Istituzionale di Sviluppo" (Institutional Development Contract) and financed by the Development and Cohesion Fund 2014-2020, which is included among the context measures of the Area Strategy for the programming period 2014-2020. Analysing this tool allows us to corroborate the idea that the Strategy has limitations in capturing the regenerative practices of self-government of inner areas, still focusing too much on single-sector interventions imposed from above that do not take into account the landscape evolution of Molise.

In this context, in March 2024 the Masterplan for the recovery of the Molise sheep tracks was presented by the Stefano Boeri Architetti studio, involving 59 municipalities (Campodipietra is the lead municipality) and the Land

5 https://www.iltascabile.com/letterature/vie-erba-vuoto/

Reclamation Consortium "Sud Bacino Moro-Sangro-Sinello e Trigno" with the aim of recovering, protecting and enhancing the tratturi and the events related to them, with specific actions aimed at the tourist development of the territory through the historical-cultural and artistic recovery of the villages crossed by the "tratturi". As stated in the intervention planning document of "Contratto Istituzionale di Sviluppo", the intention is to launch joint actions aimed at safeguarding the landscape and the "tratturi" heritage, focusing attention on dedicated tourist-cultural itineraries, with particular attention to minor destinations and the recovery of public assets attributable both to the "minor heritage" – typical local traditional buildings (villages, farmhouses, refuges, etc.) and artefacts related to local network systems (shepherd's houses, watering holes, crossings, etc.) – that to the "valuable cultural heritage" – historical-artistic emergencies (monasteries, castles, villas), all divided into two axes of intervention; axis 1 – tratturi; axis 2 – villages.

The Alto Medio Sannio area, as delimited by SNAI, is not mentioned in the Institutional Development Contract but is addressed by the project with interventions of both axis 1 and axis 2. For axis 1, a variety of interventions are planned, from marking the tratturi path by installing adequate trail signs and new wooden fences, to the restoration of equipped rest areas, to the reconversion of cultivations to tratturi soil (meadow), to clearing, deforestation, reclamation, restoration of rows, to the creation of horse/cycle paths equipped with various aids such as adapted tandems and electric wheelchairs (*buggy bike*), to the arrangement of the former loan quarry of the Chiauci dam, to the restoration of connecting roads with the villages, to the interactive tourist signage and signage equipped with QR-Codes for sites of interest etc. Interestingly, for the municipality of Civitanova del Sannio the project envisages allowing the maintenance of the tratturi by entrusting it to farmers who have located their agricultural-livestock businesses in the same areas crossed by the "tratturo", practicing grazing of their animals aimed at promoting the cleaning of the tratturi area. While for the maintenance of the structures (equipped rest areas, tourist boards, wooden bridges, etc.) that have been located mainly in the vicinity of homes, the use of the so-called "Administrative Barter" is proposed, which provides for interventions entrusted on a project basis to citizens who request to compensate the tax burden with their own performance through interventions of urban decorum, recovery and reuse, with purposes of general interest, of unusable areas and real estate.

Another intervention that we consider relevant is in the Fonte le Frassi district where there is a village of 8 wooden houses built in 2002 following the earthquake and currently used by a single family unit that occupies one of the structures. With small restoration and adaptation interventions, the project foresees a tourist accommodation function or the creation of small points of sale of local products and a possible support point for demonstrations and events along the "tratturi" axis. For axis 2, the architectural redevelopment and urban recovery of some villages and hamlets is planned, promoting the existing historical-cultural and environmental-landscape heritage, the restoration of the Transhumance house of Frosolone to create a refreshment point and museum, the creation of an artistic path that uses the exhibition of elements of traditional copper art of Agnone etc., the redevelopment of a building in Pietrabbondante to be used as a Multipurpose/Cultural Centre, the redevelopment of the San Basilio staircase and the recovery for recreational and cultural purposes of the municipal building, former ERP (public residential construction) building in Salcito, the redevelopment of the former ECA (Municipal Welfare Agency) building in the historic centre of Lucito for rural tourism accommodation purposes, the recovery of the properties available to the municipality of Trivento for hospitality purposes and the adaptation of their accessibility, the adaptation of the former school of Poggio Sannita to Casa della Salute (House of Health), and so on.

Of considerable interest is the securing of a municipal building in Montagano for the creation of a socio-cultural center for which attention will be paid by the operators and the Municipality in continuous and interactive reference with the responsible subject, to integrate and improve the offer in relation to the relationships already in place with national and foreign tour operators, and to the forms of collaboration and cooperation with the help of various subjects, such as schools and universities, including institutional ones such as the Superintendency, the Molise Region, etc. The intervention of the Masterplan appears impressive to us, it involves 236 km of "tratturi", 38 km of "tratturelli" and 39 km of "bracci" (secondary routes), it includes the creation of 7 starting and finishing gates (Castel del Giudice, San Pietro Avellana, Montalto, Rionero Sannitico, Sepino, Gambatesa, Santa Croce di Magliano), to then be divided into 36 intermediate stages.

The ambition of the Masterplan is to equate the tratturo to an ecological corridor, as a result of a rigorous application of topographic rules that give it a specific configuration and geometry, recognisable in the pattern of ancient and modern signs of the landscape. Therefore, this proposal, although it is the first of such a global

nature that concerns the tratturi, seems to ignore the current state of the tratturi system and does not question enough the self-reproducibility of the system, imposing from above a series of specific interventions that do not involve local agents, with the exception of the municipalities. In February 2024, there was an autonomous initiative by scholars and citizens to meet in Sepino to create a civic committee that would work alongside the institutional control room, but the proposal for discussion remains evanescent to date, considering that the project is still in the embryonic stage.

It is implied that slow tourism acts as a driving force for increasing employment and against demographic impoverishment but, as Nunzio Marcelli, a breeder-entrepreneur who practices transhumance, claims in an interview (14 March 2024)[6], there is concern that it will turn into the usual opportunity to announce a title, and that the funds will then be used without contextualisation, which happens when the planners insert a single component that leads to the decontextualisation and nullification of a useful opportunity to bring these territories back to playing a leading role in sustainable development. On the other hand, there is an interesting phrase repeated several times within the "Contratto Istituzionale di Sviluppo" programming document that would suggest an attention to the theme of coevolution, that is that the "path of the ancient tratturo" can therefore offer visitors unique landscapes, colours and atmospheres, in which the "evident man-nature binomial becomes evidence of the measured use of the territory and its resources". Another interesting aspect is present among the objectives of the Masterplan, namely the definition of guidelines for the management of the "tratturi", with new methods

of public-private co-management with the relaunch of the role of the agricultural operator as a central figure for the maintenance of the characteristics of the "tratturo" over time. The Masterplan documents do not specify how this objective can be achieved.

Conclusions

Figure 3 - Evidence of tratturo Celano-Foggia in Alto Medio Sannio. Ph. Francesca Giangrande, 2024.

There is no doubt that signs of innovation are emerging in Italy; a multi-scalar, co-evolutionary approach between human settlement and environment, aimed at understanding and maximising the resilience of internal and marginalised territories, at building alliances and collaborative processes and at promoting place-making developed with communities, animates practices and processes initiated at different scales and in different

6 https://www.amolivenews.it/2024/03/14/progetto-cis-tratturi-molisani-nunzio-marcelli-opportunita-imperdibile-per-rendere-attrattivo-il-territorio/#google_vignette

territorial contexts, not only within the SNAI (De Vita *et al.*, 2021). The approach of the "RE-PLACE" project implies the need to support the (re)discovery of ancient and new forms of local knowledge which allow the continuous adaptation to the mutability of environmental contexts and whose loss undermines the effectiveness of interventions implemented in more recent times. It also encourages the establishment of new relations between human societies and non-human environmental elements that allow the continuous generation of innovative local knowledge (De Bonis, Ottaviano, 2024a). The matching between the growth of "place awareness" of local communities and the identity characteristics of the heritage make possible to produce "territorial added value" (Magnaghi, Dematteis 2018) based on visions, strategies and tools and on new forms of self-government of territorial commons, namely place-specific values and resources, sedimented over time.

In this contribution we have analysed the critical issues of the SNAI and the EU place-based approach, suggesting to pay particular attention to the interpretation of territories as socio-ecological systems, and consequently to the importance of the concept of fragility/resilience and of self-organising properties in "marginal" territorial SES. We have also put forward a hypothesis for triggering a multifunctional regeneration process of the transhumance landscapes (De Bonis, 2023b) in the inner area studied in the PRIN "RE-PLACE", in particular through the valorisation of the heritage system of the tratturi, considered not in isolation but as a whole, and according to more collaborative and cooperative trajectories than those currently dominant. In recent decades, globalisation and socio-economic forces have affected not only production dynamics but also the co-evolutionary relationship between communities and territories, leading to important changes in the ways of working, consuming and socialising. The weakening of relationships, which had consolidated the process of community place attachment and the formation of civic consciousness and sense, influences citizenship practices and the production of places. It is therefore essential to restart, especially in areas that suffer the marginalising effects of the aforementioned globalising dynamics, processes of retro-innovative re-establishment of self-organising relationships between human and non-human entities of territorial SES, intrinsically and simultaneously conservative and regenerative of territorial heritages.

With reference to the Molise case study of the PRIN "RE-PLACE", and in particular to one of its most relevant heritage elements, it can be concluded that if there must exist a system of sheep tracks, made up of paths, stops, mown meadows, natural areas, villages, pastoralism, agriculture, civic uses, which also have a value (at different intensity) such as CES, that is, as a producer of biodiversity, bearer of aesthetic values, sense of place, cultural heritage values, recreation and ecotourism, spiritual values, educational values, places of social relations, places of inspiration, cultural heritage values for communities, should be recognised by the local communities themselves, according to a true place-based approach, restoring the autonomous initiative of all local and translocal subjects who wish to participate in the self-government of sustainable development.

Lastly, the "RE-PLACE" project attempts to build new languages, the result of the dialogue between expert knowledge and contextual knowledge, for which experts should be able to get involved in the construction of "co-knowledge". The evaluation approach of the CES is not objective, but rather related to that of a "socially constructed value practice" (Ernstson, Sorlin 2012). We believe that knowledge of CES is relevant and allows us to have a sufficiently clear picture to set up a truly sustainable and fair policy that aims at restoring eco-social balance. The growing reference to the local dimension of well-being has opened the horizon of the subjective investigation of its perception and its construction (Magnaghi, 2020). Starting from participant observation and design interaction with social practices, it is possible to develop an adequate evaluation tool that has as its objective the maintenance and regeneration of territorial SES.

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Author contributions

Although this work as a whole arises from the close collaboration between the authors, the writing of § 3,4 is by Francesca Giangrande, the writing of 1 is by Luciano De Bonis, the writing of 2 is by Giovanni Ottaviano.

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Track 2

PLANNING AND LAW

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Use of New Municipal Fiscal Powers for Sustainable Urban Development: Development and Application of a Strategic Financial Planning Method in the City of Mascouche

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Abstract
Over time, the Québec government has granted municipalities broad monetary levy powers. While these do not ensure full financial autonomy, they enable revenue diversification, reduce reliance on property taxes, and support policy goals like combatting climate change and land speculation.

However, many cities hesitate to use these powers, often keeping tax rates low and depending on new developments for growth. To address this, the City of Mascouche sought the services of our team, resulting in a 2025–2030 Strategic Revenue Plan.

This paper outlines the methodology used to prioritize over 25 fiscal tools. It presents evaluation criteria and details the municipality's selected measures. While these decisions reflect trade-offs between fiscal potential and environmental efficiency, administrative simplicity and legal risk played a dominant role in decision-making.

Keywords: local finances, cities, ecological taxation, municipalities, Québec

Introduction

Over the years, the Government of Québec has granted Québec municipalities extensive monetary levy powers. Aiming to enhance their autonomy and recognize their role as proximity governments, the provincial government provided municipalities with general taxation and regulatory charges powers in 2018 (Tremblay-Racicot et al., 2023). In 2023, additional powers were introduced, enabling municipalities to vary property tax rates based on different sectors or any characteristic of the property assessment roll, excluding the property's value.

Although these new powers do not render municipalities fully financially autonomous, they allow diversification of revenue sources and reduce dependence on property taxes (Federation of Canadian Municipalities, 2024). They also offer opportunities to achieve various public policy objectives, such as mitigating or adapting to climate change, combating land speculation, or promoting a circular economy, through ecofiscal measures or by making property taxes more progressive. For instance, municipalities can impose regulatory charges targeting major traffic generators to encourage transportation management plans, tax vacant land or buildings, address underdensity through floor area ratio taxes, or impose higher tax rates on luxury properties ("monster houses") and lower rates on denser housing or areas with vulnerable populations.

In a pre-electoral context, many municipal officials and managers are questioning how to prudently use these new legislative powers, particularly as cities have historically tended to keep tax rates low while relying on new property assessments to grow their tax base. To address this, the City of Mascouche, located in Quebec, sought the services of our research team to assist in identifying and planning fiscal measures to prioritize over the next five years. This collaboration resulted in the December 2024 submission of a 2025–2030 Strategic Revenue Plan, offering recommendations to guide the City in prioritizing and phasing the deployment of fiscal tools (Tremblay-Racicot et al., 2024).

This paper aims to showcase the novel methodology developed to identify priority measures among over 25 documented fiscal tools. It is divided into five sections: 1) Presentation of the approach and methodology; 2)

Mascouche's fiscal and financial profile; 3) Eco-tax measures; 4) Measures enabled by the new powers of Bill 39; 5) Summary of recommendations and timetable; 6) Conclusion.

Presentation of the approach

In the spring of 2024, the City of Mascouche debuted a process aimed at diversifying its revenue sources and making use of under-utilized monetary levies, particularly in the area of eco-taxation. Drawing on its expertise in municipal taxation, and more specifically in the innovative use of new monetary powers by Quebec municipalities, a team from the Centre de recherche sur la gouvernance (CERGO) of the École nationale d'administration publique (ENAP), led by Professor Fanny Tremblay-Racicot, was commissioned to support the town in identifying and planning the fiscal measures to be prioritized over the next five years.

The resulting Strategic Revenue Plan makes recommendations to enable the city to document the prioritization and phasing of the fiscal tools to be deployed. As the analysis of the various measures, their prioritization and the timetable were carried out in collaboration with representatives of the town's various departments. Because the decision of adopting a strategic revenue plan was based on the need of diversifying the municipalities' revenue sources, our team validated this perceived issue by first carrying out an analysis of its fiscal and financial profile, which is presented in the next section.

As for the recommendations included in the plan, they were based on a co-construction process (3 work meetings and e-mail exchanges over a period of 6 months) conducted with the city representatives. This process allowed for the identification, prioritization and phasing of measures to be implemented under two areas of intervention: eco-taxation and new taxation powers arising from Bill 39 (B39) on municipal taxation.

Prioritization criteria

The choices were made jointly by the research team and representatives of the municipality's departments on the basis of the four dimensions explained in the following paragraphs: fiscal potential, sound administrative management, acceptability and equity, and environmental performance.

Fiscal potential

The purpose of this dimension is to evaluate the growth and sustainability of a financing tool's net revenues. To be able to generate net revenue growth that ensures the sustainability of financing, the tool must be able to rely on a sufficiently broad tax base, have growth potential on this base, and have some leeway on the levy rate, without undermining the city's fiscal competitiveness. This dimension is assessed on the basis of the criteria listed below. It should be noted that a preliminary assessment presenting a range of potential revenues is also included in the analysis of this criterion. This range has been estimated by the units responsible for the Town of Mascouche.

Evaluation criteria

- Does the tax base involve a number of taxpayers or a monetary flow or stock large enough to ensure short-term revenues that can be considered significant? (Tax base width);
- Does the tax base have a reasonably foreseeable growth potential in the medium and long term? (Growth potential);
- Considering Ville de Mascouche's tax competitiveness, can the current levy rate on this tax base be considered as already high? (Margin for manoeuvre on the levy rate).

Sound administrative management

This dimension relates to the technical and legal issues that can influence the applicability and efficiency of implementing a financing tool.

Choices regarding the selection and phasing of a measure will be made on the basis of its administrative simplicity and the savings in human and technical resources it entails, its efficiency, the principle of "the right levy for the right service", and the user-pays principle, which can help optimize resource allocation. In addition, coherence with other measures and objectives of the City is taken into account. This dimension is assessed on the basis of the following criteria.

Evaluation criteria
• Would an additional levy on this tax base require resources, whether in terms of fixed assets, operations or tax compliance, the cost of which can be considered high or even prohibitive? For example, is the collection process compatible with the current method of managing the tax account? (Administration costs);

• Is the measure based on the user-pays principle? In particular, does the measure make it possible to increase the financial participation of certain categories of taxpayers whose consumption of public services exceeds the municipality's production costs? (User-pay);

• In the short term, are the data or technology required to implement the measure available and applicable according to current practices at Ville de Mascouche? (Applicability);

• Does the measure contradict any regulations or policies currently in force at Ville de Mascouche? Does the measure require the creation of a new regulatory regime or a modification of existing regulations? (Coherence)

• Does the measure present a risk of legal challenge?
Does the measure reinforce the provisions of the Ville de Mascouche's Strategic Plan for Sustainable Development (Strategic Plan).

Acceptability and equity
The purpose of this dimension is to assess the social acceptability and equity issues of financing tools, particularly with regard to the ability of businesses and residential taxpayers to pay. This dimension was assessed on the basis of the following criteria.

Evaluation criteria
• Would the measure receive a higher level of approval from the population than could be expected from a tax levy? (Perception);
• In principle, can a taxpayer reduce or even avoid the levy by modifying his or her behavior? (Availability of alternatives);
• Does the measure have a greater financial impact on vulnerable people? (Vulnerable population)
• Does the measure make it possible to reasonably increase the financial participation of legal entities or individuals with a greater ability to pay? (Ability to pay);
• Does the measure make it possible to target certain categories of taxpayers who have benefited in recent years from a favorable tax transfer? (Temporal equity);
• Does the measure potentially have a greater impact on taxpayers in certain sectors of the municipality?
• Where applicable, does the measure have an effect on housing affordability (Affordability).

Environmental efficiency
This dimension aims to assess the potential of measures in terms of dissuading or encouraging those subject to them to change their habits to adopt environmentally-friendly behaviors. Where applicable, this dimension is evaluated on the basis of the following criteria.

Evaluation criteria
• Is the measure the most appropriate means of achieving the environmental objective? (Relevance);
• In principle, does the measure offer the potential to optimize land use or favor compact forms of land development? (Land use);
• In principle, does the measure offer the potential to enhance the area's attractiveness or direct growth towards already more urbanized areas to curb urban sprawl? (Attractiveness);
• In principle, does the measure have the potential to contribute to the resilience of ecosystems (Resilience);
• In principle, is the measure likely to encourage land use that is conducive to sustainable mobility (Sustainable mobility);
• In principle, does the measure make it possible to internalize negative environmental externalities, or to involve the generators of nuisance financially? (Polluter pays).

Methodology
The financing tools identified for each of the two axes (eco-taxes and measures arising from PL39) were analyzed on the basis of the criteria presented above. The relevant information for each tool was collated in an analytical sheet (found a Supplementary Document), and the results were grouped together in a summary table (Appendix A) and a phasing grid for measures to be prioritized (example presented in Appendix B).

The purpose of analytical framework is to analyze the main advantages and disadvantages of the financing tools identified in the following sections. To do this, an evaluation was carried out for each measure on each of the criteria, which means that the potential subjectivity inherent in such a process must be taken into account. The analysis framework generally used to limit this type of bias is the multicoder method, in which several people carry out an independent evaluation on the basis of a pre-defined analysis grid (example presented in Appendix C). This method achieves a level of inter-coder reliability, a criterion that enables the analysis grid to be validated. This method then enables a conciliation process between coders based on a deliberative process to determine which codes are not unanimously supported by the coders. This method does not completely eliminate subjectivity, but it does greatly reduce its risks. Following the analysis carried out by the two principal investigators from the CERGO team, a working session was held with the Mascouche team to validate the results obtained.

Mascouche's fiscal and financial profile
On January 21, 2021, Amyot Gélinas Conseils inc. presented the Town of Mascouche with a report analyzing the municipality's fiscal and financial situation. The Amyot Gélinas Conseils team made two main observations: 1) a lack of revenue diversification, resulting in a property tax overcharge, particularly for residential units; and 2) little room for manoeuvre with regard to property tax rates to remain competitive with rival towns.

Against this backdrop, the Town of Mascouche has undertaken to diversify its sources of revenue in order to strengthen its financial stability and share the tax burden more equitably among the various categories of taxpayers. The Town has implemented the following measures:

- A 3% increase in real estate transfer tax for all taxable income in excess of $500,000;
- A contribution to infrastructure and equipment during the construction of real estate projects, also known as a "development levy". The city also has agreements with real estate developers for the infrastructure required for development, a contribution for park purposes, and a contribution for affordable social housing.
- A special general property tax rate for buildings with six or more units;
- A special property tax rate for industrial and non-residential buildings;
- Special property taxes for debt servicing, social or family housing funds, regional files and public transit and rail;
- Fees for waste collection, water and sanitary sewer services;
- Compensation for snow removal in certain sectors;
- A special property tax for sanitation in certain sectors.

The tax picture shows that the Town makes effective use of the powers at its disposal in urban planning matters. It is even in the vanguard when it comes to developers' contributions to the financing of municipal infrastructure and strategies for financing social and family housing. What's more, no value-for-money issues have been identified.

The purpose of this report is to analyze other possibilities for diversifying the Town of Mascouche's sources of revenue in order to share the tax burden even more equitably and achieve certain environmental objectives.
Financial profile

The Ministère des Affaires municipales et de l'Habitation (MAMH) publishes an annual financial profile of municipalities. This profile provides financial and fiscal data, ratios calculated from this data, and comparisons with different groups of municipalities. Indexes are also presented, enabling comparisons between municipalities for a given year. Among the various indicators published, three appear to be relevant for analyzing Mascouche's fiscal situation:

• Non-residential standardized taxable assessment, which establishes the share of property wealth occupied by businesses and industries;
• The overall tax rate (TGT), which measures tax pressure, i.e., the percentage ratio of tax levies applied to taxable properties over the total value of these properties; and
• The proportion of operating expenses financed by the general property value tax. This last indicator measures dependence on property taxes.
Table 1 shows the distribution of these three indicators for Mascouche, the municipalities in its population class, its MRC and its administrative region, as well as the results for Quebec as a whole.

Table 1: Ville de Mascouche compared with its peers on three financial indicators

	Nb.	Standardized taxable assessment non-residential (%)	Overall tax rate (TGT) Per $100 of assessment (%)	Financing of operations by property value tax %
Mascouche	1	9,7	0,9681	65,0
Population class	35	15,4	0,9095	59,4
RCM	2	11,3	1,014	61,4
Administrative region	57	10,0	0,9550	57,6
All of Quebec	1104	14,6	0,8994	52,3

Source: MAMH, Financial Profile 2023.

Analysis of this data reveals three main findings:
• The tax base for non-residential buildings is much lower in Mascouche than elsewhere.
• The overall tax rate (TGT) is higher in Mascouche than in municipalities of comparable size, but fairly similar to the average for the administrative region.
• Property tax financing is higher in Mascouche than elsewhere, accounting for 65% of operating revenues. This observation justifies the pursuit of revenue diversification and an analysis of the various possibilities open to the Town.

Comparison with neighboring towns
In order to take into account the context of fiscal competitiveness in which budget planning takes place, Mascouche should also be compared with neighbouring towns. The table below includes the towns of Blainville, Terrebonne, Saint-Eustache, Repentigny, Varennes and Mirabel. Four indicators are presented: the ratio of residential to non-residential property wealth, property tax revenues from residential to non-residential properties, the average tax burden of dwellings and the ratio of non-residential to residential tax rates.

Table 2: Ville de Mascouche compared with its neighbors on four financial indicators

	Residential vs. non-residential property wealth (%)	Residential vs. non-residential property tax revenues (%)	Average tax burden on housing ($)	Average non-residential vs. residential tax rate ratio (no. of times)
Mascouche	90	73	2 750	3,2
Average	84	61	2 378	3,5
Blainville	89	71	2 767	3,3
Terrebonne	88	72	3 019	2,8
Saint-Eustache	80	56	2 182	3,1
Repentigny	90	73	2 828	3,3
Varennes	74	37	1 997	4,7
Mirabel	83	54	1 472	4,0

Source: MAMH, Financial Profile 2023; Municipal budgets

An analysis of these data reveals five main findings:
• The share of property wealth derived from residential assessment units (90%) versus non-residential units (10%) is greater in Mascouche than in comparable neighboring towns. Only Repentigny has a similar share.
• The ratio of residential property taxes (73%) to non-residential taxes (27%) is higher in Mascouche than in comparable neighboring towns, with the exception of Repentigny (73%), Terrebonne (72%) and Blainville (71%), where the level is similar. As a result, property tax revenues are heavily dependent on residential properties.
• The share of property wealth generated by residential properties (90%) is greater than the share of tax revenues that the city derives from them (73%). It is possible to observe a tax transfer from residential to non-residential properties, which helps to alleviate some of the burden on Mascouche residents.

• At $2,750, the average tax burden per dwelling is higher in Mascouche than in most comparable neighboring towns, but lower than its direct neighbors Blainville ($2,767), Repentigny ($2,828) and Terrebonne ($3,019). Taking into account the context of tax competitiveness, the level of taxation on housing is close to the threshold.
• At 3.2 times the average residential rate, Mascouche's average non-residential tax rate is slightly below the average of comparable neighboring towns (3.5 times). Only Varennes (4.7 times) and Mirabel (4 times) have a significantly higher level. Considering the context of tax competitiveness, the level of taxation of non-residential buildings is also close to the threshold.

Implications for the Strategic Revenue Plan
The above findings suggest a number of implications for the present Strategic Revenue Plan:
• The scope for increasing property tax revenues remains limited, since it already occupies a significant share of revenues, the level of tax burden on residential assessment units is close to the threshold limit, and high rates are already applicable to non-residential properties.
• To establish a strategy for diversifying the municipality's revenues, the search for a fairer distribution of the tax burden is to be favoured.
This search for balance can be achieved through the following principles:
• Making greater use of the user-pays principle wherever possible, in particular so that taxation better reflects the intensity of use of municipal services.
• Involve the generators of nuisance and other negative externalities to a greater extent in financing the city.
• Optimize the value of properties already served by municipal infrastructure.
• Target certain categories of taxpayers who have benefited from favorable tax transfers in recent years.
• Modulate tax effort according to ability to pay.

Definition of Eco-fiscal measures
The eco-fiscal measures analyzed in this Strategic Revenue Plan represent a municipal levy based on a pollutant, product or service that deteriorates the environment or results in a levy on natural resources (Tremblay-Racicot et al., 2023). Ecofiscal measures dissuade or encourage those subject to them to modify their habits, unlike more coercive measures that force certain changes in behavior or usage. Thus, other types of instruments, including regulation or prohibition, subsidies, standards and awareness programs, can be addressed, but only within regulatory regimes financed by a tax or charge. The three categories of levy analyzed in eco-taxation are pricing, general power to tax and general power to levy regulatory charges.

Pricing
In the economic sense, pricing is the establishment of a contribution related to the production costs of a service, based on the user-pays principle. It should be pointed out at the outset that the Act respecting municipal taxation (LFM) presents a specific definition of pricing that departs from the classic economic definition. In fact, the MTA also considers a property tax based on a characteristic of the building other than its value, such as its surface area, its frontage or any other of its dimensions, to be a tariff. The MLA also broadens the concept of user-pay, since a fee must be related to the benefit received. This notion of benefit received includes not only the benefits derived from the use of a service, but also those arising from its availability, regardless of its consumption. For the purposes of this report, we focus on defining two forms of pricing permitted by the LFM, but distinct from a property tax:

1) The first form is a fee charged to the owner or occupant of a building for the use of a service. For example, a fee could be linked to the number of lifts of a residual materials bin, or the total weight of residual materials disposed of by a property assessment unit. Another example could be the number of cubic meters of drinking water consumed by the assessment unit. In this case, to set a rate, the municipality must be able to accurately establish the cost of a service and the consumption of this service by the various assessment units on its territory. The tariff will be the price which, once multiplied by consumption, will balance revenues with the costs of the service.

2) The second form is a one-off or subscription-based compensation for the use of a good or service, or for the benefit derived from an activity. For example, this could be an annual fee for water or waste billed to the municipal tax bill. In this case, the municipality must be able to establish precisely the costs of a service and the number of assessment units where the service is available. The fee will be set by dividing the costs by the number of units. It will then be equivalent to the average cost of the service per unit served.

General taxing power
The general taxing power (GTP) allows local municipalities to impose any direct tax on their territory, and to provide for any exemption or criteria under which the amount or rate of this tax may vary. Unlike the General Regulatory Levy Power (GRP), which is intended to fund a regulatory regime, taxes adopted under the TMP are primarily intended to generate general revenues to be paid into a municipality's general fund, although they may also be dedicated to a service. Municipalities must, however, respect a number of exclusions, including the main tax fields already occupied by the governments of Quebec and Canada. In addition, municipal taxes cannot be applied to the State, its agents and public and parapublic organizations, thus excluding hospitals, schools and national museums, for example. Insofar as the rate and amount levied can vary according to certain criteria, in addition to being accompanied by exemptions, the tax can send a price signal that encourages or discourages certain behaviors or uses by those subject to it, whether legal entities (businesses) or individuals (citizens). Taxes therefore also have the potential to help achieve environmental objectives. GTP could, for example, be used to levy a tax on the use of, or the right to use, an asset. For example, a TMP could be used to levy a tax on paved surfaces, a tax on land use coefficients, or a tax on vehicle registration.

General Regulatory Levy Power
In contrast to a tax, which is used to raise general revenues for the municipality, the main purpose of a General Regulatory Levy Power (GRP) is to finance a regulatory regime under municipal jurisdiction. Thus, although it may resemble a tax, a regulatory levy is different in nature from a tax; it must serve to finance a regulatory regime (a program, a service, an infrastructure, etc.) or, through the level of the levy, it must aim to encourage or dissuade certain behaviours on the part of those subject to it (Tremblay-Racicot et al., 2020 : 30). Whether it is intended to finance a service or influence behaviour, a regulatory fee must be linked to a complete and

detailed regulatory regime. The person subject to the charge, whether a legal entity or an individual, may be the beneficiary of the regime, or the person whose activities make it necessary. In Quebec, a special fund must be set up to hold exclusively the sums collected through the levy. Moreover, since the sole purpose of a regulatory royalty regime must never be to raise general revenues, the associated fund must not generate significant or permanent surpluses, unless the regime is intended to influence behaviour.

The GRP shares a number of exclusions with the GTP, including the inability to apply to the State, its agents and public and parapublic organizations. On the other hand, the distinct nature of the royalty gives it the advantage of being similar to an indirect tax. As a result, the three exclusions provided for in the GTP do not apply to the GRP. It is therefore possible to levy a charge: 1) in respect of the supply of a good or service; 2) on the presence of an individual on the territory of the municipality; and 3) on a person using a public road, within the meaning of article 4 of Code de la sécurité routière (chapter C-24.2) or in respect of equipment placed under, on or over the public road to provide a public service.

The measures under consideration for the eco-fiscal intervention axis are divided into five areas of activity, depending on the objective pursued:
- Urban planning and development
- Reducing drinking water consumption and improving soil permeability
- Sustainable mobility
- Reducing the quantity of residual materials sent to landfill
- Air quality and GHG reduction

New taxes arising from Bill 39's new powers
In addition to eco-fiscal measures, a series of new possibilities were also included in the analysis. The Act to amend the Act respecting municipal taxation and other legislative provisions, Bill 39, was assented to on December 8, 2023. It is part of the new partnership between the Québec government and local governments. The resulting measures are intended to help modernize municipal taxation by giving municipalities new fiscal powers and greater flexibility in the use of existing fiscal powers.

Varied property tax rates by sector/areas of the municipality
It is now possible to apply differentiated taxation by sector. This system can be used to encourage densification in certain sectors, or to support other economic situations (e.g., downtown revitalization or major work on a commercial artery). Sector prime rates must not deviate by more than 33.3% from a uniform rate, which must correspond to the average of sector rates weighted in proportion to the total assessed value of each sector. In concrete terms, the uniform rate corresponds to the base rate that would apply if the local municipality did not use sector-based taxation. The sectors concerned must be defined when a new assessment roll is filed. However, to enable a greater number of municipalities to apply this new power, a transitional measure allows the municipal territory to be divided into sectors for any roll in effect on January 1, 2024.

Extend the use of varied property tax rates to residential properties and remove constraints limiting the number of non-residential sub-categories

To encourage sustainable land development through targeted tax rates, municipalities may now determine separate rates applicable to residential properties, or to sub-categories chosen by the municipality. Separate rates must fall within a range of 66.6% to 133.3% of the prime rate. For example, such a measure could encourage densification by allowing a lower tax rate for buildings with more than one dwelling unit. For the sake of concordance, certain adjustments have been made to the provisions relating to non-residential buildings. For example, there is no longer a limit on the number of non-residential sub-categories that may be established by municipalities. These sub-categories must be defined prior to the filing of a new assessment roll. It should be noted that the preliminary roll, which was previously mandatory for the creation of non-residential sub-categories, now becomes optional.

Increase the maximum tax rate applicable to serviced vacant lots
Since 2001, a municipality has been able to set a rate of up to twice the prime rate (residential rate) for properties in the vacant land category served by water and sanitary sewer services. Local municipalities may now set a special rate for serviced lots of up to four times the prime rate.

Allowing the imposition of a property value tax on vacant residential units
Municipalities may now impose a tax on the property value of buildings containing a vacant or underutilized housing units for residential purposes. The tax rate applicable to vacant or underutilized dwellings may not exceed :
• 1% when the municipality begins imposing the tax;
• 2% when the municipality has been imposing the tax for at least one year;
• 3% when the municipality has imposed the tax for at least two consecutive years.

This power applies to buildings containing at least one dwelling unit that is not occupied for a minimum of 180 days a year by the owner, a relative or another occupant, in the latter case by virtue of a lease, including a sublease. In addition, to be subject to the tax, a dwelling must have certain characteristics. In addition, exemptions from the tax are provided for social and affordable housing.

Public transit regulatory charge
This new power enables all local municipalities to finance the costs of public transit infrastructure, equipment and operations through a dedicated development charge. The fee could be charged in a variety of ways, including when a permit is issued for construction or renovation work. Municipalities are empowered to define, by bylaw, the various parameters for implementing the charge, such as the calculation method, the rate and the sectors that would be subject to it. To ensure consistency with the development charge, the Minister of Municipal Affairs has the regulatory authority to exempt persons from payment of the transportation charge and to specify the types of work subject to it. Also, until such time as this regulation is enacted, the Act provides that a transportation charge cannot be levied in respect of social and affordable housing.

Allow local municipalities and MRCs to impose a vehicle registration tax to finance public transit, and empower the Société de l'assurance automobile du Québec (SAAQ) to enter into collection agreements.

Municipal laws have been amended to allow local municipalities in whose territory a public transit corporation has jurisdiction under the Act respecting public transit corporations, and RCMs that declare jurisdiction over public transit, to impose, by bylaw, a tax on the registration of any passenger vehicle in the name of a person whose address entered in the SAAQ register corresponds to a location within their territory. This tax must be earmarked for financing public transit. The by-law of the municipality or MRC must indicate the amount payable. Such a tax cannot be imposed on the territory of a local municipality that is part of the Communauté métropolitaine de Montréal (CMM), nor on the territory of Saint-Jérôme, since the CMM already has such a power on the territory of the Autorité régionale de transport métropolitain.

Summary of recommendations
As discussed earlier, these tools were selected based on a diagnostic assessment of the City's financial profile and four prioritization criteria: (1) fiscal potential; (2) sound administrative management, including legal risks; (3) social acceptability and equity; and (4) environmental efficiency.

The report puts forward three types of proposals:
• Measures **to be prioritized**, the design and deployment of which should be undertaken in the short term;
• Measures **under study** between 2026 and 2030, which could eventually be implemented, but which should not be prioritized due to strategic or management imperatives; and
• **Non-recommended measures** that have been discarded, as others are preferred to them based on the analysis of results.
Recommendations are described in the next paragraphs. For the sake of this paper, only the measures to be prioritized or under study are presented (excepted for Sustainable mobility). They are grouped under 8 categories:
• Urban planning and development
• Reducing drinking water consumption and improving soil permeability

• Sustainable mobility
• Reducing the quantify of landfill waste
• Air quality and greenhouse gas (GHG) reduction
• Varied rates by building category
• Varied property tax rates by sector
• Other provisions of Bill 39

Urban planning and development
Recommended measures
- Analyze the introduction of a **tax on the floor-area ratio** (FAR).
The purpose of this tool is to increase the financial contribution of businesses and industries whose buildings occupy a land area below a certain threshold, in order to maximize their use. A tax on the floor area ratio could be applied to any owner of an assessment unit belonging to the non-residential building category or the industrial building category that is served by a municipal water and sewer service and has a floor area ratio of less than 20%. The results of the analysis show that the measure receives a very favourable or favourable evaluation on all four dimensions studied. In addition, Mascouche estimates a 30% loss of revenue resulting from under-occupation of the ground for buildings that could be affected by the measure. Particular attention, both financial and administrative, will need to be paid to the geomatics tools required for deployment and annual data updating.
- Analyze the introduction of a **tax on non-vegetated surfaces**
This tool could target businesses and industries whose property exceeds a certain threshold of mineralization or soil sealing. The measure is designed to increase revenues from buildings that constitute heat islands and major generators of surface water in municipal infrastructures. It also aims to internalize environmental costs for the city, reinforce best practices and reward the greening of the territory. The results of the analysis show that the measure receives a very favourable or favourable assessment on the four dimensions under study. Particular attention will need to be paid, both financially and administratively, to the geomatic tools required for deployment and annual data updating.

Reducing drinking water consumption and improving soil permeability
Recommended measures
- Examine the possibility of increasing **pool fees**
Pool fees are currently set at $25. This rate has never been revised since it was introduced. According to the city, there are some 7,000 pools on the territory. However, the results of the analysis show that the measure could give rise to an acceptability issue. The measure could require an in-depth analysis to determine an increase in the current rate, or its transformation into a tax adopted under the TMP. Fees could also be modulated according to pool type.
- Analyze the implementation of a **drinking water use and treatment rate** for industrial, commercial and institutional **(ICI) users.**

This measure stems from a government obligation under the Quebec Strategy for Drinking Water Conservation. Pay-per-use pricing requires water meters. The installation of water meters will improve the accuracy of the municipality's water balances. Once the volume of water consumed is known, building owners can be given the tools they need to target abnormal consumption, and thus better select the actions to be taken to promote drinking water savings. The results of the analysis show that the measure receives a very favourable assessment for three of the four dimensions of the analysis. However, from the point of view of sound administrative management, short-term challenges remain in adjusting municipal bylaws, supplying and installing meters, and monitoring user consumption. Detailed deployment planning may be required.

Measures under consideration
- Investigate and document the elements required for the implementation of **user-based pricing and drinking water treatment** for the **residential sector.**

This measure is consistent with the government's obligation to estimate residential water consumption under the Stratégie québécoise d'économie d'eau potable. However, pay-per-use pricing requires the presence of water meters in all residences, whereas the obligation requires an estimate based on sampling only. The measure could

be kept under review to ensure that the municipality is ready and sufficiently equipped to deploy it, should it be deemed necessary. A pilot project could be considered, given the scope of such a project for the residential sector.

- Investigate and document the elements required to **implement a wastewater discharge charge.**
The purpose of a wastewater discharge charge is to levy an amount to be determined according to the quantity of wastewater and the level of contamination discharged by industries over a given period. The levy thus serves to finance a regulatory regime set up by the city, and to influence a reduction in discharges, particularly of contaminants, on the part of the industry or company targeted by the levy. The measure could be kept under review in order to detail the issues involved in its application, particularly for older buildings, and to assess the effects of implementing a user charge on industrial and commercial wastewater discharges.

Sustainable mobility
In the case of sustainable mobility, no measures were recommended. Below is the rationale explaining the reason they were excluded.

Measures not recommended
- Levy on major trip generators
This tool consists of a fee levied on major trip generators, such as large employers and organizers of major events, who do not have a travel management program in place. This measure has little potential, as there are few major trip generators in Mascouche.
- Pricing or on-street parking stickers
On-street parking pricing or parking stickers correspond to the implementation of a rate to control and manage certain parking-related issues in a given city or sector. In Mascouche's current context, analysis shows that on-street parking pricing has little potential in terms of revenue, and poses a number of challenges in terms of sound administrative management and acceptability.

Given Mascouche's poor public transit service, heavy dependence on the automobile and the metropolitan context in which transportation planning is taking place, it is recommended that the Town of Mascouche not immediately rely on eco-taxes to achieve its sustainable mobility objectives, but rather on increasing public transit supply and prioritizing active mobility corridors through greater investment in this area, which is beyond the scope of the mandate.

Reducing the amount of landfill waste
Measure under study
- Investigate and document the implementation of a **fee for Construction, Renovation and Demolition (CRD) waste;**

This tool consists of introducing a levy on construction, renovation and demolition permits to divert residual materials from disposal. Applicants subject to the fee who have a materials management plan in place, or who have improved source separation of certain materials, could be exempted from the fee. The revenues collected could be allocated to assistance and support programs promoting the circular economy in the construction sector and reducing the quantities of materials disposed of. As the city does not currently have an ecocenter, this measure may be difficult to apply. The measure could be kept under review in order to detail the issues involved.
- Investigate and document the implementation of **incentive-based pricing for the collection and processing of residual materials** (smart collection).

The costs associated with waste collection and disposal services are currently covered by a fixed fee of $167 per year per dwelling or business. Incentive pricing, based on the number of lifts and the size of the bin, for example, could help reduce the amount of material going to landfill. However, the implementation of incentive-based pricing is complex, given the heterogeneity of buildings, types of collection and equity between multi-unit buildings and single-family homes. Challenges in processing the data required for pricing are also to be expected. However, in view of its effectiveness and the anticipated renewal of the residual materials collection contract, its analysis is desirable with a view to deployment.

Air quality and greenhouse gas (GHG) reduction
Recommended measure
- Examine the possibility of introducing a **tax on homes without a tree in the front yard.**
The tool targets the absence of a tree in the front yard of residential, commercial and industrial buildings. The presence of a tree in the front yard is mandatory under current regulations. The presence of a tree can be determined using the Jakarto survey. According to the city, some 2,200 properties do not comply. According to the analysis, the measure has a strong potential to influence compliance with the regulations. The analysis also shows that the measure scores favourably on all four dimensions under consideration.

Measure under consideration
- Investigate and document the introduction of a tax on oil-fired systems or dual-energy systems using oil.
The tool consists in imposing a tax on owners of residential buildings with oil-fired heating appliances or a dual-energy system with oil. Since the analysis highlights the presence of an acceptability issue, it may be necessary to analyze in greater detail the data concerning the number of taxpayers targeted, the rate that could be imposed and the phasing of the measure, in particular to ensure predictability for those subject to the measure.

According to information obtained by the City's appraiser, the data are not totally reliable. An administrative effort will be required upstream of the measure's deployment to validate properties with this type of equipment.

Varied rates by building category
Recommended measures
- Analyze the option of introducing a **variable rate based on living area** for single-family dwellings exceeding a certain threshold.
The aim is to implement a higher property tax rate for very large single-family homes. Since many municipal services are currently financed by compensation and not by property tax, these properties benefit to some extent from a tax transfer on these services. Moreover, the analysis shows that the measure scores favourably on all four dimensions under study.

It should be noted, however, that prior to implementing this measure, particular attention will need to be paid to the criteria for tax liability. It should be noted that a minimum property value per square metre cannot be used as a threshold or criterion for tax liability. The additional rate that could be imposed, as well as the phasing, will need to be considered in order to ensure a certain level of predictability for the taxpayers concerned, and to ensure that the measure reaches the buildings and citizens that meet the underlying objectives.

- Analyze the option of establishing tax subcategories by **value bracket** for **non-residential buildings**.
The tool consists of creating a property tax system with varying rates per value bracket for non-residential buildings. Two separate property tax brackets for non-residential or industrial buildings, based on assessed value, could be envisaged. Analysis shows that the tool is favorably evaluated for its fiscal potential, sound administrative management, acceptability and fairness. However, there are no environmental benefits to be anticipated from this measure.

Measures under consideration
- Investigate and document the option of establishing higher tax subcategories for buildings whose **land use code (LUC)** is related to the production of **nuisance or negative environmental externalities or** to **a higher intensity of use of municipal services**, and a lower tax subcategory for buildings whose **LUC** is related to the **production of environmental benefits and is to favor businesses working in the circular economy**.

Although the analysis was carried out separately for each type of CUBF, since different effects were noted for certain criteria, it is recommended that they be merged at the time of implementation for reasons of administrative simplicity and consistency in application. When the results are combined, the analysis shows a favorable assessment for one or other of the CUBF code categories on the four dimensions under study. In this sense, in the first instance, a higher rate for buildings generating nuisances or negative externalities is recommended in a first phase of deployment.

- Investigate and document the option of a **varied property tax rate** for **additional categories of number of dwellings in multi-unit rental buildings**.

The tool consists of increasing the number of dwelling categories where a varied property tax rate is applied, compared with what currently exists. The analysis shows potential impacts on equity and acceptability of the measure, as well as on environmental efficiency. Before introducing an additional number of categories, it may be necessary to study in greater detail the effects on affordability and the municipality's densification efforts, particularly if the objective is to apply a higher rate for buildings with a larger number of units.
- Investigate and document the option of a **varied property tax rate** based on the physical link for **condominium-type residential buildings.**

The tool consists of implementing a higher property tax rate for assessment units integrated with a condominium-type residential building. The analysis shows potential impacts on equity, particularly in terms of mitigating assessment roll effects, and the acceptability of the measure, as well as on environmental efficiency. Before implementation, it may be necessary to study in greater detail the effects on affordability and the municipality's densification efforts.

Varied property tax rates by sector
Measure under study
- Investigate and document the option of using the **five sectors** set out in Bylaw **1286** on contributions to municipal infrastructure and equipment, currently in force, to establish **a varied rate for these sectors.**

The aim of this tool is to implement a varied property tax rate for five sectors of Mascouche identified by the by-law on contributions to municipal infrastructure and equipment. Analysis shows that the measure could pose a challenge in terms of acceptability and fairness. Before its implementation, it may be necessary to study in greater detail the additional funding requirements for each sector, particularly in relation to the level of service received. It should be noted that the measure could also help to balance, in part, the impact of the new assessment roll on taxpayers, thus addressing the equity issue.

Other provisions of Bill 39
Recommended action
- Analyze the option of **increasing the special rate for vacant lots served** at four times the basic rate.
Ville de Mascouche already uses this financing tool. The measure consists in increasing the special rate according to the new parameters allowed by law. The analysis shows that the tool receives a favorable or very favorable evaluation on the four dimensions under study.

Conclusion
While these decisions reflect difficult trade-offs between fiscal potential and environmental efficiency, administrative simplicity and legal risk emerged as dominant factors guiding the choices. The co-development process and exploration of new possibilities also led to the prioritization of innovative, progressive fiscal measures that are environmentally sustainable, such as the floor-area ratio tax or the increased property tax rate on "monster houses". Combined with measures adopted in other Quebec municipalities, these advancements suggest a paradigm shift in the financial planning approaches of Quebec municipalities, where the practice of keeping tax rates low and relying solely on real estate development growth to balance the short-term budget is replaced by a longer-term, more integrated and coherent approach to diversify revenue sources and align service and infrastructure needs with revenue sources that both can fund these needs and support other policy objectives.

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Appendix A – Summary Table

Measures	Fiscal potential	Sound administrative management	Acceptability and equity	Environmental performance
1. Use of neighborhood units to establish a varied property tax rate by sector	Favorable	Unfavorable	Unfavorable	Neutral
2. Varied property tax rates by sector	Favorable	Very favorable	Unfavorable	Favorable
3. Property tax subcategories for buildings whose land use code (LUC) is related to the production of nuisance or negative environmental externalities or to a higher intensity of use of municipal services	Favorable	Unfavorable	Favorable	Favorable
4. Property tax subcategories for buildings whose land use code (LUC) production of environmental benefits and is to favor businesses working in the circular economy	Unfavorable	Unfavorable	Favorable	Very favorable
5. Tax subcategories by value bracket for non-residential buildings	Favorable	Favorable	Favorable	Neutral
6. Property tax rate for residential buildings with a lot size exceeding 9,000 sq. ft	Unfavorable	Favorable	Favorable	Favorable
7. Property tax rate for residential properties where it is possible to divide the land above a threshold that makes the land constructible.	Favorable	Unfavorable	Very favorable	Favorable
8. Varied property tax rate based on the physical link for condominium-type residential buildings	Favorable	Unfavorable	Favorable	Unfavorable
9. Variable rate based on living space area	Favorable	Favorable	Favorable	Favorable
10. Varied property tax rate according to number of dwelling units in multi-unit rental buildings	Favorable	Favorable	Unfavorable	Unfavorable
11. Vacant property tax	favorable	Very favorable	Favorable	Very favorable
12. Increased rate for vacant lots (four times the basic property tax rate)	Unfavorable	Unfavorable	Favorable	Neutral
13. Tax for units without a tree in the front yard	Favorable	Favorable	Favorable	Favorable
14. Canopy loss reduction levy	Favorable	Unfavorable	Unfavorable	Very favorable
15. Tax on oil-fired appliances or dual-energy systems using oil	Favorable	Favorable	Unfavorable	Very favorable
16. Incentive-based pricing for the collection and processing of residual materials	Very favorable	Neutral	Unfavorable	Very favorable
17. Regulatory charge for Construction, Renovation and Demolition (CRD) waste	Very favorable	Unfavorable	Favorable	Favorable
18. Pricing or on-street parking stickers	Unfavorable	Unfavorable	Unfavorable	Favorable
19. Regulatory charge on major trip generators	Unfavorable	Unfavorable	Very favorable	Very favorable
20. Stormwater user charges	Favorable	Unfavorable	Very favorable	Very favorable
21.User-based pricing and drinking water treatment for the residential sector	Very favorable	Neutral	Unfavorable	Very favorable
22. Rates for use and treatment of drinking water for institutions, commercial and industrial properties	Very favorable	Neutral	Very favorable	Very favorable
23. Fee for swimming pools	Very favorable	Very favorable	Unfavorable	Neutral
24. Floor-area ratio tax	Favorable	Favorable	Very favorable	Very favorable
25. Tax on non-vegetated surfaces	Favorable	Favorable	Very favorable	Very favorable

Appendix B

Example of timetable

Floor-area ratio tax

Period	F 2024	W 2025	Sp 2025	Su 2025	F 2025	W 2026	Sp 2026	Su 2026	F 2026	W 2027
Start		•								
Analysis			•							
Design				•						
Adoption of the bylaws					•					
Implementation						•				

Appendix C

Example of an evaluation carried out using the analytical grid

	Regulatory charge to reduce canopy loss
Fiscal potential	Favorable
Tax base width	1
Growth potential	-1
Margin for manoeuvre on the levy rate	1
Saine gestion administrative	Unfavorable
Administrative costs	-1
User pays	0
Applicability	-1
Coherence	-1
Legal risk	-1
Strategic plan	1
Acceptability and equity	Unfavorable
Perception	-1
Availability of alternatives	-1
Vulnerable population	0
Ability to pay	1
Temporal equity	0
Territorial equity	0
Affordability	-1
Environmental performance	Very favorable
Relevance	1
Land use	1
Attractivity	0
Resilience	1
Sustainable mobility	0
Polluter-pay	1

Land Take and Logistics Hubs: Castel San Giovanni, the Milan Logistic Region's Gateway to Emilia-Romagna (Italy)

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Abstract
This research examines the impact of logistics infrastructure on land take in Castel San Giovanni, a municipality hosting one of Italy's largest logistics hubs. Situated on the southern edge of the Milan Logistic Region, the town has undergone rapid transformation due to fragmented planning and the large-scale expansion of its Logistic Park. By analysing development documents and measuring land take over time, the study illustrates the consequences of insufficient planning coordination. These are assessed in light of regional directives, focusing on Emilia-Romagna's Regional Law No. 24/2017. In the absence of a national regulatory framework, this law reflects the ongoing tension between strategic environmental goals, such as the EU's Net Zero Land Take target by 2050, and local dynamics marked by deregulated growth and limited institutional oversight.

Key words: Land Take, Logistic platforms, E-commerce, Emilia-Romagna region

1. Introduction

1.1. The role of logistics platforms in land take growth

In recent decades, land take in Italy has undergone a significant acceleration, driven by the growing expansion of logistics settlements linked to the strengthening of distribution networks and the explosion of e-commerce (ISPRA, 2024). This phenomenon has particularly affected Northern Italy, where the pressure from logistics and e-commerce has led to the radical transformation of entire territories. The consequences of this model include the degradation of ecosystem services, the reduction of landscape quality, and increased pressure on private mobility and natural resources (Artmann, 2016; Dupras et al., 2016; Ursić et al., 2016). According to ISPRA data (The Italian Institute for Environmental Protection and Research), the phenomenon currently affects more than 7.16% of the national territory, with an estimated average annual loss of 456–501 million euros in ecosystem services such as water regulation, carbon sequestration, and biodiversity habitats (ISPRA, 2024). Land use changes entail not only the removal of highly fertile agricultural areas but also a reduction in the natural services essential to environmental quality and community well-being. Moreover, the transformation of agricultural and rural areas also results in a profound redefinition of cultural heritage and place identity, marking a rupture with historical settlement traditions (EEA, 2013).

In this context, the urgency for more conscious territorial governance is tied to the need for regulatory and planning tools capable of integrating environmental, social, and landscape dimensions in land use regulation. At the European level, a comprehensive soil directive has not yet been adopted, but the "Soil Monitoring Law," recently proposed by the European Commission, incorporates the principle of "Healthy Soil" into the Green Deal to ensure the preservation and restoration of soil ecosystem functions. This kind of proactivity, together with the goal of No Net Land Take (NNLT) (European Commission, 2023), represents an important sign of attention, although the most significant actions to limit land consumption and promote regeneration practices remain at the national and regional levels. These policies not only address soil protection and urban sprawl but are also consistent with broader EU environmental strategies, such as biodiversity conservation goals outlined in the EU Biodiversity Strategy for 2030. It is therefore of fundamental interest to examine the regulatory frameworks that govern logistics settlement development, to understand how their application, and often limited enforceability, influences actual territorial transformation processes on the ground.

1.2. The significance of Castel San Giovanni as a representative case study

The logistics hub of Castel San Giovanni, located in the province of Piacenza, stands out for the exceptional speed and scale of its development, making it an emblematic case in the Italian logistics landscape. The analysis of its chronological process highlights how the synergy between regulatory flexibility, local political will, and significant private capital has prevailed over an integrated vision of territorial transformation. This predominance has led to significant consequences not only on the environmental and ecological level but also on the social, economic, and urban structure of the area. Castel San Giovanni thus represents a paradigmatic and accentuated example

of a phenomenon that is spreading widely across Northern Italy: the rapid and fragmented expansion of logistics settlements, often carried out in the absence of effective supra-local coordination and the safeguarding of the social fabric of the affected contexts.

The province of Piacenza, moreover, has long been characterised by an explicit logistics vocation, recognised in the strategic objectives of the main planning tools (Gabellini et al. 2010) from the Regional Territorial Plan (PTR) to the Provincial Territorial Coordination Plan (PTAV) and further formalised in the Simplified Logistics Zones (ZLS) documents, developed from national directives and subsequently adapted at the regional level. However, this vocation is realised through a settlement process that is often not fully recognisable in official planning documents due to its incremental, ad hoc, and fragmented nature.

1.3. Objectives and methodology of analysis

This research aims to critically investigate the relationship between the development of logistics platforms and land consumption, with particular attention to the regional regulatory framework and, primarily, to Regional Law No. 24/2017[1] of Emilia-Romagna, which governs the protection and use of the territory. The analysis focuses on the case study of the Logistic Park of Castel San Giovanni, intending to reconstruct its development process and highlight the central role played by planning and implementation tools, which have constituted the normative and procedural backbone of this development. In particular, the main instruments at the municipal, provincial, and regional levels are examined, from structural plans to territorial agreements and procedural plan amendments, which have enabled the progressive realisation of the hub through an incremental and exceptional approach.

The regulatory component is integrated with a quantitative analysis of land consumption, carried out using GIS tools applied to land use data provided by the Emilia-Romagna Region, relating to the period 2003–2020. This analysis allows for a precise mapping of the territorial transformations that have occurred, outlining their spatial extent and temporal dynamics. The methodology adopted, therefore combines a documentary and regulatory review with a territorial investigation at the municipal scale, aimed at measuring the impact of planning decisions.

The multi-level approach makes it possible to identify the critical issues that have enabled a development markedly inconsistent with the guiding principles of the regional legislation itself and the European directives on the sustainable use of land.

2. General context: Italian land take by the logistic framework

2.1. Development of the logistics sector in Italy and Europe: the role of the RLM

In recent decades, the logistics sector has experienced exponential growth throughout Europe, driven by the globalisation of production chains and the integration of markets. In this context, Italy has become a key node in continental goods flows thanks to its strategic geographical position at the centre of the Mediterranean and the convergence of major trans-European corridors. Lombardy in particular stands out as a national and European logistics hub: from a transport perspective, it lies at the centre of a macro-area defined as the Milan Logistic Region (RLM). This territory transcends regional administrative boundaries and also includes neighbouring areas of Piedmont (Novara) and Emilia-Romagna (Piacenza). This functional region, with Milan at its centre, is characterised by an economic connective tissue represented precisely by logistics flows (Dallari and Curi, 2020) and has been described as equivalent to the circulatory system of an organism, an essential network ensuring the distribution of resources necessary for economic functioning.

According to a study by the LIUC Logistics Research Centre, Milan and its logistics region handle around 140 billion euros in goods annually, involving over 35 million people, including operators, employees, and service users (Dallari and Curi, 2020). The RLM covers an area of approximately 27,770 km² with 10.7 million inhabitants (a density of 385 inhabitants/km²) and contributes around 18% of Italy's GDP, confirming itself as one of the country's and Europe's leading economic engines.

At the national level, logistics real estate has become one of the most dynamic sectors in the market. Since 2017, the logistics segment, once marginal, has seen extraordinary growth, establishing itself as the leading asset class in the Italian property market (Marchesini 2024). In 2023, investments in logistics properties reached approximately 1.7 billion euros, accounting for over a quarter (27%) of the total national real estate market

1 Emilia-Romagna Regional Law of 21 December 2017, No. 24, "Regulations on the protection and use of the territory".

volume (ISTAT, 2024). This represents an unprecedented level of capital for the sector and highlights the strategic importance logistics has assumed in the economic landscape. In terms of physical volumes, 2023 marked the fifth consecutive year with over 2 million m² of new warehouses leased or purchased (take-up), and forecasts for 2024 indicate a further increase of 1.7 million m² to be occupied by the end of the year (ISTAT, 2024). Overall, the logistics sector in Italy currently employs 1.16 million people and generates a value of 92.7 billion euros, equivalent to 5.4% of national GDP (Tecnocasa, 2024). These figures confirm that logistics, from being an ancillary function, has become a primary economic driver for the country.

Within the RLM, the province of Piacenza plays a particularly significant role as a hinge area. Piacenza is, in fact, the first Emilia-Romagna territory immediately south of Milan and benefits from a favourable geographical position at the intersection of several communication routes. Traditionally, Piacenza lies along the Via Emilia (east-west axis), which connects the main centres of Emilia-Romagna, but in recent years its importance has extended to transversal links between north-western and north-eastern Italy. In perspective, the Piacenza area connects, on one side, Liguria, Piedmont, and south-eastern France, and on the other, Verona, north-eastern Italy, and eastern Europe. This central position along multiple routes, combined with its relative proximity to a major international seaport such as Genoa, has favoured the development of a strong local logistics hub: already in 2010, the Provincial Territorial Coordination Plan indicated that around 50% of new productive areas developed in the province of Piacenza between 2000 and 2010 were destined for logistics (PTCP, 2012). The area's infrastructure supports this vocation: Piacenza features a strong intermodal character, with navigable waterways (the River Po), an extensive railway network (with both passenger and freight links on the Milan-Bologna line and secondary routes), as well as a primary motorway network. At the A1 Motorway (Milan–Bologna) intersection with the A21 (Turin–Brescia), the Piacenza area offers excellent road accessibility for freight transport. Several nearby motorways exit, and the possibility of activating rail links to logistics hubs (such as Castel San Giovanni, already equipped with dedicated tracks awaiting use) makes this area extremely attractive to national and international logistics operators.

2.2. The increase in demand: e-commerce, just-in-time, and the transformation of logistics

The reasons behind the boom in contemporary logistics are multiple and linked to structural changes in economic and consumption models. Firstly, the explosion of e-commerce has redefined distribution needs: the widespread diffusion of online shopping, further accelerated by the Covid-19 pandemic (Casaleggio Associati, 2021), has generated unprecedented demand for sorting centres, proximity warehouses, and delivery platforms. E-commerce and retail companies require advanced logistics bases to ensure fast and reliable deliveries across the territory, increasing the demand for modern logistics spaces. Secondly, the adoption of the just-in-time (JIT) model and, more generally, of Lean Management practices in production chains has led companies to minimise warehouse stock at production sites, relying instead on frequent and timely supplies. This reorganisation implies that logistics is no longer seen as a mere transport service downstream of production, but rather as an integral and decisive part of the production process itself. What was once considered a phase of transport is now in all respects an autonomous and crucial production segment: efficient logistics management can generate savings of between 5% and 15% of a company's profits by optimising production, storage, and distribution (Farioli, 2019). In other words, global competition is pushing companies to reorganise their supply chains, often outsourcing logistics to specialised operators and investing in logistics innovation to improve delivery times and costs (Panfilo, 2018).

The consequence of these dynamics is that logistics has become an independent industrial sector, with its actors, capital, and spatial requirements. The phenomena that we can detect in the logistic spots of the territory of Piacenza province highlights how large contract logistics companies and 3PL (third-party logistics) operators have emerged, managing the entire flow of goods on behalf of producers and distributors, thus promoting the rise of increasingly large and technologically advanced logistics hubs (Alfieri,2023). Contemporary warehouses differ greatly from traditional industrial sheds: large single-storey surfaces of tens (if not hundreds) of thousands of square metres, high internal clear heights to maximise vertical storage, and extensive fully impermeable yards for manoeuvring and loading/unloading, allowing easy access for articulated lorries and heavy vehicles. This building typology, the mega-warehouse or big box, is designed to meet the market's continuous demand for flexibility (Marchesi,2023), such as rapid reconfiguration of interior spaces and the ability to manage variable goods flows. At the same time, however, it exerts strong pressure on the territory, given its out-of-scale dimensions to the traditional urban fabric. Entire peri-urban agricultural areas have been rapidly converted into logistics districts, with particular concentration in flat areas near major metropolitan hubs – contexts where

the availability of relatively cheap land, combined with proximity to consumer markets, creates ideal conditions for logistics settlements (Dallari & Curi, 2020). The Italian landscape, especially in the Po Valley, has thus seen a multiplication of large warehouses with standardised architecture, often located near motorway junctions.

2.3. Logistics and land take: the scale of the phenomenon

Land consumption driven by the growth of logistics represents one of the most critical aspects in terms of territorial sustainability. In Italy, land consumption has reached alarming levels in recent years: according to ISPRA data, in 2023, new artificial land cover affected 72.5 km², with net consumption amounting to 64.4 km², equivalent to approximately 17.6 hectares per day, or 2.3 square metres of land per second. Between 2006 and 2023, the country lost a total of 1,289 km² of natural or agricultural surfaces. In 2023 alone, more than 72 km² of new land were sealed (ISPRA 2024). These transformations are due to various factors (residential urbanisation, infrastructure, industrial sites, etc.), but the logistics sector has contributed increasingly, especially in Northern Italy.

Precisely quantifying the land consumption attributable to logistics is not straightforward, as official land use databases and municipal urban plans lack a specific category for logistics settlements. These are generally included under industrial or commercial zones, making it difficult to isolate and monitor the phenomenon. Recent studies provide useful strategies to address this methodological gap, highlighting how the absence of an ad hoc classification in land use data hinders the implementation of targeted policies to contain land consumption linked to logistics hubs. To address this limitation, research is currently experimenting with innovative mapping methodologies, combining photointerpretation from aerial images and auxiliary data, to allow the quantification of the phenomenon through in-depth studies (Ronchi et al., 2023).

Although not ranking first at the national level, the Emilia-Romagna Region is also among the territories most affected by land consumption. The percentage of regional land now sealed reached approximately 8.91% in 2023 (ISPRA, 2024), placing Emilia-Romagna fourth in Italy after Lombardy (12.1%), Veneto (11.86%), and Campania (10.57%).

Although this figure is lower than that of the leading regions, it reflects significant anthropic pressure, particularly concentrated along the foothill belt and the plain crossed by the Via Emilia. In this context, the province of Piacenza stands out for the speed with which logistics areas have expanded in recent years. In addition to the emblematic case of Castel San Giovanni, where an area of about 200 hectares has been urbanised to make way for one of the largest logistics hubs in the country, the entire provincial territory has seen a proliferation of storage and distribution facilities, including in smaller municipalities, often near motorway exits. Land consumption in the province of Piacenza has increased significantly, contributing to the regional figure. According to ISPRA, in 2023, the province of Piacenza recorded land consumption of 128.9 hectares (ISPRA 2024), with previously agricultural areas being covered by warehouses, yards, and new access infrastructure.

3. The regulatory framework

3.1. National and regional regulation

In Italy, the regulation of land consumption and territorial transformations is entrusted to a complex, multi-level system involving national, regional, provincial, and municipal regulations. Although in recent years public decision-makers have shown increasing intention to address the phenomenon of land consumption by attempting to activate policies and programmes aimed at responding to this issue (Ronchi et al., 2018), at the national level the absence of a specific framework law on soil has created a regulatory vacuum, leaving ample room for intervention by regions and local authorities. Among the main environmental and urban planning regulations, Legislative Decree No. 152/2006 (Environmental Code) sets out the general principles of environmental protection, but does not address the phenomenon of land consumption in a systemic way. In particular, it does not provide an explicit definition of "land consumption", leaving room for heterogeneous interpretations and applications at the regional level.

The environmental management of logistics areas and transformations is complex. On the one hand, there are national plans and programmes aimed at strategically strengthening the logistics sector; on the other, regional regulations are introduced in very different ways into the landscape of territorial governance. This heterogeneity is accentuated by the absence of a specific urban planning category for logistics, which is often assimilated

into general productive functions, despite having distinct characteristics and impacts. At the national level, the intense market pressure and the growing demand for territorial areas that meet specific requirements, such as adequate infrastructure, efficient connections with highly specialised supply chains, and integration with tertiary and administrative sectors, have led public decision-makers to reconsider the issue of land consumption with greater attention, recognising the need to counter the phenomenon of "logistics sprawl" (Aljohani & Thompson, 2016). This strategic direction is accompanied by the need to rationalise spending on new road and rail infrastructure, as well as to govern the location processes of logistics functions. In this context, policies such as the Simplified Logistics Zones[2] (ZLS) emerge as tools to incorporate these needs and provide national-level guidance (Bonfantini et al., 2022). The ZLS are indeed configured as strategic areas for regional economic development, where the infrastructure system supports coordinated growth of the productive fabric. Companies located in these zones benefit from economic and financial incentives and procedural simplifications. Considered from a national perspective, the ZLS, together with the Special Economic Zones (ZES), are intended to identify growth-driving areas, catalysts for small, medium, and large enterprises intercon

nected within an integrated infrastructure system operating on a European scale (Bonfantini et al., 2022).
Despite these references, a unified national regulatory framework capable of systemically addressing the phenomenon of land consumption is still lacking. Territorial management is largely entrusted to the Regions, which have developed differentiated and often uncoordinated legislative tools. Some Regions, such as Lombardy, with the recent Regional Law No. 15/2024[3], have adopted specific regulations to govern logistics settlements and their territorial impacts, while others, such as Emilia-Romagna, have integrated these issues within general land governance laws. This legislative asymmetry produces uneven effects, with direct consequences on the spatial distribution of logistics functions and the ability to manage their environmental impact.

The Emilia-Romagna Region has adopted advanced regulatory and planning tools for soil protection and sustainable territorial development. At the heart of this system is Regional Law No. 24/2017, which promotes urban regeneration and places strict limits on new land consumption, giving priority to the reuse of existing areas through municipal-level General Urban Plans (PUG). Supporting this, PRIT 2025 guides the location of infrastructure in a way consistent with territorial planning, while the Pact for Labour and Climate sets out ambitious programme goals, such as net-zero land consumption by 2050. More broadly, instruments such as the Regional Territorial Plan (PTR) and the Landscape Plan contribute to ensuring coherence between economic development, environmental protection, and landscape quality.

3.2. Regional Law Emilia-Romagna 24/2017: governing transformations between controversies and prospects
Regional Law 24/2017 "Regional rules on the protection and use of territory" represents an ambitious attempt by the Emilia-Romagna Region to combine economic growth, environmental protection, and urban quality. The law was introduced in a context marked by growing concerns over land consumption and aims to steer territorial transformations towards goals of sustainability, resilience, and regeneration. However, despite its integrated vision, the law does not include a specific regulatory tool for logistics settlements, which continue to be treated in the same way as generic productive functions. Among the central objectives of LR 24/2017 are: the limitation of irreversible land consumption; urban regeneration as the priority principle of transformation; the introduction of environmental, ecological, and landscape criteria into planning processes; and the obligation for implementing parties, including logistics operators, to provide ecological compensation and mitigation measures.

The law also adopts a multi-level governance model and promotes tools such as the General Urban Plan (PUG) – a new integrated tool replacing the former Structural Plan (PSC) and Operational Plan (POC) – and the Programme Agreement for supra-municipal projects. In support of the emphasis the law seeks to place on the containment of land consumption, it states: "Territorial and urban planning may provide, for the entire period, an overall land consumption limit of no more than 3 per cent of the urbanised territory surface area" (LR 24/2017).

Despite its advanced theoretical framework, the implementation of LR 24/2017 has revealed several critical issues.

2 The Simplified Logistics Zones (ZLS) were introduced by the 2018 Budget Law (Law of 27 December 2017, No. 205, "State Budget for the financial year 2018 and multi-year budget for the three-year period 2018–2020").
3 Lombardy Regional Law of 8 August 2024, No. 15, Regulation of logistics settlements of supra-municipal relevance.

In particular, the law has struggled to curb the uncontrolled development of logistics platforms, often authorised through urban planning amendments, as will be demonstrated in the documentary analysis of the case study examined in this research. Furthermore, it should be noted that the law includes a list of categories exempt from the calculation of net land consumption, meaning that certain areas are not counted in the containment calculation. Among these are precisely those areas that "Are not counted for the purposes of calculating the maximum share of land consumption: new productive settlements of regional strategic interest that are subject to settlement and development agreements [...]" (LR 24/2017). Thus emerges a side of the law that controversially responds to the declared aim of containing land consumption while, conversely, allowing for a rather broad list of exceptions. The lack of a specific urban planning category for the logistics sector has also made it difficult to distinguish between traditional productive settlements and large logistics hubs, hindering any ex-ante assessment of environmental and landscape impacts. The absence of sector-specific regulatory tools has led to fragmented local policies, where municipal administrations, often under pressure from economic operators, are left to manage complex projects without adequate technical and regulatory support.

One of the most problematic aspects in the management of territorial transformations, finally, is the systematic use of urban planning amendments, as evidenced in the results of the analysis conducted on the case study considered in this research. These instruments allow for modifications to current urban planning tools to approve new developments, often as exceptions to the goals of limiting land take. Their use has been particularly frequent in the logistics sector, where investors' tight timelines and economic pressure push for rapid and simplified solutions.

4. The Logistic Park of Castel San Giovanni: one of the largest logistics hubs in Italy

4.1. Castel San Giovanni: territorial context and strategic role

Castel San Giovanni, located at the westernmost edge of the province of Piacenza, is today one of the most significant logistics nodes in Northern Italy. With fewer than 15,000 inhabitants, the municipality lies in a highly connected geographical position, strategically located at the intersection of the Via Emilia, the A21 (Turin–Brescia) and the A1 (Milan–Bologna) motorways, near the border with Lombardy and only 70 km from the Milan node. This infrastructural configuration makes it a key junction between the western Po Valley and the Milan metropolitan system, effectively positioning it as the logistical gateway of Emilia-Romagna to the Milan Logistic Region (RLM). Functionally, over the past twenty years, Castel San Giovanni has assumed the role of a territorial gateway, supported not only by road accessibility but also by the availability of large, flat agricultural surfaces that were easily convertible. Before its transformation, the area was characterised by extensive agricultural use, strong landscape continuity, and a local ecological network linked to major waterways, particularly the Tidone Valley and the River Po, just a few kilometres north of the site. This setting facilitated a rapid shift toward logistics development (Figure 1), which began in the early 2000s, supported by supra-municipal planning instruments and an active local political willingness. Castel San Giovanni is, in fact, one of the first cases in Emilia-Romagna of systematic conversion of agricultural land to logistics use, carried out in the absence of a truly organic programme, through a sequence of specific agreements and planning amendments.

In just over a decade, the municipality transitioned from a compact urban structure, surrounded by agricultural fields, to a functionally dual landscape, polarised between the historical town centre and the new logistics development, which now extends over more than 200 hectares (2 km²), nearly equaling the area of the historical centre (2.9 km²). The Logistic Park currently employs approximately 2,500 workers and is organised under a condominium management model divided into two main blocks (Condomini A and B). Its principal logistics typology is third-party logistics (Gazzola, 2022), and it hosts major companies such as AMAZON ITALIA, LEROY MERLIN, FIEGE – ZARA, CLOSE2YOU, GEODIS, VAILOG, and GXO Logistics. This expansion has resulted in significant soil sealing and has intensified infrastructural, environmental, and social pressures on the existing territory.

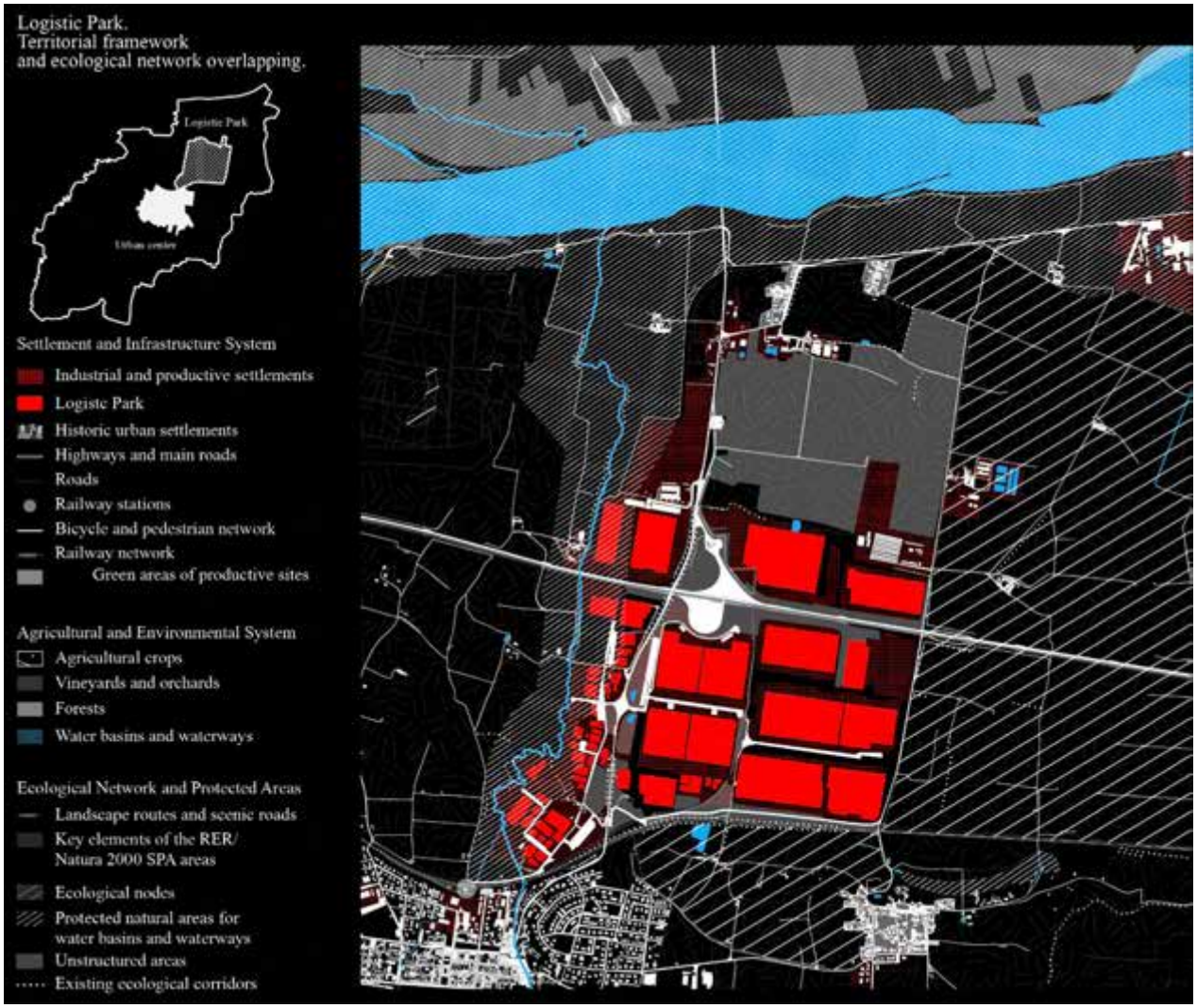

Figure 1: Territorial framework and ecological network overlapping of the Logistic Park.

This image represents the current state of the logistics hub's expansion as of 2023. As can be seen, during the various phases of expansion, the additive planning approach repeatedly intersected areas belonging to the ecological network. Author's elaboration based on data from the Emilia-Romagna Geoportal. (Appendix Figure 1)
4.2. Timeline and instruments: the development of the logistics hub

The Castel San Giovanni Logistic Park represents one of the most significant examples of territorial transformation driven by the growth of the logistics sector in Emilia-Romagna. The development of the hub has an intriguing origin, rooted in what was once locally known as the "Fallimento Speranza" (Speranza Bankruptcy) lands (Gazzola, 2022). The idea to establish one of the region's most important Territorial Development Production Hubs in Castel San Giovanni emerged from a strategic decision to revitalise a large industrial area within the municipality, an area that would be reoriented toward the growing logistics and freight movement sector. This strategic direction began to take shape in the 1990s, when a local private investor acquired extensive plots of land, previously occupied by a major pig farm near the highway, following the bankruptcy of the former enterprise. Although the vision was ambitious, it initially raised concerns, particularly within the local administration, which feared it might not be equipped to manage the implications of hosting such a large-scale logistics development within its jurisdiction. These concerns were especially evident during the early stages, as the municipality worked to define the types of functions and activities that could be allowed in the area. In this context, PTCP formally designated Castel San Giovanni as a Territorial Development Production Hub (PPST), thereby reinforcing its logistical vocation, a direction that was later confirmed and operationalised through subsequent municipal planning instruments.

The first formal local act dates back to 2002, with the approval of the then-current General Regulatory Plan (PRG), which already included provisions for new productive settlements south of the town, although not yet explicitly designated for logistics. The new Municipal Structural Plan (PSC), approved in 2007, incorporated these provisions, identifying that area as a potential zone for productive expansion. The scale shift occurred shortly thereafter, in 2007, when the site was formally designated as the future "Logistic Park" through a planning amendment under the SUAP procedure (One-Stop Shop for Productive Activities), promoted by a group of private investors and approved by the municipal administration with a view to supporting local economic development. This exceptional intervention via SUAP effectively bypassed the standard Operational Plan (POC), avoiding unified planning for the logistics park as a whole: subsequent expansions were thus implemented through ad hoc amendments rather than within an overarching framework. However, SUAP, designed to streamline procedures for initiating specific productive activities, appears ill-suited for managing large-scale, structural transformations. In the case of Castel San Giovanni, the procedure was used as a shortcut to initiate planning amendments and fast-track approvals, undermining the coherence and strategic evaluation required by comprehensive planning.

In 2008, a Programme Agreement was signed between the Municipality, the Province, and private operators, legitimising the start of the first developments and providing for the construction of primary and secondary infrastructure (new access roads, utility connections, environmental mitigation measures). Despite the lack of supra-municipal coordination or an integrated territorial vision, this agreement enabled construction work to begin quickly: by 2010, the first logistics platforms were already operational, including those for Zara and Geodis. Between 2011 and 2015, the logistics park expanded further east and south, through new sectors implemented via successive amendments that bypassed existing planning instruments. During this phase, global operators such as Amazon established a presence, with a platform of approximately 100,000 m² active since 2015. Amazon's arrival marked another scale leap: in addition to attracting further investors, it triggered increased pressure on municipal services, a sharp rise in local housing demand, and an acceleration in landscape transformation.

During this period, in 2012, a Territorial Development Agreement was signed between the Province of Piacenza and the Municipality of Castel San Giovanni. This agreement provided the institutional and regulatory framework for consolidating the logistics hub and its future expansions. It defined the characteristics of the Territorial Development Production Hub (PPST), including implementation methods, mitigation and compensation measures, ecological infrastructure, and mobility networks, in accordance with the PTCP and urban planning regulations.
At the regional level, Regional Law No. 24/2017 on land governance introduced stricter requirements for sustainable planning. However, by the time it came into force, most of the Logistic Park had already been developed. From 2014 to 2021, successive expansions were implemented through SUAP planning amendments within the "possible expansion" zones outlined in the Territorial Agreement (Figure 2). These allowed for the rapid construction of new sectors — Lotti P–R (2016), S (2017), Z (2018), Y–T (2020) —based on operators' requests.

The SUAP process, designed to simplify procedures for production-related developments, bypassed more structured urban planning assessments and all procedures required to ensure appropriate compensation measures for the impact of the logistics complex considered as a whole. By 2020, all designated expansion areas had been built out, with new logistics players, such as Leroy Merlin, joining Amazon, Geodis, and Zara. The hub reached full build-out despite growing concerns over traffic, land consumption, housing pressure, and habitat fragmentation—issues that underscore the regulatory tensions between strategic environmental objectives and local implementation practices.

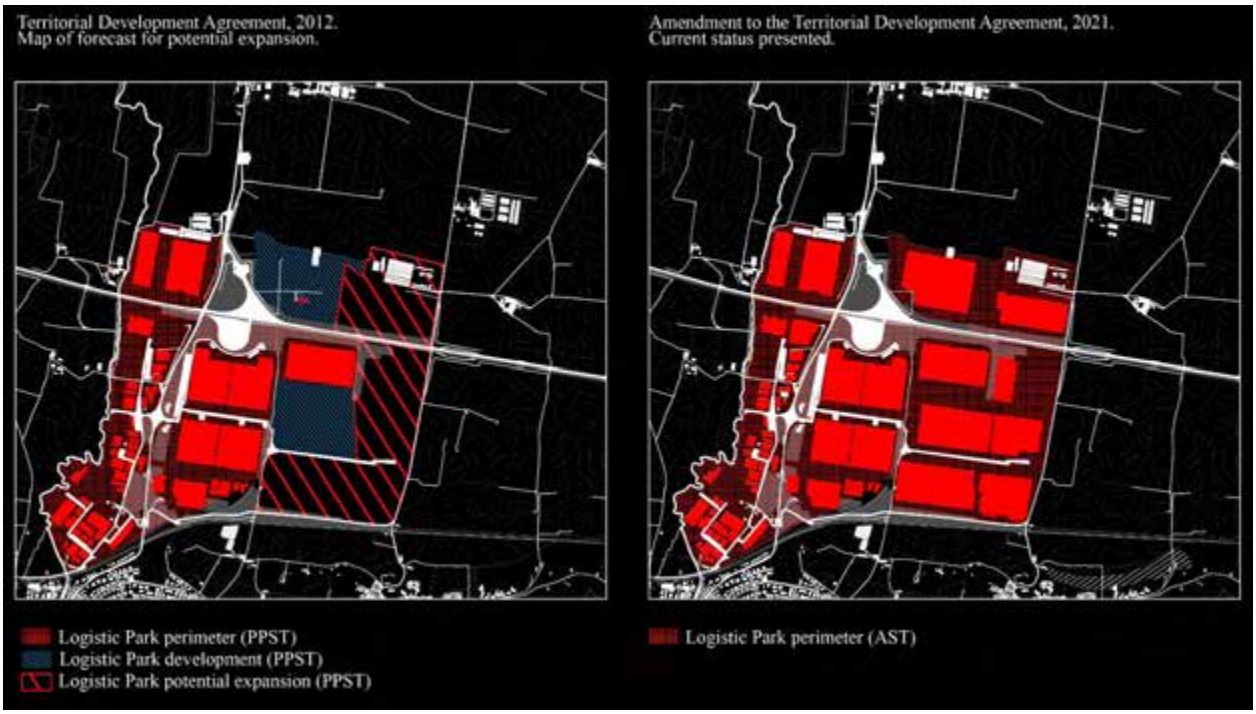

Figure 2: Comparison between potential expansion and final layout in 2021.

The data are processed using the information contained in the documents supporting the approval of the completion of the logistics hub, and refer to the potential expansion scenario outlined in the development agreement signed between the municipality and the province in 2012, and its subsequent update in 2021. (Valsat, 2020). Author's elaboration on Valsat document. (Appendix Figure 2)

4.3. Territorial transformations: land take analysis

The development of the logistics hub in Castel San Giovanni has led to a significant transformation of the local territorial structure, with extensive effects on the agricultural landscape, land use, and the urban morphology of the municipality. The settlement has substantially altered the traditional relationship between town and countryside, creating a new functional centrality that goes beyond the boundaries of the historical urban core and reshapes priorities in terms of accessibility and infrastructure at the municipal scale. To investigate the impact of the logistics hub's integration into the pre-existing agricultural fabric, this research includes a land use change study based on regional data from the Emilia-Romagna geoportal. This dataset provides percentage indicators for urbanised areas, agricultural zones, natural areas, and wetlands from 2003 to 2020. A further analytical step involved quantifying the percentage variation in consumed and renaturalised land—elements of direct relevance to Regional Law 24/2017. The data confirm a drastic change in land use (Figure 3). In just 17 years (2003–2020), urbanised surface area increased by approximately 387 hectares, while the municipality lost around 531 hectares of agricultural land. This brought the municipal land consumption rate to 18.22%, one of the highest figures in the province of Piacenza. For comparison, the entire province of Piacenza recorded, in 2023 alone, an increase of 128.9 hectares of consumed land, largely due to the expansion of new logistics settlements. Analysing the direct proportionality between the urban centre and the logistics sector, the current urbanised territory of Castel San Giovanni reveals the rapid and unbalanced settlement growth that occurred in just over a decade.

The logistics hub grew in a modular and additive fashion, with sectors progressively added without integrated planning for the remaining open spaces or urban edges. Each new intervention was conceived independently, lacking an overall coordinated design. This has resulted in a fragmented and polarised configuration of the local landscape: the municipal territory is now clearly divided between the traditional urban core and the new productive zone, while the remaining green areas appear fragmented, marginal, and unintegrated into the pre-existing ecological network.

Visual and functional connections between the urban centre and the surrounding countryside have been disrupted, and the internal infrastructure of the logistics hub has assumed an autonomous character, poorly connected to the existing urban fabric.

The urbanisation methods adopted, lacking environmental mitigation or ecological compensation measures, have exacerbated the impacts on the territory. The constructed warehouses are characterised by their monofunctional scale and standardised architecture: single-storey platforms reach surface areas of 30,000–70,000 m², with heights of 12–15 metres. The vast asphalted yards surrounding them, dedicated to heavy vehicle movement and parking, form extensive additional impermeable surfaces, increasing rainwater runoff and local flood risk.

Overall, large-scale soil sealing has compromised the land's ability to absorb stormwater, raising the likelihood of flooding and altering the natural hydrological regime. Simultaneously, territorial fragmentation has reduced ecological continuity between agricultural and natural areas, with negative effects on biodiversity and the local microclimate. No green infrastructure or adequate vegetated buffer zones were planned to mitigate the impact, nor are there public functions or communal spaces within the logistics complex: the logistics hub thus appears as an autonomous element, poorly integrated into the broader urban system.

From a settlement perspective, the expansion did not follow a principle of urban compactness but instead produced an external body, a 'twin city' with a logistics character. The new built lots developed in succession along the road infrastructure built for the hub, prioritising heavy vehicle functionality but proving inefficient in landscape and ecological terms. The large scale and uniform appearance of the buildings, combined with the absence of green transitions, have accentuated the visual rupture with the rural context, creating a landscape impact perceptible even from a distance. Ultimately, the territorial transformations induced by the logistics hub have replaced the former agricultural landscape with a continuous built and asphalted environment, marking the territory irreversibly from both ecological and morphological perspectives.

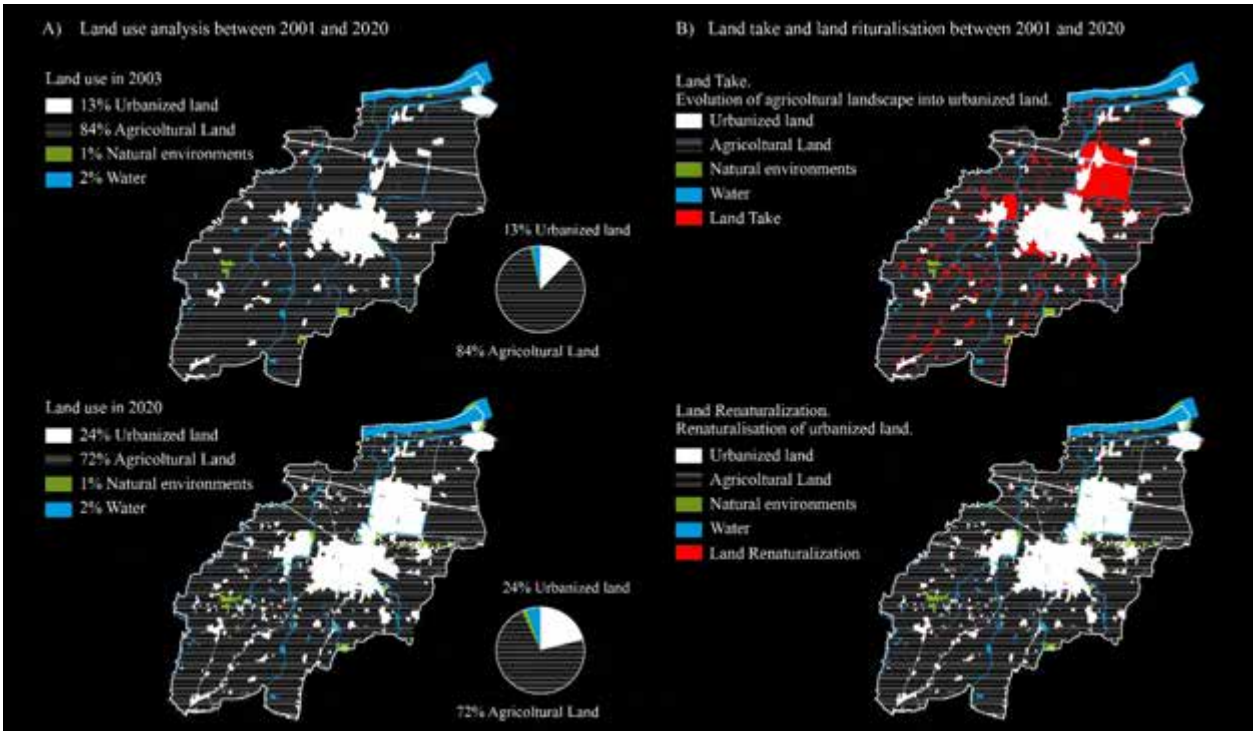

Figure 3: Land use analysis and land take, and land renaturalisation process analysis. Study conducted within data from 2003 and 2020.

A) Land use in the municipality of Castel San Giovanni in 2003 (above) and in 2020 (below). The map and pie charts show the expansion of artificial surfaces (grey areas) at the expense of agricultural land (yellow areas) between 2003 and 2020. In 2003, urbanised land accounted for 13% of the municipal surface, while by 2020 it had reached 21%.

B) Land consumption (in red) and minor renaturalisation phenomena (in dark green) in the municipal territory of Castel San Giovanni between 2003 and 2020. The red areas indicate agricultural or natural surfaces converted into urbanised land during the period, mostly concentrated in the logistics hub quadrant, while the limited renaturalisation efforts appear as isolated fragments within an increasingly artificialised landscape. Author's elaboration based on data from the Emilia-Romagna Geoportal. (Appendix Figure 3)

5. Conclusions

The case study of Castel San Giovanni offers a critical lens through which to interpret the complex interplay between logistics-driven territorial development and regional planning frameworks in contemporary Italy. The findings reveal a dissonance between the objectives of sustainable land governance, such as those outlined in Emilia-Romagna's Regional Law No. 24/2017, and the mechanisms through which large-scale logistics settlements have been realised in practice.

The logistic transformation of Castel San Giovanni occurred through an incremental and ad hoc process, heavily reliant on SUAP amendments, which permitted bypassing standard urban planning instruments and, crucially, the systematic assessment of environmental and cumulative territorial impacts. While such procedures have facilitated the rapid deployment of logistics infrastructure, they have simultaneously undermined the integrative principles of land-use regulation, resulting in the fragmentation of the local ecological network, the erosion of agricultural land, and a significant landscape discontinuity between the historic urban core and the logistics enclave.

This empirical evidence corroborates broader criticisms raised in recent discourse surrounding the implementation of LR 24/2017. As highlighted by investigative analyses (Pileri, 2023; Rosano, 2023), the exemption of strategic productive settlements from soil consumption calculations, coupled with the delayed adoption of General Urban Plans (PUGs) by the majority of municipalities, has significantly weakened the law's regulatory efficacy. In the absence of a national framework law, regional initiatives risk being rendered ineffectual by institutional fragmentation and political-economic pressures at the local scale.

These dynamics have repercussions beyond the regional context, aligning with broader European concerns about soil sealing and the unsustainable expansion of settlement areas. The European Commission's Soil Strategy for 2030 acknowledges the centrality of land as a non-renewable resource, setting the target of No Net Land Take by 2050 as a guiding principle for Member States. This target is grounded in recognition that artificial soil cover causes irreversible losses of ecosystem functions, such as water regulation, carbon storage, and biodiversity support, and imposes long-term socio-environmental costs (European Commission, 2021; EEA, 2019).

Considering such findings, it becomes imperative to reconsider the instruments governing territorial development. A shift is required toward a governance model that transcends market-driven logic and embraces the intrinsic value of soil, cultural landscapes, and the well-being of communities. This highlights the need for a supra-local and possibly national governance scale to effectively regulate logistics-driven development, overcoming the current fragmentation and enabling coordinated, strategic planning across administrative boundaries. Future planning strategies should embrace adaptive and environmentally conscious frameworks capable of responding to emerging pressures. These frameworks must aim to mitigate environmental degradation and address the spatial fragmentation produced by uncoordinated development. In the case of Castel San Giovanni, overcoming the current disconnection between urban growth and territorial coherence requires a rethinking of planning priorities. However, any future intervention must be embedded in a long-term, coordinated vision that recognises the complexity of territorial transformations and ensures that land-use governance aligns with both ecological sustainability and social equity.

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Appendix:

Figure 1:
Author's GIS elaboration on regional data available at: https://geoportale.regione.emilia-romagna.it/, together with the combination of raster data available on the regional planning document (PTR- Piano Territoriale Regionale) and the maps provided by the region about the Ecological Network (RER – Rete Ecologica Regionale).

Figure 2:
Author's GIS elaboration based on regional data available at: https://geoportale.regione.emilia-romagna.it/, combined with data extracted from the analysis of the Territorial Development Agreement (2012) and its Amendment (2021), available on the Piacenza Province website at:
file:///C:/Users/margh/Downloads/2_1_xy_documento_di_valsat_30122020-172754.pdf,
https://www.provincia.pc.it/Allegati/Livelli/AT_Rep_n_144_del_9_9_2021_28022022-161131.pdf.
The original Territorial Development Agreement document is not available; however, relevant maps are included in the Valsat document (environmental legitimacy procedure), which was drafted to support the future expansion of the logistics hub.

Figure 3:
Author's GIS elaboration on regional data available at: https://geoportale.regione.emilia-romagna.it/. Due to differences in the data acquisition methods used by the region to detect land use across different years, some inconsistencies may be observed. However, the data remain broadly consistent with the results obtained and accurately reflect the overall transformation trends.

Exploring the Application and Challenges of Urban Planning Legal Systems Guided by Nature-Based Solutions: A Case Study of Kaohsiung City, Taiwan

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Abstract
This study focuses on examining Nature-Based Solutions (NbS) within urban planning across different spatial scales in Kaohsiung City, Taiwan, particularly evaluating the content of planning regulations and their implementation strength. By constructing an NbS relevance matrix and integrating the Strategic Environmental Assessment (SEA) framework, the study conducts regional risk and potential analyses to assess the feasibility of planning strategies in each area. The findings indicate that the incorporation of NbS in spatial planning regulations remains insufficiently systematic. Therefore, the study recommends promoting the mainstreaming of NbS through institutional reforms and enhancing climate adaptation and sustainable urban transformation by referencing international case studies and strengthening multi-level governance.

Keywords: Nature-based Solutions (NbS), Urban Planning, Climate Adaptation, Sustainable Urban Development

1. Introduction

1.1 Global Context and the Importance of the Issue

In recent years, as global warming intensifies, the frequency of extreme weather events increases, and ecosystems continue to degrade, urban areas worldwide are facing unprecedented pressure on sustainability and resource availability, particularly in terms of land, water, and infrastructure. According to the United Nations Environment Programme (UNEP, 2024), countries must commit, in the next round of Nationally Determined Contributions (NDCs), to reducing emissions by 42% by 2030 and 57% by 2035; otherwise, the Paris Agreement's 1.5°C target will be unattainable, with global temperatures potentially rising to between 2.6°C and 3.1°C(United Nations Environment Programme, 2024), leading to severe impacts on human society, ecosystems, and the global economy. The IPCC (2023) similarly highlights that cities are not only major sources of carbon emissions but also at the frontline of climate impacts, particularly vulnerable to risks such as biodiversity loss. Future climate scenarios must incorporate irreversible risks such as ecosystem collapse, limits to species adaptation, and social tipping points, while also addressing the unequal impacts of climate change across different social groups. The report further calls for interdisciplinary and multi-level cooperation to develop adaptation strategies that are inclusive and locally grounded, in order to effectively respond to increasingly complex environmental challenges.

1.2 The Rise and Multiple Benefits of Nature-based Solutions (NbS)

Drawing on insights from both international reports, it is increasingly evident that traditional engineering-dominated solutions are reaching their limitations and are no longer sufficient to address today's complex environmental and social challenges alone. This has prompted cities around the world to shift towards more sustainable and resilient strategies. In recent years, Nature-based Solutions (NbS)—offering multiple co-benefits in climate adaptation, carbon reduction, ecological restoration, and human well-being—have gained significant global attention.

NbS has been formally integrated into international frameworks such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD), and is closely aligned with Natural Climate Solutions (NCS), the Sustainable Development Goals (SDGs), and net-zero strategies. Overall, NbS has evolved from a traditional ecological tool into a multi-level, multi-objective governance strategy, playing an increasingly important role across environmental, social, and economic dimensions.

Environmentally, NbS contributes to carbon sequestration, alleviates the urban heat island effect, regulates the water cycle, and reduces flood risks. Socially, urban green spaces enhance mental well-being, strengthen community interaction, and build resilience. Economically, NbS stimulates green investment, creates employment opportunities, and reduces infrastructure maintenance costs (Raymond et al., 2017; UNEP, 2024).

2. Theoretical Background

2.1 The Importance of NbS for Cities and Urban Planning

Nature-based Solutions (NbS) are increasingly recognised as context-specific and adaptive urban policy tools that can respond to particular societal needs while delivering multiple co-benefits. Cities such as Rotterdam, Copenhagen, and Singapore have already incorporated NbS into spatial planning, climate risk management, and urban design frameworks (Frantzeskaki, 2019).

Recent research also highlights the close relationship between NbS and urban planning and land-use systems, demonstrating their potential to enhance urban resilience, public health, and social inclusion (de Luca et al., 2021). Practical applications such as permeable green spaces, green walls, and green roofs serve as illustrative examples. NbS has also been embedded within the Sustainable Development Goals (SDGs), no longer serving solely as a conservation tool but evolving into a comprehensive strategy that integrates spatial planning, social policy, and infrastructure development.

For urban planners, NbS represents not only a means for adaptation and carbon reduction, but also a critical strategy for ecological restoration, social equity, and sustainable development. It enables the integration of multiple urban challenges and supports transformative change in cities (Liu, Jay & Chen, 2021).

2.2 Practical Applications and Classifications of NbS in Urban Spaces

The European Union has actively promoted Nature-based Solutions (NbS) through major initiatives such as Horizon 2020 and Horizon Europe, applying them widely across urban renewal domains including green corridor development, water system integration, biodiversity enhancement, and brownfield regeneration. Among these efforts, the Naturvation project's development of the Urban Nature Atlas (UNA) stands out for systematically collecting empirical NbS cases from European cities, serving as a key reference for public authorities and planners worldwide (Almassy, Maia & Pinter, 2022).

Bona et al. (2023) analysed 24 NbS projects across European cities, categorising them by spatial scale into micro (buildings and plots), meso (communities and neighbourhoods), and macro (cities and regions), thus facilitating multi-level integration. Liu, Jay, and Chen (2021) classified NbS based on urban planning terminology, including interventions such as green roofs, vertical greening, and river restoration. Pirouz et al. (2024) further emphasised that systematically embedding NbS into planning frameworks helps reduce dependence on natural resource consumption while promoting the integration of ecological services and social well-being.

NbS can achieve multiple objectives—including climate adaptation and resource circularity—by combining green infrastructure interventions such as urban forests and rain gardens across different spatial scales. Its advancement also depends on cross-sectoral collaboration, policy incentives, and financial instruments to transition from pilot initiatives to institutionalised models. As such, NbS should not be viewed merely as a spatial intervention tool, but rather as a core institutional strategy for urban development (Pirouz et al., 2024).

2.3 Challenges in Implementing NbS in Urban Planning Policies

According to the UNDP Ukraine (2021) report, although certain policy documents in Ukraine have begun to reference Nature-based Solutions (NbS), the term is still largely absent from most urban planning, environmental protection, and climate adaptation legislation. While the current legal framework offers potential support, it lacks specific provisions and implementation guidelines. The report calls for the urgent formal integration of NbS into legal statutes, planning documents, and technical standards, alongside the enhancement of institutional, financial, and educational support systems to meet the demands of sustainable urban governance.

Even in countries where NbS has reached a more advanced stage of development, its application in urban planning often encounters conceptual stagnation, a lack of operational frameworks, and the absence of monitoring mechanisms. Moreover, the role of urban planning departments remains unclear, highlighting the persistent gap between academic discourse and practical implementation (Dumitru et al., 2020). As a result, effectively integrating NbS into urban plans and infrastructure strategies has become a key priority for many nations seeking to advance sustainable and climate-resilient development (Xie & Bulkeley, 2020; Wickenberg et al., 2021).

2.4 Development Trends and Research Gaps in Taiwan

Taiwan's complex spatial characteristics and governance structures differ significantly from those of European countries, resulting in a comparatively late start in developing and applying Nature-based Solutions (NbS). Relevant research has only recently gained traction, initially assessing ecological impacts and effectiveness in rural contexts to establish localised guidelines and models. Responding to the NbS principle of triple social, environmental, and economic benefits, studies emphasised enhancing urban resilience (Chen, 2020; Chiu et al., 2024). Subsequently, Taiwan's academia and policymakers clarified and deepened NbS definitions, core concepts, and practical frameworks (Li, 2022), increasingly focusing on urban spatial governance and climate change adaptation through policy frameworks that emphasise spatial re-naturalisation and integrated multi-benefit approaches (Chou et al., 2023). Further studies explored opportunities from spaces released by building setbacks for NbS implementation, such as green infrastructure, permeable pavements, and tree canopy expansion, noting green infrastructure design as key to urban effectiveness (Tsai, Hsu & Lin, 2023).

Policy-wise, Taiwan initiated action through drafting the 2012 "National Climate Change Adaptation Policy Framework" (Shih, 2024). Responding to growing global emphasis on NbS, the National Development Council in 2022 led cross-ministerial meetings, resulting in consensus to integrate NbS into climate adaptation policies, with the Forestry and Nature Conservation Agency of the Ministry of Agriculture coordinating cross-sectoral implementation. Recently, the Executive Yuan formally approved the "National Climate Change Adaptation Action Plan (2023–2026)", embedding NbS strategically within national climate governance and promoting cross-departmental collaboration. This plan positions NbS as a pivotal tool and core policy philosophy.

Despite active promotion, a gap remains between NbS theory and practice. While individual case studies have yielded valuable insights, comparative analyses across urban or regional contexts remain limited, confining applications to specific scenarios (Chou et al., 2023). Public and professional awareness of NbS remains vague, with institutionalised planning methods and technical guidelines still lacking. Moreover, NbS has yet to be systematically integrated into urban planning and building regulations, restricting effective implementation. At the local government level particularly, improvements in technical capacity, budgets, and access to reference cases are urgently needed.

2.5 Kaohsiung City as a Case Study: Opportunities and Challenges

Against this backdrop, Kaohsiung City—one of Taiwan's six special municipalities—stands out as a potential demonstration site for implementing Nature-based Solutions (NbS), owing to its industrial transformation and high-density urban development. However, it also faces distinct challenges compared to other international contexts. In recent years, Kaohsiung has actively sought to transition from a heavy industrial city to a smart, low-carbon, and sustainable green metropolis, developing locally adaptive strategies to address climate risks, enhance ecological resilience, promote social equity, and drive green economic development.

According to the 2024 Kaohsiung Voluntary Local Review, the city government has aligned its policy framework with the Sustainable Development Goals (SDGs) and has actively advanced sponge city initiatives and green infrastructure construction. To date, 36 stormwater retention ponds have been completed within development sites, along with 25 publicly constructed retention ponds. The total area of urban green space has reached 2,536 hectares. Furthermore, the Kaohsiung House 4.0 programme promotes vertical greening and energy-efficient building design. A dedicated Sustainable Development and Climate Change Response Council has been established to coordinate cross-departmental resources, strengthen urban resilience, and expand the deployment of nature-based infrastructure.

Nonetheless, current discussions and policy initiatives remain fragmented. The key challenge now lies in how to systematically incorporate NbS into urban planning frameworks and effectively integrate natural elements into spatial strategies.Accordingly, this study adopts an urban planning perspective to examine the feasibility and obstacles of integrating NbS in Taiwan, using Kaohsiung City as a case study. It focuses on two distinct areas: Aozihdi, a newly developed zone transitioning from agricultural use; and Gushan, an older district vulnerable to flooding. By reviewing planning documents and spatial strategies, the study assesses the potential and limitations of NbS implementation in these contexts and offers locally grounded integration proposals.

Drawing on international experience, it aims to provide concrete strategies to strengthen Kaohsiung's resilience and guide its sustainable transformation, while also serving as a policy reference for other cities seeking to pursue NbS as a dual pathway toward climate adaptation and long-term sustainability.

3. Methodology

3.1 Research Design

Many studies have employed NbS matrix systems to examine relevant indicators and the approaches and status of policy integration (Goličnik Marušić, Dremel and Ravnikar, 2023), viewing them as strategies tailored for different urban contexts (Zwierzchowska et al., 2019). Researchers have combined matrix systems with Strategic Environmental Assessment (SEA) frameworks to promote the legal integration of NbS into urban planning, enabling comprehensive environmental and regulatory assessments at early policy stages, thereby reducing future implementation risks and improving environmental outcomes (Figueiredo Gallardo et al., 2022). Consequently, this research aims to develop an integrated conceptual framework, systematically embedding NbS into each primary stage of SEA to enhance the overall resilience of urban land-use planning in response to climate change. By systematically aligning diverse NbS strategies with SEA planning phases corresponding to climate impacts, the study seeks to facilitate climate adaptation-oriented urban planning practices (San Jose et al., 2025).

This research uses Kaohsiung City, Taiwan, as a demonstration case, selecting detailed plans corresponding to primary urban plans for analysis. This approach allows a consistent and clear analytical framework and comparative benchmarks, as detailed plans typically reflect the spatial strategies and land-use implementation from primary plans. By excluding specific, case-oriented detailed plans such as redevelopment or special development zones, the study avoids heterogeneity issues arising from differences in regulations and planning objectives, ensuring more generalisable and representative results.

To further assess NbS applicability and challenges in varying urban contexts, the research focuses on two representative spatial types: (A) Gushan District's detailed plan, an early-developed urban area with high flood risk, whose drainage systems and topography are sensitive to climate impacts, suitable for exploring NbS resilience strategies in built environments; and (B) Aozihdi area's detailed plan, transformed recently from agricultural land to urban uses, representing one of Kaohsiung's key urban expansion zones(Table 1). Its recent development and planning flexibility facilitate examining NbS as a proactive development tool. These two areas reflect different phases of Kaohsiung's urban development, addressing diverse climate risks and governance needs, thus providing valuable comparative insights and policy implications.

Table 1: Strategic Environmental Assessment Matrix

region	Assessment Aspects (Key Risks/Challenges)	
A	Key Risks	• Located near the mouth of the Love River, the area faces dual flood risks from tidal surges and heavy rainfall. • Dense development has resulted in a lack of green space connectivity, undermining ecosystem functions and urban resilience.
	challenge	• Hydrological Risks – Water Resource Management • Ecological Conservation – Green Spaces, Habitats and Biodiversity, Climate Adaptation and Restoration, and Mitigation Actions.
B	Key Risks	• The area was formerly rezoned from agricultural land and has undergone extensive residential and commercial development, resulting in high development pressure and population concentration. • The area is low-lying and prone to flooding during heavy rainfall.
	challenge	• Hydrological Risks – Water Resource Management • Warming Risks – Climate Adaptation and Restoration, Mitigation Actions, and Environmental Quality

3.2 Data Collection

Literature indicates that Taiwan has actively explored and developed NbS primarily within the last five years Systematic promotion of Nature-based Solutions (NbS) in Taiwan only began to take shape in the past five years, approximately since 2020 (Lin, Chan, and Hsu, 2021). This study uses detailed urban plans completed in Kaohsiung between 2020 and 2025 as its core dataset, with a particular focus on cases from the most recent two years that contain NbS-related provisions or spatial strategies. Selected samples include three detailed plans from the Gushan District and eight from the Aozihdi area. All materials are sourced from officially published planning documents and maps by the Kaohsiung Urban Development Bureau, encompassing a wide range of spatial typologies and enabling analysis of NbS application potential.

3.3 Analytical Process and Methods

This study adopts a mixed-methods approach, combining qualitative and quantitative techniques to systematically assess the representation and spatial appropriateness of NbS within urban planning texts (Sarabi et al., 2022). The process begins with a literature-based compilation of keywords related to NbS and green infrastructure, as well as the corresponding environmental and social challenges they address, forming the basis of an evaluation indicator list. The NbS matrix method is then applied to conduct clause-by-clause analyses of the Gushan and Aozihdi plans, identifying the frequency and proportion of relevant keywords to quantify the extent of NbS integration.

Further analysis is carried out using the Strategic Environmental Assessment (SEA) framework to evaluate each area's capacity to respond to key challenges such as hydrological risks and the urban heat island effect. From a regulatory perspective, the study assesses the potential environmental impacts of the plans and the depth of NbS integration. A scoring system is employed to identify implementation gaps, based on which targeted recommendations for improvement are proposed.

3.4 NbS Typologies and Scope of Analysis

This study draws on the policy framework "Building a Resilient Greater Bay Area through Nature-based Solutions", along with other scholarly sources (Debele et al., 2019), to adapt the classification of NbS for urban environments in Asian cities. The classification is structured into three main categories:

(1) **Blue Infrastructure:** Centred on water resource management, this includes riverside and waterfront systems and coastal wetland systems. Key functions encompass flood adaptation, water purification, and aquatic habitat maintenance.

(2) **Green Infrastructure:** Focused on terrestrial ecosystems and urban greening, it includes open spaces (e.g., parks, greenbelts) and ecological spaces (e.g., protected areas, habitats), providing recreational services and enhancing biodiversity.

(3) **Hybrid Infrastructure:** Combining green infrastructure and grey engineering to create synergistic benefits, this category includes detention ponds, permeable pavements, vertical greening on buildings, and ecological corridors.

To ensure statistical accuracy and analytical consistency, the study applies a set of exclusion criteria: repeated mentions from the same source are counted only once; interventions lacking ecological functionality or those that are purely engineering-oriented are excluded; vague or non-specific terms (e.g. references to "greening" without classification) are not included; existing infrastructure that has not undergone retrofitting is excluded; and appendices or procedural documents are disregarded unless they contain specific NbS design descriptions.

4. Results

4.1 Distribution of NbS Types

From the distribution of NbS types in urban planning documents over the past five years, both Gushan and Aozihdi districts primarily emphasise green open spaces (e.g., urban parks, greenery), representing the most frequently mentioned NbS measures. Gushan had 17 occurrences(Table 2), while Aozihdi had 56(Table 3), highlighting urban greening as the current priority NbS strategy. In mixed NbS categories, Aozihdi notably shows greater diversity and frequency of application compared to Gushan. Although Gushan also mentions permeable paving and

green corridors, these appear less frequently, and ecological conservation-oriented NbS are entirely absent, indicating a stronger emphasis on landscape enhancement and spatial reuse. However, the frequency of NbS mentions, while indicative of strategic preferences, is insufficient to reflect actual implementation effectiveness or institutionalisation.

Table 2: Quantification of Frequencies in the NbS Relevance Matrix -Gushan District

Location	Nature-based Solution (NbS) Categories Based on Nature as the Solution frequency Proportion of NbS-related provisions			Documents from Gushan District within the past five years	
city	blue	River, Riverbank	Riverside and waterfront parks	1	1. Riverbank restoration transformed into a riverside park. (100%)
		coast	Coastal wetland	0	
	green	Open space	*Urban Park, Greening (planting, tunnels)	*17	1. The establishment or expansion of parks and green spaces (an increase in quantity)(59%) 2. Land Resource Integration and Conversion (including support for greening (strategies)(29%) 3. Disaster Prevention, Evacuation, and Resilience Functions(12%)
		Ecological space	Nature/Ecological Reserve	0	
	Hybrid	Open space	Flood retention function	0	
			Permeable pavements and waterways (natural water management)	1	1. Pavement permeability improvement (basic pavement renewal)(100%)
		Architectural space	Building Greening (Green Roofs, Green Walls, etc.)	0	
		semi-open space	Atrium and Rain Garden	0	
		ecological space	Green infrastructure network, Pedestrian trail, Green corridor	10	1. Utilization of the Green Corridor after Railway Undergrounding(70%) 2. Integration of Blue-Green Infrastructure Network(30%)

Table 3: Quantification of Frequencies in the NbS Relevance Matrix-Aozihdi District

Location	Nature-based Solution (NbS) Categories Based on Nature as the Solution frequency Proportion of NbS-related provisions			Documents from **Aozihdi District** within the past five years	
city	blue	River, Riverbank	Riverside and waterfront parks	1	1. Construct a waterfront park and recreation area.(100%)
		coast	Coastal wetland	0	
	green	Open space	***Urban Park, Greening (planting, tunnels)**	***56**	1. **Establishment or expansion of parks and green spaces (quantitative increase)(50%)** 2. Ecological education and multifunctional greening (qualitative enhancement) (30%) 3. Disaster prevention, evacuation and resilience functions(13%) 4. Greening aesthetics of blocks and boundaries.(7%)
		Ecological space	Nature/Ecological Reserve	0	
	Hybrid	Open space	Flood retention function	5	1. Detention basins and stormwater retention facilities(100%)
			Permeable pavements and waterways (natural water management)	9	1. Permeable Pavement Installation (Base Pavement Upgrading)(56%) 2. Stormwater Retention and Natural Drainage Facilities(44%)
		Architectural space	Building Greening (Green Roofs, Green Walls, etc.)	3	1. Building setback greenbelt and site green coverage ratio(100%)
		semi-open space	Atrium and Rain Garden	0	
		ecological space	Green infrastructure network, Pedestrian trail, Green corridor	116	1. Utilization of the Green Corridor after Railway Undergrounding (62.5%) 2. Linking Ecological Corridors and Species Habitats(37.5%)

4.2 NbS Application Intensity and Clause Proportions

The NbS matrix analysis reveals that both areas have included a considerable proportion of NbS-related clauses in their urban planning documents, reflecting their respective emphasis and priorities at the planning stage.

In Gushan district, NbS clauses focus predominantly on 'green open spaces' (17 clauses), with new or expanded public green spaces comprising 59%, highlighting an aim to increase overall greenery. Land consolidation and adjustments to green spaces account for 29%, indicating an attempt to identify greening opportunities through spatial reorganisation in high-density settings. Greening combined with disaster prevention accounts for only 12%, suggesting a supplementary role. Mixed-type NbS mainly involve green corridors and reuse of underground spaces (70%), emphasising regeneration and spatial revitalisation, with permeable paving and waterway design at 30% (Table 2).

In Aozihdi, 'green open spaces' are central (56 clauses), reflecting a strong emphasis on green infrastructure and ecological integration during urban development. New or expanded parks and green spaces constitute the primary policy direction (50%), while multifunctional green areas combining ecological education and aesthetic landscaping comprise 30%, underlining educational and landscape values. Disaster prevention facilities represent 13%, with urban visual greening at 7%. Mixed-type NbS (16 clauses) predominantly focus on green corridors and underground space reuse (62.5%), highlighting spatial connectivity; permeable paving and rainwater management systems represent 37.5% (Table 3).

4.3. SEA Analysis: Spatial Potential and Strategic Evaluation for NbS Integration

The evaluation mainly covers three core dimensions: strategic focus, implementation strength, and site-specific identification. The scoring criteria reference Fischer & Gazzola's (2006) SEA implementation study, which employs a three-level rating (high, medium, low) to compare institutional effectiveness, as well as the IPCC Fourth Assessment Report (AR4), which uses likelihood scales such as 'very likely (>66%)', 'likely (33–66%)', and 'unlikely (<33%)' for quantifying scientific evidence strength. This approach, recognised internationally for semantic grading, continues to be applied in IPCC's Sixth Assessment Report (AR6), thereby forming a combined assessment standard(Table 4).

When assessing the focus of urban-plan provisions or design elements, one judges whether a clause explicitly addresses a specific risk or challenge—such as flooding or ecological crises. If the wording directly and concretely corresponds to such challenges, it is deemed "high focus," indicating a clear, purpose-driven strategy. If it only partially addresses the challenge, leaving ambiguity or lacking full implementation detail, it is classified as "medium focus," showing that policy intent is emerging but still open to refinement. Conversely, if a clause makes no explicit reference to any risk or response and remains at the level of abstract vision, it is regarded as "low focus," signifying that the strategy lacks specificity and actionable guidance.

When evaluating implementation strength, clauses with high strength (≥ 66 %) are typically expressed in unequivocal, legally binding language—common terms include "shall," "must," "may not," "in accordance with...," or "only if," for example: "New buildings shall incorporate permeable paving over at least 30 % of the site." Medium strength clauses (33–66 %) combine mandatory and encouraging language—terms such as "encourage," "recommend," "should" or "may" appear, some with legal effect and others merely advisory, for instance: "The site may include an ecological detention basin" or "Developments should retain native planting." Low-strength clauses (≤ 33 %) are largely optional, lacking legal compulsion and reliant on developer discretion; wording such as "may," "encourage," "recommend" or "subject to conditions" is used, for example: "It is encouraged to adopt low-impact development principles" or "The site may consider a retention basin to improve runoff."

Site-specific identification is judged by whether a clause clearly specifies applicable locations and spatial design requirements. High identification (≥ 66 %) occurs when clauses explicitly name districts, plots or zoning categories and provide concrete spatial standards. Medium identification (33–66 %) applies where clauses mention applicable types or spatial approaches but remain vague or lack detailed criteria (e.g. "applicable to development zones" or "may include ecological spaces"). Low identification (≤ 33 %) is when clauses are purely conceptual—merely referring to "enhancing green amenity" or "developing green spaces" without specifying any location, type or method—indicating low site specificity.

By applying these criteria, one can systematically gauge a planning policy's strategic focus, enforcement efficacy and on-the-ground feasibility, thereby informing subsequent policy diagnosis and optimisation.

Table 4: SEA Scoring Criteria

Evaluation Dimension	Definition	Evaluation Criteria
Priority Dimension (Strategic Focus)	Assess whether the urban planning regulations or designs explicitly address this risk or challenge.	1. Fully addresses the challenge with appropriate and clearly defined measures → High 2. Partially addresses the challenge, but with room for improvement. → Medium 3. Fails to address any challenges → Low
Implementation strength (Legal Mandate of Provisions)	Assess whether the provisions in the planning documents are 'optional' or 'mandatory'.	1. ≥ 66 % of clauses are explicit and mandatory with non-compliance affecting planning approval → High implementation strength 2. 33 - 66 % of clauses blend compulsory and encouraging language, indicating a middle-age of enforcement → Medium implementation strength 3. ≤ 33 % of clauses are framed as encouragement, guidance or optional, relying on developer discretion → Low implementation strength
Site-specific Identification (Implementation Potential)	Assess whether the applicable location is clearly specified and whether spatial design conditions are provided.	1. ≥ 66 % of clauses explicitly specify applicable locations and operational conditions → High site specificity 2. 33 - 66 % of clauses mention locations or spatial conditions but remain partly vague → Medium site specificity 3. ≤ 33 % of clauses make no concrete reference to locations or conditions → Low site specificity

Justification and indicative references

1. **Priority Dimension (Strategic Focus):**
   Frantzeskaki (2019): Explores whether Nature-based Solutions (NbS) serve as a core strategy for urban transformation and identifies how they explicitly correspond to specific challenges for evaluation.
2. **Implementation Intensity (Legal Mandate of Provisions)**
   Kabisch et al. (2016): pointed out that many urban Nature-based Solutions (NbS) measures are merely recommendatory provisions, resulting in low implementation rates.
   Gómez Martín et al. (2020): encouraged planning documents to include clearly action-oriented clauses corresponding to specific risks.
3. **Site-specific Identification (Implementation Potential)**
   In the study by Xie, L. and Bulkeley, H. (2020) within the Urban Nature Atlas (UNA), it is suggested that assessing the spatial specificity of NbS design holds a certain level of importance.
   San Jose et al., (2025) and Figueiredo Cardenia et al. (2022), when applying the SEA framework, emphasize that aligning Nature-based Solutions (NbS) with specific spatial locations leads to higher implementation potential. If the spatial areas are not explicitly defined, the likelihood of effective strategy implementation is reduced.

The analysis indicates that Gushan's NbS clauses concentrate on expanding urban green spaces. While this partly addresses ecological conservation, provisions for water management, blue–green corridor connectivity and biodiversity remain underdeveloped. Only 31% of clauses explicitly tackle climate risks, and most are advisory rather than legally binding. Although 70% specify particular locations, the overall profile is "moderate focus, low enforceability, high site specificity."

In Aozihdi, green space expansion also predominates, with additional clauses on water management reflecting stronger support for both total green cover and adaptive reuse of vacant sites. However, references to hydrological or heat risk measures are still few. About 58% of its clauses address climate challenges with moderate enforceability, and 85% name exact locations, yielding a "moderate focus, moderate enforceability, high site specificity" profile.

Overall, despite Kaohsiung's green energy ambitions, regulatory and local context responses need strengthening. The gap between Gushan and Aozihdi stems largely from differing legal enforceability: Aozihdi's higher proportion of mandatory, location specific clauses establishes a firmer implementation basis, whereas Gushan's advisory approach limits its potential. Accordingly, this study stresses that successful NbS adoption depends not only on spatial suitability but also on clear, enforceable institutional design. To this end, a comparative case analysis framework will examine clause types, implementation responsibilities, spatial clarity and strategic integration to pinpoint institutional bottlenecks and inform future policy refinements.

Table 5: Strategic Environmental Assessment Matrix

region	Assessment Dimensions of NbS Implementation (Regulatory Provisions)			General Description
A	Focus area	Project Intensity	regional identification	Although the location is clearly specified, the overall legal provisions lack sufficient enforceability, and there is still room for improvement in strategic focus.
	Actively expanding green spaces, but still insufficient in flood prevention and blue-green infrastructure integration.	Only about 31% of the provisions are legally binding regulations, resulting in relatively limited enforceability.	Only 69% of the provisions explicitly specify applicable locations (such as along the Love River, Shoushan, etc.).	
	◈ Moderate potential	◈ Low potential	◈ High Potential	
B	Emphasizes the enhancement of green spaces and considers stormwater retention, but still requires improvement in addressing hydrological risks.	Approximately 58% of the provisions are legally binding regulations, but there is still room for improvement in enforcement capacity.	85% of the regulations explicitly specify applicable locations (such as Aozihdi Forest Park).	The location is clearly specified, and the regulation has a moderate level of enforceability, but there is still room for improvement in strategic focus.
	◈ Moderate potential	◈ Moderate potential	◈ High Potential	

5. Discussion

5.1 International Case-Comparison Methodology

This study uses the Urban Nature Atlas (UNA) to identify an international city—Hamburg, Germany—with spatial characteristics and climate risks akin to those of Kaohsiung. Employing a case-comparison framework, it contrasts the two contexts to pinpoint local challenges in climate adaptation and urban resilience, extract policy-implementation lessons from Hamburg's successes, and reveal gaps in Kaohsiung's spatial planning, regulatory application, inter-agency collaboration and implementation resources, thereby bolstering the prospects for institutionalising NbS locally (Dignum et al., 2020).

5.2 International Case-Comparison Methodology

Hamburg's HafenCity, situated on the banks of the Elbe and formerly an industrial and port district, has been transformed into a high density, mixed use urban quarter. Its low lying topography and extensive impermeable surfaces have long exposed it to flooding and the threats posed by extreme rainfall under climate change, while ecological restoration and infrastructure renewal remain challenging.

The proliferation of dense housing and infrastructure has dramatically increased surface runoff, overwhelming the city's drainage systems; coupled with increasingly frequent and intense downpours, this exacerbates urban inundation, surface water flooding and water pollution risks. In response, in 2009 the City of Hamburg and the municipal water utility, HAMBURG WASSER, launched the RISA (RegenInfraStrukturAnpassung) programme to establish an integrated, nature based stormwater management system. RISA's objectives are to restore the city's natural hydrological balance, boost on site rainwater retention and infiltration, enhance flood resilience, protect aquatic ecosystems and incorporate rainwater as a key element of urban design and green infrastructure. The initiative unfolded in four phases: in 2010, comprehensive risk analysis and climate scenario modelling; in 2011, the development of guiding principles to align stormwater policy with land use planning; pilot demonstrations of permeable pavements, green roofs and retention landscapes; and, in 2015, the publication of the Regenwasser 2030 Structural Plan, fully integrating stormwater policy into urban governance. A cross departmental framework brought together experts in urban planning, water engineering, transport and landscape architecture, supported by GIS based vulnerability mapping and site assessment tools to inform spatial prioritisation and policy design. Despite regulatory ambiguities, overlapping departmental responsibilities, varied site conditions and limited public engagement, RISA overcame implementation barriers through regulatory reinforcement and institutional transformation. Ultimately, the Regenwasser 2030 Plan became a milestone in Hamburg's evolution into a water sensitive city, demonstrating a systematic approach—from technical innovation and governance integration to regulatory reform and public education—that not only enhances urban climate resilience and spatial quality but also offers a highly replicable nature based water management model for other port and high density cities.

6. Institutional Comparison and Conclusions

Contrasts two institutional models for integrating NbS, focusing on governance integration, legal mandates and interdepartmental cooperation rather than spatial scale or project count. In Hamburg, the RISA system explicitly designates climate adaptation and water management as statutory, cross-departmental objectives, integrating land use, building regulations and drainage via the HafenCity Masterplan so that resilience underpins rather than merely embellishes urban planning(Table 6).

Table 6: Comparative Analysis of International Case Studies

Analytical dimension	(Aozihdi + GushanDistrict) (2019–2024)	Case: Germany RISA – Hamburg (2005-2015)
Major Types of Implemented Nature-based Solutions (NbS)	Urban parks and greening, greenway trails and corridors, permeable pavements, detention and stormwater management facilities, and building greening	Water Resource Management Green Spaces and Sustainable Urban Drainage Systems.
Implementation Instruments (Initial Institutional Arrangement)	Urban planning, urban renewal, and BOT implementation have not yet established an integrated stormwater management tool.	Project-Oriented Climate Adaptation Plan and Spatial Integration HafenCity Masterplan + RISA System (Rainwater Adaptation Platform).
Regulatory and Planning Integration	Although the concept has been incorporated into detailed plans, there is a lack of legally established NbS indicators and institutionalized financial support.	Explicitly incorporate into the Urban Planning Act and Building Act, establish a stormwater management fund and development obligation mechanism.
Implementation approach	Low level of departmental integration, primarily driven by urban development agencies; community participation is preliminary or unclear.	Establish the RISA coordination platform to enable cross-sectoral integration (including environmental protection, water resources, urban planning, real estate developers, and communities).
Key Development Priorities	Some spaces show potential (such as green buildings), but all are implemented through general green infrastructure.	Integrate data-driven engineering and land policies, and provide pilot implementations as models for other cities to follow.

In Kaohsiung, by contrast, NbS measures such as greening, retention basins and permeable paving remain at case-by-case or advocacy stages, lacking clear legal status, mandatory standards or defined responsibilities; departmental collaboration platforms (e.g. urban development, water, environment and construction) are undeveloped and agencies largely act independently, preventing systemic benefits. Kaohsiung's planning framework also lacks the technical integration and task-oriented governance exemplified by Hamburg's institutional platforms and pilot mechanisms. This analysis not only exposes Kaohsiung's governance bottlenecks but also offers transferrable lessons from international practice to inform policy innovation and deepen institutional capacity. Success will require elevating NbS from planning tool to statutory core by setting explicit targets and tasks, establishing cross-departmental governance structures, enacting regulatory frameworks and spatial instruments, and involving stakeholders at all levels, thereby enabling Taiwan's urban planning system to achieve a truly nature-based, sustainable and climate-adaptive transformation.

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Legal Pathways for Urban Mobility Resilience : A Content Analysis of Policy Documents for Istanbul's Transport Systems

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Abstract
Urban transport systems face escalating disruption risks by challenging resilience in megacities like Istanbul. This study systematically evaluates the presence and coherence of resilience-related strategies across multiple policy levels within Istanbul's transportation policy and legislative frameworks. Employing content analysis on 14 national and 21 local policy documents, main policy themes and granular sub-themes were first identified. Benchmarks for urban mobility resilience were then developed. Subsequently, these benchmarks were applied to assess gaps within each identified main policy theme across both national and local documents. The analysis reveals critical policy gaps which highlight inconsistencies. Our findings pinpoint areas for legal and policy reform to strengthen Istanbul's transport resilience against increasing threats, which ensures system continuity and public safety.

Keywords: content analysis, disaster preparedness, Istanbul's transportation system, policy frameworks, urban mobility resilience

Introduction

The increasing vulnerability of urban transport systems to both natural hazards and human-induced disruptions poses a critical challenge for modern cities. Urban areas, as hubs of economic, social, and infrastructural complexity, rely heavily on effective and resilient transport systems to maintain their functionality during and after disruptive events. As climate change intensifies the frequency and severity of extreme weather events, such as floods and earthquakes, ensuring the resilience of transport systems becomes a key priority in urban sustainability efforts (Priolo et al., 2023).

The problem addressed by this research is the insufficient integration of disaster risk preparedness within the existing legislative and policy frameworks for urban transport planning. Despite the importance of resilience in maintaining urban functionality, many transport systems remain vulnerable to cascading failures due to inadequate coordination between policy frameworks, infrastructure design, and disaster risk management strategies (Mattsson and Jenelius, 2015). This gap poses significant risks, especially in highly urbanized regions such as Istanbul, which faces both seismic threats and climate-related hazards (Priolo et al., 2023). Transport network disruptions can paralyze entire regions, which leads to severe economic losses, compromised public safety, and disruptions in essential services.

Transport networks are interconnected with other critical infrastructure systems which amplify the consequences of their failure (Yang et al., 2022). As cities continue to grow and densify, particularly in hazard-prone regions, addressing these vulnerabilities by assessing the content and structure of current policies at various governance levels becomes essential for sustainable urban development and public safety.

This paper aims to answer the following questions:
1. Which governance strategies and interventions are most effective for enhancing disaster resilience in urban transport systems?
2. How are disaster preparedness and resilience integrated into Istanbul's transport policy and legislative frameworks by examining the distribution of efforts across different policy levels and key thematic areas?

The primary objectives of this research are to systematically map and analyze the extent to which Istanbul's transport policies address disaster preparedness and resilience, including a detailed thematic breakdown of policy provisions at national and local scales. This study also seeks to identify critical gaps and areas for improvement in existing policies based on this internal analysis while proposing strategic recommendations for

enhancing Istanbul's transport resilience through integrated planning and policy adjustments. Ultimately, this research contributes to the broader discourse on resilient urban systems by emphasizing the role of transport infrastructure in disaster risk reduction and by providing a detailed examination of a major city's policy landscape by offering insights for policymakers aiming to enhance urban resilience. Interpretations regarding international perspectives are also discussed in the conclusion to contextualize the findings. The following section will focus on establishing a theoretical foundation by exploring key concepts, metrics, and international frameworks for transport system resilience within policy frameworks.

Understanding Transport System Resilience: Key Theories and Metrics

Transport resilience theory provides a conceptual basis for understanding how urban transport systems can withstand and recover from disruptions caused by natural disasters, climate events, and human-induced crises. Resilience, in this context, refers to the capacity of a system to resist, absorb, adapt to, and recover from external shocks while continuing to provide essential services (Bešinović, 2020). The resilience of this underlying transport system is a critical determinant of broader mobility resilience, which concerns the ability of individuals and goods to maintain necessary movement and access during and after such events.

The concept has evolved from ecological and systems theory, with Holling (1973) introducing resilience as a system's ability to absorb disturbances without shifting to a different functional state. Bruneau et al. (2003) expanded this understanding in infrastructure systems by defining the "4R" framework of robustness, redundancy, resourcefulness, and rapidity as key attributes of resilience in critical infrastructure.

Robustness refers to a transport system's ability to endure disruptions without significant performance degradation while redundancy involves the availability of alternative routes and transport modes to ensure service continuity during disruptions. Resourcefulness captures the capacity to mobilize resources and implement strategies for crisis response, and rapidity highlights the system's ability to restore normal operations quickly following disruptions (Bruneau et al., 2003; Bešinović, 2020). These dimensions together define the structural and operational stability of transport networks under stress, which directly impacts the continuity of mobility for the urban population.

Resilience indicators are essential tools for measuring and evaluating how effectively a transport system manages disruptions and, consequently, supports sustained mobility. These indicators can be categorized across three critical phases of disruption management: pre-event, during-event, and post-event capacities. Pre-event indicators assess proactive measures like risk assessments, disaster mitigation strategies, and infrastructure design for hazard resistance (Yang et al., 2022). During-event indicators evaluate absorptive capacity, focusing on network capacity, travel delays, and the availability of alternative routes while a disruption occurs (Murray-Tuite, 2006; Leobons et al., 2019). Post-event indicators measure recovery effectiveness by examining how quickly and efficiently normal operations are restored and whether long-term disruptions to overall mobility are minimized (Yang et al., 2022).

Transport resilience also operates across multiple dimensions that reflect the diverse aspects of urban mobility systems. Physical resilience pertains to the structural integrity and durability of infrastructure against hazards like floods and earthquakes. Operational resilience deals with maintaining service functionality and minimizing disruptions during crises. Social resilience ensures equitable access to mobility and protection for vulnerable populations, while economic resilience focuses on minimizing financial losses and ensuring recovery funding. Governance and policy resilience, though explored separately in the next section of the literature review, plays a crucial role in supporting effective resilience planning and implementation that ultimately enhances mobility for all users (Yang et al., 2022; Mattsson and Jenelius, 2015).

The theoretical principles of transport resilience, including the "4R" framework, resilience indicators, and multi-dimensional analysis, will form the foundation for the content analysis of Istanbul's transport policy documents in this study. This theoretical basis will assist in developing coding categories for assessing how well disaster preparedness and strategies for achieving mobility resilience are integrated into the city's transport policies and will contribute to identifying existing gaps and areas for improvement.

International Policy Frameworks for Transport Resilience: Implications for Istanbul, Türkiye

In response to growing challenges posed by climate change, rapid urbanization, and increasing natural and man-made disasters, various international frameworks have been developed to guide cities in enhancing the resilience of their transport systems. These frameworks emphasize proactive risk reduction, sustainability, and equitable urban mobility, recognizing that resilient transport systems are essential for maintaining the functionality of urban areas during and after disruptive events. This section reviews key international frameworks and strategies that serve as foundational references for operationalizing transport resilience strategies in urban mobility planning.

The Sendai Framework for Disaster Risk Reduction (2015-2030) is a global standard emphasizing proactive disaster risk management. It outlines four key priorities for action: understanding disaster risk, strengthening disaster risk governance, investing in disaster risk reduction, and enhancing disaster preparedness for effective response and recovery. Within transport resilience, the framework calls for the integration of risk reduction principles into infrastructure planning and the reinforcement of critical infrastructure such as transportation networks to withstand extreme events. The Sendai Framework stresses the importance of multi-level governance and coordination among policymakers, planners, and emergency responders (UNDRR, 2015).

Complementing the Sendai Framework, the European Green Deal (2019) provides a comprehensive policy roadmap aimed at achieving climate neutrality by 2050. A core component is the reduction of transport-related emissions by 90% while promoting sustainable and resilient mobility systems. The Green Deal underscores the dual need for both climate change mitigation—through emission reductions—and adaptation, ensuring urban infrastructure, including transport systems, can withstand climate impacts such as floods and heatwaves. It also emphasizes multimodal and low-emission transport networks, urging the adoption of clean energy technologies and digitalization to support sustainable urban mobility (European Commission, 2019).

Building on these climate resilience goals, the EU Urban Agenda and its associated Transport Resilience Guidelines further operationalize resilience by providing detailed frameworks for city-level transport planning. The Urban Agenda fosters cooperation among member states, cities, and stakeholders to improve the quality of life in urban areas through integrated planning processes. The guidelines encourage cities to adopt Sustainable Urban Mobility Plans (SUMPs) that integrate disaster risk reduction measures into their transport strategies. They emphasize risk-informed decision-making, stakeholder engagement, and the need for cities to align transport resilience efforts with broader sustainability goals, such as those outlined in the Sustainable Development Goals (European Commission, 2021).

A significant contribution to the resilience planning discourse is the 100 Resilient Cities Initiative (100RC), which introduced seven key principles for urban resilience: reflectiveness, robustness, redundancy, flexibility, resourcefulness, inclusiveness, and integration. Applied to urban mobility, these principles guide the development of systems that can withstand and recover from shocks while maintaining essential services. Cities like Rotterdam and Singapore have implemented these principles by investing in modular infrastructure, data-driven flood management systems, and flexible public transit networks that can adapt during crises (100 Resilient Cities, 2015).

The CIVITAS Initiative and its publication Planning for More Resilient and Robust Urban Mobility offers further strategic guidance by integrating resilience principles into Sustainable Urban Mobility Planning (SUMP) processes. The guide emphasizes the importance of preparedness, risk assessment, and policy coherence across multiple governance levels. It also promotes measures such as multimodal networks, improved public transport integration, and the use of climate-resilient materials in infrastructure development (POLIS & Rupprecht Consult, 2021).

Finally, the Sustainable and Smart Mobility Strategy by the European Commission presents a forward-looking roadmap for the transport sector, aligning with the European Green Deal's goals. It emphasizes digital transformation, climate adaptation, and crisis preparedness. Key strategies include promoting multimodal transport hubs, expanding low-emission zones, and incorporating climate risk assessment tools into infrastructure planning processes. The strategy highlights the need for both long-term systemic transformation and short-term adaptive measures in urban mobility planning (European Commission, 2021).

While these global frameworks provide a cohesive set of principles and strategies for operationalizing transport resilience and emphasize integrated governance, proactive risk management, sustainability, and equitable mobility access, their application must be contextualized for local challenges. The Turkish context, in particular, underscores the importance of aligning these international principles with local disaster risk profiles. Türkiye faces unique vulnerabilities due to rapid urbanization, geographical exposure to seismic activity, and an ageing infrastructure system. Istanbul, as one of Türkiye's most densely populated urban centers, is highly exposed to disasters such as earthquakes and flash floods. Its location along the North Anatolian Fault, combined with increasing extreme weather events, creates complex challenges for its urban transport systems. Historical disasters such as the 1999 Marmara earthquake and recurrent flooding events have revealed systemic vulnerabilities in Istanbul's transport infrastructure, emphasizing the urgent need for a more resilient and adaptive mobility strategy (POLIS & Rupprecht Consult, 2021).

In recent years, Istanbul has initiated critical efforts to improve transport resilience, including seismic retrofitting of key infrastructures and the adoption of GIS-based disaster monitoring tools. However, significant gaps may still exist when considering comprehensive approaches to resilience, such as fully integrating principles like inclusiveness, ensuring vulnerable populations are prioritized in emergency transport planning, and flexibility, which involves creating alternative routes and modes of transport to maintain mobility under extreme conditions. The principles established in the international frameworks discussed above provide valuable insights that can help contextualize and inform the assessment of Istanbul's transport policies.

This review of theoretical background and international policy frameworks sets the stage for a detailed examination of Istanbul's own policy landscape. The insights gleaned from these global perspectives, combined with the theoretical understanding of resilience, will help frame the subsequent content analysis of Istanbul's transport policy documents. The next section will delve into Istanbul's current policy framework while the methodology will outline how its legislative frameworks will be analyzed to identify policy gaps and areas for strategic improvement in disaster risk reduction and resilient urban mobility planning based on its inherent characteristics and stated goals.

Istanbul's Current Policy Framework for Resilient Mobility: Opportunities, Gaps, and Limitations

Istanbul's urban mobility systems are critical not only for ensuring the city's daily operations but also for maintaining public safety and economic stability during and after crises. As a megacity located on the North Anatolian Fault and exposed to significant climate-related risks such as flooding and landslides, Istanbul faces unique challenges that make disaster resilience an essential focus. Rapid urbanization, aging infrastructure, and high population density further compound these risks, which places immense pressure on its transportation networks. These vulnerabilities highlight the importance of developing an integrated mobility resilience framework, as the ability to ensure the continuity of transport networks during disruptions is fundamental to safeguarding lives and enabling recovery efforts.

The policy framework governing Istanbul's mobility resilience is shaped by a combination of national and local strategies. At the national level, directives such as the National Earthquake Strategy and Action Plan (NESAP) and the Türkiye Disaster Risk Reduction Plan (TDRRP) provide overarching guidelines for disaster preparedness and risk reduction. These documents emphasize critical measures such as retrofitting transport infrastructure by establishing emergency logistics hubs, and integrating disaster response protocols into urban planning (IMM, 2024). Locally, the Istanbul Metropolitan Municipality (IMM) plays a pivotal role in implementing these strategies through initiatives like the Istanbul Provincial Disaster Risk Reduction Plan (IPDRRP) and the Istanbul Climate Change Action Plan (CCAP). IMM's Disaster Coordination Centre (AKOM) has key efforts to retrofit key transport structures, develop emergency evacuation routes, and deploy Geographic Information Systems (GIS) for real-time disaster monitoring (AKOM, 2024).

Despite these initiatives, Istanbul's mobility resilience framework faces significant gaps and limitations. Coordination between national and local entities, though formalized, is often fragmented. Overlapping responsibilities between institutions like IMM, the Disaster and Emergency Management Presidency (AFAD),

and district municipalities have led to delays in the implementation of resilience measures (IMM, 2024). Informal settlements, which house a large portion of Istanbul's vulnerable populations, remain inadequately integrated into disaster planning.

These settlements are frequently located in flood-prone or seismically vulnerable areas and lack access to critical infrastructure and emergency resources, leaving residents disproportionately exposed to risks (IPDRRP, 2024).

Technological advancements have introduced opportunities to enhance Istanbul's disaster preparedness. For example, the adoption of GIS and Intelligent Transport Systems (ITS) has improved real-time monitoring and enabled better emergency traffic management. However, the lack of centralized data-sharing platforms limits the integration of these tools across institutions, which impeds effective decision-making (IMM, 2024). While Early Warning Systems for earthquakes and floods are under development, their implementation remains inconsistent, with significant room for improvement. Additionally, partnerships with international organizations, such as the World Bank and the European Bank for Reconstruction and Development (EBRD), have supported projects like the Istanbul Seismic Risk Mitigation and Emergency Preparedness (ISMEP) initiative, which has funded retrofitting and resilience measures for key public and transport infrastructure. Yet, these efforts have not been sufficient to address long-term funding needs, particularly for underserved areas (ISMEP, 2024).

The challenges faced by Istanbul's mobility resilience framework are symbolic of the broader issues encountered by rapidly urbanizing cities with high disaster risk profiles. In the context of this paper, In the context of this study, Istanbul serves as an essential example of how disaster preparedness and resilience can be integrated into mobility systems. Its experiences demonstrate that while technological advancements and international partnerships can support progress, sustainable resilience requires a cohesive policy framework that bridges gaps between national and local strategies. By analyzing Istanbul's mobility resilience framework, this research contributes to broader efforts to improve disaster preparedness in urban contexts, offering policymakers actionable recommendations for creating more adaptive and inclusive cities.

Methodology

This study employs a qualitative content analysis approach to analyze Istanbul's transport policy landscape by focusing on how disaster preparedness and mobility resilience are addressed across different policy levels and thematic areas. The aim is to map the presence and distribution of key resilience-related themes within selected national and local policy documents, ultimately visualizing these relationships to understand current policy emphases and potential gaps.

The dataset for this research comprises a comprehensive collection of 35 policy documents including 14 national-level (coded N1-N14) and 21 local-level (coded L1-L21) texts, selected for their direct relevance to disaster resilience, mobility preparedness, urban planning, and transport strategies pertinent to Istanbul. The initial identification of this collection of documents was based on two key deliverables of the Istanbul SUMP Stage II project: the Inception Report and the Analysis of Current Planning Practices. These documents, sourced from official government portals and institutional repositories, span a wide temporal range and cover both strategic frameworks and operational plans to ensure a comprehensive overview of governance approaches (Table 1). As acknowledged within the source project, this foundational list may be further enriched during related pilot initiatives such as the one focused on Istanbul's earthquake and flood risks (Pilot Project 5.5.1), which the first author is involved in.

Table 1. The list of selected policy documents

Document Code	Document Title	Year
N1	The Twelfth Development Plan	2024-2028
N2	Annual Presidential Programme 2025	2025
N3	Transport and Logistics Master Plan 2053	2053
N4	National Earthquake Strategy and Action Plan (NESAP)	2012 – 2023
N5	Türkiye Disaster Risk Reduction Plan (TDRRP)	2022 – 2030
N6	National Transportation Master Plan 2035	2017
N7	Türkiye Disaster Response Plan (TDRP)	2012 – 2023
N8	Road Traffic Safety Strategy Document and Action Plan	2021-2030
N9	National Intelligent Transportation Systems Strategy Document and Action Plan	2020-2023
N10	Accessible Transportation Strategy and Action Plan	2021-2025
N11	Türkiye Bicycle Route Network Master Plan	2021
N12	National Climate Change Action Plan	2010-2023
N13	Green Deal Action Plan of Türkiye	2021
N14	Integrated Urban Development Strategy and Action Plan (KENTGES)	2010-2023
L1	Istanbul Metropolitan Municipality Strategic Plan	2020-2024
L2	Istanbul Vision 2050 Strategy	2023-2050
L3	Istanbul SUMP I	2050
L4	Istanbul Provincial Disaster Risk Reduction Plan (IPDRRP)	2022
L5	Istanbul Provincial Disaster Logistic Plan	2013
L6	Istanbul Debris Management Plan Report	2021
L7	Fleet Management Emergency Action Plan	2018
L8	Istanbul Transportation Master Plan	2011
L9	Istanbul Public Transportation Master Plan	2019
L10	Marmara Region Spatial Development Strategic Framework	2030
L11	Istanbul Traffic Safety Master Plan	2016
L12	Istanbul Urban Transformation Strategy and Action Plan	2015-2025
L13	Istanbul Provincial Disaster Response Plan (IPDRP)	2019
L14	Istanbul Logistics Master Plan	2018
L15	Istanbul Local Level Disaster Evacuation and Relocation Planning Group Operational Plan	2024
L16	Istanbul Pedestrian Transportation Master Plan	2011
L17	Istanbul Bicycle Master Plan	2020
L18	Istanbul Parking Master Plan	2022
L19	Traffic Demand Management Plan for Historic Old City	2014
L20	Istanbul Climate Change Action Plan	2021 (2030-2050)
L21	Istanbul Green City Action Plan (GCAP) (Draft)	2025-2030

MAXQDA software was utilized primarily for efficient document management, facilitating navigation through the extensive dataset, searching for specific keywords and concepts related to resilience, and annotating relevant sections within the policy texts to support the thematic analysis. The core analytical process was developed through a two-stage process. First, a hybrid inductive-deductive thematic analysis was conducted, which results in featured main themes and granular sub-themes. To move beyond thematic identification to a critical evaluation, a five-point ordinal scale was then developed to serve as a benchmark for assessing policy gaps.

This scale utilizes a graduated color scheme to visually represent the strength of policy articulation for each main theme. The color intensity progresses across the five-point scale, where the lightest indicates no relevant or only an indirect strategy, and the darkest signifies the highest level of policy actionability and strenght with an identifiable strategy supported by a defined performance indicator. The findings from this thematic mapping and visualization are then interpreted to identify patterns, current priorities, and potential areas for strengthening Istanbul's overall approach to resilient mobility.

Findings and Results

The policy landscape governing Istanbul's urban mobility resilience is a complex interplay of national directives and local implementation. The flow of policy focus, which provides a comprehensive visualization of the relationships between the two policy levels, 8 main themes identified in this study, and 30 granular sub-themes are mapped out with an alluvial diagram (Figure 1). The width of each flow is proportional to the intensity of policy attention, which allows for a visual assessment of strategic priorities, areas of convergence, and critical gaps.

The diagram immediately reveals a clear division of labor between the national and local policy levels. The national level predominantly focuses on establishing high-level frameworks and standards. A significant portion of its policy output streams into the themes of "National Strategic Frameworks & Standards" and "Disaster Specific Operations & Local Resilience". This flow further breaks down into granular sub-themes such as "NatDisasterFrameworks" (e.g., TDRP, TDRRP), "LongTermTransportVision" (e.g., Vision 2053), and setting national "TransportSafetyStandards" and "EvacRouteDesignStds". This pattern underscores the national role in setting the overarching strategic direction and legal foundation for disaster management and transport planning across the country.

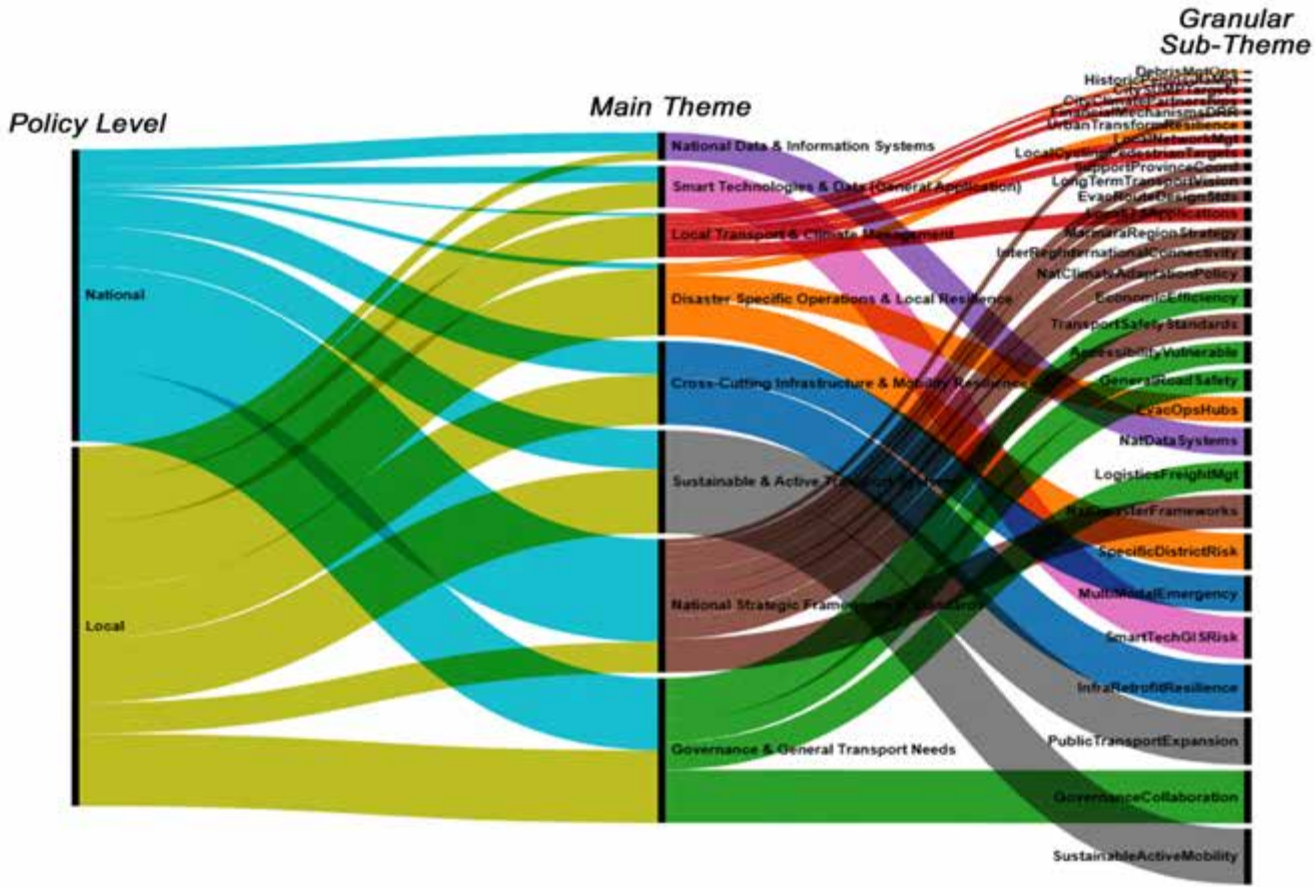

Figure 1. Alluvial diagram of main themes and granular sub-themes of national and local level policy documents (created by authors)

Conversely, the local policy level is overwhelmingly focused on governance, service delivery, and on-the-ground implementation specific to Istanbul. The two largest streams originating from the local level are directed toward "Governance & General Transport Needs" and "Sustainable & Active Transport Systems". These flows are linked to highly operational sub-themes like "PublicTransportExpansion," "GovernanceCollaboration," and "SustainableActiveMobility," which reflects the municipality's direct responsibility for managing and expanding public transport by engaging with stakeholders, and promoting green mobility. Furthermore, the local level's focus on place-based solutions is evident in sub-themes such as "CitySUMPTargets" and "LocalCyclingPedestrianTargets," which are fed exclusively by the local policy stream.

While there is a clear divergence in primary roles, the diagram also highlights crucial areas of convergence. The 'Disaster Specific Operations & Local Resilience' theme is a key area of shared responsibility, receiving significant policy attention from both national and local levels. This combined flow addresses a wide array of sub-themes, including "MultiModalEmergency" operations, identifying "SpecificDistrictRisk," and establishing "EvacOpsHubs," indicating a necessary collaboration in crisis management. Similarly, "Cross-Cutting Infrastructure & Mobility Resilience" is another area of mutual focus, channeling policy effort into the critical sub-theme of "InfraRetrofitResilience" for key transport assets.

Most importantly, the diagram provides a stark visualization of the strategic gaps identified in this research. A critical disconnect is visible between disaster planning and sustainability. There are no significant flows connecting the main theme of "Disaster Specific Operations" with sustainability-oriented sub-themes like "LocalCyclingPedestrianTargets." Likewise, the massive policy stream dedicated to "Sustainable & Active Transport Systems" does not meaningfully connect with disaster-related sub-themes, visually confirming that these two powerful policy agendas operate in parallel rather than in an integrated manner. This lack of integration represents a significant vulnerability in the overall resilience framework for Istanbul's transport system.

Investigating the source of this vulnerability requires a deeper analysis of the documents themselves, beginning at the national level. The analysis of 14 national policy documents reveals a foundational, yet incomplete, legal and strategic framework for strengthening the resilience of Istanbul's transport systems. The findings show a clear national trend toward data-driven governance and a dual focus on disaster resilience and sustainability. However, critical inconsistencies and gaps exist, which have direct consequences for a megacity like Istanbul (Figure 2).

A primary finding is the national shift towards measurable, evidence-based policymaking, which provides an essential foundation for Istanbul's resilience efforts. Recent cornerstone documents like the Twelfth Development Plan (N1) and the Annual Presidential Programme (N2) mandate the creation of national data systems such as the Infrastructure Information System (see Article 605.6) and the Disaster Management and Decision Support System (DMDS). These national systems provide the essential data landscape upon which Istanbul's municipal agencies must build their own resilience monitoring and decision-making tools. However, a significant gap is noted in TDRP (N7), which lacks a clear data analytics component by creating a potential challenge for Istanbul's integrated emergency management.

The national policy landscape is strongly shaped by two parallel strategic pillars: disaster resilience and sustainable mobility. The resilience pillar offers direct legal pathways for action in Istanbul. N1 includes a specific mandate to increase the resilience of critical infrastructure in the Marmara Region (see Article 838.1), directly targeting Istanbul. This is reinforced by the TDRRP (N5), which calls for making urban infrastructure earthquake resistant (see Action D.6.3), a core task for the city. Similarly, the sustainability pillar with its national goals for reduced emissions (Green Deal Action Plan, N13) and a 6000 kilometre expansion of bicycle routes (Bicycle Route Network Master Plan, N11), provides the strategic backing for Istanbul to advance its own green transport initiatives.

Despite the individual strength of these two areas, a critical inconsistency emerges where they fail to connect, a gap that creates a direct vulnerability for Istanbul. The analysis shows that national disaster response frameworks, particularly the TDRP (N7) and the NESAP (N4), do not integrate sustainable transport modes into their operational plans. This national-level oversight is highly problematic for a densely populated megacity like Istanbul, where alternative transport modes like bicycles could be vital for maintaining mobility and delivering aid when primary road networks are compromised during a disaster.

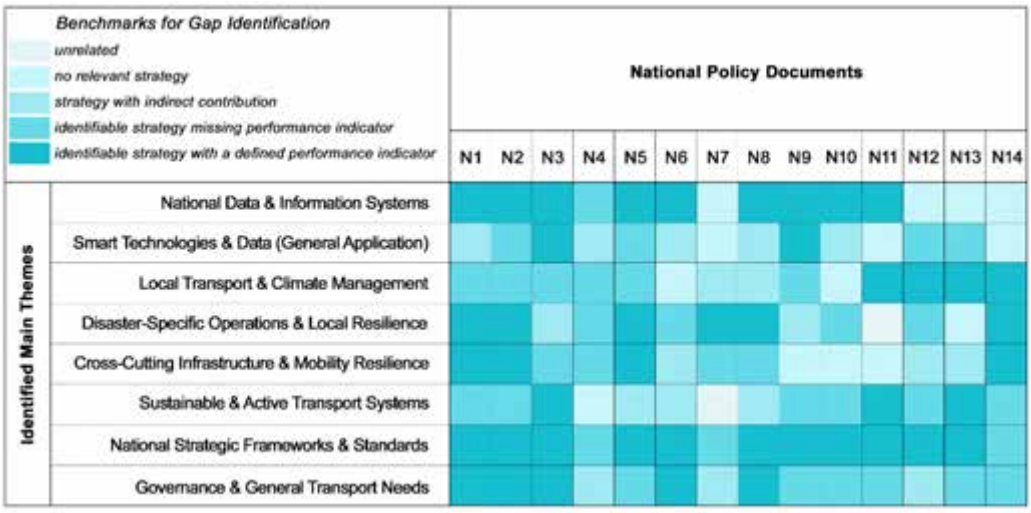

Figure 2. Assessment matrix for gap identification across national policy documents (created by authors)

The findings also highlight that while a clear policy evolution is underway, from older, non-metricized strategies like the NESAP to newer, key performance indicator-driven plans like the Twelfth Development Plan, the effectiveness of this national framework in protecting Istanbul hinges entirely on its translation into coherent local policy. National documents provide the top-down mandate, but their success depends on the creation of legally-binding, adequately funded, and technically sound municipal plans and actions. This points to the need for a deeper analysis of Istanbul's local documents to determine if these national strategies are being effectively implemented or if significant gaps in local legislation are undermining the city's transport resilience.

On the other hand, the analysis of 21 local policy and planning documents for Istanbul reveals a dynamic, ambitious, and highly operational policy environment. At this municipal level, strategic objectives are translated into actionable plans, which provide concrete legal pathways for enhancing urban mobility resilience. However, the analysis also uncovers significant inconsistencies, particularly in the integration of parallel policy streams, which creates vulnerabilities in the city's overall resilience framework. A defining characteristic of this local policy landscape is its robust and detailed approach to disaster operations (Figure 3).

The theme of 'Disaster-Specific Operations & Local Resilience' is exceptionally strong in the key operational plans. For instance, the IPDRRP (L4) moves beyond strategy to define measurable key performance indicators such as reduction in travel time during evacuation scenarios. This is further operationalized by the Istanbul Local Level Disaster Evacuation Operational Plan (L15), which provides granular detail on 204 transferring areas and additional 46 potential areas registered in DMDS for use during emergencies. Plans like the Istanbul Provincial Disaster Logistic Plan (L5), the Debris Management Plan (L6), and the Fleet Management Emergency Action Plan (L7) provide a comprehensive, multi-faceted framework for response and recovery, which indicates that Istanbul's legal and administrative capacity for managing a crisis is well-established and highly structured.

In parallel, the local documents demonstrate a powerful and measurable commitment to sustainable and active transport. This is a clear policy priority for the Istanbul Metropolitan Municipality (IMM). The IMM Strategic Plan (L1) sets ambitious, quantifiable targets such as increasing the total cycling infrastructure length from 266 km to 1,050 km and raising the share of rail transport in public transit from 20.6% to 30%. This vision is reinforced by dedicated documents like the Istanbul SUMP I (L3), the Istanbul Cycling Master Plan (L8), and the Pedestrian Master Plan (L9), all of which have identifiable strategies with a defined performance indicators for their core sustainability objectives.

However, a critical policy gap emerges where these two priorities should intersect. The city's strong sustainability agenda operates largely in isolation from its disaster resilience framework. While documents like the Bicycle Master Plan (L17) and Pedestrian Master Plan (L16) excel in promoting active transport, their summaries contain little to no mention of how these networks could be leveraged during an emergency. For disaster-related

themes, these plans either offer only an indirect contribution or have no relevant strategy at all, which creates a significant inconsistency. This failure to integrate the two pillars means that the legal and operational potential of Istanbul's growing active transport network as a resilient mobility option during a crisis remains unrealized.

Beyond these core themes, Istanbul's local governance is data-rich. Many key documents including L1, L4, and IPDRP (L13) demonstrate exceptional strategic maturity by defining clear, measurable performance indicators for their focus on creating and integrating data systems such as performance monitoring platforms and GIS-based risk maps. However, the application of this data through smart technologies is less mature. While many plans mention leveraging technology, they often lack specific, measurable outcomes. For example, the Vision 2050 Strategy (L2) and L5 refer to integrating smart technologies and advanced analytics systems, but do not define how the success of these implementations will be measured. This suggests a gap between the city's capacity for data collection and its ability to systematically deploy that data for smart, resilient operations.

Furthermore, the analysis reveals a mixed approach to vertical policy coherence. The city's disaster-specific plans (L4, L13, L15) show strong alignment with national frameworks by explicitly referencing documents like the TDRP. This formal, documented alignment provides a clear and measurable legal pathway for coordinated national-local disaster response. In contrast, most other local strategic documents including L1, L3, and various master plans, do not explicitly reference their alignment with corresponding national strategies. They operate in parallel with national goals rather than being formally nested within them, which results in what this study classifies as an indirect contribution. This suggests a potential gap in legal and administrative coherence, where ambitious local initiatives may not be fully harmonized with the broader national strategic direction, potentially leading to inconsistencies in long-term implementation. In summary, Istanbul's local policy landscape provides strong legal pathways for operational disaster response and sustainable transport. However, the findings pinpoint a critical need for policy reform to bridge the gap between sustainability and resilience planning. Integrating these two domains and ensuring greater vertical coherence between local and national frameworks are essential next steps to strengthen the resilience of Istanbul's transport systems against future disruptions.

Figure 3. Assessment matrix for gap identification across local policy documents (created by authors)

Conclusion

This study embarked on a thematic content analysis to evaluate the legal and strategic pathways for urban mobility resilience within the complex policy landscape governing Istanbul. By examining 35 national and local documents, the research aimed to map the coherence of resilience-related strategies, identify critical policy gaps, and pinpoint areas. The analysis confirms that while Istanbul possesses a sophisticated and highly operational policy environment for both disaster management and sustainable transport, significant vulnerabilities arise from the lack of integration between these two powerful, yet parallel, policy agendas.

The findings reveal a clear division of responsibility: national policies provide the foundational legal frameworks while local policies focus on operationalization. National documents such as the NESAP and the TDRRP establish

a strong mandate for resilience by emphasizing the retrofitting of critical transport infrastructure. At the local level, this translates into exceptionally robust and detailed operational plans such as the IPDRRP, which defines measurable key performance indicators like reduction in travel time during evacuation scenarios, and the Debris Management Plan, which outlines post-disaster logistics. Simultaneously, both policy levels demonstrate a powerful commitment to sustainable mobility. National documents like the Green Deal Action Plan and the Bicycle Route Network Master Plan set ambitious targets for emissions reduction and a 6,000-kilometre expansion of cycling routes. This is mirrored locally by the IMM Strategic Plan, which aims to increase cycling infrastructure from 266 km to 1,050 km, and by a suite of dedicated master plans for active transport. However, the most critical finding is the systemic failure to connect these two agendas. National disaster frameworks, particularly the TDRP, do not integrate sustainable transport modes into operational plans and assign municipalities limited direct responsibility. This national-level oversight is replicated locally, where active transport plans for cycling and pedestrians show little to no consideration for their potential role during emergencies.

These findings hold significant implications when contextualized within the international frameworks and theoretical principles of resilience. The strong multi-level governance structure for disaster planning in Istanbul aligns well with the priorities of the Sendai Framework for Disaster Risk Reduction, which emphasizes coordinated action across administrative levels. The city's detailed operational plans also reflect key attributes of the "4R" framework, particularly in building robustness through infrastructure retrofitting and ensuring resourcefulness through pre-planned crisis management. However, the lack of integration of active transport highlights a critical weakness in achieving redundancy and flexibility. Furthermore, while Istanbul's ambitious sustainability goals are consistent with the European Green Deal and SUMP principles, the analysis reveals that the city has not yet fully realized the integrated approach these frameworks advocate, where disaster risk reduction is a core component of sustainable mobility planning, not a separate activity.

To bridge these identified gaps and strengthen the legal pathways for resilience, this study proposes several key policy recommendations. This requires amending national frameworks like the TDRP to explicitly include roles for non-motorized transport in emergency response and mandating that local active transport plans incorporate disaster preparedness scenarios. Second, vertical policy coherence must be strengthened. While local disaster plans show strong alignment with national directives, other strategic documents like the IMM Strategic Plan operate in parallel, formalizing the alignment of all local strategies with national goals is essential. Finally, to bridge the gap between data collection and action, investment is needed in integrated smart city platforms that can utilize real-time data for both daily traffic management and dynamic crisis response.

While this study provides a comprehensive analysis of the policy landscape, it is limited to the content of the documents themselves and does not assess their on-the-ground implementation. Future research should therefore focus on evaluating the effectiveness of these policies through case studies and assessing the allocation of financial and human resources. Further studies could also explore the perceptions and preparedness of vulnerable communities to determine if these top-down strategies are effectively reaching those most at risk.

In brief, this research demonstrates that building urban mobility resilience in a megacity like Istanbul is not merely a technical or infrastructural challenge, but a profound issue of policy integration and governance. Closing the documented gaps between disaster planning and sustainable mobility is essential for creating a transport system that can not only withstand future shocks but also continue to serve the needs of all its citizens by providing system continuity and public safety against increasing threats.

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Legislative innovations in times of crisis. The proposal for a new Italian law on territorial governance and the experimentation in the Marche Region

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Abstract
Within the current framework of territorial governance, new planning models are emerging, focused on urban regeneration, the reduction of soil consumption, and regulatory simplification. The legislative proposal put forward by INU and its implementation in the Marche Region represent a key step in the redefinition of Italian urban planning. These legislative instruments respond to the need to move beyond the traditional system and to address contemporary challenges, marking the beginning of a new phase oriented towards flexibility, sustainability, and the revitalisation of urban planning.This article reconstructs the historical, regulatory, and scientific development that led to the new proposal, examining the contributions that have emerged within the national and regional debate, and assessing the innovative scope of the Marche law as the first concrete experimentation of the INU model.

Keywords: territorial governance – urban planning – national reform – urban planning legislation – Marche Region;

1-Introduction

Through the reconstruction of a historical-critical account of the evolution of planning in Italy and of the main phases of territorial transformation, the aim is to highlight the discontinuities and persistences that continue to shape the institutional and planning framework of the country. This process culminates in the recent reform proposal, the "Law of Fundamental Principles and General Norms for Territorial Governance", drafted by the National Institute of Urban Planning (INU) in 2024.The INU's proposal has reactivated a significant area of reflection within the urban planning community, which, however, has never ceased to show concern for the need for a reform of territorial governance. Since 2022, a large part of the INU's efforts has been devoted to a systematic in-depth process, carried out through publications, public discussions, and conferences, leading to the presentation of the draft law in the Senate in July 2024. These activities have contributed to rekindling—and to some extent consolidating—the debate within the field of urban planning on the urgency of a new national law.

In the current context of debate—marked by a widespread consensus on the obsolescence of Urban Planning Law No. 1150/1942—a consolidated practice has emerged among various Italian regions, aimed at updating their planning systems through autonomous regional legislation. In this scenario, the significant legislative development of the Marche Region has adopted a regulatory framework explicitly inspired by the proposal developed by the INU through Regional Law No. 19/2023[1]. Rooted in the principles promoted by the Institute, the Marche law opens up a further and significant field of inquiry, while also representing the first testing ground for the concrete implementation of the contents and guidelines set out in the national proposal.

The current interpretation of the Italian framework—characterised by autonomous regional legislative initiatives and by a new national reform proposal—does not represent an isolated process, but rather fits within a broader European context.In this scenario, European policy has gradually embraced urban regeneration, within the wider framework of sustainability, as a structural paradigm of its strategy, recognising its central role in processes of cohesion and competitiveness. It is with the Toledo Declaration of 2010 that the concept of integrated urban regeneration was introduced, based on a multidimensional and cross-cutting approach.

1 Regional Law No. 19 of 30 November 2023, Marche Region, Provisions on Planning for Territorial Governance.

Although it emerged in response to an economic and financial crisis affecting Europe, urban regeneration was proposed not only as a driver of development, but also as a tool to strengthen social cohesion and environmental sustainability (Giaimo, 2025a).

While the issue of urban planning appears to have "disappeared from the horizon of both politics and society" (Brenna, 2021, p. 61), a scientific community has gradually built a complex and substantial wealth of knowledge. This extensive body of thought and material highlights the innovations that have taken place in the field of planning and critically examines the progressive marginalisation of the discipline within public, political, and social debate.

Alongside the well-established contribution of the broad community of urban planners and architects—who have long been engaged in developing new instruments for territorial governance, experimenting with innovative planning models, and analysing regional legislation aimed at moving beyond the framework of Law No. 1150/1942—a significant contribution has also come from the legal community. The latter has addressed major issues such as the reform of Title V[2] of the Constitution and the current project for differentiated autonomy[3] for the Regions. Today, however, its focus is increasingly directed towards urban regeneration, conceived as "a set of actions, if not a true function, through which to guarantee both the right to the city and the tools necessary for urban life" (Giusti, 2021, p. 441).

In today's crisis scenario, marked by structural fragilities and ongoing uncertainties, the contribution evaluates the innovation within the ongoing debate both inside and outside the relevant scientific communities. It reflects on the role and potential revitalisation of urban planning within an institutional and social system undergoing profound transition.

2-Data And Methods

2.1 Methodology: Acquisition And Study Of Sources

For the definition of the state of the art and the reconstruction of the process that has accompanied the debate on territorial governance, the study began with an in-depth analysis of the two most recent regulatory references. These constitute the central core around which the proposal for a "*Law of fundamental principles and general rules for territorial governance and planning*,"[4] developed by INU, revolves, alongside the regional law of Marche, LR No. 19/2023.

The examination of the two texts allowed for the identification of the conceptual pillars and the paradigms that support them, as well as for the detection of convergences. In particular, even in an initial review, it was possible to recognise significant structural and substantive affinities, including:

- the redesign of planning instruments, notably with the introduction of the General Urban Plan (PUG) as a municipal tool structured around three functions: structural, regulatory, and operational;
- the adoption of inter-institutional co-planning as a collaborative method aimed at ensuring coherence and simplification across different planning levels;
- the adoption of the principle of coherence as a methodological criterion for the vertical and horizontal integration of planning content, understood as a relationship of functionality, efficiency, effectiveness, compatibility, consistency, and absence of contradictions among the various components;
- a redefinition of the concept of infrastructure and services, moving beyond an exclusively quantitative interpretation to also include qualitative and performance-based criteria;
- the enhancement of public-private partnership in planning processes;

2 The reform of Title V, Part II, of the Italian Constitution, implemented through Constitutional Law No. 3 of 2001, established territorial governance as a matter of concurrent competence between the State and the Regions.

3 Law No. 86 of 26 June 2024, containing provisions for the implementation of differentiated autonomy for Regions with ordinary statute, pursuant to Article 116, third paragraph, of the Constitution.

4 The draft law of the National Institute of Urban Planning, presented to the Senate on 16 July 2024, aims to replace Law No. 1150 of 1942.

- the establishment of an integrated knowledge framework, conceived as a shared and dynamic territorial database, serving as a technical-operational tool for planning and interoperability between entities;

- a broader definition of the concepts of soil consumption reduction and urban regeneration, considered foundational principles of contemporary urban planning.

Following the analysis of the two most recent legislative references and their evident and declared interconnection, the investigation focused on an in-depth study of the materials constituting the current debate surrounding them. In particular, it was considered essential to examine the sources reflecting the process of constructing the reform proposal, as well as the reflections and experiments associated with it.

Following the analysis of the two regulatory references and their evident and declared interconnection, the investigation focused on an in-depth examination of the working materials and sources related to them, which contributed to the process of developing the reform proposal. A large portion of these materials originates from the INU scientific community, specifically from the journal *Urbanistica Informazioni*. This journal has played a fundamental role in documenting and spreading the debate since 2022, the year in which, following the Bologna Congress, INU formally initiated the process of drafting the new legislative proposal.

Through a systematic analysis of the issues published, it has been possible to reconstruct the structure of the reasoning that accompanied the process of defining the national proposal, as well as the main contributions that have increased the reflection on regional planning. This collection of materials represents the most significant knowledge base to identify the principal conceptual trajectories and to highlight the structural weaknesses of the current planning system. These contributions have made it possible to identify the unresolved challenges and priority issues that the draft law aims to address and overcome through a renewed regulatory framework, while simultaneously offering an interpretative key to the elements characterising both the INU text and the Marche regional law. In particular, the following themes emerge:

- the intention to confer unity upon the national planning system, at the threshold of a new urban planning era;
- the updated, broad, and detailed definition of the concept of territorial governance, in line with contemporary needs;
- the development of planning instruments capable of effectively integrating the principles of urban regeneration and the reduction of land consumption;
- the overcoming of the obsolete regulatory framework of Urban Planning Law No. 1150/1942 and of the hierarchical-vertical model of territorial governance generated;
- the repeal of Ministerial Decree 1444/1968, particularly with regard to the regulation of urban standards;
- the resolution of the predictive rigidities inherent in traditional General Urban Plans (PRG), in favour of more flexible and adaptive planning.
-

Having identified the main themes emerging from the debate and their regulatory translation in the two aforementioned references (the INU proposal and the regional law of Marche), a more extensive review of the literature was undertaken. This review aimed to reconstruct, through a retrospective method, the evolution of the process that led to the current configuration of the debate. The investigation was conducted by selecting specific keywords: i) some relating to broad themes and general issues ("planning," "regional planning," "territorial governance," "regional laws," "urban reform," "planning tools"); ii) others more specific and linked to the current concerns of contemporary debate ("urban regeneration," "combating soil consumption," "structural plan," "urban equalisation").

Among the identified materials, contributions published in the last 15–20 years were considered. The subsequent selection was carried out through a preliminary reading of the abstracts, aimed at verifying their relevance to the research objectives and ensuring thematic coherence with the interpretative lines that had emerged.

From the contributions thus filtered, open access texts deemed most significant for reconstructing the main developments of the debate and the conceptual challenges leading to the current phase of proposal and regulatory experimentation were further explored and analysed.

2.2 Summary And Discussion Of The Issues Emerging

The in-depth study conducted on materials pertaining to the first area of investigation (i), related to territorial governance and planning in a general sense, enabled the reconstruction of a broad and complex evolutionary framework. The selected contributions, often focusing also on the genesis and analysis of regional laws, proved fundamental for identifying the main chronological sequences and outlining the normative and conceptual transformations that have affected the national planning system.Simultaneously, the investigation carried out in the second area (ii), centred on specific topics emerging from the current debate and identified through targeted keywords, produced more sectoral contributions which, although limited in scope, proved essential for integrating and completing the general framework reconstructed in the first field of investigation. This, in turn, contributed to the definition of a coherent, multi-level interpretative system.

The analysis of the collected scientific contributions highlighted a close correspondence between the phases of intensification in the disciplinary debate and certain significant historical and institutional turning points that shaped its content and interpretative directions. In particular, it was possible to identify four main time periods, each characterised by specific thematic focuses:

- **2000–2005:** In this initial phase, the focus of scientific output was predominantly on the INU's 1995 legislative proposal, which introduced elements of discontinuity compared to the traditional framework and stimulated significant reflections on the future of territorial governance. The debate took place within the broader context of institutional reform processes, culminating in the reform of Title V of the Constitution (2001), which redefined territorial governance as a concurrent matter between the State and the Regions. This encouraged the Regions to initiate autonomous legislative processes, incorporating some of the innovations proposed by the INU.
- **2005-2015:** This decade is marked by an intense scientific output focused on the analysis of the first new-generation regional laws and the experimentation with the planning models derived from them, with particular reference to the municipal scale. The innovations introduced during this phase represent the initial concrete experiences of reform, constituting a break from the traditional regulatory framework. The differences that emerged in the various approaches adopted at the regional level gave rise to a plurality of planning models, which the scientific community has considered important to examine.
- **2015-2020:** In this phase, a progressive sectorialisation of scientific interest can be observed, with growing attention towards new planning paradigms: urban regeneration, the containment of land consumption, and urban equalisation[5]. These themes are increasingly recognised as foundational to the so-called "fourth generation of urban planning". At the same time, the contribution of the legal community is gaining strength, initiating a structured reflection on the legal framing of these concepts and their systematic integration into the broader framework of territorial governance.
- **2020-2025:** The final identified time period is marked by a strong concentration of contributions attributable to the INU, following its commitment to draft a new national legislative proposal. The materials produced focus on the development of the fundamental principles of the reform, the analysis of the current system's critical issues, and the necessity to overcome its now obsolete legacies. During this period, visions oriented towards the comprehensive renewal of the regulatory framework are consolidated, increasingly clarifying the coordinates of the emerging new phase in urban planning.

Within the broader context of these publications, five main topics and research foci have been identified. These structure the following paragraphs with the aim of providing a critical synthesis of the state of the art:

i) The origins of the reform: territorial governance between the State and the Regions, and the INU legislative proposal of 1995.
ii) Initial reform experiences: regional models in Italy within the renewed planning system.
iii) Urban regeneration and the fight against soil consumption: paradigms of fourth-generation urban planning.
iv) Towards a new urban planning era? The contemporary scenario.
v) The INU proposal within Regional Law Marche 19/2023.

5 A tool for the fair distribution of development rights among landowners involved in urban transformation, overcoming the strict divide between buildable and non-buildable areas. It allocates proportional rights even to unaffected properties, preventing disparities and supporting the creation of the public city. Today, it plays a key role in urban regeneration strategies.

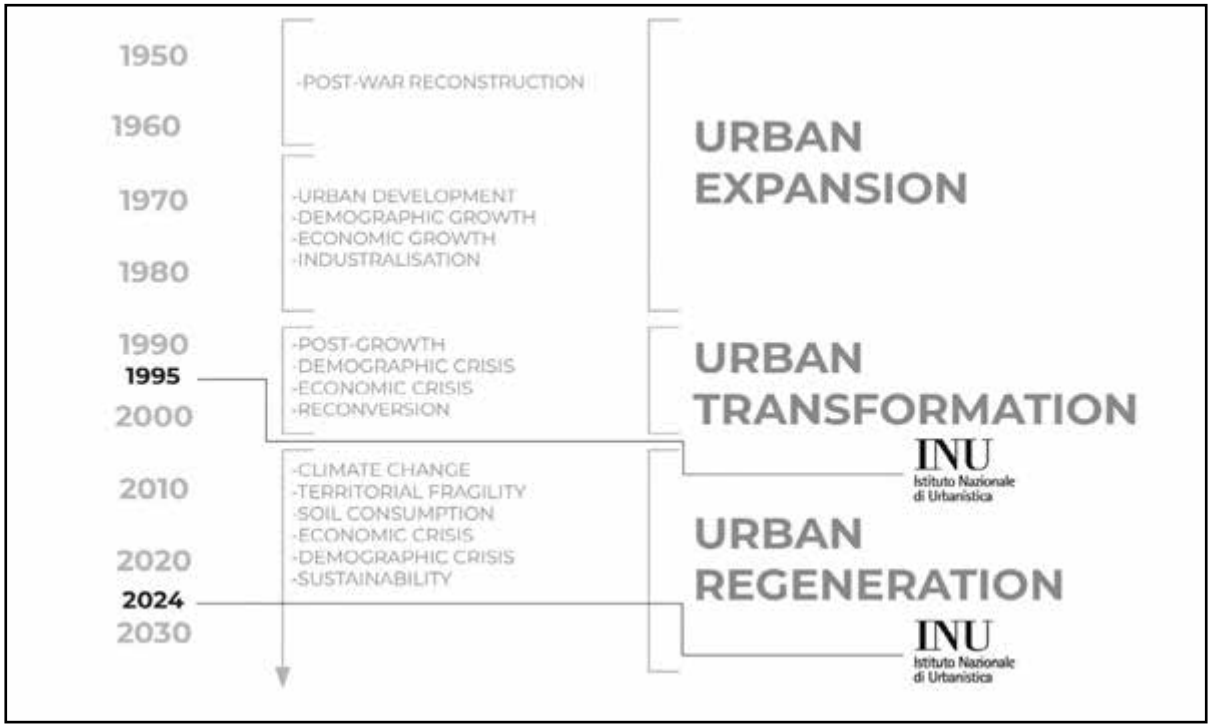

Fig.1 Main urban planning phases in the Italian context and the historical placement of the most significant INU reform proposals.

2.2.1- The origins of the reform: territorial governance between the State and the Regions, and the INU legislative proposal of 1995.

The 1990s mark a crucial turning point for territorial governance in Italy. This period is characterised by two main, parallel factors:

- The State's normative and institutional system, which expands the content of urban planning regulations and implements a gradual process of administrative decentralisation.
- A substantial shift in the needs and paradigms of urban planning, marked by a transition from "urban expansion" to "urban transformation."

Between 1970, the year of the establishment of the Regions[6], and the 1990s, the first regional laws on urban planning were developed. These are defined as "first-generation" laws because they merely paraphrased the contents of Law no. 1150/1942, without altering its conceptual and hierarchical framework. In the 1990s, however, a second cycle of reform began, marked by the emergence of "second-generation" regional laws that started introducing the first innovations in urban planning. Two key national legislative milestones facilitated this process. On one hand, Law no. 142/1990 on local autonomies, which acted as a framework law for the organisation of territorial authorities, assigning a central role to the Province, understood as an intermediate level of coordination between Municipalities and the Region.

On the other hand, a package of environmental laws contributed to this process, including Law no. 431/1985 (the Galasso Law), which, beyond protecting areas of particular environmental interest, introduced landscape planning; and Laws no. 183/1989 and no. 394/1991, which established, respectively, basin authorities and national parks, providing for the creation of entities endowed with managerial autonomy and their own planning instruments.

It is clear that, as a result of these processes, both the content and the very form and nature of urban planning instruments have been expanded, "significantly broadening the scope of action of the Regions and local

6 D.P.R. January 15, 1972, No. 8, Article 1: The administrative functions exercised by the central and peripheral bodies of the State concerning urban planning are transferred, for the respective territories, to the ordinary statute Regions.

autonomies to the point of integrating, within the same instruments—both at the territorial and urban planning levels—provisions for the territory, provisions for the landscape, and provisions for the environment" (De Luca, 2015, p.7).

This regulatory process is accompanied by a broader shift in national socio-economic conditions. During this phase, a progressive crisis of the General Regulatory Plan (PRG) becomes apparent—an instrument introduced by Law No. 1150/1942, which had governed and managed the urban expansion of cities in the post-war period. Faced with a new scenario transitioning from a phase of expansion to one of transformation, the PRG "appeared inadequate to address the new situations emerging, such as the increasing availability of disused industrial areas for reuse, the opportunities for the reconversion of old railway zones, historic port systems, and large public services, which had become central in the urban context but now obsolete" (Oliva, 2012, p.136). Indeed, the PRG showed clear signs of ineffectiveness, proving insufficient to respond to emerging situations. Critical elements were partly due to its excessive predictive rigidity and strong prescriptive character, a result of zoning. At the same time, to meet the growing needs for urban transformation, the approach of "derogatory interventions" was established in those years.

This was introduced by laws that created Urban Recovery Programs (Programmi di Recupero Urbano, PRU) with Law No. 493/1993 and Urban Redevelopment and Sustainable Territorial Development Programs (Programmi di Riqualificazione Urbana e di Sviluppo Sostenibile del Territorio, (PRUSST) (Ministerial Decree of 8 October 1998), following a logic where the project takes precedence over the plan.

Within a decade marked by significant institutional transformations and new territorial needs, the INU proposal of 1995 is situated. The main innovation of this proposal lies in the attempt to overcome the crisis of the PRG by proposing a new type of municipal plan structured into three distinct components:

- a structural component, which is a planning document of a non-binding and non-prescriptive nature, but aimed at defining the future layout of the city;
- a regulatory component, which deals with the management of the existing city;
- an operational component, of a binding and prescriptive nature, intended to manage the main transformations, with a temporal validity of five years.

Additional innovative elements concern the introduction of instruments such as urban equalization and compensation, designed to overcome the long-term difficulties associated with expropriation. These tools are conceived with the aim of acquiring areas intended for public use through the attribution of building rights that can be freely traded.

The INU proposal was immediately embraced by the Tuscany Region, which, through Regional Law No. 5/1995[7], introduced the structural component within municipal planning. In doing so, Tuscany paved the way for subsequent regulatory developments in other regions, within a future landscape of differentiated regional models—a process that would become fully evident with the amendment to Title V of the Constitution in 2001.

2.2.2 Initial reform experiences: regional models in Italy within the renewed planning system

The reform in 2001, which marked the culmination of a process of administrative decentralisation initiated in previous years, represented a turning point for the Regions in matters of spatial planning. Within this new institutional framework, several Regions launched innovative legislative initiatives, effectively becoming the first experimental field. On the other hand, it can be observed that the constitutional reform itself proved to be of limited practical relevance. Rather, it served to legitimise innovation processes that were already underway (De Petris & Stefani, 2005). The regulatory experiences initiated during this phase are commonly classified as belonging to the "third generation" and played a central role—as well as serving as a testing ground—in the urban planning debate between 2005 and 2015. They were particularly significant for analysing the differences and similarities between regional models and the first observable effects on the territory.

The main feature shared by the new regional legislations is a common intent to revise the municipal urban plan according to new criteria of innovation and flexibility. Based on this need, the Regions, through their renewed

7 Regional Law of 16 January 1995, No. 5, Region of Tuscany, Provisions for Territorial Governance.

regulatory frameworks, gave rise to two main reference models: the Tuscan model and the Lombard model. The Tuscan model (initiated with Regional Law No. 5/1995 and revised by Regional Law No. 1/2005[8]), characterised by a primacy of public authority in the field of urban and territorial transformations (De Luca, 2015), introduced an internal distinction within the municipal urban plan between a structural component—which includes general development guidelines and medium- to long-term strategic choices—and an operational component—which implements structural objectives by addressing the actionable operational contents and detailing specific transformations (Cappelletti, 2012). This model, to which Emilia-Romagna largely adheres, identifies the Structural Plan as the main hallmark of regulatory evolution. It also includes an initial attempt to address land consumption through a policy whereby "new land commitments for settlement and infrastructure purposes are permitted only if there are no alternatives for the reuse and reorganisation of existing settlements and infrastructures[9]."

By contrast, Lombardy (Regional Law No. 12/2005[10]) adopts a regulatory framework that diverges from the structural/operational logic. Instead, it bases the municipal plan on a strategic-political planning document, in which urban transformation areas are identified without establishing rigid quantitative rules or altering the legal status of land.

From this document, the process moves directly to the implementation plans, which enjoy a high degree of flexibility and are assessed on a case-by-case basis by the Regional Executive, without requiring approval by the Municipal Council (Cappelletti, 2012).

In this context, it is important to emphasise that, despite the reformist momentum demonstrated by certain Regions, a national framework law on territorial governance has never been enacted. This absence has contributed to the consolidation of a highly heterogeneous dynamic among the various regional systems. The failure to approve a framework law has led to what has been described as a form of "runaway urban federalism" (Oliva, 2012, p. 89), in which the lack of a unified national direction has fuelled regulatory fragmentation, thereby preventing the development of a coherent and shared vision for reforming the national planning system.

Within the context of the first reformist wave, there was also an initial attempt to introduce a national reform of territorial governance through a framework law. This was Bill No. 3519 Mantini & Lupi, approved by the Chamber of Deputies on 28 June 2005 but never enacted into law due to the end of the legislature and the consequent failure to obtain approval from the Senate. The draft law essentially adopted the Lombard planning model but sparked extensive debate and received opposition from much of the urban planning scientific community, including INU. In particular, the law would have unjustifiably introduced numerous specific deregulation procedures, which implicitly reflected a project aimed at dismantling public territorial governance (Magnaghi & Marson, 2005).

2.2.3 Urban regeneration and the fight against soil consumption: paradigms of fourth-generation urban planning

With the conclusion of the era of so-called "third-generation" laws, the last decade has been characterised by a renewed debate surrounding planning, driven by the emergence of new socio-economic demands within the country as well as new requirements in urban planning. Among the central issues, the need to contain soil consumption has increasingly asserted itself with urgency, closely linked to the demand for the redevelopment of the existing built environment. During this phase, urban planning consolidates a paradigm shift that had already begun, also guiding new regional policies.

Although urban regeneration has become a central paradigm of a new phase in urban planning, it lacks a consolidated definition due to the complexity and multiplicity of the contexts in which it can be applied. This difficulty stems from the heterogeneous nature of the interventions encompassed by this category and the heightened interest in transversal topics, ranging from the broader issue of territorial governance to the sphere of individual rights (Giusti, 2018).

8 Regional Law of 3 January 2005, No. 1, Region of Tuscany, Provisions for Territorial Governance.

9 Article 3, paragraph 4, Regional Law 1/2005, Region of Tuscany. In Article 3, "The Essential Resources of the Territory," this law promotes and guarantees the protection of the essential resources of the territory as common goods that constitute the heritage of the community.

10 Regional Law of 11 March 2005, No. 12, Region of Lombardy, Law on Territorial Governance.

The regional experiences of the last decade have served as the initial field of observation to verify whether urban regeneration and the related objective of containing soil consumption found expression in a shared regulatory lexicon, sufficient to legitimise the hypothesis of a fourth generation of urban planning laws.

In the absence of a national framework law, regional experiences present a diverse landscape. However, an initial survey reveals recurring elements, such as the direct correlation between urban regeneration and the containment of soil consumption. There is also a well-established distinction between regeneration—which refers to a cluster of models and techniques integrated with actions on the social front (urban welfare) and environmental front (remediation, renaturalisation, etc.)—and redevelopment, which concerns individual building elements (Boscolo, 2017).

Among the most significant regional models to emerge in this phase are those of Tuscany (Regional Law 65/2014[11]) and Veneto (Regional Law 14/2017[12]). In both cases, the areas subject to urban regeneration interventions are identified within the operational component of their respective planning instruments: the Operational Plan in Tuscany and the Intervention Plan in Veneto.

Also noteworthy is the experience of Emilia-Romagna (Regional Law 24/2017[13]), which partially diverges from this approach. Although it does not explicitly define specific areas or detailed prescriptions for urban regeneration[14], the law establishes, within the General Urban Plan (PUG), the criteria for urban expansion—permitted up to a limit of 3% of the urbanised territory[15]—and for significant transformations within the urban boundary, to be assessed through operational agreements.

The challenges posed by urban regeneration reflect a broader crisis within urban planning, largely due to its excessive prescriptiveness. The debate and the so-called fourth-generation laws thus initiate a new approach aimed at rethinking the entire discipline, promoting a more active, interactive, and strategic form of planning (Dipace, 2014). This latter approach is reaffirmed as the guiding logic within which the municipal plan must operate, in light of new needs—not seeking to interpret the future through rigid prescriptions that immobilise situations, but rather adopting greater flexibility and directives capable of facilitating public-private agreements (Urbani, 2017).

2.2.4 Towards a new urban planning era? The contemporary scenario

Urban planning can draw upon a vast body of past experience and is currently facing a historically significant transition in light of new contemporary challenges. The path initiated by the "fourth generation" laws, focused on urban regeneration and combating land consumption, now encounters new factors of relevance that further influence its evolution. Events such as the Covid-19 pandemic, geopolitical instability, increasing international conflicts, and the climate emergency have profoundly affected society and the political landscape. This series of events has deeply impacted the country's socio-economic stability, reflecting in territorial governance as a growing crisis of predictive capacity. The speed at which contemporary dynamics unfold, alongside the urgency to accelerate public policy responses, has progressively weakened the role of planning as an instrument capable of envisaging and guiding the future scenarios of communities and territories (Giaimo, 2025b). As a consequence, there is significant disorientation and a profound crisis of public and institutional legitimacy, expressed through the increasing marginalisation from decision-making processes.

Alongside the development of the new regulatory framework, a renewed recognition of the central role of the plan has emerged, notably during the most recent INU Congress held in May 2025 with the theme "The Useful Plan." The plan is conceived as the instrument that must address current crises and evolve in response to

11 Regional Law of 10 November 2014, No. 65, Region of Tuscany, Provisions for Territorial Governance.

12 Regional Law of 6 June 2017, No. 14, Region of Veneto, containing provisions for the containment of soil consumption and amendments to Regional Law of 23 April 2004, No. 11, "Provisions for Territorial Governance and Landscape Matters."

13 Regional Law of 21 December 2017, No. 24, Region of Emilia-Romagna, Regional Regulation on the Protection and Use of Soil.

14 As provided by Article 33 of Regional Law 24/2017 of Emilia-Romagna, "the General Urban Plan (PUG) may not establish the building capacity, including potential capacity, of areas within the urbanised territory, nor may it set out detailed regulations for interventions whose implementation is subject to an operational agreement or a public initiative implementation plan."

15 As stipulated by Article 6 of Regional Law 24/2017 of Emilia-Romagna, "territorial and urban planning may provide, for the entire period, for a total soil consumption not exceeding the maximum limit of 3 percent of the surface area of the urbanised territory."

changing economic, social, and environmental conditions. In a scenario characterised by a gradual decline in the resident population, the obsolescence of the building stock, and the growing need to respond to the effects of climate change, the urban plan is called upon to interpret the demands of urban regeneration in relation to the specificities of each context, while simultaneously outlining the contributions that public and private actors can offer to the transformation process (Stanghellini, 2025).

Essentially, the contemporary debate recognises the shortcomings of the urban plan in its predictive function. It is now widely accepted that the plan should no longer be based on forecasts but should be conceived as an innovative tool for the discipline itself. It must respond flexibly and adaptively to ongoing transformations, enabling decision-making that remains coherent with changing conditions.

2.2.4.1 The INU proposal within Marche Regional Law 19/2023

The proposed "Law of Principles for Territorial Governance" promoted by INU represents a definitive overcoming of the legacies of past urban planning. In parallel, the Regional Law of Marche No. 19/2023 marks a comprehensive and profound change in its regulatory framework, clearly departing from a legislative model considered among the most canonical and faithful to the structure of Law No. 1150/1942.

The INU proposal, which aims to establish a unified framework in response to excessive regional fragmentation, begins by adopting the notion of territorial governance as a "broad set of interrelated functions[16]," and is based on a series of innovative principles and concepts, such as:

i) urban and territorial regeneration and the fight against soil consumption are identified as central and cross-cutting objectives of territorial governance[17]. The aim is to overcome the traditional concept linking planning to urban expansion by adopting a paradigm shift that positions regeneration as part of a circular economy.
ii) A redesign of competences in territorial governance is proposed within a multilevel framework based on co-planning and participation, in which: a) the State assumes a strategic role and outlines development objectives consistent with those of the EU; b) the Regions adopt principles according to specific territorial needs; c) Municipalities, Provinces, Metropolitan Cities, and Unions plan territorial arrangements and define sustainable development strategies within their respective competences[18]. The objective is to overcome fragmentation and the lack of coordination among the different levels of territorial governance.
iii) The method of Interinstitutional Co-planning[19] is proposed as a multilevel horizontal governance approach to be implemented through Interinstitutional Conferences. Simultaneously, the planning instruments and the respective roles of Regions, metropolitan areas, provinces, and municipalities are redefined[20]. The objectives are to overcome the traditional planning system based on hierarchical conformity and the "cascade" model of plans under Law 1150/42, aiming instead for a collaborative and integrated method.
iv) A new model of municipal urban planning is proposed through the General Urban Plan (PUG)[21], structured into three functions: a) structural-strategic component (objectives, strategies, and future configuration of the city, non-prescriptive); b) regulatory component (management and regulation of the existing city and consolidated areas, assigning building rights); c) operational component (relating to areas of transformation, to be implemented through agreements between public and private initiatives).

The objective is to abandon the vision of the plan as a static and purely prescriptive instrument, adopting instead a dynamic, flexible, and continuously updated approach.
v) Planning centred on the principle of coherence[22], understood in terms of efficiency, compatibility, consistency,

16 Definition provided in Article 1, "Scope of Application and Notion of Territorial Governance", of the draft law.
17 Draft Law, Title II: Fundamental Principles and Objectives of Territorial Governance. Article 2: Fundamental Principles and Objectives - Article 3: Territorial and Urban Regeneration - Article 4: Delegation in Matters of Urban Regeneration - Article 5: Containment of Soil Consumption and Territorial Risk Mitigation.
18 Draft Bill, Title III: Actors, Competences, Levels, and Functions of Territorial Governance. Article 6 Duties and Functions of the State - Article 7 Duties and Functions of the Regions - Article 8 Duties and Functions of Local Territorial Entities.
19 Article 10 – Co-Planning and Interinstitutional Evaluation.
20 Article 12 – Instruments of Territorial Planning.
21 Article 14 – Functions and Instruments of Urban Planning.
22 The principle of coherence is reiterated throughout the entire legislative proposal, particularly regarding the relationship between the different levels of planning. Its clearest articulation is found in Article 14, where it is presented as a criterion aimed at avoiding the systematic recourse to amendments: "In application of the principle of coherence and

and the absence of contradictions between plans and plan functions. The objective is to plan effectively in uncertain contexts and to overcome the rigid, prescriptive, and all-encompassing nature of traditional plans, promoting adaptability in place of strict "conformity" and the frequent recourse to variations.
vi) Introduction of Essential Levels of Performance (LEP)[23] for urban standards, with uniform quantitative and qualitative criteria for public facilities and services across the entire national territory. The objective is to overcome the concept of urban standards derived from Ministerial Decree 1444/68 and the resulting fragmentation and heterogeneity of current standards, ensuring not only quantitative but also qualitative levels.
vii) Introduction of urban and territorial equalisation as tools to encourage regeneration, allow the free transfer of land for public facilities, and increase the flexibility of the plan[24]. The objective is to overcome the rigidity of traditional urban planning instruments in order to promote regeneration policies.

Regional Law No. 19/2023 of the Marche Region currently represents the most comprehensive normative expression at the regional level of the proposal developed by INU. The foundational principles of the proposal, articulated across various articles, find direct reflection both in the general structure and in the specific provisions of the new Marche urban planning law. The Marche Region was previously governed by Regional Law No. 34/1992[25], which can be classified as a "second-generation" law model, primarily focused on control but also on supporting urban expansion. This was adopted during a phase of building growth and territorial transformation that lasted until the crisis of 2008–2010. In this context, the new normative framework places the Region, for the first time, in front of the challenges of planning that must offer a vision of the territory not only as a space for construction, but as a complex ecosystem in which sustainability, environmental coherence, resilience to climate change, and quality of life prevail (Centanni, Vitali & Veschi, 2025).

It is important to highlight that the innovativeness of the Marche regional regulation lies not only in its alignment with the principles of the INU proposal but also in the introduction of elements that represent a discontinuity with respect to the previous regional regulatory framework. In particular, the law incorporates and updates those reform initiatives that have already been tested by other regions within the framework of the so-called "fourth generation" laws, outlining a more advanced and effective model of territorial governance.

the principle of simplification, amendments are limited to cases where they are not consistent with the objectives and the structural-strategic contents of the General Urban Plan" (Article 14, paragraph 12).

23 Article 17 – Minimum and Non-Derogable Urban and Territorial Provisions.

24 Article 18, "Urban and territorial equalisation, compensations, and incentives".

25 Regional Law of 5 August 1992, No. 34, Marche Region, Regulations on urban planning, landscape, and territorial organisation.

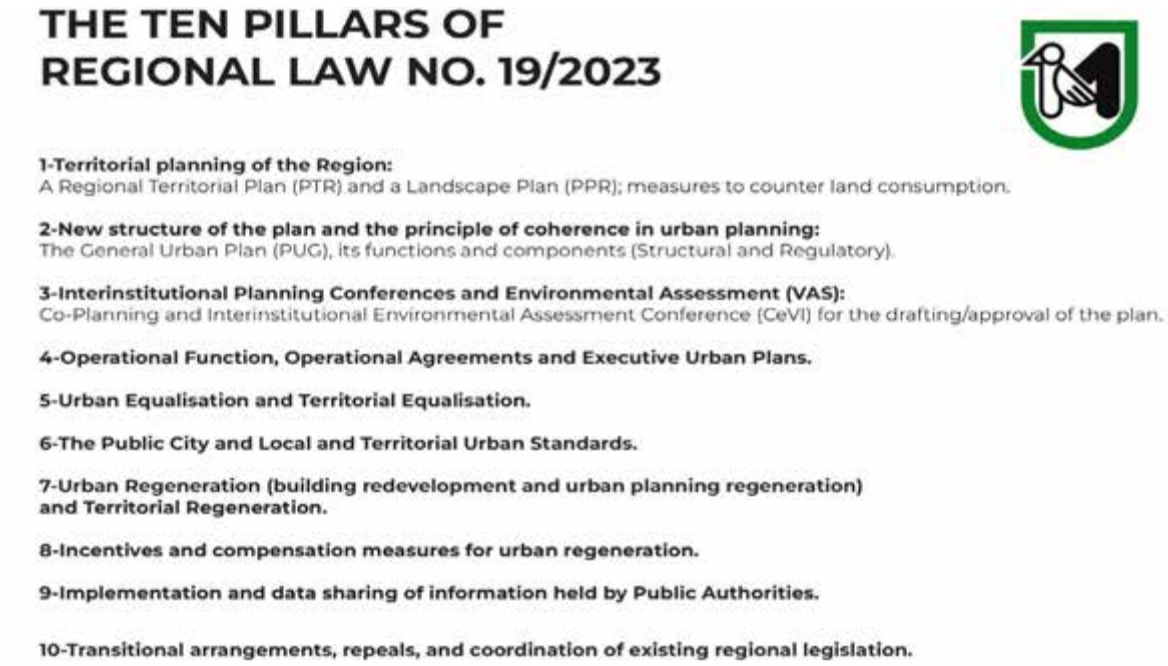

Fig.2 The Pillars of Regional Law No.19/2023. Reworking by Pierpaolo Cicconi of an image from the presentation by the Marche Region entitled "*THE NEW REGIONAL LAW ON TERRITORIAL GOVERNANCE. Regional Law No. 19/2023 – Planning Provisions for Territorial Governance. First implementation*", held in Civitanova Marche (MC) on 4 May 2024.

A significant element is represented by the comprehensive redesign of the planning instruments system[26], which is profoundly reorganised from the regional to the municipal level. While the previous legislation was based on a hierarchical-vertical structure, with a descending sequence of plans — from the Regional Environmental and Landscape Plan (PPAR, approved in 1989), to the Provincial Coordination Territorial Plans (PTCP), and finally to the municipal General Regulatory Plans (PRG) — following a logic of adjustment and conformity, the new law introduces a framework founded on principles of coherence and joint planning.

At regional level, two main instruments have been introduced and reformulated:

- **The Regional Landscape Plan (PPR)**[27], which must be prepared in accordance with the European Landscape Convention (2001) and in compliance with the Cultural Heritage and Landscape Code (Legislative Decree 42/2004). The Regional Landscape Plan (PPR) is responsible for identifying the landscape systems and the elements deserving protection, defining and delimiting the landscape areas, and establishing specific usage regulations for each of them.

- **The Regional Territorial Plan (PTR)**[28], introduced anew with a structural and strategic function, it defines the general guidelines, medium- to long-term strategies, and objectives for the sustainable development of the regional territory. It constitutes the framework of reference for economic planning and for the integration of regional sectoral policies.

At provincial level, the central role of the **Provincial Coordination Territorial Plan (PTCP)**[29] is maintained, serving as an intermediate instrument between regional and municipal planning. The PTCP defines strategic objectives, spatial frameworks, and development guidelines for the provincial territory, with a view to ensuring multi-level coherence and inter-institutional coordination.

26 The new structure of the planning instruments is defined in Article 3, "Planning Instruments," of LR 19/2023.
27 Article 8 of Regional Law 19/2023 (LR 19/2023, art. 8).
28 Article 10 of Regional Law 19/2023 (LR 19/2023, art.10).
29 Article 12 of Regional Law (LR 19/2023, art.12).

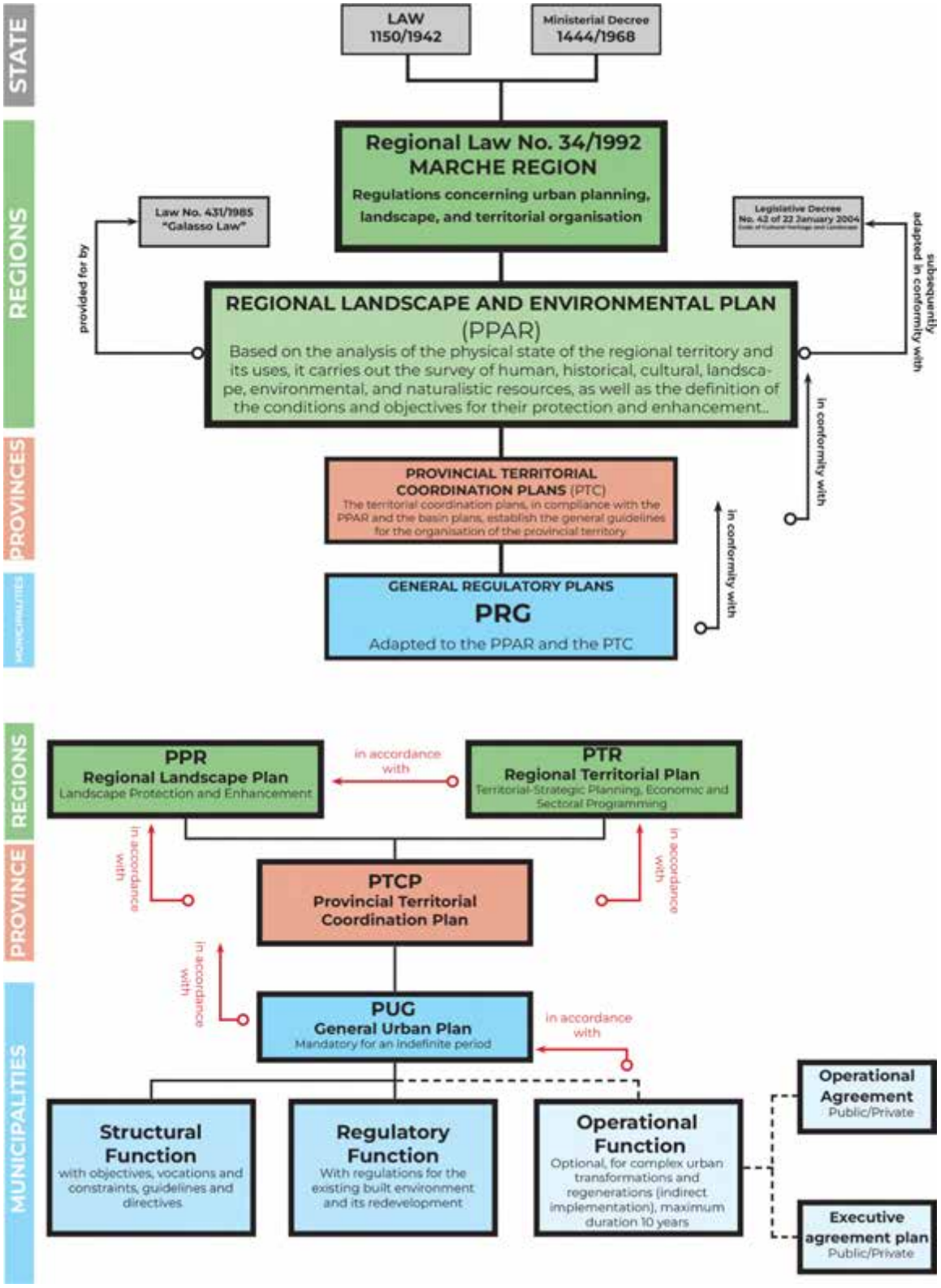

Fig.3 Comparison between the previous hierarchical-vertical model of territorial governance (above), established by Regional Law 34/1992, and the new "horizontal" model of planning instruments (below).

At municipal level, Regional Law no. 19/2023 introduces a new general planning instrument: the **General Urban Plan (PUG)**[30], which represents the focus of municipal planning actions in accordance with the principles of sustainability, regeneration, and containment of soil consumption. The PUG is structured into **three functional components**, each with a specific role in the territorial governance process:

- **Structural component: performative and strategic** in nature, it serves as a guiding and orienting tool for territorial transformations over the long term. It does not grant building rights but it outlines the strategic vision of the municipal territory, translating general sustainable development objectives into expected outcomes in terms of landscape, environmental, socio-economic, and cultural performance. It establishes the distinction between urbanised territory and rural or agricultural land, guiding decisions towards **urban and territorial regeneration**, resource enhancement, and the **containment of soil consumption**.
- **Regulatory component:** it concerns areas not subject to complex urban transformations, such as **agricultural zones, natural areas, parts of the existing settlement system**, and **consolidated infrastructural networks**. It establishes the urban and building regulations governing permissible interventions in these areas, determining **building rights** and thus allowing implementation through **direct intervention**.
- **Operational function**: it is aimed at the planning and implementation of complex urban regeneration and territorial regeneration interventions, in line with the choices set out in the structural component. It constitutes the implementing part of the strategies of the General Urban Plan (PUG) and is carried out through **Executive Urban Plans (PUE)** and **Programme Agreements (AO)**, initiated by **public and/or private actors**.

The law assigns a strategic role to **urban regeneration**[31], defining it as the set of interventions—both on buildings and on public and private spaces—aimed at the recovery and redevelopment of existing areas through operations such as demolition and reconstruction, new construction, and densification, with the objective of **raising environmental, architectural, and functional quality standards**.

The regulation also introduces a significant and potentially effective distinction between two levels of intervention, which has already emerged in other advanced regional experiences and in the scientific debate:

- **Building rehabilitation:** falling within the **regulatory** component of the General Urban Plan (PUG), it includes operations such as reuse, renovation with extension, demolition and reconstruction with extension, and building replacement. These interventions aim to improve the **seismic, energy, hygienic-sanitary, and environmental performance** of the existing building stock.

- **Urban regeneration:** pertaining instead to the **operational** component of the PUG, it qualifies as a process of **complex and integrated** transformation of marginal, degraded, or disused urban areas. This process is implemented through **Programme Agreements** and **Executive Urban Plans**, promoted by public and/or private entities.

For such interventions, the law introduces a further element of innovation through the explicit recognition of **urban equalization**[32] as a technical-operational tool, functional to the implementation of the objectives of territorial transformation and redevelopment.

30 As established by Article 14, "Municipal urban planning is exercised through acts with structural and strategic-forecasting, regulatory, and operational functions."

31 According to Article 25, paragraph 1 of Law no. 19/2023, "The planning instruments referred to in this law are primarily aimed at urban and territorial regeneration, as an integrated mode of territorial governance to counter soil consumption, to redevelop existing settlement and infrastructure systems, and to eliminate situations of degradation."

32 According to Article 20 of Law no. 19/2023, urban equalization, in addition to being a preferred tool for urban regeneration operations, becomes an operational technique aimed at avoiding disparities in treatment between real estate properties and at ensuring the development and enhancement of the public city.

Finally, with regard to soil consumption, the law provides a precise definition as "a change from a non-artificial land cover to an artificial land cover," allowing for a further distinction into:

- **Consumed soil,** expressed as an absolute quantity;
- **Degree of artificialization,** expressed as a percentage of the total territorial surface area.

The approach adopted by the law is aimed at achieving a **zero soil consumption balance** through the introduction of **mandatory compensatory measures**. These measures are to be implemented in cases of new soil sealing and include interventions such as **renaturalisation, soil de-sealing, and ecological restoration**.

The operational implementation of these objectives is entrusted to the **Regional Territorial Plan (PTR)**, which is tasked with defining **criteria, guidelines, and qualitative and quantitative parameters** to monitor and regulate the impact of transformative interventions on soil consumption.

3.Conclusions

The research has highlighted the growing and consolidated perception of a discipline in structural and identity crisis, caught between, on the one hand, a regulatory framework regarded as excessively restrictive, bureaucratic, and prescriptive; and, on the other, an increasing demand for greater flexibility, adaptability, and promptness in territorial governance processes. Within this context—often amplified by reductive and overly simplified narratives, at times populist or technocratic—urban planning is frequently accused of being an obstacle rather than a resource.

However, a fundamental element is often overlooked: the intrinsic complexity of urban planning, which cannot be reduced to a mere technical tool, but must be understood as a political, strategic, and cultural practice of territorial design. Hence the need—repeatedly emphasised in recent debate—for a reformulation of the discipline not only in operational terms but also in conceptual ones, so that it may acknowledge its multidimensional, interdisciplinary and complex nature, without resorting to excuses or justifications.

From this perspective, it is legitimate to ask whether the current crisis is attributable solely to internal limitations of the discipline, or rather to external factors: economic stagnation, demographic decline, and the changing dynamics of settlement and production. It is, therefore, also a contextual crisis, which imposes objective constraints on the effectiveness of planning instruments and their capacity to guide territorial transformations in accordance with the objectives of equity, sustainability, and resilience.

It is within this context that the new regulatory phase must be interpreted, as represented by the INU's legislative proposal and, concretely, by Regional Law no. 19/2023 of the Marche Region. Both aim to radically redefine the system of planning instruments, particularly at the municipal scale. As highlighted by the central themes addressed in the present work, the debate has been most intensely focused on the form and function of the municipal plan—particularly on the need to move beyond the traditional rigid framework and to introduce more performance-based, integrated, and strategic models, which have already been tested by many Regions over the past two decades.

This element, amplified by the INU's own initiative regarding the "Useful Plan," which seeks to reflect on the meaning, function, and effectiveness of urban planning today, raises significant questions: Why is urban planning considered to be in crisis today, if many Regions have long adopted advanced models? Why do the INU proposal and the Marche law resume certain well-established solutions? And finally, why does the three-function plan model (structural, regulatory, operational) continue to be proposed, despite already being widespread and consolidated in various regional experiences?

Are the currently proposed regulatory and methodological innovations (which the debate continues to define as such) genuinely innovative, or do they instead represent an attempt to reiterate already established solutions, without managing to address the systemic limitations afflicting the discipline? In other words, is there a risk of falling into a condition of self-referentiality and operational ineffectiveness, not due to intrinsic shortcomings, but because of the inability to influence processes of economic, social, and territorial crisis that lie beyond its scope of action? At this point, the task of the discipline is not only to formally reinvent itself but also to legitimize

its role as the orchestrator of territorial transformations, demonstrating the capacity to confront contemporary challenges and the uncertainties of our time.

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Public Interest or Private Profit?
A Case Study of How Public Interest is Redefined Through Political Power And Land Commodification in Istanbul

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Abstract
This study examines how public interest is defined and applied in Turkish urban planning through the case of the Etiler Police School site in Istanbul. Using Robert K. Yin's explanatory case study method, it explores the legal and institutional processes that enabled the site's transformation from a public educational facility into a high-rise private development. The findings show that public interest was strategically invoked to justify zoning changes and shift planning authority to central government, despite no disaster risk or public input. Though legally framed, the process contradicted planning principles of equity, transparency and spatial justice. The study argues that public interest was used more as rhetorical justification than ethical guidance, highlighting the need to restore its normative function in planning systems.

Keywords: Public interest; urban planning; land transformation; spatial justice; planning law.

1. Introduction

The concept of public interest has long served as a normative and guiding principle in urban planning theory and practice. Rooted in classical democratic ideals, public interest is expected to balance individual and collective needs while legitimising spatial interventions (Mumford, 1938). Yet, in practice, particularly in contexts with centralised governance traditions, it is frequently instrumentalised to justify top-down, profit-oriented urban transformation projects. In Turkey, while public interest is repeatedly cited in legal and planning documents, it often lacks critical scrutiny in terms of whose interests it truly represents and what spatial and socio-political consequences it produces.

This paper investigates the transformation of the former Etiler Police School site in Beşiktaş, Istanbul, which was sold and redeveloped under the pretext of public interest. Despite its initial educational function and public ownership, the site was rezoned for commercial and tourism purposes, replaced by high-rise towers, and ultimately privatised. This controversial case provides a rich context to examine the shifting meaning and use of public interest in Turkish planning processes, especially within the frameworks of constitutional law, spatial planning legislation, and institutional policy dynamics.

The case is analysed through an embedded case study design, following Yin's (2018) methodology, where the macro-level discourse of public interest is examined through the micro-level planning decisions, legal instruments, and implementation strategies applied to a single site. Multiple layers of analysis are adopted: (1) the normative legal basis as defined in the Turkish Constitution and administrative court decisions; (2) the planning rationale as framed by the Spatial Plans Regulation and zoning reports; (3) the policy instruments that enabled the central government to override local planning authority (such as disaster-risk area declarations); and (4) the spatial and social outcomes, including the erosion of public services and the commodification of land.

The Etiler case was selected for its exemplary demonstration of how public land can be transformed into a speculative asset through legal and institutional manoeuvres. Moreover, the project's scale, location within a protected area, and direct contradiction with planning principles make it a compelling case to question the operational meaning of public interest in Turkey's contemporary urban planning system.

In doing so, this study aims to answer the following research question: How is the notion of public interest defined, interpreted, and operationalised in the transformation of public land in Istanbul? The study adopts a qualitative case study approach, based on document analysis, policy review, planning legislation, and media reports, using pattern-matching logic to explore the gap between declared objectives and actual outcomes.

2. Theoretical Background

Public interest has long been considered a foundational principle in urban planning, yet its definition remains fluid, context-dependent, and often politically contested. The concept is generally assumed to represent the collective needs of society, as opposed to individual or corporate interests (Mumford, 1938; Bozeman, 2007). However, despite its normative appeal, public interest is rarely neutral in practice. Instead, it frequently becomes a rhetorical and strategic tool employed by political and economic actors to legitimise decisions that may otherwise lack democratic or ethical grounding (Campbell & Marshall, 2002).

In Turkey, the term "public interest" (kamu yararı) is deeply embedded in legal and planning discourse, yet its invocation often lacks substantive scrutiny. Article 5 of the Turkish Constitution frames public interest as a central function of the state, while spatial planning regulations mandate adherence to public interest as one of the guiding principles in plan-making. However, the discretionary power of central government institutions, particularly in the post-2010 period, has increasingly led to top-down decision-making in which public interest is equated with state-defined priorities, often without public consultation or transparent justification. In this sense, the term functions less as an ethical commitment and more as an instrument of governance—frequently aligned with market logics and private capital flows.

Beyond legal and political frameworks, the public interest is also a key subject of debate in planning ethics. Scholars have argued that planning is no longer a purely technical domain but a profoundly normative one, requiring practitioners to make explicit value-based judgments (Upton, 2002; Taylor, 1992; Campbell, 2002). Campbell (2002) argues that planning must be seen as a "moral endeavour", in which planners consider the long-term implications of their decisions on justice, equity and sustainability. Public interest, within this frame, is not simply a policy aim, but a moral compass guiding spatial decisions in line with social fairness and intergenerational responsibility.

Yet ethical consensus on the meaning of public interest is difficult to achieve. Diverse philosophical frameworks—such as deontological and teleological ethics—suggest different ways to evaluate planning actions (Howe, 1994). While deontological approaches emphasise rights, duties and procedural integrity, teleological perspectives are concerned with the consequences of actions, often measured in terms of social welfare or utility. The tension between these perspectives is particularly pronounced in planning decisions involving land ownership, displacement, and redevelopment—areas where outcomes can be deeply unequal despite formal procedural compliance.

Recent decades have witnessed a shift in planning rationalities towards more entrepreneurial and neoliberal modes of governance. In this context, the public interest is often reduced to fiscal efficiency or economic growth, as cities compete globally for investment and prestige (Harvey, 1989; Taşan-Kok & Oranje, 2017). The commodification of public goods—especially land and infrastructure—has become increasingly normalised, and planning has in many cases become a facilitator of speculative urban development. As noted by Allmendinger and Haughton (2012), the rise of "soft spaces" of planning and informal governance arrangements often bypass democratic processes and blur the boundaries between public and private interest.

In the Turkish context, the centralisation of planning authority and the expansion of emergency legal instruments—such as the declaration of disaster-risk areas (Law No. 6306)—have enabled the state to bypass standard planning procedures. These mechanisms are frequently justified on the grounds of public interest, yet their application often leads to the concentration of power, the weakening of local authorities, and the displacement of communities. Şengül (2002) refers to this process as the "depoliticisation of planning through technocracy", where technocratic justifications mask underlying political and economic motivations.

A critical distinction must be made between procedural legality and substantive justice. In many cases, planning decisions are made within the bounds of formal legal frameworks but fail to deliver equitable or sustainable outcomes. Legal instruments are frequently stretched or reinterpreted to accommodate political priorities, while the language of public interest provides an aura of legitimacy. This is particularly evident in the manipulation of zoning regulations, the redefinition of land uses, and the transfer of public land to private entities.

Professional bodies such as the Union of Chambers of Turkish Engineers and Architects (TMMOB) have repeatedly contested such practices, arguing that they undermine the integrity of planning and erode public trust. Judicial rulings, including those by the Council of State, have on occasion annulled plans for failing to meet basic planning principles despite their formal legality. These tensions highlight the urgent need to evaluate public interest not merely as a legal condition, but as a multidimensional concept encompassing ethical, social and spatial considerations.

3. Methodology

This research adopts a qualitative case study methodology, following Robert K. Yin's (2018) explanatory approach to investigate how the notion of public interest is framed, interpreted and operationalised within a concrete planning case. The study is designed as a single-case inquiry, focusing on the transformation of the former Etiler Police School site in Istanbul. The site was chosen not only for its spatial and institutional complexity, but also for its significance in reflecting wider dynamics of centralised planning, legal manipulation, and the instrumentalisation of public interest discourse in Turkey.

As Yin suggests, explanatory case studies are particularly suitable for exploring causality in complex socio-political environments where the researcher does not have control over events. This approach allows for the systematic tracing of how planning decisions unfold over time, and how actors use legal and discursive tools to justify their interventions. The case is structured as an embedded design, incorporating several units of analysis—including legal decisions, planning documents, zoning changes, institutional reports, and media narratives—all of which contribute to understanding how public interest was invoked and implemented across different phases of the project.

Data collection relied primarily on document analysis, drawing from a wide range of sources. These include official spatial plans and plan modification notes, national legislation and regulations (such as Law No. 6306 on disaster-risk area transformation), court rulings, policy documents from local and central government agencies, media reports, and technical assessments such as geological surveys and planning justifications. The use of multiple sources enabled data triangulation, enhancing the reliability and construct validity of the research.

The analytical process employed pattern matching as the principal strategy, where theoretical expectations derived from planning ethics, legal norms, and professional standards were compared with the actual development trajectory of the site. Specifically, the study examined whether the justification of public interest in official documents aligned with the observed outcomes in terms of land use, institutional authority, social benefit, and spatial justice. Through this approach, the research aimed not only to reconstruct the sequence of events, but also to expose the gaps between normative principles and practical implementation.

Importantly, this case study does not seek generalisation in the statistical sense, but rather aims to contribute to analytical generalisation, where findings from a well-documented case inform theoretical understanding of how public interest is contested and negotiated in planning practice. In doing so, the study foregrounds the complex interplay between planning law, political authority, ethical judgement, and public accountability within the evolving landscape of urban governance in Turkey.

4. Case Study: The Etiler Police School Site Transformation

The Bosphorus Law No. 2960 was enacted to protect and develop the cultural and historical values and natural beauties of the Bosphorus Area of Istanbul in the public interest and to determine and regulate the zoning legislation to be applied in order to limit the construction that will increase the population density in this area. According to this law, the Bosphorus Area is divided into zones and different construction and protection categories are defined. The land of Etiler Police School is located in the Bosphorus Backsight Area within the scope of the Bosphorus Law enacted in 1983. In terms of authority, Istanbul Metropolitan Municipality's Bosphorus Zoning Directorate has the authority over the Bosphorus Foresight Zone, while district municipalities have the authority over the Bosphorus Backsight Zone.

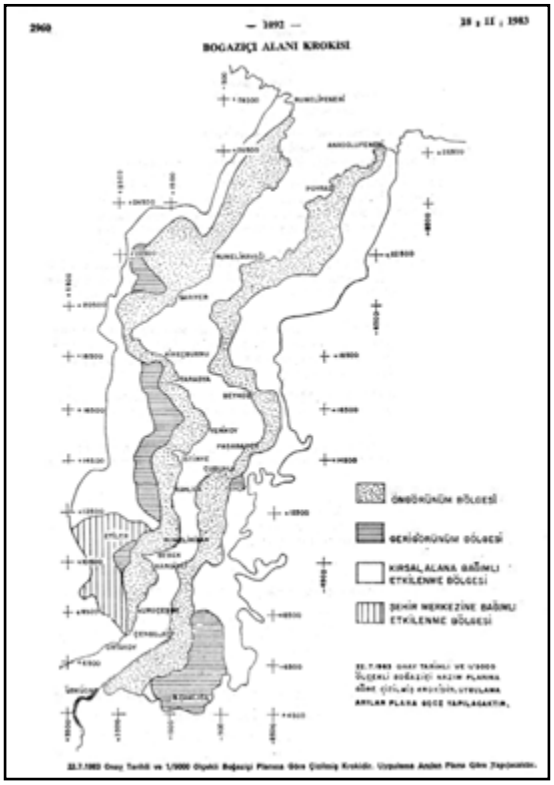

Figure 1. Bosphorus Area

In 1966, the Etiler Police School was opened in the area located in the Bosphorus Backsight Zone. In the December 10, 1993 dated Conservation Revision Implementation Zoning Plan, the parcel where the Etiler Police School is located is marked as "police college" in the plan.

Figure 2. Conservation Development Plan Approved on December 10, 1993

On January 20, 2010, the Istanbul Project Coordination Unit of the Special Provincial Administration of the Governorship of Istanbul decided to reconstruct some of the buildings belonging to the Etiler Police School as they did not meet the needs of the Istanbul Etiler Police Training Center Directorate and the Provincial Directorate of National Education and as the retrofitting of the existing buildings was not economically feasible. This reconstruction process was financed by the European Investment Bank (EIB). The value of services received from the EIB for the Etiler Police School and 40 other school buildings or dormitories was documented as EUR 4,312,900.

The decision taken in 2010, which covers reconstruction and retrofitting projects, was completed in 2012, according to the annual report of the Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP), which was established under the Governorship of Istanbul in 2006.

Again in 2012, the Etiler Police School land was transferred from the Treasury of Finance to the Istanbul Metropolitan Municipality in accordance with the protocol signed between the Istanbul Metropolitan Municipality and the General Directorate of Security on April 07, 2012. This transfer was followed by an amendment to the Implementation Zoning Plan dated December 26, 2012.

Şekil 10 : Planlama Alanının İptal Edilen 26.12.2012 t.t.'li Uygulama İmar Planındaki Durumu

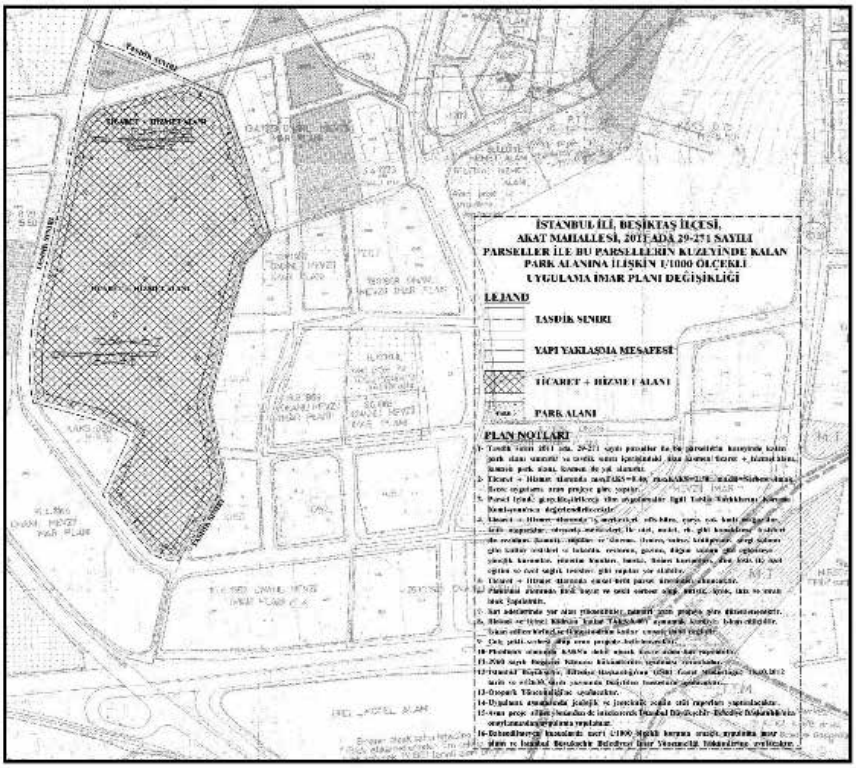

Figure 3. Zoning Plan Amendment dated 26 December 2012

According to this Implementation Zoning Plan amendment, it is seen that the area, whose function appears as an educational facility (police college) in the old plan, has been functionalized as a trade + service area in the new plan.

When the construction conditions of the Etiler Police School land, where all buildings including the administrative building, dormitory and school buildings are currently 5 storeys, are examined according to the new plan; it is seen that the maximum height is left free, the building coverage ratio is processed as 2.50, and a construction permit is given as a trade + service area and 100 thousand square meters of construction right is provided on the land.

According to the Council of Ministers' Decision No. 2013/5118, published in the Official Gazette on July 24, 2013, the area located within the boundaries of Rumeli Hisarı Neighborhood, Beşiktaş District, Istanbul Province, as

delineated by the attached map and list indicating its boundaries and coordinates, has been designated as a "risky area" pursuant to Article 2 of Law No. 6306 on the Transformation of Areas at Risk of Natural Disasters. This decision was adopted by the Council of Ministers on July 8, 2013.

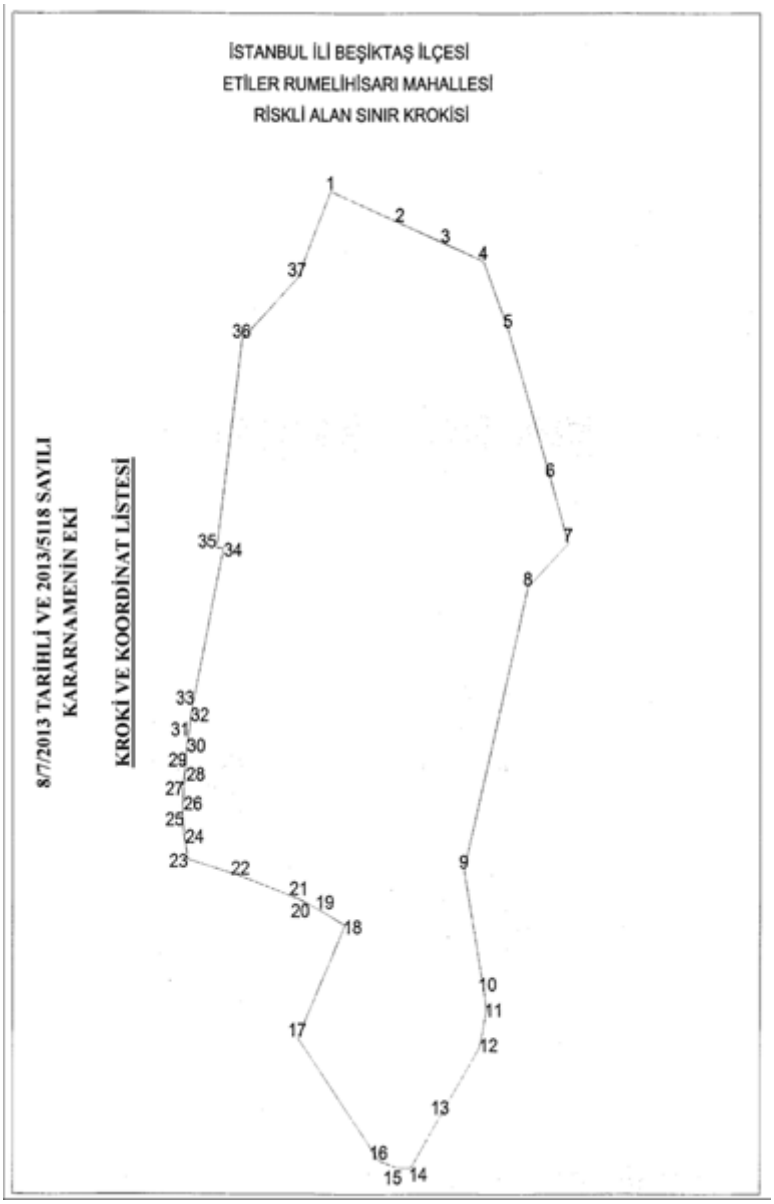

Figure 4. Etiler Rumeli Hisarı Neighborhood Risky Area Boundary

Law No. 6306 on the Transformation of Areas Under Disaster Risk, in force since May 31, 2012, aims to reduce disaster risks. The law states that in order for an area to be declared a risky area, the ground structure or the building stock on it must have a risk of collapse in a possible earthquake, and the analyses to be made in determining this risk are explained step by step.

According to the data obtained from the geological-geotechnical survey report of the zoning plan prepared by the Ministry of Environment, Urbanization and Climate Change in 2022 for the study area, it has been determined that the area is located in "suitable areas" and "rock environments" and that there is no risk element that carries a disaster risk in this context. At the same time, according to the letter prepared by the Disaster and Emergency Management Presidency (AFAD), there is no "Disaster-Prone Zone" decision for the study area.

In this context, the designation of an area classified as having stable ground conditions in official Ministry reports as a "risky area" in a city like Istanbul, which is highly susceptible to earthquakes, is open to debate in terms of public interest. This is particularly significant given the existence of regions in Istanbul that are far more critical in terms of disaster risk. Moreover, the selection of this area and the fact that its building stock had already been renewed with funding from the European Investment Bank in 2012—one year prior to this decision—necessitate a thorough evaluation of the entire process from a public interest perspective.

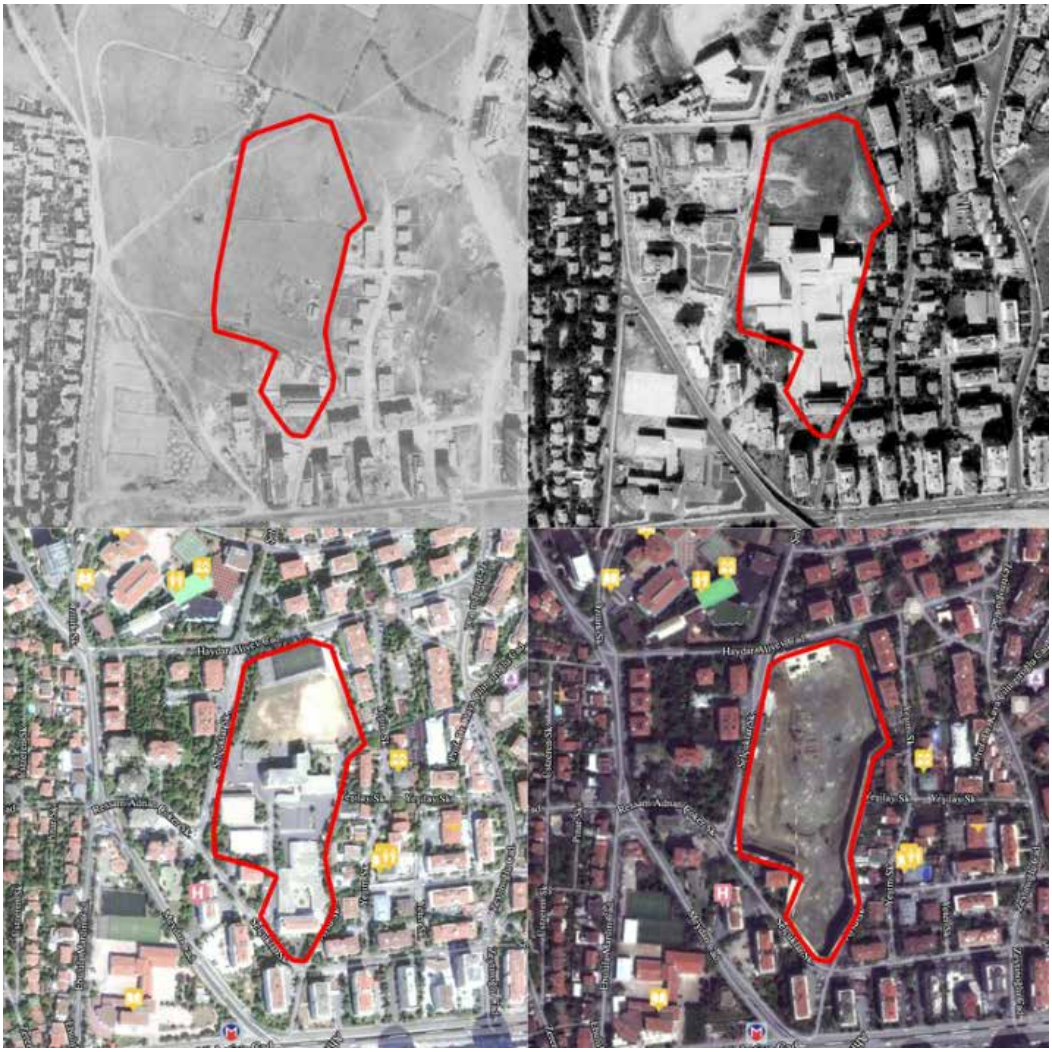

Figure 5. Aerial Photographs of Etiler Police School in 1966, 1987, 2011 and 2021

With the declaration of the area as a disaster risk area, the authority to make all kinds of plans in the area was transferred to the Ministry of Environment, Urbanization and Climate Change.
UCTEA Chamber of Architects and UCTEA Chamber of Urban Planners filed a lawsuit against these plan amendments on May 6, 2013, and two expert reports obtained within the scope of the file found that the plans were contrary to the principles of urbanism and the law.

In 2014, Etiler Police School was closed by the Council of Ministers' Decision No. 2014/6831. In 2018, the demolition of the Etiler Police School began. In the same year, the Istanbul Metropolitan Municipality put the land up for sale, and the tender was won by Istanbul Konut İmar Plan Sanayi ve Ticaret A.Ş. (KİPTAŞ), a subsidiary of the municipality, for 1,388,520,000 TL. Subsequently, KİPTAŞ organized a selective bidding process for the construction project, which was won by the partnership of Yapı ve Yapı Sanayi Ticaret A.Ş. + ASTAŞ Gayrimenkul Yatırım A.Ş. The winning partnership developed a project consisting of three skyscrapers with a height of 36 stories. The project includes 251 residential units in two blocks, while the third block will be operated as a hotel by the renowned hotel and

residence operator, Mandarin Oriental Group. The hotel will feature 156 rooms, 16 suites, and three restaurants. Following these developments and tender processes, a retaining wall construction permit was issued on July 27, 2018, and new building permits were granted on November 1, 2018. On November 7, 2018, the establishment of floor ownership was registered, creating 536 independent units within the project.

In a 2018 court decision, the project was deemed to serve the public interest. However, the Istanbul Regional Administrative Court's 4th Administrative Litigation Chamber overturned this ruling on September 20, 2019, under Decision No. 2019/1568, annulling the zoning plan in question. This decision was definitively upheld by the 6th Chamber of the Council of State on June 28, 2021. The court's ruling emphasized that the zoning plans granted construction rights significantly exceeding the environmental building conditions.

In a joint statement, the Istanbul Branch of the Chamber of City Planners and the Istanbul Metropolitan Branch of the Chamber of Architects, affiliated with UCTEA, expressed their stance on the matter, stating, "What belongs to the public should be returned to the public without further delay." In 2021, the Istanbul Metropolitan Municipality annulled the construction permits issued in 2018. In 2022, the Ministry of Environment, Urbanization, and Climate Change, the sole authority responsible for planning the area, prepared a new plan. This plan adhered to the existing project, designating two blocks with ground floor + 32 stories and one block with ground floor + 36 stories. The land use, previously classified as commerce + service, was revised to commerce + tourism. In 2023, following the new plan, the company obtained a construction permit from the Ministry and resumed construction. That same year, professional chambers once again filed lawsuits against the plan and the construction permit.

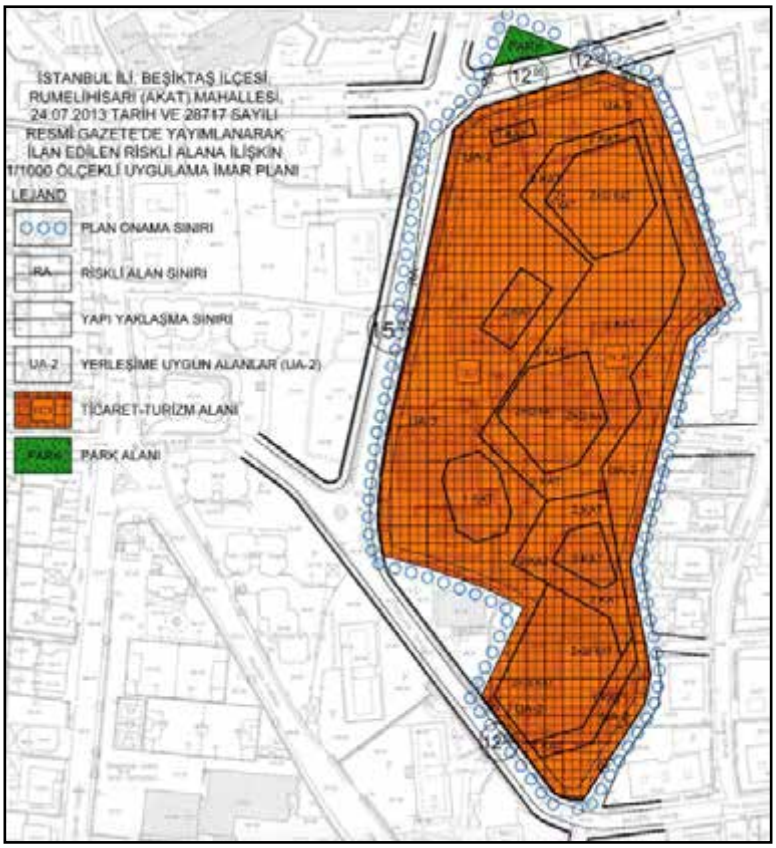

Figure 6. Zoning Plan Prepared by the Ministry of Environment, Urbanization and Climate Change

5. Findings and Discussion

The case of the Etiler Police School illustrates a complex interplay between formal planning mechanisms, legal frameworks, and political strategies that ultimately facilitated the transformation of a public educational site into a luxury mixed-use development. While each procedural step was framed within legal instruments—such as zoning amendments, disaster-risk legislation, and institutional protocols—the cumulative effect of these decisions reveals a pattern of instrumentalising the concept of public interest to legitimise a highly profit-oriented project.

One of the most striking findings concerns the strategic use of Law No. 6306, which permits central government intervention in areas designated as disaster-prone. Despite the lack of geological or structural evidence supporting such a designation, the area was declared "risky" just one year after its reconstruction was completed with international funding. This decision effectively bypassed local planning authority and transferred all regulatory power to the Ministry of Environment, Urbanisation and Climate Change. As highlighted in the theoretical framework, this shift represents a textbook case of policy-based depoliticisation, where risk is mobilised as a neutral technical category to enable centralised planning and high-density development (Allmendinger & Haughton, 2012; Şengül, 2002).

The pattern of actions observed in this case also exemplifies what Bozeman (2007) describes as the erosion of substantive public interest. While officials claimed the project would bring urban value through tourism and economic development, the outcomes contradicted fundamental planning principles such as transparency, social equity, and sustainability. The rezoning process, conducted with limited public engagement, prioritised maximum construction rights over considerations of infrastructure capacity, environmental impact, or spatial justice. This aligns with critiques in planning theory that warn of "public interest" being reduced to economic utility, thereby marginalising ethical obligations to the broader community (Campbell & Marshall, 2000; Campbell, 2002).

From a legal standpoint, the annulment of the zoning plans by the Council of State in 2021 reaffirms that the process violated not only planning ethics but also the principles enshrined in Turkish legislation. The court's recognition that the new density "exceeded surrounding urban conditions" serves as a rare but critical institutional acknowledgment of the misuse of legal tools for political-economic gain. This also reveals the fragility of procedural legitimacy: even when decisions are technically legal, they may still be overturned if they fail to fulfil the broader mandate of the planning system, which includes safeguarding public interest in a meaningful sense.

Ethically, the case further problematises the role of planners and public institutions. The transition from a publicly funded educational facility to a privatised luxury enclave raises profound questions about the ethics of land use decisions in neoliberal governance contexts. The use of public resources for reconstruction, followed by rapid reclassification and sale, underscores what many scholars term the commodification of public assets (Harvey, 1989). Here, public interest was invoked not as a moral commitment but as a discursive shield—deployed to rationalise a sequence of decisions that ultimately undermined social equity and public trust.

Finally, the resistance mounted by professional chambers, supported by expert reports and legal actions, illustrates the contested nature of public interest in practice. Their emphasis on planning integrity and social accountability signals the importance of maintaining institutional counterbalances to state-led commodification. However, their limited success in halting the project reflects the structural imbalance of power in Turkey's planning system, where central authority increasingly dominates local governance, often with limited channels for participatory input or ethical scrutiny.

In sum, the Etiler case exemplifies how public interest can be selectively interpreted, politically instrumentalised, and legally stretched to accommodate speculative urban agendas. While formally legal, the process deviated from ethical planning standards, undermined democratic oversight, and privileged private gain over public benefit. It thus calls for a critical reassessment of how public interest is defined and operationalised in planning—particularly in contexts marked by strong centralisation and market-oriented urban policy.

6. Conclusion and Recommendations

This study has examined how the notion of public interest is defined, negotiated, and operationalised in the transformation of public land within the Turkish urban planning context. Through an explanatory case study of the Etiler Police School site in Istanbul, the research has demonstrated that while public interest remains a central term in both planning law and political discourse, its meaning in practice is far from fixed. Rather, it is subject to reinterpretation by institutional actors, often in ways that align with market-oriented development agendas.

The findings indicate that the transformation process was shaped by a combination of legal mechanisms, institutional restructuring, and strategic discourse, all of which facilitated the commodification of a formerly public educational facility. Despite the procedural legality of the actions taken, the process violated substantive planning principles, undermined local governance, and prioritised private profit over collective benefit. This case illustrates a broader tendency within contemporary urban governance to instrumentalise public interest as a justificatory narrative, rather than uphold it as an ethical or constitutional obligation.

Moreover, the research contributes to planning theory by reaffirming the importance of distinguishing between formal legality and ethical legitimacy. While laws and regulations provide the procedural framework for decision-making, they do not necessarily guarantee just or equitable outcomes. In contexts of strong centralisation and limited public participation, the invocation of public interest must be critically scrutinised—particularly when used to justify the transfer of public land to private capital.

In light of these findings, several recommendations are proposed for both policy and practice:

Reconceptualising public interest: Planning authorities and practitioners must adopt a more inclusive and deliberative understanding of public interest, one that foregrounds social equity, environmental sustainability, and long-term collective well-being rather than short-term economic gains.

Reinforcing institutional checks and transparency: The roles of professional chambers, judicial review, and civil society must be strengthened to ensure accountability in plan-making processes. Legal frameworks should incorporate clearer criteria for risk designations and land use changes, supported by independent assessments.

Restoring the ethical foundation of planning: Planning education and practice must place greater emphasis on ethics, particularly in contexts where the boundaries between public and private interests are increasingly blurred. Planners should be empowered to act not only as technicians but as ethical agents responsible for upholding public values.

Rebalancing planning authority: There is a need to re-empower local governments and communities in planning decisions. Centralised interventions should be limited to exceptional circumstances and must be accompanied by transparent justification, participatory mechanisms, and rigorous impact assessments.

The transformation of the Etiler Police School is not an isolated case, but rather a manifestation of systemic shifts in the governance of urban space. As such, it serves as a cautionary example of how the language of public interest can be co-opted to enable spatial injustice. Reclaiming the integrity of this concept—both legally and ethically—is essential for building more democratic, just, and sustainable cities.

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Track 3
MOBILITY

The walkability potential matrix – a new method for measuring sustainable destination configurations in town and city centres

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Abstract
The object of this present study is to reveal the spatial configuration of 55 Norwegian towns and cities related to degree of walkability potentials. The aim is to investigate to what extent the street or road profile affect the walkability potentials in the town centres based on the distribution of roads in comparison of streets based on street names. The focus is on the town centres, because they tend to have the largest walkability potentials. For this, the last part of the street or road names is used to identifying whether it is a balanced street or a road encouraging car use. Likewise, the number of X and T junctions is counted in the town centre. Correlations between T and X junctions were made, and correlations between road and streets were made for the town centre of all 55 Norwegian towns and cities.

The results show that the higher number of X-junctions in correlation with T-junctions, the shorter urban blocks, implying higher degree of walkability potentials in the town centres. Likewise, the higher numbers of streets in correlation with roads in a town centre, the higher degree of facilitation of pedestrian friendly pathways. Three different clusters are identified in the statistical analyses, in which comply with the reputations the various town and city centres have regards walking attractiveness or private car dependency. The higher number of X-junctions in correlation with T-junctions, the more integrated the town centre is on a local as well as global scale. Likewise, the higher number of streets in correlation with roads, the more integrated the town centre is. Finally, the more the town or city centres have an orthogonal grid structure consisting of streets, the higher integration and thus higher walkability potentials.

The method is a first step to have an operational and easy applicable tool to measure degrees of walkability potentials in town and city centres.

Keywords: walkability potentials, street names, street profiles, junction type, urban centres.

Introduction – measuring attractive walkable town and city centres

Town and city centres are regional attractors and attractive destinations where a diversity of functions is clustered, and the building densities are higher than the surroundings. During the last 30 years, town and city centres are perceived to be beneficial for encouraging sustainable transport means such as providing an efficient public transport and facilities for walking (Banister 2008, Murgante et al 2023, van Nes 2021a). But how can the physical and spatial framework of walking friendliness be measured? Often it is believed that high building density and high degree of land use diversity encourage short walking distances and hence more people in streets (Ewing and Cervero 2010). Therefore, densification of the built mass and intensification of land use diversity if often used as a strategy for making sustainable town and city centres. However, the spatial configuration of the mobility network is often forgotten in the sustainable city debate (van Nes 2021a). The application of various space syntax analyses on a wide range of cities world-wide highlight that town and city centres have high spatial to- and through movement in relation to the whole town or city (Hillier et al 2007). However, the degree of walkability of the mobility network is difficult to identify with only the space syntax method. Therefor the aim of this contribution is to present a different approach to measure walkability potentials in town and city centres, based on street profiles and junction type. To what extend play street profiles and junction type for the walkability potential in town and city centres? How can street profiles be measured or quantified?

Most Norwegian towns and cities have small urban centres surrounded by many single-family houses. Oslo, the largest city of Norway, has three large local centres (van Nes 2003) and they are surrounded by sub-urban neighbourhoods consisting of flats, row houses and single-family homes. Bergen is the second and Trondheim is the third largest city in Norway, and both cities have one small urban centre surrounded by sub-urban neighbourhoods consisting of mostly single-family homes, and some flats and row houses. Since the 1960s, urban growth in Norway has been much planned around the private car. The effects are the emergence of low-density urban sprawl, location of large out of town car-based shopping malls, and acceptance of new land use plans facilitating single-family houses in the countryside and into the forest (Aarsæther, Falleth, Nyseth, & Kristiansen 2012).

There exist several reports where researchers have been trying to measure various sustainability indicators for Norwegian towns and cities. The sustainability indicators have been to measure the populations' distance to nature or parks, population density on build up land, distance to kindergarten, primary school, grocery shops and daily travel behaviour. What is missing are various means for identifying the spatial framework for making walking attractive instead of using the private car for distances lesser than 1,5 km.

As space syntax research has shown, streets with high to- as well as through movement potentials on a local scale, combined with well-integrated main routes running through them tend to be lively neighbourhoods with high walkability potentials (Kråkenes et al 2022, Bolset et al 2022, van Nes 2021 a and b). Often these neighbourhoods have short urban blocks, tend to have high building densities and a large variation of functions inside buildings (Ye and van Nes 2014, van Nes 2021c, Berge et al 2022). Often town and city centres score high on these spatial analyses. Therefore, space syntax analyses are conducted of all 55 Norwegian cities and towns. The results from the space syntax analyses in the town and city centres are tested on junction type, based on Stephen Marshall's work (2005), and path type, based on Job Eldijk's method (2014) on classifying streets regards their functions or users. The number of X and T junctions is counted and correlated with one another. Furthermore, the total number of roads and highways in correlation to all other streets is investigated in the city and town centres based on pathnames. The reason for focusing on the centres, is that the walkability potentials are largest there and the various spatial structures of these centres gives an indication of the degree of private car dependency.

The first part of this paper will present the state of the art of current sustainability policies and practice in Norway. The second part will present the scope of this inquiry with the method used, whereas the third part present the results from the various spatial analyses and the statistics. An outline for a walkability potential matrix is presented. The fourth part discuss the findings, and the fifth part reflects over the usefulness of the walkability potential matrix.

Sustainability parameters, planning policies, and practice

Norway has a short urban history. Before the industrial revolution, Norway had a strong farming culture (van Nes 2022). There were a few towns along the coastal areas with small urban centres. These centres are still existing. During the industrial revolution, around 1850 in Norway, some new towns grew up where the large factories were located whereas others expanded around the old historic cores. In general, most Norwegian towns up to 1960 were small and compact, and developed according to the pedestrian, bus and in some cases trams.

After 1961, everyone was allowed to buy a private car in Norway. Since then, Norwegian built environments are transformed and planned around the private car. Except from the large cities, Norwegian towns are extremely private car dependent. During the last decade, there exist national policies to make towns and cities more sustainable by improving public transport, implement high parking fees, reduce parking facilities, implementing bicycle lanes, implement road payments etc. However, little of this can be seen in Norwegian small and medium sized towns (Kråkenes et al 2022).

During the last 30 years, the consideration of the environment has put some influence on the planning of Norwegian towns and cities. The focus is on finding good solutions for pedestrians and cyclists, increasing the building density within existing built-up land, and providing large investments in new solutions for public transport in the large cities in Norway. The concept of sustainability was first incorporated in planning in the national policy documents in 1993 and then substituted by governmental planning guidelines in 2014.

The problem of measuring sustainability parameters in Norway

So far, it seems that the large cities are better at implementing sustainable planning measurements than the smaller towns of Norway (Kråkenes et al 2022). This problem is revealed by comparative case studies of large as well as small sized Norwegian towns and cities the last decades. The report 'Byer og Miljø' (Cities and Environment) focus on the state of the environment and sustainable development in the 13 largest municipalities in Norway. The total population in these 13 municipalities represents 36% of Norway's total population (Kommunal- og Moderniseringsdepartementet 2016).

Based on their parameters, the results in this report show that the largest cities in Norway score higher on environmental status and sustainable development than the average values for all towns in Norway. For example, the report shows that smaller towns have a larger built-up area per inhabitant compared to the larger cities. In 2012, Oslo had the lowest built-up area with 224 m2 per inhabitant but has the highest density of buildings within the built-up area. Conversely, Tromsø city, with a significantly high density of buildings per inhabitant, had the lowest density of buildings in the period 2011-2012 with 50%. Overall, the density of buildings within the conurbation boundary of these 13 municipalities was 72%, while it was on a national average 43%. The results in this report clearly show that cities with high density of buildings are also the cities that are most able to live up to the authorities' targets for densification. Densification refers to the part of new housing that is established within existing urban boundaries (Haagensen 2015, p.20-22).

The report's indictor of walkability potentials is based on metrical distances from homes to grocery shops, schools, and kindergartens. Oslo scores highest with 90% on the indicator 'residents living with less than 500 meters away from a grocery store' in the municipality. Stavanger city is second on this list where 75% of the residents is living close to a grocery store. Most inhabitants in the largest cities have a short distance from home to a grocery store. These distances seem to increase the lower the population is in a town. This trend can also be seen by comparing the average from these 13 towns and cities with the average for the country (Haagensen, 2015, p.51). Likewise, regards distance from home to primary school, Oslo has the largest number of children living lesser than 500 meters betweeen their homes and primary school. In 2014, 96 % of the children had a short distance between home and primary school. The national average is lower than the average of these 13 cities, which is 63% versus 85%. Thus, the lower population density in a city, the longer distances between home and primary schools (Haagensen, 2015, p.55).

A report from the Institute of Transport Economics about land use and transport development for climate-friendly and attractive cities shows that there are clear correlations between densification and car dependence. Densifying in and around the existing town and city centre reduce private car dependency, reduces urban sprawl into the countryside, gives positive impact on the attractiveness of cities by contributing to high variation of services and land uses, contributing to lively and vibrant urban areas. Improved public transport services results in reduced car use. Furthermore, densification and transformation in the city centre contribute to increased accessibility, a provision of a variation of jobs, and increased attractiveness for the establishment of advanced businesses that requires highly skilled and specialized employees (Tennøy, Øksenholt, Tønnesen and Hagen 2017, p. 19).

Another important finding from this report was that the compact urban centres in the large cities provided at least as good access to public outdoor areas as the low-density towns. Arrangements for public transport, cycling and walking in combination with restrictive measures to regulate car traffic contributed to many of the same effects. At the same time, the report shows that restrictions on car traffic in heavily car-based cities are experienced as a significant disadvantage for those who work or live in areas where one is heavily dependent on the private car for daily activities (Tennøy, Øksenholt, Tønnesen, and Hagen 2017, p. 19).

Current trend in Norwegian towns and cities

Through restrictive municipal plans and strong agreements with governmental institutions, the large cities have shown ability to act in line with national policies and guidelines. Since 2014, the objective of the national transport plan is zero growth in private car transport. However, the small and medium-sized cities in Norway are lagging behind regards enhancing compact town centres and avoiding urban sprawl (Kråkenes et al 2022). For example, the town Notodden decided to reduce 180 acres of virgin land in favour of one hundred new detached residential plots in 2015. This is happening at the same time as state planning guidelines emphasize densification and transformation in already built-up areas. Four years later, Notodden's out of town shopping centre was granted permission to expand for car-based retail. At the same time, the regional plans discourage these kinds of developments for preventing deterioration of existing old town centres and increased passenger car traffic (Kråkenes et al 2022). The following features is taking place in most Norwegian towns during the last 20 years (Kråkenes et al 2022):

- Large car-based shopping centres are established outside the city and town centres,
- Agriculture and natural resources are being demolished through implementing new buildings on nature land,
- Important urban functions, such as homes, workplaces, etc. are established far from each other,
- The proportion of dwellings that require space, energy and resources is high, such as for the establishment of detached single-family houses,
- The car is given high priority as a means of transport in the cityscape despite increased government investment in more climate- and environment-friendly modes of transport such as walking, cycling and public transport,
- Important downtown streets and main squares are dominated by car parking spaces,
- Large new residential areas are established at a long distance from the city centre, which contributes to increased private car dependency and long travel journeys between work, school, leisure activities and shopping.

Thus, there is a large gap between national and regional planning policies and local implementation practice.

Relevant writings on walkability in an international context

It is believed that a town centre with good walkability facilities can contribute to lesser use of the private car and encourage densification strategies inside and around the existing town centre. The recent used concept 'the 15 minutes cities' indicated that everything should be accessible within 15 minutes walking within the city centres and from public transport stops. The concepts short travel time, high building density, high land use diversity and proximity of everything are used to describe the '15 minutes city' (Murgante et al 2023). Except from Oslo, most Norwegian town centres can be crossed within 15 minutes of walking.

There exist a large body of literature on measuring walkability potentials. In the study of Cervero and Kockelman (1997) the authors found out that compact neighbourhoods with a synergy of high building density, mixture of functions and pedestrian friendly design encourage reduction of vehicle trips. The authors propose a concept of 3Ds (density, diversity, and design), where the definitions of density and diversity is well defined. However, when it comes to the definition of design, it is defined to consist of sidewalks, tree rows, and providing facilities for pedestrian and cyclists. The study is slightly touching upon street profiles. However, the underlying spatial configuration of the mobility network is lacking. The authors are aware of that short block lengths encourage walking.

Later, Erwing and Cervero (2010) changed the 3Ds to 5Ds, now standing for density, diversity of land use, design, distance to transit, and destination accessibility. Still the concept of design is vague, and the issue of street profiles and street network configuration is lacking. The distances between homes and transit are now considered. In research on evaluating the state of transit-oriented development in the InterCity-Triangle of the Oslo fjord region, density and degree of function mixture was considered and correlated with space syntax analyses and strong correlations between them were found (Myklebust et al 2022). However, the street profiles were not considered in this research.

In another research, Moudon et al (2006) attempt to make operational definitions of walkable neighbourhoods. The authors also claim that higher residential density, smaller street blocks, presence of sidewalks, and finer mixes of uses promote high degree of neighbourhood walkability. Closeness of shops and retail have the largest impact of walking.

The concept 'walking the last mile' is used for understanding the various parameters for making walking attractive from the public transport stop to a destination (Braun et al 2022). However, what kind of spatial structure can enhance the initiative that people choose to move on foot or by car? There must be something more the built environment can offer rather than short metric distances or good pavement surfaces. Does the spatial structure and profile on the path network really matter? How can they be combined in one method?

In 2014 Job van Eldijk developed a method for street profiles based on street functions or street or road users (Eldijk 2014). He divides the mobility network in the following four categories: 1) pedestrian and bicycle streets, 2) balanced streets, 3) vehicle dominated roads, and 4) vehicle only roads. The purpose of the analysis is to examine how the street and road network is used by the various road user groups, and who dominates street use.

As research has shown, traditional town centres and neighbourhoods tend to have a high number of balanced streets. These streets are constituted by buildings entrances adjacent to the pavements and the buildings tend to have 'active frontages' oriented towards the pavements (Olsen et al 2022, Berge et al 2022, Meinert et al 2019). Modern neighbourhoods tend to have mostly vehicle dominated roads and separate pedestrian and bicycle paths (Stedal et al 2022, Kråkenes et al 2022). Buildings tend to lack entrances and windows on ground floor level along the roads.

Based on earlier space syntax research, urban centres with both high local and global integration, and the main routes need to be well connected to the neighbourhood seems to be well frequented by pedestrians (de Koning et al 2020a,b, van Nes & Yamu 2020, van Nes 2021a,b,c). Seemingly, urban environments with short urban blocks and a high number of X-junctions tend to have high spatial integration values (Shi and van Nes 2009). On a micro scale level, the street profiles seem to enhance walking (Meinert et al 2019). That means that buildings need to face streets with active frontages (Rønneberg Nordhov et al 2019), and a balanced street with both access for cars and pedestrians, or spatially well-integrated streets for pedestrians only (Berge et al 2022). Seemingly, encouraging sustainable mobility means that it is not enough to have high building density and high degree of land use diversity. It is the structure of the street and road network that influence the degree of density and land use diversity (van Nes et al 2012, Ye and van Nes 2014, de Koning et al 2021a,b, van Nes 2021b).

Method for developing the walkability potential matrix

For the town and city centres, the total number of T and X junctions are counted based on Stephen Marchall's work from 2005 (p.96-98). For junctions consisting of five arms and more, are registered as X-junction. A correlation is made between the total number of T and X junctions in relation to the total number of junctions. When the value is close to 1, the higher number of X junctions.

A correlation is made between roads and streets versus the total number of paths. For this, the last part of the street or road names is used to identify whether it is a balanced street that enhance walkability or a road encouraging car use. Based on Eldijk's classification system on street function, a separation of category 1) and 2) from category 3) and 4) is made based on the last part of path names. The first two categories are pedestrian friendly streets, whereas the last two part are roads designed for vehicles.

A path's name consists of mostly two parts. One part is a particular name given to the specific path for identification of a particular place and wayfinding, whereas the other part indicates the type of path (street, road, avenue etc). The 'particular name' part can be named after persons, things, animals, objects from the nature, unique shapes, places, or hierarchy of pathways (for example: Main Street, or in Norwegian 'Storgata'). The focus on this inquiry concerns the second part of the name, which often indicates for the type of users and the type of path.

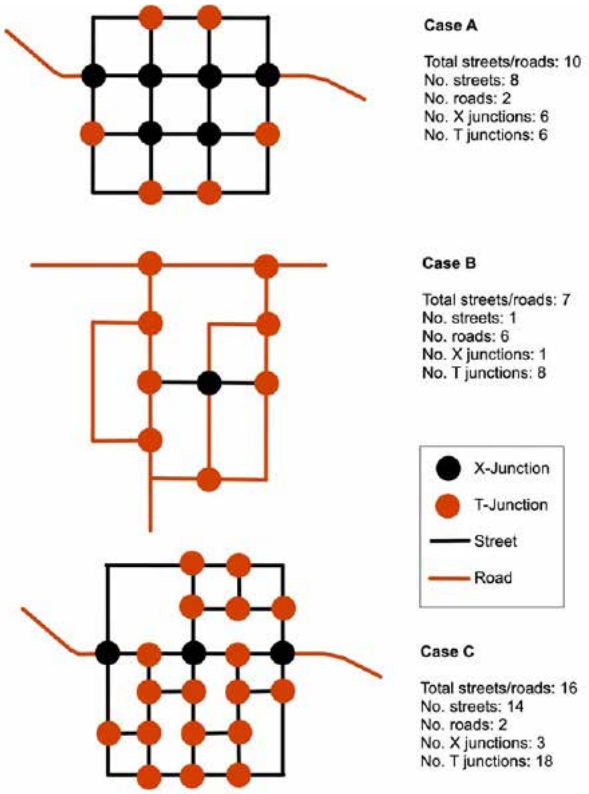

Figure 1: Three types of town centres based on path type and junction type.

In many northern European build environments, the balanced streets tend to have names ending on 'street' whereas the vehicle dominated roads ends on 'road'. In Norway the word 'gate' is used for 'street' and 'vei' for road. In this inquiry, all the paths with the name ending on 'vei, veg, veien, and vegen are registered as 'roads' in all 55 town and city centres. The names of the motor- and highways in Norway tend also to end on road ('vei', 'veg', 'veien' or 'vegen'). The remaining streets we classify as balanced or pedestrianized. A check was made with google street view. There are some exceptions, but the number is very low. For example, one of Oslo's main shopping streets is named 'Bogstadveien'. In the past it was a road leading from Oslo's city centre towards Bogstad farm. Through city growth, the road was urbanised and have today a balanced street profile.

In historic city centres, there exist a small number of paths with names that not always are ending on street (gate in Norwegian). Examples are 'smau' (pedestrian dominated path), 'almenning' (balanced street), 'aveny' (balanced street) or 'kroken' (balanced street). Therefore, they are all put into the category 'street' because they are pedestrian friendly streets. A correlation is made between the categories 'roads' and 'streets.' When the value is close to 1, the higher number of streets in correlations to road a city or town centre has.

Space syntax analyses are conducted of all 55 Norwegian towns and cities in 2022 with purpose to ascertain how various Norwegian towns and cities perform spatially. In sum, all these analyses indicate to some extend walkability potentials in these centres. All axial maps are hand drawn. It was possible to correlate the spatial data with data regards car ownership and building activities from the CBS of Norway for 47 towns and cities. For the larger cities, data about travel behaviour for public transport was gained for 6 cities. However, the resolution of all these data is too rough for correlations with the space syntax variables.

Regards the space syntax analyses, various normalised angular integration (NAIN), and normalised angular choice (NACH) analyses with both 500 (local) and 5000 (global) radii are conducted. The NAIN analyses show the to-movement potentials, whereas the NACH analyses show the trough-movement potentials of the street and road network. In addition, the angular step depth analyses taken from all the main routes are used for revealing how the main routes are connected to the local streets of the various neighbourhoods (van Nes 2021c).

These space syntax variables are used to test the results from the walkability potential matrix.

Hypotheses

As world-wide space syntax research has shown, streets with high through- and to- movement potentials on a local scale has the highest number of pedestrians in and along streets. Regards the theory of the natural movement (Hillier et al 1993), the higher level of through movement potentials on a local scale, the higher walkability potentials. At the same time, these locally integrated streets need to be well-connected to the main route network, in which is identified by calculating the through movement potentials on a city scale (de Koning and van Nes 2019).

On the scale of the town and city centres, one hypothesis is that the higher number of X-junctions in correlation with T-junctions, the shorter urban blocks, the more locally integrated the neighbourhood is, and the higher walkability potentials. Seemingly, the more the town or city centres have an orthogonal path network structure, the higher integration and thus higher walkability potentials. Another hypothesis is that the higher numbers of streets in correlation with roads in a town centre, the more integrated the urban area is and the higher walkability friendliness. Streets tend to have pavements and buildings located in a row with active frontages faces towards the pavements and streets. Conversely, roads tend to have free standing buildings that have frontages that are turned away from the streets. The entrances are often located on the side or the back side of the buildings.

Most town centres in Norway tend either to have an orthogonal street grid structure with a high number of streets and X junctions, or a road network structure consisting of mostly roads and T-junctions. The hybrid variant is a town centre having a street network with high number of streets with a high number of T-junctions. Figure 1 shows a diagram of three types of town centre.

Case A has an orthogonal grid structure with a high number of X-Junctions and high number of streets. Examples of these types of town centres are Kristiansand and Sarpsborg centres. Case B has a high number of T-junctions and roads. Examples on these kinds of town centres are Alta, Sandvika and Karasjok. Case C has high number of streets and seems to have an orthogonal grid structure but has a high number of T-junctions. Examples of this case are Arendal and Kragerø centre.

Developing the walkability potential matrix and statistical testing

The walkability potential matrix consists of identifying the degree of walkability potentials of town and city centres based on correlating junction and path type. The 4-star diagrams are used to visualise how each town scores. In the regression analyses, the mean values for all space syntax analyses are used for the whole city or town, and for only the town centre. The reason for correlating the findings from junction and path type with space syntax analyses is to reveal how the walkability potential matrix affects the degree of to- and through movement potentials in town and city centres.

Findings

The space syntax analyses of all 55 cities shows that the main centre appears to have the highest degree of through as well as to-movement potentials on town or city level. Figure 2 shows the to-movement potentials (NAIN) of twelve towns and cities centres of different sizes in Norway. Often it is difficult to see on a space syntax map to what extend a city centre is vehicle dominated or pedestrian friendly. The six cases on the top are towns with a high degree of private car dependency. The centres consist of car-based shopping centres surrounded by parking lots. Likewise, these town centres consist of mostly roads and has a high number of T-junctions, in line with case B in figure 1.

The six cases below have an orthogonal street network consisting of a high number of X-junctions and high number of streets, in line with case A in figure 1. These town and city centres have linear shopping streets with a high variation of individual shops easily accessible on foot. However, nothing can be said about the degree of walking friendliness of the streets of these towns based on the various space syntax analyses.

If it is so that local integration matters for enhancing walkability, figure 3 shows the NAIN and NACH analyses with a low metrical radius (500 meters), and street function analyses of three different Norwegian town centres. Trondheim centre has a high number of T-junctions but consists of mostly streets. The local to-movement as

well as through-movement potentials are high. Moreover, most of the streets are balanced. Trondheim centre is known to have a high number of people frequenting streets and is also very bicycle friendly. Conversely, Alta centre consists of roads and has a high number of T-junctions. These roads are vehicle dominated. The local to-movement potentials are low, and it has average values on the local through movement potentials. The shopping centre is turned away from the roads and is surrounded by large parking lots. Kristiansand has a high number of X-junctions and a high number of streets. It has a high number of balanced streets, with a high number of pedestrians frequenting the streets.

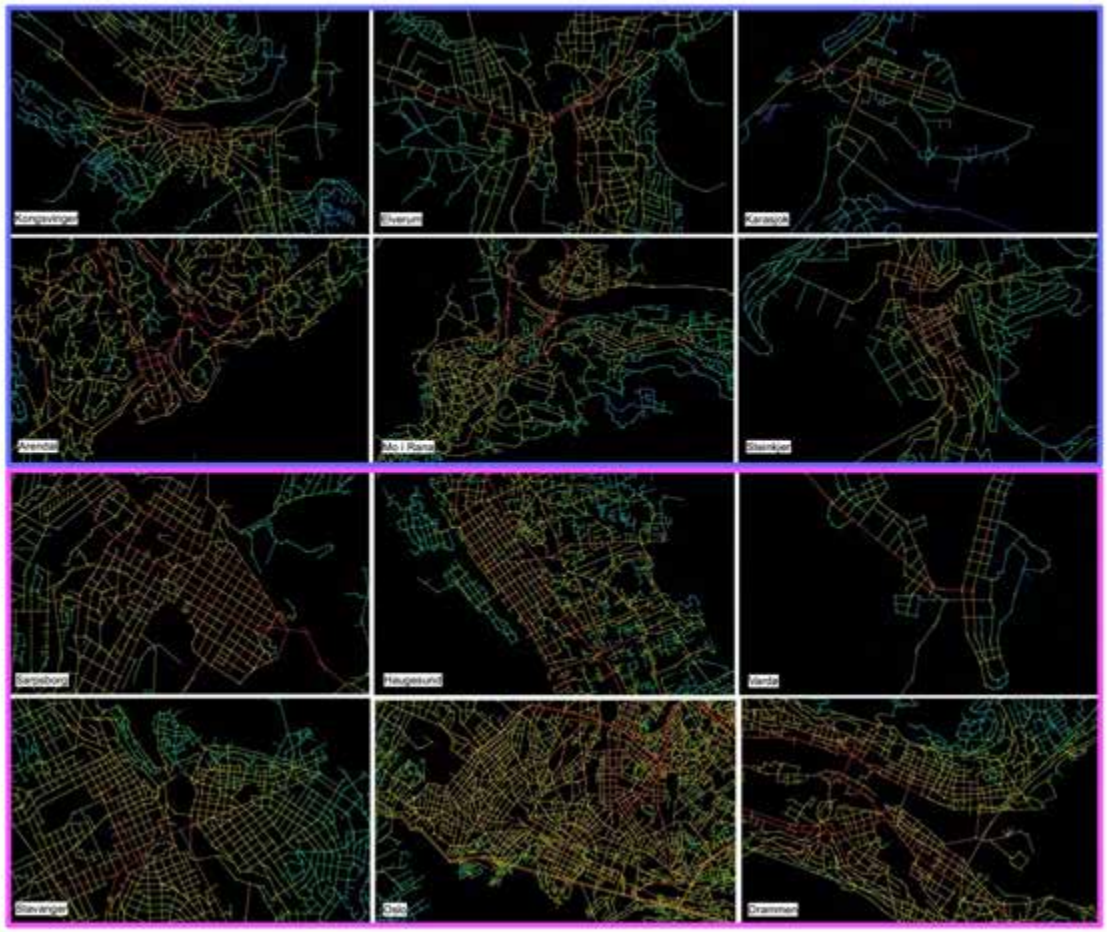

Figure 2: NAIN analyses with high radius of 12 Norwegian town and city centre. The six cases on the top have high number of T-junctions and consist of mostly roads, whereas the six cases below have high number of X-junctions and consists mostly of streets.

From the space syntax and the street function analyses it is not clear to what extend the level of the walkability potentials are in the town and city centres. Therefore, a closer view on junction and path type is revealed in the next chapter.

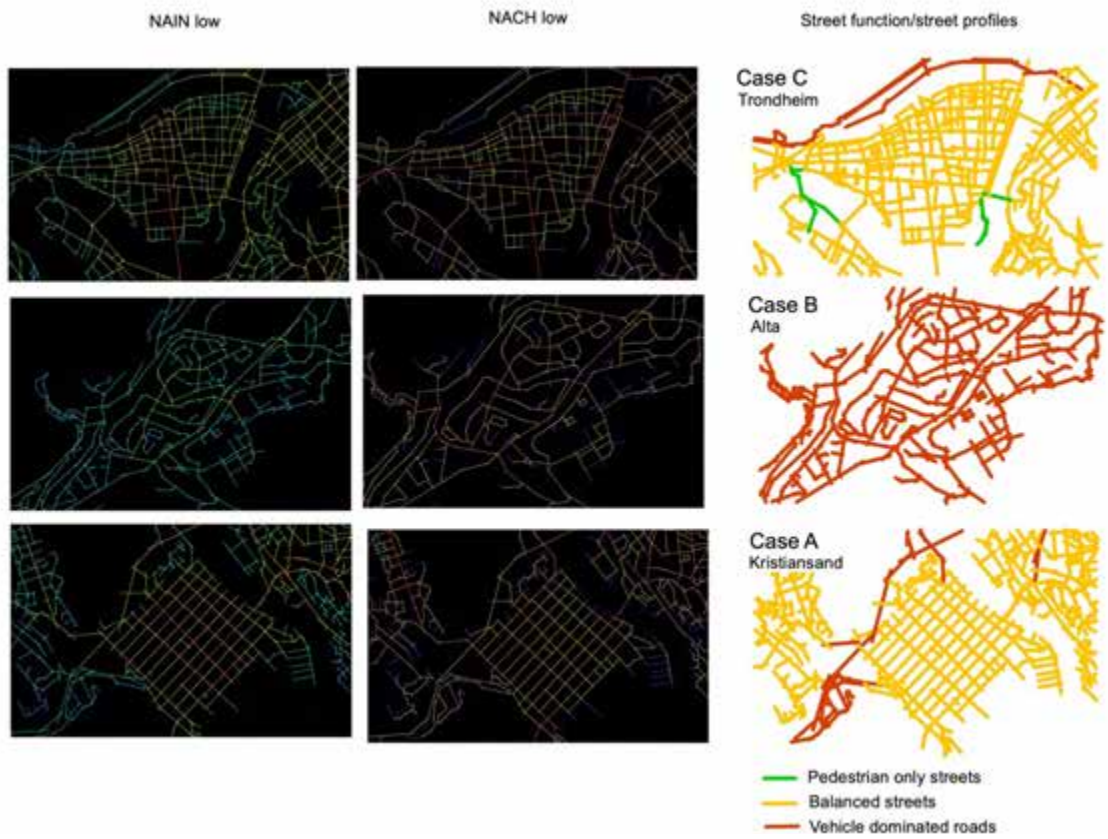

Figure 3: Space syntax and street function analyses of Trondheim (top), Alta (middle) and Kristiansand (below).

The correlation between path and junction types

A 4-star diagram can visualise how each town and city perform in relation to others regards the junction and path types. First, the correlation is shown between T-junctions and X junctions in relation to the total number of junctions, and the correlation between street and roads in relation to the total number of paths. The centres are grouped into large, medium, and small sized cities or towns.

Figure 4 shows a 4-star diagram of Norway's 6 largest cities. Kristiansand (green line) has the lowest number of T junctions due to that the centre consist of a strict orthogonal street network with mostly X-junctions. Trondheim's centre (blue line) consists of mostly streets with mostly T-junctions. Oslo (red line) scores average on all analyses.

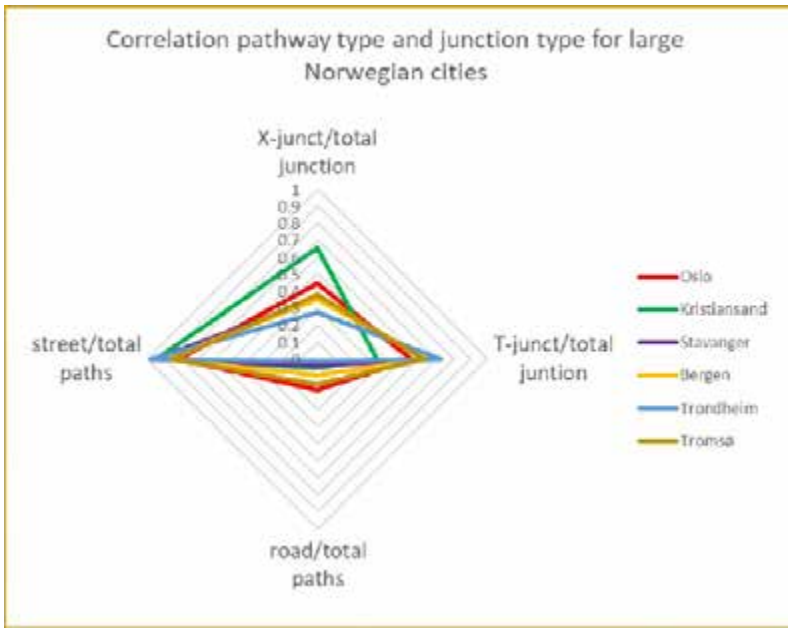

Figure 4: a 4-star diagram of Norway's 6 largest cities showing the correlation between streets, roads, X-junctions, and T-junctions.

Figure 5 shows a 4-star diagram of the medium sized town centres. Alta centre (red line) scores high on the number of T-junctions and roads, whereas Halden centre (blue line) scores high on the number of streets, and Sarpsborg centre (dark purple line) high on the number of X-junctions.

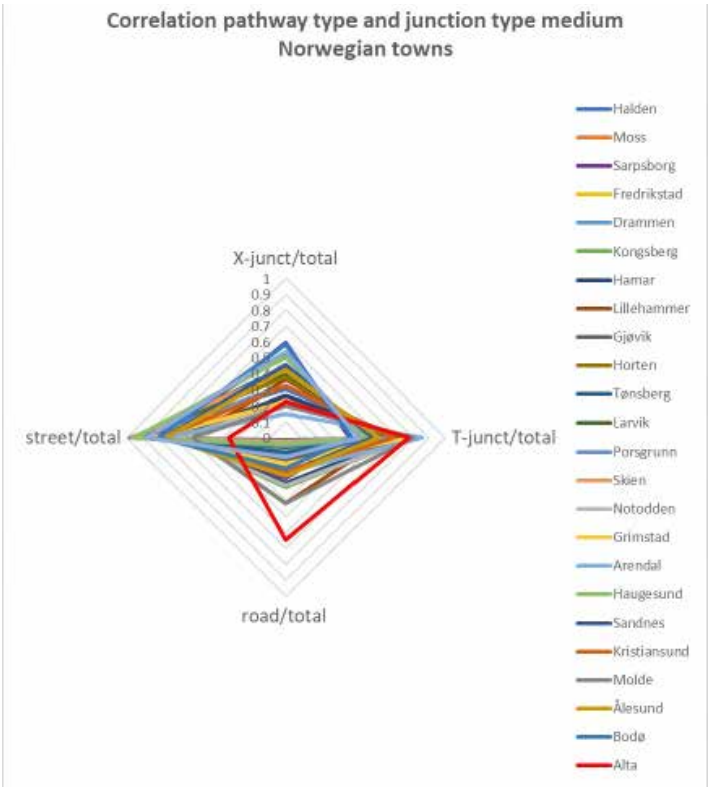

Figure 5: a 4-star diagram of Norway's medium sized towns showing the correlation between streets, roads, X-junctions, and T-junctions.

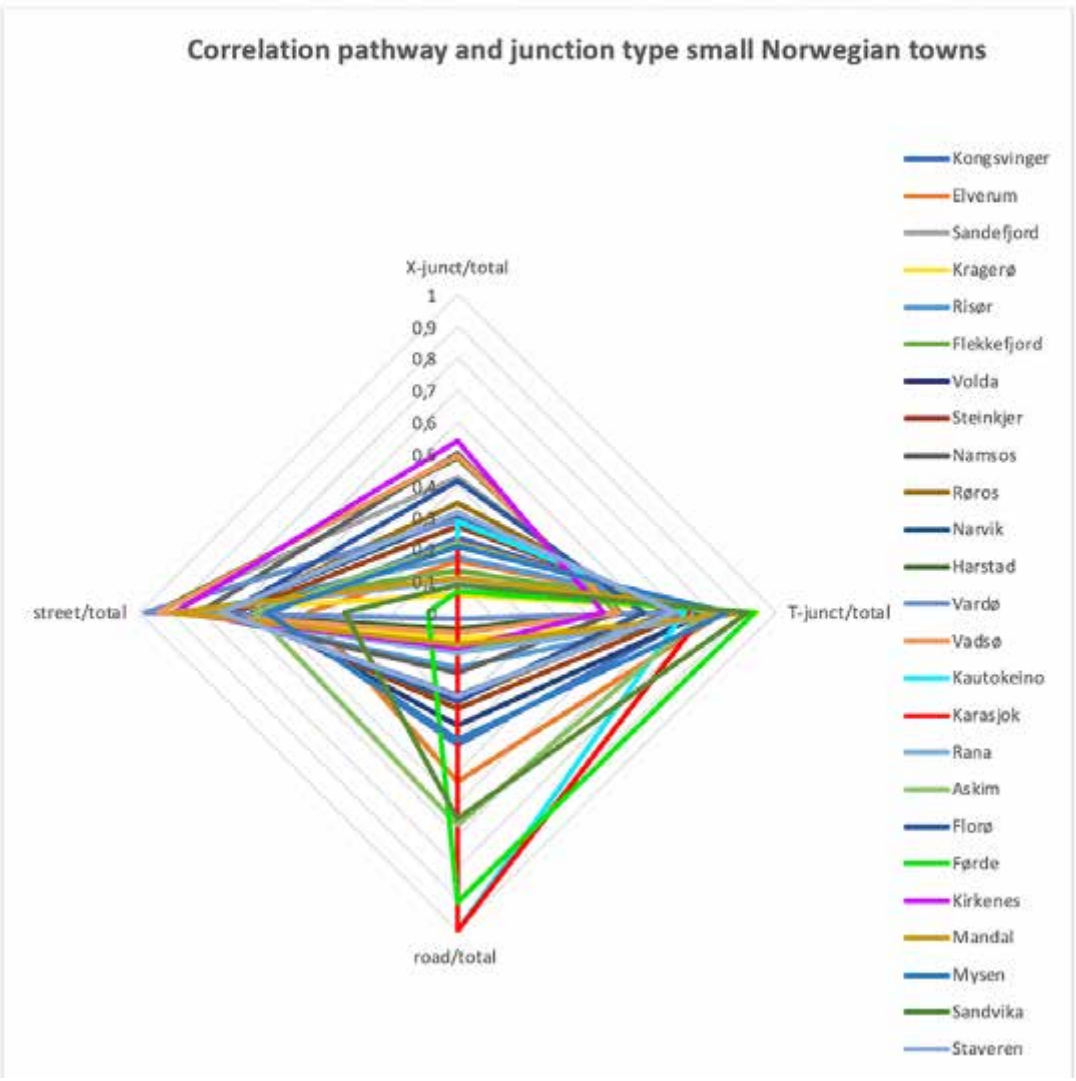

Figure 6: a 4-star diagram of Norway's small sized towns showing the correlation between streets, roads, X-junctions, and T-junctions.

Figure 6 shows the correlations of the centres of small Norwegian towns. The old coastal towns with an orthogonal street grid structure scores high on the X-junction and the percentage of streets. Conversely, the two Sami towns Karasjok (red line) and Kautokeino (turquoise line) consists of only roads. Likewise, the centres of the new towns, such as Førde (green line) and Sandvika (dark green line) have high number of roads and T-junctions. The small southern Norwegian town Kragerø (Yellow line) has a high number of streets and high number of T-junctions. The northern Norwegian coastal town Kirkenes (purple line) and Vadsø (orange line) has the highest number of X-junctions.

Figure 7 shows a scatterplot with the correlation between junction type and path type, and three different examples of town centres. The scatterplot represents the walkability potential matrix. On the Y axis, the closer a centre is to number 1, the higher percentage of streets in correlation to total number of paths. On the X axis, the close a centre is to number 1, the higher percentage of X-junctions in relation to the total number of junctions in a centre.

Three clusters can be seen in the scatterplot, in which comply with the three cases shown in figure 1. The town and city centres with orthogonal street grid are clustered together on the upper right corner in the scatterplot. Kristiansand centre has the highest number of X-junctions and streets. In the other cluster, town centres that has a small orthogonal grid in it centres, high number of streets, but has a high number of T-junctions in relation

to X-junctions. The towns Kragerø, Rana and Flekkefjord are examples of this. On the lower right part of the scatterplot the towns Elverum, Alta, Sandvika, Førde, Karasjok and Kautokeino are located. These towns have mostly roads and T-junctions.

The town centres that are located on the upper right in the scatterplot are case A towns, whereas towns centres located on the lower left in the scatterplot are case B towns. The case C towns are those who are located on the upper right in the scatterplot.

In many ways the scatterplot shown in figure 7 is a walkability potential matrix based on only junction and path type. The three clusters shown in the scatterplot comply with the reputation these towns have. Town centres in cluster A are known to be pedestrian friendly, town centres in cluster C are car-based, whereas towns in case B are also pedestrian friendly due to the high number of balanced streets. These streets are constituted by buildings that are oriented towards the streets with entrances and windows.

Below in figure 7 a four-star diagram is shown with the three most extreme cases representing each cluster. The shape and the location of the diamond indicate the type of town. The green diamond is on located on the upper left and consist of a high number of streets and T-junctions. These towns have robust centres enhancing pedestrian-based shopping streets and has a high level of walkability, in which indicate high level of sustainable transportation modes.

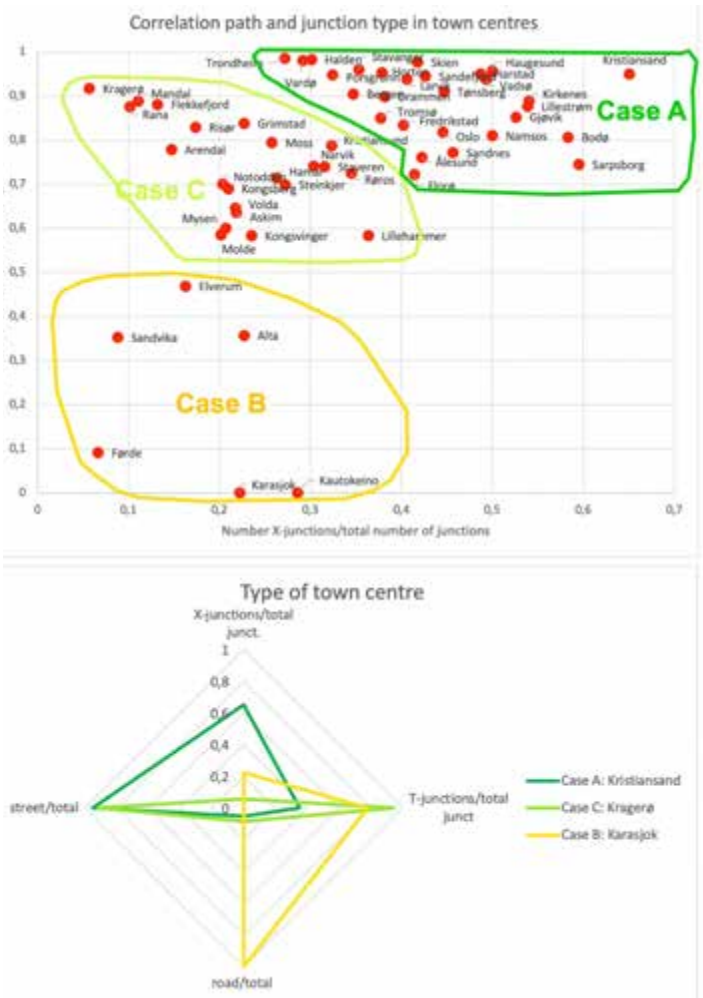

Figure 7: Top: The walkability potential matrix - Scatterplot showing the correlation between junction and path type. Bottom: 4-star diagram showing examples of three different towns representative for each cluster.

The light green diamond is flat and stretched out on the horizontal levels. The towns belonging to this category are small old town centres that either are squeezed between small hills or narrow valleys or along a coastal line. The biggest threat of these towns are the establishment and expansions of out-of-town shopping malls. Often these shopping malls are causing town centre decline due to that shops move out to these car-based shopping malls. Therefore, these town centres are very woundable when expanding due to population growth.

The yellow diamond is located on the lover right in the diagram. Towns belonging to this category are villages that recently got the status as town due to their regional position or population growth, or they are new towns. Their centres are developed around a T-junction, and everything is dimensioned around private car usage. Traffic safety, road capacity rules from the road engineer handbooks have steered the development of these town centres.

The next is to reveal to what extend the number of various junction and path types correlates with space syntax variables through regression analyses.

Regression analyses between junction type and space syntax
To what extend do these three types of town and city centres score on the spatial configuration of the street and road network? The axial map does not make any difference between path as well as junction type. Scatterplots were made for revealing the regression (R2) between space syntax analyses and path and junction types for all 55 town and city centres. The strongest correlations were found with the local NAIN and NACH analyses with a radius of 500 meters.

The correlation coefficient between the junction type and local NACH is R2 = 0,3701 and local NAIN is R2 = 0,3325 for all town and city centres. Thus, high number of X-junctions matters for generating high integration with high local to- and through-movement potentials. As research has shown, central urban areas with high local integration are attractive for pedestrians and contributes to low energy use for transport (de Koning et al 2020b).

Figure 8 shows a scatterplot with a differentiation between the size of the cities and towns. Regards the local to-movement potentials (mean NAIN low), the medium sized towns have the highest correlation with the percentage of X-junctions. Conversely, the larger the town or city, the stronger the correlation is between the percentage of X-junctions and local through movement potentials (mean NACH low). Seemingly, large towns and cities has a well-integrated main route network well-connected to adjacent larger neighbourhoods than the medium and small towns. Many of the small towns that just got the town status have a centre that is consisting of mostly roads with several T-junctions. Most of them are small villages that has expanded.

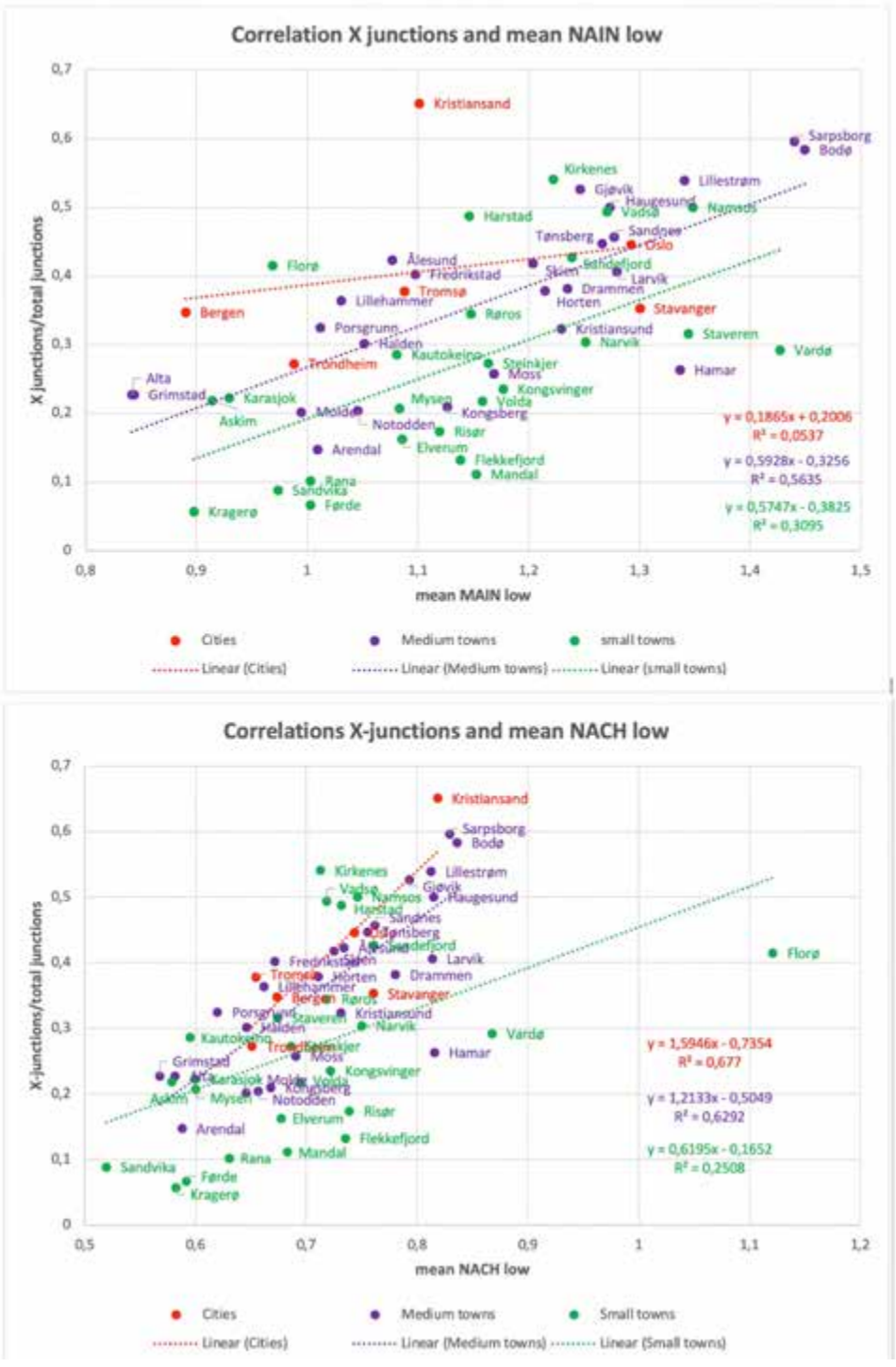

Figure 8: Regression analyses of X junctions and local mean NAIN and NACH with a differentiation of the town and city size.

Regression analyses between path type and space syntax

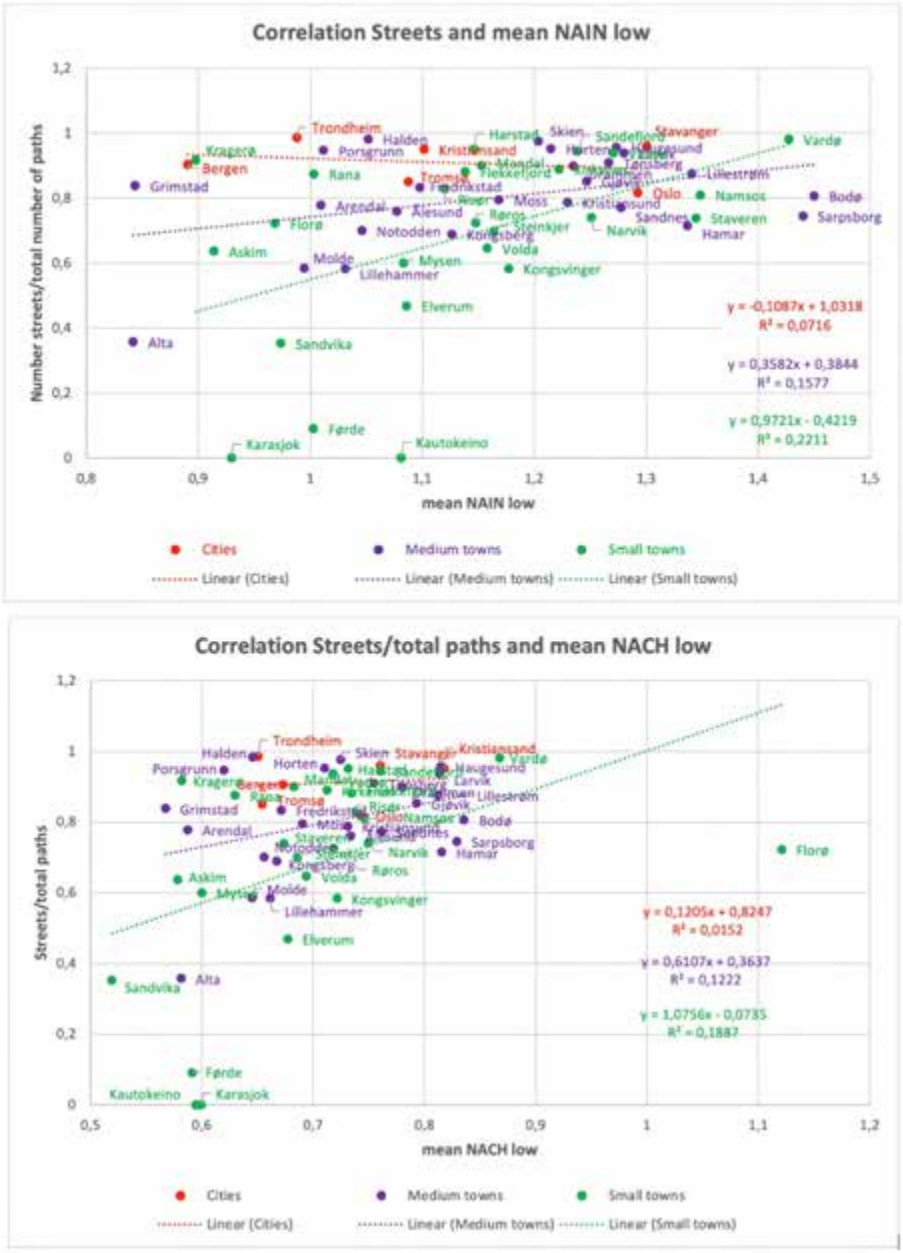

Figure 9: Regression analyses of percentage of streets and local mean NAIN and NACH with a differentiation of the town and city size.

Regards the correlation coefficient between the percentage of streets in relation to roads with local to- and through movement potentials for all towns and cities, they are slightly lower than the X-junctions. The correlation coefficient between the path type and local NACH is R2 = 0,1627 and local NAIN is R2 = 0,13 for all town and city centres. When making a differentiation between the sizes of the city and towns, as shown in figure 9, the small towns show the strongest correlation between the percentage of streets and local to- and through movement. The smallest towns have the largest variation of all three cases. Thus, the percentages of streets in relation to roads seems to matter to some extend in the various local integration analyses.

Discussion

As the results of all the 55 Norwegian town and city centres show, a high number of X-Junctions in correlation with T-junctions combined with a high number of streets in correlation to roads contribute to high degree of walkability potentials. Often town centres with an orthogonal street grid, have many X-junctions and tend to have short urban blocks. All streets in these towns and cities have pavements or are pedestrianised. In the streets with car accessibility, there is a balanced use between pedestrians and car drivers. In most cases, the buildings tend to be faced towards the streets with active frontages.

Conversely, town centres with high number of roads in relation to streets tend to be dominated by T-junctions. The urban blocks tend to be large, in which increase walking distances. Even though most of the roads have pavements, it is still vehicles dominating these roads. Buildings are mostly turned away from roads, in which makes walking as a boring experience. Town centres with these spatial features tend to have a car-based shopping centre and few people frequenting streets on foot. Often a random chosen small area is reserved for a square with some benches to sit, often named 'torget' (the square).

Figure 10 shows some google street view images of four different town and city centres. The two cases on the top are car dominated towns with a car-based shopping centre surrounded by parking lots. The buildings are turned away from the roads, in which reduce the perception of safety and attractiveness for walking. The two cases below are from city centres that are dominated by streets. Whereas Kristiansand centre consists of mostly X-junctions and Trondheim centre consists of mostly T-junctions, the centres consist of mostly streets with pavements. All buildings have active frontages oriented towards the streets.

Figure 10: Google Street view images of the car dominated roads in the centres in Alta and Mo i Rana, and the balanced streets in the centres of Kristiansand and Trondheim.

The percentage of X-junctions have the strongest correlation with the degree of local to- and through movement potentials. High number of X-junctions contributes to short urban blocks and high local integration, in which creates short movement routes and high degree of land use mixture. A high percentage of streets in relation to roads contribute to make the path network attractive for walking, due to that the buildings along streets tend to have active frontages with many entrances orientated towards the streets. This stimulates the senses and gives a nice walking experience. Moreover, the location pattern of shops tends to have a linear pattern. The variation of shops tends to be high in these kinds of centre, in relation to the centres that are dominated by roads and T-junctions. Conversely, the location pattern of shops tends to be clustered in a car-based shopping centre in towns dominated by roads and T-junctions. Most shops are from branches and offers few opportunities for individual shops.

Conclusions – the walkability potential matrix measures the destiny configuration
A first step to enhance sustainable mobility means is to focus on the path network in city and town centres. It is not enough with high density of buildings and high degree of land use diversity. The spatial structure and the profile of the path network also matters. Metric or topological distances do to some extend matters for enhancing walkability but must be seen together with the path type and the junction type. The first one is about making walking is comfortable, safe, and enjoyable (stimulating the senses during walking), whereas the second one is about the degree of routes choices (dealing with monotony versus variation). Seemingly, the spatial framework for the so-called '15 minutes cities' or for 'walking the last mile' indicates the following spatial parameters:

- High number of X junctions in relation to T Junctions,
- High number of streets in relation to roads,
- High global as well as local to- and through movement potentials regards the spatial configuration.

All these parameters together contribute to enhancing potentials for walking friendly town and city centres. A street with buildings faced towards it, short urban blocks and large choice of routes makes walking far more attractive than a road with adjacent building turned away from it and large urban blocks with few route choices. These parameters needed to be incorporated into the 'design' part of the 5Ds proposed by Ewing and Cervero (2010). Or a 6th 'D' needs to be added, such as for example 'destination configuration'.

How can the walkability potential matrix be applied into current planning and urban design practice? In general, all present urban planning and design activities must start from to build on information about the town or city where the intervention takes place. Those responsible for planning must be able to obtain this information. A regrettable fact is that many planners and urban designers do not distinguish between qualifications for preparing plans and qualifications for obtaining relevant information and analysing such information for planning. The aim of this contribution focus on the latter.

Over the past decades, knowledge has been developed both for obtaining and analysing information that has given both planners and urban designers far better tools than before to carry out analyses of urban structure and its characteristics for space use than before. However, it is still a long way to go from research into planning practice.

The use of the walkability potential matrix will give indications of how attractive it is to be a pedestrian in the various street profiles. This attractiveness is also affected by light, sunlight etc. This is probably one of the reasons why small urban blocks are more attractive than large urban blocks. Large parts of Norway lie at the same latitude as Greenland, where several streets have shade with snow and ice on the ground for about 6 months per year. When implementing high density of houses in central urban areas in line with the central authorities' recommendations in neighbourhoods consisting of large urban blocks with new roads with buildings turned away from it, contribute to pedestrian unfriendly streets.

The walkability potential matrix is needed to assess the formulation of policies at a higher level than at a municipality level. This is needed to make policies for a good street network suitable and attractive for pedestrians. Moreover, this method can be used to make a screening for new planning proposal for neighbourhoods to test to what extend the path network contributes to high degree of walkability. The biggest challenge is to upgrade and change the road engineer's path network dimension 'bible' containing rigid road standards requirements

mostly suitable for vehicle dominated roads in the Norwegian countryside. Requirements for street dimensions in an urban context is lacking in this book. Likewise, requirements must be set for new buildings in land use plans, such as enhancing active frontages with windows and doors facing towards streets on ground floor level.

Even though the focus in this inquiry focused only on junction and path types, the next step is to obtain information about the characteristics of streetscapes and buildings in terms of attractive pedestrian movement routes and its relation to shadow and sunlight analyses. Likewise, the next challenge is to obtain detailed travel behaviour data from each town and city for correlating the results with the walkability potential matrix. What is clear is that the weather conditions do not influence a town or city's walkability potentials. Some of the towns are in areas with rough climate and weather conditions. Moreover, the walkability potential matrix needs also to be tested on town and city centres from other countries.

Most streets in Norwegian town and city centres came into being before the explosion of private car ownership. Therefore, most building entrances and windows on ground floor level are oriented towards the streets. Therefore, a note of warning must be given to current urban planners and designers: When giving a new pathway a name ending on 'street', it is not a guarantee for that it will facilitate pedestrian movement. Seemingly, the path needs pavements, building with entrances and windows (active frontages) oriented towards the path on ground floor level for making walking attractive, safe, and enjoyable.

For generating walking friendly and sustainable town and city centres in Norway, the largest challenges need to be put on the road engineers. The current road planning manuals need updates regards requirements for street profiles with good urban qualities. The road engineer needs to look further outside the road or street's boarder and incorporate the adjacent buildings to a street when intervening in built environments (van Nes 2021b). Likewise, the rigid planning standards on maximum noise is based on models based on origin and destination traffic models. All these requirements create anti-urban urban centres, in which make walking boring. In addition, the challenge for urban planners is to put requirements on building facades and street profiles in land use plans. The adjacent buildings to streets need active frontages with doors and windows on the ground floor facing streets for making walking safe and enjoyable. Streets with blind walls and buildings turned away from streets are perceived as boring, dull, and unsafe.

At present, villages with a regional central position are expanding in Norway. Recently, many of them are getting a town status. Often these village have a tiny old centre consisting of one or two streets. When the number of inhabitants is growing, often large new neighbourhoods containing single-family houses are spread out into the countryside around these small centres. This creates long travelling distances along roads that are boring to walk on, which again are contributing to that these centres are planned around the private car. Again, this contributes to the establishment of car-based shopping centres adjacent to these tiny old centres. Therefore, the largest challenge is to introduce street planning and traditional balanced street profiles for creating short and attractive walking distances in town and city centres.

The next step is to try out the walkability potential matrix on other cities outside Norway. The historic and the local context need to be considered regards identifying the path type from path names. In Norway the last part of street names correlates with Eldijk's street profiles classification. Hopefully, the walkability potential matrix can contribute to refine the 'design' concept from the 5Ds or to add a 6th D named 'destination configuration.'

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Optimisation of non-motorised facilities in urban fringe sheltered housing areas: Transport Accessibility and Equity Enhancement Based on Supply and Demand Analysis

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Abstract:
As affordable housing developments continue to expand toward the urban fringe, limited public transportation connections and extended commuting distances have intensified mobility challenges for residents. Owing to their affordability and flexibility, non-motorized vehicles have become a key solution for bridging the "last mile." However, the current supply of parking facilities for such vehicles is inadequate, leading to reduced travel efficiency and increased inequality in the distribution of transportation resources. This study examines 13 affordable housing communities on the outskirts of Xi'an, utilizing 473 valid survey responses to develop a supply-demand assessment and travel behavior model. Findings reveal that demand for non-motorized vehicle parking is 1.8 times the current capacity, particularly among low-income and long-distance commuters. In response, the study proposes a set of optimization strategies: dynamic adjustment of parking layouts, implementation of intelligent management systems, enhancement of public transit connectivity, and repurposing of underutilised motor vehicle spaces. The results offer practical insights for promoting transportation equity in peripheral urban areas.

Keywords: Affordable Housing; Urban Fringe; Non-motorized Vehicle Facilities; Transportation Equity; Supply-Demand Analysis

I. Introduction

With the continuous enhancement of China's urban housing security system, the spatial distribution of affordable housing has increasingly extended to the urban periphery (Vinda et al., 2023). While these emerging areas have helped alleviate residential pressure in central urban districts, they are also confronted with underdeveloped transportation infrastructure and inadequate public service systems (Chen, 2023). In particular, factors such as limited rail transit coverage, sparse distribution of bus stops, and generally long commuting distances have significantly increased both the travel costs and time burdens for residents. Against this backdrop, non-motorized vehicles—valued for their flexibility, affordability, and adaptability—have gradually become the primary mode of transport for last-mile commuting in affordable housing communities.

However, the growing share of non-motorized travel has not been matched by corresponding improvements in supporting infrastructure. In many peripheral affordable housing areas, insufficient parking space for non-motorized vehicles, imbalanced facility distribution, and outdated management practices have led to frequent issues of "parking difficulty and disorder" during peak commuting hours. These challenges not only reduce travel efficiency but also disrupt the order of shared community spaces, further exacerbating inequalities in transportation resource allocation and reinforcing the stratification of urban social space.
Moreover, the high usage rate of non-motorized vehicles reflects the income sensitivity of residents in their travel mode choices. Due to financial constraints, this population often lacks access to private vehicles (Zhao and Zou, 2025), while inadequate public transportation coverage fails to provide viable alternatives—rendering non-motorized vehicles a form of "passive adaptation." This structural disparity in access to transportation resources reveals the essence of transport equity issues: not in the vehicles themselves, but in the unequal rights to mobility (Currans et al., 2020).

Therefore, optimizing the non-motorized vehicle facility system is both a practical necessity for improving commuting efficiency and a strategic approach to promoting transportation equity and spatial justice in peripheral affordable housing areas (Linlin et al., 2022). A systematic analysis of facility imbalances from the threefold perspective of "infrastructure supply–resident behavioral response–spatial equity" helps address the structural oversight of "prioritizing housing over mobility" in current urban planning, and advances a people-oriented, green, and low-carbon transition in urban transportation systems.

This study selects 13 typical affordable housing communities located in five districts of Xi'an—High-Tech Zone, Qujiang, Xincheng, Lianhu, and Weiyang—as empirical cases. Through questionnaire surveys and field observations, a total of 473 valid samples were collected. A facility supply-demand ratio model is employed to assess configuration tension, and a binary Logit model is used to analyze the determinants of non-motorized commuting behavior. Based on the empirical findings, this paper proposes an optimization strategy for non-

motorized vehicle facilities that targets both "livability" and "equity," focusing on total capacity expansion, spatial layout refinement, smart management mechanisms, and public transport system enhancement. The study aims to provide empirical support and policy recommendations for transportation planning and resource allocation in peripheral affordable housing areas.

The structure of the paper is as follows: Section II reviews the relevant literature and theoretical foundations; Section III introduces the study area, data sources, and model specifications; Section IV presents the empirical results and diagnostic analysis; and Section V offers countermeasures and planning implications.

II. Literature Review

2.1 Commuting Challenges Faced by Residents of Affordable Housing in Urban Peripheries

The siting of affordable housing projects in urban peripheries often places them far from city centres, leading to limited public transportation coverage and significantly extended commuting distances (Deng, 2021). These areas are mainly inhabited by young people and low-income groups, whose travel behavior shows a high dependence on non-motorized vehicles (Han, 2022). Cheng pointed out that even when housing projects are located near rail transit stations, the absence of continuous connecting routes and pedestrian infrastructure results in relatively low actual accessibility (Cheng, 2024). These studies collectively indicate that the commuting disadvantage faced by residents in peripheral affordable housing areas is both widespread and structural.

2.2 Supply-Demand Imbalance and Facility Allocation Issues of Non-Motorized Vehicles

With the rising frequency of non-motorized vehicle use, the mismatch between supply and demand for related facilities in affordable housing communities has become increasingly prominent. Han found that many youth-oriented public rental housing projects in Xi'an face challenges such as a shortage of parking spaces, poor nighttime lighting, and lack of management, all of which negatively impact commuting experience and safety (Han, 2022). Lu Yuan et al. highlighted frequent conflicts between non-motorized and motorized vehicles in Shunyi District, Beijing, which reflect spatial mismatches in parking resource allocation (Lu et al., 2023). Notably, some affordable housing communities exhibit a phenomenon of facility mismatch: although the proportion of residents using private vehicles is low, the number of motor vehicle parking spaces often exceeds those for non-motorized vehicles. This reflects the continued application of commercial housing standards without due consideration of the travel needs of affordable housing residents. International studies have also shown that the travel intensity of motor vehicle use among low-income populations is significantly lower than that of the general public, and a lack of differentiation in development evaluations may lead to misallocation of resources (Amanda et al., 2018).

2.3 Theoretical Approaches to Accessibility and Transportation Equity

Recent research has gradually shifted from a narrow focus on individual travel behavior to more systematic investigations into infrastructure provision and transportation equity. Scholars widely agree that transportation equity involves not only freedom of mode choice but also travel capability, accessibility efficiency, and balanced spatial resource allocation (Geurs and van Wee, 2004). However, most of the relevant literature remains centreed on urban core areas and lacks systematic assessments of the equity of non-motorized vehicle facility allocation in peripheral affordable housing zones. Although some studies have attempted to measure equity through indicators such as supply-demand ratios, service radius, and facility density, there is still a notable absence of integrated application in the field of non-motorized transportation (Sun et al., 2021).

III. Research Design and Methods

3.1 Study Area and Sample Selection

As the affordable housing supply system in Xi'an has gradually improved, the spatial distribution of affordable housing communities has extended to the urban periphery. This has led to the formation of typical affordable housing clusters in areas such as the High-Tech Zone, Qujiang New District, Weiyang District, Xincheng District, and Lianhu District. During the site selection process, the planning orientation often followed the principle of "locating away from the core of the main urban area and closer to emerging industrial zones." While this approach has contributed to relatively high land-use efficiency, it has also brought about increasingly prominent issues related to lagging transportation infrastructure.

This study selected 13 representative affordable housing communities from the five aforementioned districts as the survey samples, covering various types of affordable housing, including public rental housing, housing coordinated through the housing provident fund, and resettlement housing. Specifically, the selected communities include:

Figure 1. Distribution of Sample Affordable Housing Communities in Xi'an

District	Community Name	Housing Type
Qujiang New District	Gongzuo I Public Rental Housing, Gongzuo II Public Rental Housing	Public Rental Housing
High-Tech Zone	Lanbo Apartment, Jinye Apartment, Software Apartment	Public Rental Housing
Xincheng District	Tianlun George Mansion, Qujiang Mingfu Jiayuan	Resettlement / Provident Fund Coordinated Housing (Mixed)
Lianhu District	Fenghefang, Vanke Golden Joy City, Yirun Garden	Provident Fund Coordinated Housing
Weiyang District	Xipu Tuozhai, Zhongpu Tuozhai, Xiaoli Provident Fund Community, Poly Wutongyu	Resettlement / Public Rental Housing (Mixed)

The selected communities are situated within the transitional zone between the central urban area and industrial new districts, typically exhibiting a pattern of "peripheral distribution along major rail corridors." Although some housing projects are located near rail transit nodes or arterial roads, their actual accessibility remains limited due to the absence of continuous pedestrian networks and convenient transfer pathways. This is particularly evident in the generally excessive walking distances to subway stations (often exceeding 2 kilometers), low-frequency bus services, and expansive service radii—factors that have significantly increased residents' reliance on non-motorized modes of transport.

From a spatial planning perspective, these affordable housing developments are commonly located beyond the control boundaries of rail-related land use and at the fringe of urban functional zones. While such locations benefit from low land costs and favorable policy support, they are often designated in higher-level planning documents as "development reserves" or "ecological control zones." Consequently, they lack adequate urban-scale public service infrastructure, resulting in mismatches in the provision of transportation, education, and healthcare services. In some cases, despite their proximity to transit corridors, barriers such as the lack of pedestrian crossings, indirect or fragmented walking paths, and steep elevation differences give rise to a planning paradox: **spatial proximity but functional disconnection**.

Regarding sample composition, a total of 500 questionnaires were distributed, yielding 473 valid responses—an effective response rate of 94.6%. Stratified random sampling was conducted based on housing unit quantity, population density, and administrative divisions. GIS verification was employed to ensure spatial coverage was evenly distributed, housing types were diverse, and commuting characteristics were representative.

3.2 Data Sources and Indicator Construction

(1) Data Sources and Collection Methods

The data for this study were primarily obtained through two channels: in-person questionnaire surveys and on-site observations conducted in selected residential communities. The survey was carried out between January and February 2025, covering both weekdays and weekends. Researchers visited 13 affordable housing communities to conduct face-to-face interviews and distribute paper questionnaires, supplemented by an online version. Respondents were permanent residents aged 18 or older who had lived in the community for at least six months. The survey focused on their daily commuting patterns, usage of transportation facilities, and perceptions of mobility and access.

Simultaneously, using a combination of street-view image analysis and field inspections, researchers recorded the quantity, spatial distribution, and saturation level of non-motorized vehicle parking facilities in each community. In some cases, video surveillance coverage was also used as a supplementary validation tool to enhance data accuracy and timeliness.

To ensure the scientific rigor and effectiveness of the questionnaire design, this study referenced the *Urban Residential Area Traffic Survey Manual* (Ministry of Housing and Urban-Rural Development, 2020) and the indicator framework of the Place Pulse 2.0 perception model. Based on these sources and aligned with the study's objectives, a multi-dimensional structured questionnaire was developed, encompassing residents' demographic characteristics, commuting behavior, satisfaction with transportation facilities, and travel preferences.

(2) Questionnaire Structure and Variable Distribution

The questionnaire is composed of four core modules and 22 variable items. The main components are detailed in the table below:

Figure 2. Questionnaire Structure and Variable Types for Residents of Affordable Housing in Xi'an

Module	Example Variables	Sample Questions	Variable Type
Resident Demographic Information	Age, Gender, Household Income	What is your current total monthly household income?	Single choice / Interval
Commuting Behavior Characteristics	Commuting Distance, Primary Mode of Transport	What is your primary mode of transport for commuting to work or daily activities?	Single choice
Usage of Non-Motorized Facilities	Frequency of Use, Parking Space Shortage	Do you often find it difficult to find a non-motorized vehicle parking spot?	5-point Likert scale
Perception of Travel Environment	Nighttime Lighting, Sense of Safety, Transfer Convenience	Do you find the route from your community to the nearest metro station convenient?	Subjective perception variable

The facilities usage section employs a 5-point Likert scale (ranging from "very dissatisfied" to "very satisfied") to assess residents' perception of the rationality of the configuration, management, and distribution of non-motorized vehicle parking spaces; the behavioral preference section sets multiple-choice questions based on the frequency and substitutability of travel modes to identify the degree of residents' reliance on non-motorized vehicles.

(3) Estimation Method for the Supply and Demand of Non-Motorized Vehicle Facilities
To objectively assess the actual supply-demand balance of non-motorized vehicle parking facilities, this study adopts a combined approach using both theoretical demand estimation and on-site capacity verification, and constructs the following model:

Facility Supply-Demand Ratio = Actual Number of Parking Spaces ÷ Estimated Number of Required Spaces
The estimated number of required parking spaces is calculated using the formula below:

Estimated Demand = Ownership Rate × High-Frequency Usage Rate × Per Capita Demand Coefficient × Residential Population

Where:
Ownership Rate refers to the proportion of households owning non-motorized vehicles per 100 households;
High-Frequency Usage Rate refers to the proportion of residents who use non-motorized vehicles five or more times per week;
Per Capita Demand Coefficient is set at 1.1, taking into account spare spaces and rotation needs;
Residential Population refers to the actual total number of residents in each community.
Based on survey results, the average facility supply-demand ratio across the 13 sample communities is only 0.56, indicating that the demand is approximately 1.8 times the current capacity. This finding aligns closely with residents' subjective perceptions of facility shortages. Particularly in communities located in Weiyang District and Qujiang New District, parking saturation during morning and evening peak hours approaches 100%. As a result, some residents are forced to park in informal areas such as greenbelts, building corners, and fire access lanes—raising concerns over safety and spatial order.

3.3 Model Construction and Variable Specification

(1) Model Selection and Theoretical Foundation
To explore the factors that significantly influence the likelihood of residents choosing non-motorized vehicles as their commuting mode, this study employs a **binary Logit model** for empirical analysis. This model is suitable for cases where the dependent variable is dichotomous, and it can estimate the marginal effects of various independent variables on the probability of choice.

The Logit model is grounded in the **Random Utility Maximization (RUM)** theory, which assumes that individuals tend to select the travel mode that offers the **highest net utility** among all available alternatives. The decision to commute by non-motorized vehicle is jointly influenced by travel behavior characteristics, facility supply conditions, and socioeconomic attributes.

The basic form of the Logit model is as follows:

$$Pr(Y = 1) = 1 / [1 + \exp(-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n))]$$

Where:
Pr(Y = 1) represents the probability that a resident chooses non-motorized commuting;
X ,X ,...,X are the explanatory variables (e.g., commuting distance, facility satisfaction, etc.);
are the parameters to be estimated.
In this model, one of the core explanatory variables is the **facility supply-demand ratio**, calculated as:

$$\text{Facility Supply-Demand Ratio} = \text{Actual Parking Spaces} / \text{Estimated Demand}$$

With the estimated demand computed as:

$$\text{Estimated Demand} = \text{Ownership Rate} \times \text{High-Frequency Usage Rate} \times \text{Per Capita Coefficient} \times \text{Residential Population}$$

Where:
Ownership Rate: the proportion of non-motorized vehicle ownership per 100 households;
High-Frequency Usage Rate: the proportion of residents who use non-motorized vehicles five or more times per week;
Per Capita Demand Coefficient: set to 1.1 to account for spare capacity and turnover needs;
Residential Population: the estimated total number of residents in each community.
(2) Variable Settings and Index Explanations
The dependent and independent variables selected for this study are listed in the table below.

Figure 3 Variable Definitions and Descriptions Used in This Study

Variable Name	Type	Description	Coding
Use of Non-motorized Vehicle	Dependent Var.	Whether the resident primarily uses a non-motorized vehicle (e-bike/ bicycle) for commuting	Yes = 1, No = 0
Commuting Distance (km)	Continuous	One-way distance from residence to regular commuting destination	Numeric
Monthly Household Income)	Continuous	Total household income, reflecting economic capacity and transport preferences	Numeric
Proximity to Subway Station	Dummy Variable	Whether the residence is within 15-minute walking distance to a metro station	Yes = 1, No = 0
Satisfaction with Parking Facilities	Continuous	Satisfaction level with non-motorized vehicle parking (5-point Likert scale)	1 to 5 Likert scale
Ownership of Private Car	Dummy Variable	Whether the household owns a private motor vehicle	Yes = 1, No = 0
Youth Group Indicator	Dummy Variable	Whether the resident is aged between 18 and 35, indicating travel activity level	Yes = 1, No = 0

(3) Basis for Variable Selection
This study constructs an explanatory model of non-motorized commuting behavior based on three key dimensions: *travel capacity*, *travel environment*, and *facility conditions*. The objective is to establish a logically coherent analytical framework that supports subsequent policy simulations and spatial planning with theoretical justification and empirical data.

In terms of variable selection, commuting distance serves as one of the most critical determinants, as it directly reflects whether non-motorized vehicles are viable for actual travel routes. Monthly household income captures the residents' financial capacity to afford transportation and is closely linked to their sensitivity to travel cost and

flexibility. Proximity to metro stations is used to assess the availability of rail transit as a supplementary mode; a lack of metro access often increases reliance on non-motorized vehicles. Satisfaction with non-motorized parking facilities reflects the residents' subjective evaluation of infrastructure quality and functions as an important mediating variable influencing behavioral choices. Private car ownership represents the availability of alternative travel modes and poses a practical constraint on non-motorized vehicle usage. Lastly, a youth group indicator is included to control for demographic structure, acknowledging that younger residents tend to have higher levels of cycling acceptance and commuting frequency.

4.Empirical Results and Problem Analysis

4.1 Residents' Travel Structure and Mode Preferences

Through a survey of 13 low-income housing communities located on the outskirts of Xi'an, a total of 473 valid questionnaires were collected. The results showed that residents in these communities were more inclined to use non-motorized vehicles (electric bikes and bicycles) for commuting. This mode accounted for 42.5%, which was much higher than the average level of residents in the city centre. Among them, the usage rate of electric bikes was 31.3%, and bicycles accounted for 11.2%; followed by public transportation (28.6%), subway (14.1%), walking (12.4%), and private cars (10.5%).

This trend indicates that in these suburban areas, non-motorized vehicles have gradually become the preferred mode of transportation for residents' commutes due to their flexibility, economy and convenience. The majority of the respondents' commuting distances fall within the range of 2 to 5 kilometers (accounting for 54.7%), which is exactly the optimal range for the efficiency of non-motorized vehicles. Under this distance condition, the efficiency of walking is low, the coverage of the bus network is limited, and subway stations are often quite far apart (mostly more than 2 kilometers), thus non-motorized vehicles play a crucial role in connecting residential areas with transportation nodes and employment locations in the "last mile" of the journey.

When divided by age groups, there are significant differences in travel preferences. Among the young and middle-aged group aged 20 to 45, the usage rate of non-motorized vehicles is as high as 58.3%, significantly higher than that of other age groups. Moreover, even in households with private cars, over 35% of the respondents prefer to choose electric bicycles for daily travel, which also indicates that non-motorized vehicles are not only alternative transportation methods but have also formed a structural reliance in these areas.

It is worth noting that the use of non-motorized vehicles is not limited to commuting purposes. The research results indicate that 62.8% of the residents stated that they would choose electric vehicles or bicycles for daily travel, such as shopping, picking up children, commuting for transfers, etc. Due to the high usage frequency and dense travel demands, the requirements for community internal supporting facilities have also been continuously increasing. However, the current facility supply clearly does not match the actual usage intensity.

Overall, the travel patterns of these residents of edge-served affordable housing show a typical pattern of "short distances, high frequencies, and low costs". Non-motorized vehicles have become an important part of their daily transportation. This behavioral characteristic not only reflects the guiding role of urban spatial layout in travel choices, but also reveals the real dilemmas faced by residents in terms of travel fairness and efficiency in the context of infrastructure deficiencies.

4.2 Income Levels and Constraints on Transportation Choices

Survey data reveal that residents of affordable housing communities on the outskirts of Xi'an generally have low household incomes. Specifically, 37.6% of households report a monthly income below RMB 3,000, while 41.2% fall within the RMB 3,000–5,000 range. Combined, these groups account for over three-quarters of the total sample, indicating a significant concentration of low-income households and a marginal presence of middle- and high-income earners. This underscores the role of such housing developments in accommodating economically disadvantaged populations.

Income levels strongly influence residents' sensitivity to transportation costs. The findings indicate that the lower a household's income, the higher the likelihood of using non-motorized modes of transport. Among households earning less than RMB 3,000 per month, 59.2% rely on non-motorized vehicles—primarily electric bikes and bicycles—for daily commuting. In contrast, this proportion drops to 27.4% among those earning over RMB

5,000. Respondents widely reported that non-motorized transport offers a low-cost, low-maintenance solution that circumvents the limitations of infrequent bus routes, distant metro stations, and long walking distances—making it the most cost-effective commuting option under current living conditions.

Further analysis suggests that low-income groups tend to bear more family caregiving responsibilities, such as escorting children to school, shopping for groceries, or accompanying family members to medical appointments. These activities are characterised by high frequency, irregular timing, and dispersed destinations, necessitating a flexible and readily available mode of transportation. In this context, public transit and metro systems—which depend on fixed schedules and require transfers or walking connections—fall short. Meanwhile, private cars remain out of reach for many due to prohibitive costs associated with purchase and upkeep.
However, the higher the reliance on non-motorized transport, the greater the dependency on supporting infrastructure. In many affordable housing areas, the availability and quality of such facilities are inadequate. Common issues include insufficient parking shelters, poor spatial planning, and disorganized management. Due to limited financial means, many residents are unable to rent or purchase formal parking spaces and must instead rely on improvised open spaces within the community. This leads to the encroachment of green areas, blocked access points, and heightened fire safety risks.

From the perspective of transport equity, the lack of infrastructure for non-motorized vehicles exacerbates existing inequalities in mobility conditions. Given the same commuting routes, higher-income individuals are able to access more comfortable and efficient transport options such as private cars or ride-hailing services. In contrast, those choosing environmentally friendly and space-efficient modes are often left with no designated parking, inadequate lighting, and a lack of secure storage.

In sum, the lag in non-motorized transport infrastructure in affordable housing communities is not merely a technical oversight, but a central issue in the broader discourse on transportation equity and just urban governance.

4.3 Manifestations of Supply–Demand Imbalance in Non-Motorized Vehicle Facilities
In affordable housing communities located on the urban periphery, non-motorized vehicles have become the primary mode of transportation for both commuting and everyday mobility. However, this high frequency of use stands in stark contrast to the inadequate provision of supporting infrastructure, resulting in a structural imbalance characterised by high demand and low supply.

According to combined field observations and questionnaire-based estimates, the average supply-to-demand ratio for non-motorized vehicle parking facilities across 13 sampled communities is only 0.56—indicating that existing facilities can accommodate just 56% of estimated usage. The Pi Tuozhai West Community in Weiyang District has the lowest ratio, at 0.39, while Jinye Apartments in the High-Tech Development Zone also perform poorly, with a ratio of 0.44. These figures suggest that even newly developed projects in economic and technological zones have failed to keep pace with the rapid growth in cycling demand.

Field observations further corroborate the survey findings. During peak hours, many communities experience fully occupied parking sheds, disorganized parking near entrances, and electric bicycles obstructing stairwells. Some 73.2% of residents reported regularly being unable to find legal parking spaces during rush periods, while 45.6% admitted to parking in "informal" areas such as greenbelt edges, stair landings, or beside waste collection points. Although some communities are equipped with underground garages, low utilization rates persist due to inadequate lighting, the absence of charging stations, and lack of surveillance, leading to a spatial mismatch in which surface-level areas are overcrowded while underground spaces remain underused.

From a spatial planning perspective, current non-motorized vehicle infrastructure suffers from three typical deficiencies:

Insufficient quantity of parking spaces: Most communities lack independently planned parking areas for non-motorized vehicles. Temporary sheds are often installed in vacant plots or at the edges of green spaces, without systemic design or integration.

Fragmented spatial layout and poor circulation design: Parking locations are frequently disconnected from main entrances or pedestrian flow paths, forcing residents to detour or pass through vehicular areas, which reduces usability and convenience.

Weak management mechanisms: Property managers rarely assign staff for supervision. Access control to sheds is often inoperative, unified charging systems are lacking, and nighttime lighting and basic security are insufficient.

Additionally, some older affordable housing communities face functional misuse of space, with bicycle sheds being repurposed as storage rooms or electric vehicles occupying car parking spaces, further compressing already limited parking capacity. In the context of spatial scarcity, parking availability has gradually become a contested resource, leading to informal competition that disrupts community order and exacerbates tensions among residents.

4.4 Spatial Disparities and Equity in Non-Motorized Transport Infrastructure

In the affordable housing communities of Xi'an, spatial inequality in the distribution of non-motorized transport (NMT) facilities has become a critical factor influencing both commuting efficiency and transportation equity. Based on field research and cross-sectional comparisons across five administrative districts—Qujiang New District, High-Tech Zone, Weiyang District, Lianhu District, and Xincheng District—this study identifies significant variations in facility quantity, spatial layout, management quality, and resident satisfaction. These findings reveal a pronounced regional imbalance in the allocation of NMT infrastructure.

The current landscape of NMT facility provision can be categorized into four typical patterns:
High-Demand, Low-Supply Zones: Exemplified by Qujiang New District, where residential and employment functions are densely integrated, resulting in concentrated commuting demand. In Qujiang's public rental housing (Yiyuan and Eryuan), the average supply-to-demand ratio is only 0.42, and resident satisfaction scores fall below 2.3 (on a 5-point scale). Over half of respondents report having to detour or park in traffic lanes, reflecting a structural mismatch between growing demand and lagging supply.

Well-Equipped but Underutilised Zones: Found in recently developed communities within the High-Tech Zone (e.g., Lanbo and Jinye Apartments), where a relatively adequate amount of NMT parking was included during initial construction. However, more than 30% of parking spots remain unused long-term. The main reasons include poor management, absence of signage, insufficient lighting, and lack of theft protection—all of which discourage resident use. This reflects a common issue of quantity without quality.

High Usage, Weak Governance Zones: Characteristic of suburban fringe areas in Weiyang District, where the resident population is predominantly young and commuting by non-motorized modes is frequent. Yet, infrastructure is seriously underdeveloped, with the lowest supply-demand ratio of 0.39. Many neighborhoods feature makeshift sheds built by residents, green spaces converted into parking, and blocked pathways. The lack of formal management and mixed land use creates both spatial disorder and safety risks.

Centrally Located, Aging Infrastructure Zones: Seen in older affordable housing projects in Lianhu and Xincheng Districts, which benefit from proximity to public transit nodes (bus and metro). Despite relatively lower NMT dependence, existing facilities are outdated and insufficient. For instance, Fenghefang community faces parking shortages and limited capacity for upgrades due to unclear property rights and tight land availability.

From a broader spatial perspective, the distribution of NMT facilities in Xi'an displays a dual structure of "planned-priority zones" versus "neglected-demand zones." While some newly developed areas have formally reserved space for such infrastructure, the lack of adaptive planning mechanisms results in low utilization rates. Conversely, areas with the most urgent demand often lack systematic provision and everyday oversight, leading to an inverse mismatch between supply and actual usage patterns.

5.Optimization Strategies and Policy Recommendations

Based on the preceding empirical analysis of non-motorized travel behaviors, facility supply-demand dynamics, and transportation equity issues in affordable housing communities on the urban fringe of Xi'an, it is evident

that these areas commonly face challenges such as insufficient facility supply, imbalanced spatial distribution, weak management mechanisms, and inequitable allocation of transportation resources. In response, this paper proposes an optimization strategy for non-motorized vehicle (NMT) facilities, guided by the dual goals of livability and equity. The strategy encompasses five key areas: facility expansion, spatial restructuring, smart management, multimodal connectivity, and institutional safeguards.

In terms of infrastructure supply, a dynamic planning mechanism based on behavioral data should be established. During the housing design phase, indicators such as NMT usage intensity, commuting distance, and demographic composition should be incorporated to more accurately forecast demand and avoid immediate oversaturation upon project completion. A two-pronged approach is recommended—combining incremental expansion with flexible adjustments. For existing communities, additional parking spaces can be created by repurposing unused land or converting idle areas. For new developments, regulatory oversight should be enforced in accordance with the *Technical Guidelines for Non-Motorized Facilities in Residential Areas of Xi'an*, ensuring minimum provisioning standards and dynamic monitoring mechanisms. Priority should be given to high-demand areas such as Weiyang and Qujiang, where commuting frequencies are high and metro access is limited, in order to establish a more function-oriented resource allocation framework.

With regard to spatial integration, efforts should be made to align NMT parking with key nodes such as metro stations, bus stops, and community entrances, thereby building a continuous "cycle–transit–walk" travel network. Micro-level layout should avoid poorly lit, inconvenient, or underutilised areas in order to improve facility visibility and usability. GIS-based simulations may be employed to model facility placement in relation to actual resident travel paths, enhancing the logic and efficiency of spatial design.

On the management front, the implementation of intelligent operation systems is recommended. These should include digital tools for real-time space monitoring and reservation, as well as integrated modules offering charging, lighting, and security features to increase the utilization of underground garages and centralized sheds. Community co-governance should also be encouraged, such as the formation of NMT user associations or volunteer-based riding order monitors, in order to strengthen grassroots-level oversight and participation.
As NMT serves a vital role in last-mile connectivity, its infrastructure must be integrated into the broader urban transport system. This includes optimizing micro-circulation bus routes in peripheral areas to enhance short-distance accessibility, establishing high-capacity transfer hubs near metro stations, and embedding cycling lanes and parking facilities into the design of transit infrastructure. Such integration helps reduce private vehicle dependency and improves mobility for underserved populations on the urban fringe.

Finally, institutional support is essential. The planning and operation of NMT facilities should be incorporated into the performance evaluation and acceptance criteria for affordable housing projects to ensure traceability and accountability. A public funding mechanism should also be established to incentivize communities that demonstrate high-quality facility construction and strong user satisfaction. Furthermore, underutilised motor vehicle parking spaces can be converted—via functional reallocation and physical separation—into areas designated for NMT parking and charging, promoting a more equitable redistribution of spatial resources.

6.Conclusions and Outlook

This study focuses on affordable housing communities located on the urban periphery of Xi'an, using questionnaire surveys, spatial analysis, and field observations to investigate non-motorized travel behavior, infrastructure supply-demand imbalance, and transportation equity. The results indicate that electric bikes and bicycles have become the dominant travel modes among residents, particularly under conditions of short-to-medium commuting distances, low household income, and limited metro connectivity. However, supporting infrastructure in most communities remains inadequate, with an average supply-demand ratio of just 0.56 and even lower figures in some areas. Common issues include severe parking shortages, mismatched spatial layouts, and ineffective facility management. Travel choices are significantly influenced by commuting distance, income level, and satisfaction with infrastructure. A structural mismatch is evident between facility provision and usage intensity across different districts, revealing a lack of behavior-oriented and dynamically adjustable planning mechanisms.

To address these issues, the study proposes an optimization strategy guided by the dual goals of livability and equity. Key directions include expanding facility supply, improving spatial integration, promoting smart management, enhancing connections to public transit, and strengthening institutional support. Specific recommendations include establishing behavior-data-driven allocation models, repurposing underutilised spaces, reinforcing intelligent operations and community participation, and fully integrating non-motorized systems into the broader urban transport network.

This research broadens the perspective on non-motorized travel in peripheral urban areas and introduces a transportation equity-based evaluation framework for facility planning, filling a gap in empirical studies at the intersection of transport and housing policy. Future research could incorporate dynamic mobility data to further analyze travel behavior, compare travel patterns across different types of affordable housing, and develop more adaptive policy tools to support green mobility and equitable governance in urban fringe areas.

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'15-MINUTE CITY' IN TURKEY: A FRAMEWORK FOR SUSTAINABLE URBAN PLANNING AND GOVERNANCE IN MID-SIZED TURKISH CITIES

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Abstract
This paper examines the feasibility of applying the 15-minute city model in Turkey's mid-sized cities, where compact form and walkability offer an existing foundation for proximity-based planning. Despite this potential, rising car use, fragmented governance, and weak coordination between land use and transport planning constrain progress. Emphasizing the principles of proximity, diversity, density, and ubiquity, the study highlights the need for integrated transport systems, pedestrian-friendly design, and mixed-use development to improve daily life quality. Using tools like the Next Proximity Index (NEXI) and drawing from international experiences and localized urban contexts, the authors call for participatory governance and adaptive reforms. The study concludes that meaningful implementation of the 15-minute city in Turkey depends on restructured planning and governance frameworks responsive to local needs, spatial equity, and the evolving dynamics of urban mobility and accessibility.

Keywords: 15-minute city; sustainable urban planning; public transportation; mid-sized cities; Turkey.

Introduction

This study explores the potential of Turkey's mid-sized cities to align with the "15-minute city" concept, emphasizing proximity, inclusivity, and sustainability. These cities, characterized by compact urban areas where most residents live within a 3-km radius, inherently support walkable, proximity-based urban planning. However, rising automobilization and minimal car use restrictions along with uncoordinated transportation policies in Turkey pose significant risks to the realization of this concept. This study underscores the need for integrated transportation strategies, pedestrian-focused urban planning, and stringent parking policies to support 15-minute city while mitigating car dependence and fostering sustainable urban environments.

Central to the "15-minute city" framework is the reorganization of urban functions to ensure proximity within neighborhoods, necessitating systemic changes in resource allocation patterns and governance schemes (Pozoukidou and Chatziyiannaki, 2021). The concept also emphasizes principles of proximity, diversity, density, and ubiquity, aiming to reduce reliance on motorized transport while promoting sustainable and equitable urban living (Moreno et al., 2021). Practical frameworks for neighborhood-level transformations and multimodal connectivity with an emphasis on public engagement and behavioral shifts in Moreno (2024) are particularly relevant for Turkish cities in transition.

For Turkish cities, rethinking public transportation as the backbone of urban mobility is essential. Developing trunk transit systems free from regular traffic conditions can increase reliability and encourage shifts from private vehicle use. Public transport nodes, such as rail and bus stations, should be integrated into neighborhoods to support seamless multimodal connectivity while reducing car travel.

Pedestrian-friendly design is another critical component. Enhancing walkability through well-maintained sidewalks, safe crossings, and traffic-free inviting public spaces can significantly encourage active mobility. Walkable neighborhoods not only promote physical health but also contribute to cognitive well-being and social interaction, particularly among vulnerable populations like the elderly (Zhang et al., 2023). Moreover, pedestrian infrastructure must account for inclusivity, addressing the "last millimeter" challenges to ensure accessibility for all (Buliung, 2024).

Parking policies play a pivotal role in reducing car dependency. Stringent regulations, such as limiting parking availability in central areas and imposing higher fees, discourage car use and reclaim urban space for pedestrian and community activities (Núñez et al., 2024).

Mixed land-use planning further supports proximity by ensuring essential services, amenities, and recreational spaces are distributed across neighborhoods, thereby fostering local economies and social cohesion (Pozoukidou and Chatziyiannaki, 2021).

While the theoretical underpinnings of the "15-minute city" are rooted in principles of proximity and inclusivity, practical implementation requires data-driven approaches. Tools like the Next Proximity Index (NEXI) can assess accessibility levels and identify gaps in urban planning, guiding tailored interventions (Olivari et al., 2023). Besides, the experiences of cities worldwide provide valuable insights. For instance, European cities with high pedestrian accessibility and diverse land use demonstrate reduced car reliance and enhanced urban equity (Vale and Lopes, 2023). Similarly, compact neighborhoods in ultra-dense cities like Shanghai showcase how mixed-use planning and walkability can foster cognitive and physical health (Zhang et al., 2023). These examples underscore the importance of adopting integrated urban design principles that prioritize human-centric planning over car-oriented development.

Although Turkey's mid-sized cities possess unique opportunities to lead by example in movement, transitioning to the "15-minute city" in these cities requires addressing existing challenges, including societal car dependency and fragmented urban governance. The study explores different traits of collaboration across for sustainable urban planning goals. Moreover, community engagement in planning processes ensures that interventions reflect local needs and aspirations, fostering public support and long-term success (Pozoukidou and Chatziyiannaki, 2021).

The '15 Minute City' Paradigm

The concept of the 15-minute city has rapidly emerged as a transformative paradigm in contemporary urban planning, addressing the critical issues of environmental degradation, socio-spatial inequality, traffic congestion, and the erosion of community life. Its intellectual roots trace back to historical planning movements such as Clarence Perry's neighborhood unit, the garden city movement, and compact city theories. What distinguishes the 15-minute city is its shift from spatial to temporal framing of accessibility, ensuring that essential services—housing, employment, education, healthcare, commerce, and leisure—are accessible within a 15-minute walk or bike ride. The COVID-19 pandemic acted as a catalyst for re-centering urban discourse around these principles. Moreno et al. (2021) redefined urban planning by emphasizing accessibility over mobility, repositioning neighborhoods as the nucleus of urban resilience. Expanding this understanding, Whittle (2024) situates the 15-minute city within a broader critique of 20th-century planning ideologies, arguing that the model is not merely a design response, but a shift toward human-centric governance that reclaims the neighborhood as a democratic, semi-autonomous unit of everyday life. This interpretation underlines the 15-minute city as both a spatial strategy and a socio-political agenda aimed at reviving local urban agency in an age of globalization and centralized planning inertia.

The 15-minute city is structured around four foundational principles: proximity, diversity, density, and ubiquity (Moreno et al., 2021). Proximity ensures that daily needs are within a short walking or biking distance, promoting a high quality of life and reducing reliance on motorized transport. Diversity introduces a functional and social mix that sustains inclusive and vibrant communities. Density, reconceptualized from sheer population concentration to efficient land use, underpins both economic viability and the infrastructure necessary for active mobility. Ubiquity ensures that these attributes are not confined to affluent areas, but equitably extended across all neighborhoods, fostering spatial justice. This framework promotes polycentricity, envisioning urban regions as interconnected networks of semi-autonomous, self-sufficient neighborhoods. Echoing this vision, Whittle (2024) articulates that such neighborhoods must not only support daily functions, but also be empowered units of democratic and cultural life, capable of nurturing local identity, adaptability, and resilience. In doing so, the 15-minute city model diverges from 20th-century doctrines of speed and spatial expansion, instead cultivating a human-scaled, time-sensitive geography that invites deeper civic participation and localized governance.

Pozoukidou and Chatziyiannaki (2021) offered a vital critical perspective that builds on the conceptual optimism of 15-minute city framework by addressing its institutional blind spots. They contend that while spatial reconfiguration is a necessary condition for realizing the 15-minute city, it is insufficient without complementary institutional transformation. Specifically, they underscore that the success of this paradigm hinges on localized service delivery supported by adaptive governance, cross-sector collaboration, and participatory mechanisms that reflect the diverse needs of urban populations. Their critique highlights the danger of reducing the 15-minute city to a technocratic or aesthetic endeavor, warning that such interpretations risk rendering the model a symbolic gesture rather than a functional reality. By calling attention to the political, procedural, and resource dimensions of urban reform, Pozoukidou and Chatziyiannaki deepen the discourse, insisting that proximity must be institutionalized not only spatially, but structurally and democratically.

Empirical work by Olivari et al. (2023) introduced the Next Proximity Index (NEXI), a tool for quantifying access to essential services within 15-minute radii. Positioned as a response to critiques such as those raised by Pozoukidou and Chatziyiannaki (2021), NEXI operationalizes the abstract ambitions of the 15-minute city into measurable and actionable indicators. The index is calculated by identifying and mapping key urban functions—such as education, healthcare, retail, green space, and public transport—and assessing their presence within a 15-minute walking radius from residential areas. Each function is weighted based on its essentiality and frequency of use, and the index aggregates these weighted scores to produce an overall proximity measure for each neighborhood. Their studies across Italian cities revealed wide disparities influenced by urban form and historical development, highlighting the importance of context-sensitive planning. Crucially, NEXI extends beyond mapping spatial proximity to integrate dimensions of social inclusion, climate resilience, and mobility justice. This transformation from a technical metric to a normative planning instrument marks a significant step in addressing the procedural and distributive shortcomings emphasized in earlier critiques. By enabling planners to diagnose accessibility gaps and tailor interventions, NEXI exemplifies how empirical tools can support equitable urban transformation and embed the principles of the 15-minute city into grounded governance practices.

Building on the empirical rigor introduced by NEXI, which translates the abstract ideals of the 15-minute city into actionable planning metrics, subsequent studies has further expanded the paradigm's operational and normative dimensions. For instance, Núñez et al. (2024) questioned whether reductions in car usage are primarily driven by modal shifts or by the simple act of shortening travel distances. Their findings underscored that while investments in sustainable mobility infrastructure are important, the most transformative outcomes stem from co-locating services and residences. This reinforces the notion, already embedded in NEXI's design, that land-use planning must be foregrounded in sustainable urban transformation—thereby validating Pozoukidou and Chatziyiannaki's (2021) call for procedural and distributive reforms. Zhang et al. (2023) contributed a public health dimension, revealing how 15-minute neighborhoods in Shanghai foster cognitive and emotional well-being among aging populations. They demonstrated that walkable access to diverse urban amenities reduces isolation and bolsters autonomy, extending the paradigm beyond logistical convenience into the realm of social health and cohesion. Likewise, Vale and Lopes (2023) mapped pedestrian accessibility across over 100 European cities and exposed systemic disparities, where affluent neighborhoods benefited disproportionately. Their research warned that without explicit redistributive planning, the 15-minute city could exacerbate spatial injustice. They also highlighted the specter of "green gentrification," urging integration of equity and participatory governance into urban design. Finally, Buliung (2024) expanded the discourse by introducing the concept of "last millimeter" barriers—micro-scale urban design flaws that significantly hinder access for individuals with disabilities. He argued that while macro-level walkability metrics are often celebrated, they overlook the experiential and embodied dimensions of mobility. His critique strengthens the paradigm's commitment to spatial justice by insisting that true accessibility must be measured not just by distance, but by the ease, dignity, and autonomy with which urban space is navigated. Together, these works illustrate how the paradigm of the 15-minute city continues to evolve—anchored not just in visionary theory, but in inclusive, context-sensitive, and empirically grounded planning practice.

Lately, Moreno (2024) has recast the 15-minute city not merely as a spatial model, but as a profound philosophical and cultural response to the crises of contemporary urban life—namely, speed, fragmentation, and commodification. Accordingly, the 15-minute city is conceptualized as a temporal revolution—an urban condition that values slowness, synchronicity, and an enriched experiential engagement with place. This approach challenges prevailing urban paradigms that prioritize acceleration and efficiency. By positioning the

15-minute city as a multidimensional framework encompassing climate action, public health, and governance innovation, Moreno (2024) calls for a redefinition of urban rhythms and relationships. Central to this vision is the neighborhood as a "complete habitat," where decentralization and human-scale urbanism become catalysts for inclusivity, resilience, and civic engagement. In this formulation, the 15-minute city transcends traditional planning logic to become a vehicle for reimagining urban time, social proximity, and collective futures.

Cumulatively, the literature has progressed from foundational theory to the development of operational tools, empirical validation, and normative elaboration, offering a comprehensive framework for the 15-minute city. Rather than positioning it as a universal or static solution, the discourse affirms the model as a flexible and evolving paradigm of holistic urban transformation. A critical thread running through this body of work warns against the pitfalls of technocratic overreach, superficial implementation that neglects local contexts, and the perpetuation of socio-spatial exclusion. Success in realizing the 15-minute city, as emphasized across multiple studies, depends fundamentally on inclusive and transparent governance structures, iterative and reflexive planning mechanisms, and strategies that are grounded in the cultural, institutional, and spatial particularities of place. This expanded understanding reinforces that the paradigm's long-term viability hinges not merely on infrastructure or design interventions, but on the depth of institutional commitment to equity, participation, and contextual sensitivity.

For mid-sized Turkish cities, the rapidly expanding 15-minute city literature offers a dual perspective—serving as both a source of inspiration and a framework for critical reflection. These cities often display inherently compact morphologies and localized social cohesion, which could form a promising basis for implementing proximity-based urban strategies. However, the rapid motorization observed across Turkey—where vehicle ownership continues to rise despite being far from saturation levels—has compounded the challenges of spatial equity and environmental sustainability (see Şenbil and Yetişkul, 2020). Compounding this issue is the widespread inadequacy of public transit systems in mid-sized cities, which are frequently characterized by fragmented service coverage, irregular scheduling, and limited multimodal integration. The predominance of centralized governance and institutional inertia further impedes transformative urban action. As such, the realization of the 15-minute city in Turkey must be envisioned not as a superficial adoption of global trends, but as a profound transformation that responds to the nation's unique socio-political, infrastructural, and spatial conditions. This necessitates the decentralization of urban governance, a targeted redistribution of public investment toward marginalized neighborhoods, and the institutionalization of participatory planning mechanisms that amplify community voices. In this context, investments in walkable public realms, socially inclusive services, and responsive governance structures are not supplementary but essential. Only through such a multidimensional and locally grounded approach can Turkish mid-sized cities fully embody the principles of the 15-minute city and deliver meaningful outcomes in accessibility, social equity, and urban resilience.

Reframing Urban Planning for 15-Minute City

The 15-minute city, as conceptualized by Moreno (2024) and elaborated throughout contemporary urban planning literature, represents a transformative break from conventional paradigms of city-making. By shifting the primary focus of planning from spatial hierarchies and mobility efficiency to temporal proximity and everyday accessibility, this model reorients urban policy toward a more human-scaled, equitable, and inclusive logic of spatial organization. Unlike earlier approaches that emphasized expansion, zoning rigidities, and centralized nodes of urban activity, the 15-minute city emphasizes integrated, decentralized neighborhoods that embed urban functions within a walkable or bikeable radius. Rather than merely pursuing environmental metrics or sustainability benchmarks, this model urges a reconfiguration of how cities are experienced and governed—placing daily life, local autonomy, and temporal dignity at the center of urban transformation. The 15-minute city is not merely a design proposition, but a cultural and political reclamation of local agency—a response to the alienation and fragmentation produced by twentieth-century planning orthodoxy (Whittle,2024). In this light, the planning system must be gauged anew, not simply adjusted, to accommodate a neighborhood-oriented urbanism that values inclusivity, accessibility, and autonomy.

Despite the compact morphology and latent proximity potential of many Turkish mid-sized cities, the prevailing planning system remains ill-suited to realize the ambitions of the 15-minute city paradigm. In the face of rapid motorization—which continues to accelerate despite Turkey's relatively low car ownership levels compared to developed nations—urban infrastructure remains overwhelmingly designed to accommodate growing vehicular

demand rather than to foster a modal shift toward active mobility and short-distance accessibility. The current planning approach privileges high-capacity roads and automobile-centric development, sidelining investments in walkable, bikeable, and transit-supportive urban forms. Compounding the issue, while modifications for single-plot developments are often processed with relative ease, comprehensive area-wide changes face severe institutional and procedural constraints.

Plan changes that require the reorganization of plots, reallocation of public or community spaces, and realignment of shared infrastructure demand cumbersome legal navigation, tax obligations, and inter-agency coordination.

These hurdles are particularly acute in already built-up neighborhoods, where fragmented land ownership, outdated cadastral alignments, and an absence of operative neighborhood-scale planning mechanisms render transformational interventions practically unfeasible. A reframed planning approach must thus reorient public investment and legislative design toward neighborhood-scale and city-wide accessibility solutions—such as short transit route circulators, protected cycling corridors, pedestrian-first streetscapes, and multimodal feeder systems—while simultaneously streamlining regulatory pathways for retrofitting established urban areas. Current practices are dominated by rigid, centrally imposed master plans and a heavily top-down governance architecture that inhibits local adaptation and hinders organic neighborhood evolution. Plan modifications—particularly those aiming to introduce mixed-use zoning or reallocate services to enhance daily accessibility—are often stalled by bureaucratic inertia. The process is burdened by convoluted approval mechanisms, complex legal scrutiny, and considerable taxation burdens, especially for modifications involving broader land reorganizations in already built areas. These are particularly complex because they often require the adjustment of parcel boundaries, the provision or redesign of public and community spaces, and the integration of common goods into a new spatial logic compatible with proximity-based planning. Apart from reorganization of informal housing areas—which more or less face similar institutional and procedural bottlenecks—there is next to no planning agency in Turkey currently capable of undertaking neighborhood-based reorganization or transformation projects aimed at retrofitting already built-up urban areas into more sustainable, proximity-oriented forms.

Notably, while single-plot amendments are somewhat easier to process and more commonly approved, area-wide changes that necessitate the reconfiguration of multiple plots, the realignment of public and communal spaces, or adjustments to shared infrastructure are met with substantial institutional resistance. These comprehensive transformations, essential for enabling integrated neighborhood-level accessibility, often encounter insurmountable procedural barriers unless channeled through large-scale urban transformation projects. Yet even these projects are primarily aimed at housing reconstruction and disaster resilience, rarely contributing to the diversification of urban functions or the realization of complete neighborhoods. This rigidity undermines the capacity for incremental, context-sensitive interventions vital for achieving spatial justice and temporal proximity. Turkish urban planning remains entrenched in functionally segregated zoning and infrastructure priorities that favor high-speed, motorized mobility over fine-grained, pedestrian-oriented accessibility. As a result, neighborhoods remain disconnected from daily needs and incapable of supporting self-reliant urban life, thereby contravening the fundamental logic of the 15-minute city model.

This institutional void mentioned above severely limits the possibility of adapting existing neighborhoods to meet the spatial and functional requirements of the 15-minute city paradigm. While plan amendments for individual plots are relatively more feasible, area-wide modifications—particularly those involving the reorganization of already developed urban zones—encounter substantial procedural obstacles. These difficulties stem from strict legal requirements, high taxation, and the need for consensus among multiple landowners, especially where public spaces, communal facilities, and infrastructure must be reconfigured to meet proximity-based planning goals. Such interventions demand collective coordination, legal harmonization, and public consent—all of which are administratively cumbersome and procedurally opaque under the current regulatory regime. To reframe urban planning for the 15-minute city, it is essential to transition toward planning tools and institutional frameworks that prioritize flexible and adaptive instruments for retrofitting existing urban areas. This shift involves enabling fine-grained, incremental changes at the neighborhood scale that accommodate diverse local conditions and promote temporal proximity, rather than enforcing large-scale, top-down spatial reorganizations. This entails redefining neighborhood units as semi-autonomous, self-reliant territories where residents can access essential services, employment, education, and leisure within a short walking or cycling distance.

Achieving this transformation necessitates mainstreaming mixed-use zoning within Turkish land-use legislation, accompanied by support for incremental and context-sensitive development rather than the enforcement of rigid, large-scale masterplans. To do so, the planning system must be diametrically transformed to foster area-based planning and enable comprehensive urban retrofitting aimed at sustainable and proximity-based outcomes. Current regulatory structures tend to facilitate changes on individual plots, while rendering broader area-based interventions—those requiring coordinated reorganization of plots, reallocation of communal spaces, and integration of public amenities—exceptionally difficult. Without fundamental reform, the capacity to recalibrate existing urban fabric in alignment with 15-minute city goals remains structurally constrained. Such flexibility is key to cultivating resilient, self-sufficient neighborhoods. Whittle (2024) emphasizes that mid-sized urban territories hold significant potential to spearhead this shift by embracing agile, human-scale planning practices. These cities, rather than mimicking the infrastructure-heavy and centralized models of major metropolises, can become exemplars of localized governance and proximity-based urbanism, aligning closely with the ethos of the 15-minute city.

Quantitative tools like the Next Proximity Index (NEXI) introduced by Olivari et al. (2023) offer critical insights into how proximity can be operationalized through spatial analysis. By mapping the availability and diversity of essential services within a 15-minute walking radius, NEXI helps planners diagnose service gaps and prioritize interventions at a granular level. Crucially, this index accounts for both spatial coverage and the qualitative utility of services, integrating considerations of usage frequency and community importance. Pozoukidou and Chatziyiannaki (2021) emphasize that without such tools—and without integrating them into institutional processes—15-minute city initiatives risk becoming superficial or unevenly distributed. Indeed, NEXI embodies a procedural response to their critique, translating normative goals into technical diagnostics that can guide context-sensitive interventions in Turkish cities. In addition, Marquet et al. (2025) have revealed that the widespread adoption of the 15-minute city concept has incited political backlash, conspiracy narratives, and polarized reactions, particularly in the post-COVID planning climate. This skepticism, sometimes grounded in ideological opposition to centralized planning, at other times fuelled by misinformation, challenges planners to reconceptualize how participatory legitimacy and public trust are secured. Their study calls attention to the necessity of transparent, inclusive, and dialogic planning processes that not only inform but also engage communities in shaping their urban environments. The authors categorize critiques from baseless conspiracy theories to legitimate equity concerns, urging planners to discern and respond with sensitivity to context.

However, most Turkish mid-sized cities suffer from poor and insufficient planning units. This institutional weakness is not merely a matter of capacity but also of legal and procedural design. To meet the spatial demands of the 15-minute city, planning departments must be structurally enhanced through targeted capacity building. This includes mandating, by law, the employment of certified city planners in all municipal planning offices and equipping them with the legal authority and technical resources to initiate neighborhood-based retrofitting projects. Furthermore, these units must be supported by a set of model frameworks and toolkits for urban retrofitting—flexible yet enforceable templates that can be adapted to local socio-spatial conditions. Compulsory area-based planning practices, centered around 15-minute city metrics, should be embedded into national planning regulations, ensuring that all plot arrangements, public space configurations, and communal services are strategically designed to maximize proximity. Mixed-use densification and pedestrian-centered public realm design should be codified through new legislation to ensure that neighborhoods evolve as cohesive, accessible, and self-sufficient territories.

Fundamentally, reframing Turkish urban planning for the 15-minute city means dismantling its static, top-down blueprinting tradition and replacing it with adaptive, participatory, and neighborhood-responsive mechanisms. It requires a regulatory architecture that promotes mixed-use overlays, flexible zoning, and simplified plan amendments. Planning offices must be transformed from enforcement units into platforms for co-creation and public engagement. As Whittle (2024), Moreno (2024), and Marquet et al. (2025) assert, this transformation is as much about governance as it is about spatial design—it is about restoring time, agency, and dignity to everyday urban life. Training a new generation of planners equipped with the skills for equity-driven, participatory planning is paramount. Only through this deep institutional renewal—supported by empirical tools like NEXI and grounded in the lived geographies of Turkish cities—can planning systems evolve to meet the demands and opportunities of the 15-minute city model.

Enforcing and Enabling Mid-Size Cities for 15-Minute City in Turkey

To complement these reforms, it is crucial to establish advanced monitoring frameworks that ensure accountability, performance benchmarking, and feedback loops in the implementation of 15-minute planning. This necessitates integrating tools like the NEXI (Olivari et al., 2023) into the routine planning workflow, accompanied by open data policies that allow citizens and stakeholders to track progress in real-time. In addition, legal instruments must be revisited to introduce enforceable thresholds and measurable indicators for service accessibility, walkability, and land-use mix within Planning Zones (PZ). For instance, municipalities should be required to provide yearly audits evaluating whether each PZ meets designated proximity and inclusivity metrics, triggering corrective measures in case of persistent gaps.

Mid-size cities in Turkey represent a critical scale for operationalizing the principles of the 15-minute city, balancing human-scale urban form with regional development needs. Despite their latent potential, these cities are increasingly at risk of following the sprawling, car-dependent trajectories of metropolitan counterparts unless significant legislative and institutional reforms are introduced. As highlighted in Özdemir Sarı et al. (2019), Turkey's existing urban planning framework remains largely reactive, fragmented, and unfit for promoting integrated neighborhood-scale transformations. Therefore, to realize the promise of the 15-minute city model, a recalibration of planning legislation, spatial governance, and urban design practice is imperative.

A key strategic reform must involve the legal demarcation of Urban Settlement Areas (USAs), beyond which suburban and peri-urban expansion should be tightly controlled. These USAs should serve as statutory growth boundaries, akin to urban containment strategies seen in the UK and parts of Northern Europe, to focus investment, planning attention, and infrastructural development within a defined, optimally compact urban envelope. As Moreno (2024) argues, the 15-minute city is incompatible with low-density sprawl because it fragments service provision, increases travel distances, and undermines efforts to build cohesive, self-reliant neighborhoods. Therefore, USAs should be embedded within national and regional legislation, accompanied by clear development guidelines and enforcement mechanisms to prevent encroachment on agricultural land, ecological zones, or disaster-prone areas.

In the Turkish context, however, the definition and scope of USAs in current upper-level plans—particularly Territorial Plans—are often far too expansive relative to realistic future settlement needs. These designations frequently stem from inflated population projections that lack robust demographic analysis and ignore ongoing trends such as stagnating urban growth and accelerated aging in mid-size cities. This tendency is largely inherited from a planning culture forged during Turkey's rapid urbanization years, when population growth and urban expansion were seen as inevitable. However, Turkey now finds itself in a post-urbanization phase, where population growth is either negligible or negative in many mid-sized cities, and where demographic aging is a dominant trend (e.g., Senbil and Yetiskul, 2022). Consequently, existing settlement areas can accommodate most of the anticipated demand, making further expansion both unnecessary and inefficient. The pressing challenge, therefore, is not how to manage outward urban growth, but how to retrofit and revitalize already built-up areas to align with sustainable, proximity-based planning principles. Despite this, existing USAs assume expansive urbanization trajectories, implicitly endorsing urban sprawl through land reserves that exceed actual development demands. This disconnect results in low-density, fragmented urban expansion incompatible with compact, walkable, and service-rich neighborhoods envisaged in the 15-minute city paradigm. A recalibration is urgently required—one that realigns USA definitions with principles of urban compactness, land efficiency, and proximity-based planning. These redefined USAs should reflect current and projected demographic realities, explicitly prioritizing retrofitting and densification within existing built-up areas rather than speculative outward growth.

Within these designated settlement areas, cities must be subdivided into Planning Zones (PZs) that become the primary units for implementing the 15-minute city paradigm. Each PZ should encompass a population size, urban footprint, and service threshold appropriate for the realization of temporal proximity goals—meaning that residents can access essential services, jobs, education, public spaces, and mobility options within a 15-minute walk or bike ride. These zones should not be conceptualized as static units but as dynamic, semi-autonomous neighborhoods with tailored retrofitting plans. As emphasized in Whittle (2024), each urban context requires flexible adaptation of the 15-minute framework; thus, zoning must allow for local specificities, historical development patterns, and community needs.

Operationalizing this framework demands that each Planning Zone be governed through an integrated tripartite approach encompassing planning, design, and infrastructure development. The planning component must involve the preparation of neighborhood-scale development plans that align land use with proximity metrics, prioritizing mixed-use development, densification, and functional integration. These plans must also be legally enforceable and nested within higher-scale municipal plans, ensuring vertical coherence across planning levels. According to Pozoukidou and Chatziyiannaki (2021), one of the most common pitfalls of 15-minute city initiatives lies in the failure to link morphological transformations with institutional change, thereby resulting in fragmented or tokenistic interventions.

The design element should focus on human-centered urban form—walkable block structures, interconnected street networks, well-distributed public spaces, and universal design principles. As Buliung (2024) warns, pedestrian-friendly designs are often undermined by micro-barriers that inhibit access for the elderly, disabled, or those with mobility impairments. Therefore, design standards must be informed by inclusive design guidelines and be co-produced with community input. Participatory design workshops, citizen audits, and tactical urbanism can all serve as tools to ground spatial transformation in local realities while maintaining alignment with 15-minute city principles.

Infrastructure development is the final and perhaps most capital-intensive pillar. Within each PZ, infrastructural upgrades must prioritize multimodal mobility, green and blue networks, and digital connectivity. In particular, neighborhood-level investments in public transit circulators, bike lanes, stormwater management, and renewable energy micro-grids can reinforce spatial resilience and sustainability. The findings of Olivari et al. (2023) through the Next Proximity Index (NEXI) show that accessibility must be both physical and qualitative, measuring not only distance but also frequency, diversity, and the usability of services. NEXI-like metrics should be institutionalized into municipal planning offices as diagnostic and monitoring tools.

Planning departments should be at the core of this effort, with new legislative mandates to conduct compulsory areal plans for each PZ. These units must be capacitated through professionalization policies—requiring that every municipality with more than 10,000 residents employ at least one certified planner, with an additional certified planner mandated for every subsequent 25,000 residents. According to data from the Turkish Statistical Institute, there are 664 such municipalities in Turkey exceeding this population threshold, indicating the wide-reaching implications and feasibility of such a policy framework. This approach fosters a neighborhood-level, holistic planning perspective, enabling municipalities to engage in detailed spatial analysis, proactive retrofitting, and integrated service delivery aligned with the principles of the 15-minute city. Furthermore, planning departments should operate as proactive coordinators, monitoring the consistency of planning, design, and infrastructure projects, and ensuring that all interventions are evaluated through the lens of proximity, accessibility, and inclusivity. As emphasized in the urban governance frameworks articulated by Pierre (2011) and Healey (2006), local institutional capacity is the linchpin of sustainable urban transformation. Without embedded, empowered, and well-resourced local planning units, even the most visionary reforms risk stalling at the level of rhetoric.

In addition to statutory enforcement, enabling mechanisms are essential to translate legal provisions into built reality. This includes fiscal incentives for mixed-use development, subsidies for adaptive reuse and infill housing, and technical assistance programs for small-scale developers and cooperatives. Drawing from the work of Jessop (2002), urban policy must be seen as a multi-level governance challenge, requiring coordination between local, regional, and national actors. Therefore, Turkey must adopt a planning governance model that incentivizes cross-sector collaboration, reduces bureaucratic inertia, and foregrounds place-based innovation. Moreover, Turkish planning legislation must recognize retrofitting—not greenfield development—as the core strategy for spatial transformation. most mid-size cities are already largely built up, and meaningful 15-minute city implementation hinges on adapting existing neighborhoods rather than constructing new ones. Retrofits must include parcel reorganization, communal facility integration, and mobility recalibration, and should be guided by flexible but enforceable planning codes. These codes must mandate minimum service thresholds per PZ, specify mixed-use quotas, and enforce building design standards that enhance accessibility and reduce carbon footprints.

Turkey's new planning vision must also embed democratic and participatory practices. As Marquet et al. (2025) reveal, backlash against 15-minute city initiatives often stems from perceived top-down imposition and lack of transparency. To mitigate these risks, public deliberation should be embedded into the DNA of the

planning process, including participatory budgeting, neighborhood councils, and inclusive design charrettes. Only then can spatial proximity be translated into social proximity, nurturing the civic trust essential for long-term sustainability. To further elaborate on these strategies, it is critical to design monitoring frameworks with clear accountability lines and publicly accessible benchmarks. These systems must go beyond simple audits and incorporate layered data reporting mechanisms tied to annual municipal performance reviews. Legal instruments must be complemented with compliance indices that are transparently tracked through centralized digital dashboards, enabling civic oversight and targeted funding. International examples, such as France's Quartiers Prioritaires de la Politique de la Ville (QPV) and Spain's Barrios en Riesgo programs, show how legal precision, transparent criteria, and community involvement can mutually reinforce urban proximity planning. By studying Italy's use of NEXI in cities like Bologna, Turkish mid-sized cities can refine data granularity and develop tailored proximity indices. Applying these insights will support the translation of 15-minute planning concepts into localized and enforceable frameworks, while anchoring implementation in institutional learning and peer benchmarking across municipalities.

Conclusions

This study underscores that the 15-minute city paradigm, far from being merely a planning slogan or fleeting policy trend, represents a multidimensional and transformative framework that aligns with the specific conditions and evolving aspirations of mid-sized Turkish cities. Mid-sized cities in Turkey present unique opportunities to integrate the principles of proximity, accessibility, and equity, owing to their inherently compact urban forms, walkable neighborhood structures, and manageable urban scale. These settlements, while less burdened by the spatial complexities of large metropolitan regions, offer fertile ground for retrofitting urban spaces in line with the 15-minute city ideal. Yet, their planning potential remains underutilized due to fragmented governance, under-resourced local planning units, and a lack of participatory frameworks. Recognizing these characteristics, mid-sized cities could serve as pilot grounds for implementing neighborhood-based planning initiatives that prioritize short-distance access to key services and amenities. Moreover, their scale allows for more direct citizen engagement, enabling planners to co-create solutions in real-time with community members. Such localized and iterative approaches are essential for embedding the values of the 15-minute city in urban practice, especially in contexts where formal planning instruments often fail to capture everyday spatial and temporal needs.

However, these opportunities remain largely untapped in the face of rapidly increasing motorization, ineffective and underfunded public transit systems, and entrenched bureaucratic rigidity in planning procedures. A key challenge lies in the disjunction between spatial proximity—often achievable given the compactness of mid-sized cities—and actual operational accessibility, which is hindered by systemic inefficiencies and uneven resource distribution. This gap becomes more pronounced due to a planning regime that, while allowing for frequent plot-level changes, imposes significant legal and financial barriers to area-based transformations involving the reorganization of parcels, communal facilities, and shared infrastructure. Moreover, apart from interventions limited to the rehabilitation of informal housing areas, there is a conspicuous absence of institutional mechanisms or planning agencies capable of orchestrating neighborhood-scale retrofitting initiatives. Consequently, spatial inequalities persist, and the transformative potential of mid-sized cities to implement the 15-minute city paradigm remains unrealized, hindered by fragmented institutional support and the lack of cohesive planning mechanisms capable of executing neighborhood-scale, integrated interventions.

Through extensive engagement with contemporary literature and international best practices, the research highlights how the 15-minute city calls for a fundamental recalibration of urban planning and governance models in Turkey. Moreno (2024) and Pozoukidou and Chatziyiannaki (2021) frame the paradigm not only as a spatial design logic but also as a governance philosophy that values local autonomy, decentralized decision-making, and democratic inclusivity. These values are especially relevant in Turkish urban contexts, where top-down master planning and regulatory rigidity stifle innovation at the neighborhood scale. In this regard, the 15-minute city paradigm serves as both a corrective lens and a strategic tool for reframing Turkish urbanism toward a more human-scaled, temporally sensitive, and equity-centered model of development. It provides a much-needed counterbalance to the prevailing top-down, regulation-heavy planning approach, which often prioritizes standardized land use efficiency over everyday human experiences. By emphasizing the quality and immediacy of access to services within neighborhoods, the paradigm invites a restructuring of planning priorities around lived realities and localized needs.

Its implementation would encourage urban planning to shift from abstract, long-range projections to immediate, people-focused practices, thus embedding flexibility, inclusiveness, and responsiveness at the core of policy and spatial decision-making.

The research reinforces the imperative to redefine urban governance structures by aligning them with flexible planning tools, adaptive zoning frameworks, and area-based retrofitting strategies that can respond to localized socio-spatial dynamics. It proposes the formal subdivision of strictly demarcated urban settlement areas (USAs) into Planning Zones (PZs), each of which should operate as a semi-autonomous and self-sufficient neighborhood unit. The boundaries of USAs must be carefully defined and strictly enforced to prevent unplanned sprawl, which has long been fueled by inflated population projections and outdated assumptions of perpetual urban expansion. These expansive territorial designations—often inherited from the rapid urbanization era—no longer reflect current demographic trends, which show stagnation or decline in many mid-sized cities across Turkey. Therefore, spatial containment and urban compaction must underpin any attempt to retrofit urban areas for proximity-based living. Within these redefined and realistically bounded USAs, PZs must be governed through integrative processes that fuse spatial planning, urban design, and infrastructure development in a synergistic manner. The objective is to ensure that PZs function as complete urban habitats capable of fulfilling daily life needs—such as access to employment, education, healthcare, and recreation—within a short walking or cycling distance. Drawing on the Italian implementation of the Next Proximity Index (Olivari et al., 2023), which provides a scalable tool for evaluating proximity-based service delivery, and incorporating the "last millimeter" design considerations detailed by Buliung (2024), the study highlights the necessity for inclusive and accessible urban design. This must be supported by robust participatory planning mechanisms, dynamic data-driven monitoring systems, and iterative feedback loops that enable continuous refinement of interventions to match evolving community needs and preferences.

As Marquet et al. (2025) highlight, backlash and misinformation regarding the 15-minute city concept make participatory legitimacy crucial. Therefore, governance frameworks must be constructed not solely on legal mandates but on sustained civic engagement, transparency, and accountability. This necessitates an expanded role for professional city planners—not only as technical experts but as facilitators of community dialogue and co-design. Planners must be embedded in local governance structures with the mandate and capacity to engage residents, mediate conflicting interests, and translate proximity-based planning ideals into locally resonant strategies. Equally critical is capacity-building within municipal planning departments: municipalities must be legally required to employ professional planners at proportional scales to population, thereby fostering a neighborhood-level, holistic planning approach. This structural reform ensures that context-sensitive, neighborhood-scale plans are not only drafted with community input but also effectively implemented and monitored.

This study ultimately calls for a comprehensive and systemic transformation of Turkey's planning apparatus, one that is deeply rooted in democratic co-production, context-sensitive urban retrofitting, and a steadfast commitment to spatial justice. The entrenched rigidity of the current planning system must give way to mechanisms that facilitate adaptable, area-based strategies capable of responding to diverse neighborhood needs. Central to this transformation is the institutionalization of the core values of the 15-minute city—proximity, diversity, density, and ubiquity—within legal and procedural planning frameworks. These principles must be operationalized not as abstract ideals but as actionable criteria embedded in zoning regulations, design standards, and administrative practices. Only through such integrative and enforceable reforms can Turkish mid-sized cities evolve beyond mere functionality and efficiency, and become truly inclusive, resilient, and livable urban environments.

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IS SUMP A PANACEA FOR DYNAMIC CITIES? BRIDGING AMBITION AND REALITY: A CASE STUDY OF ISTANBUL

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Abstract
Sustainable Urban Mobility Plans (SUMPs) aim to improve urban transport by integrating land use, public transit, and active mobility in an equitable and sustainable way. Initially designed for European cities, SUMPs face challenges in fast-developing urban contexts in the Global South. This paper reflects on Istanbul—a fast-growing, car-dependent developing megacity with complex governance structures. Istanbul's evolving landscape offers a lens to explore how SUMP strategies can adapt to rapid urban growth, institutional fragmentation, and shifts from flexible bus networks to fixed rail systems. The study emphasizes integrating land use, institutional capacity, and multimodal systems, while recognizing informal transport and expanding stakeholder engagement. Rather than critiquing SUMPs, it seeks to amend and localize them to better suit dynamic metropolitan realities in developing regions.

Keywords: SUMP; Istanbul; Sustainable Transport; Dynamic Cities; Mobility Planning

Introduction

Sustainable Urban Mobility Plans (SUMPs) have emerged as a key framework for addressing transportation challenges in urban areas by emphasizing sustainability, inclusivity, and environmental responsibility. Developed within the European Commission's broader policy landscape, SUMPs aim to integrate public transport, active mobility options such as walking and cycling, and land-use planning into a unified strategy to reduce greenhouse gas emissions and ensure equitable access to urban opportunities (Rupprecht Consult, 2019; Werland, 2020). While adaptability is one of the core principles guiding SUMPs, their implementation in fast-growing and complex cities reveals notable deficiencies.

This shortcoming becomes especially visible in Istanbul, where the city's official SUMP highlights the struggle of a rigid planning framework to respond to the rapidly shifting urban landscape and fragmented institutional terrain. Istanbul's soaring car ownership, its spatial sprawl, and the disjointed expansion of its rail transit system all underscore the limited adaptability of a framework originally designed for more stable and regulated urban environments. SUMPs, when not meaningfully tailored to local dynamics, fail to keep pace with the urgency and scale of urban change in cities like Istanbul.

Although Istanbul's SUMP aspires to promote sustainable modes of transportation, it falls short in integrating land-use strategies and urban design principles. The city's disjointed pedestrian and cycling networks illustrate this disconnect, diminishing the effectiveness of active mobility initiatives. Furthermore, while the SUMP includes measures such as congestion pricing, low-emission zones, and parking constraints, their limited scope and weak enforcement significantly undermine their capacity to meaningfully curb private car use. This gap reveals a deeper contradiction: while SUMPs declare adaptability as a founding value, their real-world performance in cities like Istanbul illustrates how this principle remains underdeveloped in practice (Przybylowski, 2018; Spadaro and Pirlone, 2021).

Additionally, Istanbul's significant investments in rail transit expansion reveal a missed opportunity to integrate new infrastructure into a broader land-use and urban transformation strategy. Rather than aligning new metro and rail lines with transit-oriented development principles, the expansion has largely occurred in isolation from policies that could steer urban growth patterns, reshape spatial hierarchies, or prevent car-dependent sprawl. The inadequate integration between metro, tram, bus, and ferry systems further compounds inefficiencies, weakening the effectiveness of multimodal connectivity and undermining the return on infrastructure investment (Yaoundé SUMP Summary, 2019; Kiba-Janiak and Witkowski, 2019). These missed opportunities

highlight the urgent need for SUMPs to move beyond static infrastructure delivery and incorporate dynamic urban development considerations. Integrating real-time data analytics and scenario-based planning tools could better align mobility interventions with ongoing transformations in land use and demographic patterns, allowing policies to evolve alongside the city's rapid changes (Wołek, 2014; Rutka et al., 2024).

Central to overcoming these challenges is the need for institutional changes in Istanbul's administrative structure. The existing framework, characterized by fragmented and distributed decision-making across various agencies, compromises the coordination necessary for effective land use and transportation planning. This disjointedness hinders the alignment of transit infrastructure with evolving urban form, missing opportunities to guide urban transformation through strategic land-use policies. A restructured governance model that consolidates authority under a unified institutional body is therefore essential. This centralized body should not only oversee transportation planning but also ensure its integration with broader spatial development strategies. Without such institutional reforms, the successful implementation of SUMP initiatives will remain out of reach, and their transformative potential will be stifled by bureaucratic inefficiencies and contradictory policy agendas.

Urban mobility cannot be effectively addressed in isolation; it requires close collaboration with urban design and development strategies. Above all, the rail transit system should be recognized as a strategic driver of urban transformation, with station areas serving as focal points for transit-oriented development and densification. This targeted approach not only strengthens multimodal integration but also leverages infrastructure investment to reshape urban form in a more sustainable and efficient manner. Furthermore, aligning station-area development with disaster-resilient urban renewal initiatives offers an opportunity to meet immediate needs for safer and more adaptable urban environments. A governance framework that formalizes the relationship between these domains can enable more cohesive policies, facilitating the creation of mixed-use developments, resilient transit-oriented neighborhoods, and pedestrian-friendly public spaces. Such alignment would not only enhance the feasibility of sustainable mobility solutions but also strengthen urban resilience, support climate adaptation efforts, and contribute significantly to improving the overall quality of urban life.

This study proposes a reimagined SUMP framework for Istanbul, emphasizing land-use integration and transit-oriented development. Policies such as enhancing public spaces for pedestrians, expanding non-motorized transport networks, and introducing innovative car-use restrictions are essential to fostering a sustainable mobility culture. Moreover, effective stakeholder engagement, including citizens, policymakers, and private entities, is crucial for implementing inclusive and responsive strategies (Lindenaua and Böhler-Baedeker, 2014; Andréi and Papuc, 2021). Istanbul's experience offers valuable lessons for cities facing similar challenges, underscoring the necessity of adapting SUMPs to local contexts. By aligning long-term urban development goals with flexible, innovative mobility strategies, and implementing critical institutional changes, SUMPs can transcend their current limitations, providing transformative solutions for the cities of tomorrow. This paper aims to contribute to propose a vision for advancing SUMPs in rapidly changing urban contexts, offering a roadmap for sustainable and inclusive mobility planning.

A Critical Look into Sustainable Urban Mobility Plans

Sustainable Urban Mobility Plans (SUMPs) have emerged as a significant response to the persistent limitations of traditional transport planning, which historically emphasized vehicle flow and infrastructure over sustainability, equity, and multimodal integration (Banister, 2008; Rupprecht Consult, 2014). In contrast, SUMPs promote long-term, inclusive mobility strategies that center people over cars and support broader goals of urban development and climate responsibility (Rupprecht Consult, 2014, 2019). Originating from European policy shifts in the early 2000s, SUMPs developed through initiatives like the EU's Green Paper on Urban Mobility.[1] Grounded in sustainability, inclusivity, and systemic integration, SUMPs embrace systems thinking—addressing mobility not just as movement, but as embedded in social, spatial, and environmental systems (Curtis and Low, 2012; Bertolini et al., 2005).

A careful reading of SUMP documents reveals an institutionalized planning framework grounded in eight core principles: transparency, participation, integration, cooperation, comprehensiveness, evaluation, adaptability, and sustainability (Table 1). These principles were clearly outlined and operationalized in the first and second

1 https://eur-lex.europa.eu/EN/legal-content/summary/green-paper-towards-a-new-culture-for-urban-mobility.html?fromSummary=32 (Accessed on May 16, 2025)

editions of the SUMP Guidelines (Rupprecht Consult, 2014, 2019). SUMPs advocate participatory planning and emphasize goal-oriented evaluation, data-informed decisions, and resilience to shocks. What differentiates SUMPs from conventional transport plans is their redefinition of success through accessibility and urban equity (Curtis and Scheurer, 2016). They encourage integrated governance that aligns transport and land use, inclusive stakeholder involvement, and modal shifts from cars to public and active transport for better health, safety, and environmental outcomes (Werland, 2020; Spadaro and Pirlone, 2021).

Tablo 1. SUMP Principles and Their Basic Tenets

SUMP Principle	Basic Tenet
Transparency	Planning process should be open and accessible to all stakeholders, thereby fostering trust and legitimacy.
Participation	the active involvement of citizens, local authorities, businesses, and civil society is critical for grounding decisions in lived experiences and building consensus.
Integration	Alignment of policies across sectors and transport modes should facilitate coordinated and cohesive planning.
Cooperation	Planning process should extend beyond local actors to include regional, national, and international institutions, enabling multi-level governance and resource sharing.
Comprehensiveness	Planning process should address all aspects of urban mobility—such as public transport, walking, cycling, freight, and private vehicles—within one strategic framework.
Evaluation	Planning process should include evidence-based planning by embedding monitoring tools and performance indicators throughout the planning cycle.
Adaptability	Cities should be able to respond to changing circumstances, emerging challenges, and new opportunities, ensuring the plan remains relevant over time.
Sustainability	The entire approach should focus on long-term environmental, social, and economic objectives, making SUMP a cornerstone of broader urban development strategies.

SUMPs follow a structured yet flexible process that unfolds through four key stages: (1) Preparation and analysis, (2) Vision development and strategy formulation, (3) Measure planning, and (4) Implementation accompanied by continuous monitoring and evaluation. Each phase is designed to foster collaboration, support evidence-based decision-making, and encourage local adaptation. Performance indicators, such as those tracking greenhouse gas emissions, modal shares, and accessibility, are central to evaluating progress and informing iterative improvement (Rutka et al., 2024).

Numerous case studies highlight the practical value of SUMPs. Gdynia, Poland, an early adopter, achieved success through strong political leadership, stakeholder involvement, and targeted initiatives like bus network reorganization and pedestrian-friendly infrastructure (Przybylowski, 2018). Similarly, cities such as Tallinn and Brno utilized SUMPs to drive institutional reform and build planning capacity. EU programs like CIVITAS have been instrumental in facilitating knowledge exchange and scaling best practices.However, SUMPs are not universally applicable in their standard form. Scholars such as Werland (2020) warn against overly rigid applications, emphasizing that rapidly evolving urban environments require adaptable strategies. In regions where governance is fragmented or coordination is weak, applying a one-size-fits-all model can undermine planning effectiveness and limit impact.

To succeed, SUMPs must genuinely reflect their core principle of adaptability by operating as flexible toolkits deeply grounded in local realities. However, current implementations often fall short in translating this principle into actionable strategies, particularly in complex and rapidly evolving contexts like Istanbul. The rigid application of SUMP frameworks risks overlooking informal transport modes, entrenched governance fragmentation, and distinct socio-cultural conditions. For SUMPs to be truly effective, they must be recalibrated to include adaptive

governance structures, integration of paratransit and informal systems, and planning processes that are continuously responsive to shifting urban dynamics. This requires more than inclusivity in principle—it demands context-sensitive approaches that prioritize local agency, political structures, and community-led insights. In cities like Istanbul, where transport challenges evolve rapidly, the transformative potential of SUMPs depends on this deeper institutional flexibility and operational responsiveness.

Transportation in the Developing World: A Misfit for SUMP?

Urban mobility systems in the Global South operate within markedly different socio-political, economic, and spatial contexts than those in the Global North, where Sustainable Urban Mobility Plans (SUMPs) were initially conceived. As Vasconcellos (2001) explains, transportation in developing countries is deeply entangled with institutional fragility and social inequality. While cities in the Global North typically enjoy stable governance, robust land-use regulation, and established public services, many urban centers in the Global South contend with rapid population growth, informal settlement expansion or uncontrolled urban sprawl, and fragmented institutions.

In these settings, transportation reflects power hierarchies and socio-economic disparities. Infrastructure investments often prioritize central areas and affluent populations, reinforcing spatial inequities. Peripheral and informal neighborhoods remain underserved, and public transit, when available, is frequently unreliable and underfunded—conditions that primarily impact low-income residents. Despite low car ownership rates, urban development continues to favor automobile infrastructure, fueled by policy inertia, aspirational consumer behavior, and the symbolic appeal of modernity. The institutional landscape in many Global South cities complicates planning further. Fragmented responsibilities and weak coordination between agencies hinder coherent mobility strategies. This often results in transportation policies that perpetuate exclusion rather than mitigate it. SUMPs, though well-intentioned, tend to be based on assumptions that rarely align with local realities—such as readily available data, established participatory mechanisms, and effective multi-level governance (Spadaro and Pirlone, 2021).

Paratransit systems—minibuses, motorcycle taxis, shared vans—are central to urban mobility in many Global South cities, especially where formal transit falls short. These informal systems are adaptable, affordable, and responsive to demand. While SUMPs do acknowledge paratransit to some extent, it is often framed narrowly, typically relegated to a feeder role for formal networks like rail or BRT systems. This limited recognition, although a positive step, fails to account for the full potential of paratransit as a backbone of everyday mobility for millions. The omission reflects a formalist bias that equates modernity with regulation and informality with dysfunction (Vasconcellos, 2001; Schipper et al., 2020). Moreover, efforts to replace or formalize paratransit often lack transition strategies, leading to service disruptions and resistance from communities and operators. A more inclusive and pragmatic approach would acknowledge paratransit's broader function and integrate it meaningfully through supportive regulation, infrastructure investments, and participatory reform processes. Sustainable mobility in the Global South depends not on the elimination of informality but on recognizing and empowering systems that already serve vast segments of the population.

A critical and often overlooked reality is that urban transportation systems in these regions are in a state of continuous flux. Infrastructure investments, such as new rail lines, can rapidly alter demand patterns and land use, potentially leading to gentrification or displacement. Simultaneously, urban sprawl—largely driven by increased car ownership—further undermines long-term transport planning. In response, SUMPs must evolve into genuinely reflexive and adaptive frameworks that can respond to these unpredictable dynamics. Istanbul exemplifies these challenges acutely. The city's sprawling geography, uneven development, and income disparities contribute to profound mobility inequalities. Peripheral districts often lack reliable public transit options, while a surge in car ownership among the middle class intensifies congestion and emissions. Although the city adopted a formal SUMP in 2022, it continues to struggle with entrenched car dependency, fragmented multimodal integration, and institutional fragmentation. Between 2019 and 2024, while the population increased by only 1%, the number of private vehicles surged by 32%, underscoring the disconnect between policy ambitions and actual mobility outcomes. The SUMP's treatment of paratransit further reflects this misalignment. Although paratransit is acknowledged, it is limited to a feeder role for the rail network—a framing that, while a positive step, fails to capture the full potential of services like the minibus/dolmuş system. These systems provide vital, flexible, and demand-responsive connectivity, particularly in underserved and peripheral areas. By reducing

them to a subordinate status, the plan overlooks their strategic role in addressing Istanbul's broader mobility challenges. A truly adaptive and inclusive SUMP would integrate paratransit more holistically into the city's transport ecosystem, leveraging its capacity to fill systemic gaps left by formal infrastructure.

Indeed, the cultural symbolism of car ownership adds another layer of complexity. As Gwilliam (2003) and Pojani and Stead (2015) observe, cars are often perceived as symbols of autonomy, modernity, and upward mobility—particularly in contexts where public transport is stigmatized or unreliable. Consequently, policies such as congestion pricing or vehicle quotas, effective in many European settings, often encounter resistance in cities of the Global South. These cultural and perceptual dynamics further expose the limitations of SUMPs when transposed without critical adaptation. For SUMPs to succeed in such contexts, they must go beyond rigid templates and evolve into genuinely flexible toolkits. This requires co-development with local actors and responsiveness to the institutional, cultural, and socio-economic specificities of each setting. Engaging informal operators, inclusively upgrading infrastructure, and investing in collaborative governance are all essential strategies. Only under such conditions can mobility planning transcend technocratic control and emerge as a catalyst for spatial justice and urban dignity. As Vasconcellos (2001) reminds us, mobility constitutes a core dimension of citizenship—integral not only to freedom of movement, but also to equitable access to public life. Sustainable mobility in the Global South will not emerge through replication of Northern models, but through the construction of grounded, pluralistic, and inclusive alternatives rooted in lived realities.

Compounding these challenges are the persistent issues of governance fragmentation and limited community engagement, which significantly undermine the effectiveness of mobility planning. In many Global South cities, decision-making remains highly centralized and technocratic, often excluding informal transport operators, residents of peripheral neighborhoods, and civil society organizations from meaningful participation. This top-down orientation reveals the difficulty of directly transplanting Northern planning models—rooted in stable governance and institutional coherence—into dynamic, diverse, and often politically fragmented Southern urban environments. As Cervero (2013) and Dimitriou (2013) argue, effective transport planning in such contexts must be deeply embedded within broader developmental agendas, encompassing poverty alleviation, livelihood support, and inclusive governance mechanisms. Mobility, in this perspective, is not merely a logistical or infrastructural issue but a fundamental right that connects people to opportunities in education, employment, healthcare, and civic life.

SUMP in Developing Cities: A Reflexive Proposal

In order to transcend the limitations of conventional Sustainable Urban Mobility Plans (SUMPs) when applied to complex, fast-growing cities in the Global South, a reflexive approach is required—one that does not merely adapt European practices to local contexts but reconfigures the planning paradigm itself. Drawing from the works of Vasconcellos (2001) and Dimitriou (2013), this proposal outlines the contours of a rearticulated SUMP framework that is responsive to the political, spatial, and institutional contingencies of cities such as Istanbul. Vasconcellos (2001) asserts that transport planning in developing countries must start not from abstract, imported objectives but from deeply situated understandings of structural inequality, pervasive informality, and unequal access to urban opportunities. Transportation in these contexts is not merely a logistical issue but a dynamic social contract—one that reflects and reinforces patterns of privilege, marginalization, and spatial exclusion. Planning must therefore be attentive to the lived realities of the majority, particularly those relegated to informal settlements or peripheral areas. Similarly, Dimitriou (2013) emphasizes the need for cultivating an "appropriate planning culture"—a concept that demands planners engage with the political economy of local institutions, recognize the historical trajectories of urban development, and co-create mobility strategies through inclusive and participatory mechanisms. Rather than treating planning as a one-way transfer of best practices, this approach calls for a dialogical, adaptive process grounded in stakeholder empowerment and cultural sensitivity.

Within this reframed paradigm, SUMPs must reposition themselves as facilitators of socio-spatial justice. This means reorienting the planning process away from technocratic idealism and toward political and institutional realism. Horizontal integration of diverse actors—from municipal planners and informal operators to community leaders and transit users—must be treated as an essential design principle, not a peripheral engagement strategy. The goal is not to achieve universal best-fit models but to foster locally negotiated, collectively stewarded mobility systems that enhance equity, dignity, and sustainability. To achieve this, a reflexive SUMP must begin with a diagnostic phase that acknowledges the co-existence and interdependence of multiple mobility systems within a city—not only formal infrastructure like buses and rail lines but also paratransit services, informal

transport networks, non-motorized pathways, and even seasonal or event-driven mobility patterns. This stage must move beyond traditional planning assumptions that privilege measurable technical indicators to embrace methodologies that uncover the deeper socio-spatial dynamics of movement. Rather than relying exclusively on modal split, congestion metrics, or emissions data, the diagnostics should incorporate ethnographic observation, participatory mapping, and spatial storytelling to surface the textures of everyday mobility, especially among marginalized and underserved communities.

In practice, this could involve community-led audits of access barriers, mobile interviews with commuters across class and gender lines, and the use of digital tools to document experiential geographies such as zones of fear, waiting, or exclusion. Such approaches not only broaden the evidentiary base of planning but also reframe mobility as a lived and contested experience. This deeper diagnostic insight reveals where formal networks fail, how paratransit fills systemic voids, and why certain routes, modes, or practices persist despite being institutionally invisible. Ultimately, the goal is to generate a holistic and inclusive mobility portrait that identifies not only gaps in infrastructure but also structural exclusions and power asymmetries that shape how, where, and for whom the city moves.

From this basis, the visioning phase must foreground mobility as a human right and as a fundamental pillar of social citizenship, shaping not only how individuals move but how they participate in the economic, cultural, and political life of the city. This requires a deliberate and sustained inclusion of marginalized voices—particularly women, the urban poor, disabled individuals, informal transport workers, and users of non-motorized modes—who are often excluded from formal planning discourses despite their deep experiential knowledge of the mobility landscape. Vernacular expertise must be brought to the center of deliberative processes, with planning spaces structured to facilitate not just consultation but co-creation. This could involve neighborhood assemblies, mobile town halls, or storytelling workshops that draw out latent mobility aspirations, anxieties, and place-based knowledge. Through these engagements, the visioning phase becomes not a normative projection from planners but a shared construction of future mobility imaginaries.

Vision statements should thus emerge from iterative dialogue and collective deliberation that extend beyond technocratic or environmental benchmarks. These statements must reflect a pluralistic synthesis of values—articulating goals that transcend narrow, efficiency-based definitions of sustainability to embrace a deeper normative agenda of urban dignity, intergenerational equity, spatial inclusion, and collective belonging. In a context marked by institutional fragility and spatial inequality, such visioning must function not only as aspirational rhetoric but as a strategic, co-produced claim on urban futures. In this reflexive frame, mobility transforms into an emancipatory space through which urban residents assert their right to the city—a right not just to access but to shape and inhabit public space, economic opportunity, and civic life on just and equitable terms. Mobility, thus conceived, becomes a catalyst for democratizing urban governance and redistributing spatial power.

Strategic goals in a rearticulated SUMP must be structured around equity-driven imperatives rather than conventional modal or infrastructure-based categorizations. The planning framework should explicitly ask: who is currently excluded from mobility systems, who stands to gain in terms of reduced travel time, improved safety, or increased opportunity, and who disproportionately absorbs the social and environmental costs of urban transport? This reframing positions equity not as a peripheral concern but as a core organizing logic of the entire planning apparatus.

By anchoring strategic priorities in redistributive justice, planning interventions can be aligned to directly redress historical exclusions, elevate the needs of peripheral and vulnerable communities, and reconfigure the spatial allocation of public investment. This may include prioritizing last-mile connectivity for informal settlements, enhancing pedestrian infrastructure in underserved areas, or subsidizing informal transport operators who serve essential routes. Ultimately, strategic goal-setting must function as a political act—deliberately tilting the balance of mobility benefits toward those who have been structurally disadvantaged by previous planning regimes. At the level of measures, SUMPs must adopt a flexible, modular approach capable of navigating institutional fragmentation, fiscal limitations, and infrastructural unevenness typical of many Global South cities. This flexibility is not only a logistical necessity but a strategic response to the plural mobility ecosystems that define such urban contexts.

While formal interventions—such as the development of dedicated bus corridors, transit-oriented development, or pedestrianization schemes—can play a vital role, they must be conceived as part of a broader integrative strategy that includes and elevates informal systems rather than displacing them.

A reflexive SUMP must treat informal transport—such as minibus/dolmuş services—not as a problem to be solved but as a vital asset to be supported, regulated, and incrementally improved. While current SUMP frameworks sometimes acknowledge the role of paratransit as a feeder to high-capacity rail corridors, this limited framing underestimates its broader significance in the mobility ecosystem. Informal modes often serve as primary transport solutions in peripheral neighborhoods, act as critical connectors between fragmented formal services, and embody community-responsive systems that adjust flexibly to shifting spatial and temporal needs. Planning should identify and enhance the complementarities between formal and informal systems through the design of shared nodes, integrated ticketing schemes, corridor coordination, and non-punitive regulation. Additionally, measures must address the labor conditions, safety norms, and environmental performance of informal transport to ensure these systems are not only functional but also dignified and sustainable. Such an approach recognizes that informal systems are often the outcome of adaptive problem-solving in environments where the state has failed to provide adequate services. Therefore, measures should be embedded in an ethos of collaborative governance, where planners act not as enforcers of top-down standards but as facilitators of negotiated arrangements that improve efficiency, accountability, and equity across the entire mobility system.
The implementation phase should be viewed as a multi-scalar and iterative governance process, wherein national ministries, municipal agencies, metropolitan authorities, and neighborhood-level organizations collaboratively co-create, pilot, and adapt mobility initiatives over time. This polycentric governance structure must be deliberately cultivated to accommodate varying capacities, political interests, and jurisdictional overlaps, which are often pronounced in the context of developing cities. Effective implementation demands a redefinition of roles—not merely top-down enforcement or bottom-up advocacy, but shared responsibility and mutual accountability across levels.

Capacity building within this phase must go beyond technical training or institutional restructuring; it must encompass political negotiation, relational trust-building, and mechanisms for ongoing conflict mediation. This involves developing facilitative leadership, transparent communication channels, and participatory budgeting mechanisms to ensure that diverse stakeholders remain engaged and empowered throughout the process. Importantly, implementation should not be treated as a linear execution of predetermined plans but as a dynamic, feedback-driven learning cycle that accommodates shifts in social, economic, and political conditions. Only through this reflexive, inclusive implementation architecture can SUMPs in developing cities begin to generate meaningful and durable mobility transformations.

Monitoring and evaluation must be reframed as dynamic, participatory processes that go beyond conventional performance indicators and embrace reflexive, socially grounded metrics (Peters and Reisch, 2023). Rather than solely emphasizing quantitative outputs such as kilometers of track laid, ridership growth, or modal shift percentages, evaluative frameworks must also scrutinize qualitative dimensions of equity, inclusion, and empowerment. Questions like: Has physical and economic access improved for women, children, and people with disabilities? Are informal transport operators more secure in terms of income, labor rights, and institutional recognition? Have commute times and cost burdens been reduced for residents in peripheral and underserved areas?—must become central to the assessment matrix. To support this, monitoring systems should incorporate community-led evaluation tools, participatory feedback loops, and context-sensitive indicators that are co-defined by stakeholders during earlier planning phases. Mixed-method approaches, including ethnographic fieldwork, user experience diaries, and real-time digital platforms for commuter reporting, can enrich the evaluative process and foster ongoing civic engagement. Importantly, evaluation must be adaptive and recursive—feeding insights back into the planning and implementation pipeline to refine goals, modify interventions, and maintain accountability. In a reflexive SUMP, monitoring becomes not an endpoint but a learning architecture that sustains continuous transformation toward greater urban mobility justice.

What about Istanbul?

In the case of Istanbul, where the population has remained relatively stable over the past five years, the dramatic 32% increase in motorized vehicle ownership during the same period underscores a deepening reliance on private

cars and a stark misalignment with the aims of sustainable mobility. This accelerating automobilization, unmatched by population growth, signals not only policy inertia but also the inadequacy of current planning paradigms to influence transport behavior meaningfully. A reflexive SUMP would necessitate a fundamental departure from the existing technocratic and infrastructure-heavy orientation that dominates Istanbul's mobility strategy. While the SUMP report for Istanbul demonstrates commendable alignment with EU-defined planning procedures and sustainability language (Canitez et al., 2020), it ultimately mirrors a prescriptive framework developed for mature European cities. It emphasizes quantitative metrics, modal efficiency, and high-cost infrastructure projects—such as metro expansions and congestion pricing—without adequately responding to the lived experiences, socio-spatial inequalities, and plural mobility practices that define Istanbul's dynamic urban fabric.

One of the major risks in Istanbul's current approach stems from its insufficient capacity to anticipate and adapt to the shifting equilibrium conditions that inevitably follow significant mobility and land use interventions. The introduction of new metro lines and transit extensions—while ostensibly aimed at promoting modal shift and reducing congestion—has led to a spatial reconfiguration of travel demand and intensified land speculation in proximity to these new transit nodes. In several cases, this has catalyzed urban transformation processes such as gentrification, displacing lower-income populations and altering the socio-economic fabric of these districts. Simultaneously, urban sprawl continues to expand Istanbul's peripheries, driven in part by rising car ownership and auto-oriented development paradigms that remain insufficiently challenged by the current policy framework.

These concurrent phenomena have created a fluid, often volatile landscape of mobility behaviors and spatial patterns. Modal preferences, trip lengths, and travel times fluctuate as new corridors emerge, housing markets shift, and job centers decentralize. In this dynamic context, SUMP strategies that rely on static baselines or pre-defined mode targets risk obsolescence and misalignment. Without adaptive feedback loops and real-time monitoring mechanisms, infrastructure investments can inadvertently generate induced demand or reinforce existing spatial disparities. A truly reflexive SUMP must therefore integrate scenario planning, continuous impact assessment, and responsive institutional coordination to remain aligned with the evolving urban metabolism. It must move beyond infrastructure provision as a deterministic force and recognize its catalytic role in shaping, and being shaped by, broader urban transformations.

A reflexive SUMP for Istanbul would begin by acknowledging the city's complex and plural mobility ecologies that encompass formal transit lines, informal systems like dolmuş and minibuses, ferry routes shaped by the city's geography, and the daily pedestrian flows that characterize many lower-income districts. The current SUMP process has only marginally addressed the social logic of these systems, treating informal transport as a residual phenomenon rather than as a strategic component of the urban mobility network.

Furthermore, Istanbul's SUMP underutilizes participatory methods. Public engagement has been limited to consultation rounds rather than constituting a co-productive planning process. A reflexive model would invert this logic—planning would begin with ethnographic inquiry, spatial storytelling, and neighborhood-level assemblies to co-diagnose problems and formulate contextually meaningful interventions.

Institutional fragmentation and jurisdictional overlaps continue to impede mobility coherence in Istanbul. The current SUMP does little to resolve these governance issues beyond recommending coordination. A reflexive SUMP would treat governance integration not as an administrative fix but as a political process that requires cross-level negotiation, interdepartmental trust-building, and shared accountability.

To improve Istanbul's SUMP, it must move toward a deliberative framework that emphasizes procedural justice and localized knowledge. This includes formalizing the role of informal actors in planning councils, adopting community-based evaluation indicators, and reframing infrastructure decisions around distributive equity. Rather than deploying standardized tools like congestion pricing without adaptation, Istanbul should develop hybrid solutions that balance demand management with improved access for peripheral and low-income areas. In sum, Istanbul's mobility planning must transition from a compliance-driven blueprint to a reflexive, adaptive, and locally resonant transformation process.

Such a framework, while grounded in the values of the original SUMP model—sustainability, inclusiveness, and integration—must diverge methodologically and politically. It must embrace uncertainty, foreground local agency, and frame mobility not as a matter of control, but as a collective negotiation over space, access, and rights.

In doing so, SUMPs in the Global South can evolve from prescriptive models into emancipatory processes, capable of reshaping the urban future from below.

Conclusions for Istanbul, The Biggest (Developing) City in Europe

Sustainable Urban Mobility Plans (SUMPs) have emerged as a transformative framework for urban transport planning, emphasizing sustainability, inclusivity, and environmental stewardship. Developed by the European Commission, SUMPs aim to reconfigure urban mobility systems to prioritize public transport, active modes of transport such as walking and cycling, and the integration of land-use planning with transport infrastructure. Unlike traditional strategies focused on vehicular flow, SUMPs align mobility planning with broader socio-economic and environmental objectives. Their adoption addresses urban challenges like congestion, greenhouse gas emissions, and social inequality (Rupprecht et al., 2019; May, 2015). SUMPs are built on principles of participatory planning and integrated development, tailoring policies to each urban area. Key goals include reducing the environmental impact of transportation, improving public health through active mobility, and fostering equitable access. They contribute to the European Union's climate goals and align urban development with the United Nations' Sustainable Development Goals (Werland, 2020; Spadaro and Pirlone, 2021). A key feature of SUMPs is their focus on short- to mid-term interventions that can be scaled and adapted. These include enhancing public transport efficiency, expanding cycling and pedestrian infrastructure, and integrating multimodal networks. Such strategies mitigate the negative externalities of high car usage, like air pollution and congestion (Lindenaua and Böhler-Baedeker, 2014; Broseta, 2015). Adaptability is crucial for accommodating evolving urban dynamics.
However, implementing SUMPs in rapidly growing cities like Istanbul reveals critical limitations. Istanbul's context—marked by sprawling urban development and rising car ownership—presents challenges that conventional SUMPs, originally tailored for stable European settings, are not fully equipped to manage. One fundamental issue is the failure to adequately address the city's systemic transition from a bus-based to a rail-based transit system. Over the past two decades, Istanbul has shifted from a flexible, point-to-point bus network—valued for its economies of scope, thick market and adaptable routing properties—to a more rigid, hub-and-spoke rail system dependent on economies of scale. This transition signifies both a structural and cultural transformation. Bus systems often feature movable stops and adaptable service paths, while rail systems are anchored by fixed stations that serve as enduring spatial nodes. These nodes have significant implications for surrounding land use in terms of densification, economic clustering, and shifts in real estate dynamics. Despite these changes, the current SUMP does not sufficiently account for the spatial repercussions of this shift. It reiterates observations of spatial transformation but stops short of embedding them in actionable strategies. This oversight reflects a broader pattern in which the planning system remains passive—adopting a laissez-faire approach instead of strategically engaging with the systemic transition. To achieve meaningful sustainability outcomes, planning institutions must go beyond merely acknowledging change and take an active role in shaping development. This requires a proactive integration of land use and transit planning that leverages the transformative power of fixed rail infrastructure. Only through such engagement can the full potential of costly transit investments be realized and sustainability targets met.

Although SUMP documents reference integration and multimodal coordination, they lack a comprehensive grasp of the systemic change that is reshaping urban mobility in Istanbul. Without explicitly addressing the full implications of this rail-centric transition—and its interdependence with land use and service delivery—SUMP initiatives risk remaining fragmented and ineffective. The lack of a holistic view inhibits progress toward meaningful sustainability goals. To address this gap, a revised SUMP must prioritize this structural transition at its core, proposing a cohesive, forward-looking framework that aligns land use, accessibility, and multimodal connectivity with Istanbul's evolving rail-based urban form (Torrisi et al., 2020). A notable issue is the inadequate support for sustainable modes like walking and cycling, which remains disconnected from a broader spatial vision. Aspirational goals are undermined by the absence of a flexible land-use strategy, particularly one centered on urban transformation around high-capacity rail transit stations. Pedestrian infrastructure is not systematically linked to multimodal hubs, reducing its utility, while cycling paths are fragmented and insufficiently embedded into daily mobility networks. To realize the full potential of costly transit investments, a grand urban transformation strategy based on transit-oriented development (TOD) is essential—one that balances density and diversity of

land uses in both newly built and already developed urban areas. Without such an approach, SUMP risks failing to curb car ownership and the growing demand for road and parking space, ultimately weakening its capacity to deliver sustainable mobility outcomes (Przybylowski, 2018; Vujadinović et al., 2021).

Another shortcoming is the limited adaptability of the current SUMP to Istanbul's evolving transport landscape. While rail transit investments such as metro and tram expansions are underway, these high-capacity systems are not integrated into a broader land-use and transit strategy. To maximize the value of such investments, the existing bus-based transit topology must be comprehensively restructured. This reconfiguration should involve redefining the metropolitan area into coherent transit zones aligned with transit-oriented development (TOD) principles. These zones should support a hierarchical, polycentric urban model, in which multiple centers are interconnected by a unified and strategically layered transit system. Such a system would ensure seamless integration between modes—including rail, bus, and ferry—while enabling flexible land-use responses in both new and established urban areas. Without this level of coordination and adaptive planning, the SUMP will be unable to fully leverage its infrastructure investments or meaningfully reduce car dependency and its attendant demands for road and parking space (Yaoundé SUMP Summary, 2019; Kiba-Janiak and Witkowski, 2019).

Addressing these challenges requires a reimagined SUMP framework tailored to dynamic cities—one that goes beyond technical fixes and embraces strategic planning engagement. While adaptive tools like real-time data analytics are essential to identify shifting mobility patterns and anticipate intervention impacts, they are not sufficient on their own. Without an overarching vision anchored in institutional responsibility and proactive policy-making, even the most sophisticated data-driven tools may fall short. A genuinely effective SUMP must not only adapt to evolving conditions but also shape them by deliberately guiding urban growth, land use, and mobility behavior. This means abandoning the current laissez-faire attitude, where systemic transitions are acknowledged but not strategically acted upon, in favor of a planning culture that leads rather than follows urban change. In this paradigm, data serves not just as a mirror to urban trends but as a catalyst for visionary, sustainability-oriented decision-making (Wołek, 2014).

Institutional changes are also essential to realizing SUMP initiatives in Istanbul. The current administrative structure, characterized by fragmented decision-making, hinders effective coordination. Without a centralized governance model that consolidates transportation planning and aligns it with land-use policies, the implementation of SUMP will likely fail. Effective integration demands a governance framework that establishes clear relationships between land use and transportation planning, ensuring decisions are made with a holistic view of urban development. Only by restructuring institutional frameworks can Istanbul overcome the challenges of siloed operations and fragmented accountability, paving the way for successful SUMP execution (Rupprecht et al., 2019). Sustainable initiatives in Istanbul must pair land-use policies with context-driven urban design strategies to achieve meaningful results. While mixed-use developments integrating residential, commercial, and recreational spaces can reduce commute needs, these alone are insufficient without a parallel emphasis on urban design. Transit-oriented development (TOD) should not only enhance accessibility but must also be anchored in complete street design principles that prioritize inclusive, safe, and legible public spaces. Urban transformation around transit hubs must include pedestrian-friendly streetscapes, protected cycling infrastructure, accessible transit stops, and vibrant public realms that accommodate all transport modes equitably. These urban design interventions must be tailored to varied neighborhood contexts—densely built historical cores, new development areas, and informal settlements alike. Without such targeted and comprehensive design efforts, even well-conceived land-use strategies may fail to deliver sustainable mobility outcomes or foster the modal shift necessary for reducing car dependency (Andréi and Papuc, 2021; Salazar Deza et al., 2021).

Curbing private car usage is critical. Policies such as congestion pricing, low-emission zones, and parking management are vital tools to discourage automobile dependence and redirect funding toward sustainable projects. However, these measures must extend beyond boutique or pilot applications confined to limited districts like historical peninsula in Istanbul. To be effective, they should be scaled across the entire metropolitan built-up area and consistently engage private mobility in all urban settings. Comprehensive application ensures that car use is managed holistically, not just in selected city centers. At the same time, these measures must be coupled with substantial improvements in public transport—particularly in terms of coverage, frequency, and reliability—to offer credible and attractive alternatives to car use (MobiliseYourCity, 2023).

Expanding non-motorized transport networks, such as bike lanes and pedestrian zones, also remains essential to building an inclusive and balanced mobility system (Kiba-Janiak and Witkowski, 2019).

Stakeholder engagement is another critical SUMP component. Truly inclusive planning must involve a wide spectrum of stakeholders, ranging from neighborhood councils and local civic organizations to metropolitan-scale construction firms, mobility providers, and transport unions. Ensuring that citizens, businesses, and policymakers are actively included allows policies to more accurately reflect localized needs, values, and challenges. Beyond that, integrating private-sector stakeholders—especially those involved in large-scale construction, transit operations, and urban development—can support both the acceptance and implementation of mobility strategies. A multi-scalar and cross-sectoral engagement process strengthens social legitimacy and enhances the responsiveness of the SUMP to Istanbul's complex metropolitan dynamics (Lindenaua and Böhler-Baedeker, 2014).

Istanbul's experience underscores the need to adapt SUMPs for fast-growing cities. While sustainability and inclusivity remain central, practical applications must reflect local challenges. Without recalibration, SUMPs risk becoming aspirational documents with limited impact. By adopting innovation and context-sensitive approaches, cities like Istanbul can realize SUMPs' full potential and set benchmarks for addressing urban complexities (Rupprecht et al., 2019; Spadaro and Pirlone, 2021). Lessons from Istanbul highlight the importance of aligning mobility strategies with long-term goals and institutional capacity. As the primate city of Turkey, Istanbul not only holds the largest population and economic weight but also possesses the highest institutional capacity for urban and transport planning. This leadership role makes Istanbul a reference point for other Turkish metropolitan areas, which frequently adopt its policies, institutional frameworks, and operational models. As such, the development and refinement of a robust, context-sensitive SUMP in Istanbul carries significant potential for transferability and scaling. Even the specific policy and operational proposals outlined in Istanbul's SUMP could serve as a blueprint for institutional and legal revisions in municipal governance and local service delivery. A carefully reiterated and effectively implemented SUMP in Istanbul could thus function as a national model, offering tested frameworks and adaptable strategies that reflect both ambition and practicality. Achieving this outcome will require technical expertise, investment, political will, and sustained public engagement. As cities across Turkey grapple with rapid urbanization and climate change, a resilient and well-localized SUMP in Istanbul can inform a scalable, nation-wide shift toward sustainable urban mobility planning (Werland, 2020).

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URBAN RAIL TRANSIT USAGE IN DEVELOPING COUNTRIES: THE CASE OF ISTANBUL

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ABSTRACT
This study examines urban rail transit usage in Istanbul to shed light on broader challenges faced by developing countries. Using models based on node and place characteristics of stations, it evaluates their impact on passenger volumes across the rail network. Despite major investments and rapid urbanization since the 1960s, only a fraction of station areas saw concurrent increases in passenger and population figures between 2017 and 2022. While node and place variables showed some significance, the regression models could not fully explain usage variability, suggesting that institutional, socio-economic, and spatial dynamics play a disruptive role. The findings indicate that stations have been treated more as isolated nodes than integrated components of the urban fabric. The study calls for a planning approach that combines rail transit with broader urban development, tailored to the complex realities of developing cities for maximizing the transformative potential of rail investments and promote sustainable urban growth.

Keywords: Urban Rail Transit, Developing Country, Istanbul, Node and Place Characteristics

Introduction

Investments in urban rail systems have increased significantly on a global scale, encompassing both developing and developed nations (Newman & Kenworthy, 2015). This trend underscores the growing recognition of urban rail as a crucial solution to contemporary urban challenges. However, is urban rail exclusively concerned with enhancing public transportation efficiency? Certainly not. Scholars assert that rail stations have the potential to serve as dynamic urban hubs, fostering economic development by attracting businesses and residents to the surrounding areas (Yang, Zhong, & Gao, 2022). While this proposition appears promising, its applicability in developing countries remains an open question.

Developing cities are constantly evolving, driven by both urbanization and natural population growth. As a result, these cities undergo significant expansion, extending both horizontally through suburban sprawl and vertically through high-density development (Mahtta et al., 2022). However, urbanization in these regions is often chaotic, characterized by fragmented investments and weak urban planning (McGill, 1998; Abdi & Daudén, 2021). The rapid pace of urban growth often outstrips the capacity of local governments to implement effective infrastructure and regulatory frameworks. This lack of coordination leads to inefficient land use, inadequate transportation networks, and increasing socio-economic disparities. As a result, many urban rail projects face challenges in integrating seamlessly with the surrounding urban fabric, limiting their overall effectiveness. So, what happens when urban rail is introduced? The results vary—some areas attract more people, while others remain unchanged or even see decline. Why? The dynamic nature of developing cities plays a huge role. In this study, we dive into Istanbul—a city that perfectly captures these trends.

As the most populous city in Europe, Istanbul has embraced the global "railization" movement (Gökçe, 2024). This shift has been driven by increasing urban congestion, environmental concerns, and the need for sustainable mobility solutions. Consequently, the city has prioritized expanding its rail network to enhance connectivity and reduce reliance on automobile transport. These efforts align with broader global trends that seek to integrate public transportation more effectively into urban planning. Since 2000, the city has invested heavily in suburban, metro, and light rail lines. By 2017, almost 57% of the population had a rail station within a kilometer (Gökçe, 2024, p. 8). However, the presence of a nearby station has not consistently resulted in increased ridership or population growth. This discrepancy raises an important question: what underlying factors contribute to this unexpected outcome?

Building upon these observations, a comprehensive analysis was conducted on 137 station areas within a one-kilometer radius to evaluate changes in population and passenger usage between 2017 and 2022. The results

indicated that only 27 stations (19.71%) experienced simultaneous increases in both population and passenger numbers. In contrast, 57 areas (41.61%) saw an increase in ridership despite a decline in population, while 53 stations (38.69%) experienced a reduction in passenger numbers. Notably, 20 stations with growing populations reported a decrease in transit users. These findings suggest that factors such as rail type, capacity, and land use significantly influence transit trends. However, they also highlight broader structural challenges in the development and integration of urban transit networks within rapidly evolving cities.

From these findings, valuable insights can be drawn regarding urban rail transit in rapidly evolving cities. This study provides an in-depth examination of urban rail transit in Istanbul, utilizing models based on node and place characteristics (Bertolini, 1996). Furthermore, it identifies inefficiencies within the system and proposes strategies to better integrate "transportation transformation" with "urban transformation." The study is structured as follows: Section 2 reviews transport trends in developing countries, Section 3 examines Istanbul's rail expansion, and Section 4 presents three analytical models—the Node model, the Restricted Node-Place model, and the Node-Place model—employing data from 2013, 2015, 2017, and 2019.

Nevertheless, a key challenge remains—while the models confirmed the significance of node and place characteristics, they did not fully account for the misalignment between ridership and population trends across the 137 stations. No statistically significant patterns were observed, suggesting that Istanbul's rapid urban transformation and shifting demographic patterns may have disrupted the anticipated relationship between transit usage and population density. This finding underscores an important consideration: rather than functioning as integral components of the urban fabric, Istanbul's rail stations have primarily been treated as isolated network nodes.

To effectively address these challenges, cities, particularly in developing regions, must integrate public transit—especially rail—as a core element of urban planning. This integration should emphasize accessibility, efficiency, and sustainability to ensure long-term viability. Moreover, seamless coordination between transportation policies and urban development strategies is crucial to maximizing the socio-economic benefits of rail transit investments. Engaging the public and ensuring equitable access to rail services can further enhance the effectiveness and acceptance of these initiatives. Given that these concerns extend beyond Istanbul, they are equally relevant to cities worldwide. A well-structured planning framework that prioritizes transit in urban development is essential for optimizing rail investments. The fifth section provides key recommendations for addressing these issues and enhancing the role of rail transit in rapidly evolving urban environments.

The Background: Transportation In Developing Countries

Urban transportation in developing countries presents a complex and multifaceted challenge. The transportation systems in these regions often reflect a hybrid of modern and traditional elements, resulting in inefficiencies unique to the developing world context. Rapid urbanization, economic constraints, and evolving social dynamics necessitate a nuanced understanding of urban mobility. Despite the global trend of "railization," transportation networks in developing nations continue to grapple with mobility issues like those identified by Gakenheimer (1999).

One of the most pressing challenges is the rapid pace of motorization, which often outstrips the capacity of existing transportation infrastructure. This imbalance leads to severe congestion, with cities such as Istanbul experiencing higher congestion levels despite lower vehicle ownership rates compared to many developed cities. Moreover, excessive travel demand further exacerbates congestion, as transportation networks fail to keep pace with the growing number of private vehicles on the road.

Public transit remains a crucial component of urban mobility in developing countries, carrying a significant share of urban trips. However, the effectiveness of public transportation is frequently hampered by political and institutional challenges, including inadequate funding, fragmented governance, and policy inconsistencies (Cervero, 2013). The dominance of bus systems, which often suffer from congestion-related delays, underscores the need for strategic investments in dedicated transit lanes and signal prioritization.

Disparities in transportation access further complicate urban mobility, leading to inequitable distribution of resources and services. In many developing cities, marginalized communities face longer commute times

and limited transit options, exacerbating socio-economic divides (Gakenheimer, 1999). Addressing these issues requires targeted policy interventions and infrastructure investments that prioritize inclusive and equitable transportation solutions. The decentralization of urban functions, often driven by motorization, tends to relocate employment opportunities to suburban areas, making access difficult for lower-income, non-motorized populations.

Additionally, the urban structures of many developing cities are not conducive to high levels of motorization. Narrow roads, often inherited from historical urban layouts, limit the space available for expanding vehicular infrastructure. The high density of both residential and commercial establishments further restricts the feasibility of large-scale road expansions. As a result, transportation planners must seek alternative mobility solutions that align with the existing urban fabric and prioritize sustainable transport options. Limited street space, high population densities, and mixed land-use patterns contribute to infrastructure inadequacies, further straining transportation networks (Bertolini, 2008). These constraints make it challenging to develop large-scale road expansion, leading to congestion and inefficiencies. Furthermore, mixed land-use patterns result in complex travel behaviors, as people need to navigate between residential, commercial, and industrial areas within short distances. The combination of these factors necessitates the adoption of innovative urban mobility solutions, such as improved public transit networks and non-motorized transport infrastructure, to enhance overall accessibility.

A significant factor fueling motorization is the strong desire for private vehicle ownership. Economic growth and aspirations for a modern lifestyle drive an increasing demand for automobiles, which, in turn, exacerbates congestion and environmental concerns. The introduction of new road systems often has a more pronounced impact on urban development in developing countries compared to their developed counterparts. The construction of highways, for example, tends to accelerate urban sprawl and alter existing urban structures, sometimes to the detriment of sustainable mobility (Cervero et al., 2009).

Furthermore, the diversity of vehicle types on the streets of developing cities presents unique challenges in traffic management. A mix of human-powered vehicles, motorcycles, minibuses, and high-speed cars complicates the efficiency and safety of urban transport. While informal transit options such as tuk-tuks in Thailand and minibuses in Turkey offer flexible mobility solutions, they also contribute to congestion and regulatory challenges.

Despite the increasing adoption of urban rail systems as a potential solution to congestion, rail transit alone cannot resolve the mobility crisis in rapidly growing urban environments. The success of such systems hinges on comprehensive planning, robust policy frameworks, and sustained political commitment (Cervero, 2013). Cities that fail to integrate rail investments with broader urban planning efforts risk underutilization and continued congestion.

Many developing cities also face institutional inefficiencies and social inequities that further complicate transportation management. Limited political will, insufficient administrative capacity, and corruption hinder the development of cohesive land-use and transportation strategies. In several cases, the influx of second-hand vehicles from high-income countries exacerbates congestion and contributes to higher greenhouse gas emissions. The fragmentation of urban services and a reactive rather than proactive approach to transportation planning often result in disjointed and ineffective mobility solutions.

The expansion of transportation infrastructure frequently leads to urban sprawl, marked by a “flattening of the density gradient” (Cervero, 2013, p. 14). This phenomenon is particularly evident in megacities like Istanbul, where transit investments can inadvertently contribute to socio-spatial segregation. Lower-income populations are often displaced to peripheral areas, while central urban districts undergo modernization catering to wealthier residents. However, successful cases from Bogotá and Curitiba demonstrate that well-integrated transportation and urban development strategies can lead to more sustainable and equitable mobility solutions. Investments in Bus Rapid Transit (BRT) systems and cycling networks have helped these cities accommodate growing mobility needs while promoting compact urban development.

Sustainable urban mobility in developing cities necessitates a strategic integration of land-use planning and transportation policies that emphasize accessibility and operational efficiency. The implementation of smart

growth principles can significantly contribute to lowering emissions, improving air quality, and fostering overall urban livability. A comprehensive and resilient mobility framework must incorporate a diversified array of transportation modes, targeted infrastructure investments, and systematic institutional reforms. Among these, rail investments hold paramount importance as they mitigate congestion, enhance urban connectivity, and provide an environmentally sustainable alternative to road-based transport. When seamlessly integrated with land-use planning, rail systems have the potential to reduce reliance on private automobiles and facilitate transit-oriented development. Consequently, a clear strategic vision and sustained commitment from policymakers are essential for developing nations to not only alleviate congestion but also stimulate economic growth and promote social inclusivity.

The Backdrop: İstanbul's Changing Face Of Public Transit

Istanbul, with an estimated population approaching 16 million, is the largest metropolitan region in Europe—when considered alongside the adjacent Gebze region to the east, the total population nears 17 million. Since the 1960s, the city has undergone rapid urbanization, with its population expanding from approximately one million to its current scale. This unprecedented demographic surge, primarily driven by migration, necessitated extensive northward (inland) expansion, resulting in the proliferation of informal settlements, commonly referred to as squatter housing. By the 1980s, these initially low-rise, one- to two-story structures underwent significant transformations into multi-story apartment complexes to accommodate the escalating population density. Consequently, the urbanization of Istanbul has been characterized by a dual process of internal densification and peripheral sprawl, reshaping the city's spatial and infrastructural landscape (Figure 1).

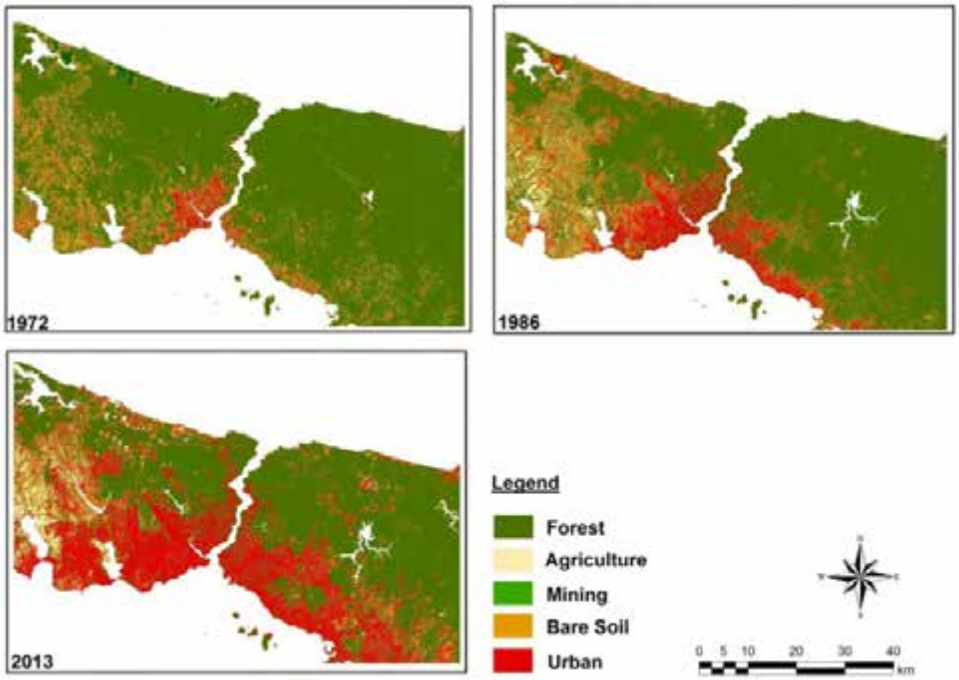

Figure 1 Urban expansion of İstanbul from 1972 to 2013 (Source: Akın et al., 2015, p. 506)

This densification, however, has left Istanbul grappling with inadequate infrastructure on multiple fronts. The swift population growth and the shift from squatters to apartments have placed immense pressure on the city's infrastructure, which has struggled to keep pace with the demands of such rapid urban development. Essential services and facilities, including transportation, sanitation, and public utilities, have often been overwhelmed, leading to significant challenges in terms of quality of life for residents. The city's infrastructure, originally designed for a much smaller population, has not been adequately upgraded to meet the needs of its current size, resulting in persistent issues with congestion, housing, and basic urban services.

To address these challenges more comprehensively, the municipal system for metropolitan areas was transformed into a two-tier system in the early 1980s. This new structure features an upper tier known as

the metropolitan municipality and a lower tier consisting of district municipalities. The aim was to enhance effectiveness and efficiency by leveraging economies of scale through metropolitan-wide investments in transportation, water supply, wastewater management, and other essential services. This restructuring intended to streamline administration and improve service delivery across the rapidly growing urban landscape.

Recently, the concept of the metropolitan municipality has evolved into what is now termed the "greater municipality," with jurisdictional areas extending to provincial borders while maintaining the two-tier system. Provinces with populations exceeding 750,000 are designated as greater municipalities. This latest iteration of the municipal system has integrated rural areas into urban governance, placing them under the same administrative umbrella as their urban counterparts. This change aims to ensure more cohesive and unified management of resources and services, addressing both urban and rural needs within the same administrative framework (Tekeli & Okyay, 2014).

Before the 1990s, Istanbul's public transportation infrastructure was relatively underdeveloped. Apart from a century-old two-stop rubber-tired funicular, locally known as the "Tunnel," which connected the seashore to a higher point in the city center on a very short line, the city had two old suburban rail lines. These lines terminated at Sirkeci on the European side and Haydarpaşa on the Asian side, both located at the southern tips of the Bosporus. These suburban rail lines formed the backbone of public transit, running through legally established housing strips parallel to the Sea of Marmara, an inland sea that connects the Black Sea to the Mediterranean Sea. To the north of both suburban lines, towards the inner areas of Istanbul, a state highway (namely E5, which was later recoded as D100, connecting Turkey's interior regions to Europe) served as the main urban artery (Tekeli, 2009). In these northern areas, illegal housing settlements were linked to this backbone by small entrepreneur-operated minibuses and public buses operated by the Istanbul Electric Tram and Tunnel Company (İETT). The minibus transit system has evolved flexibly with urban expansion and, in many cases, has supported urban expansion in the form of squatter housing (Tekeli & Okyay, 1981).

The establishment of a metropolitan municipality brought significant changes to Istanbul's transportation landscape. In the 1990s, financially empowered metropolitan administrations began investing in rail transit lines. This period marked the beginning of an incipient "railization," although efforts to expand the rail network were initially hampered by economic downturns in the Turkish economy. Despite these challenges, the trend towards rail transit steadily increased after 2000, with new metro and tramway lines extending from the city center to densely populated inner areas. The central government further spurred these developments by taking charge of the rail construction phase, boosting the expansion of rail infrastructure. A significant milestone was the recent completion of a high-tech, driverless metro line connecting the newly built Istanbul Airport, one of the three largest airports in Europe, to the city center. Today, two of the main airports, bus terminals, and intercity rail terminals, as well as main activity centers, are interconnected via the urban rail network, highlighting the substantial progress made since the 1990s.

Recently, the Bosporus has been underpassed by two tunnels: one for the suburban rail line (Marmaray Tunnel inaugurated in 2013), which connected independent lines on the European and Asian sides, and the other for motor vehicles (Eurasia Tunnel inaugurated in 2016). The addition of a third bridge on the northern frontier of the Bosporus has further increased urban mobility, which seems to be driving further urban expansion in the northern regions. Today, a seamless trunk suburban line, Marmaray, runs from Gebze, the westernmost district of the neighboring Kocaeli province, to Halkalı, the terminal station of the suburban line on the European side, covering a stretch of 86.6 km with 43 stations (Figure 2).

Figure 2. Main road corridors and Marmaray suburban line (highlighted in solid red line) in İstanbul (Source: Canitez et al. , 2020)

Over nearly three decades, the sustained effort in "railization" has transformed Istanbul's transportation system from a predominantly rubber-tired network to a more sophisticated rail network based on a node-place topology. Historically, the metropolitan administration's organizational structure was not designed to support such a network; it was geared towards a rubber-tired system. This necessitated significant changes to adapt to the new rail-based system. However, these changes required not only extensive physical infrastructure investments but also a thorough organizational restructuring to manage and operate the new node-place topology effectively (Cervero, 2013).

The main issue is that the rail network in Istanbul is designed for nodes without adequately developed station areas (i.e., places). This is a serious problem that needs to be addressed through capacity building. Developing station areas into functional, vibrant places is essential for maximizing the benefits of rail transit. Enhancing the integration of these nodes into the urban fabric will require strategic urban planning, improved land use policies, and the creation of amenities and services that make these areas attractive and accessible to residents (Bertolini, 1996, 2008; Cervero, 2008, 2013). By focusing on building capacity in these areas, Istanbul can ensure that its rail network not only serves as a means of transportation but also contributes to the overall livability and functionality of the city.

Especially after 2010, rigorous investments in rail transit has turned disconnected rail lines into a highly connected rail network as depicted in Figure 3a. As of 2024 number of transfer stations has increased to more than 40 stations (including with BRT system, the Metrobüs). In the next ten years the network is likely to increase another 250 km reaching the network depicted in Figure 3b.

-a-

-b-

Figure 3. The 2024 rail network (a) and the expected rail network at 2030(b) in İstanbul (Source: Metro Istanbul Accessed: October 15, 2024)

To support this transformation, Istanbul had to build new capacities within its administrative framework. This included developing specialized skills and capabilities within the city's transport authorities and restructuring existing organizations to better manage the integrated rail network. The transition also necessitated the implementation of new technologies and management practices to ensure the efficient operation of the expanded rail system. As Istanbul continues to grow, the ongoing development of its rail infrastructure remains a critical priority. The city plans to further expand the network, particularly along the south-north axis, to meet the needs of its burgeoning population and to maintain its position as a major metropolitan hub in Europe.

Urban Rail Transit Usage And Population Interaction Around Station Areas In Istanbul

Between 2017 and 2022, Istanbul experienced a 5.85% increase in population, expanding from 15,029,231 to 15,907,951. In parallel, Turkey's total population grew by 5.53%, rising from 80,810,525 to 85,279,553. Simultaneously, Istanbul's urban rail transit system recorded a substantial 47.95% increase in weekly ridership, surging from 14,408,882 to 20,844,589. This expansion was primarily attributed to the introduction of new lines and stations. Notably, when using 2013 as a baseline instead of 2017, the increase in weekly trips reaches 116.26%, underscoring the rapid growth and utilization of rail transit over the past decade.

For the 137 stations that were operational in both 2017 and 2022, weekly passenger numbers increased by 9.20%, a rate surpassing the overall population growth during the same timeframe. Analyzing these stations in terms of passenger volume and station area populations—where 103 of the stations are on the European side—reveals no significant difference in passenger usage between the European and Asian sides of the city.

Among the 137 stations examined, 84 stations (61.31%) registered an increase in weekly passenger numbers. A paired t-test shows an average increase of 9,561 weekly passengers per station between 2017 and 2022 (p=0.063, d.f.=136), adding to an average weekly ridership of 103,894 passengers per station. As discussed in the introduction, the stations have been categorized into four groups based on changes in passenger volumes and surrounding population between 2017 and 2022 (Figure 5).

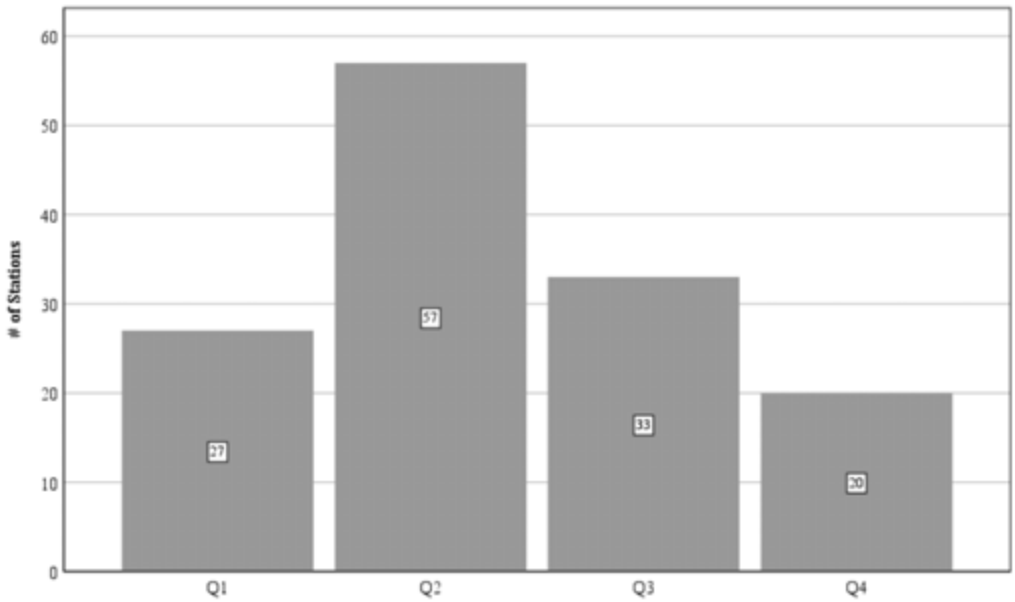

Figure 4. Changes in passenger values of rail stations and population of station areas (1 km radius) between 2017 and 2022

The first group (Q1) consists of stations where both population and passenger numbers increased. The second group (Q2) includes stations where passenger numbers rose while population figures declined. The third group (Q3) represents stations where both population and passenger values declined. Lastly, the fourth group (Q4) encompasses stations where the station-area population increased while passenger usage decreased. Figure 4 illustrates the distribution of stations across these four groups.

A general trend of population decline is observed in station areas categorized as Q2 and Q3, representing 65.69% of the total stations. The number of stations experiencing population loss (Q2 and Q3) surpasses those witnessing passenger growth (Q1 and Q2). Additionally, more stations recorded simultaneous declines in both population and ridership (Q3) than those where both increased (Q1). The mixed findings in Figure 4 suggest a strong intra-metropolitan shift of both population and commercial activities, facilitated by increased motorization. A detailed examination of land use patterns and their changes in different station groups offers explanations for these shifts.

Stations in Q1, where both passenger numbers and population increased, are predominantly residential areas near the city center. Conversely, Q2 stations, situated in central locations or urban transformation zones, have seen a decline in population due to redevelopment activities. Stations in Q3, which primarily serve mixed land-use areas dominated by retail businesses, appear to have suffered from both population relocation to outer areas and widespread business closures, particularly during the COVID-19 pandemic. Q4 stations, which primarily belong to metro lines running parallel to the D100 highway, seem to have lost passengers to private vehicle usage.

A more comprehensive analysis is conducted using a panel regression model, incorporating weekly passenger data from the second week of December in 2013, 2017, 2019, and 2022 as the dependent variable. The Random Effects Panel Regression model employed in this study is structured as follows:

(1) $$y_{it}=\beta_1+\boldsymbol{\beta}'\mathbf{x}+(e_{it}+u_i)$$

where,
y = natural logarithm of passenger values
x = the column vector of independent variables
β = the row vector of parameters
t = years of observation (2013, 2015, 2017, 2019, 2022)
i = rail transit station
e = station based temporal error term
u = station based error term
In this system a generic error term is defined as

(2) $$v_{it}=(u_i+e_{it})$$

Variance of the generic error term is as

(3) $$\sigma_v^2 = \mathrm{var}(v_{it}) = \mathrm{var}(u_i + e_{it}) = \sigma_u^2 + \sigma_e^2$$

In the model provided above, the covariance between the measurements of a station at two different times is assumed to be the same for all stations, while the covariance between two stations at the same time is set to zero. Using these assumptions, the correlation of the number of passengers served by a station between two time periods is calculated as follows:

(4) $$\rho = corr(v_{it}, v_{is}) = \frac{cov(v_{it},v_{is})}{\sqrt{var(v_{it})var(v_{is})}} = \frac{\sigma_u^2}{\sigma_u^2+\sigma_e^2}$$

In the model structure presented above, two groups of independent variables are used. The first group represents node characteristics, while the second group consists of place variables that characterize the station areas. However, not all independent variables are available for all years. Station area populations are available for 2017 and 2022, while the number of work locations is available only for 2022. Therefore, place variables are not usable for all years. Table 1 provides the dependent and independent variables along with summary statistics. Variables are categorized according to Bertolini's scheme (12, 13).

There are five node variables and two place variables. Note that the population variable restricts the panels to only two time points, 2017 and 2022. The number of work locations reduces the analysis to multiple linear regression as it is only observed in 2022.

Table 1. Descriptive Statistics of Regression Variables

Variable	# of Observations	Mean	Std. Deviation	Min.	Max.
N. of Passengers (ln) / dependent variable	762	11.01	0 .89	6.93	13.358
N1: Indicator for suburban rail, MARMARAY	762	0,13	0,34	0	1
N2: Indicator for light rail transit	762	0.35	0,48	0	1
N3: Indicator for European side rail	762	0,73	0,44	0	1
N4: Number of transfers to other lines at the station	762	0,16	0,41	0	2
N5: Number of stations to go on the line to reach the city center	762	9,95	6,44	1	29
P1: Resident population in 1 km radius of the station (ln)	324	10,64	1,15	3,14	12,30
P2: Number of work locations in 1 km radius of the station (ln)	180	7,87	1,38	3,91	10,91

Based on the dataset depicted in Table 1, three regression models were devised and named according to the variables included. For all the available years in the dataset, i.e., 2013, 2015, 2017, 2019, and 2022, since we only have node variables, the model is named **the Node Model** (Table 2). There are two regression models based on panel data, i.e., ***Model 1***, and ***Model 2***. While ***Model 1*** is named as the Node model, ***Model 2*** is named as **the Restricted Node-Place Model** as it includes only resident population around 1 km of stations (***P1***) without including data on work locations (***P2***)—data about work locations were only available for 2022. ***Model 2*** reveals insignificant coefficient value for the place variable (***P1***). However when we turn to a linear regression model conducted for a single year, 2022 (***Model 3***), both place variables (***P1***, ***P2***) attain significant positive coefficient values. Estimation of the regression coefficients are presented in Table 2.

In all models, we have negative coefficients for Marmaray (***N1***) and LRT (***N2***). Unlike metro rail stations, which are actively used throughout the week, both LRT and Marmaray stations serve fewer passengers on average. Weekly passenger levels at Marmaray and LRT stations are approximately 10% and 40% lower, respectively, than those at metro stations, respectively. Therefore, we have negative coefficients for Marmaray (***N1***) and LRT (***N2***) stations. The regression based on panel data does not reveal significant coefficients for the European side rail, ***N3***. However, the regression model conducted for a single year (2022) reveals a significant, but negative, value. Consistent negative results lead us to conclude that the Anatolian side population is more reliant on the rail system than the European side population. This is closely related to the development patterns on both sides of the Bosporus, as shown in Figure 1. The number of transfers (***N4***) available at a station increases weekly passenger levels to more than twice the average values. Although its effect decreases in models that include place variables, it still retains its importance as a node feature.

The southern tips of the Bosporus on both the European and Asian sides resemble city centers in terms of the rail network. Nearly all rail trips use these two locations as reference points in daily journeys. A station's relative position on the network, denoted by ***N5***, is determined with respect to intermediate stations and the city center. The models reveal significant and consistent values for the ***N5*** variable, which remain unaffected by the inclusion of place variables. The relative position is relatively immune to additional explanatory variables in the models. City centers on both sides of the Bosporus are important hubs for all rail trips. There is always an increasing trend of passengers at stations toward the city center, regardless of the rail type. We do not expect changes in this pattern in the future, even with the ongoing relocation of the population.

Table 2. Regression Results

Variable	The Node Model (Model 1)		The Restricted Node-Place Model (Model 2)		The Model 3: The Node-Place Model (Model 3)	
	Linear Regression with Random Effects (Years of The Panel Dataset: 2013, 2015, 2017, 2019, 2022)		Linear Regression with Random Effects (Years of The Panel Dataset: 2017, 2022)		Linear Regression (Year of The Dataset: 2022)	
	Coefficient	z-statistic	Coefficient	z-statistic	Coefficient	t-statistic
Constant	11.26**	78,50	10,58**	21,34	8,64**	12,87
N1	-0,33*	-2,27	-0,05	-0,31	-0,07	-0,51
N2	-0,22	-1,59	-0,20	-1,49	-0,30*	-2,16
N3	-0,05	-0,40	-0,05	-0,41	-0,26*	-2,05
N4	0,99**	10,56	0,87**	6,78	0,71**	5,45
N5	-0,02*	-2,46	-0,02*	-2,28	-0,03**	-3,57
P1			0,70	1,56	0,16**	2,78
P2					0,18**	4,16
# of Stations	194		187		180	
# of Observations	762		324		180	
u	0,71		0,60		NA	
e	0,31		0,43		NA	
	0,84		0,66		NA	
R^2	0,21		0,22		0,35	

** = significance <0,01, * = significance <0,05

The results presented above suggest that the impact of node and place characteristics on rail station usage is mixed and insufficient to explain more complex relationships. This could be due to the unique characteristics and inherent dynamism of developing countries, a phenomenon elaborated in the second section. Additionally, each developing country has its specific backdrop, as detailed in the third section for Istanbul. Although the regression analyses provided intuitive results, further investigation is needed to explain the mixed outcomes observed for the 137 stations (see Figure 4).

We believe Figure 4 reflects the unique context and dynamism of developing countries, in contrast to the regression results. Since none of the regression analyses conducted on the 137 stations yielded significant coefficients for population change on changes in passenger values, there must be other intervening factors, such as institutional and administrative dynamics, as well as ongoing socio-economic and demographic processes. In an urban setting that is still evolving, as seen in developing countries, should rail transit planning adopt a different approach? This question highlights the need for a new planning paradigm that considers these unique challenges.

Conclusions

In the context of developing countries, urban transportation systems often face unique challenges and exhibit specific characteristics. Rapid urbanization in developing countries results in a mismatch between old and new infrastructures, which creates inefficiencies and ineffectiveness. Moreover, the specific backdrop of each developing country adds another layer of complexity. In Istanbul, significant investments in the rail network began in the 1990s, marking the start of an "incipient railization." Despite economic downturns, this trend continued, leading to a substantial expansion of the rail network in the post-2000 era.

The central government's support further accelerated "railization", with notable achievements such as undersea tunnels over the Bosporus, driverless metro line connecting Istanbul Airport to the city center. However, the mixed results from the 137 stations between 2017 and 2022 underscore the varied impact of these investments. While some stations saw increased passenger values and populations, others did not, reflecting the city's complex urban dynamics and the multifaceted nature of urban transportation challenges in developing contexts.

The regression models, although they provide insights into rail transit usage, do not fully capture the complexity of the observed patterns, necessitating further exploration of the interplay between urban dynamics, socio-economic factors, and transportation infrastructure in developing countries. Addressing these challenges requires a multifaceted approach. Developing countries need to prioritize integrated urban planning, ensuring coordination between transportation and land use policies. Strengthening regulatory frameworks and institutional capacities is essential to create an environment conducive to investment and sustainable development.

In this framework, each rail station should be viewed as an asset to foster policies that enhance both node and place characteristics. Accordingly, each station should be considered a reference point for developing an urban fabric conducive to sustainable transportation modes such as walking, bicycling, and transit altogether, rather than merely a node for transit access (Newman & Kenworthy, 2015; Cervero et al., 2009; Cervero & Murakami, 2009). In conclusion, while urban rail investments have the potential to transform land use and promote sustainable development, realizing these benefits in developing countries requires addressing them in a broader context. By adopting integrated planning approaches, strengthening institutional capacities, and fostering inclusive development, developing countries can unlock the full potential of urban rail investments and create vibrant, equitable, and sustainable urban environments.

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Socioeconomic Disparities in Daily Activity Spaces: Insights from Smartphone Mobility Data on Non-Commuting Trips

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Abstract
Urban mobility significantly influences accessibility, social cohesion, and equity; however, non-commuting travel remains understudied. This study investigates the impact of income, age, and gender on non-commuting mobility in Seoul, utilizing large-scale smartphone data. We measure activity space distance and destination diversity to assess disparities in leisure-related movement in four different time periods of the day. Results show that higher-income groups travel farther and to more diverse destinations, while lower-income, middle-aged women, and older adults are more spatially constrained. Importantly, Gini coefficient analysis reveals significant intra-group disparities, indicating that individuals from the same demographic group but different neighbourhoods experience unequal access to mobility. These findings underscore the need for inclusive, place-sensitive mobility policies that address both intergroup and intragroup inequalities in daily urban life.

Keywords: Non-commuting mobility, activity space distance, destination diversity, socioeconomic disparities, Gini coefficient

1. Introduction

Contemporary cities face mounting pressures to ensure equitable access to urban life as mobility patterns evolve beyond routine commuting. Non-commuting travel, comprising over half of urban trips in developed economies (Miyauchi et al., 2021), includes leisure, social visits, caregiving, and errands, and plays a vital role in shaping individual physical well-being, social cohesion, and vitality (Sulis et al., 2018; Jin et al., 2024; Wang et al., 2024). The more a group of people travels to various parts of the city, the more opportunities they have for social exchange and interaction, which benefits both individual well-being and collective urban life (Mouratidis & Poortinga, 2020). Especially, the diversity in the pattern of mobility makes the catalytic impact for local economic vitality (Chong et al., 2020; Pentland, 2020). Economically, discretionary trips drive patronage of small businesses, accounting a significant part of retail spending in walkable neighbourhoods (Moyano et al., 2020). Physically, active travel modes during these trips contribute to meeting WHO-recommended daily exercise thresholds, reducing chronic disease risks (Sahlqvist et al., 2012). However, unequal access to mobility-enabling infrastructure may exacerbate socioeconomic disparities in these benefits. Cities must address inequalities in accessing vibrant areas for different socioeconomic groups, as disparities can impact physical activity and social interaction (Zhang & Warner, 2023). Barriers like safety concerns, lack of transportation, and inadequate amenities in lower-income areas often limit access for women, the elderly, and other vulnerable groups (Gauvin et al., 2020; Shoval et al., 2010).

Yet, despite its growing significance, non-commuting mobility remains underexplored in urban research. Unlike commuting, which is often fixed and purpose-driven, non-commuting mobility reflects deeper layers of spatial preference, lifestyle, and access to opportunity (Mouratidis & Poortinga, 2020; Nilforoshan et al., 2023). Disparities in such mobility, driven by income, age, gender, and neighbourhood infrastructure, can limit physical activity, social interaction, and access to vibrant areas, particularly for vulnerable groups such as women and the elderly (Shoval et al., 2010; Gauvin et al., 2020). Understanding how diverse populations navigate cities beyond the workplace is crucial for addressing spatial inequality and designing inclusive urban policies, particularly in highly stratified contexts such as Seoul (Han, 2022; Jin et al., 2024).

The primary objective of this study is to investigate how income, gender, and age influence non-commuting mobility patterns in Seoul, with a particular focus on both inter-group and intra-group disparities in access to urban spaces. Using large-scale smartphone mobility data, the study quantifies differences in activity space distance and destination diversity across four distinct time periods of the day: morning, daytime, evening, and nighttime. By applying entropy measures and Gini coefficients, it captures both spatial and temporal variation in non-commuting travel behaviour across demographic and socioeconomic lines. Through this approach, the

research aims to uncover structural inequalities in daily mobility beyond work-related travel, informing the development of inclusive, time-sensitive urban policies that support equitable access to leisure, caregiving, and social opportunities for diverse population groups.

2. Literature Review

Urban mobility contributes significantly to urban sustainability by fostering social cohesion, stimulating economic activity, and reducing segregation (Xu et al., 2018; Bettencourt, 2013; Barbosa et al., 2021). It enables encounters among diverse social groups, breaks down barriers, and supports local economies by facilitating movement across neighborhoods (Chong et al., 2020; Pentland, 2020). As Jacobs (1961) noted, such everyday interactions in public spaces build community and contribute to a more inclusive urban fabric.

Mobility also plays a crucial role in mitigating urban segregation. Studies show that the places people visit for daily activities are often more socially diverse than their residential neighbourhoods (Jones & Pebley, 2014; Pinchak et al., 2021). This exposure to diversity through movement, particularly non-commuting travel, can help offset spatial isolation at home (Boterman & Musterd, 2016; Wang & Li, 2016; Lin & Ta, 2023). For example, Silm et al. (2018) found, using mobile phone data, that activity spaces beyond home and work locations tend to show lower levels of segregation. These findings highlight how everyday mobility fosters social interaction across groups.
Patterns of mobility-based segregation reveal how social divides are mirrored in travel behaviour. In U.S. cities, studies have shown significant racial segregation in mobility patterns (Hilman et al., 2022). Likewise, in Colombian cities, Lotero et al. (2016) found that individuals largely frequented places associated with their own socioeconomic class, indicating a high level of stratification. Dong et al. (2017) further demonstrated how segregation in mobility can reinforce social boundaries rather than build bridges. While South Korea is more ethnically homogeneous, it faces distinct mobility challenges, particularly disparities related to gender, age, and income, which influence who can access which parts of the city.

Built environment research frequently emphasises transport networks as mechanisms for fostering interaction across social groups (Netto et al., 2015; Carpio-Pinedo, 2021). Network centrality analyses, particularly within space syntax, are commonly used to identify highly accessible areas via walking, driving, or public transit (Rokem & Vaughan, 2018; Yunitsyna & Shtepani, 2023). These approaches assess network segregation by mapping the potential for social encounters based on spatial configuration. Expanding on this, Carpio-Pinedo (2021) introduced the concept of multi-accessibility, which captures how multimodal transport infrastructures enhance access and opportunities for social mixing. However, while these methods reveal structural potential, they do not account for actual travel behaviour, which may be constrained by socioeconomic factors, highlighting the need for empirical mobility data.

Recent mobility studies have adopted a dynamic approach to socio-spatial disparities through the concept of activity space, which captures individuals' actual travel behaviours and daily destinations (Barbosa et al., 2021; Gao et al., 2022). This perspective enables a more accurate analysis of segregation by focusing on actual patterns of urban engagement beyond the home and workplace. The increasing availability of large-scale mobility datasets, often linked with demographic attributes, enables researchers to assess how activity spaces differ across social groups. Compared to static network analyses, these data-driven methods offer more nuanced and empirical insights into how mobility behaviours shape access, inclusion, and exclusion in cities.

Several established methods exist to quantify activity space patterns, each capturing different dimensions of mobility behaviour (Barbosa et al., 2021; Yan et al., 2011). These include the gyration radius, which measures how far an individual typically moves from their centre of activity and reflects the spatial spread of movement (González et al., 2008; Yan et al., 2011); the mean activity space distance, which assesses the average travel distance or time, indicating how constrained or expansive one's daily mobility is (Barbosa et al., 2021); and destination diversity, which captures the variety of unique locations visited, often measured through entropy. Higher entropy values reflect broader engagement with the urban environment. Together, these indicators provide a comprehensive view of the magnitude and richness of mobility, enabling the identification of spatial inequalities across demographic and socioeconomic groups. While gyration radius and travel frequency require individual-level trajectory data, activity space distance and destination diversity can be derived from aggregated mobility datasets, making them especially valuable for large-scale spatial equity analysis, such as in this study.

Although age, gender, and income are widely recognised as key determinants of mobility (Panahi et al., 2023), much of the existing research tends to generalise their effects. Many studies focus on demand-side factors, such as transport infrastructure and network connectivity (Seyedrezaei et al., 2023), with limited attention to the actual mobility behaviours of vulnerable groups. Metrics such as activity space size, destination diversity, and temporal variation are essential for diagnosing spatial disparities, yet remain underutilized, particularly in studies relying on small-scale surveys. While large-scale datasets such as GPS and mobile phone records offer more objective and granular insights, their potential for revealing urban mobility inequalities has not been fully realised.

Despite growing theoretical discussions on gendered urban spaces in Korea (Ahn, 2011), empirical research on gendered mobility patterns in Seoul remains limited. This gap is particularly significant given the city's dense, transit-oriented urban form and the critical role that gender plays in shaping access to urban opportunities. At the same time, Korea's rapidly ageing population presents distinct mobility challenges, as older adults often exhibit different travel behaviours due to physical, cognitive, or social constraints (Giménez-Nadal et al., 2024; Arentze et al., 2008). Mobility disparities linked to income also persist, with lower-income individuals facing obstacles such as limited transport options and reduced access to diverse destinations (Yabe et al., 2023). Understanding how gender, age, and income intersect to shape urban mobility is crucial for designing equitable cities. This is particularly urgent in metropolitan areas like Seoul, where, contrary to expectations, residents often experience lower exposure to socioeconomically diverse populations, suggesting that spatial segregation may be more pronounced in cosmopolitan settings than assumed (Nilforoshan et al., 2023).

Socioeconomic factors play a pivotal role in shaping how individuals navigate and utilise urban spaces (Gauvin et al., 2020; Giménez-Nadal et al., 2024; Jo et al., 2020). Variables such as income, education level, and occupation influence where people live, work, and participate in leisure activities (Macedo et al., 2022; Salon & Gulyani, 2010). These characteristics are closely linked to mobility patterns, which reflect a city's broader social and economic structure (Chong et al., 2020). For example, lower-income individuals may lack access to private transportation and rely more heavily on public transit, which limits their spatial reach and activity spaces. Analysing these socioeconomic dimensions helps identify the root causes of spatial inequity and informs the development of targeted policy interventions.

Socioeconomic disparities in mobility have critical implications for inclusive urban planning. Mobility data can guide policies that ensure all residents, regardless of income, age, or gender, have equitable access to services, jobs, and leisure opportunities. By addressing spatial inequalities and anticipating the needs of ageing populations and gender-specific mobility patterns, cities can become more resilient, adaptive, and socially cohesive. In Korean cities especially, demographic trends point to a growing challenge: without proactive planning, elderly residents and women may face increasing constraints in accessing activity spaces (Kim & Kim, 2020). To address these issues, this study employs data-driven methods to investigate spatial and temporal disparities in non-commuting mobility across Seoul.
By focusing on the diverse array of activities beyond the traditional commute, our study contributes to a more nuanced understanding of urban mobility. This perspective is essential for developing more liveable, inclusive, and efficient urban environments, enabling urban planners and policymakers to better address the needs of various demographic groups and foster a more equitable and vibrant city.

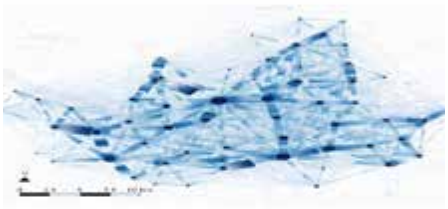
3. Methodology

3.1. Data and study area

This study focuses on the city of Seoul, South Korea, which is home to over 9 million residents and characterised by a high-density urban environment. Seoul presents a compelling case for mobility research due to its marked socioeconomic diversity, rapidly ageing population, and spatial disparities in neighbourhood income. We utilise two datasets in this study.

To analyse non-commuting mobility patterns, we employed anonymised large-scale smartphone mobility data from KT (Korea Telecom), made available through the Seoul Open Data Plaza (data.seoul.go.kr). The dataset captures origin–destination (O–D) flows between administrative neighbourhoods (dong level), disaggregated by age, gender, and purpose of travel. Mobility records are timestamped and categorised by trip type, allowing us to isolate non-commuting activities, such as leisure, caregiving, and errands (Table 1). The dataset was also crucial for analysing socioeconomic indicators and their relationship with urban mobility.

Table 1. Structure and visualization of O–D mobility data

Classification	Structure	O-D Visualization
Departure time	yyyy/mm/dd hh:mm (20-min span)	
Arrival time	yyyy/mm/dd hh:mm (20-min span)	
Departure area	Neighbourhood unit	
Arrival area	Neighbourhood unit	
Age groups	5-year-old span	
Mobility type	H – residence, W-Work and school, E- Other	
Travel time	Average travel time (minutes)	
Number of people moving	Sum of people moving	

To examine the impact of socioeconomic factors on urban mobility patterns, we used indicators related to age, gender, and income. Age and gender data were sourced from the KT Human Movement dataset, which provides mobility information segmented by 5-year age groups. In addition, we incorporate neighbourhood-level income data from the Smart Policing Big Data Platform, which aggregates mean income estimates to the same spatial units used in the mobility data. This integration allows us to examine how income intersects with age and gender in shaping daily non-commuting mobility across the city.

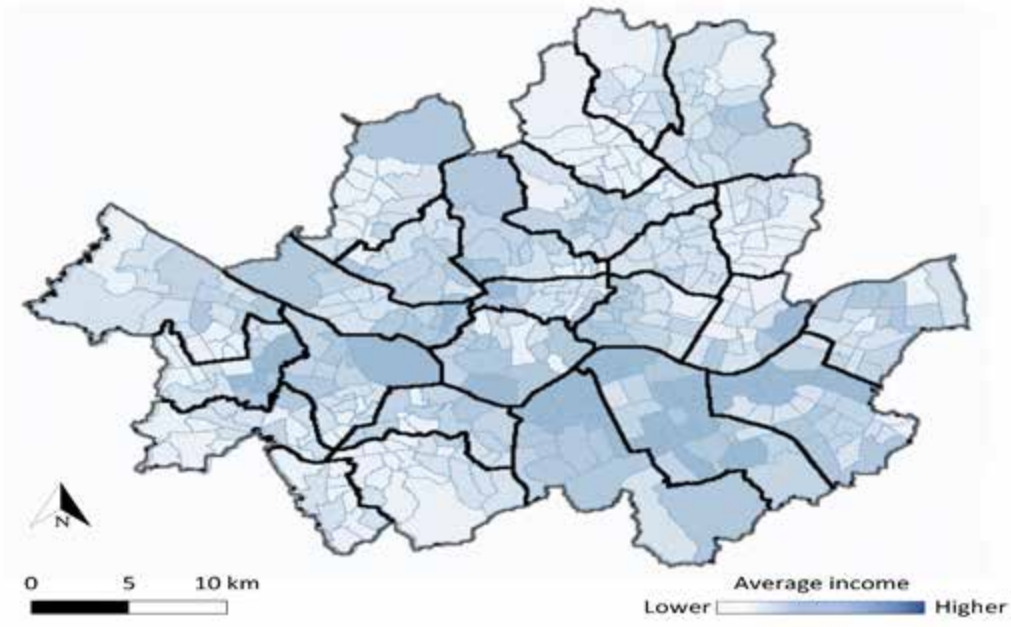


Figure 1. Average income of neighbourhoods in Seoul

3.2. Pattern extraction and processing

We began by preprocessing the origin–destination (O–D) mobility data to remove invalid records (Figure 2). Trips were limited to those within Seoul, with filters applied to exclude identical origin-destination pairs, travel times exceeding 100 minutes to remove implausible trips and outliers, and individuals under the age of 10.

Trip types were classified using purpose codes, and commuting trips (e.g. HW, WH, EH, EW) were excluded. Only non-commuting trips, including EE (other–other), HE (home–other), and WE (work–other), were retained, representing discretionary activities such as leisure, social visits, shopping, and personal errands. Records were grouped into four time periods (morning, daytime, evening, and nighttime) to enable temporal analysis.

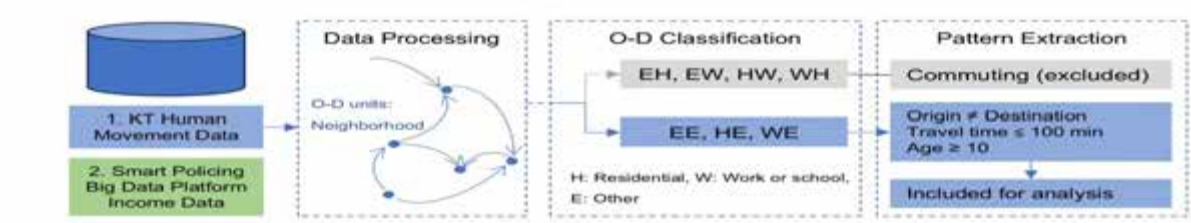


Figure 2. Data Processing and Pattern Extraction Workflow for Non-Commuting Mobility Analysis

The cleaned mobility data were then merged with neighbourhood-level income data using administrative codes. This integration produced a structured dataset disaggregated by gender, age, time of day, and income, which formed the basis for our analysis of activity space distance and destination diversity.

3.3. Mobility and inequality metrics

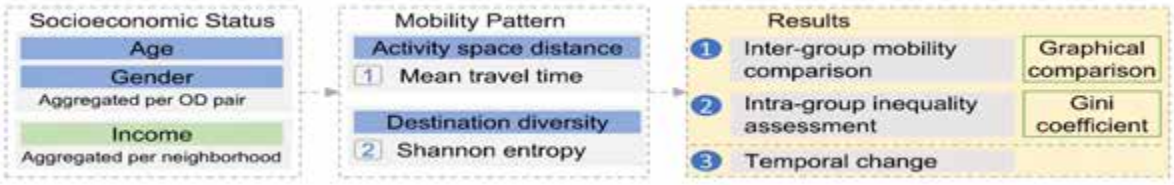


Figure 3. Framework for measuring and comparing socioeconomic disparities in non-commuting mobility

The empirical analysis in this study aims to explore urban mobility patterns within Seoul's neighbourhoods, with a focus on variations across different socioeconomic groups, particularly age, gender, and income. To quantify non-commuting mobility, we employed two key indicators: activity space distance and destination diversity (Figure 3). Activity space distance refers to the average travel time (minutes) from a given origin neighbourhood, weighted by the number of individuals from each socioeconomic group taking each trip. It serves as a proxy for the spatial reach of daily movement. Higher values reflect a broader reach of urban activities, implying that individuals are willing or able to travel longer durations to access diverse areas of the city, while lower values may indicate spatial constraints or reliance on nearby amenities.

To calculate activity space distance, we used the following formula to determine the average travel time for an individual's or group's trips:

$$Activity\ space\ distance = \frac{1}{N}\sum_{i=1}^{N} t_i$$

N is the total number of trips made by within a group during the specified time period,
t_i represents the travel time (in minutes) for each trip from the origin to the destination.

To calculate destination diversity, we used Shannon entropy based following formula:

$$Destination\ diversity = -\sum_{i} p_i \log_2(p_i)$$

where;
p_i is the proportion of visits to destination i relative to the total number of visits across all destinations for a person or group.

Next, destination diversity is measured using Shannon entropy (log scale), which captures the variety and evenness of destination choices. Entropy values increase with the number and distribution of unique destinations, providing insight into how dynamic or concentrated a socioeconomic group's urban engagement is. A higher entropy value indicates that a person visits a wider range of destinations, suggesting a more varied and dynamic urban experience. In this study, entropy was calculated for each gender–age group and income level, across four daily time periods. Using graphical visualizations, first, we showed intergroup mobility comparison between different socio-economic groups.

Secondly, to assess intra-group inequality in mobility access within the same socioeconomic groups, we computed the Gini coefficient for both indicators across neighbourhoods. This metric reveals how equally activity space distance or destination diversity is distributed within demographic groups. A higher Gini suggests greater internal disparity, some individuals in the group are more mobile or spatially privileged than others. This approach allows us to capture not just average behaviour, but also equity of mobility access within each group. The formula for Gini coefficient is as follows:

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\bar{x}}$$

Where x_i and x_j represent values of the mobility indicator for each neighbourhood, n is the number of observations, and $\bar{x}$ is the mean value of the indicator.

Thirdly, we examined temporal variation in mobility by dividing the day into four distinct periods: morning (06:00–08:59), daytime (09:00–15:59), evening (16:00–18:59), and nighttime (19:00–23:59). This segmentation captures fluctuations in mobility behaviour across the daily cycle, allowing us to observe how different demographic groups engage with the city at various times. For example, working-age adults may be more active during rush hours, while older adults may concentrate their trips in midday periods. This temporal lens was applied not only in the graphical inter-group analysis, but also in the intra-group inequality assessment, enabling us to investigate whether mobility disparities persist or vary by time of day.

Together, these metrics support a multidimensional understanding of urban mobility: activity space distance reflects the scale of movement, entropy captures spatial diversity, and the Gini coefficient uncovers hidden inequalities in access. This framework enables us to examine how age, gender, and income shape not only who moves, but also how equitably urban opportunities are distributed among similar individuals

4. Results

This section presents the main findings on non-commuting mobility. Results are organised into two parts: inter-group differences across age, gender, and income groups, and intra-group disparities within the same socio-economic groups at the neighbourhood level. We first report patterns in activity space distance and destination diversity, followed by an assessment of inequality using the Gini coefficient.

4.1. Inter-group differences in mobility

In this investigation, we focused on urban mobility, examining activity space distance and destination diversity, to understand demographic differences in urban movement patterns across Seoul.

4.1.1 Activity space distance

Figure 4 and Figure 5 illustrate gender and age differences in activity space distance across four daily time periods. These periods, morning, daytime, evening, and nighttime, were defined to reflect typical daily rhythms in urban life, capturing commuting hours, discretionary travel, and evening activities. This temporal segmentation enables a more nuanced understanding of how mobility patterns shift across the day. While some trends remain consistent, such as the reduced mobility of older adults and children under 15, other patterns, particularly gender gaps among younger groups, vary considerably depending on the time of day.

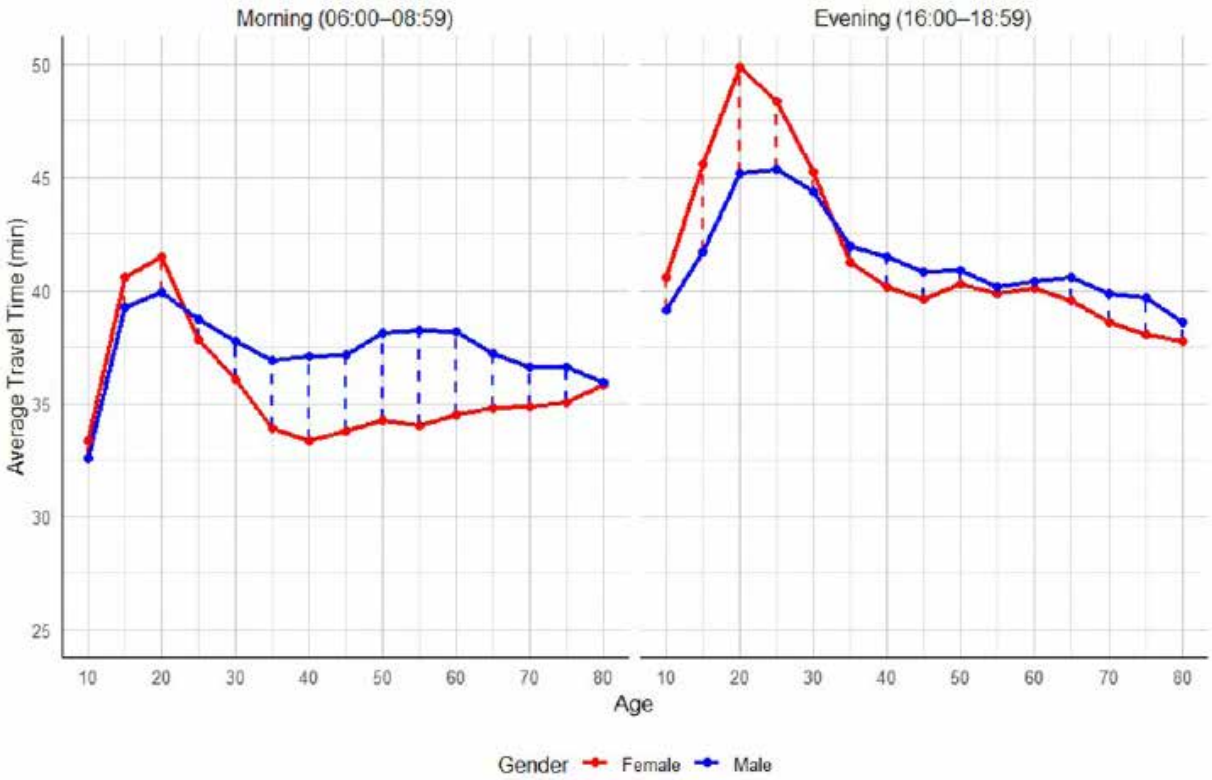


Figure 4. Gender and age differences in average travel time across morning and evening.

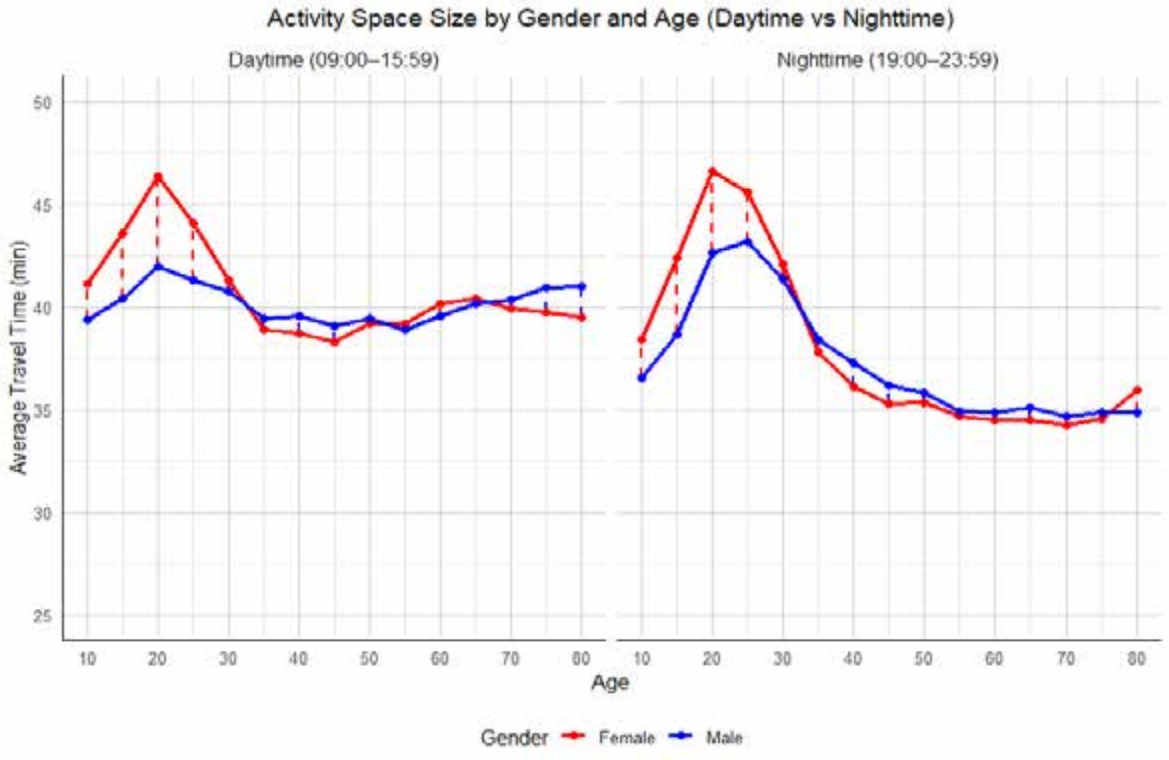


Figure 5. Gender and age differences in average travel time across daytime and nighttime

During the morning period, activity space distance is relatively short compared to the other three periods, suggesting more spatially constrained leisure or caregiving activities in the early hours. As the day progresses, travel distances increase, peaking during the daytime and remaining relatively high into the evening, before declining slightly at night. When disaggregated by gender and age, individuals in their 20s and 30s consistently exhibit the greatest spatial reach, while children under 15 and older adults maintain shorter travel ranges across all periods. The generational mobility gap is most pronounced during the evening and nighttime.

Gender differences are most notable in the morning, where men over the age of 25 tend to travel farther than women in the same age group. In other time periods, this gender gap among adults narrows. However, across the daytime, evening, and nighttime, young women under the age of 25 consistently travel farther than young men, likely reflecting their engagement in discretionary activities such as shopping or social visits. This trend stabilises after age 30, where gender differences become minimal.

Next, we examined how neighbourhood income influences travel distance across daily periods (Figure 6 & Figure 7). The results reveal a clear negative association between income and activity space distance during the morning (06:00–08:59), where residents of lower-income neighbourhoods tend to travel farther than those from higher-income areas. This trend is supported by a moderate R^2 value of 0.31, indicating a meaningful level of explanatory power. The pattern may reflect unequal distribution of leisure or essential amenities, forcing residents in less affluent areas to travel farther during early hours to reach services located in wealthier parts of the city.
During the daytime, however, the relationship between income and travel distance almost disappears (R^2 = 0.008), suggesting a more level playing field for mid-day mobility regardless of income. In the evening and nighttime, the association reverses slightly, particularly in the evening (R^2 = 0.119), with higher-income residents exhibiting longer average travel distances. This shift could be attributed to lifestyle-related discretionary activities, such as dining or cultural outings, which are more accessible to wealthier populations. These findings demonstrate how mobility inequality fluctuates throughout the day, with structural limitations more pronounced in the morning and lifestyle-based divergence emerging later in the day.

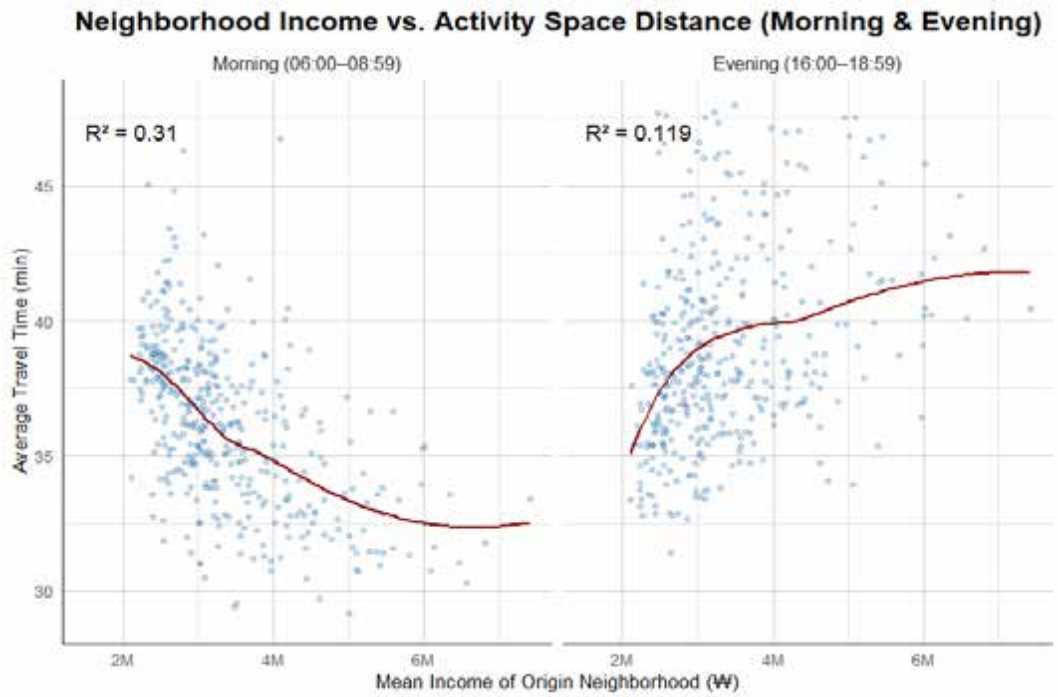


Figure 6. Neighbourhood income levels and average travel time across morning and evening

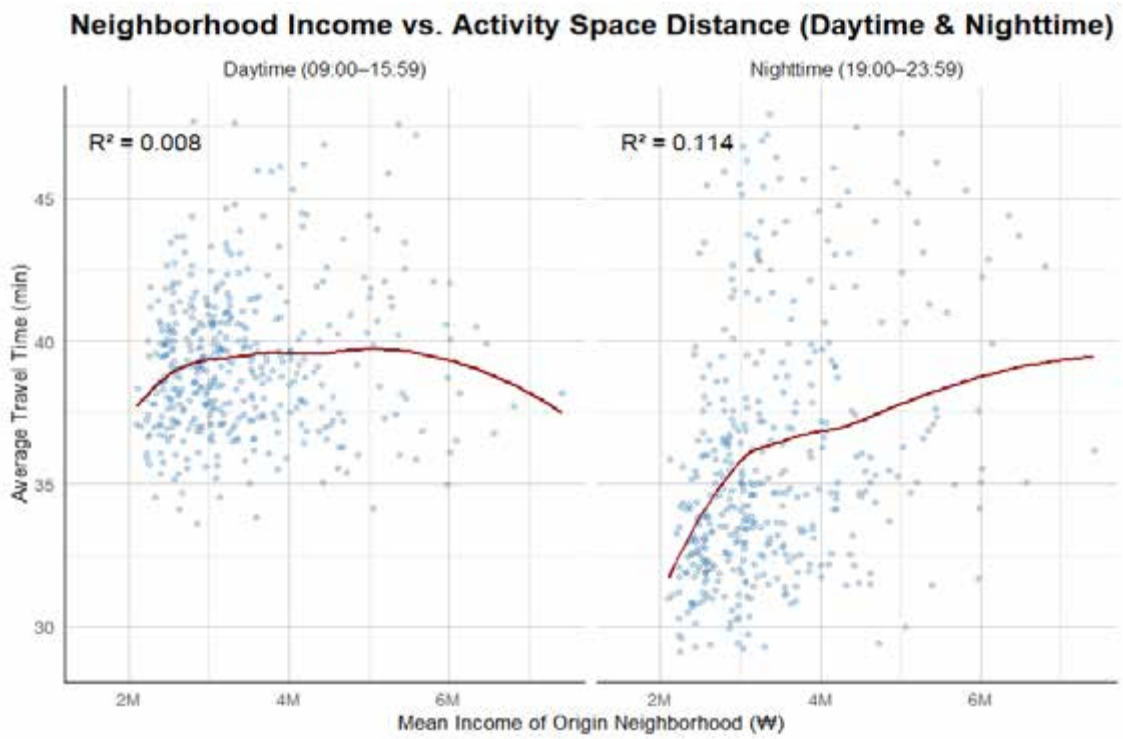


Figure 7. Neighbourhood income levels and average travel time across daytime and nighttime

While the income-travel time correlation is relatively weak, these observations provide valuable insights for transportation planning, as income-level disparities impact accessibility and the spatial distribution of activity spaces across the city.

4.1.2 Destination diversity

Our second investigation of inter-group mobility differences, destination diversity, is measured using Shannon entropy. It captures the extent to which individuals or groups visit a wide range of neighbourhoods during non-commuting trips. Unlike activity space distance, which measures the scale of travel, entropy captures the variety and distribution of destinations, reflecting the breadth of urban engagement. Higher values indicate more diverse mobility patterns and potentially greater access to urban opportunities, while lower values suggest spatial confinement or routine-based travel. Entropy is particularly useful for identifying subtle mobility inequalities, where long distances may mask limited exposure to different areas.

Figure 8 and Figure 9 Illustrate gender and age differences in destination diversity across four daily time periods. Patterns of destination diversity show distinct trajectories for men and women. Notably, children under 15 and elderly individuals over 60 exhibit generally lower destination diversity across both genders, suggesting that these groups tend to frequent a smaller, more consistent set of locations in their daily non-commuting activities. However, the gap between the two genders is small in both the early and later stages of life.

For women, entropy peaks in the 20–25 age group across all time periods and declines steadily with age, suggesting that younger women are more likely to engage with a broader set of destinations, possibly linked to lifestyle, education, or social activities. After age 25, their spatial diversity gradually narrows, reflecting more routine-based mobility or caregiving responsibilities. In contrast, men exhibit a more sustained level of high entropy between the ages of 25 and 60, particularly during the morning and daytime, with a peak around age 45 in the morning period. This implies that adult males maintain a broader range of destination choices throughout middle adulthood. However, during nighttime, men's entropy declines more rapidly after age 30, mirroring the trend observed in women. These gendered patterns highlight how mobility diversity is shaped not only by age but also by differing social roles and temporal rhythms across the day.

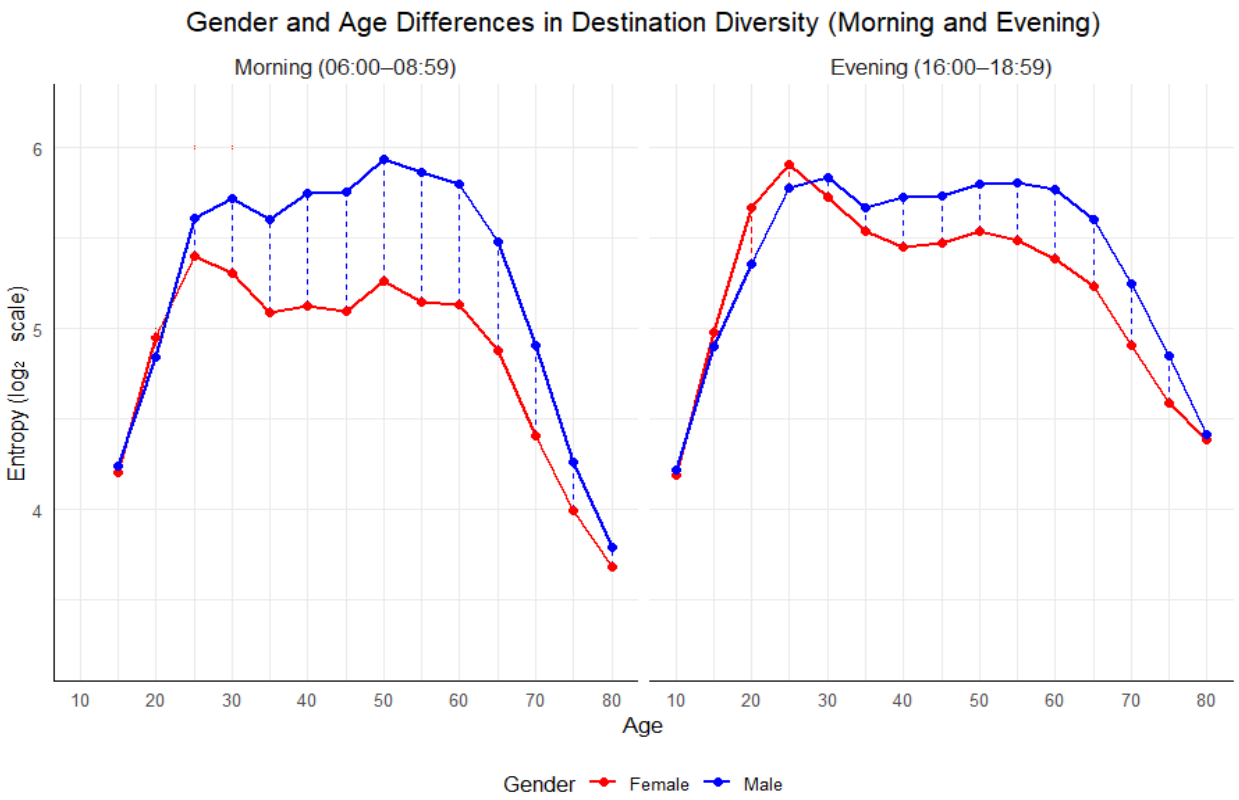


Figure 8. Gender and age differences in destination diversity across morning and evening.

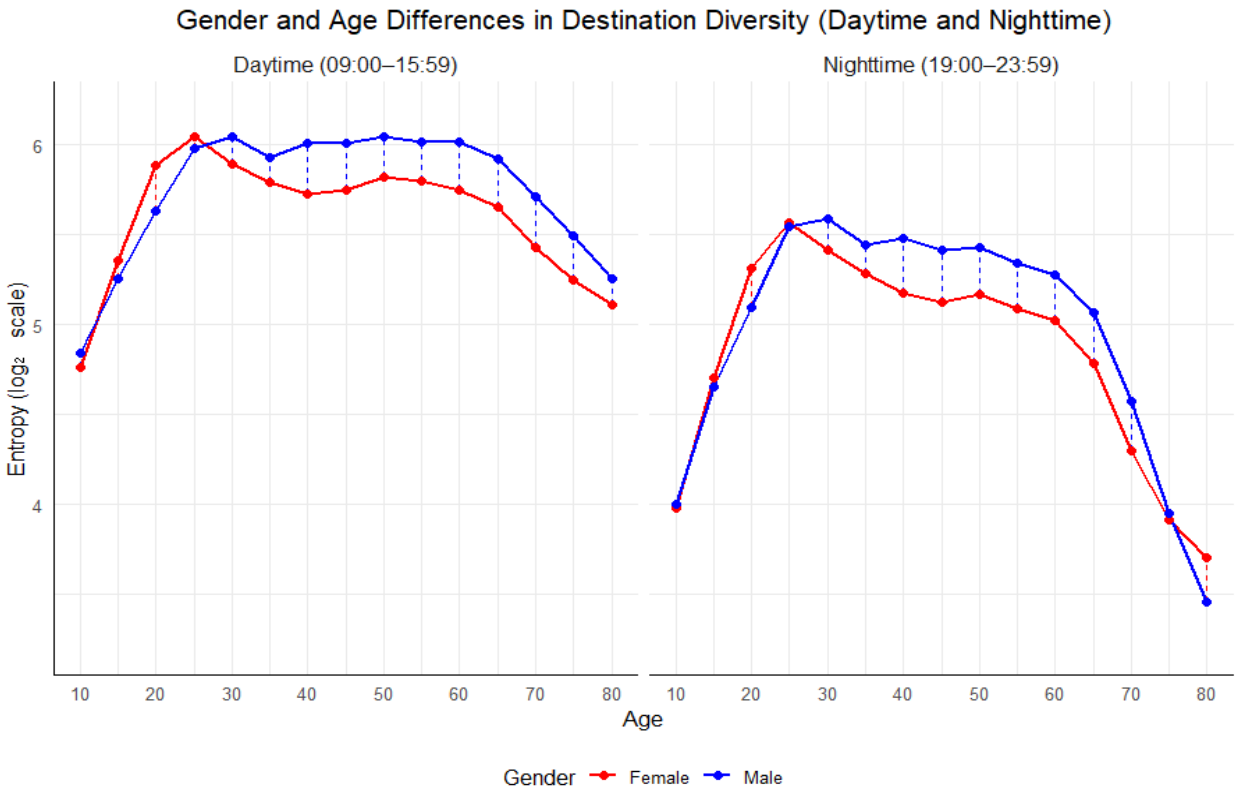


Figure 9. Gender and age differences in destination diversity across daytime and nighttime

Next, we examined how neighbourhood income levels influence destination diversity across four daily time periods (Figure 10 & Figure 11). The analysis reveals a distinctive temporal pattern. In the morning period (06:00–08:59), individuals from higher-income neighbourhoods display lower entropy, indicating more routine-based or spatially confined travel. Higher-income residents might be more likely to engage in early morning activities that are routine and closer to home, such as visiting local parks or cafes, which are less diverse in nature compared to activities later in the day. This contrasts with the rest of the day, when entropy increases with income, suggesting that wealthier individuals engage with a broader variety of urban destinations. This shift reflects the greater flexibility and resources that higher-income groups have to access a diverse range of activities across the city. These results highlight how spatial inequality unfolds throughout the day. While high-income residents initially show lower diversity in the morning, their access to varied destinations expands in later periods. In contrast, lower-income groups consistently exhibit more limited spatial diversity, suggesting constraints in reaching a broad range of urban amenities. This persistent disparity may reduce opportunities for social interaction and urban participation, highlighting the need for policy efforts that enhance access to diverse destinations in underserved areas. The observed differences in destination diversity highlight the need for targeted urban planning interventions to address the specific mobility needs and constraints of different demographic groups, promoting more equitable access to urban resources and opportunities. This intervention not only promotes social equity but also enhances the overall vibrancy and sustainability of urban communities.

Figure 10. Income factor in destination diversity across morning and evening

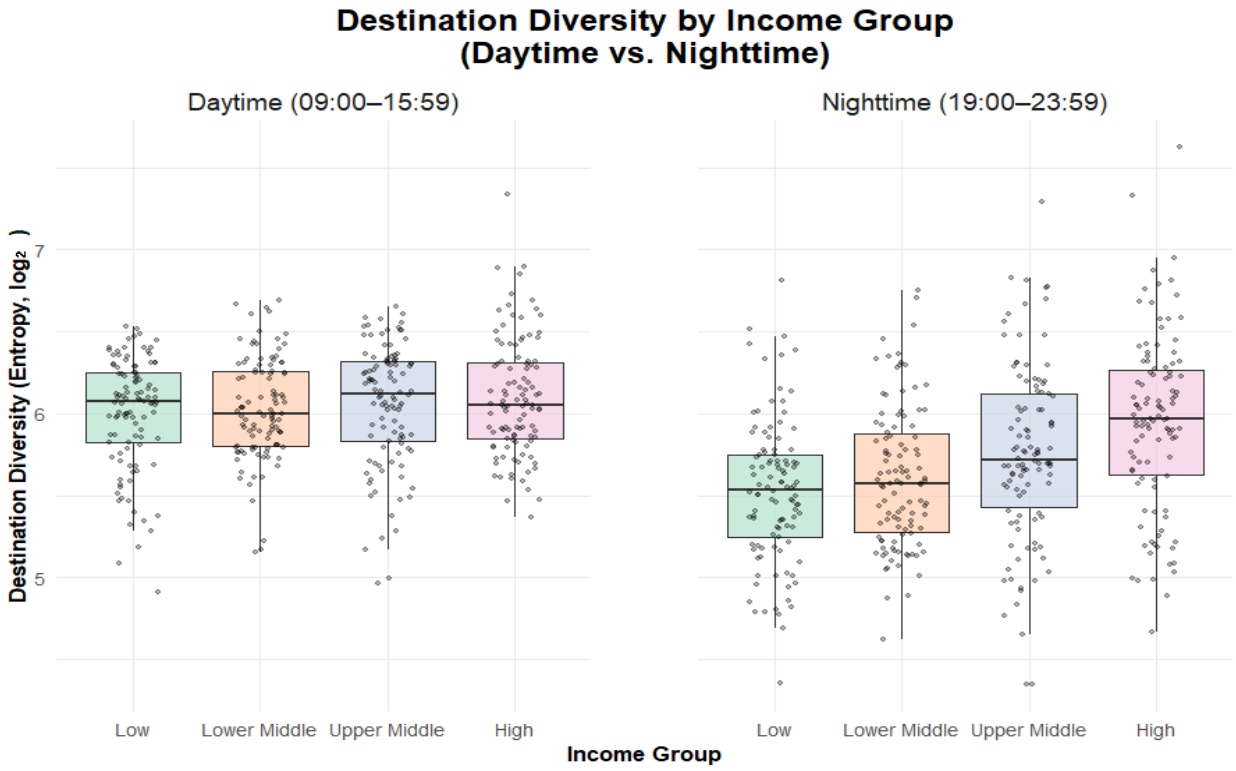


Figure 11. Income factor in destination diversity across daytime and nighttime

4.2. Intra-group mobility inequality

To complement inter-group comparisons, we calculated Gini coefficients for both activity space distance and destination diversity across Seoul's neighbourhoods, segmented by age group, gender, income group, and time of day (Table 2 & Table 3). These inequality metrics provide a more profound insight into intra-group spatial disparity, revealing the varied mobility experiences within the same demographic or income bracket. While average values describe general mobility levels, the Gini coefficient highlights how unevenly mobility is distributed within groups. A higher Gini value indicates greater internal disparity, suggesting that some individuals enjoy broader spatial access while others remain more constrained. This approach allows us to uncover hidden inequalities in access to urban opportunities, even among individuals who share similar socioeconomic characteristics.

The Gini coefficients for activity space distance reveal notable intra-group disparities across both demographic and income groups (Table 2). Among age groups, younger individuals under 25 exhibit the highest inequality, particularly in the morning (Gini = 0.109 for males; 0.110 for females), suggesting that travel opportunities within this group vary widely depending on neighbourhood context. In contrast, middle-aged adults (35–60) consistently exhibit low Gini values across all time periods, indicating more uniform spatial behaviour within this group. Gender differences are minimal overall, though young women display slightly higher inequality than their male counterparts during the evening and nighttime periods.

Table 2. Intra-group inequality in activity space distance (Neighbourhood-level Gini coefficients)

Socioeconomic Factors			Gini coefficient of Activity Space Distance (unit = neighbourhood)			
			morning	evening	daytime	nighttime
Age / Gender	Under 25	M	0.109	0.077	0.051	0.081
		F	0.110	0.081	0.055	0.087
	25-34	M	0.074	0.065	0.047	0.081
		F	0.073	0.071	0.054	0.092
	35-60	M	0.073	0.059	0.042	0.066
		F	0.067	0.061	0.044	0.068
	60+	M	0.075	0.057	0.040	0.080
		F	0.079	0.063	0.041	0.079
Income	Low		0.083	0.060	0.046	0.072
	Lower-Middle		0.082	0.060	0.046	0.073
	Upper-Middle		0.081	0.071	0.050	0.088
	High		0.081	0.069	0.054	0.084

When examining income groups, the distance between activity spaces becomes more unequal among higher-income groups, especially during evening and nighttime hours. This may reflect greater individual variation in lifestyle flexibility and mobility choices among wealthier residents. Additionally, the spatial heterogeneity of affluent neighbourhoods may contribute to this disparity, as some high-income areas are centrally located with dense access to amenities. In contrast, others are situated in more suburban or secluded zones. This geographic variation could lead to differing levels of dependency on travel, thus widening intra-group inequality. Conversely, lower-income groups exhibit slightly more constrained but uniform mobility patterns, likely reflecting shared limitations in transportation access and discretionary travel options. Temporal differences are also evident: inequality is generally lowest during daytime, suggesting that mobility is more evenly distributed across groups in midday hours compared to mornings or evenings. The Gini coefficients for destination diversity highlight additional layers of inequality within socioeconomic groups (Table 3). Unlike activity space distance, which reflects the extent of spatial reach, entropy-based Gini values capture variation in the diversity of urban experiences. The analysis reveals that younger age groups, particularly those under 25, consistently exhibit the highest intra-group inequality across all time periods, especially during the morning and evening hours. This suggests that while some young individuals engage with a wide range of destinations, others in the same group remain limited to a narrow set of familiar locations. In contrast, older adults (60+) display more consistent and lower levels of entropy inequality, reflecting relatively uniform, though limited, mobility behaviour across this group.

Table 3. Intra-group inequality in destination diversity (Neighbourhood-level Gini coefficients)

Socioeconomic Factors			Gini coefficient of Destination Diversity (unit= neighbourhood)			
			morning	evening	daytime	nighttime
Age / Gender	Under 25	M	0.141	0.083	0.062	0.090
		F	0.154	0.092	0.070	0.099
	25-34	M	0.053	0.040	0.037	0.054
		F	0.055	0.043	0.039	0.060
	35-60	M	0.046	0.048	0.035	0.059
		F	0.051	0.053	0.037	0.066
	60+	M	0.105	0.083	0.050	0.121
		F	0.095	0.082	0.052	0.106
Income	Low		0.119	0.078	0.057	0.095
	Lower-Middle		0.112	0.077	0.053	0.094
	Upper-Middle		0.109	0.077	0.055	0.102
	High		0.099	0.075	0.051	0.096

Gender patterns are also notable: while overall differences between males and females are small, women consistently exhibit higher inequality in destination diversity compared to their male counterparts. This may reflect a divergence in lifestyle and access, where some women participate in diverse activities across the city. In contrast, others remain more spatially restricted due to social or safety concerns. As with activity space distance, the middle-aged group (35–60 years old) shows the most uniform diversity patterns across neighbourhoods.

Across income groups, the highest Gini values are observed in high-income neighbourhoods, particularly during daytime and nighttime hours. This mirrors the pattern observed in activity space distance and likely stems from the same spatial heterogeneity of affluent areas, some offering rich, central amenities and others being more peripheral. In contrast, lower-income groups exhibit more uniform but limited diversity, highlighting again the shared constraints in their activity space. These results highlight that even within high-mobility groups, inequality in access to urban variety persists, with some individuals enjoying rich urban experiences while others remain excluded.

Across income groups, differences in Gini values for destination diversity are relatively modest, but a few patterns emerge. In the morning, lower-income neighbourhoods show slightly higher inequality, suggesting that access to diverse destinations may be more uneven at the start of the day. And, in general, inequality is lower in daytime and evening for all income groups.

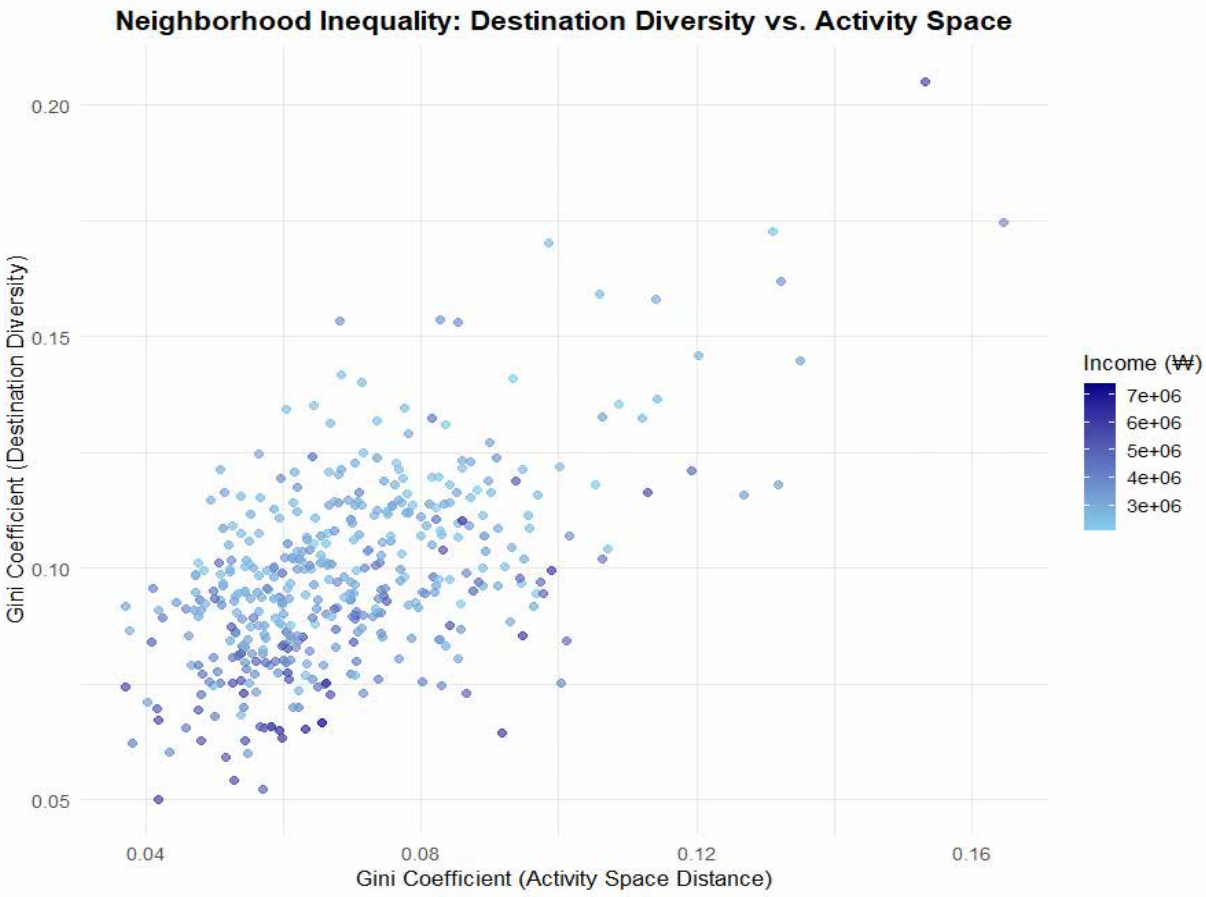


Figure 12. Relationship between intra-neighbourhood inequality in activity space distance and destination diversity. Each dot represents a Seoul neighbourhood; colour intensity reflects average neighbourhood income.

Figure 12 presents a bivariate relationship between neighbourhood-level inequality in activity space distance and destination diversity, with each dot representing a Seoul neighbourhood and coloured by average income level. The weak positive trend suggests that these two dimensions of spatial inequality are related but not strongly correlated, indicating that they capture different aspects of mobility disparity. While some neighbourhoods show low inequality in both metrics, others experience high disparity in either scale or diversity of movement. Notably, higher-income areas (darker dots) appear across a wide range of Gini values, reinforcing earlier findings that wealth does not necessarily imply internal equity. This figure underscores the importance of analysing both activity space and destination diversity to fully understand the multi-faceted nature of urban mobility inequality.

5. Discussions and Conclusions

5.1. Discussions

This study examined non-commuting mobility patterns in Seoul using large-scale smartphone data, focusing on the spatial scale and diversity of daily movement across different socioeconomic groups. We found clear inter-group disparities: higher-income individuals and those in their 20s and 30s travelled farther and engaged with a broader range of destinations. At the same time, older adults and children exhibited more spatially confined routines. Gender differences were more complex; middle-aged women tended to show reduced spatial reach, likely due to caregiving roles or safety concerns, whereas younger women displayed broader destination diversity, especially during daytime and evening hours.

In addition to group-level differences, we revealed substantial intra-group inequalities by calculating Gini coefficients for both activity space distance and destination diversity. These disparities were especially pronounced in young individuals and high-income neighbourhoods. Temporal segmentation further revealed how mobility inequalities shift throughout the day; morning periods exhibited more uniform travel patterns, while

evening and nighttime hours amplified these disparities. Together, these findings highlight that urban mobility is stratified not only across but also within demographic and income groups, necessitating multidimensional and time-sensitive approaches to equity analysis.

This study provides new theoretical insights into how socioeconomic status affects both the scale and diversity of urban mobility. By employing two complementary indicators —activity space distance and destination diversity —we demonstrate that these dimensions, together, provide a nuanced understanding of spatial inclusion. Higher mobility is not just about travelling farther, but also about engaging with a broader array of destinations, each essential for capturing different facets of urban opportunity and interaction.

Our findings reinforce the value of temporal segmentation in mobility analysis. By examining morning, daytime, evening, and nighttime periods separately, we uncover dynamic patterns that would be masked in daily aggregates. Gender disparities, for instance, are not static: younger women display high diversity during the daytime and evening, while the gap narrows or reverses at other times. Similarly, older adults consistently exhibit reduced mobility diversity, suggesting age-related constraints that persist regardless of time. These findings extend earlier work (Gauvin et al., 2020; Zhou et al., 2022) by demonstrating how gender- and age-related disparities in mobility persist across different groups and vary over time. For instance, the gap between genders for both activity space distance and destination diversity of adults (30-60) is highest in the morning. This reinforces the importance of temporally sensitive planning strategies.

Our findings reveal notable variations in mobility patterns across women's life stages. Women under 30 display higher mobility diversity and longer travel distances, likely reflecting more flexible lifestyles and fewer caregiving responsibilities. However, this trend reverses after the age of 30, when mobility becomes more localised, suggesting increasing spatial constraints linked to societal expectations around work and family. On the other hand, for both genders, mobility inequality is highest among younger individuals under 25. This may reflect differing levels of family dependence or opportunity; some youth experience greater autonomy and flexibility in their daily routines. In contrast, others remain more constrained by family obligations or limited resources. These findings extend urban mobility theory by demonstrating how gendered and generational life-course transitions influence spatial behaviour, and they underscore the importance of policies that address mobility equity across different life stages.

Importantly, we argue that activity space distance and destination diversity function as proxies for access to urban social and economic life. Broader activity spaces and richer destination portfolios increase opportunities for interaction, participation, and inclusion. These mobility patterns should therefore be seen not only as behavioural outcomes but also as indicators of underlying urban equity, or lack thereof. As Jacobs (1961) argued, diverse, interconnected urban experiences are key to vibrant city life; our findings show how mobility constraints limit these opportunities for certain groups.

While our study interprets broader activity spaces and greater destination diversity as indicators of opportunity and inclusion, it is important to acknowledge that these patterns do not universally reflect enhanced access or well-being. In some cases, longer travel distances may result from a lack of proximate amenities—indicating spatial exclusion rather than mobility freedom. Conversely, shorter travel distances can signal either convenience and sustainability, or constraints imposed by social, economic, or physical barriers. This duality underscores the complexity of interpreting activity space distance. For instance, the principles of the n-minute city (Moreno et al., 2021) emphasise the benefits of proximity-based living, where diverse urban functions are accessible within a short distance, supporting convenience, equity, and environmental sustainability. From this lens, high mobility may sometimes reflect urban inefficiencies rather than voluntary engagement. While destination diversity is often a clearer indicator of social interaction and urban integration, it too must be contextualised. Future research should distinguish between proximity by choice and proximity by constraint, ideally by integrating mobility data with spatial, social, and qualitative indicators to better understand the lived experience behind observed patterns.

The findings of this study carry important implications for designing more equitable and inclusive urban policies. First, the consistent disparities observed across age, gender, and income groups suggest the need for targeted interventions to support the mobility of underrepresented populations, particularly elderly residents,

lower-income individuals, and middle-aged women. Enhancing access to diverse and proximate amenities in underserved neighbourhoods can reduce spatial exclusion and promote urban sustainability. Furthermore, by promoting broader spatial engagement, as highlighted by Wang et al. (2024), infrequent, non-commuting activities can have a significant impact on economic outcomes. Second, the temporal segmentation of mobility patterns highlights that inequality fluctuates across the day, signalling an opportunity for time-sensitive policies, such as improving nighttime transit services or ensuring daytime safety for women and elderly populations. Third, planners should adopt a multidimensional framework that integrates both activity space distance and destination diversity into accessibility metrics. For instance, Zhou et al. (2022) demonstrated that elderly individuals rely heavily on public transport to access essential services. This should also be considered in relation to daily time periods. Rather than focusing solely on commute distances, future urban planning should account for the richness of everyday spatial engagement as a measure of urban inclusion. By doing so, cities can move closer to the ideals of the 15-minute city, where all residents, regardless of socioeconomic background, can access opportunities within reach, by choice rather than by constraint.

While this study provides valuable insights into non-commuting mobility patterns using large-scale smartphone data, several limitations must be acknowledged. First, the analysis is based on aggregated origin–destination flows at the neighbourhood level, which restricts our ability to fully capture individual-level variability or motivations behind trips. Second, although we isolate non-commuting trips, the categorisation of trip purposes may still contain ambiguities, especially in overlapping activities such as shopping combined with caregiving. Third, the study is limited to Seoul, a highly transit-oriented and socioeconomically stratified city; thus, findings may not be directly generalisable to cities with different spatial forms or transit systems. Fourth, mobility patterns were examined without direct integration of spatial built environment variables, such as walkability, land use mix, or centrality, which may influence both activity space distance and diversity. Finally, while entropy and travel distance serve as useful proxies for mobility inequality, they do not capture subjective dimensions such as perceived safety, comfort, or purpose-driven constraints, factors that could enrich the interpretation of disparities across groups. These limitations underscore the need for future studies combining spatial metrics with qualitative and survey-based insights to fully understand the drivers of mobility inequality.

Additionally, while this study emphasizes income as a key factor shaping mobility, neighbourhoods with similar income levels may exhibit distinct spatial characteristics, some of which are centrally located with high accessibility. In contrast, others are more peripheral and residential. These locational differences can influence both the scale and diversity of activity spaces. Future research should therefore incorporate centrality or spatial accessibility metrics to understand better how socioeconomic and geographic factors interact to shape mobility patterns.

5.2. Conclusions

This study highlights that spatial equity in non-commuting mobility is not only a question of access, but a critical dimension of urban sustainability and social justice. By analysing activity space distance and destination diversity through entropy and Gini coefficients across different times of day, we reveal how socioeconomic factors, particularly age, gender, and income, shape both the extent and equity of mobility in Seoul. The combination of these indicators with temporal segmentation offers a novel, multidimensional perspective on urban mobility patterns, providing actionable insight into where and when mobility inequalities are most pronounced.

Looking forward, future research could build on this work by employing longitudinal data to observe how mobility patterns evolve over time in response to urban development or policy interventions. Comparative studies across cities with varying spatial forms and transport systems could also deepen understanding of contextual influences. Furthermore, integrating mobility metrics with built environment features, such as land use diversity, connectivity, or centrality, and incorporating qualitative perspectives from residents could help uncover the lived experience behind the numbers. Such approaches will be essential for designing urban environments that are not only efficient but also inclusive, responsive, and just.

Future research could also explore the underlying social, cultural, and institutional factors that shape the observed disparities in activity space distance and destination diversity, helping to unpack not just where and when disparities occur, but why they persist. For example, the widening gender gap in both mobility scale and diversity after the age of 30 warrants further examination, particularly in relation to caregiving roles, workplace

expectations, or safety perceptions. Comparative studies across different cultural or urban contexts would also help to validate and expand these findings. In addition, evaluating the effectiveness of time-sensitive interventions, such as enhancing nighttime accessibility for older adults or increasing the diversity of amenities in underserved areas, could offer practical guidance for inclusive mobility planning.

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Correlation Analysis Between Rail Network Nodal Attributes and Passenger Staying Rate: A Case Study of China's Yangtze River Delta Region

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Abstract
The development of railway station areas hinges on their transition from "transfer hubs" to "destinations," where the scale and structure of passenger flows determine how built environments respond to traveler needs. Traditional node-place models often characterize station node attributes using volatile metrics like passenger volume or train frequency. This study selects 49 railway stations in China's most economically developed region, constructing a multilayer L-space rail complex network model from timetable data to investigate how nodal attributes across distinct rail networks influence Passenger Staying Rate and Passenger Structure. Key findings reveal that the Economically-Weighted PageRank (integrating city GDP) in the Integrated Rail Network exhibits significant correlations with all passenger-related metrics. Ultimately, a "Node-Passenger" analytical framework is established, offering new perspectives for railway station area development.

Keywords: Station areas; multi-scale accessibility; multi-centrality analysis; node-place model

1. Introduction

The emergence of high-speed rail (HSR) technology heralds the advent of the "Second Railway Era," further compressing spatiotemporal distances between cities. This acceleration has intensified intercity rail passenger flows, significantly boosting urban economic growth and regional integration. Within this context, as noted by Professor Edwards of the University of Sheffield School of Architecture in The Modern Station: New Approaches to Railway Architecture, "Railway stations stand as integral elements of urban life and culture. Their unique significance stems from serving as interfaces between 'two worlds'—the convergence points of railway systems and urban ecosystems."(Edwards, 2013). The railway system, a network of constant flow, has railway passenger stations as its nodes. In contrast, the urban system is where people live and conduct various activities, functioning as a place. Nodes represent movement and transfer, while places imply stays and activities. As a key public space in cities, the development of railway station areas hinges on transforming stations from mere transfer points to destinations for diverse social interactions. This shift not only saves time for time-sensitive passenger groups like business and commuter travelers but also reduces overall transportation costs and alleviates environmental pollution from urban congestion and car dependency (Carlton, 2009).

Since the launch of its high-speed rail system in 2008, China has witnessed the rapid development of its high-speed rail network. However, there remain significant differences between China's railway passenger structure and that of Europe and Japan. In China, long-distance travelers constitute a larger proportion, whereas the number of commuters and business travelers is relatively smaller. Variations in passenger volumes and the composition of passenger types at different stations place diverse demands on the built environment of station areas. As conduits for transporting various passenger flows, is there a relationship between the configuration of different railway networks and the types of passenger groups they serve? Can this relationship be observed at the meso-scale level of station areas?

To answer these questions, Section 2 provides a review of relevant literature, Section 3 outlines the methodological approach, data sources, and study scope, and Section 4 presents and analyzes the research findings. Finally, Section 5 concludes the study.

2. Literature Review

The classic Node-Place model proposed by Bertolini(1999), has been widely used in station typology research and in analyzing development strategies for station areas—that is, assessing whether a station area should further develop its "place" functions or enhance its "node" functions. This model has been extensively applied around

the world, including in the Netherlands, Japan, and Australia(Chorus and Bertolini, 2011; Kamruzzaman et al., 2014; Peek et al., 2006; Zemp et al., 2011) Internationally, transit oriented development (TOD. It is not only used to analyze railway station areas but also stations along urban rail transit and bus rapid transit (BRT) corridors(Amini Pishro et al., 2022; Pezeshknejad et al., 2020)Transit-Oriented Development (TOD.

The model often evaluates the strength of a node based on quantitative indicators, such as the number of train services or passenger volumes. This approach works well in regions where differences in passenger types are minimal. However, in China, long-distance travelers still dominate the railway system overall. Yet, in economically developed regions, the proportion of business and commuting passengers has been increasing, thanks to the rapid expansion of high-speed and intercity rail in recent years. These two groups exhibit distinct behavioral patterns, travel choices, functional needs, and sensitivity to time. Therefore, whether passenger volume alone can accurately reflect the “node value” of a station remains questionable in the Chinese context.

On the other hand, passenger volume and train frequency are values that are easily influenced by the built environment and are subject to fluctuations over time. Changes in the built environment inherently imply potential shifts in passenger flow. For newly constructed stations or those undergoing major redevelopment, it is difficult to accurately predict future passenger volumes or train frequencies, which, to some extent, limits the applicability of the Node-Place model.

However, as the conduit for passenger flows, the structure and characteristics of a transport network influence the ease of movement within it. A station’s node attributes within different types of networks may offer a more stable proxy for the “node value.” Yet, most existing studies on railway complex networks typically treat cities rather than individual railway stations as nodes, making them of limited value when addressing development issues at the meso-scale of station areas.

At the “place” level, traditional Node-Place models often use indicators such as the number and diversity of employees across industries (Zemp et al., 2011)which focuses on transport related issues, blending performance with preconditions at a given site. We argue that a classication system for strategic planning should focus on the demands and conditions of the site within which the railway station must function, i.e. system context. Here, we present such a classication system: a cluster analysis of the 1700 Swiss railway stations relying solely on context factors. The resulting classes vary primarily in density (of land use and transport services, rental prices of various types of buildings, or the number of public facilities (Amini Pishro et al., 2022). However, these indicators are not direct measures of the extent to which a station area serves as a true “destination” for travelers. In recent years, with the advancement of big data technologies, Location-Based Services (LBS) data have made it possible to directly determine whether travelers remain in the station area after alighting, and what activities they engage in, allowing for the inference of passenger types. Such indicators can serve as direct performance metrics for evaluating the degree to which a station area functions as a destination.Therefore, this study employs complex network analysis techniques to quantify the centrality of stations within different network structures and explores the relationship between network centrality and both passenger volume and passenger composition using LBS data. Finally, the study attempts to construct a Node-Place model based on these two dimensions, offering a new perspective for analyzing and understanding station area development.

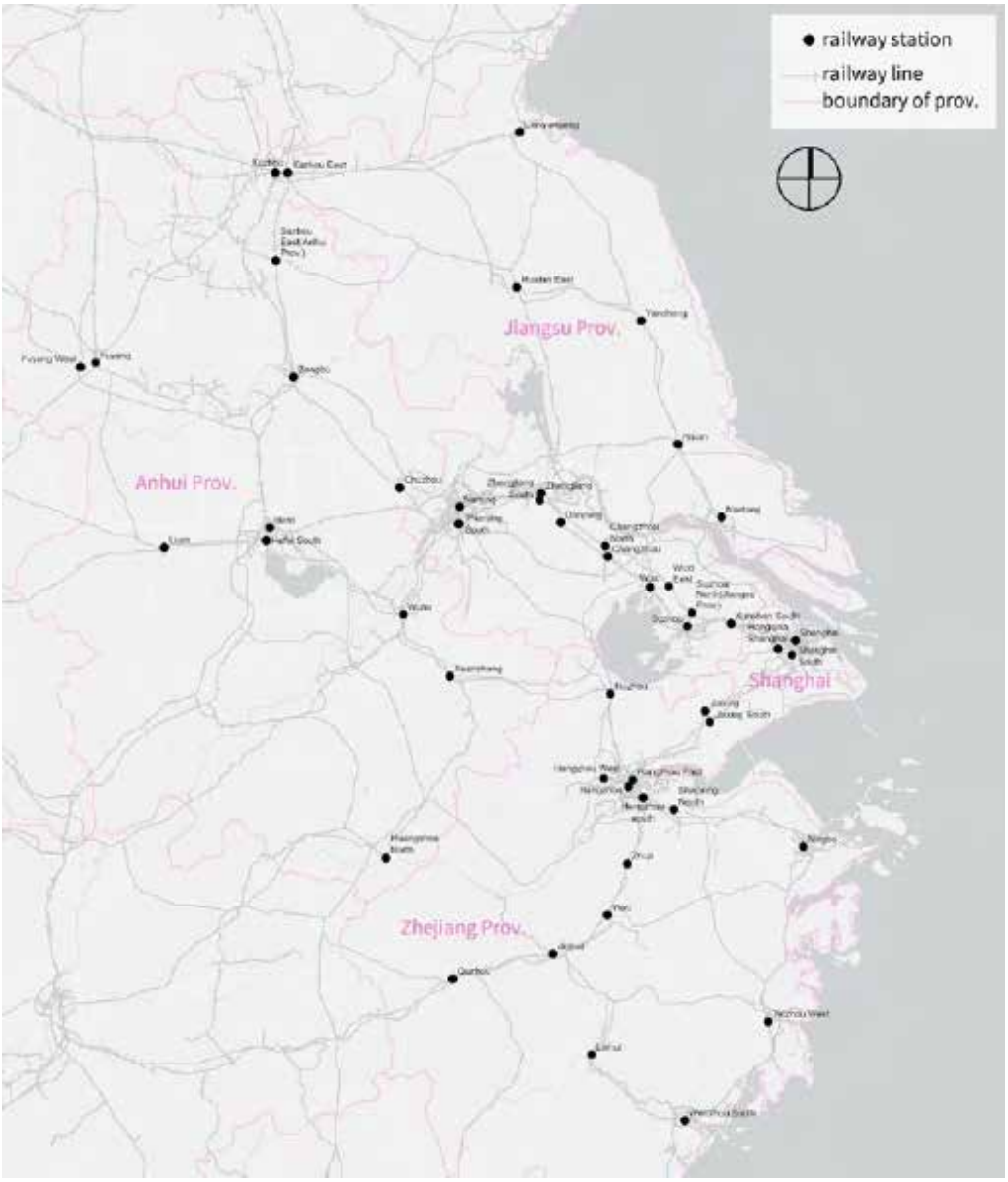

Figure 1. The research cases

3.Methodology

3.1 Samples and the Data Source

This study selects 49 railway stations within the Yangtze River Delta—one of the most economically developed regions in China—as research subjects. These stations are all served by at least two railway lines, with at least one being a high-speed or intercity rail line (Fig. 1). Passenger group data associated with these stations are derived from Sun Juan et al. (2024), who used LBS trajectory data covering 72 million person-trips in the Yangtze River Delta railway station areas in 2021. Individuals who traveled by train and conducted activities within a 5 km radius of a station (excluding the station itself) were defined as "arrival-activity travelers." Among them, travelers who stayed in office buildings for more than one hour and for longer durations than in leisure venues were defined as "business travelers." Travelers who spent more than one hour in scenic areas, shopping zones, or entertainment venues—and whose time in these areas exceeded time spent in business districts—were defined as "leisure travelers."Travelers whose residence and workplace (for more than three months) were located in different cities and who regularly commuted by train were categorized as "commuters." All remaining travelers were classified as "other travelers," with travel purposes including cross-city medical visits, family or friend visits, and transport transfers.

The railway network data were obtained from the Chinese Railway Passenger Train Timetable, which includes train numbers, station information, and departure and arrival times. The dataset contains a total of 10,737 passenger trains and 3,212 railway stations. The initial letter of each train number indicates its type, with a total of eight categories

(Wang et al., 2020) (see Table 1). Due to differences in speed and ticket pricing among these train types, their correspondence with different passenger groups also varies.

Business travelers and commuters, who are generally more time-sensitive, mainly correspond to the G, D, C, and S train types. These are grouped in this study as "High-speed/Short-haul trains," and the corresponding railway network is referred to as the HSR (High-Speed Railway) Network. The remaining train types—Z, T, K, numeric-only trains, and Y—are classified as "Conventional/Long-haul trains," forming the CLR (Conventional Long-distance Railway) Network, which mainly serves passengers with lower time sensitivity.The combination of both networks is referred to as the Integrated Railway Network, abbreviated as IR.

Table 1. Chinese Passenger Train Classification Framework

Type		Discreption
Z	Non-Stop Express Passenger Train	- Max speed: 160km/h - Limited intermediate stops - Point-to-point service
T	Limited-Stop Express Train	- Max speed: 140km/h - Major city stops only - Medium-long distance focus
K	Fast Passenger Train	- Max speed: 120km/h - Multi-stop configuration - Cost-effective service
-	Conventional Local Train	- Speed: ≤120km/h - Green-body coaches - Frequent stops, low fares
Y	Scenic Tour Train	- Max speed: 120km/h - Routes: Tourist attractions - Themed service
G	High-Speed EMU Train (G-Series)	- Design speed: 250-400km/h - Business/Top-class seats - Long-distance premium service
D	High-Speed EMU Train (D-Series)	- Operating speed: 200-250km/h - Regional corridor service - Medium-distance comfort
C	Intercity EMU Shuttle	- Speed: 200-350km/h - High-frequency operation - Metropolitan area connectivity
S	Metropolitan Commuter Rail	- Speed: 100-160km/h - Urban-suburban transit - Mass transit configuration

3.2 Modeling the Railway Networks

There are various methods for constructing railway complex networks. In this study, the L-space approach is adopted, where stations are represented as nodes, and any two adjacent stations traversed by the same train are considered connected(Lin and Ban, 2013). The train number and travel time between each pair of adjacent stations are recorded, and the average travel time of all trains passing through that segment is used as the time cost of the corresponding edge. This process is conducted separately for the HSR, CLR, and IR networks.

The constructed HSR network contains 1,629 nodes and 9,771 edges nationwide, with an average edge travel time of 30.05 minutes. The CLR network consists of 2,071 nodes and 7,049 edges, with an average edge travel time of 77.48 minutes. The average travel time between CLR stations is 257.58% of that between HSR stations. The combined IR network contains 3,212 nodes and 15,810 edges (Fig. 2).

3.3 Measuring Node Attributes of Stations in the Rail Network

This section proposes a multidimensional node evaluation framework that systematically assesses the structural functions and strategic positions of stations within the railway network. The framework integrates the topological characteristics of different networks with both the time cost between stations and the economic attributes of the cities where the stations are located. The measurement system includes two core indicators: Temporal Closeness Centrality and Economically-Weighted PageRank.

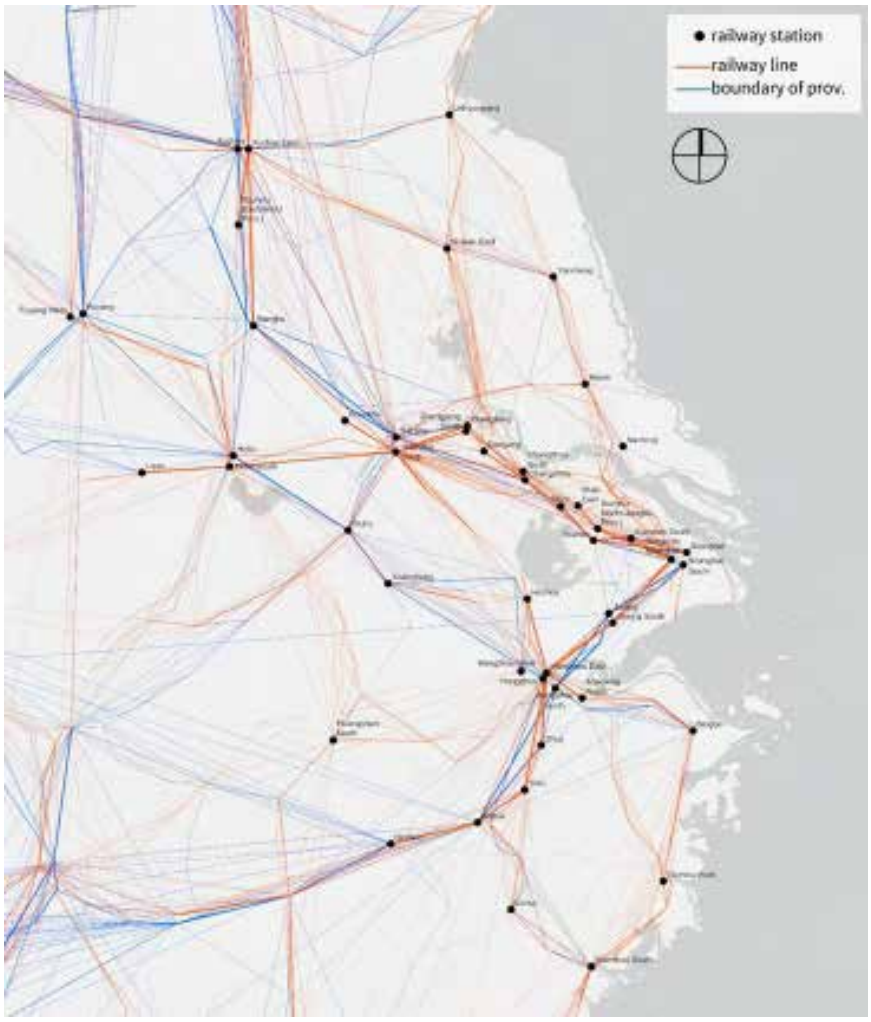

Figure 2. Multi-tiered Rail Complex Network in L-Space Constructed from Train Services (Link width corresponds to service frequency between stations)

Given prior research confirming the symmetric nature of China's railway network (Wang et al., 2020), all indicator calculations in this study are based on an undirected network. By weighting the traditional closeness centrality with time cost between stations, the Temporal Closeness Centrality is defined as follows:

$$Closeness_v = \frac{n-1}{\sum_{u \neq v} T_{uv}} \quad (1)$$

Where $Closeness_v$ represents the Temporal Closeness Centrality of station v; T_{uv} denotes the shortest travel time between stations u and v (assuming u and v are within the same connected component), calculated as the sum of average travel times across all edges in the time-optimal path between them; and n is the number of nodes within the connected component that includes station v. Temporal Closeness Centrality measures the average ease (or difficulty) of reaching all other stations from station v, using travel time as the cost metric across different types of railway networks.By incorporating both the economic context of each city and the connectivity between stations, we define the following:

$$PageRank_v = \alpha \sum_{u \in M(v)} PR_0(u)/L_u + (1-\alpha)/N \quad (2)$$

$$PR_0(u) = GDP/m \quad (3)$$

Where a is the damping factor, set to the default value of 0.85; N is the total number of stations within the connected component; $M(v)$ denotes all neighboring stations of station v; L_u is the number of neighboring nodes of station u; and $PR_0(u)$ is the initial importance of station u, calculated as the GDP of the city where station u is located divided by the number of railway stations (m) in that city. After several iterations, the final importance values for each station can be obtained.

This study calculates both Temporal Closeness Centrality and Economically-Weighted PageRank for each station in the HSR, CLR, and IR networks, and analyzes their correlations with different types of passenger group indicators at each station (Table 2).

Table 2. The Metrics and Specifications

Dimension	Metric	Specification
Node Metrics	Closeness	Temporal Closeness Centrality
	PageRank	Economically-Weighted PageRank
Passenger Metrics	N_Y	number of yearly passengers depart only
	P_S	Proportion of passengers staying in the station area
	P_B	Proportion of business passengers among passengers staying in the station area
	P_C	Proportion of commuters among passengers staying in the station area
	P_L	Proportion of passengers for leisure among passengers staying in station area
	P_O	Proportion of other passengers among passengers staying in station area

4. Results

4.1 Correlation Analysis

Among the 49 station samples, 23 stations only have high - speed rail lines. Thus, samples with only high - speed rail lines will be excluded when calculating CLR - related indicators. After normality testing, C_IR, C_HSR, PR_CR, P_B, P_L, and P_O follow a normal distribution. The Pearson correlation coefficient will be used to calculate the correlation between them. For the rest, the Spearman correlation coefficient will be applied (Table 3).

Table 3. The Correlation Analysis Results

Rail Networks	Metric	N_Y	P_S	P_B	P_C	P_L	P_O
IR	Closeness	0.066	0.028	*-0.092*	-0.111	*-.366***	*0.229*
	PageRank	**.726****	**.639****	**.577****	.456**	.331*	**-.597****
HSR	Closeness	0.087	0.006	*-0.144*	-0.108	*-.301**	*0.253*
	PageRank	**.632****	.490**	**.525****	.477**	0.245	**-.514****
CLR	Closeness	0.091	0.079	-0.015	-0.278	-0.247	0.088
	PageRank	0.350	.406*	*0.198*	-0.058	*0.172*	*-0.207*

Italicized values in the table represent Pearson correlation coefficients;
**. Significant at the 0.01 level (2-tailed);
*. Significant at the 0.05 level (2-tailed).

The correlation calculation results reveal the following characteristics:
(1)PageRank Correlations: Station PageRank on IR and HSR networks correlates with passenger metrics, with stronger overall correlations on IR (except for Proportion of commuters, where HSR PageRank shows a stronger correlation).

(2)CLR Network Irrelevance: Station node properties on the CLR network generally show no significant correlation with passenger metrics, except for the Proportion of passengers staying in the station area, which has a significant positive correlation with CLR PageRank (correlation coefficient: 0.406).

(3)Temporal Closeness Centrality: On IR and HSR networks, Temporal Closeness Centrality only shows a significant negative correlation with the Proportion of passengers for leisure and no correlation with other metrics.
(4)Strongest Correlation: Proportion of passengers staying at the station area has the strongest positive correlation with IR PageRank, followed by HSR PageRank.

(5)Significant Negative Correlation: Proportion of other passengers shows a strong significant negative correlation with PageRank on both IR and HSR networks.

These characteristics indicate that the High-speed and Short-haul Rail Network is positively correlated with the proportion of business and commuter travelers but negatively correlated with other traveler types. As stations become more important in the HSR network, the increase in business and commuter travelers outpaces that of leisure and other travelers. Node importance considering urban GDP better explains station attractiveness than high temporal accessibility, and the Integrated Rail Network, combining HSR and CLR, shows stronger explanatory power.

Despite the Yangtze River Delta being one of China's most HSR-developed regions, incorporating the conventional rail network into railway complex network modeling for station analysis remains valuable.

The PageRank of stations in the conventional long-distance rail network positively impacts passenger station-area staying rates. This might be because the conventional rail system, with a longer development history, has more mature and comprehensive urban construction around high-importance stations, making them more attractive for passenger stays.

4.2 Node-Passenger modal

Drawing on the Node-place model for 'Node-Passenger' analysis: Min-max normalize the PageRank values of stations in the IR network and the Proportion of passengers staying at station areas. Plot the normalized PageRank values on the x-axis and the normalized proportion of passengers on the y-axis, then perform curve fitting(Fig. 3).

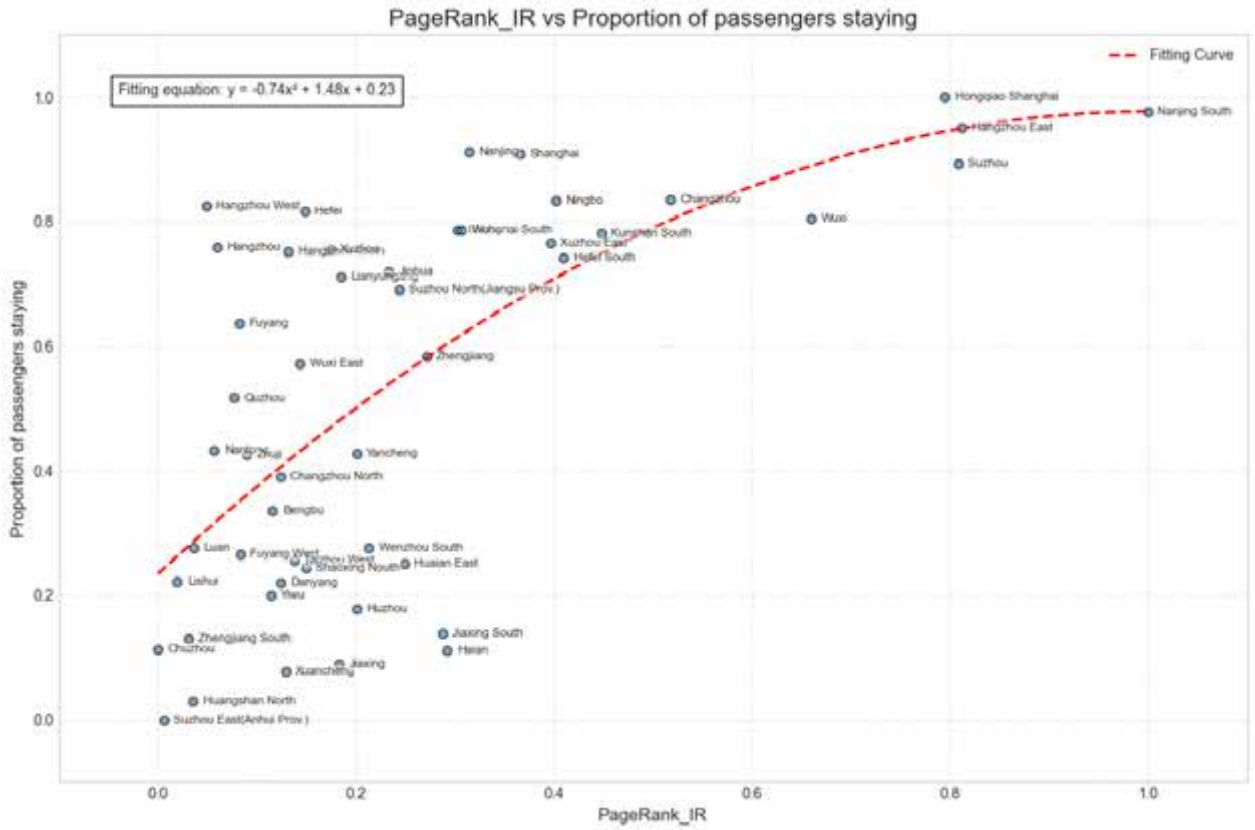

Figure 3 Node-Passenger Modal

The fitted trend line, a parabola, shows that in the Yangtze River Delta, the proportion of passengers staying at station areas increases with the PageRank value of stations in the IR network, but at a declining rate. When PageRank reaches around 63%, growth in passenger proportion halts.

Five stations hitting this threshold are Nanjing South, Hongqiao Shanghai, Hangzhou East, Suzhou, and Shanghai Station, all major stations in the region's most economically advanced cities.

Using the classic Node-Place Theory to explain the Node-Passenger model shows no "unbalanced nodes" in the Yangtze River Delta, but many "unbalanced places" cluster in the upper-left quadrant. These are mostly old stations (e.g., Hangzhou, Hefei, and Xuzhou Stations) with low railway network importance but high urban development around them, making them attractive for passenger stays. Numerous Dependency stations are in the lower-left quadrant. They have low IR network importance, struggle to attract business and commuter travelers, and thus have low passenger retention rates and destination-formation levels.

5. Conclusions

This paper focuses on railway stations' node properties in rail networks. It uses stable and accessible network structure indicators instead of the volatile and hard - to - get passenger flow and train frequency indicators to represent station node properties. It checks their correlation with the Proportion of passengers staying, which directly shows the "destination-formation degree" of stations. Results show that PageRank (considering city GDP) of stations in the combined HSR and CLR networks strongly correlates with passenger activity rates (correlation coefficient: 0.726) and with proportions of business, commuter, and leisure travelers. This proves that stations' importance in HSR networks significantly attracts time-sensitive passenger groups. It also finds an upper limit

(63%) for passenger retention rates in the Yangtze River Delta.

For future research, it's suggested to include more built-environment indicators in the analysis system. This will help form a comprehensive "Node - Passenger - Place" analysis system.

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An Exploration of Route Synergy between Attractions in Xi'an's Main Urban Area Based on the Node-Place Model

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Abstract
Currently, China is in the period of high - quality and intensive urban development. Handling the relationship between the traffic value and the tourism value of the routes between scenic spots is crucial for the efficient utilization of tourism resources. This paper takes 120 public transportation connection routes among 15 scenic spots above 4A level in the main urban area of Xi'an as the research object. It establishes an index system for the traffic value and tourism value of the routes, and uses the ArcGIS platform to conduct a minimum resistance analysis of each index. Based on the node - place model, it evaluates the current development status of each route. The research results show that there is a phenomenon of non - coordinated development among the routes: the scenic spots can be divided into four states: balanced, subordinate, pressured, and imbalanced. Corresponding development strategies are proposed for each state. For example, in the balanced state, the values should be increased or decreased simultaneously; in the subordinate state, the traffic and tourism facilities need to be improved; in the pressured state, the traffic pressure should be relieved; in the imbalanced state, the value structure should be optimized. This research provides a basis for improving the public transportation facilities in scenic spots, optimizing traffic organization, and enhancing the level of intelligent transportation services.

Keywords: Node-place model; Minimum resistance model; Public transportation routes; Tourist needs; Main urban area of Xi'an

Introduction

With the acceleration of the global urbanization process, the efficient utilization of urban space and sustainable development have become the focus of attention for governments and academia around the world. Against this backdrop, the optimization of the urban transportation system and the rational allocation of tourism resources are of particular importance. As the link connecting various functional areas within the city and external regions, the public transportation system is not only the "lifeblood" of urban operation but also an important driving force for urban tourism development. However, how to balance traffic efficiency with the harmonious co - existence of tourism experience and the urban environment has become a major challenge in current urban planning and transportation management.

Luca Bertolini proposed the node - place model, which profoundly reveals the dual characteristics of station areas. That is, the dialectical relationship between its attribute as a key node in the transportation network and its attribute as a place for diverse urban life spaces. This theoretical framework points out that station areas need to efficiently integrate multiple transportation modes to ensure the smooth transfer of people and goods, meeting the rapid - flow needs of modern society. At the same time, it shoulders the heavy responsibility of urban function expansion, integrating multiple activities such as business, leisure, and entertainment, attracting and promoting people to stay and interact in specific areas. The core of the node attribute lies in promoting the efficient distribution of people, while the place attribute focuses on creating a pleasant environment to encourage people's in - depth participation and experience.

The tension and synergy between the two constitute the internal dynamic mechanism for the development of station areas. On the one hand, the improvement of node efficiency (such as the optimization of transportation facilities) can attract more people, laying the foundation for the realization of place value. On the other hand, the enrichment and quality improvement of place functions further stimulate transportation demand, forming a positive cycle. This process reflects the trend of the harmonious co - existence of node value and place value in dynamic adjustment, which is a model for urban space optimization and transportation system integration.

In terms of results, the node - place model describes three synergy states: The subordinate state means that the node value and the place value are in synergy but at a low level, indicating low - level development in the area; The balanced state is the ideal state, where the node value and the place value are in synergy and at a moderate level, representing sustainable development in the area; The pressured state means that the node value and the place value are in synergy but at a high level, indicating over - development in the area; An imbalanced node means that the node value is much higher than the place value; An imbalanced place means that the place value is much higher than the node value. The practical significance of the node - place model lies in summarizing the

complex problems of station areas into the synergistic interaction relationship between the node value and the place value, and using quantitative means to evaluate the development status of station areas, guiding the key points of future construction in station areas and proposing targeted development ideas.

Based on this understanding, Luca Bertolini proposed the node - place model in 1999. This model quantifies two performance indicators of station areas - node value and place value - by establishing an index system. Scholars highly recognize Luca Bertolini's ideas and have conducted some fruitful research. There are also quite a number of studies in the context of Chinese cities. For example, Zheng Degao and others pointed out that transportation hubs should be combined with urban planning, with a focus on the value of transportation nodes and the value of urban places; Chen Lan and others summarized station areas as "multi - modal transportation nodes" and "functionally complex urban places"; Wang Chengfang and others proposed a planning and design idea for station areas based on the dual characteristics of nodes and places in combination with the conceptual design scheme of the new public transportation system in Nanhai District, Guangzhou.

In summary, scholars generally believe that the mutual coordination and promotion of node value and place value are the keys to the sustainable development of station areas. Based on this, this paper uses the traffic value of routes as the node value and the tourism value as the place value, extending it to the traffic - tourism value of public transportation routes between scenic spots, and studies the development synergy of public transportation routes between scenic spots in the central urban area of Xi'an. Studying the integration between scenic spots and the existing urban transportation also provides a basis for improving the public transportation facilities in scenic areas, optimizing traffic organization, and enhancing the level of intelligent transportation services in a targeted manner.

1 Research Design

1.1 Overview of the Research Area

The research area of this paper is the main urban area of Xi'an, which includes Yanta District, Beilin District, Lianhu District, Weiyang District, Baqiao District, and Xincheng District, with a total area of approximately 832 square kilometers. Xi'an is one of the first batch of famous historical and cultural cities. As the core development area of Xi'an, the main urban area has 15 scenic spots above 4A level, such as the Big Wild Goose Pagoda, Shaanxi History Museum, and Daming Palace National Heritage Park, attracting a large number of domestic and foreign tourists. Therefore, the number and distribution of scenic spots in the research area are appropriate, providing sufficient data samples. Meanwhile, with the acceleration of the old - city renovation and urban renewal process, how to coordinate the intensive development of urban scenic - area resources has become a major challenge for cities. In summary, selecting the main urban area of Xi'an as the research area has important demonstration value (Figure1).

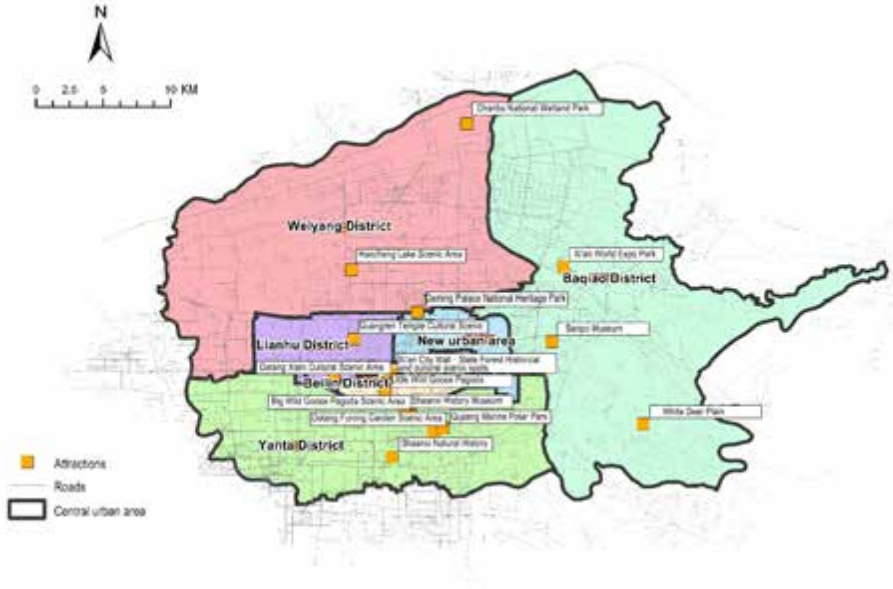


Figure 1. Scope map of main urban area of Xi'an

1.2 Research Steps

First, the optimal routes for 15 scenic spots in the main urban area of Xi'an were selected through the recommendation of Gaode Map and recorded using the ArcGIS platform (Table 1). Then, by reviewing relevant literature and considering the characteristics of tourist needs, a factor system for the traffic and tourism values of scenic - area routes in the main urban area of Xi'an was determined. The traffic value includes the density of public - transportation stations and road - network density, while the tourism value includes the density of characteristic shops and scenic - spot density. The method of constructing resistance surfaces was used to generate individual - factor resistance surfaces and classify and overlay them to obtain the traffic and tourism resistance values of each tourism route (Table 2).

The Minimum Resistance Model is an academic theoretical framework used to describe and analyze that when systems, individuals, or groups face multiple possible paths or choices, they tend to choose the paths with the least resistance, lowest cost, or highest efficiency.

Finally, the node - place model analysis was conducted using the two types of resistance values obtained for each route to get the synergy results of the development of five types of tourism routes.

To eliminate the differences in dimensions and orders of magnitude among indicators, this paper first performed max - min standardization on the data. The specific formula is as follows: In the transformation function, x is the original data value, x' is the standardized value, max is the maximum value in the original data, and min is the minimum value in the original data.

$$\chi' = \frac{\chi - min}{max - min}$$

1.3 Data Sources

In terms of scenic - spot selection, this paper referred to the data published by the Xi'an Culture and Tourism Bureau and screened 15 scenic spots at or above 4A level within the main urban area of Xi'an. The road - network data were sourced from the 2023 Chinese road data published on the Open Street Map website. The text data of bus and subway stations and lines were obtained from the official website of Xi'an Metro and the urban rail development plan of Xi'an. The route directions were selected from the optimal public - transportation routes recommended by Gaode Map, including transfer data and travel - time information. The POI data of shops were obtained from the Baidu Map API interface.

2. Research Process

Table 1. List of scenic spots in the main urban area of Xi'an

Number	Level	Name of scenic spot
1	5A	Big Wild Goose Pagoda Scenic Area
2	5A	Datang Furong Garden Scenic Area
3	5A	Xi'an City Wall · Stele Forest Historical and cultural scenic spots
4	5A	Xi'an City Wall · Stele Forest Historical and cultural scenic spots
5	5A	Shaanxi History Museum
6	4A	Qujiang Marine Polar Park
7	4A	Datang Xishi Cultural Scenic Area
8	4A	Banpo Museum
9	4A	Xi'an Museum (Little Wild Goose Pagoda)
10	4A	Xi'an World Expo Park
11	4A	Hancheng Lake Scenic Area
12	4A	Chanba National Wetland Park
13	4A	Shaanxi Natural Museum
14	4A	White Deer Plain · White Deer Warehouse Scenic Area
15	4A	Guangren Temple Cultural Scenic Area

Table 2. Resistance factor table

First order factor	Secondary factor	Grading method	Resistance coefficient	Weight
Tourist experienceSite properties	Scenic spot density	According to nuclear density or linear density analysis, it is divided into five categories by natural breakpoint method	1-9	0.35
	Characteristic store density			0.25
Road connectivityNode properties	Road network densityRoad network density			0.15
	Density of bus and subway stations			0.25

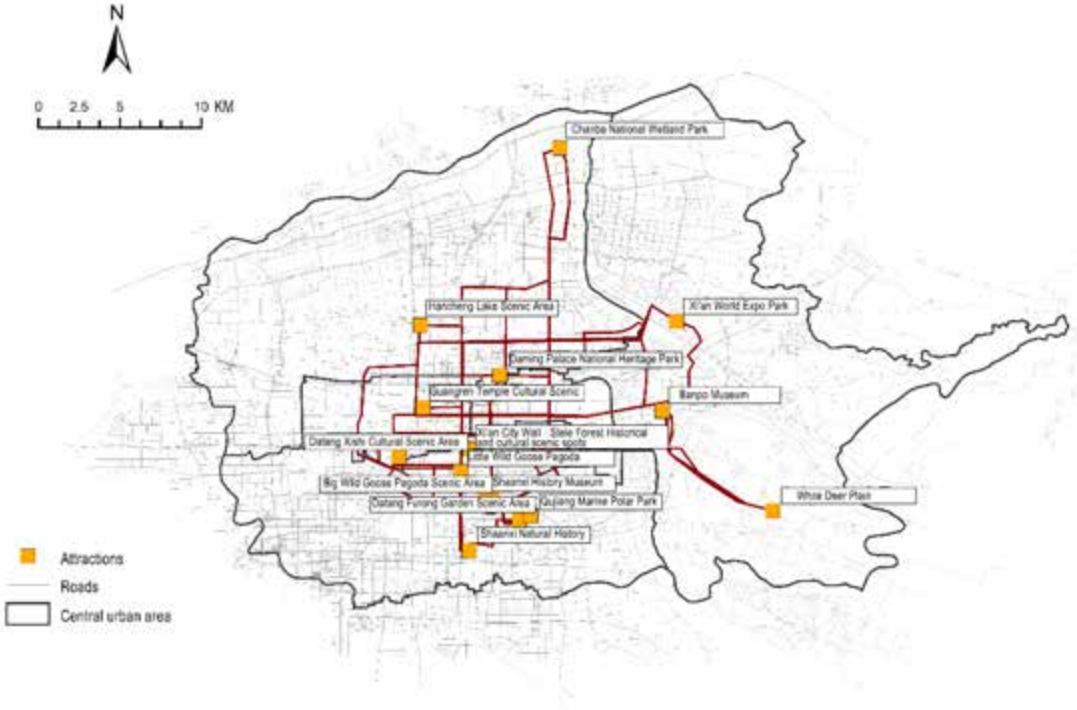


Figure 2. Traffic routes between scenic spots

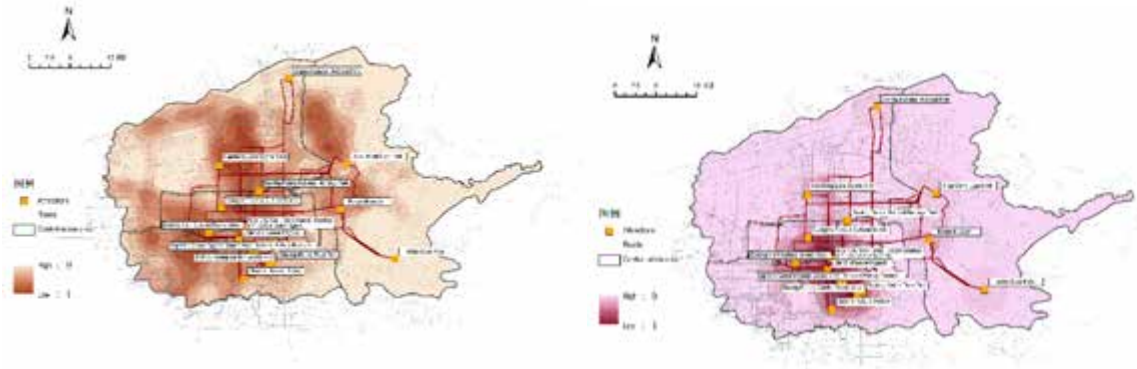


Figure 3. Traffic value (left) and tourism value (right) resistance results

This research takes public transportation as the research perspective and uses Gaode Map as the platform. The selected travel modes include a combination of subway, bus, and walking (more than 1 km) for public transportation. The ArcGIS platform is used to record the starting points, transfer times, and overall travel time data of each route. A total of 120 routes between 15 scenic spots are screened (Figure 2).

2.2 Node (Traffic) Value Measurement

2.2.1 Public Transportation Station Density

The density of public transportation stations (bus stops and subway stations) can represent their distribution and, to some extent, reflect the closeness of the connection between scenic spots and the city. This paper uses the Kernel Density tool for cluster analysis. The results show that the station distribution density around Han City Lake Scenic Area, Datang West Market, Expo Park, Banpo Museum, and the Ming City Wall area is relatively large, and the public transportation accessibility in these areas is better.

2.2.2 Road Network Density

The road network density represents the convenience of tourists' transfers to some extent. In areas with a high density, there are more transportation options and better accessibility. The analysis using the Kernel Density tool shows that the road network density around Datang West Market, the Big Wild Goose Pagoda, and the Ming City Wall area is relatively high. Scenic spots like Bailuyuan are far from the urban area, so the road network density is low.

2.2.3 Quantitative Superposition Results

By referring to relevant literature, weights are assigned to the two factors of public transportation station density and road network density, and reclassification is carried out. Then, the Weighted Sum tool is run to obtain the comprehensive resistance surface of traffic value (Figure 3).

2.3 Place (Tourism) Value Measurement

2.3.1 Characteristic Shop Density

In this paper, the POI data of characteristic shops are obtained from the Baidu Map interface. Shops such as homestays, specialty stores, and characteristic food stores that meet the six major needs of tourists, namely "eating, accommodation, transportation, sightseeing, shopping, and entertainment", are screened. Therefore, areas with a high density of characteristic shops represent, to some extent, the more developed tourism areas in the main urban area of Xi'an. The analysis using the Kernel Density tool shows that the density of characteristic shops near the Bell and Drum Towers and the Datang Ever - Bright City is relatively high, with relatively high tourism value and more attractive to tourists. The tourism industry construction near the Expo Park and the Bailuyuan Scenic Area is relatively poor.

2.3.2 Scenic Spot Density

The scenic spot density can represent the concentration of tourism resources to some extent. The analysis using the Kernel Density tool shows that the area composed of the Shaanxi History Museum, the Big Wild Goose Pagoda, the Datang Furong Garden, and the Qujiang Ocean Polar Park has a relatively high scenic spot density and is more attractive to tourists.

2.3.3 Quantitative Superposition Results

By referring to relevant literature, weights are assigned to the two factors of characteristic shop density and scenic spot density, and reclassification is carried out. Then, the Weighted Sum tool is run to obtain the comprehensive resistance surface of tourism value .

2.4 Node - Place Model Construction

Analysis of 20m buffer area for routes between scenic spots. Using the 14 routes of each scenic spot as a mask, the raster data of traffic value and tourism value are extracted, and the average value of each scenic spot's route is recorded. The obtained data are processed by max-min standardization to get two values for each scenic spot (Table 3). Taking the traffic value as the y - axis and the tourism value as the x - axis, a node (traffic) - place (tourism) model is established. Through model evaluation, it can be found that half of the scenic spots are in a balanced state, and some are in a subordinate state, a pressured state, or an imbalanced state.

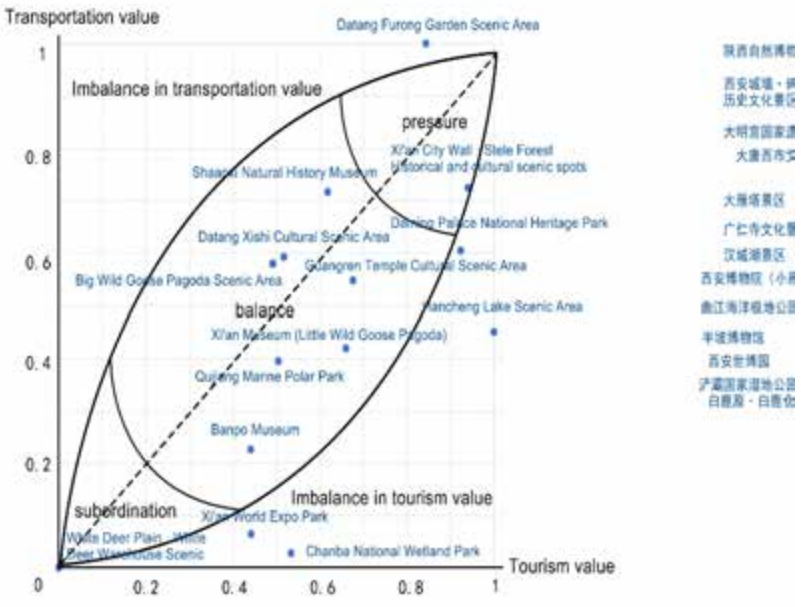
3. Development Judgment and Development Strategies

3.1 Balanced State

Table 3. Table of transportation tourism value of each scenic spot

Name of scenic spot	Traffic value	Tourism value
Big Wild Goose Pagoda Scenic Area	0.51	0.42
Datang Furong Garden Scenic Area	0.16	0.00
Xi'an City Wall · Stele Forest Historical and cultural scenic spots	0.06	0.28
Xi'an City Wall · Stele Forest Historical and cultural scenic spots	0.08	0.40
Shaanxi History Museum	0.51	0.42
Qujiang Marine Polar Park	0.50	0.61
Datang Xishi Cultural Scenic Area	0.48	0.41
Banpo Museum	0.56	0.77
Xi'an Museum (Little Wild Goose Pagoda)	0.34	0.58
Xi'an World Expo Park	0.56	0.94
Hancheng Lake Scenic Area	0.00	0.55
Chanba National Wetland Park	0.47	0.97
Shaanxi Natural Museum	0.38	0.28
White Deer Plain · White Deer Warehouse Scenic Area	1.00	1.00
Guangren Temple Cultural Scenic Area	0.32	0.45

Figure 4. Traffic tourism value model of scenic spots in the main urban area of Xi'an



According to the result analysis, the Shaanxi Natural History Museum, the Qujiang Ocean Polar Park, the Xi'an Banpo Museum, the Xi'an Museum (Xiaoyanta), the Guangren Temple Cultural Scenic Area, the Xi'an Datang West Market Cultural Scenic Area, the Xi'an Big Wild Goose Pagoda Scenic Area, and the Shaanxi History Museum are all in a balanced state, but their synergy levels vary. Specifically, the Big Wild Goose Pagoda Scenic Area and the Datang West Market Scenic Area are close to the 45° line, showing a better synergy state. Therefore, in their subsequent development planning, emphasis should be placed on ensuring that the traffic value and tourism value increase or decrease simultaneously to maintain and promote the continuous evolution of the synergy state. In contrast, although the Banpo Museum and the Xi'an Museum maintain a balanced state, they deviate significantly from the 45° line. Therefore, in the subsequent strategic deployment, attention should be focused on optimizing the value structure: strengthening the relatively low - level elements of their traffic value to avoid potential imbalance risks and ensure the robustness of overall balance and coordinated development.

3.2 Subordinate State

According to the result analysis, the Bailuyuan·Bailucang Scenic Area is in a subordinate state, with the traffic and tourism values being in synergy but at a low level, and the two values are equal and both low. In the later stage, targeted optimization strategies can be proposed, such as creating tourism special lines, adding bus stops, and increasing the implantation of characteristic shops.

3.3 Pressured State

According to the result analysis, the traffic value and tourism value of the Xi'an City Wall·Beilin Historical and Cultural Scenic Area are both at a high level, belonging to the pressured state. The advantages of popular scenic spots are fully reflected, and the node value and place value are relatively high, which is also consistent with people's general perception. The future development of this scenic area should focus on relieving traffic and urban development pressure and avoiding over - tourism development and traffic congestion as much as possible.

3.4 Imbalanced State

According to the result analysis, the Xi'an Datang Furong Garden Scenic Area, the Xi'an Chanba National Wetland Park, the Xi'an Expo Park, the Daming Palace National Heritage Park, and the Xi'an Han City Lake Scenic Area are all in an imbalanced state. Among them, the Datang Furong Garden Scenic Area is in a traffic - value imbalanced state, and the others are in a tourism - value imbalanced state. Therefore, in the subsequent tourism development, the Datang Furong Garden Scenic Area should pay attention to relieving traffic pressure and appropriately balancing tourism resources; the other scenic spots have good traffic accessibility but insufficient tourism development. In the future, attention should be paid to the implantation of the tourism industry to improve the tourist experience.

4. Conclusion

In summary, based on Luca Bertolini's node - place model, this research takes 15 scenic spots at or above 4A level in the main urban area of Xi'an as the research object and deeply explores the synergy between the traffic value and tourism value of public transportation routes between scenic spots. By constructing a comprehensive resistance surface, key factors such as public transportation station density, road network density, characteristic shop density, and scenic spot density are quantitatively analyzed, and then the development states of each scenic spot in the node - place model are revealed. The research results show that the development states between scenic spots are diverse, including the balanced state, the subordinate state, the pressured state, and the imbalanced state. According to the characteristics of each state, corresponding optimization strategies are proposed: for scenic spots in the balanced state, the traffic and tourism values should be increased or decreased simultaneously to promote coordinated development; for those in the subordinate state, the overall value should be improved by adding transportation facilities and enriching the tourism industry; for scenic spots in the pressured state, attention should be paid to traffic diversion and the balance of tourism carrying capacity to avoid over - development; for those in the imbalanced state, according to the specific situation, the transportation facilities should be optimized or the tourism industry should be implanted to achieve value balance and improvement. This research not only provides a scientific basis for the optimization of public transportation routes between scenic spots in the central urban area of Xi'an but also offers valuable references for the integrated development of transportation and tourism in other cities.

Referencing style

Journal article:

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Evaluation and Optimization of Public Service Facility Accessibility in Planning Future Community Living Circles: A Case Study of Yangpu District, Shanghai, China

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Abstract
Addressing imbalanced public cultural and sports facility (PCSF) allocation amidst China's urban quality enhancement and "15-minute community life circle" initiatives, this study investigates Siping Road Sub-district, Shanghai, to reveal PCSF supply-demand contradictions and propose optimization strategies. It innovatively employs an "availability-accessibility-adaptability" framework, integrating objective supply-demand metrics with subjective satisfaction surveys. Availability is assessed via current statistics; accessibility via the 2SFCA method and resident usage (time, preferences); and adaptability via questionnaires and regression models analyzing satisfaction and its influencing factors. Finally, the Importance-Performance Analysis (IPA) model identifies core contradictions, with "place-based" and "people-based" optimization suggestions providing empirical references for precise PCSF allocation and "15-minute community life circle" construction.

Keywords: Life Circle; Public Cultural and Sports Facilities; Supply-Demand Relationship; Accessibility; Satisfaction

1. Introduction

1.1 Research Background

The "14th Five-Year Plan" mandates accelerating urban development transformation, promoting urban spatial structure optimization and quality improvement. Consequently, the "Shanghai '15-Minute Community Life Circle' Planning Guidelines (Trial)" emerged, offering a new policy framework for improving residential public service facility allocation(Wu and Sun 2024).However, despite China's promotion of national fitness and modern public cultural services, public cultural and sports facility supply-demand contradictions persist(Peng et al. 2023).These include insufficient venues, uneven high-quality resource distribution, service-need disconnects, and varied facility management levels, causing significant allocation imbalances and inadequacies (Song, Kong and Cheng 2024).Shanghai's "15-minute community life circle" initiative, which prioritizes rectifying cultural and sports facility shortcomings and enhancing service efficiency to improve community life quality and resident well-being, necessitates this research.

1.2 Research Purpose and Significance

This study selects Siping Road Sub-district, Yangpu District, Shanghai, to: comprehensively evaluate its public cultural and sports facility allocation and resident perception; deeply analyze facility supply and resident demand matching (supply-demand ratio, usage behavior, satisfaction); accurately identify current allocation's main contradictions; and propose targeted, operable optimization strategies from the "15-minute community life circle" perspective, integrating "place-based" and "people-based" ideas.

The research's significance is: theoretically, constructing a multi-dimensional "Availability-Accessibility-Adaptability" evaluation framework for cultural and sports facility planning, deepening understanding of community residents' behavioral geography; practically, providing decision support for Siping Road Sub-district and similar areas' cultural/sports facility planning and "15-minute community life circle" construction, aiming to enhance living environments and resident well-being.

1.3 Relevant Theoretical Basis

This research uses Public Service Facility Accessibility theory. Accessibility, a core measure of residents' ease of accessing public services, includes physical access (distance, transport) and non-spatial dimensions (service acquisition fairness, subjective service quality perception). Classic methods include shortest distance and 2SFCA. (Xie et al. 2023)

This study adapts Wiszbinski and Thomas et al.'s 5A service accessibility model (Availability, Accessibility, Affordability, Acceptability, Adaptability). (Peng et al. 2023)Considering cultural/sports facilities' public welfare nature and research focus, a localized, simplified three-dimensional framework was built:

1)Availability: Objective supply level of public cultural/sports facilities (type, quantity, scale, coverage)—the basis for evaluating supply-demand.

2)Accessibility: Convenience of resident access/utilization and facility service capacity manifestation—how supply-demand plays out in service. Measured by supply-demand ratio and resident usage behavior (time, preference).

3)Adaptability: Degree facilities meet diverse, personalized resident needs and residents' subjective service evaluation—demand feedback. Measured by resident satisfaction and influencing factors.

This framework aims for a comprehensive evaluation from "objective facility existence" to "actual resident use" to "residents' subjective feelings," reflecting true service effectiveness.

2.Research Area Overview and Facility Status

2.1 Overview of Siping Road Sub-district

Siping Road Sub-district, in central-western Yangpu District, Shanghai (approx. 2.64 km²), is core to the "Tongji Knowledge Economy Circle." Dominated by education/research and residential functions, it hosts many design/creative industries. Residential buildings, mainly 1950s-1980s workers' new villages (low-rise, high-density), face renewal pressure. High population density shows an "elderly, young, and highly educated" structure: many over 60s and college-educated individuals, plus adolescents, creating diverse demands for public cultural/sports facilities.

2.2 Current Status of Public Cultural and Sports Facilities in Siping Road Sub-district

Field surveys, data collection, and POI analysis show:

Sports Facilities: Mainly outdoor small fitness points and simple park venues; lacks large, comprehensive indoor stadiums. Quality resources (standard fields, pools) are concentrated in units like Tongji University, with limited community sharing, creating scarcity. Overall: "many small points, limited types, difficult quality resource sharing, limited service radius," failing to meet growing, diverse fitness needs, especially for young/middle-aged groups.

Cultural Facilities: Mainly elderly activity rooms, neighborhood center chess/card/reading rooms; lacks comprehensive centers, libraries, exhibition halls, small theaters for all ages, especially young/middle-aged. Uneven spatial distribution (mostly southeast) shows: "elderly-focused, singular functions, no comprehensive venues, uneven distribution," failing diverse cultural exchange, learning, leisure needs. Generally, Siping's facilities lack sharing, quantity/quality, functional diversity, and balanced layout, short of "15-minute community life circle" goals.

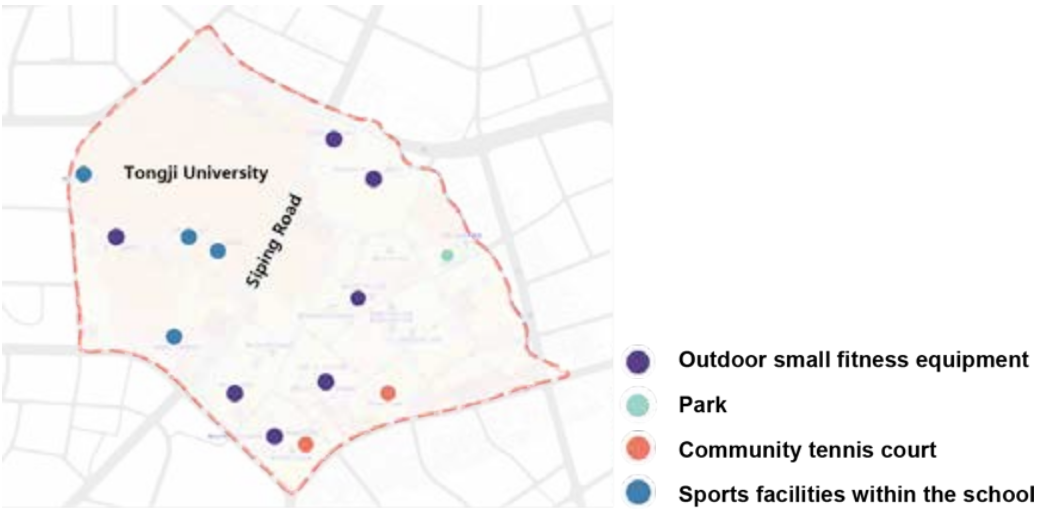

Fig.1. The current distribution of sports facilities

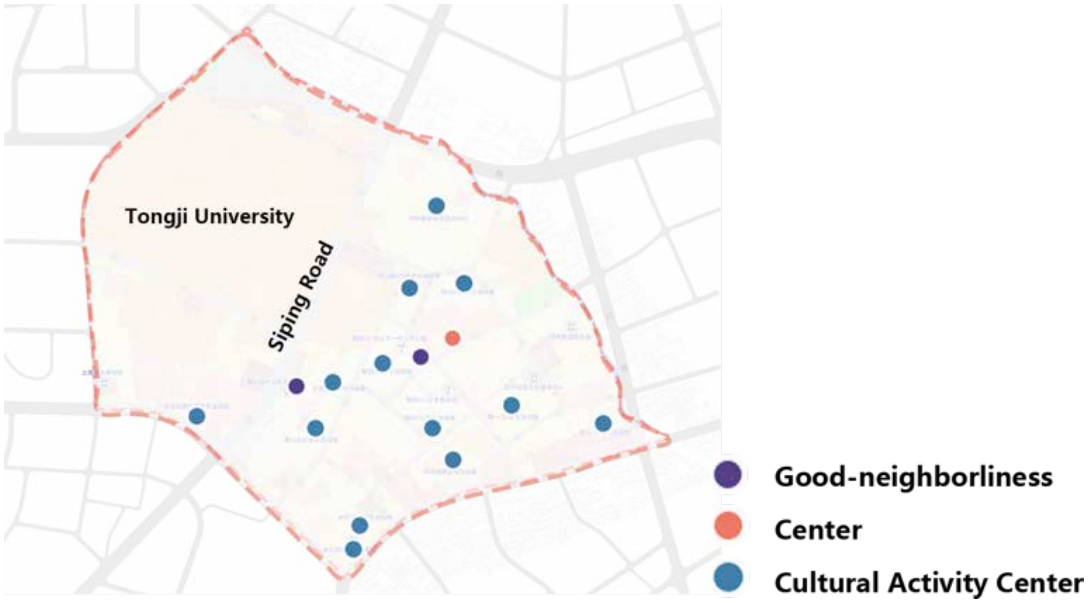

Fig.2. The current distribution of cultural facilities

2.3 Life Circle Division and Resident Cognition
Siping Sub-district has two main life circle types:

1 University Life Circle: Around Tongji University, serving mainly students, faculty, some nearby residents. Facilities are partly campus-internal, with sharing barriers.

2 Residential Life Circle: Covering vast workers' new villages; high population density, high aging, urgent need for embedded, accessible cultural/sports facilities.

A preliminary survey on resident facility perception found: over half feel a lack of facilities (especially cultural), prominent in southeastern older areas. Information is mainly via community/internet promotions. Nearly a quarter perceive no facilities within a 15-minute walk. Most are willing to use facilities, but unsuitable functions, poor accessibility, conflicting hours, and outdatedness are obstacles. A 10-15 minute walk is desired. These findings underpin deeper analysis and highlight the need for a resident-centric view.

3. Research Design and Methods
This study, using the "Availability-Accessibility-Adaptability" framework, employs multi-source data and quantitative methods to evaluate Siping's public cultural/sports facility supply-demand. Availability evaluation integrates field surveys, government data, and Gaode POI data (facility types, quantities, distribution), using GIS for spatial visualization/density analysis. Accessibility evaluation (neighborhood committee as unit) uses 2SFCA to quantify facility service capacity-population demand matching, with spatial autocorrelation for supply-demand ratio clustering. Concurrently, 182 resident questionnaires analyze usage frequency, time preferences, and functional demand differences. Adaptability evaluation (subjective resident perception) uses multiple linear regression to identify impacts of eight factors (e.g., environment, functional richness) on overall satisfaction. IPA, correlating supply-demand ratios with satisfaction, identifies four contradictory area types (e.g., high supply-demand/high satisfaction), guiding differentiated optimization.

Data sources: 1) Facility data: field mapping, government documents, POI cross-validation. 2) Population data: sub-district office's neighborhood committee-level statistics. 3) Resident behavior/satisfaction: stratified sampling (online/offline surveys) covering usage, satisfaction, importance ranking. Methods: GIS spatial analysis (layout balance), 2SFCA (spatial accessibility), statistical regression (satisfaction drivers), IPA (priority improvement areas), achieving objective supply-subjective demand diagnosis.

4.Research Results and Analysis

4.1 Availability Analysis of Public Cultural and Sports Facilities

As per Section 2.2, Siping's facilities are deficient in total quantity, type diversity, spatial distribution balance, and quality resource sharing. Sports facilities are mainly small-scale/outdoor; large comprehensive venues are scarce, campus resources undershared. Cultural facilities favor elderly services, lacking comprehensive, high-quality venues for other groups. This supply-level "inherent deficiency" underlies subsequent supply-demand issues.

4.2 Accessibility Analysis of Public Cultural and Sports Facilities

4.2.1 Supply-Demand Matching Analysis (based on 2SFCA)

2SFCA calculation of Siping's neighborhood committee cultural/sports facility supply-demand ratios shows significant overall "demand exceeding supply." Spatially, matching is heterogeneous: Tongji University and adjacent areas have higher ratios (due to campus resources, despite sharing issues); most dense, older workers' new villages are supply-demand "lowlands" due to severe under-configuration. Spatial autocorrelation (Moran's I) confirmed non-random spatial distribution: significant positive correlation (high-high, low-low clustering). Local LISA maps identified "Low-Low" clusters, mainly in workers' new villages—key deficient areas needing urgent attention.

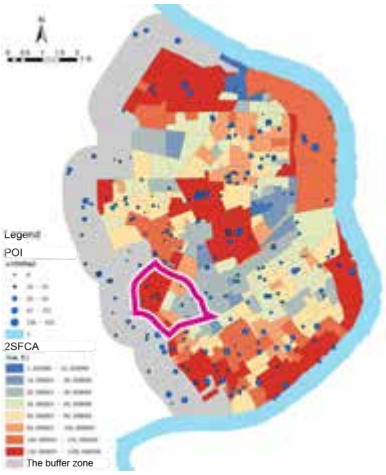

Fig.3. 2SFCA for calculating the supply-demand ratio

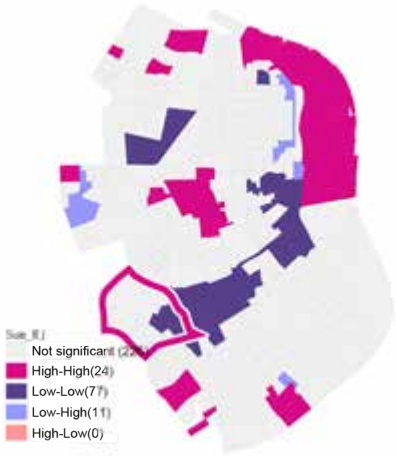

Fig.4. Spatial clustering analysis

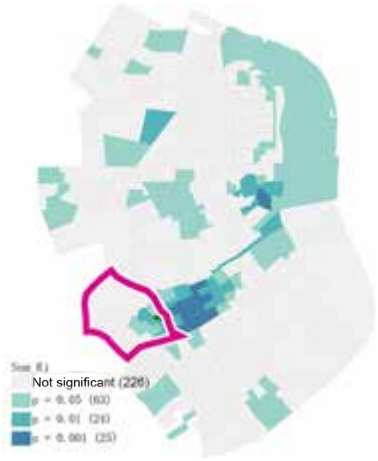

Fig.5. Analysis of spatial agglomeration significance

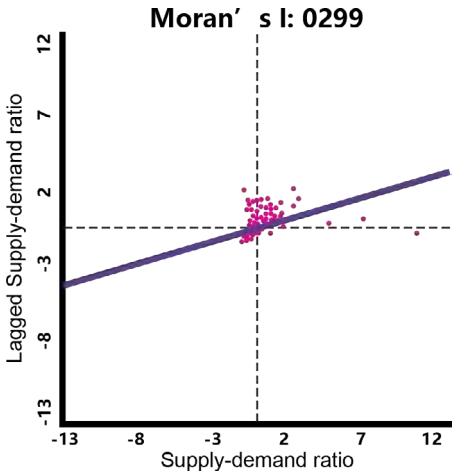

Fig.6. Moran index scatter plot

4.2.2 Analysis of Resident Usage Time Characteristics

Questionnaire data show distinct age-group patterns in facility usage times:

Usage Frequency: Younger (19-28 years) and elderly (over 60 years) groups are more frequent users. Younger individuals for post-study/work leisure/fitness; elderly due to more retirement leisure. Middle-aged (29-45, 46-60 years) use is less frequent/consistent, likely due to work/family pressures.

Overall, sports facility usage frequency is generally higher than cultural facilities, reflecting stronger daily fitness demand.

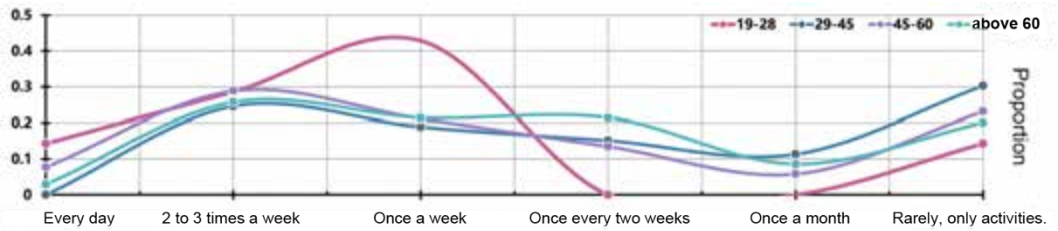

Fig.7. Frequency of use of public cultural facilities

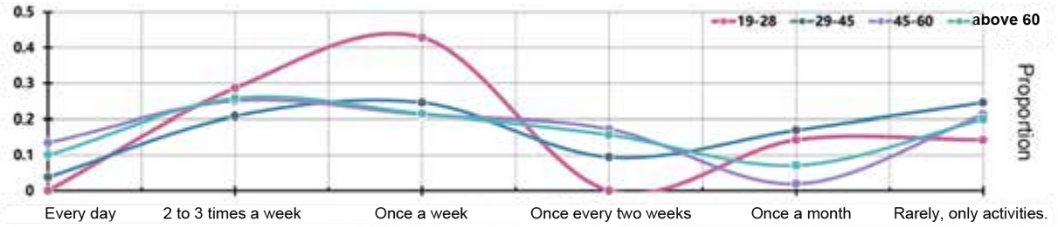

Fig.8. Frequency of use of public sport facilities

Usage Duration:Younger and elderly groups spend longer average times per visit. Middle-aged groups prefer shorter, efficient use (e.g., <30-min fitness). Elderly cultural activity time is increasing.

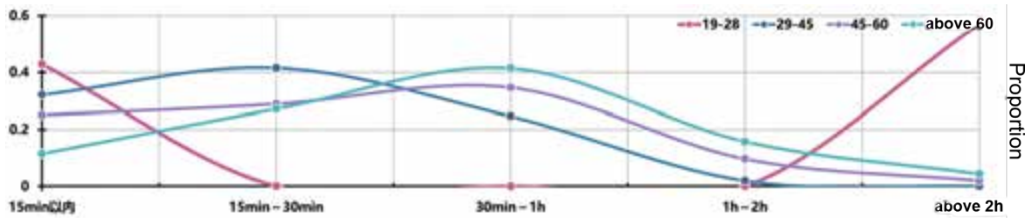

Fig.9. The duration of use of public cultural facilities

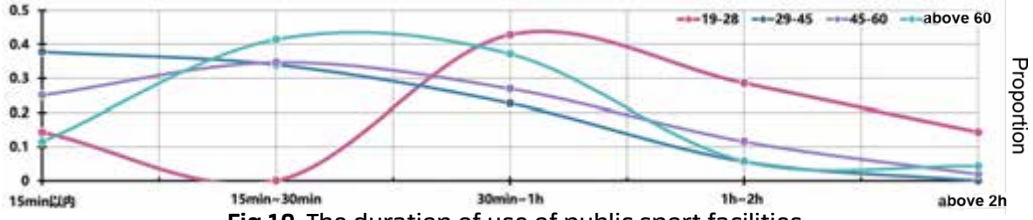

Fig.10. The duration of use of public sport facilities

Usage Time Distribution (Weekdays and Weekends):
Cultural Facilities:
1-Younger groups: Mainly weekend daytime (e.g., 9:00-18:00).
2-Middle-aged groups: More often weekday evenings (e.g., 18:00-21:00) and weekends.
3-Elderly groups: Widely distributed, but early mornings (weekdays/weekends) (e.g., 6:00-9:00) are a peak for cultural activities (morning exercises, reading).

Sports Facilities:Bimodal or multimodal characteristics across age groups.
1-Younger groups: Peaks on weekday evenings and weekends.
2-Middle-aged groups: Primarily weekday evenings for fitness.
3-Elderly groups: Early mornings (weekdays/weekends) (morning exercises) and off-peak daytime are main times.

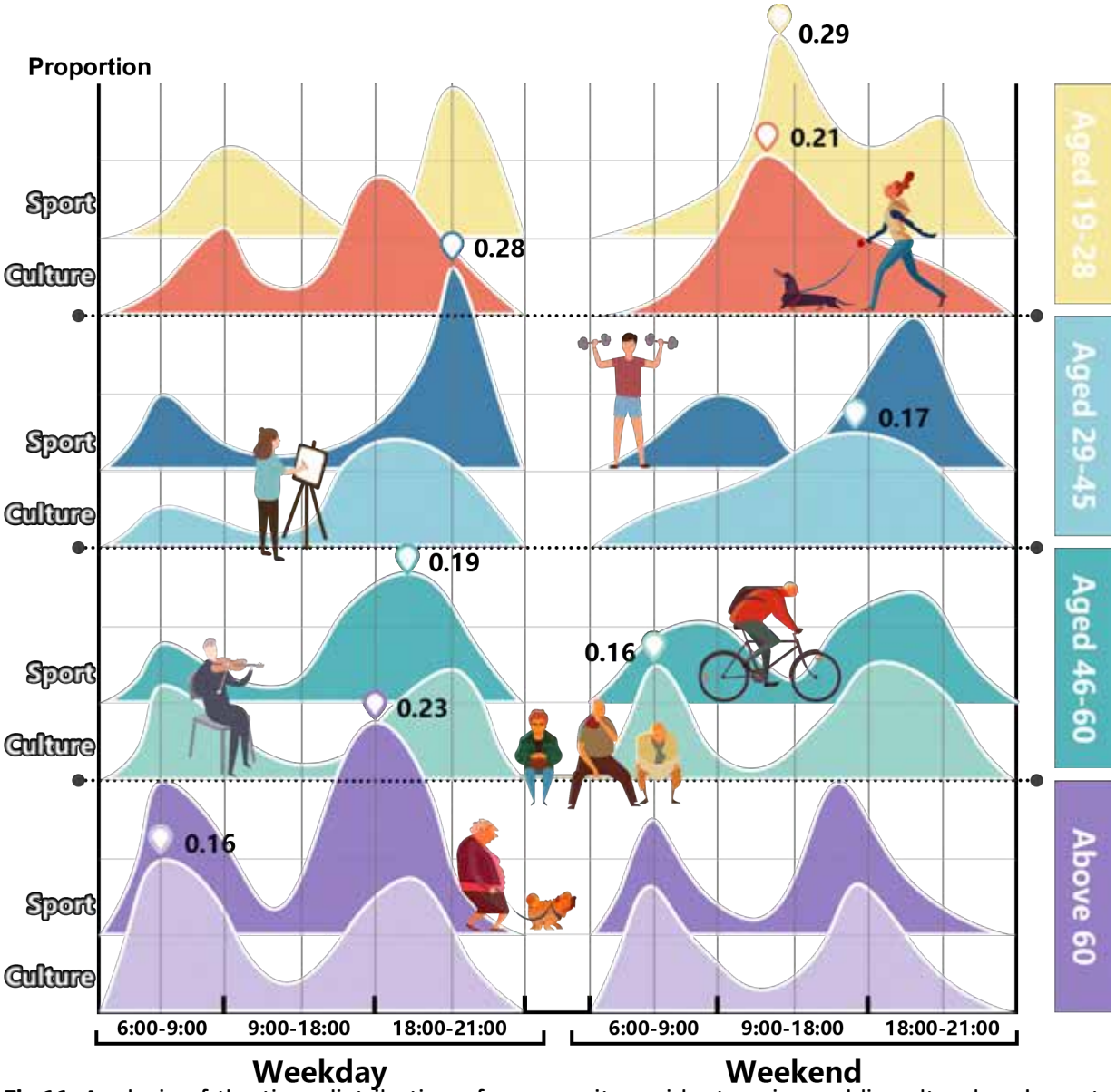

Fig.11. Analysis of the time distribution of community residents using public cultural and sports facilities

These time differences demand specific facility opening hours, off-peak guidance, and enhanced nighttime service.

4.2.3 Analysis of Resident Usage Preferences
Facility type/function preferences show significant age differentiation:

Cultural Facility Preferences:
Facility Type:
1-All ages: Libraries and cinemas (if available/accessible) are popular.
2-Younger: Higher demand for museums, art/exhibition halls.
3-Middle-aged: Besides libraries, community classrooms, art studios (skills/interests).
4-Elderly: Strongest demand for community cultural centers, elderly activity/chess/calligraphy rooms.

Facility Function:
1-Younger: Emphasize exhibitions, reading/research, knowledge acquisition, skills training.
2-Middle-aged/Elderly: Prefer leisure/entertainment, social interaction, cultural activities/festivals.
3-Universal: Leisure/entertainment and reading/research are core expectations.

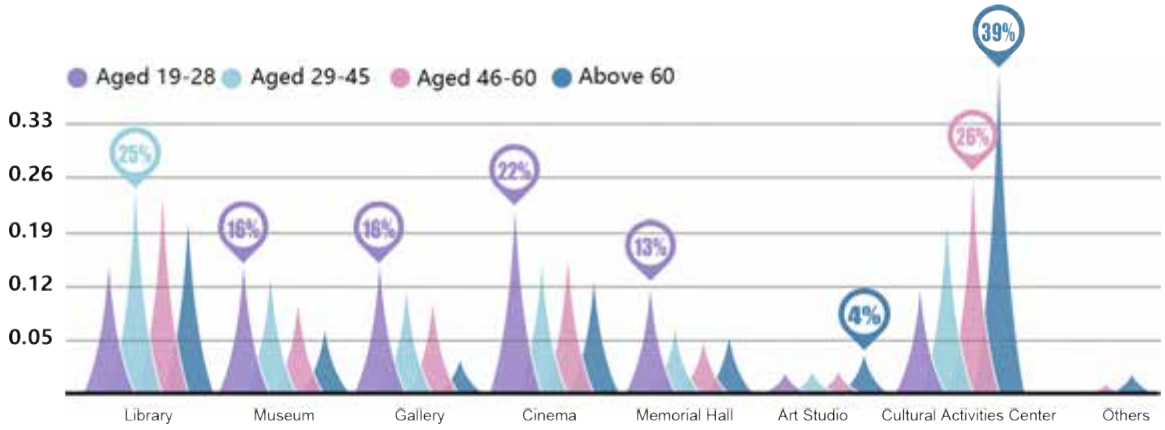

Fig 12. Analysis of Public Cultural Facilities Preference Types

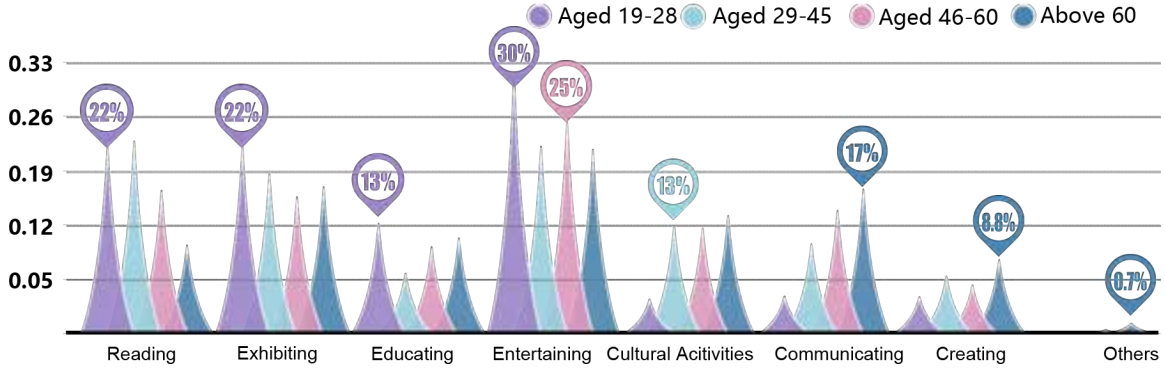

Fig 13. Analysis of Functional Preferences for Public Cultural Facilities

Sports Facility Preferences:
Facility Type:
1-Younger: Prefer comprehensive fitness centers, pools, courts (basketball, badminton, tennis), climbing gyms; strong demand for open school facilities.
2-Middle-aged: Higher demand for gyms, multi-functional sports grounds, fitness trails.
3-Elderly: Most use outdoor venues (parks, squares), outdoor equipment, gateball courts, Tai Chi areas, community fitness trails; indicates lack of suitable indoor elderly facilities.
Community sports centers (if composite) can meet some needs across ages.

Facility Function:
1-All ages: Fitness/exercise is core.
2-Younger: Prefer sports training, competitions, courses.
3-Middle-aged: Also health guidance, relaxation.
4-Elderly: Increasing demand for leisure, social interaction, health preservation.

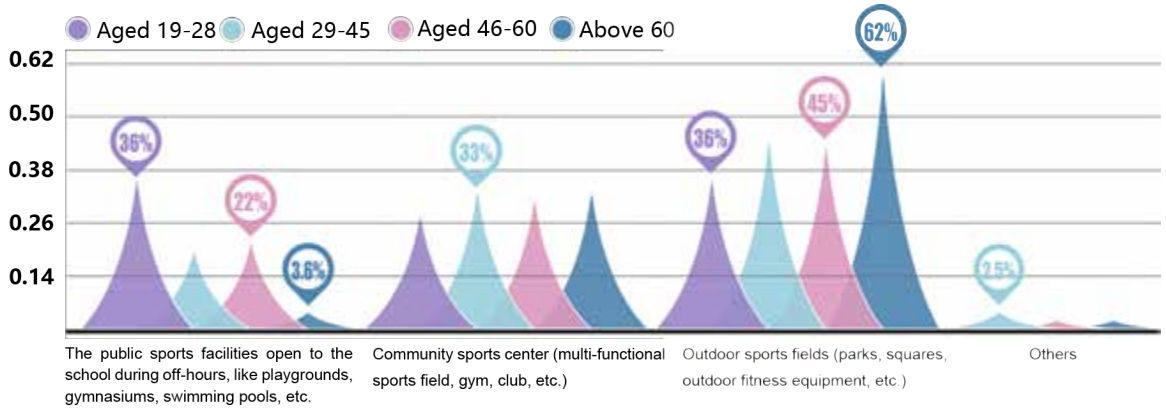

Fig 14. Analysis of Public Sports Facilities Preference Types

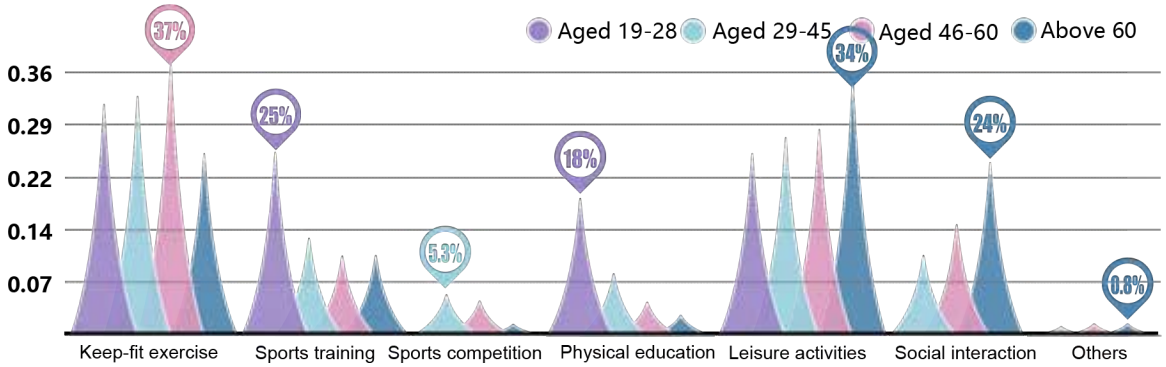

Fig 15. Analysis of Functional Preferences for Public Sports Facilities

Matching Degree: Existing Functions vs. Resident Needs:
1-A significant gap exists; complete matching is very low. Original data: cultural facilities 10.7% complete match, sports 3.6%.
2-Specific mismatches: High demand for cultural leisure/reading, but supply/quality need improvement, especially for middle-aged/elderly. Sports: high demand for fitness/leisure, but existing facilities insufficient, especially for middle-aged. Elderly better, but need age-appropriate, guided indoor options.
3-The middle-aged group (29-45 years) shows severe cultural/sports functional mismatch, needing focus.
These preferences guide facility type, function, design, and service innovation.

4.3 Adaptability Analysis of Public Cultural and Sports Facilities (Satisfaction Evaluation)

4.3.1 Overall Resident Satisfaction

Relatively high overall dissatisfaction: Over 30% "overall dissatisfied" or "somewhat dissatisfied." Sports facilities: 35% dissatisfied; cultural: 33.5%. Widespread problems meeting expectations.

Significant age differences:
1-Elderly (over 60): lowest overall satisfaction. Possibly due to stronger reliance but unmet needs (accessibility, age-friendly design, service).
2-Middle-aged (29-45), especially younger segment: relatively higher satisfaction. Possibly due to lower use frequency or expectations; needs further analysis.

Satisfaction with specific indicators:
1-Sports: 19-45 age group: higher satisfaction with opening hours, environment, functional richness, participation convenience. Elderly (over 60): significantly lower satisfaction with accessibility, opening hours (insufficient morning/early evening closure), environment (outdated equipment, uneven grounds, no shade/rain protection).
2-Cultural: 19-45 age group: higher satisfaction with environment, functional richness, participation convenience, educational value. Over 46, especially elderly (over 60): lower satisfaction, particularly accessibility (distance, no elevators), opening hours (insufficient lunch/weekend opening), environment (small spaces, poor lighting, uncomfortable seating).

Key factors influencing satisfaction (resident perspective, preliminary ranking): Facility accessibility, opening hours, environment, special group friendliness considered most important. Cleanliness, safety, comfort directly impact experience; distance/transport affect use; schedule-matching opening hours crucial; elderly/child-friendly design significantly enhances satisfaction.

4.3.2 Analysis of Satisfaction Influencing Factors (Based on Multiple Linear Regression Model)

To more scientifically reveal the specific contribution of each sub-item to overall satisfaction, this study utilized multiple linear regression analysis.

Table 1. Analysis of Influencing Factors of Satisfaction

	Facility accessibility	Opening hours	Facilities and environment	Functional richness	Convenience of participation	Educational Value	Interactive experience	Friendliness to special groups
Satisfaction with public sports facilities	0.07	0.083	0.357	0.195	0.19	0.02	0.098	0.024
Satisfaction with public cultural facilities	0.203	0.134	0.218	0.087	0.045	0.257	0.032	0.138
Comprehensive satisfaction with public cultural and sports facilities	0.125	0.09	0.256	0.137	0.168	0.151	0.041	0.056

Main drivers of satisfaction with public sports facilities:
1-Facilities and Environment (largest standardized regression coefficient, strongest impact): This includes the cleanliness of the venue, the condition and maintenance of equipment, safety during use, and overall aesthetics and comfort. A good physical environment is fundamental to guaranteeing the sports activity experience.
2-Functional Richness: This refers to whether the types of programs offered by sports facilities are diverse and can meet the needs of different age groups and people with different sports preferences. Facilities with monotonous functions struggle to attract residents in the long term.
3-Convenience of Participation: This includes the simplicity of the reservation process, waiting time for venue use, and ease of information access. Convenient participation channels can effectively increase usage frequency and satisfaction.

Main drivers of satisfaction with public cultural facilities:
1-Educational Value (largest standardized regression coefficient, strongest impact): This refers to whether the content provided by cultural facilities contributes to knowledge dissemination, skill learning, cultural inheritance, and personal literacy improvement. Residents' demand for the spiritual and cultural aspects of cultural facilities is increasing.

2-Facilities and Environment: Similar to sports facilities, the cleanliness, comfort, safety, and cultural atmosphere of cultural facilities are also important factors affecting satisfaction.
3-Facility Accessibility: Convenient geographical location, smooth traffic connections, and reasonable walking distances are prerequisites for residents to choose and use cultural facilities.

Gap analysis between importance and current satisfaction status:
By comparing the "importance" scores (representing expectation levels) and "satisfaction" scores (representing current status evaluations) for each sub-item in the questionnaire, it was found that: for both public sports facilities and public cultural facilities, residents' average expectation level for each indicator was higher than their average evaluation of the current situation.

The items with larger gaps, indicating significant shortcomings, were mainly concentrated in: Facilities and Environment (high expectations, but generally low current evaluations), Functional Richness (desire for diverse facility functions, but current supply is monotonous), and Friendliness to Special Groups (e.g., designs and services suitable for the elderly and children, high expectations, but generally insufficient currently). These gap items are the key areas where future facility optimization and improvement efforts should be focused and invested.

4.4 Analysis of Supply-Demand Contradictions in Public Cultural and Sports Facilities (Based on IPA Model)

To comprehensively present the complex relationship between supply-demand matching (represented by the "supply-demand ratio") and residents' subjective perceptions (represented by "overall satisfaction"), this study drew on the IPA model concept to classify each neighborhood committee into four quadrants, thereby identifying different types of supply-demand contradictions. Fig.16 illustrates the supply-demand ratio values for each neighborhood committee, Fig.17 shows the overall satisfaction with public cultural and sports facilities in each neighborhood committee, and Fig.18 depicts the heterogeneity of the IPA result space.

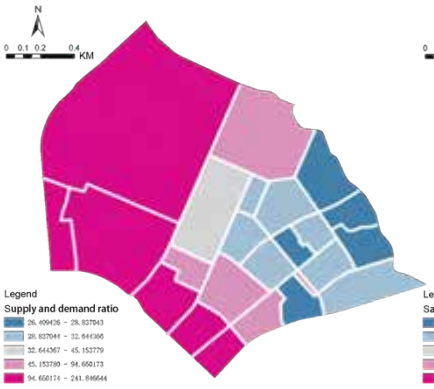

Fig.16. The supply-demand ratio values of each neighborhood committee

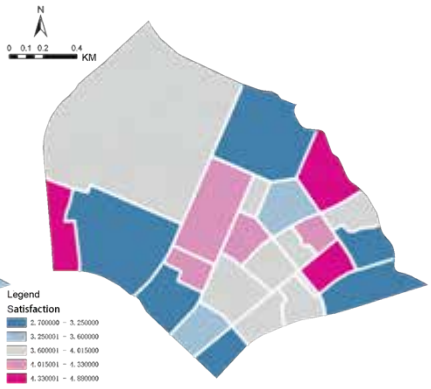

Fig.17. Overall satisfaction with public cultural and sports facilities in each neighborhood committee

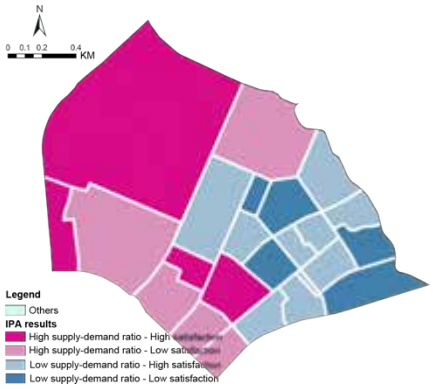

Fig.18. Heterogeneity of the IPA result space

Quadrant A: High Supply-Demand Ratio - High Satisfaction (Advantage Maintenance Zone):
∑ **Characteristics**: These areas (such as Miyun Road Neighborhood Committee, Jin'an Neighborhood Committee, etc., mentioned in the original report) have relatively abundant cultural and sports facility resources, and residents' satisfaction with these facilities is also high.

∑ **Interpretation**: This indicates that in these areas, not only is the quantity of facilities relatively guaranteed, but their quality, operation management, and services also effectively meet residents' needs. Strategically, existing service levels should be maintained and enhanced, and these areas can serve as models for promotion.

Quadrant B: Low Supply-Demand Ratio - High Satisfaction (Potential Mining Zone / Priority Area for Improving Supply):
∑ **Characteristics**: In these areas (such as Anshan Third Village Neighborhood Committee, etc.), although the objective supply of cultural and sports facilities (supply-demand ratio) is not high, residents' satisfaction is relatively high.

∑ **Interpretation**: This may imply that the few facilities in these areas are of high quality and well-operated, or that residents have low expectations for community facilities, or that specialized services accurately meet the needs of specific groups. Strategically, while maintaining the existing service quality and features, the focus should be on increasing the quantity and types of facilities to alleviate the pressure of insufficient supply and further enhance the overall service level.

Quadrant C: High Supply-Demand Ratio - Low Satisfaction (Key Service Improvement Zone / Prominent Human-Oriented Contradiction Zone):
∑ **Characteristics**: These areas (such as Tongji New Village Neighborhood Committee, Anshan Sixth Village Neighborhood Committee, etc.) have a relatively large number of cultural and sports facilities (higher supply-demand ratio), but residents' satisfaction is low.

∑ **Interpretation**: This is a typical phenomenon of "supply-demand mismatch" or "quantity without quality". Possible reasons include: facility types not matching residents' needs, outdated and poorly maintained facilities, chaotic management, poor service quality, unreasonable opening hours, or overcrowding leading to a poor user experience. Strategically, instead of blindly increasing quantity, the focus should be on improving facility quality, optimizing functional combinations, enhancing operational management, and enriching service content to address unmet "human-oriented needs".

Quadrant D: Low Supply-Demand Ratio - Low Satisfaction (Comprehensive Improvement Zone / Coexisting Human-Land Contradiction Zone):
∑ **Characteristics**: In these areas (such as Anshan First Village Third Neighborhood Committee, etc.), the supply of cultural and sports facilities is severely insufficient, and residents' satisfaction is also very low.

∑ **Interpretation**: This is the most problematic area, with significant shortcomings in both the quantity and quality of facilities, representing the most concentrated manifestation of supply-demand contradictions. Strategically, comprehensive and systematic improvements are needed, including increasing facility quantity, optimizing spatial layout, enhancing facility quality, and enriching service content.

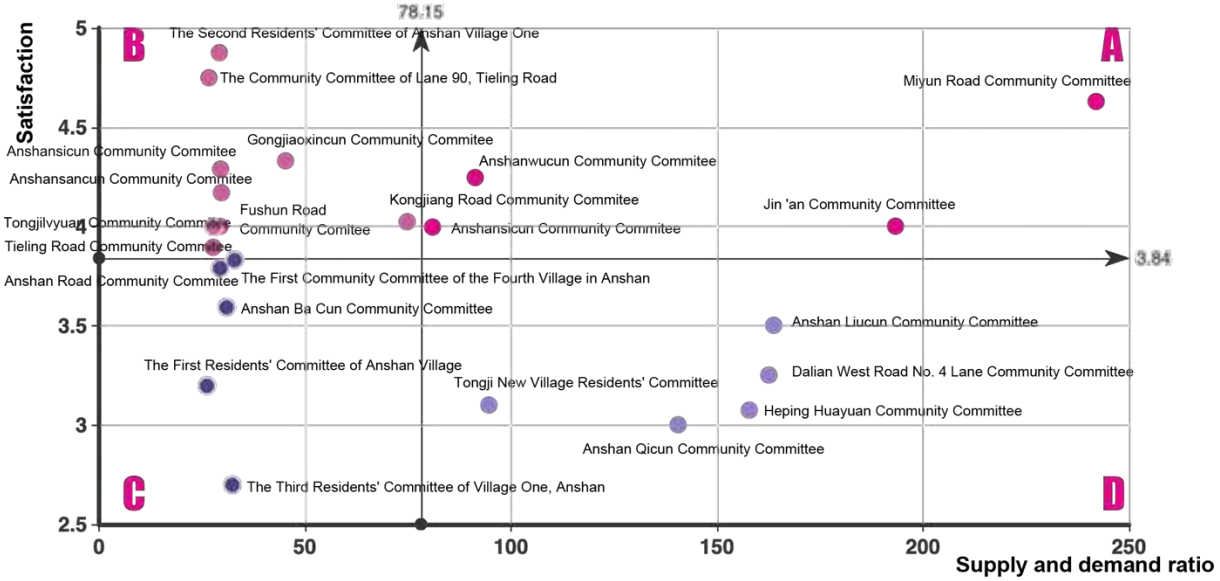

Fig 19. IPA Model Analysis

Based on the above analysis, the core supply-demand contradictions of public cultural and sports facilities in Siping Sub-district can be summarized as follows:

∑ **1-Contradictions at the Availability Level**: Insufficient total quantity and monotonous types of facilities make it difficult to cover and meet the basic cultural and sports needs of diverse populations within the sub-district (especially for the young and middle-aged groups and those with different interest preferences). Barriers to the sharing of high-quality resources (such as facilities within universities) exacerbate the scarcity of available resources.

∑ **2-Contradictions at the Accessibility Level**: Uneven spatial layout leads to some densely populated old residential communities becoming service blind spots or weak areas, resulting in poor convenience for residents to actually reach and use facilities. The functional supply of existing facilities does not fully match the actual usage behavior habits of residents (such as time preferences, functional preferences), leading to inefficient resource utilization.

∑ **3-Contradictions at the Adaptability Level**: The quality, maintenance level, operational management, and service content of existing facilities have failed to effectively respond to the actual needs and expectations of residents, especially special groups such as the elderly, leading to low subjective satisfaction among residents. Facilities have shortcomings in terms of humanized design, professional guidance, interactive experience, and cultural atmosphere creation.

The identification of these contradictions lays a solid foundation for proposing targeted optimization strategies in the next stage.

5. Conclusions and Optimization Suggestions

5.1 Main Conclusions

Based on a systematic analysis of the availability, accessibility, and adaptability of public cultural and sports facilities in Siping Sub-district, this study draws the following main conclusions:

1-Coexistence of Supply-Side Structural Shortages and Spatial Imbalances: The total quantity of public cultural and sports facilities in Siping Sub-district struggles to meet the actual demands of its high-density population, presenting an overall situation where "supply falls short of demand". Concurrently, prominent issues include the homogeneity of facility types (sports facilities are predominantly small-scale outdoor equipment, while cultural facilities are largely oriented towards elderly services) and an uneven spatial distribution (high-quality resources are concentrated within universities or specific areas, with insufficient coverage in older residential communities). There is a particularly severe undersupply of cultural and sports spaces catering to young and middle-aged groups and meeting diverse, high-quality needs.

2-Significant Group and Temporal Differentiation in Resident Usage Behavior: The "young and old" demographic groups (youth and the elderly) are the primary users of public cultural and sports facilities, exhibiting relatively higher usage frequency and longer single-use durations. Clear, differentiated characteristics are observed among different age groups concerning preferences for facility types (e.g., youth prefer professional sports and experiential cultural activities, while the elderly favor outdoor fitness and social-cultural activities), functional demands (e.g., youth prioritize skill enhancement and knowledge acquisition, whereas middle-aged and elderly individuals focus on leisure, entertainment, and health-related social interaction), and usage time slots (e.g., youth during weekends and weekday evenings, the elderly in mornings and daytime).

3-Overall Resident Satisfaction is Not High, with a Gap Between Service Experience and Expectations: Over thirty percent of residents expressed dissatisfaction with existing cultural and sports facilities. Elderly groups, in particular, reported significantly lower satisfaction regarding facility accessibility, reasonableness of opening hours, comfort of the facility environment, and friendliness towards special groups. Regression analysis identified facility environment, functional richness, educational value (for cultural facilities), and convenience of participation as key factors influencing resident satisfaction. Residents' expectation levels for these factors generally surpassed their current evaluations, reflecting a considerable disparity between the service quality and experiential aspects of existing facilities and the actual needs and expectations of the residents.

4-The Phenomenon of Supply-Demand Mismatch Cannot Be Ignored; Precise Alignment is Key to Improvement: The IPA model analysis revealed instances of "high input (high supply-demand ratio) - low satisfaction" or "low input (low supply-demand ratio) - low satisfaction" in certain areas. This indicates that merely increasing the quantity of facilities cannot fully resolve the issues; the crucial aspect lies in achieving a precise alignment between facility provision and actual resident needs across multiple dimensions, including facility type, function, quality, and operational management.

5.2 Optimization and Improvement Strategies

Based on the above conclusions and identified core supply-demand contradictions, this study adheres to the principles of "problem-oriented, demand-led, context-specific adaptation, and classified policy implementation". From both "place-based" (focusing on spatial optimization and facility layout) and "people-based" (focusing on population needs and service improvement) dimensions, an "identification-evaluation-optimization-improvement" action system is constructed, proposing the following specific optimization and improvement strategies:

5.2.1 The "Identification-Evaluation-Optimization-Improvement" Action System Construction Logic

This system emphasizes first identifying specific supply-demand contradictions and their characteristics in different areas and for different facility types through scientific methods (such as 2SFCA, questionnaire surveys, IPA model); then conducting a multi-dimensional evaluation to clarify the severity of the problems and influencing factors; based on this, targeted optimization plans are formulated; finally, through continuous monitoring and feedback, the service capacity is continuously improved.

5.2.2 Specific Optimization and Improvement Strategies (Category-based Policies)

1-**For "High Supply-Demand Ratio - Low Satisfaction" Areas (Prominent Human-Oriented Demand Contradiction, corresponding to Quadrant C of the IPA model):**The core strategy for this area is to improve quality and efficiency and optimize the service experience. Specific measures include: comprehensively inspecting and optimizing the quality and environment of existing facilities, such as updating old equipment, improving site conditions (increasing lighting, seating, enhancing cleanliness, etc.), and creating a safe and comfortable atmosphere; conducting in-depth research on resident needs (especially for low-satisfaction groups) to reshape facility functions or update content, introducing more popular projects and courses; flexibly adjusting opening hours based on residents' usage time characteristics (e.g., extending evening hours, ensuring weekend availability), promoting staggered usage, and introducing professional management or volunteers to enhance guidance and service levels, and establishing convenient reservation and feedback mechanisms.

2-**For "Low Supply-Demand Ratio - Low Satisfaction" Areas (Coexisting Human-Land Demand Contradiction, corresponding to Quadrant D of the IPA model):**The core strategy for this area is to address shortcomings and improve quality simultaneously, carrying out systematic comprehensive improvement. Specific measures include: prioritizing from a "people-based" perspective, based on the demographic structure and needs assessment of the area, supplementing the most lacking facility types that residents urgently need, such as professional sports venues, fitness centers, or youth centers for young people, multi-functional activity rooms and fitness trails for young and middle-aged people, and health and wellness activity places and teaching points for elderly universities for the elderly; simultaneously, considering "place-based" conditions, fully tapping into potential spaces (such as idle factories, community rooms awaiting renovation), conducting scientific site selection and intensive, networked layout according to facility service radius and coverage gaps, avoiding new imbalances; and promoting the "1+N" embedded spatial layout model, i.e., creating a functionally composite "People's Square" style community comprehensive service core, supplemented by flexible, scattered "Six Arts Pavilion" style micro-service contact points, connected by slow-traffic systems to form a conveniently accessible service network.

3-**For "Low Supply-Demand Ratio - High Satisfaction" Areas (Prominent Place-Based Demand Contradiction, corresponding to Quadrant B of the IPA model):**The core strategy for this area is to focus on increasing supply while maintaining service quality. Specific measures include: learning from the successful operational experience of existing facilities, maintaining their service characteristics and quality; accurately identifying spatial coverage gaps, prioritizing the addition of similar or related types of high-quality facilities in service blind spots or underserved adjacent areas;

rationally determining the type and scale of new facilities based on available site conditions and coordinating with the surrounding environment; while increasing quantity, continuously monitoring and enhancing facility quality and capacity to prevent service quality decline due to scale expansion.

4-**Universal Optimization Strategies (Applicable to all areas):**The open sharing of cultural and sports facilities in campuses and enterprises/institutions with the community should be vigorously promoted, with sound incentive and management mechanisms established to open up high-quality resources in phases, at different times, and under certain conditions to alleviate insufficient supply. At the same time, flexible and small-scale embedded cultural and sports spaces, such as the "Six Arts Pavilion" model (e.g., community shared living rooms, neighborhood libraries, pocket park fitness corners), should be actively introduced and cultivated to meet residents' immediate and fragmented needs. In all new construction, renovation, and operation of facilities, high attention must be paid to comprehensively improving friendliness towards special groups such as the elderly, children, and persons with disabilities, implementing barrier-free designs and age-appropriate/child-friendly services. Furthermore, intelligent empowerment and information-based management need to be strengthened, establishing a unified information release, inquiry, and reservation platform, promoting online services, and optimizing facility operations through big data analysis. Finally, social forces should be encouraged to participate in facility construction and operation through policy guidance, service procurement, and cooperative operation, forming a positive situation of multi-subject co-construction and co-governance.

6. Research Deficiencies and Prospects

Although this study has conducted a relatively systematic analysis of the supply-demand relationship concerning public cultural and sports facilities in Siping Sub-district and proposed specific optimization strategies, certain limitations still exist:

1-Sample Representativeness and Generalizability: Despite efforts to ensure the coverage of the questionnaire survey sample, the sample size (182 respondents) is relatively limited due to constraints in research time and resources. Caution should be exercised when generalizing these conclusions to a broader context. Future research could further expand the sample size and employ more refined stratified sampling techniques to enhance the statistical validity and generalizability of the findings.

2-Tracking of Dynamic Demand Changes: This study primarily reflects the demand situation of residents at a specific point in time. However, resident needs are dynamic and influenced by various factors such as social development, lifestyle changes, and unforeseen events (e.g., pandemics). Future research could consider incorporating longitudinal tracking surveys to better capture the evolutionary trends of demand.

3-Depth of "Qualitative" Assessment: The assessment of facility "quality" in this study relies mainly on residents' subjective satisfaction evaluations and some objective indicators (e.g., facility environment, functionality). For aspects such as the professionalism of services, the depth of cultural content, and the quality of activity organization, future research could employ more in-depth qualitative methods, including expert evaluations, in-depth interviews, and participatory observation.

4-Feasibility Assessment of Strategy Implementation: The optimization strategies proposed in this report are currently at a conceptual and directional level. Their concrete implementation requires more detailed feasibility assessments and scheme refinements, considering the sub-district's fiscal capacity, land resource constraints, multi-departmental coordination mechanisms, and residents' willingness to participate.

Looking ahead, the planning and development of urban public cultural and sports facilities will increasingly emphasize a people-oriented approach, precise supply, intelligent operations, and resilient adaptation.

Subsequent research can be extended in the following directions:

1-Refined Demand Profiling and Dynamic Monitoring Based on Big Data: Utilizing big data resources such as mobile signaling, social media, and smart wearable devices to more accurately delineate the spatio-temporal behavior patterns and cultural/sports activity preferences of different population groups, thereby achieving dynamic monitoring and prediction of demand.

2-Research on Revitalization and Innovative Design of Existing Stock Spaces: Against the backdrop of increasingly scarce land resources, in-depth research is needed on how to activate existing urban spatial resources through micro-renewal, adaptive reuse, and composite function implantation to create more attractive and vibrant community cultural and sports venues.

3-Exploration of Multi-Actor Collaborative Governance and Sustainable Operation Models: Investigating the establishment of effective collaborative governance mechanisms among government, market actors, social organizations, and community residents, and exploring sustainable development models featuring diversified investment, professionalized operation, and community participation.

4-Planning Responses for Cultural and Sports Facilities from the Perspectives of Healthy Cities and Active Aging: In conjunction with the "Healthy China" strategy and the national strategy for actively responding to population aging, future research should focus on how the optimized allocation of cultural and sports facilities can promote the formation of healthy lifestyles among residents and enhance the quality of life and sense of community integration for the elderly.

Through continuous in-depth research and practical exploration, it is anticipated that greater wisdom will be contributed to the improvement of planning, construction, operational, and managerial standards for urban community public cultural and sports facilities in China, ultimately aiding in the construction of a more equitable, efficient, inclusive, and vibrant city for the people.

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A Study on the Travel Characteristics of Rail Transit Passengers in Township Areas of Wuxi City

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Abstract
With China's new urbanization driving integrated urban-rural transport, this study examines the Wuxi–Jiangyin S1 township rail line serving over 30,000 daily riders. Using high-precision LBS data from October 2024, we identified township passengers via spatio-temporal filters, inferred trip purposes through a white-box model combining spatial and temporal rules, and classified last-mile modes with fuzzy membership functions. Ridership is dominated by middle-aged, multi-generational households; leisure trips comprise over 50%; medium-distance (8–29 km) travel prevails; and bicycles/motorcycles lead access/egress. More than 60% of travelers make no station-area stops, indicating weak station-city integration. Findings offer guidance for service optimization, TOD planning, and policies to enhance sustainable township rail development.

Keywords: Rail Transit; Township Areas; Wuxi City; Travel Characteristics

1 Introduction

National strategies for new urbanization and integrated urban-rural development are driving the evolution of intercity railways, which are reshaping urban-rural spatial links. The "Yangtze River Delta Regional Integration Development Plan Outline" aims to establish a "one-hour commuter circle," fostering composite transportation systems that merge urban rail transit (metro) with intercity railway functions. Township rail transit, through technical standard compatibility (e.g., platform spacing, vehicle types) and innovative operational modes (e.g., bus-like scheduling, through-line operations), creates high-frequency, efficient connections between core metropolitan cities and outlying townships (Li Fengjun et al., 2020; Yang Shaohui et al., 2022; Zhang Pei et al., 2017). By 2023, the Yangtze River Delta's intercity railway network surpassed 1500 km, projected to exceed 3000 km by 2025, deeply serving low-urbanization areas (2000-5000 people/km²), signifying a new "rail transit extending to townships" phase.

The Wuxi-Jiangyin S1 Line in Wuxi exemplifies such systems, pioneering through-operation between an intercity railway and an urban metro in China. It connects Jiangyin's urban area, township nodes like Zhouzhuang and Qingyang, and Wuxi's main urban area via a "one-train direct access" model, serving over 30,000 daily bidirectional urban-rural commuters. Its data reveal unique spatio-temporal distribution, travel purposes, and behavioral preferences of township rail passengers. While current research focuses on urban rail transit, a gap exists regarding township rail passengers with both intercity and metro characteristics. Analyzing these patterns is vital for optimizing transportation in urban-rural integration and addressing dilemmas like the "urban siphon effect" versus "township transportation deserts". This study analyzes the S1 Line's township passenger travel characteristics to inform operational optimization, station-area land use planning, and broader urban-rural transport policies.

2 Literature Review

Rail transit, as a pivotal component of urban public transportation systems, demands systematic investigation of passenger travel characteristics to optimize operational strategies, enhance service quality, and inform future infrastructure planning. With accelerating urbanization and shifting socio-economic structures, usage patterns among distinct passenger cohorts have become markedly heterogeneous. Accordingly, segmenting passengers by individual attributes—such as age, gender, and occupation—or by behavioral characteristics—such as trip purpose and frequency—is a critical step in understanding and addressing diverse needs. Through such segmentation, the unique travel patterns of specific groups can be identified, furnishing a basis for designing personalized services that elevate overall passenger satisfaction and system efficiency. Furthermore, targeted research on special populations (e.g., the elderly, children, and persons with disabilities) facilitates the development of more inclusive policies, ensuring that all members of society enjoy equitable access to effective rail transit services.

Travel characteristics differ significantly across passenger groups. Research categorizes groups by individual attributes, travel features, or combined factors. Some studies focus on age and gender impacts. Xiong Meicheng et al. (2022) found that older elderly (≥70) in Kunming have reduced mobility but increased public transport reliance compared to younger elderly (60-69). Yang Hong et al. (2023) noted Wuhan's elderly avoid peak hours and prefer shorter distances. Xiaohan Liu et al. (2024) found travel distance, time, and space variations among different gender and age groups.

Other studies examine travel purposes and frequencies to identify patterns and drivers. Cheng Xiaoyun et al. (2020) proposed a classification framework based on travel days, daily trips, concentration, time consumption, and line utilization entropy. Comprehensive approaches consider multiple simultaneous factors. Rezwana Rafiq et al. (2021) used Latent Class Analysis (LCA) for user classification, identifying five activity-travel patterns, such as employed white males on simple transit-based work trips and employed white females on complex work trips. Some research classifies passengers by activity within hub station areas, finding differences in activity range and travel time distribution (Cheng L et al., 2024).

Travel characteristics are often described by time, space, and intensity (Zou Qingru et al., 2024). Spatial attributes include origin (LE M K et al., 2015), path, stations (MA X et al., 2013), and commuting distance (JI Y J et al., 2019; and Kang Hehe et al., 2018). Temporal attributes include average travel time (Long Ying et al., 2015), departure time (LE M K et al., 2015), journey time (MA X et al., 2013), and first departure time (JI Y J et al., 2019). Rail usage intensity is measured by trip counts over periods (El MAHRSI M K et al., 2017) or average trips and travel days (Liu Ying et al., 2019).

Effective classification algorithms are critical(Cheng Xiaoyun et al., 2020). Studies have used DBSCAN, GMM, OPTICS (VENUGOPAL S et al., 2016), LCA, k-means++ (Xu Xiaowei et al., 2017), and hierarchical clustering with k-means (ZHAO J J et al., 2014; Pang L et al., 2023) for urban rail user segmentation, providing rich methods for understanding travel diversity.

Existing research offers robust perspectives and methods for urban rail optimization. However, township rail stations and passengers remain understudied. Townships differ from urban centers in population density, land use, economic activities, and lifestyles, leading to unique passenger flow and demands at their rail stations. Lines like the Wuxi-Jiangyin S1, connecting cities with townships and integrating with urban metros, may serve complex demands (commuting, services, leisure) and exhibit distinct travel behaviors (purpose, duration, access/egress modes) compared to traditional urban or suburban rail users. This disparity is this study's focus, as specialized research on such hybrid-feature township rail transit is scarce.

This research aims to fill this gap by studying Wuxi-Jiangyin S1 Line's township passengers, detailing their attributes and behaviors for a comprehensive understanding of their composition and needs. This supports S1 Line's operational optimization and service improvement, offering empirical references and theoretical insights for non-urban rail service models and station-area integrated development.

3 Research Content and Methods

3.1 Research Scope and Data

This study focuses on the Wuxi-Jiangyin S1 Line, stretching 30.4 km (10.5 km underground, 0.2 km transitional, 19.7 km elevated) with 10 stations (5 underground, 5 elevated) and a design speed of 120 km/h, operating through-service with Wuxi Metro Line 1. The Jiangyin urban section is underground; the Xuxiake Avenue section is elevated. Qingyang, Xuxiake, and Science City stations are elevated. The selected suburban section includes Nanzha, Qiaoqi, Qingyang, Xiake Bay Science City, and Mazhen Stations (Figure 1).

The study uses LBS data from Wuxi City (October 14-20, 2024), providing high-precision user spatio-temporal trajectories, enabling capture of travel chains, stay point identification, and travel purpose inference.

3.2 Research Methods

3.2.1Identification of Rail Transit Passengers in Township Areas

LBS data provide certain spatial identification of metro stations, allowing high-precision matching via hard thresholds. The study first anchors metro travel to maintain base passenger group purity, adopting a phased identification: first, identify township rail passengers, then use fuzzy theory for access/egress modes, balancing data traits and research goals.

A framework for identifying township rail passengers uses multi-source data fusion and spatio-temporal analysis. High-precision LBS data (error ≤ 50m) and geofencing match user stay points with metro station coordinates, filtering records within a 100m station buffer with stay duration ≥3 minutes. Travel chain continuity rules extract records of continuous visits to different metro stations consistent with prior knowledge, identifying metro users. To target township rail passengers, travel chains through township stations (Mazhen, Qingyang, Science City, Qiaoqi defined as township functional stations) are extracted, identifying those with at least one township station stop.

3.2.2 Stay Point Identification Based on Density

Trajectory stay point identification is key for mining travel activity semantics and characterizing crowd demands. Existing methods include cluster-based, probability-based, and discrimination-based strategies (Lu Jianfeng et al., 2020). Cluster-based density algorithms are common but spatially limited. Probability-based methods (Bayesian, Gaussian mixture models) infer frequent locations but ignore trajectory temporal sequences. Discrimination-based methods focus on stay/representative points, missing spatio-temporal aggregation (Zhang Xun, 2022). To address these, Li Yuru et al. (2018) proposed SPID (Stay Point Identification based on Density), which considers temporal continuity, directionality, and spatio-temporal aggregation.

This study uses SPID for Wuxi's LBS data. Steps: Identify trajectory points; calculate distances to other points chronologically (forward/backward); add points within distance thresholds to a set; stop when distances exceed thresholds. Stay points are determined by point set density (He Guofeng, 2022). Following literature (Jin Tanhua, 2019), spatial threshold is 100m, time threshold is 15min.

3.2.3 Travel Purpose Inference

To ensure effective semantic identification of passenger activities and precise crowd feature characterization, this study builds on identifying daily township rail users and stay points. It uses LBS travel chain data and stay point spatio-temporal attributes (period, duration) for activity chain semantic recognition for each passenger's daily stay points. Rail station spatio-temporal matching rules extract metro travel segments for precise analysis of purposes and patterns.

Traditional activity chain data from surveys are costly and not timely (Hartgen et al., 2009; Collia et al., 2003; McDonald et al., 2008). Mobile phone data are now used. Methods include: 1) Regression models, like Diao et al. (2016) using multinomial logit for semantic labels from activity time, weather, etc.; 2) Hidden Markov Network (HMN) sequence models, e.g., Widhalm et al. (2015) on Boston/Vienna data, and Yin et al. (2018) with HMN optimized by activity transfer patterns; 3) Machine learning (e.g., random forests), like Zhao Pengjun et al. (2020) using RF for metro trip purpose classification. However, these methods have limitations: 1) "Black-box" models lack interpretability (HMNs, ML). 2) Data dependency versus universality: require proprietary survey data for transition probabilities or fine-grained land use/large training sets, creating researcher barriers. 3) Massive data processing challenges (Cao, J. et al., 2019; Deville, P. et al., 2014).

This study, referencing Yin L et al. (2021), uses a transparent, rule-based inference algorithm considering spatial/temporal features for activity purpose, with Monte Carlo for final determination. This ensures interpretability and uses open-source geographic data, offering an operable tool.

• Stay Point Type Classification. This study classifies travel activity purposes into five categories: living, working, schooling, leisure, and other. Since the attributes of activities (start time, end time, location) are long-term choices made by individuals and authorities in the case of fixed activities, while the characteristics of flexible activities vary greatly among different people and on different days for the same person. Therefore, this study, based on the dual dimensions of activity priority and spatio-temporal decision-making freedom, divides activities into

fixed and flexible. According to activity priority from high to low, they are special, fixed, semi-flexible, and flexible activities (Figure not provided).

• Calculating Activity Purpose Probability Based on Spatial Features. People's daily activities are closely related to the spatial features (such as land use type and building type) around their activity locations (Yang et al., 2019). The relationship between daily activities and geographical attributes can be used to support the inference of one attribute given the other (Yin L et al., 2021). To infer activity patterns from geographical attributes, the research by Widhalm et al. (2015) and this study both use the basic assumption: the activity a person engages in is closely related to the corresponding spatial features. Therefore, a link must be established between spatial features and activity purposes. Spatial features are usually described as enumerated types. Combined with POI service capacity (Li S et al., 2021; Liu J et al., 2023), different weights are assigned to each POI type to assess the probability that a specific activity category is dominant at each location.

• Calculating Activity Purpose Probability Based on Temporal Features. Residents' daily activity arrangements are often constrained by prevailing social norms and life rhythms, thus forming daily behavioral patterns with a certain cadence. The transition patterns between different types of activity purposes (e.g., departing from "home" for "work" in the morning, returning from "work" to "home" in the evening, or engaging in "leisure" activities on weekends) can effectively characterize this regularity. These transition patterns can be extracted from auxiliary data, such as historical resident travel surveys, social network check-in data, or through statistical analysis of large-scale LBS data (Yin L et al., 2021). This study will set corresponding temporal transition probability matrices based on different demographic attributes (e.g., age groups) and date types (weekdays/weekends) to reflect the likelihood of different activities occurring at specific times.

• Inferring Activity Purpose Based on the Combination of Spatial and Temporal Features. To integrate spatial and temporal features and clearly demonstrate their impact on activity purpose inference, this study adopts a concise model that linearly combines these two features. Specifically, a weighting parameter[0,1] is used to flexibly combine the activity purpose results inferred from spatial and temporal features. We denote by the combined probability that an individual performs an activity of type k during a certain stay. A straightforward intuitive method, defined by the formula, is used to combine the probabilities derived from the two types of features.

A Monte Carlo simulation method is employed to determine the specific activity purpose for each stop based on the activity purpose probability distribution .

• Model Validation

Due to the unavailability of ground truth for activity chains derived from mobile phone location data, this study employs methods such as manual comparison with attribute information inherent in LBS data and small-sample questionnaire survey data to validate the reasonableness and effectiveness of the model inference results.

3.3 Research Content

This study's core content involves: 1) Focusing on the Wuxi-Jiangyin S1 Line, a typical township-serving rail line. 2) Using LBS travel chain data and multi-stage screening to identify core township rail passengers. 3) Applying SPID to LBS trajectories for stay point identification, extracting spatio-temporal stay point data. 4) Using a transparent, rule-based "white-box" model integrating spatio-temporal features to infer activity types (travel purposes) of stay points. 5) Extracting complete metro travel segments (origin/destination stations, related stay points). 6) Using fuzzy theory (prior knowledge, membership functions) to infer last-mile access/egress modes.

After data processing, a structured township rail travel dataset with rich attributes will be analyzed for passengers' ontological (socio-demographics, residence) and behavioral (purpose, spatio-temporal patterns, access/egress choices) characteristics. Findings aim to provide evidence for optimizing township rail operations, guiding station-area development (TOD models), and enhancing urban-rural transport integration.

4 Analysis of Travel Characteristics

4.1 Indicator Construction

To comprehensively and systematically characterize the features of township rail transit passenger groups, this study has constructed an indicator system comprising two main categories: ontological attributes and behavioral attributes. The selection of these indicators aims to capture key factors influencing travel behavior and the multidimensional manifestations of travel behavior itself.

Ontological attributes primarily reflect the relatively stable demographic, socio-economic, and spatial locational characteristics of the passenger group (Table 2). These indicators are chosen because an individual's natural attributes (e.g., age, gender), social attributes (e.g., education level, income, family structure), and the geographical location of their residence profoundly influence their travel demand, travel capability, choice of travel mode, and expectations for transportation services. For example, "age" is closely related to travel activity levels and the composition of travel purposes; "household size" in township areas may be more associated with joint travel as a family unit; "income level" directly affects sensitivity to travel costs and demand for travel comfort; and "residential location" directly reflects the service coverage and attractiveness of rail transit to different areas (Jiangyin townships, Jiangyin sub-districts, Wuxi townships, Wuxi sub-districts, and other areas).

Table 2. Ontological Attributes

Ontological attributes	Attribute category	Quantitative indicators	Label extraction
Natural attribute	Gender	Male	Male
		Female	Female
	Age group	20-29 years old	Youth
		30-49 years old	Middle-aged
		Above 50 years old	Elderly
	Education level	Junior high school and below	Low education
		High school or junior college	Medium education
		Bachelor's degree or above	High education
	Household size	1 person	Single
		2 people	Small family
		3 people and above	Big family
Social attribute	Income level	Monthly income of 4.5K and below	Low income
		Monthly income: 4.5K-10K	Medium income
		Monthly income of more than 10K	High income
Regional attribute	Residential location	Whether it belongs to a township area of Jiangyin City	Jiangyin Township
		Whether it belongs to a sub-district of Jiangyin City	Jiangyin Sub-district
		Whether it belongs to a township area other than Jiangyin in Wuxi City	Wuxi Township
		Whether it belongs to a street in Wuxi City other than Jiangyin	Wuxi Sub-district
		It doesn't belong to the heart of Wuxi City	Other places

Behavioral attributes focus on the dynamic manifestations of the passenger group while using rail transit (Table 3). These indicators are selected because they can directly reflect the passenger group's travel purposes, spatio-temporal preferences, travel efficiency, degree of reliance on rail transit, and solutions for the "last mile." "Travel semantics" reveals what kinds of needs rail transit meets; "temporal characteristics" describe the timing, duration, and frequency of travel, where labels like "happy commuting" for "travel duration" provide a preliminary assessment of the travel experience; "spatial characteristics" focus on the spatial span of travel and the utilization of station areas, with "number of activities at station" being an important indirect indicator of station-city integration; "subway connection method" within "travel diversity" is particularly crucial for township areas with inconvenient transportation.

Table 3. Behavioral Attributes

Behavioral attributes	Attribute category	Quantitative indicators	Label extraction
Temporal characteristics	Day of travel	10.14.-18.	Weekday
		10.19.-20.	Weekend
	Working/non-working travel time	6:00-10:00	Morning rush hour
		10:00-15:00	Noon
		15:00-19:00	Evening rush hour
		19:00-6:00	Night
	Travel duration	None	None
		Within 45min	Happy commuting
		Within 45-60min	Normal commuting
		Above 60min	Extremely long commuting
	Frequency	Once a day	Low frequency
		Twice a day	Intermediate frequency
		3 times a day	High frequency
		4 times a day or more	Ultra-high frequency
Spatial characteristics	Subway travel distance	Within 8km	Short-distance travel
		8-29km	Medium-distance travel
		Above 29km	Long-distance travel
	Number of arrival activities	0 times	No arrival activities
		1 time	Arrival activities included
		2 times or more	Rely on rail transit to connect activities

4.2 Analysis of Ontological Dimensions

Based on a multi-dimensional analysis of natural, social, and regional attributes, the township rail transit passenger group exhibits significant structural characteristics (Table 4). In terms of natural attributes, the core of the passenger group is middle-aged individuals (30-49 years old, 80.61%), with family structures predominantly being large, multi-generational households (71.51%). Education levels are concentrated at medium (high school or junior college, 52.89%), reflecting the typical characteristic of the middle-aged labor force in township areas shouldering dual family and economic responsibilities. The travel demands of this group often revolve around fixed activities such as work commutes and children's education, and are significantly influenced by family cooperation patterns. In terms of social attributes, income distribution shows a "spindle-shaped" structure, with the medium-income group (monthly income 4.5K-10K, 51.29%) accounting for the highest proportion. High-income (17.09%) and low-income (31.62%) groups form two poles, suggesting that rail transit services need to balance fare affordability with comfort upgrades to meet differentiated needs. Regional attribute analysis further reveals the spatial distribution characteristics of the passenger group: a clear trend of localization and agglomeration is evident, with local residents from Jiangyin and Wuxi collectively accounting for 84.3% (Jiangyin Township 28.62%, Wuxi Sub-district 21.41%, etc.), while users from other areas only account for 15.7%. This indicates that rail transit primarily serves the medium and short-distance travel of permanent residents. Significant differences exist in urban-rural distribution: township users (Jiangyin Township 28.62%, Wuxi Township 7.29%) rely on rail transit to address issues of inadequate access and egress facilities, while urban users (e.g., Wuxi Sub-district 21.41%) are more inclined towards multimodal travel combinations.

Overall, the passenger group's behavior patterns are driven by both demographic structure and socio-economic attributes: the middle-aged and family-oriented characteristics reinforce the priority of fixed activities such as commuting and medical care; the predominance of the medium-income bracket requires a balance between efficiency and cost in service design; and differences in urban-rural distribution necessitate targeted optimization of access/egress networks (e.g., adding dedicated bus lines in townships, improving transfer efficiency in urban areas). The portrait system constructed in this study provides data support for the precise matching of "demand-service" for township rail transit. In the future, dynamic spatio-temporal behavior data can be incorporated to further deepen the analysis of causal mechanisms.

Table 4. Profile of Township Rail Transit Passengers

Variable	Percentage/%
Natural attribute	
Gender	
Male	52.62
Female	47.38
Age group	
Youth	9.70
Middle-aged	80.61
Elderly	9.68
Household size	
Single	24.65
Small family	3.85
Big family	71.51
Education level	
Low education	32.69
Medium education	52.89
High education	17.22
Social attribute	
Income level	
Low income	31.62
Medium income	51.29
High income	17.09
Regional attribute	
Residential location	
Jiangyin Township	28.62
Jiangyin Sub-district	26.98
Wuxi Township	7.29
Wuxi Sub-district	21.41
Other places	15.70

4.3 Analysis of Behavioral Dimensions

(1) Temporal Characteristics

Travel time characteristics are a crucial dimension for understanding passenger travel patterns and evaluating the efficiency of transportation services. This section will analyze the distribution of travel on weekdays/weekends, the temporal distribution of different travel purposes throughout the day, travel duration, and the frequency of metro usage.

According to data analysis (Table 6), work-related travel during the morning rush hour (6:00-10:00) accounts for 13.60%, which is the main period for work travel, consistent with basic commuting patterns. It is noteworthy that work-related travel during the midday period (10:00-15:00) also reached 14.10%, while the evening rush hour (15:00-19:00) accounted for 11.00%, and the night period (19:00-6:00) was lower at 4.39%. The higher proportion of work travel during midday may reflect that some township residents are engaged in non-standard work hours (such as in the service industry or freelance work), or that there are instances of round trips between work and home (or other activity points) during midday. The 56.91% of "None" for work travel time corresponds to the previously mentioned proportion of passengers whose trips do not include work.

Non-work-related travel, however, exhibits different temporal distribution characteristics. The midday period (10:00-15:00) and the evening rush hour period (15:00-19:00) are the two peaks for non-work travel, accounting for 27.26% and 28.08% respectively. This aligns closely with the occurrence times of activities such as leisure and shopping. Non-work travel during the morning rush hour (6:00-10:00) accounts for 17.13%, and non-work travel during the night period (19:00-6:00) also constitutes a certain proportion (14.35%), indicating the broad timing of leisure activities for township residents. The 13.18% of "None" for non-work travel time corresponds to passengers with no non-work activities or only work activities in their travel purposes.

Table 6. Proportion of temporal characteristics

Variable	Percentage/%
Temporal characteristics	
Working travel time	
Morning rush hour (6:00-10:00)	13.60
Noon (10:00-15:00)	14.10
Evening rush hour (15:00-19:00)	11.00
Night (19:00-6:00)	4.39
None	56.91
Non-working travel time	
Morning rush hour (6:00-10:00)	17.13
Noon (10:00-15:00)	27.26
Evening rush hour (15:00-19:00)	28.08
Night (19:00-6:00)	14.35
None	13.18
Day of travel	
Weekday	67.28
Weekend	32.72
Travel duration	
Within 45min	42.93
Within 45-60min	10.16
Above 60min	46.90
Frequency	
Once a day	45.67
Twice a day	32.83
3 times a day	13.20
4 times a day or more	8.31

Weekday travel (Oct 14-18, 2024) is 67.28%; weekend (Oct 19-20) is 32.72%. Higher weekday volume links to commuting regularity and some weekday leisure (e.g., post-work).

Travel duration: 42.93% are "happy commutes" (≤45 min); 10.16% "normal" (45-60 min); 46.90% "extremely long" (>60 min). The S1 line, connecting Jiangyin townships to Wuxi, serves long distances, causing many long trips, likely cross-regional work/leisure commutes.
Daily metro frequency: 45.67% once (one-way/one leg of round trip); 32.83% twice (typical round trip); 13.20% thrice; 8.31% ≥4 times (ultra-high). Most use it 1-2 times daily (low/medium frequency).

In sum, township rail users travel mainly on weekdays; non-work travel peaks midday/evening. High "extremely long commuting" is notable. If for high-value leisure (to Wuxi centers), tolerance for long travel may be high, suggesting S1 expands activity space and life choices, justifying longer travel for higher needs.

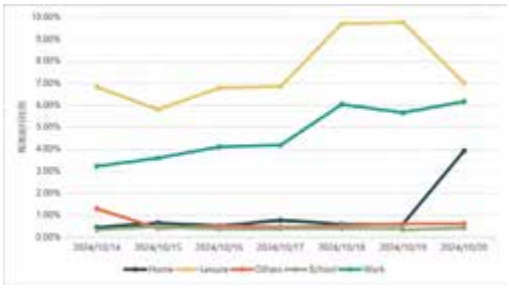


Fig 1. Statistics of the number of various types of trips every day within a week

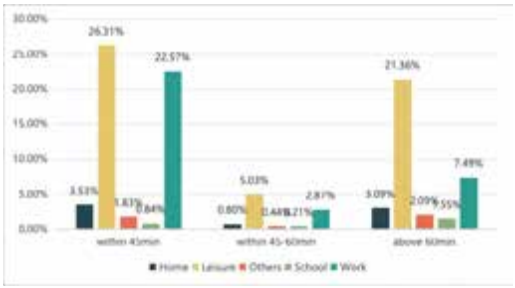


Fig 2. The distribution of travel duration for various types of trips

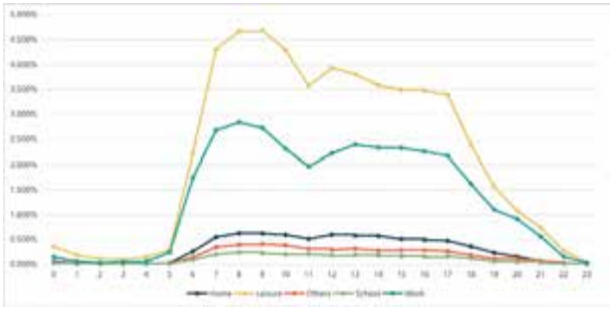


Fig 3. The distribution of travel start times for various types of trips

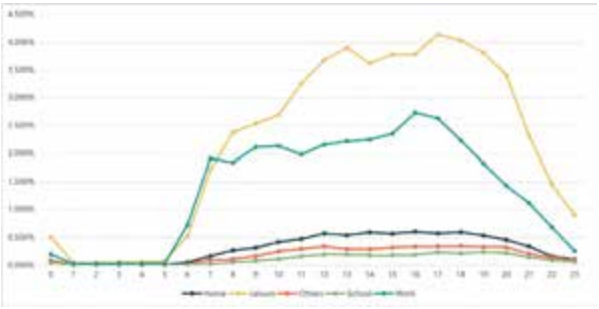
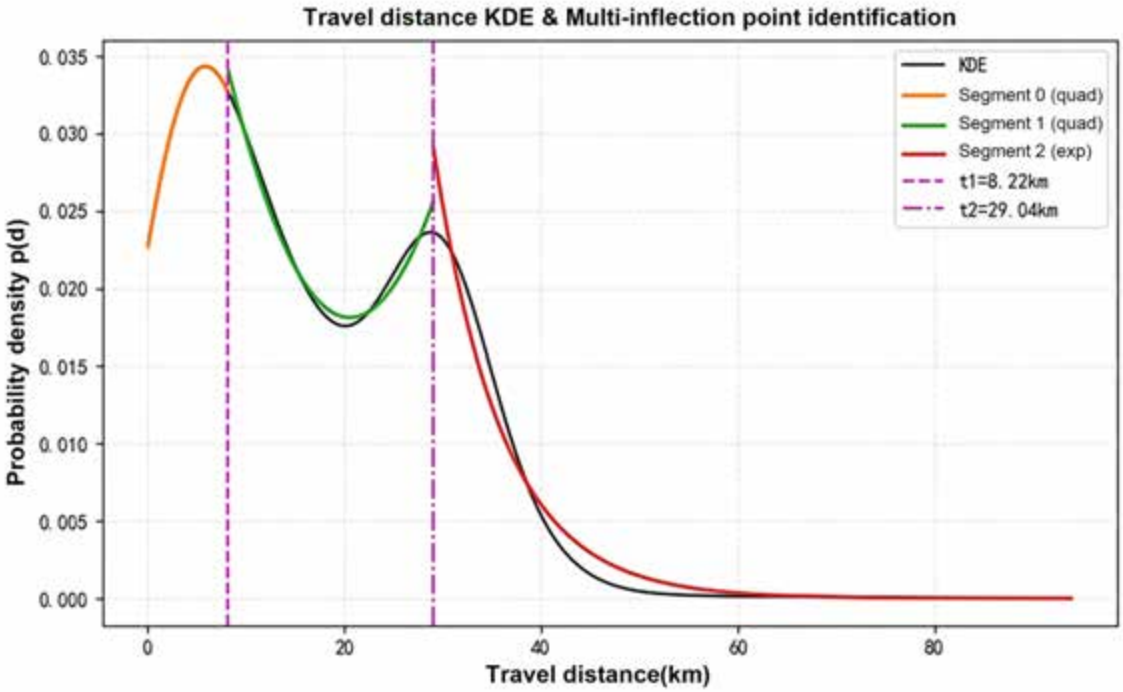


Fig 4. The distribution of travel end times for various types of trips

(2) Spatial Characteristics
This study mainly refers to the research of Qiao et al. (2019), Raja et al. (2015), and Shi Ruizheng et al. (2022). It employs the Euclidean distance between the origin and destination of passengers' metro trips, i.e., the shortest straight-line distance between the two points, as the travel distance for each metro trip. Using travel distance as the fitting object, a probability distribution function for travel distance is fitted, with different distributions at its two ends. By comparing the coefficient of determination R^2 for different distances, the corresponding travel distance cutoff thresholds are determined (Qiao Mengling et al., 2019). The specific method uses Kernel Density Estimation (KDE) to divide travel distances by thresholds, with the optimal fit shown in the figure.



Remark: The first segment is fitted with a quadratic function, model , ; the second segment is fitted with a quadratic function, model , ; the third segment is fitted with an exponential function, model ,

Fig 5. The optimal fitting situation of the probability distribution graph of travel distance

The travel distance for passengers using township area rail transit follows a quadratic function when less than 8.22km (Model 1, yellow line); it follows a quadratic function distribution when the distance is between 8.22-29.04km (Model 2, green line); and it follows an exponential function when the distance is greater than 29.04km (Model 3, red line). For statistical convenience, thresholds are rounded to integers, determining cutoff values of 8km and 29km.

Based on this, a statistical analysis of travel distance was conducted (Table 7). It can be seen that medium-distance travel (64.77%) is mainstream for township rail transit passengers, followed by short-distance travel (22.91%), with long-distance travel being the least common (12.32%). Looking at different travel purposes, medium-distance leisure travel has the highest proportion (23.94%), indicating that cross-city leisure trips from Jiangyin residents to Wuxi commercial districts, scenic spots, etc., are numerous. Although short-distance work travel accounts for over 40%, considering the "2024 China Major Cities Commute Monitoring Report" released by the China Academy of Urban Planning and Design, the average one-way commute distance in Wuxi is 7.4km, with 55% of commutes being "happy commutes" within 5km. Work travel on the Wuxi-Jiangyin S1 Line is still dominated by medium to long-distance commutes. As a cross-city rail line, its passengers' travel characteristics are significantly different from those of Wuxi's main urban metro. Residential and school-related travel are mainly medium-distance, reflecting that some families may choose a "dual-city life" model of living in Jiangyin and schooling in Wuxi. For other (medical) travel, short-distance travel has the highest proportion, but at the same time, the proportion of long-distance travel is the highest among the five categories, indicating a prominent rigid demand for long-distance medical treatment.

Further analysis of the coverage of township rail transit stations (Table 7) reveals that over 60% of passengers have no additional activities after arriving at the station, indicating a lack of commercial and service facilities around the stations, with passengers merely using rail transit as a "point-to-point" commuting tool. Cross-analysis (Figure 6 and Figure 7) shows that leisure travel accounts for the highest proportion within the station coverage area, indicating that the rail coverage area primarily serves leisure demand, but activity frequency is still low, mainly single instances. Work-related travel covered by stations is relatively small, only half of that for non-station-

based work activities. According to the "2024 China Major Cities Commute Monitoring Report," the proportion of commutes covered by rail transit in Wuxi is only 9%, meaning the proportion of the commuting population whose residences and workplaces are both within 800 meters of a rail station is far below the national average of 20%. This indicates that Wuxi's rail transit provides weak support for residential and employment spaces, and the Wuxi-Jiangyin S1 Line shares this problem. In addition, school-related travel within station coverage areas is much lower than non-station-based travel, possibly because schools are often located in areas not covered by rail, exacerbating the pressure of "cross-district schooling." The low frequency of activities at S1 Line stations and Wuxi's weak rail coverage for commuting jointly point to the core contradiction of "rail construction being disconnected from urban functions." It is necessary to promote the new urbanization process in township areas through "comprehensive station development + equalization of public services," rationally allocate public service facilities, and upgrade rail transit from a "commuting corridor" to a "vitality link."

Table 7. Spatial Characteristics of Township Rail Transit Passengers

Variable	Percentage/%
Spatial Characteristics	
Subway travel distance	
Short-distance travel	22.91
Medium-distance travel	64.77
Long-distance travel	12.32
Number of arrival activities	
0 times	61.60
1 time	26.39
2 times or more	12.01

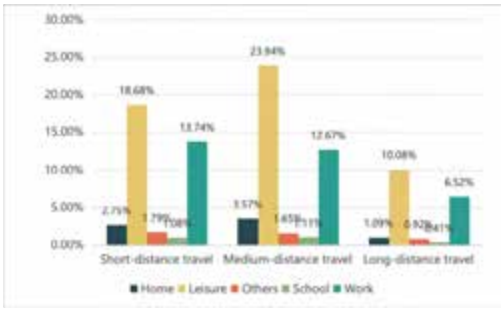


Fig 6. The distribution of travel distances for various types of trips

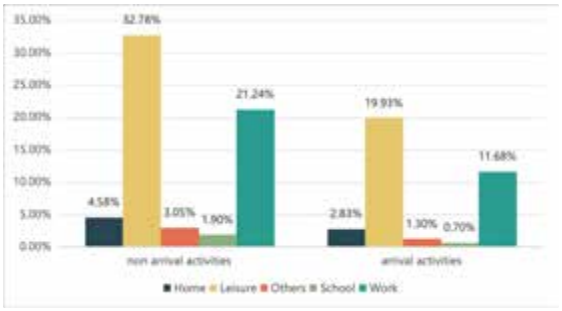


Fig 7. The distribution of arrival activities for various types of travel

5 Conclusion

This study of Wuxi-Jiangyin S1 Line using LBS data analyzed township rail passenger attributes and behaviors, revealing unique traits and offering insights for service optimization and regional development.

- Distinct Passenger Profile: Core users are middle-aged (30-49), from larger local families, with medium/low education and income, differing from urban metro users; their needs may be more complex/pragmatic.
- Leisure Travel Dominance: Over 50% of trips are for leisure, far exceeding work travel, unlike traditional commute-focused rail. S1 is a "lifeline" expanding lifestyle options and activating cross-regional leisure consumption.
- Medium-Long Cross-District Travel: Medium (8-29km) and longer trips are common for leisure, work, and medical needs, reflecting S1's role as an intercity urban-rural connector. Some "extremely long commutes" (>60min) exist.
- Severe Lack of "Station-City Integration": >60% of passengers have no activities around township stations. Stations are mere transfer points, poorly integrated with urban functions; "rail-city disconnect" is prominent, failing TOD potential.

Optimize services for passenger traits. Address family needs (middle-aged, large families) with off-peak/weekend family tickets, better in-carriage facilities (storage), and improved station accessibility (barrier-free, maternal-child facilities). Empower leisure/lifestyle travel by linking S1 with attractions/commercial centers, enhancing station-city integration for vitality. Implement locally adapted TOD: treat station areas as township renewal nodes, introducing mixed uses (retail, community services, entertainment, offices) matching resident needs and local resources to create vibrant micro-centers, requiring planning/transport/land development synergy.

LBS data may have representation bias (e.g., underrepresenting elderly, non-smartphone users). Stay point/purpose inference accuracy is limited by data granularity and algorithm universality. The study is mainly quantitative, lacking qualitative depth on motivations/perceptions. It's a cross-sectional study, not capturing dynamic evolution; characteristics may change with township development and S1 operation time.

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Modelling Access Ergonomics to Daily Life Resources using Sustainable Modes within the Eurométropole de Strasbourg

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Abstract
High-quality surroundings and the comfort of journeys encourage the use of sustainable modes of transportation to attend daily-life resources. Spatial ergonomics studies the capacity of a territory to fulfil the needs of its inhabitants at least costs. Its subdomain access ergonomics which provides an approach through mobility, offer a relevant analytical framework to assess if a territory enables its residents to access essential daily-life resources, efficiently and comfortably. Ergonomics should be analysed both qualitatively and quantitatively, and simulation provides many insights relevant to this evaluation. This paper focuses on a state of the art of ergonomics in urban planning then proposes a framework to improve precision in access ergonomics assessment using multi-agent modelling to simulate mobility behaviours based on socio-spatial profiles.

Keywords
access ergonomics; sustainable mobility; multi-agent models; proximity; accessibility

Introduction

Since the 1980s, many European cities have implemented several policies to reduce transportation and mobility related negative externalities, especially those caused by individual cars. Among them, the Eurométropole de Strasbourg, a mid-size city located in the extreme east of France, along the German border. Strong measures have been introduced to limit car use while promoting sustainable transport (Stambouli, 2005, Héran, 2020). This includes developing public transportation, enhancing shared and active modes (walking, cycling) usage, and urban planning focused on a "proximity metropolis" model (Eurométropole de Strasbourg, 2024) to support sustainable mobility. Furthermore, the Eurométropole de Strasbourg has restricted motorized mobility, particularly internal combustion engine vehicles, by creating one of the first Low Emission Zone in France covering its 33 municipalities. The city also supports energy transition, encouraging the adoption of electric vehicles including electric bikes through purchase subsidies. Strasbourg is also a precursor in France for its actions to encourage cycling. It has had a significantly higher cycling modal share than other French cities from 1980 to 2000 (Guidez, 2007) and the Eurométropole de Strasbourg is the French metropolis with the highest modal share for cycling in the 2021 census. Like many other cities, previous studies have shown that amenities and transportation infrastructures are not uniformly distributed throughout the city (Hached, 2019) and that some areas are underserved for active modes users (Saint-Gérand et al., 2021). The main question is how well the Eurométropole de Strasbourg enables its residents to access essential daily-life resources, efficiently, comfortably, and at which cost (financial cost, effort, risk, emissions, energy, and time) while using sustainable transport modes. The obtained indicators (both a synthetic score and subscores on a 200 by 200 metre grid) can then be employed to assess equity and highlight social disparities.

This paper focuses on three aspects: first a review of the uses of ergonomics applied in urban settings, in particular to urban mobility, with a focus on access ergonomics, its similarities and differences with related concepts. After a review of modelling methods to find the most suitable one to assess access ergonomics. Then, we propose an integrated method for the appraisal of ergonomics of access through multi-agent modelling. The proposed approach deploys multi-agent activity-based modelling to place trips in activity chains. In further studies, more parameters will be considered to assess access ergonomics on a larger scale.

1. Review of urban ergonomics

Ergonomics is "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance" (IEA, 2000). On an etymological standpoint, it is the science of work, also referred to as human factors engineering, especially in American English and workplaces are historically the first places where ergonomics was developed and applied. In this paper, we will consider its applications and transpositions to urban settings. In the Scopus Database, as of May 20th, 2025, 632 documents[1] contain both the words urban and ergonomics (Figure 1). Of those, 151 are applied to vehicles (including 80 regarding cars and motorcycles[2]) and 110 are applied to the urban scale, with 15 of them considering the ergonomics of urban mobility and 11 of them considering pedestrian behaviours in cities.

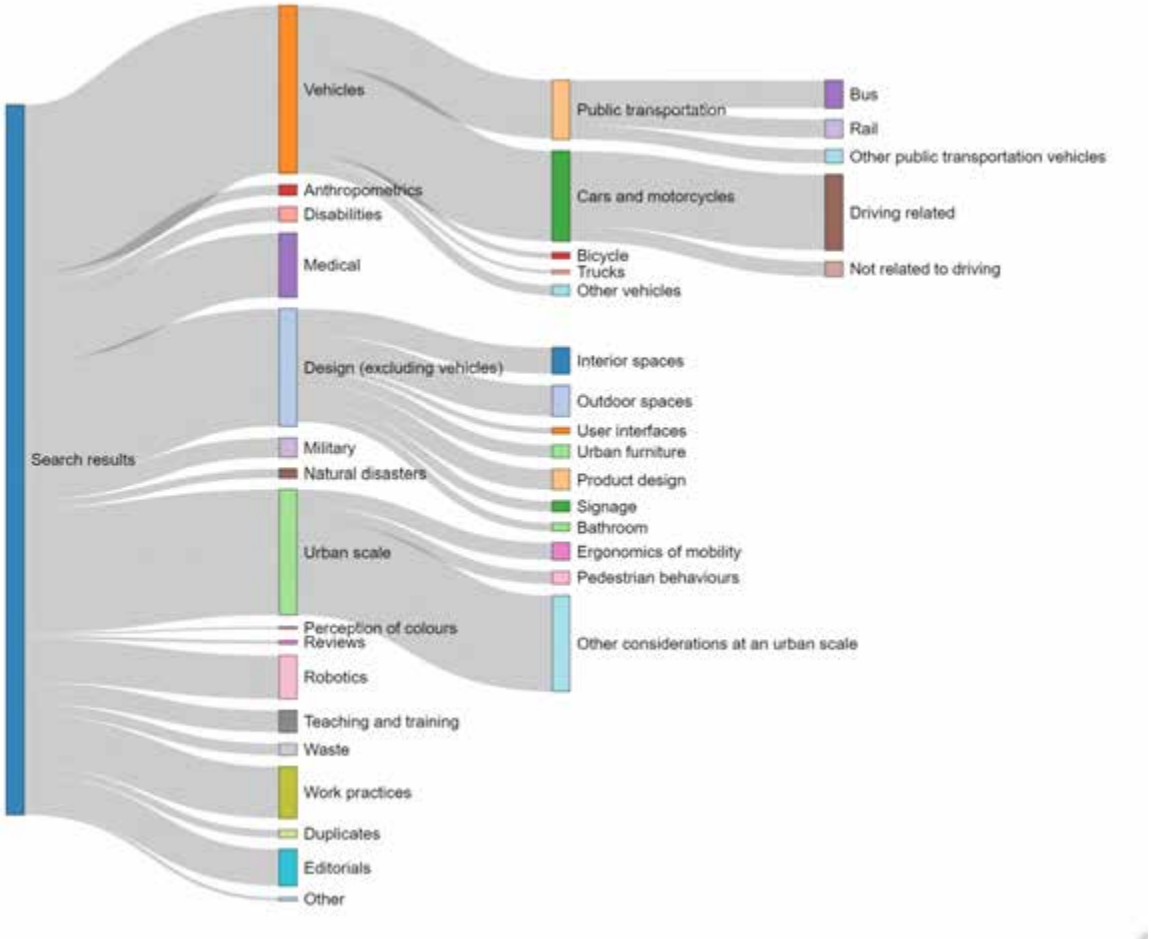

Figure 1: Topics covered in Scopus (Hacquard, 2025)

Macroergonomics (Hendrick, 1985), developed from the end of the 1970s considers organisational aspects in ergonomics, opposed to the human-machine interactions (microergonomics) that were solely considered before and relies on group dynamics. Its scope not only includes work but "any form of human effort or activity, including recreation and leisure pursuits" (Hendrick, 2002). As such, macroergonomics have been leveraged as community ergonomics to improve inner cities (Smith et al., 1994) and for the analysis of mobility in the Brazilian city of Belo Horizonte (Botelho et al., 2018). Several authors have used the concept of ergonomics in geography and urban planning. In their paper Human Factors in Urban Transportation, Hoag and Adams (1975), note the overwhelming proportion of data from military settings considered in ergonomics and their low relevance for urban transportation. They analyse the travel conditions, not only on an anthropometric standpoint, but also on

1 Seven duplicates are found in the results and are not processed further.
2 A paper (Nathanael et al., 2019) concerns pedestrian-vehicle interactions and is classified both in pedestrians and vehicles.

a psychological one, and envisioning user evaluation. De Carvalho (2012) proposes ERGOPOLIS: an ergonomics approach applied to a city, mobilising the macroergonomics and listing nine projects that might be considered for an ergonomic approach to the city, including accessibility and improvement of urban mobility. The same term ergopolis is also used in unrelated manners by Gangadhar, Nagendra and Chikkarangaswamy (2012) about sustainable rural development and at a French roundtable with both researchers and practitioners (POPSU, 2016) where ergopolis (also called ergonomic metropolis in the roundtable's report) is defined as a "territory that takes better into account the question of work" (J.M. Offner in the said roundtable), also underlining that "a metropolis should deliver to its users, not only to its inhabitants", as a reference to the origin of ergonomics as the science of work.

Other authors have considered ergonomics of walking: Stevens and Salmon (2015) apply cognitive work analysis to footpaths and public places to make them more inclusive, further research was then performed on other spaces (Stevens et al., 2021). Appolloni et al. (2020) developed an approach to evaluate walkability with ergonomic criteria, three main needs for the "Human-Environment Interface" are identified: well-being, safety and usability, the weight for the different factors has been elaborated with "a multidisciplinary panel of 10 experts", the methodology has been applied to various areas in Rieti, Italy.

Antoni (2014) has reviewed various approaches of spatial ergonomics in the French-language literature. Sperandio (1976) proposed the concept of "ergonomics of the built environment" as he remarked that "ergonomists [were] starting to take interest in the design of built environment" with scales ranging from the interior to neighbourhoods. His research on this topic were not pursued, mostly due to ergonomists taking interest on human-machine interfaces in computer science (Sperandio, 2011). Hached and Propeck-Zimmermann (2021) have proposed a methodology to assess ergonomics of access of daily life resources. Their approach includes most of the criteria considered by other authors for walkability and cyclability but can also be applied to other modes. We retain the ergonomics of access (also called access ergonomics in other sources), as this framework is suitable not only for a specific mode but can be applied to different modes, including intermodal trips.

2. Access ergonomics: spatial ergonomics applied to access to daily life resources

The ergonomic approaches in urban settings can then be classified in two groups: either the city is a human-machine system to which the methods from ergonomics of workplaces can be directly applied (Sperandio, 1976) or a conceptual transfer is needed from classical ergonomics such as in spatial ergonomics (Saint-Gérand, 2002).

Spatial ergonomics is a conceptual transfer from ergonomics as it is applied in industrial settings to geography (Saint-Gérand, 2002, Propeck-Zimmermann et al., 2018). The geographical space is assimilated (Figure 2) to the industrial settings considered in classical ergonomics, while socio-economic resources are assimilated to the industrial settings' products and resources (Propeck-Zimmermann et al., 2018). Spatial ergonomics is then defined as the "endogenous and exogenous capacity of a space to provide a population/society with the entire set of social and economic resources they require at the least cost" (Saint-Gérand, 2002).

Ergonomics		Spatial ergonomics
working action		daily life actions
worker	⟷	population (individual, categories, spatial community)
workshop / workplace	semantical translation and / or change of conceptual space	space (daily life area)
materials		resources
tools		amenities (infrastructures)
costs	⟷	costs
process		social and spatial behaviour (stability/mobility)
efficacity / productivity		adequation / performance

Figure 2: Spatial Ergonomics Concepts translated from Saint-Gérand (2002)

Access ergonomics (Hached, 2019) is a subdomain of spatial ergonomics as an approach through mobility. It provides a framework for the analysis of the disposal of daily life resources and "assesses the more or less capacity to minimize the costs (in the broad sense) of appropriating the resources that the population needs in daily life" (Hachette, Propeck-Zimmermann and L'Hostis, 2024). This approach assesses accessibility while focusing on its conditions not only regarding travel duration but also considering daily-life resources availability, infrastructure, as well as mobility conditions and quality (facilities, safety, comfort, environment) adapted to each transport mode. Access ergonomics relies on the hypothesis is that a high-quality environment helps to promote sustainable transport, especially for active modes. Mobility behaviours are known to be influenced by safety, comfort, and environmental factors (Piombini, 2013). Access ergonomics integrates these factors into a synthetic access ergonomics score composed of several sub-indicators to identify and analyse socio-spatial inequalities in accessing daily resources. The sub-indicators consider the urban environment, network and infrastructure, alternative resources availability, number of proximity resources, diversity of proximity resources, availability of resources, and safety. Access ergonomics consider interactions between three constituents of the territory: the resource potential, population and stakeholders needs and practices, and the structure of the territory (Figure 3).

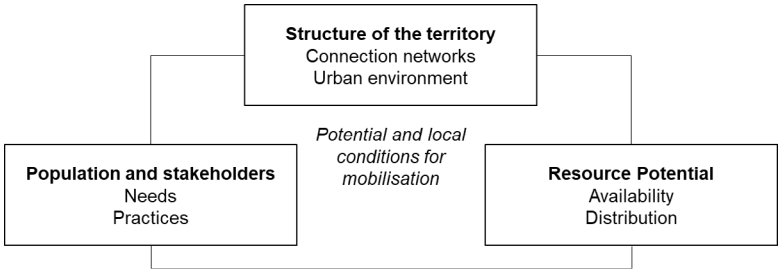

Figure 3: General model of access ergonomics (Hachette, Propeck-Zimmermann and L'Hostis, 2024)

Two previous approaches for access ergonomics have been developed:

- A large-scale isochrone-based approach, used to assess ergonomics of access to resources of the whole Eurométropole de Strasbourg (Propeck-Zimmermann et al., 2018).
- A more detailed route-based approach (Figure 4) has been used to assess ergonomics of access for 13 locations in the Eurométropole de Strasbourg (Hachette, Propeck-Zimmermann and L'Hostis, 2024).

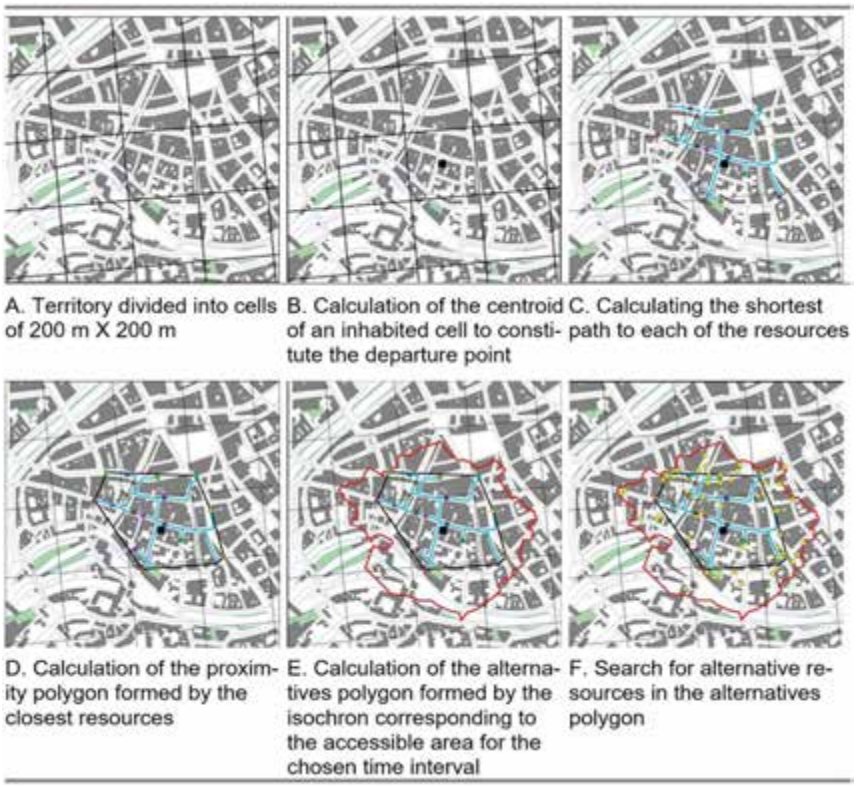

Figure 4: Computation of Access Ergonomics (Hachette, Propeck-Zimmermann and L'Hostis, 2024)

Both methods use a 200 × 200 m grid corresponding to the highest resolution (in France) for income and census data and use the shortest path from the centre of each tile. Both approaches consider not only the closest amenity but also its suitable alternatives. The detailed method generates a synthetic score from 0 to 100 but its subscores can also be analysed individually to distinguish between situations with the same synthetic score while having different characteristics. In both approaches, travel times were not issued from modelling, but from the distance travelled. Hached (2019) showed significant variability in access ergonomics across the Eurométropole de Strasbourg through a synthetic indicator built using GIS for active modes, showing a gradient from the centre and comparing it between walking, cycling and driving. The highest ergonomics of access for bicycles and pedestrians was in the city centre whereas it was highest in the outer ring by car, due to traffic calming actions in the city centre. The amenities considered are classified from a statistical classification (nomenclature d'activités française) to classes containing similar amenities (Table 1) that are considered together in the assessment of ergonomics of access.

Table 1: Amenities considered in Hached, 2019

Category	Class	Resource type in the *nomenclature d'activités française*
Shops	A	Bakery
		Pastry shop
		General food store
		Grocery
		Butcher shop
	B	Small-size supermarket
		Medium-size supermarket
	C	Large supermarket
	D	Tobacco shop
		Newsstand and stationery shop
	E	Pharmacy
	F	Market
Schools	G	Preschool
		Primary school
	H	General secondary school
Healthcare	I	Hospital
		Surgical activities (clinics)
	J	General practitioner
		Nurse or midwife
	K	Radiodiagnosis or radiotherapy
		Dental practice
		Medical laboratory
Public services	L	City hall
		Police station
		Medical and social centre
		Employment agency
Leisure	M	Cinema
		Museum
		Performance venue
	N	Public library
	O	Sports clubs
		Sport facility

Evaluations of access ergonomics were performed considering a temporal threshold. Three values (5, 10 and 20 minutes) were considered. This corresponds to a proximity criterion, in line with the renewed interest in proximity, in particular with the rise of the 15-minute city concept. Electric vehicles and micromobility were not considered, nor was public transportation. The rise of micromobility and intermodality requires adaptation of these analyses. Hachette, Propeck-Zimmermann and L'Hostis (2024) also note that access to employment should ideally be considered. Access ergonomics, as its name suggests, attach importance not only to ergonomics but also to accessibility. As such, its assessment can only be performed it the condition of accessibility is ensured.

3. Notions close to access ergonomics: accessibility, proximity, and mobility

Access ergonomics is linked to several other notions: ensuring accessibility is possible is a prerequisite to the appraisal of access ergonomics. Accessibility can be attained through two means: proximity and mobility whereas walkability and cyclability are applications of accessibility to a particular means of transportation. The differences in scales, modes, and goals of these close notions are summarised in Table 2.

Accessibility is considered "an important dimension of quality of life" and though it has varying meanings among authors, it can be defined as "the ease of reaching desired activities" (Silva et al., 2024). It is a major field of interest in geography, Silva et al. (2024) note that "scientific papers concerned with accessibility have grown tenfold in one decade, surpassing the average of 200 papers per year in 2014" though mobility is still more represented in scientific literature. Dumolard (1999) distinguishes distance, an "abstract and theoretical notion", and accessibility which is a "more contextual and concrete metric of remoteness". Geurs and Van Wee (2004) categorize four components of accessibility: "transport component", "land-use component", "temporal component" and an "individual component"; these components can be analysed through four types of measures: "infrastructure-based", "location-based", "person-based" and "utility-based". They note that interpretability and communicability need to be improved and that "spatial–temporal constraints" of an individual should be included in accessibility studies.

Silva and Larsson (2019) describe accessibility as a goal whereas proximity and mobility are means towards accessibility. Hachette, Propeck-Zimmermann and L'Hostis (2024) differentiate spatial ergonomics and accessibility on their objectives: "access ergonomics seeks to understand the overall functioning of the territory and its capacity to meet needs through different elements, in particular the arrangement of its resource potential and its ability to respond to disturbances, whereas accessibility focuses on a very specific aspect of the functioning of the territory, that of travel and transport".

The 15-minute city concept (Moreno et al., 2021), which relies on proximity of amenities by walking or cycling to improve accessibility while reducing the need for motorised transportation between activities is gaining traction; 98 cities were identified by Teixeira et al. (2024) as implementing or planning to implement the concept or practices close to it. However, Papadopoulos, Sdoukopoulos and Politis (2023) identified multiple shortcomings in the current approaches to measure compliance with the 15-minute city concept, noted a focus on walking but a lack of consideration of the different walking speeds among the population and recommend the use of disaggregated origins to represent the travellers. They also note a low scalability in most of the considered studies.

Table 2: Comparison between access ergonomics and close notions (Hacquard, 2025)

Term	Scale	Mode	Goal
15-minute city	Citywide	Walking, cycling or other active modes	Proximity of resources so inhabitants can fulfil their needs within a 15 min radius
Access ergonomics	Living area	Ideally multimodal	"*Understanding of the overall functioning of the territory*"
Accessibility	Varying (from the building to global)	Varying between studies (can be mode-focused or multimodal)	Ease of reach
Cyclability	Varying (from the neighbourhood to city-wide)	Cycling	Ease of reach by cycle
Mobility	Varying (from the neighbourhood to global)	Varying between studies (can be mode-focused or multimodal)	Ease of reach through efficient transportation
Proximity	Neighbourhood to living area	Usually either walking or cycling	Ease of reach through low distances
Walkability	Varying (from the neighbourhood to city-wide)	Walking	Ease of reach by walking (Cervero and Kockelmann's 3D: density, diversity, design)

4. Transportation modelling approaches

Most of the forementioned notions include spatial and temporal (either travel time or variation during the day) aspects. Modelling allows to analyse both spatial and temporal travellers' behaviours, which can refine the assessment of access ergonomics. In this part, we review different modelling approaches to find the most suitable one to analyse access ergonomics.

Multi-agent systems are made of agents, which are "computing entities able to act and interact to perform a fragmentary task in a system where the consideration of complexity is left to the interactions" (Dumolard, 1999). These systems can be used for modelling purposes. Agent-based models in transportation provide a "microscopic representation of travel individuals as they move from place to place" (Kagho et al., 2020) whereas activity-based models are transportation models describing activities of the population of interest with transportation as a derived need between activities. Agent-based models have multiple advantages, especially the possibility to have individuals as agents as well as a representation of interactions between individuals, making them particularly relevant for activity-based models (Ortúzar and Willumsen, 2016).

Activity-based models are used for evaluating accessibility through a trip completion rate by measuring the proportion of the trips below a certain threshold (Somanath et al., 2025). This approach however does not consider key parts of access ergonomics (safety and convenience of trips). Staves et al. (2025) use an agent-based model to estimate travel times and take street-level environment into account to model active travel accessibility in Greater Manchester. Their approach includes gradient, surface, ambience and stress though a mix of open and proprietary data with parameters that "were chosen through an iterative process and validated in consultation with regional experts" from heuristics and literature. Cycling accessibility is assessed through personas who can cycle on links with varying levels of cyclable infrastructure.

Activity-based models require a population with multiple socio-economical characteristics for each individual and an initial demand with initial activity plans. As these data are not directly available, either from census or from surveyed individuals, for privacy concerns among others, a synthetic population is necessary to run most activity-based models. Hörl and Balac (2021a) have developed eqasim, an open-source and reproducible pipeline to recreate a synthetic population and its travel demand for the Île-de-France region using only open access data. The use of the pipeline for other locations in France such as Nantes (Le Bescond et al., 2023), Lyon (Manout and Diallo, 2023) has been successfully done and for locations in other countries including Switzerland (Grübel et al., 2023) and China (Hu et al., 2022). The required input data for the pipeline is laid out in a data paper (Hörl and Balac, 2021b) and consists of national census (which in France contains commute flows between municipalities), income distribution data (Fichier Localisé Social et Fiscal, FILOSOFI), an household travel survey (either a local one or the national household travel survey), the address database (Base Adresse Nationale, BAN), enterprise census (Système national d'identification et du répertoire des entreprises et de leurs établissements, SIRENE) and a service and facility database (Base permanente des équipements), OpenStreetMap and GTFS data are additionally used to create the MATSim network. The travel demand and activities of the synthetic population are built around "primary activities" (home, work and education) while "secondary activities" are fitted in the schedule around the constrained primary activities.

5. Assessing access ergonomics through multi-agent modelling

To answer the question stated in the introduction, we retain access ergonomics as the approach considers not only travel time but also travel conditions and alternatives. It can be extended to include more modes and to consider access to other amenities. To overcome limitations from previous approaches, in particular the fact that trips related to work are not considered, nor is public transportation; a new methodology is being developed to improve realism and precision in evaluating access ergonomics (Figure 5). Multi-agent modelling is used to simulate mobility behaviours based on detailed socio-spatial profiles, considering diverse socio-economic and demographic data at a fine scale (200 × 200 m). These profiles are fed to a geographic information system to assess access conditions using various transport modes (car, public transportation, cycling and walking). Trips are analysed within activity chains, where each activity (work, leisure, services) can be interconnected. The model also considers resource availability and transport service schedules, identifying potential inconsistencies that impact access ergonomics.

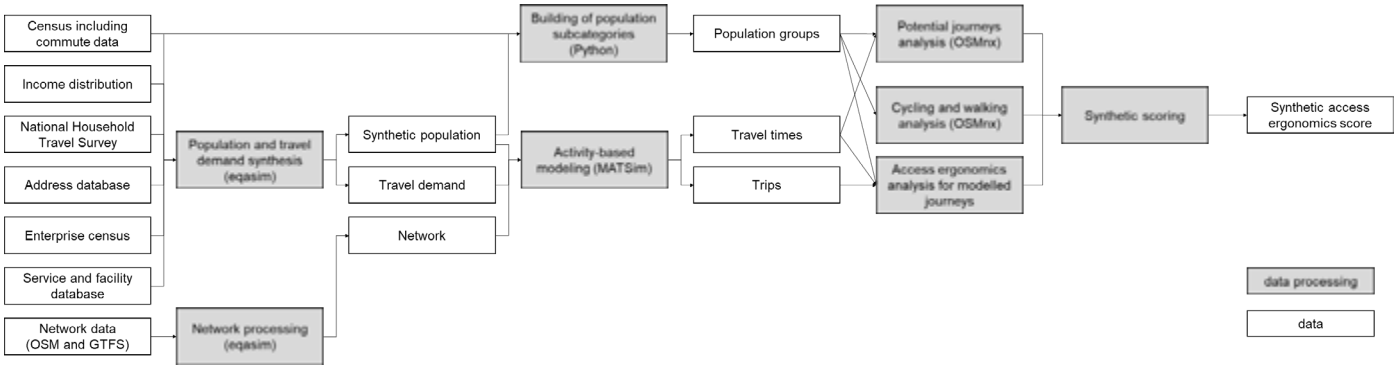

Figure 5: Data processing steps (Hacquard, 2025)

The study relies on open geographic and statistical data covering the Eurométropole de Strasbourg. The synthetic population is generated using eqasim (Hörl and Balac, 2021a) with the input data following its accompanying data paper (Hörl and Balac, 2021b). The main difference with the Île-de-France Region considered in the data paper is that public transport networks are in different GTFS files as multiple competent local authorities cover the sector. As the latest local household travel survey (Enquête Mobilité 2019) is not in open access and a newer household travel survey is being performed in 2024-2025, the national household travel survey (Enquête Nationale Transports et Déplacements 2008) has been used instead. The multi-agent model is larger than the Eurométropole de Strasbourg and includes the whole département of Bas-Rhin (1,152,662 inhabitants in the 2021 census) where the Eurométropole is located to include interactions with the surroundings.

Simulations are performed using MATSim (Horni et al., 2016) and are run using a sampling rate of 10%. Car assignment is performed with QSIM (Dobler, 2010) while public transport routing is performed using SwissRailRaptor (based on Round-Based Public Transit Routing, Delling et al., 2015), this method considers journeys using different public transport modes and walking. In accordance with the eqasim pipeline, bicycle and pedestrian routing is not performed and replaced with beeline distance factors to estimate travel time.

The national household travel survey does not contain data about micromobility such as electric scooters. Results from local household travel surveys in France between 2021 and 2023 show that micromobility represents 0.4 % of the trips of the surveyed individuals aged between 15 and 44 (Cerema, 2024). Due to its low share, as a first approach, micromobility is not modelled and is only considered in the score computing phase.

Two types of journeys need to be considered to assess ergonomics of access: the ones that actually took place (or the one modelled in this case) and the one that would have happened, should the users have decided to travel to a resource. Both must be separated in the modelling phase as potential journeys should not cause congestion.

Public transportation and car journeys representing the journeys that would have happened in the modelled day are directly available from the multi-agent model whereas the links travelled cycling or walking are rebuilt using OSMnx (Boeing, 2025). Potential travels are modelled using OSMnx and NetworkX (Hagberg, Schult and Swart, 2008) on a network with the travel times from the simulation at peak periods for car journeys and without taking congestion into account for other modes.
Population groups are built to recreate the variation of walking speed between age classes, to reflect the varying use of cycling according to age and to reflect the needs of various groups (i.e., households with young children need access to childcare).

6. Study case

The Eurométropole de Strasbourg regroups 33 municipalities with population ranging from 802 to 291,313 in the 2021 Census and a total population of 514,651. The Eurométropole is located on the left bank of Rhine River which is the border between France and Germany in this area. The highest population densities are in the central part of Strasbourg and in neighbouring municipalities (Figure 6).

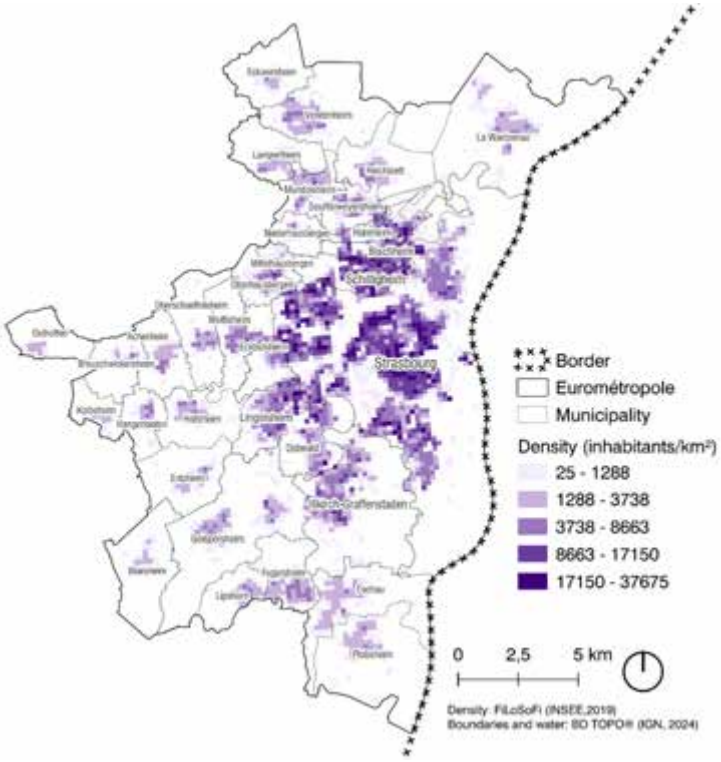

Figure 6: Population density in the Eurométropole de Strasbourg

Mobility in the Eurométropole de Strasbourg is characterised by a higher modal share of cycling compared to other cities in France; with a 14.3 % share for commuting trips in the 2021 Census, cycling in the Eurométropole de Strasbourg has the highest modal share of all 22 French metropolises.

The meshed tram network (Le Tourneur, 2016) serves Strasbourg as well as 6 other municipalities in the Eurométropole (Bischheim, Hœnheim, Illkirch-Graffenstaden, Lingolsheim, Ostwald and Schiltigheim) and Kehl in Germany with 6 lines, some of them partially overlapping. The tram network is completed by two bus rapid transit lines that serve municipalities also served by the tram network.

7. First Results

The literature review for ergonomics in urban settings indicates that published documents are split between three major topics: vehicle-related topics, urban-scale matters and design. Cars and motorcycles constitute the main part of the literature on vehicle-related topics and most of the documents consider the ergonomics of driving. On urban-scale matters, various authors have written on methodologies to assess urban ergonomics, especially regarding mobility; most of them focus on a particular mode and walking is particularly represented. Most of the approaches rely on existing data on travel conditions.

The proposed methodology uses open data, is sensitive to changes in travel conditions and aims to be replicable. The post-processing mitigates some artifacts that may happen with population synthesis: the use of personas alleviates some issues linked to structural zeroes. This method is however more computer intensive than methods solely relying on isochrones made from existing travel times or purely distance based.

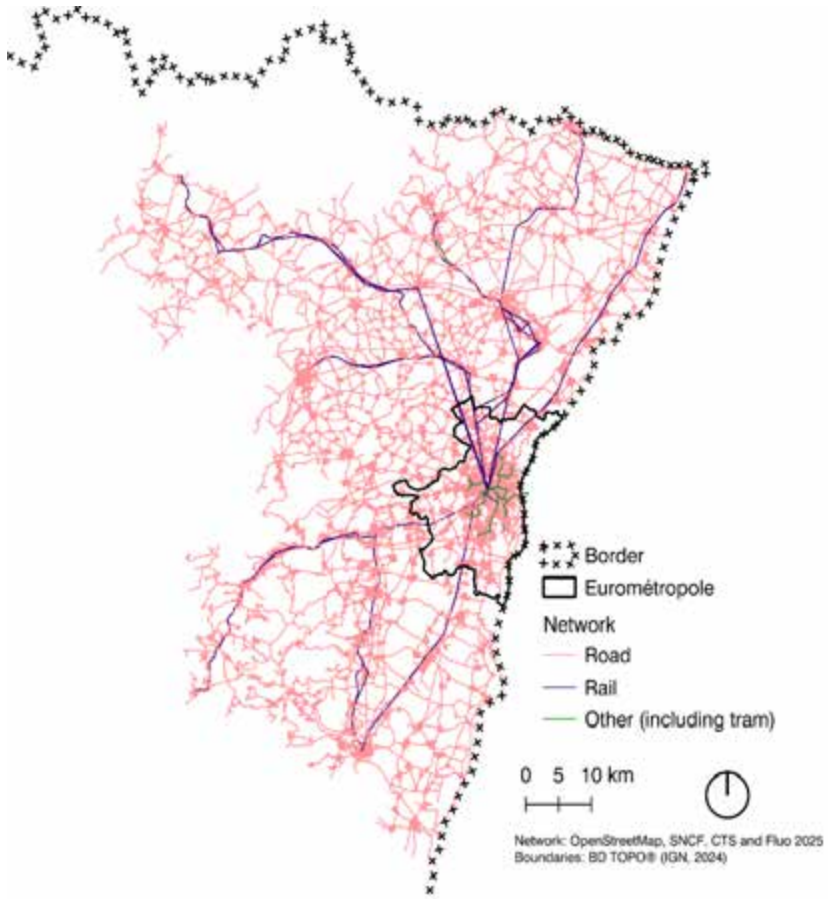

Figure 7: Modelled network

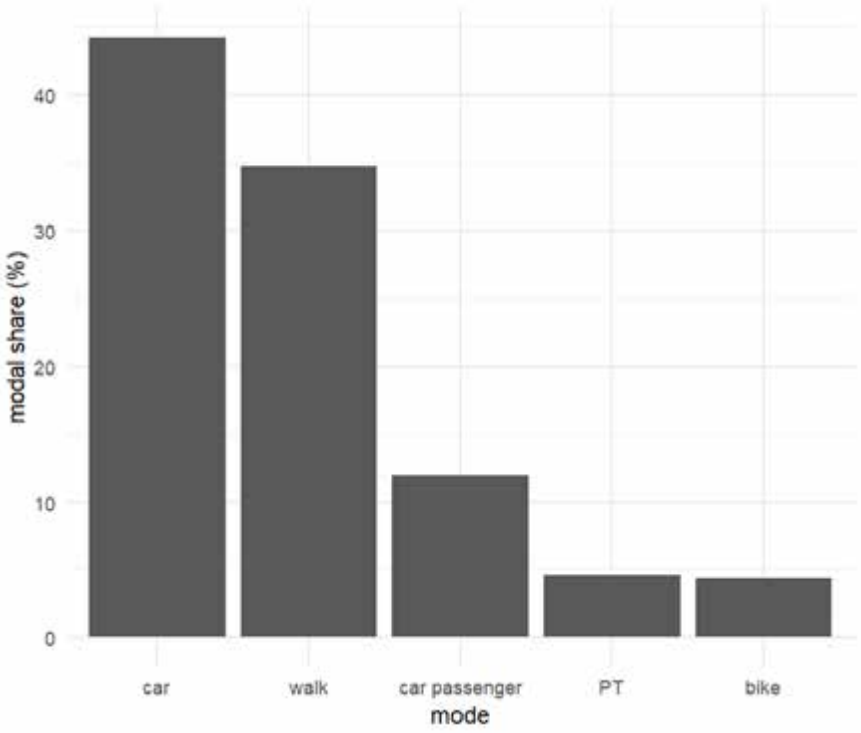

Figure 8: Modal shares

The modelled network (Figure 6) covers a wider area than the Eurométropole and includes 161,269 links. The German side of the border is not modelled due to the difference between data sources. The modal share (Figure 7) differs from the ones for Bas-Rhin in the 2021 census, this is due both to a lack of calibration and to differences in the way data is accounted for as modal share in the census only includes home to work travels.

8. Discussion

Many approaches in urban ergonomics are defined and trialled in an initial paper but are not applied further in other places. The transferability of many methods seems to be a significant issue as most of them rely on data that either requires manual input or depends on local authorities and is not standardised among data sources, qualitative approaches are more sensitive to this issue. The challenge is however that most datasets that cover more places are less defined. A challenge is then to find an equilibrium between data definition and availability, the identification of correlation between lower-scale elements and higher-scale indicators may be a way to reduce the number of needed data sources in further studies while considering the quality of surroundings during journeys.

Regarding modelling and post-processing, a further goal is also to streamline the process and develop a tool which will generate an access ergonomics score for each inhabited grid square, providing a detailed and comprehensive view of socio-spatial inequalities. The synthetic score broken down into sub-indicators (travel time, safety, comfort, etc.) and transport modes will enable comparison across the territory. These results will help to identify actions for improving access ergonomics and for reducing inequalities. In further studies, the developed tool will be improved by considering the aspect of energy transition, especially to take its consequences into account on the access ergonomics. The electric scooter availability is considered uniform in the study area in the present study. As the newer household travel survey will include data about micromobility vehicle availability, further studies may represent variations in the availability rate, the same way car ownership is modelled. The current model is uncalibrated as the latest local household travel survey results are to be released and uses the national household travel survey from 2008. Pedestrian and bicycle routing might also be an enhancement of the model, though these modes are less prone to congestion. Disposal of resources in Germany is not considered in this current paper though some communities in France near the border include amenities in Germany for their daily life, mostly for shopping purposes according to the report of the 2019 Household Travel Survey. A synthetic population of Bavaria has been built (Hörl et al., 2025) using an adapted version of the eqasim pipeline. Data availability in Baden-Württemberg (the German state neighbouring the Eurométropole de Strasbourg) and data heterogeneity between the two countries represent however a significant challenge.

Conclusion

Ergonomics in the city includes both the ergonomics of objects or spaces in the city as well as the ergonomics of the city as a system. Though the original definitions of ergonomics initially considered the human-machine interactions at the workplace, several authors have written about non-work activities and have created a wider frame for ergonomics: macroergonomics considers not only human-machine interactions, but the interaction between humans and organisations, on activities that are not limited to work. Macroergonomics have been applied to transportation systems since the 1970s with approaches such as the one Hoag and Adams applied to public transportation networks.

More recently, the return of consideration of proximity is linked to a renewed interest in the environment during travels as the users of active modes being more sensitive to their environments and literature regarding walkability includes elements of ergonomics. Most of the approaches however are either focused on a particular means of transportation or lack quantitative elements. The ergonomics of access has mostly been trialled with walking and cycling, but its outline can be adapted to other transportation modes, especially public transportation.

The proposed framework links the assessment of access ergonomics to a multimodal activity-based multi-agent model. The multi-agent paradigm allows the analysis of interactions between users and the analysis of individual properties of each agent. As access ergonomics not only describe travels done by users but also the potential ease of access to amenities including their alternatives, post-processing of the transportation simulation is necessary.

The objective to the approach is to provide a toolkit for a more holistic analysis of access to resources that is sensitive to changes in mobility conditions, whether from the network or from the demand. The multi-agent paradigm also allows further developments such as considering competition between the users for resources.

Acknowledgements
The Sankey diagram (Figure 1) has been generated with the networkD3 (Allaire et al., 2025) and Figure 7 has been created with ggplot2 (Wickham, 2011). dplyr (Wickham et al., 2023) was used to process data to produce the figures and census with the R language (R Core Team, 2024).

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Impact of Multi-Station Aggregate Hub Redevelopment on Surrounding Urban Areas: A Case Study of London's King's Cross

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Abstract
Multi-station aggregation hubs – interconnected transport nodes in high-intensity urban areas – significantly influence metropolitan growth, yet systematic research on their regional development impacts remains limited. This study examines London's King's Cross–St Pancras hub redevelopment using spatiotemporal data (1996–2023). Three analytical zones (Core zone, Central Impact Zone and Wider Impact Zone) were established to assess transport networks, functional vitality, and development intensity via GIS and qualitative methods. Findings indicate a 25:11:8 ratio of renewed building areas across zones, with development intensity strongly correlated to hub proximity. The core zone saw significant growth in consumer/service-oriented POIs, evolving into a mixed-use creative hub. Insights are provided for redeveloping similar hubs in high-density cities, particularly China.

Keywords
Multi-Station Aggregation; Transportation Hubs; Urban Area; King's Cross; Spatiotemporal Evolution

1 Introduction

Rail transit is reshaping existing urban spatial configurations and travel patterns (Chu and Wei, 2017; Li et al., 2015), even accelerating the redefinition of architectural boundaries, pathways, and frequencies, thereby creating new spatial forms oriented toward speed (Chu and Su, 2024). Since the 21st century, the rapid development of urban rail transit systems, exemplified by metro networks in Chinese metropolises, has profoundly transformed spatiotemporal perceptions of urban spatial development. In Asia, large cities are planning and implementing massive investments in public transport networks, where the promotion of transit-oriented development (TOD) policies has become pivotal to building public transport-centric cities (Kidokoro, 2020). For instance, Tokyo's rail system enhanced transport capacity and efficiency through measures such as double-track expansions, metro development, new route creation, express services, and station upgrades, supporting the city's transition toward compact and low-carbon spatial structures (Cao, 2022). Rail transit development influences urban layout and intensity, offering sustainable frameworks for creating compact, mixed-use communities around transport hubs in city centers.

Existing studies on the integration of rail transit stations and surrounding land development primarily focus on single-station-centered approaches, categorizing research based on station functions or locational characteristics. However, as cities evolve, urban transport hubs increasingly interconnect with neighboring stations, while metro lines constructed in different periods form complex spatial structures (Li et al., 2024). In recent years, metropolises central areas have witnessed intensified rail station clustering and increasingly intricate network configurations (Yang, 2021). Due to factors such as the alignment of new lines, construction challenges, and infrastructure constraints, later-built stations may not align with existing ones but could emerge within walkable distances. These stations, through infrastructure upgrades, coalesce into multi-station aggregation hubs (Zhu and Wang, 2022). Such hubs, often located in urban cores or critical transport nodes, present significant opportunities for shaping surrounding areas (Li et al., 2024; Desjardins, Maulat and Sykes, 2014). Over the past three decades, these hubs have proliferated in global urban development, with their optimized layouts structurally enhancing spatial quality in central districts (Yang, 2021). Nevertheless, systematic research on multi-station hubs and their interconnected urban functional districts remains insufficient, and their spatiotemporal evolution mechanisms require further study.

The King's Cross area in London, a vital transport hub and urban core in the city's northeast, hosts two major rail stations (King's Cross and St Pancras) and six underground lines. Its closely linked stations exhibit rich spatial hierarchies and order, making it a representative multi-station aggregation hub. This study traces the redevelopment of King's Cross over the past two decades, employing multi-source archival surveys, GIS-based quantitative analyses of transport networks, functional shifts, and development intensity, and typological examinations of renewal modes. By combining quantitative and qualitative methods, it analyzes the impact of

multi-station hub redevelopment on regional development, aiming to uncover patterns of influence exerted by such transport complexes on urban growth. The findings are expected to provide insights for the planning and redevelopment of multi-station aggregation hubs in other emerging metropolises.

2 Research Methods

2.1 Case: King's Cross, London

The King's Cross area is located in the northeast of central London, at the junction of the Camden and Islington boroughs, serving as a critical transport hub where King's Cross Station and St Pancras Station converge. After World War II, containerized rail freight replaced traditional freight methods, leading to large areas of land and buildings within the region being repurposed for cargo storage. Due to poor management, the station environment became increasingly dirty and dim, while unemployment severely impacted local communities. By the 1980s, the area had become a region in urgent need of urban revitalization. However, redevelopment efforts in the 1980s and 1990s repeatedly failed due to challenges in coordinating land ownership, incomplete public facilities, and unclear industrial targets.

The real reconstruction of the area began in 2000 with the Channel Tunnel Rail Link project. A development consortium named King's Cross Central Development Partnership (KCCLP), composed of companies such as Argent, LCR, and Exel, was established as the sole landowner to lead the redevelopment of the King's Cross core zone. Building on comprehensive upgrades to King's Cross and St Pancras stations, the project capitalized on high transport connectivity to integrate multiple underground lines, transforming former industrial sites into a mixed-use urban district combining commerce, culture, creativity, and research. This revitalization became a new engine for urban development, driving growth in surrounding areas. The urban transformation also brought significant opportunities: between 2010 and 2022, the number of companies in the core zone nearly doubled to 800, office rents surged from 48% below to 19% above central London averages, and employment increased from 8,000 to 27,000 jobs (Regeneris Consulting, 2017). The King's Cross redevelopment project stands as one of the UK's largest and most notable urban regeneration initiatives of the past three decades.

As a representative multi-station aggregation hub with nearly two decades of redevelopment history and a stabilized built environment in recent years, King's Cross was selected as the focus of this study. Based on reports published by the King's Cross development authority (Regeneris Consulting, 2017) and the King's Cross Master Plan (Allies and Morrison Architects, 2007), the research scope was divided into three zones (hereafter referred to as the "Three Zones," Figure 1): Core zone, Central Impact Zone and Wider Impact Zone.

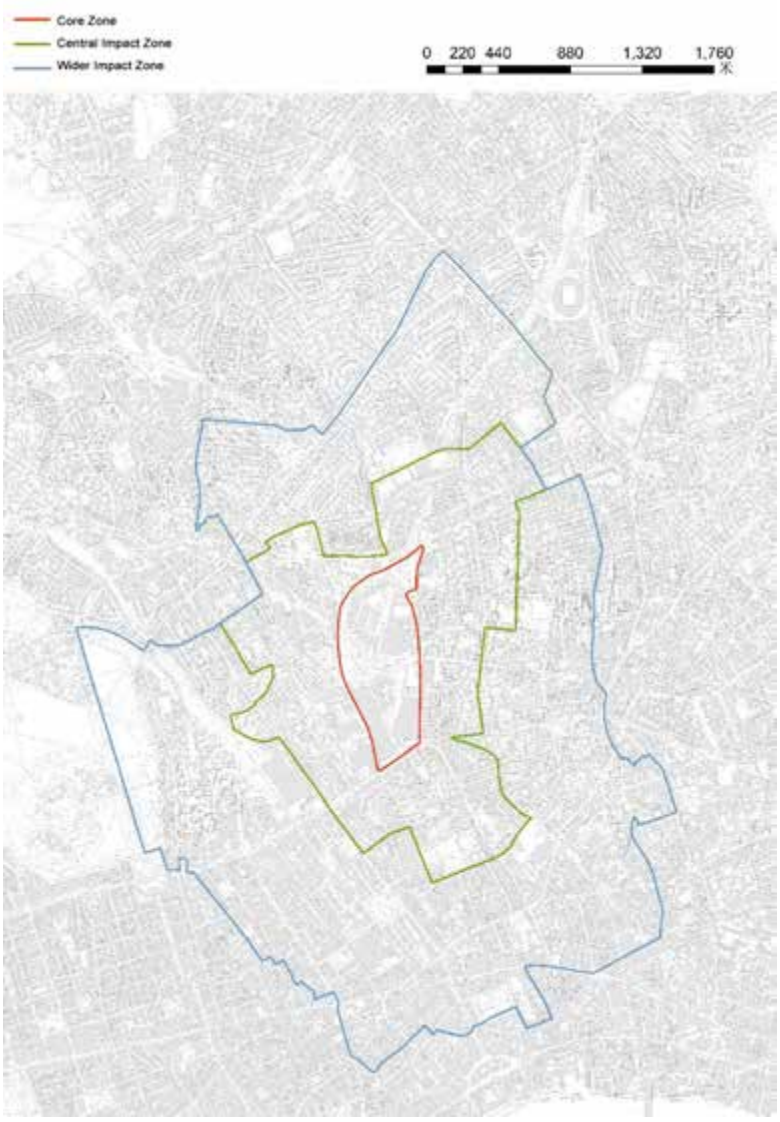


Figure 1: Three Analytical Zones of King's Cross

2.2 Data Sources: Documents and Spatial Data

This study collected and analyzed documents and spatial data related to the redevelopment of King's Cross from multiple sources. For documentary data, this included historical records of the area, planning and design proposals from developers and urban designers, relevant planning documents published on the official websites of the Camden and Islington local authorities, progress reports on the King's Cross core zone (2008–2024) published by KCCLP on its official website, and a 2017 construction evaluation report for the core and impact zones by Regeneris Consulting (Regeneris Consulting, 2017). For spatial and statistical data, the study acquired: Ordnance Survey datasets (2007–2023): Built-environment typology maps, building height data, and Points of Interest (POIs); Transport for London (https://tfl.gov.uk): Ridership statistics for stations (2007–2017); UK Office for National Statistics (www.ons.gov.uk): Census data (2001, 2011, 2021) at the Output Area (OA) level, with each OA typically covering 40–250 households.

2.3 Analytical Methods: Integration of Qualitative and Quantitative Approaches

The research first clarified the historical development trajectory of King's Cross through document analysis, with a particular focus on the evolution of the core zone's built environment and the historical integration of rail and underground lines. Historical changes were mapped visually. At the macro level, ridership variations across stations were visualized, while transport networks, functional vitality, and development intensity within the three zones were analyzed and visualized using ArcGIS to quantify the impact of multi-station transport

development on surrounding areas. Building on this spatial analysis, the study classified and examined spatial renewal patterns across the three zones. Typical buildings were categorized by renovation scale, from largest to smallest:1) Brownfield redevelopment, 2) Demolition and reconstruction, 3) Functional adaptation and renovation, 4) Vertical or horizontal expansion. The development of King's Cross was systematically analyzed through both renovation typologies and spatial layouts.

3 Multi-Station Aggregation Hub and Regional Impact in King's Cross

3.1 Aggregation Development of Transport Hubs

In the 1990s, the King's Cross–St Pancras underground station comprised three distinct stations: the Metropolitan/Circle Line (constructed 1864–1870), the Piccadilly/Northern Line (1906–1907), and the Victoria Line (1968). These stations were connected by narrow, temporary passageways, which became severely congested by the late 1990s due to escalating passenger volumes (Bessant, 2004). Following the 1987 King's Cross fire, the 1989 Fennell Report (Fennell, 1989) by the UK House of Commons recommended that London Underground investigate "riderships and overcrowding at stations and implement remedial measures." The London Underground (King's Cross Station) Act 1993 authorized infrastructure upgrades to alleviate congestion. The underground connectivity project, designed in 1999 and constructed from 2000, was implemented in two phases: Phase I (2006): Expanded the original ticket hall and constructed a new western ticket hall adjacent to St Pancras Station, directly linking to the Metropolitan/Circle Line platforms; Phase II (2009): Added a northern ticket hall with tunnel access to the Piccadilly Line and improved accessibility features (Figure 2).

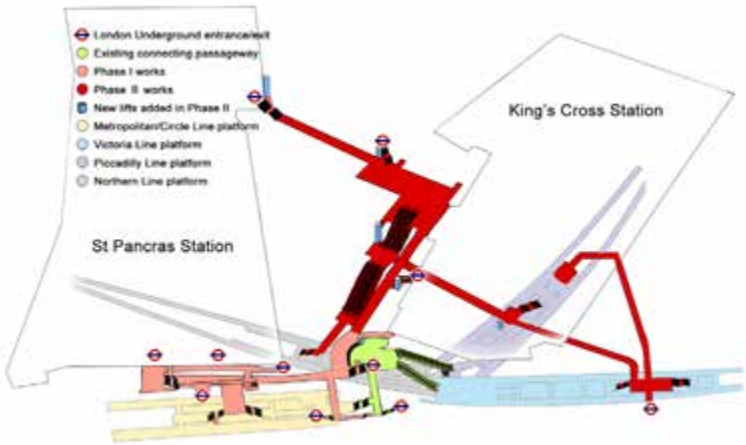


Figure 2: Schematic Diagram of the Multi-Station Aggregation Project at King's Cross

The redevelopment added six new access points in Phase I and two in Phase II, resulting in 11 underground entrances across three ticket halls. These upgrades integrated six underground lines and two national rail stations, resolving congestion and providing capacity for the 2012 London Olympics. The consolidation of previously fragmented stations into a multi-station aggregation hub significantly improved accessibility, enabling the hub to accommodate Eurostar's high-speed rail services and catalyzing large-scale urban renewal in the surrounding core zone (Allies and Morrison Architects, 2007).

Following the November 2007 opening of St Pancras International Station and further optimization of underground and above-ground facilities, rail and underground riderships exhibited steady growth. From 2008 to 2017, annual ridership at King's Cross–St Pancras underground station increased by 46%, King's Cross rail station by 40%, and St Pancras International nearly doubled. The growth rate at King's Cross–St Pancras far exceeded the London Underground average and ranked highest among surrounding stations (Figure 3), driving substantial ridership growth in the King's Cross area, particularly in the core zone.

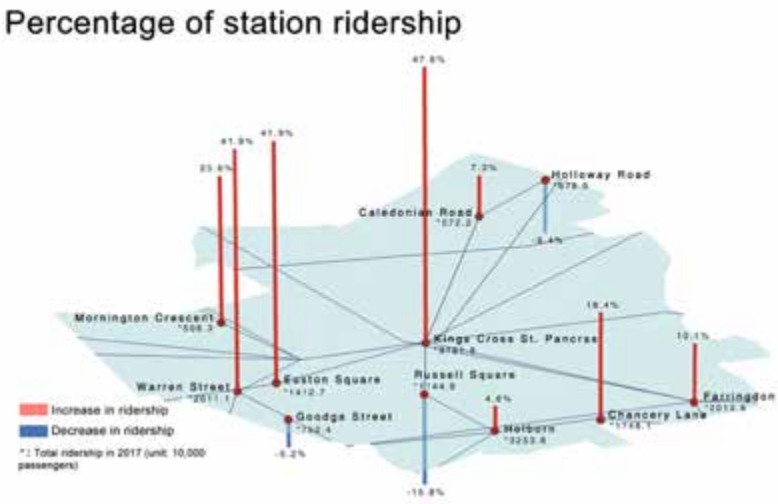


Figure 3: Annual Ridership Changes at King's Cross Stations (2007–2017)

3.2 Evolution of the Transport Network

The redevelopment of the King's Cross area has had an impact on the transport network mainly in terms of the reconfiguration of roads in the core zone, where the northern part of the site, which was previously divided by transport routes and freight depots, has been reconfigured in a phased manner, and the links with the surrounding area, in particular the aggregated sites, have been enhanced in the following ways (Figure 4): Early redevelopment focused on opening east-west freight routes and extending Camley Street and Pancras Road into the core zone. These newly connected arteries, alongside the existing York Way, redefined the primary transport network of King' s Cross. In the middle of the redevelopment, two narrow historic canal bridges were replaced with 18-meter-wide pedestrian bridges—dual-function structures designed for daily foot traffic and emergency access (e.g., firefighting). This phase also rationalized key north-south connections, establishing a cohesive axis from York Way through the canal to the station area and onward to A501 Road. In the concluding stage, vacant plots were systematically redeveloped to form a comprehensive pedestrian network. Newly constructed building clusters integrated well-defined public spaces and streetscapes, further enhancing the core zone's vibrancy. Post-redevelopment, the entire zone achieved a balanced yet diverse street layout, markedly improving traffic fluidity and urban functionality.

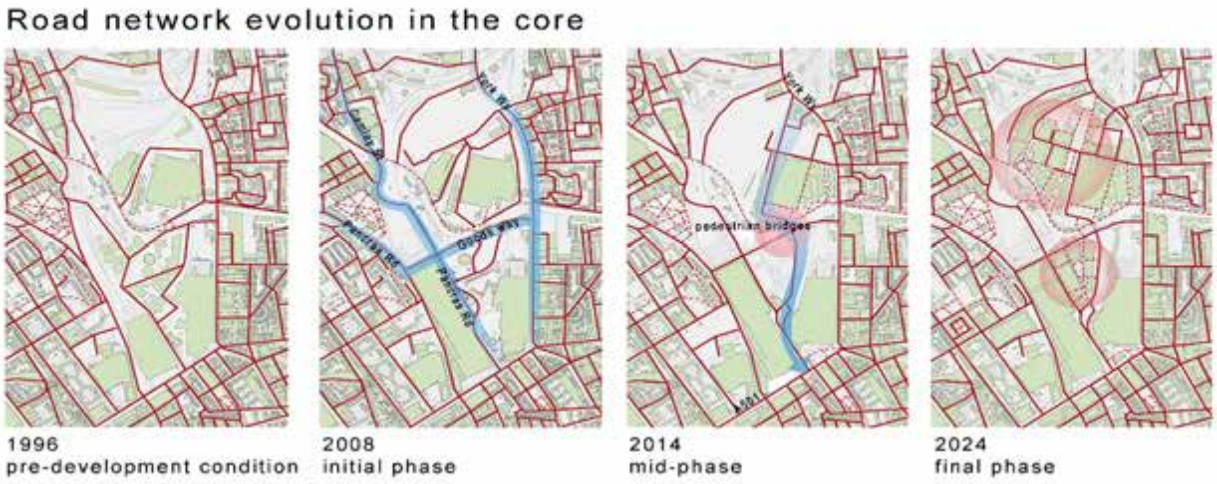


Figure 4: Road network evolution in the core zone (1996–2024)

3.3 Functional Vitality Transformation

The redevelopment of King's Cross spurred significant socio-economic agglomeration, with increased activity levels across surrounding areas. Points of Interest (POI) data, reflecting the diversity and density of urban functions, provide critical insights into the spatial evolution of economic and social activities driven by the hub's growth (Desjardins, 2014). Between 2014 and 2023, the total number of POIs across the entire King's Cross area remained relatively stable, with minor fluctuations. Notably, manufacturing-related POIs experienced a sharp decline of 19.5%, signaling the outward relocation of industrial activities and the reallocation of space for commercial and social uses (Regeneris Cunsulting, 2017).

A comparative analysis of the three zones reveals divergent trends. While the central and wider impact zones saw slight decreases in total POIs, the core zone experienced a 102.7% surge over the decade. Specifically, consumption and entertainment POIs in the core zone grew by 127.4%, and commercial services POIs surged by 200%, contrasting with marginal declines in the other two zones (Figure 5). This transformation underscores the core zone's emergence as a dynamic urban functional district. Its enhanced functional diversity and economic agglomeration capacity have revitalized the once transit-dominated hub into a vibrant, attractive destination.

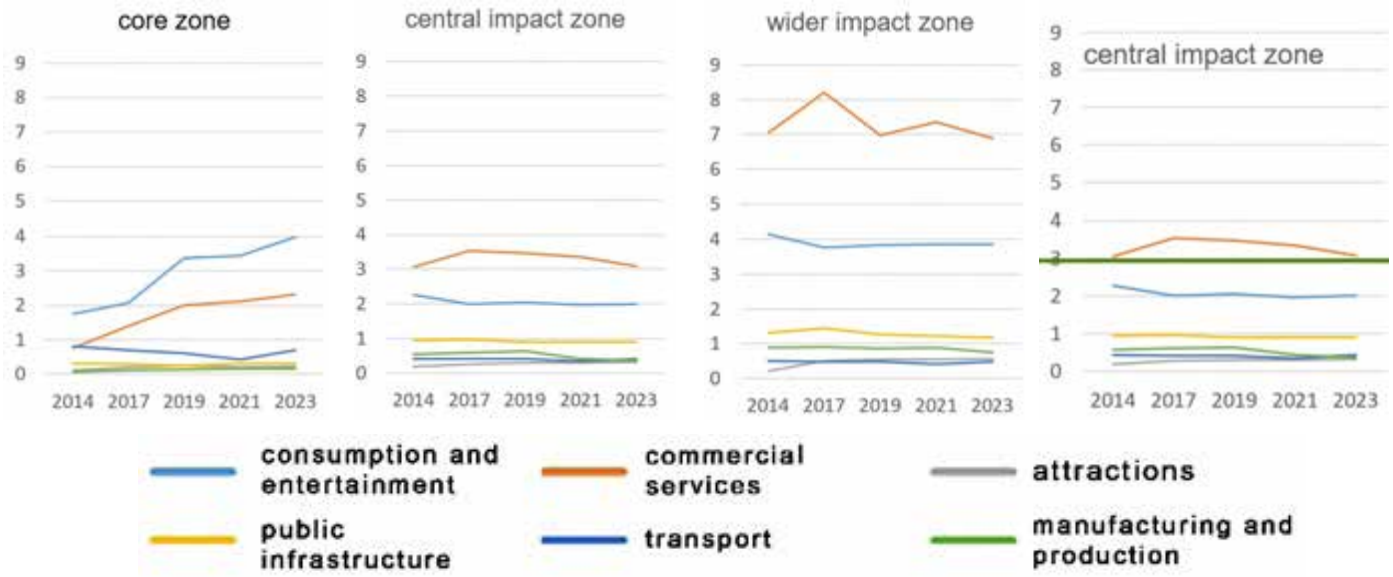


Figure 5: Changes in POI density per hectare across zones (2014–2023)

3.4 Intensity of Spatial Development

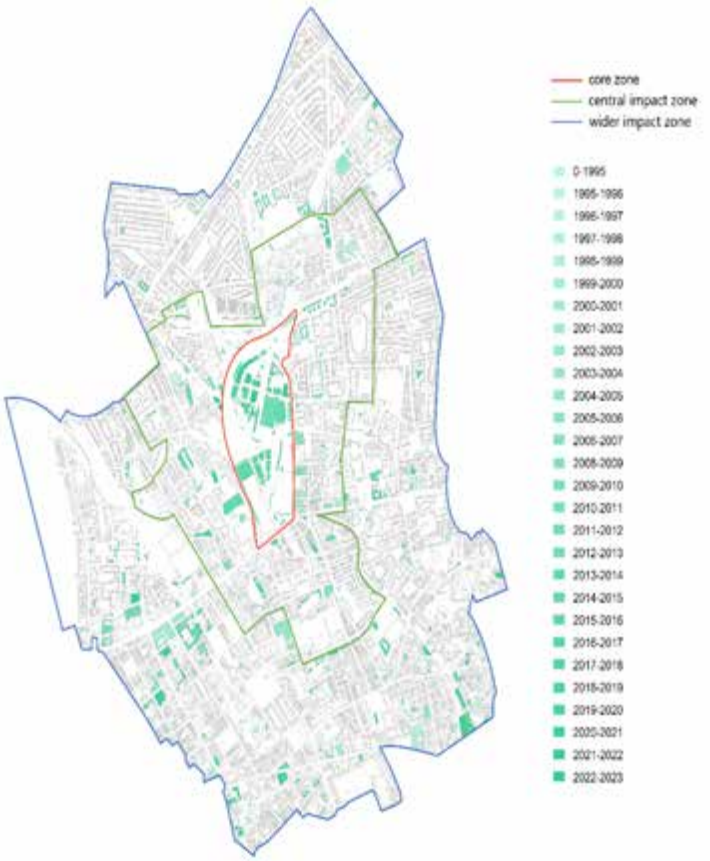
Analysis of building volume records since 1996 reveals stark disparities in development intensity across the three zones. core zone, central impact zone and wider impact zone exhibited a 25:11:8 ratio in newly added floor area per hectare. Driven by extensive brownfield regeneration opportunities, the core zone—despite occupying less than 5% of the total study area—accounted for over quarter of the total development volume, far outpacing the other zones. The central impact zone saw slower growth, with approximately 1% of buildings undergoing annual additions or major expansions, a renewal rate higher than that of the potential impact zone, which represents typical central London development patterns (Table 1).

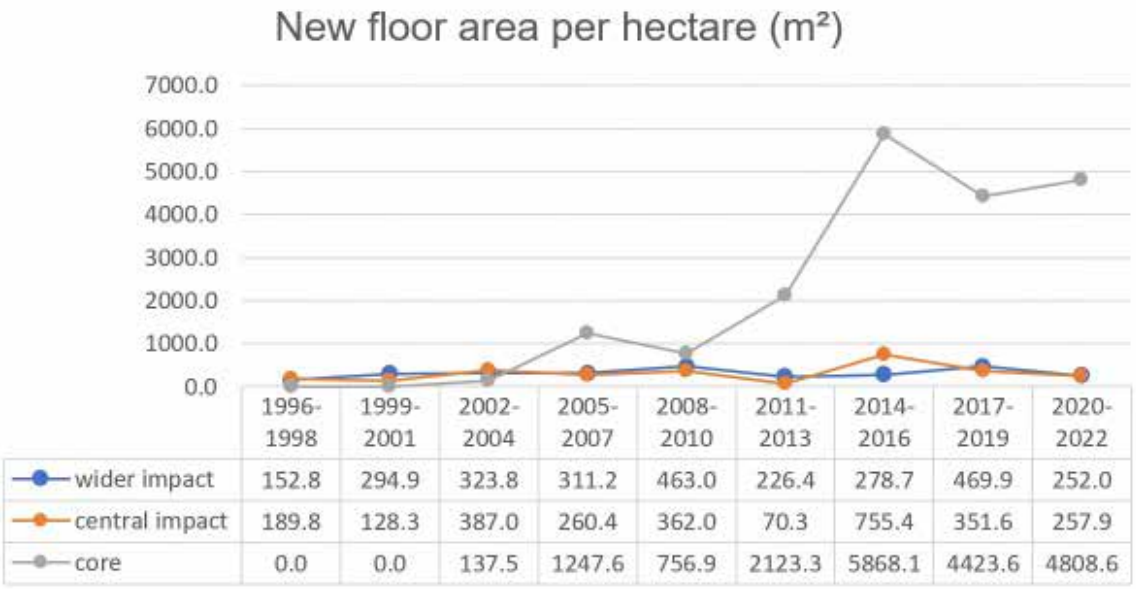
This pattern underscores the catalytic role of the King's Cross–St Pancras multi-station hub in amplifying spatial development momentum. Overall, the development rate exhibits a strong positive correlation with proximity to the hub: areas closer to the aggregated transport nodes demonstrate higher spatial value and greater redevelopment incentives.

Table 1: Spatial Development Metrics Across Zones (1996–2023)

Metric	core zone	central impact zone	wider impact zone
Newly added floor area (10,000 m²)	93.3	73.6	196.8
Total floor area (10,000 m²)	126.5	275.0	977.4
Land area (hectares)	48.0	266.6	709.6
New floor area per hectare (100 m²)	193.7	27.6	27.7
Proportion of building volume renewal	73.7%	26.8%	20.1%
*Floor area is estimated based on building morphology and height data, assuming an average floor height of 3.5m.			

The three zones exhibited distinct spatiotemporal development trajectories. Notably, the core zone did not immediately witness large-scale construction at the outset; in fact, no buildings were completed in the four years following the integration of St Pancras International Station, primarily due to delays in the development cycle. Significant construction commenced in 2007, spurred by the influx of passengers from Eurostar services and the aggregation of multi-station connectivity. This catalyzed the area's transformation into a hub for cultural, research, and corporate institutions, attracting multinational corporations, startups, and Central Saint Martins (University of the Arts London) to occupy office complexes built on regenerated brownfield sites. From 2011 onward, a wave of high-intensity development swept the core zone, with buildings progressively erected from south to north. By 2020, however, most core-area projects had been completed, leading to a decline in development rates. In contrast, the primary and potential impact zones experienced far lower construction volumes, characterized by fluctuating, modest growth. Yet, at every stage, the primary impact zone consistently outpaced the potential impact zone in development volume, reflecting the substantial momentum generated by the King's Cross hub aggregation. Spatially, most developments in the primary impact zone clustered around the core zone (Figure 6). Planned developments in adjacent areas further amplified this effect. For instance, Islington Council proposed high-density developments along York Way (adjacent to the core zone), including office, retail, leisure, and residential spaces. The plan identified four sites for high-rise buildings (30+ meters) and prioritized commercial floor space categories such as Grade-A offices, mixed-use spaces, and co-working facilities. (Islington Concil, 2023)





	1996-1998	1999-2001	2002-2004	2005-2007	2008-2010	2011-2013	2014-2016	2017-2019	2020-2022
wider impact	152.8	294.9	323.8	311.2	463.0	226.4	278.7	469.9	252.0
central impact	189.8	128.3	387.0	260.4	362.0	70.3	755.4	351.6	257.9
core	0.0	0.0	137.5	1247.6	756.9	2123.3	5868.1	4423.6	4808.6

Figure 6: Spatial distribution and comparative metrics of redeveloped buildings (1996–2022)

4 Spatial Renewal Methods in King's Cross Area

The King's Cross Opportunity Area, driven by the demand for foot traffic from transportation aggregation nodes, has spatially sought a variety of development patterns to promote economic agglomeration and diversification in and around the core zone. By tracing the spatial changes within the three King's Cross districts from 2007 to 2023, this study summarizes the development patterns into four types of patterns based on the underlying conditions

and spatial changes: overall demolition and redevelopment patterns, functional renewal and alteration, and expansion upwards and to the periphery (Figure 7). These types provide a large number of possibilities for spatial change and growth in multi-site agglomeration lots in already built-up urban high-density areas, progressively optimizing the relationship between transportation-space-function.

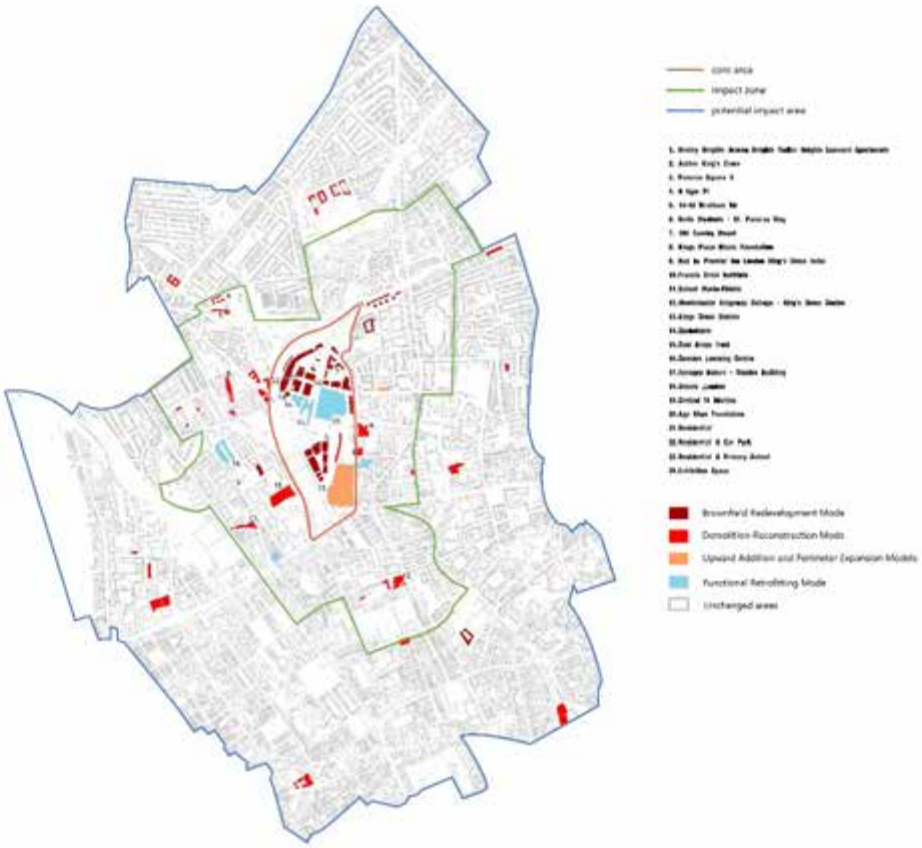


Figure 7: Distribution of the four development patterns in the King's Cross area

4.1 Brownfield Redevelopment Mode

The King's Cross and St Pancras stations, with their long histories, historically required extensive land for freight yards and rail operations. With advancements in transportation and logistics, many low-efficiency lands previously used for storage and rail operations were repurposed for redevelopment. This mode involves completely transforming the original land use to meet new spatial demands, significantly enhancing land value and utilization. Due to the abundance of brownfield sites in the northern part of the core zone, this became the most prevalent renewal mode in King's Cross (indicated by wine-red buildings in Figure 7).

A representative example is Pancras Square in the core zone. Located in the triangular area between King's Cross Station and St Pancras International Station, this prime urban site was previously occupied by rail yards and gas holders. After relocating the gas holders, redevelopment began in 2008, resulting in seven medium-height, high-density office blocks arranged in a street-like layout (Figure 9). Completed between 2013 and 2023, these buildings include Pancras Square 1 (designed by David Chipperfield Architects) and Pancras Square 4 (designed by Eric Parry Architects), which harmonize new structures with preserved historical buildings. The lower floors feature publicly accessible amenities such as retail, dining, a library, and leisure spaces, while the upper floors provide premium office space. The area's superior transport connectivity and livable environment have attracted global corporations like Universal Music, Google, and Meta.

Figure 8: Aerial view of Pancras Square (Source: Apple 3D Maps)

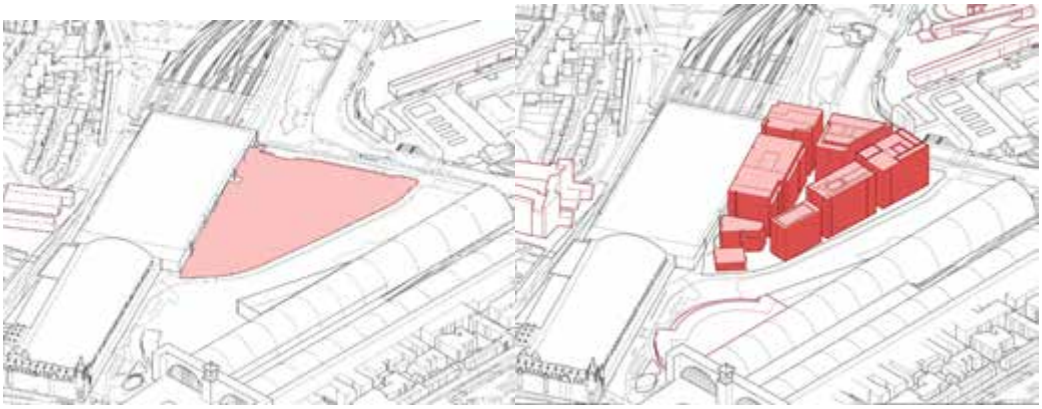


Figure 9: Before-and-after comparison of Pancras Square 1–7.

4.2 Demolition-Reconstruction Mode

Driven by the development momentum generated by multi-station aggregation, non-historic buildings with poor quality or low intensity near the hub were demolished and replaced with higher-density structures. This mode primarily occurred in the primary impact zone, where original buildings held limited historical value (marked by red buildings in Figure 7).

The Francis Crick Institute, a major biomedical research center west of St Pancras Station, exemplifies this approach (Figure 10). Construction began in 2007 with the demolition of fragmented, low-value buildings on the site. Completed in 2016, the 12-story, 100,000 m² complex integrates one-third of its structure below street level to minimize visual impact and creates public gardens. The institute now employs over 1,000 scientists, further energizing the area.

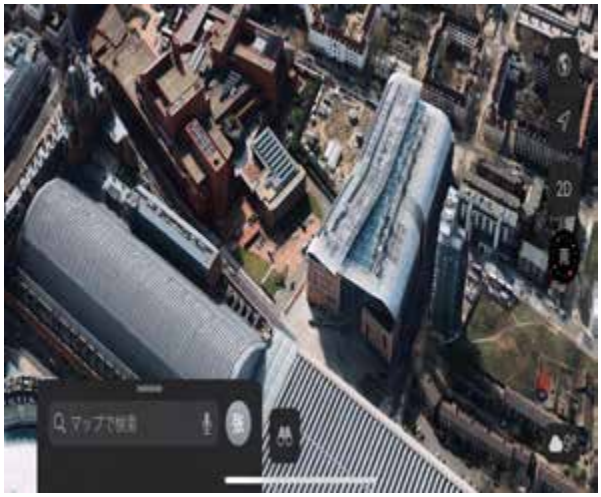


Figure 10: Aerial view of the Francis Crick Institute (Source: Apple 3D Maps).

Figure 11: Francis Crick Institute Before and After

4.3 Functional Retrofitting Mode

This mode involves partial renovations or expansions of existing buildings to adapt to new functions. It is categorized into three types:

1. Partial Retrofitting: Modifying specific sections of a building to enhance functionality or aesthetics while complying with regulations.
2. Functional Conversion: Repurposing structures while retaining their core framework (e.g., converting factories to residences or shops to offices).
3. Complete renovation with structural retention: Preserving the original structure but fully refurbishing it for new uses.

Heatherwick Studio undertook the restoration and adaptive reuse of two Victorian-era warehouses in the King's Cross core zone. These elongated brick warehouses, constructed in 1850 alongside railway viaducts, were interconnected via elevated walkways to create cohesive public spaces (Figures 12 and 14). The design introduced sloping glass extensions that extend upward from the original gabled roofs, forming interconnected upper-level spaces that serve as focal points for events and retail activities. The lower levels feature double-height volumes for hosting concerts, while the preserved cobblestone courtyards and historical façades maintain the site's industrial heritage. While creating new elements, the project's careful restoration of the surviving Victorian buildings and cobblestone courtyards to retain their historic character has created an unusual mix of retail spaces through the adaptation of internal spaces.

Figure 12: Coal Drop Plaza Elevation and Existing Conditions

The adaptive reuse of three historic gas holders exemplifies functional conversion combined with structural preservation. The original cast-iron gasometers—iconic symbols of the area's industrial past—were relocated and repurposed into residential complexes housing over 140 apartments (Figures 13 and 14). The design preserved the gasometers' industrial aesthetic and physical integrity while introducing a fourth "virtual drum" at their intersection to form shared courtyards for residents. The apartments range from studio to three-bedroom layouts, with the interstitial spaces between the gasometers transformed into landscaped gardens.

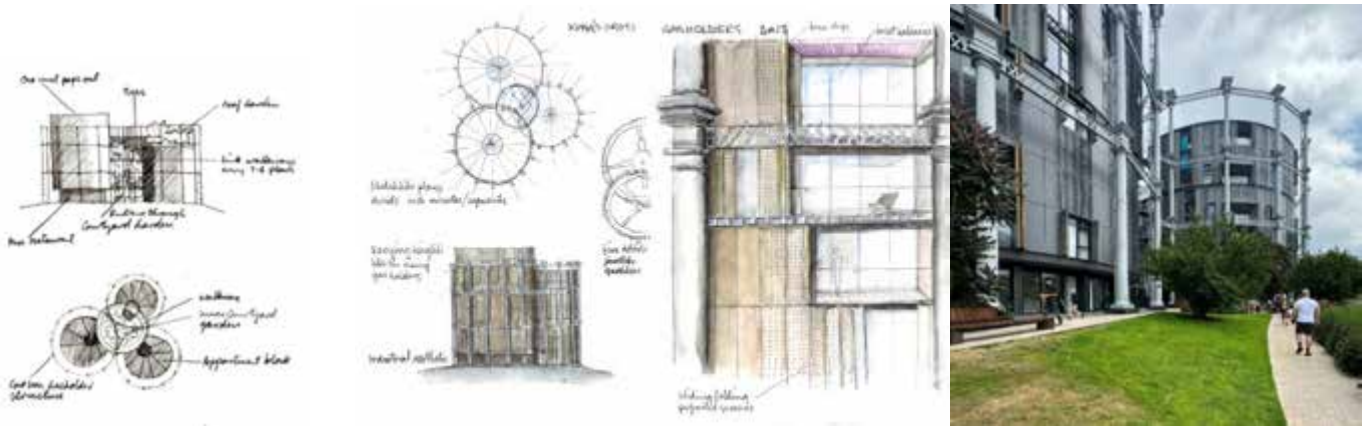


Figure 13: Triplex Gas Storage Tank Design Analysis Diagram and Current Status

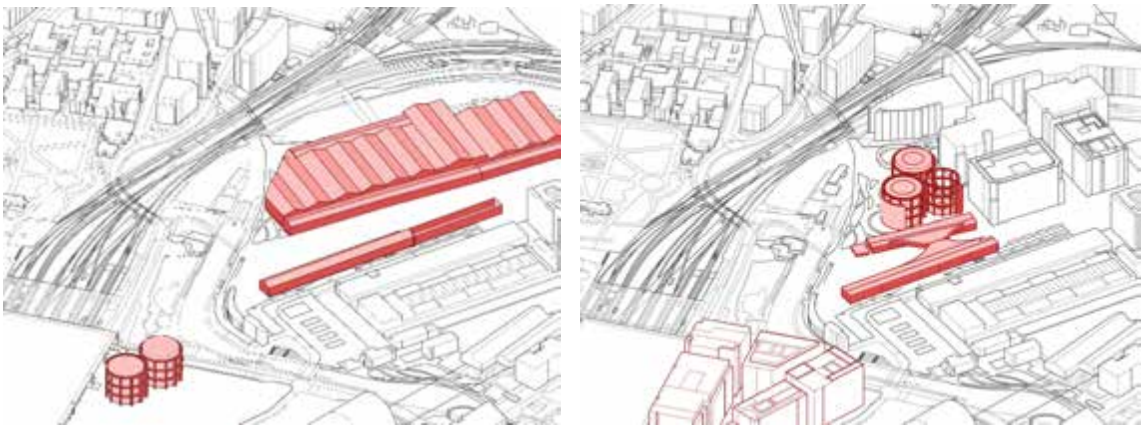


Figure 14: Comparison of Triplex Gas Storage Tank and Coal Drop Plaza before and after construction

4.4 Upward Addition and Perimeter Expansion Models

This mode expands buildings vertically (adding floors) or horizontally (extending laterally) to meet spatial demands.

The original height of buildings on some plots is lower than the upper limit of statutory requirements or urban design guidelines, or there are available plots in the vicinity, and reasonable expansion is carried out through optimization of design to meet the present new space requirements, which can be classified into two modes according to the two dimensions of expansion: 1) Horizontal Expansion - adding a Horizontal expansion - adding a new structure or building next to or around the original building to expand its scale or function and integrate with the original building; 2) Vertical expansion - adding a new floor or structure on top of the existing building to increase the available space.

The new west side ticket hall between King's Cross and St. Pancras International stations is a typical example of a horizontal expansion (Figures 15-16). The new West Side Ticket Hall extension designed by John McAslan + Partners (JMP) is an important extension to achieve multi-station interconnectivity as King's Cross and St. Pancras stations become increasingly important as transport hubs and St. Pancras becomes the starting point for access to the continent, and in anticipation of the London 2012 Olympic Games. The new West Side Ticket Hall Extension, designed by John McAslan + Partners (JMP), is an important extension that will enable the interconnection of multiple stations. Echoing the adjacent Great Northern Hotel, the hall is 20m high and dominated by a 150m span semi-circular arch that spans the west elevation of the existing Grade I listed King's Cross station, creating a new entrance to the station that leads from the southernmost point of the structure to the northernmost point of the station's west concourse. Considering the protection of the original station façade, the structural survey report concluded that only the central part of the original station façade could have a structural support base. Therefore, the project was cleverly designed as a semi-circular dome structure to fully utilize this structural support foundation. The dome was independently supported by 16 dendritic steel columns and was the largest single-span structure in Europe at the time. The transformation of the ticket hall was both visually striking and able to accommodate 50 million passengers a year, acting as a catalyst for the transformation of King's Cross into London's new transportation hub.

Figure 15: Aerial view of the new Western Ticket Hall and human eye viewpoints

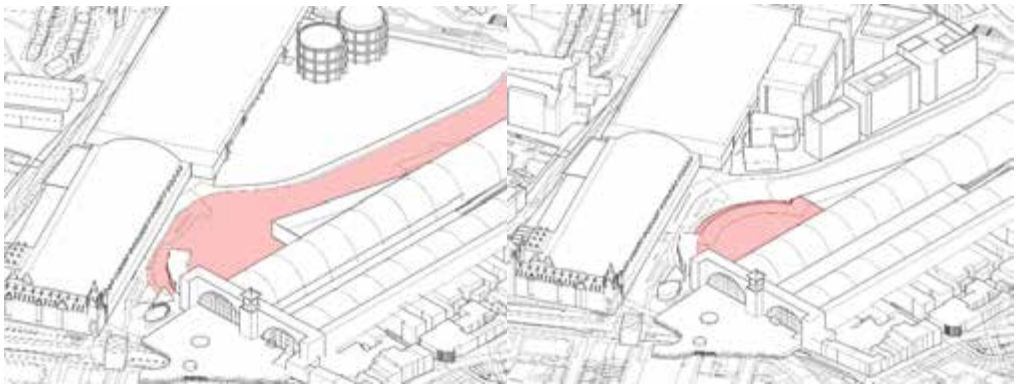


Figure 16: Comparison of the New Western Ticket Hall before and after its completion

5 Discussion and Conclusions

The redevelopment of King's Cross demonstrates that the aggregation of transport hubs—through the expansion of rail networks and integration of existing stations—creates efficient connectivity, driving increased passenger flows and stimulating demand for complementary functions and spatial provisions. The introduction of Eurostar services in 2007 and the completion of two multi-station ticket halls between 2006 and 2009 streamlined passenger transfers, amplifying the hub's aggregation effect. From 2008 to 2017, annual passenger growth at King's Cross rail station, St Pancras International, and the King's Cross–St Pancras Underground stations exceeded 40%, surpassing London-wide average growth. This passenger flow has generated a greater demand for more intensive spatial usage, as evidenced by the significant growth of consumption/entertainment and commercial services POIs in the core zone. Over the 1996–2023 period, the emergence of new economic and employment models transformed the transport-aggregated area into a creative industry cluster, fostering a live-work balance that established King's Cross as a desirable mixed-use district.

In recent years, reduced demand for freight storage and rail infrastructure—driven by containerization and rail-overbuild technologies—has freed up land for multi-station hub redevelopment (Chen and Zhuang, 2022; Chen, 2018). At King's Cross, the shift from a historic freight-passenger hub to a passenger-dominant transport node unlocked underutilized rail yards and storage sites. Post-2007, the core zone prioritized redeveloping the strategic corridor between St Pancras and King's Cross, creating Pancras Square—a high-density office and retail cluster. Subsequent phases regenerated northern brownfield sites, integrating cultural, educational, residential, and commercial functions into a cohesive urban district.

Proximity to the multi-station hub strongly correlates with development intensity. From 1996 to 2023, 25: 11: 8 of new floor area per hectare was added in the core, central impact, and wider impact zones, respectively. Spatiotemporal analysis reveals that most developments occurred post-2009, following the completion of St Pancras International's integration and underground connectivity upgrades. Market-driven dynamics prioritized sites closest to the hub, where spatial value and redevelopment incentives peaked. For instance, Islington Council's high-density plans along York Road—adjacent to the core—emphasized Grade-A offices and mixed-use spaces, reinforcing the hub's catalytic role.

Against the backdrop of global urbanization shifting from expansion-driven growth to stock optimization, how to strategically reshape urban structures and functions through spatial regeneration has become a shared challenge for cities worldwide. King's Cross exemplifies how rail-concentrated areas can lead urban renewal. Aggregating proximate existing and planned stations enhances foot traffic, driving spatial-functional optimization and broader regional revitalization. It is foreseeable that with continuous advancements in transportation technology, the reduced demand for ancillary transport infrastructure and increased functional integration will enable sophisticated mixed-use design to unlock greater development potential in urban multi-hub aggregation zones. Under the synergistic effects of various urban models, such approaches will significantly enhance district functionality and elevate spatial quality. This transportation-hub-driven regeneration model may well become an indispensable pathway for emerging cities to achieve low-carbon, efficient, and human-centered urban transformation.

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Urban freight mobility modes recognition classification and inclusive freight policy exploration based on truck trajectory data: A case study of Shanghai, China

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Abstract
In high-density cities like Shanghai, freight trucks are essential but face significant constraints and high costs. This study addresses the shortfalls of current "one-size-fits-all" freight policies. Using extensive GPS data from heavy trucks and a two-step clustering method, the research identifies typical activity patterns from a micro-perspective. It classifies truck activities into two main categories and five sub-categories, revealing significant differences in travel distance, hub stops, and journey types (intra-city vs. inter-city). Based on these findings, the study proposes targeted management suggestions, such as more detailed requirements for short-distance trucks and flexible traffic restrictions informed by big data, paving the way for innovative, localized urban freight systems.

Keywords: Freight mobility modes, Inclusive policies, Sustainable mobility systems, Truck trajectory data, Shanghai

1. Introduction

1.1. Background and Significance

The intricate web of freight transportation is indispensable to the daily lives of households and the seamless operations of businesses, profoundly influencing urban development and prosperity. Within the dense fabric of high-density urban areas, freight trucks serve as the undisputed backbone of goods movement. However, their critical role is often juxtaposed with significant operational constraints and substantial costs (Li, 2020). Understanding the nuanced behaviour of freight trucks is not merely an academic exercise; it is foundational for enhancing the efficiency of freight transport, optimising supply and demand forecasting, and refining urban governance strategies.

Historically, the analysis of freight activity has often relied on aggregated data or macroscopic models, which can obscure the underlying complexities of individual truck movements. This 'one-size-fits-all' approach to freight policy, while administratively convenient, frequently overlooks the diverse operational requirements and characteristics of various freight activities. This oversight can lead to inefficiencies, increased costs for logistics operators, and exacerbated urban challenges such as traffic congestion, air pollution, and noise (Liu and Zhang, 2023).

The necessity of delving deeper into urban freight truck activity is multifaceted. Firstly, from an economic perspective, gaining a profound understanding of these behaviours can significantly contribute to cost reduction and efficiency gains within the freight transport sector, thereby fostering economic growth. Secondly, from an urban planning and management viewpoint, a detailed analysis of truck activity patterns is an imperative for the precise refinement of urban traffic governance and the substantial improvement of road network operational efficiency. Traditional approaches to urban freight management often lack the granularity required to implement effective, tailored policies that acknowledge the varied functions and impacts of different truck operations.

The feasibility of conducting such micro-level research has dramatically improved in recent years. The proliferation of high-frequency truck trajectory data, primarily derived from Global Positioning System (GPS) devices, has opened unprecedented avenues for detailed observation and analysis. This wealth of data makes it possible to investigate the microscopic patterns of truck activity, uncover underlying behavioural regularities, and construct more sophisticated models of freight movement (Ma et al., 2016; You and Ritchie, 2018). This study leverages these advancements to provide a comprehensive analysis of urban freight mobility in Shanghai, China.

1.2. Research Content

This study aims to address the aforementioned gaps by undertaking a detailed examination of freight truck activity patterns, supported by extensive high-frequency trajectory data. The research encompasses several key areas:

- **Characterisation of Truck Travel Characteristics:** Utilising high-frequency truck trajectory data, the study first focuses on identifying stop points and performing path map matching. This process extracts fundamental travel information, which is then used to characterise various aspects of truck travel, including trip duration and frequency, spatial distance and range, and the utilisation of infrastructure.
- **Inference of Truck Activity Purpose:** By integrating diverse data sources such as land use, enterprise registration information, and Points of Interest (POI) data, the research moves beyond a mere empirical understanding of individual truck trajectories. It explores methodologies to infer the specific purposes behind observed truck activities, providing crucial insights into the 'why' of their movements.
- **Categorisation of Truck Activity Modes:** Drawing upon the insights gleaned from the characterisation of truck travel characteristics and the inference of activity purposes, the study aims to summarise typical truck activity modes. This involves exploring classification methods to identify distinct patterns of freight movement.
- **Management Recommendations for Different Truck Activity Types:** Based on the identified and categorised truck activity types, the research proposes management recommendations. These suggestions are developed in consideration of existing urban freight management policies and are designed to be more congruent with industry needs and the inherent patterns of truck activity. The ultimate goal is to formulate more inclusive and effective freight policies that cater to the diverse operational demands of urban logistics.

2. Literature Review

Understanding freight truck movement patterns is a multidisciplinary challenge that draws insights from urban planning, logistics, transportation engineering, and data science. This section reviews existing literature, highlighting key methodologies and findings pertinent to this study.

2.1. Stop Point Identification

The identification of "stop points" or "stay points" from raw GPS trajectory data is a crucial preliminary step for understanding vehicle behaviour. A stop point signifies a period when a vehicle remains stationary or moves within a very limited area, often indicating an activity such as loading, unloading, parking, or waiting. Various methods have been proposed for stop point identification, typically involving thresholds for speed, time, and spatial proximity.

Early approaches often relied on simple speed thresholds, deeming any point below a certain speed as part of a stop (e.g., Wang et al., 2012). However, this can be problematic in congested urban environments where slow movement does not necessarily equate to a stop. More sophisticated methods incorporate time thresholds, defining a stop as a period where the vehicle remains within a predefined spatial radius for a minimum duration (e.g., Li, 2020). For instance, Li (2020) utilised a method that clusters GPS points within a certain radius and time window to identify stop points, a common practice in freight research.

Recent advancements in stop point detection involve more complex algorithms, including density-based spatial clustering of applications with noise (DBSCAN) or grid-based methods, which are more robust to GPS signal fluctuations and varying speeds. Ji et al. (2019) proposed a parallel algorithm that combines stay point features and moving features to detect traffic patterns, showcasing the evolution towards more integrated approaches. The accuracy of stop point identification directly impacts the subsequent analysis of activity chains and trip purposes.

2.2. Freight Trip Chaining Analysis

Freight trip chaining, or the sequence of stops and movements that constitute a complete vehicle tour, offers a holistic view of freight operations. Unlike passenger trips, freight tours often involve multiple stops for pick-ups and deliveries, making the concept of "trip chaining" particularly relevant. Analysing these chains helps in understanding the operational logic, efficiency, and spatial distribution of freight activities.

Ma et al. (2016) explored freight trip-chaining behaviour using a spatial data-mining approach with GPS data, revealing common patterns and influencing factors. Their work underscored the importance of geographical context in understanding trip structures. Similarly, You and Ritchie (2018) developed a GPS data processing framework specifically for the analysis of drayage truck tours, highlighting the unique characteristics of port-related freight movements.

The duration and sequence of stops within a trip chain are critical indicators of efficiency and potential bottlenecks. Duan et al. (2020) further advanced this area by comprehending and analysing multiday trip-chaining patterns of freight vehicles using a multiscale method with prolonged trajectory data, demonstrating the complexity and continuity of freight operations over longer periods. Their research emphasized that freight vehicles often exhibit complex multi-day activity patterns, not just simple round trips. Liu and Zhang (2023) focused on identifying urban freight stay behaviour based on truck GPS data, providing a model that can pinpoint where and for how long trucks pause, which is crucial for infrastructure planning.

2.3. Freight Activity Purpose Inference

Inferring the purpose of freight activities is perhaps the most challenging aspect, as GPS data alone provides location and movement, not intent. This typically requires integrating external data sources, such as land use, Points of Interest (POI), and business registration data.

For instance, a truck stopping at a logistics park or warehouse is likely involved in loading/unloading, while a stop at a retail area might indicate delivery to a store. Chen et al. (2022) analysed the spatiotemporal differences and influencing factors of heavy freight vehicle travel, implicitly touching upon the varied purposes behind these movements. The integration of land use data allows researchers to contextualise stops, inferring purposes based on the type of activity typically conducted at that location. For example, stops in industrial zones often relate to manufacturing or warehousing, while stops in commercial areas are usually for retail delivery.

Some studies have employed machine learning techniques to classify activity purposes based on a combination of GPS features (e.g., duration of stay, frequency of visits, average speed) and external data. However, the accuracy of such inference heavily relies on the quality and granularity of the supplementary data. The challenge lies in developing robust methodologies that can accurately distinguish between, for example, a delivery stop, a maintenance stop, or a driver rest stop.

2.4. Freight Activity Mode Classification

Building upon trip chaining and purpose inference, the next logical step is to classify recurring freight activity patterns into distinct "modes" or "typologies." This classification helps in understanding the heterogeneity of freight operations and developing targeted policies.
Common classification criteria include:

- **Journey Type:** Intra-city vs. inter-city, reflecting different operational scales and regulatory environments.
- **Vehicle Type:** Heavy-duty vs. light-duty trucks, each with different capacities, speeds, and road access restrictions.
- **Cargo Type:** While difficult to infer directly from GPS, this is a key differentiator in freight logistics.
- **Operational Pattern:** E.g., hub-and-spoke operations, direct deliveries, multi-stop routes, return trips, or maintenance trips.

Research often uses clustering algorithms (e.g., K-means, hierarchical clustering, or two-step clustering) to group similar trip chains or activity sequences. The effectiveness of these classifications depends on the features used for clustering, which can include trip distance, duration, number of stops, stop duration distribution, and inferred activity purposes. The aim is to identify distinct operational profiles that can be used for policy differentiation.

2.5. Inclusive Freight Policy Development

Traditional urban freight policies often adopt a blanket approach, applying the same restrictions or incentives to all freight vehicles regardless of their specific operational needs. This can lead to inefficiencies, increased costs for businesses, and unintended negative consequences. The reviewed literature strongly suggests a move towards more "inclusive" or "differentiated" freight policies that acknowledge the diversity of freight activities.

Such policies could include:

- **Time-window restrictions:** Differentiated by vehicle type or purpose.
- **Access restrictions:** Based on emission standards, vehicle size, or specific routes.
- **Loading/Unloading Zones:** Strategically located and managed to minimise disruption.
- **Pricing mechanisms:** Such as congestion charges or differentiated tolls.

The core idea is to tailor regulations to the specific characteristics of different freight activity modes. For instance, short-distance, intra-city deliveries might require different policy interventions than long-haul inter-city movements. This requires a granular understanding of freight behaviour, which is precisely what the preceding research areas aim to provide.

This study aims to bridge the gap between microscopic behavioural analysis and macroscopic policy formulation, offering data-driven insights for more effective and inclusive urban freight management in Shanghai.

3. Data and Methodology

This section details the data sources utilised and the methodologies employed for stop point identification, truck trip generation, and activity mode clustering.

3.1. Data Sources

The primary data source for this study is high-frequency GPS trajectory data from a large fleet of heavy freight trucks operating in Shanghai. This dataset provides a rich, granular record of truck movements over an extended period. Each GPS record typically includes:

- **Vehicle ID:** Unique identifier for each truck.
- **Timestamp:** Date and time of the GPS recording.
- **Latitude and Longitude:** Geographical coordinates of the truck's location.
- **Speed:** Instantaneous speed of the truck.
- **Direction:** Bearing of the truck's movement.

The data covers a significant number of heavy trucks, ensuring a representative sample of freight activity within and around Shanghai. The high frequency of data points (e.g., every few seconds or minutes) allows for precise identification of movement patterns and stationary periods.

In addition to GPS data, the study incorporates supplementary data for activity purpose inference:

- **Land Use Data:** Provides information on the predominant activities in different urban zones (e.g., industrial, commercial, residential). This helps contextualise truck stops.
- **Points of Interest (POI) Data:** Offers specific information about businesses, facilities, and infrastructure (e.g., logistics parks, warehouses, retail centres, wholesale markets). POI data is crucial for inferring the specific nature of activities at stop points.
- **Enterprise Registration Data (where available):** Can provide insights into the type of business operating at a specific location, further aiding in purpose inference.

3.2. Stop Point Identification

Accurate identification of stop points is fundamental for segmenting continuous GPS trajectories into discrete trips and activities. The methodology for stop point identification in this study combines spatial and temporal thresholds to distinguish genuine stops from brief pauses or slow movements due to traffic.

The process involves:

a) **Initial Filtering:** Raw GPS data is first cleaned to remove outliers or erroneous readings (e.g., sudden jumps in location or unrealistic speeds).

b) **Candidate Stop Point Detection:** For each truck, consecutive GPS points are examined. If a sequence of points exhibits a speed below a predefined threshold (e.g., 5 km/h) for a continuous duration exceeding a minimum time threshold (e.g., 5 minutes), these points are flagged as a potential stop.

c) **Spatial Clustering:** Candidate stop points are then clustered spatially. If multiple GPS points from the

same truck within a short time window fall within a small geographical radius (e.g., 50 meters), they are grouped into a single stop point. The centroid of these clustered points is designated as the stop location.

d) Stop Duration Calculation: The duration of a stop is calculated from the timestamp of the first point to the last point within the identified stop cluster.

e) Trip Segmentation: Once stop points are identified, the continuous trajectory is segmented into individual "trips" (movements between two stop points) and "stops." A typical trip chain would look like: Stop A – Trip 1 – Stop B – Trip 2 – Stop C, and so on.

The selection of appropriate speed, time, and spatial thresholds is critical and often determined through empirical analysis of the data and domain knowledge to best represent actual truck activities.

3.3. Truck Trip Generation

Following stop point identification, individual truck trips are generated. A "trip" is defined as the movement segment between two consecutive stop points. For each generated trip, key attributes are extracted:

- **Origin Stop ID and Destination Stop ID:** Linking trips to their respective start and end locations.
- **Trip Start Time and End Time:** Derived from the timestamps of the origin and destination stop points.
- **Trip Duration:** Calculated as the difference between end and start times.
- **Trip Distance:** Calculated by summing the distances between consecutive GPS points along the trajectory, or using map-matched distances.
- **Average Speed:** Total distance divided by total duration.
- **Number of GPS Points:** Indicating the data density for the trip.

3.4. Path Map Matching

To enhance the accuracy of trip distances and ensure that trajectories align with the actual road network, a path map-matching algorithm is applied. This process maps the raw GPS points onto the most probable roads on a digital map. Map matching helps:

- **Correct GPS Errors:** Reducing the impact of signal drift or inaccuracies.
- **Obtain Realistic Distances:** Calculating distances along the actual road network, which is more accurate than straight-line distances or distances derived from raw GPS points in complex urban environments.
- **Identify Road Segments Used:** Providing insights into routing patterns and network utilisation.

The map-matching process typically involves algorithms that consider the proximity of GPS points to road segments, the topological connectivity of the road network, and the sequence of GPS points.

3.5. Inference of Truck Activity Purpose

Inferring the purpose of a truck's activity at a stop point is a complex task. This study employs a rule-based approach, combining geographical context from land use data and specific facility information from POI data. The methodology involves:

a) Geocoding Stop Points: Each identified stop point is geocoded to obtain its precise location.

b) Overlay with Land Use Data: The stop point location is overlaid with urban land use maps. This provides a general categorisation of the area (e.g., industrial zone, commercial area, residential area, logistics park).

c) Proximity Analysis with POI Data: A buffer zone (e.g., 100-200 meters) is created around each stop point. All POIs within this buffer are identified.

d) Rule-Based Inference: A set of heuristic rules is applied to infer the activity purpose. Examples of rules include:

- o If a stop is in an industrial zone and near a warehouse or factory POI, the purpose is likely "Loading/ Unloading - Industrial."
- o If a stop is in a commercial area and near a retail store or supermarket POI, the purpose is likely "Delivery - Commercial."
- o If a stop is near a logistics park or distribution centre POI, it's likely "Transshipment/Distribution."
- o If a stop is prolonged and near a residential area, it might be "Driver Rest" or "Home Base."
- o Specific POI categories such as petrol stations, repair shops, or truck stops can indicate "Refuelling/ Maintenance" or "Rest."

o Stops with no clear POI or land use match, or very short durations, might be categorised as "Traffic Wait" or "Unidentified."

This rule-based approach, while requiring careful definition of rules and thresholds, provides a robust framework for associating observed stops with likely freight activities.

3.6. Truck Activity Mode Clustering

To identify typical truck activity patterns, a two-step clustering method is applied to the processed truck tour data. This method is particularly suitable for large datasets with mixed data types (numerical and categorical). The clustering process involves:

a) Feature Selection: Key features representing the characteristics of each truck's activity tour are selected for clustering. These features include:

- **Total Daily Travel Distance:** A measure of the scale of operation.
- **Total Daily Travel Duration:** Reflecting time spent on the road.
- **Number of Stops per Day:** Indicating the complexity of the tour.
- **Average Stop Duration:** Revealing the nature of activities at stops (quick deliveries vs. lengthy loading/unloading).
- **Proportion of Intra-city vs. Inter-city Trips:** Distinguishing between local and regional operations. This is determined by analysing if origin and destination points of trips fall within or outside Shanghai's administrative boundaries.
- **Number of Unique Hub Stops:** Defined as frequently visited locations (e.g., logistics parks, distribution centres) that serve as primary operational bases.
- **Distribution of Inferred Activity Purposes:** Proportions of different activity types (e.g., proportion of loading/unloading stops, delivery stops, rest stops).

b) Two-Step Clustering Algorithm:

- **Pre-clustering (Distance-Based):** In the first step, a distance-based clustering algorithm (e.g., agglomerative hierarchical clustering or a custom grid-based approach) is used to group similar observations into pre-clusters. This step is efficient for handling large datasets by reducing the number of individual instances.
- **Clustering (Model-Based/Hierarchical):** In the second step, a more sophisticated clustering algorithm (e.g., hierarchical clustering or K-means on the pre-clusters) is applied. This step aims to identify the optimal number of clusters and define the distinct activity modes. The optimal number of clusters is often determined using statistical criteria such as the Bayesian Information Criterion (BIC) or silhouette scores.

The output of the clustering process is a set of distinct truck activity modes, each characterised by a unique profile based on the selected features. These modes represent different operational strategies and roles of freight trucks in the urban logistics system. The results of this clustering will form the basis for differentiated policy recommendations.

4. Results and Discussion

This section presents the findings from the data analysis, including the characterisation of truck travel, the identified activity purposes, and the derived truck activity modes.

4.1. Characterisation of Truck Travel in Shanghai

The analysis of high-frequency GPS data from heavy freight trucks in Shanghai reveals several key characteristics of their travel patterns:

- **Trip Length Distribution:** The majority of truck trips within Shanghai are relatively short, reflecting the high density of urban activities and the prevalence of last-mile and intra-city distribution. A significant proportion of trips fall within the 10-50 km range, indicating intensive urban logistics operations. However, a noticeable tail exists for longer trips (over 100 km), representing inter-city or regional freight movements that connect Shanghai with its surrounding provinces (As shown in **Figure 4.1.1.**).

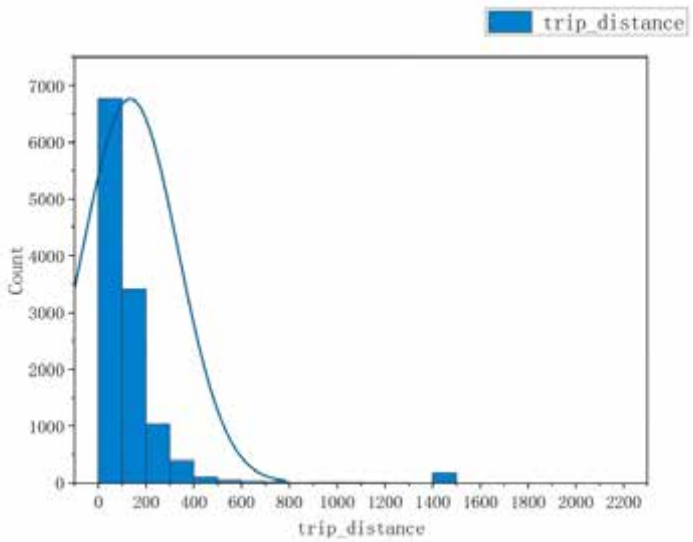

Figure 4.1.1. Distribution Map of Travel Distances (Image source: Self-drawn)

- **Trip Duration:** While trip lengths might be moderate, trip durations are often extended due to urban congestion, traffic restrictions, and the time spent at stop points for loading/unloading. The average speed of trucks within the city proper is generally low, especially during peak hours (As shown in **Figure 4.1.2.**).

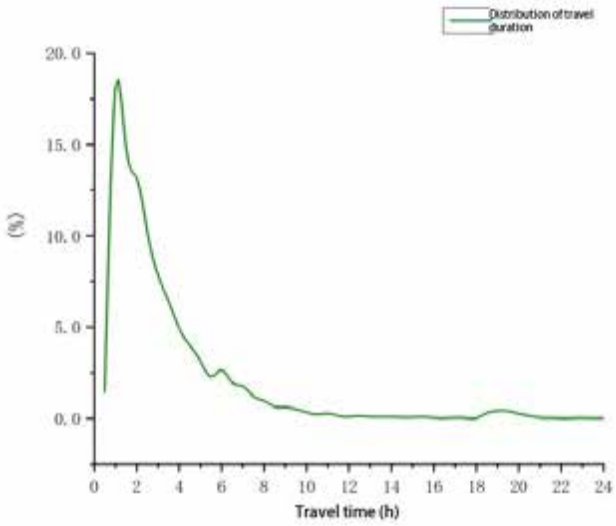

Figure 4.1.2. Travel duration distribution map (Image source: Self-drawn)

- **Stop Frequency and Duration:** Trucks exhibit a high frequency of stops, particularly those engaged in urban distribution. The duration of these stops varies significantly. Short stops (e.g., 15-30 minutes) are typical for quick deliveries or drop-offs, while longer stops (e.g., 1-3 hours or more) are associated with major loading/unloading operations at warehouses, logistics parks, or industrial facilities.
- **Spatial Distribution of Activities:** Truck activities are heavily concentrated in specific areas:

    - **Logistics Hubs:** Areas with a high density of warehouses, distribution centres, and freight yards show intense activity, serving as major origins and destinations.
    - **Industrial Zones:** These areas are key for raw material input and finished goods output.
    - **Commercial Districts and Wholesale Markets:** Represent significant destinations for deliveries, often involving multiple stops.
    - **Port Areas:** For Shanghai, port-related drayage is a distinct and high-volume activity, involving movements between ports and inland logistics facilities.

- **Time-of-Day Patterns:** Heavy truck movements often exhibit distinct diurnal patterns influenced by urban traffic regulations. A significant portion of inter-city movements occurs during off-peak hours or at night to avoid daytime traffic restrictions. Intra-city deliveries, while also affected by restrictions, might have more dispersed patterns depending on the type of goods and recipient requirements. There is usually a surge in activity during early mornings and late evenings (As shown in **Figure 4.1.3.**).

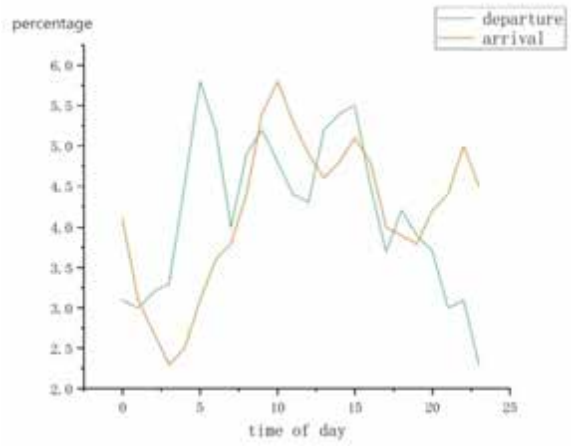

Figure 4.1.3. Travel time distribution map (Image source: Self-drawn)

These characteristics highlight the dynamic and constrained operational environment for freight trucks in a high-density urban context like Shanghai.

4.2. Inferred Truck Activity Purposes

Based on the integration of GPS data with land use and POI information, the primary purposes of truck activities at identified stop points were inferred and broadly categorised. The findings indicate a diverse range of activities beyond simple pick-up and delivery:

- **Loading/Unloading at Industrial/Warehousing Facilities (approx. 40%):** This category represents the most frequent activity, occurring at factories, large warehouses, and logistics parks. These stops are typically longer, indicating significant cargo handling.
- **Delivery to Commercial/Retail Outlets (approx. 25%):** These stops are often shorter and more numerous, characteristic of last-mile delivery to shops, restaurants, or smaller businesses within commercial zones.
- **Transshipment/Cross-docking (approx. 15%):** Occurring primarily at distribution centres or logistics hubs, these stops involve the transfer of goods between different trucks or modes of transport. This highlights the multi-stage nature of many freight operations.
- **Driver Rest/Personal Activity (approx. 10%):** These stops, often at designated rest areas, service stations, or even residential areas, reflect non-freight specific activities essential for driver well-being and regulatory compliance.
- **Vehicle Maintenance/Refuelling (approx. 5%):** Stops at petrol stations, repair shops, or maintenance depots.
- **Waiting/Congestion-related Stops (approx. 5%):** These stops are often involuntary, due to traffic queues, entry/exit delays at facilities, or waiting for appointments. While not a "purpose" in the productive sense, they represent significant operational time.
- **Other/Unidentified:** A small percentage of stops where a clear purpose could not be definitively inferred from the available data.

The distribution of these inferred purposes underscores the complexity of urban freight, involving not only the movement of goods but also associated logistical, regulatory, and human-factor considerations.

4.3. Classification of Truck Activity Modes

The two-step clustering algorithm, applied to the selected features of truck activity tours, successfully identified distinct activity modes. The analysis revealed two main categories of truck activities, further subdivided into a total of five sub-categories (The proportion of each subcategory is shown in **Figure 4.3.1.**), each with unique characteristics, as shown in **Tables 4.3.1. -4.3.3.**:

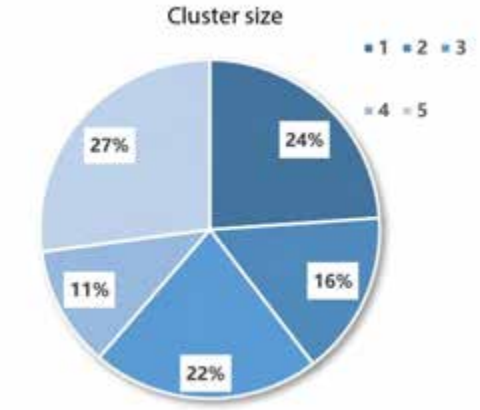

Figure 4.3.1. Clustering modeling results (Image source: Self-drawn)

Table 4.3.1. Characteristics of Travel Distances and Expressway Usage Proportions of Different Categories (Source: Self-drawn by the Author)

Average value		Trip-distance		Highway-ratio	
		Standard deviation	Average value	Standard deviation	
Category	1	42.89	29.18	0.49	0.33
	2	112.66	77.12	0.68	0.27
	3	167.06	118.54	0.57	0.33
	4	328.54	480.82	0.59	0.34
	5	116.36	95.21	0.51	0.32
	Combination	133.82	200.44	0.56	0.33

Table 4.3.2. Characteristics of Different Types of Travel Purposes (Source: Self-drawn by the Author)

Frequency 0		Light industry		Heavy industry		Transportation, warehousing and postal services		Wholesale and retail trade	
		1	0	1	0	1	0	1	
Category	1	2871	0	2871	0	2871	0	0	2871
	2	1484	403	1887	0	1887	0	1160	727
	3	2609	0	2609	0	2609	0	0	2609
	4	1350	42	163	1229	1379	13	1307	85
	5	2085	1170	3255	0	2145	1110	3255	0
	Total	10399	1615	10785	1229	10891	1123	5722	6292

Table 4.3.3. Stopping Characteristics of Different Types of Large Transportation Hubs (Ports, railway stations, etc.) (Source: Self-drawn by the Author)

Frequency		hub			cross-type	
0		1	2	0	1	
Category	1	2871	0	0	0	2871
	2	0	1843	44	1490	397
	3	2609	0	0	2609	0
	4	1218	174	0	1053	339
	5	2986	265	4	2036	1219
	Total	9684	2282	48	7188	4826

Main Category 1: Localised Urban Freight Operations This category predominantly involves trucks operating within the metropolitan area, characterised by shorter travel distances, higher stop frequencies, and intense interaction with the urban fabric.

- **Sub-category 1.1: Multi-Stop Urban Distribution (e.g., "City Courier")**
  - **Characteristics:** Short daily travel distances (e.g., 50-150 km), high number of stops (e.g., 10-20+ per day), short average stop duration (e.g., 15-45 minutes), almost exclusively intra-city trips. Few, if any, hub stops, typically starting from a single depot. The specific example is shown in **Figure 4.3.2.**.
  - **Inferred Purpose Dominance:** Delivery to Commercial/Retail Outlets, Collection from businesses.
  - **Operational Profile:** These trucks are typically engaged in last-mile delivery of varied goods (e.g., parcels, perishables, retail supplies) to multiple addresses within a specific urban zone. Their efficiency is highly dependent on route optimisation and quick turnaround times at delivery points.

Figure 4.3.2. Pattern 1.1 Representative trip Trajectory Analysis Diagram (Image source: Self-drawn)

- **Sub-category 1.2: Dedicated Industrial/Commercial Haulage (e.g., "Industrial Shuttle")**
  - **Characteristics:** Moderate daily travel distances (e.g., 100-300 km), moderate number of stops (e.g., 2-8 per day), longer average stop duration (e.g., 1-3 hours), primarily intra-city but potentially short inter-district trips. Often involves repeated trips between a limited set of industrial or large commercial hubs. The specific example is shown in **Figure 4.3.3.**.

o **Inferred Purpose Dominance:** Loading/Unloading at Industrial/Warehousing Facilities, Transshipment.
o **Operational Profile:** These trucks specialise in transporting goods between specific industrial sites, large warehouses, or major commercial distribution centres. Examples include moving raw materials to factories, finished goods from factories to distribution centres, or large-volume deliveries to hypermarkets. Their routes are often fixed or semi-fixed.

Figure 4.3.3. Pattern 1.2 Representative trip Trajectory Analysis Diagram
(Image source: Self-drawn)

- **Sub-category 1.3: Differentiated Intra-city Logistics (e.g., "Service Provider")**
  o **Characteristics:** Highly variable daily travel distances (e.g., 30-200 km), low to moderate number of stops (e.g., 1-5 per day), stop durations can vary significantly (e.g., 30 minutes to several hours), entirely intra-city. May include stops for specific services or irregular deliveries. The specific example is shown in **Figure 4.3.4.**.
  o **Inferred Purpose Dominance:** Could be a mix of specialised deliveries, waste collection, construction material transport, or service-related stops (e.g., maintenance, utilities).
  o **Operational Profile:** This heterogeneous group includes trucks performing specialised tasks not directly tied to general merchandise distribution. Examples include construction material delivery, waste management, or technicians' vehicles carrying heavy equipment. Their routes are less predictable and more demand-driven.

Figure 4.3.4. Pattern 1.3 Representative trip Trajectory Analysis Diagram
(Image source: Self-drawn)

Main Category 2: Regional/Inter-city Freight Operations This category comprises trucks primarily engaged in long-distance movements connecting Shanghai with other cities or regions, often involving fewer stops within the city itself, but longer hauls.

- **Sub-category 2.1: Long-Haul Inter-city (e.g., "Regional Connector")**
  - **Characteristics:** Long daily travel distances (e.g., 300-800+ km), very few stops (e.g., 1-2 per day), typically long stop durations at origin/destination hubs (e.g., 3-8 hours), high proportion of inter-city travel. Origin and destination are often outside Shanghai, with a single stop within Shanghai for loading/unloading at a major logistics hub. The specific example is shown in **Figure 4.3.5.**.
  - **Inferred Purpose Dominance:** Loading/Unloading at Logistics Hubs, Transshipment.
  - **Operational Profile:** These trucks are the backbone of regional and national supply chains, transporting goods between major cities. Their time is primarily spent on the road, with concentrated activities at large-scale distribution centres or intermodal terminals. They are heavily impacted by highway regulations and cross-provincial logistics networks.

Figure 4.3.5. Pattern 2.1 Representative trip Trajectory Analysis Diagram
(Image source: Self-drawn)

- **Sub-category 2.2: Hub-and-Spoke Regional (e.g., "Regional Distributor")**
  - **Characteristics:** Moderate to long daily travel distances (e.g., 200-500 km), moderate number of stops (e.g., 2-5 per day), variable stop durations, a mix of inter-city (to/from a central hub) and intra-city (distribution from the hub) trips. Characterised by a primary hub stop within Shanghai and subsequent distribution to peripheral urban or suburban areas. The specific example is shown in **Figure 4.3.6.**.
  - **Inferred Purpose Dominance:** Transshipment/Distribution from Hub, followed by Delivery to Commercial/Retail Outlets or Industrial Facilities.
  - **Operational Profile:** These trucks operate within a hub-and-spoke model, where a major logistics centre in Shanghai serves as a consolidation or break-bulk point. Goods arrive from other cities, are processed at the hub, and then distributed to destinations within Shanghai or its immediate hinterland, or vice versa.

Figure 4.3.6. Pattern 2.2 Representative trip Trajectory Analysis Diagram
(Image source: Self-drawn)

Key Differences and Insights:
The classification highlights significant differences across the identified modes:

- **Travel Distance:** Ranges from short (Sub-category 1.1) to very long (Sub-category 2.1), indicating different operational scales.
- **Number of Stops:** Differentiates between point-to-point transfers and multi-point distribution.
- **Hub Dependence:** Some modes (Sub-category 2.2) are highly dependent on major logistics hubs, while others (Sub-category 1.1) operate more autonomously from a single base.
- **Intra-city vs. Inter-city Focus:** This is a fundamental discriminator, with distinct policy implications for local versus regional traffic management.

These distinct profiles underscore the limitations of "one-size-fits-all" urban freight policies. Recognising these activity modes provides a robust foundation for developing targeted and effective policy interventions.

5. Management Recommendations and Policy Implications
The detailed understanding of truck activity modes derived from this study offers a unique opportunity to refine urban freight management policies in Shanghai, moving towards a more nuanced and inclusive approach. Current policies often impose uniform restrictions that disproportionately affect certain freight operations while failing to adequately address the specific challenges posed by others. Based on the identified two main categories and five sub-categories of truck activities, the following targeted management suggestions are proposed:

5.1. Tailored Regulations for Localised Urban Freight Operations
The "Localised Urban Freight Operations" category (Sub-categories 1.1, 1.2, 1.3) represents the majority of heavy truck movements within the immediate urban area, directly impacting daily urban life.

- **For Multi-Stop Urban Distribution (Sub-category 1.1 – "City Courier"):**
  - **Challenge:** High stop frequency, short distances, often operating in congested commercial/residential areas. Existing blanket time-window restrictions can severely limit their operational efficiency.
  - **Recommendation:** Implement more flexible and granular time-window restrictions. Instead of broad bans, consider designated delivery windows for specific zones (e.g., pedestrian streets) or allow access during certain off-peak hours for smaller, cleaner trucks. Promote the use of dedicated urban loading/unloading zones that are clearly marked and enforced, potentially equipped with smart sensors to manage usage. Explore micro-consolidation centres at the edge of high-density areas to reduce the number of large trucks making individual stops.
  - **Policy Focus:** Optimising last-mile delivery efficiency and minimising urban disruption.

- **For Dedicated Industrial/Commercial Haulage (Sub-category 1.2 – "Industrial Shuttle"):**
  - **Challenge:** Regular, heavy-volume movements between fixed points, often requiring access to industrial parks and large commercial complexes. These routes might intersect with general traffic, contributing to congestion.
  - **Recommendation:** Develop dedicated freight corridors or preferential routes for these regular high-volume movements, especially connecting industrial zones with major logistics hubs or arterial roads. Implement intelligent traffic signal priority systems for heavy trucks on these designated routes where feasible. Consider differentiated access permits based on destination and frequency, rather than blanket restrictions.
  - **Policy Focus:** Ensuring efficient supply chain connectivity for industries and large businesses, and mitigating their impact on general traffic flow.
- **For Differentiated Intra-city Logistics (Sub-category 1.3 – "Service Provider"):**
  - **Challenge:** Diverse operations, often unpredictable routes, and varied cargo types (e.g., construction waste, specialised equipment). Their impact on traffic can be sporadic but significant.
  - **Recommendation:** Categorise and regulate based on cargo type and vehicle purpose where appropriate. For instance, specific routes or disposal sites for construction waste trucks. For service vehicles, consider issuing special permits for access during restricted hours if their work is critical and time-sensitive (e.g., utility repairs). Promote technology adoption (e.g., dynamic routing, real-time communication) to optimise their movements.
  - **Policy Focus:** Facilitating essential urban services while managing their varied impacts.

5.2. Strategic Management for Regional/Inter-city Freight Operations

The "Regional/Inter-city Freight Operations" category (Sub-categories 2.1, 2.2) plays a crucial role in connecting Shanghai to the broader national and international supply chains, but their long hauls and large sizes pose different challenges, particularly at urban entry points.

- **For Long-Haul Inter-city (Sub-category 2.1 – "Regional Connector"):**
  - **Challenge:** Primarily concerned with efficient movement between major urban centres, often operating on highways, but needing smooth access to and from large logistics hubs within Shanghai. Time-window restrictions at urban entry points can lead to bottlenecks.
  - **Recommendation:** Implement "big data informed, flexible traffic restrictions." Instead of fixed time-window bans, use real-time traffic data, weather conditions, and predicted demand to dynamically adjust access times to major logistics parks or expressways leading out of the city. Promote the use of off-peak hours and night-time for these movements. Invest in intelligent truck parking facilities at the urban periphery to manage waiting times before entry.
  - **Policy Focus:** Enhancing regional connectivity and reducing congestion at urban gateways.
- **For Hub-and-Spoke Regional (Sub-category 2.2 – "Regional Distributor"):**
  - **Challenge:** A combination of long-haul movements to a central hub and subsequent intra-city distribution. This requires efficient transshipment and effective last-mile delivery from the hub.
  - **Recommendation:** Prioritise investment in and optimisation of urban logistics hubs (e.g., multi-storey warehouses, automated sorting facilities) that serve as critical interfaces for these operations. Policies should encourage the use of smaller, cleaner vehicles for the intra-city distribution leg from these hubs. Facilitate intermodal transfers at these hubs where possible (e.g., rail or water links). Provide clear, efficient routes from highways to these hubs.
  - **Policy Focus:** Streamlining the interface between long-haul freight and urban distribution, promoting sustainable last-mile solutions.

5.3. Cross-Cutting Policy Considerations

Beyond mode-specific recommendations, several overarching policy directions emerge:

- **Leveraging Big Data and AI:** The success of these differentiated policies relies heavily on continuous data collection and analysis. Shanghai should invest further in smart city infrastructure to gather real-time freight data, use AI for predictive analytics (e.g., congestion hotspots, optimal delivery times), and support dynamic policy adjustments.
- **Green Freight Initiatives:** Differentiated policies can also be used to incentivise greener freight vehicles. For example, preferential access or reduced charges for electric or low-emission trucks, particularly for urban distribution (Sub-category 1.1).

- **Collaboration with Industry:** Effective policy implementation requires strong collaboration with logistics companies, industry associations, and drivers. Pilot projects and feedback mechanisms can help refine policies to ensure they are practical and beneficial for all stakeholders.
- **Infrastructure Investment:** Targeted investment in critical freight infrastructure, such as multi-functional urban logistics hubs, dedicated truck parking, and improved last-mile delivery infrastructure, is essential to support the proposed policy changes.
- **Driver Welfare:** Any policy reforms should also consider the impact on truck drivers, including access to rest facilities, clear communication of regulations, and support for their working conditions.

By moving away from simplistic, uniform rules, Shanghai can develop an urban freight management system that is more responsive to the diverse needs of freight operators, more efficient in its use of urban space, and ultimately, more conducive to a sustainable and prosperous urban environment. This study provides the empirical foundation for such a transformative shift.

6. Conclusion

This study embarked on a comprehensive investigation into urban freight mobility in Shanghai, leveraging extensive high-frequency GPS trajectory data from heavy trucks. The research successfully moved beyond aggregate observations to infer the underlying activity patterns and purposes of individual truck movements, providing a micro-perspective crucial for effective urban freight management.

Through rigorous data processing, including precise stop point identification and path map matching, the fundamental characteristics of truck travel in a high-density urban environment were thoroughly detailed. The integration of land use and Points of Interest data allowed for a robust inference of activity purposes at various stop locations, revealing the complex interplay of industrial, commercial, and logistical functions.

The application of a two-step clustering method was pivotal in identifying distinct truck activity modes. The study successfully classified freight truck operations into two main categories: "Localized Urban Freight Operations" and "Regional/Inter-city Freight Operations," which were further subdivided into five specific sub-categories. These categories exhibit significant differences in key operational attributes, such as daily travel distance, the number and nature of stops, and the predominant travel scope (intra-city versus inter-city). This differentiation underscores the inherent heterogeneity of urban freight and highlights the inadequacy of traditional "one-size-fits-all" policy approaches.

Based on these findings, the study proposes a suite of targeted management recommendations. These suggestions advocate for a paradigm shift towards more inclusive and differentiated urban freight policies. For instance, specific requirements are suggested for short-distance, multi-stop urban distribution trucks, acknowledging their unique challenges in congested areas. Simultaneously, the study proposes the implementation of flexible traffic restrictions for long-haul and regional trucks, dynamically informed by real-time big data, rather than rigid, static time windows.

The insights generated by this research pave the way for the development of innovative, localised urban freight systems in Shanghai and potentially other high-density cities. By understanding and addressing the specific needs and operational patterns of different freight activity modes, urban planners and policymakers can foster a freight ecosystem that is not only more efficient and cost-effective for businesses but also more harmonious with urban life, contributing to reduced congestion, lower emissions, and improved quality of life for residents. Future research could explore the integration of real-time traffic conditions into activity mode prediction and the socio-economic impacts of implementing these differentiated policies.

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GenAI Street Experiments: A Critical Framework for Urban Design Teaching and Learning

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Abstract
The recent rise of generative artificial intelligence (GenAI) tools promises to disrupt how cities are planned and designed. Some of these tools aim to empower diverse stakeholders to "reinvent their streets" by visualising how adopting a cycling lifestyle or adding outdoor seating could transform an urban environment. Implemented as part of educational exercises, text-to-image generative AI offers opportunities to help future planners envision different urban scenarios in a studio learning environment. However, biases, injustice and glitches remain a pressing concern, underscoring the need for future planners to critically engage with these technologies. In this paper, we draw on our experience designing and teaching a course focused on fostering critical skills for engaging with GenAI in urban design studio learning. Using a novel framework, we discuss how these tools can be integrated into planning education.

Keywords: Generative AI; Street experiments; Urban design pedagogy; Critical framework; Studio-based learning; AI bias

1 Introduction

Future generations of urban planners and designers will confront intertwined challenges of climate change, social justice and rapid digital transformation. To navigate such complexity and uncertainty, students must master transformative tools and skills (Bertolini, 2020; McCune et al., 2023). A core competence is the ability to catalyse societal transitions. Tassone et al. (2018) highlight three essential abilities for future planners: a) engagement with real-world problems; b) responsiveness in formulating actions; and c) critical thinking that questions preconceived assumptions. Further, pedagogical approaches grounded in regenerative education—learning that remains within the planet's socio-ecological boundaries—can strengthen students' sense of agency (Mang, n.d.). Planning curricula are therefore beginning to embed futuring exercises: active, critical and reflective explorations of alternative futures (Bertolini et al., 2024; Hoffman et al., 2021). These activities respond to the urgency of environmental crises while challenging expert-determined modes of thought. Urban design, urban experimentation and tactical-urbanism modules offer a practical entry point, with several programmes now introducing courses on street re-allocation and street experiments, defined as temporary interventions that subvert car-oriented streetscapes, re-allocate space to prioritise active mobility and public life, to help communities to envisage radically different mobility systems (Bertolini, 2020).

A growing body of educational material is being developed on street experiments. Open-access MOOCs such as Street Experiments for Sustainable and Resilient Cities (Technical University of Munich / EIT Urban Mobility, Coursera) and Reclaiming the Street for Liveable Urban Spaces (University of Amsterdam, Coursera) guide learners through planning, implementing and evaluating street experiments, while Planetizen's Learning Tactical Urbanism video series provides practitioner-led tutorials. At the university level, semester-long studios—for example, California College of the Arts' Active Urbanism: Tactical Interventions and the University of New Mexico's Urban Design Methods elective—immerse students in tactical-urbanism projects. Together, these courses illustrate the range of teaching formats that can be adapted when embedding futuring exercises in planning curricula. However, teaching such interventions demands that students collect, and compile detailed local spatial data, design alternative streetscapes and create visualisations—even though the intent of these projects is limited in duration and spatial extent.

Digital transformation in urban planning and design education is prompting debates on technology's role in education (Mishra et al., 2025). Generative artificial intelligence (GenAI) tools, as text-to-image generators are poised to reshape urban design studio teaching and learning. New platforms enable stakeholders—including students—to "reinvent their streets" and imagine allegedly 'healthier environments' (NL, 2025). They can illustrate, for example, how a cycling lifestyle or outdoor seating might transform a specific street. While GenAI opens fertile ground for experimentation, questions of how students and educators will consider mobility justice and equity

and biases remain pressing and demand critical engagement. To date, we know little about the pedagogical opportunities and challenges of GenAI in urban design studio learning and how to improve AI literacy in teaching and learning and critically engage students and educators with the visual material produced in urban planning and design studios.

This paper addresses that gap by evaluating a pilot studio format introduced at the University College Dublin that integrated text-to-image Generative AI into a placemaking and urban design module centred on street experiments. In what follows we retrace media studies scholarship on critical content analysis of AI-generated images and present an analytical framework for interrogating AI-generated streetscapes and their cultural, social and political assumptions. After, we outline the urban design studio structure, tools adopted and implementation and report preliminary learning outcomes and student reflections. We conclude by identifying opportunities and challenges for future studio practice, proposing directions for further research, including longitudinal studies of GenAI-enhanced planning education and the development of open-source teaching resources.

2 Artificial intelligence in urban planning and design education

Recent research focuses on the emergence of generative AI in education and its impact on creativity and learning. A transformative application of generative AI in planning education offers opportunities for empowerment and creativity within the learning environment. An AI-enabled approach to higher education can enhance students' agency: it "embraces the idea that learners should pursue paths that align with their individual interests and potential, leading to diverse rather than uniform outcomes" (Mishra et al., 2025: 252). Previous studies indicate that generative AI can serve as a tool to support this agency—whether through storytelling, visualising abstract concepts or historical settings (Choi and Chang, 2025).

Yet, within planning we still know little about AI's potential to help envision alternative futures; meanwhile, mobility injustice remains a pressing concern, underscoring the need for planners to engage critically with these technologies. Planning education continues to struggle to integrate transformative skills into curricula. We aim to address this challenge by introducing and evaluating an educational approach that draws on one interdisciplinary module developed at University College Dublin.

2.1 Characteristics of Text-to-Image Generators for Studio-based Learning

Recently, Generative Artificial Intelligence (GenAI) has introduced new methodologies that can facilitate visualisation alternatives to urban design scenarios. This is particularly in relation to the domain of street experiments and mobility transformations. One of the advancements of this tool is the text-to-image generators. These generators can allow urban planners and designers to quickly conceptualise design alternatives for streetscapes. This is usually done by converting language descriptions into vivid visualisations (Virtual City Systems, 2024; Valença et al., 2025; Cabrera-Nyst, 2024). GenAI tools generally streamline urban design's conceptual and creative process. In addition, they ease the participatory planning process by making complex design ideas accessible to a broader range of stakeholders (Virtual City Systems, 2024; Valença et al., 2025).

2.2 Existing theories of text-to-image AI critical use

Established scholarship in media studies reflects on how images and other visual material are a "collective representation" (Barthes 1977), such that they reproduce social, cultural, ideological and historical meanings. Typically, meanings are encoded into images by their creators (e.g. photographer, designer) and decoded by the viewers. While in the past humans were the creators of images and were encoding meanings into them, now novel AI tools produce images that are a representation of data, and infographics for their underlying dataset (Salvaggio, 2023). Diffusion-based models are trained on collections of image-text pairing datasets, which are in turn assembled by humans (Salvaggio, 2023). The training images-and-text pairing datasets are created within specific social, economic and political contexts, thus exemplifying unstated assumptions, inscribed into datasets. Machine learning models by identifying patterns, reveal underlying assumptions of the human-gathered datasets. 'Just as archives are the stories of those who curate them' AI generates images are representations of information in the training datasets (Salvaggio, 2023). Details that are absent or poorly indexed in the dataset are omitted, indicating that ai-generated images can be analysed. Recent research in media studies suggests that as datasets are encoded into AI-generated images, we can understand and analyse layers of socio-cultural encoding within the data used to produce them (idem).

3 Critical framework for the analysis of GenAi street experiments in studio learning

Our overarching aim was to set up studio-learning sessions based on a framework that would allow students and educators to critically analyse how well AI-generated images reflect the realities and aspirations of street experiments or open streets, uncover biases in the underlying datasets, and use the images as discussion points for urban planning learning. The framework aims to critically analyse AI-generated images that depict various street experiments, such as car-free streets, pedestrian zones, or public open spaces. Using prompts and AI tools (e.g., Bing Image generator), in a studio learning environment, students will generate images and examine them through a detailed framework, identifying both strong and weak design elements, biases, and urban planning relevance. Based on the media studies scholarships on encoding/decoding meaning in images (Salvaggio, 2023) and urban design pedagogy, we developed a five-phase framework that guided the students throughout their systematic street experiments' AI-generated images critique (Table 1, Figure 1). The development of the framework was also guided by the following questions:

- How much does AI know about street experiments?
- What are the biases and glitches in ai-generated street experiment images?
- Are there clear references to one city/context?
- What about the use of colours/materials/transport means/people?
- Are there aspects in the Ai-image that openly undermine the aim of street experiments?
- How does the AI-generated street vary from the street experiments you analysed as groups?

This method allows students to critically analyse how well AI-generated images reflect the realities and aspirations of street experiments or open streets, uncover biases in the underlying datasets, and use the images as discussion points for urban planning.

Table 1 Critical Analysis Framework for AI-Generated Images of Street Experiments

Phase	Aim	Guiding Question	Analytical Focus
1. **Create a Sample Set**	Identify patterns	What do we see?	First-pass visual scan of dominant elements, activities and omissions.
2. **Content Analysis**	Identify strengths & weaknesses	What works and what glitches?	Systematic listing of well-rendered versus distorted or missing features. **Strengths:** Identify which elements are consistently well-rendered and accurate, e.g. clean streets, open spaces, or vibrant community activity. These might reflect frequent representations in the underlying datasets. **Weaknesses:** Look for distortions, missing features, or underdeveloped aspects, such as widespread car presence, poorly defined interactions between pedestrians and cyclists, unrealistic street furniture, or inaccessible design for differently abled people. This can indicate biases in the dataset, such as overrepresentation of certain types of cities or demographics.
3. **Link patterns to Dataset**	Interrogate values embedded in the data	- Whose streets, whose narratives? - What types of urban environments are overrepresented or underrepresented (e.g., car-centric cities vs. pedestrian-friendly ones)? - What cultural, social, or political biases might have influenced the data?	Tracing cultural, social and political assumptions that surface from the underlying training data. Considering if these datasets reflect specific societal priorities like sustainability, safety, or inclusivity in urban planning.
4. **Connotative Analysis**	Examine social implications	Who benefits, and who is marginalised?	Reflection on potential equity impacts when applying each AI output to real contexts. Reassessment the original image and develop hypotheses about what might be missing or emphasized due to biases.
5. **Start Over**	Test hypotheses & model boundaries	Can we prompt alternative, fairer futures?	Iterative re-prompting to probe the latent space and validate (or reject) initial assumptions. Experimentation with prompts that push the AI to generate alternative or diverse visions of street experiments, Evaluation of how well the AI adapts to more niche or socially conscious prompts.

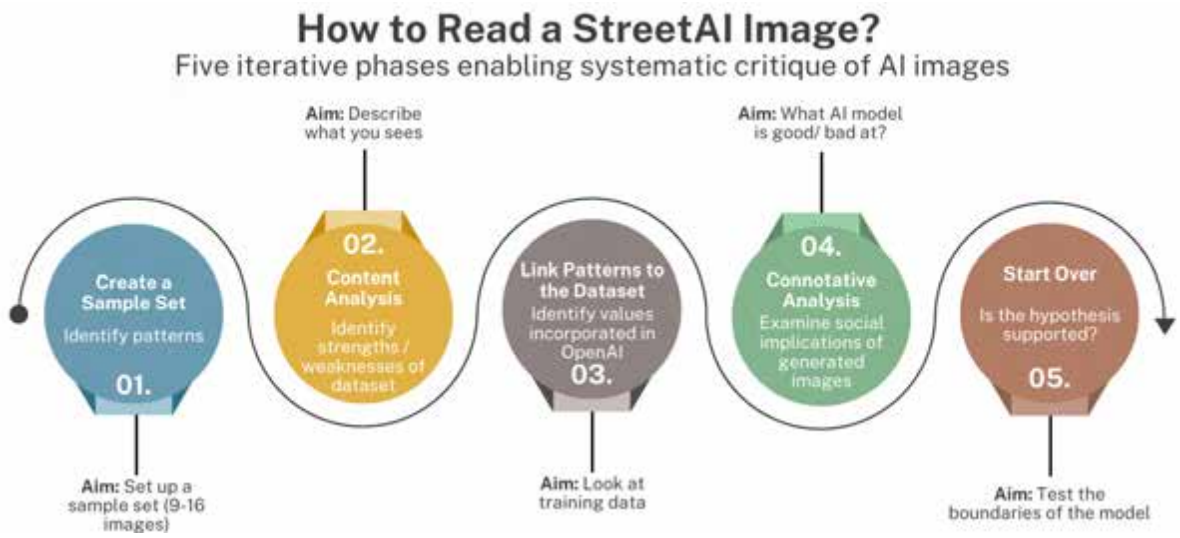

Figure 1 Five Phases for Systematic Critique of AI Images

4 Methods and Case Study

For this paper, we used the Placemaking Urban and Rural Design module (Plan4005W) run at the Chang'an–Dublin International College of Transportation (CDIC), University College Dublin as a case study. It focuses on the fundamentals of urban design, tactical urbanism and analysis of street experiments across cities around the world. Within this module, the students were introduced to the concept of generative AI and its integration into urban design. Students practice using this new tool in a studio-based exercise as part of one assessment of the module. Within this exercise, the students were asked to examine and critique the images produced by AI text-to-image generators.

Three experimental lab sessions aimed to explore with students: (1) the use of AI-image generation services to create images of street experiments, (2) to build on and develop terminology on and about street experiments and use it as AI-image generation prompts, and (3) to critically examine the images created by AI, based on bias/glitch/strength/weakness.

For each phase, a corresponding tutorial and hands-on studio task were delivered during Autumn 2024. In the assignment, the students (n = 116) were required to analyse selected case studies of pedestrian streets, street experiments, play streets or open streets. Students worked in groups of 4–5 and generated 9–16 images per prompt using the platforms listed below (section 5.1). The students also documented their reflections in an individual report.

This exercise aims to enhance the student's ability to critically evaluate how AI-generated visuals can support or misrepresent urban design principles discussed during the theoretical lectures of the module. Consequently, by the end of this exercise, the students should be able to a) understand how AI-generated images can visualize urban street experiments, b) develop critical thinking skills to analyse visual representations in urban design, c) identify biases in AI-generated content and reflect on their implications for urban planning, and d) synthesize their findings into an actionable urban design reflection.

By engaging with readings and texts assigned during theoretical lectures, students demonstrated their knowledge of relevant urban design literature in their assignments. In the assignment students critically analysed AI-generated images based on prompts that they developed that depict various street experiments, such as car-free streets, pedestrian zones, or public open spaces. Using prompts and AI tools (e.g., Bing Image generator), they generate images and examine them through the critical framework (section 3), identifying both strong and weak design elements, biases, and urban planning relevance of the AI-generated images.

Four generative AI platforms (Playground AI, Lumenor, GETIMG, and Bing Image Creator) were introduced to provide students with a broad overview of available technologies. However, students were instructed to select and work with only three tools for their assignments. This decision was based on several pedagogical and practical considerations:

1- The assignment sought to allow the students to deeply engage with the AI tools and the generated images. Thus, engaging with three platforms was more practical in allowing the students to perform an in-depth critical analysis of each tool's outputs.
2- Time and workload constraints were also contributing factors. The studio module took place within a limited number of sessions. Therefore, there was a risk of overwhelming the timeframe allocated for hands-on experimentation, prompting refinement and reflective writing, if we had asked the students to engage meaningfully with all four tools.
3- Some platforms had occasional access issues for students based on their geographic location or region. This could have introduced inconsistencies across students' submissions and hindered steady progress and completion of the assignments.
4- Lastly, giving the students the freedom to choose their preferred AI platforms encouraged comparative learning.

Data sources included teachers' feedback (based on the assessment rubric) and diary entries from in-class observations, students' individual reflective reports, and formal course evaluations. Images generated through text-to-image generative AI are referenced following the UCD Library Artificial Intelligence Library Guide (University College Dublin Library, 2025)

5 Findings

In this study, a selection of text-to-image generation tools has been tested in an urban design studio-based class to assist the students in the conceptualisation and communication of innovative streetscape design ideas. The incorporation of these AI-driven tools into pedagogical practices has been proven to be valuable for rapid design ideas generation and conceptualisation. However, adopting GenAI also has some drawbacks and challenges. For instance, during the studio classes, it was quite challenging for students to generate images with relevance and realism. Besides, Seneviratne et al. (2022) claim that addressing potential biases in data training and managing the technical learning curve is critical, particularly for new users of these tools.
This section outlines the different characteristics, strengths and limitations of each GenAI tool that has been utilised in the urban design studio-based classes. The aim is to emphasise the applicability of these tools in urban design pedagogical practices.

5.1 Overview of Generative Tools

We utilised four image-generation software: Playground AI, Lumenor, GETIMG, and Bing Image Creator (powered by DALL·E 3). They were selected based on their accessibility, diversity in model architectures, ease of use, and relevance to participatory and educational applications in urban design and planning. Most of these tools interpret natural language prompts to generate images, however, their performance and applicability differ (Table 2).
Recent studies indicate that the potential of utilising GenAI in generating urban design ideas is growing. GenAI tools enable users to generate novel forms of spatial expressions using language-based prompts (Paananen et al., 2024; Seneviratne et al., 2022). Nevertheless, these tools usually reflect a degree of inherited biases in data training and architecture models. This limits the applicability of tools in diverse or non-western contexts (Wang et al., 2025).

5.1.1 Tools Descriptions

- **GETIMG**

This AI-powered image generation tool is a comprehensive tool that can be used by designers and creators. It can allow users to select the AI model they prefer (e.g., GPT Image and FLUX.1). This tool has greater flexibility in its use; it can facilitate the following:

- Text-to-image generation by using text prompts.
- Image-to-image transformation through existing image modifications.
- AI Canvas (outpainting) through the expansion of images beyond their original borders.
- DreamBooth custom AI Models that enable users to train their own model (good for experimentation and idea modifications). (Getmig.ai, n.d.)

• Playground AI
This AI platform features a highly flexible web-based interface that supports multiple AI models, including Stable Diffusion and DALL-E (Liu et al., 2024). It has the flexibility of using language-based prompts and reference image upload. Also, it allows users to train their own models. It offers stylistic control and model switching, which makes it ideal for experimentation and learning environments (Liu et al., 2024). Nonetheless, the outputs of this platform are mostly aesthetic rather than analytical. In addition, they lack the spatial logic needed for rigorous urban planning applications (Paananen et al., 2024). Despite these drawbacks, this tool is still considered useful for composition and exploring visual ideas.

• Lumenor AI
This platform is an advanced AI-powered image generation platform. It is mainly designed to aid in digital art creation. It uses advanced AI algorithms that facilitate image generation based on various inputs such as text descriptions and image references (Access Newswire, 2023; Newswire, 2023). This tool is similar to Playground AI in its ease of use and flexibility. Thus, making it applicable for learning purposes. Yet, it also has cultural and contextual biases.

• Bing Image Creator
This platform is powered by DALLE.E 3. It offers a user-friendly interface that uses text-based prompts to render or generate images. Bing Image Creator has the potential to recognise and understand urban elements such as streets, sidewalks, signage, bike lanes, street furniture, etc. However, the architectural or spatial quality and scale of its outputs can be inconsistent since it is still under training (Seneviratne et al., 2022). Moreover, the outputs of this interface usually lack cultural specificity. Nevertheless, altering the prompts to give more description of the geographical location can enhance the cultural representation of the generated image.

Table 2 Summary of the different AI platforms during the studio-based learning

Tool	Model Type	Strengths	Weaknesses	Input Types	Best Use Case
Playground Ai	Stable Diffusion, DALL·E	Flexible model selection; strong prompt control	Stylised outputs may require prompt tuning	Text prompts and reference image	Iterative design, prompt testing
Lumenor AI	Proprietary ML/DL models	High-quality digital art generation, adaptive learning; seamless integration with design software	Limited documentation on backend architecture; potential lack of urban planning specificity	Text prompts and reference image	Iterative design, prompt testing
GETIMG	Custom generative model	Equity-oriented; designed for mobility visualisations	Comprehensive toolset; user-friendly interface; supports custom model training	May require a learning curve for advanced features; potential limitations in architectural specificity	Iterative design, prompt testing
Bing	Transformer + Diffusion	Clear visual-semantic match, text rendering, and user-friendly interface	Can misrepresent urban scale; less stylistic nuance	Text Prompts	Planning demonstrations, quick visuals

5.2 Illustrative Student Assignment
This assignment, authored by one of the students (Code - **S1**), presents a critical analysis of AI-generated images from three platforms (Lumenor, GETIMG and Microsoft Bing). The student in this assignment evaluated how well these outputs support the transformation of urban spaces through street experiments. The student critiqued

the AI-generated images using the analytical framework that examines functionality, social impact, aesthetics, and sustainability (see section 3). Following the assignment brief, the student used 5 variations of prompts on every one of the three platforms and compared their outputs. The three prompts are as follows:

• **Prompt 1:** "A street experiment (an intentional, temporary change of the street use, regulation and/or form, aimed at exploring systemic change in urban mobility, away from "streets for traffic", and towards streets for people)" (see Figures 2, 3 and 4).

Figure 2 Image generated using Lumenor. The image was generated in response to the prompt 1

Figure 3 Image generated using GETIMG. The image was generated in response to Prompt 1.

Figure 4 Image generated using Microsoft Bing. The image was generated in response to Prompt 1.

Prompt 2: "A parklet is a small, intentional, temporary conversion of a parking space or street segment into a public space designed for people rather than vehicles. This intervention typically includes seating, greenery, and amenities that encourage social interaction, relaxation, and community engagement. Parklets serve to reclaim underutilized road space, fostering a shift in urban mobility paradigms towards more pedestrian-friendly environments and enhancing the overall quality of urban life" (see Figures 5, 6 and 7).

Figure 5 Image generated using Lumenor. The image was generated in response to Prompt 2.

Figure 6 Image generated using GETIMG. The image was generated in response to Prompt 2.

Figure 7 Image generated using Microsoft Bing. The image was generated in response to Prompt 2.

Prompt 3: "Play streets are designated areas where vehicular access is restricted to create a safe and inviting environment for children and families to engage in play and recreation. This intentional, temporary street transformation promotes community interaction and active lifestyles by repurposing the street as a dynamic space for games, activities, and social gatherings. Play streets challenge traditional street use, advocating for a vision of urban mobility that prioritizes children's needs and fosters a sense of community" (see Figures 8, 9 and 10).

Figure 8 Image generated using Lumenor. The image was generated in response to Prompt 3.

Figure 9 Image generated using GETIMG. The image was generated in response to Prompt 3.

Figure 10 Image generated using Microsoft Bing. The image was generated in response to Prompt 3.

Prompt 4: "Open streets are temporary closures of public roads to motor vehicle traffic, transforming them into vibrant spaces for pedestrians, cyclists, and community activities. This street experiment aims to explore the potential of urban thoroughfares as public plazas, promoting active transportation and social cohesion. By facilitating outdoor activities, such as markets, performances, and recreational events, open streets encourage a fundamental rethinking of street design and usage, prioritizing people over cars in urban environments" (see Figures 11, 12 and 13).

Figure 11 Image generated using Lumenor. The image was generated in response to Prompt 4.

Figure 12 Image generated using GETIMG. The image was generated in response to Prompt 4.

Figure 13 Image generated using Microsoft Bing. The image was generated in response to Prompt 4.

Prompt 5: "The reuse of public space refers to the intentional, temporary adaptation of existing public areas to serve new functions, such as community gatherings, art installations, or pop-up markets. This approach seeks to maximize the utility of underused urban spaces by fostering social interaction and cultural expression. By experimenting with diverse uses of public space, cities can better understand the needs and desires of their communities, leading to more responsive urban planning and a shift towards spaces that prioritize people and community engagement over traditional vehicular traffic" (see Figures 14, 15 and 16).

Figure 14 Image generated using Lumenor. The image was generated in response to Prompt 5

Figure 15 Image generated using GETIMG. The image was generated in response to Prompt 5

Figure 16 Image generated using Microsoft Bing. The image was generated in response to Prompt 5

For the critical analysis of the AI-generated images, the student followed the structure of the five-phase critical framework introduced in the course. This student's work demonstrates how this framework can be operationalised in student work.

In Phase 1 (Create a Sample Set - Identify patterns**):** The student conducted the first visual scan of recurring elements in the images. For instance, the frequent presence of greenery, benches and pedestrian zones (see Figures 5, 6 & 3). S1 was also able to note the absence of some elements such as seasonal variations and representation of elderly and disabled users. This indicates the student's awareness of the inclusion and omission of AI-generated visuals.

In Phase 2 (Content Analysis – Identify strengths and weaknesses): S1 highlighted some strengths within the outputs, such as green infrastructure, seatings, social interactions and pedestrian-friendly layouts. Besides, the student was also able to indicate some homogeneous design features and unrealistic or utopian representations (see Figures 4, 10 & 14).

In Phase 3 (Link patterns to Dataset – interrogate values embedded in data): S1 critically examined the underlying assumptions in the data training of GenAI platforms. For example, S1 identified some cultural and socio-economic biases that were represented in the Western design aesthetics of the urban contexts in the images (see Figures 2, 12 & 15). This indicates that GenAI tools tend to neglect the needs of diverse users or non-Western environments in their urban design visuals.

In Phase 4 (Connotative Analysis – examine social implications): The student linked the embedded biases to real-world planning consequences. S1 highlighted that privileging one aesthetic or demographic group can create a state of inequality. In the analysis, the student also indicated that these misrepresentations can unintentionally marginalise certain groups that are not visualised by GenAI tools.

In Phase 5 (Start Over – Test hypotheses and model boundaries): Even though S1 did not provide wide variations of prompting examples, the student was able to reflect on the value of each prompt iteration to refine the outcomes and challenge the initial assumptions. S1 discussed how rephrasing the prompting language or words could produce more inclusive and context-sensitive outputs and visuals

.

Beyond applying the analytical framework, S1 compared the generated outputs of the different tools used in the assignment. S1 indicated that each tool provided visually engaging streetscapes, however, the quality and the degree of realism differed greatly between each tool. For instance, Bing Image Creator was identified as having the capability to produce coherent urban compositions and plausible human figures. Nevertheless, Lumenor AI and GETIMG were noted for generating images with distorted or surreal elements, which questions their design capabilities.

In the student's report, some discrepancies in the way each tool interprets prompts were identified. This aligns with Salvaggio's (2023) and Seneviratne et al. (2022) findings that these tools still have limited platform-specific training data and algorithmic parameters. This comparative analysis shows the importance of tool selection and critical cross-platform evaluation when employing GenAI in urban design pedagogy.

5.3 Key Strengths and Challenges in Using GenAI in Studio Classes

As part of the studio-based module undertaken by students, a portion of their assessment involved evaluating their critical reflection and engagement with the GenAI tools used in their urban design tasks. By going through the students' work and writing their feedback, key distil trends were noticed. Table 3 summarises the main strengths and challenges observed.

Table 3 Summary of Key Strengths and Challenges in Student Engagement with GenAI Tools

Category	Observed Strengths	Observed Challenges
Critical Reflection	Most of the students carefully questioned the results of AI-generated images and were able to highlight ethical issues.	Some students lacked depth in analysing AI biases or broader implications.
Understanding of Bias	The students had some degree of awareness of cultural and geographical limitations in image outputs.	For some students, it was hard to explain how biases show up in visuals or impact fairness in cities.
Urban Design Theoretical Framework Application	Most of the students successfully integrated theoretical frameworks to guide their critiques.	There were some inconsistent applications of theoretical frameworks; some students relied more on aesthetics than critical analysis.
Prompt Engineering	Most of the students used creative and well-structured prompts that generated contextually rich outputs.	Several students struggled with specificity and realism in their prompt design.
Use of Visuals	The students presented clear visual representations, which supported their arguments effectively.	It was noticed that most of the students were over-reliant on visuals with insufficient accompanying critique.
Engagement with Tools	The students demonstrated a strong ability to navigate and use multiple GenAI platforms.	There was limited comparison between the different platforms; some focused only on tool functionality rather than outcomes.
Equity and Mobility Lens	The students showed a strong understanding of how AI tools can reveal or obscure mobility injustices.	There was a tendency to generalise equity concerns without linking them to concrete design implications.

These findings indicate that the students successfully engaged, reflected on, and critically analysed the integration of GenAI image generation tools in their module. They were also able to highlight the biases attached to these tools. However, more support is needed, particularly regarding integrating analytical frameworks in the prompt creation and output image analysis.

6 Discussion and conclusion

This paper explored the applicability of integrating GenAI tools into urban design education through a structured studio exercise. The objective was to investigate ways to develop students' transformative skills through an integrated learning approach designed to equip university students to navigate complex challenges and support societal transitions. This application also seeks to elevate the students' competencies in critical analysis, reflexivity and spatial justice awareness. These competencies align with the broader pedagogical aims of planning education, which includes developing future literacy, responsiveness, and the capacity for ethical reasoning as claimed by Tassone et al. (2018) and McCune (2023).

This paper presented a five-phase critical framework as part of an urban design studio-based module. This framework offers a clear structure for deconstructing GenAI outputs. The exercise undertaken by the students built on media studies theories of visual encoding and decoding (Salvaggio, 2023; Barthes, 1977), which encouraged them to look beyond general urban design aesthetics and look deeper to critique assumptions encoded in generated image datasets. This analytical approach adheres to the call for considering AI ethics and digital humanities when utilising algorithmic outputs (Crawford, 2021).

Throughout the studio classes and assessment of the students' individual reports, it was evident that the students were able to generate and analyse images and interrogate embedded socio-cultural and political assumptions. The student's assignment example presented here in this paper demonstrated how utilising the critical framework can support layered analysis. This layered analysis included not just identifying patterns, but also questioning whose narrative are being visualised. In addition, the student's comparison across the different used platforms in the exercise highlighted the major interpretive differences in GenAI tools. This supports the existing concerns in the literature about the opacity and variability of large text-to-image models (Seneviratne et al., 2022; Valença et al., 2025).

Furthermore, several pedagogical challenges were observed. Some students struggled with prompt engineering, which confirms the findings by Paananen et al. (2024) that prompt specificity is a skill and at the same time a barrier in GenAI-based design. Other students were struggling with articulating the spatial or equity-related implications of AI imagery. This indicates that the students need more scaffolding to connect urban theory to AI visual critique.

Generally, the findings of the paper indicate that GenAI can enhance urban design pedagogy when incorporated into urban design studio classes, particularly when using a structured/critical framework. GenAI can also foster the development of ideas, support visual thinking and enhance digital literacy. Nevertheless, there is a risk of reproducing dominant design imaginaries and marginalising alternative urban futures when implemented without explicit critical guidance, as claimed by (Townsend, 2020; Wang et al., 2025).

In conclusion, AI platforms provide opportunities and challenges as futuring exercises. Open dialogue between educators and students should foster debates on the development of culturally responsive prompts and integrate comparative analysis within the curriculum to expose the students to a wide range of tools. Moreover, the future direction of GenAI in urban design should include extensions to non-Western urban contexts, include the needs of marginalised groups, and develop collaborative pedagogy with open-access repositories of tested prompts and images. This pilot studio reinforces the imperative of embedding AI literacy in urban planning curricula as a technical and ethical practice.

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Exploring Pedestrian Comfort and Urban Mobility: A Multi-Modal Assessment of Walking Experiences at Popular Restaurant Destinations in Shanghai

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Abstract
This study examined pedestrian comfort and urban mobility in Shanghai's inner-core restaurant destinations by identifying three distinct access patterns: Public transportation + non-motorized/ long distance walk (PNLW), Public transportation + short distance walk (PSW), and Motorized vehicle + short distance walk (MSW). Using spatial audits, navigation data, and social media text analysis, it evaluates comfort through pedestrian characteristics and traffic conditions. Findings reveal that MSW destinations—despite being less sustainable—offer the highest pedestrian comfort due to better-designed access zones and reduced pedestrian-electric scooter conflict. PSW areas suffer from congestion and inadequate micro-scale planning, while PNLW zones are most impacted by infrastructural shortcomings. The study concludes that pedestrian comfort depends on the continuity and convenience of the space where different modes of transportation changed.

Keywords: pedestrian comfort; travel; destination;

1. Introduction

The travel behavior of citizens is closely related to urban space and urban transportation systems. In megacities such as Shanghai, the evolution of mixed-use developments, commercial hubs, and transit-oriented infrastructure has heightened the need for pedestrian-friendly environments. More comfortable walking can enhance travelers' willingness to travel actively (Knowles, et al, 2020) and is a core part of the sustainable travel transformation (Loo, 2021). Walking comfort is a measure of the quality and attributes provided by the walking environment through space and walking facilities, which makes the walking experience easier (Ma, et al, 2021). It includes material, physical and psychological comfort (Sarkar, 2003). However, walking during travel is not an isolated process: As a higher-level walking demand (Alfonzo, 2005), the comfort of walking is also dynamically influenced by factors such as the relationship between the person and the vehicle and travel characteristics.

Among various urban functions, dining play a unique role in shaping urban pedestrian flow. Popular restaurant destinations, often located in high-footfall commercial districts, naturally attract large volumes of pedestrian movement and serve as key nodes in urban pedestrian networks. While existing research primarily examines broad walkability metrics such as land use and infrastructure, fewer studies focus on how walkway conditions, traffic flow, and transportation infrastructure impact pedestrian experiences during the travel.

This study adopts the destination-oriented approach, aiming to fill this gap by evaluating the pedestrian comfort in Shanghai's inner-ring commercial areas, focusing on locations with high restaurant-driven foot traffic. By integrating navigation data, spatial audits, and text analysis from social media platforms, this research provides a comprehensive understanding of pedestrian experiences and offers multi-modal data-driven recommendations for urban planning and design. Specifically, it focuses on understanding how pedestrian comfort varies across different arrival modes and urban fabric at popular restaurants destinations.

The study has three primary objectives:
1) To analyze the access pattern of popular restaurant destinations in Shanghai's inner core area and the relationship with their urban fabric and transportation infrastructure.
2) Evaluate the pedestrian comfort in these areas based on walkway quality, pedestrian characteristics, and traffic conditions, and add other special criteria such as dedicated parking areas, station facilities, and attractiveness according to different arrival patterns. The relevant high-frequency words that appear on social media are also important supplementary evidence for the evaluation.
3) Seek the correlation between access patterns and pedestrian comfort.

2. Literature Review

Studies on pedestrian comfort in urban design focus on the influence of built environments on pedestrian behavior and perception, encompassing both objective and perceived characteristics of the built environment, as well as walking behavior and related factors. This research further examines pedestrian comfort during travel, investigating how travel characteristics—such as trip purpose, mode of transportation, and travel time—affect comfort levels.

Walking serves as a critical link between various travel segments and transportation modes, spanning multiple stages from origin to transfer points and final destinations. Pedestrian comfort directly influences individuals' willingness to adopt other modes of transportation. High-quality walking environments, convenient pedestrian facilities, and appropriate walking distances can significantly enhance residents' travel satisfaction (Van Lierop et al, 2018).

From a travel perspective, research on walking comfort treats walking as a distinct mode of transportation, views pedestrians as individual units within traffic flow, and integrates pedestrian systems as an essential component of urban transportation networks. This approach emphasizes the systemic role of walking in shaping overall mobility experiences and urban accessibility.

2.1 The influence of travel links on pedestrian comfort

Academic research has established that pedestrian comfort in transit station areas - encompassing bus stops, metro stations, and railway terminals - significantly influences travelers' modal choices and willingness to walk to transit nodes. Empirical studies utilizing citizen satisfaction evaluations demonstrate that perceived walkability (Gan et al, 2021) and sidewalk conditions, pedestrian facilities, and intersection design (Gupta et al, 2022) in station access zones, positively correlate with metro ridership. For Bus Rapid Transit (BRT) systems, research indicates that pedestrian comfort perceptions depend fundamentally on sidewalk quality and cleanliness, with tree-shaded routes particularly enhancing walking propensity (Jiang et al, 2012). Emerging scholarship employs quantitative measures like street tree density and bench availability to assess how Light Rail Transit (LRT) station-area built environments (within 5-minute walk radii) support active transportation adoption (Oluyomi et al, 2019).

Transfer stations present unique comfort considerations, where platform accessibility, vertical circulation systems, and crossing infrastructure substantially impact commuter experience, as evidenced by studies in Indian contexts (Sil et al, 2022). Alexander's seminal work establishes 180-200m (approximately 3-minute walk) as the maximum acceptable transfer distance for maintaining passenger comfort (Alexander, 2018).

The first-mile/last-mile (FMLM) challenge remains a critical barrier to transit adoption (Fehr & Peers et al, 2015). High-quality FMLM environments simultaneously enhance both utilitarian functionality and experiential quality of transit journeys (Tilahun et al, 2016). Ergonomics research reveals that travelers' overall comfort evaluations are disproportionately weighted toward terminal trip segments (Richards, 1978), with destination-area microclimate comfort particularly influencing satisfaction assessments (McKercher, 2015). Improved walkability in FMLM zones demonstrates pro-social impacts, enabling greater transit use among low-income commuters - with origin-area walkability proving more influential than destination conditions (Ha et al, 2023). For bus riders, FMLM comfort and transfer duration exert greater satisfaction impacts than in-vehicle conditions (Park et al, 2021).

Regarding metro access, "last-mile" qualitative aspects like sense of place outweigh basic facility availability in promoting walking mode share (Chidambara, 2019).

2.2 Pedestrian characteristics and pedestrian comfort

The fundamental significance of pedestrian comfort lies in optimizing travel experience, making micro-scale behavioral metrics essential for operationalizing comfort assessment. Under optimal conditions, empirical studies document an average walking speed of 1.24 m/s (Chen and Dong, 2005), with personal space requirements of 1.4-2.3 m^2/person (Fruin, 1971) and flow rates below 23 persons/m·minute maintaining perceived environmental freedom. The personal space construct, encompassing both pacing zones (physical movement requirements) and sensory zones (psychological buffer areas), has emerged as a robust proxy for design quality and level-of-service evaluation.

Contemporary research methodologies employ diverse approaches: sidewalk width-to-volume ratios for crowd density analysis, computer vision processing of transit vehicle dashcam footage for crossing behavior studies (Fan and Loo, 2021), and IoT-enabled environmental sensors (e.g., air quality monitors) capturing spatiotemporal usage patterns (Loo and Tang, 2019). Wi-Fi signal clustering techniques also effectively detect group movement patterns. Participatory sensing through opt-in smartphone applications further enriches data granularity by correlating mobility patterns with individual attributes.

While demographic (age/gender), socioeconomic, and cultural factors preclude universal comfort standards, consensus emerges around three core requirements: unimpeded walking pace, adequate personal space allocation, and controlled pedestrian densities. Comfort manifests behaviorally through unconstrained movement patterns-characterized by purposive gait unaffected by negative psychological states, minimal flow conflicts (<15° angular deviation in trajectory intersections), and limited friction with other modal users (vehicular/bicycle). These observable parameters collectively establish an evidence-based framework for comfort evaluation across varied urban contexts.

2.3 Auditing Frameworks and Criteria of pedestrian comfort measurement

Comfort has been explicitly incorporated into various walkability audit tools and guidelines, which can be categorized by scale and methodology. At the macro urban scale, quantitative tools provide comprehensive assessments of city-wide factors, while micro street-scale evaluations qualitatively characterize outdoor spaces through user perception. Current measurement instruments are inherently context-specific, can be classified into five methodological approaches:

1) Perceptual Tools
Neighborhood Environment Walkability Scale (NEWS) (Cerin et al, 2002)

2) Perceptual-Observational Hybrid Tools
Pedestrian Environment Data Scan (PEDS) (Clifton et al, 2007)
Systematic Pedestrian and Cycling Environment Scan (SPACES) (Pikora et al, 2002)
Systematic Social Observation of Public Spaces (SSO) (Sampson and Raudenbush, 1999)

3) Observational Tools
Chinese Urban Built Environment Scan Tool (CUBEST) (Su et al, 2014)
Analytic Audit Tool (AAT) (Brownson et al, 2004)
Active Neighborhood Checklist (ANC) (Hoehner et al, 2007)
Neighborhood Active Living Potential (NALP) (Gauvin et al, 2005)

4) Observational-Archival Hybrid Tools
Walkability Framework for Health (WFH) (Zuniga-Teran et al, 2016)
Pedestrian Level of Service - Quality (Q-PLOS) (Talavera-Garcia and Soria-Lara, 2015)

5)Archival Tools
Walkability Index (WAI) (Frank et al, 2010)
Walk Score (WS) (Arellana et al, 2020)
The Physical Activity and Redesigned Community Spaces (PARCS) study (Huang et al, 2016)

3. Methodology

3.1 Study Area and Site Selection

This study focuses on popular restaurant destinations within Shanghai's inner-ring commercial areas, selected based on Gaode Map navigation data. The inner ring represents the city's core zone, characterized by the highest density of transportation and pedestrian activity. To ensure that walking segments occur exclusively in outdoor built environments and urban streets, restaurants located within TOD (Transit-Oriented Development) buildings were excluded from the analysis.

The selection of restaurants was determined by Gaode Travel Score, a data-driven metric derived from real user navigation behavior, including travel popularity and experience quality. This score reflects a restaurant's relative

standing compared to others in the same category and urban context. The data is updated daily based on a 30-day dynamic rolling window, ensuring objectivity without manual intervention or manipulation.

To capture representative dining destinations, the study identified the top three most-visited restaurants in each administrative district within the inner ring, ensuring spatial diversity and high pedestrian accessibility (Fig.1). In addition, Yangpu District and Pudong District have no restaurants that meet the requirements. This approach allows for a systematic evaluation of walkability and pedestrian comfort in high-traffic urban dining areas.

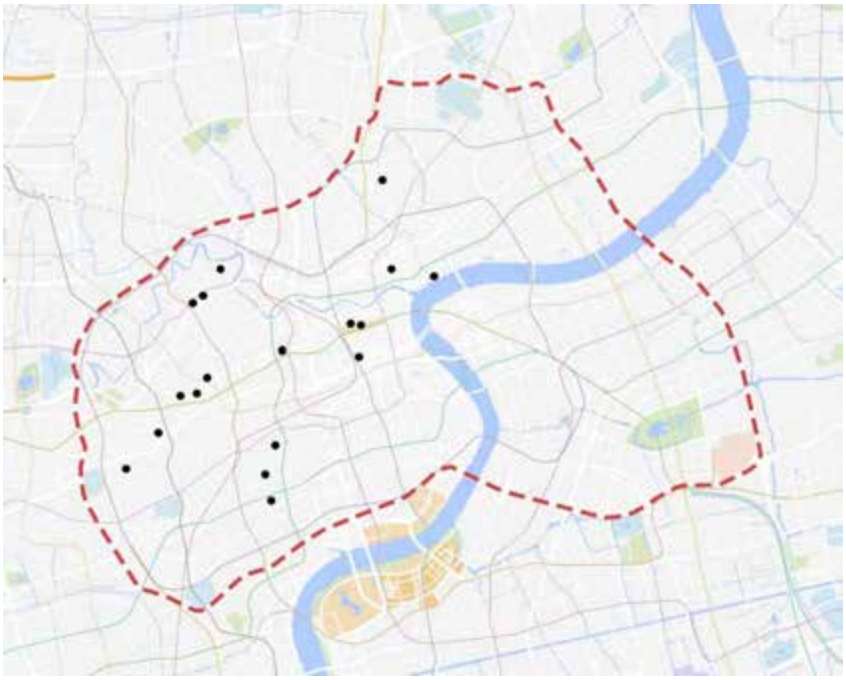

Figure 1 Selected restaurants

Source: Author's own illustration based on raw data from Gaode Map.

3.2 **Online Data Sources and Collection Methods**

This study employed a comprehensive multi-source data collection framework to systematically evaluate the pedestrian environment surrounding selected restaurants. The spatial analysis was conducted within an 800-meter radius buffer zone centered on each restaurant location, encompassing key pedestrian transportation infrastructure elements including sidewalks, parking facilities, and public transportation nodes including bus stops (within 300 meters) and subway stations (within 500 meters). These geospatial datasets were acquired through application programming interfaces (APIs) from Gaode, ensuring data accuracy and temporal relevance.

For dynamic pedestrian flow analysis, the study utilized Baidu Map's heatmap functionality, which provides real-time visualization of human mobility patterns through anonymized location data from mobile devices. Data collection was strategically scheduled during peak activity periods - specifically weekday evenings (17:30) and weekend noontime (11:30) - to capture maximum pedestrian volumes. These temporal samples enabled identification of high-traffic corridors for subsequent field observations while providing quantitative evidence of congestion patterns (Fig.2).

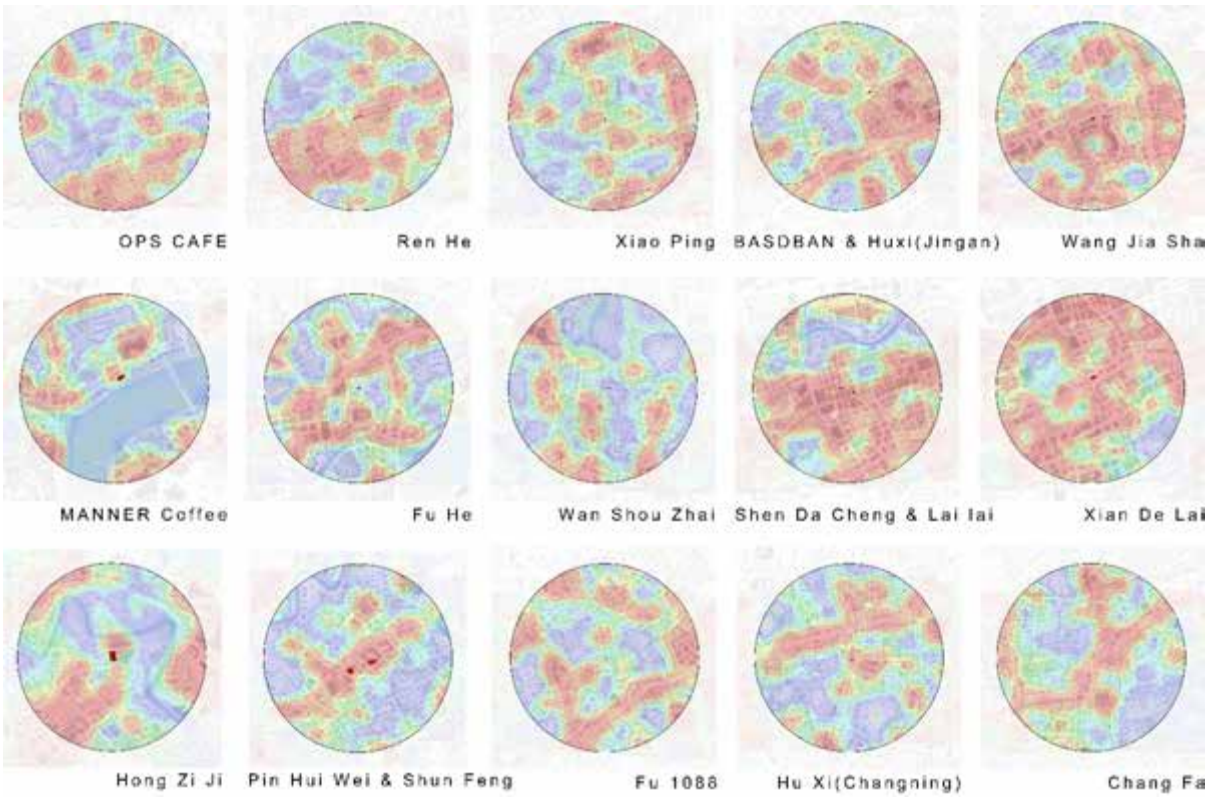

Figure 2 Heat map of the restaurants

Source: Author's own illustration based on raw data from Baidu Map.

Complementing the pedestrian flow data, shared bicycle availability data were extracted from the Meituan platform's real-time feed. This dataset, collected synchronously with the heatmap recordings, provided insights into micro-mobility patterns and last-mile connectivity around each study site. Spatial analysis of bicycle distribution patterns helped identify parking hotspots and potential conflicts with pedestrian flows.

To complement spatial and mobility data, social media text data was extracted from Xiaohongshu (Little Red Book), a platform where users share image-text posts. A structured keyword search protocol was implemented using terms such as "walking experience", "accessibility", and "pedestrian comfort" in combination with each restaurant's name.

This multi-method approach, combining spatial analysis, movement pattern visualization, and text analysis, provided a robust foundation for evaluating pedestrian comfort from both objective and subjective perspectives.

3.3 Quantitative pedestrian comfort evaluation method

Building on previous mobility-focused studies of pedestrian comfort, this research categorizes evaluation metrics into 4 common criteria (universally applicable criteria for all access pattern) and 9 specialized criteria (context-sensitive measures tailored to specific access patterns). To enable precise quantification, each restaurant is systematically scored across all relevant indicators using a standardized 0-2 point scale (where 0 = poor, 1 = moderate, 2 = optimal), with summation generating a composite Pedestrian Comfort Score (PCS) for individual restaurant (Tab. 1).

Table. 1 pedestrian comfort evaluation

Evaluation criteria			Pedestrian comfort score			Access pattern		
Category	criteria	Description	0	1	2	PNLW	PSW	MSW
Common criteria	Sidewalk Quality	Width	2m	2-3m	>3m	√	√	√
		maintenance	uneven and dirty surface	slightly uneven with minor stains	flat and clean surface			
	Pedestrian Characteristics	Pedestrian Flow Rate	>30 or <10 persons/min	20-30 persons/min	10-20 persons/min	√	√	√
		Queue Encroachment	queue obstructs sidewalk	minor queue	no queue			
	Traffic Conditions	traffic congestion	severe congestion (vehicles cannot move)	moderate congestion (vehicles slow down)	no congestion	√	√	√
		Pedestrian-Electric Scooter Mixing	frequent mixing (pedestrians avoid vehicles)	occasional mixing	no mixing			
Special criteria	Dedicated Parking Areas	Pavement Material Differentiation	no differentiation	marked differentiation	material differentiation	√	×	√
		Direct Access	no direct access	access via underground/ overground passage	direct entrance access			
		Dedicated Waiting Area	no dedicated waiting area	dedicated waiting area	no dedicated waiting area	×		
		Independent Parking Lot	no parking lot	available but insufficient	sufficient independent parking			
	Station Facilities	Escalators at Exits	no escalators	escalators available	escalators and accessible elevators	×	√	×
		Exit Time	underground passage and multi-level vertical transit	underground passage or multi-level vertical transit	no underground passage or multi-level transit			
		Bus Stops	<10	10-20	>20			
		Walking Distance to Nearest Metro	>800m	500-800m	<500m	√		
	Attractiveness	-	ordinary street	historic/ commercial district	central business district	√	√	×

3.4 Pedestrian Comfort Audit

According to the evaluation framework (Tab. 1), the study employed a rigorous, multi-dimensional approach to assess pedestrian comfort through systematic field audits. Quantitative measurements followed standardized protocols: 1) sidewalk width was recorded using laser distance meters at 5-meter intervals along restaurant frontages, with three measurements taken at each point to ensure reliability (recording minimum, maximum and average widths). 2) Pedestrian flow rates were measured in units of 5 minutes through manual counting at 15-minute intervals during both weekday evening (17:30-19:30) and weekend midday (11:00-13:00) peak periods. 3) Queue encroachment was documented through scaled photographs and actual measurements of occupied sidewalk area, with particular attention to instances where more than 50% of walkway width was obstructed.

Qualitative assessments employed structured observation protocols. 1) Pathway maintenance was evaluated by features such as surface evenness, cleanliness, visual coherence, and drainage conditions. 2) Traffic conditions were analyzed through photograph recording during audit periods, with conflict points mapped. 3)Parking infrastructure was inventoried through field surveys documenting, including dedicated bicycle parking capacity, electro mobile parking encroachment, and vehicle parking lot capacity serving the restaurant. 4) Metro station accessibility was assessed through timed walk tests from nearest exits, documenting vertical circulation options and wayfinding signage to make sure how to smoothly reach the concourse level from the platform level and find the exit.

The audit incorporated specialized vertical mobility assessments, including inventory of skyway and step counts for underground passages. These vertical elements were found to disproportionately affect pedestrian comfort due to additional physical exertion required and the increased difficulty of finding the way.

All audit data was collected by trained teams using standardized digital forms with geotagged photographs and timestamped observations. The comprehensive methodology enabled both cross-site comparisons and context-specific analysis of pedestrian comfort determinants across Shanghai's varied urban environments. Particular attention was given to transitional spaces between different transport modes, where comfort compromises were most frequently observed. The audit framework successfully captured both measurable physical parameters and subjective user experience factors affecting pedestrian comfort.

3.5 Identifying Pedestrian Access Patterns Through Field Survey

To determine how pedestrians arrive at restaurants, the study employs a multi-method field audit protocol that combines behavioral observation, infrastructure mapping analysis and text analysis from Xiaohongshu.
Pedestrian access patterns during peak hours (weekday evenings (17:30-19:30) and weekend midday (11:00-13:00) by observing:1) Whether pedestrians used means of transportation such as vehicles, bicycles or electric bikes or wore helmets when they arrived. 2) Randomly track an array of pedestrians at the nearest subway exit, and calculate the proportion of these pedestrians who reach the destination restaurant among the total number of people who arrive at the restaurant during this period.

An analysis of the transportation infrastructure around the restaurant can also obtain supplementary evidence: 1) A distance of less than 500 meters from the restaurant to the nearest subway station is more likely to be dominated by public transportation. 2) The dense bicycle parking area near the restaurant will encourage pedestrians to ride bicycles at "the last mile". 3) Restaurants that are over 800 meters away from subway stations, have their own parking lots and are not popular check-in spots are more likely to be reached by private cars or ride-hailing services. 4) When the destination restaurant is highly attractive, such as having a good urban view or being located in a historical district, pedestrians are more likely to tend to reach it on foot.

In addition, by searching for Xiaohongshu posts with keywords such as "restaurant name", "travel", "subway", and "walking", and conducting word frequency analysis on the transportation methods within them, it can also help study and determine the arrival methods of most travelers.

Finally, the research will determine the access patterns of a certain restaurant based on the most dominant arrival means. This identifying method effectively reduces subjective bias through cross-validation of multi-dimensional data.

4. Results and Findings

4.1 Classification of Arrival Patterns

This study categorizes pedestrian access patterns into three typologies based on infrastructure constraints and behavioral preferences: PNLW (Public transportation combined with Non-motorized or Long-distance Walk), PSW (Public transportation combined with Short-distance Walk), and MSW (Motorized vehicle combined with Short-distance Walk). It should be noted that the usage frequency of buses has significantly decreased in both the field research and in text analysis of Xiaohongshu. The public transportation referred to in the research is more about the subway.

Each pattern reflects distinct urban fabric conditions—historic-district morphologies for PNLW, transit-oriented development for PSW, and motor-centric adaptations for MSW—collectively shaping pedestrian comfort and route choices. The classification underscores how spatial design and transport resource allocation either facilitate or hinder more comfortable last-mile connectivity.

4.1.1 Public transportation + Non-motorized/ long distance walk (PNLW)

The formation of the PNLW (Public Transportation + Non-motorized/Long-Distance Walk) access pattern is primarily attributed to restaurants being located beyond 500 meters or even 800 meters from metro stations,

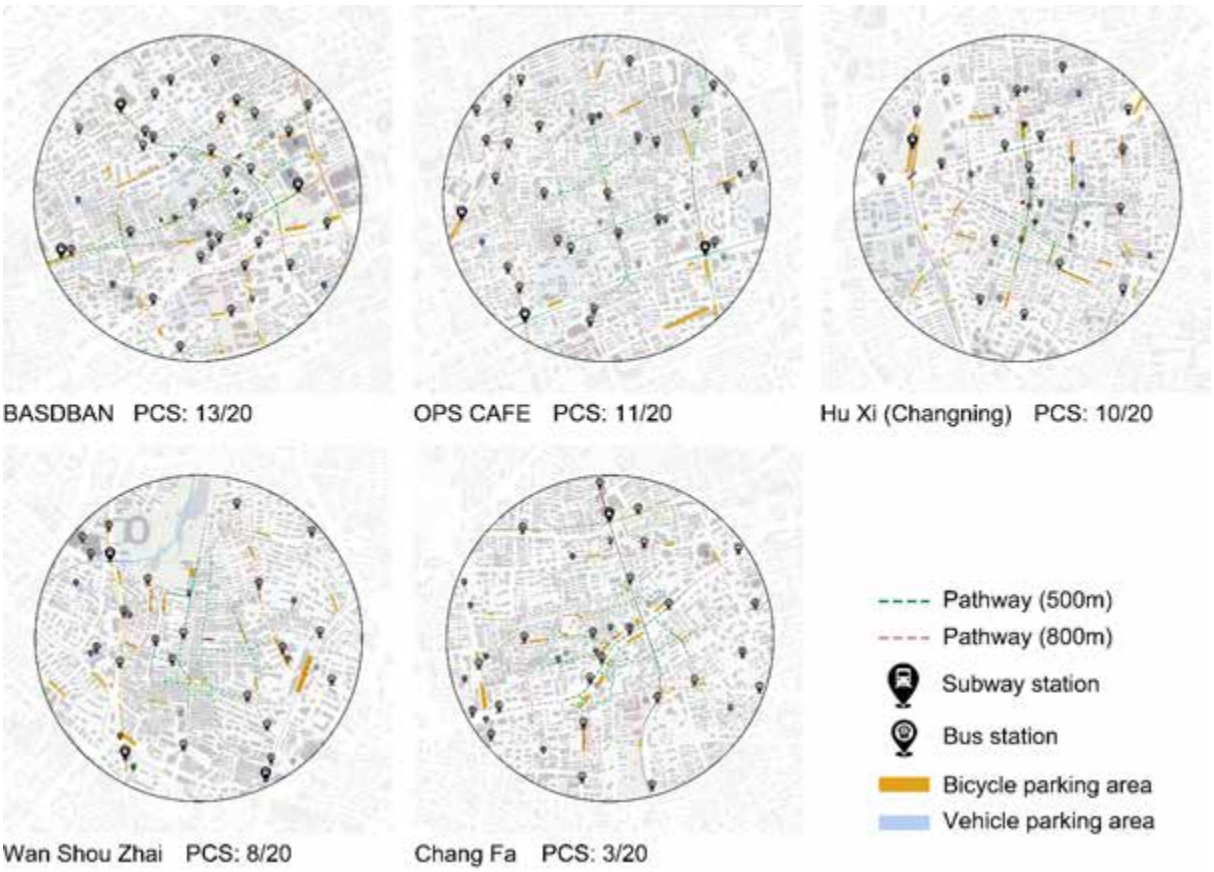

Figure 3 PNLW restaurant mapping
Source: Author's own illustration based on raw data from Gaode Map.

"Check-in" restaurants in historical district—such as BASDBAN, OPS CAFÉ, and Wan Shou Zhai—represent the first category of PNLW destinations due to: 1) Narrow roadways lacking dedicated bicycle lanes, forcing cyclists to share roads with motor vehicles, 2) Artificially enforced bicycle-restricted zones that create pedestrian-only segments along access routes.

Despite these constraints, such destination restaurants often benefit from being clustered with adjacent attractions, creating hybrid bicycle-and-walking routes that maintain strong pedestrian appeal.

The second category of PNLW destinations includes establishments like Hu Xi (Changning) and Chang Fa located near elevated roads. These sites present unique accessibility challenges: 1) Pedestrian flows are fragmented by overpass structures; 2)Certain road sections remain impassable for bicycles.

This spatial configuration effectively forces longer walking distances while limiting alternative micro-mobility options, reinforcing the PNLW pattern's dominance in these locations. The combination of physical barriers and policy restrictions creates a distinct pedestrian experience that differs markedly from transit-oriented or motor-centric access patterns.

4.1.2 Public transportation + short distance walk (PSW)

The PSW pattern emerges when restaurants are within 500 meters of the nearest subway exit (Fig. 4). These destinations—typically "check-in" spots—attract predominantly tourist visitors. Top-rated Huangpu District

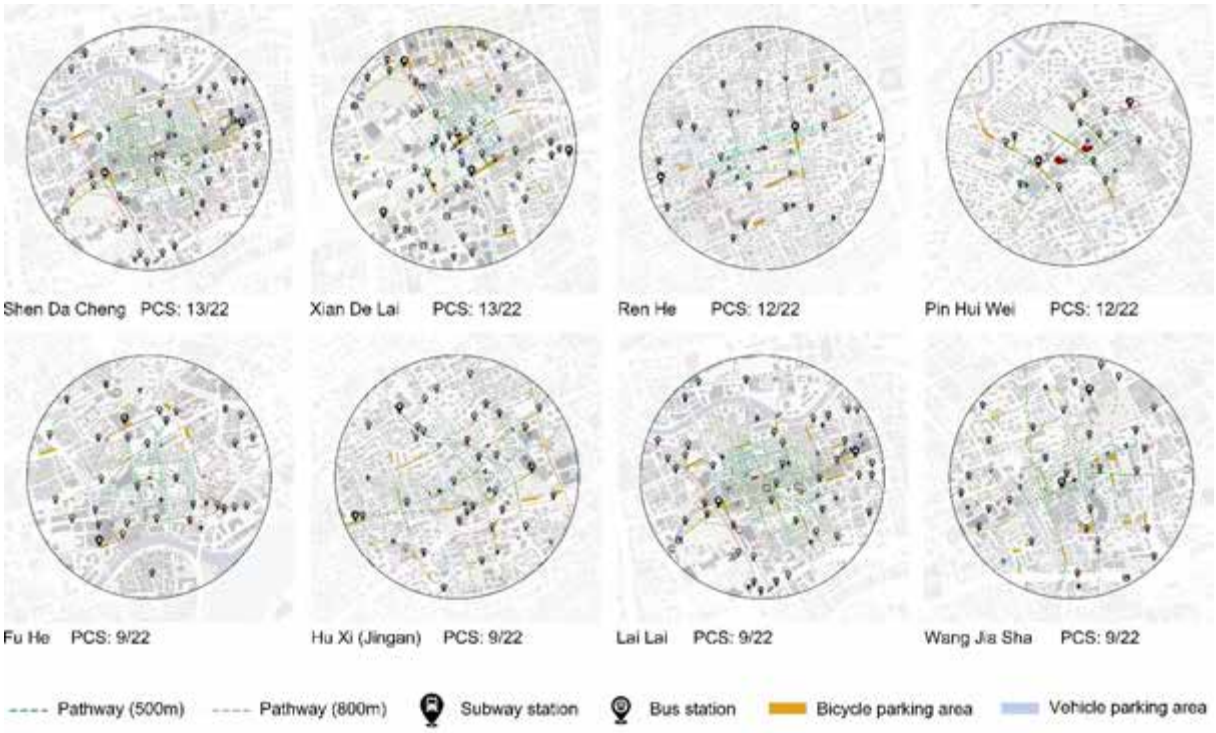

Figure 4 PSW restaurant mapping
Source: Author's own illustration based on raw data from Gaode Map.

Critical transit nodes that facilitate this pattern include major interchange stations, including Nanjing East Road (Lines 2/10), Jing An Temple (Lines 2/7/14), Nanjing West Road (Lines 2/12/13), Chang Shou Road (Lines 7/13), and Jia Shan Road (Lines 9/12). These hubs create concentrated restaurant clusters by capitalizing on two key advantages: their role as transportation interchanges and their embeddedness within vibrant commercial or historic districts. The resulting pedestrian networks enable dense, multimodal access to dining establishments. Moreover, PSW restaurants are supported by high bus-stop density (more than 10 stops within 300 meters, sometimes exceeding 20), reinforcing transit convenience.

This comprehensive transit ecosystem ensures consistent pedestrian flows while minimizing access friction, creating an environment particularly conducive to casual dining and tourism-oriented food establishments. The spatial efficiency of these areas demonstrates successful transit-oriented development principles in practice, where transportation infrastructure and commercial land uses achieve symbiotic integration.

4.1.3 Motorized vehicle + short distance walk (MSW)

The MSW pattern represents a distinct category where travelers predominantly utilize private vehicles or ride-hailing services to access restaurants, followed by brief pedestrian segments. This access mode emerges under two primary circumstances: 1) when restaurants are situated beyond convenient walking distance from metro stations (>800 meters) but provide dedicated parking lots; and 2) when the dining occasion involves group gatherings where motorized transport is preferred for social or logistical reasons (Fig. 5).

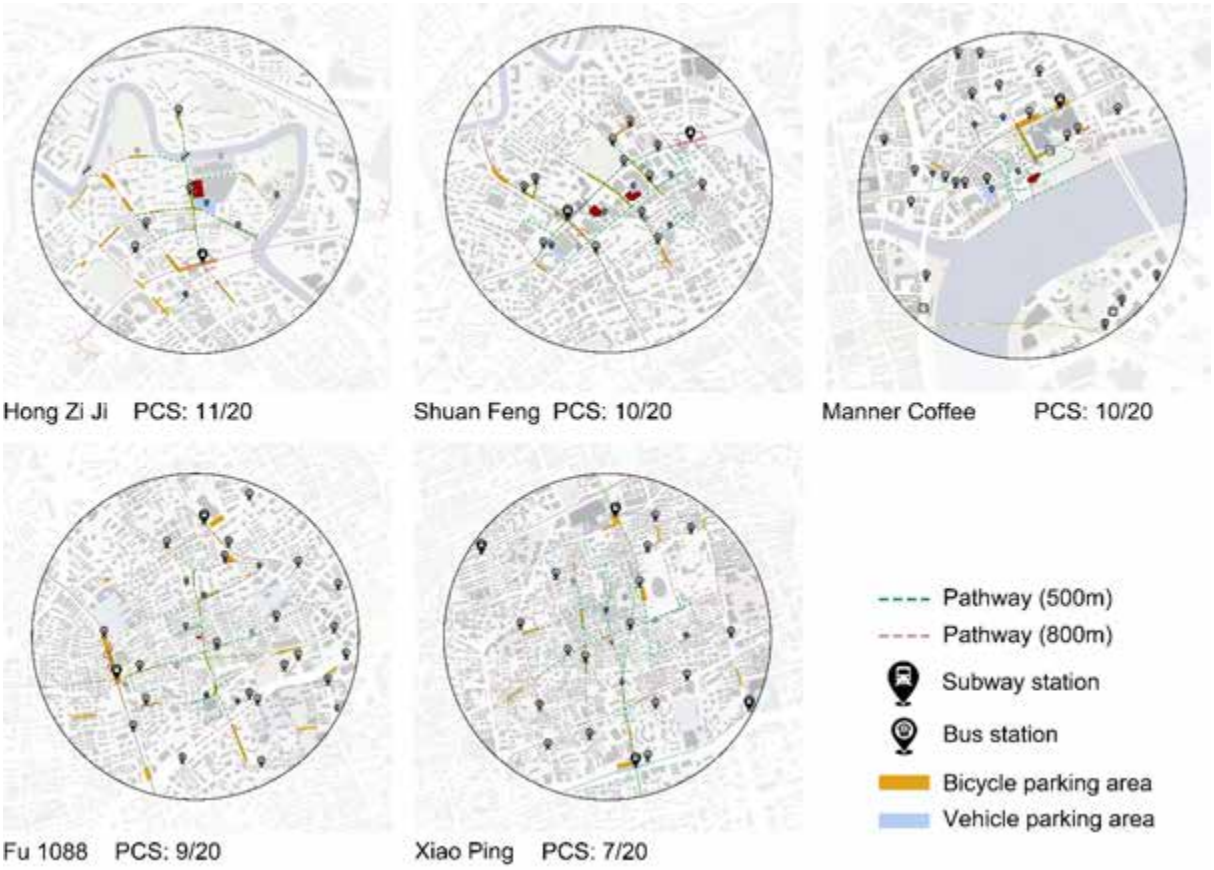

Figure 5 MSW restaurant mapping
Source: Author's own illustration based on raw data from Gaode Map.

Notably, restaurants located in historical districts - such as Fu 1088 - present unique challenges for MSW accessibility. These establishments are typically surrounded by low-rise commercial buildings with limited parking capacity, as most available spaces are allocated to private lots serving adjacent properties. This parking scarcity inadvertently increases reliance on short-distance walking, as patrons are often compelled to park at more distant locations and complete their journey on foot.

The spatial analysis reveals that MSW pattern restaurants cluster in two distinct urban contexts: 1) commercial centers with sufficient surface parking lots (e.g., Hong Zi Ji, Shun Feng), and 2) where public transport coverage is sparse but road infrastructure supports convenient vehicle access such as urban waterfront spaces (e.g., Manner Coffee and Hong Zi Ji) and lower-grade urban roads (e.g., Fu 1088, Xiao Ping). In both settings, the walking segments, though short, often present disproportionate comfort challenges due to inadequate sidewalk provisioning and lack of weather protection along parking-to-restaurant routes.

4.2 Pedestrian Comfort Assessment

The pedestrian comfort scores (PCS) varied notably across the three access patterns. On average, restaurants accessed via the MSW pattern achieved the highest comfort score (11.6/20), followed by PSW pattern with 10.5/22, and PNLW pattern with the lowest score of 9.0/20. These differences primarily stem from distinct infrastructure

challenges: MSW's transitional zone deficiencies, PSW's crowd management issues during peak hours, and PNLW's inherent distance penalties compounded by narrow sidewalks. The superior performance of MSW destinations can be attributed to clearer spatial organization, dedicated parking access, and better-maintained pedestrian zones. In contrast, PSW areas, while benefiting from proximity to transit infrastructure, often suffered from high pedestrian density and queue encroachment near exits. PNLW destinations showed the greatest variability, with comfort scores largely dependent on sidewalk quality and traffic mixing conditions.

These results highlight how pedestrian comfort is shaped by both macro-level accessibility and micro-scale design solutions specific to each access pattern. Sidewalk infrastructure, traffic separation, and spatial crowd management are critical determinants of perceived pedestrian comfort, often outweighing the presumed advantages of public transit-oriented accessibility.

4.2.1 PNLW: Structural and Psychological Barriers in Long-distance Walk

The PNLW access pattern exhibits several challenges that significantly compromise pedestrian comfort (Tab.2). Primary issues include inadequate sidewalk infrastructure, with most restaurants scoring only 1 or 2 for width (2-3m) and several scoring 0 (<2m), particularly Chang Fa and Wan Shou Zhai. This spatial constraint is exacerbated by frequent queue encroachment (scoring 0-1 across all cases) and poor maintenance conditions (0-2 scores). Traffic conditions present another major barrier, with most locations experiencing moderate to severe congestion (scores 0-1) and problematic pedestrian-vehicle mixing (scores 0-1). Queuing for road occupation, pedestrian flow and road width have basically the same impact on pedestrian comfort. Although both OPS Café and BASDBAN have queuing situations, walkways of different widths accommodate a different number of pedestrians, so the actual difference in appearance is not significant (Fig.6).

Figure 6 PNLW restaurants of different PCS
Source: Photographed by author.

The pattern's defining characteristic - long walking distances which more than 500 meters from subway station - combines with these infrastructure deficiencies to create range pedestrian discomfort. Furthermore, the lack of direct access (scores 0-1) and inconsistent pavement material differentiation (scores 0-2) contribute to navigation difficulties. These cumulative factors resulted in half of the restaurants having a pedestrian comfort score of less than 10/20, with the highest score being only 13/20. Chang Fa (Fig. 6) representing the most severe case of compromised walkability due to its combination of narrow sidewalks (1), poor maintenance (0), and frequent pedestrian-electric scooter mixing (0). The data suggests that PNLW destinations require comprehensive improvements in both physical infrastructure and operational management to enhance pedestrian experiences.

4.2.2 PSW: Infrastructure and Operational Challenges

The PSW access pattern, while generally demonstrating better pedestrian comfort than long-distance walking scenarios, still presents several persistent challenges that hinder optimal walkability (Tab.3).

The most critical issues stem from inconsistent sidewalk maintenance, with scores ranging from 0 (poor) to 2 (excellent) across different locations, creating uneven pedestrian experiences even within the same access pattern. Queue management emerges as another significant problem, particularly at popular destinations like Shen Da Cheng and Wang Jia Sha, where pedestrian flow scores of 0 indicate severe congestion during peak hours (Fig. 7).

The pedestrian- electric scooter mixing remains problematic at multiple sites, with mixing scores of 0-1 reflecting ongoing conflicts between walkers and micro-mobility users.

Figure 7 PSW restaurants of different PCS
Source: Photographed by author.

While metro proximity is generally excellent (with most locations scoring 0-1 for distances <500m), the supporting vertical circulation infrastructure shows variability and the exit method is usually rather complicated, as evidenced by escalator availability scores ranging from 0 to 1.

These operational shortcomings are compounded by the pattern's inherent vulnerability to peak-period stress, where even minor infrastructure deficiencies become magnified under heavy pedestrian volumes. The data reveals that while the PSW pattern's fundamental premise of short transit-to-destination distances provides a solid foundation for walkability, its full potential remains unrealized without addressing these persistent issues in infrastructure quality and crowd management.

4.2.3 MSW: Last-50-Meter Discontinuities in Motorized Access

The evaluation of Motorized Vehicle + Short-distance Walk (MSW) pattern restaurants revealed a moderate level of pedestrian comfort, with Pedestrian Comfort Scores (PCS) ranging from 9/20 to 13/20 (mean=11.6±1.6). As shown in Table 3, the top-performing establishments (Hong Zi Ji and Shun Feng, both 13/20) demonstrated balanced performance across all indicators, while Xiao Ping (9/20) represented the most compromised case (Fig. 8). Three key performance characteristics emerged from the analysis:

Figure 8 MSW restaurants of different PCS
Source: Photographed by author.

First, sidewalk infrastructure showed significant variation, with width scores ranging 1-2 (mean=1.4) and maintenance scores 0-2 (mean=0.8). Notably, all restaurants scoring 0 in maintenance (Hong Zi Ji, Xiao Ping) underperformed their width-adjusted PCS potential by 1.5-2 points, suggesting maintenance quality disproportionately impacts comfort in motorized-access environments.

Second, transition zone elements proved critical determinants. Restaurants with superior parking-to-walkway transitions (Hong Zi Ji: parking=2, direct access=2) achieved 1.3× higher PCS than those with poor transitions (Xiao Ping: parking=0, direct access=2). The dedicated waiting area variable showed particularly strong discrimination, with establishments scoring 2 (Shun Feng, Manner Coffee) averaging 12.5/20 versus 10.3/20 for others.

Third, electric scooter conflicts emerged as a newly significant factor. While traffic congestion scores averaged 1.0±0.8, pedestrian-scooter mixing scores averaged just 0.4±0.5, indicating this emerging mobility form creates disproportionate discomfort. Manner Coffee's exemplary scooter management (score=0) contributed significantly to its 12/20 PCS despite parking deficiencies.

The data suggests MSW comfort depends less on individual element excellence than on avoiding critical weaknesses - no restaurant overcame multiple 0 scores in core categories. This "weakest link" phenomenon differentiates MSW from other access patterns and underscores the need for holistic design approaches in motorized-access environments.

Table. 2 Pedestrian comfort score of PNLW pattern restaurants

Restaurant	Sidewalk quality		Pedestrian characteristics		Traffic conditions		Special criteria				PCS
	width	maintenance	pedestrian flow rate	queue encroachment	traffic congestion	pedestrian-electric scooter mixing	pavement material differentiation	direct access	distance to nearest metro	attractiveness	
OPS CAFÉ	1	2	2	0	1	2	0	1	0	2	11/20
BASDBAN	2	2	1	1	2	1	1	1	0	2	13/20
Hu xi (Changning)	1	1	2	1	1	2	1	1	0	0	10/20
Chang fa	1	0	2	0	0	0	0	0	0	0	3/20
Wan shou zhai	0	0	2	1	1	1	0	2	1	1	8/20

Table. 3 Pedestrian comfort score of PSW pattern restaurants

Restaurant	Sidewalk quality		Pedestrian characteristics		Traffic conditions		Special criteria					PCS
	width	maintenance	pedestrian flow rate	queue encroachment	traffic congestion	pedestrian-electric scooter mixing	escalators at exits	exit time	bus stops	distance to nearest metro	attractiveness	
Pin Hui Wei	2	0	0	1	1	1	1	1	0	2	1	10/22
Shen Da Cheng	2	2	0	1	0	2	1	0	1	2	2	13/22
Lai Lai	0	0	2	0	0	1	1	0	1	2	2	9/22
Xian De Lai	1	0	2	2	1	2	0	1	2	2	1	13/22
Ren He	2	1	1	1	1	2	0	2	0	2	0	12/22
Hu Xi (Jingan)	2	1	1	1	0	1	1	0	1	1	0	9/22
Wang Jia Sha	2	2	0	0	0	0	1	0	0	2	2	9/22
Fu He	0	0	1	1	1	1	1	2	1	1	0	9/22

Table. 4 Pedestrian comfort score of MSW pattern restaurants

Restaurant	Sidewalk quality		Pedestrian characteristics		Traffic conditions		Special criteria				PCS
	width	maintenance	pedestrian flow rate	queue encroachment	traffic congestion	pedestrian- electric scooter mixing	dedicated waiting area	pavement material differentiation	direct access	independent parking lot	
Hong Zi Ji	1	0	2	2	2	1	1	0	2	2	13/20
Shun Feng	2	1	0	2	1	1	2	1	1	1	13/20
Xiao Ping	1	0	2	1	0	0	0	1	2	0	9/20
Fu 1088	1	1	0	2	2	0	1	1	2	1	11/20
Manner Coffee	2	2	2	2	0	0	2	1	1	0	12/20

The text analysis of Xiaohongshu posts shows that: 1) Citizens are generally very sensitive about the distance from the destination restaurant to the subway station, which is a key factor determining the travel mode of most people. 2) The different purposes of dining at restaurants do indeed determine the mode of travel chosen by travelers. For instance, "checking in" and "dining together" are to some extent directly related to public transportation-oriented travel and motor vehicle-oriented travel respectively. 3) Travelers are quite concerned about the "uncomfortable" factors in the last mile, such as the inconvenience of parking. In addition, shading, cleanliness and clear signs are also key comfort factors that are often mentioned. Crowded intersections and overpasses are usually regarded as problematic places.

Overall, the quality of the sidewalk are the most fundamental factors affecting the pedestrian comfort, while different arrival patterns have corresponding key factors decided by urban fabric and transportation facilities.

5. Discussion and Recommendations

This study assessed pedestrian comfort around popular restaurant destinations in Shanghai by classifying access modes into three patterns: pedestrian + non-motorized / long distance walking (PNLW), public transportation + short distance walking (PSW), and motorized vehicle +short distance walking (MSW). The results indicate clear differences in comfort scores across these patterns, highlighting the influence of infrastructural, environmental, and traffic factors.

5.1 Comparing Comfort Across Modal Patterns

This study examined pedestrian comfort around popular restaurant destinations in Shanghai across three access modes: MSW, PSW, and PNLW. The findings reveal that MSW destinations achieved the highest average pedestrian comfort score (11.6/20), followed by PSW (10.5/22), and PNLW (9.0/20) as the lowest.

The MSW pattern's superior performance reflects the impact of dedicated design for vehicular arrivals, which often includes better-maintained sidewalks, clearly defined access routes, and lower congestion levels near destinations. Although the parking facility conditions of Manner Coffee and Hong Zi Ji are quite different, both offer smooth transitions from the parking areas to the entrance and minimal pedestrian conflict zone. Therefore, their PCS do not show significant differences either. This challenges conventional assumptions about parking's role in pedestrian comfort.

In contrast, PSW destinations, despite benefitting from public infrastructure, frequently suffer from overcrowding, bottlenecks near transit exits, and unmanaged queuing, which compromise comfort. While locations like Shen Da Cheng and Ren He performed reasonably well due to integrated exits and escalators, many PSW restaurants scored poorly on pedestrian flow and queue encroachment.

The PNLW group scored the lowest overall, showing the greatest variance. These areas tend to lack formal pedestrian facilities, rely on mixed-use streets shared with bicycles and scooters, and are less supported by municipal planning. Locations like Chang Fa and Wan Shou Zhai showed severe deficits in sidewalk condition, traffic mixing, and overall accessibility.

This pattern suggests that, in practice, pedestrian comfort does not automatically correlate with proximity to transit or active mobility infrastructure. Instead, purpose-built vehicle access or well maintained side walk—when paired with clear pedestrian design—can offer unexpectedly high comfort. The MSW data particularly highlights crumbling sidewalks' psychological impact on drivers-turned-pedestrians.

5.2 Key Indicators Influencing Comfort

Across all access patterns, sidewalk quality remained the single most influential determinant of pedestrian comfort. Restaurants with wide, well-maintained walkways—such as BASDBAN (PNLW), Shen Da Cheng (PSW), and Manner Coffee (MSW)—consistently scored higher in total PCS. This underscores the foundational role of physical walking space in perceived comfort, supporting earlier studies that emphasize the need for uninterrupted and navigable pathways.

In MSW environments, traffic separation and controlled pedestrian access helped reduce conflict. Many locations featured independent parking lots, clearly demarcated walking routes, and dedicated waiting areas, improving safety and spatial clarity. While traditionally seen as car-oriented and hostile to pedestrians, when benchmarked against PSW (11.5/22) and PNLW (9.0/20) patterns from prior studies, this positions MSW as neither superior nor inferior, but distinctly different in its comfort determinants. The MSW zones can achieve high comfort when pedestrian access is intentionally designed and carefully integrated with transportation systems

Conversely, in PSW pattern restaurant, pedestrian-electric scooter mixing and queue encroachment were common problems. Restaurants near busy metro stations often struggled with overlapping pedestrian streams, particularly where escalators were absent or exit times were long. Although these areas benefit from public infrastructure, poor micro-scale spatial planning appears to negate the walkability advantages typically associated with transit zones.

PNLW destinations, while more organically integrated with surrounding neighborhoods, lacked investment in street quality, often displaying broken pavements, encroaching electric scooters, and weak signage. The unmanaged interface between pedestrian and non-motorized traffic contributes significantly to discomfort in these locations.

5.3 Environmental & Behavioral Factors

Beyond physical infrastructure, the study also reveals the importance of spatial programming and aesthetic quality in pedestrian comfort. MSW destinations benefited from clear access flow and often had lower pedestrian density, reducing psychological and spatial stress. Manner Coffee, despite being in a vehicle-oriented area, achieved one of the highest comfort scores due to clean, clearly defined paths and attractive surroundings.

PSW destinations experienced congestion-induced discomfort, particularly in areas without escalators or wayfinding tools. While Xian De Lai and Ren He maintained decent scores through efficient layouts, restaurants like Lai Lai and Wang Jia Sha struggled due to high pedestrian overlap and limited waiting zones.

In all patterns, attractiveness—referring to visual interest, urban greenery, or engaging storefronts—played a supportive but not decisive role. Locations with higher attractiveness scores (e.g., OPS CAFÉ, Hong Zi Ji) tended to be more favorably rated overall, suggesting a synergistic effect between visual quality and functional infrastructure.

Behavioral patterns such as queuing spillover, temporary obstructions, and sidewalk vending also impacted comfort. These issues were particularly prevalent in PNLW and PSW zones, where space is more contested. This underscores the need for micro-level pedestrian management, including buffer zones, signage, and crowd channeling.

This study reveals a surprising reversal of conventional assumptions: motorized access patterns (MSW) currently provide the highest level of pedestrian comfort in Shanghai's popular restaurant areas, primarily due to intentional spatial design, clear vehicular-pedestrian separation, and lower density conflict zones. In contrast, public transit-linked (PSW) and non-motorized (PNLW) access patterns, often promoted for their sustainability, suffer from crowding, poor micro-scale design, and limited infrastructural support.

Ultimately, while promoting sustainable mobility remains essential, this study suggests that true pedestrian comfort requires attention to spatial design details across all modes—not just mode choice itself.

6. Conclusion

This study provides a comprehensive assessment of pedestrian comfort and urban mobility in Shanghai's commercial restaurant hubs. By combining navigation data and other online GIS data, spatial audits, and text analysis, it offers a multi-modal perspective on pedestrian comfort in high-footfall areas.

By categorizing pedestrian access patterns into three modes—Public transportation + short distance walk (PSW), Public transportation + short distance walk (PSW), and Motorized vehicle + short distance walk (MSW)—the research offered a comparative analysis of pedestrian comfort using a detailed spatial audit framework. Incorporating both physical observation and quantified evaluation, the study contributes to a more nuanced understanding of how infrastructural, behavioral, and environmental factors shape pedestrian comfort in dense commercial zones.

Contrary to conventional assumptions that prioritize public transit and active mobility as inherently walkable, the findings reveal that MSW destinations achieved the highest average comfort score (11.6/20), outperforming both PSW (10.5/22) and PNLW (9.0/20) patterns. This unexpected outcome highlights the importance of pedestrian-oriented spatial design, even in car-accessible areas. In particular, MSW locations benefitted from wider sidewalks, reduced traffic mixing, and clearer pedestrian channeling from parking areas to restaurant entrances.

In contrast, PSW areas—despite being linked to sustainable transportation—often suffered from congestion, poor queue management, and inadequate vertical circulation infrastructure near transit hubs. While transit integration offered some advantages, these were frequently offset by high density and poorly managed transitions. PNLW zones exhibited the greatest variability in comfort, largely influenced by local sidewalk quality, vehicle encroachment, and inconsistent traffic control. These findings suggest that mode of access alone does not guarantee a comfortable pedestrian experience; rather, comfort is the result of deliberate design, clear separation of movement modes, and effective micro-level planning.

Several key factors emerged as strong predictors of pedestrian comfort: sidewalk width and maintenance, level of pedestrian-vehicle interaction, and the presence of guiding infrastructure, such as signage, shading, and waiting areas. While attractiveness and environmental aesthetics played a complementary role, they were less influential than core infrastructural elements in determining overall PCS.

This study also demonstrates the methodological value of combining spatial audits with mode-specific criteria, allowing for context-sensitive assessments of pedestrian environments. The hybrid framework developed here—drawing from observational data and structured scoring—can be replicated in other urban contexts to evaluate the effectiveness of pedestrian planning strategies. The relevant high-frequency words that appear in the posts and comments on Xiaohongshu also provide qualitative evidence for the assessment of pedestrian comfort through text analysis.

From a policy perspective, the findings advocate for a shift in focus from mode-centric planning to experience-centric design. Urban designers and transportation planners should prioritize interventions that enhance micro-scale pedestrian experiences, particularly in areas surrounding popular destinations with mixed arrival patterns. By addressing sidewalk continuity, traffic separation, and flow organization, cities can create walkable environments that are not only sustainable in function but also inclusive and comfortable in form.
While this study yields significant findings, several methodological limitations must be acknowledged. Primarily, the geographic scope is confined to Shanghai's inner-ring area, potentially limiting the generalizability of results. Additionally, the analysis does not incorporate comparative assessments during off-peak periods, and may be subject to cultural specificity in pedestrian comfort perceptions.

Future research could extend this study by incorporating real-time pedestrian behavior data, expanding the sample size, or comparing multiple cities to further validate the framework. As cities evolve toward more complex and multi-modal urban forms, understanding the qualitative dimensions of walking will be critical in shaping equitable and livable public spaces.

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Performance Analysis of 15-Minute City Zones Through Spatial and Machine Learning Techniques

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Abstract
This study presents a methodology for evaluating pedestrian accessibility within the 15-minute city framework, focusing on Istanbul's Küçükçekmece district. By integrating spatial clustering, slope-adjusted walking speeds, and categorized point-of-interest (POI) data, the study assesses accessibility across 15-, 20-, and 25-minute intervals. The Mean Shift algorithm identified 42 urban clusters based on building density. The findings show that while 71.5% of the district is accessible within 15 minutes, significant spatial inequalities remain, especially in cultural facility access in peripheral neighborhoods. High-density areas with irregular urban forms exhibit limited internal connectivity, which reduces walkability. The study highlights the need for inclusive planning in underserved areas and provides a framework for promoting equitable, resilient, and pedestrian-friendly urban development.

Keywords: 15-Minute Cities; Accessibility; GIS; Machine Learning; Performance Metrics

1. Introduction

Modern cities have faced a multitude of complex challenges, ranging from growing social inequalities and economic instability to pressing environmental concerns such as climate change and resource depletion. To address social, economic, and environmental challenges, various planning principles have been adopted, including livable, inclusive, sustainable, and walkable designs that prioritize accessibility and active mobility (Akrami, Sliwa, and Rynning, 2024). In recent times, the world has faced two significant challanges: the COVID-19 pandemic and the growing climate crisis. These events have significantly reshaped urban priorities, prompting cities to reevaluate how space, mobility, and public health are intertwined. As a result, urban areas are increasingly committed to fostering healthy, resilient, and equitable environments (Liu, Kwan, and Wang, 2023). Amid this backdrop, Professor Carlos Moreno introduced the concept of the "15-minute city" in 2016. This innovative concept seeks to establish self-sufficient areas that encompass essential functions for humans, including living, working, commerce, healthcare, education, and entertainment (Khavarian-Garmsir, Sharifi and Sadeghi, 2022).

This approach is designed to create mixed-use, densely populated, and pedestrian-friendly neighborhoods, allowing residents to access all essential amenities within a 15-minute walk. Additionally, the concept of the 15-minute city is grounded in chrono-urbanism, which posits that the quality of urban life diminishes as the time spent on transportation increases (Moreno et al., 2021). The novel concept aims to enhance transportation efficiency, reduce automobile-related pollution, and transform urban environments so that residents can access essential services and facilities within a designated time frame (Olivari et al., 2023). Additionally, the concept of the 15-minute city is built on four pillars that address various issues, resulting in improvements to both human well-being and urban resilience: proximity, density, diversity, and digitalization (Moreno et al., 2021).

The 15-minute city concept seeks to create urban environments that are mixed-use, livable, sustainable, and pedestrian-friendly (Allam et al., 2024). Since its introduction in 2016, this innovative urban model has sparked ongoing studies and debates, resulting in a continually evolving definition and scope. The effective implementation of the 15-minute city largely depends on the spatial characteristics, as well as the social, environmental, and economic dimensions of each specific urban area. As a result, various adaptations have emerged, leading to the development of cities centered around different time thresholds, collectively referred to as the "x-minute city" concept (Logan et al., 2022). For instance, there have been numerous implementations and studies related to time-based urban models across different cities: the 1-minute city in Stockholm (Schwimmer and Schaufler, 2023), the 5-minute city in Copenhagen (State of Green, 2016), the 10-minute city in Stavanger (Kesarovski and Hernández-Palacio, 2022), the 15-minute city in Milan (Abdelfattah, Deponte, and Fossa, 2022a), the 20-minute city in Tempe, Arizona (Da Silva, King, and Lemar, 2019), and the 30-minute city in Montreal (Birkenfeld et al., 2023).

The literature presents a range of approaches to evaluating accessibility in time-based urban areas. For instance, Staricco (2022) conducted a study in Turin that measured pedestrian accessibility within 5-, 10-, and 15-minute intervals. However, this study focused solely on the number of accessible facilities and did not implement a categorical classification of services. In contrast, another study introduced a categorical framework, grouping facilities into six categories: groceries, healthcare, education, recreation, services, and public transport. This systematic approach aimed to assess accessibility and identify spatial inequalities. Furthermore, this research proposed an innovative index to evaluate the 15-minute city concept, emphasizing the importance of considering a broader spectrum of urban opportunities and addressing the varied needs of populations with different social identities (Guzman, Oviedo, and Cantillo-Garcia, 2024). Additionally, Pour and Partanen (2024) conducted a two-level spatial analysis to examine Tallinn's alignment with the principles of a 15-minute city. The first level focused on population distribution, transport infrastructure, and access to essential services, while the second level identified suitable areas for urban expansion using land use/land cover data, a digital elevation model (DEM), and proximity analysis. Similarly, Ferrer-Ortiz et al. (2022) carried out a network-based accessibility analysis using cadastral parcels, classifying urban social functions into five main categories: care, education, provisioning, entertainment, and public/non-motorized transportation.

Numerous studies have examined accessibility analysis within the context of the 15-minute city concept. Nevertheless, there remains a notable gap in comprehensive and realistic assessments of pedestrian accessibility that account for topographical conditions. Furthermore, defining the spatial structure and layout of the 15-minute city poses a significant challenge for its practical implementation in varying urban contexts. This research aims to address two fundamental questions: a) how to develop appropriate 15-minute zones within already constructed areas, and b) how accessibility varies under different topographical conditions across various time intervals. To accomplish this, the study will evaluate the performance of 15-minute city zones through the application of spatial and machine learning techniques. In the first stage, points of interest (POI) data for various facilities were gathered using the Google Maps Platform Places API and categorized into ten groups to address daily needs. The second stage assessed accessibility based on topographical conditions by utilizing a Digital Elevation Model (DEM) and road network data from OpenStreetMap (OSM) through zonal analysis. The third stage involved obtaining building footprint data from the Humanitarian OpenStreetMap Team (HOT) and applying the Mean Shift clustering algorithm to identify potential 15-minute accessibility zones, with hyperparameter tuning to ensure accuracy. Finally, the fourth stage conducted accessibility analyses over three-time intervals—15, 20, and 25 minutes—and compared the results.

2. Data and Methodology

This study consisted of four steps: a) pre-processing input data, b) clustering of buildings, c) accessibility analysis for three different time intervals, and d) evaluation of accessibility results.

2.1. Study Area

This study examines the Küçükçekmece district of Istanbul to assess the 15-minute city concept, taking into account the district's active participation in related projects. Küçükçekmece is situated in the southwestern part of Istanbul, on the European side, and is approximately 15 km from the city's historical center. The district spans an area of 37.75 km² and is home to a population of 792,030, resulting in a population density of about 17,600 people per square kilometer (Endeksa, 2025). This high density is evident from land cover analysis. Based on land cover data from Esri (ESRI, 2025) for 2023, the land use in Küçükçekmece is diverse, but predominantly urban. Residential areas account for 93% of the district's total land use, highlighting its highly urbanized and densely populated character. Agricultural land comprises 3%, while forested areas make up only 2%, indicating a significant reduction in rural and natural spaces. Furthermore, green spaces constitute just 1% of the total land area, underscoring the limited amount of public open space and the relatively low share of greenery per capita. Bare ground is virtually nonexistent at 0%, with other land uses representing the remaining 1%. This suggests that nearly all available land has been developed, primarily for residential and urban purposes.

2.2. System Architecture

The system architecture is shown in Figure 1 and consists of four essential steps: pre-processing, clustering, accessibility analysis, and evaluating results. Each step is briefly explained below.

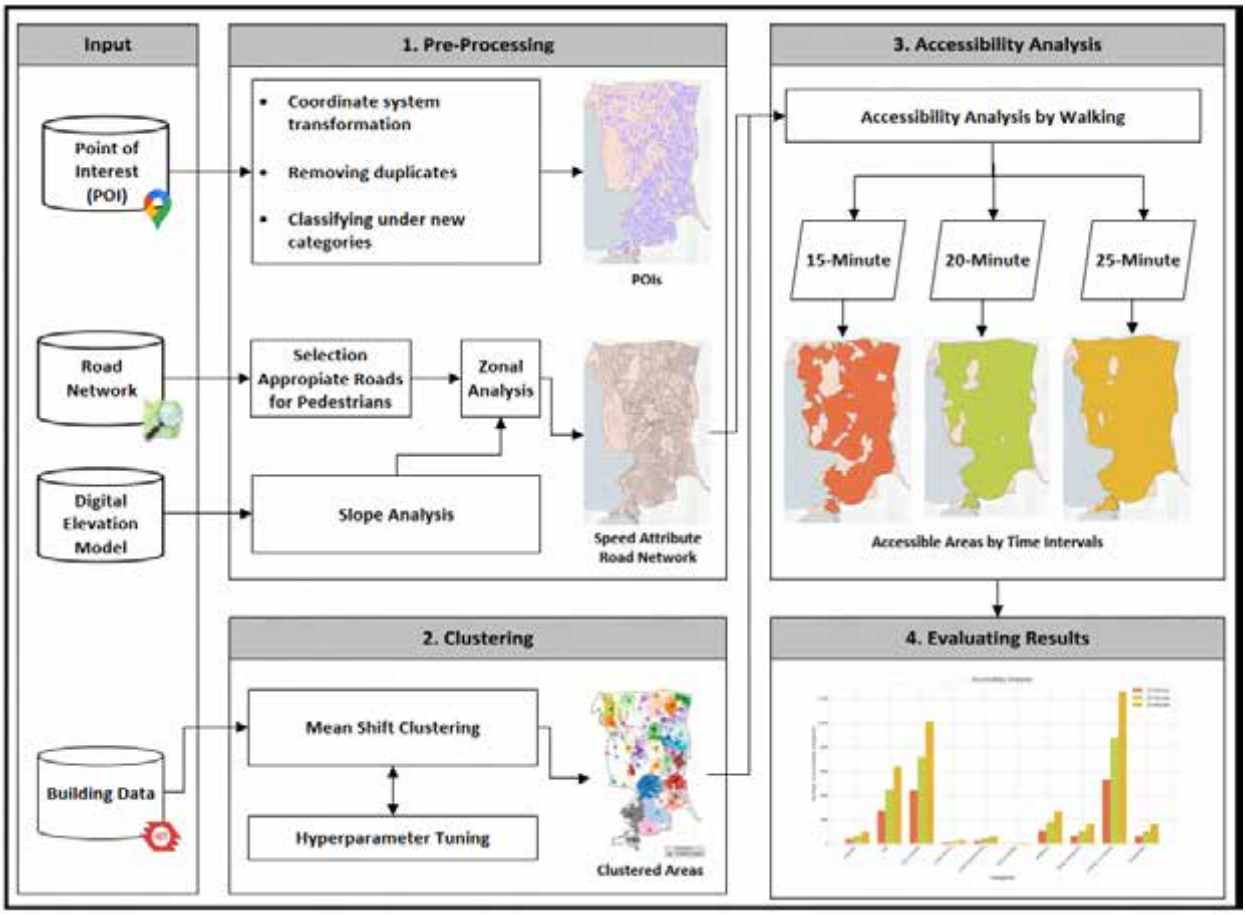


Figure 1. The proposed framework for evaluating 15-minute city concept.

To initiate the analysis, data is gathered from a diverse range of sources, including both open-source repositories and commercial mapping service. Initially, POI data, which covers various types of facilities, is sourced from the Google Maps Platform Places API, a commercial repository. This API offers detailed location information, and for this study, it is utilized within the constraints of its free data request allowance (Google Maps Platform, 2025). For the accessibility analysis, the road network constitutes another crucial dataset. In this research, road data is obtained from the well-regarded open-data platform, OSM (Geofabrik, 2025). To assess variations in walking speed in sloped areas, a Digital Elevation Model (DEM) is employed. The specific model utilized is the Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global data from the United States Geological Survey (USGS, 2025). Lastly, to develop clustered areas within the district for evaluating the 15-minute city concept, building data is incorporated. This data is sourced from the HOT, which updates building footprints on a monthly basis (Humanitarian Data Exchange, 2025).

2.2.1. Pre-Processing

The essential initial phase in interpreting spatial data is pre-processing. This stage involves several key steps: transforming the coordinate system, removing duplicate POIs, and classifying the retrieved data based on predefined categories. In the proposed framework, the coordinate system of the POI dataset was converted to a projected coordinate reference system, which supports metric-based calculations and is essential for accurate accessibility analysis. Due to limitations associated with the Google Maps Platform Places API, duplicate POIs may appear within the dataset. To prevent misleading results, these duplicates must be identified and

removed prior to analysis. Also, there are various approaches to assess accessibility based on categories. One of these was developed by Prof. Dr. Carlos Moreno in 2021, encompassing six categories: living, working, commerce, healthcare, education, and entertainment (Moreno et al., 2021). In another study, nine categories were determined namely food/grocery stores, commercial stores, cultural venues, educational facilities, parks and green spaces, restaurants, health facilities, sports facilities and other (Abdelfattah, Deponte and Fossa, 2022b). Moreover, according to Regulation on the Preparation of Spatial Plans of Türkiye (Official Gazette, No. 29030), some spatial areas are defined such as small industrial areas, cultural areas, social infrastructure areas, and social facility areas. Hence, within this study, in order to cover all relevant aspects of daily urban life and align with both international and national frameworks, a customized categorization scheme was developed. This classification integrates widely accepted categories from the literature with those defined in national planning regulations.

Moreover, slope is an important factor on pedestrian accessibility. Sloping walkways tend to diminish pedestrian flow performance compared to level surfaces (Wei et al., 2023). Considering DEM in accessibility analysis is essential. However, there is a notable gap in the literature regarding the use of DEM for assessing accessibility within the 15-minute city concept. To address this shortcoming, the present study incorporates slope information derived from a DEM to adjust walking speeds throughout the road network. This adjustment enables the analysis to account for the effects of terrain variations on walking accessibility, resulting in a more accurate representation of areas that can be reached within designated time thresholds. This approach not only enhances the methodological rigor of evaluations related to the 15-minute city but also introduces topographic realism into pedestrian accessibility modelling.

2.2.2. Clustering

The study employs the Mean Shift clustering algorithm, a popular machine learning technique that is also used in spatial clustering applications (Chen et al., 2018; Peng et al., 2024). This clustering algorithm is introduced by Fukunaga and Hostetler in 1975 (Fukunaga and Hostetler, 1975). Mean Shift clustering is an unsupervised learning algorithm that organizes data according to its natural distribution. One of its most notable characteristics is that it does not require any prior knowledge of the number or positions of the cluster centers. Furthermore, Mean Shift imposes no assumptions about the shape of the clusters and places no restrictions on their size (Tehreem et al., 2017). The study clusters building data using the Mean Shift algorithm and applies hyperparameter tuning to optimally identify clustered areas based on building density.

2.2.3. Accessibility Analysis

The concept of the 15-minute city encompasses several time-based proximity approaches. Initially proposed by Prof. Dr. Carlos Moreno in 2016, this framework seeks to enhance walkability and develop pedestrian-friendly neighborhoods. Since its introduction, various time-oriented strategies such as 15, 20, and 30 minutes have been implemented across different regions to further this objective (Giuffrida et al., 2024). Overall, the policy directions related to this concept are inconsistent across thematic areas and geographic regions (Lu and Diab, 2022).

The built-up surface per capita is 13 m^2/capita in Küçükçekmece resulting high density and compact city (OECD Local Data Portal, 2020). This study analyzes pedestrian accessibility by examining three walking time intervals for clustered areas with varying building densities: 15, 20, and 25 minutes. These intervals are utilized to define the spatial reach of services and amenities from the centers of clusters identified through the Mean Shift algorithm. The cluster centers represent the most densely developed areas within the study region and serve as potential focal points for urban activity. By creating service areas around these centers for each time threshold, the study seeks to quantify how far individuals can walk within the specified time frames and to assess the distribution and coverage of accessible urban functions in relation to population density.

2.2.4. Evaluation of Results

In this step, pedestrian accessibility results for various time intervals, 15, 20, and 25 minutes, are assessed and compared to provide insights into how accessibility levels shift with walking time. The analysis aims to highlight differences in the spatial extent of reachable areas from each cluster center and examines how these variations correspond to the distribution of urban amenities. In addition to this comparative evaluation, special emphasis is placed on outlier areas—locations that significantly fall outside the primary clustered accessibility zones.

These outliers are analyzed to identify spatial mismatches, underserved regions, or peripheral zones with limited access to urban functions. The recognition of such areas is essential for uncovering potential gaps in service provision and informing equitable urban planning strategies.

3. Results and Discussion

3.1. Pre-Processing

In this step, walking accessibility is evaluated by pre-processing the collected spatial data from various perspectives. Initially, the coordinate system of POI dataset is transformed to a projected coordinate reference system (EPSG:5254) to ensure necessary metric-based spatial accuracy for accessibility analyses. Subsequently, duplicate POIs are removed to eliminate any potential skewing or misleading outcomes in the accessibility results. The POI dataset, which originally contained a range of labels such as "bank," "police," "food," and "supermarket," is reclassified according to a system developed for assessing 15-minute cities. A refined classification system comprising ten thematic categories is utilized, reflecting essential components of daily urban life: education, food, daily essentials, public services, small industrial areas, cultural facilities, healthcare services, social infrastructure, commerce & economy, and transportation. Each category is considered crucial for fostering a well-rounded and accessible urban environment. In the Table 1, POI labels for defined categories are given.

Table 1. Defined categories and belonging POI labels.

Categories	POI Labels
Education	primary_school, school, secondary_school, university
Food	supermarket, bakery, convenience_store, food, grocery_or_supermarket, liquor_store
Daily essentials	shoe_store, restaurant, parking, meal_takeaway, meal_delivery, laundry, hair_care, atm, beauty_salon, clothing_store, gas_station
Public services	post_office, police, local_government_office, city_hall, courthouse, fire_station, lawyer
Small industrial areas	*These category is evaluated manually from POI data.*
Cultural facilities	library, movie_theater, museum
Healthcare services	veterinary_care, physiotherapist, dentist, doctor, drugstore, health, hospital, pharmacy
Social infrastructure	stadium, spa, premise, place_of_worship, park, night_club, mosque, amusement_park, aquarium, gym, lodging
Commerce & Economy	store, shopping_mall, roofing_contractor, real_estate_agency, plumber, pet_store, painter, locksmith, jewelry_store, insurance_agency, home_goods, hardware, general_contractor, furniture_store, finance, electronics_store, electrician, department_store, accounting, bank, bar, bicycle_store, book_store, cafe
Transportation	taxi_stand, train_station, transit_station

In the second step, a DEM was used to improve the accuracy of accessibility measurements by incorporating topographic features. Firstly, the appropriate roads for pedestrians were selected from road dataset. Specifically, slope values for the Küçükçekmece district were extracted from the DEM. These slope values were then integrated with the road network through zonal analysis, creating a slope-attributed road dataset where each segment reflects its corresponding gradient. According to Giannoulaki and Christoforou (2024), the average walking speeds for males and females in Türkiye are 1.34 m/s and 1.27 m/s, respectively. For this study, an average walking speed of 1.31 m/s was utilized to represent the general population.

By combining this standardized walking speed with the slope information for each road segment, adjusted walking speeds were calculated, allowing for a more accurate modelling of pedestrian accessibility across varying terrain conditions.

3.2. Clustering

In the proposed assessment system for a 15-minute city, the Mean Shift clustering algorithm is used to categorize buildings based on their densities and analyse potential areas for the 15-minute city. To do that, building footprint dataset is utilized in Mean Shift clustering algorithm. In the Mean Shift clustering algorithm, the bandwidth parameter is essential for determining the results of clustering. It defines the kernel radius used to estimate data density, which influences the number, size, and shape of the clusters formed. A larger bandwidth results in fewer, broader clusters, while a smaller bandwidth creates more, smaller clusters that capture local variations in the data. To determine the appropriate bandwidth value for the Mean Shift algorithm, hyperparameter tuning was conducted by evaluating both quantitative metrics and visual interpretations of the resulting clusters. Although slightly higher Silhouette scores were observed with alternative bandwidth settings, a bandwidth defined by a quantile value of 0.02 and 300 samples was ultimately selected, yielding a Silhouette score of 0.38. This configuration was preferred because it provided a good balance between cluster compactness and spatial interpretability, ensuring that the identified clusters aligned well with the underlying built environment and urban density patterns. As a result of this hyperparameter selection, a total of 42 clusters were generated. In the Figure 2, the clustered buildings and cluster centers are presented.

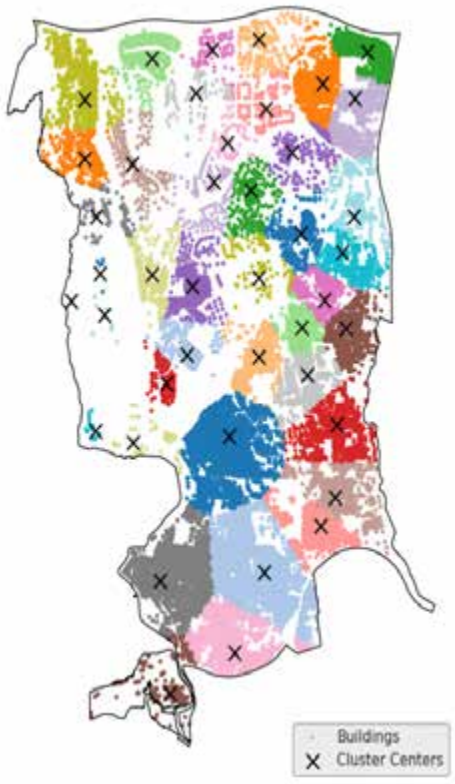


Figure 2. Clustered buildings and cluster centers.

It has been noted that the southern part of the study area has developed through unplanned and irregular urbanization. In this region, residential density has increased in a fragmented and uncontrolled manner, resulting in a significant decline in the continuity and accessibility of green spaces. Conversely, the north-western part of the study area displays a more organized urban layout, where the balance between green spaces and built-up areas has been preserved through careful planning. This spatial contrast is clearly reflected in the Mean Shift clustering results. As illustrated in Figure 2, clusters in the planned areas are smaller and more compact, while those in regions affected by irregular urbanization are larger and more dispersed. This observation underscores a strong correlation between unplanned urban sprawl and building density, a relationship further confirmed

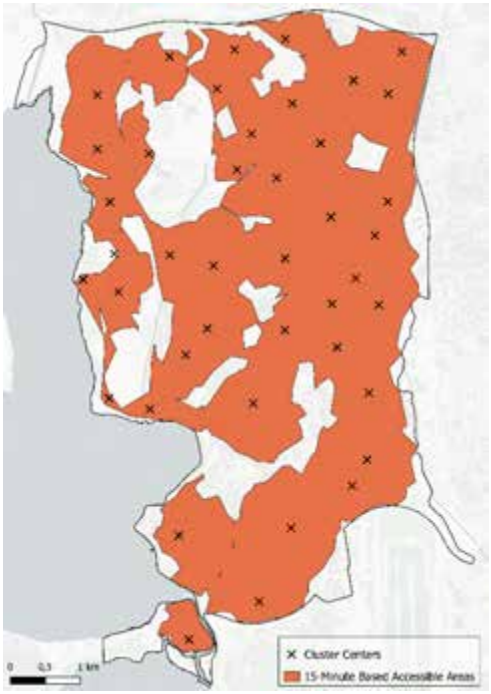
by the Mean Shift clustering analysis. Figure 3 presents a comparative example of high- and low-density urban zones within the study area. Moreover, it has been observed that the data sourced from the HOT does not entirely capture ground realities. When compared to actual field conditions, certain areas lack complete building footprints or contain outdated information.

a) Southern side of the study area. **b)** North-western side of the study area.

Figure 3. Clustering results from urban layout: (a) urban area with high building density, (b) urban area with low building density (yellow crosses indicates cluster centers).

3.3. Accessibility Analysis

This study examines accessibility in the Küçükçekmece district by analyzing designated cluster centers and utilizing a modified road network that reflects variations in walking speed due to slope data. The objective of the analysis is to determine the spatial reach of areas accessible on foot within specific timeframes. The findings reveal that approximately 71.5% of the district can be accessed within a 15-minute walking distance, 85.5% within 20 minutes, and 91.6% within 25 minutes. These results indicate that a significant portion of Küçükçekmece lies within walking distance of the identified urban clusters, reinforcing the viability of the 15-minute city concept in certain areas of the district. These results are shown in Figure 4.



a) 15-minute based accessible areas.

b) 20-minute based accessible areas.

c) 25-minute based accessible areas.

Figure 4. 15-,20- and 25-minute based accessible areas.

When examining accessibility from a comprehensive perspective, it becomes clear that the north-western portion of the study area—comprised of planned residential neighborhoods with a balanced distribution of green spaces and buildings—remains partially inaccessible, despite its proximity to major arterial roads. This inaccessibility can be attributed to the design of these areas as enclosed systems surrounded by major thoroughfares, which results in a lack of pedestrian-friendly internal connectivity. In the southern parts of the district, characterized by significantly higher building density, the algorithm encounters difficulties in identifying an adequate number of cluster centers. As a result, despite the high residential density and substantial pedestrian potential, these areas cannot be reached within a 15-minute walking threshold. The 20-minute analysis reveals an expansion in overall accessibility, owing to the extended walking time. However, certain regions—particularly newly developed neighborhoods and high-density residential zones—remain unreachable because of their distance from the identified cluster centers and the limited pedestrian infrastructure available. The 25-minute analysis demonstrates that a considerable portion of the district becomes accessible. Nevertheless, areas without any development, especially in the north-eastern part, continue to lack pedestrian access and remain unreachable in all time-based scenarios. Moreover, across all analyses, it is observed that accessibility improves in regions with steep terrain as the time threshold increases. However, during the 15-minute interval, these high-slope areas remain notably less accessible. Overall, the findings underscore that construction sites and enclosed residential complexes in the north-western part of the study area face significant challenges regarding pedestrian accessibility, highlighting their unfavorable position within the urban landscape.

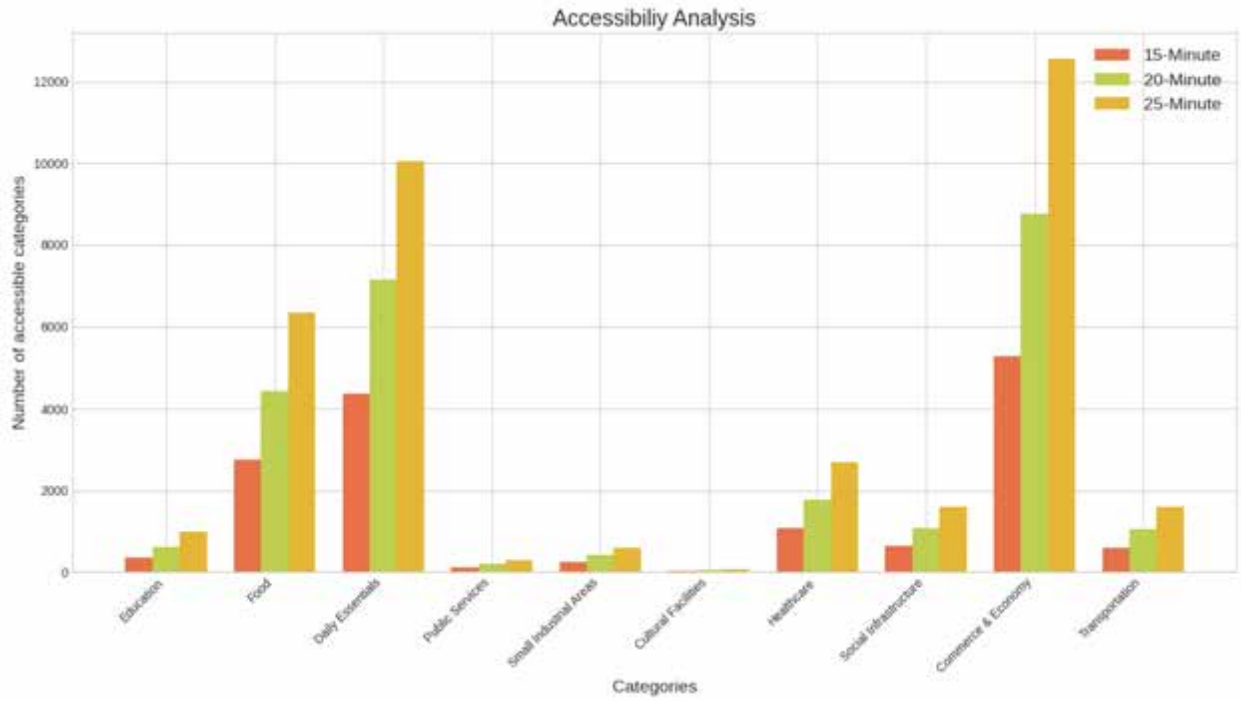


Figure 5. Number of accessible categories regarding to different time-based intervals.

As depicted in Figure 5, the number of accessible facilities increases considerably as walking time expands. This trend is particularly evident in categories such as daily essentials, food, and commerce and economy. For instance, there are 4,368 facilities reachable within 15 minutes, which escalates to 10,047 within 25 minutes, indicating a relatively well-distributed supply of these services across the district. In contrast, categories like public services and, more notably, cultural facilities demonstrate low levels of accessibility. Cultural facilities consistently rank the lowest in accessibility across all time intervals, with only 27 facilities reachable within 15 minutes and just 80 within 25 minutes. This observation highlights not only the scarcity of such facilities but also their concentration in specific areas of the district. Moderate and relatively balanced accessibility patterns are found in education, healthcare, social infrastructure, and transportation. This suggests a more deliberate spatial distribution for these services. However, some deficiencies are still apparent, particularly in newly developed neighborhoods and peripheral zones of the district. Additionally, the findings reveal that accessibility levels are closely tied to

both functional distribution and urban form and morphology. While the planned and orderly developments in the north-western part of the district exhibit high pedestrian accessibility, the irregularly developed areas in the south show more limited and uneven access. This is particularly noticeable in gated communities or unplanned residential areas, which, despite having a high building density, suffer from poor internal connectivity, significantly impeding walkability within a 15-minute range.

4. Conclusion

This study offers a comprehensive methodology for assessing pedestrian accessibility within the framework of the 15-minute city concept, using the Küçükçekmece district of Istanbul as a case study. By integrating spatial clustering, elevation-based speed adjustments, and categorized POI data, the analysis effectively captures both the physical and functional aspects of accessibility in a densely populated urban environment. The findings indicate that while over 70% of the district is reachable within a 15-minute walking distance, notable spatial disparities persist across various areas and functional categories. Though services related to daily needs, food, and economic activities are fairly well-distributed, essential public services and cultural facilities remain limited in both quantity and spatial coverage. This imbalance highlights the necessity for more inclusive spatial planning to ensure equitable access to all urban functions, especially those linked to cultural participation and civic engagement. Furthermore, the study emphasizes the influence of urban form on accessibility outcomes. Well-planned and integrated areas in the north-western part of the district generally facilitate walkability, whereas fragmented and irregular developments—particularly in the southern and peripheral areas—encounter structural barriers to pedestrian movement, such as disconnected street networks and gated communities. Incorporating slope data into the accessibility model further refines the analysis by illustrating how terrain variation can significantly impact walkability, especially within shorter time thresholds. In conclusion, this research demonstrates that the 15-minute city framework is partially attainable in a high-density context like Küçükçekmece. However, to fully capitalize on its potential, Geomatics Engineers, Urban Planners and decision-makers must advocate for a more equitable distribution of public and cultural services and prioritize pedestrian-oriented urban design, particularly in high-density and newly developed areas. The methodology presented in this study can also be adapted for use in other urban settings seeking to enhance proximity-based accessibility and cultivate more resilient, inclusive, and livable cities.

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The Appropriate Intensity of Rail Transit Station Area near Historic Districts: A Case Study of Shanghai, Nanjing, Kyoto and Tokyo

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Abstract
Recent urban trends focus on integrated development around metro stations, promoting intensive, three-dimensional land use. This necessitates re-evaluating the redevelopment potential of rail transit stations area of historic districts. However, strict building height controls for urban fabric and heritage preservation challenge increasing development intensity there. Existing research lacks fine-grained quantitative studies on development intensity in such areas. This study first establishes a multi-dimensional intensity index system (building height, density, above/below-ground floor area ratio). Selecting 18 stations in historic areas of Shanghai, Nanjing, Tokyo, and Kyoto, it quantitatively analyses development intensity through multi-path comparisons. This considers precise station accessibility isochrones and spatial relationships to the historic district, aiming to identify suitable development intensity under multi-dimensional balance.

Keywords: Transit Oriented Development,Urban Rail Transport, Historical Blocks, Development Intensity.

1. Development Trends of Suitable Intensity in Historic Districts Around Transit Stations

In recent years, with the rapid development of the global economy and the acceleration of urbanization, the comprehensive development and utilization centreed around urban rail transit—particularly the integration of transit stations and their surrounding areas—has become a significant trend in urban development. This trend is driving transit station areas toward more intensive, three-dimensional, and integrated development. Concurrently, re-evaluating the redevelopment potential of rail transit stations area of historic districts is imperative. However, due to the requirements for preserving the urban fabric and historical landscape, construction and development in these historic districts face strict controls on building heights, posing challenges to enhancing the development intensity around rail transit stations.

Existing studies on the renewal and protection of historic districts around transit stations predominantly focus on directional strategies prioritizing preservation, with limited quantitative analysis. Research on the development intensity of station area spaces has primarily addressed specific planning measures and implementation steps, while the conceptualization of development intensity itself has seen scholars globally explore multi-indicator frameworks to comprehensively assess it. These frameworks often categorize and regulate development based on station hierarchy, types, and spatial layers (e.g., concentric zones). Such approaches provide a reference for this study's subsequent investigation into influencing factors and relationships among indicators of development intensity. In the field of historic district construction and utilization, Western countries began exploring floor area ratio (FAR) transfer or incentive mechanisms as early as the 20th century, while many Chinese cities initiated similar explorations after 2000. However, quantitative studies from the perspective of "suitable intensity" remain scarce, particularly lacking a refined synthesis of the impacts of rail transit stations and historic districts.

This paper addresses the inherent tension between development and preservation in historic districts around rail transit stations. Drawing on case studies of high-density Asian cities such as Shanghai, Nanjing, Kyoto, and Tokyo, the study constructs a multi-dimensional indicator system to measure development intensity, incorporating metrics such as building height, building density, above-ground and underground floor area ratios. By integrating statistical methods with GIS spatial analysis, the research conducts multidimensional comparative analyses of the compiled data to quantitatively identify patterns and regularities in the distribution of development intensity across intra-urban contexts, inter-city comparisons, and different developmental timelines within historic districts adjacent to rail transit stations.

2.. From Unidimensional Indicators to Indicator Clusters

2.1 Concept of Suitable Intensity

In historic districts, the development intensity of rail transit stations is primarily influenced by two factors: first, the constraints imposed by heritage protection planning, which mandates strict adherence to regulatory requirements. Development intensity must be controlled through regulations on building height, volume, and spatial form to maintain the integrity of the heritage character. Second, the surrounding areas of transit stations, due to the agglomeration effect of rail transit, possess higher development potential. Thus, this study defines the "suitable intensity" of station area spaces in historic districts adjacent to rail transit stations as a concept that integrates the impacts of both the historic district and the transit station's influence zone. The term "suitability" here refers to a framework centreed on rail transit stations, ensuring the protection of historical heritage integrity while simultaneously balancing the development potential of land parcels and the reasonable utilization of economic efficiency. The core connotation lies in establishing refined, parcel-specific construction intensity control standards tailored to the functional positioning and spatial characteristics of different zones, thereby achieving synergistic optimization between heritage conservation and urban development value.

Based on existing studies, the urban space within a 5-minute walking time (approximately 200 meters) from a transit station has been identified as the area most directly influencing pedestrian behaviour. The 10-minute walking radius (approximately 400–500 meters) is recognized as the reasonable walking range and is defined as the direct influence zone, where the station exerts the most immediate impact on land development intensity. Therefore, this study delineates the 5-minute walking isochrone as the core zone and the 10-minute walking isochrone as the influence zone. The research focuses specifically on metro stations where historic districts overlap with the 10-minute walking isochrone, with the study scope encompassing all land parcels within this 10-minute isochrone boundary.

2..2. Construction of Indicator Clusters

Previous studies have predominantly used floor area ratio (FAR) as the primary metric to assess land development intensity. However, in historic districts, development must balance the preservation of unified urban heritage character with compliance to local planning regulations, where underground space development has emerged as a critical direction. Simultaneously, building density and building height are key determinants of architectural spatial form, collectively influencing FAR. Therefore, this study constructs a comprehensive indicator cluster by integrating maximum building height, building density, above-ground FAR, and underground FAR to holistically measure land development intensity.

Land parcels within historic districts must adhere to stringent heritage control requirements. Based on the protective planning frameworks of respective cities, this study categorizes parcels into three hierarchical zones: core conservation areas, construction control zones, and general zones. A differential scoring system (Table 1 [H]) is applied to these zones to enable fine-grained evaluation of heritage impact. This tiered mechanism allows for flexible land development potential across broader spatial scales while maintaining heritage integrity.

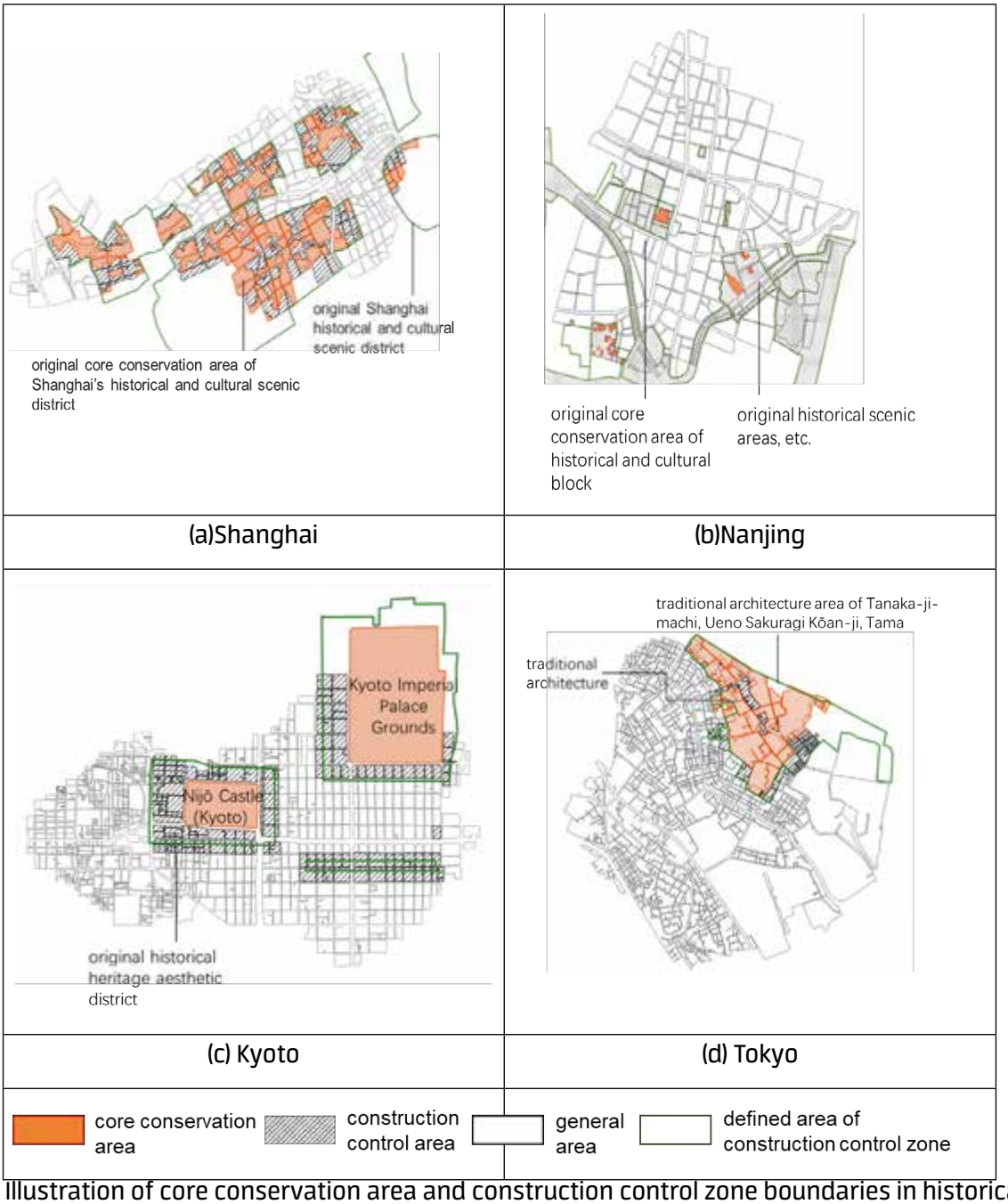


Figure 1. Illustration of core conservation area and construction control zone boundaries in historical cities.

Land parcel development intensity is closely related to both proximity to transit stations and location within heritage zones. In terms of station proximity, rail transit stations significantly influence the functional layout, transportation organisation, and land value of surrounding areas, with the magnitude of each impact correlated to distance from the station. High-intensity, mixed-use development in the core area of rail transit stations has become a societal consensus, as the station's influence intensity and spatial boundary are tightly linked to pedestrian accessibility. Based on existing research, it is generally recognized that the closer a parcel is to a station, the higher its commercial development value and development intensity tend to be. To facilitate cluster analysis in subsequent studies, the authors assigned values to 17 possible scenarios based on the isochrone layers in which the land parcels are located (Table 1 [L]).

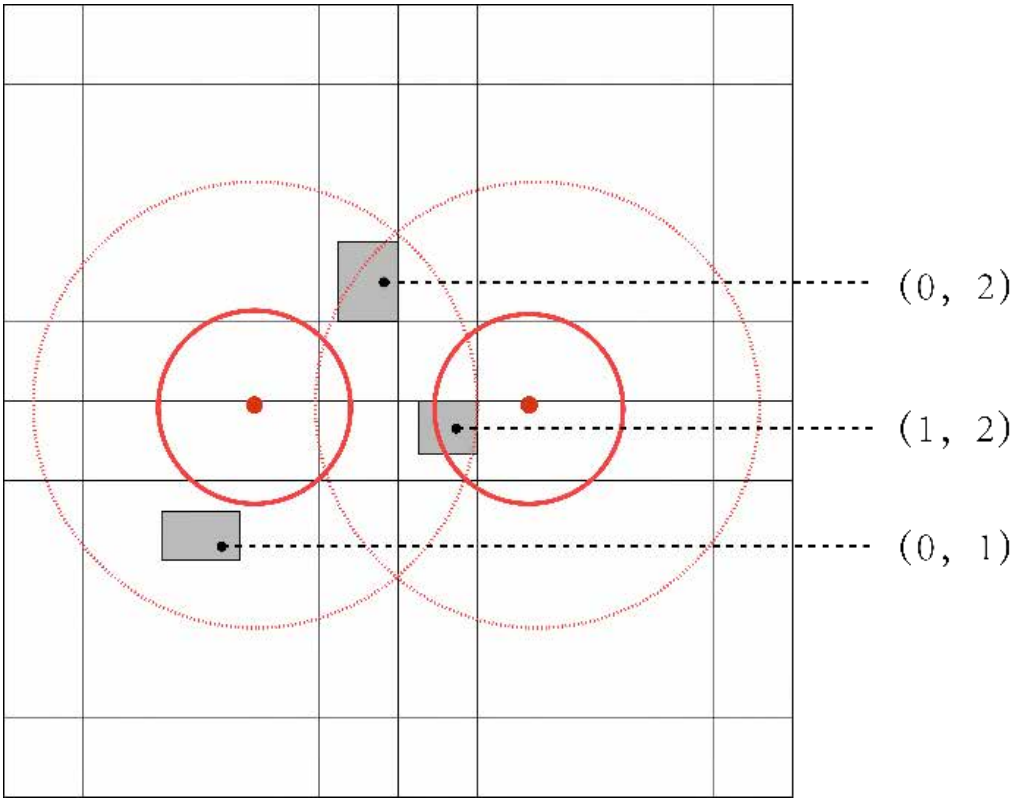


Figure 2. Labeled schematic diagram of spatial relationships between land parcels and station isochrones.

Table 1. A multidimensional indicator system for development intensity in station areas of historical districts.

Category	Specific Feature Value		Unit/Representation	Description	Data Source
Development Intensity-Related Attributes (D)	Maximum Building Height		Meters (m)	Maximum value	Baidu Map and government open data
	Building Density		Percentage (%)	Average value	Baidu Map and government open data
	Above-Ground Floor Area Ratio (FAR)		Dimensionless	Total above-ground floor area divided by parcel area	Baidu Map and government open data
	Underground Floor Area Ratio (FAR)		Dimensionless	Total underground floor area divided by parcel area	Baidu Map and government open data
	Total FAR (Above-Ground + Underground)		Dimensionless	Combined above- and underground FAR values	Calculated from above metrics
Relationship with Heritage Conservation Zones (H)	Located in Core Conservation Area		a		
	Located in Construction Control Area		b		
	Located in General Area		c		
Relationship with Station Isochrone Layers (L)	Located in the 5-minute isochrone of 3 stations	10-minute isochrone of 5 stations	(3, 5)		
		10-minute isochrone of 4 stations	(3, 4)		
		10-minute isochrone of 3 stations	(3, 3)		
	Located in the 5-minute isochrone of 2stations	10-minute isochrone of 5 stations	(2, 5)		
		10-minute isochrone of 4 stations	(2, 4)		
		10-minute isochrone of 3 stations	(2, 3)		
		10-minute isochrone of 2 stations	(2, 2)		
	Located in the 5-minute isochrone of 1 stations	10-minute isochrone of 5 stations	(1, 5)		
		10-minute isochrone of 4 stations	(1, 4)		
		10-minute isochrone of 3 stations	(1, 3)		
		10-minute isochrone of 2 stations	(1, 2)		
		10-minute isochrone of 1 stations	(1, 1)		
	Located in the 5-minute isochrone of 0 stations	10-minute isochrone of 5 stations	(0, 5)		
		10-minute isochrone of 4 stations	(0, 4)		
		10-minute isochrone of 3 stations	(0, 3)		
		10-minute isochrone of 2 stations	(0, 2)		
		10-minute isochrone of 1 stations	(0, 1)		
Land Use Type (U)	Refer to municipal land use planning documents				

3. Study Object and Methodological Framework

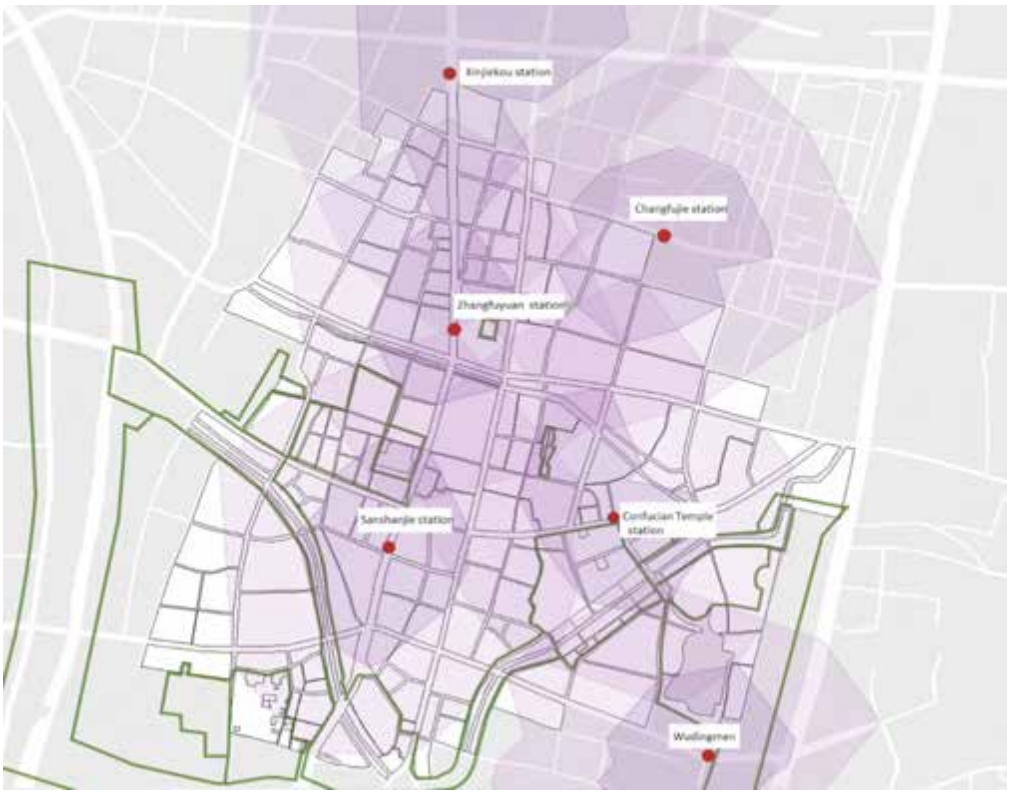
3.1 Study Object

This study selects Shanghai, Nanjing, Tokyo, and Kyoto as case cities due to their shared characteristics of a high-density urban context, mature rail transit systems, and representative historical district conservation practices. The station study scope focuses on central urban areas, encompassing diverse locational relationships with historical districts and varying spatial scales to enhance the specificity of case analysis.

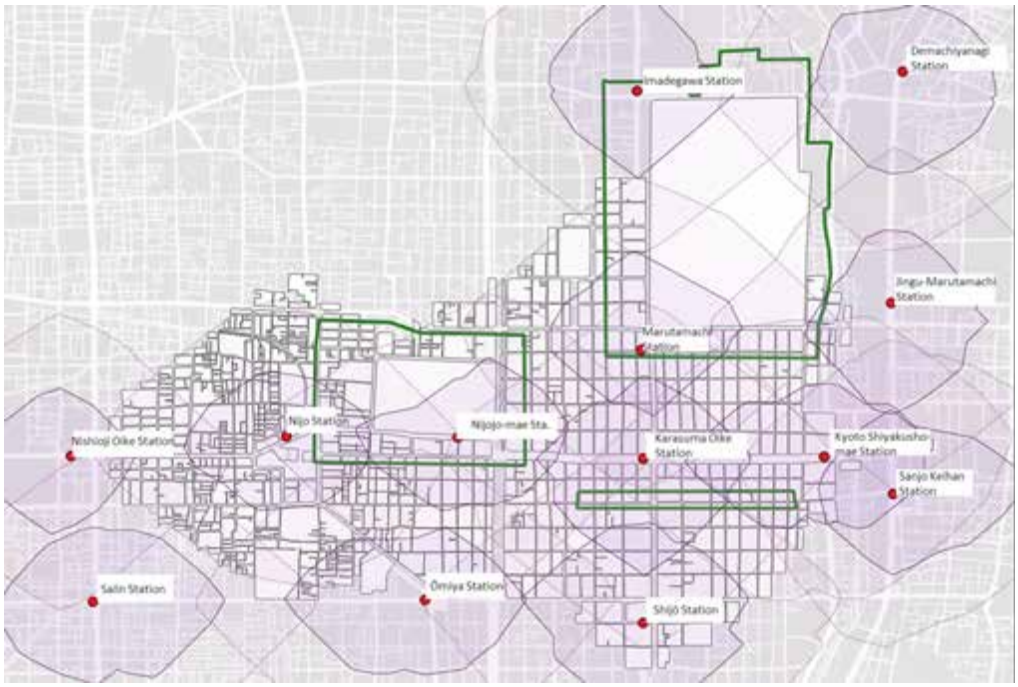
Table 2. Selected rail transit case study sites.

City	Historic District Name	Station	Location within Historic District			Number of Transfer Lines
			Inside	Periphery	Outside	
Shanghai	People's Square Historic Cultural Area	People's Square	√			3
		Dashijie			√	2
	Nanjing West Road Historic Cultural Area	Nanjing West Road	√			3
	Hengshan Road–Fuxing Road Historic Cultural Area	Jing'an Temple		√		3
		Shaanxi South Road	√			2
		New World		√		2
		Huangpi South Road			√	2
	Yuyuan Road Historic Cultural Area	Zhongshan Park			√	3
Nanjing	Southern City Historic Area	Sanshan Street	√			1
		Fuzimiao		√		1
		Zhangfuyuan			√	1
Tokyo	Tanimachi Temple–Ueno–Koyo-en Temple Traditional Architecture Area	Chikko Wood	√			1
		Nezu		√		1
		Toho University			√	1
Kyoto	Historical Heritage-Type Aesthetic Area	Umon Okuie			√	2
		Nijo			√	2
		Nijō-jō Omote	√			1
		Marutamachi		√		1

(a) Shanghai



(b) Nanjing



(c) Kyoto

(d) Tokyo

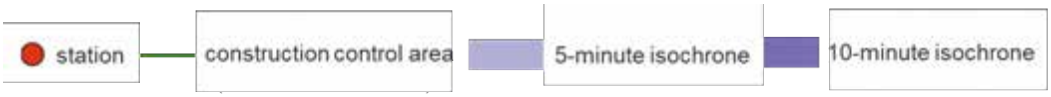


Figure 3. Study area of case study sites in various cities

3.2 Data Sources

The foundational urban data for Japanese cities in this study are sourced from the PLATEAU open data portal (https://www.mlit.go.jp/plateau/open-data/) of Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT). For Chinese cities, building data were obtained from Baidu Maps, while plot data were derived by importing open-source road network data from OpenStreetMap into ArcGIS for segmentation. Subsequently, metrics such as floor area ratio (FAR) and building density were calculated using ArcGIS.

To account for the temporal influence of construction sequences on the suitability of land development intensity, this study utilized high-resolution satellite/aerial imagery from different historical periods to compare the architectural texture of plots. Specifically, plots exhibiting significant changes in architectural characteristics—such as building height, density, and FAR—were annotated. This enabled the classification and comparative analysis of all plots based on their periods of redevelopment. The historical aerial imagery was sourced from the Geospatial Information Authority of Japan (GSI) (https://service.gsi.go.jp/map-photos/app/), Google Maps, and the USGS Lockheed Martin (Keyhole) satellite imagery archive.

3.3 Methodological Framework

This study conducts a comparative analysis of how multi-station isochrone overlays influence development intensity distribution around historic district transit stations, primarily through the following two pathways:

Pathway 1: Inter-City Comparison

By constructing a multi-city comparative framework, this pathway examines the similarities and differences in development intensity distribution among cities, considering their distinct urban development models and policy orientations. The analysis operates at a macro level to identify patterns influenced by regional contexts.

Pathway 2: Temporal Sequencing Comparison

This pathway employs a dual-time axis analytical framework to integrate the temporal sequence of construction with the cycles of conservation and planning policies. It emphasizes the spatiotemporal evolution of land development intensity, revealing the interactive relationship between urban construction activities and institutional planning mechanisms. This approach provides empirical evidence to elucidate the historical pathways shaping the intensity of land use.

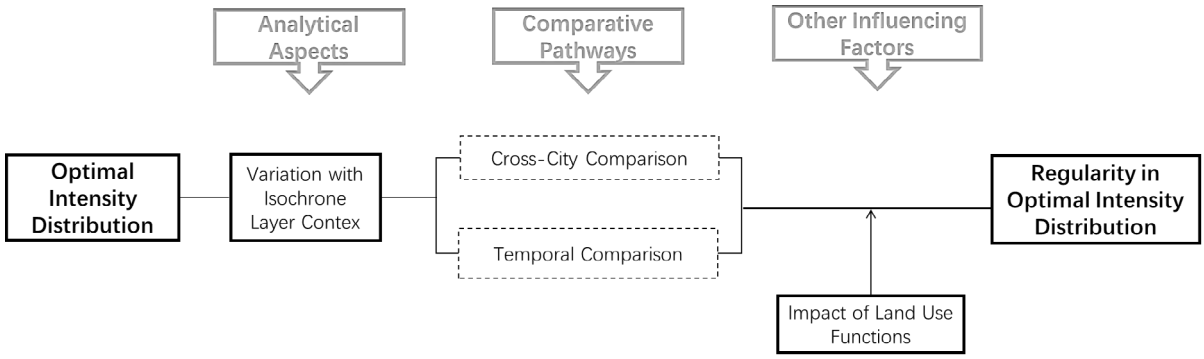


Figure 4. A comparative multi-path analysis framework.

4. Inter-City Comparison: Policy-Oriented Correlation of Development Intensity Distribution

Through comparative analysis of floor area ratio (FAR), maximum plot height, and building density in the vicinity of historical stations in Shanghai, Nanjing, Tokyo, and Kyoto, this study reveals significant spatial differentiation patterns and policy-oriented disparities in development intensity and urban form characteristics across the four cities.

4.1 Floor Area Ratio (FAR) Comparison

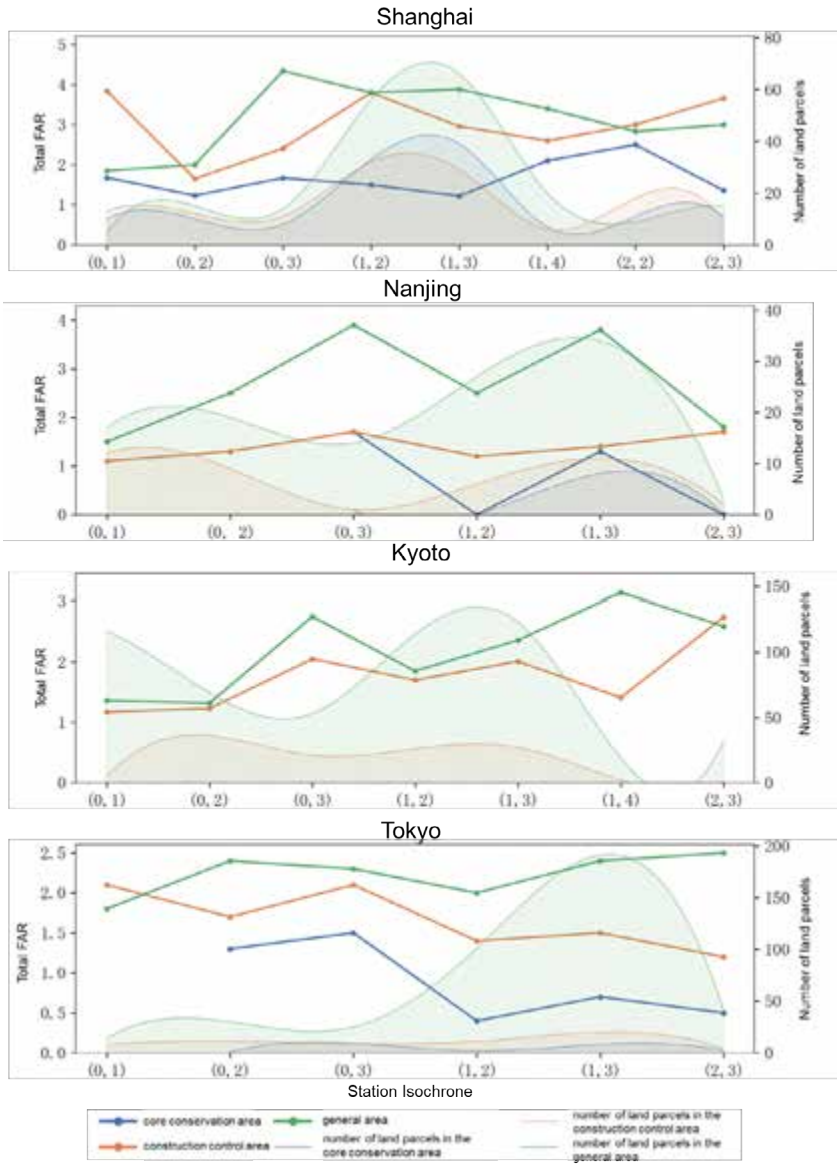


Figure 5. Comparison of floor area ratios (FAR) in four cities.

In terms of absolute FAR values (Figure 5), Shanghai exhibits the highest development intensity, with general areas and construction control zones predominantly ranging between 2–4. Nanjing follows a similar pattern, with general areas also ranging between 2–4, while Kyoto's general areas and construction control zones show lower values (1.5–3), and Tokyo demonstrates the lowest intensity overall (1.5–2.5). These differences reflect Shanghai's rapid urbanization and high-intensity development trajectory.

Spatial distribution patterns in relation to station proximity further highlight policy-driven distinctions. Across all four cities, a gradient variation in FAR is observed within core protection zones, construction control zones, and general areas. In Shanghai, Nanjing, and Tokyo, the disparity between general areas and construction control zones is particularly pronounced. Conversely, Kyoto exhibits a more nuanced gradient, with significant differences only in select regions. This underscores Kyoto's stringent protection strategies for its historical urban core, where cautious regulatory measures effectively mitigate the intensity gap between construction control zones and general areas, ensuring the continuity of the city's historical character.

Additionally, all four cities demonstrate notable FAR peaks in multi-isochrone overlapping areas—specifically, within (0, 3) and (1, 3) time-based concentric zones around stations (Figure 5). These peaks illustrate the cumulative effect of layered development intensity driven by overlapping station influences, highlighting the spatial superposition phenomenon in multi-station contexts.

4.2 Comparison of Maximum Building Heights by Plot

Building height, to some extent, reflects the urban form presented by plots within a city. The magnitude of height differences between areas indirectly indicates the variation in morphological characteristics. In terms of the absolute values of maximum plot heights (Figure 6), plots in Shanghai's General Areas and Development Control Zones, as well as Nanjing's General Areas, are significantly higher than those in Tokyo and Kyoto, predominantly falling within the 60-90 meter range. Furthermore, the height difference between Shanghai's Core Conservation Areas and its Development Control Zones/General Areas ranges between 20 and 60 meters, representing a significantly wider difference. In contrast, the height variation between different zones in Tokyo is within 5 meters, and in Kyoto, it is even less than 3 meters. This analysis reveals/has revealed that within the study areas of the two Japanese cities, morphological differences between different zones are minimal, resulting in a stronger overall visual coherence in the urban landscape. This finding aligns with the actual characteristics of the cities' urban form.

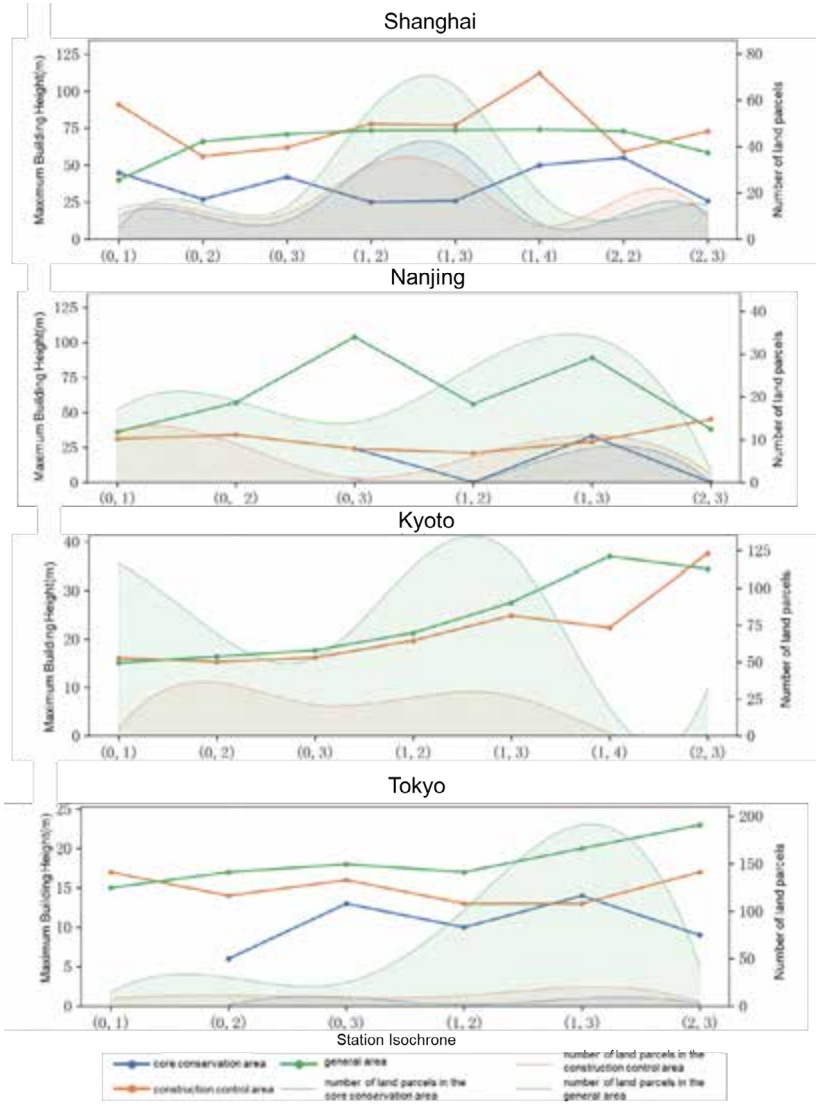


Figure 6. Comparison of maximum building height in four cities.

Regarding trends in building height changes, Shanghai exhibits pronounced fluctuations. Building heights demonstrate a high-low-high-low oscillation pattern as the isochrones expand. This pattern reflects the alternating occurrence of high-density, low-rise buildings and low-density, high-rise buildings during Shanghai's urban development process. Differing markedly from this, Tokyo displays a relatively stable trend in building heights, maintaining levels between 12 and 20 meters with minimal variation. This stability stems from restrictions imposed by historical and cultural preservation policies on both the density and height of land development in Tokyo, resulting in/leading to a limited potential for significant increases in building height. Kyoto's building heights exhibit a gradual upward trend, reaching a maximum of 37.6 meters. Notably, significant height increases occur in areas farther from the core, particularly in zones (1,4) and (1,3). This indicates that as isochrones expand, areas in Kyoto increasingly distant from the core, influenced by multiple stations, are gradually subject to/ experiencing greater development pressure.

4.3 Comparison of Building Density

Building density serves as a critical indicator of urban spatial form and textural characteristics. The Tongji University team led by Zhuang Yu (Zhuang et al., [reference number]) previously conducted empirical research, categorizing sample blocks in Shanghai's central urban area into typical morphological types such as low-rise high-density (historical heritage protection zones), mid-rise medium-density, high-rise low-density, and high-rise medium-density. This classification validated the correlation between building density variations and regional landscape characteristics.

In terms of absolute values (Figure 7), Tokyo and Kyoto exhibit significantly higher building densities compared to Shanghai and Nanjing, consistently maintaining levels between 60–70%. This reflects the spatial strategies of these two Japanese metropolitan areas, which prioritize high-density development to achieve efficient land resource utilization. Notably, the construction of subways has not disrupted the established urban fabric, demonstrating the coexistence of intensive development and preserved historical character.

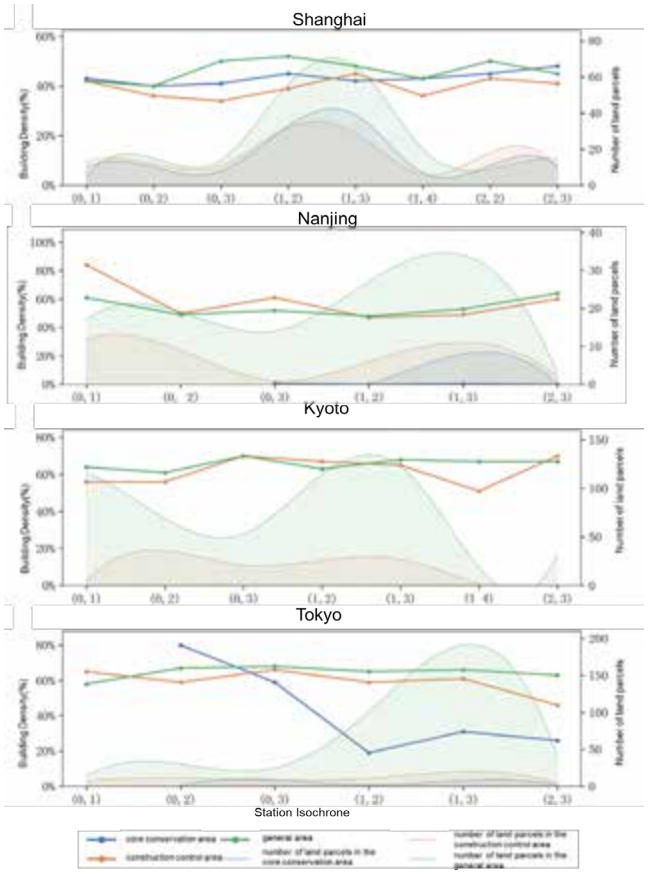


Figure 7. Comparison of building density in four cities.

In terms of density variation trends, Shanghai exhibits marked fluctuations, with significant disparities in building density between core protection zones, construction control zones, and general areas. This spatial differentiation is closely linked to the temporal sequence of urban land development and the dynamic updates of historical preservation policies—divergent development priorities across different periods have resulted in substantial spatiotemporal disparities in building density.

In contrast, Tokyo and Kyoto demonstrate a progressive growth trend in building density. Tokyo reaches a stabilized density of 70% in areas within the (1, 3) isochrone range, reflecting effective control over density thresholds during development. Kyoto's density distribution curve mirrors Tokyo's pattern but achieves stronger overall coherence in preserving the historical street fabric through a gradual, incremental increase in density gradients (Figure 7).

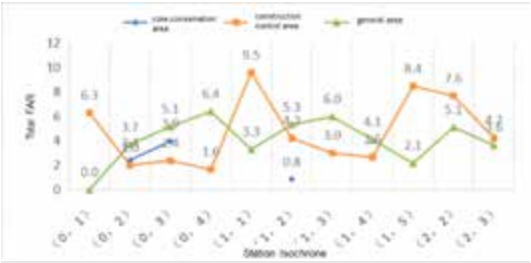
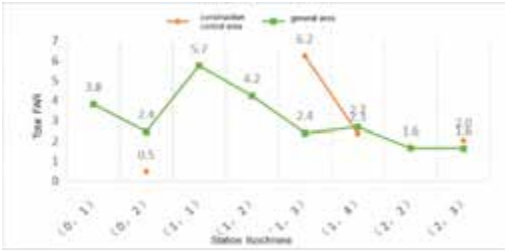
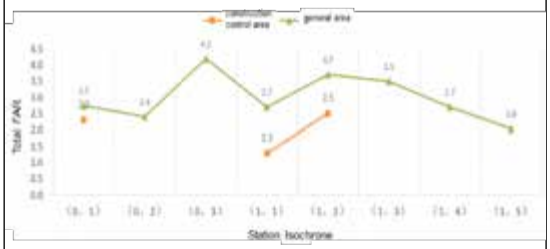
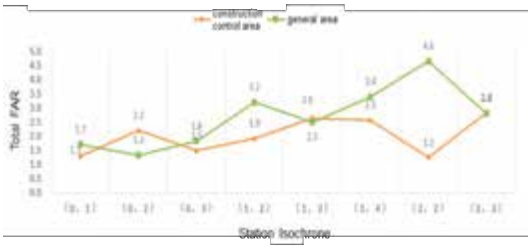
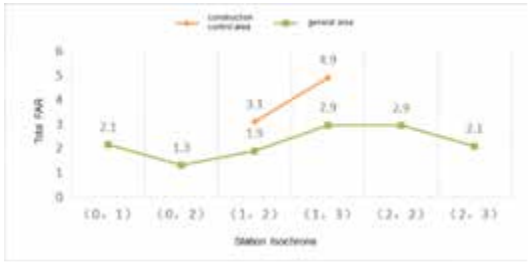
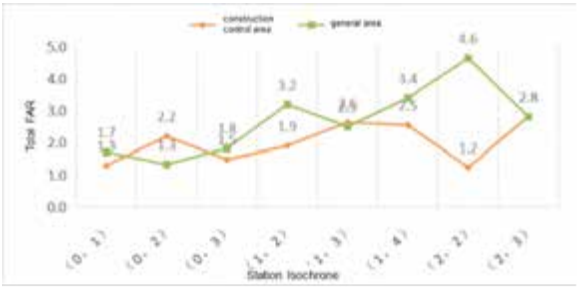
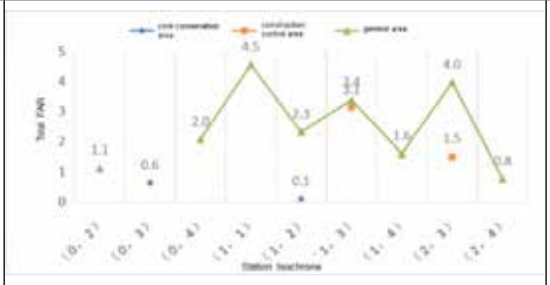
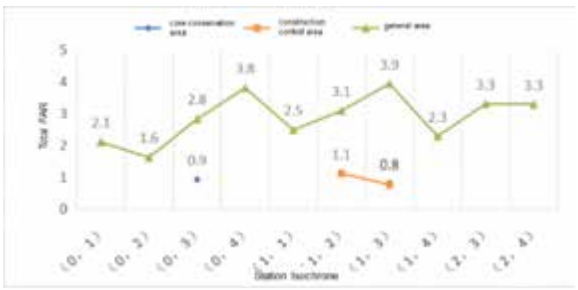
5. Temporal Comparison: Assessment Principles Based on Construction Chronology

The comparative analysis reveals that the chronological relationship between the implementation of conservation planning and rail transit construction timelines in different cities significantly influences the distribution of development intensity in urban blocks surrounding historical station areas.

Table3. A Temporal comparison of development and conservation sequences in case study cities.

	Shanghai	Nanjing	Kyoto	Tokyo
Timeline of Conservation Planning Implementation	1991: Designation of historical character protection zones; 2003: Revised core protection and construction control boundaries under the Shanghai Historical and Cultural Landscapes and Excellent Historic Buildings Protection Regulations.	1984: First Nanjing Historic City Conservation Plan designating Qinhuai River scenic zones as priority protection areas; 2010: Expanded to three historic urban cores, nine historic districts, 22 historic landscapes, and 10 general heritage sites with strict height controls.	1972: Designation of Aesthetic Zones under the Kyoto Urban Landscape Regulation Ordinance; 1973: Designation of Height-Control Zones.	1984: Grassroots preservation initiatives; 2000: Sugamo-Ueno-Sakuragaoka Urban Development Charter established .
Timeline of Station Construction	1993: Line opening; 1996: Station completion.	2005: Opening of Metro Line 1.	1981: Kyoto Subway Uzumasa Line operational; 1997: Opening of the East-West Line.	1969: Kanda and Rootsu Stations operational; 1996: Todai-mae Station operational [Todai-mae Station, 2025-05-04].
Type	RetroactivOe Conservation Model	Proactive Conservation Model	Proactive Conservation Model	Dual-Track Model
Characteristics	Metro construction preceded conservation planning, leading to significant fluctuations in development intensity. Some areas failed to meet both heritage preservation and station development requirements.	Metro construction followed conservation planning. Post-planning, pre-construction redevelopment led to relatively homogeneous intensity distribution but limited synergistic interaction with stations.	Metro construction followed conservation actions. Restrictive redevelopment in construction control zones ensured landscape coherence, while general areas adapted to station development, reflecting zonal regulation strategies.	Metro construction preceded conservation planning. However, spatial constraints and community engagement mechanisms limited intensity increases in construction control zones, while general areas adapted to station development.

Table 4. Comparative analysis of land parcel intensity distribution across cities and time periods.

City & Model Type	Phases of FAR Distribution Changes	
Shanghai (Retroactive Planning)	 (a) Rail transit construction commencement – Pre-refinement of conservation planning	 (b) Post-refinement of conservation planning
Nanjing (Proactive Planning)	 (a) Conservation planning – Rail transit construction commencement	 (b) Post-rail transit construction commencement
Kyoto (Proactive Planning)	 (a) Conservation planning – Rail transit construction commencement	 (b) Post-rail transit construction commencement
Tokyo (Parallel Development & Conservation)	 (a) Rail transit construction commencement – Pre-initiation of conservation efforts	 (b) Post-initiation of conservation efforts: Concurrent development and conservation

5.1 Retroactive Planning Model

Although Shanghai's historical heritage protection system is relatively comprehensive and detailed by domestic standards, the temporal disarray between conservation and development has led to a "cross-waved" phenomenon in Table 4, where "historical districts" are juxtaposed with "high-rise buildings." Professor Zheng Shiling noted that "over the past two decades, high-rise buildings have been inserted into marginal areas of historical sites in Shanghai, often resulting in urban forms driven by profit rather than heritage, creating a fragmented spatial pattern where new and old structures intersect." Similarly, Professor Zhang Song of Tongji University observed that "Shanghai's old city renewal has never ceased, yet historical preservation has remained intermittent and localized." This inconsistency partly explains why Shanghai had to expand its protection scope and re-designate historical cultural landscapes in later planning stages to mitigate heritage loss.

5.2 Proactive Planning Model

In contrast, Kyoto, a model of Japanese historical cities, employed height zoning to regulate urban form prior to rail transit development (Table 4). This proactive approach ensured that post-development intensity remained within controlled thresholds, gradually adapting to station areas. The result was a harmonious coexistence of modernity and heritage, offering insights for optimizing development intensity in historical station zones:

(1) Proactive Planning Promotes Suitable Intensity Distribution

Kyoto's differentiated regulatory mechanisms—such as height zoning and development strategy zoning—established clear intensity gradients and controllable vertical differences. This framework balanced rail transit development with heritage preservation, enabling functional renewal while maintaining the coherence of historical districts.

(2) Moderate Intensity Gradients Between Zones

Rail transit influenced different zones unevenly: general areas and construction control zones exhibited distinct intensity variations.

However, Nanjing, another proactive model, demonstrated a more homogeneous intensity distribution in redevelopment areas before metro construction. Post-metro opening, development intensity did not align with the expected increase in isochrone overlap around stations. This discrepancy stemmed from Nanjing's rapid expansion during the late 20th to early 21st century, where infrastructure and building projects were concentrated without foresight for rail transit integration. Consequently, existing facilities and subsequent metro systems lacked functional compatibility, leading to missed opportunities for high-potential sites to leverage transit-driven intensity. This temporal misalignment is particularly evident in Nanjing's southern historical districts.

During periods of rapid rail network expansion, strict heritage policies constrained new construction heights, limiting floor area ratio (FAR) growth and weakening synergies between development and stations.

5.3 Dual-Track Model

Tokyo's Sugamo-Ueno-Sakuragaoka area (Yanaka, Ueno, Sakuragaoka) experienced slow redevelopment over 56 years since the Kanda and Rootsu stations opened in 1969. Unlike other regions, its renewal dynamics involved complex interplay of factors. A 1984 community-based preservation initiative marked a turning point, dividing the timeline into two phases:

Pre-Preservation Phase: Road networks primarily guided land use along corridors.
Post-Preservation Phase: Development shifted to the western general areas and the eastern side of the JR railway line, while historical zones (construction control and core protection areas) focused on "reproductive" updates—adaptive reuse of existing structures.

This duality created two intensity-balancing mechanisms: incremental updates and large-scale development. Consequently, regional intensity harmonized across broader zones, and post-mid-development synergies with stations emerged (Table 4).

6 Conclusion and Discussion

6.1 Station Cluster Effect

The findings demonstrate that in urban districts, a certain coupling relationship exists between station isochrone overlap (m, n) and development intensity (FAR, building density, building height).

(1) Positive Correlation Between Development Intensity and Isochrone Overlap
Across all cities studied, development intensity generally increases with the degree of isochrone overlap. For example, as isochrone overlap shifts from (0, 2) to (1, 4), development intensity intensifies accordingly. This trend aligns with Transit-Oriented Development (TOD) principles, emphasizing compact, high-density urban growth driven by dense subway station networks.

(2) Non-Linear Relationships Under Station Cluster Influence
Development intensity data across multiple cities exhibit fluctuating growth patterns and localized peak phenomena. For instance, FAR peaks at (0, 3) and building height peaks at (1, 4). These peaks indicate that development intensity does not follow a simple linear relationship with isochrone layers: an area overlapping a 5-minute isochrone may not necessarily exhibit significantly higher intensity than one overlapping a 10-minute isochrone.

From a spatial geographic perspective, station clusters—comprising multiple stations—generate stronger influence than single stations. Regions such as (1, 3) and (1, 4), where multiple 10-minute isochrones overlap, show substantial intensity fluctuations. This suggests that areas affected by overlapping station clusters possess higher development value and potential. Planners should prioritize these zones when formulating strategies to optimize urban intensity distribution.

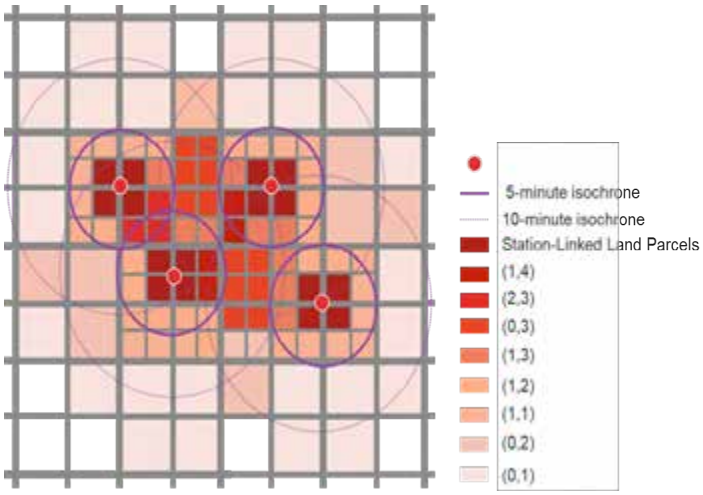


Figure 8. Schematic diagram of intensity distribution in general areas of kyoto.

6.2 Formation of Appropriate Development Intensity

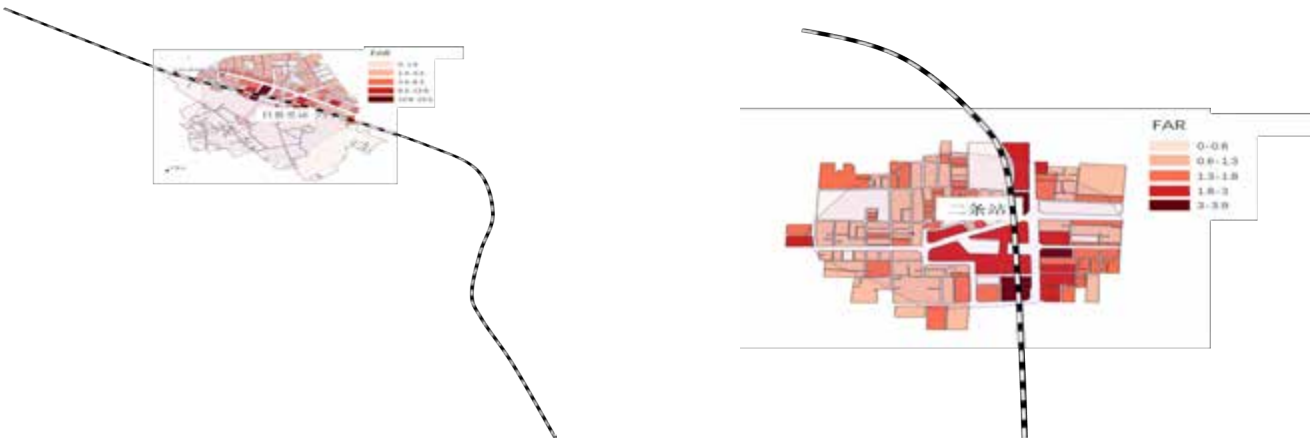
Core protection zones in historical districts prioritize heritage preservation, requiring development intensity to balance landscape conservation, functional vitality, and urban transit adaptability. Unlike ecologically protected regions, their regulatory logic emphasizes a dynamic equilibrium between historical context preservation and moderate renewal. Therefore, integrating and coordinating intensity across core protection zones, construction control zones, and general areas is critical. The comparative analysis across multiple cities and regions reveals the following key conclusions:

(1) Differentiated Intensity Gradients Across Protection Hierarchy
The analysis demonstrates a prevalent intensity gradient of "core protection zones < construction control zones < general areas" among historical districts. This pattern is particularly pronounced in Kyoto and Tokyo, where heritage preservation is well-maintained. As isochrone overlap levels escalate from (0, 1) to (1, 4), the disparity in development intensity between control zones becomes more pronounced. For example, in Kyoto, the FAR difference between general areas and construction control zones widens progressively with increased isochrone overlap. This phenomenon highlights that general areas benefit more from station-driven radiating effects, while construction control zones face constraints due to heritage regulations. Additionally, intensity gradients may be influenced by land-use characteristics and policy implementation timelines in specific contexts.

(2) Inter-Zonal Coordination and Overall Balance
The observed intensity gradients between zones enhance flexibility in development distribution around historical stations, enabling an overall balance across core protection zones, construction control zones, and general areas. This balance effectively reconciles conservation and development objectives.

Core Protection Zones: Strict intensity controls are essential to safeguard heritage integrity.
General Areas: Higher FAR or building density can optimize land use efficiency.
Construction Control Zones: A balanced approach is required—limiting intensity to preserve landscape coherence while allowing sufficient development space to avoid over-restriction and promote sustainable urban form.

The balanced relationship also exists within station areas. In individual stations in Kyoto and Tokyo (e.g., Hizuminokita Station in Tokyo, Nijo Station in Kyoto), it was observed that due to the integration of JR lines and subway lines at transfer stations, the presence of elevated tracks leads to significant spatial disparities in development intensity between the two sides. This results in one side exhibiting high-intensity development while the other remains low-intensity, creating a notable floor area ratio (FAR) transfer phenomenon within the station area.



(a) Nippori Station in Tokyo (b) Nijo Station in Kyoto

Figure 9. The plot ratios on both sides of the special station demonstrate balance within the station area.

(3) Multi-dimensional Index Coordination and Appearance
The analysis above reveals significant regional differentiation in the impact of building density and height on floor area ratio (FAR): in core conservation zones, strict height restrictions constrain development intensity, which is primarily driven by building density. In contrast, in general areas with relaxed height controls, "low-rise podium + high-rise" mixed-use commercial complexes achieve high FAR through vertical expansion.

Diverse morphological mechanisms exist for high-intensity districts across cities. Kyoto attains high FAR via low-rise, high-density layouts, while Shanghai relies on high-rise, low-density configurations to achieve similar intensity levels. This indicates that under different regulatory contexts, multiple balancing pathways and spatial

forms for development intensity coexist. Specifically, in general areas within the (0, 3) range, high-intensity development is often realized through "verticalization" strategies—increasing building floors while reducing density. Conversely, in construction control zones constrained by appearance coordination requirements, "horizontal expansion" models (prioritizing building density and limiting height) still achieve intensity balance. These differentiated index combinations signal a shift from single FAR constraints to multi-dimensional index coordination in development regulation.

6.3 Impact of Construction Sequencing on Intensity Distribution

(1) Conservation Planning and Rail Transit Construction Sequencing Determine Regulatory Effectiveness

Comparative analysis of development intensity distribution in updated plots across Shanghai, Nanjing, Kyoto, and Tokyo reveals that plot intensity varies temporally due to differing dominant factors. When conservation planning precedes rail transit construction (as in Kyoto's model), a "pre-defined control framework followed by adaptive development" mechanism emerges. This enables rigid control in conservation zones, moderate construction in buffer zones, and flexible, TOD-oriented development in general areas, forming a gradient model. This proactive coordination between construction and regulation is characteristic of such cities.

Conversely, when conservation planning lags behind rail transit construction (e.g., in Shanghai's study area), some plots in buffer zones already exhibit high-intensity development before designation, while others remain underdeveloped due to earlier construction. This results in stark intensity disparities between buffer zones and general areas, exemplified by adjacent high- and low-rise structures. Such spatial misalignment reflects planning delays and coordination failures. These findings underscore the need for conservation planning to prioritize foresight, comprehensiveness, and integration to avoid reactive regulation. Kyoto's "planning-first, development-adaptive" approach offers a replicable temporal coordination model for cities balancing historic preservation and rail transit expansion.

(2) Plot Differentiation Evaluation Under Temporal Relationships

Plot development intensity arises from long-term interactions of multiple factors, with construction and conservation sequencing as critical variables. Establishing plot classification evaluation principles based on these temporal relationships enables more precise identification of intensity imbalances, facilitating targeted optimization strategies.

(3) Identification of Appropriate Intensity Distribution Patterns

By comparing intensity distribution characteristics across cities with divergent planning and construction sequences and integrating urban appearance analyses, this study preliminarily reveals that "planning-precedence" models better support appropriate intensity distribution. For example, Kyoto's model demonstrates a reasonable intensity gradient between core conservation zones, buffer zones, and general development areas, with buffer and general zones synergizing with rail transit station development.

6.4 Conclusion

As most global cities transition from incremental construction to stock-based renewal, historic districts near rail transit stations face deepening tensions between preservation and development. This study, starting with plot-level zonal assessments and constructing an indicator system through comparative case analysis, identifies four key distribution patterns of development intensity in high-density historic station areas across cities. It elucidates interactive mechanisms among factors such as station size, layered land use, historical appearance protection, and construction sequencing, providing a reference for non-early-stage cities seeking appropriate intensity evaluations.

However, limitations persist: the broad geographic and temporal scope, coupled with restricted access to historical data, necessitate manual data collection. Further refinement is required for underground FAR estimation and the completeness of historical renewal records.

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Travel Characteristic of Elderly People in Towns of Shanghai Metropolitan Area: An Urban-Rural Mobility Network Analysis

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Abstract
With the intensification of low birth rates and population aging in China, the proportion of elderly individuals is steadily increasing. Currently, research on the travel behavior of the elderly largely focuses on urban areas, with relatively limited attention paid to rural elderly populations. However, towns—which serve as a vital link between urban and rural areas—present more complex geographic, social, and transportation conditions that significantly impact elderly travel. This study employs network analysis methods, combining mobile signaling data with transportation survey data to deeply investigate the travel characteristics of township residents aged 65 and above in their daily lives. It also analyzes and summarizes the key influencing factors and proposes corresponding planning strategies.

Keywords: Elderly travel; Town; Urban-rural population mobility; Shanghai Metropolitan Area

1. Introduction

China's population development has entered a "new normal" phase, characterized by negative population growth, declining birth rates, an aging population, shrinking household sizes, and increasingly differentiated spatial distribution across regions (Liu, 2021; Qi, 2019). The country is transitioning from focusing on child-rearing to elder care, as the working-age population continues to decline and both demographic size and structure become more polarized. With these trends intensifying, the proportion of elderly individuals is steadily increasing, prompting the government to place greater emphasis on meeting the social needs of older adults.

In the Shanghai metropolitan area, Shanghai itself is not only the earliest city in China to enter an aging society, but also the one with the most severe aging level. Other cities in the region, such as Nantong, have also entered a stage of deep population aging. The growing travel demand of elderly populations makes building an age-friendly and inclusive society a key focus of urban and regional planning.

To date, most research on elderly travel behavior has concentrated on urban areas, with relatively little attention paid to elderly individuals in rural settings. Townships, which serve as critical links between urban and rural areas, face more complex geographic, social, and transportation conditions. Due to the frequent outmigration of younger labor forces, a significant number of elderly people are left behind in these townships. Compared to resource-rich urban areas, township-dwelling elderly populations deserve greater attention, which is an essential component of constructing an inclusive society. With the advancement of mobile signaling data, it is now possible to analyze the travel characteristics of rural elderly populations, offering a foundation for governments to allocate urban-rural resources more effectively and build an age-friendly society.

This study focuses on all townships within the Shanghai metropolitan area. Using network analysis methods and integrating mobile signaling data with transportation survey data, it constructs urban-rural and rural-rural population mobility networks. The study deeply explores the travel characteristics of township residents aged 65 and above in their daily lives and examines the relationship between these characteristics and the socioeconomic development of the townships. It identifies the main influencing factors and attempts to provide a clearer understanding of the spatial mobility and cross-regional interactions of elderly people from the perspective of population mobility networks. The findings reveal the specific needs and behavioral patterns of the elderly in townships, offering insights for differentiated planning tailored to the unique characteristics of elderly populations across different regions. This will support government efforts to improve transportation infrastructure, enhance social support services, and optimize medical resource allocation—contributing to the development of an inclusive society and addressing the challenges of population aging.

2. literature review

In the context of an increasingly aging population, the daily activity patterns and travel convenience of the elderly have drawn significant attention from scholars both domestically and internationally. Unlike younger age groups who often occupy a more "mainstream" position in society, elderly individuals tend to have lower incomes and diminished physical capacities. As a result, they rely more heavily on public service systems, healthcare systems, and social welfare programs. This dependence contributes to a range of "social isolation" issues faced by the aging population.

Unlike other countries, elderly travel behavior in China is influenced by its unique social environment, leading to distinct patterns. In recent years, there has been a growing body of research focused on the travel behavior of older adults in China. For example, Zhang et al.(2007) used travel survey data from Beijing residents to compare the travel characteristics (including travel rate, time, distance, mode, and purpose) of elderly individuals aged 61–65 with those of people aged 19–60. They also examined how travel modes and purposes change with age and analyzed differences in travel behavior between elderly residents of central and non-central urban areas at a spatial level.

Similarly, Hu et al.(2013) conducted surveys and analyses of elderly travel behavior in Changchun, exploring aspects such as travel frequency, travel purpose, and mode choice. They compared travel behavior in developing and developed countries, identifying the causes of differences, and proposed urban transportation policies to improve the travel frequency and comfort of the elderly. These policy recommendations included the integration of transportation and land use planning, improvements to pedestrian infrastructure, and enhanced accessibility of public transportation services. Zhang et al.(2019) argued that issues such as traffic congestion, complex traffic environments, and poor travel comfort for the elderly have long been neglected. To address this, they applied a Nested Logit model to study the travel patterns of the elderly in Beijing, finding that public buses play a crucial role in elderly mobility.

When it comes to analyzing the factors that influence elderly travel behavior, the literature points to a combination of socioeconomic conditions, external environmental factors, and policy-related influences. Socioeconomically, studies have shown that age, gender, education level, income, car ownership, and household size significantly affect elderly travel behavior. In terms of the external environment, factors such as population density, diversity, urban design, destination accessibility, and distance to public transit also impact travel decisions. From a policy perspective, welfare initiatives targeting the elderly—such as free or discounted public transportation and improved accessibility through barrier-free infrastructure—can significantly encourage elderly use of public transit and enhance social inclusion, thereby helping to mitigate social isolation (Zhang, 2019).

Overall, existing research on elderly travel characteristics tends to focus primarily on urban populations, with limited attention given to elderly individuals living in townships. There is also a lack of analysis concerning the mobility characteristics of elderly populations moving between urban and rural areas. Moreover, while many studies rely on statistical or travel survey data, fewer incorporate big data approaches, such as mobile signaling data, which could offer deeper insights into travel patterns.

3. Methodology and data

The Shanghai Metropolitan Area, located in eastern China, is a key component of the Yangtze River Delta region. The planning area encompasses the "1+8" administrative units, including Shanghai, Wuxi, Changzhou, Suzhou, Nantong, Ningbo, Huzhou, Jiaxing, and Zhoushan. With a diverse population and a relatively high degree of aging, the region experiences frequent inter-regional transportation connections. Township elderly populations also exhibit notable travel demands, making the study of their travel characteristics crucial for promoting urban-rural integration.

This study takes the Shanghai Metropolitan Area as the research region and divides the nine cities into 913 sub-city administrative units at the subdistrict (township) level. Based on the "Statistical Compilation Rules for Administrative Division Codes and Urban-Rural Division Codes"

(index no. 410A03-1201-201708-0006) from the National Bureau of Statistics of China, each subdistrict or township is classified according to the first digit of its urban-rural division code: 1 for urban and 2 for rural. In total, 404 urban subdistricts and 495 rural townships were identified (Figure 1).

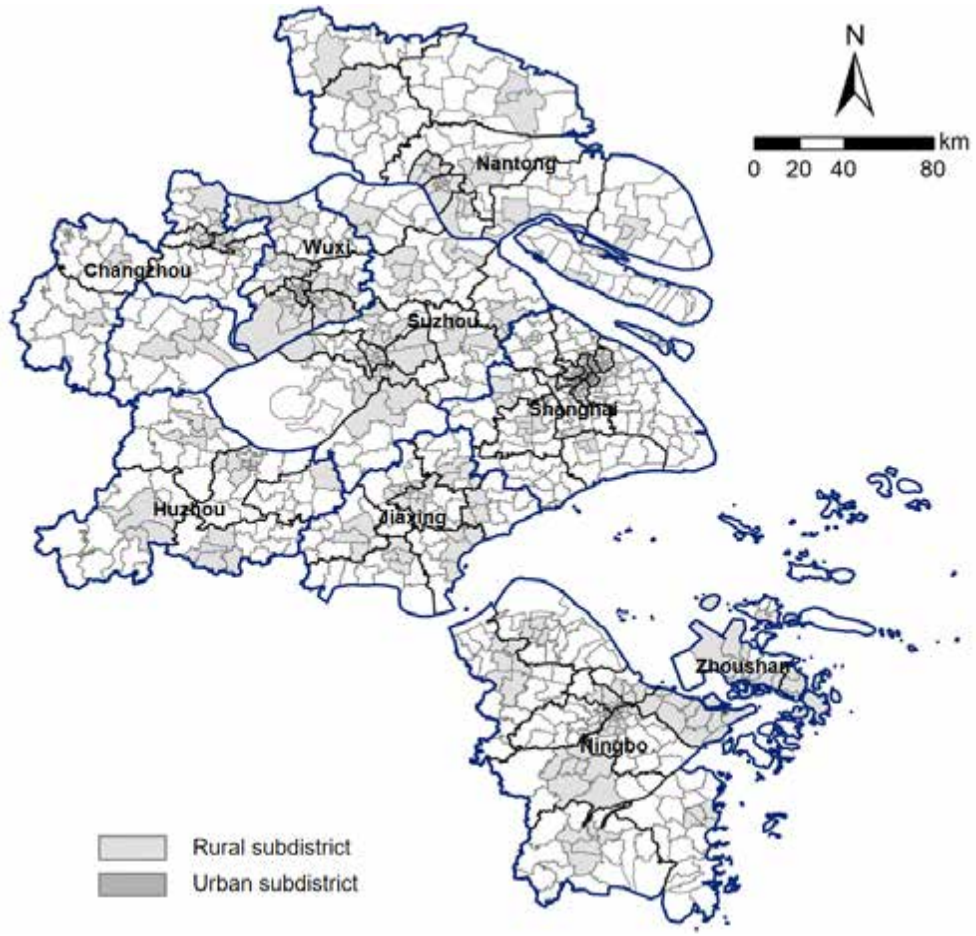

Figure 1. Location and urban-rural classification layouts of Shanghai metropolitan area

The primary data sources for this study include mobile signaling data and POI (Point of Interest) data. The mobile signaling data is derived from travel OD (origin-destination) data from October 2022, using base station grids to locate users' movements. The dataset captures trips for all purposes. By combining POI locations with dwell time, the purposes of trips are inferred to better understand the travel patterns of the elderly population in townships within the Shanghai Metropolitan Area.

Unlike traditional static data analysis, this study adopts a regional spatial network perspective to analyze the travel behaviors of elderly people between urban areas and townships, as well as between different townships. First, a population mobility network within the Shanghai Metropolitan Area is constructed using big data on population movements. The study explores the travel characteristics of elderly individuals through two layers: urban-rural and rural-rural mobility networks, thereby examining interconnections from a broader urban-rural perspective. Second, a statistical analysis is conducted on the travel destinations of elderly individuals for both urban–town and town–town trips. Finally, the study summarizes elderly travel characteristics and preferences by integrating survey data and other contextual information.

4. Results and discussion

4.1 The characteristics of urban-rural travel for the elderly in towns

Using mobile signaling data, this study extracts travel information of the elderly population and constructs urban–rural and rural–rural travel OD (origin–destination) networks. Due to age-related limitations, the number of elderly mobile phone users is relatively small, resulting in a lower overall volume of travel connections. However, observable patterns of elderly travel connectivity still emerge.

In the urban–rural travel network, high-intensity connections are mainly concentrated in Suzhou, showing a multi-centered structure. Although Shanghai exhibits tighter internal linkages between districts, the overall volume of connections is lower. This difference is directly related to the population composition of the two cities—Shanghai has a higher proportion of young people due to its more prominent emerging industries, whereas Suzhou's central districts have a higher proportion of elderly residents, resulting in stronger urban–rural travel connections among the elderly. In other cities within the metropolitan area, elderly urban–rural connections in townships are weaker and more pronounced in peripheral areas. Elderly individuals in townships mainly form direct connections with their regional urban centers, and travel distances are somewhat constrained. Only elderly residents in townships near city centers show relatively frequent travel. In the outer townships of each region, the elderly population generally has little direct interaction with urban districts, which is closely tied to differences in local economic industries and transportation accessibility.

Additionally, there are few cross-jurisdictional travel connections. Only limited intercity linkages are observed between Shanghai and Suzhou, while elderly mobility in other areas remains largely confined within municipal boundaries, typically within district or county-level jurisdictions. Some cross-district or cross-county elderly travel occurs within cities such as Wuxi, Changzhou, and Ningbo.

In the rural–rural travel network, elderly mobility demonstrates a more distinct networked structure. Centered around Suzhou and Shanghai, there is more frequent movement of elderly individuals between townships. Furthermore, elderly cross-border activities between townships are more evident, indicating that inter-township linkages are less constrained by administrative boundaries. In peripheral areas, elderly movement between townships is more frequent than between townships and cities, with elderly individuals tending to travel within nearby townships.**(Figure 2)**

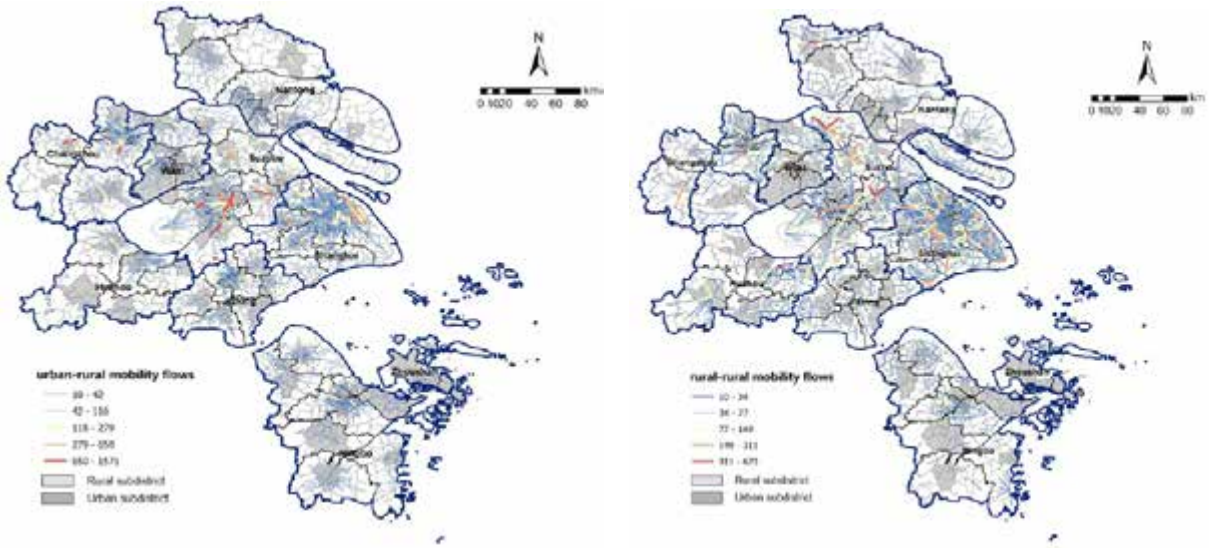

Figure 2. Characteristics of urban - rural elderly population flow network in towns of Shanghai metropolitan area

Overall, both urban–rural and rural–rural elderly travel connections are strongly influenced by distance and administrative boundaries. These constraints are closely related to elderly travel preferences, as most elderly travel in townships occurs within the local area—primarily driven by needs such as family visits, social interactions, and shopping. In contrast, intercity or cross-regional travel is less common, though certain groups—such as those with specific medical needs or those with children living in urban centers—exhibit higher frequencies of long-distance travel.

4.2 The characteristics of urban-rural travel purpose for the elderly in towns

The destinations of elderly travelers were extracted and analyzed separately for urban–rural and rural–rural travel patterns, revealing distinct differences between the two types of mobility.

For elderly individuals traveling between urban and rural areas, a significant portion have specific medical needs or children living in urban districts. Although these elderly residents live in townships, they often travel to urban centers for family visits or medical checkups, indicating that social needs and the availability of public services have a direct impact on their travel behavior. Additionally, shopping and leisure activities account for a relatively high proportion of urban–rural travel. This is largely because urban areas offer a wider range of public services and cultural facilities, attracting elderly township residents to engage in recreational activities. In contrast, travel purposes such as grocery shopping, running errands, child care, and work account for a smaller share of urban–rural travel. These types of travel are more common among elderly residents of townships that are geographically closer to urban centers and are more sensitive to distance and transport accessibility.

For elderly individuals traveling between townships, their travel purposes are closely related to the functions of the respective townships. Firstly, daily shopping accounts for a higher proportion of such travel. These trips typically involve going to central towns to purchase daily necessities such as food and household items, addressing basic everyday needs. Compared to urban–rural travel, the proportions of travel for purposes such as child care and participation in educational or community activities for the elderly are relatively higher, reflecting a preference for frequent, short-distance daily activities. On the other hand, the shares of travel for shopping, leisure, and medical purposes are lower in rural–rural contexts, likely due to smaller differences in service facilities between townships, which leads to reduced demand for such activities.

Moreover, visits to relatives and friends are also less common in rural–rural travel, suggesting that this type of travel is more often driven by the presence of children in urban areas. This pattern is closely related to China's urbanization process, wherein many young and middle-aged township residents have relocated to urban areas for work, prompting elderly family members to travel between rural and urban areas. Finally, since most elderly individuals are already retired, commuting for work is uncommon, with low proportions observed in both urban–rural and rural–rural travel. **(Figure 3)**

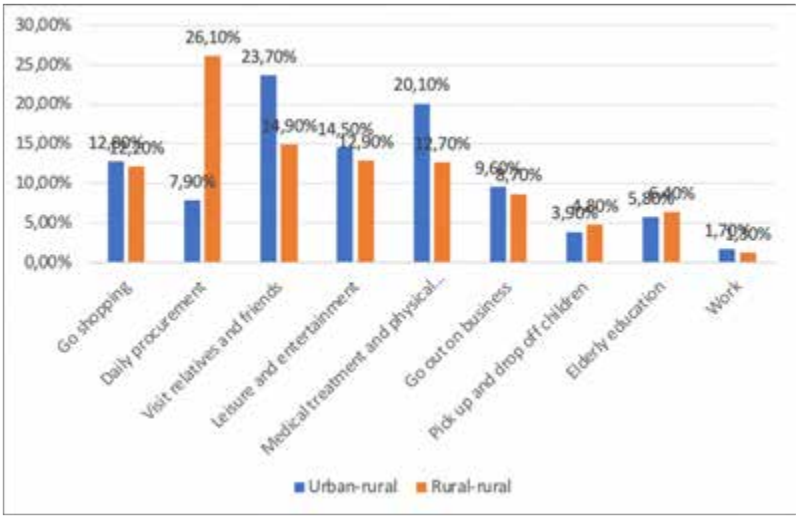

Figure 3. Characteristics of urban-rural travel purposes for the elderly in the Shanghai metropolitan area

4.3 Travel characteristics of the elderly based on traffic surveys

Based on the analysis of mobile signaling big data, this study incorporates survey data on the travel behavior of the elderly population in township areas of Shanghai. It statistically analyzes travel purposes, frequency, and timing across different age groups of elderly individuals. These travel behaviors are significantly influenced by factors such as physical health conditions and exhibit clear patterns and regularities.

4.3.1 Travel purpose

Shopping is the most fundamental travel activity for the elderly, accounting for over 35% of total trips and remaining above 33% across all age groups. The younger elderly group (ages 60–65) has a higher proportion of shopping-related travel. Leisure, entertainment, and cultural activities constitute a relatively stable share of travel across age groups, generally maintaining around 10%.

Due to increased health awareness and rising demand for medical services, doctor visits and health check-ups have become a significant travel purpose for the elderly, accounting for over 10% of trips. As age increases and physical function declines, the proportion of travel for medical reasons rises significantly—from 8% in the 60–64 age group to 35.7% among those aged 80 and above.

In contrast, travel for visiting family and friends, handling personal or household affairs, escorting others, and work-related purposes tends to decrease with age. **(Figure 4)**

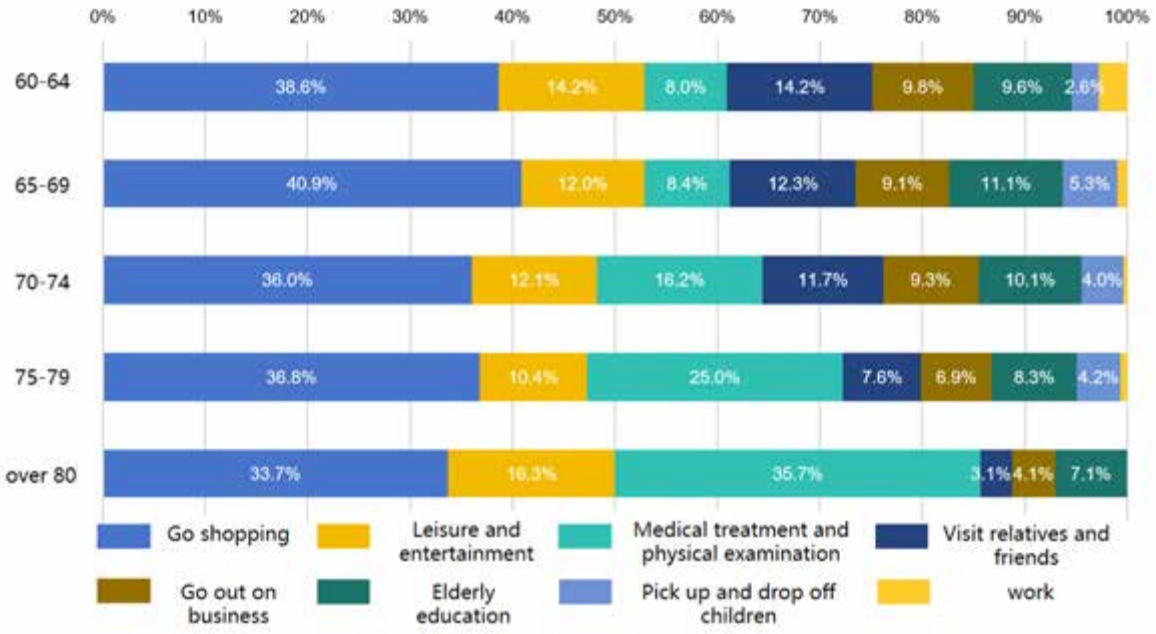

Figure 4. The travel purposes of the elderly of different age groups

4.3.2 Travel frequency

Elderly travel frequency is highly correlated with age. Survey results indicate that travel frequency decreases significantly as age increases: elderly individuals aged 60–62 make an average of 2.27 trips per person per day, while those aged 83 and above make only 0.77 trips per person per day.

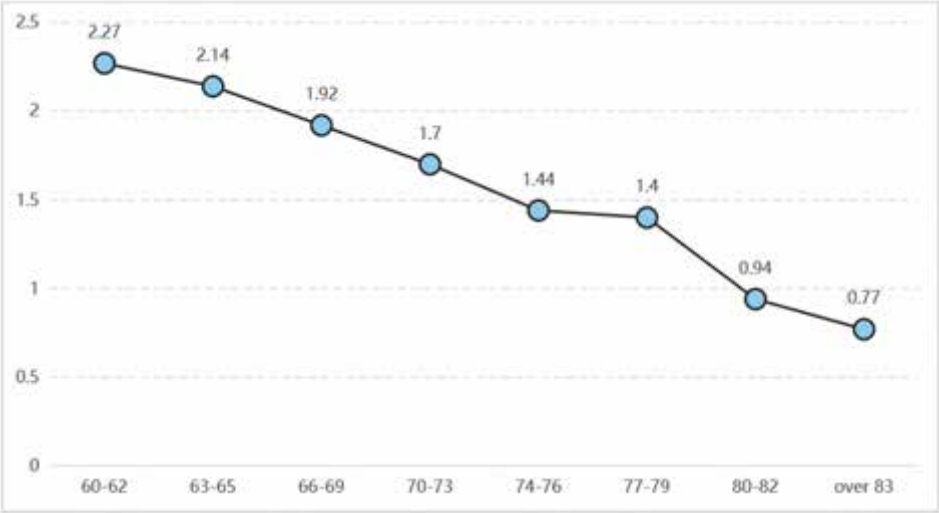

Figure 5. The travel frequency of the elderly of different age groups

From a frequency perspective, the travel level of the 60–65 age group (2.27 trips/day/person) is close to that of residents in central Shanghai (2.37 trips/day/person), suggesting that this age group represents a key transitional phase from working life to retirement. After age 66, travel frequency gradually declines, particularly after age 80, when physical deterioration becomes more pronounced and average travel frequency generally falls below 1.0 trip per person per day.**(Figure 5)**

4.3.3 Travel time

Cross-analysis results show that there is no significant correlation between travel time and age among the elderly. The distribution of travel times across different age groups is generally consistent, displaying two distinct peak periods: 7:00–9:00 a.m. and 1:00–2:00 p.m., with the morning peak showing significantly higher travel volume than the afternoon.

This pattern reflects the elderly's relatively abundant and flexible time management capacity. Their travel activities are more driven by daily habits and personal needs rather than by changes in age. It also indicates that, in post-retirement life, elderly individuals are able to choose more comfortable travel times that avoid congestion, resulting in regular but non-compulsory peak travel behaviors.**(Figure 6)**

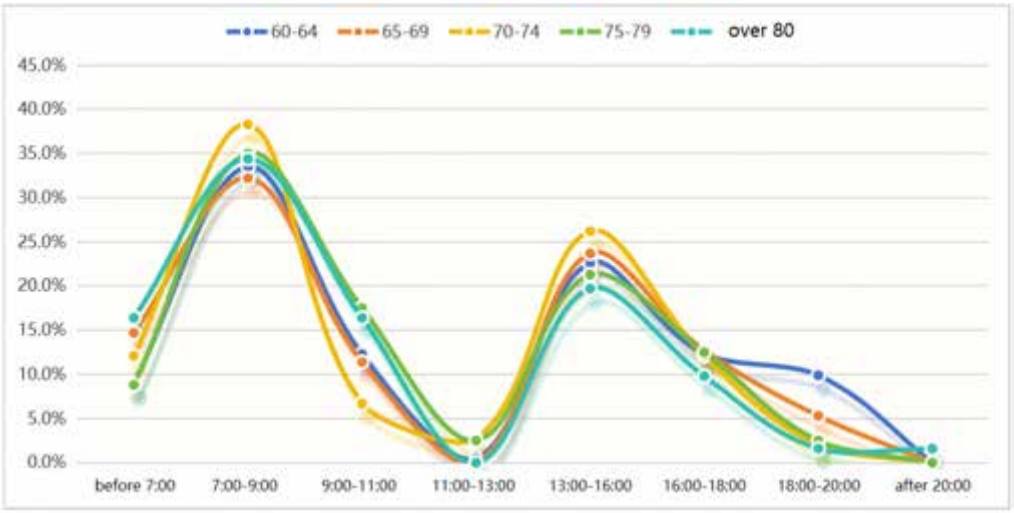

Figure 6. The travel time characteristics of the elderly of different age groups

4.4 Influencing factors of travel for the elderly in towns

Combining the previous data analysis and travel surveys, the travel characteristics of elderly residents in townships are influenced by multiple factors, primarily dominated by physical health and age stage, and constrained by geographic distance, transportation infrastructure, family structure distribution, and administrative boundaries. Among these, health needs, distribution of relatives, and availability of service resources are the core drivers for non-routine cross-regional travel by the elderly, while proximity-based daily life needs still dominate their everyday travel behavior.

First, individual characteristics play a role: physical decline due to aging directly affects travel frequency, travel time, and mode choice. After retirement, elderly people's travel purposes shift from "survival-oriented" to "life-oriented" activities (such as shopping and leisure), with a reduction in travel range, frequency, and duration. Health status and medical needs also have a direct impact, as medical visits and checkups become major travel purposes for the oldest age groups.

Second, spatial and geographic factors are influential. Whether urban-to-rural or rural-to-rural travel, trips tend to be limited to short distances and localized areas. Especially for elderly residents in peripheral townships, connections to urban core areas are weak, and activities tend to revolve around their immediate surroundings. The urban-rural spatial structure difference means urban centers—with their dense resources—attract more township elderly for medical visits, shopping, and family visits; meanwhile, township-to-township travel is more oriented toward daily needs like shopping and caregiving, with smaller service facility disparities leading to weaker incentives for cross-township trips. Both urban-rural and rural-rural elderly population flows are largely confined within municipal and district/county boundaries, with relatively few cross-administrative boundary connections, reflecting the continuing barrier effect of administrative borders on travel behavior.

Third, transportation and service facility distribution matter. The proportion of high-age elderly using public transit declines due to fixed routes, boarding difficulties, and balance issues, limiting their willingness to use buses. Township transportation infrastructure is relatively weak, making walking the primary mode; rigid needs such as medical visits often rely on taxis or private cars. Currently, elderly self-driving rates are low, but with generational shifts and improvements in transportation systems, township elderly driving rates may increase in the future, which could in turn affect travel frequency and range.

Fourth, social relationships and family structure influence travel motivations. The residential distribution of relatives affects travel purposes; urban-rural family visits are closely related to children's places of residence. Family structure and intergenerational residential separation are important drivers of elderly cross-regional travel. Daily caregiving responsibilities, such as picking up grandchildren and managing household chores, increase travel frequency within townships, especially among those aged 60 to 70.

5. Conclusions

The travel behavior of elderly residents in townships is characterized by "short-distance, life-oriented, and high dependency," influenced by multiple factors including age-related physical capacity, service resources, transportation infrastructure, and spatial structure. Elderly travel is not only a transportation issue but also an important reflection of eldercare services, urban-rural integration, and social equity. The travel needs of township elderly should be incorporated into long-term strategies for urban-rural integration and the equalization of public services. Through a combination of "soft and hard" measures, a low-cost, highly accessible, continuously serviced, and user-friendly travel system should be built. This paper proposes the following planning and policy recommendations focusing on transportation facilities, service layout, travel support, and spatial coordination:

1. Improve Elderly-Friendly Transportation Facilities System: Optimize non-motorized transport systems and enhance the age-appropriateness of public transit services. Improve bus route coverage to address shortcomings in inter-urban and rural transit, and increase medium- and short-distance shuttle lines between core towns and townships. Promote "customized bus" services by piloting appointment-based travel services for the elderly, meeting high-frequency demands such as medical visits and shopping.

2. Strengthen Balanced Layout of Public Service Resources Between Urban and Rural Areas and Townships: Address gaps in basic township-level services and enhance medical, shopping, and cultural facilities in central towns to meet elderly residents' daily needs for shopping, entertainment, and medical care, thereby reducing pressure for cross-district travel. Allocate medical resources reasonably and establish grassroots medical outreach for the elderly, especially in remote townships, promoting "village doctors at home" services to reduce travel for medical care among the oldest elderly. Enrich local activity spaces for the elderly by establishing senior centers, cultural halls, and other venues in townships to foster localized social and recreational environments.

3.Promote Diversified Travel Support Policies for the Elderly: Expand age-friendly transportation subsidies, especially for elderly individuals with high cross-district travel frequency between urban and rural areas (such as those regularly seeking medical care), to alleviate economic burdens. Establish a dynamic elderly travel data monitoring system that integrates mobile signaling data, transportation surveys, and community feedback to identify demand hotspots and weak points dynamically, supporting infrastructure optimization. Encourage volunteers or social workers to assist elderly persons during frequent and essential trips (e.g., medical visits, errands), improving travel safety and comfort.

4. Promote Cross-Administrative Regional Coordination and Resource Sharing: Strengthen regional collaborative transportation planning and establish mechanisms for elderly cross-city travel coordination in highly integrated areas. Optimize the allocation of cross-boundary public service resources, especially in regions where elderly residents frequently travel to other cities for medical care (e.g., elderly residents from Suzhou seeking treatment in Shanghai). Facilitate medical insurance recognition across cities, dedicated direct transit lines, and service linkage mechanisms.

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Why public transport interventions work or not? A meta-analysis based on the behaviour change wheel model

Jiayu Gu, Luyao Niu & Wenjia Zhang

Abstract

Public transportation promotion policies are vital for reducing carbon emissions, improving public health, and fostering sustainable urban development. However, assessing their effectiveness is challenging due to inconsistent research findings and methodologies stemming from varied classification criteria. Additionally, existing meta-analyses often fail to explain why certain policies are more effective, primarily due to a lack of theoretical frameworks underlying these policies. This uncertainty can lead to the misallocation of financial resources, diminished public trust in policy initiatives, reduced overall policy impact, and the persistence of inefficient urban growth patterns. Therefore, there is an urgent need to develop a clear and unified classification framework for evaluating public transport policies, which would standardize future research and meta-analyses, thereby promoting deeper insights and advancements in this field. To address the research gap, our study pioneers the use of the Behaviour Change Wheel (BCW) to analyze public transport policies. Originally developed for public health and environmental protection, the BCW enhances policy design by systematically integrating factors that drive individual behavior change. This framework breaks down interventions into three layers: policy, intervention strategies, and the Capability-Opportunity-Motivation-Behaviour (COM-B) model. Within the BCW, the intervention strategies layer encompasses targeted actions that directly influence behaviors, while the COM-B layer identifies and addresses the key factors—capability, opportunity, and motivation—that drive or impede these behaviors. Existing research has extensively evaluated the impact of public transportation promotion policies using the Behaviour Change Wheel (BCW) framework, which comprises three dimensions: policy, intervention strategies, and the Capability-Opportunity-Motivation-Behaviour (COM-B) model. The policy layer categorizes these policies into six types: **1) Guidance; 2) Environmental and social planning; 3) Service provision; 4) Fiscal; 5) Communication and marketing; 6) Regulations,** which are further broken down into specific strategies within the intervention layer and analyzed for their effects on individuals' capabilities, opportunities, and motivations in the COM-B layer. By conducting a meta-analysis across all three layers, this study aims to provide a deeper understanding of policy effectiveness, particularly in explaining why certain interventions are more effective than others.To deepen the analysis of policy effectiveness, this study conducted a meta-analysis within the BCW framework, synthesizing data from 24 high-quality studies across 16 countries with over 5.59 million data points. We systematically coded each policy into the BCW's three layers and performed stratified subgroup analyses to investigate the causal effects and mechanisms of six public transportation policy categories in promoting transit adoption. The key findings are as follows:

1. The overall meta analysis effect size of public transport policies is 0.5165. Within the policy layer, only guidance policies surpass this average; in the intervention strategies layer, incentivization, coercion & restrictions, modelling, and enablement demonstrate effect sizes above the average; within the COM-B layer, social opportunity and automatic motivation show effect sizes that exceed the mean.
2. Guidance policies are the most effective in promoting public transit adoption (n=12, d=0.881), including incentivization, education, and coercion & restriction interventions. They work well because they enhance reflective motivation (n=7, d=0.3418), automatic motivation (n=5, d=0.9034), and physical opportunities (n=5, d=0.4102), providing strong support for behavioral change.

3. Environmental and social planning policies are least effective policies (n=17, d=0.2093), including environmental restructuring interventions. These measures mainly improve physical opportunities through environmental changes (n=16, d=0.4102), but their limited impact on motivation makes it harder to sustain long-term behavior change.

4. Service provision policies provide substantial long-term benefits (n=21, long term d= 0.5285), which combine environmental restructuring and enablement interventions. These approaches strengthen automatic and reflective motivation (n=7, long term d= 0.6998; n=11, long term d=0.4148) and physical opportunities (n=17, long term d=0.438), leading to both immediate behavior changes and sustained public transit adoption.

Keyword: Public Transit; Behavior Change Wheel; Policy Intervention; Meta-Analysis;

1.Introduction

Public transportation interventions are essential for reducing carbon emissions, improving public health, and promoting sustainable urban development (C40 Cities, 2021; Doru, 2021; Bibri et al., 2020). In recent years, the number of studies on various public transportation interventions has been steadily increasing, signifing the academic community's growing focus on optimizing public transportation system interventions and promoting sustainable travel modes (Bamberg et al., 2021)2015(Pluntk, 2013;Gaerling et al., 2022;Zeiske et al., 2021). However, the effectiveness of these interventions presents significant challenges, as current research often lacks

consistency in findings and methodologies due to the varying criteria used to classify interventions.
Even existing meta-analyses fail to explain why a particular intervention is effective, due to a lack of theoretical basis for the mechanisms through which these interventions operate. Therefore, this underscores the need for a more systematic approach to evaluate these measures.

A significant challenge in current public transportation research is the absence of a clear theoretical framework and standardized classification for intervention measures. Existing studies attempt to categorize interventions into two categories (Bamberg et al., 2011; Graham-Rowe et al., 2011; Steg, 2003): "hard" interventions aim to change transportation behavior by modifying the physical environment (e.g., building bicycle lanes) and through legal or economic policies (e.g., congestion pricing); "soft" interventions aim at influencing people's beliefs, attitudes, values, and norms (Steg, 2003, p. 190) , which rely on persuasion, incentives, information provision, etc (Möser & Bamberg, 2008). However, these classifications often lack consistent theoretical support, leading to blurred boundaries between categories,. For example, policies like introducing car-sharing schemes, which including both infrastructure and promotion, may simultaneously fall into both "hard" and "soft" interventions (Berg et al., 2019). The current binary classification system complicates the systematic understanding and evaluation of intervention effects, hinders the development of a unified framework for assessing their effectiveness, and obstructs the integration and application of research findings in policy design. Consequently, there is an urgent need to establish a clear and unified classification framework for intervention measures. Such a framework would provide standardized guidance for future public transportation research and meta-analyses, fostering deeper insights and advancements in this field.

A significant body of existing studies has focused on classifying and evaluating the effectiveness of different public transportation policies. However, these studies often fall short in explaining why certain policies are more effective than others. While some research has attempted to employ methods such as SEM, ITS, and targeted learning to shed light on policy mechanisms(Niu & Zhang, 2023; Thorhauge et al., 2019; Y. Zhang et al., 2025), these approaches are often empirical and subjective, subject to contextual changes. Our perspective is that to understand the true mechanisms behind policy effectiveness, it is crucial to recognize that a single policy can be implemented through a variety of interventions, each driven by distinct subjective motivations, which can lead to varying outcomes depending on the contextual backdrop. Thus, to offer more applicable policy recommendations, we have to analyze both the objective interventions and the subjective motivations behind policies. Additionally, we find that many existing studies focus solely on the immediate effectiveness of policies, neglecting their long-term impacts, which may evolve or accumulate over time and require a temporal perspective for a more comprehensive analysis.

The Behaviour Change Wheel (BCW) offers a solution by providing a comprehensive framework that dissects interventions into three interconnected layers: policy, intervention strategies, and the Capability-Opportunity-Motivation-Behaviour (COM-B) model. Originally applied in public health and environmental protection, BCW helps in understanding and designing effective policies by systematically integrating the factors driving individual behavior change. By breaking down each intervention policy into specific strategies and examining how these strategies influence individuals' capabilities, opportunities, and motivations, BCW facilitates a deeper analysis of why certain interventions are effective. This framework thus bridges the gap in existing research, providing a more nuanced understanding of the mechanisms through which public transportation policies can achieve their intended outcomes.

In this study, we aim to apply the Behaviour Change Wheel (BCW) framework to clearly demonstrate how public transport interventions achieve their effects and conduct a meta-analysis within this framework. The primary goal of this approach is to address key questions left unanswered by existing research:

1. Do the seven types of policies—Regulation, Service Provision, Communication and Marketing, Environmental and Social Planning, Guidelines, Fiscal Measures, and Legislation—effectively influence individuals' travel behavior and encourage greater use of public transportation?
2. What explains the varying effectiveness of these policies, considering the different intervention strategies and the underlying motivations driving them?
3. How do the effects of these policies differ when implemented in the short term versus the long term, and what mechanisms account for these differences?

The paper is structured as follows. Section 2 presents a literature review, discussing existing studies on the effectiveness of public transport interventions and defining the Behaviour Change Wheel while exploring its application in understanding the mechanisms behind public transport interventions. Section 3 outlines the methodology used for our meta-analysis, along with details of our data cleaning, coding, and analysis processes. In Section 4, we present the results of the meta analysis, providing a detailed explanation of the specific processes involved in various public transport interventions. Finally, Section 5 discusses the implications of our findings for policymakers.

2.Literature Review

2.1 Effectiveness of Public Transport Interventions

Public transportation interventions play a crucial role in promoting sustainable urban development and improving residents' travel behaviors. In existing studies, public transportation interventions are generally categorized into several types:1 built environment improvement, including.....2)... (such as infrastructure upgrades and transportation network optimization), soft interventions (such as public education and behavior guidance), incentive measures (such as economic incentives and subsidies), and planning policies (such as land use policies and traffic control) (Bamberg et al., 2021)2015(Pluntk, 2013;Gaerling et al., 2022;Zeiske et al., 2021). These classification methods vary across studies but share a common goal of increasing public transportation usage and reducing reliance on private vehicles.

The effectiveness of different intervention types varies significantly in evaluation. For example, built environment improvements can substantially enhance the attractiveness of public transportation, but their effectiveness often depends on long-term implementation and substantial financial investment(Kärmeniemi et al., 2018). Soft interventions and incentive measures are more flexible, but their effectiveness may vary depending on the target audience (Semenescu et al., 2020). Additionally, the effectiveness of planning policies is often closely linked to the enforcement strength and consistency of local governments. Therefore, when evaluating the effectiveness of public transportation interventions, it is essential to carefully distinguish and analyze the effects of different types of interventions (Tirachini & Cats, 2020)2020.

In recent years, many studies have employed meta-analysis to synthesize and evaluate the effectiveness of various public transportation interventions on travel behavior. These analytical methods integrate results from multiple studies to provide quantitative support for the overall effectiveness of different interventions. However, while meta-analyses can reveal which interventions are generally more effective, they often fail to explore why these interventions work and struggle to uncover the underlying mechanisms. Particularly due to the diversity of research methods and data sources, meta-analysis results often lack consistency in explaining the effectiveness of interventions (Pluntk, 2013; Gaerling et al., 2022; Zeiske et al., 2021).

2.2 Application of the BCW in Understanding Public Transport Intervention

To better understand the mechanisms through which public transportation interventions achieve their effects, it is necessary to introduce a framework that can systematically analyze these measures. In this context, the Behaviour Change Wheel (BCW), a comprehensive framework for analyzing behavioral interventions, offers a new perspective for understanding and optimizing the effectiveness of public transportation interventions (Bamberg et al., 2021)2015.

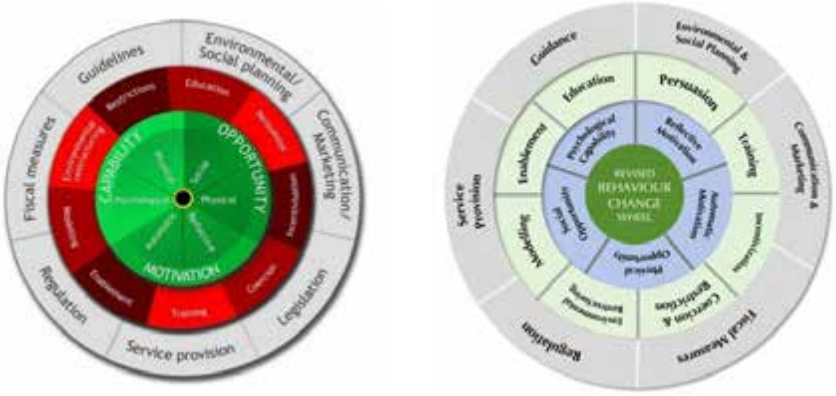
The Behaviour Change Wheel (BCW) is a comprehensive behavioral intervention analysis framework proposed by Michie et al. in 2011, aimed at unifying and simplifying interdisciplinary theories of behavior change. The BCW model integrates 19 different behavior analysis frameworks and uses the Capability-Opportunity-Motivation-Behavior (COM-B) model to systematically identify and design effective behavioral interventions. The structure of BCW consists of three layers: the core layer, which is the COM-B model; the intervention strategy layer; and the policy layer (Michie et al., 2011)but it is not clear how well they serve this purpose. This paper evaluates these frameworks, and develops and evaluates a new framework aimed at overcoming their limitations. A systematic search of electronic databases and consultation with behaviour change experts were used to identify frameworks of behaviour change interventions. These were evaluated according to three criteria: comprehensiveness, coherence, and a clear link to an overarching model of behaviour. A new framework was developed to meet these criteria. The reliability with which it could be applied was examined in two domains of behaviour change: tobacco control and obesity. Nineteen frameworks were identified covering nine intervention

functions and seven policy categories that could enable those interventions. None of the frameworks reviewed covered the full range of intervention functions or policies, and only a minority met the criteria of coherence or linkage to a model of behaviour. At the centre of a proposed new framework is a 'behaviour system' involving three essential conditions: capability, opportunity, and motivation (what we term the 'COM-B system'. Currently, the BCW has been widely applied in various fields, including public health (e.g., smoking cessation and obesity prevention), environmental protection (e.g., reducing plastic waste), and healthcare (Belanger-Gravel, 2019; Gould et al., 2017) Coupe et al., 2021). These application cases demonstrate that the BCW has broad applicability and practicality in understanding and designing behavioral interventions.

Although the BCW has been successfully applied in multiple fields, its application in public transportation interventions remains relatively limited. However, with the onset of the COVID-19 pandemic, the potential of the BCW in transportation behavior analysis has gradually emerged. For example, Wells et al. (2022) utilized the BCW model to analyze post-pandemic traveler behavior in selecting distant destinations, finding that improving transportation facilities and providing value-based social information effectively changed travel behavior . Similarly, Krusche et al. (2022) used the BCW to analyze the barriers and facilitators of public transportation use among UK residents to identify more effective communication strategies that could enhance public confidence in using public transportation.

2.3 BCW in Public intervention policy research

The BCW model, with its three-layer structure, provides a systematic analytical tool for understanding the specific pathways through which public transportation interventions exert their effects. First, the COM-B model helps identify how interventions influence individuals' capabilities, opportunities, and motivations, thereby guiding behavior change. Second, the intervention strategy layer offers nine strategies targeting different behavioral influences, which can be used to design more effective public transportation interventions. Finally, the policy layer provides the necessary policy support and environmental conditions for implementing these strategies (Michie et al., 2011)but it is not clear how well they serve this purpose. This paper evaluates these frameworks, and develops and evaluates a new framework aimed at overcoming their limitations. A systematic search of electronic databases and consultation with behaviour change experts were used to identify frameworks of behaviour change interventions. These were evaluated according to three criteria: comprehensiveness, coherence, and a clear link to an overarching model of behaviour. A new framework was developed to meet these criteria. The reliability with which it could be applied was examined in two domains of behaviour change: tobacco control and obesity. Nineteen frameworks were identified covering nine intervention functions and seven policy categories that could enable those interventions. None of the frameworks reviewed covered the full range of intervention functions or policies, and only a minority met the criteria of coherence or linkage to a model of behaviour. At the centre of a proposed new framework is a 'behaviour system' involving three essential conditions: capability, opportunity, and motivation (what we term the 'COM-B system'. By utilizing the BCW model, researchers and policymakers can gain deeper insights into and optimize the effectiveness of public transportation interventions. This enables the design of more targeted and effective strategies that increase public transportation usage and ultimately achieve sustainable urban transportation systems.



a. The original Behavior Change Wheel **b.** the modified Behavior Change Wheel in this study

Fig. 1 The framework of Behavior Change Wheel

3.Method

This study conducted a systematic review and meta-analysis following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (see Fig. 2), to evaluate the effectiveness of interventions designed to promote public transportation use. Strict inclusion, exclusion criteria, and a structured team-based review process ensured the reliability of study selection and the inclusion of high-quality evidence. The research procedure involved developing a search strategy, selecting relevant databases, defining screening criteria, reviewing and selecting studies, extracting and coding eligible data, and performing the meta-analysis.

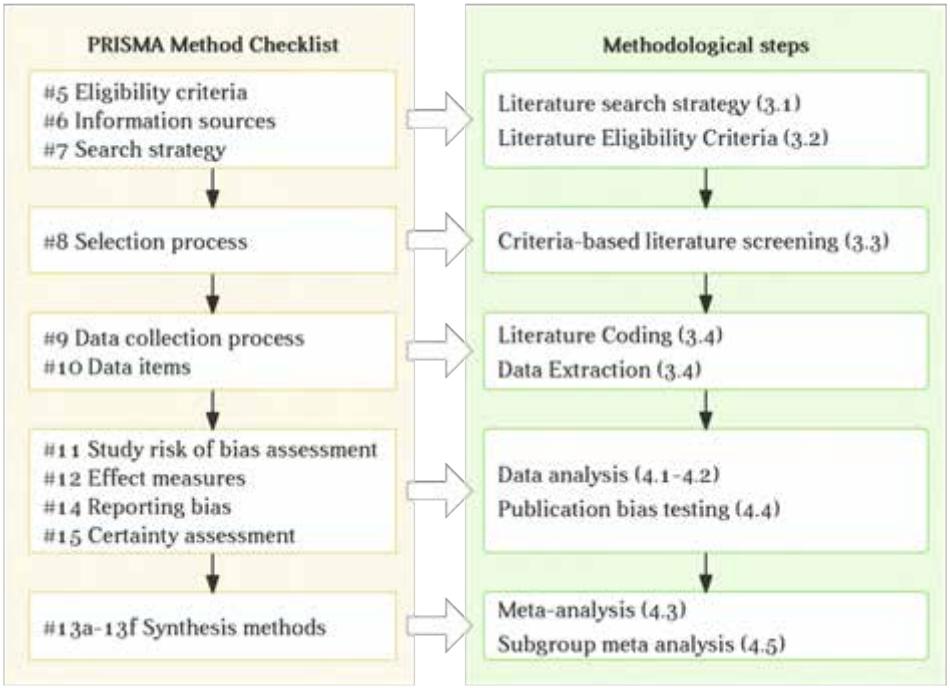


Fig. 2 PRIMA Checklist

3.1 Literature Search Method

The literature search primarily focuses on interventions aimed at promoting public transportation use. The search strategy incorporated key terms (see Supplemental Material Table S1) related to

- public transport modes (e.g., “public transport”, “bus”, “metro”, “rail”, “BRT”).
- intervention behaviors (e.g., “reduce”, “decrease”, “incentive”, “promote”).
- intervention types (e.g., “built environment”, “policy”, “program”).
- study designs (e.g., “natural experiment”, “quasi-experiment”).

The main databases are Scopus, Web of Science, and the Transportation Research Information Service (TRIS). Additionally, reference lists of included studies were manually screened (snowballing) to identify potentially relevant research missed by the database search.

3.2 Eligibility Criteria

Studies retrieved from the search were screened based on the following pre-defined inclusion and exclusion criteria:

(1) Publication Period: Studies published between 2000 and 2023.

(2) Language: Studies published in English.

(3) Publication Type: Peer-reviewed quantitative studies. Reviews, qualitative studies, and preprints were excluded.

(4) Research Field: Studies within behavioral science, transportation, mobility, urban planning, human geography, social sciences, urban studies, or geographic information systems. Studies from unrelated fields (e.g., biology, medicine, chemistry, physics) were excluded.

(5) Study Focus: Studies examining individual public transportation behavior (e.g., bus, BRT, subway, light rail).

(6) Study Design: Studies employing natural or quasi-experimental designs to assess interventions influencing the shift from non-use to regular use of public transport.

(7) Participants: Studies involving general population samples. Studies focusing on specific subgroups (e.g., children, women, students, elderly) were excluded.

(8) Intervention Type: Studies evaluating interventions explicitly designed to promote public transportation use. Studies where public transport use was an indirect outcome (e.g., impact of ride-sharing services like Uber) or where intervention effects were confounded by uncontrolled variables were excluded.

(9) Outcomes: Quantitative studies reporting outcomes related to actual public transport usage (e.g., mode share, frequency, trip duration), based on objective or self-reported data. Studies measuring only behavioral intentions or relying on hypothetical scenarios were excluded.

(10) Data Availability: Studies providing sufficient data to calculate effect sizes, including pre- and post-intervention means and standard deviations (SDs), or values convertible to SDs (e.g., 95% confidence intervals (CIs), standard errors (SEs), p-values, t-values), following Higgins et al. (2019). Studies were excluded if necessary data remained unobtainable after contacting authors for missing data.

3.3 Literature Screening Process

The initial search yielded 11,918 records. After removing 6,824 duplicates using Endnote, 5,094 records remained. Two researchers independently screened titles and abstracts based on criteria 3-5, resulting in 179 potentially relevant studies for full-text review.

These 179 full texts were then independently assessed by the same two researchers against all eligibility criteria (1-10). Disagreements were resolved through discussion with a third researcher. Ultimately, 24 studies (reporting 38 independent effect sizes) met all criteria and were included in the meta-analysis. Key reasons for exclusion at the full-text stage were: non-intervention studies (n=85), inappropriate statistical models (n=37), insufficient data for effect size calculation (n=28), and inaccessible full texts (n=5). The detailed screening process is illustrated in Fig. 3.

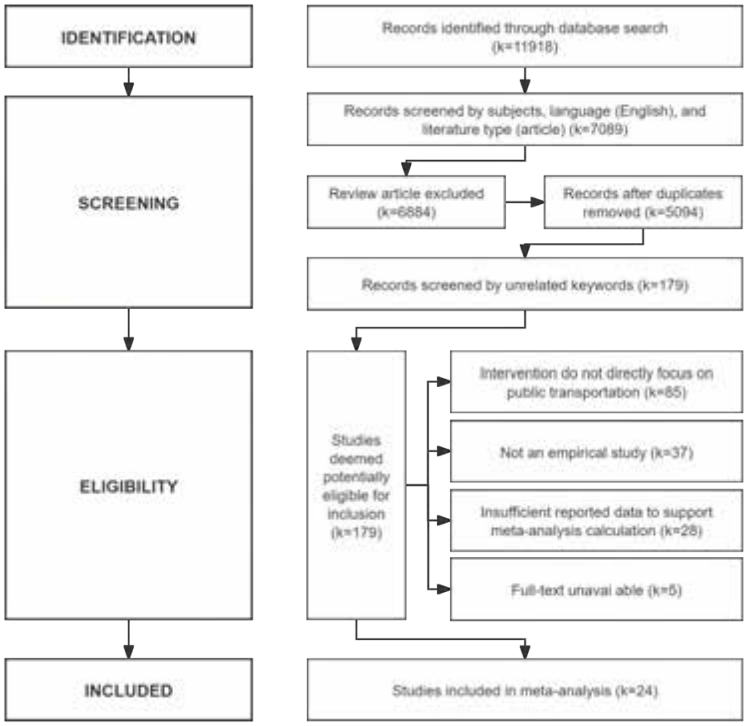


Fig. 3 Literature screening process and details

3.4 Data Extraction and Coding

We developed and employed a standardized form (details in Supplemental Material Table S2) to extract and code data from the 24 included studies (representing 38 effect sizes). Key information extracted included:

(1) Basic Study Information: Authors, publication year, source.

(2) Study Characteristics: Study Design, location (country/city), target transport mode, intervention duration (short-term: ≤180 days; long-term: >180 days), intervention start/end years, sample characteristics (unit of analysis, sample size, presence of self-selection).

(3) Intervention Description: Detailed account of the intervention implemented.

(4) Outcome Measures: Specific public transport behavior outcomes (e.g., ridership, frequency, share), measurement methods (objective/self-reported), data type (e.g., count, survey).

(5) Quantitative Results: Data required for effect size calculation (e.g., sample sizes, means, standard deviations, or convertible statistics like CIs, SEs, p-values, t-values).

(6) BCW Coding: Each intervention was classified according to the Behaviour Change Wheel (BCW) framework, including policy category, intervention function(s), and relevant COM-B components (Capability, Opportunity, Motivation). Detailed coding rules are in Supplemental Material Tables S3-S5.

Two researchers independently performed data extraction and coding. Discrepancies were resolved through discussion to ensure accuracy and consistency. Effect sizes (Cohen's d) and their standard errors (SE) were calculated or converted using the Campbell Collaboration's online tool (Wilson, 2023), following the methods recommended by Higgins (Higgins et al., 2019).

3.5 Meta-Analysis Strategy

This study performed a random-effects meta-analysis, assuming variability in true effect sizes across studies due to the diversity of interventions, contexts, and designs. The analysis strategy included:

(1) Handling Multiple Outcomes: If a study reported multiple related outcomes for one intervention, effect sizes were calculated for each and treated as independent comparisons in the analysis. Sensitivity analyses were conducted where potential dependencies existed.

(2) Handling Multiple Time Points: If a study reported outcomes at multiple post-intervention time points, effect sizes were calculated separately for the earliest (short-term) and latest (long-term) measurements.

(3) Sample Size Allocation: If intervention and control group sample sizes were not reported separately, the total sample size was divided equally between the groups.

(4) Heterogeneity Assessment: Cochran's Q test assessed statistical significance of heterogeneity, while the I^2 statistic quantified its magnitude (interpreting <25% as low, 25%-75% as moderate, and >75% as high heterogeneity)

(5) Moderator Effect Analysis: Subgroup analyses and meta-regression explored the influence of pre-specified moderators (e.g., BCW classifications, intervention duration, sample characteristics, location) on effect size variability.

(6) Publication Bias Assessment: We visually inspected funnel plot symmetry and used Egger's regression test to quantitatively assess potential publication bias.

All meta-analyses were conducted using the 'metafor' package in R software.

4.Results

4.1 Search Result

The literature search initially yielded 11,918 records across the selected databases (Fig. 3). After removing duplicates, 5,094 records remained for title and abstract screening, from which 179 studies were selected for full-text review. Following the application of all eligibility criteria and excluding five articles where the full text could not be accessed, 24 studies were deemed relevant. These 24 studies reported a total of 38 independent effect sizes, which formed the basis for this meta-analysis.

4.2 Study Characteristics

Key characteristics were extracted from the 38 included effect sizes (derived from the 24 studies), as detailed in Supplemental Material Table S6. Publication years ranged from 2002 to 2023, with a majority (60.5%) published between 2020 and 2023. Geographically, studies originated primarily from the United States (n=15 effect sizes) and China (n=5), with others from the Netherlands (n=5), Singapore (n=4), Italy (n=2), and Japan (n=2). Interventions targeted buses (n=18), Bus Rapid Transit (BRT) (n=6), subways (n=5), and light rail (n=9).

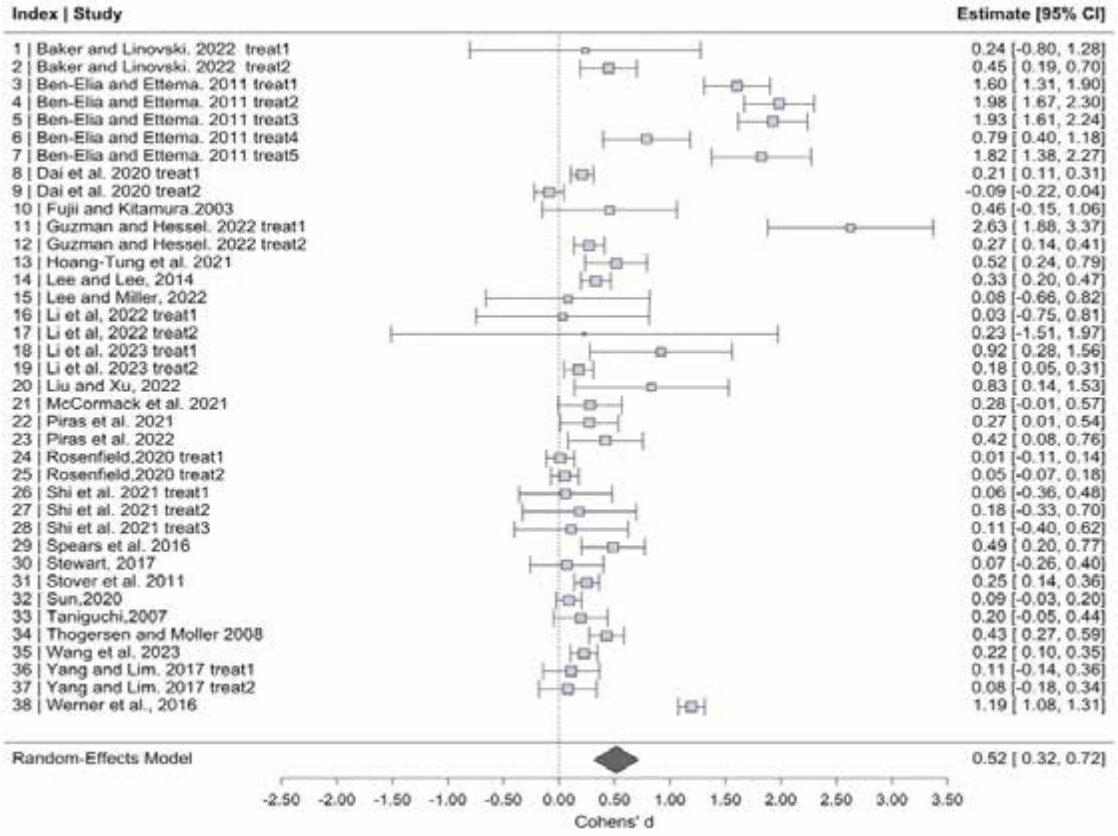
All included studies utilized experimental or quasi-experimental designs. Data sources varied, including travel big data (n=11), surveys (n=20), and statistical yearbooks (n=7).

Most interventions were classified as long-term, lasting over 180 days (57.9%), although intervention durations varied significantly, ranging from a single day to 15 years. The unit of analysis was typically the individual (n=22), but some studies analyzed effects at the level of roads/stations (n=11) or cities (n=5). Sample sizes were predominantly medium (n=20) or large (n=11), with fewer small samples (n=7). Baseline sample sizes ranged from 2 to 270,000, and follow-up samples ranged from 4,000 to 140,000. Most studies (n=27) employed designs that minimized self-selection bias. Control groups consisted of participants not exposed to the specific public transport intervention under investigation, while treatment groups received the intervention. Supplemental Material Table S7 provides a summary of the interventions.

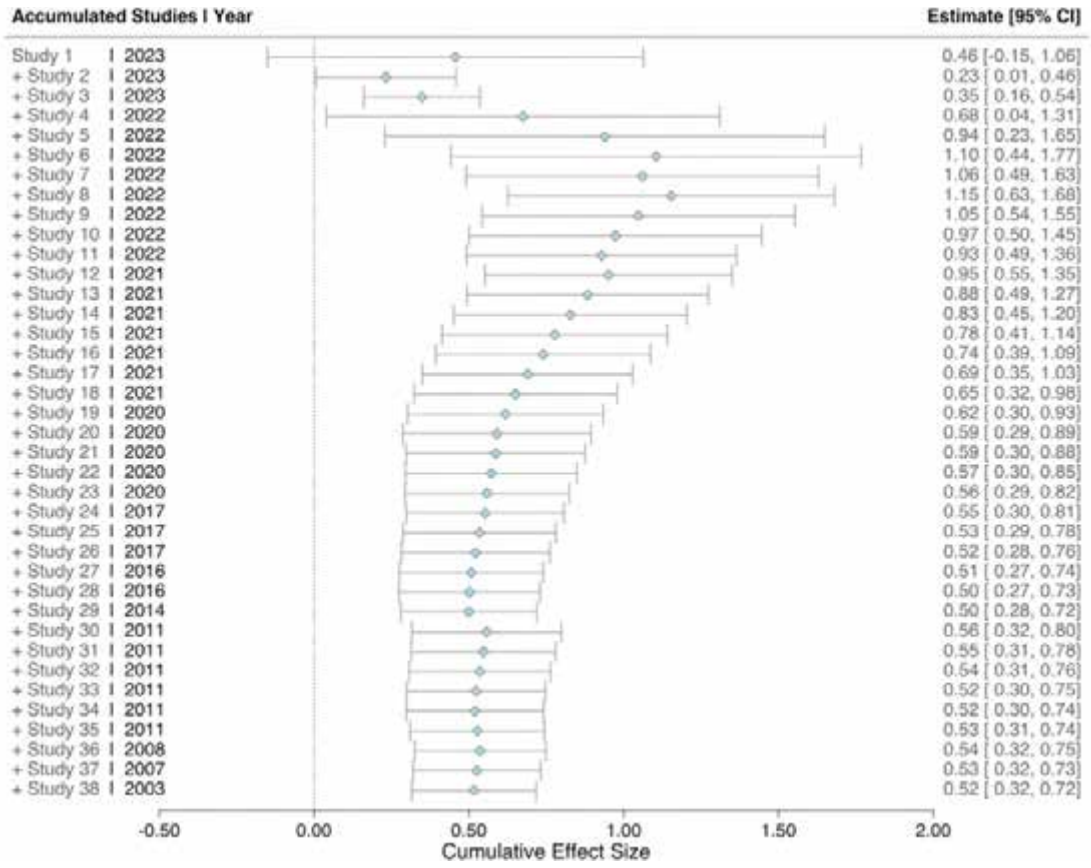
The primary outcome measure across studies was public transport usage frequency or ridership, although some also reported changes in total trips, distance, or mode share (Hoang-Tung et al., 2021; Li et al., 2023a; McCormack et al., 2021). Effect sizes (Cohen's d) and standard errors were calculated for each study outcome. Supplemental Material Table S8 summarizes sample sizes, results, and effect characteristics for each included effect size.
Overall, interventions generally showed a positive effect on public transport usage. However, some studies reported non-significant findings (Marshall Baker & Linovski, 2022), and the magnitude of effects varied considerably across interventions. No studies reported negative (suppressive) effects, likely because all included studies focused on promoting public transport. This variability underscores the importance of investigating potential moderators of intervention effectiveness.

4.3 Meta Analysis and Moderators

We used Cohen's d as the standardized effect size metric to quantify the impact of interventions on public transportation behavior. Positive Cohen's d values indicate that the intervention promoted public transport use. Conventionally, effect sizes are interpreted as small ($d < 0.2$), moderate ($0.2 \leq d < 0.8$), or large ($d \geq 0.8$). Given the substantial expected heterogeneity across the diverse interventions, study designs, contexts, and measurement approaches, we employed a random-effects model for synthesizing the 38 independent effect sizes.



a. Forest Plot of Meta Analysis



b. Cumulative Forest Plot

Fig 4. Results of General Meta-Analysis

The meta-analysis included 38 effect sizes from 24 studies, encompassing a total of 756,328 participants. Using a random-effects model, the overall summary effect size was moderate and statistically significant (Cohen's d = 0.5165, 95% CI [0.3158, 0.7172], z = 5.0437, p < 0.0001). This indicates that, on average, interventions effectively promoted public transportation use.

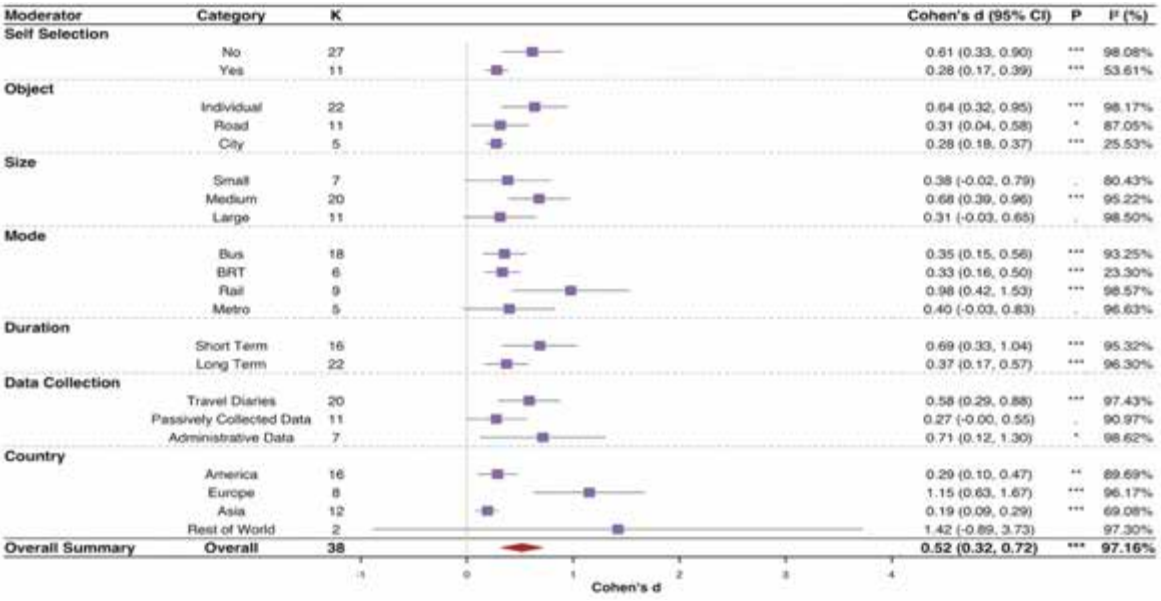


Fig. 5 Moderators of the impact of interventions on public transport travel

Table 1. Moderators of the impact of interventions on public transport travel

Moderator	Category	k	Cohen_d	se	CI	P_Val	I2
Self Selection	No	27	0.6147	0.6147	[0.3336,0.8957]	***	98.08%
	Yes	11	0.2787	0.2787	[0.1709,0.3865]	***	53.61%
Object	Individual	22	0.636	0.6360	[0.3245,0.9474]	***	98.17%
	Road	11	0.3123	0.3123	[0.0404,0.5842]	*	87.05%
	City	5	0.2751	0.2751	[0.1839,0.3664]	***	25.53%
Size	Small	7	0.3834	0.3834	[-0.0223,0.7891]	.	80.43%
	Medium	20	0.6774	0.6774	[0.3912,0.9635]	***	95.22%
	Large	11	0.3104	0.3104	[-0.0312,0.652]	.	98.50%
Mode	Bus	18	0.3518	0.3518	[0.1478,0.5558]	***	93.25%
	BRT	6	0.3313	0.3313	[0.1649,0.4977]	***	23.30%
	Rail	9	0.9768	0.9768	[0.4248,1.5287]	***	98.57%
	Metro	5	0.3975	0.3975	[-0.0337,0.8288]	.	96.63%
Duration	Short Term	16	0.6856	0.6856	[0.3334,1.0379]	***	95.32%
	Long Term	22	0.3718	0.3718	[0.1686,0.575]	***	96.30%
Data Collection	Travel Diaries	20	0.5845	0.5845	[0.2936,0.8754]	***	97.43%
	Passively Collected Data	11	0.2748	0.2748	[-0.0035,0.5531]	.	90.97%
	Administrative Data	7	0.7132	0.7132	[0.1228,1.3036]	*	98.62%
Country	America	16	0.2868	0.2868	[0.102,0.4715]	**	89.69%
	Europe	8	1.1498	1.1498	[0.6298,1.6698]	***	96.17%
	Asia	12	0.1923	0.1923	[0.0902,0.2945]	***	69.08%
	Rest of World	2	1.42	1.4200	[-0.887,3.7269]		97.30%
Total		38	0.5165	0.1024	[0.3158, 0.7172]	***	97.16%

However, significant heterogeneity was detected across studies ($Q(37) = 706.93$, $p < 0.0001$; $I^2 = 97.16\%$), indicating substantial true variation in intervention effects beyond sampling error (Semenescu et al., 2020). This high heterogeneity necessitated moderator analyses to explore potential sources of variation.

We examined several pre-specified moderators related to study characteristics (Table 1). Significant differences in effect sizes were found based on the unit of analysis: interventions showed larger effects when measured at the individual level (d = 0.636, n = 22) compared to the road/station (d = 0.312, n = 11) or city level (d = 0.275, n = 5). Effect sizes were notably larger in studies with medium sample sizes (d = 0.677, n = 20) compared to those with large (d = 0.310, n = 11) or small samples (d = 0.383, n = 7). Data collection method also moderated effects: studies using statistical yearbook data reported the largest average effect (d = 0.713, n = 7), followed by survey data (d = 0.584, n = 20), while studies using objective measurements (e.g., smart card data) showed smaller effects (d = 0.275, n = 11). Studies avoiding self-selected samples reported larger effects (d = 0.615, n = 27) than those with potentially self-selected participants (d = 0.279, n = 11), suggesting self-selection bias may attenuate observed effects. Regional differences were observed, with interventions appearing generally more effective in Europe, Africa, and South America compared to North America and Asia. Effects also varied by transport mode, with light rail interventions showing the strongest effects compared to bus, subway, or BRT interventions.

High heterogeneity persisted within several moderator subgroups, particularly for studies using individual or city samples, medium sample sizes, statistical data, non-self-selected samples, and long-term interventions. The duration of the intervention emerged as a key factor related to heterogeneity; long-term interventions exhibited higher variability than short-term ones. Furthermore, cumulative meta-analysis suggested a trend of decreasing effect sizes over time (Fig. 4b), potentially indicating that initial intervention impacts may diminish as the duration increases.

4.4 Publication Bias

We assessed potential publication bias using a funnel plot (Fig. 5) and Egger's regression test. The funnel plot visually relates study effect sizes to their precision. A symmetrical plot suggests low risk of bias, while asymmetry can indicate missing studies (often those with non-significant or small effects). Our funnel plot displayed some asymmetry, with studies clustering more densely on the right side (positive effects), particularly in the lower precision (bottom) part of the plot. This could suggest potential publication bias against non-significant or negative findings, or it might reflect the true distribution of effects given that all included interventions aimed to promote public transport use, coupled with the high heterogeneity observed.

Egger's regression test was performed to quantitatively assess funnel plot asymmetry. The result was not statistically significant ($t = 1.8661$, $p > 0.05$ [based on t-value and df=36]; intercept $b = 0.1310$, 95% CI [-0.1297, 0.3916]). Therefore, Egger's test did not provide significant evidence of publication bias. The observed asymmetry in the funnel plot is more likely attributable to the substantial heterogeneity among the included studies rather than systematic publication bias.

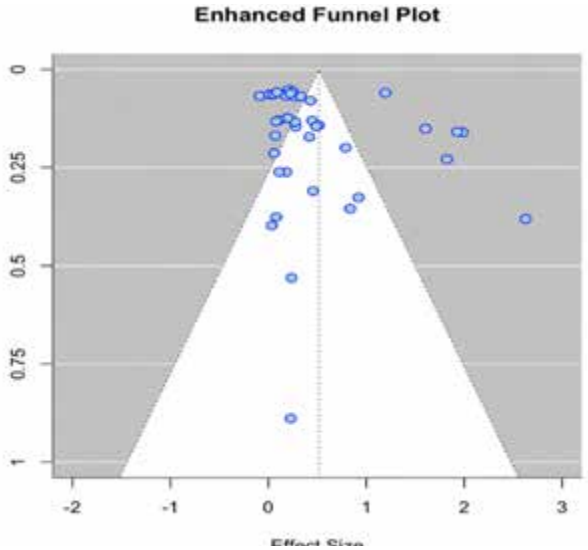


Fig. 6 Funnel plot of publication bias

4.5 Intervention and BCW

We coded the interventions from the 38 included effect sizes according to the three layers of the BCW framework: policy categories, intervention functions, and COM-B components (details in Supplemental Material Table S3-S5). Subgroup analyses were conducted based on these BCW classifications to evaluate differential effects on public transportation behavior (Table 2). Following common meta-analytic practice, subgroup analyses are reported only for categories containing three or more independent effect sizes(Leong et al., 2023).

4.5.1 Policy Categories

At the policy level, representing macro-level strategies, interventions most frequently involved Service Provision (e.g., real-time bus information; n=19), Environmental and Social Planning (e.g., new subway lines; n=16), and Guidance (e.g., bus riding guides; n=12). Subgroup analysis revealed significant differences in effectiveness, with Guidance policies showing the largest positive effect ($d = 0.881$, n=12, $I^2 = 95.3\%$), while Environmental and Social Planning policies showed the smallest effect ($d = 0.209$, n=16, I^2 high). Service Provision ($d = 0.462$, n=19, $I^2 = 97.7\%$) and Fiscal policies (e.g., monthly passes; $d = 0.418$, n=10, I^2 high) also yielded moderate positive effects. Communication/Marketing and Regulation policies were excluded from subgroup analysis due to insufficient

studies (n<3). High heterogeneity was observed within most policy categories. Intervention duration significantly moderated policy effects: Guidance policies were most effective in the short-term (≤ 80 days; d = 1.087, n=8), whereas Communication/Marketing (d = 0.555, n=3) and Service Provision (d = 0.529, n=14) demonstrated substantial positive effects over the long-term (> 180 days). Although Fiscal policies showed positive long-term effects (d=0.656, n=5), this was not statistically significant. Notably, Guidance policies had significantly stronger short-term effects compared to their long-term impact (d=0.380, n=4), while Communication/Marketing effects appeared stronger long-term (short-term d=0.261, n=3). Heterogeneity remained high within policy subgroups across both short- and long-term durations, particularly for Guidance, Service Provision, and Fiscal policies.

Table 2. Effect sizes of interventions categorized by the BCW framework

Subgroup		Duration	Estimate	CI	pval
Policy					
	Guidance	Total	0.881	[0.4379,1.3241]	***
		Long term	0.3796	[-0.0466,0.8058]	.
		Short term	1.0872	[0.5093,1.6651]	***
	Environmental & Social Planning	Total	0.2093	[0.1048,0.3139]	***
		Long term	0.1968	[0.0862,0.3073]	***
		Short term	0.2653	[-0.0388,0.5694]	.
	Communication and Marketing	Total	0.3077	[0.1334,0.4821]	***
		Long term	0.5547	[0.0297,1.0798]	*
		Short term	0.261	[0.0768,0.4453]	**
	Service Provision	Total	0.4615	[0.2393,0.6838]	***
		Long term	0.5285	[0.2113,0.8457]	**
		Short term	0.3473	[0.208,0.4867]	***
	Fiscal Measures	Total	0.4275	[-0.0102,0.8652]	.
		Long term	0.6561	[-0.2136,1.5259]	
		short term	0.1492	[0.0077,0.2907]	*
Intervention		Total			
	Education	Total	0.2595	[0.0928,0.4262]	**
		Long term	0.3796	[-0.0466,0.8058]	.
		Short term	0.2729	[0.1151,0.4307]	***
	Persuasion	Total	0.2729	[0.1151,0.4307]	***
		Short term	0.2729	[0.1151,0.4307]	***
	Incentivization	Total	0.9719	[0.454,1.4897]	***
		Long term	0.9451	[-0.6312,2.5214]	
		Short term	0.9959	[0.4499,1.5418]	***
	Restriction & Coercion	Total	1.1118	[0.5637,1.6599]	***

		Short term	1.3968	[0.8273,1.9663]	***
	Environmental Restriction	Total	0.3177	[0.1538,0.4816]	***
		Long term	0.34	[0.1435,0.5365]	***
		Short term	0.26	[0.0137,0.5064]	*
	Modeling	Total	0.5547	[0.0297,1.0798]	*
		Long term	0.5547	[0.0297,1.0798]	*
	Enablement	Total	0.5756	[0.0916,1.0597]	*
		Long term	0.6634	[-0.1462,1.4731]	
		Short term	0.4291	[0.2911,0.5671]	***
COM-B		Total			
	Psychological Capability	Total	0.2459	[0.114,0.3777]	***
		Long term	0.2613	[-0.033,0.5556]	.
		Short term	0.3361	[0.2144,0.4578]	***
	Social Opportunity	Total	0.5547	[0.0297,1.0798]	*
		Long term	0.5547	[0.0297,1.0798]	*
	Physical Opportunity	Total	0.4102	[0.2018,0.6186]	***
		Long term	0.4388	[0.1781,0.6996]	***
		Short term	0.3697	[0.1598,0.5797]	***
	Automatic Motivation	Total	0.9034	[0.4495,1.3573]	***
		Long term	0.6998	[-0.2017,1.6012]	
		Short term	1.0168	[0.4838,1.5498]	***
	Reflective Motivation	Total	0.3418	[0.1783,0.5053]	***
		Long term	0.4148	[0.1765,0.6532]	***
		Short term	0.2372	[0.0916,0.3828]	**

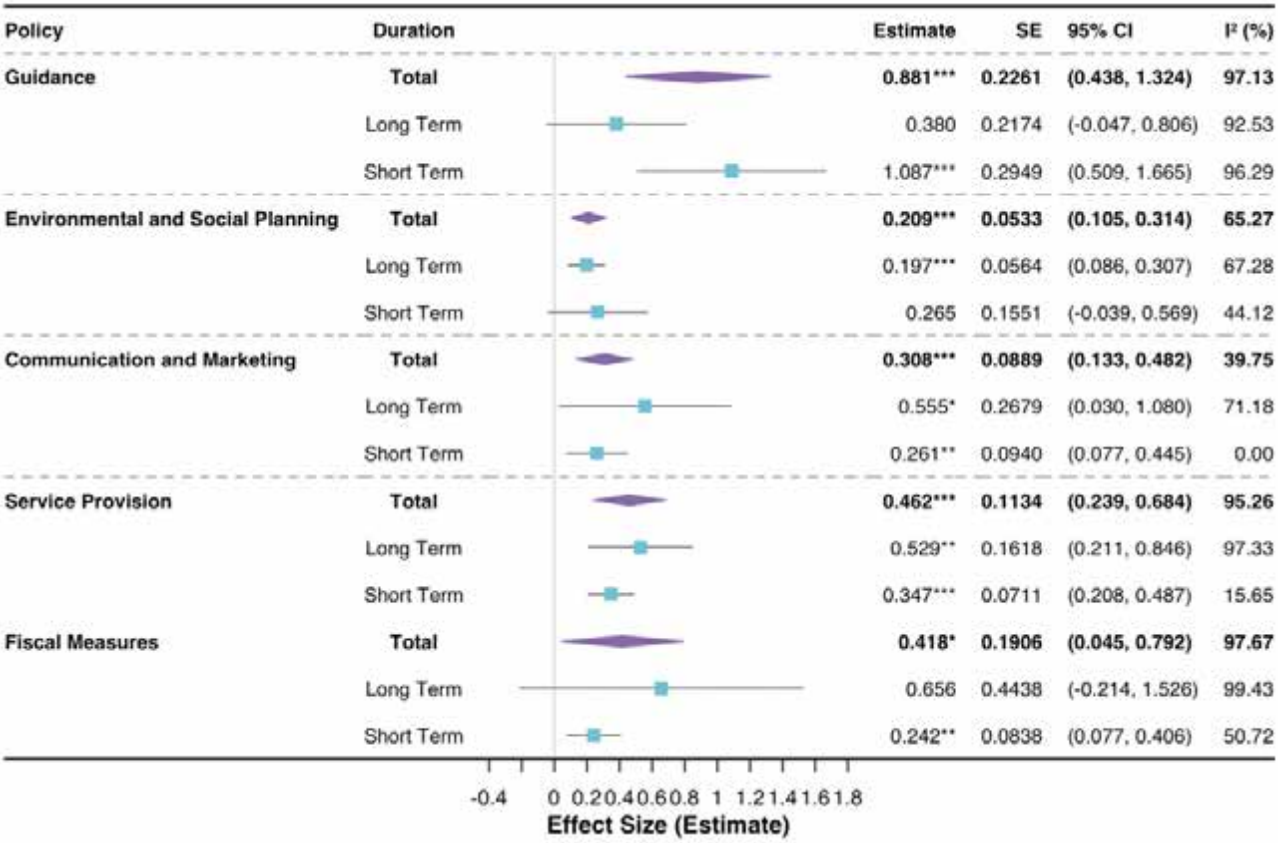


Fig. 7 Sub-group analysis of Policy Layer

4.5.2 Intervention Functions

Examining intervention functions, which describe the specific implementation mechanisms, we found Environmental Restructuring (e.g., building new lines; n=20), Incentivisation (e.g., free rides; n=12), and Enablement (e.g., passenger assistance; n=9) were the most common, while Persuasion (n=3) and Modelling (n=3) were least frequent. Subgroup analysis showed statistically significant positive effects for all functions with sufficient data. Coercion and Restriction yielded the largest effect (d = 1.11, n=8, I^2 = 97.9%), closely followed by Incentivisation (d = 0.93, n=13, I^2 = 98.1%). Conversely, Education (d = 0.084, n≥3, I^2 = 99%) and Persuasion (d = 0.27, n=3, I^2=?) showed the smallest effects. Training interventions were too few for analysis (n<3). High heterogeneity was prevalent within most function categories. In the short-term, Coercion/Restriction (d = 1.40, n=6) and Incentivisation (d = 0.94, n=10) were most effective. For long-term interventions, Modelling produced significant positive effects (d = 0.55, n=3); Incentivisation (d = 0.95, n=3) and Enablement (d = 0.66, n=6) also showed strong positive effects, although these were not statistically significant in the long-term subgroup analysis. Effect sizes for most functions were broadly similar across durations, often slightly larger long-term. Heterogeneity remained high within function subgroups and generally increased for long-term interventions compared to short-term ones.

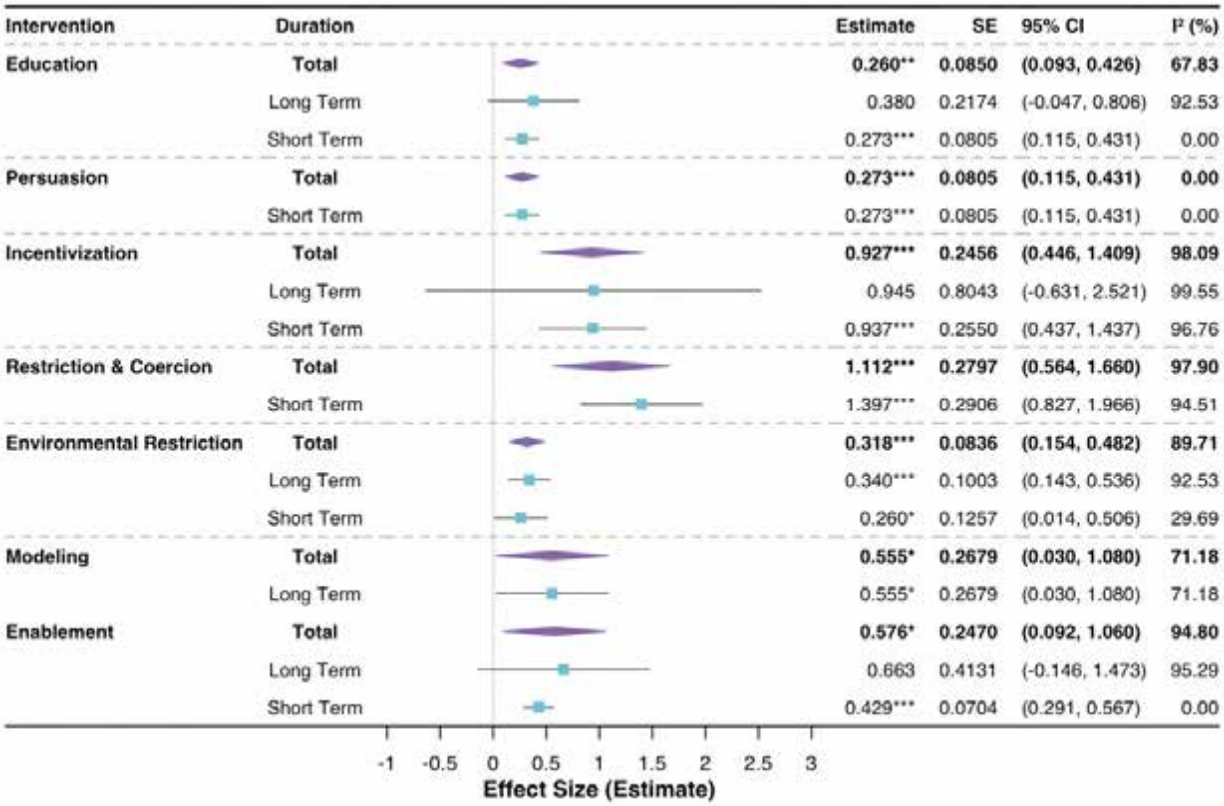


Fig. 8 Sub-group analysis of Intervention Layer

4.5.3 COM-B Components

Finally, analyzing interventions based on the target COM-B components (Capability, Opportunity, Motivation), we found Physical Opportunity (e.g., adding stations; n=23) and Reflective Motivation (e.g., promotional posters; n=17) were most frequently addressed, while Social Opportunity (e.g., school travel projects; n=3) was targeted least often. Subgroup analysis indicated that targeting Automatic Motivation yielded the largest overall effect (d = 0.87, n=15, I^2 = 97.6%), followed by targeting Social Opportunity (d = 0.55, n=3, I^2 = 71.2%). Targeting Psychological Capability (e.g., providing information to reduce perceived complexity) was least effective (d = 0.20, n=9, I^2 = 58.6%). High heterogeneity was observed within the Automatic Motivation subgroup. Considering duration, targeting Automatic Motivation showed the strongest short-term effect (d = 0.96, n=10), while targeting Reflective Motivation had a smaller short-term effect (d = 0.17, n=5). For long-term interventions, targeting Social Opportunity was most effective and showed relatively low heterogeneity (d = 0.55, n=3). Targeting Automatic Motivation also produced a large long-term effect (d = 0.70, n=5), though this was not statistically significant in the long-term subgroup. Interventions targeting Psychological Capability had similarly small effects in both short-term (d=?) and long-term analyses (d = 0.26, n=5). Comparing durations, the effect of targeting Automatic Motivation appeared slightly attenuated long-term, whereas the effect of targeting Reflective Motivation was substantially larger long-term (d = 0.41, n=12) compared to short-term (d = 0.16, n=5). As with other BCW layers, heterogeneity within COM-B subgroups was generally higher for long-term interventions compared to short-term ones.

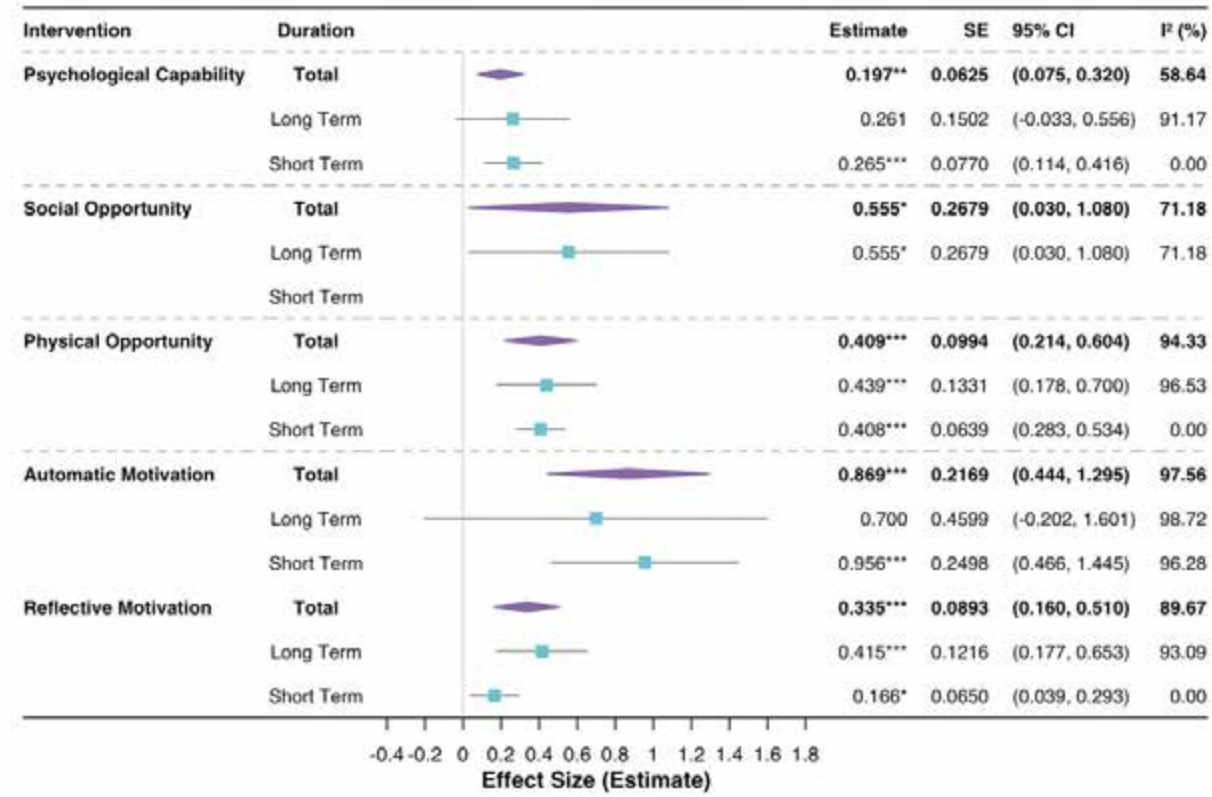


Fig. 9 Sub-group analysis of COM-B Layer

5.Discussion

This study presents a meta-analysis evaluating interventions aimed at promoting public transportation use, employing the Behaviour Change Wheel (BCW) framework to classify these interventions and elucidate the mechanisms underlying their effectiveness. By analyzing how different interventions, categorized by the BCW, influence travel behavior, we sought to understand why certain approaches are more successful than others. Our findings offer a structured understanding of intervention mechanisms, providing theoretical and practical insights for developing more effective future public transport policies.

Synthesizing data from 38 effect sizes across 24 studies and 16 countries, our meta-analysis revealed a statistically significant, moderate positive overall effect of interventions on public transportation usage (Cohen's $d = 0.5165$, $p < 0.0001$). This general finding aligns with previous research indicating that various interventions can successfully promote public transport adoption(Aravind et al., 2024; L. Zhang et al., 2019). However, the analysis also uncovered substantial heterogeneity ($I^2 = 97.16\%$), signifying considerable variability in intervention effectiveness across different contexts, populations, and intervention designs. This variability is exemplified by contrasting findings, such as the large effect reported for ticket discounts by Guzman & Hessel (2022; $d \approx 2.63$) compared to the negligible effect of transport card subsidies found by Rosenfield et al. (2020; $d \approx 0.01$). (Guzman & Hessel, 2022; Rosenfield et al., 2020). Such discrepancies underscore the necessity of delving deeper into the specific conditions and mechanisms—as facilitated by the BCW framework—that determine why and when interventions succeed or fail.

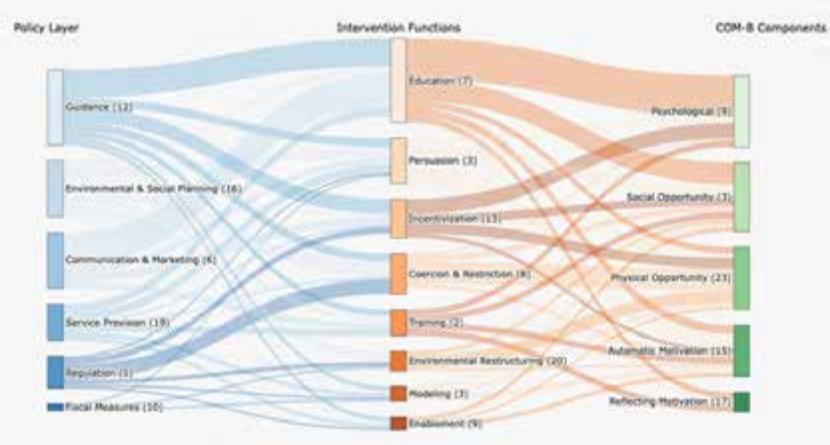


Fig. 10 Distribution of included studies within the BCW framework

To elucidate the mechanisms linking public transportation policies to behavior change, this study employed the Behaviour Change Wheel (BCW) model. We developed a novel three-level analytical framework categorizing interventions by 'policy category', 'intervention function', and 'COM-B component' (Capability, Opportunity, Motivation). This approach reveals how macro-level policy tools translate into impacts on individual travel decisions. Our analysis suggests a hierarchical pathway: policy categories establish strategic direction, implemented via specific intervention functions, which ultimately drive behavior change by influencing individuals' capabilities, opportunities, or motivations (COM-B). The interplay between these levels explains not only the key factors influencing behavior but also the causal pathways and necessary conditions for intervention effectiveness. Thus, policy success hinges on the synergy between the chosen intervention functions and their alignment with relevant COM-B targets.

Applying this BCW framework, we mapped the distribution of intervention types across the included effect sizes (Fig. 7). This revealed distinct patterns: Environmental and Social Planning (n=16 coded instances) and Service Provision (n=19) were the predominant policy categories. These typically relied on Environmental Restructuring (n=20) and Incentivisation (n=13) as core intervention functions, primarily targeting Physical Opportunity (n=23) and Reflective Motivation (n=17). This pattern supports a dual-pathway mechanism for behavior change, emphasizing improvements in infrastructure accessibility (Physical Opportunity) and influencing conscious decision-making through incentives (Reflective Motivation). The strong association observed between Physical Opportunity and Environmental Restructuring interventions (representing 43.5% of all coded connections) highlights the focus on infrastructure optimization within these policy types. In contrast, Guidance policies exhibited more complex pathways, often combining multiple functions (e.g., Education, n=7; Persuasion, n=3) to influence Automatic Motivation (n=15), underscoring the role of cognitive approaches in reshaping habits. The scarcity of interventions classified under Regulation (n=1) or Training (n=2) suggests potential gaps in research and practice regarding institutional constraints and skills development.

Significant variations exist in the effectiveness and pathways of different policy interventions. Our meta-analysis identified Guidance policies as the most effective overall (d = 0.881), significantly exceeding the average effect size (d = 0.5165). This aligns with findings from included studies where strategies like rewarding commuters (Ben-Elia & Ettema, 2011) or establishing pilot low-carbon cities (Li et al., 2023b) substantially increased public transport use, consistent also with related literature (Zarabi et al., 2024). The BCW analysis helps explain this high effectiveness: Guidance policies often integrate multiple intervention functions, such as Incentivization, Education, and Coercion/Restriction. This multi-pronged approach simultaneously targets Reflective Motivation (e.g., changing attitudes via education), Automatic Motivation (e.g., fostering habits via incentives/restrictions), and Physical Opportunities (e.g., providing convenient information), thereby removing barriers while strengthening drivers for behavior change (Bamberg et al., 2007). Their success likely stems from this ability to influence both conscious deliberation and automatic habits, potentially creating feedback loops that reinforce habit formation, perhaps through mechanisms related to reward processing (Schultz, 2015). This aligns with their strong short-term effects (d = 1.087). However, the diminished long-term impact (d = 0.380) may reflect processes like hedonic adaptation or diminishing marginal utility over time (Loewenstein & Ubel, 2008).

Our analysis revealed that Environmental and Social Planning policies, despite their frequent implementation, yielded the weakest overall effect on promoting public transport use (d = 0.209), significantly below the average intervention effect. Illustrative examples include the negligible impacts observed following the opening of Singapore's CCL Circle Line (Dai et al., 2020) or the introduction of Washington State's RapidRide BRT service replacing traditional buses (Cohen's d = 0.0705, SE = 0.1683)(Stewart et al., 2017). The BCW framework clarifies this finding: these policies predominantly utilize Environmental Restructuring functions to enhance Physical Opportunity (e.g., adding infrastructure). While seemingly contradictory to studies highlighting the positive effects of environmental changes (Nagaraja, 2002; Wu et al., 2023) , our BCW-informed analysis suggests these interventions often fail because they neglect the motivational components of the COM-B model. This creates an "infrastructure-motivation gap," where improved physical access does not translate into a willingness to change established travel behaviors (Chen et al., 2022). The insufficient focus on motivation likely also explains why the long-term effects of these policies were weaker (d = 0.197) than their short-term effects (d = 0.265). This aligns with theoretical perspectives suggesting that interventions lacking cognitive engagement may be ineffective (Sunstein, 2017) and highlights that overcoming ingrained preferences often requires more than infrastructure improvements alone, especially considering external factors like the rise of ride-hailing or remote work (Erhardt et al., 2022). Therefore, relying solely on physical infrastructure enhancements typical of Environmental and Social Planning policies appears insufficient to bridge the "infrastructure-motivation gap" and drive substantial shifts towards public transport. Achieving synergistic effects and promoting sustained behavior change likely requires complementing these structural interventions with strategies that actively engage cognitive and motivational factors, such as targeted incentives or behavioral guidance.

Furthermore, this study highlights intervention duration as a critical moderator of policy effectiveness, revealing distinct temporal patterns consistent with dual-process theories distinguishing immediate responses from considered intentions (Kahneman, 2002). Guidance policies, particularly those employing Coercion/Restriction or Incentivization functions, exhibited significantly stronger short-term effects (d = 1.087) compared to their long-term impact (d = 0.380). This suggests such approaches can induce rapid behavioral shifts, but their effects may decay without sustained reinforcement. Conversely, Service Provision policies demonstrated the most substantial and enduring positive effects over the long term (d = 0.529). This resonates with research indicating that consistent improvements in service quality and accessibility foster sustained public transport use (Hynes et al., 2018; Zarabi et al., 2024). Interventions like providing updated bus information pamphlets (Taniguchi & Fujii, 2007), or enhancing station accessibility and payment systems (Lee & Miller, 2022) function akin to "fluency nudges" (Ölander & Thøgersen, 2014), simplifying the user experience and gradually reshaping preferences. These policies typically combine Environmental Restructuring and Enablement functions, addressing not only Physical Opportunity but also enhancing information access (Capability) and convenience (Motivation). By targeting multiple COM-B components, they foster positive experiences that, consistent with the Theory of Planned Behavior (Ajzen, 1991), can solidify attitudes and intentions, leading to more lasting behavior change.

Our analysis consistently highlights the centrality of COM-B components in driving behavior change. Evaluating the pathways from policy through intervention functions to COM-B targets reveals significant differences in effectiveness based on which behavioral determinants are addressed. Using COM-B components as moderators confirms that interventions targeting Motivation (both automatic, $d \approx 0.90$, and reflective, $d \approx 0.34$) yield the largest effects. In contrast, interventions focusing primarily on Physical Opportunity or Psychological Capability demonstrated weaker impacts (pooled effect $d \approx 0.25$). This underscores that while enhancing opportunities (e.g., via infrastructure) is necessary, effectively stimulating motivational drivers is crucial for promoting behavior change. Furthermore, intervention functions that directly influence motivation, such as Incentivization, Modelling, and Enablement, appear particularly effective precisely because they successfully engage these motivational levers.

This study also examined the moderating influence of contextual factors on intervention effectiveness. Findings indicate that effectiveness is significantly shaped by multiple contextual dimensions. The level of analysis emerged as a key factor, with interventions targeting individuals ($d \approx 0.64$) showing larger effects than those at the road/station ($d \approx 0.31$) or city level ($d \approx 0.28$), reflecting potential "proximity effects" where interventions closer to the individual decision-maker are more impactful. However, city-level analyses exhibited greater stability (lower I^2), suggesting policy-level interventions might possess greater cross-context robustness. Measurement method also mattered significantly: effect sizes derived from administrative census data were largest ($d \approx 0.71$) but showed extreme heterogeneity ($I^2 > 98\%$), possibly reflecting variations in data protocols.

Critically, objective travel data yielded significantly smaller effect sizes ($d \approx 0.27$) compared to self-reported data ($d \approx 0.58$; $\Delta d \approx 0.31$, $p < 0.01$). This likely reflects social desirability bias in self-reports (Paulhus & Reid, 1991), suggesting that evaluations relying solely on subjective measures may systematically overestimate intervention impacts. Geographic characteristics showed complex relationships; for instance, mid-sized cities appeared to be effective intervention contexts ($d \approx 0.68$), potentially due to a balance of social norms and resources. Higher effects were observed in Europe compared to Asia ($d \approx 1.15$ vs. 0.19), possibly reflecting cultural or policy environment differences. The intervention duration effect was confirmed, with short-term interventions ($d \approx 0.69$) outperforming long-term ones ($d \approx 0.37$), potentially hinting at behavioral inertia and suggesting the value of intermittent reinforcement strategies. Finally, transport mode mattered: interventions involving rail systems showed larger effects ($d \approx 0.98$) than other modes, possibly due to their structured nature, although the diminished effect for mature metro systems ($d \approx 0.40$) suggests a potential threshold effect where excessive system rigidity might limit further intervention impact. Collectively, these findings emphasize the crucial role of context in shaping intervention outcomes, necessitating customized strategies.

These findings yield important practical implications for public transportation policy. First, policymakers should move beyond single-strategy approaches towards integrated, multi-layered intervention systems. Such systems should strategically combine enhancements to Physical Opportunity (e.g., infrastructure via Environmental/ Social Planning) with efforts to stimulate and sustain Motivation (e.g., via Guidance, Communication/Marketing, Service Provision). For instance, new infrastructure should be paired with informational campaigns, seamless payment systems, and potentially targeted incentives to bridge the "infrastructure-motivation gap." Second, strategies must be temporally aligned with policy goals. For rapid behavioral shifts, approaches like incentives or restrictions (often under Guidance policies) may be prioritized due to their strong short-term effects. However, fostering sustainable habits requires a longer-term focus on enhancing Service Provision and Enablement, continuously improving the travel experience and system efficiency. Third, given the identified synergy between opportunity and motivation, and the risk of solely focusing on infrastructure, initiatives must strategically balance investments in both physical and psychological domains to maximize resource efficiency and policy impact. Finally, intervention design must be context-sensitive, tailoring approaches based on factors like city size, cultural context, existing transport system characteristics, and target population characteristics to optimize effectiveness.

This research offers several novel contributions. Primarily, by systematically applying the BCW framework, it provides an integrated theoretical lens for analyzing diverse public transportation interventions, decomposing them into policy categories, intervention functions, and target COM-B components to clarify their operational logic. Second, moving beyond typical meta-analyses focused on overall effects or broad categories, this study delves into the underlying mechanisms driving intervention success or failure. It quantifies effectiveness differences (e.g., Guidance vs. Environmental Planning policies) and, crucially, offers explanations grounded in behavioral theory for why these differences exist, particularly emphasizing the distinct roles of opportunity and motivation. Third, through rigorous coding and detailed subgroup analyses, the study provides robust empirical evidence supporting these mechanistic explanations. Overall, this comprehensive framework bridges behavioral science theory and empirical policy evaluation, offering a theoretically sound basis for designing more sophisticated and effective public transportation strategies.

Despite these contributions, the study has limitations that warrant caution in interpretation. First, the substantial heterogeneity observed ($I^2 > 97\%$ in some analyses) indicates that intervention effects are influenced by numerous unmeasured factors, including specific study designs, implementation fidelity, local contexts, and concurrent events. While moderator analyses explained some variance, considerable heterogeneity remains, highlighting the need for future research employing more controlled designs or focusing on more homogeneous intervention types. Second, our inclusion criteria (English-language, quantitative studies, 2000-2023) may introduce publication and selection biases, potentially omitting relevant findings. Future syntheses could broaden inclusion criteria. Third, reliance on Cohen's d as the primary effect size metric, while standard, simplifies complex behavioral shifts; future work could benefit from incorporating richer, multi-dimensional outcomes or mixed-methods data. Finally, while the BCW framework is comprehensive for behavioral analysis, it inherently focuses less on broader external factors (e.g., political dynamics, macroeconomic trends) that undoubtedly influence public transport use. Future research employing mixed methods and expanding geographic/temporal scope could further enrich understanding of intervention effectiveness and mechanisms within these wider systems.

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6.Conclusion

This study systematically evaluated the impact and underlying mechanisms of public transportation interventions using a novel three-level analytical model based on the Behaviour Change Wheel (BCW) framework. By synthesizing evidence on the short- and long-term effects of different policy categories, we draw the following main conclusions:

First, Guidance policies demonstrate the largest overall positive effect on promoting public transport use. These interventions, often employing education, promotion, and social norm strategies, effectively enhance awareness and positive attitudes, leading to significant short-term increases in ridership. By fostering understanding of environmental and economic benefits and shaping social norms, they contribute to reinforcing positive attitudes and building a foundation for longer-term behavior change. However, our analysis suggests that the impact of Guidance policies may diminish over time if not complemented by other sustained strategies, highlighting the need for integrated approaches rather than relying solely on guidance for long-term sustainability.

Second, Environmental and Social Planning policies, while crucial for improving the physical environment and accessibility of public transport through infrastructure development, exhibit limited effectiveness in driving sustained behavior change independently. This underscores the challenge of the "infrastructure-motivation gap," where structural improvements alone often fail to overcome ingrained travel habits. To achieve lasting impacts and enhance transportation sustainability, these policies must be integrated with interventions that actively engage motivational and capability factors, such as targeted incentives or behavioral guidance strategies.

Third, Service Provision policies demonstrate significant positive effects, particularly notable for their lasting impact over the long term. These policies succeed by not only enhancing Physical Opportunity but also by providing ongoing support, convenience, and technological innovations that address other key behavioral determinants. From a COM-B perspective, effective Service Provision often targets multiple components—including Opportunity, Motivation, and Capability—thereby comprehensively supporting the adoption and maintenance of public transport use.

In conclusion, achieving sustainable public transportation systems requires comprehensive, integrated strategies that leverage the strengths of different policy approaches. Effective interventions should combine the motivational impetus often provided by Guidance policies, the essential infrastructure improvements from Environmental and Social Planning, and the sustained, multi-faceted support offered by well-designed Service Provision. Utilizing frameworks like the BCW to understand these mechanisms allows for the design of more targeted, efficient, and ultimately more effective policies. Such evidence-informed policy design is crucial for promoting public transport use and contributing to the development of greener, healthier, and more livable urban environments. Continued research, expanding methodological approaches and scope, will be vital for further refining our understanding and fostering adaptive, resilient public transportation systems.

Supplemental Material

Table S1 Search strategy

Table S2 Standardized Form of Extracting and Coding data

Table S3 Definitions of policy categories as described by the Behaviour Change Wheel

Policy category	Definition	Public Transport Examples
Guidelines	The development and dissemination of documents that make recommendations for action in response to defined situations	Orientation documents issued in the programme (e.g. some pilot zones)
Environmental and social planning	Architecture, urban and rural planning, object and location design, and planning for housing, social care, employment, equality, benefits, security and education	Construction, improvement of public transportation routes
Communications and marketing	Mass media campaigns, digital marketing campaigns, and correspondence	Leafleting, SMS, large screen publicity, etc.
Service provision	Provision of any kinds of service or material resource and aids, whether they be structured or ad hoc, financed or unpaid	Fare subsidies, new lines, etc.
Regulation	Development and implementation of rules regarding behaviour that instruct the behaviour and possibly provide rewards and punishments for conforming	temporary incentives in MRT(a full rebate of subway fare)
Fiscal measures	Use of taxation and tax relief	public transit tax credit

Table S4 Definitions of intervention types as described by the Behavior Change Wheel

Interventi-on type	Definition	Pub-lic Transport Examples
Environmen-tal restructu-ring	Changing the physical or social context	construct new met-ro line
Education	Increasing knowledge or understanding	Promote information on health/public transpor-tation/environment;
Persuasion	Using communication to induce positive or negative feelings or sti-mulate action	Providing public transit information through communication and lectures
Incentiviza-tion	Creating an expectation of reward	Free tickets, subsidies, differential pricing po-licies
Coercion and Restriction	Creating an expectation of punishment or cost or use of rules to reduce opportunities to engage in target behaviors	Increase in gasoline prices∆Restrictions on automobile travel
Training	Imparting skills	Emerging transit software use through training
Modelling	Providing an example for people to aspire to or imitate	Workplace mobility ma-nagement program
Enablement	Increasing means/ reducing barriers to increase capability (be-yond education and training) or opportunity (beyond environmen-tal restructuring)	Simplifying ticket pur-chasing by smart-card system

Table S5 Components of the COM-B model

	COM-B model compo-nent	Definition	Public Transport Examples
C	Physical capa-bility	Physical skill, strength, or stamina	?
	Psychologi-cal capability	Knowledge or psychological skills, strength, or stamina to enga-ge in the necessary mental processes	Real-time Information System; Mobi-le apps and GPS trackers to provide motiva-tions and advice
O	Physical oppor-tunity	Opportunity afforded by the environment involving time, resour-ces, locations, cues, and physical 'affordance'	BCT, Integrated Mass Transit Sys-tem, new railway, new metro line, entran-ce of Uber
	Social oppor-tunity	Opportunity afforded by interpersonal influences, social cues and cul-tural norms that influence the way that we think about thin-gs, e.g. the words and concepts that make up our language	Workplace pt programme
M	Reflective moti-vation	Reflective processes involving plans (self-conscious intenti-ons) and evaluations (beliefs about what is good and bad)	Use of mobile apps and GPS trac-kers to provide motivation and advice
	Automatic mo-tivation	Automatic processes involving emotional reactions, desi-res (wants and needs), impulses, inhibitions, drive states and ref-lex responses	Temporary incentives in MRT (a full reba-te of subway fare)

Table S6 Key characteristics of Studies

Index	study	country	Start Year	Duration	Duration Type	Data Source	Experimental group Sample size	Control group sample size	Total sample size	Self-Selection	Sample Type	Sample Type	Size	Travel Mode
1	Baker and Linovski. 2022 treat1	USA	2012	2555	long	Passively collected data	4	32	36	non-self-selection	Road	Midium		BRT
2	Baker and Linovski. 2022 treat2	USA	2012	2555	long	Passively collected data	121	121	242	non-self-selection	Road	Midium		BRT
3	Ben-Elia and Ettema. 2011 treat1	Netherland	2006	91	short	Travel Diaries	232	232	232	non-self-selection	individual	Midium		Rail
4	Ben-Elia and Ettema. 2011 treat2	Netherland	2006	91	short	Travel Diaries	232	232	232	non-self-selection	individual	Midium		Rail
5	Ben-Elia and Ettema. 2011 treat3	Netherland	2006	91	short	Travel Diaries	232	232	232	non-self-selection	individual	Midium		Rail
6	Ben-Elia and Ettema. 2011 treat4	Netherland	2006	91	short	Travel Diaries	108	108	108	non-self-selection	individual	Midium		Rail
7	Ben-Elia and Ettema. 2011 treat5	Netherland	2006	91	short	Travel Diaries	108	108	108	non-self-selection	individual	Midium		Rail
8	Dai et al. 2020 treat1	Singapore	2009	1095	long	Travel Diaries	1122	1122	2244	non-self-selection	individual	Large		Rail
9	Dai et al. 2020 treat2	Singapore	2009	1095	long	Travel Diaries	1122	1122	2244	non-self-selection	individual	Large		Rail
10	Fujii and Kitamura.2003	Japan	2002	30	short	Travel Diaries	23	20	43	selfselection	individual	Small		Bus
11	Guzman and Hessel. 2022 treat1	Colombia	2013	2190	long	administrative data	144697	271046	361744	non-self-selection	individual	Large		Bus
12	Guzman and Hessel. 2022 treat2	Colombia	2013	2190	long	administrative data	144697	271046	361744	non-self-selection	individual	Large		Bus
13	Hoang-Tung et al. 2021	Vietnam	2016	540	long	Travel Diaries	501	501	501	selfselection	individual	Midium		BRT
14	Lee and Lee, 2014	USA	2002	3285	long	administrative data	7197	7197	7197	non-self-selection	City	Large		Bus
15	Lee and Miller, 2022	USA	2018	365	long	Passively collected data	952	952	952	non-self-selection	Road	Large		BRT
16	Li et al, 2022 treat1	USA	2017	730	long	Passively collected data	18	11	29	non-self-selection	Road	Small		Bus
17	Li et al, 2022 treat2	USA	2017	730	long	Passively collected data	9	2	11	non-self-selection	Road	Small		Bus
18	Li et al. 2023 treat1	China	2010	2190	long	administrative data	571	2874	3445	non-self-selection	City	Midium		Bus
19	Li et al. 2023 treat2	China	2010	2190	long	administrative data	571	2874	3445	non-self-selection	City	Midium		Bus
20	Liu and Xu, 2022	China	2010	2190	long	administrative data	600	3105	3705	non-self-selection	City	Midium		Bus
21	McCormack et al. 2021	Canada	2018	365	long	Travel Diaries	80	116	196	selfselection	individual	Midium		BRT
22	Piras et al. 2021	Italy	2019	1	short	Travel Diaries	116	109	225	selfselection	individual	Midium		Bus
23	Piras et al. 2022	Italy	2019	1	short	Travel Diaries	59	83	142	selfselection	individual	Midium		Rail
24	Rosenfield,2020 treat1	USA	2016	240	long	Passively collected data	481	494	975	non-self-selection	individual	Large		Bus

25	Rosenfield,2020 treat2	USA	2016	240	long	Passively collected data	489	494	983	non-self-selection	individual	Large	Bus
26	Shi et al. 2021 treat1	USA	2014	180	short	Passively collected data	34	62	96	non-self-selection	Road	Small	Bus
27	Shi et al. 2021 treat2	USA	2014	180	short	Passively collected data	18	78	96	non-self-selection	Road	Small	Bus
28	Shi et al. 2021 treat3	USA	2014	180	short	Passively collected data	17	79	96	non-self-selection	Road	Small	Bus
29	Spears et al. 2016	USA	2012	180	short	Travel Diaries	128	79	207	selfselection	individual	Midium	Metro
30	Stewart, 2017	USA	2010	1095	long	Travel Diaries	93	57	150	non-self-selection	Road	Midium	BRT
31	Stover et al. 2011	USA	2004	1770	long	administrative data	631	631	631	non-self-selection	City	Large	Bus
32	Sun,2020	China	2015	365	long	Travel Diaries	833	456	1289	selfselection	individual	Large	Metro
33	Taniguchi,2007	Japan	2004	92	short	Travel Diaries	367	79	446	selfselection	individual	Midium	Bus
34	Thogersen and Moller 2008	Den-mark	2002	30	short	Travel Diaries	471	251	722	selfselection	individual	Midium	Bus
35	Wang et al. 2023	China	2004	2555	long	Travel Diaries	524	524	1048	non-self-selection	Road	Large	Rail
36	Yang and Lim. 2017 treat1	Singa-pore	2015	70	short	Travel Diaries	120	119	239	selfselection	individual	Midium	Metro
37	Yang and Lim. 2017 treat2	Singa-pore	2015	70	short	Travel Diaries	109	119	228	selfselection	individual	Midium	Metro
38	Werner et al., 2016	USA	2012	365	long	Passively collected data	22	43	65	non-self-selection	Road	Small	Metro

Table S7 summary of the interventions of Studies

Table S8 Coding Results of Studies

Planning amidst Planetary Crisis: Rethinking Theory and Practice through Adaptive Transformations in Public Transport

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Abstract
Planetary climate and resource crises reshape urban spatial logic and transport networks. With diverse mobility modes emerging, sustainable and adaptive planning is key to managing uncertainty. Traditional approaches fail to capture dynamic demand and complex variables, causing supply adjustments to lag. This study explicates adaptive planning theory, revisits the pivotal support role of buses and structural causes of imbalances, and proposes an adaptive evaluation framework integrating spatial and social indicators. It embeds mobility-mode interactions and uncertainty-response methods to extend conventional bus-planning paradigms. Analysing representative cities' bus supply–demand matching in China and Europe, we propose possible pathways for adaptive response, including multi-level governance, data-driven systems, resource allocation, and emergency mechanisms, which provide resilient, science-based decision support for transport planning in crises.

Keywords: Adaptive Transformations; Mobility Crisis; Public Transport; Evaluation System; Sustainable Development

1. Introduction

1.1 Background and Problem Statement

Composite shocks from climate change, energy scarcity and public health crises are systematically reshaping the sustainable development agenda of urban transport (Meyer and Weigel, 2011; Gaskin, Zare and Delarmente, 2021; Payakkamas, de Kraker and Dijk, 2023; Macdonald et al., 2024). Against a backdrop of frequent extreme weather events, heightened dependency risks on fossil fuels and routine epidemic control, public transit—as a critical urban system embodying social equity (Palm et al., 2021; Gadson and Park, 2024) and environmental benefits (Jiang, Zhou and Liu, 2019; Zhao et al., 2024)—have transcended mere mobility services to become core carrier for urban resilience construction (Goncalves and Ribeiro, 2020; Mirzaee and Wang, 2020).

However, the traditional transport planning paradigm, long constrained by efficiency-driven static optimisation logic (Horiuchi et al., 2024; Li et al., 2024), exhibits clear limits when addressing dynamic supply–demand imbalances, service Resilience deficits and shock events (Cats and Jenelius, 2015). Classical tools such as the four-stage model, due to excessive reliance on historical extrapolation and steady-state equilibrium assumptions (Li et al., 2021), fail to adapt to non-linear evolutions like sudden demographic change (Kasu and Chi, 2018), heterogeneous travel behaviour (Wang et al., 2024) or urban–rural transport dynamics (Xiao and Xu, 2022).

For instance, the pandemic-induced collapse in bus ridership revealed a stark mismatch between rigid service supply and elastic travel demand (Petrov and Petrova, 2020), exposing structural flaws in vulnerability assessment and adaptive regulation within modern bus systems (Man, Andor and Birsanuc, 2022). This underscores the urgent need to shift from a predict–control paradigm to a monitor–respond approach, reconstructing an adaptive methodology for planning and transport under uncertainty by integrating Adaptive Planning theory with socio-technical transition frameworks (Xiang et al., 2023; Deng et al., 2025).

1.2 Research Questions and Objectives

This study addresses three questions: **First**, how can we deconstruct the theoretical core of adaptive planning under planetary crisis, and delineate its transformational features—in value orientation, methodology and implementation—relative to traditional paradigms? **Second**, how can we develop a dynamic, feedbackcapable evaluation framework for bus systems that accurately identifies supply–demand imbalance transmission

mechanisms? **Third**, how can innovative governance models translate planning concepts into operational practice?

To answer these, we integrate complex adaptive systems theory with Transformation Planning thought to build an Adaptive Planning framework for buses, propose sociotechnical transition analysis tools, and construct a dynamic evaluation model. Descriptive analyses of representative Chinese and Central European cities then distil governance pathways for transport Adaptive Planning under varied institutional contexts.

1.3 Significance and Innovation

By uniting the theoretical lineages of Adaptive Planning and Transformation Planning, this study transcends the cognitive limits of traditional static analysis paradigms. Employing a multicriteria dynamic evaluation system, it introduces a quantitative method to assess vulnerability transmission pathways in bus systems. This method exemplifies the interdisciplinary nexus of urban planning, public policy, equity, environmental sustainability and system Resilience, offering effective policy interfaces for innovating bus service provision in the postpandemic era. The paper unfolds along the logic of theory review–dilemma analysis–method development–case validation–policy translation.

2. Theoretical Foundations: Adaptive Planning and Its Transformative Logic

2.1 Overview of Adaptive Planning Theory

Adaptive Planning, emerging as a novel paradigm for navigating uncertainty and complexity under the planetary crisis (Pelling, O'Brien and Matyas, 2015), centres on continuous adjustment and feedback to ensure co-evolution between planning systems and external environments (Smith, 2016; Thomas Machiels et al., 2023). Rooted in late-20th-century concepts of Dynamic Planning and Adaptive Management (Margoluis and Salafsky, 1998; Schreiber et al., 2004), it later integrated with theories of urban resilience and complex adaptive systems (Dovey, 2012; Meerow, Newell and Stults, 2016), culminating in a process-oriented, systems-thinking framework (Ahern, 2011; Davoudi, 2021).

The theoretical evolution of Adaptive Planning spans ecological resource management and urban resilience enhancement, eventually advancing into multidimensional, collaborative governance tailored to climate crises and digital transformation (Varzeshi, Fien and Irajifar, 2024). Three core principles underpin this approach:

Dynamic Responsiveness: Enhancing systemic responsiveness to external disruptions—such as extreme climate or public health emergencies—through real-time monitoring and flexible adjustment mechanisms.

Multidimensional Collaboration: Building cross-sectoral (transport, energy, environment), cross-scalar (urban–regional–national), and multi-actor (government, residents, enterprises, planners) governance networks that transcend administrative boundaries and conventional models.

Social Inclusiveness: Embedding equity in planning decisions, prioritising the needs of vulnerable groups, particularly in relation to mobility and welfare.

Essentially, Adaptive Planning operationalises the Sustainable Development Goals (SDGs) and the principle of equity. Through phased policy adaptation and flexible interventions (Haasnoot et al., 2024), it aims to mitigate spatial exclusion (Ghasemi et al., 2025).

2.2 Transformative Logic of Adaptive Planning

Transformative Planning entails a paradigmatic shift from linear growth thinking to circular, low-carbon, and resilience-oriented transformation (Huq, 2020; Novalia and Malekpour, 2020). Its intellectual foundations lie in Socio-Technical Transitions (Kern, 2012) and Just Transition frameworks (Forde, 2024). Within the planetary crisis context, urban planning transformation engages three interlinked dimensions:

Cognitive Reconstruction: A shift from static, blueprint-oriented visions to dynamic goals of safety, resilience, and liveability;

from fixed long-term planning cycles to a hybrid of short-term action and long-term targets; and from linear planning–implementation–completion trajectories to iterative cycles of identification–action–evaluation–adjustment–re-identification.

Institutional Innovation: A transition from top-down decision-making to bottom-up, citizen-driven governance. This involves multi-level institutional architectures integrating central policy guidance, urban pilot innovations, and community co-governance.

Technological Transformation: Leveraging tools such as digital twins and AI-based forecasting to enhance systemic resilience, enable adaptive planning implementation, and ensure rapid response.

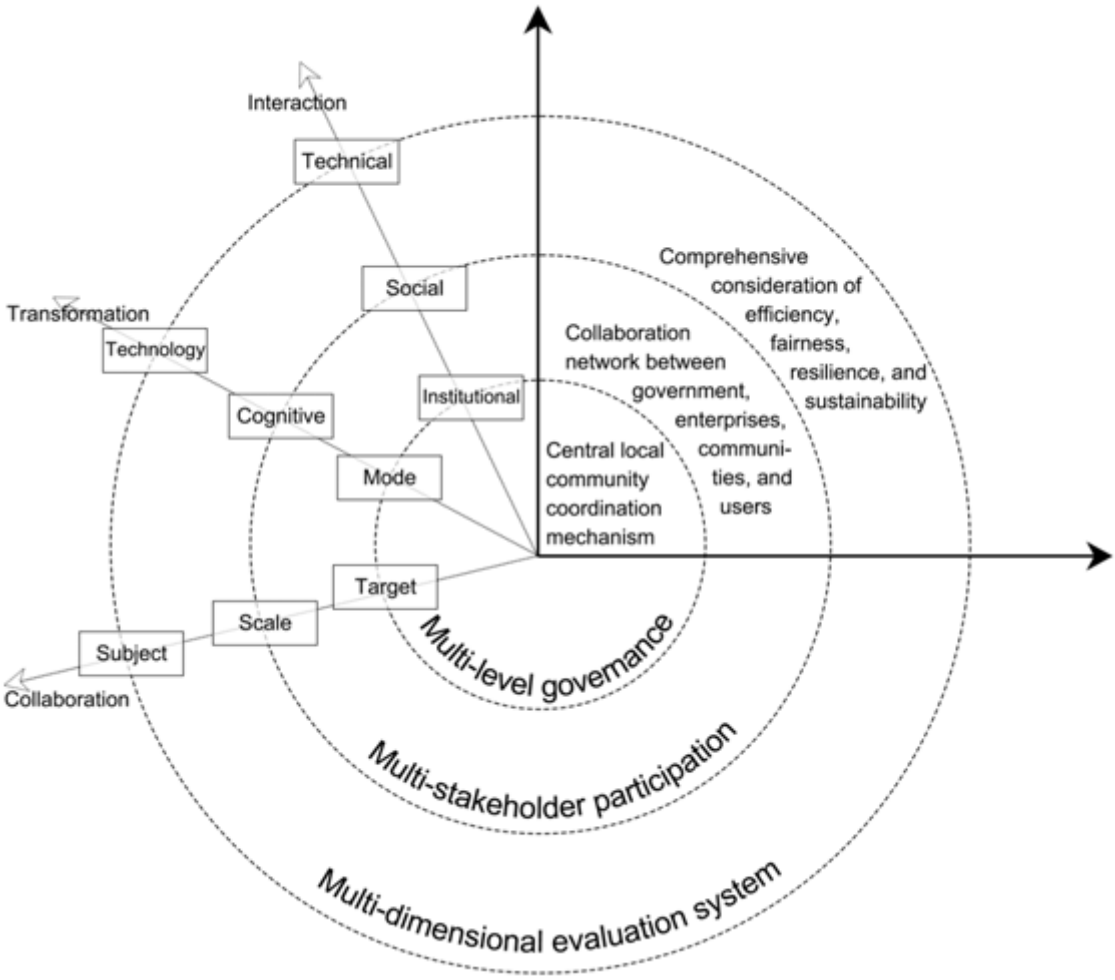

Fig.1 Theoretical Framework for Adaptive Planning Transformation

Overall, the transformation of planning should follow a co-evolutionary pathway across technological, social, and institutional domains (Figure 1). On the governance front, it entails forging risk-sharing and benefit-sharing coalitions among governments, businesses, and the public. On the evaluation front, it necessitates establishing composite indicator systems that integrate efficiency, equity, resilience, and sustainability (Fu and Li, 2022).

3. Role Reconfiguration: Supply–Demand Imbalance and Coopetition in the Context of the Mobility Crisis

3.1 Global Mobility Crisis and Transport Challenges

The dominant paradigm of public transport planning—rooted in car-centric and efficiency-focused logics—is increasingly being challenged. In the face of unpredictable disruptions triggered by climate, economic, or health-

related events, the limitations of conventional planning models become evident. Their reliance on static equilibrium assumptions and technocratic optimisation tools renders them ill-equipped to address dynamic and uncertain conditions. This often results in structural rigidity within transit networks and inadequate responsiveness in resource allocation (Schmidt and Meyer, 2009; Efthymiou et al., 2018).

Globally, the transport sector faces dual pressures from planetary crisis-induced events and shifting mobility demand. Climate imperatives compel a low-carbon transition in bus systems, necessitating breakthroughs in energy structure and emission intensity (Yang, Ma and Sun, 2018). Simultaneously, recurring public health and extreme weather events expose vulnerabilities in operational resilience. Moreover, the proliferation of remote work and diversified travel behaviours have profoundly altered demand structures, rendering fixed-service models increasingly mismatched with spatially and temporally dispersed patterns (Van Nieuwerburgh, 2023).

In China's rapidly urbanising context, these mobility crises are even more acute. While urban expansion fuels travel demand, a car-centric mobility structure exacerbates congestion and pollution. Persistent underfunding, spatial mismatches between networks and jobs-housing patterns, and uneven service quality underscore deeper structural tensions. Temporal and spatial imbalances in supply and demand of public transport remain evident (Wan, Wang and Sperling, 2013).

Resolving these contradictions requires a multidimensional analytical framework encompassing spatial fragmentation (e.g., jobs–housing separation), social stratification (e.g., limited accessibility for vulnerable groups), and technological lag (e.g., inadequate real-time demand sensing). Adaptive planning offers a mechanism for institutional transformation, bridging the disjuncture between static planning paradigms and dynamic urban change. It provides a pathway for bus systems to integrate environmental resilience and social equity as core values (Wall et al., 2015).

3.2 Coopetition between Diverse Transport Modes and Bus Systems

Amid mobility transformation, bus systems are undergoing a critical redefinition of roles (Knowles, Ferbrache and Nikitas, 2020). The interplay among diverse transport modes exhibits dynamic and complex characteristics. Real-time data-sharing platforms dismantle information silos, enabling responsive demand sensing—setting the stage for adaptive transformation in the transport domain.

On the side of coordination, the innovation of "bus+" models has facilitated deep multimodal integration. A composite network combining trunk-line buses and microcirculation feeders can achieve seamless modal linkages. For example, shared bicycle systems extend the effective service radius of buses, while multimodal hubs promote regional integration. This requires planners to reassess the foundational role of buses as both structural backbones and connective supports.

On the side of competition, emerging mobility modes are reshaping urban transport hierarchies. Rising private car ownership and the immediacy of ride-hailing services place buses at a disadvantage in terms of time efficiency and comfort. Micromobility options—such as shared bikes and e-scooters—have significantly diverted demand for short-distance trips (3–5 km). Surveys in cities like Beijing indicate that up to 15% of bus demand has already been displaced by such modes.

In the future, disruptive technologies such as autonomous driving and vehicle–infrastructure integration may trigger fundamental shifts in mobility structures. Market mechanisms also deepen inequality: high-income groups shift towards customised services, while marginalised populations bear the brunt of declining service quality. This necessitates public service safeguards within competitive transport ecosystems.

In sum, the evolution of future transport systems will increasingly hinge on the diversified roles of multiple modes.

The digital revolution is accelerating adaptive transformation: real-time demand sensing and optimisation algorithms enable dynamic system adjustments (Legaspi et al., 2020). Consequently, buses can be deeply integrated within service-oriented platforms such as Mobility-as-a-Service (MaaS), shifting from physical connectivity to service fusion.

With digital technologies as enablers, governance mechanisms should also undergo adaptive transformation to balance market dynamism with public value. Crucially, beyond redesigning institutional arrangements such as bus priority or carbon quota trading, policy frameworks should also recognise the public nature of buses—reinforcing their role in mobility systems through precise targeting, quality enhancement, and service innovation. Ultimately, this would enable a strategic leap for bus systems—from mere transport vehicles to resilient urban infrastructure. A rational understanding and evaluation of the bus system constitutes a critical step in this policy pathway, serving as a fundamental reference for quality service innovation.

4. Rethinking Approach: Evaluation Framework and Indicator System for Adaptive Bus Planning

4.1 Design Principles and Structural Logic of the Evaluation Framework

In response to the transformative demands of bus systems under the planetary crisis, this study develops a dual-layered evaluation framework (Figure 2). Grounded in the paradigm shift towards the reconfiguration of planning values—efficiency (accessibility), equity resilience, and sustainability—it aims to enhance crisis responsiveness, service sustainability, and social inclusiveness through multidimensional coordination mechanisms.

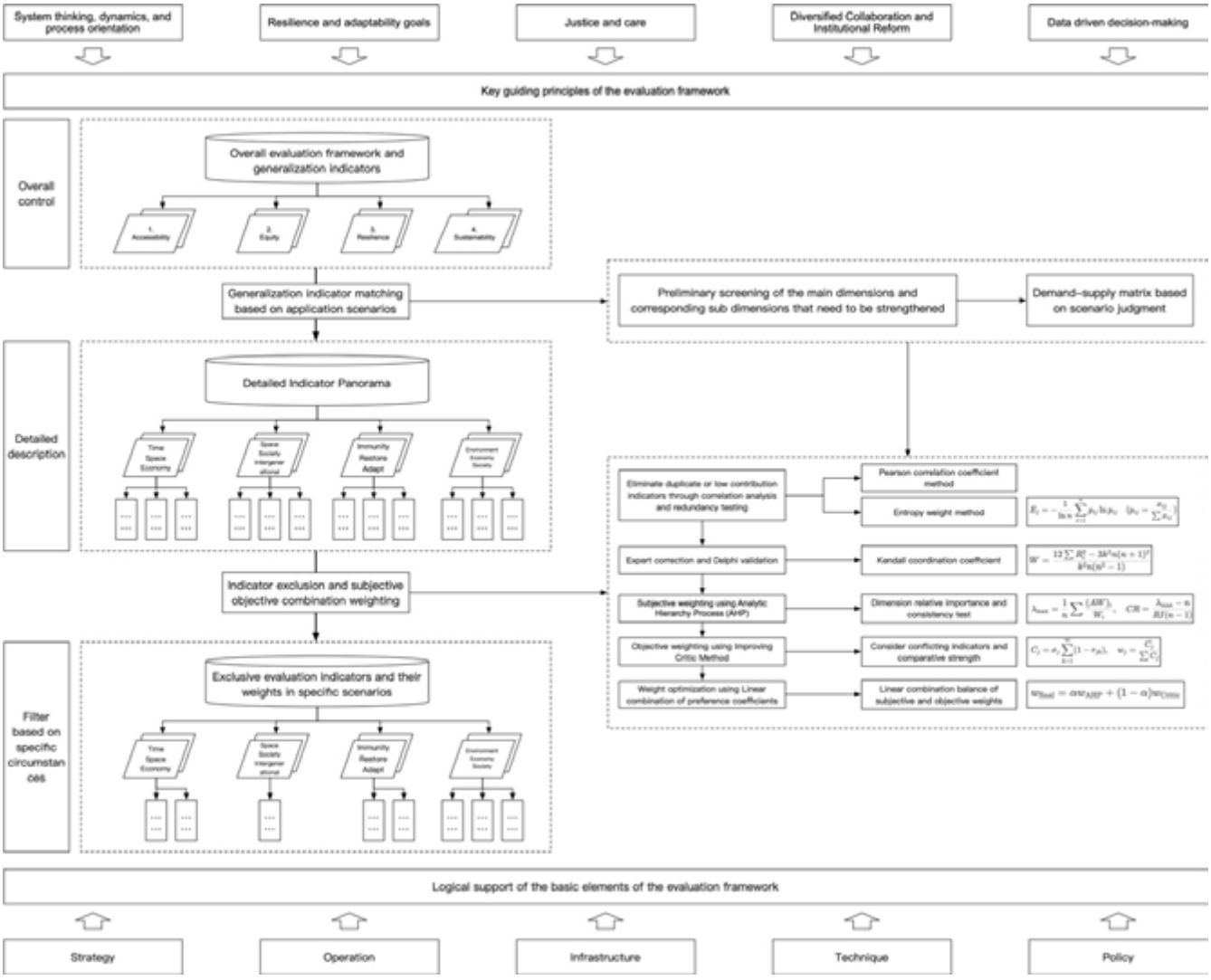

Fig.2 Evaluation Framework for Adaptive Bus Planning

The framework follows a three-tiered progressive structure.

First, at the value level, it moves beyond the efficiency-dominant paradigm, drawing on degrowth theory and care mobility to propose a holistic evaluation matrix centred on accessibility, equity, resilience, and sustainability.

Generalised indicators are accordingly introduced to capture the coupling of system resilience, environmental sustainability, and spatial justice.

Second, a scenario-oriented indicator mapping process constructs a panoramic indicator library, offering dimensional depth as the foundation of the framework.

Third, through systematic indicator screening and a combined subjective-objective weighting mechanism, context-specific indicators and weighting schemes are developed to support tailored evaluations. This process involves correlation analysis, redundancy detection, expert-based elimination, hybrid weighting, and linear combination optimisation.

The framework is supported by a multi-level logic structure. Strategically, it incorporates long-term visions and multi-scenario planning to guide adaptive mechanisms. Operationally, it introduces flexible network and frequency scheduling. Infrastructurally, it addresses the integration of stations, energy, and other physical resources. Technically, it considers real-time data monitoring. Also, at the policy level, it emphasises crisis preparedness and low-carbon mobility incentives.

These are reinforced by key guiding principles such as dynamic systems thinking, resilience-oriented mechanism design, and pluralistic participatory models grounded in social equity. Collectively, these elements enable iterative feedback loops and continuous system evolution under conditions of uncertainty.

4.2 Multi-Criteria Indicator System for Adaptive Evaluation: Accessibility, Equity, Resilience and Sustainability

Under the integrated framework, a comprehensive multi-criteria indicator system is established (Table 1), spanning both supply and demand dimensions. Centred on four core principles—accessibility, equity, resilience, and sustainability—the system bridges internal operational efficiency and external societal effects, providing a dynamic tool for adaptive planning.

Supply-side indicators address resource allocation, service provision, and operational control, while demand-side indicators reflect user satisfaction, perceived equity, and environmental interaction. Their interaction captures the multidimensional essence of bus system transformation.

Tab.1 Multi-Criteria Evaluation Indicators

		Supply Side	Demand Side
1. Accessibility	Space Time Economic	Service coverage, Service frequency, Site coverage……	Walking distance, Ticket affordability, Travel time cost ……
2. Equity	Spatial Social Intergenerational	Regional allocation of public transportation resources, Coverage of barrier free facilities… …	Satisfaction rate of vulnerable groups' needs, Subjective evaluation of fairness……
3. Resilience	Immunity Recover Adaptability	Emergency response time, Redundancy of backup facilities……	Evaluation of passenger diversion efficiency, Reliability of emergency services……
4. Suitability	Environmental Economic Social	Carbon emission intensity, Operational efficiency, On-time performance……	User satisfaction, Public participation……

The framework further disaggregates each dimension, yielding a panoramic set of 68 supply-side and 60 demand-side indicators, serving as a reference for context-specific indicator selection in diverse scenarios.

4.2.1 Accessibility Evaluation: Coupling Spatial-Temporal Opportunity and Cost Constraints

As the core functional expression of bus services, accessibility should be analysed through spatial, temporal, and economic lenses (Table 2).

Spatial accessibility is assessed via supply indicators such as S1 and S3, reflecting network layout efficiency, while demand indicators like D1 and D4 measure users' practical ease of network access. Temporal accessibility

relies on supply-side operational parameters (e.g., S8, S11) and demand-side metrics (e.g., D6, D9) that quantify user experience in space-time cost. Economic accessibility combines supply indicators (e.g., S15, S16) capturing affordability policies with demand indicators (e.g., D10, D14) that reveal service penetration across socio-economic gradients. This dimension also introduces GIS-based spatial analytics, incorporating non-transport variables to evaluate the system's latent support for urban functions.

Tab.2 Accessibility Evaluation

1. Accessibility	Space	S1	Stop density	D1	Average distance of walking to the nearest stop
		S2	Line network density	D2	Walking accessibility time distribution
		S3	Service coverage rate within xx meters	D3	The straight-line distance from residential areas to stations
		S4	Coverage rate within a 500 - meter service radius	D4	Differences in accessibility among different landuse types
		S5	Number and distribution of transfer nodes		/
		S6	Network connectivity index		/
		S7	Average distance between stops		/
	Time	S8	Departure frequency	D5	Average travel time
		S9	Length of operating hours	D6	Total door-to-door travel time
		S10	Average operating speed	D7	Delayed time during peak hours
		S11	On-time performance rate	D8	Time costs between different Origin-Destination (OD) pairs
		S12	Stability of headway	D9	User perception of time reliability
		S13	Transfer waiting time		/
	Economic	S14	Fare level setting	D10	The ratio of fares to household income
		S15	Fare structure (sectional/zonal)	D11	Travel cost per unit distance
		S16	Transfer discount policy	D12	Comparison of costs with other modes of transportation
		S17	Fare discounts for special groups	D13	Price sensitivity among different income groups
		S18	Allocation of operating costs	D14	Travel cost burden index

4.2.2 Equity Evaluation: Aligning Spatial Balance and Group Justice

Equity evaluation transcends traditional homogenised approaches by integrating spatial, social, and intergenerational dimensions (Table 3).

Spatial equity is reflected in indicators such as S19 and S21, which reveal spatial disparities in resource allocation, while D18 captures travel exclusion experienced by residents in marginalised areas. Social equity includes institutional inclusiveness (e.g., S24, S28) and demand-side perceptions of justice (e.g., D20, D23). Intergenerational equity introduces long-term low-carbon transitions into present planning via indicators like S29 and D25. This dimension highlights path dependence rooted in historical injustices and interrogates structural contradictions embedded in bus service distribution.

Tab.3 Equity Evaluation

		Supply Side		Demand Side	
2. Equity	Spatial	S19	Standard deviation of service levels in different regions	D15	Evaluation of travel convenience for residents in different regions
		S20	Service ratio between the central urban area and the peripheral regions	D16	Inter - regional accessibility difference coefficient
		S21	Gini coefficient of bus network coverage	D17	Travel time cost for residents in peripheral areas
		S22	Spatial distribution equilibrium of transport capacity input	D18	Spatial Deprivation Index
		S23	Regional differences in facility configuration standards	D19	Differences in services atisfaction across different regions
	Social	S24	Coverage rate of barrier-free facilities	D20	Travel satisfaction levels among different age groups
		S25	Proportion of low-floor vehicles	D21	Evaluation of Travel Convenience for People with Disabilities
		S26	Multilingual information service coverage	D22	Bus dependence of low-income groups
		S27	Configuration of special facilities for the elderly and children	D23	Gender differences in perceived travel safety
		S28	Service policies for special groups	D24	The degree of travel exclusion for vulnerable groups
	Intergenerational	S29	The proportion of renewable energy use	D25	Intergenerational sharing of environmental costs
		S30	Level of investment in green technology	D26	Satisfaction of future travel demand prediction
		S31	Environmental protection facilities configuration standards	D27	Preferences for sustainable travel mode selection
		S32	Proportion of sustainable development investment	D28	Assessment of intergenerational environmental burden
		S33	Technology upgrade cycle	D29	Long-term development benefit distribution

4.2.3 Resilience Evaluation: Reconstructing Systemic Resilience and Adaptive Capacity

The resilience of bus systems is assessed through a tripartite framework encompassing resistance, recovery, and adaptation (Table 4).

Structural robustness, as an expression of resistance, is captured by supply-side indicators such as S34 and S39, while D30 and D31 reflect the social cost of disruption propagation on the demand side. Recovery is evaluated

through technical metrics including S40 and S44, alongside behavioural adjustment processes tracked by D36. Adaptation focuses on the system's capacity for dynamic realignment under climate variability and demand fluctuations. The coupled analyses using S47 and D40 reveal the system's evolutionary potential. This dimension emphasises stress testing and scenario simulation, validating resilience indicators through compound scenarios involving extreme climate and energy crises.

Tab.4 Resilience Evaluation

		Supply Side		Demand Side	
3. Resilience	Immunity	S34	Network redundancy coefficient	D30	Impacts cope of single-point failures
		S35	Identification and protection of critical nodes	D31	Passenger detention time during service interruptions
		S36	Number of backup facilities/paths	D32	Availability of alternative routes
		S37	System fault-tolerant design level	D33	Performance of system stress testing
		S38	Completeness of emergency response plans	D34	Service stability perceived by users
		S39	Dispersion of critical facilities		/
	Recover	S40	Emergency response time	D35	User acceptance time after service restoration
		S41	Average duration of fault repair	D36	Travel mode conversion during the recovery period
		S42	Emergency vehicle and personnel deployment	D37	Users' satisfaction with the recovery effect
		S43	Response speed of information release	D38	Increased travel costs during the recovery process
		S44	Initiation time of alternative services	D39	Time to reach normal service level
		S45	Standardized process for resuming operations		/
	Adaptability	S46	System upgrading and transformation capabilities	D40	Adaptability of response to demand changes
		S47	The application level of technological innovation	D41	New technology acceptance and utilization rate
		S48	Flexibility in adjusting the operation mode	D42	Adaptation time for service mode changes
		S49	Adaptability of long-term planning	D43	Long-term evolution trends of travel modes
		S50	Diversified services supply capacity	D44	The dynamism of meeting user needs

4.2.4 Sustainability Evaluation: Dynamic Equilibrium of the Triple Bottom Line

Sustainability is assessed through a lifecycle-based framework aligned with the environmental-economic-social triple bottom line (Table 5).

Environmental sustainability is quantified via S51 and S52, indicating progress towards low-carbon Transformation, while D45 captures ecological behavioural responses. Economic sustainability is reflected in balanced cost inputs (S57) and the long-term market viability of service provision (D50, D52). Social sustainability transcends conventional satisfaction metrics, with indicators such as S64 and S67 illuminating the social capital underpinning system operation, while longitudinal data like D60 trace the cumulative effect of institutional credibility.

Tab.5 Sustainability Evaluation

		Supply Side		Demand Side	
4. Suitability	Environmental	S51	Carbon emissions per unit of transport volume	D45	The proportion of bus trips replacing private car trips
		S52	Proportion of new energy vehicles	D46	Residents' preference for environmentally friendly travel choices
		S53	Energy consumption efficiency	D47	Users' awareness of environmental benefits
		S54	Noise control level	D48	Degree of change in green travel behavior
		S55	Air pollutant emission standards	D49	Acceptance of internalizing environmental externalities
		S56	Green infrastructure configuration		/
	Economic	S57	Operation cost control level	D50	Stability of fare affordability
		S58	Degree of diversification of income structure	D51	Matching degree between demand growth and input
		S59	Degree of dependence on government subsidies	D52	Changes in users' willingness to pay
		S60	Asset utilization efficiency	D53	Service quality-price satisfaction
		S61	Payback period	D54	Long-term awareness of financial sustainability
		S62	Operation efficiency indicators		/
	Social	S63	Maintenance of service quality standards	D55	User satisfaction and its trends
		S64	Stability of practitioners	D56	Perceived stability of service quality
		S65	Level of investment in technical training	D57	Social recognition and support
		S66	User complaint handling mechanism	D58	Perceived continuous improvement of travel experience
		S67	Degree of community participation in decision - making	D59	Perception of equity in public services
		S68	Level of information transparency	D60	Long-term service trustworthiness

Taken together, the integrated panorama of supply–demand indicators across the four dimensions offers a robust foundation for selecting context-specific metrics in diverse application scenarios. The framework's value lies not only in its comprehensiveness but in its dynamic calibration mechanism. Through regionalised adjustment of weighting parameters (as detailed in Figure 2), tailored submodules may be derived for mountainous cities,

high-density metropolises, and suburban development zones, thereby providing methodological support for differentiated Transformation of bus systems under planetary crisis.
Preliminary findings suggest that while enhanced accessibility may exacerbate spatial inequity, improved resilience often entails economic trade-offs. In practical planning scenarios, the equity threshold and resilience baseline may be constrained in accordance with specific planning goals, enabling differentiated strategies. The following case studies and planning propositions will offer more targeted insights.

5. Case Outlook: Descriptive Comparison and Evaluation Application of Chinese and European Cities

5.1 Research Design and Methods

This study selects Shanghai, Shenzhen, and Paris as core cases to preliminarily explore adaptive strategies of urban bus systems under differing institutional and cultural contexts in response to the planetary crisis, using descriptive comparative analysis. The study also aims to demonstrate the potential application of a multidimensional evaluation framework.

Shanghai and Shenzhen, as megacities in China, respectively represent characteristics of high-density built-up areas and rapidly expanding urban forms. Paris exemplifies a mature European metropolitan region, with its "15-minute city" vision and low-carbon policies offering global reference value. While Chinese cities are primarily driven by top-down planning, European cities emphasise participatory processes and multimodal integration. These divergences between the two make their comparison more representative.

Drawing on publicly accessible policy documents and interview materials, this section identifies both commonalities and divergences among the three cities. It distils their planning logics and governance attributes while reflecting on existing shortcomings. This provides insight into the mutual responsiveness between evaluation frameworks and planning practices. Additionally, the study assesses the framework's feasibility in each case, incorporating both the effectiveness of routine planning and dynamic scenarios involving extreme events.

5.2 Case Comparison and Evaluation Application

5.2.1 Shanghai: Exploring Bus System Resilience in a High-Density City

Shanghai's high-density built-up areas feature a complex bus network, yet significant passenger loss persists due to modal competition. In recent years, improvements in service efficiency have been achieved through bus electrification and intelligent dispatching platforms such as Shencheng Mobility. However, deficiencies remain in suburban coverage and peak-time capacity. During the pandemic, partial suspension of bus services exposed severe supply–demand mismatches under extreme conditions.

This suggests that even under normal conditions, Shanghai's bus services face persistent imbalances and operational inefficiencies. During crises, buses have yet to serve as effective mechanisms for dynamic response and baseline mobility provision. It is therefore essential to establish an evaluation system that accounts for both regular and emergency scenarios, and to develop corresponding mechanisms for dynamic coordination in infrastructure and operations.

5.2.2 Shenzhen: Supply–Demand Mismatch in Rapid Urbanisation

Shenzhen's bus system supports the city's polycentric expansion through an extensive road network. The Transit Metropolis policy has successfully integrated buses with metro systems and shared bikes. In response to extreme coastal weather, real-time route adjustments and reserve dispatching have proven effective. Nonetheless, accelerated urbanisation has resulted in lagging bus services in peripheral areas, with equity indicators significantly lower than in the city centre.

Although the technologically driven planning model has enhanced operational efficiency in new districts, the key issue lies in its limited community engagement, resulting in insufficient responsiveness to vulnerable groups. An evaluation framework guided by mobility equity goals should therefore be introduced to identify deficiencies and enhance public participation and interdepartmental coordination.

5.2.3 Paris: Dual Pathways of Decarbonisation and Resilient Governance

Beyond its bus network, Paris operates a multi-tiered public transport system including metro and RER services.

Recent efforts have centred on decarbonisation through the "15-minute city" initiative and policies focused on low-emission zones (Zone à faibles émissions, ZFE), aimed at reducing car dependency. Measures include bus fleet decarbonisation, cycling infrastructure expansion, and carpooling promotion to reduce transport-related emissions.

However, Paris's green transition has prompted concerns over policy efficiency and fiscal sustainability. Thus, evaluation frameworks for Paris and similar cities should adopt an environment- and sustainability-oriented scenario, with indicators explicitly addressing effective mobility and economic viability. This would help avoid compromises in service quality due to fiscal constraints and efficiency challenges.

5.3 Preliminary Insights from Comparative Analysis

Descriptive comparison reveals divergent patterns in urban bus planning between Chinese and European cities. Chinese cases exhibit technology-driven, centralised responses prioritising hardware upgrading and large-scale interventions. In contrast, Paris emphasises societal engagement and green transformation, focusing on policy flexibility and equitable distribution.

Preliminary findings suggest: Shanghai's central areas enjoy good bus accessibility but suffer from peak-hour pressure. Shenzhen shows strong resilience in crisis scenarios but should enhance equity in service provision. Paris ensures equitable bus coverage but still faces questions regarding operational efficiency and fiscal viability.

The proposed Evaluation Framework for Adaptive Bus Planning demonstrates cross-cultural applicability by enabling tailored indicator systems for varying scenarios. Given data limitations, the study uses 2013 data from Shenzhen to illustrate urban bus supply–demand conditions (Figure 3, 4). Future research should employ updated datasets to better characterise dynamic patterns, integrate supply–demand modelling, and contribute to globally relevant strategies for planning transformation under planetary crisis.

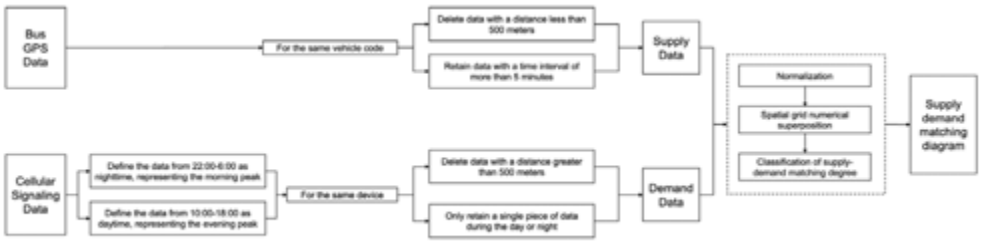

Fig.3 Flowchart of the Supply–Demand Matching Analysis

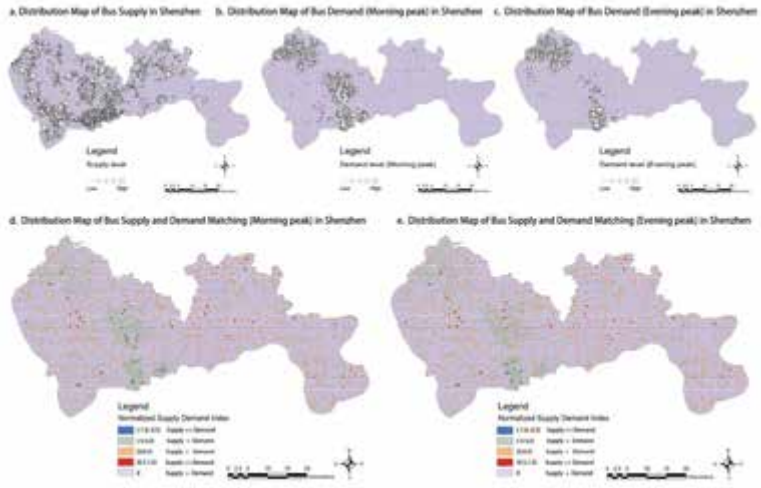

Fig.4 Bus Supply–Demand Conditions and Matching in Shenzhen in 2013

6. Discussion: Planning and Policy Implications

6.1 Theoretical Linkages and Transformative Innovation of the Framework

The adaptive transformation and evaluation framework for bus systems developed in this study integrates resilience-oriented design and community engagement mechanisms, achieving theoretical convergence with urban resilience theory, the Sustainable Development Goals, and system transformation theory.

By incorporating both the shock resistance of physical infrastructure and the self-organising recovery capacity of socio-ecological systems, the framework underscores the structural advantage of public transport in achieving dynamic balance during the adaptation–transformation process. This advantage lies in turning short-term crisis responses into long-term drivers of low-carbon technology adoption, inclusive service provision, and intelligent governance upgrades, thereby shifting planning paradigms from passive adjustment to proactive guidance.

Conceptually, adaptive planning for buses reflects three major shifts. **First**, it reorients from efficiency-driven to equity-led values, restructuring spatial justice through optimised accessibility. **Second**, it moves from static blueprints to dynamic adaptation, establishing real-time data-driven planning responses. **Third**, it transforms governance from siloed departments to cross-sectoral, multi-system coordination.

To ensure the framework's policy feasibility, institutional safeguards are needed—such as planning standards, emergency protocols, and public participation procedures—alongside fiscal instruments including green bonds and reinvestment of carbon trading revenues. These institutional designs, together with the multidimensional evaluation model proposed in this study, form a dynamic monitoring synergy that underpins governance for adaptive transformation in transport systems.

6.2 Planning Strategies for Coping with Crisis and Uncertainty

6.2.1 Establishing a Data-Driven and Scenario-Based Dynamic Response System

Addressing complex and evolving internal and external shocks requires a dynamic mechanism that integrates real-time sensing, intelligent analytics, and agile responses.

First, a real-time monitoring network should be deployed to continuously and accurately track passenger flows, traffic conditions, and service quality, thereby providing timely data support for decision-making.

Second, intelligent dispatching capabilities should be enhanced through big data analytics and demand forecasting, enabling flexible capacity allocation and dynamic optimisation of bus operations to improve resource efficiency.

Third, a feedback and iteration mechanism should be established to ensure closed-loop management based on performance evaluation, driving continual improvement in service processes and standards.

Lastly, scenario simulation and risk assessment should be deepened by constructing multiple future scenarios—such as climate events, technological shifts, and demographic changes—to identify latent vulnerabilities in the bus network and to pre-develop targeted strategies for risk mitigation and adaptive planning.

6.2.2 Advancing Innovation in Emerging Technologies

Technological empowerment is a critical driver of bus system transformation. In the era of planetary crisis, the development of intelligent technologies offers new possibilities for adaptive bus planning.

Advanced tools—such as big data, artificial intelligence, and synthetic population modelling—should be leveraged to enhance the scientific rigour and operational efficiency of bus systems. This includes real-time route optimisation, intelligent dispatching, and improved transparency of information services.

Forward-looking exploration is also needed, including the integration of autonomous driving and vehicle–infrastructure cooperation technologies, which may offer complementary functions to conventional bus services, such as automated feeder systems.

6.2.3 Enhancing Operational Resilience and Flexibility through Institutional Empowerment
On the one hand, innovative models of operation and governance should be promoted, including the adoption of flexible routes and service modes. Responsive service models—such as network optimisation based on real-time demand and on-demand buses—should be developed to enable finely tuned operational adjustments.

On the other hand, redundancy mechanisms should be established through the strategic reserve of routes, vehicles, and critical infrastructure to ensure rapid recovery and the maintenance of minimum service levels during major disruptions. This calls for the deep integration of all transport subsystems in emergency planning, resource sharing, and coordinated dispatching, supported by a more flexible and responsive dynamic planning decision-making framework.

6.2.4 Strengthening Equity-Oriented Resource Allocation and Multi-Actor Collaboration
Ensuring the inclusiveness and accessibility of bus services is vital for maintaining basic societal functioning during crises. This demands planning based on fine-grained travel demand analyses, especially focusing on the mobility patterns of vulnerable groups, to optimise route networks and ensure balanced and effective service coverage. It also requires targeted support policies, such as fare subsidies for low-income populations and the widespread implementation of accessible infrastructure, to guarantee mobility rights for disadvantaged users.

Moreover, spatial equity under multi-modal coordination should be prioritised by enhancing the physical integration and operational synergy between buses, walking, micro-mobility, and rail systems to reduce service disparities through shared resources.

Deepening participatory governance and collaboration is also key to advancing social equity in transport. This includes building multi-actor platforms led by government, operated by service providers, engaged by communities, and supported by academic institutions, to foster public participation in planning, evaluation, and oversight, and to explore effective models of public–private partnerships and community co-governance.

7. Conclusion
In response to the urgent need for planning transformation under the planetary crisis, this study first systematically reviews adaptive planning theory and interrogates the mobility crisis alongside the developmental dilemmas of buses. Building on this foundation, it proposes a resilience-oriented adaptive planning framework for public buses, accompanied by a multi-criteria evaluation system. By integrating transport efficiency, social equity, system resilience, and environmental sustainability into a unified decision-making perspective, the study extends the theoretical boundaries of adaptive planning within the transport domain.

Case-based analysis reveals interurban disparities in bus adaptability. Cities with high resilience typically exhibit institutional flexibility, technological inclusiveness, and deep civic engagement, confirming the framework's practical efficacy in enhancing system robustness. The resulting policy implications underscore a shift from passive defence to proactive adaptation, requiring legislative safeguards, fiscal incentives, and smart technological empowerment.

Nonetheless, this study has limitations. Case selection is constrained by data availability, particularly the lack of long-term operational data from cities in the Global South. Specific dynamic crisis scenarios—such as cascading disaster chains or multi-modal low-carbon transitions—remain underexplored, and their associated weighting mechanisms call for further empirical validation.

Future research should leverage big data and updated datasets for quantitative refinement of the evaluation framework, conduct comparative analysis across more cities, investigate the impacts of other crisis types on bus planning, and explore theoretical and practical extensions across disciplines and transport network models.

In the era of planetary crisis, the planning paradigm should shift from growth-oriented to resilience-centred. As the backbone of urban life, the adaptive transformation of public transport is not merely a technical endeavour but a governance revolution—redefining human-environment relations and advancing spatial justice.

Critical research frontiers remain open, including context-specific localisation and transnational cooperation aimed at dismantling epistemic silos and co-developing crisis-responsive knowledge systems. What is certain, however, is that embedding adaptive logic into the core of planning institutions offers a guiding compass for navigating urban uncertainty.

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Adapting the 15-Minute City Model for Suburban Areas: Key Performance Indicators (KPIs) and Multimodal Mobility Strategies

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Abstract
The 15-minute city (15minC) model has emerged as a guiding framework for just and sustainable urban development, prioritising proximity, connectivity, and diversity to enhance residents' quality of life. While widely applied in dense urban centres, its implementation in suburban areas faces particular challenges. In this paper, we define a set of Key Performance Indicators (KPIs) to explore the potential of digitalisation and integrated multimodal mobility strategies as enablers of the 15minC principles in suburban contexts. Six diverse case studies are examined across six countries in Europe: Spain, Portugal, Hungary, Italy, Germany, and Turkey.

Keywords: 15-Minute City – Key Performance Indicators – Multimodal Mobility – Suburban Development

1. Introduction

The 15-minute city (15minC) model has emerged as a guiding framework for just and sustainable urban development, prioritising proximity, connectivity, and diversity to enhance residents' quality of life (Moreno et al., 2023). While widely applied in dense urban centres, its implementation in suburban areas faces challenges due to lower density and limited land-use diversity, which often characterise these areas. From a 15minC model perspective, this results in insufficient connectivity due to poorly integrated and inaccessible transportation networks, such as limited public transport options. This, in turn, leads to car dependency, negatively impacting residents' quality of life in terms of health, time, and financial costs.

To reduce suburban distances, promote accessibility, and achieve the 15minC vision in peripheral areas, this research contributes to the rethinking of distance as a function of time, and defines Key Performance Indicators (KPIs) aligned with the principles of chrono-urbanism—emphasising faster and more cost-effective solutions (Moreno et al., 2023), such as the integration of mobility hubs and the promotion of public transport and active mobility modes. The 15minC model presents itself as a contemporary urban vision (Moreno et al., 2023), as its guiding principles tend to remain aspirational, rather than process-oriented, without clear spatial planning methodologies nor operational frameworks. This paper addresses the aspirational aspect of 15minC mobility strategies and renders them measurable through relevant KPIs.

Accordingly, this study aims to bridge existing research gaps in data-driven methodologies and analytical frameworks, by defining a set of KPIs to assess how digitalisation and integrated multimodal mobility strategies can support the principles of the 15minC in suburban contexts. To achieve this, six diverse case studies are examined across six European countries: Spain, Portugal, Hungary, Italy, Germany, and Turkey.

As part of the FORTHCOMING project (FC)1, the development of the KPIs follows a methodological approach that includes: identifying successful 15minC strategies within selected case studies, assessing available data sources, and integrating insights gathered through focus group workshops with local experts from the respective case study areas.

Ultimately, the study will share preliminary findings on the relevance and applicability of the proposed KPIs in establishing a measurable framework for the 15minC concept, while also reflecting on and examining the challenges and opportunities related to further contextualisation—particularly through the definition and implementation of urban living labs within the case study cities in upcoming project phases.

1 FORTHCOMING: Fostering the City of Proximity through MaaS Integration" is an applied research project under the Driving Urban Transitions (DUT) Partnership. It will develop and test data-driven, user-centric 15-minute city models for suburban contexts, drawing on best practices from central urban areas. https://www.forthcoming.info/

2. Context

2.1. 15minC Dimensions

The dimensions that make up the 15minC framework applied in the FC project are adapted from the concept's core characteristics (Moreno et al., 2023), resulting in the four following dimensions: density, proximity, inclusivity, and digitalisation.

- Density is viewed in terms of mixed land use in a built environment (e.g., retail, residential, offices, leisure & green spaces, etc.), where the number of people in a given area can comfortably sustain the urban service delivery, opportunities, and resources.
- Proximity refers to the spatial and temporal accessibility to opportunities related to transportation, employment, healthcare, education, entertainment, access to green spaces, and retail for every resident through active or sustainable transportation modes.
- Inclusivity refers to addressing everyone's needs and experiences in relation to the opportunities offered by the 15mC, regardless of economic means, age, gender, disability, diversity, race, or ethnicity. Mobility justice, accessibility, social cohesion, and participatory decision-making are at the heart of inclusiveness as well as assessing cautiously the risks of exclusion and gentrification.
- Digitalisation refers to the enabling of the proximity, inclusivity, and density's dimensions using digital technology, such as Mobility-as-a-service (MaaS), smart city management tools, digital twins, and end-user applications.

The dimensions are evaluated in relation to the city's essential services. According to Moreno et al. (2023), essential services are defined through the High Quality of Societal Life (HQSL) index, which identifies six key urban functions that contribute to residents' daily well-being: living, working, getting supplies, enjoying, learning, and caring/being healthy. These social functions serve as the primary domains through which the four dimensions of the 15minC are assessed in practice.

2.2 Key Performance Indicators (KPIs)

KPIs originated in business management as means to measure the success of specific activities against strategic objectives. In urban planning, KPIs similarly serve as means to monitor the performance of key initiatives, aligning with broader goals such as sustainability, liveability, and inclusivity. They offer both quantitative and qualitative methods to assess the effectiveness of urban development strategies—particularly relevant in the context of planning concepts such as the 15minC concept examined in this study. This urban model emphasises proximity to essential services, aiming to create more accessible and sustainable neighbourhoods. In this context, KPIs ensure that goals such as improved resource allocation, enhanced accessibility, and a better quality of life are met through data-driven planning (Pozoukidou and Chatziyiannaki, 2021).

The 15minC model represents a shift toward more localised urban planning, where essential services are reachable within a short radius—such as a 15-minute walk, bike ride or public transport trip. KPIs are crucial in addressing the vision of 15minC, as they help measure factors such as proximity, walkability, and the effectiveness of public transport—elements vital to achieving strategic urban objectives like reducing carbon footprints (Moreno et al., 2023) and enhancing social equity (Pozoukidou and Angelidou, 2022).

Within the framework of the FC project, which encompasses case studies across six countries, KPIs will guide the transfer of 15-minute city mobility strategies to suburban areas. The overarching objective of the project is to adapt and transfer successful city centre strategies to suburban contexts, with a focus on multimodal mobility, user-centric models, and digitalisation—all within the broader aim of promoting public transportation as the backbone of FC's approach to rethinking distance as a function of time.

Overall, the selected KPIs will serve as key criteria for assessing 15minC strategies, determining their effectiveness in the suburban context, and providing measurable insights

3. Research Methodology

The selection process of KPIs was structured into three main phases: (1) consolidation and assessment of successful 15minC strategies across all six case studies; (2) clustering and drafting a list of potential KPIs; and (3) refinement and validation through local focus groups workshops.

Each case study consists of an urban central area (i.e., higher-density regions) and a corresponding suburban area (i.e., lower-density regions), described below:

- Spain: Madrid (urban) and Las Rozas (suburban)
- Portugal: Lisbon (urban) and Vila Franca de Xira (suburban)
- Hungary: Debrecen (urban) and Kertváros (suburban)
- Italy: Turin (urban) and Settimo Torinese (suburban)
- Turkey: Istanbul (urban) and Küçükçekmece (suburban)
- Germany: Hamburg (urban) and Hamburg-Altona (suburban)

In the following sections, the case studies will be referred to by their respective country names for ease of reference; however, this should be understood as referring specifically to the urban core and its corresponding suburban area, as described above.

3.1. Successful 15-minute City Strategies in Six Case Studies

In the first phase of data collection, a comprehensive questionnaire was designed and distributed across the case studies project partners and their local network. This process facilitated the examination of how local planning strategies align with initiatives adopted by planning bodies and transport authorities—such as Sustainable Urban Mobility Plans (SUMPs) (European Commission, 2023) and other relevant official documents—particularly in relation to the 15minC concept. The questionnaire covered several key areas: integration of the 15minC concept with local planning and strategies; practical application of the 15minC approach; perception and public engagement; progress and evaluation; and future directions and additional comments.

Once the responses were collected, each case study's objectives, guiding principles, and strategies were compiled. These strategies were then organised within a comparative framework to identify overlaps and gaps. This facilitated both the rapid identification and later in-depth review of best practices that strongly align with 15minC-based urban mobility strategies.

Across the six case studies, the derived strategies converge around several core themes. A common priority was the improvement of public transport through increased service frequency, expanded network coverage, upgraded rolling stock, and the introduction of new modes. For example, Portugal and Turkey focus on infrastructure, with Istanbul advancing public transport optimisation via station upgrades and hub renovations. Hungary emphasises speed and comfort enhancements in public transport. Germany and Italy aim to increase service frequency and modernise rolling stock, with Turin also expanding intercity rail services. Spain introduces peak-hour express buses, zero-emission routes, fleet renewal, and on-demand services.

Shared mobility solutions are implemented through micro-mobility services and free shuttle systems. Germany enhances its local mobility app, while Italy offers free internal shuttles for students and the elderly. Spain, for instance, develops integrated hubs featuring secure bike parking, EV charging stations, and car-sharing facilities. Turin incorporates a pay-as-you-go system to promote affordability and Mobility-as-a-Service (MaaS) integration.

Active mobility strategies are also prominently featured. All six case studies highlight the expansion of cycling infrastructure, with emphasis on safety improvements and reducing car dependency. Turkey and Spain additionally focus on improving bicycle parking and, in Spain's case, promoting e-bike sharing. Walkability is a shared objective, with initiatives to enhance sidewalks, create pedestrian zones, and develop attractive public spaces that encourage walking. Turkey introduces "shared streets" and prestige corridors accommodating multiple transport modes, while Hamburg promotes flexible public space usage.

People-centered urban design and tactical urbanism are central to several case studies. These include strategies to redevelop public spaces, enhance safety, and support community engagement through participatory processes. Madrid reduces speed limits on school streets; Germany develops multifunctional street furniture; and Lisbon promotes interventions in public squares. Community engagement strategies include workshops, surveys, and public consultations, with Turkey and Spain also utilising digital tools like Decide Madrid [2] to enable digital participation.

2 https://decide.madrid.es/

Additional actions address environmental sustainability, such as expanding green spaces, promoting clean transport, and creating nature-integrated cycling paths or traffic-calmed zones like Italy's "Zone 30."[3] Digital tools are increasingly adopted across the case studies but remain underdeveloped in Portugal, indicating potential for future enhancement. Strategies such as digital twins and MaaS applications are being used to advance planning and digital innovation.

Urban logistics strategies also integrate digital solutions. These focus on improving loading zones and real-time data applications. Turkey implements smart logistics measures, including construction material consolidation centres and the use of ICT/IoT technologies.

3.2. Cluster Formation of Key Performance Indicators for 15minC Strategies

Following the consolidation and assessment of successful 15minC strategies and best practices across the case studies, a collaborative strategy mapping exercise was conducted. This aimed to establish a structured approach for developing KPIs aligned with the identified strategies. During the exercise, a pre-defined set of strategies and policies was reviewed, refined, and validated by project partners from each city to ensure completeness and accuracy in light of their specific contexts. Project partners also contributed to identifying and developing relevant KPIs within their focus areas, organised by both strategy and scope.

Building on the outcomes of this collaborative process, an initial list of KPIs was drafted. This list was then expanded through literature review, which served to establish working definitions and gather additional potential KPIs alongside successful measures identified in previous project phases. Throughout this phase, representatives from the six case studies provided continuous input and feedback to ensure the KPIs reflected locally grounded realities.

This resulted in a list of over 90 draft KPIs—relevant to a range of dimensions in the assessment of 15minC—, capturing in greater detail all relevant gathered inputs, expanding on key elements while avoiding premature definitions of specific metrics and data sources. The intention was to provide a flexible but structured foundation for subsequent filtering and detailed definition. These KPIs were grouped into eight thematic clusters:

- Proximity
- Inclusivity
- Digitalisation
- Density
- Sustainability and Climate Action
- Governance
- Modal Share
- Economic Impact

The clusters of Proximity, Inclusivity, Digitalisation and MaaS, and Density and Land Use reflect adaptations of Moreno's (2023) core dimensions (see Section 2.1). Governance and Modal Share emerged from the specific thematic priorities of the FC project, emphasising the role of policy frameworks and mobility patterns:

- Governance refers to transparent, accountable, and participatory urban management, ensuring that public policies align with local planning strategies and that citizens and stakeholders are actively involved in the decision-making process (Chinellato, M. and Morfoulaki, M., 2019).
- Modal Share refers to the distribution of various transportation modes (such as walking, cycling, public transit, and driving) used by residents within a short, easily accessible radius (Poorthuis and Zook 2023).

Meanwhile, Sustainability and Climate Action and Economic Impact correspond to two of the three pillars of sustainable development—Environmental Sustainability and Economic Sustainability:

- Sustainability and Climate Action aims to reduce environmental impact by cutting carbon emissions, enhancing energy efficiency, promoting green spaces, and climate-conscious policies to mitigate climate change (Sahertian and Sari, 2024).

3 https://www.nuoverigenerazioni.eu/tutte-le-news/1298-citta30subito

- Economic Impact refers to the financial impact on local businesses, property values, and employment resulting from urban planning strategies that prioritise accessibility to essential services within a 15-minute walk or bike ride (Bartzokas-Tsiompras, 2022).

The interim list of KPIs addressed diverse analytical scopes relevant to each cluster and was organised accordingly. The following provides an overview of the clusters and the scopes addressed in that interim list:

- Proximity: Public Transport Access; Essential Services Access; and Green and Blue Space Access.

- Inclusivity: Social Inclusion; Affordable Housing; Socio-ecological Equity.

- Digitalisation: Smart Traffic Management; Smart Technologies Integration; Data Governance; Multimodal Integration and MaaS.

- Density: Diversity of Land Use; Urban Density, Public Space Utilisation; Building Utilisation; Traffic Calming.

- Sustainability and Climate Action: Emission Reduction; Air Quality and Green Coverage; Resilience and Climate Adaptation; Energy Efficiency.

- Governance: Citizen and Stakeholder Engagement; Policy Integration and Governance; Economic Sustainability; Sustainable Mobility Policies.

- Modal Share: Public Transport Modal Share; Active Mobility; Shared Multimodal Mobility; Modal Shift; Car Dependence Reduction.

- Economic Impact: Local Business Growth; Real Estate and Property Value; Circular Economy; Freight and Logistics Efficiency; Return on Investment (ROI).

3.3. Focus groups workshops to define the list of KPIs

Following the consolidation of the interim draft list of KPIs, focus group workshops (FGs) were conducted in each case study city. These workshops involved a broad range of local experts and stakeholders—including representatives from academia and research, planners and transport professionals, municipal staff from urban and suburban transport and planning departments, as well as local transport associations. These stakeholders will later participate in the establishment of urban living labs in their respective case studies (see Section 5).

The primary objective of these workshops was to gather insights and expert opinions to advance the implementation of 15minC strategies and to validate and refine the initial KPI list according to contextual relevance and feasibility. The focus group process included two main parts:

1. A SWOT analysis was conducted to identify local opportunities, challenges, and priorities in urban planning, mobility, and sustainability across the four core dimensions of the 15minC concept (see Section 2.1).
2. A ranking process followed, in which participants evaluated the eight thematic clusters and their corresponding interim list of KPIs (see Section 3.2).

3.3.1. SWOT Analysis Results

The discussions during the FGs revealed contrasting strengths and challenges across the case studies, shaped by varying levels of urban density and infrastructure. Experts from Germany and Portugal highlighted that higher-density areas naturally support walkability, mixed-use development, and efficient public transport. In contrast, participants from Spain and Hungary, where urban density is lower, highlighted the struggle with car dependency and service accessibility.

Reports from the local FGs also showed significant variation in public transport effectiveness. Germany and Portugal reported benefits from well-integrated networks, whereas experts from Turkey noted that heavy congestion reduces efficiency. Areas with ongoing revitalisation efforts, such as Hungary and Italy, focus on improving infrastructure and redistributing populations to enhance connectivity.

Urban diversity and socioeconomic factors also influence mobility patterns. Inequalities in transport access were highlighted in Turkey and Spain, particularly for vulnerable populations. Meanwhile, Germany and Portugal emphasised inclusive housing policies and mixed-use developments, although gentrification was noted as a shared concern.

Digitalisation presents both opportunities and barriers. Case studies with more advanced digital integration can improve accessibility and mobility services but also risk widening social inequalities, as noted in Portugal and Germany. Meanwhile, Spain and Turkey stated that the struggle with real-time data availability and digital infrastructure gaps could limit their ability to implement smart mobility solutions effectively.

Overall, the discussions showed varying degrees of adaptability toward the 15minC concept. While both groups of experts from Italy and Portugal agreed on the relevance of exploring strategies for proximity-based urban living, practitioners from Spain and Hungary separately concluded that there are substantial structural limitations. The reuse of public spaces emerges as a common opportunity, yet governance, funding, and administrative silos remain persistent challenges across multiple cities.

The discussions ultimately suggest that sustainable urban mobility is contingent upon the establishment of a balance between infrastructure investment, accessibility, and density. Addressing congestion and gentrification risks is imperative for high-density cities, while innovative solutions are required for low-density areas to reduce car dependency and improve the viability of public transportation. Digitalisation offers a pathway for cities to optimise mobility, but its success relies on equitable implementation and governance.

3.3.2. 15minC-derived thematic KPIs Cluster Ranking

The eight aforementioned KPI clusters and their corresponding potential KPIs were ranked using a simple dotmocracy method - a participatory approach to prioritisation, where attendees of a focus group rank ideas, statements, or proposals to determine collective preferences (Hidalgo, 2018). The results of the ranking are summarised in the following table, with 1 representing the highest priority and 9 the lowest across the case studies:

Table 1: Table Overall table of KPI clusters ranking results by case studies

KPI Cluster	Spain	Germany	Hungary	Italy	Portugal	Turkey	All
Modal Share	1	2	1	3	2	1	1
Proximity	2	1	1	5	1	3	2
Density	3	3	4	6	5	2	3
Sustainability & Climate Action	4	7	3	2	4	5	4
Inclusivity	6	3	8	1	7	4	5
Governance	7	6	6	4	6	6	6
Digitalisation	5	5	5	7	8	6	7
Economic Impact	8	8	7	8	3	8	8

The Modal Share cluster ranks highest in importance across all case studies, reflecting a strong focus on transportation mode distribution. Proximity and Density follow in ranks 2 and 3, emphasising the role of accessibility and urban planning in mobility strategies.

Sustainability and Climate Action holds a mid-level joint ranking of 4, highlighting varied national priorities in environmental policy. Inclusivity, Governance and Digitalisation are ranked 5, 6 and 7 respectively, indicating that

while they are considered important, they are not the primary focus. Economic Impact has the lowest ranking at 8, suggesting that economic considerations may be less immediate than social, environmental, and infrastructural aspects.

The results indicate that Modal Share and Governance exhibit the lowest variation, showing strong consistency across case studies. Digitalisation, along with Density, also demonstrate stable importance. Proximity and Sustainability and Climate Action show moderate variation, while Economic Impact and Inclusivity have the highest deviations, indicating significant fluctuations in their rankings among different case studies. This suggests a general consensus on the importance of Modal Share and Governance, while Inclusivity and Economic Impact are more context-dependent.

4. Definition of the Key Performance Indicators (KPIs)

Based on the previously mentioned research and analysis conducted across the six case studies, we identified a selection of KPIs. These are categorised as follows: 1) Common KPIs – applicable across all six case studies and 2) Specific KPIs – relevant to one or more of the case studies

The KPIs outlined in the following sections represent a concise yet comprehensive baseline, developed within the resource and capacity boundaries of the FC project. We acknowledge that these indicators are not definitive, as further refinement and updates are expected in subsequent project phases, particularly during the data collection stage and the further development of the Urban Living Labs (ULLs) (see Section 5) in suburban regions.

We defined both quantitative and qualitative KPIs. Notably, studies focusing on end-user KPIs remain relatively scarce in the urban field (Soriano-Gonzalez et al., 2023). As such, we prioritised indicators accessible from a "City Manager" perspective—more often quantitative—drawing on open-source and readily available datasets. This approach aligns with the practical limitations of the project, which does not include extensive surveying or in-depth user data collection. Nonetheless, qualitative indicators are also represented where they can be drawn from in situ observations, interviews, and exchanges with local stakeholders—documenting, for example, the presence or absence of specific spatial or service-oriented characteristics relevant to 15minC mobility strategies.

4.1. Common KPIs

The following table (Figure 3) provides an overview of nine Common KPIs, thematically clustered and ordered based on their relevance as determined through the focus group workshops. It is important to note the following:

- The KPIs vary in complexity, as reflected in their associated key metric(s). These differences will be further explored in later phases of the project.
- All KPIs will be gathered during the upcoming project phase. Consequently, the data release year will reflect the most recent available datasets and may vary slightly across case studies and individual KPIs due to differences in data availability.
- We acknowledge that KPIs should ideally be calculated over different time intervals to fully evaluate their performance. However, due to the limited duration of the project, the KPIs will be calculated specifically for low-density areas and subsequently cross-analysed both within and across the individual case studies.

Cluster	KPIs	Key Metrics Description	Units
Modal Share	Active Mobility Infrastructure[4]	Percentage of the active road length with sidewalks, cycle paths, and pedestrian zones, relative to the total road length of the selected area	%
Proximity	Proximity to Green, Blue and Public Spaces[5]	Percentage-based estimate of the selected area that lies within a 15-minute walking or biking distance to green, blue, and public spaces such as parks, recreational areas, city waterfronts, ponds, lakes, and more. <u>Breakdown as follows:</u> • Walking access – Area within a 15-minute walk. • Biking access – Area within a 15-minute bike ride	%
	Proximity to Essential Services[6]	Percentage-based estimate of the selected area that lies within a 15-minute walking or biking distance of each of the six essential service categories (i.e., points of interest POIs). <u>Breakdown as follows:</u> • Walking access – Area within a 15-minute walk for each category • Biking access – Area within a 15-minute bike ride for each category	%
	Proximity to Public Transport and Demand-Responsive Transport Services[7]	Percentage-based estimate of the selected area that lies within a 15-minute walking distance of fixed-route public transport and, if applicable, demand-responsive transport (DRT) services. <u>Breakdown as follows:</u> • Public transport access – Area within a 15-minute walk of a fixed-route public transport stop • (If applicable) DRT access – Area within a 15-minute walk of DRT service stops or operating zones	%
		<u>Service Frequency:</u> Average number of public transport vehicles (buses, trams, trains, etc.) arriving per hour at stops within the selected area. Include a breakdown by transport mode (e.g., inter-urban vs. intra-urban lines), peak vs. non-peak hours, and weekdays vs. weekends.	rides per hour
Density	Built-up Surface (Urban Density)[8]	<u>Built-up Surface:</u> Amount of built-up land area available per person in a selected area	m2/ppp
		<u>Total Built-Up Area Ratio.</u> Ratio of the total built-up area (including residential, commercial, industrial, etc.) to the total land area.	%
	Diversity of Land Use[9]	<u>Types of Mixed-Use Developments:</u> Identification and count of the different combinations of mixed-use developments[10] within the selected area.	count
		<u>Ratio of Key Land Uses to Total Area:</u> Ratio of key land uses (e.g., educational, residential, commercial, recreational, green spaces, etc.) to the total urbanised area.	%

4 Sources: Bartzokas-Tsiompras and Bakogiannis, 2023; Soriano-Gonzalez et al. 2023
5 Source: Soriano-Gonzalez et al. 2023
6 Sources: Zhang et al., 2022; Graells-Garrido et al., 2021; IUTP et al. 2019
7 Sources: Moreno et al., 2023
8 Sources: Abbiasov et al., 2022; Dutta et al. 2020
9 Source: Carpio-Pinedo et al., 2021; Pozoukidou and Chatziyiannaki, 2021
10 Developments refer to urban built and construction (e.g. existing and new buildings) and land-use changes (e.g. infrastructures such as roads, parks, public spaces)

Inclusivity	Inclusivity in Accessing Mobility Infrastructure[11]	Availability of Discounted Public Transport Ticket Types: Types of discounted fare options available for different user groups (e.g. students, seniors, low-income individuals, people with disabilities, families, and more).	count
		Quality of Barrier-Free Walking Infrastructure: Existence and quality of inclusive and accessible pedestrian infrastructure based on pre-defined criteria (e.g. tactile paving, audible pedestrian signals, curb ramps at intersections, etc.)	count and rating
Governance	Citizen Participation in Urban Planning[12]	Number of Public Consultations and Forums: Number of public consultations, forums, and public engagement events held. Include a breakdown by top-down and bottom-up process (if applicable).	count
		Citizen Feedback on Public Consultations: Quality of public consultations from the citizen perspective, based on available feedback (e.g. from municipality records or online platforms).	N/A
Digitalisation	Availability of Multi-modal Mobility Services[13]	Availability of Mobility Services Types: Availability of mobility services in the selected area, including public transport, shared mobility, and micro-mobility services.	count
		Level of Integration Across Mobility Services Degree of integration among various mobility services, focusing on shared travel planning, booking, and payment functions. (e.g. real-time route planning, ticketing integration, in-app payment, etc.)	level

Table 2: Common KPIs List

4.2 Specific KPIs

Consistent with the common KPIs, the following table provides an overview of six specific KPIs, thematically clustered and ordered according to their relevance as determined through focus group workshops. It is important to note that not all case studies include the same number of specific KPIs; for example, in the case of Lisbon, no additional specific KPIs were required to capture local urban strategies and characteristics unique to that context.

Cluster	KPIs	Key Metrics Description	Units	Case Studies
Density	Traffic Calming Zones[14]	Roads with Lower Speed Limits: Percentage of total street kilometers in the selected area with speed limits of 20–30 km/h or lower.	%	Italy; Spain
		Car-free, pedestrian zones streets: Percentage of total street kilometers in the specified area designated as pedestrian-only or car-free zones through traffic-calming measures.	%	
	Public Space Utilisation[15]	Percentage of public spaces (e.g., parks, plazas) actively used by residents, based on measured foot traffic. Breakdown by factors such as time of day and user demographics to be clarified.	%	Hungary
	Land Use Density Around Transit Corridors[16]	Land Use Density Percentage-based estimate of the total built-up area (residential, commercial, industrial, etc.) within a specific radius (e.g., typically 400-800 m) from public transit stations or stops	%	
		Average total floor area (FRA) of all (residential) buildings located within that specific radius	ratio	Turkey; Germany

11 Source: Bartzokas-Tsiompras and Stefanidas 2022
12 Source: Belausteguigoitia, 2021
13 Source: Strommer et al., 2022; Kriswardhana and Esztergár-Kiss 2022; Narayanan and Antoniou 2023
14 Sources: Distefano and Leonardi, 2022; Bartzokas-Tsiompras, 2022; Salleh et al. 2020
15 Source: Khoshkhah et al. 2022
16 Sources: Carpio-Pinedo et al., 2021; Pozoukidou and Chatziyiannaki, 2021

Digitalisation	Investment in Smart City Technolo-gies[17]	Total amount of (public) funds allocated for the development and implementation of Smart City technologies, including Digital Twins, within a specific year.	euro per year	Turkey
	Parking Control Man-age-ment[18]	Average Parking Occupancy: Percentage of parking spaces occupied or available during daily use. Breakdown by day of the week and time of the day.	% per day per time	Spain
		Parking Turnover Rate Number of different vehicles that occupy a single parking space over a specified period of time (typically per day)	count per space per day	
Economic Impact	Pilots and Innovation Implemen-tation[19]	Number of innovative mobility projects—such as carpooling systems, shared e-bike networks, or similar sustainable mobility initiatives—launched within a specific year.	count	Hungary

Table 3: Specific KPIs List

5. Next steps and Urban Living Labs (ULLs)

The list of Common and Specific KPIs, developed from general insights across the case studies, will be further refined during the next project phase through the establishment of ULLs (Nesti, 2018; Molinari and Concilio, 2015) in the lower-density suburban areas. These living labs will be set up in collaboration with the local stakeholders identified in the focus groups workshops (see Section 3.3). Their role will be to contextualise the KPIs and to collect data necessary for calculating them, considering each area's specific local characteristics—such as land-use structure, transport options and mobility patterns, as well as existing planning and mobility regulations (Noennig et al. 2025).

ULLs are widely recognised as experimental spaces, testbeds, in cities where diverse stakeholders collaborate to develop, test, and refine innovative solutions for urban sustainability challenges (Nesti, 2018; Molinari and Concilio, 2015). Key characteristics of ULLs include geographical embeddedness, participatory experimentation, active user involvement, leadership, and continuous evaluation (Voytenko et al., 2015).

Notably, while traditional ULLs are predisposed to situations that call for real-world implementation and/or scaling of a sustainable innovation (von Wirth et al., 2018), the FC project adopts a modified approach to ULLs, to emphasise knowledge exchange and vision-sharing. Unlike traditional ULLs that often engage in pilot testing a physical intervention (e.g., smart technologies or urban mobility interventions), FC ULLs serve as a platform for analytical and co-creation in selected neighbourhoods across six partner cities.

In the FC ULLs, researchers and local stakeholder (e.g., public administration, citizens, private actors) engage in more focus group discussions to a) build a common understanding of the 15mC concept; b) identify potential KPIs for measuring 15mC adaptation to suburban areas and c) discuss possible future outcomes & governance impact of operationalisation.

FC ULLs emphasises stakeholder alignment and shared visioning, which is critical for long-term policy integration (Nesti, 2018). The proposed ULL format addresses a gap in the concept's literature regarding conceptual adaptation (e.g., applying 15mC to suburbs) rather than just technological experimentation. However, the lack of implementation focus raises questions about long-term efficacy, suggesting a need for hybrid models that combine visioning with prototyping. Future research could explore how such "soft ULLs" intersect with traditional governance and participatory planning.

17 Sources: Boreham, 2024; Klimek, 2024
18 Source: Jakob and Menendez 2020
19 Source: Aba and Estergár-Kiss 2024

6. Conclusion

On the background of the growing traction of the 15minC concept as a paradigm shift towards a more proximate and diverse lifestyle in dense urban areas, we sought to identify and define KPIs that assess the transferability of 15minC mobility strategies from higher-density to lower-density areas. This assessment draws on six diverse case studies across Spain, Portugal, Hungary, Italy, Germany, and Turkey, highlighting variability in local priorities and the maturity of (planned) 15minC-based mobility strategies.

Through a series of stakeholder exchanges and data collection activities in each case study, it became clear that all locations emphasised the importance of achieving the 15minC through favouring active and sustainable transportation modes. This emphasis underscores the importance of proximity to essential services for local residents. At the strategic level, this is reflected in efforts to improve active and public transport services in all locations—such as increasing service frequency, enhancing network coverage, and expanding cycling infrastructure—with the goal of reducing car dependency. These efforts predominantly address the proximity and digitalisation dimensions of the 15minC.

However, less consensus emerged regarding the other 15minC priorities such as inclusivity, sustainability, and density. For instance, case studies in Italy and Germany ranked these aspects as high priorities, in contrast to Hungary and Portugal, which assigned them lower priority.

Taking this variability into account, we introduced a list of Common KPIs—applicable across all case studies—and Specific KPIs—tailored to individual contexts. Combined, they aim to capture and establish a baseline understanding of the 15minC concept within the mobility domain, while considering the project's time, resource, and capacity constraints.

These KPIs include both quantitative and qualitative measures. Quantitative indicators involve data-intensive methods (e.g, GIS-based analyses) to assess KPIs such as proximity to essential services, proximity to green/blue public spaces, and public transport availability. In contrast, qualitative indicators rely on more observation-based approaches (e.g., in-situ observations or data from open-access sources) to evaluate land-use diversity, availability of shared mobility services, and levels of citizen engagement.

The definition of these KPIs was derived—and in some cases challenged—by the diversity of the case studies: a process that was imperative to capture their broad spectrum, while acknowledging the potential risk of generalisation. Moving forward, iterative data collection and validation processes will be carried out in collaboration with case study stakeholders, primarily relying on publicly accessible sources. Therefore, the precision and applicability of the KPIs will be contingent upon—and informed by—the quality, availability and quantity of data provided by municipalities and local stakeholders.

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«Beyond Growth» in China: Coordinated Optimisation Strategies for Rail Transit Networks and Regional Spatial Structure in the Post-Urbaniastion Context

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Abstract:
This study investigates the role of multi-level rail transit systems in optimising spatial structures during China's post-urbanisation phase under the "high-quality development" framework. By comparing international urbanisation trajectories, it identifies China's unique tension: a need to support continued urban development amid population decline and fiscal constraints. The study proposes a multi-scalar optimisation strategy—regional corridors, metropolitan integration, and urban-scale structural reinforcement—highlighting selective, structure-oriented approaches over extensive construction. Using Shanghai's metropolitan region as a case, the paper demonstrates the feasibility and strategic value of this approach in supporting spatial balance, efficient mobility, and sustainable urban transformation.

Keywords: Cities beyond growth; High-quality development; Rail transit network; Regional integration; Spatial structure

1. Introduction

In recent years, terms such as "stock-oriented development" (, development based on existing assets) and "high-quality development" (, development emphasising sustainability, equity, and efficiency) have become increasingly prevalent in government documents and academic publications on urban planning in China (Xi, 2022). After four decades of rapid and large-scale urbanisation, major cities and developed regions in China have begun to exhibit characteristics of a post-urbanisation stage in terms of population growth, economic structure, and spatial expansion. These regions now face associated challenges (Wu and Phelps, 2011). Globally, many cities have experienced slowing or even negative population growth, stabilising or contracting spatial expansion, and a growing need to discuss "de-growth". Against this backdrop, "beyond growth" has emerged in Western contexts, emphasising the optimisation of spatial structures, equitable allocation of public resources, and environmental sustainability rather than continued expansion. However, in China, although some cities display typical features of post-urbanisation, unbalanced regional development, ongoing urban migration, and continuous industrial restructuring mean that China cannot simply replicate the development trajectory of Western countries. Instead, it must adopt a distinct approach through "high-quality development" to respond to the "beyond growth" concept.

Under this framework, rail transit has become more than a mere mode of transport; it now plays a strategic role in optimising spatial structure, fostering regional coordination, and enhancing urban quality (Wu et al., 2020; Cao, 2023). Nevertheless, the development and operation of rail transit in major Chinese cities currently face a series of pressing challenges, including limited corridor capacity, insufficient reusable infrastructure, rising construction costs, and fragmented operational governance. These constraints highlight the urgent need to shift from a traditional expansionist approach to a more layered, structural, and coordinated rail transit system.

This study, therefore, adopts a regional integration perspective contextualised within China's unique urbanisation process to investigate the critical role of rail transit in optimising spatial structure. Focusing on the Yangtze River Delta and the Shanghai Metropolitan Area1 As cases, the study draws on literature review, policy analysis, and case studies to construct a multi-level, collaborative rail optimisation framework tailored to the Chinese context. The main contribution lies in clarifying cross-jurisdictional and multi-scalar spatial coordination strategies under

1 In the Chinese planning context, the term "Metropolitan Area" (Da Dushi Quan, , literally "Metropolitan Circle") often refers to a broad spatial unit centred on a megacity, encompassing multiple adjacent cities with strong functional and economic linkages. For example, the "Shanghai Metropolitan Area ()" covers over 56,000 square kilometres and includes more than ten major urban centres (Shanghai Municipality People's Government et al., 2022). This scale and structure go well beyond the conventional international definition of a "Metropolitan Area," which typically refers to a single large city and its contiguous suburban or satellite areas. To avoid confusion, this paper refers to the Chinese concept of "Da Dushi Quan" as an "Extended Metropolitan Region (EMR)," emphasising its cross-jurisdictional, polycentric, and functionally integrated nature.

China's specific developmental background, thereby enriching theoretical and practical links between high-quality development and rail transit planning.

The paper is structured as follows: first, it outlines the research background and theoretical foundations; second, it examines China's urbanisation stage and its comparison with international processes; third, it analyses the current challenges in rail transit development and proposes multi-scalar optimisation strategies for the regional, metropolitan, and suburban levels; and finally, it evaluates the applicability and feasibility of these strategies through a case study of Shanghai and its surrounding areas.

2. Theoretical Framework and Literature Review

2.1 Definition and Characteristics of Post-urbanisation

Around the 1970s, population stagnation and even decline in some large Western cities attracted attention in the fields of planning and geography. This prompted research on whether urban dispersal signified a new stage of development (Korcelli, 1980). Berry (1980) introduced the concept of "counter-urbanisation" to describe the shift of population from metropolitan areas to smaller towns and rural areas. Subsequent studies have explored various features of "post-urban society", including ageing populations, urban shrinkage, and the governance of urban regeneration (Mitchell, 2004; Tateishi et al., 2025).

Existing literature often evaluates whether a region has entered a "post-urbanisation" stage based on population dynamics, spatial patterns, and industrial transformation (Martinez-Fernandez et al., 2012). The most typical indicator is demographic: a marked slowdown in urban population growth, stabilisation of urbanisation rates at a high plateau, and signs of zero or negative growth in urban population. Under continued population decline, urban shrinkage becomes tangible (Tateishi et al., 2025). Spatially, cities experience slower expansion, decoupling economic growth from land development and trends such as polycentricity, suburbanisation, and counter-urbanisation. Central areas may see declining density and functional reconfiguration (Bontje, 2004; Wan et al., 2023). Industrially, a shift from industrial to service-oriented economies—i.e., post-industrialisation—is observed. Urban development transitions from incremental expansion to productivity enhancement and innovation-driven growth, relying less on population and land increases (Cai et al., 2020).

2.2 Post-urbanisation in the Chinese Context: New Urbanisation and High-Quality Development

"Post-urbanisation" is rarely used in Chinese official and academic discourse. Instead, phrases such as the "later stage of urbanisation" or "second half of urbanisation" are more common and often discussed in relation to concepts like "counter-urbanisation" and "urban shrinkage". Data indicate that China's population began to decline in 2021. However, due to regional disparities, the urbanisation rate of the resident population continues to rise—reaching approximately 67% by the end of 2024—marking an entry into the late stage of urbanisation.

Scholars remain divided on whether China is entering an era of urban shrinkage. Some argue that due to large rural populations and uneven development, China still has untapped potential for rural-to-urban migration, and the demographic dividend of urbanisation has not yet been exhausted (Xie and Lin, 2023). Others note that China's working-age population has already peaked, with one-third of cities exhibiting signs of shrinkage (Li et al., 2025) and that the momentum of urbanisation is weakening. Some scholars contend that, given China's vast territory and internal heterogeneity, post-urbanisation phenomena first appear in megacities and developed regions, while less developed areas remain in earlier stages. There is also no consensus on the urbanisation rate at which China will stabilise: some estimates suggest it will not exceed 80% (Qiao et al., 2018), while others anticipate it will surpass that threshold (Chen and Luo, 2006). Nonetheless, there is broad agreement that China's developed regions and megacities already exhibit post-urbanisation traits. Most researchers advocate for proactive planning responses to the profound impacts of demographic and spatial changes (Wu et al., 2020).

From a policy perspective, the Chinese government has shifted its urban development focus from rapid expansion to stabilisation, calling for a transition from incremental to stock-based optimisation. As such, Chinese discourse centres more on "new urbanisation" or "high-quality development", emphasising rural-urban integration, regional coordination, and qualitative urban enhancement, rather than adopting the "post-urbanisation" label.

In this sense, China's interpretation of "post-urbanisation" implies a phase of quality improvement and structural optimisation, rather than an outright decline following complete urbanisation.

2.3 Optimising Spatial Structures and the Role of Rail Transit under High-Quality Development

The effective interplay between spatial structure optimisation and transport systems is essential for achieving regional high-quality development. In China, megacities showing post-urbanisation features must simultaneously restructure their economies and support regional growth, necessitating refined spatial strategies. Theoretical foundations for spatial structure optimisation—such as central place theory, growth pole theory, polycentricity, and corridor–node theory—have evolved and combined in planning practice to provide robust conceptual tools. It is now widely acknowledged that transport systems—particularly rail transit—play a pivotal role in shaping and improving urban–regional spatial configurations (Urena et al., 2009; Gu and Kou, 2017; Hu et al., 2023). Transport influences spatial form, evolution, and restructuring by enhancing accessibility, guiding land use, and shaping corridors and nodes. International experiences in metropolitan regions reveal the profound effects of rail systems on spatial transformation, underscoring the need for coordinated transport–land use planning as a foundation for structural optimisation (Cao, 2023; Sun, 2024; Chen et al., 2010).

3. "Beyond Growth" in China: Indicators and Contradictions in the Post-urbanisation Stage

3.1 Assessing China's Urbanisation Stage: Domestic and International Comparisons

(1) China's Urbanisation Stage

In recent years, China has entered a transitional period characterised by population decline and a continued rise in the urbanisation rate. This is particularly evident in megacities such as Beijing and Shanghai, where post-urbanisation features have emerged. Although the national urbanisation rate has not yet stabilised, government policy has clearly shifted towards "stock optimisation" and "decremental development", emphasising spatial quality and efficiency more.

From a macro perspective, China raised its urbanisation rate from 20% to 67% within four decades, adding 670 million urban residents. This rapid increase has begun to slow. Meanwhile, by 2024, the national population had fallen to 1.408 billion, with a natural growth rate of –0.99‰—the third consecutive year of negative growth. The proportion of the population aged 65 and above rose to 15.6% and continues to climb (NBS, 2023; NBS, 2024; NBS, 2025). In 2024, the natural growth rates of Beijing and Shanghai were 0.01‰ and –1.53‰, respectively (Beijing Municipal Bureau of Statistics and NBS Survey Office in Beijing, 2025; Shanghai Municipal Bureau of Statistics and NBS Survey Office in Shanghai, 2025). Both cities have adopted "zero growth" targets for built-up areas, and the tertiary sector accounts for over 75% of their GDP, illustrating clear signs of post-urbanisation. However, beyond these megacities, many large cities remain in an expansion phase.

(2) Origins of the "Beyond Growth" Framework: An International Comparison of Urbanisation

Regional disparities in China have resulted in population migration toward cities continuing even as the total population declines. This means that urbanisation is still unfolding even as the negative growth sets in. Despite resource constraints and social tensions, megacities must continue growing to support surrounding underdeveloped areas. During the high-speed urbanisation era, motorisation accompanied urban expansion, leading to spatial growth driven mainly by land development and road construction, while rail transit development lagged. As a result, applying the "beyond growth" framework in China requires addressing both the limitations of growth-dependent planning and the historical challenges of rapid urbanisation.

International comparisons reveal that China's urbanisation exhibits distinct temporal and structural differences. First, China's urbanisation process has been speedy and involves a massive population. While its speed is comparable to that of Japan and South Korea, the scale is much larger. When Japan and South Korea surpassed 60% urbanisation, they had urban populations of approximately 103 million and 41 million, respectively. In contrast, China's population reached 1.4 billion in 2019 when the urbanisation rate hit 60.6%, placing greater pressure on infrastructure and public services. Second, the sequencing of urbanisation and population decline differs significantly. In most developed countries, population decline followed stabilisation at urbanisation rates of over 70%. In China, however, population decline began when the urbanisation rate was around 65%, and rural-to-urban migration had not yet concluded. Urbanisation is still advancing. Consequently, China must simultaneously address ageing, absorb migrating populations, and continue urban development—creating unprecedented fiscal and planning pressures. Third, rail transit development lagged behind motorisation, exacerbating structural urban challenges. Road-based expansion dominated during China's rapid growth phase, but rising congestion now hinders efficiency. Moreover, China entered the post-demographic-dividend phase before fully transitioning to a service economy. As a result, cities face dual pressures: job provision and revenue generation.

In summary, China cannot directly adopt the "stop expanding" model of developed countries. Even in a post-urbanisation context, structural optimisation and functional transformation are necessary to promote spatial efficiency and regional balance—goals for which rail transit is a key driver.

3.2 The Demand and Dilemmas of Rail Transit under High-Quality Development

China's unique urbanisation background explains the necessity of rail transit development and the conditions it must address. As a guiding principle, high-quality development imposes new structural demands on spatial planning and infrastructure systems. Functionally, rail transit is no longer simply a commuter tool but a critical mechanism for urban structural adjustment and transformation of the urban settlement system (Chen et al., 2017; Chen et al., 2022).

However, in practice, Chinese metropolitan rail transit systems still face multiple challenges. First, corridor capacity is limited and construction space in central areas is nearly saturated. Second, reuse rates of existing railways remain low, especially for mid-level suburban rail networks, which are severely underdeveloped (Li, 2022). Third, marginal returns are diminishing, with high construction costs, low returns, and rising fiscal pressure. Fourth, operational fragmentation persists, with inadequate cross-jurisdictional collaboration and a lack of integrated systems.

In response to these issues, China's rail transit must move beyond linear, expansion-based logic and adopt a more efficient, structural, and coordinated development model. On one hand, the system should support regional rebalancing and the reorganisation of urban–rural structures, ensuring strong connections to new towns and key regional nodes. On the other hand, it must also evolve internally—from quantity-driven supply to quality-oriented structure—achieving a clear division of labour and coupling within a multi-level rail system.

Based on these goals, this paper proposes a rail transit optimisation framework across three spatial scales: the regional level, the metropolitan level, and the suburban level. This framework aligns with the values of high-quality development—equity, efficiency, and sustainability—and aims to provide systematic support for spatial restructuring and industrial transformation in China's megacities during this critical "window period".

4. A Framework for Coordinated Optimisation Between Rail Transit Networks and Regional Spatial Structures: Strategy and Case Study

4.1 Key Elements and Framework for Coordination Between Rail Transit Networks and Spatial Development

(1) The Nature of Coordinated Development

The coordinated development between rail transit networks and urban spatial structures is fundamentally a dynamic, bidirectional interaction. Each influences and reinforces the other, forming a feedback mechanism. Urban spatial development goals support and guide the optimisation of rail networks, while rail networks themselves serve as a critical system for directing resource allocation and the evolution of spatial structure.

Optimising rail network layout requires a sound understanding of current spatial conditions and development objectives. A clear strategic vision for spatial development forms the foundation for identifying rail priorities and improving network efficiency. Rail systems, built upon corridors and nodes, directly affect population mobility, land use, and industrial distribution. By improving accessibility and strengthening regional linkages, rail transit shapes spatial structure and influences resource allocation efficiency.

(2) Core Elements and Multi-level Framework

When urban and regional development demands are reflected in rail networks, they manifest as spatial connections and expectations regarding travel time and service intensity. A multi-level framework can represent these dynamics from a spatiotemporal perspective.

This framework should include at least three spatial levels, each with distinct functions and elements. The three core components for coordinated optimisation are rail lines (enabling the flow of resources across different scales), nodes or hubs (connecting systems and spaces), and policy mechanisms (ensuring implementation and governance) (Figure 1). Specifically:

At the regional level, intercity and high-speed rail connect major urban nodes, support the formation of strategic corridors, and serve business travel needs. The target is to reach metropolitan hubs within one hour.
At the metropolitan level, rail systems—comprising suburban rail, intercity lines, and metro—link central cities, new towns, and peripheral urban areas, supporting medium- to long-distance commuting.

At the central level, metro systems form dense intra-city networks primarily used for short-distance daily travel. Service coverage should also reach within an hour.

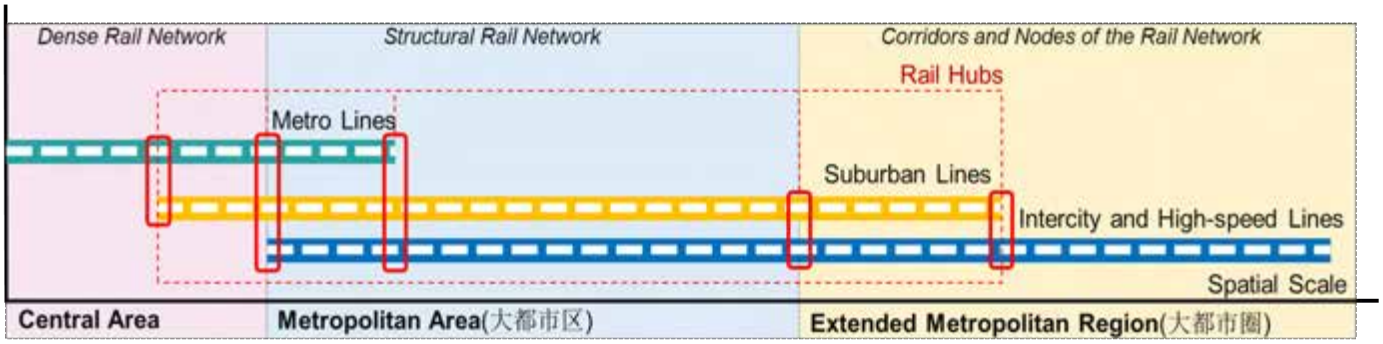

Figure 1. Multi-level Rail Transit Network Framework

4.2 Specific Strategies and Case Studies for Coordinated Optimisation of Rail Transit and Spatial Structure

4.2.1 Objectives and Strategies of Rail Transit Optimisation

The objectives of rail transit network optimisation should be determined by regional challenges and strategic development goals. In the current Chinese context, rail transit optimisation aims to establish a multi-level rail transit system operating across three spatial levels: the regional level, the metropolitan level, and the central level. This system facilitates development goals through strategic node connections and varying operational frequencies.

Specific strategies include: Firstly, at the regional level, enhancing functional corridors centred around major cities to guide the urban settlement system. Secondly, at the Extended Metropolitan Region (EMR) level, promoting efficient resource mobility through multi-layered, multifunctional rail hubs and mitigating spatial fragmentation caused by administrative boundaries. Thirdly, at the metropolitan level, establishing suburban rail as the structural backbone network to overcome the limitations of existing dense metro networks and efficiently connect central urban areas with peripheral new towns (Figure 2).

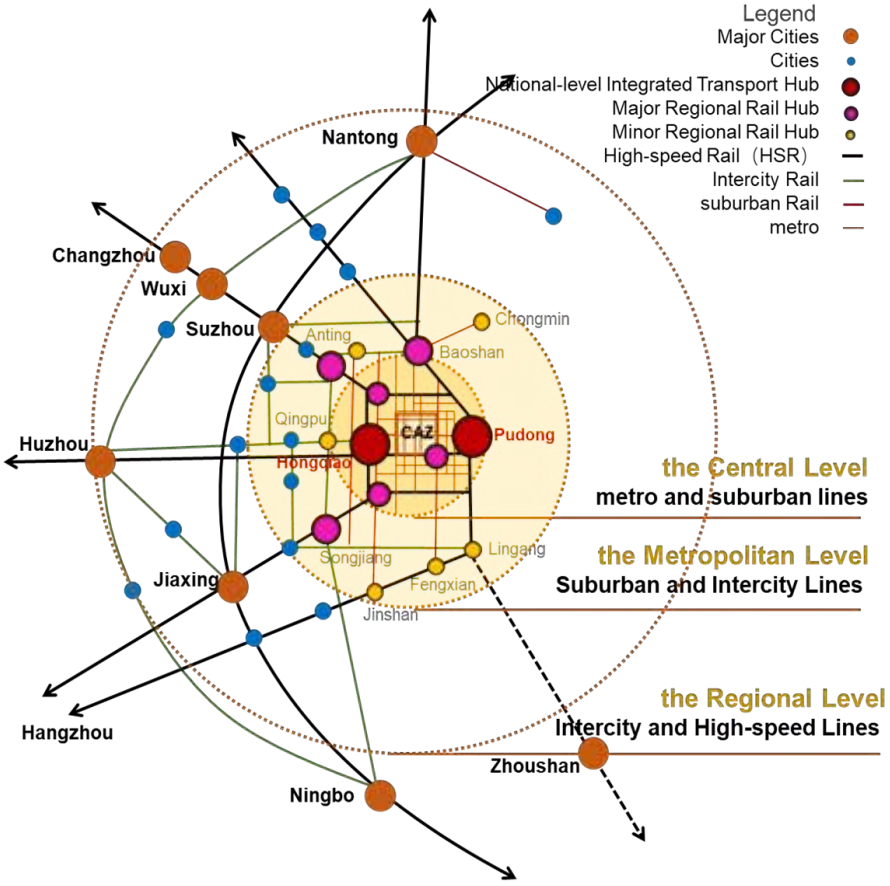

Figure 2. Multi-level Spatial Structure of Rail Transit

The following sections use the Yangtze River Delta and Shanghai Metropolitan Area to further illustrate these strategies.

4.2.2 Urban Agglomerations and Extended Metropolitan Regions: Corridors and Nodes

(1) Regional Corridors and Urban Strategies

At the regional level, rail transit serves not only connectivity functions but also as a strategic instrument for urban development, guiding the implementation of regional goals related to population mobility, economic development, ecological protection, and cultural exchange.

Taking the Shanghai Metropolitan Area as a case, optimisation strategies are developed around these regional strategic goals. Six strategic corridors have been identified: Shanghai–Nanjing, Shanghai–Hangzhou, Yangtze River Corridor, Coastal Corridor, Hangzhou Bay Corridor, and Shanghai–Huzhou Corridor. The Shanghai–Nanjing and Shanghai–Hangzhou corridors should enhance service frequency to maximise existing capacity. The Yangtze River and Coastal Corridors are reserved corridors prioritised based on industrial development demands, while the Shanghai–Huzhou Corridor is prioritised for immediate development, serving tourism and cultural needs (Figure 3). The analysis evaluates corridor performance through both industrial and cultural lenses, ensuring that key natural and cultural nodes—such as World Heritage Sites—are connected to external hubs via rail transit. (Figure 4).

Figure 3. Strategic Rail Corridors in the Shanghai Metropolitan Area

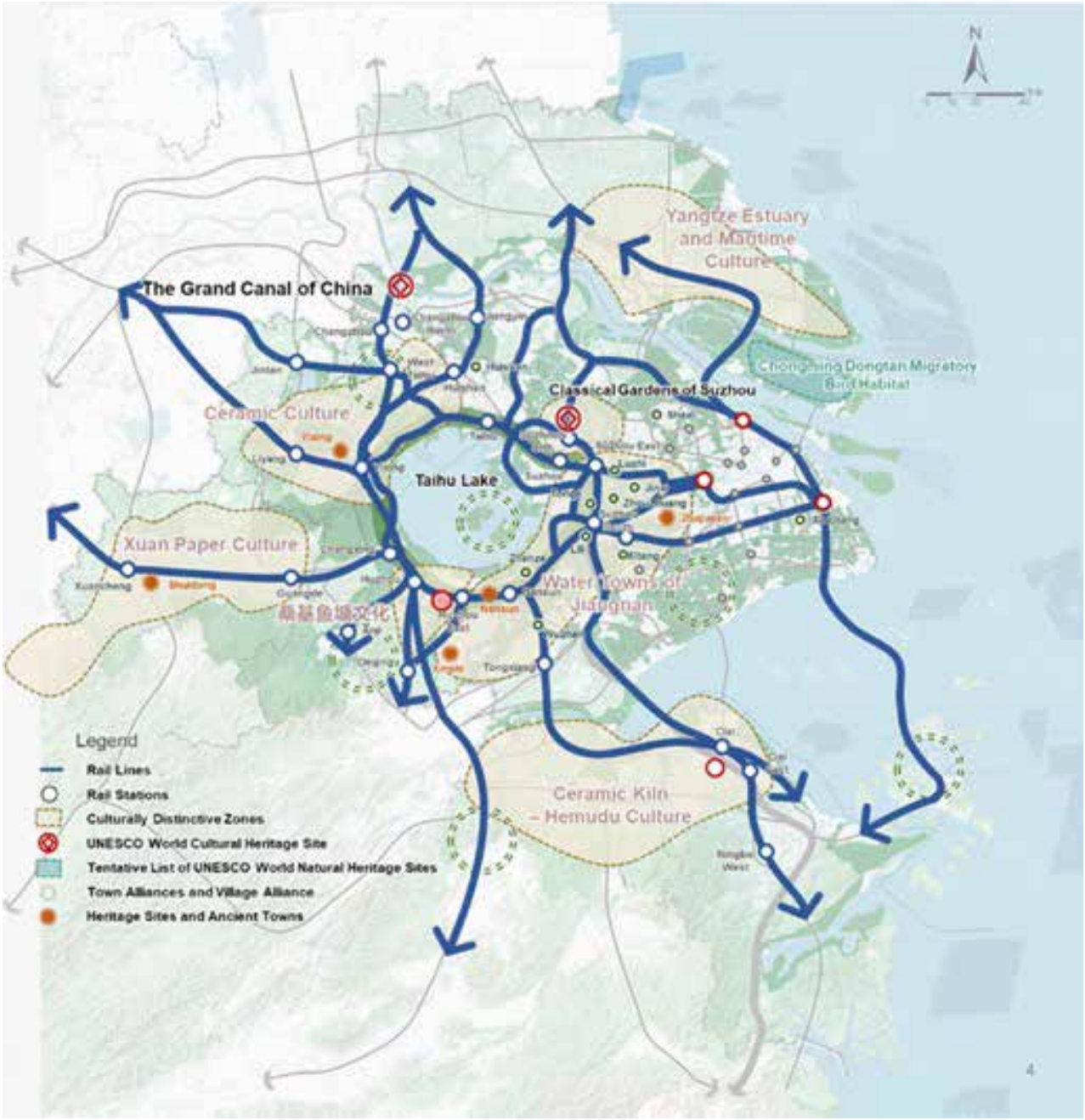

Figure 4. Rail Transit System Supporting Natural and Cultural Heritage in the Shanghai Metropolitan Area

(2) Multi-level Networks and Urban-town Systems
Establishing multi-level rail transit systems supports the optimisation of regional spatial structures and urban settlement systems in the framework of high-quality urbanisation. Rail transit networks should address three connection types: intercity connections at the regional level, daily commuting within Extended Metropolitan Regions, and internal city connections.

Using the Shanghai Metropolitan Area as an example, the study analyses urban development roles and inter-city connectivity, proposing layered and composite optimisation strategies. It emphasises compound utilisation of corridor resources, detailed layered scheduling, and differentiated stop schemes to enhance overall network efficiency and spatial structural optimisation (Figure 5).

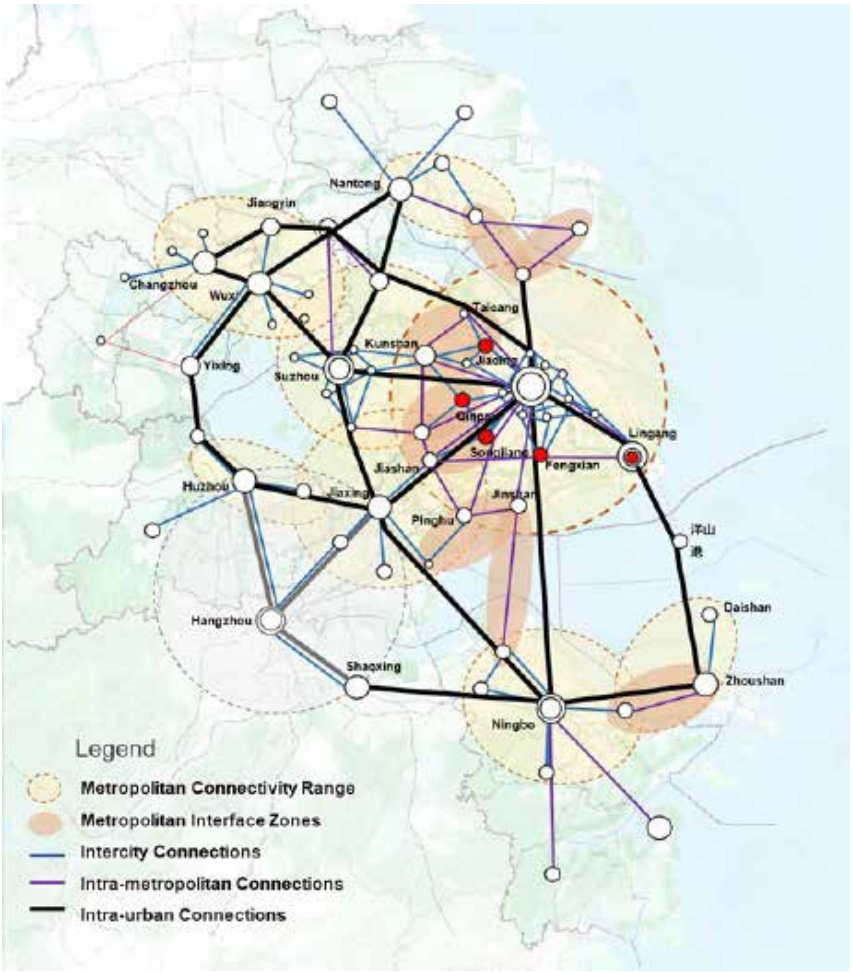

Figure 5. Inter-city Connectivity in the Shanghai Metropolitan Area

4.2.3 Metropolitan Area: Structural Network

(1) Hub Systems and Resource Allocation

Rail stations serve as critical interfaces linking transit systems with urban spaces. Rather than relying on a single mega-hub, tiered and functionally differentiated hub systems can more effectively facilitate the allocation of urban resources. This study proposes a classification of five hub types, divided into two categories. Type I includes national and regional hubs: national-level integrated transport hubs (such as the Hongqiao Integrated Transport Hub), major regional rail hubs, and minor regional rail hubs (Figure 6).. Type II includes suburban network hubs, which consist of new town hubs (designed to link newly developed urban areas with the broader regional network) and central hubs (which integrate suburban rail with metro systems to enable seamless transfers) (Figure 7).

In the case of Shanghai, the city's excessive dependence on the Hongqiao Integrated Transport Hub—currently handling 60% of all rail passengers and operating at nearly 90% of its designed capacity—necessitates a more balanced hub network. To address this, the study recommends strengthening the role of the Eastern Hub, centred around Pudong International Airport, to ease pressure on the western corridor. It also advocates for the enhancement of Baoshan and Longyang Road stations to complement the functions of Shanghai, South, and West stations as part of the regional hub system. Additionally, the study proposes establishing general-purpose suburban hubs along the urban periphery, designating new town hubs in each of the five new towns, and developing new central hubs at the edge of the central area to improve integration between suburban rail and metro services.

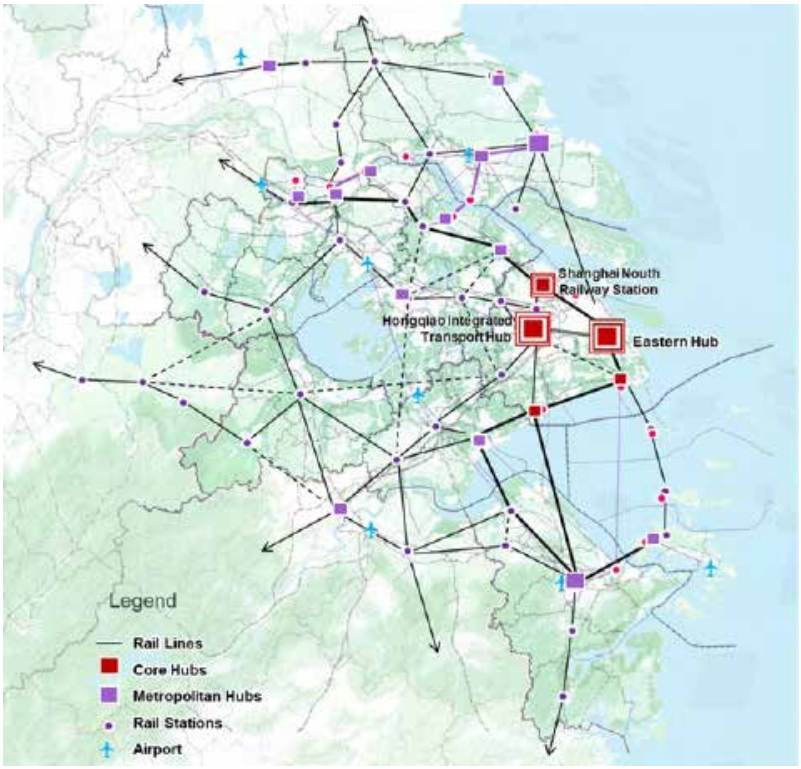

Figure 6. Rail Hub System of the Shanghai Metropolitan Area

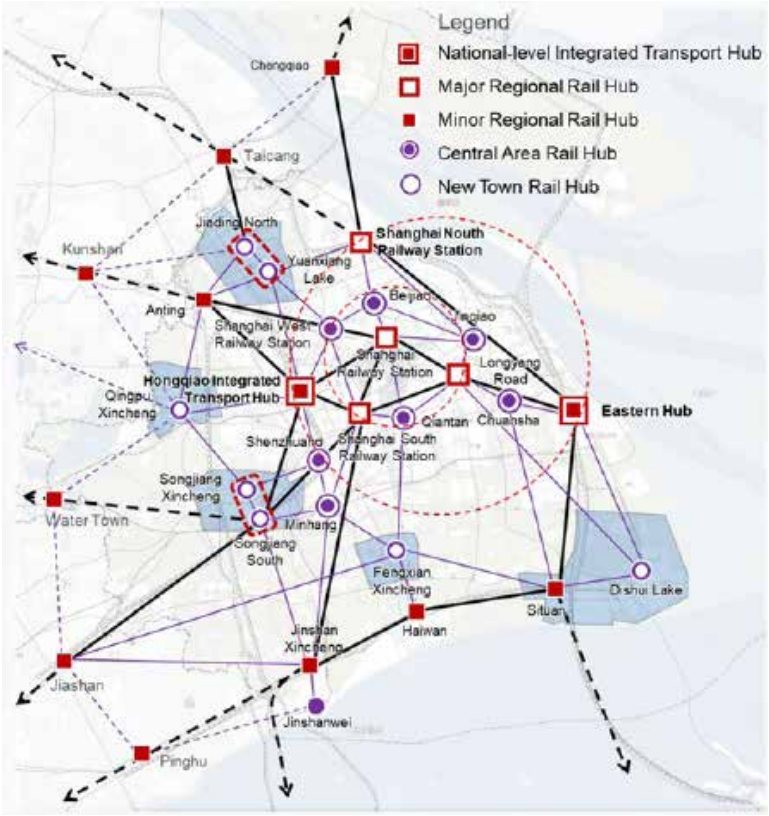

Figure 7. Rail Hub System of Shanghai and Its Adjacent Areas

(2) Suburban Rail and Inter-jurisdictional Cooperation
With increasing cross-boundary commuting within metropolitan areas, administrative boundaries currently limit the effectiveness of rail systems, hindering new town development. The study suggests integrating suburban and intercity rail at boundary regions to enhance connectivity.

In the Shanghai Metropolitan Area, insufficient suburban and intercity rail infrastructure currently restricts cross-city commuting, risking increased traffic congestion. Drawing lessons from Paris and Tokyo, this study advocates detailed reclassification of rail lines within boundary areas, aiming to strengthen regional cooperation and transform peripheral new towns into multifunctional urban nodes, thus preventing their evolution into mere residential towns (Figure 8).

Figure 8. Cross-boundary Rail Coordination

4.2.4 Metropolitan Areas: Structural Dense Networks
Central urban rail networks are increasingly complete in most major cities, but peripheral areas remain inadequately supported. As a structural backbone, suburban rail efficiently links central and peripheral areas. The study recommends a phased, demand-driven approach rather than extensive new construction.

In Shanghai, peripheral central areas experience high commuting pressures, significant industrial and population renewal, and severe congestion. Structural reinforcement through constructing a central loop line and radial suburban lines is proposed to strengthen connectivity between central areas and new towns, optimising regional spatial structures (Figure 10).

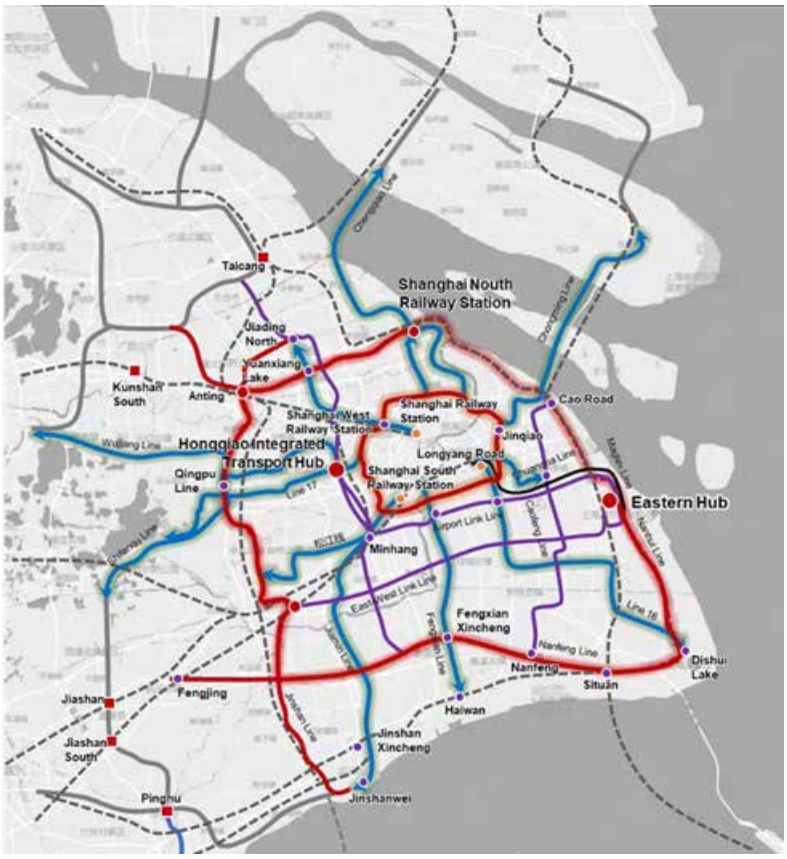

Figure 10. Suburban Rail Structure in Shanghai

4.2.5 Development, Construction and Operation Modes

Clear delineation of rail transit development, construction, and operation responsibilities is critical for sustainability. The study highlights the importance of clarifying roles between central and local governments and establishing inter-jurisdictional coordination mechanisms.

It recommends that Shanghai leads coordination efforts, establishing a comprehensive planning, construction, and operation platform involving neighbouring cities. The coordination should define technical schemes, operational responsibilities, and service standards for network integration. Diversified financing models and Transit-Oriented Development (TOD) approaches should be adopted to ensure sustainable rail transit development.

5. Conclusion

This study, situated in the context of China's transition to the mid-to-late stage of urbanisation, explores the key role and practical challenges of rail transit in promoting spatial optimisation and facilitating the flow of urban elements under the high-quality development paradigm.

Comparative analysis reveals that China's urbanisation path differs significantly from Western models: population decline has begun before urbanisation is complete; inefficient spatial expansion resulted from delayed rail development; and industrial restructuring is under pressure due to an underdeveloped service sector. These contradictions make it clear that China cannot follow a "de-growth" model but must pursue a focused, structure-oriented, high-quality development strategy within the "beyond growth" framework.

To this end, the study proposes a multi-level rail transit optimisation framework across regional, metropolitan, and suburban scales. Unlike traditional large-scale expansion, the proposed approach emphasises structural reinforcement, integrated corridor use, and hub function reconfiguration:

At the regional level, high-speed and intercity rail should support corridors and key nodes.

At the metropolitan level, cross-jurisdictional coordination and balanced functionality are key.

At the suburban level, suburban rail should form the backbone, supported by the metro system, to enhance commuting efficiency and reduce central city pressure.

The case study of the Shanghai Metropolitan Area confirms the framework's applicability and feasibility. Practices such as structural optimisation, corridor integration, and operational coordination align with today's resource constraints and governance complexities more than blind expansion.

This research expands the theoretical discourse on rail transit and offers a context-specific strategy for China's development model. It may also be a reference for other countries facing similar post-urbanisation challenges. Nonetheless, limitations remain—for instance, further research is needed to assess economic impacts and operational mechanisms in greater detail. Future studies should explore the design of inter-jurisdictional governance systems and assess the long-term spatial and socio-economic effects of rail transit strategies.

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Beyond Access: A Grid-Based Framework for Measuring Service Levels and Inequity in Multimodal Public Transit

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Abstract
Conventional transport studies, focused on accessibility, often fail to capture the actual service levels and spatial inequity of public transport. This study develops a novel grid-based multimodal multiplex network framework for South Korea to overcome these limitations. Using nationwide GTFS data, we model each transport mode as a distinct layer on a 1km² grid, incorporating service frequency as a weight to measure service levels. The analysis reveals extreme spatial polarization: service levels are overwhelmingly concentrated in metropolitan cores while vast non-urban areas experience severe service deprivation. This framework provides a robust tool for diagnosing transport inequity with high precision, offering data-driven evidence for policies aimed at building a more inclusive and sustainable transport system.

Keywords: Multimodal Public Transport, Multiplex Network, Spatial Accessibility, Spatial inequality, Nationwide spatial analysis

1. Intrduction

Transportation services are fundamental to urban functionality, acting as the circulatory system that facilitates the flow of goods and people and enables complex social interactions. Public transport, in particular, is critically important as it provides a broader range of citizens with equitable access to urban opportunities and the freedom of mobility (ITF-OECD, 2023).

Modern cities rely on Public Transport Networks (PTNs) to achieve efficient and sustainable mobility (Kujala et al., 2018). These networks have become critical infrastructure in cities worldwide, offering access to essential services such as employment, education, and healthcare, thereby facilitating diverse activities and social interactions (ITF-OECD, 2023).

In response to rapid urbanization and growing transportation demand, public transport plays a vital role in supporting urban growth and sustainable development (Ding et al., 2019). By enabling large-scale commuter flows, it serves as the foundational infrastructure essential for sustaining core urban functions and enhancing the sustainability of metropolitan areas.

However, despite their importance, PTNs, as complex networks, are inherently characterized by an uneven distribution of service (Mouronte-López, 2021). This structural imbalance, wherein a few hub nodes account for a disproportionate share of network connectivity, not only leads directly to issues of network vulnerability and robustness but also extends to create disparities in service levels and accessibility.

Transport networks fulfill the critical roles of connecting key locations and providing the urban-wide framework for interaction. However, access times from residential areas to essential services and transport facilities vary significantly by region type (Bae et al., 2016).

Specifically, urban areas, with their close proximity to public transport stops and stations, tend to have lower car dependency. In contrast, most low-density regions, such as rural townships (eup and myeon areas), exhibit higher car dependency due to poor public transport accessibility. This reflects a stark disparity in the spatial coverage and service density of PTNs between urban and non-urban areas.

This uneven distribution of transport services risks exacerbating the vulnerability of specific demographic groups. The high demand for subsidized transport options, such as welfare taxis and Demand-Responsive Transit (DRT), in low-income and low-service-density areas serves as empirical evidence of this service imbalance (Kim G. et al., 2019).

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As the demand for mobility is derived from the need to access opportunities (ITF-OECD, 2023), a lack of transport services can exclude people from participating in educational, employment, and various social and leisure activities. This issue transcends a mere physical deficit of transport services, leading to severe socio-economic imbalances such as heightened inequality, restricted access to essential services, and hindered regional development.

In rapidly urbanizing areas where economic gaps are widening, the uneven spatial distribution of social resources can intensify feelings of deprivation among vulnerable populations. This, in turn, may trigger psychological changes and social discontent, potentially affecting social stability (Han, C. et al., 2019). Crucially, the gap in transport accessibility between urban and non-urban areas—which diminishes quality of life and constrains opportunities for social participation—poses a direct threat to the realization of transport rights and social equity (Han, C. et al., 2019; Kujala et al., 2018; Mo C. et al., 2013).

On the other hand, as car-centric urban environments create persistent problems such as traffic congestion and pollution, the importance of public transport is ever-increasing. However, existing methodologies for evaluating Public Transport Networks (PTNs) have significant limitations in capturing the complexity of real-world urban transport systems.

Approaches centered on Origin-Destination (OD) data focus primarily on pairwise connectivity between locations, failing to reflect the overall structural properties of the network or actual service operations data (Koo et al., 2024). Consequently, analyzing a transport network based solely on physical links overlooks the service connectivity actually experienced by users. This leads to a loss of critical information, which not only diminishes analytical accuracy but also hinders the formulation of effective policies (Hong D. et al., 2014).

Furthermore, a substantial body of research in transport network analysis has concentrated on evaluating the performance or structural characteristics of single-mode networks. While this approach can be useful for analyzing the efficiency of a specific transport mode, it overlooks the reality that urban travel occurs within a multimodal environment (Hong J. et al., 2019). Specifically, these models have a fundamental limitation in their inability to adequately incorporate user choices and inter-modal connectivity that arise during the transfer process.

Another fundamental reason why existing network analyses fail to capture real-world complexity lies in their methodological choices: namely, the selection of spatial units for analysis and an overemphasis on the dimension of accessibility. Many previous studies, driven by convenience or data availability, have utilized administrative districts such as eup, myeon, and dong as nodes or units of spatial aggregation (Hwang M. et al., 2023; Byeon P. et al., 2016; Park G. et al., 2023; Jang D. et al., 2015). This approach is inevitably subject to the Modifiable Areal Unit Problem (MAUP). This means that analytical results can vary significantly depending on the scale and shape by which a region is partitioned and aggregated, which in turn poses a serious threat to the reliability and generalizability of the findings.

Administrative boundaries rarely align with actual travel behaviors or the spatial distribution of urban functions (Kim J. et al., 2019; Hwang M. et al., 2023), and their areas vary widely even within the same hierarchical level. Consequently, constructing and analyzing networks based on these arbitrary boundaries inherently limits the ability to capture micro-spatial patterns and carries a significant risk of distorting analytical results.

Furthermore, accessibility in public transport is typically defined by the mere presence of physical infrastructure and the potential reach it provides. While the goal of enhancing spatial accessibility through infrastructure improvements is commendable, it overlooks a critical dimension of service quality. For instance, even if a transport service allows for a 15-minute trip to another area, it is of little practical value if the actual service volume is insufficient. The essence of public transport lies not merely in providing the possibility of movement, but in guaranteeing the freedom and quality of mobility. Therefore, examining the quantitative dimension of available services, in addition to their qualitative aspects, becomes a critical subject for investigation.

To address these limitations, this study first redefines user-centric service in terms of the **"Through-Route"**: the set of all pairs of stops that can be reached on a single, transfer-free journey. This concept will serve as the

fundamental unit of connection (the link) in our network analysis. Furthermore, to reflect the complex interactions and transfers between various transport options, this study will construct a multi-modal network by leveraging a **multiplex network** structure—a powerful analytical framework from complex network theory. In this model, each mode of transport (e.g., bus, subway, rail) constitutes a distinct layer, while inter-layer connections representing transfers are established through shared grid-based nodes.

To further enhance analytical reliability and spatial resolution, this study diverges from the common practice of using arbitrary administrative boundaries. Instead, we employ a uniform 1km² grid across the entire nation as the fundamental spatial unit. Each grid cell functions not only as a proxy for a "public transport living zone" but also as a node in the multimodal network model. This large-scale network will be constructed using a comprehensive, nationwide public transport database based on the General Transit Feed Specification (GTFS), thereby relying on big data rather than on samples or estimations.

Moreover, for the links connecting these nodes, our model incorporates service frequency as an additional weight, moving beyond traditional metrics like distance or time. This approach allows us to examine not only the mere possibility of movement but also to investigate the freedom and quality of mobility available to citizens.
This framework will provide a robust foundation for effectively embedding the high-resolution mobility patterns and activity information afforded by big data into our unit of analysis. On this methodological basis, this study seeks to address the following research questions:

1. How can a multimodal public transport network model be constructed to holistically integrate various transport modes and the dynamics of their transfers?

2. When analyzed using the proposed high-resolution, grid-based model, what is the spatial distribution of public transport service quality, and what novel perspectives does this offer compared to conventional analyses based on administrative units?

3. What are the policy implications of incorporating the quantitative dimension of service level into traditional, accessibility-focused public transport analyses?

In conclusion, this study proposes a novel analytical framework—a grid-based, multimodal public transport network analysis—designed to overcome the methodological limitations of prior research. Through this framework, we aim to achieve a comprehensive understanding of the complex structural properties of the nationwide multimodal public transport network, the spatial distribution of its service levels, and the quantitative aspects of service that extend beyond conventional accessibility analysis.

This endeavor, by integrating insights from complex systems science, spatial analysis, and transport planning, seeks to deepen our understanding of urban transport systems. It aims to inform effective policy directions for promoting sustainable urban development and transport inclusion. The findings are expected to contribute by precisely identifying transport-disadvantaged areas, providing data-driven evidence for the efficient allocation of limited resources, and ultimately, suggesting concrete improvements to route planning and transfer systems to mitigate regional service disparities.

2. Literature Review

2.1 Introduction

This chapter builds the theoretical foundation for this study by critically reviewing the literature on public transport performance and equity. It delves into three core research streams to establish the necessity and originality of the proposed framework.

First, it traces the conceptual shift in transport planning from mobility to accessibility and, more recently, to equity and justice, arguing that conventional accessibility metrics are insufficient and a Level of Service (LoS) perspective is required.

Second, it interrogates the limitations of prevailing network models, demonstrating why multi-layer network theory offers a more robust alternative to single-mode or aggregated representations.

Third, it examines the Modifiable Areal Unit Problem (MAUP) as a persistent challenge in spatial analysis and validates the methodological superiority of a grid-based framework.

Through this review, the chapter identifies a critical gap at the intersection of these domains and culminates by presenting the academic and policy significance of this study's integrated approach.

2.2 From Accessibility to Equity and Level of Service

2.2.1 The Normative Shift in Transport Planning

The core paradigm of transport planning has undergone a decisive shift from a "mobility-centric" approach, which prioritizes vehicular flow, to an "accessibility-centric" one that emphasizes connectivity between people and places (Cervero, 2005). This reframed transport systems as social institutions that directly impact quality of life and opportunity, prompting calls in contexts like South Korea to reorient infrastructure policy from efficiency toward equity (Jang et al., 2015).

More recently, this evolution has progressed further, establishing transport equity and spatial justice as central academic and policy agendas (Ruiz-Pérez et al., 2023). This discourse moves beyond simple resource allocation to scrutinize how transport systems may cause or exacerbate the social exclusion of vulnerable populations (Pereira et al., 2021; Smith et al., 2018).

This concern is prominent in South Korean policy, where concepts like the "Transport Inclusion Index" and "inclusive mobility" have been developed to address accessibility gaps and counteract new forms of inequality (Bae et al., 2016; KOTI, 2022). Consequently, ensuring equitable access to essential opportunities for all citizens stands as a core normative goal of modern transport policy.

2.2.2 The Limits of Conventional Accessibility Metrics

While traditional accessibility measures, such as cumulative opportunity and gravity models, have been instrumental in visualizing the uneven distribution of opportunities (Rodrigue et al., 2013), they suffer from several pronounced limitations.

First, they focus on potential reachability while overlooking the actual level of service. The mere existence of a network connection does not guarantee high-quality service (ITF-OECD, 2023). This limitation is starkly illustrated by the problem of "ghost buses"—routes with such low frequency as to be practically unusable. This disconnect suggests that conventional efficiency-driven logic, such as cost-benefit analysis, can create structural problems by failing to adequately consider regional equity, sometimes leading to unintended consequences like the "straw effect" where investment in core areas drains vitality from the periphery (Kim et al., 2020).

Second, and relatedly, they fail to integrate the quantitative dimension of service, particularly operational frequency. As frequency directly impacts user waiting times and travel flexibility, its omission leads to analyses largely disconnected from the actual user experience (Han et al., 2019). Recognizing this, transport authorities have begun to advocate for "minimum service standards" that include frequency as a key component (Kim et al., 2020).

2.2.3 A New Perspective: Integrating Level of Service (LoS)

To overcome these limitations, this study argues that integrating a Level of Service (LoS) perspective is essential. LoS is a multidimensional concept representing the quality and quantity of transport service, with operational frequency as a core, measurable indicator. The increasing availability of standardized public transport big data like the General Transit Feed Specification (GTFS) makes such LoS-based analysis practically feasible (Kujala et al., 2018). GTFS timetable data allows for the extraction of service frequencies, enabling weighted network analysis that reflects the actual supply of service (Háznagy et al., 2018; Ha & Lee, 2017). This integration is the crucial step to realizing the philosophy of "Beyond Access," shifting the focus from supplier-side infrastructure to the quantity and quality of service that users actually experience.

2.3 Representing Multimodal Complexity

2.3.1 Network Science as an Analytical Toolkit

Network science provides a powerful toolkit for quantitatively analyzing the underlying topological properties of transport systems, which can be abstracted as a set of nodes and links (Newman, 2018). Centrality analysis, in particular, is widely used to identify critical hubs and transfer points (Ding et al., 2019), and has been applied extensively in the South Korean context (Koo et al., 2024; Hong et al., 2019). Furthermore, these tools are used to assess network robustness and vulnerability by simulating the impact of node or link failures (Mouronte-López, 2021; Meng, 2024).

2.3.2 The Challenge of Multimodal Representation

Despite the utility of these tools, their application has been hampered by two conventional limitations in representing real-world multimodal systems. First is the oversimplification of the network through aggregation. Aggregating distinct transport modes into a single layer has been empirically shown to severely distort structural properties and produce critical analytical errors, as it erases the unique operational characteristics of each mode (Aleta et al., 2017). Second is the bias toward single-mode analysis, which overlooks the complementary relationships between different modes and fails to model the complex dynamics of transfers. These modeling failures contribute directly to the disconnect between measured accessibility and the actual LoS experienced by users.

2.3.3 The Alternative: A Multi-layer Network Framework

The most promising alternative is the multi-layer network framework, which models different transport modes as distinct but interconnected layers (Alessandretti et al., 2022). This approach is methodologically superior as it: (1) preserves the unique characteristics of each transport mode (Aleta et al., 2017); (2) enables a sophisticated modeling of transfer dynamics through inter-layer links, which is crucial for assessing system-wide properties like resilience (Xu & Chopra, 2023; Ma et al., 2019); and (3) facilitates a more realistic measurement of service level by simulating journeys across multiple modes (Baggag et al., 2018; Alessandretti et al., 2016). Therefore, this study adopts the multi-layer framework as a necessary choice to represent the complexity of the multimodal system with greater precision.

2.4 The Dilemma of Spatial Analysis

2.4.1 The Modifiable Areal Unit Problem (MAUP)

The selection of a spatial unit for analysis is a critical decision that decisively influences research findings. The conventional use of administrative districts is subject to the Modifiable Areal Unit Problem (MAUP), a persistent challenge in spatial science where analytical results change depending on the scale and zonation of the units used for aggregation (Rey & Franklin, 2022). This practice is problematic because administrative boundaries rarely align with actual travel behavior, vary drastically in size and density, and mask micro-level patterns, thereby posing a serious threat to analytical reliability (Bae Y. et al., 2016; Hwang M. et al., 2023).

2.4.2 The Alternative: A Grid-Based Framework

To overcome MAUP, this study adopts a uniform grid-cell as the unit of analysis. This approach is superior for three reasons. First, it ensures objectivity and comparability by mitigating scale and zonation biases. Second, it holds theoretical validity by employing a systematic and neutral "spatial container" to analyze human mobility, which is known to be constrained by geographic context rather than being scale-free (Alessandretti et al., 2020). Third, it aligns with cutting-edge research trends, both internationally and domestically, where grid-based analysis is becoming a standard for leveraging high-resolution data (Hwang M. et al., 2023; Ha & Lee, 2017). The combination of this grid-based framework with the multi-layer network model constitutes the core methodological innovation of this study.

2.5 Synthesis and Originality of the Study

This critical review reveals that while the fields of transport equity, network science, and spatial analysis have advanced, they have largely proceeded in disconnected silos. A critical research gap emerges at their intersection: there is an absence of an integrated framework that can simultaneously (1) measure the quantitative level of service, (2) capture multimodal complexity, and (3) overcome the MAUP with a precise spatial unit.

Therefore, this study aims to fill this gap by proposing and applying a Grid-Based Multimodal Multiplex Network Framework. This novel approach simultaneously addresses the three core challenges by incorporating service frequency into a multi-layer network built upon a uniform grid. This integrated framework will enable the identification of service-vulnerable areas with unprecedented precision, broadening the methodological horizons of transport planning and contributing significantly to policies aimed at promoting national balanced development and transport inclusion.

3. Methodology

This chapter details the methodology designed to diagnose the spatial performance and equity of the nationwide multimodal public transport network in South Korea. The methodology comprises three main parts. First, it describes the process of constructing a nationwide, multi-layer public transport network database by integrating various data sources into a standardized format. Second, it establishes the analytical framework by defining a comprehensive set of indicators to measure the network's efficiency, connectivity, and accessibility. Finally, it outlines the process for identifying transport-vulnerable areas by synthesizing these multifaceted indicators.

3.1 Research Framework and Process

This study adopts a systematic research process, as illustrated in Figure 3.1, to overcome the limitations of prior research and to address the proposed research questions. The process consists of four main stages: (1) data collection and preprocessing; (2) construction of the multiplex network model; (3) calculation and analysis of network indicators; and (4) interpretation of the results and formulation of policy recommendations. Each stage is sequentially and logically linked to the results of the preceding stage, ensuring the reproducibility of the research and the reliability of the analytical results.

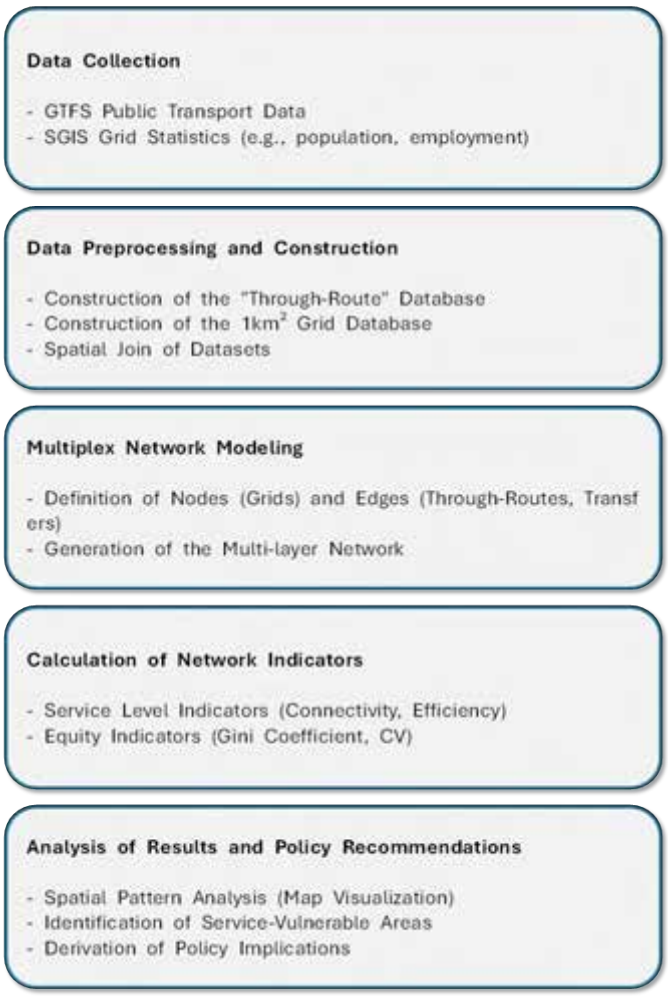

Figure 3.1 Research Process Flowchart

3.2 Data Construction and Preprocessing

A reliable, detailed, and standardized database is a prerequisite for a nationwide analysis of a multimodal public transport network. To this end, this study integrates "Through-Route" information for each mode of transport—derived from TMAP's public transport data which adheres to the General Transit Feed Specification (GTFS) format—with grid-based socioeconomic data from various public and private sources. This process aims to establish a clear and robust foundation for the network analysis.

3.2.1 The GTFS-Based Nationwide Public Transport Database

The foundational data for this research is a 2024 nationwide GTFS dataset provided by TMAP. As a global standard for publishing public transport schedules and associated geographic information, the relational structure of GTFS, comprising files such as stops.txt, routes.txt, trips.txt, and stop_times.txt, allows for a detailed reconstruction of the transport network's spatial and temporal dimensions. The dataset covers the entirety of South Korea and is highly multimodal, including not only intra-city modes like local buses and subways but also inter-city modes such as express/intercity buses, rail, maritime services, and aviation.

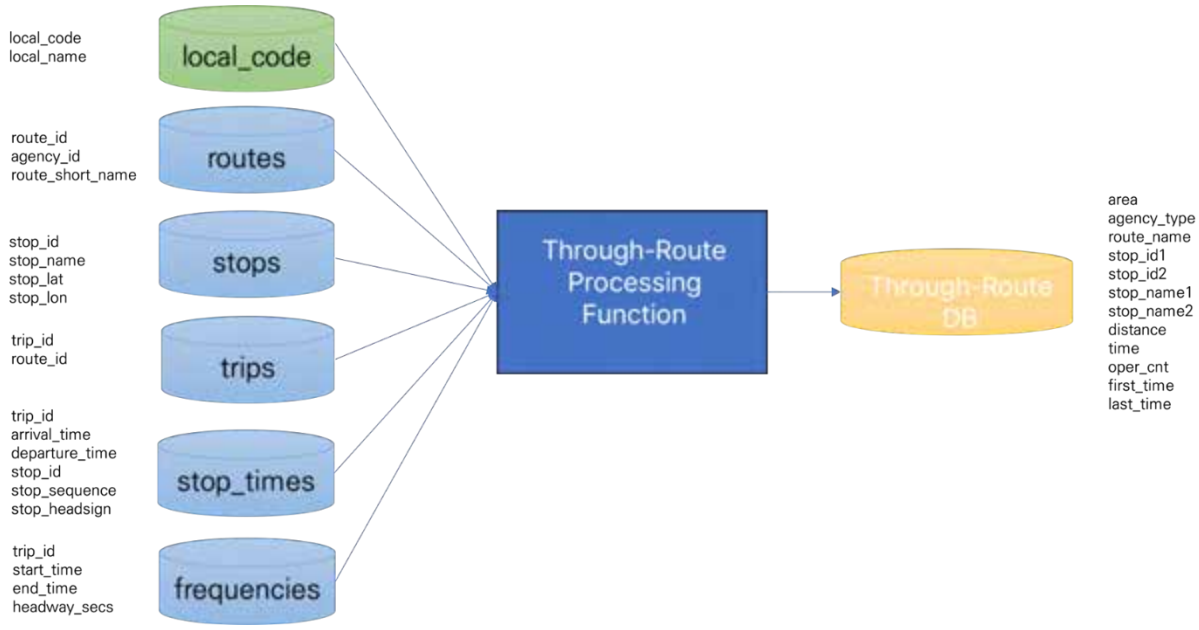

Figure 3.2 GTFS based Public Transport Through-Route DB Processing Process

Table 3.1 Summary of the number of routes and stops in the analysis dataset

Mode	Number of Routes	Number of Stops
Metro	57	1,082
Bus	24,973	192,411
Express Bus	11,851	1,426
Train	13,918	235
Flight	103	13
Marine	2,375	340

3.2.2 Construction of the "Through-Route" Database

To analyze the network from a user-centric perspective, this study first constructed a "Through-Route" database. A "Through-Route" is operationally defined as the set of all pairs of stops that can be reached on a single, transfer-free journey on a given route. This concept serves as the fundamental unit of direct service connectivity. The construction process was as follows:

1. Extraction of Stop Combinations: Utilizing the routes, trips, and stop_times files, all possible sequential origin-destination stop pairs were extracted for each individual trip.
2. Calculation of Travel Attributes: Based on the stop_times data, the travel time for each through-route was calculated. The travel distance was computed using the coordinates from stops.txt. Furthermore, the total number of daily services for a standard weekday was calculated for each route using data from the frequencies. txt or trips files.
3. Calculation of Transport Capacity: The transport capacity for each through-route was calculated by establishing a standard vehicle capacity for each transport mode and multiplying it by the total number of daily services.

3.2.3 The Grid-Based Socioeconomic Database

As discussed in Chapter 2, to overcome the Modifiable Areal Unit Problem (MAUP) inherent in analyses using administrative boundaries, this study adopts a 1km×1km grid system that covers the entire nation. The data were sourced from the Korean Statistical Geographic Information Service (SGIS) for the year 2022, with key variables including total population, age demographics, number of households, and the number of businesses and employees. Each public transport stop was mapped to its corresponding 1km² grid cell. A spatial join was then performed to link the transport network data with the socioeconomic attributes of each grid, creating a rich, multi-layered dataset for analysis.

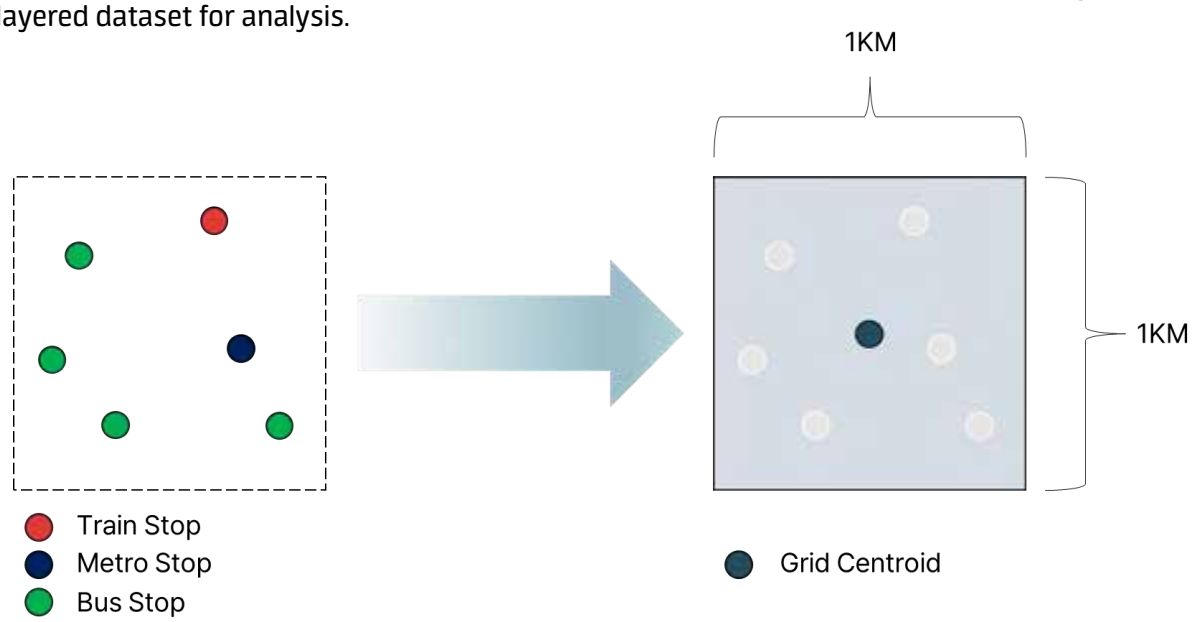

Figure 3.3 Conversion of origin and destination points of public transportation (stop unit – grid unit)

3.3 Construction of the Multiplex Network Model

3.3.1 Definition of Nodes

The nodes of this network model are defined as the 1km² grid cells containing at least one public transport stop. Each node is attributed with the socioeconomic data constructed in Section 3.2.3, including its grid ID, population, number of employees, and Functional Urban Area (FUA) type.

3.3.2 Definition of Edges: A Multi-layer Connectivity Structure

This model possesses a multi-layer structure that treats each distinct mode of transport as a separate layer.

- Intra-layer Edges: These represent connections within each transport mode layer and are generated based on the "Through-Route" data constructed in Section 3.2.2. If a through-route exists from a stop in grid A

to a stop in grid B, a directed and weighted edge is created from node A to node B. The attributes of this edge include weights for travel time, service frequency, and transport capacity.

- Inter-layer Connections and Transfers: Conventionally, transfers in network models are often represented by artificially generating pedestrian links between stops of different modes located within a certain proximity. While this method allows for the explicit addition of transfer penalties, it also introduces artificial links to the original data, which can distort analyses of network connectivity.

Therefore, to avoid this issue, this study does not add artificial transfer links. Instead, it leverages the inherent structure of the multiplex network itself to account for transfers. By fixing the spatial grid cell as the node, transfers are implicitly modeled as movements between different layers at the same node. All stops located within a single 1km² grid cell—a walkable catchment area—are considered mutually accessible, thus enabling transfers between all transport modes present within that grid.

3.3.3 Final Model Specification and Implementation

The constructed network can be represented as a directed, weighted graph G = (V, E), where V is the set of transport hub grid cells, and E is the set of multi-layer edges representing through-routes. For the analysis, this study primarily utilizes the Graph-Tool and GeoPandas libraries in Python, which are optimized for the analysis of large-scale networks.

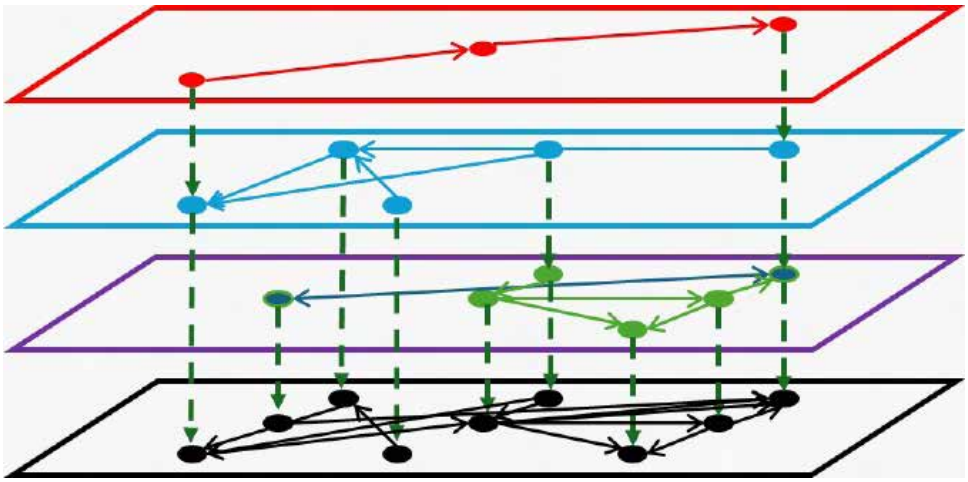

Figure 3.4 Multimodal-Multiplex Network Model

3.4 Selection of Analytical Indicators

To diagnose transport network vulnerability, this study analyzes the network from three dimensions—service level, equity, and structure—using the following selected indicators.

3.4.1 Service Level Indicators

- Weighted Degree Centrality: To move beyond a simple count of connections, this study employs weighted degree centrality, often referred to as node strength, to measure the total volume of service associated with each node. This metric is calculated by summing the weights of all links connected to a node

$$s_i = \sum_j w_{ij}$$

where s_i is the strength of node i, and w_{ij} is the weight of the link between node i and node j. In this study, the weight w_{ij} represents the service frequency or total transport capacity of a given through-route. Therefore, a high node strength indicates that a grid cell is not just connected to many other locations, but that it is served by a high volume of public transport services, marking it as a key hub in terms of service supply.

- Harmonic Closeness Centrality: This measures the overall efficiency of the network and the temporal accessibility of a specific node by using travel time as a weight.

$$H(\Omega) = \sum_{\omega \neq \Omega} \frac{p(\omega, \Omega)}{I}$$

- Cumulative Opportunity Accessibility: This indicator suite measures the practical outcome of the transport service by calculating both the raw number of accessible opportunities and the per capita accessibility within predefined time thresholds.

First, the raw accessibility score calculates the total number of jobs accessible from a given location, providing a measure of the place's potential. The formula is:

$$A_i^T = \sum_j O_j \cdot f(C_{ij}) \quad \text{where} \quad f(C_{ij}) = \begin{cases} 1 & \text{if } C_{ij} \leq T \\ 0 & \text{if } C_{ij} > T \end{cases} \quad \cdots (\text{Eq. 3.8})$$

where A_i^T is the raw accessibility score for node i, O_j is the number of jobs at node j, C_{ij} is the shortest travel time, and T is the time threshold (15, 30, 45, 60 minutes).

Second, to advance a person-centric equity analysis, we calculate the Per Capita Cumulative Accessibility. This metric normalizes the raw accessibility score by the population of the origin node, reflecting the level of competition for opportunities and providing a more nuanced measure of individual-level access. It is calculated as:

$$PA_i^T = \frac{A_i^T}{P_i} = \frac{\sum_j O_j \cdot f(C_{ij})}{P_i} \quad \cdots (\text{Eq. 3.9})$$

where PA_i^T is the per capita accessibility for node i, and P_i is the population of node i.

3.4.2 Equity Indicators

- Gini Coefficient and Lorenz Curve: These are used to quantify the degree of inequality across the entire network by analyzing the distribution of service level indicators (e.g., weighted degree centrality) among the grid cells.

$$G = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |x_i - x_j|}{2n^2 \bar{x}}$$

- Coefficient of Variation (CV): This measures the relative disparity in service levels between different regions.

$$CV = \frac{\sigma}{\mu}$$

3.4.3 Structural Indicators

- Clustering Coefficient, Largest Connected Component (LCC) Ratio, etc.: These fundamental metrics are utilized to understand the overall topological characteristics of the network.

$$C = \frac{3 \times \text{number of triangles}}{\text{number of connected triplets}}$$

- Largest Connected Component (LCC) Ratio: This measures the proportion of nodes that belong to the largest single connected component of the network, indicating the overall integration of the system.

$$\text{LCC Ratio} = \frac{N_{LCC}}{N}$$

where N_LCC is the number of nodes in the largest connected component and N is the total number of nodes in the network.

4. Results

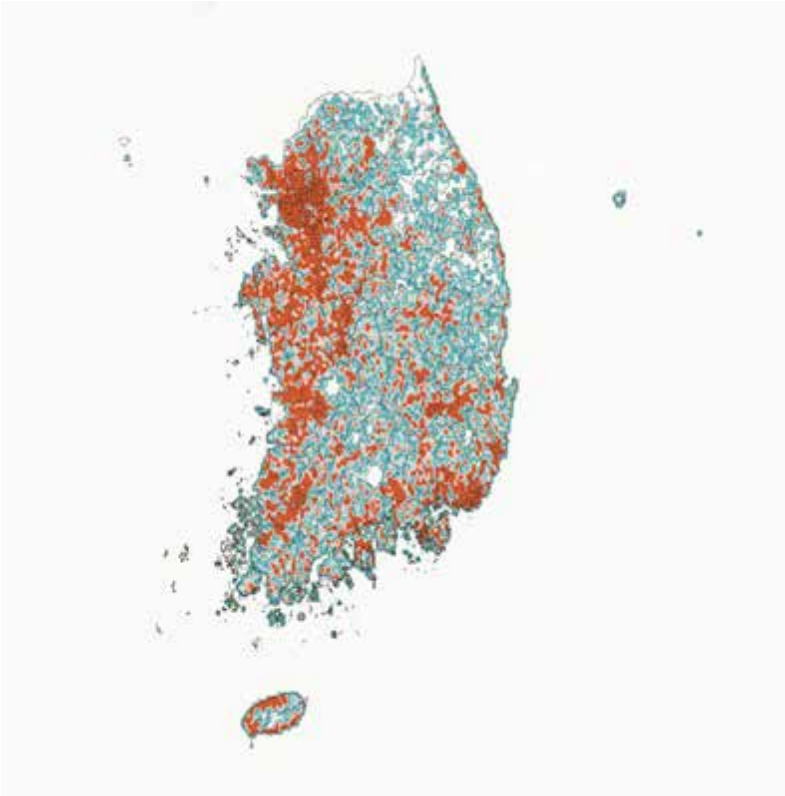

Figure 4.1 Network Node Distribution

Category	Name	Value
Structural Indicators	Number of Nodes	41,552
	Number of Edges	2,179,454
	Network Density	0.001175(0.12%)
	Avg. Out-Degree	84.40
Clustering Coefficient	Avg. Local CC	0.8449
	Global CC	0.4338
LCC	LCC Size	41,552
	LCC Ratio	99.97%

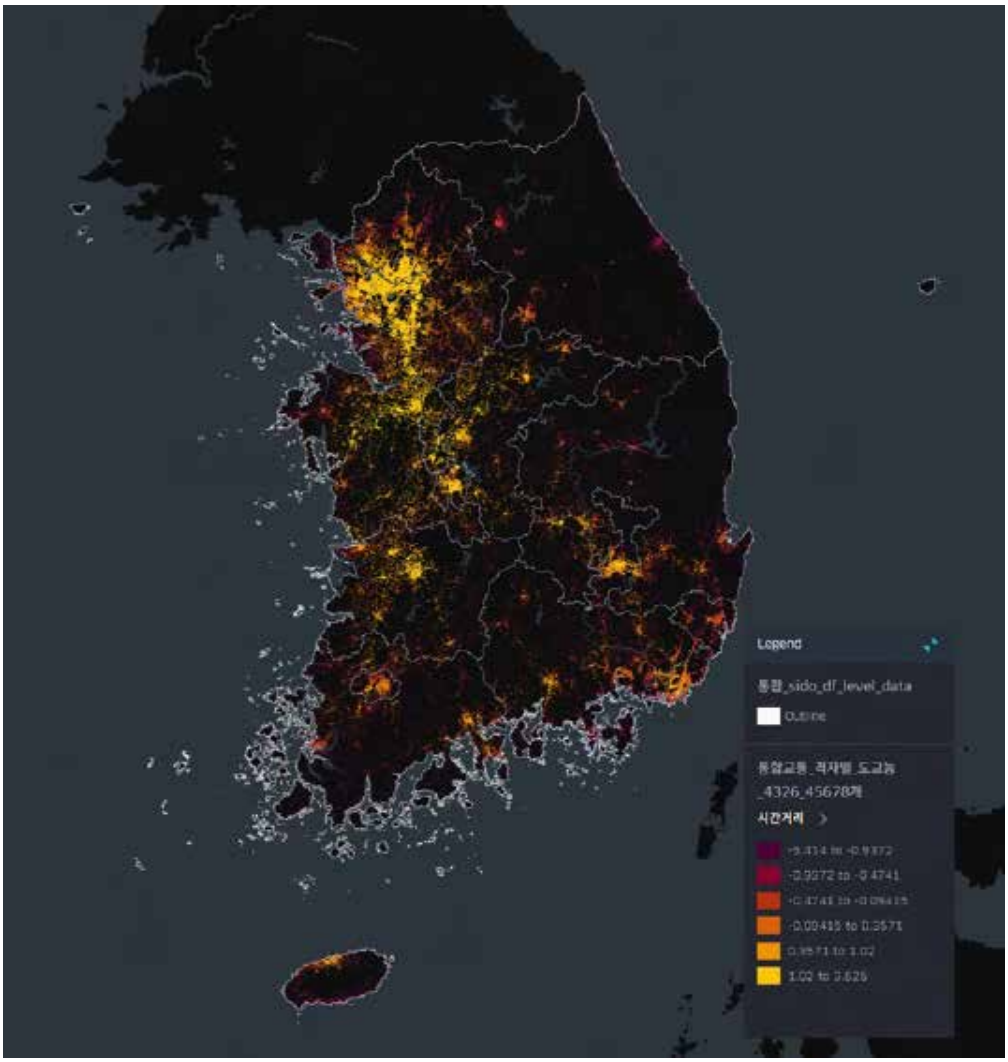

Figure 4.2 Distribution of Harmonic Closeness Centrality of PTNs

Network efficiency, indicating how quickly any point can be reached from a specific location via public transport, was measured by calculating the harmonic closeness centrality for each grid cell (node) based on the shortest path travel times to all other reachable cells.

The results reveal a concentration of overwhelmingly high efficiency in the Seoul Metropolitan Area (SMA), which appears as a broad yellow area on the map. This suggests a dense and rapid network of interconnected public transport modes, including subways and metropolitan buses. Similarly, other major metropolitan cities such as Busan, Daegu, Daejeon, and Gwangju exhibit high efficiency centered around their urban cores. In contrast, efficiency is markedly lower in non-urban and peripheral regions, including the mountainous areas of Gangwon-do, the northern and eastern parts of Gyeongsangbuk-do, and the southern and insular areas of Jeollanam-do. This indicates that travel to other regions via public transport from these locations requires significantly more time.

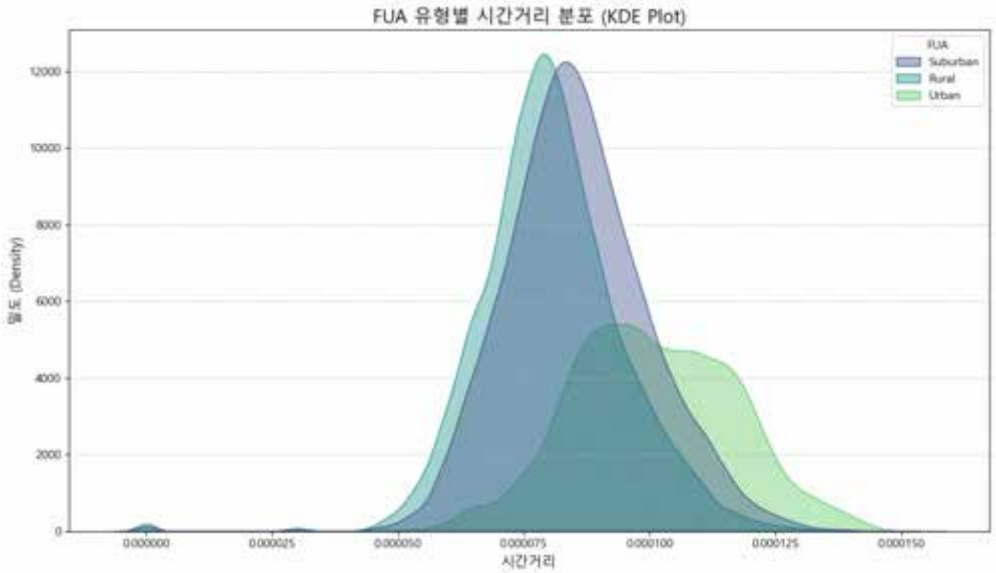

Figure 4.3 The distribution of public transport efficiency by FUA

The distribution of public transport efficiency across different Functional Urban Area (FUA) types is visualized using a Kernel Density Estimation (KDE) plot (Figure X.X). The plot indicates that urban areas exhibit a distinctly higher level of public transport efficiency, whereas suburban and rural areas show similar, lower-efficiency distributions. This suggests that, in terms of travel time, reaching other regions via public transport is substantially faster from urban areas compared to their non-urban counterparts.

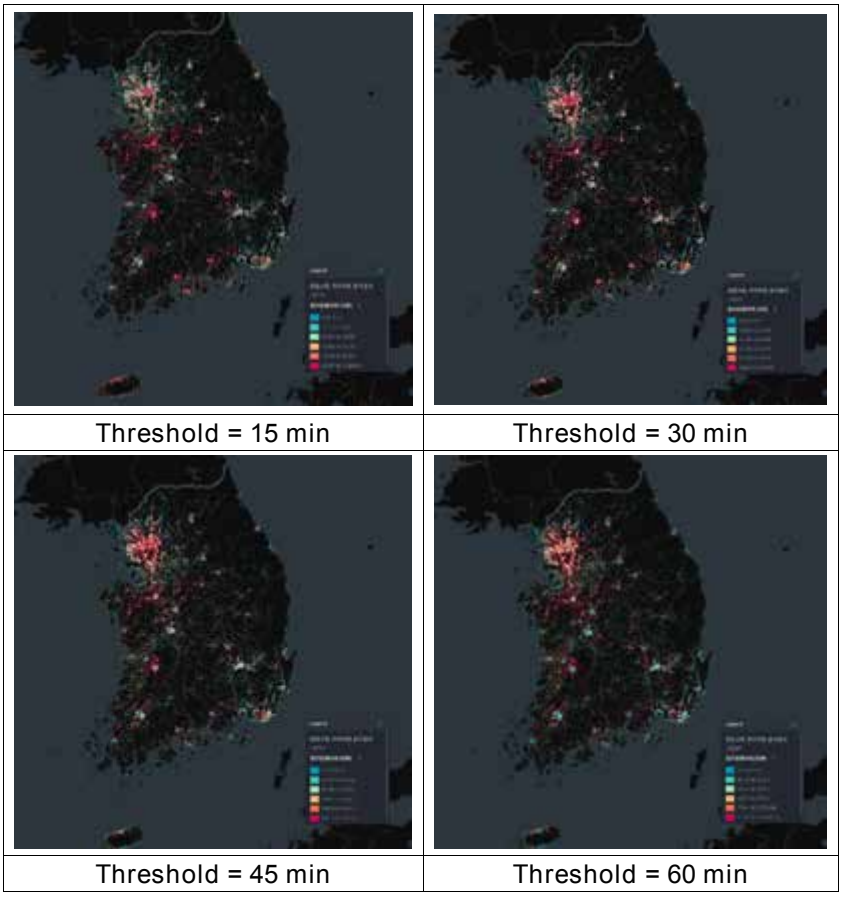

Figure 4.4 Distribution of Cumulative Opportunity Accessibility (Reachable Job)

The analysis of per capita accessibility reveals the number of jobs reachable by an average resident of each grid cell within specified time thresholds (e.g., 15, 30,45, 60 minutes). Unsurprisingly, areas encompassing Seoul's major business districts—the Central Business District (CBD), Gangnam Business District (GBD), and Yeouido Business District (YBD)—exhibit exceptionally high job accessibility within a 15-minute threshold. As this threshold expands to 30, 45, and 60 minutes, the number of accessible jobs per capita increases, altering the spatial landscape of accessibility.

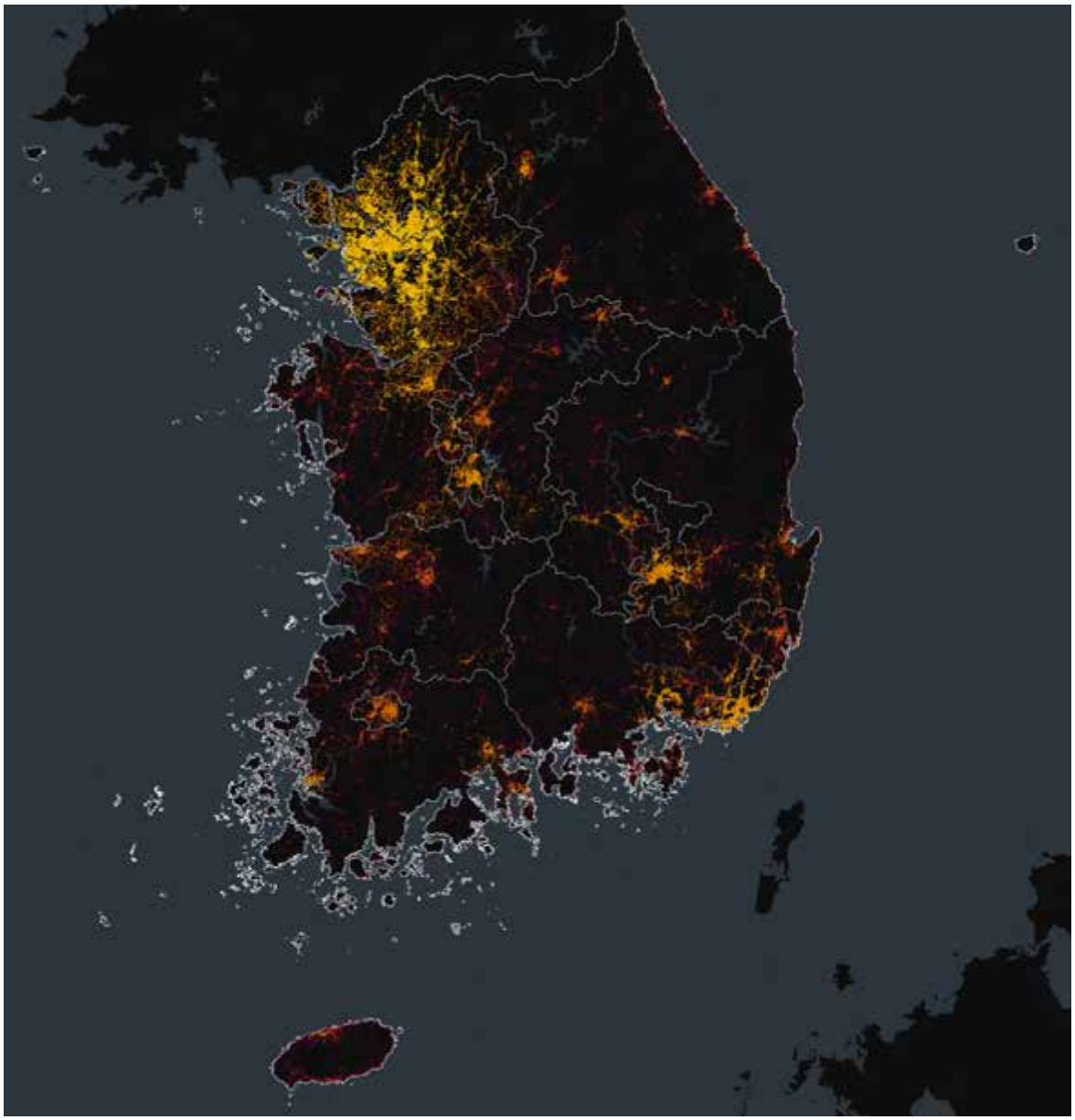

Figure 4.5 Distribution of Weighted Eigenvector Centrality (Oper capacity)

Transport capacity-weighted eigenvector centrality is an indicator that represents a node's influence within the flow of the public transport network's "people-carrying ability" (i.e., its transport capacity), rather than its influence derived from a simple count of connections or its position on shortest paths. A high score for a given node signifies that it is well-connected to other nodes that are themselves high-capacity hubs. In essence, it measures a node's access to the high-volume corridors of the public transport system.

5. Conclusion

5.1 Summary of Research and Key Findings

This study was initiated with the goal of expanding the paradigm of public transport service evaluation from a narrow focus on physical "access" to a broader understanding of "service level" and "equity" as experienced by actual users. To this end, we proposed and applied a novel analytical framework designed to overcome the methodological limitations of prior research, namely: analyses focused on single transport modes, the use of administrative units prone to the Modifiable Areal Unit Problem (MAUP), and the neglect of the quantitative dimension of service.

The core methodological contribution of this research lies in the construction of the "Grid-Based Multimodal Multiplex Network Framework," which is built upon GTFS big data. This framework conceptualizes various transport modes across South Korea—including buses, subways, and rail—as distinct layers in a network. It integrates the quantitative level of service into the model by utilizing the "Through-Route" concept and by employing service frequency and transport capacity as weights. Furthermore, by adopting a uniform 1km² grid as the fundamental spatial unit of analysis to overcome the limitations of MAUP, we established a foundation for analyzing the nationwide public transport system with unprecedented precision.

Our key findings reveal that while South Korea's public transport network exhibits a high degree of overall connectivity (LCC Ratio of 99.97%), its service level is distributed in a highly uneven manner. Both network efficiency, measured by harmonic closeness centrality, and the actual service supply, reflected in weighted centrality metrics, showed extreme spatial polarization, with services being overwhelmingly concentrated in the Seoul Metropolitan Area and the urban cores of other major metropolitan cities. In contrast, non-urban and peripheral areas, such as the mountainous regions of Gangwon-do and the outer regions of Gyeongsangbuk-do and Jeollanam-do, were found to be in a state of severe service deprivation. Notably, a comparative analysis demonstrated that our grid-based approach could empirically identify micro-level service disparities and genuinely transport-disadvantaged areas far more clearly than conventional analyses based on administrative units, which tend to mask such issues.

5.2 Discussion and Policy Implications

5.2.1 Theoretical and Methodological Implications

The findings of this study offer several important implications for the fields of transport planning and spatial analysis.

First, this research empirically operationalizes and validates the "Beyond Access" concept. By demonstrating quantitatively how inequities become more pronounced when service levels like operational frequency are integrated into the analysis, this study presents a clear direction for the future of transport equity research.

Second, this study makes a significant methodological contribution by fusing three previously fragmented fields of research—transport equity, network science, and spatial analysis—into a single, integrated framework. The proposed "Grid-Based Multimodal Multiplex Network Framework" serves as a robust and replicable model for analyzing complex, nationwide transport systems, and holds the potential to become a new standard for related research.

5.2.2 Policy Implications

This research provides concrete answers to Research Question 3: "What are the policy implications of incorporating the quantitative dimension of service level into network models?"

First, it challenges the traditional efficiency-oriented transport policy paradigm. Infrastructure investment decisions based primarily on cost-benefit analysis (B/C analysis) can exacerbate the kind of severe spatial inequalities identified in this study. Our findings strongly suggest that when allocating limited public resources, social equity criteria, such as guaranteeing a minimum level of service, must be employed as core evaluation standards alongside economic efficiency.

Second, it provides a practical tool for precise, data-driven transport policymaking. The high-resolution maps of service levels and vulnerability generated in this study can be used by policymakers as objective and scientific evidence to clearly identify which areas are genuinely transport-disadvantaged and to determine investment priorities.

Third, it contributes to the formulation of specific policy directions. Based on the analytical results, tailored, area-specific policies can be proposed. For instance, for high-density areas with low service levels, new bus routes or increased service frequency could be recommended. For isolated rural areas, an expansion of Demand-Responsive Transit (DRT) or public-purpose taxis that connect to core network hubs could be prioritized. For areas with high transfer potential but low network efficiency, improvements to transfer centers and enhancements to the connecting transport system could be implemented.

5.3 Limitations and Future Research

Despite its significant findings, this study has several limitations, which in turn open avenues for future research.

First, there is the static nature of the data. As this research is based on GTFS data, which contains scheduled timetable information, it does not capture dynamic fluctuations such as delays, cancellations, or traffic congestion. Future research is needed to integrate real-time transport data to analyze the dynamic reliability and stability of the network.

Second, the analysis has a supply-side focus. This study primarily analyzes the supply of public transport and does not explicitly model passenger demand. Future work could produce more sophisticated policy implications by integrating smart card or mobile phone data to analyze the interaction and potential mismatch between supply and demand.

Third, there is an absence of new mobility services. This analysis primarily deals with scheduled, route-based public transport and does not consider connectivity with emerging modes such as shared mobility or personal mobility devices (PMDs). Research that incorporates these services into the multi-layer network model to evaluate the integrated performance of the entire mobility system is required.

5.4 Concluding Remarks

This dissertation, under the guiding principle of "Beyond Access," proposed and validated a novel integrated framework for diagnosing the practical service levels and spatial equity of public transport. The analysis revealed the state of severe spatial imbalance within South Korea's public transport system at a high resolution, shedding light on micro-level issues that were difficult to capture with conventional analytical methods.

True transport equity is not achieved by simply providing identical infrastructure to all regions. It begins by guaranteeing an "adequate and sufficient" level of service tailored to the characteristics and needs of each region, so that all citizens have an equal opportunity to access the services they need. It is hoped that the data-driven, precise diagnostic methodology presented in this study can make a meaningful academic and policy contribution toward building a more sustainable and inclusive transport system in South Korea.

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Sustainable Urban Mobility Plans: a catalyst for transformative urban practices?

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Abstract
Sustainable Urban Mobility Plans (SUMPs) are strategic planning tools to govern the urban mobility system for a better quality of life. However, their capacity in bringing about effective changes is limited, also due to the governance system in which they are embedded. This paper comparatively examines the multilevel governance framework of sustainable urban mobility planning in 8 case studies across Europe, considering SUMPs as part of their spatial governance and planning system. First, it analyses the interaction between the urban legal framework and the SUMP. Then, it analyses practices in one case study from the JUST STREETS project. The paper sheds light on the possibility of SUMPs as catalysts for transformative practices contributing to mobility justice, and the room for improvement in this respect.

Keywords: Sustainability Urban Mobility Plans (SUMPs), spatial governance and planning system (SGPS), Multilevel governance, mobility justice, JUST STREETS

1.Introduction

Sustainable Urban Mobility Plans (SUMPs) are strategic planning tools meant to improve mobility patterns in cities and their surroundings for a better quality of life. According to the European Commission, "A SUMP offers a comprehensive, vision-led, flexible and resilient approach by serving as a long-term mobility plan that includes packages of measures addressing short-term objectives and targets the reaching of which can be fast-tracked in response to changing needs." (EUR-Lex - 32023H0550 – EN). However, the capacity of SUMPs and other similar mobility planning instruments in bringing about effective changes towards more sustainable and just mobility practices has been questioned (Maltese, Gatta and Marcucci, 2021; Wågsæther et al., 2022; Hidayati and Tan, 2025) social, and environmental issues in transport policy at the urban scale from a long-term strategic perspective. Indeed, urban policymakers intend adopting measures to cope with the negative externalities generated by transport. The focus is on reducing traffic flows (number and length. Aiming to shed light on the matter, this paper starts from the assumption that in order to understand the effectiveness of SUMPs it is necessary to consider them as part of a spatial governance and planning system (SGPS). SGPSs reflect the complex and multidimensional interaction among the urban legal framework (Berisha et al., 2021). This interaction shapes and determines the possibility for SUMPs to improve urban mobility towards more sustainable and just mobility practices. By combining literature, policy and document analysis, the paper comparatively examines the multilevel governance framework of sustainable urban mobility planning across Europe, through the analysis of 8 case studies from the JUST STREETS project, analysing the multilevel frameworks in which the 8 SUMPs are developed and implemented, from the European to the local scale. The paper is organised as follows: first, in the next section, the concept of SGPS is briefly presented, together with a focus on the origin and aims of SUMPs and their supposed role in fostering more sustainable and just mobility practices. Section 3 analyses the multilevel governance frameworks that shape the development and implementation of Sustainable Urban Mobility Plans (SUMPs) across eight European pilot cities involved in the JUST STREETS project: Amsterdam, Braga, Cugir, Kozani, London-Wesminster, Metropolitan City of Milan, Riga, Vilnius. The interaction between the urban legal framework

(structure) and the SUMP (tools) is inquired. Section 4 brings the lens closer to practices, focusing on one local case study from the JUST STREETS project, the Metropolitan City of Milan – Corsico municipality. It analyses the mutual interactions between the Metropolitan planning tools (including the SUMP), and municipal planning and practices. Overall, the paper sheds light on the possibility of SUMPs as a catalyst for actually contributing to mobility justice, and the room for improvement in this respect.

2.SUMPs within Spatial Governance and Planning Systems framework

Spatial governance and planning systems (SGPSs) are institutional arrangements that guide and control spatial development in accordance with property rights, public interest, and market forces. They emerge from a complex and multidimensional interplay among several key components: the legal framework or structure, the tools for spatial planning, the practices that enact planning, and the discourses that shape and reinterpret them over time (Berisha et al., 2021). Sustainable Urban Mobility Plans (SUMPs) are among the crucial spatial planning tools within this framework, steering urban transformation by integrating land use, mobility, and environmental considerations into cohesive strategies.

The structure of SGPSs establishes the foundational legal and administrative rules for spatial development, providing a framework for decision-making and governance. Tools like SUMPs translate these rules into planning, setting out visions, goals, and regulatory instruments that respond to dynamic urban contexts and sustainability imperatives. Practices encompass the concrete ways in which these plans are implemented, adapted, or contested by various actors, from public authorities to private developers and community stakeholders. Meanwhile, discourses, i.e. narratives and debates surrounding urban planning, inform how these structures and tools are interpreted, negotiated, and legitimized, shaping shared understandings of public interest, urban futures, and governance priorities. Together, these interwoven dimensions of SGPSs determine the capacity of public authorities to influence urban change, manage development pressures, and promote sustainable, equitable, and resilient urban environments.

SUMPs, as key tools within SGPSs, exemplify the importance of strategic, integrative approaches to urban development and mobility in this broader governance landscape. Moving beyond car-centric paradigms, SUMPs embody the shift towards people-centered, low-emission, and equitable transport systems that address not only mobility needs but also broader environmental, social, and economic goals in urban and peri-urban areas (Jordová, 2021). In this sense, SUMPs are more than mobility strategies; they are integral instruments of SGPSs, embedded in and shaped by the interplay of legal frameworks, planning practices, and discursive narratives.

The European Commission (2019) defines the core objectives of SUMPs as enhancing accessibility and quality of life for all, including marginalized groups; ensuring environmental sustainability through pollution reduction and modal shifts; promoting social equity by recognizing the needs of disadvantaged populations; improving health and safety through active mobility; and fostering integrated policy and governance across sectors such as transport, land use, health, and energy. The SUMP process should follow a 12-step iterative methodology (European Commission, 2019) that spans preparation, visioning, implementation, and monitoring. It begins with establishing inclusive governance structures and stakeholder engagement to ensure that planning is transparent and participatory. Cities assess the current mobility context, identify spatial inequalities, and co-develop scenarios to envision inclusive futures. These scenarios should inform strategic visions, translated into SMART targets (i.e. Specific, Measurable, Achievable, Relevant, Time-bound), and operationalized through integrated policy packages that balance infrastructure investments and behavioral interventions. Implementation is phased, flexible, and subject to continuous review. Success depends not only on technical soundness but also on responsiveness to community feedback and urban dynamics.

To align SUMPs with the ideals of just transition, a shift to transformative governance is necessary (Schwanen, 2021). This includes i) actively dismantling automobility dominance and enabling inclusive active transport; ii) co-producing policies with underrepresented communities; iii) evaluating interdependencies between mobility, housing, and social systems; and iv) recognizing spatial and temporal inequities that affect access and agency. Ultimately, the success of SUMPs depends not only on achieving emission targets but on cultivating mobility systems that are resilient, inclusive, and co-owned by diverse urban communities.

However, while SUMPs offer a promising pathway for urban transformation, their justice implications must be fully addressed. More generally, the literature on SPGS shows gaps in the consideration of justice implications. Wågsæther et al. (2022) warn of "justice pitfalls" (ibid) in sustainability transitions, such as tolling systems or densification strategies that inadvertently burden low-income or marginalised groups. Schwanen (2021) expands this perspective, arguing that distributive justice alone is insufficient. Equally critical are procedural justice, which ensures inclusive and meaningful participation, and recognition justice, which acknowledges the diversity of mobility needs and lived experiences. SUMPs that narrowly focus on climate and efficiency targets risk marginalizing the very groups they aim to uplift. Further, Schwanen calls for attention to epistemic justice, i.e. valuing local and marginalised knowledge systems, requires expanding planning practices to include storytelling, participatory mapping, and deliberative forums that centre non-dominant voices.

3.The multilevel governance of sustainable urban mobility planning in JUST STREETS' cities

This section analyses the multilevel governance frameworks that shape the development and implementation of Sustainable Urban Mobility Plans (SUMPs) across eight European pilot cities involved in the JUST STREETS project and leveraging on the results of the CIVITAS' analysis of SUMPs (2018). These cities represent a wide range of governance systems ranging from strongly centralised systems with top-down decision-making to more decentralised or multilevel frameworks that rely on bottom-up collaboration, negotiation, and adaptive planning. The analysis also explores the legal frameworks (structure) in which SUMPs (tools) are conceived, shedding light on how authority and responsibilities are distributed among national, regional, and local authorities as well as the varying capacities of these levels to implement mobility strategies (Tables 1 and 2).

Considering their SGPS frameworks, JUST STREETS countries can be clustered into three main models: conformative systems, neo-performative systems, and performative systems (Berisha et al., 2021). Each model reflects a distinct approach to how public authorities manage spatial development and how they balance state control with market forces in urban planning, and this influences SUMPs development, as one of the main tools for mobility planning.

The conformative systems cluster includes Italy, Portugal, Romania, and Greece. These countries rely on comprehensive, binding general plans as the primary instrument for steering urban transformations. These plans are meant to establish a clear legal framework and guide spatial development decisions. In practice, however, they often incorporate mechanisms for modifications and adjustments, such as variants in Italy or amendments in Greece and Portugal, enabling flexibility in responding to shifting market demands or political pressures. This dual character of rigidity and adaptability underscores a dynamic interplay between formal structures and everyday practices. Despite their formal reliance on state-led planning, these systems have increasingly allowed market influences to shape development outcomes, particularly as urban growth pressures and private sector interests have grown stronger in recent decades.

The neo-performative systems cluster comprises the Netherlands, Lithuania, and Latvia. In these countries, general plans provide a broad framework for land use, but the actual allocation of development rights is negotiated in highly detailed plans. These negotiations typically involve close collaboration between public authorities, landowners, and developers. Such an approach reflects a planning culture that prioritises flexibility and responsiveness to market dynamics while still maintaining a degree of public control. The result is a more adaptive governance model that can accommodate development-led practices within the bounds of public policy objectives. In the Netherlands, for instance, negotiations ensure that spatial development aligns with broader public goals, even as market actors actively shape the details of projects. In Lithuania and Latvia, this neo-performative approach has emerged as a response to post-socialist transitions, combining new market pressures with inherited state frameworks.

The performative system is exemplified by the United Kingdom, where spatial governance is structured around discretionary decision-making rather than rigidly binding plans. In this model, the state manages urban development on a case-by-case basis, offering flexibility and negotiation space at the local level. While this performative approach can enable context-sensitive planning and adaptability, it can also create uncertainty for investors and developers. In the UK, successive reforms have retained the discretionary character of the system, with local authorities holding significant sway in development decisions.

However, this approach has also exposed the planning system to criticisms of excessive market influence, especially when broader social and environmental objectives are not robustly integrated into planning processes.

Collectively, these models reveal how SGPSs adapt to contemporary challenges, each reflecting a distinct balance of public control, market influence, and community participation in shaping urban futures, and this includes mobility planning tools, among which SUMPs are counted.

In the majority of JUST STREETS countries, i.e. Portugal (Braga), Romania (Cugir), Greece (Kozani), Latvia (Riga), and Lithuania (Vilnius), national authorities such as Ministries of Transport hold primary responsibility to define urban transport strategies, allocate funding infrastructure, and ensure compliance with international or EU-level commitments. Local authorities primarily serve as implementing agencies, with constrained autonomy and limited room for strategic innovation. Their roles are often confined to public service delivery, traffic control, and local roads and infrastructure maintenance. For instance, in Romania, the Ministry of Transport, Infrastructure, and Communication establishes the legal and procedural framework for mobility planning while requiring municipalities like Cugir to operate within a narrowly defined legislative framework (Framework Law no. 195/2006), by proving its conformative nature. A comparable dynamic is observed in Portugal, where the central government determines transport priorities while municipalities such as Braga manage urban services under strict administrative guidelines. These top-down highly centralised structure reflects the conformative nature of the Portuguese SGPS. Although this model ensures institutional coherence and streamlined vertical coordination, it often supresses local flexibility and weakens the transformative potential of SUMPs, particularly when plans are legally binding but procedurally rigid.

A particularly noteworthy case is Lithuania where the governance structure remains centralised with strong vertical coordination between national and local levels. Unlike other countries with established sub-national authorities, Lithuania lacks regional authorities that could facilitate coordination between central and municipal stakeholders. The absence of a regional authority hinders efforts to integrate spatial planning and mobility services across urban areas. The resulting meso-level governance gap undermines cross-jurisdictional alignment in the implementation of SUMPs.

In contrast, the Netherlands demonstrates a decentralised governance system grounded in horizontal coordination among local and regional authorities. Subnational actors such as municipalities and provinces are empowered to lead transport planning, public infrastructure, mobility management, and implementation while the national government provides solely strategic roadmap, proving its neo-performative nature. Although the Dutch planning system is framed by national policy objectives, it is inherently non-binding and operationalised through informal institutional trust and inter-municipal cooperation.

Italy and England, despite having a conformative and performative system respectively, embody more complex multilevel governance systems that combine vertical coordination where national and regional authorities set overarching strategic goals with horizontal cooperation mechanisms that promote inter-municipal integration and adaptive implementation. The Metropolitan City of Milan is an example of institutionalised multilevel governance, where the metropolitan city ensures the alignment of the SUMP with national, regional and metropolitan mobility objectives. London, within a performative SGPS, is particularly symbolic of a hybrid governance model in which the Department of Transport sets overarching regulations, and the Transport for London (TfL) functions as both a strategic and operational authority. Local boroughs such as Westminster develop their own transport strategies aligned with TfL's London Plan. In these contexts, SUMPs are formally binding, but their development often occurs through coordinated and flexible dialogues across levels.

Table 1 – Mobility planning structure in JUST STREETS countries/cities

Pilot cities	Authorities responsible for mobility planning
Amsterdam (NE)	***National authority*** **Ministry of Infrastructure and Water Management** – in charge of national transport policy (roads, railways, aviation, maritime, inland water transport) **Institute of Transport Policy Analysis** – supports policymaking with data and knowledge at the Ministry of Infrastructure and Water Management **ProRail** – a government-owned private-law body, manages rail infrastructure and operations **Dutch Railway** – has the sole right to operate passenger services on the main railway network | manages the train accessibility
	Regional authority **Provinces** - coordinate strategic transport planning, manage regional infrastructure (roads, railways, cycle paths) | regulate public transport concessions | oversee transport safety and logistics
	Local authority **Municipalities** – manage urban planning, local public transport, road and cycling infrastructure, parking management, and traffic regulation
Braga (PT)	***National authority*** **Ministry of Infrastructure and Housing** – defines and implements national transport policies **Ministry for the Environment and Energy Transition** – oversees urban transport and suburban passenger service **Ministry of the Sea** – coordinates maritime affairs, manages ports and maritime transport, oversees national and EU funding related to the sea **Ministry of Internal Affairs** – develops road safety policy **Infrastructure Portugal** – state company responsible for design, maintenance, modernisation of road and national rail networks **The Institute for Mobility and Transport** – a central administration body, regulates and coordinates inland transport, and ensures quality standards for the protection of consumer's rights **Bureau for the Prevention and Investigation of Aviation Accidents (GPIAA)** - incident aviation investigation authority
	Regional authority **Autonomous Regions of Azores and Madeira** - manage regional infrastructure, including roads, ports, airports, and sea, air, and land transport, with full responsibility for regional mobility and logistics
	Local authority **Municipalities** – responsible for urban transport, local road networks, municipal aerodromes and heliports, school and touristic transport **Intermunicipal entities** – manage abovementioned functions under agreement with the municipalities **Parishes** – responsible for maintenance of shelters, signage, roads, and pavements.
Cugir (RO)	***National authority*** **Ministry of Transport, Infrastructure, and Communication** – responsible for national legislative framework, strategy, infrastructure projects implementation, and international obligations | coordinates scientific research and SMART CITY strategies | Oversees state-owned transport companies and signs performance contracts with operators | Manages EU alignment and national-level projects
	Regional authority **Counties** – shared powers with the central government (e.g., management of roads of county interest), legal basis: Article 26 of Framework Law no. 195/2006 (revised)
	Local authority **Municipalities, towns, and communes** – responsible for local roads and local public transport shared competences with national authorities in managing the road infrastructures of local interest at commune level, legal basis: Article 21 & 24 of Framework Law no. 195/2006 (revised)

Kozani (GR)	***National authority*** **Ministry of Infrastructure and Transport** – develops national transport policy and legal framework, manages infrastructure projects at the national level, road safety
	Regional authority Extensive regulatory and licensing functions including licensing public transport vehicles, driving permits, new intercity and interregional bus services (KTEL), vocational training for transport managers, vessel licensing, fuel stations, taxi permits, and private roads | coordinates inspections, safety rules, and environmental regulations for transport
	Local authority **Municipalities** – in charge of urban planning, traffic regulation, local roads and public spaces | operate municipal public transport (particularly for social groups such as elderly, children, people with disabilities) | Issue transport-related licenses (driving training, vehicle maintenance)
London – Westminster (UK)	National authority Department for Transport (DfT) – a ministerial department, provides national transport policy, regulates roads, rail, aviation, and maritime; funds local authorities; regulates vehicle safety and licensing; and oversees national investigations Other central agencies - Highways England (roads), Network Rail (rail infrastructure), Office of Rail and Road (regulator), British Transport Police, Maritime & Coastguard Agency
	Regional authority Devolved authorities (Scotland, Wales, Northern Ireland) control most aspects of transport in their regions. In United Kingdom, regional coordination is more fragmented, but Transport for London (TfL) plays a major role in strategic regional mobility planning and delivery across Greater London | Strategic bodies coordinate some cross-border policies (e.g., North-South Ministerial Council with Ireland)
	Local authority **Westminster City Council** (a London borough) develops local transport strategies in line with **TfL's London Plan** | Responsibilities include traffic management, local roads, parking, active travel infrastructure, and neighbourhood public transport. Local authorities across the UK differ in powers, but in London, local and regional coordination is strong and driven through TfL and the Mayor's office
Metropolitan City of Milan (IT)	***National authority*** **Ministry of Transport and Infrastructure** – responsible for national transport systems (road, air) and water transport systems, traffic regulation, and major infrastructure | Keeps current competences with regions over ports, airports, and strategic networks
	Regional authority In charge of regional public transport, maritime infrastructure, inland vegetation, regional railways, inter-regional roads, and large-scale public works of regional interest
	Local authority **Provinces** – manage provincial transport, maintenance of provincial roads, and driving school licensing **Metropolitan cities** - ensure compatibility between urban mobility plans and local municipal plans **Municipalities** - manage local public and urban transport, traffic control, road maintenance, and land-use planning
Riga (LV)	***National authority*** **Ministry of Transport and Maritime Administration** – develops national policy on transport and traffic | oversees rail, maritime, inland water, and air transport systems | Coordinates EU legal alignment and advocates Latvian interests | Oversees the financial framework for inter-urban and regional public transport routes and unified ticketing systems | Manages public-use railway infrastructure
	Regional authority Responsible for regional public transportation networks and financial oversight | Proposes new or improved regional routes | ensures coordination between local and national actors | Oversees proper use of state and municipal transport budgets
	Local authority manages urban public transport planning and service delivery | maintains bus stops and related infrastructure, and coordinates with regional authorities | Responsible for maintenance and lighting of local roads, streets, and public squares
Vilnius (LT)	***National authority*** **Ministry of Transport and communication** – Development and implementation of national transport policy, coordinate logistics, manages infrastructure for all transport modes (road, rail, sea, air, inland waterways) | Oversees state-owned ports and airports, and develops national strategies including transit and combined transport
	Regional authority -------
	Local authority Local governments manage planning and maintenance of local roads, traffic safety, local route licensing, and compensation mechanisms for socially inclusive transport (e.g., rural school transportation)

Table 2 – The tools for mobility planning in JUST STREETS cities

Pilot Cities	Mobility planning tools - SUMPs
Amsterdam **(NE) | 2013**	**Title:** Mobility Approach Amsterdam 2030 **Objective(s):** Prioritising cost-efficient and space-saving modes of transport while optimizing the use of available infrastructure
Braga **(PT) | 2019**	**Title:** Sustainable Urban Mobility Plan for the City of Braga **Objective(s):** Promote soft modes (pedestrian, cycling), improve public transport, reduce car use, and support intermodality
Cugir **(RO) | 2023**	**Title:** Sustainable Urban Mobility Plan, 2022-2030 (PMUD) **Objective:** Provide an efficient and sustainable transport system to ensure accessible, safe, and sustainable transport to all in urban/periurban areas
Kozani **(GR) | 2020**	**Title:** Sustainable Urban Mobility Plan (SUMP) of the Municipality of Kozani (PMUD) **Objective(s):** Develop a sustainable, inclusive mobility system by shifting from car use to active/shared modes, improving quality of life, and integrating smart technologies
London – Westminster **(UK) | 2017/2014**	**Title:** Walking strategy - Cycling strategy **Objective(s):** Make Westminster a national leader in walking and cycling by improving safety, accessibility, and uptake of active travel modes
Metropolitan City of Milan **(IT) | 2021**	**Title:** Sustainable Urban Mobility Plan (SUMP) of the Metro city of Milan **Objective(s):** Satisfy the demand for mobility in urban and metropolitan areas
Riga **(LV) | 2020**	**Title:** Towards a better everyday life Riga mobility vision **Objective(s):** To create a sustainable, inclusive, people-centered mobility system that promotes equality of life, urban livability, public health, while addressing environmental and economic challenges
Vilnius **(LT) | 2018**	**Title:** Vilnius city sustainable mobility plan – action plan (SUMP) **Objective(s):** To create clean, safe, inclusive, and sustainable urban mobility systems, enhance quality of life, a modal shift from walking and cycling and support climate neutrality initiative

4.Multilevel planning in action: the Metropolitan City of Milan - City of Corsico case study

The Metropolitan City of Milan (CMM) is the second most populous metropolitan area in Italy (after Rome), encompassing 133 municipalities and over 3 million inhabitants. CMM was formally established in 2015 through the Delrio Law (Law No.56/2014), which reformed local government in Italy and instituted 14 "città metropolitane" in the country's largest metropolitan areas, in substitution of the respective provincial governments (Casavola et al. 2024). Metropolitan cities are responsible of three key planning instruments: the metropolitan strategic plan (PSM), the metropolitan general spatial plan (PTGM) and the sustainable urban mobility plan (PUMS). In more detail, they inherited the competences of the former provincial governments they substituted, and additional functions, such as strategic, spatial and mobility planning, organisation of coordinated systems for the management of public services, mobility and transport, promotion and coordination of digitalisation and economic and social development. While the PSM and the PUMS are non-binding strategic planning tools, the PTGM is a binding spatial planning tool. In essence, the PTGM assumes binding functions for land-use and urban planning, regulating the activities of municipalities regarding infrastructure and services under metropolitan jurisdiction, as well as land consumption. However, effective control over municipal land in the municipalities that are part of the metropolitan city is up to the municipalities themselves, through their land-use plan, a planning and land-use regulation tool that has no predefined time frame. As a result, the adjustment of municipal plans to what the metropolitan plan establishes depends on the willingness of municipalities to issue a new plan or a variant to it. In addition, it should be considered that Italian metropolitan cities are second-tier public bodies, that is, not directly elected. This results in weak political representation on the ground.

Within the metropolitan city, the municipality of Corsico emerges as a densely populated suburban municipality, located in the first belt, approximately 7 kilometres southwest of the city centre of Milan, with a resident population of around 34,000. Corsico is highly integrated into the metropolitan transportation and economic systems. It functions as part of the daily commuter belt and benefits both urban and regional public transport services.

This case study is analytically significant for two key reasons. Firstly, it demonstrates the dynamic between metropolitan-level strategies such as SUMPs and institutional capacities, political priorities, and operational constraints at the municipal level. Secondly, the Corsico pilot city provides a valuable lens to examine the mechanisms of multilevel governance in translating metropolitan strategies into localised implementation. This is particularly pertinent in suburban contexts, where disparities in urban density, socioeconomic context, political leadership, and administrative capacity among municipalities pose distinct challenges for coherent policy implementation.

The metropolitan city of Milan shows significant interest in active and sustainable mobility. Active mobility is treated as a strategic priority and deeply embedded with broader goals of environmental efficiency and modal shift. In particular, the SUMP of Metropolitan city of Milan supports its low-impact mobility strategy through the development of comprehensive cycling network via its dedicated Biciplan (Metropolitan Plan for Cycling Mobility), alongside safety improvements for pedestrian around key nodes particularly around schools, transit hubs, and public institutions. In doing so, the metropolitan city aims to support people in rethinking their mobility choices towards more sustainable forms, through both home-city centre connections and the strengthening of interchange functions between all transport networks. This change in behaviour is the main challenge of the Metropolitan City of Milan, especially in places where the concentration of people, mobility and functions is greater, such as in station areas, intended as modal interchanges centres.

As regards transit hubs, the metropolitan SUMP and the PTGM, approved almost simultaneously in April and May 2021 respectively, present a common vision and consistent indications with respect to the territorial role of the stations and the areas surrounding them. They identify, at the stops of the Milanese suburban railway lines and the other main modal interchange nodes, the so-called Luoghi Urbani della Mobilità - Urban Places for Mobility (LUM). LUMs are areas around the main public transport interchange stops within which, in view of their high accessibility, the location and strengthening of services and infrastructures necessary to enhance the interchange function and urban functions and services to people and businesses, aimed at improving the safety and liveability of the area, should be promoted. They provide for the regeneration and settlement of urban functions and services to people and businesses, as well as services and infrastructures necessary for the interchange function.

This coherence between metropolitan planning tools concerning settlement development and mobility creates fertile ground for TOD-oriented development and to promote more active and sustainable mobility. Although it may appear to be a reasonable coordination and present in all Italian metropolitan cities, the case of Milan is among the few to operate this synergy in Italy (Staricco and Vitale Brovarone, 2021, 2023).

As part of the JUST STREETS Project, the Metropolitan City of Milan intends to experiment by bringing the action of the metropolitan level closer to that of the municipal level, through a process of co-definition of guidelines and regulations for the development of LUMs. In this respect, the Corsico LUM would be considered as a pilot to experiment innovative multilevel planning practices. The guidelines for the organisation of inclusive and sustainable accessibility of the interchange nodes are then meant to be replicable in other mobility nodes in the territory of the Metropolitan City of Milan. They are also inspired by what has already been provided for and indicated in the planning tools of the metropolitan city. This initiative intends on the one hand to scale down the planning practices of the metropolitan authority, on the other hand to scale up local practices and instances, in particular with regard to the actions carried out by grassroot associations. The latter are the subject of investigation through interviews and focus groups, and will be involved in the process of co-creation of the guidelines. In this way it will be possible to integrate the perceptions and needs of the community, integrating them with the analysis of the territory and the regulatory framework through a process of listening and active involvement never before experienced by the metropolitan city in its planning tools.

Bringing the lens closer to the municipal level, the municipality of Corsico, although not formally involved in the partnership of the Just Streets project, has shown interest in the project and intends to cooperate in the co-definition of the guidelines for the development of the LUM. The LUM of Corsico poses particular challenges regarding accessibility and active mobility, being a minor suburban station in a car-oriented context, worsened by the presence, near the station, of two industries that provide for the continuous passage of heavy vehicles along a narrow road used by pedestrians and cyclists. This is therefore, in theory, an optimal opportunity to experiment with multilevel and multi-actor governance, involving different types of actors (public administrations, public transport operators, research centres, third sector associations) operating at different administrative levels (metropolitan city, municipality), in different sectors (urban and mobility planning, local development, advocacy of marginalised social groups) to improve mobility justice.

However, at the time of writing this paper, we cannot go further in the analysis, as the co-planning process, however promising, has been for several months breathed into institutional quibbles related to the signing of a formal collaboration agreement between the metropolitan city and the municipality, without which the metropolitan city is not authorised to carry out any initiative (not even intangible) within the municipality.

This suggests the challenges posed by a multi-level governance process of this type and, more generally, how much traditional metropolitan planning tools, including SUMPs, are able to catalyse and implement transformative mobility practices.

5.Discussion: lessons learnt from Corsico and the Metropolitan City of Milan

The governance structure and institutional dynamics observed in the Corsico case reveal critical insights into the transformative potential of SUMPs. While SUMPs are intended as strategic tools for sustainable mobility, their real impact is heavily influenced by the multilevel governance arrangements in which they are embedded. A key challenge emerging from the Milan-Corsico case is the persistent asymmetry between metropolitan and local governance levels. Although the Metropolitan City of Milan's SUMP and related plans like the PTGM and Biciplan offer robust visions for sustainable mobility, municipalities such as Corsico often lack the institutional and financial capacity to align local practices with these metropolitan objectives. The non-binding nature of strategic plans like SUMP, and the limited power of the metropolitan institution in implementing its plans at the municipal level, further complicates this dynamic, as it leaves room for local resistance or inaction, especially in municipalities with limited resources or conflicting priorities. This reinforces the observation that transformative mobility practices require not just visionary plans but also capacity-building mechanisms and funding streams that support local adaptation.

The Italian SGPS combines flexibility in municipal land-use planning with rigid binding frameworks at the metropolitan and regional levels. While this duality theoretically allows for local responsiveness, in practice, it

can produce institutional deadlock. In Corsico, the potential for active mobility improvements is constrained by the absence of a formal collaboration agreement, which delays project implementation and underscores the importance of procedural flexibility and trust-building in multilevel governance. This suggests that rigid legal frameworks (though essential for ensuring consistency) can inadvertently stifle local initiatives if not balanced with procedural flexibility and shared governance practices.

The case of Metropolitan City of Milan-Corsico in the JUST STREETS project highlights both the promise and the pitfalls of participatory co-production processes in mobility planning. The engagement of grassroots organisations and civil society actors through co-creation of LUM guidelines offers a powerful example of how SUMPs can catalyse more inclusive and context-sensitive mobility practices. However, the institutional inertia that has stalled formal cooperation also demonstrates that genuine co-production cannot be an afterthought; it must be embedded and institutionalised within planning processes and supported by governance structures that facilitate rather than hinder local experimentation.

The Corsico pilot also sheds light on the justice dimensions of mobility transitions. While the metropolitan SUMP framework prioritises active and low-carbon mobility, the challenges faced by Corsico, such as heavy vehicle traffic along narrow, pedestrian-inhabited corridors, underscore the need to address not just climate goals but also social equity and accessibility. Integrating community voices and ensuring that plans are sensitive to the everyday realities of disadvantaged or marginalised groups are essential steps towards realising mobility justice. Ultimately, the Corsico experience underscores that SUMPs' transformative potential depends on navigating the tensions between metropolitan strategies and municipal implementation, between binding legal structures and local adaptation, and between formal governance frameworks and community-driven practices. Future research should explore how these dynamics play out across other municipalities and how inclusive, flexible governance models can be strengthened to turn visionary plans into transformative, justice-centred urban mobility systems.

6.Conclusion and avenues for future research

The Corsico-Metropolitan City of Milan pilot underscores the complex interplay between SGPS and the transformative potential of Sustainable Urban Mobility Plans (SUMPs). While the multilevel governance structures in Milan-Corsico showcase innovative visions for active and sustainable mobility, they also reveal how rigid frameworks, capacity asymmetries, and fragmented implementation can undermine these ambitions. At the same time, the co-creation process involving local actors and communities hints at a promising pathway towards more inclusive and justice-oriented urban mobility transformations.

Future research could delve deeper into these critical tensions by explicitly integrating the conceptual framework of SGPS and the mobility justice lens. While SGPS literature has largely focused on how legal structures, planning tools, and institutional arrangements shape spatial development, it often falls short of interrogating how these systems interact with social inequalities and justice concerns. Conversely, mobility justice scholarship foregrounds questions of equity and inclusion but may not always fully engage with the institutional and procedural underpinnings of spatial governance.

Bridging these two domains could open fertile ground for understanding not only how SUMPs are developed and implemented, but also whose interests they serve and whose voices are excluded in the process. For instance, future studies could explore how the procedural dimensions of SGPS, such as participatory mechanisms, co-production of knowledge, and local negotiation, affect the realisation of mobility justice goals like equitable access, environmental sustainability, and recognition of diverse mobility needs. Comparative research across different metropolitan and municipal contexts could also help identify best practices and structural barriers in reconciling top-down planning with bottom-up initiatives.

Another promising direction involves examining the performative role of discourses within SGPS, i.e. how narratives around "smart" or "sustainable" mobility either enable or constrain justice-oriented planning. This could include analyses of how discursive frames shape priorities within SUMPs and how these narratives are contested or reinterpreted by marginalised groups. Embedding this focus within SGPS research would offer richer insights into how mobility justice can be more than an add-on goal, becoming an integral part of planning systems and governance structures.

Finally, the Corsico–Metropolitan City of Milan case study suggests that multilevel governance arrangements are not inherently good or bad for mobility justice; rather, their transformative potential depends on how they are activated through inclusive processes, shared visions, and flexible institutional frameworks. Unpacking these relational dynamics across SGPS components (structures, tools, practices, and discourses) can reveal pathways for fostering more equitable and resilient urban mobility futures.

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Analysis of Regional Disparities in Public Transportation Accessibility: A Spatial Approach to Equal-Time Job Accessibility

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Abstract
This study empirically analyzes regional disparities in public transportation service levels between the Seoul metropolitan area and other South Korean regions, offering policy implications for balanced national development. Overcoming prior research limitations like reliance on administrative boundaries or a single-transportaion mode, this study utilizes nationwide direct-link transit data to evaluate mobility and accessibility at a fine 500m x 500m grid cell resolution. Mobility is defined as reachable grid cells and accessibility, as accessible jobs, both within one hour. Analysis reveals the Seoul metropolitan and Busan-Ulsan-Gyeongnam have the highest mobility and accessibility, while Gangwon ranks lowest. Notably, dense industrial clusters show high public transport job accessibility, underscoring that improving transit access to employment centers, not just attracting businesses, is key to enhancing regional competitiveness.

Keywords : Spatial inequality, Public transportation, Disparity, Spatial coverage, Job Accessibility

1. Introduction

In modern cities, public transportation is a crucial element that ensures individuals' ease of mobility to various destinations. Notably, in South Korea, public transportation accounts for a high modal share of 32.7% (Ministry of Land, Infrastructure and Transport, 2022) when considering travel distance and ridership, thus playing a pivotal role in mobility. The competitiveness of a city is influenced by the level of public transportation services, and efficient allocation can facilitate balanced development (Shabanam et al. 2024).

Public transportation has a greater societal impact compared to private vehicle use. This is because public transportation offers high road utilization efficiency and low usage costs, making its services accessible to diverse social strata. Specifically, low-skilled and economically vulnerable populations are more dependent on public transportation than private cars, necessitating the establishment of an adequate service level to provide them with employment opportunities (Elgeziry, M, 2022). Regions with inadequate public transportation systems face limited mobility, which degrades access to employment and educational services, leading to disparities in regional development and quality of life (Stewart, 2017).

Public transportation also contributes to industrial and economic development by enhancing labor market and consumer accessibility (APTA, 2022). An efficient public transportation system in a nation increases the likelihood of attracting various industries and businesses, and induces a higher volume of commuting and business activities (Lee et al., 2023). High values in indicators of public transportation infrastructure, such as bus stop density and public bicycle usage, enable urban residents to conveniently travel to various destinations like workplaces, schools, shopping, and cultural facilities. This, in turn, enhances accessibility to living infrastructure such as housing, education, and commercial facilities, thereby revitalizing the region (Kim, 2024).

The disparity in public transportation services between regions is identified as a representative factor of imbalance in urban and regional development in South Korea (Park, 2023). The establishment of a public transportation network involves not merely road construction but also substantial budgets, compelling the nation to make cautious investment decisions. In this context, there is a clear tendency for public transportation services to be primarily supplied to the Seoul Metropolitan Area, where population and jobs are concentrated.

In fact, the widening gap in regional public transportation infrastructure has accelerated even further since the COVID-19 pandemic (Korea Research Institute for Human Settlements, 2023). The increasing closures of local terminals and reductions in intercity bus routes and frequencies have drastically degraded convenience for local residents. In stark contrast, discussions for large-scale metropolitan railway projects, such as the GTX lines and Shinansan Line, are actively progressing in the Seoul Metropolitan Area, with continuous investment being made.

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This contrasting situation in public transportation service levels between the Seoul Metropolitan Area and other regions further exacerbates the inter-regional accessibility gap, which directly translates into restricted mobility in local areas and can lead to significant problems such as an imbalance in regional revitalization and quality of life (Hwang et al., 2024).

Literature Review

Improving accessibility, a key indicator for evaluating public transportation service levels, is considered a core task for governments (Yoo et al., 2021). While various efforts are underway to enhance transport accessibility, the term "accessibility" is not uniformly defined, which can lead to ambiguity in evaluation. According to Cho (2014), public transportation accessibility can be largely categorized into three types: first, the ease of reaching public transportation facilities such as stops and stations; second, the geographical area reachable within a specific time using public transportation; and finally, the number of opportunities (e.g., medical services, education, employment) accessible via public transportation.

In this study, we define accessibility as the number of opportunities reachable by public transportation, specifically focusing on employment opportunities. The reason for prioritizing employment among various opportunities in a city is that commuting is the primary purpose for citizens using public transportation (Korea Transport Institute, 2014). In this context, the distance between one's workplace and residence is directly linked to life satisfaction; shorter commute times are associated with higher job satisfaction and quality of life for workers (Han.L, 2022).

ITF-OECD (2023) evaluated the level of public transportation infrastructure in the Seoul Metropolitan Area, comparing the number of accessible jobs when using a car versus public transportation. The analysis revealed no significant difference in the number of accessible jobs by mode in the central urban areas of the capital and some areas adjacent to railway lines. However, in most suburban areas with high commuting demand to Seoul, public transportation accessibility was found to be severely low, leading to high car dependency. Despite its insights, this study had limitations in clearly identifying the accessibility of public transportation itself, as it primarily examined the service level of public transportation relative to private vehicles.

Beyond Korea, studies in major U.S. metropolitan areas and recent EU cities highlight that a lack of private vehicle accessibility and inadequate public transportation services pose significant barriers to employment access and retention (e.g., Cervero et al., 2002; Korsu and Wenglenski, 2010; Sanchez et al., 2004). Fransen et al. (2019) confirmed that possessing a driver's license positively influences job accessibility. In the case of the Flanders region in Belgium, a positive correlation was observed between driver's license ownership and high job accessibility, suggesting relatively low job accessibility via public transportation. Furthermore, the importance of public transportation in the labor market is underscored by the significant negative correlation between job accessibility and the probability of long-term unemployment. However, this study indirectly revealed the high accessibility associated with private vehicle ownership rather than directly presenting job accessibility through public transportation. This limits its ability to ascertain the clear impact of public transportation.

Elgeziry (2022) revealed that job accessibility through public transportation has a greater impact on vulnerable populations. Through a case study in San Bernardino, California, the research analyzed the effect of affordable and convenient public transportation access on employment opportunities for low-skilled and economically vulnerable residents. The findings indicated that despite the availability of jobs for economically vulnerable and low-skilled residents, the existing public transportation system did not adequately cover their work hours and job locations, severely limiting job access. While this study is highly contributory due to its consideration of operating hours based on workers' job locations, its limitation lies in analyzing the mobility of specific social strata, making it difficult to grasp the overall effect of public transportation. Bastiaanssen (2022) confirmed that in urban areas of the UK (excluding London), employment elasticity showed a positive value when public transportation accessibility increased at the census tract level. This had a greater impact on people without cars and low-income individuals. This study is significant for using employment probability as a dependent variable to measure people's actual opportunities, but it has limitations in quantifying the number of opportunities.

Research Contribution and Differentiation

Previous studies evaluating public transportation accessibility based on the number of accessible jobs have primarily focused on the job accessibility levels of specific social strata or compared travel ranges within the same time using private vehicles. This approach has made it difficult to conduct a direct, region-by-region comparison of public transportation as a standalone mode. Therefore, this study aims to analyze job accessibility via public transportation for all citizens, not just specific groups, to understand the service level across all social classes. Furthermore, the analysis will focus exclusively on public transportation, excluding private vehicle use.

The key questions guiding this research are:
Within a given urban area in South Korea, what is the geographical range that can be reached by public transportation within a specific timeframe?
What are the disparities in the number of accessible jobs within the same timeframe across different regions?

This study will empirically analyze the regional differences in public transportation accessibility across South Korea, measured by the number of accessible jobs. We will also identify the number of jobs reachable by public transportation (Ma L. et al., 2021), which can serve as a metric for urban competitiveness. Understanding the number of jobs accessible in each region can help identify areas where public transportation needs improvement and contribute to establishing economic hubs by forming central transportation axes when planning new cities. Ultimately, this research will provide crucial foundational data for developing policies that foster balanced development and strengthen inter-regional cooperation.

2. Methodology

Previous studies on public transportation accessibility have faced several methodological limitations. For instance, Han Dae-ho (2016) evaluated public transportation levels in Seoul based on administrative dong units. However, these units often fail to reflect actual population distribution or area differences. In contrast, this study measured transport accessibility at a more granular spatial unit by employing a 500m x 500m grid-based analysis. This approach is advantageous for evaluating public transportation services based on actual residential areas.

Furthermore, studies by Yoo Kyeong-sang et al. (2020) and Jeong Yong-il (2021) utilized grid units but were limited to specific cities like Seoul or Cheongju, North Chungcheong Province, hindering the generalizability of their findings. This study overcomes this limitation by conducting a nationwide analysis. By classifying regions based on urban area categories officially announced by the government (Committee for Balanced National Development, 2023), rather than simple administrative districts, we enhanced the policy applicability of our research.

Finally, most existing studies primarily considered single modes of transportation like buses or subways (Rural Service Standards, 2023) and failed to incorporate actual public transportation usage characteristics such as transfer possibilities. To address this, our study attempted a more realistic assessment of public transportation accessibility by conducting a network analysis that considers integrated approaches across various transportation modes and transfer routes.

The data used for this analysis, as of December 2024, includes:
- GTFS direct section data for national regional buses, express/intercity buses, trains, subways, aviation, and maritime transport from TMAP.
- 500m x 500m grid SHP files from SGIS, along with population, household, business, and employee count data.
- Province and city/county shapefiles from the National Geographic Information Institute.

The direct section data can be considered as links connecting nodes (origin and destination). These nodes are spatially mapped onto the 500m x 500m grid files, transforming movement between stops into movement between grids.

Table 1: Example of Direct Section Data

Area	Agency Type	Route Name	Stop ID 1	Stop ID 2	Stop Name 1	Stop Name 2	Distance (m)	Time (sec)	Oper_ Count	First Depart	Last Depart
Gangwon	Express Bus	Express Bus : Gang-neung-Goyang	300070	300006	Gangneung Terminal	Goyang Terminal	184,663	10,200	5	7:00:00	19:40:00

For transfer calculations, a threshold distance of 800m was defined as the walkable range for transfers (Streb. M, 2022), assuming a walking speed of 1.2 m/s. Waiting times were also factored into the total travel time: 450 seconds for intra-regional movement and 900 seconds for inter-regional movement.

The analysis target area was set nationwide, and the spatial unit was structured based on a 500m x 500m grid cell system. Out of a total of 418,637 grids, 185,216 grids that actually contained population were selected for analysis to ensure relevance from a service perspective.

Table 2: Public Transportation Direct Section Data Structure (Grid-to-Grid Travel)

Agency Type	GRID ID 1	GRID ID 2	Dist (m)	Time (s)	Speed (km/h)	Oper Count
Transportation	Start	End	Distance	Time	Speed	Oper per day

· Spatial coverage
This study aims to analyze public transportation service levels within major metropolitan areas from the perspective of spatial accessibility. To achieve this, we evaluated public transportation-based mobility by combining the spatial range reachable within a set time (1 hour) via public transportation with the population size within that range.

For the mobility assessment, we adopted an accessibility analysis method based on travel time between origin and destination. This allowed us to quantitatively calculate the actual travel range provided by the public transportation network. For grids where a population exists, we evaluated the connectivity between all grids reachable within a maximum of 60 minutes using public transportation, starting from the public transportation stops located within each grid.

The public transportation direct section data used for this analysis totaled 5,772,986 records, from which 3,646,722 grid pairs reachable within 60 minutes were derived. To ensure the validity of the reachable range, cases where the destination grid had no population were excluded. This process resulted in the removal of 166,770 direct sections based on origin and 165,865 direct sections based on destination. Ultimately, only significant travel routes were extracted, and the range of movement possible within one hour was calculated for a total of 67,323 grids.
For spatial analysis, this study categorized the entire nation into seven major metropolitan areas: the Seoul Metropolitan Area, Gangwon Region, Daejeon-Chungcheong Region, Jeonbuk Region, Gwangju-Jeonnam Region, Daegu-Gyeongbuk Region, and Busan-Ulsan-Gyeongnam Region. Within each of these wider metropolitan areas, we analyzed public transportation accessibility and population distribution characteristics.

· Job Accessibility
In this study, accessibility is defined as the total number of jobs located within all destination grids reachable from a given origin grid within one hour, using the direct sections converted from grid-to-grid movements. We will then calculate the average number of reachable jobs per grid for each urban area to compare regional differences.

To compare regional accessibility, we will utilize the metric proposed by Allen et al. (2019), which is derived from the number of jobs reachable within a specific time in each region. The formula is as follows:

$$A_{ij} = \sum_{i=1}^{J} O_j f(t_{ij})$$

A_{ij} = Accessibility at location i

O_j = Number of opportunities at location j

$t_{i,j}$ = Travel cost (time or distance) from location i to j

$f(t_{ij})$ = Decay function based on travel cost

T = Threshold (travel time)

A_{ij} is a measure of accessibility for location i. O_j is the number of opportunities at location j. O_j can be interpreted as the attractiveness or gravity of location j. $f(t_{ij})$ is a decay function of travel cost t from i to j and threshold (T) for travel time or the number of transfers is set, meaning it is reflected if it is below the threshold and excluded if it exceeds it.

To understand the relationship between the level of public transportation service establishment and jobs, a correlation analysis was conducted between internal grid data (population, number of households, number of businesses, number of jobs) and the number of public transportations stops to enhance justification. The correlation analysis results, transformed into log values, showed a correlation coefficient of 0.35-0.38 between the number of stops and the intra-grid data. The number of stops has a significant correlation with socioeconomic indicators, and it can be seen that this should be considered when assessing public transportation service levels.

Table 3: Number of Stops within Grids

Metric	Value
count	71,830
mean	2.72
std	1.94
Min	1
25%	2
50%	2
75%	3
Max	27

Table 4: Population within Grids

Population	Grid
0	233,421
1-10	73,411
11-100	86,363
100-1,000	14,064
1,000-10,000	11,211
10,000+	166

3. Results

Spatial Coverage

We examined the percentage of grids reachable within 1 hour by public transport relative to the number of populated grids in each urban area. The Seoul Metropolitan Area showed the highest proportion at 47.2%, demonstrating its well-established transfer system, including bus-subway connections. Following Seoul, the Busan-Ulsan-Gyeongnam area (BUK area) also exhibited a high level of public transport service, likely due to its inclusion of two metropolitan cities and their larger populations.

Conversely, the Gangwon region had the lowest proportion at 27.1%, indicating that the spatial reach of public transport is significantly limited there. The Daejeon-Chungcheong, Jeonbuk, and Gwangju-Jeonnam regions showed similar proportions. Further analysis of factors like population and job numbers in these areas is necessary to determine if their current public transport distribution is adequate.

Table 5: Ratio of 1-Hour Reachable Grids to Populated Grids by Urban Area

Metropolitan Area	SIDO	Number of Populated Grids	Grids Reachable Within One Hour	Percentage
Seoul Metropolitan Area	Seoul	30,069	14,195	47.2
	Incheon			
	Gyeonggi			
Gangwon Area	Gangwon	18,529	5,029	27.1
Daejeon Chungchung Area	Daejeon	38,023	13,453	35.3
	Sejong			
	Chungnam			
	Chungbuk			
Jeonbuk Area	Jeonbuk	15,688	5,561	35.4
Gwangju Jeonnam Area	Gwangju	24,620	8,731	35.4
	Jeonnam			
Daegu Gyeongbuk Area	Daegu	31,229	10,273	32.8
	Gyeongbuk			
Busan Ulsan Gyeongnam Area	Busan	23,525	8,696	37.0
	Ulsan			
	Gyeongnam			

Job Accessibility

When analyzing by urban area, the Seoul Metropolitan Area consistently had the highest number of jobs reachable by public transportation. This region recorded more than twice the number of employees and businesses compared to the next highest-ranking area. Following the Seoul Metropolitan Area, the Busan-Ulsan-Gyeongnam area (BUK area) showed the next highest accessibility. The average number of reachable jobs in other regions was found to be similar across them.

Table 6: Average Number of Reachable Jobs and Businesses within 1 Hour per Grid by Urban Area

SIDO_NM	Number of job	Number of Businesses
Seoul Metropolitan Area	1202.4	265.3
Gangwon Area	200.6	60.4
Daejeon Chungchung Area	298.1	86.7
Jeonbuk Area	230.8	68.6
Gwangju Jeonnam Area	250.2	70.2
Busan Ulsan Gyeongnam Area	527.9	145.5
Daegu Gyeongbuk Area	266.2	77.5
Jeju Area	283.8	85.5

The Seoul Metropolitan Area shows high accessibility to jobs via public transportation. In most grids, it's possible to reach over 400 jobs within an hour. Specifically, areas like Yongsan-gu, Jung-gu, Gangnam-gu, Songpa-gu, Seocho-gu, and Yeongdeungpo-gu in Seoul demonstrate the highest accessibility, with over 5,800 jobs reachable per grid. Outside of Seoul, areas such as Bundang-gu in Seongnam City (including Pangyo Techno Valley), Suji-gu in Yongin City (home to a semiconductor cluster), Yeongtong-gu in Suwon City, and Giheung-gu in Yongin City also offer access to a relatively large number of jobs. This indicates that the presence of large industrial complexes or business districts near a grid leads to a high number of reachable jobs.

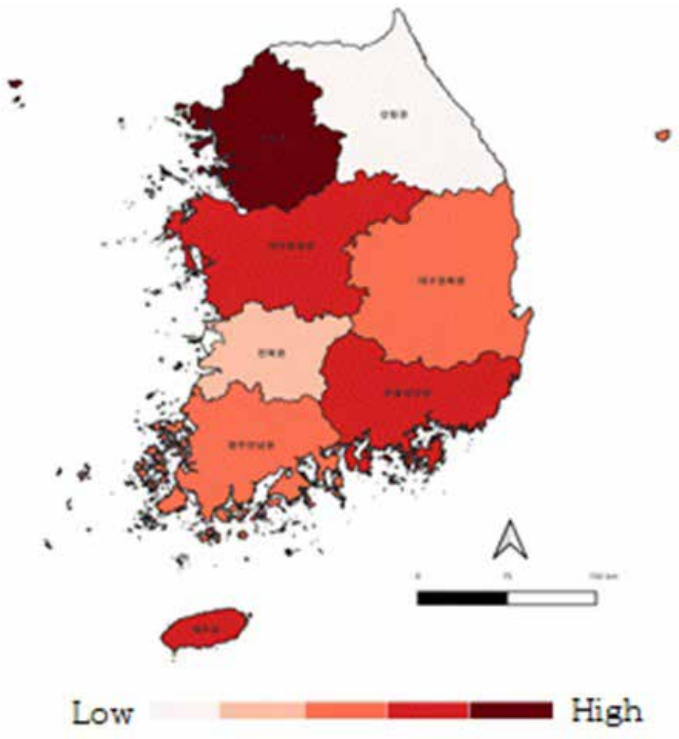


Figure 1: Average Number of Reachable Jobs per Grid within 1 Hour by Urban Area

In the Gangwon region, only Chuncheon City, Wonju City, Gangneung City, and Donghae City have grids where the number of reachable jobs exceeds 500. Most areas in Gangwon show limited accessibility via public transportation. This reflects the challenges posed by the Taebaek Mountains, resulting in insufficient public transportation infrastructure, and the lack of a proper industrial ecosystem development since the decline of mining.

The Daejeon-Chungcheong region also exhibits varying levels of job accessibility. Areas around Cheonan City's Seobuk-gu and Dongnam-gu, where Seoul Subway Line 1 passes, and Cheongju City's Heungdeok-gu, Seowon-gu, and Sangdang-gu, around Osong Station, have grids where approximately 1,000 jobs are reachable. Sejong City, with its active BRT system, also has grids where over 1,000 jobs are accessible via public transportation. Daejeon emerged as the region with the best job accessibility, largely due to its well-established public transportation system, including the subway, and the presence of numerous jobs in areas like the science research complex, which contributes to an increased number of reachable jobs per grid.

In the Gwangju-Jeonnam region, Gwangju Metropolitan City exhibits the best public transportation job accessibility, with the highest number of grids offering access to over 1,100 jobs. Additionally, Mokpo, Yeosu, Suncheon, and Gwangyang also show a high number of reachable jobs. Mokpo's strong performance is attributed to its KTX station and extensive accessibility via maritime transport, while Yeosu, Suncheon, and Gwangyang benefit from being major centers of heavy chemical industries, hosting numerous jobs.

Within the Jeonbuk region, Jeonju has the most grids with accessibility to over 1,000 jobs. Iksan, a KTX stop, and Gunsan, with its Saemangeum development and industrial complexes hosting automotive manufacturing plants, also show high job accessibility.

The Daegu-Gyeongbuk region finds Daegu Metropolitan City with the best accessibility. It boasts the most grids that allow access to over 1,300 jobs, with some grids offering access to a maximum of approximately 3,600 jobs. This high accessibility appears to be influenced by Daegu's subway system and Dongdaegu Station. Furthermore, Gumi City, home to production plants of large corporations, and Pohang, a hub for heavy chemical industries, also have numerous grids providing access to over 1,300 jobs. Most other areas in this region recorded similarly low accessibility levels.

In the Busan-Ulsan-Gyeongnam region, Busan has the highest number of grids with access to over 2,400 jobs, with some grids reaching up to approximately 8,600 jobs. Jinju and Changwon, both with concentrated KTX stations and industrial complexes, have many grids with access to over 1,500 jobs. Ulsan, a prominent industrial city, also has numerous grids offering access to over 1,500 jobs via public transportation.

Finally, in the Jeju region, grids providing access to over 1,100 jobs are predominantly concentrated in Jeju City, forming around the airport.

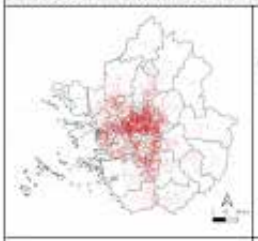
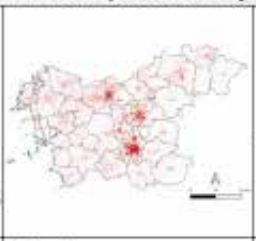
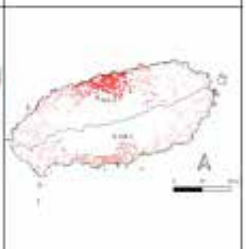
Integrated Results

The Seoul Metropolitan Area and the Busan-Ulsan-Gyeongnam Area (BUK Area) showed the highest numbers of reachable jobs per grid, relative to their populated grids. In the Seoul Metropolitan Area, this is due to the concentration of businesses and talent from metropolitan centralization, and the establishment of a public transportation system capable of accommodating a large population. Furthermore, the presence of KTX stations and the metropolitan subway system enhances job accessibility for citizens. In the BUK Area, the presence of KTX stations and industrial complexes, including Ulsan, provides a large number of jobs that are well-connected by public transportation.

The Jeonbuk Area and Gwangju-Jeonnam Area, which had similar proportions of reachable grids via public transportation relative to populated grids, also showed similar numbers of reachable jobs. In the case of the Daejeon-Chungcheong Area, despite having a similar proportion of public transport-reachable grids relative to populated grids as the Jeonbuk and Gwangju-Jeonnam Areas, its higher number of reachable jobs suggests that the public transportation service infrastructure might be relatively weaker compared to the abundance of jobs. Conversely, the Daegu-Gyeongbuk Area, which had a lower proportion of public transport-reachable grids relative to its populated grids, showed a higher number of reachable jobs than the Jeonbuk and Gwangju-Jeonnam Areas, demonstrating the significant impact of industrial complexes. Such industrial complexes contain a large number of jobs, and improving their accessibility through public transportation could lead to a more efficient transportation service establishment.

Lastly, the Gangwon Area recorded the lowest proportion of public transport-reachable grids relative to its populated grids, and also showed the lowest number of reachable jobs. This suggests that while public transportation services may be insufficient, the supply is proportionate to the smaller population.

Table 7: Number of Reachable Jobs within 1 Hour per Grid - by Urban Area

			
Seoul Metropolitan Area	Gangwon Area	Daejeon Chungchung Area	Gwangju Jeonnam Area
			
Jeonbuk Area	Daegu Gyeongbuk Area	Busan Ulsan Gyeongnam Area	Jeju Area

4. Discussion

This study aimed to overcome the limitations of existing public transportation accessibility and mobility analyses. It did so by using nationwide empirical data to measure public transportation service levels at a precise spatial unit (500m x 500m grid). The research distinguishes itself from previous studies by integrating various transportation modes beyond single modes or administrative district analyses. It also quantified mobility and accessibility by constructing a direct section network based on actual usage data.

Public transportation mobility was defined as the "number of grids reachable within the same time," and accessibility was defined as the "number of jobs reachable within the same time." Based on these definitions, the study empirically analyzed inter-regional disparities in transportation services across urban areas. The results showed that the Seoul Metropolitan Area and the Busan-Ulsan-Gyeongnam Area exhibited the highest levels in both the number of grids and the number of jobs reachable within one hour via public transportation. This signifies that these regions possess well-established infrastructure and transfer systems. In contrast, the Gangwon region recorded the lowest figures for both public transportation accessibility and the number of reachable jobs, confirming the existence of a service gap between regions.

Specifically, it was confirmed that regions with economic hubs, such as industrial complexes, have more job opportunities when public transportation accessibility is high. This suggests that for regional areas, simply attracting businesses is not enough; the quality of transportation services that enable access to these jobs is crucial for enhancing regional competitiveness. To counter the concentration in the Seoul Metropolitan Area, it is essential to build competitive public transportation networks within each urban area. This can serve as an important strategic criterion for establishing regional balanced development policies.

5. Conclusion

This study moved past traditional administrative district-focused approaches by doing a grid-based, precise analysis. This let us assess actual service levels based on where people truly live. This method can provide helpful foundational data for creating public transportation policies that are practical for daily life and ensure fairness across regions.

However, this study has a few limitations. First, we didn't categorize reachable jobs by industry type, so we couldn't analyze which industries are more closely tied to public transportation accessibility. Second, even though different public transportation modes affect how people move in various ways, we didn't consider factors like transport capacity or service density. This might lead to a difference between the perceived and actual service levels. Third, we didn't re-integrate the grid-based analysis results back into administrative district units, which would have made them more applicable for policy.

This research is important because it used real-world, nationwide transportation network data to quantify and visualize the actual travel ranges and reachable opportunities for citizens. This clearly highlighted the imbalance in public transportation across different regions. In the future, we can expand this into more detailed policy-based research by adding analyses like job accessibility by industry, comparing the influence of different modes, and re-integrating data at the administrative district level. This will help us develop customized mobility policies.

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Exploration of the Relationship between Travel Activity Chains and Self-Assessed Health of Rural Community Residents: Based on Multi-Source Data and Health Survey Questionnaire

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Abstract
At present, most of China's population still lives in rural areas, and the allocation of health facilities in rural areas is generally weaker than that in urban areas. The factors affecting the healthy life of rural residents need to be studied. This study took six rural communities in Pujiang County, Chengdu, Sichuan Province as the research object, and randomly selected 172 residents as samples to investigate the relationship between the characteristics of daily travel activities and self-rated health level of rural community residents, in order to provide a scientific basis for the construction of healthy rural communities and their surrounding supporting facilities. In view of the difficulty of data collection in rural areas, such studies are relatively rare in China. The research comprehensively uses multi-source data, including GPS data obtained by wearable positioning equipment, health questionnaire data, POI data of Amap and building vector data of MapWorld. Firstly, this study uses AT-DBSCAN algorithm to cluster the travel trajectory points to obtain the location information of residents' stay points between 8:00-22:00, and divides the study area into 120m long grids. The TF-IDF algorithm is used to obtain the functional attributes of the grid based on the classified POI data, and then infer the type of stay point activities. For rural areas without POI data, the daily travel activity chain of rural community residents is constructed by combining building vector data. Then, the Word2Vec word embedding model is used to vectorize the activity chain data, and the K-means clustering analysis is used to obtain different daily travel activity patterns. Finally, combined with the residents' self-rated health data obtained from the health questionnaire, the Nonparametric Tests was used to analyze the differences between the self-rated health levels of different travel activity modes. The results show that there are significant differences in self-rated health level among rural community residents with different travel activity modes, which provides a reference for rural community planning and health management.

Keywords: Travel activity, characteristics, Rural community, Self-rated health.

Introduction

With the development of social economy, people pay more and more attention to the healthy lifestyle. In addition to basic physical and mental health, residents' daily travel contact with the living environment is also closely related to healthy life. Studying the relationship between the environmental characteristics and health status of residents' travel activities will help managers create a healthy living environment from the planning and design level. At present, the research on the relationship between the characteristics of travel activities and residents' health is relatively rich in urban areas, but insufficient attention is paid to rural areas. The prediction released by the United Nations in 2018 shows that China's urbanization rate will be 70.6% and 80.0% in 2030 and 2050, and the population in rural areas will be about 399million and 272million(United Nations Department of Economic and Social Affairs, Population Division, 2019)ΔAt the same time, China's 2021 census shows that 36.11% of the population still lives in the built-up environment in rural areas (National Bureau of Statistics of China, 2021)Δand the allocation of health facilities in these areas is generally weaker than that in urban areas, which significantly affects the health level of rural residents. In the past, China's research on rural health mostly focused on medical services (Gao *et al*., 2024; Yang *et al*., 2024) and environmental factors, but the link between residents' daily travel activities and health was rarely involved. In fact, daily travel activities have a direct or indirect impact on rural residents' access to medical care, leisure and social services, which can't be ignored in rural health research.

In view of this, this study selected some residents from six rural communities in Pujiang County, Chengdu, Sichuan, China to investigate and analyze the relationship between their daily travel activity characteristics and their self-rated health level, focusing on the characteristics of stay activity area and activity time allocation, so as to provide a scientific basis for the construction of healthy rural communities and their surrounding supporting facilities. Considering the difficulty of data collection in rural areas, relevant research in this field is relatively rare. In this study, multi-source data, including GPS data obtained by wearable positioning equipment, health questionnaire data, POI data of Amap and building vector data of MapWorld, were comprehensively used to explore the potential relationship between travel activity characteristics and health level, and provide beneficial reference for improving the health status of rural residents, optimizing rural community planning and health management.

Literature Review

Relationship between travel activity characteristics and health

Travel activity characteristics mainly include travel time characteristics, travel space characteristics, activity type, travel frequency, travel mode, travel destination, etc. Many studies have confirmed the correlation between travel activity characteristics and health, mainly through the built environment as the medium, from the aspects of physical activity promotion, environmental exposure, nature of activity sites, environmental healing (Frank *et al.*, 2019; Mahmoudi, 2022; Sharma and Jain, 2023). Choosing an active travel mode that can promote physical activity (such as walking, cycling, etc.) and increasing the travel time allocation of physical activity have many impacts on health promotion (Ali *et al.*, 2020, 2024; Dėdelė *et al.*, 2020; Foley *et al.*, 2018). Environmental exposure in travel activities has significant effects on health(Frank *et al.*, 2019; Poom *et al.*, 2021) , but such effects have duality. On the one hand, active travel modes such as walking and cycling make individuals more vulnerable to traffic related air pollution and noise, increasing the risk of respiratory and cardiovascular diseases. On the other hand, if the travel path passes through green space, it can have a positive effect on mental health by contacting nature and relieving stress (Le and Poom, 2024) . In addition, the role of environmental exposure and differences in travel mode, time period selection and personal perception vary, and there is a significant socio-economic imbalance (Briggs *et al.*, 2008; Ma *et al.*, 2021) . There are differences in the impact of staying in different places of activity on health. For example, leisure activities in places such as commercialservices, leisure and entertainment (Fancourt D *et al.*, 2021) and natural areas (Aerts *et al.*, 2018; Bratman *et al.*, 2019; Ewert and Chang, 2018) can promote health, while long-term activities in places such as office areas (Rasheed *et al.*, 2021) and industrial areas (Xu *et al.*, 2020) are generally considered to have adverse effects on health. In addition, Zhu and Fan et al. Found that travel mode, travel duration and distance, and destination choice were associated with emotional health (Zhu and Fan, 2018) . Bicycle travel has a psychological healing effect, while public transport travel has the opposite effect. The longer the travel duration, the lower the happiness and the higher the pressure. The positive mood of travel for the purpose of free activities such as leisure and entertainment is higher. The urban blue-green space and healing built environment that travel through have a certain healing effect on people's mental health and can relieve people's pressure and negative emotions (Vert *et al.*, 2020; Zhang *et al.*, 2019). To sum up, the characteristics of travel activities can affect health through a variety of mechanisms, and there is a theoretical basis for mining the correlation between rural residents' daily travel characteristics and health from the perspective of time distribution of travel activities and stay activity areas.

Travel activity characteristics and limitations of health research in rural areas

In the research on the relationship between residents' travel activity characteristics and health, the current literature mainly focuses on the relevant research in urban environment, while the research in rural areas is relatively less. The number and quality of transportation facilities, service facilities and travel activity places in rural areas are generally worse than the average level in cities, and there are also significant differences in the characteristics of residents' travel activities. At present, the research on the characteristics of travel activities in rural areas mostly focuses on travel distance, travel time, travel mode selection, etc. for example, Akinlotan et al. Revealed the differences in distance and time of rural residents in medical or dental care travel by using the data of the 2017 national family Travel Survey (NHTS) , and pointed out that the travel distance of rural residents is more than twice that of urban residents, and the travel time is also significantly longer (Akinlotan *et al.*, 2021) . In addition, Hearn et al. Also showed that the travel time of rural cancer patients is longer, which may be related to the lack of transportation facilities in rural areas (Hearn *et al.*, 2024).

In terms of the relationship between travel activities and health, some studies began to pay attention to the impact of travel activities on health of residents in rural areas. For example, Berga and Ihlström found that rural residents' daily activities and travel behavior were significantly affected by traffic conditions through qualitative interviews with rural residents in Sweden. In particular, the lack of Public Transport Services Limited residents' independent travel ability, thereby affecting their opportunities to participate in social activities and obtain health services (Berg and Ihlström, 2019)ΔIn addition, McCrorie's research in Scotland found that rural children have shorter sedentary time and longer time of mild physical activity than urban children, which may be related to the more spacious living environment and more opportunities for outdoor activities in rural areas (McCrorie *et al.*, 2020)ΔThese studies show that there is a complex correlation between the characteristics of travel activities and residents' health in rural areas, but at present, the relevant research is still relatively limited and needs to be further discussed.

In general, the existing literature has a certain foundation in the correlation between the construction of transportation facilities, service facilities, travel activity places and residents' travel activity characteristics in rural areas, but there is still a large gap in the research on the relationship between travel activity characteristics and residents' health. Future research should strengthen the research on the relationship between travel activities and health in rural areas, so as to better guide the traffic planning and health policy-making in rural areas and improve the quality of life of rural residents.

Data preparation

The data used in this study are from a travel trajectory and self-rated health survey conducted by the author's team in Pujiang County, Chengdu, Sichuan Province from July to August 2023 (Fig 1). This study surveyed 172 residents from six rural communities in the region, namely Hongfu Community, Dongyue Community, Shuangsh Community, Bajiaojing Village, Fuxing Community and Mingyue Village, and was conducted in two batches. The number of residents surveyed in each village is shown in Table 1.

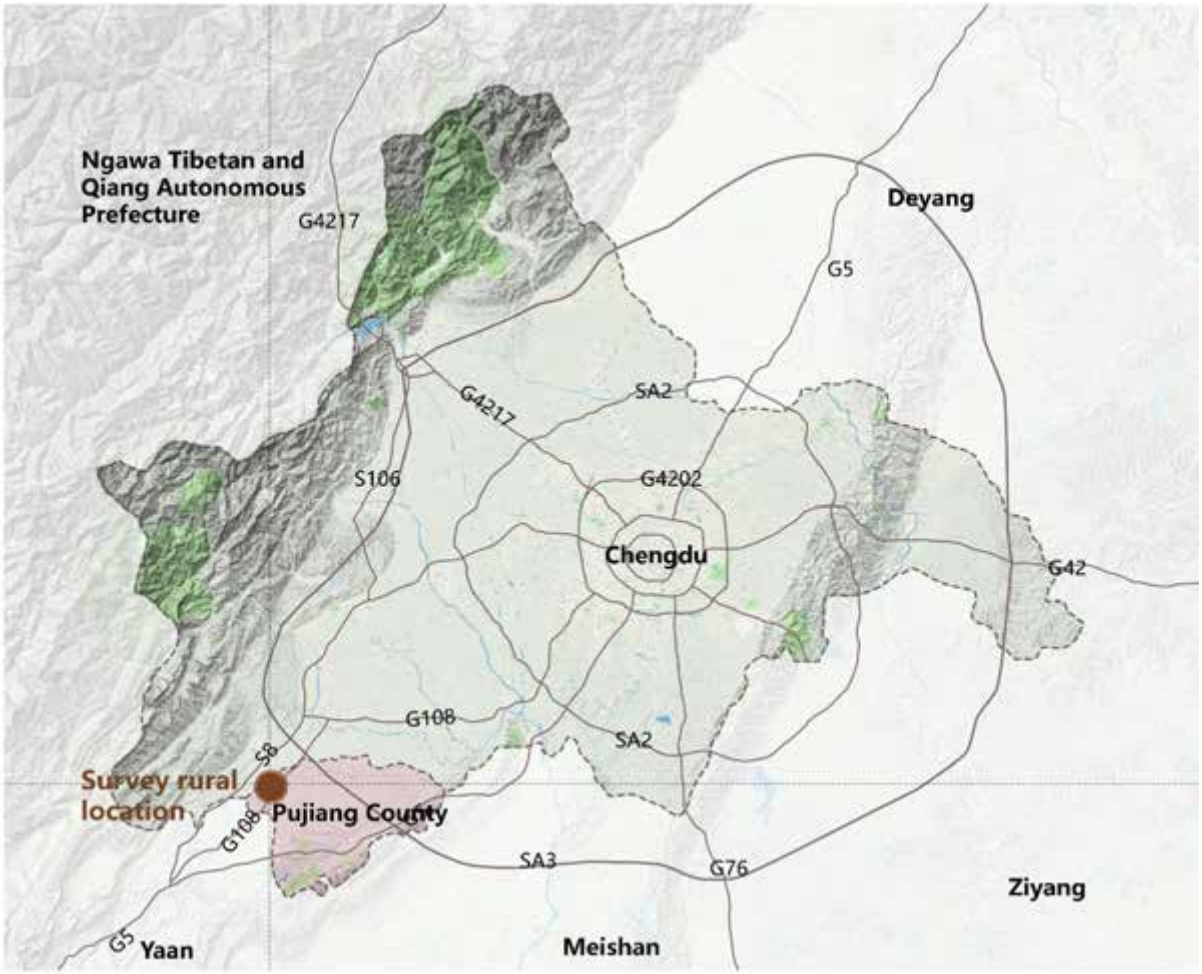

Fig 1. Study area scope and sample source

Table 1. Number of residents surveyed in each village

Number of residents surveyed in each village

Village name	Number of residents surveyed
Hongfu Community	31
Shuangshi Community	33
Dongyue Community	33
Mingyue Village	39
Fuxing Community	32
Bajiao Village	4

GPS positioning data

The GPS data used in this study was obtained by a smart watch with positioning function. The track data recorded by the positioning watch uses WGS 1984 geographical coordinate system, and the positioning accuracy can reach within 30 meters. During the collection process, all positioning watches are set to record trajectory data points every minute, and their information mainly includes longitude and latitude coordinate values, sample numbers, batch number, dates and times (Table 2). During the data collection process, participants were required to wear a positioning watch between 8:00-22:00 within 7 days, and were not allowed to remove the device without special reasons, so as to ensure the continuity of research data collection.

Table 2. GPS data sample

GPS data sample

date	time	sample number	batch number	latitude	longitude
2023-07-12	11:51:00	9617605926	1	30.278349	103.3772225
2023-07-12	11:51:00	9618007196	1	30.28061	103.3820817
2023-07-19	12:13:00	9618007145	2	30.26369	103.3239
2023-07-22	12:12:00	9618007135	2	30.27283	103.3311

As it is difficult for residents to fully cover the entire required number of days for wearing equipment, after screening, a total of 1116 daily behavior tracks were collected, including 584 in the first batch and 532 in the second batch. Fig 2 shows the main distribution range of the trajectories. Most of the data are concentrated in Pujiang County, Qionglai city and Mingshan District, Ya'an City.

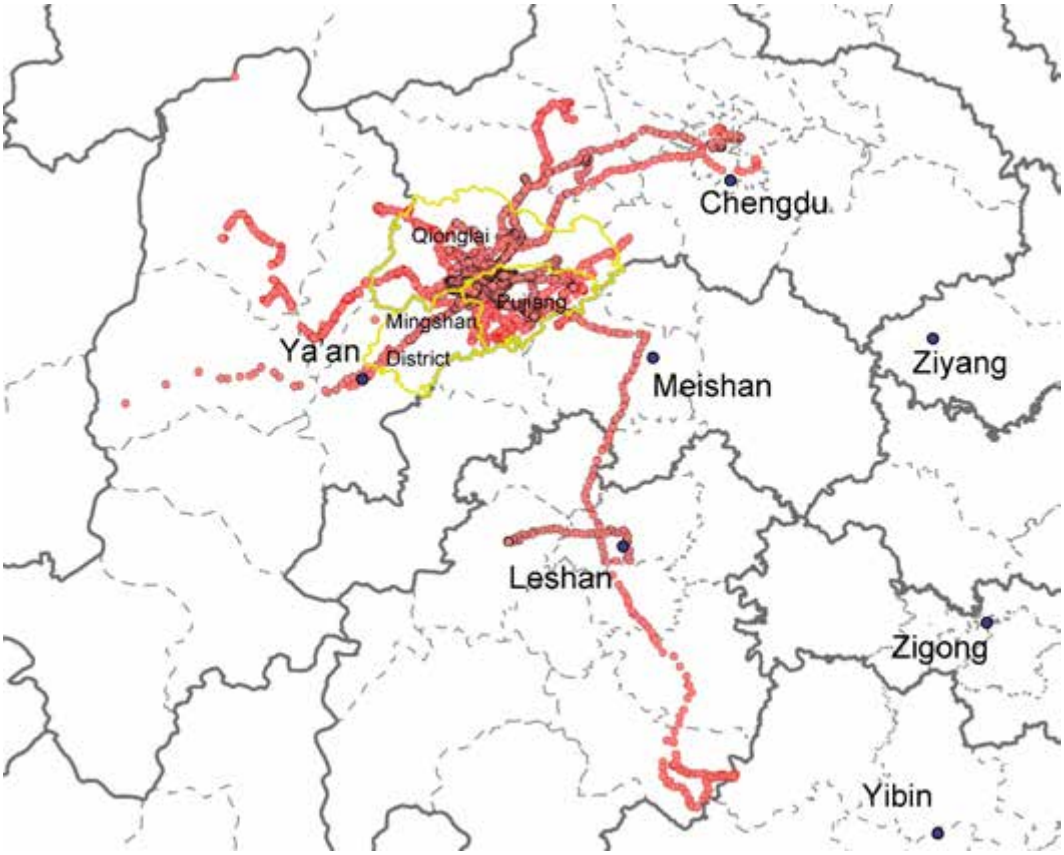

Fig 2. overall distribution of travel trajectories data

Health questionnaire survey data

Self-rated health has been proved to be able to effectively reflect the health level of individuals (Fayers and Sprangers, 2002) . The questionnaire used in this study mainly includes two parts: personal basic attributes and self-rated health scale. The basic personal attributes mainly include 10 items, including sample number, gender, age, occupation, marital status, address, length of residence, residential area, number of families, agricultural labor situation ,and annual family income. SRHMS v1.0 (Self-rated Health Measurement Scale V1.0) was used in the self-rated health scale. SRHMS v1.0 has good content validity, structure validity and calibration validity, which is more in line with the characteristics and habits of Chinese residents, and is suitable for all kinds of people over the age of 14. The content of the scale consists of three subscales of self-rated physical health, mental health and social health, as well as four parts of the overall self-evaluation, with a total of 48 items, which can be divided into nine dimensions: physical symptoms and organ function (B1), daily physical activity (B2), physical activity ability (B3), psychosocial symptoms and negative emotions (M1), positive emotions (M2), cognitive function (M3), role activity and social adaptability (S1), social resources and social contact (S2) and social support (S3). The overall self-assessment includes the overall physical self-test, the overall psychological self-test, the overall social self-test and the overall health self-test. The maximum score of each item is 10 points, the minimum is 0 points, and the maximum possible score is 440 points after removing the self-evaluation part of auxiliary verification. The scores of items 4, 5, 7, 24, 25, 26, 27, 28, 29 and 30 are scored in reverse to ensure the validity of the questionnaire (Xu *et al.*, 2000; Xu, 2001; Chuqun *et al.*, 2021)Δ

Due to potential problems such as residents' personal willingness to fill in, only 125 valid health questionnaire data were collected in this study. Table 3 shows the basic information data of the respondents, and Fig 3 shows the distribution of the total self-rated health scores of the sample population.

Table 3. General Information of the Respondents

The General Information of the Respondents(N=125)

Item	Number of samples(%)
Village name	
Hongfu Community	19(15.2%)
Dongyue Community	30(24%)
Shuangshi Community	26(20.8%)
Bajiaojing Village	3(2.4%)
Fuxing Community	15(12%)
Mingyue Village	32(25.6%)
Gender	
male	52(41.6%)
female	73(58.4%)
Age	
Children and adolescents (0-19)	5(4%)
Young adults (20-39)	35(28%)
Middle aged adults (40-59)	60(48%)
Elderly (≥ 60)	25(20%)
occupation	
farmer	102(81.6%)
Public officials	1(0.8%)
Individual business	2(1.6%)
worker	2(1.6%)
Others (including unfilled)	18(14.4%)
Living conditions	
Local resident population	106(84.8%)
Immigrant population	9(7.2%)
Others (including unfilled)	10(8%)
Residence	
Old house	25(20%)
New rural community	94(75.2%)
Houses in counties and other cities	1(0.8%)
Others (including unfilled)	5(4%)
Years of residence	
≤ 10 years	29(23.2%)
11-30 years	30(24%)
31-50 years	33(26.4%)
≥ 51 years	30(24%)
Others (including unfilled)	3(2.4%)
marital status	
unmarried	11(8.8%)
married	104(83.2%)

	Divorce	4(3.2%)
	Bereavement	4(3.2%)
	Others (including unfilled)	2(1.6%)
Family size		
	<3 persons	7(5.6%)
	3-5 persons	86(68.8%)
	5 persons	24(19.2%)
	Others (including unfilled)	8(6.4%)
Annual household income		
	<10000	15(10.44%)
	10000-20000	18(17.4%)
	20000-30000	35(25.0%)
	30000-50000	18(14.6%)
	50000-100000	22(20.1%)
	100000-200000	5(3.5%)
	>200000	2(1.4%)
	Others (including unfilled)	10(7.6%)
Farming conditions		
	Yes, there is still farmland to be cultivated	107(85.4%)
	No. no more farmland	18(13.9%)

Note: processed according to the questionnaire data

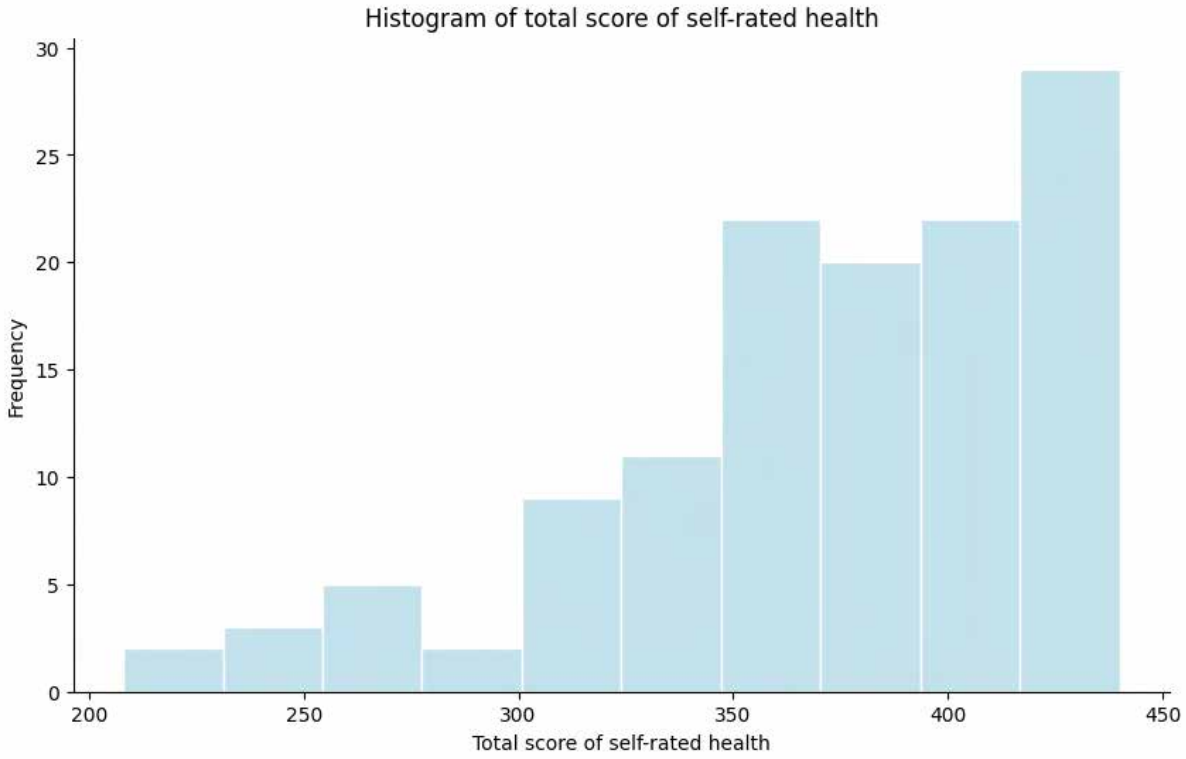

Fig 3. Histogram of total score of self-rated health

Built environment data based on Web Map

The built environment data used in this study mainly include POI data and building vector contour data within the scope of the study. POI data is obtained from Amap, which includes 22 categories and is limited within the administrative boundaries of Pujiang County, Lushan County, Mingshan District of Ya'an City and Qionglai City, with a total of 52784 items. In previous studies, the original POI data is usually reclassified according to the research purpose, such as taking the residents' service attribute as the core (Yang et al., 2021) and the urban functional area attribute as the core (Gu et al., 2018; Yang et al., 2020) . In order to meet the requirements for the identification of stay activity functional areas in this study, the POI of Amap is reclassified into 11 categories (Table 4) by focusing on the attributes of resident services, so as to facilitate the identification of subsequent residents' travel characteristics. The building contour vector data is obtained from the MapWorld, which mainly contains the outer contour vector shape data of all buildings in the three counties and cities, so as to help judge the resident stay activity category in the POI missing area.

Table 4. POI data category reclassification

POI data category reclassification

Amap category	Category after reclassification	Simple category name
Enterprises (Factory, Farming, Forestry, Animal Husbandry and Fishery Base)	Industrial and agricultural production	Labor
Enterprises (Enterprises, Famous Enterprise, Company)	Enterprises and offices	Work
Finance & Insurance Service	Financial service	Finance
Science/Culture & Education Service	Educational and cultural services	Education
ResidenceResidence and related servicesPlace Name & Address (Village name, building number, community name and doorplate information)		
Commercial House		
Accommodation Service		
MedicalMedical related services-Medical Service		
EntertainmentLeisure and entertainment servicesSports & Recreation		

TourismRecreational tourismPlace Name & Address(Natural Place Name)

Tourist Attraction

TransportationTransportation facilities and related servicesTransportation Service

Auto Service

Auto Dealers

Auto Repair

Motorcycle Service

ShoppingCommercialand life servicesFood & Beverages
Daily Life Service

Shopping

MunicipalGovernment and public servicesGovernmental Organization & Social Group

Public Facility

Methods

Travel trajectory activity point acquisition

At present, there are four main directions for the research of stay activity point recognition in travel trajectory. First, based on the fitting of road network information and travel trajectory, the distance between trajectory points and road vectors is calculated to identify stay points (Du and Aultman-Hall, 2007). This method needs more detailed regional road network information as an auxiliary, which is suitable for use in urban areas with relatively complete road network data. It is not suitable for use in rural natural environment with insufficient construction of standard road network and serious lack of road network data. The second is to use the velocity characteristics of the trajectory points to judge and detect the trajectory points whose velocity approaches zero as the stay points (Zhang et al., 2013) . This method is aimed at the stay points in slow travel activities in rural areas, and requires equipment with high-precision speed collection ability. The third is to judge the stay point based on geographical semantics. For example, the SMoT (Stops and Moves of Trajectories) model first presets the locations of the points of interest that the samples often go to, generates appropriate geographic geometric entities based on such locations, and judges the stay activities through the residence characteristics of the sample motion trajectory in the geometric entities (Alvares et al., 2007). The fourth is based on density clustering to identify stay points. As the stay activities will be concentrated in a region for a long time, the stay point can be better found through density judgment. DBSCAN algorithm based on density clustering has a good performance in the identification of travel purpose. It only needs the location and time stamp data of trajectory points. By setting the clustering limit parameters such as EPS neighborhood and Minpts, it can expand the core points, divide the clusters by density reachability, and calculate the cluster center point as the stay point (Ester et al., 1996) .

On this basis, Zhou Yang and Yang Chao analyzed the shortcomings of existing ST-DBSCAN (Birant and Kut, 2007), TrigDBSCAN(Yan, 2011), C-DBSCAN(Gong et al., 2015) algorithms in the required data complexity, scientific threshold, core point search method, cluster merging method, and path overlap, and proposed the AT-DBSCAN algorithm (Zhou and Yang, 2018) The algorithm checks the internal trajectory points by setting a fixed length sliding window, so as to cluster and identify the core points, forming the initial cluster and cluster, and finally calculates the center points as the stay points after filtering the cluster according to the length of time. It requires the initial data and can better eliminate the influence of noise in the original trajectory data.

Due to the difficulty of data collection in rural areas, where residents' activities involve non built environments such as farmland and wilderness, it is difficult to manually determine the range of interest locations. In addition, the GPS data collected in this study has certain errors and noise effects. Therefore, this paper chooses to draw on the idea of AT-DBSCAN algorithm for identifying travel trajectory stay points. The AT-DBSCAN algorithm has five main parameters that need to be set, namely the sliding window length "k", time interval "I", spatial neighborhood distance "Eps", minimum trajectory point count threshold "MinPts", and minimum stay points duration "DU". Due to the fact that the GPS trajectory points data recording interval used in this study is 1 minute, considering that stay activities with a duration of too short are of little significance to this study, stay activity points with a duration of more than 15 minutes are included in the research scope. In this study, k=21, I=10min, Eps=60m, MinPts=10, DU=15min are set, and 172 residents' trajectories are respectively clustered to identify the stay activity points. Firstly, use a sliding window to mark trajectory points within the spatial neighborhood with a number of neighboring points exceeding the MinPts value as core points. Then, starting from random core points, traverse all unclustered core points and cluster the core points within the spatial neighborhood Eps range with a time interval of no more than 2 minutes as the initial cluster. Then start from the initial cluster with the highest density, merge other adjacent clusters with a time interval less than I, repeat this operation until all the clusters that can be merged are merged, and finally exclude the clusters with a duration less than Du. The final data includes the longitude and latitude coordinates of the stay activity point, the cluster number, the start and end time of the stay activity, the stay time, the date number, and the sample number (Table 5). An example of space-time diagram of clustered data trajectories is shown in Fig 4.

Table 5. Stay point information

Stay point information							
Longitude	Latitude	Cluster number	Start time	End time	Stay time (minutes)	Date	ID
103.4714407	30.4045981	1	08:16:00	08:32:00	16	12	9618007128
103.4600468	30.400223	2	08:55:00	10:03:00	68	12	9618007128
103.4602874	30.40206229	3	10:11:00	10:27:00	16	12	9618007128
103.3760856	30.27748183	4	12:17:00	18:51:00	394	12	9618007128
103.3756631	30.27752271	5	00:12:00	06:42:00	390	12	9618007128
103.4726061	30.40617506	6	07:42:00	08:11:00	29	12	9618007128
103.4604299	30.40223265	7	10:30:00	10:56:00	26	12	9618007128
…	…	…	…	…	…	…	…

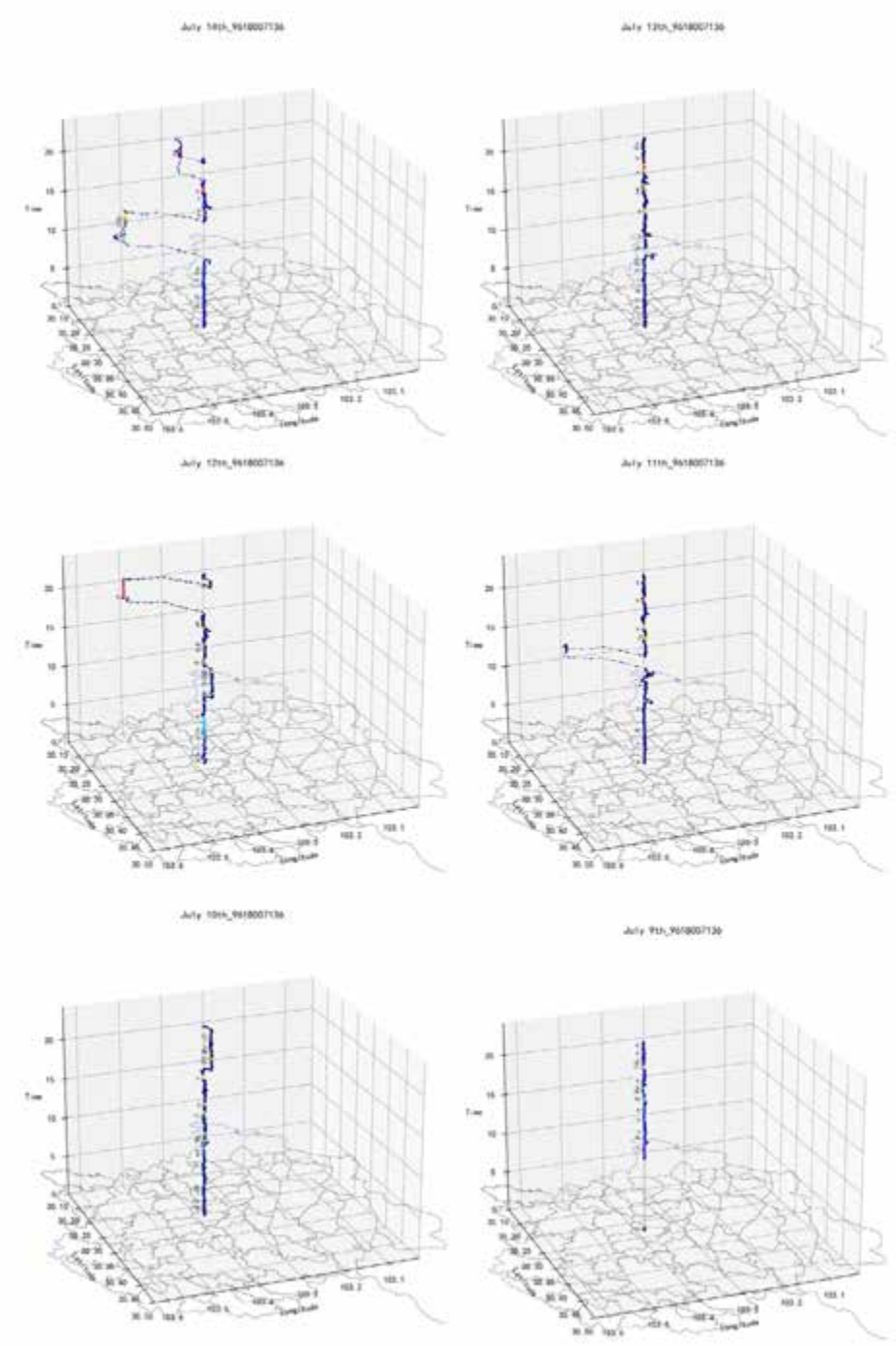

Fig 4. Example of Trajectory space-time diagram

Stay activity attribute judgment

After obtaining the stay activity point of the sample by clustering, it is necessary to infer its functional type. We choose to use POI data to judge, refer to the combination of TF-IDF algorithm and grid division method used in the related research of function area judgment, identify POI weights, determine grid function attributes, and further infer the type of stay activity points (Sparck Jones, 1972; Zhu, 2024). The specific method is to divide the area within the research scope into multiple grids according to the side length of 120m, and determine the weight

of each functional category in the POI data falling into the grid. In the weight calculation part, using the good classification ability of TF-IDF algorithm, each grid area is regarded as a single text, and the proportion of POI categories in a single text is regarded as word frequency. IDF (Inverse Document Frequency) is used to represent the importance of different POI categories, and finally the POI weights of each category in each grid are obtained. Then the weight proportion is calculated, and the function of grid area is divided according to the proportion. In this study, when the weight of a certain type of POI in the grid area accounts for more than 50%, it is considered that the functional category of the grid area is the same. When the weight of two types of POI is between 20% and 50%, it is considered that the function category of the grid area is a combination of two types of functions. When the weight of all POIs is 0%, the function category of the grid area is considered as no data area. Other cases are classified as comprehensive functions. After determining the function of the grid area, assign it to the function type of all stay activity points falling in the grid.

However, in rural areas, there are many grids that are judged as no data area due to the lack of POI. In fact, these areas include built-up environmental areas such as villages and settlements, as well as natural areas such as fields and mountains. Therefore, it is necessary to combine the building contour vector data to assist the judgment. In rural areas, areas without POI but with buildings are generally within villages where residents live, and these areas can be regarded as functional areas of "Residence". In this study, for the trajectory stay point marked as "no data area", judge whether there is a building outline intersecting with it within the 120m diameter of the section. If there is, change the functional attribute of the point to "Residence", otherwise, change it to "Natural area". Finally, the potential activity type characteristics of each stay activity points are obtained.

Travel activity chain clustering

After obtaining the functional attributes of the sample stay activity points, it is necessary to build the sample daily activity chain. We first divide the trajectory of each sample in the time range of 8:00-10:00 into 28 time blocks in 30 minutes. Then judge whether the time range of each time block is within the start and end time range of the stop activity point in order. If it is within the range, the function attribute of the stay active point is assigned to the time block. Then all time blocks that are not assigned the function attribute of the active point are identified as "moving" activities. Finally, the activity chain data with granularity of 30 minutes is formed. Due to the relatively small sample size of 124 data collected by the self-rated health questionnaire, in order to ensure the consistency between the subsequent analysis and the self-rated health questionnaire data, the activity chain without corresponding questionnaire data was deleted according to the sample number before the activity chain clustering, and 709 travel activity chain data remained.

In the part of activity chain clustering, this paper draws on the trajectory vectorization and clustering method based on word vector model (word2vec) proposed by liwenxiang et al. (Li et al., 2024) In this study, the activity unit is mapped to a word vector, and the activity chain is mapped to a sentence vector, so that the activity pattern recognition problem is transformed into the semantic similarity measurement between the sentence vectors of the activity chain. Through cluster analysis, user groups with similar activity patterns can be identified. This method shows good effect in multi day activity pattern recognition. The daily activity chain data of all samples are converted into comma separated sentence text composed of functional attributes such as "Residence", "Labor", "Work", "Transportation", "Finance", "Education", "Medical", "Tourism", "Entertainment" "Shopping", "Municipal", "Comprehensive", "Natural", "Move", in chronological order. Then use text data to train word2vec model, set the word vector dimension vector_size=19, the context window size window=20, and the minimum occurrence frequency of reserved words min_count=1, that is, words that appear at least once in the corpus will be retained. Finally, the daily travel activity chain sentence vector of each sample is generated, and SVD (Singular Value Decomposition) method is used to decompose the sentence vector to remove the main components in the data, so as to achieve normalization, which is convenient for feature recognition in subsequent clustering(Gargiulo et al., n.d.)Δ

After that, this study chose to use k-means algorithm to cluster the sentence vectors generated by the daily activity chain of samples. The algorithm has good interpretability for the results. The centroid of each cluster is the mean value of all data points in the cluster, which can directly reflect the central position and main characteristics of the cluster data (Li et al., 2020; Lin et al., 2009) . Because the k-means algorithm needs to specify the number of clusters in advance, the elbow method combined with the comprehensive judgment of contour coefficient can better distinguish the appropriate number of clusters (Humaira and Rasyidah, 2020), as shown in Fig 5. Combined

with the actual travel activities, elbow diagram and contour coefficient results, the preset clustering number k=7 is selected to obtain the final clustering data.

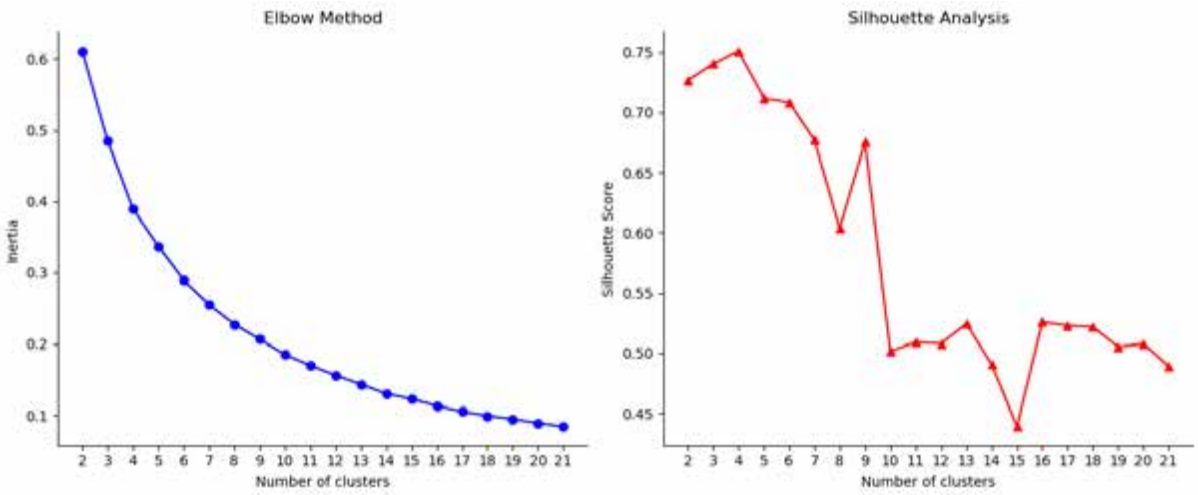

Fig 5. Elbow diagram and contour coefficient diagram Fig 6.

Analysis of health level differences among different travel mode

After mapping the self-rated health questionnaire data with the clustered activity chain data according to the sample number, it is necessary to analyze the difference of health level between different activity chain clusters. The commonly used statistical analysis methods for differences mainly include Analysis of Variance, Chi-Square Test, and Nonparametric test (le Cessie et al., 2020; Lee et al., 2013). Variance analysis requires that the dependent variable is a continuous variable and meets the homogeneity and normality of variance. Chi square test is applicable to the case where the dependent variable is classified variable. Using SPSSAU data analysis platform, the health score data corresponding to all travel activity chains were normalized and then tested for normality(SPSSAU, 2025). The results showed that the p value was less than 0.05, and the residents' self-rated health score data did not conform to the normal distribution (Table 6). Since the distribution of self-rated health data does not conform to the normal distribution, and the dependent variable is a continuous variable, this study uses a nonparametric test to analyze the difference of self-rated health scores between clusters in the activity chain.

Table 6. Analysis results of normality test

Analysis results of normality test

Shapiro-Wilk		Kolmogorov-Smirnov		kurtosis	skewness	standard deviation	average value	sample size	Name
p	Statistic W	p	Statistic D						
0.000**	0.928	0.000**	0.106	0.345	-0.867	0.228	0.715	650	Total health score(normalization)

* $p<0.05$ ** $p<0.01$

Results

In order to better analyze the activity patterns represented by each activity chain cluster, the functional attribute weights of all activity chains in each cluster are calculated and represented as images (Fig 6). It can be seen that the stay activities of the samples in cluster 0 are distributed in "Natural", "Comprehensive", "Residence" and "Shopping", and the weight of "Residence" is relatively high, but not more than 50%. The stay activities in cluster

1 are obviously concentrated in “Residence”, and a small part are distributed in “Natural”. The stay activities in cluster 2 are less distributed in “Residence “, relatively balanced in “Finance”, “Medical” and “Shopping”, and there are stay activities in some “Medical” areas. In cluster 3, “Medical” has the highest weight, followed by “Residence” and “Shopping”, and there are also a few stay activities in the “Medical” area. The stay activities in Cluster 4 are obviously concentrated in the “Comprehensive” area. The stay activities in cluster 5 are mainly “Work”. Cluster 6 is mainly distributed in “Natural”, “Tourism”, “Entertainment”, “Shopping” and other “Entertainment” areas, but in addition to “Residence”, there are also “Medical” areas in other activities.

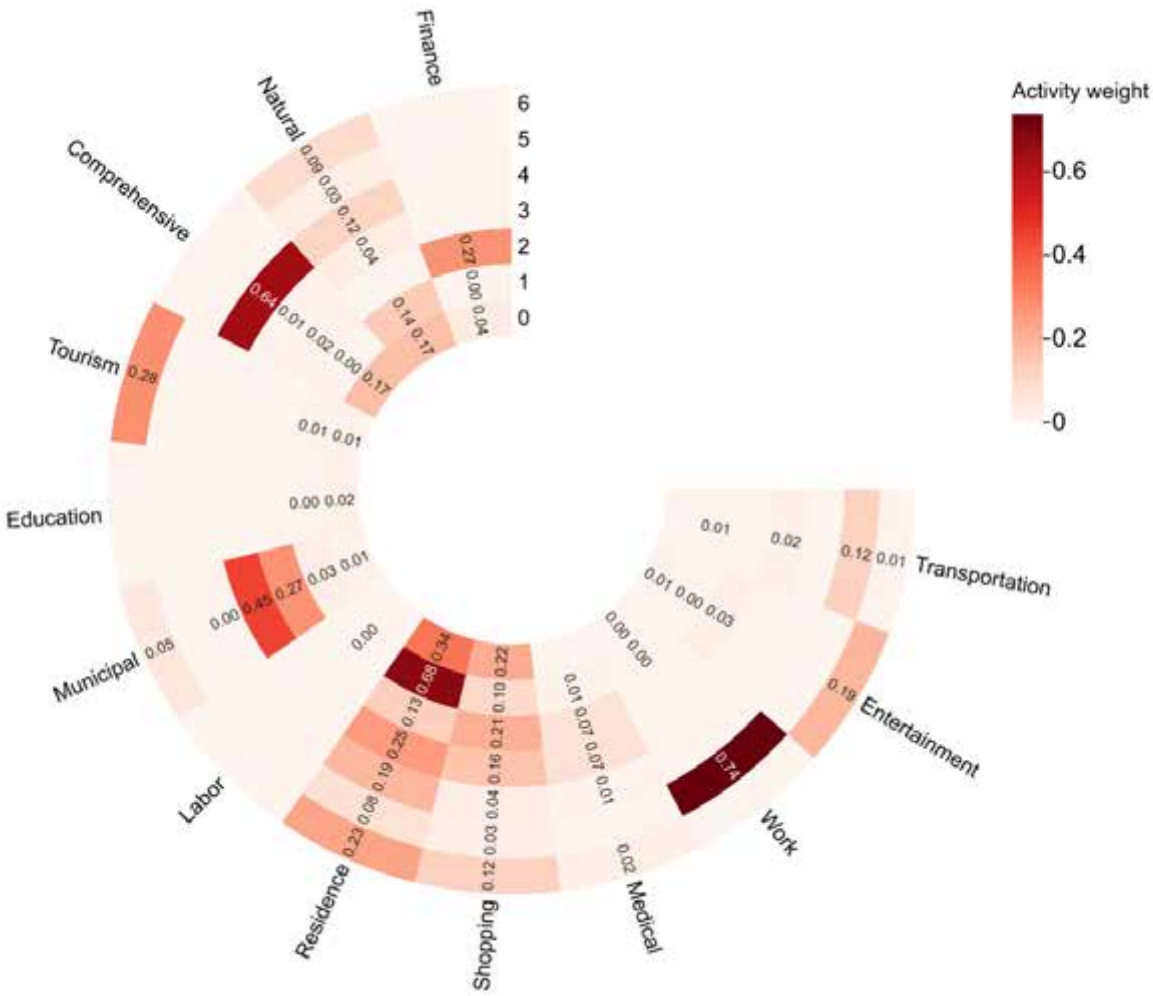

Fig 6. Feature weight of clustering activities

Nonparametric test was used to analyze the health differences among clusters of activity patterns. The results are shown in the table below (Table 7). The original hypothesis was that there was no difference in the self-rated health scores among the activity mode clusters. Since the p value was equal to 0.011 and less than 0.05, the original hypothesis was rejected and it was considered that there were differences in the self-rated health scores among the activity mode clusters. Draw a box plot to further analyze the specific differences in self-rated health scores among various activity modes (Fig 7).

The median of self-rated health score in cluster 2 is the highest 440, and the data distribution is relatively concentrated, with small variance, but the sample size is too small, and it shows an obvious left deviation distribution. The median of self-rated health score in cluster 0 was 403, which was at the second high level. 75% of the data were concentrated between 328 and 419.8, which had a certain concentration. The median self-rated health score of cluster 1 was 382.0, and the score distribution was between 339.5 and 414.0. Compared with cluster 0, the 75% data distribution was more concentrated. The median self-rated health score of cluster 3 was 373.0, and 75% of the scores were distributed between 271.0 and 420.0, indicating that the cluster had a wide range of health scores, and the self-rated health scores were not concentrated enough and showed a left skewed distribution, with more head data. The median self-rated health score of cluster 6 was 356.0, and 75% of the scores were concentrated between 294.0 and 385.0, which was significantly lower than that of cluster 0, 1, 2 and 4. The self-rated health score data of cluster 5 are all 352. Due to the small amount of data, it is considered as a special activity chain cluster with obvious characteristics. The median self-rated health score of Cluster 4 was 348.5, and 75% of the scores were distributed between 323.0 and 422.0, showing a right deviation distribution, with more tail data. Combined with the median and data distribution, the overall self-rated health score in this cluster is lower than that in clusters 0, 1, 2 and 3.

Table 7. Nonparametric test analysis results

Nonparametric test analysis results

*p*Kruskal-Wallis test statistic H	Cluster	median M(P_{25} P_{75})
0.011*	16.477	356.0
	6.0(*n*=19)	(294.0,385.0)
	5.0(*n*=5)	352.0
	4.0(*n*=6)	(352.0,352.0)
	3.0(n=19)	348.5
	2.0(*n*=6)	(323.0,422.0)
	1.0(n=626)	373.0
	0.0(n=28)	(271.0,420.0)
		440.0
		(398.8,440.0)
		382.0
		(339.5,414.0)
		403.0
		(328.0,419.8)
		Total score of self-rated health

* $p<0.05$ ** $p<0.01$

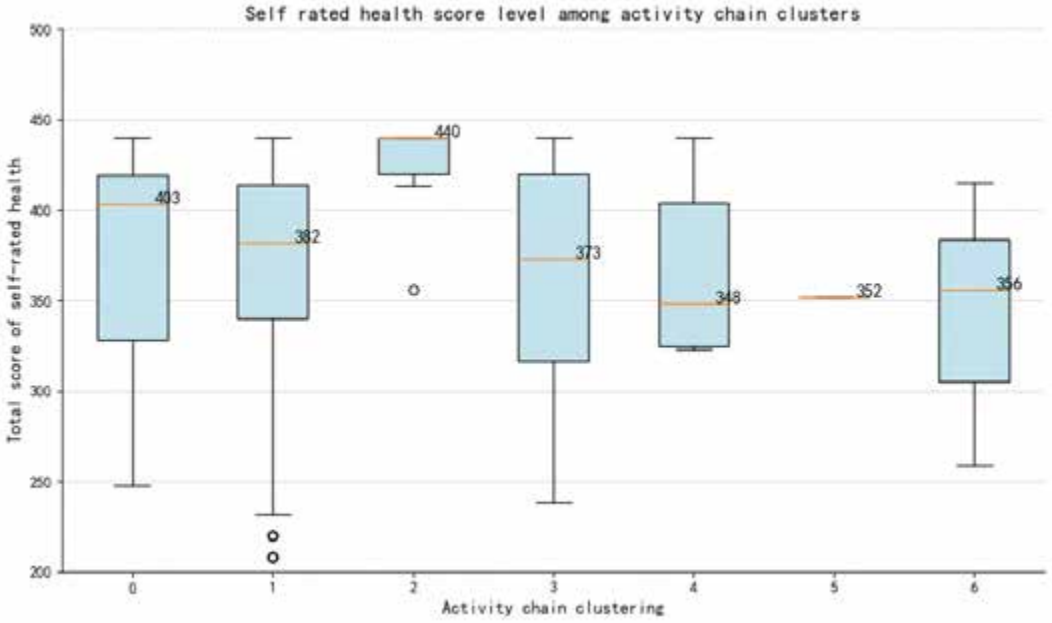

Fig 7. Box plot of self-rated health scores among different activity clusters

Discussion

This study found that in the daily life of residents in rural areas, the scope of activities of most people is relatively small, only staying in the village and its surrounding areas. According to the actual situation, cluster 0 is defined as "residential-mixed" travel activity mode, cluster 1 as "residential-natural" travel activity mode, cluster 2 as "commercial service" travel activity mode, cluster 3 as "municipal facilities" travel activity mode, Cluster 4 as "comprehensive functional" travel mode, cluster 5 as "office" travel mode, and cluster 6 as "entertainment" travel mode.

The health level of "commercial service" travel activity mode is the highest, and its activities are mainly concentrated in financial, municipal, commercial services and other areas, and a certain proportion of activities occur in medical areas. Commercial activities are usually associated with higher economic income and better living conditions, which may further promote the health status of residents (Contoyannis and Jones, 2004). However, the data volume of this cluster is small, and the data presents a significant left biased distribution, which may limit the universality of the results. Future studies need a larger sample size to verify this finding.

The self-rated health score of the "residential-mixed" travel activity mode is the second highest, covering activities in a variety of functional areas, including residential and related services, comprehensive functional areas, commercial service areas, etc. This diversified mode of travel activities may enable residents to access different types of resources and services, thus having a comprehensive positive impact on health. Residential areas usually provide basic living security, while comprehensive functional areas and business service areas may provide additional facilities and social opportunities. These factors work together to help maintain a high level of health.

The "residential-natural" travel activity mode has the largest amount of data, and the overall health level is widely distributed, and most of them are concentrated in the high score level, second only to "commercial service" and "residential-mixed". The stay activity of this mode are mainly concentrated in "Residence" and "Natural". According to the questionnaire, most rural residents need to go to farmland and woodland for labor in their daily life, and the moderate intensity physical activity brought by labor may promote their health level (Blair et al., 1992; Posadzki et al., 2020) . At the same time, the natural environment usually has a positive impact on mental and physical health, helping to relieve stress, improve mood and enhance physical activity (Ewert and Chang, 2018; Jimenez et al., 2021). However, there are still some residents with relatively low scores in this mode. This may be related to the quality of the living environment, the accessibility and utilization of natural areas, and the

sensitivity of individuals to the natural environment. In addition, the relatively single type of activities may limit the healthy development of residents to a certain extent. The sample size of this cluster is 626 samples, which is one of the clusters with the largest sample size. The results have certain representativeness and reliability, but the impact of individual differences on health still needs to be considered.

The stay activities of the "municipal facility" travel activity mode are mainly concentrated in the "Municipal", "Residence" and "Shopping" areas, and there are also a few stay activities in the "Medical" areas. The use of municipal service facilities provides residents with basic public services and convenience, and helps to promote the healthy lifestyle of residents. However, the cluster has a wide range of health scores, and the median advantage is not prominent, which may indicate that different individuals have different health benefits in the use of municipal facilities, which are affected by many factors such as individual health awareness, lifestyle, facility accessibility and so on. And the amount of clustering data is small, and the data distribution may also be affected by the sample characteristics. Further research is needed to clarify the specific mechanism behind it.

The "comprehensive functional" travel activity mode is mainly parked in the comprehensive functional area, and the overall level of self-rated health score is lower than the first few. Comprehensive functional areas usually integrate many functions such as residence, commerce, office and leisure. Although they provide convenient living and working conditions, such areas may also have adverse health factors, such as noisy environment, poor quality and high density, which will have a negative impact on the health of residents, and then affect their health. The amount of clustering data is small, and the data distribution may have large deviation. More research is needed to verify this hypothesis.

The stay of "leisure and entertainment" travel activity mode is mainly distributed in "Natural", "Tourism", "Entertainment", "Shopping" and other areas, as well as "Residence" and "Medical" areas. Leisure and recreational activities are generally considered to be beneficial to mental and physical health, and can relieve stress, enhance physical activity and promote social interaction (Fancourt D et al., 2021; Paggi et al., 2016). However, the health score of this cluster is not high, which may be related to the type, duration, frequency of leisure activities and the subjective experience and response of individuals to these activities, and may also be related to the stay activity of these data in the "medical" area. The amount of clustering data is small, and the data distribution has some limitations. More research is needed to explore the complex relationship between leisure and entertainment activities and health.

The self-rated health score of the "office" travel activity mode is the lowest, mainly in the "office" area. Long term office activities may lead to problems such as reduced physical activity, increased work pressure, and increased psychological burden, which may have a negative impact on health (Kouvonen et al., 2013) . However, the sample size is small and the source is single, which may be due to the small number of people in the daily regular office travel mode in rural areas.

Conclusion

The results show that there are differences in self-rated health level among rural community residents with different travel activity modes. Among them, the residents' health score of the "commercial service" model is the highest. It is speculated that social interaction and economic interaction in business activities have a positive effect on health, and may also be related to the higher economic level of people engaged in business activities; The health level of residents in the "residential-mixed" mode is second, and the diversified types of activities enable residents to contact multiple types of resources and services, which has a certain promoting effect on health. The "residential-natural" travel activity mode is the main mode of daily travel for residents in rural areas. In this type of travel activity mode, most residents' self-rated health level is relatively high, which may be related to the fact that some residents in rural areas are engaged in agricultural activities to promote physical activity. The residents' self-rated health score level of the "municipal facility" travel activity mode is relatively scattered, indicating that the travel mode has no obvious centralized health level characteristics, and the health level of the group may have more complex correlation with personal factors. The residents' self-rated health score of the "comprehensive functional" travel activity mode is lower than that of the first three activity modes. It is speculated that the comprehensive functional areas in rural areas may have poor environmental quality, which is not conducive to health promotion. The self-rated health score of residents in the "entertainment" mode is relatively poor, which is contrary to the generally believed promotion effect of leisure and entertainment

activities on health. This kind of activity mode has the activity stay in the medical area, which may indicate that these people's health level is poor, so they choose leisure and entertainment activities for treatment, leading to different conclusions. The health score of residents in "office" mode is the lowest, which is consistent with the conclusion that physical activity decreases and stress increases due to long-time office work in previous studies. In view of the differences between different travel activity modes and the self-rated health level of rural community residents, it is suggested to reasonably arrange various functional areas in rural community planning, encourage the development of commercial services and mixed functional areas, enhance economic vitality and social communication opportunities, and promote residents' health. In rural areas, the environmental quality of comprehensive functional areas should be optimized to avoid adverse effects on health. At the same time, increasing the planning and configuration of leisure areas should not only meet the residents' needs for treatment, but also consider how to enhance the health promotion effect of activities. In addition, when planning the office area, we should pay attention to the health status of office residents, reasonably arrange the working hours and environment, and reduce the health risks caused by reduced physical activity and increased stress, so as to comprehensively improve the health level of rural community residents.

However, this study also has limitations. The sample size is relatively small and concentrated in specific areas, which may affect the universality of the results; The data collection time is short and does not cover the impact of different seasonal changes on travel and health. Future research should expand the sample size and geographical scope of rural areas, extend the time of data collection, and combine more objective health indicators with travel monitoring methods to further verify and deepen the research conclusions, so as to provide more comprehensive and accurate guidance for rural community health planning.

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Track 4
GOVERNANCE

Rethinking Policy Learning in Urban Policy Mobility

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Abstract
Since the 'mobility turn', urban researchers have made important contributions to our understanding of the contentious and relational nature of cross-border policy learning. Yet, seldom has extant research explored the contextual influence of local policymaking on the localization process of a traveling policy practice beyond the initial encounters of policy elites with its simplified narrative. To fill this gap, this article investigates the link between policy learning and policy outcome by disaggregating its complex interactive and iterative process into distinctive policy stages of urban policy mobility. The case of participatory budgeting in Vienna adds an empirical dimension to this approach. The findings reveal how multiple types of learned lessons, drawn from diverse sources of knowledge, become enmeshed, streamlined and articulated into the local formulation and implementation of an international 'best practice' in a context-bound policy space. It concludes by highlighting some analytical advantages of this policy-oriented approach for researching urban policy mobility and directions for future research.

Keywords: citizen participation; participatory budgeting; policy learning; policy mobility; urban governance

Introduction

The question of how policy learning affects the localization of globally circulating policies has been central to our understanding of urban policy mobility. Within the policy mobilities literature, scholars from various disciplines, ranging from anthropology to geography and sociology to urban planning (see Harris and Moore, 2013; Healey, 2012; McCann and Ward, 2013; McKenzie, 2017), have captured the interconnected urban processes and outcomes of global policy circulation, wherein policy elites learn and move policy ideas from place to place through global networks of policy communities. Combined with new communication technologies and logistical means in transnational flows of knowledge (see Ward, 2024), existing works consider that such cross-border relationships between actors, institutions, instruments and ideas enable not only spatial, but also temporal compression of traveling policy practices (Peck and Theodore, 2015), featuring 'ready-made, quick-fix, off-the-shelf policies from other jurisdictions or from private consultants' (McCann, 2011: 121).

From a policy perspective, however, the current use of policy learning within the policy mobilities literature has some limitations to fully grasp its multifaceted dimensions and their varying influences on the urban process and outcome of policy travel. Of course, there is no doubt about the role of globally connected policy actors, including epistemic communities (Haas, 1992), in promoting transnational exchange of policy knowledge and selective adoption of 'best practice' solutions in different cities (see Stone et al., 2020). Yet, this understanding of policy learning in urban policy mobility only partially describes the policymaking behaviors and learning activities of policy elites that primarily occur in the earliest moments of its overall experience. In practice, their localization will feature more complex adaptive dynamics and interactions, in which various learned lessons and their (uneven) deliberation flow constantly between its constitutive stages. In other words, the travel, mediation and mutation of traveling policy practices through policy learning is more than ideological predispositions of partisan or self-interested policymakers. Rather, it entails multiple forms of knowledge exchange between a diverse range of policy actors from different governance levels with varying capacities to influence specific policy components. Together, they will have a specific consequence for the localized process and outcome of urban policy mobility.

In this article, we explore diverse patterns of policy learning and their implications for policy outcome as an international 'best practice' not only travels to and arrives in a city, but also lives through multiple interrelated stages of its life cycle. The purpose is to highlight how multiple types of learned lessons, drawn from diverse sources of knowledge, become differently enmeshed, streamlined and articulated into the local formulation and implementation of a traveling policy practice, extending beyond the initial encounters of policy elites with its simplified narrative of success. It argues that the way in which the specific capacities of policy actors intersect with prevailing contextual circumstances at the local level will have a significant influence on the translation of

learned lessons into concrete substances for policy outcome. Indeed, there are growing considerations into the 'topological' influences of local policymaking on urban policy mobility (McKenzie et al., 2021). However, the link between policy learning and policy outcome, influenced by context-bound social and political interactions in the iterative process of local policymaking, remains underexplored in the current policy mobilities literature.

The case of participatory budgeting for climate change mitigation (*Wiener Klimateam*) from Vienna, Austria, illustrates this theoretical approach empirically. In recent years, the global circulation of participatory budgeting (PB) has gained considerable attention within the policy mobilities literature and beyond (see Bartocci et al., 2022; Lehtonen, 2022; Montero and Baiocchi, 2022; Peck and Theodore, 2015; Wampler et al., 2021). While these studies have identified their diverging characteristics in terms of background, objective and design, less has been said about the critical role of their interactive and iterative policy processes within which policy actors build knowledge to frame issues, choose instruments, implement solutions and evaluate their outcomes. In this light, the empirical findings presented below zoom the relationship between policy learning and policy outcome in *Wiener Klimateam* into five separate – yet interrelated – stages of its overall policy cycle: 1) issue-framing; 2) instrument selection; 3) participatory process; 4) output implementation; and 5) evaluation. The discussion of these findings will connect the recent theoretical advances in policy studies on policy learning with extant research on urban policy mobility.

The proceeding sections are structured as follows. The second section outlines the current understanding of policy learning within the policy mobilities literature and identifies remaining issues and gaps. The third section sketches out the theoretical approach and the analytical framework of this article. The fourth section introduces the case study setting and describes the research methods used. The fifth section illustrates the varieties of policy learning and their implications for policy outcome in the localization experience of PB in Vienna. The sixth section discusses these results and their practical implications in reflection of recent studies on policy learning beyond the policy mobilities literature. It concludes by highlighting some analytical advantages of the presented approach to future studies of urban policy mobility.

Policy Learning in Urban Policy Mobility: Issues and Gaps

The current understanding of policy learning in urban policy mobility emerged from the call to rethink global policy circulation beyond simple cross-border emulation of policy solutions and to consider the power-laden process of their reproduction at the urban scale (see Cochrane and Ward, 2012; McCann, 2011; Peck, 2011). The conception of policy learning within the policy mobilities literature after this 'mobility turn' (Sheller and Urry, 2006) can be summarized as below.

First, powerful policymakers who strive to advance their political or personal agenda selectively choose and adopt from policies that circulate through growing transnational policy networks and exchange opportunities (see Baker et al., 2016; Peck and Theodore, 2015; Wood, 2015). In this process, policy experts beyond the immediate local policymaking circle, such as consultancies, think-tanks and universities as well as international, supranational and non-governmental organizations, play a crucial role in framing expert knowledge and promoting model practices across borders (see Andersson and Cook, 2019; González, 2011; Hudson and Kim, 2014). The underlying argument is that 'urban politics…is…global or international in a much deeper sense' (Ward, 2018: 279), invoking the mutually constituted and relational aspect of urban policy mobility.

Second, the change effect of policy learning on the actual process and outcome of local policymaking is therefore minimal. The content of policy learning that is drawn from policy expertise, designs and recommendations of epistemic communities is limited to 'success' narratives of abstract policy ideas rather than concrete institutional reform agenda and their specific policy mechanisms (see Montero and Baiocchi, 2022). Here, the selective definition of policy success becomes a rhetorical device to mobilize political support and resources for specific policy agenda, which may however falter amid various contextual constraints and – despite some generative effects (see Baker and McCann, 2020; Chang, 2017; Lauermann, 2016) – fail to materialize anticipated outcomes (see Stein et al., 2017).

Third, existing contextual barriers for urban policy mobility imply that many aspects of mobile policies are in fact immobile and thus non-transferable beyond their places of origin.

While most obvious examples include institutional and physical infrastructures that are fixed in place, the policy mobilities literature has increasingly reflected upon deliberate attempts by policy actors to purposefully render undesired elements invisible from the policy success – or failure – stories (see Lovell, 2017; Nciri and Levenda, 2020; Webber, 2015).

Therefore, policy learning in urban policy mobility is constructed not only geographically and historically, but also 'through socially contextualized means' (Peck and Theodore, 2015: 28), discursively forming policy imaginaries and specific learning patterns (see also Temenos and McCann, 2012).

Issues and Gaps

The 'mobility turn' in these recent writings has generated some important scholarly contributions to our understanding of urban policy mobility regarding its much contentious nature. However, a few issues and gaps remain in the current use of policy learning in the policy mobilities literature, which limit a more systematic reflection on complex interactions and processes between actors, institutions, instruments and ideas in the real-world context of policymaking.

The first concern is the limited consideration into the path-shaping role of the broader circle of policy actors in urban policy mobility, such as citizens, civil society organizations and street-level bureaucrats, whose influence stretches beyond the mobilization of support for or against traveling policy practices. Certainly, there has been growing attention to the intermediary role of diverse non-elite policy actors and their expertise to shape the translation of mobile policies into the local context (see Baker et al., 2020; Lauermann and Vogelpohl, 2019; Temenos, 2017; Weller, 2017). Yet, most of the discussion has been restricted to their activities in advocacy for or resistance to policy adoption outside the policymaking arena, failing to situate their actual roles for contributing to concrete policy components within the overall policy cycle.

Second, the diversity of policy actors who are – although unevenly – present across various moments of the policy process indicates that policy learning in urban policy mobility can occur in diverse forms about different aspects of policymaking with diverging effects that will be drawn from multiple sources of information. Recognizing the multiplicity of the sources, contents and timing of policy learning thus has an important implication for understanding the deliberate policy choices to select information from a vast amount of emerging knowledge, transform those lessons into policy instruments and utilize them in specific policy stages. Much is indeed said about how piecemeal learning about policy ideas and narratives frames and moves – or fails – traveling policy practices as a whole (see Bok and Coe, 2017; Borén and Young, 2021; Pitton and McKenzie, 2022). However, seldom has the literature touched upon the link between policy learning and the actual policy actions that puts together policy elements and implements them into effect.

Third, the localization of traveling policy practices, spanning from their initial encounter, selective lesson-drawing and instrument choice to final implementation, occurs in a context-bound policy space, which features place-specific – and varying – capacities and constraints for different policy actors within and across multiple governance levels. In policymaking, context refers not only to the geographical, institutional and social embeddedness of urban policy mobility within the relational politics of scale-making (see McKenzie and Aikens, 2021; Prince, 2017; Robinson, 2015; Savage, 2020). Also, and more importantly, it entails sets of multifaceted competences (skills) and capabilities (resources) that challenge the practical ability of policy actors to understand burgeoning social problems, formulate their policy solutions and put those decisions into action (see Wu et al., 2015; see also McLean and Borén, 2015). So far, the contextual understanding of urban policy mobility has revealed less about the political, organizational and technical conditions of local policymaking that may facilitate or obstruct the effective translation of learned lessons into the unfolding policy process.

Situating Policy Learning in the Local Policymaking Context

The main tenets of the policy mobilities literature draw from the limits of the earlier political science concepts for policy learning, namely policy transfer and diffusion (see Dolowitz and Marsh, 2000; Rose, 1991; Stone, 1999). Since then, however, a much wider literature on its multidimensional characteristics has emerged, aiming to decipher the ambiguous relationship between their contributing factors and generative effects for policy change (see Dunlop et al., 2018).

Contrary to the common assumption behind the innate capacity of policy actors to learn, these writings provide a more nuanced understanding of its diverse patterns and their implications for local outcomes of urban policy mobility along the following analytical elements: *actors*; *sources*; *types* and *effects*.

Actors of Learning
Broadly speaking, policy actors refer to all possible individuals, groups, organizations and networks who make both direct and indirect contributions to policymaking activities at any point in time (Howlett et al., 2020: 92). As the policy process moves forward, however, only a smaller number of them will be able to frame problems, make alternative solutions and convert them into outputs, each of whom will have a specific level of policy capacity to undertake their roles and tasks (Kingdon, 2011). As such, epistemic communities comprise an important issue-framing subset of the policymaking circle in cross-border policy learning (Dunlop, 2009).

Yet, their epistemic authority may not always extend to the rest of the key activities in urban policy mobility. Instrument selection, decision-making or output implementation – and their evaluation – require different sets of skills and resources to navigate through the political and technical complexities of policymaking at a collective level (see Capano et al., 2024). Furthermore, the increasing collaborative nature of urban policies points to the important relevance of citizens and civil society organizations and their deliberative power in knowledge production across multiple decision points in the policy process.

Sources of Learning
While not always rational, policymaking inevitably involves a deliberate act of decision-makers to process some kind of knowledge that will in one way or another influence the succeeding policy pathway (Chindarkar et al., 2017). Despite being an important one, international 'best practices' are not the only source of evidence and information in this process. As modern policy studies have already acknowledged, policy learning does not take place in a historical vacuum (see Hall, 1993). It occurs in a context-bound policy space with established actors, institutions, instruments and ideas, all of which feature significant enduring legacies, prompting decision-makers to utilize available knowledge about existing policy elements from their past actions (see Dussauge-Laguna, 2012).

This iterative nature of policymaking implies that policy learning in urban policy mobility is not a one-time event that is isolated from other stages of the policy process. As traveling policy practices become formulated into and implemented as local policies, decision-makers deal with a variety of new information about on-the-ground policy experiences through monitoring and evaluation of adopted, ongoing or finished interventions (Vedung, 2010). Although challenging, such a reflexive feature of policymaking can provide them a knowledge base from which to make in-process assessments, in-flight adjustments and *ex-post* changes to the next round of the policy process (see Nair and Howlett, 2016).

Types of Learning
Understanding how acquired knowledge becomes utilized across the policy process ultimately begs the question of how policy learning takes place by whom in what learning capacity. While 'learners' in policy learning are typically considered as those who hold decision-making power at any stage of the policy process (Dunlop and Radaelli, 2013: 606), a long line of research has theorized diverse types of policy learning that different 'learners' may undertake to varying extents (see Bennett and Howlett, 1992; May, 1992; Sabatier, 1988).

The first learning type concerns the acquisition of problem-centered knowledge to frame policy issues at stake and set corresponding objectives (*Problem Learning*), which can be sourced from diverse types of experts within epistemic communities (see Dunlop, 2010). The second type concerns learning about the means-ends connection between policy instruments and their anticipated outcomes (*Instrumental Learning*), gaining knowledge about technical details of policy tools from instrument experts (see Simons and Voß, 2018). The third type concerns accumulating lessons about the political complexities of the policy steering process (*Political Learning*) that pertain to the working relationships between relevant governmental actors toward effective policy delivery (see Howlett et al., 2015). The last type concerns the more fundamental form of learning that results from multi-stakeholder communication within the broader policy universe (*Social Learning*), influencing decision-makers' political-ideological frame of reference to make transformative changes (see Siddiki et al., 2017).

Effects of Learning

Regarding the complexity of translating learned lessons into policy outcomes, the policy mobilities literature has shown the negative and unintended results of policy learning in urban policy mobility, such as policy failure (see Temenos and Lauermann, 2020). Yet, a more detailed look at its entire process reveals more substantive effects of policy learning, which can occur at different levels of abstraction, influence various aspects of policymaking and thus go beyond the discursive framing of success or failure (see Howlett and Cashore, 2009; see also Moyson et al., 2017).

One, and the most typical, effect of policy learning is minor adjustments to existing policy instruments as well as their real-life use without modifying the policy objectives on the agenda (*Incremental Change*), struggling to move beyond the established mode of operation (see Baek et al., 2018). Another typical effect is major modifications to key policy instruments and specific program contents that are utilized to achieve existing policy objectives (*Program Change*), which, however, do not influence the overall policy goals and the belief system of decision-makers (see Voorberg et al., 2017). Lastly, although rare, policy learning can also generate a more systematic shift in the policy paradigm that fundamentally alters the main ideas, preferences and priorities of policymaking (*Paradigmatic Change*), resulting in radical changes to the decision makers' way of doing policy work (see Zaki et al., 2023).

Case Study Setting and Methods

Wiener Klimateam is Vienna's first citywide PB. It was launched as a pilot project of the city's energy planning department (MA20) in six districts between 2022 and 2023. It was developed through the collaboration between an international NGO and the City of Vienna within the EU's climate innovation initiative (EIT Climate-KIC). It shares a few design features that are common across the recent examples of PB in European cities, in terms of objective (democratic awareness-building/governance innovation), tool (digital participation) and resource (strong government support) (see Wampler et al., 2021). The participating districts in the annual budgeting cycle divide the budget of 6.5 million EUR depending on their respective population size, which are spent on citizen projects that are developed through the following stages: a) on-/offline idea submission; b) expert screening; c) co-creation workshop; and d) citizens' jury. Once the final projects are selected, the districts – based on the recommendations from the co-creation workshop – have the responsibility to reach out to the municipal departments with relevant jurisdiction to implement them, which are to be realized within two years.

The analysis below illustrates the link between policy learning and policy outcome in the localization experience of PB in Vienna, focusing on one of the first *Wiener Klimateam* pilot districts: Margareten. It highlights the interconnections and relationships between different actors, sources, types and effects of policy learning within and across its five core policy stages: 1) issue-framing; 2) instrument selection; 3) participatory process; 4) output implementation; and 5) evaluation (see Figure 1). The use of tailored methods reflects this stage approach: i) a qualitative content analysis of 13 expert interviews with the key stakeholders from the issue-framing and instrument selection stages; ii) participant observation of the co-creation activities and their systematic analysis along theory-driven process evaluation criteria; iii) two stakeholder workshops and 10 additional expert interviews with the district office and the municipal departments who are responsible for the implementation of the final projects; and iv) a comparative analysis of the participatory designs of the pilot and the current *Wiener Klimateam*, using the evidence from its internal evaluation, to assess the longer-term feedback effects.

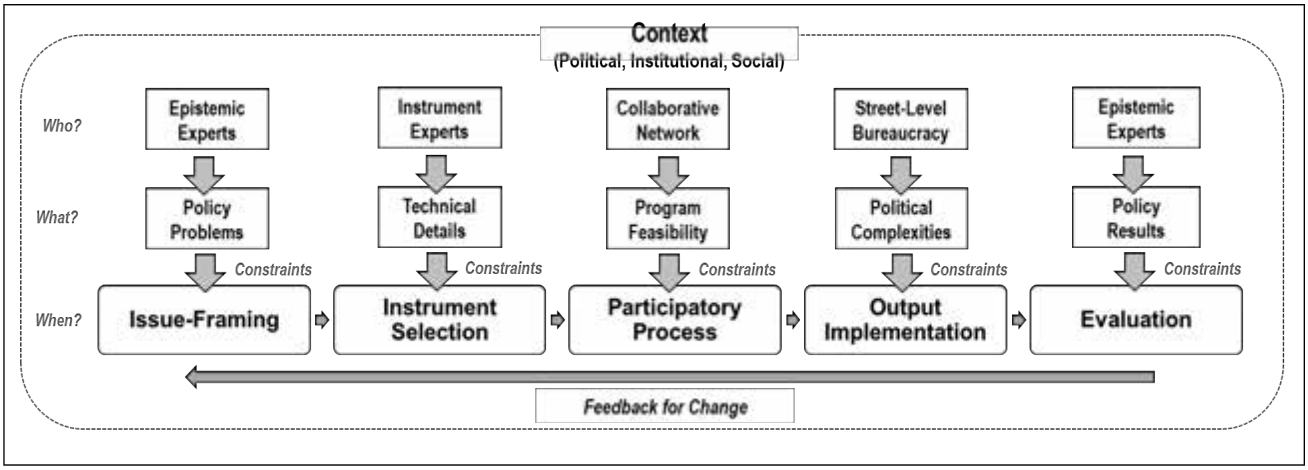

Figure 1. A Heuristic Model: The Flow of Knowledge in Policy Learning within Wiener KlimateamSource: Authors' own elaboration after Dunlop et al. (2024); Goyal and Howlett (2024); and Howlett et al. (2017).

Varieties of Policy Learning in Urban Policy Mobility

The collaboration between the City of Vienna and the partners of EIT Climate-KIC was a crucial milestone for *Wiener Klimateam*, resulting in a broad policy concept to mainstream citizen participation into climate budgeting in Vienna. One fundamental contribution was the new working relationship with an international NGO with multiple consulting experiences in other European PB projects, who was later commissioned to steer the formulation process of a concrete policy program. As we will see, however, the learning processes that shaped the core components of *Wiener Klimateam* and influenced their outcomes varied and occurred far beyond this cross-border partnership.

Policy Learning in Issue-Framing

For framing the issues to be resolved through PB, another set of policy actors with a different type of knowledge entered the preparatory phase of *Wiener Klimateam*. This comprised a group of local civil society organizations, scientific and public-sector experts who were mobilized by MA20 as an advisory board. Their main task was to guide the identification of the vulnerable social groups in the city's decision-making process and the strategies to activate their participation as well as the formulation of the key *Wiener Klimateam* objectives (climate protection; democratic awareness-building; governance innovation; and social justice).

The acquisition of expert knowledge on Vienna's social and environmental issues was accompanied by existing scientific evidence and past policy experiences among the members of the advisory group, whose expertise was related to specific local issues. On the one hand, the quantitative indicators that were developed in prior studies were used to identify the city's districts that are most affected by Vienna's socio-spatial inequalities. On the other hand, the district offices who had previously experimented with similar budgeting projects provided qualitative inputs about some practical criticalities, including the low participation rate of vulnerable social groups and the street-level implementation of participatory outputs (see Ahn et al., 2023).

The utilization of the acquired knowledge took place in two concrete ways. First, the varying levels of socio-spatial inequalities across the city's 23 districts were used to select the first *Wiener Klimateam* pilot districts with one of the highest vulnerability scores based on heat island effect, socio-economic inequalities, life satisfaction, and green infrastructure. Second, the perceived failures of the previous budgeting projects were used to set greater inclusion targets in an open-to-all participatory process as one of the main agendas, resulting in the additional selection of civil society organizations and public institutions to act as local multiplicators. These decisions to expand the representativeness of the wider public based on district-level inequalities marked the key difference with the democratic objectives of earlier PB cases, which had explicit rules for targeted participation of the urban poor at the neighborhood level (see Fung, 2006).

Policy Learning in Instrument Selection
The actual role of the international NGO, in contrast, was limited to developing the participatory instruments for *Wiener Klimateam* and informing the key program stakeholders, such as the municipal departments, the district offices and the local multiplicators, about their practical use to achieve the set agenda. This knowledge exchange drew from their prior experiences with similar instruments in the PB projects in Antwerp, Lisbon and Paris, which were, however, modified through stakeholder processes and brought in line with the main policy priorities of the City of Vienna and the program objectives of *Wiener Klimateam*.

Therefore, the transfer of expert knowledge by the international NGO focused not only on the successful instrument use in the 'best practice' examples of PB. Through multiple stakeholder workshops, involving some 70 local policy actors in total, the instrument selection process also kicked-off mutual learning about the applicability of the proposed participatory tools to the local governance environment and their compatibility with the specific needs of the program stakeholders. As such, the selection of the *Wiener Klimateam* instruments built on merging both international and local knowledge bases with the instrumental thinking of the knowledge holders about how the instruments could work in a practical setting and advance the anticipated program objectives.

The resulting effects of such two-way knowledge transfer can be traced in the application of new participatory instruments that set *Wiener Klimteam* apart from the 'best practice' examples considered. The first of these elements is the use of methodological toolboxes that were distributed to offline participants. These contained information about the environmental conditions and existing policy programs in the participating districts as well as interactive learning tools to facilitate their effective participation in the budgeting process. Second, greater emphasis was laid on face-to-face deliberation of citizens in the formulation of concrete participatory outputs through co-creation and their final selection by citizens' juries. This priority for real-time collaboration between citizens, scientific and public-sector experts in the participatory process showed a contrast with the strong reliance on online tools in other European PBs (Wampler et al., 2021).

Policy Learning in Participatory Process
The participatory process of *Wiener Klimateam* aimed at generating place-based climate actions from the bottom up. They were first gathered through on-/offline idea submission, which were then screened and selected by the municipal departments and the district offices according to their topical relevance and technical feasibility. The co-creation workshops were intended to refine these ideas into implementable projects based on the collaboration between the citizens whose ideas were selected in the screening phase, practitioners from the municipal departments and the officials from the participating districts.

While the main source of knowledge in the collaborative process originated from the citizen ideas in the initial submission phase, the importance of guiding information from MA20 must be acknowledged. The participating citizens and the public-sector experts of the co-creation workshops were given scores (from high to low) for the foreseen feasibility of each of the successfully screened citizen ideas based on the *Wiener Klimateam* selection criteria[1]. Based on this knowledge, they could voluntarily choose any submission of their preference, combine related ideas and provide new information about the content, location, tasks, cost estimates, anticipated climate and social benefits for the final projects.

The core contribution of the collaborative network was the creation of new policy outputs (five in Margareten), which were yet framed by the co-creation design based on the priorities of Vienna's existing climate policy framework. The effect of collaborative learning in the presence of strong public stewardship was thus connecting expert-led solutions from the expert-identified problems to the expert-formulated objectives. In turn, the participating citizens were given little structured guidelines and relevant information to make independent decisions for co-creation outputs based on previously identified climate needs and challenges from the bottom-up.

Policy Learning in Output Implementation
The five final *Wiener Klimateam* projects pertained to small-scale circular economy, urban greening and climate awareness-building measures: a) Repair Café; b) Superblock; c) Car-free Saturday; d) Street Greening; and e) Façade Greening. Since MA20, in charge of developing energy concepts and strategies, has no administrative

1 1) climate impact; 2) community orientation; 3) time feasibility; 4) legal feasibility; 5) cost feasibility; 6) maintenance feasibility; and 7) jurisdiction.

responsibility for such activities, these were first transferred to the district office of Margareten, which was tasked to contact the competent municipal departments and to steer their implementation. As the implementing agencies, the selected municipal departments on the other hand had a great level of freedom to reinterpret and redesign the final projects based on their own interests, competences and capabilities.

Once the implementation began, however, the different municipal departments faced a multitude of constraints to carry out the final projects as intended by the participants in the co-creation process. The first of these constraints was their ambitious and sometimes ambiguously formulated objectives and content, which made their realistic operation in the actual implementation setting difficult. Second, multiple municipal departments were assigned to jointly undertake the final projects without sufficient coordination mechanisms to oversee their effective communication and collaboration. They were left to self-determine their roles and responsibilities in the implementation process. Third, the incentives from taking on the implementation task were considered by the implementing departments as "minimal" both in political and financial terms. Moreover, they were competing with their running programs and putting an extra burden on their limited human resources.

The major lessons that were generated through the implementation activities therefore referred to the political complexities behind translating citizen ideas into actionable solutions. While the key actors within MA20 maintained informal communication with the implementing departments, the utilization of this new knowledge became highly restrained by the lack of their continuous involvement to monitor *Wiener Klimateam* beyond the participatory process and make *ad hoc* adjustments to the unforeseen challenges of implementation. As a result, several changes were made to all final projects, in terms of their designs and objectives as well as target groups and areas. This followed substantial negotiations between the district office and the implementing municipal departments, causing serious delays to the initial implementation plan. While the official Wiener Klimateam process in Margareten ended as of December 2024, only two of the final projects (Repair Café and Car-free Saturday) were fully implemented.

Policy Learning in Evaluation

The participatory activities of *Wiener Klimateam* were accompanied by an internal monitoring and evaluation process. In the first pilot year, 2022, a research team from a local university was commissioned by MA20 to develop evaluation indicators, which were used by a public agency of the City of Vienna to observe and review the next budgeting cycle in 2023. Focus groups, participant observation and participant feedback were used to elicit evaluation data.

Given the evaluation methods used and the type of questions asked, the acquired information about the operation of *Wiener Klimateam* was strictly limited to the perceived quality of the participatory process based on subjective assessment rather than the effectiveness and impact of the overall program against the set objectives. The qualitative indicators, such as informedness, satisfaction and willingness to participate in similar events, were less adequate to reveal the critical challenges to *Wiener Klimateam* that went much beyond the participatory process itself. As a result, for instance, it was not possible to verify if their activation strategies were indeed able to involve those who are most affected by climate hazards and democratic deficits. Similarly, the process evaluation, only involving the participating citizens, proved to be difficult in identifying the critical barriers that the implementing departments faced in order to implement the results of the participatory process at the street level.

Based on the evaluation results, the most recent *Wiener Klimateam* from September 2024 pays special attention to facilitate transparent and simple communication for potential citizen participants. One resulting change to the participatory design is the addition of open-to-all citizen participation at the screening stage, who now co-select citizen ideas for the co-creation workshops with public-sector experts. The feedback effect of learning from monitoring and evaluation therefore pertained to the minor modification of the participatory process that was deemed more open and inclusive. Consequently, there were no major changes to existing activation strategies and participatory instruments toward enabling explicit recruitment of disadvantaged social groups in climate change mitigation nor sustained engagement of most relevant policy actors throughout the whole budgeting cycle.

Discussion

The localization experience of PB in Vienna suggests that urban policy mobility is a complex multifaceted process. It involves more than just policy elites' selective reproduction of traveling policy practices based on professional know-how of transnational policy communities. Although globally circulating expert knowledge plays a significant role in this process, it is not the only source of inspiration for local policymaking. Rather, as shown, key decision-makers uproot various types of policy input from a diverse range of sources and actors throughout different stages of the policy cycle. Consequently, policy learning can take multiple forms according to who learns from whom, about what, and at what time. The specific type of learning that emerges will have a distinct effect on the overall policy process, contingent on the decision-makers' capacity and willingness to apply the lessons learned.

Table 1. Multistage Policy Learning and Outcome in *Wiener Klimateam*

Stage	Issue-Framing	Instrument Selection	Participatory Process	Output Implementation	Evaluation
Actors	Scientific/ Public	International NGO	Citizens/ Public	Street-Level Bureaucrats	Scientific/ Public
Source	Past Practice	Best Practice	Co-creation Process	On-the-Ground Experience	Internal Evaluation
Content	*Problems/ Failure*	*Instruments/ Practicality*	*Solutions/ Feasibility*	*Barriers/ Conflicts*	*Perception/ Success*
Type	Problem	Instrumental	Instrumental	Political	Political
Constraints	*Admin.*	*Design*	*Operational*	*Admin.*	*Design*
Effect	Program Change	Program Change	Program Change	No Change	Incremental Change

Source: Authors' own elaboration. See also Dunlop and Radaelli (2013) and Wu et al. (2015).

Table 1 summarizes the complex dynamics of such multistage policy learning and its link with concrete policy outcomes in *Wiener Klimateam*. The key decision-makers of Wiener Klimateam engaged in epistemic learning, where specialist knowledge is used to define uncertain problems and guide the selection of appropriate instruments (Dunlop and Radaelli, 2013: 609). This process, however, extended beyond abstract policy concepts and 'best practice' tools offered by international experts. They drew significant lessons from locally sourced evidence and information, which were crucial in framing specific policy issues and tailoring policy instruments to the local context. Continuous internal learning took place as *Wiener Klimateam* advanced through each stage. This learning emerged from ongoing interactions between decision-makers and local policy actors facilitated through stakeholder engagement, public-citizen collaboration, and process evaluation. Each actor contributed specialized knowledge based on their unique roles and responsibilities within the evolving policy process.

The effects of policy learning revealed many constraints on the *Wiener Klimateam*'s ability to acquire and use policy-oriented knowledge effectively in real-world policymaking (see also Ahn and Kazepov, 2024). The first of these constraints was *administrative*. Without explicit competence, MA20 was unable to effectively oversee and control the implementation activities, which otherwise would have been considered to breach the administrative autonomy of the implementing departments. This lack of competence provided the implementing departments with some discretionary power at the street level, for instance, by allowing them to make substantial modifications to the original participatory outputs. The second constraint pertained to *design*. The open-to-all participatory approach was inadequate to enhance the involvement of vulnerable groups experiencing climate vulnerability and a democratic deficit, which were the original objectives of *Wiener Klimateam*. Despite the genuine innovative outreach effort through local multiplicators, their working areas and target audience had less connection to the identified target vulnerabilities from the issue-framing stage. This led for instance to a spatial concentration of the submissions around the local multiplicators and offline events rather than the most needed areas with disadvantaged individuals and communities. Detection of such limitations was made difficult by the design of its monitoring and evaluation framework that was geared toward highlighting the subjective success factors of

the participatory process. Another critical constraint was *operational*. The lack of a clear collaborative structure in the co-creation workshop made it difficult for the participating citizens to deliberate their needs and interests from the bottom up to co-develop actionable solutions with public-sector experts. Many of the participants were not the ones who submitted the selected ideas and were not provided with sufficient knowledge about the practicalities around their implementation to make informed decisions based on group deliberation and collaboration. This resulted in highly unfocused participation dynamics that were dominated by individual expert participants who mostly created workshop outputs based on single citizen ideas.

Conclusions

Since the 'mobility turn', the policy mobilities literature has shed light on the highly politicized nature of urban policy mobility. Scholars in this debate argue that interest-driven policy actors selectively – and limitedly – draw lessons from international 'best practices' and modify them in line with prevailing economic pressures and anticipated political gains. Departing from the earlier positivist idea that lesson-drawing follows instrumental thinking of rational policy actors, they lay special emphasis on power-laden policymaking behaviors that frame particular narratives, contents and objectives of policy learning at the urban scale. So far, however, less effort has been made to consider the contextual influence of local policymaking on diverse patterns of policy learning and their varying implications for place-specific policy outcome by looking at the entirety of the policy process. This article, in contrast, links the dynamic process of policy learning with the actual learning effect on the policy process by disaggregating its complex relationship into the five core stages of the policy cycle. This analytical approach enabled a detailed assessment of the concrete learning processes and the flow of the acquired knowledge that together shaped the course of urban policy mobility in its truer local form. The results have illustrated that policy learning in urban policy mobility can occur in multiple forms and involve a diverse range of policy actors at different stages of its life cycle. However, the effects of this learning can vary depending on existing political, operational and analytical capacity constraints in policymaking.

Our policy-oriented approach, and the framework that we have put forward, presents a few analytical advantages over the current use of policy learning in the policy mobilities literature in the following ways. First, it captures the implications of the diverse roles and responsibilities, skills and resources of policy actors throughout the entire localization process of a traveling policy practice. This allows to disentangle the multiple objects of policy learning in urban policy mobility that emerge from their specific characteristics. Second, it locates multiple sources of policy learning and their movement across different stages of the policy process. This reveals the capacity and willingness of decision-makers to selectively extract lessons from emerging information, thereby determining the type of learning that ensues. Third, it helps to distinguish different types of learning and their generative effects on policy outcomes. It elucidates which policy outputs originate from specific learning activities at different levels of abstraction, as well as its political (in)ability to influence broader policymaking in the long run. Together, these elements enable a more systematic assessment of the expected policy effects from different types of policy learning under various policy circumstances. So far, this relationship remains elusive in existing research on urban policy mobility.

Within the policy mobilities literature, the interpretative lens on policy learning in urban policy mobility is considered to have been shaped by the 'discipline-specific specialization' of urban researchers, which differs from a more diagnostic approach in policy studies (Temenos and Lauermann, 2020: 1114). Yet, both strands of literature share a common ground: to uncover the complex social and political interactions that determine who teaches and who learns, which ideas become mobile and which ones remain immobile, and which lessons localize and which ones do not. What separates urban studies on policy mobility from other disciplines, however, is the strong thematic focus on urban policies that feature specific learning characteristics compared to national policies. These increasingly include, among others, learning from collaborative knowledge production through community-based participatory instruments within non-hierarchical network-based governance arrangements. Together, they can generate more complex patterns and processes of policy learning that do not always follow the traditional policymaking steps in a clear-cut fashion. Future research then may consider the policy-specific factors and effects of policy learning that shape the localization process of mobile 'urban' policies.

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Actors in power networks: an institution framework of historic urban district renovation actors in China

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Abstract
The powers, resources, motivations, and mindsets of actors play a critical role in shaping the conservation, renovation, and redevelopment of historic urban districts, as well as broader contemporary urban issues. Yet, understanding the roles of individuals and institutions remains challenging. Referring to bounded rationality hypothesis and Michael Mann's theory of power networks, this paper proposes a comprehensive analytical framework to examine the actor-institution landscape. It offers a panoramic view of the intricate and often chaotic interconnections among key actors as well as their power resources, institutional affiliations, interrelations, and action logics. This framework is then applied to the case of historic urban district renovation in China, providing insights from an actor-institutionalist perspective, such as the imbalanced power distribution and party-state authority fragmentation.

Key words: Actor; power network; institution; historic urban district; Chinese urban renovation

1.Introduction

Actor constellation plays a crucial role in urban renovation, conservation, and redevelopment. (Neugebauer, 2014, pp. 57–66; Imperiale et al., 2024; Li, 2025) Since the processes and the results of the urban interventions can be largely shaped by different actors' power, resources, motivations, and mindsets (Li, 2025), it is essential to recognize the intentions, capacity, and behaviour pattern of the actors, especially the key actors involved in historic urban district (HUD) transformation. However, it is far from an easy task to describe and understand the diverse array of individuals in real-world urban issues.

The paper adopts an actor-centred institutionalism perspective and bounded-rationality hypothesis, provides a descriptive framework that examines the power resources, interrelations, institutional organization, mindsets, and action logic of key actors based on Michael Mann's philosophy. Then the paper will apply this description framework in the context of residential and commercial-residential-mixed HUD renovation in China, describing the characters of four key power networks, namely political network, local community network, economic network, and expertise network based on extensive theoretical and experimental studies on representative organization studies and renovation cases. In the end, the study offers insights and critical reflections on the power distribution and the actor institutional contexts in the HUD renovation in China as well as the potential and limits of the descriptive framework. The proposed framework and contextual analysis aim to contribute to a foundational understanding for future research in HUD renovation and broader urban governance issues.

2.Literature Review

2.1Bounded-rational hypothesis and actor-centred institution

HUD renovation and regeneration typically involve a wide array of actors, varying significantly in capacity, mindset, and patterns of action. It is nearly impossible to analyse each individual actor in detail. A more feasible approach is to identify and focus on the shared characteristics, power resources, and decision-making logics that meaningfully influence urban renovation within specific groups of actors.

Several academic hypotheses and theoretical perspectives have been proposed to explain shared behaviours, decision-making patterns, and action logics that extend beyond the individual level. Two of the most influential hypotheses are (1) the rationality hypothesis and (2) the bounded rationality hypothesis. According to the rational hypothesis, individuals are assumed to make a rational choice and "systematically and purposefully do the best they can to achieve their objectives, given the available opportunities," (Mankiw, 2015, p. 6) or to say, actors can "order" the outcomes of the game according to their consistent preferences. (Lucchetti, 2011, p. 5) The "ordering" or "decision-making" always involves a comparison of marginal benefits and marginal costs (Mankiw, 2015, pp. 6–7), mathematically towards maximizing a certain utility or payoff function. While the rationality hypothesis remains prevalent in economic analysis and certain areas of social science, it can be limited when comes to urban studies. In the case of HUD renovation and other complex urban issues, the "bounded rationality" hypothesis (Simon, 1997;

Gigerenzer, 2020) can be a more referential framework. The bounded rationality hypothesis acknowledges that actors often face cognitive constraints (Simon, 1990), and are thus they may be unable to collect all the necessary information, calculate the marginal benefits, costs, and utility, and make an optimized or fully informed decision, even though sometimes they intend to act in a rational manner.

Institutional studies and "actor-centred institution" discussions serve as another referential perspective in understanding actors' mindsets and behaviours under the bounded rational hypothesis especially when actors are not fully informed or capable of purely rational decision-making. "Institution" can refer not only to organizations or agencies, but to a wider range under the New Institutionalism discourse, including "a set of formal rules, shared norms and understandings, and standard operating practices." (Sorensen, 2017, p. 251) It can be taken as "the rules of game... that shape human interaction" (North, 1990, pp. 38–40)Douglass North develops an analytical framework for explaining the ways in which institutions and institutional change affect the performance of economies, both at a given time and over time. Institutions exist, he argues, due to the uncertainties involved in human interaction; they are the constraints devised to structure that interaction. Yet, institutions vary widely in their consequences for economic performance; some economies develop institutions that produce growth and development, while others develop institutions that produce stagnation. North first explores the nature of institutions and explains the role of transaction and production costs in their development. The second part of the book deals with institutional change. Institutions create the incentive structure in an economy, and organisations will be created to take advantage of the opportunities provided within a given institutional framework. North argues that the kinds of skills and knowledge fostered by the structure of an economy will shape the direction of change and gradually alter the institutional framework. He then explains how institutional development may lead to a path-dependent pattern of development. In the final part of the book, North explains the implications of this analysis for economic theory and economic history. He indicates how institutional analysis must be incorporated into neo-classical theory and explores the potential for the construction of a dynamic theory of long-term economic change. Douglass C. North is Director of the Center of Political Economy and Professor of Economics and History at Washington University in St. Louis. He is a past president of the Economic History Association and Western Economics Association and a Fellow, American Academy of Arts and Sciences. He has written over sixty articles for a variety of journals and is the author of The Rise of the Western World: A New Economic History (CUP, 1973, with R.P. Thomas, which can structure the "courses of actions that a set of actors may choose" (Scharpf, 1997, pp. 38–40) and the departmental identities of actors shape their selective perceptions. Actors are likely to take into consideration the established, customary rules and traditions that form a cultural and normative institutional framework, including but not limited to as their roles in organizational structure, their interpersonal networks, path depending, traditional customs, etc. (Li, 2025) Even though the "rules of game" may not be the only determinant that influences actor choices and renovation results in all cases, they still provide meaningful insights into how social activities are organized and regulated. Moreover, they help render actors' decisions and behaviours intelligible—and even "predictable" to "those sharing in rule knowledge," albeit in a "limited conditional sense." (Burns, Baumgartner and Deville, 1985, p. 256; Scharpf, 1997, p. 40)

2.2.Power network: Michael Mann's studies

Michael Mann's "power network" framework (Mann, 2012, pp. 1–33) provides an insightful structure by examining actors' mindset and behaviour as well as their power and capacity within institutionalized "power networks." It can be highly referential to urban studies and HUD renovations for (1) it can enable a panoramic description framework out of the complex, chaotic and intertwined interconnections and interactions among diverse actors in the real world; (2) it can shed light on understanding the motivations and mindsets of the actors within social "rules of game;" (3) by situating the actors within the power networks, it can serve as a methodology for studying organizational power (Mann, 2012, p. 6) and help to elucidate actors' power, resources, and capacities, offering insight into how different actors can shape the real-world activities and impacts including HUD renovation processes and results.

Michael Mann interprets societies as "multiple "overlapping and intersecting socio-spatial networks of power" (Mann, 2012, p. 1) from an "organizational level of analysis." (Mann, 2012, p. 2) In his studies, these power networks are "overlapping networks of social interactions" as well as "particular organizational means each possesses to attain human goals." (Mann, 2012, p. 2) The power networks can be authoritative or diffused, intensive or extensive (Mann, 2012, p. 9), while they always feature real connections among people (Collins, 2006, p. 23) and functional

ends and means. (Mann, 2012, p. 12) The overall model presented in Mann's studies can be illustrated in Figure 1. It integrates power, institution, and actor motivation in a single conceptual framework. While it is worth noting that the highlighted "power networks" can only encompass some of "the broadest contours" of the messy human societies. (Mann, 2012, pp. 29–30) Identifying power networks can be tailored according to different scenarios and academic understandings. For example, when Mann applied this methodology framework to national and global history studies, he used identified four fundamental power networks, namely ideology, economy, military, and state(s). However, as for urban issues or HUD renovation at a relatively smaller scale, it remains necessary to re-define and reinterpret the key power networks.

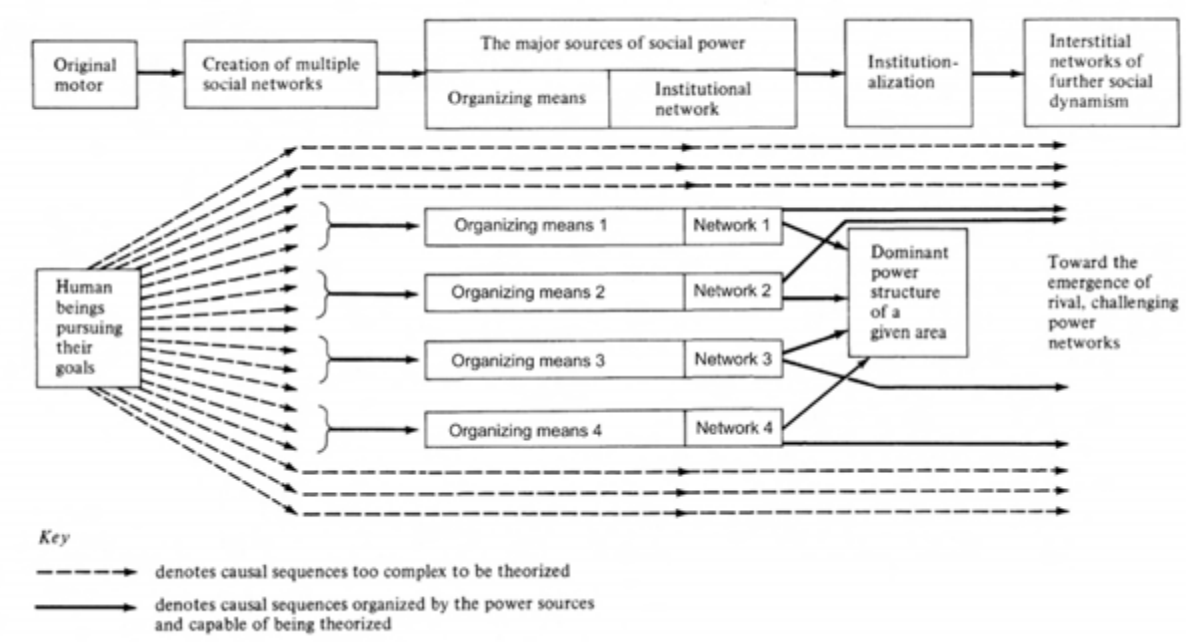

Figure 1: The framework of power network, adapted from (Mann, 2012, p. 29)

3.Create actor power networks in Chinese HUD renovation

3.1.Four key actor power networks in Chinese HUD renovation studies and actions

The paper adapts Michael Mann's theoretical approach to the Chinese residential and commercial-residential-mixed HUD renovation studies and proposes an actor power network framework building on the previous work of Li (2025). Four actor networks are highlighted in these scenarios, namely the political networks, local community networks, economic networks, and expertise networks. Table 1 provides a summary of the interpretation and key actors of each networks in the Chinese HUD renovation context.

Table 1: the four key actor power networks in Chinese HUD renovation studies (key reference (Mann, 2012; Li, 2025))

Power network	Power network interpretation in China	Key actors of the power network in China
Political network	Stem for "the usefulness of centralized, institutionalized, territorialized regulation of many aspect of social relations" (Mann, 2012, p. 26) beyond individuals.	The "party-state" system (Wu and Zhang, 2022) including different levels of government and the Chinese Communist Party (the Party)
Local community network	Stem for the basic requirement and desire on making a better living within a local quarter/ neighbourhood/ jurisdiction	Various local residents and communities in the neighbourhood
Economic network	Stem for "the satisfaction of subsistence needs through the social organization of the extraction, transformation, distribution, and consumption of the objects of the nature" (Mann, 2012, pp. 24–25)	Entrepreneurs, merchants, customers involved in circuits of production, distribution, exchange, and consumption and capital circuits, especially the chengtou platform and property management companies.
Expertise network	Stem for the pursue and recognition of expertise with "social-spatially transcendency" (Mann, 2012, p. 23)	Professional committees, planning institutes, educational and academic institutes, and some professional-based NGS, etc.

These four power networks interacting with each other can contribute to a foundational framework to understand the actor-institution landscape of HUD renovation in specific contexts, both within and beyond China. In the following sections, we would like to examine each of these four networks, depicting and analysing the power sources, institutional structures, mindsets and motivations of actors in Chinese HUD renovation. This part has been summarized from social governance studies, exemplified by the renowned scholars Zhou Li-an (2017; 2019), Zhou Xueguang (2017), and Wu Fulong (Wu, 2015; Feng, Wu and Zhang, 2022; Wu and Zhang, 2022). The research has also examined extensive HUD renovation case studies in big metropolises (such as Beijing) and small/middle-sized cities (such as Anyang).

3.2.Political Network

The power of the political network, primarily referring to the party-state in China, comes from both the state power, such as the administrative and adjudicatory power granted through the elected People's Congress, as well as the leadership of the Party. (Li, 2025) Key actors in the political network can possess extensive authority and extensive resources affecting various aspects of social lives including HUD renovation. They are always among the dominant players with "significant discretionary power." (Zhou, 2019, p. 409) In some cases, their influence can be far-reaching and ambiguously defined, especially when the local states act more as "development leaders" with an "entrepreneurial nature" rather than functioning solely as service-oriented administrators. (Zhao, 2021, p. 157) At the same time, the expansive political power also brings challenges. As the phrase suggests "unlimited power, unlimited responsibility" (Hu and Zhang, 2022, p. 92), heavy political power can lead to the overburden of the governmental systems, especially the ones operating at the grassroots communities.

In response to the challenges of managing a vast territory with diverse social affairs and a large population, the Chinese party-state has established a "hierarchical and multi-scalar" structure (Wu and Zhang, 2022), characterized by a matrix form extending vertically from central (the upper level) to local level (the lower level) and horizontally across a range of function sectors at each level. Scholars (Mertha, 2005; Zhang, 2013, p. 34) have also frequently described the structure of Chinese governance as "tiao (条)" and "kuai (块). "Tiao," or "line" in Chinese, refers to vertical clearances among functional bureaucracies;" while "kuai" captures geographic divisions of local governments" at one hierarchical level. In many, if not most, of the real-world cases in China, tiao-tiao management, that a functional sector is under the direct oversight of central or upper-level departments within the same vertical chain, and kuai-kuai management, that a functional sector is directly accountable to local leaders, are deeply intertwined, resulting in a highly intricate management system.

One other essential aspect of this system is that the political promotion of the lower-level governmental officer is always "determined or directly influenced" by the performance evaluation of the upper-level leaders or supervisors (Wei, 2024, p. 148). Such "upward accountability" (Zhou, 2013, p. 12; X. Zhou, 2017, p. 140) mechanism tends to induce a political-performance-orientated or personal-evaluation-oriented tendency in regeneration projects, such as pursuing fast and visible results without threatening social stability (Wang, Wu and Zhang, 2024; Wei, 2024). Since the state apparatus structured in "matrix form" with functional authority division and "the superior authorities have a strong personal influence in performance evaluation, governmental sectors tend to shrink their governance boundaries (Shi, 2022, pp. 209–228) Therefore, when it comes to highly intricated urban issues requiring interdisciplinary and inter-sector cooperation exemplified by HUD regeneration, the strategies or actions are often fragmented into diverse short-term sections within the shrank scopes of different functional authority and the performance indicators can be over-simplified or drop-dimensioned (Shi, 2022; Li, 2025).[1]

3.3.Local community network

The power of local community network is primarily derived from the direct rights and interests of the local community members from grassroots level. Real-estate property-related rights and rights as neighbourhood member/ "the public" can be two major categories of the actors in this network. Real-estate property rights, based on the Constitution (National People's Congress of the PRC., 2018, art. 13) and the Civil Code (National People's Congress of the PRC, 2020, Article 114, 117& 207), are among the fundamental de jure power bases worldwide. (Li, 2025) In the context of HUD regeneration, there can exist multiple forms of real-estate property related rights (Liu et al., 2014; Li, Song and Lv, 2020), some times even distributed in a highly "fragmented" manner (Shi, 2022, pp. 159–184) resulting from multiple reasons including the path-dependent of Danwei (working unit) collectivism, the housing policy switches, and the influx of migrants since the late 20th century. There are multiple types of housing rights in the Chinese residential and commercial-residential HUDs, including private ownership, public housing ("Zhiguan" public housing, Danwei-owned public housing, military Danwei-owned public housing, etc) [2], tenants in private owned houses, informal temporary. (Wu, 2007; Li, 2025) Beyond real-estate property rights, local communities can also possess power as neighbourhood members or "the public" when comes to non-private affairs such as Hutong alley renovation and courtyard renovation for community outreach, though the legal basis of this right can be vague and controversial.[3]

Local residents can have various preferences when it comes to detail. While generally speaking, when the basic living conditions in HUDs are still limited, the locals are likely to prioritize the issues directly related to their real estate property and housing conditions over shared courtyards over the improvement of shared courtyards or "public" spaces and services, such as streetscape enhancements. (Shi, 2022, p. 256; Li, 2025) They tend to seek direct and visible benefits and address "practical issues" like expanding their housing space, upgrading basic living facilities such as kitchen and restroom facilities, and improving insulation and drainage. (Li, 2019, p. 50)

1 As an example, addressing HUD population pressure may be reduced to merely reducing the total population in the quarter, without taking into consideration the micro-scale population imbalances or the further rehabilitation of vacated housing.

2 Public housing is a product of the planned economy time in the last century. The de-jure owner of these properties is the local Housing Management Bureau (Zhiguan public housing)or property-owned Danwei (multiple types of danwei housing) and the household can "rent" the houses at a low cost and the lease can function as a "de-facto infinite contract" (Ni, Zhang and Huang, 2017, p. 66) that can be passed to their off-springs. The households of the allotted public housing can not merely be considered as "tenants" and their scope of property-related interests is not clearly-defined in the switch away from the planned economy since the late 20th century.

3 Agreements have not been reached whether the local residents should be considered as "stakeholders" or merely "the public" in this kind of issues. (Zhao, 2015)

They may also make "private intrusion into public space" (Amin, 2008, p. 23; Li, 2021, p. 400), wait for governmental support as "free riders"(Li, 2018, p. 72), and appear to offer "flexible and tactful" arguments (Wei, 2024, p. 156) based on their own interests.[4]

The structure of the local community network is comparatively loosely-organized and holds limited power. In urban conservation contexts, three main types of organizations at grassroots level are commonly observed, namely Neighbourhood Committees (NCs, "ΔΔΔ"), Owner's Committees (OCs), and community-based Civil Social Organizations (CSOs). Among them, NCs are always the most fundamental and widespread setting throughout urban China, featuring a dual nature. (Li, 2025) On one hand, they serve as "self-governance" bodies intended to support local residents in "managing their own affairs, educating themselves, and serving own needs." (Standing Committee of the National People's Congress (NPC), 2018) On the other hand, they function as grassroots extension of the party-state bureaucracy, especially when implementing tasks delegated by local governments and their agencies. In practice, some NC members may adopt a behaviour logic of "selective policy implementation" (Yang and Yu, 2012, p. 107) among the administrative sub-contracts and diverse local interests.[5]

In addition to these formal organizations, there can also exist informal and implicit institutions in the local communities. For example, there can be small-scale endogenous structures in some HUD courtyards (with multiple families and households) through kinship, prestige, tenancy relationships, and long-term gaming, etc., and there might be a endogenous "leader" or "facilitator" within this structure. (Li, 2025) When it comes to HUD renovation, the courtyard "leaders" in these endogenous structures can serve as important roles during multi-actor negotiations. (Feng et al., 2020, p. 47)

3.4.Economic Network

The power of the economic network lies in the possession, control, or authorized use of diverse forms of resources in the circuits of production, exchange, distribution, etc. (Li, 2025) In the Chinese context, the institutional structure of economic networks is characterized by intricate interactions between state control and capital appreciation especially through market operations. Instead of "the functioning of the government will have to follow market principles," (Zheng and Huang, 2018, p. 23), the market in China is always "subordinate to the state" and operates "within the boundaries set by the latter." (Zheng and Huang, 2018, p. 58) and the state can control over key scarce production factors, such as land and natural resources. In HUD renovation, the key production factors, the ownership and use rights of urban construction lands, often playing a dominant role in the practical circuits of economic activity.

As for HUD renovation and redevelopment, the key actors in the economic network always feature a combination of state management and market operation. These entities typically function both as participants in the marketplace and as "operators" extending the influence of local states. Among the most representative organizational forms are Chengtou platforms (urban investment platforms) and venture companies jointly established by developers and local state actors. (Li, 2025) Chengtou platforms are state-owned enterprises "specialized in urban development and investment." (Feng, Wu and Zhang, 2022, p. 1260) They are always responsible for specific governmental-led projects related to financing, infrastructure construction, urban development, and public sector management. Most, if not all, Chengtou platforms depend significantly on governmental resource injection, operate in alignment with local state objectives, instead of simply prioritizing short-term profit as purely market-driven players. However, the state affiliation cannot exempt them from the rules of financial and production markets. (Li, 2025) Even with local state backing up, Chengtou platforms have to pay attention to their debt risks and cash flow circuits. Therefore, a number of key actors in the economic networks, exemplified by the Chengtou Platform and the venture companies, can feature a dual character of state governance and market functioning.

4 As for an example, residents in cramped living spaces may argue the encroached areas as public when seeking governmental funding for yard renovation, yet assert ownership of the additions when requesting compensation for demolition. (Li, 2021, p. 401)

5 As an example, Li-Alin, a university scholar, and her team once worked on a Beijing Hutong courtyard improvement in Dashilar. (Li, 2018) At first, the local NC actively supported Li and her team since the NC members wanted to make Li's renovation as part of their administrative achievements in performance assessment. When they found that the local state would not cover all the expenses and the courtyard residents have to pay around 80% of the renovation cost, they considered it a "thankless task" and might create conflicts with the courtyard residents. So they stopped their support for Li's renovation project. The switch in the attitude of the local NC indicates their selective priorities in the course of time.

In addition to real-estate property operation entities, HUD renovations may also involve other marketplace-related actors, including actors and companies engaged in creative industries and tourism development as well as local-based business associations and chambers of commerce (Wu, 2014).Similar as the Chengtou platforms, not all of these actors prioritize on the top of the list the monetary profits under a capitalized market, which can be further discussed in more specific cases or scenarios.

3.5.Expertise network

The power of the expertise network comes from the recognition and authority of expertise, the reliable judgement based on professional knowledge, rules, theories, and standards. (Li, 2025) Actors within this network, such as university scholars and industry experts, often share foundations in philosophical orientations, methodological approaches, education backgrounds, or normative principles in their specialized fields and these consensuses can be reflected in academic research, professional practices, and collaborative projects. (Li, 2025) The expertise network may be described as a community with "a certain degree of autonomy" (Chen, 2018, pp. 144–151) grounded in shared professional consensus, typically camped at academic or professional institutions, exemplified by planning institutes, colleges, and universities. Ideally speaking, the actors in the expertise network adhere to their professional standards and ethical norms, though in practice their decisions are often shaped by competing concerns and contextual constraints that need be further examined in specific scenarios.

HUD renovation projects call for the engagement of expertise network actors, particularly those in urban studies, planning, architecture, landscape design, and heritage conservation. Currently in China, they are most likely to take on roles as technical supporters and consultants -- exemplified by the urban planners and conservationists drafting HUD planning plans and proposals for the local states – or as procedure reviewers, such as the Expert Committee, assessing and evaluating the conservation plans. However, in most of the cases, the experts as technical supporters are not collaborators for decision-making and it is local party-state that have the actual power to make the final decisions. (Wei, 2024, p. 147)

In addition to technical supporters and procedure reviewers, actors in the expertise networks have increasing chances to be involved in a growing scope of grassroots-level HUD renovation. For example, urban planners and university scholars in Beijing now have the opportunity to act as "responsible planners," serving as versatile roles covering "planning issue researcher, planning and design document reviewer, neighbourhood/ community renewal guide, cooperation facilitator and coordinator, public participation organizer" (Tang and Zhang, 2023, p. 140) in various community-building and environmental improvement practices.

3.6.Other Actors

There are also other actors in the renovation that embody the characteristics of multiple power networks depending on the case. NGOs, for example, may play an active role particularly in incremental HUD renovation projects rooted in local communities. NGO members may come from the expertise network, offering skills in design, environmental management, and community engagement, while others may be part of the local community network, such as long-term residents or Neighbourhood Committee workers involved in daily governance and grassroots coordination.

4.Discussion

4.1Reflections on the Chinese HUD power network

Drawing on the bounded rationality hypothesis and actor-centred institutionalism, the study proposes a theoretical framework to depict and analyse the actors' power, institutional structure, mindsets and behaviour pattern. It may not capture the full complexity of every individual actor, but it can contribute to understanding HUD renovation mechanism from an actor institutional perspective as well as creating explanations for renovation processes and results. Through the identification and analysis of major actor networks in China, the research generates insights into both the contextual features and practical pathways of HUD renovation efforts.

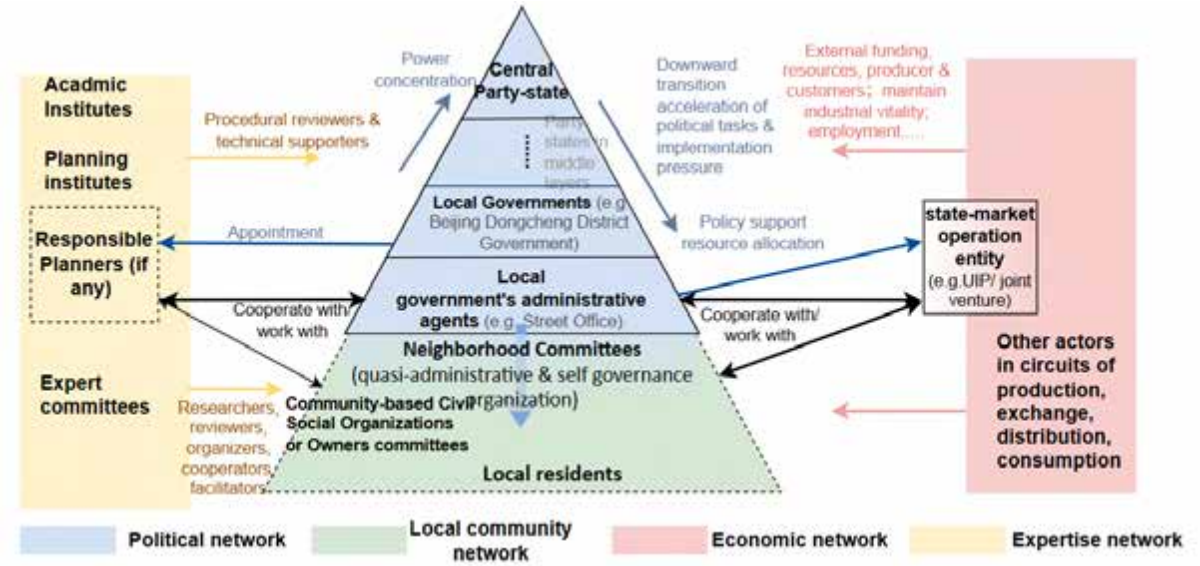

Figure 2 Diagram of the four network interaction in a typical Chinese HUD renovation/regeneration cases

First, party-state institutions in China possess substantial power and resources, enabling them to more readily initiate or promote HUD renewal projects and act as a leading role in major decision-making processes. A number of key actors in other networks, exemplified by the Neighbourhood Committee members (local community network) and Chengtou Platform (economic networks), and even some professional groups (expertise network), often feature dual nature and take into party-state interests into account. Thus it highlights the importance of closely examining the behavioural logics of the party-state institutions. Therefore, promoting inclusive, multi-actor engagement must go hand-in-hand with efforts to strengthen internal motivation within state institutions, for example, by establishing more balanced and context-sensitive performance evaluation criteria within the governmental system. In addition, given the risk of functional fragmentation among different governmental sectors, fostering inter-departmental collaboration may be a key challenge in HUD renovation, particularly in addressing interdisciplinary concerns and achieving holistic improvement.

Further explorations are required on an increasingly inclusive participatory approach, where local communities and professionals play increasingly significant roles in the decision-making process. As we can see, though the other three networks have been largely impacted by the power of the party-state, they still have separate primary thrusts and power sources other than political power and a number of local residents, experts, and business operator have their own mindsets, interests, and insistence beyond or against the pursuit of local governmental political goals and personnel evaluation, and many of they did or do challenged the local party-state decisions through multiple channels based on their rationale or principles. (He, 2016, pp. 88, 133–135, 158–159; Zhang *et al.*, 2019; Wei, 2024) For example, it can be encouraging to see a growing trend of professionals in urban planning, architectural design, and heritage conservation engaging in long-term, locally rooted studies. Rather than serving solely as technical consultants to local authorities, they are more likely to create a deeper and more comprehensive understanding of the sites and the local communities and contribute to more resilient, empathetic, and place-sensitive renovation strategies by immersing themselves in the site and developing interpersonal relationships with local residents.

4.2.Reflections on the power network analyse framework

The research creates the four-power network framework and applies it to the context of Chinese HUD regeneration contexts. The framework proves effective in analysing and illustrating the power source and institution-shaped motivation and behaviour patterns of various actors involved. However, its application in the Chinese context reveals that the framework serves more as a preliminary tool for analysing actor participation. While diverse actor networks can be identified, they are often not fully independent in practice. Its application to the Chinese HUD contexts indicates that the framework is just a starting point of the actor participation analysis. Though diverse actor networks can be identified, they are not that independent in real cases. In the Chinese contexts, it is

clear to see that the power of the party-state can always be more determined and dominant than others in the Chinese contexts and actors in other networks can feature dual characters shaped by the pervasive influence of the party-state apparatus. Therefore, further case-specific studies are still required to look into the interactions and negotiations among different networks.

5.Conclusion

The study draws on the bounded rational hypothesis and Mann's power network framework and proposes a descriptive and analytical methodology for examining actor institutions within the context of Chinese HUD renovation. By constructing a panoramic overview of key actors' power bases, organizational structures, and motivations and mindsets, the study identifies several institutional challenges regarding the Chinese HUD renovation, especially the imbalanced power distribution. Although the methodology is applied specifically to the Chinese urban renewal context, it holds potential for broader implementation by categorizing and analysing various types of power networks and their distinctive features in other cases. One of the key strengths of this approach lies in its capacity to interpret actor-related urban dynamics from an integrated and holistic perspective. By examining the institutional mechanisms underlying individual actions, it helps to reveal the structural drivers behind actor decision-making, thereby offering meaningful implications for future institutional design.

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Typologies and Dynamics of Urban Growth Projects in Ethiopia: A Discursive Analysis

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Abstract
This paper analyses the typological evolution and discursive construction of urban growth projects (UGPs) during the EPRDF and Prosperity Party (PP) periods in Ethiopia. Using typological analysis and critical discourse analysis (CDA), the study identifies three types of UGPs, namely housing and infrastructure, urban renewal, and industrial parks, and reveals their continuity at the material level despite their different development patterns. Despite the Prosperity Party's critique of the EPRDF model, both use UGPs as a legitimising tool for governance. The study highlights that UGPs consolidate authoritarian governance pathways, shift discursive logics from state-led industrialisation to market-oriented global competition, and document grassroots tensions between national narratives and local realities.

Keywords: Ethiopia; Discourse; Urban Growth Projects

1 Introduction

Ethiopia is one of the fastest growing economies and urbanising countries in sub-Saharan Africa. The rapid expansion of existing urban areas and the significant increase in the number of new cities highlight the remarkable trend of urban growth in Ethiopia. Up to 2015, Ethiopia's GDP growth rate exceeded 10%, and although the growth rate has slowed in recent years, it remains above 5% per annumΔWorld Bank, 2025Δ Urbanisation has also progressed at a remarkable pace alongside economic growth, with an urbanisation rate of 23% by 2022, indicating a period of rapid urbanisation. According to the Blue Ribbon Panel Report, the urbanisation rate is projected to reach 37.5% by 2050 (Ethiopia2050). According to Ethiopia's Ten-Year Development Plan, the country has approximately 4,000 urban areas, while the 2007 National Population and Housing Census recorded over 2,000 urban areas. The significant difference between these figures not only reflects adjustments in statistical methodologies, but also highlights the rapid urban development that Ethiopia has experienced over the past decade. In the context of rapid urbanisation, the Ethiopian government has long promoted urbanisation and modernisation at the national level through a series of large-scale Urban Growth Projects (UGPs). These projects are not only spatial development initiatives, but also crucial tools for national governance, economic restructuring and the construction of political legitimacy.

I tracked three major types of urban development projects implemented in Ethiopia after the collapse of the Derg regime in 1992, with a particular focus on comparing project dynamics during the EPRDF and Prosperity Party eras. We found that the Prosperity Party emerged as a challenge to the EPRDF's failed attempts at democratisation and ethnic issue management, promoting political and economic policies that were fundamentally different from, and even in conflict with, the EPRDF's vanguard capitalism. It has widely criticised the material legacy of the EPRDF era, pointing out that numerous large-scale development projects (such as the urban light rail, industrial parks and the Addis Ababa-Djibouti railway) have faced controversy and challenges in implementation, reflecting the UGP's 'fragility' and 'insecurity' at the material level. However, the two parties share continuity in the types of large-scale projects they choose to develop and similarities in the material forms they adopt. Nevertheless, the symbolic functions of these projects in national narratives, the construction of ethnic identities and the maintenance of regime legitimacy remain powerful. To explain this contradiction between ideological denial and practical consistency, we further introduce the method of Critical Discourse Analysis (CDA), following a research path of 'textual analysis-interpretation-explanation', to explore the discursive practices of the UGP in different discursive contexts, as well as their continuity and discontinuity in the ideological dimension. Focusing on the linguistic construction practices of Ethiopian discourse, this study attempts to explain the representation of the discourse of large-scale urban projects from the perspective of critical discourse analysis, demonstrating its role within the framework of national ideological formation and governance logic.

This study first outlines the "toolkit" for promoting the growth of urban spaces in the Global South. Second, we describe the typology of urban growth in Ethiopia through its urban policy documents and urbanisation policies, and compare the similarities and transformations in their trajectories between the EPRDF period and the PP period. In the fifth part, we analyse representative discourse cases to examine their constitutive functions, especially in relation to the macro-political environment, and the interpretive role of macro-discourse in the projects.

2. A toolkit for spatial growth in sub-Saharan African cities

Under the dual influence of globalisation and neo-liberal development, cities in sub-Saharan Africa are widely adopting different urban development projects. Through radical 'character-shaping' approaches, they are reconfiguring territorial resources, transforming social structures and pre-emptively establishing urban economic systems(Ansar et al., 2017; Flyvbjerg, 2014) to help emerging cities - especially megacities in sub-Saharan Africa - move towards the vision of becoming "global cities"(Hirschman, 2014). These tools are diverse, including radical mega-urban renewal projects, new city concepts such as smart cities and eco-cities, and location-based industrial policies represented by industrial parks (IPs) and special economic zones (SEZs). The spatial growth instruments of cities in sub-Saharan Africa can be divided into two categories based on their interaction with the local economic system and urban structure: inward-oriented and outward-oriented.

The core of outward-looking spatial policy tools lies in the creation of 'hyper-localised' spatial hubs to effectively connect cities in the Global South to the global network. These tools often break through existing spatial patterns and functional divisions of urban systems, constructing new engines of growth that are relatively parallel to the local economic system but serve global capital flows and supply chain integration. Among these, place-based policy instruments, represented by industrial parks (IPs) and special economic zones (SEZs), are widely seen as the key link between industrialisation and urbanisation(Kihiko, 2018; Shen et al., 2023; Weldesilassie et al., 2017a). In sub-Saharan Africa, industrialisation is widely recognised as an effective way of improving factor productivity, promoting labour transfer and optimising resource allocation. Faced with the twin pressures of urban sprawl and rapid population growth in the context of globalisation, SEZs and IPs have therefore been given high priority by governments as important strategies for promoting urban growth.

In addition to IPs and SEZs, new cities have also emerged as an important spatial form in recent years. Compared with traditional industrial parks, new cities are more flexible in terms of spatial location and functional positioning, usually located on the outskirts of cities, with diverse structures and composite functions. These new cities are not only key components of the country's overall political and economic strategy, but also take on the task of promoting the development of specific industrial sectors (such as information technology, ecological and environmental protection, and smart city construction)(Côté-Roy and Moser, 2022). It is worth noting that new city projects are often led by private capital or multinational corporations, targeting the middle-class consumer market(Keeton, 2019), with the core objective of attracting foreign direct investment (FDI) and stimulating economic growth(Watson, 2014). In contrast to SEZs and IPs, which prioritise the integration of industry and urban development, new cities place greater emphasis on spatial image, livability and the incorporation of global governance concepts, serving as 'showcase spaces' that link local and global contexts.

Inward-looking UGP aims to address structural deficiencies in existing urban systems by activating the productivity of local elements through spatial interventions, typically implemented within urban boundaries. This category includes mega urban renewal projects and green space projects within cities, such as light rail infrastructure projects. MURP serves as a tool for large-scale restoration and redevelopment of urban spaces, reshaping the topography of existing large cities as part of efforts to strengthen the economic competitiveness of megacities in the context of global competition(Swyngedouw et al., 2002). Due to widespread structural problems in sub-Saharan African cities, such as weak infrastructure and inadequate governance frameworks(Kamana et al., 2024) African cities in a quest for modernity and prosperity have been urgently playing catch up to deal with the increasing demand for adequate urban systems and infrastructure. At the turn of the 21st century, many spatial planning models, technological trends, environmental challenges, and socio-economic realities are influencing African cities' dynamics largely causing confusion and a lack of consistent planning policies. To efficiently guide a coherent and coordinated vision, frame an integrated long-term spatial logic, and give a precise direction for sustainable urban development, this paper aims to develop a localized and contextualised analysis of urban planning challenges and development strategies shaping African cities. The study provides a broad perspective

looking at the potentiality of spatial planning practices to envision and transform urban life by prospecting integrated urban planning and development strategies to face increasing urban challenges in Africa. Through Systematic Literature Review (SLR, urban renewal in these cities is based on rapid urbanisation and slum expansion, and aims to comprehensively and radically reshape the existing spatial structures of several African cities(Grant, 2015). Drawing on examples from South Africa and Ethiopia, MURPs can also be part of broader modernisation reforms that follow the neoliberal logic of urban development(Lindell, 2019), accompanied by global mobility and gentrification(Hayes and Zaban, 2020). National governments drive regional development through large-scale investment, using the externalities of urbanisation to stimulate other sectors of the economy(Zhang et al., 2023). These cities undergoing large-scale reconstruction are typically the capitals of African countries, which use MURPs to reshape the urban landscape and spatial layout, thereby demonstrating the power of the national government(AFRICA, 2018).

3. Methodology

This study aims to analyse the typological evolution of UGPs in Ethiopia through different historical periods and the logic underlying their discursive construction. Given the complexity of urban development policies in the dual dimensions of 'materiality-symbolism' and 'practice-narrative'(Smith, 2016), single spatial or institutional analytical approaches are insufficient to fully explain how UGPs are continuously conceived, legitimised and adapted as tools of development governance. Therefore, this study adopts a research approach that combines typological analysis and critical discourse analysis (CDA) to reveal the spatial practice mechanisms and discursive legitimation logic of UGPs within the political-economic structure.

3.1 Theoretical Methods

First, this paper uses typological analysis to identify the main characteristics of urban growth projects in Ethiopia across different time periods in terms of policy orientation, spatial form and governance models, and identifies four types of UGPs represented by mega-infrastructure projects, urban renewal, industrial parks/special economic zones. This classification not only facilitates spatial comparison, but also reflects the interactive logic between UGP and national development strategies, and forms the basis for structural analysis.

In order to understand the operational mechanisms of UGP projects not only as "material entities" but also as "symbolic representations", this study also introduces CDA as a core explanatory tool. Based on a constructivist theoretical stance, which posits that social reality is not an objective, independently existing entity, but a social process of constant construction, negotiation and reproduction through language and discourse in specific contexts(Fairclough, 2013; Van Dijk, 2015), discourse exists in a dialectical relationship with the social world(Mendes et al., 2024). The core assumption of discourse analysis is that "discourse not only reflects policy but also constitutes policy itself", with policy practices and discourse structures being mutually embedded and co-constructing reality(Hansen, 2013). CDA focuses on the role of discourse in structural elements such as power relations, ideology, institutional arrangements and social identity(Van Dijk, 2015). The theoretical tradition of CDA includes two main strands: the Marxist-oriented macro-historical discourse analysis, which focuses on the relationship between power structures and ideology; and the post-structuralist-oriented micro-discourse practice analysis, which focuses on the detailed interpretation of discourse practices in specific contexts(Sonn and Park, 2023). This study draws on the macro-level analytical approach of the Marxist tradition(Lees, 2004) and focuses on how discourse shapes the meaning and practice of urban growth projects in the intertwined power structure of state, capital and society. It situates linguistic practice within institutional settings and historical processes, revealing the dynamic relationship between events and discourse in UGP, as well as the diachronic changes of UGP in different institutional settings.

This paper introduces Fairclough's (1992) three-dimensional analytical framework(Lees, 2004), namely text analysis, discourse practice analysis and social practice analysis. Text analysis focuses on the use of vocabulary, grammatical structures, rhetorical devices and narrative strategies. The discourse practice level examines the production context of policy texts in relation to their interactive relationships with other texts, speeches and discussions. The social practice dimension discusses the ideology and power effects carried by discourse in specific social contexts, revealing how discourse shapes institutional arrangements and spatial practices.

3.2 Data and Method

This paper collects policy documents, project planning texts, speeches by leaders, memoranda of cooperation, mainstream media reports, and official promotional materials at multiple scales and levels, such as official development planning texts, development project texts, and influential media materials such as Addis Fortune, Addis Standard, and ENA. These texts constitute the 'official expression' sources for the discourse construction of the UGPs and provide the primary corpus for discourse analysis.

In addition, the research draws on fieldwork conducted in Ethiopia in 2024 and online and offline tracking of Ethiopian developments since 2016 to obtain interview material from a range of stakeholders, including government officials, Chinese company managers, local officials, project residents, academics, and media professionals. In addition to formal interviews, the research team conducted ongoing field observations and informal interactions during visits to the Eastern Industrial Park, Bole Lemi Park, and Corridor Plan sites during the UGP, and recorded informal conversations to further supplement the micro-level understanding of discourse practices.

4. Continuity of Ethiopian UGPs

Since the EPRDF (Ethiopian People's Revolutionary Democratic Front) came to power, Ethiopia has promoted three types of urban growth projects: first, housing and infrastructure projects, which are at the core of the EPRDF's strategy and are used to promote regional economic integration and national spatial integration; second, urban renewal projects, which were systematically implemented during the PP (Prosperity Party) period; and third, location-based industrial park development projects, which promote the coordinated development of industrialisation and urbanisation.

4.1 Mega-infrastructure

Large-scale infrastructure projects are key tools in the EPRDF's urban growth strategy, particularly in addressing the population pressure, urban poverty and developmental imbalances caused by rapid urbanisation. The EPRDF government emphasises strengthening regional connectivity and national unity through state-led infrastructure projects. Under the Growth and Transformation Plan (GTP), such projects not only serve to reshape the spatial structure of the country, but also symbolise the construction of a modern state.

In terms of transport infrastructure, the Addis Ababa Light Rail Transit (AALRT) and the Addis Ababa-Djibouti Railway are representative projects. The AALRT, which began construction in 2011 and was completed in 2015, is Africa's first electrified urban light rail system. It was built by the China Railway Group and the China International Engineering Consulting Corporation, financed primarily by low-interest loans from the China Exim Bank, and reflects the urban planning concept of Transit-Oriented Development (TOD). The 752km Addis Ababa-Djibouti Railway began construction in 2011, began trial operations in 2016 and was officially opened in 2018. It is East Africa's first modern electrified railway, built to Chinese standards by China Railway Group and China Civil Engineering Construction Corporation. It serves as a model for integrating the Belt and Road Initiative into Ethiopia's national development strategy.

While the policy logic and implementation pathways for infrastructure development underwent adjustments during the PP era, they continued to adhere to the basic characteristics of state-led, foreign investment-driven and engineering-integrated development established during the EPRDF era. Building on traditional road, rail and hydropower infrastructure development, the Abiy Ahmed government has continued to prioritise renewable energy projects, including wind farms such as Ashegoda, Adama I & II and Aysha. These projects not only meet the energy needs of industrial zones, but also support rural electrification and the Green Legacy initiative. Infrastructure projects during this period also showed more diversified characteristics, such as the experimentation with public-private partnership (PPP) models, the introduction of private capital, and the promotion of local government involvement in early project planning to improve implementation efficiency. At the same time, some projects attempted to localise the industrial chain, such as wind power projects that introduced local equipment manufacturing and tower production enterprises to explore ways for industrial synergy and development.

4.2 Urban renewal projects

During the EPRDF era, urban renewal was in its initial exploratory phase, focusing mainly on the spatial renovation of a small number of public nodes in urban core areas and the construction of civic amenities such as squares, parks and memorials. These projects showed clear characteristics of national image building and the strengthening of capital city functions. Overall, however, they remained fragmented and engineering-driven, lacking a systematic spatial intervention logic.

The Integrated Housing Development Programme (IHDP), launched in 2004, was the first institutionalised large-scale urban plan of this period, aiming to achieve multiple objectives such as spatial governance, social stability and urban image reconstruction through the construction of housing and the provision of infrastructure to address informal settlements. In Addis Ababa, the programme built nearly 500,000 low-income housing units over 20 years, primarily in the city's peripheries and secondary centres such as Bole-Summit, Yeka-Abado and Bole Arabsa, and extending to regions such as Legetafo-Legedadi in the Oromia region. This formed a model of urban expansion based on "residential orientation", which encouraged inter-district commuting and labour mobility.

During the PP era, urban renewal increasingly prioritised improving the city's image and global competitiveness, promoting a number of commercial, high-end and iconic urban projects, including the ADWA Museum and Unity Park, which are national symbolic engineering projects. Real estate and business development projects such as the 'Future City Economic Zone' (Lemi Future City) led by China Communications Investment Group, the La Gare Complex, Gelan Gura Village and Windows of Africa have also become key drivers of land restructuring and urban form transformation.

Launched in 2022, the Corridor Development Plan (CDP) has been hailed as 'the first development-centred public urban project since 2020' and represents the PP government's most ambitious urban spatial strategy. The CDP focuses on regional centres and major urban nodes, with road upgrades at the forefront, and integrates infrastructure network upgrades (including drainage, electricity and internet), slum rehabilitation, public service facility construction, tourism revitalisation and land development, reflecting the multiple objectives of African cities under the modernisation paradigm, environmental utopianism and the 'park city' ideal.

The most representative component of the CDP is the Addis Ababa Corridor Development Plan (AACDP), which was launched by the Addis Ababa City Administration in December 2022 and covers all of the city's sub-cities. The corridors in the plan range in length from 3.1 kilometres to 40.4 kilometres, with functions ranging from transport connectivity to urban renewal, such as the Anbesa Garage-Jakros-Goro section and the Kasanchis-Meskel Square-Arat Kilo axis. Each corridor links residential, commercial, industrial and entertainment zones, promoting multi-dimensional urban regeneration.

In addition, the plan includes two waterfront development projects: the Qebena River Corridor and the Entoto-Peacock River Corridor. These projects redefine the future development direction of the city by restructuring spatial interfaces. According to a relevant official from the Addis Ababa Planning Bureau (who was involved in the 2017-2027 Structural Plan and the design of the AACDP), although the AACDP, as an independent project, has a certain degree of 'planning exceptionality', its spatial structure still inherits to a large extent the urban structural design established during the EPRDF period, continuing the TOD concept and the high-density mixed-use development strategy of Zone 2.

4.3 Place-Based Industrial and Urbanisation Projects

IP projects represent the high degree of integration of the 'spatial expansion-industrial transformation' logic in Ethiopia's urban growth strategy. Since the establishment of the Eastern Industrial Park (EIP) through Sino-Ethiopian cooperation in mid-2007, Ethiopia has begun to formulate a spatial strategy for industrialisation based on the "enclave" model - the establishment of industrial parks in specific areas to attract the relocation of production and boost employment, exports and economic growth.

The EPRDF government sees SEZs and IPs as key instruments of its industrial policy, combining urban planning(Tesfaye, 2021), infrastructure development and investment promotion measures to establish functional parks in key cities(Tang, 2019).

The Ethiopian Industrial Zone Development Corporation (EIZDC), established in early 2010, serves as the national implementing agency for park development and was reorganised in 2014 as the Industrial Park Development Corporation (IPDC) to centrally coordinate the development and investment promotion of state-owned parks(Rodríguez-Pose et al., 2022; Zhang et al., 2018).

Since the establishment of institutions and legal frameworks for industrial park development, Ethiopia began to systematically plan and construct industrial parks. Currently, Ethiopia has 13 state-owned industrial parks, including the Bole Lemi Industrial Park, the Bahir Dar Industrial Park and the Hawassa Ecological Industrial Park, as well as 6 private industrial parks, 4 agro-processing parks and 2 public-private partnership special economic zones(Gao and Wang, 2025). However, criticism of Ethiopia's industrial park strategy has outweighed praise, with media, academic literature and official government reports widely pointing to its limited role in promoting industrial transformation, creating urban linkages and driving external infrastructure development(Weldesilassie et al., 2017b). The New Property Party and Prime Minister Abiy have adopted an ambiguous stance towards the legacy of the EPRDF, such as its intellectual property policy, while federal government officials at all levels have expressed a preference for economic zones in both public statements and private conversations(Wang and Zhang, 2024). In April 2024, the Ethiopian Parliament approved the Notification No. 1322/2024 (Economic Zone Declaration) to regulate Special Economic Zones (SEZs) [v]. In September 2024, the management teams of the country's industrial parks were required to transition to economic zones within a short timeframe, and the EIC established a new project office to oversee this process. At the same time, the EIC announced the upgrading of 10 out of 13 IPs under the IPDC to SEZs, including industrial parks such as Adama, Bahir Dar, Bole Lemi and Jimma. All private (mostly Chinese-invested) industrial parks were excluded from this process. An interview with an EIC consultant supported this view: "*Private parks (investors) can choose whether to upgrade to an SEZ, provided the procedures are followed. We are not currently taking any proactive measures to urge them (to upgrade)*". Taking the AWSEZ as an example, the construction of the ATSEZ, including the land preparation activities carried out by the city government before making the land available to CCCC, is part of the Capital Corridor Development Plan since 2023, marking the first integration of economic zones into the city's strategic framework. The ongoing Addis Ababa Corridor Development Project connects other areas of the capital with the ATSEZ in the Gotera region, positioning it beyond a traditional industrial park to become what the mayor has described as a "new city within the city" repositioning Addis Ababa's global urban competitiveness, commercialising land and becoming a major international shopping destination.

Figure 1: Project render of ATSEZ
Source : https://en.ccccltd.cn/xwzx/ywfb/202408/t20240823_215757.html

5 Discussion: The Discourse of Urban Growth Projects in the Dynamic Structure of National Governance

UGPs are not only tools for economic development and spatial restructuring, but also important arenas for the operation of state power and the production of ideology. Different types of UGPs are always embedded in the national development strategies and political governance logics of specific historical stages during their implementation, and their discourse forms and institutional settings exhibit complex dynamics. This chapter uses CDA to explore how the discursive dimensions of UGPs reflect, construct and shape national governance structures, and to analyse their manifestations in legitimacy construction, ideological production and discursive negotiation.

5.1 The Continuity of Power Discourse: The Multiform Expression of Authoritarianism

Although Ethiopia has undergone changes in its political structure and ruling ideology during the transition from the EPRDF to the PP, and the urban political discourse has been adapted and updated accordingly, the logic of power and the pathways of governance exhibit a high degree of continuity. This continuity is manifested in the state's continued dominant control over urban growth projects, their high degree of embedding in the spatial discourse, and the continued use of urban development as a tool for reshaping national identity and constructing legitimacy.

Three categories of urban growth projects - including IHDP, symbolic urban node projects (such as Unity Park and the ADWA Museum), and CDP - differ in their specific implementation content, policy objectives, and mobilising language. However, they all serve a common governance purpose: to reinforce the dominance of the state in the urban space, to shape the national development discourse, and to demonstrate national capacity in the context of globalisation. They concretise national development goals at the spatial level, mobilise collective emotional identity at the social level, and reaffirm the legitimacy of the regime at the political level.

The symbolic significance of these projects is particularly striking. In the IHDP, large-scale public housing not only attempts to solve the problem of urban slums, but also reflects the state's definition and norms of 'modern life'. Cultural landmark projects such as the ADWA Museum and Unity Park spatialise national historical narratives and the ideology of ethnic unity, reinforcing identification with national identity; the Corridor Plan, with its grand narrative of 'connecting to the future', projects a modern image externally while legitimising governance internally, serving as a multifaceted tool for urban governance and national construction. Media, government propaganda and policy texts often use discourses such as 'global gateway', 'model for African urban revival' and 'new spaces for the future' to legitimise development visions and integrate them into urban spatial practices.

More importantly, these projects translate national visions into tangible spatial entities that shape 'visible development'. In a context of relatively limited fiscal resources and administrative capacity, the visibility of development becomes a crucial mechanism for the exercise of power. By prioritising resources for a few symbolic projects, the government creates a visual landscape that conveys the state's control over the future, exerting a powerful perceptual influence on both the public and external observers. This approach perpetuates the spatial governance logic of authoritarian regimes, where 'symbolism trumps substance' - even if the actual services and welfare outcomes of projects are limited, their discursive efficacy can be manifested far beyond the projects themselves, providing a visualised legitimation for the state-led development logic.

In this process, discourse is not just a packaging language for policies, but an integral part of governance. Although the 'national imagination' behind urban growth projects takes different forms at different stages, it is highly normative and exclusive in nature, defining what constitutes the 'ideal space', the 'ideal citizen' and the 'ideal development'. This is the multifaceted expression of authoritarian governance discourse: it achieves political control through physical space and regulates social expectations and collective memory through cultural narratives. Urban space thus becomes a vehicle for ideology, and projects themselves are imbued with symbolic and emotional significance that transcends their functional purpose.

Urban growth projects are therefore not only economic and technical development practices, but also key tools of state governance discourse and symbolic politics. They embed symbolic structures of regime legitimacy in urban space and serve as important strategies for maintaining the ruling order 'in the name of development', revealing the deep-seated interaction between the continuity of urban policies and the symbolic logic of governance under Ethiopia's authoritarian governance.

5.2 From "developmental" to "development" The shift in development discourse

Ethiopia's development discourse has undergone significant changes under different regimes. From the 'developmental state' discourse of the EPRDF era to the 'development' discourse centred on governance performance and market orientation under the PP party, the nature and discourse logic of the UGP has also undergone a transformation.

During the EPRDF era, the development discourse was characterised by state-led initiatives, planning priorities and structural transformation, emphasising the promotion of 'industrial catch-up' and 'spatial balance' through state-led large-scale infrastructure and industrial policies. For example, Arkebe Oqubay, a key figure in Meles Zenawi's senior official team, frequently cited China's reform and opening up and the East Asian miracle as development experiences, and proposed the strategic goals of 'structural transformation' and 'industrial catch-up', closely linking the country's industrialisation efforts with China's assistance[i][ii]. The discourse of this period had a strong institutional learning orientation, describing development as a collective national goal whose legitimacy was derived from the state's right to shape the 'future'. This development logic emphasises state-led development, the prioritisation of large-scale projects and the institutional design of a developmental state. The development trajectory is based on structural economic conditions, a political party with a vanguard ideology of centralised policy and a capitalist market. Rents are seen as a strategic resource to expand the regime's economic base, redistribute wealth to integrate different social strata into the EPRDF, and promote sectoral and regional integration[iii]. These projects are directly linked to the EPRDF's state development discourse and its ideology-driven, organisation-based political system.

Since Abiy Ahmed came to power, the development discourse has placed greater emphasis on governance performance and market logic, in line with the state's radical privatisation of state-owned assets. The promotion of urban renewal projects often uses terms such as 'livability', 'connectivity' and 'transformation', representing a shift in the development narrative from statism to urban entrepreneurship. This shift in discourse structure reflects not only the evolution of development concepts, but also the shift in the state's approach to legitimacy - from "development promise legitimacy" to "governance performance legitimacy".

In addition, the development discourse expresses the competitive aspirations of the global city, selectively defining the actors of development rather than the socialist ideology of equity and integrated development emphasised during the developmentalist period. These projects became the PP's standard discourse for implementing neoliberal reforms, which gradually evolved into an entrepreneurial discursive framework centred on the 'image of the global city', 'investability' and 'efficiency of spatial governance'. Corporate discursive frameworks. Promotional materials and government statements use terms such as 'vibrant', 'liveable', 'competitive', 'transformation' in an attempt to transform urban space into a showcase for attracting capital.
"(AACDP) is the first development-focused public project since 2020, when completed, will deliver significant long-term benefits to relevant stakeholders. "

5.3 Counter-narratives and bargaining practices in the discursive space

Although the content of the discourse has been constantly adjusted under different regime changes, its logic of power and path of implementation show a high degree of continuity. The discursive forms of the three types of urban growth projects, although different, serve to consolidate national spatial dominance and the development discourse.

Urban growth projects are highly symbolic in the political space of Essex. They are not only tools for development, but are also used to carry the national imagination, demonstrate political achievement and guide identity. For example, the ADWA Museum has been described as a "spiritual symbol of national unity' and the Corridor Project as 'Addis Ababa's gateway to the world city".

By projecting and legitimising visions, the government creates a tangible visibility of development and reinforces its discourse with spatial objects. This symbolic politics plays a key role in the production of regime legitimacy, especially in the context of the state's relatively limited financial and administrative capacity, and the UGP is imbued with political and emotional significance beyond its function.Each of these discourses, although very different in form, has a normative role and is an integral part of the discourse of authoritarian government, with utility usually manifesting itself outside the project as a vehicle for the ideology of a given period.

Dominant discourses are not ironclad and are not always fully accepted or internalised. In specific local practices, the implementation of UGPs is often accompanied by a complex process of re-semanticisation, generating multiple negotiations and tensions around planning visions, spatial legitimacy and distributive justice. In the process of sinking, the national discourse faces both the reproduction of legitimacy and the challenge of resistance and counter-narratives.In the field research, some of the residents interviewed interpreted the 'modernisation' project as a process of 'displacement and exclusion', questioning its inclusiveness and local benefits. For example, a trader who has lived around Unity Park for almost a decade said of the park's construction: 'It's not our park, it's for tourists to take pictures of. For her, spatial regeneration does not mean a redistribution of public resources, but rather 'invisible exclusion' under the guise of 'visible development'. This micro-discursive practice reveals the tension between the dominant discourse of the state and the lived experience of the locality, as well as the multiple meanings of 'development' as a discourse of governance. Not only ordinary residents, but also local technical officials often play the role of negotiators and 'translators' in the implementation of projects. Not only do they have to carry out the spatial transformation tasks assigned by the central government, but they also have to respond to local realities of land disputes, relocation and resettlement, social stability, and other issues. As a result, some urban planners have confessed in interviews that in designing UGP projects they have to 'find a compromise between the national vision and local affordability', an act of mediation that reflects the 'gaping operating space' of planning in an authoritarian environment.

In addition, outside the mainstream discourse, some independent media and international observers in Ethiopia have gradually developed a counter-critical approach to the UGP discourse. Local media such as Addis Standard and Addis Fortune have repeatedly pointed out the lack of contractual transparency in large-scale infrastructure projects built by Chinese companies (e.g. the Addis Ababa-Djibouti railway, the 'beautification of Shegele' project and the Oriental Industrial Park), Addis Ababa-Djibouti railway, the 'Beautification of Shegele' project and the Oriental Industrial Park) have been criticised for their non-transparent contracts, unsustainable finances and limited local employment and technology transfer. These criticisms not only challenge the national narrative of 'development success'[ii], but also reflect the fact that there is a lack of transparency and financial sustainability behind the scenes of development projects. They also reflect the asymmetrical power relations inherent in development projects.

Although these critical voices are often subject to political regulation, censorship restrictions and even exclusion from official planning texts, they form the 'echo of marginal discourse' in the ecology of urban discourse and continue to influence public discussions and policy adjustments. These counter-narratives have not completely undermined the dominant discourse of the state, but they have forced it to make compromises and adjustments in practice, reflecting the 'limited space for negotiation' in an authoritarian environment. Ultimately, the UGP project is not a 'linear' process of development, but a field in which multiple forces, discourses and practices are intertwined. The generation of meaning is not predetermined at the outset, but is negotiated, contested and reconstructed in dynamic power relations. It is within these local tensions and negotiations that the true politics of the UGP project are revealed.

Notes

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Institutional Supply and Practical Pathway for Self-Renewal of Old Residential Areas in Hangzhou from a Multi-Agent Collaboration Perspective: A Case Study of Zhegong New Village

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Abstract
China's urban development is shifting from expansion to quality enhancement, with urban renewal emerging as a key policy priority. The Zhegong New Village case in Hangzhou presents an innovative resident-funded renewal model that addresses limitations of traditional approaches. Through a "Rules-Roles-Procedures" analytical framework, this study identifies three critical success dimensions: (1) supportive policy environment and favorable economic conditions; (2) collaborative governance featuring government's service transformation and enhanced resident participation; and (3) transparent procedural mechanisms including early engagement and professional evaluations. This model not only reduces fiscal burdens but also redefines responsibility allocation mechanisms, demonstrating significant improvements in both efficiency and social sustainability. The findings provide valuable insights for developing context-sensitive urban renewal models that balance economic viability with community empowerment, offering a replicable framework for China's ongoing urban quality improvement initiatives.

Keywords: Old Urban Residential Communities Resident-Funded Renewal Multi-Agent Collaboration Rules-Roles-Procedures Zhegong New Village

1. Introduction

China's urbanization rate is approaching the inflection point of 70%(Gu *et al.*, 2017), with urbanization entering its second half. Urban development is shifting from "high-speed growth" to "high-quality development"(Cao *et al.*, 2014; Guan *et al.*, 2018), making urban renewal the primary agenda for city development at this stage(Cao *et al.*, 2024; Shen *et al.*, 2024). According to China's Seventh National Population Census data, the country's urban housing stock reaches 33.3 billion square meters, with buildings constructed before 1990 accounting for 8.7% (approximately 2.9 billion square meters) and those built before 2000 representing 27.5% (about 8.1 billion square meters). China faces increasingly heavy pressure to renew aging communities(Liu *et al.*, 2024).

However, amid the downturn in the real estate market pressures, traditional development-oriented demolition-and-reconstruction renewal models and government-led old neighborhood renovations confront severe challenges(Xie *et al.*, 2024). The traditional renewal model, driven by sharing differential land rent through real estate demolition and resettlement, has seen its feasibility significantly decline due to high land replacement costs, making it difficult to meet current urban development needs and urgently requiring innovation and reform. In 2020, the General Office of the State Council issued the "Guiding Opinions on Comprehensively Advancing Urban Old Community Renewal Work," demanding the establishment of a "reasonable cost-sharing mechanism for renovation funds among government, residents, and social forces," rationally implementing residents' funding responsibilities, and actively promoting resident-funded renovations according to the principle of "who benefits, who pays."

In recent years, cities such as Beijing, Hangzhou, and Guangzhou have begun exploring renewal practices led by social forces, where residents actively participate in in-situ reconstruction(Wang *et al.*, 2022). These efforts provide new ideas for resolving urban renewal dilemmas and offer new pathways for improving living environment quality, stimulating effective consumption, and promoting high-quality urban development. Autonomous renewal is not merely simple in-situ reconstruction; its requirements for property rights integration, planning management, fiscal finance, and social governance reforms essentially constitute a comprehensive restructuring of China's spatial governance system and represent important content in the modernization of national governance capacity. Among these initiatives, Hangzhou's Zhegong New Village autonomous renewal project has achieved phased success. It has not only realized resident self-funding, conserving government financial resources, and redefined the division of responsibilities between government and residents in housing improvement and maintenance, but also significantly reduced renovation costs and substantially enhanced renovation efficiency and quality through supply-demand matching.

This paper uses the Zhegong New Village case as a window, combined with multi-agent collaboration theory, to propose a "rules-roles-procedures" analytical framework, attempting to decode the practical pathway and internal mechanisms of autonomous renewal in Hangzhou's old neighborhoods.

2. Literature Review and Analytical Framework

2.1 Paradigm Shift in Stock Land Renewal and Special Challenges of Community Renewal

China's urban community renewal is undergoing a profound paradigm shift. During the early reform and opening-up period under the land finance-driven incremental development model, community renewal primarily manifested as government-led physical space reconstruction and developer-driven commercial projects, exhibiting distinct economic-oriented characteristics(Sun *et al.*, 2025). With the implementation of the new urbanization strategy and the advent of the stock development era(Zhang *et al.*, 2024), renewal philosophies have gradually evolved from "spatial reproduction" to "social reorganization," extending from "physical environment improvement" to "community governance innovation". This transition demonstrates three salient features: a value orientation shifting from efficiency-first to balancing equity and efficiency, operational methods transitioning from large-scale demolition to incremental micro-renewal, and participation structures transforming from government-market duality to pluralistic co-governance. Particularly after the 14th Five-Year Plan proposed urban renewal actions, policy directions have increasingly emphasized historic preservation, equitable public services, and community resilience enhancement, fostering a people-centered, quality-oriented development paradigm(Chen *et al.*, 2016; Chen *et al.*, 2019; Zhao *et al.*, 2024).

The urban renewal process involves complex interactions among government, market, and societal actors(Liu and Zhang, 2024). Governments exert foundational influence through policy formulation and fiscal investment, yet exhibit distinct functional differentiation across administrative levels: central government focuses on institutional design, local governments on policy implementation, while grassroots units handle conflict mediation. Market entities, driven by investment returns, dominate commercial projects but frequently abstain from public-good initiatives with long payback periods. Social stakeholders-including residents and NGO-influence decisions through participatory mechanisms, though their effectiveness is constrained by organizational capacity(Zhuang *et al.*, 2019). These tripartite actors engage in dynamic game theory interactions: governments prioritize policy goals, markets seek profit maximization, and communities emphasize livelihood improvements. Innovative models like Chengdu's Caojialiang self-governance and Shanghai's public-private partnerships demonstrate successful equilibrium-seeking under institutional constraints.

Residential stock renewal faces unique implementation challenges requiring tailored mechanisms. Compared to commercial projects, residential renewals exhibit: 1) complex property rights structures with fragmented ownership, 2) economic infeasibility due to "negative rent gaps," and 3) divergent resident demands regarding facility upgrades(Zheng *et al.*, 2020). Consequently, residential renewal mechanisms rely on blended government-resident financing, grassroots party-building coordination, and synchronous maintenance systems. Current nationwide old neighborhood renovations demonstrate "government-led, community-participated, market-supplemented" characteristics, utilizing special subsidies and shared-cost mechanisms. Persistent challenges including funding sustainability and governance deficits necessitate breakthroughs in property rights systems and financial instrument innovation.

2.2 Public Participation Theory and Research Dilemmas in the Chinese Context

Sherry Arnstein's Ladder of Citizen Participation (1969) establishes an eight-rung typology from "non-participation" to "citizen control," systematically articulating hierarchical levels of public engagement and substantive influence(Varwell, 2022). This framework categorizes participation into three tiers: "non-participation" (manipulation and therapy) as tokenistic power-dominated pseudo-participation; "tokenism" (informing, consultation, placation) representing formalized limited involvement; and "citizen power" (partnership, delegated power, citizen control) signifying genuine decision-making authority(Lane, 2005). The theory reveals participation's essence as power redistribution, providing analytical tools for assessing participation quality across political systems. Subsequent theoretical developments evolved along three trajectories: 1) Hierarchical refinement, exemplified by Connelly's 12-level "participation continuum" emphasizing digital-enabled "virtual participation"; 2) Quantitative metrics, notably the World Bank's "Participation Intensity Index" employing 21 indicators across five dimensions for cross-national comparison; 3) Critical reconstruction, where scholars like David Harvey critique the theory's insufficient attention to capital's distortion of participatory processes,

advocating integration with "spatial justice" theory(Innes and Booher, 2004). Notably, global urban renewal practices since the 21st century demonstrate that "citizen control" remains rare in large-scale projects, with gradational government-led participation predominating.

China's urban public participation typically originates at the community level, emerging from governance issues concerning communal affairs. It is initiated by appeals to individual, collective, and localized public interests, mobilized by influential stakeholders, and expands from neighborhood committees to grassroots governmental agencies – thereby broadening channels for orderly political participation in grassroots governance. Community participation constitutes a governance behavior wherein resident groups and local authorities employ deliberative interaction, interest articulation, and public service provision under institutional, regulatory, and cultural frameworks to safeguard civic rights and communal interests in public affairs.

Arnstein's theory encounters three adaptive challenges in China's localization context: First, China's "strong government–weak society" tradition diverges from Western civil society foundations, creating disjuncture between formal participation and substantive impact during model transplantation. Second, community renewal complexities necessitate transcending linear participation models – evidenced by Beijing's "Jinsong Model" proving effective participation requires a government-market-resident "triangular governance structure." Research reveals China's community participation exhibits "embedded development": multi-stakeholder co-governance under Party leadership (e.g., Shanghai's "Red Property Management"); closed-loop procedures encompassing "demand collection-joint deliberation–implementation oversight-impact evaluation" (Chengdu's Caojia Alley model); and legal frameworks anchored in the Urban Residents Committee Organic Law. Third, while Carol Pateman's participatory democracy theory prioritizes individual rights, Chinese communities emphasize collective interest balancing. Consequently, "co-decision" concepts transform into "deliberative consensus" models during localization, exemplified by Guangzhou's Yongqing Lane renewal adopting "neighborhood covenants" to reconcile private rights and public welfare. Successful localization cases exhibit three characteristics: public-interest orientation at the value level, incremental renewal strategies operationally, and institutionalized participation channels at the governance level.

2.3 Analytical Framework: Institutional Foundations for Public Participation in Urban Renewal

Multidimensional practices in urban renewal reveal that the localization dilemmas of public participation and governance efficacy fundamentally stem from structural deficiencies in institutional foundations. The adaptation of Western participation theories in China exposes a core contradiction: when power allocation models encounter the traditional "strong government-weak society" governance structure, purely technical transplantation fails to achieve substantive empowerment; when capital logic intervenes in community renewal, value conflicts emerge between market entities' profit-seeking motives and the inclusivity of public welfare; when multiple stakeholders enter deliberative arenas, communication barriers arise between professionalized discourse systems and residents' quotidian demands. These structural contradictions manifest acutely in residential renewal projects-Chengdu's Caojia Alley redevelopment stalled through 107 failed negotiations due to fragmented property rights, while Guangzhou's Yongqing Lane commercial development ignited disputes over local cultural preservation, both reflecting trust crises rooted in institutional supply gaps(Ye *et al.*, 2021).

Essentially, the validity of public participation depends not merely on participation ladder gradations but crucially on institutionalized capacities enabling multi-stakeholder collaboration, requiring three safeguards: normative establishment of legal frameworks defining rights and responsibilities to avoid "tokenistic participation" traps; cultivation of professionalized stable actor networks to balance diverse interests; and operational design of predictable procedural mechanisms to reduce deliberation costs.

Therefore, transcending the conventional "government-market-society" tripartite analytical paradigm becomes imperative to focus on systemic institutional construction. This paper proposes a "Rules-Roles-Procedures" framework where rules encompass urban renewal legislation, technical standards, and certification systems; roles denote key institutional actors operating predictably through reputation and expertise, including renewal implementers, expert decision-making systems, and independent social intermediaries; and procedures refer to regularized action plans such as standardized renewal protocols, robust participation/supervision mechanisms, and full-cycle information disclosure.

Collectively these constitute stabilized standardized shared expectations: roles and procedures directly form explicit expectations while rules indirectly shape expectations through institutionalizing roles and procedures. Together they establish the institutional bedrock for trust-building in urban renewal.

3. Study Area Context and Key Challenges

3.1 Background of Hangzhou's Urban Renewal

Hangzhou's urban renewal process exhibits distinct phased evolutionary characteristics. In the early 21st century, the city pioneered old-town renewal projects focused on improving living environments, primarily addressing aging infrastructure and public service shortages. With accelerated urbanization after 2008, efforts shifted to urban village redevelopment through spatial restructuring to enhance urban aesthetics and functionality. From 2015 onward, systematic renewal emerged, with comprehensive neighborhood revitalization as the cornerstone, promoting equitable public services and intensive land use. Entering the 2020s, Hangzhou transitioned to holistic renewal, balancing high-quality economic development with quality-oriented urban enhancement. By 2023, cumulative implementation of 2,498 renewal projects with 48.9 billion yuan in investment had created a dual-pattern emphasizing both scale and demonstration effects.

In governance innovation, Hangzhou progressively established a pluralistic collaborative modern governance system. In terms of actors, it evolved from government-dominated approaches to "government-market-society" co-governance-exemplified by Gongshu District's "community planner" system introducing professional expertise, and Shangcheng District's "resident council" mechanism ensuring public(Innes and Booher, 2004) participation. Methodologically, practices shifted from crude "demolition-reconstruction" approaches to refined quality improvement of existing assets, as seen in Xihu District's "micro-renewal" techniques preserving historic neighborhood character. Strategically, renewal models transitioned from real estate-driven development to sustainable operations, with Qiantang District piloting "renovation+operation" integrated models to balance social and economic benefits. The 2023 Implementation Opinions on Comprehensive Urban Renewal institutionalized tasks like dilapidated housing renewal and neighborhood rehabilitation, marking a new standardized phase.

3.2 Zhegong New Village: Profile and Renewal Challenges

3.2.1 Basic Profile

Zhegong New Village, situated in Gongshu District of Hangzhou, was established in 1983 as faculty housing for Zhejiang University of Technology (ZJUT), representing a typical aging residential community. The complex comprises 13 residential buildings constructed before 2000, with unit sizes ranging from 38 m² to 93 m². The property rights consist of a mix of public housing and privatized public housing, primarily occupied by university faculty and their families. In 2014, four buildings (including Building 67) were professionally assessed as Class C dangerous structures, indicating compromised load-bearing capacity and safety risks. Since 2012, residents had repeatedly negotiated renewal with district authorities. In 2015, the former Xiacheng District government proposed a complete reconstruction plan for all 13 buildings, but it was suspended due to failure to achieve the required 90% resident consensus. Subsequently, resident representatives persistently advocated for renewal through legislative proposals and petitions. After 11 years of efforts, the organic renewal project formally commenced in April 2023 under an innovative "resident-initiated application and demand with government service provision" model. The project achieved key milestones including resident agreements finalized in June 2023, project approval in August, feasibility study endorsement in September, preliminary design completion and resident relocation in October, and construction permit acquisition with demolition commencement in November – setting the "Zhegong Speed" benchmark for Hangzhou's urban renewal. Total investment reached approximately 532 million yuan, with residents contributing about 470 million yuan (88.5%), supplemented by government special funds for old community renewal, elevator installation, and future community development. As Hangzhou's inaugural resident-led renewal pilot, it established a "resident-funded, government-subsidized" renewal paradigm.

3.2.2 Key Challenges

As a typical university-affiliated community, Zhegong New Village exhibits three demographic features: high aging rate (71% aged 60+), high homogeneity (68% retired faculty), and high property rights complexity (public/privatized/commercial housing mix).

First, multi-dimensional conflicts hampered consensus-building. According to official records, significant financial disparities divided the 538 households: owners of 38 m² units faced 360,000 yuan expansion fees under Hangzhou's 2021 pricing standards, while larger-unit owners paid only base reconstruction costs. Community surveys revealed 43% of elderly residents could not afford expansion fees, resulting in polarized support. During June 2023 signing, 132 households (24.5%) objected – 89 being small-unit owners. Furthermore, 35% public housing tenants needed upfront payments of 50,000–80,000 yuan for ownership conversion per municipal regulations, with 62% unable to shoulder dual expenses.

Second, institutional barriers arose from complex property rights. The coexistence of unconverted public housing (35%), privatized public housing (60%), and commercial housing (5%) created complications. Twenty-eight public units had unresolvable historical ownership issues per real estate registry records. Area expansion policies triggered disputes: while provincial guidelines allowed purchasing ≤20 m² at 18,000 yuan/m², 41% residents deemed this higher than the neighborhood's 12,000 yuan/m² market average. Ownership allocation of new underground parking spaces (231 added to original 82) also caused conflicts, with ground-floor residents claiming priority rights.

Third, financial sustainability concerns persisted due to an inverted pyramid funding structure. Residents bore 88.5% (471 million yuan) of total costs. Owners of 38 m² units faced combined fees of 739,000 yuan – equivalent to 9.7 times their average annual income. Twenty-seven low-income households could afford no payments, with compensation only permitting 16 m² housing purchases in remote suburbs. The requirement for an initial 60% payment severely strained cash flows for over half of residents relying on housing fund withdrawals.

4. Analysis and Discussion

4.1 Changes in the Environment

4.1.1 Changes in Political-Economic Environment

The advancement of self-renewal in Hangzhou's old residential communities first stems from macro policy guidance and shifts in local fiscal models. Since 2020, national policies such as the Guidelines on Comprehensively Promoting Urban Renewal in Old Residential Districts have explicitly required establishing a sustainable renewal mechanism of "government guidance, market operation, and public participation." As a common prosperity demonstration zone, Zhejiang Province pioneered a fiscal fund "phase-out" mechanism, with provincial urban renewal special funds decreasing by 37% in 2023 compared to 2021, forcing local governments to innovate financing models. Hangzhou achieved breakthroughs through three key measures: first, establishing a "shared renovation cost" mechanism, exemplified by the Zhegong New Village project where residents bore 60% of construction costs, government subsidies covered 30%, and enterprises conceded 10%; second, innovating the "renewal unit" land policy, allowing increased floor area ratio post-renovation to generate value-added benefits for cost balancing; third, issuing China's first "special urban renewal bond," with Shangcheng District raising ¥1.26 billion through this channel in 2024. This transformation effectively avoided government debt risks from traditional shantytown redevelopment, reducing Hangzhou's government debt ratio by 4.2 percentage points in 2024 compared to 2021.

4.1.2 Socio-Cultural Environment Changes

Increased resident agency consciousness and improved community governance systems formed the social foundation. A 2023 survey by Hangzhou's Housing and Urban-Rural Development Bureau revealed that 68% of residents in core urban old communities held bachelor's degrees or higher, with average household financial assets reaching ¥2.87 million, driving strong demand for asset-value preservation. In the Zhegong New Village case, a resident-initiated renewal committee achieved a 98.4% signing rate after 11 months of consultations with all 252 households—setting a record for Hangzhou's renewal projects. This high compliance resulted from three mechanisms: First, the "sunshine disclosure" system requiring three rounds of community hearings for renovation plans; second, the "tiered reward" policy granting 5%–15% area incentives to early-signing households; third, the "objection negotiation" platform implementing individualized solutions (e.g., "property-right exchange + rental subsidies") for seven disadvantaged households. Notably, integrating community renewal with "Future Community" initiatives completed 56 standard installations (e.g., elevators, smart security systems) by 2024, directly enhancing resident satisfaction.

4.1.3 Transformation of Urban Renewal Concept

A paradigm shift from "development-oriented" to "operation-oriented" reshaped value assessment frameworks(Ouyang *et al.*, 2025). Hangzhou's 2022 Urban Renewal Action Plan established the "Three No's Principles": no large-scale demolition, no destruction of historical features, and no floor-area ratio increases for resource overdraft. Three implementation pathways emerged: For brick-concrete structures built before the 1980s (23% of total inventory), adopting "structural reinforcement + functional implantation," such as converting textile factory dormitories in Gongshu District into cultural-creative spaces; for frame-structure buildings constructed in the 1990s (61%), implementing "comprehensive refurbishment + facility upgrades," exemplified by photovoltaic roofs and rainwater recycling systems in Cuiyuan area; only Grade-D dangerous buildings (16%) underwent reconstruction. Crucially, Hangzhou established a "whole-life-cycle" revenue assessment model incorporating 20 years of operational income into scheme evaluations, shifting social capital from "quick profits" to "long-term operation."

4.1.4 Innovations in Planning Policy Support

Systematic institutional breakthroughs provided implementation safeguards. Hangzhou created a "1+4+N" policy framework: "1" refers to the 2023 Hangzhou Urban Renewal Regulations, legally affirming self-renewal legitimacy; "4" comprises specialized documents on planning management, land policy, funding mechanisms, and technical standards; "N" denotes district-level implementation rules. Operational innovations included: First, a "dual-track" approval process reducing processing time from 96 to 15 days for sub-3,000 projects via a filing system; second, a "renewal land price" system valuing land at original-use prices (40–60% below auction prices); third, an "architect responsibility system" requiring design institutes to oversee 10-year operations. These innovations shortened average project cycles from 3.2 to 1.8 years, with 2024 new project launches increasing 217% year-on-year.

4.2 Transformation of Participant Roles and Division of Labor

4.2.1 Government Entity: Paradigm Transformation from Administrative Dominance to Collaborative Service

The Hangzhou municipal government achieved a systematic shift from unitary management to diversified services in urban renewal, with core changes manifested in three dimensions: in organizational structure, establishing a three-tier governance system of "leading group decision-making - task force coordination - local government implementation," integrating approval authorities of 12 departments to create a "one-stop urban renewal" comprehensive window, reducing project approval time from an average of 96 days to 15 days; in institutional innovation, promulgating the Hangzhou Urban Renewal Regulations and 11 supporting rules, establishing the legal validity of "self-renewal agreements" to provide institutional guarantees for projects like Zhegong New Village; in funding mechanisms, forming a diversified financing model of "fiscal guidance + market participation + resident sharing," with the proportion of direct municipal fiscal investment decreasing from 62% to 38% in 2024 while simultaneously increasing social capital participation to 41%. This transformation shifted the government role from "omnipotent manager" to "rule-maker" and "service provider," achieving 100% nearby relocation for elderly residents through special fund support in Zhegong New Village while establishing transitional rent compensation mechanisms to protect other residents' rights.

4.2.2 Resident Entity: Identity Evolution from Policy Object to Governance Subject

Resident groups achieved role upgrading through triple mechanisms: legally, the Hangzhou Urban Renewal Regulations granted property owners plan joint-review rights and renovation supervision rights, enabling Zhegong New Village residents to possess substantive veto power over key indicators like FAR adjustments, with the exercise rate of this right decreasing from 17% in 2019 to 3% in 2024; implementationally, establishing a "sunshine disclosure + tiered incentives" system requiring all renovation plans to undergo three rounds of community hearings while granting 5%-15% area rewards to early-signing residents; in rights protection, constructing a dual-track protection system for "property owners - tenants," covering 1,327 tenant households through rent differential compensation and transitional relocation measures, with cumulative provision of 12,000 units of guaranteed rental housing by 2024. This shift transformed residents from passive recipients into governance subjects with decision-making, supervision, and benefit-distribution rights, as demonstrated in Zhegong New Village where residents determined 7 unit-type plans and 468 parking space allocation standards through self-renewal agreements.

4.2.3 Market Entity: Business Logic Restructuring from Short-Term Development to Long-Term Operation
Developers and operators underwent profound business model transformations: in operational mechanisms, adopting 15-20 year franchise rights models, such as Binfen Community operators allocating 30% of Δ0.8/m²/ month property fees specifically for public facility maintenance to form sustainable capital cycles; in design innovation, implementing "community planner" residency systems where 74% of projects adopted participatory design methods, with Zhegong New Village requiring 7.3 rounds of plan modifications to finalize 7 unit-type ratios; performance evaluation shows every 10% increase in market entity participation reduces post-project complaint rates by 6.2 percentage points. This transformation propelled market entities from traditional "development-sales" models to "investment-operation" models, evidenced by Zhegong New Village's design institute achieving 65-117 unit gradient configurations through customized plans while reserving public service spaces for elderly care and fitness.

4.3 Clear Rules
4.3.1 Equity Dimension Analysis
Zhegong New Village embodied the integration of procedural justice and substantive fairness in its housing replacement rule design. The core replacement formula "old unit's internal area ÷ new unit's usable area ratio" ensured precise property area conversion; the benchmark unit price of ¥1,350/ referenced Hangzhou's 2019–2021 average renovation cost for old communities, validated by third-party auditors as market-reasonable. A minimum 53 guarantee standard covered all households originally below 48, with fiscal subsidies bridging 23% of the cost gap. The 20 expansion policy adopted a "graded pricing" mechanism, where the ¥34,520/ assessed price deviated within 8% from surrounding commodity housing prices and allowed installment payments to ease resident burdens. This "basic guarantee + market-oriented" dual-track design prevented post-renovation living standard downgrades while providing a legal pathway for improvement needs.

4.3.2 Independence Dimension Verification
The project established a "tripartite checks-and-balances" decision-making supervision system: the Resident Self-Renewal Committee drafted proposals, the subdistrict office acted as a neutral procedural supervisor, and the District Urban Development Group solely served as the construction agent. Key stages implemented "double-blind review," such as anonymous submissions of unit layout designs by seven design institutes, with resident representatives voting without knowing designers' identities. Third-party evaluations showed a 79% resident opinion adoption rate across 213 consultation meetings, with no forced voting or selective listening. Notably, 13 building representatives were elected through competitive voting, with candidates signing Conflict of Interest Commitment Letters requiring disclosure if relatives contracted project work.

4.3.3 Transparency Implementation Pathway
Information disclosure adopted an "online + offline + mobile" full-channel model. Fund management followed a "dual-account" system: ¥470 million in resident-raised funds underwent bank-supervised account custody, with every expenditure requiring tripartite co-signatures from the Resident Self-Renewal Committee, subdistrict office, and auditors. Key milestones like construction drawing reviews invited on-site supervision by 5% of resident representatives with signed confirmations. A "objection-recheck-arbitration" three-tier mechanism resolved disputes, with all 17 area determination conflicts settled through third-party remeasurement.

4.3.4 Representativeness Safeguard Mechanism
A "one representative per building" system ensured all 13 buildings' differentiated needs entered decision-making. Representatives were selected via "open nomination + rotational duty," with one-third rotated quarterly to prevent power consolidation. Critical decisions set a "dual 95%" threshold: resolutions required 95% attendance and 95% approval, with 13 actual votes averaging 98.6% approval. For elderly residents, a "voice broadcast + proxy participation by children" system enabled full-process engagement for 32 solitary seniors. Post-project evaluation showed ≤7% satisfaction gaps in scheme fairness across income groups.

4.4 Standardized Procedures
The project established physical consultation points equipped with self-service kiosks in community rotundas according to Gongshu Release's November 2023 report while Hangzhou Housing Bureau released 32 policy interpretations through the "Gongshu Urban Renewal" official account; The two-stage lottery system for unit selection implemented the first-round supervision by Hangzhou Notary Office per Gongshu Housing Bureau's

January 2024 Selection Announcement with the second round executing published unit-type price tables as confirmed by Zhejiang Online in March 2024; Zhejiang University of Technology's April 2024 disclosure indicated 12 architectural experts participated in quality supervision while Hangzhou Construction Quality Safety Supervision Station records showed 63 rectification notices issued; Hangzhou Development and Reform Commission's December 2023 approval document set resident contributions at ¥1,350-1,580/Δ and Transparent Real Estate Network's January 2025 data demonstrated a 58% post-renovation secondary housing price increase.

5. Conclusions

5.1 Main Findings

This empirical study of Zhegong New Village reveals the unique mechanism of public co-production in China's urban renewal. The research identifies a distinctive "top-down meets bottom-up" model under China's centralized governance and underdeveloped civil society, differing from Western grassroots activism and traditional administrative-led approaches. The project established innovative implementation principles ("resident-led, government-guided, construction department-propelled, subdistrict-executed, construction entity-accountable") and a shared funding mechanism combining resident contributions with government subsidies. The success stems from unique participant traits: as a university faculty community, residents' high education levels, stable pensions, and strong community attachment formed essential social capital. These enabled technical empowerment, democratic consultation, and efficient fundraising. Three governance breakthroughs emerged: government transitioning from omnipotent regulator to rule-maker; resident participation evolving from token consultation to substantive co-decision; implementation shifting from campaign-style to standardized procedures. This reflects both institutional supply since 2013's governance modernization and rising civic awareness. Limitations include replication barriers: social capital prerequisites; institutional adaptation costs (policy breakthroughs); technical capacity demands While demonstrating humanistic values, mature mechanisms require further development in evaluation standards decision tools, and dispute arbitration.

5.2 Implications The project demonstrates a viable path for community-led renewal within China's governance system, establishing a "government-market-society" synergy. Key insights include institutional clarification of "resident-led/government-guided" frameworks through 12 supporting policies, suggesting future improvements in land development rights trading and dynamic property valuation standards; procedural innovation via the "two-stage lottery + blockchain" model proving transparent decision-making benefits from full documentation disclosure and third-party arbitration; and a replicable triple empowerment system granting residents legal decision-making rights, technical advisory support, and professional training. The "five-party responsibility list" achieved precise state-society interface, providing developing nations a "controlled autonomy" reference. Challenges like heterogeneous needs necessitate dynamic interest mediation through property swaps and tiered subsidies. Deeper institutional innovation requires land value recapture mechanisms via property tax standards and public facility feedback policies to sustain community benefits. This "policy pilot-local adaptation-diffusion" gradualist approach aligns with China's governance logic while contributing global solutions.

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Cross-Scale Transactions and Multi-Level Governance on Spatial Gains of Commons: A Comparative Study from Türkiye[1]

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Abstract
In the current era of intersecting global crises, crisis discourse has evolved to encompass holistic and inclusive frameworks. Terms such as "planetary crisis," "Anthropocene crisis," "Capitalocene crisis," "polycrisis," "meta-crisis," "cumulative crisis," and "technological crisis" reflect the multidimensional nature of these challenges. These crises manifest across multiple scales and generate profound social, political, economic, and spatial transformations. This study takes the 2008 global crisis as a paradigmatic moment and examines the social movements in Turkey that have catalyzed radical spatial and political change. It investigates how actors operating at different scales have responded to spatial interventions, the dynamics of cross-scalar interactions, the spatial gains achieved through these struggles, and how these gains have reshaped the meaning and character of space.

Keywords: Governance, scale, Cross-Scale transactions, commons

1.Beyond Scales

Brenner describes the crises that capitalism entered after the 1970s as "creatively destructive" and endorses Lefebvre's concept of explosion. He emphasizes that restructuring at all spatial scales is implemented through processes of "destruction and creation" (Brenner, 2003). These practices are referred to as "restructuring," but these processes are unstable and polarizing. Neoliberalism's fundamental restructuring slogan is carried out through the creation of space, capital, and hegemonic spaces. This is done through ideas such as "localization, glocalization, decentralization, expansion of spatial networks, new regionalizations, and learning regions," as well as through practices involving these ideas. Such terms and practices, including those that place socio-spatial restructuring processes at the geographical level within a hegemonic perspective, have been identified (MacLeod & Goodwin, 1999; Swyngedouw, 2004).

In urban space debates, the scale of the city reflects the material organization of capitalist processes. Urban scale, shaped by diversification under capitalism, gains meaning not in isolation but through its relationship with broader geographical scales (Giordano, 2003). Today, rural areas are increasingly framed as resources serving urban functions. The urban-centric face of capitalism masks extractive operations—mines, landfills, and fields—now restructured as rural production zones (Cash et al., 2006).

. Modern capitalism operates across multiple scales—local, regional, national, and global. These scales are not fixed; rather, they are shaped by contested political and economic relations. The social movements that emerged in the 1970s were, in essence, movements that challenged these scales, opened the way to produce alternatives for restructuring, and introduced a new dimension to the debate on scaling (Brenner, 2019). The issue of scale has been a subject of discussion in various disciplines of critical urban studies since the 1990s, with a focus on socio-spatial relations. Castells (1977) conceptualizes the city as a "collective consumption space," while Baudrillard (2017) defines it as a "showcase for consumption objects," a stage for simulation and hyperreality. Despite their divergent theoretical approaches, scholars who conceptualize cities as sites of consumption posit that urban space constitutes more than merely a physical structure; rather, it is a social arena in which economic, cultural, and social relations are shaped. Consequently, it is imperative to conceptualize space as the aggregate of social relations and processes, necessitating the adoption of a socio-political perspective in this regard. Discussions regarding scales are generally defined as "local, regional, national, global," and this definition expresses the spatiality of capitalist production relations and these relations. These spatialities establish connections between

1 This study was prepared based on the initial findings of the doctoral thesis titled "Urban Space and Commoning Practices: Examples From Turkey And Spain," which was prepared at Akdeniz University, Faculty of Architecture, Department of Urban and Regional Planning, under the supervision of Prof. Dr. Hilal Erkuş. This paper contains early-stage findings from doctoral research and is intended solely for presentation purposes at [AESOP Congress, 2025, Istanbul]. It will not be published elsewhere in this format.

disparate geographical regions due to the heterogeneity of production activities, thereby exacerbating existing inequalities across geographical areas (Termeer et al., 2010; Gibson et al., 2000). Consequently, the differentiation and inequalities between production and consumption spaces both differentiate and expand scales (Smith, 2017). As the situation progresses, diverse forms of engagement emerge at both the national and local levels. Conducting analyses based on specific geographical scales results in the rejection of dynamic processes involved in these forms of engagement. The rejection of these forms of interaction has been demonstrated to contribute to the escalation of conflicts at various levels. For instance, national policies restricting local policies, and place-specific dynamic factors have the potential to intensify existing conflicts. Because of this relationship, spaces become a shared arena for these conflicts (McCann, 2016).

Crises and conflicts that are caused directly by human activity at different spatial scales have global impacts. Neil Brenner and Christian Schmid (2014) identify " planetary urbanization" as the primary cause of these issues and propose the implementation of multi-scale governance models as a solution to address these spatial crises and conflicts. The most significant roadmap for creating this alternative is predicated on the spatial and political gains achieved through social struggles. The challenges encountered in shared spaces have been shown to offer a novel spatial perspective and a new ontology of politicization in the creation of this roadmap and the development of a new alternative (De Angelis, 2017). In this novel ontology, relationality, processes, and inquiries concerning human-nature relations are rendered accessible through a "multiple perspective" (Caffentzis & Federici, 2014). The concept of "commons," which emphasizes inter-scale and even inter-level interaction and reciprocity, offers an important conceptual framework and highlights the "use value" in all spatialities (Akbulut, 2018).

2.Commons and Scales

The concept of the commons entered academic discourse with Hardin's (1968) "The Tragedy of the Commons," which argued that shared resources such as forests, oceans, and pastures are inherently prone to overuse unless privatized or nationalized. Ostrom (2002) challenged this view, demonstrating that local communities often develop effective, context-specific governance models and that problems typically arise from external interventions. She framed commons as spaces where collective rights and decision-making emerge, constituting a sphere beyond conventional public–private binaries (Angelis & Harvie, 2017). As such, commons became a conceptual response to complex environmental challenges involving multi-level governance (Bakker, 2007). The underlying cause of this conflict stems from the efforts of various actors, such as institutions, community interests, political identities, and different civil society organizations, to participate in these processes (Brenner, 2019). A subset of these initiatives prioritizes safeguarding the space and the human and living communities that collectively constitute the environment. A secondary set of initiatives underscores the utilization value of the space to maximize its economic return.

Critical approaches extend beyond Ostrom's bounded definition, drawing on Lefebvre's (2015) concepts of "transforming life by transforming the city" and the "right to the city"—an assertion of society's collective authorship of space (Caffentzis & Federici, 2014; Angelis & Harvie, 2017; Stavrides, 2019). Within this literature, the commons is understood not merely as a resource or an economic alternative, but as a political project enabling social reconstruction and cross-scalar interaction. Within this literature, the commons is understood not merely as a resource or an economic alternative, but as a political project enabling social reconstruction and cross-scalar interaction.

The idea of commonality shows how a group works together. It also shows the important parts of a group's life and living space. The whole group can take part in decisions about these things (Bianchi, 2019: 80). In social theory, space is generally viewed as the ground for action and is treated as fixed and static. At this stage, time is regarded as an independent variable, while space is defined as a dependent variable. In social theory, Lefebvre redefines this meaning by approaching space as a process and revealing the dialectic between the social and the spatial. Lefebvre (2014) defined the spatial triad, referring to absolute space, sacred space, historical space, abstract space, contradictory space, and differential space. He studied these types of space through periodization, addressing changes in modes of production over time.

The historical process is defined as a combination of building blocks, not as the end of one period and the beginning of another.Common space is defined as an "alternative" social space that intersects with these processes and emerges in response to spatial practices during moments of crisis (Dardot & Laval, 2018).

Theorists of spatial scale argue that scale encompasses more than spatial or temporal metrics; it also refers to jurisdictional, institutional, and epistemic dimensions in today's interconnected world (Cash et al., 2006; Termeer et al., 2010; Young, 2002). Social movements defending the commons operate across multiple scales, revealing that scale is not merely a geographical construct, but a political terrain shaped by governance dynamics and actor relations (Swyngedouw, 2004; Brenner, 2004)

Defending the commons typically begins at the local level, grounded in local knowledge (De Angelis, 2012). Yet such localized organization often links with national and global networks as struggles intensify and institutional pressure grows, forming a multi-level political transaction space (Cash & Moser, 2000). The widely cited principle of the commons—"belonging to no one and yet belonging to everyone"—captures the motivation behind these cross-level interactions (Caffentzis & Federici, 2014). This networked, upward scaling fosters socio-political spaces rooted in community rather than capital, enabling the reclamation of space and the transfer of public goods and commons governance to local actors (Berkes, 2002). In this governance model, or practice of commoning, central and local governments are expected to operate independently of market forces, with decisions shaped by active local participation. However, upward involvement remains essential to preserve the heterarchical and self-managed nature of the commons, and to ensure lasting institutional outcomes (Brenner, 2019; García-López et al., 2021; Cash et al., 2006; Harrison, 2006).

3.Fields and Methods of the Study

The study examined social movements (rural and urban) carried out in Türkiye on different scales in 2008 and thereafter, as well as the actors of different scales with whom these movements established relationships during the process of achieving their gains. To establish the study's scope, a media scan was conducted from 2008 to 2023 using the keywords "protest, struggle, urban movement, and environmental action." This scan also encompassed related terms such as "resistance, action, and activism," drawn from the digital archives of newspapers offering diverse perspectives, including liberal, right-wing, and left-wing viewpoints. Consequently, these scans have led to the identification of movements that have been met with public acclaim and have achieved success. The following examples illustrate these findings: A multitude of social movements have emerged in opposition to various development projects, including those involving the construction processes in Validebağ Grove, the planned mining activities in Kazdağları, the Çeşme Tourism Project, the Gerze Thermal Power Plant, the Düzce Hope Houses Cooperative, the Alpu Coal Thermal Power Plant, and the cooperative movement initiated by the BÜKOOP Consumer Cooperative concerning the spatiality of food.

A total of 125 interviews were conducted with local people, experts (planners, lawyers, academics, architects, doctors, engineers), NGOs (local, national, regional, and global), and local governments through semi-structured interview forms. These interviews were conducted directly at the sites between April 24, 2024, and May 28, 2024. The qualitative data were analyzed manually. Interview transcripts were read repeatedly to understand the narratives. Recurring patterns, frames, and configurations were identified. These themes were then categorized around key conceptual axes such as interaction across scales, commoning practices, governance dynamics, and spatial gains. The comparison across seven cases allowed for tracing similarities and divergences in coalitions, resistance, and scalar politics. An interpretive model guided the analysis to uncover the embedded meanings, spatial strategies, and power dynamics articulated by actors.

4.Findings and Discussion

4.1.Social Movements Against Development in Validebağ Grove

Validebağ Grove is one of the last remaining green spaces in Istanbul's dense urban landscape. It is a first-degree natural protected site that hosts numerous historical structures (Akyıldız, 2019). However, it has been targeted for development under various projects, including religious complexes, parking areas, housing, and a "nation's garden." For the past 26 years, the local residents, professional chambers, environmental organizations, activists, academics, and experts from various disciplines have opposed these spatial interventions, demanding the preservation of the grove's natural and cultural heritage. Throughout this lengthy struggle, collective practices have emerged, including prolonged vigils, events, forums, open-air classes, and spontaneous conversations at

petition stands, which have contributed to the commoning of the grove. Local actors integrated the protection of the grove and the capacity to swiftly respond to threats into their daily routines. After many years of legal proceedings, the public struggle ultimately prevailed. The Validebağ Grove movement is a significant example of defending the use value of a common space and reconstituting space as a socially produced entity. The ongoing struggle against various interventions has fostered an upward scaling of the commons through interactions among neighborhood, judicial, and global-level actors.

4.2.Boğaziçi University Members' Consumer Cooperative (BÜKOOP) — Istanbul

The Boğaziçi University Members' Consumer Cooperative (BÜKOOP) is an initiative that emphasizes the spatial nature of food, asserting that the local and spatial aspects of food production and consumption generate a commoning relationship. As a consumer cooperative, BÜKOOP organizes collective production and distribution based on principles of "clean, fair, and local food," serving as an important example of shared food and knowledge practices (Saydam ve Kadirbeyoğlu, 2019) Opposing the commodification of food by the capitalist system, BÜKOOP regards food as "common knowledge, common production, and common consumption." For the cooperative, the physical structure known as "BARAKA" had functioned as a common space where knowledge, production, and consumption practices were enacted. However, in 2022, the BARAKA was dismantled by an anti-democratic university administration, forcing the cooperative to relocate. Nevertheless, members viewed the new space as a platform for continuing commoning practices, where food and knowledge are re-produced daily. What began as a practice within the university has gradually developed relationships with producers and institutions at other scales, demonstrating an upward scaling interaction rooted in solidarity across levels.

4.3.Düzce Tenant Homeless Earthquake Victims Solidarity Housing Cooperative - Düzce

In the aftermath of the Düzce earthquake that occurred on November 12, 1999, housing assistance was exclusively allocated to property owners, thereby neglecting to provide support to tenants affected by the seismic event. In response to this inequality and the resulting housing crisis, tenant survivors formed a housing cooperative and initiated a rights-based struggle for housing (Yucak, 2004: 375). The local community constituted the primary actor in this movement, with subsequent participation from various NGOs, academics, and international networks. Following an extended period of legal proceedings, the plaintiffs successfully obtained the rights to allocate land for residential development. The design of the housing units was conducted collaboratively, with all cooperative members participating in the process. The project was constructed through participatory and co-design principles, and its implementation resulted in the creation of physical dwellings as well as the formation of a community-wide practice of commoning. The cooperative's organizational structure was entirely dependent on civil initiative and legal efforts, initially at the local level but eventually evolving into a model of upward scaling. The movement has established a multi-level governance model through both legal and organic ties with actors at different levels.

4.4.Social Movements Against the Gerze Thermal Power Plant – Sinop

A thermal power plant project that was proposed in 2009 in the Gerze district of Sinop aimed to cut down 16,000 trees in a region containing natural protected areas, forests, and agricultural land. The opposition to the project was initiated by the Gerze Municipality and the Yaykıl village leadership, and subsequently received support from villagers, ecological organizations, professional chambers, and NGOs and activists operating at local, national, and international levels(Kaymaz, 2017 ; Aldemir, 2016) Consequently, the project was terminated because of this determined and far-reaching social and legal struggle. A modest resistance outpost, erected on the site of struggle, was transformed into a symbol of collective memory. Subsequently, it was converted into a "resistance museum," thereby becoming a space for shared heritage. The Gerze example elucidates a commoning practice in which the use value of space was defended against market logic that emphasizes exchange value. This upward scaling movement offers a compelling illustration of cross-scalar interaction.

4.5.Social Movements Against the Alpu Coal-Fired Power Plant – Eskişehir

In 2017, the Ministry of Energy and Natural Resources unveiled plans for an underground coal mine project in Alpu Plain, a region distinguished by its exceptional agricultural productivity and situated within Eskişehir. The initiative was endorsed by substantial modifications to the urban planning framework. Local people, farmers, local authorities, NGOs, professional chambers, the Eskişehir City Council, and activists united in opposition to the coal plant, arguing that land is the foundation of life and that this polluting project should be canceled.

After public mobilization and legal proceedings, the project was officially terminated, thereby ensuring the preservation of the agricultural nature of the land(Temiz Hava Hakkı Platformu, 2018). The scientific reports, prepared collaboratively by experts from various fields, along with the detailed public information efforts, created a "knowledge commons" that enabled the space to gain collective value. The Alpu case exemplifies a top-down neoliberal scaling process initiated by the state. However, it also demonstrates a counter-intervention that was carried out through cross-scale collaboration among actors. This movement underscores the potential of commoning in counteracting neoliberal agendas that prioritize exchange value, thereby emphasizing the significance of use value in economic activities.

4.6.Kazdağları: Social Movements Against the Gold Mining Project – Çanakkale, Balıkesir

In 2010, environmental initiated protests gold mining operations near Kirazlı in the Kazdağları region, where approximately 350,000 trees were scheduled to be harvested for cyanide-based extraction. These demonstrations evolved to encompass local people and a diverse array of other stakeholders. The project posed grave ecological threats due to the area's biodiversity and vital water resources (MAD, 2020). Beginning in 2010, the implementation of continuous watch camps, festivals, workshops, and open-air discussions contributed to the preservation of the area, while concurrently facilitating its reconstruction as a collective living space. Legal victories in 2019 led to the project's complete cessation. The Kazdağları case demonstrates that scaling is not confined to upward scaling; it also occurs horizontally and diagonally. It underscores the importance of local knowledge in commoning and demonstrates a multi-scalar defense of the commons supported by international interaction.

4.7.Social Movements Against the Çeşme Tourism Project – İzmir

The Ministry of Culture and Tourism has proposed the "Çeşme Tourism Project," which encompasses approximately 16,000 hectares. This project encompasses natural protected zones, agricultural and pasture lands, and olive groves (TMMOB İzmir, 2020).. This case exemplifies a downward neoliberal scaling process. Local people, professional chambers, national and local NGOs, environmental groups, bar associations, and various experts opposed the project, arguing that it would harm nature, cultural heritage, and the public interest. Concurrent with the ongoing legal and social resistance, archaeological discoveries were made in the area, and a portion of the region was designated as an archaeological site. The area's reclassification as a "cultural and ecological commons" can be attributed to heightened public awareness and collective mobilization. The Çeşme case demonstrates the significance of upward, multi-scalar actor networks in resisting neoliberal downward scaling of state processes and exemplifies their capacity to redefine space.

5.Conclusion

In the social movements examined in this study, it is predominantly local-scale actors who initiate mobilization, while the support of national-scale actors proves crucial throughout the process. At the local level, residents, local NGOs, and local governments (municipalities and neighborhood heads) are typically seen as initiators of social struggles. At the national level, professional chambers and national NGOs play a prominent supportive role. In cases where support from local governments is strong—such as in Gerze and Alpu—success was achieved more quickly. These spaces of success demonstrate an upward rescaling process, while the presence of global actors during and after the process also signals a multi-level rescaling dynamic that includes both upward and downward interactions. The connections established with global actors provide valuable insights into the expanded scope of governance scales and the cross-scalar nature of interactions.

The struggles in rural areas and the involvement of urban actors further validate cross-scalar interactions, revealing that these actors' expectations for urban life align with the principles of sustainable nature and participatory governance. When considering the views of actors in the spaces where success was achieved, it becomes clear that cross-scalar interaction has significantly increased, necessitating multilayered and multilevel forms of governance. The success of these movements is contingent upon their ability to establish networks and reconfigure spaces through the implementation of multi-scalar governance strategies.

Our findings from the field reveal that space is not merely perceived as something to be preserved, but rather as a commons practice that is collectively re-produced and within which social relations are restructured. An alternative mode of organization has emerged, characterized by commoning practices. This framework is characterized by collective organization of decision-making processes, the production and sharing of knowledge, and the subjectification of space as a commons. The scaling processes observed in the cases examined

demonstrate not only upward scaling but also the development of alternative multi-level governance practices, indicating the expansive influence of scale (Young, 2002).

The limitation of local policies by national ones provides a clear indication that cross-scalar dynamics are being disregarded. The lack of attention to place-based (local) knowledge at the national and international levels remains a significant issue (Brenner, 2019). The primary motivation for diverse levels of organizational support for these movements lies in the ability to communicate local knowledge through scientific means to national and international media.

In terms of the legal framework in Türkiye, although there are certain protection mechanisms in place, it is evident that legal authority has been undermined in many areas. The main reasons for this include arbitrariness in the application of law, the politicization of judicial processes, inadequate institutional capacity, and the prevalence of decision-making mechanisms that facilitate market operations at the expense of participatory principles (Bakker, 2007). In contrast, the scale interactions and scalar fluidity created by these social struggles are supported by legal capacity aligned with local actors, expert knowledge and professions that scientifically demonstrate the interconnection between nature and public health, media visibility, international solidarity networks, and the persistent engagement of the public in organized resistance.

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Pursuing total volume or efficiency? A study on the coupling pattern of rural population and space: A case study from Huangyan District, Zhejiang Province, China

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Abstract
Under globalization, rural areas worldwide are experiencing population decline and built-space decay. Traditional rural development theories posit a positive correlation between residential population size and built-space efficiency. Following this theoretical assumption, China's eastern coastal villages should follow the trajectory of rural decline observed in developed nations. However, a paradoxical phenomenon of "quantity reduction with quality enhancement" has emerged in some eastern villages, which cannot be adequately explained by conventional "aggregate quantity coupling" models linking population and built space. This study proposes an "efficiency coupling" theoretical framework, demonstrating that rural systems can maintain vitality through spatial efficiency compensation when quantity balance falters. We identify three underlying mechanisms driving this transition and validate the efficiency coupling model through multi-scale case studies in Huangyan District and Shatian Village, Zhejiang Province. The analysis particularly examines Shatian Village's efficiency coupling mechanisms through two critical dimensions: companionship-based planning and multi-stakeholder co-creation. These findings offer new insights for villages grappling with population loss and spatial decay during urbanization processes.

Keywords: Quantity; Efficiency; Coupling Modes; Rural Residential Population; Built-up Space

Introduction

Under globalization, rural areas worldwide are grappling with dual challenges of residential population loss and built-environment decay[1]. UN-Habitat (2022) data indicates that over half of rural regions have experienced functional degradation since the 21st century, manifested through rising housing vacancy rates, declining utilization of public spaces, and fractured social networks[2]. Scholars such as Gobillon, L. (2003) have further elucidated the mechanisms linking population outflow to rural decline: when residential population density falls below the critical threshold required to sustain built environments, economies of scale in infrastructure vanish, marginal costs of public services surge, and spatial quality enters a downward spiral[3]. This evolutionary trajectory aligns with theories of "shrinking villages" in Europe and North America[4-6], as well as empirical studies on Japan's "marginal settlements" (genkai shūraku) and "hyper-depopulated villages" (kasoka sonraku)[7]. Against this backdrop, addressing the "hollowed village" dilemma and achieving dynamic equilibrium between population and built space has emerged as a pivotal issue for rural development.

Traditional rural development theories posit a positive correlation between residential population size and utilization efficiency of built-up spaces (Woods, 2011)[8]. Under this theoretical framework, coastal villages in eastern China would ostensibly follow the trajectory of "rural demise" observed in developed nations, as evidenced by statistical trends showing continuous reduction in natural village numbers and unidirectional outflow of registered residents[9]. However, intensive field observations reveal counterintuitive spatial practices: in economically vibrant regions such as the Yangtze River Delta and Pearl River Delta, certain villages demonstrate distinctive adaptive renewal capabilities in their built environments despite experiencing negative population growth. Field investigations by Zhu et al. (2022) further corroborate this phenomenon, showing that 43% of sampled villages in the Yangtze River Delta maintained or enhanced built-space utilization efficiency amidst persistent population outflow[10]. This paradoxical phenomenon of "quantitative contraction and qualitative enhancement" challenges conventional population-space equilibrium models, suggesting the emergence of novel systemic balancing mechanisms.

The theory of spatial production provides a critical lens for deconstructing this paradox. Lefebvre's (1984) triadic spatial dialectic posits that when the material function of physical space becomes decoupled from residential population size, dynamic equilibrium within the system can be achieved through the reconstruction of spatial representations[11]. Empirical cases from eastern Chinese villages demonstrate that traditional farmhouses, through functional conversion into cultural-creative spaces, not only preserve their material structures but also reconfigure the social value of built environments (Zhang et al., 2025)[12].

This process of "spatial re-territorialization" (Brenner, 1999) fosters novel coupling mechanisms[13]: despite persistent outflows of permanent residents, the adaptive recalibration of built-space functions alongside periodic influxes of mobile populations sustains or even enhances spatial utilization efficiency (Yunqi Guo, 2024) [14].

Building upon conventional "aggregate coupling" frameworks, this study proposes an "efficiency coupling" theoretical paradigm: rural systems can sustain robust functionality when built-space efficiency compensates for quantitative imbalances. This transformation is fundamentally driven by three mechanisms: First, adaptive retrofitting of rural built environments through the integration of agricultural production spaces with emerging industries such as cultural consumption and e-commerce; Second, innovative preservation and creative reinterpretation of historical-cultural resources, enabling traditional villages to undergo metamorphosis and revitalization; Third, urban creative cohorts, empowered by digital media and social networks, emerging as novel users and critical stakeholders in rural built-space utilization, actively engaging in community co-governance. These mechanisms collectively facilitate "efficiency re-coupling"—achieving enhanced output per unit area through spatial intensification, even as residential population density declines.

This theoretical framework demonstrates three distinctive innovations compared to existing paradigms: First, diverging from Western-centric concepts of rural gentrification (Smith, 2002) [15-16]or amenity migration (Gosnell & Abrams, 2011)[17], the Chinese model reveals unique advantages in government-market collaborative governance. Village collectives, through coordinated land consolidation leasing and joint development with market entities (Zhou, L., 2024)[18], construct hybrid governance structures that transcend institutional path dependence. Practically, the proposed efficiency-coupling framework advances beyond traditional quantitative equilibrium analyses by establishing an efficiency-oriented evaluation system for rural built environments, offering an Eastern perspective to "smart shrinkage" theory (Hollander, 2018)[19]. Methodologically, the study innovatively integrates census data to track demographic shifts, POI data to decode rural functional transitions, and multi-temporal remote sensing imagery (2000–2022) for land-use change detection, thereby developing novel tools for quantifying population-space adaptation. Ultimately, these findings align with China's new-type urbanization and dual-circulation development strategies, while providing actionable insights for resolving the paradox of "population decline versus spatial underutilization" in rural revitalization.

1. Literature Review and Theoretical Framework

1.1 Aggregate Coupling Model

Existing research on the coupling between residential population and built-up spaces predominantly focuses on absolute coupling, which posits that within a defined geographical unit, the total residential population and the scale of built-up spaces must adhere to a "rigid matching" principle. This hypothesis underscores an absolute correspondence between population and spatial capacity, asserting that the number of residents in a specific area must strictly align with the available spatial scale to achieve efficient resource utilization and rational spatial allocation. Deviations beyond established threshold intervals are theorized to trigger systemic risks, including resource mismatches, infrastructure vacancy, and economic decline (see Figure 1).

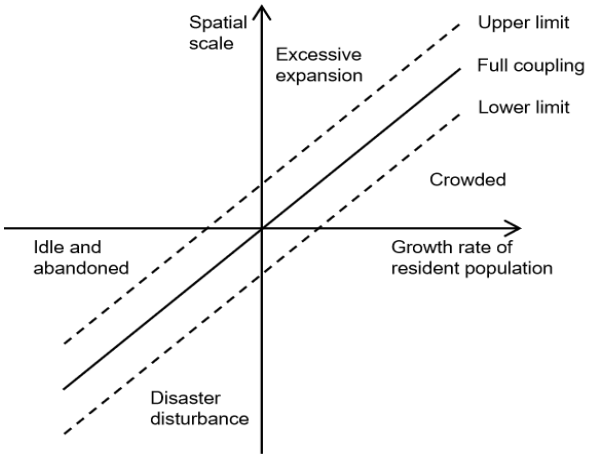

Figure 1 Traditional Resident Population–Built Space Coupling Model

To quantify such imbalances, scholars have introduced the Residential Population-Land Urbanization Index (a), defined as:

$$a = D_R / L_R$$

where a represents the coupling coefficient between residential population urbanization (D_R, annualized change rate of population urbanization level) and land urbanization (L_R, annualized change rate of spatial expansion). An a value of 1 indicates synchronized progression of population and land urbanization; a > 1 signifies spatial overexpansion relative to population growth, while a < 1 reflects population agglomeration outpacing spatial supply. Empirical evidence from international studies suggests that regions with sustained a values exceeding 1.2 consistently surpass the 15% critical threshold for vacant land ratios.

1.2 Efficiency Coupling Model

The absolute coupling model between residential population and built-up spaces establishes linear correlations to provide a quantitative diagnostic framework for urban shrinkage and rural hollowing. However, this paradigm reduces complex human-environment interactions to static correspondences, overlooking dynamic feedback mechanisms between systems and underestimating the built environment's capacity for resilient adaptation under population decline. Consequently, it struggles to explain empirical phenomena in rural China, where sustained population outflows coexist with "contraction without decline" or even "reverse revitalization" outcomes.

Building on traditional "aggregate coupling" principles, this study proposes a theoretical framework for the Residential Population-Built Space Efficiency Coupling Model. The framework posits that spatial efficiency can compensate for quantitative imbalances through resilient adaptation strategies—such as functional repurposing of spaces and adaptive reuse of structures—to maintain or enhance spatial performance despite population loss, thereby sustaining systemic viability in rural areas.

This transformation is fundamentally driven by three mechanisms: First, adaptive retrofitting of rural built environments is propelled by industrial shifts, such as converting agricultural production spaces into cultural consumption hubs or e-commerce facilities. Second, innovative preservation and creative reinterpretation of historical and cultural resources enable traditional villages to revitalize through heritage-led regeneration. Third, under the influence of digital media and social networks, urban innovators (e.g., digital entrepreneurs, cultural creators) emerge as new users and key stakeholders in co-managing rural built spaces.

The efficiency coupling paradigm challenges traditional developmentalist approaches by prioritizing functional transformation and spatial innovation over population retention. Theoretically, it repositions built spaces as dynamic productive assets rather than passive containers. Practically, it offers innovative pathways for rural revitalization that transcend simplistic narratives of reversing population outflows.

2. Research Methodology and Case Selection

2.1 Study Area Overview

This study selects Huangyan District in Zhejiang Province as a representative case, given its significance in reflecting urban-rural transition dynamics in China's developed coastal counties. Statistical data reveal that from 2020 to 2022, the rural population in Huangyan District decreased from 261,745 to 255,150—a reduction of 6,595 residents[20]. However, through spatial functional restructuring and capital infusion, the district had established 30 provincial-level beautiful villages by the end of 2022[21]. This paradoxical phenomenon of "population outflow alongside spatial upgrading" underscores the complexity of rural system restructuring under China's new urbanization paradigm, where demographic decline does not inevitably lead to spatial decay but may instead enhance the coupling efficiency between residential populations and built environments.

For a micro-scale analysis of the "high-efficiency coupling" model between residential populations and built spaces under new media-driven community co-management, this study further selects Shatian Village in Yutou Township as a nested case. Located in the southeastern part of Yutou Township, Huangyan District, Taizhou City, Zhejiang Province, Shatian Village experienced a period of decline after the relocation of the Yutou Township government in the late 1990s. However, leveraging the national Qianwan Project (Thousand Village Demonstration

Project), the village underwent organic renewal under the guidance of Professor Yang Guiqing's team from Tongji University's School of Urban Planning and Architecture. Through adaptive spatial transformations, it introduced diversified economic activities such as conference training, tourism, and rural e-commerce, ultimately becoming a provincial-level demonstration village for beautiful habitation.

2.2 Data Sources and Processing

This study employs a multi-source heterogeneous data fusion analysis approach, integrating three primary datasets: population distribution, spatial elements, and land use. Population census data were sourced from the Huangyan District Population Census Yearbook (2010) and Huangyan District Population Census Yearbook (2020), with permanent population statistics aggregated at the administrative village level and supplementary data compiled at the township level.

POI (Point of Interest) data, a core geospatial dataset in digital mapping, represent specific geographic entities such as restaurants, shopping centers, schools, hospitals, and tourist attractions. Each POI is geocoded as a point feature with attributes including name, category, address, and contact information. The POI data used in this study were extracted from Amap (AutoNavi Map) for the years 2015, 2017, 2019, 2021, 2023, and 2025.

Land use data were derived from the SinoLC1 database developed by Wuhan University, featuring 1-meter resolution and 73.61% classification accuracy. The dataset categorizes land cover into 11 types: Tree cover, Shrubland, Grassland, Cropland, Building, Traffic route, Barren and sparse vegetation, Snow and ice, Water, Wetland, and Moss and lichen. The "Building" category, representing built-up spaces, serves as the focal land use class for this research.

3. Empirical Analysis: A Case Study of Huangyan District, Taizhou City, Zhejiang Province

3.1 Regional-Level Analysis

3.1.1 Residential Population Dynamics

This study systematically examines the spatiotemporal evolution of population distribution in Huangyan District using census data and floating population surveys. The findings reveal differentiated development trajectories in the western mountainous and hilly areas: Beiyang and Ningxi Towns have emerged as secondary population agglomeration centers, leveraging their roles as central towns to establish local growth poles. In contrast, townships such as Yutou and Shangzheng, constrained by topographic limitations, exhibit persistently low population densities.

Temporal analysis (2010–2020) demonstrates pronounced spatial heterogeneity in population mobility. Western mountainous townships generally faced population decline, with Shangzheng Township recording the region's highest negative annual population growth rate. Conversely, Beiyang and Maoshe Townships experienced modest population rebounds, with Maoshe Township showing particularly notable growth trends.

Figure 2a 2010 Permanent Resident Population

Figure 2b 2020 Permanent Resident Population

Figure 2c 2010–2020 Permanent Resident Population Change

Figure 2d 2010–2020 Permanent Resident Population Growth Rate
Figure 2 Resident Population Statistics in Huangyan District

3.1.2 Characteristics of Built-Up Space Distribution

This study investigates the evolutionary trajectory of built-up areas in Huangyan District, eastern Zhejiang Province, through three temporal cross-sections (2000, 2010, and 2020), revealing phased characteristics and spatial differentiation patterns in urban-rural restructuring. The analysis demonstrates a persistent expansion of built-up spaces in the study area. Between 2000 and 2010, the central urban built-up areas expanded markedly outward, while township-level built-up spaces largely retained their original spatial configurations, with only localized low-intensity infill development.

Post-2010, spatial expansion exhibited a gradient diffusion effect. The central urban areas continued their outward growth, while key western towns entered a phase of rapid built-up area expansion, forming contiguous development zones. Mid-sized townships displayed edge-permeation growth, with built-up spaces extending outward along existing settlement boundaries to create compact spatial forms. Notably, in ecologically sensitive zones, built-up areas in certain townships showed limited scale increases but adopted discrete patch-like distribution patterns, reflecting spatial adaptation strategies for rural construction under ecological constraints.

3.1.3 Coupling Characteristics of Residential Population and Built-Up Space

An analysis of the coupling relationship between residential population size and built-up area changes in Huangyan District from 2010 to 2020 reveals significant differentiation in coupling patterns across townships: Yutou and Maoshe Townships exhibited basic coupling, with slight synchronized growth in both population and built-up areas at comparable rates. In contrast, Shangzheng, Ningxi, and Tuotuo Townships displayed anomalous inverse revitalization patterns, contradicting field observations of spatial stagnation phenomena such as hollowing-out traditional villages and idle rural homesteads. The study hypothesizes that administrative seat towns may attract rural populations through spatial reproduction strategies—such as concentrated educational and medical resources or industrial park development—while ordinary villages continue to face persistent population outflows. To unravel this paradox, further investigation into the micro-scale dynamics of population and built-up space changes at the village level is required.

3.2 Village-Level Analysis

3.2.1 Development Overview of Shatang Village

Shatang Village in Huangyan District was historically a declining settlement plagued by population exodus. Located in the western mountainous and hilly terrain, the village faced dual constraints of inadequate transportation accessibility and diminished regional economic influence due to its complex topography and peripheral location. Although the historic Taiwei Temple complex embodies local cultural and spiritual heritage, its lack of designation as a protected cultural site hindered the conversion of its cultural capital into tourism appeal. As a traditional agrarian village, its spatial organization initially aligned with small-scale farming practices. However, accelerated regional urbanization triggered sustained outmigration of working-age residents, resulting in a hollowed-out demographic structure dominated by elderly populations, which further eroded community vitality. Public space systems deteriorated into disorder due to insufficient maintenance, with alleyway textures eroded by encroaching vegetation and functional streets devolving into waste accumulation zones.

Since 2013, the Tongji University Huangyan Rural Planning team initiated the formulation and implementation of the Beautiful Village Plan for Shatang Village. During built environment optimization, planners adopted acupuncture-style interventions to repurpose vacant farmhouses into multifunctional community service facilities, preserving villagers' spatial habits while integrating tourism functions. This spatial reproduction strategy effectively revitalized existing architectural resources, enhancing built space utilization efficiency. As environmental quality improved, the village gradually integrated into the regional tourism network, leveraging its strategic position as a key node in the Rou River Scenic Area to attract emerging industries such as educational tourism and cultural innovation.

3.2.2 Coupling Characteristics of Residential Population and Built Environment in Shatang Village

As of the end of 2023, Shatang Village comprises 300 households with a registered population of 1,074. Between 2019 and 2023, the village's registered population exhibited a gradual decline. According to the Seventh National Population Census, individuals aged 21 or younger account for 22% of the total population, while those aged 60 or older represent 11%.

In 2023, the village's operational income reached ¥1.52 million, with collective income amounting to ¥786,100. The per capita annual income of villagers in 2022 was ¥20,000. The village currently hosts eight enterprises specializing in plastic products, cardboard packaging, daily goods, agritourism, and agricultural products, alongside 24 convenience stores and 11 restaurants. A development model led by the Rural Revitalization Academy, managed by professional teams, and operated with collective village equity has been established, generating over ¥200,000 in annual revenue and driving sales of local agricultural products exceeding ¥15 million.

Shatang Village has cultivated a robust cultural tourism industry. Anchored by the Rou River Scenic Area (4A-rated), the village now includes one hotel (Zhenshan Hotel Rou River Branch), two boutique guesthouses (Mountain Letters·Grain Lodge and Xiaoqi Homestay), one bar, two bookstores (Sanjing Book House and Rural Study), one restaurant (Family Restaurant), two cafés (Wangchuan Coffee and Dounai Coffee), and seven retail outlets (two convenience stores, three steamed bun shops, one△△△[traditional rice cake shop], and one rice wine shop). In 2023, the village received over 1.1 million tourists (Figure 3).

Figure 3 Spatial Distribution of Projects in Shatang Village

An analysis of residential population dynamics and built environment utilization efficiency reveals that over the past decade, despite the persistent decline in permanent residents due to urbanization, the functional efficiency of built spaces has paradoxically increased. This inverse evolution of population-space efficiency challenges traditional coupling models, which posit a linear correlation between population size and spatial utilization—where population shrinkage should theoretically reduce efficiency. Field investigations, however, demonstrate that through functional repurposing and spatial reproduction of vacant rural dwellings, traditional residences have been transformed into hybrid-use spaces, including cultural exhibition halls, maker workshops, and homestay clusters. These interventions have significantly enhanced the frequency of use and service capacity per unit of built space. Consequently, this "inverse revitalization" scenario aligns more closely with the residential population-built space efficiency coupling model proposed in this study.

3.2.3 Analysis of Efficiency Coupling Mechanisms in Shatang Village

β1βCompanion-Style Planning

Since 2013, the Tongji University Huangyan Rural Planning team has formulated and implemented the Beautiful Village Plan for Shatang Village. By systematically assessing the distribution patterns and structural conditions of underutilized public facilities, the plan strategically integrates future village development with the adaptive reuse of existing infrastructure, anticipating new functional demands under evolving urban-rural dynamics.

Over a decade of implementation, the village has acquired new socioeconomic roles while preserving its original spatial texture and architectural heritage. Eight vacant public facilities in the Old Street Block—all constructed during the People's Commune era (1960s–1980s)—have been revitalized and repurposed (Figure 4). For instance, a disused grain storage station was transformed into a homestay, a derelict veterinary station became a tourist service center, and an abandoned township administrative building was converted into a boutique hotel. This approach balances preservation and adaptation, retaining the village's historical memory while revitalizing its physical fabric. Such interventions not only safeguard cultural continuity but also create spatial prerequisites for attracting new demographics and economic activities.

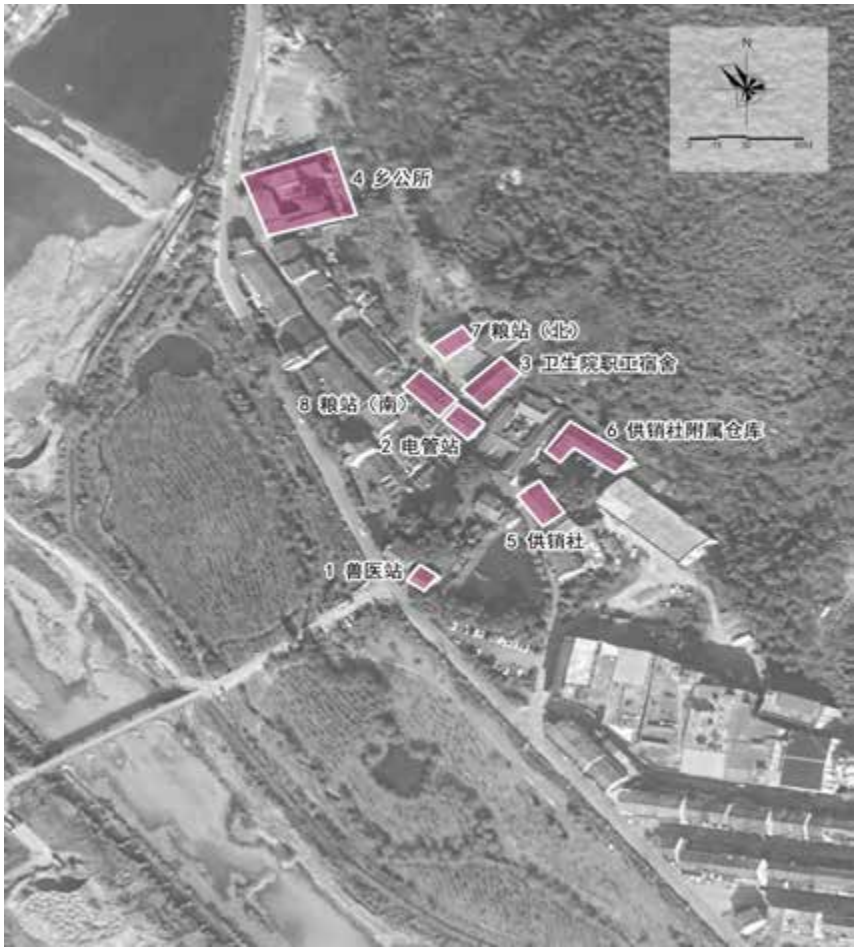

Figure 4 Adaptive Reuse of Existing Assets in Shatang Village

β2β Multi-Actor Collaborative Placemaking

During the initial phase of revitalizing Shatang Old Street, the absence of both tourists and commercial tenants posed a significant challenge. Following deliberations between village cadres and resident representatives, a bold policy was enacted: three years of rent-free occupancy for businesses operating on the Old Street. This incentive attracted local enterprises such as A'ling Steamed Buns and Xiaoya Rice Cake shops, alongside external businesses including Dounai Coffee, Grain Lodge Homestay, and Yuguang Bar.

Their establishment filled critical gaps in the street's commercial ecosystem, while the steady influx of visitors generated robust revenue streams, transforming these venues into social media hotspots.

Notably, Dounai Coffee—an unremarkable rural residence in early 2024—was revitalized in April through collaborative efforts by the Huangyan District Youth League Committee, Huangyan Young Entrepreneurs Association, and the Wenyi Society team. Leveraging platforms like Xiaohongshu and Weibo, the café achieved over one million online impressions (Figure 5), drawing nearly 1,000 young visitors. Its innovative operational model has injected vitality into rural revitalization, with daily coffee sales exceeding 100 cups during peak holidays (e.g., Labor Day, National Day). Collaborations with local heritage brands like Da Huang Steamed Buns have created hybrid "coffee + local culture" consumption experiences. Concurrently, the Yutou Has Light | Youth in the Village sustainable rural art festival (Figures 7, 8) has attracted over 100 young artists nationwide, fostering the Rural Art Creation Officer residency program.

Huang Kunpeng, founder of Da Huang Steamed Buns, transitioned from the competitive e-commerce sector in 2024 to explore opportunities in his hometown. Starting with no prior experience, he apprenticed under local artisans to master traditional bun-making techniques. Struggling initially with distribution, he pivoted to social media marketing, posting short videos on Xiaohongshu to amplify brand visibility (Figure 6). His account now boasts 19,000 followers and 98,000 likes, driving a surge in orders. To meet demand, Huang recruited over 10 villagers, structuring operations into three specialized divisions—digital marketing, sales, and production—to optimize efficiency under a novel business model.

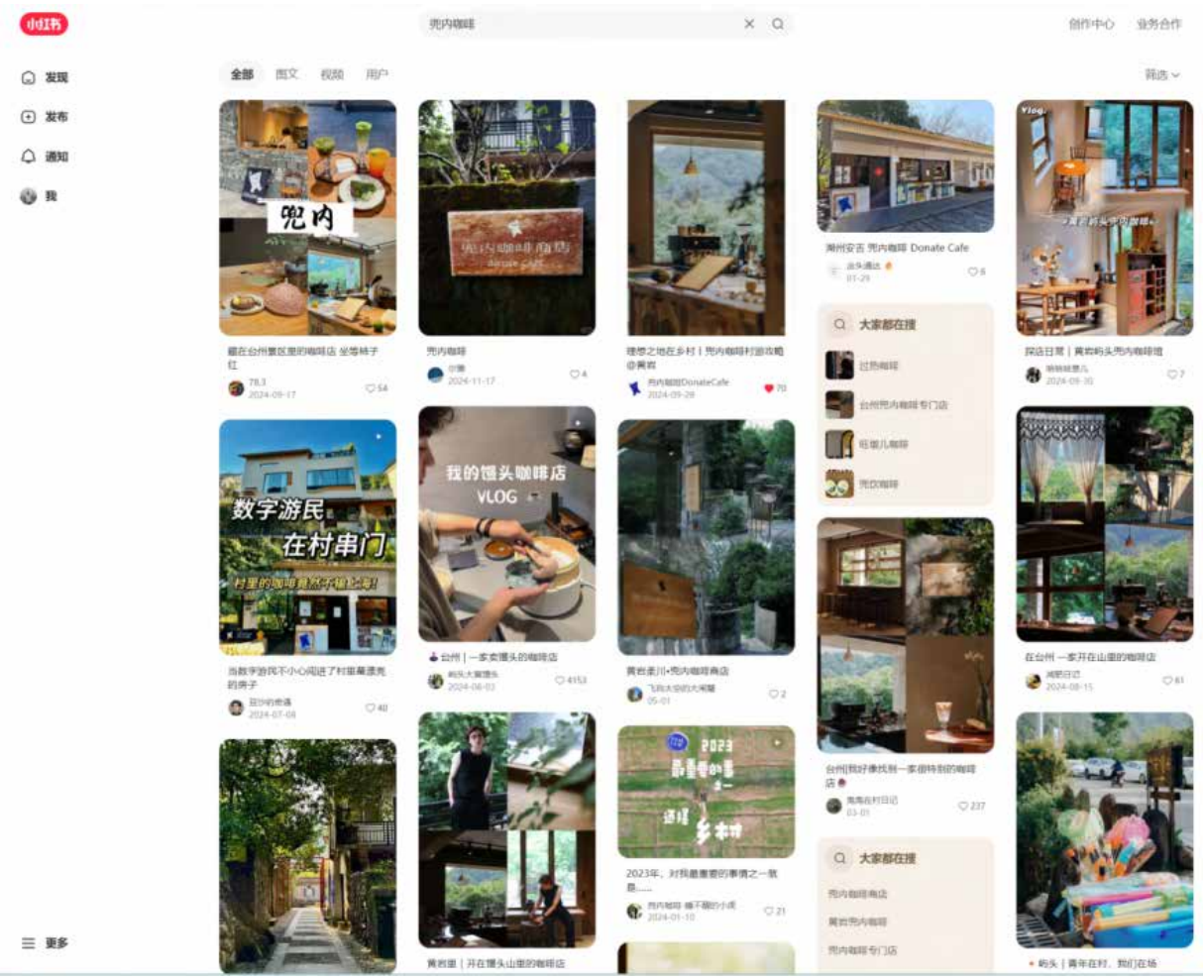

Figure 5 Interface Display of Dounai Coffee's Xiaohongshu Account

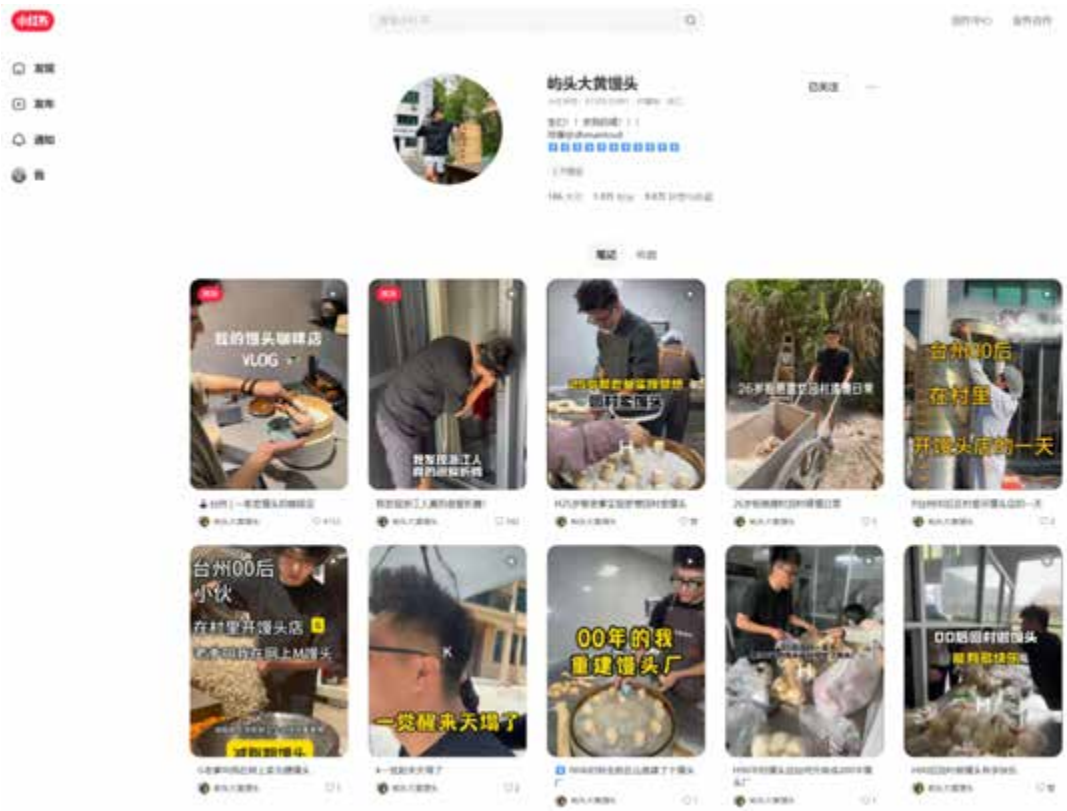

Figure 6 Page Display of Da Huang Steamed Buns' Xiaohongshu Account

Figure 7 Recruitment for the 2024 Inaugural Youth in the Village Sustainable Art Festival

Figure 8 Recruitment for the 2025 Shatang Village Youth Art Season

Further analysis delves into the tripartite actors influencing the "resident population–built space efficiency coupling" in Shatang Village—original inhabitants, returning migrants, and new migrants—and their evolving complementary synergies.

Original inhabitants, as core nodes of the rural social network, not only serve as inheritors of traditional lifestyles but also effectively express governance agency through participation in collective decision-making mechanisms. Their place-based knowledge ensures cultural compatibility in spatial transformations, exemplified by their role as cultural gatekeepers in architectural style preservation and public space layout. Returning migrants, leveraging cross-regional social capital and modern management concepts, act as bridges for bidirectional urban-rural resource flows. By introducing external market resources through entrepreneurial ventures in homestays and cultural industries, this group generates demonstration effects. Their dual identity mitigates conflicts between external capital and local culture. New migrants, as carriers of heterogeneous innovation, drive functional upgrades in traditional spaces by introducing urban consumption cultures and new economic formats. Their professional expertise in artistic interventions and brand marketing significantly enhances the market recognition of rural spaces, injecting innovation momentum into community development through their external characteristics.

The interaction mechanisms among these multiple actors exhibit distinct spatiotemporal evolutionary characteristics. During the initial stage of spatial reproduction, policy-guided resource aggregation formed a primary commercial ecosystem. As social networks between actors deepened, this evolved into a value co-creation model anchored in cultural identity. Specific synergies include: the complementary relationship between original inhabitants' spatial usage rights and new migrants' operational management; returning migrants' social capital reducing transaction costs; and the continuous influx of consumer groups reinforcing positive feedback mechanisms in spatial reproduction. Notably, the role boundaries among the three actors in spatial practices demonstrate a dynamic blurring trend. This deepening intersubjectivity facilitates a transformation from the traditional "host-guest dichotomy" to a symbiotic network.

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Research on Demand-Side Oriented Spatial Governance in Innovation Districts: A Case Study of Hangzhou West Sci-Tech- Innovation Corridor

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Abstract
To address global competition and economic transition, the development of innovation districts necessitates an urgent shift from a supply-side to a demand-side orientation. This shift implies that the "bottom-up" practical demands should be given due attention. This paper identifies entrepreneurs and employees, the key practitioners in the spatial production of innovation districts, as the parameters for effective demand. Using the Hangzhou West Science & Technology Innovation Corridor as a case study, this paper conducts in-depth fieldwork, surveys, and interviews. By thoroughly analyzing and understanding their characteristics, spatial needs, and the inadequacies of current regional supplies, the study proposes strategies for sustainable planning and governance of innovation districts based on these findings.

Keywords: Innovation District; Entrepreneurs; Employees; Spatial Governance

1. The development needs of the innovation districts shifting to the "demand side"

Since the reform and opening-up policy in1978, China's rapid industrialization and urbanization have fueled the construction of industrial zones. Local governments have adopted a cycle of large-scale new city (district) planning, land development, industrial and real estate investment, land financing, and new development projects, leading to the formation of various industrial zones, development zones, science and technology parks, and new cities. In response to the uncertainties in the global economic system since the 21st century and the transform demands between old and new economic drivers domestically, China's existing industrial zones or new districts have begun to transition from a "large-scale infrastructure + real estate" model to a "technological innovation + digital economy" model. Driven by policy incentives, a multitude of innovation districts have emerged, shaping diverse innovation spatial forms such as technology corridors, future science and technology cities, Characteristic Towns, maker spaces, and smart valleys. These innovative spatial forms not only provide a vast stage for industrial innovation but also inject new vitality into economic transformation and upgrading.

However, despite the remarkable achievements in the construction of innovation zones, the supply-oriented land development model still faces multiple challenges, including mismatch between the supply and demand of spatial products [1], inefficient resource allocation [2], imbalance between industrial and urban relations as well as jobs-residence relations [3], inadequate bearing capacity of public facilities, and spatial segregation [4]-[7]. Against this backdrop, the development of innovation zones urgently needs to shift from the supply side to the demand side to better accommodate the demands of the new economy. Specifically, this shift implies the need for effective demand benchmarking and planning guidance, that is, focusing on the genuine user demands within innovation districts and adjusting spatial supply and governance to meet the requirements of technological innovation and industrial transformation. Therefore, this paper takes entrepreneurs and employees in innovation districts as the practitioners of spatial production and regards them as parameters for effective demand. By exploring their characteristics and spatial demands, this paper explores spatial governance strategies for innovation districts, which holds certain contemporary significance and academic value for the planning and research of innovation districts.

2. Innovation District Spatial Governance Approach: People-Oriented and Demand-Driven

The concept of "the production of space" was first proposed by French sociologist Henri Lefebvre in 1974 [8]. He interpreted space as the fundamental organizational form of all human social production and practical activities, encompassing three dimensions: "spatial practice," "representations of space," and "spaces of representation." Space is "(social) space as a (social) product," and "each epoch produces its own space" [8]. Since then, scholars such as Manuel Castells, David Harvey, and Edward Soja have linked space to society, history, and social actors from the perspectives of the network society, space of flows, spatial capital, and spatial justice. They regard humans as the practical subjects of space and interpret the dynamic mechanisms of spatial development in urban or rural areas through the "dialectics" of space [9]-[12].

Led by Lefebvre, the theory of spatial production breaks through the "container" perspective of space. The manifestation of space is not merely seen as an objective entity but as a system of spatial production and relational reconstruction by social actors. Spatial entities continuously develop and change through purposeful human practices, thereby forming conceptualized abstract spaces. Society operates through space, and the boundaries of groups, along with their social power relations, are embedded and embodied in specific spatial structures [13]. In other words, space interacts with behavior, and each acting subject interprets and expresses their understanding and utilization of space through their practical activities in space, thereby constructing a unique and meaningful space.

From the perspective of spatial production, the spatial practice in innovation districts is a process of actors' (i.e., governments, entrepreneurs, and employees) practices and the reconfiguration of their relationships within regional spaces. As the spatial suppler in innovation districts, the government proactively recalibrates land use configurations, spatial provisions, and managerial support frameworks through integrated planning, development, and construction initiatives. This macro-level intervention crystallizes the "representations of space"—manifesting as the government's strategic vision for innovation district development.

Concurrently, entrepreneurs and employees on meso-micro level, functioning as demand-side spatial users, construct the "spaces of representation" through innumerable location-choosing and career-seeking activities with industrial development trends and personalized needs. These real demands behind these spatial representations serve as the direction for the adjustment of innovation districts. The dialectical interaction between supply-side interventions and demand-side responses constitutes the core mechanism of spatial practice within innovation districts (See Figure 1).

In light of this, this study investigates the genuine spatial demands from entrepreneurs and employees within innovation districts, and basing on the existing space supply background, it proposes a holistic methodology for spatial development adjustment. Taking the Hangzhou West City Sci-Tech Innovation Corridor as a case study, through a mixed methods investigation of corridor-based practitioners—including enterprise' organizational growth aspirations and employees' occupational and personal requirements—the study establishes a demand-based framework for spatial supply and governance in innovation districts. This framework informs spatial strategies to align physical environments with the dynamic needs of innovation ecosystems, ensuring sustainable and inclusive development of innovation districts.

2.1 Individual characteristics and types subdivision of practitioners

Entrepreneurs and employees, serving as the key practitioners driving spatial production of innovation districts, continuously mold the region's spaces of representation through their actions. This spatial environment is profoundly imbued with the distinct characteristics of these practitioners, encompassing their personal experiences, value, production methodologies and lifestyles. These elements seamlessly integrate into the regional cultural, exerting a far-reaching influence on the cultural ethos of the local entrepreneurial ecosystem. They further shape entrepreneurial activities by establishing acceptable entrepreneurial practices and norms [14]. At the level of physical space, the industry choices of entrepreneurs and their establishment (or " selecting location ") directly impact the composition of the regional industrial landscape. Similarly, the occupational preferences and mobility patterns of employees are intricately intertwined with the region's spatial structure.

Consequently, this study from the perspectives of people-oriented and demand-driven, initiates its inquiry by examining the individual characteristics and categorizations of the region's practitionersΔby focusing on the interconnections between the practitioners and the spatial production, sociocultural dynamics, economic growth trajectories, and value orientations of innovation district. It offers insights for a profound understanding of the spatial production within innovation districts.

2.2 Entrepreneurship and Spatial Representation Characteristics

Innovation districts function as a spatial carrier for government-led industrial innovation and clustering, reflecting the government's vision regarding industrial spatial layout. The ultimate realization of this planning vision hinges on the enterprises established by entrepreneurs, meaning that the location choices made by enterprises directly shape the actual configuration of industrial space within the innovation district. The process

of enterprise location selection adheres to the "principle of maximum satisfaction" [15], being influenced by numerous factors such as the personal preferences of decision-makers (entrepreneurs), costs, market dynamics, labor availability, the socio-political environment, and the natural environment. It is a "bottom-up" process, and companies with different levels of development have different needs. Drawing on previous entrepreneurial research [16] [17], this paper classifies entrepreneurial enterprises into four categories: start-ups (established within 42 months), growth-stage enterprises (established between 42 months and 8 years), mature enterprises (established for over 8 years), and declining enterprises (determined based on the firm's specific circumstances) (as shown in Table 1). From the dimensions of entrepreneurial needs, motivations, modes of innovation, spatial preferences, organizational inclinations, and practical requirements, this study conducts an in-depth exploration of the spatial demands and representative features of industrial development within the innovation districts.

Table 1 Classification of Entrepreneurial Enterprise Cycles (Source: Drawn by the Authors)

Stage	Definition	Classification Criteria	Main Characteristics
Start-up Enterprises	The stage where enterprises newly enter the market seeking survival	Within 42 months of establishment	Facing issues such as resource scarcity, market instability, information asymmetry, etc., known as "new entry defects," with a high mortality rate
growth-stage Enterprises	The rapid development stage of enterprises	42 months to 8 years after establishment	Enterprises gradually stabilize in the market, their products begin to be accepted by customers, and their organization and scale grow, integrating into the industrial ecosystem
Mature Enterprises	The stage where enterprises expand to have a certain degree of market discourse power	Over 8 years after establishment	Having market influence, stable operations, sound industrial mechanisms, and typically occupying key links in the industrial ecosystem
Declining Enterprises	The period when enterprises enter a stage of decline or weakness in development	Judged based on the enterprise's own situation	Due to market saturation, product substitution, or management rigidity, they often maintain the status quo and need to restructure industrial relations to prevent decline

2.3 Employment and Spatial Representation Characteristics

Employees are not only crucial participants in the regional industrial economy but also significant shapers of the regional spatial landscape. While the regional industrial structure selects employees, it is simultaneously influenced by their occupational choices and mobility. This interactive dynamic further impacts the development of regional production and living facilities, as well as other functional aspects such as commerce, leisure, and residential areas. From the perspective of employment development, this study explores the demands and representation characteristics of industrial spaces, various supporting facilities, and spatial configurations within innovation districts by examining the considerations of employees in terms of career choice, location selection factors, spatial preferences, and resource inclinations.

Based on the exploration of the individual characteristics of the practitioners (entrepreneurs and employees) in regional representation spaces and the factors behind their spatial location choices, this study discusses spatial governance strategies for innovation districts. Taking the Hangzhou West Science and Technology Innovation Corridor (referred to as the Grand Corridor) as an example, questionnaires were distributed and over 60 open-ended interviews were conducted with practitioners of the innovation district. The questionnaires were disseminated via WeChat, and individuals outside the Grand Corridor were excluded based on IP addresses. A total of 158 questionnaires from entrepreneurs and 171 from employs were collected, totaling 329 valid questionnaires.

The questionnaire respondents comprehensively covered the main industries in the Grand Corridor, and the industry distribution closely aligned with the regional industrial pattern, demonstrating good reliability (Figure 2). Based on this data, the paper proceeds with its analysis.

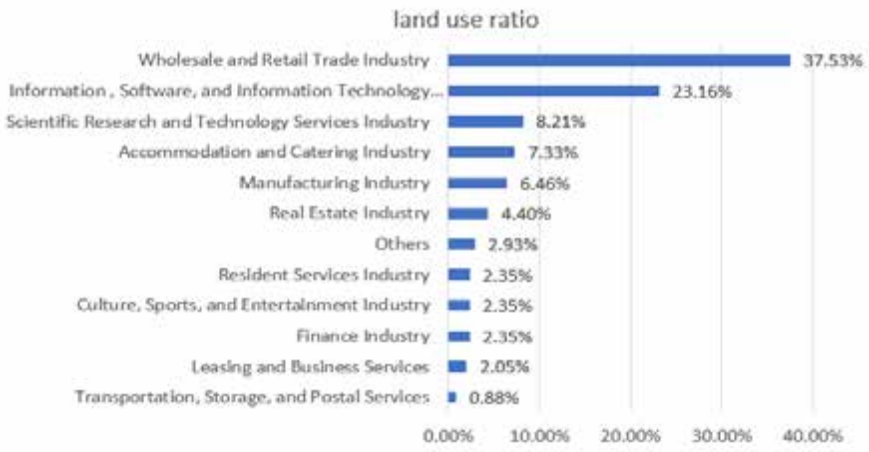


Figure 2: Industry Distribution of 329 Enterprises (Source: Questionnaire Survey)

3 "People-Oriented" Spatial Representation Characteristics in Innovation Districts: A Case Study of the Hangzhou West Science and Technology Innovation Corridor

The Hangzhou West Science and Technology Innovation Corridor (referred to as the Grand Corridor) originated from the West Science and Technology Industry Cluster Zone which is established in 2009.It was the only cluster zone focusing on science and technology innovation among Zhejiang Province's 15 industrial cluster zones. At the end of 2015, it was officially renamed as the Grand Corridor, as a key development zone by Zhejiang Province and Hangzhou City for promoting economic transformation and upgrading .Situated in the western part of Hangzhou City, Zhejiang Province, the Grand Corridor spans from Zijingang Campus of Zhejiang University in the east, to Zhejiang Agriculture and Forestry University in the west, encompassing numerous universities and research institutions. According to the "The 14th Five-Year Plan for the Development of Hangzhou Chengxi Science and Technology Innovation Corridor (2021)" planning , the Grand Corridor covers a total area of 416 square kilometers (Figure 3).

As outlined in "The 14th Five-Year Plan for the Development of Hangzhou Chengxi Sci-Tech Innovation Corridor (2021)", the Grand Corridor's planning vision (presentations of space) aims to establish a globally leading digital science and technology innovation center, a leading area for high-quality development, a pioneer area for urban modernization, and a demonstration area for integrated intelligent governance. It seeks to initially construct an innovation source that embraces the world, leads the future, serves the nation, and propels the entire province (Figure 4).

Figure 3. Location Map of the Hangzhou West Science and Technology Innovation Corridor

Figure 4: Schematic Diagram of the Corridor's Development Layout (Source: The 14th Five-Year Plan for the Development of Hangzhou Chengxi Sci-Tech Innovation Corridor)

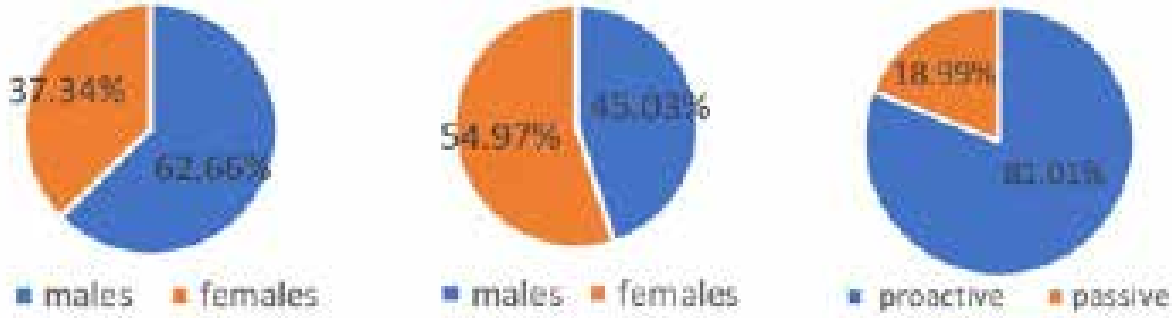
3.1 Characteristics of the Practitioners in the Grand Corridor

Survey findings reveal distinct characteristics of the practitioners of the Grand Corridor. Entrepreneurs are predominantly male (62.66%), with individuals aged 26-35 constituting the main entrepreneurial force (50.63%). Furthermore, a significant majority of entrepreneurs possess at least a bachelor's degree (80.38%) and extensive work experience with 61.4% having more than 5 years of work experience . Among employees, females account for a slightly higher proportion 54.97% than males, with the "18-25" and "26-35" age groups making up 75.44%. The educational background is predominantly bachelor's degree or above, with a relatively balanced distribution of work experience years, reflecting the stable mobility of employees in the region. Both entrepreneurs and employees predominantly originate locally, supplemented by inflows from outside the region. This indicates that entrepreneurs in the Grand Corridor generallexhibit individual traits of localization, youthfulness, high educational attainment, and substantial work experience, while employees demonstrate localization, youthfulness, high educational attainment, and stable mobility (Figures 5-12 and Tables 2-3).

Table 2: Survey on the Channels Through Which Entrepreneurs in the Region Came to Hangzhou

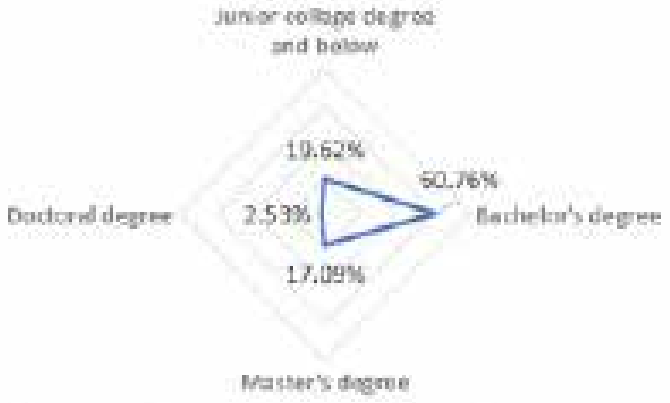
Channels of Coming to Hangzhou	Number	Proportion
Local Background (Studying or Having Family Locally)	81	51.27%
Recommendations from Relatives/Friends/Colleagues/Classmates	49	31.01%
Government Promotion (Competitions and Talent Introduction)	10	6.33%
Corporate Recruitment	15	9.49%
Recommendation or Introduction by Agencies	3	1.90%
Number of Valid Responses	158	100%

F5: Gender Ratio of Entrepreneurs; F6: Gender Ratio of Employees 6; F13: Entrepreneurial Initiative



F7: Age Distribution of Entrepreneurs

F8: Educational Background Composition of Entrepreneurs



F9: Work Experience Duration of Entrepreneurs in the Region (Source: Questionnaire surveys)

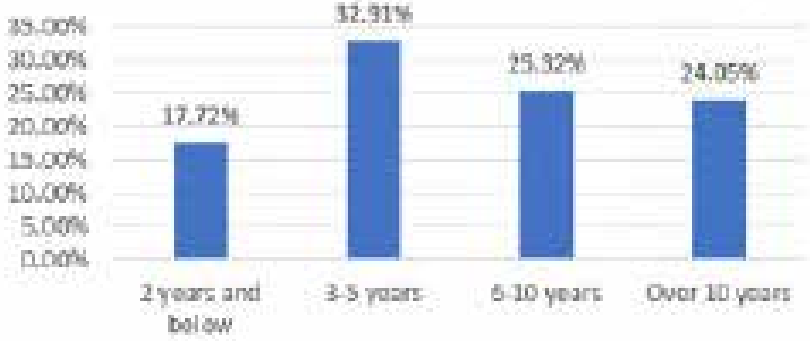


Table 3: Survey on the Channels Through Which Employees in the Region Came to Hangzhou

Channels of Coming to Hangzhou	Number	Proportion
Local Background (Studying or Having Family Locally)	83	48.54%
Recommendations from Relatives/Friends/Colleagues/Classmates	42	24.56%
Government Promotion (Competitions and Talent Introduction)	12	7.02%
Corporate Recruitment	28	16.37%
Recommendation or Introduction by Agencies	6	3.51%
Number of Valid Responses	171	100%

Table 4: Entrepreneurial Cognition Measurement: Entrepreneurs

Options	Number	Proportion
Few people around me are starting their own businesses.	47	29.75%
Many people around me are starting their own businesses.	97	61.39%
Prefer stable employment.	40	25.32%
Hope to start a business if there's an opportunity.	61	38.61%
Number of Valid Responses	158	100%

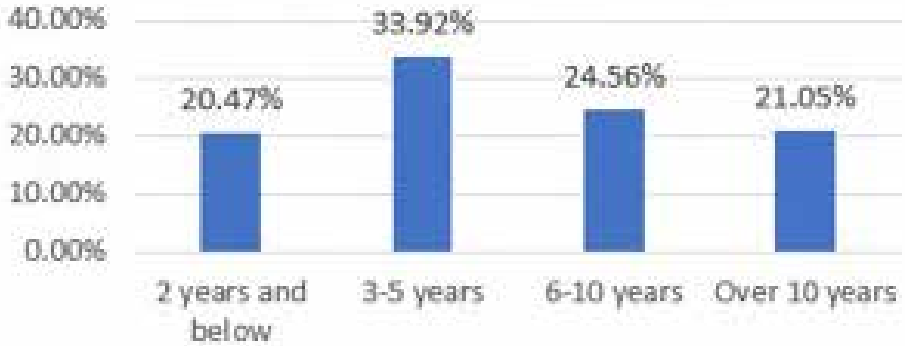
Table 5: Entrepreneurial Cognition Measurement: Employees

Options	Number	Proportion
Few people around me are starting their own businesses.	43	25.15%
Many people around me are starting their own businesses.	78	45.61%
Prefer stable employment.	67	39.18%
Hope to start a business if there's an opportunity.	46	26.90%
Number of Valid Responses	171	100%

F10: Age Distribution of Employees

F11: Educational Background Composition of Employees

F12: Work Experience Duration of Employees in the Region (Source: Questionnaire surveys)



The Grand Corridor boasts a high proportion of "proactive" entrepreneurs (81.1%), in contrast to a mere 18.9% of passive entrepreneurs (Figure 13). Not only do entrepreneurs acknowledge the entrepreneurial opportunities available in Hangzhou, but a substantial portion of employees also harbor aspirations for entrepreneurship. Among interviewed entrepreneurs (Table 3), over 60% report having "many acquaintances who are entrepreneurs." Similarly, among interviewed employees (Table 5), nearly half perceive "many individuals around them as

entrepreneurs," with only 39.18% preferring stable employment, whereas 26.9% express a willingness to "attempt entrepreneurship if given the opportunity." Almost one out of four employees could be a potential entrepreneur. The local populace has a strong sense of initiative in entrepreneurship, and the region is imbued with a robust entrepreneurial action attribute.

This phenomenon may be attributed to the region's long-standing tradition of valuing commerce, which can be traced back to the Spring and Autumn Period in the history, exemplified by the era of "Business Saint" Fan Li. Over time, the practice of valuing both culture and commerce has cultivated a cultural tradition that "values commerce and technology" and "considers industry and commerce as foundational," alongside a behavioral pattern characterized by "pragmatism" and "daring to innovate."

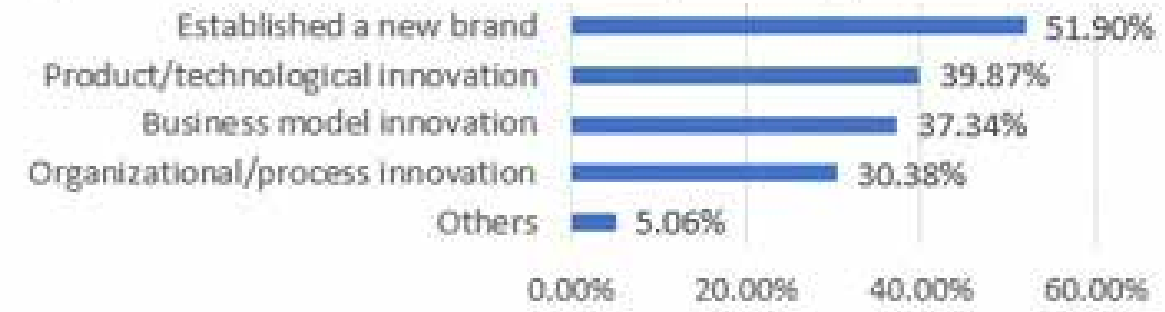
Consequently, the local populace has developed a distinct preference for risk, with more prominent business opportunity capture capabilities and risk tolerance, thereby fueling widespread entrepreneurial and innovative endeavors within the region.

3.2 Entrepreneurship and Its Spatial Representation

This study delves into the industrial space of innovation districts that is selected and constructed by the entrepreneurial cohort, through the perception of entrepreneurs. From the perspective of entrepreneurial motivation, "identifying good business opportunities" stands out as the primary driving force for entrepreneurs in the Grand Corridor, followed by "increasing wealth," "achieving self-worth," and "pursuing freedom." The proportion of those who start businesses due to "being unable to continue with their current jobs" is the lowest (Figure 14). This indicates that entrepreneurs in the region are relatively proactive in their ventures, with most being motivated by business opportunities and a keen sense of market trends, thus belong to proactive entrepreneurship.

Figure 14: Survey on Entrepreneurial Motivations of Entrepreneurs in the Region

Figure 15: Ranking of the Proportion of Enterprise R&D Types



F16: Importance Analysis of Innovation Idea Sources

Options	Score (Likert 5)
Customer requests	4.08
Market reports from distributors	4.03
Collecting ideas internally and conducting independent R&D	3.9
Market reports from universities or research institutions	3.61
Drawing on or imitating peer products	3.58
Collaborating with universities or research institutions	3.53
Purchasing products or patent licenses	3.35

F17: Survey on Innovation Models

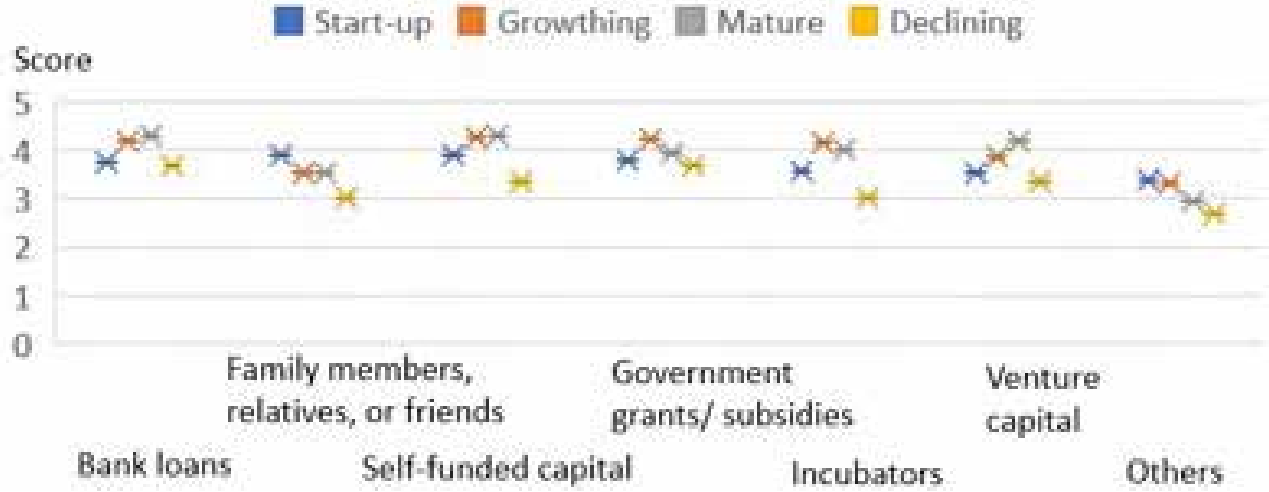
Options	Proportion
Internal R&D by the company's team	78.48%
R&D collaboration with local enterprises	18.35%
R&D collaboration with non-local enterprises	17.72%
R&D collaboration with local universities/institutes	18.99%
R&D collaboration with non-local universities/ institutes	8.23%

Table 6: Proportion of Employee Size at Different Business Development Stages (Source: All from Questionnaire Survey)

(Unit: Persons)

Phase	≤10	10-50	50-100	100-300	>300
Start-up	68.75%	23.75%	7.50%	0	0
Growthing	5.66%	45.28%	35.85%	11.32%	1.89%
Mature	0	4.35%	14.49%	37.68%	43.48%
Declining	0	16.70%	16.70%	50.00%	16.70%

F18: Scoring of Funding Sources for Enterprises at Different Stages (Rating Scale: 1-5)



In terms of innovation, while establishing new brands, the region entrepreneurs place equal emphasis on multiple innovation models (Figure 15). Innovation is significantly influenced by the product market. The largest proportion of research and development (R&D) activities are driven by "customer requirements" and "dealer market reports," followed by internally generated ideas. Self-directed R&D is the main approach, with a certain demand for external collaborative innovation (Figures 16 and 17).

From the perspectives of resource demands and spatial choices, entrepreneurs exhibit distinct needs at different stages of their ventures, generally leveraging existing social connections or resource networks. During the start-up phase, most enterprises have fewer than 10 employees, affording a relatively small scale (Table 6). Beyond self-funded capital, "family members,", "friends and relatives,", and "colleagues" emerge as the primary and most immediate sources of financial support for startups, predominantly sourced through the entrepreneurs' personal resource pools and network ties (Figure 18). Consequently, startups prioritize "preferential policies and financial support" as the most crucial factor, followed by "low costs for pilot-scale production and processing" and "low office rental costs." This prioritization is linked to the exploratory and uncertain nature of products during the startup phase, which necessitates continuous capital infusion (Figur19).

In terms of location selection (Figure 20), the "favorable atmosphere for innovation and entrepreneurship" in the Grand Corridor is a significant influencing factor for startups choosing to establish themselves there, with a satisfaction rating of 4.17. This is closely followed by "attractive preferential policies and incentives" (4.12), "proximity to relevant industrial clusters" (4.11), and "convenient transportation and facilities" (4.09). Other factors, such as "a beautiful urban environment", "abundant human resources", and "proximity to customers or suppliers", also play a role. Evidently, when considering the cost expenditures and opportunities associated with setting up a business, entrepreneurs often opt for regions with a vibrant entrepreneurial atmosphere and access to preferential policies. They also take into account costs related to transportation and facilities, preferring areas with convenient transportation and well-developed public infrastructure.

Hence, when it comes to specific spatial selections (Figure 21), startups exhibit a preference for "small but excellent" spaces. The option of "characteristic courtyard spaces" garners the highest preference rate among startups (44.38%), closely followed by "shared workstations with complete facilities" (41.25%) and "technology parks that match their professional fields" (41.25%). These choices underscore the startups' quest for comprehensive entrepreneurial support facilities while keeping costs low. However, field research has revealed that "small yet exquisite" spaces favored by startups, such as Dream Town, often come with high entry barriers and insufficient supply. As a result, more startups can only be located in surrounding villages and towns, collective land, old factories, and other areas with low rent and close to intellectual density and convenient transportation. In choosing their locations, startups prioritize convenience within the framework of economic affordability.

The resource requirements of enterprises in the growth stage significantly differ from those of startups (Figure 19). The growth-stage enterprises prioritize "entrepreneurial services such as product promotion and patent applications," reflecting their urgent need to meet market production capacity demands. Subsequently, they emphasize "venture capital" and "preferential policies and financial support"," as capital remains a pivotal factor determining their ability to expand production and explore new markets. The office and pilot-scale production costs, which were once major considerations, are no longer primary focuses for these enterprises. From the perspective of funding sources (Figure 18), "incubators" are an important channel for growth-stage enterprises to obtain capital, which is closely related to the one-stop incubation services mainly provided by incubators in the Grand corridor. Incubators represent the primary avenue through which growth-stage enterprises can readily access funds and other resources. The following incubators, such as "government subsidies"," "self-financed capital"," and "bank loans" are also significant funding sources. "Family, relatives, or friends" have become less important as entrepreneurs expand their external channels and are no longer the main funding channels they rely on.

In terms of location selection (Figure 20), "favorable entrepreneurial policies" (84.44%) emerged as the most crucial factor for growth-stage enterprises when choosing to settle in the Grand Corridor. This was followed by factors such as "having a relevant industrial chain foundation" (82.89%), "abundance of relevant talents" (81.61%), "strong reputation and a favorable atmosphere for innovation and entrepreneurship" (81.19%), and "convenient technical support/R&D cooperation" (81.14%). Next in importance were "sufficient land for enterprise expansion

and development" (79.02%) and "local background" (76.89%). It is evident that the growth-stage enterprises place greater emphasis on obtaining preferential funds, market access, and talent acquisition, which are essential for establishing a foothold in the market. Regarding specific spatial choices (Figure 21), the growth-stage enterprises prioritize spaces that offer growth and development potential in the future. As a result, comprehensive and high-quality science and technology parks are the preferred choice for these enterprises, followed by "modern large-floor-space premises" (39.62%) and "independent buildings" (38.68%).

Compared to other enterprises, mature enterprises pay more attention to industry prospects and new business opportunities (Figure 19). They rank "industry technology and information" and "entrepreneurial services such as product promotion and patent applications" as their top priorities, indicating their development needs to explore new growth points and maintain a leading position. In terms of accessing entrepreneurial funds (Figure 18), apart from profits generated from enterprise sales, "bank loans" and "venture capital" are important channels for them to obtain funds, followed by "incubators" and "government subsidies"." As enterprises grow, "self-funded capital" and "funds from family, relatives, or friends" become less significant. Mature enterprises have successfully established a resource network based on themselves, demonstrating strong anti-risk capabilities and smooth access to market-oriented investment and financing channels.

In terms of location selection (Figure 20), mature enterprises prioritize "abundant human resources" (4.22) and "sufficient development space/land" (4.19). This is followed by factors such as "proximity to customers or suppliers" (4.15), "attractive policy incentives and rewards" (4.12), and "having a local background" (4.08). Other factors include "a beautiful urban environment"," "a favorable atmosphere for innovation and entrepreneurship"," "convenient transportation and facilities"," and "proximity to industrial clusters"." It can be seen that considering their development scale and the ease of talent acquisition, entrepreneurs of mature enterprises tend to choose regions with relatively abundant human resources and surplus land. They also pay more attention to the overall technological foundation and knowledge level of the region. The mature enterprises surveyed in this study generally possess independent buildings or parks, indicating a certain degree of independence in their spatial location choices. Many enterprises have expressed a vision for later relocation and expansion, but they are cautious about new locations, preferring to move within the same region rather than deviating from existing human or resource channels. Their location selections are more proactive and prudent. Regarding specific spatial choices (Figure 21), mature enterprises prefer independent land use, favoring "independent buildings" (51.68%) and "modern large-floor-space premises" (49.13%). This is related to the expansion of their organizational structure and employee scale. To alleviate the sense of oppression brought about by their scale, mature enterprises place greater emphasis on the leisure and stress-relieving aspects of their internal office areas, paying more attention to the spiritual relief needs of public spacesuch as natural spaces.

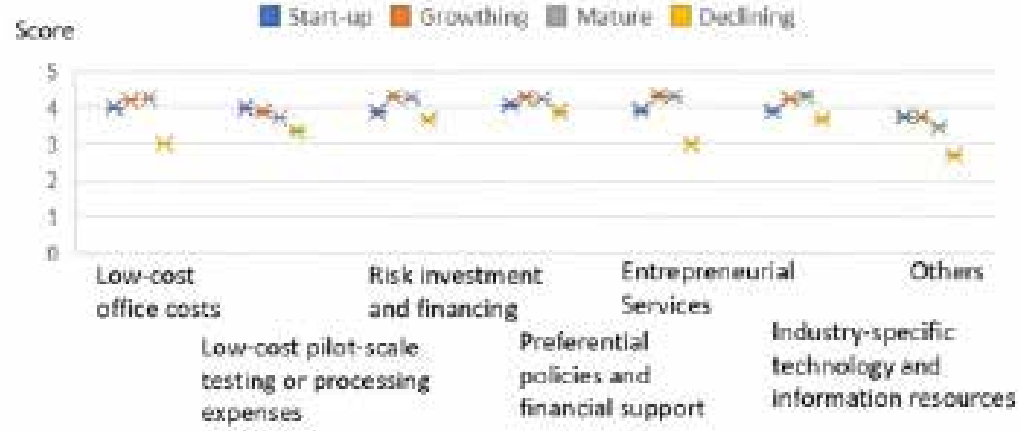
Decline enterprises are relatively limited in number, and thus their analysis primarily relies on interview data. Most of the decline-stage enterprises surveyed were established before the naming of the "Grand Corridor". These enterprises are predominantly from traditional manufacturing sectors such as electronics, electrical appliances, textiles, or and building materials. Due to the factors such as technological substitution, market renewal, and upgrades, they have progressively lost their competitive edge in the industry and are now at risk of being phased out. They harbor aspirations to develop new business ventures but are simultaneously apprehensive about the associated risks, leading to a lack of innovation drive.

Maintaining the status quo yields low profits and inadequate cash inflows. "Bank loans" and "government subsidies" are their main channels for obtaining external financial support, and their demand for innovation is significantly lower than that of enterprises in the other three stages. Consequently, in the evaluation of resource preferences, declining enterprises place the highest value on preferential policies and financial support. They also require external resources like industry-specific technological information and venture capital to facilitate industrial transformation or enhancement. However, their overall resource preference ratings are not high, suggesting limited internal initiative.

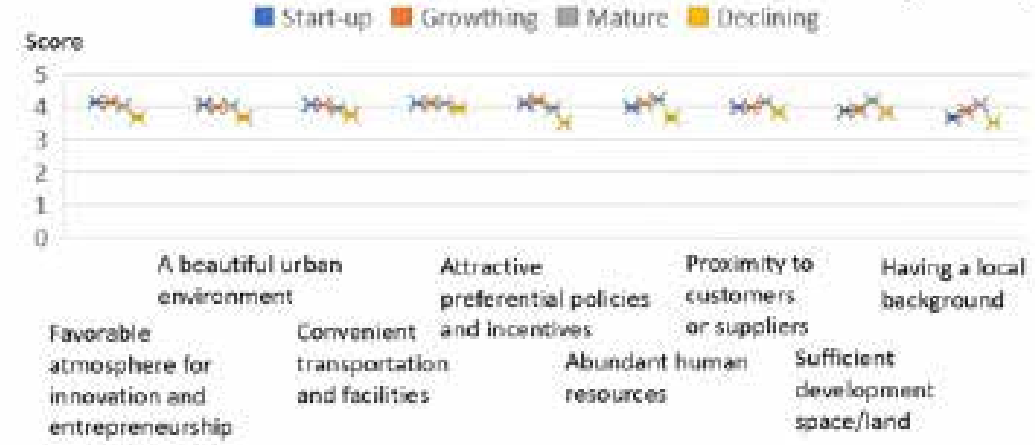
In terms of location selection, urban improvements and economic development have enhanced the appeal of their locations, resulting in an appreciation of enterprise land values.

Nevertheless, most enterprises opt to increase the output value and corporate earnings of their existing lands by leasing or selling them, reflecting insufficient innovation momentum. They express hopes for policy-driven relocation or replacement processes but exhibit low proactivity in independently choosing new locations.

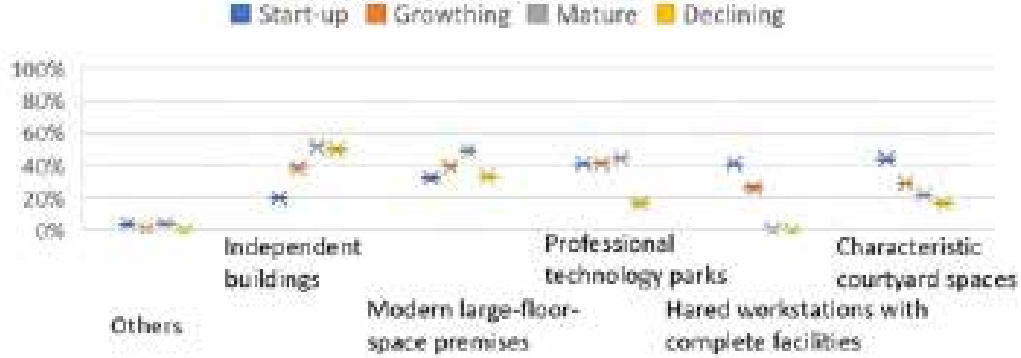
F19: Evaluation of Resource Needs for Enterprises at Different Stages (Rating Scale: 1-5)



F20: Evaluation of Location Selection Needs for Enterprises at Different Development Stages



F21: Analysis of Specific Spatial Choices for Enterprises at Different Development Stages (Source: All from Questionnaire Survey)



3.3 Employment and Its Spatial Representation

By examining the perceptions and job-selections of employees, we can understand the characteristics of the industrial spaces preferred by employees, as well as the representation of other functional spaces involved in their production and daily lives. From the perspective of job-selection motivations (Figure 22), respondents in the questionnaire ranked “salary” and “self-actualization” as their top two priorities, followed by “alignment with corporate culture”, “personal interest”, “promotion opportunities”, and “commuting distance”.” Next came

"alignment with one's major" and "work environment". Employees in the Grand Corridor do not regard salary as their sole pursuit; instead, they place greater emphasis on realizing their own value and matching their individual spirits with enterprise. This reflects a high-level spiritual need among employees in the Grand Corridor to transcend salary pursuits and value the alignment between their own worth and that of the enterprise.

This spiritual pursuit is similarly manifested in considerations for job location selection. In open-ended interviews, the majority of employees deemed the Grand Corridor as their ideal employment area. Exploring the reasons behind this (Figure 23), "beautiful urban environment" emerged as the top factor, followed by "promising development prospects of the industry", "a large number of like-minded individuals"," and "high government efficiency"." Next were "well-developed public facilities", "convenient transportation", "strong foundation for cooperation and innovation"," and "preferential policies and incentives". Finally came "cost of living or work"." This reflects a characteristic among employees where they prioritize personal growth over cost considerations in employment, placing greater importance on regional environment, job prospects, and opportunities for their own development.

Specifically, these characteristics vary among employees of different age groups. Firstly, the motivations driving job location selection differ among age groups (Figure 25). The "18-25" age group places significantly higher emphasis on "convenient transportation", "well-developed public facilities", and "relatively low living or working costs" compared to other age groups. This can be attributed to their new entry into the job market, limited resource accumulation, and concerns about convenience and economic pressures. The "26-35" age group exhibits relatively balanced ratings across various factors, indicating a comprehensive and meticulous consideration of all aspects. The "36-45" age group places the utmost importance on "salary". Employees in this age bracket often serve as the primary financial providers for their families and hope to reflect their professional value and sense of accomplishment through higher salaries. The "46-55" age group prioritizes "the development prospects of the industry they belong to". Employees in this age range are typically in the later stages of their careers and place greater importance on industry stability and long-term development trends.

Secondly, the pursuit of innovative spirit also varies among age groups. The "36-45" age group has the highest proportion (31.58%) of employees who "feel that they have the opportunity to try entrepreneurship", followed by the "26-35" age group (28.24%). The "18-25" age group has the lowest proportion (22.73%) of those willing to attempt entrepreneurship. These differences result in distinct demands for the employment environment among different groups of employees.

Thirdly, the demands for regional spatial amenities also differ across age groups. Based on the survey of job environment satisfaction, employees within the Grand Corridor are generally quite satisfied with the existing employment environment. Those expressing "relatively satisfied" or "very satisfied" attitudes account for 66% of the total respondents, while only 5% hold "dissatisfied" or "very dissatisfied" views (Figure 24). Specifically, the "18-25" age group exhibits lower satisfaction levels with the surrounding transportation and public facilities, particularly noting a lack of diverse recreational and entertainment amenities. Employees in the "26-35" age group believe that the most pressing areas for improvement in their current industrial parks are external supporting facilities, followed by external transportation conditions and the availability of public transportation. Within the park, they express relatively high satisfaction with the spatial organization and indoor environmental quality of the enterprises they work for. They perceive the need for improvement primarily in "internal supporting facilities", particularly advocating for an increased supply of high-quality spaces and amenities for communication and leisure activities.

Both the "36-45" age group and those aged "46 and above" highly appreciate the cultural atmosphere and beautiful natural environment of the Grand Corridor. Nevertheless, they note a relative dearth of high-quality supporting facilities such as education, healthcare, and recreational amenities. In particular, the scarcity of high-quality educational facilities struggles to meet the expanding needs of families. This is also reflected in the interviews, where the majority of employees mention that the most urgent areas for improvement in the Grand Corridor are public facilities related to transportation, commerce, leisure, daily living, as well as communication spaces.

In terms of office space and facility usage within specific park, many employees have a high level of satisfaction with the internal and external environment, building appearance, building functions, and building space of the park or office building where they are currently employed (Figure 26). "Open-plan offices" and "flat organizational structures" are widely recognized and accepted forms of office organization among employees, who believe that these arrangements can effectively enhance office efficiency and facilitate collaborative efforts.

Public spaces focus on stress relief and relaxation, but the supply varies depending on the conditions of the enterprise (Figures 27 and 28). Start-up enterprises and declining enterprises prioritize basic needs in the use of public spaces, making the "dining area" the most popular space among startup personnel (30.63%). Growth-stage enterprises exhibit needs similar to those of start-ups, but there is a notable increase in the preference for natural spaces that aid in stress relief and tea-break areas for relaxation. In contrast, employees in mature enterprises show the strongest preference for "outdoor natural spaces" (31.88%), followed by "fitness and exercise areas" (23.19%), "dining areas" (20.29%), and "tea-break areas" (13.04%). This indicates a growing emphasis on the mental and emotional well-being aspects of public space utilization, a trend that gains prominence as enterprises expand in scale and enhance their capabilities.

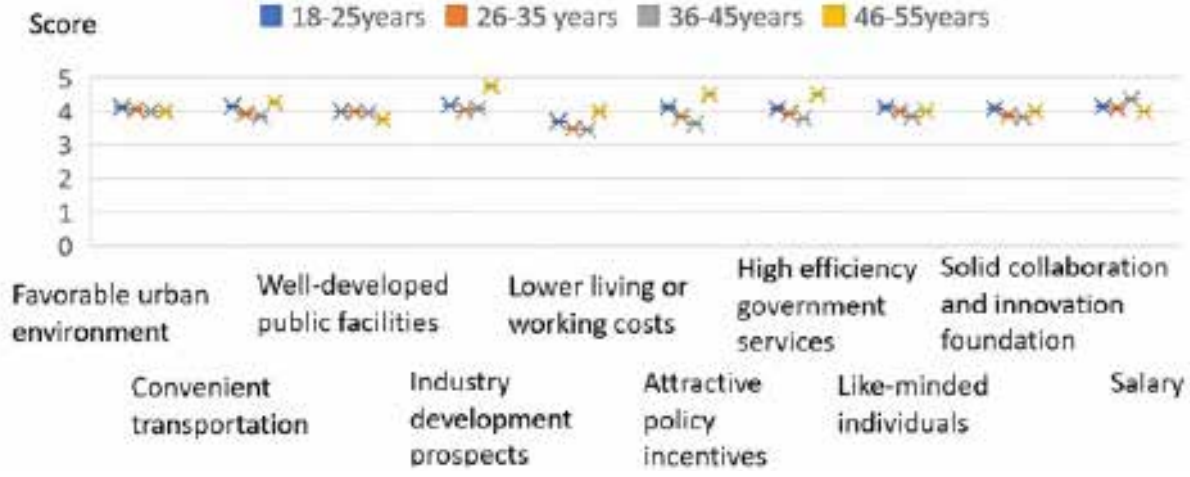
F22: Survey on Entrepreneurial Motivations of Entrepreneurs in the Region

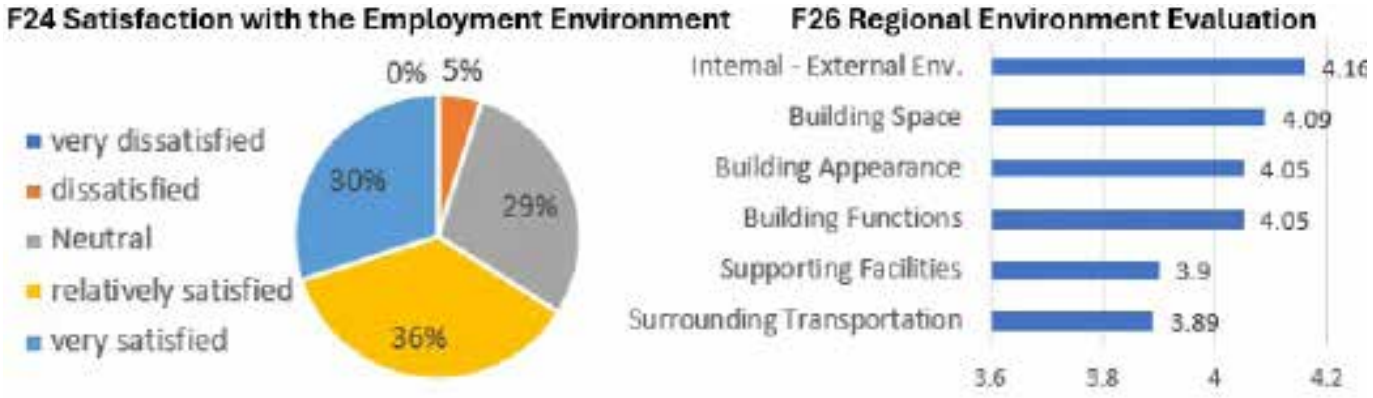
Options	Score (Likert 5)
Work environment	3.89
Alignment with one's major	3.95
Promotion opportunities	4.01
Commuting distance	4.01
Personal interest	4.04
Alignment with corporate culture	4.06
Self-actualization	4.12
Salary	4.15

F23: Importance Assessment of Location Selection Considerations for Employees in the Region

Options	Score (Likert 5)
Work environment	3.89
Alignment with one's major	3.95
Promotion opportunities	4.01
Commuting distance	4.01
Personal interest	4.04
Alignment with corporate culture	4.06
Self-actualization	4.12
Salary	4.15

F25: Job Selection Consideration Ratings for Employees in Different Age Groups in the Region





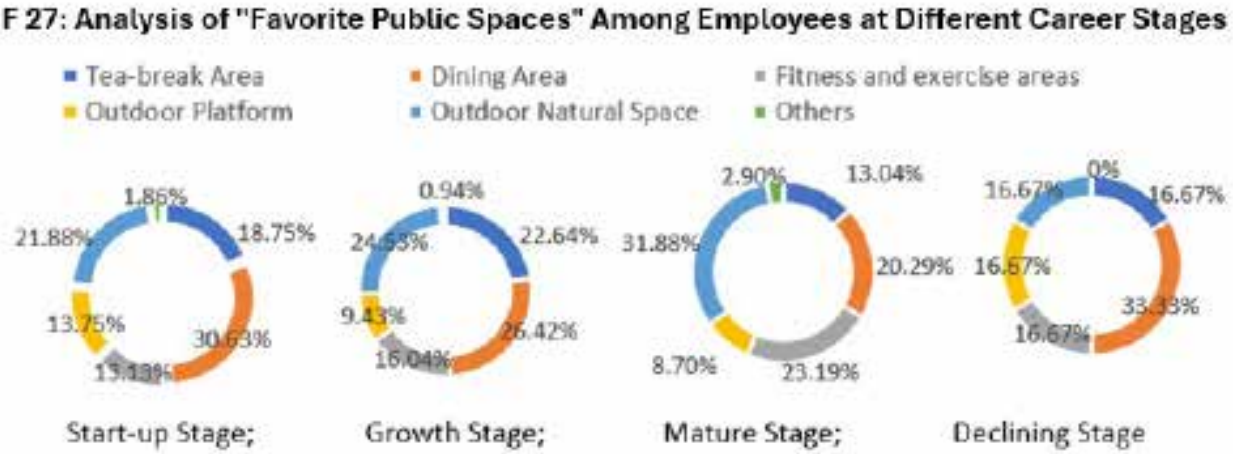
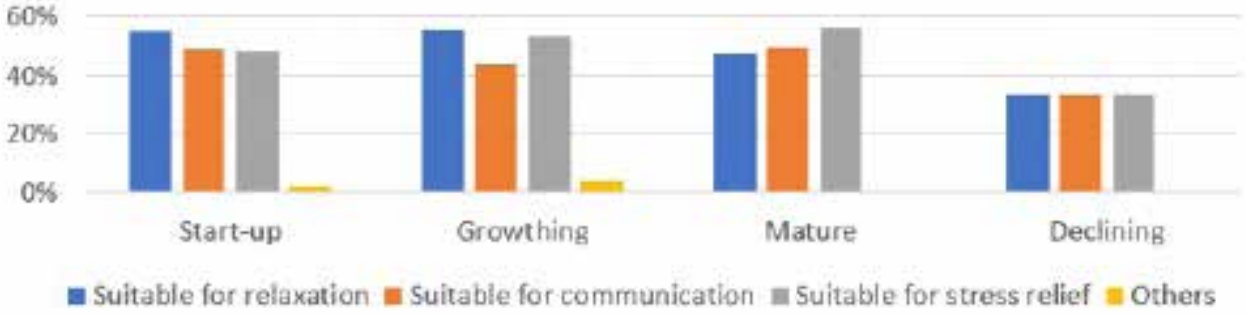


Figure 28 Survey on the Reasons for Liking the Above-mentioned Public Spaces



4 Suggestions for "People-Oriented" Spatial Governance Strategies in Innovation Districts

Based on the characteristics of the practitioners and the spatial representations of entrepreneurs and employed individuals within the Grand Corridor, this paper proposes "people-oriented" spatial governance strategies for innovation districts.

4.1Overall-Level: Strengthening Regional Characteristics and Industrial Resources to Construct a "People-Centered" Spatial Governance Framework for Innovation Districts

On one hand, anchored in the region's long-standing cultural tradition of "merchant-oriented" values and the population's inherent trait of "risk-taking spirit," we aim to establish the regional image of the "entrepreneurial and innovative haven "in the Grand Corridor, , thereby mentally unifying the spatial governance approach of the innovation district.

Through urban marketing strategies such as elite guidance, policy incentives, and case shaping, we can encourage or emphasize the region's innovativeness and inclusiveness, attracting innovators to settle down and fostering the emergence of entrepreneurs and employees.

On the other hand, we spatialize the perception of the image. Beginning with the spatial requirements of entrepreneurs and employees, we construct a "people-oriented" spatial governance framework for the innovation district. Firstly, we build a cultural concept of "humanistic pragmatism" and "risk-taking spirit", "and efficient inclusive policy mechanism. Secondly, starting the dimensions of cultural image implantation, public space creation, industrial space revitalization, and supporting facilities provision, and utilizing the ecological foundation and rich historical context of the region's "Three Lakes and Two Belts", the Grand Corridor will be transformed into a "wetland lake chain, innovative street, and shared living room" innovation district (Figure 6). By connecting six "lake chain living rooms"," thirty town living rooms, and hundreds of neighborhood living rooms with forty-nine "interesting innovation streets," a multi-level spatial landscape pattern of the innovation district is formed, which seamlessly blends industries with landscapes, and where production and social interaction are vibrant and dynamic. Through multi-level planning and collaborative governance, we achieve the governance goal of diversified development of industrial innovation space at all levels in the region.

4.2 Meso-level: Adhering to Entrepreneurial Demands and Organizational Patterns to Promote a Governance Approach for the Diversified Development of Enterprises

The spatial characteristics of entrepreneurship indicate that entrepreneurs in the Grand Corridor demonstrate a high degree of initiative. In the initial stages of entrepreneurial endeavors and resource acquisition, they predominantly rely on their personal networks. As enterprises grow, there is a gradual shift towards networks constructed by the enterprises themselves. Consequently, it is imperative to implement differentiated policy provisions and spatial supply strategies tailored to the diverse needs of enterprises at various developmental stages in institutional design.

For start-up enterprises, increased financial grants and resource-matching initiatives should be provided. Specialized venture capital funds or guiding funds targeting startups should be established, and social capital should be actively encouraged to participate in the incubation service ecosystem for startups. This will facilitate the establishment of collaborative mechanisms between startups and other enterprises, industry associations, scientific research institutions, etc.

For grow-stage enterprises, market-oriented expansion is the linchpin. This can be achieved by strengthening intellectual property protection, establishing robust channels for industry-university-research collaboration, streamlining administrative procedures, and enhancing resource integration and operational efficiency. These measures will continuously broaden the avenues for socialized innovation , thereby meeting the growth needs of enterprises.

For mature enterprises, the focus should be on enhancing their industry-leading capabilities and promo the construction and expansion of their industrial ecosystems. This can be achieved by encouraging continuous innovation and the cultivation of new industries through research funding subsidies and innovation platform collaborations. Support for talent acquisition should be provided through talent recruitment programs, vocational education initiatives, and the development of supporting infrastructure. Additionally, facilitating upstream and downstream cooperation and innovation within the industrial chain through information-sharing platforms and industry alliances will be crucial.

For declining enterprises, facilitating industrial transformation, optimization, or orderly exit can be achieved through the introduction or collaboration with new industries, the establishment of an orderly exit mechanism (such as transformation subsidies, M&A collaborations), employee resettlement and education, as well as the reuse of inefficient spaces.

4.3 Micro-level: Design Strategies Prioritizing Human-centric Needs to Foster a Diverse, Integrated, and Inclusive Innovative Spatial Environment

Given the characteristics of the regional practitioners, which are youthfulness and high educational attainment, there are distinct differences in their demands for facilities and venues related to work, life, entertainment, and leisure compared to those in typical urban areas. Therefore, the spatial supply in the Grand Corridor should center on the needs of practitioners, through urban design methods, solutions should be proposed to meet the humanistic needs of various groups, and a diverse, composite, and characteristic shared spatial environment should be jointly constructed in the region.

Firstly, various functions should be organized with public spaces as the core, creating a high-quality open public space system that serves as an "entrepreneurial and innovative haven "in the Grand Corridor. Taking advantage of the region's favorable ecological environment, the construction of public spaces should emphasize the integration of ecological advantages with entrepreneurial landscapes, shaping urban memories and a sense of place that combines innovative culture with ecological culture, thereby fostering more possibilities for entrepreneurial and innovative activities.

Secondly, in terms of land utilization, a human-oriented approach should be adopted to augment the flexibility of land use. The composite utilization of industrial land should be actively encouraged, fostering spatial integration and innovation. New spatial units that integrate multiple elements, such as entrepreneurial campuses, innovative parks, maker communities, creative scenic areas, and intelligent manufacturing industrial zones, should be constructed in accordance with local circumstances, forming environmental carriers conducive to communication and innovation. In the layout of living areas, boundaries between production and daily life should be boldly broken, encouraging the composite development of small-scale, non-polluting industries with other functions to create living spaces with community-based industrial functions.

Thirdly, in terms of facility support, it is imperative to prioritize the equitable distribution and accessibility of diverse facilities across the industrial spaces within the region. Life service facilities should be provided to cater to the differentiated needs of multi-level talents in the innovative industries. This includes not only facilities for the general public but also tailored for practitioners. Attention should also be given to the psychological, emotional experiences, and value identification of various groups. While ensuring convenient and economical facilities for employees, cultural, artistic, commercial, and leisure functions should be integrated to enhance the region's cultural, recreational, and service capacities for multi-tiered talents. Spatially, it's important to monitor and adapt to demand changes over time, such as upgrading educational and healthcare facilities to meet the evolving needs of a younger workforce.

Additionally, for micro-architectural spaces, greater importance should be attached to the design of communication and learning areas, with a focus on integrating natural elements. Functions such as ecology, leisure, and entertainment should be embedded to soften the work environment and infuse innovation spaces with a human touch. Utilize natural elements such as water bodies and green plants to create leisure spaces, establish public dining, entertainment, and fitness centers, and promote the formation of informal learning and communication. Exploring the integration of office landscapes, ecological landscapes, commercial landscapes and tourist landscapes, foster a sustainable and vibrant ecosystem that promotes economic, social, and cultural coprosperity. This also serves as a response at the planning level to the needs of practitioners.

5 Conclusion

This paper, adopting a human-oriented and demand-side-oriented perspective, delves into the spatial needs of the key actors in innovation districts—entrepreneurs and employees. This analysis facilitates the formulation of more precise and effective strategies for constructing innovation spaces, thereby promoting higher-quality development of innovation districts.

The research findings, exemplified by the case of the Hangzhou West Science and Technology Innovation Corridor, indicate that: • Demographic Traits: Entrepreneurs exhibit localized, youthful, highly educated, and experienced individual traits, daring to actively start their own businesses; employees are localized, youthful, highly educated, and have stable mobility, pursuing self-worth. These traits are associated with the region's "mercantile" cultural characteristics. • Spatial needs: Enterprises at different stages present different resource needs and spatial

choices. Startups prioritize low costs and convenience, growing enterprises focus on the potential for specialized development, mature enterprises emphasize access to human resources and future expansion possibilities, while declining enterprises look forward to the reuse of inefficient spaces; employees prioritize personal growth over employment cost considerations, and employees of different age groups have varying motivations for job location choices and needs for spatial amenities, leading to different spatial location choices. Δ Local supply: Existing planning focuses on the supply of industrial spatial resources in the region, with insufficient attention to startups and declining enterprises; the supporting industrial spaces in the region still follow traditional layouts, neglecting the special needs of high-quality talents in innovation districts.

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Redefinition of Urban-Rural Boundaries Under Centralized Governance: Urban Ecological Movements in the Case of a Coastal Town, Ayvalık, Turkey

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Abstract
This paper investigates the socio-ecological impacts of Turkey's 2012 Metropolitan Law (No. 6360) by analyzing how it redefined urban–rural boundaries through the case of Ayvalık. The law expanded metropolitan jurisdictions to include rural areas, intensifying top-down governance and triggering land use transformations. Drawing on urban political ecology and planetary urbanisation, the study explores how environmental movements in Ayvalık resist these changes and advocate for participatory governance. Through ethnographic research and spatial analysis, it reveals the tensions between centralized state planning and local socio-ecological dynamics. The findings highlight Ayvalık as a metropolitan hinterland shaped by contested governance, contributing to debates on planning amid planetary crisis and the need for more inclusive, ecologically tailored governance frameworks.

Keywords: Urban-rural boundaries; Centralized governance model; Urban ecological movements; Metropolitan Law; Ayvalık

Introduction

More than half a century ago, Henri Lefebvre had a strong assessment with the following hypothesis: "Society has been completely urbanized" (Lefebvre, 2003, p. 1). A notion of 'urban society' has been put forward as a result of an urbanisation process. He had a considerably sharp argument towards the disruption in 'well known' distinctions between the city and the rural through pointing out the emergence of the urban society. Since the emergence of Lefebvre's thesis, the notion of urban served as the encompassing phenomenon beyond the 'limits' of the city towards the rural areas, where the borders between them sought to disappear. His ideas have pioneered new theoretical frameworks and provided the understanding of the necessity to discuss changing urbanisation processes. Based on this, the crucial threshold of total urbanisation has exposed as being surpassed, indicating the practical realization of a "planetarization of the urban" (Lefebvre, 2014, p. 569).

The assertion that the urbanisation process, in serving as a paradigm, has come to delineate the entire globe, was expanded by Neil Brenner and Christian Schmid (2014), acquiring contemporary relevance through the concept of "planetary urbanisation". This development has also infused new vitality into critical urbanisation theories and led the way to critically reconceptualize the relation between the urban–non-urban, city–rural, and centre–periphery. In the context of these dialectics, the emerging urban era is started to be discussed as characterized by planetary social and environmental interactions, establishing novel constraints on the utilization and alteration of the global built environment, presenting the potential for significant disparities and conflicts, while simultaneously offering new opportunities for democratic engagement and self-appropriation, reclaim of space across all scales. From a political ecological perspective, urbanisation involves a profound transformation of both physical and social environments. David Harvey (1996) points to the ecological dimensions of urbanisation as contingent upon the reproduction of specific socio-spatial relations. Similarly, Cronon (1992) emphasizes that these processes continually produce new urban natures—hybrid socio-natural formations that reflect shifting modes of production and resistance. Under capitalist urbanisation, nature is not only physically absorbed into the urban fabric but also symbolically redefined, serving as both a site of exploitation and a terrain of contestation. Urban natures are thus constantly reshaped through the dynamic interplay of political economy, social struggle, and spatial transformation.

Urban Political Ecology (UPE) has emerged as a critical framework capable of addressing these complexities. While Angelo and Wachsmuth (2014) were dealing with the unexplored aspects and, correspondently, potentials of UPE by telling the story of it in relation to current urbanisation dynamics and theories, they asserted that, there is a need for a return by adhering to UPE's previously adopted understandings—the desire to reinterpret urbanisation through Lefebvrian roots of provocative thinking. In line with this, the urbanisation process must then be understood as the "production of specific and quite heterogeneous spatio-temporal forms embedded within different kinds of social action" (Angelo et al., 2014, p. 381). The idea of reinterpreting urbanisation as a 'socionatural' process is argued to provide means to critically reframe urban environmental issues within a broader context embracing economic, social, and historical dimensions. Thus, a political ecology of urbanisation

is made possible to be discussed through focusing on the process of "densely connected but unevenly differentiated urban fabric" (Angelo et al., 2014, p. 11). In this context, UPE has the potential to explore the planetary, ecological, political understanding of contemporary urbanisation when it is addressed in a diverse range of scales, encompassing 'city' and 'non-city' sites (Arboleda, 2016). However, the promise of a truly transdisciplinary UPE research agenda capable of capturing the implications of planetary urbanisation remains only partially fulfilled. I aim to address this by analysing a coastal town amidst intensifying urban-environmental tensions, where socio-spatial struggles unfold not only within conventional urban boundaries but also across peripheral and ruralized territories shaped by extractive and speculative pressures.

Urbanisation, is increasingly understood not as confined to the city but as a planetary process that restructures socio-natural relations across both urban and rural territories. In Turkey, this understanding has been institutionalized through a long-standing nationalist-conservative governance agenda that prioritizes urban expansion, leading to the growth of metropolitan areas to encompass their rural hinterlands. A key turning point in this trajectory was the enactment of Law No. 6360 in 2012—popularly known as the "Metropolitan Law" (Bütünşehir Yasası)—which extended the jurisdiction of metropolitan municipalities to entire provincial territories, thereby dissolving the legal distinction between urban and rural areas (Mengi et al., 2024). The law redefined the administrative structure by absorbing villages and small towns into metropolitan districts, transforming them into urban neighbourhoods and effectively marginalizing rural governance and identity (Batuman, 2017). This paper, in this context, examines the socio-ecological implications of these transformations in the case of Ayvalık, a coastal town in western Türkiye renowned for its ecological and cultural heritage.

Within this context, Ayvalık is conceptualized as a "metropolitan hinterland"—a space absorbed into the urban regime yet politically and geographically peripheral. Here, nature becomes simultaneously instrumentalized and symbolically contested, revealing the contradictions of neoliberal urbanisation. The study argues that the restructuring of governance and space under the Metropolitan Law has intensified socio-environmental inequalities and catalysed new forms of grassroots resistance. These dynamics are explored through the lens of urban political ecology, which provides a critical framework for analysing how capitalist urbanisation reshapes both environments and the social movements that emerge in response.

Although urban social movements have been widely studied, ecological resistance in administratively urbanized but geographically peripheral contexts remains underexplored. This paper posits that the ecological movements in Ayvalık represent an emergent form of urban ecological resistance—a localized response to the restructuring of nature as part of urban space. By confronting the contradictions of planetary urbanisation, these movements offer a situated critique of centralized planning and a reimagining of the urban-rural interface. Accordingly, the central research question guiding this study is: What kinds of environmental movements evolve in response to the changing conceptualization and perception of 'nature' under the conditions of planetary urbanisation intensified by a governance reform such as the Metropolitan Law?

The analysis is based on qualitative social science research conducted in Ayvalık over a period of 2 years (2023-2025) complemented by policy document analysis and a review of academic and gray literatures. This involved 6 in-depth interviews with the actors of resistance (activists and locals who comprise the resistance), academicians, and architects working specifically on Ayvalık and the ongoing spatial change. In doing so, it contributes to critical planning and urban theory by illuminating how peripheral geographies expose the uneven, multi-scalar nature of urbanisation and the political possibilities that arise from it. By foregrounding the role of legal instruments in reshaping territorial governance, the study demonstrates how planetary urbanisation reconfigure both material environments and forms of political agency. Through the case of Ayvalık, the paper reveals the entangled geographies of urban and rural transformation and the grassroots resistances that contest and redefine these boundaries under centralized governance.

Tracing The Urban-Rural Boundary Through Ayvalik's Socio- Ecological Transformations

The coastal town of Ayvalık is located in the Aegean region of Balıkesir Province, in northwestern Turkey. It is bordered by Gömeç to the north, Dikili to the south, and Bergama to the southeast (Figure 1). Characterized by its undulating topography, Ayvalık is an archipelago consisting of more than twenty islands and islets, the most prominent being Cunda Island—also known as Alibey. Due to its positioning within an archipelago, Ayvalık lies on a small inland sea, protected by Cunda within a sheltered bay. The broader geographical context includes

the Madra Mountains to the east and the Aegean Sea to the west, with the city itself expanding between coastal areas and hills rising 100–200 meters inland. Over time, the urban fabric has extended toward these hills and further northward. Its location on the western edge of this inland sea, formed between Central Anatolia and the island of Lesvos (Midilli), has long shaped Ayvalık's identity as a key node in olive oil production since the 19th century.

Figure 1. The location of Ayvalık. Source: Google Earth.

Ayvalık is designated both as an 'urban conservation area' due to its historic port and traditional settlement patterns, and as a 'natural conservation area' to preserve its olive groves and protected landscapes. A range of legal frameworks concerning cultural heritage, forestry, and agriculture regulates and safeguards the region. The olive groves, central to Ayvalık's heritage, are protected under specific agricultural policies, and conservation designations cover areas such as Cunda Island, parts of the Hakkı Bey Peninsula, and 20 of the 22 surrounding islands. Portions of this landscape have also been incorporated into a national park to ensure long-term ecological preservation. In recognition of its cultural and industrial significance, the Ayvalık Industrial Landscape was added to the UNESCO World Heritage Tentative List in 2017 (Tentative List Ref. No. 6243). The town's well-preserved industrial buildings, along with its port, traditional settlement, and olive groves—covering 13,200 hectares—offer a comprehensive portrayal of the industrialization process (UNESCO World Heritage, 2017). By the 1980s, with the growing prominence of the tourism sector, Ayvalık began to be recognized as a desirable tourist destination due to its coastal features and natural beauty.

The earliest documented references to Ayvalık date to the 16th century, while local oral traditions trace its founding to around 1580 by members of the Greek community (Şahin Güçhan, 2008). Despite a lack of continuous documentation, it is known that Ayvalık was granted autonomy by imperial edict around 1789, marking a period of rapid urban growth and a predominantly Greek population (Sağlam, 2022). During the 19th century,

within the Ottoman Empire, Ayvalık became a key port town on the western Anatolian coast, owing to its thriving olive oil and soap production and trade networks (Akin Akbüber, 2015).

By this time, Ayvalık was home to over a hundred olive oil presses and more than thirty soap factories. It supplied a substantial portion of Istanbul's olive oil and soap needs, with exports extending to regions such as Thrace, Macedonia, and even Russia (Yaman-Kocadağlı, 2011). This economic boom, especially during the late 18th and early 19th centuries, significantly increased the town's population and wealth. Infrastructure developments, alongside the olive oil industry's profitability, transformed Ayvalık from a modest coastal settlement into a significant "commercial harbor city" within just a century (Akin Akbüber, 2015, 2020; Uçar, 2015; Sağlam, 2022). Despite the enduring spatial imprints of its port-based industrial identity, Ayvalık's urban fabric and social composition have been continually reshaped by social and ecological upheavals. From the earliest records to the 2000s, major shifts in population, social structure, and spatial organization can be attributed to Ayvalık's coastal geography and ecological vulnerability. However, the nature and impact of these ruptures have evolved considerably in recent decades (Figure 2).

In the 18th century, the population was predominantly Turkish. However, by the 19th century, the influx of Greek migrants dramatically shifted the demographic composition (Balcı Akova, 2011; Yaman-Kocadağlı, 2011). Nationalist sentiments following the French Revolution contributed to uprisings among the Greek population, and the first major rupture in Ayvalık's socio-environmental history was the 1821 Greek Revolution. While this period was devastating, historical accounts emphasize Ayvalık's resilience and subsequent recovery (Sağlam, 2022). Later crises included a destructive earthquake in 1866 and, nearly fifty years later, the turmoil and abandonment caused by the Turkish War of Independence (1919–1923).

The 1923 population exchange between Turkey and Greece marked a fundamental transformation, permanently displacing the original Greek inhabitants and replacing them with Turkish populations from Lesvos, Crete, and Thrace (Anastassiadou, 2012, as cited in Sağlam, 2022). This exchange drastically altered the city's social, spatial, and economic structures (Balcı Akova, 2011; Yaman-Kocadağlı, 2011). According to the 1927 national census, Ayvalık's population had dropped from 31,894 in 1914 to 16,873, reflecting the effects of war and forced migration. Two additional earthquakes in the 1940s marked the final major crises in the town's pre-contemporary history.

Periodic uprisings and interethnic tensions in this once multi-religious, multilingual, and multiethnic town disrupted both its economy and built environment. The aftermath of the population exchange triggered a period of stagnation, as the newly settled communities faced challenges adapting to the existing social and economic structures. However, by the 1960s, Ayvalık entered a new phase of development. While agriculture and agro-industrial activities remained important, tourism began to play a growing role in the town's economy. Investments in accommodation facilities, beaches, and coastal infrastructure increased tourism revenues (Yorulmaz, 1997, p. 127). After 1963, the Turkish government provided financial support for coastal tourism development, and in 1969, Ayvalık was designated a priority area for tourism investment (Cantimur, 2011). This sector expanded significantly after the 1980s, becoming central to Ayvalık's urban and economic trajectory (Yaman-Kocadağlı, 2011).

The increasing influence of tourism created an urgent need for a structured development plan in the second half of the 20th century. A 1/1000-scale development plan was prepared in 1972, but its implementation was limited. Proposed developments on Cunda and Lale Islands were not realized due to low construction demand (UNESCO World Heritage, 2017). A major initiative from this plan—the relocation of olive oil factories outside the city—was implemented in the 1980s. During this time, Ayvalık and parts of Cunda were designated as Natural and Historic Conservation Areas in 1976, followed by temporary development regulations in 1978. Until 1982, the plan was revised and partially applied outside the conservation zones (Şahin Güçhan, 1986, pp. 28–35; UNESCO World Heritage, 2017).

The Protection of Cultural and Natural Properties Law (Law No. 2863), enacted in 1983, brought Ayvalık under the jurisdiction of the newly formed Bursa Regional Conservation Council. In the late 1980s, the boundaries and regulations of the conservation zones were revised. Regional development plans were approved in 1990 for non-conservation areas, and in 1994, an urban heritage conservation plan was adopted and remains in use (Şahin Güçhan, 1986, pp. 28–35).

Between 1976 and the mid-1990s, new developments were permitted only outside urban conservation zones, leading to the construction of low-density summer houses and tourism facilities. The relocation of polluting industries helped mitigate some environmental issues, but also left many industrial buildings unused. However, since the 2000s, there has been renewed interest in preserving these structures through local initiatives involving businesses, the municipality, and civil society organizations. These efforts contributed to a more organized heritage conservation strategy in Ayvalık (Cantimur, 2011; UNESCO World Heritage, 2017).

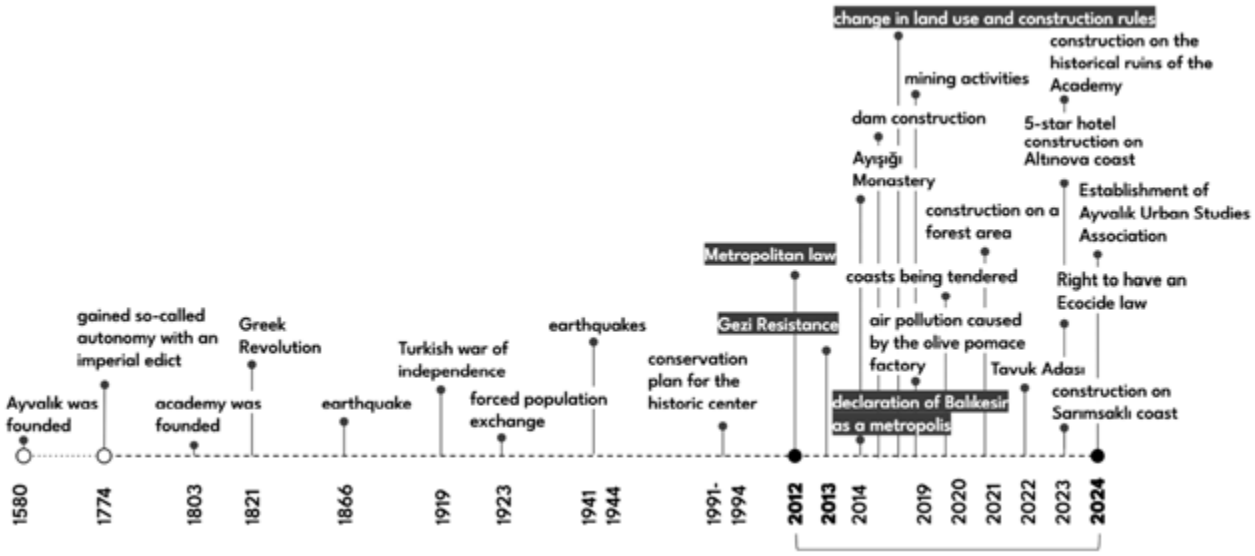

Figure 2. The brief history of Ayvalık. Produced by the author.

The social and ecological crises in Ayvalık—referred to here as "ruptures"—involve abrupt transformations in population dynamics (Balcı Akova, 2011), spatial organization (Sağlam, 2022), and urban governance. David Harvey (2011, 2012), in his analysis of urban revolutions, identifies such crises as intrinsic outcomes of capitalist accumulation, noting that urban environments are both sites of accumulation and of resistance. In Ayvalık, these crises have intensified since 2012 with the growing influence of neoliberal urbanism and tourism-driven development, accompanied by the privatization of public goods and services and a consequent decline in quality (Harvey, 2012; Friedmann, 2014). In this context, nature has increasingly been commodified, repurposed as a vehicle for capital accumulation (Smith, 2007), yet these processes have also provoked significant resistance.

Metropolitanization: Planetary Urbanisation Arrives In Ayvalik

Back in 2002, 65% of Turkey's population was noted as urban, with more than half residing within the boundaries of sixteen metropolitan municipalities. Early in its term, the AKP government moved to expand these metropolitan boundaries through legislation in 2004. By 2012, as a result of a series of reforms, 76% of the population lived in areas designated as metropolitan, which encompassed 55% of the nation's land (Arıkboğa, 2013; Zengin, 2014). At the latter end, the last regulation in 2012 redefined the metropolitan structure and villages were integrated into metropolitan districts by expanding municipal governance into peripheral areas. This does not only entail the expansion of municipal administration to the peripheries, it also changes the definition of urban with the increasing influence of the periphery in urban politics (Batuman, 2017, p. 110).

Balıkesir was among the provinces affected by these governance and policy changes. With the enactment of Law No. 6360, titled "The Establishment of Metropolitan Municipalities in Fourteen Provinces, the Formation of Twenty-Seven Districts, and Amendments to Certain Legislative Decrees," which was adopted on November 12, 2012, and published in the Official Gazette on December 6, 2012, Balıkesir Metropolitan Municipality was established, and its jurisdiction was defined as the entire provincial territory (Resmî Gazete, 2012). According to the Turkish Statistical Institute (TÜİK), as of 2014, Balıkesir no longer has a statistically defined rural population due to its designation as a metropolitan municipality. In 2012, however, 61.32% of the population resided in provincial and district centres while 38.68% lived in towns and villages (Balıkesir Büyükşehir Belediyesi, 2024).

In addition to Balıkesir, in the provinces of Aydın, Denizli, Hatay, Malatya, Manisa, Kahramanmaraş, Mardin, Muğla, Ordu, Tekirdağ, Trabzon, Şanlıurfa, and Van, metropolitan municipalities were established under the same name, with their jurisdiction defined by the provincial administrative boundaries (Resmî Gazete, 2012). Consequently, the existing provincial municipalities in these areas were restructured as metropolitan municipalities. With the legislative amendment, the number of metropolitan municipalities in Turkey has reached 30.

The regulation became effective in 2014 with the local administration general elections held on March 30. Since that time, Balıkesir has been governed as a Metropolitan Municipality. In the days following the elections, public statements began appearing in the media, emphasizing plans to transform Balıkesir into an "attraction center." It was announced that numerous new projects would be introduced to achieve this goal. These projects ranged from infrastructure developments, such as wastewater treatment facilities to reduce marine and environmental pollution, and the construction of overpasses and highways, to large-scale investments aimed at making both the city center and its districts key attraction points. These included tourism centers, ports, a regional hospital, an airport, shopping malls, and new residential developments. The Balıkesir-Çanakkale Planning Region 1/100,000 Scale Environmental Plan also provided a higher-level framework supporting these large-scale projects and investments. Additionally, the invitation and brochure for the 7th Emerging Cities Summit, held on May 6–7, 2015, described Balıkesir as the "shining star of the Marmara region," highlighting its central location at the intersection of major highways and positioning it as a prime destination for investors (Özerk, 2017). During presentations at the summit, Balıkesir's strategic location—close to major highways and metropolitan areas—was emphasized to attract investment for planned projects. Meanwhile, numerous so-called "visionary projects," promoted under the goal of making Balıkesir a "brand city," began to receive extensive coverage in both print and digital media (Özerk, 2017).

The delineated concentration of production, population, and infrastructure within the metropolitan area serves as a driving force for capital accumulation and transformation of locations, regions, and landscapes across various spatial scales (Soja, 2000; Krätke, 2014; Scott et al., 2015). As previously discussed and presented in earlier sections, contemporary forms of urbanisation are already disrupting and redefining the traditional boundaries of cities, including those of major metropolitan areas, as they alter existing regional arrangements and increasingly blur the distinction between urban and non-urban areas (Brenner, 2013; Brenner et al., 2014). The metropolitan law on the other hand has adopted a disruptive approach, accelerating and evolving the process and drawing its own boundaries. In this sense, legal and regulatory changes have been politically instrumentalized within the context of urban spatial reproductions to find new ways of capital accumulation.

Ayvalık was deeply affected by the changes in metropolitan structure. In 2012, Balıkesir was declared a metropolitan city, and Ayvalık's local administration saw changes in its authority. Similar to what has been argued with the thesis of planetary urbanisation, the Metropolitan law can be considered to crystallize the explosion and expansion of the urban, leading to the autonomy of small and medium-sized cities, transforming them into the 'virtual colonies of the metropolis' (Schmid, 2014, p. 69). In this sense, Ayvalık became liable to be conceptualized as a 'virtual colony' of its neighbouring metropolitan cities, namely Izmir and Istanbul, considering the established trade network settled primarily on olive.

Upon examining the urbanisation process following the change in administration in Ayvalık, urban projects tendered or proposed by the Balıkesir Metropolitan Municipality have been brought forward. Following this decision, what is frequently emphasized is the revival of numerous proposals, which were previously planned but reportedly suppressed in the past due to strong opposition from the local municipality. In addition, one of the most significant challenges currently facing the local community is the lack of sufficient attention and support from the metropolitan municipality towards local issues. The ongoing socio-ecological issues of Ayvalık are being marginalized by the metropolitan municipality, eliciting apprehensions regarding the prevailing perception of an unattended local voice.

Following Balıkesir's declaration as a metropolitan city in 2014, Ayvalık experienced negligible advantages. The top-down management style of the metropolitan municipality was unable to adequately address the local needs. (A representative of ATP)

With the changes in jurisdiction, the Water and Sewerage Treatment Plants were transferred to the metropolitan municipality. In the past, we saw that these treatment plants were not being operated before the election. We organized many protests and made significant efforts to get the treatment plants running, but we couldn't achieve any results. The Metropolitan Municipality Law has also become something that exacerbates such problems and disruptions from an ecological perspective. I believe it was entirely created out of political concerns (TİP Balıkesir Provincial Administration Ecology Officer)

Giving the decision-making power to higher levels of governance undermines the autonomy and effectiveness of district municipalities. This shift in power diminishes the decision-making capacity and active participation of local governments, which are best suited to manage and respond to the immediate needs of their communities, such as waste collection and maintaining clean streets. Governance should be grounded in the local context, where the management of daily life is most effective, and where resources, personnel, and decisions can directly address the specific needs of the area. Centralizing authority not only disrupts the functionality of local governance but also weakens the direct connection between the government and the community it serves.

Delegating governance to a higher level inherently means bypassing the local will. It restricts decision-making capacity, reduces agency, and diminishes participation. In essence, it strips the locality of its governing power. A district municipality operates at the smallest scale—handling tasks such as waste collection, street maintenance, and addressing community needs. Governance must be approached from within the flow of everyday life; it cannot be effectively managed from a different scale. Managing the district requires establishing a framework that aligns with its budget, personnel, and tangible presence in daily life. (Group member of AKVG)

The shift in the governance model shows the indicators of metropolitanization and how planetary urbanisation have arrived in Ayvalık through different modes of reshaping urban space and nature. Whether through appropriation or degradation, and whether under protection or without, nature remains central to capitalist strategies, which seek to integrate it into the circuits of capital accumulation, often without regard for the resulting socio-ecological consequences (Cortes-Vazquez et al., 2019). In this sense, employing a historically and geographically grounded approach to the study of urban nature production allows for a critical understanding of the unequal power relations shaping these processes, which also guides the potential transformation of these power relations (Swyngedouw, 2006). In the case of Ayvalık, the changes in authority and legislation embark on the socio-ecological exploitations, which have also manifested themselves through several cases within the contemporary capitalist form of urbanisation patterns embedded in the urban realm.

Despite Ayvalık having confronted various instances of social and environmental disruption in the past, including earthquakes, the Greek Revolution, and the population exchange between Greece and Turkey, it has never experienced such heightened socio-ecological degradation as it currently faces in the present neoliberal era. The AKP government has demonstrated a distinctly exploitative approach toward nature (Çoban, 2019). Since 2002, the government has worked hand in hand with capital, depleting both human and non-human aspects of nature to sustain and expand a capitalist accumulation regime. However, the environmental destruction caused by the AKP government is not a new phenomenon in Turkey. This phenomenon is not limited to the advanced economies of the West but is even more pronounced in emerging centres of capitalist expansion, such as China, Turkey, and India. The restructuring of urban and natural environments plays a pivotal role in the accumulation and circulation of capital in the contemporary era (Karakayali et al., 2014). As history has shown, wherever capitalism exists, environmental degradation inevitably follows (Çoban, 2019). Nevertheless, Ayvalık endeavours to resist and firmly preserve its pre-established urban and ecological identity which is characterized by designated urban and natural conservation areas, alongside first-degree protected islands and nature parks. Despite efforts to preserve Ayvalık's established urban and ecological identity, current urbanisation trends are largely shaped by ongoing changes in governance, planning, and legislation. The dissolution of district municipalities, modifications to urban plans, and shifting regulations have created conditions that enable capitalist-driven environmental exploitation, exerting a dominant influence over the region's development.

Recent developments, especially over the past five years, serve as indicators of the impact of neoliberal urbanisation in Ayvalık; every part of the city bears the results of various exploitations (TİP Balıkesir Provincial Administration Ecology Officer)

The urbanisation of Ayvalık has not only altered its material and administrative configuration but also transformed its socio-political landscape. As urban expansion reaches peripheral territories, existing environmental conflicts have intensified, while new socio-spatial tensions have emerged. These developments reflect broader patterns of socio-environmental inequality and undemocratic spatial change, hallmarks of the neoliberal urban condition (Cortes-Vazquez et al., 2019). In this context, resistance movements have acquired an urban ecological character—rooted in the localized defence of nature yet shaped by planetary processes of urban transformation. These movements challenge rent-seeking urban development and centralized governance while articulating alternative visions of ecological stewardship, spatial justice, and democratic agency. Additionally, as cities increasingly become arenas for financial speculation, urban spaces have emerged as primary sites of contestation, where struggles focus on preserving and shaping the fundamental conditions of human life—including public spaces, neighborhoods, and natural landscapes (Karakayali & Yaka, 2014). In this context, within the framework of consciousness towards the democratic 'rights'—the right to the city and nature, as the activists have frequently stated— the accumulation of socio-ecological challenges in Ayvalık has originated urban ecological movements. Furthermore, resistance in these areas acquire a potentially radical and transformative nature, as it directly challenges the urban and environmental transformations that have become central to capital circulation in the neoliberal era (Karakayali & Yaka, 2014).

Urban Ecological Movements In Ayvalik

The interaction between urban spaces and natural environments has become increasingly complex, particularly in contemporary capitalist relations. In cities like Ayvalık, where commercial activities and tourism largely depend on natural resources and a capital-oriented approach to urbanisation is prevalent, the city, and nature are simultaneously contradictory and mutually reinforcing. The expansion of the urban, in this sense, can also be associated with the exploitation of natural resources, significantly altering the relationship between cities and the environment. It is driven by economic imperatives, where both nature and urban are reconstructed by the forces of capital. This process of reconstruction was argued to be defined as urban interference towards nature, in which the transformation of nature into urbanized environments reflects broader trends in neoliberal development. In this section of the study, I will exemplify nature that has been intensely subjected to urban interventions driven by dominant urban and environmental policies.

A considerable number of areas in Ayvalık, particularly those located in the coastal region, have been experiencing a process of spatial and ecological degradation as a result of urban interventions, which are primarily driven by profit-oriented projects. These environmental issues have become focal points of resistance for volunteers, residents, and civil initiatives, leading to the recreation of both urban space and nature, as well as the adoption of new social practices. In this context, spaces shaped by the intersection of environmental degradation and collective opposition begin to constitute what can be described as oppositional landscapes—geographies marked by contestation, grassroots activism, and alternative imaginaries of urban-nature relations.

While these oppositions have been spatially grounded in Ayvalık, their roots lie in a broader trajectory of ecological activism across Turkey. In particular, in the Black Sea, Marmara, and Aegean regions, numerous local and civil initiatives are actively organized in opposition to the planned energy investments. These mobilizations have been so effective that they have led to a stay of execution (Kadirbeyoglu, 2005; Gönenç, 2022). In this context, the concept of 'counter-hegemonic flows' (as conceptualized by E. Turan & AydΔn, 2023) has experienced a resurgence as local ecological struggles have expanded opposition to renewable energy in Turkey. Although environmentalism provided the most effective critique of neoliberal urbanisation in Turkey, its influence declined significantly after the 2011 elections, as evidenced by the failure of environmental activists to get most hydroelectric power plant (HPP) projects cancelled (Batuman, 2017). However, the Gezi Park protests in 2013 marked a critical turning point, revitalizing environmental activism and broader urban struggles. As a defining moment, Gezi not only lend impetus for collective mobilization against neoliberal urbanisation but also introduced a new vision of urban social movements in Turkey, bringing environmental concerns to the urban agenda (Karakayali et al., 2014) by fostering new political imaginaries that connected and reinforced various grassroots and political mobilizations that had preceded it (Erensü et al., 2017). While some studies have pointed to the absence of a cohesive environmental movement and limited political representation, along with the financial constraints hindering rural communities from engaging in sustained activism (Duru, 2013; Paker, 2013), the past fifteen years have nonetheless seen significant civil society efforts and government-led initiatives opposing large-scale investments at both local and national levels. The impact of the Gezi protests extended well beyond its time, with the so-called 'Gezi spirit'

continuing to inspire opposition movements and shape Turkey's cultural landscape and political discourse (Erensü et al., 2017, p. 2). Consequently, the urbanized conditions of Ayvalık have come to delineate new forms of resistance shaped around the accumulation of urban crises and the extension or spread of the urban resistance agenda, gained during and after the Gezi Park protests.

In the wake of the 2014 local elections, a substantial part of the coastal area in Sarımsaklı Beach was leased to the Metropolitan Municipality with the intention, as expressed by the municipality, of capitalizing on and incorporating it into the market to promote Ayvalık as a global brand and boost tourism (Durgun, 2023). The initial proposal according to this intention was unveiled in 2015, however, postponed due to strong oppositions from the community of Ayvalık. Nevertheless, as of 2021, Sarımsaklı coast has been reclassified from a 'public beach' to a 'sustainable protection and controlled utilization area', rendering the existing plan ineffective. Based on this, the construction on the beach has started following the proposed design. The natural environment was attempted to be instrumentalized as an accumulation strategy. It is defined as an urbanized intervention that has led the way for the further construction of Sarımsaklı and the marketing of Ayvalık under the name of tourism. As discussed earlier, alterations in the conservation status of areas in Ayvalık, influenced by top-down decisions, are dominant factors shaping the condition of 'natural' spaces within the current neoliberal urbanisation dynamics.

This change in Sarımsaklı coast has paved the way for construction under the label of 'Recreation Area,' marking the final step of a long-planned project. Despite claims by authorities that the ongoing construction on Sarımsaklı beach is situated in a degraded sandy area, this assertion does not align with the actual circumstances. Since the enactment of the Metropolitan law, district governance has been marginalized in addressing this dimension of the socio-environmental crisis. In addition to this, despite repeated claims by Balıkesir Metropolitan Municipality that the process was conducted with public participation through field research in 2022, the project has encountered significant opposition from both the local populace and resistance groups; the criticisms mainly pointing out the deviations from coastal law, planning and urbanisation principles, and public interest.

The social practices that have emerged in response to ongoing spatial and environmental interferences in Ayvalık manifest in the form of petition campaigns, press statements, and organizing demonstrations; the sites hosting these movements show the differentiated modes of urbanisation by looking at the emerging social practices. The resistances that we would like to specifically mention in this section are the 'Beach Towel Revolt' that took place in Sarımsaklı beach and the coastal resistances mobilized with the frame of "We are all on the coast," reclaiming the coastal areas by demanding the right to the city and nature.

The most recent protest in Ayvalık concerns the privatization of the coasts and demanding the implication of existing coastal laws; it has spatialized in various points locally and nationally encompassing the other coastal towns, i.e. Bodrum, Datça, Çeşme, Fethiye, Burgazada, Daylan, etc. The struggle has evolved into an urban ecological movement because of the reason for it and the connections established among the national sites of resistance. The interconnectedness of sites of protest emphasizes the powerful potential of environmental issues to resonate with one another, making it easier to achieve collective unity in the resistance. In this regard, while Sarımsaklı Beach stands as a protest site that overlaps directly with the object of contention, other instances in Ayvalık illustrate how spatial strategies of resistance can also unfold in more symbolically charged or centrally located public spaces.

Figure 3. Excavator traces on sand, Sarımsaklı. Photographs are taken by the author in January 2024.

The ongoing construction on Sarımsaklı Beach (Figure 3) and the restriction of public access have manifested in a form of protest rarely encountered in an 'urban' context, as part of broader urban and environmental activism by the local people and resistance groups. In response to the call by the Ayvalık Initiative for the Protection of Cultural and Natural Heritage (Ayvalık Kültür ve Tabiat Varlıklarını Koruma Girişimi – AKVG) and Ayvalık Nature Platform (Ayvalık Tabiat Platformu – ATP) under the 'Beaches Belong to the People' movement, residents of Ayvalık mobilized in streets, squares, and beaches symbolically using 'beach towels' to claim the right to the city and reappropriate the contested urban space through bodily engagement. Soon after the actions and press statements of activists from the ATP, environmental volunteers, and the AKVG began to be organized at Sarımsaklı Beach, the area was transformed from a site of daily life into a space for activism. These individuals, institutions, and initiatives, characterized by their opposition, played a crucial role in the spatial transformation of the beach by organizing activities that intertwined with the ordinary flow of daily life at the beach—events that would otherwise be considered unusual and extraordinary at any other beach.

Through their practices, Sarımsaklı Beach has been transformed and differentiated, becoming a place where political activism has become an ordinary part of everyday life. This illustrates how the daily routine in a space where urban and non-urban intersect is momentarily disrupted by the dynamics of differential urbanisation, transforming the beach into both a site of protest and a site of resistance (Dinçer, 2016). Therefore, while Sarımsaklı Beach is ecologically significant due to its endemic plant diversity and holds importance as a popular tourism and holiday destination, it can be said that the activism on the beach has further emphasized its distinctiveness distinguishing it from other beaches.

Figure 4. A photograph taken during an urban ecological movement happening in Sarımsaklı. Source: Archives of Ayvalık Nature Platform

What sets Sarımsaklı Beach apart is the intertwining of daily life with political activities in a space where the effects of environmental destruction and neoliberal urban and environmental policies are most clearly observed. Notably, the Beach Towel Revolt transformed the most common activity on the beach—sunbathing—into an expression of protest, making protest a natural part of life at the beach (Figure 4). This convergence and integration mean that the beach is seen as more than just a site for demonstrations; it allows the potential for individuals from the flow of everyday life at the beach to participate in the resistance. Thus, resistance becomes a practice that can be experienced within daily life, even at the beach, allowing anyone to become an actor in collective activism. Here, the ease and perceived 'safety' of participating in resistance efforts with an environmental aspect, compared to other types, undoubtedly has a significant impact.

I find the ecological struggle to be somewhat successful because it is one of the forms of activism that people find most comfortable and easy to participate in. They start out with a love for nature and animals, and it doesn't necessarily require a serious political consciousness at first. That political awareness develops throughout the process. (TİP Balıkesir Provincial Administration Ecology Officer)

These actions occur as practices that do not interrupt the ongoing daily life at the beach, but rather integrate into it. Political activities and sunbathing, along with swimming, occur in the same space, becoming intertwined. Yet, the protest was not limited to a certain site; with resonance on social media among locals of Ayvalık, it also evolved into action to protect public areas under the Coastal Law. These protests highlighted the socio-ecological exploitation occurring in an area previously designated as a 'Public Open Beach,' now reclassified as a 'Recreation Area.' Hence, the ongoing socio-environmental exploitation and urban ecological movements in the Sarımsaklı coast exemplify the urbanized interventions during the period of neoliberal urbanisation.

Concluding Remarks

This paper has examined the socio-ecological implications of Law No. 6360 through the lens of Ayvalık, highlighting how centralized governance mechanisms reshape the urban–rural interface under the conditions of planetary urbanisation. By extending the jurisdiction of metropolitan municipalities, the law not only redefined legal and administrative boundaries but also restructured material environments and social relations across previously rural territories. According to the analyses it is observed that in Ayvalık, these transformations have intensified land commodification, environmental degradation, and socio-spatial inequalities—revealing the deep entanglement of ecological and political crises within the contemporary urban condition.

Framing Ayvalık as a metropolitan hinterland has allowed us to trace the uneven geographies of state-led urbanisation, where peripheral spaces are subsumed into the urban regime while remaining politically marginalized. Yet, these same geographies have become sites of contestation, where grassroots actors engage in ecological resistance not merely to preserve landscapes, but to reclaim decision-making power, assert local autonomy, and articulate alternative spatial imaginaries. These movements expose the contradictions of capitalist urbanisation and challenge the symbolic and functional erasure of the rural under centralized rule.

By foregrounding the relational production of space and nature, this study contributes to a growing body of work within urban political ecology that seeks to re-theorize urbanisation as a socio-natural process. It suggests that attention to peripheral, administratively urbanized territories can reveal important insights into the workings of state power, the material politics of planning, and the emergence of new forms of environmental activism. In doing so, it calls for planning and governance frameworks that are ecologically informed, territorially sensitive, and democratically accountable—capable of recognizing the situated knowledge and lived experiences of those who inhabit urbanizing landscapes.

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Construction of Regional Multi-dimensional Proximity Network from the Perspective of Collaborative Agglomeration — Analysis of Geographical Proximity Networks in Contiguous Rural Spaces

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Abstract
This study applies collaborative agglomeration theory to investigate how geographical proximity influences rural spatial networks across 678 villages in Xinghua, China. We analyze three key dimensions of geographical proximity network: morphological distribution patterns, geographical scale relationships, and cultural superposition characteristics. Based on this, it was found that the river network and historical wei-field development jointly shaped the settlement pattern of clustering in the east and dispersion in the northwest. And the region forms a "core-edge" network structure with the urban area and Dainan Town as the core, and the northwest water network area as the edge. Water-aligned cultural resources show dual-core clustering with collaborative potential. Study provides spatial optimisation basis for rural contiguous development, and further integration of industrial and social proximity will be constructed in the future.

Key Words: Geographical proximity network; Rural space; Morphology agglomeration; Gravity model; Regional multi-dimensional proximity

1. Introduction

In the context of global urbanisation and sustainable development, the concept of "Collaborative Governance" proposed in the 2016 United Nations New Urban Agenda breaks through the limitations of traditional administrative boundaries and advocates cross regional collaboration to address global challenges such as climate change. This concept has gained widespread consensus not only in the study of various factors such as environment and transportation in cities (Fan et al., 2022, Wang and Zhao, 2021, Jinsoo and Suh, 2012), but also in the analysis of urban networks(Luo et al., 2025) and industrial associations between urban clusters, revealing the promoting effect of collaborative agglomeration on regional innovation (Ma et al., 2021, Huggins and Prokop, 2017, Shearmur, 2012). Similarly, rural spaces are also showing a significant trend of collaborative development(He et al., 2019, Luo et al., 2020), gradually transitioning from dispersed layout to networked agglomeration through resource integration and functional complementarity. This new paradigm of coordinated urban-rural development provides important theoretical support and practical paths for regional spatial reconstruction.

The formation and development of contiguous rural spaces are the result of multiple factors working together. This study draws on the concept of multi-dimensional proximity (Tobler, 1970, Ma et al., 2021, Zhou et al., 2024) in economic geography, which is divided into geographic proximity, social proximity and cognitive proximity. The study applied them to rural spatial analysis to reveal how these factors synergistically shape the spatial organisation of rural spaces. From a spatial perspective, geographical proximity shapes the similarity of regional background characteristics through natural geographical conditions and historical accumulation. From the perspective of development, social proximity is manifested as the convergence of industrial technology paths and development directions. From a cognitive perspective, the values of villagers and development vision constitute the impetus for promoting collaborative development. Through complex interactions of the three dimensions, they jointly affect the agglomeration form and collaborative development path of rural spaces. This study takes the geographical proximity of rural spaces as the starting point, and provides a theoretical basis for revealing the underlying factors of regional coordinated development by analyzing their spatial distribution characteristics and network correlation mechanisms.

In terms of the geographical agglomeration of contiguous rural spaces, academic and practical study on rural areas mainly focuses on three aspects: spatial distribution patterns, historical dynamics, contiguous protection methods, and patterns. 1) Study on the spatial distribution patterns of villages. Most studies evaluate the spatial layout of rural spaces at the meso and micro scales through modeling methods such as gravity models and rank scale rules(Liu et al., 2024, Sun et al., 2025), and use this as a basis to divide rural clusters and optimise resource allocation. 2) Study on the formation and evolution mechanism of rural geographic space from the perspective of historical evolution. By proposing a hierarchical model of the "human-earth-network" relationship in cyberspace (Guo et al., 2021), the relationship between different elements combined and overlaid in space to

form different spatial forms can be determined. Then, the correlation analysis and classification of the division of concentrated contiguous areas were carried out, emphasizing the layering of history. 3) Exploration of traditional village contiguous protection methods and models. This aspect emphasises the formation of a comprehensive control system covering the entire process from the perspective of operational management and control (Pan et al., 2024). The three major stages are sorting out the resource base before application, formulate protection and utilisation guidelines during planning, and regularly monitor the results after implementation, which are interrelated. Most current study examines key villages through multi-factor analysis while neglecting studies on ordinary village patterns. Additionally, these studies consistently overlook historical and cultural dimensions in their assessment of village influencing factors.

In the process of conducting study on rural spaces, the geographical background characteristics serve as the basic carrier of spatial similarity and functional connections, providing a background explanatory framework for identifying the agglomeration characteristic of rural space. After incorporating historical and cultural factors, they profoundly influence the spatial organisation mode and development path of rural space together. This study constructs a geographical proximity network analysis model from the perspective of collaborative agglomeration. Through quantitative analysis of geographical scale, history and other data, it not only intuitively displays the spatial distribution pattern of villages, but also reveals the potential multi-dimensional proximity relationship network between settlements. Thus, it can break through the static description limitations of traditional rural spatial study. By combining this with subsequent social and cognitive proximity analysis, study could deepen from spatial proximity to functional proximity. Thereby we can identify key hubs and weak links in regional collaborative development more accurately.

2. Study region and background

Xinghua is a county-level city under the jurisdiction of Jiangsu Province and managed by Taizhou in China. It is located in the central part of Jiangsu Province, between the Yangtze River and the Huai River. The total area of the city is 2393 square kilometers, with 26 townships and 3 streets under its jurisdiction, and a total of 678 incorporated villages. Xinghua is a typical Lixiahe Plain, centered around a plain depression based on beach tidal flats. The overall style is unique and has the potential for collaborative agglomeration and development. And it has currently achieved full coverage of development-oriented village planning, shouldering the important task of national-level rural revitalisation work such as the Construction of Characteristic Rural Demonstration Areas. This study combines the case of Xinghua to illustrate the practical characteristics of rural space, providing ideas and practical guidance for the delineation of regional collaborative agglomeration units.

The landform of the same origin is gradually differentiating, with distinctive features

Geomorphic bases with similar regional ranges will gradually generate regional differentiation due to the dual effects of human intervention and natural evolution. For example, Xinghua is located in the hinterland of the Lixia River. Since ancient times, the hydrographic net has been dense and the lakes and marshes have been intertwined. Although the terrain is similar, it has gradually differentiated due to the evolution of the hydrographic net and human activities during history, forming unique landscape patterns such as raised fields, wei-fields, and lakes and marshes (Yuan, 2025). In the early days, our ancestors lived by water, built embankments and fields, and piled up soil which formed raised fields to adapt to the water environment, laying the foundation for the basic agricultural form (Shi et al., 2022, Yuan and Wang, 2019). With the development of water transportation and the rise of docks along the river, commercial and handicraft industries have gathered, and the settlement pattern has evolved accordingly(Hu, 2024). Areas with dense river networks form streets and markets due to the prosperity of commerce and trade. On the edge of the lake, fishing villages have emerged due to aquaculture. Areas with less dense river networks are still dominated by traditional agriculture.

Settlements are difficult to cluster due to their scattered and disordered distribution

The traditional small-scale agricultural production methods and scattered rural industries have jointly led to the inefficient spatial structure of villages. It manifests as limited residential area size and scattered factor allocation, making it difficult to form agglomeration effects. Despite the continuous efforts of the country's rural development policies in recent years, the problems of low space utilisation efficiency and fragmented layout have not been fundamentally alleviated. For example, Xinghua rural areas also have problems of scattered scale and spatial fragmentation. Due to the scattered raised fields formed during the development of wei-fields in the Ming Dynasty, farmers settled nearby, forming a “one wei-field, one village” pattern. Some villages are distributed

in a bead-like pattern along tributaries such as the Bangyan River and the Luting River. The average size of these villages is much smaller than that of incorporated villages in Jiangsu Province, China, where the average village typically has about 350 households. Due to the overall lack of central agglomeration areas, coupled with the trend of hollowing out and idle homestead land, there are serious problems of scattered scale and spatial fragmentation.

The phenomenon of insufficient resource utilisation and uneven development of villages and towns is prominent

The insufficient utilisation of characteristic resources, policy differences, and varying development drivers can lead to the formation of a multi-level differentiated development pattern in the region (Wang et al., 2024). For example, the development of rural areas in Xinghua presents obvious characteristics of differentiated driving forces, forming an unbalanced spatial pattern. The cultural and tourism driven areas, represented by Shagou Town and Qianduo Town, rely on historical and cultural resources and raised field landscape to drive the development of tourism supporting industries in surrounding villages. But due to their limited radiation range, villages 5 kilometers away have not been affected and are still dominated by traditional industries. Therefore, the development of villages is insufficient and uneven.

3. Construction of geographic proximity network and empirical study of Xinghua

The geographical proximity network is mainly divided into three components, namely morphological distribution characteristics, geographical scale characteristics, and cultural superposition characteristics. Study uses morphological distribution characteristics as the geographical background attributes of this region to determine its resource endowment and spatial agglomeration properties. During the study process, regional differences were followed. On this basis, specific network analysis is carried out through the geographical scale characteristics of the region, representing the multi-dimensional connectivity of village and town clusters, emphasizing the connectivity of network scale. Finally, an abstract network analysis is conducted based on the cultural attributes of villages and towns to determine the relationship between different geographical backgrounds and cultural elements, focusing on the collaborative development of culture.

Morphological distribution characteristics

Construction of morphological characteristics method system

In order to determine whether villages and towns have similar resources and characteristics in morphology, the study is divided into two dimensions based on terrain, land use, resource endowment, and other characteristics. Firstly, eight types are extracted from the patch and class agglomeration characteristics to study their morphological distribution agglomeration patterns. Then, from the perspective of the overall pattern, the above types will be assigned contract values to distinguish the degree of difference between each indicator. Thus, the aggregation, cohesion, and fragmentation characteristics of the geographical distribution of villages and towns were determined. The overall regional morphological features were summarised.

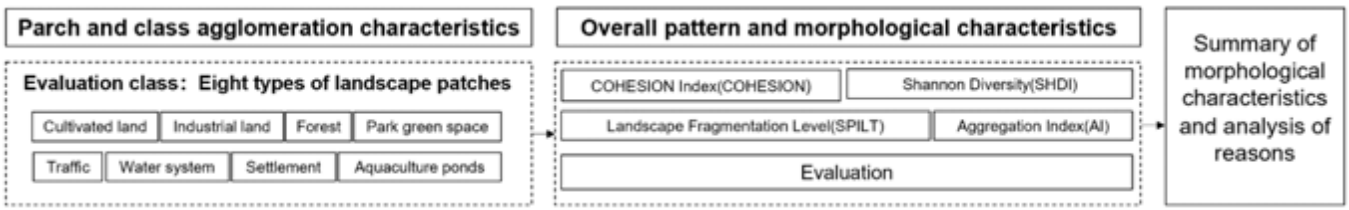

Fig.1 Technical route for evaluating morphological distribution characteristics

The study evaluated the region using the landscape pattern index tool in Fragstats, and the moving window algorithm was employed for image generation and processing. The moving window algorithm opens an analysis window centered around each pixel, calculates the selected level of indicators, and returns the calculation results to the centre of the window. By repeating this process for each pixel, the final result is the generation of a new grid surface that represents a gradient of the local landscape structure. This can reflect the detailed features of the landscape pattern and the differences in internal space.

Tab.1 Patch and class agglomeration characteristics and overall pattern and morphological characteristics indicators

Index	Formula	Formula description	Index explanation
Shannon Diversity (SHDI)	$SHDI = -\sum_{i=1}^{m}(P_i \times \ln P_i)$	Measurement index based on information theory, reflecting landscape heterogeneity.	In a landscape system, the richer the land use and the higher the degree of fragmentation, the greater the content of uncertain information, and the higher the calculated SHDI value.
Aggregation Index (AI)	$AI = \left[\frac{g_{ii}}{max - g_{ii}}\right](100)$	Used to describe the degree of aggregation of different patches or regions in a landscape, as well as the connectivity between patches of each landscape type.	A higher degree of aggregation indicates that patches of the same type are clustered together, while a lower degree of aggregation indicates that they are more dispersed and can be used to evaluate the agglomeration patterns of patches of the same type in the landscape.
Cohesion Index (COHESION)	$CO = \left[1 - \frac{\sum_{j=1}^{m} p_{ij}}{\sum_{j=1}^{m} p_{ij}\sqrt{a_{ij}}}\right]\left[1 - \frac{1}{\sqrt{A}}\right]^{-1} \times 100$ p_{ij} represents the circumference of the num. j patch in the num. i type landscape, A is the total area of the landscape	Used to describe the degree of aggregation of spatial structures within patches in a landscape, the index reflects the spatial connectivity or aggregation within patches of the same type.	A higher COHESION value indicates that different types of plaques are more concentrated or densely distributed together, forming a more compact spatial structure.
Landscape Fragmentation Level (SPILT)	$S = \frac{N_i}{A_i}$ N_i is the number of patches in landscape i, A_i is the total area of landscape i	The degree of fragmentation or fragmentation of a landscape refers to the degree of separation between different patches in the landscape.	When the landscape is divided into multiple smaller segments, the degree of fragmentation is higher; When the landscape maintains large continuous patches, the degree of fragmentation is lower.

3.1.1. Measurement of morphological characteristics

In the analysis of patch and class agglomeration characteristic, this study quantified the agglomeration patterns of eight types of landscape patches in Xinghua, including cultivated land, aquaculture pond, water system, forests, transportation, settlement, green space, and industrial land, based on aggregation index.

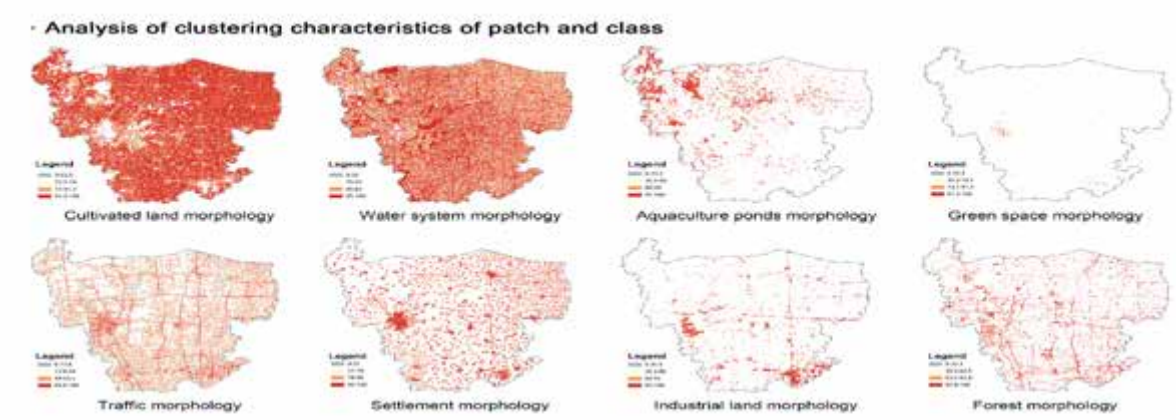

Fig.2 patch and class agglomeration characteristics

The results indicate that cultivated land shows significant agglomeration in the northeast and southwest regions, while the agglomeration degree is weaker in the central, western, and northwest regions. The complementary spatial feature is the high concentration of aquaculture ponds and water systems in the northwest. The aquaculture ponds are uniformly clustered in small areas in the north, and are less distributed in the south. The water system forms an overall uniform agglomeration pattern in the eastern and southern parts, but is more scattered in the central and northwestern parts, with scattered large blocks distributed irregularly.

In terms of settlement agglomeration characteristics, Xinghua presents three significant agglomeration cores. Firstly, there is a radiating agglomeration area centered around the central urban area of Xinghua in the central and western regions. Secondly, there is an industrial led agglomeration area centered around Dainan Town in the southeast, consisting of multiple secondary agglomeration points. Finally, there is a small-scale agglomeration area centered around Anfeng Town in the northwest. The distribution of other settlements is relatively scattered and has not formed a clear centripetal structure. The transportation network is highly consistent with the agglomeration pattern of settlements, with the main agglomeration areas distributed in the central and western regions, southwest, southeast, and northeast. The eastern transportation nodes are evenly distributed, while the northwest is significantly sparse.

This spatial differentiation is closely related to the regional geomorphological features. As can be seen from Figure 3, the overall geomorphology of Xinghua can be divided into swamp, western raised field, southern wei-field, central small wei-field and east big wei-field five parts.

Wei-fields are widely distributed throughout the region, indicating that Xinghua has a low-lying terrain and has long relied on artificial reclamation to transform swamps into farmland. The wei-field system has universality in this region. So in the analysis of the clustering characteristics of cultivated land, we found that there is not much difference in the clustering level of the entire region. On the basis of this regular distribution in the water network system, the transportation system is evenly distributed in the northeast and south, with big wei-fields concentrated in the northeast and small wei-fields distributed uniformly in the south. And artificial embankments for flood control and irrigation have been built in the northeast, combined with natural water systems, to develop into contiguous and orderly big wei-fields.

There are a large number of swamp areas in the central and northwestern parts. Corresponding to the clustering characteristics of aquaculture ponds, it was found that the current swamp areas are a composite form of wetlands, lakes, wei-fields, and aquaculture ponds. It can be seen that this area has not only been transformed into wei-fields for traditional agricultural planting, but also diversified development through raised fields and aquaculture ponds, such as aquaculture and wetland tourism development. Swamp and wetland resources are utilised at multiple levels in this way.

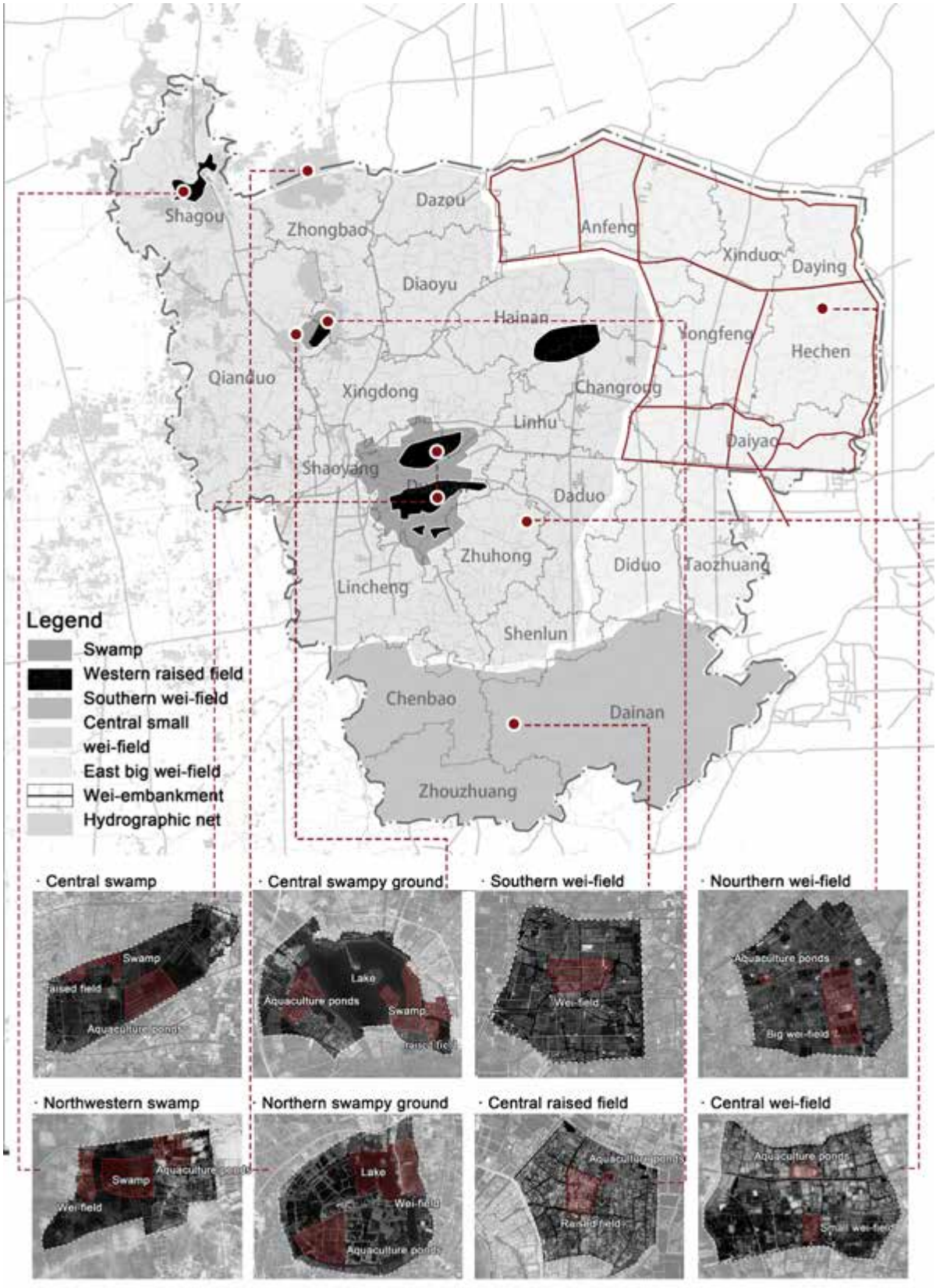

Fig.3 Regional geomorphic features: Explanation for agglomeration characteristic of patch and class

In the analysis of the overall pattern and morphological characteristics, this study selected four landscape pattern indicators, namely aggregation index (AI), cohesion index (COHESION), Shannon diversity index (SHDI), and landscape fragmentation level (SPILT), to systematically quantify the spatial structure of Xinghua. These indicators reveal the characteristics of regional landscape patterns from four dimensions: patch aggregation degree, spatial connectivity, type diversity, and landscape segmentation degree.

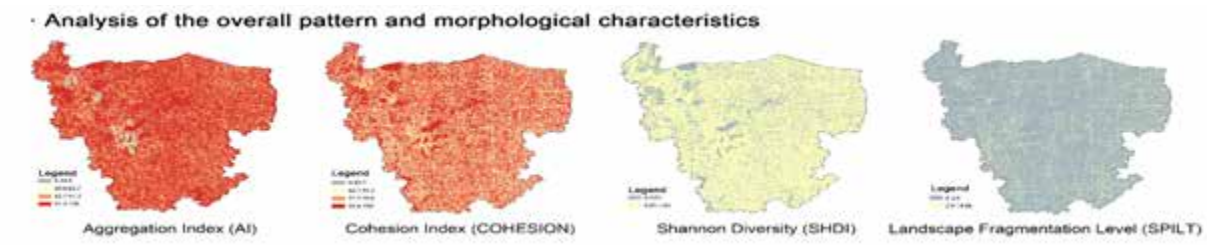

Fig.4 Overall pattern and morphological characteristics

The aggregation index shows that the overall aggregation degree of Xinghua is relatively high, indicating that the same type of land use patches in the region tend to be concentrated. Specifically, the eastern and southern regions exhibit obvious clustering characteristics of the same type of patches, which is mainly related to the local large-scale agricultural production layout. There are three significant areas of low polymerisation degree in the central and northwestern regions, indicating that the distribution of patches of the same type in these areas is relatively scattered. It should be influenced by the natural terrain such as swamps and the historical development model of raised fields and scattered wei-fields formed as a result.

The cohesion index shows that the overall spatial connectivity of the region is strong, with the index generally>82.7, but there is significant spatial differentiation. It is worth noting that the central and northwestern regions exhibit abnormally high values, reflecting that although these areas have a lower degree of aggregation. But different types of patches have formed a dense and interwoven compact spatial structure, which is related to the traditional raised field agricultural system in the area. In contrast, the cohesion index distribution in the eastern and southern regions is uniform and the values are moderate, indicating that the patch combinations in these areas are relatively loose. Their spatial connectivity needs to be improved.

The Shannon diversity analysis results show that the overall SHDI value is relatively low, indicating that the overall land use types in the region are relatively single, which is consistent with the landscape characteristics of Xinghua dominated by agriculture. However, the northwest region exhibits significantly higher diversity values, indicating the coexistence of multiple land use types and the formation of a more complex landscape mosaic fusion area. This high diversity is firstly due to the transitional geographical location of the region, and secondly due to the diverse land use patterns such as raised landscape planting, aquaculture, and wei-field agricultural planting. The landscape heterogeneity and uncertainty it brings need to be taken seriously in subsequent planning.

The results of landscape fragmentation show that the overall landscape integrity of the region is strong, and the degree of fragmentation is relatively low. Further analysis shows that this integrity is mainly due to the developed water system network in the region. These water systems not only divide the landscape, but also serve as a link between different landscape units. It is worth noting that although the overall fragmentation is low, a certain degree of landscape segmentation can still be observed in local areas, such as around towns, which should be the result of human disturbance caused by land reclamation and construction activities.

3.2 Geographical scale characteristics

3.2.1 Construction of geographic scale network based on gravity model

In response to the problems of scattered scale and spatial fragmentation, we introduce and improve “network methods” such as gravity models and social network analysis based on the various scale characteristics and transportation accessibility of villages and towns. By doing so, we can characterise the connectivity of rural communities from multiple dimensions, identify high-level nodes, and determine the “centre” and “edge” of the

region. And the study emphasises network connectivity, with the aim of identifying rural areas that are spatially dispersed and have integrated elements under low-density conditions.

The gravity model can measure the interaction between two spatial entities and is widely used in the study of regional spatial structures. Based on the spatial scale characteristics of rural areas, the following improvements are made to the traditional gravity model to measure the network correlation strength of geographical scale between villages and towns. The study replaces the "comprehensive quality parameter" with the "comprehensive geographic scale of villages and towns" as the core parameter for measuring the attractiveness and radiation effect of villages and towns. Traditional gravity models typically use single indicators such as total population and GDP to represent mass parameters. However, rural areas are different from cities in that their population size is small and the differences are not significant. In addition, Xinghua has always had a landscape with dense river networks and intertwined lakes. Therefore, the study comprehensively considers the size of villages and towns, water systems, cultivated land, and population, and incorporates them into the gravity model.

$$R_{ij} = K_{ij}\frac{M_i M_j}{D_{ij}^2}$$

$$K_{ij} = \frac{g_i}{g_i + g_j} = \frac{G_i/p_i}{G_i/p_i + G_j/p_j}$$

R_{ij} is the strength of the connection between village node i and village node j. M_i and M_j respectively represent the comprehensive calculation results of the indicator items of a certain village node, which is the gravity value of the village. D_{ij} represents the distance between node i and village node j. K_{ij} is the correction coefficient. G_i and G_j represent the area of the town or street where the village is located. p_i and p_j represent the population of the township or street where a village is located. The correction coefficient is used to adjust the size of villages and towns based on township data.

Tab.2 Index of comprehensive geographic scale

Element	Index	Unit	Data sources	Weight
Area Scale	Total area of administrative village	km^2	Survey data of land-use	0.190769
	Proportion of land area for village construction	%	Survey data of land-use	0.28968
Scale of water system	The total length of the water system flowing through the village area	km	*List of Backbone Rivers in Jiangsu Province Revised in 2018* OpenStreetMap	0.117638
	Proportion of water area within the village area	%	OpenStreetMap	0.052713
Scale of cultivated land	Proportion of cultivated land area in villages	%	Survey data of land-use	0.141012
Population scale	Population of administrative villages	/	Jiangsu Government Service Network https://www.jszwfw.gov.cn/*Layout planning of towns and villages in Xinghua Revised in 2022*	0.208188
Area Scale	The area of the town or street where the village is located	Km^2	Survey data of land-use	/
Population scale	The seventh population census of the township or street where the village is located	/	*Statistical Review of Xinghua*	

3 .2.2 Data standardisation processing and weighting

The study used Min-Max normalisation method to normalise data such as village area and river length. And the entropy weight method and analytic hierarchy process are used to calculate the weights of each indicator separately and comprehensively consider them to obtain the weight of each indicator, thereby calculating the gravity value of the village node. According to the gravity model formula mentioned above, the strength of the connections between two villages can be calculated. When processing data, the distribution of network related data will exhibit a heavy daily distribution characteristic, and the core structure will be obscured by a large amount of data with excessively small connection values. The study used heavy tail extraction method to extract network associations that are greater than the average, and ignored the association values between two villages that are less than the average as being too small. The gravity model constructed in this study is an undirected matrix between two villages, and the pairwise connections between each village are visualised on the ArcGIS platform. Study categorises the size of connection values using the natural breakpoint method and constructs a network association pattern for the geographic scale of villages and towns.

3.2.3 Measurement of the network correlation pattern of geographical scale

Preliminary assessment of the centrality based on the comprehensive scale of village and town geography to determine the level of each village and town, clarify the unit centre and the geographical network correlation pattern between each village and town. Firstly, the centrality of each village and town is determined based on their comprehensive geographic scale, and the villages and towns are divided into three levels. From the perspective of node attributes (Fig.5), strong gravity villages and towns are mainly concentrated in the central urban area of Xinghua, Dainan Town in the southeast, and Anfeng Town in the northeast, forming a multi-core structure. The villages and towns with moderate gravity are distributed in a circular pattern around the core nodes. The weak gravity village points are scattered in the northwest and the edge of the village, forming the end nodes of the network system. This “core edge” spatial differentiation pattern reflects the uneven agglomeration of regional geographic scale factors. From Fig. 6, it can be seen that the centrality of geographical scale and network correlation strength within the region are consistent with the distribution of transportation networks. The comprehensive geographical scale of villages and towns in the central and eastern regions with developed transportation routes is relatively strong. It shows an opposite trend to the distribution of water networks to some extent, with areas with denser water networks having relatively weaker overall geographic scale of villages and towns.

There is a significant “core-edge” differentiation pattern in the strength of geographical scale network associations within the region. The high-intensity correlation is concentrated in two core areas: the central and western regions centered around the Xinghua central urban area, and the southeastern Dainan Town area. The correlation strength between these two core areas is the highest, forming the main axis of the regional network. Medium intensity checkpoints are mainly distributed around the core area, connecting secondary nodes such as Anfeng Town and Zhouzhuang Town. But the regularity of their correlation is not obvious. Low intensity associations are sporadically distributed in the densely populated water network areas in the northwest and the agricultural areas in the east, exhibiting short distance and low-density connectivity characteristics. However, the hierarchical nature of the overall network correlation strength and the secondary centres of aggregation are not obvious.

The geographical factors that contribute to the formation mechanism are influenced by topography and hydrology. High intensity association areas are mainly distributed in the central and southern small wei-field areas with good water system connectivity but moderate water network density, while low-intensity association areas are concentrated in the northwest lake and depression areas. The complex water system significantly reduces regional connectivity. And it is related to the distribution characteristics of settlements. The first level associated nodes are located in areas with large settlement scales and dense distributions, which conforms to the core agglomeration law of the central place theory. The small and scattered settlement scale in the edge area leads to a decrease in network connection strength. At the same time, it is also affected by the accessibility of transportation, and the high-strength interconnected corridor is spatially consistent with major transportation channels such as provincial highway and Yanjing River. However, the northwest region is affected by water system segmentation, and the land transportation network is sparse, which directly restricts the frequency of node interaction. From the perspective of historical development path, the central urban area, Dainan Town, and Anfeng Town, as traditional regional centres, have long accumulated infrastructure and public service

advantages, making them natural hotspots of network attraction. The peripheral areas are limited by natural geographical conditions and transportation location, and their development is relatively lagging behind.

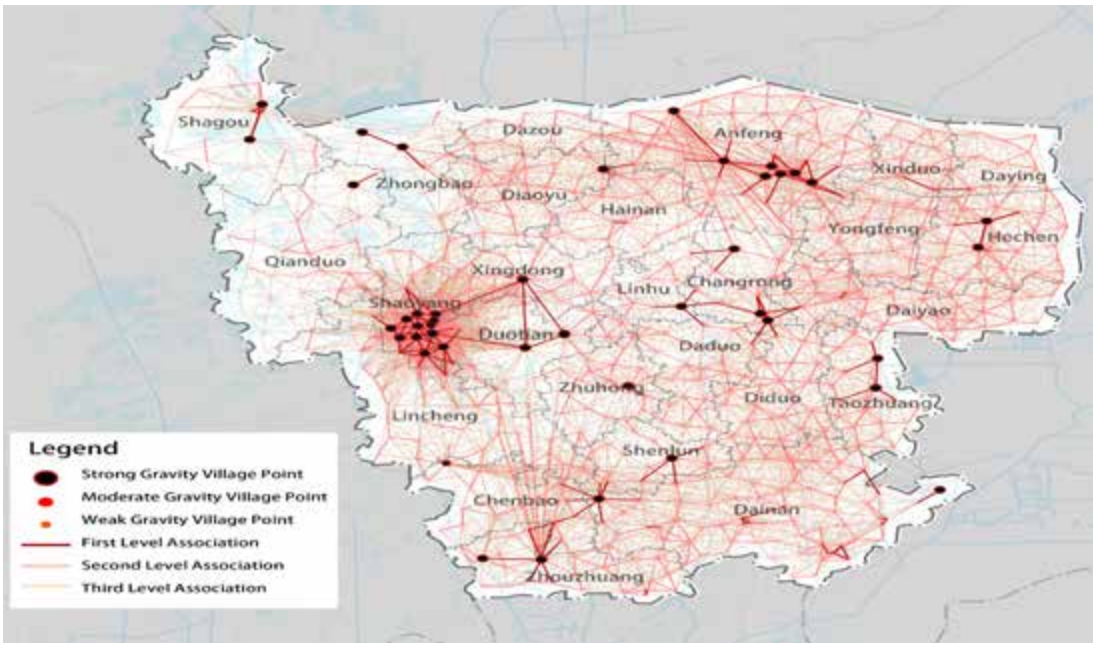

Fig.5 Geographical scale network correlation gravity model for villages and towns

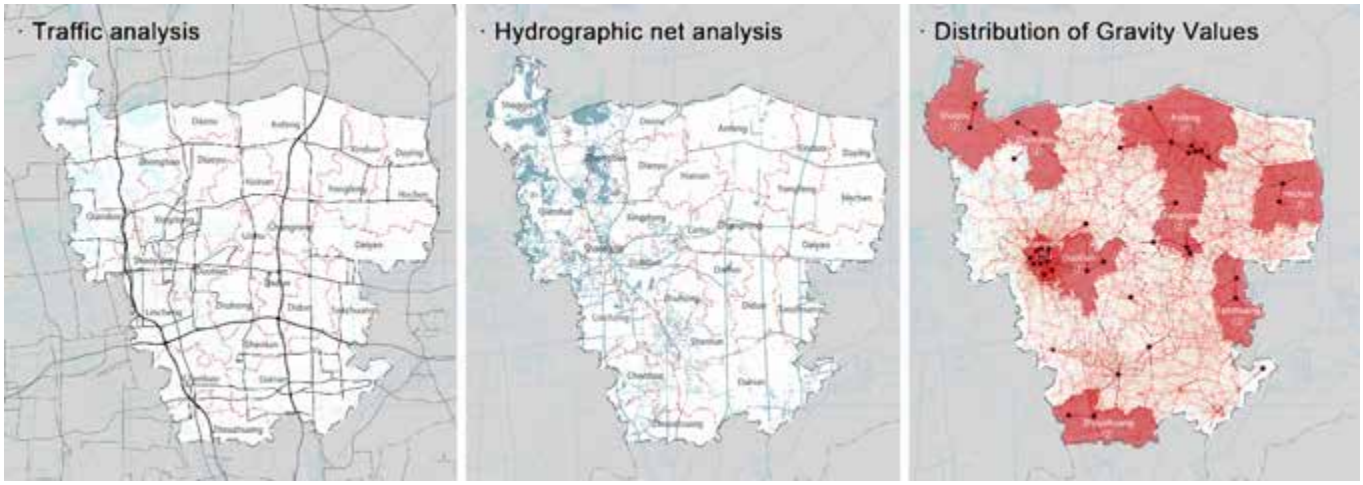

Fig.6 Geographic feature analysis of gravity model

3.3 Cultural superposition characteristics

3.3.1 Distribution characteristics of geographical name categories

The classification of place names and distribution of settlements in Xinghua area exhibit significant geomorphic adaptability and explicit features of historical elements. The settlement types can be divided into four categories: water dominated, agricultural, commercial, and military. The distribution pattern of these settlements is closely related to the unique swamp and wei-field landform and historical and cultural factors in the area.

Tab.3 Geographical name classification explanation

Type of place name		Main Words	Settlement type	Description
Natural geographical name	River system	ditch	Water dominated settlement	Flowing water channel
		sea		The waters near the connection between the mainland and the ocean
		jiang		The general term for large rivers
		river		Natural or artificial large waterways
		port		A river bay that can be anchored
		marsh		Shallow water lake, a depression with accumulated water and grass
		bay		Bend of river
		sand		Arable land by the water's side
		bridge		A bridge, a building erected on water or in the air for passage
		dam		Buildings used to reinforce embankments in hydraulic engineering
	Agriculture	duo	Agricultural settlement	A raised high field formed by excavating a network of deep trenches or accumulating soil along a lake or river network
		pasture		Fields in suburb
		wei		Rice paddies surrounded by earthen embankments
		mount		The towering part formed by the ground, the soil slope
		forest		Clusters of trees
		yard		Vegetable garden, orchard
Humanistic place name	Business	yao	Commercial settlement	Places for firing bricks, tiles, and ceramic vessels, coal kilns
		zao (stove)		Salt boiling household
		chang		Flat open space, threshing ground
	Military	fort	Military type settlement	Small fort, a market town or shop with a city wall
		ton		A few smaller households are established, with surnames added in front of them
		manor		The post station belongs to the official and garrison fields, as well as some official villages
		guan		Temporary stationed barracks
		town		The walls surrounding the city are used for defense
		barrack		Living and camping around the soil

The distribution of settlements and the types of place names in Xinghua area deeply reflect the dual influence of natural landforms and historical culture. Water dominated settlements are widely distributed in areas with dense river networks, and settlements named after words such as "port" and "bay" highlight the adaptive use of water environment by local residents. Agricultural settlements are marked by characters such as "duo" and are concentrated in artificially transformed wei-field and stack areas, reflecting the wisdom of wetland agriculture development. The distribution of military settlements such as "fort" and "ton" in the northern region is not only related to flood control needs, but also closely related to the history of Zhang Shicheng's uprising in this area at the end of the Yuan Dynasty. Some defensive settlements may be remnants of military activities at that time. Commercial settlements such as "yao" and "zao" are scattered, reflecting the layout of salt and handicraft industries relying on water transportation. This settlement distribution pattern vividly demonstrates the human land relationship jointly shaped by natural wetland environment and historical and cultural elements.

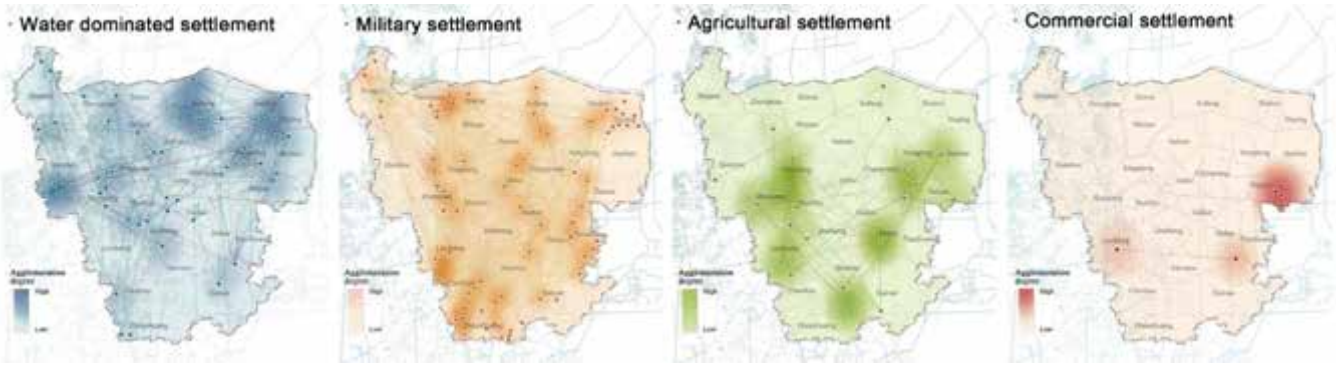

Fig.7 Geographical name analysis results

3.3.2 Analysis of the distribution of historical and cultural values

Tab.4 Historical and cultural elements

Heritage type	Category	Quantity	
Cultural relics	Archaeological Sites	5	337
	Traditional architectural group	9	
	List of Historical Buildings	197	
	artifacts of the revolution	14	
	Traditional street and alley spaces	19	
	All levels of cultural heritage preservation units	93	
Intangible cultural heritage	Traditional skills, folk customs, traditional music, traditional dance, traditional drama, folk literature, traditional medicine	124	

By sorting out the carriers of historical and cultural values in Xinghua, they are divided into two parts: Cultural relics and intangible cultural heritage. The distribution of historical and cultural values is analyzed using kernel density and gravity models. The results show that the historical and cultural resources in Xinghua area have formed a distribution pattern centered on the urban area and radiating along the main water systems. The high-density areas are mainly concentrated in two areas: one is the core cultural circle centered on Xinghua Ancient City, which includes a large number of Ming and Qing Dynasty ancient buildings and celebrity residences. The second is

the sub-centre cultural circle around Shagou Ancient Town, characterised by modern commercial buildings and revolutionary sites. These two high-density areas are interconnected through a water transportation network, forming the main axis of regional culture. And there is a significant cultural radiation effect within the region. The national level cultural heritage sites in the central region, such as the Jiangzhuang Site and Xinghua Duotian, as well as provincial-level cultural heritage sites, constitute the main attraction source and have a significant attraction effect on the surrounding cultural resources.

From the perspective of time and space, the formation of this distribution pattern has a profound historical and geographical background. The sites from the Neolithic Age to the Spring and Autumn Period and Warring States Period are mostly distributed around lakes with higher terrain, reflecting the survival strategy of early humans who chose to live higher. During the Ming and Qing dynasties, with the development of wei-field agriculture and the prosperity of imperial examination culture, a gentry cultural circle centered on ancient cities and spread along water systems was formed. It is manifested as densely distributed literati residences and clan ancestral halls. Since modern times, commercial activities and revolutionary movements have left unique cultural imprints in ancient towns such as Shagou, making the region a typical representative of multicultural integration.

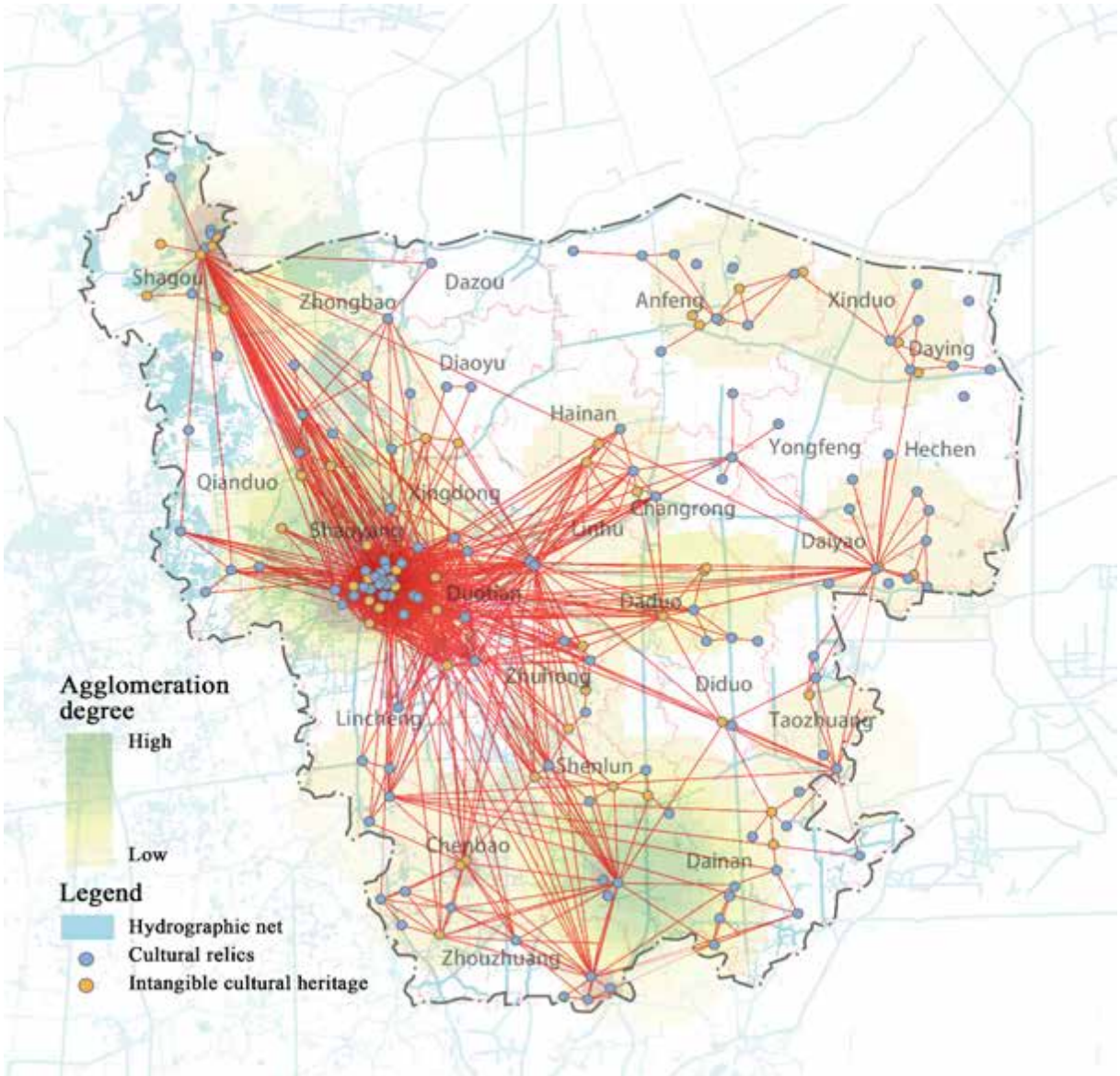

Fig.8 Analysis of gravity model and agglomeration degree based on historical and cultural values

Overall, the spatial distribution of cultural resources is highly consistent with the regional water system network and the geographical scale network of villages and towns measured in the previous section. Bridges, docks and other water transportation facilities are distributed along the river, forming a key link connecting various cultural nodes. Special cultivation methods such as raised field and wei-field are also transformation methods that people adopt based on hydrological conditions. This cultural landscape pattern, with water as its veins, vividly demonstrates the characteristics of the relationship between people and land in Xinghua as a water town area. At the same time, the cultural layering effects of different historical periods have resulted in significant spatiotemporal overlapping features of regional cultural landscapes, providing important samples for understanding the historical and cultural evolution of the Lixiahe region.

4. Conclusion and discussion

This study is based on the perspective of collaborative agglomeration and systematically investigates the multi-dimensional proximity relationships of rural contiguous spaces in Xinghua by constructing a geographical proximity network analysis model. The study reveals the profound impact of geographic background characteristics, scale network correlations, and cultural superposition effects on the spatial organisation of rural settlements, providing new theoretical basis and practical inspiration for regional coordinated development.

4.1 Geographical morphological characteristics shape the spatial differentiation of settlements

The morphological distribution characteristics of rural settlements in Xinghua reflect the synergistic effect of geographical background conditions and cultural development activities. As a typical area in the hinterland of Lixia he, the natural geographical features of dense river networks form the basic framework of settlement distribution, while the artificial wei-field system formed in historical periods further strengthens this spatial pattern. Specifically, the eastern big wei-field area has benefited from the systematic construction of embankments, forming a concentrated and orderly cluster of settlements. The northwest lake and swamp area maintains a relatively scattered distribution of settlements due to the preservation of natural wetlands. This spatial differentiation is manifested in the landscape pattern as follows: the eastern and southern agricultural dominated areas have higher patch aggregation and lower landscape diversity, reflecting the characteristics of large-scale agricultural production. The northwest region, on the other hand, exhibits high landscape heterogeneity due to the coexistence of various utilisation methods such as raised field agriculture and aquaculture. Moreover, the core agglomeration area of the settlement is highly aligned with the main transportation corridors in space, which confirms the crucial role of transportation conditions in the development of the settlement. At the same time, the traditional development of “one wei-field, one village” formed since the Ming Dynasty, and the resulting small-scale characteristics of settlements, still influence the distribution pattern of regional settlements today. These findings not only reveal the decisive influence of natural geographical conditions on the spatial organisation of settlements, but also demonstrate the lasting shaping effect of historical development paths on contemporary settlement patterns, providing important basis for understanding the spatial evolution mechanism of rural settlements.

4.2 The correlation of geographic scale networks presents the fundamental correlation characteristics of centrality

This study constructs a gravity model based on geographic scale indicators, including basic elements such as area, water system, cultivated land, and population, aiming to strip away complex factors and focus on the fundamental impact of geographic background on village associations. We found that the village and town network present a spatial agglomeration pattern centered on the central urban area of Xinghua and Dainan Town, while the water network intensive area in the northwest forms an associated vulnerable area due to natural barriers. This “core-edge” structure reflects the basic distribution law of geographical scale elements: strongly correlated nodes are mostly concentrated in areas with superior transportation conditions and complete geomorphic units, and the correlation strength decays significantly with distance. However, this single dimensional analysis also exposes limitations: Firstly, the network structure presents a flattened feature, which can only identify explicit associations in spatial proximity and lacks explanatory power for cross regional functional connections. Secondly, some villages with collaborative potential, such as those with rich cultural resources but smaller scale, have not been highlighted. This indicates that although geographic scale networks can effectively characterise the spatial basis of village associations, in order to comprehensively reveal the mechanism of collaborative development, it is still necessary to incorporate dimensions such as cultural proximity and industrial complementarity for comprehensive analysis.

4.3 Cultural superposition effect strengthens regional synergy potential

The analysis of place names and the distribution of historical and cultural resources reveal the spatiotemporal layering of natural and cultural elements. Water dominated settlements are distributed along the river network, agricultural settlements are concentrated in wei-field areas, and military settlements are related to historical defense needs. The cultural resources present a distribution pattern with Xinghua Ancient Town and Shagou Ancient Town as the dual cores, and radiate to the surrounding areas through the water system network. Moreover, cultural layers from different historical periods exhibit significant overlapping effects in space. For example, Neolithic sites are mostly distributed around lakes with higher terrain, while literati residences from the Ming and Qing dynasties are distributed in a strip along the main water system. The deep interweaving of cultural landscapes and geographical environments not only strengthens regional cultural identity, but also provides a spatial framework based on historical context for cross village functional collaboration.

The study breaks through the limitations of traditional administrative boundaries and reveals the spatial differentiation pattern and network connectivity characteristics of rural settlements in Xinghua from the perspective of geographical proximity. It lays the foundation for the subsequent integration of multidimensional proximity research such as organisational proximity and social proximity. The geographical background characteristics shape the initial distribution pattern of settlements, while the cultural overlay effect further enriches the potential for regional coordinated development. Moreover, there is a significant spatial autocorrelation between the types of landforms and the distribution of cultural heritage, revealing the layered effect of the coupling between nature and culture. To promote regional coordinated development, it is necessary to innovatively utilise the cultural aspects of villages based on similar geographical resources. Cultural coding strategies can be used to transform agricultural place names such as “duo” and “wei” into ecological agricultural brand logos, such as Qianduo Town achieving tourism revenue growth through the “duo tian (raised field)” IP. Utilise existing resources to activate historical networks. For example, by utilizing the Ming and Qing water transportation corridors to connect scattered cultural nodes, a cross-town cultural industry chain can be formed in the Dainan Shagou area, driving the participation of surrounding villages in collaborative operations. This transforms the hierarchical effect of historical and cultural heritage into an endogenous driving force for the development of rural characteristics. This can not only solve the problem of mismatch between spatial planning and administrative boundaries, but also organically integrate cultural heritage into development planning through quantitative historical and cultural analysis, achieving the coexistence and prosperity of natural ecology and humanistic values.

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Are you a Stakeholder or Streekholder? Formal and informal planning in the Flemish-Dutch Delta

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Abstract
Grenspark Groot Saeftinghe (Borderpark of Saeftinghe), a transboundary region along the Scheldt estuary in the Flemish-Dutch Delta, faces overlapping ecological, climate, and socio-political pressures. As part of the INTERREG project, this region brings together formal stakeholders, and local citizen groups known as "*streekholders*" (Grenspark Groot Saeftinghe, 2025). This paper investigates how formal stakeholders and *streekholders*, co-shape spatial planning decisions in this contested landscape. Drawing on qualitative methods, including stakeholder mapping, literature review and discourse analysis, the study analyses partnerships across formal, informal, and research-based planning domains. It reveals how tensions between environmental, economic, and cultural values are negotiated through multi-actor collaborations. By comparing dynamics at both regional and delta scale, the paper illustrates how the planning arrangements can enhance adaptive governance and demonstrate pathways towards resilient and transnational development.

Keywords: Transnational territory; Stakeholder dynamics; Spatial planning; Flemish-Dutch Delta.

1. Introduction

Spatial planning in transboundary regions increasingly requires governance approaches that transcend national jurisdictions, administrative silos, and sectoral boundaries (Slinger, 2023; Merk & Notteboom, 2013). This paper proposes to examine spatial planning and governance across two interrelated scales. At the macro-regional level, it considers the Vlaams Nederlandse Delta as a complex, coordinated but fragmented visions (OECD, 2013; CBK Zeeland, 2020) where ecological vulnerabilities and socio-economic transitions converge with intricate institutional arrangements (Deelstra et al., 2020). At the local level, it focuses on Grenspark Groot Saeftinghe, a tidal landscape at the border of Flanders and Zeeland, where water management, ecological restoration, and cultural heritage practices demonstrate embedded modes of "living with water" (Grenspark Groot Saeftinghe, 2024; Interreg Vlaanderen–Nederland, 2023). This dual-scale lens provides insight for an interesting case to understand how formal governance frameworks interact with more informal and culturally embedded planning practices in cross-border contexts (Slinger, 2023; Van der Valk & Van Dijk, 2009). The urgency of climate adaptation adds another layer of complexity, requiring coordinated action across different sectors and administrative systems.

A key inquiry is how governmental institutions, civil society groups, research consortia, and local collectives are integrated into decision-making processes. By identifying the interscalar dynamics between formal stakeholders and informal "*streekholders*" Grenspark Groot Saeftinghe, 2025), this paper contributes to the discourse on adaptive and inclusive governance under conditions of climate transition and ecological uncertainty (Mundell, 2018; (van Bets et al., 2020).

The research is developed alongside the New European Bauhaus project *Bauhaus of the Sea Sails*[1], which facilitates co-design activities with regional actors. Data are drawn from storytelling sessions, participatory workshops, and interviews conducted as part of this broader PhD research. This article presents the first phase of an ongoing research project, aimed at analysing the current institutional and governance configurations of the selected case study. In the coming years, the research will be expanded to examine historical path dependencies and explore future-oriented planning scenarios.

1 https://bauhaus-seas.eu/

2. Setting the transnational context

Water has a major role in maintaining peace and political stability across borders (Transboundary water cooperation, European Commission2). This research focuses on two significant scales for spatial analysis: the Border Park of Saeftinghe and the Flemish Dutch Delta. In the Border Park of Saeftinghe, water emerges as a pivotal force driving collaboration among stakeholders. Conversely, at the larger scale, Flemish Dutch Scheldt Delta, the foundation is water for shaping both the physical and socio-economic fabric of the region. However, due to the presence of the two largest ports, Rotterdam and Antwerp-Bruges, water presents challenges marked by conflicts and competition, reflecting the complexities of industrial and urban landscapes intertwined with maritime activities. Each of these scales reveals distinct dynamics concerning the relationship between water, land, and human activities. As a result, spatial planning in such a transnational delta calls for a multi-scalar governance approach that bridges institutional divides and connects strategic visioning with operational capacity.

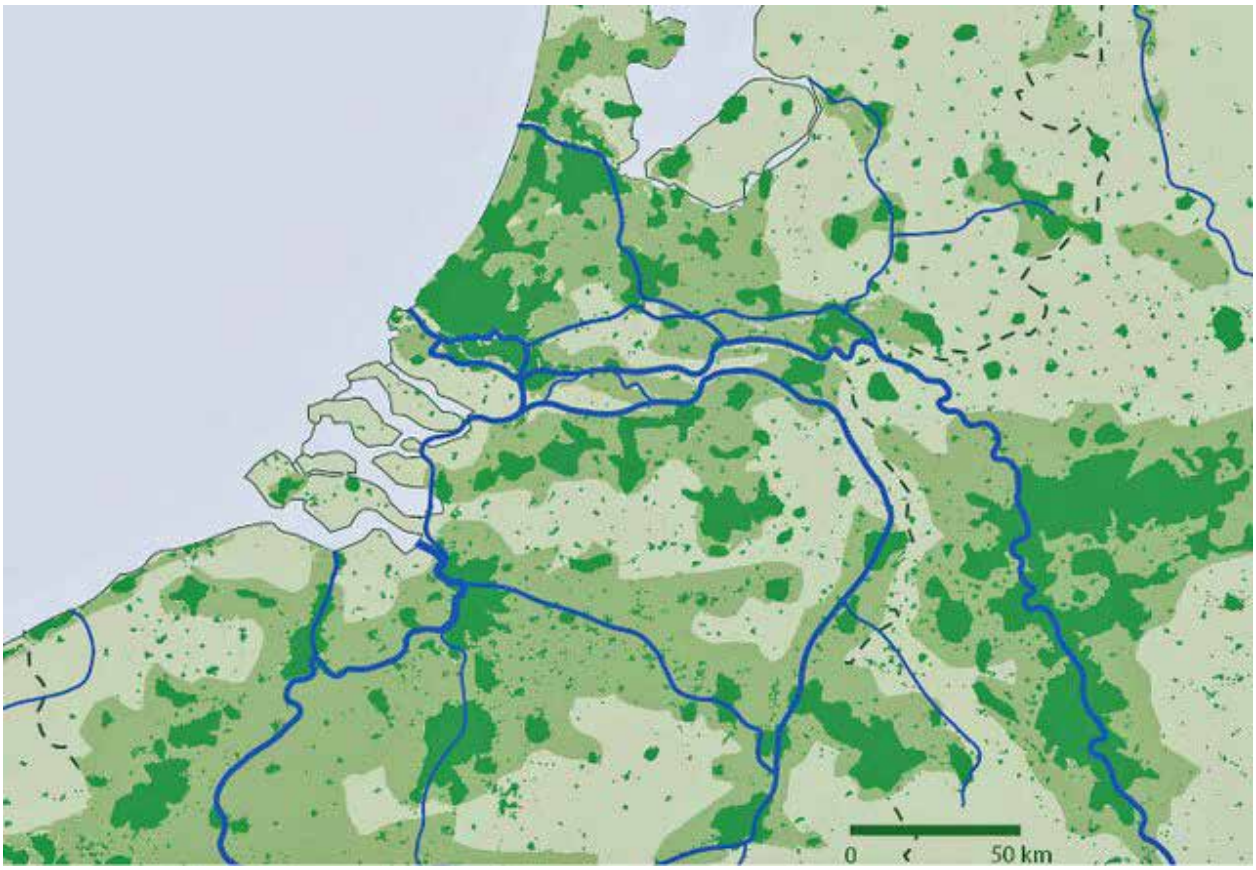

Fig 1: The Dutch Belgian Rhine Meuse Scheldt Delta Deltanet-2014

2.1 Grenspark Groot Saeftinghe (GGS) (Region and community)

At the very local scale of Scheldt estuary, spanning the border between the Netherlands and Belgium, is the Drowned Land of Saeftinghe (*Verdronken land van Saeftinghe*). Along with the drowned land, one of the largest contiguous salt marshes and mudflat ecosystems in Europe, covering 3,500 hectares is the area of Grenspark Groot Saeftinghe, including 18000 hectares and roughly 27,000 population (2020). It connects with adjacent reclaimed polders such as the Hedwige, Prosper, and Doel polders, forming a border zone shaped by hydrological dynamics, port development, and agrarian landscapes (Grenspark Groot Saeftinghe, 2024). This spatial configuration brings together ecological sensitivity and strategic economic infrastructure, as the park borders the Port of Antwerp and the Doel nuclear power plant (The Brussels Times, 2022).

2 https://international-partnerships.ec.europa.eu/policies/climate-environment-and-energy/transboundary-water-cooperation_en

Fig 2: Gebiedsagenda Grensark Groot Saeftinghe, 2019

In recent decades, the Saeftinghe region has been shaped by a series of overlapping dynamics that bring competing spatial agendas into conflict. The expansion of the Port of Antwerp has frequently intersected with ecological protection and local community interests, particularly in the contested future of the village of Doel, which was designated for demolition in the 1960s to accommodate industrial expansion but was officially returned to its residents in 2022 following prolonged civic opposition (The Brussels Times, 2022). Simultaneously, the decision to depolder the Hedwige and Prosper polders was formalised through the 2005 Dutch-Flemish Scheldt Treaty and later upheld by the Dutch Council of State in 2012. This triggered intense political controversy in the Netherlands, where farmers and local representatives opposed the intentional flooding of agricultural land for estuarine habitat restoration (Van Buuren & Warner, 2014). The measure was framed as nature compensation for deepening the Western Scheldt shipping channel, which was necessary to maintain the competitiveness of the Port of Antwerp. These events illustrate a spatial environment where water safety, environmental policy, and economic development collide, producing a complex and politically charged planning landscape.

In response to these intersecting dynamics and competing spatial agendas, Grenspark Groot Saeftinghe was formally established through a cross-border EU INTERREG project launched in 2016. This initiative was supported by the EU's Interreg Vlaanderen-Nederland programme and co-funded by regional governments and environmental agencies (Interreg Vlaanderen-Nederland, 2025; (Nationale Landschappen en Nationale Parken, 2019)). The project sought to integrate ecological restoration with economic and cultural development, creating a cross-sectoral planning agenda for this vital border region. Key formal stakeholders involved in the GGS include the Province of Zeeland and the Province of East Flanders, nature conservation bodies, as well as various municipal administrations and port authority. These actors operate within a collaborative framework that has been further institutionalised by the European Grouping for Territorial Cooperation (EGTC) Linieland van Waas en Hulst, established in 2011 to promote structured governance between border municipalities (EGTS Linieland, 2024).

In addition to institutional actors, the GGS initiative places significant emphasis on civic participation through the concept of "streekholders." These are local citizens, farmers, and entrepreneurs who are actively involved in the planning and development of the park. They contribute to working groups, thematic sessions, and decision-making processes, offering locally grounded perspectives on nature-based solutions and cultural heritage (Grenspark Groot Saeftinghe, 2024). Their involvement reflects a broader shift toward participatory spatial governance at the landscape scale.

2.2 Flemish-Dutch Delta (Territory and governance)

The Flemish Dutch Delta (Vlaams Nederlandse Delta) is a transboundary estuarine region located in the southwestern part of the Netherlands and northern Belgium. It spans six provinces: Zeeland, South Holland, and North Brabant in the Netherlands, and East Flanders, West Flanders, and Antwerp in Belgium. The delta has a population of approximately 1.5 million people and is shaped by the interaction of the Rhine, Meuse, and Scheldt river systems (Vanelslander et al., 2011). Spatial developments in this delta are shaped by decisions taken at multiple levels of government. At the national level, spatial and environmental strategies are influenced by the Dutch Ministry of Infrastructure and Water Management and the Flemish Department of Environment and Spatial Development. At the provincial level, spatial policy and land-use regulation fall under the authority of the respective provincial governments, who act as key stakeholders in planning processes and cross-border cooperation (Vanelslander et al., 2011). These government institutions also contribute to joint spatial visions and regional development strategies.

Fig 3: Administrative boundaries of Vlaams Nederlandse Delta (https://www.vndelta.eu/)

The confluence of river delta and the coastal front of North Sea creates a dynamic hydrological system of tidal wetlands, estuarine ecologies, complex freshwater–saltwater gradients and reclaimed landscapes. Due to the ecological pressures such as salinisation and sea-level rise, a range of environmental stakeholders are active in the region (Schelde Delta Geopark, 2024), including Rijkswaterstaat (Netherlands) and the Flemish Environment Agency, and nature conservation organisations such as Natuurpunt and Staatsbosbeheer. These actors are involved in water management, flood risk mitigation, and the ecological restoration of tidal zones (Schelde Delta Geopark, 2024). These agencies are not merely supportive actors; they constitute the backbone of ecological stewardship and climate adaptation in the region.

The territory occupies a central position and plays a significant role in European and global trade. The broader Seine to Scheldt zone accounts for around 17 percent of the European Union's gross domestic product and manages 60 percent of its maritime trade (Advisory & Oost-Vlaanderen, 2013). The two principal maritime

stakeholders are the Port of Rotterdam Authority and the Port of Antwerp-Bruges. Both institutions have far-reaching influence on regional infrastructure, industrial zoning, and hinterland connectivity. Their role in shaping spatial development is reinforced by their partnership in spatial-economic initiatives such as the North Sea Port District (including Ghent-Terneuzen- Vlissingen). These economic stakeholders are integral to port expansion, land reclamation, and affecting the delta regarding climate adaptation.

3. Research question and methodology

This study is fundamentally guided by the central research question: "How do formal and informal governance frameworks/partnerships interact in transnational spatial planning, and what role do stakeholder and "*streekholder*" dynamics play in shaping sustainable development in the Flemish-Dutch Delta?" This overarching inquiry is further explored through two key lines of investigation: identifying the various types of partnerships and collaborations at play and gaining a deeper understanding of the "*streekholders*" concept, particularly how local citizens are actively influencing and shifting established narratives in spatial planning.

To answer this, the study adopts a multi-scalar qualitative research. The analysis focuses on two interlinked spatial levels: (1) the Vlaams Nederlandse Delta as a macro-regional, transboundary planning context shaped by intergovernmental coordination; and (2) Grenspark Groot Saeftinghe as a localised case of civic participation situated along the Dutch-Flemish border. This dual-scale lens allows for an exploration of how formal planning institutions (e.g., governments, port authorities, interregional commissions) interface with informal actors (e.g., citizens, farmers, civil society groups), particularly in contexts where ecological urgency and socio-economic transformation converge.

Empirical data were collected through a combination of qualitative methods. These include extensive document analysis of strategic planning documents, INTERREG project reports, and online communication platforms maintained by GGS. Stakeholder mapping is employed to systematically identify and categorise the diverse actors involved in the region's governance and planning. Participatory observation in storytelling workshops and co-design sessions carried out as part of the *Bauhaus of the Sea Sails* project. Semi-structured interviews are conducted with key formal stakeholders from public authorities and port entities, as well as representatives from civil society groups. A reflective component is highlighted in this method and is critical for interrogation of the literature, highlighting discrepancies and convergences between documented policies and on-ground practices. A comprehensive literature review situates the study within broader academic and policy discourses on interscalar governance and transnational collaboration. This approach enabled triangulation across multiple sources and actor perspectives, offering grounded insights into the existing governance arrangements and frictions. The methodology is designed to bridge theoretical frameworks with practical insights, providing a nuanced understanding of the interplay between formal planning structures and informal "*streekholders*."

The structure of this paper reflects the layered nature of the inquiry. Following the introduction, context-setting of the two spatial scales, the problem statement, section 5-6 presents the partnership analysis in transnational spatial planning, distinguishing between formal, informal, and research-based configurations, examining actor roles, scalar negotiations, and tensions between environmental, economic, and cultural objectives. Section 7-8 concludes by identifying opportunities for adaptive and inclusive governance, emphasising the potential of transboundary planning to respond to climate, ecological, and social challenges when both stakeholders and streekholders are meaningfully involved.

4. Problem statement – escalating conflicts and environmental pressures

The governance of the Flemish-Dutch Delta is characterised by a "wicked problem" where economic, environmental, and societal conflicts are not isolated but deeply interconnected and intensified by the overarching impacts of climate change. This intricate web of interdependence means that addressing one issue often creates unintended negative consequences in another, making the interplay between nature, industry, and society a continuous process of negotiation. While the region is functionally interdependent, it remains institutionally fragmented across national borders, challenging the development of cohesive and resilient spatial planning.

The Flemish-Dutch Delta, despite its historical resilience and economic importance, is currently grappling with intensifying environmental pressures that fundamentally threaten its long-term sustainability. Formal cooperation has emerged between institutional actors through the Vlaams Nederlandse Delta platform, which facilitates

coordination between provinces and includes national ministries, planning departments, and intergovernmental entities such as the Benelux Union and are engaged in policy alignment and development of shared planning agendas (Vanelslander et al., 2011). On the local scale, Grenspark Groot Saeftinghe, a landscape of intersecting future opportunities, climate-related vulnerabilities, and ongoing tensions between conflicting interests, where efforts toward environmental resilience are continually challenged by socio-economic transformation. GGS illustrates how formal and informal governance frameworks must interact in complex border landscapes, where spatial planning must mediate between environmental resilience and socio-economic transformation.

Social acceptance is eroded by this policy patchwork. The inherent tension between nature, port, and society is not merely a policy challenge but a fundamental conflict deeply embedded in the delta's identity. This conflict is demonstrably intensifying with the climate crisis and the lack of efficient decision-making frameworks. Local residents perceive ecological restoration as an imposed sacrifice for metropolitan shipping interests; port communities fear economic stagnation if draft limitations are introduced; and farmers view nitrate caps as threats to cultural identity. Without a governance framework capable of coupling economic, ecological and cultural values across scales, each incremental intervention re-ignites hidden conflicts.The contested future of the village of Doel is a stark example, having been designated for demolition in the 1960s for industrial expansion, only to be officially returned to its residents in 2022 following prolonged civic opposition (The Brussels Times, 2022).

Economic growth or dredging or PFAS, what are port activities - On both scales, port-driven growth is the principal engine of prosperity yet simultaneously the main driver of cumulative environmental degradation, dredging, land reclamation and heavy logistics emit pollutants (PCBs, PFAS, trace metals) and accelerate habitat loss (Baeyens et al., 2005). While deepening the Western Scheldt shipping channel secures Rotterdam and Antwerp-Bruges in global trade networks, it also triggers compensatory depoldering of agricultural polders such as Hedwige-Prosper, provoking intense local resistance and exposing a persistent gap between national competitiveness narratives and everyday rural livelihoods (Van Buuren & Warner 2014).

Pollution illustrates this systemic misalignment. High livestock densities load the delta with nitrate and phosphate, fuelling eutrophication and biodiversity decline (Van Meerbeek et al. 2015). Intensive agriculture in the region contributes significantly to nutrient pollution, leading to high concentrations of nitrogen and phosphorus in surface and groundwater (Greenhood, 2025). Simultaneously, sediment-bound POPs and heavy metals from historical industrial discharges exceed ecological thresholds in the Scheldt estuary, making routine seafood consumption unsafe (Van Ael et al., 2012). Emerging PFAS contamination now compounds these legacies, highlighting weak preventive regulation and fragmented monitoring regimes. Addressing any one pollutant in isolation risks displacement effects: dredged contaminated sediments are relocated, nutrients are exported downstream, and carbon-intensive port retrofits shift emissions offshore.

Water is the binding medium of these tensions. Centuries of "Dutch Approach" hydraulic engineering have produced a technically safe but rigid landscape whose dykes and sluices struggle to accommodate twenty-first-century sea-level rise, salt-water intrusion and episodic droughts (Meijer, 2016; Interreg 2 Seas[3]). In Saeftinghe the tidal gradient between salt marshes and reclaimed polders increasingly undermines farming viability, while across the wider delta peat dykes desiccate, freshwater shortages intensify, and salinisation erodes both ecological integrity and agroeconomic resilience (Vermeulen 2025). Climate change thus multiplies the trade-offs already inherent in the port–nature–society triangle.

Living with water and sea-level rise. Sea-level rise and climate change impacts pose an existential threat to the Flemish-Dutch Delta. Global mean sea level is projected to rise significantly by 2100 and potentially by 2 to 5 meters by 2300, necessitating urgent and comprehensive adaptation strategies (Interreg 2 Seas). While the Drowned Land of Saeftinghe showcases dynamic estuarine processes, the surrounding reclaimed polders highlight the constant challenge of living with water in intensely used land. This includes the direct impacts of tidal dynamics, the complex interplay of fresh and saltwater (salinisation in coastal areas), and the vulnerabilities of agricultural lands being less suitable for traditional crops to changing water levels. These intensive uses of the delta landscape, coupled with the impacts of climate change, collectively threaten the integrity of natural ecosystems, the viability of agricultural areas, and the overall resilience of urban environments (Vermeulen, 2025).

3 https://www.interreg2seas.eu/

5. Mapping the actor landscape

The actors involved in the governance and planning of the Flemish-Dutch Delta, particularly within the Grenspark Groot Saeftinghe framework, are 11 partner organisations from the Netherlands and Flemish side of the border. They are typically governmental bodies at various levels, including the Province of Zeeland and East Flanders, De Vlaamse Waterweg, Municipality of Beveren and Hulst, which operate within established legal and administrative frameworks. Environmental organisations like Stichting Het Zeeuwse Landschap, Maatschappij Linkerscheldeoever, Agentschap voor Natuur & Bos and Natuurpunt Waasland also fall into this formal category, advocating for nature conservation and ecological restoration and includes influential Port of Antwerp-Bruges, whose economic interests are central to the region's development. It also includes EU funded organisation EGTC (European Grouping of Territorial Cooperation) Linieland van Waas en Hulst, which in itself is a group of eight Flemish and Dutch authorities joining forces around various themes

In contrast, Informal "*Streekholders*" represent a grassroots layer of engagement. This group encompasses local citizen groups, residents, farmers, businesses, tourism guides, youth, and enthusiastic volunteers. They are distinguished by their deep connection to and commitment to the future of their immediate region, or "streek". Volunteers, such as the "hosts and hostesses" in GGS, provide invaluable local knowledge and lead excursions, further integrating community perspectives into the region's activities. Table 1 provides a comprehensive overview of these key organisations and groups, illustrating their respective roles within the Grenspark Groot Saeftinghe project.

Table 1: Key actors in Grenspark Groot Saeftinghe

Actor Type	Organisation	Critical review
Lead Partner (2023–2026)	EGTS Linieland Van Waas en Hulst	Key facilitator of cross-border cooperation; its legal structure enables formalised collaboration, yet it may struggle with visibility at the community level.
Co-lead Partner	Province Zeeland (NL)	Strong institutional actor with strategic oversight; however, it may be constrained by national priorities or limited regional flexibility.
Governmental Authority	Gemeente Beveren (VL)	Crucial for implementing local strategies but may face political pressure from port expansion, land-use tensions and lack of finance.
Governmental Authority	Gemeente Hulst (NL)	Provides local governance input; may have limited resources compared to larger partners.
Governmental Authority	Province Oost-Vlaanderen (VL)	Important for aligning regional planning, though its coordination with other provinces, across the border and national authorities may be complex.
Port Authority	Port of Antwerp-Bruges (VL)	Economically dominant actor, positively influencing economy and negatively influencing land and water; pressurised for sustainable transformation.
Nature Conservation	Stichting Het Zeeuwse Landschap (NL)	Anchors ecological concerns in governance; its involvement in crowdfunding reflects creative approaches to citizen engagement.
Nature Conservation	Natuurpunt Antwerpen Noord vzw (VL)	Key player in preserving biodiversity; complements state-led efforts but lack political leverage.
Governmental Authority	Vlaamse overheid (Flemish Government) (VL)	Provides overarching governance support and coherence across sectors; but perceived as distant from local needs.
Governmental Authority	Vlaamse Landmaatschappij (VLM) (VL)	Key in land management and farming-related strategies; bridges rural stakeholder interests with ecological targets.
Governmental Authority	De Vlaamse Waterweg (VL)	Critical for flood safety and water infrastructure; however, technical focus underrepresent socio-cultural factors.
Tourism Body	Toerisme Oost-Vlaanderen (VL)	Promotes regional identity and sustainable tourism; yet their role in spatial planning remains secondary.
Informal Actors	"*Streekholders*"	Represent bottom-up, place-based knowledge; strengthen cultural sensitivity but lack of decision-making power.
Volunteers	Hosts and Hostesses	Act as knowledge representation; enhance public outreach, though their input is often symbolic rather than decisional.

6. Multi-scalar partnerships in transnational spatial planning

Spatial planning challenges in border regions often transcend administrative boundaries, requiring strategies that integrate efforts across various levels of governance, from local to global (Laine, 2016). Metropolitan regions have emerged as dominant economic units globally, with their growth governed by complex networks of organisations that extend beyond single geographic bounds and involve multiple levels of government (Healey, 2007). This necessitates multi-scalar interactions, often forming large institutional networks. Effective spatial planning in such dynamic and complex environments requires collective action and collaboration across various actors and scales (Marin et al., 2023). The integration of diverse perspectives and resources, from local communities to international bodies, is crucial for developing sustainable and equitable solutions that address interconnected challenges like climate change, pollution, and socio-economic disparities (Adger, 2003). This section elaborates on the necessity of such partnerships and defines key typologies: formal planning partnerships, informal planning partnerships, and research-based (or research by design) partnerships.

6.1 Formal planning partnerships

Formal planning partnerships are collaborative arrangements involving established governmental bodies, intergovernmental organisations, and legally recognised entities. These are partnerships which are structured within defined institutional frameworks, typically formalised through treaties, agreements, or statutory mandates (Perkmann, 2003). They have clear mandates, hierarchical or coordinated decision-making processes, and are often designed to operate on and across national, regional, and local administrative levels in order to achieve shared policy objectives (Popescu, 2008).

Such partnerships play a crucial role in fostering cross-border cooperation, particularly in spatial and territorial development. For example, the European Outline Convention on Transfrontier Co-operation between Territorial Communities or Authorities (Madrid Convention) offers a legal basis for establishing cooperative frameworks between municipalities or regional governments across borders (Council of Europe, 1980). These institutional arrangements can take the form of Euroregions[4], cross-border metropolitan platforms, or European Groupings for Territorial Cooperation (EGTCs), and are often designed to support sustainable regional development initiatives (Sustainable Planning, 2018).

Table 2: Analysis of formal planning partnerships

Initiative	Description	Key Actors	Reflection
Flemish-Dutch Long-Term Vision for the Scheldt Estuary (LTV) (Slinger, 2023)	A foundational bilateral policy adopted in 2001 to create a healthy and multifunctional estuarine water system, balancing safety, accessibility, and nature. Established specific cross-border organizations for daily management.	Netherlands (Government, Parliament), Flanders (Government, Parliament), Technical Scheldt Commission (TSC), Joint Nautical Authority (GNA)	The LTV stands as a monumental achievement in cross-border governance, providing a foundational, enduring bilateral framework for integrated estuarine management. Its strength lies in explicitly balancing competing objectives (safety, accessibility, nature) and establishing dedicated cross-border organisations (TSC, GNA). However, its "long-term" nature can sometimes struggle with adapting to rapid, unforeseen challenges (like extreme climate events or new pollution concerns), and achieving the delicate balance in practice often leads to ongoing political and social tensions, as demonstrated by depoldering controversies.
INTERREG Projects (e.g., Grenspark Groot Saeftinghe)	European Union funding instrument promoting cross-border cooperation. The GGS project (2016-2021 and 2023-2026 phases) brings together numerous partners to balance ecological, economic, and social interests in a transnational nature park.	11 institutional partners (government organisations)[5]	INTERREG projects are vital catalysts for fostering transnational cooperation by providing dedicated funding and a structured framework for diverse partners. Their strength is the direct promotion of cross-border integration and the ability to address specific regional challenges through collaborative action. However, their project-based, time-limited nature can create challenges for long-term sustainability and institutionalisation of outcomes once funding cycles end. Moreover, coordinating such a broad range of formal actors across different national legal and administrative systems remains inherently complex.

4 Euroregions: http://www.espaces-transfrontaliers.org/en/resources/territories/euroregions/

5 11 partners - EGTS Linieland Van Waas en Hulst (Lead Partner), Provincie Zeeland (Co-lead), Gemeente Beveren (Waas), Gemeente Hulst, Provincie Oost-Vlaanderen, Stichting Het Zeeuwse Landschap, Port of Antwerp-Bruges, Agentschap voor Natuur en Bos, Natuurpunt Antwerpen Noord vzw, De Vlaamse Waterweg

Dutch Delta Program / Multilayered Safety (MLS)	A national program in the Netherlands aimed at flood risk management, shifting from traditional prevention to a more adaptive, polycentric governance approach emphasising resilience and adaptivity.	Dutch Delta Program, various levels of Dutch government, civil engineers, planners, spatial designers	This program represents a progressive shift in national flood risk management, moving beyond solely "hard" engineering to embrace adaptive, polycentric governance and resilience. Its strength is its systemic approach to climate adaptation, integrating spatial planning with water safety. A potential critique is that while it advocates polycentricity, its implementation can still be largely driven by national priorities and expert-led frameworks, sometimes struggling with genuine local-level integration and the inherent socio-cultural resistance to transformative land-use changes.
International Scheldt Commission (ISC)[6]	An international body involving France, Belgium (Walloon Region, Brussels-Capital Region, Flanders), and the Netherlands, focused on integrated water management for the entire Scheldt river basin.	Governments of France, Belgium (Walloon Region, Brussels-Capital Region, Flanders), Netherlands	The ISC is fundamental for comprehensive, basin-wide water management across multiple nation-states. Its strength lies in providing a high-level, formal platform for international dialogue and coordination on shared water resources and pollution control. However, as an intergovernmental body, its effectiveness can be limited by the lowest common denominator of agreement among sovereign states, potentially slowing down decisive action or limiting the scope of truly integrated, binding policy implementation across the entire basin.
Territorial Water Management Strategies (Belgian Pilot Action) [7]	A Belgian initiative under the Territorial Agenda, focusing on cross-border cooperation to address risks of flooding, drought, and water shortages, involving regional governments and European partners.	Brussels-Capital Region, Flemish Region, Walloon Region, European partners (e.g., European metropolis of Lille)	This initiative highlights a commendable effort within the Belgian context to address water risks through cross-border cooperation at a regional level, linking to broader European agendas. Its strength is the direct focus on specific risks (flooding, drought) and involving regional governments. The challenge often lies in scaling up pilot actions, ensuring consistent implementation across different regional administrations, and securing sustained political will and funding beyond the initial pilot phase.
Vlaams-Nederlandse Scheldecommissie[8] (VNSC) and Schelderaad	Promotes collaboration between Flanders and the Netherlands on Scheldt Estuary policy and management, including monitoring and research. The Schelderaad is an advisory platform to the VNSC.	Vlaams-Nederlandse Scheldecommissie (VNSC), Schelderaad, scientists, policymakers, water authorities	The VNSC is a critical operational arm of the LTV, ensuring ongoing collaboration between Flanders and the Netherlands on the Scheldt Estuary. Its strength lies in providing a dedicated, structured platform for policy coordination, monitoring, and research. The inclusion of the Schelderaad as an advisory platform is positive, but a critical perspective would examine whether this advisory role genuinely translates into significant influence on policy and decision-making, particularly when faced with strong economic or political imperatives.
Interreg Flanders-Netherlands	A specific INTERREG program funding cross-border projects like Grenspark Groot Saeftinghe, focusing on smart, green, and inclusive growth.	European Union (ERDF), EGTS Linieland van Waas en Hulst, Provincie Zeeland, other project partners	As a specific INTERREG program, its value lies in providing targeted EU funding and a clear framework for cross-border projects within this specific region. It directly supports smart, green, and inclusive growth, fostering practical cooperation. Similar to other INTERREG initiatives, its project-based funding can lead to a focus on discrete project successes rather than deeply embedded, continuous institutional change, and long-term financial sustainability for the outcomes of these projects remains a concern.
EGTS Linieland van Waas en Hulst	Lead partner for the current phase of the Grenspark Groot Saeftinghe INTERREG project, responsible for territorial cooperation.	EGTS Linieland van Waas en Hulst	As a European Grouping for Territorial Cooperation, EGTS Linieland provides a crucial legal and institutional framework for cross-border collaboration between local and regional authorities. Its strength is formalising and structuring territorial cooperation, enabling more effective joint planning and project management (e.g., as lead partner for GGS). A potential weakness lies in its administrative overhead and the need for continuous political commitment from constituent municipalities to fully leverage its potential and move beyond coordination to integrated governance.
Zuidwestelijke Delta[9] (Southwest Delta)	A regional program in the Netherlands focused on water safety, freshwater supply, and spatial quality in the southwest delta region, including coastal realignment initiatives.	Dutch government, regional authorities, water boards, local communities	This regional program is essential for integrating water safety, freshwater supply, and spatial quality challenges at a sub-national level in the Netherlands. Its strength is its comprehensive, multi-faceted approach to regional delta management, including potentially controversial initiatives like coastal realignment. The challenge lies in managing the complex trade-offs between these different objectives and ensuring local community buy-in and acceptance for potentially impactful interventions, as seen in past depoldering resistance.

6 https://www.isc-cie.org/en/
7 https://territorialagenda.eu/pilot-actions/territorial-water-management-strategies/
8 https://vnsc.eu/over-de-vnsc/schelderaad-en-samenwerking/
9 https://www.zwdelta.nl/

North Sea Port (North Sea Port, 2025)	A merged port authority encompassing Vlissingen, Terneuzen, and Ghent, designated as a NOVEX area, crucial for regional economy and quality of life in Zeeuws-Vlaanderen.	North Sea Port Authority, municipalities of Vlissingen, Terneuzen, Ghent, Dutch government	The merger of Vlissingen, Terneuzen, and Ghent into North Sea Port represents a powerful strategic move for economic competitiveness and efficiency, and its designation as a NOVEX area highlights its national strategic importance. Its strength is its unified approach to port development and logistics. However, its immense economic power often places it in direct tension with environmental protection and local quality of life. A critical analysis would focus on the effectiveness of its sustainability pledges, its real commitment to mitigating its environmental footprint, and how genuinely it integrates broader societal and ecological concerns into its expansion and operational strategies beyond economic imperatives.

The formal planning partnerships reveals a consistent engagement of governmental and intergovernmental bodies, such as national ministries, regional authorities, and cross-border governance platforms like the European Grouping for Territorial Cooperation (EGTC). These stakeholders typically possess formal authority and high decision-making power, grounded in legal mandates and institutional legitimacy. Their actions are often governed by structured procedures and long-term planning agendas, enabling policy continuity and spatial coherence across borders.

Long-Term Vision for the Scheldt Estuary (2001), which involves Dutch and Flemish authorities cooperating on flood protection, accessibility, and ecological restoration is an example of how formal partnerships address complex environmental and economic priorities through negotiated, treaty-based agreements(Slinger, 2023). Although top-down in nature, these partnerships may include consultative frameworks to engage municipalities or regional platforms. Their strength lies in orchestrating durable, cross-border strategies that transcend electoral cycles. However, there are lack responsiveness to emergent local dynamics and societal values, unless actively integrated with informal or participatory processes. This integration of administrative coordination with participatory governance makes formal planning partnerships a foundational component of multilevel territorial governance. In the Flemish-Dutch Delta, formal partnerships serve as institutional transnational cooperation, structuring governance in regions where ecological interdependence and logistical functions coincide.

6.2 Informal planning partnerships

Informal planning partnerships includes communities and citizens as community-led initiatives, grassroots groups, and local networks that emerge organically, often in response to local needs or perceived gaps in formal planning processes. These partnerships are flexible with ad-hoc decision-making structures, relies on social norms, trust, and reciprocity, and may operate outside formal governmental regulations, though they can interact with formal structures (Meijer, 2018).

Such initiatives are frequently driven by inhabitants who possess a deep connection to their local living environment. They play a crucial role in shaping spatial development, particularly in contexts where formal planning mechanisms may be insufficient or unresponsive to local needs. In the Netherlands, for example, community-led planning has been observed in rural regions where residents initiate projects to preserve public facilities or develop village plans, often navigating complex policy domains and sometimes conflicting with formal planning systems (Meijer, 2018).

Table 3: Analysis of informal planning partnerships

Initiative	Description	Key Actors	Reflection
Streekholders in Grenspark Groot Saeftinghe	Local citizen groups, residents, farmers, businesses, tourism guides, and youth who actively preserve the region's socio-cultural identity and provide local insights. They complement formal governance and use mechanisms like the "Grenspark Denktank."	Local residents, farmers, businesses, tourism guides, youth, enthusiastic volunteers (hosts and hostesses), Grenspark Denktank members	This initiative represents a significant and innovative step towards genuine co-creation in spatial planning, moving beyond tokenistic public consultation. Its strength lies in integrating local experiential knowledge and fostering social cohesion, potentially mitigating the top-down tensions historically seen in the Delta. However, its long-term effectiveness will depend on truly empowering "*streekholders*" beyond advisory roles, ensuring their contributions genuinely shape outcomes, and preventing potential co-option by more powerful formal actors or fragmentation of local interests.
Room for Rivers (Local Implementation)	While a formal national program, its success relies on local engagement and adaptation, linking water safety directly to spatial quality, social issues, and broader economic and ecological improvements.	Local communities, farmers, landowners, environmental groups, local authorities	As a formal program with local engagement components, "Room for Rivers" is commendable for fostering broader ecological and economic improvements alongside water safety. Its success hinges on effective local mediation between diverse stakeholders (farmers, landowners, environmental groups). A critical aspect is ensuring that local implementation truly reflects community needs and equitably distributes the benefits and burdens of land-use changes, rather than being a merely consultative layer on a predetermined, national strategy.
Crowdfunding for Bird Hides (Grenspark Groot Saeftinghe)	A specific local initiative within GGS where a nature conservation organization (Stichting Het Zeeuwse Landschap) raises funds from the public to enhance park features, demonstrating community support and informal contributions.	Stichting Het Zeeuwse Landschap, local citizens, birdwatchers, nature enthusiasts	This is an excellent example of a specific, tangible local initiative within a larger park framework that leverages citizen support and informal contributions for conservation. Its strength lies in direct community engagement and ownership of small-scale nature enhancements. However, while valuable for local impact and demonstrating commitment, such initiatives are typically limited in scope and cannot address systemic, large-scale environmental challenges or substitute for robust institutional funding and strategic planning for core conservation goals.

Doel 202010	A local action group advocating for the preservation of the village of Doel, often in response to port expansion plans, representing community resistance and heritage preservation efforts.	Local residents of Doel, activists, heritage preservationists	Doel 2020 exemplifies profound and sustained community resistance against top-down port expansion plans, successfully challenging a decades-long designation for demolition. Its critical role lies in asserting local agency and heritage preservation against powerful economic interests. While demonstrating the power of civic opposition, its reactive nature highlights the inherent tension between economic development and local identity, and the considerable social cost and protracted conflict that can arise from a lack of early and genuine participatory planning.
Participative Platform11 (Grenspark Groot Saeftinghe)	An online platform facilitating direct engagement and feedback from local citizens within the Grenspark Groot Saeftinghe initiative, allowing citizens to participate in various groups.	Local citizens, Grenspark Groot Saeftinghe team	This online platform is a tool for facilitating direct and ongoing engagement, democratising access to participation beyond physical meetings. Its strength lies in its potential to broaden reach and enhance transparency, fostering continuous feedback loops. The critical challenge will be to ensure that online engagement translates into tangible influence on decision-making, bridging the digital divide, and preventing the platform from becoming a mere 'listening' mechanism rather than a true co-design space where diverse local voices are genuinely heard and integrated into park management.

Informal planning partnerships, studied in this research, highlights the role of grassroots actors, local associations, cultural institutions, and civic coalitions. These stakeholders often emerge in response to perceived gaps in formal governance, acting autonomously or semi-autonomously to represent local values, challenging top-down decisions, or even articulating alternative futures. While their formal decision-making power is limited and may lack structural durability, their influence can be substantial in shaping public discourse and pushing institutional actors toward more inclusive or culturally sensitive agendas. A prominent example is the Doel 2020 movement, where local residents resisted port expansion and advocated for cultural preservation and heritage-based regeneration. These partnerships tend to focus on socio-cultural sectors, landscape heritage, and identity politics, often linked to spatial claims over land, water, and memory. Their temporality may be fluid and adaptive, but they demonstrate a strong sense of place-based continuity.

6.3 Research-based planning partnerships

Research-based partnerships or Research by Design partnerships involve collaborations between academic institutions, research organisations, knowledge institutes, and practitioners to generate, integrate, and disseminate spatial knowledge. These partnerships aim to inform policy, improve planning practices, and develop innovative solutions through data collection, analysis, modelling, and participatory knowledge exchange. They are crucial for understanding complex social-ecological systems and developing transformative pathways (Henrick et al., 2017). These are long-term, mutually beneficial collaborations that promote the production and use of research. They often involve co-production of knowledge, where researchers and practitioners work together to address persistent problems of practice (Coburn et al., 2013). By integrating diverse perspectives and expertise, research-based partnerships can produce more relevant and actionable insights for policy and practice (Farrell et al., 2021).

In the context of spatial planning, research-based partnerships can facilitate the development of innovative

10 http://www.doel2020.org/index.php

11 https://www.streekholders.grensparkgrootsaeftinghe.eu/default.aspx

instruments, tools and approaches, such as scenario planning, to support decision-making processes (Geertman et al., 2013). They also play a vital role in capacity building, enhancing the skills and knowledge of both researchers and practitioners (Penuel et al., 2015).

Table 4: Analysis of research-based planning partnerships

Initiative	Description	Key Actors	Reflection
Schelde Monitor12	A Flemish-Dutch knowledge and information system established in 2003 for research and monitoring in the Scheldt Estuary. It provides expertise, literature, datasets, measurements, projects, maps, and indicators to support policy and management.	Flemish-Dutch Scheldt Commission (VNSC), scientists, policymakers, water authorities	ScheldeMonitor is a foundational asset for evidence-based decision-making in the Scheldt Estuary. Its strength lies in centralising and continuously providing comprehensive, multi-disciplinary data, research, and expertise, crucial for informed policy and management. A potential critique is ensuring its accessibility and usability for diverse stakeholders (beyond just scientists and policymakers) and maintaining its independence and funding to continue providing objective data in a politically charged environment. Its long-term operation since 2003 speaks to its established value.
SPADES13 Project (EU Soil Mission)	A Horizon Europe project combining 19 partners in 10 countries, including Deltares and TU Delft. It investigates integrating soil health into spatial planning and design through 17 pilot projects in urban, peri-urban, and rural areas.	Deltares (project coordinator), TU Delft, 19 partners from 10 European countries (universities, knowledge institutes, private partners), spatial planners, policymakers	The SPADES project is a highly relevant initiative addressing the critical but often overlooked issue of soil health within spatial planning, connecting it directly to EU policy goals. Its strength is its transnational, multi-partner approach, integrating diverse knowledge institutes and applying research through practical pilot projects. The challenge lies in ensuring that the insights from these 17 pilots are effectively scaled up and translated into implementable policy changes across varied national and regional contexts, overcoming bureaucratic and practical barriers to adoption.

12 Schelde Monitor - https://www.scheldemonitor.be/nl
13 SPADES - https://www.spades4soils.eu/

"Estuaries on the MOVE" (EMOVE) EU Interreg Project (Jan et al., 2015)	An EU Interreg project aiming to turn stakeholders into "shareholders" by fostering a shared understanding of the estuary's physical and ecological functioning and collectively formulating projects. It involves scientists and policymakers.	Scientists, policymakers, various stakeholders (e.g., environmental groups, port authorities)	EMOVE's ambition to turn stakeholders into "shareholders" by fostering shared understanding of estuarine functioning is a commendable step towards deeper collaborative governance. Its strength is building common knowledge and promoting collective project formulation among diverse actors, which is crucial for complex socio-ecological systems. However, achieving genuine "shareholder" status requires more than just shared understanding; it necessitates power-sharing, which can be challenging to implement in projects with inherent power imbalances among stakeholders (e.g., between port authorities and environmental groups).
Collaborative Eco-morphological Modeling (Scheldt LTV)	A specific activity during the development of the Scheldt Long-Term Vision (1999-2001) that used modeling to facilitate communication and create a shared understanding of the estuary's intrinsic character among diverse actors.	Scientists, policymakers, various actors involved in LTV development	This specific modeling activity during the LTV development demonstrates the power of scientific tools in facilitating communication and building shared understanding among diverse stakeholders regarding complex natural systems. Its strength is in using visual and data-driven methods to bridge knowledge gaps and facilitate consensus. However, the models are only as good as their inputs and assumptions, and their complexity can sometimes alienate non-expert stakeholders if not effectively communicated, potentially limiting genuine co-production of knowledge.
"Drought in the Delta" (IABR Atelier)[14]	A design research project portraying freshwater shortages in the Dutch Delta through visualizations and design proposals, aiming to inform a change in thinking and acting towards water retention.	IABR (International Architecture Biennale Rotterdam), researchers, designers	This initiative highlights the critical role of design research and visualisation in raising awareness and fostering new perspectives on pressing environmental challenges like freshwater shortages. Its strength is its ability to communicate complex issues through accessible design proposals, inspiring a change in thinking and action. A potential limitation is that design proposals, while visionary, often require significant political will, funding, and public acceptance to move from conceptualisation to large-scale implementation.

14 https://iabr.nl/en/research/atelier-droogte-in-de-delta

Deltaplatform Living Labs15	Initiatives focused on fostering knowledge exchange and developing practical, scalable solutions for urban resilience and water management through collaborative discussions.	Deltaplatform, international experts, various urban contexts	Living Labs are excellent mechanisms for fostering real-world knowledge exchange and developing practical, scalable solutions through iterative, collaborative processes. Their strength is in their hands-on, experimental approach that directly involves end-users and promotes rapid learning cycles. The challenge for Deltaplatform's labs lies in ensuring that the solutions developed within specific urban contexts are truly scalable and adaptable to other diverse environments, and that the knowledge generated is effectively disseminated and integrated into broader policy frameworks.
Bauhaus of the Seas	An EU initiative promoting new ways of living with water, integrating design, science, and art, with pilot projects like the Delta pilot (including Grenspark Groot Saeftinghe) as living examples.	New European Bauhaus, researchers, designers, local communities, public agencies	This EU initiative, connecting design, science, and art to re-imagine living with water, is highly innovative and holistic. Its strength is its interdisciplinary approach and emphasis on practical pilot projects like the Delta pilot, offering "living examples" of new ways to interact with aquatic environments. A potential challenge is translating broad, aspirational visions into concrete, universally applicable policy measures, and ensuring that artistic and design-led approaches are genuinely integrated with scientific rigor and policy implementation.
Panorama Zeeuws-Vlaanderen16 (De Zwarte Hond)	An investigative design study exploring the coexistence of a flourishing economy with an aging society in Zeeuws-Vlaanderen, focusing on quality of life and cross-border cooperation.	De Zwarte Hond, municipalities of Sluis, Hulst, Terneuzen, Creative Industries Fund	This investigative design study is valuable for exploring the complex interplay of economic prosperity, demographic shifts (aging society), and quality of life at a regional scale, with a focus on design solutions. Its strength is its holistic perspective and emphasis on cross-border cooperation for sustainable regional development. As a design study, its impact relies on the subsequent political uptake and financial commitment to implement its proposals and ensuring that design-led insights are fully integrated with broader planning and economic development strategies.

The aim of such partnerships, as studied within this research, is to co-produce spatial knowledge and develop experimental or adaptive planning frameworks. A key feature is their sectoral breadth, ranging from climate resilience (e.g., Resilient Delta17) to socio-economic transitions and port-city interrelations (e.g., PortCityFutures18). These partnerships often include universities as knowledge anchors, combining empirical analysis with

15 https://www.deltaplatform.nl/en/living-labs
16 https://dezwartehond.nl/projecten/panorama-zeeuws-vlaanderen
17 https://convergence.nl/resilient-delta/
18 https://www.portcityfutures.nl/

normative policy recommendations. Their decision-making power is indirect but influential, operating through policy advice, scenario development, and evidence-based recommendations. Long-term thinking is embedded in their iterative and systemic approaches, often guided by principles of transition management, participatory design, or adaptive planning.

In most of the cases, there are some partners from the government organisations in for implementation and dissemination of knowledge. While the formal government organisations are not part of the project decisions, they act as mediators between sectors and scales. By aligning research with planning needs, these partnerships can influence formal agendas and bridge governance gaps, particularly in complex transboundary contexts like the Flemish-Dutch Delta.

7. Discussion - Stakeholder and "*Streekholder*" dynamics

The governance in the Flemish-Dutch Delta illustrates a complex and elaborately intertwined interactions of diverse actors, ranging from established formal institutions to community-driven groups, referred to as "*streekholders*" (Grenspark Groot Saeftinghe, 2024). The divergent priorities of these groups, the underlying vulnerabilities of the region and the cultural mindsets, inherent the dire need for structural collaboration.
There are 4 focus points areas recognised for this region; (i) Economically, formal stakeholders such as port authorities are focused on continuous economic development and enhanced accessibility for shipping. (ii) Environmentally, this objective frequently generates friction with conservation goals pursued by environmental organisations and certain governmental bodies, particularly in a sensitive ecological zone like the Scheldt estuary. (iii) At the policy and management level, living with water inherently involve balancing the water management "safety," "accessibility," and "nature" of the Scheldt estuary. (iv) At the local level for the communities, "*streekholders*" often prioritise the preservation of their socio-cultural identity, their livelihoods (e.g., agriculture), and their quality of life.

Reflecting on the actor landscape

After critically reflecting on the vast array of partnerships, reveals certain gaps and limitations. A primary missing element is a truly unified political leadership at the transnational level capable of consistently "breaking down" borders and overcoming entrenched national interests and diverse regulatory landscapes. Despite the understanding of the advantages of cross-border collaboration, the full realisation and implementation of the potential remains largely a "political problem". Informal actors, or *streekholders*, focus on maintaining socio-cultural integrity, livelihoods, and community quality of life, which can (sometimes) directly clash with regional or national objectives, or the long-term bigger picture, vividly illustrated by the protests against depoldering initiatives (Van Buuren & Warner, 2014). Existing partnerships tend to underrepresent or inadequately integrate certain voices, including youth, marginalised communities, and small-scale local entrepreneurs, leading to a governance gap wherein grassroots perspectives remain peripheral or symbolic rather than decisively influential (Meijer, 2018).

Patterns and trends in partnerships

The evolution of stakeholder partnerships in the Flemish-Dutch Delta reveals a gradual yet persistent shift toward multi-actor engagement. Since the early 2000s, initiatives such as the Grenspark Groot Saeftinghe have increasingly institutionalised informal stakeholder involvement through frameworks like EU-funded INTERREG projects (Interreg Vlaanderen–Nederland, 2025). These initiatives have fostered dialogue among formal and informal actors, significantly marked by structured entities such as EGTC Linieland van Waas en Hulst (EGTS Linieland van Waas en Hulst, 2024). Despite growing inclusivity, the decision-making influence of informal actors remains constrained, highlighting an ongoing imbalance where strategic and economic stakeholders dominate the core decision-making processes (Popescu, 2008).

Learnings from these partnerships

The lack of integration of informal and local perspectives into formal planning frameworks to enhance legitimacy, resilience, and adaptive capacity (Adger, 2003) is purely visible. The GGS initiative itself functions as a testing ground, fostering experimental and adaptive governance approaches adept at addressing complex interactions among ecological vulnerabilities, socio-cultural identities, and economic interests. It is vital to ensure that planning processes are not only effective but also socially accepted. Thus, fostering truly inclusive governance requires specific mechanisms that formalise the roles of *streekholders* in decision-making processes, facilitate continuous dialogue, and mediate conflicting interests through sustained, adaptive collaboration (Henrick et al., 2017).

8. Conclusion and recommendations

This paper demonstrates that the future of transnational spatial planning lies not only in formal structures but in the symbiotic relationship between institutional stakeholders and local *streekholders*. In the Saeftinghe case, this interplay has produced experimental and adaptive governance models that navigate ecological vulnerabilities, socio-cultural identity, and economic interests. The study reveals that when local voices are actively incorporated, as in the case of *streekholders*, planning processes gain legitimacy and resilience. This dual involvement challenges conventional stakeholder frameworks and offers a more inclusive, place-based approach to transboundary spatial governance. The insights from Saeftinghe provide a valuable precedent for regions across Europe facing similar multi-scalar complexities. Despite promising initiatives on multiple levels, formal governmental planning, informal planning grassroots initiatives and research driven partnerships, the study reveals a critical disconnect. These approaches currently operate in parallel in different scales, limiting the potential for inclusive and resilient and integrative spatial planning in the delta. Why it matters? Below are some initial recommendations for more holistic governance at regional and delta scales:

Power of shared visions – Lack of shared frameworks for integrating diverse perspectives across scales, sectors and stakeholders, hinders the co-creation of a shared vision of future proof solutions. A centralised platform that facilitates data sharing and communication between all scales and actors could promote intentional collaboration and implementation of interventions.

Formalised process of inputs – Policy frameworks in a transnational scale, which actively incentivises collaboration across governmental, research and citizen-led initiatives. Aligning institutional mandates with participatory planning is essential for legitimacy and impact. A clearly articulated process for integrating local knowledge and feedback mechanisms into decision-making would further enhance transparency, responsiveness, and long-term institutional learning.

Navigating values and tensions – GGS presents a trinity of nature, port, and agriculture as both identity and site of contestation. This conflict is also a strength. On a delta scale, the ports hold a strong hand and are responding to these escalating pressures, strategies are emerging to balance economic growth with sustainability. Ports like Rotterdam have adopted "Green Port" initiatives, investing in renewable energy sources such as wind and solar power and actively developing a hydrogen economy to reduce reliance on fossil fuels. Antwerp also demonstrates leadership in green logistics through initiatives like dual-fuel watercraft.

Nature inclusive long-term approaches – The growing advocacy for Nature-Based Solutions as an alternative to traditional "hard" infrastructure (e.g., concrete dikes) for coastal protection and climate adaptation, are being proposed for their environmental benefits, contributing to climate resilience and biodiversity enhancement. These approaches restore ecosystems while offering flexible, robust climate adaptation strategies, while simultaneously providing vital flood protection.

Rebalancing power and sustaining collaboration – The success of integrating "*streekholders*" demonstrates that local ownership and community-based approaches are vital for the long-term sustainability and social acceptance of large-scale regional development initiatives. Interventions such as coastal realignment, while designed to enhance ecosystem services, have met with negative social responses due to the perceived loss of cultural ecosystem, including agricultural polders and traditional livelihoods. By granting local communities "real agency" and ensuring their voices are genuinely heard for building trust, initiatives must address the socio-cultural implications of spatial interventions.

Embrace adaptive and integrated planning – The evolution of governance in the Flemish-Dutch Delta reveals a dynamic interplay, or paradox, between centralisation and decentralisation in adaptive planning. While the Dutch approach has shifted towards "multilayered safety," a more polycentric and inclusive model, there remains an ongoing discussion about "Decentralisation of the Spatial Planning System" versus a potential "Recentralisation of Planning" due to doubts about locational choices. This indicates that effective adaptive governance in deltas is not a simple linear progression of control, but rather a continuous re-scaling of governance functions. Multilayered governance must balance top-down strategic direction with bottom-up contextual implementation. Such dynamic fosters a "network of governance" that is better equipped to navigate spatial challenges across administrative and national borders.

Addressing legal and administrative obstacles in cross-border water management demands systemic coordination across sectors and scales. This includes integrating water, spatial, and economic strategies to address "wicked problems" holistically, recognising their interconnected nature. Regular and sustained dialogue is therefore crucial for encouraging commitment and synergy between national and local actions, ensuring that strategies are truly effective across all levels of governance. These recommendations stem from the early phase of research within the Bauhaus of the Sea Sails project and fieldwork in the Borderpark of Saeftinghe. As a research-in-progress contribution, the next steps will deepen the analysis of institutional evolution, path dependencies from the history and future trajectories for delta scenarios. This will include extending the empirical base with national, provincial, regional and municipal policy documents from the Netherlands and Belgium.

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The Bioeconomy, Experimental Governance, and Spatial Planning

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Abstract
Spatial planning, deeply rooted in institutional contexts, is a key enabler of societal transitions towards sustainability. The governance structures that influence planning are shaped by institutional frameworks and regulations determining land-use and developmental decisions. While agendas like the bioeconomy offer pathways to sustainability, their implementation is often hindered by rigid governance, fragmented coordination, and slow processes stemming from divergent perspectives and institutional inertia. Sustainability-focused governance models can improve planning effectiveness. Experimental approaches such as testbeds and living labs encourage institutional learning and collaboration among stakeholders, enabling co-creation. However, they also introduce challenges related to stakeholder interests and power dynamics. This paper analyses the interplay between planning systems and sustainable transitions such as the bioeconomy, whilst exploring how experimental governance can address some these challenges.

Keywords: *the bioeconomy; spatial planning, sustainability transitions, experimental governance, living labs*

Introduction

"Deliberately steering societal change towards a desired future is an endeavor of tremendous size and complexity." (McCrory et al., 2018, p.3).

Sustainability transitions require profound shifts in socio-technical practices, behaviours, and governance to address complex challenges like climate change and inequality (Truffer et al., 2010). Contemporary research emphasises the need to navigate uncertainty, ambiguity, and non-linearity in these transitions, advocating for learning, reflexivity, and experimentation as adaptive strategies (McCrory et al., 2018).

A growing body of literature frames human settlements and natural environments as integrated socio-ecological systems (SES), characterised by dynamic, interconnected relationships across spatial and temporal scales (Martínez-Fernández et al., 2021). Spatial planning plays a crucial yet often underdeveloped role in managing these complexities, especially in emerging fields like the bioeconomy (Grossauer and Stoeglehner, 2020).

Urban experimentation has become a prominent approach, shifting from rigid planning to open, iterative exploration (Andersson et al., 2024). Urban experiments (UEs) are deliberate interventions designed to trigger sustainability transitions (Baatz et al., 2024), but their effectiveness is deeply shaped by the socio-ecological and spatial contexts in which they occur (Sauer et al., 2015). Researchers using socio-ecological systems frameworks realised that this approach didn't account for the role of technical infrastructure in urban areas (Andersson et al., 2024). This led to the development of 'social-ecological-technical systems' (SETs), which focus on interactions between ecological, social, and technological aspects (*ibid*). Current research uses this framework to analyse urban issues like risks, resilience, ecosystem services, justice, and nature-based solutions (*ibid*).

Urban experiments unfold within specific "sites" defined by unique socio-spatial configurations physical, cultural, and institutional which actively shape and are shaped by social actions (Baatz et al., 2024). These configurations influence both the outcomes of experiments and the potential for transformative change. Experiments can disrupt established routines, alter perceptions, and reshape regulatory or cultural aspects of space (Gaba and Bretagnolle, 2020; Ehnert, 2023).

Ultimately, effective sustainability transitions depend on the dynamic interplay between experimental governance, socio-ecological-techical systems, and spatial contexts. Recognising the embeddedness of agency within these configurations enables a more nuanced understanding of how transformative change can be facilitated or constrained (Gaba and Bretagnolle, 2020).

The Bioeconomy: Navigating Spatial Dynamics, Governance Challenges, and Inherent Tensions

The bioeconomy is widely recognised as a key strategy for providing essential goods, replacing non-renewable resources with renewables, and preserving natural resources (Wohlfahrt et al., 2019). It is central to current

sustainability transitions agendas, particularly within Europe (Halonen et al., 2022). The European Commission introduced the "knowledge-based bioeconomy" in 2005, emphasising the role of education, research, and collaboration in unlocking the value of biological resources across sectors (Birner, 2017; McCormick & Kautto, 2013). Since the early 2000s, the European Union (EU) has promoted bioeconomy policies at multiple levels, launching its bioeconomy strategy in 2012 and updating it in 2018 (Lühmann, 2020). This strategy aims to foster a low-carbon, sustainable growth model, focusing on food and energy security, biodiversity conservation, and effective resource management (Altoukhov et al., 2022; Ronzon et al., 2022).

Despite being touted as inherently sustainable, the bioeconomy faces criticism. Early emphasis on biotechnology led to a focus on innovation and technical fixes, often at the expense of interdisciplinary approaches and practical solutions (Priefer et al., 2017). Critics also highlight risks of commercialising nature, prioritising market interests over environmental and social well-being, and concerns about land grabbing and greenwashing (Birner, 2017). Thus, a comprehensive understanding of the bioeconomy must go beyond techno-economic perspectives, considering spatial and governance dimensions and inherent tensions (Wohlfahrt et al., 2019; Ahlqvist & Sirviö, 2019).

The bioeconomy's spatial dynamics are rooted in specific territories, relying on local biomass and value chains, and shaped by both local and global networks (Wohlfahrt et al., 2019). Its manifestations vary by scale: globally, it involves market-driven dynamics; nationally, it creates uneven development; regionally, it highlights tensions between industrial resource use and alternative land-uses (Ahlqvist & Sirviö, 2019). Strategic spatial planning is important in balancing environmental, social, and economic goals and addressing land-use conflicts (Grossauer & Stoeglehner, 2020).

While the bioeconomy offers potential for sustainable development, it is also subject to conflicts. Debates persist over whether it perpetuates capital accumulation within neo-liberal frameworks or can drive transformative change (Ahlqvist & Sirviö, 2019). Policy frameworks often favour corporate interests, risking continued resource exploitation and exceeding ecological limits (Ville, 2023). For instance, Finland's forest bioeconomy may reinforce resource extraction rather than rural revitalisation (ibid). Integrating sustainability and circularity principles is critical to avoid replicating traditional models (Holden et al., 2022). The "biosave regime," which prioritises reduced resource use based on ecological principles, has been proposed as an alternative to growth-oriented paradigms (Halonen et al., 2022). A comparative analysis of the "biosave regime" and other predominant regimes in bioeconomy development is provided in Figure 1.

	Biotech regime	Biomass regime	Biosave regime
Idea	Technical innovations resolve ecological problems with new 'less polluting' solutions	Renewing bioresources replace the 'more polluting/non-renewing' resources and thence resolve ecological problems. Requires more efficient use of the resources so the resource use does not increase	Degrowth and restricting the use of the resource to the minimum resolve socio-ecological problems. Techno-economic solutions have a minor role
Progress	Driven by markets - > R&D and investment support, and policies follows	Driven by normative policies and related R&D and investment support - > markets follow	Driven by normative policies and regulations - > markets follow
Role of institutions	Supporting of the markets	Guiding the markets and resource use	Restricting and restraining of the markets
Driving actors	Economic/market-oriented actors, e.g. companies, business organisations	Public organisations, NGOs	Public organisations, NGOs, citizens
Supporting/enabling actors	Public organisations, consumers	Companies, customers	Companies, customers

Figure 1: *Characteristics of bioeconomy regimes (Halonen et al., 2022, p.3).*

The bioeconomy faces a salient challenge of reconciling economic growth with finite biological resources and ecological boundaries (de Schutter et al.,2019). Current bioeconomy activities are often linked to environmental degradation (e.g. intensified agriculture and land conversion leading to habitat loss and disruption of local ecosystems) (*ibid*). While the bioeconomy can contribute to Sustainable Development Goals (SDGs), it can also undermine their achievement (*ibid*). A truly sustainable bioeconomy requires actively recognising the ecological foundation of all activities and the physical boundaries of social and economic systems (Pungas, 2023).

Moreover, the bioeconomy must grapple with questions of social justice and equity (Halonen et al., 2022). Ensuring an inclusive bioeconomy constitutes an active area of research. The concept of a 'just transition' is regarded as crucial for ensuring the sustainable transition to a bioeconomy that is equitable (Faulkner et al., 2024).

Therefore, while the bioeconomy presents prospective avenues for resource substitution and advancement towards sustainability, it embodies an intricate paradigm intrinsically linked to spatial considerations, governance frameworks, and the inherent discordance among economic expansion, ecological constraints, and equitable practices. The realisation of a sustainable bioeconomy mandates a comprehensive navigation of these multifaceted challenges via spatially nuanced regional integration, robust and harmonised governance mechanisms, and dedicated initiatives to confront fundamental contradictions and safeguard equity.

Theoretical Foundations

Institutional Frameworks in European Spatial Planning

Conventional spatial planning paradigms have been critiqued for their limited capacity to effectively address increasingly intricate and unpredictable challenges (Raynor et al., 2018). The complexity of these issues stems from their cross-sectoral nature, multi-scalar operation, and the involvement of diverse stakeholders with varying perspectives and values (*ibid*). Planning processes have often perpetuated existing inequalities and followed established trajectories, projecting current conditions onto future scenarios without critical evaluation (*ibid*). This reflects a broader issue of inflexibility and path dependency within socio-technical systems, which are understood as dynamically stable complexes shaped by the co-evolution of individuals, technology, and institutions (Jensen et al., 2019). These systems tend to evolve incrementally due to lock-in effects and path dependence, which impedes radical transformation (*ibid*). Furthermore, established administrative practices significantly influence the elasticity or rigidity of public administrations in response to reform initiatives (Polverari et al., 2024).

A further challenge lies in the sectoral nature of planning and governance (Hansen and Coenen, 2015). Governing sustainability transitions necessitates encompassing multiple policy areas (Polverari et al., 2024). However, planning systems often operate in silos, impeding policy integration (*ibid*). This can sometimes be linked to the different degrees of politicisation within the public sector (Kalogiannidis et al., 2024). Addressing complex interdependencies is difficult when governance functions are dispersed, especially within multi-level systems (*ibid*). While consensus-oriented approaches exist, the increasing complexity of governance implies that the ability of urban and regional authorities to control these processes may be diminishing, with some central regulatory functions transferred to national or supranational levels (Hansen and Coenen, 2015).

Importantly, transitions are inherently and deeply political (Jensen et al., 2019). They challenge existing relations of power and capital, involving trade-offs between competing visions of the future (*ibid*). Power asymmetries are central to the politics of transitions (*ibid*). Power dynamics can shape the organisation of knowledge and institutional arrangements, potentially emphasising particular aspects of urban systems while concealing others, thereby rendering some stakeholders and actions more significant than others (*ibid*). Unequal power relations can be masked by seemingly neutral concepts like 'sustainability' or 'best practices', which can be appropriated to legitimise particular agendas or practices (*ibid*). Different actors, such as policymakers, industry associations, social movements, technology manufacturers, and individual professionals, contribute to change, but their relationships, roles, and relative positions can shift as a transition unfolds (Farla et al., 2012). Incumbent actors with established networks are often expected to favour existing systems, while newcomers may push for alternatives (*ibid*). Understanding these power dynamics, the struggles between actors with competing interests, and the resources they mobilise is crucial for assessing the governing conditions under which sustainability transitions can materialise (*ibid*).

The convergence of systemic rigidity, fragmentation, and power imbalances poses substantial obstacles to achieving sustainability transformations. While urban sustainability experiments, defined as localised, intentional interventions designed to prototype alternative future scenarios are frequently undertaken, the translation of initial political support into effective governance mechanisms for systemic change remains limited (Jensen et al., 2019). These dynamics shape the persistence of established systems, the perpetuation of power inequalities, and the distribution of advantages and disadvantages. Advancing sustainability necessitates planning strategies that are more adaptable, resilient, and responsive, with a focus on inclusive stakeholder engagement and participatory processes (*ibid*). This entails a comprehensive understanding of systemic complexity and the inherent political dimensions of transformative change (Raynor et al., 2018). Future research should further investigate strategies for actors to effectively operate within existing systems and explore mechanisms for fostering collective action to catalyse sustainability transitions (Farla et al., 2012).

Introduction to Experimental Governance

The urgent need for a fundamental societal transformation toward sustainability presents major challenges for established governance and planning systems (Laakso et al., 2017). Traditional regulatory and bureaucratic frameworks often struggle to manage the complex, non-linear dynamics of sustainability transitions (ibid). These systems have also faced criticism for ambiguity and increasing commercial influence, particularly under neo-liberalisation and local financial constraints (Haderer, 2023).

Sustainability transitions research investigates how large-scale system change occurs and how actors can influence these processes (Laakso et al., 2017). A key concept is governing through experimentation defined as inclusive, practice-based, and challenge-led initiatives that promote system innovation and social learning amid uncertainty (Sengers et al., 2019). Experimentation is seen as a vital governance tool for fostering innovation and transformative change (Kivimaa et al., 2017).

Experimental governance, alongside approaches like Strategic Niche Management (SNM) and Transition Management (TM), offers alternatives to rigid, fragmented planning (Kok, 2022). Unlike hierarchical, command-and-control regulation, experimental governance supports adaptable, exploratory, and reflexive strategies that mobilise diverse actors, develop shared visions, scale innovations, and foster learning (Kivimaa et al., 2017; Kok, 2022). It emphasises stakeholder inclusion, deliberation, and co-creation, recognising that transformative change requires collaborative and multi-actor processes (Kok, 2022).

In urban and spatial planning, experimental governance is operationalised through testbeds, living labs, and innovation districts dedicated arenas for collaboration and real-world testing of solutions (Berglund-Snodgrass & Mukhtar-Landgren, 2020). These labs prioritise co-innovation and co-creation, with continuous feedback between users and innovators, enhancing participatory planning (Massuga et al., 2024; McCrory et al., 2018; Knickel et al., 2021). Intermediary actors, such as spatial planners, often facilitate stakeholder engagement and balance diverse interests (Berglund-Snodgrass & Mukhtar-Landgren, 2020; Kok, 2022).

However, integrating experimental governance within traditional systems is challenging, requiring policy changes and risking fragmented or short-term outcomes (Grönholm, 2022). There are concerns about neo-liberal co-optation, reduced accountability, and the sidelining of public authority (Haderer, 2023). Addressing these risks demands systemic changes, democratised co-production, and reconceptualised governance to align with experimental approaches (Kok, 2022; Haderer, 2023). Ultimately, successful experimental governance in spatial planning requires intentional, coordinated efforts to confront political dynamics and avoid reinforcing existing inequities (Kok, 2022).

Living Labs as a Mechanism of Experimental Governance: Conceptualisations, Open Innovation Ecosystems, and Their Role in Advancing Sustainable Regional Development

Experimental governance, characterised by "learning by doing" and adaptive objective-setting, provides a valuable framework for addressing the complexities of sustainability transitions (Van Poeck et al., 2020). It involves actively testing new forms of territorial governance and engaging diverse stakeholders to tackle multifaceted societal challenges (*ibid*). Within this context, Living Labs (LLs) have emerged as prominent mechanisms, functioning as "societal laboratories" that foster innovation and experimentation in real-world settings (Eneqvist, 2022).

LLs are closely related to "testbeds" and "real-world laboratories," representing an experimental, co-creative approach to innovation policy (Engels et al., 2019). They are defined as user-centred, open innovation ecosystems that integrate research and innovation processes in real-life communities (ibid). LLs aim to test, demonstrate, and advance new socio-technical arrangements and governance modes under real-world conditions (Lupp et al., 2021). A central feature is their emphasis on placing citizens at the heart of innovation, fostering collaborative partnerships among public, private, and community stakeholders (Engels et al., 2019; Lupp et al., 2021). These environments enable experimental and experiential learning, involving diverse users and stakeholders (Mbatha & Musango, 2022). However, not all initiatives labelled as LLs align with these core principles (ibid). LLs can also serve as sites where the meaning of sustainability is contested and negotiated (McCrory et al., 2022).

A typology of sustainability-oriented labs includes "empower and govern" labs, which are partnership-based and focus on understanding and responding to complex sustainability challenges, often at the urban level (Mbatha & Musango, 2022). These labs catalyse relational or institutional experimentation rather than solely technical or commercial innovation (McCrory et al., 2022). LLs are intrinsically linked to spatial contexts, frequently situated in cities, neighbourhoods, or regions (Lupp et al., 2021; Mbatha & Musango, 2022). They expedite co-creation and implementation across value chains, as seen in agricultural LLs (Lupp et al., 2021; Martins et al., 2025). Their key features include fostering innovation, openness, spontaneity, knowledge generation, and the development of sustainable solutions (Martins et al., 2025).

LL methodologies are iterative and phase-based, typically involving problem understanding, stakeholder engagement, solution development and testing, and outcome evaluation (Lupp et al., 2021). Evaluation often using theory-driven or developmental approaches is crucial for supporting generative experimentation and producing actionable knowledge (Dekker et al., 2021).

LLs are increasingly used to support urban planning, enabling transformative place-making and the shaping of socio-spatial identities (Eneqvist, 2022; von Wirth et al., 2018). They make experimentation tangible for landscape and nature-based solutions by functioning as both virtual and real spaces (Lupp et al., 2021). Urban LLs are experimental forms of governance designed to address urbanisation, climate change, and resilience (Mbatha & Musango, 2022), while regional LLs promote sustainable regional planning (ibid). Implementation can be challenging due to tensions with traditional planning practices, but regulatory flexibility within LLs can foster creativity and innovation (Lupp et al., 2021).

Experimental governance and LLs are increasingly seen as essential for advancing sustainability transitions, acting as real-world laboratories to test and refine solutions (von Wirth et al., 2018). Addressing sustainability challenges requires deep system-level innovation (McCrory et al., 2022). LLs enable regions to experiment with new ideas and engage with complex issues, aligning with the broader goals of sustainability transitions. They also serve as platforms for societal reflection and learning (ibid). Labs may pursue incremental or disruptive change, contributing to global sustainability transitions and supporting UN Sustainable Development Goals, such as protecting cultural and natural heritage (SDG 11.4) (Pastorelli, 2022). The regenerative development approach, which shares elements with LLs, further informs their potential to address root causes of unsustainable development and redesign humanity's relationship with the planet (ibid).

Living Labs and the Regional Advancement of the Bioeconomy

The shift towards a sustainable bioeconomy system is increasingly recognised as important, with regions playing a central role in driving this change (Szarka et al., 2023). While most strategies and policies have been formed at the national level, there is growing awareness of the need for regional bioeconomy strategies to capitalise on local strengths and priorities, because industrial activities tend to be concentrated regionally (Ayrapetyan et al., 2022).

Regional development is a multifaceted concept that extends beyond just economic growth (Medeiros, 2022). It should encompass a broader range of factors contributing to the overall well-being of a region, such as social equity, environmental sustainability, institutional strength, governance effectiveness, and spatial planning (*ibid*). Economic growth remains a component but should not be the sole focus.

Traditional regional development theories centred on economic growth fail to adequately capture the multi-dimensional nature of development and the importance of integrated, place-based approaches (*ibid*). This has led to the emergence of alternative paradigms like sustainable development, place-based development, and knowledge-based development, which adopt more holistic, location-specific perspectives (Barca, 2009).

LLs and experimental governance are being applied to study and promote the bioeconomy (Pinsky et al., 2024). Experimental governance using LLs can help shift stakeholders from conflicts based on different economic interests towards cooperative solutions (*ibid*).

However, advancing the regional bioeconomy through this approach faces challenges, including policy coordination issues, limited collective action among actors, and a lack of incentives for systematic experimentation and learning from local experiences (Pinsky et al., 2024). Key elements for unlocking the potential of experimental governance in this domain include political will, a long-term strategy based on metrics, and a system for peer review of local experiments to support policy decisions and joint learning (ibid). The experimental problem-solving approach can have a significant impact by demonstrating and replicating successful initiatives, fostering systematic learning, and promoting socio-economic opportunities alongside environmental conservation (ibid). LLs serve as a potential mechanism within the broader framework of experimental governance, providing real-world sites and methodologies for testing, learning, and co-creating solutions to complex challenges. As open innovation ecosystems, they bring together diverse actors, to develop place-based innovations. Their link to spatial contexts makes them relevant for urban and regional planning, while their focus on experimentation and multi-stakeholder involvement positions them as key enablers for sustainable transitions. Applied to the regional bioeconomy, experimental governance facilitated by LLs offers a valuable pathway towards fostering sustainable growth, collaboration, and systemic learning, despite challenges related to coordination and institutional capacity. Successful application depends on developing organisational capacity within public institutions, ensuring democratic legitimacy, and strategically embedding experimental practices. The conceptual diagram illustrates the interconnectedness of experimental governance, bioeconomy, strategic spatial planning, socio-ecological-technological systems (SETs), living labs, and urban experimentation (see Figure 2).

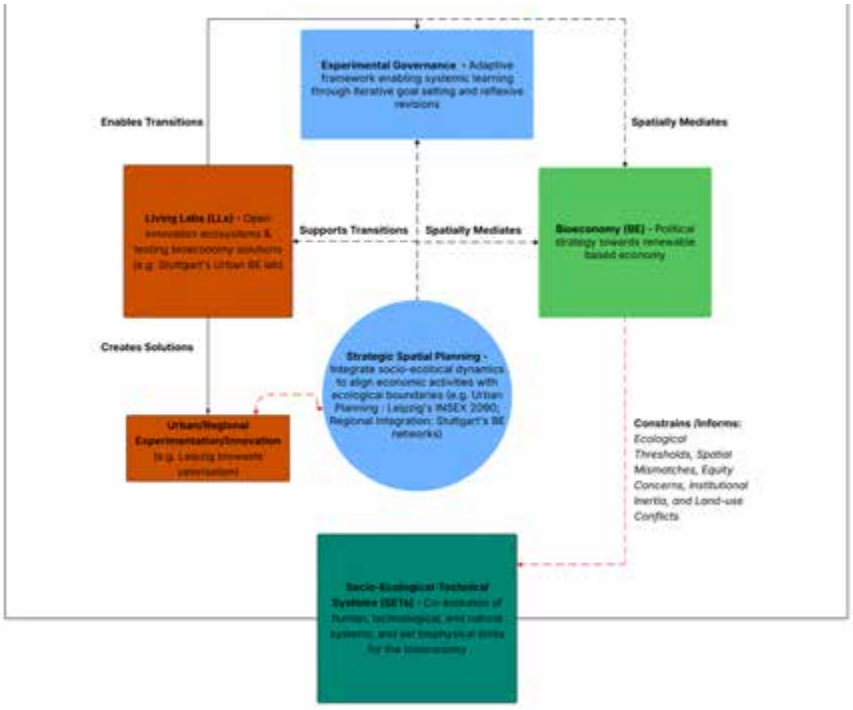

Figure 2: *Conceptual diagram showing the interconnectedness experimental governance, bioeconomy, strategic spatial planning, socio-ecological-technological systems (SETs), living labs, and urban experimentation (de Almeida, 2025)*

Methodology
This study adopts a qualitative, comparative case study design to investigate how experimental governance particularly through living labs and strategic spatial planning advances bioeconomy transitions in urban regions. The research focuses on two German cities, Stuttgart and Leipzig, selected for their contrasting yet complementary approaches to integrating innovation ecosystems and territorial coordination within Germany's national bioeconomy strategy.

Case study selection and rationale:
Stuttgart exemplifies a technical, living lab-driven model, operationalising experimental governance through the Circular Bioeconomy Strategy (ZirBioS) and the Urban Bioeconomy Lab, which integrate cascading biomass use and cross-sectoral stakeholder platforms into urban redevelopment. Leipzig, by contrast, is analysed for its policy-driven "bio-principled city" vision, embedding bioeconomy goals within the Integrated Urban Development Concept (INSEK) 2030 and piloting innovative public-private partnerships for biowaste valorisation and urban agriculture.

Data collections:
- Peer-reviewed journal articles with the broad fields of spatial planning and urban studies, urban governance, experimental governance, sustainability transition and socio-technical studies, bioeconomy and circular economy, political science and power dynamics, and environmental policy and justice.
- Policy document analysis of strategic plans (Stuttgart and Leipzig).

Analytical Framework:
A socio-ecological-technological systems (SETs) perspective is employed to assess institutional alignment, stakeholder power dynamics, spatial-material integration, and the outcomes of experimental governance. Comparative analysis highlights how multi-level governance, network structures, and spatial planning instruments mediate the effectiveness and equity of bioeconomy transitions.

Comprehensive Analysis of German Bioeconomy Transitions: Stuttgart and Leipzig Case Studies
This analysis examines experimental governance approaches to bioeconomy development in two German cities, revealing how spatial planning mediates sustainability transitions through institutional innovation and multi-stakeholder coordination. The contrasting experiences of Stuttgart and Leipzig demonstrate both the potential and limitations of experimental governance mechanisms in advancing urban bioeconomy strategies, highlighting critical factors that influence the effectiveness of spatially embedded policy integration within Germany's national bioeconomy framework.

Germany's Approach to Bioeconomy Transition: Comparative Case Studies
National Context and Urban Opportunities
The transition towards a sustainable bioeconomy represents a key strategic priority for Germany, supported by comprehensive national strategies implemented since 2010 (Wen, 2024). While rural areas have traditionally been prioritised for their biomass potential, urban regions increasingly offer significant opportunities, particularly through knowledge creation and innovation networks (Stöber et al., 2023). This analysis explores bioeconomy advancement in Stuttgart and Leipzig, two German cities that exemplify distinct approaches to experimental governance, strategic spatial planning, and institutional coordination within the broader context of national bioeconomy policy.

The involvement of diverse industries, including process and mechanical engineering, highlights the cross-sectoral nature and economic relevance of the bioeconomy beyond traditional bio-based sectors (Stöber et al., 2023). This approach demonstrates experimental governance through targeted research funding and network analysis designed to understand knowledge dynamics (ibid). However, the concentration of funding and projects among large, established actors suggests potential structural limitations, possibly hindering wider participation and network resilience across different stakeholder groups (ibid).

Stuttgart: Living Labs and Circular Bioeconomy Integration
Stuttgart's selection as a case study is anchored in its adoption of living lab methodologies to test bioeconomy solutions within urban-industrial systems. The city's Circular Bioeconomy Strategy (ZirBioS) operationalises experimental governance by prioritising cascading biomass use, carbon sink development, and cross-sectoral stakeholder platforms (Schuchardt et al., 2024). The Urban Bioeconomy Lab, a Fraunhofer Institute-led initiative, functions as a "transformation model" where municipal authorities, industries, and researchers co-design circular systems for wastewater, biowaste, and construction materials (*ibid*). This approach aligns with academic frameworks emphasising spatial experimentation as a tool for overcoming sectoral fragmentation in bioeconomy transitions (Stöber et al., 2023).

Stuttgart's strategic spatial planning further mediates these experimental initiatives through institutional coordination mechanisms. The Preparatory Land-Use Plan integrates bioeconomy objectives into urban redevelopment processes, ensuring that brownfield sites and industrial corridors are systematically repurposed for bio-based value chains (Dieckhoff et al., 2020). Academic analyses highlight how such spatial coordination enables Stuttgart to reconcile competing land-use demands while scaling pilot projects from experimental phases to broader implementation (Stöber et al., 2023). The city's governance model combines Baden-Württemberg's state bioeconomy strategy with municipal spatial planning, providing a replicable blueprint for multi-level experimentation across different administrative scales (Bioregions Facility, 2023).

Stuttgart's Network Dynamics and Institutional Challenges
Despite these innovative approaches, Stuttgart's bioeconomy innovation network exhibits concerning centralised characteristics that limit broader participation and systemic resilience (Stöber et al., 2023). The University of Hohenheim, the Fraunhofer Institute, and the University of Stuttgart have been identified as key gatekeeping institutions that control knowledge inflow and diffusion within the regional network (*ibid*). This concentration of institutional influence is mirrored in resource allocation patterns, where federal funding disproportionately benefits established research actors, allowing them to "soak up funding and relevant knowledge" while marginalising smaller stakeholders (*ibid*). Such dynamics can lead to "weak network failures," limiting collaboration and innovation among less-connected, peripheral actors and ultimately hindering the overall resilience and inclusivity of the regional innovation ecosystem (*ibid*).

Leipzig: Bio-Principled City Vision and Policy Coordination Challenges
In contrast to Stuttgart's technical focus, the Leipzig case study examines policy frameworks for transitioning towards a "bio-principled city," a comprehensive vision that integrates biological principles into urban life for enhanced sustainability and resilience (Boldt and Thrän,2023). Research indicates that Leipzig's current policy mix for this transition remains complex, uncoordinated, and lacks definitive implementation actions (*ibid*). The bioeconomy is explicitly addressed mainly at supra-national and national levels, with limited focus at state or municipal levels, despite local initiatives such as Leipzig's bioeconomy working group (*ibid*). This situation highlights significant flaws in vertical policy coordination and reveals the limited autonomy of German local governments, which remain dependent on higher policy levels and earmarked funding mechanisms (*ibid*).

Leipzig showcases elements of experimental governance through its integration of bioeconomy principles into cross-sectoral urban development frameworks. The Integrated Urban Development Concept (INSEK) 2030 embeds bioeconomy targets within a holistic vision for sustainable growth, linking circular economy initiatives such as zero-waste centres to spatial priorities including green corridors and mixed-use districts (Heinig et al., 2018). This approach reflects the New Leipzig Charter's emphasis on transformative, multi-stakeholder governance, which academic literature identifies as critical for aligning bioeconomy transitions with socio-ecological resilience objectives (Risi et al., 2020; Zeug et al., 2021).

Leipzig's Experimental Mechanisms and Governance Constraints
Leipzig's experimental governance is further evidenced by its adaptive policy mechanisms and innovative funding approaches (Kramer et al., 2024). The city's green recovery projects, funded through federal programs, test novel public-private partnerships for biowaste valorisation and urban agriculture initiatives (*ibid*).

These projects are spatially mediated through Structural Concepts that allocate land for biorefineries and community composting hubs, ensuring bioeconomy innovations align with demographic and climatic realities (Heinig et al., 2018), Academic studies note Leipzig's success in leveraging EU funding to pilot spatially targeted governance models, representing a key criterion for case study selection in sustainability transitions research (Zeug et al., 2021).

Despite these pioneering efforts in urban bioeconomy initiatives and commitment to developing "bio-principled city" concepts, Leipzig reveals significant power asymmetries at the multi-level governance scale (Boldt and Thrän, 2023). Policy-making is predominantly driven by supra-national and national actors, particularly the European Commission, constraining German local governments' financial and political capacity to implement bioeconomy transitions effectively (*ibid*). This dependency restricts their capacity for independent experimental governance and urban innovation (ibid). Furthermore, while broad stakeholder involvement is deemed essential, the lack of capacity and financial resources for comprehensive cooperation at the local level indicates that power imbalances can marginalize vital local participation (*ibid*).

Comparative Analysis of Experimental Governance Outcomes
Contrasting Governance Effectiveness
The contrasting experiences of Stuttgart and Leipzig highlight key determinants of effective experimental governance in bioeconomy-oriented spatial planning. Stuttgart's Urban Bioeconomy Lab demonstrated success through multi-level coordination, technical mediation, and spatial integration (Ministry of the Environment BW & Ministry of Rural Affairs BW, 2019). By embedding circular bioeconomy principles into land-use planning, Stuttgart enabled scalable pilot projects and resource circularity (Schuchardt et al., 2024). The Fraunhofer Institute's intermediary role fostered iterative learning and policy refinement (Federal Ministry of Education and Research, 2025). However, Stuttgart's centralised innovation network concentrated resources among dominant institutions, marginalising SMEs and grassroots actors (Stöber et al., 2023).

In contrast, Leipzig's INSEK 2030 struggled with vertical policy misalignment and limited local autonomy, impeding the translation of its bioeconomy vision into action (Boldt & Thrän, 2023; Webb et al., 2023). Fragmented coordination, rigid funding, and weak SME engagement further constrained Leipzig's circular bioeconomy initiatives (Webb et al., 2023).

Critical Success Factors for Experimental Governance
Effective experimental governance in bioeconomy transitions depends on several key conditions. Multi-level institutional alignment is fundamental: Stuttgart's success was driven by synergies between the Baden-Württemberg state bioeconomy strategy and municipal planning, which supported living labs (Webb et al., 2023). In contrast, Leipzig's fragmented policy mix revealed how misaligned agendas can undermine experimentation. Decentralised innovation networks are also crucial—while Stuttgart's centralised hubs accelerated technical solutions, they limited diversity and inclusion; Leipzig's lack of intermediaries hindered knowledge diffusion. Balancing technical efficiency with grassroots participation is essential. Spatial-material integration matters as well: Stuttgart's land-use plans anchored experiments in industrial ecosystems, enabling resource circularity (Schuchardt et al., 2024), whereas Leipzig's broad visions lacked spatial specificity, delaying implementation (Webb et al., 2023). Finally, financial and political autonomy empowers adaptive management, as seen in Stuttgart, while rigid federal funding constrained Leipzig (Ministry of the Environment BW & Ministry of Rural Affairs BW, 2019; Webb et al., 2023).

Strategic Implications and Future Directions
Both cases address strategic spatial planning dimensions that reveal important insights for bioeconomy development. Stuttgart's analysis differentiates network structures at regional and supra-regional levels, demonstrating how spatial scale influences innovation dynamics (Stöber et al., 2023). Leipzig's study strongly emphasises the urban-rural relationship, arguing that establishing the bioeconomy cannot be limited to urban areas due to biomass resource constraints (Boldt and Thrän, 2023). The city is envisioned as a nucleus driving regional structural change by revitalising urban-rural ties and fostering regional value-added networks (*ibid*). However, this approach requires improved connections to rural areas and greater involvement of SMEs, which are currently lacking (ibid).

The studies reveal key areas requiring further research and policy development. For Stuttgart, similar analyses in other urban regions are needed to validate findings and uncover regional differences (Stöber et al., 2023). For Leipzig, future work should assess how the policy mix can be improved and adapted to accelerate transitions, including mechanisms to ensure adequate funding at local levels (Boldt and Thrän, 2023). More broadly, empirical evidence is needed on the effectiveness of institutional innovations like bio-clusters on green productivity, and comparative studies across countries with different bioeconomy strategies would yield valuable insights (*ibid*).

Failure in experimental governance arises when experiments remain siloed or subordinated to incompatible higher-level agendas, as demonstrated by Leipzig's fragmented policy landscape. Future strategies should prioritise polycentric governance models that distribute agency across sectors and scales, ensuring bioeconomy transitions align with place-specific socio-ecological realities (O'Connor et al., 2023). While Stuttgart and Leipzig showcase potential avenues for bioeconomy advancement through innovation networks and integrated urban-rural systems, their experiences underscore the challenges of translating national strategies into coherent, effective local action. The current governance landscape, characterised by uncoordinated policies and limited local autonomy, reflects an experimental phase still in its 'infancy' with identifiable structural flaws. Addressing these issues through targeted policy interventions and continued research is crucial for realising the transformative potential of urban and regional bioeconomy development in Germany and across Europe more generally. See Table 1 for a comparative summary of experimental governance and bioeconomy spatial planning in Stuttgart and Leipzig, Germany.

Table 1: *Comparative Summary of Experimental Governance and Bioeconomy Spatial Planning in Stuttgart and Leipzig (de Almeida, 2025).*

Aspect	Stuttgart	Leipzig
Strategic Vision	Circular bioeconomy strategy (ZirBioS) with clear municipal and state alignment; vision operationalised through land-use planning and cascading biomass systems.	"Bio-principled city" vision embedded in INSEK 2030; remains mostly programmatic with limited concrete actions at local level.
Governance Structure	Strong multi-level coordination (municipal, state, research institutes); centralized innovation network with key gatekeepers (Fraunhofer, Hohenheim, Stuttgart University).	Fragmented policy mix; high dependence on supra-national/national directives and earmarked funds; weak local autonomy.
Experimental Approaches	Living Labs (Urban Bioeconomy Lab) as real-world testbeds for circular systems; pilots in biowaste, wastewater, construction materials.	Urban experiments in green recovery, biowaste valorisation, and urban-rural biomass networks; limited spatial and institutional integration.
Stakeholder Involvement	Broad mapping of stakeholders but practical influence concentrated among large institutions; SMEs and grassroots actors marginalised.	Policy rhetoric supports broad participation, but lack of resources, capacity, and SME engagement limits real involvement.
Spatial Planning Integration	Bioeconomy targets integrated into Preparatory Land-Use Plan; brownfield and industrial corridors repurposed for bio-based value chains.	Bioeconomy principles referenced in spatial plans, but urban-rural linkages and land allocation for biorefineries remain underdeveloped.
Key Successes	Scalable pilot projects; institutional learning; spatial mediation of bioeconomy; strong technical expertise and iterative policy refinement.	Piloting of new public-private partnerships; leveraging of EU funding for targeted innovation; recognition of urban-rural interdependencies.
Key Challenges/Failures	Centralized network limits resilience and innovation diversity; risk of "weak network failure" and knowledge gatekeeping.	Policy fragmentation, lack of vertical coordination, insufficient local autonomy, and weak translation from vision to action.
Lessons for Experimental Governance	Success linked to multi-level alignment, spatial-material integration, and financial/political autonomy; risk of exclusion if networks are too centralised.	Effective governance requires improved coordination, empowerment of local actors, and concrete mechanisms for stakeholder engagement and resource flows.

Discussion

The advancement of the bioeconomy, a key strategy for sustainability transitions, is shaped by the interplay of governance, spatial dynamics, and institutional contexts. Spatial planning plays a crucial, though often underdeveloped, role in navigating the complexities of the socio-ecological-technological systems central to the bioeconomy. Traditional planning frameworks marked by rigidity, fragmentation, and power imbalances can impede transformative change, as dominant interests may shape strategic visions and institutional inertia discourages experimental approaches.

Experimental governance, including strategies like Urban Experiments (UEs) and Living Labs (LLs), has emerged as a promising response to these challenges. These approaches advocate adaptive, reflexive, and exploratory governance that involves diverse stakeholders. LLs, in particular, act as user-centric, open innovation ecosystems embedded in real-world settings, fostering co-creation and collaborative innovation processes, often in urban or regional contexts. Such initiatives make experimentation more tangible and applicable to spatial issues.

However, the application of experimental governance faces significant obstacles. The Stuttgart case study demonstrates that bioeconomy innovation networks often revolve around prominent institutions acting as knowledge gatekeepers, with funding and projects concentrated among large, established actors potentially limiting wider stakeholder participation. The Leipzig case highlights difficulties in translating conceptual ideas into practice, revealing a fragmented and uncoordinated policy landscape and weak vertical policy coordination. This underscores the importance of urban-rural relationships but also reveals insufficient connections and SME involvement needed for effective regional transformation.

A fundamental challenge is the spatial nature of the bioeconomy, which involves production, processing, and consumption in specific locations, leading to geographical contradictions and uneven development, potentially creating resource peripheries. Spatial mismatches where governance boundaries do not align with environmental or social issues are critical, as is institutional fragmentation, which hinders the coherent implementation of experimental approaches. Addressing bioeconomy transitions effectively requires spatially integrated and regionally differentiated strategies that can navigate these complexities.

Conclusion

Steering societal transitions toward sustainability particularly through the bioeconomy is a complex challenge. While the bioeconomy promises to replace non-renewable resources and advance sustainability, its implementation is hampered by rigid governance, fragmented coordination, and institutional inertia. Power dynamics and resistance from incumbent actors further impede transformative change and experimentation. The bioeconomy's success is also shaped by spatial considerations and tensions between economic growth, ecological limits, and equity, often resulting in uneven development and spatial mismatches in governance.

Spatial planning, rooted in institutional contexts, is a crucial enabler for these transitions. When combined with a socio-ecological systems perspective, spatial planning helps map opportunities and threats, set strategic direction, and foster innovation. Experimental governance through mechanisms like testbeds and Living Labs (LLs) offers a way to address the inflexibility of traditional systems. LLs serve as real-world sites for co-creation and learning, encouraging institutional learning and collaboration, and marking a shift from top-down governance to more decentralised, participatory approaches.

However, integrating experimental governance within spatial planning is not without challenges. There is a risk of fragmentation or co-optation by powerful interests, which can perpetuate existing inequities. Overcoming these barriers requires a fundamental rethinking of systemic structures and power relations. Case studies highlight practical difficulties, such as innovation networks favouring established actors and the complexities of coordinating policy across urban and rural contexts.

Achieving a truly sustainable bioeconomy demands spatially nuanced regional integration, robust and harmonised governance mechanisms, and initiatives that address fundamental contradictions and promote equity. Multi-level governance coordinating efforts from international to local scales is essential.

Ongoing research is needed to develop strategies for collective action, spatially explicit governance instruments, and effective regional bioeconomy approaches. Ultimately, successful transitions depend not just on innovative interventions, but on their dynamic alignment with local social and ecological processes.

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Rural Revitalization Beyond Administrative Boundaries: A Case Study of Villages Surrounding Taihu Lake, Chinai

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Abstract
This study explores cross-boundary rural revitalisation in the "Six Villages around Taihu Lake," a pilot zone for urban–rural integration in Huzhou, China. Facing challenges such as fragmented governance and resource imbalance, the villages adopted a collaborative model centred on spatial planning, industrial coordination, shared infrastructure, and multi-stakeholder governance. This approach has transformed administrative divisions into functional communities, fostering industrial complementarity and inclusive governance. The model shifts focus from an "administrative region economy" to a more resilient "functional area economy," offering valuable insights for overcoming boundary constraints and promoting sustainable rural development in China and beyond.

Keywords: Rural Revitalisation; Urban-rural Linkages ; Administrative Boundaries ; Urban-rural Governance

1 Introduction

Against the backdrop of intensifying global challenges—ranging from climate change and land competition to food security crises and ecological degradation—the spatial dynamics of urban–rural interactions are being fundamentally reshaped. These compound pressures impose systemic constraints on regional sustainable development. In this context, Urban–Rural Linkages have emerged as a pivotal concept in the global sustainable development agenda, offering a pathway to address entrenched development dilemmas. The United Nations' 2030 Agenda for Sustainable Development explicitly calls for the strengthening of national and regional planning frameworks to foster social, economic, and environmental connections between urban agglomerations, peri-urban zones, and rural areas (United Nations, 2015). In alignment with this, the UN-Habitat (2019) publication *Urban-Rural Linkages: Guiding Principles outlines a value-based and operational framework* designed to support integrated territorial development through context-specific strategies.

Correspondingly, China has advanced its own agenda through policies promoting urban–rural integration and rural revitalisation, shifting from a historically dualistic spatial structure toward a stage characterised by bidirectional flows of factors and functional complementarity. However, local implementation of these national strategies continues to face significant challenges—chief among them, the constraints imposed by administrative boundaries. These boundaries hinder the efficient flow of resources, perpetuate uneven development, and dilute governance effectiveness. Overcoming such institutional fragmentation is thus critical for advancing regional coordination and integrated development.

This study focuses on the rural areas along the Taihu Lake shoreline in Huzhou, a city within the Yangtze River Delta region that was designated in 2019 as a national pilot zone for urban–rural integration. As an early experimental site for reforms in land allocation, population mobility, infrastructure connectivity, and cross-boundary rural revitalisation, Huzhou offers a valuable case for empirical analysis. This paper addresses three core research questions:

(1) What specific initiatives have facilitated rural revitalisation across administrative boundaries?
(2) Which policies and programmes have supported these efforts?
(3) What outcomes have been achieved as a result?

2 Literature Review

As a major national strategy in China, rural revitalisation aims to stimulate endogenous rural development by promoting thriving industries, liveable environments, social civility, effective governance, and increased prosperity. However, conventional rural development models—predominantly based on individual administrative units—alongside traditional administrative-region-based economies, have increasingly revealed their structural limitations. Administrative boundaries often act as invisible barriers to the free flow of resources, integrated industrial development, joint infrastructure provision, and coordinated ecological governance. These limitations have resulted in inefficient resource allocation, industrial homogeneity, insufficient innovation (Yu and Zhao, 2009),

duplication or inadequacy in public infrastructure, and fragmented responses to cross-boundary ecological challenges. Consequently, they constrain the enhancement of regional competitiveness and the achievement of sustainable development goals.

Given these challenges, traditional governance structures based on administrative divisions no longer suffice to meet the complex demands of rural revitalisation. Breaking down administrative silos and promoting cross-boundary planning, coordination, and collaboration is therefore essential for overcoming rural development bottlenecks and unlocking the systemic benefits of regional integration. It is within this context that trans-boundary planning has emerged as a vital strategy for spatial restructuring, coordinated resource allocation, and collaborative regional development. As urban–rural integration and regional cohesion accelerate, rural areas are no longer isolated or static spaces but rather nodes embedded within multi-level, multi-actor interaction networks.

Trans-boundary planning plays a crucial role in three main respects. First, it enhances resource allocation efficiency, particularly in rural areas where ecological, industrial, and infrastructural advantages are unevenly distributed. Coordinated planning across administrative boundaries enables the optimal mobilisation and integration of such diverse resources (Yang and Chen, 2024). Second, it fosters systemic governance by addressing the integrated nature of ecosystems, infrastructure networks, and cultural landscapes—many of which transcend administrative borders. Governance based on natural or functional spatial units is often more scientific and coherent than purely administrative approaches. Third, it supports collaborative industrial development by enabling innovation ecosystems, industrial chains, and service systems to operate beyond jurisdictional limits, responding more flexibly to cross-boundary demands (Zhu, Sun and Li, 2024).

Trans-boundary planning in China operates at multiple scales (Luo, Qiu and Liu, 2023). At the macro level, inter-provincial planning forms part of major national strategies—such as the Yangtze River Delta Integration, the Greater Bay Area initiative, and Beijing–Tianjin–Hebei coordinated development (Tao, 2020). These efforts require strong central leadership, high-level institutional mechanisms (e.g. joint conferences between provinces), and aim to address infrastructure, watershed governance, ecological barriers, and market integration (Chen and Zhong, 2017). Inter-municipal planning focuses on collaboration between adjacent prefecture-level cities within a province. With more concentrated coordination mechanisms, these plans address industrial synergies, integrated transport, shared public services, and peri-urban cooperation within urban agglomerations or metropolitan areas (Li, Duan and Jiang, 2025). Inter-county planning, within or between neighbouring prefecture-level cities, is more operationally feasible, tackling development imbalances at county borders, industrial connectivity, environmental protection, and coordinated social governance. It plays a key role in bridging the “last mile” of regional integration. At the micro level, inter-town and inter-village planning targets localised collaboration between adjacent rural settlements, focusing on integrated resource use, reducing redundant competition, and developing functional rural clusters such as agricultural parks or tourism zones. These efforts also support joint public services and the governance of cross-boundary environmental concerns, such as river basins and waste management, boosting collective competitiveness and strengthening grassroots collaboration.

These different levels of planning are interlinked and mutually supportive, forming a multi-scalar, layered coordination framework that spans from macro strategy to micro-level implementation. Together, they provide a robust pathway for advancing rural revitalisation beyond administrative constraints.

In recent years, trans-boundary planning has become a key topic in urban and regional studies, with expanding and deepening academic interest. One central focus has been the design of governance mechanisms, including intergovernmental collaboration, multi-stakeholder participation, and regional governance platforms. Another key area involves planning tools and methodologies, such as integrated spatial planning, functional zoning, and ecological network design—particularly prominent in environmentally sensitive and peri-urban areas.

A third concern relates to interest alignment and policy coordination, as the diversity of stakeholders and the fragmentation of administrative authority pose challenges to cost-sharing, benefit distribution, and sustainable cooperation. However, existing research has largely concentrated on urban agglomerations, metropolitan peripheries, or large-scale cross-boundary zones, with relatively limited attention paid to village- and township-level planning in rural contexts (Yang and Lu, 2023).

In practice, trans-boundary planning spans a wide range of applications. One key area is ecological governance, especially in river basin management and landscape-level restoration efforts, which inherently cross administrative borders and require coordinated action (Li et al., 2021; Talukder et al., 2020). Another is joint tourism development, where multiple villages or counties collaborate to leverage shared natural or cultural resources and build regional tourism brands—benefiting local economies and residents (Manyane, 2017). Additionally, shared infrastructure development—such as road networks, water supply systems, waste disposal, and sewage treatment—has become a practical focus area (Chavez et al., 2013), helping to reduce redundancy and resource waste. Cultural heritage preservation and intangible heritage promotion are also emerging areas, with efforts to jointly apply for heritage recognition, co-organise exhibitions, and coordinate branding and communication strategies.

In summary, trans-boundary planning is transitioning from conceptual exploration to institutionalised practice, from single-sector interventions to integrated approaches, and from isolated examples to more standardised mechanisms. It not only expands the spatial and systemic horizons of rural revitalisation but also catalyses fundamental changes in governance structures and development models. Within the broader context of spatial integration, regional coordination, and urban–rural linkages, trans-boundary planning is set to remain a crucial instrument in shaping new rural geographies and achieving high-quality revitalisation.

3 Study Area: The Six Villages around Taihu Lake in Huzhou

3.1 Geographic Location

The Six Villages around Taihu Lake are located in the northern part of Wuxing District, Huzhou City, along the southern shore of Taihu Lake. The area spans two administrative units: the High-Tech Zone and Zhili Town. It comprises six administrative villages: Huanlou, Xulou, Yanglou, Yigao, Wupu, and Miaodou, covering a total area of 17.1 square kilometres. Situated within the "urban belt along the southern shore of Taihu Lake," the Six Villages serve as a transitional zone between Huzhou's urban core and the surrounding lake region. The area lies approximately 15 kilometres from downtown Huzhou and 12 kilometres from Huzhou East High-Speed Railway Station.

To the north, the region borders Taihu Lake and the Ring Taihu Road, while the southern boundary adjoins the Shanghai–Chongqing Expressway. To the east, it connects with the Zhijiang East Expressway. The location benefits from accessibility to three international airports—Shanghai Hongqiao, Hangzhou Xiaoshan, and Nanjing Lukou—all within a two-hour drive.

3.2 Resource Endowments

The "Six Villages around Taihu Lake" are situated in the core area of the Taihu Lougang waterway system, endowed with unique and rich resources. The Lougang system is an ancient hydraulic engineering network developed by early settlers to adapt to the low-lying, water-rich environment along the Taihu lakeshore. Its hallmark lies in distinctive wetland drainage techniques, an engineered structure of transverse ponds and longitudinal channels, and a complementary set of water management infrastructures. Originating in the Xia and Shang dynasties and undergoing extensive embankment construction and channel regulation from the Spring and Autumn period to the Five Dynasties, the system gradually perfected the lakeside dykes and sluice gate waterways that regulate Taihu's water storage and discharge. This facilitated the gradual transformation of tidal flats into a complex landscape of rivers, farmlands, settlements, towns, and an integrated water management regime, establishing the Taihu Lougang and Tangpu Weitian systems and turning the Taihu basin from a sparsely populated land into a prosperous "land of fish and rice". By the Song dynasty, intensified land use and the rise of commercial agriculture along the Lougang embankments led to rapid growth in high-value industries such as sericulture and aquaculture, positioning Huzhou as a nationally important production centre for agricultural products and textiles.

The Six Villages boast an 8-kilometre lakeside scenic corridor along Taihu Lake, characterised by picturesque natural landscapes of paddy fields, egrets, and streams, evoking the poetic imagery of the Jiangnan water towns. Notably, the water quality of Taihu has significantly improved in recent years, achieving national standards for a good-quality lake throughout the year for the first time. The Lougang water system forms the ecological backbone of the area, underpinning the urban green and blue infrastructure. Numerous historical and cultural assets are closely intertwined with this water system.

This area also possesses a profound historical and cultural heritage, serving as the core zone of Taihu Lougang culture. Yigao Village preserves a wealth of ancient architecture, including the Taihu Lougang Culture Exhibition Hall, the Woodblock Printing Art Museum, and the Lake Mirror Hall, collectively known as the "Six Halls, One Institute, and One Plaza". Local cultural vitality is further expressed through traditional agricultural festivals such as the "Taihu Lougang Folk Tourism Harvest Festival", which actively promotes the Lougang cultural identity. Additionally, the Six Villages have nurtured related cultural strands including canal culture, rice cultivation culture, and silk culture, creating a distinctive cultural corridor.

To safeguard and transmit these resource endowments, Huzhou City has enacted protective regulations to institutionalise the conservation of the Taihu Lougang system. Complementary cultural events continue to foster the cultural heritage of the region. Through cluster-based rural operations, the Six Villages have established market-oriented entities that connect stakeholders' interests, attracting over 60 new industrial and business projects annually with a total investment exceeding 1.5 billion RMB.

Figure 1. Distribution Map of the Lougang Waterway System in Southern Taihu
(Source: https://m.sohu.com/a/425597230_434584)

3.3 Development Challenges

The traditional advantage industry of the Six Villages around Taihu Lake lies in aquaculture, with crab farming being a key activity. Villages such as Xulou, Huanlou, and Yanglou primarily focus on fruit and vegetable cultivation, with Xulou Village having a relatively sizeable loquat plantation; however, its development has been constrained by limited brand recognition. At the outset of their collective development efforts, the Six Villages faced multiple challenges. Firstly, there was uneven resource endowment across the villages, each encountering distinct development bottlenecks: some were constrained by land scarcity limiting project capacity, others struggled with a narrow industrial structure and short value chains, while some suffered from low visibility and insufficient local attraction. Secondly, based on their individual development situations, villages often adopted a "go-it-alone" mentality—leading early-developing villages to fear resource dilution and loss of

competitive advantage, culturally rich villages to worry about losing their core status, and weaker villages to risk industrial marginalisation, resulting in varied willingness to collaborate. Furthermore, cross-administrative coordination required overcoming the traditional fragmented 'each village for itself' approach, with the absence of unified planning and benefit-sharing mechanisms increasing the cost of cooperation. Additionally, industrial homogeneity among the villages was evident, with a lack of clear, effective differentiation in industrial roles, which risked internal competition rather than fostering synergies.

Table 1. Basic Industries and Primary Sources of Income for Villagers in the Six Villages around Taihu Lake
Source: Compiled by the author based on *the Wuxing District 'Six Villages around Taihu Lake' New Era Beautiful Countryside Model Area Planning Scheme*

Administrative Village	Primary Industries	Main Sources of Income for Villagers
Huanlong Village	Small-scale aquaculture, Taihu Lake fishing, vegetable cultivation	Income from Taihu fish market (fishing), home-based children's clothing workshops
Xulong Village	Crab aquaculture, loquat cultivation, leisure agriculture, organic vegetables	Home-based children's clothing workshops, loquat cultivation
Yanglong Village	Crab aquaculture, vegetable cultivation, guesthouses	Home-based children's clothing workshops, vegetable cultivation
Yigao Village	Historic village tourism, crab aquaculture, vegetable cultivation	Tourism services, home-based children's clothing workshops
Wupu Village	Aquaculture, fruit cultivation, vegetable cultivation	Home-based children's clothing workshops, gardening and landscaping work
Miaodou Village	Aquaculture, fruit and vegetable cultivation	Home-based children's clothing workshops, aquaculture

4 Cross-Administrative Boundary Rural Development Practices in the Taihu Lake Region

4.1 Integrated Spatial Planning: Crafting a Unified Development Blueprint

Huzhou's "Six Villages around Taihu Lake" have broken free from the spatial governance constraints typical of traditional administrative villages by employing cross-scale spatial restructuring combined with integrated multi-plan coordination. This has established a systematic framework for regional collaborative development. At its core, the approach is guided by principles of functional complementarity and factor mobility, reconfiguring dispersed village spaces into an organically connected "regional economic community." From a planning perspective, a comprehensive spatial industrial layout covering all six villages has been developed, clearly defining differentiated functional roles—such as catering services, homestay clusters, cultural tourism experiences, youth innovation incubation, agricultural production, and new industry experimentation—resulting in a spatial structure of "core nodes – functional clusters – network system." This integrated planning not only enables the holistic allocation of land, ecological, and cultural resources but also promotes infrastructure connectivity (e.g., cross-village greenways, waterway routes) and shared public services, reducing regional transaction costs and providing a physical foundation for industrial collaboration and factor flow. Fundamentally, this model transforms the "divisive effect" of administrative boundaries into a "cohesive effect" of functional complementarity through institutional innovation in spatial planning, offering a valuable practical example of spatial governance for urban-rural integration at the county level.

Figure 2: Functional Zoning Plan of the "Six Villages around Taihu Lake"
(Source: Agriculture and Rural Affairs Bureau of Wuxing District, Huzhou City)

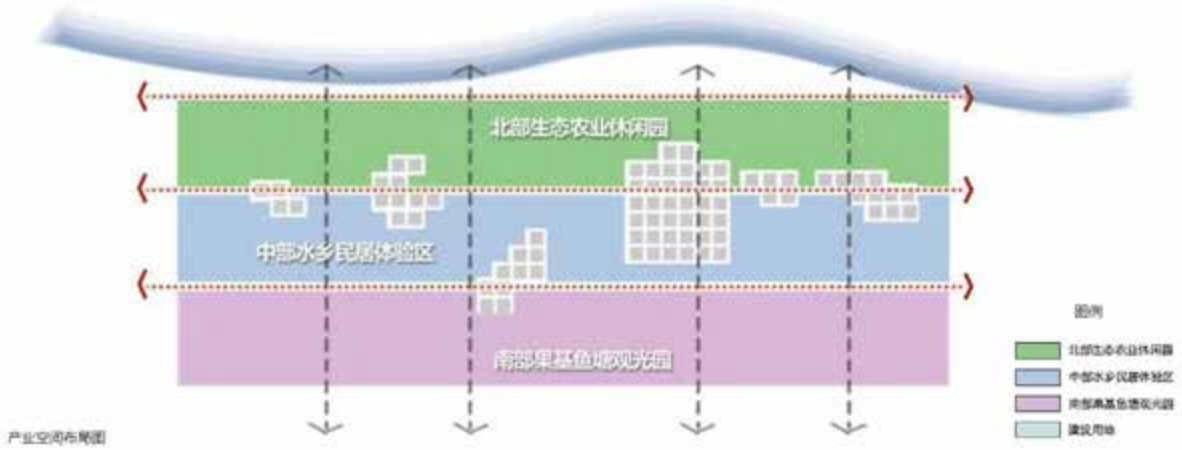

Figure 3: Industrial Layout Plan of the "Six Villages around Taihu Lake"
(Source: *Wuxing District 'Six Villages around Taihu Lake' New Era Beautiful Countryside Model Area Planning Scheme*)

4.2 Economic Development Coordination and Complementary Specialised Industries

The Six Villages around Taihu Lake have established an industrial coordination model characterised by differentiated positioning, integration of industrial chains, and cross-village flow of factors. Based on the principle of 'one village, one product' with specialised divisions of labour, a complementary industrial layout has been formed:

Huanlou Village focuses on dining (such as the 'Yili Xiang' Food Street), Yanglou Village specialises in homestays, Yigao Village develops cultural tourism (Lougong Cultural Park), Wupu Village introduces youth entrepreneurship ventures (cafés, creative spaces),

Xulou Village advances specialised agriculture (loquat cultivation), and Miaodou Village expands modern tourism (low-altitude economy, RV camping sites). Each village's industrial positioning is precisely differentiated, effectively avoiding homogeneous competition and jointly forming a complete consumption chain covering food, accommodation, tourism, creativity, agriculture, and emerging business models.

At the level of industrial integration, the six villages focus on the deep fusion of agriculture, culture, and tourism as the core development path. Speciality agricultural products (such as loquats and lake crabs) have extended from simple production to experiential consumption, creating a full value-added chain from cultivation through processing to cultural tourism experiences. Typical examples include loquat picking in Xulou Village, the cultural-tourism operation of the 'Yang Guizhen' Crab Manor, and large-scale crab farmers driving over 200 households across the six villages to participate in bundled packaging. This transforms agricultural resources into cultural-tourism attractions, achieving an average household income increase of 20,000 yuan. This integration not only enhances the added value of agricultural products but also strengthens regional industrial resilience through diverse activities such as educational tours, team-building exercises, and festivals.

Another key feature is the free flow and collaboration of industrial factors across villages. Production factors overcome administrative village barriers to achieve efficient allocation: labour is divided across villages within the crab industry chain (for example, crab farming in Xulou and joint processing involving all six villages); customers are shared across villages through unified brand marketing and integrated tourism route design (such as combined tickets for dining, homestays, and cultural experiences); and capital and social projects (such as cafés and camping sites) are established according to each village's differentiated positioning. This dynamic circulation activates resources across the entire region, forming an industrial ecosystem characterised by 'distinct village specialities and coordinated regional linkage.'

Table 2 Collaborative Economic and Industrial Model of the Six Villages around Taihu Lake(Source: Compiled by the author)

Coordination Mechanism	Specific Practices	Typical Cases	Outcomes
Differentiated Industrial Roles	'One Village, One Speciality' with precise positioning: • Huanlou (Dining), Yanglou (Homestays), Yigao (Cultural Tourism) • Wupu (Youth Entrepreneurship), Xulou (Agriculture), Miaodou (Emerging Industries)	Huanlou's 'Yili Xiang' food street accommodates 2,000 diners; Wupu cafés attract young entrepreneurs	Avoids internal competition and builds a complementary industrial chain
Industrial Chain Integration	Agricultural extension into secondary and tertiary sectors: • Agriculture (Loquat/Crab) → Processing → Cultural tourism experiences (e.g., fruit picking, educational tours, cuisine)	Crab farmers expand operations across villages, involving 200 households with an average income increase of ¥20,000; Yang Guizhen Crab Manor certified as a National 3A Tourist Attraction	Extends the value chain and increases the premium of local produce (e.g., crab farming)
Cross-Village Flow of Factors	Cross-village movement of labour, visitors, capital, and branding: • Labour: Division of labour in the crab industry chain • Visitors: Tourism routes linking all six villages • Branding: Unified regional IP operation	Joint development of the 'Six Villages around Taihu Lake' tourism brand; Village-hopping routes integrate homestays, dining, and cultural sites	Activates underutilised labour and generates income across the entire region

4.3 Joint Infrastructure Development and Regional Resource Sharing

4.3.1 Integrated Transport Infrastructure

The Six Villages around Taihu Lake have implemented a coordinated approach to transport infrastructure by integrating resources to construct a 6.9-kilometre interconnected pedestrian greenway and a 2.6-kilometre circular waterway. These routes not only facilitate daily travel for local residents but also provide convenient corridors for tourists. In addition, the scenic enhancement project of the Huxue Road, spanning 4.5 kilometres and covering Yanglou, Huanlou, and Wupu villages, included façade renovations, utility line upgrades, greening and lighting improvements, and landscape nodes. Another key initiative, the Shuichan Road upgrading project, stretches 7.5 kilometres from Huanlou to Wupu and comprises road surface improvements, roadside landscaping, and upgrades to adjacent industrial park access roads. Shared mobility facilities, such as public bicycles, have also been introduced to enhance local mobility and connectivity.

4.3.2 Shared Public Services Infrastructure

The six villages have jointly mobilised multi-level public funds totalling 628 million yuan, of which 370 million yuan has been allocated to infrastructure support. These funds have supported the upgrading of village-level infrastructure and living environments, including the development of parking facilities, parks, and cultural exhibition spaces. For instance, the former silk cocoon station in Yigao Village has been repurposed into the Taihu Lougang Culture Exhibition Hall, enhancing the village's cultural atmosphere and identity.

4.3.3 Digital Transformation and Smart Countryside Development

A digital upgrading initiative has been launched across the six villages to modernise service infrastructure. Rooted in local resource endowments, geographical features, industrial strengths, and cultural heritage, this initiative aims to build future-oriented rural settlements that are distinctive in character, well-functioning, industry-driven, environmentally appealing, digitally connected, and governed with integrated smart systems. The vision encompasses an ecologically sustainable, economically productive, and socially vibrant countryside that reflects the principles of common prosperity.

4.3.4 Ecological Restoration and Environmental Enhancement

Infrastructure development in the Six Villages has been closely aligned with ecological conservation objectives. Wuxing District has systematically promoted ecological governance across the Lougang region, including ongoing dredging of waterways and the ecological restoration of lakes and ponds. To date, 7.51 million cubic metres of silt have been cleared and seven key Lougang channels leading into the lake have been expanded. A further 16.9 kilometres of lakeside greening has been implemented, enhancing the ecological landscape. The area has also developed a 25-kilometre section of the Zhejiang Loop Trail encircling the villages. Within the cluster, 21 bus stops have been installed along two main roads, with six public e-scooter stations currently in place and 14 more planned, significantly improving accessibility and transport connectivity across the region.

4.4 Social Capital Investment and Rural Operation

The *Six Villages around Taihu Lake* (Binhu Six Villages) in Huzhou have demonstrated notable success in exploring innovative models of rural operation. At the heart of this success lies the construction of a collaborative governance and development mechanism involving multiple stakeholders. Throughout this process, both municipal and district-level governments have played a pivotal role in strategic planning and policy support.

Specifically, the Huzhou Municipal Government and Wuxing District Government jointly led the formulation of the *Special Development Plan for the Binhu Six-Village Cluster*, which defined the region's overall development orientation, designated responsible construction entities, and clarified the direction for leading industries. In parallel, a dedicated working group – the *Binhu Six Villages Green Common Prosperity Taskforce* – was established, with earmarked fiscal investment allocated to ensure the delivery of infrastructure upgrades and the implementation of key projects.

Under the guidance of government, a multi-layered participation structure has emerged. At the village level, each administrative village has actively embraced the group-based development strategy, pooling resources and coordinating planning to jointly forge the 'New Lougang of Taihu' regional brand. This has significantly strengthened inter-village cooperation and complementary development.

Village collectives have also contributed by participating in project construction and providing key resources such as land, thereby sharing in the added value generated by rural operations.

On the market side, professional rural operation firms have been introduced, while private capital has also played an increasingly proactive role. For instance, Huzhou Miqi General Aviation Services Co., Ltd. invested in and operates an aerial sightseeing project in Huanlou Village, adding diversity to the local tourism offering. From the perspective of civil society, successful rural activation initiatives—such as *Gudui Xiangchuang* in Longshan Village, Miaoxi Town—have provided valuable reference points for creative revitalisation across the Binhu Six Villages.

Professional operating firms serve as central coordinators within the Binhu model. Wuxing Xinglou Construction and Development Co., Ltd. exemplifies such a role, taking responsibility for unified infrastructure planning, project investment promotion, and long-term operational management. Their standardised project implementation has markedly enhanced the rural built environment and overall quality. More importantly, the firm has systematically integrated the six villages' resources to build the 'New Lougang of Taihu' regional brand, which has accelerated the integration and value uplift of agriculture, culture, and tourism sectors. This in turn has improved regional visibility, attracted tourist footfall, and drawn external investment. Furthermore, Wuxing Xinglou has proactively partnered with leading national cultural-tourism operators, bringing in specialised expertise to elevate operational standards.

In terms of financial sustainability, Binhu Six Villages have pioneered a diversified investment and financing model, combining state-owned capital leverage, private sector participation, financial sector backing, and village collective co-funding. This mechanism has ensured stable capital flows to support the smooth implementation of numerous integrated agriculture–culture–tourism projects.

Talent revitalisation is another critical pillar underpinning the model. Wuxing District has introduced a series of targeted policies to facilitate the return of rural talent, including platforms for young people to launch rural start-ups and the rollout of the *Youth in the Village Initiative*. These efforts have attracted 45 entrepreneurial teams and over 900 young professionals to settle and innovate in rural areas. Capitalising on the collaborative development model, the Binhu Six Villages have emerged as a 'New Era Rural Community', characterised by strong resource agglomeration, compelling investment potential, and a high degree of attractiveness to both talent and capital. A supportive entrepreneurial ecosystem and broad development prospects have, in turn, rekindled enthusiasm among young people to return to and invest in rural revitalization.

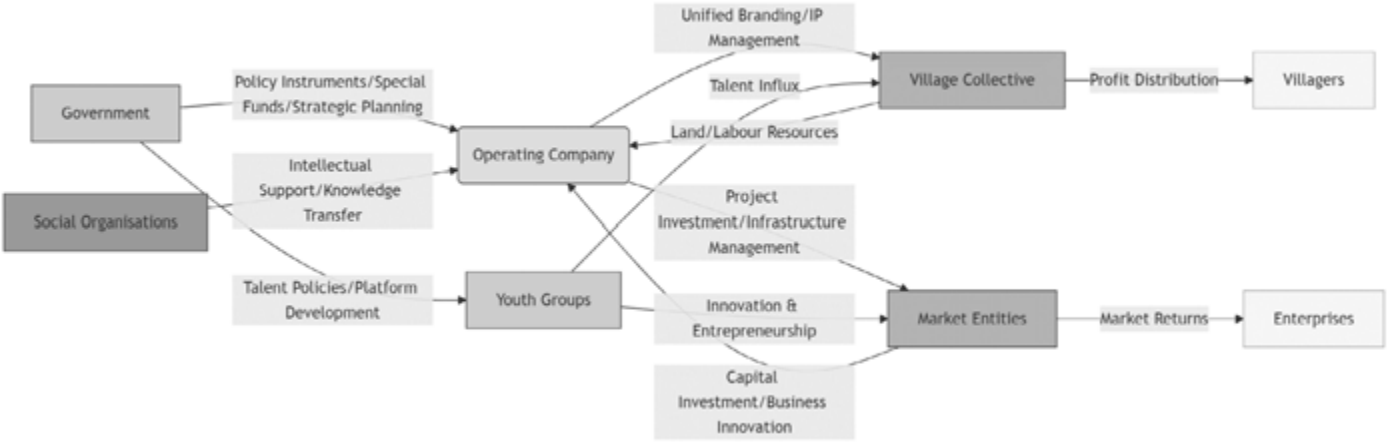

Figure 4. Operational Framework for Rural Development in *The Six Villages around Taihu Lake* (Source: Compiled by the Author)

5 Conclusions

The case of the Six Villages around Taihu Lake in Huzhou represents an innovative and pioneering approach to collaborative rural revitalisation across administrative boundaries. At its core lies an institutional breakthrough and systemic reorganisation that effectively integrates dispersed administrative villages into a functionally complementary and synergistically linked *regional economic community*.

In terms of spatial planning, the villages have adopted a unified planning framework to dismantle traditional administrative barriers. A territory-wide industrial spatial layout was developed, assigning differentiated roles to each village and establishing a networked spatial structure. This integrated approach enables the holistic coordination of land, ecological, and cultural resources. By enhancing infrastructure connectivity and enabling the joint development and sharing of public services, the initiative transforms the 'fragmentation effect' of administrative boundaries into a 'convergence effect' of functional synergy. It thus provides a new spatial governance paradigm for urban–rural integration at the county level.

From an economic perspective, the Six Villages have adopted an industrial coordination strategy centred on differentiated positioning, industrial chain integration, and cross-village factor mobility. Through clear functional specialisation, the villages avoid redundant competition and jointly build a comprehensive and diversified consumption chain. Deep integration of primary, secondary, and tertiary industries extends the value of local agricultural products from basic production to cultural and tourism experiences, thereby enabling full-chain value enhancement. The free movement of productive factors—labour, visitor flows, and capital—across village boundaries ensures efficient allocation and underpins the formation of a resilient regional industrial ecosystem characterised by 'village-level specialisation, regional-level synergy'.

Shared infrastructure serves as the physical foundation of this regional collaboration. The integration of transport systems, public services, and ecological governance enhances the support capabilities of the region. Concurrently, digital transformation and the construction of smart villages have improved overall development resilience. Environmental restoration and ecosystem enhancement efforts not only safeguard ecological security but also lay the groundwork for sustainable industrial development.

Crucially, multi-stakeholder collaborative governance ensures the sustainability of the model. The government plays a leading role in planning and policy guidance, while professional operating companies are responsible for infrastructure development, brand operation, and commercial investment. Social capital and village collectives participate through equity-based resource contributions, enabling a hybrid governance structure that combines the efforts of government, market actors, and local communities. A diversified financing mechanism—leveraging public enterprise capital, private investment, financial support, and village collective funds—has ensured a stable flow of resources to key rural development projects. Meanwhile, targeted talent revitalisation policies have reactivated rural innovation potential, successfully attracting over 900 young entrepreneurs and 45 startup teams back to the villages, thereby injecting long-term vitality into the region.

The Six Villages model demonstrates three key transitions:

- **From 'administrative islands' to a 'functional community'**: Spatial reorganisation through cross-scalar planning incorporates fragmented settlements into an integrated development framework, allowing for more efficient and coordinated allocation of resources and functions.
- **From 'homogeneous competition' to 'complementary symbiosis'**: With differentiated division of labour, integrated industrial chains, and dynamic factor flows, a robust and flexible regional economic network has been created.
- **From 'single-agent control' to 'multi-stakeholder governance'**: A cooperative governance model has emerged in which government, enterprises, collectives, and villagers share benefits and jointly assume responsibilities, ensuring inclusive and sustainable development.

This model, through the coordinated transformation of spatial structure, industrial organisation, and governance mechanisms, redefines the concept of the traditional 'administrative-region economy' as a 'functional-region economy'.

It not only enhances economic performance and improves livelihoods but also offers a replicable pathway for rural revitalisation by overcoming the limitations of administrative fragmentation through institutional innovation. Its core value lies in demonstrating that functional integration can unleash the endogenous potential of rural areas and unlock systemic dividends from regional collaboration—offering a scalable paradigm for urban–rural integration and cross-boundary revitalisation at the county level across China.

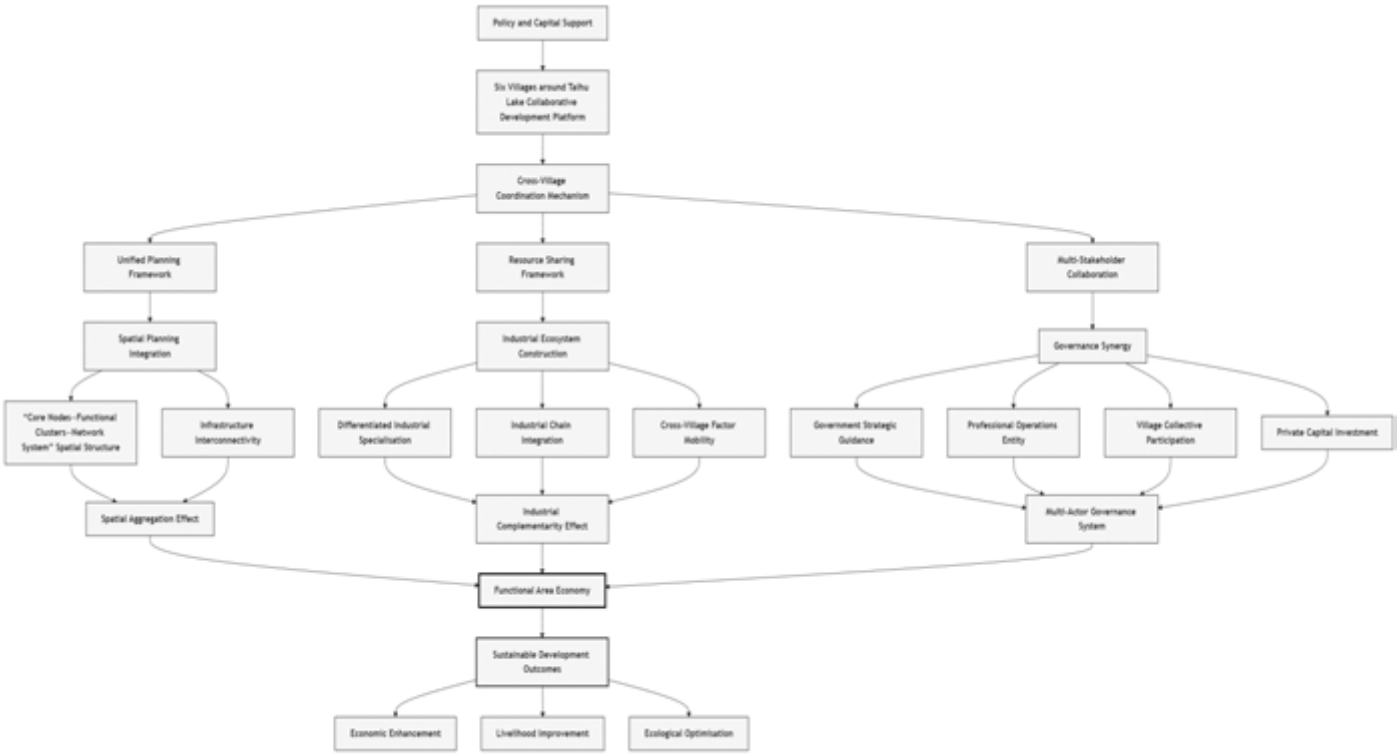

Figure 5. Cross-Boundary Rural Revitalisation Pathway of the Six Villages around Taihu Lake (Source: Compiled by the author)

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Zero Net Land Take Policy Mapping: A Multi-Level Analysis in the Context of Italy and Emilia-Romagna

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Abstract
The Zero Net Land Take (ZNLT) policy seeks to reconcile urban development and land conservation by 2050. This study reviews ZNLT-related policies at the European, national, and regional levels, focusing on Emilia-Romagna region, Italy. Analysis of legal documents reveals that while strategic objectives are set at the European level, member states and regions implement ZNLT with varying approaches, reflecting their governance and planning traditions on example of Emilia-Romagna region. This study underscores the importance of a coherent multi-level governance structure to achieve ZNLT. Misalignments between national guidelines and regional or local practices create fragmentation, undermining cohesive policy action. Analyzing these gaps is crucial to advancing sustainable urban development aligned with ZNLT goals.

Key words: ZNLT, Land Consumption, Policy Mapping

Background and Rationale

Recent rapid urban expansion has led to extensive land consumption and ecological degradation. To balance growth with preservation, the EU has prioritized sustainable spatial planning, notably the Zero Net Land Take (ZNLT) objective, which seeks to match land consumed for urban development with renaturalization of previously developed areas by 2050, ensuring no net increase in urbanized land (European Commission, 2021a; 2021b). ZNLT's prominence in strategic frameworks reflects its connections to land conservation, climate adaptation, biodiversity protection, and ecosystem restoration. These strategies underscore that mitigating urban sprawl and soil sealing is vital for environmental sustainability, urban resilience, and climate adaptation.

There is a growing recognition of ZNLT policies' importance across multiple governance levels - several EU member states have adopted policies aligned with ZNLT, such as France's binding target for 2050 (République Française, 2021) and Flanders' 2040 target (Departement Omgeving, 2018), or Italian Regional Law No. 24/2017 (LR 24/2017), aiming to achieve ZNLT by 2050; however significant challenges persist, that hinder the cohesive and wide implementation of ZNLT across member states.

Local priorities, fiscal constraints and sectoral silos frequently dilute strategic intent (Idt et al., 2024; Decoville & Feltgen, 2023; Schatz et al., 2021). Fragmented competencies and limited inter-sectoral coordination further widen the gap between policy and practice (Gradinaru et al., 2023; Geneletti et al., 2017). Conceptual ambiguities allow divergent interpretations, while the absence of harmonised monitoring indicators hampers consistent tracking and accountability (Löbmann et al., 2022; Zoppi & Lai, 2014). Economic incentives for greenfield development often outweigh the long-term benefits of land neutrality, reducing local commitment to ZNLT goals (Schatz et al., 2021). Finally, stakeholder participation remains sporadic, risking the exclusion of critical perspectives needed for equitable spatial planning (Lacoere & Leinfelder, 2023; Stankovics et al., 2020). ZNLT balances fresh urban land uptake with renaturalisation or brownfield reuse so that total "consumed" land does not rise by 2050. Interpretations and implementation, however, vary widely among member states, revealing notable conceptual gaps between EU and national levels (Decoville & Feltgen, 2023; Schatz et al., 2021).

Additionally, a considerable conceptual ambiguity persists: European policies variously employ the terms No Net Land Take (NNLT) and Zero Net Land Take (ZNLT), breeding unnecessary uncertainty. NNLT, used in EU frameworks (e.g., Resource- Efficient Europe Roadmap 2011; Biodiversity Strategy 2020; Soil Strategy 2021), seems to emphasize prevention of new soil sealing, whereas the term ZNLT appears to sanction development only if it's offset by de-sealing, ecological restoration, or brownfield reuse, projecting a looser, "balance-of-accounts" stance. Besides,

as highlighted by Elisabeth Marquard (Marquard et al., 2020), there are different copes of the discussed concepts and indicators in relation to different land use/land cover categories. There is significant conceptual ambiguity in the terms to describe land conversion processes: land consumption, land take, soil sealing, artificialization, etc. The primary objective of this study is to provide a comprehensive multi- level analysis of ZNLT policy frameworks at the EU level, and their adoption, adaptation, and operationalization at national and regional scales (with Italy and Emilia-Romagna region as case studies). It seeks to identify persistent cross-level misalignments, institutional fragmentation, and operational challenges hindering ZNLT objectives local implementation. By analyzing policy adoption, the study seeks to clarify conceptual ambiguities in translating EU directives into effective land-management practices.

Methodology

This study adopts a multi- phase qualitative policy mapping to identify, analyze, and evaluate ZNLT instruments and governance frameworks at European, national, and regional scales. The study employs a mixed- methods policy- mapping framework, integrating qualitative document analysis with quantitative network- analytic metrics to interrogate the ZNLT governance architecture at supra- , national, and subnational scales.

The case studies—Italy at national level and Emilia-Romagna at regional level—were chosen for their contrasting policy landscapes: Emilia-Romagna has proactively enacted a no-net-land-take law, whereas Italy as a whole remains without a unified ZNLT framework. This divergence provides an instructive lens through which to examine the complexities of multi-level governance, highlighting both the region's innovative advances and the national–subnational coherence and enforcement challenges that arise in the absence of an overarching legal architecture.

In phase one of the study, policy documents were systematically collected that explicitly or implicitly linked to ZNLT thematic pillars. The search was built around the following topics: land take and soil sealing; urban regeneration, sustainable land management, and ecosystem restoration; and reuse of previously developed areas. Guided by a literature and policy review, the desktop search used official sources, legal databases, institutional reports, and spatial planning guidelines. The corpus of polices was enriched by involving expert consultation, database enrichment, and policy validation with sectoral representatives from Emilia-Romagna public administration,

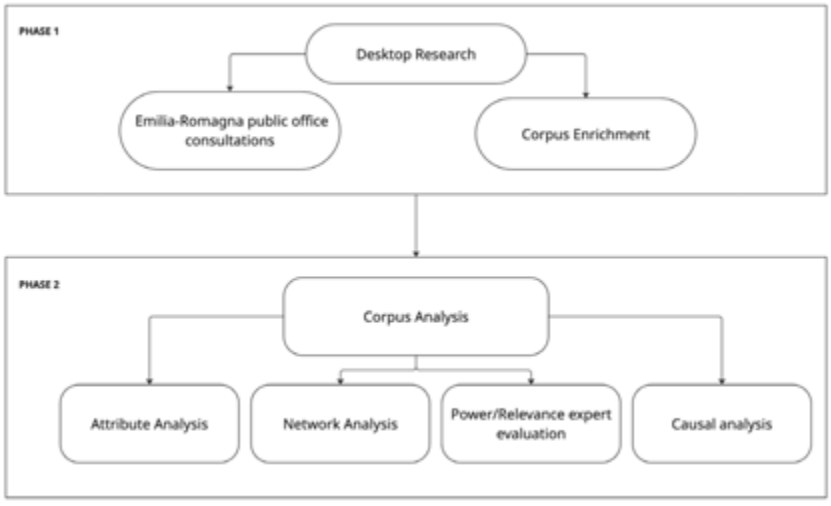


Figure 1. Methodological framework of the study, source: authors

An inclusion protocol ensured analytical rigor and relevance by requiring that documents be currently in force, and explicitly or implicitly related to at least one of the land take thematic.

The collected policies were then analyzed to assess their attributes, their linkages to other policies, their causal roles, and their relevance to local practices in Emilia-Romagna.

1. Comparative Framework and Analytical Lens

The review encompassed legally binding instruments, and non-binding strategic programmes, guidance documents, and implementation frameworks. Contextual analysis interrogated both external and internal analysis: exogenous policies attributes that affect wider governance environment and the policies' intrinsic characteristics.

To assess the governance environment, network analysis was applied to the assembled policy corpus. The principal links were grouped as following: subordinated implementation links (policies serving as subordinate components within broader frameworks), strategic execution links (policies translating high-level strategies into actionable goals without strict subordination), and operational links (policies providing financial, regulatory, or procedural mechanisms to implement other policies). Expert collaboration with Emilia-Romagna public administration further enriched and validated the findings. Based on Kristensen's (2004) framework, policy objectives were coded by entry date and DPSIR node (Drivers, Pressures, States, Impacts, Responses), revealing temporal gaps and concentrations that affect adaptive governance.

At the content analysis, policies were systematically compared across different dimensions:
1. Instrument Classification (Howlett, 2009; Belin et al., 2014): instruments were categorized as legal (binding), economic (incentives/disincentives), informational (guidance), or strategic (non-binding visions) to assess enforceability and leverage.
2. Thematic Clustering: Land Use and Soil Protection; Biodiversity and Ecosystem Restoration; Environmental Quality and Pollution Prevention; Sustainable Urban Development and Regeneration.
3. Land Conversion Scope Correspondence: Policies were grouped by targeted land conversion processes, using different terms from described in Marquard study (Marquard et al., 2020) - soil sealing, land take, land consumption, SDG 11.3.1 and also also fragmentation (division of habitats due to conversion).
Soil sealing: Permanent covering of land by impervious materials, impairing soil functions.

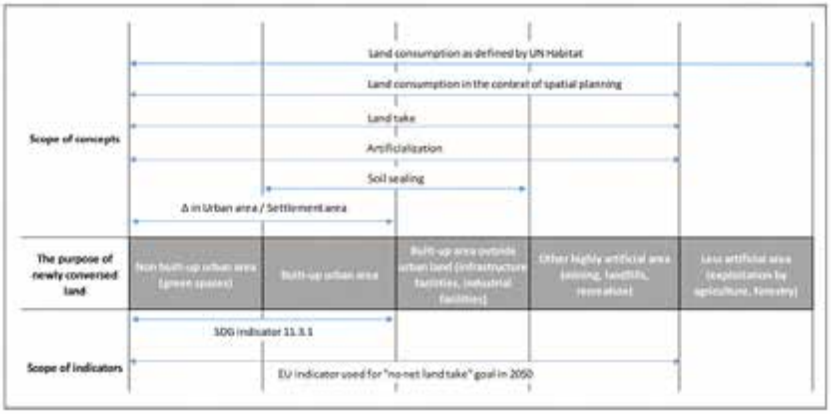


Figure 2. Scopes of the concepts and indicators in relation to different land use/land cover categories, source: Marquard et al., 2020

Each policy's relevance and contribution to reusing abandoned land was jointly scored by researchers and Emilia-Romagna experts according to their relevance to local practices on ZNLT, ensuring analytical rigor and practice-oriented evaluation.

2. Defining the ZNLT Policy Corpus at European, National, and Regional Tiers

Following a desk review, the first 44 policy documents were identified. Subsequently, policy officers from the Emilia-Romagna administration recommended three additional texts. This corpus then served as the basis for a network-mapping analysis designed to visualise inter-document linkages and thematic overlaps (SocNetV tool).

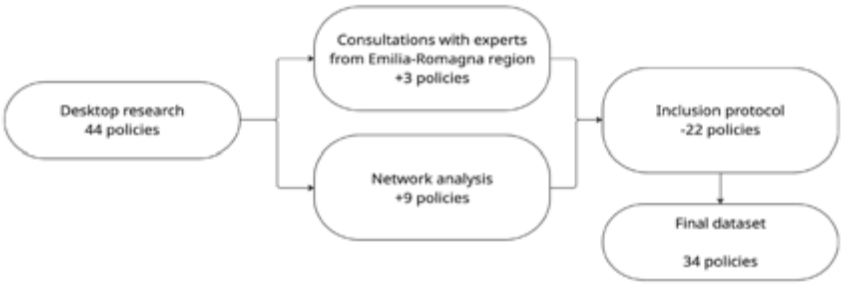


Figure 3. Policy mapping process, source: authors

Policies acted as nodes in networks, linked by references, legal hierarchies, or shared objectives, with their centrality indicating structural importance. Central hubs exhibit the highest degree, each spawning more than a dozen subordinate regulations and guidelines in the intermediate rings. Secondary hubs further translate these directives into territorially specific measures. In contrast, the sparsity of links in the upper- right sector corresponds to under- transposed objectives related to ecosystem- service valuation, suggesting a gap between strategic intent and operational uptake. Overall, the topology confirms a "command- and- translate" hierarchy: supranational norms initiate the causal chain, national legislation refines scope and enforcement, and regional plans supply context- dependent tools, yet the uneven distribution of subordinate ties highlights domains requiring additional transposition efforts to achieve full multi- level alignment.

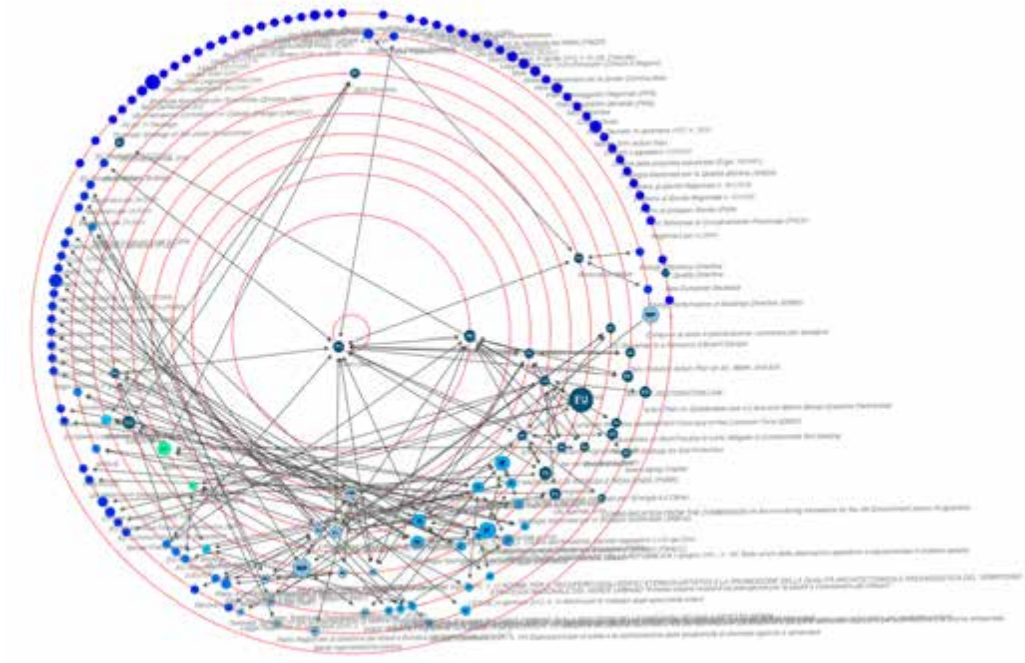


Figure 4. Policy network mapping, subordinated implementation links, source: authors (SocNetV tool)

The second radial graph shifts the lens from hierarchical subordination to horizontal connectivity, visualizing explicit cross- references and shared implementation clauses that bind the corpus into a cohesive governance web. In this layout, a dense inner core of EU- level strategies—including the European Green Deal, Biodiversity Strategy 2030, and Soil Thematic Strategy—functions as a multi- policy "switchboard" with the highest betweenness centrality, channeling over one- third of lateral edges. National framework laws (e.g., Italy's Climate Law 2020

and the Circular Economy Action Plan) occupy mid- rings, forming cross- sector bridges that synchronize energy, land- take, and restoration agendas. Outermost rings host specialized regulations—such as regional territorial plans and sectoral decrees—that derive operational guidance from multiple upstream sources, reflected in their high out- degree but low reciprocity. A pronounced edge density along the southeast arc highlights an execution "cluster" where climate- adaptation, brownfield redevelopment, and renewable- energy mandates reinforce one another, indicating strong integrative capacity in those domains. In contrast, the sparse link field in the northwest quadrant signals thematic silos around ecosystem- service valuation and social equity, showing these topics are weakly embedded in current execution chains. Overall, the topology reveals a governance architecture that is horizontally well- connected for mitigation and circular- economy objectives but remains fragmented for socio-ecological valuation, pinpointing strategic areas where future policy knitting is needed.

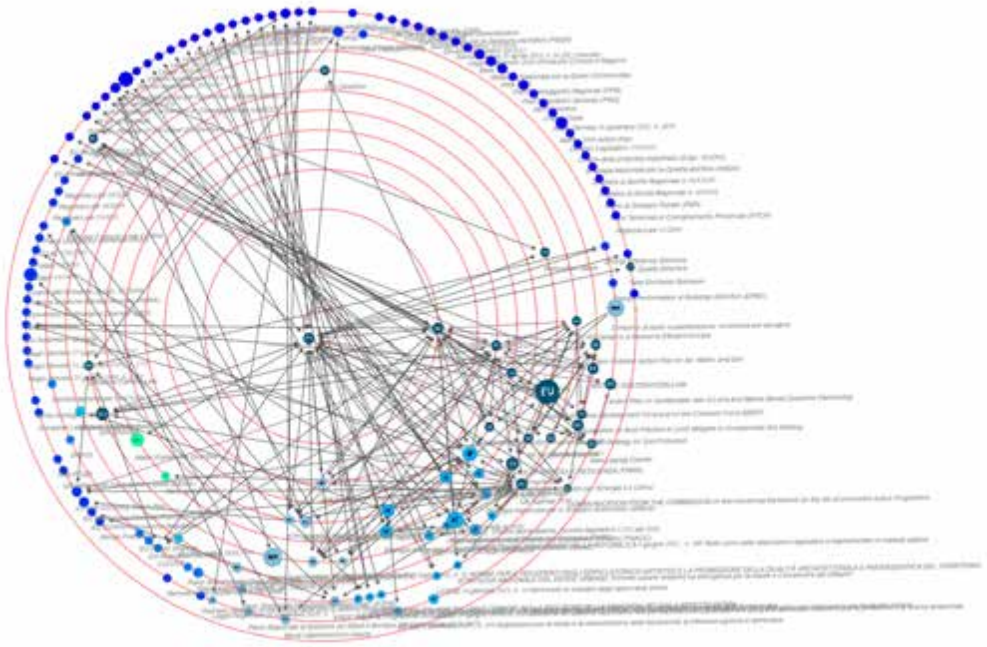


Figure 5. Policy network mapping, strategic execution links, source: authors (SocNetV tool)

The operational layer of the policy web comprises concrete instruments that translate strategic goals into codified procedures, monitoring schemes, or financing mechanisms. At the graph's centre lies a single dominant hub—a regulation with top- decile degree and highest betweenness—representing a cross- cutting implementation framework serving as the procedural backbone for multiple thematic domains. From this hub radiates a dense fan of edges to mid- tier policies forming an "execution cluster" in the south- eastern arc; their moderate betweenness but high degree indicates they collect mandates from the central hub and redistribute them into sectoral toolkits without bridging to other clusters. Conversely, the north- western quadrant contains smaller peripheral nodes with low degree and negligible betweenness, reflecting policy instruments operating largely in isolation and weakly institutionalized within mainstream operational machinery. Overall, the topology reveals a governance architecture dominated by a few procedural heavyweights, while several thematic areas lack robust linkages. Closing these gaps will require augmenting existing hubs' mandates or establishing new bridging instruments to align operational execution with strategic ambition.

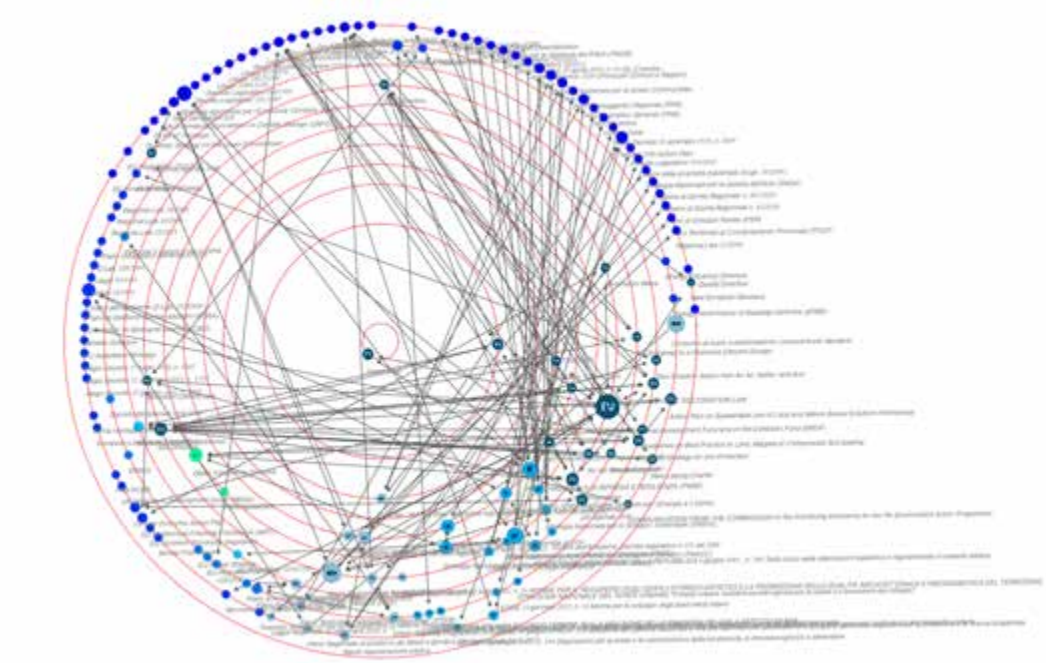


Figure 6. Policy network mapping, Operational execution links, source: authors (SocNetV tool)

The network analysis enabled the identification of prominent nodes both through visual inspection and quantitative centrality metrics (degree, betweenness, and eigenvector). High-scoring nodes that were not present in the initial corpus were flagged as omissions, resulting in the inclusion of nine additional policies. The full texts of 56 candidate policies were systematically reviewed to assess their fit to inclusion protocol and extract the necessary data. This screening process yielded a final dataset of 34 policies for all subsequent analyses (see Appendices).

3.1 ZNLT at the European Level

The concept of ZNLT has gradually evolved into a cornerstone of the European Union's environmental and spatial planning agenda. Anchored in the broader objectives of land degradation neutrality, biodiversity conservation, and sustainable urban development, the ZNLT goal aims to halt the net conversion of natural and agricultural land into artificial surfaces by 2050. The progression from soft strategic guidance (2006–2011) to operational planning (2020–2021) and finally to enforceable legal mandates (2024) represents a significant trajectory in EU land governance. Initially, the 2006 Thematic Strategy for Soil Protection set limits on soil sealing and promoted brownfield rehabilitation, introducing "limitation–mitigation–compensation" principles. The decisive milestone came with the EU Roadmap to a Resource Efficient Europe (European Commission, 2011), which introduced the 2050 ZNLT target. It also proposed the development of indicators (soil sealing and urban density) as tools for monitoring progress toward sustainable land use. Building upon this, in 2020, EU Biodiversity Strategy for 2030 emphasized land preservation for biodiversity, committing to restore 15 % of degraded land and mandating Urban Greening Plans. In 2021, EU Soil Strategy for 2030 reaffirmed ZNLT, recommending national soil management plans, land reuse incentives, and participatory governance, prioritizing degraded land and promoting land recycling rates above 70 %. Finally, in 2024 Nature Restoration Law introduced binding targets to prevent green urban area loss by 2030, expand green cover, and prioritize disused urban land for redevelopment, institutionalizing monitoring of urban tree canopy and habitat fragmentation. The law embedded the ZNLT concept within enforceable national restoration plans, marking a shift from strategy to obligation. It also institutionalized monitoring requirements on urban tree canopy, and habitat fragmentation, closing previous gaps in enforcement and transparency.

The analyzed final dataset includes 12 documents, functional typology of which reveals that strategic frameworks dominate: most texts set politically endorsed but non-binding objectives; three documents serve primarily as informational tools (providing monitoring guidance or methodological standards); and only the Nature Restoration Law constitutes a legally binding instrument, creating enforceable obligations. This distribution

forms an implementation pyramid, where a broad strategic apex funnels into a narrow base of binding regulations, potentially diluting enforcement consistency across the Union. Applying a categorical clustering to their policy objectives shows a predominant emphasis on land use and soil protection: of the twelve high-level instruments, five target land-use and soil protection, focus on biodiversity restoration, pollution prevention, urban regeneration, climate adaptation is less present, illustrating a strong corpus focus on soil governance.

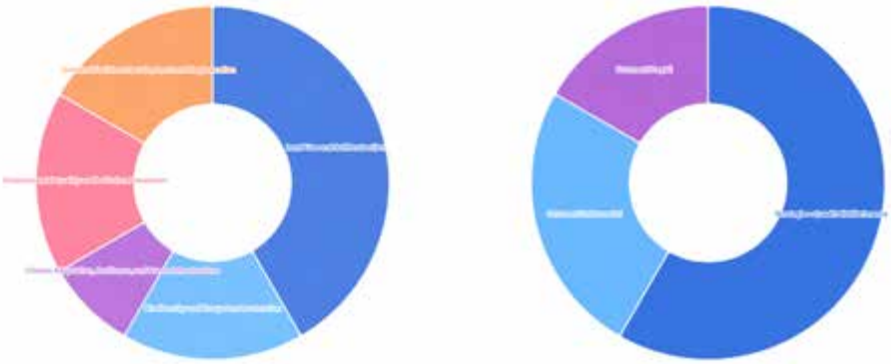
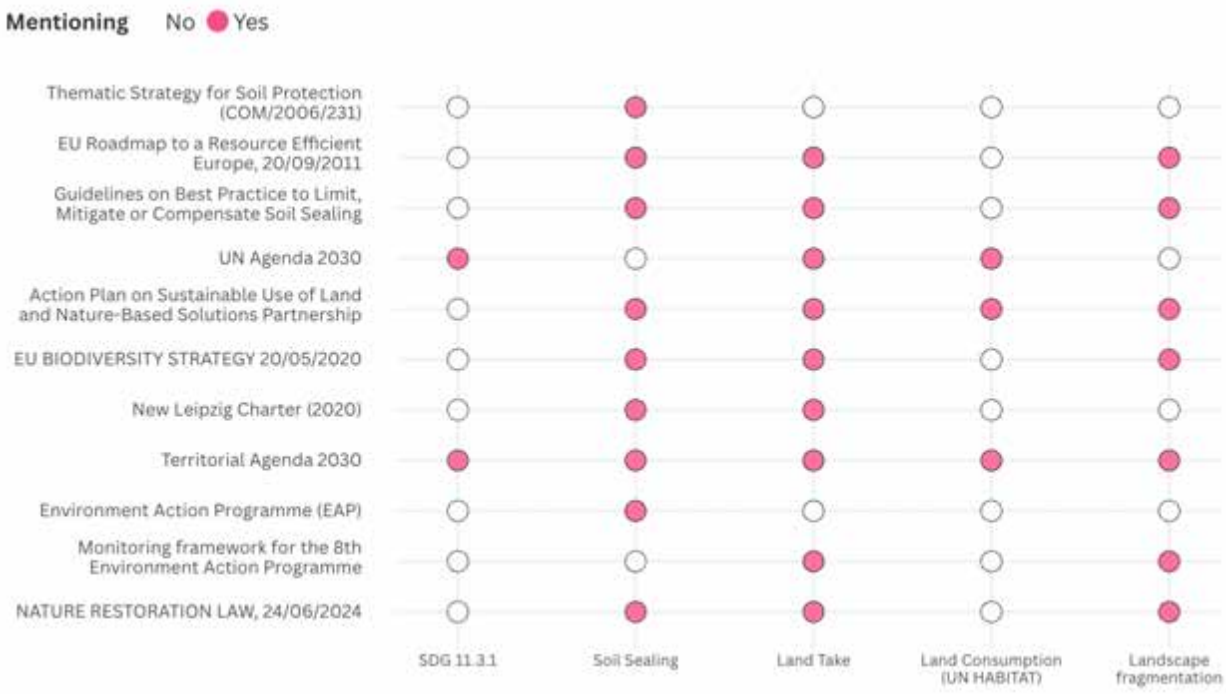


Figure 7 (from left to right) Categorical clustering and functional typology of supranational dataset, source: authors

The content analysis highlights a significant presence of soil sealing and land take terms, which are addressed in ≈75% policies. In contrast, broader socio-ecological concepts such as land consumption (UN-Habitat) and SDG 11.3.1 appear in only 25% and 17% of documents respectively, while Landscape fragmentation is cited in ≈58%, mainly in biodiversity-focused instruments, but is mainly absent from soil or resource-efficiency strategies.



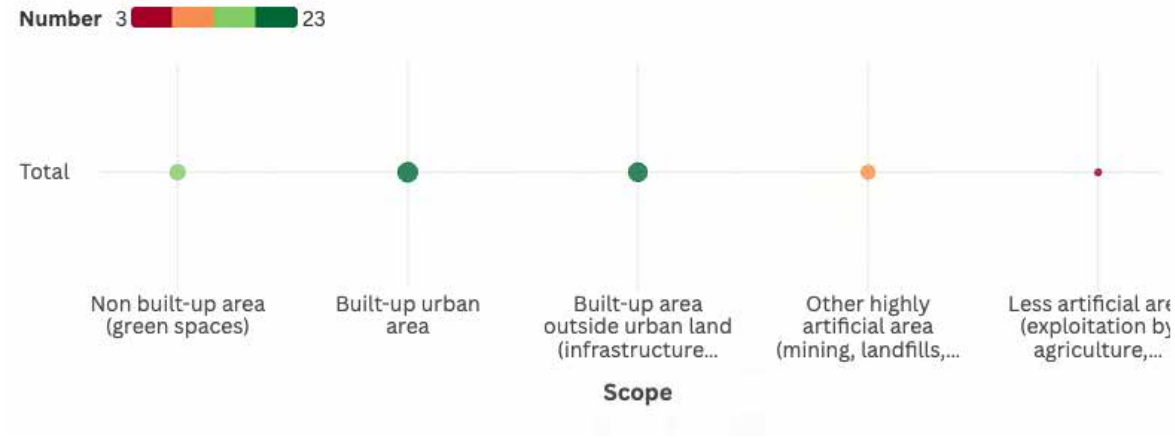


Figure 8: Terminology Trends (top) s and Spatial Focus (bottom) in EU ZNLT Policies, source: authors

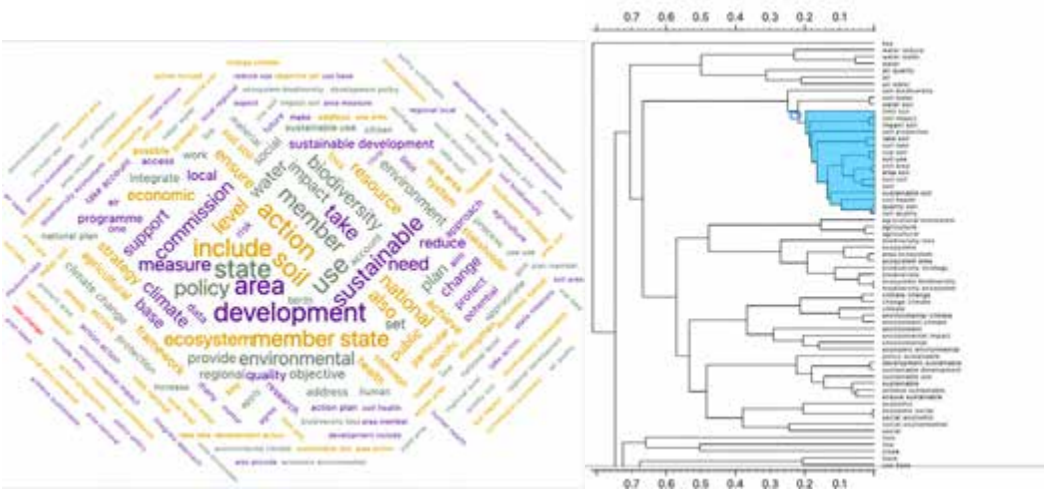


Figure 9. Machine learning text mining, supranational level, source: authors (Orange machine learning tool)

Tri- layer network analysis corroborates the textual findings by revealing stratified policy roles. Certain documents serve as normative hubs or "procedural spines" underpinning governance, i.e. EU Biodiversity Strategy functions as a hierarchical anchor, exhibiting high eigenvector centrality in both subordinated implementation (76.98 %) and strategic execution (94.48 %) layers, confirming its pivotal role in setting normative objectives across subordinate policies.

Figure 10. Policy network centrality analysis (supranational level), source: authors

In contrast, the Nature Restoration Law acts as an operational engine with the highest eigenvector centrality in the operational layer, translating strategic objectives into concrete procedures, monitoring requirements, and enforcement protocols. Between these poles lie strategic orchestrators, such as the EU Soil Strategy and Territorial Agenda 2030, which display elevated betweenness centrality in the strategic execution network, bridging high-level goals with implementing acts. Foundational texts like the Thematic Strategy for Soil Protection and the EU Roadmap to a Resource Efficient Europe retain moderate degree centrality in subordinated implementation, anchoring early policy cascades.

Network analysis reveals that several high-centrality documents, though silent on land conversion, serve as critical connectors in governance. The EU Green Deal leads in eigenvector centrality for subordinated implementation and strategic execution (100%), and in subordinated betweenness (≈9%), positioning it as the macro-framework for climate neutrality and the circular economy. The Floods Directive 2007 also emerges as a key vertical bridge linking soil and water governance. High strategic but low operational eigenvector centrality for UN Agenda 2030, the New Urban Agenda, and Territorial Agenda 2030 (≥17%–42% vs. <6%) underscores their role as agenda setters rather than direct implementers.

Overall, the corpus exhibits a multi- tiered topology: hierarchical anchors establish land- take targets, strategic orchestrators integrate cross- sectoral ambitions, and operational engines drive implementation, forming a resilient, though uneven, governance network.

3.2 ZNLT in Italy: National Framework

Over the last two decades Italy has moved from treating soil sealing as an indirect planning concern to recognising ZNLT as a core dimension of ecological transition. While a single framework statute is still absent, a review of national laws, strategies and investment plans reveals a cumulative layering of restrictions, incentives and monitoring duties that increasingly converge on the ZNLT logic.

The term *consumo di suolo* starts appearing in national policy documents only after 2010, while early 2000s statutes dealt with land take mainly through landscape- or contamination-related provisions. Earlier laws, such as Legge Urbanistica (Governo Italiano, 1942), addressed land take indirectly by mandating municipal master plans, promoting regeneration, and protecting green strips. Articles 13 and 20 directed growth toward degraded urban zones, mandating their redevelopment and allowing expropriation if owners failed to act. Article 18 empowered

municipalities to reclaim idle plots for public use, discouraging land speculation, while Article 25 protected private gardens and green strips, safeguarding permeable soil and urban vegetation. The Codice dell'Ambiente (D.Lgs. 152/2006) introduced precautionary and remediation principles for contaminated soils; Article 239 framed land degradation as an environmental liability, anchoring future anti- sealing debates (Governo Italiano, 2006). The policy narrative gained explicit soil-consumption language only after the EU Roadmap to a Resource-Efficient Europe fixed the 2050 ZNLT horizon. Domestically, a sequence of soft-law and targeted statutes began to translate that horizon.

In response to EU prompts, Italy made several attempts to approve a framework law to limit land take. The first, the "Catania" bill (2012), proposed capping agricultural land conversion caused by impermeabilization, urbanization, and non- agricultural construction (Naldi, 2012). The 2013 draft (Redazione Carteinregola, 2013) aimed to reduce soil consumption gradually, targeting zero by 2050 in line with European objectives. A 2014 proposal amending the Legge Urbanistica sought to encourage urban regeneration and discourage greenfield development to combat sprawl (ANSA, 2014). None of these drafts passed. In 2015, the Strategia Nazionale di Adattamento ai Cambiamenti Climatici (SNAC, 2015) identified soil sealing as a driver of hydrogeological risk and ecosystem fragmentation, linking climate adaptation with land- take control (Ministero dell'Ambiente e della Sicurezza Energetica, 2015). In 2016, the comprehensive bill "Contenimento del consumo del suolo e riuso del suolo edificato" (Atto C. 2039–A) was approved by the Chamber of Deputies on 12 May 2016 and transmitted to the Senate as Atto Senato 2383 (Senato della Repubblica, 2016). However, it did not receive final Senate approval before the end of the XVII Legislature and thus did not become law.

Concurrently, Law 132/2016 (Istituzione del Sistema nazionale a rete per la protezione dell'ambiente e disciplina dell'Istituto superiore per la protezione e la ricerca ambientale) established a national network comprising ISPRA and regional/provincial environmental agencies, which issued guidelines and annual reports quantifying land take via soil-sealing (imperviousness) indicators (Senato della Repubblica, 2016). The Strategia Nazionale per lo Sviluppo Sostenibile (SNSvS) formally adopted SDG-aligned soil-sealing indicators and designated ISPRA as the national monitoring hub, inaugurating a coordinated data regime for land take (Ministero dell'Ambiente e della Sicurezza Energetica, 2017). The Piano Nazionale Integrato per l'Energia e il Clima (PNIEC) advanced a "zero-additional-soil" criterion for renewable-energy siting (Ministero dello Sviluppo Economico, 2019). After 2021, Italy's Piano Nazionale di Ripresa e Resilienza (Presidenza del Consiglio dei Ministri, 2021), and Ecological Transition Plan (PNTE) (Ministero della Transizione Ecologica, 2022), have linked ZNLT to brownfield reuse, restoration, and advanced targets to 2030. The Strategia Nazionale del Verde Urbano (Ministero della Transizione Ecologica, 2021) promoted de-sealing and urban nature-based solutions, while the Strategia Italiana di Lungo Termine (Ministero dell'Ambiente e della Sicurezza Energetica, 2021) recognized conflicts between renewable energy rollout and soil conservation, proposing degraded-land restoration as a mitigation measure.

In 2023, a bill on soil consumption and urban regeneration titled "Disposizioni per il contenimento del consumo di suolo e la rigenerazione urbana" (Atto Camera 1179) was introduced in Parliament but did not reach a vote before dissolution (Camera dei Deputati, 2023). It is now under examination by the VIII Commissione Ambiente of the Chamber of Deputies, with review having begun on 3 October 2023. The proposal aims to create a national framework for progressively reducing land consumption in line with the EU's goal of zero net land take by 2050. Italy has developed robust indicators to track progress on land take. The National System for Environmental Protection (SNPA) – comprising ISPRA and regional environmental agencies – monitors land consumption annually using satellite imagery and GIS data. Their flagship report "Consumo di suolo, dinamiche territoriali e servizi ecosistemici" provides detailed statistics by region and municipality (SNPA, 2024).These data are published openly and serve as a basis for policy adjustment.

The collected corpus of 12 polices is predominantly of soft power: only 25% are binding, supplying juridical backbone for urban development controls, tree-planting mandates and environmental monitoring, but precede or stand apart from the EU-driven sustainability agenda of the last decade. The other 75%, such as SNAC, PNIEC, and PNRR, are non-binding but strategic, reflecting a model that promotes coordination but risks fragmented implementation due to weak enforcement mechanisms. Thus, Italy's land-use regulation rests on a robust legal base for basic controls, while its post-2015 sustainability objectives rely primarily on aspirational instruments whose effectiveness depends on their integration into regional and municipal law. Thematic analysis shows that half of corpus belongs to "climate adaptation, resilience, and green infrastructure".

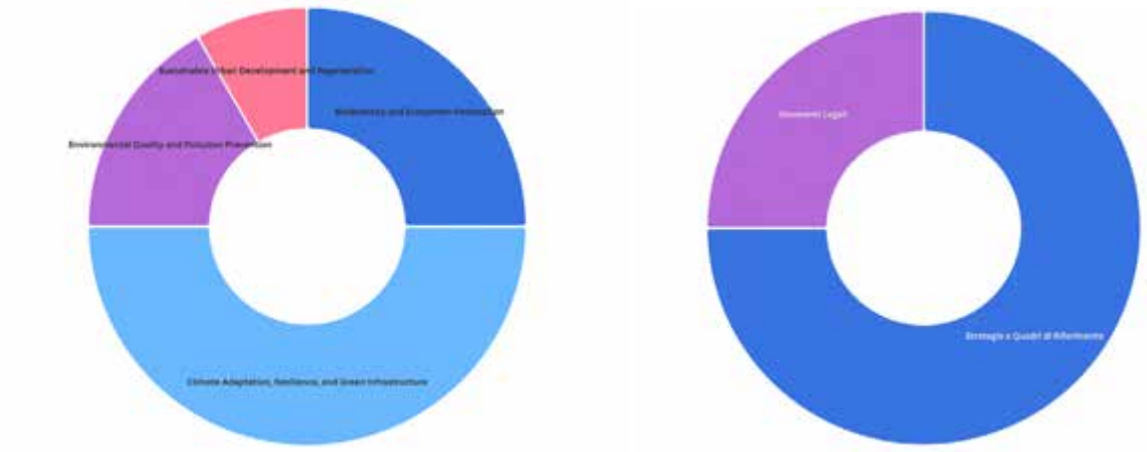


Figure 11 (from left to right) Categorical clustering and functional typology of national dataset, source: authors

In Italy is mainly used the term consumo di suolo, which according to ISPRA[1] refers to the transition from non-artificial to artificial cover, whether permanent (buildings, paved roads) or reversible (construction sites, ground-mounted PV, unpaved depots). Agricultural and forestry uses are excluded, as they retain biophysical cover; permeable greenspaces only count if the soil structure is irreversibly altered. ISPRA equates consumo di suolo with the EU's "land-take" indicator, while UN-Habitat's broader "land consumption" (SDG 11.3.1) includes intensive agriculture and cropland or forest expansion—highlighting ISPRA's narrower, sealing-focused approach. In this way, content analysis reveals land take, landscape fragmentation and soil sealing dominate Italian policy discourse, while "land consumption"and SDG 11.3.1 are less referenced.

1 https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio/suolo/il-consumo-di-suolo

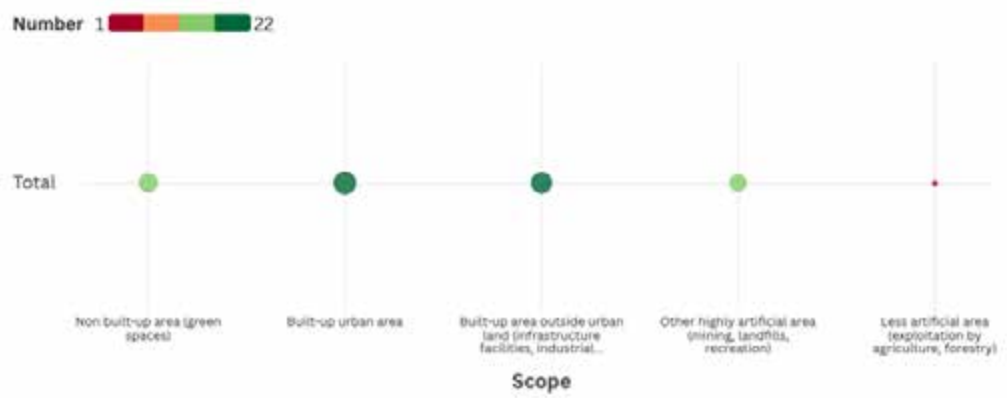


Figure 12: Terminology Trends (top) s and Spatial Focus (bottom) in IT ZNLT Policies, source: authors

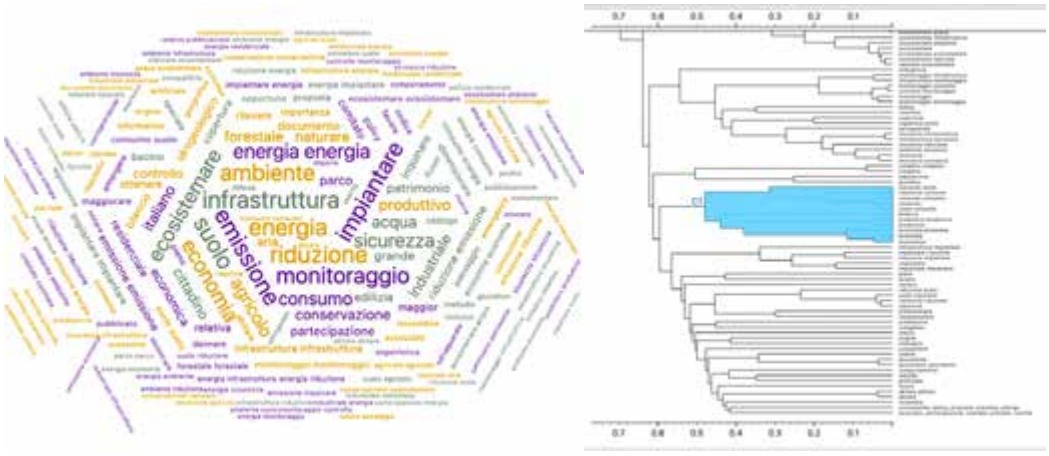
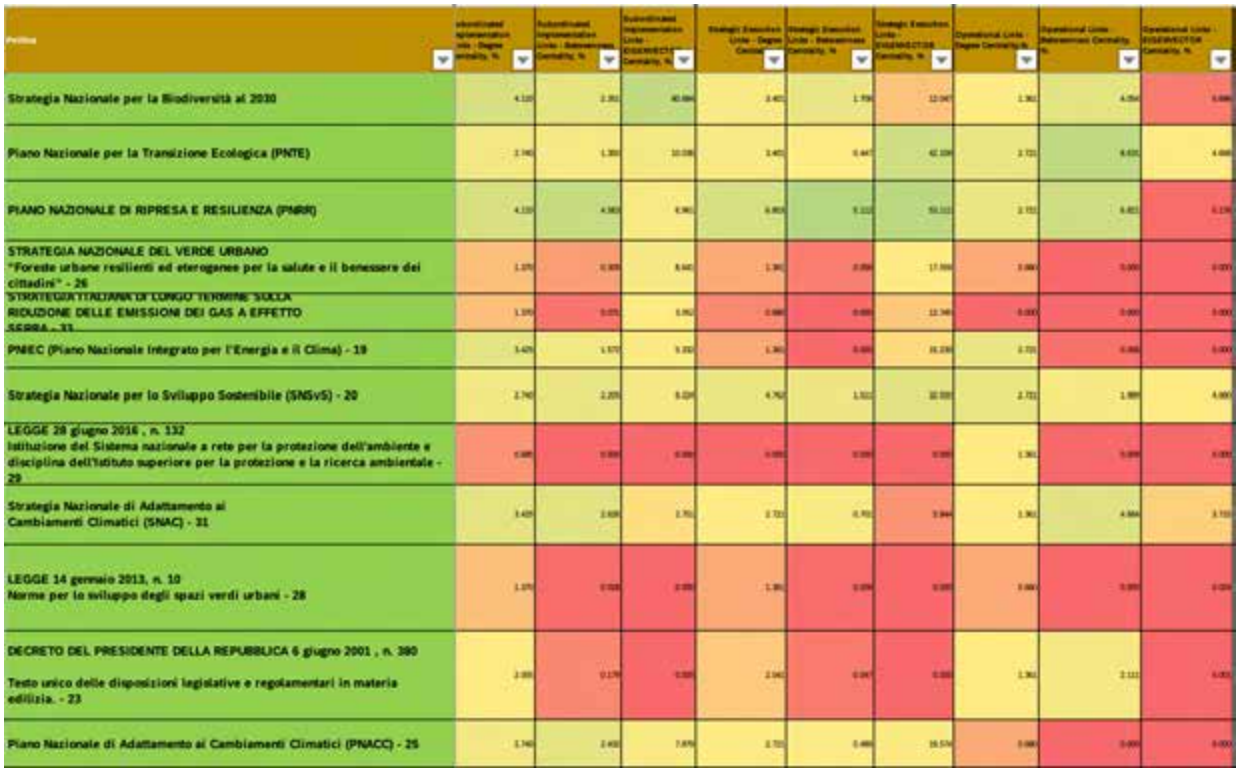


Figure 13. Machine learning text mining, national level, source: authors (Orange machine learning tool)

Network analysis reveals a stratified policy architecture. The SNSvS serves as a normative hub, with high eigenvector centrality in subordinated implementation (~9%) and strategic execution (~33%), unifying various statutes. The PNRR is the chief orchestrator, exhibiting the highest strategic-execution eigenvector (~53%) and high degree and betweenness. Operational engines like PNACC and SNAC show strong operational centrality (~3–4%) and betweenness, translating strategic objectives—such as sealing mitigation and flood-risk reduction—into local regulation and financing. Notably, several frequently cited statutes (D.Lgs. 42/2004, D.Lgs. 152/2006) occupy important procedural roles but lack explicit land-take clauses, creating "silent-but-central" gaps that undermine policy cohesion.



Policy									
Strategia Nazionale per la Biodiversità al 2030									
Piano Nazionale per la Transizione Ecologica (PNTE)									
PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR)									
STRATEGIA NAZIONALE DEL VERDE URBANO "Foreste urbane resilienti ed eterogenee per la salute e il benessere dei cittadini" - 26									
STRATEGIA ITALIANA DI LUNGO TERMINE SULLA RIDUZIONE DELLE EMISSIONI DEI GAS A EFFETTO SERRA - 31									
PNIEC (Piano Nazionale Integrato per l'Energia e il Clima) - 19									
Strategia Nazionale per lo Sviluppo Sostenibile (SNSvS) - 20									
LEGGE 28 giugno 2016 , n. 132 Istituzione del Sistema nazionale a rete per la protezione dell'ambiente e disciplina dell'Istituto superiore per la protezione e la ricerca ambientale - 29									
Strategia Nazionale di Adattamento ai Cambiamenti Climatici (SNAC) - 31									
LEGGE 14 gennaio 2013, n. 10 Norme per lo sviluppo degli spazi verdi urbani - 28									
DECRETO DEL PRESIDENTE DELLA REPUBBLICA 6 giugno 2001 , n. 380 Testo unico delle disposizioni legislative e regolamentari in materia edilizia. - 23									
Piano Nazionale di Adattamento ai Cambiamenti Climatici (PNACC) - 25									

Figure 14. Policy network centrality analysis (national level, Italy), source: authors

This assessment indicates that Italy has advanced in embedding ZNLT principles, yet its policy architecture is still characterised by a mosaic of sector-specific measures and largely non-binding strategies rather than a single statutory backbone. Key statutes address land conversion peripherally, with climate-resilience strategies prevailing. The hub-and-spoke architecture depends heavily on multi-mission plans such as the PNRR, leaving gaps whereby absent soil-consumption clauses may permit indirect land take. Although the PNRR, PNIEC provide operational leverage and SNSvS, SNAC offer normative guidance, weak soft–hard integration might sustain fragmentation and regional inertia.

3.3 Regional Implementation: Emilia-Romagna Case Study

In the absence of a national land-take statute, regional governments took the lead in limiting land take, primarily using their planning powers. Emilia-Romagna's Piano Territoriale Regionale (PTR, Regione Emilia-Romagna, 2010), approved in 2010, provides the broad strategic framework for territorial development and coordination of local plans. By the time of its drafting in the 2000s, awareness of uncontrolled land consumption (consumo di suolo) was growing in Italy. The PTR embeds the principle of limiting land take as a key policy guideline. In fact, language echoed later in law can be traced to the planning ethos of that time – for example, treating land as a "bene comune e risorsa non rinnovabile" (common good and non-renewable resource) that must be preserved.

In 2013, a significant initial step was taken with the establishment of an interdepartmental working group, the "Valorization of Agricultural Areas and Containment of Land Consumption, that equipped with detailed knowledge of land consumption patterns and the status of rural territories, and proposed operational methodology that not only quantified existing soil consumption but also enabled a qualitative spatial analysis. Building on this foundation, Emilia-Romagna launched a pioneering soil consumption monitoring program culminating in the 2015 regional report (Consumo di suolo e pianificazione: conoscere per decidere, Regione Emilia-Romagna, 2015). A crucial conceptual advance was the precise definition of consumo di suolo: the irreversible conversion of agricultural, natural, or semi-natural areas into sealed or permanently artificialized surfaces (e.g., buildings, roads, industrial yards).

The set of land uses that lead to the loss of natural characteristics, resulting in an artificial surface whose purpose is not the production or harvesting of biomass. It was described as a dynamic process that alters the nature of the territory, moving from natural conditions to artificial conditions, of which impermeabilization represents the final stage. Importantly, the methodology excluded temporary or reversible uses and permeable green areas from the "consumed" category until conversion was made permanent.

The subsequent LR 24/2017, signaled a major shift toward achieving ZNLT by 2050 by capping new land take and prioritizing urban regeneration over greenfield development. The law restricts new construction to cases where all reuse or replacement options are exhausted and reinforces urban growth boundaries. Its provisions require that any new construction is permissible only after all feasible options for the reuse or replacement of existing buildings have been exhausted, effectively relegating greenfield expansion to a last-resort status. By reinforcing urban growth boundaries and explicitly demarcating built-up areas, the law curtails further encroachment on undeveloped land. The law limits new land take to a maximum of 3% of the urbanized land area (as of 1 January 2018) up to the year 2050. In practice, this functions as a "land take budget" for each municipality and the region as a whole. Importantly, LR 24/2017 defines "land take" in net terms, as the balance between newly urbanized areas minus any areas returned to natural state through de-sealing within urban boundaries.

Urban planning was restructured with the introduction of the Piano Urbanistico Generale (PUG), replacing prior municipal plans and emphasizing regeneration, with detailed zoning assigned to secondary instruments. Municipalities were required to adopt new PUGs by the end of 2020. By January 2025, dozens of new PUGs had been adopted or approved.

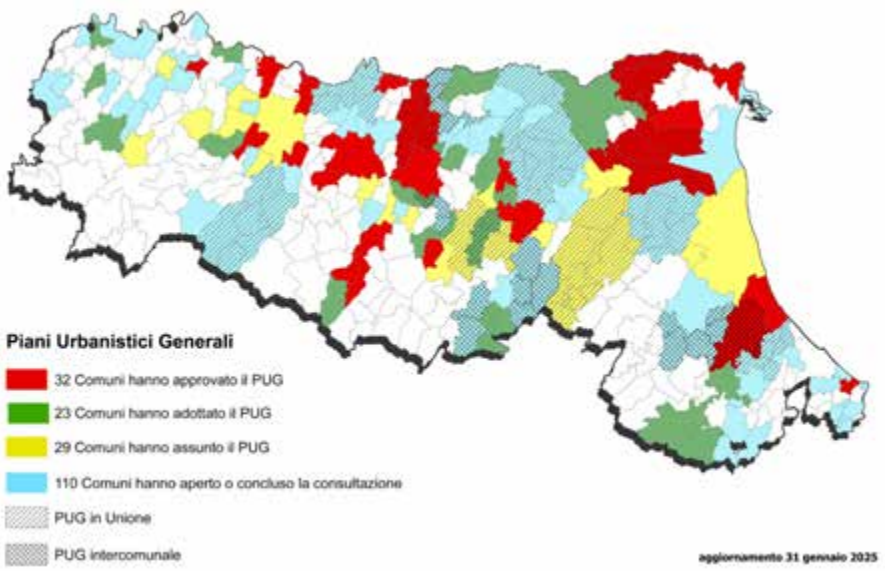


Figure 15. Level of PUG approvement at municipal level, source: Emilia-Romagna region

Emilia-Romagna has established a multi-layered governance system to monitor and enforce its land take policies. Municipalities are obliged to submit digital data on any land transformations. Each January, the region compiles the previous year's land take data and publishes the results. The region's open data portal also provides shapefiles of the officially recognized urbanized territory per the new plans. The success of LR 24/2017 led to the integration of ZNLT principles into subsequent regional policies. The Regional Strategy for Agenda 2030 commits to ZNLT, aligning with SDGs 11 and 15 and the EU's 2050 target, focusing on urban regeneration, brownfield restoration, and compliance with the 3% cap. The Piano Regionale di Gestione dei Rifiuti e Bonifica delle Aree Inquinate 2022–2027 prioritizes brownfield reuse for waste infrastructure, promoting regeneration in line with ZNLT goals. The ERDF Programme 2021–2027 incorporates land take reduction, using LR 24/2017 as a benchmark, funding urban transformation agendas that prioritize regeneration and reuse over greenfield development.

The functional typology and clustering of Emilia-Romagna's policy corpus reveal clear patterns in both legal force and thematic orientation. Binding instruments belong to Sustainable Urban Development and Regeneration and Land Use and Soil Protection clusters, respectively, reflecting their role as normative hubs that mandate redevelopment-first approaches and set soil- consumption ceilings. In contrast, non- binding strategies occupy the Climate Adaptation and Sustainable Urban Development clusters, serving primarily as high- level vision documents that lack enforceable provisions. Economic instruments, explicitly target Sustainable Urban Development and Regeneration. Lastly, informational tools, epitomized by "Consumo di suolo e pianificazione: conoscere per decidere", are classified under Land Use and Soil Protection, furnishing data for evidence- based decision- making without direct regulatory authority.

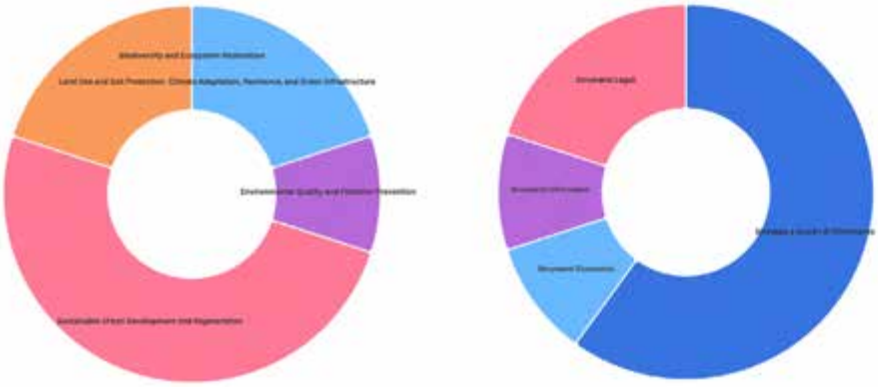


Figure 16 (from left to right) Categorical clustering and functional typology of regional dataset, source: authors

Across all ten documents, there are explicit provisions addressing land-take reduction. Although soil sealing appears in nearly all documents, its treatment differs markedly depending on the policy family. Land-take itself appears as a headline metric, signalling broad acceptance of this concept as the principal proxy for horizontal land conversion. However, only four instruments (e.g., L.R. 24/2017, PER 2030, the Regional Strategy for Agenda 2030, and PTPR) pair land-take with explicit restorative language such as de-sealing or ecological compensation. Equally significant is the limited uptake of the broader "land-consumption" concept as defined by UN-Habitat.

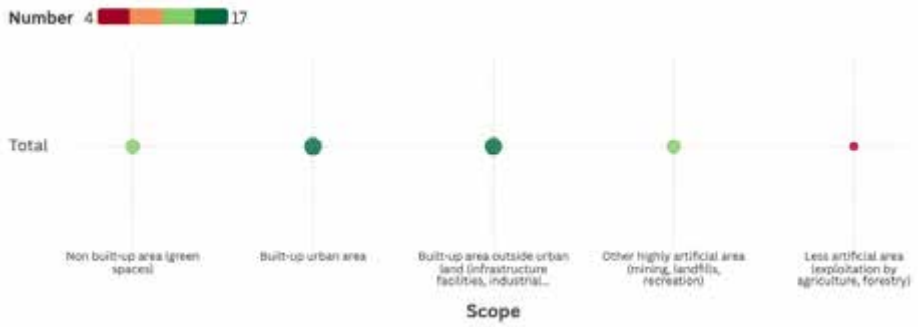


Figure 17: Terminology Trends (top) s and Spatial Focus (bottom) in ER ZNLT Policies, source: authors

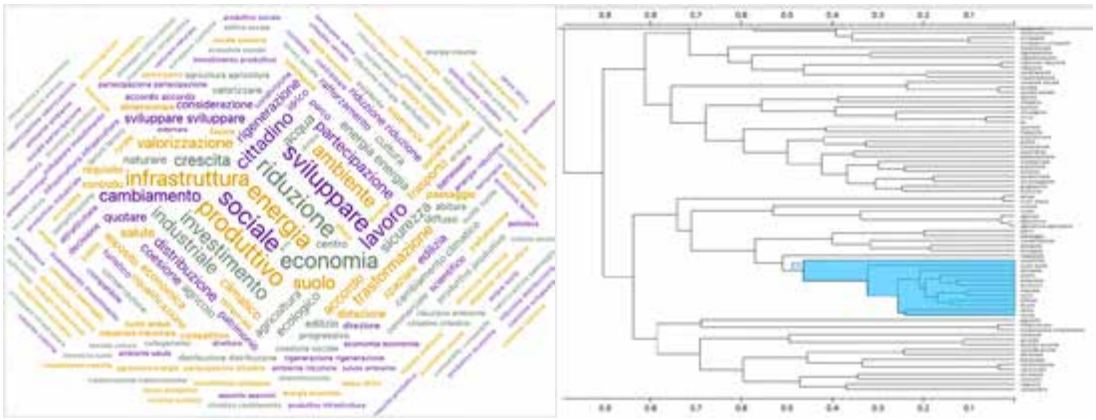


Figure 18. Machine learning text mining, regional level, source: authors (Orange machine learning tool)

Network-centrality metrics highlighted the following. The Regional Strategy for Agenda 2030 and LR 24/2017 show high betweenness and eigenvector centrality, acting as key orchestrators and hierarchical anchors that connect multiple policy tiers, even without directly addressing land consumption. In contrast, instruments like Bandi rigenerazione urbana and the Smart Specialisation Strategy suggest low centrality, indicating peripheral roles with limited integrative capacity. Secondary anchors, such as PRAP and Legge Regionale 16/2002, provide coordination but lack direct land conversion provisions, creating potential alignment gaps.

Bandi regenerazione urbana									
Piano Regionale di Gestione dei Rifiuti e Bonifica Siti Contaminati 2022–2027									
Regional Strategy for the Agenda 2030									
ERDF Regional Programme 2021-2027									
Law No. 24/2017, titled "Disciplina regionale sulla tutela e l'uso del territorio,"									
Piano energetico regionale 2030 (PER)									
Piano Territoriale Paesaggistico Regionale" (PTPR)									
Smart Specialisation Strategy (S3)									
Piano Territoriale Regionale (PTR)									
Consumo di suolo e pianificazione: conoscere per decidere.									

Figure 19. Policy network centrality analysis (regional level, Emilia-Romagna), source: authors

The analysis showcased institutional innovation and strong multi-level governance, embedding the ZNLT target through spatial analysis, monitoring, and land-take caps. However, gaps persist where non-binding fiscal tools lack explicit land-consumption metrics. The next policies revision (or the drafting) of peripheral to ZNLT, energy-transition or climate-adaptation policies, incorporating quantitative sealing thresholds (e.g., maximum km² of new impermeable surfaces), could enforce the net-gain logic that underpins ZNLT.

3.4 Cross-Level Analysis and Policy Gaps

In collaboration with Emilia-Romagna experts, the corpus was evaluated for relevance to the process of land take reduction and re-using abandoned or previously-used land in Emilia-Romagna. Combining scores with policies' legal bindingness, it allowed to map these scores onto a Power/Relevance matrix, where:

Key policies (High relevance and power) directly address land-take prevention or land-reuse through binding provisions (laws, directives, mandatory funding conditions). Rigorous execution and regular updating are essential, as gaps might pose immediate risks. Influential policies (high relevance, low power) provide technical guidance, strategic visions, or soft-law recommendations promoting ZNLT without binding force. Strengthening them requires converting these into binding obligations; until then, their impact relies on political will, peer pressure, and funding alignment. Contextual policies (low relevance, high power) are binding legal acts that have only secondary or indirect practical usefulness for the ZNLT processes. Often "sleeping giants," small amendments can produce major effects. Effective cross-sector coordination is needed to prevent these powerful instruments from unintentionally promoting new land take. Peripheral policies (low relevance, low power) — Soft-law or legacy documents that target adjacent sustainability objectives with minimal or no explicit focus on the regional ZNLT effort. They provide entry points to embed ZNLT terminology into wider policy contexts.

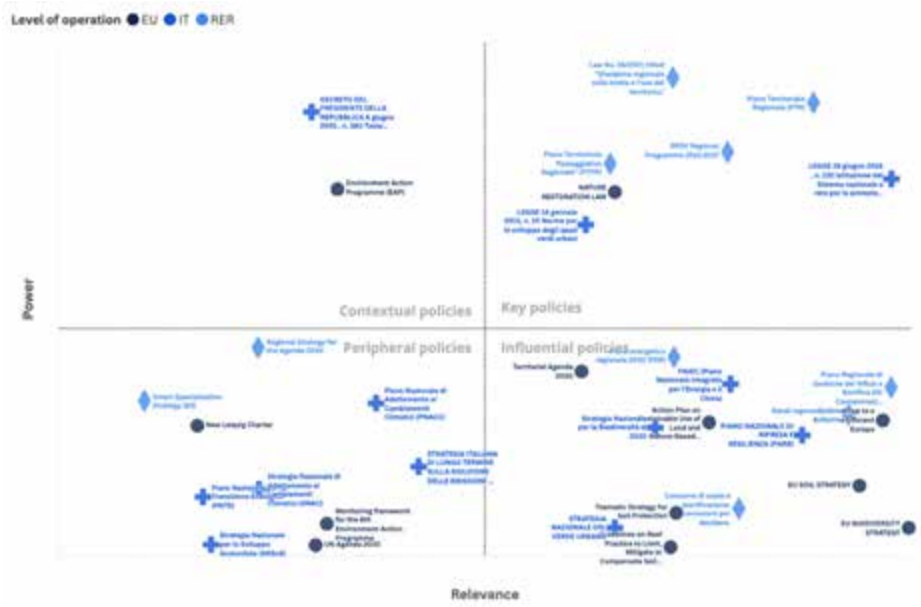
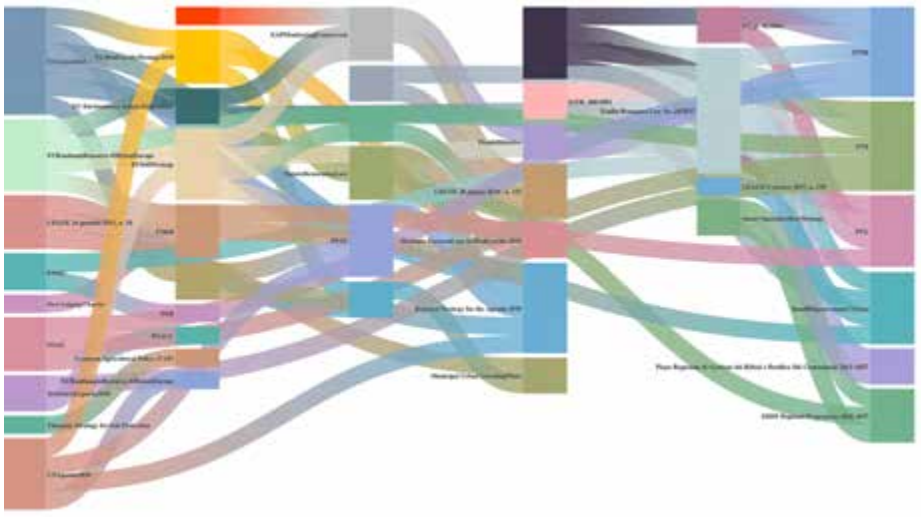


Figure 20. Policy Power/Relevance matrix, source: authors

The self-evaluation revealed that only 21% of the corpus emerged as Key policies, that practitioners regard as directly operational for achieving ZNLT (e.g. the EU Nature Restoration Law 2024; LR 24/2017; the ERDF 2021-2027 programme; and the PTR/PTPR tandem). The largest cluster (44%) falls in the Influential quadrant, where soft-law strategies and thematic action plans can be widely consulted but lack coercive force. Finally, 29 % were deemed Peripheral: overarching frameworks (i.e. UN Agenda 2030, National Ecological Transition Plan and Regional Smart Specialisation Strategy, etc), which provide little concrete leverage for practitioners. And only two high-power texts were rated as Contextual (6%)—notably 8th Environment Action Programme and the national Consolidated Building Code (DPR 380/2001).

Network-analysis and expert-evaluation results were consequently onto the DPSIR framework. DPSIR was recalibrated, categorizing objectives as Drivers, Pressures, States, Impacts, or Responses to construct a governance-oriented causal network. Policies containing multiple objectives were mapped according to their most relevant DPSIR categories, enabling accurate representation across different analytical nodes.



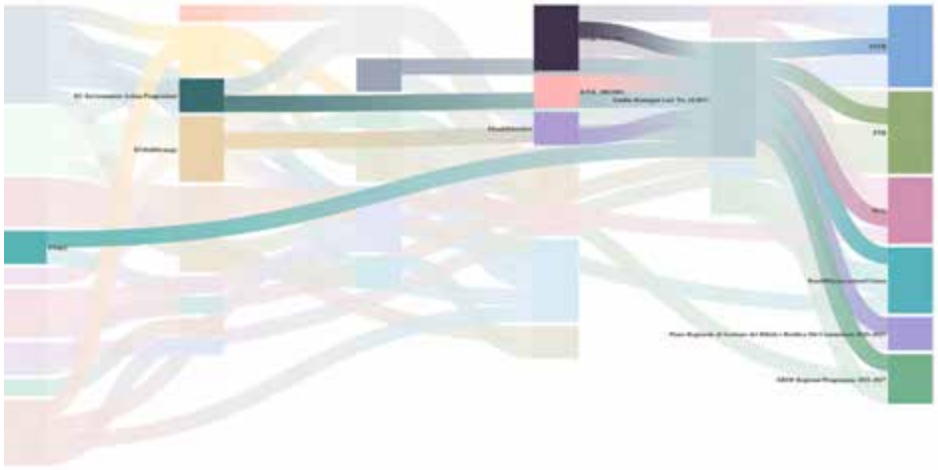


Figure 21. Sankey diagram (transition of policy objectives), source: authors

At the Driver level, agenda-setting strategies such as the European Green Deal, EU Biodiversity Strategy 2030, and EU Soil Strategy position land-take neutrality, ecosystem restoration, and soil health as central economic priorities. High strategic centrality scores reflect their ideational influence, but limited operational centrality signals persistent implementation barriers. Pressure policies, as Nature Restoration Law and LR 24/2017, translate strategic goals into enforceable quantitative limits. Urban regeneration incentives and brownfield prioritization in national and EU funding schemes further operationalize the "reuse before new take" hierarchy. State-focused instruments remain peripheral: few policies establish systematic monitoring of land condition or biophysical baselines. Notable exceptions are the 8th Environment Action Programme Monitoring Framework, Italy's Law 132/2016, and Emilia-Romagna's "Conoscere per decidere." Their low centrality underscores a monitoring deficit, weakening adaptive management. Impact-oriented measures are more consistent, targeting ecosystem and social consequences of land conversion. The EU Biodiversity Strategy and adaptation policies promote connectivity, habitat restoration, and nature-based solutions to mitigate flood and heat risks. Urban green space mandates and financial instruments (PNRR, ERDF) support mitigation and compensation, though most objectives remain qualitative, diluting their regulatory effect. Responses comprise a stratified layer of operational instruments and funding mechanisms translating prior targets into practice. High-relevance statutes such as LR 24/2017 and regional ERDF programmes drive implementation via updated local plans and dedicated investments, while non-binding strategies maintain high strategic influence but limited coercive force. Institutional mechanisms, including the SNPA monitoring system, enhance enforcement capacity and policy learning.

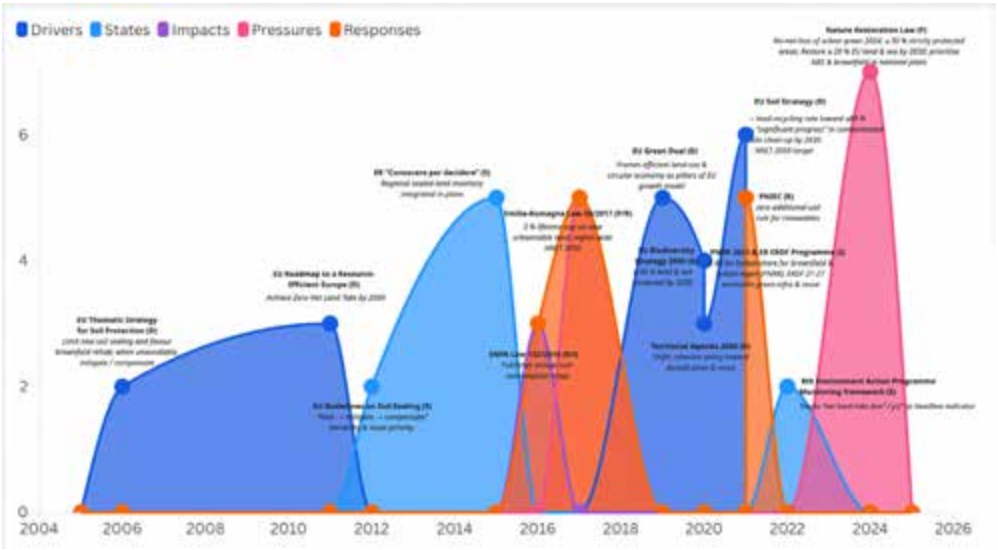


Figure 22. Sankey diagram (transition of policy objectives), source: authors

The longitudinal reconstruction of ZNLT corpus discloses a six-phase "policy stratigraphy" in Emilia-Romagna in which successive DPSIR nodes accrete rather than co-evolve. Early Driver texts—the EU Thematic Soil Strategy (2006) and the Resource-Efficient Roadmap (2011)—conferred a macro-narrative of circular growth and set a 2050 neutrality horizon, yet remained programmatic. Only after a distinct State layer (2012-15) had produced the first sealed-soil baselines did impact-mitigation pilots surface, linking annual soil-consumption reporting (SNPA, 2016) with modest urban-greening offsets. Hard Pressures arrived abruptly: LR 24/2017 imposed a 3 % lifetime land-take cap, while the 2024 EU Nature Restoration Law crystallised a 20 % ecosystem-repair mandate and an urban-green "no-net-loss" rule. An intervening consolidation wave (2019-21) re-embedded ZNLT within the Green Deal's climate-neutrality calculus and paired it with restoration (30 % strict protection; 20 % degraded-land recovery), thereby recasting neutrality from a stand-alone limit into a limit-plus-repair paradigm.

Overlaying temporal and functional layers reveals systemic discontinuities. Drivers precede enforceable Pressures by 6-8 years, creating windows of political drift in which implementation relies on voluntary Response finance (PNRR, ERDF 2021-27). Monitoring capacity remains front-loaded and stagnant: after 2016 no major State instrument has been added, jeopardising the evidentiary basis for the 2050 neutrality claim. Conversely, rhetoric on ecological and social impacts proves catalytic, synchronising surges in mitigation funding with the 2016 and 2021 policy waves.

3. Conclusions and Recommendations

This study has demonstrated that ZNLT ambition is embedded within a richly textured but uneven multi-level governance architecture. Clear vertical alignment emerges through the top-down diffusion of EU objectives, such as no net land take and land degradation neutrality, explicitly reflected in national strategies. At the supranational level, flagship initiatives such Biodiversity Strategy 2030, and Soil Thematic Strategy serve as powerful "normative anchors," diffusing the 2050 neutrality target through hierarchical subordination and strategic execution networks. Yet the translation of these objectives into binding national and regional instruments varies markedly: Italy's national framework remains a patchwork of soft-law strategies and piecemeal statutes, while Emilia-Romagna has pioneered one of the most coherent subnational approaches with its LR 24/2017 cap and advanced de-sealing pilots. This divergence vividly illustrates how policy innovation at one tier can catalyze—or be held back by—gaps at another, highlighting the need for stronger vertical coherence.

The analysis revealed some potential governance imbalances. The land-use policy landscape functions as a multi-level governance system, where interactions among European, national, and regional policies reveal alignment, redundancy, and governance gaps. Strategic "Drivers" dominate the policy topology, whereas "monitoring baselines and some quantitative thresholds are under-represented, weakening adaptive feedback loops. Enforcement of pressure measures are unevenly applied: Emilia-Romagna's 3 percent land-take budget exemplifies a clear cap, whereas national and EU funding programmes often offer only aspirational incentives. At the same time overlapping instruments might create administrative complexity and "strategy fatigue" unless well-integrated.

In summary, the linkages show a multi-level orchestration at work: when properly aligned (as in the case of the 2050 target cascading down to Emilia-Romagna's law), governance becomes coherent and mutually reinforcing. Where levels are misaligned – such as a national policy vacuum – adaptive governance suffers, as lower-level efforts may lack broader support and higher-level goals remain aspirational. The network of policies is densely interconnected, but the strength of those connections (alignment vs. fragmentation) greatly influences outcomes on land-use sustainability.

As the draft Italian land-take law moves forward, lawmakers face a choice: keep the narrow, sealing-centred metric for regulatory simplicity, or broaden the definition toward full land consumption to capture agricultural encroachment and forestry conversion.

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Abbreviations

EAP	Environmental Action Programme
EU	European Union
FUA	Functional Urban Areas
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale
NNLT	No Net Land Take
PNIEC	Piano Nazionale Integrato per l'Energia e il Clima
PTR	Piano Territoriale Regionale
PUG	Piano Urbanistico Generale
RER	Emilia-Romagna Region
SDG	Sustainable Development Goals
SNAC	Strategia Nazionale di Adattamento ai Cambiamenti Climatici
SNSvS	Strategia Nazionale per lo Sviluppo Sostenibile
ZNLT	Zero Net Land Take

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Appendices

- Corpus of analyzed policies
- Network Mapping

Participatory Community Planning and Collaborative Governance in the Post-Growth Era: A Case Study of the Nanning Love-U Garden Network in China

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Abstract
Collaborative governance of community regeneration is the essential need of the community as living space, and also provides an effective path for community spatial governance. This paper combs the connotation of collaborative governance and the necessity of community collaborative governance. Through the analysis of three typical cases of Nanning Love U Garden, this paper summarizes three types of community garden co-construction modes: external empowering type, internal and external collaboration type and internal autonomy type, and discusses three optimized mechanisms of the collaborative governance: whole-process participatory co-construction mechanism, flexible cooperation and co-maintenance mechanism, and differentiated co-financing mechanism. It has certain reference significance for other cities in China to build community garden networks, promote collaborative governance of community regeneration and promote sustainable development of communities.

Keywords: Participatory Community Planning; Collaborative Governance; Public Engagement; Love-U Garden

1 Introduction

Many cities in the world today are facing the slowdown in economic growth, the reduction in fiscal revenue, and the resulting challenges in public space governance. With the slowdown in China's economic growth, urban construction has also entered the stock regeneration era from incremental development. Community planning and community regeneration based on the built environment require the engagement of multiple local actors and the collaborative governance of multiple departments. So, how can different collaborative governance models be used to stimulate community engagement for different types of communities? How can actors play the role of catalyst and driver in community collaboration and engagement? How to optimize the mechanism of participatory community planning and collaborative governance based on the existing institutional environment? However, current research mostly stays in macro-framework design and isolated case studies, lacking networked practice and continuous observation. Therefore, it is urgent to sort out the multiple models of collaborative governance and the optimisation of participatory community planning mechanisms in combination with long-term systematic spatial practice.

The "Love-U Garden" action in Nanning, China, which began in 2021, has built a rare city-level garden network. Empowered and accompanied by social organisations, the Clover Nature School, it encouraged residents to build and maintain spontaneously, innovated collaborative governance mechanisms, and ultimately became a model for the regeneration and governance of urban community green spaces. This study sorts out the concept of "collaborative governance", combines Habermas's "life world" theory, analyzes the co-construction model and mechanism optimisation of Nanning Love-U Garden, and attempts to provide practical references for the old communities' regeneration.

2 Background

2.1 The connotation of "collaborative governance"

Collaborative governance is an administrative theory that has emerged since the 1990s. It still lacks a clear and unified definition. It is generally believed that collaborative governance originates from the intersection of synergy theory in natural science and governance theory in social science (Huang, 2023). Collaborative governance advocates that multiple governance subjects (including public departments, enterprises, social

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organisations and individuals) jointly participate in decision-making and jointly solve public problems based on the mutual dependence of resources and interests (Wikipedia, 2025). Collaborative governance can achieve more than any one sector could achieve on its own. The core of its theory is to emphasize the diversity and synergy of governance subjects, which contrasts with the monocentric governance power (Yu, 2013). The fields that use collaborative governance more frequently are political science and management, and most of them focus on the characteristics of collaborative governance as an alternative to managerialism and adversarial approaches. In the field of urban and rural planning, collaborative governance is also seen as an important tool to promote cross-regional and cross-departmental cooperation and to solve the difficulties in public service supply and social and economic development (Hu, 2014). At the same time, in recent years, the concept of "co-governance" has also been frequently used in China's urban planning field, often in the form of "multi-party co-governance" or "co-construction, co-governance and sharing", and its core is also to emphasize the diversity and coordination of spatial governance subjects. It can be said that the concept of "co-governance" in the field of urban and rural planning is basically equivalent to the connotation of "collaborative governance" in administrative science. In general, whether in the fields of political science, management science, or urban planning, scholars emphasize the differences between collaborative governance and traditional administrative management methods, but there are few studies that implement it in actual projects and put forward operational suggestions.

2.2 Community as "life world"

German philosopher Jürgen Habermas believes that modern society consists of two basic areas: life world and system (Finlayson, 2005). Life world refers to the ordinary world in which we live together with others. System is the accumulated structure and established instrumental behaviour type. The two have completely different rules, mechanisms and behaviour patterns, corresponding to communicative behaviour and instrumental behaviour respectively. Life world and communicative behaviour have the function of social integration, building consensus, preserving social significance, and carrying out social and cultural reproduction. System mainly includes two subsystems, money and power, whose main functions are to produce and circulate materials (products and services) and to systematically integrate behaviours. System is embedded in life world, but in fact it is parasitic on life world, so life world takes precedence over system (Habermas, 1990).

Community space is a typical life world, in which money and power are difficult to play a leading role, and the consciousness of "living community" based on daily life collaboration becomes the spiritual foundation of community cohesion (Liu, 2023). At the same time, community space is a typical public space that requires space governance and public services. Therefore, the governance of community space needs to obey the underlying logic of the life world - communicative rationality, which means respecting the diversity of communicative subjects in the community and the right to equal dialogue, so as to reach a consensus and form an orderly social structure. Therefore, "cooperative governance" is the essential requirement of community governance.

Collaborative governance is applied to the community space level, emphasizing the equal consultation and participation of all stakeholders in spatial renewal, which is different from traditional unitary management and bureaucratic management. Since China's community planning has not yet been included in the statutory planning system, the existing collaborative governance research on community renewal mainly focuses on macro, top-down framework design and academic discussion, lacking micro, bottom-up model induction and governance mechanism optimisation. Nanning Love-U Garden is a rare city-level community garden network in China. This article will study three cases from the perspective of collaborative governance to summarize its collaborative governance model and mechanism.

2.3 From Laoyou council to Love-U Garden

Nanning City officially launched the regeneration of old residential communities in 2019, and proposed a plan to complete the regeneration of old residential communities built before the end of 2000 by the end of 2025, involving about 1,270 residential communities and about 165,000 residential units. However, the regeneration of old residential communities in Nanning faces four major problems: 1) Low participation, and local residents lack subject awareness; 2) Difficult communication and coordination, diverse residents' needs, some residents are unwilling to give up vested interests, and it is difficult to reach a consensus; 3) Difficulty in raising funds, the demand for old regeneration funds is large, and in addition to government investment, residents also need to crowdfund part of the funds, which is difficult to raise; 4) Difficulty in management, the number of old residential communities is large, and most of them do not have property management and property committees, and lack

effective management mechanisms.

Therefore, the Nanning Municipal Government purchased services and introduced a professional team to establish the "Laoyou-council", and refined and formulated the "Twelve Rules of Laoyou-council" to standardize the work process and build a long-term community management mechanism. The functions of the Laoyou-council are to train community and council representatives, collect regeneration intentions, determine regeneration plans, collect personal contributions, coordinate regeneration conflicts, and supervise construction quality. As of April 2024, Nanning has established 1,024 Laoyou Councils, elected 6,723 Laoyou-councils' representatives, held 2,832 special consultation meetings on the regeneration of old residential communities, and solved more than 16,000 community regeneration issues. The Laoyou Councils allows residents to express their different opinions, promotes the community to reach a consensus, and gradually solves the difficulties of old residential community regeneration (Housing and Urban-Rural Development Department, 2020).

After the regeneration of old residential communities, on the one hand, the management team needs new forms of participation to mobilize residents more widely and promote the depth of participation in public affairs; on the other hand, the government hopes to promote the "Laoyou-council plus" working method and give full play to its long-term effect; in addition, the regeneration of old residential communities and the work results of the Laoyou-council also need to be presented in a more "visual" way to increase residents' sense of gain and satisfaction. Therefore, the municipal government and the Luobo team invited the Shanghai Clover Nature School team to mobilize residents to build community gardens in the communities that have completed the regeneration, called Love-U gardens.

3 Love-U Garden project

Love-U gardens are small community gardens in Nanning City, which are guided by the Nanning Housing and Urban-Rural Development Bureau, hosted by the Nanning Urban Renewal and Property Management Guidance Centre, and invited by the third-party professional team Shanghai Clover Nature School to empower and accompany the community during the regeneration of old residential areas in Nanning. It encourages residents to participate in the construction and maintenance of the gardens. Through the Laoyou Councils, discussions are held, and empowerment training is conducted by professional organisations. It aims to activate idle space, cultivate public spirit, and point to sustainable development (Clover Nature School, 2021).

The goals of Nanning Love-U gardens are as follows:

1) Improve physical space. Based on a survey of 155 communities in Nanning, a participatory design method of co-creation and construction with residents is used in front of and behind the doors of apartment buildings to realize the implementation of 1,000 community gardens of 3 to 5 square meters, improving the living environment of the community.
2) Cultivate a community of flower lovers. Through participatory design and construction, the team incubates a community of flower lovers locally, provides professional planting skills, cultivates a self-organized team of flower lovers, and encourages flower lovers to discuss, build and share together.
3) Activate autonomous action. Laoyou Garden has created a scene where everyone can discuss and work together to transform the public space, and has fostered the community's ability to reach consensus and act collaboratively. This ability helps to stimulate residents' sense of subjectivity and their enthusiasm for future participation in public affairs.

As of October 2023, Clover House has assisted in the construction of 1,020 Love-U gardens in 92 communities in Nanning. (Figure 1) According to the location and size of the garden, it can be divided into gate gardens, roof gardens, building gardens, central gardens and street gardens. A large number of gardens of different types have formed a city-level green public engagement network, fully mobilizing residents of different ages and classes to participate in it, and reconstructing the relationship between residents and the community and society.

Figure 1 Nanning Love-U Garden Network

4 Analysis

The co-construction of Nanning Love-U Garden is a process of tapping community resources, linking participating entities, multi-party collaborative actions, and establishing a long-term mechanism. It can be divided into three progressive stages: the first stage is external empowerment, with community R as a typical representative. Due to the weak local participation foundation and public awareness, the construction of Love-U Garden relies more on external empowerment, and social organisation plays the role of project leader. The second stage is internal and external collaboration, with community J as a typical representative. With the development of the work, citizens began to accept the concept of the community garden, and external forces such as social organisations, universities, and social actors began to intervene to achieve internal and external collaboration. The social organisation gradually changed from a leader to a co-builder. The third stage is internal autonomy, with community N as a typical representative. With the further enhancement of public awareness and internal motivation, professional teams retreated behind the scenes and turned into technical supporters, and local residents began to autonomously co-fund, realizing conscious initiation, spontaneous construction, and self-management. This study will select three typical cases to illustrate three different co-construction models.

4.1 External empowering type

As the community with the largest number of Love-U gardens and flower lovers in Jiangnan District, community R was built in 1999. It is the first batch of housing estates in Nanning City and the first community built by Ronghe Group as a real estate developer. The property management quality is good. Most of the owners were middle and high-income groups at that time, with a high average quality. In 2019, community R was included in the first batch of old community regeneration in Nanning City. In 2022, the external empowering team, a social organisation named the Clover Nature School began to build the first batch of Love-U gardens in community R.

4.1.1 Construction of the benchmark

In the early stage of the construction of the Love-U gardens, there were few responses and slow progress because residents did not understand the concept of the community garden. The Children's Garden in the first phase of community R is a turning point in the construction of the Love-U gardens in the community. The backyard of Teacher Qin's children's picture book library in the community is full of construction waste and has serious rat infestation. He hoped that with the help of the Love-U Garden project, the green space downstairs will be transformed into a public rest space for neighbors and a venue for nature education. Through the demonstration

and leadership of a external professional team, the construction of the Children's Garden has attracted the attention and participation of other residents. In response to residents' questions about the publicness of the garden, the team patiently explained that all Love-U gardens cannot be closed to ensure that all the residents can share them, and that each garden requires at least three flower lovers to sign in order to gain support. In the end, the Children's Garden received unanimous praise from residents and triggered a wave of applications for Love-U gardens in the community (Figures 2 and 3).

Figures 2 Children's Garden

Figures 3 Public engagement

4.1.2 Spread of gardens

The benchmark effect has driven the discussion and dissemination of public issues. With the continuous empowerment of the external team, the community action of the Love-U Garden has spread with the help of the social network. Due to the limited number of applications, the team had to raise the standard. Each garden requires 20 residents to sign in order to obtain project support. The growth and spread of the garden are reflected in three aspects: 1) The cost of a single Love-U Garden is limited. The team encourages some flower lovers to crowdfund and purchase more beautiful and durable rest tables and chairs and other garden facilities, which are used as references in other gardens. 2) The team provides professional guidance to assist residents in expanding garden design and improving garden quality. 3) Residents who have not applied for the project are encouraged to learn from the experience of the Love-U Garden and improve their own gardens downstairs. By April 2023, community R has completed the construction of 228 Love-U gardens, cultivated 370 flower lovers, and built a systematic garden space network and a social network of flower lovers of all ages.

4.1.3 Negotiation of responsibilities

After the guidance and coordination of the external team, the residents and the property management company reached a consensus on the maintenance of the Love-U gardens: the property company equipped the core flower lovers with the public faucet key, the flower lovers were responsible for daily watering and maintenance, and the property company was responsible for the bottom and provided professional support. After the garden was built, there were also neighborhood conflicts. Some Love-U gardens added hard paving and seats due to the needs of socializing and resting, and other residents complained that the project reduced the greening rate of the community. Under the guidance of the professional team, the flower lovers quickly drafted and collectively signed an application to retain the existing Love-U Garden, which was supported by the government and finally successfully protected the achievements of the Love-U gardens. The Love-U gardens have become the common property of the community.

4.2 Internal and external collaboration type

Community J is the only large-scale Love-U Garden in Xingning District and also the community with the largest number of flower lovers in Xingning District. The community was built in 1999 and is one of the first batch of high-rise residential communities in Nanning. It consists of 4 high-rise buildings surrounding a central garden. However, due to its age, the greening design cannot meet the living needs of residents, and poor maintenance has caused some green spaces to become barren.

4.2.1 Space exploration

The construction of Love-U gardens adheres to the concept of companionship construction and gradual regeneration. In May 2022, the external team entered the community J. At the beginning, because residents, the community owners committee and the property management had low acceptance, the professional external team chose a messy corner next to the fitness area as the startup project. There are three reasons for this decision. Firstly, the difference between before and after is obvious. Secondly, it was close to the activity areas for children and the elderly. And thirdly, it was close to the residents' fitness area. As the project progressed, residents turned from bystanders to participants and put forward more demands for garden renovation. On the technical level, professional teams, social organisations and local residents jointly explored sustainable garden design, tried to grow local edible plants, experimented with kitchen waste composting technology, and used idle old items to make simple rainwater collection device system.

Figures 4 Love-U Garden in community J

Figures 5 Rainwater collection device system

4.2.2 Collaborative construction

The construction of the Love-U gardens attracted the participation of many partners. The environmental protection social organisation held 8 edible garden course trainings, which assisted the implementation of the garden and attracted other local participants. As a semi-open community, this community is also a playground for children from the nearby vegetable market. The destructive behaviour of outside children caused dissatisfaction among the children in the community. But when they participated in the Love-U Garden construction, the barriers gradually disappeared, and the previous opposition turned into concerted action. Guangxi Academy of Arts led residents to complete the construction of the Travel Garden and the Windmill Garden using on-site waste. The social organisation "Little Volunteers" collaborated with community children to upgrade rainwater collection devices, create stone paintings, and realize the implementation of the Colorful Garden and the Bubble Garden. From May to August in 2022, Community J cultivated 88 flower lovers and completed 64 Love-U gardens, including one large garden.

4.2.3 Continuous community action

During the design and construction process, residents put forward more practical suggestions, such as the installation of seats and irrigation facilities, and continued to negotiate and co-create in the maintenance of the garden. The Edible Garden designed a compost tower, but after it was built, residents thought its shape was unlucky and had a peculiar smell, and asked to remove it. After communication, the external team decided to dismantle the compost tower and transform the materials into round planting boxes, named "Bubble Garden", and the residents who originally opposed it also happily participated in the construction. After the overall completion of the garden, the co-construction team launched a guide training program to cultivate concept disseminators and community connectors for the community garden. At the end of August, Community J held the "Cooling Party", which not only spread the concept of the Love-U Garden, but also enhanced the residents' sense of community identity and cohesion.

4.3 Internal autonomy type

Community N, located in Qingxiu District, was built in 2003. It was once one of the highest-quality residential communities in Nanning at that time and was rated as an "advanced greening unit". However, over the past 20 years, due to poor operation and management of the community, the facilities have aged and it was listed as a "poor" community by the Nanning Housing and Urban-Rural Development Bureau in 2022. After several years of hard work by the community owners, a temporary owners' meeting was finally established in 2023, and the original property company was replaced by a state-owned property company under a commission system. Therefore, community N has a good foundation for community autonomy and public engagement.

4.3.1 Leverage of crowdfunding

In 2023, the Love-U Garden project team launched the Love-U Garden Seed Fund Plan, providing a menu-style material package to encourage the community to raise funds to build a small community garden. After the active introduction of property management company, a design workshop was organized in the community in July of the same year. More than 10 flower lovers discussed the garden plan with the designer to determine the site selection and bill of materials. Flower lovers began to spontaneously crowdfund funds based on the material package. After a building invested five material packages, residents not only raised about 30,000 yuan in construction funds, but also actively contacted nearby auto repair shops to use recycled tires to make garden scenery, and finally transformed the garden area to 30 square meters (Figure 6). As of the beginning of 2024, community N has invested a total of 30 material packages and successfully mobilized owners to raise a total of 70,300 yuan.

Figures 6 Love-U Garden in community N

Figures 6 Star Garden

4.3.2 Links of actions

The Star Garden is the first Love-U Garden in community N. It was initiated by an enthusiastic flower lover and built in advance (Figure 7). Driven by the pioneers, the community ushered in an unprecedented self-organized construction. In the end, a total of 22 Love-U gardens were applied for and built, with more than 200 residents participating. In the early stage of garden construction, there were also cases of tools and plants being lost, but some flower lovers took the initiative to provide help between the gardens. On one hand, it stimulated the public awareness of other residents. Everyone began to share plants and tools and help each other. Some white collars also participated in the construction until late at night after get off work; on the other hand, the construction action built a neighborhood network. The flower lovers' dinner after the construction made neighbors who had not communicated with each other become familiar with each other. The property company also actively supported and participated in the construction of the garden, and carried out daily cleaning and maintenance of the garden, becoming a part of the life community.

4.3.3 Co-creation of festivals

Love-U gardens in community N introduced digital community participation tools. Flower lovers used WeChat applet to record the process of garden construction, which not only preserved precious construction memories, but also became a platform for daily communication, sharing poetry creation and life details of the subsequent garden growth. While Love-U gardens improved daily rest space, they also inspired more public communication behaviours.

Some residents took the initiative to take out tea sets and invite neighbors to share and maintain. The owners spontaneously organised a community garden festival and invited the government, property management and professional teams to celebrate together. Flower lovers wrote lyrics to connect the names of all gardens and sang them on the spot.

Through the construction of Love-U gardens, the relationship in the community N has become more harmonious, and the sense of belonging and identity of the community has been further strengthened, becoming an "urban utopia" in the mouths of residents.

5.Conclusion

The three models of Love-U gardens summarized in this article each have their own applicability. The external empowering type mainly relies on the guidance, demonstration and long-term empowerment of professional institutions. It is suitable for communities with both aging infrastructure and population, weak public participation foundation, and scarce social resources. However, its limitation is that it requires high capabilities and investment from professional institutions. The internal and external collaboration type mainly relies on external diverse social forces for collaboration and co-creation. It is suitable for communities with relatively rich social resources, rich community age structure, and strong participation potential. Its limitation is that it requires high resource integration capabilities of the community, and it is necessary to improve the later maintenance and co-management mechanism of the garden. The internal autonomy type mainly relies on the endogenous power of the community and the self-driving force of residents. It is suitable for communities with a good public engagement foundation, relatively complete infrastructure, and strong community self-organizing ability. Its limitation is that it requires high community autonomous management capabilities and the coordination of owners.

The concept of collaborative governance is introduced throughout the entire process of Love-U gardens. In the planning and design stage, Laoyou-councils' meetings are held to summarize the real needs of residents. In the construction stage, designers plant plants with residents to stimulate residents' physical participation. In the maintenance and management stage, the external team guides internal residents and other parties to clarify responsibilities, co-create a long-term maintenance mechanism, and determine different maintenance models for gardens of different sizes. The external team accompanies the entire process, hoping to use Love-U gardens as a starting point to allow the community to generate more internal spontaneous public actions.

For the application of different community garden construction models, the specific operational suggestions are as follows: 1) The external empowering type should further promote the construction of the entire process. Through the construction of an integrated mechanism of planning, construction, management and operation, the dual improvement of "material" and "non-material" in old communities can be achieved. 2) The internal and external collaboration type should actively link the participation of all age groups, create an all-age friendly participation path by linking multiple resources, cultivate a self-organized team of flower lovers, and promote the sustainable growth of community gardens. 3) The internal autonomy type should focus on encouraging multi-channel fund raising, introducing social forces to create inclusive projects, leveraging residents' independent co-funding and self-empowerment, and achieving continuous construction and long-term operation and maintenance.

As a city-level community garden network construction practice, Nanning Love-U Garden is also a social experiment in community space collaborative governance based on community deliberation. The Love-U gardens not only improve the living environment of old residential areas, but also reshape local social interactivity through public engagement, enhance residents' subjectivity and sense of belonging, mend and repair community social networks, and promote the formation of community consciousness, becoming the finishing touch of Nanning old residential area regeneration. At the same time, the practice of Nanning Love-U gardens also has certain theoretical guidance and practical reference significance for other Chinese cities to create community garden networks, promote collaborative governance of community regeneration, and promote sustainable development of urban communities.

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PARTICIPATION AFTER DISASTER: CENTRAL GOVERNMENT APPROACH TO PARTICIPATION PLANNING

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Abstract
The 21st century is an era of crises, driven by the increasing impact of climate change and successive crises ranging from environmental degradation to social and economic inequalities. This multi-crisis environment has necessitated the adoption of holistic, inclusive, and participatory approaches in managing disaster risks. The focus of this study is to examine the participation perspective in Türkiye's recovery process after the February 6, 2023, Kahramanmaraş earthquakes from the institutionalized participation understanding in the world. In this context, the stakeholder participation plan in the Rural Areas Earthquake Recovery and Reconstruction Project (KADİYAP) carried out by the Ministry of Environment, Urbanization, and Climate Change was examined, and the central government's approach to managing the participation process was evaluated in line with the determined criteria.

Keywords: Disaster Management; Participation; Stakeholders; Inclusivity; Central Administration

Introduction

The crisis period that emerged in the early 21st century, after the concept of the Anthropocene was defined the successive crises experienced in the world. The world continues to experience crises related to each other due to the irreversible impact of humanity on the environment. Şengül (2023) points out a complex structure and interaction, and groups global crises under the following six main headings: Economic/Financial, Social Welfare, Ecological, Border/Refugee, Urban, Governance/Democracy. Just as the governance systems of all countries have difficulty adapting, Turkey's governance system is also struggling with crises. The current governance system is expected to overcome the crisis by intervening with short-term policies in the face of crises. However, the crisis experienced by complex social, economic, spatial, and environmental relations networks causes other crises. According to Lister and Wilde (2020), governance systems that can adapt to the constantly changing needs, expectations, rights, and abilities of all actors and institutions that make up our societies need to be created. Such a system will require deliberative dialogue and engagement with many actors (business, civil society, politicians, communities, trade unions) and political coalitions at all levels.

Turkey, like the rest of the world, has had to deal with economic crises, epidemics, fires, floods, and earthquakes one after another. Especially after the February 6, 2023, earthquakes, it was observed that the central government's ability to respond to disasters from a single source was not possible due to related crises. Therefore, responsibility should be shared with local governments, communities, and the central government in response to disasters and the recovery process. All actors are expected to participate in the process to meet their needs.

Methods

Effective disaster management relies on the active involvement and collaboration of governmental bodies, civil society organizations, and the general populace. Engaging local communities in the recovery efforts following a disaster can mitigate the risk of future crises. However, the central government needs to adopt a deliberate political system that facilitates the participation of various actors. This study aims to evaluate the approaches included in the stakeholder participation plan prepared by the central government during the post-disaster recovery process and to develop a guiding framework with new strategies that will enhance social participation.

The research topic focuses on how the central government addresses social participation in post-disaster recovery processes. This necessitates asking the following questions:

How does the central government approach social participation in post-disaster recovery processes?
Does the strategy for community involvement in post-disaster recovery align with the established principles of participation as outlined in existing literature?

The first section explains the concepts of participation and disaster management and evaluates their relationship with each other. This paper examines societal-focused strategies in disaster management, providing both conceptual frameworks and methodological insights, while also identifying key principles essential for engaging

communities in post-disaster recovery, based on a thorough review of existing literature on these strategies. The second section examines how the central government involved local communities in the rebuilding after the February 6 earthquakes. The final section presents a conclusion and evaluation based on the assessments of all previous sections.

Within the scope of the study, concepts and approaches were examined to create a conceptual theoretical framework. As a result, the parameters affecting participation in contemporary Turkey and the issues that need to be considered were identified. As a result of these examinations, the stakeholder participation plan in the Earthquake Recovery and Reconstruction in Rural Areas Project (KADİYAP) carried out by the Ministry of Environment, Urbanization, and Climate Change with the financing of the World Bank was examined and the central government's approach to managing the participation process was evaluated. All information regarding the meetings to be attended by the public and the reports prepared after the meetings was announced on the General Directorate of Construction Works website. The data sources obtained from these reports are;

- Participation methods of the Stakeholder Groups determined within the Scope of the Project,
- Complaint Methods,
- Number of people attending official meetings held after the disaster,
- Question-and-answer sections of the meetings.

This data was evaluated using the participation principles determined from the literature.

Conceptual framework

The Concept of Participation and Participatory Processes

The term participation has been discussed and used in literature in various ways by different authors throughout history. Western authors have used it to understand the relationship between citizens and state institutions. Arnstein (1969) examined citizen participation and its relationship with the social imperatives of the time. In answering these questions, he created a participation ladder consisting of 8 levels of participation. Each step in these eight levels of participation corresponds to the degree of citizens' power to determine the final product (Figure :

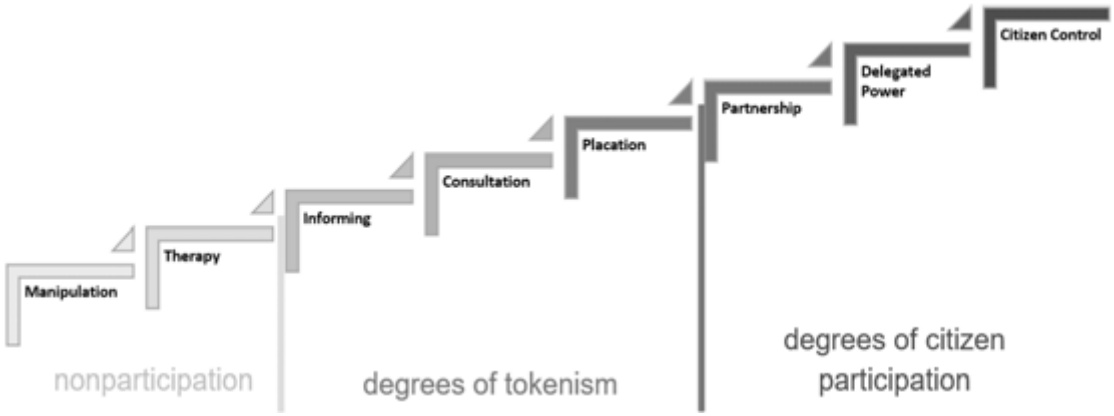

Figure 1: Arnstein's participation ladder

Many organizations, such as the International Association for Public Participation (IAP2), are inspired by Arnstein's participation ladder and propose a public participation spectrum. However, there are criticisms about these participation spectrums that do not cover all segments of the population in the world. For example, Cornwall and Goetz (2005) emphasize fairness to marginalized groups, especially women, in the radical redistribution of resources and power relations. According to authors such as Cornwall, Goetz, and Arnstein, one of the criteria to be considered in a participation process is to ensure a fair sharing of power.

From a planning theory perspective, efforts should be made to ensure that all interests are considered and met in a general plan during participation (Innes & Booher, 2002). This can only be achieved if the process includes all segments of society.

As Arnstein also mentioned in the participation ladder, participation is, in theory, the cornerstone of democracy. The OECD (2001) provided information on the elements that indicate the quality of democracy in its report on participation. Governments demonstrate the success of democracy through the transparency, accountability, and effectiveness of their policies and decision-making processes by increasing information, public consultation, and active participation. Governments must be responsible for using citizens' input received through feedback, public consultation, and active participation. In short, governments are expected to manage a transparent and accountable process by creating an area where citizens can actively participate.

Disaster Management and Post-Disaster Recovery Processes

To determine the criteria for post-disaster participation, scientists from various fields working on disasters were considered. Quarantelli, one of the pioneers of disaster sociology, considered disasters to represent fragility, reflecting "weaknesses in social structures or social systems" (Rodriguez, Quarantelli, & Dynes, 2006). In the same book, he mentioned that disasters are not just physical events. They affect individual coping patterns and the inputs and outputs of social systems. They are also rooted in the social structure and reflect the processes of social change. Due to the characteristics of the social system, it is fragile against disasters (Rodriguez et al., 2006). To better understand the vulnerabilities and responses of the social system during disasters, including local communities in the process, ensures a more effective and fair recovery. Geographer Cutter (1996) addresses the fragility of the social system by relating it to space. When addressing fragility spatially, he evaluates it according to its proximity to the disaster, the frequency of the event, its magnitude, and its duration. In the social system, factors such as infrastructures that meet basic needs, populations with special needs, poverty indicators, gender, and race are addressed (Cutter, 1996). It is of great importance to include all affected community groups, especially women, children, the elderly, the disabled, and ethnic minorities, in post-disaster processes.

Earthquakes have also been evaluated in terms of their impact on administrative processes and their effects on society. The United Nations Office for Disaster Risk Reduction (UNDRR) has prepared the Sendai Framework (2015) for disaster risk management at national and local levels, focusing on earthquakes. It emphasizes the shared responsibility between the central government and national authorities, sectors, and stakeholders, following national conditions as one of its basic principles. UNDRR has prepared a guide to support the implementation of the Sendai Framework, ensure the participation and ownership of all stakeholders in action, and strengthen accountability in disaster risk reduction. Another international organization, IFRC (2011), emphasizes transparent information sharing, meaningful beneficiary participation, effective and efficient use of resources, learning systems, and responding to concerns and complaints in line with accountability.

Oliver-Smith (2018) has studied the lack of such coordination in post-earthquake displacement processes. The basic approach of the post-disaster government is to maximize the number of houses built based on the idea of housing, leaving only a physical object to be transferred to the residents, who are given little opportunity to participate in the process. There was also harsh criticism of corruption and politically motivated aid distribution. In explaining the difficulties faced by both people and planners, he argues that a fully participatory approach is necessary because resettlement has inherent complexity, with "a range of factors from different orders such as cultural, social, environmental, economic, institutional, and political being interrelated." From Oliver-Smith's critiques of the post-disaster process, the importance of transparent information sharing in the participatory process emerges.

The conceptual framework (Figure 2) developed to evaluate the effectiveness of participation in post-disaster recovery processes is based on the principles of justice and power sharing, transparency and accountability, and inclusiveness. This framework aims to ensure equal access to decision-making processes for all stakeholders and to strengthen communities based on social equality. Transparency ensures that decision-makers are accountable to communities through the open and understandable flow of information, i.e., a responsible process. The principle of inclusiveness ensures the participation of all segments of communities in the processes. In addition, feedback mechanisms and continuity of processes enable more responsive and long-term solutions to be provided to the needs of communities. This framework is a one-to-one guide for effectively evaluating participation processes.

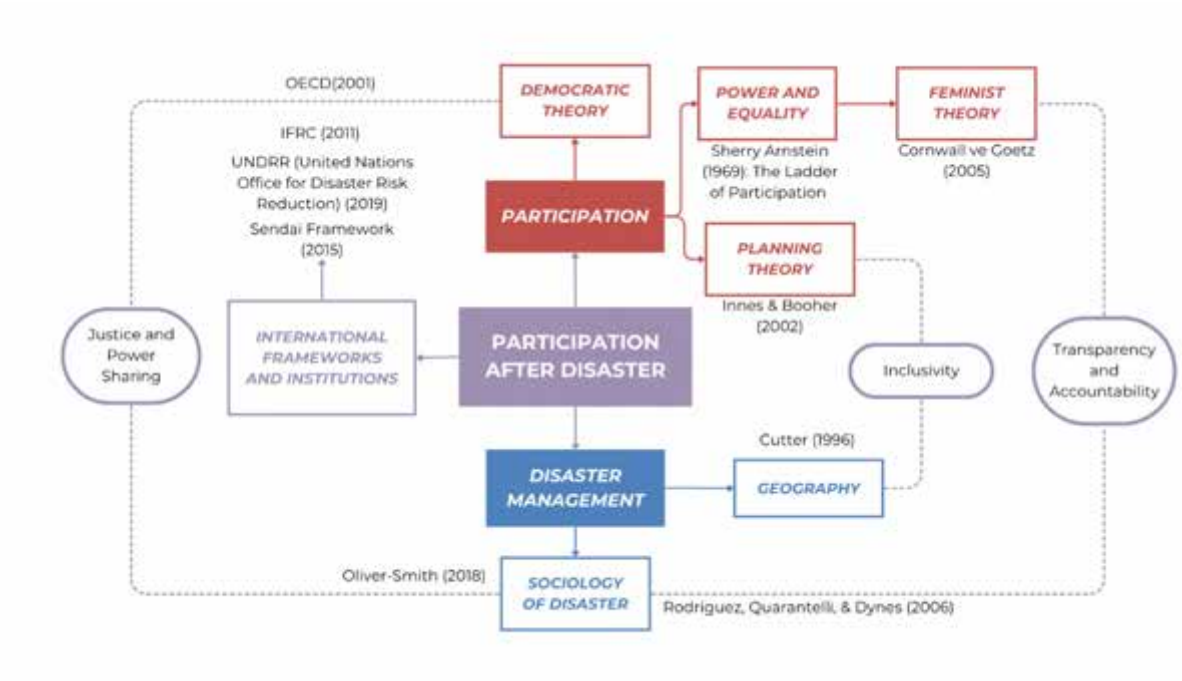

Figure 2 Conceptual Framework Created Based on Literature

Recovery process after the February 6 Kahramanmaraş earthquake

On February 6, 2023, two earthquakes centered in Kahramanmaraş with magnitudes of 7.7 and 7.6 Richter occurred, affecting 11 provinces and more than 14 million citizens. As 22 months have passed since the earthquakes, the government has begun to deliver the houses built after the disaster.

The Turkey Earthquake Recovery and Reconstruction Project (TDİYP) was developed for housing to be built in rural areas, managed by the Ministry of Environment, Urbanization and Climate Change (ÇŞİDB) and the Disaster and Emergency Management Presidency (AFAD). Financed by the World Bank, this project has prepared a Stakeholder Engagement Plan (SEP) per the ESS10 standard titled "Stakeholder Engagement and Disclosure of Information". The project aims to ensure continuous participation and consultation of its stakeholders throughout the project period.

The project aimed to conduct meaningful consultations with the stakeholders on;

i) designs,
ii) scope of agreements and financial obligations,
iii) identify other needs of stakeholders that can be considered/supported and match these with the existing support provided by the government.

After the damage assessment studies were completed, information meetings were held with the participation of the local people, mukhtars, NGOs, and district governors (Figure 3). The Q&A section of these meetings, where the concerns and suggestions of the people were received and housing designs were presented, was not reported because there was no ministry staff. As can be seen in the photograph in Figure 3, it was observed that there was little female participation in these meetings held in the first two months of the earthquake. In addition, the lack of reporting of Q&A shows a lack of transparency in participation.

Figure 3 Malatya-Akçadağ-17.03.2023

Project Stakeholder Participation
Project stakeholders and interested parties with a stake in the project are directly or indirectly affected. The implementation is aimed at being implemented with three basic principles;

- Openness and life cycle approach
- Informed participation and feedback
- Inclusiveness and sensitivity

It is planned that the participation activities of the determined stakeholders will continue throughout the project. All information regarding the meetings to be attended by the public has been announced on the YİGM website. Meetings are also held to receive the feedback of the muhtars for the houses whose construction process has been completed.

Inclusivity is A common theme in the participatory planning literature and project principles. Efforts have been made to provide participation support according to needs to include disadvantaged groups affected by the project, but cannot convey their concerns or understand the project outcomes (Table 1).

Table 1 Participation Methods of Stakeholder Groups Determined within the Scope of the Project (H: High; M: Medium; L: Low)

Stakeholder Group		Interest Level	Impact Level	Participation Method	Additional Resource Support
Direct Stakeholders	Rights holders whose houses were damaged	H	H	High Consultation meetings, Face-to-face meetings, CSIDB website, Digital communication tools, social media, Project information brochures/flyers, Online meeting, Grievance Mechanism (CM)	
	CSIDB, KTB, SB, UAB, ETKB, TOB, TB, Presidency of Religious Affairs	H	H	One-on-one meetings Official meetings, Consultation meetings	
Indirect Stakeholders	Landowners and land users adjacent to buildings, the Municipality, and neighborhood residents	M	H	Consultation meetings, CSIDB website, Digital communication tools, social media, Project information brochures/flyers, Online meetings, Grievance Mechanism (GMM)	
Other Relevant Parties	Governorships/District Governorships and municipalities	H	H	Communication (Letter, Phone, Emails) One-on-one meetings	
	Construction companies and workers, Consultants, controllers	H	M	Face-to-face meetings	
	NGOs – Associations at local and national level, Media, General public	L	M	Communication (Letter, Phone, Emails) One-on-one meetings Official meetings Consultative meetings CSIDB website Digital communication tools social media	

Vulnerable individuals or groups	Individuals with disabilities	H	M	Face-to-face meetings Audio devices Accessible platforms etc.	Special education needs Special education coordinators, Sign language interpreters/ Translators
	Elderly individuals	H	M	Face-to-face meetings Communication methods in inaccessible areas	Not required
	Immigrants, refugees, and non-native Turkish speakers	H	M	Face-to-face interviews Translated documents Special interpreters Communication in inaccessible areas	Translators
	Pregnant women and/or Women with young children Female-headed households	H	M	Face-to-face meetings Communication in inaccessible areas and methods	Not relevant
	Children	H	M	Face-to-face meetings Trained facilitators	Specially designed communication environments and approach
	People with post-traumatic Stress Disorder (PTSD) / mental health issues.	H	M	Face-to-face meetings Trained facilitators Psychologists	Psychological support

The fact that the disadvantaged group is treated differently in the project's stakeholder groups brings another question. While the beneficiaries whose houses were damaged are the ones who are directly affected and interested, the level of impact on the disadvantaged groups is at a medium level. No additional source has been provided regarding the inclusion of women whose houses were damaged, especially the women heads of the family. In addition, although it is stated in the report that regional organizations and NGOs representing the rights of the disabled will be discussed, these institutions and NGOs are not included in the report.

Stakeholder Engagement Activities

The report published in November 2024 includes information on the participation of stakeholders in the meetings. A table is provided where we can see the distribution of the participating stakeholders by gender. In this context, the information in Figure 4 from two different districts of the 4 cities where the meetings were held

is summarized. As seen in Table 1, although additional resource support is not deemed necessary for women's participation, women's participation varies from place to place. For example, in Malatya, women's participation is very low in the Pütürge district, while in the Ören district, women's participation is higher than men's. The same situation applies to Elazığ and Diyarbakır. In Adıyaman, it is seen that women's participation was very low in the first meetings that had just started. Table 2 also shows the number of houses to be built in the neighborhoods where these meetings were held. Here, there are neighborhoods where total participation is very low compared to the number of houses to be built.

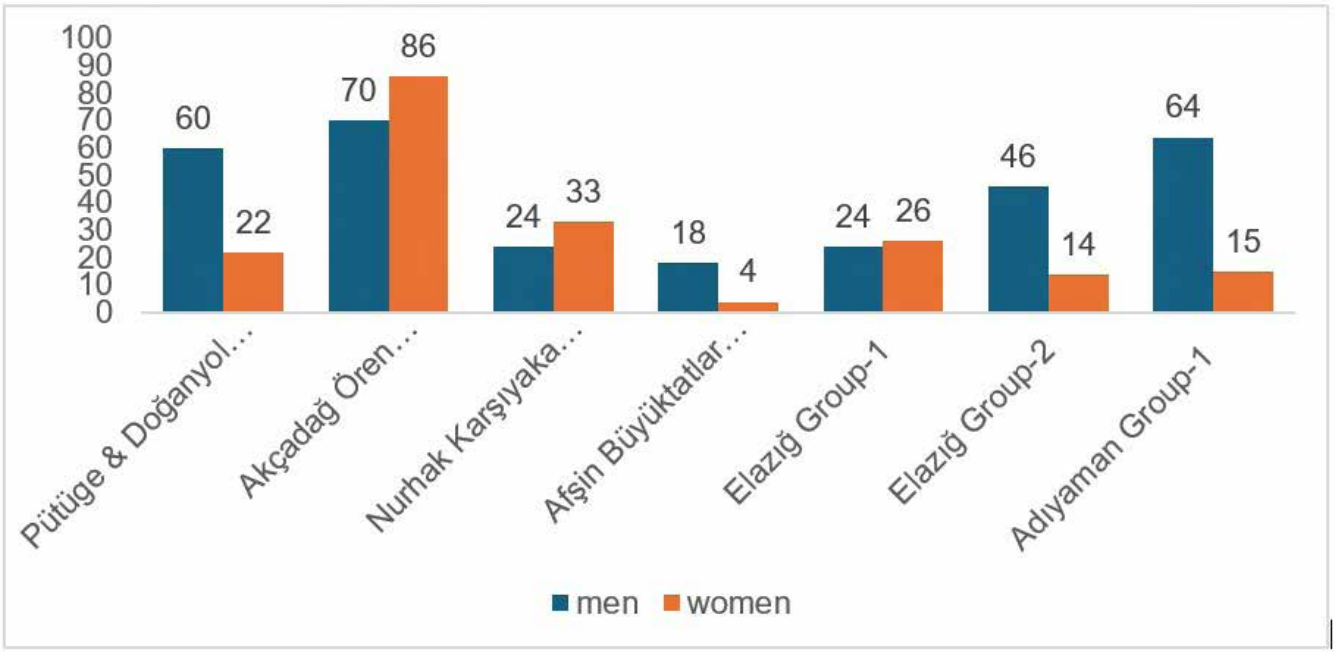

Figure 4: Number of male and female meeting attendance

Table 2: Participation in meetings and the number of houses to be built

	men	women	total	Number of houses to be built
Pütürge & Doğanyol /Malatya	60	22	82	105
Akçadağ Ören Mahallesi /Malatya	70	86	156	287
Nurhak Karşıyaka neighbourhood / Kahramanmaraş	24	33	57	243
Afşin Büyüktatlar neighbourhood / Kahramanmaraş	18	4	22	23
Elâzığ Group-1	24	26	50	79
Elâzığ Group-2	46	14	60	172
Adıyaman Group-1	64	15	79	80

Most of Dessup's reports are on the website under Environmental and Social Management Plans (ESMPs). These reports also include Q&A sessions from village-based meetings.

Dessup – 01 Malatya

The summary of the Q&A session at the meeting held in Malatya Ören Neighborhood on November 9, 2023, is given in Table 3. The ESMP prepared for the project was hung at the Neighborhood Headman's Office entrance in Container City for 1 week (Figure 5). In the face-to-face meeting,

- Social Expert from the Administration;
- Social Expert from the Audit Consultant (Koltek);
- Technical team;
- Construction Site Manager from the Contractor (Pekintaş);
- Neighborhood Headman participated.

Table 3: Public Participation Meeting – Questions and Answers

Questioner	Question	Answer
Neighborhood Resident	The application was rejected because the warehouse was not demolished and registered as a house.	The delivery process of the house is related to AFAD. It was suggested that he meet with AFAD.
Neighborhood Resident	Cost / Credit	to be determined by the President
Neighborhood Resident	Natural gas in new housing Infrastructure requested	It is not included in the current plan. However, the Ministry of Energy and Natural Resources may direct a revision of the plan.
Neighborhood Resident	An increase in the number of housing units was requested	AFAD determines it
Neighborhood Resident	It was stated that the debris removal works were not completed, and there was a health risk due to asbestos among the rubble.	It was stated that the previous debris removal contractor left the job unfinished shortly after starting. A new contractor has been selected and is expected to arrive on-site soon.
Neighborhood Resident	Tenants	It was recommended that the tenants apply to TOKİ.
Neighborhood Resident	Suitability of houses for disabled individuals	It was mentioned that the interior arrangements can be made after the houses are allocated if an application is submitted to the Administration.

As mentioned above, questions were asked about the many mistakes that went wrong in the village areas. It was also stated that the number of houses was insufficient for the neighborhood. Guidance was given by saying that these two issues were under the responsibility of AFAD. Since the fees and installment method of the houses were not determined, questions were directed about this issue, but no clear information was given by the authorized persons on this issue. Natural gas infrastructure was requested for the houses, but it was conveyed that it was not included in the project and that the project could be revised if the Ministry of Energy and Natural Resources decided. It cannot be said that a healthy question-and-answer process was experienced due to the absence of state institutions that were the addressees of all these questions.

Figure 5 ESMP Suspension Photos (November 3, 2023) and Public Participation Meeting Photo
Dessup-02 Kahramanmaraş

Dessup-02 Kahramanmaraş
The Environmental and Social Management Kahramanmaraş reports dated May 2024 stated that the meetings had not been held yet, and there was no information about them. In the Stakeholder Participation Report published in November 2024, only photographs of the meetings were included (see Figure 6).

Figure 6 Dessup-02 Kahramanmaraş PKT photos

Dessup-03 Elazığ
In Elazığ, villages were divided into three groups based on proximity, and meetings were held accordingly. The ESMPs were hung in the mosques, Mokhtar's offices, and village construction sites (Figure 7). Who will have access to the hangar hung on the construction site is unknown.

Figure 7 Kambertepe and Altınkuşak ESMP Hanger Photos

In the face-to-face meetings, authorized names from the construction came as in Dessup 1. Therefore, the problem of not having people to whom the questions were addressed in Dessup 1 continued. The inquiries posed during the meeting exhibit a greater degree of reproach compared to those in Malatya, primarily due to the involvement of individuals who experienced a loss of rights following the 2020 earthquake. Individuals who were unable to acquire legitimate ownership of the earthquake-constructed residences from late 2020 to 2023 were once more referred to officials at AFAD. Another sensitive issue was that the barn for animal husbandry, a vital source of income for the villagers, was not included in the project. Due to the nature of the emergency, officials consistently emphasized that only shelter would be provided. Despite the presentation showcasing various homes, attendees were more focused on inquiries regarding payment options and costs rather than selecting a property. A further concern involved religious venues and community amenities. Just like the barn issue, they are not included in the scope of this project.

Table 4 Public Participation Meeting – Questions and Answers

Questioner	Answering the question	Question	Answer
Village Resident (Saman)	EMAY (Social Expert)	The barn is our main source of income; how will we survive without it if the project does not include one?	Since this is an "emergency" project, priority has been given to housing construction. Unfortunately, the barn is not included in the project.
Village Resident (Halkalı)	Administration (Environmental Expert)	We, as a family, are victims of the 2020 earthquake. Our houses were also destroyed along with the houses that were determined to be severely damaged in the 2023 earthquake, and we were not given the right of ownership; we were left homeless.	This situation is within the authority of AFAD. There is nothing we can do about it as the Ministry.
Village Resident (Çakmakkaya)	Administration (Social Expert)	Why is our village being built somewhere else, everything we have will remain here. We, as a people, are not happy with the new settlement.	You can also submit this to the complaint mechanism as a request. The parcel will probably not change, but let's talk to the Ministry
Village Resident (Kambertepe)*	Administration (Social Expert)	The Site Plan has changed, our houses are being built in a different place than the parcel we previously accepted. We want the previous site plan.	There are conditions for changing the Site Plan, it cannot be changed without reason. It cannot be changed without the knowledge of the Contractor and Consultant. Please put your complaints in the complaint boxes.
Village Resident (Kambertepe)	Administration (Social Expert)	Everything needs to be rebuilt in the new place. These (mosque, imam house) need to be built urgently. Will these be built?	Places of worship and other social facilities are not within the scope of this project. All needs are evaluated in the site plans, and planning is done accordingly.

*Participants in Kambertepe did not sign the participant list because if they had, the location of the parcel would have been considered accepted.

Figure 8: Stakeholder Participation Meeting Photos

Complaint Resolution Mechanism:
The World Bank has established a transparent and accountable process for stakeholders to voice their complaints, concerns, and suggestions regarding projects it finances. This mechanism aims to document complaints and systematically provide feedback and learning. Table 5 outlines the various methods for stakeholders to file complaints related to this project's framework.

Table 5 Grievance Redress Mechanisms by Level

Level/Area	Implementation Details
PIU Level CCM	Confidentiality and Anonymity: The right to file a complaint is guaranteed. Registration Process: Complaint information is recorded in a complaint log by trained personnel. a. Stakeholder name and contact information (personal information is not shared with third parties). b. Details how and when the complaint was submitted, accepted, responded to and resolved.
National Level SCM	Complaint Channels: a. Presidential Communication Center (CİMER) b. Foreigners Communication Center (YİMER)
World Bank Grievance System	All projects financed by the World Bank have a Grievance Service (GRS).
Worker Grievance Redress Mechanism	Workers may use a separate grievance mechanism to report: a. Working conditions b. Financial concerns c. Child labor/forced labor d. Legal issues e. Workplace gender-based discrimination and sexual harassment.
Sexual Exploitation and Harassment Management	Grievance Line: A grievance line has been established to address SSI/ST cases arising from project activities. Labor Management Procedures (LMP): The August 2023 report details behavioral guidelines for contractor personnel to prevent sexual assault.

Ongoing KADİYAP Feedback:
The KADİYAP project has received significant feedback from stakeholders through the PIU. The most common complaints, suggestions, and concerns include:

- Issues with property rights.
- Dust generated by construction machinery.
- Damage to village roads from heavy equipment.
- Lack of appreciation for project implementation.
- Requests for additional housing.

The complaints received from the feedback are also common in the meetings. However, the central administration has made no new decisions regarding these complaints during the process. The process continues as it started. This mechanism is limited to listening to citizens only. In addition, if the responses given to the complaints received are in the form of directing them to another institution, as in the meetings, this participation will be put in a vicious circle.

My request for information via Cimer for the writing process of this statement has been left unanswered for 2 months. All these are elements that disrupt the transparency of the process. Finally, the feedback system for harassment management, which is explained in detail in the labor procedure, raises new concerns about the participation of women in rural areas.

Evaluation and conclusion

The stakeholder participation plan prepared by the central administration for the accountability of the KADİYAP project, financed by the World Bank, has been examined. It is the first study conducted in Turkey to ensure participation in a disaster of this scale. In addition, the World Bank announced in its press release published in December 2024 that it approved new financing to support the Improvement of the Agricultural Sector in Earthquake-Affected Regions of Turkey. This participation plan, aligned with KADİYAP, seems to lead the way for other projects. To eliminate the errors and deficiencies made in line with the literature for plans, 3 main criteria for participation should be emphasized.

The main goal of international organizations such as UNDP is to ensure democratic participation where stakeholders can have power in recovery through the participation process. However, in this project, stakeholders are content with only receiving information about the process. Most of the statements cannot be eliminated from being one-sided, such as not doing anything other than referring AFAD officials to the housing ownership situation, which is the most common issue in the Q&A section of the meetings. Power sharing between the central administration and the local government is achieved through mutual dialogue. Otherwise, as Arnstein mentioned in the participation ladder, the participation process is only manipulation. The participation process has been seen as a procedural requirement only, and no extra work has been done to include all disaster victims in the process fairly. Regarding the fair distribution of power, it is striking that Adana, Diyarbakır, Gaziantep, Hatay, Kilis, Osmaniye, and Şanlıurfa, out of the 11 provinces that experienced the earthquake, were not included in the reports, and there was no reason for not including them.

This brings us to another problem: the process is not being inclusive. As Cornwall and Goetz mentioned, marginalized groups should be worked with to distribute resources and power equally. Given that women's participation differs from one village to another, it is essential to assess field-specific strategies, and collaborating with village associations or NGOs could prove beneficial. Furthermore, the established complaint mechanisms can serve as excellent models of inclusivity globally. Nonetheless, the effectiveness of these mechanisms relies on the central government, leading to citizens' apprehensions about their involvement. Thus, it is crucial to align the complaint mechanisms more closely with the efforts of NGOs and local governments.

Another issue is transparency and related accountability. The project prioritizes this objective, leading to the establishment of meetings and the implementation of complaint resolution systems. However, there is a power dynamic created by a complaint mechanism that is completely dependent on the central administration. Gathering complaints directly under the central administration transforms participation into a system where the government controls the citizens. Communicating grievances directly to the government is a symbolic means of involvement. Their goal is to calm the public reaction against the administration rather than real change. Finally, for this plan to be interactive and participatory, it needs to create areas where stakeholders can negotiate among themselves, and it is expected to be a flexible and transformative process for the upcoming process.

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Identifying Barriers to Compact Urban Growth in the Irish Housing Sector: Insights from Industry Experts

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Abstract
Low-rise, low-density housing continues to dominate Ireland's housing sector, despite policy ambitions and climate targets that promote compact urban growth (CUG). This study investigates the persistent gap between national planning goals and actual housing delivery. Using a qualitative approach, semi-structured interviews were conducted with developers, architects, and housing experts to examine barriers to implementing CUG. Key themes that emerged include typology viability, embodied carbon, and future housing trajectories. Findings highlight regulatory constraints, car-centric planning practices, and market preferences for low-density housing as key barriers. These insights reveal a critical misalignment between policy and practice, offering a foundation for more targeted interventions to support sustainable, low-rise, medium-density housing in Ireland.

Keywords: Compact urban growth, housing delivery, planning barriers, embodied carbon, Ireland

Introduction

Ireland is experiencing an ongoing housing crisis (Ibec, 2023), with a system that fails to meet the needs of its growing population. Despite sustained policy efforts, housing output continues to lag behind demographic demand (OECD, 2025). In 2022, Ireland's population surpassed five million for the first time since 1851 and is projected to reach seven million by 2057 (Central Statistics Office, 2022). National policy currently targets the delivery of 33,000 new homes annually over the next decade, though recent analysis suggests that this figure may need to rise (The Housing Commission, 2024). However, if these dwellings are provided using a 'business as usual' approach to embodied carbon and a 'target achieved' operational carbon reduction scenario, Ireland will fail to reach its carbon targets (O'Hegarty & Kinnane, 2023).

Currently, the most delivered housing typology is low-rise, low-density, often located on greenfield sites on the edge of urban areas (SCSI, 2023). This model generates roughly 30% more embodied carbon per unit compared to infill alternatives, due to the additional infrastructure required (Brady et al., 2024). Shifting toward low-rise, medium-density infill housing could significantly reduce emissions while making more efficient use of land (Brady et al., 2024).

Irish government policy strongly supports compact urban growth. The *National Planning* Framework 2040 prioritises high-quality urban places and compact settlement, with 'Compact Growth' as the lead objective in the *National Development Plan 2021–2030*. Action 16 of *Town Centre First* promotes local TCF Plans aligned with this approach. The Sustainable Residential Development and Compact Settlements (SCSG): Guidelines for Planning Authorities (DHLGH, 2024) further support CUG through changes such as reduced back-to-back distances and lower parking requirements near public transport. Yet in practice, compact housing delivery remains limited: in 2022, 64% of homes were detached or semi-detached, while terraced homes—aligned with compact forms—accounted for just 19% (Central Statistics Office, 2022).

These patterns reflect Ireland's history of dispersed, low-density urban development (Mccafferty, 2019), marked by segregated land use, car dependency, and weak coordination between housing, transport, and planning (Mccafferty, 2019; O'Driscoll et al., 2023) . Despite policy commitments, spatial practices shaped by historic norms and infrastructure continue to dominate (Rau, 2009).

This paper examines the barriers to implementing compact, low-rise, high-density housing in Ireland. Interviewees were asked to identify current obstacles to delivering such housing, defined here as approximately 80 dwellings per hectare over four storeys on appropriate sites (RIAI, 2022). Drawing on semi-structured interviews with planners, policymakers, developers, architects, and housing experts, the study highlights the regulatory, institutional, and market challenges that constrain delivery. It offers a practice-based, multi-stakeholder perspective that contributes to ongoing debates on sustainable urban development and climate-responsive housing.

Literature Review

Defining Compact Urban Growth

The OECD (2012) frames CUG as a model that promotes efficient land use while reducing energy consumption and car dependency. In the Irish context, the Royal Institute of the Architects of Ireland (RIAI) defines compact urban growth as a strategic approach to urban development that prioritises building within existing cities and towns, rather than expanding into low-density greenfield areas. This concept focuses on optimising land use, enhancing sustainability, and improving the quality of life for residents (RIAI, 2020).

Complementing this, the *Sustainable and Compact Settlements Guidelines for Planning Authorities* (2024) frame compact growth as a key policy objective aligned with the National Planning Framework. The guidelines aim to accommodate 50% of housing growth within the existing built-up footprint of Ireland's five main cities, and 30% in other settlements, primarily through infill and brownfield redevelopment. This supports the creation of integrated, connected, and liveable urban environments that efficiently utilise existing infrastructure and contribute to national climate (DHLGH, 2024). To facilitate this, the RIAI promotes a low-rise medium-density housing typology, defined as own-door homes delivered at densities of 35–80 dwellings per hectare, which supports sustainable urban consolidation while maintaining compatibility with existing suburban contexts (RIAI, 2022).

Impacts of Compact Urban Growth

Empirical studies demonstrate clear environmental and energy-related benefits of compact urban forms. Zeng et al. (2022) show that compact growth significantly reduces carbon emissions by clustering development near services and infrastructure. Gaur et al. (2024) reinforce these findings in the Irish context, noting that dense urban areas exhibit lower energy demands due to reduced reliance on private vehicles and individual heating systems. Literature also supports a correlation between increased building height and lower embodied carbon. Drewniok et al. (2022) found that buildings with 4–6 storeys strike the optimal balance in terms of material efficiency and embodied emissions. Increasing urban density can further support sustainable development by reducing travel needs, enabling resource efficiency, and preserving land for agriculture.

Studies across major European cities, including London, Paris, Berlin and Istanbul, confirm that compact or taller residential buildings consume less energy than low-density, detached housing forms (Ding et al., 2022; Iddon & Firth, 2013). In Chinese cities, Ding et al. (2022) show a similar trend, with $CO\Delta$ emissions decreasing in compact urban configurations, though moderated by specific density thresholds. Iddon & Firth (2013) also highlight that apartment buildings tend to have lower operational energy use, particularly in temperate climates, while detached homes offer better potential for renewable energy integration in warmer regions.

Compactness also supports shared infrastructure, reduces land take, and facilitates more efficient public transport (Ding et al., 2022; Iddon & Firth, 2013). Beyond environmental performance, compact urban growth can deliver social benefits such as improved access to amenities, equitable transit, and more inclusive communities (Ahlfeldt et al., 2018; Burton, 2001). These benefits, however, are contingent on high-quality spatial design and governance. Anderson (2015) shows that shared outdoor spaces can significantly enhance community interaction and liveability, provided they are thoughtfully integrated.

Economically, compact urban development supports productivity through agglomeration effects and reduces infrastructure costs. Research by Glaeser and Resseger (2010) and Litman (2015) shows that mixed-use, high-density environments increase land value, commercial activity, and tax revenue. In the Irish context, Wall & Crowe (2024) find that centrally located coworking spaces in compact towns stimulate local economies by boosting footfall and supporting service-based businesses, reinforcing the broader economic value of compact urban growth.

Barriers to Implementing Compact Urban Growth

While the benefits of CUG are well established, its implementation is consistently challenged by institutional, regulatory, and market constraints. Zu Ermgassen et al. (2022) warn that without a shift away from low-density development, emissions targets will remain out of reach. Barriers such as restrictive zoning, high land prices, and fragmented governance continue to favour suburban expansion, even where policy supports more compact forms (Farris, 2001; Rode, 2018).

Developers face increased costs and unclear sustainability expectations, while planning systems often prioritise high-rise, small-unit models over diverse, medium-density formats (Candel & Törnå, 2022; Parker et al., 2023). Suburban aspirations, outdated tools, and undervaluation of compact housing further reinforce low-density ((Gilbert et al., 2020; Haarhoff et al., 2013). Suggested responses include zoning reform, pilot projects, and cross-sector collaboration to enable more responsive and viable housing strategies (Parker et al., 2023).

Parker et al. (2023), examining the case of Ontario, show that even where demand for mid-density, family-oriented housing exists, entrenched development practices and investor preferences sustain a high-rise-dominated model. Their findings highlight how institutional inertia and market logic can override both policy intentions and public needs. This evidence supports growing calls for more grounded, stakeholder-focused approaches to planning reform.

Despite strong policy backing for compact growth in Ireland, there is a notable gap in research on how those delivering housing experience its barriers. Most existing literature emphasises policy or spatial modelling, offering limited insight into real-world implementation. This study addresses that gap by exploring how planners, developers, architects, and policymakers in Ireland perceive and navigate the practical challenges to delivering compact, low-rise, medium-density housing.

Materials & Methods

Qualitative Research

This research employed a qualitative methodology, using semi-structured interviews to explore the research questions in depth. Semi-structured interviews occupy a middle ground between structured and unstructured formats, combining a predetermined set of questions with the flexibility to explore emerging themes based on participant responses (Robson & McCartan, 2016).

Study Design & Participants

Primary data was collected through ten semi-structured interviews carried out in May and June 2023. Interviewees included five home builder developers (private and semi-state), one approved housing body, two architecture practices, one estate agency and one quantity surveying practice. Participants were selected based on their membership of the Irish Green Building Council (IGBC) and Construct Innovate (CI), along with their experience in the delivery of housing at scale in Ireland (>100 unit developments). A full list of interviewees can be seen in Table 1.

All conversations were carried out online and lasted approximately 1 hour. They were recorded to enable verbatim transcription, and each participant was allocated a pseudonym. An academic peer review was carried out in advance to ensure ethical compliance.

Table 1: A List of Study Interviewees

Position	**Type of Organisation**
Quantity Surveyor, Director	Quantity Surveying Practice
Architect, Urban Design Team	Architecture Practice
Architect, Director	Architecture Practice
Head of Sustainability	National Developer
Managing Director	Estate Agent Company
Head of Design	Approved Housing Body
Architect, Director	Architecture Practice
Planner	National Developer
Architect, Design Manager	Semi-State Developer
Director of Design	National Developer

Interview Structure

To explore contemporary challenges in delivering compact urban growth in Ireland, a series of semi-structured interviews were conducted with housing industry professionals. The purpose of the interviews was to investigate three core themes: the viability of different housing typologies, strategies to reduce embodied carbon, and anticipated future trends in housing delivery. These themes were selected to align with national policy priorities and to understand practical barriers and opportunities from the perspective of practitioners.

A common set of guiding questions was developed (see Table 2), with additional prompts available to expand on specific responses. Each session began with a brief introduction to the research project and the interview team (a lead and a supporting interviewer), followed by a short self-introduction from the interviewee. This approach ensured consistency while allowing for flexibility to follow emerging insights in real time.

Table 2: Interview questions
Viability 1. What type(s) of housing developments do you find viable to build in Ireland within the regulations and density guidelines at present? **Barriers** 2. What are the current barriers to building low-rise, medium-density housing of circa 80 dwellings per hectare over 4 storeys on these sites? **Embodied Carbon** 3. Who is measuring carbon in the housing development industry at present in Ireland? 4. How can embodied carbon be reduced in the construction of housing developments in Ireland? 5. Are home-buyers concerned about carbon and/or Building Energy Rating (BER)? **The Future** 6. How do you see these housing developments evolving by 2030?

Results

Interview Results & Discussion

This section presents the results of the interview process, followed by a discussion of key findings and methodological limitations. Interviews were conducted via Zoom and transcribed using Otter.ai. The transcripts were then imported into NVivo for coding and thematic analysis. The discussion is organised around the key themes that emerged during this process and is supported by direct quotations from participants. Particular emphasis is placed on Question 1, due to the strength and relevance of the responses it generated.

Part 1: Viability

The first question asked of participants was what type(s) of housing developments they find most viable to build in Ireland within the regulations and density guidelines at present? Nine out of ten respondents stated that single-family dwellings in semi-detached or terraced format on greenfield sites at a density of 30-40 dwellings per hectare (dph) are most viable.

Architect 1 stated, "*The developer's answer to this is going to be houses, houses all day long. They can be built in a timber frame system, can be rolled out quickly, can be completed in phases and sizes that suit them; they can sell them incrementally, which works with their funding model.*"

Developer 5 echoed this sentiment, "*In an ideal world for us, it would be housing, pure traditional terraced housing... at the moment, because of interest rates and all the rest, the only thing that's viable is owner-occupied housing. Duplexes or apartments just aren't viable for the private market.*"

However, in order to achieve densities dictated by policy, higher-density models are also built as part of these developments. Two of the nine noted that, given the availability of the State as a buyer, these higher-density models are equally viable at present.

Developer 2 noted, "*In terms of low density, [we've] no issue selling privately all day long but having said that, there are other routes to market, which are available at the moment, which means that the high density schemes are perfectly viable in the current political or economic climate....*

What we're seeing now is that entire schemes or certainly entire blocks will be purchased by either the LDA [Land Development Agency] or an AHB [Approved Housing Body]."

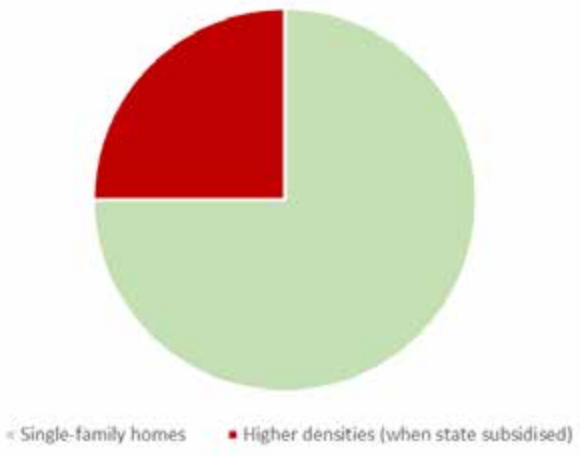

Figure 1: Industry Expert Responses to the Question: "What Is Currently Viable?"

Barriers

Interviewees were asked to identify the current barriers to delivering low-rise, medium-density housing, defined here as approximately 80 dwellings per hectare across four storeys on suitable sites. The two most commonly cited challenges were the difficulty of accommodating car-related infrastructure in line with stakeholder expectations identified earlier, and the increased costs associated with additional regulatory requirements. One underlying tension relates to the application of the Design Manual for Urban Roads and Streets (DMURS) — a national guidance document first published in 2013 and updated in 2019, which promotes street design that prioritises pedestrians, cyclists, and public transport within compact, walkable neighbourhoods (Government of Ireland, 2019). While DMURS supports reduced car dominance in urban areas, its principles are not always fully reflected in practice, where conventional standards around car access and parking continue to shape development layouts. This can limit the feasibility of delivering denser, low-rise housing formats on available urban sites.

Car-Related Infrastructure

The provision of, on average, two parking spaces per dwelling and associated roads limit achievable density. The reasons referenced for providing this quantum of parking, however, varied across interviewees; some attributed the issue to local authority requirements, while others related it to market preferences.

According to Architect 1, *"developers are very comfortable in the shared surface space and with DMURS and the reduction of the percentage of site that is occupied by road infrastructure."* Said architect noted the conflict between *"many development plan standards and DMURS and the conservative attitude of particularly the engineering departments within those local authorities"*.

This sentiment was echoed by Developer 5, who stated, *"Notwithstanding official policy, a lot of local authorities will still look for two parking spaces per house. We can live with one parking space per unit, but a lot of the time, they're looking for two. The planners will never override the role of engineers. The road engineers are still kind of the kings."*

Similarly, AHB1 noted a *"pushback from local authorities"* with regard to a reduction in the quantum of parking. Developer 1 stated, *"DMURS makes much more sense than the way we're forced to build roads around these estates. They are still predominantly car-focused rather than people."* One particular local authority dictates that houses are only built upon one side of a road: *"One of the issues we have from a density point of view is the requirement for roads that only have houses on one side."*

On the contrary, several interviewees stated that market preferences are the driver behind the quantum and type of car parking provided.

Developer 2 noted, *"Generally, we put a relatively high figure against the parking."* For example, in relation to Strategic Development Zones where there is a cap on parking, they stated that their *"marketing team are having to work hard to get their heads around how we sell something which doesn't have a dedicated parking space with it."*

Meanwhile, Architect 1 relayed anecdotal evidence from a homebuyer: *"If I can't see the headlights of my car from the sitting room, I don't want the unit."* However, it was added that this attitude is changing in well-connected locations.

Similarly, Estate Agent 1 noted that attitudes are changing within the market. *"The last six months have been transformative in terms of how people think around sustainability and their footprint. Last October [2022], nearly every other sale was cancelled because people were saying "we can't just deal with one car space", but there's an awareness now that it's the right thing to do, so it's less of an issue."* They also noted that *"Car charging is a much bigger issue now, so if you've off-curtilage parking, how do you charge your car?"*

Developer 3 described how these two issues of local authority requirements and market preferences are linked. *"The local authorities can say no. Fingal now wants 0.5 space for a 2-bed house. Now, that's all very well, in principle, but people are still going to buy two cars or at least a car, so it's going to be abandoned on the street, so your streetscape is going to be dire, there's no way of controlling that. Unless it's infrastructure-led, it just won't work."*

Costs

Respondents stated that higher density typologies (including duplexes and apartments) cost more to construct than houses and sell for less.

Developer 3 described the situation: *"A 2-bed apartment costs twice as much to build as a 2-bed house. A 2-bed apartment on average will cost €400,000 plus to build, a 2-bed house would be around €200,000/220,000."*

Estate Agent 1 echoed this sentiment: *"Typically, the guidance we're getting is that the duplex construction cost is somewhere between an apartment and a house. Then depending on where the policy supports are, the duplex will trade below a house".*

Developer 2 noted, *"If we had our way, we probably wouldn't want to build duplex blocks. They have a lower value than a house, and they're more complicated to build, so therefore, the return on them is lower than on the house."* The key factors contributing to the higher construction cost for denser typologies are outlined below in order of frequency mentioned.

a) Building regulations/Technical Guidance Documents (TGD)

According to respondents, when units are stacked to increase density, compliance with the building regulations becomes more complex. For example, accessibility requirements (TGD M) mean larger staircases and the introduction of lifts, while additional fireproofing between dwellings dictates a change to floor build-ups (TGD B).

Developer 2 stated, *"The regulations will dictate that we deliver a really high quality product. It makes them very expensive to build, and there's no getting away from that. If you had a four storey walk-up and you didn't have to put in lifts and so on and so forth, is that going to bring the price down? Yes, of course it is."*

Architect 2 backed this up *"What we're advocating for is that we make allowances to keep the existing provisions of Part M, to allow a duplex with an apartment on top or an apartment on the bottom with a duplex on top or duplexes stacked and also allow up to four floors with a Part M residential type staircase in the centre, which allows you to go 1800mm between breaks of landings, with two apartments per floor. That would really open up a much more economical way of doing housing with a provision to put a lift in at a later date if required."*

Architect 1 noted, albeit with an acknowledgement of the importance of the regulations, "*Over the last 10 years, nearly every aspect of the Building Regulations has become more onerous... the cumulative effect of all those things does make things more expensive. What would be useful is if there were percentages where there could be latitude. If you had, for example, 20% of units in a scheme that had a lower level of Part M accessibility, you will begin to see a different pattern emerging.*"

The method of construction for houses is familiar and quick. Much of the construction can take place off-site and is not reliant on specialist subcontractors or external design teams. Many respondents noted complexities associated with achieving compliance with TGDs when constructing duplexes and apartments using a timber frame system but stated that they are currently trialling solutions.

Developer 5 stated: "*Traditionally, for housing for a long time, we've been doing timber frame, but that's more of a cost decision rather than a green decision....I think it's challenging to do duplexes with timber frames. If we could do three and four-storey buildings in timber frame, I think that'd be a useful thing.*"

Developer 2 stated, "*We have trialled a model of using a fully timber-framed duplex unit.*"

Developer 1 noted, "*We'd like to go down the mass timber route for some of those [higher density schemes], but then we fall into the fire regulation limitations on that. That's something that is definitely holding back that side because we can find a business case for building with mass timber from the cost point of view, but it's something that just isn't as feasible at the moment with those fire regs.*"

b) Space standards

Back-to-back distances and garden sizes were noted by 40% of respondents as a barrier to compact urban growth. These interviews occurred during the summer of 2023, in the period when the Sustainable Residential Development and Compact Settlements (SCSG): Guidelines for Planning Authorities (DHLGH, 2024) released in January 2024 remained in draft (known then as the Sustainable Compact Settlement Guidelines). Discussions acknowledge the reductions in garden sizes and back-to-back distances proposed by the draft document.

Developer 4, who had examined the changes proposed by the draft SCSG noted, "*When we looked at it, it resulted in wider houses, your garden is shorter because they've reduced the back to back, but in order to get the minimum area, you end up building wider houses.... You end up losing out in the other dimension in terms of the density.*"

Developer 2 noted, "*At the moment, for a house, you have to [have] over 45 square metres of private open space etc. Whereas, for an apartment, you only need 7 square metres of balcony. Is there something that can happen there?*" They also stated the impact of these guidelines on typologies. "*Typically, to get over 35 or 40dph, you would have had to build some duplex blocks. With the compact growth [proposed SCSG guidelines], you may no longer need to build a duplex block; you could potentially do a scheme of all housing, quite compact housing onto a site now, just over 35dph.*"

Equally, regarding the internal layout of dwellings (and storage in particular), respondents noted the multiple standards and differing criteria depending upon whether a dwelling is classified as a house or an apartment. For example, as outlined in the '*Design Manual for Quality Housing*' and consistent with the 2022 '*Sustainable Urban Housing: Design Standards for New Apartments, 2022*', a 3-bed/5P House requires internal storage of 5 square metres while an equivalently sized apartment requires 9 square metres.

As Architect 1 noted, "*If you're providing a three-bedroom duplex, and you have to provide nine metres squared of storage internally within that unit, then it ends up being bigger than a house.*"

Developer 3 stated, "*The fact is, we have our minimum house area, but then we have about eight other sub-standards, minimum living room area, minimum living room width, and they don't relate to each other. So to deliver all those sub-standards, we have to inflate our house by 20% above the minimum.*"

With regards to apartments, Developer 4 has addressed this issue through the exclusion of en-suites. *"The way the areas have been set for apartments is if you don't have an ensuite, largely they're achievable. If you have an ensuite, it can be quite challenging to get down to the minimum areas."*

c) Financing

The manner in which the construction of lower-density houses is financed usually differs from that of multi-unit apartment or duplex developments. Houses can be built in small numbers and sold off incrementally to finance subsequent phases, whereas developers are often reliant on external sources of financing for longer periods of time when constructing higher-density typologies.

When referring to apartment schemes Architect 2 noted, *"All of those schemes depended on international funding, largely because you had to build the entire scheme out, and you have to finish the whole damn thing and pay the interest costs on borrowings etc, until the whole scheme is finished."*

While Developer 3 stated, again with reference to apartment schemes, *"So a lot of developers have to carry or forward fund that for up to two years before you get any profit, whereas, in a housing development, you can subdivide it and release sections."*

With regards to traditional low-density, low-rise houses, QS 1 noted, *"They can build 10, sell 10, build 10, they can self-fund."*

d) Planning risk

Due to the lengthy timescales associated with achieving planning permission, respondents were reluctant to take any risks in this area.

Architect 1 stated, *"At the moment, what our clients are saying to us is that it takes them multiple times longer to get planning permission than it does to build something. They can build a scheme in six months or a year, but it might take them two or three years to get to the point where they have planning permission, and that's a real problem."*

Developer 5 reflected this position: *"We know what the mix is, what the market is looking for, we know the local authorities, we have a relationship with individuals within local authorities, and we know what they look for."*

Developer 2 stated, *"We need to have a better agile planning system to give us more transparency in terms of timelines and more guarantees as well."*

Developer 2 noted, *"Do we just stick to what we know? There is a certain element of that, and there is a risk associated with bringing something new to market... It'd be safe to say that we don't take on planning risk very lightly."*
Architect 1 elaborated upon the relevant complexities within the planning system. Although these points were not raised in this manner by others interviewed, it is recognised that they are key regulatory drivers of issues noted by others, and as such, the information is included here.

A recurring theme among interviewees was the disconnect between national policy and local implementation, with local development plans often taking a more conservative stance driven by local objectives. As one interviewee noted, *"One of the benefits of the SHD (Strategic Housing Development) system was that when you were sitting in a tripartite meeting with the board and the Local Authority, the board was very, very clear that national policy was the primary legislation."*

In contrast, planning mechanisms such as Strategic Development Zones (SDZs) were viewed positively by developers for offering greater certainty and predictability in the planning process. One developer observed, *"I think the SDZ might be the favourite form of development model for a lot of developers. It gave them such security, making the planning process timely and predictable."*

Similarly, there was early enthusiasm for Urban Development Zones (UDZs) , though some uncertainty remains about their implementation: "*There was genuine excitement from developers when the idea of the UDZ first came out.*"

However, uncertainty around the release of updated planning guidance and standards is having a chilling effect on development. Several interviewees described how this lack of clarity is leading developers to delay or scale down projects. As one architect explained, "*Do we not think at scale until such a time as we have a new set of standards and some clarity on what has been achieved before 2030 in terms of sustainability and decarbonising?*" Finally, participants emphasised the need for a more agile mechanism for making small amendments to planning applications, arguing that the current process is overly bureaucratic and time-consuming. As one developer put it, "*So instead of a six-week turnaround on a quick change, which might be the trigger to releasing your project, it just doesn't happen at all because nobody has the appetite to go through that process for small changes.*"

e) Market preferences

A reluctance amongst home-buyers to purchase higher density own-door typologies such as duplexes or maisonettes beyond metropolitan centres was stated by almost all respondents as a barrier to compact urban growth. Respondents noted that semi-detached dwellings are seen as 'premium products'; end-of-terrace units sell for more than mid-terrace; and duplex units sell for less than houses. These market preferences influence site layouts and dictate terrace lengths.

Although duplex units or small apartment blocks are built as part of these developments to achieve densities dictated by planning regulations, developers' business model relies upon these units being sold back to the state for use as social and affordable housing due to a lack of appetite within the private market.

Developer 3 described this process: "*At the moment, with the current development standards, own door housing maxes out at about 31 units per hectare, so that falls short of the minimum 35 for Celbridge or Lexlip. You always have to introduce the apartments and duplexes to bring it up. Now, it's alright. We can offload a portion as social housing, but again, there is less demand for that.*"

Architect 2 elaborated upon the reason these typologies [duplexes and apartments] are favoured neither by estate agents nor the market. "*There is a predisposition in house builders against duplexes....Estate agents don't like them because basically, you've got quite a nice unit just upstairs, but the problem is you only get balconies, so you've effectively got an apartment over two floors with balcony accommodation.*"

Developer 5 stated, "*Traditionally, we haven't liked duplexes, I think largely because the ones that were built in the 90s and the naughties weren't very sophisticated. They were pretty ugly, looking very basic. We steered away from them, but we can't avoid it now. So we are looking at different ways of doing it. We are looking at things like perhaps a shared garden area at the back, rather than traditional back gardens of 60 square metres; that you would have courtyards that would be shared by families. That could address a lot of the bin store and bike store problems....*"

AHB 1 noted issues in accessibility associated with duplex units: "*...the problem with duplexes is my client is very different to what the private sector client is; there might be two or three young kids. If we have a ground floor unit for an elderly person and we have a 2/3 bed duplex above that, I'm asking someone to drag a buggy, or their shopping, up two or three flights of stairs potentially.*"

Of the private developer home builders interviewed, all relied upon a combination of in-house team expertise (customer research teams) and Estate Agents' knowledge to inform typologies. Developer 1 described this process, "*I have arguments with them [Estate Agents] about whether we should have heat recovery ventilation in a house. They say oh no, people would prefer an extra toilet.*"

While Estate Agent 1 noted the lack of built examples of compact urban growth available to inform home buyers of possibilities. "*We've been advocates of low rise medium density, we've been in Cambridge a couple of times, but we can't bring all the buyers to Cambridge to show them it.*"

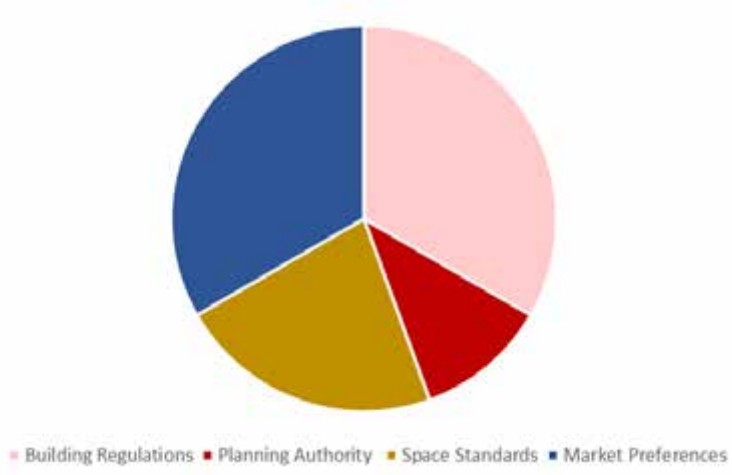

Figure 2: Industry expert responses to the question of what are the barriers to Compact Urban Growth?

Part 2: Embodied carbon
Interviewees were then asked three questions on the extent to which the stages of whole life carbon assessment influence design and construction decisions for these housing developments.

Firstly, when asked "Who is measuring carbon in the housing development industry at present in Ireland?", all developers, both private and public, responded that they are currently calculating the carbon associated with their developments; however, in most cases, this information has not yet started to inform any changes. Of the two architects interviewed, both stated that they are not currently calculating carbon, while the quantity surveyor we spoke to suggested that their profession is best placed to calculate embodied carbon.

Architect 1 referred to a first principles approach: *"We smuggled in a lot of thinking around this kind of stuff because it wasn't really on anybody's agenda."* They noted, *"Developers, from my point of view, are not really there yet. They're not forced to be there. Compliance with all the regulatory regimes is still very much their preoccupation."*

Architect 2 stated, *"Disappointingly no. We'd love to, but we haven't because we're mostly working in the private sector and haven't been asked to do it."*
Developer 4 stated *"We're asking our design teams to provide some analysis under embodied and operational carbon. We're still in the data collection stage of it.... we'd obviously see an alignment between reduced carbon and reduced cost in that sense."*

QS1 noted, *"Last year, we developed a tool to do the upfront embodied carbon calculation...We're now rapidly developing a tool to model the whole life because the conversations have changed so quickly from just the upfront embodied to the whole life assessment. It will be part of our remit, as QSs, anything that needs measuring and quantifying should sit with us."*

Secondly, when asked "How can embodied carbon be reduced in the construction of housing developments in Ireland?", the majority of respondents stated that they had not commenced addressing this issue but suggested solutions.

Developer 2 noted, *"I think it has to be legislation. If not, carbon tax. That'd be another big stick to threaten people with."* Similarly, developer 5 noted, *"I think the general assumption is that there's going to be a carbon tax, which is going to impact the cost of concrete. We're trying to move away from concrete."*

All developers interviewed stated that they were looking at solutions relating to the embodied carbon of the dwellings alone. Developer 3 noted, *"Infrastructure is going to be a challenge because that's where we haemorrhage a lot of our money and a lot of our carbon, below the ground. We're looking at solutions for the house at the*

moment but we need to come up with solutions for the infrastructure.... We're focusing on the units themselves and the houses and getting our typologies right so we can enhance our pre-manufacture value on those."

Three out of the four private developers interviewed cited Modern Methods of Construction as a means of reducing carbon associated with these developments. Developer 3 noted, *"We are removing the brick outer leaf because it is a high carbon offender. We want to go with a lightweight product"* in this with a synthetic product to mimic brick in order to *"bring the consumer on the journey."*

Architect 1 noted, *"Our clients from the private side are more aware of it now, but the decarbonising of transport as a solution is their main interest."*

Finally, when asked "Are home-buyers concerned about carbon and/or Building Energy Rating (BER)?", Estate Agent 1 summarised *"Of course, we want to buy organic if you could afford it, but if you can't, you can't."* implying that a higher cost is associated with a lower carbon home. In terms of their marketing strategy, they noted, *"It is less carbon footprint and more around community, diversity and biodiversity. There's a total acknowledgement in terms of the climate crisis, but we're not selling houses on the basis of the climate crisis."*

On the matter of BER ratings, Estate Agent 1 discussed the low impact from a cost perspective of different A ratings. *"When BER came in, there was a differentiation, and we'd be asked, and we're still asked, the difference between an A3 and an A1 or an A1 and an NZEB. To achieve those levels is really, really hard. It's nice to have, but it doesn't drive the value."*

This question was not discussed with other interviewees in any detail; however, developer 3 noted that *"millennials are very much invested in sustainable development and a reduction of carbon."*

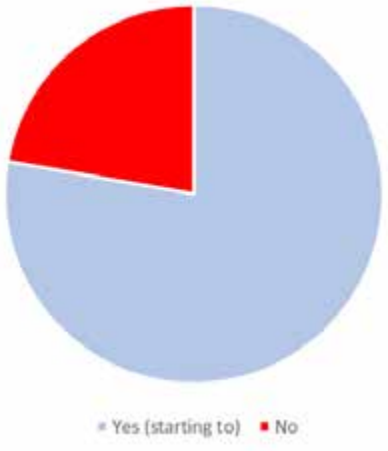

Figure 3: *Industry expert responses to whether embodied carbon associated with developments is currently counted?*

Part 3: The Future

Respondents were asked how they see these housing developments evolving by 2030.

The use of more modern methods of construction (MMC) was the most noted response to this question. Reasons noted for employing MMC included a diminishing labour force and the streamlining of the construction process. The ability to measure carbon was a secondary benefit of this approach. On MMC, QS 1 stated, *"I think the catalyst of carbon, the greater accuracy, and the reduction in waste.... It brings a cost benefit as well because of the efficiency, so it's a win-win. Higher quality, lower carbon, lower cost, quicker. It needs the economies of scale."* Developer 4 stated, *"We are trying to get our standardisation in place and then the next element of that would be to pursue a lot more MMC, which will hopefully improve the embodied carbon within the projects as well."*

Issues with the certification of new materials (such as more natural insulation or alternatives to brick cladding) are limiting options for innovation. Developers 1 and 3 spoke of the lengthy timelines and high costs involved in this process. Developer 1 noted that *"The certification process is so slow and so costly, we're looking at 18 months*

to get something approved, and then it is going to cost €60-70,000. So people decide to just keep going as we are.... it is a big restriction on how much innovation we can actually put into the homes." Likewise, developer 3 stated, *"certification could take you three to five years, it's quite constrained at the moment just to get one material certified in Ireland through the NSAI certification process."*

Developer 3 also noted the need to increase density. *"We need to increase density. At the moment it's 30 to 50, now that's changing to 40 to 80. I'd be cautious about going up to the 80. ... You can't have a low density housing scheme and then a very high density scheme right beside it in an area where there's no public transport."* Developer 1 referred to a reduction in dwelling sizes, *"It's also about reducing the size of our homes because the size of our homes in Ireland is crazy compared to the rest of Europe. So if we can reduce that, then we're reducing materials but yet giving people the same functionality in the home."*

Developer 2 focused on operational carbon, stating that energy efficiency is where they see the largest impact, *"the biggest dial turner that I can see now, based on what we know today, is energy efficiency."* Developer 5 also noted their attempt at addressing this issue: *"We have been unable to do anything in terms of district heating to date, not for the lack of asking the question on our side."* Developer 1 noted, *"We are definitely looking at more terraced houses because you can have more energy-efficient homes as they don't have as many exposed facades to lose heat through; that's something we're actively looking at."*

Key Findings and Their Implications

This study identifies a significant gap between Ireland's policy ambitions for CUG and the realities of housing delivery. Interviewees consistently pointed to low-rise, low-density, single-family homes on greenfield sites as the most viable option under current market and regulatory conditions. This preference is shaped by developers' funding models, construction efficiencies, and market demand for housing types that can be built and sold incrementally. While higher-density models are occasionally feasible, particularly when state bodies act as buyers, these remain exceptions.

Two principal barriers constrain CUG implementation: car-related infrastructure and regulatory costs. Although the DMURS promotes pedestrian-friendly, low-car environments, dominant expectations around car access and parking continue to shape planning and development practices. This car-centric approach inflates land and infrastructure costs, reducing the financial viability of medium-density schemes.

The regulatory environment also poses challenges. High compliance costs and vague sustainability requirements introduce uncertainty for developers. Fragmented governance and institutional inertia further reinforce traditional low-density development, stalling innovation. These findings echo international research pointing to zoning, land costs, and market preferences as persistent obstacles to compact growth.

Broader Context and Contribution

This research offers a grounded, practice-based perspective on sustainable urban development in Ireland. While existing literature outlines the benefits of compact growth, such as reduced emissions, infrastructure efficiency, and improved liveability, this study highlights the enduring gap between policy frameworks and implementation. It reveals how legacy planning practices, car dependency, and market dynamics continue to drive low-density outcomes despite national goals.

Achieving Ireland's housing and climate targets requires more than strategic plans. Addressing practical barriers is essential. This includes reforming parking and road standards to align with DMURS, streamlining regulatory processes, and fostering collaboration across sectors to encourage viable medium-density development.

Limitations

The study's small sample size of ten participants limits the generalisability of findings. Developers made up half the respondents, which may have biased the results. Future research should involve a broader range of stakeholders, including Approved Housing Bodies, planners, architects, and local authority staff.
Additionally, the qualitative approach carries the risk of bias, both from interviewees and interviewers, all of whom were trained architects. Despite efforts to maintain neutrality, this shared background may have influenced how responses were interpreted.

Nonetheless, the study provides valuable insight into the barriers to compact urban growth and offers a foundation for further research.

Conclusion

This paper outlines the regulatory, infrastructural, and market challenges that hinder compact urban growth in Ireland. It demonstrates how car-centric planning standards, regulatory complexity, and entrenched preferences for low-density housing continue to shape development patterns, despite policy commitments to more sustainable urban forms.

Although frameworks like the National Planning Framework and Town Centre First advocate compact, climate-responsive development, fragmented governance and policy-practice disconnects impede implementation. Addressing these issues requires coordinated action to reform planning norms, clarify regulatory expectations, and shift market dynamics.

With targeted interventions, Ireland can foster low-rise, medium-density housing that aligns with climate targets and urban liveability goals. Further research should evaluate the impact of recent policy changes, incorporate a wider range of stakeholder views, and examine the long-term implications of CUG strategies to inform evidence-based reforms.

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Navigating Conflicts and Paradoxes: Analyzing the Interaction of Urban Regeneration, Local Governance, and Public Policy in the Tirana Riverside Project

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Abstract
This paper critically examines the Tirana Riverside Project as a paradigmatic case of post-disaster urban regeneration in Albania, unfolding amidst the dual crises of the 2019 earthquake and the COVID-19 pandemic. These emergencies catalysed a shift toward centralized governance and fast-track planning, enabling the implementation of large-scale projects with limited community consultation. Drawing on five intersecting theoretical frameworks—rational planning, advocacy planning, collaborative planning, the just city paradigm, and post-disaster urbanism—the study interrogates the paradoxes between technical innovation and social justice. Using a mixed-methods approach, which includes policy analysis, spatial documents, grey literature, and resident's interviews, the study reveals deep disjunctions between the project's smart-city vision and the lived experiences of displacement, exclusion, and institutional opacity. The findings demonstrate that resilience-oriented planning, when detached from democratic governance and procedural fairness, risks reinforcing inequality and transforming into an alibi-urbanism. The paper advocates for a post-crisis urbanism grounded in transparency, participation, and equitable recovery, particularly in contexts of fragile and contested governance and transitional countries like Albania.

Keywords: Post-disaster urban regeneration, centralized planning, Tirana Riverside Project, governance and community engagement, urban complexity and policy innovation.

Introduction

Albania went through two crises in a row only a few months apart from each other: the earthquake on November 26, 2019, and the Covid-19 pandemic lockdown in march 2020. The human tragedies triggered by these dual crises and their post-disaster consequences, significantly transformed the policies toward the urban environment. Justified by the necessity of rapid responses in governance decision-making, the rebuilt process forced rapid innovation in governance structures and regeneration strategies. The reconstruction of the earthquake-affected areas and the strategy to expand into new territories, required a new *ad hoc* legislative framework. The new norms and regulations, approved by the Council of Ministers, as action plans were issued by the *ad hoc* Ministry of Reconstruction, working closely with local governments and the National Territorial Planning Agency (AKPT). Its ad hoc creation, transitioned decision-making on the urban environment into a more centralized, top-down planning model. Justified by the urgency of the situation and articulated within an exceptional legal system, the *ad hoc* norms and instruments utilized fast-track urban planning tools for disaster recovery and public necessity, establishing also a precedent for managing emergencies related to urban growth in the future.

One of the first decisions of the Council of Minister after the earthquake of 2019, was passed on December 24, 2019DCoM No. 887), aimed to expedite the formulation and ratification of the "*Mandatory Local Plan (PdyV)*"[1] in the targeted regions chosen as post-disaster rebuilding zone. This legislation enabled authorities to bypass existing planning procedures, prescribed by the Planning and Development Law 107/2014 (Kuvendi, 2014) identify new development zones (even on private land), and sanction urban designs without public consultation or municipal council approval.

The "5 Maji" area renewal masterplan, was approved on March 3, 2020. The Municipality of Tirana altered the zone's classification from "development" as approved by Tirana 2030 General Local Plan, to "redevelopment". This redesign of the general local plan, designed as a green isolated neighbourhood disregarded the city infrastructure, network, history and identity. Individual property rights were disregarded also, while compelled residents to relinquish their homes via a non-negotiable contract, frequently lacking transparent information regarding compensation or subsequent housing arrangements.

This research examines the Tirana River Project case study, the renewal project that was designed to replace the existing neighbourhood. Located in the northern part of the city, alongside the river of Tirana, the "5 Maji"

1 The Mandatory Plan was an ad hoc new instrument, that was added to the Planning legislative framework after the Earthquake of 26 November 2019.

neighbourhood, was organically created after the 90s, and was home to communities that migrated in the capital after the communist regime fell (Aliaj et al., 2003)which is continuous, and incorporates mixed structures and historical events. Tirana is a symbol of urban culture between the sea and the mountain, preserving Illyrian, Roman, Byzantine cultures in a Oriental atmosphere;... between European elements and those typical Mediterranean' and Balkans' ones; surviving from the most authoritarian urban planning discipline of fascism and communism to the most anarchist chaos of medieval and modern times of 21-st century...\n\nIn short, Tirana is actually one of the most dynamic cities in Europe and obviously represents a city of a typical and prolonged transition, which remains still the main and most dramatic challenge of the present days.\n\nStarting from 1920, Tirana city has been always subject to studies and works to improve its architectural and urban development. Several studies are carried out recently also since 1994 and today, the most significant to be are \"The Strategic Plans for the Greater Tirana and Kamza Municipality\", which constitute a full set of documents including the complexity of the numerous social-economical issues, land use principles as well as future activities, infrastructure needed for normal development, what represents so far, the most recent urban research work for Tirana and Albania.\n\nIn the eve of the new millennium Municipality of Tirana initiated important urban operations that are completely changing the image of the Albanian capital. Tirana Municipality's goal is to prepare a vision of development that is flexible and adaptable to the rapid changes of the city. This necessarily requires the complete reformation of the town planning legislation as a process that should go side by side with the development of the city. The new urban regulation of Tirana can serve as good starting point for the new package of laws on Town Planning, which the country needs desperately. The drafting of this new regulatory plan as a process and in partnership with many specialized institutions and other interested groups and communities, regardless of the differences that might exist, is likely to be efficient and not prone to raise contestations or create obstructions and urban chaos as it's been the case so far. Let us hope for a positive change in the future.\n\nIt bears stressing also that authorities of Tirana Municipality have realized that developing a new urban development plan should not be over estimated, for this plan cannot resolve automatically all the complicated problems of Tirana, except for it will raise transparency and will guide better the municipal administration in the process of outlining a clear vision for the city's development by considering improving the logic of development in the hope that distortions similar to those we have witnessed so far will be minimized and prevented.\n\nFollowing the lessons learned from the urban planning in the past, taking into consideration the current urban phenomena, as well as the new proposed urban plans for Tirana Region (what is described in this Guide. Approved as a mandatory local plan (PdyV), the ambitious 29-hectare urban regeneration project (Figure 1), designed by the Italian architect Stefano Boeri, aimed to transform this low rise, low density, into a dense and smart city district, "*an accessible and self-sufficient district from the point of view of clean energy, water, food, and all urban public services*" (Boeri, n.d.). According to the architect, this renewed district would be self-sufficient in energy and would have the necessary infrastructure to guarantee supply and quality of life even during lockdown periods (Boeri, n.d.) (Figure 2).

As part of the new development plan, the Municipality of Tirana required residents to sign a compulsory agreement to relinquish their property without acknowledging their properties development rights. Residents strongly opposed the demolition of their homes, citing a lack of trust, as accused the municipality for non being transparent on the aims and decisions made, particularly regarding the property "exchange" agreement, which lacked clear information about how the re-allocation would happen. Many reported they were only notified about the evacuation date, without any further details on where they would live in the meantime, their housing arrangements or even the procedures of their displacement.

To the government, this large-scale urban renewal project was necessary because it would house more than 12,000 people, many of whom were homeless due to the earthquake, while the others would be the new families and social housing (Figure 3).

The public interest discussion made room for the arguments used by both local and central governments to justify the project. Suddenly in December 2021, the municipality gave a short notice to the residents to empty and leave their houses while inviting them to apply for a rent bonus, but without success, as the residents refused to leave their houses and didn't agree to the budget for rent, which was half of what an apartment rent used to be in Tirana at the time. This situation triggered a daily protest from the residents, gathering at the entry of the main road reaching their neighbourhood.

"*The Masterplan, planned to accommodate 12,000 people, is a 29-hectare green neighbourhood, equipped with all the technologies of a Smart City and able to guarantee the safeguards and health safety requirements necessary to face contemporary seismic and pandemic emergencies.*" (Boeri, n.d.)

The Tirana Riverside Masterplan case study, is one of the 43 designated post-earthquake rebuilding and redevelopment zones declared by the Council of Ministers. It is chosen as through it we could analyse the interaction between technical planning, (presented as smart planning), and political policies during intricate recovery phases. It aims to answer the question of how centralized planning instruments in post-disaster contexts affect procedural justice and community agency in urban regeneration projects.

The article draws on a range of critical urban planning theories to frame the analysis of post-earthquake renewal and rebuilding in the case of the Tirana Riverside project in Tirana. The theoretical framework used for this research is organized around five main ideas that helped us think critically about the Tirana Riverside project. First the rational planning, then followed by advocacy planning, collaborative planning, the Just City concept, and the post-disaster urbanism. Jane Jacobs' critique of orthodox planning's is also part of the discussion. It addresses a significant deficiency by examining how post-crisis rebuilding in Albania, an EU-aspiring yet governance-challenged state, serves as a platform for *ad hoc* urban planning, democratic manipulation, and controversial regeneration. It contributes to a nascent yet underexplored domain that examines how disasters function as both spatial disruptions and political catalysts, particularly within weak democracies.

These situations, characterized by weak institutions, mixed governance practices, and informal land tenure systems, hinder fair and democratic recovery in these countries were achieving democracy is both a struggle and a challenge. There is a notable gap in research regarding post-disaster urbanism in transitional and post-socialist states, despite extensive studies in developed and institutionally stable countries like Italy and the United States. There is limited understanding of how crisis-driven regeneration interacts with political instability and spatial inequality, primarily due to the lack of focused studies in these contexts. Therefore, the case of Tirana, Albania, following two significant post-disaster events, is particularly relevant to the discussion on post-disaster urbanism.

The study employs a mixed-methods approach to investigate the complex dynamics of post-disaster urban regeneration, with a focus on the Tirana Riverside Project case study. Combining qualitative insights with quantitative analysis and documentary evidence, the research aims to provide a multi-layered understanding of governance practices, spatial transformation, and community impact. The governance practices are studied through the examination of institutional practices and decisions, while the spatial transformation is investigated through planning documents and site observation. To address the challenges of the community impact, interviews were carried out with the members of the community and urban activists involved in the process. Media articles from that period, public declarations by government officials have all served as sources of information for the research. The content analysis was the main framework used to analyse documents, and responses of the interviews.

Theoretical Framework

The philosophy of urban planning has changed a lot in the past hundred years. It was once technocratic and rationalist, but during time shifted to be now, more dialogic, participative, and justice-focused. The transitioned from the rational planning paradigm, which was popular after World War II, and saw planning as a linear, scientific, and expert-led process, to participatory raised a wide debate in the West scholars and researchers. This paradigm emerged as predominant in the post-war decades, influencing both the role of planners and expectations of planning outcomes.

According to Taylor (1998), objectivity and technical efficiency were essential to rational planning, as it was based on the positivist philosophy, which made it all about looking at data, setting clear goals, and finding the best solutions. The rational plan helped things recover back to normal quickly after the war, as it changed the way people thought about planning, especially when coming up with quick fixes after war-related disasters. The rational planning decision-making was a logical and rational series of steps based on facts, evidence, and a clear goal. This model of planning leads people to believe that only planners can engage in the planning process, viewing it as a scientific and technical endeavour.

Planners were seen as value-neutral (see Davidoff, page); as a result, they were in charge of finding the best and most practical solutions by gathering information and using logical reasoning. This planning model used to look at numbers and scientific facts, disregarding other problems like injustice, oppression, gentrification, and marginalization (Taylor, 1998). In the years following WWII, the 1960s-1970s, more and more people spoke out against this way of thinking, as it didn't include people in the process, which meant it didn't take into account real-life problems and local knowledge.

Jane Jacobs, in 1961, wrote an important critique in her book "Death and Life of Great American Cities" of what she called "orthodox planning" (Jacobs, 2002). She attacked rational planning at the very first pages of the book as a top-down model that ignores the complexity, spontaneity, and social life of real urban neighbourhoods. Jacobs criticized planners for being too abstract and for being detached from the day-to-day realities of city life. To the author, forced redevelopment often destroys the real things that make cities alive, like community networks, informal economies, and social diversity.

In 1965, another scholar, Paul Davidoff, came up with the idea of "advocacy planning. He stated that planners should speak up for groups that are underrepresented and disadvantaged instead of staying neutral. To the author, the planner has to take a normative statement, like a lawyer does for his client, to push for fairness and diversity in the process of making public decisions (Davidoff, 1973). Thus, planners should help groups that don't receive enough attention by changing the way the project is set up to ensure that to include their voices and to make sure everyone can participate and by making rules and changes.

To Davidoff, it is impossible to suggest appropriate planning from a value-neutral perspective because "*values are inescapable elements of any rational decision-making process*." (Davidoff, 1973, p. 423), and to do its job well, "*the planning profession must engage itself thoroughly and openly in the debate surrounding political determination*."(Davidoff, 1973, p. 423). To the author, fair notice and public hearings, which are meant to gather supporting evidence for further cross-examination, are important ways to find the truth and make sure that the decision is not biased (Davidoff, 1973).

After that, planning became more collaborative and communicative. According to Patsy Healey, *communicative planning* is a planned and cooperative process meant to help stakeholders reach an agreement with the inhabitants. Patsy Healey's collaborative planning theory changed the approach to planning from instrumental rationality to communicative rationality (Healey, 2003). It was based on Habermas's idea of communicative rationality but used in a real-world planning system, dealing with normative objections, building on them, and coming up with a new way of looking at planning as a communicative and negotiated process. To Healey, the planning process should be open, clear, and ongoing, and it should take into account local values and knowledge (Healey, 2003). The author put more value on talking, being open to everyone, and learning from others than working only on technical knowledge. This model of planning is especially important in communities that are broken up because it's easy to question the legitimacy of authority (Healey, 2003).

Fainstein's "Just City" thesis extends beyond the planning process to encompass the outcomes of such planning (Fainstein, 2010). According to the author, we should evaluate urban development based on fairness, democracy, and diversity, particularly when evaluating "green" or "smart" initiatives. When dealing with these initiatives, we should look at how well they redistribute resources, reduce unfairness, and extend power to marginalized groups. The author believes that this model is especially useful when dealing with a situation after a disaster because redevelopment can hide social and spatial exclusion by using progressive language. Susan Fainstein's "just city" view makes the collaborative framework better by saying that urban planners should work hard to achieve their goals, which should include diversity, fairness, and participation in democracy. According to Fainstein's lens, we need to look at smart cities and sustainable master plans and see if they really do promote fairness and give everyone the same chances (Fainstein, 2010, p. 117)democracy, and diversity are important considerations. This is in contrast with the city as growth machine. Fainstein examines three cities: New York, London, and Amsterdam. She provides a history of post–World War II planning and then focuses on fairly recent cases of development in each. Her goals, though modest, are important if growing inequality in urban areas is to be reversed. Recommended.\"— ChoiceFor much of the twentieth century improvement in the situation of disadvantaged communities was a focus for urban planning and policy. Yet over the past three decades the ideological triumph of neoliberalism has caused the allocation of spatial, political, economic, and financial

resources to favor economic growth at the expense of wider social benefits. Susan Fainstein's concept of the \"just city\" encourages planners and policymakers to embrace a different approach to urban development. Her objective is to combine progressive city planners' earlier focus on equity and material well-being with considerations of diversity and participation so as to foster a better quality of urban life within the context of a global capitalist political economy. Fainstein applies theoretical concepts about justice developed by contemporary philosophers to the concrete problems faced by urban planners and policymakers and argues that, despite structural obstacles, meaningful reform can be achieved at the local level.In the first half of The Just City, Fainstein draws on the work of John Rawls, Martha Nussbaum, Iris Marion Young, Nancy Fraser, and others to develop an approach to justice relevant to twenty-first-century cities, one that incorporates three central concepts: diversity, democracy, and equity. In the book's second half, Fainstein tests her ideas through case studies of New York, London, and Amsterdam by evaluating their postwar programs for housing and development in relation to the three norms. She concludes by identifying a set of specific criteria for urban planners and policymakers to consider when developing programs to assure greater justice in both the process of their formulation and their effects.","event-place":"Ithaca","ISBN":"978-0-8014-7690-7","language":"English","number-of-pages":"224","publisher":"Cornell University Press","publisher-place":"Ithaca","source":"Amazon","title":"The Just City","author":[{"family":"Fainstein","given":"Susan S."}],"issued":{"date-parts":[["2010"]]}},"locator":"117","label":"page"}],"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"} . The author believes this is crucial when people are forced to leave their only homes or are pushed out of society.

Vale and Campanella's (2005) theory of post-disaster urbanism provides us a new way to think about how the Tirana River Project came to be. This model of planning shows how disasters in cities can be both political triggers and physical barriers at the same time and space. The authors of the book "*The Resilient City: How Modern Cities Recover from Disaster*" (Vale & Campanella, 2005) argue that disasters are more than just physical breaks; they are "critical junctures" in the history of cities. (Vale & Campanella, 2005, p. 7) Disasters are rarely neutral; instead, they act as catalysts that bring out and worsen existing inequalities, making it easier for political and spatial agendas to be put into action quickly, even if they would have faced opposition otherwise (Vale & Campanella, 2005). To the authors, post-disaster governance, often under the pretense of urgency, enables bypassing regulations and consolidating authority through centralized control. In these situations, it can even employ emergency powers to change the urban configuration in ways that favor strategic or commercial interests. Thus, reconstruction is not merely about putting things back together the way they were before; it is selective, strategic, and often exclusionary, and the governmental actors and urban elites often use the crisis narrative to redesign and rebrand long-standing programs as essential for recovery. Their approach is called "opportunistic urbanism" (ibid.).

In addition to the five main planning theories, the case of Tirana's Riverside reflects also some elements of Austerity Urbanism (Peck, 2012)selectively targeting the social state, is a long-established trait of neoliberal governance, but it has been enforced with renewed systemic intensity in the period since the Wall Street crash of 2008. The paper develops the argument that these conditions are defining a new operational matrix for urban politics. Examining some of the leading and bleeding edges of austerity's 'extreme economy' in the USA, the paper seeks to locate these developments in the context of mutating processes of neoliberal urbanism, commenting on some of its social and spatial consequences.","container-title":"City","DOI":"10.1080/13604813.2012.734071","ISSN":"1360-4813","issue":"6","note":"publisher: RSA Website\n_eprint: https://doi.org/10.1080/13604813.2012.734071","page":"626-655","source":"Taylor and Francis+NEJM","title":"Austerity urbanism: American cities under extreme economy","title-short":"Austerity urbanism","volume":"16","author":[{"family":"Peck","given":"Jamie"}],"issued":{"date-parts":[["2012",12,1]]}}},"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"} which finds its place when urban crises legitimize extraordinary governance and reduce citizens' participatory rights in decision-making. Originally characterized by the transformation of cities in the US and Europe during periods of financial constraints, today it can used to refer to the impact of emergency narratives on urban governance, which potentially undermine democratic norms, instruments, and principles accepted before the emergency. Although Albania's situation does not arise from fiscal cuts, the political logic of using the crisis as an opportunity for governance closely resembles how austerity regimes function in Western cities. These regimes often bypass democratic norms and impose technocratic control under the guise of innovation and recovery.

This notion was particularly relevant in the areas recovering from disasters or crises, where it is essential to employ both analytical methodologies and participatory decision-making. Patsy Healey's collaborative planning pays attention to inclusion, conversation, and accessibility and shows us how important communicative rationality and the persuasion of many stakeholders are. Participatory planning inherently conflicts with technocratic, top-down approaches to planning, while Susan Fainstein's concept of the "just city" provides a framework for assessing whether democratic outcomes are equitable and diverse and that planning should be evaluated not only for its effectiveness but also for its impact on underrepresented groups.

The state of the art triggered some more questions regarding the case under study. Is the mandatory rebuilt master plan technically effective and at the same time socially equitable? Does the Tirana Riverside master plan embody inclusivity and participatory engagement by local stakeholders, replacing traditional top-down planning, or does it represent a form of "authoritarian greenwashing" that is justified by post-disaster emergencies?

These theories helped us to understand how community members navigate urban complexity after a post-disaster and the conflicts generated through the crise in transitional countries like Albania. The investigation allowed us to assess whether the Tirana Riverside project represents a democratic paradigm of post-disaster urban planning, or functions as a mechanism for centralized governance under the pretext of sustainability and innovation.

To ground these theoretical reflections in a real context, the following section examines the Tirana Riverside Project as a representative case study of post-disaster renewal in Albania.

Case Study: Tirana Riverside Project

The Tirana Riverside Masterplan is one of the 43 post-earthquake rebuilding zones, part of the governmental strategy to tackle post-earthquake disasters. The masterplan aimed to create a resilient and smart urban area that included smart mobility infrastructure, affordable housing, green spaces, high density, and integrated public transport access (Boeri, n.d.). The project was presented as a state-led initiative with centralized oversight, yet its success depended (and still does) on navigating the local governance environment and inhabitants' expectations.

The master plan, designed by Stefano Boeri Architetti and SON-Group, planned to accommodate 12,000 people in a 29-hectare "*green neighbourhood, equipped with all the technologies of a Smart City and able to guarantee the safeguards and health safety requirements necessary to face contemporary seismic and pandemic emergencies*," according to the architect's masterplan description (Architetti, 2020). Its concept advocated mixed use, mixed housing, cultural integration, public administration buildings, schools, playgrounds, and even cult buildings (Figure 1). Public services were organized into three pedestrian-friendly hubs, creating a zero-emission, polycentric community that included schools, administrative offices, and a university center (Architetti, 2020). The project also sought to achieve the involvement of local SMEs, facilitating economic revitalization and setting new benchmarks for urban excellence (Architetti, 2020).

Figure 1: Tirana Riverside Master Plan Layers and functions. Source: Stefano Boeri Architetti https://www.stefanoboeriarchitetti.net/en/project/tirana-riverside/

Presented as a post-disaster innovative project, the new redesigned neighbourhood promoted smart urban design capable of withstanding both seismic events and health crises. The new plan emphasized the creation of open green spaces, intelligent infrastructure, low-emission transportation, and sanitary facilities, which collectively reflect an advanced approach to urban planning (Figure 2).

Figure 2: The top view area of the plan being built; Source: Stefano Boeri Architetti https://www.stefanoboeriarchitetti.net/en/project/tirana-riverside/

Pandemic Governance and Its Influence on Urban Planning

Albania was already in a state of emergency due to the earthquake of 29 November 2019 when the COVID-19 pandemic emerged in early March 2020, exacerbating the situation. The Albanian Parliament declared a national state of calamity, imposing a lockdown on public life. This empowered the government to implement specific measures on health, territory, and administration, while the prolonged emergency persisted for several months, grounding terrain for facilitating expedited urban planning and development decisions (Këshilli i Ministrave, 2019).

The government, compelled to revise its urban development strategies to tackle the earthquakes and later the epidemic, used "normative acts" as the main policy documents alongside executive orders. With the power set by the emergency of both legislative and executive, to design expedited laws and by-laws, the council of ministers approved a new set of norms and new plans for the post-disaster crisis. This new legal framework seeks to govern the operations of entities tasked with the rehabilitation and reconstruction of towns and regions impacted by natural or other disasters, in addition to the development of new territories (Këshilli i Ministrave, 2019).

The new policies, positioned as recovery instruments, necessary and obligated by the disasters in a few days, redesigned and replanned massive parts of the urban and rural territories. 43 post-earthquake rebuilding zones were approved by the normative act No. 9, dated 16.12.2019, new neighbourhoods that would host the affected families. In this setting, governance evolved into a top-down, emergency framework that facilitates the rapid advancement of urban innovation, thereby normalizing accelerated design methodologies and allowing the rebirth of the broad, atypical metropolitan territory (Këshilli i Ministrave, 2019).

Figure 3: The masterplan official document; Source AKPT online upload

A Disjunction Between Vision and Lived Experience

"Tirana Riverside overlooks a river park dedicated to the community and designed to preserve an ecosystem capable of increasing biodiversity in the urban environment, becoming a refuge and biological habitat for non-domestic species, and promoting the creation of microclimates useful for the surrounding civic well-being." (Architetti, 2020)

The Boeri masterplan, was designed to be implemented in an existing built neighbourhood at the north of Tirana. Positioned alongside the river Tirana, the district labelled as "5 Maji" was home to hundreds of families. Some architectural magazines published at the time several articles about the Tirana Riverside Project as a good example of how to reconstruct cities after disasters by integrating smart technologies, green infrastructure, and mixed-use design (Ravenscroft, 2020). But the individuals who live in the vicinity of these rebuilding zones witnessed that there is a wide difference between what the project says it would do and what people really see. The difference brings up crucial questions about who will create the future of cities and who will be left behind in the process. It also shows how planning is done poorly in transitional societies following a disaster.

This 29-hectare area, 35 years before, was predominantly a suburban region characterized by low-rise structures and some collective housing. It functioned primarily as an agricultural zone, frequently of a semi-rural nature. After the fall of the communist regime in 1990, the authorities lacked the capacity to cope with people migrating within the country, while hundreds of families moved from rural areas toward the outskirts of the capital. One of the area affected by the migration displacement was 5 Maji zone.

Figure 1: Tirana Riverside Master Plan 3D Image. Source: Stefano Boeri Architetti https://www.stefanoboeriarchitetti.net/en/project/tirana-riverside/

In the absence of week institutional presence, they built their own homes by themselves, without any pre-approved projects or permits. Some of them even occupied the land, while others bought it but didn't have clear legal papers. In 2005, these buildings attempted to navigate via the legalization process and were declared as being built informally. But, unlike the gradual and negotiated substitution processes observed in Kashar and Astir (Kacani, 2024), the transformation in the 5 Maji neighbourhood was imposed more abruptly through top-down decisions.

The objective of the Boeri masterplan to transform, with the principle of *tabula rasa*, the current neighbourhood into a smart city meant tearing down the homes of more than 300 families. People who lived in the area didn't accept the idea of tearing down their houses, as they didn't see why they should tear down what wasn't damaged by the earthquake. They said they weren't briefed about the project or allowed to be part of the design process, and no negotiations were made possible for them.

Most of them declared that they found out about it through the news.

At the time of the project's approval, some homeowners were still seeking to legalize their properties and secure full ownership rights, but the government proceeded with the project's implementation and, due to the lack of legal ownership of the site, exercised eminent domain only partially, interest thus expropriation was easier as the compensation was not obligatory. This logic mirrors broader patterns observed in Albania, where informal settlements are often overlooked as legitimate socio-urban formations, and their residents are treated as obstacles to development rather than holders of urban rights (Aliaj & Kacani, 2020).

The municipality claimed that would be in the "public interest," arguing that the new neighbourhood will also be home to those who lost their houses in the earthquake. Even though they were considered "illegal residents" and had no recognized rights to the land, the government promised to facilitate their return to the neighbourhood once the rebuilding was complete. Through a contract of understanding, those who would sign would be granted a rent bonus of 180 euros and, afterwards, an apartment. Data from a structured survey of residents from the former "5 Maji" neighbourhood demonstrates that none of the respondents reported being meaningfully consulted at any stage of the planning or implementation.

From Displacement to Precarity

The negotiation process between the residents and the government unfolded in a tense atmosphere, characterized by early morning police operations that forcibly displaced individuals and demolished some houses. The government referred to this initiative as "displace by force and demolish" (Figure 5; Figure 6). Citizens. al, an online media outlet, has provided a detailed account of the forced displacement of individuals and the demolition of structures in the "5 Maji" district of Tirana in early 2022. The empirical analysis incorporates these real-time articles from the operation.

Under police protection, the Territorial Protection Inspectorate (IMT) demolished twelve residences on February 22, 2022. The operation commenced prior to dawn, while residents resisted by nonviolent protests, forming human chains, and confronting police, who deployed tear gas and made arrests. The on-site journalist sources narrate the violent demolishment of the "5 Maji" district to make room for the Tirana Riverside Project from the perspective of eyewitnesses. The article, "Five Stories from 5 Maji," complements this legal and procedural analysis with the personal testimonies of the individuals impacted (Ndrevataj, 2022).

A young man handcuffed himself to the rooftop of his house as a sign of the last resistance while the police forcibly removed him; an elderly woman who had to leave her home of thirty years and an emigrant couple who lost their life savings invested in informal housing frame the operation's narrative by highlighting the human cost of development under duress, where affected citizens are treated not as stakeholders but as obstacles to be cleared. Through these accounts, the Tirana Riverside project emerges not only as an urban planning case but as a socially and ethically contested terrain.

Figure 5: The demolishment operation of 5 Maji neighborhood. Source: Citizens.al, Facebook 09.02.2022

Figure 6: Police presence during demolishment process. Source: Citizens.al, Facebook 09.02.2022

None of the individuals impacted had executed contracts for compensation. Their attorneys asserted that the proposed contracts were inequitable and that their notarization was unlawful. The ombudsperson criticized the absence of explicit documentation, the deficiency of legally mandated compensation, and the employment of emergency legal measures to circumvent public consultation.

We conducted 10 semi-structured interviews with displaced residents in April 2025 to investigate issues related to displacement, institutional transparency, and community involvement. We performed an examination of urban density measures, land-use change patterns, and transportation accessibility indices in the areas before

and after the project. We performed a comprehensive examination of pertinent urban design plans, legal documents, policy briefs, municipal resolutions, and planning records. Attention was directed towards the normative legislation employed during the period of emergency and the formal redevelopment framework. We employed the triangulation of data to enhance the validity and dependability of the results. This integrative methodology facilitated the juxtaposition of official narratives with the experiences of impacted communities, revealing deficiencies in participatory governance and spatial equity.

A majority of respondents still live in temporary, substandard, or overcrowded housing, while the promised "smart neighbourhood" remains either inaccessible or unaffordable. Only a handful had signed return contracts, and even fewer had been reinstated. Nearly 60% of participants rated their current quality of life as worse than before displacement. Interviews uncovered material hardships, such as insufficient rent bonuses and legal barriers to property registration, and emotional and psychological stress due to prolonged uncertainty, social fragmentation, and the loss of community networks.

From Plan to Practice: Evaluating Tirana Riverside through a Theoretical Lens

As part of Albania's recovery plan after the earthquake, the Tirana Riverside masterplan, approved in 2020, promotes a smart and sustainable neighbourhood that can hold 12,000 people on 29 hectares. Stefano Boeri Architetti in charge of the masterplan, promoted smart housing, green transportation, biodiversity, and renewable energy systems, which all worked together and composed a resilient smart neighbourhood. On the surface, it fits with the rational planning model of Taylor, (1998), a target-oriented and data-driven, centralized, and efficiency-focused plan to deal with urban environments after crises. However, when viewed through the lens of Advocacy and Collaborative Planning, the project's legitimacy appears diminished.

Applying Patsy Healey's theory of Collaborative Planning (1997) to the Tirana Riverside Project is compelling, especially in light of Albania's post-disaster environment, which is characterized by institutional fragility, political centralization, and profound social heterogeneity. The goals and meaning of urban transformation are jointly shaped by a variety of actors, including citizens, public institutions, technical experts, and civil society, in Healey's lens, which views planning as a deliberative and inclusive process rather than a technocratic exercise. This approach stands in stark contrast to top-down, rationalist models, which place a higher value on efficiency, speed, and centralized control—frequently emphasized in post-crisis situations. The urgency of the COVID-19 pandemic and the 2019 earthquake in Albania resulted in a highly centralized planning response that left little room for local knowledge, dissent, or discussion.

Healey's caution is especially pertinent in this case: planning techniques that avoid candid discussion and consensus-building run the risk of losing their social acceptance and usefulness in fractured societies. The Tirana Riverside project kept away impacted communities from meaningful engagement, rather than encouraging a participatory dialogue on reconstruction. According to Healey's perspective, this case required not only physical reconstruction but also an institutional process based on equity, openness, and cooperative visioning—elements that were mostly lacking during the project's execution.

Healey says that the complexity of cities shouldn't be seen as a problem but as a chance to come up with new policies. Tirana Riverside shows how collaborative ideas at first glance can be questioned, changed, or used in a limited way.

Adding to this study, Susan Fainstein's (2010) idea of The Just City, we can look at both the processes and results of Tirana's rebuilding after a disaster. Collaborative planning puts a lot of weight on participation, discussion, and coming to an agreement through negotiation, while Fainstein argues that planning must also achieve substantive justice, especially in cities that are changing quickly and becoming more unequal while following neoliberal principles. Feinstein says that fairness, democracy, and variety should be the main ideas that guide decisions made in cities. The Tirana Riverside Project raises some important questions about these ideas. Has the improvement of the area made it easier for everyone to get to homes, public places, and services? Have people who used to live in the area gotten the right amount of money, been included, or been made full beneficiaries? How much does the project encourage people to interact with each other, and how much does it encourage people to stay away from others by making green spaces look nice?

While the Boeri smart project emphasizes eco-friendly mobility, rooftop gardens, and digital infrastructure, the social infrastructures necessary for just urbanism, such as housing rights, participatory accountability, and redistributive equity, remain critically underdeveloped. From a Fainstein (2010) perspective, the project fails to deliver on the core principles of the "just city," namely, that urban development must be evaluated not only by its design but also by its equitable outcomes and ability to empower the most vulnerable. This contradiction is especially salient in the context of the post-disaster urban redevelopment process, as Vale & Campanella (2005) have argued; crises often serve as catalysts for pre-existing political agendas, enabling the fast-tracking of plans that may otherwise have met community resistance.

In the case of the Tirana Riverside project, there is strong evidence that the earthquake was used to accelerate elements of the previously approved 2017 Tirana 2030 Masterplan, bypassing deliberative norms and replacing informal communities with formal architectural visions not shaped by those who lived there (Bateman, 2021). Further, this process reflects what Swyngedouw (2005) and Gunder (2010) critique as "post-political" urbanism: the masking of contentious political decisions under the language of resilience, innovation, and sustainability. The danger, they warn, is that "smart" cities become new mechanisms of exclusion, where design excellence is decoupled from social justice. The Tirana Riverside project is a good example of what Swyngedouw (2005) calls "Janus-faced governance. This implies that even though public discourse promotes new technologies, sustainability, and inclusivity, the planning process itself is still quite bureaucratic and exclusive. Both city and government officials told to the public stories about the 5 Maji, citizens that were both bullying and exclusionary, often labeling them "usurpers," "illegal," or suggesting they cared more about the interests of the opposition political party than their own family, while Boeri's project was shown as a solution to fix things after the earthquake and as a plan for a smart and powerful city. This behavior of both local and central authorities generated a "post-urban politics" where decisions were decided centrally and people became spectators of a growth tale that is shaped from top-down and imposed by force.

The government (both central and local) made decisions that were often communicated through general announcements in the media or on social media. These announcements didn't give enough information or allow for personal interaction with local government and its constituents. The fact that there aren't many ways for people to get involved is a major criticism of technocratic planning models by Healey (1997). She argues that these models always ignore the importance of local knowledge and different ways of thinking. People didn't see co-creation or meaningful consultation; instead, they saw what Miraftab (2009) calls "invited spaces," which are places with strict rules where community participation is predetermined, shallow, or non-existent (Miraftab, 2009).

Citizens.al (2021) investigative reports reveal that the transition from the "5 Maji" neighbourhood to the new smart and green city was characterized by a lack of transparency and the exclusion of residents. Important documents, such as the Compulsory Local Plan, were not made available to the public, and no public hearings or consultations were conducted. As a result, residents were unaware of decisions that would impact their homes and lives. Many residents were uncertain about whether they would need to relocate, receive compensation, or become part of the new community.

Many of the residents who were interviewed said that they were not allowed to legalize their homes before they were torn down, even though they were waiting for decades and even paid for the legalization procedure. This meant that they lost their property rights, and besides the fact that they lived there for more than 20 years, according to the civic code, they were eligible to be declared as owners. This goes against Davidoff's belief that planning should clearly recognize and support the rights of people who are politically disenfranchised. These testimonies strongly support Vale and Campanella's thesis on post-disaster urbanization, in which disasters are used to justify carrying out pre-existing development plans that often ignore justice, transparency, and citizen involvement.

Besides the right to the property and the right to an adequate house, the imposed plan, the violent arbitrary intervention, and forced redevelopment, according to Jane Jacobs's lens, destroy the things that make cities lively, like community networks, informal businesses, and a mix of different types of people.

The case of 5 Maji shows that centralized smart-city plans took the place of a neighbourhood that was built by the community but didn't involve the community. Jacobs' criticism is in line with what people in this study said, which shows that functional homes are being torn down without following the rules in the name of urban progress.

This critical lens let us look behind the appealing language of "green" and "smart" planning and instead focus on how these words were used in larger political and economic goals. The Tirana Riverside Project was shown as a symbol of forward-thinking urbanism, but our research shows how planning processes may be made less political and less democratic. It wasn't just a question of infrastructure or new ideas, instead it was also a question of fairness, inclusion, and power. These ideas make us think more about how post-disaster urbanism works in shifting and post-disaster situations and how planning, as both a field of study and a way to run a city, has to deal with the conflict between ambition and recklessness.

Conclusions and some final thoughts

The Tirana Riverside Project is a good example of how to rethink the stories, tools, and effects of urbanism after a disaster, especially when governments are changing and institutions are weak. At initially, the project was sold as a smart and forward-thinking redevelopment zone that would show how cities might be more resilient, adapt to climate change, be more resilient to pos-disaster, be adaptable for pandemic situations and come up with new innovative lifestyle. But doing it highlighted how hard it is to follow planning rules when they are enforced in a strict and top-down approach.

Our research shows that the project's official vocabulary, which included words like "smart," "green," and "resilient," was not backed up by processes that included everyone and focused on community involvement, spatial justice, or transparency. Instead, these ideas were used to justify actions that moved vulnerable people, ignored informal tenure, and went around deliberative governance. What was promised as change turned out to be a tightly controlled removal of informal urbanism, organized by business interests and hidden behind the language of innovation.

Masterplans and visualization techniques were useful technical tools, but they were also ideological tools that let people make cities without politics. This raises further concerns about how urban planning is being deployed in post-disaster contexts, not to protect or empower communities, but to control and reshape them. In moments of crisis, urgency is often manipulated to justify interventions that shut down negotiation and weaken democratic oversight. In the long run, planning shifts from being a tool for public good to a mechanism for state-led accumulation and investor confidence—frequently in conflict with the lived realities of those most affected by the disaster.

To truly understand post-disaster urbanism today, especially in transitional countries like Albania, we need to do more than just look at design frameworks. We need to ask important questions such as: Who decides what is an emergency? Who decides what to do? Who gains from the it, and who pays for it? These are not just questions about how things work or how to run things; they are questions about fairness. To rethink how cities work after a disaster, we need to face the hard truth that planning is often used as a way to keep people out of politics. It is important to stop the depoliticization of space and bring planning back to democracy, collective memory, and social repair.

Planning as a Field: Between Desire and Anger

The Tirana Riverside example illustrates a fundamental issue in the realm of urban planning: how to achieve an optimal equilibrium between the objectives of democracy and its function as an instrument of institutional aggression. Urban planning aspires to provide greener cities, equitable infrastructure, and adaptable lifestyles, on the other hand, it remains essential to the power structures that create the injustices it seeks to eliminate.

This contradiction increases in areas recently affected by a calamity, particularly in transitional democracies. When people experience a necessity for rapid action, planning frequently becomes expedited, more technical, and less sensitive to the social and physical contexts it influences. Projects are defined by polished presentations, global best practices, and indicators that are useful for investors. The complexity of local lives is either obscured or utilized as a mechanism.

Tirana Riverside not only demonstrated planning logic but also employed it: a progressive ideology that masked displacement, a narrative of inclusivity that concealed elite consolidation, and an aesthetic that rendered suffering invisible.

This indicates that the discipline is going through a more profound crisis. Planning is always subject to bias. It involves more than merely creating spaces or preventing rapid urban expansion. It constitutes a political act, a narrative concerning culture, and frequently serves as a means of exclusion. We must closely examine the frameworks employed to instruct, implement, and validate planning. What do our instruments represent? Whose voices are reflected in our plans? Whom are we assisting, and what is the expense involved?

To restore planning as a democratic and ethical endeavor, we must resist its allocation by market dynamics and governmental propaganda. It signifies acknowledging its role in exclusion while also advocating for its capacity to nurture, correct, and collaboratively create. A significant gap exists between aspiration and assertiveness that necessitates serious rethinking. In this context, planning is not imposed or removed, but conducted collaboratively with those who will be most impacted by its consequences.

In this domain, planning can initiate assistance not just for the city as an entity but also for the urban experience as a collective condition rooted in memory, conflict, belonging, and hope.

The TRP Dilemma and Post-Socialist Urbanism

The Tirana Riverside Project exemplifies post-disaster planning and the aftermath of socialism, all under the guise of authoritarian modernity. The initiative is formally designated as a "state-of-the-art urban regeneration project," although its execution illustrates how calamity can serve as a pretext for major changes in urban environments. The transition from ambitious masterplanning to social conflict indicates that knowledge of technology alone cannot substitute for ethical governance.

In the absence of explicit legislation and mechanisms for public engagement, regeneration is executed upon individuals rather than in collaboration with them. Our analysis indicates that the obligations related to inclusion and improvement were not fulfilled. New edifices and thoroughfares were constructed; yet, for several residents who previously inhabited the area, access to public services decreased. A significant number of individuals were compelled to relocate to the periphery or to temporary accommodations characterized by inadequate infrastructure and connectivity. The public transportation system is inadequate, and expenditures on walkability and social infrastructure have not increased correspondingly.

The majority of residents received inadequate compensation and poor alternatives. Standardized contracts, frequently signed under pressure, stripped individuals of their rights to negotiate, capitalize on increasing urban values, or maintain ties to their dwellings. A multitude of individuals possessed unsettled tenure claims, complicating their negotiation efforts. Engagement was superficial and hierarchical, with economic advantages going to private developers rather than the displaced populations.

Urban planning post-disaster must be equitable and inclusive of all stakeholders. This necessitates the implementation of planning strategies which are transparent, collaborative, and respect the rights and values of inhabitants. The increased density of residences and enterprises in Tirana Riverside Masterplan imposes greater pressure on the city's current infrastructure, particularly its roadways. Insufficient funding for public services may exacerbate traffic congestion and marginalize individuals from society.

The master plan orchestrated by Boeri promotes sustainable mobility, verdant thoroughfares, and cohesive transportation; yet, it lacks detailed information regarding the practical implementation of these systems. It displays roads, but not the traffic conditions. Public transit appears to prioritize managing the present rather than anticipating the future. It fails to consider the hundreds of thousands of square meters of dwellings that will shortly be occupied. The project may become an isolated enclave without multimodal, high-speed transit linking Tirana Riverside Masterplan to the northern periphery of Tirana.

The inconsistent utilization of public transit and infrastructure raises concerns around greenwashing and symbolic. It illustrates the compatibility of a progressive style with retrograde politics and underscores the paramount importance of critical, justice-oriented planning.

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Public-Private Joint Ventures in Urban Area Development: Identifying and Governing Value Tensions

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Abstract
Public-Private Partnerships have been widely applied across Europe. However, critical perspectives question whether PPPs can safeguard public values or prioritize private interests over societal goals. Public-Private Joint Ventures (PPJVs) face particular criticism for governance designs that benefit efficiency while potentially undermining transparency and accountability. This paper examines Dutch PPJVs in area development. By adopting theoretical perspectives on contractual and relational governance, the study explores how these shape value tensions. Evidence from interviews suggests that although value tensions are not explicitly governed as such, they are affected by contractual and relational governance aimed at securing interests, mitigating risks, and managing opportunism, indicating reciprocity: underlying values give rise to diverging interests, which actors manage through contractual and relational governance—that, in turn, shapes how value tensions emerge and are addressed throughout the collaboration.

Keywords: urban development, Public-Private Partnerships, value tensions, Public-Private Joint Venture, public value

1.Introduction

Public-Private Partnerships (PPPs) are often seen as promising governance strategies for tackling complex urban challenges by leveraging the complementary strengths and resources of public and private actors — particularly in the European context, where PPPs have been widely applied since the 1990s (Ansell & Torfing, 2021; Hodge and Greve, 2007; Kort and Klijn, 2011). Meanwhile, literature raises critical perspectives on PPPs, particularly regarding their ability to safeguard public values. Scholars question whether PPPs foster public value creation, or whether they risk prioritizing private interests over broader societal goals, especially when governments take on a primarily facilitating role (Mazzucato and Ryan-Collins, 2022). Public-Private Joint Ventures (PPJVs), in particular, face criticism for governance designs that distance local politics from operational decision-making, benefiting progress and efficiency on the one hand, but potentially undermining values such as democratic legitimacy, transparency, and accountability on the other (European Commission, 2004; Reynaers, 2014; Tasan-Kok *et al.*, 2019). Another critique is that the differing organizational cultures and objectives of public and private actors can lead to conflicts over priorities and decision-making processes, potentially undermining the effectiveness of the partnership and putting public goals or values at stake (Van der Wal, 2008).

While much of the existing research on PPPs focuses on infrastructure or public service delivery, there is comparatively less attention for PPPs for urban development projects, specifically area development—as governance process towards realizing area-based spatial projects that includes important planning work. Moreover, there is limited empirical insight into how value tensions are experienced by stakeholders in planning practice, and how they manifest in partnerships. The first aim of this paper is therefore to identify value tensions through literature and empirically explore how they become evident within Dutch area development PPJVs.

By framing the Netherlands as exemplary context, this paper provides nuanced insights into the governance of value tensions in area development. Rather than seeking definitive solutions, the paper seeks to contribute to a better understanding of the influence of relational and contractual governance on value tensions in PPJVs, and to inform ongoing discussions about governance models that can support public value creation by governing tensions assumed to be inherent to these partnerships.

The Dutch context is illustrative for a declining trend in number of PPP projects across different sectors throughout Europe (European Investment Bank, 2016, 2024). Following a period of pioneering with PPPs under the Fourth Memorandum on Spatial Planning Extra (Vierde Nota Ruimtelijke Ordening Extra: Vinex) policy programme since the 1990s, the financial crisis of 2008 led to a decline in the use of PPPs in area development in the Netherlands, with many partnerships being dissolved or restructured (Heurkens, 2012; Buitelaar, 2014). Recently, there has been renewed interest in PPPs as Dutch area developments seek to address challenges such as housing shortages, sustainability, and social equity (BPD, 2023; Hümmels, 2017; Ten Have *et al.*, 2017).

This renewed attention prompts questions about what can be learned from earlier partnerships, particularly regarding the management of value tensions: how can governance arrangements in this new phase of PPPs be improved to better accommodate the inherent value tensions that arise in such collaborations?

This paper adopts theoretical perspectives on both contractual governance—emphasizing formal agreements to structure exchanges between actors—and relational governance—focusing on relational aspects such as trust, communication, and shared norms (Cao and Lumineau, 2015; Warsen *et al.*, 2019). While both approaches are seen as relevant to explain the performance of partnerships, their interplay and influence on value tensions in area development PPPs remain underexplored. The second aim of this paper is therefore to demonstrate empirically how contractual and relational governance mechanisms shape the emergence of value tensions in Dutch area development PPJVs.

2.Method

Empirical material for this research was collected through eight in-depth, semi-structured interviews conducted in 2024 with professionals engaged in joint ventures for large-scale area development projects in the Netherlands. While the primary focus of the study was not on contractual or relational governance or value tensions, the interviews did address these themes and thus offer valuable insights into stakeholder perspectives within Dutch PPPs. The interviewees were selected based on their extensive experience in joint venture developments and included three directors of PPJVs—either operating independently or seconded from municipal organizations—two senior executives within PPJVs, two professionals serving as supervisory board members or shareholders, and one senior manager with broad experience in PPPs from a major urban development firm.

These interviews were conducted and coded using Atlas.ti as part of the first phase (focused on the evolution of PPJVs from an institutional perspective) of the author's PhD project. The analysis of value tensions presented in this paper offers an initial empirical exploration of this theme. While the findings help to formulate and ground hypotheses, further empirical research is planned to deepen these insights.

In addition to the interviews, the research was informed by a literature review and by informal conversations with professionals throughout the research process. These included discussions with practitioners during thematic sessions at professional conferences, which provided further context and helped to validate and nuance emerging insights.

3.PPPs: Value tensions and governance challenges

3.1 (European) perspectives on PPPs and tensions

Despite the widespread application of PPPs, their impact on public values remains a subject of debate among scholars. This section discusses both the arguments in favour of PPPs and the main criticisms, and identifies several value tensions that can arise in PPJVs.

Proponents argue that PPPs can create synergies between public and private sectors, leading to improved efficiency, innovation, and value for money in public service delivery (Hodge and Greve, 2007). The involvement of private sector expertise and financing is seen as a way to overcome public sector resource constraints and deliver projects more efficiently (Kwak *et al.*, 2009). Some scholars suggest that PPPs can enhance public value by accelerating developments, improving service quality, and generating wider social benefits (European Investment Bank, 2011). Advocates claim that PPPs can improve risk allocation by transferring risks to the party best equipped to handle them (Grimsey and Lewis, 2002). This risk transfer, combined with private sector incentives, is argued to result in more realistic planning and improved project management (Verweij *et al.*, 2021). The long-term nature of many PPP contracts is also seen as encouraging a life-cycle approach to asset management and service delivery (Roehrich *et al.*, 2014).

However, critics have raised concerns about the impact of PPPs on public values. Some argue that the profit motives of private partners may conflict with public interest objectives, potentially leading to a prioritization of financial returns over social outcomes (Hodge and Greve, 2010). The complexity and long-term nature of PPP contracts can also make it difficult for governments to maintain flexibility and adapt to changing public needs over time (Willems and Van Dooren, 2016).

There are also concerns about the transparency and accountability of PPPs. The confidentiality often surrounding PPP negotiations and contracts can limit transparency and democratic oversight (Siemiatycki, 2007). Critics argue that this lack of transparency can increase the risk of corruption and reduce public trust in decision-making processes (Boardman and Vining, 2012).

The impact of PPPs on public sector capacity is another area of debate. While proponents argue that PPPs can bring in private sector expertise, critics worry about the potential hollowing out of public sector expertise. Over-reliance on private partners for critical functions can diminish institutional knowledge within the public sector, leaving governments less capable of independently managing future projects (Jooste and Scott, 2012; Osborne *et al.*, 2010).

Based on the discussion above and additional literature, several value tensions are relevant in Public-Private Joint Ventures in particular and displayed in table 1. These value tensions illustrate the governance challenges that PPJVs face in aligning the objectives of public and private sector partners.

Table 1: Key value tensions between public and private partners in Public-Private Joint Ventures.

Value Tension	Public Sector Perspective	Private Sector Perspective	Source(s)
Public value vs. profit maximization	Focus on equity, accessibility, and long-term social benefits; public interests are central	Primarily concerned with profitability and efficiency; financial outcomes are key	Osborne *et al.*, 2010; Greve and Hodge, 2010
Accountability and transparency vs. confidentiality & efficiency	Must be transparent and accountable to citizens; open decision-making is important	Prefer confidentiality to protect competitive position and avoid political interference	Forrer *et al.*, 2010; Willems and Van Dooren, 2016
Risk transfer vs. risk minimization	Seeks to transfer significant risks to private partners but wants to keep control over key services	Tries to minimize own risk while maximizing returns; prefers clear limits on risk exposure	Burke and Demirag, 2017; Greve and Hodge, 2010
Bureaucratic stability vs. market-driven agility	Follows stable, bureaucratic processes and formal procedures	Values flexibility and quick decision-making; prefers agile approaches	Huxham and Vangen, 2010; Villani *et al.*, 2017
Public control vs. private governance	Wants to maintain strategic control to ensure public goals are met	May have more influence over governance due to financial input or expertise	Hodge and Greve, 2010
Social impact vs. financial performance	May define success by social outcomes and long-term benefits	May define success by financial performance and measurable returns	Grossi *et al.*, 2017
Public ethics vs. private interests	Guided by public sector ethics and pursuit of public value	Driven by profit, which may sometimes conflict with public sector ethics	Reynaers and De Graaf, 2014

3.2 Contractual and relational governance

The value tensions outlined above illustrate the complex challenges that PPJVs face in balancing public and private interests. To better understand how these tensions are addressed in practice, it is essential to examine the governance mechanisms that underpin these partnerships.

The following section explores the role of both contractual and relational governance arrangements in shaping the dynamics and outcomes of PPJVs.

Traditionally, many PPPs are structured around detailed contracts that define risk allocation, responsibilities, performance metrics, and provisions for sanctions if performance is inadequate (Solheim-Kile and Wald, 2019). While PPPs are often associated primarily with their contractual nature, they actually encompass more than just these formal agreements between public and private partners. These partnerships also rely heavily on relational elements, such as trust, communication, commitment, and mutual respect, which can play a crucial role in the success of the collaboration (Cao and Lumineau, 2015). Such relational factors are key in managing project uncertainties and changes. A strong partnership enables the parties to address issues that go beyond what the contract stipulates. This relational dimension is slowly gaining more recognition in PPP research (Warsen *et al*., 2019). Literature identifies numerous critical success factors to explain the performance of PPPs, which can be traced back to two main theoretical perspectives on performance: contractual and relational.

The contractual perspective, rooted in economic institutionalism, principal-agent theory, and transaction cost theory, has traditionally dominated PPP research and practice (Lowndes and Roberts, 2013; Williamson, 1996). This approach views PPPs as a principal-agent relationship, with the public partner acting as the principal and the private partner or consortium as the agent. Both parties are considered rational actors pursuing their own interests in a relationship that is characterized by diverging preferences and information asymmetry. In this context, the principal relies on the agent for information about performance, creating potential for opportunistic behaviour. The agent may attempt to misuse the information asymmetry to their advantage. To mitigate these risks, contractual governance emphasizes the importance of well-written contracts, clear performance indicators, appropriate risk allocation, and the ability to apply sanctions (Warsen *et al*., 2019). However, the complexity of how exchanges take place between different actors makes it impossible to anticipate and structure all aspects through contracts beforehand, leading to incomplete contracting.

The relational governance approach suggests that instead of making contracts endlessly detailed, incomplete contracting is 'managed' by social relationships. The relational perspective is inspired by relational contracting, sociological institutionalism and governance (Deakin and Michie,; Lowndes and Roberts, 2013). This perspective emphasizes the process of cooperation and relational interplay. It highlights the significance of trust, informal communication, and openness for the successful functioning of PPPs (Warsen *et al*., 2019). This perspective views PPPs as collaborative partnerships instead of purely principal-agent relationships, emphasizing joint problem-solving and collaboratively addressing unexpected events that may arise during the contract period (Barretta *et al*., 2008; Reeves, 2008).

It is important to note that these two perspectives are not mutually exclusive. Rather, they can be seen as complementary lenses to look at how the complexities of PPPs are managed. Combinations of contractual and relational mechanisms are more likely to explain the success of partnerships (Warsen *et al*., 2019; Weihe, 2009). By looking at the behaviour of actors in PPPs from both perspectives, it is recognized that while contracts do shape interactions between partners, they do not entirely determine them .

3.3 Hypothesizing a reciprocal relationship between values, interests, and governance practices

This study assumes that value tensions are inherent to Public-Private Joint Ventures (PPJVs) and persist throughout the collaboration. It is expected that these tensions are not typically the object of explicit negotiation. Rather, public and private actors primarily focus on securing their respective interests within the collaboration and on managing risks—particularly where those interests diverge. In doing so, they seek to mitigate opportunistic behaviour, ensure implementation, and maintain control over critical issues, often without framing these challenges in terms of normative value tensions.

Nonetheless, these governance challenges are related to underlying values. For example, efforts by public actors to ensure transparency and accountability reflect concerns about legitimacy, while private actors' wish for confidentiality stems from commercial risk management and protecting competitive advantages. It is hypothesized that while actors do not explicitly govern for *values*, the contractual and relational governance mechanisms they adopt to govern *interests* do shape how value tensions emerge and are managed. For instance, formal governance structures—such as clear decision-making procedures or oversight mechanisms—can

address tensions around transparency and accountability, even if public and private actors prioritize legitimacy and efficiency differently. Similarly, contractual elements such as performance indicators or risk-allocation can help align expectations on what constitutes success, balancing social impact and financial performance.

Simultaneously, relational governance plays a role in mitigating tensions throughout the partnership that cannot be fully addressed contractually. For example, it can mitigate cultural frictions between bureaucratic stability and market-driven agility, and support mutual adjustment when unforeseen developments challenge initial agreements.

This study hypothesizes that while value tensions are continuously present in PPJVs, their occurrence is influenced by (contractual and relational) governance aimed at securing respective interests and managing risks in practice. Although value tensions stem from differences in public and private values, they become visible through the ways in which actors pursue and protect their respective interests. These tensions are not static, but shaped over time by how actors try to manage their interdependence. Governance arrangements—both contractual and relational—are primarily aimed at securing respective interests and managing risks (opportunistic behaviour, conflicts). In doing so, they also influence how value tensions manifest throughout the collaboration. This reflects a reciprocal relationship: underlying values give rise to diverging interests, which actors manage through governance practices—practices that, in turn, shape how those value tensions emerge.

4.Exemplary context: PPJVs in Dutch planning practice

The Netherlands has a longstanding tradition of employing PPPs as governance strategy to achieve urban policy objectives, such as housing provision and infrastructure development. Since the mid-1980s, public-private collaboration has been integral to Dutch spatial planning. Over time, various PPP models have emerged and evolved within Dutch planning practice, including PPJVs, each reflecting different levels of integration, responsibilities and risk-sharing between public and private actors.

PPJVs represent a distinctive form of PPP within Dutch urban development practice. Unlike traditional contractual PPPs—where governments set clear terms for private service provision—PPJVs involve the creation of a jointly governed legal entity. In these ventures, public and private actors cooperate intensively over a prolonged period, often merging governance structures and sharing both risks and responsibilities throughout nearly all phases of the development process (Klijn and Van Twist, 2007; De Zeeuw, 2018). Notably, PPJVs are long-term in nature, typically spanning 15 to 20 years.

PPPs in general have been highlighted as potential solutions to the increasing complexity of area development, where projects are required to address a growing range of societal challenges such as sustainable energy, climate adaptation, and social inclusion (Heurkens *et al.*, 2020; Janssen, 2024). This increasing complexity and interdependence between public and private actors has led to renewed calls from policymakers, developers, and academics for a revival of PPPs as suitable governance strategies for area development (BPD, 2023; Hümmels, 2017; Ten Have *et al.*, 2017).

5. Empirical findings: Value tensions in Dutch PPJVs

As a first main insight of this study, the interviews underscore that value tensions are inherent to PPPs, particularly in 'strong' PPP models such as joint ventures. The findings reveal a core tension between the need for transparency and democratic legitimacy on one hand, and the desire for progress and efficiency on the other. While transparency and accountability—especially towards municipal councils—are critical for legitimacy, an overemphasis can slow down decision-making and reduce the ability to act swiftly in complex area development projects. Conversely, prioritizing efficiency and progress may come at the expense of public oversight and trust. There is a continuous search for the right balance between keeping politics at a sufficient distance to allow for efficiency, while safeguarding legitimacy and transparency.

Another persistent tension is found between societal and financial returns. Public actors are primarily concerned with contributing to societal demands, whereas private partners focus on financial returns. The interviews underscore the importance of openly acknowledging and balancing these differing expectations at the outset, thus preventing future conflict and fostering a more sustainable partnership.

Finally, risk allocation is another recurring source of tension. When risks are divided unequally, distrust can arise, undermining the partnership. Interviewees stress that a more balanced risk distribution, even if private actors initially seek to minimize their exposure, is essential for fostering a sense of shared responsibility and long-term collaboration. A balanced risk allocation fosters greater trust and a more equal relational basis among partners, as everyone shares similar stakes and potential losses.

5.1. Governing value tensions in PPJVs

As a second main insight from this study, it became clear that the relationship between contractual and relational governance is central to understanding value tensions in Dutch PPJVs. These tensions are not only inherent to the public-private dynamic but are also shaped by how formal agreements and trust-based practices are combined. Interviewees point out that contractual governance provides the structural backbone for managing expectations and reducing opportunistic behaviour. Mechanisms such as exit strategies, clear and equal risk allocation, and supervisory boards are mentioned to become increasingly applied, especially following the financial crisis, as actors learned the importance of flexibility and the ability to adapt to changing circumstances. Well-designed contracts clarify roles, responsibilities, and dependencies, which can help prevent disputes and foster a sense of fairness. However, if contracts are too rigid or detailed from the outset, they can create an atmosphere of suspicion and inflexibility, undermining the collaborative spirit that is essential for long-term projects.

Relational governance, on the other hand, is built on trust, mandate, and informal cooperation. Trust enables partners to navigate uncertainties and adapt to unforeseen developments, which is particularly crucial in the long-term context of area developments. Giving project managers sufficient mandate and fostering open communication channels can accelerate decision-making and help balance the need for transparency with the demand for progress. Yet, too much reliance on informal trust without adequate contractual safeguards can lead to discomfort or even mistrust, especially from political stakeholders who require accountability.

The interviews reveal that the most effective PPJVs strike a balance between these two dimensions. For example, a 'light' contract that focuses on essentials, combined with regular informal engagement and clear channels for political input, can both safeguard public values and enable operational efficiency. Control mechanisms like dual-directorates, (internal) four-eyes principles, and external (financial) audits are seen as protective, ensuring transparency and enhancing trust without necessarily obstructing collaboration. Moreover, interviewees noted that, although private partners may have a preference for carrying less risk, a more balanced allocation of risks is generally considered preferable from a business strategy perspective. This is because such balance encourages a sense of shared responsibility, which can strengthen collaboration within the partnership and is viewed as advantageous for achieving long-term success and future business opportunities.

Moreover, the interviews suggest that actors in Dutch PPJVs do not appear to consciously govern value tensions as explicit objectives within their collaboration. Instead, their primary focus lies on securing their respective interests, mitigating risks, and managing potential conflicts to ensure successful implementation. This pragmatic orientation towards governance aligns with the hypothesized perspective that value tensions remain largely implicit rather than explicitly addressed.

Nevertheless, the contractual and relational mechanisms employed to manage interests and risks inherently shape how value tensions emerge and are handled in practice. For instance, efforts to allocate risks clearly and to establish trust-based cooperation influence the balance between values like transparency and accountability, and values such as confidentiality and efficiency. Thus, even though actors do not explicitly state that their governance activities are aimed at addressing value tensions, their governance practices have impact on how these tensions manifest and evolve throughout the collaboration.

This finding supports the hypothesis that governance arrangements in PPJVs are primarily interest- and risk-driven but simultaneously affect how value tensions emerge and are managed, confirming the earlier formulated reciprocal relationship.

5.2. Lessons and evolving perspectives in Dutch PPPs

The Dutch PPP landscape is evolving in response to both external pressures and internal learning. The complexity of area development has increased due to stricter regulations, broader societal challenges, and more demanding financial and risk management requirements, for example due to EU legislation (Basel III & IV). In this context, actors are innovating in structuring PPPs and governance arrangements after a period of decline.

The interviews indicate a shift towards lighter, more flexible partnership structures. Instead of transferring all land and responsibilities into a single joint venture, area developments now seem to seek governance designs that are suitable to accommodate more segmented developments, with responsibilities divided among smaller, task-specific entities (e.g., for energy, mobility, or above-plan infrastructure). Cost-allocation organizations are mentioned as vehicle to manage shared expenses (for example for construction of public space) and phased development approaches are adopted to reduce risk and allow for adjustment over time.

These innovative governance designs reflect a move away from the independent and rigid structures like PPJVs, which often struggled with inflexibility and demanded large investments upfront. The lessons learned from past joint ventures—such as the benefits of working out exit strategies, balanced risk-sharing, and the importance of combining contractual clarity with relational flexibility—influence the design of contemporary PPPs.

The interviews suggest a prevailing perspective that emphasizes the need for adaptability, mutual trust, and a careful balance of public and private values, with governance structures that can evolve in response to changing institutions and societal demands.

6.Conclusion

This paper has argued that we can currently observe a 'new phase' of PPPs in Dutch area development—a governance process around area-based spatial projects that includes important planning work—marked by adaptations that respond to contemporary challenges like increased financial constraints and the need to integrate multiple disciplines to address a wide range of societal issues. We set out to explore to what extent this new phase also addresses the value tensions inherent in PPPs, i.e. long-term collaborations between public and private actors. As PPPs are yet again emerging in the field because of the need for joint action to address contemporary urban development challenges, the central question seems not how to eliminate the tensions inherent to the partnerships, but how to acknowledge and 'govern' them within their evolving structures.

The findings indicate that PPJVs can mediate value tensions while maintaining effectiveness by finding the right combination of contractual and relational governance. Structured agreements play a crucial role in aligning financial objectives with societal goals, for example through balanced risk-sharing and contractually defined objectives. At the same time, keeping contracts as lean as possible helps preserve efficiency and flexibility, allowing actors to navigate the partnership based on relational norms and trust. Contractual control mechanisms—such as the appointment of an independent director, the use of external financial audits, and internal checks—can safeguard public values like transparency and accountability, reduce the likelihood of opportunistic behaviour, and help mitigate value tensions. Empirical evidence suggests that relational governance—embodied in mutual trust, open communication, and adaptability—can mediate or even compensate for the limitations of formal contracts, especially in a long term development process in which not all contingencies can be specified in advance. Conversely, well-designed contracts can provide a stable foundation that enables the development of relational norms and trust, particularly in the early and more vulnerable phases of a partnership. The Dutch context shows that managing value tensions in PPJVs requires a mutually reinforcing mix of formal agreements and trust-based practices, tailored to the specific context while leaving room to jointly adapt to changing circumstances. This dynamic interplay between contractual and relational governance offers actionable perspectives for managing value tensions in area development partnerships.

Empirical evidence also supports the hypothesis that actors do not explicitly govern value tensions, but primarily aim to secure their interests, manage risks, mitigate opportunistic behaviour, and maintain control. In doing so—often without consciously framing their actions in terms of value tensions—they still influence how value tensions are managed. This confirms the hypothesized reciprocal relationship: underlying values give rise to diverging interests, which actors manage through contractual and relational governance arrangements—arrangements that, in turn, shape how those value tensions emerge and are addressed throughout the collaboration.

Taken together, these insights indicate that value tensions can be managed to a certain extent through a thoughtful combination of contractual and relational governance. Embracing these inherent tensions, rather than seeking to eliminate them, is crucial for developing governance models that support public value creation in the complex context of area development.

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Designing A Comprehensive Indicator System For An Evidence-Based Spatial Planning System Integration In Fringe Regions Of The EU: A South Balkan Case Study

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Abstract
Integration of spatial planning systems across the EU's fringe regions is often challenged by institutional asymmetry, fragmented governance, and uneven territorial capacities. These conditions hinder the development of coherent evaluation tools capable of capturing the complexity and evolving nature of integration processes in such contexts.

This paper proposes a methodological framework that combines theoretical insights from territorial capital with a time- and process-sensitive evaluation logic. Inspired by the conceptual modelling techniques, the framework aims to assess spatial planning integration by linking contextual conditions, institutional dynamics, and cooperative processes. The South Balkan region is used as a contextual reference to guide framework development, offering illustrative territorial and institutional complexities, without serving as an empirical test site.

The approach is intended to support flexible, multiscalar, and temporally aware assessments of integration efforts, especially in regions where formal alignment may not reflect substantive cooperation or institutional readiness. By reframing spatial planning system integration as a dynamic and relational process, the framework offers an adaptable tool for future empirical research and policy evaluation in territorially diverse European regions.

Keywords: Spatial Planning System Integration, Territorial Capital, Indicator System, EU's Fringe Regions

1.Introduction

Integration of spatial planning systems is often seen as a complex, yet critical challenge in achieving meaningful territorial cohesion. During the late XX century and especially since the turn of this century, conditions for urban and regional development have been changing dramatically for countries and cities in Central, and more recently in Southeastern Europe. The process of integration has created new settings for capital flow, mobility of labour forces, and exchange of goods and services, consequently triggering new potentials and problems. Fuelled by the increasing globalization of economic activities, the pressure of competition between countries and cities/ regions has grown significantly thus making it crucial force in shaping the development paths of territories.

These problems seem to be even more intense in the EU's fringe regions. The territories in question are often characterized by complex socio-economic conditions, deep historical and cultural legacies, specific techno-political dynamics, and diverse governance structures, all of which are reflected in the regional territorial capital. Therefore, understanding the interplay of these tangible and intangible elements within the unique local contexts, together with accurate assessment of the extent and impact of Europeanisation processes on the planning systems, becomes fundamental for defining paths towards sustainable territorial development, grounded in the integration and cohesion.

However, conventional methodologies that provide frameworks for understanding and leveraging regional assets seem to face significant hurdles in these dynamic environments. The concept of "territorial capital" (TC), notably advanced by Roberto Camagni, has played a critical role in categorizing the diverse assets. Coming from an economic perspective Camagni (2007, 2008) discussed the term in a comprehensive way, introducing different types of territorial capital and essentially paving the way for further research. As Moretta (2021, p. 104) notes, "The originality of this concept lies on the fact that, for the first time, the attention focuses on the analysis of a certain place in a more holistic and comprehensive way, considering a wider set of tangible and intangible assets located in it".

Yet, applying such frameworks to the EU fringe regions, especially those encompassing mixed membership statuses, reveal several gaps, either from a contextual or structural perspective. The discussion of these gaps, asks for a new methodological approach, one that will enable an indicator system in support of an evidence-based spatial planning system integration. Therefore, the aim of this research is to address these limitations by providing a structured, adaptable, and solution-oriented methodology of identifying the relevant components as assets of the TC in the fringe regions and suggesting more dynamic understanding of how territorial potential is activated, leveraged, and transformed through policy interventions and governance processes.

Methodologically, this involves critically engaging with the concept of territorial capital but augmenting it with a process-oriented approach capable of capturing dynamics, evaluating performance, and informing adaptive strategies. We propose integrating the diagnostic strengths of TC taxonomies with evaluative and dynamic framework of Input-Output-Outcome-Process (IOOP). This combination provides complementarity in a way where understanding the existing capital will provide context for policy design, while the IOOP model will allow evaluation of how effectively, specific policies mobilize or enhance that capital to achieve desired outcomes. The IOOP framework formalizes the pathways that are supported by the assets and resources (Inputs), then are activated through governance mechanisms and institutional practices (Processes), will lead to tangible short-term results (Outputs) and, ultimately, will provide long-term transformations (Outcomes).

The primary geographical focus of this study is the South Balkan region, selected for its representative complexities, commonly found in the EU's fringe areas characterized by mixed membership, diverse developmental trajectories, and significant integration challenges. Here, it is worth noting that the paper develops a comprehensive indicator system, where the proposed case-study plays the role of contextual anchor - a reference that helps inform the structure and logic of the proposed system. However, it does not report on the application or findings of this framework, which will be the focus of future empirical work.

2.Conceptual Framework and Methodology

2.1.*Territorial capital: challenges*

The concept of territorial capital (TC) closely tied to debates of urban competitiveness (Begg, 1999; Boddy & Parkinson, 2004) and integration policies, was introduced by the OECD (2001) and further developed by Camagni (2007, 2008). It highlights the role of endogenous assets alongside exogenous factors in unlocking development potentials. To systematize these assets, Camagni proposes a taxonomy based on two axes: rivalry (private, impure or club, and public goods) and materiality (tangible, mixed, and intangible). This approach, eventually results in a 3x3 matrix of nine types of capital, all contributing to local competitiveness and, if accumulated positively, to sustainable development. At its corners, within the so-called "traditional square", the matrix identifies the following capital forms: private fixed capital (tangible, high rivalry), natural/cultural resources and infrastructure (tangible, low rivalry), human capital (intangible, high rivalry), and collective action (intangible, low rivalry). The remaining five types of capital, form an "innovative cross" in the matrix center, including proprietary networks, university spin-offs, agglomeration economies, relational capital, and governance networks. Within this taxonomy, the relational capital and cooperation networks highlight the social and policy-driven dimension of TC, thus emphasizing place-specific qualities and comparative advantages that go beyond purely functional assets.

However, applying the territorial capital (TC) methodological approach directly to EU fringe regions for assessment purposes reveals significant limitations, broadly falling into two categories: contextual and structural challenges. The first, come from misalignment between the framework and socio-political, economic, and cultural realities of the EU fringe regions, while the latter, stem from the internal design and operational limitations, particularly in its application to diverse and data-scarce contexts.

Over the years, contextual criticism has challenged Camagni's framework for being too static and failing to capture the dynamic evolution of territorial capital in response to global shifts like digitalization, migration, or climate change (Rodríguez-Pose, 2018), specifically for the regions experiencing rapid socio-economic transitions (e.g. EU integration processes). Some have found the taxonomy's Eurocentric bias, rooted in Western institutional models, to overlook the unique historical and cultural contexts of non-EU states, where informal institutions and power dynamics play significant roles (Marques & Morgan, 2018)and the economic crisis that ensued, have exposed even further the persistent pattern of uneven development which has plagued the European Union (EU.

In this context, TC taxonomy appears to be irresponsive to the effects and underdeveloped roles of institutions in these states, primarily in regard to the institutional quality, trust, and governance capacity. These are vaguely categorized, limiting the framework's ability to address the complex institutional landscapes of fringe regions, where alignment with EU standards is a priority for candidate countries (Cojanu & Robu, 2019). Namely, Camagni's framework assumes harmonious mobilization of territorial assets, underestimating political conflicts and power asymmetries, deep ethnic divisions and contested borders within and between territories (Rodríguez-Pose, 2013). In the fringe regions for example the governance capacities significantly differ between EU members and candidates, consequently leading to oversimplifying the challenges of cross-border cooperation and resource allocation (Medeiros et al., 2024).

Camagni's taxonomy has been confronted in structural terms too. Pike et al. (2016) discuss the empirical application challenges posed by blending of physical, human, relational, and institutional assets, which often result in blurred boundaries. Terms like "social capital" and "relational capital" lack rigorous operational definitions, complicating their measurement in diverse contexts such as the South Balkans, where trust and cooperation vary significantly across borders (Storper, 2005). Finally, the largely normative nature of the taxonomy, offering few concrete indicators for measuring territorial capital across regions (Affuso & Camagni, 2010) is emphasized as critical gap in these fringe regions, where data availability is inconsistent, and comparable metrics are essential for evidence-based policymaking.

In response to these challenges, aforementioned scholars have expanded their research on the dynamics of the regional development processes and relational dependencies. For instance, Storper (2005) highlights relational assets and untraded dependencies, through a context-specific, path-dependent lens; Boschma and Martin (2010) emphasize historical trajectories and local capabilities in their "evolutionary economic geography"; and Rodríguez-Pose (2018) introduces the "Geography of Discontent", linking underdevelopment to inequality, discontent and governance failures. Martin and Sunley (2015) focus on institutional thickness and fit, addressing Camagni's underdeveloped treatment of institutions; Faludi (2010) and Davoudi (2003) promote polycentric development as an alternative to agglomeration models, aligning territorial capital with spatial planning and providing a policy-oriented lens to operationalize assets like infrastructure and relational networks. Barca (2008) stresses place-based, participatory approaches that operationalize territorial capital through stakeholders engagement; Moulaert et al. (2013) explore community driven solutions, Capello et al. (2009) offer frameworks for fringe-regions innovation ecosystems, and Servillo (2010) investigates governance innovation – all enhancing Camagni's model with tools for institutional alignment, collaboration, and policy relevance.

The extensive engagement of scholars with Camagni's territorial capital taxonomy (Camagni, 2007, 2008, 2009) affirms its status as cornerstone in regional development, offering multidimensional lens to classify, both tangible and intangible assets that drive territorial competitiveness and cohesion. However, all these takes on Camagni's taxonomy have limited application to complex contexts, such as the EU fringe regions. As Morretta (2021) argues, the taxonomy's strength lies in its integrative approach, which combines endogenous and exogenous forces to enhance local resources and improve well-being. The framework successfully moves beyond the limitations of purely top-down strategies that overlook local dynamics, while avoiding the narrow scope of bottom-up approaches focusing solely on local actors. However, its effectiveness relies on more nuanced and context-sensitive application of the taxonomy or as Morretta's observes: "... territories are endowed with different local actors and types of tangible and intangible resources of variable quantity and quality. Although both types of resources are important in determining and shaping the territorial characteristics and potential of a certain place, intangible forms of capital such as governance, innovation, networking and entrepreneurship are crucial to release this potential and trigger the process of endogenous development" (Morretta, 2021, p. 111).

2.2.*Structural support of evidence-based indicator system*

The discussion above, clearly underlines that, designing a comprehensive indicator system for spatial integration in EU fringe regions requires more than a static mapping of territorial assets; it demands a dynamic, adaptive, and politically sensitive framework capable of capturing the evolving, contested, and multilayered nature of territorial development. In contrast to specific and narrow conceptual frameworks, such as Storper's relational assets, Boschma and Martin's evolutionary economic geography, Rodríguez-Pose's geography of discontent, and Barca's place-based development, this study will focus on the Input-Output-Outcome-Process (IOOP) model, as operationally complete and strategically more flexible approach.

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Grounded to some extent in the Logic-Model Theory (Kellogg, 2004; Wholey, 1979) and Program Theory (Chen, 2012; Rogers, 2008; Weiss, 1995), Figueiredo et al. (2018) in the OECD document titled as "Indicators for Resilient Cities" provided one of the first major application of the so-called IOOP model in European urban policy evaluation. While the traditional logic models are often linear and do not provide feedback loops for policy evaluation, the program theory prioritizes causal and contextual logic, but when it comes to practical adaptation, it lacks operational and policy-focused loops. The IOOP model (Figueiredo et al., 2018) aligns with Logic models by using the same categories: inputs, processes (as activities), outputs, and outcomes as core components, tailoring them into a framework, specific for territorial policy in complex, multi-scalar contexts. It also draws from Program Theory's outcome orientation and iterative evaluation but formalizes a more operational, policy-oriented structure. The strong practical applicability of this model has been acknowledged by many scholars including Giffinger and Kramar (2023) who developed an indicator system of distinct components for liveable cities, and in his later work, Giffinger (2024) expands the IOOP model with learning processes by adopting a phase-specific, processual approach.

Drawing from the literature review and driven by an overarching objective to address the complexities of spatial planning system integration in the EU's fringe regions, we argue that combining Camagni et al.'s TC taxonomy (2007, 2008) and Figueiredo et al. (2018) IOOP model will provide structural framework for building comprehensive indicator system. This framework isn't driven by the compatibility of the two methodological approaches, rather by their complementarity, as they answer different questions. Camagni et al. focus on the statics of potential (territorial assets) while Figueiredo et al. focus on dynamics of intervention, as input describing the policy performance. Understanding the territorial capital provides the context for designing relevant policies and evaluating those policies could show how effectively that capital is being leveraged or enhanced to achieve direct outputs and ultimately, as outcomes of policy interventions. In other words, the complementarity of these models lays not in its common denominator, rather in what each doesn't primarily focus on:

- Gap from Policy Evaluation Perspective: The Figueiredo et al. (2018) approach, while evaluating a policy, might not explicitly account for the underlying territorial context defined by its specific mix of territorial capital. The success or failure of a policy (it forms of its output) can be heavily influenced by the pre-existing territorial capital (e.g. a skills policy will have different outcomes in a region independent of its initial level of human capital). Hence, this framework measures policy results but doesn't inherently diagnose the underlying territorial conditions that shape those results.
- Gap from Territorial Capital Perspective: Camagni's taxonomy provides a rich diagnosis of a territory's assets and potentials (which are outcome of former development) but doesn't inherently evaluate how specific policies are mobilizing, utilizing, or changing that territorial capital. It describes the potential but doesn't measure the effectiveness of actions taken to leverage it. We know what capital exists, but not necessarily how well certain policy is using or building the corresponding types of capital.

Table 1: Key differences

FEATURE	FIGUEIREDO ET AL. (2018) (policy evaluation)	CAMAGNI (territorial capital)
WHAT IT LOOKS AT	A specific policy or program	A territory (region, city)
MAIN GOAL	Evaluate policy performance/impact	Diagnose territorial potential/assets
FRAMEWORK	Performance Measurement Logic Chain	Asset Taxonomy / Classification
NATURE	Evaluative (How did X perform?)	Diagnostic (What does Y possess?)
ELEMENTS	Inputs, Process, Outputs, Outcomes	Types of Capital (Human, Social...)

Figueiredo's emphasis on feedback loops and adaptive cycles provides a crucial upgrade of Camagni's TC taxonomy. Evolutionary economic geography adds an important temporal dimension, but adaptation often appears organic rather than structured. In the IOOP model, feedback from Outcomes provides necessary information for the reassessment of Inputs and Processes, thus creating an explicit mechanism for learning and reconfiguration.

In the context of the EU's fringe regions, where fragmented histories, contested borders, and uneven economic transitions define spatial dynamics, designing a robust indicator system for spatial integration demands an approach that captures not only territorial assets, but also ways these assets are activated and transformed through policies. As a result, conceptualization of these policies is directly rooted in the outcomes of the feedback loops, provided by the IOOP model.

Table 2: Complementarity of Camagni's taxonomy and Figueiredo et al. IOOP methodology

ASPECT	CAMAGNI'S TAXONOMY	ENHANCED BY IOOP	WHY CRITICAL FOR FRINGE REGIONS
CORE LOGIC	Static typology of territorial capital	Dynamic sequencing (Input - Output – Outcome-Process)	Fringe regions need dynamic assessment of activation, not just listing assets
RELATIONAL ASSETS HANDLING	Acknowledged but not operationalized	Focuses on relational activation mechanisms	Detects failures to mobilize existing tangible networks and infrastructures
GOVERNANCE EVALUATION	Implicit, general	Explicit assessment of processes and capacities	Identifies governance gaps, common in politically fragmented fringe regions
CONTEXT ADAPTABILITY	Assumes stable institutional contexts	Includes feedback loops, adaptive to shocks	Captures rapid socio-political and economic changes typical of fringe areas
PLAN VS OUTCOME MEASUREMENT	Largely descriptive	Tracks discrepancies between plans and outcomes	Exposes implementation bottlenecks, crucial where planning often underdelivers
INSTITUTIONAL SENSITIVITY	Eurocentric stability bias	Sensitive to hybrid, informal, evolving institutions	Suitable for fragile, mixed-governance settings of fringe regions
MULTI-LEVEL, CROSS-BORDER FIT	Territory	Accommodates multi-scalar, cross-border dynamics	Fits the transnational, cross-border realities of EU peripheries

2.3.***Identifying key territorial dimension for SPSI in EU's fringe regions***

In the ever-evolving landscape of European spatial governance, the notion of spatial planning system integration (SPSI) has become increasingly central. As the European Union has expanded eastward and southward, it has incorporated a broader array of political traditions, institutional cultures, and territorial challenges, only to instigate re-definition of the term integration. In the theoretical discourse, the act of spatial planning system integration refers to the processes and mechanisms aimed at enhancing coherence, coordination, and cooperation between distinct spatial planning systems across different administrative levels (vertical integration) and policy sectors (horizontal integration) (Davoudi & Strange, 2008; Stead, 2014; Stead & Meijers, 2009)this book examines spatial planning at different places throughout the British Isles. Six illustrative case studies of practice examine which conceptions of space and place have been articulated, presented and visualized through the production of spatial strategies. Ranging from a large conurbation (London. Yet, the realities of integration differ substantially between EU core regions, endowed with mature planning institutions and dense territorial capital

and fringe regions, where fragmented governance, asymmetrical institutional capacity, and geopolitical tensions frequently complicate integration efforts. While in both cases, the ultimate goal is to create a more harmonized and synergistic approach to territorial governance that transcends administrative borders (Moulaert et al., 2010), we observe key differences in the properties of these two types of regions. By employing previously established methodology as a guiding analytical framework, we will explore how different forms of capital, condition the nature and success of spatial planning system integration. The main objective is to identify the key component(s) for successful SPSI in EU's fringe regions.

In contrast to the EU core regions, which often exhibit high relational capital in form of well-positioned logistical and economic networks, EU's fringe regions, particularly those along the eastern and southeastern peripheries face a distinctly different reality. Here, SPSI efforts contend with historical legacies of centralized governance, weak planning institutions, limited policy coherence, and geopolitical fragmentation. Examples include the Western Balkans, and to some extent already integrated parts of Eastern Europe and Baltic states, which exhibit fragmented and underdeveloped territorial capital, resulting in weak spatial planning integration. Furthermore, centralized governance legacies, limited administrative capacities, and sectoral fragmentation constrain institutional capital and cross-border coordination (Nienaber & Wille, 2020). The results of the ESPON COMPASS project (2018) find that many of these systems are "proto-conformative" or "erroneously performative" planning systems, in which policies exist in formal documentation, but are weakly implemented in practice and often subordinated to investor interests. Path dependency, rooted in professional and institutional inertia, further hampers reform (Dąbrowski & Piskorek, 2018), while market-led development with weak public oversight defines the "neo-performative model" common in the areas (Berisha et al., 2021).

Economic capital remains central to integration, yet disparities in infrastructure and investment undermine planning capacity, especially in the Eu's fringe, cross-border regions (Perkmann, 2003), which is why Jakubowski (Jakubowski, 2020) stresses that gaps in physical infrastructure demand tailored, place-specific policies. In addition, the limited market access weakens relational capital, thus hindering the implementation of strategic visions (Zonneveld, 2005), which escalates the necessity of data harmonization and infrastructure systems for effective cross-border planning (Frank et al., 2017). Finally, as Perkmann (2003) notes, low social capital, driven by historical divisions, weak trust, and fragile regional identities further obstructs cooperation, which underscores the importance of fostering shared identity and trust.

All of these shortcomings across different components of the territorial capital in the fringe regions greatly impede the integration of spatial planning systems and therefore addressing them efficiently requires targeted interventions. But what actually constitutes effective spatial planning system integration and what are the key territorial dimensions? Literature review, shows that scholars seem to agree on several key properties:

- Policy Coherence: Alignment of strategic objectives, policies, and instruments across different planning systems and levels (Stead, 2014; Stead & Meijers, 2009);
- Inter-administrative Cooperation: Established formal and informal mechanisms for joint working, communication, and decision-making between planning authorities (Zonneveld & Stead, 2024);
- Shared Territorial Vision: A collectively agreed-upon understanding and set of goals for the future development of the shared territory (ESPON, 2018);
- Harmonization of Frameworks: Efforts to align legal, regulatory, and procedural aspects of planning systems to facilitate joint action, though full harmonization is often complex and not always the primary goal (Janin Rivolin, 2008);
- Joint Implementation and Monitoring: Collaborative execution of planning strategies and projects, supported by shared monitoring and evaluation systems (Waterhout, 2008);
- Adaptive Capacity: The ability of the integrated system to learn from experience and adapt to changing socio-economic, environmental, and political contexts (Healey, 2006).

While, SPSI relies on synergy among various forms of territorial capital, the aforementioned properties of effective spatial planning system integration are intrinsically linked more to certain types of territorial capital, mostly: Relational Capital, Institutional Capital, Cooperation Networks & Governance, Social Capital and Human Capital.

Camagni et al. define relational capital as "bilateral and multilateral linkages" rooted in trust, shared values, and the ability for cooperation and collective action (2011, p. 5). As a key form of intellectual capital, its intangible and flexible nature makes it crucial in navigating diverse planning cultures, especially in cross-border contexts (Nienaber & Wille, 2020; Purkarthofer, 2018). Its "club good" nature means that benefits are shared mainly among active participants, underscoring the value in joint planning efforts, where cooperation yields both direct and wider regional benefits. In fringe regions, relational capital helps overcome cognitive and cultural gaps, promotes socio-cultural integration and enables knowledge sharing (Camagni et al., 2011; Fogarsi, 2024). Unlike human capital, which is rivalrous and private, relational capital enables transformation of potential into effective cooperation and by doing so it addresses Boschma's "proximity puzzle" (Boschma, 2005). Thus, while social capital reflects the slow-building trust of a community, relational capital centres on active, strategic linkages between actors.

Institutional capital is also essential for SPSI, particularly in cross-border regions, where fragmented governance hinders spatial collaboration (Nelles & Durand, 2014)the number of cross-border cooperation structures in Europe has exploded owing to political and financial support by the European Union aimed at encouraging cohesion and developing peripheral regions. These policies are part of processes of de-bordering and political rescaling that have profoundly affected cross-border areas by creating new institutional territories and political structures. The purpose of this paper is to study the institutional history of cross-border metropolitan governance in Europe through the comparison of two of the most advanced cross-border metropolitan regions: Lille and Luxembourg. This paper asks how these cross-border structures have developed and changed. What can their patterns of institutional evolution contribute to understanding governance in other cross-border regions? Are these new spaces evidence of political rescaling? This paper presents and redefines cross-border governance as a cyclical and a long-term process and also explores the challenges that these partnerships face in becoming functionally effective and autonomous policy actors. Ultimately, we find that there is no replicable ideal of cross-border governance and that even long-standing partnerships are in a period of exploration and reinvention. Establishing a competitive and coherent cross-border metropolitan region is ambitious and complex, and it necessitates the coordination of policies at multiple scales and across institutionally diverse territories. This project requires the modification and/or construction of new institutional and legal frameworks. This reorientation of political attention has resulted in a reconceptualization of political space but not the empowerment of new political actors, indicating that the process of rescaling may be a work in progress.","container-title":"European Urban and Regional Studies","DOI":"10.1177/0969776411431103","issue":"1","page":"104-122","title":"Political rescaling and metropolitan governance in cross-border regions: comparing the cross-border metropolitan areas of Lille and Luxembourg","volume":"21","author":[{"family":"Nelles","given":"Jen"},{"family":"Durand","given":"Frédéric"}],"issued":{"date-parts":[["2014"]]}}],"schema":"https://github.com/citation-style-language/schema/raw/master/csl-citation.json"} . Although Camagni's taxonomy doesn't list it as separate entity, institutional capital intersects with both social and cultural capital, blending tangible infrastructure with intangible norms and governance "software" (Giffinger et al., 2007). Institutions function as public goods but face limitations in light of different scales of legal harmonization and Europeanization. This means that institutional capital can create enabling frameworks, yet it does not ensure stakeholder action or capacity. In fact, it is often determined by the political will and bureaucratic rigidity (Camagni, 2019; Jakubowski, 2020). Thus, formal structures alone are insufficient without strong relational dynamics and adaptive governance practices.

Considering the discussion above, while we recognize that SPSI is a multifaceted process influenced by a variety of territorial capitals, we underscore the prevalent comparative importance and favourability of relational capital. Its ability to activate and sustain mechanisms of cooperation, particularly in fragmented and asymmetric governance environments, alongside its embeddedness in trust-based linkages, joint action, and shared learning proves that the relational capital is the most context-sensitive and policy-relevant component of territorial capital for enabling meaningful spatial integration. Therefore, in the following section, we turn to explore how relational capital can be systematically integrated into the IOOP model, enabling us to assess not only the presence of territorial assets, but also their activation through strategic cooperation, collective competence, and adaptive planning practices.

2.4.***Integrating Relational Capital into the IOOP model for SPSI***

In order to provide operational completeness, embedded feedback mechanisms, and capacity for theoretical integration we will implement the Input-Output-Outcome-Process model, thus enabling more coherent integration policy evaluation. By doing so, we align with Giffinger and Kramar's path-oriented approach, which considers "the urban dynamics over time and therefore provides evidence on speciΔc transformation processes" and their recommendation that designing a comprehensive indicator system should be "based on a place-based and process-orientated understanding of urban development, which can be expressed by appropriate indices for measurable trends"(Giffinger & Kramar, 2023, pp. 45, 50).

In the context of EU's fringe regions, this means understanding the temporal dynamics of relational capital, or how trust, cooperation, and institutional embeddedness emerge and evolve. Therefore, our first challenge will be to map the relational capital across the four stages in this model and try to identify how relationships are built, operationalized, tested, and matured throughout the integration process in spatial planning or governance. Emphasizing the importance of policies when designing indicators, comes from the following objectives: creating goal-oriented framework, providing effective policy discussion, supporting comprehensive evaluation, delivering evidence-based recommendation and encouraging meaningful, stakeholder engagement. Consequently, full integration of the relational capital into the IOOP model necessities discussion over what should be addressed by the selected indicators, what should be acknowledged and what should be measured.

The Input phase lays the relational foundation for cooperation by building trust, aligning norms, and identifying stakeholders (including underrepresented groups like: local authorities, civil society, cross-border institutions). Early recognition of asymmetries in power dynamics, resources, and knowledge is essential to prevent dominance by stronger actors later. Understanding divergent governance cultures, harmonizing planning terminologies, and comparing legal frameworks and policy cycles supports conceptual alignment. It is during this phase that acknowledgement of past cooperation or conflicts will inform setting realistic agenda and joint visioning.

The Output phase shifts to tangible deliverables: strategies, agreements, instruments to name a few, that reflect coordination across sectors (horizontal) and governance levels (vertical). Outputs gain legitimacy when embedded in laws or administrative procedures, which in later stages should be accompanied by clear implementation plans (timelines, funding, responsibilities). These must reflect local socio-economic realities and include feedback loops for monitoring and revision, ensuring adaptability. In contrast, outputs that are technically sound but socially or institutionally fragile indicate that the system remains fragmented under the surface.

The Outcome phase demonstrates the transformative value of the entire process. As noted by Figueiredo et al. (2018), this is where the maturity of relational capital is assessed via policy changes, service improvements, or greater territorial cohesion. Indicators of success include formalized cross-border institutions, aligned procedures, and joint governance bodies. Spillover effects, like regional synergies or transferable planning models signal systemic change. Additionally, signs of healthy trust, stakeholder engagement, and public satisfaction confirm that integration is continuing beyond project cycles.

Finally, the Process phase tests the authenticity of collaboration. As Healey (2006) describes, planning is an "arena" where actors negotiate and coordinate. It is only foreseeable that relational capital will be activated through joint decision-making, adaptability, and conflict resolution, whereas symmetrical power dynamics, mutual accountability, and inclusion of smaller actors reveal the depth of cooperation. This phase depends on strong human and institutional capital: facilitators, secretariats, and support structures, all important to sustain momentum and resilience.

Table 3: Indicator properties per stages of IOOP model

IOOP Stage	What Should Be Addressed	What Should Be Acknowledged	What Should Be Provided / Measured
INPUT	- Identify actors, mandates, and willingness - Build trust foundations - Mobilize shared resources	- Power asymmetries - Trust gaps - Lack of shared vision or institutional continuity	- Stakeholder mapping - Shared intent statements - Initial trust scores - Cross-border legal/financial provisions - Baseline network connectivity
OUTPUT	- Generate co-produced outputs - Institutionalize learning and procedures - Ensure shared ownership	- Imbalance in workload or influence - Superficial or symbolic outputs	- Number and quality of co-produced plans - Legal standing of outputs - Follow-through rate on commitments - Process quality reflected in outputs
OUTCOME	- Institutionalize cooperation culture - Sustain long-term relationships - Support mutual learning	- Political turnover - Fragile institutional memory - Risk of "project fatigue"	- Long-term policy alignment - Survival of partnerships - Stakeholder satisfaction trends - Adaptive capacity - Indicators of spatial cohesion and trust continuity
PROCESS	- Enable coordination platforms - Align decision-making practices - Ensure transparency and inclusivity	- Informal leadership and champions - Conflicting routines or vocabularies - Participation fatigue	- Frequency and diversity of joint meetings - Equitable participation metrics - Joint task forces - Conflict resolution practices - Decision autonomy and reciprocity

Understanding each of the phases of the IOOP model in regard to the relational capital, provides us with means to address its main components: cooperation capability, collective action capability and collective competence. Here, we utilize the following understanding of the components: Cooperation capability – the ability of actors to engage, communicate, and maintain relationships, Collective action capability – the capacity to coordinate and act jointly toward shared objectives and Collective competence – the shared knowledge, routines, and skills enabling effective joint problem-solving and adaptation. These components could be connected to particular phases of the IOOP model. Cooperation capability is most crucial in the Input and Process stages, as without it, partnerships lack trust and fail to activate; Collective action capability peaks in the Process and Output stages, when entities must act jointly and Collective competence becomes visible in Output and Outcome phase, as it reflects whether knowledge, routines, and learning are institutionalized. However, this categorization is very tentative, as the components are interdependent, not isolated; they are iteratively evolving across all IOOP phases and reinforce themselves over time through feedback loops. For example, key identifier of cooperation capability is trust-building, which starts in input phase, but is continually tested and reinforced in Process, Output, and only proves sustainable in the Outcome phase; collective action capability begins as coordination attempts in process phase, but its real expression is in joint delivery (Output) and long-term policy embedding (Outcome); and collective competence emerges from shared learning and experience, which is built in the Process and Output phase, but has its maturity reflected in the Outcome phase. This is why rather than exact mapping of the components at certain stage of the IOOP process, we should trace their development and expression across time.

Table 4: Relational capital components integration in IOOP model

RC Component	INPUT (effort)	PROCESS (action)	OUTPUT (efficiency)	OUTCOME (effectiveness)
Cooperation Capability	Build trust Align visions	Sustain dialogue Encourage openness	Coordinate authorship Ensure shared visibility	Institutionalize trust Measure stakeholder confidence
Collective Action Capability	Define shared intent Negotiate roles	Coordinate tasks Resolve conflicts	Deliver together Monitor contribution balance	Sustain cooperation Enable continuity of actions
Collective Competence	Recognize skills Identify learning needs	Share knowledge Create joint procedures	Co-produce strategies Document learning	Adapt policies Embed learning into governance culture

3.Multilayered system of relational capital and indicators

Building on the preceding discussion and methodological framework, the next step is to identify indicators linked to key components of relational capital relevant for Spatial Planning System Integration (SPSI). Here, we underline that indicator selection is context-sensitive, differentiating core EU regions, which can rely on outcome-oriented indicators, from the fringe regions, which benefit from indicators measuring input and processes.

Considering the fringe-specific pre-conditions, it becomes evident that a comprehensive indicator system for evaluating SPSI should be grounded in a multi-layered conceptual structure that runs across the IOOP Cycle. At its foundation, the system must be built upon place-dependent factors that reflect the unique spatial, institutional, socio-economic, legal, and cultural characteristics of each region. This makes them cross-cutting as they influence all four IOOP phases. While they are mainly anchored in the Input phase, where they describe the foundational conditions but their effects are most visible in the Output and Outcome phase. In essence, these factors provide the structural core that ensures any policy development process is territorially anchored, context-sensitive, and capable of addressing the real conditions and constraints of a given region.

The use of policy-oriented concepts as the organizing logic, indicators should be designed to assess fundamental goals of spatial planning integration, such as institutional coherence, subsidiarity, alignment of planning instruments, stakeholder participation, and governance efficiency. The indicators for this layer of our system, define the normative orientation of the planning system which makes them valuable for establishing the preconditions and guiding principles. As expected, they are mainly located in the Input phase of the IOOP Cycle, although some indicators like stakeholders' engagement could indicate results in Process and Output phase too. Indicators based on these concepts help evaluate readiness and capacity, they reflect the strategic cognition of actors, in terms of how they understand integration, what they prioritize, and what they perceive as barriers or enablers. Nevertheless, though framed around normative policy objectives, these types of indicators must be reflective to the specificities of place, allowing the system to maintain both, comparability and local relevance. Misplacing the indicators for policy-oriented concepts into the output or process phase, exposes a risk of treating the guiding values as results, which inverts the logic of a policy design.

Finally, to operationalize and evaluate the development of SPSI over time, the system must adopt a path-oriented framework. Such a framework enables the analysis of trajectories, institutional learning, and cumulative capacities through all stages of the IOOP model. However, the key indicators for this framework are primarily anchored in the Outcome phase because there, they capture the cumulative, long-term, and emergent effects of integration. This dimension of our system, consequently ensures that the SPSI is evaluated as a dynamic and historically contingent process, not just a snapshot of plans or actions.

In sum, the integration of place-dependency as the structural core, policy-oriented concepts as the design framework, and path-orientation as the temporal-evaluative logic provides us with a comprehensive system of relevant indicators evaluation of spatial planning system integration in EU's fringe regions.

Having established the structural framework of the system and indicator relevancy filters, the next step is to run the system across the three dynamic components of relational capital: cooperation capability, collective action capability, collective competence.

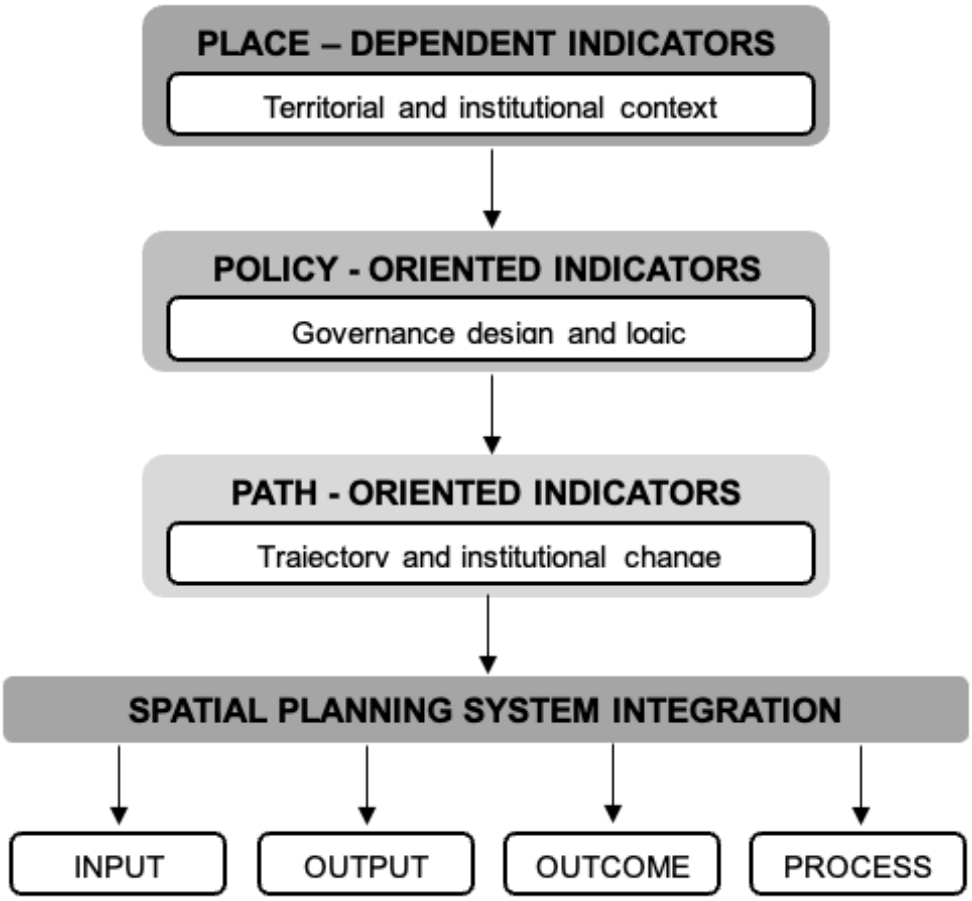

Figure 1: Indicator relevancy filters

The relationship between these components vis-à-vis indicator types and the IOOP phases is mostly horizontal and cross-cutting, although some relational capital indicators are inherently phase-dependent, meaning they are not strictly independent and interact with all phases. Accordingly, we adopt the understanding of this relationship as cross-phase and interactive, dependent on two analytical dimensions and one sequential. This means that relational capital can be analysed as transversal dimension: it is activated in the Process phase, shaped in Input, reflected in Output and Evaluated in Outcome phase. Indictor types (place-dependent, policy-oriented and path oriented) as diagnostic lens, shape the temporal logic, that is they organize how we observe relational capital, not when it happens; and finally, the IOOP model gives structure to systemic change, from conditions to coordination to outputs and implications.

In Table 5, we provide graphic interpretation of Indicator relevancy for each component of relational capital per particular phase within the IOOP model. The different shades of colour, along with descriptions above, indicate the analytical role and relevance of each indicator type within the IOOP model. The values (strong, cross-cutting and not applicable) help clarify how each indicator is used in evaluating SPSI and where it holds the most analytical weight. So, when certain indicator is anchored then it is directly connected to its relevancy, meaning it is fully applicable, and designed to measure variables or dynamics specific to that phase. For example, place-dependent indicators are anchored in the Input phase, because they measure initial conditions like institutional maturity, legal structure, or governance asymmetry, whereas the path-oriented indicators are anchored in the Outcome phase, because they assess trajectory, learning, and long-term change, which are only visible over time. The cross-cutting indicators provide interpretive insights, helping to understand, contextualize, or explain variations in that

phase. In this case, the place-dependent indicators are cross-cutting in the Output phase, as they help explain why some regions produce better-integrated plans or agreements than others, based on territorial conditions but they don't measure the outputs themselves. Similarly, the policy-oriented indicators are cross-cutting in the Outcome phase because they help interpret whether governance design influences long-term results but they're not designed to measure impact over time. Finally, when indicators are marked as "not applicable" or "not yet observable", then they are inapplicable in that particular phase, usually because the conditions they measure, don't exist yet. In this case, we cannot apply path-oriented indicators in the Input phase because there hasn't been any time or activity yet to observe change or evolution. The different shades, tentatively indicate the indicator importance in this particular phase.

Table 5: Indicator relevancy for each component per stage

IOOP Phase	Relational Capital **Component**	Place-dependent Indicators	Policy-oriented Indicators	Path-oriented Indicators
INPUT	**Cooperation capability**	**Strong importance (anchored)** Defines regional preconditions for cooperation	**Strong importance (anchored)** Design of institutional cooperation mechanisms	**Not applicable** Requires time-based data
	Collective action capability	**Strong importance** Maps asymmetries and capacity gaps	**Strong importance** Assesses subsidiarity and alignment	**Not yet observable**
	Collective competence	**Strong importance** Institutional maturity and knowledge base	**Strong importance** Evaluates the system's readiness to learn	**Not yet observable**
PROCESS	**Cooperation capability**	**Cross-cutting (interpretative)** Explains ease/difficulty of cooperation	**Relevant importance** Assesses participatory and procedural norms	**Emerging importance** Early signals of trust or coordination evolution
	Collective action capability	**Cross-cutting** Explains coordination feasibility	**Relevant importance** Joint mechanisms and decision-making structures	**Emerging importance** Initial changes in coordination dynamics
	Collective competence	**Cross-cutting** Explains variation in learning speed	**Relevant importance** Procedural adaptability	**Emerging importance** Learning-in-action
OUTPUT	**Cooperation capability**	**Cross-cutting** Explains variability in output quality	**Moderate importance** Embedded collaboration tools	**Visible importance** Institutionalization of cooperation over time
	Collective action capability	**Cross-cutting** Explains delivery variation	**Moderate importance** Output relevance to joint goals	**Visible importance** Depth of coordination output (e.g., cross-sector plans)
	Collective competence	**Cross-cutting** Explains technical and strategic output quality	**Moderate importance** Responsiveness of tools and institutions	**Visible importance** Adaptation based on implementation feedback
OUTCOME	**Cooperation capability**	**Cross-cutting (moderate)** Long-term enabling conditions	**Cross-cutting (moderate)** Explains outcome durability	**Strong importance (anchored)** Trust durability, embedded norms
	Collective action capability	**Cross-cutting (moderate)** Explains long-term coordination success/failure	**Cross-cutting (moderate)** Gaps in governance design affecting delivery	**Strong importance** Expanded joint implementation capacity
	Collective competence	**Cross-cutting (moderate)** Explains differences in outcome sustainability	**Cross-cutting (moderate)** Effectiveness of institutional learning structures	**Strong importance** Institutional learning, policy adaptation, system change

We believe that the proposed tri-layered indicator system offers a comprehensive and adaptive framework for evaluating Spatial Planning System Integration (SPSI), especially in complex, EU's fringe contexts. By integrating place-dependence, policy orientation, and path-dependence, the indicator system reflects territorial diversity, institutional logic, and long-term transformation. Its design supports evidence-based learning, strategic adaptation, and feedback loops, which are key elements for building an explicitly resilient planning system. Finally, being tested by the components of relational capital, throughout different stages of the IOOP model, allows the framework to be more time-sensitive and process-aware.

4.Discussion

The main objective of this paper is to design a methodological framework for evaluating Spatial Planning System Integration (SPSI) in EU fringe regions. The main outcome is a tri-layered indicator system, that combines Camagni's territorial capital taxonomy with the IOOP (Input-Output-Outcome-Process) model, that addresses a critical gap in current spatial planning literature: the lack of operational tools capable of systematically evaluating integration efforts in structurally weaker and politically diverse European regions. Rather than focusing narrowly on outcomes or institutional forms, the proposed system allows for process-aware, time-sensitive, and territorially grounded assessment. The analytical strength of the system lies in its capability to enable evaluators to move beyond static measures of policy alignment, and instead to trace the evolution of spatial integration as a dynamic interaction between territorial resources, institutional processes, governance culture, and cooperation mechanisms.

Although the South Balkan region is referenced throughout the text, this paper does not provide empirical findings instead, the region serves as a contextual anchor - a reference frame that helps inform the structure and logic of the proposed system. The multitude of different planning environments in this region reflect the challenges faced by similar EU fringe regions, including: historical legacies of centralized planning, fragmented and asymmetrical administrative structures, and uneven EU integration. Therefore, the design process of the indicator system was informed by the spatial and institutional properties of this area, thus ensuring that the framework would be relevant, grounded, and sensitive to real-world constraints, without being limited by the specifics of a single case.

During the development of the indicator system, a notable methodological insight emerged: its potential for diagnostic reversibility. Originally designed to evaluate SPSI from inputs to outcomes or starting with the presence of enabling conditions and tracking their transformation into cooperative practices and strategic results, the model was found to also function effectively in reverse. This is especially relevant in contexts where spatial planning outputs appear formally aligned with EU objectives, but lack systemic grounding in territorial capital, institutional continuity, or cooperative capacity. This is why, when designing the system, our focus was turned towards the indicators capturing key dimensions of relational capital: relational capabilities, collective action capabilities, and collective competence, whose observation from regional context was informative and not of empirical nature. Ultimately, they signaled the type of questions that this framework is designed to provoke in future studies: Are planning outputs anchored in shared diagnostics and institutional memory? Are relational processes maintained beyond individual projects and/or funding cycles? Are integration practices embedded in legal and organizational routines? These questions demonstrate how the framework functions, not only as an evaluative tool, but also as a diagnostic lens for deeper institutional reflection.

Finally, similar to any other conceptual framework, the proposed indicator system has its own limitations. The effectiveness of the system depends on the availability and quality of data, particularly concerning the intangible forms of capital such as trust, cooperation, and institutional behaviour. What is more, some indicators will have to rely on proxies or qualitative assessments, which potentially could affect standardization and comparability. When it comes to the IOOP model's complexity, it may also require simplification in regions with low planning maturity or limited administrative capacity. Therefore, any future research should prioritize empirical testing, beginning in the South Balkans and extending to other EU fringe regions such as the Baltic states and Eastern borderlands. This would help evaluate the system's scalability, adaptability, and diagnostic precision, while refining indicators for diverse territorial contexts. In cases where institutional readiness is limited, simplified applications or pilot testing could support incremental uptake. Additionally, future work might expand the framework to include indicators on digital planning, resilience, and cross-sectoral integration, enhancing its relevance for emerging policy challenges.

5.Conclusion

This paper presents a novel and adaptable framework for evaluating Spatial Planning System Integration (SPSI), developed through a tri-layered indicator system rooted in Camagni's territorial capital taxonomy and structured via the IOOP (Input-Output-Outcome-Process) model. The system integrates three interrelated layers: place-dependency as the structural core, policy-orientation as the design logic, and path-orientation as the temporal-evaluative dimension. These are filtered through the dynamic dimensions of relational capital to produce a context- and time-sensitive, process-aware, and stage-reversible tool for assessing integration, especially in EU's fringe regions, where systemic coordination remains a challenge.

Rather than offering a case-based analysis, the study uses the South Balkan region as a contextual anchor, with the explicit objective not to demonstrate results, but to ensure the system's relevance to the complexities commonly found in EU fringe territories. In doing so, the territorial and institutional diversity of the region in question was leveraged to reinforce the framework's potential for broader application.

In this paper we emphasize the relational dynamics, institutional coordination, and temporal progression, so that we can provide framework that moves beyond conventional, output-focused evaluation methods. By doing so, we rely on multidimensional territorial indicators and diagnostic reversibility which in our view deepens the understanding of the systemic drivers and constraints that influence the spatial development processes. As a result, the paper contributes to academic discourse and policy practice, by addressing a long-standing methodological gap in European spatial governance.

At the end, three key takeaways emerge from this work. First, effective SPSI evaluation requires frameworks that incorporate relational, institutional, and procedural dimensions, not just static outcomes. Second, the system's diagnostic reversibility provides a powerful tool to assess whether formal planning outputs are truly supported by or result of meaningful cooperation and systemic readiness. Third, while the conceptual framework of the indicator system is theoretically strong, future empirical testing and iterative adaptation will depend on data quality and availability.

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Multi-Level Collaborative Governance for Environmental Protection and Climate Adaptation: Insights from EU-funded Projects

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Abstract
The implementation of the EU's ambitious goals for ecological transition and climate adaptation calls for a paradigm shift toward systemic, inclusive, and nature-based governance models for managing environmental assets. Recognizing the growing strategic relevance of the interdependence between governance and stewardship, this contribution offers a critical reflection on the implementation and outcomes of several EU-funded projects (LIFE and Interreg) led by the Roma Tre research group in the Agro Pontino. These projects have fostered the development of an innovative, collaborative, and adaptive governance framework that integrates formal regulatory mechanisms with voluntary agreements (Pacts and Environmental Contracts) and community-driven initiatives (Land stewardship agreements). Operating across multiple governance levels, this approach aims to enhance participatory environmental management, strengthen institutional capacity, and support long-term socio-ecological resilience.

Keywords: collaborative governance, land stewardship, environmental contract

Introduction: Integrating Collaborative Governance and Environmental Stewardship for Climate Resilience in Europe and the Mediterranean Basin

Climate change represents one of the most pressing and complex challenges of the 21st century, with profound implications for ecosystems, societies, and economies worldwide. Nowhere is this more evident than in the Mediterranean Basin, a region identified as a global climate change hotspot due to its accelerated warming – approximately 20% faster than the global average (IPCC, 2022). This region is increasingly vulnerable to extreme weather events, prolonged droughts, biodiversity loss, and land degradation, all of which threaten ecological integrity and socio-economic stability (EEA, 2020).

In response to these escalating threats, the European Union (EU) has articulated a comprehensive policy framework aimed at fostering climate resilience and ecological sustainability. Key initiatives such as the European Green Deal (European Commission, 2019), the EU Biodiversity Strategy for 2030 (European Commission, 2020), and the EU Strategy on Adaptation to Climate Change (European Commission, 2021) underscore the need for systemic, inclusive, and nature-based approaches to environmental governance. These strategies emphasize the restoration of degraded ecosystems, the expansion of protected areas, and the integration of biodiversity considerations across all sectors of policy and planning.

However, the implementation of these ambitious goals necessitates a paradigm shift in governance models. Traditional top-down approaches, while still relevant, are increasingly being complemented by collaborative governance frameworks that emphasize co-production of knowledge, shared decision-making, and multi-actor engagement (Ansell & Gash, 2008). Collaborative governance is particularly well-suited to address the multifaceted and cross-sectoral nature of climate adaptation and biodiversity conservation, where ecological, social, and institutional dynamics intersect in complex ways.

The collaborative governance model, as defined by Ansell and Gash (2008), involves formal, consensus-oriented, and deliberative processes in which public agencies engage non-state stakeholders in collective decision-making. This model is characterized by iterative cycles of trust-building, shared understanding, and incremental successes that reinforce stakeholder commitment and deepen collaboration. In this context, the adaptive governance approach incorporates learning, monitoring, and feedback to enhance governance effectiveness over time (Folke et al., 2005; Westerink et al., 2017).

In parallel, the concept of environmental stewardship has gained prominence as a complementary framework for implementing governance strategies at the local level. Environmental stewardship refers to actions undertaken by individuals, groups, or networks to protect, care for, or responsibly use the environment in pursuit of both ecological and social outcomes (Bennett et al., 2018). These actions are deeply embedded in local contexts and are influenced by a range of factors, including social, cultural, financial, and institutional capital.

The interdependence between governance and stewardship is increasingly recognised in the literature. While governance structures provide the institutional scaffolding necessary to mobilize actors and allocate resources, stewardship actions operationalize these strategies through concrete, place-based interventions. Johnson et al. (2020) highlight the critical role of civil society in environmental governance, emphasizing that local stewards – often organized in formal and informal civic networks – play a pivotal role in managing and transforming local environments.

This synergy is particularly vital in hybrid landscapes characterized by overlapping peri-urban, rural, and natural components. In such contexts, governance processes must be coordinated across multiple scales and sectors, requiring the activation of diverse stakeholders and the transparent management of shared resources. The landscape approach advocated by Westerink et al. (2017) exemplifies this need for spatially coordinated multi-actor governance arrangements in agri-environmental management.

Moreover, the effectiveness of both governance and stewardship is contingent upon the capacity of local actors. Capacity encompasses a range of assets, including social networks, cultural traditions, financial resources, physical infrastructure, human skills, and institutional frameworks (Bennett et al., 2018). External actors such as governments and NGOs can play a facilitative role by enhancing local capacity, providing incentives, and fostering partnerships.

A critical component of this integrated approach is the co-production of knowledge. Effective environmental governance requires the integration of scientific and local knowledge systems, a process that is often hindered by communication barriers, trust deficits, and institutional constraints (Rodela & Swartling, 2019). Transdisciplinary collaborations and social learning processes are essential for overcoming these challenges and for building a shared understanding of environmental issues and solutions. Social learning is a powerful mechanism for fostering inclusive and context-sensitive governance. It enables individuals and groups to learn collectively by sharing knowledge, experiences, and perspectives.

In this context, this article proposes to address climate and environmental challenges facing Europe and the Mediterranean Basin, applying an integrated approach that combines collaborative governance with environmental stewardship. Such an approach must be adaptive, inclusive, and grounded in local contexts. It must also prioritize the co-production of knowledge and the empowerment of local actors.

Specifically, this contribution explores the multi-layered governance model developed and tested in the Agro Pontino (Italy) from the perspective of the research group actively involved in EU-funded projects highlighting critical tensions, challenges, opportunities and potential trajectories emerging from the intersection of collaborative governance and stewardship practices fostering transformative action for environmental sustainability and climate adaptation.

Methodological approach

The methodological approach adopted is grounded in an innovative multi-level governance model structured on two interrelated levels: a territorial level with a strategic function and a local level with an operational function. This framework enables the integration of formal regulatory instruments with voluntary mechanisms, fostering inclusive, adaptive, and action-oriented decision-making processes that are essential for addressing environmental sustainability and climate adaptation challenges.

The first, strategic and territorial level is implemented through two main governance instruments: Pacts and Environmental Contracts. These tools operate under the principles of vertical and horizontal subsidiarity through voluntary commitments promoting cohesion between institutions across multiple levels and sectors. Specifically, the Pact is an open and permanent working group where a plurality of actors – including public authorities, associations, small enterprises – define shared goals for environmental sustainability and climate adaptation. Likewise, the Environmental Contract is a voluntary governance tool that engages institutions, local authorities, associations, and citizens in a participatory process to promote the sustainable management of a water basin, integrating water resource protection, hydrogeological risk prevention, ecological and landscape enhancement, and socio-economic development (Bastiani, 2011).

The second, operational and local level is realised through Land Stewardship Agreements (LSAs), a voluntary public-private collaborative tool that fosters cooperation between landowners and users (farmers, foresters, shepherds, hunters, fishers, passive recreationalists) to promote the sustainable management and conservation of natural and cultural landscapes through long-term, participatory commitments involving a wide range of civil society groups (Sabaté et al., 2013). LSAs – typically lasting ten years – formalize the commitments of stakeholders for the implementation, management, and maintenance of green infrastructure in peri-urban and rural areas, providing the necessary institutional and financial scaffolding to ensure their durability. By sharing a management model and objectives for landscape maintenance and biodiversity conservation, landowners and users become active players (Magaudda et al., 2020).

The innovative contribution of the model lies in the structurally and functionally integrated relationship between the two levels. Pacts and Environmental Contracts serve as strategic coordination frameworks, aligning planning instruments, policy priorities, and institutional efforts across sectors in a coherent and systemic manner. LSAs, on the other hand, serve as implementing tools that translate strategic goals into concrete actions, strengthening the operational dimension of climate adaptation by embedding resilience and ecological connectivity at the community scale and ensuring their long-term effectiveness and continuity. This governance system is based on an iterative, flexible and participatory process involving networking activities, stakeholder consultations, joint drafting of strategies and agreements, definition of planning and incentive criteria, and identification of funding resources.

Case studies: LIFE BEEadapt and Interreg Euro-MED Coastrust in the Agro Pontino

Study area

The Agro Pontino, a vast coastal plain in southern Lazio bordered by the Lepini Mountains and the Tyrrhenian Sea, is the result of a radical transformation of both its natural and cultural landscapes. This transformation occurred during the 1930s through the implementation of the so-called 'Great Reclamation', a major hydraulic engineering effort that drained extensive marshlands and converted them into arable land. The intervention profoundly altered the region's ecological systems, land use patterns, and settlement dynamics, giving rise to a landscape now dominated by agricultural infrastructure and a dense network of drainage canals. The territory also includes a significant stretch of coastline, encompassing ecologically valuable systems such as sandy dunes, coastal lakes (including Fogliano, Monaci, Caprolace, and Paola), and wetlands, many of which are protected within the boundaries of Circeo National Park. These areas are biodiversity hotspots and represent highly sensitive ecosystems that are increasingly vulnerable to anthropogenic pressures. While agriculture remains the dominant land use, tourism has emerged as a growing component of the region's socio-economic profile. The coastal zone, with its unique natural features, historical settlements, and recreational amenities, attracts a wide range of visitors throughout the year. However, the expansion of tourism – particularly in the absence of adequate regulation – can exacerbate land use conflicts, contribute to habitat fragmentation, and place additional stress on water resources and waste management systems. Thus, balancing economic development with environmental sustainability poses an ongoing challenge for regional planning and governance. Despite

the historical significance of its agricultural matrix, the Agro Pontino is currently facing multiple environmental challenges (Magaudda et al., 2019). The unchecked expansion of urban and rural settlements, coupled with the intensification and industrialization of agricultural practices, has led to a progressive decline in the ecological functionality and biodiversity of the landscape. These dynamics are eroding the resilience of the region's agroecosystems and exacerbating the impacts of climate change.

In this context, the coastal and peri-coastal zones of the Agro Pontino emerge as a particularly relevant case study for analysing the interactions between agriculture, tourism, urbanization, and ecological conservation. The pressing need for integrated landscape management strategies – capable of reconciling productivity, biodiversity conservation, and climate adaptation – is increasingly evident, especially considering the threats posed by sea-level rise and the growing fragility of coastal ecosystems (Fig. 1).

Figure 1 – Coastal ecosystem of the Agro Pontino (Giovanni Mastrobuoni).

Over the past two decades, the Province of Latina has played a central role in initiating a process of environmental recovery and territorial requalification across the Agro Pontino. Recognizing the potential of green and blue infrastructure systems – such as windbreak strips, canal banks, and riparian buffer zones – as ecological connectors, the Province has promoted a planning approach aimed at restoring landscape continuity and enhancing ecosystem services (Benelli et al., 2022). In alignment with the objectives of the EU Water Framework Directive (2000/60/EC) and the Habitats Directive (1992/43/EEC), the Province has undertaken numerous studies and monitoring activities focused on the region's environmental conditions and challenges. This commitment culminated in the adoption of the Provincial Territorial Coordination Plan (*Piano Territoriale Generale Provinciale* – PTGP) in 2010, which formally integrated the Provincial Ecological Network as a strategic planning tool. This network represents a key instrument for the conservation of local habitats and the restoration of ecological processes, with particular attention to agricultural landscapes through targeted strategies aimed at reducing pollution and re-establishing ecological continuity.

This wide-area planning framework has been reinforced through a series of EU-funded projects that have mobilized territorial stakeholders and supported demonstrative interventions. These projects – LIFE Rewetland (2010 - 2014), LIFE Greenchange (2018 - 2023), Interreg MED Coasting (2018 - 2019), LIFE BEEadapt (2022 - ongoing), and Interreg Euro-MED Coastrust (2024 - ongoing) – have collectively contributed to an evolving model of integrated governance for environmental regeneration (Fig. 2).

They emphasize collaboration, the valorisation of natural capital, and the operationalization of green and blue infrastructure as key elements for sustainable land management and climate resilience.

The Agro Pontino thus represents a dynamic laboratory for exploring innovative approaches to regional governance that combine ecological restoration, sustainable agriculture, and inclusive territorial development. Through a gradual yet continuous process, the region is moving toward a more balanced relationship between human activity and the environment, underpinned by strategic planning, multi-actor engagement, and an increasingly structured framework for ecological connectivity.

Figure 2 – Agricultural and natural landscape of the Agro Pontino (LIFE Greenchange).

Life BEEadapt

The LIFE BEEadapt project "A Pact for Pollinator Adaptation to Climate Change" (LIFE21CCA-IT-LIFE BEEadapt/101074591) is funded under the LIFE Programme's Climate Action subprogramme and coordinated by the National Park of the Tuscan-Emilian Apennines. It brings together a diverse network of institutional, scientific, and civil society actors, including the Institute for BioEconomy of the National Research Council (CNR-IBE), the Sustainable Development Foundation, the University of Camerino, Legambiente, RomaNatura, the Municipality of Aprilia, Confagricoltura Latina, U-Space srl, and the Department of Architecture at Roma Tre University. The project addresses the increasingly severe impacts of climate change on wild pollinators – such as bees, hoverflies, moths, and butterflies – by adopting an integrated approach that combines ecological, agronomic, and territorial governance measures. These actions aim to strengthen the adaptive capacity of pollinator communities in response to climate-induced stressors. LIFE BEEadapt is situated within a broader context of declining pollinator populations across Europe and the Mediterranean, a trend largely attributed to altered phenological cycles and the growing frequency and intensity of extreme weather events (Gordo & Sanz, 2010; IPBES, 2016; ISPRA, 2023). In this regard, the project places pollinators at the centre of local adaptation strategies by promoting ecological connectivity and habitat diversity. This is operationalized through the development of flower meadows, shelters, and other green infrastructure interventions within urban, peri-urban, and rural areas, thereby extending flowering periods, re-establishing synchrony between floral and pollinator phenology, and ensuring the availability of refuge habitats. These ecological interventions are integrated with agronomic and land-use practices that enhance resource availability and functional landscape management.

Pilot activities are being implemented in five target areas across Italy: the Tuscan-Emilian Apennines National Park, the Torricchio Nature Reserve in the Marche region, the agricultural landscapes of the Agro Pontino, the Municipality of Aprilia, and protected areas within the city of Rome managed by RomaNatura. To facilitate

the implementation of these interventions, the project fosters a collaborative multi-level governance model, articulated through two primary instruments: Pacts for the Adaptation of Pollinators to Climate Change and LSAs. In the Agro Pontino, the Pact is coordinated by Confagricoltura Latina and is conceived as a strategic governance instrument to coordinate and promote the active participation of territorial stakeholders in climate adaptation initiatives, both during and beyond the LIFE BEEadapt project period. The Pact seeks to integrate existing planning and programming frameworks to improve access to funding opportunities for local actors, support environmental management through technical documentation, and enhance the territorial effectiveness of ecological interventions through a network-based logic. Land stewardship agreements are identified as the primary implementation mechanism for the on-the-ground management of pollinator-friendly green infrastructures. The governance process underpinning the Pact is guided by key principles, notably the activation of an open and inclusive participatory process to ensure the comprehensive identification of challenges and the co-definition of actionable solutions, which are essential for achieving durable and measurable outcomes. Furthermore, the Pact is designed to align with the specific territorial, social, and institutional contexts in which it operates, ensuring coherence with existing regulatory frameworks, planning tools, and strategic programs. A central output of the Pact is the development of a Local Agenda, comprising a dynamic and evolving set of actions aimed at achieving the Pact's objectives. This agenda is structured as a living document, designed to be continuously updated and expanded based on the evolving needs and contributions of stakeholders.

The governance framework established by LIFE BEEadapt builds upon the foundation laid by the previous LIFE Greenchange project, which was coordinated by Province of Latina. LIFE Greenchange aimed to enhance the ecological integrity of the Agro Pontino, as well as northern Malta and Gozo, by restoring ecological connectivity and increasing the availability of natural habitats within agricultural landscapes. These efforts sought to mitigate the effects of fragmentation caused by infrastructure development, urban sprawl, and intensive farming. A key component of LIFE Greenchange was the creation of a governance mechanism – the Pact for Biodiversity – signed on September 3, 2020, by representatives of regional and local institutions, environmental authorities, and farmers' associations. This Pact functioned as an open and permanent forum for dialogue, aiming to coordinate the management of agricultural areas through the sharing of practices, tools, and knowledge. It also sought to harmonize priorities and funding mechanisms for ecosystem conservation and restoration (Magaudda et al., 2020).

Within this context, LIFE BEEadapt continues and expands upon the governance architecture established by LIFE Greenchange in the Agro Pontino region.

On one hand, through a renewed participatory process, the project organizes targeted stakeholder workshops addressing pollinators and sustainable agricultural practices – such as the event on Eco-Scheme 5 (March 31, 2025, held with Confagricoltura Nazionale and ANSA, with 50 farmers in attendance) – to develop a shared strategy for strengthening pollinator resilience to climate change and promoting the adoption of LSAs. Key stakeholders involved in the Pact include Province of Latina, representatives from agricultural associations (Confagricoltura, CIA, Coldiretti), Circeo National Park, Municipalities of the Agro Pontino (Latina, Sabaudia, San Felice Circeo, and others), farmers and environmental NGOs.

On the other hand, LSAs function as the operational tools of the Pact, facilitating the on-the-ground implementation of conservation measures. To date, six LSAs have been signed by farms directly involved in pilot interventions. These agreements include three key parties: the beneficiary of the LIFE BEEadapt project (Confagricoltura Latina), which is responsible for the implementation of green infrastructure using LIFE funds and serves as the designated landscape stewardship organization; the farms tasked with the management and maintenance of the green infrastructure; and the landowners, when distinct from both the beneficiary and the farms, whose participation is essential for the legal and operational validity of the agreements. The participating farms serve as demonstration sites for adaptive land management practices aimed at enhancing pollinator conservation. By signing the LSAs, farmers formally commit to managing the green infrastructure developed through the LIFE project in accordance with jointly defined principles and standardized protocols. Additional LSAs will be formalized throughout the project's duration, with the expectation that many will remain active beyond the project's conclusion. This ongoing engagement underscores the long-term sustainability and potential for broader replication of the governance model established by LIFE BEEadapt.

Interreg Euro-MED Coastrust

The project Coastrust "Promoting shared stewardship for Mediterranean Coasts, led by the Region of Western Greece, was funded in 2024 by the Interreg Euro-MED Programme 2021-2027, under the priority 'Greener MED', Specific objective RSO2.7 'Enhancing protection and preservation of nature, biodiversity and green infrastructure'. It is framed within the Mission 'Protecting, restoring and valorising the natural environment and heritage' and will run until 2026. The project consortium is composed of nine partners from seven countries (Croatia, Greece, Italy, Malta, Spain, Albania, Bosnia and Herzegovina), ensuring a wide geographical coverage within the Programme area. Partners consist of a variety of organisations with complementary roles and expertise, belonging to the public administration (Region of Western Greece, Regional Development Agency of the Dubrovnik-Neretva County, Institute for Nature Conservation in Albania, Office of The Prime Minister of Herzegovina - Neretva Canton Government, Andalusian Federation of Towns and Provinces), the non-profit sector (SUBMON, Nature Trust Malta, Sustainable Development Foundation) and the academia (Roma Tre University). Additionally, nine associated partners (mostly local authorities) take part in the project, with different roles ranging from advisory, to dissemination and replication of results, to operational support to pilot actions implementation.

Coastrust addresses the need to sustainably use, manage, protect or restore ecosystems with the involvement of stakeholders and citizens, consistently with the European orientations promoting participatory approaches to biodiversity conservation. It is a 'Testing' type of project, i.e. intended to 'experiment common instruments, policies, strategies and action plans already developed to validate concrete solutions to be transferred' (Interreg Euro-MED, 2022). To this aim, the project applies the environmental stewardship concept to coastal areas undergoing anthropogenic pressures and aims to test and establish multi-level and multi-stakeholder governance mechanisms to support the sustainable management of natural resources at land and sea. The composition of the consortium mirrors this multi-level approach, by involving public institutions with different scopes and jurisdictions (a Macro Region, a Regional authority, an association of Municipalities in Spain, a Regional Development agency) in order to shed light on the diverse administrative, organizational and management challenges posed by participatory governance models.

The project works on both the strategic/methodological level and at the implementation/operational one. At the first level, it intends to establish the necessary conditions to enable environmental stewardship and to develop a methodology for defining common goals for sustainably manage coastal areas through stewardship. A preliminary version of this methodology has already been released and will be further refined throughout the project lifetime to be ready for transferring and replication within the Programme area. At the implementation/ operational level, the project supports the development of pilot activities, including both a strategy and a set of actions for each of the 8 coastal areas targeted, developed with the engagement of institutions and private actors at all scales and consistently with the areas' specificities and needs. Target areas were chosen so as to feature the widest range possible of site-specific environmental, geographical and socioeconomic issues, in order to allow for the design of more comprehensive stewardship strategies: river mouths (i.e. the Neretva Delta in Croatia and Bosnia y Hezergovina and the Buna River in Albania), protected coastal and marine areas (i.e. the Circeo National Park in Italy and the Ċirkewwa Marine Park in Malta), coastal lagoons, sandy beaches, etc.

In the Province of Latina, the activities that are being carried out by the Department of Architecture of Roma Tre University were designed to build on the outcomes and actions of previous initiatives, which since 2010 have been testing multi-level governance tools and mechanisms for improving the sustainability and effectiveness of the management of local assets: the LIFE projects Rewetland and Greenchange, the River Contracts of Cavata – Linea Pio, Amaseno and Ufente, and the Coast Contract developed within the framework of the Interreg MED Coasting. All these initiatives had served to mobilize the local stakeholders' network and engage different categories (local authorities, protected areas management bodies farmers, NGOs) in co-design processes, raising awareness on environmental protection issues and on the need of a change of paradigm in territorial governance.

Coasting specially builds on the Coasting experience, which in turn aimed to capitalize previous experiences of multi-stakeholders' contractual tools for sustainable and collaborative territorial governance (such as the *Contrat de Baie* of Marseille and the River Contracts), by applying their methodology to the coastal tourism sector in the Mediterranean area. This was achieved through participatory workshops involving both public and private actors, which in the area considered led to the development of the Agro Pontino Coast Contract, the first practice transferring the River Contract tool to a coastal area in Lazio region (Magaudda et al., 2021). Promoted by the

Lazio Regional Government and coordinated by the Province of Latina, the process acknowledged the synergic connection between biodiversity, landscape, climate change and tourism (Magaudda et al., 2021) and aimed at developing an integrated strategy for the management of the coastal area, balancing the improvement of the tourism sector and the maintenance and enhancement of the area's environmental quality.

As a matter of fact, the Coast Contract has been taken as a reference strategic framework to give continuity to: thus, the Roma Tre team is working to use environmental stewardship as an operational tool to implement those parts of the Contract that are most suitable to actively mobilise the local civil society – environmental associations, schools, neighbourhood committees, etc. Members of these target groups will be encouraged and tutored into presenting concrete stewardship initiatives to be supported by the project and implemented in the Circeo National Park by means of stewardship agreements involving the park authority and other interested parties (i.e. beach concessionaires).

In order to proceed with the target groups mobilization, the Roma Tre team, in collaboration with the Province of Latina (that is associated partner in the project) has organized a series of meetings to explain the project rationale, build the participants' capacities on environmental stewardship, and establish and operate a Local Action Group to develop the coastal stewardship strategy and the actions to implement it. The main actors targeted, besides local authorities, were relevant entrepreneurial associations (beach resorts managers, fishermen, etc.), small enterprises, and especially non-profit organizations already active in the protection and enhancement of the environmental assets of the area. Attendance to the meetings was deemed satisfactory, and the process was particularly successful in establishing contacts among NGOs, which often work separately, unaware of each other's activities.

Nevertheless, meetings attendance and involvement were negatively affected by widespread feelings of saturation, on one hand, and disappointment, on the other. Saturation is here intended as a condition of over-stimulation of territorial actors, which have been called to engage in numerous consecutive projects that, from their standpoint, have still not led to concrete results. Despite the organizers' effort to clarify the specific scope of Coastrust and highlight its continuity with previous initiatives, this feeling persisted especially in 'veteran' stakeholders. Moreover, the fact that the Coast Contract was virtually shelved, due to multiple reasons including lack of coordination, political input, and dedicated funding, generated a sense of disappointment that can ultimately put at risk the project success. In a wider perspective, these criticalities can even rise questions about the effectiveness of using EU-funded projects for the gradual implementation of governance mechanisms. In fact, in the case of Coastrust, the promoters' willingness to resume and bring forward the work done so far is now clashing with some stakeholders' disappointed expectations towards public authorities, which are blamed for not giving course to the decisions taken with the local community, somehow downplaying past participation efforts.

Conclusion and future perspectives

Collaborative learning processes are crucial to address contemporary environmental challenges and support resilient socio-ecological transitions.

The experience gained through the LIFE BEEadapt and Interreg Euro-MED Coastrust projects in the Agro Pontino confirms that combining multi-level collaborative governance models and land stewardship tools is a promising way to carry out this process. Strategic instruments (Pacts and Environmental Contracts) and operational mechanisms (LSA) can be mutually reinforcing and, when properly integrated, can help overcome common challenges in environmental governance, such as institutional fragmentation, discontinuous stakeholder engagement, and lack of coordination among sectoral policies. In fact, while the governance framework provides the institutional architecture for collective learning, coordination, and adaptive management, stewardship operationalizes these principles on the ground through concrete actions and incentives. Together, they create a dynamic system capable of fostering community empowerment, aligning public and private interests into dynamic collaborative networks to respond to environmental pressures, and promoting shared responsibility in the management of common goods.

However, structural limitations persist that may put collaborative learning at risk and ultimately jeopardize the long-term sustainability of these processes. Chief among them are the dependence on project-based EU funding, the weak institutionalization of Pacts as formal governance tools, and the risk of stakeholder disillusionment and desertion in the absence of tangible follow-up.

The case studies analysed suggest that the implementation of the model should imply an intentional, well-structured process that cannot be confined to the boundaries of EU projects, which are limited in terms of both duration and funding. Such projects, though able to trigger the process, should be framed within a clear long-term vision and engagement system, adaptive and flexible enough to include non-traditional actors in the management of environmental assets, and able to overcome institutional and epistemological barriers, as well as to acknowledge the value of the local communities' knowledge and initiatives. These challenges call for a rethinking of the mechanisms used to support and enhance land stewardship, including the structural integration of stewardship practices into public plans and programmes, their continuous, adaptive monitoring and follow-up, and the introduction of payment schemes for ecosystem services (PES) to reward stakeholders' engagement.

In conclusion, the convergence of collaborative governance and land stewardship represents a promising pathway for advancing the EU's goals for climate resilience and biodiversity, and for ultimately building resilient socio-ecological systems. It aligns with the EU's vision of a just and green transition, where local communities are empowered to shape their environmental futures and contribute meaningfully to global sustainability goals. However, in the light of the experiences analysed, there is a clear need to strengthen the institutional and social infrastructure of territories through tools capable of linking strategic vision with concrete action. This entails investing not only in pilot projects, but also in capacity-building pathways, regulatory recognition, and incentive mechanisms. Collaboration between practitioners, public officers and academia, as demonstrated in the case of the Agro Pontino, can support this transition.

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Collaborative governance through the Mediterranean. Framing a Community of Practice for Wetland Contracts

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Abstract
Wetlands are vital ecosystems, hosting 40% of global biodiversity and providing services such as flood regulation, carbon storage, and water purification. Despite their importance, wetlands face severe threats, with over 35% lost globally in the past 50 years due to urbanization, agriculture, and pollution. The Mediterranean region is particularly affected, requiring urgent action to ensure wetland preservation and sustainable management. This paper aims to explore the potential of Wetland Contracts as participatory governance tools for wetland conservation. It focuses on the WE GO COOP project, which scales Wetland Contracts through a Mediterranean Community of Practice (CoP) and adapts them to new contexts. The paper also highlights the role of a virtual collaborative platform in fostering stakeholder engagement and knowledge exchange, showcasing its effectiveness in addressing wetland challenges through innovative governance.

1. Wetlands governance in the Mediterranean

Mediterranean wetlands, as defined by the Ramsar Convention (1971), are "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters." These ecosystems, while covering only 2-3% of the Earth's surface, host 30% of vertebrate species, highlighting their extraordinary biodiversity and ecological significance. Beyond their ecological value, wetlands provide essential ecosystem services that benefit both the environment and human society. These services include water purification, flood regulation, carbon sequestration, climate change mitigation, and the provision of habitat for a wide variety of species. Wetlands also support vital economic activities such as fisheries, agriculture, and tourism, which are especially important in the Mediterranean region.

The Ramsar Convention, formally known as the Convention on Wetlands of International Importance, was adopted in 1971 in Ramsar, Iran. This international treaty focuses on the conservation and sustainable use of wetlands worldwide, recognizing their ecological, economic, and cultural value. Ramsar mandates that member states promote the protection of wetlands through direct conservation measures and encourage sustainable use of these vital areas. A key aspect of the Ramsar Convention is the establishment of the List of Wetlands of International Importance, which includes sites recognized for their global ecological significance. These sites are specially protected to safeguard biodiversity and the essential ecological functions they provide, such as water purification, climate change mitigation, and habitat for numerous species of flora and fauna.

Despite their importance, Mediterranean wetlands face severe degradation, with their surface area having declined by nearly 50% since the 1970s (Ramsar Convention Secretariat, 2018). This loss is driven by anthropogenic

pressures, including urbanization, agricultural land conversion, water abstraction, and disruptions to hydrological cycles. These stressors have been compounded by the absence of an integrated governance framework, resulting in fragmented conservation efforts and inadequate spatial planning.

Effective spatial planning is critical to addressing these challenges and ensuring the sustainable management of wetlands. Often, wetlands face the challenge of being governed by a patchwork of regulations and authorities, each focusing on narrow, sectoral interests, such as agriculture, urban development, or water management, without considering the holistic ecosystem dynamics. To avoid further degradation, spatial planning must be more integrated and ecosystem-based, recognizing the interconnections between wetlands and surrounding environments. A coordinated approach to land use, water management, and conservation is needed to balance human activities with ecological preservation.

In recent years, the EU Nature Restoration Law has brought wetlands into the spotlight as critical ecosystems to restore. The law, which was proposed by the European Commission in June 2022 and approved in June 2024 by the EU Parliament, sets ambitious targets for the restoration of Europe's degraded ecosystems, habitats, and species, including wetlands. The law is designed to ensure the restoration of biodiversity across the EU, addressing the severe degradation of ecosystems due to human activity, pollution, climate change, and over-exploitation. Wetlands are explicitly included as key ecosystems to restore due to their crucial role in environmental health (European Parliament and Council, 2024).

The Nature Restoration Law emphasizes that many of Europe's wetlands have been lost or degraded over previous centuries, primarily due to drainage for agriculture, infrastructure development, pollution, and climate change. However, wetlands are invaluable in achieving the EU's broader environmental, climate, and biodiversity goals. They provide vital ecosystem services, such as filtering pollutants, securing clean drinking water, reducing flood risks, and supporting biodiversity. Moreover, wetlands help mitigate and adapt to climate change, making their restoration essential for the EU's climate and social objectives.

By including wetlands in the Nature Restoration Law, the EU aims to unlock the potential for wetland restoration, which can have far-reaching benefits for both nature and society.

In this framework, this paper aims to highlight how the Interreg Euro-MED WE GO COOP – *Improving WEtland GOvernance through a COmmunity Of Practice* project attempts to address these governance challenges by promoting multilevel, ecosystem-based management approaches (Muccitelli *et al.*, 2023). The project is based on the capitalization of the Wetland Contract, facilitates collaboration among diverse stakeholders to harmonize wetland conservation with sustainable use. This approach seeks to mitigate conflicts between development and preservation, creating a common framework for addressing the complex dynamics of wetland management and for reaching the European and international goals (EC, 2020).

2. Wetland Contracts as a collaborative tool for e governance in Europe

In the last decades of the 20th century, under the broader framework of the European Union, relevant processes of devolution and transfer of competences were initiated.

The principle of subsidiarity, formally established by the Treaty on European Union (TEU), asserts that decisions should be made as close as possible to the citizen, with regular assessments to ensure that action at the EU level is warranted considering the capabilities at national, regional, or local levels.

Several countries in Continental Europe, operating under the so-called *civil law system* rooted in Roman law, have been encouraged to reconsider their traditional centralized legal frameworks. This has led to the incorporation of numerous contractual arrangements. Within this context, private stakeholders are explicitly involved, with recognized opportunities to influence change and participate in decision-making processes (Table 1).

Table 1. Civil Law System vs Common Law System

	Civil Law System	Common Law System
Geographical Areas	Predominantly in Continental Europe	Predominantly in Anglo-Saxon countries
Entities Responsible for Public Interest	Public authorities are entrusted with general interest matters, following a hierarchical institutional structure	A broad range of actors – including universities, non-profit organizations, foundations, and trade associations – are encouraged by social, economic, and cultural milieu to enter into binding agreements with public authorities
Written Constitutions	Always present	Not always present
Judicial Decisions	Not binding on third parties; however, administrative and constitutional court rulings on laws and regulations are binding on all	Binding on future cases (precedent applies)
Influence of Legal Scholarship	Legal scholars have significant influence in certain jurisdictions	Minimal influence from legal scholars
Freedom of Contract	Limited – many legal provisions are automatically implied into contracts	Extensive – very few legal provisions are automatically implied into contracts

Decision-making and managerial input have assumed particular significance in environmental governance. It is not merely the rigidity of regulations but rather the architecture of the decision-making framework that shapes expectations and obligations. This approach was notably implemented in France during the 1980s through the introduction of *Contrats de Rivière* (River Contracts). These contracts are defined as technical and financial agreements aimed at the comprehensive and sustainable management of a coherent hydrographic unit. They represent a shift toward participatory and multi-stakeholder governance in water resource management.

Inspired by this French model, wetland contracts have gradually gained traction across Europe. These instruments clearly express the necessity for participatory governance by facilitating coordinated action for the conservation and sustainable management of wetland ecosystems. Their increasing adoption reflects the growing awareness of the crucial role wetlands play in climate change mitigation, biodiversity conservation, and water cycle regulation.

The evolution and dissemination of such governance tools are closely linked to the development of European environmental policy, particularly the Water Framework Directive (2000/60/EC). This directive emphasizes participatory planning at the river basin level and introduces the objective of achieving a "good ecological status" for all water bodies. It thus encourages integrated, locally driven approaches to resource management. Throughout the years, the Contract has proven effective in France and Belgium, offering a structured yet flexible tool that enables stakeholders, including landowners, local authorities, and private organizations, to define and pursue shared goals for wetland conservation and sustainable use (Bastiani, 2011; Scaduto, 2016). These contracts exemplify a bottom-up approach to governance, aligning biodiversity preservation with sustainable practices such as eco-tourism and agriculture.

In Italy, the implementation of wetland contracts is relatively recent, since the beginning of the 2000s, but expanding rapidly, supported by a favorable regulatory environment and experience gained through river contracts.

Also in this case, the Italian Environment Code focuses mainly on rivers, having formalized the river contract in 2015 as "a voluntary tool of strategic and negotiated planning for the protection and better management of water resources, valorization of river landscape and mitigation of hydraulic risk, contributing to the local development." (Italian Environment Code, 2006/2015)

Many Regions have been actively promoting these tools through their legislation and dedicated calls and programs. These processes are often initiated by local governments or regional environmental agencies, in collaboration with environmental associations, universities, and land reclamation consortia. The wetlands involved are typically under significant anthropogenic pressure, such as intensive agriculture, fishing, urbanization, or tourism, underscoring the need for a shared, multi-level vision for their protection (Ernoul *et al.*, 2021).

The governance model of wetland contracts is based on a participatory and multi-level structure, involving a broad range of public and private actors. A typical framework includes a Coordinator and a Management Board with a political role, supported by the Technical Secretariat tasked with developing studies and operational proposals and conducting the participatory process. Finally, the Assembly includes all the stakeholders involved in the process.

Community engagement is facilitated through active participation tools, including forums, territorial workshops, public consultations, and co-design sessions. The formal signing of the contract by participating entities is voluntary yet binding, with each signatory committing to responsibilities in line with their competencies and resources.

From a spatial planning perspective, the wetland contract serves as a catalyst and integrator for existing policies. It operates in synergy with urban, landscape, environmental, and agricultural plans, offering a cross-cutting and coherent vision of the challenges and opportunities related to wetlands. As such, the contract acts as a strategic coordination platform, helping to overcome institutional fragmentation and enhance the value of existing regulatory tools. Furthermore, it facilitates access to European and national funding by providing a structured and monitorable framework for concrete actions.

3. The Interreg Euro-MED WE GO COOP project: partnership and objectives

Building on the increasing relevance of wetland contracts across Europe and their evolution into strategic tools for integrated territorial governance, the WE GO COOP project represents a pivotal step toward the institutional consolidation and geographical expansion of this governance model. Funded under the Interreg Euro-MED programme, the project is designed to strengthen, transfer, and coordinate Wetland Contract experiences at both transnational and local levels across the Mediterranean.

WE GO COOP addresses the need to move beyond isolated pilot cases by structuring a shared framework for wetland governance, rooted in participatory planning and multi-level collaboration. It responds to the growing urgency to protect and restore wetland ecosystems facing anthropogenic pressures, ecological degradation, and policy fragmentation.

Central to the project is the promotion of the Wetland Contract, a voluntary agreement among public institutions, private stakeholders, and civil society organisations aimed at the sustainable management and enhancement of wetlands. This tool fosters local ownership and shared responsibility through the co-definition of objectives, action plans, and governance mechanisms. Although the model has already been implemented in several Mediterranean regions, WE GO COOP seeks to consolidate, harmonise, and scale its application, addressing both the need for institutional coherence and the diversity of territorial contexts.

The project adopts a dual strategy. On one hand, it seeks to scale up the Wetland Contract model by establishing a Community of Practice (CoP) at the Mediterranean level, a transnational platform of exchange and coordination. This community brings together public authorities, academics, NGOs, and technical experts to capitalise on existing experiences, share methodologies, and promote integrated approaches to wetland management. On the other hand, WE GO COOP aims to scale down the model by transferring it to new implementation areas, specifically Albania, Croatia, Portugal, and parts of the Southern and Middle Eastern Mediterranean, while also reinforcing its application in countries where it is already active, such as Italy, Greece, and Spain.

The initiative is organised around two main work packages: the first dedicated to the development and facilitation of the CoP, and the second to the transfer and contextualisation of Wetland Contracts in the designated pilot areas. These components are supported by transversal activities such as stakeholder engagement, knowledge dissemination, and alignment with regional and EU policy frameworks.

The partnership (Figure 1) is led by ANATOLIKI S.A. – Organisation for Local Development (Greece), and includes:

- MedWet Initiative (France), leading the CoP and overseeing the extension of project activities in Middle East and North Africa (MENA) regions;
- Department of Architecture of Roma Tre University (Italy), providing scientific insight into collaborative planning and stakeholder engagement processes;
- FAMP – Andalusian Federation of Towns and Provinces (Spain), contributing long-standing expertise with environmental contracts in wetland contexts;
- Nature Park Vransko Lake (Croatia), piloting actions in a vulnerable Ramsar site;
- PPNEA – Protection and Preservation of Natural Environment (Albania), adapting the methodology to the Vjosë-Nartë Protected Landscape;
- RCDI – Development and Innovation Network (Portugal), targeting wetlands influenced by agriculture and tourism dynamics in the Alentejo region.

Figure 1. Interreg Euro-MED WE GO COOP: partnership and main project data.

The consortium is complemented by a wide array of associated partners, including municipalities, universities, and protected area authorities, which enhance the territorial reach and thematic scope of the initiative.

Importantly, WE GO COOP builds upon the outcomes of a series of EU-funded projects that, over the past decade, have contributed to shaping and testing the Wetland Contract model in various environmental and institutional settings. These include:

- Interreg MED WETNET (2016–2019), which pioneered Wetland Contracts in six Mediterranean countries through coordinated multi-actor agreements;
- Interreg MED COASTING (2018-2019) and COASTING PLUS (2021–2022), which expanded the participatory governance model to coastal areas and sustainable tourism planning;
- Interreg IT-HR CREW (2018–2021), which focused on coordinated wetland management in the Italy-Croatia transboundary context;
- Interreg MED TUNE UP (2019–2022), which translated the Wetland Contract methodology into the marine domain, targeting Marine Protected Areas (Palazzo *et al.*, 2021).

By integrating and systematising these diverse experiences, WE GO COOP contributes to the consolidation of a common governance culture. It develops a transferable framework capable of accommodating ecological variability, socio-economic diversity, and policy asymmetries across the Mediterranean.

With a total budget of €999,784, of which €799,827.20 is provided by Interreg Euro-MED funds, and a duration of 27 months, the project actively supports European objectives in biodiversity, water protection, and climate adaptation. By enhancing collaborative capacity, facilitating cross-border cooperation, and fostering inclusive governance structures, WE GO COOP represents a key milestone in the advancement of a Mediterranean-wide, participatory approach to wetland conservation and sustainable territorial development.

4. Towards the Wetland Contracts Community of Practice

At the heart of the project's upscaling efforts is the creation of a Community of Practice (CoP) dedicated to Wetland Contracts in the Mediterranean, encompassing both EU and MENA regions. This transnational network brings together policymakers, researchers, practitioners, and local communities to foster dialogue, exchange knowledge, and disseminate best practices. It supports the development and implementation of participatory governance tools such as Wetland Contracts and provides a collaborative space where stakeholders can bridge the gap between scientific research, policy frameworks, and community action, promoting multi-level and multi-stakeholder cooperation.

The CoP was intentionally designed as a bottom-up initiative, building on existing experiences with Wetland Contracts across the Mediterranean. Its framework responds to the needs of organizations that face challenges in wetland governance and view the Wetland Contract as a promising opportunity for change.

A kick-off event, "*Gathering the Community of Practice*," was held in Seville in October 2024, bringing together an initial group of over 30 experts and organizations interested in launching the CoP. The participants focused on shaping a Mediterranean-specific vision of the Wetland Contract model and integrating it into the CoP. Three guiding questions structured the discussion:

- *Why establish a Mediterranean CoP on Wetland Contracts?*
- *Who should join the CoP?*
- *What should the CoP do?*

The session adopted a participatory approach, engaging both in-person and online attendees. The Mentimeter tool was used to conduct a live survey, capturing real-time responses that reflected participants' expectations and shared visions for the future of the CoP. The survey results highlighted key values such as cooperation, governance, sustainability, and community, underscoring participants' commitment to a collaborative approach to wetland management. Among the CoP's priority objectives, capacity building (15%) and networking (13%) were ranked highest, demonstrating a shared need to strengthen knowledge and foster stronger connections among actors. Other emphasized areas included monitoring, learning, and mentoring, positioning the CoP as a platform for ongoing improvement and engagement. The main perceived benefits of joining the CoP included enhanced management skills, expanded networks, and increased recognition of the Wetland Contract's value. Participants indicated that their main contributions would be intangible knowledge (27%) and introducing new stakeholders (27%), reflecting a strong emphasis on sharing experiences and broadening the community. To ensure its effectiveness, participants suggested tools such as a repository of best practices, regular meetings, online platforms, and strategic planning mechanisms to facilitate continuous information exchange and cooperation.
Another key milestone was the first thematic seminar, "*Framing the Community of Practice*", held in Rome in January 2025. This event provided a space for stakeholders to discuss common challenges, define governance goals, and explore strategies for improving wetland management. It emphasized the need for tools that enable cross-sectoral collaboration and the integration of diverse perspectives in decision-making. Using the World Café methodology, participants contributed proposals in three thematic areas to help shape the vision and objectives of a Mediterranean CoP focused on Wetland Contracts (Table 2).

Table 2. Thematic areas, guiding questions and key outcomes discussed during the World Cafè session in Rome to shape the objectives of the Mediterranean CoP on Wetland Contracts.

Topic	Guiding questions	Key outcomes
Legal Acknowledgment and Advocacy	*How can legal frameworks for Wetland Contracts be strengthened?*	Analyze national regulatory frameworks for Wetland Contracts
	What advocacy actions are needed to increase recognition?	Highlight links between Wetland Contracts and the Nature Restoration Law
		Engage policymakers in the CoP
		Promote leadership coaching to support Wetland Contract dissemination
Knowledge Sharing and Capacity Building	*What tools or platforms can facilitate knowledge exchange?*	Emphasize the benefits of Wetland Contracts
	How can training enhance stakeholder capacity?	Deliver know-how through the MedWet platform
Finance for Governance and Action	*What are the most effective funding mechanisms for governance?*	Develop a business plan for the CoP
	How can long-term financial sustainability be ensured?	Promote new EU-funded projects on Wetland Contracts
		Define a quality certification for Wetland Contracts

The second part of the Rome seminar focused on defining key elements of a forthcoming policy paper, aimed at promoting the integration of Wetland Contracts into European environmental strategies and frameworks. The seminar marked the beginning of a collective reflection on necessary recommendations, as well as challenges and opportunities that should be addressed. A brainstorming session helped identify priority policy areas where Wetland Contracts can play a meaningful role, namely:

- Climate change adaptation
- Landscape and socio-cultural heritage
- Nature restoration and biodiversity protection

In each of the aforementioned areas, Wetland Contracts can empower local communities to take action by sharing responsibilities and commitments. By providing a shared vision and a practical action plan, Wetland Contracts can also support effective investments through greater integration and synergy across all sectors. Wetland Contracts has been acknowledged as able to promote integrated governance by engaging stakeholders in shared decisions and actions. They support climate adaptation, biodiversity restoration, and cultural heritage by aligning local priorities with broader environmental goals through participatory and place-based strategies.

5. A web platform to assess the current implementation of Wetland Contract at Med level

One of the key activities supporting the creation of the Community of Practice (CoP) for wetland governance in the Mediterranean is the development of a virtual collaborative web platform. This platform serves as a transnational hub designed to monitor, document, and disseminate good practices and data related to signed Wetland Contracts across the region. It is conceived as an open and interactive tool that fosters knowledge exchange among CoP members, while also facilitating continuous interaction and capacity-building processes.
The structure and tools of the platform are inspired by previous Mediterranean experiences that have contributed to building shared knowledge on wetland management. The data were primarily collected and selected from open-source datasets such as:

- *Gest'eau*, the French platform that promotes integrated and sustainable water resource management. It provides information on planning tools such as SDAGE, SAGE, PTGE, and basin contracts, facilitating cooperation among local stakeholders. It is managed by the International Office for Water with support from the the Ministry of Ecological Transition. A dedicated section focuses on the *Contrats de Milieu* (Environmental Contracts).
- The Mediterranean Wetlands Observatory (MWO) that monitors the health of Mediterranean wetlands, providing data and indicators to guide conservation efforts. It supports sustainable water and biodiversity management. Established in 2008, it is coordinated by Tour du Valat.
- The Interreg Italy-Croatia CREW Observatory that is a transnational hub focused on monitoring and sharing best practices and data related to coastal wetlands in the Italian-Croatian cross-border region. It promotes sustainable wetland management through tools like the Wetland Contract, encouraging collaboration among public and private stakeholders.
- The inventory of Environmental Contracts in Mediterranean Ramsar and marine sites, developed within the framework of the Interreg MED TuneUp project.
- The inventory of Wetland Contracts signed in Italy provided by the Italian Board of River Contracts (*Tavolo Nazionale dei Contratti di Fiume*).

The WEGOCOOP platform, currently under experimentation, is organized into different sections that enable key environmental governance actors to interact through tools such as a repository, a WIKI, and a WebGIS. The core of the platform is the WIKI, which include river, lake, wetland, coastal, marine, and aquifer agreements, are categorized by typology and georeferenced for spatial analysis (Figure 2).

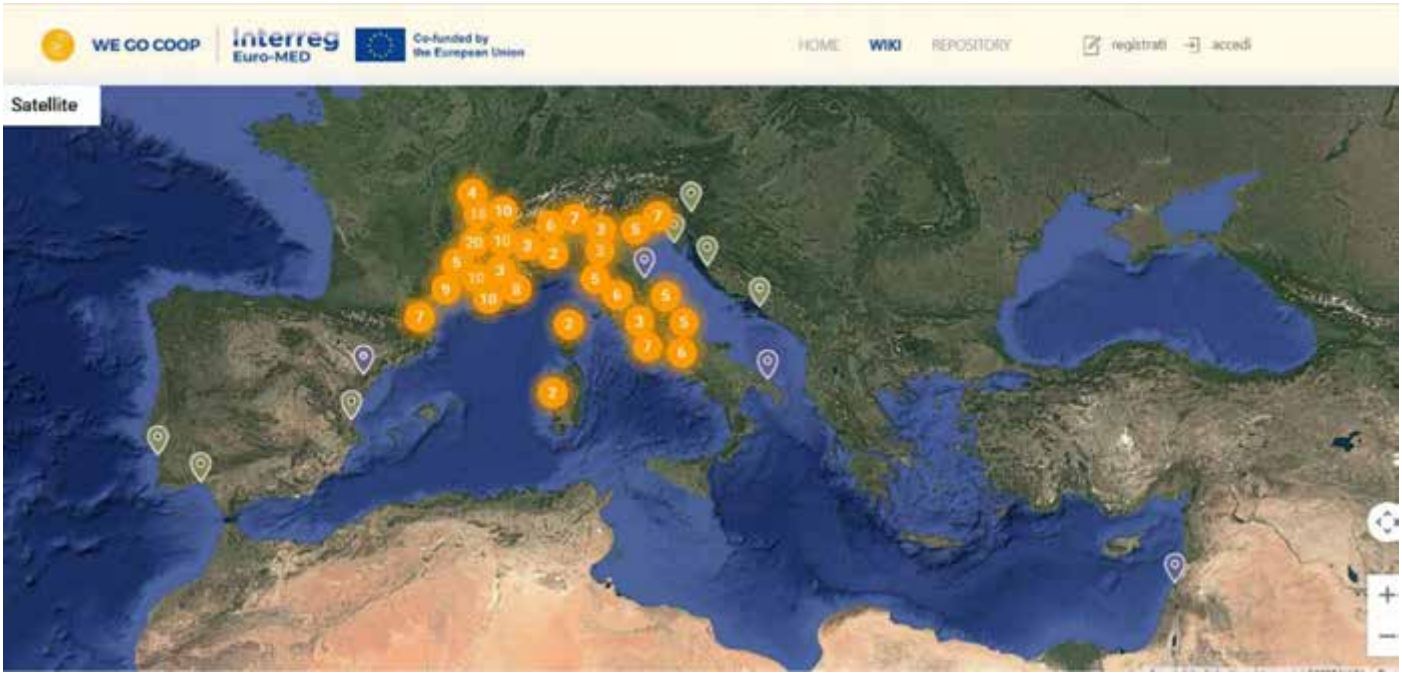

Figure 2. Current state of updating of the WE GO COOP virtual platform.

Each case study is documented through a standardized set of fields that capture both institutional and ecological dimensions. Key descriptors include the location (longitude and latitude of the centroid), contract's name, year of signature, and the main source of funding, ranging from international and EU programs to national or local funds. The platform also records the typology and identity of the reference organization, contact details, and the geographical and ecological context of the water body involved, including whether it falls under nature protection regimes such as Natura 2000 or regional parks. Governance characteristics are detailed through the number and type of signatories (public/private), sectors involved (e.g., agriculture, tourism, fisheries), and thematic priorities such as flood management, pollution control, and biodiversity conservation. Financial aspects are addressed through estimates of required and activated funding, while qualitative insights are captured via self-assessment metrics on stakeholder engagement, knowledge sharing, and strategic planning. Finally, each contract entry may include links to official documents and lessons learned, offering a comprehensive and comparative view of environmental governance practices in the Mediterranean region.

By integrating these resources into an accessible digital space, the platform enhances the effectiveness, scalability, and transferability of collaborative governance practices. This work presents the initial outcomes of the WE GO COOP project and demonstrates how the virtual platform functions as a pivotal tool for advancing wetland governance. By enabling the CoP to access, share, and co-create knowledge, the platform plays a central role in addressing the ecological and socio-economic challenges faced by wetlands in the Mediterranean and beyond.

6. Perspectives and ways forward

Wetland Contracts represent a forward-looking governance instrument, specifically designed to support the conservation, restoration, and sustainable management of wetlands and associated ecosystems. Developed within the framework of key European environmental policies, such as the Water Framework Directive and the Nature Restoration Law, they offer concrete means of advancing the European Green Deal's biodiversity and climate adaptation objectives. These policies emphasize the need for integrative, inclusive, and multi-level governance approaches capable of addressing the ecological degradation of aquatic and terrestrial environments while promoting socio-economic resilience.

At the heart of Wetland Contracts is a participatory model of governance that mobilizes a broad spectrum of territorial actors, including public authorities, environmental NGOs, private landowners, scientific institutions, and local communities. This collaborative framework enables the co-production of knowledge and the alignment of diverse interests around shared ecological and socio-economic goals. Through coordinated interventions, Wetland Contracts support actions such as the removal of artificial barriers to restore hydrological connectivity, wetland re-naturalization to enhance carbon sequestration and flood mitigation, and the establishment of ecological corridors to combat habitat fragmentation.

Despite their innovative potential, the implementation of Wetland Contracts still presents several critical challenges. These include the need for stable funding mechanisms, the variability in institutional capacities across regions, and the complexity of coordinating heterogeneous stakeholder interests over the long term. In some cases, the lack of clear legal frameworks or integration with existing planning instruments can also hinder their full operationalization.

In this context, the Community of Practice (CoP) promoted by the WE GO COOP project plays a crucial role. It serves as a collaborative environment in which these challenges can be openly addressed through the exchange of experiences, joint problem-solving, and the development of shared methodologies. By facilitating structured dialogue among practitioners, policy-makers, researchers, and local actors, the CoP fosters mutual learning and contributes to the progressive refinement of Wetland Contracts as effective governance tools.

Beyond their immediate ecological and social benefits, Wetland Contracts may also contribute to broader biodiversity conservation frameworks, particularly to the definition of the so-called *Other Effective Area-Based Conservation Measures* (OECMs). Recognized under the Convention on Biological Diversity (CBD), OECMs refer to areas that, although not formally designated as protected, achieve sustained biodiversity outcomes through effective and enduring governance (CBD, 2018; IUCN-WCPA. (2019).

The governance architecture of Wetland Contracts, emphasizing long-term engagement, adaptive management, and inclusive participation, can help identify and support such areas, especially where conservation objectives are achieved through locally driven processes.

By embedding Wetland Contracts within a dynamic and structured Community of Practice, governance is strengthened on multiple fronts: horizontally, by fostering collaboration and knowledge exchange among diverse actors; and vertically, by aligning local actions with national and European policy frameworks. This multi-level configuration enhances institutional coherence, improves implementation capacity, and ensures that wetland restoration efforts are both scientifically grounded and socially legitimate.

In conclusion, the combined approach of Wetland Contracts and the CoP promoted by WE GO COOP represents a robust and adaptable governance innovation. By addressing existing implementation challenges, supporting participatory and evidence-based decision-making, and contributing to broader conservation strategies such as OECMs, this model advances Europe's goals for biodiversity restoration, climate resilience, and territorial cohesion. It offers a replicable and scalable pathway for sustainable ecological governance in diverse socio-ecological contexts.

Attributions
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Enhancing resilience in water management agriculture: A Social Network Analysis approach to identify Leverage Points for climate adaptation

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Abstract:
Climate change exposes vulnerabilities in water-agriculture governance by straining information flows, collaboration, and norms. This study couples Social Network Analysis (SNA) with resilience theory to examine how Murcia's actor configurations enable absorption of shocks, adaptation, and transformation. Using COSMIC—a platform co-developed with HDA that integrates multilingual surveys, real-time validation, and instant network visualization—stakeholders provided organizational profiles, mapped inter-actor ties, and identified leverage points. COSMIC generated an undirected graph and computed node metrics (degree, betweenness, closeness, eigenvector) plus network indicators (density, modularity). Preliminary findings reveal a polycentric structure: a core of interconnected institutions sustains redundant pathways (absorptive resilience), while clusters suggest opportunities for cross-sector collaboration (adaptive resilience). Qualitative interviews confirm public and academic actors perceive high cohesion—validating hubs' buffering roles—whereas civil society's lower cohesion ratings expose outreach needs. Divergent views on sustainability versus productivity highlight "intent"-level leverage points requiring value-focused dialogues. COSMIC's survey-to-analysis workflow enables rapid diagnosis of structural strengths and weaknesses, guiding parameter-level (data-sharing), feedback-level (incentives, mediation), and intent-level (value alignment) interventions. These preliminary insights will be tested and refined across remaining FARMWISE case studies.

Keywords: Climate Resilience, Social Network Analysis (SNA), Leverage Points, Water Management, Agricultural Governance

1.Introduction

The intertwined challenges of climate change and water scarcity are redefining the boundaries of sustainability in agriculture. Nowhere is this more evident than in semi-arid regions like Murcia, in southeastern Spain—a territory characterized by structural water stress, increasingly erratic precipitation, and intensifying socio-environmental pressures. With an average annual rainfall of only 300–350 mm and a historical dependency on intensive irrigation systems, the region has long been on the frontline of adaptive water governance (García-Ruiz et al., 2011; Iglesias & Garrote, 2015). Compounding the issue, Murcia has experienced at least 17 extreme weather events associated with DANAs (Depresiones Aisladas en Niveles Altos) since 2000, including the devastating floods

of 2019, which brought more than 500 mm of rainfall in a matter of days (Pérez-Morales et al., 2021; Zabalza et al., 2018). These disruptions underscore the urgent need for governance systems that can anticipate, absorb, and adapt to climatic shocks.

Remarkably, Murcia has also emerged as a global reference in water reuse and efficiency. It currently recycles approximately 98% of its treated wastewater, compared to 9% in the rest of Spain and just 5% across Europe (Esamur, 2022). This performance reflects a sophisticated network of infrastructures and actors—ranging from public water authorities like the Confederación Hidrográfica del Segura and the Mancomunidad de los Canales del Taibilla, to regional administrations, farmer cooperatives, water user associations (WUAs), and municipal operators. Yet, despite this apparent success, the very complexity of this governance landscape may become a liability in times of crisis. Fragmented responsibilities, institutional inertia, and weak coordination mechanisms often erode the system's adaptive potential (De Stefano et al., 2015; López-Gunn et al., 2012).

Most research to date on Murcia's water governance has emphasized technological and infrastructural solutions. What remains underexplored is the role of actor configurations and network structures in shaping adaptive capacity. In other words, *how resilience is organized*, and not merely what technical tools are deployed. To address this gap, this paper adopts a relational perspective grounded in Social Network Analysis (SNA), resilience theory, and the concept of leverage points (Meadows, 1999; Bodin, 2017). We argue that understanding who interacts with whom, and how, is essential to revealing hidden vulnerabilities and unlocking transformative potential within governance networks.

Our case study draws on the ongoing Horizon Europe project FARMWISE, which aims to support climate adaptation in agriculture across eight European regions, both through the use of digital models and the inclusion of water innovations in each of the 8 case studies (Spain, Poland, Italy, The Netherlands, United Kingdom, Sweden, Finland and Ukraine). In this paper, we start by applying our methodology to Murcia - a region that exemplifies both institutional innovation and structural tension in water management - to later extend the approach to the other case studies in subsequent phases of the research. Our objective is threefold: (1) to map the actor networks involved in water-agriculture governance in the Murcia region; (2) to identify structural leverage points that may enhance system-wide resilience of the network; and (3) to offer strategic insights for more adaptive and inclusive governance arrangements in the region.

The study addresses three core questions:

- How are actors in Murcia's water-agriculture governance system interconnected, and what structural network patterns emerge?
- Where are the leverage points—nodes or relationships—that hold potential for amplifying resilience?
- How can these insights inform adaptive governance interventions in climate-vulnerable regions?

To operationalize this analysis, we developed a digital tool—**COSMIC (Collaborative Stakeholder Mapping of Interactions and Collaborations)**—built from the ground up through a collaboration between the Universitat Politècnica de València (UPV) and the University of Applied Sciences Darmstadt (H_DA). COSMIC facilitates the participatory mapping of governance networks through structured surveys, enabling the quantification and visualization of stakeholder relations. Governance networks refer to relatively stable configurations that emerge from the interactions of interdependent yet operationally autonomous actors, operating within a self-regulating framework shaped by external forces. These networks contribute to the collective attainment of public goals through ongoing coordination and collaboration (Isett et al., 2011; Kapucu, 2015; Sørensen & Torfing, 2005). Combined with qualitative data from interviews and focus groups, this mixed-methods approach allows us to trace not only the structure but also the meaning of interactions, what they enable, constrain, or fail to deliver.

By reframing resilience as an emergent property of relational dynamics, rather than a fixed institutional trait, this study contributes to ongoing debates on how to govern complex socio-ecological systems under increasing uncertainty (Folke et al., 2010; Chaffin et al., 2014; Biggs et al., 2012). Our findings have the potential to inform new strategies for leveraging collaboration, amplifying adaptation,driving reflection among stakeholders, and fostering long-term system transformation through governance.

2.Theoretical Framework

In this study, we are using 3 theoretical frameworks: SNA, Leverage points and resilience theory. The notion of leverage points is used as a conceptual bridge between network analysis and resilience theory. By identifying actors or relational patterns that play a disproportionately influential role in shaping collective behavior—such as brokers, connectors, or isolated subgroups—we aim to locate critical entry points for policy and intervention. These leverage points may not only signal opportunities for enhancing communication, trust, or legitimacy, but may also reveal deeper barriers to transformation, such as power asymmetries, siloed mandates, or entrenched mental models (Westley et al., 2011; Pereira et al., 2018).

2.1 Social Network Analysis in environmental governance

Social Network Analysis (SNA) has become an increasingly influential tool for understanding the relational underpinnings of governance in complex socio-ecological systems. Moving beyond static or institutionalist views, SNA conceptualizes governance as a dynamic web of interactions among diverse actors—government agencies, civil society organizations, private entities, and knowledge institutions—whose positions and relationships shape decision-making, knowledge circulation, and adaptive capacity (Wasserman & Faust, 1994; Prell et al., 2009; Janssen et al., 2006).

In the domain of environmental governance, SNA enables researchers to uncover not only *who* is involved, but *how* they are positioned relative to each other, *what kinds of ties* connect them (e.g., collaboration, authority, knowledge exchange), and *which structural properties, at the individual and network level* —such as centrality, density, or modularity—facilitate or constrain collective action (Bodin & Crona, 2009; Ingold & Balsiger, 2015). At the individual level, for instance, actors with high *degree centrality* often serve as visible influencers due to their numerous connections, while those with high *betweenness centrality* act as brokers or gatekeepers, strategically positioned to control the flow of information across otherwise disconnected subgroups (Burt, 2005; Bodin et al., 2006; Long et al., 2013). These positions can greatly influence the distribution of power, the legitimacy of decisions, and the ability to coordinate across scales or sectors (Knoke & Yang, 2008; Crona & Parker, 2012).

At the network level, measures such as *density* (the extent to which all possible ties are realized), *reciprocity* (mutuality of interactions), *modularity* (degree of clustering), and *centralisation* (unevenly a network's ties are concentrated on one or a few nodes rather than being evenly distributed) provide insight into how well-connected or fragmented a governance system is (Newman & Dale, 2005; Scott, 2017; Gava et al., 2025; Sandström, A. & Carlsson, L., 2008). Cohesive networks may promote trust, shared norms, and institutional learning (Henry & Vollan, 2014), while the presence of weak ties or bridging connections across clusters—what Granovetter (1973) famously called "the strength of weak ties"—can be crucial for accessing novel information and enhancing adaptive flexibility (Bodin, 2017; Sayles et al., 2019).

Empirical studies have demonstrated the relevance of SNA for water and agricultural governance. In Zimbabwe, Manzungu and Machiridza (2005) used SNA to expose how informal hierarchies and poor coordination among irrigation users led to inefficient water allocation and conflict, rooted in a lack of structural cohesion. In coastal Kenya, Crona and Bodin (2010) showed that actors occupying central and bridging positions were essential for linking ecological knowledge with governance processes, particularly in fragmented watershed contexts. Meanwhile, Berardo and Scholz (2010) analyzed U.S. estuarine policy networks, revealing how the *density* and *multiplexity* of ties—actors interacting across multiple domains—fostered cooperation and trust in conditions of uncertainty. Their "risk hypothesis" posits that actors facing high interdependence are more likely to establish stable, cooperative ties, thus enhancing the system's capacity to self-organize.

Methodologically, SNA provides a versatile platform to examine both the **structural** properties of governance systems (who is connected, how, and how often) and the **functional** implications of those structures—how power, influence, or knowledge circulate; where bottlenecks or gaps exist; and which nodes or relationships are most critical for systemic change (Reed et al., 2009; Borgatti et al., 2009). Moreover, by incorporating *tie content* (e.g., cooperation, conflict, funding, regulation), researchers can analyze not only the form but also the quality of interactions—an essential dimension in climate governance, where institutional misalignment and power asymmetries often hinder transformative action (Stein et al., 2011; Bodin, 2017).

2.2 Leverage points in complex systems

In the context of complex socio-ecological systems, the question of *where* to intervene is often more consequential than *how* to intervene. This idea lies at the heart of the concept of *leverage points*, introduced by Donella Meadows (1999), who argued that certain elements within a system exert disproportionately high influence over system behavior. Leverage points are strategic locations where a small change can catalyze substantial and lasting transformations across the whole system.

Meadows (1999) proposed a hierarchy of leverage points, ranging from shallow interventions—such as adjusting numerical parameters—to deep interventions that shift the goals, structures, or paradigms of the system itself. While shallow leverage points may offer immediate results, they are often insufficient to address persistent or structural problems. Deep leverage points, by contrast, target underlying causes and worldviews, and therefore hold greater transformative potential, even if they are more politically or institutionally challenging to access (Abson et al., 2017; Fischer & Riechers, 2019).

This distinction has gained increasing relevance in sustainability science, where the complexity of environmental challenges calls for change processes that go beyond technical fixes or incremental adjustments. Abson et al. (2017) identify four realms of leverage—design, intent, parameters, and feedbacks—and argue that interventions targeting design (e.g., governance architectures) and intent (e.g., normative goals) are more likely to result in transformative change than those focused on parameters or feedback regulation. Similarly, Fischer and Riechers (2019) contend that leverage points must be approached relationally, as interacting across different system levels—material, institutional, and cognitive—in ways that either reinforce or obstruct change.

In governance contexts, leverage points are not limited to technical solutions but include shifts in institutional arrangements, collective behaviors, and underlying narratives. For instance, transformative governance may emerge from changes in how problems are framed, how legitimacy is distributed, or how power asymmetries are addressed (Westley et al., 2011; Blythe et al., 2018). Transformative potential also depends on timing and context; socio-political shocks, crises, or policy windows can act as catalysts for deeper shifts if actors are prepared to engage with them strategically (Herrfahrdt-Pähle et al., 2020; Patterson et al., 2017).

Importantly, the identification of leverage points is not a purely analytical task—it is deeply normative. What constitutes a desirable intervention point depends on whose values, interests, and visions of change are prioritized (Meadows, 1999; Leach et al., 2010). This insight has led scholars to advocate for participatory and reflexive approaches to leverage points research, emphasizing inclusion, imagination, and collective learning as vital components of any transition process (Pereira et al., 2018; O'Brien, 2012).

Ultimately, leverage points thinking invites a fundamental reorientation in how we approach change. Instead of treating symptoms, it seeks to act on root causes. Instead of managing systems, it asks how systems can evolve. And instead of focusing solely on action, it also engages with intention—shifting not only what we do, but what we aim for, and why (Table 1).

Table 1. Leverage Points for Sustainability Transformation (Adapted from Abson et al., 2017)

Leverage Point Depth	Type of Intervention	Description	Examples	Transformative Potential
Shallow	**Parameters**	Adjustments to measurable variables within the system without altering its underlying structure or goals.	Tax rates, efficiency targets, emission limits	Low
	Feedbacks	Modifications to feedback mechanisms that regulate the system's behavior over time. They can dampen or reinforce systemic patterns.	Environmental fines, subsidies, performance incentives	Moderate
Deep	**System Design**	Changes to the institutional architecture, decision-making rules, and power relations that shape how the system functions.	Multi-level governance, participatory platforms	High
	System Intent (Goals & Paradigms)	Shifts in the overarching purpose, values, or dominant paradigms that define what the system is for and how success is measured.	From GDP growth to wellbeing, degrowth narratives	Very High

2.3. Resilience as a property of governance networks

The concept of resilience has become central to the analysis of socio-ecological systems and the governance arrangements that shape their capacity to withstand, adapt to, and transform in response to shocks and long-term stressors. Originally rooted in ecological theory (Holling, 1973), resilience has evolved into a multi-dimensional concept encompassing the ability of systems not only to absorb disturbances and maintain function (*persistence*), but also to adapt their structure (*adaptability*) and even shift into new regimes when needed (*transformability*) (Folke et al., 2010; Walker et al., 2004).

When applied to governance systems, resilience entails more than technical robustness or institutional efficiency. It reflects the degree to which institutional configurations, actor relationships, and decision-making processes can respond flexibly and innovatively to emerging challenges—particularly those associated with climate change, resource scarcity, or socio-political conflict (Biggs et al., 2012; Pahl-Wostl, 2009). In this view, governance networks are not merely instruments of control or regulation, but dynamic arenas in which resilience is continuously negotiated, reproduced, or undermined.

A resilient governance network is characterized by features such as diversity of actors and knowledge systems, redundancy in roles and responsibilities, modularity to contain cascading failures, and the capacity for learning and self-organization (Berkes et al., 2003; Janssen et al., 2006). Polycentricity—the coexistence of multiple centers of authority—is also considered a key feature, as it enables more adaptive and context-sensitive responses across scales and sectors (Ostrom, 2010; Huitema et al., 2009).

Critically, resilience is not a neutral or universally beneficial property. Scholars have warned against uncritically celebrating resilience without examining *what* is being made resilient and *for whom* (Cote & Nightingale, 2012; Béné et al., 2012). Systems can be resilient in maintaining unsustainable or unjust arrangements, such as elite capture of resources, exclusionary institutions, or maladaptive dependencies.

Therefore, assessing resilience in governance networks requires a normative lens—one that interrogates not only the system's capacity to endure, but also its ability to evolve toward more equitable, democratic, and sustainable configurations (Westley et al., 2011; Chaffin et al., 2014).

In the context of climate adaptation and water governance, resilience is increasingly conceptualized as a relational property that emerges from the interactions among actors, institutions, and ecological processes (Pahl-Wostl, 2009; Bixler et al., 2016). The structure and quality of relationships—trust, accountability, shared visions—are essential to understanding how governance systems mobilize collective action, coordinate across fragmented mandates, and navigate uncertainty. It is within this relational perspective that the integration of resilience thinking with network-based approaches finds its relevance: not as a static attribute of institutions, but as a dynamic, distributed, and contested capacity that is embedded in governance configurations.

3.Murcia As Case study

The Region of Murcia is one of Europe's most water-stressed agricultural areas, with irrigation withdrawals totaling nearly 1.7 billion m^3 per year—over 80 % of regional use—and a structural deficit of roughly 20 % covered by the Tagus–Segura inter-basin transfer and advanced wastewater reuse schemes (FAO, 2021; Confederación Hidrográfica del Segura, 2021). Remarkably, Murcia reclaims and reuses approximately 98 % of treated wastewater for irrigation—well above the EU average—underscoring its position at the forefront of agricultural water reuse (Regional Government of Murcia, 2018; European Commission, 2020).

Despite these innovations, water quality remains a critical concern: nitrate concentrations in Segura-basin aquifers frequently exceed the 50 mg/L limit of the Nitrates Directive (91/676/EEC), while phosphate runoff drives eutrophication events in the Mar Menor coastal lagoon, fueling stakeholder conflicts between irrigation communities seeking expanded transfers and desalination and environmental groups demanding stricter fertilizer controls and reuse quality standards (Confederación Hidrográfica del Segura, 2021). This combination of extreme scarcity, pioneering reuse, and contested water-quality challenges makes Murcia an ideal case for exploring how governance networks and technological interventions co-evolve under these constraints.

This analysis will be complemented by comparative case studies in the Netherlands, Poland, the United Kingdom, Sweden, Finland, Italy, and Ukraine, in future stages of the study.

4.Methodology

The methodology of this study is supported by COSMIC1, an open-access, interactive virtual platform that integrates data collection, actor-network visualization, and social network and leverage point analysis. COSMIC serves as both an academic research resource and a practical tool for multi-actor governance, centralizing data from the eight FARMWISE case studies (ES, IT, FI, ND, UK, UKr, PO, SW). As introduced before, in this work in progress paper, only the Spanish case study, in the Murcia region, will be introduced.

The sampling universe varies according to each case study's territorial context, acknowledging that an innovation system may be either regional or national: in the Murcia region in Spain, stakeholders are selected at the autonomous-community level - NUTS2 (regional)[2].

The number of participants was established according to a qualitative representativeness criterion validated jointly by the pilot coordinator and relevant local organizations, rather than through a strict statistical sampling method. Respondent recruitment was based on lists provided by regional leaders, supplemented by contacts identified through the iterative interview process, with explicit recognition and assessment of potential snowball bias (a sampling bias in which participants refer to similar contacts; Bethlehem, 2010). The study employed a

1 https://sus.media.h-da.de/ Developed jointly with the Darmstadt University of Applied Sciences.

[2] NUTS1/2 (national/regional): in countries with smaller administrative subdivisions, such as the Netherlands, where the study is conducted at the national level. / NUTS1 (national): in contexts covering one or more NUTS2 regions within a larger administrative framework, such as those used in Italy.

bottom-up mapping approach, progressively incorporating new stakeholders as they emerged during the interviews. Specifically, representatives of organizations such as irrigation communities, water-and-agriculture innovation firms, public research bodies, agricultural development agencies, farming cooperatives and federations, and journalists and media outlets specialized in environment and agriculture, among others, were surveyed. This iterative process continued until theoretical saturation was reached, ensuring the capture of the diverse perspectives essential for the analysis without relying on formal probabilistic estimates.

Using a multilingual questionnaire through the COSMIC platform, that will be available in eight languages, we collected three types of data structured in three sections: (1) nodes: general organizational information (10 items); (2) edges: description of key interactions among actors (7 items); and (3) leverage points: assessment of water-management leverage points (12 items) using a Likert scale. The main objective of the survey is to provide a robust database for analyzing both social networks under the Social Network Analysis framework (SNA; Wasserman & Faust, 1994) and leverage points from a systems perspective (Abson et al., 2017), thereby visualizing the complexity of the innovation and water-management ecosystem across the FARMWISE regions. Information about the actor network allows the researchers to get qualitative information about the actor network.

This survey was reviewed in a pilot phase by experts in agriculture, sustainability, and governance at the Polytechnic University of Valencia, ensuring coverage of the hydric innovation system's dimensions and internal consistency of the scales, and validating linguistic adaptation with each case-study leader (Dillman, Smyth & Christian, 2014).

Data collection is currently underway only for the FARMWISE Case Study in Spain, specifically in the Murcia region, carried out between February and April 2025. Surveys are administered by telephone during business hours, while simultaneously introducing the data in the COSMIC platform, with an average completion time of 15–18 minutes.

Raw data is stored in a JSON file feeding COSMIC's visualizations. This workflow enables calculation of key metrics—degree, betweenness, density, and modularity—and the creation of force-directed layouts that highlight the most significant interactions (Wasserman & Faust, 1994). All procedures comply with ethical and data protection regulations: participants sign informed consent under the GDPR, with advice from the UPV Data Protection Delegation.

5.Results (under construction

As the network remains under development, the following serves as a provisional illustration of the conclusions that may emerge.

5.1 The use of COSMIC platform

Data collection and preliminary social network computation were executed through the COSMIC (Collaborative Stakeholder Mapping of Interactions and Collaborations) platform, which implements a semi-automated pipeline from survey dissemination to metric extraction:

- **Questionnaire distribution**

A unique, multilingual survey link is generated for each case study and disseminated to identified stakeholders. Respondents provide organizational attributes and enumerate inter-organizational ties via structured fields. This standardized digital instrument reduces measurement error and enhances comparability across contexts (Dillman et al., 2014).

- **Automated data parsing and validation**

Submitted responses are encoded in JSON format. The platform performs syntactic and consistency checks—flagging incomplete metadata or implausible tie entries—and prompts researchers to resolve discrepancies, thus preserving data integrity.

- **Network construction and visualization**

Upon validation, COSMIC automatically interprets the JSON edge list, instantiates an undirected graph, and generates a force-directed sociogram. This immediate visual feedback facilitates iterative sampling adjustments and early detection of structural anomalies.

- **On-the-fly metric computation**

Core SNA metrics at node/individual-level (degree, betwenness, closeness cenetralities) and at network level (node and edge counts, density, average degree, and modularity via the Louvain algorithm) are computed server-side and logged alongside raw data.

- **Data export for advanced analysis**

Processed networks and attribute tables can be exported in interoperable formats (e.g., GEXF, GraphML, CSV), enabling seamless integration with external analytic environments (e.g., Python's NetworkX, R's igraph).

- **Automated workflow with human intervention**

COSMIC transforms a single shared survey link into a parameterized network model with minimal manual intervention. Nevertheless, because stakeholder identification and response completeness rely on participant engagement, rigorous follow-up protocols—including reminder communications and targeted outreach—are required to achieve sufficient coverage, mitigate snowball bias, and satisfy theoretical saturation criteria.

5.2 Murcia's water and innovation social network

Rank	Degree Centrality	Betweenness	Closeness	Eigenvector
Explanation	Proportion of all possible direct ties an actor actually has; high values identify "hubs" with many immediate connections for rapid information/resource exchange.	Extent to which an actor lies on the shortest paths between others; high values flag "brokers" or gatekeepers controlling key communication channels.	Average proximity of an actor to all others (via shortest paths); high values mark those who can reach every stakeholder in a few steps, ideal for quick mobilization.	Influence via association: actors connected to other well-connected peers score highly, marking them as indirect opinion leaders whose reach is amplified by powerful neighbors.
Notes	Identifies actors with the most direct ties, key hubs for transmitting information or resources.	Pinpoints actors that bridge otherwise disconnected groups—critical brokers for cross-cluster coordination.	Highlights actors best positioned for rapid outreach—efficient conduits for time-sensitive communication.	Reveals actors whose influence is amplified by connections to other influential peers—ideal targets for indirect opinion-leader interventions.
1	CEBAS-CSIC	CEBAS-CSIC (171.67)	COBET Tratamientos del Agua SL (1.00)	Universidad Politécnica de Cartagena (1.00)
2	ESAMUR	ESAMUR (100.33)	ESAMUR (0.607)	CEBAS-CSIC (0.954)
3	Confederación Hidrográfica del Segura	Confederación Hidrográfica del Segura (72.00)	CEBAS-CSIC (0.595)	ESAMUR (0.944)
4	Comunidad de Regantes Campo Cartagena	Comunidad de Regantes Campo Cartagena (64.00)	Confederación Hidrográfica del Segura (0.565)	Comunidad de Regantes Campo Cartagena (0.835)
5	AZUD	AZUD (40.67)	SAT #557 (0.554)	Confederación Hidrográfica del Segura (0.760)

Concerning degree centrality, which represents the proportion of all possible direct ties that an organization actually has (i.e., a measure of its immediate interconnectedness), the five highest-scoring actors were CEBAS-CSIC, ESAMUR, Confederación Hidrográfica del Segura, Comunidad de Regantes Campo Cartagena, and AZUD.

This means that these organizations maintain the greatest number of direct relationships within the Murcia governance network, positioning them as key conduits for exchanging information, coordinating activities, and mobilizing resources across stakeholders.

Concerning betweenness centrality, which captures how often an organization lies on the shortest paths linking other pairs of actors (i.e., its potential to broker or gatekeep information flows), the top five and their scores were: CEBAS-CSIC (171.67), ESAMUR (100.33), Confederación Hidrográfica del Segura (72.00), Comunidad de Regantes Campo Cartagena (64.00), and AZUD (40.67). This indicates that these organizations occupy pivotal intermediary positions in the network, controlling key channels through which information and resources traverse between otherwise disconnected stakeholders.

Concerning closeness centrality, which quantifies an organization's average proximity to all other actors in the network (i.e., its capacity for rapid outreach), the highest values were observed for COBET Tratamientos del Agua SL (1.00), ESAMUR (0.607), CEBAS-CSIC (0.595), Confederación Hidrográfica del Segura (0.565), and SAT #557 (0.554). This means that these organizations are, on average, fewer steps away from all other stakeholders, enabling them to disseminate information or coordinate actions across the network more quickly than their peers.

Concerning eigenvector centrality, which reflects influence via connections to other well-connected actors (i.e., indirect prestige or endorsement power), the leading organizations were Universidad Politécnica de Cartagena (1.00), CEBAS-CSIC (0.954), ESAMUR (0.944), Comunidad de Regantes Campo Cartagena (0.835), and Confederación Hidrográfica del Segura (0.760). This indicates that these organizations are not only well-connected themselves but are also linked to other highly connected stakeholders, granting them enhanced indirect influence and prestige within the governance network.

Together, these centrality measures paint a consistent picture of Murcia's water-governance network as a polycentric yet hub-driven system. A small group of organizations—most notably CEBAS-CSIC, ESAMUR, and the Confederación Hidrográfica del Segura—occupy the most direct ties, broker the majority of indirect exchanges, and sit closest on average to all other actors, making them essential for coordination, information flow, and rapid outreach. Meanwhile, the Universidad Politécnica de Cartagena and CEBAS-CSIC extend their reach even further by connecting to other highly central stakeholders, amplifying their indirect influence across the network. This overlap of high-degree hubs, high-betweenness brokers, high-closeness disseminators, and high-eigenvector influencers underscores the critical role of a core group in maintaining network cohesion, facilitating cross-cluster links, and accelerating the spread of innovations or policy directives. At the same time, it points to potential vulnerabilities should any of these central organizations be disrupted, as well as to strategic opportunities for leveraging their positions to achieve system-wide impact.

5.3 Murcia's stakeholders perception about the about their network

Stakeholders from five sectors provided Likert-scale ratings (1 = "completely disagree" to 5 = "completely agree") on three dimensions of network leverage points. Table 6 summarizes, for each sector, the number of respondents (N), mean score, and standard deviation (SD) for each survey item. In each sector, all items received between 1 and 5 ratings, with most sectors providing 2–4 responses per item.

Sector-specific descriptive statistics for network perception items

SECTOR	ITEM	N	MEAN	SD
Surface level				
Academia	The network is strong and cohesive.	2	4.50	0.71
	The network is very diverse.	2	4.00	0.00
	Efficient coordination mechanisms exist.	2	3.50	0.71
Comunicación	The network is strong and cohesive.	1	5.00	–
	The network is very diverse.	1	4.00	–
	Efficient coordination mechanisms exist.	1	4.00	–
Private sector	The network is strong and cohesive.	4	3.50	1.73
	The network is very diverse.	4	4.00	0.82
	Efficient coordination mechanisms exist.	4	3.25	1.50
Sector Público	The network is strong and cohesive.	3	4.00	1.00
	The network is very diverse.	3	4.33	0.58
	Efficient coordination mechanisms exist.	3	3.67	0.58
Sociedad Civil	The network is strong and cohesive.	2	2.50	0.71
	The network is very diverse.	2	3.00	1.41
	Efficient coordination mechanisms exist.	2	3.00	1.41
Intermediate level				
Academia	I would like to collaborate more.	2	4.00	0.00
	Influential actors facilitate sustainable practices.	2	3.50	0.71
	Conflicts impede innovation.	2	2.50	0.71
Communication	I would like to collaborate more.	1	3.00	–
	Influential actors facilitate sustainable practices.	1	3.00	–
	Conflicts impede innovation.	1	2.00	–
Private sector	I would like to collaborate more.	4	4.25	0.96
	Influential actors facilitate sustainable practices.	4	3.50	0.58
	Conflicts impede innovation.	4	3.25	1.50
Public sector	I would like to collaborate more.	3	4.33	0.58
	Influential actors facilitate sustainable practices.	3	3.67	0.58
	Conflicts impede innovation.	3	3.00	0.00
Civil society	I would like to collaborate more.	2	3.50	0.71
	Influential actors facilitate sustainable practices.	2	3.00	1.41
	Conflicts impede innovation.	2	3.00	0.00

Deep level				
Academia	Network prioritizes sustainability over productivity.	2	2.50	0.71
	Ecosystem ready for collaborative governance.	2	4.00	0.00
Communication	Network prioritizes sustainability over productivity.	1	3.00	–
	Ecosystem ready for collaborative governance.	1	4.00	–
Private sector	Network prioritizes sustainability over productivity.	4	2.25	0.83
	Ecosystem ready for collaborative governance.	4	2.25	0.83
Public sector	Network prioritizes sustainability over productivity.	3	2.67	0.58
	Ecosystem ready for collaborative governance.	3	3.67	1.15
Civil society	Network prioritizes sustainability over productivity.	2	3.00	0.00
	Ecosystem ready for collaborative governance.	2	3.50	0.71

Stakeholder groups differed in how they rated the cohesion, diversity, and coordination of the Murcia governance network ("surface level"). Academic and Public Sector respondents consistently rated network strength and diversity highly (mean scores ≥ 4.0 out of 5) and judged coordination mechanisms to be moderately efficient (3.5–4.0). Private Sector actors provided more varied answers, with average scores of 3.5 for cohesion, 4.0 for diversity, and 3.25 for coordination. Civil Society gave the lowest surface-level ratings (2.5–3.0), while the sole Communications respondent rated all three dimensions between 4 and 5.

On the "intermediate level," which addresses actors' willingness to collaborate, the role of influential organizations, and the impact of conflicts, Public and Private Sector participants expressed the strongest desire to work more closely with the network (means slightly above 4.0). Academics' willingness to collaborate was similarly high (4.0), whereas Civil Society and Communications scored this item at 3.5 and 3.0, respectively. Across sectors, opinions were moderate on whether key actors facilitate sustainable practices (means around 3.5) and on whether conflicts obstruct innovation (means ranging from 2.5 to 3.25).

At the "deep level," concerning the network's underlying goals and readiness for new governance models, all groups gave lower ratings on whether sustainability takes priority over productivity (means between 2.25 and 3.0). In contrast, perceived readiness for a more collaborative, sustainable governance approach was rated highest by Academia and Communications (4.0) and lowest by the Private Sector (2.25), with Public Sector and Civil Society falling in between (3.5–3.7).

6.discussion: qualitative integration of stakeholder's network perceptions (under construction)
Drawing on resilience theory and leverage-point concepts, stakeholder perceptions help us understand Murcia's governance network in three ways: its ability to absorb shocks, to adapt over time, and to transform fundamentally.

Absorptive capacity (surface-level perceptions & parameter levers)
High ratings of network cohesion and diversity among Academia and Public Sector actors align with a capacity to absorb disturbances through redundant ties and multiple information channels (Berkes et al., 2003). These perceptions corroborate the high-degree centrality of CEBAS-CSIC and ESAMUR, suggesting that immediate "parameter" interventions—such as enhanced data-sharing protocols—can be readily deployed via these hubs to buffer short-term shocks. In contrast, Civil Society's lower ratings suggest some groups may be left out, pointing to areas where we need focused outreach to strengthen these weaker points.

Adaptive capacity (intermediate-level perceptions & feedback levers)
Strong expressed willingness to collaborate (especially in Public and Private sectors) reflects a positive feedback orientation—actors are ready to adjust practices in response to evolving conditions (Pahl-Wostl, 2009). This theme resonates with high-betweenness metrics: brokers like ESAMUR occupy positions to catalyze adaptive loops by convening multi-stakeholder working groups or piloting iterative policy-learning exercises. However, moderate

concern about conflicts suggests that without clear feedback mechanisms—like performance-based incentives or mediation forums—adaptation may stall.

Transformative capacity (deep-level perceptions & intent levers)
Views diverged on whether sustainability goals outweigh productivity goals. Some actors remain focused on traditional mandates, while others are open to deeper change, despite both actors can be innovating and fostering paradigm shifts (Folke et al., 2010). These normative divergences correspond to Meadows' "intent" leverage points: changing goals and paradigms is inherently political and requires deliberate engagement of central institutions (e.g., Confederación Hidrográfica del Segura) to convene reflexive dialogues. The relatively higher readiness perceived by Academia and Communications suggests pockets of transformative potential that can be activated through strategic framing exercises and co-creation workshops.

7.Preliminary conclusıons
The COSMIC platform was pivotal in this research, providing an end-to-end, semi-automated pipeline from survey deployment to network visualization and metric extraction. Its multilingual interface, real-time validation checks, and built-in SNA computations enabled rapid development of a fully parameterized network model from a single questionnaire link.
However, ensuring that peripheral actors were included—and thereby mitigating snowball bias—required diligent follow-up by the research team.

Overall, the combination of COSMIC-enabled network analytics and qualitative insights offers a scalable, replicable methodology for diagnosing resilience and guiding multi-level interventions: simple "parameter" fixes via data-sharing protocols, "feedback" instruments like incentives and demonstration projects, and "intent" dialogues to realign system goals. Future research should broaden stakeholder engagement, track network dynamics over time, and pilot the identified leverage-point interventions to assess their impact on adaptive capacity and transformative change.

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How meaningful is formal participation in environmental assessments? Examining the case of large-scale linear infrastructure projects in Germany.

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Abstract
Public participation informs and underpins the authorities' decision-making in the approval of large-scale energy and mobility infrastructure projects. Despite well-established knowledge on the prerequisites for meaningful engagement, participatory practices frequently remain limited to fulfilling minimum legal obligations.

This contribution examines which requirements for public participation in impact assessments are currently fulfilled and which aspects remain in need of improvement. The analysis focuses on the German approval processes for motorways, railways, and electricity transmission grids.

The analysis reveals that, although formal participation requirements remain limited in scope, they offer potential entry points for more meaningful engagement. Particularly, the dimensions of communication, mutual learning, and procedural innovation emerge as key areas for authorities to experiment with and advance participatory practices.

Keywords: environmental assessment; public participation; meaningful stakeholder engagement, large-scale infrastructure; energy and mobility transition

Glossary
MSE – Meaningful Stakeholder Engagement
EA – Environmental Assessment
E(I)A – Environmental (Impact) Assessment (project level)
SEA – Strategic Environmental Assessment

1.Research interest and relevance
Measures to accelerate the planning and approval processes for energy and mobility projects have become a heavily discussed topic in political debates worldwide (Enríquez-de-Salamanca, 2021; Fischer et al., 2023). In the German context, there is an urgent need to expand infrastructure to support climate goals and reduce greenhouse gas emissions. On top of that, the country's ageing infrastructure demands immediate attention and maintenance (Dullien et al., 2024; Schroeder, 2020). Policymakers are under increasing pressure to drive progress on both fronts simultaneously. The widely perceived lengthy timespans between the initiation and final approval of infrastructure projects have intensified public and political calls for faster approval processes and led to the implementation of new policies[1,2]. However, accelerating these processes without consideration of trade-offs may harm the environment and democratic standards (Bond et al., 2014; Geißler and Jiricka-Pürrer, 2023).

When discussing barriers to accelerated infrastructure development, one instrument frequently takes centre stage: environmental assessments (EA)[3]. Originating in the 1970s, EAs have since become the globally recognised standard for assessing potential impacts of infrastructure projects and guiding informed, environmentally conscious decision-making (Hanna and Arnold, 2022). However, five decades later, EAs are increasingly under pressure.
As Bond et al. (2024, p. 410) note, the instrument "is under threat in many jurisdictions" due to a growing perception that it has "failed to convince sceptics that it represents value for money.

1 Recommendation for a resolution and report by the Committee on Transport (15th Committee) on the Federal Government's draft bill - printed matter 20/6879 - Draft law to speed up approval procedures in the transport sector and to implement Directive (EU) 2021/1187 on streamlining measures to accelerate the realisation of the trans-European transport network (original language: German)
2 DIRECTIVE (EU) 2023/2413 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652
3 Environmental Assessments are a type of Impact Assessments

Despite the worldwide implementation and success, EAs are perceived as being „too expensive, take too long, get in the way of development, and are ineffective in helping protect the environment or to meet environmental objectives" (Fischer et al., 2023, p. 181; Sinclair and Burdett, 2024). Despite the lack of empirical evidence, participation processes and appeals against permits are often cited as one of the main reasons for delays. Therefore, measures to accelerate approval processes often focus on weakening participation processes (Geißler and Jiricka-Pürrer, 2023; Zschiesche and Grünberger, 2024).

Fischer et al. (2023, p. 181) define environmental assessments as a "(...) participatory ex-ante assessment framework for policies, programs, and projects (...)", highlighting the central role of participation. The involvement of diverse actors – including the general public – enhances the quality of environmental assessments by contributing to well-informed decision-making (i.a. Sinclair and Diduck, 2017; Glucker et al., 2013; Morrison-Saunders et al., 2023; Suškevičs et al., 2023). Early and continuous participation is thus essential for democratic decision-making and plays a crucial role in ensuring transparency, legitimacy, and public acceptance (Doelle and Majekolagbe, 2023). Particularly, the legitimacy and societal acceptance of projects related to the energy and mobility transition(s) hinge on the meaningful engagement of stakeholders (Kamlage et al., 2018; Rehhausen et al., 2018). However, there seems to be a consensus that these transitions, and therefore the planning and approval of respective projects, need to be accelerated (Skjølsvold and Coenen, 2021).

Discussions about the adaptation and development of approval processes, both in academia and practice, are as old as the instrument itself (Bonnell, 2025). Sinclair et al. (2022) highlight the discrepancy between the theoretical goals of the instrument and the differing implementations in practice. They argue for a „next-generation impact assessment" to close this gap. While public participation is increasingly subject to rationalisation and adaptations, next-generation impact assessments underscore the value of meaningful public participation (ibid). The normative concept of Meaningful Stakeholder Engagement (MSE) promotes participatory approaches centred on the needs of affected communities (Buhmann et al., 2024).

This contribution adds to the discussion on stakeholder participation and EA. It will be examined to what extent participation in the current formal approval system in Germany (organised by competent authorities) can meet the criteria of MSE. Informal forms of participation and the possibilities of stakeholders other than authorities to steer the participation process were not the object of the analysis. Furthermore, it reflects and discusses whether MSE is a valuable concept for analysing national EA systems.

The text is structured into four parts. First, characteristics of MSE in EA processes are outlined. Second, the German EA system is introduced as a case. An initial overview is presented, followed by a focused examination of approval procedures for large-scale linear infrastructure projects and associated participation mechanisms. Key debates surrounding the acceleration and streamlining of these procedures are also addressed. Third, a set of elements and requirements of MSE is applied to the German context. Finally, the findings and broader implications are drawn.

2.Method, data collection, and case

The methodology consists of two parts. First, a structured literature review (Bryman, 2012) on public participation and the acceleration of planning and approval processes. Second, a document analysis of legal documents using the case of Germany (Bowen, 2009). The categories of analysis are defined by elements and requirements of Meaningful Stakeholder Engagement (MSE), as proposed by Sinclair and Burdett (2024).

Case selection: The selected case is the legal framework for environmental assessments (EA) of large-scale infrastructure projects in Germany. Germany serves as a valid case regarding its dynamic discussion on the adaptation of approval processes and consequences for participation (Geißler and Jiricka-Pürrer, 2023; Zschiesche and Grünberger, 2024). Moreover, the country's geographical position in Central Europe, as well as its size, offers the possibility to build on the experience of many large-scale and highly controversial infrastructure projects (Hellmuth and Jakobs, 2021).

This analysis focuses in particular on three types of linear infrastructure projects: railways, motorways, and electricity grids. They provide useful cases due to the scale of the projects, the public debate and disputes

surrounding them, as well as the environmental impacts (Gharehbaghi et al., 2022).

Literature review: The procedure for collecting relevant literature is based on highly cited publications and documents such as handbooks[4]. Based on these, the snowball method (backward citation tracking) was applied to gather documents in this field (Hirt et al., 2023). The seed element of the citation tracking (through Scopus and Google Scholar) built the most recent articles (published before April 2025). Finally, a keyword search of Scopus and Google Scholar was carried out to check whether further relevant documents weren't covered by previous steps (keywords used: "meaningful" AND "public participation" AND "environmental assessment" OR "impact assessment"). While the international literature was mainly collected via the Scopus database, documents on the German national context were also found via Google Scholar or via relevant institutions such as the German Federal Environmental Agency.

Analysis of participation in the EA: An existing framework (Sinclair and Burdett, 2024) was used to analyse participation in the context of impact assessment. This framework comprises ten distinct elements, organized into 31 requirements that form analytical categories (see Appendix 1). Based on these categories, laws were analysed and assessed. Four different categories were introduced to show the degree of fulfilment (see more in the results chapter). The attribution of the relevant parts of the documents to the categories is based on the descriptions of the categories and of the respective parts in the documents.

3.Participation in Environmental Assessments

Discourse and challenges

Environmental assessments (EAs) serve as a bridge between the technical design of infrastructure projects and their real-world environmental and societal impacts. The inclusion of diverse stakeholders and their perspectives is essential, as assessment outcomes cannot be based solely on technical considerations (Ulibarri et al., 2019). Public participation in EA has been the subject of extensive scholarly discussion. Suškevičs et al. (2023) show that participation focuses mainly on formal arenas, whereas „(...) guaranteeing public/stakeholder impact in decision-making and timing of the participatory process are still among the most problematic issues in the EA context" (ibid, p. 13). Despite the existence of extensive legislation and numerous guideline documents, participation often remains at a consultative level, which may lack sufficient depth or significance to ensure a meaningful impact on final decisions.

While Suškevičs et al. (2023) focus on the European context, Buhmann et al. (2024, p. 3) highlight a „(...) growing frustration with (...) public participation in the decision-making processes of (...) projects and plans proposed or implemented by companies or governments" at a global level. The concept of Meaningful Stakeholder Engagement (MSE) has emerged in response to these challenges (Buhmann et al., 2024, p. 3). MSE emphasizes the inclusion of affected stakeholders and the consideration of their needs in planning, assessment, and approval processes. As such, it offers an analytical lens for examining existing legislation on EA.

Conceptualisations of (meaningful) public participation

The conceptualisation and current debates on MSE build upon and are closely linked to key contributions from earlier conceptual frameworks. In particular, two publications have been highly influential in shaping the discourse on public participation in (environmental) impact assessments. Glucker et al. (2013) expand upon O'Faircheallaigh's (2010) earlier framework by distinguishing three central rationales of participation: the instrumental (leads to legitimacy and resolving conflict), the substantive (contributes to a „better" outcome), and the normative rational (reflects democratic ideals and fosters empowerment).

MSE contributes to the ongoing discourse on participation in environmental assessments (EA). In this context, the essential elements of public participation identified by Sinclair and Burdett (2024) serve as a framework for analysis. Drawing on both practitioner and scholarly experience, as well as insights into assessment systems, the authors highlight "(...) meaningful public participation, starting early, continuing throughout (...)" as a key element,

4 Handbook of Environmental Impact Assessment (edited by K. Hanna 2020).

Handbook of Environmental Impact Assessment (edited by A. Fonsecca 2022)
Handbook on Meaningful Stakeholder Engagement (edited by Buhmann et al. 2024)

Handbook of Public Participation in Impact Assessment (edited by Burdett and Sinclair 2024)

framing stakeholder engagement as a "(...) core feature of assessment deliberations." Although the conception is rooted in the Canadian context, the authors emphasize its broader relevance, "(...) to inform assessment improvement efforts anywhere" (Sinclair et al., 2022, p. 4).

Sinclair and Burdett (2024) differentiate ten elements (see Table 1), which are further specified through 31 detailed requirements (see Appendix 1). Together, they provide a comprehensive set of analytical categories for the analysis. Table 1 shows that all elements cover the rationales mentioned above (Glucker et al., 2013) and therefore align with the existing literature on the requirements of public participation.

Table 1 - Central elements of MSE in combination with basic rationales of public participation, based on Glucker et al. 2013, Sinclair and Burdett 2024, and own attribution

Element-No.	Elements of MSE Sinclair and Burdett (2024)	Instrumental (What leads to legitimacy and resolving conflict?)	Substantive (does the element contribute to a "better" outcome?)	Normative (Does the element reflect democratic ideals and foster empowerment)
1	Adequate notice			√
2	Access to information			√
3	Participation assistance		√	√
4	Opportunity for public comment	√	√	
5	Access to public hearings			√
6	Early and ongoing participation	√	√	
7	Deliberative forums	√	√	√
8	Decision Impact	√		√
9	Learning oriented		√	√
10	Fair and open	√		√

The allocation of elements to the respective rationales was made deliberately, based on Glucker et al.'s (2013, p. 106 ff) description and guiding questions, presented in the first row of Table 1. The attribution was strict; e.g., the element „opportunity for public comment" alone does not necessarily lead to the achievement of the normative rationale. However, it can be seen that the normative rationale covers most of the essential elements, while the instrumental and substantive rationales could be attributed to only half of the elements. This aligns with the normative aspirations and the claim of MSE to be a concept centred on the needs of those affected by projects (Buhmann et al., 2024).

As the conceptualisation of Sinclair and Burdett (2024) is relatively recent, no publicly available scientific studies were identified that apply this approach to the analysis of a specific national EA system[5]. This study can therefore be regarded as an exploratory effort to assess the applicability and analytical utility of the framework in a national context.

4.Case: Approval, environmental assessments and participation for linear infrastructure in Germany

Overview of participation in the German EA system

Both contestations and implementations of international law shaped public participation in environmental assessments (EA) in Germany. One of the most influential policies is the Aarhus Convention. Ratified in 2007, it guarantees public participation, access to justice, and access to information[6]. Additionally, the implementation of EU law led to the obligatory standardised assessment of projects and plans (Schütte et al., 2023).

5 besides a Master's thesis of one of A. John Sinclair's students (Bayuelo Gonzalez (2025) on the national case of Colombia) at the University of Manitoba, Canada

6 https://unece.org/environment-policy/public-participation/aarhus-convention/text, last call May 2025

Initially, the global rise of „environmental movements" led to increased public awareness of environmental values and fostered growing opposition to large-scale infrastructure projects (Odparlik and Köppel, 2013; Ohlhorst, 2018; Wende, 2018). Schütte et al. (2023) state that public participation and awareness of the impacts of projects in Germany developed particularly through highly confrontative cases. The Stuttgart 21 railway project is a notable example of civic resistance, public protest, and demands for more progressive participation processes (BMVI, 2014; Böhm, 2011). Such large-scale infrastructure projects have come to symbolise what Schütte et al. (2023, p. 23) describe as "non-functioning and ineffective participation processes" (own translation). In response to persistent conflicts and legitimacy deficits, participatory processes have been gradually expanded. One key reform introduced the possibility of early public participation[7] – a process initiated before the formal application for approval. As a result, competent authorities are now required to actively promote preliminary public involvement in the planning phase (Ziekow, 2018).

A range of legal frameworks governs the depth and scope of public participation in EA in Germany. Among these, the Environmental Impact Assessment Act (UVPG) and the Administrative Procedure Act (VwVfG) constitute the core legal foundations for participatory processes within the EA system. Additionally, various sector-specific laws – depending on the type of project and the jurisdiction (i.e. federal state) – further define participation requirements and procedural steps (Köppel et al., 2004, p. 241; Ziekow, 2018).

Participation in linear energy and mobility infrastructures in Germany

The focus on linear infrastructure enables a cross-sectoral analysis across three distinct yet comparable domains: motorways, railways, and electricity grids. While these sectors differ in terms of responsible authorities, they are similar regarding their socio-environmental impacts, the public discourses they generate, and the regulatory framework of project approval (Biasotto et al., 2022; Gharehbaghi et al., 2022). Each project type plays a significant role in political debates surrounding the transition to sustainability and economic development. Moreover, they are of national and international relevance (European Parliament, 2024).

In the German context, linear infrastructure projects follow a comparable planning and approval logic. A specific project requiring formal planning approval (the so-called "Planfeststellung") typically reflects a series of preliminary decisions made at various strategic planning levels. These processes range from demand assessments to corridor selection (see Table 2). EAs, such as strategic environmental assessments (SEA) and environmental impact assessments (EIA), are embedded in these steps. Consequently, the legally mandated participatory steps associated with EAs also apply throughout the entirety of the approval procedure.

Derived from the legal documents, four essential steps can be differentiated:

Table 2 - overview, evolution from strategy to project of railway, motorway and electricity grid projects (BMVI, 2014; Bundesnetzagentur, 2021)

Step	Instrument	Participation
The strategic level – necessity and demand – strategic plan	Grid development plan[8], National plan of traffic routes[9]	SEA - Mandatory through EIA law (UVPG)
Fixing of connections (starting and endpoint)	Demand plan[10]	Law process
Planning of corridors and alternatives	Specific plan[11]	SEA, mandated by EIA law (UVPG)
Planning and permit - final project	Planning approval[12]	EIA and approval process, mandated by EIA law and Administrative Procedure Act (UVPG & VwVfG)

7 German term: „frühzeitige Öffentlichkeitsbeteiligung" (§25 VwVfG)
8 Netzentwicklungsplan
9 Bundesverkehrswegeplan
10 Bedarfsplan
11 Fachplan
12 Planfeststellung

Each of the steps listed in Table 2 applies chronologically to all three linear project types. Between the strategic level and the final project, there are several opportunities for participation (BMVI, 2014; BMWi, 2021). At the same time, considerable time lags often occur between the initial idea and final implementation.

Participating in every single step or keeping track of the entire process and the decisions made at each step is a difficult task, especially for non-experts. Participation thus becomes a complex and challenging exercise in itself (Fung, 2015). If concerns are not addressed at an early stage, conflicts or resistance could arise at a very late stage. Typically, by the time major decisions are made, the possibility of influencing the project is already low (Mathur et al., 2008). This highlights the importance of a transparent and comprehensive summary of the preliminary process, significant decisions, and opportunities to influence the projects at an early stage. It is evident that the earlier participation starts, the more concerns can be raised, addressed, and conflicts prevented. Accordingly, various guidance documents (BMVI, 2014; BMWi, 2021) and academic literature (i.e. Doelle and Majekolagbe, 2023) highlight the need for early and continuous participation.

However, this aspect is not broadly reflected in the law. During the approval process, formal participation is limited to the opportunity for stakeholders to submit comments and participate in a public hearing. Additional steps, such as preliminary public participation before the application for approval, are mentioned in law, but not mandatory (Ziekow, 2018).

Discourses on streamlining and simplification in Germany

Discussions about adapting and simplifying EAs are as old as the instrument itself (Faith-Ell, 2023; Noble, 2023). EAs are assumed to be too expensive, too long, and don't provide value for money. The debate is further fuelled by the urge to implement projects that boost the economy and facilitate the transition to renewable energy and mobility systems (Bond et al., 2014). Enríquez-de-Salamanca (2021) argues that discussions on streamlining are driven by a "(...) political trend that sees EIA as an obstacle to necessary investments". While various actors hold differing views on streamlining processes, it's commonly understood that acceleration is required (Skjølsvold and Coenen, 2021). The challenge, however, is to determine the acceptable trade-offs for achieving this speed.

In the German context, the primary reasons for accelerating approval processes are the urgency of the climate crisis (coal and nuclear phase-out, energy transition), the aging infrastructure, the need to become independent of Russian gas, and the desire to boost economic growth (Deutscher Bundestag, 2023).

In recent years, numerous measures have been implemented to accelerate processes, primarily through new EU Directives and Regulations (mainly for electricity grids and renewable energies) and national laws (also for mobility projects) (Zschiesche and Grünberger, 2024; Geißler and Jiricka-Pürrer, 2023).

Starting in 2018, several "acceleration" laws were implemented, unfolding impacts on the infrastructure sector, including rail, road, and the electricity grid. Measures include, for example, excluding certain project types from EIA, defining a special public interest for projects relevant to the energy and mobility transition, shortening timeframes, adapting public participation, changing material standards, modifying requirements for mitigation and compensation measures, or limiting opportunities for legal challenge and appeal. Further on, there is a tendency towards a stronger focus on the strategic level[13]. This tends to lead to simplification of assessments at the project level or even to no mandatory assessment at all (Geißler and Jiricka-Pürrer, 2023; Zschiesche and Grünberger, 2024). Two recent projects demonstrated radical measures to accelerate the assessment and approval process. The first was a project that began construction before the final approval had been issued. Simultaneously, a large number of human resources within the authority were mobilised (Tesla Giga Factory, see: Kühn, 2023). And second, a project that did not require an EIA at all because it was considered by law to be of high public importance (LNG terminal, see: Kment and Fimpel, 2022).

All in all, many measures tend to weaken the EA instrument and public participation. Furthermore, there is an increasing complexity in determining which assessment is applicable in a given case. Last but not least, for some types of projects, the opportunities for stakeholders to participate and raise concerns were weakened. The

13 Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652

ongoing and dynamic discourse, along with concrete measures to accelerate processes, shape the possibilities for public participation.

In Germany, adaptations to EA legislation that weaken participation structures often lack sufficient empirical evidence of their effects (Geißler and Jiricka-Pürrer, 2023). To help address this gap, the following analysis evaluates if and how existing legal provisions incorporate the requirements for MSE.

5.Meaningful stakeholder engagement in the German environmental assessment system

The conceptualisation of a Meaningful Stakeholder Engagement (MSE) by Sinclair and Burdett (2024) was applied. The set consists of ten elements, further divided into 31 specific requirements. Each element comprises at least one requirement (see Appendix 1). For each requirement, corresponding statements in relevant German law were identified. Different categories were assigned based on how well each requirement was met. (1) Fulfilled, (2) partly fulfilled, (3) not required by law but the possibility exists, (4) or not part of the law and not within the competence of the authority.

Results

No element completely fulfils the means of the MSE concept (this would be the case if all requirements were fulfilled). Zooming in on the requirements, a heterogeneous picture emerges. Four requirements fully meet the criteria, while only one requirement cannot be met by the authorities and laws. The vast majority of the requirements are either partially met (11) or not met but possible (15).

The classifications for the different categories are discussed below chronologically from 1 (fulfilled) to 4 (not part of law and competency). Table 4 presents the category of partly fulfilled requirements, accompanied by an argumentation. This category is of particular interest because improvements could be addressed within the existing legal framework.

(1) Fulfilled

Fulfilled requirements relate to the communication about the process itself and the opportunity to raise concerns and receive feedback. As required by constitutional principles as well as the pillars of the Aarhus Convention and subsequently ratified into German law, the principles of natural justice and procedural fairness are followed. Those elements reflect fundamental principles of participation.

Table 3 - requirements identified as "fulfilled" (based on Sinclair and Burdett 2024)

Element	Requirement
Adequate notice	notice about assessment, where future information is located and where comments can be directed to
Decision impact	Input can impact and change the course of the decision at hand - no treated as advisory only
Learning oriented	Feedback to participants about how their input has, or has not, been used
Fair and open	Public participation processes follow principles of natural justice and procedural fairness

(2) Partly fulfilled

The requirements categorised as „partly fulfilled" deal with: the access to and transparency of processes and decisions, the means and forms of communication, as well as different forms and depth of stakeholder engagement.

Table 4 - requirements identified as "partly fulfilled", (based on Sinclair and Burdett, 2024 and the author)

Element	Requirement	Argumentation
Adequate notice	direct notice to affect individuals and organizations	This depends on the stakeholder, who can be notified indirectly through the EIA-portal and a newspaper. In general, the authority can achieve this requirement through various means of notice. *(§73 VerwVfG)*
Access to information	Easy access through a public registry or other means	By law, it must be officially accessible during the public consultation period. A digital EIA-Portal exists, but not all information is available at all times. Consists only of the documents necessary for the application – no internal documents of the authority on the process. *(§20 UVPG)*
Opp. for public comment	Open to all interested parties and individuals	Yes, generally speaking, everyone who wants can address issues (but not everyone has the same rights). Those affected and those who have raised official concerns can participate in the entire process. Others who didn't raise a concern are precluded at a later stage. *(§18 & §19 UVPG)*
	Allows for consideration of „need for" and „alternatives to"	Yes – one part of the EIA-report (but often not negotiable because already preset). Questions on alternatives and „need for" are part of preliminary strategic steps, before an EIA is started. The EIA report provides a more comprehensive conclusion of those preliminary steps. *(§16 UVPG)*
Access to public hearings/ADR	Transparency and timely written decision	Whether it is „timely" is hard to assess. However, there must be a written decision at a transparently communicated time. (Literature and stakeholders often criticize that there is too little time) *(§24 UVPG, §69 VwVfG)*
Early and ongoing participation	Stakeholder involvement in many assessment choices	Depending on what is understood by „many" and „assessment choices", stakeholder involvement in EIA is formally limited to statements. At the same time, rail, road, and electricity offer different levels of strategic opportunities for participation. *(Own attribution based on the author's knowledge)*
Deliberative forums	Open dialogue in a non-judgmental environment	Depends on how „open dialogue" is defined. Public debate opens space for a dialogue and discussion, but often in a very formal setting. Authorities can potentially work towards enhancing the openness. *(Own attribution based on the author's knowledge)*
	Establishing sustainability as a concept and a goal	This criterion itself is subject to extensive debate, so it would be necessary to clarify what is meant by sustainability first. To some extent, it can be argued that EIA law incorporates forms of sustainability with its goals and mitigation hierarchy. *(§2 UVPG)*

Fair and open	Transparent	The formally mandated participation process is transparent in that it is communicated publicly, allowing affected parties to participate and ensuring that a final decision is made publicly. All statements have to be commented. Other aspects, such as the planning process, are in the hands of the proponent; authorities cannot directly influence transparency in this regard. *(Principles of Constitution and Aarhus Convention)*
	Open to all interested parties and individuals	Yes, generally speaking, everyone who wants can address issues (but not everyone has the same rights. Later in the process, only those who filed a statement can formally take part. *(§18 UPVG)*

Table 4 illustrates the connection between the requirements and the relevant sections of the German law. This category indicates that many requirements allow authorities to meet them. Qualitative and normative wordings like "easy access", "open dialogue", or "timely" don't offer explicit categories for evaluation.

(3) Not required by law, but the possibility exists

The results within this category (see Table 5) show opportunities to expand and innovate participation practices. These include the use of diverse communication channels such as phone, email, or social media; the provision of inclusive and informal spaces for deliberation; the involvement of the public in designing the participatory process itself; and the implementation of interactive formats that go beyond conventional tools like open houses or online submissions.

Table 5 - requirements identified as "Not required by law but the possibility exists", (based on Sinclair and Burdett, 2024)

Element	Requirement
Adequate notice	use of phone, email or social media
Participant assistance	Need for assistance because of complex issues (focus on funding)
Opp. For public comment	Interactive modes of participation beyond open houses and website submissions
Access to public hearings/ADR	Frequent and creative use of the hearing process
	Inclusive, informal venues for deliberation
	Negotiation and mediation
Early and ongoing participation	Public engaged in the design of the participatory program to be followed
	Extension of participation to the follow-up stage
	Reasonable timelines established
Deliberative forums	Emphasis on knowledge integration
	Face-to-face decision-making
	Incorporate future methods such as visioning and scenario development
Learning oriented	Promotes learning "about" and "through" IA
	Fosters mutual learning among all participants
	Ensures lessons from past ass. as well as process experiences are considered in future ass. & ass reform

In addition to experimenting with participatory formats, another key set of requirements concerns the recognition and integration of diverse forms of knowledge, as well as the promotion of mutual learning throughout the assessment process.

(4) Not part of the law and not within the competence of the authority
One aspect could be identified as not being required by law and not within the authority's remit: „transparent, ongoing and timely exchange of information between all parties". Much information, especially at the planning stage, is held by the proponent. It is the proponent's choice when the first information is made public. Authorities can work towards an exchange and provide means of communication, but they cannot mandate it. Furthermore, it is unclear what is meant by "all parties". As soon as the proponent gets in contact with the authority and applies for permission, this requirement is within the competence of the authority.

Discussion
Most of the requirements fall into categories that are partly fulfilled or not mandated, but could be put forward by authorities. Referring to the above-mentioned rationales of public participation (Glucker et al., 2013), current legislation doesn't cover the instrumental and normative rationales. This shows that aspects of legitimacy and conflict resolution, as well as the fulfillment of democratic ideals and empowerment, fall short. The findings align with existing research, which suggests that formal participation processes tend to meet only the minimum requirements (Eckerd and Heidelberg, 2020; Fonseca and Fitzpatrick, 2024; Fung, 2015). It therefore reflects that the benefits of public participation, although intensively discussed in the literature, are still not sufficiently embedded in law.

Nevertheless, it was shown that participation is widely regarded as an essential component of environmental assessment (EA). Against this background, the results could also be seen in a more positive light. Despite the low number of fulfilled requirements, there are several opportunities to enhance participation. The analysis focused on the possibilities and competencies of the authorities responsible for the formal participation process. The allocation of resources (both staff and time) is crucial to design, organise, and sustain meaningful participation processes (see also Tryjanowski and Zschiesche 2020; Geißler and Jiricka-Pürrer 2023). To establish participation processes that extend beyond statements and public hearings, authorities need to analyse and reflect on their current routines. Meaningful participation processes can be better informed by combining experience from successful initiatives and existing expertise with an understanding of current systems' strengths and weaknesses, gained through learning and experimentation.

Communication is a key factor contributing to unfulfilled requirements. One important aspect is to recognise different worldviews, knowledge, and stakeholders' needs. Guidelines of German authorities (BMWi, 2021) already reflect these aspects to a certain extent. This points to an existing discourse and sensitivity regarding this topic. In summary, an EA practice that integrates participation as an essential part of successful approval processes must be willing to reflect on and modify existing routines. The results show that authorities need to act beyond the minimum legal requirements, for example, by experimenting with deliberative forms of stakeholder involvement. Furthermore, a focus on mutual learning reflects elements of experimental governance (Newig et al., 2019).

It was assessed whether the set of elements and requirements by Sinclair and Burdett (2024) offers a valuable tool to analyse the German EA system. Based on the knowledge of the logics of the EA system and the respective laws, all of the elements and requirements could be applied. With the help of the literature and own expertise, it was possible to draw primary conclusions. Those conclusions are in line with existing knowledge. Nevertheless, there is potential for improvement - e.g., it is not apparent how to assess and value normative elements such as "lengthy process", "sustainability as a goal", "easy access", or "timely response". Some aspects are formulated too generally and should be adjusted and complemented to fit the particular geographic context (for the German context, for example, with the elements of early participation or the various strategic steps). To increase the reliability and replicability of the results, a further refinement of the requirements is necessary. A preliminary consultation phase involving interviews or a Delphi method should be implemented to define the categories in more detail. Following the initial allocation, a second consultation phase with experts would facilitate further discussion and reflection on the results.

6.Conclusion

The objective of this contribution was twofold: first, to examine the German environmental assessment (EA) system for large-scale infrastructure projects in terms of its capacity to achieve meaningful participation processes. Second, to examine to what extent the framework developed by Sinclair and Burdett (2024) serves as a valuable analytical tool. The theoretical base for the analysis was the discussion of the discourse surrounding Meaningful Stakeholder Engagement (MSE) in EA in general. Further on, the main characteristics and challenges of the German context were outlined.

The analysis shows that there is potential for the development of environmental assessments that meaningfully engage stakeholders in Germany, although this potential is currently unrealised. At the same time, it is evident that most of the requirements are not fully met or mandated by law. To address this, the authorities would need to promote participatory processes that exceed minimum legal requirements.

Although the environmental impacts, approval procedures, and, consequently, participation processes of the three project types – motorways, railways, and electricity grids – are broadly comparable, different competent authorities can pursue distinct strategies and cultures of participation. The willingness and experience of authorities play a crucial role in implementing MSE, an aspect that warrants further investigation.

The elements and requirements of MSE by Sinclair and Burdett (2024) proved to be a useful analytical tool, as it incorporates the three main rationales of participation in environmental assessments (defined by Glucker et al., 2013) and consists of a comprehensive and detailed set of requirements. Some aspects were identified to develop the applicability of the concept further. For example, there is a need for an ongoing discussion about how to formulate and describe its elements and requirements. To ensure the replicability of attributions, it's important to clarify terms like "good," "timely," or "often," as they can be open to interpretation. This links closely the validation and discussion of the findings. Therefore, consecutive validation steps should follow the initial attribution.

Further research needs to consider additional policies that influence EAs. This also comprises guidelines and sub-statutory regulations. Further expert evaluation and practical insights are needed to effectively align policies with requirements. Furthermore, analysing different country contexts could help refine the set of requirements and foster transnational learning.

The "value for money" (Bond, 2014) of public participation must be communicated in a way that is tangible to a broad audience. Notably, early and continuous engagement is increasingly recognised not only as a democratic imperative but also as a key factor in achieving effective governance. It also serves as a medium- to long-term benefit for project proponents and authorities, as it can help prevent conflicts and gather valuable data about the project's impacts. This aspect becomes particularly significant in the context of current efforts to accelerate planning and approval procedures.

Remarks

The AI software: Grammarly AI, Chat GPT, and DeepL were used to refine writing style. No text was generated by AI.

Due to the limits on words, not all the arguments for the contributions (like Table 4) to the elements and requirements were mentioned in the text. The whole table of attributions can be submitted upon request.

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Appendix 1 - Meaningful Stakeholder Engagement (MSE), Elements and Requirements

Essential elements	**Specific requirements**
Adequate notice	direct notice to affect individuals and organizations
	use of phone, email or social media
	notice about assessment, where future information is located and where comments can be directed
Access to information	transparent, ongoing and timely exchange of information among all parties
	Easy access through a public registry or other means
Participant assistance	Need for assistance because of complex issues (focus on funding)

Opp. for public comment	Open to all interested parties and individuals
	Allows for consideration of "need for" and "alternatives to"
	Interactive modes of participation beyond open houses and website submissions
Access to public hearings/ ADR	Frequent and creative use of the hearing process
	Transparency and timely written decision
	Inclusive, informal venues for deliberation
	Negotiation and mediation
Early and ongoing participation	Public engaged in the design of the participatory program to be followed
	Extension of participation to the follow-up stage
	Value judgments when choosing trade-offs
	Reasonable timelines established
	Stakeholder involvement in many assessment choices
Deliberative forums	Emphasis on knowledge integration
	Face-to-face decision-making
	Open dialogue in a non-judgmental environment
	Establishing sustainability as a concept and a goal
	Include forms of alternative dispute resolution
	Incorporate future methods such as visioning and scenario development
Decision imact	Input can impact and change the course of the decision at hand - no treated as advisory only
Learning oriented	Promotes learning "about" and "through" IA
	Fosters mutual learning among all participants
	Feedback to participants about how their input has, or has not, been used
	Ensures lessons from past ass. as well as process experiences are considered in future ass. & ass reform
Fair and open	Public participation processes follow principles of natural justice and procedural fairness
	Transparent
	Open to all interested parties and individuals

Source: Sinclair and Burdett, 2024, p. 31f.

Building institutional capacity for social value – reflections from the 'Back to the Neighbourhood'-project in the Netherlands

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Abstract
While most studies on institutional capacities for social value in planning practice stem from public perspectives, contemporary European urban transformations often involve both public, private and civic actors. This paper presents a Dutch market-led practitioner's research project of four *ex post* evaluations on social sustainability in newly realized urban neighbourhoods, in which the author actively participated. From a collaborative governance perspective, the paper reflects on the project's contribution to building institutional capacity for social value in urban development practice. Preliminary findings reveal how the market holds specific—perhaps hidden—capacities in terms of mobilization, communication skills, shared knowledge production and development of relational networks, yet tends to hold on to a limited perspective on social sustainability and to make a more incidental than structural impact.

Keywords: institutional capacity, private sector capacity, civic capacity, citizen participation, social sustainability

1.Introduction

As many cities in Europe and beyond face social challenges such as socioeconomic segregation, loneliness or unequal access to services for different social groups, creating social value through urban planning and development is considered increasingly important in theory and practice. Social value is defined by the UK Green Building Council as "created when buildings, places and infrastructure support environmental, economic and social wellbeing, and in doing so improve the quality of life of people" (UKGBC, 2021). By promoting a broader understanding of value than monetary alone, social value closely aligns with the more specific policy ambition for social sustainability, i.e., the ambition to improve people's quality of life, individual and collective well-being, for generations living now but also in the future (Weingaertner & Moberg, 2014)

Moreover, researchers increasingly call for anthropological understandings of social sustainability in the built environment that go beyond its understanding through tangible—'traditional planning'—aspects such as adequate housing or public space, but also through human-oriented aspects such as well-being, agency and capability (Dissart & Ricaurte, 2023; Janssen & Basta, 2022; Woodcraft, 2016). In the same line of thought, the process of involving local communities has become central to debates on social value to understand the impact of decisions on people's lives (Social Value UK, 2023). Similarly, the many varied frameworks that exist in social sustainability literature mention participation and inclusion of local actors as a key indicator of social sustainability in the built environment (see e.g. Dixon & Woodcraft, 2013; Janssen et al., 2023; Kjeldsen & Stender, 2022).

Involving local communities not only leads to a better understanding of local needs and potentially more effective plans, but meaningful citizen-planner dialogues also help to foster trust and to enhance social cohesion (Othengrafen et al., 2024). A common challenge of participatory practices, however, is that they remain incidental and exclusive and fail to make a wider social impact. This challenge can relate to issues of capacity in planning practice—for example, the lack of regulatory frameworks, policy support, and financial or human resources are reasons why creating social value through citizen involvement fails to be embedded in regular governance processes.

While various studies reporting on capacities for social value focus on institutional capacities, thereby referring to public perspectives (e.g., Cuthill & Fien, 2005; Polk, 2011) contemporary European urban transformations often involve both public, private and civic actors. Although market actors are often seen as actors merely incentivized by maximizing profit, regulatory frames such as ESG policy by the European Committee motivate investors and financers in urban development to create social value or 'to make a social impact'. This shift has led market parties such as property developers and construction companies to develop programs in which they operationalize liveability, resident wellbeing or social equity goals – thereby increasingly experimenting with citizen participation approaches.

This conference paper reflects on a conducted participatory action research project in the Netherlands in which the author participated in a market-led practitioner's project of *ex post* evaluations on social sustainability in newly realized urban neighbourhoods. The paper aims to explore the contribution of this applied research project to institutional capacity building for social value creation in contemporary urban development practice. Meanwhile, the paper tests a preliminary framework to analyse capacities for social value creation in terms of different actors—either public, private, or civic— and different levels—either individual, collective or institutional. Finally, the paper defines questions for the continuation of this research.

2.Towards an analytical framework

2.1 Citizens as a serious actor in collaborative governance for social value

Citizen participation has been widely discussed in planning literature. Often forming part of the collaborative planning discourse (Healey, 1999; Innes & Booher, 2004) research foci range from public participation as an extension of local governance, as cocreation and coproduction as development forms where citizens exercise power and can co-decide on interventions (Rosen & Painter, 2019), or as citizen engagement as the activities that (groups of) citizens initiate and undertake themselves in the sphere of civic society, for example through voluntary, non for profit and cooperative activities (Knaps et al., 2024). While the strive after consensus in the communicative turn in planning has been criticized for its neglect of pluralistic worldviews (Mouffe, 1999; Young, 2015), involving citizens in planning practices remains to be considered an essential approach for various instrumental—i.e., better knowledge of local matters—and intrinsic purposes—i.e., enlarging citizen's voice or enlarging democratic capacity (Uittenbroek et al., 2019).

Normatively, participation is considered a key principle of what 'good governance' is about (OHCHR, 2025). More descriptively, conceptualising citizen participation as an essential part of collaborative governance for social value underscores that places are developed through the activities of not only public but also private and civic actors (Emerson et al., 2012). As such, considering citizens as actors in collaborative governance implies that citizens, next to other actors, are not only representing their self-interests (i.e., NIMBY-ism), but can also be oriented towards a public goal in planning practice— for instance, the transformation of an urban area, the perseverance of a liveable neighbourhood, or more general, creating social value.

2.2 Capacities for collaborative governance in urban development practice

In response to reconfiguring state-economy-civil society relations in governance practices in Europe and beyond in the early 21st century, Healey et al., (2003) developed a relational understanding of institutional capacity that concentrates on the shared responsibilities of actors for public purposes around the locality of a place. According to Healey (1998), institutional capacity includes knowledge resources, relational resources and mobilization capacity. Polk (2011), who applies this framework to sustainable development, defines:

- *knowledge resources* as formal and informal types of expertise and know-how, including formal, tacit and experiential types of knowledge.
- *relational resources* as "individuals gaining greater personal and professional relationships with colleagues within a wide range of organisations and agencies involved in local and regional planning. Some of the potential outcomes of social relations include the establishment of trust, respect and reciprocity between participants". (Polk, 2011, p188)
- *mobilization capacity* as the concrete impact, including less tangible long-term impact, that a governance area has in formal planning processes on the local and regional level.

Although Healey's (2019) sociological-relational understanding of institutions certainly does not limit her interpretation of institutional capacity to a governmental focus alone, recent notions of private sector and civic capacity from other authors can help to specify further what resources and abilities are needed for solving complex societal problems. In recent strands of literature on climate adaptation in public policy for example, the capacity of the private sector to influence policy agendas and to develop sector-specific operating procedures or technologies are mentioned as important pathways to achieve climate mitigation or adaptation goals (Sarzynski, 2015).

In addition, from a more normative perspective, civic capacity distinguishes from a general notion of capacity by including a dimension of agency and freedom of choice: "Civic capacity [...] as the extent to which the sectors that make up a community are (1) *capable* of collective action on public problems (the resource dimension), given the norms and institutional arenas for local action; and (2) *choose* to apply such capabilities (the dimension of effort, will and choice, or "agency")" (Briggs, 2008, p13). It is thus not only important that civic society possesses resources to be able to undertake action, but also that there is room for choosing to do so— think for example of a political climate in which it is safe as a citizen to decide to participate in urban discussions, or in which a citizen simply has time available to do so.

Adopting a collaborative governance perspective thus implies a broader interpretation of institutional capacity in which institutional is not limited to 'the public' but particularly includes private sector and civic capacities. Furthermore, the participatory approaches that urban social sustainability demands give reason to emphasize capacity in planning practice not only as occurring at an institutional, 'regulatory policy-level', but also at the individual (e.g., residents or professionals) and collective (e.g., local communities or other forms in which citizens unite themselves) levels where participatory interaction can take place. As such, Table 1 presents a preliminary framework of actors in urban development and their capacities that play a role in collaborative governance for social value creation. In contrast to the individual and collective ones, the structural level does not refer to *actors* in urban development but to long-enduring structures in society that shape and are shaped by those actors— such as rules, cultures, traditions and beliefs (Ostrom, 2009)

Table: Analytical framework (preliminary, by author): institutional capacity for social value creation in urban development practice

	Civic	**Private sector**	**Public sector**
Individual	**Actors**: Residents, users of urban areas **Capacities**: Personal abilities, skills, knowledge, choice	**Actors**: Professionals, developers, local entrepreneurs **Capacities**: Personal abilities, skills, knowledge	**Actors**: Civil servants, governors, politicians **Capacities**: Personal abilities, skills, knowledge
Collective - intraorganisational	**Actors**: Collective citizen groups, cooperatives, political groups, associations **Capacities**: Mobilization resources, relational resources, knowledge, choice	**Actors**: Companies, shareholders **Capacities:** Mobilization resources, relational resources, knowledge	**Actors**: Local, regional and national governments **Capacities**: Mobilization resources, relational resources, knowledge
Collective – interorganisational	**Actors**: Citizen group networks, platforms **Capacities**: Shared mobilization resources, shared relational resources, shared knowledge, shared choice	**Actors**: Professional networks and platforms **Capacities**: Shared mobilization resources, shared relational resources, shared knowledge	**Actors**: Governmental networks and platforms **Capacities**: Shared mobilization resources, shared relational resources, shared knowledge
Structural	**Structures**: Collective values, cultures, traditions **Capacities**: Collective culture, private law	**Structures**: Working culture, beliefs and assumptions **Capacities**: Working culture, private law	**Structures**: Public values **Capacities:** Public management culture, public law and policy instruments

3.Method

3.1 Empirical reflections of a participatory action research

This conference paper aims to reflect on the Back to the Neighbourhood-project's (BTTN) contribution to build institutional capacity for social value in urban development practice, and meanwhile, to test the suitability of the preliminary framework in Table 1 to understand such capacity building. The BTTN-project (see 3.2) concerns an applied research project in which four newly developed neighbourhoods in three large cities in the Netherlands (i.e., Amsterdam, Rotterdam, and The Hague) were evaluated in terms of social sustainability. The project was conducted via a cooperation between the Foundation for Knowledge on Area Development at TU Delft and a socially oriented property developer in the Netherlands, while also including various other public and private urban actors such as architects, urban designers, civil servants, and other property developers.

The author of this paper was actively involved in the project as co-developer and co-coordinator, for which this paper can be considered as participatory action research. The choice for this active involvement of the researcher in the practitioner's project served an adjacent objective of the BTTN-project— namely to test the value of a scientifically argued framework to evaluate social sustainability in urban areas based on the Capability Approach in Dutch urban development practice (see outcomes for this objective in Janssen, 2025). This paper does not elaborate further on the function and impact of this evaluative framework but intends to draw reflections that serve a new research agenda on institutional capacity. By actively participating in all the evaluations throughout the entire duration of the BTTN-project, the author was in the position to do many field observations and have abundant informal conversations with the participants of the project. No formal semi-structured interviews were yet conducted. The observations presented in chapter 4 should therefore be seen as preliminary observations that, although based on intensive participation, should be complemented by future interviews or focus groups with the participants.

3.2 The Back to the Neighbourhood Project

Between April 2024 and January 2025, a Dutch property developer initiated a program to perform ex post neighbourhood evaluations in areas that the company had developed in the recent decade. While such urban development projects are, after realization, typically evaluated in terms of costs and construction performance, the BTTN-project aimed to concentrate on how the qualitative goals of such projects— such as increasing people's quality of life, and stimulating social encounters— had come into practice. Whereas the project was thus initiated by a single market actor and focused on the urban development projects of this actor, the BTTN-project formed a collective learning program in which many partner organisations in the field, including municipalities, housing organisations, architects and urban designers, participated.

The setup of the BTTN-project was as follows. Four recent urban development projects that had specific goals regarding social sustainability were selected to be evaluated. Those goals were for example formulated as "this project needs to be a stepping stone for surrounding residents", or "this project needs to become an area where people feel at home, and neighbours meet each other and form a community". Per neighbourhood, a group of between 15-25 professionals were mobilized to perform interviews with residents living in the newly developed areas. The group of practitioners consisted of employees of the property developer itself—with various roles stretching over various development stages, from concept development to project execution— but also of practitioners from other (partner) organisations. As such, the project not only served to draw lessons on the performance regarding social sustainability but also to train practitioners in engaging with residents.

Each neighbourhood evaluation lasted for a period of approximately four weeks. This period started with a 'kick-off'-session in which the practitioners were briefed and had the opportunity to train their interview skills. This was followed by a period of two or three weeks in which the participants went 'back to the neighbourhood' and performed interviews with residents. Residents were approached on the spot, by ringing the doorbell or by being approach on the street or were approached via local social media channels. After this period, the practitioners came together for a feedback session to exchange the findings to which residents were invited as well. The findings were analysed by two researchers participating in the coordination team of the project.

4.Preliminary empirical findings: building capacities through the BTTN-project

This chapter discusses how specific capacities in the BTTN-project were relevant to the creation of social value. It also reflects on whether certain types of capacities were lacking, and on whether the project contributed to building new capacities relevant for social value in the Dutch urban development practice.

4.1 Capacities at individual, collective and structural levels

A first observation in the BTTN-project is that an important type of capacity for social value occurs at the individual level of professionals, namely in the communication skills of the practitioners who took part in the project. As citizen participation was not a daily task for most practitioners, conducting a qualitative semi-structured interview with a resident was a first experience for some. All participants received the same guiding material with the key questions, yet the quality and intensity with which practitioners engaged with citizens varied widely. It became clear how professionals who are in their regular jobs are responsible e.g., floor management, client communication or team leadership, benefitted much from their experience with daily 'social' work activities. Although such an empirical observation may not be surprising, it points out that a potential capacity for social value in the built environment is 'hidden' among professionals—yet would need to be made use of to create actual value in practice.

At the inter-organisational level, capacity building took place through shaping new relational resources among the various public and private urban actors in Dutch planning practice who participated. Although those actors, of course, already interacted in their regular work activities, the BTTN-project provided a platform where they intensively collaborated on a relatively simple assignment in a neutral setting (i.e., without interests or negotiations) and could collectively build trust. Moreover, the experiences that the practitioners gained from participating in the BTTN-project can be seen as contributing to a collective knowledge of social sustainability and citizen involvement among urban actors in the field. It had been an explicit objective of the BTTN-project to conduct the resident interviews with a large group of professionals—instead of a single researcher or consultant taking care of all interviews. This decision proved to be successful: many participating professionals feedbacked that simply 'doing it yourself' had made a true difference in their understanding of what citizen engagement is about and what social impact can mean to residents.

Finally, at the structural level, the project's contribution to capacities was found to take a small step in a transition towards new working cultures needed for social value in planning practice. By making the BTTN-participants enthusiastic about the neighbourhood evaluations, the BTTN-project aimed to normalize discussing social sustainability in urban debates and to normalize the engagement with citizens in urban development practice. Nevertheless, the enduring impact of the BTTN-project for the future can be questioned due to the incidental character of the project. As participation in the project was not formally commissioned nor financially rewarded, it was noticeable how practitioners already struggled with their available time to participate in one of the evaluations, limiting the project to making a more structural impact.

4.2 The specifics of private sector capacity

The fact that the BTTN-project was initiated and co-organised by a private actor seemed to have several advantages for social value. In one of the neighbourhoods, for example, it was observed how a local citizen initiative had grown into an important social infrastructure for the area. This concerned a not-for-profit café that performed social activities in a glasshouse such as urban greening, distributing food leftovers, and organizing workshops and weekly dinners for neighbours. After having engaged with this citizen initiative for some weeks, the property developer learnt that the initiative faced difficulties in receiving municipal budgets to insulate the physical space, which hindered it from performing the activities during the winter period. The market actor quickly responded to this observation by activating a fund and financing the retrofit of the glasshouse, enabling the initiative to widen the social activities in the neighbourhood.

While this situation illustrates how a combination of private actors being able to mobilize financial resources and being able to respond quickly to locally emerging needs can make a concrete impact on people, the private sector also has limitations for social value creation. It became clear during the BTTN-project, for example, that the leading interest of the property developer in social sustainability eventually mainly concerned their own clients, being the private buyers or investors renting out their rental apartments.

How quality of life was experienced by communities living just outside the newly developed housing areas, was less of a concern to the market actor—whereas this would be a main concern from an urban social sustainability perspective.

Moreover, it was noticeable how making enough time available to perform the neighbourhood evaluations was challenging, particularly for those participants working in the private sector. To them, participating in the BTTN-project meant doing something 'extra' on top of regular working priorities, in some cases giving up a free evening or day on the weekends. Although collaboration with local (governmental) actors who are more permanently active in the neighbourhoods was sought after, the BTTN-project failed to collaborate with those actors to ensure that the resident-professional relationships would last for a longer period of time. Beyond the one-off feedback session at the end of each evaluation period, the BTTN-project did not include further follow-ups with residents or other local actors in the neighbourhoods.

Finally, although a key element of the BTTN-project was to engage with residents of the new urban neighbourhoods, civic capacity was used or expanded only to a very limited extent. By choosing interviews as the main method of civic engagement in the BTTN-project, little attention was paid to the developing knowledge of residents or the mobilization of relational resources. Moreover, the specific notions of choice and agency, that are characteristic to civic capacity, played a minor role in the project—residents were mostly offered only one predefined way to participate in the project, at one moment.

5.Discussion: towards enlarging institutional capacity for social value in urban development practice

The overarching aim of this paper was to explore how collaborative governance practices can contribute to institutional capacity building for social value creation in planning practice. This contribution reflected on the Back to the Neighbourhood-project, a market-led project in the Netherlands in which a property developer evaluated four newly developed neighbourhoods together with the author of this paper and other public and private actors in Dutch planning practice.

Preliminary findings from the BTTN-project reveal how the market holds specific —perhaps 'hidden'—capacities that contribute to social value creation in urban areas in terms of mobilization capacity, communication skills, shared knowledge production and development of relational networks. The lack of specific policy frames and regulations on social sustainability benefit the private sector to be able to respond quickly to locally emerging needs once those are observed. Although this reflexive characteristic of the market is certainly an advantage for social value creation, it also risks steering exclusive interventions, for example when certain local needs are heard less than others.

Using an analytical framework to investigate institutional capacity among individual, collective and structural levels and public, private and civic spheres, helps to elucidate what the 'thicker' and the 'thinner' potential contributions of a planning practice to institutional capacity for social value creation are. The empirical findings for example show how private sector capacities in the BTTN-project are limited ('thin') in terms of adopting a comprehensive perspective on social sustainability that considers the wider communities living in cities, and in terms of making their 'best practices' for social impact creation more structural than incidental. It was also observed how the BTTN-project had a limited contribution in terms of building civic and public capacity.

Developing this framework further in future research can help to find out when exactly various capacities complement each other and lead to effective collaborative governance for social value creation. For this, it is needed to further investigate and define when participatory approaches 'create social value' to people living in urban areas and what conditions facilitate those approaches. European studies on for example neighbourhood planning in the UK (Wargent & Parker, 2018), Community-Led Local Development by the EU (Servillo, 2019), or the institutionalised *Gebietsbetreuungen* in Vienna (Janssen, 2024) can be discussed to explore what capacity elements help citizen participation to become more structurally embedded in planning practices.

Concluding, in a planning context where the market plays an increasingly dominant role, it is promising to strive after a collaborative governance for social value in which capacities of public, private and civic actors complement each other. Yet, several questions require further inquiry. What exactly are those specific capacities,

theoretically and empirically? Are they conditional or optional, are they generic or situation-dependent? When exactly are capacities complementary and do they foster successful collaborations among actors in practice? And in what form do those capacities enable true social value creation that aligns with the lived experiences of those whose policies are aimed?

The questions raised here will be addressed in the continuation of this research. The findings presented in this paper are based on the author's initial observations after participating in the Back-to-the-Neighbourhood-project. Although based on intensive participation, the findings should be validated by additional research methods, such as interviews groups with the participants, or by adding one or several comparative cases.

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Self-government processes of the urban bioregion: insights from a study on the Metropolitan City of Rome Capital

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Abstract
The relevant transformation processes that affect contemporaneity require a radical transformative change across all fields in terms of relations among human activities and the environment. The research illustrated in this contribution addresses the issue of change through the lens of territorial planning, discussing the hypothesis that in practices of territorial self-government it is possible to define 'minimum units of bioregional planning' enabling virtuous co-evolutionary interactions between humans and the environment. Drawing on theoretical insights and empirical work in the Aniene River basin, the study emphasizes the need to transcend the institutional/non-institutional divide and support subsidiary planning processes. Within this framework, digital platforms, such as a GeoSocialWeb, are conceived as enabling environments for interaction, fostering relational governance processes and context-specific forms of territorial self-government.

Keywords: bioregion; natural resources; agreement tools; self-government; river contract

1. Introduction

This contribution presents the conceptual framework and some findings from the ongoing work of the authors within the italian PRIN (Research Project of Significant National Interest) "Bioregional planning tools to co-design life places. Empowering local communities to manage and protect natural resources"[1].

Based on the urban bioregion approach developed within the italian territorialist school, the research project's main goal is to contribute to the drafting of a framework for agreement tools for territorial planning, which could support collaborative forms of management and use of environmental resources directly empowering the communities that live in the territory.

These agreement forms of planning are intended as flexible environments in which the actors involved in each specific planning process are able to define the most suitable tools to allow effectively the implementation of the principle of vertical and horizontal subsidiarity, in the perspective of addressing at different scale both local and global challenges.

The focus of this contribution regards the concepts of urban bioregion approach, natural resources management, agreement planning tools, and interactive spatial planning as intended by the authors.

Moreover, it illustrates how within the research project a bioregion has been selected as case study in the area of the Metropolitan City of Rome Capital and the neighbouring Province of Frosinone, and the partial findings identified by the authors at the date, including the denotation of some experiences of territorial governance that, in different ways, extend beyond traditional institutional planning frameworks.

1 The project, funded by the PNRR (Recovery and Resilience Italian Plan) and running from October 2023 to the end of February 2026, is led by a Research Unity from the University of Florence (PI prof. Daniela Poli) and involves RUs from the University of Cagliari (Associated PI prof. Anna Maria Colavitti), University of Genoa (Associated PI prof. Giampiero Lombardini), University of Palermo (Associated PI prof. Filippo Schilleci), and University of Molise (Associated PI prof. Luciano De Bonis), to which all the authors are affiliated.

2. The urban bioregion approach

The concept of urban bioregion has been developed within the italian territorialist school, mainly through the work of Alberto Magnaghi. It represents an evolution of the bioregion concept, which emerged in the Sixties and Seventies in the context of northamerican ecological movements (Berg, 1978; Todd, 1984; Sale, 1985), and was based on its Greek-Latin etymology, combining "bios" (life) and "regere" (to govern), signifying a region governed by nature (Magnaghi 2014a).

The "urban" adjective, which distinguishes Magnaghi's approach from the above bioregional model, is aimed both at overcoming ineffective anti-urban opposition, recognizing the widespread nature of contemporary urban phenomena at their current geographical scale, and steer clear of deterministic view that tie human settlements solely to environmental factors (Magnaghi 2014a).

Additionally, according to Dematteis, Magnaghi employs that adjective to emphasize that the "return to the territory" civilization he advocates is inherently urban, in the particular sense of a "return to urbanity" as a space of relationship and proximity, and as a process capable of re-establishing the idea of the city in a new bioregional perspective (Dematteis, 2021).

Basing on the consideration of the social dimension of the bioregion (Berg, 1978), the socio-ecological and municipalist vision of Bookchin (1970), and with particular reference to the ecological geography studies (De la Blache, Martonne, 1903), as well as the experiences of the Regional Planning Association of America (Friedmann, Weaver, 1979) and Mumford's (1963) concept of the "region of the human community", Magnaghi (2014a) anchors the concept of the bioregion to the territorial project, i.e. he refers above all to the principle of coevolution between place, work and folk of the bio-anthropocentric Valley Section by Geddes (1915).

It is worth noting that Magnaghi (2014a) refrains from defining the urban bioregion by fixed territorial boundaries. Instead, he presents it as an analytical and, more importantly, planning tool for managing a territory, a concept that Dematteis (2021) identifies as the planning outlet of the entire territorialist theory.

In this respect, it is also important to emphasize that, once clarified that the physical boundaries of an urban bioregion are not fixed, but must be defined in a contextual manner, Magnaghi also states that in the governance of the territory the urban bioregion should translate into in interpretative and planning tool at the level of the of the "minimum units of territorial and landscape planning" of a large area of a region (Magnaghi, 2014a)

The definition of these minimal units remains a subject of debate among territorialist scholars. However, for our purposes — namely, opening the way to a form of living understood as a complex interplay between human societies and the environment that transcends mere habitation — we believe that, among the various components constituting a bioregional complex, political factors enabling forms of self-government hold particular significance (De Bonis, 2024). Therefore, identifying the "minimum units of bioregional planning" must first and foremost refer to such forms of self-government. These units should align with territorial areas governed by self-organized entities engaged in a productive and co-evolutionary relationship with their environment (De Bonis, 2024).

3. Natural resources management in the urban bioregion

The productive and co-evolutionary relationships that can take place between human societies and the environment within the area that we identify as the minimum unit of bioregional planning reflect an approach to the relational dynamics between human and non-human that seeks to overcome dualistic visions, which generally result in hierarchical and sterile forms of inter- and intraspecific interaction.

In fact, if the concept of urban bioregion were to be understood solely according to an ideal of "return to nature" in opposition to development models that are not environmentally sustainable, the transformative and planning potential that it intrinsically possesses would be significantly decreased, failing to counter those global political trends that reduce the environmental issue to the imposition of rules and limits on the use of environmental resources and the emission of polluting and climate-altering substances.

In addition to contributing to the creation of that "techno-fascist" scenario (Gorz, 2015) towards which contemporary society has predominantly oriented itself for several decades now, adopting a 'sterile' approach to the concept of urban bioregion would also foster a nostalgic vision of nature (Fabbri, 2019), conceived as incapable of self-regeneration, in need of human intervention to survive and return to an idealised, primordial and uncontaminated state, according to a form of "naturalist demagogy" (Baudrillard, 2019) which is far from the most intimate essence of nature itself.

The urban bioregion project, on the other hand, has the potential to enhance the relational continuum in which all organisms are immersed, including humans, avoiding both the initiation and perpetuation of processes of value extraction from natural resources (De Bonis, Ottaviano, 2024), and those approaches based on a "bad conscience" (Magnaghi 2010, citing the expression used by Françoise Choay in *L'Allégorie du patrimoine*, 1992), which manifest in strictly conservationist instances that tend to reduce or exclude the interaction between humans and ecosystems. Therefore, by overcoming the principle that the difference between human and non-human presupposes separating boundaries, and that human action is always imbued with an 'original sin' towards the environment, the urban bioregion project can interpret this difference as a relational interface within an osmotic environment, constantly seeking states of equilibrium between the components of the system.

It is widely reported in literature that the human role as an ecological factor goes well beyond the negative meaning to which it is generally associated in contemporary times. The long-term interaction between agro-forestry-pastoral activities and the environment has often produced highly diversified ecosystems that are now recognised as being of particular value (Gauquelin *et al.*, 2018), and the interruption of historical co-evolutionary processes can cause a decline in ecosystem richness (Conti, Soave, 2006).

Even the IUCN - International Union for Conservation of Nature - recognises[2] the value of OECMs (Other effective area-based conservation measures), i.e. those practices of land use and management that allow the achievement of positive results in the long term for biodiversity conservation and ecosystem functioning, also in association with cultural, spiritual and socio-economic values. Among the practices that can be recognised as OECMs, we include those involving the use of "rural commons", which we can certainly consider the most evident form of those "territorial common goods" that Magnaghi defines as "intergenerational collective products that are distinguished from natural common goods as they are entirely produced by human action as a human environment [..]" (Magnaghi, 2015, 139), and one of the most symbolic forms of territorial self-government found throughout history and across the world.

4. From institutional planning to planning through agreement tools

The need to develop tools that enable forms of territorial self-government is particularly relevant to the advancement of the urban bioregional approach, because it is by starting from areas in which such forms of self-government are exercised that we can identify the minimum units of bioregional planning.

Magnaghi notes that the process of progressive reconstruction of territorial common goods finds concrete expression in the activation of "multi-actor, multi-sector and multi-functional contractual and pact forms to address the governance of the territory as a common good" (Magnaghi, 2015, 151), in which the processes of self-organisation among local actors precede institutional involvement.

Furthermore, in the same text Magnaghi recognises a particular interest in the contractual forms aimed at the management of water resources (such as river contracts, which will be discussed in more detail in paragraph 5 as one of the components of the project's case study), because they invert the top-down logic of sectoral policies, paving the way for new forms of care and planning by the local community, which only subsequently extend upward, involving institutional sectors (Magnaghi, 2015).

Well, as already argued elsewhere (De Bonis 2024b; FC; De Bonis, Ottaviano, 2024), we reiterate here that Magnaghi's interpretation of these processes can not only be considered a potential evolution towards innovative institutions of collective action that generate commons, but also, in this context, provides a meaningful and distinctive

2 In December 2024, IUCN co-organised, together with ICCA Consortium, International Association for the Study of the Commons, and University of Lausanne, the event "The European Commons, Territories of Life and OECMs Conferences". <https://ruralcommons.eu/> (Last accessed: June 2025)

contribution from territorial planning. This contribution lies in the creation of 'collective rules for individual use', which form the core essence of the above non-state institutions (Ostrom, 1990).

It is also particularly interesting, in the context of this contribution and the research project outlined here, how Ostrom shifted the focus of her discussion from a purely theoretical level to the search for real-world experiences in which collective resource management practices were effective, and how the integration of her insights into the bioregional design approach enriches them with a generative dimension capable of producing entirely new commoning practices.

In the specific Italian regulatory context to which the research project refers, the possibility of implementing forms of territorial self-government must be sought within the spaces that the institutional planning system, rigid and hierarchical by nature, leaves open to actions grounded in the principle of subsidiarity (De Bonis, 2019). Article 118 of the Italian Constitution, following the 2001 reform, attributes all administrative functions to the Municipalities "unless, to ensure their unitary exercise, they are conferred to the Provinces, Metropolitan Cities, Regions and State, on the basis of the principles of subsidiarity, differentiation and adequacy" (clause 1). It also establishes that all the administrative bodies mentioned in clause 1 must promote "the autonomous initiative of citizens, individually and in association, for the performance of activities of general interest", based on the same principle of subsidiarity (De Bonis, 2019).

Furthermore, the Law on Local Authorities (Legislative Decree 267/2000, art. 3, clause 5), even before the constitutional amendment of 2001, establishes that Municipalities and Provinces, in carrying out both their inherent and delegated functions, perform their functions also through activities that can be adequately exercised by the autonomous initiative of citizens and their social groups, again in accordance with the principle of subsidiarity (De Bonis, 2019).

This means that experiences of "voluntary" planning and design, implemented by local communities even without involving the institutions, can be considered fully compliant with the constitutional and regulatory provisions, as an application of the principle of subsidiarity in the field of territorial governance (Ottaviano, De Bonis, 2021). Among the voluntary land planning tools, the river contract is arguably the one that has attracted the most attention in recent years[3], both from local actors and from institutions.

Formally introduced into the Italian legal system by Law no. 221 of 28 December 2015, through the addition of Article 68-bis to Legislative Decree 152/2006 (Environmental regulations), the river contract is defined as a voluntary tool "for strategic and negotiated planning" aimed at protecting and managing water resources and enhancing of riverine territories, with the goal of supporting local development. It also contributes to the definition and implementation of district planning tools at the level of the hydrographic basin and sub-basin.
This makes it a tool that complements institutional planning of river contexts (typically under the responsibility of River Basin Authorities, though it often incorporates broader, multi-sectoral aspects) by actively and non-hierarchically involving non-institutional actors such as associations, committees, businesses, and individual citizens. Furthermore, within the river contract framework, "variable geometries" of planning relationships between different actors frequently emerge, allowing for the overcoming of rigid administrative boundaries. These flexible, contractual, and voluntary arrangements often are more adaptable than the rigid structures of the institutional planning framework (Ottaviano, De Bonis, 2021).

5. The Aniene river basin as a case study of urban bioregion

In order to support the process of defining adequate forms of self-government of territorial resources that can be effectively implemented in bioregional areas, the research project included experimental analytical work in some areas identified as case studies.

The research unit of the University of Molise therefore examined the vast territory of the Metropolitan City of Rome Capital, also following up on previous research work carried out by a research group from the University of Florence[4], and in particular focused its research work on the bioregional sub-area corresponding to the

3 According to data from the National River Contracts Table observatory, in May 2024 more than 200 River Contracts were activated, of which 80 have been signed. Moreover, in all Basin Management Plans, drawn up by the District Basin Authorities, there are references to River Contracts.

4 The work, carried out under the scientific responsibility of Professor Daniela Poli, and which saw the participation of the

hydrographic basin of the Aniene river, in the eastern portion of the Metropolitan City.

This area is particularly interesting due to the variety of landscapes and socio-economic contexts that it traverses over its almost 100 km length, from its sources at about 1900 m above sea level on the Simbruini Mountains in the province of Frosinone to its confluence with the Tiber at the northern vertex of Villa Ada Savoia, just upstream of its entry into the consolidated city of Rome.

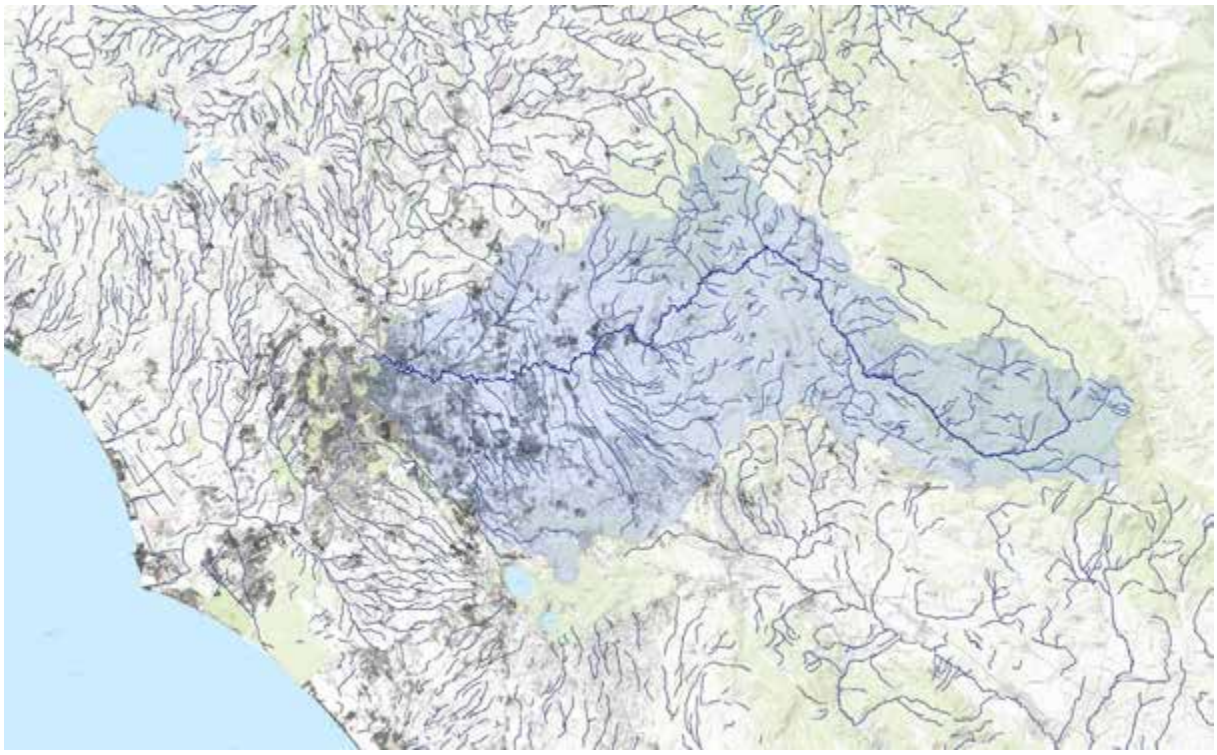

Figure 1 - The basin of Aniene river in the context of the hydrographic network (in blue) and the widespread urban fabric (buildings in black) of Lazio region. Elaboration by G. Ottaviano.

The Aniene has played a significant role in shaping the settlement structure of the territorial area that is headed by Rome, in particular along the linear axis of the ancient Via Tiburtina Valeria from the city to Tivoli, which acts as the valley outlet of the river and from which a polycentric network of numerous hill and mountain towns extends. The principal upstream element, in both historical and contemporary terms, is Subiaco.

The presence of a watercourse of significant flow enabled the development in ancient times of various productive activities that exploited its driving force, in addition to agricultural and fish farming practices that in some forms persist today. In the upstream section, which is largely consistent in social, economic and demographic characteristics with the broader context of Italy's inner and mountainous areas, grazing and forest use have also been historically significant.

A further element of interest within the ongoing research is the existence of a River Contract for the Aniene, which

scientific committee consisting of Professors Alberto Magnaghi (president), Alberto Budoni, Luciano De Bonis, Claudio Cerreti, Paolo Cesaretti, Carla Masetti, Claudia Mattogno, and the working group composed by Doctors Monica Bolognesi and Eni Nurihana, is presented in the research report "Studi, ricerche e linee strategiche per riorganizzare la Città Metropolitana di Roma in un sistema di bioregioni urbane resilienti e autosostenibili" ("Studies, research and strategic lines to reorganise the Metropolitan City of Rome into a system of resilient and self-sustainable urban bioregions").

concerns nearly the entire extension of its hydrographic basin[5], involving numerous institutional, economic and civil society actors.

The activities leading to the River Contract definition began in the early 2000s, well before this instrument gained recognition in practices and in the regulatory system. The Forum for the Aniene, which generated numerous meetings and events open to a wide range of entities interested in environmental and socio-economic issues relating to the river territory, can be considered as both the original nucleus and the catalyst of that associative dynamism which has expanded over the years and now comprises numerous actors with interest in actively participating in the management of the watercourse.

The formal River Contract process began in 2014, initiated by the Committee for the Aniene, to which numerous associations[6] belonged, also with the support of various individual actors. This initiative prompted the engagement of the Mountain Community X of the Aniene, which in 2016 assumed a leading role and broadened the group of institutional and associative actors involved, up to approximately 100 parties that, in 2018, formalised a Document of Intent outlining the objectives and governance structure of the River Contract.

In February 2020, the Lazio Region allocated funding to support the process, integrating the financial contribution of the Mountain Community X of the Aniene and enabling the definition of an Action Programme, comprising 94 project initiatives (Figure 2), and the formal signing of the River Contract in 2022.

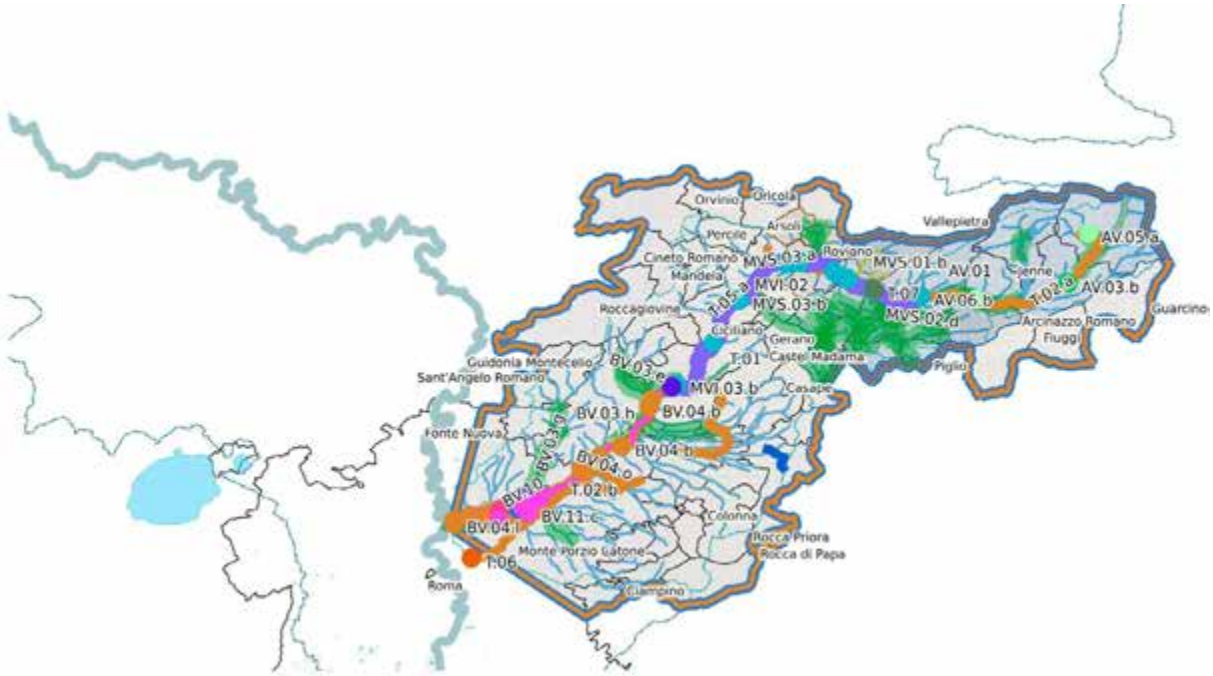

Figure 2 - The WebGis map of the project initiatives of the Action Programme. Source: WebMap of the River Contract, accessed 06 June 2025, <https://shorturl.at/9KTCi>

The initiatives within the Action Programme refer to four general objectives: i) mitigation and adaptation to hydrogeological risks; ii) environmental improvement; iii) sustainable use of environmental resources; iv) tourist-recreational enhancement of the environment. For each initiative, the Action Programme designates the responsible party (single or multiple) and additional actors potentially involved in implementation.
The analysis of the initiatives reveals that responsibility is distributed among 61 actors, predominantly with exclusive assignments. Shared responsibility is more common among associations. Responsible actors include

5 With the exception of a portion of approximately 2 km2 (equivalent to less than 0.15% of the entire surface area of the river basin) which falls within the administrative territory of the neighbouring Abruzzo region.

6 Associazione Insieme per l'Aniene Onlus, Canoa Kayak Roma Assex, Canoanium Club Subiaco, Associazione Sistema Ambiente (clubs of Tivoli and Subiaco), Legambiente, WWF, Italia Nostra (section Aniene - hub Vicovaro Mandela), Compagnia del Casone (Castel Madama), Associazione Amici dei Monti Ruffi, F.I.E. - Sentiero Verde.

22 municipalities, 20 local associations, 5 territorial bodies (such as managing authorities of protected areas, mountain communities, and basin authorities), 4 municipal districts of Rome Capital, 4 local sections of national associations, the Lazio Region, 2 companies or business networks, 2 professional orders, and the Autonomous Institute of Villa Adriana and Villa d'Este.

Across the 94 initiatives, 164 actors are cited as either responsible or involved in implementation. In addition to the aforementioned typologies, these include public service providers, universities and research centres, schools, public agencies and consortia, ministries, superintendencies, museums, local action groups, municipal unions, and the Metropolitan City of Rome Capital.

The most frequently cited actor is the Lazio Region, involved in a total of 58 initiatives, but designated as responsible in only two. Likewise, the two regional parks (Monti Simbruini and Monti Lucretili), the Regional Authority RomaNatura, the Mountain Community X of the Aniene, the municipal districts II, III, IV and V of Rome, the Basin Authority, and certain associations ("Insieme per l'Aniene" and "V.A.R.A. - Valle Aniene Rete Associazioni") participate extensively, but rarely as responsible parties.

Both the Municipality and the Metropolitan City of Rome Capital are involved in numerous initiatives (20 and 27 respectively), yet never with positions of responsibility, similarly to the public company managing the integrated water service Acea (involved in 29 initiatives).

In addition to the typological mapping of the involved actors and the relational geometries envisaged in the Action Programme, the research assessed the coherence of each initiative with the four general objectives, categorising each initiative accordingly.

Furthermore, a typological classification of the proposed interventions was conducted to analyse the project contents of the River Contract, resulting in the identification of 32 types of action.

The objective of tourist-recreational enhancement is the most prominent (68 out of 94 initiatives, including 33 where it can be considered as its exclusive objective), followed by the objective of environmental improvement (51 occurrences, of which 14 as an exclusive objective). Mitigation and adaptation to hydrogeological risks (19 total occurrences, 2 exclusive) and sustainable use of environmental resources (15 total occurrences, 3 exclusive) are significantly less represented.

Among the planned actions, the most frequents concern the restoration, improvement or enhancement of soft mobility infrastructure (e.g., paths, cycleways, pedestrian routes) with 44 occurrences; removal of environmental criticalities (19); creation of recreational or visitor spaces (16); river maintenance (12); restoration of buildings or structures (12); and environmental redevelopment (12).

The analysis results are substantially consistent with what can be hypothesised on the basis of the overall objectives of the River Contract, i.e. the environmental protection and management of the river area and socio-economic development, which in high-quality, environmentally sensitive contexts, is generally predominantly referred to tourist and recreational use only.

While acknowledging the preferability of protective and valorising territorial approaches over extractive and deteriorative practices, we argue that these do not fully restore the centrality of the relational continuum between human society and the environment necessary to sustain the processes of virtuous co-evolution that the urban bioregion project should aim for.

Points of interest do emerge from certain initiatives focused on reactivating sustainable production practices, such as agri-food and phytotherapeutic production, and local, multi-source energy generation integrated with other territorial management cycles.

Another noteworthy aspect from the Action Programme is the dynamism of non-institutional, and not exclusively associative, actors. Some entrepreneurial entities, both within and outside the formal framework of the River Contract, have initiated projects enhancing innovation, multifunctionality, and the valorisation of territories and

agricultural practices in Rome's urban area.

Moreover, ongoing research to identify practices within the Aniene basin that reflect reproductive and virtuous co-evolutionary relationalities between human society and the environment has highlighted some experiences that present interesting features.

One of them concerns the farmers' markets in Tivoli and Frascati, promoted by the Slow Food Foundation for Biodiversity, which aim to foster local agricultural production conducted according to methods ensuring quality and sustainability.

Additional relevant practices are the development of a network of urban gardens (which also intersects with some River Contract initiatives), a Solidarity Purchasing Group, and the process of establishing a renewable and solidarity-based energy community in Rome, promoted by an association with active citizen involvement.

6. Co-producing planning action: the project's GeoSocialWeb platform

The process of defining the minimum bioregional units, previously discussed, cannot disregard the enabling of forms of territorial self-government. They configure an "interactive context" characterised by "high complexity and instability" (Crosta, 2003), in which the actors "make themselves" during the implementation of the practices, and within the same process decide upon the tool that regulate them, whether through intentional or unintentional actions (Crosta, 2007).

In this way, paths are enabled that contribute, to some extent, to the "social production of the plan" within the broader "social production of territory", that is, a rethinking of planning action as a process of "self-formation that gives inhabitants the sense of belonging to a community and a place" (Giangrande, 1998) or, even more fittingly in light of the complexity of contemporary socio-geographical contexts and relations, a sense of simultaneous belonging to multiple communities and places, defined by the "variable geometry" of involvement in trans-scalar and trans-local processes of "differentiation of interaction spaces" (Crosta, 2003).

The activation of these social ecosystems of planning requires an opening of territorial governance practices to forms of "projects in planning", understood as the implementation of the principle of subsidiarity within the framework of territorial planning. As illustrated in paragraph 4, recognising the constitutional legitimacy of self-determined design practices would also support overcoming the "clear distinction between 'institutional' and 'non-institutional'" planning (De Bonis, 2019).

The agreement tools would allow the "transition from government to governance" (Micciarelli, 2014) and the emergence of those "forms of federalism from below" necessary for the "integral application of the principle of subsidiarity" (Magnaghi, A. in Becattini, 2015), through a network of relationships across multiple organisational levels, such that each issue can be addressed at its most appropriate level (Micciarelli, 2014).

It is clear that the most suitable form of self-government must be identified in each specific context, as any attempt to formalize or establish the forms in which communities can exercise their power of self-determination would lead to the paradox of "self-management of heteroregulated units", which Gorz (2015) describes as "a nonsense or a mystification".

The activation of planning action by local actors can be significantly supported through technological tools that lower the barriers to accessing technical skills and facilitate the exchange of information with planning potential. Research shows a spontaneous tendency among grassroots initiatives to leverage new technological tools, and in particular collaborative mapping in our case, as a means to construct new images of the territory (De Bonis *et al.*, 2020, 2019).

For this reason, and in continuity with approaches that the authors of this contribution have been developing over the years (De Bonis, 2009), the research project included the creation of an interactive web environment (GeoSocialWeb), interoperable with the information systems used in planning processes and based on the integration of GIS and WebGIS with emerging technologies in the field of neogeography, in the framework of a platform that allows asynchronous communication and peer-to-peer online production (Social Web) of content.

The choice to adopt this technology is based on the recognition that the production of geographic information has undergone a profound transformation in recent years. From being a specialized domain, it has evolved into a multi-actor and widespread process of information production. These forms of neogeography rely primarily on digital tools and the co-production of data through mobile applications and web-based platforms. This phenomenon is associated with the so-called data revolution (Kitchin, 2014).

Among the practices of collaborative mapping and location-based social networks, or geosocial (Kitchin, Lauriault, Wilson, 2017), there are experiences of integration between open source software for web mapping, collaborative writing, and communication, also based on DokuWiki platforms. These systems enable interaction among users for the collaborative construction and sharing of geographically referred analytical frameworks and territorial images (De Bonis *et al.*, 2020).

Such platforms foster interaction between users, facilitating the integration of different approaches and competences. They can be understood as socio-technical learning environments, which transcend the sectoralisation of specialised territorial knowledge production and incorporate other forms of spatial intelligence (Mattern, 2017).

GeoSocialWeb is therefore a tool to enable the production of cartography through collaborative approaches, and it is designed to facilitate decentralised and collaborative, bottom-up map-making processes that combine expert knowledge, contextual awareness, and creative expression from all kinds of users.

The system, currently under development, is conceived as an integration of existing tools for the production and sharing of geographic information with those that facilitate social interaction among users. It represents an environment of extensive online interaction aimed at sharing territorial knowledge and collective visions of the future: at the same time, a digital infrastructure and social space for encouraging action and interaction among researchers, territorial communities, and any user interested in contributing their vision of a place.

GeoSocialWeb functions as an environment of online interaction for territorial communities, aimed at experimenting processes of co-produced mapping apt to strengthen sense of place and "place consciousness" (Magnaghi, 2010), encouraging the drafting of bottom-up future scenarios oriented towards community self-government, thus overcoming the fragmentation typical of various "participatory planning" approaches.

While the initial population of the platform (i.e. the first set of maps) could be provided by the members of the research group, the key feature of the GeoSocialWeb lies in its openness to contributions from all registered users.

These users can create and share data about the territory and interact with other users around uploaded content. The platform is developed as a digital environment for the collaborative creation and management of interactive forums, based on the sharing of text (comments, discussion) and various media types (images, videos, audio). Use of the platform is open to any user, but full functionality (such as the ability to comment or modify content) is reserved for registered users.

Each forum is necessarily linked to a map embedded into the webpage (Figure 3). The platform under development is being optimised to allow interaction on cartographic bases generated through the uMap application[7], which enables the creation of interactive and shareable maps based on OpenStreetMap.

7 https://umap.openstreetmap.fr/

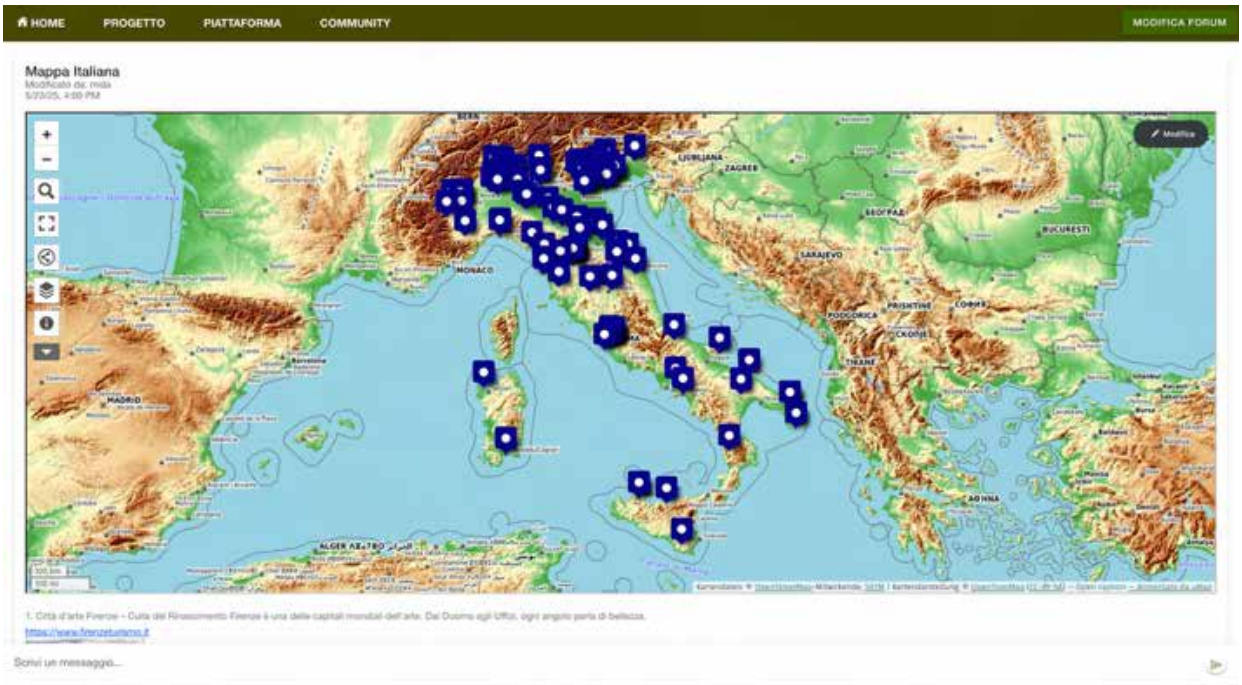

Figure 3 - Map embedding in a test forum page within the alpha version of the GeoSocialWeb under development. Courtesy of M. Daniele

Forums also include dynamic fields for inserting descriptive texts, external links, multimedia files, and customised iFrames (Figure 4). The platform integrates functionality for storing and displaying the history and attribution of changes to the forum, thereby allowing users to track the evolution of interactions around specific territorial issues.

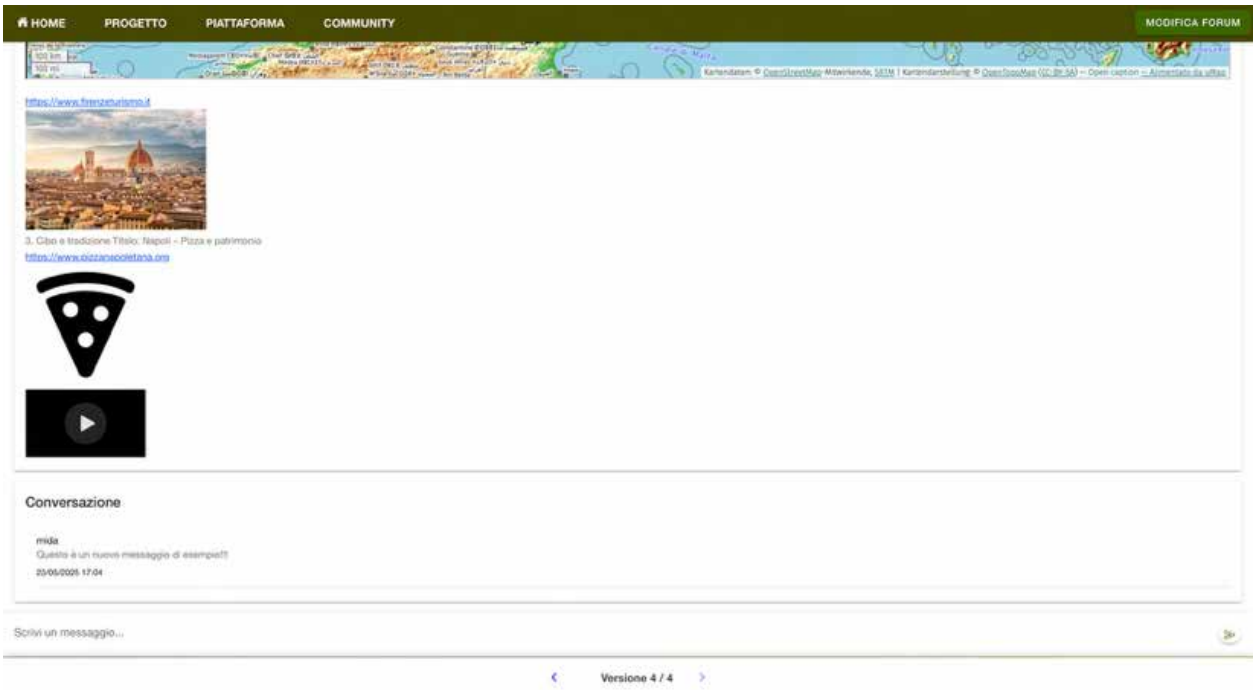

Figure 4 - Media sharing in a test forum page within the alpha version of the GeoSocialWeb under development. Courtesy of M. Daniele

7. Conclusions

Having as a general reference the theoretical insights expressed in paragraph 2, 3, and 4, the ongoing research in the Aniene River basin has revealed a number of elements worthy of deeper analysis and further development. Among these, the experience of the River Contract stands out as an example of an agreement tool that, although still largely framed within institutional logics, shows the potential to act as a complementary instrument to formal planning.

This is also demonstrated by the geometries of interaction between the actors, in which there is a greater involvement of subjects progressively as one moves towards the lower scale, with a particularly relevant role of local associations.

We suggest that the River Contract can be interpreted as a flexible and inclusive framework that may serve as a connection level between institutional planning and community-driven forms of self-governed territorial action. The process that led to the Aniene River Contract, from the wide engagement of associative networks to the subsequent institutionalisation of a participatory governance structure, highlights the complex dynamics behind subsidiary territorial governance.

The Action Programme of the River Contract, with its 94 project initiatives and over 160 involved actors, reflects both the strengths and limitations of the current participatory planning configuration. The prevalent focus on tourist-recreational valorisation suggests a relatively narrow interpretation of territorial enhancement, often disconnected from deeper, more transformative engagements with local socio-ecological systems.

On the other hand, certain project proposals (particularly those aimed at reactivating sustainable production cycles, e.g., local food and phytotherapeutic supply chains, local energy systems) and ongoing practices outside the formal framework (such as farmers' markets, urban gardens, and emerging energy communities) indicate a latent potential for self-organised, co-evolutionary planning practices. These initiatives, although still fragmented, offer promising ground for experimentation of territorial self-government.

In this evolving context, the GeoSocialWeb platform could support decentralised, collaborative mapping and the co-production of territorial images, fostering place awareness and the networking of place-based initiatives. In doing so, it may contribute to addressing one of the main challenges highlighted also by the Aniene case: the need to shift from participation understood as consultation or project delivery toward active forms of self-government that are grounded in local knowledge, relational engagement, and shared responsibility.

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Author contributions

Although this work as a whole arises from the close collaboration between the authors, the writing of § 3 and 6 is by Giovanni Ottaviano, the writing of § 2 is by Luciano De Bonis, the writing of § 4 is by Giovanni Ottaviano and Luciano De Bonis, the writing of § 5 is by Giovanni Ottaviano and Francesca Giangrande, and the the writing of § 1 and 7 is shared by all authors.

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Assessing the effectiveness of participation in urban planning processes: a dual perspective on civic engagement and process efficiency

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Abstract
The present paper proposes a methodology for the evaluation of participatory planning processes through an integrated lens that connects institutional design with civic experience. The model synthesises objective indicators – such as timing, access, and policy integration – with subjective dimensions – like trust, agency, and place attachment. This enables it to capture the interplay between governance structures and lived participation. The framework is situated at the intersection of institutional practice and democratic innovation, thereby facilitating cross-boundary learning between public actors, communities, and planning professionals. This exploratory study establishes the foundation for subsequent empirical validation. It provides a versatile instrument for evaluating and collaboratively designing participatory pathways that enhance citizen empowerment and fortify democratic resilience across various territorial contexts.

Key words: Process evaluation; Participatory planning; Civic Engagement; Agency.

Introduction

Public participation in decision-making is widely acknowledged as a foundational element of contemporary urban and territorial planning. It serves not only as a safeguard of deliberative democracy (Smith, 2006), but also as a mechanism for promoting more equitable, informed, and context-sensitive policies (Healey, 1997). In this perspective, participatory planning has assumed a central role in shaping urban policies that reflect social complexity and emerging territorial needs (Ansell & Gash, 2008; Fischer, 2012).

Despite its growing institutionalization, evaluating the effectiveness of participatory processes remains a complex task. Existing assessment models are often polarized between procedural approaches, focused on efficiency and organizational criteria (Rowe & Frewer, 2000), and experiential approaches, concerned with participants' perceptions, relational dynamics, and subjective outcomes (Bherer, Gauthier, & Simard, 2021; Quick & Feldman, 2011). This methodological divide limits the ability to frame participation as a systemic phenomenon shaped by both design quality and lived experience (Kapucu, 2021).

This study proposes an integrated evaluation framework that brings together structural and experiential dimensions. On the one hand, it considers process-related variables such as transparency, time management, accessibility, and the integration of participatory outcomes into planning decisions (Reed et al., 2018; Partidário & Mourato, 2020). On the other, it incorporates subjective dimensions including trust, motivation, agency, and place attachment (Zimmerman, 1995; Manzo & Perkins, 2006; Christens, 2012).

The framework is designed with two main objectives: first, to offer a comprehensive tool for evaluating participatory processes across diverse planning contexts; and second, to foster critical reflection on the relationship between structural design and democratic meaning in participatory governance.
The key contributions of this work are as follows:

- To test the hypothesis that participatory effectiveness results from the interaction between procedural efficiency and experiential engagement (Michels & De Graaf, 2017);
- To investigate how process characteristics shape participants' perceptions, particularly regarding institutional trust, sense of belonging, and civic activation (Baiocchi & Ganuza, 2017);
- To provide a transferable methodological model that can be adapted to evaluate a variety of participatory planning cases;
- To identify enabling and constraining factors that influence the transformative capacity of participatory processes;
- To highlight the critical role of perceived authenticity and the actual integration of public input in shaping long-term civic trust and engagement (Nabatchi & Leighninger, 2015; Voinov et al., 2022).

The paper is structured as follows: section 2 reviews the theoretical foundations and key approaches to evaluating participation; section 3 presents the proposed methodology and analytical tools; section 4 discusses potential applications and expected outcomes and offers critical reflections. Through this structure, the study aims to contribute a methodological foundation for more reflective and effective participatory planning practices, integrating both process quality and civic experience.

Background

Participation in territorial planning is now widely acknowledged as a key component of democratic and inclusive governance, aimed at the co-production of urban policies. Beyond mere consultation, participatory planning is conceived as a deliberative and transformative process, capable of redistributing decision-making power, fostering collective learning, and valuing local knowledge (Healey, 1997; Innes & Booher, 2004). It is rooted in a dialogical and pluralistic vision of urban space, where the co-construction of spatial decisions strengthens both civic identity and collective responsibility (Sandercock, 1998).

An effective participatory process not only broadens the decision-making base but also reinforces policy legitimacy, promotes socio-spatial justice, and enhances community capacity for stewardship. Collaborative planning enables forms of relational justice by recognizing cultural and social differences (Healey, 1997), while participation that acknowledges diversity contributes to a more equitable democracy (Young, 2000). The literature on collaborative governance (Ansell & Gash, 2008) emphasizes trust, dialogue, and mutual learning as essential to shared and sustainable outcomes.

Evaluating participatory effectiveness is thus central to understanding its real impact on territorial transformation. Participation yields both instrumental benefits, by incorporating local knowledge into better decisions (Innes & Booher, 2004), and normative ones, by enhancing democratic legitimacy and social capital (Fung, 2006; Smith, 2006). Effectiveness entails measuring not only tangible outputs but also relational impacts and civic empowerment (Michels, 2011; Nabatchi & Leighninger, 2015).

Fundamental participatory principles include inclusiveness, equity, transparency, mutual accountability, and informed deliberation (Smith, 2006; Fung, 2006). For these principles to be effective, they must be operationalized into procedural mechanisms that ensure meaningful influence on decision-making (Arnstein, 1969; Fung, 2006). This dual nature, both transformative and technical, demands evaluation tools that can capture both the experiential quality of civic involvement and the structural efficiency of the process.

Objective evaluation tools focus on structural, procedural, and organizational features, offering criteria to assess process coherence and efficiency. Key aspects highlighted in the literature include: well-calibrated timing that allows for reflection and input (Reed et al., 2018); clarity in roles and expected competences to avoid informational inequalities (Partidário & Mourato, 2020); accessibility in terms of physical, digital, and temporal dimensions (Voinov et al., 2022); the quality and traceability of outputs (Reed et al., 2018); and the degree to which outputs are integrated into subsequent planning phases (Partidário & Mourato, 2020). Such tools are instrumental for ensuring accountability and comparability, especially in complex institutional settings, and form the basis of evaluation models adopted by public agencies and international organizations (Abelson et al., 2003). More recent approaches propose multi-scalar frameworks that integrate formal criteria with indicators of relevance, impact, and sustainability (Voinov et al., 2022).

Among these procedural variables, time management is particularly significant: appropriately paced processes facilitate meaningful engagement while avoiding rushed or diluted participation (Reed et al., 2018). Clear definitions of roles and competencies foster equitable involvement, while transparent expectations and information access are prerequisites for informed engagement (Partidário & Mourato, 2020). Ensuring logistical and technological accessibility is equally critical (Voinov et al., 2022).

Effective participatory processes also produce outputs that are relevant, accessible, and verifiable. Transparent reporting and clear documentation enhance trust and process legitimacy (Reed et al., 2018). Moreover, the integration of these outputs into actual planning decisions is a key indicator of transformative capacity (Partidário & Mourato, 2020).

While objective tools are essential, they must be embedded within broader evaluation strategies that reflect on context, purpose, and long-term effects (Reed et al., 2018; Partidário & Mourato, 2020). Participatory evaluation itself can enhance democratic quality and empower communities (Voinov et al., 2022; Osei-Kyei et al., 2023). Frameworks such as MEPPP (Monitoring and Evaluation of Participatory Planning Processes) aim to support collective learning and address the complexity of knowledge co-production (Kusters et al., 2017).

Subjective evaluation, in turn, focuses on participants' experiences and perceptions, offering a complementary lens to structural analysis. It captures the relational and symbolic dimensions of participation, how citizens feel engaged, heard, and empowered. The literature emphasizes that beyond inclusive mechanisms, perceived authenticity is crucial to meaningful participation (Papadopoulos, 2012; Bussu & Bartels, 2014; Brandsen et al., 2018).

The concept of empowerment is central to subjective evaluation. It refers to individuals' perceived capacity to influence decisions, contribute meaningfully, and act effectively. Empowerment is multidimensional: intrapersonal (self-confidence and perceived efficacy), interactional (understanding and navigating processes), and behavioral (active participation and responsibility) (Zimmerman, 1995; Christens, 2012). These dimensions intersect with trust in institutions (Fung, 2006), personal and collective motivation (Bherer, Gauthier & Simard, 2021), and emotional place attachment (Manzo & Perkins, 2006).

Empowerment is not only individual but also contextual and relational. It reflects how a participatory process fosters authentic engagement, mutual recognition, and shared learning (Fischer, 2012; Baiocchi & Ganuza, 2017). In essence, it is about enabling citizens to move from passive spectatorship to active agency.

Subjective effectiveness thus lies not in strictly measurable parameters, but in the ability to generate meaningful involvement, recognition, and transformative learning (Fischer, 2012; Nabatchi, 2012). These experiences offer a privileged lens to assess whether participants feel empowered, develop new forms of engagement and trust, and perceive their contributions as valued.

Evaluating these elements requires appropriate methodologies that go beyond declared opinions to explore relational dynamics, dialogic quality, and emotional responses (Quick & Feldman, 2011; Baiocchi & Ganuza, 2017; Kapucu, 2021).

Objective and subjective evaluations are complementary and inseparable in assessing participatory effectiveness. Structural analysis reveals key procedural elements—such as timing, accessibility, and transparency—while subjective analysis captures lived experiences, perceptions of agency, and transformative outcomes.

Literature calls for integrated models that link process design to experiential outcomes (Michels & De Graaf, 2017; Bherer et al., 2021), recognizing that procedural features shape participation quality, and that citizens' perceptions, in turn, affect process legitimacy and impact (Kapucu, 2021).

In this light, integrated evaluation emerges as a crucial approach for capturing the complexity of participation. It requires mixed methods, capable of combining quantitative and qualitative, observable and interpretive data, and indicators that reflect both efficiency and civic engagement (Innes & Booher, 2004; Reed et al., 2018).

Only through such an integrated approach can we fully understand the dual nature of participation—as both a democratic arena and a technical device—and promote planning practices that are more equitable, reflective, and oriented toward collective learning.

Compared to existing evaluation frameworks such as the IAP2 Spectrum of Public Participation or the MEPPP (Monitoring and Evaluation of Participatory Planning Processes), the model proposed in this study offers a more integrated and flexible approach. While these models often prioritize either procedural phases or outcome indicators, our framework explicitly connects objective and subjective dimensions, placing equal emphasis on structural features and civic experiences. The added value lies in the model's capacity to adapt across contexts while maintaining a multidimensional focus that includes institutional design, trust-building, empowerment, and place-based engagement. It is conceived not only as a technical tool for analysis, but also as a reflective device to support the design of more meaningful participatory practices.

In order to clarify the distinctive contribution of the proposed evaluation model, it is useful to compare it with two of the most established frameworks in the field of participatory planning evaluation: the IAP2 Spectrum of Public Participation and the MEPPP (Monitoring and Evaluation of Participatory Planning Processes).

The IAP2 Spectrum is a widely used tool that classifies public involvement into five levels (Inform, Consult, Involve, Collaborate, Empower). While it provides a practical guide for designing participatory activities, it focuses primarily on the degree of control or influence granted to citizens, offering little insight into the quality or effectiveness of participation in terms of outcomes or experiential depth.

The MEPPP, on the other hand, adopts a more structured approach to monitoring and evaluating participatory processes, with attention to outputs, relevance, and sustainability. It proposes a multi-scalar model capable of assessing both the planning content and participation dynamics. However, MEPPP tends to concentrate on formal and procedural criteria, and while more robust than IAP2, it does not explicitly integrate subjective and experiential dimensions such as trust, empowerment, or place attachment.

By contrast, the framework proposed in this study explicitly aims to bridge this gap by integrating objective structural indicators (e.g. timing, access, use of outputs) with subjective experiential dimensions (e.g. trust, motivation, agency, place attachment). It provides a multidimensional and flexible instrument, adaptable to diverse contexts, and suitable not only for evaluation but also as a co-design support tool for future participatory processes.

As shown in Table 1, the three frameworks differ significantly in their integration level, focus, and intended use.

Table 1: comparative overview of participatory evaluation frameworks.

Framework	Evaluation Focus	Key Dimensions	Level of Integration	Adaptability	Primary Use
IAP2 Spectrum	Participation phase/type	Inform, Consult, Involve, Collaborate, Empower	Low – phase-based classification only	Medium – standardized model	Participation typology and design
MEPPP	Process monitoring and output analysis	Participation levels, outputs, sustainability, inclusiveness	Medium – procedural + some impact focus	High – scalable and modular	Monitoring and evaluation
Proposed Framework	Structural + experiential evaluation	Timing, Access, Trust, Agency, Empowerment, Place Attachment	High – combines objective and subjective	High – adaptable and reflective	Evaluation, learning, and co-design

Methodological proposal

Building on the theoretical foundations outlined in the previous section, this study proposes a methodology to evaluate the effectiveness of participation in urban and territorial planning. The approach adopts a dual perspective, objective and subjective, aimed at constructing an analytical framework that links the structural features of participatory processes with citizens' perceptions and lived experiences.

The objective evaluation focuses on structural and functional characteristics of participatory processes that influence their capacity to include, inform, and empower citizens. A first key dimension is time—not only the overall duration but also the process phasing and its alignment with planning stages. As Healey (1997) argue, a well-paced process fosters meaningful participation and collective reflection, avoiding symbolic or purely consultative forms of engagement.

A second dimension concerns required competences. Clarity of language, accessible content, and potential training opportunities are essential to ensure informed participation. Reducing cognitive asymmetries is central to inclusive processes. Providing clear and accessible information strengthens trust and comprehension (Mahajan et al., 2022), while training enhances participants' ability to contribute constructively, fostering individual and collective empowerment (Yamaguchi et al., 2024).

Accessibility extends beyond physical or organizational factors to include scheduling, communication methods, digital access, and outreach to marginalized groups. Authentic participation requires attention to access inequalities (Nabatchi & Leighninger, 2015), and inclusive digital tools can expand engagement to underrepresented populations (Pinto et al., 2023).

Another critical factor is the quality of outputs—defined by clarity, relevance, and consistency of results. Effectiveness depends not on the quantity of inputs but on their synthesis, feedback to participants, and transformative potential. Clear, coherent outputs support legitimacy and institutional uptake (Fung, 2006), and effective feedback mechanisms build trust and civic engagement (Mahajan et al., 2022).

Finally, use of outputs measures whether outcomes are integrated into subsequent planning or policy-making phases. This assesses institutional responsiveness and the coherence between participation and implementation. A process becomes transformative when outputs inform real decisions (Smith, 2009; Michels & de Graaf, 2021), marking a shift from symbolic consultation to substantive participation.

Table 2: structural criteria for the objective evaluation of participatory planning processes.

Criteria	Indicators
Time	Overall duration, process phasing, coherence with planning stages
Required Competences	Clarity of content, level of knowledge needed, support provided
Accessibility	Access methods, meeting times, information and digital inclusion
Process Outputs	Clarity, traceability, and relevance of participatory outcomes
Use of Outputs	Degree of integration into subsequent planning or programming

The subjective evaluation acknowledges citizens as active agents and focuses on their perceptions of the participatory experience. Several key dimensions underpin this perspective, while the corresponding structural indicators used to assess these aspects are summarised in Table 2. Trust in the process and institutions emerges through transparency, perceived coherence, and legitimacy of decisions. Transparent communication enhances trust (Fung, 2006), while coherence strengthens procedural legitimacy (Innes & Booher, 2004).

Motivation reflects the reasons driving participation—ranging from civic duty to personal interest or the desire to improve one's community. It is shaped by perceived efficacy and recognition of contributions (Bherer, Gauthier & Simard, 2021).

Agency refers to the perceived capacity to influence outcomes and be heard. It connects to empowerment, a multidimensional construct encompassing self-confidence, understanding of the process, and active engagement. Empowerment strengthens awareness and participation effectiveness (Yamaguchi et al., 2024).

Lastly, place attachment denotes the emotional and symbolic bond with one's environment. This connection fosters participation and care for local spaces. Recent research highlights how place attachment contributes to well-being and resilience (Kamani Fard & Paydar, 2024), making it a critical factor in participatory planning.

These dimensions are interdependent and collectively shape the perceived quality of the participatory process. To assess them, a structured questionnaire is proposed, based on validated or adapted scales from established literature:

- Trust: Measured using a 5-point Likert scale adapted from Fung (2006) and Innes & Booher (2004), focusing on perceived transparency, coherence, and institutional reliability.
- Motivation: Captured through items exploring extrinsic (e.g., civic duty, personal interest) and intrinsic (e.g., satisfaction, perceived contribution) drivers (Bherer et al., 2021).
- Agency: Assessed via perceptions of influence and capacity to express views, based on Christens (2012).
- Empowerment: Measured following Zimmerman's (1995) model, including intrapersonal (self-efficacy), interactional (process understanding), and behavioral (active participation) components.
- Place Attachment: Explored through statements on emotional connection, territorial identity, and care responsibilities (Manzo & Perkins, 2006; Kamani Fard & Paydar, 2024).

Table 3 uses Likert-scale responses (1 = strongly disagree to 5 = strongly agree), preceded by filter questions on process familiarity and participation frequency.

Table 3: dimensions and sample items for subjective evaluation of civic participation experience.

Construct	Sample Items
Trust	"The participatory process was transparent"; "Information provided was coherent and reliable"
Motivation	"I felt motivated to improve my community"; "My contribution could make a difference"
Place Attachment	"I feel emotionally connected to where I live"; "This place is part of my identity"
Agency	"My opinion was listened to and considered"; "I played an active role in decision-making"
Empowerment	"I feel more competent after participating"; "I gained tools to influence future decisions"

As highlighted by Fung (2006) and Innes & Booher (2004), effective participation balances procedural adequacy with participants' perceptions of being heard and valued. Baiocchi & Ganuza (2017) further show how public recognition of participants' views strengthens trust and agency. Similarly, Manzo & Perkins (2006) demonstrate that place attachment deepens civic engagement, especially when coupled with a participatory context that fosters empowerment.

Potential applications and critical reflections

This study offers a preliminary theoretical framework for evaluating the effectiveness of participatory processes in urban and territorial planning. As an exploratory contribution, it does not yet include empirical validation but is intended as a foundation for future applied research. Similar to other conceptual or methodological studies in the planning field, the aim is to develop a coherent evaluative model that can be tested, refined, and adapted across different case studies and territorial contexts (see e.g., Innes & Booher, 2004; Reed et al., 2018).

Recognizing the active role of local communities in territorial governance is essential to address the complex challenges of contemporary societies. Participation should not be confined to token consultation; rather, it must be seen as a structural component of governance, capable of enabling citizens to act as informed and responsible agents. This shift moves beyond the spectator-actor dichotomy, placing communities at the center

of local development strategies. Empowerment, in this perspective, is not a by-product but a core outcome of participatory inclusion, fostering civic awareness, decision-making autonomy, and access to tools for social and territorial transformation (Rota, 2023).

From this standpoint, territory should be conceived not merely as a physical space but as a common good requiring sustainable, inclusive, and collaborative management. Valuing local resources and strengthening cooperation networks emerge as crucial strategies for building cohesive and identity-driven development models. Promoting collaboration between public and private actors, and across urban and rural settings, is key to fostering resilient territorial systems. These dynamics call for the establishment of community learning networks to cultivate a culture of sustainability and active citizenship, equipping communities with knowledge and skills for collective decision-making.

In this view, sustainability becomes not only a goal but a guiding principle for reshaping territorial governance. It functions as a heuristic and educational device that steers collective choices toward fairer and more enduring models of coexistence. Addressing socio-economic transformations requires a holistic approach, where endogenous knowledge is integrated with participatory governance and adaptive management. Within this framework, cultural heritage plays a strategic role—not as a static legacy but as a dynamic force capable of enabling regeneration processes and reinforcing collective identity (Carta, 1999).

Future research should focus on how participatory governance can reframe the relationship between people and place, particularly in contexts affected by deterritorialization and the erosion of local identity. Reinforcing the idea of territory as a "common home" (Tanca, 2015) involves recognizing it as a relational space where social and cultural capital can generate resilience and self-determination. The organization of space according to local specificities and the valorization of endogenous resources are essential for ensuring long-term cultural and social reproduction.

Active participation is therefore a decisive element for building inclusive and resilient governance models. Through deliberative processes and participatory research methods, communities can cultivate a deeper sense of belonging (Ilovan, 2022). The interplay between territorial identity and place attachment becomes central in planning, as emotional and symbolic bonds to place directly affect levels of civic engagement. Shared narratives and collective memory transform space into an essential component of community life.

In this light, public policies must account for the relational dimension of governance, acknowledging how interactions between individuals, groups, and institutions influence territorial attachment. Standardized approaches risk neglecting the cultural and symbolic specificity of places. Qualitative methodologies—such as in-depth interviews and discourse analysis—are increasingly recognized as valuable tools to explore the emotional and experiential dimensions of civic engagement.

Future research directions should also address how global dynamics and growing mobility are reshaping local identities. Urbanization, labor market transformations, and digital interconnectivity are altering the ways individuals relate to their environments. It is therefore necessary to explore the ambivalent, and at times conflictual, relationships people develop with their lived spaces. This awareness is key to designing planning strategies that are more sensitive, inclusive, and attuned to local needs and experiences (Ilovan, 2022).

Despite the absence of empirical validation in this study, the proposed framework has the potential for a wide range of applications. For instance, it could be applied to participatory budgeting processes in medium-sized European cities, where evaluating both procedural transparency and residents' sense of agency is crucial. Alternatively, it could provide a framework for the evaluation of place-based cultural regeneration projects in rural areas, where community attachment and trust in institutions are significant variables. The following hypothetical applications illustrate how the framework can be adapted to different participatory settings, serving both as a diagnostic and a design-support tool.

This work is intended to be conceptual in nature and is presented as a proposal. It is argued that the proposal provides a foundation for a more nuanced understanding of participation as both a technical and democratic process.

It is imperative that future empirical studies are conducted in order to test the framework, evaluate its applicability across diverse contexts, and refine its indicators to ensure relevance, reliability, and transformative potential.

While the proposed roadmap outlines a coherent path towards empirical validation, further reflection is required on two critical aspects: scalability and the active involvement of local actors in the evaluation process.

Firstly, the scalability of the framework will be addressed through a modular and adaptable design. The framework has been designed to function at different scales, including project, neighbourhood, municipal and regional levels. It achieves this by allowing the selective use of indicators based on contextual relevance. The calibration of structural dimensions, such as timing or accessibility, is contingent upon the complexity of the process. Conversely, experiential components, including trust and place attachment, can be adapted through the utilisation of shorter or more in-depth instruments. Furthermore, the utilisation of digital tools and online platforms will be investigated to enhance the scope of data collection, particularly in multi-site or cross-country applications.

Secondly, the involvement of institutional stakeholders and local communities will be pivotal in both the testing and refinement phases. The framework is not merely intended as a tool "for" evaluation, but as a device "with" and "through" participants. In order to achieve this objective, the empirical phase will incorporate participatory validation methods, such as co-design workshops, focus groups, and deliberative feedback sessions with public officials, community leaders, and citizens. These interactions are designed to ensure contextual calibration of indicators, enhance legitimacy, and cultivate a culture of shared learning around participatory quality.

The dual strategy of modular scalability and embedded stakeholder engagement is set to be pivotal in ensuring the relevance, usability, and transformative potential of the framework across diverse territorial and institutional settings.

To guide future research and application, Table 4 presents a phased roadmap detailing the objectives, methodologies, and expected outcomes for each step of the empirical validation process.

Tables 4: future research pathways and empirical validation roadmap.

Phase	Objective	Methodology	Expected Outcome
1. Contextualization	Identify suitable case studies across different urban and rural settings	Case selection based on diversity of governance contexts and participatory models	Comparative insight into context-sensitive variables
2. Instrument Development	Refine and operationalize indicators from the proposed framework	Pilot testing of questionnaires and interview guides; expert validation via Delphi method	Reliable tools for assessing structural and experiential dimensions
3. Data Collection	Apply the evaluation framework to real participatory processes	Mixed-method approach: surveys, interviews, participant observation, document analysis	Comprehensive datasets combining quantitative and qualitative evidence
4. Analytical Integration	Test relationships between structural variables and perceived effectiveness	Statistical analysis (e.g. SEM, regression) + narrative synthesis of qualitative insights	Validation or refinement of hypotheses on effectiveness drivers
5. Cross-Case Comparison	Identify patterns and divergences across contexts	Comparative case study methodology	Generalizable lessons and adaptive model improvements
6. Participatory Validation	Involve local actors in reviewing results and recommendations	Feedback workshops, focus groups with stakeholders	Enhanced legitimacy and usability of the evaluation tool
7. Dissemination and Scaling	Share findings with academic, institutional, and civic audiences	Publications, policy briefs, training modules	Uptake of the model in planning practices and policies

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The Risks of Purposive Transitions in Albania: Navigating the Just Green Transition in Light of Post-Socialist Legacies

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Abstract
This paper explores the risks and opportunities of Albania's Just Green Transition (JGT) in the context of its post-socialist transformation. Drawing up an updated transition theory that accounts for the complexities of purposive change and multi-dimensional justice, the Albania's post-1990 reforms with the current push for climate neutrality under the JGT are compared. The analysis reveals common transition challenges and specific risks tied to JGT's environmental focus and urgency. By mapping the lessons from Albania's post-socialist era—such as the need for participatory governance, particularly in a context of "transitions fatigue"—the paper outlines strategies to address JGT-specific risks—such as governance gaps, social inequities, and economic disruptions—drawing on developments through 2025.

This paper, through a comparative lens, underscores the importance of inclusive policymaking, balancing socio-economic and spatial justice, and leveraging international support for a successful JGT.

Keywords: Purposive Transition; Just Green Transition; Governance Challenges; Risks and Benefits; Sustainability Transitions; Transition Theory

1.Introduction

The open-ended processes of power, political, and societal transformation that initiated with the fall of the socialist regime(s) around the beginning of the 1990s marked the so-called post-socialist transition ((Müller 2019); (Petrov 2014)). This period of profound change affected numerous Central-East European (CEE) countries, leading to the widespread adoption of the term 'transition' among scholars, policy-makers, and the general public to describe this historical epoch and to label these nations as 'transition countries' (Carothers 2002). This transition signaled an epochal shift, simultaneously ushering in uncertain futures for the economies involved, which subsequently embarked on diverse hybrid political models, often diverging from the paths envisioned by Western agencies that emphasized privatization, liberalization, and democratization (Müller 2019).

Within this broader regional context, Albania's journey has been particularly stark. The nation moved from an almost feudal system in 1945 to a highly centralized and autarkic economy. Then, in 1991, it experienced an abrupt transformation towards a liberal market economy[1]. After five decades of severe repression, the post-communist era was characterized by a vacuum in legislation, policies, and institutions. This transition was initially driven by a population desperate for democracy and liberalism. However, the first decade of the 1990s culminated in a climate of escalating informality, marked by problematic tenure recognition, illegal development, forced evictions, and rampant corruption. These issues were exacerbated by the failure of several 'political experiments,' contributing to the dominance of the extralegal economy in Albania, which encompasses more than half of the country's real estate and properties. This situation, while not typical for EU member states, remains a significant technical and political challenge for Albania as it pursues EU integration.

Crucially, by the time the transition began in mid-1992, Albania lacked a tradition of participatory governance. Given the severe abuses of the previous system, citizens often perceived participatory governance not as an opportunity for engagement but as an extension of the forced labor that had been a cornerstone of their oppression.1 As with other Eastern European countries, the radical changes of the early 1990s completely reshaped Albania's political, social, and economic realities. Albania's specific circumstances led to a volatile transition, punctuated by chaotic and dramatic events. Most notable was the unprecedented economic collapse caused by the infamous pyramidal investment schemes[2] and the subsequent social unrest in 1997, which left the

1 In line with the liberal policies, after massive expropriation of private properties by the collectivist communist state, the new pluralist authorities initiated a failed privatization process, trying to establish the rule of law but without a Cadastral Office. This has marked one of the most profound challenges, yet a pressing issue for the Albanian socio-economic context.

2 The Albanian pyramid schemes of the mid-1990s were among the most devastating financial collapses in post-communist Eastern Europe. By 1996, an estimated two-thirds of Albanian households had invested in these fraudulent investment schemes, whi-

country temporarily without a government and necessitated UN intervention and a multilateral peacekeeping force to restore order (Aliaj and Kacani 2024)..

It is essential to understand that Albania's transition has been uniquely complex and markedly different from that of most European countries. Unlike others, it emerged from the most rigid orthodox system of centralized planning in the former Eastern Bloc, making the shift to a market economy and democratic governance particularly challenging. The 1999 Kosovo War further strained Albania's fragile social fabric, as the country absorbed a massive influx of refugees, compounding existing economic and social pressures. However, with the end of the Yugoslav Wars, regional stability improved, allowing Albania to enter a period of relative progress. The early 2000s saw a notable shift toward stability, economic growth, and social development, with GDP expanding at an average annual rate of 6 percent and significant advancements in socio-economic indicators. Yet, problems began to resurface around 2010 as the global recession and the logic of 'stabilocracy'—underlying financial and security aspects—slowed both economic and democratization processes.

Despite these ongoing challenges, Albania joined NATO in 2009 and remains committed to progressing towards EU membership, navigating an increasingly unstable and unpredictable global landscape. While still grappling with numerous political and economic reforms, and arguably still in transition for many initiated processes, by the end ofthe 20th century, the Government of Albania, along with other Western Balkan governments, aligned as supporters and implementers of the European agenda for green transition. This is both a necessity for pan-European commitment to address climate challenges and ensure environmental sustainability, and a crucial requirement for EU integration.

The newly presented "green transition," as Geels (2011) might suggest, is equally "purposive" for all Western Balkan countries, considering its embeddedness within the EU green agenda, the EU integration process, and the structural and technical weaknesses in the region that inhibit the spontaneous emergence of bottom-up niches of change.1 The JGT is thus layered onto a society already weary and skeptical of grand, externally-driven transformation projects, a phenomenon that can be described as "transitions fatigue". This fatigue, born from past experiences with reforms that often fell short of their promises or were perceived as imposed, creates a challenging socio-political backdrop for yet another large-scale transition.

In this context, this chapter aims to examine the JGT within the broader framework of Albania's post-socialist transformation, drawing parallels between these two pivotal periods of systemic change. Firstly, it decodes the theoretical concept of transition(s) by incorporating recent scholarly advancements and critiques. Secondly, through a comparative approach, it examines Albania's post-1990 transformation, highlighting key governance, socio-economic, and spatial challenges, while identifying lessons relevant to the JGT and exploring its multifaceted implications. This comparative lens aims to identify shared challenges and distinct features of the two transitions to draw actionable insights. The final section synthesizes the conclusions, outlines a trajectory for further discussion, offers policy recommendations, and underscores the importance of inclusive, climate-sensitive governance for Albania's sustainable future, particularly in light of its complex transitional history and the evolving understanding of what constitutes a truly "just" transition.

2.Decoding Transition(s): A theoretical exploration of the term

Transition studies, originating in biology and population dynamics, have expanded to encompass demographics, health, and, significantly, organizational management and technological innovation scholarship (Rotmans, Kemp and van Asselt 2001). Transitions, broadly defined, are processes of profound and systemic change that reconfigure societal, economic, and environmental systems over time, presumably towards an improved state that incorporates new, desirable features or contributes to solving existing problems (Loorbach, Frantzeskaki and Avelino 2017). Within academic discourse, the term has been extensively analyzed through frameworks such as socio-technical transitions, governance transitions, and socio-ecological systems (Geels 2002); (Smith, Stirling and Berkhout 2005). The concept of socio-technical transitions, central to these studies, focuses on the co-evolution of

ch promised exorbitant returns but operated as classic Ponzi schemes. The schemes thrived due to weak financial regulation, political complicity, and a lack of public financial literacy, fueled by Albania's rapid and unregulated transition to a market economy. By early 1997, the schemes collapsed, wiping out an estimated $1.2 billion—equivalent to nearly half of Albania's GDP at the time. The crisis led to widespread social unrest, mass protests, and the near-total collapse of state institutions, culminating in an intervention by a UN-sanctioned multinational peacekeeping force (Operation Alba).

societal practices, technological advancements, and institutional frameworks. Frank W. Geels (2002) introduced the Multi-Level Perspective (MLP) as a foundational approach to understanding such transitions, emphasizing three interconnected levels: niches (spaces of innovation), regimes (dominant systems), and landscapes (broader socio-political and environmental contexts).

However, the traditional understanding of transition dynamics and the applicability of established theories are being increasingly questioned in the context of contemporary sustainability challenges. Notably, insights from past transitions may offer limited guidance for the current low-carbon transition. This is because historical financial risks often stemmed from speculation in rapidly rising industries driven by new, vastly more productive technologies. In contrast, the current transition necessitates policy interventions to rapidly render declining, yet currently productive, high-carbon industries unprofitable, leading to stranded assets and locating significant financial risks within these sunset sectors. This shift implies that the "problem" of transition is evolving; it is less about the "pull" of inherently superior new technologies and more about the "push" out of undesirable, deeply embedded existing ones, creating unique socio-economic and financial disruption profiles.

2.1.Critiques and Evolutions of the Multi-Level Perspective (MLP)

While the MLP remains a cornerstone of transition studies, it has faced critiques that highlight areas for development. Some scholars argue that the MLP primarily explains transitions through a temporal lens and is best suited for bottom-up analyses, potentially underemphasizing the role of top-down influences and broader power dynamics.5 A significant critique is its perceived focus on technological aspects at the expense of adequately considering the socio-political dimensions of transitions, including agency, power, and politics.

Recent scholarship seeks to expand the MLP to address these limitations. There is a growing emphasis on incorporating multi-level governance, recognizing that transition niches can emerge and be shaped by interactions across local, regional, national, and even global governance levels.5 This is particularly relevant for sustainability transitions, where international regulations and agreements (landscape pressures) can significantly influence national policies (regime dynamics) and the development of local innovative solutions (niche activities). For a country like Albania, heavily influenced by the EU agenda, understanding these top-down pressures and multi-scalar governance interactions is crucial for analyzing the JGT. The application of MLP to analyze the circular bioeconomy transition in Nordic regions, for instance, confirmed the unique challenges faced by peripheral areas and underscored the importance of innovation, consumer choices, and overarching environmental factors like climate change impacts as drivers of transition. This highlights the MLP's utility in understanding regional specificities when its analytical scope is appropriately broadened.

2.1.1Sustainability Transitions and Justice in Sustainability Transitions

Sustainability transitions are characterized by societal, multilevel, multi-institutional, and cross-sectoral changes that affect multiple regimes—socio-technical, socio-ecological, political, and governance—as well as societal values, ideas, perceptions, ethics, and morality.These transitions involve large-scale transformations, a focus on finite, collectively owned natural resources, and inherent tensions between growth-oriented sectors and public interests regarding resource management and ethical implications.1 The complexity and dynamic interplay of dimensions such as time, space, affected sectors, actors, and overarching goals make sustainability transitions highly complex and difficult to foresee, even with careful planning world (Cedergren, et al. 2022); (Hansen and Coenen 2015); (Kemp, Loorbach and Rotmans 2007); (Rotmans and Kemp, Managing Societal Transitions. Dilemmas and Uncertainties: The Dutch Energy Case Study 2003).

The transition to a low-carbon economy epitomizes such a large-scale structural change, necessitating the expansion of "sunrise" (low-carbon) industries and the contraction of "sunset" (carbon-intensive) industries (Hunsucker and Loos 1989). A comprehensive theoretical framework that fully links this structural change to financial stability, especially concerning the risks emanating from sunset industries, is still developing.4 Sustainability itself, often defined as meeting present needs without compromising future generations' ability to meet their own 1, is not a fixed state but an evolving goal. Sustainable development is a fluid, ongoing process of transformation, where sustainability transitions represent the continuous effort to balance changing human demands with the biosphere's adaptive capacity (Derissen, Quaas and Baumgärtner 2009).

"Sustainability "meets the needs of the present generation without compromising the ability of the future generations to meet their own needs" and is therefore neither a fixed state of harmony, nor an identifiable state, coping with both the certainty and the uncertainty of change. (Kemp, Loorbach and Rotmans 2007) , (United Nations 1987, 24), (Handmer and Dovers 1996)"

The imperative for "justice" in sustainability transitions has gained significant traction. The call for 'just transitions' originated in the 1970s and 1980s with trade unions in North America concerned about job losses resulting from environmental policies, linking to broader 19th-century discourses on income and wealth distribution. The concept is now firmly established in the International Labour Organisation (ILO) Guidelines for a Just Transition Towards Environmentally Sustainable Economies and Societies for All and is reinforced by the UN Sustainable Development Goals (SDGs) and the Paris Agreement.

The understanding and scope of "just transition" have evolved considerably, particularly since 2022. Initially, the Paris Agreement focused on the "just transition of the workforce and the creation of decent work and quality jobs".

However, subsequent developments, including the 2021 Glasgow Pact and discussions at various international forums, have broadened this definition to encompass wider societal impacts on diverse groups such as women, Indigenous Peoples, low-income households, and youth.7 There is a growing recognition that a just transition must address not only distributive justice (fair allocation of benefits and burdens) but also procedural justice (inclusive and participatory decision-making) and, increasingly, restorative and transformative justice, which aim to correct historical inequities and fundamentally alter power structures.

The UN Committee for Development Policy (CDP) at its 2023 plenary emphasized that countries need to develop context-specific approaches to just transition, reflecting their unique societal needs, priorities, historical responsibilities for climate change, and adherence to principles of global climate justice and common but differentiated responsibilities.8 An open letter from world leaders in June 2023 further underscored the commitment to "a green transition that leaves no one behind".8 The operationalization of the UNFCCC Work Programme on Just Transition Pathways and the ILO's establishment of a Global Coalition for Social Justice in November 2023 (which will feed into the 2025 World Social Summit) signal a deepening institutional commitment to this broader, more demanding conceptualization of justice.

This evolving understanding suggests a spectrum of approaches to implementing a just transition, ranging from:

- Status Quo: Maintaining existing systems while compensating for negative impacts (e.g., retraining for job losses)
- Managerial Reform: Facilitating change within the current economic system, often through social dialogue.
- Structural Reform: Implying institutional change and new governance structures that challenge existing power relations.
- Transformative: Aiming for an overhaul of economic and political systems, seeking alternative development pathways and empowering grassroots movements.

Furthermore, concepts like "energy justice" and "spatial justice" are becoming integral to the discourse. Energy justice considers fairness in energy production and consumption, access, and decision-making, while spatial justice examines the geographical distribution of environmental benefits and burdens, which is highly relevant given Albania's existing urban-rural and regional disparities. The role of local activism, exemplified by movements like "our energy, our rights" in other contexts, highlights the importance of community engagement in shaping just outcomes.

The following table provides an updated timeline of key milestones in the development of the "Just Transition" concept:

Table 1: "Just Transition" Timeline

Year(s)	Milestone
1990s	In the United States, unionists and activists advocate for mechanisms to address job losses from new environmental regulations. The Just Transition Alliance is founded.
2000s	International trade union coalitions introduce the Just Transition concept into global climate discussions, including at COP15 (Copenhagen, 2009).
2011	At COP17 (Durban), South Africa initiates national discussions on a Just Transition framework.
2015	The ILO Guidelines on Just Transition are adopted. The 2030 Agenda for Sustainable Development reinforces the concept, which is officially included in the Paris Agreement (workforce focus).
2018	The Solidarity and Just Transition Silesia Declaration is signed by 50 countries at COP24 (Katowice, Poland), emphasizing fair workforce transitions.
2019	At the UN Climate Action Summit, 46 nations commit to developing Just Transition strategies.
2021	Just Transition gains prominence at COP26 (Glasgow): The Just Transition Declaration is signed. The Global Accelerator on Jobs and Social Protection for Just Transitions is launched. Glasgow Pact expands JT definition.
2022	The IPCC report, High-Level Political Forum (HLPF), and UN Secretary-General's priorities reinforce Just Transition as a key component of global climate action.
2023	UN CDP Plenary discusses JT: emphasizes context-specific approaches, historical responsibilities, global justice. June: World leaders' open letter on "a green transition that leaves no one behind".
2023 (Nov)	ILO Governing Body endorses Global Coalition for Social Justice; establishes working party for 2025 World Social Summit. UNFCCC Work Programme on Just Transition Pathways operationalized.

Source: Authors own readings

Agreeing with Abram et al. (2022), the concept of just transition still lacks a single, unified theoretical definition, partly due to the long-standing debates surrounding "justice" itself and partly due to the ongoing evolution of theoretical perspectives on transitions. For the purpose of this chapter, the focus will be on "purposive transition" and how it manifested in Albania's post-socialist experience and is now re-emerging in the context of the JGT, informed by these richer, more demanding notions of justice

2.2.Defining Purposive transition

Stemming from Petrov's (2014) analysis of the term "transition" and its widespread use to characterize CEE countries, this type of transformation signaled epochal change while simultaneously unfolding uncertain futures for the affected economies.1 The post-socialist transition in the Western Balkans is what Smith, Stirling, and Berkhout (2005) define as a 'purposive transition'. This is characterized by a deliberate goal pursued from the outset of transformation, accompanied by an explicit set of societal expectations and a heavy reliance on external resources, aid, and political orientation. The Transition Management approach, as outlined by Rotmans, Kemp, and van Asselt (2001), draws significantly from this concept, analyzing, among other things, the role of external stakeholders and resources in initiating and carrying out such transitions.

Petrov (2014) further characterizes the post-socialist purposive transition in CEE countries as 'teleological'. In this view, regime change appears "purposeful, preordained, and therefore predictable, virtually unstoppable, and impelled by a future goal," which serves as the "defined end of the transition process" (p.30).1 However, he also notes that these transitions often did not progress along the pathways or towards the goals defined by Western agencies. Instead, the uncertain futures affecting these economies led to the emergence of varying hybrid political models, irrespective of the paths designated by external actors, which typically emphasized privatization, liberalization, and democratization.

This divergence between intended purpose and actual outcome can be attributed, among other factors, to the fact that the transition itself was often not adequately informed by its wider historical context. It was frequently reduced to a singular, joint model to be followed, regardless of the heterogeneity and idiosyncrasies within the region, or, as in this case, Albania's specific circumstances.1 The experience of Albania's post-socialist transition powerfully illustrates how the intended "purpose" can be significantly reshaped or even subverted by local realities, institutional path dependencies, and societal responses.

It is these contextual socio-cultural and territorial factors—what Carothers (2002) termed "the underlying conditions ... the economic level, political history, institutional legacies, ethnic make-up, sociocultural traditions, or other 'structural' features"—that should be meticulously accounted for when furthering efforts towards any new transition.1 These factors are critically important in defining how a potential new transition, such as the JGT, will unfold within a country. Utilizing the Multi-Level Perspective (MLP) framework, these underlying conditions correspond to the socio-technical landscape in which regimes are embedded and continuously change. They encompass the spatial structure of territories, economic growth patterns, social factors, normative values, environmental challenges, potential disasters, and political dynamics.

Spain's Just Transition Strategy (ETJ), approved in 2019, offers a contemporary example of a state-led "purposive" or "managed" transition. It explicitly links national energy and climate plans (PNIEC) with the ETJ to proactively manage socio-economic impacts, aiming to maximize social benefits and mitigate negative consequences of decarbonization.11 This illustrates a deliberate, goal-oriented approach that relies on strategic planning and anticipates socio-economic disruption, hallmarks of a purposive transition. However, the success of such strategies remains context-dependent.

In Albania, these underlying conditions, coupled with fatigue from a stagnating EU integration process, conflicting narratives stemming from the post-socialist era, dominant-power politics, institutional corruption, and deep territorial disparities, have cultivated a sense of a 'never-ending transition'.1 This "transitions fatigue" can significantly complicate the preordained nature often associated with purposive transitions, as public skepticism and institutional inertia may hinder progress towards externally defined goals.

Nevertheless, Albania's history does not suggest an inherent resistance to change; on the contrary, the country has demonstrated an openness to exploring different political, economic, and social trajectories. What has been consistently missing, rather, is a cohesive governance and policy framework capable of structuring and guiding change in a systemic and strategic manner.1 This absence of a clear governance skeleton has historically hindered Albania's capacity to follow a structured transition path. Unfortunately, similar gaps persist in the case of the Just Green Transition, suggesting that even with a clear "purpose" driven by the EU Green Deal, the actual JGT trajectory in Albania could be unpredictable and heavily shaped by its unique underlying conditions and historical path dependencies, risking further disillusionment if not carefully managed and locally embedded.

2.3.Albania's Post Socialist Transition vis a vie the "new" transition(s)

In the Albanian context, the post-1990 transition from a socialist to a market-driven economy exemplifies a regime shift precipitated by external pressures, including the collapse of socialist states in Eastern Europe and Albania's reintegration into global systems.1 Similarly, the current climate imperative under the Just Green Transition (JGT) represents a landscape-level pressure requiring systemic changes to governance, energy systems, and societal behaviors. A comparative lens offers a panoramic view of both transitions, revealing instructive parallels and crucial distinctions.

2.3.1 A retrospective on Albania's Post Socialist Transition

The collapse of Albania's communist regime marked one of the most dramatic transitions in Eastern Europe. This period of profound systemic change saw the country grapple with the challenges of democratization, economic liberalization, and the reorganization of its social and spatial structures. Albania's transition was characterized by political instability, rapid urbanization, economic hardships, and a significant shift in societal values, all of which left (and still has) a lasting impact on its development trajectory.

On a systemic level, Albania's transition was uniquely complex and distinct from that of most European countries. Emerging from one of the most rigidly centralized and repressive communist regimes in the former Eastern

Bloc, Albania's governance had been shaped by an extreme form of autarky, where decision-making was highly centralized, and citizens were systematically excluded from political processes. For 45 years, Albanians were denied fundamental freedoms of speech, religion, and movement, living under an isolationist regime often compared to present-day North Korea in terms of political and economic seclusion.

The shift to a multi-party democracy was turbulent, marked by political instability, frequent government changes, and contested elections, which further eroded public trust in institutions (Biberaj 1999). The adoption of a new constitution in 1998 was a critical milestone, laying the groundwork for Albania's gradual progress toward European integration. Simultaneously, efforts to decentralize governance sought to empower local authorities and promote regional development. However, these efforts were inconsistently implemented, with local governments lacking the necessary resources and institutional capacity to carry out their responsibilities effectively. Corruption and governance deficits further hindered the state's ability to implement coherent policies, fueling widespread public disillusionment with the transition process.

In the same time, the spatial landscape of Albania underwent one of the most profound changes. Under communism, strict migration controls and centralized planning had shaped the country's urban and rural dynamics. The removal of these controls in the 1990s led to rapid urbanization, with cities like Tirana and Durrës experiencing exponential growth as people migrated in search of better opportunities (Bejko 2015). This population surge strained urban infrastructure and services, leading to the proliferation of informal settlements and unregulated construction. At the same time, rural areas were left behind, experiencing depopulation and neglect. The urban-rural divide widened, as rural regions struggled with inadequate access to infrastructure, education, and healthcare. The lack of coordinated spatial planning and governance further exacerbated these inequalities, leaving Albania with deeply entrenched spatial disparities.

Economically, Albania's transition from a centralized to an open-market economy was abrupt and poorly managed. Privatization and liberalization were implemented rapidly but without proper regulatory frameworks, leading to widespread job losses and economic insecurity. The 1990s saw severe financial instability, with hyperinflation, currency devaluation, and the collapse of pyramid schemes in 1997, which devastated household savings and deepened poverty. The private sector remained weak, while remittances became a crucial economic lifeline. Limited foreign investment, weak institutions, and unclear property rights further hindered sustainable growth, leaving Albania's economy fragile and highly dependent on external support.

However, the 2000s saw modest recovery, driven by sectors such as agriculture and later, services and tourism. Remittances from Albanian migrant workers, particularly those in Greece and Italy, became a critical source of income for many households, highlighting the country's dependence on its diaspora for economic stability.

The social fabric of Albania underwent profound changes during the transition. The shift from a collectivist, state-controlled system to an individualistic, market-driven society disrupted traditional social structures. Rising unemployment, poverty, and inequality created a sense of social fragmentation, while mass emigration transformed the country's demographics. Between 1991 and 2001, an estimated 600,000 Albanians emigrated, primarily to neighboring countries. This exodus included a significant portion of the skilled workforce, leading to a brain drain that hindered Albania's long-term development prospects. While remittances provided short-term economic relief, the loss of human capital presented a critical challenge for the country's future.

Normative values also shifted as Albania embraced Western democratic ideals. However, the rapid modernization often clashed with entrenched patriarchal and rural traditions, creating tension between old and new societal norms. The process of adapting to these changes was slow and uneven, reflecting the complexities of transitioning from one ideological system to another.

As a result of all, the rapid urbanization of the 1990s further exacerbated environmental challenges. Under communism, the emphasis on heavy industry and large-scale agricultural production had left a legacy of environmental degradation. Deforestation, soil erosion, and pollution were widespread issues, particularly in industrial and mining areas. Informal settlements and unregulated construction contributed to waste accumulation, air pollution, and water contamination, particularly in urban centers like Tirana.

Meanwhile, the lack of environmental awareness or policies during the early years of transition meant that these issues were largely ignored.

Only by the 2000s, Albania began adopting environmental protection policies, driven in part by its aspirations for EU membership. These efforts included waste management reforms and the establishment of protected areas. However, implementation and enforcement remained weak, and significant gaps persisted in aligning environmental governance with sustainable development goals.

Additionally, starting with the signing of the Stabilization and Association Agreement with EU- 2006/2007, following with the NATO integration (2009), and in 2014 gaining the EU candidate status, Albania was offered a trajectory for integration into the European Union, a commitment for which the country is still working on. This process, however, again consists of a prescribed list of structural and political reforms (Commission 2018), that despite the financial and technical support provided, only recently has gained a new momentum, with the opening of negotiations for few of the chapters in 2024.

Table 2: Economic Context of Albania: Indicators.

Main Indicators	2023 (E)	2024 (E)	2025 (E)	2026 (E)	2027 (E)
GDP (billions USD)	22.82	26.13	27.99	29.92	31.85
GDP (Constant Prices, Annual % Change)	3.5	3.3	3.4	3.5	3.5
GDP per Capita (USD)	8,299	9,598	10,386	11,211	11,938
General Government Gross Debt (in % of GDP)	59.8	58.3	57.0	56.2	55.5
Inflation Rate (%)	4.8	2.2	2.4	2.6	3.0
Unemployment Rate (% of the Labour Force)	10.7	10.7	10.7	10.7	10.7
Current Account (billions USD)	-0.29	-0.21	-0.28	-0.36	-0.22
Current Account (in % of GDP)	-1.2	-0.8	-1.0	-1.2	-0.7

Source: IMF – World Economic Outlook Database, October 2021

To conclude, Albania's transition has unfolded (and still is) through three distinct yet interconnected phases: the political and ideological shift from a rigid monist system to pluralism and democracy in the 1990s, the economic transformation from a centralized economy to a market-driven system in the 2000s, and the ongoing transition towards European and global integration over the past two decades.

At a global scale, Albania's transformation aligns with the major historical transition shifts of the post-war world: first, the Cold War era (1945–1989), which was dominated by the ideological and security struggle between the USA and the Soviet Union; second, the post-Berlin Wall period (1989–2006), which championed neoliberalism, human rights, and environmental concerns under a USA-led global economic order; and third, the post-2006 global recession era, marked by the decline of liberal interventionism and the rise of digital economies, geopolitical realignments, and increasing global competition between the Western alliance (USA/NATO) and emerging powers such as China and BRICS nations.

Albania's trajectory reflects both the opportunities and contradictions inherent in these transitions. While political pluralism, economic liberalization, and EU integration efforts have set Albania on a progressive path, deep-rooted governance weaknesses, institutional inefficiencies, and socio-economic disparities have hampered its ability to fully capitalize on the benefits of transition. Unlike many post-socialist countries in Central and Eastern Europe, Albania has not undergone a linear or structured transformation, but rather a fragmented and often reactive adaptation to shifting global trends.

As the country now navigates the challenges of sustainable development and green transition, it faces yet another test of its institutional resilience and governance capacity.

2.3.2 Contextualizing the JGT in Albania

While Just Green Transition concept and approaches are embraced at a global level, the process towards this transition in the WBs is progressing at a very slow pace and little is done in regard to societal preparedness for JGT.

In Albania, contextualizing JGT (let aside conceptualization of it) is rather a complex task. Apart from requiring the involvement of several stakeholder and institutions from all countries in the region, both contextualization and conceptualization process is faced with the (i) theoretical gaps that subsist in the definition of basic concepts such as transition and justice, for which we try to navigate in the aforementioned chapter and (ii) lack of awareness in understanding the process it requires or the policy overview specter and the place based empirical evidences such transitions bring to the societal level.

The JGT, both as a concept and as a policy framework, is being introduced in the Balkans via the Green Agenda for the Western Balkan (GAWB). Formalized in 2020 with the Sofia Declaration, the GAWB is the basis for a new growth strategy for the region, embedded in the EU Economic and Investment Plan for the Western Balkans. The same year, during the Berlin Process Summit in Poznań, the WB Leaders (Albania's included) expressed their common willingness and readiness to meaningfully contribute to an ambitious Green Agenda.

This entails the adoption of EU directives and transposition of regulation across policy areas and on a wide range of issues, from climate law, meeting energy efficiency goals, air and water quality standards, to the waste management framework, limiting pollution, increasing circularity, etc. This first step needs to be followed by implementation, leading to 'real', tangible change in all industrial/economic sectors. Despite initial enthusiasm, the Western Balkan countries continue to lag behind the EU in their efforts to combat, mitigate, and adapt to climate change. This shortfall stems not only from inadequate progress in implementing climate actions but also from the absence of a comprehensive, integrated approach that transforms both national and regional policies into climate-sensitive frameworks capable of addressing the multifaceted challenges of environmental sustainability.

Reaching the aforementioned goals cannot be accomplished overnight, as the implementation of such an ambitious agenda comes with multifaceted implications across social, environmental, economic, financial, technological, and even [geo]political dimensions. These complexities present significant challenges both regionally and nationally, primarily rooted in the lack of political commitment to improve or transform policies and insufficient financial resources to support basic services and economic activities, let alone the additional costs required to foster or nourish innovation.

2.4. Emerging Challenges & Opportunities

For countries like Albania, embarking on the Just Green Transition (JGT) is not without significant challenges. Indeed, as continuously argued, it is particularly demanding for a nation still grappling with unaccomplished prior transitions—towards a consolidated democracy, robust governance, full EU integration, and widespread economic prosperity—to envision re-entering a new transition, albeit one with a different meaning and magnitude.

A primary hurdle is a mentality barrier, deeply connected to a stigmatized perception of "political transition." This skepticism stems from both the prolonged duration of past transitions and their often-ambiguous outcomes, which have included hybrid post-authoritarian regimes that diverged from the initially proclaimed objectives of market capitalism and liberal democracy. Over the past few decades, the promises of transitioning to a liberal democracy, a free-market economy, and eventual EU membership sparked high expectations. However, many citizens have become disillusioned by the inadequate performance of implemented economic and social policies and the uncertain future these have created. This situation, as argued in a related Policy Brief 1, has produced a pervasive 'transitions fatigue'. This fatigue manifests as a general sense of skepticism, or even mistrust, towards policies perceived as prescribed by external entities, as well as towards the capacity of the domestic political class to design and implement comprehensive, effective, and place-sensitive policies.

This pre-existing skepticism makes the JGT, another complex and potentially disruptive transition, particularly vulnerable to public resistance or apathy.

Overcoming this fatigue requires exceptional efforts in transparency, genuine participation (embodying procedural justice), and delivering tangible, equitable benefits early on to rebuild trust.

A second critical challenge for just transitions is securing adequate funding and resources and ensuring their fair and just allocation and distribution. The financial burden of the JGT—encompassing investments in green technologies, infrastructure upgrades, reskilling programs, social safety nets for affected communities, and support for economic diversification—is substantial. For Albania, with its limited fiscal space (as can be inferred from its economic indicators 12), meeting these costs domestically is a formidable task. This challenge is compounded by the financial risks inherent in transitions that involve phasing out "sunset" industries, which may lead to stranded assets and significant economic write-downs.3 Consequently, a heavy reliance on external funding, primarily from the EU and international financial institutions, is likely. While such funding is crucial, it can also perpetuate the "purposive transition" dynamic, where external agendas and conditionalities might overshadow local priorities or fail to ensure equitable distribution, thereby undermining the "just" component of the transition if not carefully negotiated and nationally owned.

Furthermore, the JGT will inevitably have significant impacts on workers, communities, and consumers. These arise from the transformation of involved sectors in terms of technologies employed, guiding policies, employment opportunities (both creation and loss), and the affordability of new green services and products. The evolving understanding of "just transition" now explicitly includes a broader array of societal groups beyond the traditional focus on the industrial workforce, such as women, youth, low-income households, and other vulnerable communities. Addressing these diverse impacts requires comprehensive strategies. Serbia's Just Transition Roadmap, for example, details measures for welfare support, extensive reskilling programs, and robust economic diversification plans for its coal-dependent regions, offering concrete examples of how such impacts can be proactively managed. These efforts to secure funding and mitigate negative impacts extend to entire territories, affecting the quality of life across personal and ecological spheres, from basic life enablers to dimensions of human flourishing.

In this challenging context, without significant, internally driven efforts to foster transformation, the Just Green Transition, advanced through the GAWB, risks becoming yet another unfulfilled promise in Albania's long history of transitions. Moreover, the burden of action – or, critically, inaction – could disproportionately fall on the most vulnerable segments of society, exacerbating existing inequalities and creating new ones.

However, addressing these challenges thoughtfully also presents opportunities. Effective and genuine stakeholder engagement, drawing lessons from initiatives like Serbia's extensive dialogue processes or the co-creation models used in Open Government Partnership local action plans, can build crucial trust, foster a sense of ownership, and improve policy design and legitimacy. Successful economic diversification in affected regions, as planned in Serbia, can create new, sustainable livelihoods and resilient local economies. Additionally, the emergence of frontier technologies such as artificial intelligence, advanced robotics, and biotechnology holds potential for sustainable development and green innovation. Yet, this too is a double-edged sword: these technologies could become powerful enablers of a green transition if managed for inclusivity and equitable access, but they also carry the risk of increasing inequalities and creating new digital divides if their deployment is not carefully guided by principles of justice. The key lies in harnessing these opportunities proactively to ensure the JGT is not only green but also genuinely just and contributes to a more resilient and equitable future for Albania.

2.5. Conclusions

The journey towards a Just Green Transition (JGT) in Albania is situated within a complex tapestry of historical legacies, ongoing transformations, and evolving global imperatives. Definitions of JGT vary, but there is widespread recognition of the importance of context-specific analysis and strategies. Today, "just transition" generally refers to strategies, policies, or measures designed to ensure that no one is left behind or pushed behind in the shift to low-carbon and environmentally sustainable economies and societies.

This concept, with origins in trade union activism focused on job losses from environmental regulations, has expanded significantly. As more countries and a broader range of stakeholders engage with the challenge, the definition now often incorporates diverse dimensions of justice—distributive, procedural, and even restorative

or transformative—and addresses impacts on a wide array of social groups beyond the workforce.1 The ILO's 2015 Guidelines defined just transition as "greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind," emphasizing social dialogue, rights at work, gender equality, social protection, skills development, and international cooperation.1 Approaches now vary from status quo compensation to deeper transformations of political and economic systems aimed at correcting historical inequities.

Landing the narrative of a "new" transition in a country like Albania, which has been subject to several profound and often disruptive transitions throughout its recent history with questionable levels of success, remains a key concern. In these circumstances, the term "Just Green Transition" is, so far, often used as a buzzword, without fully generating the necessary societal awareness of the scale and transformative nature it implies.

The post-socialist transition, marked by abrupt shifts in governance, economy, and societal norms, left Albania grappling with systemic challenges, including persistent governance deficits, deep-seated social inequalities, and significant environmental degradation. These challenges have forged a legacy that continues to shape the country's capacity to undertake new, large-scale transitions. The JGT, much like the transitions that preceded it, is not merely a technical or economic transformation—it is a systemic, cross-sectoral, and profoundly societal process. However, unlike past transitions, the JGT carries the added urgency of addressing climate change and the imperative of achieving sustainability in a manner that is explicitly just and equitable. The enriched theoretical understanding of transitions, including critiques of the Multi-Level Perspective that call for greater attention to socio-political agency and multi-level governance, further underscores the complexity of steering such change.

At its core, the JGT represents both a significant opportunity and a critical test of Albania's resilience and readiness to embrace transformative change. The lessons from the post-socialist era—particularly the crucial importance of participatory governance, equitable policy frameworks, and robust, accountable institutional capacity—offer valuable insights for navigating this new transition. However, these lessons also highlight persistent risks, such as political inertia, a lack of societal preparedness exacerbated by "transitions fatigue," and the uneven distribution of resources and opportunities. Albania faces a "double challenge": the universal technical and economic hurdles of decarbonization compounded by the profound contextual difficulty of implementing such changes within a legacy of weak governance and societal mistrust.

For Albania, the success of the JGT will hinge on its ability to balance ambitious environmental goals, largely driven by the European Union's Green Agenda for the Western Balkans (GAWB), with the socio-economic realities of its population. This requires not only adopting EU directives but, more importantly, tailoring them to the country's unique context, learning from both its own past and the experiences of other nations in transition. The emphasis must be on fostering inclusive policymaking, strengthening institutions from the ground up, and bridging the urban-rural and other socio-spatial divides to ensure that no community is left behind.

Moreover, the concept of "justice" in the JGT must be operationalized beyond rhetorical commitments. It must translate into tangible actions that address existing inequalities and prevent new forms of exclusion. This involves providing targeted support to vulnerable groups, investing in education and awareness to build societal readiness, and creating robust mechanisms for meaningful stakeholder participation in all stages of decision-making processes.1 The forthcoming requirement for countries to detail their just transition strategies in their Nationally Determined Contributions (NDCs) by 2025 presents a critical opportunity for Albania to articulate a comprehensive, time-bound, and genuinely inclusive plan.

As this chapter has demonstrated, the JGT represents a critical juncture for Albania. It is an opportunity not only to align with global sustainability goals but also to redefine its development trajectory in a way that prioritizes environmental stewardship, social equity, and economic resilience. However, achieving this vision will require a concerted, coherent effort across all levels of governance, active engagement from civil society, and effective international cooperation that respects national ownership and context.

In conclusion, while Albania's journey toward a Just Green Transition is fraught with challenges, it also holds the promise of a more sustainable and equitable future. This transition must be understood not only as a national process but also within the broader framework of global climate justice and the principle of common

but differentiated responsibilities and respective capabilities, a point underscored by recent international discussions.1 Unlike high-income countries, many middle- and low-income nations, including Albania, grapple with high poverty rates, informal labor markets, limited institutional capacity, and restricted fiscal space, making the balance between economic stability, social equity, and environmental commitments particularly complex.

Therefore, the JGT should not be reduced to a mere technical exercise or a rhetorical commitment; it must translate into concrete measures that build resilience, empower local economies, and ensure social inclusion. Learning from past transitions, Albania must focus on creating sustainable economic alternatives, investing strategically in education and skills development aligned with future needs, and establishing transparent and effective mechanisms for meaningful stakeholder engagement. Further research is warranted on several fronts: exploring the political economy of JGT in contexts of "transitions fatigue"; conducting comparative analyses of JGT implementation in post-socialist Balkan states, focusing on governance models and stakeholder participation; assessing the effectiveness of different JGT policy approaches (from status quo to transformative) in specific Albanian sectors; and examining the role of frontier technologies in Albania's JGT, particularly their potential benefits and risks for equity. Only through a comprehensive, context-sensitive, nationally owned, and globally informed approach can Albania navigate its Just Green Transition successfully, ensuring that it does not become yet another unfinished transformation in its complex transition history.

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Redeveloping military land into affordable housing through a public-public partnership. The case of Valladolid's La Rubia barracks

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Abstract
This study examines the complex challenges inherent in the public-public partnership established by the Spanish government in 2023 between SEPES and the Ministry of Defence. The primary objective of this partnership is to repurpose decommissioned military sites for affordable housing, thereby fostering socially equitable urban regeneration. The transformation of these areas would necessitate enabling specific institutional aspects of planning governance (i.e. the rules, laws, and procedural requirements), as well as the possibilities opened by community practices and actors (co-)operating within these structural settings. By scrutinise the case of Valladolid's La Rubia barracks, the research uncovers the complex interplay between the stakeholders involved if ways forward are to be found in challenging the institutional capacity to achieve the public interest.

Keywords: urban regeneration; urban governance; institutional capacity; public interest; land-use planning.

Introduction

In recent decades, the progressive demilitarisation of certain territories, including Spain, has resulted in a significant amount of land left underused or abandoned by the Ministry of Defence (MoD). These include different kinds of facilities (e.g., barracks, batteries, manoeuvre fields, and warehouses) spread across the territory, located in urban, peripheral and non-urban sectors, so their management has become a subject of increasing debate in the fields of territorial planning, urban sustainability and democratic governance (Touchton and Ashley, 2019). Due to the difficulties tied to the redevelopment of such land, often conceptualised as specific type of brownfields (Bednář et al., 2024), the institutional capacity of performing appropriate solutions for enabling urban regeneration processes plays a remarkable role to foster appropriate sustainable urban development (Ural & Severcan, 2022).

A solution for triggering public benefits from disused military land and unlock many initiatives currently in stand-by, the Spanish Government launched in May 2023 an innovative public-public partnership (Ministerio de Transportes, Movilidad y Agenda Urbana, 2023a). It regards the collaboration between two state entities, SEPES[1] and the MoD, for devoting currently abandoned military facilities for residential use, particularly aimed to increasing the presence of affordable housing across the country[2]. The initiative encompasses the redevelopment of 8.25-million-m^2 50 MoD-owned assets, facilitating the construction of 19,876 affordable housing units in 34 municipalities within 15 of Spain's 17 Autonomous Communities (Figure 1), with an estimated public investment of €620 million. This project aligns with the broader state-led "Affordable Rental Housing Plan," which seeks to utilize public land for social housing development, ensuring equitable access to adequate housing as enshrined in the Article 47 of the Spanish Constitution[3]. The implementation of this specific public-public partnership entails the transfer of MoD land to SEPES, which is responsible for enabling participatory and inclusive land readjustment while integrating private-sector stakeholders into the redevelopment process.

1 SEPES is the State Public Land Entity, Entidad Estatal de Suelo in Spanish, was launched in 1965 and it currently depends on the Ministry of Housing and Urban Agenda.

2 This partnership, in turn, derived from the 2022 agreement between MITMA and SEPES to promote a national plan for affordable or social rental housing named "Affordable Rental Housing Scheme (Plan de viviendas para el alquiler asequible) (Ministerio de Transportes, Movilidad y Agenda Urbana, 2022).

3 Article 47 states "All Spaniards have the right to enjoy decent and adequate housing. The public authorities shall promote the necessary conditions and establish appropriate standards in order to make this right effective, regulating land use in accordance with the general interest in order to prevent speculation. The community shall have a share in the benefits accruing from the town-planning policies of public bodies" (Senado de España, 2024).

Successively, private investors are predicted to intervene to implement the project within the planning guidelines established for the former military land.

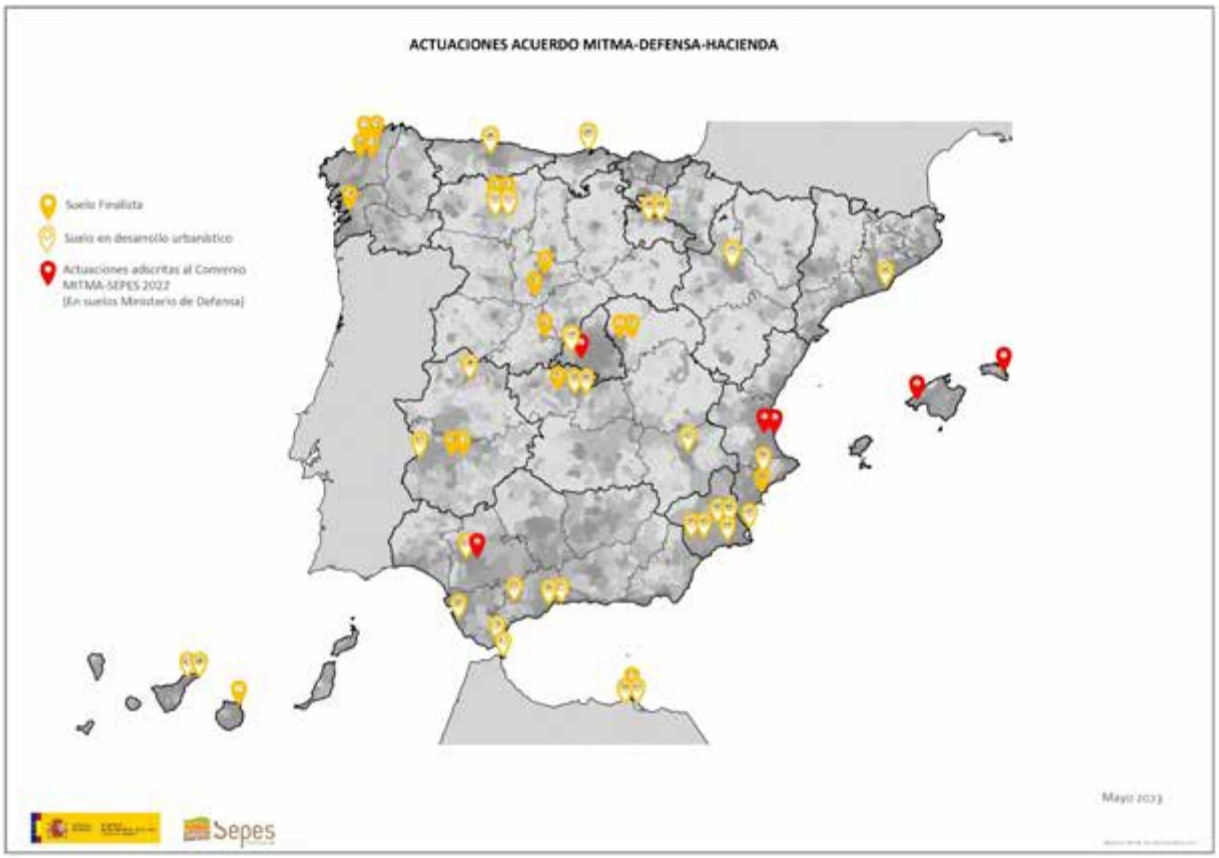

Figure 1. The map of the (*suelo finalista* is "land ready for urban development", *suelo en desarrollo urbanístico* is "land with ongoing urban development works", and *actuaciones adscritas al Convenio MITMA-SEPES 2022* corresponds to actions tied to the 2022 MITMA-SEPES agreement). Source: Ministerio de Transportes, Movilidad y Agenda Urbana (2023b).

This partnership constitutes a novel and paradigmatic example of how institutional capacity and the public interest can –and should– be articulated in the management of state assets, especially for the abandoned land that can be repurposed into sustainable and socially equitable housing solutions. This is even more urgent in the context of mounting territorial imbalances across Spain (Adalet McGowan and San Millán, 2019), along with real estate pressures and widespread challenges to accessing housing (Bonshoms-Guzmán, 2023).

In this context, both SEPES and the MoD occupy a position of considerable influence within the state apparatus, as they are equipped with legal, technical and financial resources that enable them to intervene in the territory with a strategic planning logic. Nevertheless, this capacity is neither uniform nor free of tensions, as it operates within a complex legal framework and in an ecosystem of actors, including local administrations, autonomous communities, private promoters and social entities, with diverse and sometimes conflicting interests. For instance, After the Spanish Ministry of Transport, Mobility, and Urban Agenda (MITMA) converted into the Ministry of Housing and Urban Agenda (*Ministerio de Vivienda y Agenda Urbana* in Spanish, MIVAU) in 2023, SEPES underwent a reorganisation process to become the State Public Land and Affordable Housing Entity focused on converting unused public land into public housing stock, which is still ongoing (SEPES, 2025). The consequence of this long-standing process is the delay in the implementation of the property transfer of the military land, thus undermining urban governance capacity (Healey, 1998).

The institutional capacity and the achievement of public interest in the conversion of military land into affordable housing

The 'institutional capacity' –i.e. the capacity of public administrations to effectively manage resources, coordinate actors and plan for the long term land-use of territories– has been identified as a determining factor in the success or failure for achieving the public interest in the conversion of military land to civilian uses (Ponzini and Vani, 2014). In Spain, this capacity has been affected by various structural factors, including the fragmentation of powers between administrations, the rigidity of regulations on state property and urban planning, and the absence of mechanisms for citizen participation in decisions regarding the utilisation of these lands after the military abandonment (Camerin and Córdoba Hernández, 2023b; De las Rivas Sanz, 2023).

One of the challenges of the institutional capacity is defining what 'public interest' is (Cassinelli, 1958) and this problem lies at the core of planning theories, addressing the fundamental question of the purpose and function of planning (Mazza, 1990: 48). However, the notion of the public interest is challenging to define (Moroni, 2004). Alongside the often interchangeably-used concepts of 'public good' (Deneulin and Townsend, 2007) and 'common good' (Mansbridge, 2013) the public interest can be understood as an essentially contested concept, "vague, imprecise and open to political manipulation" (Jade, 2017: 2).

By translating this to the real of military land to convert into new civilian uses, the public interest is thus manifested in the need to ensure that the redevelopment of military facilities responds to collective objectives, such as the provision of public equipment and services, the creation of affordable housing, the protection of the environment or the promotion of cultural and social activities. However, as demonstrated at both national and international level, a mercantile logic has been prioritised in these operations, driven by the search for fiscal profitability or market-oriented real estate operations (Christophers, 2018; Adisson and Artioli, 2020). This orientation has given rise to tensions with local communities, particularly in instances where opportunities to address social needs have been overlooked or spaces of high strategic and symbolic value have been privatised (Camerin, 2021).

These tensions are also at the centre of the debate between the supposed public/private dichotomy on temporalities, according to which the private sector's short-termism hinders public policy delivery, which should be all about long-term goals (Noring, 2019). However, despite the long-term goals of politicians in democratic regimes, it is important to acknowledge that these politicians are also constrained by the need to focus on short-term political goals. Such shortsighted behaviour and susceptibility to influences that go against long-term interests of the society often exacerbate the process associated with urban developments, whose process encompasses the timely execution of key tasks, including the endorsement of contracts, the initiation of projects, and the attainment of significant milestones (Hodge and Greve, 2019). This is imperative to ensure the timely delivery of planning-related programmes and the minimisation of procedural delays, which in turn will facilitate the mobilisation of the electoral support.

This is not only matter of political support, because it is pivotal to attract the private sector to the provision and management of affordable housing with an adequate balance of interests with the public sector (Canelas and Alves, 2024). This is true also for the case study of La Rubia barracks as the SEPES-Mod partnership targets the land ownership, but the redevelopment will involve private stakeholders, who will be responsible for the delivery of the project. As observed by Granath Hansson (2019), to guarantee a functional relationship, it is essential that adequate risk-return is offered to private actors to converge public and private interests, which significantly impacts delivery capacity. However, perceptions of risk-return vary due to several internal and external factors, such as the relationship between the public authorities involved and their continuous reorganisation (Adams and Tiesdell, 2010). Another salient issue is the correlation between policy stability and the attraction of private investment. The positive correlation that has been identified is partly explained by reasons related to investment planning, as well as by the upfront costs of learning to navigate new regulatory and fiscal frameworks (Raco, Livingstone and Durrant, 2019).

Methodology

The paper adopts a case study methodology to examine the changes occurred after the launch of the SEPES-MoD partnership in 2023 by the Spanish Government for the provision and management of affordable housing in the case of La Rubia barracks in Valladolid. We choose this case for three reasons. Firstly, although its innovative governance arrangement, that of a partnership between two public entities, this partnership has generated poor interest in the national and international literature. The analysis of this specificity can be relevant to understand the ways this partnership work and its impact on a specific case study. Secondly, the level of interest and

controversy this partnership generated in the public arena, as the state-led decision that may enter in conflict with Valladolid's spatial plan and the already settled agreements or procedures involved the redevelopment of the military land. Eventually, for reasons to do with data access and to keep updating the situation about La Rubia barracks after an initial attempt to approach this case study (Camerin and Córdoba Hernández, 2023a). A comprehensive understanding of the various objectives and timelines of the different stakeholders, and the manner in which these were influenced by each other, offers invaluable insights that transcend local idiosyncrasies, particularly with regard to institutional capacity, the concept of public interest, and the objectives and timelines of key stakeholders. The insights derived from this case study have the potential to inform the discourse surrounding the governance converting abandoned military land into affordable housing, thereby contributing to the enhancement of affordable housing delivery practices in the case of La Rubia and other contexts.

This paper draws on the semi-structured interview conducted in presence between January and April 2025 with two spokespersons of each Valladolid City Council, SEPES, Senate and the local grassroots association "La Rubia", culminated with the roundtable "Barracks in transformation: an opportunity for the La Rubia neighbourhood" (*Cuarteles en trasformación: una oportunidad para el barrio de La Rubia* in Spanish) held at the University of Valladolid on 24th April 2025. Additionally, through desk-based research, we identified relevant legislation and other policy documents (e.g., the 2020 general master plan, the so-called *Plan General de Ordenación Urbana* in Spanish; PGOU), including meetings from the executive and deliberative Valladolid City Council, and other material from media outputs. We identified our research participants by targeting the main bodies involved in the management of the barracks at state and local level, along with local citizens. This constitutes the basis for the interpretation of the redevelopment process before and after the launch of the SEPES-MoD partnership in 2023 to identify the impacts it has had on La Rubia barracks transformation. In particular, we categorised the information acquired on the case study in five main themes. They are the following:

- General characteristics of the barracks. Here not only the specific features of the case study are provided, but also the abandonment process the current state of the plot, the buildability, as well as the triggering factors of the redevelopment processes, such as their respective locations in the real estate market;

- Conflicts between the actors involved, including the owner (i.e. the MoD), the City Council and the citizens, even their different interests regarding new uses;

- Definition of the redevelopment costs for the public for the municipal coffers and/or derived from its environmental rehabilitation;

- Temporal evolution of the disposal process according to well-defined stages, agreed with the interested parties and framed in the context of the real estate market.

- What has happened after the launching of the SEPES-MoD partnership for converting La Rubia barracks into new affordable housing compounds.

General characteristics

La Rubia barracks, built in 1945, is situated in a predominantly residential urban sector of Valladolid, between the railway line and the Paseo de Zorrilla Avenue, in close proximity to the city's southern inner ring road VA-20 and the Vallsur shopping centre. The barracks are located within an area characterised by high-density development, with a density of 109.80 dwellings per hectare, with two primary categories of housing: closed blocks and open buildings. The neighbourhood population reaches 8,716 individuals with an average per capita income of €16,341, as reported by the National Statistics Institute (INE) for the year 2021.

In 2007, there was speculation that the barracks would be closed in 2011 and that between 500 and 700 dwellings would be built, of which 30% would be designated as social housing (Álvarez, 2007; Álvarez & Alrrúe, 2011). However, the military personnel belonging to the *Agrupación de Apoyo Logístico* nº 61 Operational Logistics Support Unit officially abandoned the barracks only in December 2014, being relocated to the military base "El Empecinado" in the surrounding municipality of Santovenia de Pisuerga. This displacement occurred in accordance with

the provisions of the PREPIDEF[4], which expected to benefit the military spending by saving €490,243 per year (Ministerio de Defensa, 2013b: 45). The situation of abandonment has persisted until the present day, resulting in the degradation of the built and open spaces within the military enclosure (Figure 2).

Figure 2. A view of the inside spaces of the military enclosure from outside. Source: photo by Federico Camerin (2025).

The surface area of the former barracks (106,866 m^2) corresponds to approximately one third of that of La Rubia neighbourhood (366,475 m^2). According to the current Valladolid's spatial plan approved in 2020 (Comunidad Autónoma de Castilla y León, 2020, pp. 2445-2447), the strategic importance of this urban void in La Rubia neighbourhood makes it a significant opportunity for territorial stitching on a city scale. In this particular instance, the barracks are located within the Urban Unit[5] no. 30 "La Rubia" (Comunidad Autónoma de Castilla y León, 2020: 19223-19226) and are conceived as the proper opportunity to improving the area to connect two relevant road axis currently separated by the disused military land, i.e. Paseo de Zorrilla and Carretera de Rueda. According to the 2020 PGOU, this strategic positioning facilitates also the introduction of new residential uses, tertiary activities and facilities, thereby generating a novel urban fabric comprising roads and pedestrian and coexistence roads.

4 The MoD set up in May 2013 the "Proposal for the rationalisation and efficient use of MoD estate" (PREPIDEF) to gradually abandon 163 sites in two steps, between 2014 and 2017 and 2018–2024 (Comisión de Defensa, 2013).

5 According to Article 85 of the Regional Planning Regulations (Reglamento de Urbanismo de Castilla y León in Spanish; Comunidad de Castilla y León, 2004), the 2020 PGOU incorporates the Urban Units as an instrument for urban regeneration. Urban Units permit a detailed approach to each part of the consolidated city, quantitatively and qualitatively specifying its urban planning parameters. By doing so, this facilitates the evaluation of actions that are executed in accordance with the PGOU, or that are proposed as modifications to it in the future.

Land-use planning and conflicts

There has been a notable change of opinion on the future of the old barracks on the part of the military that have accepted the unilateral decision taken by the City Council to assign a new use to the military land in the 2020 PGOU without a process of public participation nor with the residents or the MoD. Yet, there has been no demonstrations, protests or occupations of the area by citizens.

The 2020 PGOU classified the barracks as *suelo urbano no consolidado* (unconsolidated urban land) "SE(r).30.01 Acuartelamiento La Rubia" and as a *sector con ordenación remitida* (sector with remitted development) (Figure 3). This means that the 2020 PGOU establishes the overarching planning determinations (e.g., buildability and number of housing units), but the specific details remain to be delineated by a detailed plan, such as a special plan (*plan especial de ordenación urbana*) or a detailed study (*estudio de detalle*).

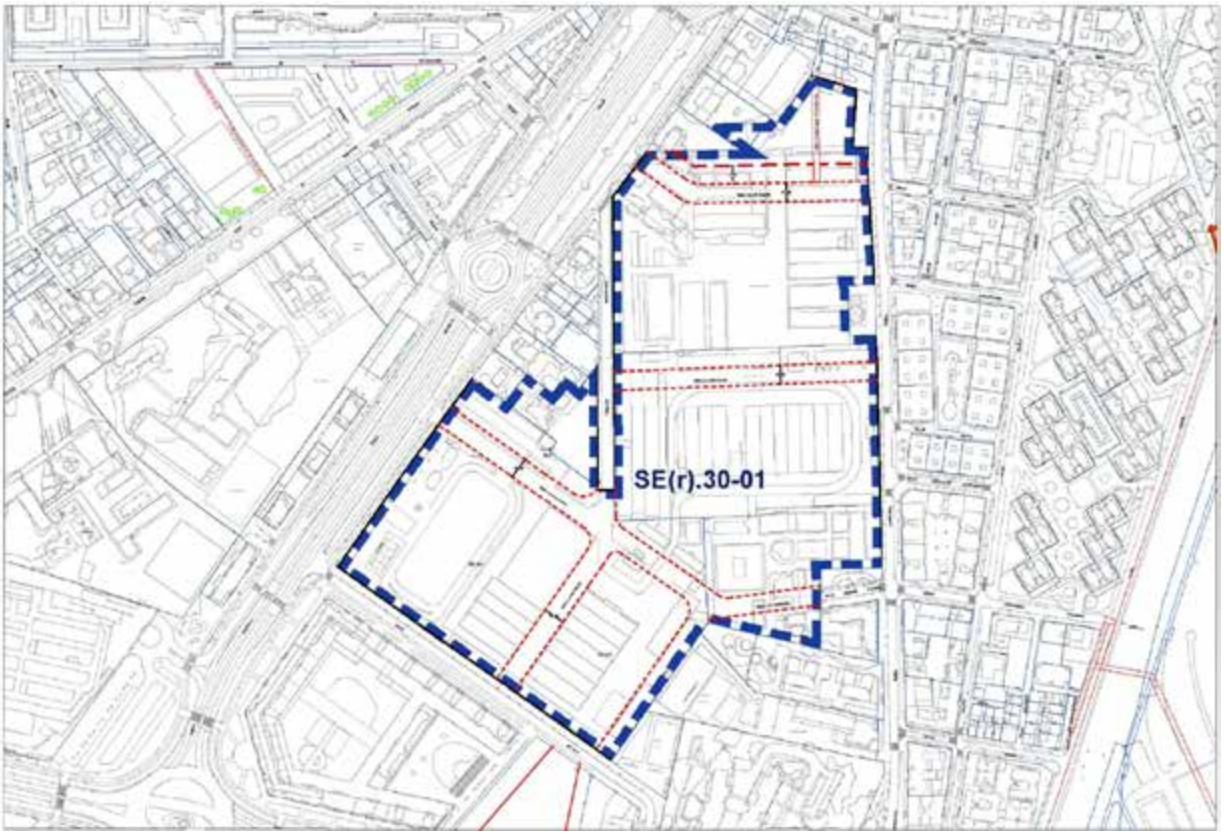

Figure 3. An image of the SE(r).30.01 Acuartelamiento La Rubia. Source: Comunidad Autónoma de Castilla y León (2020: 20456).

The objectives and criteria outlined in the 2020 PGOU included the establishment of new roads and pedestrian zones, with the intention of fostering social cohesion through mixed uses, mostly residential and productive. Three are the main contents. Firstly, the spatial plan establishes a new buildability of 64,119.53 m^3, of which 50% would be used for new 338 housing units. Of this amount, 70% will be designated as free housing (22,441.83 m^3), while the remaining 30% will be allocated for affordable housing (9,617.93 m^3). The remaining buildability (25,647.81 m^3) is earmarked for tertiary uses, including commercial and office spaces (Ministerio de Defensa, 2022, p. 14). Secondly, the developer obligations to transfer a part of the barracks to the City Council for local services (*cesiones mínimas de suelo para sistemas locales* in Spanish). A total of 6,411.95 m^2 of land would be devoted to a new equipment or facility, and 9,617.93-m^2 land to new uses –whether for additional housing or for other purposes– yet to be delineated by the local administration.[6] Eventually, the developer obligations in terms of land transfer for general benefits at city level (*sistemas generales exteriores, adscritos al sector* in Spanish) reaches 60,319.40 m^2 to locate not within the barracks' surroundings,

6 According to the Regional Planning Regulations, the total amount of new open public spaces will be at least 14 m^2/100 m^3 (art. 105), and 10 m^2/100 m^3 (art. 106) for public facilities.

but rather assigned to the "EL 05/24 Riberas del Pisuerga-Soto de Medinilla-Michelín" sector.

The MoD initially rejected these guidelines in May 2019 as the buildability was considered too low (Comunidad Autónoma de Castilla y León, 2020, 18684) but eventually accepted it in June 2020 (Comunidad Autónoma de Castilla y León, 2021, 15953) and, in turn, provides for a period of eight years to establish the detailed planning, i.e. 2028.

Redevelopment costs definition
The MoD is still to provide an adequate detailed analysis with regard to the current state of the buildings and open spaces inside the enclosure of La Rubia barracks (Ministerio de Defensa, 2022b, 4-5). The MoD's report provides unclear indications regarding the presence of polluting elements from an environmental point of view and the definition of rehabilitation costs of existing buildings. Furthermore, no study on the potential opportunities for preserving existing buildings has been considered, nor an overall analysis of the redevelopment costs.

With regard to the presence of pollution, the barracks contain buildings potentially at risk, although not quantified in terms of surface area. These include a petrol station with two buried fuel tanks, two elevated water tanks, one buried water tank, seven buried fuel tanks (including those of the petrol station), a semi-buried shooting gallery for testing with a single shooter's post, and some of the roofs of the buildings are made of asbestos-containing fibre cement slabs.

With regard to the presence of buildings earmarked for preservation, none of the existing buildings, which collectively occupy a surface area of 42,434 m^2 and range in height from one to two floors, are not listed nor considered to be protected from demolition. Many of these buildings are in a state of disrepair, necessitating comprehensive rehabilitation measures, unless their demolition is deemed the more feasible option. The 2020 PGOU proposes the demolition of these structures for the purpose of facilitating the redevelopment of the sector. Moreover, the barracks is also surrounded by a concrete block wall, which is to be demolished in order to facilitate the permeability with the urban fabric. The process of obsolescence of the buildings and shortening of their life cycle has not yet reached the point of being declared a ruin, and the area is not yet affected by notable processes of renaturalisation.

Temporal evolution
The absence of a definitive and collaboratively designed temporary programme can be attributed to the speculative approach adopted by the MoD, whose strategic intentions were evident in the retention of land that had become redundant for military purposes. The owner, in fact, waited for the City Council to approve a land-use change of the area in the new spatial plan to provide the military with the highest possible financial returns. The objective of maximising profits was made clear since October 2019, when the military organised a meeting with local businessmen to present the ways in which La Rubia could be exploited (No Author, 2019). The primary option discussed was a direct sale in the real estate market, with the secondary options of temporary assignment or rental due to the high payment that the potential buyer would have to face in a not particularly positive period for the real estate market.

However, the main challenge confronting the operation appears to be the absence of interest on the part of private entities and the paucity of public funding to develop the real estate project, as it is anticipated to be less lucrative than the one proposed in the initial conversion advances of a decade ago. As a matter of fact, from the supposed 500-700 new housing units, the 2020 PGOU established the building of just 338 dwellings. This lack of interest is being confirmed by the failure of the first auctions promoted by the MoD, published on 5 July 2022, with a bidding price of €8,280,948.74 (Ministerio de Defensa, 2022a: 33151). By the stipulated deadline of 7 September, no tenders had submitted for the barracks (Arrúe, 2022), consequently resulting in a decrease of the bidding price for the subsequent auction to €7,452,853.87.

The SEPES-MoD partnership and how it affects the redevelopment of La Rubia barracks. What's next?
In mid-June 2023 there has been various novelties having an impact on the redevelopment process. Firstly, on 6th June 2023, the MoD received a request for a direct sale from a private individual equivalent to the amount set in the second auction. In the subsequent days, on 23rd June, the applicant was notified that the transaction could not be executed because the property was included in the agreement of the Council of Ministers of 9th May 2023 for its

sale to SEPES (Estrada, 2025). Secondly, following the establishment of the new Spanish government in July 2023, the MIVAU was formed and SEPES, as it depends directly on MIVAU, has since been in a process of reconfiguring its teams and strategic priorities. Thirdly, in May 2023 the new grassroots association "La Rubia" (*Asociación vecinal La Rubia* in Spanish) was constituted. The impetus for this initiative stemmed from the necessity to revitalise the neighbourhood, necessitating the mobilisation of resources in response to unmet urban and environmental requirements, such as those related to the former military barracks.

The situation remained static until December 2024, at which point the Valladolid City Council passed a motion requesting that the central government expedite the redevelopment process (PP Ayuntamiento de Valladolid, 2024). Concurrently, the Spanish government initiated the Omnibus decree measures, encompassing Article 89 on the transfer of public assets (including military ones) to SEPES for the development of its policy on affordable housing (Jefatura del Estado, 2024: 179321-179322). However, this decree was eventually not approved, and the SEPES did not become the owner of La Rubia barracks, which still remains the property of the MoD.

In the first half of 2025, SEPES, Valladolid City Council, and La Rubia grassroots association started a dialogue based on the academic interest raised within the local Technical School of Architecture (*Escuela Técnica Superior de Arquitectura de Valladolid*, ETSAVA) belonging to the University of Valladolid, specifically in the subject "Urban rehabilitation and heritage" (*Rehabilitación urbana y patrimonio* in Spanish). The main goal of the subject has been developing specific urban policies to improve La Rubia neighbourdhood, including the former barracks. The roundtable entitled "Barracks in transformation: an opportunity for the La Rubia neighbourhood" (Figures 4 and 5) took place at ETSAV in April 2025 with the aim of discussing the current state of affairs (Alonso, 2025). In this instance, the representatives of the public authorities involved (State Housing Commission and Valladolid City Council) converged on the idea that the redevelopment of the barracks should contribute to a state-led social housing policy, and therefore to the construction of affordable housing in this area (Estrada, 2025).

As a result of the discussion, the public authorities' spokespersons agreed on the next two steps for initiating the redevelopment. The first one regards the free-of-charge property transfer of La Rubia barracks to SEPES once the internal reorganisation of the latter is completed. Only when the SEPES-MoD partnership will be executed, SEPES will be entrusted with the necessary competences to carry out the transformation process. However, this is not sufficient as the redevelopment process should also be detailed and even modified according to the fact that the 2020 PGOU can increase the urban density of the new city fragment by establishing a higher provision of housing units. Consequently, the second step is the establishment of a dialogue with the various parties involved as indispensable action for the formulation of the detailed guidelines of the redevelopment. This can take the form of an open participatory process with the local citizens to update the existing guidelines and the subsequent modification of the local spatial plan that includes the opportunity to increase the dwellings up to 600 units. This measure is expected to enhance the desirability of the real estate operation for private developers, but also to extend the benefits in terms of provision of affordable housing.

Figure 4. The poster of the roundtable *Cuarteles en trasformación: una oportunidad para el barrio de La Rubia*. Source: University of Valladolid (2025)

Figure 5. The speakers of the roundtable during the event of April 2025. Source: La Rubia grassroots association (2025).

Conclusion: How does the institutional capacity evolve towards the public interest?

The purpose of this paper is to contribute to the ongoing debates surrounding the potential of a new kind of partnership to facilitate the delivery of affordable housing. In order to achieve this objective, the present study has two overarching goals. Firstly, to uncover the rationale behind the utilisation of the SEPES-MoD partnership for the provision of affordable housing, and the operational requirements for such partnerships, including in terms of spatial planning. Secondly, to pinpoint the intertwine between the various stakeholders involved and to understand whether the 2023 partnership has been a game changer in unblocking the multi-decade abandonment of the La Rubia barracks.

The novelty of the SEPES-MoD partnership regards the property transfer from one public body (MoD) to another one (SEPES), so the intervention the private sector is going to be entrusted with the redevelopment and financing of public infrastructures through capturing land value increases in such practice (Alterman and Kayden, 1988). When it comes to providing affordable housing, one contentious issue is who is best qualified to do so, with debates often falling into three broad categories: public sector (Hodkinson, 2019), private sector (Ball, 2009), or partnership provision (Benedict et al., 2022). In the context of the SEPES-MoD partnership, the institutional capacity demands that the public sector assumes the role of supervisor. This necessitates a significant degree of freedom for action, but this action needs effectiveness (Peters et al., 2018). This means that having the capacities is not equivalent to executing them or making use of them, because the Spanish government should be capable of creating efficient and effective public policies to address the problem in question.

Cases such as the former La Rubia barracks demonstrate the lack of effectiveness in the institutional capacity to achieve the redevelopment of this abandoned site because the introduction of the SEPES-MoD partnership has blocked the previous procedure, but it has consequently opened new paths towards reaching a more appropriate public interest. The case study analysis shows also the diversity of intervention models that illustrate both the potential and the limitations of the current system of public asset management, including former military land. It is evident that, following a period of several years characterised by dialogue not always transparent to the general public, the local administration has successfully negotiated with the MoD in order to obtain its support for the future new utilisation of La Rubia barracks in the 2020 PGOU. The new local spatial plan established the incorporation of this space into its neighbourhood by an urban regeneration intervention, although it was established with no proper citizens' involvement. In fact, the absence of proactive planning in the SEPES-MoD partnership has resulted in opaque and non-participatory processes that have apparently obscured the public interest. The case of La Rubia is significant because it demonstrates the disconnection between knowledge and policy, between planning and management, insofar as a planning and social "window of opportunity" is not fulfilled. This failure is hidden among abstract debates and bureaucratic illusions, without a coherent and well-founded environment.

In light of these considerations, there is an urgent need to enhance institutional capacity for the management of disused military land. This should be achieved through the implementation of more flexible regulatory frameworks, the establishment of inter-administrative collaboration mechanisms, and, most importantly, the introduction of tools that ensure transparency and citizen participation. The urban regeneration potentially triggered by the redevelopment of these kinds of spaces should be guided by an integral perspective that considers not only economic profitability, but also social and territorial sustainability. Rethinking the future of La Rubia neighbourhood entails the assumption that military land, far from being an exclusively technical or functional legacy, is part of the collective imagination and can become a key resource for the articulation of new urban centralities at the service of the common good.

To conclude, this research constitutes another step towards a better understanding of how SEPES can expand its capacity to act in the field of affordable housing in connection with previous situations characterised by the challenging intertwine between institutional capacity and public interests materialised through the guidelines of spatial planning tools. Further research should focus on the implementation of SEPES-MoD partnership in the other cases across Spain. This will be instrumental in continuing this examination of the fundamental roles and values guiding both the private and public sectors involved in each cases, as well as the nature of partnerships established to implement the planning guidelines for triggering urban regeneration processes.

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CRediT authorship contribution statement:
- Federico Camerin: Formal Analysis; Funding Acquisition (equal); Investigation; Methodology; Project Administration; Visualisation; Writing – Original Draft Preparation (equal); Writing – Review & Editing (equal);

- Juan Luis de las Rivas Sanz: Conceptualisation; Data Curation; Software; Resources; Supervision; Validation; Writing – Original Draft Preparation (equal); Writing – Review & Editing (equal).

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Track 5

ENVIRONMENT AND CLIMATE

Inspiration for Pathways towards Multi-Scale Green Urban Regeneration and Planning Construction under Dual Carbon Goals

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Abstract
Facing climate crises, integrating green low-carbon strategies into urban regeneration proves crucial for carbon neutrality. This study examines multi-scale planning across urban agglomerations, cities, and communities through international case comparisons (US, UK, Germany, China, Japan, South Korea). Key insights: (1) Planning systems need tiered approaches - coordinating regional resources at agglomeration level, optimizing city spatial structures, and applying adaptable carbon-reduction measures locally. (2) Technology systems require ecological-industrial synergy through green corridors/renewables regionally, while focusing on microclimate improvement and green buildings locally. (3) Implementation demands multi-actor collaboration: expert committees for intercity coordination, standardised city-level frameworks, and community initiatives engaging residents and social capital. The research illustrates spatial planning's role in harmonizing economic development with ecological sustainability across spatial scales.

Keywords: Carbon peaking and neutrality goals; Multiple spatial scales; Green low-carbon regenerations; Urban planning pathways

1. Introduction

In the context of intensifying global climate change, cities, major contributors to carbon emissions (IPCC, 2022), have prioritised ecological governance and low-carbon transitions as essential pathways to achieving the "Dual Carbon" objectives of carbon peaking and neutrality. Data from UN-Habitat (2021) indicates that urban regions consume 78% of the world's energy and produce more than 60% of greenhouse gas emissions. China, undergoing one of the globe's most rapid urbanization processes, has witnessed its built-up urban area grow by over 200% since 2000 (National Bureau of Statistics, 2021). However, this expansion has amplified issues such as energy dependence, ecological fragmentation, and inadequate climate resilience, thereby demanding systematic resolutions. The 20th National Congress of the Communist Party of China underscored the importance of "coordinating industrial restructuring, pollution control, ecological conservation, and climate response," offering strategic direction for multi-scale green low-carbon regeneration.

In recent years, there have been multidimensional advancements in the field of green low-carbon urban regeneration research. At the level of urban agglomeration, Chen et al. (2021) developed a climate governance network model for European urban agglomerations, revealing nonlinear relationships between policy instruments and spatial performance. However, the applicability of this model to institutional contexts in developing countries remains unverified. At the city scale, Zhang et al. (2022) demonstrated that smart city technologies could reduce building energy consumption by 18–25% in megacities like Beijing and Shanghai, but they overlooked social equity issues in technology diffusion. Li et al. (2023) highlighted that transit-oriented development (TOD) combined with distributed energy systems could cut transportation emissions by 31% in London and Singapore, but they neglected spatial constraints in high-density built environments. For communities, Sorensen (2023) systematised Japan's Danchi regeneration model—"property rights restructuring, technological integration, and community co-creation"—showing a 42% reduction in carbon intensity through refined governance, though its transferability to land-public-ownership systems remains questionable. Marquina et al. (2024) introduced a dual-driven framework integrating low-carbon infrastructure and social capital activation in Latin American slum upgrades, but its technical solutions lack validation in temperate climates.

Despite these advancements, several critical shortcomings remain: (1) Institutional Obstacles to Cross-Scale Synergy: Most prior research has primarily centered on optimizing at a singular level. For example, Zhou et al. (2023) constructed a carbon metabolism model for the Beijing-Tianjin-Hebei region to examine industrial synergy at the regional scale. However, they did not create a vertical governance framework that connects national objectives, provincial breakdowns, and municipal execution. In another instance, Kim & Coseo (2022) introduced metrics for assessing green infrastructure performance at the community level but neglected to consider dynamic alignment with broader city-level climate goals. (2) Disparity Between Technology, Institutions, and Society: Wu et al. (2024) highlighted in the Yangtze River Delta Eco-Green Integrated Development Zone that fragmented property rights resulted in the implementation rate of technological solutions (e.g., building-integrated photovoltaics) falling

below 60% of the set targets. Additionally, Schwarz et al. (2022) found that limited public engagement reduced the efficiency of technical interventions in reducing emissions by 35–50% in the Ruhr industrial heritage regeneration projects in Germany. (3) Lack of Dynamic Adaptability: Gupta et al. (2022) showed in Chennai, India, that inflexible planning approaches were inadequate in addressing monsoon-induced failures of sponge city infrastructure. Furthermore, Yigitcanlar et al. (2023) developed a digital twin platform for real-time carbon monitoring in smart cities, but its decision-making algorithms did not incorporate feedback mechanisms for policy modifications.

Practical experiences exhibit three unique "objective-tool-actor" patterns in global green low-carbon regeneration practices. At the urban agglomeration level, the EU's Climate-Neutral Smart Cities Mission adopts a "cross-border agreement + industrial enclave" model. This model connects the industrial heritage regeneration of the Rhine-Ruhr region with the hydrogen transition in the Dutch Randstad ports, forming transnational low-carbon industrial chains (European Commission, 2023). These practices suggest that regional collaboration necessitates the disruption of traditional administrative barriers through a mechanism that encompasses mutual carbon accounting recognition, ecological compensation, and technology sharing. On the city scale, New York's 80×50 Plan innovatively links Floor Area Ratio (FAR) incentives to building carbon intensity, allowing developers to gain up to 20% additional FAR by installing rooftop photovoltaics or community microgrids (NYC Mayor's Office, 2017). This policy toolkit has led to a reduction in building-sector emissions by 23% from 2010 to 2020. At the community level, Singapore's HDB Green Towns Programme integrates "physical-digital-social" spaces through vertical greening (with a 15% annual carbon sequestration increase), smart meters (resulting in 62% resident energy-saving behavior adoption), and community carbon credit systems (with over 80% participation). This demonstrates the synergy of technological rigor, institutional flexibility, and social cohesion (HDB, 2022). However, practical challenges reveal disconnects between theory and implementation. Firstly, pervasive "data silos" are a significant issue—for instance, the Yangtze River Delta's carbon monitoring platform lacks access to 40% of enterprise-level microdata, which limits AI model accuracy (Liu et al., 2024). Secondly, policy innovation often lags behind technological advancements—hydrogen pipeline planning in Germany's Ruhr region has only achieved 65% of its 2030 green hydrogen supply target due to land acquisition regulations (RVR, 2023). Lastly, social cost considerations also pose a challenge.

This study presents an analysis of representative cases, including the Yangtze River Delta and Rhine-Ruhr urban conglomerations, transitional cities such as London and Tianjin, in addition to community-level practices like Japan's Danchi regeneration. These are utilised to construct a three-dimensional "planning-technology-implementation" framework. The paper addresses three scientific queries: (1) How can multi-level spatial governance facilitate the cross-scale transmission of carbon reduction targets? (2) What technological portfolios harmonise ecological restoration with industrial development? (3) How can collaboration among multiple stakeholders guarantee the long-term operation of regeneration projects? This research not only fills theoretical gaps in multi-scale integration but also provides replicable pathways for global urban low-carbon transitions within the framework of the Paris Agreement.

2. Methods and materials

2.1 Research framework

This study's research framework is organised in the following steps (Fig.1):

1. Case Analysis: This study systematically evaluates representative cases at the urban agglomeration, city, and urban area levels, employing three key dimensions—planning system, technical system, and implementation system.

2. Comparative Synthesis: This study provides a comparative analysis of strategic characteristics and divergences across various spatial scales, drawing on case studies. The focus is on examining different planning mechanisms, technological applications, and governance approaches.

3. Strategic Framework Development: Leveraging the aforementioned analysis, we have synthesised a goal-oriented strategic framework for green, low-carbon regeneration across various spatial scales. This framework provides actionable insights, enhancing practical planning and governance efforts.

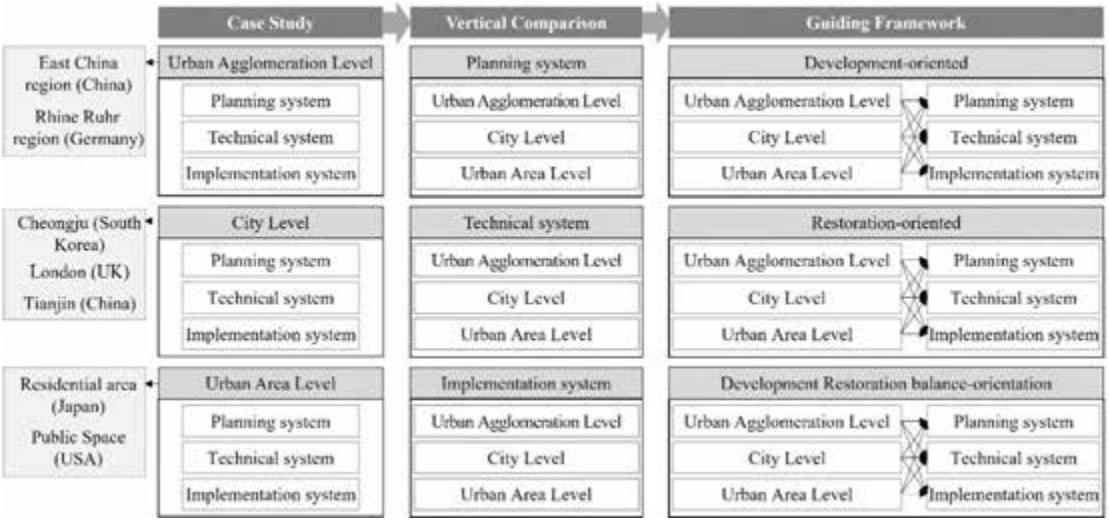

Fig. 1 Research framework

2.2 Illustrative cases of international green and low carbon regeneration efforts

This study conducts a comprehensive examination of representative cases by delving into their background, planning system, technical system, implementation strategy, and primary sources of inspiration.

2.2.1 Urban agglomeration

2.2.1.1 The Yangtze River Delta Urban Agglomeration

The Yangtze River Delta (YRD) urban agglomeration, encompassing Shanghai, Jiangsu, Zhejiang, and Anhui, represents China's most economically dynamic region, contributing 24.2% of the nation's GDP in 2023. Despite its rapid economic growth, the region faces significant carbon emission challenges. Data from the 2020 Multi-resolution Emission Inventory for China (MEIC) reveals that industrial and power sectors account for over 70% of total emissions (Liu et al., 2024). Key challenges include:

- Spatial imbalance: Emissions are concentrated in core cities such as Shanghai, Suzhou, and Hangzhou, with coastal areas exhibiting 30-45% higher emission intensity than inland regions.
- Ecological pressure: Rapid urbanization has fragmented critical ecological spaces (e.g., wetlands and forests), reducing carbon sequestration capacity by 18% since 2015.
- Policy urgency: Balancing economic expansion with dual carbon goals (peak emissions by 2030 and neutrality by 2060) requires urgent governance innovation.

(1) Planning system

To address these challenges, the YRD has adopted a dual-planning framework. First, a multi-level spatial governance system integrates cross-regional coordination at the provincial level—emphasizing ecological corridor protection and low-carbon industrial transitions through binding indicators (e.g., ≥23% forest coverage)—with localised urban-rural integration and low-carbon infrastructure development at the municipal level. Second, a spatial zoning system designates three functional areas:

- A core emission reduction zone (Shanghai-Suzhou corridor) restricting energy-intensive industries and promoting green transportation networks;
- An ecological conservation zone (southern Anhui) enhancing carbon sinks via wetland restoration;
- Carbon storage protection areas covering 30% of the territory.

(2) Technical system

The YRD employs data-driven tools, including a real-time carbon monitoring platform integrating MEIC data with transportation, energy, and land-use metrics. AI-powered scenario simulations project emission trajectories, identifying 2025 and 2028 as potential peaks under enhanced and baseline mitigation scenarios, respectively. Regional ecological networks are optimised using the InVEST model to pinpoint critical carbon sink nodes and restore blue carbon ecosystems.

(3) Implementation system
Implementation strategies combine policy innovation, industrial restructuring, and phased execution:

1. A carbon trading mechanism covering 1,200 enterprises and green finance initiatives supports market-driven decarbonization.
2. Industrial transitions target a 20% phaseout of coal-fired power plants by 2025 and promote "zero-carbon industrial parks," achieving 70% electrification of public transport by 2030, complemented by the Ningbo-Nanjing hydrogen corridor.
3. Phased actions prioritise coal consumption control and cross-city carbon sink protection during the peak period (2021–2030), transitioning to full energy system electrification and enhanced annual carbon sequestration during the neutrality period (2041–2060).

The YRD case exemplifies a globally replicable model for megaregional decarbonization, integrating systematic planning, data-driven decision-making, and market incentives. Its innovation lies in synergizing strategic top-down design with precision technical tools, balancing economic growth with ecological security to reshape sustainable development pathways for urban agglomerations.

2.2.1.2 The Rhine Ruhr urban agglomeration
The Rhine-Ruhr metropolitan region, a polycentric urban agglomeration in western Germany anchored by Cologne, Düsseldorf, and Essen, emerged as Europe's largest industrial hub, leaving a legacy of brownfields, ecological fragmentation, and carbon-intensive landscapes. Driven by the EU's Carbon Neutrality 2050 target and Germany's Federal Climate Protection Act, the region has adopted green infrastructure (GI) as a core instrument to integrate climate resilience, energy transition, and ecological restoration through multi-level planning. Key challenges include:

- Industrial brownfield regeneration;
- Cross-administrative ecological coordination;
- High-density urban regeneration.

(1) Planning system
The region integrates federal-state coordination and cross-city collaboration. At the federal level, the Spatial Planning Act establishes national ecological corridors (e.g., Rhine River), while the Federal Green Infrastructure Concept reserves renewable energy zones. North Rhine-Westphalia's State Development Plan designates Ruhr brownfields as transition zones with ≥30% green space targets. The Regional Association Ruhr (RVR) coordinates 21 cities under the Ruhr GI Master Plan, restoring the Emscher Valley and creating a "brownfield-green core-blue network." Cologne and Bonn jointly implement the Green Master Plan 3.0, forming a 200-km² Rhine-linked ecological network.

(2) Technical system
In terms of technical systems, three interconnected technical approaches drive transformation: Firstly, ecological network optimization through blue-green corridor restoration and brownfield regeneration. Secondly, climate-adaptive technologies leveraging GIS simulations to identify urban heat islands, enforce "cool islands" and ventilation corridors in high-risk zones, and deploy low-carbon infrastructure. Thirdly, renewable energy integration, including dedicated zones for wind/solar facilities and Europe's largest floating photovoltaic plant on coal-mining subsidence areas.

(3) Implementation system
Effective execution hinges on innovative policy development, active public participation, and astute monitoring and evaluation.

1. Policy innovation, exemplified by an ecological compensation mechanism requiring developers to purchase "eco-credits" for green space occupation (funding cross-regional wetland restoration) and climate budgeting aligning fiscal policies with emissions targets;

2. Public engagement, combining citizen science initiatives (e.g., mapping 5,000 protected heritage trees) and corporate partnerships (e.g., ThyssenKrupp converting 10% industrial land to public green spaces for carbon trading benefits);

3. Monitoring and evaluation via a GI performance platform tracking 12 indicators (green coverage, carbon sinks, etc.) and publishing annual resilience assessments.

The Rhine-Ruhr case demonstrates how multi-level governance, nature-based solutions (NbS), and cross-jurisdictional ecological compensation can transform post-industrial regions into climate-resilient models. Its integration of legal frameworks, technical innovation, and collaborative governance offers a replicable framework for global industrial urban agglomerations pursuing green transitions.

2.2.2 City

This study examines green-low carbon regeneration practices in three representative cities: Cheongju (South Korea), London (UK), and Tianjin (China), which exemplify central urban decay, megacity decarbonization, and industrial transformation, respectively.

Cheongju, the capital of Chungcheongbuk-do, faces urban decline in its central business district (CBD) due to population loss, aging infrastructure, and traffic congestion. Initiated in 2014, the Cheongju CBD Low-Carbon Green Regeneration Project redefined traditional high-carbon urban regeneration through systemic planning and technological innovation, establishing a Korean model for sustainable regeneration. London, the first global megacity to adopt a 2050 carbon neutrality target, achieved a 40% reduction in total emissions from 1990 to 2018. However, transportation (30% of emissions) and buildings (38%) remain critical decarbonization challenges. Tianjin, a major industrial hub in northern China, recorded a carbon intensity of 0.82 tons COΔper 10,000-yuan GDP in 2018, with fossil fuels constituting 97.4% of its energy mix (vs. China's national average of 82%), underscoring urgent energy transition pressures.

The analysis discerns context-specific challenges and contrasts strategies along three dimensions: planning systems, technical systems, and implementation systems. Key insights are succinctly synthesised (Table 1), providing valuable, transferable lessons for diverse urban environments embarking on low-carbon transitions.

Table 1. Comparative Analysis of Green-Low Carbon Urban Regeneration Strategies in Cheongju, London, and Tianjin

Aspect	Cheongju (South Korea)	London (UK)	Tianjin-China-
Key Challenges	•FAR incentives exacerbating housing affordability; mandatory affordable housing allocation. • Reliance on external carbon accounting expertise; high operational costs.	• Energy infrastructure constraints in historic districts. • Stakeholder conflicts in ZEZs implementation. • Long-term civic engagement needs.	•High costs of heavy-industry greening. •Water scarcity limiting circular economy. •Port-related freight emissions exceeding standards.
Planning Systems	• *Low-Carbon Green Growth Act* **(30% emission reduction mandate).** • TOD-driven regeneration and ecological corridor restoration.	• Three-tier system: *London Plan 2021* **designates 33 ZEZs; 15% stricter building energy standards; geothermal infrastructure planning.**	• Delineated green barrier; increased forest stock volume. • Pre-zoned offshore/onshore wind clusters; targeted non-fossil energy share. • Established industrial control lines + high-energy enterprise negative lists; phased out inefficient off-park enterprises.
Technical Systems	• Life-cycle carbon accounting (construction, transport, green spaces). • Mandatory eco-concrete, 30% BIPV coverage, hydrogen buses, rainwater recycling.	• *London Carbon Calculator Model* **(LCCM) with <5% error rate.** • Canary Wharf retrofit: Façade-integrated PV + geothermal heat pumps.	• Established a land-sea-air carbon sink monitoring network. • Piloted CCUS technology in Nangang Industrial Zone to increase CO storage volumes.
Implementation Systems	• PPP models + community-led "Low-Carbon Committees." • KETS carbon trading revenue + sub-market green bonds.	• Annual *Zero Carbon Progress Report* **(156 actions tracked).** • "Climate Action Fund" incentivizing civic participation.	• Statutory spatial planning for renewable land protection. • Tax incentives for certified low-carbon industrial parks.
Planning Insights	Demonstrates systemic "policy-space-technology-capital" integration for equitable regeneration. Highlights risks of social cost externalization in East Asian cities.	Validates "systemic policy-technology-civic governance" synergy for historic megacity transitions.	Establishes "ecological anchoring + industrial restructuring + port decarbonization" model. Proves heavy-industry cities can achieve eco-industrial symbiosis.

***Note:** TOD = Transit-Oriented Development; ZEZs = Zero Emission Zones; BIPV = Building-Integrated Photovoltaics; CCUS = Carbon Capture, Utilization, and Storage; KETS = Korea Emissions Trading Scheme.

2.2.3 The urban area

2.2.3.1 Public spaceβGreen infrastructure regeneration, US

As a high-density metropolis in the northwestern United States, Seattle faces the dual challenges of population growth and ecological conservation, including issues such as disrupted natural water cycles, intensified urban heat island effects, and uneven distribution of public spaces due to urban expansion. This study summarises the primary challenges in achieving green low-carbon regeneration of public spaces and outlines corresponding strategies across planning, technological, and implementation dimensions, as systematically presented in Table 2.

Table 2. Correspondence between Key Challenges and Systems in Seattle's Green Low-Carbon Public Space Regeneration

Key Challenges	Planning System	Technical System	Implementation System
Ecological Restoration (30% urban tree canopy by 2037)	**Macro-Micro Green Network** :• Macro: "One Core, Three Rings" framework (Central Waterfront Park, Urban Forest Ring, Neighborhood Greenway Ring, Rain Garden Ring). • Micro: Street retrofits into "Green Shared Corridors" to reduce carbon emissions.	**Nature-Based Solutions:**• Rain garden networks with "soil-plant-microbe" purification systems enhance carbon sequestration. • Smart urban forest management prioritises high-carbon-sequestration tree species.	**Cross-Department Collaboration** :• "Green Corridor Task Force" integrates road upgrades and stormwater management. • Green infrastructure (GI) integration into departmental performance evaluations.
Climate Resilience (90% stormwater facility coverage; 70% runoff pollution reduction)	**Naturalised Stormwater Management:**• Zoning based on "Infiltration Potential Maps": rain gardens (high infiltration), green roofs (medium), and underground cisterns (low).	**Digital Decision-Support Tools** :• GIS platform prioritises pocket parks in low-income areas. • Carbon footprint tracking via smart meters in public buildings.	**Policy-Financial Incentives:**• Mandatory "Stormwater Credit" purchases for developers. • Subsidies for household rain gardens and green roofs.
Social Equity (100% 5-minute park/greenway access; 50% green space equity index increase)	**Equitable Spatial Allocation** :• Neighborhood Greenways prioritise pedestrians and cyclists to reduce car dependency.	**Data-Driven Equity:**• GIS integrates demographic data to guide park distribution. • "Carbon-Neutral Corridors" enhance accessibility.	**Public Participation Mechanisms:**• "Green Home Lab" educates residents on DIY green infrastructure. • "Green Points" system rewards tree-planting with transit passes. • Participatory budgeting for funding allocation.

Seattle achieves green low-carbon regeneration of public spaces through a closed-loop framework integrating "target quantification, spatial retrofitting, technological modularization, and governance empowerment." The application of innovative technologies and broad societal participation serve as essential enabling conditions for the successful implementation of this initiative.

2.2.3.2 Residential area: Danchi regeneration, Japan

Japan has pinpointed the renovation of aging residential areas as a crucial component of low-carbon urban development. A prime example of this is the "Danchi Regeneration," primarily focused on centralised public residential areas constructed post World War II. This paper outlines the primary challenges encountered in this practice and pairs them with the corresponding strategies from the planning system, technical system, and implementation system. This pairing offers an intuitive understanding of the project's status (Table 3).

Table 3. Correspondence between Key Challenges and Systems in Danchi Regeneration

Key Challenges	Planning System	**Technical System**	**Implementation System**
Building Aging & High Carbon Emissions	Legal framework: The Low-Carbon City Promotion Act (2012) mandates emission reduction targets for old residential areas.	Building energy retrofitting: KSI housing system extends building lifespan to 100 years; solar power and ground-source heat pumps reduce carbon emissions.	Property-function replacement mechanism: Government retains public facility ownership; commercial land leases fund low-carbon retrofitting.
Community Aging & Declining Vitality	Specialised planning: Links with national plans to align spatial strategies (e.g., job-housing balance) with social sustainability goals.	/	Community co-creation: Resident participation in shared facilities (e.g., "community flower beds") lowers costs; elderly-friendly housing improves demographic balance.
Inefficient Land Use	Specialised planning: Promotes Transit-Oriented Development (TOD) to optimise land use.	Eco-restoration technologies: Permeable paving and 3D greening reduce heat island effects by 60%.	Chain-style regeneration: Phased relocation, FAR incentives, and reserved land for green spaces/public facilities enhance land efficiency.
Financial & Technical Bottlenecks	Independent management agency: UR Agency coordinates stakeholders and integrates cross-sector resources.	Resource recycling: 90% construction waste reuse; on-site composting reduces external resource dependence.	Green Bank platform: Social capital bids for low- carbon technology applications, balancing public subsidies and private investment.

Japan's "Danchi Regeneration" demonstrates that green regeneration of aging residential areas necessitates "institutional frameworks as the foundation, technological innovation as the tool, and community engagement as the core." By adopting refined planning, whole-process technological integration, and inclusive governance , this approach achieves carbon neutrality goals and provides a replicable paradigm for global low-carbon community development.

3. Results

This study performs a comprehensive analysis of representative cases across various spatial scales, aiming to delineate the common strategic features of green and low-carbon regeneration strategies within each spatial hierarchy. These strategies are examined in relation to three core systems: planning, technical, and implementation systems. Additionally, a vertical comparison is conducted to illuminate the distinct methodologies employed at different scales.

3.1 Comparative analysis of planning system

One strategic commonality across spatial scales is the adoption of multi-scale collaborative governance. Yet, there are strategic differentiations among spatial hierarchies. Urban agglomerations resolve scale mismatches with transboundary agreements and scenario modelling. Cities use statutory instruments for regulatory enforcement. Districts deploy metric-based spatial controls (Fig 2).

In urban agglomerations, planning for green and low-carbon regeneration is facilitated by a three-tiered governance framework that amalgamates national directives, regional coordination, and local implementation. Insightful case studies from the Yangtze River Delta and Rhine-Ruhr demonstrate clear organizational roles:

(1) National or Federal Policy Agencies, such as China's Ministry of Natural Resources and Germany's Federal Ministry for the Environment, establish overarching targets like carbon neutrality and provide funding for cross-regional projects; (2) Regional Coordination Bodies, for example, the Yangtze River Delta Integration Office and the Rhine-Ruhr Regional Association, arbitrate intercity infrastructure coordination tasks such as renewable energy grids and resolve jurisdictional disputes; (3) Provincial or State Governments translate national objectives into actionable plans, illustrated by Zhejiang's low-carbon industrial clusters and North Rhine-Westphalia's coal phaseout roadmap.

The implementation of the operational workflow involves three consecutive steps: (i) policy formulation, (ii) regional planning, and (iii) real-time monitoring. The federal/national level legislates emission reduction targets through climate protection acts that provide binding regulatory frameworks. Regional authorities develop spatially explicit action plans (e.g., renewable energy corridors) to ensure that the targets are met in line with local ecological and socioeconomic conditions. Multi-stakeholder working groups use common databases (e.g., GIS-based emission inventories) for implementation, monitoring and dynamic adjustment of strategies. The federal government provides legislation and financial instruments (e.g., carbon pricing) and regional authorities coordinate resource allocation. Local authorities implement site-specific projects (e.g., retrofitting green infrastructure) that link strategic objectives with their practical implementation on the ground. This hierarchical and integrated approach ensures vertical policy coherence while allowing for regional flexibility.

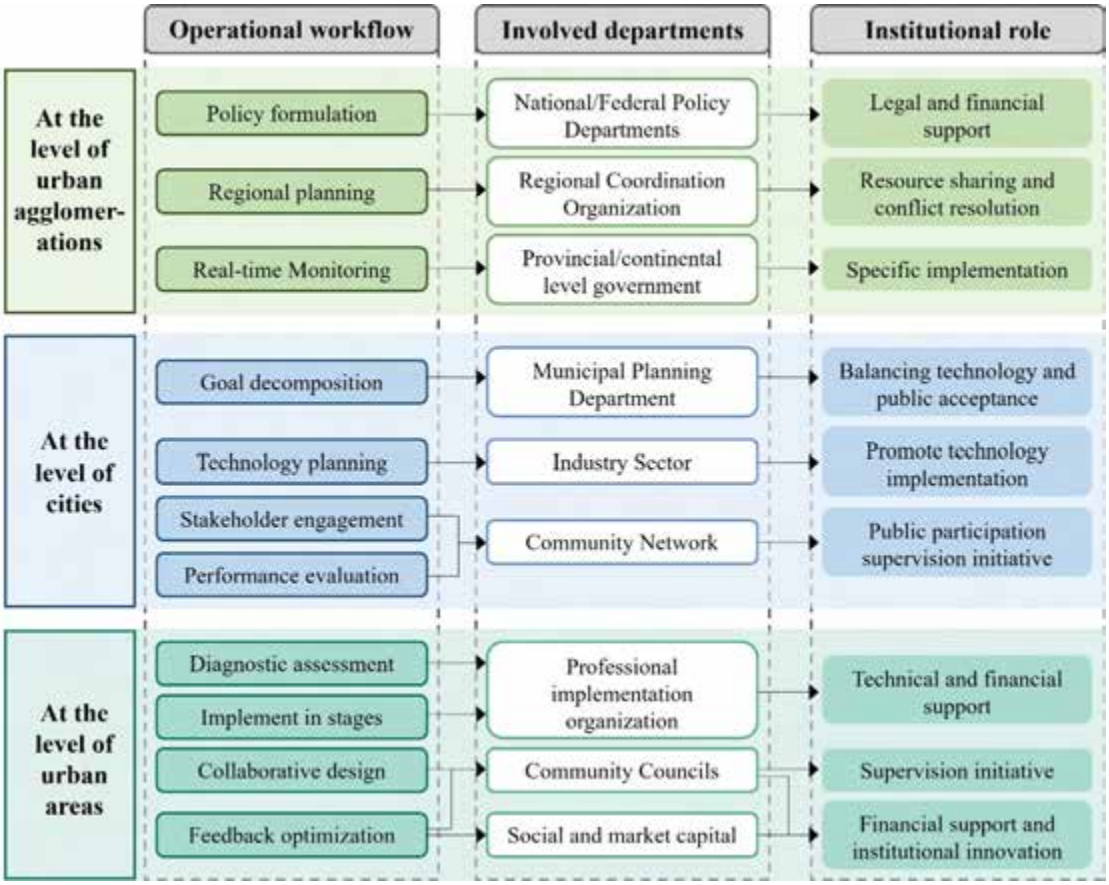

Fig. 2 Planning Processes Across Different Spatial Scales: Involved Departments and Their Roles

City-scale planning places a significant emphasis on cross-sectoral integration. Municipal authorities, such as the Greater London Authority, are responsible for formulating citywide strategies, such as the London Environment Strategy 2050. In contrast, sectoral departments like transport and energy are tasked with implementing domain-specific measures, such as Ultra-Low Emission Zones. Community networks, such as Sejong's Green Citizen Committees, serve to institutionalise participatory decision-making processes, including rooftop solar adoption. The urban planning workflow is comprised of four iterative phases: (1) the decomposition of national climate objectives into local targets; (2) the development of context-specific technical solutions, such as smart grids; (3) the embedding of social equity through stakeholder engagement, such as co-creation forums; and (4) progress tracking through digital platforms, such as IoT-enabled monitoring. This structured approach requires a delicate balance: municipal governments must reconcile technical feasibility with public acceptability, sectoral departments must drive innovation, and communities must ensure compliance with sustainability mandates.

In urban area-scale regeneration, tactical interventions are prioritised through the collaboration of multiple stakeholders. Specific agencies, such as Japan's UR Urban Renaissance Agency, oversee the entire project cycle, ranging from diagnostics to post-occupancy evaluations. Community councils like Tokyo Neighborhood Associations engage in co-designing solutions, such as energy-efficient retrofits. Meanwhile, private partners, including Mitsui Fudosan, offer their expertise and financial support, often through public-private partnership (PPP) models. The district-scale workflow is cyclical: (1) technical audits pinpoint vulnerabilities like aging infrastructure; (2) phased implementation reduces disruption by offering incremental upgrades, such as modular housing; (3) participatory workshops ensure that technical solutions align with socio-cultural priorities, including heritage preservation; and (4) the use of IoT sensors and post-occupancy surveys facilitates iterative refinements. Implementation agencies maintain technical rigor via lifecycle cost-benefit analyses, residents ensure social inclusivity via feedback mechanisms, and private stakeholders incorporate scalable technologies like prefabricated green systems. This holistic approach harmoniously blends technical precision with community adaptability in intricate regeneration scenarios.

3.2 Comparative analysis of technological system

Data-driven and modular technologies are amalgamated to establish a comprehensive hierarchical framework, spanning macro-scale simulation, meso-level integration, and micro-scale measurement. The prioritization of innovation varies across different spatial hierarchies: Urban agglomerations emphasise systemic interconnectivity. Cities have prioritised sectoral deep decarbonization, while urban areas are adopting replicable near-zero-carbon modules.

Carbon reduction strategies, when viewed across different spatial scales, exhibit hierarchical differentiation in their choice of indicators (Table 6):

Table 6. Multi-scale Carbon Emission Assessment: A Synthesis of Evaluation Dimensions and Indicators Across Spatial Hierarchies

Spatial Level	Indicator Category	Specific Indicator	Indicator Description
Urban Agglo-mera-ti-on **Level**	Energy Structure Optimization	Carbon emission intensity of industrial sectors (tons/10,000 CNY GDP)	Carbon emissions per unit of industrial output, reflecting the low-carbon transition level of industrial structure.
	Industrial De-car-bonization	Annual carbon reduction rate of ener-gy-intensive industries (%)	Annual carbon emission reductions in traditional industryies (e.g., steel, chemicals) through technological upgrades.
	Energy Networ-k Integration	Compatibility rate between renewable energy generation and grid stability (%)	Synergy between variable renewable energy (e.g., wind, solar) and grid peak-shaving capacity.
	Carbon Sink Ca-pacity	Total annual carbon sequestration in ecological spaces (mill-ion tons CO/year)	Annual carbon sequestration by forests, wetlands, and other ecological areas.
	Transportation Synergy	Intercity railway coverage rate (%)	Proportion of cities within the agglomeration connected by high-speed rail or intercity rail networks.
	Regional Carb-on Trading	Cross-city carbon quota tradin-g vol-ume (million tons/year)	Annual carbon quota transactions in regional markets, reflecting emission reductions driven by market mechanisms.

City Level	Ecological Agr-i-culture	Blue-green space ratio (%)	Proportion of water bodies (blue) and green spaces (forests, parks) in total urban land area.
		Forest stock volume (10,000 m³/ha)	Carbon storage per unit of forest area, indicating carbon sink capacity.
		Chemical fertiliser application intensity (kg/ha)	Fertiliser use per unit of agricultural land, reflecting efforts to reduce agricultural non-point source pollution.
	Energy Resou-rces	Share of locally generated renewable energy (%)	Proportion of renewable energy (e.g., wind, solar) in total energy consumption.
		Coverage rate of distributed energy supply centers (%)	Proportion of urban areas served by decentralised energy systems (e.g., combined heat and power plants).
		Installed solar PV capacity (MW)	Total solar power capacity installed on rooftops and vacant urban land.
		Coverage rate of district heating networks (%)	Proportion of urban areas served by low-carbon heating systems (e.g., waste heat recovery, geothermal).
	Industrial Deve-lopment	Proportion of value-added from strategic emerging industries in GDP (%)	Contribution of low-carbon industries (e.g., new energy, energy efficien-cy) to economic output.
		Reduction rate of energy-inten-sive enterprises (%)	Proportion of high-emission enterprises phased out through industrial restructuring.
	Transportation	Public transport modal share (%)	Proportion of trips made via metro, buses, and other green transit modes.
		Share of new energy vehicles (NEVs) in total vehicles (%)	Proportion of electric or hydrogen-fueled vehicles in the urban fleet.
		Bicycle lane density (km/km²)	Length of dedicated bicycle lanes per unit area, promoting non-motorised travel.
	Resource Circu-larity	Waste recycling and reuse rate (%)	Proportion of municipal solid waste and industrial by-products recycled or repurposed.
	Carbon Peak Tar-gets	Reduction rate of total carbon emis-sions relative to peak year (%)	Percentage reduction in total emissions by 2035 compared to the peak year (2005). Example: 5% reduction by 2035.
	Green Infrastru-cture	500-meter coverage rate of parks and green spaces (%)	Proportion of residential areas within a 500-meter walking distance of parks or green spaces.
	Building Energy Efficiency	Retrofitting rate of existing buildings (%)	Proportion of buildings upgraded with energy-saving measures (e.g., insulation, high-efficiency equipment).
	Building Decarbo-nization	Utilization rate of eco-friendly con-struction materials (%)	Proportion of low-carbon materials (e.g., recycled concrete) used in building construction.
Urban Area Level	Environmental Performance	CASBEE Community BEE Score (1–5)	Comprehensive assessment of environmental efficiency (BEE = Q/L), where Q = environmental quality and L = environmental load.
	Carbon-Neutral Communities	Number of certified carbon-neutral communities	Communities meeting standards for zero-carbon buildings and 100% renewable energy adoption.
	Energy Self-Suffi-ciency	Community renewable energy self-suf-ficiency rate (%)	Proportion of energy demand met by localised renewables (e.g., rooftop solar, geothermal).
	Resource Circu-larity	Greywater reuse rate (%)	Proportion of treated domestic wastewater reused for irrigation, toilet flushing, etc.
	Social Equity	Coverage rate of elderly-friendly facilities (%)	Proportion of residential units with age-friendly infrastr-ucture (e.g., barrier-free access, community clinics).
	Stormwater Ma-nagement	Permeable pavement coverage rate (%)	Proportion of paved surfaces using permeable materials to reduce runoff and enhance water infiltration.
	Biodiversity	Ecological corridor connectivity index (0–1)	Connectivity of green and blue spaces based on GIS n-etwork analysis (0 = fragmented, 1 = fully connected).
	Low-Carbon Buildings	Green roof coverage rate (%)	Proportion of building rooftops covered with vegetation to reduce ur-ban heat island effects.
	Low-Carbon Transportation	Share of new energy public transit routes (%)	Proportion of bus routes operated by electric or hydrogen-powered vehicles.

Urban agglomerations prioritise regional energy-industrial coordination and infrastructure-policy synergies. The Rhine-Ruhr region, for instance, exemplifies renewable energy-grid compatibility, such as wind-solar-grid matching rates, and engages in cross-border carbon trading to diminish industrial carbon intensity, particularly in sectors like steel and chemicals. These approaches tackle overarching challenges, such as energy network externalities, using collective metrics like carbon sink capacity and emission reduction ratios.

Cities are increasingly adopting multidimensional governance structures and localised transition strategies. For example, both Tianjin and London strive to balance economic growth with decarbonization objectives. They do this by maintaining blue-green space ratios of 30%, ensuring renewable energy self-sufficiency, and aiming for public transport modal shares of 40%. Their policy toolkits encompass incentives for green building and phased withdrawals from polluting industries, bolstered by moderate-granularity data such as COΔ emissions per unit of GDP.

In urban areas, technology-driven and resident-centric solutions are implemented. For instance, Japan's Danchi Regeneration and Seattle's green infrastructure projects use metrics such as per-meable pavement coverage (≥20%) and CASBEE community BEE scores (1–5) to gauge their performance. These initiatives seamlessly combine low-carbon technologies, like rooftop solar PV, with social equity measures, such as elderly-friendly facilities, and climate resilience strategies.

The hierarchical structure unveils a scalar transition from comprehensive systemic coordination to focused local action. In this context, national strategies, such as carbon markets, establish broad parameters that are then refined into city-specific objectives. These, in turn, cascade into precise community technical standards. Employing a nested governance model ensures complementarity across scales, harmonizing macro-level assessments with micro-level execution.

3.3 Comparative analysis of implementation system

Governance transitions have moved from bilateral relations between governments and markets (e.g., carbon trading in industry) to triadic relations that include civil society. Parallel to this, decision-making has shifted from strategic dominance to adaptive learning in iterative processes. The strategic differences across spatial hierarchies are as follows: Urban agglomerations focus on cross-border policy innovations for sustainability. Cities adopt market-based strategies to address financing issues.
Urban communities have been the vanguard of community-based instruments.

This study delves deeper into the analysis of disparities concerning green-low carbon transitions at various spatial levels. It does so by integrating perspectives from multiple stakeholders and employing mechanisms that balance interests (Fig. 3).

In urban conglomerations, coordination among multiple actors is underscored by cross-jurisdictional governance and industrial symbiosis. Collaboration between national/regional agencies, energy/manufacturing alliances, and research institutions is facilitated through legally binding frameworks, such as carbon trading, and shared infrastructure like renewable grids. The Rhine-Ruhr Metropolitan Association manages land-use zoning and sets emission caps, whereas East China utilises fiscal transfers to strike a balance between ecological conservation and industrial expansion. Interregional competition for resources is alleviated by compensation mechanisms, including carbon-sink subsidies, and technology-sharing platforms.

In cities such as Cheongju, London, and Tianjin, local governments use regulatory tools (e.g., low-emission zones) and public-private partnerships to steer markets toward sustainability, with planning/environmental departments, developers, utilities, and citizen assemblies often being key actors. For example, London's Ultra Low Emission Zone (ULEZ) sets stringent emission standards but provides subsidies for green retrofits. Meanwhile, Tianjin Eco-City incorporates resident input on green infrastructure design through digital platforms. To address conflicts between economic efficiency (e.g., developer profits) and equity (e.g., affordable housing), hybrid financing (e.g., green bonds) and community benefit agreements (CBAs) are used to ensure equitable distribution of benefits.

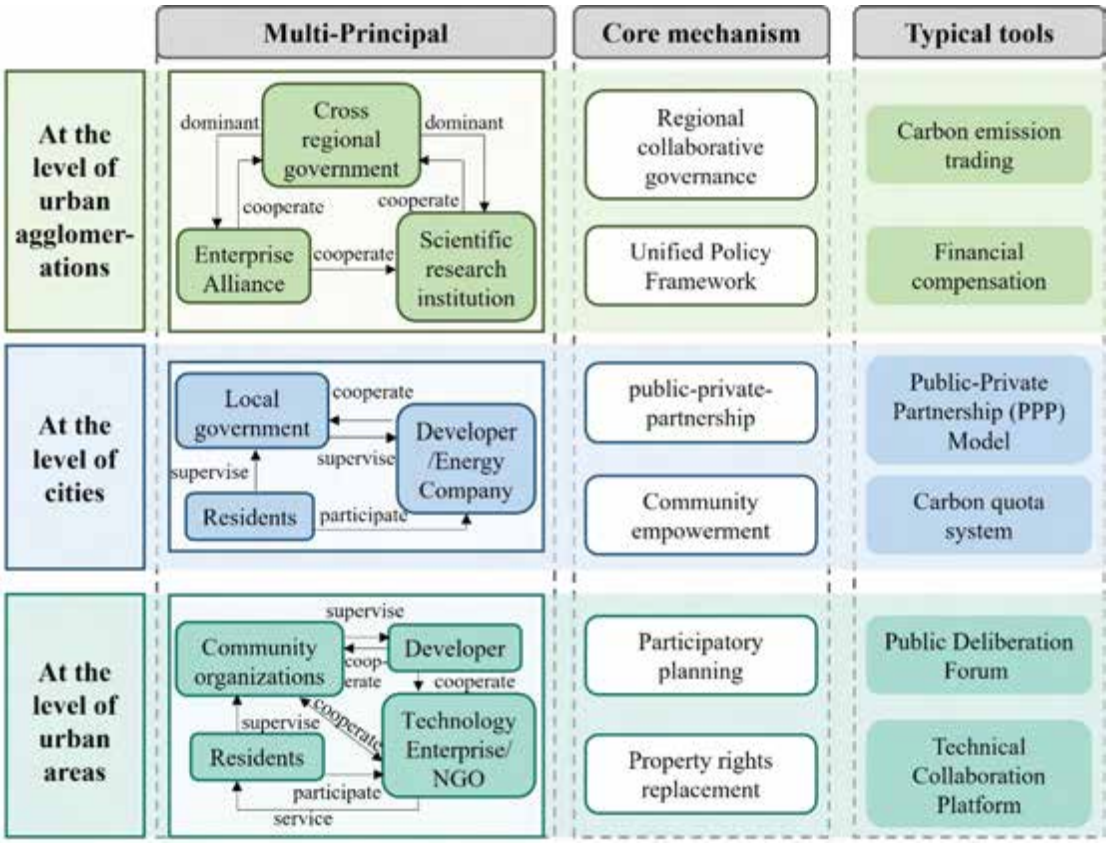

Fig. 3 Implementation Mechanisms Across Spatial Scales: Multi-Actor Interactions and Collaborative Dynamics

In urban areas, coordination among various actors is primarily focused on localised participation and micro-institutional innovation. The driving forces behind outcomes are resident committees, non-governmental organizations (NGOs), technical providers, and municipal agencies. For instance, Japan's UR Urban Agency restructures property rights in Danchi regeneration by compensating displaced residents with shared green spaces. Similarly, Seattle's grassroots organizations co-design rain gardens and pedestrian networks through citizen workshops. Land-use disputes are typically resolved through negotiated trade-offs, such as density bonuses for green roofs, and decentralised decision-making processes, thereby ensuring hyper-local legitimacy. In summary, the main features that distinguish hierarchies are as follows:

- Governance Authority: Urban agglomerations rely heavily on supranational frameworks, such as EU directives, while urban areas give precedence to community self-organization.
- Conflict Resolution: Macro-level conflicts are resolved utilizing economic tools such as carbon pricing. However, micro-level conflicts require social negotiations, for example, through the implementation of participatory budgeting.
- Actor Power Dynamics: Corporations exert a dominant influence on the agendas of city clusters, whereas non-governmental organizations (NGOs) and residents are pivotal in determining outcomes at the district level.

This structured synthesis illuminates the way spatial hierarchies shape stakeholder roles, institutional adaptability, and conflict resolution mechanisms during green-low carbon transitions. It offers concrete insights for the development of multi-scalar governance.

4. Discussion

4.1 Development-Restoration Balanced Strategies Across Scales

Green low-carbon regeneration is intrinsically connected to the strategic positioning of regional and urban development. It serves a dual purpose: the first aims to bolster urban sustainability via development-oriented interventions, and the second seeks to rehabilitate high-carbon-emission spaces that threaten urban

resilience, grounded in restoration-oriented priorities. These contrasting development orientations give rise to distinct strategic methodologies. Consequently, this study classifies strategies into three distinct typologies—development-oriented, restoration-oriented, and development-restoration balanced approaches—to cohesively summarise a multi-scale green low-carbon regeneration framework, thereby providing practical insights applicable to various spatial contexts (Fig.4).

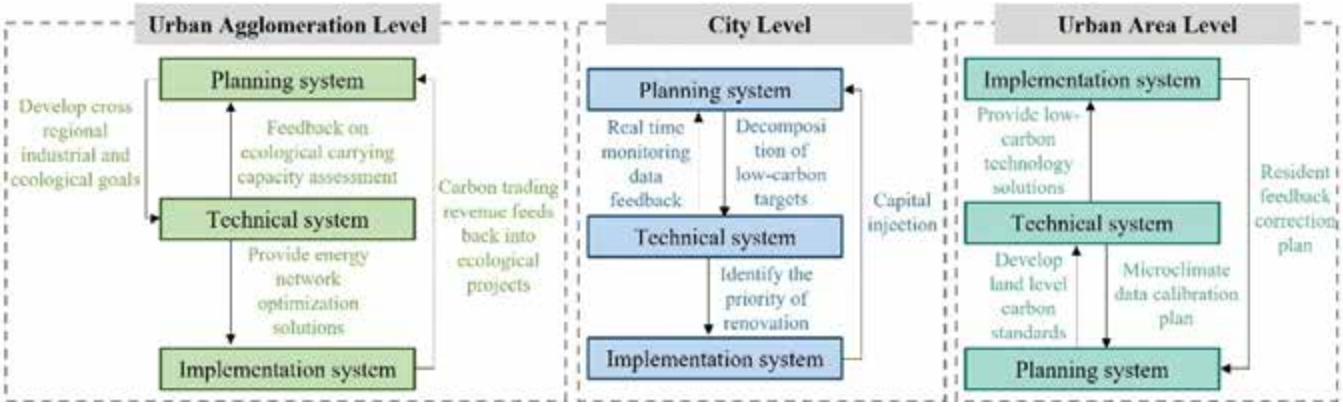

Fig. 4 Interaction mechanisms among multi-scale planning, technical, and implementation systems

4.1.1 Urban Agglomeration Level

(1) Planning system

- Development: The establishment of cross-regional renewable energy corridors and low-carbon industrial clusters is proposed as a strategy to decouple economic growth from emissions (Lin et al., 2022). Furthermore, the integration of "sponge city" principles into regional flood-resilient infrastructure planning is advocated (Yang et al., 2024).
- Restoration: Utilise circuit theory to design ecological security patterns, aiming to reconnect fragmented habitats and establish carbon sink protection redlines that encompass at least 30% of the territorial area (Liu et al., 2024).
- Integration: The implementation of a dual-control zoning system serves to strike a balance between industrial decarbonization and nature-based carbon sequestration (Bao et al., 2022).

(2) Technical system

- Development: Deploy AI-powered carbon accounting platforms for real-time monitoring of cross-border industrial emissions (error rate <5%) (Feng et al., 2022). Optimise multi-energy complementary systems (e.g., wind-PV-hydrogen storage) to achieve ≥75% renewable penetration (Wang et al., 2018).
- Restoration: Apply InVEST habitat quality models to prioritise wetland restoration sites and quantify carbon sink gains (Liu et al., 2024).
- Integration: Develop GIS-based conflict maps to resolve land-use disputes between energy facilities and protected areas (Sanchez et al., 2018).

(3) Implementation system

- Development: Initiate cross-city carbon trading markets and establish green finance hubs to facilitate funding for low-carbon transitions (Lin et al., 2022).
- Restoration: The implementation of ecological compensation mechanisms is proposed, whereby developers are required to finance off-site conservation efforts for greenfield occupation (Bao et al., 2022).
- Integration: Establish multi-stakeholder committees to synchronise industrial policies with biodiversity objectives (Xiong et al., 2021).

4.1.2 City Level

(1) Planning system

- Development: Implement transit-oriented development (TOD) mandates and 15-minute city frameworks with the objective of reducing transportation emissions by 40% (Deakin et al., 2012).
- Restoration: The process of restoring urban ecological networks and ensuring the implementation of 35%

blue-green space ratios within masterplans is imperative (Haase, 2024).
- Integration: The application of circular economy zoning is proposed as a strategy for co-locating waste recycling hubs within industrial parks, thereby enhancing sustainability (Jiang, 2024).

(2) Technical system
- Development: Enhance district heating networks through the integration of waste heat recovery systems, and ensure a minimum of 50% solar PV coverage on public buildings (Wang et al., 2015).
- Restoration: Utilise microclimate simulation tools, such as ENVI-met, to conceptualise urban forest designs capable of mitigating heat island intensity by 2–3°C (Sanchez et al., 2018).
- Integration: The process involves the creation of digital twins with the primary objective of optimizing the management of the energy-water-food nexus (Xiong et al., 2021).

(3) Implementation system
- Development: Implement carbon intensity quotas for industries and associate municipal bonds with green certification (Jiang, 2024).
- Restoration: The establishment of community land trusts is proposed as a strategic measure to safeguard green spaces against the encroachment of gentrification (Bouzarovski et al., 2018).
- Integration: Implement participatory climate budgeting to ensure congruence between fiscal policies and the priorities of citizens (Deakin et al., 2012).

4.1.3 Urban Area Level
(1) Planning system
- Development: Establish net-zero building codes and implement TOD-oriented land readjustment strategies (Wang et al., 2015).
- Restoration: The implementation of biophilic street design standards, such as having a minimum of 25% permeable surfaces and the use of native tree planting, can significantly enhance biodiversity (Sanchez et al., 2018).
- Integration: Utilise form-based coding techniques to align green infrastructure development with heritage preservation (Haase, 2024).

(2) Technical system
- Development: Scale building-integrated photovoltaics (BIPV) and shared energy storage systems to achieve 100% renewable energy blocks (Jiang, 2024).
- Restoration: Implement modular green walls and rainwater harvesting systems to decrease potable water consumption by 30% (Sanchez et al., 2018).
- Integration: Utilise IoT-enabled smart meters to monitor real-time carbon footprints of households and distribute green subsidies fairly (Bouzarovski et al., 2018).

(3) Implementation system
- Development: Provide tax rebates for environmentally friendly retrofits, such as a 20% reduction for the adoption of Building Integrated Photovoltaics (BIPV), and award density bonuses for affordable housing located near transit hubs (Wang et al., 2015).
- Restoration: The institutionalization of co-design workshops is recommended as an effective strategy for engaging marginalised groups in the planning process of green spaces (Bouzarovski et al., 2018).
- Integration: Establish eco-friendly asset management platforms to generate revenue from carbon savings and finance community initiatives (Jiang, 2024).

4.2 Theoretical Contributions and Innovations
This study advances existing literature in three dimensions:

1. Multi-Scale Vertical Comparison: Previous research has primarily centered on interventions at a singular scale, such as community-level Nature-based Solutions (NbS) (Wang et al., 2015) or city-level policy integration (Feng et al., 2022). In contrast, this study elucidates scalar interdependencies, showcasing how urban agglomeration carbon markets facilitate city-scale industrial transitions that subsequently finance district-level retrofitting. This addresses the pervasive "scale mismatch" criticism in sustainability governance (Haase, 2024).

2. Systemic Multi-Dimensional Framework: Differing from sector-specific analyses, such as energy systems (Lin et al., 2022) or social equity (Bouzarovski et al., 2018), this research amalgamates planning, technical, and implementation systems into a unified matrix. The Rhine-Ruhr case exemplifies this approach, showcasing how federal spatial planning (planning system) collaborates with regional GIS tools (technical system) and eco-credit mechanisms (implementation system) to realise comprehensive decarbonization.

3. Dual-Objective Strategy Framework: Previous research has predominantly focused on either growth-oriented strategy, such as green gentrification (Bao et al., 2022), or conservation-centric approaches like ecological restoration (Liu et al., 2024). This study offers a comprehensive strategy framework that harmonises both objectives. For instance, Tianjin's "ecological anchoring + port decarbonization" model concurrently promotes the upgradation of heavy industries (development) and the restoration of coastal wetlands (restoration), effectively addressing the dichotomy between economic progression and carbon neutrality (Xiong et al., 2021).

5. Conclusion

This study addresses urban ecological governance under climate change, exploring multi-scale green regeneration pathways aligned with Dual Carbon Goals. Through comparative analysis of urban agglomerations, cities, and communities across six nations, three key insights emerge: (1) A multi-tiered governance framework enables strategic carbon management – coordinating regional resource allocation (agglomeration scale), optimizing spatial structures (city scale), and implementing adaptive mitigation (community level). (2) Technical systems require horizontal integration of ecological restoration, industrial decarbonization, and smart governance, balancing anthropogenic-ecological synergies regionally while enhancing microclimates and green buildings locally. (3) Implementation necessitates policy-market-society coordination: expert committees for cross-regional evaluation, standardised planning protocols, and participatory models leveraging social capital. The research proposes a tripartite framework integrating planning, technical, and implementation systems, resolving fragmentation in traditional approaches through cross-scale carbon accounting and multi-stakeholder mechanisms. These findings advance sustainable urban theory and offer actionable strategies for cities at varying development stages to achieve low-carbon transitions.

This study also has two limitations. First, geographical coverage bias: the cases are concentrated in East Asia (China, South Korea, Japan) and Europe (Germany, UK), and lack representation from cities in the Global South which face distinct challenges (e.g., informal settlements in Africa). Future studies could expand the database with cases from São Paulo's favela electrification programs or Nairobi's slum-upgrading initiatives to enhance generalizability (Sanchez et al., 2018). Secondly, there are significant gaps in dynamic adaptation. The current framework prioritises static spatial strategies while neglecting the importance of temporal resilience. For instance, it reviews the phased coal phaseout in the YRD region compared to abrupt policy shifts. The inclusion of adaptive pathway methodologies such as climate-responsive zoning could enhance strategic flexibility (Yang et al., 2024).

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Return of Mythical Bird · Reborn of Wetland — Conservation and Restoration Planning & World Heritage Site Application Preparation for Fujian Minjiang River Estuary

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Abstract
The Fujian Minjiang River Estuary, a vital mudflat wetland along the East Asian-Australasian Flyway, serves as a sanctuary for numerous endangered species. In 2000, the reappearance of the Chinese Crested Tern *(Thalasseus bernsteini)*, long presumed extinct, brought new attention to the site. Today, from April to September each year, this 'bird of legend' returns, infusing the wetland with renewed vigor and vitality.

Despite ongoing restoration efforts, challenges such as marine aquaculture, invasive species, and human disturbance remain.

This paper outlines three strategies: defining protection zones, restoring waterbird habitats and hydrological system, and engaging local communities to support conservation and cultural recognition. These efforts contributed to the estuary's inclusion on the World Natural Heritage Tentative List in August 2022, marking a crucial step towards its recognition and protection on a global scale.

Key Words: world heritage; outstanding universal value; coastal wetland; habitat restoration; community development

1 Introduction

The Fujian Minjiang River Estuary, situated along the eastern coast of Fuzhou City, is a mudflat wetland formed through centuries of sedimentation from the Min River Basin(Figure 1). The area serves as a critical node on the East Asian-Australasian Flyway (EAAF) for migratory birds and provides refuge for numerous endangered species (RAMSAR, 2022).Twenty-four years ago, the reappearance of a mythical species added an element of mystery to this wetland. The Chinese Crested Tern (*Thalasseus bernsteini*, classified as Critically Endangered by the IUCN) was once believed extinct due to habitat degradation, typhoons, human interference, and low reproduction rates until its rediscovery in this area in 2000("Chinese crested tern", 2022).

Today, from April to September each year, this 'Bird of Legend' returns as expected, infusing the wetland with renewed vigor and vitality. While numerous restoration efforts have been implemented in recent years, challenges such as marine aquaculture, invasive species, and human disturbance persist(Lu, Y., D.D. Roby, Z. Fan, S. Chan, D.E. Lyons, C.-H. Hong, S. Wang, J. Yang, X. Zhou, D. Chen, H.-W. Yuan, S. Chen, 2020)especially colonies of terns (Subfamily: Sterninae. Consequently, there is an urgent need to establish graded protection zones, restore habitats for endangered waterfowl, and safeguard the ecosystem's integrity and authenticity(RAMSAR, 2022).

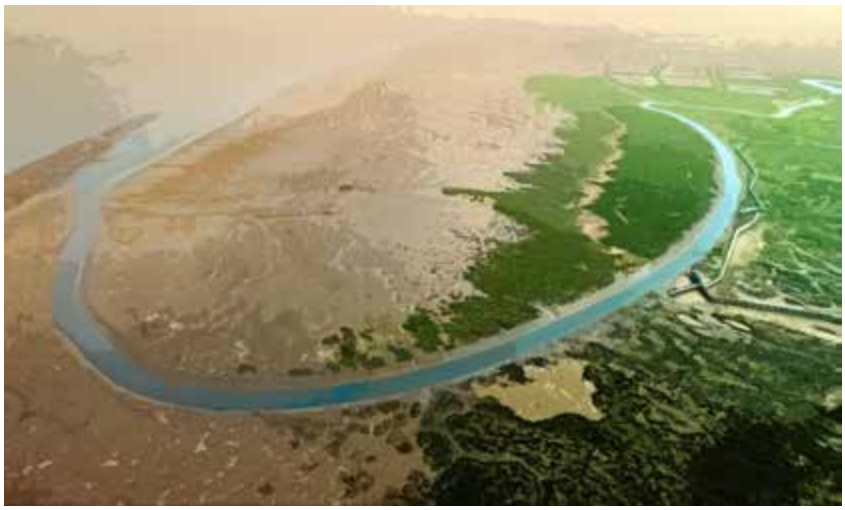

Figure 1 Minjiang River Estuary

This paper aims to introduce the restoration process, detailing how the project team managed to create a welcoming environment for returning wild birds and explore the potential for promoting harmonious coexistence between nature and humans.

The planning effort encompasses three key scopes (Figure 2): **'Research Scope'** covers the eastern coastal region of Fujian Province, extending north to Luoyuan Bay and south to Pingtan Island and Fuqing Bay, with an approximate area of 1,200 square kilometers. **'Conceptual Master Planning Scope'** is also the proposed World Heritage nomination area, covering approximately 267 square kilometers. **'Key Ecological Landscape Designing Scope'** focused primarily on the current Minjiang River Estuary Wetland Park and its surrounding areas, covering about 4.5 square kilometers.

According to each scope, the project contains three primary aspects:

1. Delineating the reservation area's boundaries, identifying Outstanding Universal Value and establishing graded control measures.
2. Optimizing the hydrological network, mitigating the impact of invasive species, and creating suitable habitats.
3. Fostering close cooperation with local communities to showcase the uniqueness and allure of a potential World Heritage Site.

As a significant milestone, the Fujian Minjiang River Estuary was successfully included in the World Natural Heritage Tentative List in August 2022(UNESCO, 2022), marking a crucial step towards its recognition and protection on a global scale.

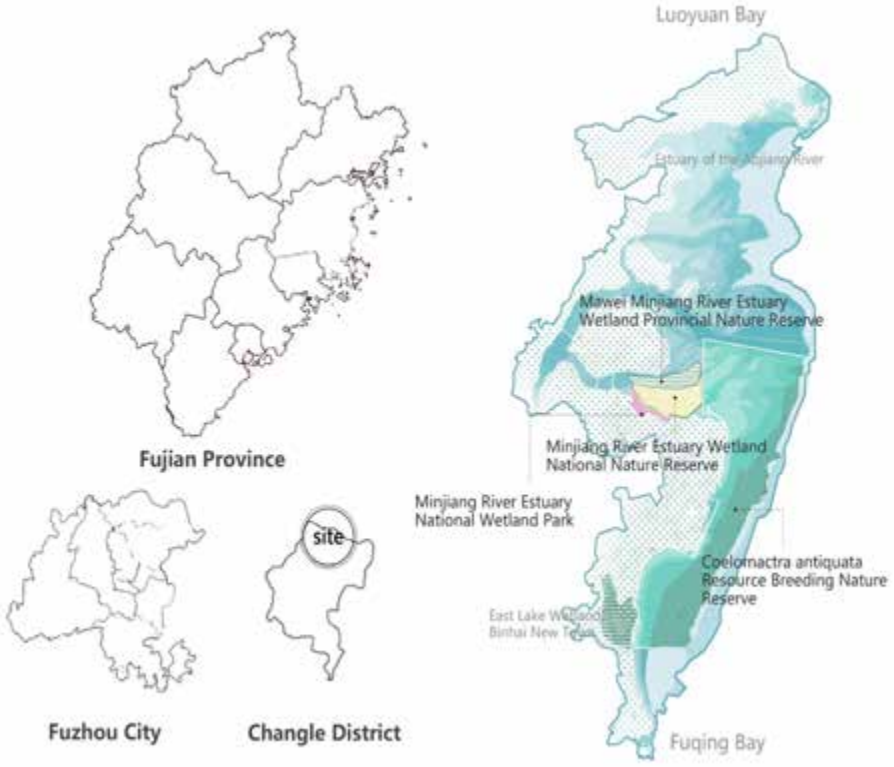

Figure 2 Project location and scope

2 Ecological Significance of the Estuary

The Fujian Minjiang River Estuary is a vital ecological zone where the Minjiang River meets the East China Sea. The estuary encompasses approximately 2,100 hectares of wetlands, including intertidal mudflats, mangrove forests, and shallow marine waters (F. Chen, H.P. Wang, Z.F. Zheng, P.H. Zhang, Y.Y. Ye,1998). As the most well-developed, natural and typical estuary delta in the East Asian subtropical region,

it was designated as a National Nature Reserve in 2013 and added to the Ramsar List of Wetlands of International Importance in 2022(RAMSAR,2022), making it reach a higher level of attention globally.

The ecological importance of the estuary can be summarized into three major aspects.

2.1 Biodiversity Hotspot

Known as the "mother river" of Fujian Province, the Minjiang River originates in the Wuyi Mountains, flows across the expansive plains of Fuzhou City, and ultimately merges into the East China Sea—where the Minjiang River Estuary is situated. (Wang, J.-Q., J. Li, Y.-J. Shih, L.-M. Huang, X.-R. Wang, T.-J. Chu, 2023)eight documents and surveyed data were collected and compared from 1990–2021. To obtain suitable analysis data, the content of the data was compared and evaluated. Explore the suitability of data based on several criteria. Among them, the bottom trawling survey carried out in 2006–2007, and non-parametric estimation methods such as Chao 2, Jackknife 1, Jackknife 2 and Bootstrap were used to estimate the fish species richness. The results of this case show that a total of 153 species of fish were caught in the trawling survey in the fourth quarter, belonging to 14 orders, 57 families and 101 genera. The 2006–2007 cruise is more complete for studying species richness. The Estimable expectations of fish species richness are: 250 (Chao 2

Located at the ecotone of two terrestrial biogeographic provinces and two marine ecological regions(D.Liu, 1995), the Minjiang River Estuary exhibits a high diversity of ecosystems and species with distinct regional characteristics, providing critical habitats for a numerous endangered species, including migratory birds, fish, large marine animals that migrating through the northwestern Pacific, and virous kinds of benthic animals (F. Chen et al.,1998).

2.2 Crucial Steppingstone of Migratory Birds

Situated along the East Asian-Australasian Flyway, the Minjiang Estuary serves as a key stopover and wintering site for numerous migratory birds. A recent survey conducted by Fujian Normal University in 2024 recorded 337 bird species in the Minjiang River Estuary Wetland, spanning 20 orders and 65 families (Fujian Normal University, 2024). Among these, 5 species are listed as Critically Endangered (CR), 10 as Endangered (EN), and 12 as Vulnerable (VU) on the IUCN Red List. Notably, the estuary is home to globally Critically Endangered (CR) species such as the Chinese Crested Tern (*Thalasseus bernsteini)* and Spoon-billed Sandpiper *(Calidris pygmaea)*, underscoring its significance as a critical node for global bird migration, biodiversity conservation, and ecological protection (Figure 5).

Figure 3 Representative Bird Species of Fujian Minjiang River Estuary

The Chinese Crested Tern *(Thalasseus bernsteini)* stands out as the most iconic species of the Minjiang Estuary. Once thought to be extinct for over six decades, it was rediscovered near Mazu Island—close to the Minjiang River Estuary—in 2000 (Lu, Y.et.al., 2020)especially colonies of terns (Subfamily: Sterninae and was given the name "Bird of Legend." Bearing the word "Chinese" in its name, the species is also imbued with cultural significance, often seen as a symbol of good fortune. Despite its symbolic status, the tern faces ongoing threats, including illegal egg collection, summer typhoons, and habitat degradation caused by sewage discharge, agricultural runoff, and industrial pollution(Lin, H., H. Lin, W. Chen, 2011). Enhancing habitat quality and expanding high-tide habitat areas are recognized as key strategies for safeguarding the future of this highly endangered species.

2.3 Coexistence of Ecosystem and Local Community.
Minjiang River Estuary has long been the central of the livelihoods, cultural identity, and heritage of surrounding communities. Exemplifies a gradient evolution of "mountains—human settlements—plain farmlands—saltwater fishponds—sea embankments—intertidal mudflats—river channels—open ocean"(Figure 4), the estuary reflects the natural landscape transition and the dynamic process of human settlement formation and development.

Figure 4 Mountain-to-sea Gradient of Minjiang River

Within the basin, the accumulated cultural activities, exchanges, and ethnic customs of settlements are linked through the Minjiang River. Over the course of history, these elements have fostered a diverse and hierarchically complete urban-rural settlement system, laying a robust foundation for the preservation and inheritance of historical and cultural heritage. By safeguarding the estuary, both cultural fabric and economic well-being of the region can be preserved, promoting a harmonious relationship between nature and local communities for generations to come.

3 Current Threats and Challenges
Over the past century, global warming, accelerated urbanization, and food insecurity have led to growing human encroachment on natural ecosystems(Chen, G., B. Fu, Y. Jiang, X. Suo, Y. Lai, Z. Chen, J. Li, L. Li, M. Lu, Y. Tang, H. Guo, R. Yang, B. Li, 2024). Recent studies indicate that natural World Heritage sites are increasingly at risk due to rapid climate change, particularly in the face of more frequent and severe climate extremes(Ke-Yi, J., W.U. Ming, S. Xue-Xin, 2011). The Minjiang River Estuary has not been immune to these pressures. Activities such as marine aquaculture, the spread of invasive species, and persistent human disturbances continue to pose significant threats to the health and stability of the wetland ecosystem, raising concerns about potential degradation.

Based on a thorough on-site investigation and a detailed evaluation against the criteria for World Natural Heritage, three key challenges have been identified in the study area. First, the ecological integrity and diversity within the existing reservation area is insufficient, and an effective control mechanism has yet to be established.

Second, the hydrological network is insufficiently connected, with ongoing threats such as invasive alien species. Additionally, critical high-tide habitats are missing, and existing waterfowl habitats are both small in scale and lacking in ecological diversity.

Third, Interaction between the wetland and surrounding communities has not been established, and there is a lack of display landmarks with heritage features.

Thus, how to protect the unique ecosystem of the Fujian Minjiang River Estuary, restore the 'home of the mythical bird', and assist in the application process for World Heritage has become a great challenge for both designers and all the other stakeholders.

4 Restoration Strategies and Implementation.
Landscape architects and engineers from various backgrounds gathered on this significant project. Starting from in-depth scientific ecological research, the project adopted nature-based solutions (NbS) to create suitable habitats for endangered water birds such as the Chinese Crested Tern, and strive to promote the regeneration of this wetland.

4.1 Solution 1: Delineate the scope of the reservation area & Establish control rules by grade
4.1.1 Analysis of Regional Uniqueness and Distinguish OUV
As part of this strategy, we began by analyzing the existing zoning framework and species survey data of the study area to distinguish its uniqueness based on its location and species. From the perspective of global terrestrial and marine biome classification systems, the project site lies within a transitional ecotone between two global terrestrial biogeographic regions—the China Subtropical Forest and the South China Rainforest—and two marine ecoregions—the Warm Temperate Northwest Pacific and the South China Sea(M.Holland,1991). Additionally, it falls within a national zoogeographic transition zone(D.Liu, 1995), highlighting its ecological and biodiversity significance.

Within this complex ecological context, multiple forms of ecosystem degradation have been observed (Figure 5). At the same time, the ecological gradient extending from the Wuyi Mountains to the East China Sea—traced by the course of the Minjiang River—has provide foundations for various ecosystems and habitat types(Wang, C., F. Cai, H. Qi, S. Zhao, G. Liu, Y. He, H. Lu, Y. Sun, T. Zhang, 2024). These include intertidal mudflats, salt marshes, shallow coastal waters and subtidal zones, scattered mangrove forests, freshwater wetlands and marshes, and chains of sandbanks and high-tide roosting islands(F. Chen, H.Wang, Feng.Z, P.Zhang, Y.Yan, 1998), providing shelters for numerous endangered species around the globe.

The regional uniqueness of the Minjiang River Estuary was defined through three key characteristics: its position at the convergence of major biogeographical provinces and marine ecoregions; its role as a critical habitat and migratory corridor for marine biodiversity; and its function as a vital staging site along the East Asian–Australasian Flyway. This conceptual framework—grounded in scientific evidence and ecological relevance—has been professionally endorsed by a group of experts, forming a solid foundation for articulating the Minjiang Estuary Wetland's Outstanding Universal Value (OUV).

Figure 5 Ecosystem types of Minjiang River Estuary

Through comparative analysis of analogous World Natural Heritage sites—such as the Wadden Sea, Suncheon Bay, and Phase I of the Yellow Sea–Bohai Gulf Migratory Bird Reserve—as well as key coastal wetlands across China, the Minjiang Estuary Wetland's exceptional value was defined (Figure 6). The site clearly meets UNESCO World Heritage Criterion (x) for its importance to in-situ biodiversity conservation and satisfies more than four Ramsar criteria for internationally significant wetlands. Based on this empirical evidence, its Outstanding Universal Value (OUV) was proposed as:

"One of the most critical natural habitats for in-situ biodiversity conservation globally"—a definition ultimately adopted in the official nomination dossier.

Comparative Analysis of Yellow Sea and Bohai Sea Heritage Sites

	Name	Criterion	Number of bird species	IUCN threatened species (birds)	Number of critically endangered species (birds)
Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase I)	Yancheng Wetland Rare Birds National Nature Reserve, Jiangsu (YS-1)	x	415	17	1
	Yancheng Wetland Rare Birds National Nature Reserve, Jiangsu (YS-2)	x			
Migratory Bird Sanctuaries along the Coast of Yellow Sea-Bohai Gulf of China (Phase II)	Yellow River Delta National Nature Reserve, Shandong	x	381	30	3
	Liaohekou National Nature Reserve, Liaoning	x	292	22	3
	Dandong Yalu River Estuary National Nature Reserve, Liaoning	x	254	23	4
	Getbol, Korea Tidal Flats	x	118	22	1
	Fujian Minjiang River Estuary	x	312	25	5

Figure 6 Comparative Analysis of Minjiang River Estuary and other sites

4.1.2 Optimization of Protected Area and Control Rules by Region

Building upon thematic studies, the zoning of the heritage sites was reconfigured, by adding two extension area – Aojiang Estuary Wetland in Lianjiang County & Donghu Wetland in Binhan New City – the ecological integrity and biodiversity conservation of the wetland ecosystem was enhanced. At the same time, the area of the wetland park, where public interaction and education take place, was reclassified as the buffer zones of heritage site. These adjustments reinforce its function as both a long-term platform for regional ecological governance and a visible interface for World Heritage interpretation.

Following the clear demarcation of the heritage site boundaries, a zoned management system aligned with international conservation standards was implemented(Ringbeck, B. 2008):

1). Core Restricted Zone (Nominated Property): Enforces strict limitations on human activity and infrastructure, consistent with IUCN Category Ia (Strict Nature Reserve) guidelines.

2). Buffer Zone: Focuses on landscape protection and ecological coherence, allowing scientific research and education under regulatory oversight.

3). Co-Development Zone: Sets clear project thresholds and prohibited activity lists, promoting sustainable use through eco-industrial frameworks, green infrastructure, and carrying capacity monitoring (Figure 7).

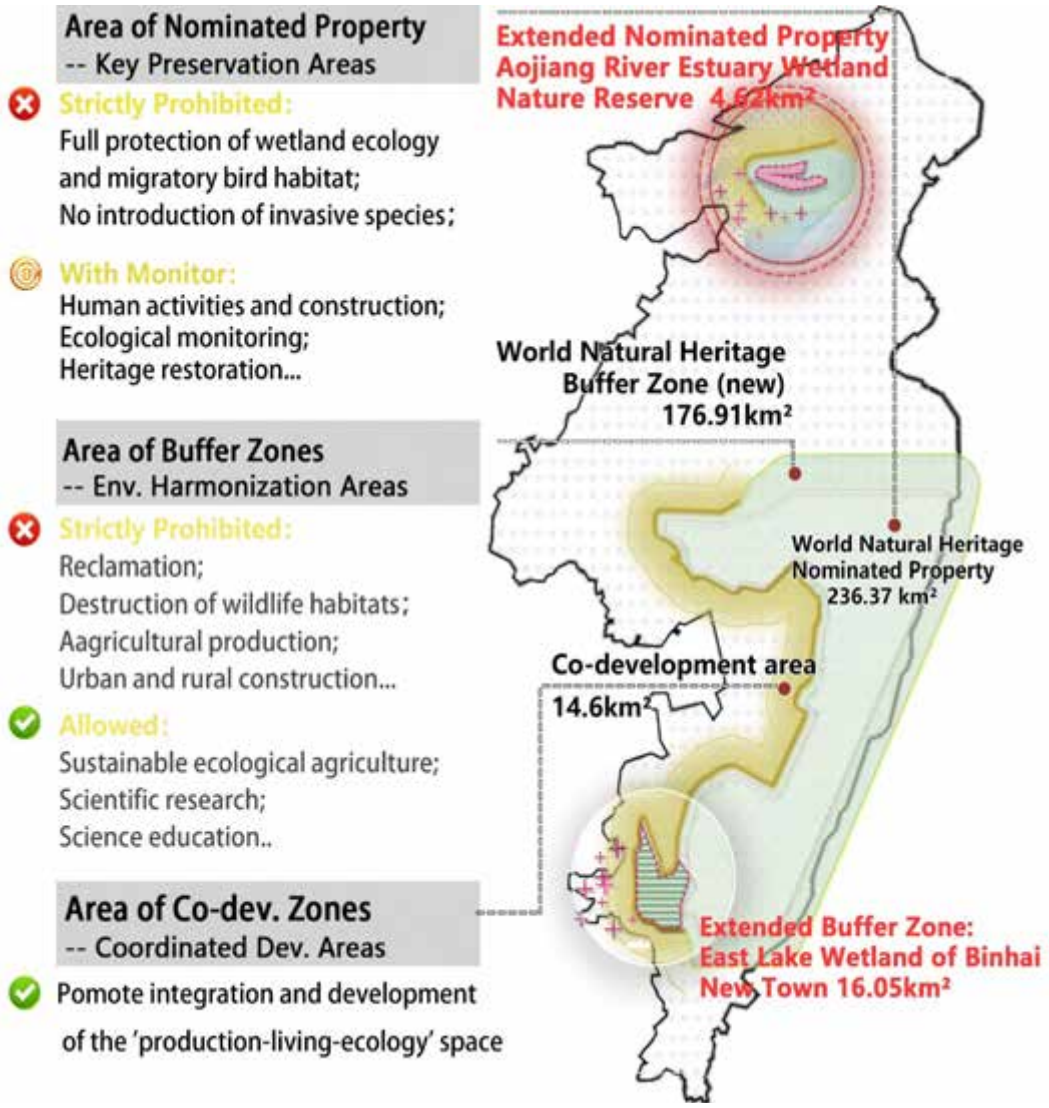

Figure 7 Reservation Area Optimization Plan

4.2 Solution 2: Systematically restore ecosystem & Create bird habitats

4.2.1 Optimization of Hydrological System

Wetlands are areas fundamentally defined by the presence of water, and water level is considered a key factor determining the species richness of waterbirds within these ecosystems(H.Liu, 2006). Fluctuating water levels can create diverse habitats that support various bird species -- for instance, shallow areas may provide feeding grounds, while deeper areas can serve as refuge during dry periods(Sánchez-Zapata, J.A., J.D. Anadón, M. Carrete, A. Giménez, J. Navarro, C. Villacorta, F. Botella, 2005)(A F Boshoff,1991). Given that the study area comprises not only natural habitats such as intertidal mudflats and mangrove forests, but also a substantial expanse of artificial environments like fishponds, designing and managing the hydrological system to provide more suitable habitats is essential to the success of our conservation efforts.

Currently, the hydrological conditions of research area are facing three major issues (Figure 8). First, there is no clearly defined mechanism for water replenishment between the internal fishponds and the adjacent open water, which puts limitation to the exchange of water that are critical for water quality, salinity balance, and the growth of benthic organisms. Second, the hydrological interconnection between each individual ponds are insufficient, leading to stagnation water conditions and signs of eutrophication. Third, the lack of a systematic hydrological regulation results in unpredictable water level fluctuations, undermining the stability and effectiveness of ongoing conservation efforts.

Figure 8 current fishponds of research area

To improve issues above, the project redefined hydrological units, managed the inlet and outlet water channels, added two smart water gates so natural exchange of water body can be realized with tides. By reshaping the pond topography, the internal water flow pathways within each individual pond can be optimized (Figure 9). For example, the northern section of Fishpond#1 has a relatively higher elevation what prevents natural drainage. The design excavates the overly elevated area thereby facilitating the water movement. Excess soil will be repurposed to consolidate the scattered habitat islands, expand the area of shallow zones and create a more coherent and efficient water flow network. In addition, water level regulation mechanism that meets the need of waterfowl habitats was developed, using monitoring data collected from 3 tide gauge stations nearby.

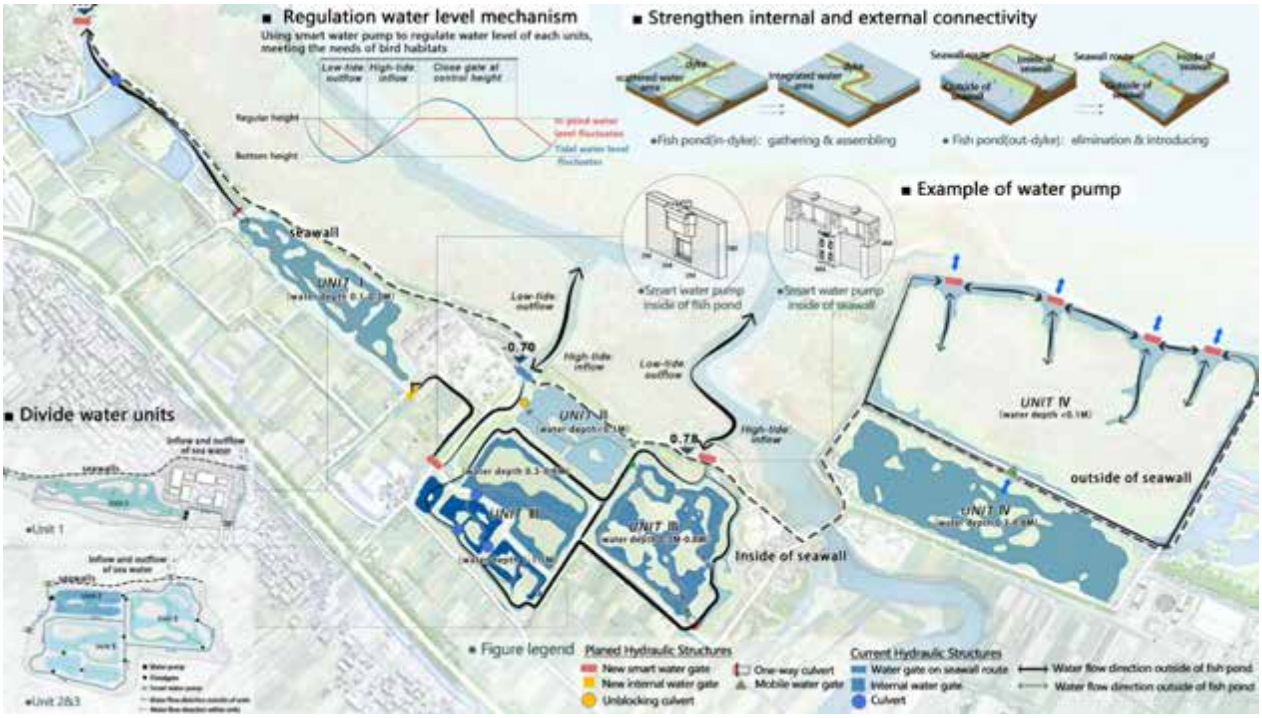

Figure 9 Optimization Efforts for Hydrological System

4.2.2 Replacement of the Occupied Ecological Niches

The Minjiang River Estuary, like other major coastal wetland along eastern China(An, S.Q., B.H. Gu, C.F. Zhou, Z.S. Wang, Z.F. Deng, Y.B. Zhi, H.L. Li, L. Chen, D.H. Yu, Y.H. Liu, 2007), has been significantly affected by invasive plant species, particularly smooth cordgrass (Spartina alterniflora) and common reed (Phragmites australis). S. alterniflora began to invade the Minjiang Estuary in 2002 and since then has gradually expanded its range(Feng, J., Q. Huang, H. Chen, J. Guo, G. Lin, 2018). Although efforts have been made to remove them and restore native vegetation – such as replanting with mangrove species like Kandelia obovata—the habitats of waterbirds remain at risk due to the invasive species occupying critical ecological niches(X.Xie, X.Sun, T.Wu, G.Jiang, L.Pu, Q.Xiang, 2020).

In the planning, a key area was designed for focused ecological management, covering approximately 1,250 hectares (Figure 10). By employing physical methods such as 'mowing, tilling, site preparation and plantation restoration'(Y.Zhu, 2025)(Figure 11), efforts would be made to manage invasive species like Spartina alterniflora (*Spartina alterniflora Loisel*) in this area. Local salt marsh plants such as mangroves, reeds *Phragmites australis*, Cyperus malaccensis *Cyperus malaccensis subsp. monophyllus*, and scirpus mariqueter *Bolboschoenoplectus mariqueter*are planted in suitable areas.

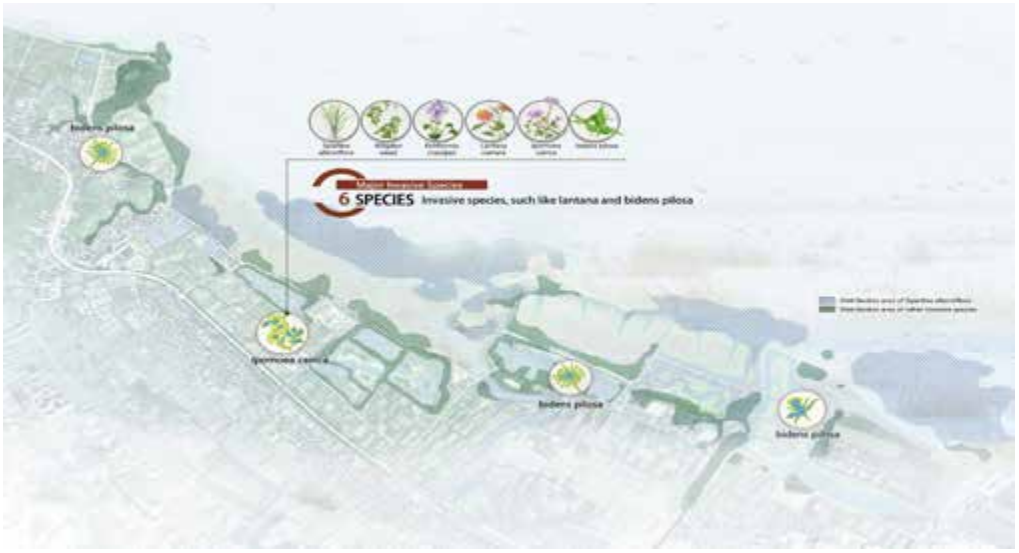

Figure 10 Restoration Area

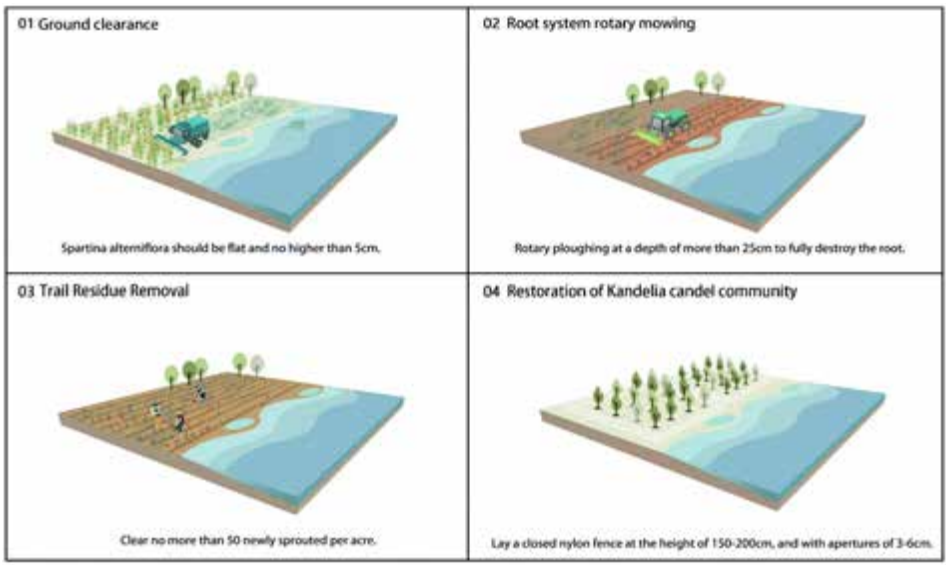

Figure 11 Management Mechanism of Spartina alterniflora

4.2.3 Creation of Diverse Waterbird Habitat

According to the 2020 winter avian monitoring data of Minjiang Estuary wetland, a total of 144 bird species were recorded across the entire area, including various groups such as shorebirds (*Charadriiformes*), geese and ducks (*Anatidae*), and egrets and herons (*Ardeidae*) (Fujian Normal University, 2024). If dividing the wetland into seven zones, labeled A through G, for statistical analysis, one could see that Zone B and E (tidal flats outside the embankment) had the highest volume of birds (Figure 12). Although the total bird counts in Zone C and D (artificial fishponds) was relatively lower, these areas exhibited higher species diversity. Based on our field investigation, the artificial fishponds serve as supplementary habitats for waterbirds during high tide times.

These habitats are moderately suitable for most species; however, due to factors such as poor habitat quality and a lack of suitable benthic organisms, the overall ecological carrying capacity of this area remains low.

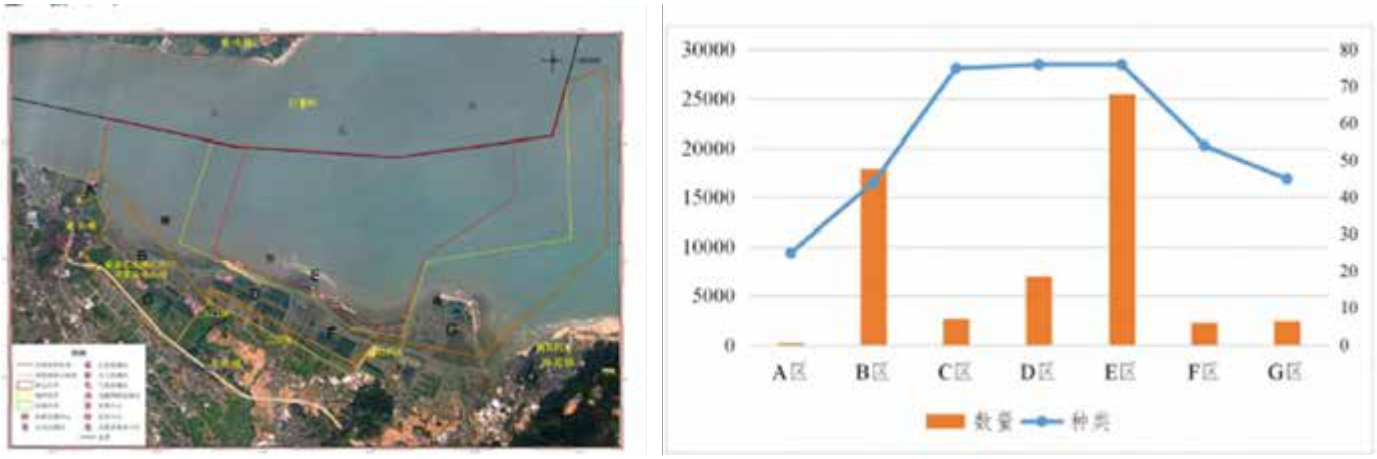

Figure 12 Bird Monitoring Data of Research Area (2020 winter)

To support the diversity of habitat and meet the ecological needs for various bird species, target conservation and management strategies were developed as follows:

For intertidal beach areas, a 100-hectoare core protected zones was designed to be the critical foraging and roosting habitats for migratory waterbirds, including the endangered 'Bird of Legend' Chines Created Tern (*Thalasseus bernsteini*). In addition, the plan suggested to actively manage invasive species to reduce the ecological competition and promote native biodiversity. Efforts such as restoring native wetland vegetation are made to enhance food availability. Tourist activities are prohibited in these core protected zones and only essential scientific research and maintenance work are permitted. In this way we could minimizes human disturbance to the greatest extent possible.

For high-tide habitats area (fishponds), an approximately 118-hectares of are tidal flats was developed to serve as supplementary habitats for waterbirds during vulnerable periods such as high tide and breading seasons. To enhance the ecological function of these restored zones, the plan removed pond dikes and barriers to restore natural water flow. In addition, benthic organisms have been introduced to enrich the food base, providing foraging resources for shorebirds and waterfowl,

Fishponds are in the wetland park, so in areas where tourists may come into close to bird habitats, protective forest belts are strategically planted, providing buffers serve to visually and acoustically isolated the bird habitat from human activity, thereby disturbance such as movement, noise, and light and be reduced.

A diverse range of habitats has been created through ecological reconstruction of selected fishponds. Water level is carefully regulated to fluctuate between 0.1 to 0.3 meters, which accommodates the foraging and nesting needs of wading birds(H.Liu, 2006). In addition, the bottom of the ponds is regraded to a gentle slope of no more that 3%, promoting sage access for birds and enabling gradual water transitions that support a range of aquatic and semi-aquatic species.

These reconstructed habitats are especially suitable for species such as the Black-winged Stilt (*Himantopus himantopus*) and the Pied Avocet (*Recurvirostra avosetta*), which require shallow water and open muddy or sandy substrates for feeding and breeding(H.Liu, 2006). The design not only increases habitat quality but also enhances ecological resilience, enabling the wetland to support a greater abundance and diversity of birdlife across different seasons and tidal cycles (Figure 13).

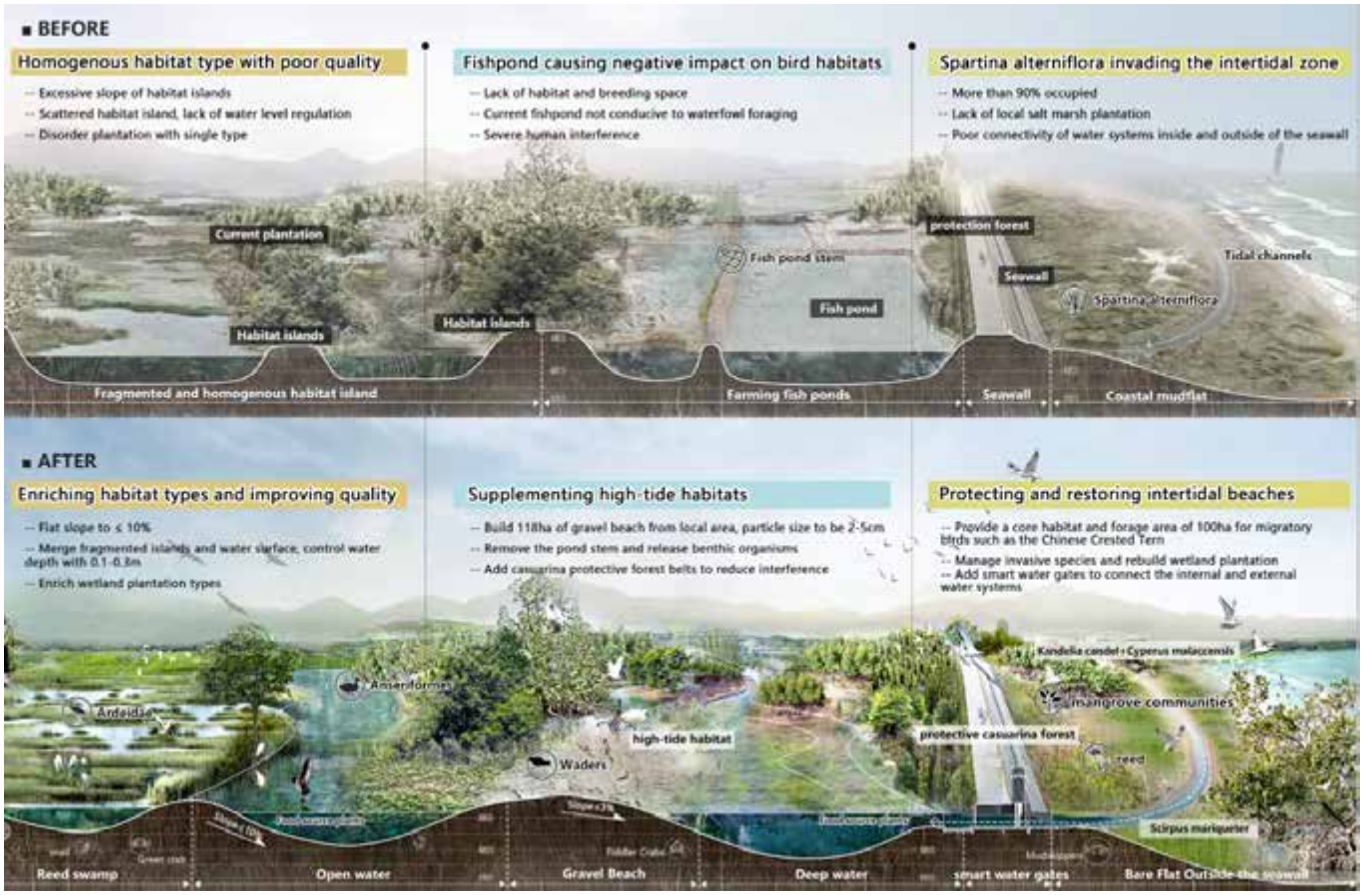

Figure 13 Landform engineering for habitat restoration

4.3 Solution 3: Collaborate with surrounding residents & Demonstrate a World Heritage Showcase

World heritage matters far more the protected area itself. The sustainability of heritage involves the sustainability of the heritage itself and its contributions to the sustainable development of the local population(Xu, L., G. He, L. Chen, 2024). According to UNESCO, World Heritage properties sustain biological and cultural diversity, which may support a variety of ongoing and proposed uses that are ecologically and culturally sustainable and which may enhance the quality of life and well-being of communities concerned(UNESCO,2024) (Lee, Y., R. Jayakumar, 2021).

4.3.1 Promoting a Synergistic Development with Surrounding Villages

The scattered villages and towns surrounding the Minjiang River Estuary Wetland serve as important settlements adjacent to this potential World Heritage site. By targeted environmental remediation and capacity building, actions plan that transform these communities into World Heritage villages were put into action. The transformation involves the strategic selection of dispersed land parcels for the establishment of facilities such as academicians' residences, research apartments, and research centers. Functional zones will be delineated based on the unique characteristics of each settlement – cultural tourism and recreation area, world heritage science and technology exhibition area and coastal leisure area. For example, Meihua Town on the eastern side of the wetland, once been an historic settlement known for its coastal defense heritage, will serve as part of 'cultural tourism and recreation area' and incorporate cultural tourism functions to create integrated pathways connecting local villages with the wetlands. This approach will also enable visitors to engage with both the region's historical and ecological assets, promoting the synergistic development of its natural and cultural heritage (Figure 14).

Figure 14 Creating a Synergistic Development with Surrounding Villages

Simultaneously, the action plan encourages creating sustainable employment opportunities by developing community-based tourism and heritage-related services. These initiatives not only stimulate the local economy but also contribute to the long-term vitality of the region. Invest in capacity building and vocational training to cultivate a new generation of skilled heritage stewards—individuals equipped with the knowledge, sense of responsibility, and practical skills needed to safeguard the site for future generations.

4.3.2 Demonstrate a Unique World Heritage Showcase

In addition to ecological restoration, the renovation of existing wetland infrastructure is a vital component of our broader project. As a symbolic gateway to the Minjiang River Estuary, the wetland museum functions not only as a visitor center but also as a crucial platform for public education and ecological awareness. Although the museum was constructed within the last decade, it suffers from several limitations—including a fragmented layout, an outdated exterior design, and overall underutilization—that falls behind the requirement the World Heritage site requires.

The renovation design draws inspiration from the nesting forms of migratory birds, particularly the iconic Chinese Crested Tern. With an outline resembling outstretched wings in flight, the new structure gently unifies the museum's once-scattered components into the protective embrace of a mythical bird, symbolizing both shelter and renewal(Figure 15).

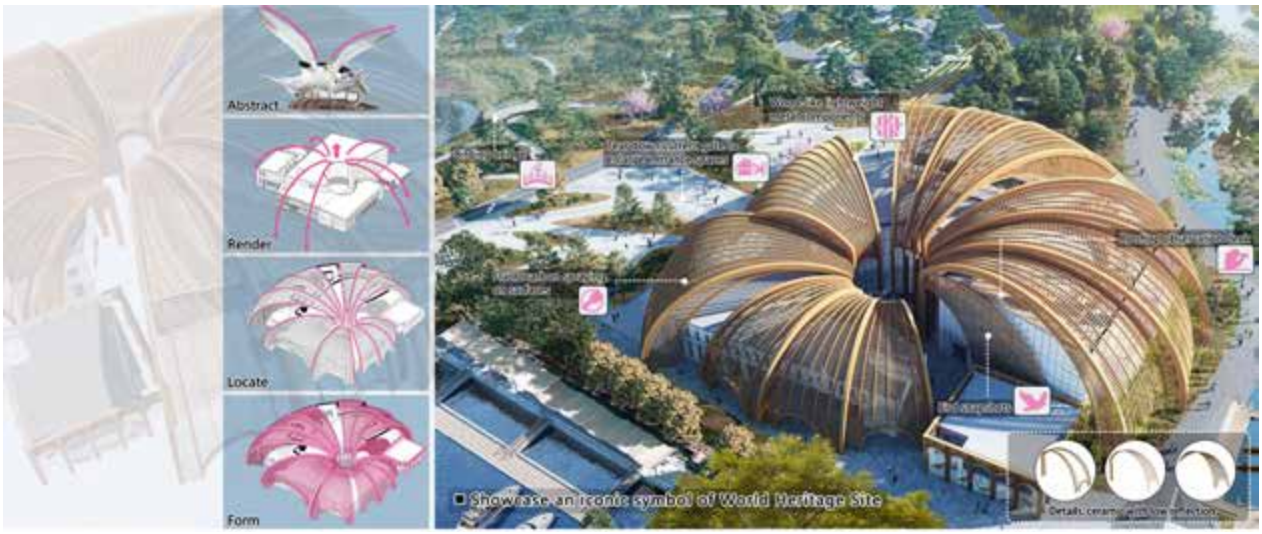

Figure 15 Renovation of Wetland Museum.

The park entrance is another focal point of the design. Inspired by the elegant wings of the Chinese Crested Tern, its fluid lines and graceful form create an inviting gesture—welcoming guests from all directions with a sense of movement, lightness, and warmth (Figure 16).

Figure 16 New design of park entrance

As part of the World Heritage application, this revitalized gateway demonstrates our commitment not only to conservation but to conveying the estuary's outstanding universal value— a shared spaces where human presence and natural life can flourish side by side.

5 Conclusion

The plan, if implemented successfully, would systematically restore 315ha waterfowl habitat, control 182ha of invasive species, supplement 118ha high-tide habitats, and lay out a 14.6km² heritage co-development zone, benefitting 20 surrounding communities and a total of 132000 residents. At the same time, the plan has greatly accelerated the process of the Fujian Minjiang River Estuary's application for Wetland of International Importance and World Natural Heritage sites. In August 2022, the 'Fujian Minjiang River Estuary: The ecotone between marine and terrestrial biogeographical regions' was successfully listed in the World Heritage Tentative List by UNESCO. In February 2023, it was included in the Ramsar Convention List of Wetland of International Importance, providing an important demonstration for the protection and restoration of natural heritage sites from a global perspective.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement
This paper is based on the award-winning project "Conservation and Restoration Planning of Minjiang River Estuary Wetland Park", which was initiated in 2022 for the International Design Competition for the Minjiang River Estuary Wetland in Changle District, Fuzhou, Fujian Province, China. Our institution won the competition and was selected as the lead design team for this project. We extend our gratitude to the project team members—Yang Zhang, Xinyan Liu, Yidi Fu, Jinkun Dai, and Peng Qin—for their dedicated efforts in producing the figures and technical materials used in this paper.

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The Thresholds of Urban Parks' Characteristics on Heat Mitigation EffectβCase Study of 120 Parks in Foshan, China

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Abstract
In the context of the increasingly severe global thermal environmental crisis, this paper examines 120 urban parks in Foshan, a representative water-network city in China's southern region. By using multi-methods integrating Boosted Regression Tree (BRT) modeling, Restricted Cubic Spline (RCS) threshold detection, and K-means clustering, the study explores cooling effectiveness of urban parks based on five metrics: Park Cooling Distance (PCD), Park Cooling Area (PCA), Park Cooling Efficiency (PCE), Park Cooling Intensity (PCI), and Park Cooling Gradient (PCG). Results reveal threshold-dependent cooling effects, with park area, blue-green ratio, and FAR as key determinant factors. Thresholds for optimal cooling efficiency occur at 2.31-4.03 km² park area, vegetation coverage exceeding NDVI 0.277, and blue-water ratio within 0.277-0.515. All the sampling parks could be clustered into four groups: high-efficiency, low-efficiency, medium-efficiency, and comprehensive cooling performance. The findings could provide reference to deeply understand the threshold mechanism in urban heat mitigation and evidence-based planning strategies for optimizing green infrastructure in water-network cities, supporting science-driven thermal environment optimization.

Keywords: Urban Heat Island Effect; Urban Parks; Green Infrastructure; Cooling Mechanism; Lingnan Water Network Cities

1. Introduction

1.1 Urban Heat Island Crisis and the Climate Regulating Role of Green Spaces

With the acceleration of global urbanization, the Urban Heat Island (UHI) effect has become an important environmental issue that threatens the health of urban ecosystems and the well-being of residents. (Oke & Maxwell, 1975; Rizwan et al., 2008). According to the 2021 IPCC report, urban surface temperatures in the 21st century have increased by 1.5-3.0°C compared to the pre-industrial period, with a significant increase in the frequency of extreme heat events (Masson-Delmotte et al., 2021). Urban green spaces have become a central vehicle for heat island mitigation through transpiration, shade effect and air flow regulation (Gong et al., 2024). A properly planned urban park can reduce the surrounding surface temperature by 1-5°C, and its cooling effect is closely related to the characteristics of park area, vegetation cover, and proportion of water bodies (GALLO et al., 1993; Kayet et al., 2016). However, the synergistic cooling mechanism of blue-green spaces in cities with dense water networks is not clear (Stewart, 2011; Zhang et al., 2024).

1.2 Thermal Environment Specificity of Lingnan Water-Network Cities

The Lingnan region is one of the fastest urbanising regions in China, with average annual temperatures 2-3°C higher than the national average and 60-90 days of high temperature in summer (Z. Yu et al., 2017). Foshan is located in the Pearl River Delta and is a typical water network city in the Lingnan region, with a hydrological pattern of the three river confluences of the West River, North River, and Sui River. Foshan has a river density of 0.8-1.2 km/km², creating a unique landscape of a water network city (Foshan Municipal People's Government, 2025). However, rapid urbanisation has led to fragmentation of green spaces and pollution of water bodies, weakening the synergistic cooling capacity of blue-green spaces (Gago et al., 2013). The cooling effect of water network urban parks is multiply affected by the distribution of water bodies, the structure of green space and the intensity of surrounding development (Bowler et al., 2010; Yang et al., 2020). However, studies addressing the threshold effect of their blue-green spaces still need to be supplemented.

1.3 Contradiction Between Threshold Deficiency and Planning Demands

Currently, urban green space planning faces challenges in the context of UHI. It is difficult to quantify the spatial cooling range and intensity of parks without comprehensive cooling performance indicators (Chang & Li, 2014; Feyisa et al., 2014). Measuring marginal effects and identifying thresholds for influencing factors such as park area and blue-green space need further research (Oliveira et al., 2011; Z. Yu et al., 2020). Local planning guidelines lack targeted strategies, leading to inefficient layout of blue-green spaces in water network cities (Ministry of Housing and Urban-Rural Development, 2020). Therefore, there is an urgent need to construct a complete framework of 'Indicators - Mechanisms - Thresholds - Strategies' to provide a scientific basis for thermal mitigation planning in water network cities.

1.4 Research Objectives and Innovations

In this study, 120 parks in Foshan City were used to quantify the spatial cooling effect of the parks by introducing five major indicators, namely PCD (park cooling distance), PCA (park cooling area), PCE (park cooling efficiency), PCI (park cooling intensity), and PCG (park cooling gradient). The non-linear relationship is resolved by identifying the marginal thresholds of factors such as scale, landscape pattern, blue-green space and the surrounding built environment. Finally, based on the k-mean clustering results, optimisation strategies are proposed for four different types of parks with different cooling performance. This study aims to reveal the mechanism of the cooling effect of water network city parks, provide a scientific basis for the optimisation of blue-green space layout, and contribute to the sustainable development of water network cities under the background of global climate change.

2. Materials and methods

2.1. Study area

This study took Foshan City (23°02'N-23°24'N, 112°51'E-113°23'E) as the study area, with a total area of 3797 km², which has a southern subtropical monsoon climate, with an average temperature of 28.5°C in summer (June-August), and extreme high temperatures of up to 39.2. The total length of urban rivers exceeds 6000 km, and the density of the river network is 1.58 km/km². In this study, 120 representative parks were selected from the screening of 382 parks larger than 1 ha. According to the park classification standard of Foshan City, the 120 parks cover five categories: community parks (36%), comprehensive parks (20%), wetland parks (8%), forest parks (12%), and special parks (24%).

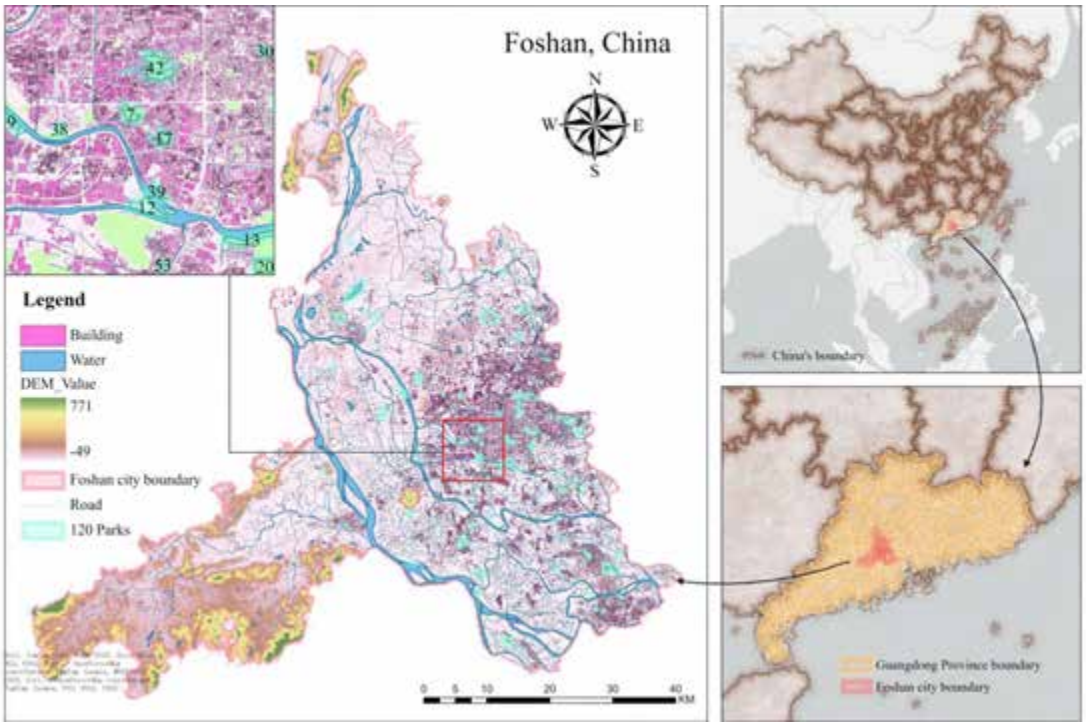

Figure 1 Distribution of the study area and 120 parks in Foshan City (Base map is from the standard map downloaded from the website of the Standard Map Service of the Ministry of Natural Resources (http://bzdt.ch.mnr.gov.cn/))

2.2 Data Sources

2.2.1 Inversion of Surface Temperature

This study used the radiative transfer equation method to invert land surface temperature (X. Yu et al., 2014) providing two adjacent thermal bands, which has a great benefit for the LST inversion. In this paper, we compared three different approaches for LST inversion from TIRS, including the radiative transfer equation-based method, the split-window algorithm and the single channel method. Four selected energy balance monitoring sites from the Surface Radiation Budget Network (SURFRAD. The basic principle involves estimating atmospheric effects on

surface thermal radiation, subtracting them from the total thermal radiation observed by satellite sensors to get surface thermal radiation intensity, and then converting it to land surface temperature.

$$L\lambda = [\varepsilon B(Ts) + (1 - \varepsilon) L-]\tau + L-$$

LΔis the thermal infrared radiation brightness observed by the satellite sensor; LΔis atmospheric upwelling radiance; LΔis the energy from atmospheric downwelling radiance reflected back after reaching the ground; B(Ts) is blackbody thermal radiation brightness; Δis atmospheric transmittance in the thermal infrared band. LΔ LΔ and Δwere obtained from the NASA website (http://atmcorr.gsfc.nasa.gov/). Δis land surface emissivity, calculated using the NDVI threshold method by Sobrino (Sobrino et al., 2004)three methods to retrieve the land surface temperature (LST. Ts is the actual land surface temperature.

$$Ts = K2 / \ln[K1 / B(Ts) + 1]$$

For Landsat - 8, K1 = 774.89 W/(m²·sr·μm) and K2 = 1321.08 K.

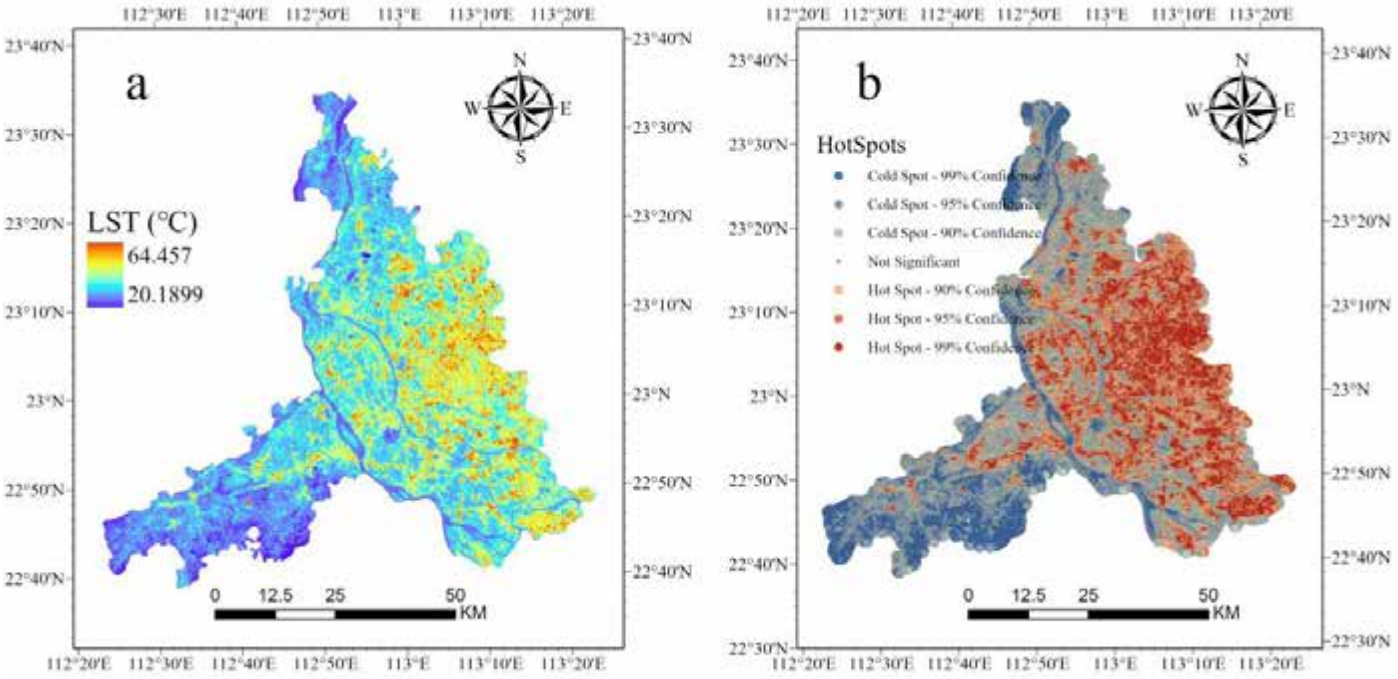

Figure 2 Mean surface temperature of the study area (a) and hotspot analysis map (b). (LST inversion in September 2022)

2.2.2 Data Sources

Remote sensing monitoring data, geospatial data, meteorological observation data and land use data were used in this study (Table 1). The surface temperature (LST) data were obtained from Landsat 8 OLI/TIRS satellite imagery, which was selected during the cloud-free period of September in the summer of 2022, and radiolabelled, atmospherically corrected, and inverted by the single-window algorithm to obtain the surface temperature distribution (Jimenez et al., 2010)thermal imagery at medium and high spatial resolution is useful in many environmental studies, such as evapotranspiration estimation from the energy balance equation, which is a key parameter when working in water resources management. In this sense, the launch in 1982 of the Thematic Mapper (TM. In addition, the field validation was carried out in September 2022, and the surface temperatures of 50 sample points were collected by portable infrared thermometers. Comparison with the satellite inversion results showed that the root mean square error (RMSE) was 1.2°C, and the absolute error was controlled within 1.5°C. The high resolution remote sensing images were collected using the GIS and the GIS. The high-resolution remote sensing image adopts GF-2 satellite data, and after orthorectification, image fusion and Support Vector

Machine (SVM) feature classification, it realises the interpretation of the landscape elements such as forest, grassland, water and impermeable surface of the park.

Table 1 Data Sources

Data Type	Source	Time Range	Preprocessing Methods
Surface Temperature (LST)	Landsat 8 OLI/TIRS (30 m)	Summer 2022 (September)	Radiometric calibration → Atmospheric correction (MODTRAN model) → Single-window algorithm inversion (Jiménez-Muñoz & Sobrino, 2003)
Remote Sensing Imagery	GF-2 Satellite (2 m)	July 2023	Orthorectification → Image fusion → Land cover classification (Support Vector Machine, SVM)
Park Vector Data	Foshan Natural Resources Bureau	2023	Boundary vectorization → Topological inspection → Attribute assignment (area, type, water body proportion, etc.)
Meteorological Data	Foshan National Benchmark Climate Station	2018–2023	Interpolation to generate 1 km resolution raster data (ANUSPLIN model)
Land Use Data	Guangdong Provincial Land Use Status Database	2022	Reclassification into 7 categories including construction land, green space, and water bodies (GB/T 21010–2017)

2.3 Methodology

2.3.1 Quantification of Park Cooling Performance

In this study, the ArcGIS multi-ring buffer model was used to quantify the spatial gradient changes and further quantify the attenuation pattern of the land surface temperature (LST) during the outward extension of the park boundary. A buffer zone is set every 30 metres from the park boundary, generating 40 concentric buffer zones covering a 1200-metre buffer zone. The buffer zone model is based on the Sanshan Forest Park, where the interior of the park is dark green, the area affected by the park cooling is mauve, and the unaffected area is yellow.

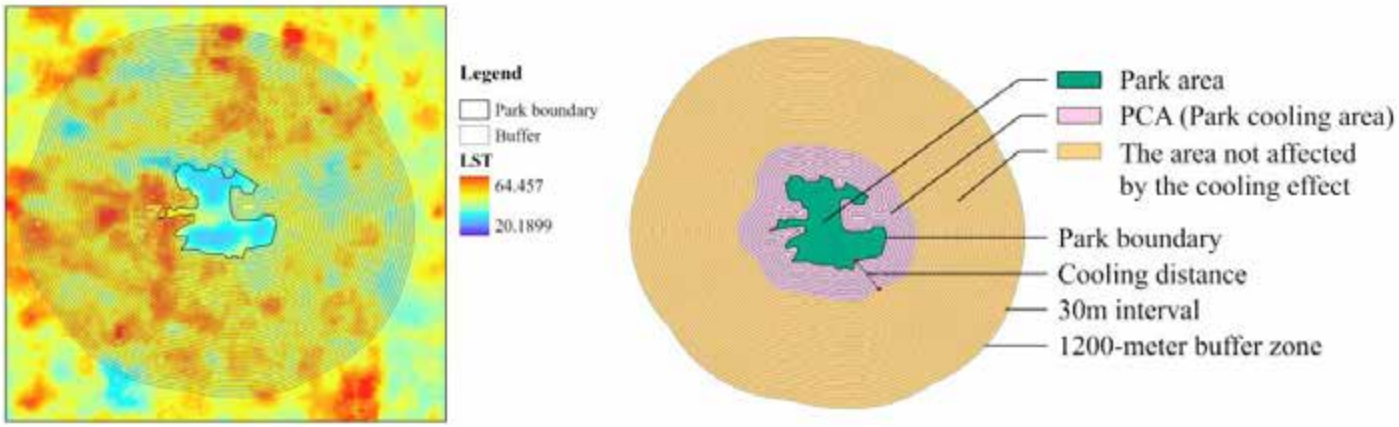

Figure 3 Schematic diagram of multi-ring buffer analysis (taking Sanshan Forest Park as an example, with 30 buffers extending to 1,200 m)

In order to quantify the thermal mitigation effect of the park on the city and to analyse the changing pattern of the park's cooling of the surrounding environment, this study fits a decay curve of the park's LST with distance from the park boundary. As shown in Fig. 4, the variation of buffer LST over the 1200 m buffer distance range of the park is depicted. The park temperature is at the starting point and represents the baseline average temperature within the park. As the distance increases, the average LST per 30 metre buffer goes from increasing to levelling off. The first turning point on the curve is a key metric that calculates park cooling intensity PCI and park distance distance PCD (Aram et al., 2019)..

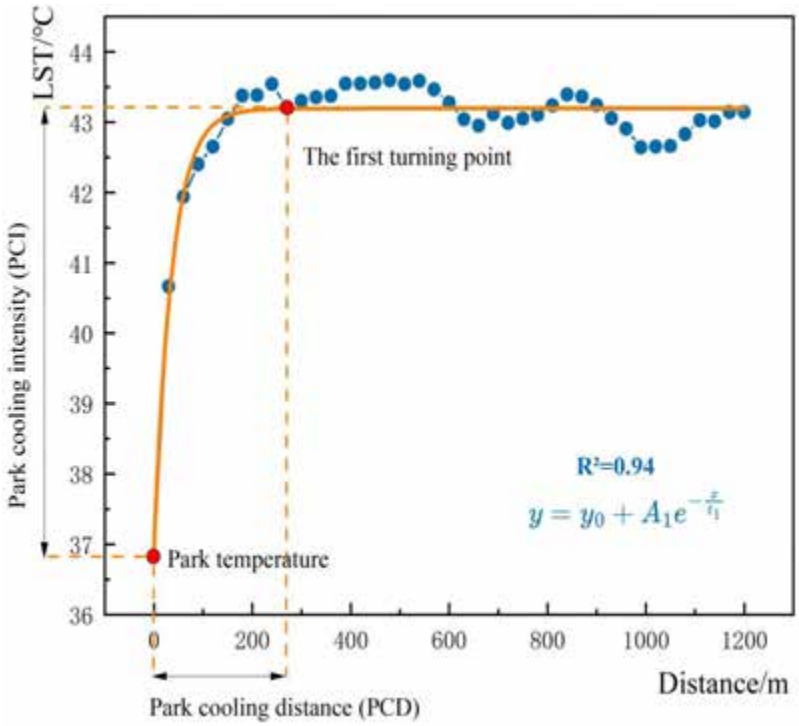

Figure 4 Curve fit of park thermal mitigation to the surroundings (average LST trend per 30 m buffer outside the park, in the case of Sansan Forest Park)

The park cooling effect evaluation system incorporates a multi-dimensional framework comprising five key metrics (Table 2): Park Cooling Distance (PCD), Park Cooling Area (PCA), Park Cooling Efficiency (PCE), Park Cooling Intensity (PCI), and Park Cooling Gradient (PCG). These indicators collectively provide a comprehensive quantification of urban parks' thermal mitigation capacity .

Table 2 Evaluation Index System for Park Thermal Mitigation Effects

Indicator	Definition	Calculation Formula	Unit
Park Cooling Distance (PCD)	Distance from park boundary to the boundary of the cooling effect	PCD = Distance from the first turning point to the park boundary (Figure 4)	m
Park Cooling Area (PCA)	Area within the park's influence range where temperature is significantly lower than the background value	PCA = Area of the buffer zone from the first turning point to the park boundary	km²
Park Cooling Efficiency (PCE)	Cooling area per unit park area	PCE = PCA / Park area	km²/km²
Park Cooling Intensity (PCI)	Average temperature drop within the cooling range	PCI = ΔT (Buffer zone LST - Park LST)	
Park Cooling Gradient (PCG)	Attenuation rate of temperature drop with distance from the park	PCG = ΔT / Distance	100m

2.3.2 Selection of Environmental Variables

In order to reveal the key drivers of thermal mitigation effects in urban parks, 20 variables were selected in this study from six dimensions: park morphology, distribution, structure, surrounding built environment, peripheral land cover and regional climate (Table 3). The first three dimensions are within the park, and the last three dimensions are located outside the park within the 1200 m buffer zone.

Table 3 Definitions and Calculation Methods of Influence Variables

Indicator Category	Specific Indicator	Abbreviation	Formula
Park Morphological Features	Park Area	PA	Vector data area
	Park Perimeter	PP	Vector data perimeter
	Elevation	DEM	Mean elevation within the park
	Normalized Difference Vegetation Index	NDVI	$NDVI = \frac{NIR - R}{NIR + Rw}$
Park Distribution Features	Impervious Surface Area Ratio	BR	$BR = \frac{\text{Impervious Surface Area in Park}}{\text{Total Park Area (PA)}}$
	Water Area Ratio	WR	$WR = \frac{\text{Water Body Area in Park}}{\text{Total Park Area (PA)}}$
	Forest Area Ratio	FR	$R = \frac{\text{Forest Land Area in Park}}{\text{Total Park Area (PA)}}$
	Grassland Area Ratio	GR	$GR = \frac{\text{Grassland Area in Park}}{\text{Total Park Area (PA)}}$
Park Structural Features	Landscape Shape Index	LSI	$SI = \frac{\text{Park Perimeter (PP)}}{2\sqrt{\pi} \times \text{Park Area (PA)}}$
	Aggregation Index	AI	$AI = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij}}{A} \times 100$
	Contagion Index	CONTAG	$CONTAG = 100 \times \frac{-\sum_{i=1}^{n} \sum_{j=1}^{n} p_{ij} \ln(p_{ij})}{2\ln(n)}$
Built Environment Surrounding	Building Density	BD	$BD = \frac{\text{Building Base Area}}{\text{Site Area}} \times 100\%$
	Floor Area Ratio	FAR	$FAR = \frac{\text{Total Floor Area}}{\text{Site Area}}$
Land Cover Surrounding Parks	Impervious Surface Ratio in Buffer	BBR	$BBR = \frac{\text{Impervious Surface Area in Buffer}}{\text{Total Park Area (PA)}}$
	Water Body Ratio in Buffer	BWR	$BWR = \frac{\text{Water Body Area in Buffer}}{\text{Total Park Area (PA)}}$
	Forest Ratio in Buffer	BFR	$BFR = \frac{\text{Forest Land Area in Buffer}}{\text{Total Park Area (PA)}}$
	Grassland Ratio in Buffer	BGR	$BGR = \frac{\text{Grassland Area in Buffer}}{\text{Total Park Area (PA)}}$
Climatic Conditions Surrounding	Surrounding Temperature	BLST	Mean LST in buffer zone
	Surrounding Wet	BWET	Mean humidity in buffer zone
	Surrounding Elevation	BDEM	Mean DEM in buffer zone

2.3.3 Analysis Models

(1) **Boosted Regression Tree (BRT) Model**

This study employed the Boosted Regression Tree (BRT) model to quantifie the influence of independent variables on dependent variables through relative Influence. This approach integrates multiple regression trees through a machine learning strategy to effectively capture complex interactions and threshold effects among variables (Elith et al., 2008; Friedman, 2001). The model's predictive accuracy was validated using the root-mean-square error (RMSE) and coefficient of determination (R^2) to ensure its reliability in quantifying the thermal effects of urban parks, providing data-driven support for subsequent spatial planning strategies.

$$RI_v = \frac{\sum_{m=1}^{M}\sum_{k=1}^{K_m}\Delta E_{m,k,v}}{\sum_{m=1}^{M}\sum_{k=1}^{K_m}\Delta E_{m,k}} \times 100\%$$

Where "v" is target independent variable (e.g., NDVI, BD); "M" is total number of regression trees; "K_m" is number of splits in the m-th tree; is reduction in squared error when variable v is used in the k-th split of the m-th tree.

(2) Restricted Cubic Spline (RCS) Curves and Threshold Identification

Restricted Cubic Spline (RCS) is a nonparametric statistical method that fits the nonlinear relationship between a continuous variable and a response variable by means of a segmented cubic polynomial function, with first and last linear constraints imposed to ensure the smoothness of the curve and the stability of the extrapolation (Govindarajulu et al., 2009; Zhao et al., 2024). The core advantage of RCS is its ability to automatically capture complex nonlinear patterns through segmental fitting and smooth connections. Its mathematical form is as follows.

$$f(X) = \beta_0 + \beta_1 X + \sum_{k=1}^{K-2} \beta_{k+1} \cdot h_k(X)$$

X is a continuous predictor variable; hk is the basis function; and tk is knots, usually taken as equidistant quartiles. In order to identify the thermal mitigation thresholds of the parks for the urban environment, the first order derivative (slope) and second order derivative (curvature) of the curves were calculated.The RCS curves allow for the identification of two critical inflection points (Fig. 5). The two critical inflection points are defined in the first-order derivative plot as the point where the slope of threshold 1 (T1) is 0 and threshold 2 (T2) is the point with the largest slope, when the rate of thermal mitigation of the park to the urban environment is likely to be optimal.

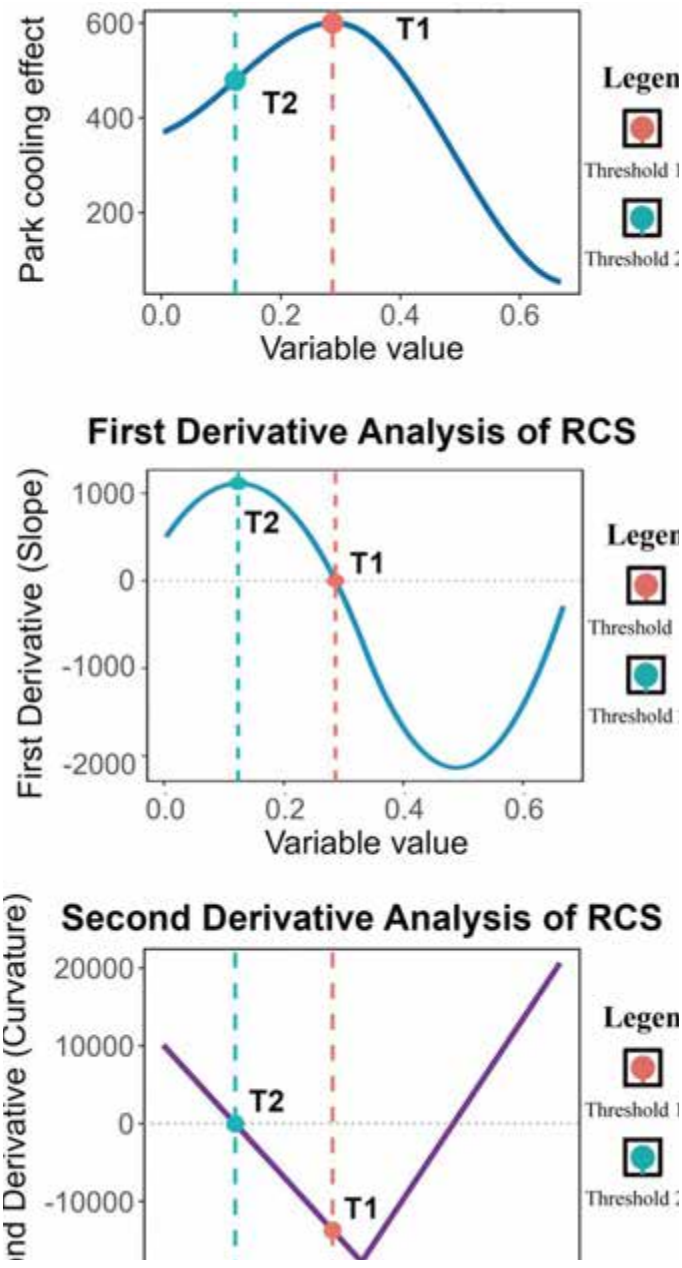

Figure 5 Schematic Diagram of Restricted Cubic Spline (RCS) and Thresholds

(3) K-means Cluster Analysis

In this study, a K-means clustering algorithm was used to classify the cooling performance of parks, with the aim of identifying clusters with similar cooling characteristics and quantifying their relative contributions (Kanungo et al., 2002)we are given a set of n data points in d-dimensional space R/sup d/ and an integer k and the problem is to determine a set of k points in Rd, called centers, so as to minimize the mean squared distance from each data point to its nearest center. A popular heuristic for k-means clustering is Lloyd's (1982. The optimal number of clusters was determined by the elbow rule in conjunction with the contour coefficient method. The elbow rule is based on the inflection point of the curve of the within-group sum of squares (WSS) with respect to the number of clusters, and the contour coefficient method is performed by calculating the average contour coefficient of 2 to 10 clusters (with values ranging from [-1,1], with larger values indicating better intra-cluster compactness and inter-cluster separation. The final result is determined (K = 4) as the optimal number of clusters.

3. Research Results

3.1 Spatial Patterns of Park Thermal Mitigation in Summer

3.1.1 Gradient Attenuation of Cooling Performance

In the spatial pattern of heat mitigation in parks in summer, the gradient decay of cooling effect showed significant regularity and spatial differentiation characteristics. Based on the buffer zone temperature analysis, all parks formed a significant cooling zone, with a mean park cooling distance (PCD) of 493.5 m and a mean cooling intensity (PCI) of 3.7 °C. The park cooling gradient (PCG) was 1.38°C/100 m, which means that the temperature drop decreased by 1.38°C with every 100 m increase in distance from the park, revealing the basic law that the park thermal mitigation effect exponentially decays with increasing spatial distance. The analysis of spatial heterogeneity shows that there are significant differences in cooling efficiency and coverage between parks of different zones and sizes. Wetland parks in the suburbs (e.g., Yundonghai Wetland Park in Sanshui, with an area of 4.35 km^2) had a park cooling area (PCA) of 6.21 km^2 and a park cooling efficiency (PCE) of 1.43 km^2/km^2, while community parks in the city centre (e.g., Zhongshan Park in Chancheng, with an area of 0.27 km^2) had a PCA of only 1.58 km^2, but their PCE was as high as 5.72 km^2/km^2. This suggests that although small parks have advantages in cooling efficiency, their absolute cooling coverage is limited due to their size (Figure 6).

The modulation of the cooling effect by the heat island background is significant. The mean surface temperature (LST) in the city centre area (Chancheng District) is 40.88°C, which is 7.3°C higher than that in the suburban area (Gaoming District), and as a result, the cooling gradient (PCG) in the city centre parks is 0.97°C/100 m, which is significantly lower than that in the suburban parks, which is 1.61°C/100 m. (Fig. 7), which suggests that the spatial decay rate of the cooling effect of the parks is weakened by the high intensity of the heat island environment. This indicates that the high-intensity heat island environment will weaken the spatial decay rate of the cooling effect in the parks, forming a spatial pattern of slowing down the cooling gradient in the thermal background.

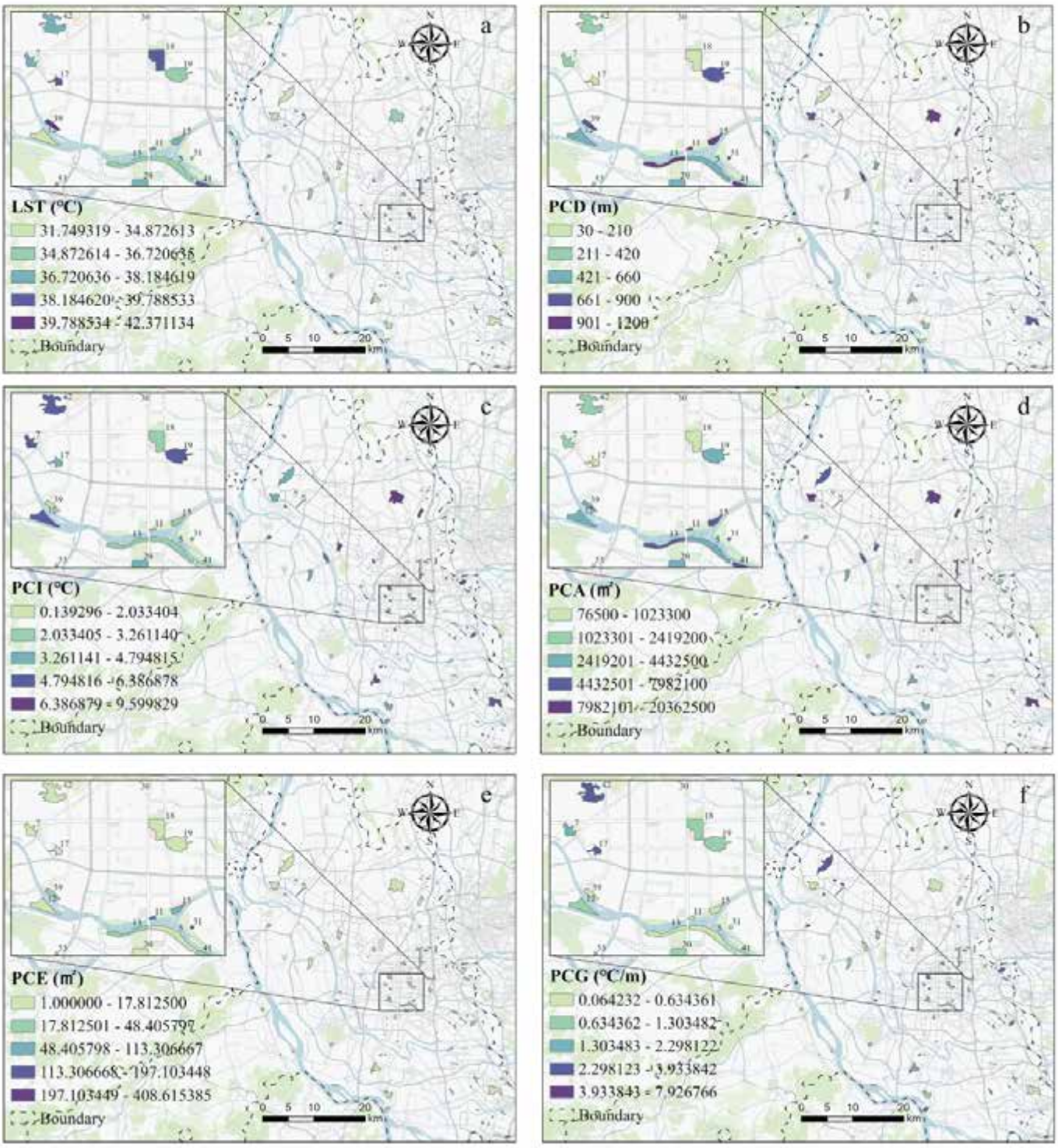

Figure 6 Spatial Distribution Maps of LST and 5 Park Cooling Performance Index for 120 Urban Parks: (a) Park LST, (b) PCD index, (c) PCI index, (d) PCA index, (e) PCE index, (f) PCG index.

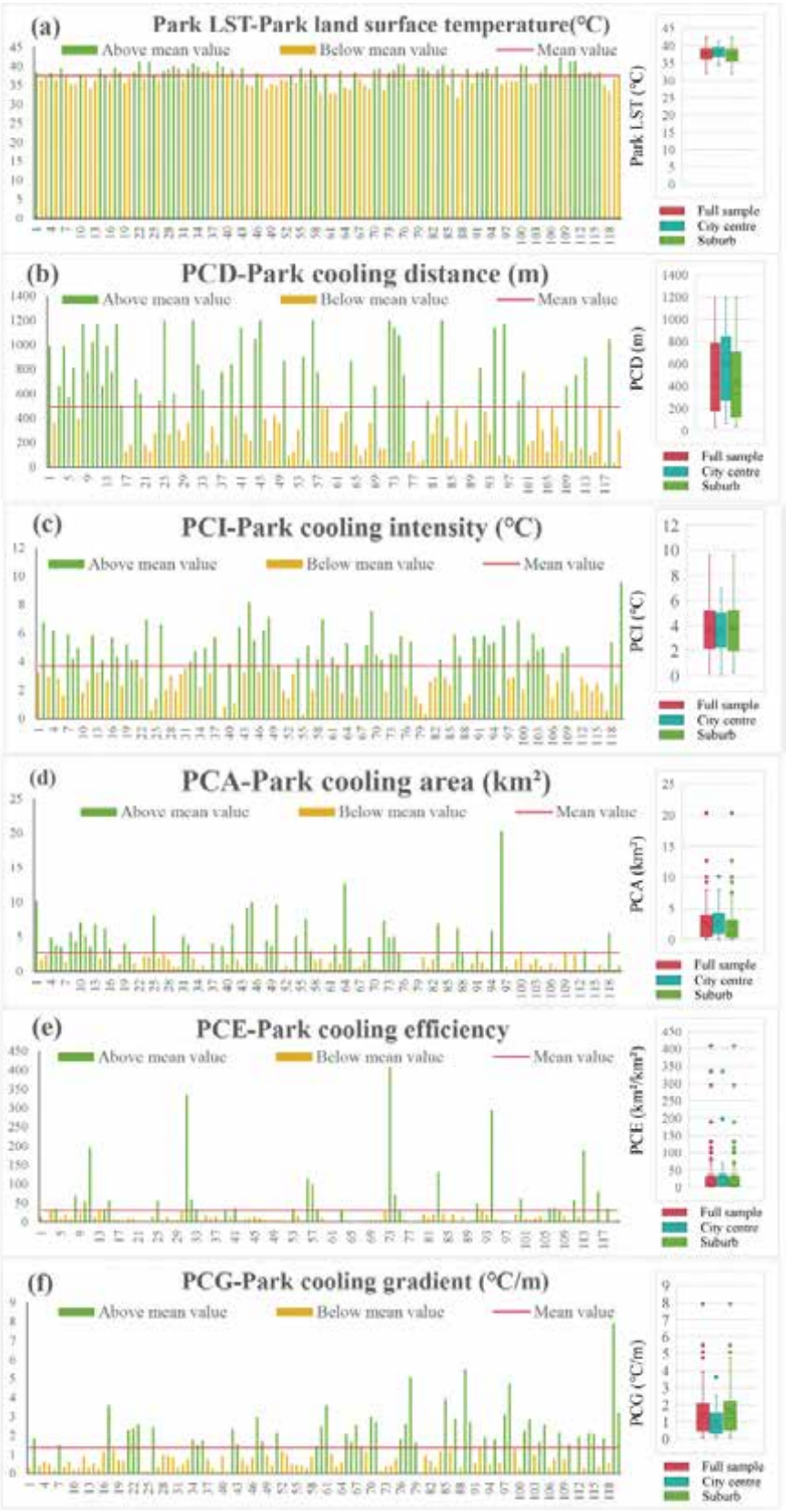

Figure 7 Bar Charts and Boxplots of Six Cooling Indices for 120 Urban Parks: The red boxplots represent the full sample, light green denotes downtown areas, and dark green indicates suburban areas.

3.1.2 Cooling Performance of Different Park Types

Based on the Foshan City park classification standard, the 120 parks included Community Parks, Comprehensive Parks, Wetland Parks, Forest Parks, and Special Parks. Among them, Forest Parks had an average PCI of 5.44±1.61°C, which was significantly higher than that of other types of parks, and their average PCA (4.84±5.38 km²) and PCG (1.8±1.4°C/100m) were higher compared with those of other parks, which was attributed to the synergistic effect of their large natural vegetation and complex ecosystems.Comprehensive Parks' PCA (4.36±3 km²) and PCD (743.75±287.75m), were outstanding, possibly due to their diverse landscaping with a large footprint. In contrast, the average PCI of specialised parks was only 2.23±1.62°C, but their PCE (43.58±98.84 km²/km²) showe1d high discrete characteristics, reflecting the differences in design elements such as vegetation configurations and water body areas in different specialised parks. Although the wetland park had a higher PCG (1.66±0.95°C/100m), its PCA was smaller (1.11±2.92 km²), which might be limited by the localised evapotranspiration of wetland water bodies.

Table 4 Cooling Performance of Different Park Types

Park Type	Sample	Mean PCI/□	Mean PCA/ km²	Mean PCE/km²/ km²	Mean PCD/m	Mean PC-G/□/100m
Community Parks	43	3.71±1.48	2.69±1.35	30.21±35.59	493.5±260.8	1.38±0.82
Comprehensive Parks	24	4.08±2.01	4.36±3	40.84±61.52	743.75±287.75	0.68±0.61
Wetland Parks	10	4.05±1.59	1.11±2.92	23.28±15.57	337.67±409.19	1.66±0.95
Forest Parks	14	5.44±1.61	4.84±5.38	11.49±18.72	555±414.32	1.8±1.4
Special Parks	29	2.23±1.62	1.81±1.81	43.58±98.84	393.1±380.09	1.56±1.88

3.2 Key Influencing Factors of Park Cooling Performance

3.2.1 Significance ranking of the Variables

Based on the BRT model results (Fig. 8), the model fit was generally satisfactory, with PCD (R^2=0.64), PCA (R^2=0.87), PCE (R^2=0.58), PCG (R^2=0.67), and PCI (R^2=0.83). Landscape pattern, land cover type, park morphological features and built environment were the core influences on thermal mitigation. Among them, in PCA, Park Perimeter (PP) was the most critical, reflecting the influence of park morphological boundaries on cooling diffusion, and Park Morphological Features accounted for 27.74%, indicating that the park's own morphological structure was the core factor determining PCA; on Cooling Efficiency (PCE), the importance of Park Area (PA) was prominent, showing that the scale effect had an impact on the cooling efficiency of unit area. Land Cover Types and Park Morphological Features together accounted for 81.98%.

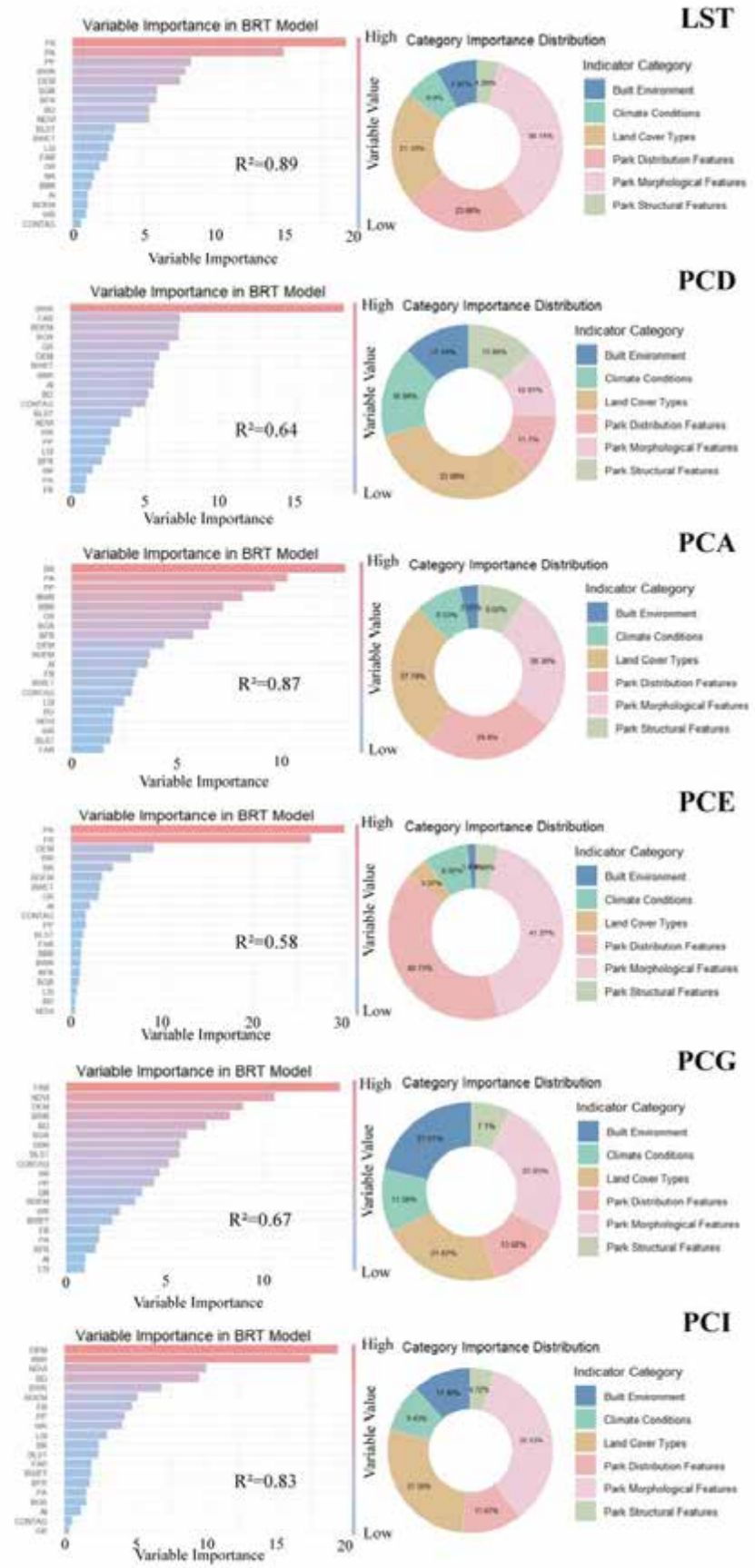

Figure 8 Importance Ranking of Influence Variables on Park Cooling Performance Based on BRT Model

3.2.2 Marginal Effect Analysis

Based on the BRT model, the study selected the five influencing variables with the highest variable ranking, constructed their restricted cubic spline curves (RCS curves) with the five park cooling performance indices (PCD, PCA, PCE, PCG, and PCI), and identified the thresholds (Figure 9). The park cooling performance index is mainly affected by various factors such as PA, DEM, FAR, NDVI, BD, BBR, BWR, etc., and shows a complex nonlinear relationship. Using the RCS curve, we can explore the increase and decrease of cooling intensity when the values of variables change, so as to guide the reasonable use of relevant variables to improve cooling intensity in park design, and then assist in determining the scope of variable control to improve cooling efficiency.

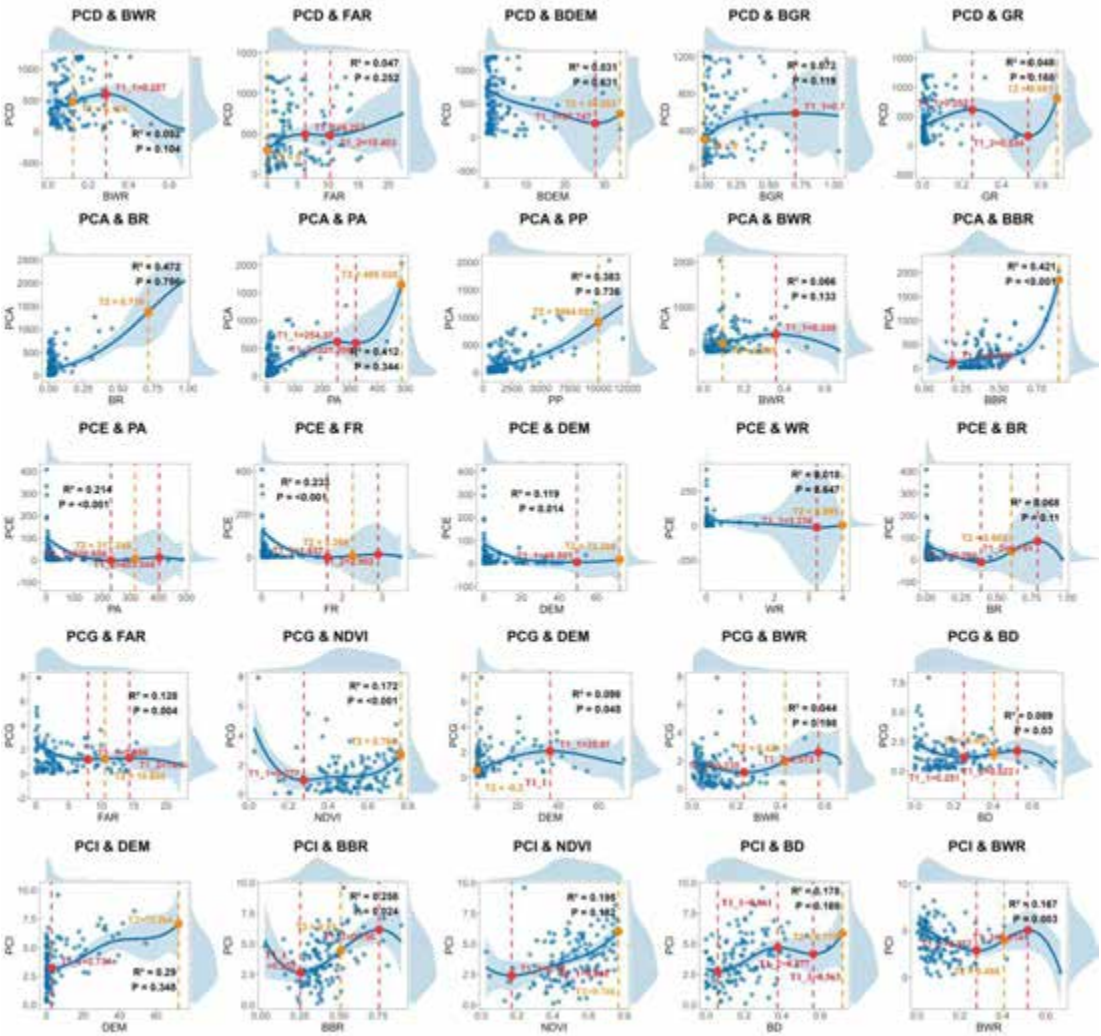

Figure 9 Restricted Cubic Spline (RCS) Curves and Threshold Identification for the Top Five Influencing Variables Ranked by the BRT Model and Five Park Cooling Performance Indices (Thresholds Marked in Yellow as T2 and Red as T1)

3.3 Threshold of Heat Mitigation Effects

Based on the RCS curve model, statistically significant thresholds were identified for 8 key variables (Table 5). Park area (PA) (R2 = 0.214, P < 0.001) showed increasing marginal utility of PCE in the interval [2.31, 4.03] k m², with the fastest growth rate at 3.17 k m², suggesting that moderately sized parks are favourable for the improvement of cooling efficiency.In terms of DEM, the effects on PCE (R2 = 0.119, P < 0.05) and PCG (R^2 = 0.098, P < (R^2=0.098, P<0.05) varied at different thresholds, with PCE changing from decreasing to increasing when the threshold exceeded 49.551m. Among the indicators of the built environment around the park, the building density (BD) (R^2=0.089, P 0.05) showed an increasing trend in the interval of [0.251, 0.523], and the fastest rate of change was observed at 0.403; the floor area ratio (FAR) (R^2=0.128, P 0.01) showed an increasing trend in the interval of [7.986, 14.34], and the

slope of increase was observed at 10.604, and the slope of increase at 10.604. The slope of the increase reached its maximum at 10.604. The NDVI (R^2=0.172, P<0.001), an indicator of vegetation cover, showed an increasing trend of PCG in the interval of [0.277, 0.766], with the maximum slope at 0.766. BBR (R^2=0.167, P<0.05) and BWR (R^2=0.167, P<0.05), positively affected PCA and PCI in the intervals [0.252, 0.756] and [0.277, 0.516], respectively, and reached the extremes of the rate of increase at the 51% and 40% thresholds.

Table 5 Thresholds of Key Variables for Cooling Performance and Their Ecological Significance

Variable	Cooling Performance Index	Threshold	Physical Meaning	Significance
PA	PCE	T1_1=2.31 km², T1_2=4.03 km²	When PA is within [2.31, 4.03] km², per-unit cooling efficiency (PCE) shows an upward trend (increasing marginal utility); outside this interval, PCE declines (decreasing marginal utility).	R^2=0.214, P < 0.001
		T2=3.17 km²	At PA=3.17 km², the slope reaches its peak, indicating the fastest growth rate of PCE.	
DEM	PCE	T1=49.551 m	Below 49.551 m, PCE decreases rapidly with elevation; above 49.551 m, PCE increases.	R^2=0.119, P < 0.05
		T2=72.266 m	At 72.266 m, the growth rate of PCE reaches its maximum.	
	PCG	T1=35.97 m	Below 35.97 m, PCG rises rapidly with elevation; above 35.97 m, PCG declines.	R^2=0.098, P < 0.05
FAR	PCG	T1_1=7.986, T1_2=14.34	When FAR is within [7.986, 14.34], PCG shows an upward trend; outside this interval, PCG declines.	R^2=0.128, P < 0.01
		T2=10.604	At FAR=10.604, PCG increases at the fastest rate.	
NDVI	PCG	T1=0.277	Below NDVI=0.277, PCG decreases with NDVI; above 0.277, PCG increases. This marks the transition point from decline to growth.	R^2=0.172, P < 0.001
		T2=0.766	Within NDVI [0.277, 0.766], PCG rises; at NDVI=0.766, the growth rate peaks.	
BD	PCG	T1_1=0.251, T1_2=0.523	Within BD [0.251, 0.523], PCG increases; outside this range, PCG decreases.	R^2=0.089, P < 0.05
		T2=0.403	At BD=0.403, the rate of PCG change reaches its maximum.	
BBR	PCA	T1=0.188	Below BBR=0.188, PCA decreases with BBR; above 0.188, PCA increases. This marks the transition from decline to growth.	R^2=0.421, P < 0.001
		T2=0.896	At BBR=0.896, PCA increases at the fastest rate.	
BBR	PCI	T1_1=0.252, T1_2=0.756	Within BBR [0.252, 0.756], PCI increases; outside this range, PCI declines. T1_1 marks the transition from decline to growth, and T1_2 marks the reversal.	R^2=0.167, P < 0.05
		T2=0.51	At BBR=0.51, the growth rate of PCI peaks, indicating the strongest positive effect.	
BWR	PCI	T1_1=0.277, T1_2=0.516	Within BWR [0.277, 0.516], PCI increases; outside this range, PCI declines. T1_1 marks the transition from decline to growth, and T1_2 marks the reversal (or significant trend change).	R^2=0.167, P < 0.05
		T2=0.405	At BWR=0.405, PCI increases at the fastest rate.	

3.4 Cluster Analysis of Four Cooling Patterns

In this study, 120 park samples were classified into 4 cooling performance clusters by K-mean clustering algorithm (Table 7, Fig. 10), revealing the differences in cooling mechanisms among different park clusters.The High-Efficiency cluster (28 samples) with PCI=0.430, PCA=1.299, PCE=0.094 and PCD=1.288, presented a high-intensity, large-area, far-radial pattern. The dominant factors of this cluster are the increasing marginal utility interval of park area (PA) over 2.31 kΔand NDVI over 0.766. Among them, Qiandeng Lake Park and Wanglugang Forest Park achieve efficient cooling through the layout of large water bodies and high vegetation cover, respectively.

The Low-Efficiency cluster (48 samples) has negative cooling indicators (PCI=-0.733, PCA=-0.432, PCE=-0.184), and is characterised by short cooling distances and gentle gradient attenuation, which is mainly due to the high BD (BD>0.523) or insufficient FAR (FAR<7.986), and insufficient NDVI (NDVI<0.277). In particular, the Half Moon Island Wetland Park had a limited cooling effect due to a high ratio of impervious surfaces in the buffer zone.

The Moderate Efficiency cluster (39 samples) had a moderate PCI=0.594 but a significantly positive PCG=1.026, with negative PCA and PCI, reflecting outstanding spatial heterogeneity. The dominant factors were DEM (DEM<35.97 m) and microtopographic differences under artificial intervention. Among them, Zhongshan Park in Chancheng formed a strong cooling gradient due to its close proximity to the built-up area but failed to reach an efficient level due to its size. Comprehensive clusters (5 samples) with PCE=4.199 were extremely high, such as the high evapotranspiration agricultural wetland model in Shuiteng Park.

Table 7 Cooling Characteristics of Four Park Clusters

Cluster Name	Samples	PCI	PCA	PCE	PCD	PCG	Typical Cases
High-Efficiency	28	0.430	1.299	0.094	1.288	-0.695	Qiandeng Lake Park, Yingyue Lake Park, Wangjiegang Forest Park
Low-Efficiency	48	-0.733	-0.432	-0.184	-0.352	-0.341	Banyuedao Wetland Park, Nan-hai National Fitness Sports Park
Moderate Efficiency	39	0.594	-0.487	-0.380	-0.706	1.026	Chancheng Zhongshan Park, Shiwan Park, Leigang Park
Comprehensive	5	0.000	0.673	4.199	1.671	-0.830	Yucun Cultural Park, Huahai Liuchao, Shuiteng Park

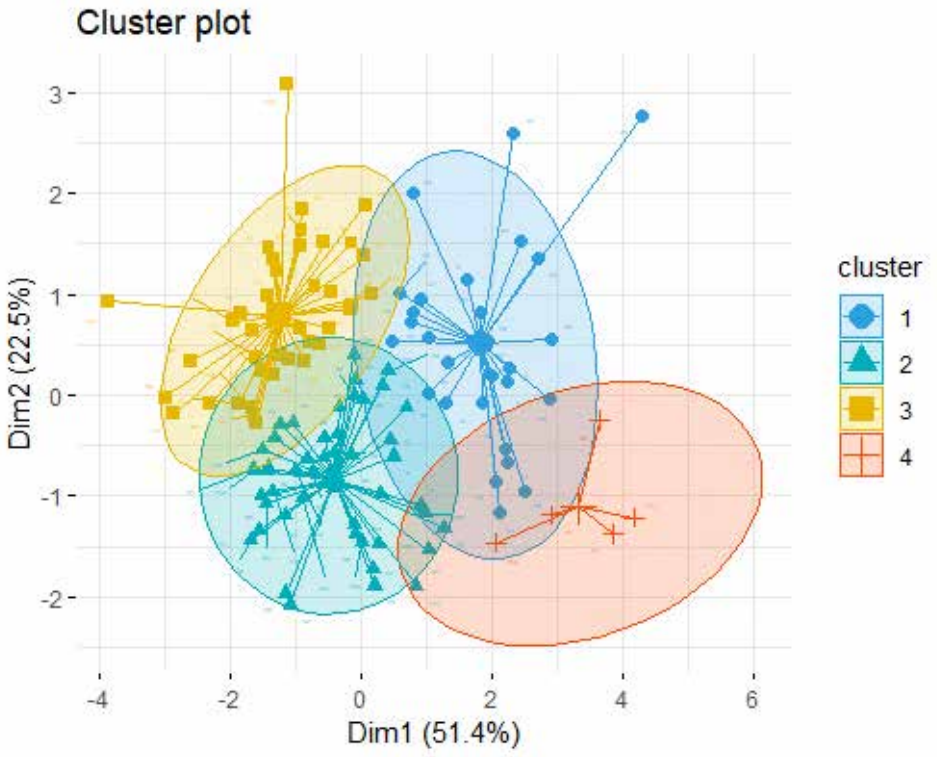

Figure 10 Cluster Diagram of Park Cooling Patterns Based on K-mean

4. Discussions

4.1Threshold Mechanisms for Heat Mitigation of Urban Parks in Water-Network Cities

The study reveals the nonlinear threshold relationship between the cooling performance of parks and key factors such as PA, NDVI, BD and BWR in water network cities, and constructs a methodological framework for the analysis of cooling performance indices and thresholds. The marginal utility of PA increases in the interval of [2.31, 4.03] km², which is a breakthrough from the traditional perception that the larger the size of the park, the better the cooling effect. It is proved that a moderate-sized park can achieve more efficient thermal mitigation by optimising the spatial layout. In addition, the decreasing and then increasing effect of NDVI with 0.277 as the turning point reveals the critical relationship between vegetation cover and cooling intensity. For the blue-green spatial indicators (BBR, BWR) of the buffer zone in the water network city, it was found that there was a threshold interval for the cooling effect. the PCI of BWR rose at [0.277, 0.516]. It provides a quantitative basis for the synergistic cooling of blue-green and enriches the thermal mitigation research on the coupling of urban ecohydrological elements.

4.2 Threshold-Based Planning Strategies

4.2.1 Hierarchical Control: Threshold Adaptation for Medium and High Efficiency Cooled Parks

For High-Efficiency Cooling Performance Parks (Cluster I), large parks with a PA greater than 2.31 km² and an NDVI greater than 0.766 should be strictly protected from fragmented development. For example, the Qiandeng Lake Park should maintain a balance between the thresholds of water body area and vegetation cover, and avoid the impervious surface ratio (BBR) of the buffer zone exceeding 0.188. For high-density built-up area parks (e.g., Wenhua Park) with BD greater than 0.523 or FAR less than 7.986 in Low-Efficiency Parks (Cluster II), the NDVI should be increased to 0.277 or above by removing walls to allow greening, vertical greening and other measures, while controlling the density of the new buildings to be ≤0.251 (Gill et al., 2007; Keeler et al., 2019)and changes to hydrology such as increased surface runoff of rainwater. Such changes are, in part, a result of the altered surface cover of the urban area. For example less vegetated surfaces lead to a decrease in evaporative cooling, whilst an increase in surface sealing results in increased surface runoff. Climate change will amplify these distinctive features. This paper explores the important role that the green infrastructure, i.e. the greenspace network, of a city can play in adapting for climate change. It uses the conurbation of Greater Manchester as a case study site. The paper presents output from energy exchange and hydrological models showing surface temperature and surface runoff in relation to the green infrastructure under current and future climate scenarios. The implications for an adaptation strategy to climate change in the urban environment are discussed.","container-title":"Built Environment (1978-. Moderate Efficiency parks (Cluster III) can use microtopography and artificial water bodies to optimise the cooling gradient, based on the PCG rise when the DEM is less than the 35.97 m threshold. For example, Zhongshan Park in Chancheng can make up for the lack of area by enhancing the temperature difference with the surrounding heat islands through the extension of the water system.

4.2.2 Spatial Optimization: Synergy between Blue and Green Networks

The blue-green network construction strategy based on horizontal and vertical threshold synergy provides a multi-dimensional spatial optimisation path for thermal environment management in water network cities. In terms of horizontal synergy, waterfront buffer zones with BWR ≥ 0.277 are combined with vegetation corridors with NDVI ≥ 0.277 in urban planning. A composite cooling chain is formed through the coupling of water evaporation and vegetation transpiration. Foshan Riverside Wetland Park enhances the PCI by 32% through the synergistic configuration of BWR=0.405 and NDVI=0.65. Secondly, vertical synergy, in the area of undulating terrain, the vegetation communities with staggered heights can be laid out. When the DEM was in the interval of 49.55-72.27 m, the effect of elevation on PCE showed a tendency of decreasing and then increasing. The cooling gradient is enhanced through the difference of transpiration in three-dimensional space. For example, the cooling efficacy of different elevation intervals was effectively enhanced by the vertical layering configuration of mountain vegetation in Wang Luegang Forest Park.

4.2.3 Optimization Strategies: Threshold Enhancement for Inefficient Parks

For the Low-Efficiency parks in cluster Δ the three-threshold priority transformation path requires systematic integration of ecological restoration and spatial planning strategies. Firstly, taking the green space threshold as the priority transformation guide, for the parks with NDVI<0.277, the vegetation cover is improved through high-density planting of native tree species, and the transformation target of NDVI≥0.4 is set. Native plants in Foshan City occupy an important position in urban greening, and the plan requires that no less than 70% of the

plant species applied in urban greening are native species. For example, Ficus microcarpa, Ficus alpina, Camphor, Viburnum, Bombax, etc. are commonly used native species in Foshan.

At the same time, the buffer zone BBR control is limited to a threshold of 0.252, and measures such as softening of the hard interface are taken to weaken the heat-reflecting effect and enhance transpiration. Optimisation through density threshold. For the area around the park with a BD greater than 0.523, planning policy tools such as volume ratio transfer will guide the building setbacks to regulate the BD to a reasonable range of [0.251, 0.523], and release ventilation corridors to promote air circulation. By implementing water body threshold supplementation, for small green spaces with PA less than 2.31 km², raising BWR to above 0.277 by introducing micro water features such as fountains and rain gardens (Keeler et al., 2019) can increase PCI by 15-20%. This progressive intervention pathway can form a chain of inefficient park renovation techniques from ecological substrate restoration to spatial structure optimisation.

4.3 Validation and Comparative Analysis of Thresholds for Park Cooling Performance

This study validates research related to thermal mitigation in parks. It has been suggested that NDVI needs to exceed 30% for significant cooling (Gill et al., 2007). This study validates this conclusion through a threshold of 0.277 NDVI and refines the mechanism of the negative effect in the low-coverage zone. In contrast to the subtropical water network city study, this study quantified the inverted U-shaped relationship between BWR and PCI (T1_1=0.277, T1_2=0.516), which complements the explanation that excessive concentration of water bodies inversely leads to a decrease in cooling efficiency. In addition, the PA marginal utility intervals found in the study were highly consistent with the optimal scale of 2-5 km² for thermal mitigation in urban parks proposed by the U.S. Environmental Protection Agency (EPA) (Wong et al., 2021), further validating the universality of the thresholds.

4.4 Research Limitations and Future Directions

The limitations of the study are that the thresholds are based on remote sensing data from a single city in a single season, and their applicability in cities with significant differences in climate zones has to be verified. Second, socio-economic variables such as population density and energy consumption were not included, making it difficult to analyse the impact of human-environment interaction on cooling performance. In the future, we can expand the sample to more cities in the Yangtze River Delta and Pearl River Delta, and construct a cross-regional threshold model. The combination of UAV thermal imaging and ground-based measurements can improve the data accuracy, and the introduction of SD models to simulate the evolution of the thermal environment under the threshold regulation can provide a tool to support dynamic planning.

5. Conclusion

In the context of the global urban heat island effect dilemma, this study reveals the mechanism of urban heat mitigation by urban parks through multi-indicator assessment and machine learning modelling. This study found that high-intensity urban heat island environments attenuate the spatial decay rate of park cooling effects. The BRT model and RCS curves revealed that there are key thresholds for the core drivers: the optimal scale of heat mitigation in urban parks is 2.3-4 km²; the NDVI of parks needs to be over 27.7% to achieve significant cooling effect; the BWR has an inverted U-shape relationship with PCI, and the optimal blue spatial threshold is 40%. Finally, 120 parks were classified into four categories, High-Efficiency, Low-Efficiency, Moderate Efficiency and Comprehensive by K-means clustering algorithm. The study proposes targeted planning strategies for the four categories of parks, among which the low-efficiency parks can improve the cooling performance by increasing the vegetation cover and controlling the building density, and optimising the blue-green space layout. This study can provide useful guidance for the development of blue-green landscape spaces in water network cities to address global climate change.

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Research on Energy-saving Renovation and Energy Consumption Correlation of Historical Residential Districts under the Background of Urban Renewal: A Case Study of Hehua Tang District in Nanjing City

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Abstract
Amid rising global energy demands and China's shift toward urban stock optimisation, this study investigates low-carbon renewal strategies for Nanjing's Lotus Pond Historical District using parametric modelling and energy simulations. Integrating Rhino/Grasshopper with a simulated annealing algorithm, multiple building height schemes were generated and evaluated for solar potential. Results demonstrated optimised schemes reduced energy use intensity (EUI) by 5.6–25 kWh/m² versus baseline. Shape coefficient strongly correlated with EUI (r=0.997), while floor area ratio (FAR) showed inverse correlation (r=-0.989). Vertical building distribution critically influenced solar gains, with self-shading reducing potential by 22%–28% in select cases. Balancing heritage preservation with energy performance, recommendations advocate limiting heights (1–2 stories), optimising shape coefficients (≤0.55), and integrating solar systems. The methodology offers data-driven insights for sustainable historical district renewal in stock-optimisation contexts.

Key words: Energy-efficient Retrofitting Historic Residential District Building Morphology Building Energy Use Intensity

Introduction

According to data from the International Energy Agency (IEA, 2022), global energy consumption increases at a rate of 6% every five years. In China, building energy consumption accounts for 28% to 30% of total societal energy use, with residential buildings contributing 61.7% of this figure[1]. The energy efficiency and emission reduction challenges in China's building sector remain a persistent focus.

Existing studies demonstrate a strong correlation between urban morphology and building energy consumption. Mutual shading between buildings influences the distribution and reflection of solar radiation, thereby affecting energy demands for lighting, cooling, and heating[2]. For instance, Mengju et al. investigated urban morphological parameters of dormitory blocks at Wuhan University, revealing that block topology and urban morphology significantly impact energy consumption and solar potential at the neighbourhood scale[3]. Similarly, Shen et al. evaluated urban morphological factors affecting photovoltaic potential and energy consumption in residential areas in Wuhan, proposing sustainable planning strategies for central China through regression analysis[4]. Researchers have introduced quantitative metrics, such as coverage ratio, average building height, and floor area ratio (FAR), to directly assess relationships between urban form and energy use. Y. Li et al. found that increasing FAR reduces heating energy density, particularly in its initial stages[5], while H. Leng et al. identified FAR as the most critical factor influencing heating energy consumption in office buildings in Harbin[6]. However, existing studies primarily focus on early-stage urban design for new developments, failing to address China's current emphasis on stock optimisation through "retention, renovation, and demolition" (RRD).

Hui et al. analysed the impact of retrofitting strategies on individual building energy consumption in Shanghai's existing residential areas using Grasshopper, ENVI-met, and EnergyPlus, recommending priority measures for hot summer and warm winter zones[7]. Ning et al. proposed microclimate-based design strategies—such as green spaces and activity zones—to enhance thermal comfort in Beijing's traditional courtyards[8]. While these studies address building-level retrofitting, few explore the energy implications of morphological and layout adjustments at the planning scale.

China's urbanisation has transitioned from large-scale demolition to RRD-based stock optimisation. In alignment with human-centric urban development principles, cities are prioritising the renovation of ageing residential areas. Historical districts, as carriers of traditional architectural heritage, require preservation of street patterns and morphology while integrating organic renewal strategies. Under the "dual carbon" goals, energy consumption during renovation must also be addressed.

Since Nanjing's designation as a National Historical and Cultural City in 1982, the municipality has accumulated extensive experience in preserving traditional residential areas. This study selects a plot in Nanjing's Lotus Pond Historical District for parametric modelling, exploring RRD-based renewal strategies to reduce energy use intensity (EUI) and analysing correlations between morphological parameters and energy consumption. The findings offer guidance for low-energy retrofitting of historical residential districts.

1. Study Scope

The Lotus Pond Historical District, located in Nanjing's southern Shuangtang Subdistrict, represents a Ming-Qing dynasty residential and silk-weaving neighbourhood. The Lotus Pond Conservation Plan mandates protection of historical streets, courtyards, and architectural heritage while permitting adaptive reuse to enhance sustainability.

The study focuses on a 6,231.35 m² northwestern plot (Figure 1), bordered by Yingao Lane (north), Mingyangli (south), Mingyang Street (west), and Xiaoshunli (east). Of the 33 buildings within the plot, 28 are traditional or general structures targeted for renovation (Figure 2). Parametric models in Rhino simplified buildings to flat-roofed forms with uniform 4-metre floor heights.

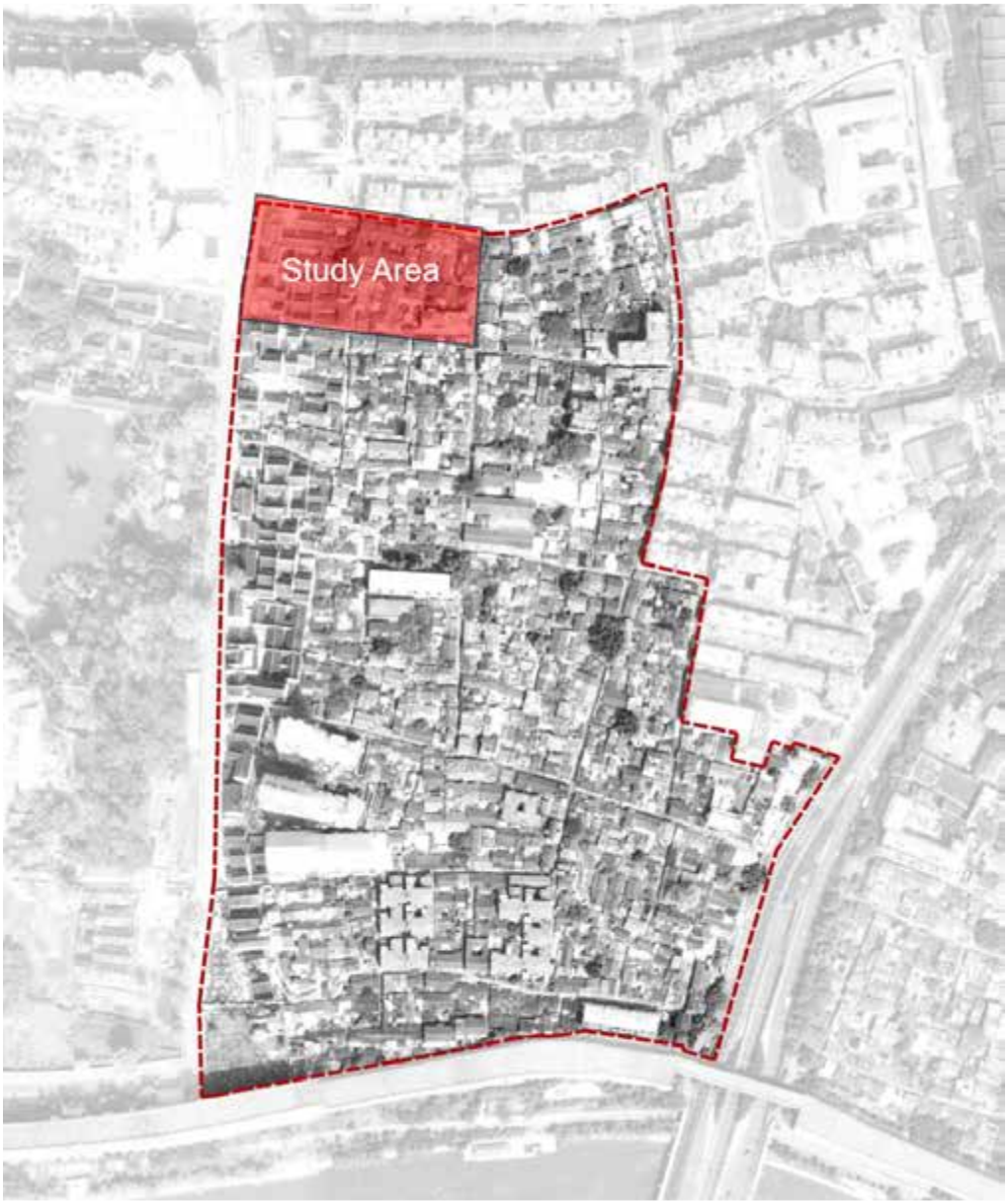


Figure 1 Study Area Boundary

Figure 2 Site Modeling and Renovation Scope Map

2. Simulation of Renovation Schemes

2.1 Height Adjustment Optimisation for Low EUI

The simulation and optimisation processes were conducted entirely within the Grasshopper platform in Rhino. Using the HB Model to OSM component in Grasshopper, Honeybee models were converted to OpenStudio models. Inputting Nanjing's meteorological parameters enabled the calculation of annual total energy consumption, including heating, cooling, indoor lighting, and equipment usage. Heating and cooling temperature thresholds in Honeybee were based on the ASHRAE 55 adaptive thermal comfort model, triggering heating below 18°C (64.4°F) and cooling above 28°C (82.4°F).

The building morphology generation logic retained the original building footprints, with randomised seed numbers controlling floor count variations (1–4 stories). The Annealing Solver in the Genome component (a simulated annealing algorithm) optimised schemes for low EUI. Simulated annealing, inspired by physical annealing processes, is suited for single or few-parameter optimisation. During the initial high-temperature phase, the algorithm explores a broad search space to avoid local optima. In the low-temperature phase, it refines solutions within a narrower range, converging toward the global optimum. Parameter settings for the simulated annealing algorithm are detailed in Table 1.

Table 1. Simulated Annealing Algorithm Parameters

Simulation parameters	Numerical value
Meteorological parameters of Nanjing City	chn_jiangsu.nanjing.582380_cswd
Building type	Midrise Apartment
Simulation cycle	From 00:00 on January 1st to 24:00 on December 31st
Floor height	4 meters
The range of changes in the number of layers	1-4 floors /1-2 floors
Gene	Random number of seeds (1-100)
Objective	Low EUI
Initial temperature	100%
Cooling rate	0.8
Drift rate	50%

2.2 Solar Radiation Potential Assessment of Renovation Schemes

To investigate the specific causes of EUI reduction during optimisation, solar radiation across all schemes was evaluated. Morphological changes, such as building height adjustments, may alter self-shading effects, reducing solar heat gain and thus cooling demand. Additionally, height modifications influence the shape coefficient (*S/V*), defined as the ratio of building surface area to volume, which affects thermal loss or gain. Therefore, solar radiation analysis is critical for each scheme.

For intuitive comparison of solar potential, the Zhejiang Provincial Construction Standard DB33/1105-2014 Code for Renewable Energy Application Accounting in Civil Buildings (Article 4.1.2) stipulates: "Roof areas with annual solar radiation exceeding 625 kW·h/(m²·a) should be prioritised for solar collector or photovoltaic panel installation." Given Nanjing's proximity to Zhejiang, this threshold was adopted.

Meteorological data, simulation periods, sensor locations, grid resolution (2m), and surface reflectivity parameters were configured as detailed in Table 2. The models and parameters were input into the Grasshopper workflow to simulate solar radiation, with results statistically analysed.

Solar radiation simulations were conducted using the Ladybug and Honeybee plugins integrated into Rhino's Grasshopper platform, leveraging the Radiance calculation engine. This method holistically accounts for building dimensions, orientation, ground reflectance, and adjacent structure reflections, generating accurate radiation values for roofs and façades across the case study (Figure 3).

Table 2. Settings of Solar Radiation Simulation Parameters

Simulation parameters	Numerical value
Meteorological data	https://climate.onebuilding.org/WMO_Region_2_Asia/CHN_China/JS_Jiangsu/CHN_JS_Nanjing.582380_TMYx.zip
Simulation cycle	From 00:00 on January 1st to 24:00 on December 31st
Measurement point position	100mm above the grid
Grid size	2 mx2 m
Building surface reflectivity	0.2
Average ground reflectivity	0.2

In this study, solar radiation potential was determined by calculating the ratio of the area exceeding the solar radiation threshold to the total exterior surface area of buildings across different simulated schemes. Using Grasshopper's component settings, measurement points surpassing the threshold were visually highlighted in the model (Figure 3). The proportion of highlighted points relative to the total measurement points served as a comparative metric for evaluating solar energy utilisation potential.

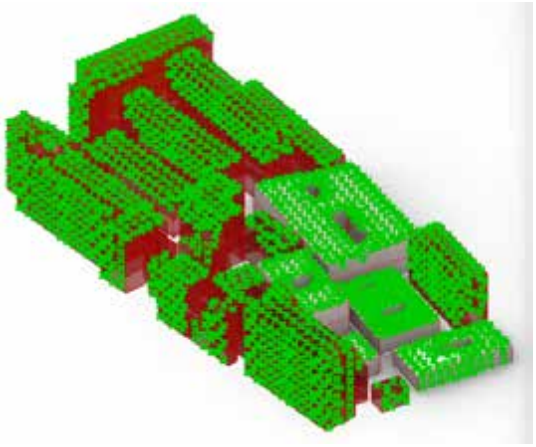


Figure 3 High-Radiation Zones (Threshold: 625 kWh/m²/a)

2.3 Correlation Analysis

Building morphological parameters and simulation results for all schemes were recorded and imported into SPSS software. Pearson correlation analysis was conducted between indicators to investigate the causes and logic behind EUI reduction in optimised schemes. The Pearson correlation coefficient (*r*) ranges from -1 (indicating a perfect negative linear correlation) to 1 (perfect positive linear correlation), with 0 signifying no linear correlation. A significance level of rat 0.01 (two-tailed) indicates statistically significant correlations.

3. Research Conclusions

3.1 Optimisation Results

The baseline EUI of the original scheme was 303.354 kWh/m². Simulation results identified 22 optimal schemes (Table 3), with unchanged energy consumption for indoor lighting (8.866 kWh/m²) and equipment (32.119 kWh/m²). The EUI of optimal schemes decreased by approximately 25 kWh/m² compared to the baseline.

Under heritage conservation guidelines—"strict protection of existing heights for heritage conservation units and historical buildings; new buildings restricted to ≤2 stories with eave heights ≤7 metres"—a secondary simulation constrained building heights to 1–2 stories. This achieved a further EUI reduction of 5.6 kWh/m².

Solar radiation potential (Table 4) decreased across low-EUI optimised schemes. The baseline potential (31.23%) was reduced post-height adjustment. Schemes 14, 16, and 22 exhibited relatively higher potential (>28%), while Schemes 2, 4, 5, 9, and 12 showed lower potential (<22%). This decline likely stems from increased self-shading effects resulting from taller building heights in optimised schemes.

3.2 Correlation Analysis

A Pearson correlation analysis between EUI results from two height adjustment phases and the shape coefficient (*S/V*) revealed a strong positive correlation (Figure 4). Further analysis of energy consumption data, morphological parameters, and annual solar radiation simulations (via SPSS) yielded the following key results (Table 5):

1 Floor area ratio (FAR) exhibited significant negative correlations with solar radiation potential, EUI, and heating/cooling energy demands.

2 Shape coefficient (*S/V*) showed significant positive correlations with solar radiation potential, EUI, and heating/cooling energy demands.

3ΔSolar radiation potential correlated positively with EUI, cooling energy consumption, and *S/V*.

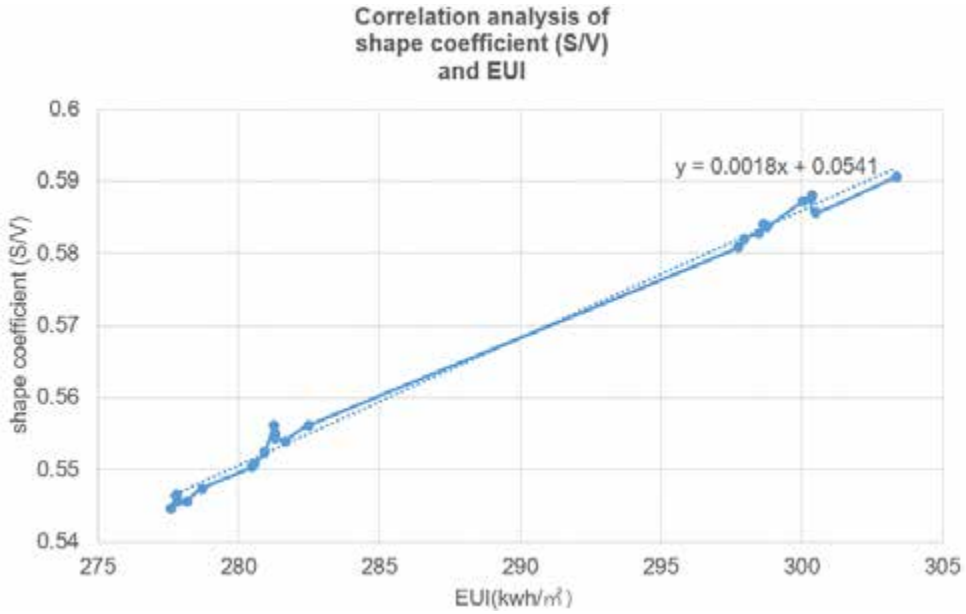


Figure 4 Correlation analysis of shape coefficients and EUI

3.3 Optimisation Recommendations

Floor area ratio (FAR) and shape coefficient (S/V) are critical morphological parameters influencing energy consumption. Reducing FAR (<1.2) and S/V (≤0.55) significantly decreases heating and cooling demands.

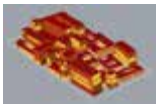
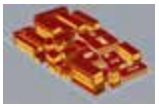
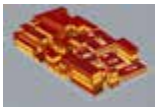
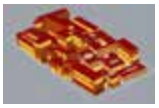
Adjusting building heights reduced EUI by 8.3% (approximately 25 kWh/m²). However, solar radiation potential decreased by 9.4% due to increased shading. Designs must balance energy efficiency with solar utilisation.

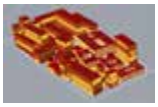
High solar radiation zones (>28%) should prioritise photovoltaic installations, but shading effects caused by taller buildings must be mitigated.

Adopt the "retain, renovate, demolish, and rebuild" (RRD) approach to preserve traditional urban fabric while optimising morphological parameters. Integrate parametric tools for precise energy consumption prediction and scheme optimisation, supporting green renewal of historical districts under China's "dual carbon" goals (carbon peaking and neutrality).

Appendix

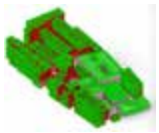
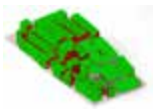
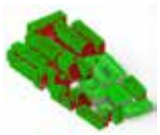
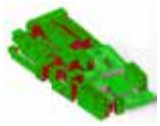
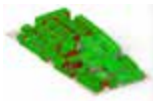
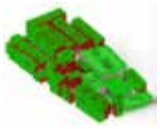
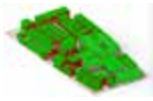
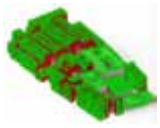
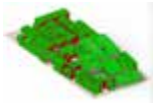
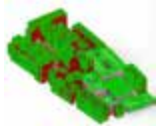
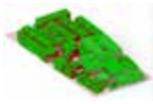
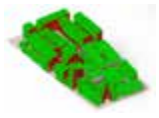
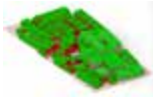
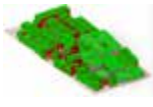
Table 3. Simulation of Height Transformation

Scheme Serial number	Picture	Energy consumption parameter (kwh/)			Architectural form parameters			
		EUI	Heating	Cooling	Total building area	Total building volume m³	Floor area ratio (FAR)	shape coefficient (S/V)
Original plan		303.354	185.344	77.026	4470.19	19837.16	0.796	0.5906
1		277.611	163.635	72.991	7365.40	31418.07	1.260	0.5446
2		277.791	163.858	72.948	7525.55	32058.67	1.286	0.5465
3		277.837	163.842	73.011	7406.34	31581.81	1.267	0.5456
4		278.155	164.162	73.008	7259.97	30996.00	1.244	0.5456
5		278.716	164.616	73.116	7350.68	31359.18	1.258	0.5474
6		280.476	166.010	73.481	6943.00	29728.47	1.190	0.5503

7		280.567	166.006	73.577	6926.09	29660.83	1.190	0.5508
8		280.942	166.093	73.865	7077.33	30265.80	1.210	0.5525
9		281.275	166.377	73.912	7632.48	32486.41	1.300	0.5561
10		281.280	166.609	73.686	7265.65	31019.07	1.240	0.5544
11		281.310	166.561	73.765	7367.87	31427.95	1.261	0.5551
12		281.663	167.128	73.550	7018.57	30030.76	1.205	0.5539
13		282.481	167.748	73.748	7036.8	30103.68	1.208	0.5561
14		297.754	180.872	75.897	4870.18	21437.19	0.860	0.5808
15		297.939	180.879	76.075	4937.07	21704.75	0.870	0.5820
16		298.492	181.397	76.111	4899.04	21552.63	0.865	0.5828
17		298.640	181.682	75.973	4982.56	21886.72	0.880	0.5841
18		298.781	181.774	76.023	4894.11	21532.91	0.860	0.5837
19		300.029	182.633	76.411	4934.84	21695.83	0.870	0.5872
20		300.348	182.924	76.440	4881.86	21483.91	0.862	0.5876

21		300.364	182.849	76.531	4884.05	21492.68	0.862	0.5881
22		300.501	183.118	76.398	4694.96	20736.32	0.832	0.5857

Table 4. Simulation Results of Solar Radiation

Scheme Serial number	Picture	Solar radiation potential (%)	Scheme Serial number	Picture	Solar radiation potential (%)
Original plan		31.23			
1		22.27	12		21.82
2		21.64	13		22.65
3		22.36	14		28.01
4		21.96	15		27.90
5		21.78	16		28.02
6		22.93	17		26.59
7		22.90	18		27.54
8		22.89	19		27.56

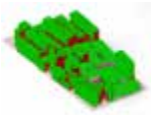
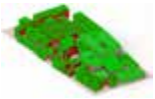
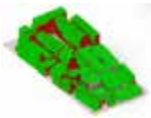
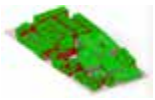
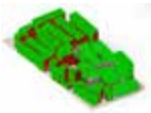
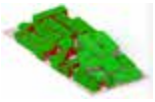
Scheme Serial number	Picture	Solar radiation potential (%)	Scheme Serial number	Picture	Solar radiation potential (%)
9		21.73	20		27.90
10		22.37	21		27.85
11		21.69	22		28.86

Table 5. Correlation Analysis

	Solar radiation potential (%)	EUI (kwh/)	Heating energy consumption (kwh/)	Cooling energy consumption (kwh/)	Floor area ratio (FAR)	shape coefficient (S/V)
Solar radiation potential (%)	--					
EUI (kwh/)	.972**					
Heating energy consumption (kwh/)	.972**	1.000**	--			
Cooling energy consumption (kwh/)	.969**	.996**	.994**	--		
Floor area ratio (FAR)	-.980**	-.989**	-.990**	-.977**	--	
shape coefficient (S/V)	.957**	.997**	.996**	.996**	-.976**	--

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Urban Wilderness Protection and Creation in China

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Abstract
Urban wilderness areas—natural spaces minimally impacted by human activity—are increasingly vital in China's rapidly urbanising cities. They offer key ecosystem services such as air and water purification, carbon sequestration, and urban cooling, while supporting biodiversity and providing public recreation. This study explores how integrating urban wilderness into Chinese urban planning can balance development and ecological preservation. Using interdisciplinary methods to assess wilderness contributions to resilience and livability. Case studies from Hangzhou, Shanghai, Lanzhou, and Yueyang illustrate effective strategies including native vegetation restoration, sustainable recreation infrastructure, and environmental education. Public accessibility and awareness are emphasised to foster environmental stewardship. Aligning wilderness conservation with China's urban planning goals supports ecological health and long-term sustainability, offering insights for policymakers, planners, and communities seeking greener, more resilient urban futures.

Keywords: Urban wilderness; ecological resilience; sustainable urban development

1. Introduction

Urbanisation has become a defining characteristic of the 21st century, with cities expanding at unprecedented rates. This rapid urban growth often leads to the degradation of natural environments, resulting in diminished biodiversity, increased pollution, and reduced quality of life for urban residents. In response to these challenges, the concept of urban wilderness has emerged as a vital component in urban planning and environmental conservation.

Urban wilderness refers to natural areas within or adjacent to urban environments that remain relatively undisturbed by human activity. These spaces, which can include forests, wetlands, grasslands, and other ecosystems, serve as critical habitats for wildlife and offer numerous ecosystem services. They play a significant role in air and water purification, carbon sequestration, climate regulation, and provide recreational and psychological benefits to urban dwellers. Moreover, urban wilderness areas contribute to the ecological resilience of cities, enabling them to better withstand environmental stresses such as climate change and natural disasters (Emily P. Zefferman, 2018) .

In the context of China, the importance of urban wilderness is increasingly recognised. Rapid industrialisation and urban expansion have led to significant environmental challenges, including habitat loss and fragmentation. However, initiatives such as the National Forest City program demonstrate a growing commitment to integrating green spaces into urban development. These efforts aim to enhance biodiversity, improve air quality, and provide residents with accessible natural areas, thereby promoting sustainable urban living (Xiaoqin Xie, 2023).

2. The Primary Objectives

This study aims to explore the role of urban wilderness in promoting sustainable urban development in China (Table 1).

Table 1: The Primary Objectives

The Primary Objectives				
To define and contextualise urban wilderness	To examine the historical evolution of urban wilderness in China	To assess global perspectives on urban wilderness protection and creation	To identify strategies for integrating urban wilderness into city planning	To evaluate the benefits of urban wilderness
Understanding the characteristics and significance of urban wilderness within the framework of urban ecology and planning.	Analysing how urban wilderness areas have developed over time and their current status in Chinese cities.	Reviewing international practices and policies that can inform China's approach to urban wilderness management.	Proposing methods for the protection and creation of urban wilderness areas, considering ecological, social, and economic factors.	Investigating the ecological services provided by urban wilderness and their impact on urban resilience and residents' well-being.

The scope of this study encompasses a comprehensive analysis of urban wilderness in China, drawing comparisons with international examples to identify best practices. It involves an interdisciplinary approach, incorporating ecological analysis, urban planning methodologies, and community engagement strategies. The research aims to provide actionable insights for policymakers, urban planners, and environmental advocates to effectively integrate urban wilderness into the fabric of Chinese cities.

3. Research approach

3.1 Interdisciplinary Approaches: Case Study; Literature Review

To effectively address the complexities of urban wilderness protection and creation, an interdisciplinary approach is essential. This involves combining insights from ecology, urban planning, sociology, and cultural studies to understand the dynamics of urban ecosystems (Table 1).

Table 2: Research approach

Research approach	
Case study	Research progress review
Case studies serve as critical tools for examining real-world examples of urban rewilding and ecological restoration. By selecting representative sites and analysing them through field observations, spatial analysis, and policy review, case studies reveal the interactions between natural systems and human interventions.	Research progress reviews synthesise existing theoretical and empirical research, identifying key themes, gaps, and debates within the field. A systematic review of scholarly articles, policy documents, and technical reports enables researchers to contextualise case findings within broader academic and practical discourses.

By integrating case study and literature review, these methods provide a robust framework for investigating the ecological, social, and planning dimensions of urban wilderness initiatives, ensuring a holistic and sustainable understanding of urban nature.

3.2 Case Studies

3.2.1 The display of cases in different parts of China

The selected case studies are geographically distributed across diverse ecological and cultural regions of China, offering a comprehensive view of urban wilderness practices in varying urban contexts (Table 3).

In Hangzhou, located in the Yangtze River Delta of southeastern China, Jiangyangfan Ecological Park showcases a low-intervention model of natural succession, where wetland habitats have been restored with minimal human alteration, emphasising biodiversity and public education.

Shanghai, as a leading coastal metropolis, showcases ecological planning at scale through Heqing Country Park, where rewilding strategies are applied within a high-density urban environment to balance biodiversity, recreation, and spatial equity.

Moving westward, Lanzhou's Yellow River riverside rewilding project addresses the ecological degradation caused by urban and industrial pressures, combining habitat restoration, community engagement, and sustainable tourism to reestablish both environmental function and cultural identity.

Meanwhile, Yueyang, located in southern China near Dongting Lake, highlights species reintroduction efforts, particularly the rewilding of Père David's deer in Junshan Houhu, contributing to both biodiversity restoration and wetland conservation.

Collectively, these geographically dispersed cases illustrate how urban wilderness practices are shaped by differing environmental conditions, cultural values, and planning frameworks across southern and northwestern China.

Table 3: Recreation of Urban Wilderness Cases in China

Case studies					
Project	**Study Area**	**Rewilding Strategies**	**Outcomes and Significance**	**Conclusion**	**Visual Representation**
Jiangyangfan Ecological Park	Hangzhou, Zhejiang province, Southern China,	a.Embracing Natural Succession b. Ecological Environment Construction	a. Ecological Restoration b. Public Education	Jiangyangfan Ecological Park demonstrates how urban rewilding and ecological restoration can transform degraded areas into biodiverse, educational natural spaces.	
Shanghai Heqing Country Park	Shanghai, Southern China	a. Minimising Human Intervention b. Habitat Restoration	a. Biodiversity Enhancement b. Ecotourism Development	Shanghai Heqing Country Park exemplifies urban rewilding by integrating ecological restoration into urban planning, enhancing biodiversity, and offering educational and recreational opportunities.	
Lanzhou's Yellow River Riverside	LanzhouΔGansu Province, Northwestern China	a. Habitat Restoration b. Community Engagement c. Sustainable Financing	a. Ecological Improvement b. Cultural Heritage Preservation	Lanzhou's Yellow River rewilding integrates habitat restoration, community engagement, and sustainable financing, transforming degraded urban riverfronts into vibrant ecological and cultural corridors.	
Rewilding of Père David's Deer in Junshan Houhu, East Dongting Lake National Nature Reserve	Yueyang, Hunan Province, Southern China	a. Habitat Assessment and Selection b. Monitoring and Adaptive Management	The reintroduced Père David's deer population shows adaptation and growth, but faces challenges from human disturbance and disease outbreaks.	Père David's deer rewilding in Junshan Houhu exemplifies effective habitat restoration and adaptive management, though challenges like human disturbance and disease persist.	

3.2.2 Strategies for Urban Wilderness Protection and Creation in China

Urban wilderness areas—natural or semi-natural spaces within or adjacent to urban environments—are vital for ecological balance, biodiversity conservation, and the well-being of urban residents. In China, rapid urbanisation has posed significant challenges to the preservation and creation of such spaces. However, various strategies have been implemented to address these challenges, focusing on native vegetation restoration, integration of sustainable recreational facilities, promotion of environmental education and public awareness, and the establishment of robust policy frameworks and governance structures (Figure 1).

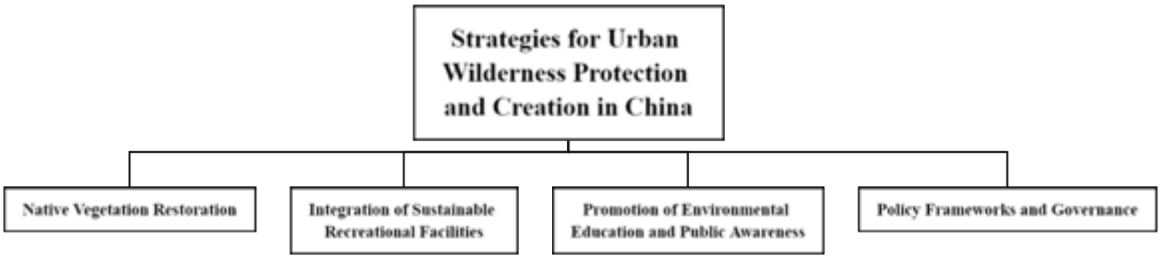

Figure 1: Strategies for Urban Wilderness Protection and Creation in China

Native Vegetation Restoration

Restoring native vegetation is a cornerstone of urban wilderness conservation in China. Programs like the "Grain for Green" initiative, launched in 1999, have converted over 15 million hectares of farmland and 17 million hectares of barren mountainous wasteland back to natural vegetation, aiming to mitigate soil erosion and flooding (Claudio O. Delang, 2015).

Similarly, the "Three-North Shelterbelt Program," also known as the "Great Green Wall," has been instrumental in combating desertification by planting over 30 million hectares of trees, increasing national forest coverage to over 25% (Reuters, 2024).

While these large-scale afforestation efforts have expanded green cover, challenges remain regarding biodiversity. The proliferation of monoculture plantations, often comprising fast-growing non-native species, has led to a decline in native forests, which have decreased by 6% due to the replacement of diverse ecosystems with single-species plantations (Kelly, 2018). To enhance ecological resilience, future restoration efforts should prioritise the use of native species and promote mixed-species plantings that support a broader range of wildlife.

Integration of Sustainable Recreational Facilities

Integrating sustainable recreational facilities within urban wilderness areas enhances their accessibility and utility for urban residents while preserving ecological integrity. Designing trails, observation decks, and educational signage using eco-friendly materials minimises environmental impact and encourages public engagement with nature. For instance, the Kubuqi Desert restoration project in Inner Mongolia transformed a barren landscape into a green area with tourism and agriculture industries, demonstrating the potential for ecological restoration to support sustainable economic development.

Moreover, incorporating green infrastructure such as eco-roofs and community herb gardens, as implemented by Future Generations China in Beijing, combines recreational and educational functions, fostering community involvement and environmental awareness. These initiatives exemplify how urban wilderness areas can serve multiple purposes, including recreation, education, and biodiversity conservation.

Promotion of Environmental Education and Public Awareness

Environmental education and public awareness are critical for the long-term success of urban wilderness initiatives. China has made significant strides in this area, establishing formal environmental education systems and integrating environmental topics into primary education curricula. Organisations like the China Environmental Education Centre (CEEC) have been pivotal in conducting environmental education and publicity activities, serving government departments, the public, enterprises, and media (Mee Young Choi, 2008).

Additionally, non-governmental organisations (NGOs) such as "Friends of Nature" and "Global Village of Beijing" have played a vital role in raising environmental awareness and promoting hands-on environmental activism since the mid-1990s. These organisations focus on education, awareness-raising, and community engagement, contributing to a more environmentally conscious society.

Despite these efforts, challenges persist, including a lack of motivation to incorporate environmental education in teaching and a contradiction between economic growth and environmental protection (Youyi Tian, 2016). Addressing these issues requires a concerted effort to enhance the quality and reach of environmental education programs, ensuring that they effectively foster environmental stewardship among the public.

Policy Frameworks and Governance

Robust policy frameworks and effective governance are essential for the protection and creation of urban wilderness areas. China has implemented various ecological restoration policies that have significantly impacted the country's terrestrial carbon balance, demonstrating the effectiveness of policy-driven environmental initiatives (Chao Yue, 2024). These policies include land management changes aimed at enhancing carbon sequestration and promoting sustainable development.

Furthermore, integrating nature-based solutions (NbS) into ecosystem restoration efforts provides both theoretical foundations and practical guidance for enhancing conservation efforts and promoting sustainable development. By incorporating NbS into policy frameworks, China can address environmental challenges more holistically, ensuring that urban wilderness areas are preserved and enhanced in the face of ongoing urbanisation.

Public participation and NGO activity are also crucial components of effective governance. Analysing the degree and types of public participation in NbS projects in China reveals the importance of engaging communities in environmental initiatives. Encouraging public involvement ensures that urban wilderness projects align with community needs and values, fostering a sense of ownership and responsibility among residents.

3.3 Research Progress Review

3.3.1 Definitions and Concepts of Urban Wilderness

The term "urban wilderness" refers to natural areas within or adjacent to urban environments that remain relatively undisturbed by human activity. These spaces, which can include forests, wetlands, grasslands, and other ecosystems, serve as critical habitats for wildlife and offer numerous ecosystem services. They play a significant role in air and water purification, carbon sequestration, climate regulation, and provide recreational and psychological benefits to urban dwellers. Moreover, urban wilderness areas contribute to the ecological resilience of cities, enabling them to better withstand environmental stresses such as climate change and natural disasters.

In the context of China, the importance of urban wilderness is increasingly recognised. Rapid industrialisation and urban expansion have led to significant environmental challenges, including habitat loss and fragmentation. However, initiatives such as the National Forest City program demonstrate a growing commitment to integrating green spaces into urban development. These efforts aim to enhance biodiversity, improve air quality, and provide residents with accessible natural areas, thereby promoting sustainable urban living.

3.3.2 Historical Evolution of Urban Wilderness in China

The development of wilderness aesthetics in China has undergone a profound and evolving cognitive process shaped by philosophical, religious, and cultural influences throughout different historical periods (Table 4).

Table 4: The Development of the Cognitive Process of Chinese Wilderness Aesthetics

The Development of the Cognitive Process of Chinese Wilderness Aesthetics		
Dynasty	Characteristics of the Era	Description
Pre-Qin Dynasty	Deification of nature; reverence for wilderness	During the pre-Qin Dynasty, the wilderness was regarded as a mysterious space associated with divine spirits. People revered and feared it. Aesthetics of wilderness focused on nature and mysticism. Thinkers described it as "nameless Dao," "non-being," "formless," and "silent."
Han Dynasty	Emphasis on forest grace and wilderness rhythms; new harmony	In the Han Dynasty, wilderness became important in Confucian moral practice. Confucian wilderness aesthetics emphasised rational beauty and ordered qualities, highlighting how wild landscapes could inspire moral reflection, e.g., the "Dao of governance" in The Analects.
Wei-Jin Dynasty	Emphasis on mountain tranquillity; wilderness as Zen transcendence	In the Wei-Jin Dynasty, wilderness aesthetics greatly influenced poetry and landscape painting. The appreciation of wilderness became more refined and integrated with natural emotions.
Sui Dynasty and Tang Dynasty	Pursuit of wild beauty and mystery; wilderness as sublime and fantastic	After the Wei-Jin Dynasty, wilderness aesthetics merged with religious and metaphysical beliefs. Mountains and waters represented the divine. Aesthetics were infused with Buddhist, Taoist meditation, focusing on quiet contemplation and transcendence.
Song Dynasty	Emphasis on mountain and water landscapes; wilderness as serene and deep	In the Song dynasty, wilderness began to be seen as shaped by human emotion and thought. It became central to poetic and landscape painting creation. Aesthetic focus shifted to secluded, elegant scenes.
Ming Dynasty and Qing Dynasty	Emphasis on mountain spirit and naturalness; wilderness as pure and natural	During the Ming and Qing periods, wilderness aesthetics spread to the public and became symbolic in literati sentiment and self-identity. Aesthetics turned toward individuality.

Together, these stages illustrate a continuous redefinition of wilderness aesthetics in Chinese thought, moving from divine reverence to humanistic integration, from metaphysical abstraction to personal expression.

China's relationship with wilderness has been shaped by a complex interplay of cultural, historical, and political factors. Traditional Chinese philosophy, particularly Taoism and Confucianism, emphasises harmony between humans and nature. The concept of "Unity of Man and Heaven" reflects an intrinsic value placed on natural landscapes (Mark, 2006). However, the 20th century witnessed significant shifts in this perspective. The rapid industrialisation and urbanisation during the mid-20th century led to extensive environmental degradation, with natural areas being converted for agricultural and industrial use (Weller, 2006).

In response to growing environmental concerns, the Chinese government initiated several conservation efforts. The establishment of National Forest Parks (NFPs) in the 1980s marked a significant step towards preserving natural landscapes. The first NFP was created in Zhangjiajie, Hunan Province, in 1982, and by 2009, China had established over 2,400 NFPs (National Forest Parks in China, 2013). These parks aimed to protect biodiversity, promote tourism, and enhance public awareness of environmental issues.

In recent years, urban wilderness has gained prominence in China's urban planning discourse. Cities like Shanghai and Chengdu have implemented initiatives to integrate natural spaces within urban environments. For instance, Shanghai's Heqing Country Park and Chengdu's "Garden City" initiative exemplify efforts to create urban wilderness areas that serve both ecological and recreational functions. These projects reflect a growing recognition of the importance of urban wilderness in enhancing urban livability and sustainability.

3.3.3 Global Perspectives on Urban Wilderness Protection and Creation

Globally, urban wilderness has been recognised for its multifaceted benefits, including biodiversity conservation, climate regulation, and human well-being. Cities worldwide have implemented various strategies to protect and create urban wilderness areas, often tailored to their unique ecological and socio-cultural contexts.

In Singapore, the "Garden City" vision has guided urban development since the 1960s, emphasising the integration of green spaces throughout the city. The establishment of nature reserves, park connectors, and rooftop gardens has transformed Singapore into a model for urban greening. These efforts have enhanced biodiversity, improved air quality, and provided residents with accessible natural spaces.

In the United States, the concept of urban wilderness has been explored through initiatives like the Urban Wilds Program in Boston. This program identifies and protects remnant natural areas within the city, recognising their ecological and cultural significance. Similarly, cities like Portland and Seattle have implemented green infrastructure projects that incorporate urban wilderness elements to manage stormwater, reduce urban heat islands, and enhance biodiversity.

European cities have also embraced urban wilderness as a component of sustainable urban planning. In Berlin, the concept of "urban wildness" has been promoted to preserve spontaneous vegetation and wildlife habitats within the city. These areas, often located on abandoned industrial sites, provide opportunities for ecological succession and community engagement (Kowarik, 2011). Such initiatives highlight the potential of urban wilderness to contribute to urban resilience and cultural identity.

These global examples demonstrate the diverse approaches to urban wilderness protection and creation, underscoring the importance of context-specific strategies. They also illustrate the potential of urban wilderness to address pressing urban challenges, including climate change, biodiversity loss, and social well-being.

3.3.4 The Role of Urban Wilderness in Sustainable Urban Development

Urban wilderness areas—natural or semi-natural spaces within or adjacent to urban environments—play a pivotal role in promoting sustainable urban development. These areas provide a multitude of ecosystem services that contribute to environmental health, biodiversity conservation, climate regulation, and the well-being of urban residents.

Ecosystem Services Provided by Urban Wilderness
Ecosystem services are the benefits that humans derive from natural ecosystems. Urban wilderness areas offer a range of these services, which are crucial for maintaining ecological balance and enhancing the quality of urban life.

Air and Water Purification
Urban vegetation, including trees and shrubs, plays a significant role in improving air quality by filtering pollutants such as particulate matter, nitrogen dioxide, and ozone. Through processes like deposition and absorption, plants remove harmful substances from the atmosphere, thereby reducing respiratory ailments among urban populations (David J. Nowak, 2006).

In terms of water purification, urban wilderness areas contribute to the filtration of stormwater runoff. Vegetated surfaces absorb and slow down rainwater, allowing for the removal of pollutants before they reach water bodies. This natural filtration process mitigates the risk of waterborne diseases and protects aquatic ecosystems (Davis AP, 2006).

Carbon Sequestration
Urban forests and green spaces act as carbon sinks by absorbing carbon dioxide during photosynthesis and storing it in biomass and soil. This process helps offset greenhouse gas emissions from urban activities, contributing to climate change mitigation. Although the carbon sequestration capacity of urban vegetation is lower compared to large natural forests, it still represents a valuable component of urban climate strategies (Churkina, 2010).

Climate Regulation
Urban wilderness areas influence local microclimates by providing shade, releasing moisture through evapotranspiration, and reducing surface temperatures. These effects help combat the urban heat island phenomenon, where urban areas experience higher temperatures than surrounding rural regions due to heat-absorbing surfaces like concrete and asphalt (Bowler, 2010). By moderating temperatures, urban green spaces reduce energy consumption for cooling and enhance thermal comfort for residents.

Enhancement of Biodiversity
Urban wilderness areas serve as habitats for a diverse array of flora and fauna, supporting biodiversity within city landscapes. These green spaces provide food, shelter, and breeding grounds for various species, including birds, insects, and small mammals. Maintaining biodiversity in urban environments is essential for ecosystem resilience, as it ensures the continuation of ecological processes and services (Goddard, 2010).

Moreover, urban biodiversity has educational and recreational value, fostering a connection between residents and nature. Exposure to diverse species can enhance environmental awareness and promote conservation efforts within communities.

Recreational and Psychological Benefits for Urban Residents
Access to urban wilderness areas offers significant recreational opportunities, encouraging physical activity such as walking, jogging, and cycling. Engagement in these activities contributes to improved physical health and reduces the risk of chronic diseases.

Beyond physical benefits, urban green spaces have profound psychological impacts. Exposure to natural environments has been linked to reduced stress, anxiety, and depression levels among urban dwellers. Studies indicate that individuals living near green spaces experience greater well-being and healthier cortisol profiles, highlighting the mental health benefits of urban nature (Maas, 2006).

Furthermore, urban wilderness areas promote social cohesion by serving as communal spaces where people can interact and engage in collective activities. This social interaction fosters a sense of community and belonging, which are vital components of mental health and societal well-being.

4. Results

China's rapid urbanisation has led to significant challenges in balancing urban development with ecological preservation. The expansion of urban areas often encroaches upon natural habitats, leading to biodiversity loss and environmental degradation. For instance, studies indicate that urban expansion in China is likely to affect habitats and biodiversity by 2030, with most provinces expected to experience urban growth near protected areas or biodiversity hotspots (Seto, 2012) .

To address these challenges, China has introduced the concept of "Ecological Civilisation," aiming to integrate ecological considerations into economic and social development. This policy framework promotes sustainable urban planning practices that prioritise ecological preservation alongside urban growth (Meng, 2021).

Climate change poses additional challenges to urban wilderness areas in China. Rising temperatures, altered precipitation patterns, and increased frequency of extreme weather events threaten the integrity of urban ecosystems. Urban areas contribute significantly to greenhouse gas emissions, exacerbating climate change impacts (Maizland, 2021).

In response, China has implemented initiatives such as the "Sponge City" program, which aims to enhance urban resilience to climate change by improving water management and reducing flood risks through the integration of green infrastructure (Li, 2017). These efforts demonstrate China's commitment to mitigating climate change impacts on urban environments.

Effective urban wilderness conservation requires active community involvement and stakeholder engagement. Public participation in environmental decision-making processes enhances the legitimacy and effectiveness of conservation initiatives. However, challenges persist in engaging diverse stakeholders and ensuring equitable participation (Chen, 2015).

To foster community engagement, educational programs and awareness campaigns are essential. For example, environmental education initiatives in urban areas have been shown to increase public awareness and support for conservation efforts (Tian, 2016). Additionally, involving local communities in the planning and management of urban green spaces can lead to more sustainable and inclusive outcomes.

5. Discussion of Results

China has implemented various policies aimed at promoting sustainable urban development and ecological preservation. The "Ecological Civilisation" framework serves as a guiding principle for integrating environmental considerations into urban planning. Additionally, initiatives like the "Sponge City" program and the establishment of national parks reflect efforts to enhance urban resilience and conserve biodiversity (Li, 2017).

While these policies demonstrate progress, challenges remain in their implementation and effectiveness. For instance, inconsistencies in policy enforcement and limited coordination among governmental agencies can hinder the success of conservation initiatives (Chen, 2015). Moreover, balancing economic development goals with ecological preservation continues to be a complex issue.

Comparing China's urban wilderness conservation efforts with international practices reveals both similarities and differences. For example, the concept of integrating green infrastructure into urban planning is common in countries like Germany and the Netherlands, where policies emphasise the multifunctionality of urban green spaces (Kabisch, 2015). Similarly, China's "Sponge City" program aligns with global trends in nature-based solutions for urban resilience.

However, China's rapid urbanisation and unique socio-political context present distinct challenges. The scale and pace of urban development in China necessitate tailored approaches to urban wilderness conservation that consider local conditions and governance structures. Learning from international experiences while adapting strategies to the Chinese context is crucial for effective conservation outcomes.

Based on the analysis of challenges and current practices, the following recommendations are proposed for enhancing urban wilderness conservation in China:

Enhance inter-agency collaboration and ensure consistent enforcement of environmental policies to improve their effectiveness.

Develop participatory planning processes that involve local communities in decision-making and management of urban green spaces.

Incorporate climate adaptation strategies into urban planning to mitigate the impacts of climate change on urban ecosystems.

Implement educational programs to raise public awareness and foster a culture of environmental stewardship.

6. Conclusion

This study has examined the multifaceted role of urban wilderness in China's sustainable urban development. Urban wilderness areas provide critical ecosystem services, including air and water purification, carbon sequestration, climate regulation, and biodiversity enhancement (Xie, 2019). Case studies from cities like Hangzhou, Shanghai, Lanzhou, and Yueyang illustrate successful integration of green spaces into urban planning, demonstrating the potential for ecological preservation alongside urban growth. However, challenges persist, such as balancing rapid urbanisation with ecological conservation, addressing climate change impacts, and ensuring equitable access to green spaces (Seto, 2012) .

The findings underscore the necessity for urban planning policies that prioritise ecological considerations. Integrating green infrastructure into urban development plans can mitigate environmental degradation and enhance urban resilience (Li, 2017). Policies should promote community involvement in the planning and management of urban green spaces to ensure that these areas meet the needs of diverse populations (Youyi Tian, 2016). Furthermore, adopting adaptive management approaches can enable cities to respond effectively to the dynamic challenges posed by climate change and urbanisation.

Future research should focus on evaluating the long-term effectiveness of urban wilderness initiatives in China. Comparative studies between Chinese cities and international counterparts can provide insights into best practices and innovative strategies for urban ecological conservation. Additionally, interdisciplinary research combining ecological science, urban planning, and social sciences can inform more holistic approaches to urban wilderness management. Emphasis should also be placed on developing metrics to assess the social and health benefits of urban green spaces, ensuring that these areas contribute to the well-being of all urban residents.

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Enhancing Sustainable Cities Through Comparative Carbon Sink Benefits of Blue-Green Spaces: Evidence from Multi-Source Data

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Abstract
Cities, characterized by the coexistence of carbon emissions and sinks, face escalating climate challenges. This study advances carbon sink research by examining integrated blue-green space benefits, emphasizing neighbourhood scales as critical nexus points for intervention, combining ArcGIS and quantitative methods, we measured carbon contributions from green (e.g., vegetation) and blue spaces (e.g., water bodies), identifying green spaces—particularly arboreal vegetation—as dominant carbon sinks. Spatial aggregation of blue-green elements was identified as key determinants. We propose neighborhood-scale climate-adaptive strategies to enhance carbon sink performance and support sustainable urban development..

Keywords: Blue-Green Infrastructure, Sustainable Cities, Carbon Sinks, Climate-Adaptive Planning

1.Introduction

Urban areas constitute primary sources of carbon emissions whilst concurrently retaining substantial carbon sink potential. As complex spatial systems wherein emissions and sinks coexist, advancing sustainable urban development through emission mitigation and sink enhancement represents a critical pathway towards achieving China's "dual carbon" goals [1-5]. Contemporary research on urban carbon emissions predominantly focuses on building lifecycle energy consumption [6], extending analyses across multiple scales through interdisciplinary methodologies [7] and has yielded mature technical approaches. Nevertheless, high-density urban development has fragmented natural carbon sink spaces—primarily vegetated areas—diminishing their efficacy.

Scholarly investigations into urban carbon sinks face limitations arising from scale-induced methodological inconsistencies and intricate operational mechanisms, resulting in a "multi-dimensional dilemma": challenges in identifying sink components, delineating sink processes, and quantifying sink benefits. Within this context, targeted research has addressed carbon sink identification and performance. Zhou et al. [8] examined forest carbon sinks and storage in Guangzhou, whilst Liu et al. [9] quantified carbon sequestration capacity within Beijing's central urban parks, revealing that urban green space sink efficiency is influenced by vegetation typologies, habitat composition, and various determinants. Regional-scale carbon sink studies benefit from robust theoretical foundations, enabling established measurement and simulation techniques including the CITYgreen and i-Tree Eco models [10-19], alongside biomass methodologies and regression-based calculations [20-28]. These contributions have significantly advanced urban carbon sink research [29-30].

However, amidst escalating global warming and extreme weather phenomena, singular carbon sink spaces prove inadequate to address contemporary complexities. Research has consequently evolved from isolated examinations of green or blue spaces towards integrated analyses of composite urban blue-green space systems [31,33]. As fundamental ecological carriers for carbon sequestration, blue-green spaces demonstrate pronounced sink potential, extensively validated within the existing literature [31-33].

Collectively, current scholarship exhibits three salient characteristics:
(1) Prevailing studies compartmentalise blue and green spaces [34], overlooking synergistic carbon sink benefits [4];
(2) Technical constraints (e.g., limited data precision, ambiguous boundaries) and theoretical limitations (e.g., complex influencing mechanisms) impede accurate quantification of the carbon sink efficiency of blue-green spaces;
(3) Urban carbon sinks constitute a multi-scale challenge wherein measurement criteria—detection methods, computational formulae, and evaluation standards—diverge significantly across macro-, meso-, and micro-scales, necessitating explicit calibration of scale-induced variations.

Consequently, developing scientifically rigorous, high-precision carbon sink measurement methodologies that account for scalar heterogeneity forms the principal focus of this research.

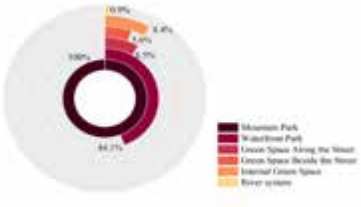
Neighbourhoods—the minimal spatial units holistically encompassing blue-green infrastructure elements and built infrastructure—are prioritised as the optimal scale for urban carbon sink investigation. Functionally, neighbourhoods integrate city-wide carbon sink systems whilst informing site-specific components, serving as critical spatial nexuses. This study therefore adopts the neighbourhood scale, integrating macro-scale remote sensing with micro-scale field data to mitigate single-source limitations. We quantify integrated carbon sink benefits and influencing factors within Nanjing's Yuejianglou neighbourhood. Subsequently, we propose climate-adaptive optimization strategies for blue-green space planning at this scale.

2.Materials and Methods

2.1 Study Area and Data Sources

This study selected the Yuejianglou neighborhood in Nanjing, China—a representative hot-summer/cold-winter climate zone—as the research case study. Nanjing possesses superior natural conditions as one of China's inaugural National Garden Cities, with built-up areas attaining 45.04 per cent green coverage by the end of 2023, establishing a robust carbon sequestration foundation. The Yuejianglou neighborhood exemplifies typical urban characteristics, incorporating blue-green infrastructure components including mountain parks (Shizishan Park), waterfront parks (Xiuqiu Park), street greenery (green space along the street), pocket greens (green space beside the street), community internal greens, and hydrological features (river system) (Table 1). Its significant low-carbon development potential renders it a representative case for investigating urban neighborhood-scale blue-green infrastructure carbon sinks.

Table 1: Spatial Types and Areas of Carbon Sink Elements in the Yuejianglou neighborhood of Nanjing

Spatial type	Vegetation type	Land area (m^2)	Area proportion
Mountain Park	Trees,	140,000	
Green Space Along the Street	shrubs,	24,300	
Internal Green Space	grasslands,	123,000	
Waterfront Park	Trees,shrubs,	95,600	
Green Space Beside the Street	grasslands, aquatic plants	13,000	
River system	Aquatic plants	135,355	

We extracted urban green space data using a generic deep learning framework [33] integrated with remote sensing. ENVI software facilitated preprocessing of green space elements, encompassing boundary delineation and area calculation, supplemented and validated through field surveys to ensure data completeness and accuracy. Vegetation typologies were catalogued via on-site investigations and statistical records; hydrological data originated from OpenStreetMap, with coordinate transformation and boundary extraction executed in ArcGIS. Carbon sink components comprised two categories: green spaces including mountain parks, waterfront parks, street greenery, pocket greens, and internal greens exhibiting point, linear, and areal spatial configurations; and blue spaces including lakes and rivers (e.g., the moat) displaying areal and linear distribution patterns. All data were standardised to uniform coordinates and units, culminating in a foundational geospatial dataset for the Yuejianglou neighbourhood's blue-green spaces (Figure 1).

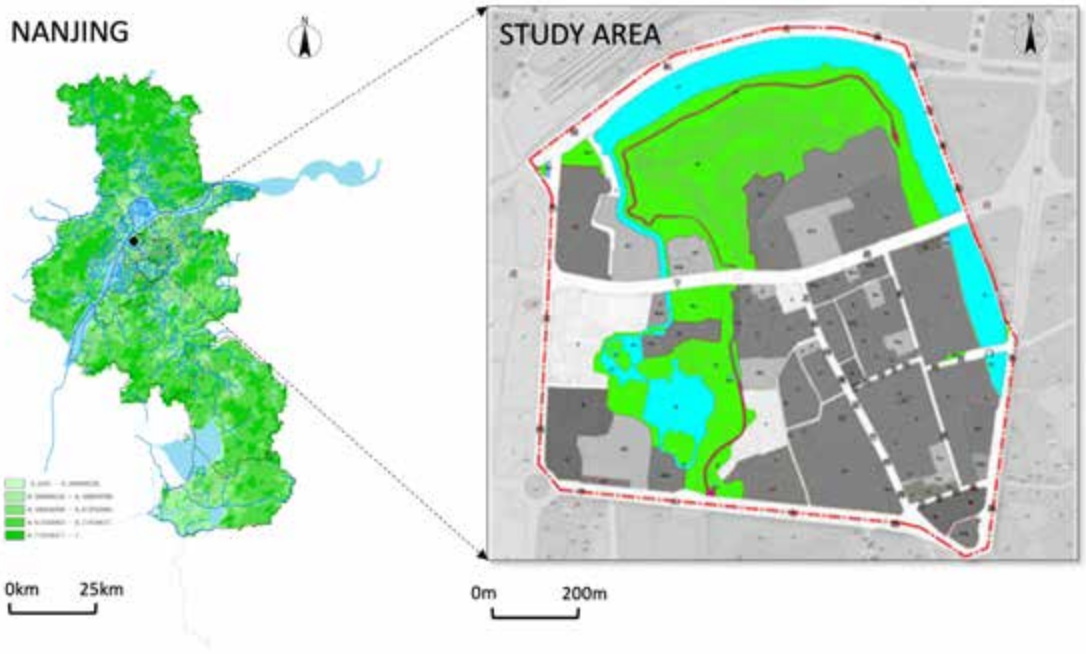


Figure 1: Distribution of Blue-Green Spaces in the Yuejianglou neighbourhood

2.2 Carbon Sink Calculation for Distinct Elements

Carbon sink quantification for neighborhood blue-green infrastructure encompassed two components.

1) Arboreal carbon sequestration: Calculated using the Landscape Performance Series (LPS) National Tree Benefit Calculator (NTBC) .

2) Shrub/herbaceous layer sequestration: Derived from established methodologies [35].

3) Aquatic carbon sinks: Computed using lake carbon sink methodologies [36-37], distinguishing contributions from water bodies and hydrophytes, with unit area sequestration rates categorised by waterbody type.

Spatial overlay analysis integrated biomass-based methods to quantify synergistic carbon sink enhancement in blue-green spatial interfaces. This approach incorporated vegetation-specific carbon sink coefficients and coverage areas, formalised as:

$$E = PVxBxVS$$

where:

E = Vegetation carbon sink (kg)

VS = Vegetation coverage area (m^2)

B = Carbon sequestration per unit area (kg/m^2)

PV = COΔpotential value (standardised to 1)

2.3 Influencing Factors of Blue-Green Space Carbon Sinks

We compiled carbon sink components (green spaces, water systems, soil, vegetation) and influencing factors, constructing a correlation model to examine their interrelationships. Influencing factors emphasised spatial patterns and configurations of components (Table 2) to inform design strategies. Pearson correlation analysis generated matrix of correlations between components and influencing factors, with statistical validation ensuring analytical objectivity.

Table 2: Constituent Elements and Influencing Factors of Blue-Green Space Carbon Sinks

Constituent elements		Influencing factors	Abbreviation
Green space	park green space area	Green space concentration degree	GSCD
	street green space area		
	internal green space area		
Water system	Water system area	Concentration degree of water system	CDWS
Soil	Permeable ground area	Vegetation richness	VR
Vegetation	Vegetation canopy width	Permeable ground coverage rate	PGCR

Note: Constituent elements refer to the elements that generate carbon sinks in the space, and the influencing factors refer to the elements that affect carbon sinks in the space

3.Results

3.1 Carbon Sink Benefits and Comparisons of Blue-Green Spaces

As illustrated in Figure 2, Shizishan Park—a mountainous park within the neighborhoods—exhibits rich vegetation communities, yielding an annual carbon sink of 806.92 t (tons), representing Yuejianglou's primary carbon sequestration zone. Street trees (predominantly Platanus spp., Cinnamomum camphora, and Celtis sinensis) contribute 79.50 t annually. Pocket greens generate 45.55 t/yr(tons/year), with vegetation including trees (Cinnamomum camphora, Celtis sinensis), shrubs (Pittosporum tobira, Loropetalum chinense, Photinia spp.), and herbaceous cover (Lolium perenne). Internal neighbourhood greens (residential greenspaces, flower beds) yield 56.24 t/yr, dominated by shrubs, herbs, and sparse trees.

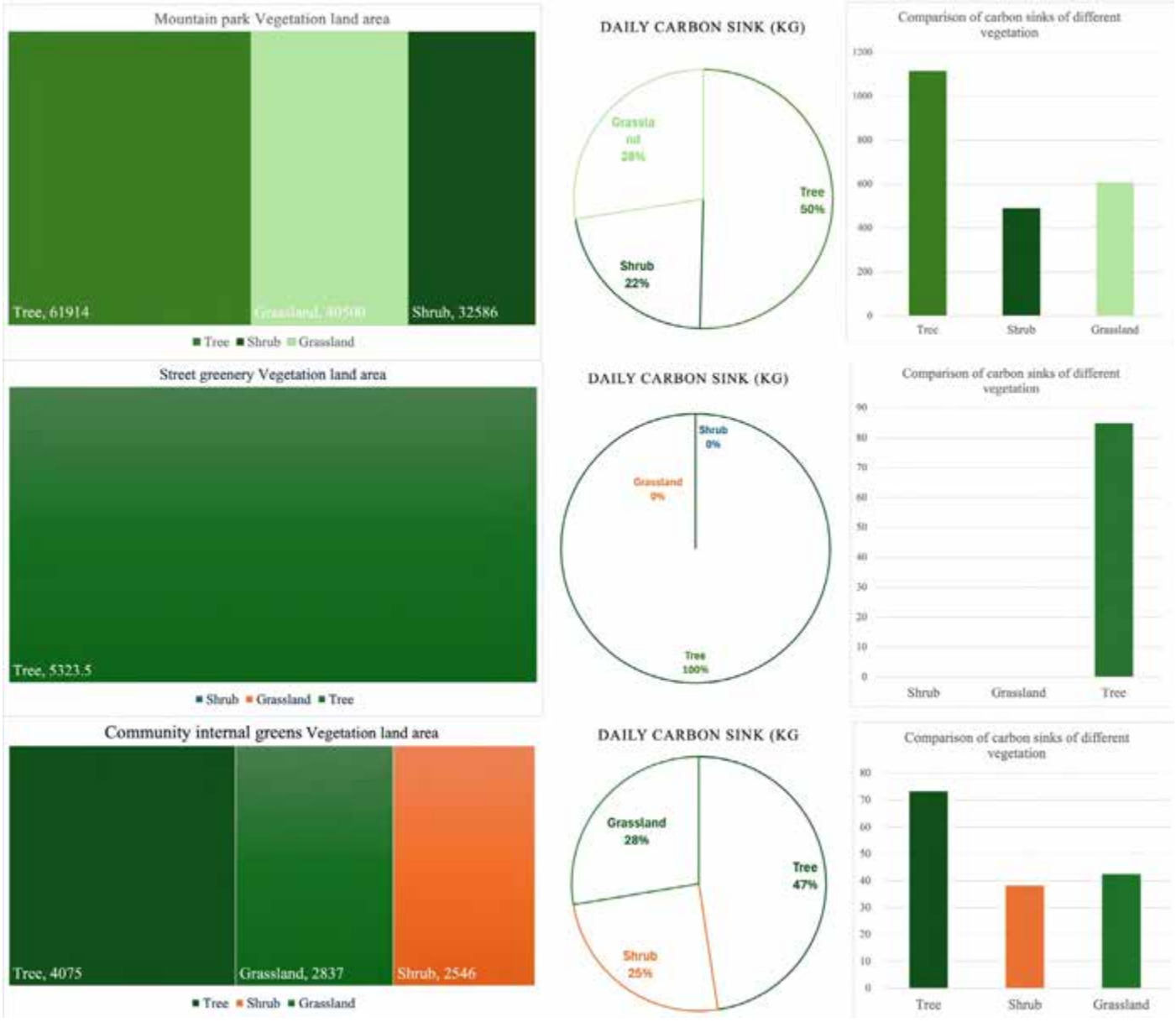


Figure 2: Area Proportion and Carbon Sink Benefits of Green Space Types (Mountain Park, Street Greenery, Internal Greens))

Blue space carbon sinks comprise lakes and rivers. Xiuqiu Park (Figure 3), a waterfront park, achieves 355.64 t/yr through integrated blue-green sequestration. However, its lake carbon sinks (79.05 t/yr) derive primarily from hydrophytes (Lythrum salicaria, Schoenoplectus tabernaemontani, Pontederia cordata, Phragmites australis), with negligible contributions from the water body itself. The moat's ecological ponds sequester 27.20 t/yr Hydrophytes account for 51% of aquatic carbon sinks despite occupying only 17% of water surface area, indicating their dominant role.

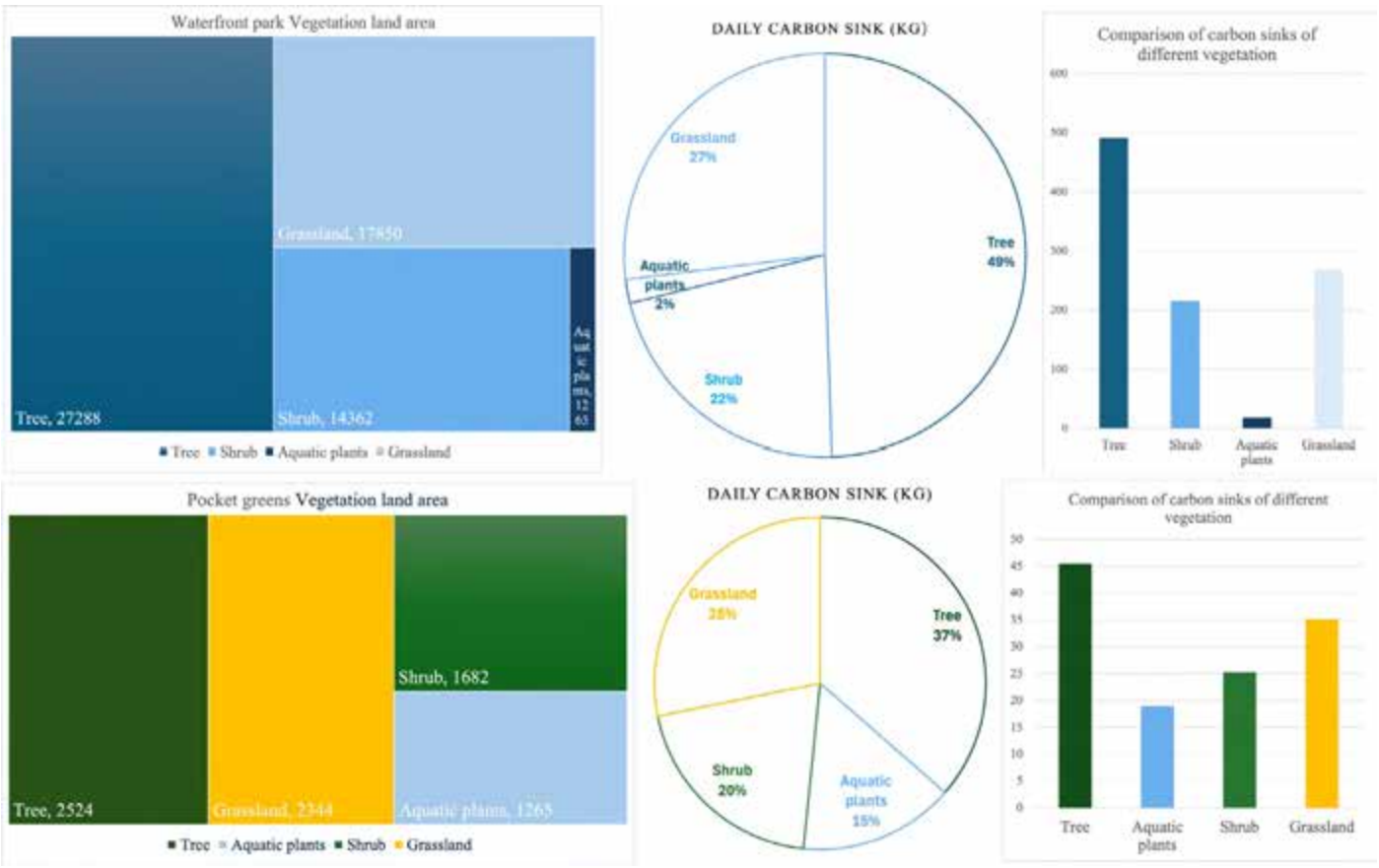


Figure 3: Area Proportion and Carbon Sink Benefits of Blue Space and Associated Riparian Greenspaces (Xiuqiu Park, Moat Riparian Zone))

Figure 4 illustrates the integrated relationship between spatial coverage and carbon sink benefits across diverse carbon sink typologies within the Yuejianglou neighbourhood.

Our analysis reveals two distinct carbon sink modalities: singular and composite systems. Shizishan Park, street trees, pocket greens, and internal neighbourhood greens constitute singular sinks predominated by green infrastructure, whilst the moat represents a singular blue-dominated system. Conversely, Xiuqiu Park and riparian green spaces along the moat exemplify composite blue-green systems, integrating lakes, hydrophytes, and terrestrial vegetation.

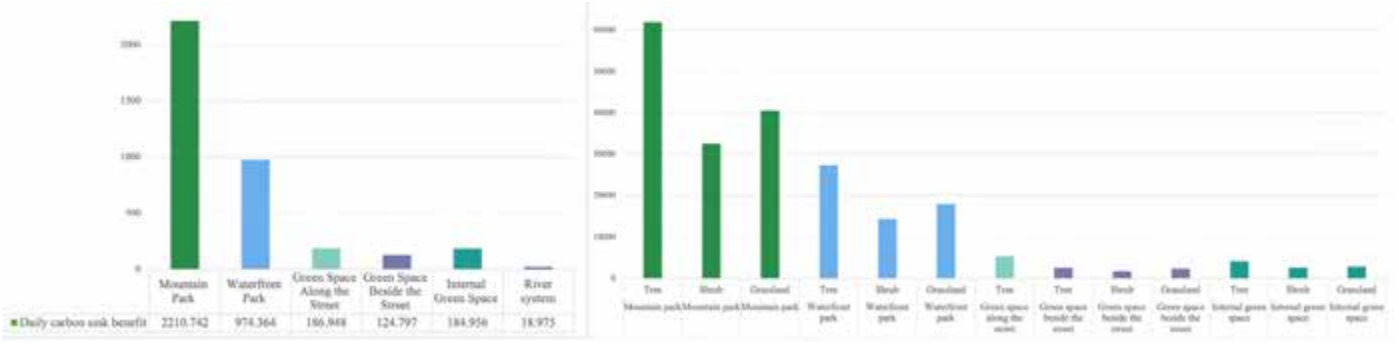


Figure 4: Relationship between Spatial Coverage Area and Carbon Sink Benefit by Space Type

3.2 Correlation Between Blue-Green Space Components and Carbon Sink Benefits

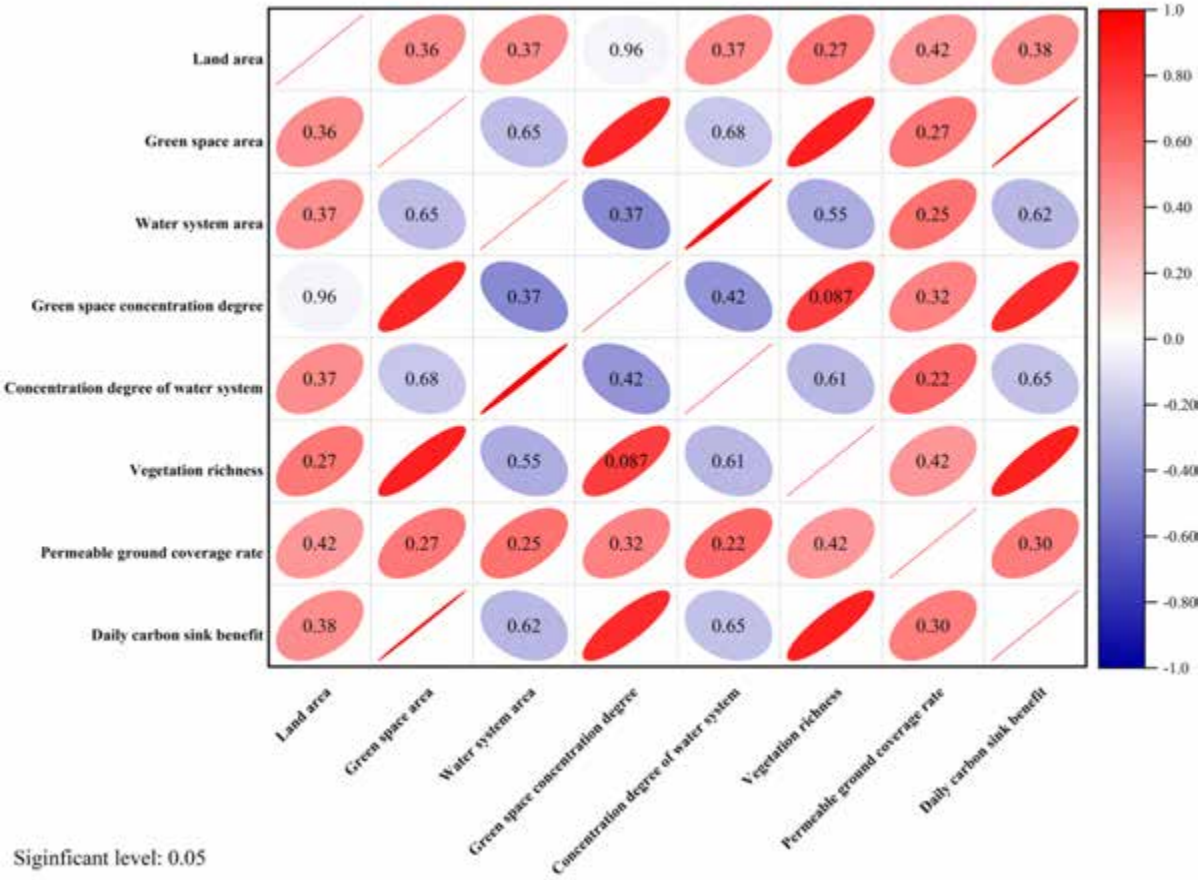


Figure 5: Correlation Analysis of Carbon sink Benefits of Blue and Green Spaces in the Yuejianglou Block

Correlation analysis (Figure 5) reveals carbon sink efficiency is jointly influenced by water system aggregation (as measured by CDWS) (r = 0.65) and green space aggregation (as measured by GSCD) (r = 0.62). Concentrated distributions of water bodies (e.g., lake-river connectivity) and green patches positively enhance overall carbon sequestration. Aggregated blue-green configurations promote efficient carbon sink functionality, with water aggregation (CDWS) exhibiting marginally stronger effects than green aggregation (GSCD).

Key correlations include:
1) Green space area and aggregation (GSCD): Strongest correlation (r = 0.96), indicating larger areas facilitate clustered green patches.
2) Total study area: Weak positive effects on water coverage and carbon sinks, but is less significant than green aggregation.
3) Water coverage: Marginal positive impact on carbon sinks.
4) Vegetation richness (VR) and water aggregation (CDWS): Moderately weak correlation (r = 0.55), suggesting aquatic clustering may mildly enhance plant diversity.
The neighbourhood's total annual carbon sink (1,314.36 t) displays significant spatial heterogeneity.

Key findings:
1) Green Spaces Dominate: Shizishan Park contributes 61.4% (806.92 t), confirming green infrastructure as the primary carbon sink component.
2) Blue Space Enhancements: Hydrophytes and riparian zones significantly boost aquatic sinks. Xiuqiu Park's water body contributes only 6% (79.05 t), but ecological riparian zones exhibit higher carbon density (1.2 t/h(tons/ha)) than hardened banks (0.4 t/h). Riparian interfaces correlate positively with terrestrial vegetation.

3) Linear Street Greenery Optimisation: Street trees (79.50 t) demonstrate a strong "tree size-carbon sequestration" relationship (R^2 = 0.73). As arboreal vegetation yields the highest per-unit sequestration, streetscapes—particularly tree-lined corridors—constitute critical optimisation spaces in high-density urban contexts.

4. Discussion

Our findings indicate that vegetation carbon sinks within green spaces predominantly contribute to overall carbon sink benefits (e.g., Shizishan Park's annual carbon sequestration of 806.92 t surpasses all other spatial types). Among vegetation categories, arboreal species—particularly large-specimen trees—demonstrate superior carbon sequestration capacity. This substantiates the principle posited by the National Tree Benefit Calculator that tree carbon sink potential correlates positively with dimensions. Concurrently, vegetation type significantly influences carbon sink efficiency, with distinct tree species exhibiting variable carbon sink coefficients. Consequently, trees characterised by high coefficients and substantial dimensions markedly enhance integrated green space carbon sink performance. Nevertheless, this remains contingent upon total green space area. Street tree selection and optimisation should therefore prioritise large-specimen trees with elevated carbon sink coefficients.

Regarding spatial correlations, water system aggregation (CDWS) (r = 0.65) and green space aggregation (GSCD) (r = 0.62) constitute primary determinants of integrated carbon sink benefits, further evidencing that carbon sink research necessitates combined analysis of blue and green spaces. More aggregated spatial configurations of water bodies and green patches enhance carbon sink functionality. Notably, water aggregation (CDWS) exerts marginally stronger effects than green aggregation (GSCD). Additionally, blue and green spaces exhibit synergistic spatial patterning, evidenced by a significant moderate positive correlation between water aggregation (CDWS) and green aggregation (GSCD) (r=0.68).This reveals that clustered aquatic areas frequently coexist with aggregated green zones (or vice versa), potentially influenced by shared topographic, planning or ecological processes. Spatial design should thus strategically adjust blue-green ratios to optimise carbon sinks within constrained areas.

Concerning influencing factors, vegetation structure and composition principally govern singular carbon sinks. For instance, broadleaf trees (e.g., Platanus spp.) sequester 12.6 kg/m² annually, which is 4.1 times the capacity of grasslands. [31] Secondly, spatial connectivity critically influences integrated sinks; blue-green ecological corridors (>30m width) elevate carbon density by 18–22%. Moreover, soil carbon sink contributions warrant attention: permeable surfaces exhibit 40% higher efficiency than impervious surfaces, while each 1% increase in organic matter boosts sequestration by 7.3%. These findings advocate incorporating "grey space" (permeable surfaces) into integrated sink frameworks, extending analysis from blue-green to blue-green-grey systems. Future research should quantify permeable soil carbon sinks and integrate them as design elements to substantially enhance neighbourhood-scale sequestration.

Optimisation Strategies focus on two dimensions: Sink enhancement: Blue spaces: Introduce hydrophytes (Lythrum salicaria, Phragmites australis) to augment aquatic contributions. Green spaces: Increase neighborhoods tree coverage from 30% to 50%, projecting 15–20% annual sink gains. Prioritise aggregated, interconnected blue-green spatial configurations.

Multifunctional synergy: Transform moat riparian zones into "carbon-neutral landscape corridors" integrating ecological, aesthetic, and recreational functions. Implement community carbon sink trading mechanisms to incentivise public engagement.

Technological advancements—particularly AI-enabled dynamic carbon flux monitoring, automated vegetation identification, and high-resolution data analytics—will refine future research precision, enabling robust, objective conclusions.

5.Conclusions

This study employed multi-source datasets to identify spatial distributions of carbon sink components in Nanjing's Yuejianglou neighbourhood, utilising ArcGIS and quantitative calculations to evaluate carbon sink benefits from green and blue spaces, establish correlations among influencing factors, and analyse determinants across spatial typologies. Climate-adaptive optimisation strategies were subsequently formulated. Key findings demonstrate

that green spaces constitute the primary carbon sink domain, with arboreal vegetation exhibiting superior sequestration capacity. Spatial aggregation of blue-green elements and green space area emerged as dominant influencing factors, with water aggregation (CDWS) exerting marginally stronger effects than green aggregation (GSCD). Notably, soil contributions—exhibiting sink benefits analogous to green spaces—were identified as a significant yet previously underemphasised dimension. Consequently, spatial design strategies are proposed: optimising blue-green ratios, enhancing street tree efficiency, adjusting aquatic plant communities, expanding riparian green areas, and establishing carbon-neutral landscape corridors.

Nevertheless, limitations persist regarding the precision of blue-green infrastructure component identification and the exclusion of carbon emission calculations during sink processes. Future research should integrate artificial intelligence algorithms for digital vegetation recognition to improve survey efficiency and accuracy. Concurrently, dynamic models capturing temporal variations in emission-sink processes would enhance the objectivity and scientific rigour of blue-green space assessments. Furthermore, incorporating microclimatic influences (e.g., urban heat island effects) through multi-scale validation via atmospheric inversion data (e.g., COΔ monitoring stations) presents a critical avenue for advancement.

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Appendices
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Preserving the past or protecting the future? Harmonizing Cultural Heritage and Climate Adaptation in Siena

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Abstract
Historic cities embody rich cultural heritage and a long-standing relationship with nature, yet they are increasingly vulnerable to climate change. This study examines the intersection of heritage preservation and climate adaptation in Siena, a UNESCO World Heritage Site. Developed through the ISOCARP YPP Workshop "Valleys of Siena," the project addresses urban overheating within the city's dense historic core. Drawing on fieldwork, GIS analysis, and case studies, the research identifies key challenges, including a lack of green space and fragmented green valley systems. Inspired by initiatives such as Paris's "Oasis Schoolyards" and Barcelona's "Streets for Kids," the study proposes context-sensitive strategies—micro-greening, water-sensitive design, thermal regulation, and inclusive public spaces—rooted in community engagement. This approach offers a replicable model for the climate-resilient transformation of historic urban environments.

Keywords: Cultural Heritage, World Heritage Sites (WHS), Siena, UNESCO, Climate Change, Climate Adaptation

Introduction

Cities evolve through a dynamic interplay between human adaptation and their natural landscapes (Izzati & Ikaputra, 2022). While some urban areas undergo rapid transformations, others, like Siena—a UNESCO World Heritage city—have maintained a remarkable continuity, preserving a unique repository of built heritage deeply intertwined with their historical ecology. During the medieval era, Siena thrived by strategically leveraging its natural valleys for resources and microclimate regulation. However, the pressures of modern urban development on the city's fringes are now causing climatic transformations that risk disconnecting new areas from these vital historical and natural roots. Therefore, understanding and leveraging Siena's historical context is crucial to ensure that future developments remain harmoniously integrated with its enduring character and ecological balance.

Climate change, characterized by long-term shifts in temperatures and weather patterns primarily driven by human activities such as the burning of fossil fuels (United Nations, 2024), poses a significant global threat. Despite commitments to net-zero emissions by 2050, global greenhouse gas emissions continue to rise. Cities, though they cover only a small portion of the Earth's surface, are major contributors—accounting for over 70% of global greenhouse gas emissions and consuming over 65% of the world's energy (European Union, 2024). Limiting global warming to 1.5°C is essential for a sustainable future (IPCC, 2022). This warming trend presents significant risks to cultural heritage sites, demanding the implementation of targeted and adaptive conservation strategies to mitigate adverse effects while respecting their intrinsic value. Moreover, climate-related hazards such as flooding, rising sea levels, and increased erosion pose serious threats to cultural heritage sites that were not built to withstand these risks (Prabowo & Salaj, 2023). Siena, as a heritage city, reflects the deep ties between urban form and nature, raising key questions about climate resilience today.

The growing adversities of climate change threaten the identity of historically significant sites globally. Historic urban landscapes (HUL) need integrated adaptive measures to preserve their cultural and natural heritage from climate-induced risks (Fatoric, 2017). The UNESCO Recommendation on the HUL (2011) promotes a landscape-based approach that recognizes the layering of cultural, natural, and built values, encouraging adaptation that respects heritage integrity. Planning, regulatory systems, financial design, and community engagement are the four pillars of an inclusive heritage-based sustainable development and management strategy (UNESCO, 2011). The HUL recommendation (2011) exemplifies landscape-based and community-led preservation and safeguarding strategies that integrate traditional ecological wisdom with contemporary planning. It recognizes tangible aspects—such as historic built fabric and environmental factors—and intangible aspects—such as socio-cultural and economic elements—as well as the engagement of key stakeholders and their governance (Donato and Lohrasbi, 2017). These approaches emphasise blue-green infrastructure, passive cooling, and water-sensitive design while maintaining the morphological and symbolic fabric of historic cores of HULs.

Various studies from European contexts underscore the potential for combining resilience with conservation practices (Pereira Roders & Oers, 2011), acknowledging these as embedded adaptive responses to environmental stress (Mehrotra, 2016).

Historic urban landscapes, like Siena, represent a delicate balance between human culture and the natural environment, and understanding these man-nature ecosystem dynamics is crucial for effective urban management. Siena's unique urban fabric and its historical climate resilience were shaped by a sustainable mechanism that integrated its natural valleys into the city's functioning, likely through careful water management and ventilation strategies inherent in its medieval design. Consequently, the city's growth and transformation over time are inextricably linked to its historical context, forming a rich heritage urban landscape (Adishakti, 2017). While mapping serves as a valuable inventory technique for tracking urban change, this study aims to delve deeper into the qualitative aspects of this evolution in Siena, particularly concerning its climate vulnerabilities within its dense historical fabric.

A significant turning point in Siena's urban development was the approval of its general master plan in 1956 (locally) and 1959 (nationally) (Maggi, 2011). This plan made a deliberate decision to direct new urban growth outside the medieval walls, preserving the "green valleys" within and restricting further construction inside the historic centre (Maggi, 2011) (Figure 1). This commitment to preservation contributed significantly to Siena's historic centre being designated a UNESCO World Heritage Site in 1995, recognized for its exceptional preservation of medieval architecture and urban planning (UNESCO, 2024).

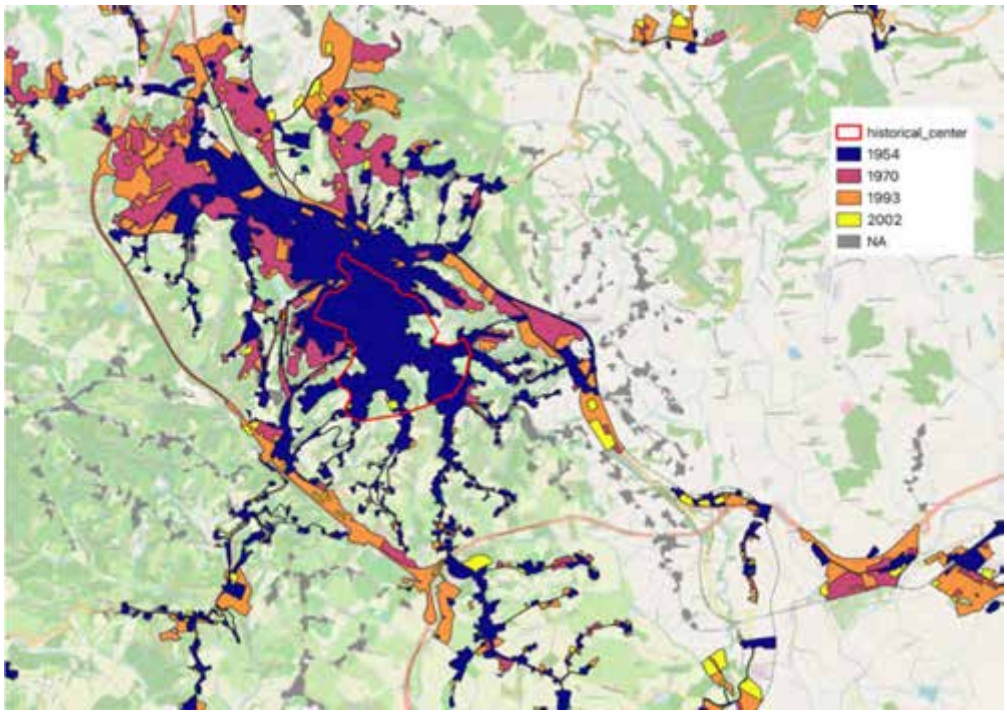

Figure 1. Spatial development of Siena. Author's elaboration.

This study, titled "Preserving the Past or Protecting the Future? Harmonizing Cultural Heritage and Climate Adaptation in Siena," emerged from the ISOCARP YPP (Young Planning Professional) Workshop "Valleys of Siena: Global Ideas for Local Connectivity." Recognizing climate change as a critical threat to the Siena region's ecological balance and its esteemed cultural heritage site, this research is inspired by Italo Calvino's *Invisible Cities*. We interpret the 'invisible' climate-related challenges—such as the intensifying urban heat island effect within Siena's dense historical structure—as being deeply embedded in its heritage-built setting, and we aim to uncover and address them. Ultimately, this project seeks to provide valuable insights for Siena by showcasing how other culturally significant sites have successfully adapted to climate change while maintaining comfortable living conditions for both residents and visitors. It aims to contribute to a more resilient and sustainable future for the city.

Materials and methods

This research employed a mixed-methods approach, combining quantitative spatial analysis with qualitative field research and comparative case study analysis to develop a practical toolkit for climate adaptation in Siena (Figure 2). The methodology was structured to: (1) diagnose the key climate-related challenges facing Siena, (2) study potential adaptation strategies from case studies all around the world, (3) define families of adaptation strategies which can preserve the cultural heritage and adapt to climate change, and (4) contextualize these strategies within Siena's specific historical, social, and environmental context.

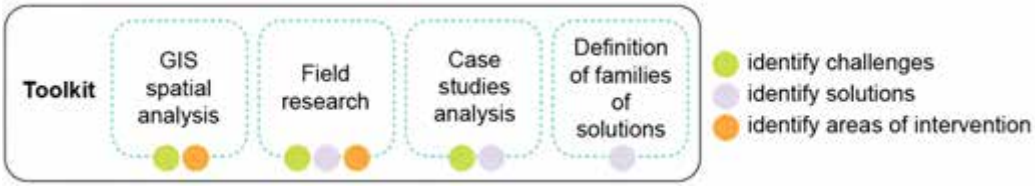

Figure 2. Scheme of the mixed-methods approach used to conduct the study.

GIS spatial analysis was conducted to map urban heat islands (UHIs), evaluate urban density, measure the distribution and quality of green spaces using NDVI, and perform an initial risk assessment to prioritize areas for intervention. **Field research** was undertaken to validate the GIS findings (Figure 3). This involved capturing visual documentation of areas with significant heat stress, extensive paved surfaces, and a lack of green spaces, as well as observations on the disconnection between the city centre and the valleys. Informal conversations with local residents and stakeholders offered valuable perspectives on their experiences and perceptions of Siena's current challenges.

Figure 3. Visual documentation from field research in Siena. This figure presents a selection of images captured during field research. Picture 1 - exploration of the surrounding valleys by bus; Picture 2 - on-foot observation within the valley areas; Picture 3 - the view of the Siena city centre as seen from the valleys; Picture 4 examples of small green interventions, such as potted plants, noted for their potential to contribute to microclimate cooling; Picture 5 - on-site perception of the urban environment; Picture 6 shows the *Tartarugone* parking area, identified as a potential site for future intervention.

A **comparative case study approach** was applied, selecting other UNESCO World Heritage Sites that have successfully implemented climate adaptation strategies, with a focus on urban heat island mitigation and small-scale, temporary interventions.

Based on the challenges identified through GIS, fieldwork, and the UNESCO case studies, we defined several **"families of solutions"**, including: Water Management, Ecosystem Enhancement, Community Engagement, Heat Control, and Places that Foster Belonging. These were then adapted to Siena's context.

By cross-referencing the spatial and qualitative findings with the solution families, we prioritized context-sensitive interventions that align with Siena's heritage values and spatial constraints.

Results

The presentation of the findings begins by outlining Siena's specific challenges. This is followed by an analysis of international case studies from contexts facing similar issues, particularly the intersection of cultural heritage and climate change impacts. Finally, we present defined solution families along with specific proposals for Siena, aimed at harmonizing heritage preservation with climate change adaptation.

Siena's Challenges

Despite Siena's renowned surrounding green valleys, its city centre presents a dense urban structure. Calculating the building coverage ratio within the city walls reveals that approximately 70% of the area is not occupied by buildings, leaving around 30% as built-up. While this relatively low building footprint might initially suggest a "green" centre, the city's valleys, encompassing public and private gardens and orchards, along with larger green spaces like "La Fortezza," are largely disconnected from the daily life within the historic core due to existing barriers. Furthermore, there is a noticeable scarcity of small green spaces integrated within the urban fabric itself. When recalculating the building coverage ratio for the central urban fabric, excluding these larger, often isolated green areas, the figure increases significantly to 47% (Figure 4A). This neighbourhood-level coverage ratio is considerably high, comparable to Densely built areas such as some neighbourhoods in Manhattan (according to the Density Atlas, 2020). The space not covered by building footprints is predominantly composed of impermeable pavements in streets and piazzas. These factors collectively contribute to the emergence of the urban heat island effect, a phenomenon that is projected to become increasingly pronounced as climate change progresses.

Analysis of the historic centre for the urban heat island effect indicated that approximately 30% of its area (excluding the green valleys, specifically 1.946–2.365 and 2.365–2.989 in the legend) is significantly affected by elevated temperatures (Figure 4B).

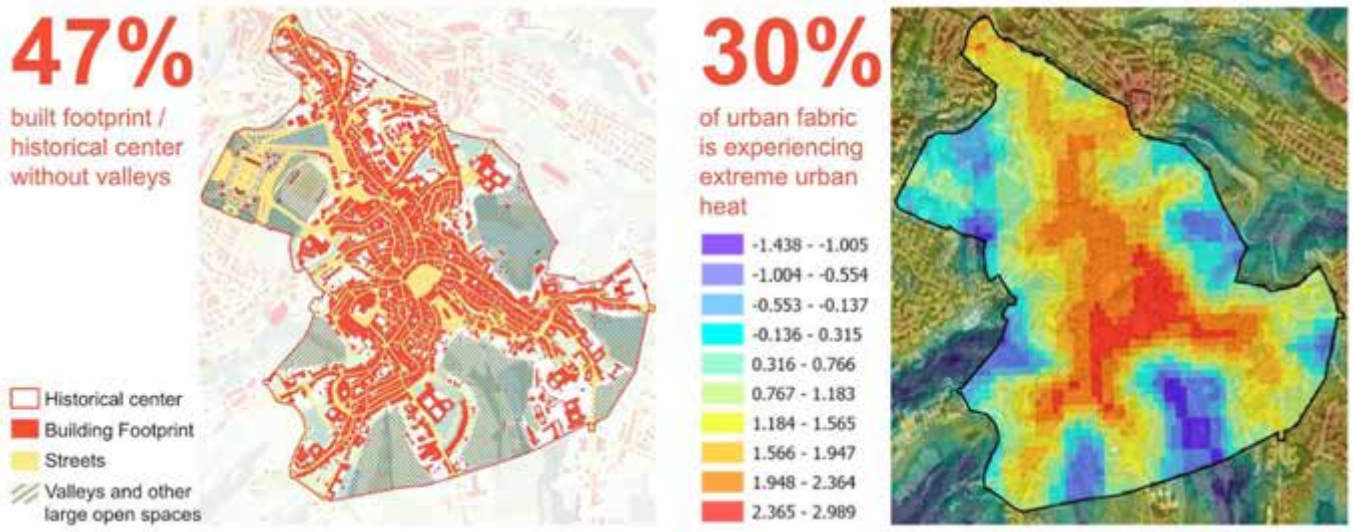

Figure 4. Built-up density and urban heat island (UHI) effect map. Author's elaboration.

Recognizing the stringent UNESCO regulations governing historical sites, we understand that the potential for large-scale interventions within such urban centres is limited. Direct alterations to the historical urban fabric and the creation of extensive greening infrastructure are often challenging. Therefore, our focus will be on small-scale interventions and temporary structures that strategically utilize existing urban spaces. GIS analysis and field research enabled the identification of several hot-spots within Siena's city centre—specific areas experiencing persistent issues requiring prompt attention (Table 1).

Table 1. Hotspots within Siena's city centre and their key challenges.

Picture	Type	Key challenges
	Larger squares	Heat absorption, lack of shade.
	Small squares	Occupied by cars, no greening or shading, lack of seating to stay instead of walking by.
	Main Streets	No or limited shade, lack of vegetation, high contribution to heat effect.
	Schools and public buildings	Fully artificialised, no or limited greening, closed to the public.
	Parking lots	Low urban quality, high contribution to heat effect, impermeable - limit water infiltration, disconnect valleys-city canter.
	Existing valleys	Prevalence of private space (gardens, restaurants, vineyards etc), lack of walkable trails, absence of urban furniture, physical disconnection.

Short interviews with local citizens and experts broadened our perspective beyond the factual data obtained through GIS analysis and documentation of climate challenges, incorporating a crucial social dimension. The Contrada communities' active role in urban life highlights the potential for citizens to act as key drivers in the adoption of sustainable greening initiatives. Considering the challenges that newcomers (e.g., students, migrants) may encounter upon arriving in Siena, we emphasize the necessity for spaces that foster social cohesion and gathering, providing opportunities for meaningful interaction among diverse individuals.

Case Studies Analysis

To address Siena's challenges, we researched potential actions implemented globally to combat similar issues. We compiled a list of relevant case studies: projects that integrate water management, reduce the heat island effect, enhance biodiversity, increase community engagement, and improve the liveability of public spaces. Based on these case studies, our aim was to identify solutions adaptable to Siena's context, enabling the city to confront its challenges while preserving its heritage. These solutions are conceived not only to help the city address its climatic challenges but also to encourage community engagement and create spaces where individuals from diverse backgrounds can meet and participate in common actions.

To address Siena's challenges, our research explored global initiatives tackling similar urban issues. We identified several relevant case studies offering adaptable solutions for water management, heat island reduction, biodiversity enhancement, community engagement, and improved public space livability (Figure 5).

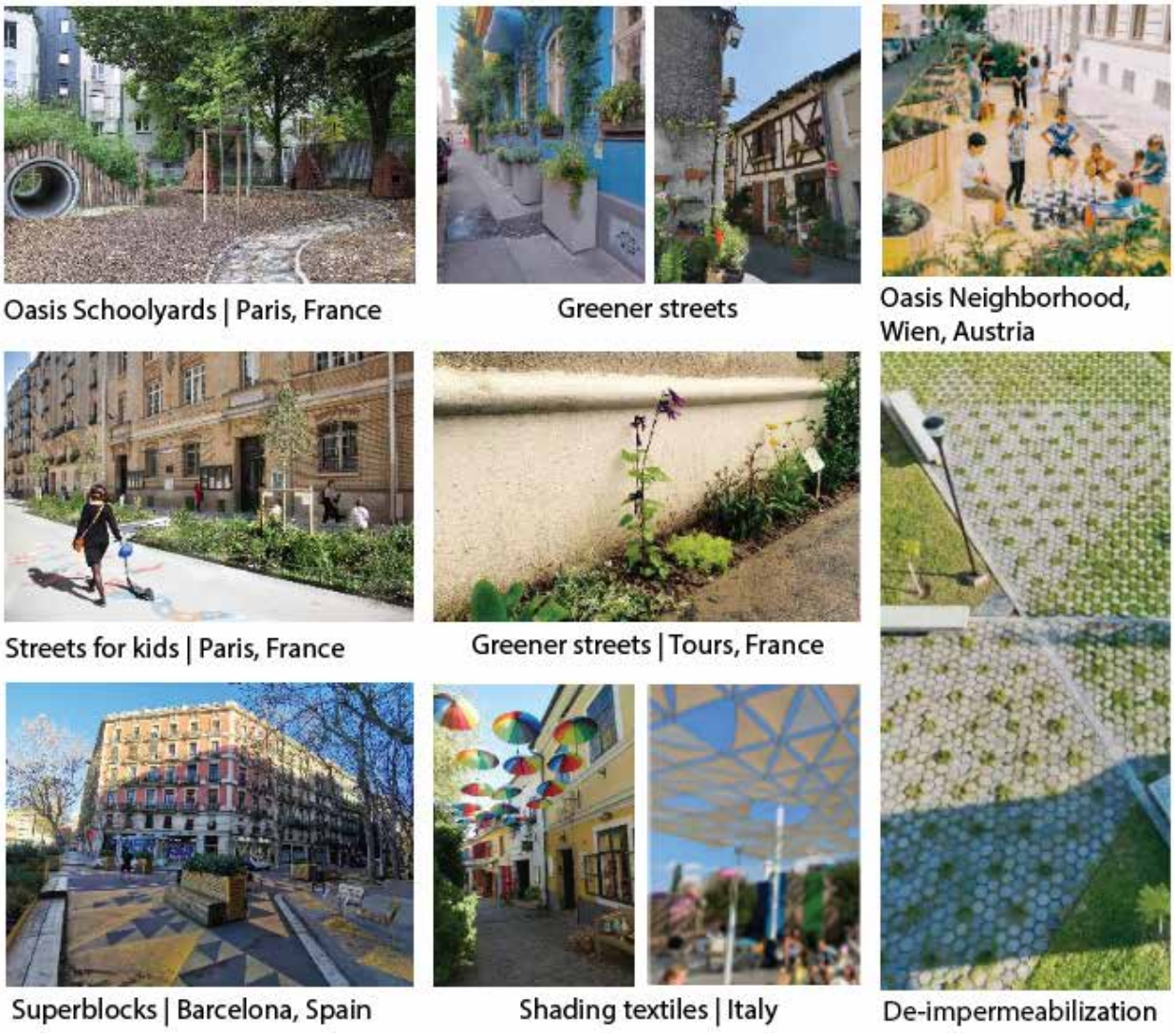

Figure 5. Case studies of cities adapting to climate change with temporary, soft, or green solutions.

One compelling example is the Paris Oasis - Openness, Adaptation, Sensitisation, Innovation, and Social Ties - Schoolyard Programme in France (Climate-ADAPT, 2022). Following the devastating heatwaves of 2003 and 2017, and in response to limited green public spaces, poor water absorption, heat island effects, biodiversity loss, and air pollution, Paris transformed schoolyards by de-impermeabilising surfaces and introducing extensive greenery. By opening these revitalised spaces to the public outside school hours, the city has encouraged community engagement, created vital social hubs, reduced urban heat, enhanced water management and biodiversity, lowered pollution levels, and improved the overall urban experience.

Similarly, the "Streets for Kids" initiative in Paris addressed the scarcity of green spaces, poor permeability, and limited biodiversity (Baierl, 2025). By reducing traffic and introducing greenery through de-impermeabilised streets and tree planting, the city created safer and more welcoming spaces for children and families. This not only reduced the heat island effect but also fostered community well-being and improved the urban ambiance.

Barcelona's "Superblocks" offer another exemplary model. Faced with limited public green space, excessive traffic, and biodiversity decline, the city reimagined car-dominated zones as pedestrian-centred green spaces (C40, 2018). Through the addition of street furniture and vegetation, Barcelona promoted social interaction, improved microclimates, enhanced biodiversity, and increased pedestrian safety.

Vienna's Vienna – Grätzloase initiative exemplifies a citizen-driven response to similar urban challenges (Lee Kuan Yew World City Prize, 2020). Temporary transformations of parking spaces into green community areas empowered residents to reclaim public space. These interventions contributed to heat island mitigation, water management, biodiversity support, and the creation of safer, more inclusive urban environments.

Simple yet impactful solutions, such as the use of plant pots or encouraging residents to green their streets, have been employed in various cities. For example, in Tours, France, the municipality enabled residents to cut through pavements and plant directly into the ground . This initiative tackled impermeability, water runoff, and heat effects while enhancing biodiversity and fostering community care for public space.

In Italy, some municipalities have addressed excessive heat in public spaces by installing temporary **shading textiles** across squares and streets (Fabbri et al. 2023). These installations reduce surface temperatures and promote the use of public spaces for social and cultural activities.

Other effective solutions include de-impermeabilising parking areas using permeable paving systems, such as concrete grids that allow grass to grow. These systems improve water absorption, reduce heat, and increase green cover in highly artificialised environments.

Collectively, these international case studies demonstrate that even modest, low-impact interventions can have wide-reaching benefits. When adapted to Siena's context, such strategies can contribute to a more climate-resilient, liveable, and socially cohesive city, all while respecting and preserving its cultural heritage.

Definition of Solutions

Drawing upon the insights gained from the analysed case studies, several families of solutions have been defined for potential implementation in Siena (Figure 6). These interconnected families are specifically designed to address the city's unique challenges while drawing inspiration from successful climate adaptation strategies observed in other UNESCO World Heritage sites. The proposed solutions are organized around five key areas of intervention. Firstly, **Water Management** strategies aim to enhance water retention and improve drainage systems, thereby playing a crucial role in reducing the risk of flooding and mitigating the adverse effects of the urban heat island. Secondly, **Ecosystem Enhancement** focuses on the restoration and improvement of natural ecosystems within and around Siena, with the goal of increasing biodiversity and improving overall air quality. Thirdly, **Community Engagement** initiatives are designed to empower local communities to actively participate in climate action through collaborative projects and shared stewardship. The fourth area, **Heat Control**, encompasses the implementation of various strategies to reduce heat absorption within urban areas and increase cooling mechanisms, thereby improving thermal comfort. Finally, the creation of **Places that Foster Belonging** is a key focus, aiming to develop accessible and welcoming public spaces that encourage social interaction among diverse groups and ultimately enhance the overall well-being of Siena's residents.

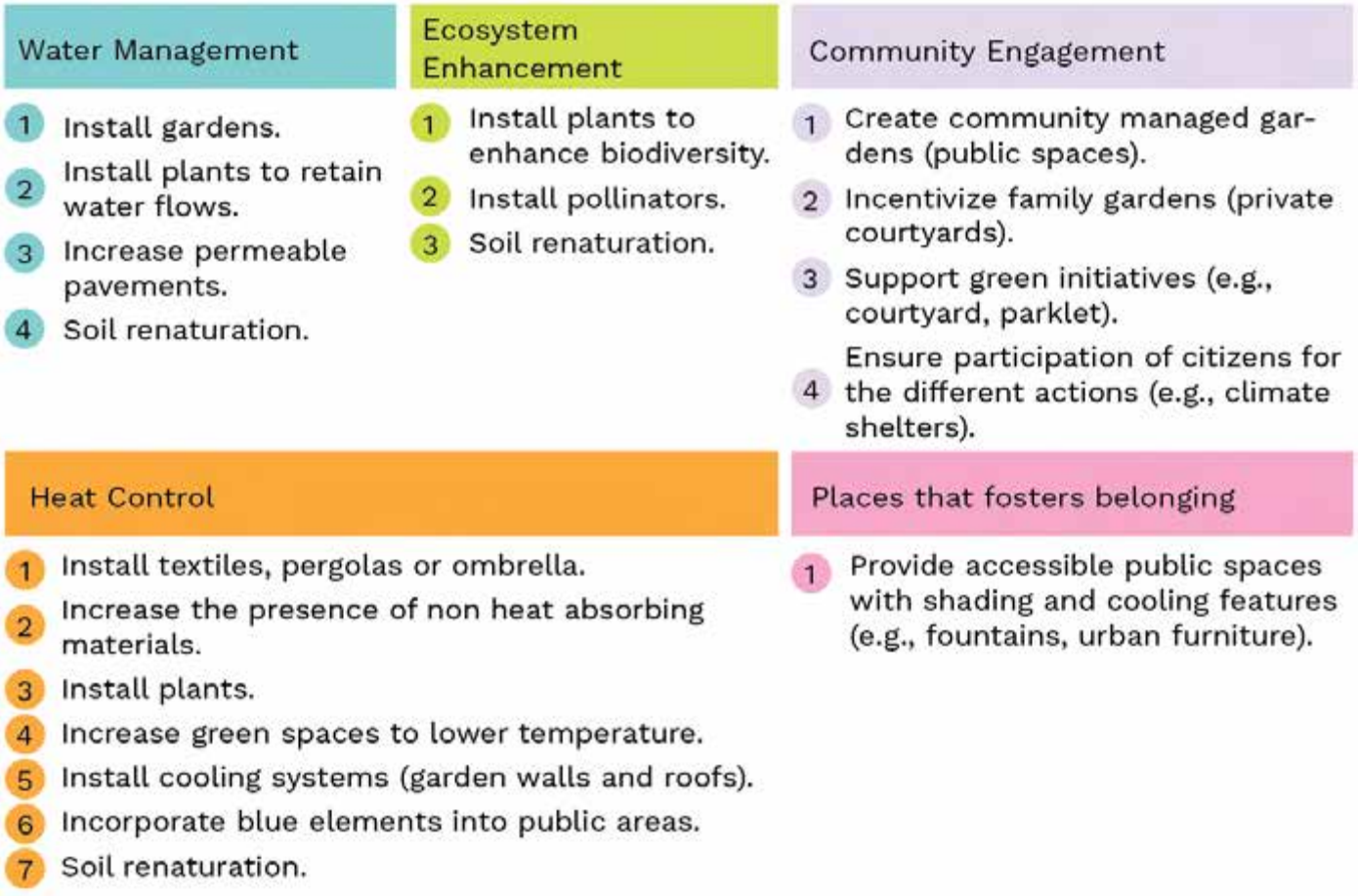

Figure 6. Families of solutions.

Furthermore, we have visually represented these solutions in a matrix (Figure 7) to assist decision-makers in understanding the relationship between specific areas in the city, their identified challenges, and the proposed solutions.

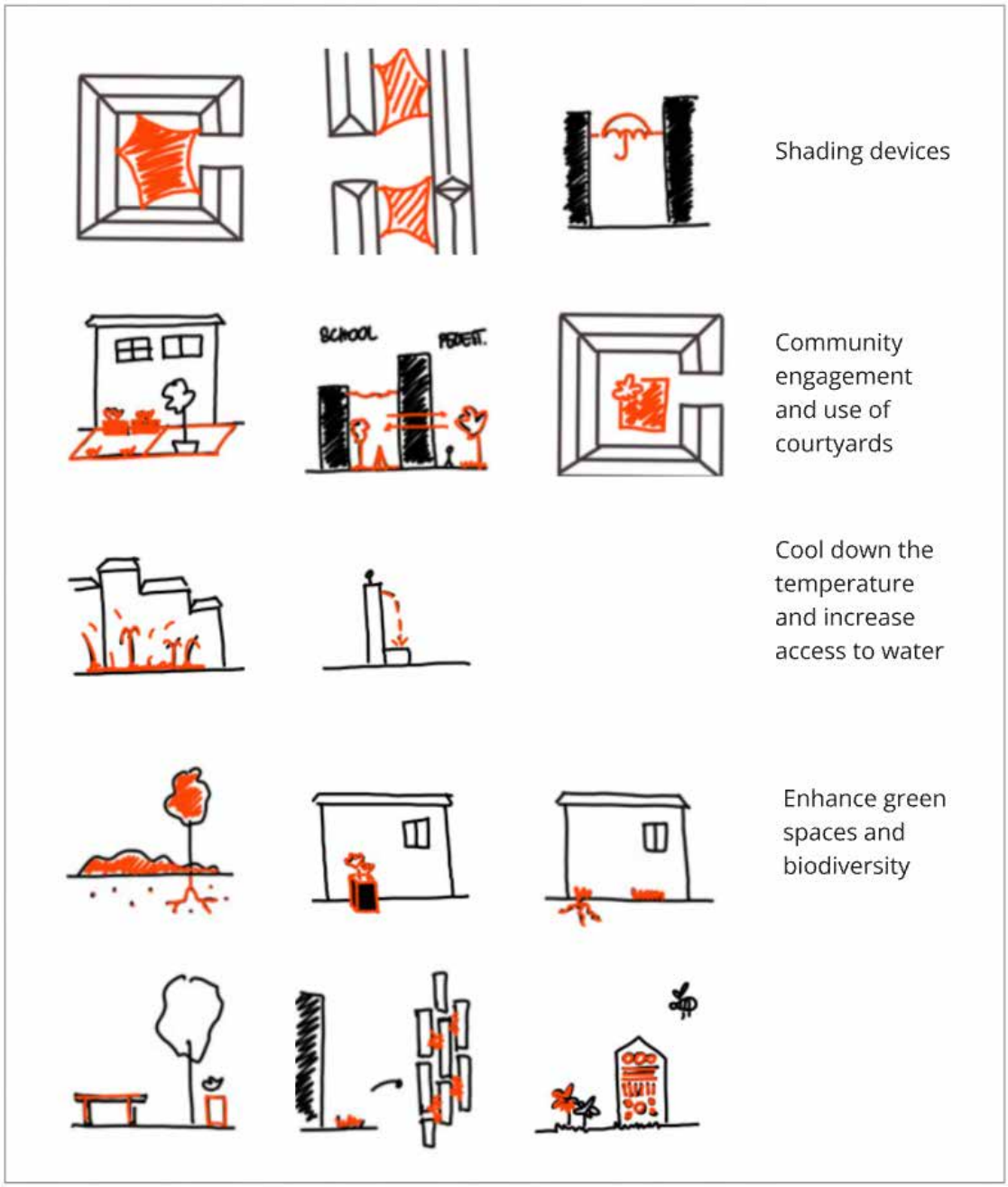

Figure 7. Solutions matrix illustration.

Mapping Actions

All defined solutions were spatially applied to the problem areas identified in the centre of Siena during the analytical phase of this work. The accompanying map (Figure 8) illustrates the locations of all identified hot-spot

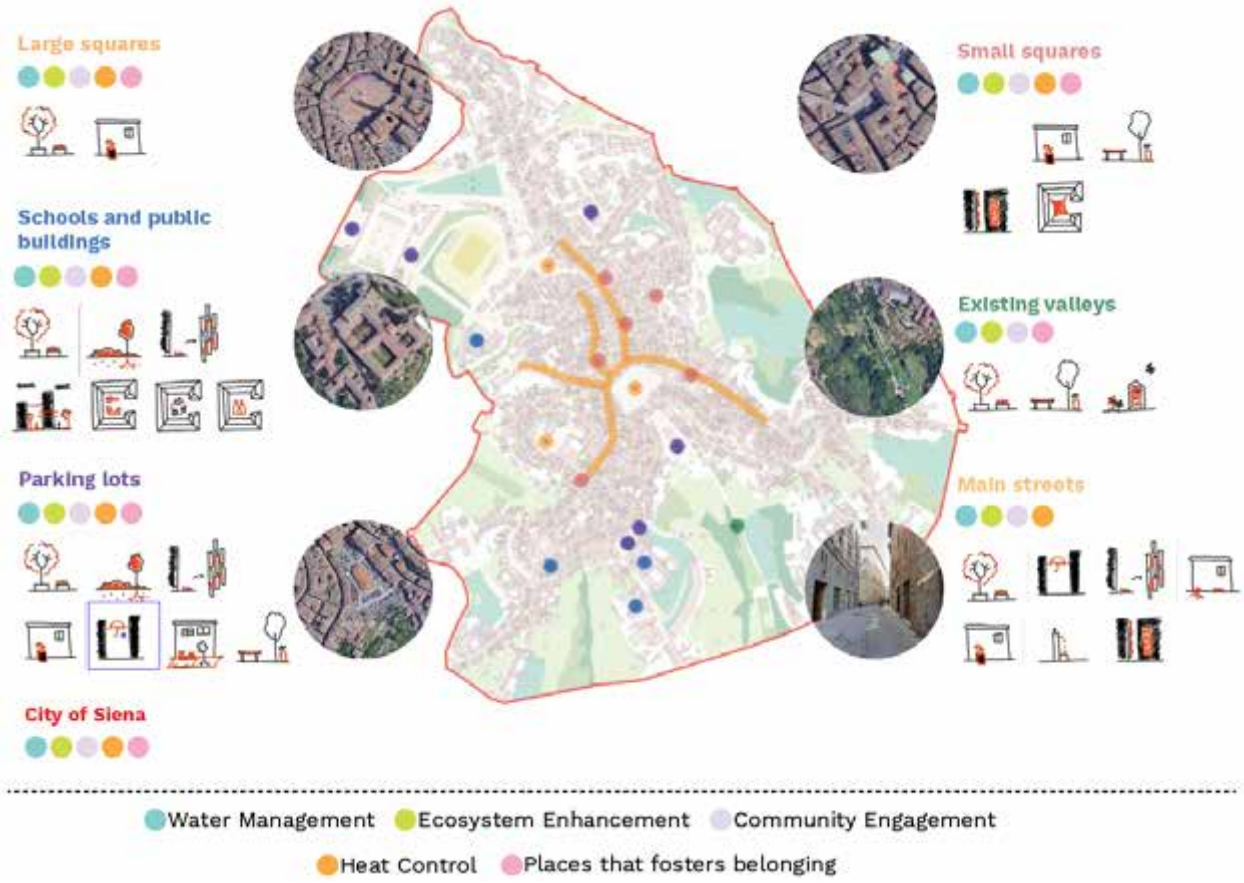

Figure 8. Interventions for climate adaptation map in Siena

Analysis of key urban spaces in Siena reveals specific challenges related to heat absorption, lack of green infrastructure, and limited public amenities. Large squares, while iconic, suffer from excessive heat due to impermeable surfaces and lack of shade, suggesting the need for citizen-involved climate shelters and planted areas to enhance biodiversity and regulate temperature. Schoolyards and public buildings often lack green spaces and could be transformed through soil renaturation, permeable pavements, vegetation, shading structures, and community-managed gardens to improve biodiversity, water retention, and provide accessible, cooled public spaces. Parking lots, prominently located, exhibit low urban quality, contribute to heat effects, and impede water infiltration and social interaction, necessitating similar interventions like soil renaturation, permeable surfaces, planting, and shading, alongside the creation of community gardens and accessible public spaces. Small squares, currently dominated by vehicles and lacking greenery and shade, could be revitalized with planting for biodiversity and heat control, citizen-led climate shelters, shading structures, cooling systems, and accessible, shaded public furniture. Existing valleys, despite their natural presence, lack accessibility and public amenities, indicating a need for pollinator-friendly planting, soil renaturation, enhanced biodiversity, community gardens, and welcoming, shaded public spaces. Main streets, characterized by full artificialization and limited shade and greenery, contribute to the heat island effect, suggesting solutions like increased planting for biodiversity and water retention, permeable pavements, shading structures, expanded green spaces, incorporation of blue elements, use of non-heat-absorbing materials, community gardens, and accessible, cooled public areas, all while maintaining urban mobility. Considering the broader city centre, including incentivizing green development in private courtyards, a combination of these localized solutions can contribute to a more climate-resilient and liveable Siena.

Conclusion

This paper investigated the potential for climate adaptation in Siena, a city distinguished by its exceptionally well-preserved historic fabric and UNESCO World Heritage status, where climate responses must be carefully balanced with cultural conservation. While UNESCO's mandate focuses on protecting cultural heritage, it does not explicitly require member states to address climate change challenges (Nguyen & Baker, 2023). Siena's compact medieval core, characterised by narrow streets, steep topography, and layered historical infrastructures, presents both constraints and unique opportunities for adaptive strategies. Working within the regulatory limits of a UNESCO site complicates asset management for climate adaptation but can also drive innovative, site-specific solutions (Pendlebury et al., 2014).

This project offered an opportunity to critically examine the tension between viewing Siena as a static open-air museum and embracing a dynamic perspective that adapts the city to contemporary and future needs while safeguarding its heritage values. Drawing on a combination of GIS analysis, fieldwork, and international case studies, the study mapped vulnerabilities such as urban heat exposure, limited green infrastructure, and geomorphological challenges within this highly protected environment.

Based on global precedents, four categories of climate adaptation strategies were identified, emphasising how environmental effectiveness can be harmonised with heritage sensitivity. These were translated into locally tailored proposals for Siena, including nature-based interventions embedded within historic street patterns, shaded public microclimates, and the revitalisation of ancient water systems. Consistent with ICOMOS guidance (2019), these site-specific and adaptive solutions respect cultural values while addressing climate risks.

Importantly, the proposed interventions prioritise non-invasive, small-scale actions strategically diffused throughout the city to generate meaningful cumulative impact. This approach aligns with principles of tactical urbanism, favouring reversible and flexible measures that can evolve through stakeholder feedback and municipal collaboration (Lydon & Garcia, 2015). Such flexibility is essential to ensure the long-term relevance and effectiveness of adaptation efforts, while maintaining respect for existing uses and cultural sensitivities.

Although Siena was used as a pilot case to develop this methodology, the framework is intended as a replicable, adaptable toolkit for other historic cities confronting the dual challenges of cultural preservation and climate change. Each application must be carefully contextualised to local histories, urban forms, regulatory frameworks, and cultural landscapes to avoid generic, one-size-fits-all solutions.

This study contributes to the emerging dialogue bridging heritage conservation and climate resilience, offering a place-based planning methodology where formal adaptation frameworks are often lacking. Future research should focus on co-designing interventions with local communities, exploring participatory governance models, and piloting projects to evaluate feasibility, cultural acceptance, and sustainability — ensuring adaptation is both environmentally sound and culturally embedded.

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Exploring Low-Carbon Urban Development at the Plot Scale: A Study of Carbon Emission Mechanisms and Empirical Exploration of Micro-Renovation for Emission Reduction

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Abstract
In response to global climate change, cities - as key spatial carriers of human activity - must refine governance strategies. Focusing on Nanjing's main urban area, this study integrates ODIAC global carbon emission data with multi-source big data and applies Multi-scale Geographically Weighted Regression (MGWR) and Geo-Detector models to analyze drivers of land-use carbon emissions. Results show that functional attributes, spatial forms and carrying capacity characteristics have a spatially heterogeneous impact on carbon emission intensity, with the carrying capacity factors contributing the most and about 60% of the influencing factors having significant synergistic effects. Based on this, a low-carbon planning strategy at the micro-plot level is constructed, and the carbon emission intensity of the plot in Liuhe District is reduced from 6.96 kg/m² to 6.38 kg/m², with an annual carbon emission reduction of 153 tons. This function-form-capacity collaborative control approach effectively reduces urban land-use carbon intensity and supports low-carbon city goals.

Keywords: Urban carbon emissions, Micro-perspective, Multi-scale geographically weighted regression model (MGWR), Geo-Detector, Low-carbon micro - renovation

1.Introduction

As global climate change intensifies, greenhouse gas emissions have become one of the major challenges faced by humanity. Cities, as areas of high population, economic, and social activity concentration, contribute approximately 70% to 80% of global carbon dioxide emissions (Kumar, 2007, Sun et al., 2022, Wang et al., 2023). Therefore, low-carbon urban development has become key to achieving the goals of carbon peak and carbon neutrality. China has proposed the "dual carbon" strategy, aiming to peak carbon emissions by 2030 and achieve carbon neutrality by 2060, which brings unprecedented pressure and opportunities for urban green transformation and planning (Shi, 2022). In this context, a deep scientific understanding of the temporal and spatial distribution characteristics of urban carbon emissions and their driving mechanisms has become the foundation for formulating precise and effective carbon reduction policies and achieving the construction of low-carbon cities.

Urban land, as the basic unit of urban space, aggregates elements such as population, industry, buildings, and transportation, and is the primary source of carbon emissions (Liu et al., 2025). Studies have shown that high-density and functionally mixed urban areas are more conducive to improving energy efficiency and reducing per capita carbon emissions compared to low-density, single-function zones (Zhang et al., 2022). Therefore, accurately grasping the carbon emission patterns at the urban land scale is the foundation for formulating low-carbon urban development strategies. However, most existing carbon emission studies primarily focus on urban or regional scales, using administrative divisions or grid units (Li et al., 2025, Liu and Zhao, 2023, Shen et al., 2023). While such studies can reveal the spatial distribution and evolution of carbon emissions from a macro perspective, their relatively coarse spatial resolution fails to reflect the differences and underlying mechanisms at the micro scale, limiting guidance for low-carbon strategies at specific plots or street block levels.

The research on the factors influencing carbon emissions is diverse. Many scholars start with macro-statistical variables such as population, industry, and energy structure, using tools such as Ordinary Least Squares (OLS), the STIRPAT model (Stochastic Impacts by Regression on Population, Affluence, and Technology) (Shahbaz et al., 2016, Zhou et al., 2015), and machine learning algorithms (Tian et al., 2024a)China (2009-2023 to analyze the driving mechanisms. Meanwhile, some studies have begun to focus on the internal spatial structure of cities, particularly the impact of land use types and spatial form on carbon emissions (Wang et al., 2025, Li et al., 2025). For instance, Wang et al. (2019), using Eindhoven City in the Netherlands as a case study, divided land functions into fourteen categories and analyzed the relationship between different land use types and urban carbon emissions, revealing the differential contribution of various functional land uses to carbon emissions.

However, existing studies mostly emphasize a single dimension or static analysis, lacking a systematic integration of multi-dimensional indicator systems to comprehensively explain the complex mechanisms of urban land carbon emissions.

In order to more comprehensively characterize the influencing factors of urban land carbon emissions, this study divides the attributes of urban land into three main categories: functional attributes, spatial form, and carrying capacity. Functional attributes encompass land use types and their proportions, reflecting the socio-economic functions of the land; spatial form includes physical characteristics such as building form, density, and number of stories, reflecting the organizational structure of urban space; carrying capacity represents the population scale, economic activity intensity, and traffic network density supported by the land, indicating the land's capacity and load level (Zhu et al., 2025, Li et al., 2021). This classification not only aligns with the practical logic of urban planning but also systematically reveals the driving paths of carbon emissions from different perspectives, providing a solid framework for subsequent in-depth analysis based on spatial statistical models.

In recent years, the introduction of spatial statistical tools such as Spatial Lag Model (SLM), Spatial Error Model (SEM), Spatial Durbin Model (SDM), Geographically Weighted Regression (GWR), and GeoDetector has effectively identified the spatial heterogeneity and interaction mechanisms of the factors influencing carbon emissions. For example, Wei et al. (2024) used the Spatial Durbin Model (SDM) to study the driving mechanisms of carbon emissions in China's urban agglomerations. Among them, Multi-scale Geographically Weighted Regression (MGWR) and GeoDetector models have gained increasing attention due to their ability to dynamically capture spatial variations in driving factors and multi-factor interactions (Rong et al., 2022, Zhang et al., 2025). The MGWR model captures the diverse driving mechanisms within regions by allowing variable coefficients to change with spatial location and scale. GeoDetector, on the other hand, identifies key influencing combinations by quantitatively analyzing the explanatory power of factors on spatial distribution and the interactions between factors.

Although existing studies have proposed low-carbon recommendations based on model results (Hurlimann et al., 2021, Woodruff et al., 2022), most lack quantitative evaluations linked to specific plots, making it difficult to verify the actual carbon reduction benefits of planning strategies at the micro spatial scale. Therefore, this study focuses on the micro-plot scale, applying both the MGWR and Geo-Detector models to systematically reveal the influence mechanisms and interactive effects of urban functional attributes, spatial form, and carrying capacity on carbon emissions, exploring their carbon reduction potential in specific plots. By combining empirical cases of micro-updating in typical plots of Nanjing's main urban area, this study quantitatively evaluates the performance of low-carbon planning interventions, filling the research gap on low-carbon micro-update performance evaluation, and providing strong support for the scientific formulation and implementation of precise low-carbon urban planning strategies.

2.Materials and Methods

2.1 **Study Area**

This study focuses on the main urban area of Nanjing as defined in the draft of the city's Land and Spatial Master Plan (2021-2035). The study area is delimited based on natural water systems and major road networks, covering a continuous urban space with a total area of approximately 970 square kilometers (see Figure 1). According to data from the China Carbon Accounting Database (Shan et al., 2017), the annual total carbon dioxide emissions in Nanjing reach 170.39 million tons, ranking second in Jiangsu Province. The choice of the main urban area as the study area encompasses not only the core region of urban development but also typical urban land use structures and carbon emission characteristics, making it both representative and valuable for research.

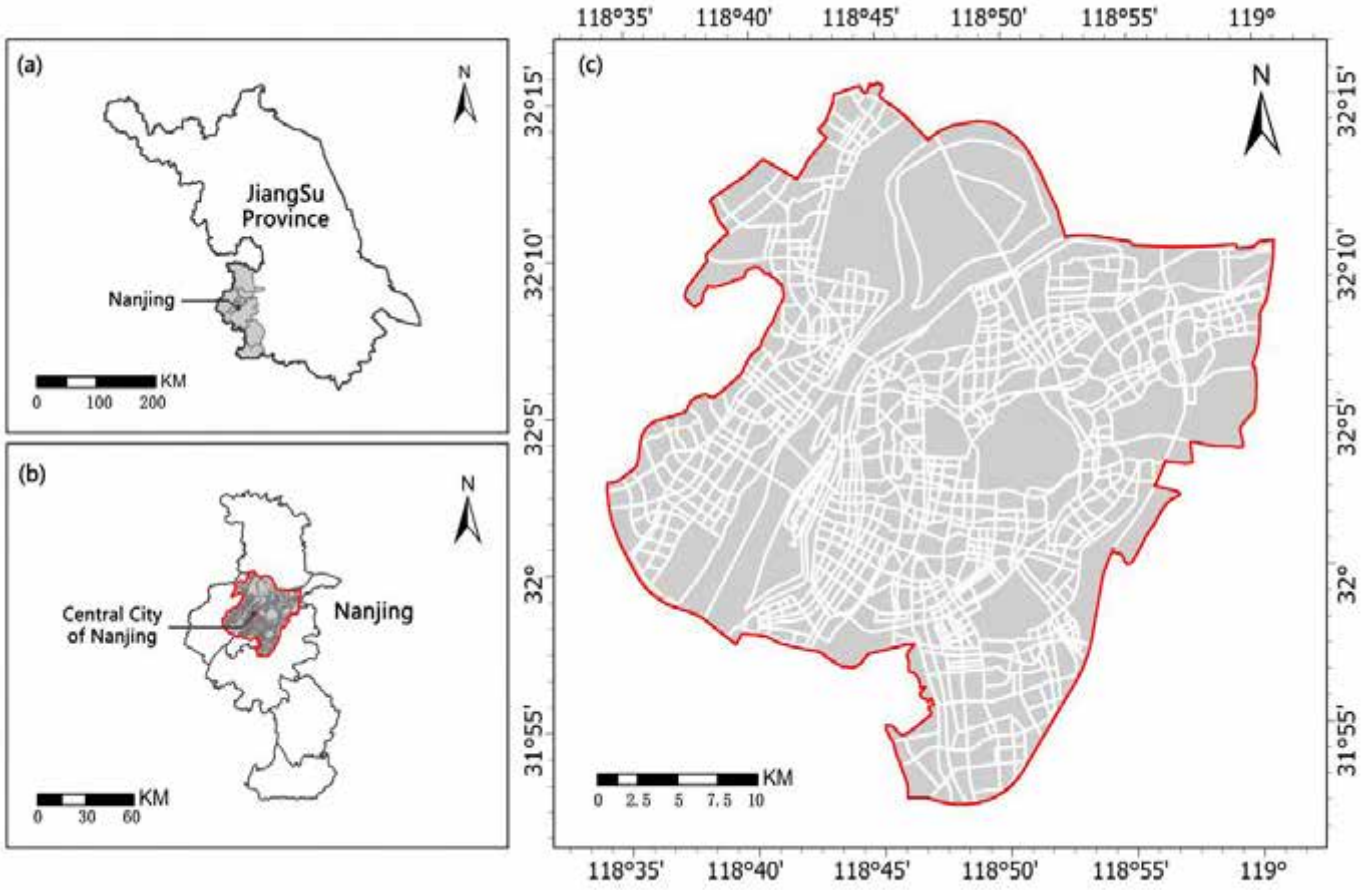


Fig. 1 Study area

2.2 Data Source

The carbon emission data used in this study is sourced from the ODIAC (Open-source Data Inventory for Anthropogenic CO2) global dataset, which is provided by the Center for Global Environmental Research (CGER). This dataset has a 1-kilometer spatial resolution. The data was clipped and regionally aggregated using ArcGIS software to extract the total annual carbon emissions for the main urban area of Nanjing in 2023, which serves as the dependent variable in this study.

The factor indicator system for carbon emissions was constructed with reference to numerous literature reviews and urban planning practices. It systematically integrates the key driving factors of carbon emissions from three dimensions: the functional attributes, spatial form, and carrying capacity of urban land. The functional attributes mainly reflect the nature and proportion of land use; spatial form indicators reflect building characteristics; and carrying capacity reflects the development intensity and spatial carrying capacity of the land. To avoid multicollinearity interference, variance inflation factor (VIF) tests were conducted to rationally eliminate and adjust the preliminary selected indicators, ensuring that the selected indicators have high independence and explanatory power. Ultimately, 14 influencing factors across the three categories were identified (see Table 1), laying a solid foundation for the subsequent model analysis.

Table 1 Indicator System for Influencing Factors and Their Statistical Characteristics

Category	Description	Mean	Standard Deviation	VIF
Functional Attributes	Proportion of commercial/service land	0.162	0.182	3.45
	Proportion of residential land	0.220	0.228	2.98
	Proportion of blue-green space	0.075	0.117	1.12
	Proportion of industrial/logistics land	0.101	0.190	3.87
	Land use mix index	1.218	0.390	4.23
	Land use evenness index	0.708	0.256	3.71
Spatial Form	Average building shape coefficient	0.0155	0.009	2.35
	Average building aspect ratio	2.899	1.237	2.79
	Building density	0.133	0.100	4.15
	Average number of floors	8.598	5.001	3.56
	Floor Area Ratio (FAR)	1.462	1.333	4.87
Carrying Capacity	Population density	97.601	71.651	3.62
	POI Density	557.414	778.443	3.99
	Road network density	0.016	0.009	2.74

2.3 Model Introduction

This study employs two spatial statistical models: Multi-scale Geographically Weighted Regression (MGWR) and Geo-Detector. The aim is to reveal the spatial heterogeneity and multi-factor interaction mechanisms affecting the carbon emission intensity of urban land use.

2.3.1 Multi-scale Geographically Weighted Regression (MGWR)

The MGWR model is an extension of the Geographically Weighted Regression (GWR) model. The difference is that MGWR allows the effect scale of different explanatory variables to vary spatially. By setting a bandwidth parameter for each variable individually, MGWR captures the strength of the effect of each variable on the dependent variable within different spatial ranges. Compared to traditional GWR, which uses a unified bandwidth, MGWR better reflects the diversity of spatial scales of driving factors in complex urban environments, and reveals the differences in the effects of various factors at local and macro scales. This helps identify the carbon reduction potential differences in land use functions, spatial forms, and carrying capacity across regions, improving the model's fitting effect and explanatory power (Laffan and Bickford, 2005).

$$y_i = \beta_0(u_i, v_i) + \sum_{k=1}^{p} \beta_k (bw_k, u_i, v_i) x_{ik} + \varepsilon_i$$

Where y_i represents the carbon emission intensity of the i-th geographic unit, x_{ik} represents the k-th influencing factor for the i-th unit, β_k is the regression coefficient with a location-dependent bandwidth, and ε_i is the error term. MGWR minimizes local weighted squared errors to estimate the spatial heterogeneity coefficients of each variable, achieving precise characterization of the spatial scale of the influence of different factors.

2.3.2 Geo-Detector

Geo-Detector is a factor influence evaluation tool based on spatial statistics, used to measure the degree of consistency between the spatial distributions of explanatory variables and the dependent variable. The core idea is that if an influencing factor shows a high spatial consistency with carbon emission intensity, it has a strong explanatory power for carbon emissions.

Geo-Detector reflects the proportion of variance in the spatial variation of carbon emissions explained by a factor by calculating a statistical value, as defined below:

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2}$$

Where N is the total sample size, σ^2 is the total variance of carbon emission intensity, N_h and σ_h^2 are the sample size and variance within the h-th subdivision, and L represents the number of subdivisions. The value of q ranges from [0, 1], with a value closer to 1 indicating stronger explanatory power.

Furthermore, Geo-Detector is used for factor interaction analysis. By comparing the combined value of factor interactions with the value of individual factors, it identifies complex interaction patterns such as factor combination enhancement and nonlinear enhancement, revealing the pathways through which multiple factors synergistically affect carbon emissions.

3. Analysis of Spatial Distribution Characteristics and Driving Mechanisms of Carbon Emissions in Nanjing's Main Urban Area

3.1 Spatial Distribution Characteristics of Carbon Emissions

Based on the ODIAC global carbon emission data with a 1-kilometer resolution, combined with the administrative boundaries and land use information of Nanjing's main urban area, this study mapped the spatial distribution of carbon emission intensity in 2023 (see Figure 2). Overall, the carbon emission intensity in Nanjing's main urban area shows significant spatial heterogeneity, with high carbon emission zones concentrated primarily in the urban core and near major transportation hubs.

Specifically, the areas with the highest carbon emission intensity are located to the west of the Xinjiekou commercial district and around Nanjing South Railway Station. These regions have frequent economic activities, high commercial density, and significant population and traffic flow, leading to higher energy consumption and carbon emission levels. High carbon emission units exhibit a clear "core-periphery" gradient structure, with emission intensity gradually decreasing as the distance from the core increases, forming a concentric "layered" distribution pattern. The carbon emissions in the urban periphery, as well as in water bodies and green spaces, are significantly lower. This distribution pattern reflects the dominant role of the urban core as a hub for economic and social activities, contributing substantially to carbon emissions.

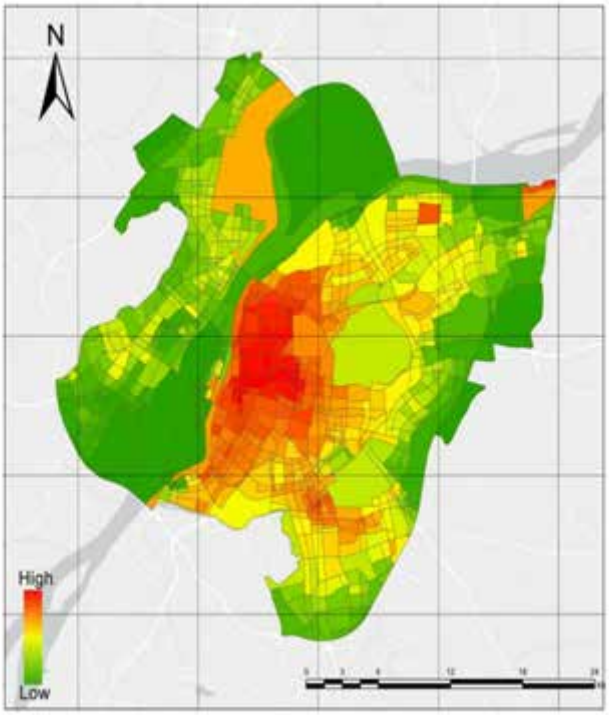


Figure 2 Spatial Distribution Map of Carbon Emission Intensity in 2023

3.2 Driving Mechanism Analysis of Carbon Emissions Based on Multi-scale Geographically Weighted Regression (MGWR)

3.2.1 Performance Comparison

To further analyze the driving mechanisms of carbon emissions in Nanjing's main urban area, this study uses the Multi-scale Geographically Weighted Regression (MGWR) model. Compared to the traditional Geographically Weighted Regression (GWR), the MGWR model is more flexible in capturing spatial heterogeneity and local variations in driving factors by selecting adaptive bandwidths (Omrani et al., 2025). This model can accurately reflect the differences in driving factors across different regions, thereby improving the model's explanatory power and prediction accuracy.

In terms of model performance comparison, we compared the Ordinary Least Squares (OLS), Geographically Weighted Regression (GWR), and Multi-scale Geographically Weighted Regression (MGWR) models. According to the results in Table 2, the MGWR model outperforms both OLS and GWR in all performance metrics. Specifically, the R-squared for MGWR is 0.7386, and the adjusted R-squared (Adj R-squared) is 0.7126, both significantly higher than those of OLS and GWR, indicating stronger fitting capabilities. This suggests that MGWR can better explain the variation in carbon emission intensity. Therefore, MGWR was chosen as the primary model for analyzing the driving mechanisms of carbon emissions in this study.

Table 2 Comparison of Model Fitting Performance

Parameter	Ordinary Least Squares (OLS)	Geographically Weighted Regression (GWR)	Multi-scale Geographically Weighted Regression (MGWR)
R-squared	0.5062	0.6748	0.7386
Adj R-squared	0.4984	0.6028	0.7126
σ^2	0.70862	0.3971	0.2874
AICc	1959.714	1856.1724	1536.6730

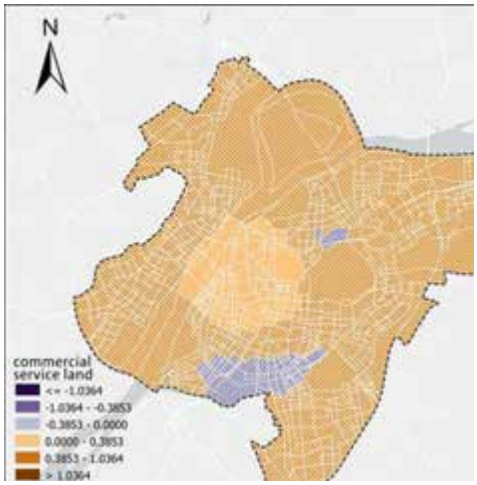
3.2.2 MGWR Results Analysis

(1) Functional Attribute Factors

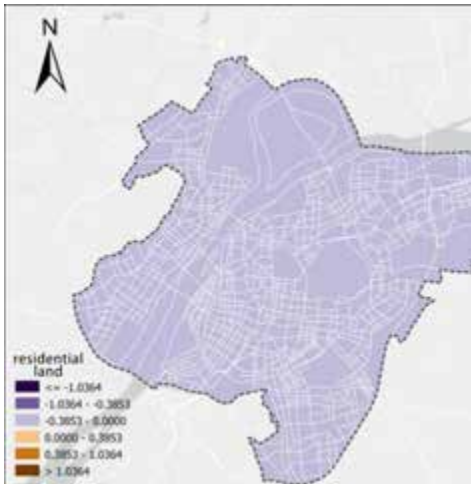
Firstly, the effects of the proportion of commercial and public service land (Figure 3a) and industrial and logistics land (Figure 3d) on carbon emission intensity exhibit significant spatial heterogeneity within the main urban area. The carbon emission intensity of commercial land generally shows a positive correlation, particularly in high-density urban core areas. As the proportion of commercial land increases, the carbon emission intensity also rises (You et al., 2023). Similarly, the effect of industrial and logistics land on carbon emission intensity is positive in most areas, especially in the urban periphery, where the expansion of industrial land tends to bring higher carbon emission levels. However, in certain specific areas of Nanjing, such as the Zhongshan Scenic Area and the southern part of the city, the increase in industrial land did not significantly raise the carbon emission intensity. On the contrary, it exhibited a weak negative correlation.

In contrast, the proportion of residential land (Figure 3b), blue-green space (Figure 3c), land use mix index (Figure 3e), and land use evenness index (Figure 3f) generally show a negative relationship with carbon emission intensity, and their influence mechanisms within the main urban area are consistent, with no significant spatial heterogeneity. Areas with a high proportion of residential land typically have lower carbon emission intensity, which is related to the fact that residential land is primarily used for daily living and has lower energy consumption (Cai et al., 2025), especially when compared to commercial and industrial land. The increase in blue-green space helps enhance the ecological function of the urban environment, thereby reducing carbon emission intensity. Blue-green spaces not only reduce carbon dioxide emissions by increasing carbon sequestration effects but also improve the microclimate and reduce the urban heat island effect, further decreasing energy consumption and carbon emissions. Both the land use mix index and the land use evenness index also show a negative relationship. Previous studies, from the perspective of urban agglomerations, have demonstrated that the rational layout of multifunctional land uses within a plot can effectively reduce carbon emission intensity (Kang et al., 2023). A high land use mix not only helps reduce long-distance travel and traffic congestion but also improves carbon emission outcomes through the introduction of ecological spaces such as parks and green spaces.

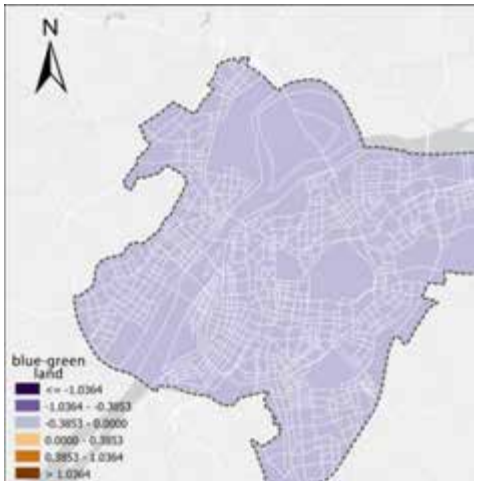
ΔaΔProportion of commercial/service land



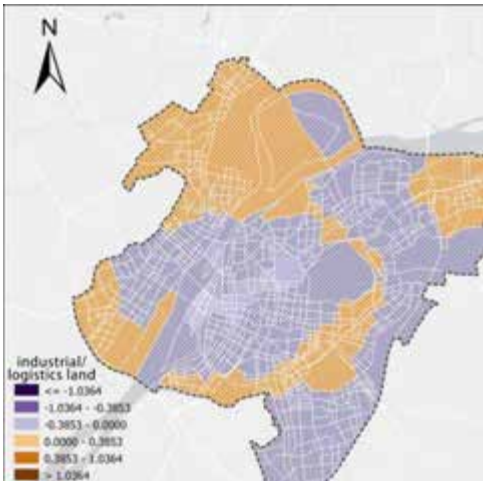
(b) Proportion of residential land



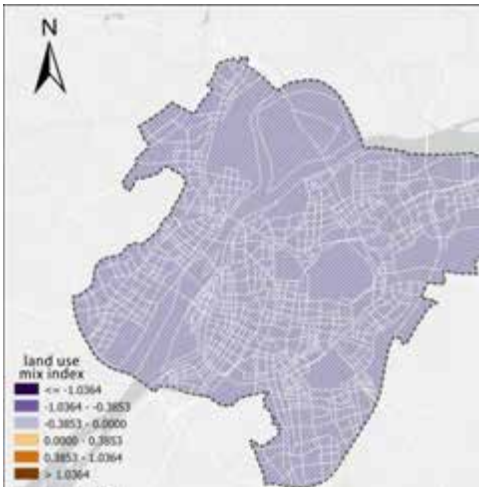
(c) Proportion of blue-green space



(d) Proportion of industrial/logistics land



(e) Land use mix index



(f) Land use evenness index

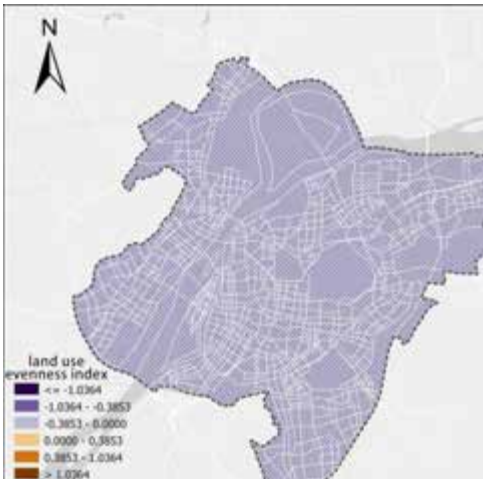


Figure 3 Analysis Results of Functional Attribute Factors

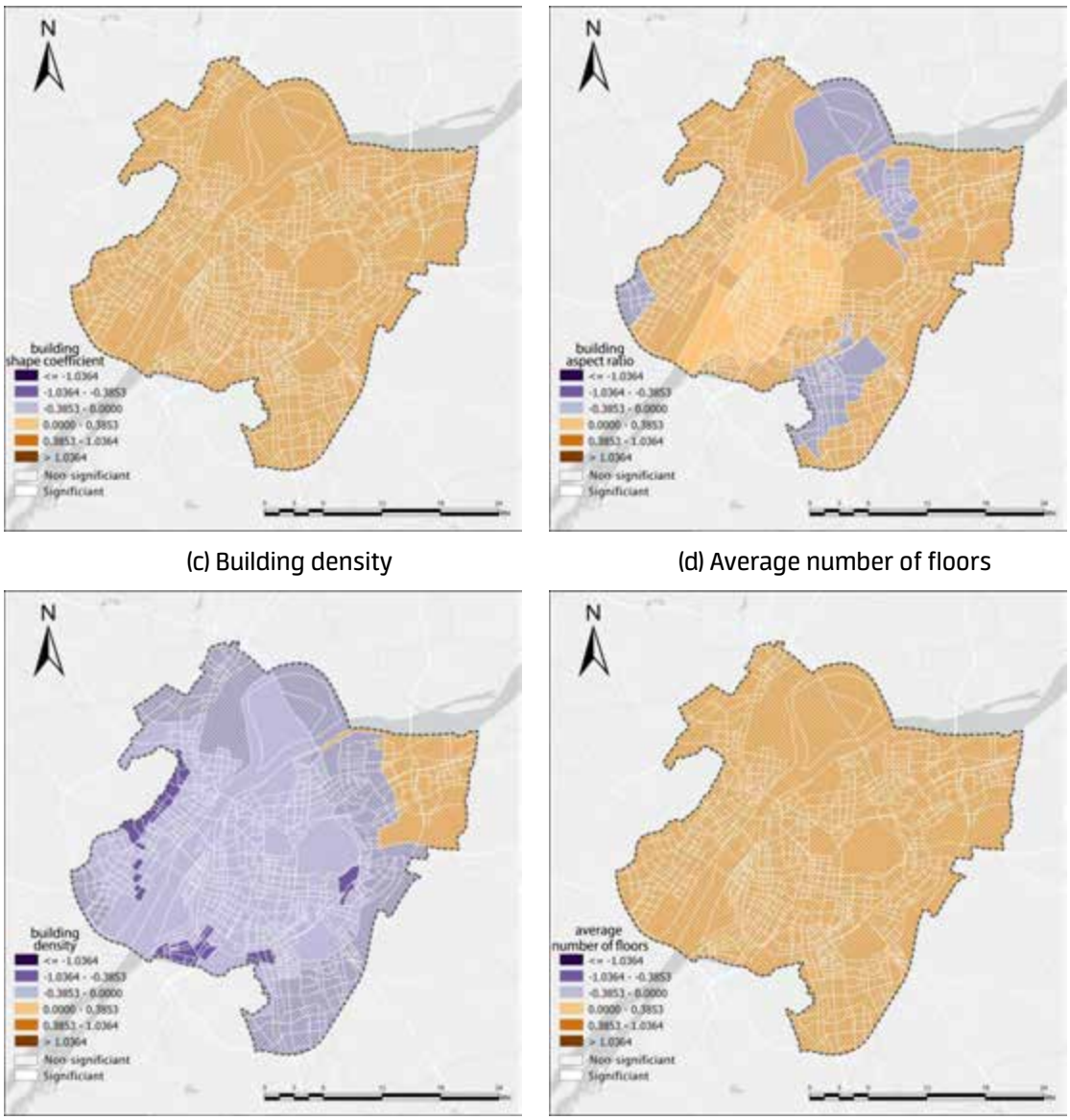
(2) Spatial Form Factor

The average building shape coefficient and average building aspect ratio are important indicators that reflect the extent of building exposure to the external environment. As shown in Figure 4a, the building shape coefficient has a positive global correlation with carbon emission intensity, meaning that as the building shape coefficient increases, the building's contact area with the environment increases, leading to higher energy consumption and, consequently, higher carbon emission intensity. In contrast, the relationship between the building aspect ratio and carbon emission intensity is more complex (Figure 4b). Higher building aspect ratios are generally associated with higher carbon emission intensity, but in areas like Bagua Island, Shuanglong Avenue, Qixia Avenue, and Wuhua Road in Nanjing, a higher building aspect ratio does not significantly increase carbon emission intensity. This may be related to local climatic conditions, building energy efficiency, and the characteristics of the surrounding environment, with microclimate effects potentially having a varying impact on the carbon emission mechanism (Dong et al., 2023).

On the other hand, the relationship between building density and carbon emission intensity shows significant spatial heterogeneity across different regions (Figure 4c). In the Xianlin area of Nanjing, building density is positively correlated with carbon emission intensity, whereas in other areas of the main urban area, building density shows a negative correlation with carbon emission intensity. This suggests that in some areas, a moderate increase in building density helps reduce carbon emission intensity. This is consistent with findings from some urban studies. For example, research in Shanghai has shown that after a certain level of floor area ratio is reached, increasing building density reduces carbon emissions, especially when land use efficiency is improved and urban sprawl is reduced, leading to decreased traffic-related emissions (Tian et al., 2024b, Sun and Song, 2024). Finally, the average number of floors in buildings is positively correlated with carbon emission intensity across all study units in the main urban area (Figure 4d). From a land use perspective, a higher average number of floors per unit area typically indicates a higher concentration of residential and commercial activities, leading to greater carbon emissions per unit area of land.

(a) Average building shape coefficient

(b) Average building aspect ratio



(c) Building density

(d) Average number of floors

Figure 4 Analysis Results of Spatial Form Factors

(3) Carrying Capacity Factors

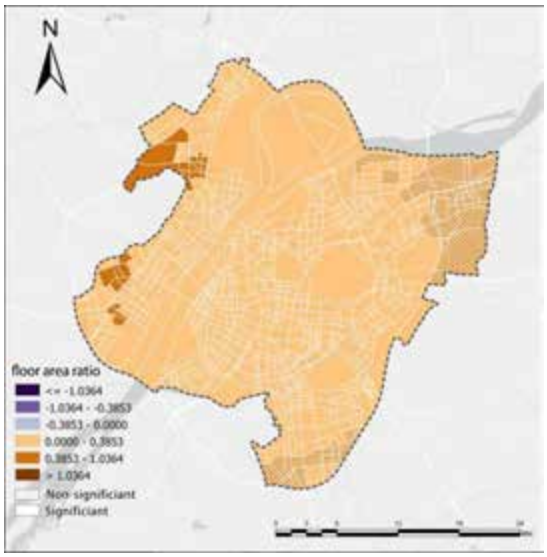
Figure 5a shows that floor area ratio (FAR) is positively correlated with carbon emission intensity globally, and most regions show high statistical significance. FAR reflects the total building volume per unit land area, meaning that the higher the FAR, the larger the building area, and the higher the energy consumption and carbon emissions. The regression results for population density in Figure 5b show significant spatial heterogeneity. In the central area of the main urban area, population density is positively correlated with carbon emission intensity, indicating that an increase in population density leads to higher energy consumption and carbon emissions. However, in some peripheral areas of the city, population density shows a negative correlation with carbon emission intensity.

Similarly, the relationship between POI density and carbon emission intensity also exhibits spatial differences (Figure 5c). In the city center, POI density is positively correlated with carbon emission intensity, suggesting that more commercial facilities, service locations, and employment opportunities attract large amounts of human and logistical traffic, thus increasing carbon emissions from land use.

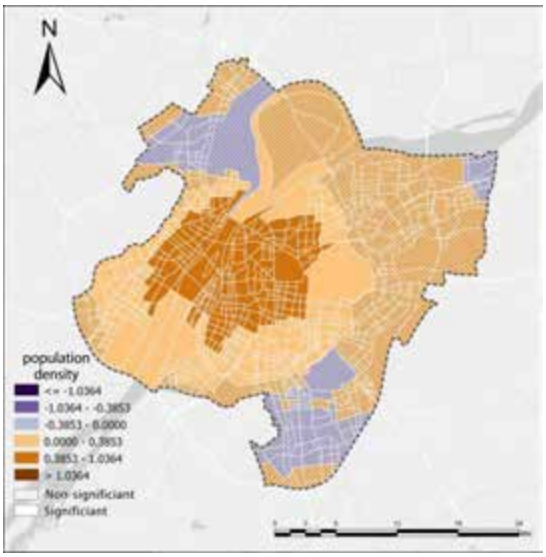
However, in some areas to the west of the Yangtze River, POI density shows a negative correlation with carbon emission intensity, indicating that areas with high POI density might promote more green travel and consumption patterns, thus reducing carbon emission intensity.

Finally, Figure 5d shows that road network density is positively correlated with carbon emission intensity across all study units in the main urban area. Although some studies suggest that high road network density helps reduce traffic congestion and encourages green travel at large scales, in the context of urban land use in this study, a dense road network often leads to higher traffic volumes, which in turn increases traffic-related carbon emissions. This indicates that the impact mechanism of road network density is scale-dependent, and different conclusions may be drawn at different scales.

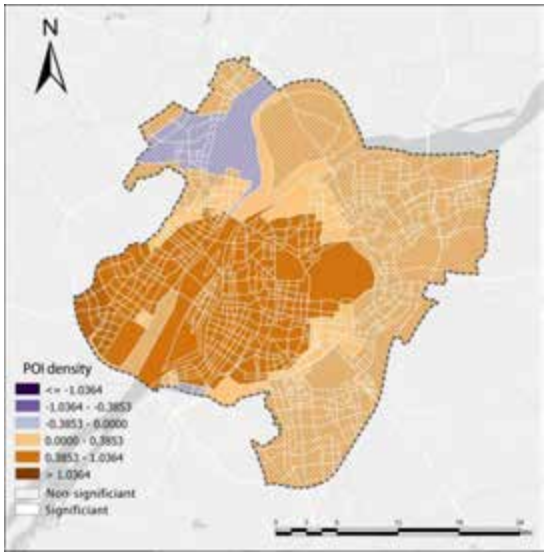
(a) Floor area ratio (FAR)



(b) Population density



(c) POI Density



(d) Road network density

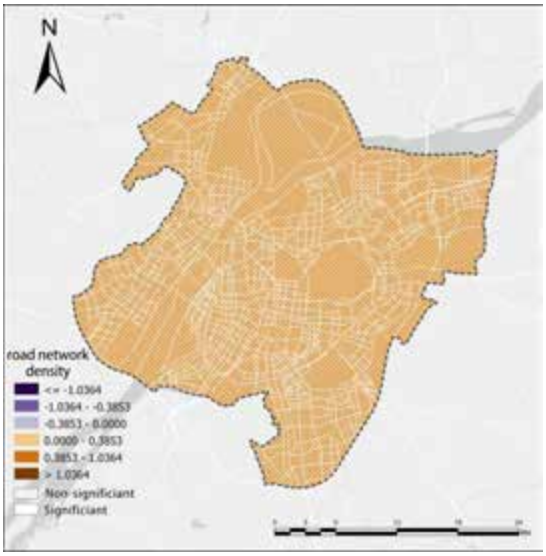


Figure 5 Analysis Results of Carrying Capacity Factors

3.3 Analysis of Factor Interaction Mechanisms Based on Geo-Detector

3.3.1 Analysis of Results from Factor Geo-Detector

This study analyzed the influencing factors of urban land carbon emissions and their explanatory power using Geo-Detector. Geo-Detector provides the explanatory weight (q value) and statistical significance (P value) of each

factor, which are used to assess the contribution of these factors to the spatial distribution of carbon emissions. According to the results (see Table 3), all influencing factors, except for the uniformity index (X6, P value = 0.078), show significant correlations with carbon emission intensity, with P values all less than 0.001. This indicates that most factors can well explain the spatial distribution pattern of carbon emission intensity.

From the q values, it is evident that the carrying capacity factors contribute the most to the spatial variation of carbon emissions. The carrying capacity factors include floor area ratio (FAR), population density, POI density, and road network density. These factors directly reflect the economic, population, traffic, and building load attributes of land units. For example, the q value for population density is 0.407, which means population density can explain 40% of the spatial heterogeneity in carbon emission intensity, making it the most influential factor. The q values for FAR and POI density are 0.340 and 0.343, respectively, indicating that they also play important roles in explaining the spatial distribution of carbon emission intensity. In contrast, the spatial form and functional attribute factors have weaker explanatory power, with generally lower q values.

Table 3: Single-Factor Geo-Detector Analysis Results

Influencing Factor	X1	X2	X3	X4	X5	X6	X7
q value	0.119	0.068	0.084	0.028	0.036	0.009	0.054
P value	0.000	0.000	0.000	0.000	0.000	0.078	0.000
Influencing Factor	**X8**	**X9**	**X10**	**X11**	**X12**	**X13**	**X14**
q value	0.024	0.162	0.113	0.340	0.407	0.343	0.115
P value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

3.3.2 Analysis of Results from Interaction Geo-Detector

Geo-Detector not only analyzes the contribution of individual factors to carbon emission intensity but also explores the interactions between these factors. The interaction Geo-Detector results in Figure 6 show that there are significant interactions between factors, and these interactions generally provide a higher explanatory power for carbon emission intensity than the individual factors alone. In particular, the interaction between population density and POI density has a q value of 0.548, indicating that the combined effect of these two factors can better explain the spatial variation of carbon emission intensity. This result further confirms that population and economic activities are the main sources of carbon emissions in cities, and their interaction amplifies their impact on carbon emissions.

Furthermore, single factors such as the proportion of commercial and public service land, residential land, and industrial and logistics land, when combined with carrying capacity factors (e.g., FAR), show significantly improved explanatory power. For example, the combination of the proportion of commercial and public service land with FAR increases its explanatory power for carbon emissions to 44.87%, while the interaction of industrial and logistics land with FAR explains 36.09% of the carbon emission intensity. These results are much higher than the explanatory power of the factors before the interaction (e.g., the proportion of commercial land at 11.9% and industrial land at 6.84%). This suggests that the influence of functional attribute factors on carbon emissions is not independent but is closely intertwined with factors such as population, economy, and transportation, and thus requires a comprehensive consideration of interactions between these factors.

Overall, among the 91 interaction influence indicators analyzed by the interaction Geo-Detector, 37 show a two-factor enhancement pattern, while the remaining 54 exhibit a non-linear enhancement pattern, accounting for more than 60%. This phenomenon indicates that the spatial distribution of land carbon emission intensity is the result of multiple factors acting together, and the formulation of carbon reduction strategies should consider the combined effects of various factors, rather than the influence of any single factor.

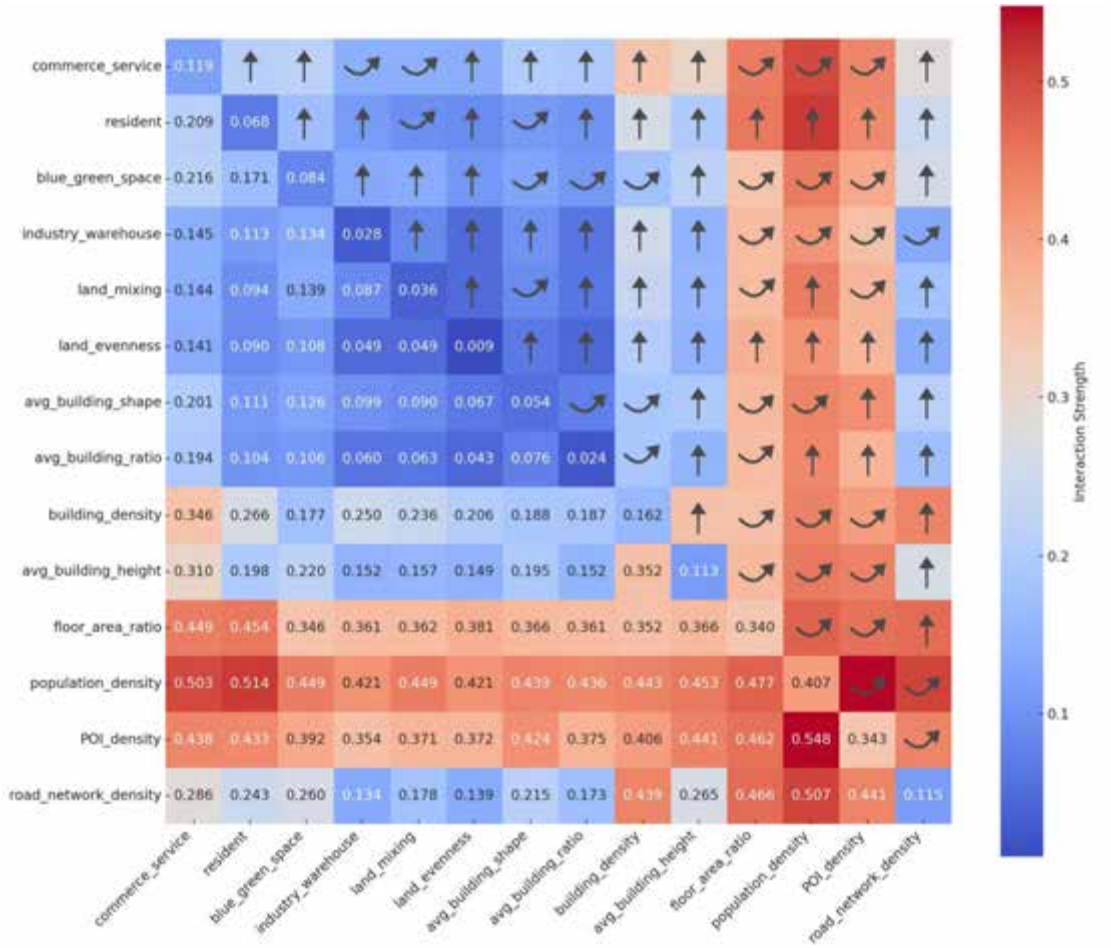


Figure 6 Two-Factor Interaction Strength Detection Results

4. Spatial Micro-Update Scheme Practice under Low-Carbon Guidance

4.1 Site Introduction

The plot selected for the micro-update design in this study is located in the northern part of the study area, within the Liuhe District of Nanjing. The existing buildings on the site are relatively old, with some facades in urgent need of repair. Additionally, there are no sizable green spaces or parks within the site, and public spaces are lacking, indicating a clear demand for urban renewal.

The current situation of the site is illustrated in Figure 7. The land use within the site is primarily residential land , with three commercial areas and some mixed-use commercial and residential land. Except for the high-rise residential area located on the northern side of the site, the remaining residential areas are low-rise (4-6 floors). Additionally, there are sanitation and gas facilities within the site. On the eastern side of the financial and insurance land, there is a section of abandoned railway land, which has lost its practical value. From a land use floor area ratio perspective, except for the high-rise residential area on the northern side (with a floor area ratio of 3.5), the floor area ratio of the remaining land is below 1.6.

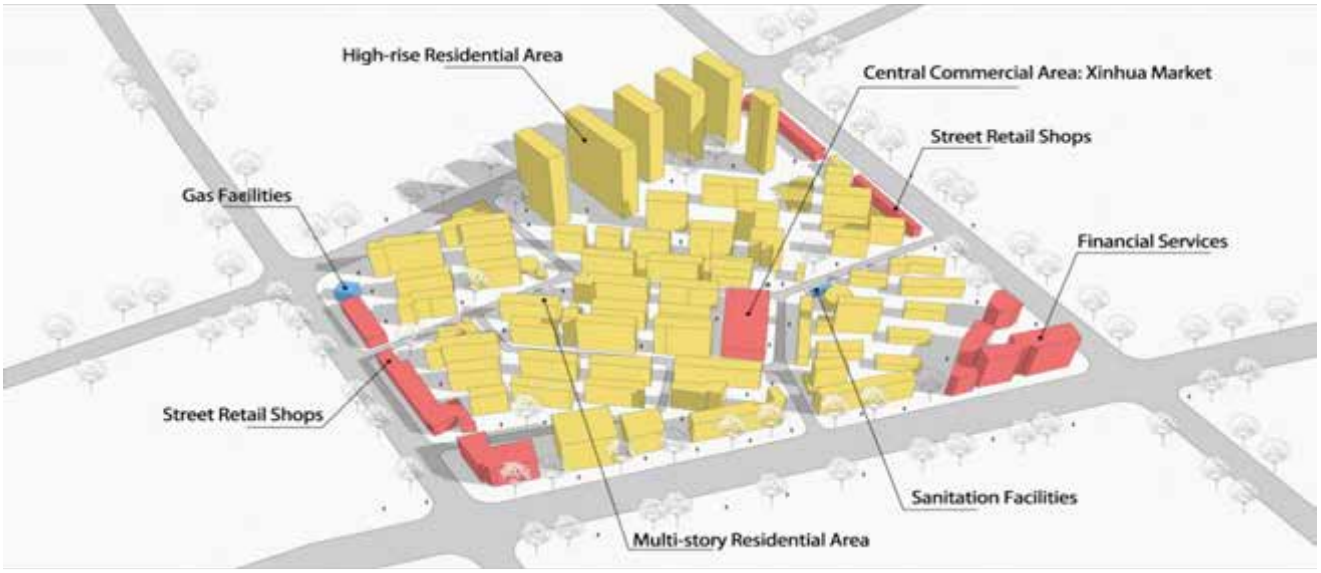


Figure 7 Current Site Situation Diagram

4.2 Micro-Update Scheme

The micro-update scheme proposed in this study focuses on fine-tuning the functional attributes and building forms of urban land plots to achieve a dual enhancement of both low-carbon benefits and environmental quality. Based on the local analysis results of the multi-scale geographically weighted regression model, of the fourteen influencing factors, the proportion of residential land, blue-green space proportion, land use evenness, land use mix, and building density have a negative impact on carbon emission intensity, while the remaining factors show a positive impact. Therefore, the core objective of this scheme is to optimize land use structure and building form, reduce the impact of positive factors, and enhance the negative factors. This will allow for a reduction in carbon emissions and an improvement in environmental quality while maintaining the overall development intensity of the plot.

(1) Fine-Tuning of Land Use Attributes

According to the regression model analysis, carbon emission intensity shows a negative correlation with land use mix, land use evenness, blue-green space proportion, and residential land proportion, and a positive correlation with industrial/logistics land proportion and commercial/public service facilities land proportion. Based on the current situation of the plot and the regression analysis results, the land use attribute adjustments in this scheme mainly include the following aspects:

- Reduce the residential land in the central part of the site from 1.7 hectares to 1.4 hectares. To maintain the land's carrying capacity, the floor area ratio (FAR) of the reduced 1.4-hectare area will be increased from 1.6 to 2.0, ensuring improved land use efficiency.
- Convert the vacated 0.4-hectare residential land into park green space, creating a centralized public space to meet the daily recreational needs of the community (Sun, 2024).
- Transform the abandoned railway land (0.34 hectares) on the eastern side of the site into park green space, constructing a linear park for residents' daily use, providing more green open space.

These fine-tuning measures not only enhance the land use mix and land use evenness but also effectively increase the blue-green space proportion from 0% to 5.05%. While providing public space, these adjustments contribute to a reduction in carbon emission intensity.

(2) Fine-Tuning of Spatial Form

In terms of spatial form adjustments, this scheme maintains the overall spatial structure of the plot while achieving low-carbon effects through localized optimization of building forms. The specific adjustment measures include:

- Break up the long continuous building facades around the site by arranging buildings in a more reasonable layout, thereby reducing the building's aspect ratio and external surface area, which in turn lowers building energy consumption.
- Utilize the existing spatial resources of the site to introduce pocket parks in appropriate locations, providing more green open space for residents.
- Based on the adjusted central park green space and the linear park on the eastern side, design a slow-traffic system running through the site and connect it effectively to the pocket parks, creating a pedestrian-friendly low-carbon commuting environment.
- Implement rooftop greening on some buildings where feasible, increasing green space to further reduce building energy consumption.
- Rebuild buildings that were demolished to make way for park green spaces after adjusting the FAR, to maintain the stability of the total population in the area and avoid socio-economic instability caused by demolition.

These spatial form adjustments make full use of the existing resources within the site, not only optimizing the building layout and improving the quality of public spaces but also creating a suitable walking environment that reduces carbon emissions from transportation. The specific spatial transformation plan is shown in Figure 8.

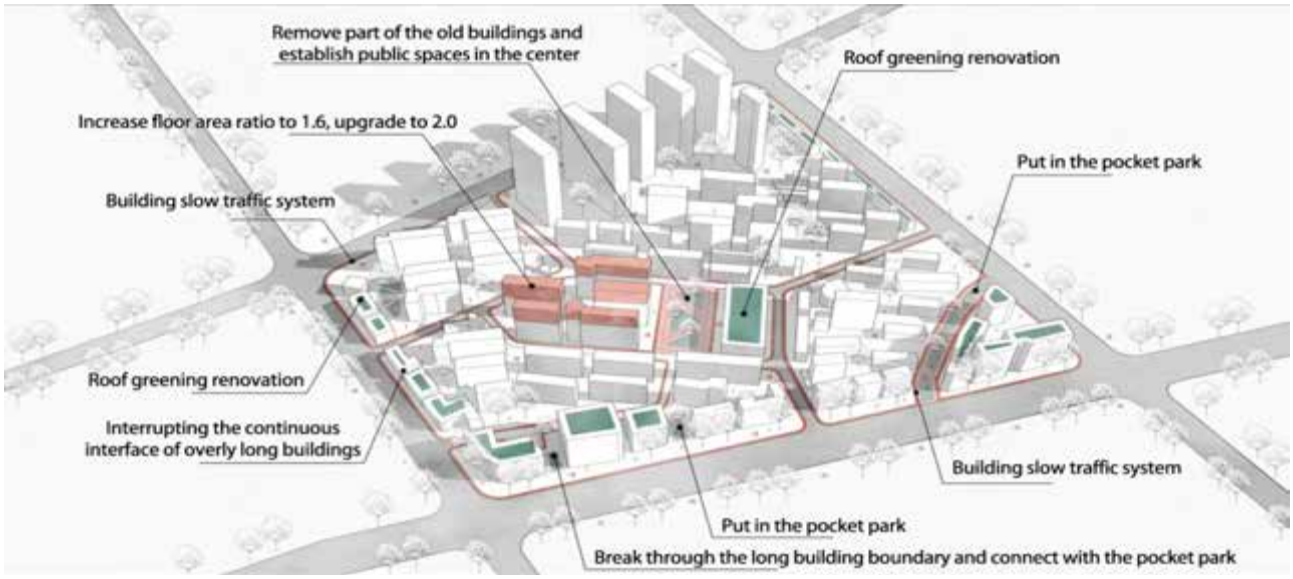


Figure 8 Adjusted Site Situation Diagram

4.3 Low-Carbon Performance Evaluation of the Micro-Update Scheme

The micro-update scheme proposed in this study includes changes in land use type and localized building spatial adjustments, aiming to reduce carbon emissions by optimizing land use and building form. Traditional low-carbon space design studies often focus on qualitative analysis, making it difficult to quantitatively assess the carbon emission performance before and after the design scheme. This study extracts the local regression equations from the multi-scale geographically weighted model for the plot, standardizes the updated influencing factors, and inputs them into the regression model to calculate the carbon emission intensity of the updated plot. This is then compared with the pre-update carbon emission intensity to quantitatively evaluate the low-carbon performance of the micro-update scheme.

According to the comparison results shown in Table 4, the update scheme mainly includes the transformation of residential land into park green space, adjustments in building density, and optimization of floor area ratio (FAR) and land use type. In terms of functional attributes, the proportion of residential land decreased from 70.7% to 68.0%, while the proportion of blue-green space increased from 0% to 5.1%. This change improved the land use mix and evenness, with values rising from 0.801 and 0.499 to 0.947 and 0.590, respectively.

Additionally, the floor area ratio slightly increased from 2.514 to 2.519, but considering the other adjustments, this change contributed little to the reduction in carbon emission intensity.

In terms of spatial form, the building shape coefficient increased from 0.311 to 0.315, indicating a slight increase in the contact area between buildings and the environment, although the change is minimal. The building aspect ratio decreased from 3.624 to 3.207, showing that adjustments to street-facing buildings effectively reduced their external surface area and energy consumption. Building density decreased from 0.233 to 0.221, indicating that appropriately increasing building density in certain areas has a positive effect on controlling carbon emissions.

According to the results from the MGWR regression model, the annual carbon emission intensity of the updated plot is 6.38 kg/m³, which is a reduction of 0.58 kg/m³ (8.38%) compared to the pre-update intensity of 6.96 kg/m³. The total annual carbon emissions for the plot decreased from 1,827.33 tons to 1,674.20 tons, resulting in a reduction of 153 tons of carbon emissions. These results demonstrate that through the optimization of land use attributes and building form in the micro-update scheme, significant carbon emission reduction can be achieved.

Table 4 Comparison of the Micro-Update Scheme Before and After

Variable Type	Variable Name	Effect	Pre-Update	Post-Update	Change
Functional Attributes	Proportion of commercial/ service land	Positive	0.069	0.069	No change
	Proportion of residential land	Negative	0.707	0.680	Decrease
	Proportion of blue-green space	Positive	0.00	0.00	No change
	Proportion of industrial/ logistics land	Negative	0.00	0.051	Increase
	Land use mix index	Negative	0.801	0.947	Increase
	Land use evenness index	Negative	0.499	0.590	Increase
Spatial Form	Average building shape coefficient	Positive	0.311	0.315	Increase
	Average building aspect ratio	Positive	3.624	3.207	Decrease
	Building density	Negative	0.233	0.221	Decrease
	Average number of floors	Positive	10.769	11.361	Increase
Carrying Capacity	Floor area ratio (FAR)	Positive	2.514	2.519	Increase
	Population density	Positive	Assumed unchanged	Assumed unchanged	No change
	POI density	Positive	Assumed unchanged	Assumed unchanged	No change
	Road network density	Positive	0.00	0.016	Increase

5. Discussion and Conclusion

This study thoroughly investigates the spatial distribution characteristics and driving mechanisms of carbon emissions in Nanjing's main urban area. Using multi-scale Geographically Weighted Regression (MGWR) and Geo-Detector models, we analyzed various factors influencing urban land carbon emission intensity and their interactions. The results show that the impacts of functional attributes, spatial form, and carrying capacity on carbon emission intensity exhibit significant spatial heterogeneity. In particular, carrying capacity factors such as population density, floor area ratio (FAR), and POI density contribute the most to carbon emission intensity, with the highest explanatory power.

First, based on the analysis of the three major categories of influencing factors, functional attributes and spatial form factors display significant differentiation. Specifically, different sub-factors do not show uniform characteristics in their mechanisms affecting carbon emission intensity. For instance, factors such as the proportion of commercial and public service land, average number of floors, and FAR have a positive effect on carbon emission intensity in most areas of the main urban region, meaning that an increase in these factors directly leads to a rise in carbon emission intensity. From a low-carbon construction perspective, it is necessary to reasonably limit the upper limits of these factors. On the other hand, factors such as the proportion of residential land, blue-green space, and land use mix generally show a negative effect on carbon emission intensity in most areas, and increasing the proportion of these factors can effectively reduce carbon emission intensity, particularly in urban core areas (Yang, 2023, Sun, 2024).

Furthermore, carrying capacity factors (such as FAR, population density, and POI density) have the highest explanatory power for carbon emission intensity, with the q value for population density being 0.407, indicating the greatest contribution to spatial heterogeneity in carbon emissions. Studies have shown that carrying capacity factors directly reflect the economic, population, traffic, and building load attributes of land units, and are positively correlated with carbon emission intensity (Ming et al., 2024). Based on this, when implementing the micro-update scheme, it is necessary to make targeted adjustments according to the carrying capacity of specific regions.

From the perspective of factor interactions, 60% of the influencing factors show significant synergistic effects, indicating that the spatial distribution of carbon emission intensity in urban land is not determined by a single factor but is the result of multiple interwoven factors. In particular, the interaction between population density and POI density, with a q value of 0.548, shows that their combined effect can better explain the spatial variation of carbon emission intensity. This result further confirms the primary contribution of population and economic activities to carbon emissions (Dong et al., 2023) and suggests that the interaction of these factors amplifies their impact on carbon emissions.

The empirical analysis of the micro-update scheme also validates the above theory. By adjusting land use attributes and optimizing spatial form, the micro-update scheme effectively reduced the carbon emission intensity of the plot. Specifically, through the adjustments in FAR, residential land, and park green space, the carbon emission intensity decreased from 6.96 kg/m^3 to 6.38 kg/m^3, and the total annual carbon emissions decreased by 153 tons, confirming the low-carbon effect of the micro-update strategy in practical application. Additionally, spatial form fine-tuning, such as adjustments in building form and building density, also contributed to reducing carbon emissions, particularly in the adjustments to building aspect ratio and building density, which effectively suppressed carbon emissions.

However, this study also has certain limitations. First, while the MGWR and Geo-Detector models provided a detailed analysis of the influencing factors of carbon emissions, assumptions about the changes in population density and POI density may not fully align with actual conditions. Future research could more precisely simulate the dynamic changes of these factors. Second, although the micro-update scheme has achieved significant reductions in carbon emissions, its comprehensive impact on urban socio-economic benefits, residents' quality of life, and urban sustainability has not been fully explored. Future studies should consider conducting comprehensive evaluations on a broader scale, especially considering the dual context of urban development and residents' needs.

Overall, this study provides a practical basis for low-carbon city construction through the quantitative analysis of the micro-update scheme's low-carbon performance. It demonstrates that optimizing land use attributes, building form, and carrying capacity can effectively reduce carbon emission intensity. The implementation of the micro-update scheme not only improves the environmental quality of the plot but also provides strong support for the realization of low-carbon cities. As low-carbon city construction goals are gradually advanced, the application of the micro-update scheme holds great potential in the renewal of small and medium-sized cities and existing urban blocks. Future work will further explore the comprehensive social, economic, and environmental impacts of the micro-update scheme to ensure the thoroughness and sustainability of low-carbon transformation.

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Retracing Critical Energy Fictions with Youth through a Comparative Analysis of Community-Based Interventions

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Abstract
Understanding both human and ecological histories in the Anthropocene demands participatory methods that include diverse voices. This research examines community interventions using worldbuilding, which is a systems-thinking approach that imagines alternative realities and challenges existing assumptions through multi-scale analysis using a timeline tool, which is based on Cultural-historical activity theory (CHAT) as an analytical lens to examine chronological triggers in selected case studies.

Through comparative analysis of six case studies (four Belgian, two Turkish), we investigated how participatory design and youth engagement create critical fictions that question current paradigms and explore alternatives for ongoing energy transitions. We examine the role of emotions in transitions, mostly related to energy, and analyze how worldbuilding tools can deepen or change emotional layers related to participatory transition processes. The analysis identifies design strategies where material and embodied elements make speculative practices concrete and generate emotional resonance.

Results demonstrate that worldbuilding serves as an effective participatory methodology for fostering critical dialogue and envisioning just futures rooted in community knowledge while confronting systemic inequalities. The research particularly emphasizes youth agency, often overlooked but vital in shaping these transformative processes.

Keywords: energy transitions; youth; participatory design; worldbuilding; emotions

Introduction: Setting the Context

The Anthropocene shows its presence through "deepening entanglement of human and more-than-human histories," demanding we abandon the comfortable fiction of human separateness. Life reveals itself as fundamentally symbiotic; through symbiogenesis and sympoiesis (Tsing et al. 2017), we discover all organisms "tangled up with each other," bound in "interdependent agential and cognitive systems between humans and non-humans."

In this entangled world, community-based interventions emerge as laboratories of possibility. Through worldbuilding, critical fictions, and speculative design, they make tangible the complex choreographies of more-than-human relationships. These methods enable "worlding", which is a process rooted in "historical materialities of meetings between humans and nonhumans", to create "speculative fabulations" that envision radically different configurations of life.

This work sidesteps the trap of crude anthropomorphism, that peculiar form of human exceptionalism that projects our narratives onto other beings (Chang, 2019). Instead, it cultivates "entirely new modes of attention" attuned to "nonanthropocentric difference" (Haraway, 2016).

Participatory design becomes the vessel for this inquiry, engaging diverse groups, with a specific focus on youth, in reimagining relationships between humans and the more-than-human world. The focus sharpens around critical ecological issues: energy production and consumption, spatial justice, the urgent choreography of ongoing energy transitions.

Critical fictions emerge as potent participatory tools, closely allied with speculative design and design fiction. They harness imaginative thinking to explore potential futures, challenge assumptions, and foster creative problem-solving within energy transitions' complex terrain.

Rather than seeking immediate answers, they use design as a medium for asking deeper questions, creating "what-if scenarios" and "parallel worlds" that probe established values and transcend perceived limitations.

To analyze these interventions, we employ worldbuilding as a theoretical lens, conducting comparative case studies across six community-based interventions in Belgium and Turkey, based on a selection chosen to span grassroots to municipal engagements across different socio-cultural contexts.

A timeline methodology, developed by Devisch (2018) through Cultural-Historical Activity Theory (CHAT) as popularized by Engeström (1987), reconstructs the chronological progression of selected interventions. We map key stages, durations, and critical 'tipping points,' tracing how temporal dynamics shape participants' emotional landscapes and reveal tacit knowledge.

While digital worldbuilding offers powerful lenses for exploring complex systems, our case studies reveal the irreplaceable value of diverse modalities, including non-digital approaches. Analogue, tangible methods prove essential for accessing "knowledge from below," vital for pursuing "radical just futures". It helps in grounding speculative practices in lived realities and ensuring participation beyond digital access or literacy.

Yet something else moves through these participatory spaces; something that resists measurement but shapes everything: the emotional landscapes that emerge when people gather to imagine otherwise. Emotions don't simply accompany worldbuilding; they become its hidden architecture, the invisible scaffolding upon which speculative futures are constructed. A teenager's sudden silence when confronted with climatic disasters, the collective exhale when a group finally names their shared fear, the spark of recognition when someone else's story mirrors your own; these affective moments create the conditions within which new worlds become thinkable.

Our inquiry turns toward these emotional currents, asking how worldbuilding practices don't just engage the mind but activate the full spectrum of human feeling. We begin to notice how certain design strategies trigger emotional responses that either open pathways to collective imagination or close them down, how the materiality creates different affective textures than digital interfaces, and how the temporal rhythms of participatory processes create their own emotional weather systems. The timeline tool becomes not just a method for tracking chronological events, but a way of tracing the emotional geographies that develop as communities move together through speculative territories.

Through this mosaic of worldbuilding lens, temporal analysis, emotional attunement, and diverse engagement modalities, the study seeks novel perspectives on energy systems and spatial justice. It aims toward a framework for co-designing critical fictions in participatory processes with youth: a methodology for imagining otherwise that honors both the rational and the felt dimensions of planetary entanglement.

2. Literature Review

2.1. When Design Becomes Speculation

In the spaces between what is and what could be, speculative design emerges as both methodology and attitude; a way of thinking that refuses the constraints of immediate needs and market demands. These approaches harness imaginative thinking to explore alternative futures, challenge assumptions, and foster creative problem-solving, particularly within energy transitions' intricate choreographies.

Speculative design operates not as pragmatic problem-solving but as a framework for speculating about potential realities, examining broader implications of current trends and proposed solutions (Auger, 2013). It uses design as medium, focusing on concepts and artifacts to ask questions rather than provide immediate answers (Mitrovic et al., 2013). The overlapping territories of Critical Design and Design Fiction share this remove from commercial constraints, employing models, prototypes, and fiction to present alternative products, systems, or worlds (Auger, 2013).

Within this landscape, practitioners distinguish between exploring speculative futures (extrapolations of contemporary systems) and designing alternative presents that reconfigure existing elements, motivations, and structures.

The most poignant speculations stay close to the present, creating "perceptual bridges" between audience's world and fictional concept through the mundane and familiar (Auger, 2013).

Critical fictions weave themselves into this fabric through deliberate creation of "what-if scenarios" and "parallel worlds"; potent instruments for exploring ramifications and challenging established values. These hypothetical situations provoke deeper thinking, encouraging stakeholders to transcend perceived limitations. When someone imagines a "Positive Energy Neighbourhood," they enter a low-stakes, imaginative space where energy transition strategies can unfold their possibilities and reveal their shadows.

2.2. The Architecture of Other Worlds

Worldbuilding emerges as the key mechanism through which speculative design and critical fictions operate; the deliberate construction of fictional settings that embody speculative ideas. From visual arts like murals to digital game art, performance scenography, and participatory design, worldbuilding makes alternative worlds visible and tangible.

This methodology draws from phenomenology's philosophies of experience and pragmatism's emphasis on praxis, informed by cybernetics and imagism. In participatory contexts, it involves collaboratively creating and playing "design language-games" (Ehn, 2017) that bridge different perspectives and practices. Worldbuilding links to creating "alternative nows"; tangible, present-day examples of different realities (Hickey et al., 2012), while challenging purely linear views of time.

The craft of new worlds involves imagining assemblages otherwise, recognizing the world's entangled state where opportunities emerge from exchange rather than imposed expectations (Mitrovic et al., 2021). In gaming contexts, worldbuilding becomes continual cross-disciplinary process involving narrative, gameplay, art, programming, and audio, with intentional gaps inviting audience imagination and co-authoring (Tremblay, 2023). These practices gain deeper resonance when explicitly incorporating systems thinking frameworks (Betley et al., 2021). Worldbuilding "depends on systems thinking" (Bucknell, 2025), offering holistic approaches to understanding "multi-scalar relationships and entanglements" within complex systems. Systems thinking moves beyond discrete parts to examine dynamic interactions, patterns, and underlying causes: particularly through leverage points where interventions prove most effective.

Donella Meadows' work reveals that deeper leverage points at changing system goals or underlying paradigms have far greater potential for lasting change than interventions targeting parameters or buffers (Betley et al., 2021). Critical fictions and worldbuilding function precisely to challenge these deeper points, intervening at the level of mental models—deeply held abstractions, beliefs, and assumptions that drive system function and limit perception of possibility.

The participatory nature of community-based interventions aligns with systems thinking's critical dimension, asking: "Who has power?" "Who is defining the system?" "Whose knowledge counts?" Deep community engagement reveals "subjugated knowledges" and "friction points" symptomatic of deeper systemic barriers (Betley et al., 2021).

The "Emissary" concept (Cheng, 2018) suggests that successful worldbuilding interventions require governance functions to ensure long-term health and growth, reconciling speculation with reality through "Containers", finite projects that act as portals implying further consequences. This function sustains "potential for aliveness" beyond temporary engagement.

2.3. The Emotional Weather of Imagined Futures

Yet something else moves through these speculative territories: the emotional landscapes that emerge when communities gather to imagine otherwise. Beyond cognitive tools for critical thinking, these interventions engage with affect and emotion as "hardwired, shifty and unsteady but palpable" forces more "directly compelling than ideologies" and "fractious, multiplicitous, and unpredictable than symbolic meanings" (Barthes, 1970).

Ordinary affects draw attention to "forces that come into view as habit or shock, resonance or impact" (Stewart, 2007), highlighting "intimate impacts of forces in circulation" and prompting reflection on what one truly cares about (Cheng, 2018). Emotions intertwine with power relations and form social norms (Zembylas et al., 2012); disrupting these norms necessitates changing associated emotions.

Narrative and worldbuilding prove particularly potent here, as story provides "direct route to our emotions" and thus becomes "important to decision-making" (Saltmarche, 2018). Storytelling "creates meaning out of patterns," "coheres communities," and "engenders empathy across difference," making possible feel probable in ways purely rational approaches might not. Emotional events are remembered more clearly, accurately, and for longer periods than neutral events (Tyng et al., 2017), suggesting emotionally resonant narratives significantly enhance impact and retention of envisioned futures.

Critical fictions, by making "alternative possibilities visible or tangible," possess significant potential to cultivate empathy: not only toward other people but crucially toward the more-than-human world implicated in energy transitions. This capacity to foster emotional resonance makes abstract realities more tangible and personally relevant, "expanding our circle of concern" through sympathy and care (Roeser et al., 2016).

The spatial and environmental dimensions of worldbuilding interventions interweave deeply with affect. Emotional space is defined by experiences it affords, aesthetic feelings it inspires, and memories it evokes (Ryan et al., 2016). Even movement through space elicits strong feelings—from "sense of freedom" to "disorientation" of being lost. By designing or reimagining spaces within narrative storyworlds, interventions directly engage participants' emotional responses to environment and potential future states.

The unfolding timeline of participatory processes itself acts as powerful mechanism for revealing and shaping emotional landscapes. As interventions encounter real-world complexities, critical moments or 'tipping points' elicit strong emotional responses offering insights into participants' "underlying concerns, hopes, and anxieties related to energy transitions." These responses reveal tacit knowledge, namely the practical understanding and lived experiences, that might remain hidden in purely hypothetical discussions.

While urgency of climate change and energy transition can generate anxiety, particularly for youth, critical fictions and worldbuilding offer facilitated spaces to explore these feelings within imagined scenarios. Hope, understood as "sense of the possible" that prevents being "overcome by the absoluteness of the present" (Ahmed, 2004), becomes emotional counterpart to fear. Cultivating hope through speculative methods can actively reshape participants' orientation toward future, potentially expanding capacity for action.

2.4. Knowledge from Below

Threading through these practices runs a deeper current: the recognition that effectively navigating energy transitions and pursuing spatial justice requires moving beyond conventional, expert-driven approaches to knowledge production. This involves recognizing "subjugated knowledges" (Halberstam, 2011), forms of knowledge "buried or masked in functional coherences" or "disqualified" as "naïve knowledges, hierarchically inferior knowledges."

Community-based interventions employing speculative design, critical fictions, and worldbuilding offer potent methodologies for accessing, validating, and elevating these subjugated knowledges. Unlike traditional approaches that might "disqualify" non-expert perspectives, creative and narrative-based methods create spaces where lived experiences, local understandings, and non-conventional insights can emerge and integrate into envisioning alternative futures.

This becomes inherently antidisciplinary practice, challenging rigid boundaries and hierarchical structures of established disciplines. Antidisciplinarity resists "mastery" and embraces less conventional ways of knowing, including what might be considered "naïve" or "nonsensical" (Khan, 2021), recognizing these perspectives can offer valuable insights outside dominant frameworks.

The very act of worldbuilding can be seen as "knowledge from below" (Halberstam, 2011), allowing participants to articulate understandings, desires, and concerns through creative expression rather than prescribed technical language. By constructing "microworlds" and speculative scenarios, interventions enable participants to draw on practical knowledge and critique existing systems from lived perspectives. This aligns with "seeing unlike a state" (Halberstam, 2011), contrasting with the state's preference for "legibility," order, and standardization.

Embracing potential "illegibility" and messiness of knowledge derived from diverse community experiences becomes powerful resistance to top-down impositions and source of genuinely innovative solutions. Integrating diverse perspectives: poets collaborating with scientists, bringing together different realms of discourse within "polyvocal" spaces (Wark, 2015); embodies this antidisciplinary spirit, creating conditions where multiple ways of knowing can cross-pollinate and generate new possibilities for collective futures.

3. Methodology: Comparative Case Study through the 'Timeline Tool'

In the tangled web of participatory worldbuilding, emotions don't simply appear. They emerge through a choreography of encounters, materials, and moments that resist easy categorization. To trace these affective currents, we turned to the timeline tool developed by Devisch (2018), itself rooted in the ground of Cultural-Historical Activity Theory (CHAT), as popularized by Engeström (1987). This was an analytical lens that could reveal not just what happened, but how feeling moved through spaces of collective imagination.

The timeline tool becomes more than methodology; it transforms into a practice of archaeological attention, excavating the sedimentary layers of emotional response that accumulate around participatory encounters. Each project timeline unfolds as a sequence of tipping points and triggers, revealing the precise moments when participants' inner landscapes shifted, when new possibilities crystallized, or when resistance hardened into protective withdrawal.

Reconstructing these timelines as sequences of tipping points and triggers provides crucial insights that might otherwise remain buried beneath the surface narratives of project success or failure. We began to notice how certain moments acted as emotional lightning rods, drawing and redirecting the collective energy of worldbuilding processes. The methodology allowed us to pinpoint potential triggers for emotional responses among participants, whose seemingly small gestures or design choices that created ripples across entire groups. These emotional landscapes develop their own topography over the course of interventions, forming peaks of excitement, valleys of frustration, and unexpected clearings where new understanding emerges. By mapping these terrains, we could begin to see patterns in how feelings flow through participatory spaces, how they pool around certain activities, and how they create the affective conditions that either nourish or constrain collective imagination.

Our research questions emerged as interconnected patches in a larger tapestry: What role do emotions play in worldbuilding practices? How does worldbuilding itself become a method for designing with emotions? Our aim crystallized around identifying specific design practices that trigger emotional responses; those moments of methodology that open or close pathways to collective futures.

The analysis unfolded through four interwoven dimensions:

- **Triggers and Emotions**: We traced the delicate choreography between events and feelings, asking what specific moments, materials, or encounters catalyzed emotional responses. Sometimes it was the collages based on historical photo archives during a material speculation exercise; other times, the sudden recognition of one's own story reflected in another participant's vision of the future.

- **Actors and Emotions**: The emotional landscape revealed itself as deeply relational. We mapped not only who experienced emotions, but who triggered them. Youth participants often emerged as unexpected emotional catalysts, their unguarded responses creating permission for adults to access their own vulnerability. Facilitators, too, became emotional actors, their own affective states rippling through group dynamics in ways that shaped entire sessions.

- **Tools and Strategies**: We examined which design strategies generated the most profound emotional resonances. Material practices (e.g. working with found objects) often created embodied pathways to feeling that bypassed rational defenses. Storytelling circles generated different emotional textures than mapping exercises, each tool carrying its own affective potential.

- **Responses and Consequences**: Perhaps most revealing was tracing what emotions triggered in return: moments of breakthrough that led to deeper engagement, or emotional overload that caused participants to withdraw, stand still, or leave entirely. These responses became their own triggers, creating feedback loops that either amplified collective energy or dampened it into protective silence.

From this analysis, we selected design strategies that demonstrated particular potency in generating emotional resonance, illustrating each through the voices of participants themselves. These quotes became more than evidence and became more a series of small windows into the lived experience of worldbuilding, revealing how abstract methodologies translate into the messy reality of collective imagination.

Each selected strategy was chosen not for its representativeness, but for its ability to reveal something unexpected about the relationship between design, emotion, and worldbuilding. In doing so, it hopes that the methodology transcends technique and becomes a practice of collective sensing into possible futures.

4. Comparative Analysis: Worldbuilding and Emotion Across Six Case Studies

What emerges when communities gather to imagine energy otherwise? In the spaces between Brussels' social housing blocks and the broader landscapes of Belgian neighborhoods, between Turkish contexts yet to be fully mapped and European regulatory frameworks, we begin to notice the delicate choreographies through which collective futures take shape. Each intervention carries its own emotional weather, its particular rhythms of hope and frustration, its unique ways of making the impossible suddenly thinkable.

The timeline tool becomes our method of attention: a way of noticing not just what happened, but how feeling moved through these participatory territories. Following Devisch's framework grounded in Cultural-Historical Activity Theory (CHAT) as popularized by Engeström (1987), we reconstruct these interventions as sequences of tipping points and triggers, moments when the emotional landscape shifted, when new possibilities crystallized or dissolved into disappointment.

Six case studies offer themselves as patches in a larger mosaic: four Belgian interventions and two Turkish explorations, each carrying different textures of engagement, different relationships between individual aspiration and collective possibility. Through the analytical lens of triggers and emotions, actors and affects, tools and their consequences, we begin to trace the often-invisible infrastructure of feeling that either nourishes or constrains the emergence of energy alternatives.

Table 1 maps these emotional geographies across selected cases, revealing patterns that resist simple categorization. Notice how *triggers* often emerge not from grand revelations but from quiet realizations, such as the dawning recognition that house-by-house renovation cannot meet climate goals, the slow understanding that traditional energy systems systematically exclude the marginalized. These moments of collective noticing become catalysts for different ways of organizing attention and action.

The *actors* column reveals the complex webs of relationship that either enable or constrain transformation: residents and municipalities, design firms and energy communities, technical experts and neighborhood cooperatives finding themselves in new configurations of possibility. Yet the table also hints at who remains absent, whose voices echo through the margins of these documented interventions.

Tools emerge not as neutral instruments but as specific ways of materializing speculation; from info display panels that make energy visible to workshops that transform everyday objects into vessels for collective dreaming. Each tool carries its own affordances for emotional resonance, its particular capacity to generate either excitement or exclusion.

The *results* column captures something more elusive, in the ways these interventions ripple outward into broader systems of feeling and knowing. Some foster hope and collective agency; others reveal the brutal friction between vision and implementation, generating frustration when co-designed futures encounter regulatory barriers and bureaucratic resistance.

Across these cases, certain patterns begin to emerge from the intersection of worldbuilding and emotion. The most powerful triggers often arise from moments of structural revelation, like when participants suddenly see the systemic nature of problems they had experienced as individual failures. The shift from "how to install solar panels" to questions of "who controls energy, who benefits, and who gets left out" marks a tipping point where technical problems become political possibilities.

The tools that generate the deepest emotional resonance tend to be those that make abstract systems tangible and relational. Display panels don't just show energy data; they create new forms of collective attention. Workshops don't just transfer knowledge; they become spaces where residents can touch and reshape the material conditions of their daily lives.

Yet **Table 1** also reveals the precarious nature of these emotional transformations. The same interventions that foster hope can trigger profound frustration when systemic barriers prevent the implementation of collectively envisioned futures. The gap between participatory imagination and institutional possibility becomes a site of intense affective charge; sometimes generative, sometimes devastating.

As we prepare to expand this analysis across all six cases, including the Turkish contexts that will bring different cultural and institutional textures to our understanding, we begin to notice questions that demand further attention: How do different regulatory environments shape the emotional possibilities of participatory worldbuilding? What happens to collective agency when it encounters the stubborn materialities of existing infrastructure? How do the temporal rhythms of institutional change interact with the more urgent temporalities of climate crisis and community need?

Table 1 becomes not just a record of what happened, but a map of how feeling moves through spaces of collective imagination, or a guide to the emotional infrastructure that either enables or constrains the emergence of energy futures we can believe in.

Table 2 that follows becomes a different kind of listening practice. Where the first focused on external choreographies (triggers and (worldbuilding) tools, actors and outcomes) this one turns inward toward the felt experience of worldbuilding itself. Here we encounter not just what happened, but how it *felt* to happen, how the possibility of energy alternatives registered in bodies and voices, in the spaces between what people said and what they couldn't quite articulate.

Notice how **Potential Emotional Dimensions** invites us to attend to the full spectrum of feeling that participatory futures-making can generate; not just the celebrated emotions of empowerment and collective agency, but also the more difficult textures of overwhelm, confusion, and the grief that comes with recognizing how much needs to change. These dimensions remind us that transformation is never purely celebratory; it carries its own shadows and complications.

The **Emotional Triggers** column returns us to those crucial moments when feelings shifted. But now, through the lens of lived experience rather than analytical observation. Here we might encounter the precise moment when a resident realized their voice actually mattered in technical decisions, or the instant when bureaucratic obstacles transformed collective excitement into bitter disappointment.

Quotes from Interviews become our most direct access to these interior landscapes. The actual words (hesitant, passionate, contradictory) carry affective information. They reveal the ways that transformation sounds when filtered through individual experience yet shaped by collective encounter.

Together, these columns create a more intimate geography of energy transition: one that acknowledges both the political dimensions of systemic change and the deeply personal ways that such change registers in the daily lives of those bold enough to participate in its unfolding. They prepare us to notice not just how worldbuilding happens, but how it feels to build worlds together, and what those feelings might teach us about the conditions that either nourish or constrain the emergence of livable futures.

5. Discussion

Listen closely to the resident from oPEN Lab, speaking about the heat pump that brings migraines alongside promised efficiency: *"It is very annoying when it makes this sound. That is my biggest problem. There is no solution for that."* In these words, we encounter something that technical reports rarely capture—the way transformation sounds in a body, the way progress can become a persistent ache that follows you through your daily routines. This complaint echoes across our comparative landscape, revealing patterns that resist the clean narratives of participatory success. The Architecture Workroom's collaborative visions bump against regulatory barriers; La Pile's energy-sharing dreams encounter the stubborn realities of landlord-tenant relations; the Turkish children's spatial insights confront mega-city pressures that dwarf their small voices. Each case carries its own frequency of friction, its particular rhythm of hope meeting constraint.

Yet notice what else emerges from these same spaces of difficulty. Sofie van Bruystegem's declaration: *"We believe in 'Can do', the joy of trying something"*, which tells that it arrives not despite the frustrations but through them. The Turkish children, despite growing up under the pressure of surrounding mega-projects, develop what Yaşar Adnan Adanalı observes as the perception that is "very clear" and awareness that is "highly developed." The young people at Architecture for All move from timidity to what the Yeşil Gazete (Green Gazette) describes as "a sense of hostility that comes from being the user of that place"; a transformation that sounds less like conventional empowerment and more like the cultivation of productive anger.

The most striking pattern across our cases involves the emergence of what we might call *emotional infrastructures*; the often-invisible networks of feeling that either enable or constrain collective worldbuilding. In La Pile, the monthly newsletters about solar production become more than information transfer; they create new rhythms of collective attention, ways of belonging to energy that had never existed before. The display panel made by residents doesn't just visualize consumption; it materializes a different relationship to power itself.

But these same infrastructures reveal their fragility when they encounter larger systems. The Brussels resident who notes that "the solar panels are from us, but the state uses this energy for itself" identifies a crucial disjuncture—the gap between participatory imagination and institutional capture. The energy belongs to the community in emotional and creative terms, yet remains trapped within regulatory frameworks that extract value elsewhere.

This tension appears differently across contexts. In Genk, the Transisthor mural creates what participants describe as aesthetic appreciation and emotional significance, yet a strategic manager in energy observes that "a lot of people don't know what it is there." The boundary object succeeds at generating conversation among those already engaged while remaining mysteriously invisible to others moving through the same neighborhood. The archive of mining history speaks powerfully to young people who feel connection with the former mining district, yet fails to translate into broader community recognition.

Perhaps the most complex emotional territory involves the relationship between local transformation and systemic change. Across our cases, participants develop profound attachments to small-scale possibilities, where the workshop where Turkish and Syrian children "have taken ownership of this space," the Genk resident who declares gratitude for gaining "a brand new house," the collaborative energy community that enables new forms of collective agency.

Yet these same attachments become sites of particular vulnerability when they encounter the temporal rhythms of institutional change. The Brupower representative's frustration about projects that "stay very local" while lacking pathways to regional scaling captures something essential about the emotional costs of participatory worldbuilding. The very intimacy that makes these interventions meaningful also constrains their capacity to address the systemic dimensions of the problems they engage.

Notice, however, how different cases navigate this choreography of scale differently. The Center for Spatial Justice's documentary approach creates a form of scaling that moves through representation rather than replication, in which the 95cm perspective travels as a method rather than an institution, creating possibilities for recognition across different contexts without requiring identical implementation.

The Architecture Workroom's network approach attempts a different form of scaling; creating connections between local experiments while maintaining their contextual specificity. Yet here too we encounter the emotional friction between vision and implementation, the frustration that emerges when "co-designed visions cannot be practically realised due to external systemic barriers."

The interviews reveal emotional territories that extend far beyond the celebratory narratives often associated with participatory design. DBV Architecten representative's observation about the first test house being "unoccupied and minimally furnished" points toward a crucial gap. Namely, the difference between technical prototypes and the complex realities of inhabited space. When the same techniques encounter "the techniques inside the homes," they generate frustration that might have been avoided through different forms of attention to the social dimensions of technical change.

The Turkish contexts bring additional layers of complexity. The Architecture for All workshops navigate language barriers and cultural differences that create initial timidity, yet this same friction becomes generative when children begin to "become aware of their rights" and develop "information ranging from working conditions to how children feel about working." The emotional trajectory moves through discomfort toward forms of empowerment that couldn't emerge without first encountering difference.

These patterns suggest that the most meaningful transformations often occur not through the smooth implementation of pre-designed interventions, but through the creative navigation of friction itself. The heat pump that causes migraines also provides warmth; the regulatory barriers that constrain energy sharing also reveal the political dimensions of technical choices; the language differences that create initial timidity also enable new forms of cross-cultural solidarity.

One of the most subtle yet significant patterns involves the different temporal rhythms of emotional engagement and institutional change. Participants often develop strong attachments to possibilities within relatively short timeframes; the workshops that generate excitement and creativity, the collaborative design processes that foster hope and collective agency. Yet the implementation of these visions often requires navigating bureaucratic processes that operate on entirely different temporal scales.

This temporal mismatch creates particular emotional challenges. The Architecture Workroom participants who develop integrated neighborhood visions may experience "significant frustration and disillusionment" when external barriers prevent realization. The OPEN Lab residents who expected smooth renovations encountered delays that "brought frustration" and "created mistrust."

Yet some interventions find ways to work creatively with these temporal disjunctures. La Pile's approach of making "structural exclusions visible" rather than offering "scalable technical fixes" creates value that doesn't depend on immediate implementation. The project succeeds by shifting conversations rather than installing technologies, creating emotional and intellectual resources that can persist even when regulatory barriers constrain immediate action.

As we step back from these six patches of engagement, certain meta-patterns begin to emerge about the relationship between emotion and transformation. The most resilient interventions seem to be those that cultivate what we might call livable complexity. These are approaches that can hold both the joy of collective imagination and the frustration of systemic constraint, both the excitement of local possibility and the overwhelm of broader challenges.

This capacity for emotional complexity appears most clearly in cases that avoid simple narratives of either success or failure. La Pile's recognition that "real transition is relational, spatial, and political" creates space for ongoing engagement even when technical solutions remain elusive. The Turkish children's clear perception of

spatial problems becomes valuable regardless of their immediate capacity to reshape urban planning processes. The Architecture Workroom's emphasis on long-term institutionalization points toward approaches that can sustain engagement across the temporal rhythms of both emotional attachment and systemic change. Rather than treating participatory processes as discrete interventions, these approaches create ongoing relationships that can evolve as circumstances shift.

6. Conclusion

What emerges from this comparative analysis is less a set of worldbuilding tools than an ecology of transformation. In other words, a recognition that meaningful change occurs through complex interactions between technical possibilities, social relationships, institutional constraints, and emotional infrastructures. The cases that generate the most sustainable engagement are those that attend carefully to all these dimensions rather than privileging any single aspect.

The emotional geographies revealed through our analysis suggest several crucial insights for future worldbuilding efforts:

- **Friction as Strength**: Rather than obstacles to overcome, the frictions between vision and implementation, between local attachment and systemic change, between different cultural contexts and temporal rhythms, often become the most generative sites for learning and adaptation. The heat pump that causes migraines teaches us something about the social dimensions of technical transition that smooth implementation might never reveal.

- **Infrastructures of Feeling**: The most powerful interventions create what we might call emotional infrastructures. In these ongoing relationships, rhythms of attention and forms of collective meaning-making can persist across changing circumstances. These infrastructures often prove more valuable than specific technical implementations, creating resources for continued engagement even when immediate goals remain unrealized.

- **Scaling Through Empowerment**: Rather than replicating successful interventions, the most effective forms of scaling seem to occur through the circulation of methods, perspectives, and forms of attention that can be adapted to different contexts. The 95cm perspective travels as a way of seeing rather than a specific intervention, creating possibilities for recognition across different urban contexts.

- **Temporal Complexity**: Meaningful transformation requires attending to multiple temporal rhythms simultaneously, where the immediate experience of participation, the medium-term processes of technical implementation, and the longer-term trajectories of systemic change are involved. Interventions that can create value across these different temporal scales prove more resilient than those dependent on immediate technical success.

- **Polyvocal Engagement**: The richest interventions seem to be those that can hold multiple voices and perspectives simultaneously, creating space for both excitement and frustration, both hope and criticism, both local attachment and systemic analysis. This polyvocal capacity enables continued engagement even when participants hold different relationships to the same processes.

Perhaps most significantly, our analysis suggests that the emotional dimensions of participatory worldbuilding are not peripheral to technical and political concerns but constitute the very medium through which transformation becomes possible. The feelings that move through these spaces (i.e., hope and frustration, belonging and exclusion, excitement and overwhelm) don't simply accompany change but actively constitute the conditions under which different futures become thinkable and livable.

As we face the urgent challenges of energy transition and climate change, attending to these emotional geographies becomes not a luxury but a necessity. The futures we need require not just technical innovation and policy change but the cultivation of emotional infrastructures that can sustain engagement with complexity, nurture resilience in the face of setback, and generate the forms of collective imagination necessary for systemic transformation.

The voices captured in our interviews with residents dealing with heat pump noise, with children perceiving spatial injustice, with activists navigating bureaucratic barriers; remind us that transformation is always also a matter of feeling, of the particular ways that change registers in bodies and communities and daily life. Learning

to listen to these voices, to notice the emotional territories they reveal, becomes an essential skill for anyone committed to building worlds we can actually live in.

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Figures and Tables:

Table 1: Comparative Analysis of six cases

Case Study	Activity	Trigger	Actors	(Worldbuilding) Tools	Result
Architecture Workroom Brussels (BE)	An initiative designed to accelerate the energy transition at the neighborhood level through collective action and integrated strategies. Recognizing that current renovations are insufficient to meet the ambitious goal of renovating 95,000 homes annually by 2050, the project advocates for a collaborative approach that is more cost-effective and inclusive. Aiming to translate collaboratively developed neighbourhood action plans into tangible interventions and bridge the implementation gap.	-A critical realization emerged that the prevalent house-by-house renovation approach was insufficient to meet the ambitious climate goals. This showed the need for a more collective strategy, a shift towards a neighborhood-wide energy transition model. -The project emphasized the importance of involving a diverse range of stakeholders, while leaving out the focus on isolated experiments. Including local authorities, addressing technical, social, and policy dimensions. -The need for integrated future steps is underlined. The importance of institutionalizing these processes. -Following up after the projects are completed with periodically arranged public programs is a means of building trust with the communities.	Local municipalities, Flemish Region, EU,VITO, KU Leuven, design firms, Residents, neighbourhood groups, cooperatives, 100 Neighbourhoods, Open Workroom network	-Small exhibition. **(Figure 1)** -Public programme, which consist of A series of workshops and debates invited stakeholders to collaborate on integrated neighborhood approaches. -Open workrooms, in which the project opened its doors to support cities, experts, designers, businesses, and policymakers working on strategic transformations, including energy neighborhoods, sponge landscapes, and societal infrastructure. Each track featured a public programme and a small exhibition contributing to a broader transformation.	Shaping systemic change at a local level. Likely fostered hope and a sense of collective agency. Could trigger significant frustration and disillusionment among participants if co-designed visions cannot be practically realised due to external systemic barriers like regulations, bureaucracy, or funding.
La Pile (BE)	Collective envisioning and subsequent implementation of a localised and equitable energy-sharing system within a social housing block (SunSud project). Developing pertinent and equitable solutions through profound community engagement and co-creation.	-Traditional energy systems often exclude marginalized communities, particularly social tenants. This realization prompted a shift towards creating inclusive, community-driven energy solutions. -The establishment of the Pilone energy community marked a milestone. It served as an example of collective energy ownership and management. -The complexities of energy sharing regulations and technical infrastructure highlighted the need for collaborative problem-solving.	City Mine(d), Residents from Brussels' Midi and North neighborhoods, Energie Commune, Pilone Energy Community, Remorque Réno, Technical and Legal Experts	-Residents participated in free workshops focusing on artefacts about energy, design, electronics, and fabrication. -Info display panel to visualize the building's solar energy production and consumption, made by residents. **(Figure 2)** -Monthly newsletters about solar production levels and individual consumption.	SunSud did not offer a scalable technical fix, but rather a provocation: it made the structural exclusions of the energy transition visible. In doing so, it shifted the conversation from "how to install solar panels" to who controls energy, who benefits, and who gets left out. It showed that real transition is relational, spatial, and political.

oPEN Lab (BE)	Renovation of houses into energy-positive buildings in Nieuw Texas. **(Figure 3)** Developing a "technological playground" vision for a neighbourhood. Gathering data on inner climate, energy consumption, and installation performance.The project by DBV Architecten is using prefab timber systems, BIM modeling, **and** Lean planning to test and implement scalable, low-disruption upgrades in a real-world living lab setting.	-Adoption of prefab system (HSB) -Use of BIM modeling -First test house, as it was a prototype, didn't reflect the possible social outcomes. -Residents not foreseeing the end results.	Residents, who experienced disruptions and provided tacit knowledge. Participants in imaginative activities. Architects. Other local NGO members, such as STEBO, WIL, GIGOS, Luca School of Arts	-Co-authored socio-spatial story shaped by logistics, human agency, and infrastructural constraint. -Simulated futures and engineering scripts that anticipate and pre-structure the spatial world. -Worldbuilding in the present tense: rather than modeling utopian futures, the project builds on top of and within the lived complexities of Genk's housing realities. -Incorporating specific activities like the "Wishing Lab" and postcard prompts to encourage imaginative thinking about desired energy futures.	-Established method for minimal disruption renovations Enabled digital prototyping and coordination, however caused delays in process which brought frustration. Exposed real-time technical and social challenges Created mistrust towards WIL and accelerated the feelings of unfairness.
Transisthor (BE)	Artistic and technological creation of speculative narratives about energy futures on a public mural. **(Figure 4)** Collaborative creation of a public mural integrating historical archives and AI-generated future imaginaries.	-Transisthor project uses art printed on solar panels as both an aesthetic and functional medium to engage and activate the community around sustainable energy, with participatory moments serving as natural triggers for awareness and involvement rather than formal trigger tools as used in other evaluation contexts. -Acting as a boundary object, this project triggered conversations around energy in the neighborhood through its tactility.	Specifically targeted youth as key participants. Genk residents. Atelier Zwiep 's youth artists. Soltec (sponsor of solar panels). GIGOS and SAAMO.	-Integrated critical fictions through artistic and technological creation of speculative narratives on a public mural printed on solar panels to show energy transition's urgency. -Pointing out to the neighbourhood's specific energy related history context by looking at mining past and archival photos.	Increased creativity and a sense of shared purpose. engaged participants in imaginative thinking and critical reflection on their relationship with energy. Co-created a dialogue and a tangible piece of critical fiction.
Architecture for All (TR)	Physical prototyping as a form of spatial speculation. Empowering young people to reimagine and physically prototype alternative spatial arrangements. Implementing temporary, low-resource interventions, often with a grassroots and volunteer-based structure. Conducting hands-on workshops.	-Discusses broader architectural concepts and spatial justice, extending beyond energy transition. -Faced direct conflict or resistance in public space and operational vulnerabilities (like burnout or resource scarcity) due to its grassroots/volunteer structure.	NGO: Multeciyim Hemserim (Translation: I am a refugee, my fellow countryman), Yarımburgaz Neighborhood Protection and Solidarity Association, Youth	-Engaged in spatial speculative worldbuilding through empowering young people to reimagine and prototype spatial arrangements. -Employed creative and hands-on methodologies. **(Figure 5)** -Emphasised accessible, analogue, and material approaches (temporary installations).	Encouraged critical engagement with their built environment and the envisioning of possibilities beyond the status quo wihin limited budgets and grassroot movements. Evoked excitement and a sense of accomplishment among young participants. Potential for disillusionment from the limited impact of temporary actions.

Center for Spatial Justice (TR)	Envisioning and working towards "radical just futures" across interconnected issues like environmental justice. The "Mini Citizens of the Mega City" project serves as a tangible speculative prototype. The documentary **(Figure 6)** follows the daily lives of four children from different neighborhoods of Istanbul through the eyes of the children. This approach reveals that cities should be made livable not only for adults but also for children.	-Children are not seen as active citizens in urban life; therefore, children's needs in urban planning -The desire to understand how accessible and livable cities are for children -Conveying the physical obstacles, access problems and spatial injustices in the city -Aiming to raise significant awareness that cities need to be made more inclusive and equitable	Kids. Refugees. Artists and architects, Urban95 initiative.	-Using the documentary as a tool to tell the story of Istanbul through the eyes of three-year-old children. The project aims to make visible the physical obstacles and spatial injustices that children face in the city, with images taken from a height of 95 cm, the height of an average three-year-old child. -The follow-up "#95cm: 3-2-1 Record!" campaign, encouraging individuals to document their own environment from a child's perspective	The documentary "95cm" exposes the inaccessibility of Istanbul from the eye level of a three-year-old child, and strikingly reveals that urban planning is actually made only for the adult, mostly male, body; it turns the understanding that postpones children as 'tomorrow's citizens' into a silent criticism.

Table 2: Comparative Analysis of emotional dimensions

Case Study	Potential Emotional Dimensions	Emotional Triggers	Quotes from Interviews
Architecture Workroom Brussels (BE)	Hope, collective agency, empathy, sense of possibility/determination	Revealing long-term planning schemes in Belgium can lead to distinct emotional trajectories.	Joachim Declerck: "The narratives are a way to reformulate a problem. It's a mix between reality and rhetorics." "We can't reduce the energy transition to a regulation—it's a project to transform society." Hanne Mangelschots: "Local authorities, businesses, and citizens can join forces and create a public-private-civil energy company, as the city of Blankenberge has done, particularly with its Public Social Welfare Centre (CMWOC), in which citizens can acquire shares."
La Pile (BE)	Belonging, solidarity, empowerment, future anxiety, frustration, eco-powerlessness, joy, creativity	Directly confronting energy poverty. Not being able to do long-term plans, thus frustration and anxiety. Advancing social justice through community-driven solutions.	"A core challenge in the Midi and North neighbourhoods is the high percentage of tenants. In "Renover Bruxelles", it has been explicitly identified that the tenant/landlord issue is a major obstacle, where landlords may lack the incentive to renovate unless they can raise the rent, creating fear for tenants." Sofie van Bruystegem "Yeah, so one of the frustrations, for instance, that we sometimes have with CityMined when we do energy sharing on a very local scale, it's that it stays very local and it's hard to find ways to upscale these kind of projects while with an energy cooperative, potentially you could have a structure which is regional and which could share energy on a regional level." Brupower Representative "We believe in 'Can do', the joy of trying something." Sofie van Bruystegem

oPEN Lab (BE)	Frustration, uncertainty, disillusionment, anxiety, overwhelm, gratitude	Overlooked needs or unintended consequences creating mistrust and disagreements, while some residents enjoy it.	"It is very annoying when it(the heat pump) makes this sound. That is my biggest problem. There is no solution for that. I get migraines from it." Resident from oPEN Lab projects "The solar panels are from us, but the state uses this energy for itself. We are not affected by solar energy right now." Resident from oPEN Lab projects "Since the first test house was unoccupied and minimally furnished, it became clear, in the initial stages of the other homes, that the execution of the works was more complex (due to the techniques inside the homes), which caused frustration among the residents." Dbv Architecten Representative "We have gained a brand new house, I don't get it; what else do they(other neighbours) want?" Resident from oPEN Lab projects
Transisthor (BE)	Aesthetic appreciation, Emotional and commemorative significance, Lack of understanding, Positive outlook on making complex concepts accessible	Not seeing long-term implementations of the participatory processes.	"Young people from Winterslag feel a strong connection with the former mining district." Nele Bronckaers "...a lot of people don't know what it is there, because there is no info panel next to this bench... all the people who collaborated on this don't know what it is. Besides on that, even if people were working in the social house, they don't know what it is about." A strategic manager in energy "It allows architecture to be more, while integrating design with energy solutions." A professional from an energy NGO
Architecture for All (TR)	Excitement, creativity, ownership, accomplishment, shared purpose, curiosity	Timidity of language barriers and cultural differences	"The results of the workshop, especially the one with the theme of child labor, were striking; from the beginning to the end of the workshop, a process developed in which children began to become aware of their rights, and information was revealed ranging from working conditions to how children feel about working." Yesil Gazete "Since Turkish and Syrian children have taken ownership of this space, they have made great strides in producing together and adapting to each other's realities, and they are still making progress." Yesil Gazete "The timidity of the early days has now been completely replaced by a sense of hostility that comes from being the user of that place." Yesil Gazete

Center for Spatial Justice (TR)	Contemplation, pressure, Empathy, Trust in youth, empowerment	Some children, particularly those in neighborhoods like Başakşehir, grow up feeling the pressure of surrounding mega-projects, housing projects, and shopping malls. The "Mega Kent" is a complex and multi-layered city, and understanding it requires looking beyond central areas to include peripheral neighborhoods, squatter settlements, and newly built sites. This implies that some areas face greater challenges in terms of urban development.	Yaşar Adnan Adanalı: "Although the children who participated in our study were at most 5 years old, they were able to identify spatial problems better than most adults, and they expressed them in their own unique way." "Children's perception of the environment in which they live is very clear, and their awareness is also highly developed." "In order to make the difficult experiences of children (living in Istanbul) (being a refugee, socio-economic injustice) more visible, we lower the camera to a 95cm perspective and try to look at Istanbul through the eyes of children."

Figure 1: from Architecture Workroom Brussels' Exhibition: Operation Energy Neighbourhoods

Figure 2: from La Pile's SunSud

Figure 3: from dbv architecten's oPEN Lab - Nieuw Texas Genk, prototype energy homes

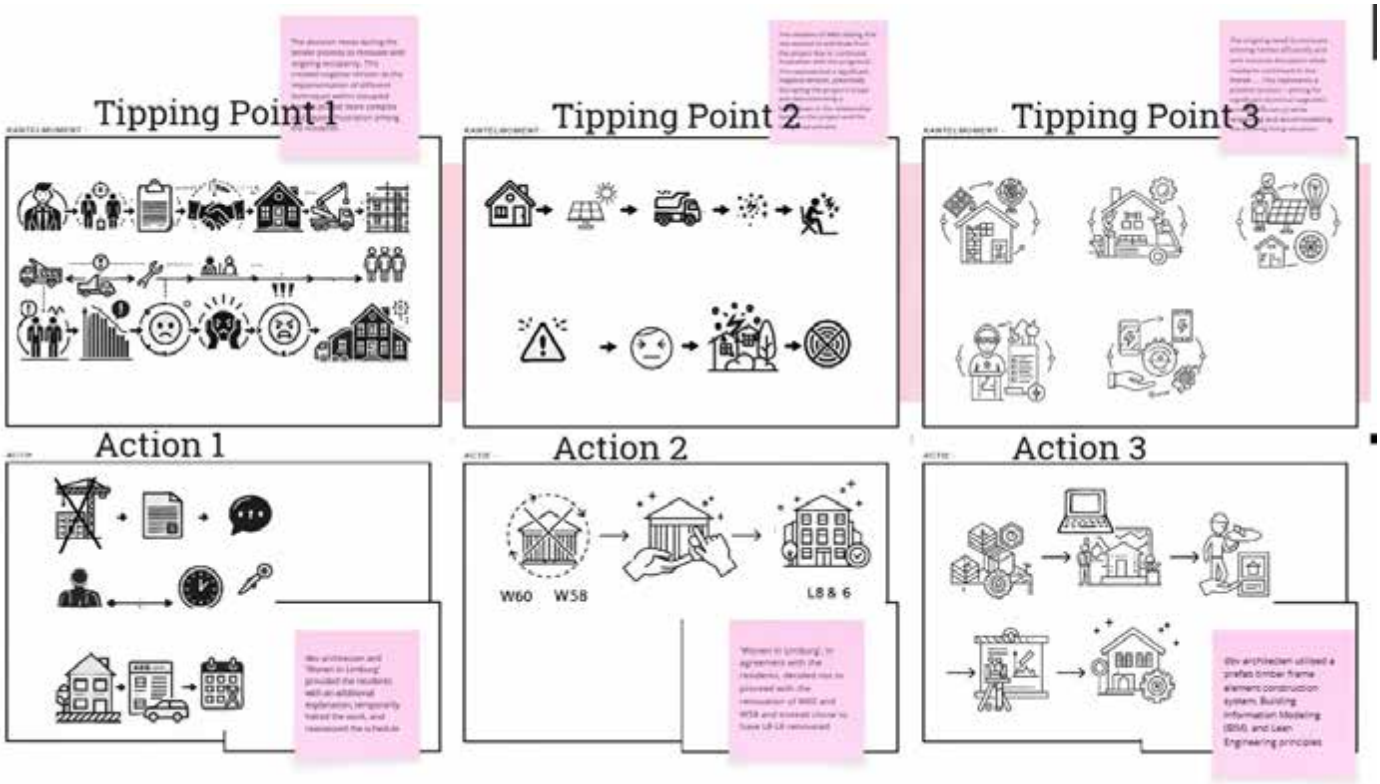
Figure 4: from Transisthor's "Now or Never"

Figure 5: from Architecture for All - Yarimburgaz Youth Workshop

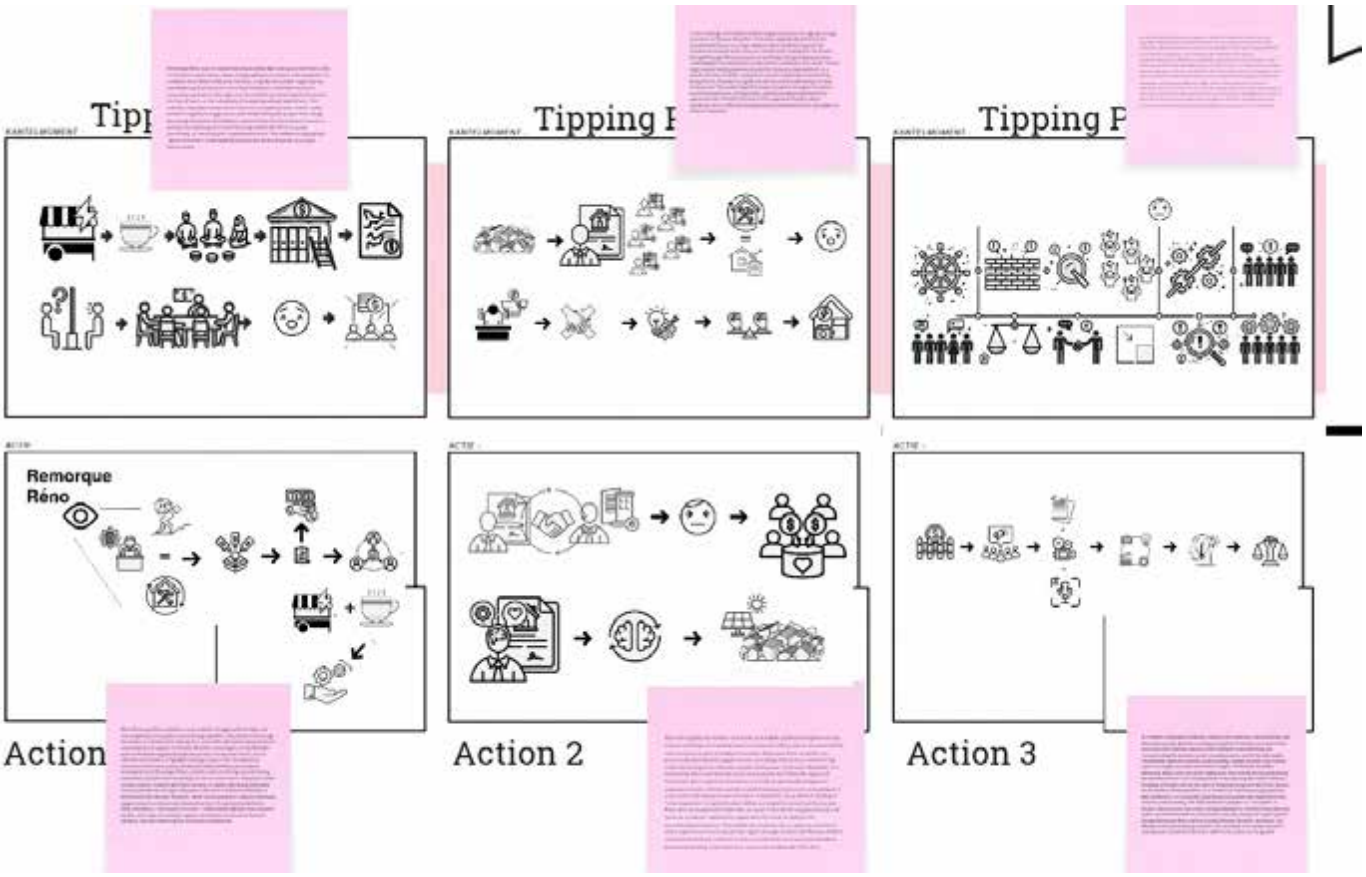
Figure 6: from Center for Spatial Justice's documentary "95 cm: Mega City's Mini Citizens"

Appendices:,

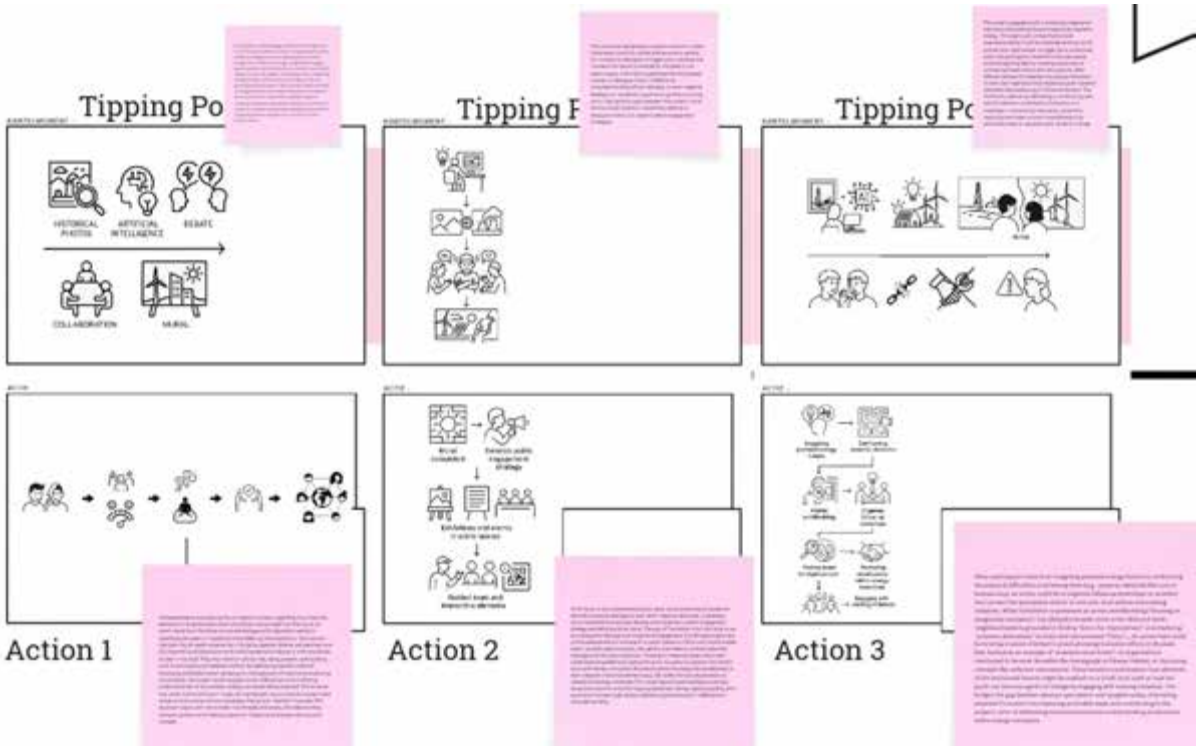
1. Timeline Tool visualised for Architecture Workroom Brussels Case:



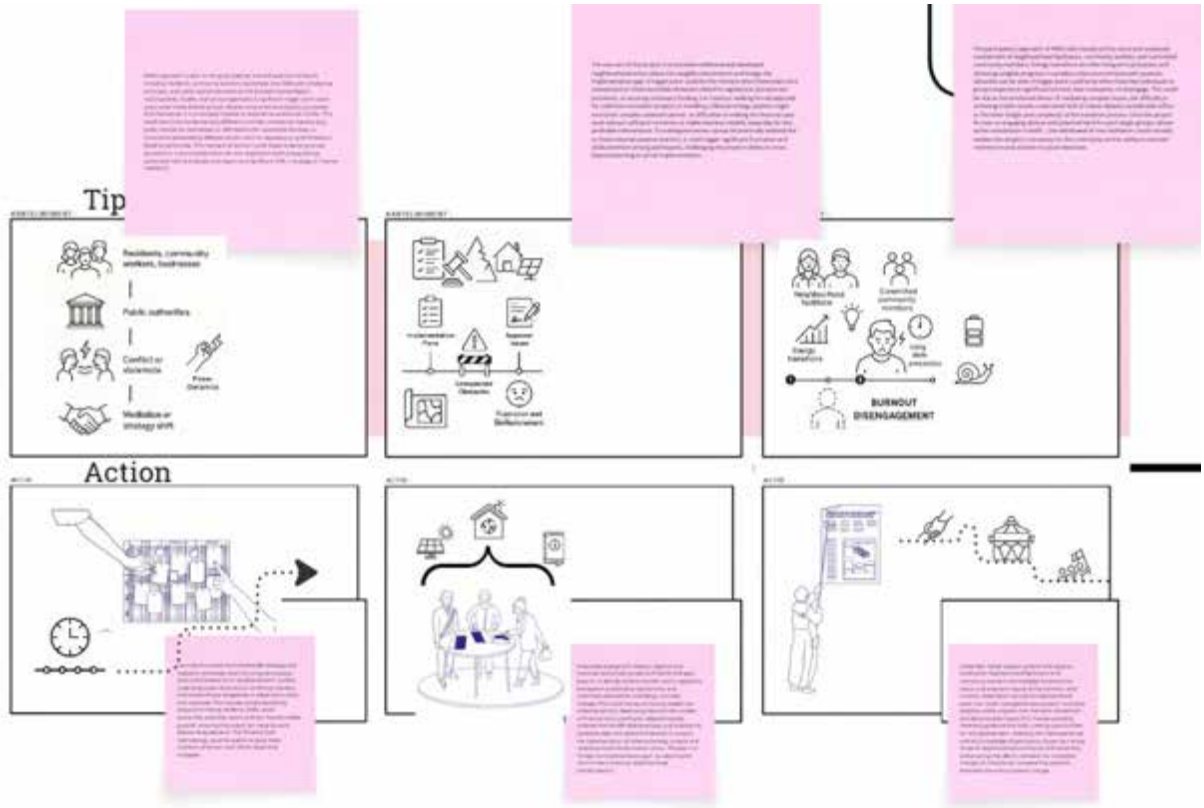
2. Timeline Tool visualised for La Pile Case:



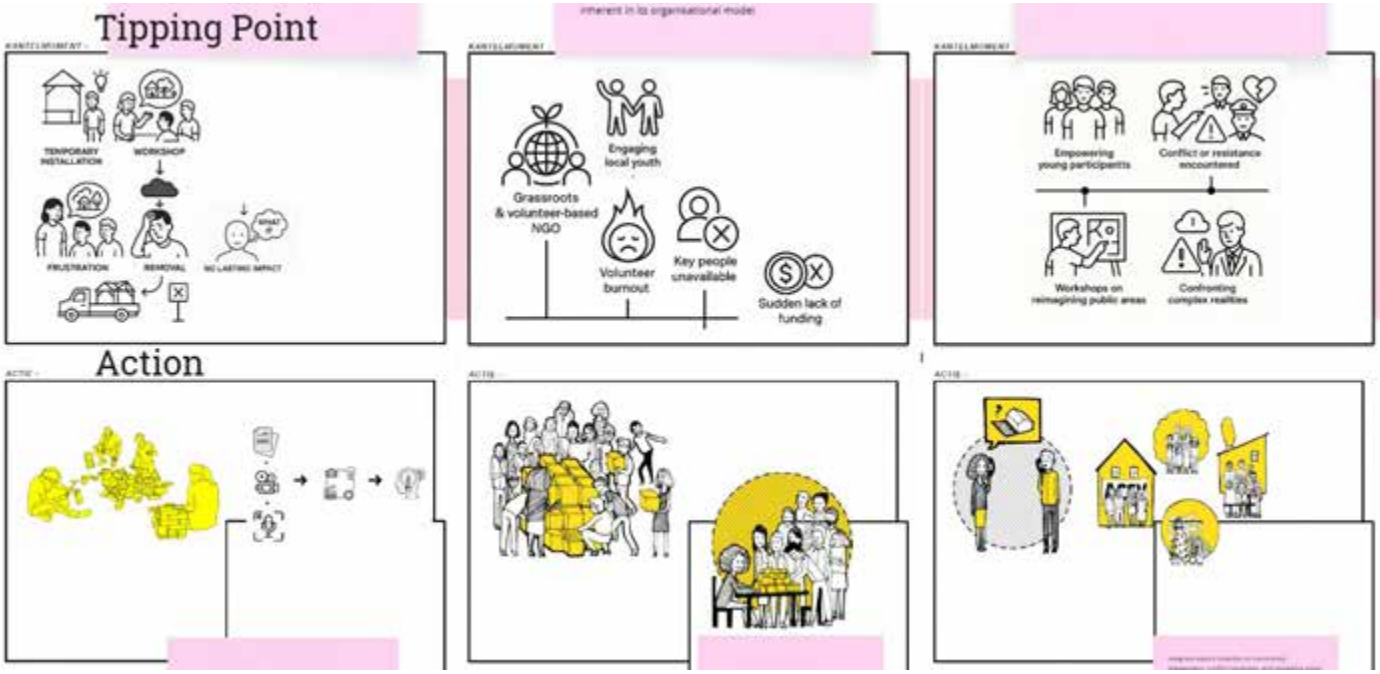
3. Timeline Tool visualised for oPEN Lab Case:



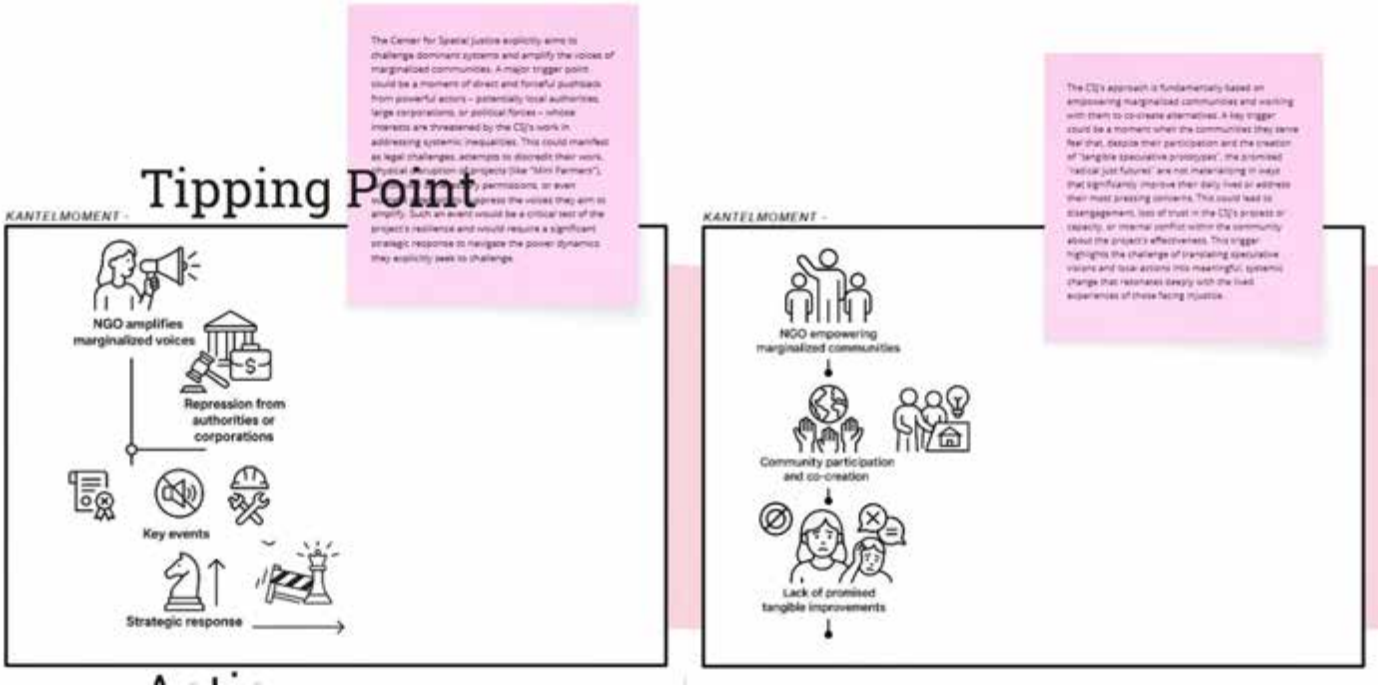
4. Timeline Tool visualised for Transisthor Case:



5. Timeline Tool visualised for Architecture for All Case:



6. Timeline Tool visualised for Center for Spatial Justice Case:



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Hydraulic Heritage and Community Identity: Examining Socio-Ecological Resilience and Heritage Transformation in Huaibei Area, China

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Abstract
This study explores the interrelations among socio-ecological resilience, identity construction, and hydraulic heritage through a case study of the Xiangyang Irrigation System in Huaibei, China. Tracing the system's transformation from a functional irrigation network to a fragmented cultural landscape, the research employs oral history, ethnographic observation, and semi-structured interviews to assess local perceptions. Findings reveal divergent community narratives shaped by varying levels of engagement and benefit. While some residents derive identity from the system's historical and cultural significance, others remain indifferent. The study concludes that hydraulic heritage contributes both to socio-ecological recovery and community identity, positioning it as a vital asset for sustainable regional development.

Keywords: Hydraulic heritage, Socio-ecological resilience, Identity construction, Sustainable development

1 Introduction

At present, the concept of resilience has an increasing impact on the concept of heritage, especially in the discussion of cultural landscapes and social-ecological systems, to explain the adaptive and sufficient capabilities of these complex systems in the face of external disturbances and changes (Rapaport *et al.*, 2018; Mrozek and Mrozek, 2021; Niu *et al.*, 2024)much attention had been given to defining, measuring and enhancing resilience at the community level. In this study we examine if and to what extent does resilience vary among communities of different types. We use type of community as a proxy for social ties in the community, to examine variances in the perceived community resilience. We utilize an innovative measurement of community resilience, Conjoint Community Resilience Assessment Measure (CCRAM. The concept of resilience includes the ability to buffer, adaptability and transformation (Figure 1), emphasising how ecology and society are deeply connected in the built environment (Folke *et al.*, 2002)evidence that has been accumulating in diverse regions all over the world suggests that natural and social systems behave in nonlinear ways, exhibit marked thresholds in their dynamics, and that social-ecological systems act as strongly coupled, complex and evolving integrated systems. This article is a summary of a report prepared on behalf of the Environmental Advisory Council to the Swedish Government, as input to the process of the World Summit on Sustainable Development (WSSD. For heritage landscapes, this concept can reflect the long-term interactive relationship between heritage communities and the surrounding environment temporarily.

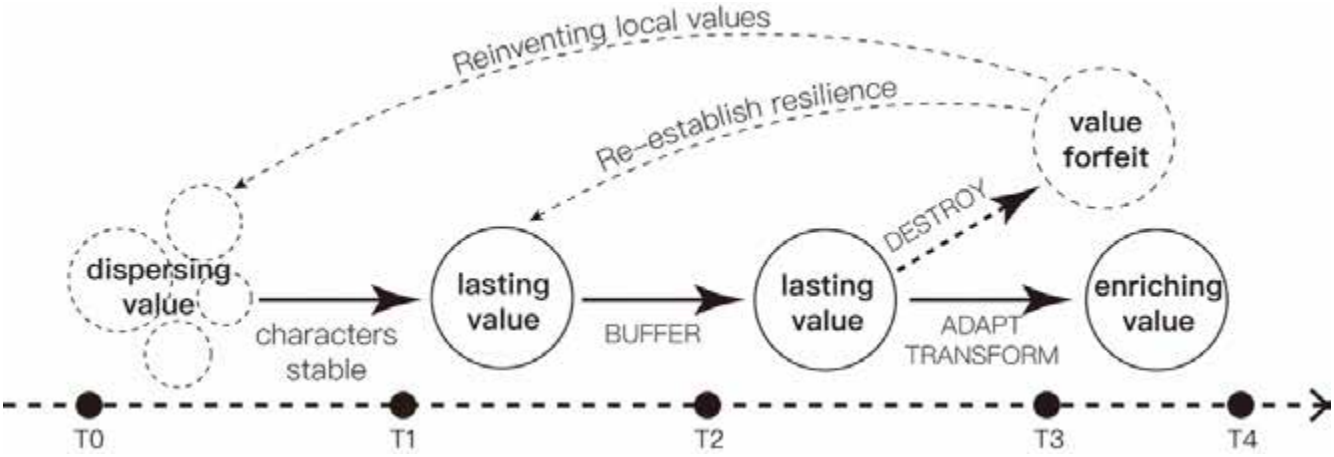

Figure 1 Evolutionary resilience model.

Hydraulic heritage refers to the historical systems designed and built for water management, including aqueducts, irrigation facilities, dams and traditional water use experience (Hermosilla Pla and Mayordomo Maya, 2016). It is a microcosm of the close co-evolution of natural resource management and society. These systems have played an essential role in the fragile environment and ecology, the allocation of water resources, the control of floods, and the improvement of agricultural production levels. Recent studies have found that in addition to the original engineering functions, hydraulic systems are often deeply bound to the cultural structure of the community and shape the community identity and collective memory (Durán-Suárez and Sáez-Pérez, 2019; Wei *et al.*, no date). As can be seen from the inclusion of China's Dujiangyan Irrigation System in the World Heritage List by UNESCO, this type of heritage is not only important as a historical project, but also as a lasting cultural landmark that provides contemporary functions.

This study attempts to answer the role of hydraulic heritage in social ecological resilience by analysing the Xuzhou Xiangyang Irrigation System in the Huaibei region of China. Historically, the Huaibei Plain has been deeply affected by many large-scale hydrological interventions, especially the diversion of the Yellow River into the Huaihe River Basin during the Song Dynasty (1128 AD) (Junya and Wright, 2013). This move was intended to strategically protect the Jiangnan region but caused widespread ecological damage and agricultural degradation in the Huaibei region. Over the next nine centuries, the region's ecological and social resilience was systematically compromised. Villagers struggled with flooding, salinised land, and agricultural stagnation for a long time, earning an unfortunate reputation as "sacrificial locals". In response to Huaibei's complex ecological and social problems, the 30-kilometre Xiangyang irrigation system was built in the context of social mobilisation in the 1970s, covering facilities such as channels, sluices, and pumping stations. It improved agricultural productivity by providing stable fresh water and reducing soil salinisation. In the new century, with the introduction of more advanced regional water resource management technologies, the irrigation function of the Xiangyang system gradually weakened, and the various facility elements lost their spatial associations, but their role in local cultural and historical identity became increasingly evident. The transformation of the meaning of hydraulic heritage highlights the contemporary value of social-ecological resilience.

This study examines the transformation of landscapes, heritage narratives, and social perceptions through a qualitative method, which integrates literature research, semi-structured interviews, participatory observation, and spatial analysis. The purpose is to understand how hydraulic heritage can promote social cohesion, and increase the resilience of eco-social systems while protecting ecological integrity. By understanding how historical infrastructure can adaptively integrate cultural and ecological elements and become a lasting resource for the development of heritage communities, this paper makes theoretical and empirical contributions to the intersection of heritage conservation, resilience theory and sustainable development.

2 Method

2.1 Literature and Archive Review

First, the academic literature and archives on eco-social resilience, cultural landscape, hydraulic heritage and historical hydrology in Huaibei, Jiangsu Province were studied, with a focus on the historical records of "taking the Huai River into the sea" and the subsequent ecological degradation. At the same time, the county annals of the former Tongshan County (now Tongshan District, Xuzhou City), hydrological engineering reports from the 1950s to the 1970s and provincial planning documents were consulted to understand the development timeline of the Xiangyang irrigation system and the positioning of the state-led hydraulic project construction in the Huaibei region under the background of the "Red Flag Aqueduct" spirit. In addition, the relevant international adaptation and resilience theoretical frameworks were sorted out, and combined with UNESCO's papers on cultural landscapes and community identity development to lay the cognitive foundation for this study.

2.2 Semi-structured interviews and participatory observations.

From 2023 to 2024, 21 semi-structured interviews were conducted in Liuquan Town, Xuzhou and neighbouring villages. Interviewees were selected by snowball sampling to ensure that a wide range of ages and social identities were covered, and the diversity of the interviewees' participation in the irrigation system was obtained as much as possible. Interviewees included the following four categories: (1) farmers who participated in the construction and early use; (2) village committee/party and mass workers who participated in village political management and hydraulic heritage maintenance; local cultural researchers and teachers who incorporated the history of the water system into the teaching system; and (3) community residents engaged in related rural

tourism. At the same time, the interviews included open-ended questions on the following topics: (1) personal or collective experience of using the Xiangyang irrigation system; (2) perceived benefits and challenges of the Xiangyang irrigation system in the past and present; (3) emotional and cultural connections to the irrigation system; (4) attitudes towards heritage commercialisation and tourism development; and (5) views on changes in the local ecological environment. All interviews were recorded, transcribed, and coded with knowledge and anonymity.

At the same time, the research team formed an ethnography of the local community by observing the interaction between local residents and the remains of the irrigation system, recording their emotional responses to water-related landmarks, and the stories they told while accompanying observers on walking tours. This record not only took their daily lives related to water as historical objects, but also analysed their current social and spatial structures.

2.3 Landscape Analysis and Spatial Mapping Framework

In order to make the above qualitative data, which are mainly based on oral and observational data, more objective, this study also used GIS tools to conduct a spatial analysis of the local built environment, including: (1) the original layout of the Xiangyang irrigation system based on engineering records and field measurements built in the 1970s; (2) the current local land use patterns and visible remains of hydraulic facilities; (3) recent development activities on related heritage, such as signboards and visiting walkways; (4) satellite images from 1970 to 2024 to record changes in land cover, vegetation and water bodies. This spatial information will be combined with the qualitative content obtained from interviews and observations to track the material state of changes in the irrigation system and explain how specific heritage sites are remembered, used or forgotten. Data analysis will be tested using triangulation methods to understand how hydraulic heritage is interpreted and how it is deconstructed and materially transformed in the context of resilience.

3. Case Study: Xiangyang Irrigation System in Huaibei

3.1 Historical Context: From Floods to Social Marginalisation

The socio-ecological trajectory of Huaibei is highly relevant to one of China's most important water events. During the Northern Song Dynasty, the Yellow River was artificially diverted into the Huai River system. In 1128 AD, under siege by the invading Jurchen army, the Song army broke through the dikes in present-day Kaifeng and released the Yellow River floodwaters southward to form a defensive barrier. Large areas of northern Anhui and Jiangsu provinces were flooded by this river change. However, the long-term ecological and socio-political consequences were much more serious. The wartime strategic shift had a significant impact on the local hydrology. The Yellow River, which previously flowed into the Bohai Sea, then usurped the Huai River channel further south and entered the Huai River basin. This diversion exacerbated local flooding problems due to changes in the river's capacity, leading to chronic waterlogging. At the same time, the large amount of sediment carried by the Yellow River led to local soil salinisation, agricultural abandonment, and large-scale displacement. Historical records show that large tracts of arable land in northern Huaibei became unusable, forming what Qing officials later called "poor mountains and bad waters."

After the 19th century, the Huaibei Plain was widely referred to as "sacrificial locality" (Ma, 2023). This was a marginal territory that was neglected in the allocation of national resources by the entire central government. The fragile ecology brought poverty, food shortages, and social exclusion, and also caused the loss of rural population. Although the Yellow River changed its course again in the 19th century, making the Huaihe River system the main water system in the Huaibei Plain, the ecological resilience was still not ready to be restored, and the salinised plains, broken waterways, and complex social environment still existed. This state also laid the foundation for a series of hydraulic projects in the Huaibei area. Because major infrastructure, including the Xiangyang Aqueduct, is not only an ecological resilience restoration project, but also an initiative to reintegrate this land into social politics.

3.2 Construction of Xiangyang Irrigation System: Engineering Hope and Collective Memory

Despite the long-term instability of the hydrological environment and the marginalisation of geographical conditions, the country launched a nationwide modernisation movement of large-scale hydraulic facilities under the leadership of the Taihang Mountain Red Flag Aqueduct Hydraulic Project in the 1970s (Figure 2).

This type of rural infrastructure project is usually initiated by large-scale mobilisation and has a significant impact on the local agricultural environment.

Figure 2 The fundamental status of the Xiangyang irrigation system.

The Xiangyang system is a set of irrigation hydraulic networks with self-weight water supply and mechanical pump assistance. Its purpose is to introduce fresh water resources from Weishan Lake in the north and newly built small and medium-sized reservoirs to Liuquan Town and surrounding villages to solve the problems of farmland salinisation and poor drainage. According to county-level archives, the system was completed in 1976, with a length of about 33.6 kilometres, including five medium-sized water transfer stations, five large aqueducts, 369 bridges and culverts, five tunnels, and 25 kilometres of high-voltage lines. It is worth noting that this facility was not implemented by a professional engineering corps, but through the labour model dominated by the people's commune, mobilising thousands of villagers and educated youth. Oral histories recorded on the ground testify to the intensity and symbolism of the work. One interviewee, 74-year-old Ms. Zhang, who worked on the project, recalled:

"There were no large machines, and we dug with our hands and shovels. Each household sent a labourer; my husband worked for 38 consecutive days. It was hard to get enough food, but free meals were provided at the construction site, and they said they were "building water (water diversion)" for the village. The work was hard, but we were all proud. The project was our own business."

This participatory practice not only achieved the construction of infrastructure, but also created a sense of "ownership" of public property. Between the 1970s and 1990s, calligraphy and paintings on the facilities, murals in the village, and local songs recorded the entire construction process. Although villagers were not clear about the role of each part of the system, for example, a vital aqueduct was called the "38-hole bridge" by the locals because of the 38 arches that supported the aqueduct. The aqueduct is certainly not a transportation facility, but due to the similarity of the image, the use of "bridge" as an alternative word can better spread the name of the project (Figure 3). The Mao Zedong quotations inscribed on the aqueduct also highlight the complex emotions of the locals, showing the embedding of emotional meaning in the material structure.

Figure 3 "38-hole bridge"

On the other hand, the hydraulic system attains ecological resilience by connecting the originally broken water bodies and providing drainage outlets. This has significantly improved local productivity. The salinity of cultivated land has dropped by more than 30% in five years, and the areas controlled by the Xiangyang Project have gone from being difficult to plant to being able to harvest twice a year. According to villagers, the yield of some lands has doubled compared to before the project was used.

More importantly, the Xiangyang hydraulic system has also reshaped the village settlement model. Due to long-term flooding, the original villages could only be built on high ground. Now the hydraulic system has become an organisational axis, and housing, markets and community centres have been repositioned around these axes. In some villages, bridges and public washing platforms are built near irrigation facilities, which have become their new infrastructure and social space. As a local retired teacher said:

"Hydraulic facilities not only bring fresh water, but also bring intimacy between people. It runs through our lives: irrigating farmland, swimming, washing clothes. It is part of our lives..."

Today, although most of the facilities still retain the integrity of their physical state, they have lost their original irrigation function. Due to the restoration of ecological resilience and new water diversion technology, the Xiangyang system has begun to transform from infrastructure to landscape, and has become an intersection of culture and emotion. It is precisely by capturing this shift that the interpretation becomes a transformation of its function and meaning.

3.3 Decline of Function and Rise of Symbolism

Since the early 2000s, the state of water resources and hydrological conditions in the Huaibei region has changed significantly. With central government investment in large water facilities, the construction of deep well systems, and the expansion of municipal water supply facilities, the region has gradually reduced its reliance on the Xiangyang system. However, unlike most infrastructure that has taken off, the Xiangyang irrigation system has begun a soft evolution, from functional infrastructure to symbolic landscape. This shift was not achieved through formal renaming, but rather through a combination of spatial intervention, community memory, and tourism development. In 2016, Liuquan Town began to promote the "Water Channel Memory Walk", installing interpretive signs along the main waterway, which is about 4.5 kilometres long. These signs include photos of the past, oral texts, and QR codes linking to students' related documentary works. Some local celebrations, such as the Spring Plowing Ceremony and the Mid-Autumn Water Lantern Ceremony, are also held near the key facilities of the waterway to strengthen the symbolic connection.

Many elderly people still describe the water system as a "gift from the past." An 82-year-old villager claimed:

"It may not be carrying water, but it carries our pride. I often go there because it's my old time." The intervention of collective art also adds to this spiritual transformation.

In 2021, a mural project organised by college student village officials (a way for the Chinese government to train grassroots officials) repainted the text on the sluice facilities, emphasising the spiritual role of the great mobilisation project in the 1970s by highlighting some of the political slogans written at the time, which also made these facilities a "red heritage." Although the scale of these practices seems small, they show a spiritual transformation: the old hydraulic infrastructure has become an anchor of rural identity. And this emotion is deeply reflected in the post-agricultural society and semi-urbanised landscape (Figure 4).

Figure 4 Political slogans that have been repaired in the structures

3.4 Landscape transformation: from aqueduct to cultural corridor

In addition to oral accounts and observations, spatial analysis also reveals how the material space of the Xiangyang irrigation system has gradually been integrated into contemporary culture and eco-society. Comparison of satellite images from 1990, 2005, and 2024 shows the following trends:

(1) **Physical form:** Although some river channels have disappeared due to land development, the main water channels remain intact and have become green corridors or channels between fields; the sides of the river channels have also become vegetation buffers, with native vegetation growing on the edge of concrete, becoming an ecological plate for amphibians and butterflies.

(2) **Social form:** In the 13 villages surveyed, administrative buildings, primary schools, public squares and other facilities in five villages have spatial intersections with the remains of the irrigation system;

(3) **Industrial form:** The 2020 tourism plan includes two theme hotels, a hydraulic cultural centre, and a souvenir shop related to hydraulic knowledge. Although the final implementation is different from the plan, it can still capture the symbolic role of the Shuili heritage in the local space.

3.5 The aqueduct as a multi-scalar heritage

The role of the Xiangyang irrigation system in terms of function and meaning can be analysed at different levels: at the micro level (village), it constructs rural neighborhood identity and spatial positioning, such as residents often point to specific landmarks, "the bridge my father built", "above the sluice", "where we played with paper boats", which shows the continued role of heritage as a spatial location marker; at the same time, it is also an aesthetic and social node, promoting the birth of local tourism and public art through narratives of events and memories. At the meso level (township), the hydraulic system has been incorporated into the strategic planning of rural revitalisation. Although it is still lacking in funding, a planning document for 2022 describes it as a heritage system that connects ecological restoration areas, rural cooperatives, and heritage clusters. At the macro level (region), scholars and planners regard this system as a typical example of hydraulic landscape heritage in the Huaibei region.

Thus, the evolution of the meaning of the Xiangyang irrigation system reflects the process of spatial heritage stratification, from functional infrastructure (1970-2000), to post-industrial memory sites (2000-2010), and to polysemic cultural landscapes (2010). This transformation of resilience is reflected not only in the ecology but also in the politics, economy and collective identity of a community. As summarised in an interview with the village party secretary:

"We used to worry about whether there was water in the aqueduct. Now we ask: does it still have meaning? Yes. It flows differently now, but it still connects us."

4. Results

This chapter presents the main empirical findings from the fieldwork. Based on 23 semi-structured interviews and participatory observations, subjects were coded. The analysis revealed that people's perceptions of the transformation of the Xiangyang irrigation system varied across generations, occupations, and geographies, leading to different interpretive patterns.

4.1 Typology of local narratives: four community positions

The subject coding of the semi-structured interviews yielded four different community positions, which we categorise as (1) governors; (2) cultural transmitters; (3) pragmatists; and (4) tool innovators.

(1) Stewards of the aqueduct

This group is mainly composed of older villagers (over 60 years old) .they either directly participated in the construction of the aqueduct or actively used it during its operation. For this group, the irrigation system is not just an infrastructure, but also a moral story of resilience and sacrifice. They see themselves as stewards of the aqueduct's memory. As one 72-year-old woman said:

"This is not just a aqueduct, it is what we built with our youth. If you tear it down, you end our lives."

This group often uses emotional terms, such as calling the irrigation system "our blood vessels," "common works," or "the backbone of the village." They prefer low-tourism, high-ritual space utilisation methods, such as worshiping ancestors by the water.

(2) Cultural disseminators

This group is more composed of middle-aged villagers (40-60 years old), teachers, local cultural researchers, and village cadres. They act as intermediaries between old memories and new interpretations. Many of them did not directly participate in the construction and irrigation work, but grew up listening to the story of the aqueduct. They noticed the material and intangible heritage value of the irrigation system. Local teacher He, 43, said:

"Our students may not know the principles of the irrigation system, but they can understand the meaning behind it. This is the result of the efforts of the Party (CCP) and the collective, and it is also a lesson for us on how to change nature."
This group actively supports heritage education, painting projects, and oral history collections. They are moderately open to tourism development, provided that it conforms to "local values" and "mainstream narratives."

(3) Pragmatists
This group is usually composed of young residents under 35 years old and those who have recently returned to the village. They show ignorance and indifference to the irrigation system and its original function. As a generation living in the context of mechanised agriculture and urban water supply, for them, it lacks direct relevance to daily life. A 27-year-old driver said:

"I cross the bridge (the 38-hole aqueduct) when I deliver to the store, and that's it. It's not part of my life."

It is worth noting that this group is not against heritage, but just thinks it is not a priority in their lives. They focus on reuse projects that can generate short-term benefits, such as whether some facilities can be converted into cafes.

(4) Tool Innovators
This group is small but growing, including local entrepreneurs, tourism planners and youth cooperatives. They see heritage as a tool for economic and social development and propose "adaptive use" of hydraulic facilities. For example, it can be integrated into agricultural tourism experiences, create VR experiences of using hydraulic facilities, or hold seasonal rituals related to them. A 34-year-old B&B owner said;

"If we only view the hydraulic facilities as history, they will disappear sooner or later. But if we view it as a resource, it can play a positive role in the economy, culture and society."

This group tends to prioritise strategic action storytelling and brand creation. Their activities are similar to other heritage-led rural development models in China and are often supported by higher-level governments.

4.2 Intergenerational friction and intra-village dialogue
The positions of these four narrative subjects together reveal a landscape of negotiated governance of heritage rather than shared memory. Multiple interviewees expressed tensions between different generations, especially in the understanding of the symbolic and economic value of the irrigation system. In several villages, intergenerational conflicts arose over the use of heritage for tourism development. In Xixiang Village, the elderly opposed the establishment of a night market near the historic sluice gate, believing that it was "interference with a place of memory." Meanwhile, young entrepreneurs saw it as an opportunity to "revitalise a corner of the village." Similar disagreements occurred in the design of rituals, such as whether the Spring Water Festival should include only traditional rituals or contemporary music performances and webcasts.

To resolve these contested opinions, there were at least four coordination meetings held in different villages. The meetings bring together village elders, youth representatives, local officials, and teachers.

They negotiate the content of facility-related activities and how they should be governed. In Dongma Village, for example, the meeting agreed to limit commercial stalls to one side of the facility, while reserving the other side for ceremonial purposes.

These hybrid governance mechanisms are still being refined, but they represent a grassroots effort to manage in a participatory way. During the interviews, both sides expressed cautious optimism.

"They are listening more now," said one elder. "At least we have a seat at the table."

"It's not about agreement," said a youth representative, "but about recognising what is important to different people.

4.3 Heritage as emotional infrastructure

In addition to its physical infrastructure and cultural brand, the Xiangyang Irrigation System functions as an "emotional infrastructure" that serves as a site for processing individual and collective feelings of loss and belonging. This becomes evident in many of the narratives associated with the aqueduct. For example, five widows whose husbands died during the construction of the aqueduct in the 1970s maintain a memorial corner next to an abandoned hydroelectric station (Figure 5), and every Qingming Festival, they perform rituals such as burning incense and chanting names, and become "aqueduct sisters". A 75-year-old woman, Ms. He, explained: *"When my husband died, I started walking along the aqueduct every morning. It's quiet, but it listens. It remembers."*

Figure 5 Memorial corner by "aqueduct sisters."

Elsewhere, a teenage boy talked about running along the aqueduct when he failed an exam, and an older man described bringing his grandson here to share family stories. In these narratives, heritage is less a structure than a space for reconnection. This emotional significance is not aligned with economic or ecological values, but it is central to the lived relevance of this place. Therefore, when assessing rural heritage frameworks, its role as emotional infrastructure should be included, recognising not only its role but also what it possesses and evokes.

4.4 Spatialized heritage visibility

Using GIS data derived from low-altitude drones and historical satellite maps, we categorise the physical remains of the Xiangyang irrigation system into three levels of visibility.

(1) Structural visibility

Includes intact and readable structures, such as water diversion channels, sluices, or pump houses, which are still clearly identifiable in shape and location. These structures are mainly distributed in Wangma Village and Dongma Village near Weishan Lake. Their integration into the agricultural space has preserved their identity.

(2) Symbolic visibility

This category includes original structures that have been completely or partially demolished, but elements of signs and murals have been retained. For example, the Red Flag Cave in Xipu Village, although the original structure is no longer visible, still retains the Red Flag Cave painting, which tells the story of political propaganda in the 1970s.

(3) Latent or forgotten visibility

In peripheral villages such as Laoquan Village, the material traces of the irrigation system are almost non-existent. Interview results also show the loss of memory. Many young people in the village could not identify the location of previous facilities. However, the landforms and water behaviour still hint at past hydraulic functions. This spatial typology reveals that visibility is not just a peripheral material condition, but also a function of cultural gain and empirical investment.

Villages that are used for investment or receive development plans often maintain material and narrative visibility.

4.5 Functional differentiation between villages
In the 13 villages where field research was conducted, three different development patterns emerged:

(1) Functional heritage villages
In these villages, the remains of the irrigation system still play a certain degree of hydraulic function. In Dongma Village, a water transfer station is used to direct runoff and seasonally irrigate collective vegetable plots, and heritage is embedded in ongoing use (Figure 6).

Figure 6 Desalination plant still in use.

(2) Cultural and tourism villages
Villages such as Wangma Village and Xinjia Village reposition heritage as heritage assets. They install signage, hold annual festivals, and transform abandoned houses into cafes (Figure 7). These villages often receive township-level development funds and appear in development plans.

Figure 7 The house planned to be transformed into a coffee shop.

(3) Marginalised villages
In Xipu Village and Laoquan Village, heritage elements were mostly removed and damaged. These villages often lack official documentation, external investment, or young returnees. Some expressed dissatisfaction in interviews, stating that

"Our facilities are equally historic, but no one promotes us."

This reflects spatial inequalities in heritage valorisation and its connection to economic opportunities.

This phenomenon suggests that the aqueduct heritage is not a unified regional asset, but a diverse landscape, which is shaped by governance priorities, local capacities, and symbolic frameworks.

4.6 Heritage as a governance network
Heritage governance in Liuquan Town operates through a multi-level governance network, including village committees, township agencies, and ad hoc working groups. Spatial analysis of project funding, signage distribution, and festival rituals revealed a striking feature: villages with strong leadership or elite participation were more likely to mobilise external resources. According to interviews and constructed actor networks, Xinjia Village and Dongma Village acted as nodes, coordinating inter-village activities such as storytelling sessions and tour guide training. In contrast, villages with limited connections to the governance network showed a disconnect. A village committee member from Xipu Village said:

"We filled out two applications for heritage funding, but there was no response. Then we heard that other villages already had plaques and visitors."

This suggests that while irrigation systems were once linear structures connecting villages through water flows, they now function as a meaningful governance network that creates spaces for unequal access driven by policy, capital, and culture.

5. Discussion

5.1 Infrastructure Construction of Heritage and Identity

The transformation of Xiangyang Irrigation System shows that infrastructure can be used not only for ecological restoration or economic development, but also as the cornerstone of collective identity. This is consistent with relevant research in the current heritage context. This scholarship believes that heritage is no longer a static, protected monument, but a dynamic process of social production. As shown in the study, hydraulic facilities are not only valued for their functions but also for actively absorbing narratives about production, sacrifice, and life continuation. Through the concept of lieux de mémoire proposed by Nora (1989), hydraulic heritage can be understood as a spatial place for collective memory and value narratives. Abukarki, Uzunahmet and Onur (2023)specifically, Byzantine mosaics in Jordan, where the Byzantine Empire left behind a rich mosaic heritage. Today, these mosaics are replicated in contemporary architectural environments. The purpose of this article is to explore the heritage discourse surrounding Byzantine mosaics in Jordanian contemporary places with a particular focus on the replication and interpretation of the mosaics in contemporary places. To do that, the relationship between the attachments to the Byzantine mosaic places, the community's level of awareness, and the replicated heritage discourse was examined. The research was conducted using several different methods, where structural equation modelling (SEM claimed that when infrastructure is entangled with collective struggles, it becomes a "cultural production tool for self-expression." This study further points out that identity construction is spatially and temporally layered. For young people who have not experienced that history, this series of hydraulic facilities is not a living past, but more like a history that is born with them. Even so, the local look brought by this symbolism also implies the continuity of collective consciousness. Therefore, the term infrastructural identity is particularly appropriate to describe how large-scale technological systems drive the self-perception process of local communities in post-disaster reconstruction. In the case of the Huaibei Plain, this identity is not passively acquired, but actively negotiated through narrative, consciousness, and space and time.

5.2 From functional system to symbolic landscape

The case of the Xiangyang system further illustrates the transformation of infrastructure into landscape, not only in visual and functional terms, but also in ontological terms. The system was originally a modern hydraulic solution to address centuries of ecological fragility. Today, it operates more as a cultural landscape in the sense of UNESCO, a microcosm of human-nature interaction in history. This change is particularly evident in the discussion of the low-visibility typology of the system (Section 4.4) and the village differences (Section 4.5). Where the system's material form is highly visible and memorialised, it is not only a place of memory but also a spatial anchor for development and tourism planning; where it has disappeared, it presents a more fragmented memory with weaker community participation. This also confirms Tilley's (1994) proposition that landscape is not neutral, but is full of meaning, constituted by memory, and organised by politics. The "heritage density" displayed by the spatialisation of the material remains of the aqueduct system reflects the power differences of factors such as funding, social attention, and political discourse. In other words, heritage landscapes are contested even when they are produced.

On the other hand, the transformation from function to symbol does not mean obsolescence. As shown in the case of "Sisters of the Aqueduct" (Section 4.3), the landscape has become a stage for rituals and emotions, and even serves as an ecological facility. This kind of soft resilience allows the space to continue to maintain its social production capacity even if the system loses its original use value.

5.3 The multi-scalar politics of heritage

The recontextualisation of the Xiangyang hydraulic system is far more than the result of a grassroots movement. From the results of Section 4.6, this governance process is multi-party. From the local village committee to the township government, to the county brand planning, each institution has its own understanding of the use of heritage and competing strategies. This reflects memory selection, tourism economy and legitimacy. Ashworth, Ashworth, Graham and Tunbridge (2007) proposed "discordant heritage" and analysed how governance structures mediate or exacerbate conflicts. The emergence of mediation committees (Section 4.2) shows that local actors negotiate and create institutions to ease such disputes. However, from the spatial network analysis, it can be seen that different subjects have obtained disproportionate visibility, resulting in an imbalance in landscape value. This imbalance reflects the differential distribution of symbolic capital proposed by Bourdieu (1986). The visibility of the irrigation system, whether material or immaterial, is a form of capital. Different actors can obtain investment, facilities and status, which shows an asymmetric cultural economic control.

Therefore, post-functional infrastructure can serve as a field for governance experiments. Currently, we see bottom-up heritage planning, cross-village cooperation, and participatory governance, rather than top-down hydraulic projects. All of this has reshaped the imagination and practice of rural governance in China.

5.4 From engineered resilience to evolutionary resilience

The transformation of the Xiangyang irrigation system also demonstrates a paradigm shift in the concept of resilience. It means from engineered resilience that emphasises stability and resilience, to adaptability and identity transformation, to evolutionary resilience. In its original design and construction, the irrigation system embodied engineered resilience, creating a system that conformed to technical rationality to mitigate hydrological dysfunction and agricultural decline. It was linear, technical, and hierarchical, reflecting the modernist desire to control nature (Scott *et al.*, 2020). The results were expressed in terms of food production, water flow, and salinity. However, after the new century, the resilience of the irrigation system has changed. The system now supports community cohesion, educational participation, and tourism innovation. These uses are not residual, but an adaptive reshaping. In essence, it is a transformation of physical infrastructure into cultural and emotional assets. The elements of the irrigation system are reconnected through community values, making it a refunctionalized infrastructure. It is not about water itself, but about what water once meant and what it means again. This also corresponds to Pelling's (2010) resilience framework:

(1)Sustainability: irrigation systems maintain their physical state and core symbols;

(2)Adaptation: irrigation systems take on new uses and meanings;

(3)Transformation: irrigation systems reposition local governance, identity and development goals.

5.5 Emotional resilience

In addition to material and institutional transformations, the emotional role played by the Xiangyang system is arguably the most enduring. Although this is rarely reflected in planning documents, these functions are far-reaching. Emotional resilience refers to the ability of individuals and communities to adapt to social and psychological pressures by rooting themselves in meaningful places. The concept of "ordinary heritage" places everyday attachments on grand narratives. For example, for the aqueduct sisters, heritage is not carefully cultivated, but cultivated through rituals and storytelling. This practice is not commodified and does not require external validation. In this way, they maintain emotional stability in the rapid changes of rural modernisation.

This resilience is particularly important in China's post-rural society. Here, population hollowing out, land consolidation and other issues have caused deep emotional ruptures (Yan, 2010). The persistence and availability of the aqueduct act as a psychogeographical plaster. The results show that heritage management should not only focus on economic and cultural resilience, but also pay attention to the emotional needs of the community. This means that planning needs to support local rituals and uncommodified memory spaces. It also requires managers to realise that heritage management includes not only what is seen and sold, but also what is felt.

5.6 Facility memory and time negotiation

Finally, the transformation of the Xiangyang irrigation system also triggered a re-examination of heritage. The system itself is a product of state intervention in the local area, a machine for dealing with historical scars and political amnesia. The Huaibei Plain has long been considered a "sacrificial area", and its construction allows the region to re-enter the narrative of national development. Then, this facility also realises a bottom-up temporal agency. Narrating the process of recovery in their own way. They reposition loss, remains and the future. For example, villagers compare the state's past neglect with the attention it has received now. Therefore, the Xiangyang system becomes a narrative balance, from forgetting to revival, from hiding to visibility. In this process, it realises what (Tsing, 2015) called "revival in ruins", that is, the ability to construct the future from the destroyed past.

On the other hand, not all participants have the same narrative. As the results show, between the old and the young, between tourism and tradition, between visibility and hiding. These disputes are not the failure of heritage, but the embodiment of vitality. Heritage, like memory, is not fixed, but a negotiated temporality where meanings are layered, modified and activated.

6. Conclusion

This study aims to investigate how post-functional hydraulic heritage can serve as a spatial medium for socio-ecological resilience, identity construction, and place-making. By delving into the history of the historically marginalised Huaibei Plain and the Xuzhou Xiangyang Irrigation System as a hydraulic intervention, this study traces the complex transformation of the irrigation system from an engineering solution to an affective, symbolic, and political infrastructure in the 1970s. Drawing on a qualitative mixed-method approach, we explain how the legacy of the hydraulic system continues to shape the daily experiences, aspirations, and ideals of the local community. The Xiangyang Irrigation System, though almost dry, continues to flow through memory, ritual, imagination, and governance. In this sense, the system is not just a story of hydraulic history, but a living example. How rural landscapes absorb trauma, adapt to change, and find meaning again, not with scars, but through scars.

6.1 Theoretical Contribution

(1) Conceptual expansion. The study of hydraulic heritage as infrastructure extends the concept of facilities beyond the technical aspect. Technical facilities can also be called social-ecological infrastructure, which shapes landscape, culture, and emotions at the same time. As in the case of the Xiangyang system, even though the original hydraulic function has ended, the structure still produces ecological, emotional and institutional meanings. At the same time, this example also establishes two important concepts, namely infrastructure identity and emotional infrastructure. The former refers to how collective identity is engraved on the material of the architectural engineering system, especially under the conditions of common labour and struggle; the latter emphasises the non-economic role of heritage in promoting emotional stability and community cohesion, especially in areas with drastic demographic and cultural changes. These two concepts provide theoretical support for understanding the interaction between heritage memory and place.

(2) Evolutionary resilience of heritage landscapes. Resilience should not only be limited to engineering, but also extend to transformation and reinterpretation. The aqueduct was not only preserved after its elimination, but also became a medium for reconstructing the future of rural areas. This process goes beyond static heritage protection and forms a dynamic negotiation platform.

6.2 Empirical Contributions

(1) Case Extension. This study provides original empirical material for the exploration of post-functional rural infrastructure in China. Through 23 semi-structured interviews, participatory observation and spatial analysis, the study documents how local communities interpret, negotiate and use heritage systems through different methods. These stories highlight the diversity of the social value of heritage.

(2) Method Extension. This study provides a spatial method for evaluating heritage systems. By dividing the system into structural, symbolic and potentially visible components, the uneven typological significance of heritage systems can be understood. This set of methods can be applied to other linear infrastructure heritage.

6.3 Strategic Recommendations

(1) Establishing a post-functional governance framework. Local institutes should identify infrastructure, which is no longer serves its original function, but remains eco-social significance. Governance should include adaptive reuse, participatory place-making, and low-cost interventions.

(2) Putting emotional resilience into rural planning. As ecological resilience has become a requirement in environmental planning, emotional resilience should be admitted in heritage policy. Protect ritual or collective spaces, even if they lack direct economic output.

(3) Promoting multi-scale heritage governance platforms. Mediation conferences mentioned before provide a model for democratic consultation. This heritage should be supported by local governments with funding and training resources, to strengthen grassroots capacity building.

(4) Solving inequalities in heritage visibility. Regional heritage policies should proactively identify marginalised villages and provide targeted support for related initiatives, in order to avoid exacerbating spatial disparities.

6.4 Limitations and Future Directions

(1) Time constraints. This study provides a rapid ethnography of heritage. The meaning and function of the Xiangyang system are constantly evolving, and long-term longitudinal research will help understand how current practices have an impact over time.

(2) Data coverage and sample representativeness. Although 13 villages and 23 interviews were included, the sample cannot guarantee the heterogeneity of Liuquan Town and even the Huaibei Plain. In particular, the views of migrant workers, women under 30 years old, and township-level planners are underrepresented.

(3) Horizontal comparison. Comparison with rural irrigation systems in other contexts can enrich the research depth and test the applicability of my theoretical model in different ecological and cultural regions.

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The Expansion of High-Tech Zone Development and Regional Carbon Emissions: A Synergistic Exploration of Spatial Heterogeneity and Environmental Justice

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Abstract
This study investigates the spatial relationship between the development scale of High-tech Industrial Development Zones (HTDZs) and regional carbon emissions in China. Using data from 168 national HTDZs, we construct a development index via the entropy method, and employ coupling coordination and multi-scale geographically weighted regression (MGWR) models to assess regional disparities and spatial heterogeneity. Results reveal that while advanced HTDZs achieve higher output with lower emissions, underdeveloped zones face disproportionate carbon burdens due to limited capacity. The findings highlight significant spatial injustice and carbon responsibility shifts. Policy recommendations include region-specific green support systems, emission coordination mechanisms, and enhanced governance. This research provides a scientific basis for promoting low-carbon, equitable, and high-quality development in China's HTDZs.

1 Introduction

Against the backdrop of intensifying global climate change, the notion of a "green transition" has emerged as a central agenda for governments and academic communities worldwide. Addressing global warming and achieving sustainable development are no longer optional choices but have become pressing imperatives for all nations (Liu et al., 2023). In this context, the restructuring and upgrading of economic systems, coupled with effective carbon emission control, have become core tasks for contemporary and future national policymaking and regional governance (Kong et al., 2021). As the world's largest developing country and the top emitter of carbon dioxide, China has put forward the "dual carbon" goals—peaking carbon emissions by 2030 and achieving carbon neutrality by 2060. This ambitious commitment not only reflects China's proactive stance in global climate governance but also imposes new internal demands for realizing high-quality development while significantly reducing greenhouse gas emissions and improving resource efficiency. Guided by these targets, China now finds itself at a critical juncture—pursuing both economic modernization and green transformation in tandem. High-tech Industrial Development Zones (HTDZs), which are specialized economic zones characterized by intensive knowledge capital and open institutional environments, play a pivotal role in this transformation (Wang et al., 2023). Leveraging policy incentives such as tax exemptions and R&D subsidies, HTDZs have become incubators of technological innovation and industrial upgrading. Today, they are strategically embedded in China's national innovation system and hold a prominent position in both the global division of labor and the domestic trajectory of green transition (Hua et al., 2023).

High-tech Industrial Development Zones (HTDZs), which are specialized economic zones characterized by intensive knowledge capital and open institutional environments, play a pivotal role in this transformation (Chen & Liu, 2022). Leveraging policy incentives such as tax exemptions and R&D subsidies, HTDZs have become incubators of technological innovation and industrial upgrading. Today, they are strategically embedded in China's national innovation system and hold a prominent position in both the global division of labor and the domestic trajectory of green transition (Wang & Feng, 2021). With this broader transition underway, the role of HTDZs as the frontier of technological innovation and economic restructuring is undergoing profound change. Since the 1990s, HTDZs in China have expanded rapidly due to policy support, concentrated resource allocation, and capital agglomeration. They have evolved into central nodes in the national innovation network, driving regional economic growth, technological advancement, and structural upgrading (Li et al., 2025). By 2024, China had established 178 national-level HTDZs, widely distributed across eastern, central, and western regions, forming high-tech clusters represented by Zhongguancun in Beijing, Zhangjiang in Shanghai, and the Optics Valley in Wuhan (Yan et al., 2024). However, as HTDZs continue to scale up and their industrial structures grow increasingly complex, their associated carbon emissions have come under closer scrutiny. The rapid expansion of these zones has inevitably brought about rising energy consumption and resource depletion, making them significant contributors to regional carbon emissions. This issue becomes more pronounced in the context of unbalanced regional development and

unequal industrial specialization (Zhong et al., 2024). Significant disparities have emerged across regions in terms of HTDZs' development levels, emission reduction capacities, and green governance models—differences that not only affect the overall effectiveness of carbon mitigation but also raise fundamental concerns of environmental justice.

Existing research on the relationship between HTDZ development and carbon emissions has primarily focused on technological innovation, energy efficiency, or reductions in carbon intensity (Wang et al.; Wang et al., 2022; Li et al., 2025). These studies often presume that HTDZs inherently contribute to low-carbon development. Yet from a broader and long-term perspective, this assumption is contestable. While HTDZs are indeed rooted in high-tech, knowledge-intensive industries that generate green spillover effects, they may also exhibit the classic "three-high" pattern—high input, high energy consumption, and high emissions—during their early development phases (Zhao et al., 2025). This is particularly true for zones located in resource-dependent cities or areas with a narrow industrial base, where the creation of HTDZs may exacerbate rather than alleviate the regional carbon burden. Furthermore, as the model of "enclave economy" and interregional industrial division deepens, some HTDZs have outsourced carbon-intensive and polluting segments of their production chains to smaller cities or rural peripheries, effectively engaging in "carbon leakage." This spatial outsourcing of environmental burden underscores not only the trade-off between economic growth and ecological protection but also deeper concerns about equity in regional development and the fair distribution of environmental responsibilities (Pan et al., 2024). While scholars have examined HTDZs' contributions to green transition—emphasizing innovation-driven growth, resource efficiency, or improvements in green total factor productivity—many studies overlook spatial heterogeneity and environmental equity dimensions (Ouyang et al., 2024; Liu et al., 2025). Despite these insights, few studies have examined the uneven spatial impacts of HTDZ expansion on carbon emissions, particularly within the framework of environmental justice (Kaya, 2021). Existing analyses often rely on administrative comparisons (e.g., across provinces or municipalities) rather than focusing on functional zones like HTDZs. Given the vast disparities in policy support, institutional capacity, and market access among HTDZs across China's regions, the lack of zone-level spatial analysis represents a major research gap (Luo et al., 2024). Moreover, although environmental justice has gained recognition in international climate discourse, its application to China's spatial development policies and HTDZ expansion remains nascent, especially in terms of empirical quantification. These spatial and developmental asymmetries may give rise to several problems: the outsourcing of emission responsibilities, the entrenchment of technological divides, and the externalization of ecological costs—all of which could compromise the overall fairness and effectiveness of China's decarbonization efforts.

In this context, clarifying the relationship between the expansion of HTDZ development scales and regional carbon emissions is both theoretically and practically significant. Theoretically, this paper integrates the perspectives of coupling coordination theory, spatial heterogeneity, and environmental justice. Coupling coordination theory emphasizes the interactive dynamics between development and emissions systems. Spatial heterogeneity theory underscores the non-uniformity of economic, social, and ecological systems across geographic units, challenging the one-size-fits-all policy approach. Environmental justice theory adds a normative dimension—arguing that the burdens and benefits of environmental outcomes must be equitably distributed and that mismatches between responsibility and capacity undermine social cohesion and policy legitimacy.

Guided by these frameworks, this study investigates 168 national-level HTDZs in China. It adopts a multi-method approach combining the entropy method, multi-scale geographically weighted regression (MGWR), and coupling coordination models to analyze the spatial coupling between HTDZ development and carbon emissions. Specifically, the study seeks to answer the following questions: (1) Does the expansion of HTDZs inevitably lead to increased regional carbon emissions? (2) Are there systematic spatial differences in the coupling and coordination between HTDZ development and carbon emissions? (3) Does HTDZ expansion exacerbate regional disparities in carbon responsibility, and does it raise concerns related to environmental justice? (4) How can policy be designed to ensure a synergistic relationship between high-quality development and low-carbon transition?

Compared with existing literature, this paper offers several contributions. First, it shifts the analytical focus from macro-level provinces or cities to HTDZs as functional spatial units, filling a critical research gap. Second, it employs a two-step empirical strategy—first measuring development-emissions coupling using a coordination model, then identifying spatial heterogeneity using MGWR—thus enhancing explanatory power. Third, it extends the debate beyond efficiency to fairness by assessing the spatial inequities in emission burdens and developmental

opportunities. Ultimately, the study aims to inform China's "dual carbon" strategy by offering differentiated policy recommendations for HTDZs, thereby enhancing both the environmental effectiveness and social equity of the green transition.

2. Data and Methods

2.1 Overview of the study area

By 2024, Chinese HTDZs have evolved from "policy lowlands" into "innovation highlands," occupying a pivotal position in global scientific innovation and the international division of labor. As of that year, there were 178 national-level HTDZs across the country, with development scale, industrial configuration, and global influence reaching globally leading standards. The geographic coordinates of these HTDZs were extracted via Baidu Maps based on their official listings. The spatial distribution of HTDZs in China currently follows a distinct "east-strong, west-weak" pattern, with the highest-output zones predominantly located in more economically advanced cities such as Beijing, Shanghai, Guangzhou, and Chengdu. In recent years, several HTDZs have begun to undergo deep transitions toward smart, green development (Figure 1). For example, Beijing's Zhongguancun HTDZ has positioned itself as a national hub for green technology research and demonstration, promoting low-carbon development through breakthroughs in renewable energy, hydrogen power, and energy storage technologies. The Zizhu HTDZ in Shanghai, capitalizing on the ecological resources of Minhang District, is exploring carbon sink trading mechanisms by quantifying the value of ecological products through urban greening and ecological restoration projects to support corporate carbon neutrality. Chengdu HTDZ is currently building a zero-carbon industrial park, equipped with a full life-cycle carbon footprint management platform to monitor and reduce emissions throughout the production chain. Meanwhile, Urumqi HTDZ in Xinjiang is experimenting with carbon emission statistics and monitoring platform to strengthen data governance for regional decarbonization.

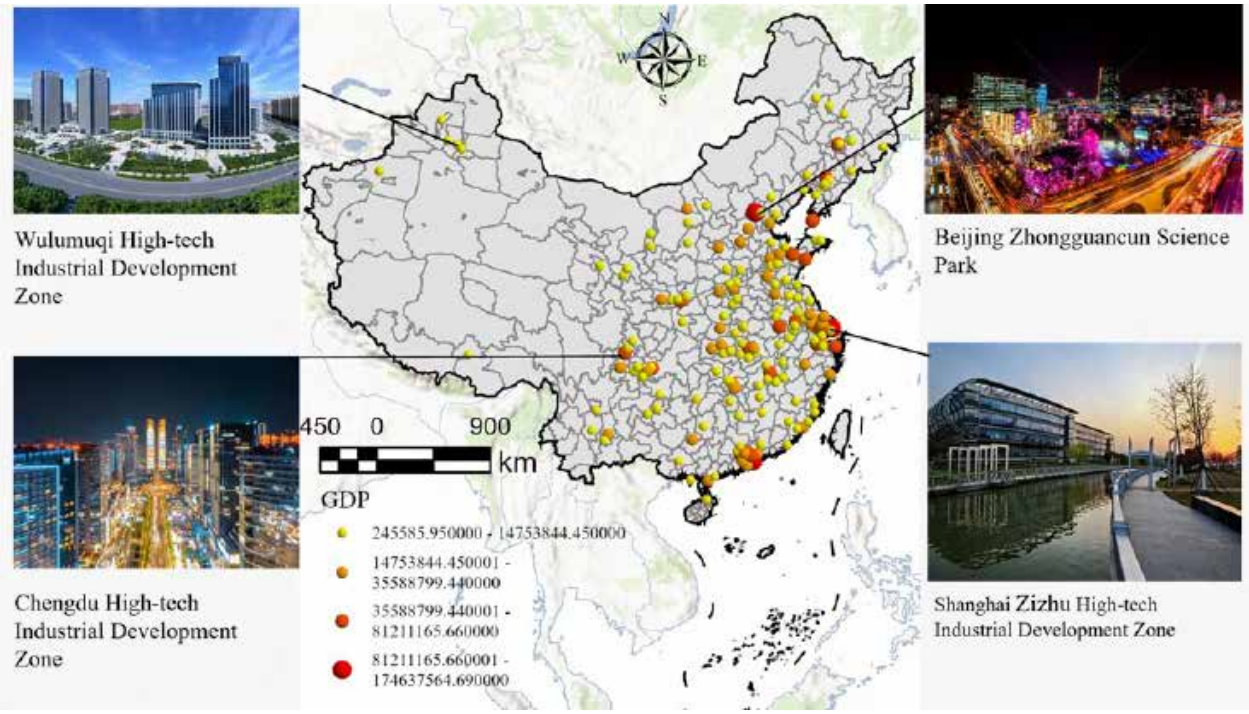

Figure 1 Overview of the study area

2.2 Research Methods

2.2.1 Entropy value method

We used relevant data from the high-tech zone and used the entropy method to calculate the index of investment, gross domestic product (GDP), technical income and export volume, and summarized it into the high-tech zone development scale index. The entropy method has the characteristics of objective weighting, comparability and flexibility. The calculation steps are as follows:

The first step involved standardizing the data by removing the units. The variable y_{ij} represents the data after the dimension was removed.

$$x'_{ij} = \frac{x - x_{min}}{xmin_{max}} \quad (1)$$

$$y_{ij} = \frac{x'_{ij}}{\sum x'_{ij}}, (0 \le y_{ij} \le 1) \quad (2)$$

The second step involved calculating the entropy value (e_j), the differentiation index (g_i), and the weight (w_j) for each indicator.

$$e_j = -k \sum_{y_{ij}} \ln y_{ij} \quad (3)$$

$$k = \frac{1}{\ln m} \quad (4)$$

$$g_j = 1 - e_j \quad (5)$$

$$w_j = \frac{g_j}{\sum g_j} \quad (6)$$

The third step involved calculating the index (c_{ij}) for the j-th indicator of the i-th HTDZ, based on the weights (w_j) of each indicator and the standardized matrix $y=\{y_{ij}\}$.

$$c_{ij} = w_j \times x'_{ij} \quad (7)$$

The fourth step involved summing up the index (c_{ij}) for each indicator to obtain the scale index (c_i) for each HTDZ.

$$c_i = \sum c_{ij} \quad (8)$$

2.2.2 Kernel density

To assess the spatial agglomeration or dispersion of HTDZ development, this study employed kernel density estimation (KDE)—a non-parametric statistical method widely used in ArcGIS to estimate spatial probability distributions. Kernel density values reflect the local intensity of industrial activity and spatial clustering. KDE provides critical insight into spatial hotspots, aiding the identification of dense innovation hubs and peripheral underdeveloped areas.

2.2.3 Coupling Coordination Model

To evaluate the degree of interaction and coordination between HTDZ development and carbon emissions, this study applied a coupling coordination model. Coupling degree is an index that quantifies the interaction intensity between two or more subsystems, indicating whether their evolution is synergistic or antagonistic. However, coupling degree alone may not capture the holistic coordination status due to dynamic inconsistencies among variables across regions. Hence, a comprehensive coupling coordination index was constructed to reflect the balance between economic development and environmental pressure. The formula is as follows:

$$\begin{cases} C = 2\sqrt{H_1 H_2 / (H_1 + H_2)^2} \\ T = xH_1 + yH_2 \\ D = \sqrt{CT} \end{cases} \quad (9)$$

where C is the degree of coupling. H_1H_2 are the normalized values of the selected elements 1 and 2, respectively. D is the coupling coordination degree $D \in$ (0, 1). and the coupling coordination degree is measured in the range of 0 to 1, which is divided into equal intervals at 0.1 intervals. From low to high, they are extremely dysbiscus, severe imbalance, moderate dissonance, mild dissonance, near dissonance, reluctant coordination, primary coordination, intermediate coordination, good coordination and good coordination. T is the harmonic coefficient of elements 1 and 2. x and y represent the weights of elements 1 and 2 respectively.

2.2.4 MGWR

MGWR is a spatial regression model developed on the basis of traditional global regression models (Ordinary Least Squares, OLS) and Geographically Weighted Regression (GWR) (Yin et al., 2024; Zhang et al., 2023). It is designed to explore the geographically varying relationships between dependent/response variables and independent/explanatory variables. The traditional OLS model does not account for potential spatial dependence and spatial heterogeneity among various influencing factors in research, which can lead to biased estimates. To address this spatial non-stationarity, the GWR model is employed. While GWR extends the OLS model by allowing local variations in relationships, it still suffers from a limitation: it uses a single bandwidth value for all variables across different regions, which may oversimplify spatial processes. MGWR improves upon the classical GWR model by incorporating spatially stationary variables, enabling each influencing factor to have its own unique bandwidth value. This enhancement makes the model estimates more accurate and reliable by better capturing the multiscale nature of spatial relationships.

$$y_i = \sum_{k=1}^{m} \alpha_k X_{ik} + \sum_{k=n+1}^{n} \beta_k(\mu_i, v_i) X_{ik} + \varepsilon_i \quad (10)$$

α_k is the global variable regression coefficient. β_k is the local variable regression coefficient. X_{ik} is the kernel density of the kth influencing factor in the i-th selection unit. (μ_i, v_i) is the coordinates of the i-th selection unit. ε_i is the random perturbation term of the i-th selection unit.

2.3 Data source

Development indicators for HTDZs include zone name, construction area, number of employees, enterprise count, GDP, technological revenues, and export volume. Construction area data were extracted from the Torch Statistical Yearbook, while the remaining economic indicators were sourced from the China Statistical Yearbook on Science and Technology. Carbon emissions data were obtained from the Emissions Database for Global Atmospheric Research database (EDGAR), allowing for the integration of environmental metrics into economic analysis (https://edgar.jrc.ec.europa.eu/).

3 Spatial characteristics of the development of HTDZs

3.1 Analysis of spatial heterogeneity in HTDZs

Geographically, the study divides China into seven macro-regions: North China, Central China, East China, South China, Northwest China, Northeast China, and Southwest China. The results reveal significant interregional disparities in the scale indices of HTDZs (Figure 2). Investment and technological scale indices vary substantially across regions, while export indices show relatively smaller disparities. GDP scale indices exhibit relatively uniform distributions across the regions. Geospatial analysis of China's HTDZs reveals persistent regional disparities in developmental patterns. Northern regions, particularly the Beijing-Tianjin-Hebei metropolitan cluster in North China and the Yangtze River Delta in East China, exhibit significantly greater input intensity and technological sophistication, manifested through concentrated capital allocation and dominant R&D expenditure profiles. In contrast, southern regions demonstrate distinctive export superiority, with the Pearl River Delta in South China and urban agglomerations in Central China achieving elevated export volumes attributed to strategic coastal logistics advantages and deep integration within global industrial value chains. Innovation resources display a pronounced north-south bifurcation, characterized by northern HTDZs' command over strategic research infrastructure, while export activities adopt a dual-peak coastal-inland distribution. Coastal zones dominate high-value electronics trade through maritime accessibility, whereas inland clusters specialize in equipment manufacturing, reflecting the spatial articulation of China's dual development strategy that simultaneously cultivates indigenous innovation capacity and promotes export-oriented economic expansion.

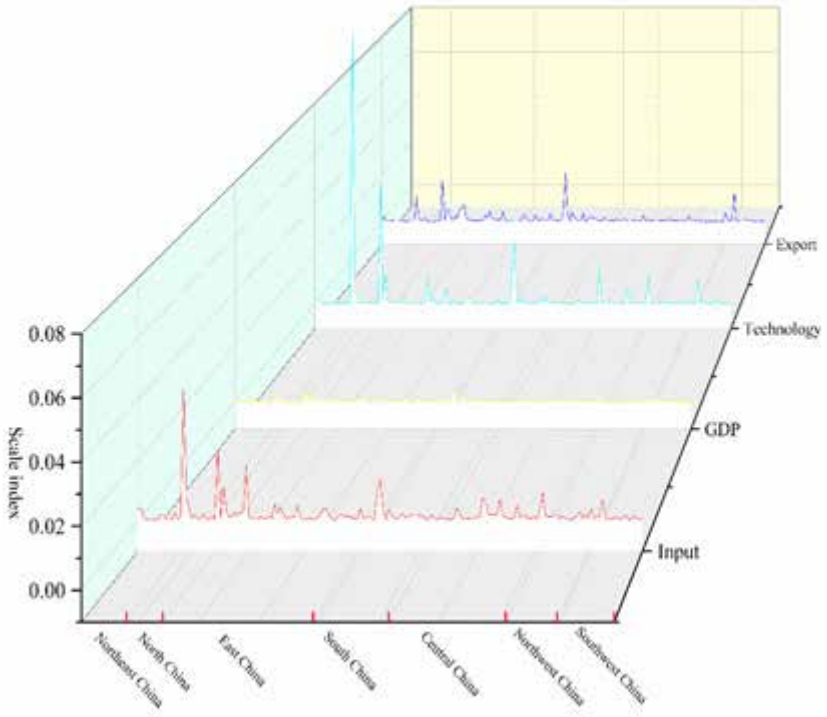

Figure 2 Heterogeneity of HTDZs

3.2 Distribution characteristics of the scale index of HTDZs

Aggregating the standardized indices of investment, technology, GDP, and exports yields a composite development scale index for each HTDZ (Figure 3). Kernel density analysis of these indices shows a "polycentric" spatial structure. Core development clusters are located in Beijing, Shanghai, and Guangzhou, which align closely with the Beijing-Tianjin-Hebei (Jing-Jin-Ji), Yangtze River Delta, and Pearl River Delta city clusters. Secondary peaks appear in Wuhan (Central China), Chengdu (Southwest China), and Xi'an (Northwest China), reflecting the radiating influence of national central cities. In contrast, HTDZs in Northeast China, parts of Northwest China, and much of Southwest China exhibit relatively low development scale values. The limited number of core clusters highlights persistent regional imbalances. While this polycentric configuration strengthens competitiveness in leading regions, it also risks marginalizing peripheral areas into a state of "low-end lock-in," where development stagnates without targeted intervention. Thus, policy mechanisms are urgently needed to enhance interregional factor mobility and collaborative governance.

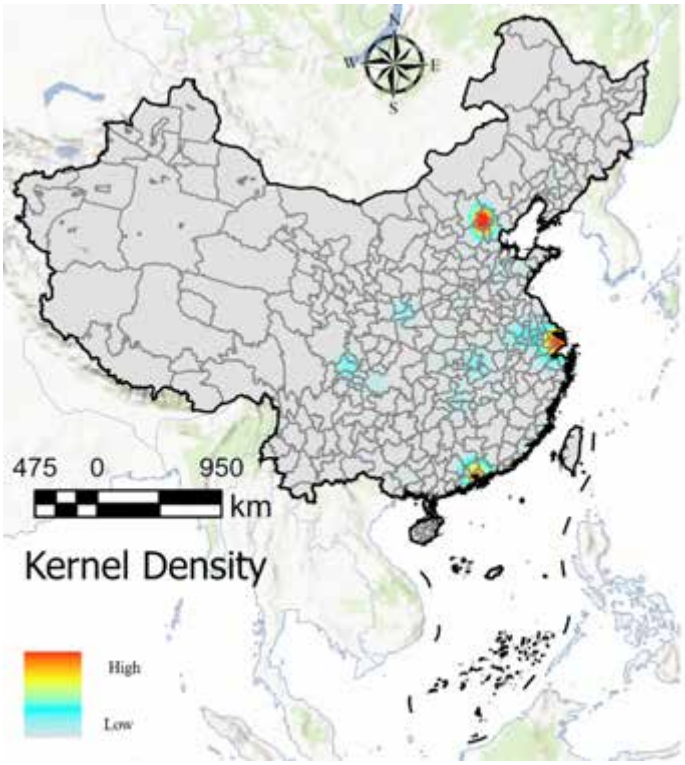

Figure 3 Results of kernel density analysis

4 Analysis of the synergistic nature of HTDZ development and carbon emissions

4.1 Differences between regional HTDZ development and carbon emissions

A significant spatial disparity also emerges in the relationship between economic output and carbon emissions across HTDZs. As shown in Figure 4, HTDZs in East and South China generate higher GDP contributions but maintain comparatively moderate carbon emission intensities, positioning them as low-carbon leaders. In contrast, HTDZs in Northwest and North China yield lower GDP outputs yet face disproportionately high carbon intensities. These findings suggest a spatially unjust distribution of emission burdens—where certain regions enjoy greater economic benefits with lower environmental costs, while others shoulder higher emissions despite lesser development returns. This spatial injustice is exacerbated by several structural mechanisms. First, leading HTDZs in the East often offload carbon-intensive segments—such as metal processing or chemical intermediates—to HTDZs in the Central and Western regions through vertical industrial disintegration. Despite this outsourcing, carbon emissions are still accounted for at the production end, effectively separating environmental responsibility from economic gain. Second, HTDZs in the Central-East region are at the forefront of green R\&D, particularly in hydrogen energy and nuclear fusion, whereas many Western HTDZs still rely on carbon-intensive technologies such as gas-fired boilers. This results in a technology divide and hinders cross-regional transition capabilities.

Third, due to spatial mismatches in policy tools and administrative capacity, HTDZs in core urban regions receive disproportionately higher subsidies for clean energy adoption, further increasing the carbon reduction burden on less-developed HTDZs.

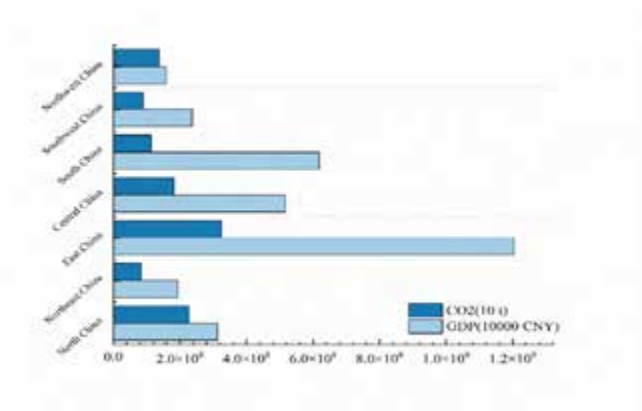

Figure 4 Output value and carbon emission of HTDZs in different regions

4.2 Coupling and coordination analysis of HTDZs and carbon emissions

To enhance the precision of measurement, this study constructed evenly spaced geographic sampling points across the national territory, calculating the micro-regional coupling coordination between HTDZ development and carbon emissions. The results indicate that overall coordination levels remain low nationwide (Figure 5). Nevertheless, relatively better coupling performance is observed in Southeastern China, coastal regions, central urban areas, and selected cities in the Southwest and Northeast. In contrast, most other regions remain in a state of serious imbalance.

These spatial disparities confirm the presence of pronounced environmental justice issues in the coordination between HTDZ development and carbon emissions. Specifically, the division of industrial labor has led to the transfer of high-carbon activities to less-developed regions without commensurate policy compensation or technology support. Meanwhile, institutional and fiscal privileges continue to concentrate in developed HTDZs, thereby deepening the structural disadvantage of others.

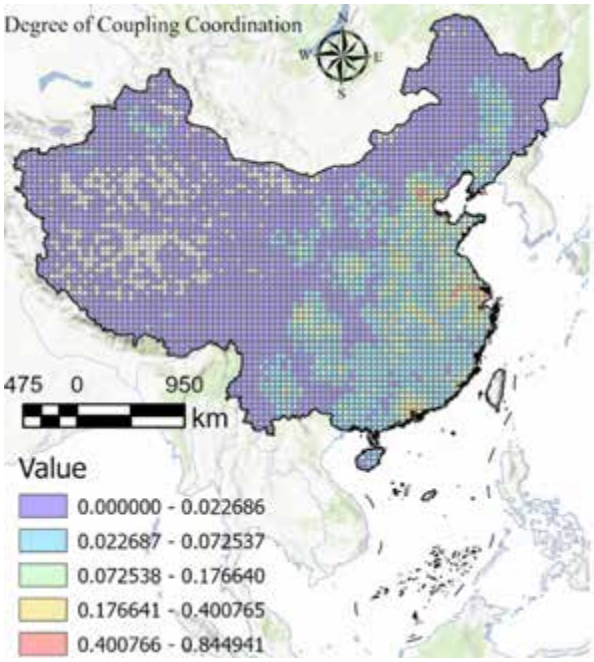

Figure 5 Coupling coordination analysis

4.3 Analysis of the impact of the development of HTDZs on regional carbon emissions

The spatial distribution of HTDZs' influence on regional carbon emissions shows significant spatial differences (Figure 6). The impact is strongest in the central-eastern regions, particularly in the Yangtze River Delta, where HTDZs are large in scale and equipped with advanced low-carbon technologies. Western regions, especially Tibet and Xinjiang, show a weak linkage between HTDZ development and regional emissions, largely due to their reliance on electricity exports and limited local green energy consumption. In these provinces, products such as electrolytic aluminum and polysilicon have high carbon footprints, and despite being powered by renewable energy, the "green electricity is exported, while carbon is retained." In the rest of the country, the influence of HTDZs on regional carbon emissions is statistically insignificant—likely due to the offsetting effect between moderate development scales and incomplete decarbonization measures.

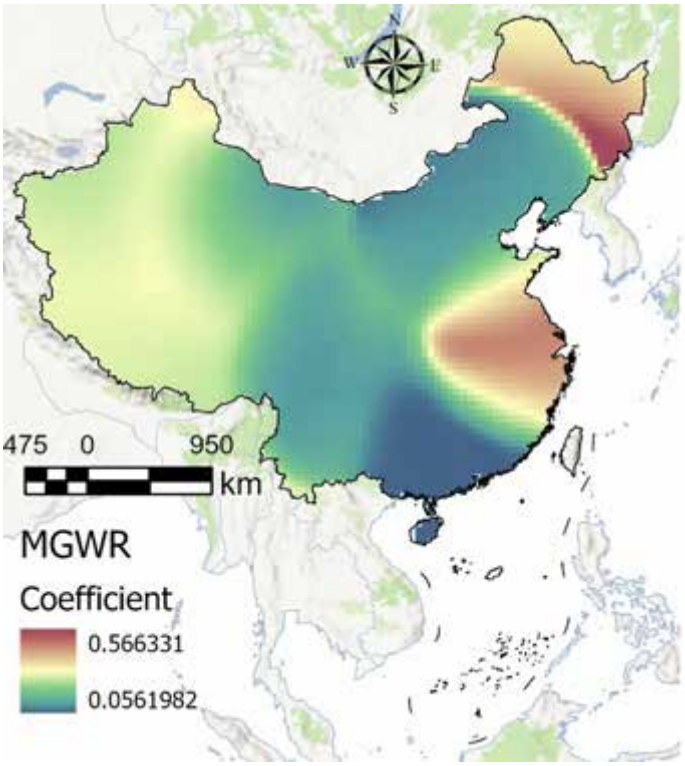

Figure 6 Mgwr model results

5 Conclusions and Recommendations

5.1 Conclusions

This study, guided by the dual perspectives of spatial heterogeneity and environmental justice, systematically investigates the complex relationship between the expansion of high-tech development zones (HTDZs) and regional carbon emissions in China. The main conclusions are as follows:

1. HTDZ development exhibits significant spatial disparities. HTDZs in eastern China—especially those located in major urban clusters such as the Beijing-Tianjin-Hebei region, the Yangtze River Delta, and the Pearl River Delta—are far ahead in terms of investment scale, technological capabilities, and economic output. These areas demonstrate a distinct "polycentric" development pattern. In contrast, HTDZs in central, western, and northeastern China remain at relatively low development levels, highlighting regional imbalances.

2. The relationship between HTDZ development and carbon emissions is spatially heterogeneous. Zones with larger development scales tend to benefit from advanced technologies and managerial efficiencies, resulting in higher resource productivity and lower carbon intensity—exemplifying a "high-output, low-emission" pattern. In contrast, underdeveloped HTDZs often face technological and financial constraints that hinder low-carbon transitions, leading to a "low-output, high-emission" outcome

3. The coupling coordination between development and emissions remains generally weak, though with clear regional variation. Coastal and economically advanced regions exhibit stronger coordination between HTDZ development and carbon emission reduction. However, most central and western HTDZs—particularly those in resource-dependent areas—display low coupling coordination, revealing a mismatch between economic growth and environmental sustainability. This reflects a deeper issue of spatial environmental injustice.

4. Environmental justice concerns are becoming increasingly prominent. Some HTDZs in developed eastern regions transfer carbon-intensive production segments to less-developed central and western zones, resulting in a "carbon responsibility shift." Meanwhile, access to clean energy R\&D and policy resources is highly concentrated in a few core regions. Peripheral zones, with limited capacity for green transition, are left with disproportionate emission burdens, exacerbating regional inequality.

5.2 Recommendations

In response to the pronounced spatial heterogeneity and environmental inequality observed between HTDZ expansion and regional carbon emissions, we propose the following four policy directions to promote greener, more equitable, and more coordinated development.

Develop regionally differentiated support systems for green development. The stark differences in HTDZ development across eastern, central, and western China render uniform policy approaches ineffective. Eastern HTDZs should continue to play a leading role in green innovation and technology diffusion, setting national standards. At the same time, targeted support mechanisms—including fiscal transfers, talent attraction programs, and technical assistance—must be established to assist HTDZs in the central and western regions. For example, a "paired assistance" model could be adopted to facilitate the transfer of green technologies from eastern to western HTDZs, bridging the technological divide and preventing carbon lock-in.

Establish cross-regional carbon emission coordination and burden-sharing mechanisms. To address issues such as carbon leakage and the retention of high emissions in underdeveloped areas, it is essential to develop mechanisms for cross-regional coordination of emission responsibilities. A shift from production-based to consumption-based or life-cycle carbon accounting would allow for more equitable attribution of emissions. Simultaneously, a multi-level carbon compensation system should be introduced—where regions that absorb high-carbon industries receive fiscal incentives and ecological compensation—to foster a synergistic and fair reduction framework.

Enhance the modern governance capacity of HTDZs in green transition. Many HTDZs currently lack robust systems for carbon data collection and green governance. We recommend accelerating the development of integrated platforms for data acquisition, monitoring, and governance to improve the digital management of emissions. A multi-stakeholder governance model—engaging governments, enterprises, research institutions, and the public—should be constructed. Emphasis should be placed on green industry entry thresholds, carbon performance evaluations, and public transparency to ensure effective policy implementation and emission reduction accountability.

Promote the synergy between green finance and technological innovation. Green finance is a critical enabler for HTDZs' transition toward sustainability. Financial instruments such as green credit, green bonds, and carbon markets should be leveraged to incentivize investments in renewable energy, environmental protection, and low-carbon technologies. Moreover, the innovation–application–diffusion chain must be accelerated by establishing green incubators and demonstration projects to facilitate the commercialization of green technologies and enhance the green production capacity of enterprises within HTDZs.

5.3 Limitations and prospects

This study proposed an empirical framework and policy recommendations from the perspective of environmental justice regarding the relationship between the expansion of high-tech zone development scales and regional carbon emissions. However, it still has the following limitations. The MGWR model used in this paper revealed spatial differences in the impact of high-tech zone development on carbon emissions but lacked causal identification methods to uncover the dynamic mechanisms of the influence pathways. Future research could incorporate econometric methods such as regression discontinuity, difference-in-differences, and event studies

to explore the mediating or moderating effects of factors like policy interventions and technological investments in the "development-emissions" relationship. The current environmental justice analysis primarily focuses on spatial comparisons between carbon emissions and development imbalances, lacking further delineation of social group disparities. Subsequent research could integrate micro-level survey data and socioeconomic variables to construct a more comprehensive environmental equity assessment framework, enabling more precise identification of environmental risks faced by disadvantaged regions and populations.

Future studies should focus on a comprehensive analysis framework of "multi-scale, multi-actor, and multi-path," enhancing the integration of data accuracy, mechanism identification, and social equity. This would provide stronger theoretical support and decision-making references for achieving the synergistic goals of regional carbon neutrality and environmental equity.

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Linking outdoor particulate pollution to children's negative experiences of their neighbourhoods: Findings from an interdisciplinary research project in Ankara

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Abstract
This study aimed to understand whether children living in neighbourhoods with higher particulate matter (PM) concentrations report more air pollution-related issues than children living in neighbourhoods with lower PM concentrations and whether these issues vary across neighbourhoods with different built environment characteristics. Data were drawn from participatory mapping activities with 9–14-year-old children living in eight neighbourhoods of Ankara, Türkiye, objectively analysed urban form characteristics of these neighbourhoods, and $PM_{2.5}$ and PM_{10} measurements in children's places in a heating and non-heating season. Results show that as the built environment characteristics and $PM_{2.5}$ and PM_{10} concentrations of children's neighbourhoods change, the proportions of air pollution-related issues reported by children alter.

Keywords: outdoor air pollution; particulate matter; children's place experiences; neighbourhood; participatory mapping

1. Introduction

Outdoor air pollution is a major threat to global public health, responsible for 4.2 million deaths worldwide in 2019 (World Health Organization, 2021). According to a report published by the World Health Organization (2018), roughly more than 90% of children under the age of 15 years breathe polluted air, affecting their health and well-being negatively. Children are particularly vulnerable due to their higher respiration rates, developing organs and proximity to ground-level pollutants. One major consequence of air pollution is asthma – a chronic inflammatory disease of the airways that usually develops in childhood (Graham, 2004; Hammad and Lambrecht, 2021; Vörös et al., 2019). Some other health impacts of air pollution to children are brain functioning problems (Markevych et al., 2021), issues related to skeletal growth (Sram et al., 2013), increased overweight and obesity (Zhou et al., 2021), increased susceptibility to respiratory infections (Krismanuel et al., 2024), and pneumonia (Nhung et al., 2017).

Additionally, prior research has shown strong associations between air pollution and academic success of children (Miller and Vela, 2013). Even the perception of polluted air may affect children's behaviour and well-being negatively (Chen et al., 2020).

There is a voluminous amount of literature linking built environment to air pollution in children's home and school neighbourhoods (Aydin and Severcan, 2024; Lim et al., 2017; Ortegon-Sanchez et al., 2021; Roche et al., 2024). A closer review of this literature shows that there are two groups of researchers concerned with these relationships. The first group, quantitative researchers, mainly consists of scientists affiliated with the departments of engineering, environmental sciences, and environmental epidemiology (see, e.g., Dadvand et al., 2015; Demirel et al., 2014; Lim et al., 2017; Mohai et al., 2011; Rivas et al., 2014). By objectively measuring outdoor air pollution and built environment, these scholars have largely questioned the physical environmental correlates of outdoor air pollution around children's homes and schools – e.g., living in an urban or rural area, traffic, building density, and neighbourhood greenness. The second group, qualitative researchers, is fewer in number compared to quantitative researchers and is mostly affiliated with the fields of sociology, psychology, and education (see, e.g., Börner et al., 2017; Duran, 2021; Manouchehri and Burns, 2023). The common characteristic of these scholars is that they have directly engaged children in research to understand whether young people perceive the environmental problems in their everyday environments (including air pollution) and the factors that affect children's perceptions. The self-reported data have been presented in qualitative, semi-qualitative or quantitative forms. In general, while these studies are exploratory in nature, their results can inform urban planning and design about how to design neighbourhoods with better air quality. Our review of the literature revealed that there is a lack of interdisciplinary research that bridges these two groups of researchers. Perhaps partly for this reason, we could not find any studies that linked children's negative place experiences regarding air pollution-related issues to the actual outdoor air quality levels of their neighbourhoods with varying built environment characteristics.

Drawing on an interdisciplinary, cross-sectional research project with a novel research design, this study aimed to understand whether children report more negative experiences about outdoor air pollution in school neighbourhoods with higher particulate matter ($PM_{2.5}$ and PM_{10}) concentrations. We also questioned whether these air pollution-related issues are related to the built environment. This study is important because finding a match between high levels of neighbourhood air pollution and a few negative outdoor experiences related to air quality can support the prior claims of qualitative researchers that there is a relationship between built environment, outdoor air pollution and outdoor place experiences of children (Börner et al., 2017). Furthermore, the results presented here may lead future studies to consider the reasons of a possible mismatch between children's negative place experiences related to outdoor air pollution and the actual air quality levels of children's neighbourhoods. They also pave the way for the creation of healthier environments for children.

The remainder of this paper is organised into three main parts. The next section provides a background information about the factors affecting PM concentrations and how these factors may affect children's place experiences. This is followed by the method and results section. The paper concludes with a discussion of the results, implications for urban planning and design, and limitations of the study.

2. Literature review

This section provides a brief summary of the literature relevant to this study.

2.1. *Factors that influence the level of $PM_{2.5}$ and PM_{10} concentrations*

PM (particulate matter), described as the mixture of solid particles and liquid droplets in the air, is one of the most serios air pollution problems in the world (Sun et al., 2014). PM is classified by particle size. Particles with size not exceeding 2.5 μm are known as $PM_{2.5}$ or "fine PM." $PM_{2.5}$ and smaller (ultra-fine particles) are known to be highly dangerous for children's health since they can penetrate deep into their lungs (Pope and Dockery, 2006). PM_{10} refers to particulate matter smaller than 10 μm in diameter.

The sources of PM can be human-made (e.g., transport- or industry-related) or natural (e.g., dust storms, volcanoes). It is commonly accepted that human-made (also called anthropogenic) sources are more important than natural sources in urban areas. Some common sources of $PM_{2.5}$ and PM_{10} in urban areas are related to industrial emissions, domestic heating, vehicle engines, and construction activities. PM_{10} mainly originates from

soil dust resuspension, construction, non-exhaust vehicle emissions and industrial dusts, whereas $PM_{2.5}$ is largely derived from combustion processes (industrial combustion), mining and construction activities, fires or burning of the wood and transformation of gaseous species (Gugamsetty et al., 2012). The main sources of $PM_{2.5}$ and PM_{10} concentrations may vary from one city to another based on their characteristics. For example, Qin et al. (2006) found that in metropolitan New York City, most of the $PM_{2.5}$ concentrations derive from transport (e.g., diesel engines and trucks), whereas another study conducted in an industrialised region of China, Pearl River Delta Economic Zone, showed that the average concentrations of $PM_{2.5}$ in roadside and industrial areas are not significantly different (Wang et al., 2016). Some other studies argued that most of the PM in the atmosphere originates from the construction industry (Cheriyan et al., 2020).

The sources of PM in urban settings are often difficult to detect, posing challenges for urban planners aiming to design neighbourhoods with improved air quality. This difficulty stems partly from the complex nature of PM, which includes both anthropogenic, natural and biological particles such as dust and pollens (Ortega-Rosas et al., 2021). For example, research shows that living close to urban green areas on the one hand and to roads with heavy traffic may increase residents' PM exposure (Capone et al., 2023; McCarty and Kaza, 2015; Vörös et al., 2019). Elevated pollen concentrations may increase PM concentrations. In green open spaces located next to industrial areas, industry-related particles may attach to pollen surfaces, increasing green space users' PM exposure (Ortega-Rosas et al., 2021). However, there is also a great deal of literature showing how green open spaces play a key role in reducing PM concentrations in cities (Han et al., 2020).

Another reason is the complexity of the relationships among the variables. Existing findings regarding the role of built environment in PM concentrations are contradictory, and thus inconclusive. Multiple factors affect an individual's PM exposure: meteorological (e.g., temperature, humidity, wind), physical environmental (e.g., elevation of neighbourhoods, proximity to major roads and industrial facilities, morphology at various scales – like leaf morphology, clustering of the vegetation or land uses) and behavioural (e.g., time of place use, duration of exposure to transport-related pollution) (Adgate et al., 2002; Han et al., 2020; Ning et al., 2018; Qin et al., 2006; Zender-Swiercz et al., 2024). These factors are in relationship with one another, causing an individual's PM exposure to differ from one place or time to another.

Meteorological factors complicate the relationship between built environment and PM concentrations. Higher PM concentrations are linked to higher air temperatures, higher humidity, and lower wind speeds (Jayamurugan et al., 2013). Thus, one can observe different associations between green open spaces (or built-up areas) and PM in different seasons (Sabir et al., 2024). Certainly, the issue that particles can travel long distances with the wind (even from one country to another) makes it challenging for researchers to relate outdoor PM concentrations to a particular built environment variable (like presence of green spaces or traffic). In urban neighbourhoods, temperature and wind speeds can be affected by various built environment features – at meso-scale, e.g., building density, layout of the buildings, and neighbourhood greenness (Bonan, 2008; Spirn, 1987).

Neighbourhoods with higher building density are usually associated with more building surfaces, and thus higher thermal load (Chen et al., 2017). Scholars like Spirn (1987) and Makvandi et al. (2024) discuss how increased building density results in a decrease in air flow at the street level. On the other hand, some scholars linked built environment attributes like building density, street connectivity, land use mix and neighbourhood greenness to greater outdoor physical activity, and thus to lower transport-related PM concentrations (Frank et al., 2006) (for conflicting results, see, e.g., Zlatkovic et al., 2019, who showed that well-connected streets in neighbourhoods is associated with high traffic density, and thus lower air quality).

At the micro-scale, various urban design characteristics may affect PM concentrations. The size of green spaces and layout of planting in these areas (Qiu et al., 2018), and presence of land uses that generate vehicle traffic (e.g., commercial and educational areas, gas stations, bus station, and construction sites) (Razak et al., 2023; Yan et al., 2019; Yang et al., 2017) are some of the factors affecting PM. At certain hours of the day (like school/business opening and closure hours), PM concentrations tend to increase around such land uses (Razak et al., 2023). Increased outdoor $PM_{2.5}$ and PM_{10} concentrations are also associated with proximity to waste dump sites (Chkwu Okeah et al., 2021; Jatau et al., 2024), wood and waste burning activities (Fuller et al., 2014; Mouganie et al., 2023), and outdoor smoking (Acevedo-Bolton et al., 2014).

2.2. *The role of air pollution in children's place experiences: What do we already know?*

Studies show that when children are asked about the problems of their neighbourhoods, they mention a variety of problems related to outdoor air quality: e.g., traffic-related pollution (Börner et al., 2017), industry-related pollution (Börner et al., 2017; Ozbil Torun et al., 2024), smelly trash cans (Loukaitou-Sideris, 2003), smoking (Duran, 2021; Pluhar et al., 2009), places with high pollen concentrations (Pluhar et al., 2009), and problems related to deforestation, urbanisation and replacement of urban green spaces with buildings (Duzenli et al., 2019). Although these problems are known to effect children's place experiences negatively, little is known whether children living in neighbourhoods with higher particulate matter (PM) concentrations report more air pollution-related issues than children living in neighbourhoods with lower PM concentrations, and whether these issues vary across neighbourhoods with different built environment characteristics. This paper aims to fill these gaps in the literature.

3. Method

This study was carried out in the capital of Türkiye, Ankara. Data were drawn from a larger-scale, interdisciplinary research project bringing together urban planners and designers, who were specialised in urban form analysis and children's geographies, environmental engineers specialised in air pollution, and paediatricians specialised in childhood asthma. Our method consisted of eight steps which are explained in the following eight subsections.

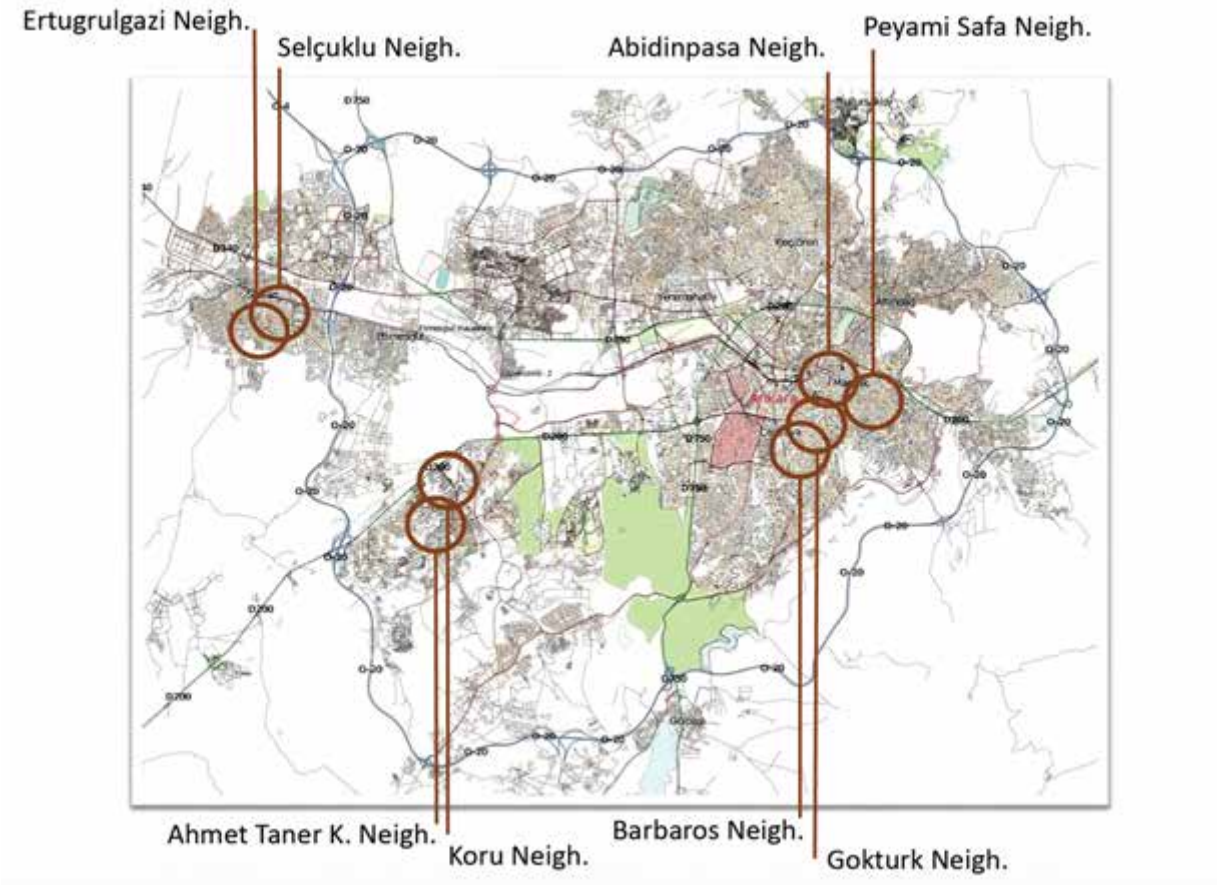


Figure 1. Location of the selected neighbourhoods.

3.1. *Site selection*

This study was conducted in eight neighbourhoods in Ankara: from Cankaya district: Gokturk, Barbaros, Koru and Ahmet Taner Kislali neighbourhoods, from Mamak district: Abidinpasa and Peyami Safa neighbourhoods, and from Sincan district: Selcuklu and Ertugrulgazi neighbourhoods. Figure 1 shows the location of these neighbourhoods in the city. Details of the site selection process can be found in Aydin (2023). All neighbourhoods differed in their built environment characteristics (e.g., proximity to industrial areas, forests, building density, land use mix, street connectivity, neighbourhood greenness, elevation, traffic) (*ibid.*)

3.2. *Investigation of the built environment characteristics of the selected sites*

Built environment characteristics of the selected sites were measured objectively using Geographic Information System (GIS) tools. The process consisted of several steps: (1) obtaining GIS data from the metropolitan municipality, (2) creating 800-meter buffers around all public schools located within the administrative borders of the selected neighbourhoods (these buffer areas represented school neighbourhood areas), (3) field observations to document the most recent land uses, building heights and building typologies in the school neighbourhoods, (4) updating the GIS data set based on the field notes, and (5) GIS-based analysis of built environment attributes of the selected neighbourhoods. Neighbourhood boundaries were defined by joining the boundaries of school neighbourhoods in each administrative area.

For the purpose of this study, we classified the selected neighbourhoods based on their land use mix and neighbourhood greenness. We selected these variables because previous studies have shown their association with PM and they were available in our data set. While our initial aim was to classify neighbourhoods based on some additional built environment variables like building density and proximity to industrial facilities, as we have shown in the following sections of this paper, children rarely mentioned such variables as problems in their neighbourhoods. We could not observe any difference between the average traffic density of the selected school neighbourhoods, which led us not to classify neighbourhoods based on this variable. However, in line with what Frank et al. (2006) suggested, we assumed that compared to children living in neighbourhoods with lower land use mix, children living in neighbourhoods with a higher land use mix would report less vehicle traffic issues.

Table 1. Built environment characteristics of the selected neighbourhoods.

		Neighbourhood greenness
Neighbourhood	Land use mix	
Barbaros	0.69	0.44
Gokturk	0.41	0.54
Koru	0.62	0.66
Ahmet Taner Kislali	0.52	0.68
Abidinpasa	0.50	0.47
Peyami Safa	0.37	0.44
Selcuklu	0.49	0.50
Ertugrulgazi	0.36	0.55

Land use mix, at the building level, was measured by the land use entropy score, indicating the level of land use diversity (Saelens et al., 2003). The index ranges from 0 to 1, where 1 refers to a perfect mix and 0 refers to a perfect homogeneity. Neighbourhood greenness was calculated by dividing the total area of permeable surfaces (softscapes) by the buffer area. Details of the analysis process can be found in the study of Aydin (2023). Table 1 shows the results of these analyses.

3.3. *Participant selection*

Child participants were selected in several stages. First, we selected all the public schools located inside the administrative boundaries of the chosen neighbourhoods. After obtaining the necessary ethical approvals from the university's ethics board and Ministry of Education, we went to the selected schools to distribute the consent forms and explain the study to 9–14-year-old children (third to eighth graders). Sixteen schools were visited for this purpose. All children who wanted to participate in the study and returned the parent-signed consent forms were accepted. This study is based on data drawn from participatory mapping activities with children.

3.4. *Participatory mapping activities with children*

Participatory mapping is a method used for linking children's views of their environments to specific geographical contexts (Ozbil Torun et al., 2024). In our study, we used this data collection technique for various reasons: e.g., to find out the most frequently used places of children so that these places can be used for measuring the outdoor PM concentrations in the further stages of our research, and to document children's negative places experiences. In total, 1687 children participated in participatory mapping activities.

The process started by grouping children into groups of 5-7 in the empty classrooms and conference rooms of the selected schools. Thereafter a trained moderator gave each group of children a 50x70cm poster, which consisted of a high-quality satellite image of the chosen school neighbourhoods and a blank map legend under it. This image showed an area within 800-meter radius of the school. Next, followed by a process where children were shown how to read satellite images, children were asked to pinpoint their homes and the places they frequent and like on the map. Two different procedures were used in this stage: while some participants were asked to explain their responses in detail (e.g., what they do in these places, why they like them) (n=881), others were not asked about such details because of the time restrictions (n=806). Finally, on another blank base map, children (n=1687) were asked to pinpoint the places they see problematic and/or dislike in their school neighbourhoods and discuss the reasons of their responses. Children used unique stickers when documenting their responses and recorded the meaning of each sticker in the legend (Figure 2). The whole process took about 1.5 hours.

Figure 2. Photographs from participatory mapping activities.

3.5. *Data coding and analysis to define children's frequently used places*

We followed a five-step process for the selection of PM measurement sites. First, we digitised 1687 children's positive places in GIS. This process resulted in the coding of 8704 positive places in the selected neighbourhoods. Second, we deleted the overlapping points in ArcGIS to avoid repetition after transferring their content (e.g., how many children mentioned them) into the retained points. This reduced the total number of points into 2355. Third, we investigated the built environment characteristics (e.g., building density, street connectivity, land use mix, neighbourhood greenness, etc.) of the surrounding of these places to select the most spatially unique PM measurements sites in the following stages of the research. Fourth, after normalizing the data, we used a hierarchical cluster analysis to group children's places with similar built environment characteristics. Twenty clusters were produced for each neighbourhood. For clustering, we used Ward's method and squared Euclidian distance. Fifth, we selected the most frequently mentioned place/point from each cluster. Thus, from eight neighbourhoods, 160 points were selected for PM measurements. A range of places were selected such as neighbourhood parks, urban parks, school yards, streets with ground floor retail and home gardens.

3.6. *$PM_{2.5}$ and PM_{10} measurements in children's frequently used places*

$PM_{2.5}$ and PM_{10} measurements were performed in the selected sites twice, one during heating season (March 22 – April 18, 2023, average temperature: 14.8 °C) and another during non-heating season (May 27 – June 15, 2023, average temperature: 20.95 °C). We used two DustTrak aerosol monitors (Model 8530), one for measuring $PM_{2.5}$ and the another for measuring PM_{10} concentrations. In each children's place, we zero calibrated the devices and concurrently carried out the PM measurements for 7 minutes at a height close to children's breathing height (Figure 3). We explained the details of this procedure elsewhere in another paper.

Figure 3. Photographs from $PM_{2.5}$ and PM_{10} measurements.

In our analysis, we considered the data obtained during the last 5 minutes of the PM measurements. Table 2 shows the average $PM_{2.5}$ and PM_{10} concentrations of each neighbourhood in different measurement periods. When presenting the results, the data obtained from Koru and Ahmet Taner Kislali neighbourhoods – two adjacently located neighbourhoods showing similar built environment characteristics – were merged for the reason we explained in next section.

Table 2. Average $PM_{2.5}$ and PM_{10} concentrations (µg/m³) in the selected neighbourhoods.

	Heating season (March-April 2023)		Non-heating season (May-June 2023)	
Neighbourhoods	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
Barbaros	26.547	24.179	42.421	48.295
Gokturk	20.274	19.158	48.905	58.863
Koru + Ahmer Taner K.	46.979	55.313	17.862	20.800
Abidinpasa	33.126	41.389	33.084	38.516
Peyami Safa	27.274	34.263	36.768	42.789
Selcuklu	48.480	47.130	22.550	25.720
Ertugrulgazi	64.863	72.800	18.032	21.168

Our findings indicate that $PM_{2.5}$ and PM_{10} concentrations diminished in peripheral neighbourhoods of Ankara (Koru, Ahmet Taner Kislali, Selcuklu, and Ertugrulgazi) while escalating in neighbourhoods near the city centre as temperatures rose. In heating season, $PM_{2.5}$ concentrations ranged from 20.27 µg/m³ (in Gokturk) to 64.86 µg/m³ (Ertugrulgazi); PM_{10} concentrations ranged from 19.16 µg/m³ (Gokturk) to 72.80 µg/m³ (Ertugrulgazi). In non-heating season, $PM_{2.5}$ concentrations ranged from 17.86 µg/m³ (Koru and Ahmet Taner Kislali) to 48.90 µg/m³ (Gokturk); PM_{10} concentrations ranged from 20.80 µg/m³ (Koru and Ahmet Taner Kislali) to 58.86 µg/m³ (Gokturk).

3.7. *Analysing children's negative places*

This process consisted of three stages. First, we digitised 1687 children's negative places in GIS, which resulted in the coding of 4171 places in eight neighbourhoods. The distribution of these places across Barbaros, Gokturk, Abidinpasa, Peyami Safa, Koru and Ahmet Taner Kislali, Selcuklu and Ertugrulgazi neighbourhoods were 370, 640, 644, 457, 335, 906 and 819 respectively. In each of these places, children mentioned one problem related to that site (e.g., "*there are gangs here*", "*There is no traffic light in this street junction*", "*there are people burning coal here*", "*there is too much traffic in this street with high vehicle exhaust*"); our GIS data set included these statements. Thereafter we exported this data set to MAXQDA, a content analysis software.

While reviewing children's explanations of their experiences, we categorised these issues based on their themes. To this end, we used a thematic content analysis method to analyse children's statements.

Our findings indicate that six main themes emerged from the data set, one of which pertains to air quality. Out of 4171 issues mentioned by children, 1378 issues were in this category. We revealed 10 sub-categories under the air quality theme. Table 3 presents the distribution of these 1378 issues across these 10 sub-themes and neighbourhoods. Because of the low number of participants in Koru neighbourhood (n=22 children), for the purpose of this study, we merged the data obtained from Koru and Ahmet Taner Kislali neighbourhoods – two adjacently located neighbourhoods showing similar built environment characteristics. This table shows that, in Abidinpasa neighbourhood, 249 children mentioned 179 air quality-related problems in their school neighbourhoods, which corresponds to around 27.8% of all the problems mentioned. Out of 644 mentioned issues in this neighbourhood, 35 (5.4%) were in the category of places with lack of vegetation. Children mentioned various problems related to air quality, including transport- and construction-related air pollution issues, places with smelly trashes and smokers, and places where tree cutting activities take place. These results are in line with most previous research (e.g., Börner et al., 2017; Duran, 2021; Loukaitou-Sideris, 2003; Pluhar et al., 2009). Our results also suggest that neighbourhood characteristics may play a role in the issues mentioned by children. For example, compared to children living far from construction sites, more children mentioned construction related issues in the neighbourhood that gives an edge to construction sites (i.e., Ertugrulgazi).

Table 3. The number and frequency of outdoor air quality-related issues in the selected neighbourhoods.

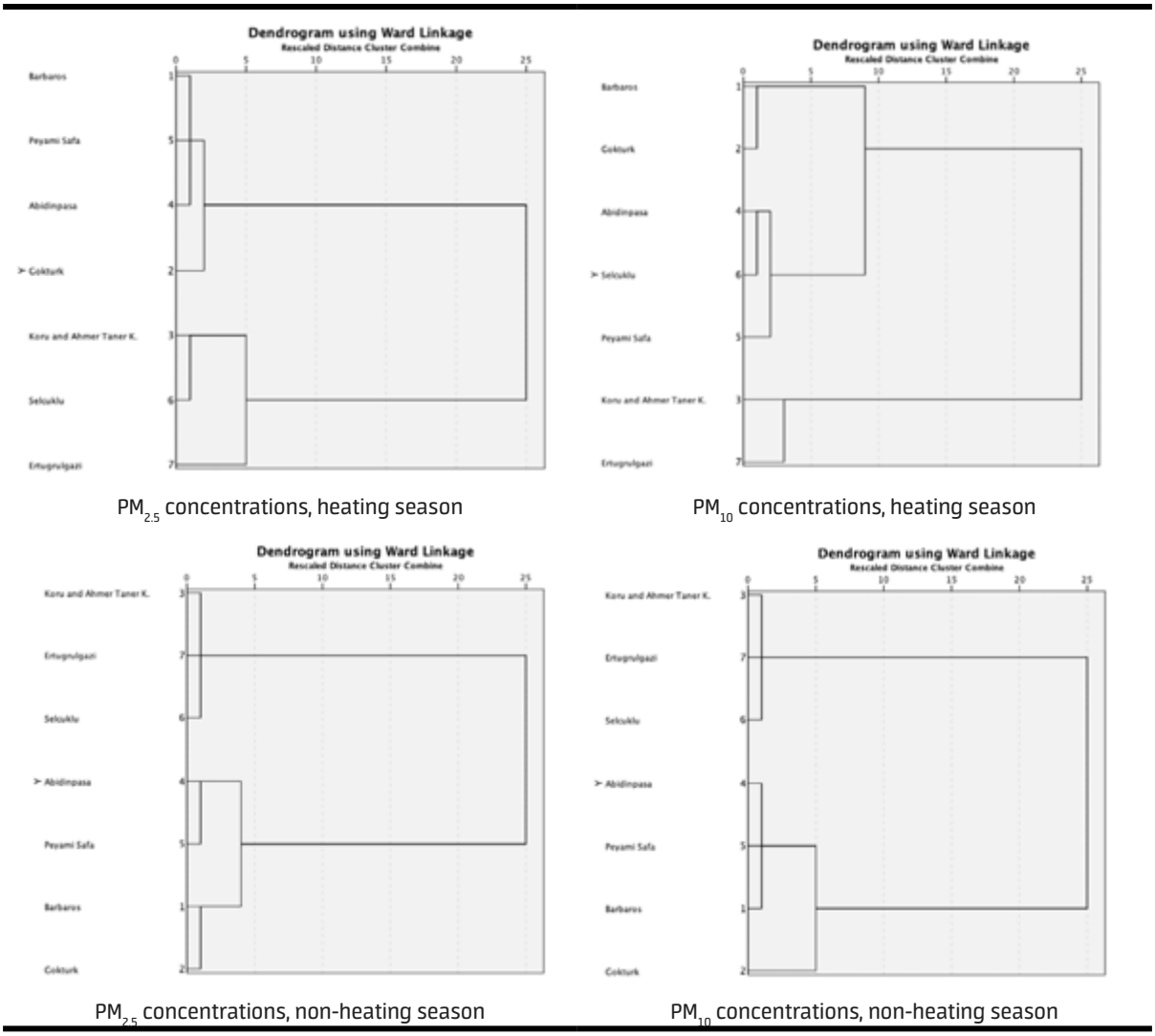
	Neighbourhoods						
	Gokturk	Barbaros	Abidin.	Peyami S.	Koru+Ah	Selcuklu	Ertugrul.
	181 child.	172 child.	249 child.	415 child.	109 child.	299 child.	262 child.
Themes	n, (%)	n, (%)	n, (%)	n, (%)	n, (%)	n, (%)	n, (%)
Places with lack of vegetation	30 (4.7%)	2 (0.5%)	35 (5.4%)	5 (1.1%)	33 (9.8%)	26 (2.9%)	9 (1.1%)
Highly urbanised places	–	–	–	–	–	7 (0.8%)	–
Places with high traffic volume / the problem of exhaust gas in streets	55 (8.6%)	99 (26.7%)	76 (11.8%)	42 (9.2%)	57 (17.0%)	64 (7.1%)	62 (7.6%)
Places with smelly trashes	68 (10.6%)	70 (18.9%)	37 (5.7%)	55 (12.0%)	113(33.7%)	93 (10.3%)	71 (%8.7)
Places with smokers	1 (0.1%)	8 (2.2%)	7 (1.1%)	13 (2.8%)	–	5 (0.6%)	9 (1.1%)
Places where coal burning activities take place	8 (1.2%)	–	–	–	–	2 (0.2%)	–
Places where people burn fire	13 (2.0%)	–	1 (0.1%)	–	2 (0.6%)	10 (1.1%)	–
Places where tree cutting activities take place	1 (0.1%)	–	–	–	2 (0.6%)	–	–
Places where construction/ demolition activities take place	–	–	–	–	–	2 (0.2%)	12 (1.5%)
Places with poor air quality with unspecified reasons	27 (4.2%)	24 (6.5%)	23 (3.6%)	24 (5.2%)	2 (0.6%)	20 (2.2%)	53 (6.5%)
Total	203 (31.7%)	203(54.9%)	179(27.8%)	139(30.4%)	209(62.4%)	229(25.3%)	216 (26.4%)

3.8. *Statistical analysis*

To respond the first research question, whether children report more negative experiences about outdoor air pollution in school neighbourhoods with higher particulate matter ($PM_{2.5}$ and PM_{10}) concentrations, we first grouped school neighbourhoods based on their average PM concentrations. Thereafter, we re-categorised the data presented in Table 3 according to our proposed new classification. To achieve the former step, we used a hierarchical cluster analysis based on Ward's method and squared Euclidian distances. As Figure 4 shows, with one exception (i.e., the clustering of the neighbourhoods based on PM_{10} concentrations in heating season), in all cases, the neighbourhoods located in the periphery and inner-city of Ankara were in separate clusters.

To respond the second research question, whether the air pollution-related issues mentioned by children are related to the built environment characteristics of their neighbourhoods, we first grouped school neighbourhoods based on their land use mix and neighbourhood greenness. Next, we re-categorised the data presented in Table 3 according to our proposed new classification. Figure 5 shows how the neighbourhoods in each cluster differed based on their built environment characteristics.

In all analysis, comparisons were made between two groups (e.g., neighbourhoods with lower $PM_{2.5}$ concentrations and higher $PM_{2.5}$ concentrations in heating season). Since the number of children were different in each cluster, we compared the percentage distribution of the air quality-related problems rather than using t-test.



$PM_{2.5}$ concentrations, heating season

PM_{10} concentrations, heating season

$PM_{2.5}$ concentrations, non-heating season

PM_{10} concentrations, non-heating season

Figure 4. Dendograms showing the clustering of neighbourhoods for different PM types and PM measurement periods.

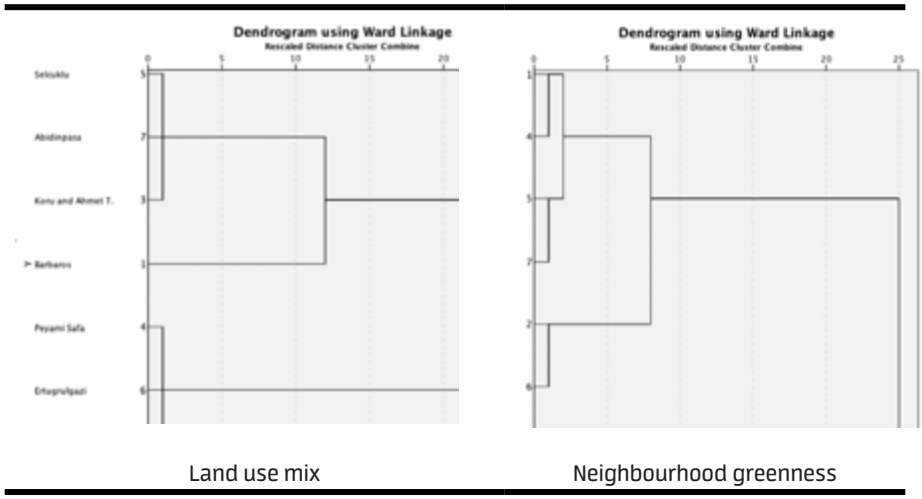


Figure 5. Dendograms showing the clustering of neighbourhoods based on their built environment characteristics.

4. Results

4.1. *Children's air pollution-related experiences and PM concentrations of their neighbourhoods in different seasons*

In heating season, children living in neighbourhoods with higher $PM_{2.5}$ concentrations did not report more outdoor air pollution-related issues than children living in neighbourhoods with lower $PM_{2.5}$ concentrations (31.4% versus 34.3%), which is an unexpected finding (see Table 4). However, as expected, children living in neighbourhoods with higher PM_{10} concentrations reported more air pollution-related issues than children living in neighbourhoods with lower PM_{10} concentrations (36.8% versus 31.6%). The responses of children in Selcuklu neighbourhood were influential in this outcome as this neighbourhood was in different neighbourhood clusters in heating season. As Table 3 shows, different from the children in other neighbourhoods, more children in Selcuklu reported issues related to high levels of urbanisation. This neighbourhood is also known with its closeness to polluting industrial facilities and construction sites (Aydin, 2023).

Table 4. The number and frequency of outdoor air quality-related issues in neighbourhoods with lower and higher $PM_{2.5}$ and PM_{10} concentrations in heating season

Themes	Neighbourhoods with lower $PM_{2.5}$ concentrations (N=2111 issues) n (%)	Neighbourhoods with higher $PM_{2.5}$ concentrations (N=2060 issues) n (%)	Neighbourhoods with lower PM_{10} concentrations (N=3017) n (%)	Neighbourhoods with higher PM_{10} concentrations (N=1154) n (%)
Places with lack of vegetation	72 (3.4%)	68 (3.3%)	98 (3.2%)	42 (3.6%)
Highly urbanised places	–	7 (0.3%)	7 (0.2%)	–
Places with high traffic volume / the problem of exhaust gas in streets	272 (12.9%)	183 (8.8%)	336 (11.1%)	119 (10.3%)
Places with smelly trashes	230 (10.9%)	277 (13.3%)	323 (10.7%)	184 (15.9%)
Places with smokers	29 (1.4%)	14 (0.7%)	34 (1.1%)	9 (0.8%)
Places where coal burning activities take place	8 (0.4%)	2 (0.1%)	10 (0.3%)	–

Places where people burn fire	14 (0.6%)	12 (0.6%)	24 (0.8%)	2 (0.2%)
Places where tree cutting activities take place	1 (0.04%)	2 (0.1%)	1 (0.03%)	2 (0.2%)
Places where construction/ demolition activities take place	–	14 (0.7%)	2 (0.06%)	12 (1.0%)
Places with poor air quality with unspecified reasons	98 (4.6%)	75 (3.6%)	118 (3.9%)	55 (4.7%)
Total	724 (34.3%)	654 (31.4%)	953 (31.6%)	425 (36.8%)

As expected, in non-heating season, children living in neighbourhoods with higher $PM_{2.5}$ and PM_{10} concentrations reported more outdoor air pollution-related issues than children living in neighbourhoods having lower $PM_{2.5}$ and PM_{10} concentrations (results were the same for $PM_{2.5}$ and PM_{10} based comparisons: 33.3% versus 31.4%) (see Table 5).

Table 5. The number and frequency of outdoor air quality-related issues in neighbourhoods with lower and higher $PM_{2.5}$ and PM_{10} concentrations in non-heating season

	Neighbourhoods with lower $PM_{2.5}$ concentrations (N=2060 issues) n (%)	Neighbourhoods with higher $PM_{2.5}$ concentrations (N=2111 issues) n (%)	Neighbourhoods with lower PM_{10} concentrations (N=2060 issues) n (%)	Neighbourhoods with higher PM_{10} concentrations (N=2111 issues) n (%)
Themes				
Places with lack of vegetation	68 (3.3%)	72 (3.4%)	68 (3.3%)	72 (3.4%)
Highly urbanised places	7 (0.3%)	–	7 (0.3%)	–
Places with high traffic volume / the problem of exhaust gas in streets	183 (8.8%)	272 (12.9%)	183 (8.8%)	272 (12.9%)
Places with smelly trashes	277 (13.3%)	230 (10.9%)	277 (13.3%)	230 (10.9%)
Places with smokers	14 (0.7%)	29 (1.4%)	14 (0.7%)	29 (1.4%)
Places where coal burning activities take place	2 (0.1%)	8 (0.4%)	2 (0.1%)	8 (0.4%)
Places where people burn fire	12 (0.6%)	14 (0.6%)	12 (0.6%)	14 (0.6%)
Places where tree cutting activities take place	2 (0.1%)	1 (0.04%)	2 (0.1%)	1 (0.04%)
Places where construction/ demolition activities take place	14 (0.7%)	–	14 (0.7%)	–
Places with poor air quality with unspecified reasons	75 (3.6%)	98 (4.6%)	75 (3.6%)	98 (4.6%)
Total	654 (31.4%)	724 (34.3%)	654 (31.4%)	724 (34.3%)

4.2. *Children's air pollution-related experiences and the built environment characteristics of their neighbourhoods*

Our results show that compared to children living in neighbourhoods with lower land use mix, more children living in neighbourhoods with higher land use mix reported traffic density and vehicle exhaust-related pollution issues (13.1% versus 8.3%) (see Table 6). Additionally, we observed more smelly trash related issues in neighbourhoods with high land use diversity than to neighbourhoods with less land use diversity (13.9% versus 10.1%).

Compared to children living in greener neighbourhoods (i.e., Koru and Ahmet Taner Kislali) more children living in less green neighbourhoods mentioned a general air quality problem in their neighbourhood environments (4.5% versus 0.6%). However, we found that compared to children living in less green neighbourhoods, more children living in highly green neighbourhoods mentioned places with lack of vegetation.

Table 6. The number and frequency of outdoor air quality-related issues in neighbourhoods with lower and higher $PM_{2.5}$ and PM_{10} concentrations in non-heating season

	Neighbourhoods with lower land use mix (N=1916 issues) n (%)	Neighbourhoods with higher land use mix (N=2255 issues) n (%)	Neighbourhoods with lower neighbourhood greenness (N=3836 issues) n (%)	Neighbourhoods with higher neighbourhood greenness (N=335 issues) n (%)
Themes				
Places with lack of vegetation	44 (2.3%)	96 (4.3%)	107 (2.8%)	33 (9.8%)
Highly urbanised places	–	7 (0.3%)	7 (0.2%)	–
Places with high traffic volume / the problem of exhaust gas in streets	159 (8.3%)	296 (13.1%)	398 (10.4%)	57 (17.0%)
Places with smelly trashes	194 (10.1%)	313 (13.9%)	394 (10.3%)	113 (33.7%)
Places with smokers	23 (1.2%)	20 (0.9%)	43 (1.1%)	–
Places where coal burning activities take place	8 (0.4%)	2 (0.09%)	10 (0.3%)	–
Places where people burn fire	13 (0.7%)	13 (0.6%)	24 (0.6%)	2 (0.6%)
Places where tree cutting activities take place	1 (0.05%)	2 (0.09%)	1 (0.02%)	2 (0.6%)
Places where construction/ demolition activities take place	12 (0.6%)	2 (0.09%)	14 (0.4%)	–
Places with poor air quality with unspecified reasons	104 (5.4%)	69 (3.1%)	171 (4.5%)	2 (0.6%)
Total	558 (29.1%)	820 (36.4%)	1169 (30.5%)	209 (62.4%)

5. Discussion and conclusion

We found that inner- and outer-city neighbourhoods had significantly different levels of $PM_{2.5}$ and PM_{10} concentrations, which shows the role of built environment in affecting PM concentrations. In a non-heating season, high $PM_{2.5}$ and PM_{10} concentrations in inner-city neighbourhoods can be attributed to factors such as high building density (and thus, increased heat islands) and low green spaces in these areas (Chen et al., 2017; McCarty and Kaza, 2015). Contrarily, low $PM_{2.5}$ and PM_{10} concentrations in peripheral neighbourhoods can be attributed to the presence of greenery and high air circulation (Han et al., 2020). Seasonal variations in PM concentrations in

neighbourhoods can be attributed to many factors, such as reduced industrial activity and domestic heating in summer seasons (Sabir et al., 2024) and neighbourhood location. These factors may explain the seasonal variation in PM concentrations observed in peripheral neighbourhoods adjacent to construction sites and forests (which cool down the air).

Our results support the prior claims of qualitative researchers that there is a relationship between built environment, outdoor air pollution and outdoor place experiences of children. Children reported more negative experiences about outdoor air pollution in school neighbourhoods with higher $PM_{2.5}$ and PM_{10} concentrations in the non-heating season; different and conflicting results are obtained in the heating season for $PM_{2.5}$ and PM_{10} concentrations. This difference in the PM concentrations triggers the following question: Whether children, who participate in participatory mapping activities, are more likely to report issues that are experienced in particular weather conditions? Certainly, one may argue that children are more likely to use outdoor environments in warmer seasons than in a winter season (see Buck et al., 2015). Thus, the results that we presented here for the non-heating season may be more reliable than those presented for the heating season if children's voices are shaped largely by their place experiences. Truly, multiple factors may affect children's perceptions of and ideas about their environments, including shared experiences within the family (Demirkaya et al., 2024). As in all cross-sectional studies, causal inference is limited in our research. Future studies can map children's neighbourhood experiences in different seasons.

In this study, we could not observe any industry-related air pollution issues mentioned by children. Likewise, while the density of the selected neighbourhoods significantly varied from one neighbourhood to another, as Table 3 shows, except for a few children in Selcuklu, none of the children in other neighbourhoods mentioned a problem related to high urbanisation rates. Furthermore, while the neighbourhood greenness values significantly differed across the selected neighbourhoods, lack of vegetation was mostly mentioned as a problem by the children living in the greenest neighbourhoods. One explanation to these findings could be that children's negative place experiences are more likely to be affected by factors that are physically and visually accessible to and that can be easily perceived and grasped by children. For example, in our study, none of the selected neighbourhoods included industrial areas. Another explanation could be that some children might have internalised the problems of their neighbourhoods, leading them to no longer view the drawbacks of their environments, such as the lack of green open spaces in highly dense neighbourhoods, as problems.

We found that compared to children living in neighbourhoods with lower land use mix, more children living in neighbourhoods with higher land use diversity reported traffic density and traffic-related pollution issues. While this result is in line with the findings of Ding and Zhao (2011), who linked places with high land use mix to high traffic density, it is contrary to what Frank et al. (2006) suggested: increasing the land use mix promotes walking behaviour in residents and decreases vehicle traffic. Since this study did not consider traffic density as an explanatory variable and since various contextual factors may affect PM concentrations, future research should investigate the associations between built environment and PM concentrations in the selected neighbourhoods. Future research should also place greater emphasis in conducting longitudinal and control-group studies.

Despite these limitations, the results of this research may provide helpful insights for urban planners to elaborate tailored and context-specific interventions to create healthier environments for children. Since the proportions of air pollution-related issues experienced by children change from one neighbourhood to another depending on their PM and built environment characteristics, our results show the need for targeted interventions and policies to address these issues.

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Coordinated Development and Coupling Mechanisms of Capital Flows and Carbon Emissions from the Perspective of Environmental Justice

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Abstract
This study explores the coordination between capital flows and carbon emissions in China's Yangtze River Delta (YRD) under an environmental justice framework. Using complex network analysis, coordination models, and multiple linear regression, we diagnose spatial disparities in coupling coordination levels across industries. Results reveal low coordination in manufacturing, power, and financial sectors, with most cities exhibiting incoordination, while construction and agriculture show higher synergy. The environmental justice framework highlights regional equity's critical role in aligning economic activities with carbon neutrality goals. Findings emphasize balancing economic growth and environmental sustainability through equitable policies, offering insights for harmonizing industrial decarbonization with development priorities in economically advanced regions.

1. Introduction

During the critical period of global response to climate change, carbon emissions have become a core challenge restricting sustainable development. Meanwhile, capital, as a key element driving economic growth, its cross-regional flow not only reshapes the global economic geography but also profoundly influences the spatial distribution of carbon emissions. The concept of environmental justice emphasizes fairness in the allocation of environmental resources and the assumption of environmental burdens. However, in the process of promoting regional economic development, current capital flows often come with regional imbalances in carbon emissions, and the issue of carbon emission transfer has become increasingly prominent. Core cities with high capital activity transfer carbon emission pressure to peripheral cities through industrial relocation, forming an "agglomeration of capital - diffusion of pollution" environmental injustice trap, which intensifies the contradiction between different regions in terms of environmental rights and development rights. For instance, developed regions transfer energy-intensive industries to less developed regions through capital outflow, which although promotes their own industrial upgrading and low-carbon transformation, imposes more environmental pressure on less developed regions. This phenomenon seriously violates the principle of environmental justice. As the most dynamic growth pole of China's economy, the Yangtze River Delta region achieved a regional GDP of 30,504.5 billion yuan in 2023. All the prefecture-level cities in the Yangtze River Delta have an economic volume of over 100 billion yuan. With less than 4% of the country's land area, it generates nearly a quarter of China's total economic output, and the scale of regional capital flow accounts for a relatively high proportion of the national total. Against this backdrop, in-depth exploration of the coordinated development and coupling mechanism of capital flow and carbon emissions from the perspective of environmental justice not only helps reveal the intrinsic connection between economic development and environmental protection but is also an urgent need for achieving regional fairness and sustainable development. It holds significant theoretical and practical significance for optimizing resource allocation and promoting green and low-carbon transformation.

2. Literature review

Since the emergence of environmental justice theory in the 1980s, it has gradually become a focus of academic attention. Scholars have interpreted environmental justice from various perspectives. Early research mainly focused on the description of environmental inequality phenomena. For instance, an American scholar found through empirical research that minority communities are often more likely to be the sites for hazardous waste treatment facilities, revealing the issue of racial inequality in the distribution of environmental burdens (Bullard R, 2000). With the deepening of research, the connotation of environmental justice has been continuously expanded, covering multiple dimensions such as intra-generational justice, inter-generational justice, and justice among different regions (Schlosberg D, 2007). At the practical level, the environmental justice movement has driven policy changes, and many countries and regions have begun to incorporate the concept of environmental justice into environmental policy-making. However, existing research has relatively insufficient exploration of the manifestation and influence mechanism of environmental justice in economic activities, especially in capital

flows. How to implement the principle of environmental justice in the coordinated development of capital flows and carbon emissions remains to be further studied.

The impact of capital flows on regional economic development has always been an important field of study in economics. Scholars at home and abroad generally believe that capital flows can promote the optimal allocation of capital factors and drive the upgrading of regional industrial structures (Feldstein & Horioka, 1980; Zhang Jun, 2002). Transnational capital flows, through spillover effects of technology and industrial linkage effects, have driven the economic growth of host countries (Pan et al., 2025). Meanwhile, the cross-regional flow of domestic capital is also reshaping the regional economic landscape. For example, the flow of capital from China's eastern regions to the central and western regions has, to a certain extent, promoted the industrialization and urbanization processes in the central and western regions. However, existing research has mostly focused on the quantitative impact of capital flows on economic growth (Zhao & Jiang, 2025), with relatively weak research on the improvement of economic development quality, especially in the aspect of coordinated development with the environment.

There is a considerable amount of research on the relationship between carbon emissions and economic growth. The "Environmental Kuznets Curve" (EKC) theory holds that in the early stage of economic development, carbon emissions will increase with economic growth. When economic development reaches a certain stage, carbon emissions will decrease due to factors such as industrial structure adjustment and technological progress (Grossman & Krueger, 1995). Many scholars have verified and expanded the EKC curve based on data from different countries and regions. Some studies support this theory, while others have found that the relationship between carbon emissions and economic growth varies among different countries and regions (Panayotou, 2003). However, most of these studies have explored the relationship from a macro perspective, with relatively few studies on how capital flows affect the relationship between carbon emissions and economic growth, and a lack of in-depth analysis of the intrinsic mechanism from the perspective of capital flows.

In recent years, the relationship between capital flows and carbon emissions has begun to attract attention. Some studies have pointed out that international capital flows can lead to the "carbon leakage" phenomenon, where developed countries transfer high-carbon emission industries to developing countries through foreign direct investment, thereby reducing their own carbon emissions but increasing the global total (Ahmad & Wyckoff, 2009). At the domestic regional level, the flow of capital from developed regions to less developed regions may also cause similar environmental problems (Niu et al., 2024; Yan et al., 2025; Zhao et al., 2021; Hata et al., 2023). However, existing research mostly focuses on phenomenon description and qualitative analysis, with relatively scarce quantitative research on the coupling and coordination mechanism between capital flows and carbon emissions, especially from the perspective of environmental justice, where the coordinated development path of the two has not been fully explored.

Overall, existing research has achieved certain results in the fields of environmental justice, capital flows, and carbon emissions. However, systematic research on the coordinated development and coupling mechanism of capital flows and carbon emissions from the perspective of environmental justice is still relatively scarce. This study will employ methods such as the capital flow network space model and the coupling coordination degree model to deeply analyze the relationship between capital flow and carbon emissions in different industries within the Yangtze River Delta region, providing theoretical basis and practical guidance for achieving regional environmental justice and sustainable development.

3. Data sources and research methods

3.1. The data sources

The indicators selected for this study include enterprise investment data, carbon emission data, and socio-economic and natural resource statistics in manufacturing, construction, power, transportation, agriculture, and finance. The enterprise investment data for 2022 is sourced from Qixinbao, which covers investment information among enterprises in cities of the Yangtze River Delta region, providing a foundation for constructing the capital flow network. Meanwhile, carbon emission data is obtained from platforms such as the China Greenhouse Gas Working Group to ensure accuracy and authority. Socio-economic and natural resource statistics are all derived from the 2023 Urban Statistical Yearbook.

3.2. Research methodology

3.2.1. Construction of a Spatial Model of Capital Flow Network

The study selected the enterprise investment data from multiple industries in the cities of the Yangtze River Delta region in 2022, including manufacturing, construction, electricity, transportation, agriculture, and finance. The data were cleaned and filtered to remove invalid or abnormal data, ensuring the completeness and accuracy of the data. The cities in the Yangtze River Delta region were regarded as the nodes of the network, and the investment relationships between enterprises were regarded as the edges. Based on the investment flow and investment relationships of enterprises, a capital flow network between cities was constructed. A weighted asymmetric matrix was built based on the investment scale data, and the elements in the matrix represented the investment weight of city i to city j. By calculating the investment flow between each city, the weighted matrix of the capital flow network was obtained, providing basic data for subsequent network analysis.

3.2.2 Network characteristic measurement method

The study selected the degree centrality as the measurement index for the activity level of nodes in the capital flow network. Degree centrality is used to measure the importance of a city in the network, that is, the number and intensity of investment connections between this city and other cities. The calculation formula is the sum of the scale of cross-city outbound investment and inbound investment by enterprises in the city.

$$W = MaxAbs(I_s + I_t) \quad (1)$$

"I_{st}" represents the scale of cross-city outbound investment by enterprises aggregated by city, and "I_{tt}" represents the scale of cross-city inbound investment received by enterprises aggregated by city.

3.2.3. Coupling coordination model

Coupling degree is an important indicator used to measure the degree of interaction between two or more elements in a research system. Due to the significant differences in the selection of indicators, the data is first standardized before calculating using the coupling degree formula.

$$C = 2\sqrt{\frac{U_1 U_2}{(U_1 + U_2)^2}} \quad (2)$$

C represents the coupling degree, U_1 and U_2 are the centrality of the capital flow network and the standardized values of carbon emissions, respectively. In certain circumstances, the coupling degree may not accurately reflect the overall degree and synergy of the two factors. Therefore, a further coupling coordination degree model is employed, and the formula is as follows.

$$D = \sqrt{CT} \quad (3)$$

$$T = \alpha U_1 + \beta U_2 \quad (4)$$

Among them, D represents the coupling coordination degree, where $D \in (0, 1)$; T is the harmonic coefficient of the central degree of the capital flow network and carbon emissions, reflecting the contribution levels of both to the

coupling coordination degree, x and y respectively represent the weights of the central degree of the capital flow network and carbon emissions, with x + y = 1. Their values can be calculated using the entropy weight method. According to the classification standard of coupling coordination degree (Table 1), its coupling coordination degree is divided into ten levels, namely extreme imbalance, severe imbalance, moderate imbalance, mild imbalance, on the verge of imbalance, barely coordinated, primary coordination, moderately excellent coordination, good coordination and excellent coordination.

Table 1 Classification standard of coupling coordination degree

D value interval of coupling coordination degree	Coordination level	Degree of coupling coordination
(0.0~0.1)	1	Extreme imbalance
[0.1~0.2)	2	A serious imbalance between
[0.2~0.3)	3	Moderate disorders
[0.3~0.4)	4	Mild disorder
[0.4~0.5)	5	On the verge of disorder
[0.5~0.6)	6	Barely coordination
[0.6~0.7)	7	Primary coordination
[0.7~0.8)	8	Intermediate coordinate
[0.8~0.9)	9	Good coordination
[0.9~1.0)	10	Great coordination

3.2.4 Multivariate Linear Regression Model

Construct a coupling and coordination mechanism model for urban capital flow and carbon emissions in the Yangtze River Delta region. Analyze it using the multiple linear regression model. The formula is as follows.

$$Y_j = a_1 \ln X_1 + a_2 \ln X_2 + a_3 \ln X_3 + a_4 X_4 + a_5 X_5 + a_6 X_6 + a_7 X_7 + c \quad (5)$$

Y_{ij} represents the coupling coordination degree of capital flow and carbon emission system in industry j of city i. $\ln X_1$, $\ln X_2$, $\ln X_3$, X_4, X_5, X_6 and X_7 are influencing factors, representing GDP, total passenger volume, annual average concentration of fine particulate matter (PM2.5), urbanization rate of permanent residents, total retail sales of consumer goods, local general budgetary revenue, and local general budgetary expenditure. α is the constant term, α_1, α_2, α_3, α_4, α_5, α_6 are the coefficient values of $\ln X_1$, $\ln X_2$, $\ln X_3$, X_4, X_5 and X_6 respectively, and c is the regression constant term.

4. Research on the Regional Characteristics of Capital Flow Linkage Network and Carbon Emissions

4.1 Research on the Multi-industry Capital Flow Linkage Network and Its Structural Characteristics

4.1.1 Research on the Multi-industry Capital Flow Linkage Network in the Yangtze River Delta Region

The capital flow network of manufacturing industry in the Yangtze River Delta presents a "multi-core with multiple sub-centers" structure, with "Shanghai - Suzhou - Hangzhou" as the main core and Yangzhou, Ningbo, Nanjing, Wuxi, and Hefei as the secondary centers. Among them, Shanghai has a relatively strong capital connection with other

regions, while Suzhou and Hangzhou have stronger local connections. Other cities also show a network feature where local connections are greater than external connections. As an international hub, Shanghai has a relatively high proportion of external capital connections and outstanding regional resource allocation capabilities; while Suzhou and Hangzhou have strong local capital connections, reflecting the localization tendency of their industrial clusters, such as Suzhou's electronic information and Hangzhou's digital manufacturing. The local connections of other secondary centers are generally higher than those with other regions, indicating that the manufacturing industry presents a "regional decentralization and concentration" feature. The manufacturing industry network relies on the dual drive of external radiation from core cities and local deepening in secondary nodes, and needs to enhance network collaboration efficiency through cross-city industrial chain division.

The capital network of the construction industry forms a multi-center pattern with five centers in Nanjing, Shanghai, Suzhou, Yancheng, and Hefei. The spatial distribution is more scattered than that of manufacturing. Among them, Suzhou and Nanjing have stronger external connections, and Nanjing and Suzhou undertake the functions of regional infrastructure hubs, mainly connecting cross-provincial projects such as high-speed rail and cross-river passages. While Shanghai, Yancheng, Zhenjiang, and Hefei have stronger local connections, Shanghai and Yancheng are closely related to local urban renewal and coastal development projects. The multi-center pattern of the construction industry is strongly related to the government-led infrastructure investment model, and attention should be paid to the risk of duplication, and a regional major project joint approval mechanism should be established.

The capital network of the power industry presents a "one main with multiple sub-centers" structure, with Ningbo as the strongest local connection and its core position derived from its port location advantage. In 2022, the coal and nuclear power installed capacity in Ningbo accounted for 23% of the total in the Yangtze River Delta. Shanghai has the strongest external connections, mainly transporting electricity to the north of Jiangsu and the Yangtze River Delta. The power network is highly dependent on geographical endowments and needs to strengthen the complementarity between Ningbo and other sub-centers through the construction of special high-voltage transmission channels to avoid the risk of a single energy center.

The capital network of the transportation industry presents a single center in Shanghai and five cities including Suzhou, Hangzhou, Nanjing, Hefei, and Ningbo as sub-centers. Among them, Shanghai has the strongest external connections, mainly undertaking international shipping and transshipment functions in the Yangtze River Delta. Hangzhou has become the only sub-center with balanced local and external capital connections, matching its position as an e-commerce logistics hub. Shanghai's single-pole hub function is temporarily irreplaceable, but it needs to build regional logistics nodes in cities such as Hangzhou and Nanjing to alleviate the pressure of trunk transportation.

The capital flow network of agriculture forms a center structure of Ningbo-Hangzhou-Suzhou, with the intensity of capital connections showing a "core prominent - periphery balanced" feature. Regions with strong connections in Shanghai, Hangzhou, and Hefei all have local connections greater than external connections. It is strongly related to the localized production models such as urban agriculture in Shanghai, tea industry in Hangzhou, and seed industry in Hefei. The agricultural network highly relies on geographical resource endowments and needs to enhance cross-regional capital flow efficiency through technological empowerment , such as research and development in Hefei seed industry - application and transformation in Shanghai.

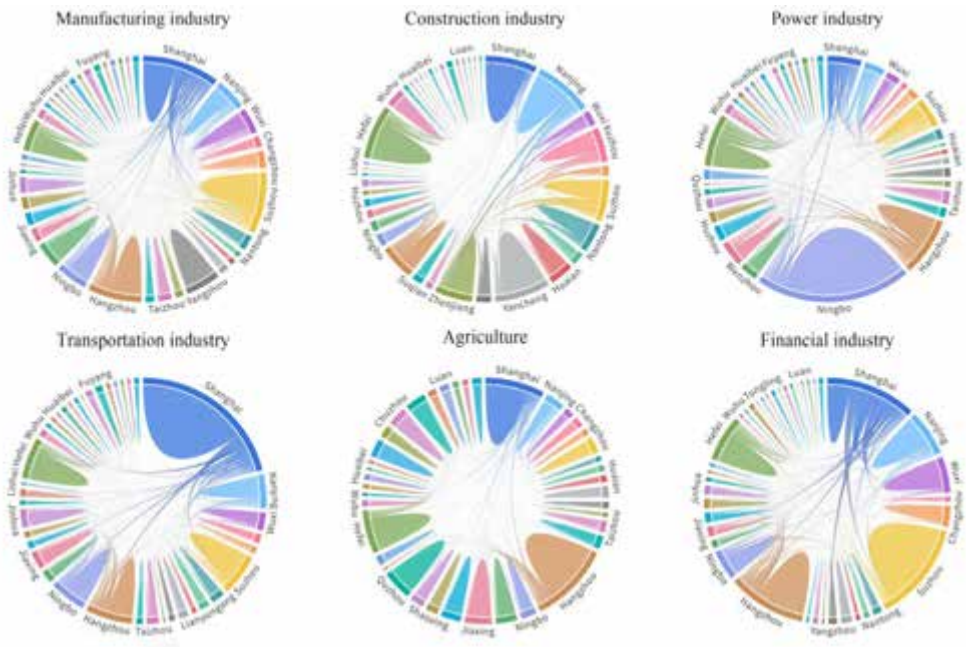

Figure 1 The network connection of capital flow in various industries in the Yangtze River Delta region

4.1.2 Research on the Structural Characteristics of Capital Flow Network in the Yangtze River Delta Region
The centrality of the urban capital flow network in the Yangtze River Delta region was analyzed (Figures 2 and 3). The centralities of cities such as Shanghai, Suzhou, Hangzhou, Hefei, and Nanjing were relatively high. Additionally, the centralities of regions like Ningbo, Zhenjiang, and Yancheng were also high. From the perspective of various industries, compared to other industries, the centralities of manufacturing and construction industries were higher, mainly concentrated in the value ranges of 431-1871 and 274-2352. Among them, the degree values of cities such as Suzhou, Shanghai, and Hangzhou were the highest in the manufacturing industry, while those of cities like Yancheng, Nanjing, and Zhenjiang were the highest in the construction industry. The centrality of the transportation industry was relatively low, mainly concentrated in the value range of 70-235. Shanghai had the highest centrality value. The centrality of the power industry was only concentrated in the value range of 92-270, with Ningbo having the highest centrality, and Hangzhou and Hefei having relatively high centrality. The centrality of agriculture was mainly concentrated in the value range of 92-262, with Hangzhou having the highest centrality, while Shanghai and Hefei had relatively high centrality. The centrality of the financial industry was mainly concentrated in the value range of 81-331, with Hangzhou having the highest centrality, and Suzhou, Shanghai, Nanjing, and Hefei having relatively high centrality as provincial capital cities.

Figure 2 The centrality and cumulative value of capital flow networks in various industries of cities in the Yangtze River Delta region

Figure 3 The distribution of centrality values of capital flow networks in various industries of cities in the Yangtze River Delta region

4.2 Spatial Characteristics Analysis of Carbon Emissions in the Yangtze River Delta Region

The spatial distribution characteristics of carbon emissions in the cities of the Yangtze River Delta region were analyzed (Figures 4 and 5). The total carbon emissions of Suzhou and Xuzhou were the highest. The carbon emissions from manufacturing and the power industry were higher than those from other industries. The carbon emissions from finance and agriculture were relatively lower. From the perspective of the spatial distribution of carbon emissions in each industry, the high-value areas of carbon emissions from manufacturing were mainly concentrated in the "Shanghai-Suzhou-Wuxi-Quanzhou-Nanjing-Ma'anshan-Hefei" urban axis. In addition, the carbon emission values in regions such as Xuzhou, Yancheng, Lianyungang, Hangzhou, Quzhou, Jinhua, etc. were relatively high. The high-value area of carbon emissions from the construction industry was relatively wide, with the highest value area concentrated in Shanghai, while the carbon emission values in cities such as Suzhou, Nantong, Yancheng, Hangzhou, Wenzhou, Ningbo, Xuzhou, Nanjing, Hefei, Fuyang, etc. were relatively high. The high-value area of carbon emissions from the power industry was mainly concentrated in cities such as Suzhou, Zhenjiang, Huainan, etc. The carbon emission values in cities such as Xuzhou, Huaihua, Taizhou, Wuxi, Ningbo, Wenzhou, etc. were relatively high. The high-value area of carbon emissions from agriculture was concentrated in cities such as Yancheng, Xuzhou, Suizhou, Bozhou, and Fuyang, while the highest value area was located in regions such as Lianyungang, Suqian, Huai'an, Chuzhou, Hefei, Suzhou, and Nantong. The high-value area of carbon emissions from the transportation industry was concentrated in Shanghai, with the highest value area located in cities such as Suzhou, Wuxi, Nanjing, Hangzhou, etc. The high-value area of carbon emissions from finance was concentrated in Shanghai and Huainan, while the highest value area was located in cities such as Ma'anshan, Wuhu, Wenzhou, etc.

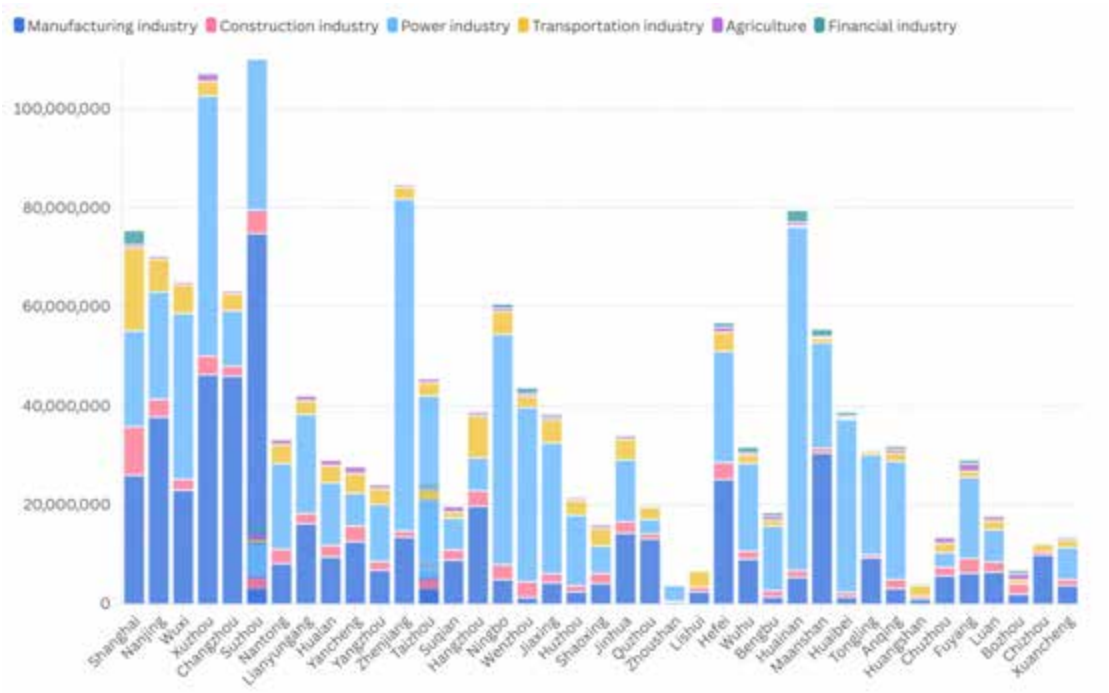

Figure 4 The total carbon emissions of multiple industries in cities in the Yangtze River Delta region

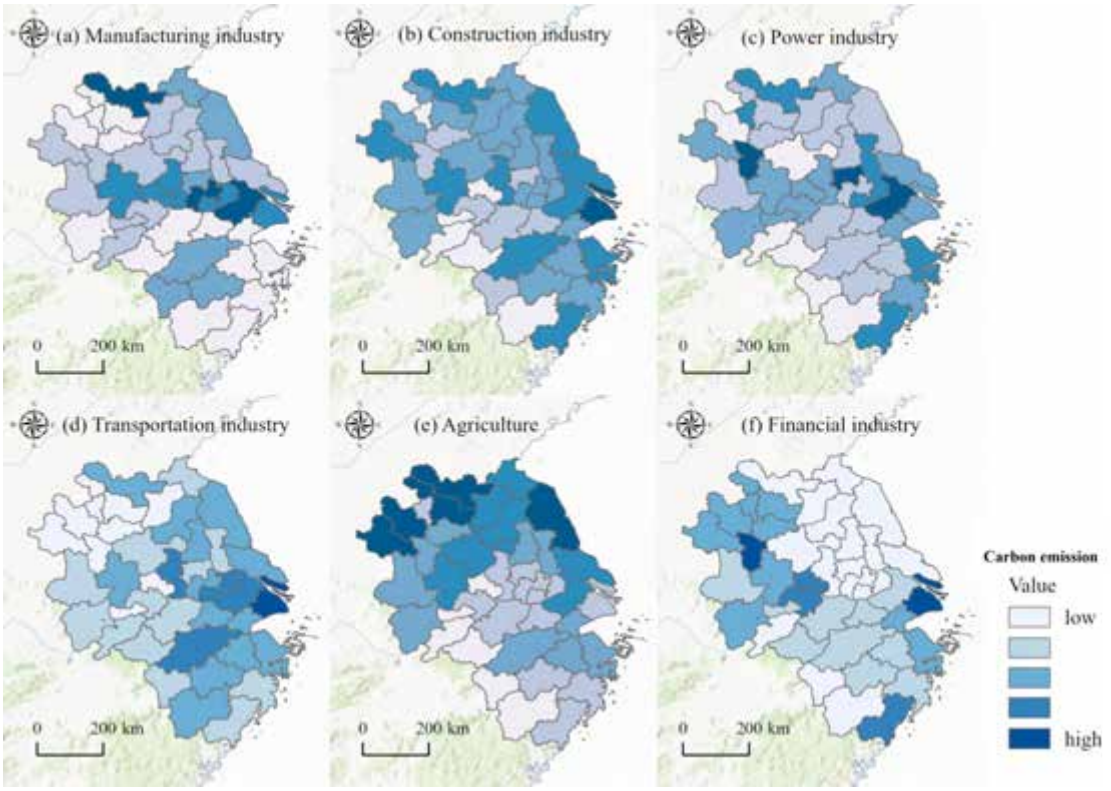

Figure 5 The spatial distribution of carbon emissions in various industries in cities of the Yangtze River Delta region

5. Research on the Coupling and Coordination Mechanism of Capital Flows and Carbon Emission System

5.1 Analysis of the Coupling and Coordination between Capital Flows and Carbon Emissions

Combining the centrality of the capital flow network and the total carbon emissions, an analysis of the current situation of the capital flow and carbon emission system in the cities of the Yangtze River Delta region is conducted (Figure 6). In the manufacturing sector, most cities are in the "low carbon emission - low capital flow" state, while only Suzhou is in the "high carbon emission - high capital flow" state. In addition, Xuzhou and Ma'anshan are in the "high carbon emission - low capital flow" state, while Shanghai and Hangzhou are in the "low carbon emission - high capital flow" state. In the construction industry, all cities are in the "low carbon emission" state, while cities such as Nanjing, Zhenjiang, Yancheng, Shanghai, Hefei, and Suzhou are in the "low carbon emission - high capital flow" state. In the power industry, all cities are in the "low capital flow" state, while cities such as Suzhou, Zhenjiang, and Xuzhou are in the "high carbon emission - low capital flow" state, and Ningbo is relatively balanced. In the transportation industry, most cities are in the "low carbon emission - low capital flow" state, while only Shanghai is in the "low carbon emission - high capital flow" state. In agriculture, all cities are in the "low carbon emission - low capital flow" state. In the financial industry, most cities are in the "low carbon emission - low capital flow" state, while cities such as Hangzhou, Suzhou, and Shanghai are in the "low carbon emission - high capital flow" state.

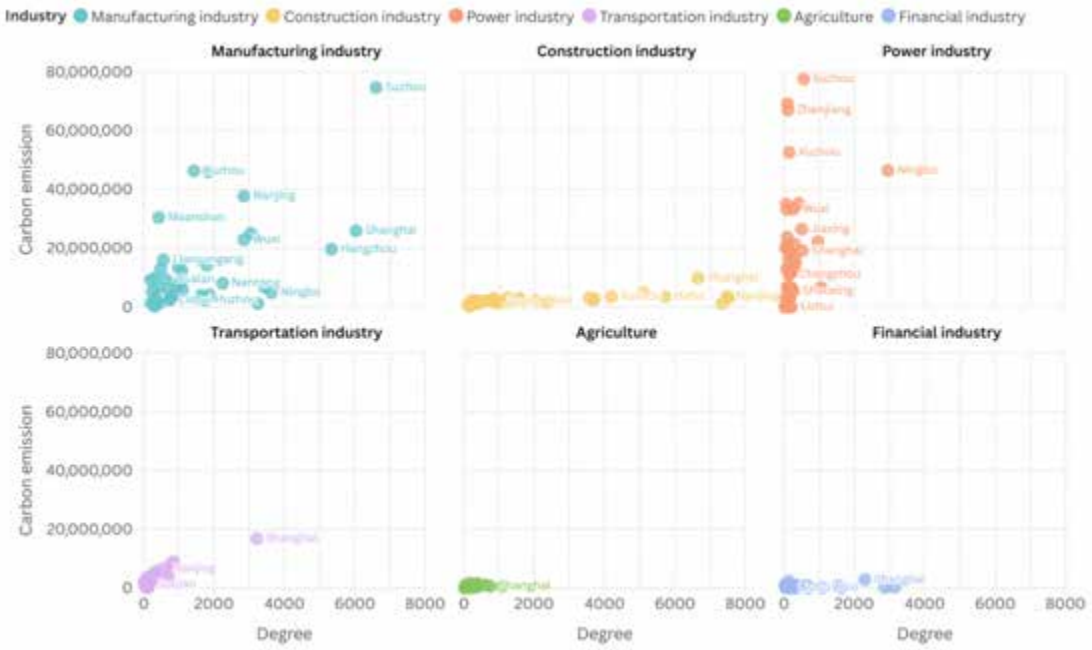

Figure 6 The current situation of multi-industry capital flows and carbon emissions in cities of the Yangtze River Delta region

According to the coupling coordination model, the coupling coordination degree of urban capital flow and carbon emissions in the Yangtze River Delta region in 2022 was calculated (Figure 7). From the perspective of manufacturing, the overall coupling coordination level of cities is relatively low, and most cities are in an uncoordinated state. Only Suzhou is in a high-quality coordination state, Shanghai is in a medium-level coordination state, Changzhou, Nanjing, Hefei, and Hangzhou are in a primary coordination state, Wuxi and Xuzhou are in a barely coordinated state, Tongling and Huaihua are in an extremely imbalanced state. The coupling coordination level of the construction industry is slightly higher than that of manufacturing. Shanghai is in a high-quality coordination state, Suzhou, Yancheng, Nanjing, and Hefei are in a medium-level coordination state, Nantong, Xuzhou, and Hangzhou are in a primary coordination state, Zhenjiang and Huai'an are in a barely coordinated state, and only Tongling is in an extremely imbalanced state. The coupling coordination level of the power industry is relatively low. Only Ningbo is in a good coordination state, Suzhou is in a primary coordination state, Hefei is in a barely coordinated state, and Lishui, Chizhou, and Bozhou are in an extremely imbalanced state. Most cities in the transportation industry belong to uncoordinated areas. Only Shanghai is in a high-quality coordination state, Suzhou is in a primary coordination state, Nanjing and Hangzhou are in a barely coordinated

state, and only Huangshan is in an extremely imbalanced state. The regional coupling coordination level of the financial industry is relatively low. Only Shanghai is in a high-quality coordination state, Hefei is in a primary coordination state, Hangzhou is in a barely coordinated state, and Lishui, Suqian, and Suzhou are in an extremely imbalanced state. The overall coupling coordination level of agriculture is relatively high. Most cities are in a coordinated state. Among them, Hangzhou, Hefei, and Fuyang have the highest coupling coordination levels, and they are in a primary coordination state, while only Tongling and Huaihua are in an extremely imbalanced state.

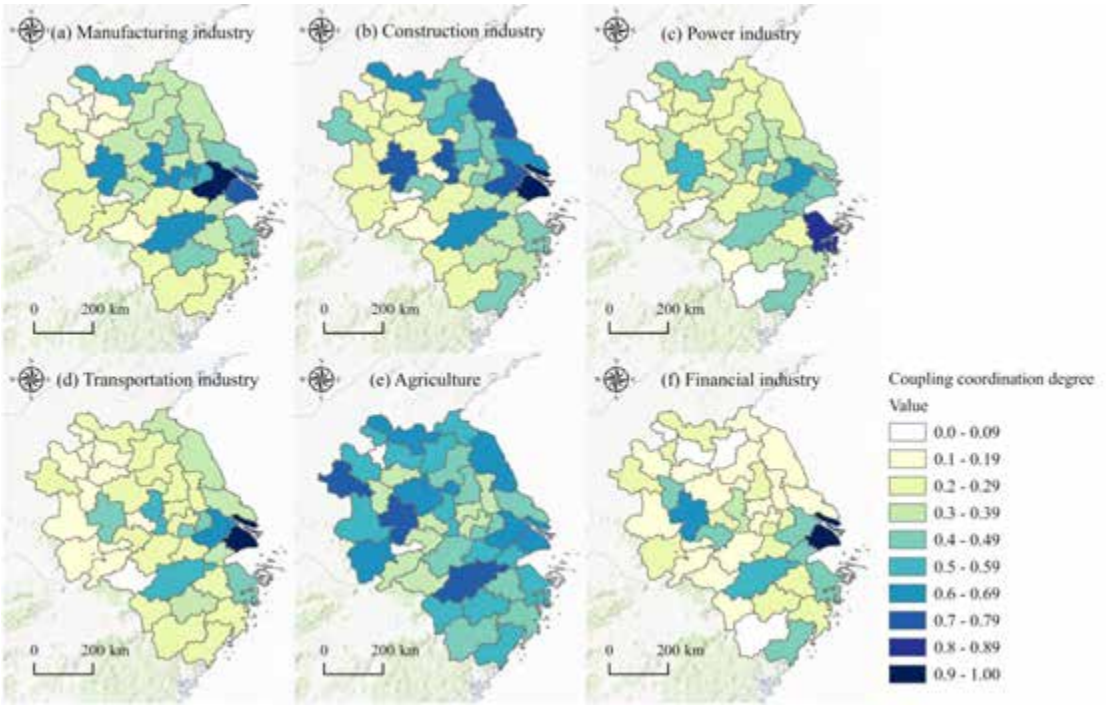

Figure 7 The spatial distribution of the coupling coordination degree between urban capital flows and carbon emissions in the Yangtze River Delta region

5.2 Research on the Coupling Coordination Mechanism of Capital Flow and Carbon Emission System in the Yangtze River Delta Region

Based on multiple perspectives such as social economy, industrial structure, and resource environment, the model was improved through stepwise regression, and the following variables were selected: GDP, urbanization rate of permanent residents, passenger volume, annual average concentration of fine particulate matter (PM2.5), total retail sales of consumer goods, local general budgetary revenue, and local general budgetary expenditure. These indicators were selected as the influencing factors of the coupling and coordination of capital flow and carbon emission system. A multiple linear regression model was used to conduct decomposition analysis of the coupling mechanism for each industry.

From the regression results of the manufacturing industry (Table 2), it can be seen that GDP, local general budgetary revenue and expenditure have a significant impact on the coupling system of manufacturing. Among them, GDP has the greatest impact on the coupling system of manufacturing, and local general budgetary revenue has a relatively significant positive promoting effect on the coupling coordination, while local general budgetary expenditure has an inhibitory effect. For every 1% increase in GDP, the coordination degree of manufacturing increases by 0.114 units, which is lower than that of the construction industry (Table 3), but higher than that of the transportation industry (Table 5), indicating that manufacturing has a moderate dependence on economic scale, but the speed of low-carbon transformation is constrained by the technology lock-in effect, such as the high cost of traditional equipment renewal. The “scissors difference” effect of fiscal revenue lies in that after fiscal revenue increases, it increases subsidies for low-carbon technologies, such as tax incentives for clean production equipment, and due to the preference of fiscal expenditure for infrastructure and projects, it occupies the green investment of manufacturingΔsuch as insufficient funds for the circular transformation of industrial parks. The reverse effect of fiscal revenue and expenditure on coordination degree reflects the target conflict

between local governments in “increasing revenue and reducing expenditure” and “low-carbon investment”. Different from the construction industryΔthe failure of PM2.5 and urbanization lies in that manufacturing may be concentrated in high-pollution industriesΔand there is a “compliance is equivalent to compliance” phenomenon in environmental regulationsΔlacking further emission reduction motivation. The coefficient of urbanization is positive but not significantΔwhich may be due to the fact that urbanization drives manufacturing demand but regional industrial homogeneity weakens the efficiency of the capital flow network. The coupling coordination degree of manufacturing is “bidirectionally pulled” by GDP and fiscal revenue and expenditure and it is necessary to solve the predicament of “relying on high-carbon industries for fiscal revenue increase and suppressing low-carbon investment with fiscal expenditure”. It is recommended to construct a “fiscal-industry” collaborative policy and embed low-carbon transformation into the hard constraints of local fiscal budgets.

Table 2 Regression results of the impact factors in the manufacturing industry

Y_1	Coefficient	Std.err.	t	P>|t|	[95% conf.interval]	
lnX_1	0.114045	0.037131	3.0700	0.0040	0.038585	0.189505
lnX_2	0.061461	0.037682	1.6300	0.1120	-0.015118	0.138039
lnX_3	0.095169	0.062288	1.5300	0.1360	-0.031414	0.221753
X_4	0.003003	0.002516	1.1900	0.2410	-0.002111	0.008116
X_5	0.000028	0.000023	1.2300	0.2270	-0.000018	0.000075
X_6	0.000151	0.000074	2.0500	0.0480	0.000001	0.000301
X_7	-0.000171	0.000053	-3.2300	0.0030	-0.000279	-0.000063
cons	-2.750605	0.579467	-4.7500	0.0000	-3.928223	-1.572987

In the coupled system of the construction industry (Table 3), GDP, annual average concentration of fine particulate matter (PM2.5), and total retail sales of consumer goods play significant roles. Among them, GDP and the annual average concentration of fine particulate matter (PM2.5) have a relatively large positive promoting effect on it, while the relative influence of total retail sales of consumer goods is smaller, but it can also promote the improvement of the coupled system of the construction industry. The construction industry is highly sensitive to the economic cycle, and economic growth directly drives the efficiency of capital flow and the low-carbon transformation. The coordination degree of the construction industry has the highest elasticity with GDP, possibly due to the large proportion of real estate investment in GDP and the linkage of green building policies and economic stimulus plans. The positive effect of PM2.5 may be because of the policy-driven mechanism. Stringent environmental regulations in high-pollution areas promote the low-carbon transformation of the construction industry, such as mandatory use of environmentally friendly building materials. The positive impact of social retail sales of consumer goods may be due to the increase in demand for commercial real estate, which promotes the optimization of the capital flow network. However, the insufficient application of low-carbon technologies leads to limited improvement in coordination degree. Therefore, priority should be given to strengthening the synergy between economic growth and low-carbon buildings, such as including the coordination degree of the construction industry in local GDP assessment and giving priority to supporting green infrastructure projects. Utilize the policy linkage mechanism for PM2.5 governance to implement building carbon quota trading in high-pollution areas. The second is driven by the consumption end. By providing consumption subsidies to guide the demand for low-carbon buildings, such as green housing purchase discounts, the positive effect of social retail sales of consumer goods can be amplified. The coupling coordination degree of the construction industry is highly dependent on economic growth, and environmental regulations (PM2.5) may indirectly promote the low-carbon transformation through the policy-driven mechanism. A “economic-environment-building” tripartite governance system needs to be constructed to strengthen the driving effect of the consumption end on green buildings.

Table 3 Regression results of the impact factors in the construction industry

Y_2	Coefficient	Std.err.	t	P>|t|	[95% conf.interval]	
lnX_1	0.191559	0.044641	4.2900	0.0000	0.100838	0.282279
lnX_2	-0.031771	0.045302	-0.7000	0.4880	-0.123837	0.060294
lnX_3	0.135850	0.074884	1.8100	0.0780	-0.016334	0.288033
X_4	-0.003030	0.003025	-1.0000	0.3240	-0.009178	0.003117
X_5	0.000048	0.000028	1.7300	0.0920	-0.000008	0.000104
X_6	-0.000039	0.000089	-0.4300	0.6670	-0.000219	0.000142
X_7	-0.000020	0.000064	-0.3100	0.7550	-0.000150	0.000110
cons	-3.041972	0.696655	-4.3700	0.0000	-4.457745	-1.626198

In the power industry (Table 4), GDP and passenger volume have a significant impact on the coupling system of the power industry. Among them, the impact of GDP is greater and it plays a positive promoting role. However, passenger volume has a marginal significant negative effect on the coupling system of the power industry. For every 1% increase in GDP, the power coordination degree increases by 0.171 units, which is significantly higher than that of agriculture (Table 5) and transportation (Table 4). This indicates that the power system is highly bound to the macroeconomy, and economic growth directly drives power investment and supply-demand matching. As a fundamental energy industry, the coordination degree of the power industry is more sensitive to economic fluctuations. Therefore, it is necessary to be vigilant of the resilience risks of the power system during economic downturns. The potential negative impact of passenger volume may lie in the fact that transportation energy consumption competes for power resources. As passenger volume increases, fuel consumption also increases, indirectly reducing investment in clean power, such as charging piles and rail transit electrification lagging behind. At the same time, there may also be investment competition, where local governments may prioritize transportation infrastructure, weakening the funds for upgrading the power system.

The coupling coordination degree of power is highly dependent on economic growth, but it is necessary to prevent the potential inhibitory effect of the expansion of passenger volume. It is recommended to build a "economic-transportation-power" collaborative policy framework, with a focus on enhancing the initiative of local finance in the power system.

Table 4 Regression results of the impact factors in the power industry

Y_3	Coefficient	Std.err.	t	P>|t|	[95% conf.interval]	
lnX_1	0.171417	0.048909	3.5000	0.0010	0.072022	0.270813
lnX_2	-0.092732	0.049634	-1.8700	0.0700	-0.193601	0.008137
lnX_3	0.075229	0.082045	0.9200	0.3660	-0.091506	0.241964
X_4	-0.000920	0.003314	-0.2800	0.7830	-0.007655	0.005815
X_5	0.000032	0.000030	1.0600	0.2980	-0.000030	0.000094
X_6	0.000022	0.000097	0.2200	0.8240	-0.000176	0.000219
X_7	-0.000075	0.000070	-1.0800	0.2880	-0.000217	0.000066
cons	-2.091331	0.763269	-2.7400	0.0100	-3.642481	-0.540181

In the transportation industry (Table 5), the GDP, local fiscal general budgetary revenue and expenditure have a significant impact on the coupling system of the transportation sector. The GDP and local fiscal general budgetary revenue have a positive promoting effect, while local fiscal general budgetary expenditure will inhibit the optimization and improvement of the transportation coupling system. The positive effect of local fiscal revenue may be manifested in the enhanced government financial strength, which can support transportation infrastructure, such as high-speed railways and ports, directly improving the system's coordination. The negative effect of local fiscal expenditure may be due to the expansion of expenditure possibly occupying transportation

special funds or reflecting low expenditure efficiency, such as repeated construction and insufficient maintenance. Therefore, considering the priority development of economy and fiscal reform, maintaining GDP growth, and focusing on investing in transportation weak areas, such as rural road networks and multimodal transportation, is necessary. Secondly, optimize the fiscal expenditure structure and establish a transportation special fund to avoid "spreading resources thinly". The coupling coordination degree of transportation is mainly driven positively by economic growth and fiscal capacity, but an unreasonable fiscal expenditure structure will weaken the system's efficiency. It is necessary to promote the coordinated development of "economy - finance - transportation", and focus on optimizing the efficiency of infrastructure investment.

Table 5 Regression results of the impact factors in the transportation industry

Y_4	Coefficient	Std.err.	t	P>|t|	[95% conf.interval]	
$\ln X_1$	0.109253	0.023508	4.6500	0.0000	0.061479	0.157027
$\ln X_2$	-0.012559	0.023856	-0.5300	0.6020	-0.061041	0.035923
$\ln X_3$	0.018781	0.039434	0.4800	0.6370	-0.061359	0.098921
X_4	-0.001719	0.001593	-1.0800	0.2880	-0.004956	0.001518
X_5	0.000013	0.000015	0.8600	0.3940	-0.000017	0.000042
X_6	0.000147	0.000047	3.1500	0.0030	0.000052	0.000242
X_7	-0.000079	0.000034	-2.3700	0.0240	-0.000148	-0.000011
cons	-1.527307	0.366861	-4.1600	0.0000	-2.272859	-0.781756

The most significant influencing factors in agriculture are numerous (Table 6). Factors such as GDP, the urbanization rate of permanent residents, local fiscal revenue and expenditure within the general budget, etc., all have a significant impact on the agricultural coupling system. An increase in GDP and local fiscal revenue within the general budget can effectively promote the improvement of the agricultural coupling system, while an increase in the urbanization rate of permanent residents and local fiscal expenditure within the general budget will reduce and inhibit the improvement of the agricultural coupling system. Among them, the impact of GDP is the greatest, reflecting the significant promoting effect of overall economic development on agricultural modernization, such as technological investment and industrial chain integration. The positive effect of local fiscal revenue can be manifested as enhanced local financial strength possibly supporting agricultural subsidies and infrastructure investment. The negative effect of local fiscal expenditure can be reflected as the expansion of expenditure possibly occupying agricultural resources, such as the flow of funds to non-agricultural fields or the reflection of an unreasonable expenditure structure. The urbanization rate of permanent residents has a significant inhibitory effect on the agricultural coupling degree, possibly manifested as labor loss, the transfer of rural population to urban areas leading to a shortage of agricultural labor force, and weakening of production intensification. The reduction of arable land and the expansion of urbanization occupying farmland directly reduce the scale of the agricultural system. Policy bias, with resources favoring urban areas, relatively insufficient agricultural investment, requires through labor substitution technologies and policies for protecting arable land to counteract its negative impact.

The agricultural coupling degree is significantly influenced by economic growth, environmental quality and fiscal policies. Considerable efforts can be made to enhance the efficiency of the agricultural system through "economic-environment-fiscal" collaborative governance. Meanwhile, GDP growth and increase in fiscal revenue remain the key driving forces for improving the efficiency of the agricultural system.

Table 6 Regression results of the impact factors in the agriculture

Y_5	Coefficient	Std.err.	t	P>|t|	[95% conf.interval]	
lnX_1	0.143406	0.049120	2.9200	0.0060	0.043583	0.243229
lnX_2	0.070262	0.049848	1.4100	0.1680	-0.031042	0.171565
lnX_3	0.072342	0.082398	0.8800	0.3860	-0.095111	0.239795
X_4	-0.010179	0.003329	-3.0600	0.0040	-0.016944	-0.003415
X_5	-0.000001	0.000030	-0.0400	0.9670	-0.000063	0.000061
X_6	0.000254	0.000098	2.6000	0.0140	0.000055	0.000452
X_7	-0.000208	0.000070	-2.9700	0.0050	-0.000351	-0.000066
cons	-2.190231	0.766556	-2.8600	0.0070	-3.748060	-0.632401

In the financial industry coupling system (Table 7), only the local government's general budgetary revenue within the scope of the general budget has a significant impact on it, but the impact is relatively small. For every 1 unit increase in local government's general budgetary revenue, the financial coupling degree may increase by approximately 0.000157 units. An increase in local government's general budgetary revenue can actively promote the optimization of the financial industry coupling system's fiscal and tax policies or help improve the financial coupling degree. The positive impact of local government revenue may be weaker than that of the manufacturing sector due to the increase in fiscal revenue leading to more investment in green finance, such as establishing green industry funds. However, the effect is much weaker. Therefore, it is necessary to leverage specialized financial policy tools, such as including the carbon intensity of financial institutions in the MPA assessment, directly constraining the carbon-oriented capital flow. It is also recommended that a proportion of the increased local government revenue be invested in a green finance risk compensation fund to amplify the weak positive effect of local government revenue.

The financial industry coupling coordination degree is insensitive to macroeconomic variables. It is necessary to break away from the traditional analytical framework and focus on the optimization of financial policy tools and capital network structure, such as carbon financial product innovation. It is suggested to establish a "fiscal-finance" linkage mechanism, incorporate green finance indicators into local government performance assessment, and prioritize the pilot program of carbon flow accounting in the financial industry.

Table 7 Regression results of the impact factors of the financial industry

Y_6	Coefficient	Std.err.	t	P>|t|	[95% conf.interval]	
lnX_1	-0.003506	0.046558	-0.0800	0.9400	-0.098123	0.091112
lnX_2	0.002173	0.047248	0.0500	0.9640	-0.093847	0.098194
lnX_3	0.055253	0.078101	0.7100	0.4840	-0.103468	0.213973
X_4	0.002104	0.003155	0.6700	0.5090	-0.004307	0.008516
X_5	0.000026	0.000029	0.9100	0.3670	-0.000032	0.000085
X_6	0.000157	0.000093	1.7000	0.0990	-0.000031	0.000345
X_7	-0.000098	0.000067	-1.4700	0.1500	-0.000233	0.000037
cons	-0.113044	0.726579	-0.1600	0.8770	-1.589631	1.363543

6. Conclusions and Recommendations

6.1 Conclusions

In terms of regional characteristics, the capital flow networks in multiple industries within the Yangtze River Delta region exhibit differentiated patterns. The manufacturing industry is centered around "Shanghai - Suzhou - Hangzhou", while the construction industry shows a multi-center and dispersed pattern. The power industry, transportation industry, and financial industry have formed network structures of "one main and multiple backups" and "multiple main and multiple backups" respectively, and the agriculture industry has formed a central structure of "combined three cores of Shanghai, Suzhou, and Hangzhou". The analysis of the centrality of

the capital flow network shows that cities such as Shanghai, Suzhou, and Hangzhou occupy important positions in multiple industries, and there are significant differences in the range of centrality values for different industries. In terms of spatial distribution of carbon emissions, the total carbon emissions of Suzhou and Xuzhou are prominent, and the carbon emissions of the manufacturing and power industries are significantly higher than those of other industries. The high-value areas of carbon emissions in each industry show obvious urban clustering characteristics, such as the manufacturing industry being concentrated in the "Shanghai - Suzhou - Wuxi - Changzhou - Nanjing - Ma'anshan - Hefei" axis, while the power industry is concentrated in cities such as Suzhou, Zhenjiang, and Huainan.

At the coupling and coordination mechanism level, the coupling and coordination levels of capital flow and carbon emission systems in various industries within the Yangtze River Delta region vary. The overall coupling and coordination levels of manufacturing, power, and finance are relatively low, with most cities being in an uncoordinated state; the coupling and coordination levels of construction and agriculture are relatively higher. The regression analysis results show that the influencing factors of coupling and coordination degrees among different industries have significant differences. GDP has a significant impact on the coupling and coordination of manufacturing, construction, power, transportation, and agriculture, reflecting the important role of economic growth in the development of various industries; local general budgetary revenue and expenditure show different degrees of promotion or inhibition effects in multiple industries; factors such as environmental regulations (such as fine particulate matter concentration), industrial scale (such as social retail sales of consumer goods), and population urbanization also have an impact on the coupling and coordination of specific industries.

6.2 Recommendations

Strengthen regional collaborative governance, optimize the pattern of capital flow and carbon emissions, break administrative barriers, and establish a collaborative governance mechanism for capital flow and carbon emissions in the Yangtze River Delta region. Based on the status of each city in the capital flow network and its carbon emission characteristics, formulate differentiated development strategies. For example, for cities with high capital flow centrality and large carbon emissions (such as Suzhou), guide them to reduce carbon emission intensity through technological innovation and industrial upgrading; for peripheral cities in capital flow, strengthen infrastructure construction and attract low-carbon industry capital inflow to narrow the environmental and development gap between regions and practice the principle of environmental justice.

Build an industry-specific policy implementation system to promote low-carbon transformation, and implement precise policy intervention based on the coupling coordination influencing factors of different industries. Manufacturing needs to break the deadlock of "relying on high-carbon industries for fiscal revenue growth and suppressing low-carbon investment through expenditures", build a "fiscal-industry" collaborative policy, incorporate the low-carbon transformation goal into the hard constraints of local fiscal budgets, and increase fiscal support for green manufacturing technology research and development; the construction industry should build a "economic-environment-building" tripartite governance system, strengthen the backward pressure mechanism of environmental regulations on low-carbon transformation, and at the same time, through consumption-side policies, enhance the demand for green buildings; the power industry needs to build a "economic-transportation-power" collaborative policy framework, optimize the energy structure, and reduce the potential inhibitory effect of passenger scale expansion on the low-carbon development of the power industry; the transportation industry should promote "economic-fiscal-transportation" coordinated development, optimize the fiscal expenditure structure, and improve the low-carbon efficiency of infrastructure investment; the agricultural sector needs to strengthen "economic-environment-fiscal" collaborative governance, through fiscal subsidies and other policies, encourage the application of low-carbon agricultural technologies; the financial industry should build a "fiscal-financial" linkage mechanism, innovate carbon financial products, incorporate green financial indicators into local fiscal performance evaluations, carry out pilot carbon flow accounting in the financial industry, and leverage finance to support the low-carbon economy.

Improve the supervision and assessment mechanism of environmental justice, establish an environmental justice assessment system covering indicators such as environmental rights distribution and regional development fairness, and regularly assess the coordinated development of capital flow and carbon emissions in the Yangtze River Delta region. Strengthen the supervision of environmental risks during capital flow, prevent developed regions from unjustly transferring environmental burdens to less developed regions through capital transfer.

Encourage public participation in environmental governance, ensure the right to information, participation and supervision of residents in each region in environmental decision-making, and ensure that the principle of environmental justice is effectively implemented in the coordinated development of capital flow and carbon emissions.

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Research on the Outdoor Wind Environment of Buildings under the Influence of Hills: The Beigushan Hill in Nanjing

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Abstract
In urban planning and architectural design, mountains in complex terrains significantly impact buildings' outdoor wind environments, but research on hill-building interactions remains limited. Taking Beigushan Hill in Nanjing as the research object, this study uses CFD simulation to comprehensively explore the effects of factors like mountain height, building height, and building canyons on outdoor average wind speeds around buildings. It finds that Beigushan's unique terrain forms a high-speed zone on its leeward side, with a hilltop speed-up effect significantly increasing wind speeds around leeward buildings. The interplay of various factors jointly shapes the wind environment. The results provide a scientific basis for architectural design and planning under complex terrain conditions.

Key words: Complex Terrain; Outdoor Wind Environment of Buildings; CFD Simulation

1 Introduction

In the field of urban planning and architectural design, the impact of complex terrains on the outdoor wind environment of buildings is of great significance. Mountains, as common complex terrains, interact with buildings, altering wind direction, wind speed distribution, and pressure changes in the wind field (Alavi et al., 2024; Talwar & Yuan, 2024), and exerting a significant influence on climate-adaptive planning (Guo et al., 2025; Sun et al., 2011), urban thermal-wind environment (Guo et al., 2023; Mei et al., 2025; Sun et al., 2011), natural ventilation of buildings (Lin et al., 2020), pollutant dispersion (Kim et al., 2001), and pedestrian-level wind conditions (Baş et al., 2024; Mittal et al., 2018). Therefore, studying the outdoor wind environment of buildings influenced by mountains can provide a scientific basis for practical engineering optimization and planning decisions.

Complex terrains can modify the dynamic characteristics of atmospheric flow and affect the distribution patterns of wind fields at different spatial resolutions. Taking Nanjing as an example, as shown in Table 1, common terrains include steep terrain, hilly terrain, and low-lying irregular terrain covered by the city (Talwar & Yuan, 2024). Numerous studies have delved into wind field simulations under complex terrain conditions. For instance, literatures (Mei et al., 2025; Kim et al., 2001; Min et al., 2024; Blocken et al., 2015; Conan et al., 2016) have strived to reveal the influencing mechanisms on the wind environment and proposed specific challenges and application directions respectively. Min Zhong and Minghui Lin conducted wind tunnel tests on low-rise buildings in mountainous terrains in coastal areas (Min et al., 2024) and successfully established wind-resistant design criteria for low-rise buildings in mountainous areas; Tanya Talwar and Chao Yuan focused on the natural terrain of high-density residential areas in Singapore and found that the terrain effect is more pronounced under buoyancy-driven conditions (Talwar & Yuan, 2024); Jae-Jin Kim et al. used a two-dimensional numerical model to clearly illustrate the influence laws of hill slopes, building layouts, and their interactions on airflows and pollutant dispersion (Kim et al., 2001).

However, existing research findings are largely confined to aspects such as wind speed profiles, turbulence characteristics, and pressure distributions. Due to the complexity of mountain structures, differences in wind tunnel setups, and the diversity of boundary condition settings, these studies are difficult to compare directly. More crucially, most of the previous research has focused on the impact of relatively high mountains on the wind environment of high-density buildings. There remains a significant research gap regarding the interaction and potential impact between relatively low - lying mountains and buildings, which urgently requires in - depth exploration.

Table 1. Common Terrain Characteristics in Human Settlements (Taking Nanjing as an Example)

Common Terrain Characteristics in Human Settlements	Geographical Concept Definition	Examples in Nanjing
Type I: Steep Terrain	Small mountain ranges generally with an altitude of less than 1000 meters and a relative height of > 200 meters	Such as Zijin Mountain, etc.
Type II: Hilly Terrain	Generally with an altitude of less than 1000 meters and a relative height of < 200 meters	Such as Fangshan Mountain, Mufu Mountain, etc.
Type III: Low - lying Irregular Terrain Covered by the City	Generally with an altitude of less than 100 meters, a relative height of 10 - 60 meters, and a ground slope of 5° - 15°	Such as Qingliang Mountain, Shijingshan Mountain, Beigushan Hill, etc.

This study focuses on the impact of low-lying mountains (hills) within urban building clusters on the average wind speed. Taking Beigushan Hill in Nanjing as an example, it deeply analyzes the influence of factors such as mountain height, building height, and building canyons on the outdoor wind environment of buildings. Section 2 will detail the computational settings and parameters of the numerical simulation; Section 3 will analyze the research results and discuss the role of each influencing factor; Section 4 will summarize the main findings and conclusions.

2. CFD Simulation: Computational Settings and Parameters

2.1 Computational Geometry, Domain, and Grid

The study area is located in Beigushan Hill, a southern branch of the Mufu Mountain range in the north of Nanjing City, Jiangsu Province, China. Its longitude and latitude range from 118° 47' 2.89" to 118° 47' 37.34" E and from 32° 6' 14.42" to 32° 6' 45.83" N, with a total area of 0.351 square kilometers. Nanjing is in the subtropical monsoon climate zone. Meteorological data required for this study, such as air properties, wind direction and speed, temperature, and humidity, are all sourced from the publicly available data of Jiangsu Meteorological Station. In the simulation, the wind direction is set as the dominant summer wind direction in Nanjing - the southeasterly monsoon (θ = 22.5°). The computational geometry of the mountain is constructed based on the digital elevation data with a spatial resolution of 30m provided by ASTER GDEM V3.

In this study, a multi-storey residential building model with a length of 40m × width of 12m × height of 24m was constructed to depict the spatial characteristics of the residential area around the mountain. The longitudinal spacing of all buildings is set at 32m, and the transverse spacing is 40m. This size layout strictly adheres to the requirements of the existing residential design code (Ministry of Housing and Urban-Rural Development of the People's Republic of China, 2018).

Based on this layout, the study further explores the influence of relevant factors such as mountain slope, building height, and building canyons on the wind environment. The specific parameter changes and model settings are detailed in Table 2.

Table 2. Parameter Changes and Model Settings

Parameter Changes	Model Settings
Basic Working Conditions	A1: Building height is 24m, mountain height is H
Changes in Mountain Height (Slope)	B1: Building cluster remains unchanged, mountain height is 0.5H B2: Building cluster remains unchanged, mountain height is 2H
Changes in Building Height	C1: Mountain remains unchanged, building height is 18m C2: Mountain remains unchanged, building height is 30m
Changes in Building Canyons	D1: Building orientation is perpendicular to the incoming wind D2: Building orientation is perpendicular to the incoming wind and arranged staggeredly D3: Based on A1, the building orientation remains unchanged, and the local building canyon morphology on the leeward side of the mountain is changed
Ideal Mountain	E1: Three sinusoidal - shaped mountain peaks, height is H

In the process of constructing the CFD simulation model, the modeling experience of existing CFD studies on complex terrains and urban forms [1, 12, 14-15] was drawn upon. As shown in Figure 1-a, the computational domain and boundary conditions were set following these principles: The inlet boundary and side boundaries were set at a distance of 30H (H is the mountain height) from the building cluster to ensure that the flow is fully developed and the side-boundary effect is eliminated before reaching the reference wind - measuring tower M0. The outlet boundary was set at a distance of 60H from the building cluster to ensure that the flow is fully developed in the wake region. The height of the computational domain is 12H. After calculation, the blockage ratio is in the range of 2.7-2.9, meeting the industry standard requirement of being less than 3%. The computational domain size and the number of meshes were effectively reduced through a working - condition-based modeling strategy. The computational domain was meshed with hexahedral meshes, and local refinement was carried out at the buildings and the mountain. The minimum mesh size is 5m, the maximum size is 50m, and the expansion coefficient of adjacent meshes is controlled at 1.2 (Figure 1-b). For different working - condition settings, the total number of meshes ranges from 1.6 million to 2 million cells, and the average mesh volume quality is greater than 87%.

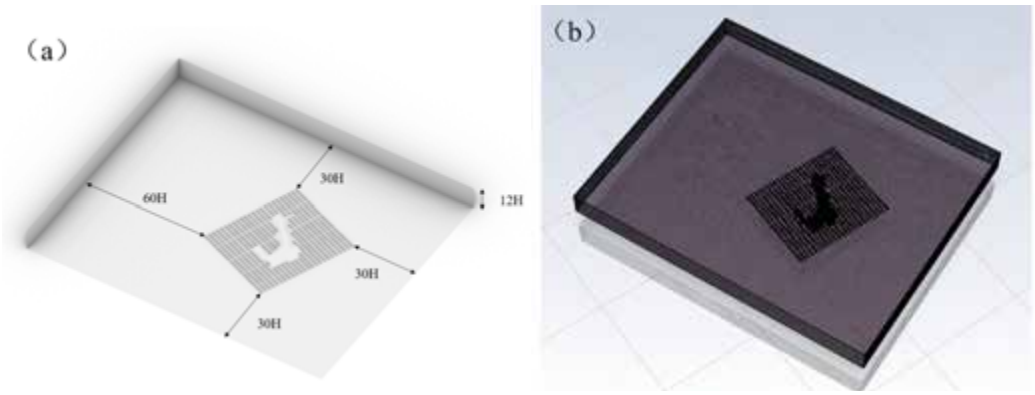

Figure 1. Computational Domain Setup (a) Size of the Computational Domain (b) Meshing and Local Refinement

2.2 Boundary Conditions and Solver Settings

At the inlet of the computational domain, the equations of Richards and Hoxey (1993) were used to impose the inlet profiles of the vertical wind speed profile U, turbulent kinetic energy k, and turbulent dissipation rate ε:

$$U(z) = \frac{U^*}{K} ln\left(\frac{z+z_0}{z_0}\right) \quad (1)$$

$$k(z) = \frac{U^{*2}}{\sqrt{C\mu}} \quad (2)$$

$$\varepsilon(z) = \frac{U^{*3}}{K(z+z_0)} \quad (3)$$

$$U^* = K \frac{U_{ref}}{\left(\frac{H_{ref}+z_0}{z_0}\right)} \quad (4)$$

where *K* is the von Karman constant, typically with a value between 0.40 ± 0.02. In this paper, the value is 0.42; *z* is the height at which the velocity is calculated (m); *Z(0)* is the aerodynamic roughness length (m), which varies depending on the landscape. In this paper, the value is 1 to represent a closed landscape, such as a mature forest, homogeneous city, and village; *Cμ* is the turbulent viscosity constant with a value of 0.09; *U** is the friction velocity, calculated by Equation (4), and the value is 0.49.

Symmetry boundary conditions were imposed on the top and sides of the domain. At the outlet boundary of the domain, a pressure - outlet condition was adopted. For the floor and building surfaces, a no - slip wall boundary condition was used. The commercial CFD code ANSYS/Fluent was used to solve the 3D steady-state Reynolds-Averaged Navier-Stokes (RANS) equations by means of the control volume method. The realizable k-Δmodel was selected to close the equations. For the convective and viscous terms of the governing equations, a second-order discretization scheme was employed. The pressure-velocity coupling adopted the COUPLED algorithm, and standard pressure interpolation was used. The simulation was run continuously until the residuals stabilized and reached a convergent state. Generally, the residual of the continuity equation is equal to or less than 10(-3), and the residuals of the velocity components \(k\) and \(\varepsilon\) are lower than 10(-5).

3. Results and Discussion

3.1 Influence of Beigushan Hill's Terrain on Wind Speed

Beigushan Hill has a unique terrain with four sub-peaks. As shown in Figure 2a, three distinct high-speed bands are generated on its leeward side. From the perspective of aerodynamic principles, due to their special terrain orientation and spatial positions, the northernmost and westernmost peaks have a more significant obstructive and guiding effect on the airflows compared to the two middle peaks, thus resulting in a more prominent acceleration effect on the leeward side. When only the mountain is present, according to the principle of flow around an object in aerodynamics, the mountain forms a shielding effect on the airflows on its leeward side, leading to a decrease in wind speed on the leeward side. However, when a low-height mountain is embedded in the building cluster, the hilltop wind-acceleration effect comes into play (Figure 2b). This effect stems from the fact that when the airflow passes over the hilltop, the streamlines are compressed. According to Bernoulli's principle, the flow velocity increases and the pressure decreases, creating a high-wind-speed zone around the leeward-side buildings in the wake region of the mountain peak. Quantified by data, under the condition of a pure building cluster without a mountain, the overall average wind speed in the study area is 0.552 m/s, which increases to 0.646 m/s when a mountain is present, with an increase of 17.04%.

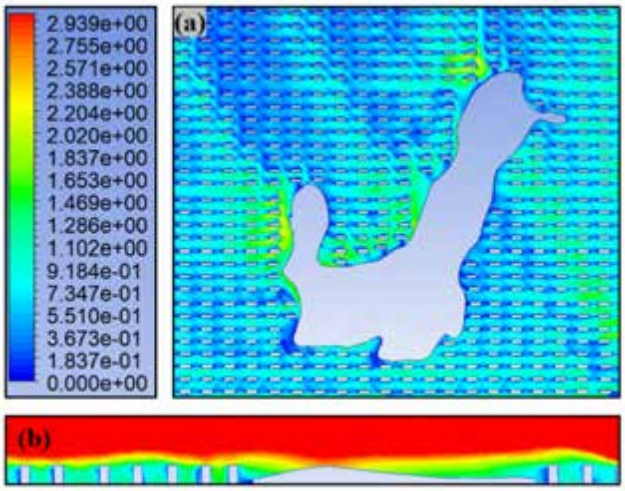

Figure 2. Wind Speed Results (m/s) for Basic Working Condition A1 (a) z=1.5m (b) y-z, x=1340m

For a uniform building array, as shown in Figure 3a, it exhibits a significant wind - blocking effect. The wind speed in the study area decays from 4-4.5 m/s in the free-stream to 0.5-1m/s, which is in line with the expectations of the Urban Canopy Model (UCM). It is worth noting that when the building cluster forms a specific angle with the incoming wind direction, due to the complex flow-around and wake-flow effects among the buildings, a high-wind-speed band will be formed in its wake region. This phenomenon should be avoided as much as possible in future experimental designs to prevent interference with the study of other factors.

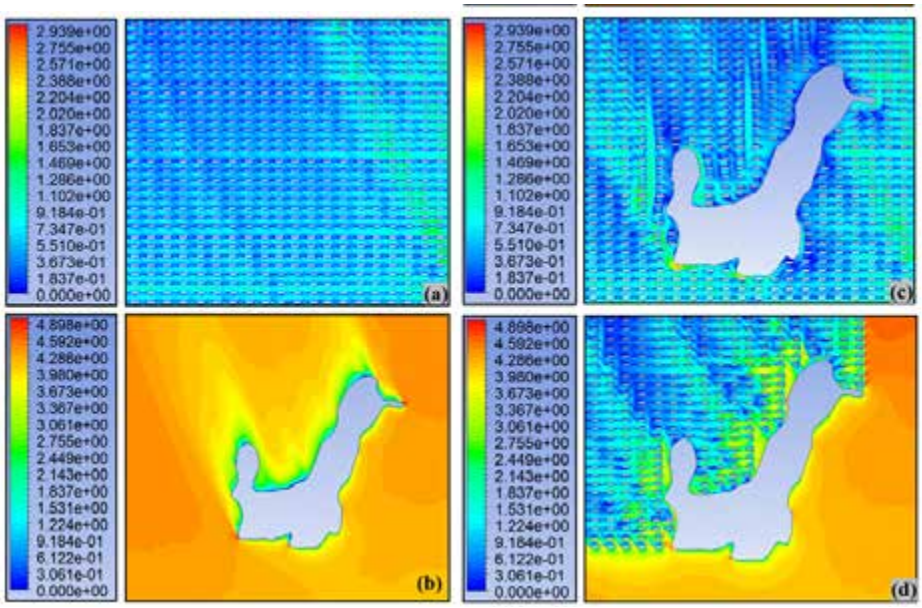

Figure 3. Wind Speed Results (m/s) for Model Validation (a) Wind speed at z=1.5m with only building clusters (no mountain) in the study area (b) Wind speed at z=1.5m with only the mountain (no building clusters) in the study area (c) Wind speed at z=1.5m when the mountain has no slope but a height of H (only mountain shape retained) (d) Wind speed at z=1.5m when buildings on the windward side of the mountain are removed

When only the mountain is present (Figure 3b), it shelters the leeward area. The windward region maintains free-stream wind speeds as it is undisturbed by buildings. On the leeward side, airflow is blocked by the mountain, causing separation and recirculation, reducing the average wind speed from 4-4.5 m/s (upwind) to 1-4 m/s—a 75% decrease from the free stream.

Although a deceleration zone also exists on the mountain's windward side, its size is smaller due to the relatively small windward surface and limited airflow obstruction, with an average wind speed reduction of only 0.5-1 m/s. Meanwhile, local high wind speed points form on both sides of the mountain due to flow-around and acceleration effects.

In scenarios where the mountain interacts with buildings (Figure 3c), corner flow acceleration and airflow separation mechanisms increase local wind speeds on the western side of the mountain. The accelerated airflow experiences a Venturi effect as it passes through mountain-building air ducts. Narrow channels formed by downstream building gaps further concentrate the airflow, creating a sustained high-speed zone.
Simulations with windward-side buildings removed (Figure 3d) still clearly show an acceleration zone on the mountain's leeward side with an unchanged spatial distribution trend. This confirms that the mountain's inherent topographic acceleration effects (e.g., hilltop acceleration, corner flow acceleration) are the primary drivers of the leeward acceleration zone. Without windward buildings to decelerate airflow, wind speeds behind the mountain are higher than in the basic case (A1, Figure 2a). Thus, windward buildings primarily affect local wind speed reduction and have limited impact on the airflow structure of the leeward side, while the leeward high-speed zone is driven mainly by terrain-building coupling effects (e.g., air duct acceleration, separation-reattachment flow).

3.2 Influence of Mountain Height on Hilltop Wind Acceleration Effect

There is a significant positive correlation between the hilltop wind acceleration effect and mountain height (Figure 2a; Figure 4a-b). When the mountain height is 0.5H (Figure 4a), the intensity and continuity of the high wind speed band on the leeward side are weaker compared to Case A1 (Figure 2a) at pedestrian level. This is because lower mountains have limited airflow acceleration capacity and cannot form stable or intense acceleration zones.

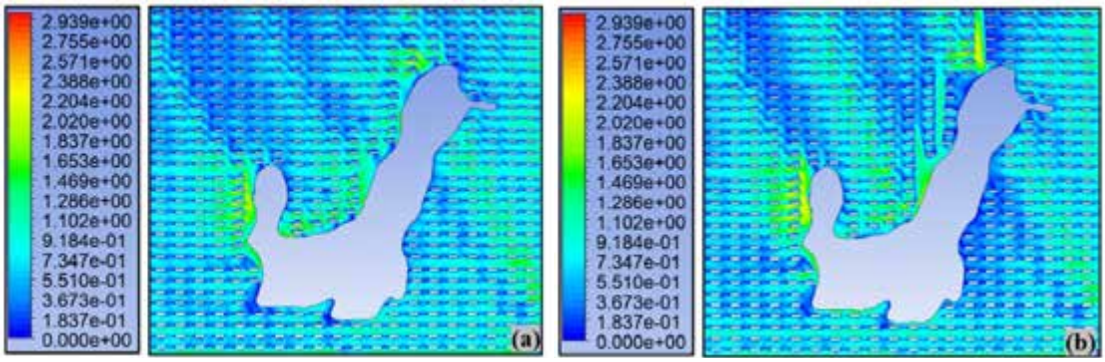

Figure 4. Wind Speed Results (m/s) for Mountains of Different Heights (a) C1 z=1.5m (b) C2 z=1.5m

When the mountain slope in B2 increases to 2H (Figure 4b), the wind speed increase at the hilltop becomes more pronounced, and the spatial continuity and intensity of the high wind speed band on the leeward side are enhanced. In the B1 case, even though the mountain height (18m) is lower than the building height (24m), according to the aerodynamic characteristics of airflow around obstacles of different heights, an acceleration zone on the leeward side of the mountain can still be observed, fully demonstrating that the acceleration effect exists even when the mountain is lower than the buildings.

3.3 Influence of Building Height on Wind Speed Distribution

When studying the influence of building height on wind speed, in C1, the building height is reduced to half of the mountain height (Figure 5a). The distribution trend of the high wind speed band on the leeward side of the mountain is the same as that in the basic working condition A1 (where the building height is 2/3H=24m), and the overall wind speed in the area increases. This is because lower buildings weaken the blocking effect on the airflow, increasing the overall wind speed. In C2, the building height is increased to be close to the mountain height (Figure 5b), and the intensity of the high wind speed band on the leeward side of the mountain increases slightly, but the effect is not significant.

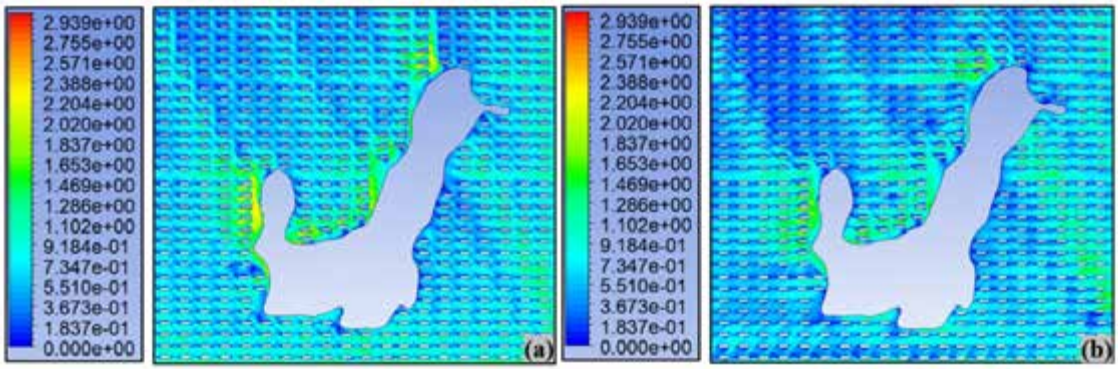

Figure 5. Wind Speed Results (m/s) for Buildings of Different Heights (a) C1, z=1.5m (b) C2, z=1.5m

Meanwhile, due to the enhanced building shielding effect, the overall wind speed in the area decreases, and the area of the calm wind zone increases. In the leeward building canyons, the continuity of the acceleration zone in C2 is significantly enhanced, with accelerated winds flowing westward; in the building canyons of C1, the accelerated winds flow northwestward. This difference may arise from the varying guidance and constraint effects of building canyons on airflow at different building heights.

3.4 Influence of Building Orientation on Wind Speed Distribution

In D1 and D2, the building orientation is changed to be perpendicular to the incoming wind direction. Under D2 conditions, where buildings are arranged in a staggered manner and there is no building canyon acceleration effect on the windward side of the mountain (dominated solely by the hilltop wind acceleration effect), the acceleration zone on the leeward side of the mountain is smaller, with a horizontal extension of approximately 4H (Figure 6b). Figure 6a clearly demonstrates the canyon acceleration effect of buildings: after the incoming wind is accelerated through the windward building canyons of the mountain and then further accelerated by the hilltop, the wind speed in the leeward building canyons reaches 3.5 m/s, significantly extending the length of the acceleration zone to a horizontal range of approximately 14H–26H. In areas without hilltop wind acceleration on both sides of the mountain, where the incoming wind is only accelerated by building canyons, the acceleration effect only persists for a short distance, and wind speeds around buildings farther from the velocity inlet tend to return to lower levels.

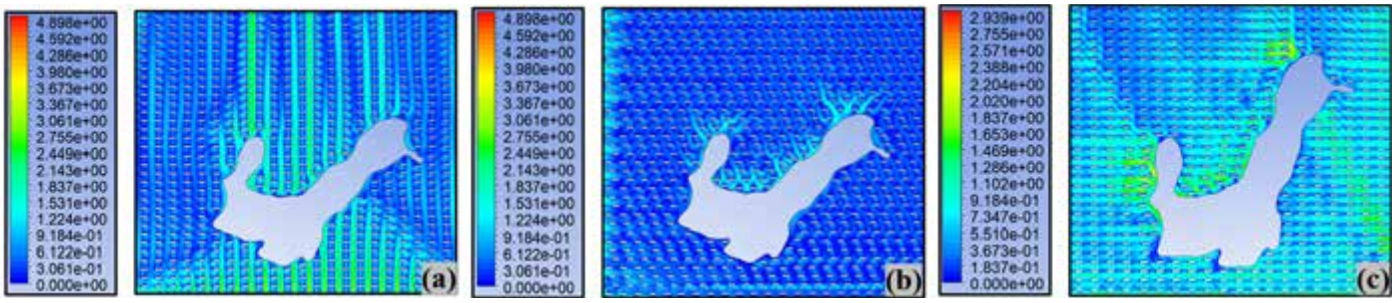

Figure 6. Wind Speed Results (m/s) for Modified Building Canyons (a) D1, z=1.5m (b) D2, z=1.5m (c) D3, z=1.5m

When the mountain and buildings form a continuous air duct, the acceleration zone extends significantly, clearly indicating that the high wind speed band on the leeward side is synergistically enhanced by the hilltop wind acceleration effect and the air duct effect (Figure 6c).

3.5 Comparison of Wind Speed Conditions Between Idealized Mountain and Standard Case

Three distinct high wind speed bands form on the leeward side of the idealized mountain, consistent with the trend observed in the standard case A1 (Figure 7a). Notably, the acceleration zone behind Peak 3 exhibits significantly higher wind speeds than those behind the other two peaks. This is because the incoming wind, pre - accelerated by the upstream buildings, is rapidly accelerated again by the hilltop, resulting in a synergistic effect that greatly enhances the acceleration (Figure 7).

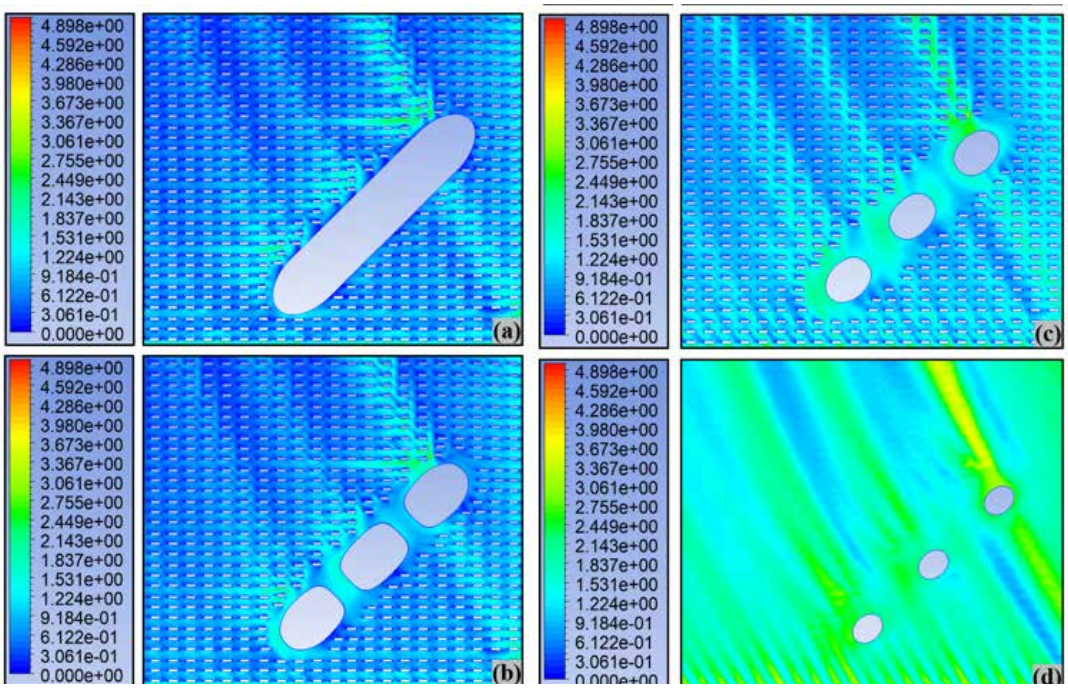

Figure 7. Wind Speed Results (m/s) for the Idealized Mountain (a) z =1.5m (b) z=10m (c) z=20m (d) z=30m

4. Conclusions

This study investigates the impact of low-lying mountains within urban building clusters on the surrounding pedestrian-level wind environment. An improved CFD model was used to simulate the urban wind environment, and the influence of multiple factors on the wind environment was analyzed by setting different working conditions. This paper provides a scientific basis for urban planning and architectural design optimization under complex terrain conditions, and lays a foundation for subsequent in-depth research on wind environments under different climatic conditions, more complex terrains, and multi - factor coupling effects, while offering technical references.

The specific research achievements and findings are as follows:

1. When a low-altitude mountain is embedded within a building cluster, the hilltop wind acceleration effect is significant. Compared with pure building conditions, this effect increases the wind speed around leeward buildings and forms high-wind-speed bands.

2. There is a significant positive correlation between mountain height and the hilltop wind acceleration effect. As the slope increases, the wind speed increase at the hilltop becomes more pronounced, and the spatial continuity and intensity of the high-wind-speed bands on the leeward side are enhanced. However, the acceleration effect still exists even when the mountain is lower than the buildings.

3. Changes in building height affect the high-wind-speed bands on the leeward side of the mountain and the overall wind speed in the area. The guiding and constraining effects of building canyons on airflows differ at different building heights.

4. When the leeward side of the mountain is dominated solely by the hilltop wind acceleration effect, the acceleration zone is small in scope. When the mountain and buildings form a continuous air duct, the acceleration zone extends significantly, indicating that the high-wind-speed bands on the leeward side are synergistically enhanced by the hilltop wind acceleration effect and the air duct effect.

In the field of architectural design and planning, the following series of valuable recommendations can be derived from the above research results, aiming to optimize building layouts and designs, improve wind environment quality, and enhance residential comfort and energy utilization efficiency:

1. Ventilative Building Layout: When planning building clusters, locate buildings with high ventilation requirements (such as hospitals and schools) in the high-wind-speed bands on the leeward side of low-altitude mountains to enhance natural ventilation through the hilltop wind acceleration effect.

2. Layout According to Mountain Height: Mountain architectural design should consider the relationship between mountain height and wind acceleration. The leeward side of high-slope mountains is suitable for installing wind power generation facilities. Meanwhile, building heights should be reasonably arranged to prevent excessive obstruction of airflows.

3. Optimized Building Canyon Design: Determine building heights according to functional and ventilation requirements. For example, in commercial pedestrian streets, adjust heights reasonably to guide airflows through building canyons and create a comfortable breeze environment.

4. Creation of Continuous Air Ducts: When planning large - scale building areas (such as residential communities), rationally design building orientations and layouts to form continuous air ducts between mountains and buildings, thereby promoting air circulation.

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Seeking a possible Positive Energy Districts (PEDs) location choice from a local context, a case study in Tainan City, Taiwan

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Abstract
COP28 emphasised the urgent need to accelerate energy transitions and decarbonisation. Cities, as major centres of energy consumption and carbon emissions, have become critical arenas for implementing these transitions. The EU and IEA have actively promoted Positive Energy Districts, shifting the focus from individual buildings to the district scale to enhance energy efficiency. This study focuses on socio-economic indicators and explores key variables influencing residential electricity consumption (REC). Using Tainan City as a case study, it combines rooftop PV generation potential and REC forecasting to evaluate the electricity self-sufficiency rate of each district. The results indicate that only "total household income" shows a significant positive correlation. Future research could utilise more granular data to improve assessment accuracy and provide evidence-based support for urban energy planning.

Keywords: Positive Energy Districts; PEDs potential; Renewable Energy; Spatial Multi-criteria

1 Introduction

The Intergovernmental Panel on Climate Change (IPCC), in its Sixth Assessment Report (AR6) released in 2023, projected that global temperatures are likely to rise by 1.5°C within the next two decades. This increase is expected to intensify climate-related hazards and may further exacerbate challenges related to energy, water resources, and food security.

In response, the 28th Conference of the Parties (COP28) to the United Nations Framework Convention on Climate Change (UNFCCC) emphasised the need for all countries to enhance their Nationally Determined Contributions (NDCs), improve energy efficiency, and adopt new technologies to advance energy transition and decarbonisation efforts. Over 100 countries have now declared net-zero emissions targets, including Taiwan, which has committed to achieving net-zero emissions by 2050. Taiwan's 2050 Net-Zero Emissions Roadmap outlines four major strategies: energy transition, industrial transformation, lifestyle change, and social transition.

According to the International Energy Agency (IEA), cities account for approximately 75% of global energy consumption and 70% of global greenhouse gas emissions. In this context, **cities—being densely populated areas with high energy consumption and concentrated carbon emissions—have emerged as critical arenas for driving energy transitions and realising net-zero goals.** Consequently, institutions such as the European Union and the IEA have initiated a range of urban-centred energy transition policies and pilot programmes. These efforts have evolved from single-building-scale initiatives, such as near-zero energy buildings (NZEBs), to larger, district-scale approaches exemplified by Positive Energy Districts (PEDs).

The European Union, under the Strategic Energy Technology Plan (SET-Plan), has set a goal of establishing at least "100 PEDs" across Europe by 2025. Simultaneously, IEA Annex 83 has been conducting research into the definitions, implementation methods, tools, and technologies associated with PEDs. Projects such as MAKING-CITY have also provided detailed methodologies and procedures for evaluating PEDs, emphasising that such evaluations must consider not only urban form and energy infrastructure, but also the social structures of the target districts.

Nevertheless, most existing studies on PEDs have focused on location suitability assessments based on comprehensive, objective indicators aimed at aiding policymakers in the strategic deployment of PEDs. While these evaluations help identify areas with higher potential for PED implementation, **the Urban Agenda for the EU underscores the critical role of public participation in energy transitions**.

Given the diverse socio-economic conditions across regions, variations in energy use behaviours and public acceptance (Rolf et al., 2007) may significantly influence the feasibility and effectiveness of PED implementation.

However, current studies seldom address the potential influence of local resident characteristics—such as economic status and demographic composition.

This study proposes the following research objectives:

1. To explore the key factors influencing REC from a "socio-economic perspective", with a particular emphasis on how resident structures affect energy behavior. This aims to address the current research gap in PEDs evaluations, which often overlooks the role of residents.
2. To conduct an empirical study in a selected city in Taiwan, integrating REC forecasting and rooftop PV potential analysis to evaluate the "electricity self-sufficiency rate" of each administrative district. The study further assesses the advantages and challenges of administrative districts as potential PEDs units.

2 Literature Review

2.1 Positive Energy Districts (PEDs)

2.1.1 Definition of PEDs

According to the European Commission, a Positive Energy District is defined as "an energy-efficient district that produces more renewable energy than it consumes, while enhancing regional energy system flexibility through smart management and local storage". Meanwhile, the SET-Plan defines PEDs as "energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net-zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy." Based on these definitions, **PEDs refer to geographically connected clusters of buildings with internal energy exchanges, aiming to achieve a net-positive energy status through the efficient and flexible use of renewable energy sources.**

The European Energy Research Alliance (EERA) further categorises PEDs into three types based on differences in geographic boundaries and energy balancing approaches: **PED Autonomous**, **PED Dynamic**, and **PED Virtual**. A PED Autonomous has clearly defined geographic boundaries and achieves complete electricity self-sufficiency within the district, allowing energy export but prohibiting external energy input. By contrast, a PED Dynamic allows energy exchange with other PED systems. A PED Virtual enables energy production and storage systems to be located outside the district while still serving energy needs within the area.

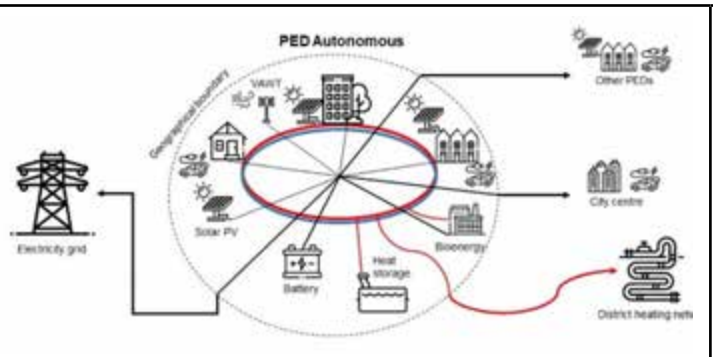

Figure 1. PED autonomous diagram

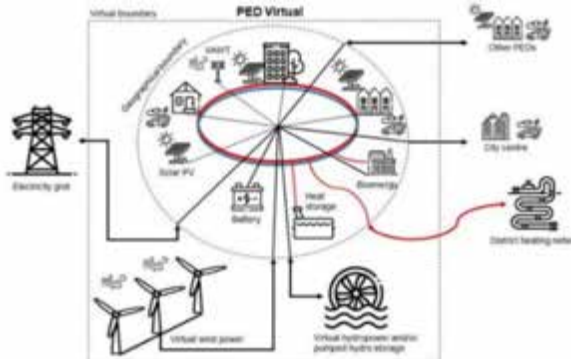

Figure 2. PED virtual diagram

2.1.2 Benefits and Challenges of PEDs

According to the Positive Energy Districts Solution Booklet, compared to achieving zero or positive energy targets at the individual building level, the diverse usage patterns of different building types often make it difficult to reach these goals in isolation, or may lead to energy overproduction and waste. **Therefore, shifting the focus to district- or community-level PEDs allows for more flexible and efficient energy utilisation.**

However, the current definition of PEDs still lacks clarity, particularly concerning "geographic boundaries" (Oscar et al., 2021), which can vary significantly depending on local characteristics. This suggests that a single

PED model may not be applicable across all contexts, and it is essential to consider local conditions during site evaluation. Furthermore, Erkinai et al. (2022) emphasise the importance of accounting for end-users and adopting an area-based policy approach tailored to local conditions, especially regarding fiscal and social dimensions. The study also criticises the idealistic nature of PED Autonomous models, which often overlook urban challenges such as high population density, limited space, and restricted access to renewable energy sources. As a result, the development of "Dynamic and Virtual" PEDs, in conjunction with Virtual Power Plants (VPPs), is regarded as a more viable pathway.

2.1.3 Methods for Evaluating PEDs Locations

Two key uncertainties complicate the definition and planning of PEDs (I. Aparisi-Cerdá et al., 2024). The first is the issue of **geographic boundaries** — the appropriate size and delineation of PEDs may vary depending on city characteristics, which in turn affect the feasibility of renewable energy deployment and local energy consumption. The second is **parameter selection** — identifying suitable PED locations depends on multiple factors across technological, social, economic, and environmental domains, each with a wide array of potential indicators. Therefore, selecting appropriate evaluation indicators is critical in PED planning.

Current methods for identifying promising PED locations often employ Geographic Information System (GIS) overlay analysis (Shnapp et al., 2020; Alpagut et al., 2020). Given the multidimensional nature of these indicators, many studies adopt Multi-Criteria Decision-Making (MCDM) or Multi-Criteria Decision Analysis (MCDA) approaches (Sassenou et al., 2024; I. Aparisi-Cerdá et al., 2024), which combine expert judgement to determine key indicators and their relative weights, followed by quantification and statistical analysis of candidate areas.

2.1.4 Why Taiwan's Urban Context is Suitable for PEDs

Taiwan is heavily reliant on energy imports, and most power plants are located far from the areas where energy is consumed. This spatial separation between energy generation and demand leads to greater transmission losses and, consequently, energy waste. **Given Taiwan's high level of urbanisation and population density, urban areas offer promising opportunities for implementing PEDs that flexibly utilise energy at the district scale.** Additionally, Taiwan faces land scarcity, and the deployment of renewable energy infrastructure often leads to land-use conflicts — particularly with agricultural land — an issue that has drawn strong opposition from environmental groups. Strategically deploying renewable energy in suitable urban areas and managing its distribution efficiently could ease pressure on valuable farmland while helping to safeguard food security.

Among Taiwanese cities, **Tainan stands out for having one of the highest installed capacities of solar photovoltaic systems and considerable solar energy potential.** The local government has taken proactive steps towards urban decarbonisation, including the development of Taiwan's first low-carbon community. However, most solar panels are currently ground-mounted and located in rural areas, far from the urban centres where energy demand is greatest. This spatial mismatch has raised concerns over land use and environmental justice. Consequently, this study selects **Tainan City** as a case area for evaluating potential PED locations. By integrating GIS-based spatial analysis with assessments of renewable energy potential, this research explores the feasibility of implementing PEDs in urban contexts and aims to provide insights for future planning and policymaking in Taiwan.

2.2 Socio-economic Indicators Influencing Residential Electricity Consumption

Residential electricity consumption (REC) is closely linked to household characteristics. Identifying the key factors that significantly influence residential electricity use not only helps to reduce consumption, but can also support forecasting future electricity demand.

Zhifeng et al. (2018) reviewed previous studies on the psychosocial factors influencing residential electricity behaviour. Commonly cited indicators include **household size, presence of children, age of household members, education level, social status, household income, and housing type.** These indicators may have either a positive (i.e. increasing) or negative (i.e. decreasing) effect on electricity use. However, the results vary across regions, indicating that the same indicator may exhibit different effects depending on the local context. This highlights the importance of identifying region-specific influencing factors and exploring the underlying reasons for such variations.

Najeeb et al. (2024) conducted a systematic review of the determinants of REC across South Asia, East Asia, and Southeast Asia, encompassing socio-economic, building-related, locational, and environmental-climatic dimensions. Within the socio-economic domain, several frequently studied indicators were identified. The review found that household income, household expenditure, household size, age of the head of household, and educational attainment of the household head were significantly correlated with electricity consumption. Conversely, indicators such as household size, age of the head, number of children, social class, household occupation, and unit electricity price showed weak or non-significant effects in certain contexts.

In addition, **within the context of the urban energy transition, public perception, acceptance, and willingness to adopt renewable energy are critical social factors. Stakeholders may hold differing attitudes towards renewable energy depending on their roles and interests.** Masoud et al. (2015) found that the acceptance of and willingness to use renewable energy are positively influenced by moral norms, attitudes, and perceived behavioural control (PBC). These factors may be useful in predicting regional willingness to adopt renewable energy technologies.

3 Methodology

3.1 Introduction to the Case Study Area

This empirical case study focuses on the former urban area of Tainan City, encompassing six administrative districts: East District, South District, North District, Annan District, Anping District, and West Central District. The total area of the study region is approximately 176.3 km², with Annan District accounting for the largest share, comprising 60.8% of the total area. As of the end of 2024, the total population of the study area is estimated at around 779,000, with Annan District having the highest population, approximately 203,000. The average population density is around 4,419 people per km².

In terms of building characteristics, the average building age across the area is approximately 33 years. West Central District has the oldest building stock, with an average age of 41 years, while Anping District has the newest, with an average building age of 25 years.

Table 1. List of basic information of the study area

District	Area (km²)	Area proportion	Population	Density (people/km²)	Building average age
East District	13.4	7.6%	181,854	13,556	33
South District	28.0	15.9%	120,151	4,285	36
North District	10.4	5.9%	125,801	12,057	33
Annan District	107.2	60.8%	203,882	1,902	28
Anping District	11.1	6.3%	70,435	6,365	25
West Central District	6.2	3.5%	77,212	12,478	41
Total	176.3	100.0%	779,335	4,419	33

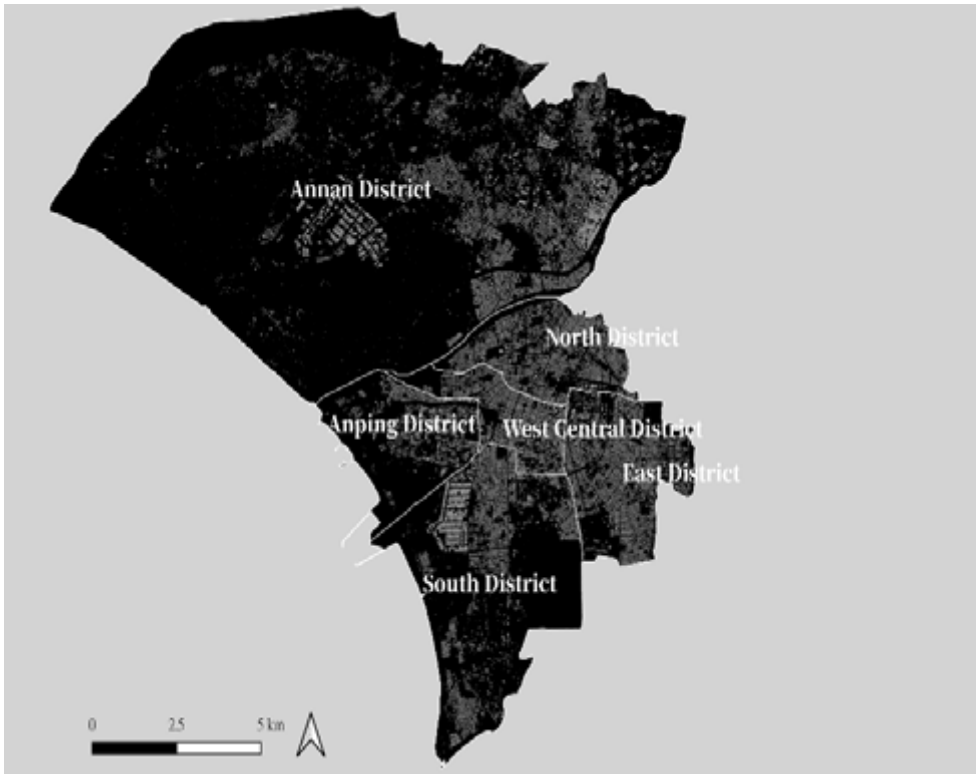

Figure 3. Case Study Area

3.2 Forecasting Trends in REC

Trends in REC are analysed using historical electricity sales data provided by Taiwan Power Company (Taipower). Based on Taipower's statistics, this study calculates annual growth rates from the historical data and applies them to project future electricity demand.

Due to a revision in the statistical reporting format in September 2020, data prior to that date differ substantially in classification and structure, and are therefore excluded from the growth rate calculation. **The study uses the average annual growth rate between 2021 and 2024 for each administrative district to estimate future trends. An exponential growth model is employed to forecast REC from 2025 to 2030.**

3.3 Correlation Analysis Between REC and Socio-economic Indicators

Assuming that Taipower's electricity sales data accurately reflect actual electricity consumption, this study adopts residential electricity sales as the dependent variable to assess the impact of socio-economic indicators on REC. The 2024 residential non-commercial electricity sales figures from Taipower serve as the dependent variable.

Socio-economic indicators are used as independent variables, selected through a review of relevant literature and contextualised for the Taiwanese setting. **Five key dimensions are considered: children, age of household, household size, educational level, and household income.** Each dimension comprises specific evaluation indicators, as illustrated in Figure 5 below.

The most recent data available from official statistical sources are utilised in the analysis. The data are then processed using SPSS statistical software to conduct a **correlation analysis**, examining both the **statistical significance** and the **direction** (positive or negative) of the relationship between each indicator and residential electricity consumption

Table 2. List of socioeconomic indicators in this study

Dimension	Indicators (Year)
Children	• Proportion of population aged 0~15 (2024) • Average number of children per household (aged 0~15 population / number of households) (2024)
Age of household	• Proportion of population aged under 50 (2024) • Proportion of population aged 51~64 (2024) • Proportion of population aged 65 and above (2024)
Household size	• Average number of persons per household (2024)
Education level	• Proportion of permanent residents with higher education (college and above) (2010)
Household income	• Total household income (NTD) (2021)

3.4 Estimation of rooftop PV Generation and Self-Sufficiency Rate

This study utilises government-provided 3D spatial data to estimate the rooftop area of buildings within each administrative district. Based on these estimations, relevant parameters are applied to calculate the potential annual electricity generation from rooftop photovoltaic (PV) systems in each district.

By comparing the estimated rooftop PV generation with REC, the self-sufficiency rate for each district is derived. Furthermore, the study conducts a series of scenario simulations to explore how variations in electricity generation and REC may influence the self-sufficiency rate.

Table 3. Summary of scenario assumptions

Scenario		Electricity generation	REC
Baseline		10% of the rooftop PV area of existing buildings	Actual REC in 2024
Scenario 1 (Pessimistic)	Generation unchanged REC increased	10% of the rooftop PV area of existing buildings	Estimated REC in 2030
Scenario 2	Generation increased REC increased	25% of the rooftop PV area of existing buildings	Estimated REC in 2030
Scenario 3 (Optimistic)	Generation increased REC unchanged	25% of the rooftop PV area of existing buildings	Actual REC in 2024

4 Results

4.1 Forecasting Trends in REC

An analysis of residential electricity sales from 2021 to 2024 across the six districts (Figure 8) reveals that Annan District consistently recorded the highest consumption, followed by East District, with Anping District having the lowest. Regarding growth rates, East and North Districts exhibited negative growth between 2021 and 2023, whereas Annan, Anping, and West Central Districts showed increases. However, all six districts experienced growth between 2023 and 2024.

Based on these trends, the average growth rate over the past three years was calculated for each district (Figure 7). Annan District recorded the highest average growth rate at 2.58%, while East District had the lowest at 0.27%. **These findings indicate that Annan District not only has the highest consumption but also the fastest growth, whereas East District, despite high consumption, shows signs of a declining trend.**
Future REC from 2025 to 2030 is projected using an exponential growth model based on the calculated average growth rates (Figure 9).

Table 4. Average REC growth rate of each district from 2021 to 2024

District	2021-2022	2022-2023	2023-2024	Average
East District	-1.5%	-0.5%	2.85%	**0.27%**
South District	-1.7%	0.3%	2.83%	**0.47%**
North District	-1.3%	-0.5%	2.67%	**0.29%**
Annan District	1.2%	1.7%	4.91%	**2.58%**
Anping District	0.4%	0.3%	4.96%	**1.89%**
West Central District	0.4%	0.1%	2.83%	**1.11%**

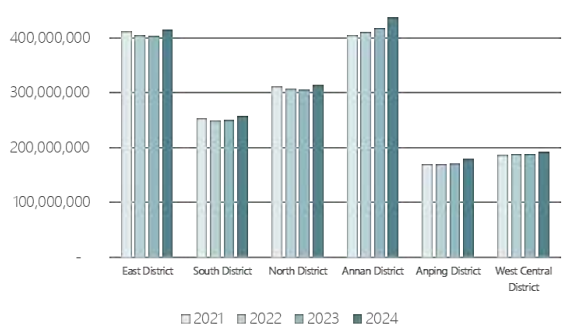

Figure 4. Residential electricity sales from 2021 to 2024

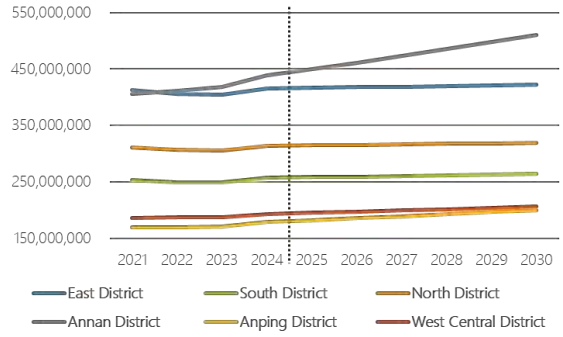

Figure 5. Estimated REC from 2025 to 2030

4.2 Correlation Analysis Between REC and Socio-economic Indicators

Using Pearson's correlation analysis, the relationships between eight indicators across five dimensions and residential electricity consumption were examined. The results show that only the variable *Total Household Income* had a significant positive correlation with REC (Pearson r = 0.814, p = 0.049 < 0.05), consistent with findings from previous literature. All other indicators did not show statistically significant correlations.

Table 5. Pearson correlation results

Dimension	Indicators (Year)	Pearson correlation	Significance (two.sided)
Children	Proportion of population aged 0-15 (2024)	0.214	0.683
	Average number of children per household (aged 0-15 population / number of households) (2024)	0.418	0.410
Age of household	Proportion of population aged under 50 (2024)	0.507	0.305
	Proportion of population aged 51-64 (2024)	-0.520	0.290
	Proportion of population aged 65 and above (2024)	-0.273	0.601
Household size	Average number of persons per household (2024)	0.671	0.145
Education level	Proportion of permanent residents with higher education (college and above) (2010)	-0.046	0.930
Household income	Total household income (NTD) (2021)	0.814	0.049*

* Significance (two.sided) <0.05 was significant

4.3 Estimation of Rooftop PV Generation and Self-Sufficiency Rate Analysis

4.3.1 Estimation of Rooftop PV Generation

The potential rooftop PV generation for each district was estimated by first calculating the available rooftop area using government-provided spatial data, then applying the following formulas:

Estimated Rooftop PV Installation Capacity (kW)= Rooftop area × 0.5 / 10
(0.5: proportion of usable rooftop area; 10 m²/kW: area-to-capacity conversion factor)

Estimated Annual Electricity Generation (kWh)= Installation Capacity (kW) × Average Annual Output per kW
(Average Annual Output = 1,246 kWh/kW)

4.3.2 Electricity Self-Sufficiency Rate Analysis

Three simulation scenarios were conducted to evaluate changes in self-sufficiency rates. In the most optimistic scenario (Scenario 3), Annan District reached a self-sufficiency rate of 40%, while Anping District reached only 17%. **The improvement in self-sufficiency ranged from 26.8% in Annan to 10.9% in Anping, highlighting significant regional disparities in the potential for electricity self-sufficiency.**

Table 6. Electricity Self-sufficiency rate results under different scenarios

District	Area (km²)	Baseline	Scenario 1	Scenario 2	Scenario 3
East District	13.4	**7.82%**	7.69%	19.24%	19.55%
South District	28.0	**12.92%**	12.56%	31.40%	32.30%
North District	10.4	**8.00%**	7.86%	19.66%	20.00%
Annan District	107.2	**16.38%**	14.05%	35.13%	40.94%
Anping District	11.1	**6.81%**	6.09%	15.22%	17.03%
West Central District	6.2	**9.01%**	8.43%	21.07%	22.52%

5 Discussion & Conclusion

This study focuses on two key analyses:
(1) The correlation between REC and socio-economic indicators; and
(2) the assessment of electricity self-sufficiency rates under varying rooftop PV generation and REC scenarios across administrative districts.

The first analysis reveals a generally weak correlation between REC and socio-economic indicators at the administrative district level, except for a significant positive correlation between "total household income" and REC. This suggests that households with higher income levels tend to consume more electricity, likely due to their greater ability to afford electricity costs. Conversely, lower-income groups may exhibit higher sensitivity to electricity pricing, indicating disparities in energy affordability. Furthermore, **the lack of significant associations across most indicators implies that the administrative district scale may be too general to identify the key social-economic factors behind PEDs.** Future research could develop and utilize sub-district level data to improve the accuracy and contextual appropriateness of PEDs.

The second analysis estimates the electricity self-sufficiency rates of each district under different rooftop PV generation and consumption scenarios. The results reveal substantial disparities among districts, likely stemming from differences in historical urban development, and zoning regulations that have led to varied urban forms. Consequently, building types and resident demographics differ significantly across districts. These findings underscore that territorial characteristics play a crucial role in shaping PEDs outcomes, particularly in electricity self-sufficiency. **Moreover, the analysis shows that in urbanized areas of Taiwan, electricity consumption cannot be met solely through rooftop PV generation within administrative boundaries. This highlights the necessity of integrating additional renewable energy sources and electricity-saving measures to achieve positive energy targets.**

In summary, this research uses the administrative district as the unit for evaluating PEDs feasibility, aiming to assess whether such spatial units can serve as the operational basis for implementing PEDs. Aparisi-Cerdá et al. (2024) also suggest that using administrative boundaries is practical due to the availability of statistical data and familiarity among experts, which simplifies the research process. The study further finds that smaller spatial units do not necessarily yield higher self-sufficiency rates. For instance, Annan District—the largest in area among the six studied districts—achieved the highest electricity self-sufficiency rate. However, from an operational standpoint, larger districts may contain more variables, such as higher population diversity and more complex stakeholder dynamics, potentially increasing implementation challenges. Figure 12 summarises the advantages and challenges of using administrative districts as the evaluation unit for PEDs, as well as potential improvements needed to better achieve PED objectives in the future.

Table 7. Summary of Advantages and Challenges of Using Administrative Districts as Statistical Units for PEDs Assessment

Aspect	Advantages	Challenges and Suggestions
Policy Alignment	Using administrative districts for local energy planning enables strong alignment with existing urban planning frameworks. This compatibility facilitates the direct integration of policy objectives and enhances the effectiveness of implementation and oversight.	The delineation of administrative boundaries does not necessarily align with the actual boundaries of energy systems, which may lead to ambiguity in planning, management. Future assessments of PEDs may need to establish formalized, cross-regional energy governance frameworks, including legal agreements and decision-making platforms.
Accessibility of Data	As administrative districts are standard statistical units used by Taiwanese government agencies, data related to them are readily accessible, stable over time, and diverse in scope. This supports systematic analysis of energy demand and socio-economic conditions relevant to PEDs, while also enabling effective policy tracking and impact evaluation.	Due to the differences of administrative districts in terms of size and characteristics, aggregated data at the district level may mask high-potential or high-vulnerability areas, thus reducing the precision of strategic planning. It is therefore essential to develop and utilize sub-district level data—such as neighborhoods, communities, or urban renewal units—to improve the accuracy and contextual appropriateness of PEDs' energy demand and management strategies.
Spatial Scope	Administrative districts typically encompass diverse land-use types such as residential, commercial, and industrial districts, which is beneficial for modelling and implementing PEDs that require energy integration, and distribution across heterogeneous areas. The district-scale spatial boundary also provides the spaces for deploying renewable energy infrastructure, such as solar PV systems, and energy storage.	Large spatial scopes and high land-use diversity make implementing PEDs more difficult due to the variety of energy needs and increased technical challenges. Future efforts should identify sub-areas within administrative districts that demonstrate relative strengths or vulnerabilities and incorporate microgrid development to gradually enhance energy resilience and increase the overall self-sufficiency rate within districts.
Cross-District Coordination and Stakeholder Engagement	Since energy is a transboundary resource, infrastructures such as electricity grids, and thermal networks, often extend beyond administrative boundaries. However, administrative districts possess well-defined local governance structures, allowing them to better coordinate and negotiate in different districts. They can also act as intermediaries for establishing cooperation frameworks with higher levels of government.	When renewable energy infrastructure is across administrative boundaries, challenges often arise related to cost and benefit allocation, and the high coordination costs associated with diverse stakeholders. Future strategies should include the formulation of cooperation agreements, transparent mechanisms for revenue and responsibility sharing, and stakeholder engagement frameworks to reduce resistance and foster PEDs deployment.

6 Limitations and Future Research

Although international definitions of PEDs currently distinguish between three types, there is still no unified standard regarding the appropriate spatial scale or delineation method. Xingxing et al. (2021) reviewed 60 PEDs projects in Europe and found that more than half of them occupy less than 1 km², with only five exceeding 5 km² in size. By contrast, even the smallest administrative district in this case study spans over 6 km²—significantly larger than most European cases. The variation in district size is also reflected in the differences in electricity self-sufficiency, reinforcing the critical role of "urban context" in PEDs planning. This study suggests that although administrative districts provide a practical initial scale for PEDs assessment, further refinement into smaller sub-units may be necessary to improve the precision and contextual relevance of PED strategies.

Finally, future research directions should include more granular consideration of rooftop PV generation potential. This includes data on building age, historical building constraints, structural types, and differences in adoption willingness among residents living in different building forms (Shnapp et al., 2020). On the consumption side, future studies could incorporate projected policy targets, resident behavioral patterns, and socio-economic indicators at the village or neighborhood level to more accurately forecast electricity demand variations across different districts.

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Land suitability modelling for Integrated Mangrove Aquaculture to adapt to salinity intrusion using Machine Learning and Deep Learning approaches in southwestern Bangladesh

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Abstract
The Sundarbans mangrove forest, located in southwestern Bangladesh, neighbors numerous vulnerable coastal communities. The mangrove forests play a crucial role in sustaining local livelihood structures and providing key ecosystem services. Climate-induced change risks contributed saline waterlogging, and salinity intrusion in low-lying lands within polders through extreme weather events, such as cyclones, storm surges, as well as coastal flooding inundation. Furthermore, the uncontrolled expansion of brackish shrimp farming has further exacerbated soil and water salinization, posing severe threats to self-sufficient community-based livelihood options.

Nature-based Solutions (NbS) offer essential tools for protecting the Sundarbans mangroves and addressing environmental challenges and livelihood threats faced by surrounding communities, including climate change, ecological degradation, loss of biodiversity, poverty, and food insecurity. The proposed Integrated Mangrove Aquaculture (IMA) practices, aligned with NbS standards and community involvement, are considered as a solution that balances mangrove ecosystem conservation and sustainable community livelihood management. Specifically, IMA provides adaptive responses to soil salinization and saltwater flooding caused by coupled climate risks, both of which increase the vulnerability of local livelihoods, aiming to develop a production model in the local saline environment that is both ecologically and economically beneficial. This study develops a machine learning-enhanced framework to optimize IMA for combating climate-driven salinity intrusion in Bangladesh's coastal communities. We used four machine learning models that integrated 18 biophysical, environmental and socioeconomic variables to assess land suitability for IMA development. Additionally, the data-driven evaluation model provides scientific support for future planning and management, facilitating implementation of IMA in vulnerable communities and ultimately contributing to the Sustainable Development Goals (SDGs).

Keywords: Machine Learning, Deep Learning, Livelihood Vulnerability, Climate Change, Integrated Mangrove Aquaculture (IMA)

1. Introduction

The Sundarbans Impact Zone (SIZ) is a distinctive region defined by its low-lying, deltaic landscape, woven with a complex network of rivers, tidal channels, and estuaries. This terrain, heavily influenced by seasonal monsoon rains and daily tidal fluctuations from the Bay of Bengal, creates a dynamic estuarine environment. Due to its proximity to the Sundarbans mangrove forest—the largest contiguous mangrove forest in the world - and the Bay of Bengal, the SIZ is exceptionally vulnerable to a range of coastal hazards. Storm surges, tropical cyclones, and saltwater intrusion frequently impact the area, posing significant risks to both human communities and ecosystems. However, this diverse ecosystem also presents challenges to human habitation and agricultural activities. The mixture of saline and freshwater conditions makes water management complex, as local communities must adapt to fluctuating water salinity that affects agriculture, aquaculture, and freshwater availability. The intrusion of saltwater during the dry season exacerbates these challenges, limiting crop choices and requiring adaptive agricultural practices to maintain productivity.

The communities living within the SIZ rely heavily on the natural forest resources of the Sundarbans for their livelihoods (Abdullah et al., 2016; Mallick et al., 2021; Mallick et al., 2021), with many engaged in small-scale fishing, honey collection, and subsistence farming. However, economic vulnerability is widespread, exacerbated by frequent natural disasters and limited infrastructure. Poverty rates are high, and many households depend on seasonal and climate-sensitive livelihoods, making them particularly vulnerable to the impacts of climate change. Despite these challenges, local communities have developed traditional knowledge and adaptive practices that allow them to navigate the complex ecological conditions. For example, some farmers have adapted to saline conditions by cultivating salt-tolerant rice varieties or by practicing integrated farming systems that combine aquaculture with salt-resistant crops. Additionally, community-based resource management practices have been established to promote sustainable use of forest resources, such as honey and non-timber products, which provide supplementary income without significantly impacting the ecosystem (Abdullah et al., 2017).

Coastal communities in the south-west zone of Bangladesh have been facing the ongoing and escalating risk of salinity intrusion, which is expected to increase existing livelihood vulnerability. Given the inevitable trend of higher salinity intrusion conditions, the fragility of current polders, and the limitations of traditional approaches in completely eliminating this risk, a strategic shift from "mitigation" to "adaptation" has become imperative. Integrated Mangrove Aquaculture (IMA) offers an innovative and adaptive solution to this pressing challenge by leveraging saline conditions as an opportunity rather than a constraint. A productive and sustainable pattern of shrimp or fish farming that involves strategic planting mangroves inside or alongside the shrimp ponds is referred as IMA. This approach not only boosts agricultural productivity but also contributes to ecosystem restoration by harnessing the ecological services provided by mangroves, such as nutrient cycling, habitat provision, and coastal protection. It relies on natural tidal water exchange for the effective water quality management and the function of mangrove as natural sources of food and nutrients. By utilizing the controlled facilities of daily tidal flows and absorbing abundant mangrove leaf litter in ponds dikes, IMA operates with minimal external inputs, making it a more eco-friendly and cost-effective approach of adaptive production pattern.

The mangrove-based integrated shrimp farming system represents a sustainable aquaculture model for coastal communities that takes into account both economic benefits and ecosystem protection. It can compensate for the mangrove forests degradation often associated with traditional intensive shrimp farming, and contributes to biodiversity protection, coastal community resilience, climate change mitigation, and enhanced food production (Alam et al., 2022).

This study aims to develop a robust, data-driven spatial framework for assessing and forecasting the land suitability of Integrated Mangrove Aquaculture (IMA) systems in the Sundarbans Impact Zone (SIZ) of southwestern Bangladesh, as an adaptive strategy to mitigate the impacts of climate-induced salinity intrusion and associated environmental challenges. Specifically, the objectives of this research are:

1) To implement and compare the performance of advanced machine learning and deep learning algorithms in assessing the IMA suitability, identifying key drivers of IMA suitability and evaluating model strengths and weaknesses in spatial inference.

2) To project future suitability scenarios (2030, 2050, and 2080) under anticipated environmental and climatic changes, providing actionable insights for climate-resilient coastal production system.

2. Data and Methodology

2.1 Study Area

With an area of about 15,458.90 km2, the Sundarbans Impacted Area (SIZ) is located in the south-west coastal zone, including five districts (Khulna, Bagerhat, Satkhira, Pirojpur, Barguna). The study area spans approximately between latitudes 21°36'N and 23°00'N, and longitudes 88°54'E and 90°00'E. Geographically, the SIZ is positioned adjacent to the Sundarbans mangrove forest, one of the largest tidal halophytic forests in the world and a critical natural barrier against storm surges and coastal flooding. This coastal region is bounded by the Bay of Bengal to the south, forming a significant ecological transition zone where freshwater from the river systems meets the saline waters of the sea.

2.2 Data Collection

Based on a literature study, a multi-class classification framework was implemented to assess IMA suitability using a total of 19 biophysical, environmental and socioeconomic variables across four suitability classes (Not suitable, Marginally Suitable, Moderately Suitable, and Highly Suitable), categorized into four domains: (1) Hydro-chemical Characteristics, including surface water salinity, soil salinity, water total dissolved solids (TDS), water pH, water temperature, dissolved oxygen (DO), and tidal inundation depth; (2) Geomorphological & Soil Properties, encompassing soil texture, soil PH, elevation, slope, and distance to river channel; (3) Ecological and environmental Factors, comprising distance to mangrove area, Land Surface Temperature (LST) and Land Use and Land Cover (LLLC), among others ; and (4) Socioeconomic & Infrastructure, involving distance to drainage, road density, and embankment density. More details are given in Table 1.

Table 1. Data Collection

Data type	Data source	Time period
Sentinel-2 Land Cover	Esri	2023
ASTER GDEM 30 m spatial resolution	NASA Earth	2013
Landsat 9 OLI/TIRS C2 L1	USGS Explorer	2023
Surface water salinity data	Hydroinformatics and Flood Forecasting Circle, Bangladesh Water Development Board (BWDB)	2024
Soil salinity data	Sarkar et al. (2024). A Root-Zone Soil Salinity Observatory for Coastal Southwest Bangladesh [Data set]. Zenodo. https://doi.org/10.5281/zenodo.14560019 SRDI 2024. Annual Report 2023-24. Soil Resource Development Institute (SRDI), Ministry of Agriculture, Dhaka-1215	2024
Water pH, Water TDS, Water DO	Surface and Ground Water Quality Report 2023. Department of Environment (DoE). Ministry of Environment, Forest & Climate Change.	2023
Soil texture; Soil pH	Bangladesh Agricultural Research Council (BARC)	2014
River channel	Local Government Engineering Department (LGDE) of Bangladesh. Humanitarian OpenStreetMap Team. OCHA Service, HDX.	2024
Drainage	United nations insititue for Training and Reaearch (UNITAR). OCHA Service, HDX. Humanitarian OpenStreetMap Team.	2018
Aquaculture Land Cover Data	Center for Geospatial Analytics. Clark University.	2022
Coastal flood inundation depth	Aqueduct Floods Hazard Maps, World Resource Institute.	2020
Mangrove forests	Explore the world's marine & coastal habitats. Ocean+ Habitats.	2020
Road Network	Local Government Engineering Department (LGED). United nations insititue for Training and Reaearch (UNITAR). OCHA Service, HDX.	2018

2.3 Criteria and Sample Data

In this study, we mapped all the selected criteria factors to convert those into thematic raster layers using GIS and RS techniques. A total of 16 distinct criteria layers were prepared under four components including water parameters, soil parameters, geographic-condition, infrastructure. Each raster layer was aligned and resampled to a common resolution (30m*30m cell) with the Universal Transverse Mercator (UTM) zone 65 north and World Geodetic System (WGS)-1984 datum to ensure spatial consistency. We used ArcGIS 10.8 software with natural break and defined interval (e.g. classes of soil salinity) statistical methods to create all the raster layers. The relevance of chosen criteria with details are provided in below.

To ensure robust and spatially balanced sample set for training and validation of the machine learning and deep learning models for Integrated Mangrove Aquaculture (IMA) suitability assessment, an MCDM-based suitability index map was developed using the Analytic Hierarchy Process (AHP) integrated with GIS overlay techniques. The index incorporated 19 standardized criteria weighted by expert-derived scores. Suitability scores were classified into four categories, from which a total of 3,200 georeferenced sample points were randomly selected using stratified sampling—800 per class - to ensure class balance and spatial dispersion. To avoid spatial autocorrelation and clustering bias, a minimum distance threshold of 300 meters between points was enforced. Approximately 70% of the sample points (n = 2,240) were used for model training, while the remaining 30% (n = 960) formed the validation set. This method is particularly appropriate for complex land-use planning problems such as IMA, where suitability is determined by the interaction of multiple biophysical, environmental, and socioeconomic factors. The sample generation process enables the integration of both quantitative spatial data and qualitative expert knowledge.

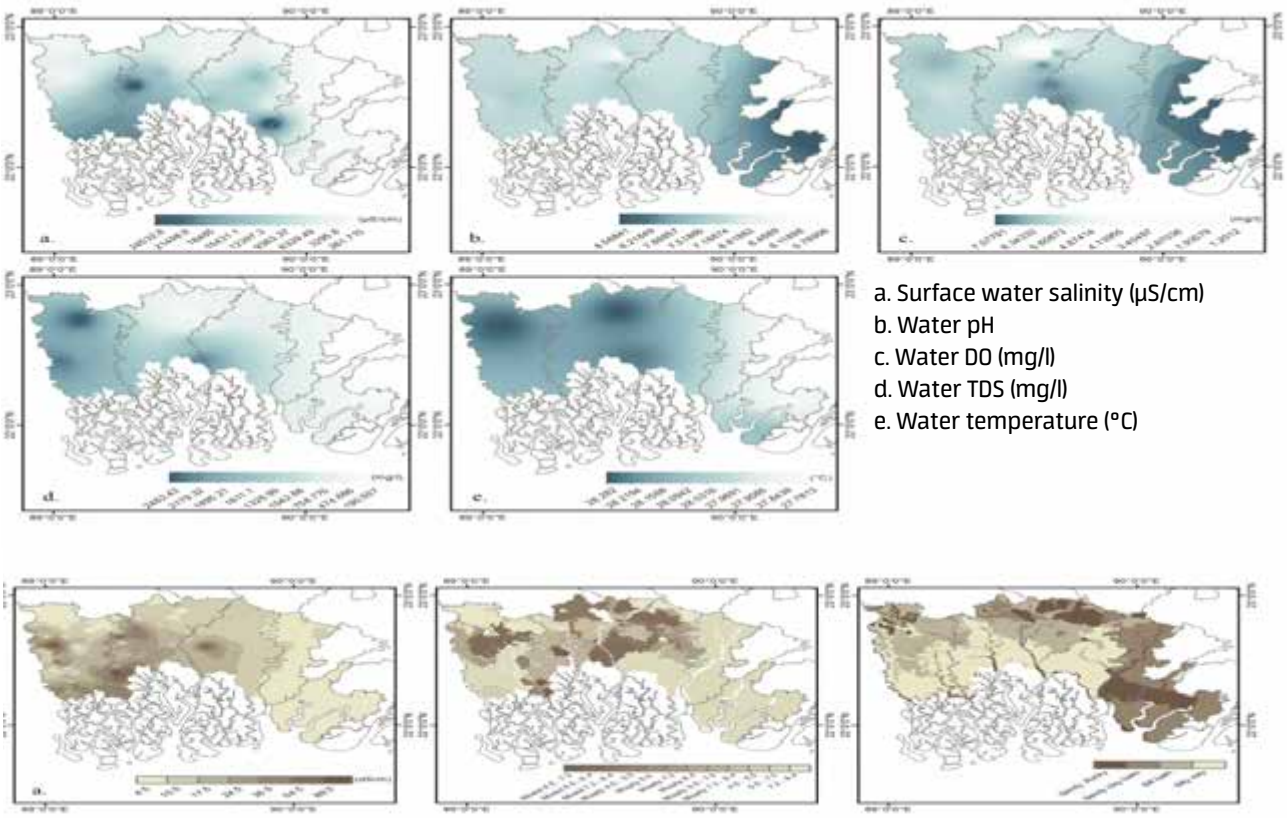
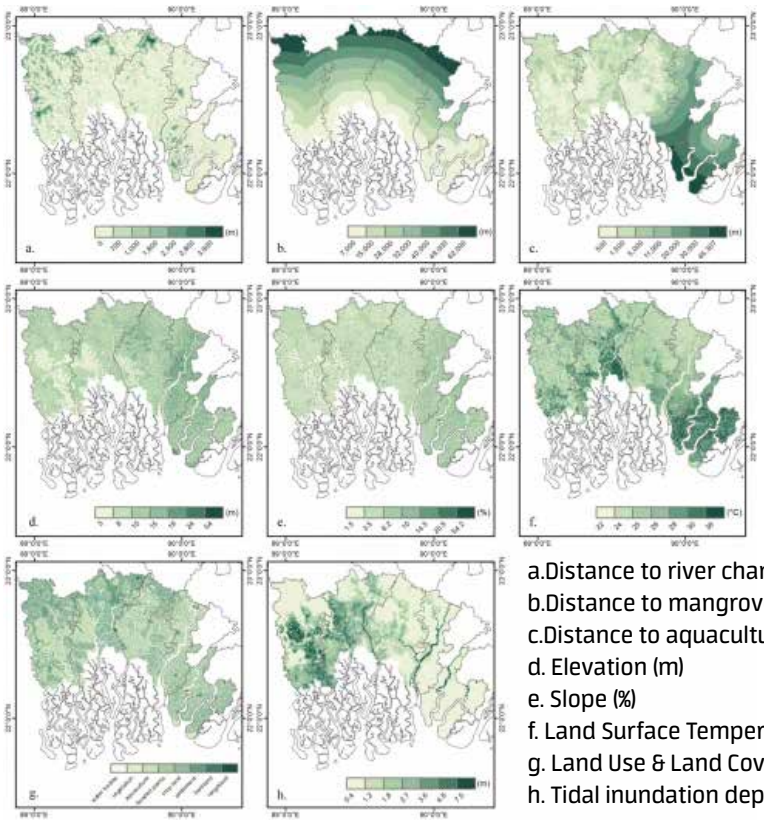


Fig 2-1. Feature maps of water parameters and soil parameters for IMA suitability. a) Soil salinity (dS/m), b) Soil pH, c) Soil texture



a.Distance to river channel (m)
b.Distance to mangrove area (m)
c.Distance to aquaculture land (m)
d. Elevation (m)
e. Slope (%)
f. Land Surface Temperature (LST)
g. Land Use & Land Cover (LULC)
h. Tidal inundation depth (m)

Fig 2-3. Feature maps of geographic-condition factors for IMA suitability.

2.4 Methodology

To predict the spatial suitability of Integrated Mangrove Aquaculture (IMA), a supervised multi-class classification framework was implemented based on prior spatial analysis of the 19 biophysical, environmental, and socioeconomic features. Specifically, spatial autocorrelation diagnostics (e.g., Moran's I and Local Indicators of Spatial Association) revealed significant non-stationarity and spatial heterogeneity across several key variables - such as surface water salinity, soil texture, and tidal inundation depth—indicating that suitability patterns vary considerably over space. These findings justified the adoption of models capable of incorporating spatial context and handling high-dimensional, non-linear, and multi-class classification tasks.

Accordingly, three algorithms were selected: Geographically Weighted Random Forest (GWRF), Extreme Gradient Boosting (XGBoost), and Convolutional Neural Networks (CNN). GWRF was chosen for its capacity to account for spatially varying relationships between predictors and response variables. XGBoost was included as a state-of-the-art ensemble method offering computational efficiency and strong generalization. CNN, a deep learning architecture, was employed for its ability to capture complex spatial dependencies and multi-scale patterns directly from the gridded input data.

All models were trained to classify each spatial unit (i.e., raster cell) into one of four suitability categories: Not suitable, Marginally Suitable, Moderately Suitable, and Highly Suitable. To evaluate model performance and interpretability in predicting IMA suitability, multiple diagnostic tools were employed, including confusion matrices, multi-class ROC curves, spatial suitability maps, and SHAP (SHapley Additive exPlanations) analysis. These tools not only quantified model accuracy but also enabled in-depth exploration of feature importance and spatial inference quality across the study region.

3. Results

3.1 Model Performance and Interpretation

The Pearson correlation heatmap revealed several linear associations among the 19 biophysical and environmental variables used in IMA suitability modeling. For instance, surface water salinity showed positive correlations with soil salinity (r = 0.63) and tidal inundation depth (r = 0.54), reflecting saline water intrusion mechanisms typical of low-lying coastal zones. In contrast, water temperature was strongly negatively correlated with both water pH (r = -0.82) and dissolved oxygen (r = -0.82), suggesting possible ecological stress or eutrophication. To account for such nonlinear relationships, machine learning models such as GWRF, XGBoost, and CNN were employed, which are better suited to capture high-dimensional and nonlinear patterns in ecological suitability data.

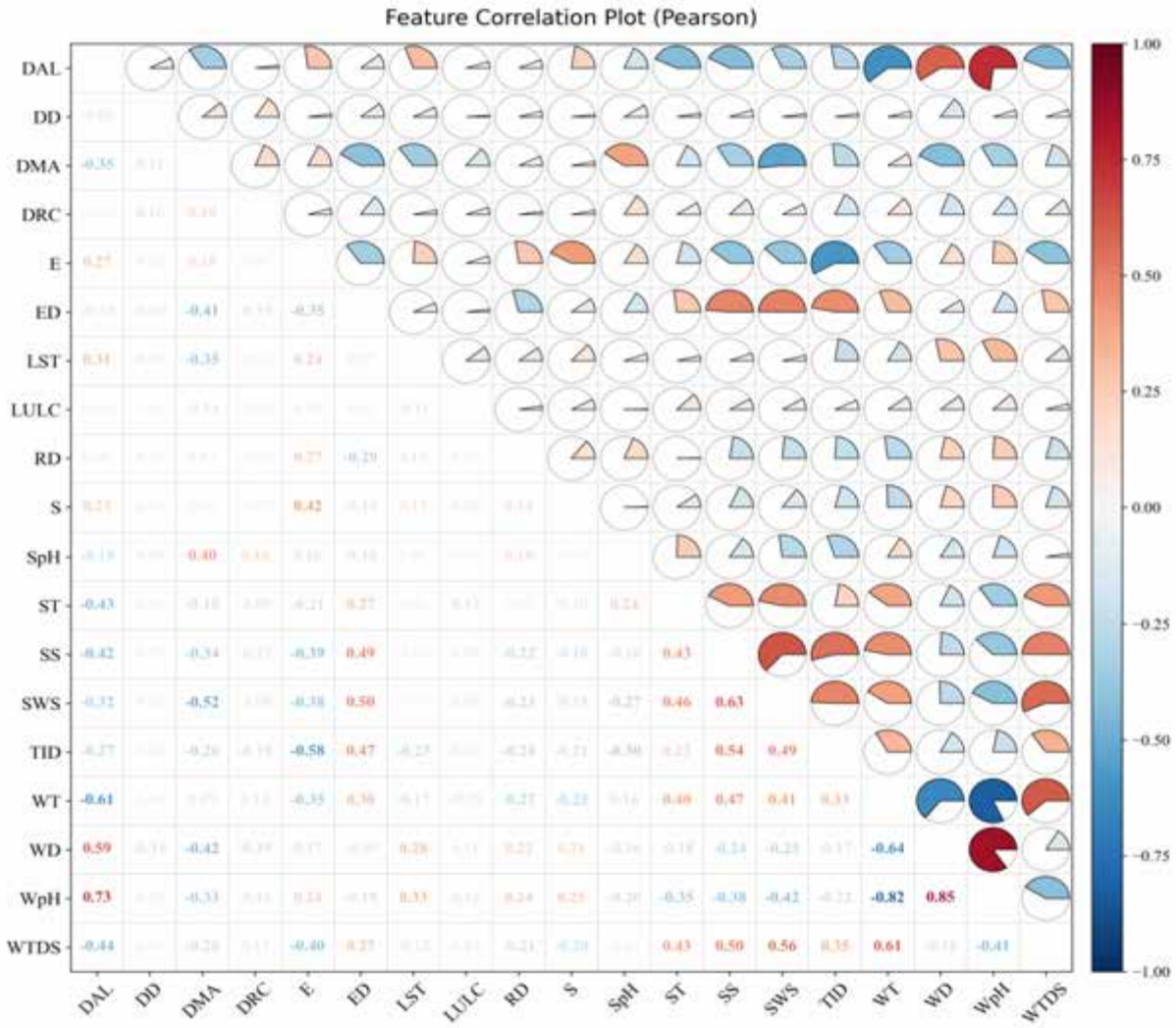


Fig 4. Feature maps of geographic-condition factors for IMA suitability

While these correlations indicate non-spatial associations, spatial dependence among variables was further assessed using Global Moran's I. The results showed that most variables exhibit statistically significant positive spatial autocorrelation ($p < 0.01$), with particularly high Moran's I values observed for soil salinity (I = 1.10), water pH (I = 1.11), and water temperature (I = 1.09). These findings confirm strong spatial clustering of key environmental conditions across the study area, reinforcing the need for spatially explicit modeling approaches. Notably, even typically static features such as distance to aquaculture land (I = 1.05) and surface water salinity (I = 1.01) displayed strong spatial structure, whereas variables like slope (I = 0.16) and land use/land cover (I = 0.38) showed relatively weaker spatial patterns.

Table 2. Global Moran's I statistics for spatial autocorrelation of input variables.

Feature	Moran I	p value
Distance to aquaculture land	1.0526987996024457	0.001
Distance to drainage	0.9605616756041764	0.001
Distance to mangrove area	1.0016094773476731	0.001
Distance to river channel	0.8768663531565697	0.001
Elevation	0.5754581473503295	0.001
Embankment density	0.8582006908652539	0.001
LST	0.6451942852321254	0.001
LULC	0.3837110055114048	0.001
Road density	0.9625494897166221	0.001
Slope	0.15743058435746807	0.004
Soil pH	0.8356389716159316	0.001
Soil texture	0.848900379598481	0.001
Soil salinity	1.1021263820529454	0.001
Surface water salinity	1.014419641284838	0.001
Tidal inundation depth	0.8346094663166448	0.001
Water temperature	1.0936460986686316	0.001
Water DO	0.9386793823138038	0.001
Water pH	1.1137741311873608	0.001
Water TDS	0.9453313275142926	0.001

The GWRF model demonstrated the highest predictive performance among the three, achieving an overall accuracy of 89.49%, with an F1-score of 0.89. The SHAP analysis (Fig. 5) revealed that surface water salinity, water pH, and distance to mangrove area were consistently dominant features across all suitability classes. The suitability map (Fig. 6a) indicates a more spatially coherent distribution of "Highly Suitable" areas, especially along mid-salinity estuarine zones. Importantly, the geographically weighted structure of this model allowed for localized variation in feature importance, making it highly suitable for modeling environmental heterogeneity - a critical factor in coastal delta systems. However, its reliance on spatial weight matrices introduces potential sensitivity to bandwidth selection and may limit scalability across broader geographies.

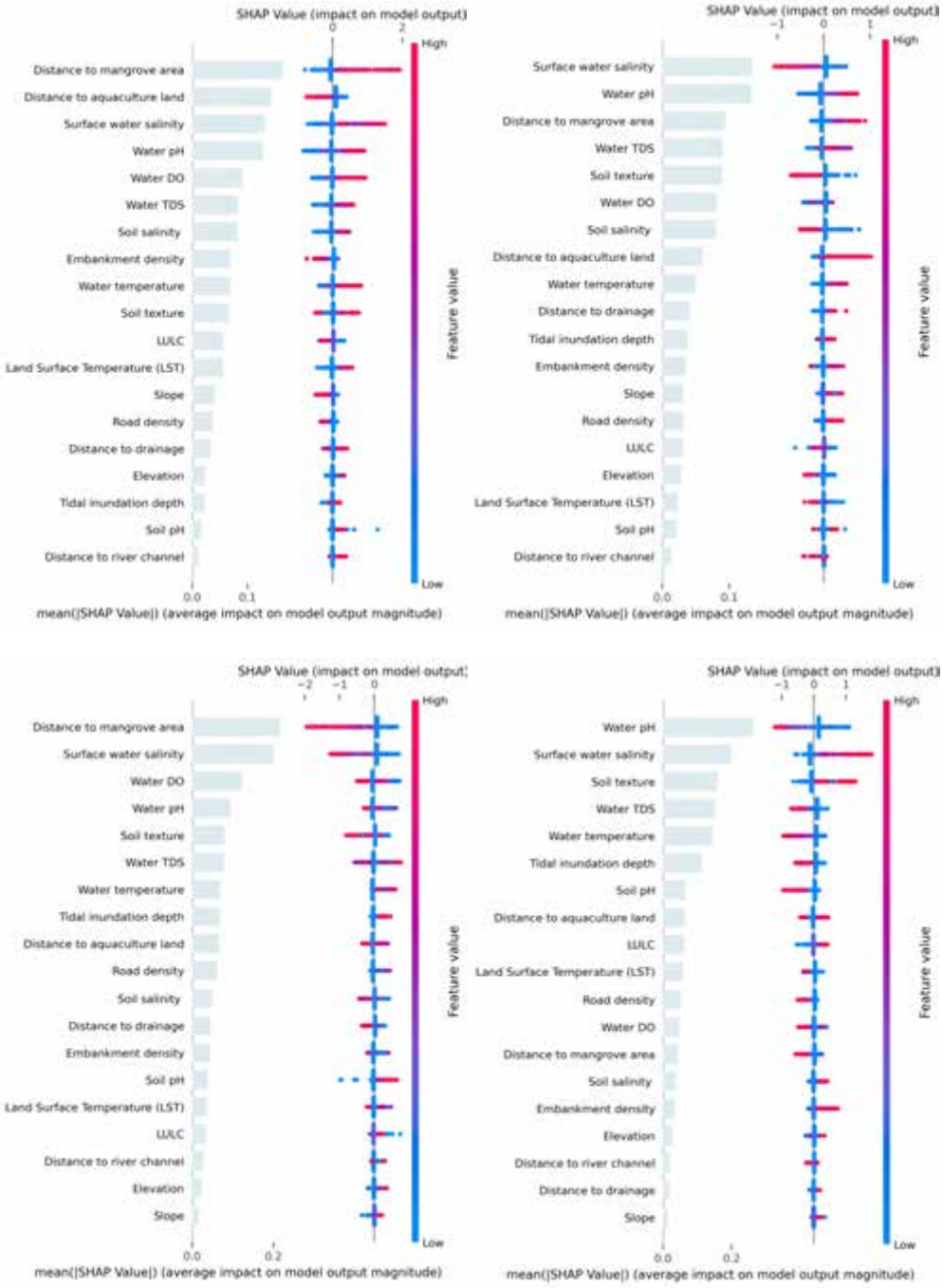


Fig 4. SHAP Value and mean(|SHAP value|) for the 4 suitability classes of IMA by Geographically Weighted Random Forest (GWRF) Model. a) Class 0 - Not suitable, b) Class 1 - Marginally suitable, c) Class 2 - Moderately suitable, d) Class 3 - Highly suitable.

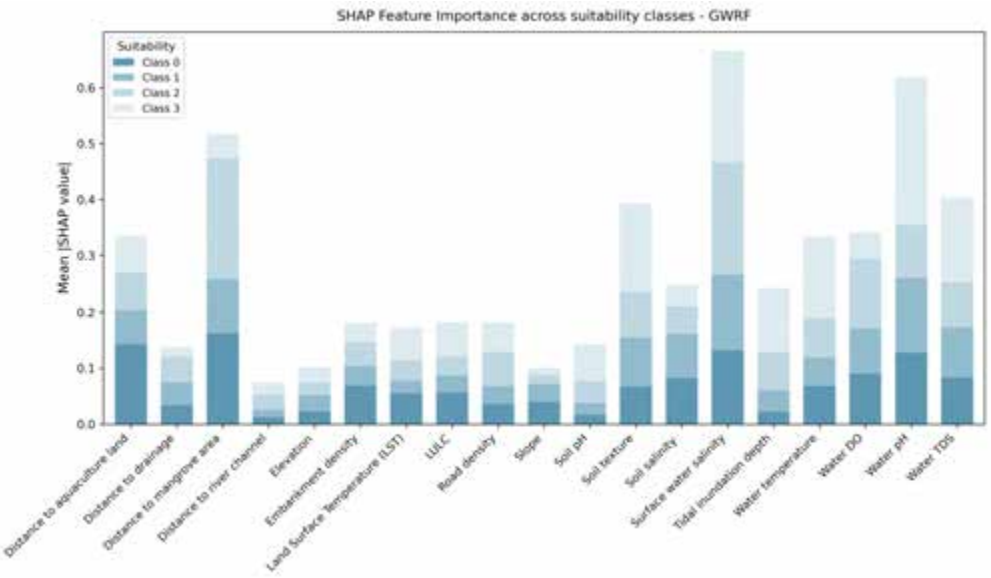
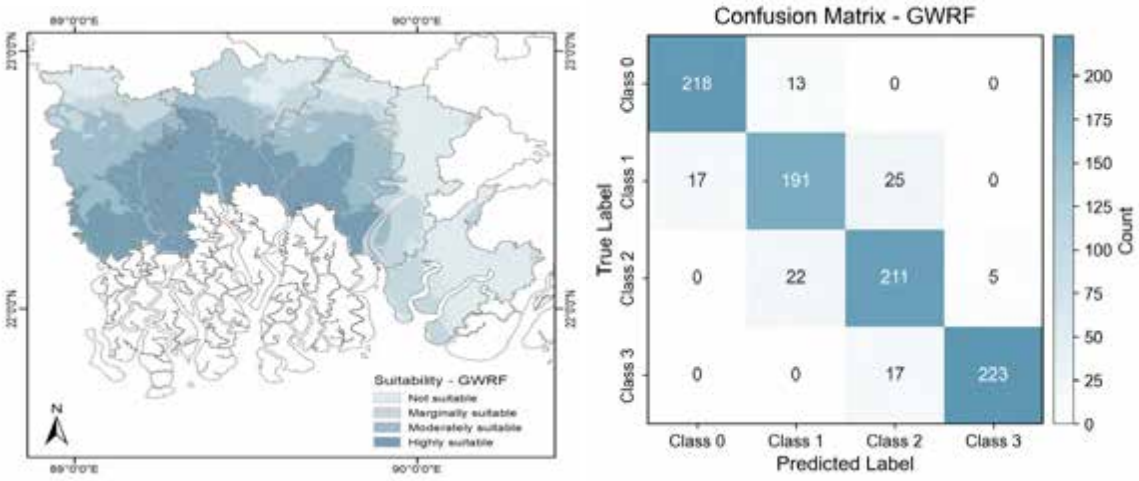
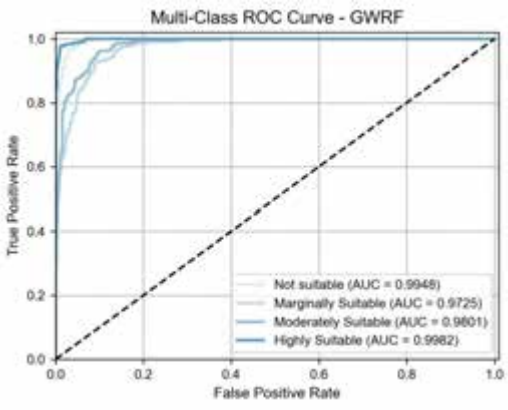


Fig 5. SHAP Feature Importance for 4 suitability classes of IMA by Geographically Weighted Random Forest



a. b.

Accuracy
89.49%
F1-score
0.89
recall
0.88
precision
0.88



c.

Fig 6. Suitability map of IMA by Geographically Weighted Random Forest (GWRF) Model. a) Suitability classes map, b) Confusion Matrix, c). Multi-Class ROC Curve.

The XGBoost model achieved slightly lower predictive performance compared to GWRF, with an overall accuracy of 86.09% and precision, recall, and F1-score all registering at 0.86. As a robust gradient-boosted ensemble method, XGBoost is particularly effective at capturing complex, non-linear relationships and interactions among high-dimensional input variables. To account for potential spatial autocorrelation and overfitting, the model was trained and validated using a spatial cross-validation framework implemented via the BlockCV package, which partitions the study area into spatially contiguous folds. This approach ensures that model evaluation reflects true spatial generalizability, avoiding overly optimistic metrics that may result from traditional random sampling. SHAP-based feature attribution revealed that surface water salinity was the top-ranked predictor in both XGBoost and GWRF models, reinforcing its central role in determining IMA suitability across the study area (Fig. 8). For GWRF, the next most important features were water pH and distance to mangrove area, suggesting that the model captured ecologically meaningful local gradients linked to both water chemistry and proximity to natural buffer ecosystems. In contrast, XGBoost identified soil texture and water TDS (Total Dissolved Solids) as key predictors after salinity. This shift toward soil-based and generalized water quality variables likely reflects XGBoost's global optimization approach, which favors variables with consistent predictive power across the entire study area, rather than those with strong but spatially localized effects. However, unlike the geographically adaptive structure of GWRF, XGBoost assigns global feature weights, which may lead to underestimation of localized spatial effects. This limitation was reflected in the resulting suitability map (Fig. 9a), where the spatial boundaries of suitability zones appeared broader and less sharply defined, suggesting a tendency toward regional smoothing and potential overgeneralization in ecologically heterogeneous zones.

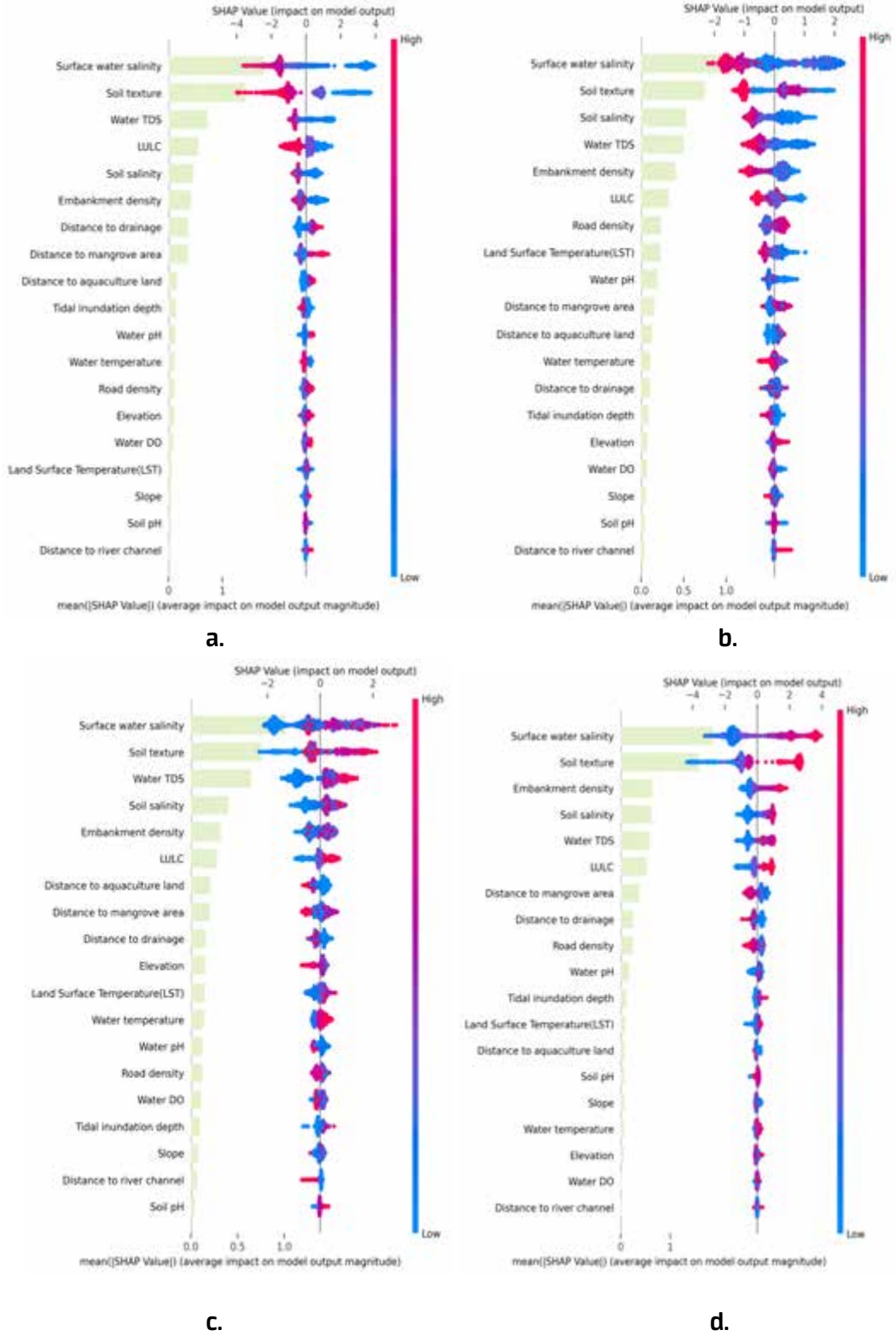


Fig 7. SHAP Value and mean(|SHAP value|) for the 4 suitability classes of IMA by XGBoost Model. a) Class 0 - Not suitable, b) Class 1 - Marginally suitable, c) Class 2 - Moderately suitable, d) Class 3 - Highly suitable.

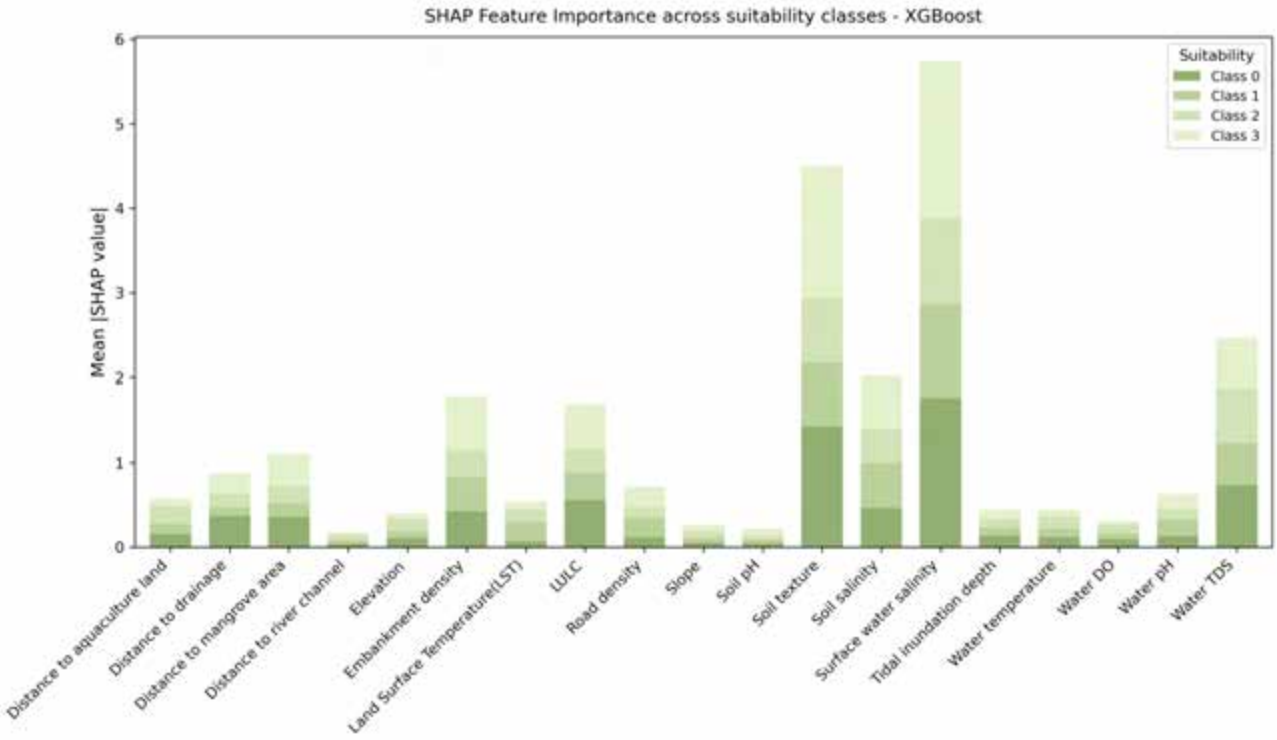
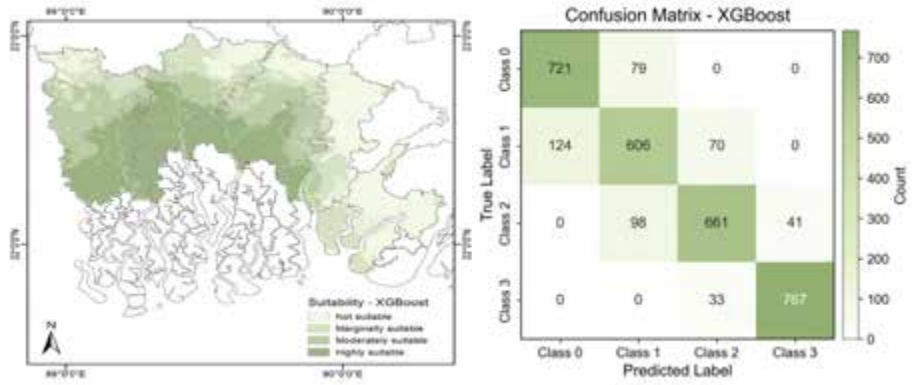
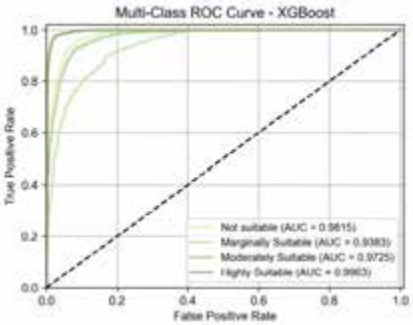


Fig 8. SHAP Feature Importance for 4 suitability classes of IMA by XGBoost Model.



a. b.

Accuracy
86.09%
F1-score
0.86
recall
0.86
precision
0.86

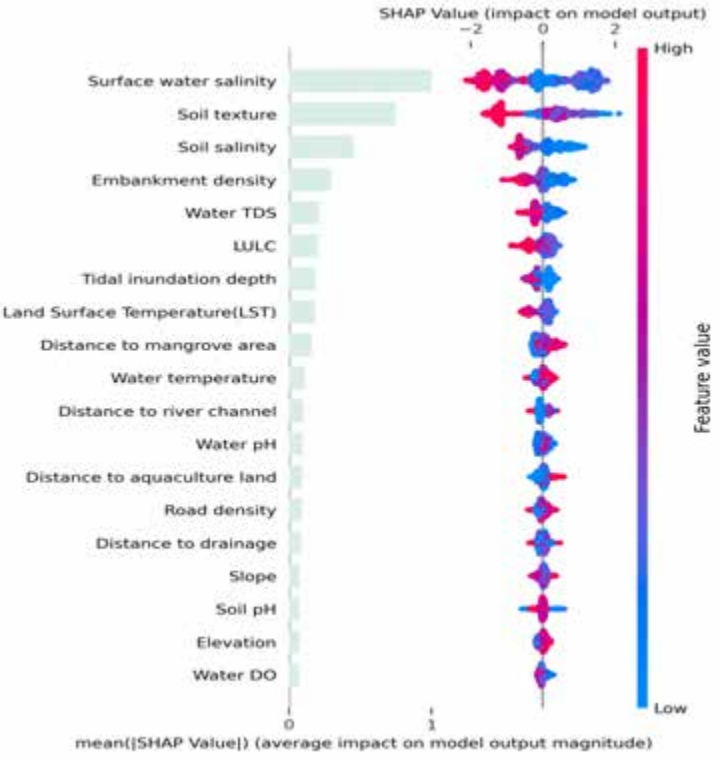


c.

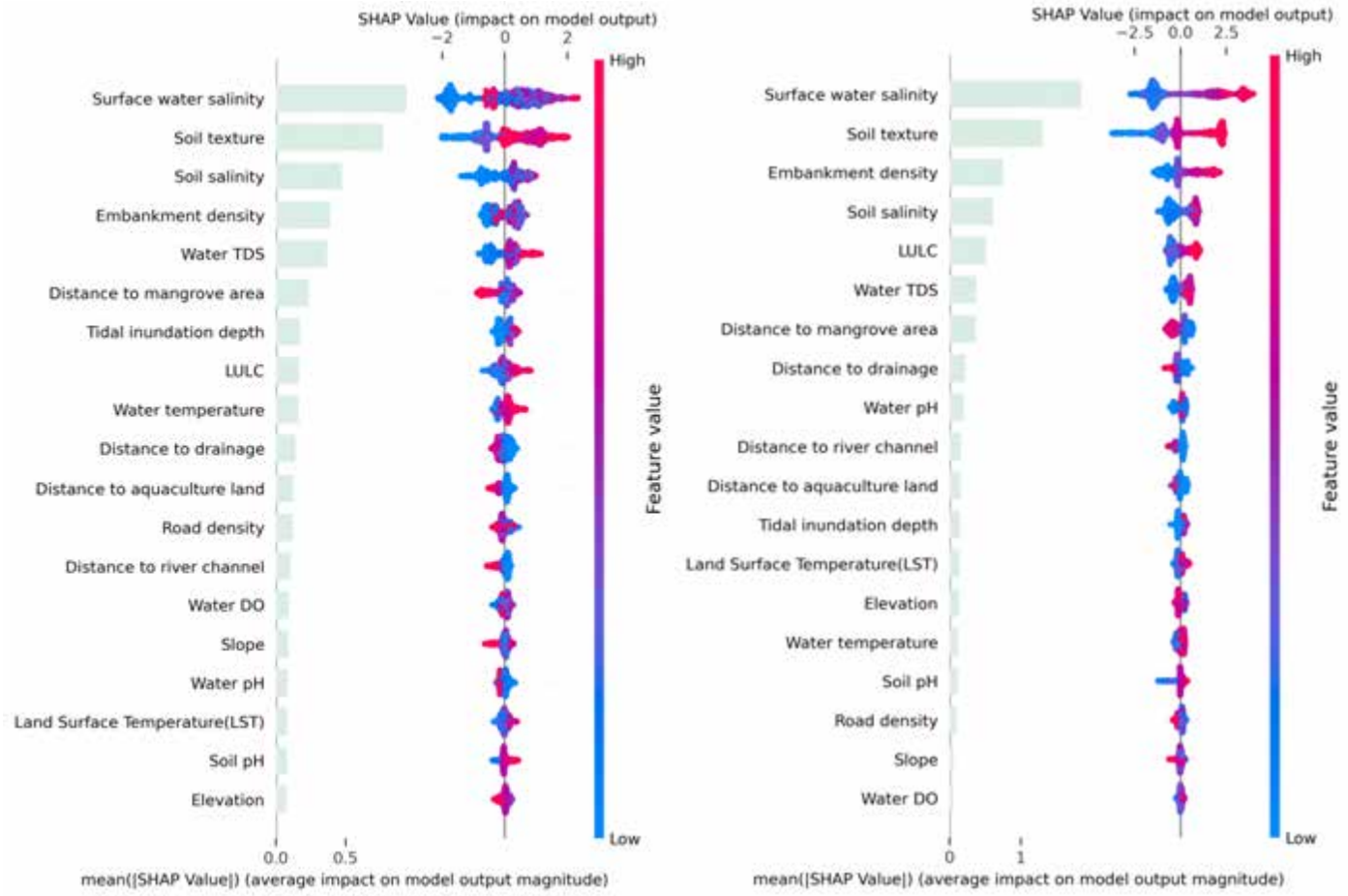
Fig 9. Suitability map of IMA by XGBoost Model. a) Suitability classes map, b) Confusion Matrix, c). Multi-Class ROC Curve.

The Convolutional Neural Network (CNN) model, while achieving slightly lower overall performance metrics compared to the GWRF and XGBoost models - 84.79% accuracy and an F1-score of 0.85 - demonstrated unique strengths in learning spatial patterns and feature interactions from gridded data. The IMA suitability map produced by the CNN model (Fig. 12a) exhibited greater spatial granularity and higher sensitivity to fine-scale landscape heterogeneity, reflecting the model's capacity to detect ecological transitions - such as embankment boundaries, soil texture shifts, or micro-salinity zones - that may be underrepresented in coarser models. SHAP analysis (Fig. 10) revealed that the CNN model prioritized a distinctive set of influential variables. The top-ranked features included surface water salinity, soil texture, embankment density, and soil salinity, indicating that the model was sensitive to both hydrological and physical infrastructure factors. Notably, the high importance assigned to embankment density - a variable less emphasized in GWRF and XGBoost - suggests that CNN was particularly adept at identifying the influence of anthropogenic structures in shaping land suitability patterns, likely due to its spatial feature extraction capabilities. The prioritization of soil texture also highlights CNN's potential to capture interactions between micro-topography and hydrological properties that are difficult to model using traditional approaches. However, the CNN model's complexity comes with certain trade-offs. Its training process is computationally intensive and more data-hungry than tree-based algorithms. The relatively moderate dataset size (n = 3,200) may have limited its full learning capacity, and overfitting risks were mitigated through regularization and dropout techniques. Moreover, while SHAP was used to enhance interpretability, the black-box nature of deep learning still poses challenges for transparent decision support in applied contexts.

a.



b.



c. **d.**

Fig 10. SHAP Value and mean(|SHAP value|) for the 4 suitability classes of IMA by Convolutional Neural Networks (CNN) Model. a) Class 0 - Not suitable, b) Class 1 - Marginally suitable, c) Class 2 - Moderately suitable, d) Class 3 - Highly suitable.

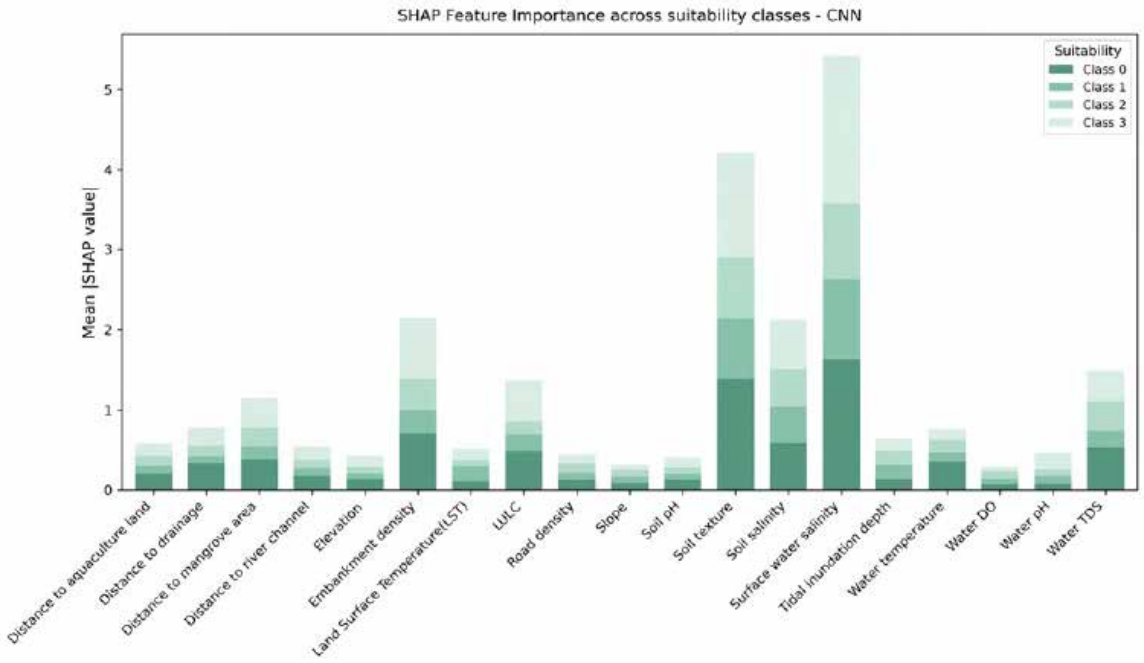
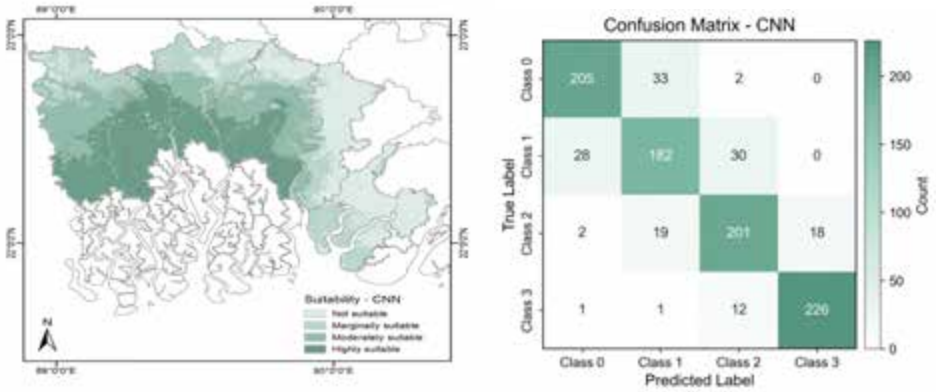


Fig 11. SHAP Feature Importance for 4 suitability classes of IMA by Convolutional Neural Networks (CNN) Model.



Accuracy
84.79%
F1-score
0.85
recall
0.85
precision
0.85

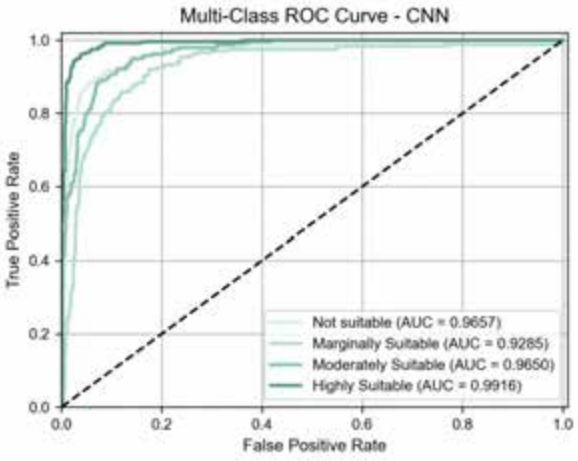


Fig 12. Suitability map of IMA by Convolutional Neural Networks (CNN) Model. a) Suitability classes map, b) Confusion Matrix, c). Multi-Class ROC Curve.

3.2 Spatial Verification of IMA Suitability Using Sentinel-2 NDWI Data

In order to verify the spatial rationality of the IMA model prediction results, this study conducted a spatial overlay analysis between the model-predicted suitability zones and the actual water body distribution derived from Sentinel-2 satellite imagery. Specifically, NDWI (Normalized Difference Water Index) was calculated using cloud-free Sentinel-2 surface reflectance data to extract surface water features for the year 2024. The resulting water body vector layer was then intersected with the suitability maps generated by the GWRF, XGBoost, and CNN models.

The results showed that the majority of NDWI-detected water bodies were spatially concentrated within areas predicted as "Moderately suitable" and "Highly suitable" by all three models, indicating strong spatial consistency between model predictions and real water features. Specifically, as shown in Table 3, the GWRF model identified 42.19% of the water bodies within "Highly suitable" areas and 27.51% within "Moderately suitable" areas, with marginal representation in "Marginally suitable" areas (3.41%) and none in "Not suitable" zones. This distribution suggests a clear spatial preference of GWRF predictions toward ecologically plausible IMA zones. In contrast, the XGBoost and CNN models further enhanced spatial alignment, with over 69% of the water body area located within "Highly suitable" zones. These two models also reduced the proportion of water bodies falling into "Not suitable" areas to below 3.5%, demonstrating better exclusion capability for unsuitable zones.

Overall, the spatial overlay verification supports the reliability of the model outputs, particularly those generated by the XGBoost and CNN frameworks, which exhibit strong agreement with actual hydrological patterns captured by NDWI. These findings reinforce the ecological validity of the predicted IMA suitability zones and provide robust support for their application in integrated aquaculture planning.

Table 3. Distribution of NDWI water body area within model-predicted suitability classes

suitability_level	GWRF	XGBoost	CNN
Not suitable	0	3.51%	3.47%
Marginally suitable	3.41%	28.09%	27.73%
Moderately suitable	27.51%	41.46%	40.02%
Highly suitable	42.19%	69.50%	69.25%

4. Conclusion

This work advances the integration of machine learning in nature-based adaptation planning, offering a replicable methodology for vulnerable coastal regions globally. The findings have direct implications for climate-resilient aquaculture planning in coastal Bangladesh, where salinity intrusion and livelihood vulnerability necessitate adaptive, nature-based interventions. The proposed methodology supports strategic zoning for IMA expansion, aligning ecological restoration with sustainable development objectives. More broadly, this study contributes to the growing literature on machine learning for nature-based adaptation, offering a transferable framework applicable to other deltaic and estuarine systems facing similar biophysical constraints. Future work may integrate temporal dynamics, stakeholder preferences, or economic optimization to further enhance the practical deployment of IMA in climate-sensitive coastal regions.

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Optimizing Decision-Making for Climate-Neutral Post-War Buildings: The Architect's Role in Sustainable Transformation

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Abstract
The paper examines the role of architects in decision-making processes for the sustainable transformation of the existing building stock, focusing on early planning phases where demolition, preservation or redevelopment of post-war buildings is considered. Based on a multidimensional theoretical framework, it develops a heuristic model identifying five dimensions of influence: design framing, mediation, normative legitimation, political positioning and navigating planning uncertainty. Combining approaches from architectural sociology, professions theory and planning theory, the paper derives a qualitative analytical framework. The aim is to systematically reconstruct modes of influence and professional agency. It presents the theoretical basis, the conceptual model, the methodological approach and initial empirical findings from expert interviews. A more detailed analysis of the interview data will follow in the next stages of the research.

Keywords: Climate Neutrality; Post-War Buildings; Architects' Role; Sustainable Transformation; Decision-Making Processes

1. Introduction

Climate change and the increasing scarcity of resources make a more efficient use of existing materials and the reduction of greenhouse gas emissions ever more urgent. In addition to achieving climate neutrality in the building stock by 2045, the provision of affordable housing is among the core challenges facing the building sector in Germany.

The existing building stock plays a central role in the social and ecological transformation of the construction sector and holds substantial potential for sustainable transformation.

With the Renovation Wave (European Commission, 2020) as part of the European Green Deal, the European Union aims to at least double the renovation rate in the building sector by 2030. The initiative highlights refurbishment and extension of existing buildings as essential strategies to meet climate goals, emphasising their role over demolition and new construction. At the national level, the Circular Economy Strategy (BMUV, 2024) refines these goals by calling for longer service lives, the reduction of construction and demolition waste, and the promotion of closed-loop material flows. Preservation and transformation of existing buildings are explicitly named as priorities over demolition and new construction.

Figure 1: Demolition of a multi-family building from the 1950s and 1960s, Billhorner Röhrendamm (Hamburg)

Particular attention is given to the post-war housing stock, especially multi-family buildings from the 1950s and 1960s (see Figure 1). These buildings were constructed before the introduction of Germany's first thermal insulation regulation in 1977, tend to be poorly modernised (BSW, 2023), and exist in large numbers[1]. They significantly shape the urban fabric of many German cities and reflect the planning paradigms of the time: they were built as part of both inner-city reconstruction on war-damaged sites and new, loosely arranged settlements on previously agricultural land. Due to subsequent urban development, many of these former urban peripheries are now situated in inner-city areas. The original low-density design and wide building gaps offer substantial potential for upgrading these neighbourhoods in line with contemporary demands for density and mixed uses.

Given the limited availability of urban land, rooftop extensions have become increasingly important. As a key strategy for densification, they contribute simultaneously to resource efficiency, energy refurbishment, and the creation of new housing units without consuming additional land.

Studies by Steger et al. (2022) and Hafner and Storck (2023) show that both the retrofitting and the rooftop extension of existing multi-family buildings, when combined with updated technical systems and energy sources, are ecologically preferable to demolition and new construction over the life cycle. Typically, such measures result in lower primary energy use and reduced greenhouse gas emissions, with the conservation of embodied energy and reduced operational emissions playing a decisive role.
Despite these well-documented benefits, the practical potential of working with the existing stock remains underutilised. Although demolition rates are relatively low overall, with only 0.07% of multi-family buildings

1 According to the 2018 Microcensus Housing in Germany conducted by the Federal and State Statistical Offices, approximately 16.7 million apartments are located in buildings constructed between 1949 and 1978, with 10.5 million of these in multi-family buildings. This represents around 42% (or 26% for multi-family buildings) of the total housing stock.

demolished in 2013[2] (ARGE, 2016), a striking two-thirds of replacement constructions were built on sites previously occupied by structures from 1949 to 1978. This is precisely the stock that holds particular urban and ecological potential for sustainable transformation.

ARGE (2016) points to deep-rooted structural barriers hindering the development of the existing stock, including a lack of strategies among housing providers, inadequate tools for systematic resource assessment, and institutional or economic preferences for new construction. Uncertainties regarding cost forecasts, approval processes, and legal frameworks often lead to retrofitting or rooftop extension being perceived as risky, with demolition favoured as a seemingly safer alternative.

Demolition decisions are frequently made without systematic assessment, often driven by aesthetic, pragmatic, or speculative motives. In most federal states, demolition does not require a permit, meaning that no expert review of the building's structural integrity or environmental value takes place (Abrisskollektiv & Rieniets, 2025). Planning decisions are often based on individual experience and assumptions. The idea that retrofitting is not worthwhile frequently functions as an implicit planning premise (Abrisskollektiv & Rieniets, 2025).

The social consequences of demolition, particularly in high-cost urban areas, are increasingly being scrutinised.[3] A growing profitability gap between old rents and anticipated returns on new construction is seen as a major driver, linking economic exploitation to planning decisions (Calbet Elias, 2025). In addition to a lack of regulation, insufficient environmental accounting standards are also criticised, since current planning processes largely ignore embodied energy as well as social impacts such as displacement or the loss of housing types relevant to urban policy (Abrisskollektiv & Rieniets, 2025).

The gap between the theoretical potential of building transformation and actual practice underscores that decisions on demolition, refurbishment, or rooftop extension are not based purely on technical, social, or ecological criteria. Rather, they result from complex negotiation processes shaped by conflicting interests, uncertainties, and institutional frameworks.

Early planning phase 0[4] provides the analytical starting point for this study, as it is particularly decisive in determining outcomes for the existing building stock. Fundamental decisions are often made in this phase, frequently under conditions of uncertainty, competing objectives, and limited information. Whether a building is demolished or retained and extended is often prefigured at this stage, implicitly shaped by assumptions about feasibility, economic routines, or institutional practices that promote certain options while excluding others.

This paper is therefore not solely concerned with the question of why the potential for rooftop extensions and retrofitting remains unused. Rather, this issue serves as a framework for the core analytical perspective: the qualitative reconstruction and analysis of decision-making processes in early planning stages.

Against this background, the focus shifts to a professional group whose relevance to sustainability-oriented decision-making in the building stock deserves particular attention: architects. As key actors in early planning stages, they are often the first to assess and communicate the architectural potential, spatial constraints, and design opportunities of a building, whether in a commissioned, advisory, or initiating role. Their influence often arises not through decision-making authority, but through the framing, visualisation, and mediation of options.

Based on the overarching dissertation project, which addresses the question "How can decision-making processes for managing post-war building stocks be optimised to achieve climate neutrality effectively and efficiently?", this paper focuses on the sub-question: **"What role do architects play in influencing and guiding decision-making processes towards sustainable and climate-conscious outcomes?"**

2 In 2013, a total of 2,114 buildings were demolished across Germany, within an overall building stock of 3,120,696. Of these demolitions, 866 were carried out as part of replacement construction measures (ARGE, 2016).

3 See Calbet Elias (2025) on this: In Berlin, the proportion of demolished multi-family buildings replaced by new constructions rose from 43 per cent in 2020 to 63 per cent in 2022, particularly in high-price areas such as Charlottenburg, Mitte or Kreuzberg.

4 The so-called phase 0 is not officially part of the Official Scale of Fees for Services by Architects and Engineers in Germany (HOAI), but it is increasingly understood in planning practice as a preliminary phase for project development and clarification. It precedes service phase 1 (Preliminary Planning) and serves the strategic preparation of construction projects. Typical components include needs assessments, site evaluations, initial feasibility considerations, and the exploration of objectives, potentials, and constraints.

2. Research Context: Previous Investigations and Preliminary Work
In the first, quantitative part of the overarching research project, the potential for rooftop extensions on three- to four-storey apartment buildings from the 1950s and 1960s, owned by Hamburg housing cooperatives, was examined. The aim was to provide decision-making support for future densification strategies through rooftop extension. The analysis of potential was carried out on three levels.

(1) Urban scale
At this level, the quantitative potential for new residential units through rooftop extensions on the relevant buildings was assessed using digital maps and aerial imagery. The findings revealed significant numerical capacity: in the case of the housing cooperatives alone, approximately 9,725 new flats could be added through one-storey rooftop extensions, and around 14,588 through two-storey extensions (up to a maximum of five storeys). This extension potential corresponds to roughly one to one and a half times Hamburg's annual housing demand. Including comparable building typologies under municipal or private ownership would further increase the relevance of this building stock (Meyer & Klotz, 2023).

(2) Building scale
This level focused on analysing 83 construction projects with regard to typological similarities. The results revealed a high degree of standardisation in terms of building depth, floor height, and construction methods, which is especially relevant for developing serial solutions for retrofitting and rooftop extension (Meyer & Klotz, 2023).

(3) Structural scale
However, the technical prerequisites for rooftop extensions are not uniformly met. Structural analyses of existing buildings showed that foundations often provide little to no load reserves. In most cases, load capacity was between 90 and 100 percent. This means that in the majority of cases, rooftop extensions cannot be implemented without additional structural interventions, such as underpinning or foundation reinforcement (Meyer & Klotz, 2023).

In principle, rooftop extensions are feasible, but often require considerable constructional effort. Their technical and economic viability depends heavily on the extent of additional structural measures needed. For this reason, it is crucial to assess candidate buildings individually and thoroughly at an early stage. Only then can reliable judgements be made regarding their suitability for rooftop extension. Despite these challenges, the refurbishment and transformation of the existing building stock often represent both technically feasible and ecologically imperative alternatives to demolition and new construction.

3. Theoretical Framework: The Role of Architects in Decision-Making on the Existing Building Stock
Architects occupy an intermediary role in decision-making processes concerning the existing building stock. This role is shaped by design-based mediation, professional interpretive competence and situational influence. Although they usually do not hold formal decision-making authority, architects shape key directional choices through design options, scenarios and the framing of planning alternatives. This is particularly relevant in the early planning phase 0, which is characterised by uncertainty, goal conflicts and incomplete information.

A culturally informed perspective on the role of architects is developed by Führ (2004), who understands them as translators in dealing with the existing building fabric. Architects operate in a field of tension between material substance, architectural heritage and current demands. Their practice is marked by reflexivity, multidimensionality and contextual sensitivity.
They do not act as neutral service providers or autonomous authors but as actors who moderate meaning, shape spatial continuities and translate cultural values into present decisions.

Beyond cultural attributions, the role of architects can be further differentiated through institutional theory. Drawing on Scharpf (2000), decision-making processes in the built environment can be understood as interactive constellations within institutional frameworks, in which actors operate with divergent resources, interests and claims to interpretation. Architects navigate these constellations between technical requirements, legal regulations, social objectives and design-based quality standards.

An actor-oriented perspective is offered by Kurath and Eisinger (2010), who describe the role of architects as an emergent function within dynamic actor networks. Based on actor-network theory as developed by Callon and Latour, they locate architectural agency not within clearly defined professional roles but within situational and project-based negotiation settings. Architects are understood not as autonomous authorities but as negotiating partners who exert influence on decision-making through translation processes between social, political, technical and design-based logics. In this model, architecture is conceptualised as an intermediary practice that not only generates meaning but also translates and mediates it.

In light of increasing demands for climate neutrality, this intermediary role is becoming increasingly normatively charged. Haines (2010) argues that architects possess a systemic understanding of problem-solving that can integrate ecological, economic and social requirements. The design process offers a structured way to engage with goal conflicts and is particularly suited to embedding sustainability as a cross-cutting principle in decision-making. Donovan (2018) likewise highlights that architects are equipped, through their interdisciplinary mode of work, not only to implement sustainability in technical terms but also to culturally anchor it. She advocates for architectural education to place greater emphasis on transformative responsibility.

A more comprehensive theoretical framing is provided by Lavaf-Pour and Meraz (2023), who propose an integral understanding of architecture. In their model, sustainability is not reduced to quantifiable measures such as energy consumption but is conceptualised as an emergent quality located between objective requirements such as COΔreduction and subjective spatial experience. Architects assume the role of mediators between rationality and meaning, as well as between technology and atmosphere.

This responsibility is given an ethical and political dimension in the concept of “critical care” developed by Fitz and Krasny (2019). Architecture is here not understood as an instrument of progress but as a practice of care, contributing to the preservation, repair and resilience of a vulnerable environment. Architects are responsible for making long-term sustainability goals visible, for negotiating them and for defending them within concrete decision-making contexts.

A related position is put forward by the collective ANA (2025), which, in response to increasing demolition dynamics and politically embedded market logics, argues for an expanded professional understanding. This approach includes not only design but also mediation, moderation and discursive positioning. Such an engaged architectural practice involves, for instance, making hidden qualities of existing buildings visible, actively negotiating goal conflicts among stakeholders or critically questioning supposed economic constraints. Here, demolition is not framed as a technical issue but as a matter of societal negotiation in which architects participate through both design and communication. This expands the understanding of the profession to include an explicitly political and transformative dimension.

A power- and discourse-theoretical perspective on the role of architects is formulated by Stumm (2025), who shows that demolition decisions are rarely made in purely technical or neutral terms. Rather, they are grounded in historically developed knowledge orders and societal imaginaries. From this point of view, architecture is not an objective planning service but part of a political order that defines, through norms and expectations, what is considered worth preserving, functional or future-oriented.

A deeper layer of analysis is added by Rellensmann and Stumm (2025), who reconstruct demolition practices as a constitutive element of modern urban production. Architects are not only designers but also historical co-producers of a culture of devaluation, erasure and re-creation.
Against this background, their role in sustainability-related decision-making is revealed not only as technical or communicative but also as politically and historically embedded.

In summary, this results in a profession-oriented approach to the research question. Architects possess specific resources, integrative design capacities, cultural translation skills and normative mediation abilities that enable them to influence decisions on the existing building stock towards more sustainable and climate-conscious options. Their role is not defined by position or authority but by their capacity to translate complex goal conflicts into actionable design strategies. The empirical study aims to systematically reconstruct these mechanisms of influence.

4. Hypothetical Model: Architects as Intervening Variables

Based on the previously developed theoretical framework, this section presents a differentiated understanding of architects as mediating actors in decision-making processes concerning the sustainable development of existing buildings. Although they generally do not possess formal decision-making authority, they exert influence through specific contributions in the early stages of planning processes, particularly in situations where decisions must be made about demolition or preservation. To analyse these dimensions of influence systematically, the following hypothetical model conceptualises architects as an intervening variable within institutional decision-making structures. The model distinguishes five primary mechanisms through which architects can shape decision-making processes.

(1) Design-Based Framing

By developing design variants and feasibility studies, architects structure the perception of available courses of action. What is perceived as technically feasible, architecturally compelling or economically viable is largely shaped by their design proposals. Especially in phase 0, when many parameters remain undetermined, the design prefigures decision logics. It creates spaces of possibility while simultaneously narrowing the field of options. This formative function of design is emphasised by authors such as Führ (2004), Haines (2010) and Lavaf-Pour and Meraz (2023), who position the design process at the intersection of cultural interpretation, systemic complexity and creative mediation.

(2) Mediation and Moderation

Architects operate at the interfaces between technical disciplines, public authorities, building owners and the broader public. In this role, they bring contradictory demands, such as cost constraints, sustainability goals and architectural quality, into structured dialogue. The task is not neutral translation but active negotiation. The manner in which arguments are introduced, and by whom, influences which objectives are pursued and which criteria become decisive. Kurath and Eisinger (2010), Donovan (2018) and the collective ANA (2025) describe this mediating role as situationally emergent and network-based, where architects do not only act as technical coordinators but also shape discursive and design-oriented moderation.

(3) Normative Legitimation

Architects possess both aesthetic authority and cultural interpretive power, which they can employ to assert normative positions, especially with regard to sustainability. By linking certain design solutions with terms such as “resource-efficient,” “future-oriented” or “climate-neutral” and presenting them in compelling visual formats, they frame construction options in ways that are not only technically but also ethically and culturally persuasive. This symbolic framing can legitimise specific approaches even when they are not economically or functionally superior. In early phases of planning, where sustainability is often just one of many competing priorities, this normative plausibilisation can be decisive for the continued consideration of specific options. Donovan (2018), Fitz and Krasny (2019) and Lavaf-Pour and Meraz (2023) describe this process as part of a design-based ethics of sustainability, which culturally legitimises technical measures and thereby alters the scope for decision-making.

(4) Political Positioning

Beyond design and communication, architects also have the capacity to act publicly, civically and politically. This includes involvement in civil society initiatives, participation in the reform of regulatory frameworks or questioning of existing assessment standards. In this way, they can act as political agents within a field of contested norms and values.

The collective ANA (2025), Stumm (2025) and Fitz and Krasny (2019) demonstrate how architects make visible that demolition decisions are not purely technical necessities but societal issues that require open negotiation and collective engagement.

(5) Dealing with Planning Uncertainty

Planning in the context of existing buildings is frequently shaped by unpredictability, incomplete data and limited controllability. While architects cannot eliminate uncertainty, they can make it productive by offering robust design variants, open process structures and spatial scenarios that allow for informed decisions despite limited knowledge. This requires not only technical knowledge but also tacit experiential knowledge, for example, in dealing with undocumented structures, material variability or changing usage requirements. In practice, this

experiential knowledge often replaces formalised evaluation tools and thus becomes a key resource in the planning process. Rellensmann and Stumm (2025) highlight the relevance of such experiential insights, while Kurath and Eisinger (2010) point to the situational generation of knowledge in hybrid settings.

This model serves as the basis for the empirical investigation of when and how architects influence decision-making processes towards more sustainable and climate-resilient outcomes, and under what conditions this influence remains limited. It also functions as a foundation for developing a category system for the qualitative analysis of expert interviews.

5. Methodological Approach

To empirically investigate the assumptions formulated in the hypothetical model, a qualitative-exploratory research design was chosen. The model does not serve as a hypothesis in the strict sense, but rather as a heuristic framework that guides the structure of the analysis and supports the development of the coding system.

The aim is to reconstruct decision-making processes in relation to existing buildings, particularly in the early planning phases where fundamental decisions are made under conditions of uncertainty and in the absence of robust decision-making criteria. The role of architects is not presupposed normatively but is to be analytically reconstructed from the perspectives of those involved. The study focuses on how architects frame decision-making options, incorporate sustainability into design and communication, and how they are either included in or excluded from negotiation processes.

The research follows a mechanism-oriented explanatory strategy that focuses on understanding the social processes through which specific decisions, between demolition, retrofitting or rooftop extension, are reached. Rather than testing quantitative hypotheses, the goal is to gradually reconstruct the conditions and constellations under which particular decision options are enabled or constrained.

The central data collection method is expert interviews based on semi-structured interview guides, following Gläser and Laudel (2010). The concept of the expert is defined in institutional terms: interviewees are not selected based on personal experience alone, but because of their access to structurally relevant decision-making contexts. The goal is to gain insight into operational and institutional "process knowledge", such as routines, evaluation patterns and decision logics that are often not documented formally. The interview guides are narrative and reconstructive in nature. They follow real decision-making trajectories across project phases and provide insight into conflicts, uncertainties and path dependencies.

Three sets of interview guides were developed, each tailored to a specific actor group: architects (as the central group of this paper), representatives of housing owners (as formal decision-makers), and structural engineers (focusing on technical assessments under uncertainty). All guides are based on a common thematic structure consisting of seven core sections. The guide for architects includes: (1) introduction and contextualisation, (2) specific decision-making situation, (3) process and influencing factors, (4) understanding of roles and communication, (5) institutional framework, (6) reflection and evaluation, and (7) additional perspectives. The guide was pre-tested in pilot interviews and allows for flexible emphasis based on the respondent's experience.

Substantively, the guide for architects focuses on interpretative patterns in dealing with the existing building stock, the integration of design perspectives into institutional decision-making, and normative argumentation strategies. The guide for structural engineers explores how technical assessments emerge, are weighted and communicated, especially under incomplete information. For housing owners, the emphasis is on internal decision routines, economic logics and the framing of options such as preservation, extension or demolition as (im)plausible.

Interview partners were selected through two pathways: based on specific planning projects involving post-war buildings undergoing retrofitting, extension or demolition, and through recommendations provided by interviewees. To reflect the diversity of relevant decision-making contexts, institutional and contractual variation was ensured, including private, municipal and cooperative housing providers, as well as architectural offices with different client structures. The projects examined are either implemented or currently under planning, and include various pathways such as demolition and replacement, retrofitting or rooftop extension.

Interview analysis follows the methodology of qualitative content analysis according to Gläser and Laudel (2010) and Kuckartz (2018), and is conducted in two steps. First, a category system is developed deductively based on the hypothetical model and inductively extended through empirically derived subcategories. This allows the analysis to capture both theoretically anticipated and unexpected factors. In the second step, causal mechanisms and interrelations are reconstructed from the material. The analysis focuses on how decisions are made, under what conditions certain options are prioritised or dismissed, and how uncertainty is dealt with. A typology is then developed to systematically compare different decision-making logics and forms of influence.

The empirical results aim to contribute both to the theoretical refinement of the model and to practical implications for the early integration of sustainability expertise in planning processes.

6. Planned Empirical Implementation and Preliminary Results

Although the empirical study is still in its early stages, the interviews conducted so far already reveal initial tendencies that confirm and further differentiate central assumptions of the research project. At the time of writing this paper, six expert interviews have been conducted: four with architects and two with structural engineers. Additional interviews are currently being prepared.

The initial insights suggest that the effectiveness of architects in decision-making processes concerning existing buildings varies significantly. Crucial influencing factors include the structure of the client organisation, the prevailing planning culture and the political environment. In one case, the decision to demolish had already been made. The commissioned architect had no influence on defining the objectives and was only tasked with designing a replacement building. In another case, an architectural office was involved in an integrative planning team that brought together expertise in building services, building physics and architecture. Within this setting, sustainable alternatives, such as a timber-based rooftop extension and a façade refurbishment without conventional external insulation („Wärmedämmverbundsystem (WDVS)“), were introduced into the discussion at an early stage. Another interview case illustrated that arguments for sustainability were only successful if they aligned with economic objectives. It also became evident that political support, for instance from a city administration‘s leadership, was a crucial condition for the implementation of ambitious retrofitting concepts. At the same time, the interpretation of technical regulations was shown to be highly dependent on individual officials. In one case, a fire safety concept that had previously been approved for a different project was initially rejected and only approved after a change in staff responsibility. In several projects, overarching urban planning objectives prevented the implementation of rooftop extensions. In two cases, a higher building density was required than could be structurally achieved in the existing stock. In another project, a social conservation ordinance prohibited the use of ecological building materials on the grounds that they would lead to an impermissible increase in quality.

Several interviews also indicate that sustainability is rarely a formal part of the decision-making process. Instead, it is often introduced through design plausibility, communicative competence and institutional proximity to the client. These forms of influence are closely tied to the situational role that architects assume within a given project context. One structural engineer described his role in the decision-making process as the “late-stage technical confirmation” of previously developed design variants. This supports the hypothesis that technical assessments are often secondary, and that architectural framing may in fact become the primary decision-shaping factor.

Based on the case studies conducted thus far, three ideal types of architectural influence in decision-making can be identified:

(1) Architect as sustainability agent

This type is characterised by a proactive stance and a clear commitment to climate-conscious solutions. Architects in this role are involved in planning processes at an early stage and explicitly address sustainability in both communication and design. A typical example is the deliberate integration of strategies for the preservation and development of existing buildings as a guiding ecological and design principle.

(2) Architect as process moderator
This type assumes a mediating role between competing interests. Sustainable options are considered, but not framed as normative imperatives. Instead, they are embedded in broader strategic arguments. In one interview example, an architect succeeded in structuring a political decision-making process by visually presenting design alternatives, without explicitly advocating for one.

(3) Architect as neutral service provider
This type adheres closely to the client's specifications. Sustainability is not actively addressed, but may appear as a secondary condition. This type includes the case of the architect who was brought into the project only after the decision to demolish had already been made, and who was then commissioned to design a replacement building. Another interviewee explicitly described his role as apolitical and purely execution-oriented.

These ideal types are analysed in terms of the institutional and planning contexts in which they arise. Relevant factors include the type of project tender, the underlying project logic and the institutional setting. The key question is whether specific institutional or planning configurations systematically correspond with certain types of architectural influence. The results aim to identify the conditions under which architects can act effectively as transformative agents in the development of existing buildings, and the conditions under which their influence is systematically limited.

7. Conclusion and Outlook
The climate-conscious transformation of the existing building stock is one of the key challenges of the coming decades. Given the architectural significance of post-war buildings and the limited resources available for new construction, increasing attention is being paid to the conditions and processes of decision-making. This paper has shown that these decisions are shaped not only by technical, legal or economic factors but also, and in particular, by professional actors involved in early planning phases. In this context, architects play a central role.

Building on a multidimensional theoretical framework, this paper has developed a heuristic model that conceptualises architects as intermediary actors in decision-making processes on sustainable development of the existing building stock. The model identifies five mechanisms through which architects can influence decisions in the direction of climate-conscious and sustainable outcomes: design-based framing, mediation and moderation, normative legitimation, political positioning and the dealing with planning uncertainty. These forms of influence are not solely the result of individual agency but are institutionally embedded. Their effectiveness depends on the configuration of clients, organisational and planning conditions, the presence of political support and the quality of collaboration with other involved actors.

At the time of writing, the empirical implementation of the research project is ongoing. Six interviews have provided initial insights into typical patterns of architectural influence. The objective is not only to refine the model based on empirical findings but also to formulate practice-oriented questions. Of particular interest are strategies for integrating architectural perspectives earlier in decision-making processes, identifying institutional formats that strengthen design agency and exploring how the professional self-image of architects can be sharpened so that their cultural, communicative and normative competencies are strategically employed in socio-ecological transformation processes.

The research follows a dual objective. On the one hand, it expands theoretical perspectives from the sociology of professions and planning theory by offering a differentiated analysis of intermediary influence in the built environment. On the other hand, it proposes a practice-oriented framework for reflection that may be relevant for education, planning practice and institutional development strategies. The paper positions itself at the intersection of architectural sociology, professional studies and planning theory. It contributes to ongoing discourses in transformation governance and offers a perspective that connects institutional change with profession-related and architectural-theoretical insights on the built environment.

By focusing on the role of architects in addressing uncertainty, goal conflicts and normative ambiguity, this paper contributes to the question of how sustainability can become not only a subject of discussion but also a design and strategic factor in planning processes.

It thus aims to be both an analytical reconstruction of existing decision-making practices and a contribution to the debate on expanding professional agency in the context of sustainable development.

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Investigating the impact of Urban Form Elements on carbon emissions at Different Development Stages: Based on GWR Models

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Abstract
With rapid urban expansion, cities consume 78% of global energy and are major carbon emitters. Due to uneven urbanisation, Chinese cities at different development stages show varied relationships between urban form and carbon emissions. This study explores the impact of 3D urban form elements on carbon emissions across development stages to promote low-carbon development and carbon neutrality. Using Geographically Weighted Regression (GWR) and Random Forest models, the study analyzed spatial heterogeneity and non-linear relationships. Key steps included classifying city development stages, estimating city-level emissions using inventories and Night Time Light data, and examining spatial autocorrelation. Results indicate that factors such as building height and built-up area have a significant impact on emissions. These findings provide targeted recommendations for carbon reduction and sustainable urban development

Keywords: Carbon emissions, Urban development Levels, Urban forms, Geographically Weighted Regression Model

Introduction

Carbon emissions have impacted global climate change, leading to a rise in global average temperature, causing extreme weather events to become more frequent, and affecting human production and life(n.d.). With the gradual advancement of global urbanisation, cities are the most vulnerable to climate change and major contributors to it. According to statistics from UN-Habitat, cities consume 78% of the world's energy, and more than 60% of greenhouse gas emissions come from urban areas(Xia et al., 2020). To address this issue, the international community has proposed the Sustainable Development Goals, the United Nations Framework Convention on Climate Change, and the Special Report on Global Warming of 1.5ºC. As the world's largest carbon-emitting country, China has also actively participated in carbon reduction and control actions, proposing the goals of peaking carbon emissions by 2030 and achieving carbon neutrality by 2060 based on its national circumstances.

China's urbanisation process is rapid. According to data from the National Bureau of Statistics, the urbanisation rate in China was 65.22% by the end of 2022, with the urbanisation rate in nine provinces exceeding 70%. Previous studies have shown that the optimisation of urban spatial form plays a significant role in reducing carbon dioxide emissions(Xia et al., 2020). Urban form is generally considered the spatial arrangement and organisational pattern of human activities, affecting land use structure, resource utilisation efficiency, transportation configuration, infrastructure construction, and even the urban heat island effect(Liang et al., 2020). Numerous studies demonstrate that urban form is closely related to urban CO2 emission levels(2012; Xia et al., 2020; Zuo et al., 2020).

Traditional studies mainly focus on analyzing the impact of two-dimensional urban form indicators on urban carbon emissions. For instance, Ou et al. found that the fragmentation pattern of urban land leads to increased CO2 emissions across all city levels(J. Ou et al., 2019). Yasuyo Makido et al. studied the relationship between CO2 emissions and urban form in Japanese urban areas(Makido et al., 2012), while Fragkias et al. pointed out that during rapid urbanisation, population growth and resource consumption lead to the expansion of urban form, which significantly contributes to the increase in CO2 emissions("Investigating the differentiated impacts of socioeconomic factors and urban forms on CO2 emissions: Empirical evidence from Chinese cities of different developmental levels - ScienceDirect," n.d.). However, with high-density cities becoming an important goal for global carbon reduction and control, three-dimensional urban form indicators can better reveal the vertical spatial development and built environment of high-density cities as compared to traditional two-dimensional urban form indicators(Lin et al., 2021; Tian et al., 2024; Wang et al., 2025). Therefore, it is necessary to analyze the impact of the three-dimensional built environment on urban carbon emissions to promote green and low-carbon development models.

At the same time, due to the varying urbanisation progress across Chinese cities, there are significant differences in the socio-economic development, energy consumption structures, and carbon dioxide emission patterns among different cities(Ou J. et al., 2019). Additionally, urban spatial morphology elements, such as the scope of built-up areas, land use structures, urban compactness, and urban spatial forms, also show considerable variation. However, how the differences in urban development levels influence the relationship between urban morphology and CO2 emissions has not been thoroughly explored in the current literature. Taking Chinese cities as an example, most studies investigating the impact of urban morphology on CO2 emissions focus on megacities while neglecting underdeveloped and low-income cities. Although it is well-known that there are substantial disparities in carbon dioxide emissions across cities with different development levels(Behera and Dash, 2017; Wang et al., 2018), existing studies lack sufficient evidence to explain the differential impacts of multidimensional characteristics of urban morphology on carbon emissions. Furthermore, they do not clarify whether compact development models have universal emission reduction effects across cities with varying economic levels in China. Given this, there is an urgent need to construct a systematic research framework to explore the differentiated mechanisms through which urban spatial structures affect carbon emission intensity, while incorporating the dynamic characteristics of urban development stages for comprehensive analysis(Ou J. et al., 2019).

This study analyses the carbon emission characteristics of cities at different developmental stages based on their three-dimensional spatial form and explores targeted sustainable development models. Cities are first classified by development levels, and a carbon emission dataset derived from energy consumption and nighttime light data is used to calculate annual city-scale emissions. Key three-dimensional urban morphological metrics are then summarized and analysed. Geographically Weighted Regression (GWR) is applied to quantify the spatial heterogeneity of COΔemissions in relation to urban morphology and socioeconomic factors. The Ordinary Least Squares (OLS) regression model identifies global driving factors of city-level COΔemissions, while the GWR model reveals local variations by providing unique parameters for each observation. This approach uncovers the spatial characteristics and carbon emission patterns of cities, offering insights into sustainable urban development models and valuable references for policymakers.

Date and methodology

Study areas

This study examines prefecture-level and above cities in mainland China, focusing on the impact of industrialisation and urbanisation since the reform and opening-up policy. From 2000 to 2016, China's GDP increased sevenfold to 74.4 trillion yuan, accompanied by rising energy consumption and greenhouse gas emissions. China accounts for 23.0% of global energy consumption and 27.3% of carbon emissions, making it the largest emitter(Shi et al., 2018). Due to regional resource endowment, industrial structure, and energy efficiency, cities show significant spatial differences in carbon emission trajectories. Identifying the dynamic evolution of carbon emission drivers is crucial for creating differentiated emission reduction strategies that consider regional heterogeneity and sustainable development.

Figure 1 The geographical distribution of five-tier cities in mainland China.

The traditional classification of cities primarily relies on indicators such as built-up area size, city GDP, urban population, and population density. To evaluate the impact of socioeconomic factors and urban morphology on carbon dioxide emissions while considering differences in development levels, this study adopts the city classification system published by China Business Network (CBN) in 2024, which categorises Chinese cities into five tiers: first-tier, second-tier, third-tier, fourth-tier, and fifth-tier cities.

These metrics are sourced from commercial and internet data, reflecting various aspects such as the level of economic development, household consumption ability, local fiscal income, education level, educational resource level, and urban infrastructure quality. Subsequently, a comprehensive commercial development index for each city is calculated through principal component analysis and a weighted scoring method(Bai et al., 2018).

As shown in Figure 1, according to the 2024 rankings of the index, there are 19 first-tier cities, 30 second-tier cities, 70 third-tier cities, 90 fourth-tier cities, and 128 fifth-tier cities in China in 2024. The first-tier cities are, in order: Beijing, Shanghai, Shenzhen, Guangzhou, Chengdu, Hangzhou, Chongqing, Suzhou, Wuhan, Xi'an, Nanjing, Changsha, Tianjin, Zhengzhou, Dongguan, Wuxi, Ningbo, Qingdao, and Hefei.

Data sources

City-level CO2 emissions

Generally speaking, carbon dioxide emission data originate from energy statistics based on standard IPCC methods(Castles and Henderson, 2003; Li et al., 2021). The current national statistical system exhibits a clear hierarchical attenuation characteristic in energy data: energy consumption data released by the National Bureau of Statistics is mostly focused on the macro level, and there are significant data gaps at the prefecture-level (particularly in central and western cities).

To address the lack of urban-scale energy statistical data, a substantial amount of work has been successfully conducted to estimate urban-scale CO2 emissions based on nighttime light imagery. Nighttime light imagery has been proven to be a potential data source for estimating CO2 emissions, as it can detect artificial light associated with human activities.

In terms of carbon emission calculations, this study utilises the carbon emission gridded data for months 1-12 from the ODIAC 2023 dataset. The primary sources of this dataset are statistical data from fields such as energy consumption and industrial production. This dataset is pioneering in its use of nighttime light data combined

with emission/location profiles of individual power plants to estimate the global spatial distribution of fossil fuel CO2 emissions. Through an innovative emission modeling approach, it has achieved a 1x1 kilometer resolution data product for global fossil fuel CO2 emissions.

This study processed the outliers of carbon emissions as 0 and greater than 10,000 in the dataset, summed up the annual carbon emissions for 2023 within the urban areas of each prefecture-level city, and assigned the results to each city boundary to obtain the annual carbon emissions within the city boundary. The formulas are as follows:

$$E_{i,j}^{annual} = \sum_{m=1}^{12} E_{i,j}^{(m)}$$

$$E_k^{total} = \sum_{(i,j)\in A_k} E_{i,j}^{annual} \times A_{i,j}^{k}$$

where $E_{(i,j)}^{annual}$ represents the annual carbon emissions of grid cell (i,j) in 2023. E_k^{total} represents the total carbon emissions within the city boundary k in 2023.$A_{(i,j)}^{k}$ represents the area proportion of grid cell (i,j) within the built-up area of city k.

Comprehensive Indicators of Socioeconomic Development and Urban Form

This study selected two types of indicators related to socioeconomic development and urban morphology to analyse their impact on CO2 emissions. The first type includes socioeconomic variables such as GDP and population density, which are often used to represent economic performance and population scale; thus, they are important factors influencing changes in urban CO2 emissions. This study utilised GDP data, population data, and population density data of various cities. GDP data for 2023 of each city and the corresponding GDP data for the Primary Industry, Secondary Industry, and Tertiary Industry were obtained from the "China Urban Statistical Yearbook" and some city statistical yearbooks. For data consistency, some cities without statistical data were excluded from this analysis. Additionally, spatial distribution raster data of China's population at 1km resolution for 2023 were obtained from the LnadScan platform. Outliers were processed during usage, and population density within each city in 2022 was derived by summing the raster data.

The second type is the urban morphology indicator. Urban morphology can influence economic functions and efficiency, produce social impacts within urban environments, and ultimately affect the design and regulation of urban spatial uses(Fang et al., 2015).

Based on previous studies(Biljecki and Chow, 2022; Chen et al., 2025; Fang et al., 2015), this paper selects the following indicators to represent urban morphological characteristics: Total Area of Urban Built-up Area (TA), Average Building Height (ABH), Shape Index of Urban Built-up Area (SI). Transportation and urban expansion also have significant impacts on CO2 emissions(Lopez-Aparicio et al., 2025; Wu et al., 2022). This paper selects Road Density (RD) to represent the transportation characteristics within urban morphology.

Table 1 summarises the calculation formulas and units of the aforementioned indicators. To facilitate subsequent analysis, these variables are subjected to Z-score standardisation to eliminate the effects of dimensionality and outliers.

Research steps

Spatial autocorrelation

Moran's I index is an important tool for evaluating spatial autocorrelation, used to measure the dependency and heterogeneity characteristics among spatial objects. From a spatial scale perspective, Global Moran's I describes the overall degree of spatial association, while Local Moran's I reflects the similarity and differences among local spatial units(Wang et al., 2023). Both range from [-1,1], with positive values indicating similarity among spatial units and negative values indicating differences.

In statistical testing, z-scores and p-values are used to assess the strength of correlation and its significance.

Table 1 Detailed information on the indicators used in this study

Indicator	Calculation Formula/Definition	Unit
PD (Population density)	P_i represents the population of grid i; i represents the area of grid i.	People/km²
IS (Proportion of secondary industry)	The proportion of the secondary industry (e.g., industry, construction, etc.) in the gross domestic product (GDP).	%
RD(Road density)	L_d represents the total road length; $\llcorner$ represents the total area of the district	km/km²
TA (Total Area of Urban Built-up Area)	Area of developed and constructed zones within the city	km²
BH (Building height)	$H_{avg} = \frac{\sum_{i=1}^{n} h_i \cdot A_i}{\sum_{i=1}^{n} A_i}$ A_i represents the building height of grid i; A_i represents the area of grid i.	m
SI (Shape index)	P represents the perimeter of the built-up area, A represents the area of the built-up area	/

In spatial clustering analysis, the global mean and local mean are key parameters. A local mean higher than the global mean forms a high-high (HH) cluster, while a local mean lower than the global mean forms a low-low (LL) cluster. Observed values higher than the local mean form a high-low (HL) cluster, while those lower than the local mean form a low-high (LH) cluster(Su et al., 2014). These cluster types are distributed in four quadrants in the Moran scatterplot, corresponding to the central trend of regression models.

The geographically weighted regression model

The Geographically Weighted Regression Model (GWR) is a local spatial technique that can be used to examine the spatial variability of regression parameters and model performance. Relationships in geographic space often vary due to differences in geographic locations. Compared to general models, while classical Ordinary Least Squares (OLS) regression is a simple linear regression, its coefficients reflect the generalised relationships within the study area but do not account for the spatial components behind these effects. The introduction of the GWR model allows regression coefficients to change with spatial location by fitting a local regression model at each geographic location, thereby better explaining spatial heterogeneity.

The GWR model can be regarded as a spatial decomposition extension of the general linear regression model. The form is as follows:

$$y_i = \beta_0(\mu_i, v_i) + \sum_{i=1}^{k} x_{ij}\beta_j(\mu_i, v_i) + \varepsilon_i, \qquad (i = 1,2,\dots,m, j = 1,2,\dots,k)$$

where Δis the error term satisfying the spherical disturbance assumption; Δ_0 (μ_i,Δ_i) is the intercept term; k represents the number of factors, and i represents the i-th city.
Δ_j (μ_i,Δ_i) is the local regression parameter to be estimated at the regression point (μ_i,Δ_i), representing the latitude and longitude coordinates of the i-th city.

Results

The spatial features of city-level CO2 emissions

Based on the aforementioned methods, due to defects in CO2 emission data in some cities, this study estimates the 2023 CO2 emissions of 371 cities in China, as shown in Figure 2. The total CO2 emissions of Chinese cities amount to approximately 12.6 billion tons. About 249 cities have carbon emissions below the average (33.9 million tons). It can be observed that cities with relatively high CO2 emissions are mostly concentrated in the Yangtze River Delta (YRD), the Pearl River Delta (PRD), the Beijing-Tianjin-Hebei region (BTH), the Chengdu-Chongqing economic circle, and the northeastern regions of China, such as Changchun and Harbin.

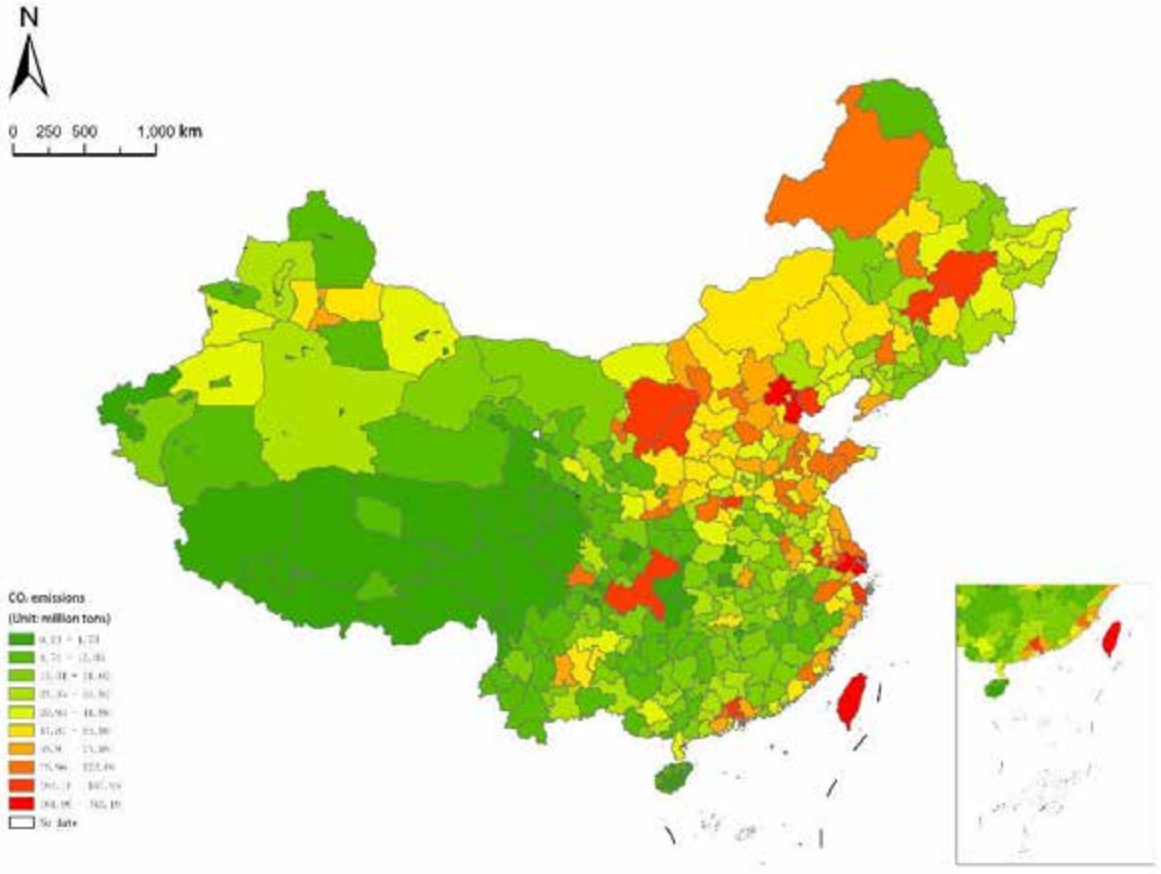

Figure 2 China's City-Level CO2 Emissions in 2023 (Million Tons)

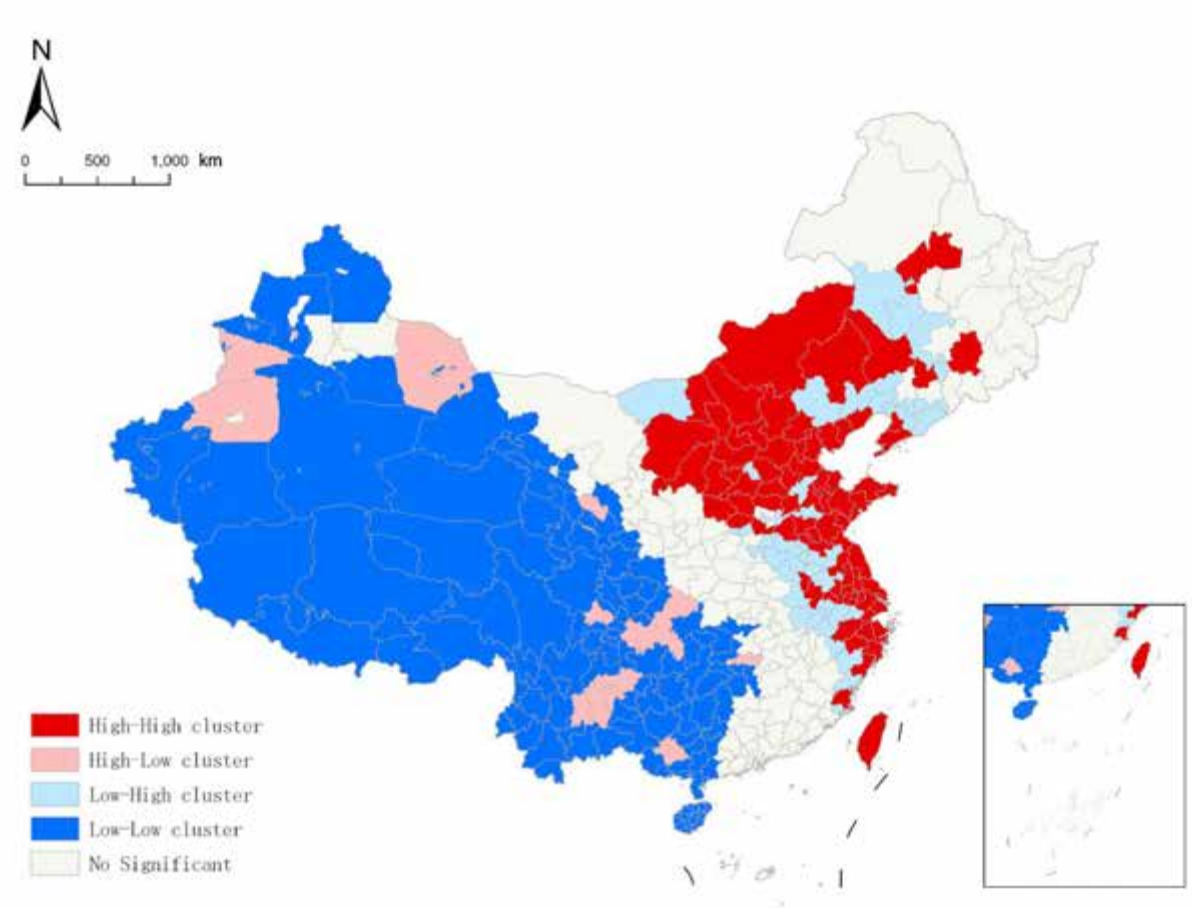

Figure 3 Local Moran's I clusters of CO2 emissions of Chinese cities

The spatial distribution of such CO2 emissions is closely related to regional development patterns. Among the top 10 cities with the highest carbon dioxide emissions, 7 are first-tier cities. These cities with higher carbon dioxide emissions benefit from favourable geographic locations or policy advantages, resulting in faster urbanisation, larger populations, more developed economies, and more intensive industries compared to other cities, particularly in the YRD, PRD, and BTH regions. In contrast, the northeastern region of China, which was once the heavy industrial base of the country, is currently undergoing policy initiatives aimed at addressing population loss in the area.

Cities with lower carbon dioxide emissions are typically located in less developed regions, including southern, northwestern, western, and parts of central China. Among these, the central region has historically sustained a large population, mostly consisting of second-tier and third-tier cities. In contrast, the western region, due to factors such as geographical conditions, has developed at a relatively slower pace. Although it occupies over 70% of China's territory, it accounts for only 30% of the population, with low urbanisation rates and slower economic development, mostly consisting of fourth-tier and fifth-tier cities.

This study calculates the global Moran's I to assess the spatial clustering of city-level CO2 emissions in China. It finds that the global Moran's I of CO2 emissions is 0.17 ($p < 0.01$), indicating a significant positive spatial autocorrelation of CO2 emissions. To further analyse the spatial characteristics of city-level CO2 emissions in China, this study employs the local Moran's I.

The CO2 emission LISA map shown in Figure 3 geographically depicts the local spatial correlation of CO2 emissions. HH clusters are mainly concentrated in YRD, BTH, parts of the Shandong Peninsula, and a few northeastern cities in China, which are densely populated and economically developed. LL clusters are primarily distributed in the northwestern and southwestern regions of China, involving some cities in the central region. HL clusters are relatively dispersed, mainly distributed in the Xinjiang region of northwestern China, the Chengdu-Chongqing

region of southwestern China, parts of Shanxi, Guizhou, and Guangxi, and form a relatively continuous concentration in Yunnan. LH clusters are mainly distributed around HH clusters. A particularly notable aspect is that HH clusters do not appear in the PRD region, which features a developed and prosperous economy and a high level of urbanisation. One possible reason for this could be the impact of CO2 emissions from surrounding cities.

Major factors influencing city-level CO2 emissions

To comprehensively understand the driving factors and effects behind city-level carbon dioxide emissions, this paper first uses the OLS model to detect the impact of eight explanatory variables on urban CO2 emissions. The Z-score standardisation is performed on these explanatory variables to eliminate the effects of dimensions and outliers. The ANOVA F-test shows that the overall model has statistical significance ($p < 0.001$), and the adjusted R-squared value (0.79) indicates a relatively high goodness of fit.

There is no issue of multicollinearity, as all variance inflation factors (VIF) reported for the variables are far below 10.

The results are presented in Table 2. The coefficients indicate that most explanatory variables are positively correlated with CO2 emissions, particularly the area of developed land, building height, and significantly contribute to urban CO2 emissions. PD and IS promote urban CO2 emissions, while RD has a significant effect on reducing urban CO2 emissions, and SI has a minimal impact.

Table 2 OLS analysis results

	Coefficient	Std. Error	T value	Pr.(>|t|)	VIF
Constant	38.5688	1.3974	27.5999	0.0000*	
PD	9.0387	5.6237	1.6072	0.1093	3.9287
IS	-10.1902	2.3048	-4.4212	0.0000*	3.5577
RD	17.5675	1.9847	8.8516	0.0000*	2.6662
TA	27.9687	3.0078	9.2986	0.0000*	5.7252
BH	0.7631	2.0443	0.3733	0.7093	2.7712
SI	9.1118	1.4244	6.3968	0.0000*	1.1014

As mentioned above, the global regression model assumes that the relationship between CO2 emissions and each explanatory variable is the same across all locations, and the results of this model fail to explain the local heterogeneity of driving factors. Therefore, the GWR model in this paper is set with the same variables. The spatially distributed local R-squared values described in Figure 4 also indicate that the comprehensive statistical effects of our explanatory variables on CO2 emissions vary between 0.702 and 0.925 among Chinese cities.

As shown in the figure, the local R-squared values roughly exhibit a ring-shaped distribution, gradually decreasing from the eastern coastal areas. The R-squared values of the GWR model for the vast majority of studied cities are higher than those of the global regression model, with only some cities in the southwestern region, parts of the central region, and parts of the northwestern region falling below the OLS threshold (0.79).

The results indicate that the range of regression coefficients relative to their standard deviations is quite broad, with the minimum value (road network density) being -8.749 and the maximum value (built-up area) being 22.438. The greater the range of variable coefficients, the greater the spatial variation in the contribution and influence of the factors, which demonstrates the appropriateness of the GWR model in providing better explanations for local estimates.

To further explore the spatial heterogeneity in the relationship between each explanatory variable and CO2 emissions, we generated maps representing the spatial distribution of coefficients for each factor (Figure 5). Consistent with the OLS model, the average building height, built-up area, and secondary industry GDP of cities were shown to have a positive impact on CO2 emissions in the studied cities, but their relationships with CO2 emissions varied spatially.

Meanwhile, other factors exerted bidirectional influences on cities' CO2 emissions, with certain differences observed among different cities—an aspect not revealed by the global regression model.

Research and development, in all the studied cities, TA is a key driver of urban CO2 emissions, maintaining a still significant coefficient. Among socio-economic indicators, the regions most affected by IS are concentrated in the eastern coastal area, the northeast region, some central cities, and some cities in the northwest. In terms of urban development levels, in some Tier 1 cities located in the eastern coastal areas, CO2 emissions are still influenced by IS. Relatively speaking, the influence degree in Tier 1 cities in the Chengdu-Chongqing area, PRD, and BTH region is smaller compared to other Tier 1 cities. This is mainly because Tier 1 cities like Beijing, with urbanisation progress and economic structure upgrades, have gradually transferred high-energy-consuming and high-pollution industries to surrounding areas (such as Hebei Province, Jiangsu Province, etc.). They have also implemented stricter environmental protection policies and carbon emission control measures.

The secondary industry in Tier 2 and Tier 3 cities overall has a significant impact on carbon emissions. This is because the economic development of Tier 2 and Tier 3 cities still primarily relies on the secondary industry, especially traditional industries with high energy consumption and high pollution (such as steel, chemical industry, cement, coal, etc.), which have high energy consumption and carbon emission intensity. At the same time, due to the division of labor in regional economies, much of the secondary industry eliminated by Tier 1 cities has shifted to Tier 2 and Tier 3 cities due to factors like costs, labor, and policies. Additionally, some Tier 2 and Tier 3 cities are resource-based cities (e.g., those rich in coal, oil, and minerals), and their economic development is highly dependent on resource extraction and processing, activities that are typically accompanied by high carbon emissions.

Interestingly, in the southwestern regions such as Yunnan, Guizhou, Guangxi, and parts of Shandong's cities, the secondary industry has a relatively small impact on urban carbon dioxide emissions. These cities are mostly Tier 4 and Tier 5 cities, with slow urbanisation processes, and some are just beginning to develop. Additionally, influenced by geographical and natural conditions, Sichuan, Yunnan, Guizhou, and Guangxi possess abundant water resources. Hydropower occupies a significant proportion in their energy structure, making them key provinces for clean energy output. Moreover, in recent years, due to low-carbon policies and eco-priority strategies, the country has implemented strict ecological protection policies in these regions, emphasizing the introduction of energy-saving and emission-reduction technologies. All these factors have resulted in the secondary industry having a minimal impact on urban carbon dioxide emissions in these cities.

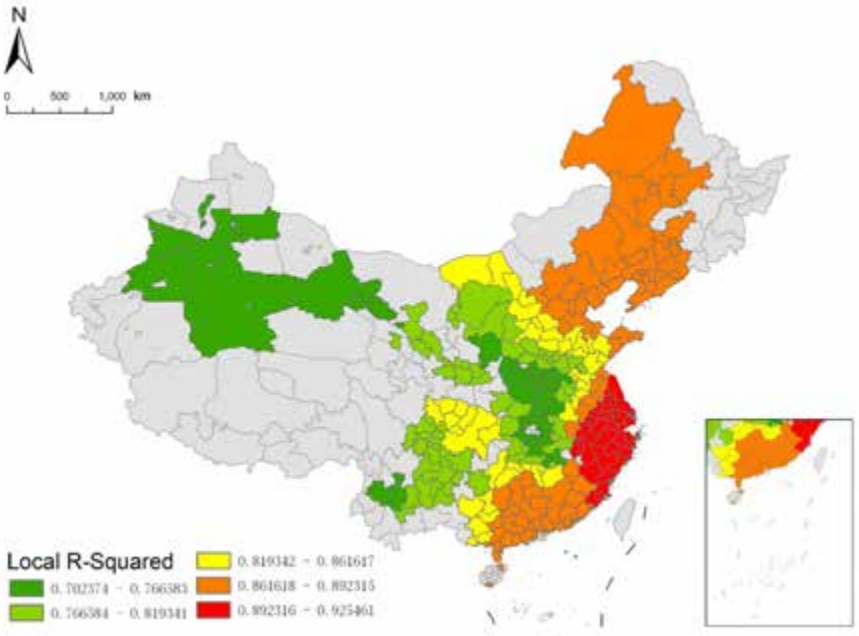

Figure 4 The spatial distribution of R-squared values from the GWR model.

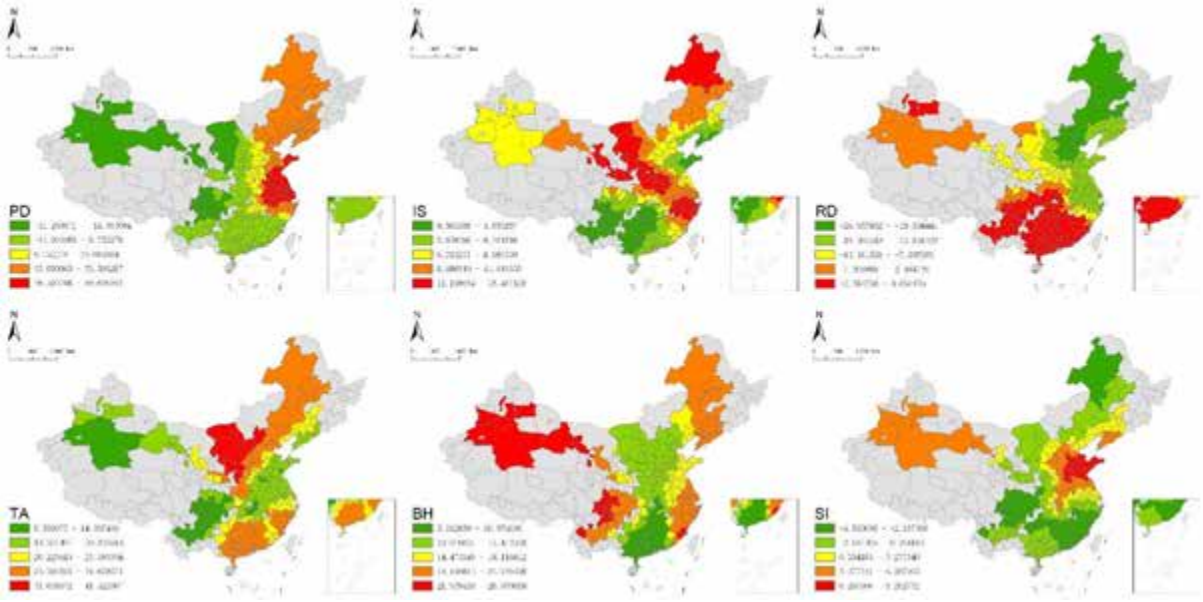

Figure 5 Spatial distribution of GWR local coefficient

Moreover, the study also found that PD has a bidirectional impact on urban CO2 emissions, generally showing a positive effect in the eastern and northern regions, while exhibiting a negative effect in the western, southwestern, and certain southern coastal regions. China's Tier 1 and Tier 2 cities are extensively distributed in areas such as the YRD and BTH regions. These areas are characterised by a generally high level of urbanisation and developed economies, which strongly attract populations, leading to significant migration to these regions. High population density implies more residential, transportation, commercial, and industrial activities, which directly result in increased energy consumption, thereby driving the rise in CO2 emissions. At the same time, high population density is usually accompanied by increased traffic pressures. Although the public transport systems in the YRD region are relatively well-developed, with further increases in population density, the use of private cars remains quite common, which can lead to traffic congestion and increased vehicle emissions, further driving up CO2 emissions.

In the central and western regions, most cities are Tier 3, Tier 4, or Tier 5 cities. These lower-level cities exhibit lower economic activity and energy consumption intensity, wherein an increase in population density actually enhances resource utilisation efficiency and reduces per capita carbon emissions. At the same time, due to their lower economic levels, cities with low development levels have limited demand for urban expansion and large-scale infrastructure construction. Compared to cities with high development levels, an increase in population density does not lead to large-scale construction activities that result in increased carbon emissions.

In the indicators of urban morphology, research has found that both BH and TA positively influence urban CO2 emissions. The impact of BH on urban CO2 emissions shows a trend of being high in the eastern coastal and western regions and low in the central region. The impact of TA on urban CO2 emissions exhibits a trend of being high in the southeastern coastal and northern regions, while relatively low in the northern coastal, southwestern, and northwestern regions.

The eastern coastal region is the core area of China's economy and industrialisation, featuring a rapid urbanisation process. Over the years of urbanisation, this has resulted in large urban built-up areas and generally taller building heights, gradually transforming into high-density cities. Greater building heights often indicate higher energy consumption, such as for elevator operation, air conditioning systems, as well as increased heating and lighting demands, leading to higher CO2 emissions. At the same time, due to greater ventilation, lighting, and cooling demands, high-rise buildings typically consume more energy per unit area than low-rise buildings, further exacerbating carbon emissions.

Additionally, eastern coastal cities concentrate a large amount of industry and services, with high population and economic activity densities. In the course of urbanisation, city expansion is required to accommodate significant population influxes, generally accompanied by substantial infrastructure construction, industrial activities, and transportation, all of which are major sources of CO2 emissions.

In the central and parts of western regions, Tier 2 and Tier 3 cities account for a large proportion. In recent years, rapid urbanisation and economic development have shown strong growth potential. Through policy support (such as the Western Development strategy), the urbanisation process has been accelerated in recent years. Some central cities (such as Chengdu, Chongqing, and Xi'an) are undergoing rapid growth, with the expansion of built-up areas and an increasing number of high-rise buildings. The energy consumption patterns of these buildings resemble those of the eastern coastal regions, resulting in building height having a significant impact on carbon emissions. In regions such as Yunnan, Guizhou, and Guangxi, where there are a larger number of Tier 4 and Tier 5 cities, most cities exhibit lower levels of urbanisation. The expansion of built-up areas is more evident in low-density urban development, with lower intensity in economic activities and energy consumption, thereby making the impact of built-up area size on CO2 emissions relatively small. In the northwestern regions (such as Xinjiang and Gansu), although the built-up area size has expanded somewhat, the low population density, relatively simplistic urban functionality, and industrialisation and economic activities concentrated in a few sectors (such as resource extraction) result in the built-up area size having a weaker impact on overall CO2 emissions.

The influence of RD on urban CO2 emissions is mainly negative, with only a few areas showing a positive impact (mostly in the PRD region). In northern regions, an increase in road density significantly reduces urban CO2 emissions, as these regions originally have low road density, potentially causing insufficient transportation networks, vehicle detours, and traffic congestion. High road density enhances connectivity within cities, providing residents with more travel options, shortening commuting distances, and reducing overall traffic carbon emissions. In contrast, the generally higher road density in the southern regions results in relatively smaller reductions in urban CO2 emissions with increased density. Additionally, the high road density in the Pearl River Delta region contributes to an increase in urban CO2 emissions. On the whole, cities at all development levels still need to further improve their road density, which aligns with the national requirement for road density to exceed 8km/km2.

Research findings indicate that SI factor also exhibits a bidirectional effect. In urban built-up areas of cities located in the northern coastal region, certain eastern coastal areas, parts of central regions, and specific regions of Xinjiang, an increase in the shape index of urban built-up areas leads to an increase in urban CO2 emissions, while an increase in the shape index in neighboring areas results in a reduction in urban CO2 emissions. This is because the irregular shape of urban built-up areas in these regions leads to increased transportation demand, thereby raising carbon emissions.

Discussion and Conclusion

Numerous studies have examined the driving factors of CO2 emissions, most of which rely on traditional regression models. These models fail to reveal spatial variations in these impacts, thereby overlooking the fact that due to differences in conditions and development statuses of these locations, the effects of factors may vary between different places. This study adopts a GWR model, which, instead of generating a single set of model parameters for the entire study subject, enables us to identify local variations in statistical relationships, where closer observations have a greater influence on the parameters than more distant ones.

Under the support of traditional regression models and geographically weighted regression models, we compared the coefficients of each driving factor globally and locally. The traditional ordinary least squares model shows that built-up area and building height are the main factors promoting CO2 emissions, while road network density negatively correlates with CO2 emissions. The remaining factors do not play a significant role in influencing CO2 emissions. Moreover, our geographically weighted regression model shows that the impact of these remaining factors varies spatially. Built-up area and building height still maintain a consistent positive correlation with urban CO2 emissions.

It is worth noting that the geographically weighted regression model used in the study also provides many important results not revealed by the ordinary least squares model, such as the bidirectional influence relationship

between factors like population density and shape index with urban CO2 emissions. For Tier 1 cities, most of the CO2 emissions are greatly influenced by factors like building height and built-up area, while being less influenced by secondary industry and shape index. Tier 2 and Tier 3 cities are greatly influenced by built-up area and also by secondary industry, building height, and road network density but are less influenced by other factors. Tier 4 and Tier 5 cities are significantly influenced by secondary industry and built-up areas.

In the eastern and central-western regions (e.g., Zhejiang, Henan, Hubei, Gansu, etc.), due to the dominance of traditional high-energy-consuming industries or high industrial aggregation, the secondary industry has a significant impact on carbon emissions. In contrast, coastal regions (e.g., the Pearl River Delta, Beijing-Tianjin-Hebei) and some Tier 1 cities (e.g., Beijing) experience a smaller impact due to industrial upgrading, relocation of high-energy-consuming industries, and strict carbon emission control policies. Population density exhibits a bidirectional impact on carbon emissions; in the eastern coastal areas, due to their strong economic attractiveness, increased habitation, transportation, commercial, and industrial activities lead to higher energy consumption. The impact of road density varies regionally; an increase in road density reduces carbon emissions in the northern regions, while in some cities of the Pearl River Delta, excessive road density increases carbon emissions. Building height and built-up area have a significant positive impact on carbon emissions, with building height having a greater influence in the eastern and western regions and a smaller impact in the central region. The built-up area has a higher impact in the southeastern coast and northern region and a lower impact in the central and northwestern regions. The shape index of built-up areas positively affects carbon emissions in the eastern and northern regions, whereas in other regions, the shape index factor reduces carbon emissions.

The advent of climate change has drawn global attention to how urban carbon dioxide emissions can be reduced. From this perspective, China's rapid development not only threatens the country's sustainable development but also impacts future climate change. However, due to varying levels of urban development and differing processes of urbanisation, it is crucial to study how disparities in urban development levels affect the relationship between urban morphology and CO2 emissions.

Despite our research findings demonstrating the increasing trend of carbon dioxide emissions, economic development remains a prerequisite for the vast majority of cities in China. However, cities at different stages of development can make industrial layout choices based on their respective carbon emission characteristics. Additionally, renewable energy sources such as wind and tidal energy can be introduced, or cities can continue developing advantageous renewable energy industries according to natural conditions. For example, cities in Sichuan and Yunnan can further develop hydropower. Policies related to population also need to be improved by controlling the population size in economically developed cities along the southeast coast and directing labor migration toward cities in the western and northeastern parts of the country. Suitable urban built-up area intensity development should be undertaken according to city rank and population density, controlling building heights and road network density to achieve compact urban development or appropriately expanding urban built-up areas to advance urbanisation processes. China undoubtedly faces significant challenges in reducing and maintaining carbon dioxide emissions according to internationally recognised standards; we hope our research contributes to this endeavor to some extent.

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Exploring the Carbon Emission Impact of Community Life Circle Shared Clusters: A Case Study of Nanjing, China

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Abstract
Aligned with global sustainability goals, this study examines how facility service and sharing structures influence urban carbon emissions. Using Nanjing as a case, a multi-scale system is developed across four facility types: education & health, culture & sports, convenience & utility, and commercial & leisure. Shared community clusters are identified via isochrone analysis and strongest-link mapping. Carbon emission impacts are evaluated using both univariate and multivariate regressions. Results reveal type-specific differences in spatial sharing patterns and emission sensitivities, with cultural facilities showing the strongest effects. A carbon-oriented planning strategy is proposed, advocating differentiated configurations of self-sufficient and shared facilities based on facility-type characteristics and spatial service structures.

Keywords: community life circle; facility sharing; cluster identification; carbon emissions

1.Introduction

Driven by sustainability goals, developing low-carbon spatial governance models has become a vital strategy for urban development. As the fundamental spatial unit of everyday life, the community life circle plays a critical role in shaping activity distribution, mobility patterns, and service efficiency, making it a key focus in low-carbon urban research (Hong et al., 2020)it is necessary to reduce energy use and associated greenhouse gas emissions in buildings through energy conservation and efficiency improvements. Computational tools empowered with rich urban datasets can model performance of buildings at the urban scale to provide quantitative insights for stakeholders and inform their decision making on urban energy planning, as well as building energy retrofits at scale, to achieve efficiency, sustainability, and resilience of urban buildings. Designing and operating urban buildings as a group (from a city block to a district to an entire city. By integrating essential services—such as education, healthcare, commerce, and cultural amenities—within walkable or short-travel distances, life circles encourage more compact, efficient, and greener lifestyles, thereby contributing to city-wide carbon reduction efforts (Bruno et al., 2024)in particular, heralded a new vision for cities where essential services must be easily accessible. Despite its undoubted merit in stimulating discussion on new organization of cities, the 15-minute city cannot be applicable everywhere, and its very definition raises a few concerns. Here we tackle the feasibility and practicability of the 15-minute city model in many cities worldwide. We provide a worldwide quantification of how close cities are to the ideal of the 15-minute city. To this end, we measure the accessibility times to resources and services, and we reveal strong heterogeneity of accessibility within and across cities, with a pivotal role played by local population densities. We provide an online platform (https://whatif.sonycsl.it/15mincity/

Most existing studies on community life circles emphasize internal completeness, focusing on service sufficiency, accessibility, or equity within individual communities. However, in practice, significant service overlap and facility sharing exist between communities. These shared connections form interconnected clusters, where multiple life circles are functionally linked through shared facilities (Pan, 2023)ΔSuch clusters often transcend administrative or physical boundaries, reflecting more complex patterns of service coverage and functional interdependence. While this configuration may enhance facility utilization and spatial flexibility, its systemic implications for mobility, service reliance, and local carbon emissions have yet to be fully understood or quantified (Chai and Li, 2019)Δ

As cities become more polycentric and resource allocation more distributed, the structure of these shared clusters may play a key intermediary role in shaping urban carbon emissions. Identifying these clusters and clarifying their impact mechanisms is crucial—not only for refining life circle planning, but also for advancing precision carbon governance at the community scale. The lack of integrated models that combine spatial structure, facility interaction, and environmental outcomes remains a critical gap in current literature.

This study takes Nanjing, China as a case to examine how spatial accessibility and facility sharing patterns influence carbon emissions at the local level. First, a multi-scale life circle system is constructed based on 5-, 10-, and 15-minute isochrones, covering four essential service categories: education & health, culture & sports,

convenience & utility, and commercial & leisure. Second, based on accessibility and spatial overlap, functionally connected shared clusters are identified through a strongest-link network approach. Third, service intensity (number of accessible facilities) and sharing intensity (the share of facilities engaged in cross-community use) are used in univariate regression models to evaluate their individual effects on carbon emissions. Finally, a multivariate regression model incorporates the combined characteristics of multiple facility types to reveal potential synergistic or compensatory effects on emissions.

This research addresses the following questions:

- How do facility configuration and inter-community sharing jointly shape shared cluster structures?
- How do service and sharing intensities across different facility types influence carbon emissions?
- Do multidimensional sharing patterns lead to synergies or trade-offs in emission outcomes?

The findings provide new insights into the functional logic linking urban facility networks and emission patterns, offering evidence-based guidance for carbon-oriented planning and optimized life circle service configurations. The proposed framework contributes to both academic understanding and practical strategies for managing the spatial-energy nexus in future sustainable cities.

2.Methodology

This study focuses on the central urban area of Nanjing and develops an analytical framework that links facility types and accessibility, sharing structures, and carbon emission impacts. Using multi-scale isochrone analysis, community-specific facility access was identified to define facility bundles for each neighborhood. Based on the overlap between these bundles, sharing relationships were established to construct facility sharing networks and delineate shared clusters. Finally, integrating community-level carbon emission data, the analysis evaluates how service intensity and sharing intensity influence emission outcomes.

2.1Classification of Facility Types and Definition of Facility Bundles

The appropriate composition of facilities within community life circles has been widely discussed in prior research. Frameworks for defining such systems typically consider two key dimensions: accessible travel time (He et al., 2024; Logan et al., 2022, p. 10; Staricco, 2022) and facility type (Liu et al., 2024; Moreno et al., 2021)there is a lack of comprehensive measures and an overall understanding of the 15-minute city status. By using the latest population census data and POI data in Hong Kong, this study proposes a 15-minute city index that holistically measures the 15-minute city status by incorporating the accessibility, which is measured by a modified two-step floating catchment area (2SFCA. Based on daily living needs, this study establishes a facility system comprising four core service functions: education & health, culture & sports, convenience & utility, and commercial & leisure. Building upon this classification, 5-, 10-, and 15-minute isochrones are introduced to define three levels of service space—self-sufficient (5-minute), neighborhood-level (10-minute), and shared (15-minute) life circles. Each level corresponds to a different spatial scale of facility provision and is associated with a set of representative facility types. The detailed facility composition is as follows (Table1):

Table 1 Facility Composition Across Life Circle Scales and Service Categories

	5min (Self-Sufficient)	10min (Neighborhood)	15min (Shared)
Commerce & Leisure (C&L)	Restaurants	Dessert shops, beverage stores Teahouses, mahjong clubs, karaoke Pet and plant markets Bathhouses, salons	Cinemas, theaters Shopping malls, amusement parks
Education & Health (E&F)	Pharmacies	Kindergartens Primary schools Clinics, specialty hospitals	General hospitals Middle schools
Culture & Sports (C&S)	Small public spaces	Cultural store Gymnasium	Museums, art galleries, cultural centers Parks, squares, stadiums Scenic spots, zoos, aquariums
Convenience & Utility (C&U)	Parcel stations Public transport (bus/metro) Convenience stores Parking lots	Telecom service centers Charging stations Wet markets	Postal services Banks Gas and fueling stations Elderly care centers

Specifically, the education & health category includes various levels of medical and educational facilities, reflecting the progressive expansion of basic healthcare and compulsory education services. The culture & sports category spans from small public spaces and local sports venues to parks, squares, and museums, covering both everyday and occasional cultural and recreational needs. The convenience & utility category comprises parcel stations, convenience stores, public transport (bus/metro), parking lots, charging stations, banks, wet markets, gas stations, and elderly care centers, addressing daily goods acquisition and mobility support. Lastly, the commerce & leisure category ranges from local entertainment facilities—such as restaurants, dessert shops, and teahouses—to cross-community consumption venues including cinemas, shopping malls, and amusement parks.

Subsequently, 5-, 10-, and 15-minute isochrones were generated for each community using central point locations and the Mapbox API. Through spatial overlay analysis, all reachable facilities within each time threshold were identified. This resulted in a multi-scale dataset of community facility bundles, recording the number and types of accessible facilities—across the four service categories—for each community at each isochrone level.

2.2 Identification of Shared Community Clusters

Based on the constructed facility bundles, sharing relationships between communities were identified by examining the overlap of accessible facilities. If two communities shared one or more facilities within the same isochrone threshold, they were considered to have a facility-sharing connection. This sharing logic was applied across two dimensions: three isochrone levels (5, 10, and 15 minutes), and four facility categories (education & health, culture & sports, convenience & utility, and commerce & leisure), resulting in a set of multi-dimensional facility sharing networks.

In each network, nodes represent communities and edges represent facility-sharing links, with edge weights indicating sharing intensity (e.g., number or proportion of overlapping facilities). To capture the most significant sharing relationships, each community's strongest sharing partner—the community with the highest sharing intensity—was identified. These links were used to construct a strongest-link sharing network, from which shared community clusters were delineated. Each cluster comprises communities that are directly or indirectly connected via their strongest facility-sharing ties.

Each facility-specific network yields a corresponding set of Shared Community Clusters, reflecting the spatial sharing structure and functional distribution of that facility type across the city. These clusters not only reveal patterns of inter-community service reliance, but also serve as the fundamental spatial units for the subsequent analysis of carbon emission impacts.

2.3 Carbon Emission Patterns under Facility Service-Sharing Structures

Following the identification of shared community clusters, this study incorporates community-level carbon emissions data and conducts a two-level regression analysis to systematically evaluate the impact of service and sharing characteristics on carbon outcomes. The analysis includes:

- Univariate regression analysis (cluster level): Each analysis unit corresponds to a set of shared community clusters derived from one specific facility type. The average carbon emission of all communities within each cluster is calculated. Two explanatory variables are extracted: the service intensity (total number of facilities within the cluster) and the sharing intensity (proportion of shared facilities). Linear regression is employed to assess the direction and significance of emissions impact across different facility types, revealing the emission patterns associated with single-type sharing structures.
- Multivariate regression analysis (community level): Each individual community serves as the unit of analysis. A multidimensional vector of service and sharing intensities is constructed, encompassing all four facility types. A multiple linear regression model is applied to evaluate the composite influence of different facility types within the overall sharing network, exploring whether their effects on carbon emissions are synergistic, complementary, or substitutive.

To enhance interpretability, the model incorporates standardized variables and controls for multicollinearity. This analytical framework facilitates a macro-level understanding of how facility sharing structures shape urban carbon emissions, while also uncovering the complex interactions among multiple services at the micro (community) level.

3.Results

3.1Shared Facility Structures in Community Life Circles

Figure 1 illustrates the facility sharing network structures across communities in Nanjing's central urban area, differentiated by isochrone thresholds (5, 10, and 15 minutes) and facility types. From the perspective of overall sharing networks, inter-community connections intensify significantly as the time radius expands. In the 5-minute life circle, only 574 sharing edges are observed, with an average degree of 0.94, indicating that most facility use is confined within individual communities. In contrast, the number of sharing edges increases to 2,517 and 7,346 in the 10- and 15-minute networks, with corresponding average degrees rising to 4.12 and 12.02, respectively. This reflects a transition from "local self-sufficiency" to "regional sharing," with a progressively higher level of spatial integration.

Facility-specific sharing networks also exhibit clear variations in network connectivity and cluster configuration. The culture & sports (C&S) network shows the highest average degree (18.77), indicating the strongest and widest sharing pattern. The commerce & leisure (C&L) and convenience & utility (C&U) networks also show relatively high degrees of connectivity (15.61 and 15.86, respectively). In contrast, the education & health (E&H) network has a lower average degree of 11.77, suggesting weaker inter-community ties and a more localized pattern of service provision.

The red edges in the figure highlight each community's strongest sharing connection, further revealing the diversity of shared community cluster structures. Across different facility types, the same community often links to distinct target communities, resulting in divergent cluster affiliations in each facility-specific network. This indicates a functional divergence in sharing behavior: communities exhibit varying patterns of cooperation and service coupling depending on the facility category. Such differentiation reflects the complexity of multi-dimensional sharing structures in urban space and lays the groundwork for analyzing how different types of facility sharing influence carbon emissions.

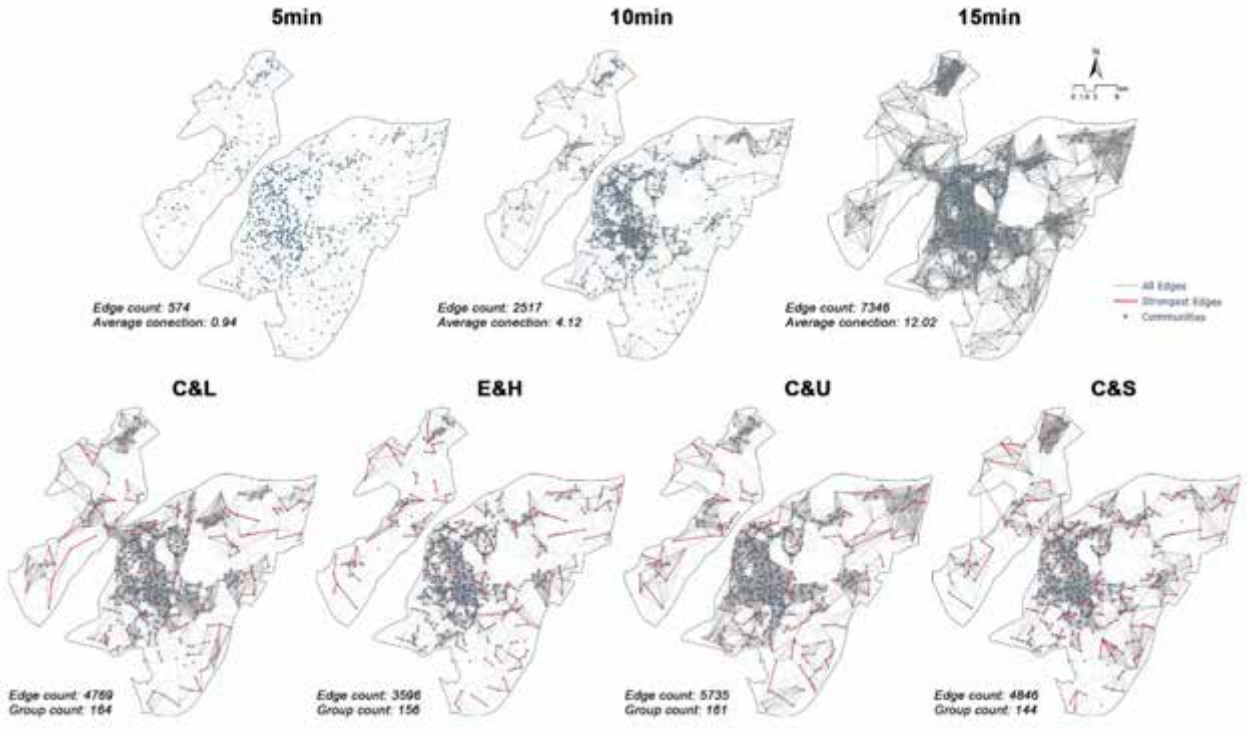


Figure 1 Community facility sharing networks under different time scales and facility types

Building upon the constructed sharing networks, two key indicators—service intensity and sharing intensity—were calculated for each community (or shared community cluster) across different facility types (Figure 2).

In terms of service intensity (left panel), the four facility categories exhibit substantial variation in spatial distribution. Commercial & leisure (C&L) facilities are markedly more abundant and widespread than the other types, with service intensity exceeding 3,000 in some communities, indicating a high-density clustering pattern. In contrast, the median and upper quartile values for education & health (E&H), culture & sports (C&S), and convenience & utility (C&U) are consistently lower, reflecting compact distributions with generally low intensity. This suggests these facilities are more evenly distributed across the city but exhibit lower localized density.

As for sharing intensity (right panel), all four categories present broadly similar distribution patterns, yet subtle differences emerge. Culture & sports (C&S) and convenience & utility (C&U) facilities show slightly higher sharing intensities, implying a greater propensity for overlapping usage across communities and stronger sharing potential. By contrast, education & health (E&H) exhibits lower sharing intensity overall, with some communities showing near-zero sharing proportions—suggesting spatially confined service areas with limited cross-community reach. Despite the high service intensity of commercial & leisure (C&L) facilities, their sharing intensity is more dispersed, indicating strong shared usage in some regions while remaining locally concentrated in others. Collectively, service intensity captures the spatial density of different facility types, while sharing intensity reflects their potential for inter-community connectivity. The combination of these metrics provides a quantitative basis for characterizing the shared facility structures within urban life circles and supports the subsequent analysis of their association with carbon emissions.

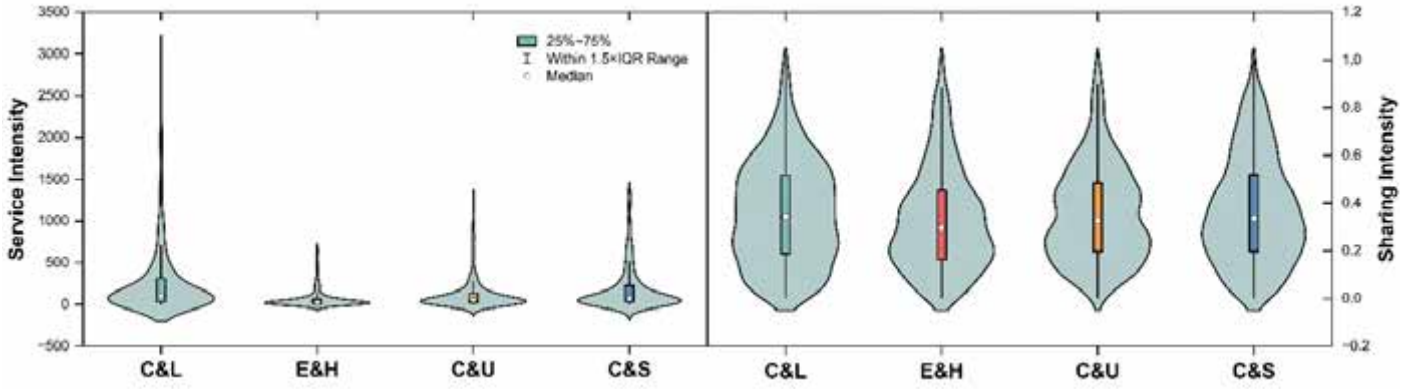


Figure 2 Distribution of service intensity and sharing intensity across facility types

3.2 Carbon Emission Patterns across Single-Type Sharing Clusters

Figure 5 presents the spatial distribution of carbon emissions at both the community level and the shared cluster level. The left panel illustrates carbon emissions at the community level, derived by overlaying ODIAΔC gridded data with community boundaries(Tomohiro Oda and Shamil Maksyutov, 2015). The results reveal a clear spatial pattern of "high in the center, low in the periphery" across Nanjing's central urban area. The emission values are right-skewed and spatially asymmetrical, aligning with the concentration of population and built-up intensity in the urban core.

The four maps on the right display carbon emissions aggregated by shared community clusters for each facility type: commercial & leisure (C&L), education & health (E&H), culture & sports (C&S), and convenience & utility (C&U). These cluster-based maps reveal notable differences in emission distribution. Clusters derived from C&L and C&S sharing networks tend to reinforce carbon concentration in central areas, indicating strong overlap of high-emission communities within their shared structures. In contrast, clusters based on E&H and C&U display more dispersed carbon emission values, suggesting a broader spatial distribution of functional dependencies and a weaker centralizing effect.

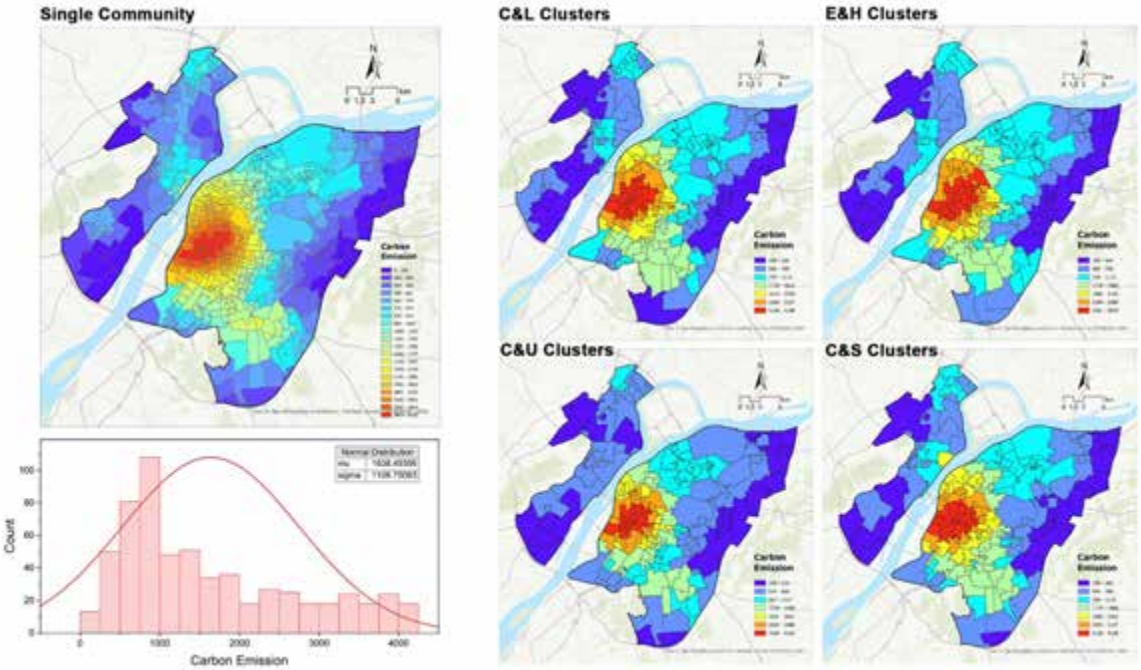


Figure 3 Spatial distribution of carbon emissions at the single community level and facility-based sharing cluster level

To further quantify the carbon implications of different facility sharing structures, Figure 6 presents the results of univariate linear regression models using service intensity (left) and sharing intensity (right) as independent variables. All four facility categories exhibit a statistically significant positive correlation with carbon emissions ($p < 0.001$), but differ notably in both explanatory power and marginal impact.

In the service intensity models, culture & sports (C&S) and convenience & utility (C&U) demonstrate the highest model fit ($R^2 = 0.351$ and 0.336, respectively), indicating their facility counts have the strongest explanatory power for community-level emissions. Education & health (E&H), in contrast, shows the steepest regression slope (22.276), meaning each additional unit of service intensity contributes the most to carbon emissions, reflecting a stronger marginal emission effect. Commercial & leisure (C&L) performs moderately in both R^2 (0.258) and slope (2.261).

In the sharing intensity models, overall explanatory power is slightly lower (highest $R^2 = 0.204$ for C&S), but the gradient of impact across facility types remains clear. E&H and C&S exhibit the steepest slopes (632.992 and 540.703), suggesting their cross-community usage significantly amplifies emissions—likely due to increased travel distances or facility aggregation effects. In contrast, C&L and C&U show weaker slopes and lower R^2 values, implying a more limited marginal effect, potentially constrained by their proximity-based service characteristics. In summary, service intensity reflects the facility provision baseline and acts as the primary determinant of carbon emissions, while sharing intensity captures the spatial extension of facility usage and contributes a type-dependent marginal modulation effect.

From a planning perspective:

- In areas with facility oversupply or high density, uncontrolled expansion of E&H and C&S facilities should be avoided, especially where local service is sufficient but sharing value is low, to mitigate marginal carbon impacts.
- For C&L and C&U, which exhibit weaker carbon implications, improving sharing efficiency through strategic coordination can help avoid redundant investments and spatial inefficiencies.
- New infrastructure should prioritize local self-sufficiency for foundational services like E&H, reducing inter-community trips.
- In contrast, C&L and C&S may benefit from enhanced sharing configurations, where well-placed nodes promote broader service coordination without compromising emission control.

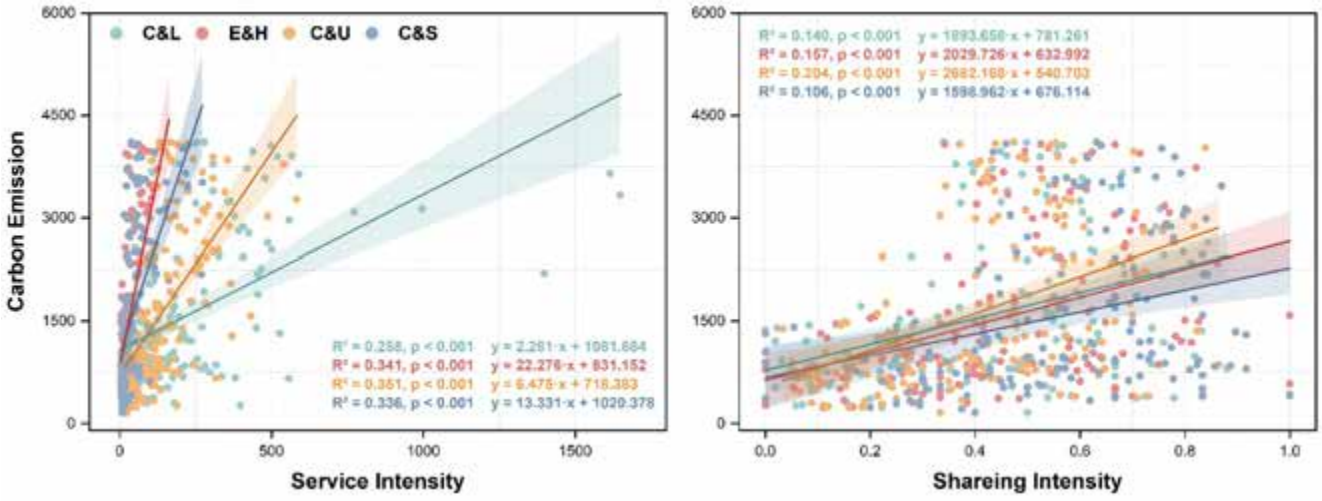


Figure 4 Univariate regression between service/sharing intensity and carbon emissions across facility types

3.3 Carbon Emission Patterns under Multi-Dimensional Sharing Structures

To further evaluate the joint effects of different facility types across both dimensions—service intensity and sharing intensity—Figure 7 presents standardized coefficients and 95% confidence intervals from a multiple linear regression model. Compared with the previous univariate results, the multivariate model controls for cross-variable interactions and reveals a more structured mechanism of carbon emission drivers.

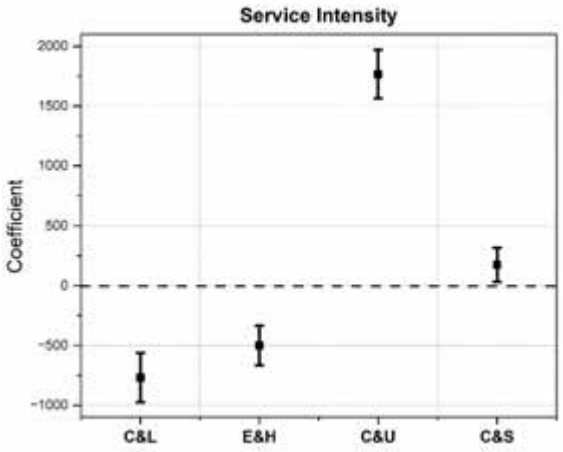
On the service intensity dimension, culture & sports (C&S) and convenience & utility (C&U) facilities continue to show significant positive effects. Notably, C&S holds the highest coefficient, suggesting that even after adjusting for other facility types, the service density of C&S facilities remains one of the strongest drivers of carbon emissions. In contrast, commercial & leisure (C&L) and education & health (E&H) show significant negative coefficients in the multivariate model—opposite to their positive trends in the univariate analysis. This suggests that, once the effects of C&S and C&U are accounted for, higher service intensity of C&L and E&H may actually correlate with reduced carbon emissions, potentially indicating a substitution effect or mixed-use efficiency in highly integrated facility zones that mitigates marginal emission pressure.

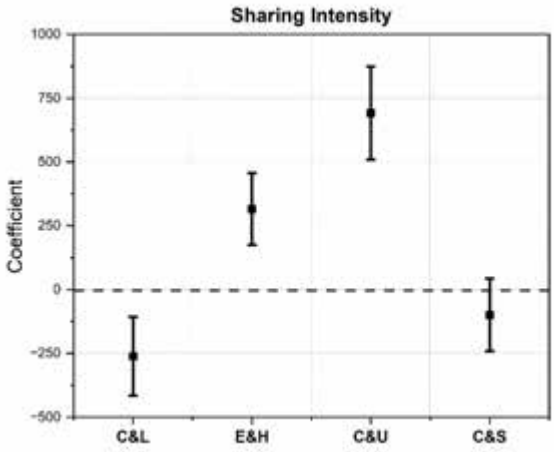
On the sharing intensity dimension, C&S again emerges with the strongest positive effect, reaffirming its high-emission association through cross-community usage. E&H also maintains a positive effect, albeit with lower magnitude. C&U shows no significant impact in the multivariate model, while C&L retains its negative association, suggesting that over-sharing in some cases may result in inefficient trips due to redundant facility usage.

Overall, the multivariate model reveals differentiated roles and interactions among facility types:

- C&S facilities contribute to increased emissions in both service and sharing dimensions, highlighting them as critical intervention targets in low-carbon facility planning.
- E&H facilities show a duality—while sharing may raise emissions, enhancing localized service capacity could yield mitigation benefits, supporting a “proximity-based” planning logic.
- C&L facilities exhibit negative marginal contributions in the multivariate context, indicating that concentrated deployment with efficient sharing could improve carbon performance.
- C&U facilities show relatively mild carbon impacts, suggesting that optimizing sharing coverage may enhance system-level efficiency without large emission trade-offs.

These findings underscore the need to avoid one-size-fits-all expansion strategies. Instead, urban planning should adopt a type-sensitive approach by aligning facility density, sharing structure, and carbon responsiveness in a coordinated framework—guiding community-scale infrastructure development toward greater efficiency, lower emissions, and structural synergy.





Effect Summary			
Source	LogWorth	PValue	VIF
Commerce & Leisure	12.1054	< 0.0001	11.6195
Education & Health	8.2963	< 0.0001	7.5318
Culture & Sports	1.7792	0.0166	5.5329
Convenience & Utility	52.8774	< 0.0001	11.2914

Summary of Fit	
R-Squared	0.5288
Adj. R-Squared	0.5257
Root Mean Square Error	759.0711
Mean of Response	1638.4936
Durbin-Watson	1.0344
Observations	611

Analysis of Variance				
Source	DF	SUM of Squares	Mean Square	F Ratio
Model	4	395135748.84	98783937.21	170.04
Error	606	352051394.53	580942.89	Prob > F
C. Total	610	747187143.37		0.0000

Effect Summary			
Source	LogWorth	PValue	VIF
Commerce & Leisure	3.0213	0.0010	4.8739
Education & Health	4.8493	< 0.0001	4.0755
Culture & Sports	0.7643	0.1721	4.1725
Convenience & Utility	12.4846	< 0.0001	6.7935

Summary of Fit	
R-Squared	0.3706
Adj. R-Squared	0.3664
Root Mean Square Error	877.3189
Mean of Response	1638.4936
Durbin-Watson	1.0296
Observations	611

Analysis of Variance				
Source	DF	SUM of Squares	Mean Square	F Ratio
Model	4	276907524.86	69226881.21	89.2054
Error	606	470279618.51	776038.97	Prob > F
C. Total	610	747187143.37		0.0000

Figure 5 Regression coefficients of service and sharing intensity on carbon emissions in a multivariate model

4.Discussion

Using Nanjing as a case study, this research systematically constructed the facility sharing network structure across communities and examined the impact mechanisms of different facility types on community-level carbon emissions through the dual dimensions of service intensity and sharing intensity. The network was established by delineating isochrone-based service areas and identifying the strongest shared facility edges between communities, forming functionally connected structures. These were further categorized into four shared community clusters, each dominated by a specific facility type. Spatial analysis revealed significant differences in emission patterns among cluster types: clusters dominated by commercial & leisure (C&L) and culture & sports (C&S) facilities exhibited dense emission hotspots in central areas, while education & health (E&H) and convenience & utility (C&U) clusters showed more dispersed distributions.

Regression analyses further highlighted the heterogeneous impacts of service and sharing intensity across facility types. In the univariate models, service intensity consistently exhibited stronger explanatory power for carbon emissions than sharing intensity, confirming facility density as a primary driver. Nonetheless, sharing intensity showed significant positive effects in C&S and E&H types, suggesting that shared facility usage may increase inter-community travel and energy consumption under certain conditions. In the multivariate models, some variables (e.g., service intensity of E&H, sharing intensity of C&L) reversed direction, indicating that spatial substitution and functional coupling among different facility types can mediate carbon outcomes.

These findings provide important implications for low-carbon urban facility planning. First, C&S facilities, which significantly contribute to emissions in both dimensions, should be key targets for emission control—through capacity regulation, spatial optimization, and managed sharing mechanisms. Second, E&H facilities are better

suited for self-sufficient local provision, minimizing reliance on inter-community travel. Lastly, C&L and C&U facilities demonstrate carbon-efficient sharing potential, and should be enhanced through regional coordination strategies to maximize service efficiency and resource utilization.

In sum, the impact of facility sharing structures on urban carbon emissions is structural and multidimensional. Effective planning must adopt type-specific strategies that align facility density, sharing patterns, and carbon responses, enabling synergistic control toward more efficient and sustainable urban living environments.

5.Conclusion

This study proposes an integrated analytical framework that combines isochrone analysis, facility sharing network construction, and carbon emission response evaluation to investigate how the sharing structures of different facility types within community life circles influence urban carbon emissions. Using Nanjing as a case study, we constructed cluster structures based on facility types and sharing intensity, quantified the dual-dimensional contributions of service intensity and sharing intensity, and employed both univariate and multivariate regression models to reveal differentiated impact patterns across facility types. The main conclusions are as follows:

- Facility sharing networks exhibit clear spatial and typological variations, with clusters dominated by different facility types displaying distinct emission concentration patterns;
- Service intensity acts as a key driver of carbon emissions, particularly for culture & sports and convenience & utility facilities, while the effect of sharing intensity is more type-sensitive, with culture & sports and education & health showing significant positive associations;
- Multivariate models reveal interaction effects and sign reversals among facility types, suggesting that the regulatory role of sharing structures on carbon emissions is complex and structural;
- Low-carbon urban planning should adopt type-specific strategies: fostering self-sufficiency where appropriate, and promoting shared usage where beneficial, to advance low-carbon and synergistic optimization of community life circles.

This research provides an empirical basis for understanding the intrinsic relationship between urban spatial structure and carbon emissions, offering concrete typological guidance for urban facility allocation and emission mitigation policies. Future studies may incorporate dynamic mobility behaviors, big-data-based flow metrics, and lifecycle emission accounting to develop more refined models of urban carbon response.

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Toward Equitable Carbon Markets: Spatial Planning for Climate Justice in Uganda[1] [2]

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Abstract
Introduced by the UN, the carbon trading mechanism aims to balance countries' GHG emissions and decrease CO2. It allows developed countries to compensate for their excessive emissions by assisting developing countries in boosting their climate resilience. However, offset projects are often criticized for prompting neocolonial practices by promoting land grabbing and overlooking local needs. This research investigates how spatial planning can support more just and effective carbon offsetting with focusing on Uganda's experience. Through policy analysis and comparative case studies, a landscape of project implementation is presented. Findings show that multilevel governance, community involvement, and land-use management are critical to deliver justice. Drawing from Uganda's experience, the study proposes that spatial planning is crucial for aligning global carbon policies with local justice goals.

Keywords: carbon trading systems, environmental justice, climate colonization, spatial planning

1.Introduction

Climate change is one of the most pressing global challenges, and although all countries share responsibility, its impacts are felt unevenly. Particularly, vulnerable regions and communities in the Global South are disproportionately affected (IPCC, 2023). These unequal impacts deepen existing social, economic, and environmental inequalities, raising fundamental questions about who contributed the most, who should act, and who has the resources to do so (Mohai et al., 2009). To address these issues, the United Nations introduced the carbon market mechanism in 1997 within the Kyoto Protocol. However, in its short but intense history, the mechanism has faced serious criticisms. Even though each country operationalized the projects in different ways regarding their own environmental, political, social, and economic contexts (Purdon & Byakagaba, 2022), the negative outcomes of the projects have raised concerns for what costs these projects have been operationalized, and the criticisms included that the mechanism laying the groundwork for neocolonization under the guise of green initiatives (Carton et al., 2020; Enríquez-de-Salamanca, 2024)

Introduced under the Kyoto Protocol in 1997, and later expanded into voluntary markets, carbon trading systems were designed to reduce global greenhouse gas (GHG) emissions by allowing countries or companies to offset their emissions through investments in mitigation projects elsewhere (UNFCCC, 1998; Michaelowa et al., 2019). In theory, these mechanisms were expected to serve both global environmental goals and local development needs. Yet in practice, carbon offset projects have often been criticized for excluding local communities, marginalizing indigenous knowledge, undermining sovereignty over land, and prioritizing market efficiency over social and ecological justice (Bachram, 2004; Gonzalez, 2021; Sultana, 2023).

Among the Global South countries, Uganda is a particularly relevant case study in this context. As one of the Least Developed Countries (LDCs), with high levels of climate vulnerability and a strong reliance on foreign investment, it has emerged as a hotspot for carbon offset initiatives. Uganda is currently the fourth-largest producer of carbon credits in Africa (EAA, 2022), the country's colonial legacy (Gebremichael, 2016), fragmented land tenure system (Fisher, 2012; Fisher et al., 2018), decentralized governance structure (Ojambo, 2012), and institutional weaknesses (Ampaire, et al., 2018; Fisher, 2012; Fisher et al., 2018) complicate the implementation of such projects.

These challenges often lead to uneven outcomes across regions and communities, where some benefit while others are displaced or excluded from decision-making.

1 The title of the proposal was changed from "Geographies of Carbon Trading: Spatial Planning Approaches for Equitable Offset Projects" to better reflect the focus of the paper.

2 The author used AI-assisted tools to improve the clarity and correctness of the language.

Although traditionally underexplored in climate finance discussions (Bumpus & Liverman, 2008), spatial planning can play a central role in operationalizing more just and effective carbon offset mechanisms (Knuth et al., 2025). Concerned with land management, policy integration, and stakeholder participation, it offers practical tools for navigating these challenges and can help guide land allocation, manage competing interests, and ensure that global climate strategies align with local needs and capabilities (Ay, 2025).

This paper aims to contribute to this discussion on how spatial planning tools can enhance the operationalization of carbon markets by analyzing how carbon offset projects are conducted in Uganda, which has a long history with such kind of mechanism, having both successes and failures. Drawing on policy analysis, a comparative case study of two offset projects, and insights from interviews with local experts, the paper investigates how governance structures, stakeholder dynamics, and land management systems shape project outcomes. The central argument is that spatial planning, if meaningfully integrated, can address many of the criticisms levelled at carbon markets, particularly around governance, inclusivity, and land management.

After this brief introduction, Section 2 sets the context for the subject at stake, introducing carbon markets from a critical standpoint and reflecting on how spatial planning can contribute to bridging the gap with Climate Justice. Then Section 3 explains the methodology implemented in this research, and Section 4 presents the outcomes. The concluding section rounds off the contribution, summarizing its main messages and paving a number of avenues for future research on the matter.

2.Carbon Markets, Justice and Spatial Planning

This section provides a brief overview of carbon markets and the critiques they have sparked in environmental and climate justice debates. Finally, it explores how carbon markets, justice concerns, and spatial planning intersect.

2.1. Carbon Markets

Aiming to balance responsibilities between developed and developing countries, the carbon market mechanism is designed to channel financial resources by converting GHG emissions into tradable units and allowing their exchange. It enables industrialized countries that exceed their annual GHG limits to invest in emission reduction projects elsewhere and, in return, purchase unused emissions allowances (Michaelowa, 2019; EAA, 2022). The main objective is to compensate for environmental damage caused by high-emitting developed countries by supporting mitigation efforts in more vulnerable countries (Bond et al., 2012). The focus of projects varies based on national needs and investor interest (EAA, 2022).

Figure 1 System of Carbon Market Mechanism (Ay, 2025)

Over the years, the mechanism has evolved under the influence of new regulations and market forces. Currently, with one of them cancelled but still having operational projects, there are three different carbon market mechanisms:

Kyoto Protocol's Mechanism

As the initiator of the carbon offset mechanism, the Kyoto Protocol offers two different mechanisms for carbon trading, namely Joint Implementation (JI) and Clean Development Mechanism (CDM). While JI has been mostly operated among developed countries (Annex A), CDM has operated between developed and developing countries (Annex B). These mechanisms were started to be operated in 2005 and they lasted until 2020. During this period of time, CDM has been a preferred mechanism to compensate GHG emissions. In these operational processes,

the main stakeholders that took roles are the UN's Executive Bodies, project developers which is also Investors, the Host's Designated National Authority, and Designated Operational Entities as the third-independent party (Pollack and Wilson, 2009; UNDP, 2015).

Figure 2 CDM's Project phases, governance structure (adapted from Kollmuss et al., 2008)

Voluntary Carbon Market

The voluntary carbon market was created by private market actors as an alternative to the Kyoto Protocol's rigid and complex mechanism in the early 2000s, and still actively used by a wide range of market players ranging from big companies to individuals (Pagop & Savard, 2024). And instead of having strict rules about the countries, projects, and actors, VCM is regulated by a set of rules and frameworks that have been created by organizations. Seven different[3] standards have been most commonly used by the market actors, and they vary based on the project types they usually accept (Kollmuss et al., 2008). Alongside the regulatory flexibility, VCM also allows all the bodies that want to be a part of the mechanism to participate in the market with almost no rules and no regulations (Ahonen et al., 2022; Bumpus and Liverman, 2008). Therefore, even though the stakeholders that take roles in the processes vary, the key actors in the process are project designers and investors; Carbon Standards; and the auditors; and, depending on the host countries' regulations, National and Local Authorities take part in the implementation of the projects (Kollmuss et al., 2008; Streck et al., 2021).

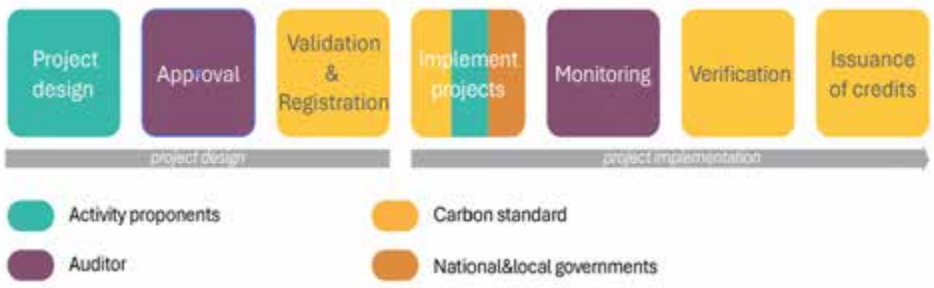

Figure 3 VCM project cycle (adapted from Streck et al., 2021)

Operationalization and Critics

These two mechanisms have been criticized for different aspects. One of the most discussed points about the Kyoto Protocol's carbon trading mechanism is its top-down approach, which starts at the supranational level and rarely reaches local levels. This has led to an oversimplification of national and subnational governance structures, prioritizing market benefits over global environmental objectives (Carton et al., 2020). Alongside that, the complexity of the documents and administrative burden have made the mechanism less accessible, especially for countries with limited institutional capacity. Moreover, the division between "developed" and "developing" countries has deepened existing inequalities, with investment flowing primarily to certain countries while others, particularly in Africa, were left behind (Akrofi, 2024).

As a result, CDM has been criticized for its complicated structure, the decisions it generated, and its failure to

3 As of 2025, the most commonly used Voluntary Carbon Market (VCM) standards include Verra (VCS), Gold Standard, Plan Vivo, Climate Action Reserve (CAR), American Carbon Registry (ACR), and Cercarbono. Project developers select the standard based on the type of project they aim to implement. While Verra, Gold Standard, ACR, CAR, and Cercarbono accept a wide range of greenhouse gas (GHG) reduction projects, Plan Vivo primarily focuses on Land Use, Land-Use Change and Forestry (LULUCF) projects (Kollmuss et al., 2008; Ecosystem Marketplace, 2024).

include or empower critical actors involved in implementation.

On the other hand, while the VCM made the mechanism more accessible by allowing various actors to participate, it has also been criticized for its lack of regulation and oversight, leading to low accountability and transparency (Pagop & Savard, 2024). As project quality declined and questionable credits continued to circulate, many initiatives were eventually labeled as greenwashing, which caused a significant loss of credibility (Oakland Institute, 2017). Overall, both mechanisms have been accused of deepening inequalities and facilitating neocolonial dynamics. While industrialized countries benefited from GHG allowances and market mechanisms, host countries, which are already dealing with internal and global injustices, were left to absorb the negative impacts (Bond et al., 2012; Enríquez-de-Salamanca, 2024). In many cases, these host countries, lacking carbon pricing mechanisms, became suppliers of credits, offering up their natural and social resources in exchange for limited benefits. Meanwhile, investors from developed countries continued to grow economically. The capitalist cycles embedded in the system, and their resemblance to colonial resource extraction, have been widely criticized for reproducing exploitative structures under the guise of environmental solutions (Bumpus & Liverman, 2008; Lahsen, 2009; Oakland Institute, 2017).

2.2.Justice and Colonization Discussion

While carbon markets are often promoted as flexible tools to mitigate climate change, they are also criticized for their role in reinforcing global inequalities. This has given rise to the concept of carbon colonialism, which was introduced to address the negative outcomes of carbon offset projects. These critiques are also directly related to broader debates on climate justice, which emphasize fairness, responsibility, and inclusion, especially for those who are most affected but least responsible.

Debates around responsibility emerged as early as the 1990s, when Agarwal and Narain (1991) coined the term "environmental colonialism." They argued that developing countries emit less, primarily for basic needs, yet suffer more, while industrialized countries emit more for luxury consumption and are more insulated from climate impacts. The term "carbon colonialism" gained traction in the mid-2000s, initially used by journalists reporting on harmful reforestation projects in Uganda. These initiatives, often led by foreign investors, were developed with little local consultation and led to displacement and ecological harm (World Rainforest Movement, 2000; Bachram, 2004). Since then, the term has been embraced by indigenous and environmental justice movements to describe unequal power dynamics in global climate governance. After that, the term started to be widely used by environmental and social justice organizations, particularly by the indigenous people and local communities (Bachram, 2004).

Aiming to call attention to these uneven distributions and responsibilities of climate change impacts, the concept of Climate Justice has started to be discussed. The concept questions the core reasons for the inequalities, including capitalist and neoliberal policies, overextraction of natural resources, and dependency on nonrenewable sources (Sultana, 2022). Rather than focusing only on local issues, the concept spans across scales and geographies, and questions the global inequalities, particularly looking at the vulnerable communities and how they experience adverse impacts of climate change (Okereke and Coventry, 2016; Sultana, 2023; Tramel, 2016).

2.3.Bridging Climate Justice, Carbon Markets, and Spatial Planning

While carbon markets are accepted as flexible tools for reaching global climate goals and balancing the impacts of climate change, their implementation on the ground reveals spatial and social inequalities. Given the deeply political and geographical nature of these mechanisms, carbon offset projects can produce a wide range of outcomes for both the local environment and affected communities. And as growing practices, these outcomes have been widely explored within economics and geography, yet there remains a notable gap in the spatial planning discourse (While, 2008; Bumpus and Liverman, 2008; Knuth et al., 2025). Considering the multilevel nature of governance, the multi-actor structure of climate projects, and their direct implications for land use, spatial planning has much to offer in understanding and addressing the uneven outcomes of carbon markets. This section examines how the operationalization of carbon markets causes injustices, and how spatial planning tools can support more equitable and inclusive solutions.

In particular, Land Use, Land Use Change and Forestry (LULUCF) projects have triggered critical discussions about justice in their implementation. While aimed at restoring degraded lands through reforestation and afforestation,

many of these projects have capitalized on low land prices in the Global South, resulting in the displacement of local communities and the exploitation of natural resources, often with minimal or no benefits for the inhabitants (Bond et al., 2012; Gonzalez, 2021; Carton et al., 2020; Vieira & Bauer, 2023). As a result, the mechanism has been criticized as a new form of imperialism that uses the resources of developing countries to generate emission allowances for developed ones (Vieira & Bauer, 2023). While industrialized countries profit from offset credits, local communities are left to bear the environmental and social burdens. Bumpus and Liverman (2008) describe this phenomenon as "accumulation by dispossession," highlighting how carbon markets can reproduce historical patterns of inequality.

To address these challenges, scholars have emphasized three key areas. First, the complex governance structure, spanning from supranational to local levels, requires more coherent, multilevel policy design with a holistic perspective (Benites-Lazaro & Mello-Théry, 2019; While, 2008; Fogel, 2004). Second, meaningful stakeholder engagement across scales is essential to ensure that the diverse needs, knowledge, and rights of communities are included, thus supporting fairness and equity (Bond et al., 2012; Tramel, 2016; Michaelowa et al., 2019). Third, careful project sitting that aligns with local needs and ecological realities is critical to avoid reinforcing spatial injustices (Cavanagh et al., 2017; Carton et al., 2020).

Carbon markets have been widely criticized for reinforcing spatial and social inequalities through top-down decision-making, poor stakeholder inclusion, and ecologically insensitive siting. These concerns are central to the climate justice discourse, which emphasizes not only who contributes to emissions, but also who suffers the consequences and who participates in shaping solutions. As a discipline concerned with governance, coordination, and land use, spatial planning holds practical tools that can help operationalize climate justice. By integrating spatial planning into carbon offset governance, it is possible to move toward more inclusive, equitable, and place-sensitive outcomes.

3.Methodology

The methodology for this research includes an iterative process of desk research and interviews that takes their basis form of qualitative approaches. Firstly, desk research has been conducted to set the background for the Ugandan context through their history, environment, and social characteristics.

Following that, policy analysis has been conducted to understand how legal frameworks set the ground for carbon markets, and how the relationship between environmental management and carbon offset projects has been formed. Thirty-nine policy frameworks that are related to spatial organization (11), environmental management and climate change (19), and their implementation (9) were selected for the content analysis. Before operating the analysis, the key terms that are important in the carbon market and urban planning fields have been selected, and they are expanded based on the terminology used in the policy frameworks. Ultimately, the content analysis was conducted with forty-two keywords under eight main topics, including the UN, international agreements, climate finance, carbon credits and markets, inclusivity, local governments, low carbon development, and sectoral terms. In addition, relevant grey and peer-reviewed literature was reviewed to further understand the policy formulation and implementation environment at the national and district levels.

Thirdly, two contradictory case studies have been examined to understand the ways the policy frameworks have been reflected in the operationalization processes of the projects. While the first case study, the Kachung Forest Project (KFP), is an initiative run by foreign stakeholders with a top-down approach, the second case study, Trees for Global Benefits (TGB), is a grassroots project led by a local NGO with a bottom-up approach. These two case studies standing as poignant examples of carbon market operationalization processes with their management styles, and environmental and social outcomes. The differences between top-down and bottom-up approaches caused to while reflected themselves in the outcomes of the project with being called as "market failure" and "best example of the practice". In order to compare two case studies, firstly, the project management processes examined by looking at stakeholders, he lagel frameworks projects relied on, site selection procedure; then implementation and operation processes have been researched through land use and zoning management, plantation procedure, and participatory approach in these operations; lastly, the social, environmental and political outcomes have been compared.

Lastly, aiming to understand the implementation processes better, experts and researchers are interviewed in order to have a broader insight. Nine people from international, national, and local institutions and universities, with different affiliations, have been contacted, including UN representatives, high-level officers from the ministries and municipalities, and researchers from universities and research institutions. The interviewees are selected from the climate change and land management departments of the institutions while the researchers are contacted based on their focuses. After that, snowball sampling has been used to by targeting the practitioners in the fields. The interviews are conducted online in a semi-structured way. Before the interviews, all participants were informed about the purpose of the research, their consent was taken with ensuring their confidentiality would be strictly maintained. Regarding the geographical distance and language barriers, any representative from the local communities could not be reached out to, however, their perspective towards the projects has been added to the research through secondary data from the existing literature. The interviews are used to complement the findings of the research and present a general overview of the operationalization processes.

Through a four-step methodology; desk research, policy analysis, comparative case studies, and interviews; this research aims to present a broader perspective on the operationalization of carbon offset projects. By starting with the historical and natural context, Uganda serves as a key case to understand how environmental justice and injustice manifest through policymaking, project management, and community engagement. The multilayered structure of carbon market projects, from the supranational to the local level, is explored through policy integration, implementation practices, and expert perspectives. This methodological approach lays the groundwork for discussing how spatial planning can contribute to the field through three key tools: multilevel governance and policymaking, community engagement, and land management and tenure.

4.Operationalizing Carbon Markets in Uganda

Uganda, like many African countries, has become a hotspot for GHG emission reduction projects due to its vast natural and degraded areas, institutional weaknesses (Bond et al., 2012; Pagop & Savar, 2024), and high climate vulnerability (Trisos et al., 2022). As one of the LDCs, Uganda has increasingly attracted carbon market investments intended to strengthen climate resilience. Given the need for investment and the conditions that facilitate project management, Uganda became the fourth-largest carbon credit producer in Africa (EAA, 2022). Understanding the implementation of carbon offset projects in Uganda requires attention to three interrelated dimensions: its colonial legacy, land tenure complexity, and institutional structure.

The colonial period and its legacies still impact Uganda's legislative system and land management practices. Historically, land in Uganda was communally owned by tribal systems. After the declaration of the British protectorate in 1894, which lasted for 68 years, private land ownership was introduced through the mailo system, under which land was owned by a single individual or group, and inhabitants became tenants without formal agreements (Tukahirwa, 2002). Colonial authorities also appointed chiefs to manage rural communities, a practice that laid the groundwork for today's decentralized governance system (Ojambo, 2012). Coupled with an easily exploited land tenure system and fragmented decentralization, colonization planted the first seeds of Uganda's current challenges.

Even though the colonial period ended in 1962, its legacies persist. The land tenure system still includes mailo along with three other types: customary (communal ownership), leasehold (limited-time rental), and freehold (unlimited ownership) (UN-Habitat, 2007). Over time, even though local groups and families gained some recognition, tenure insecurity remains widespread (UN-Habitat, 2007). Similarly, the decentralized system, though promoted by the government as a way to involve local communities in decision-making, has been criticized for weak coordination, political interference, and high levels of corruption (Friis-Hansen et al., 2013; Ampaire et al., 2018; Ojambo, 2012).

Alongside these governance issues, Uganda's land cover has further attracted carbon market interest. Agricultural land comprises 44.5% of the country's territory and is the main source of income (MLHUD, 2017), but it is also a key driver of deforestation. Although forests cover 32% of the land (MWLE, 2001), forest areas are shrinking due to expanding agriculture, urban growth, and overharvesting (MWLE, 2001). Colonial overexploitation of forest resources has also contributed to long-term environmental degradation (RoU, 2007; Oosterveet & van Vliet, 2010). Combined with increasingly frequent extreme weather events and climate-related disasters, the country's vulnerability continues to grow (MAAIF, 2018).

Taking all these facts into account, Uganda's administrative and policy design structure in spatial planning reveals a complex system. The planning scheme is divided into national and local levels, with each producing its own legally binding documents. While local authorities are responsible for preparing their own plans, they must align with directives from the national level (MLHUD, 2017; NPA, 2014). Uganda's decentralized system, which dates back to colonial times, aims to empower local governments and communities through hierarchical governance structures (Oosterveet & van Vliet, 2010; Ojambo, 2012). However, despite the apparent autonomy of local governments, their actual capacity is limited due to insufficient human resources and institutional weaknesses. Interviews with officials emphasized the shortage of skilled personnel needed for spatial planning at the district and sub-county levels (Int8, Int9). Moreover, Uganda's classification as one of the LDCs with high vulnerability to climate change allows for considerable influence from the UN and its agencies. This influence predominantly shapes national-level frameworks, but their implementation often remains weak at the local level, leading to inconsistencies and disjointed planning practices (Oosterveet & van Vliet, 2010; MWE, 2024).

Figure 4 institutional organization for spatial planning and plan types and levels (adapted from NPA, 2007; NPA, n.d.)

In this context, carbon markets appear to be a tempting instrument for building both climate resilience and economic development with posing challenges in the implementation processes. Uganda's combination of ecological potential, foreign investment needs, and governance weaknesses makes it a prime site for project developers. However, the same combination raises critical questions about justice in how these projects are implemented. In the following sections, Uganda's carbon market operationalization will be explored through a policy framework analysis and a comparative case study of two offset projects.

4.1.Policy frameworks

Uganda began enacting climate change-related policy frameworks after becoming a signatory to the UNFCCC in 1993. Since then, the country has adopted a number of frameworks aimed at environmental protection and land management. During the late 1990s, the Government initiated reform to replace colonial-era legislation, starting with the land and environment management-related policies. In 1995, the National Environment Act, in 1997, the Local Government Act, and in 1998, the Land Act were decreed to make the groundwork for future environment management and nature protection. These laws laid the institutional foundation for environmental governance and decentralized planning. The National Land Use Policy (2006) further established a formalized planning structure, reinforcing land resource protection and land use management.

In 2007, following UN requirements for Least Developed Countries (LDCs), Uganda adopted the National Adaptation Programs of Action (NAPA) to have a guideline for coping with climate change impacts with particular focus on managing degraded areas and drought. Tree planting and benefitting from indigenous knowledge and integrating climate resilience into development plans were among the proposed solutions (RoU, 2007).

NAPA marked a turning point by introducing a holistic and decentralized governance model, encouraging participation from multiple actors—particularly local communities, in climate response initiatives (Nyasimi et al., 2016; Ampaire et al., 2017).

In 2013, the Government of Uganda released Vision 2040, which shows the main path for the country's development for the next 25 years, and the following policy documents were prepared accordingly. This was followed by the National Climate Change Policy (NCCC) in 2015, which was the first climate change-focused policy framework and the cornerstone to implement projects for coping with climate change impacts. The policy frameworks emphasize the importance of international agreements and mention carbon markets for the first time in the policy frameworks (RoU, 2014; MWE, 2015). In the following years, the National Development Plan II of 2015, Green Growth Strategy of 2017, National Development Plan III of 2020, and lastly Nationally Determined Contributions (NDC) of 2022 have been prepared with taking basis from Vision 2040 and NCCC, and they prioritized sustainable development with integrating the objectives of international frameworks into their agendas while also taking into account the needs of the country. In these policy frameworks, carbon market projects have been mentioned as a tool to support development of the country (NPA, 2010; 2013; MWE, 2015). The NDC, in particular, functions as an umbrella framework for all former policy frameworks and defines a clear pathway for the country to adapt to climate change impacts. In this document, carbon market has been mentioned as one of the ways to "reach a climate-resilient and low-carbon society by 2050 that is prosperous and inclusive" (NDC, 2022, p. 15). Within this document, the LULUCF sector is prioritized, with focus areas including climate-smart agriculture, REDD+ projects, agro-industry, forest restoration, and energy efficiency.

Uganda's post-colonial policy trajectory reflects a genuine effort to build cross-sectoral, forward-looking frameworks for sustainable development and environmental resilience. Starting with Vision 2040, national policies have increasingly combined land management, environmental protection, and climate adaptation. National Development Plans have become key vehicles for implementing these objectives. Allied with recently decreed and upcoming policy frameworks, NDC acts as a connector between different policy frameworks and sectoral plans that focus on climate change actions to strengthen the country's climate resilience.

Despite this progress, significant gaps remain in the operationalization of these frameworks. Firstly, institutional structure and policy frameworks' implementation pose challenged in the country. Given the decentralized structure of the government, operationalizing the policy frameworks is a shared responsibility between different levels, and local communities are a key plank in the process with being custodians of nature, (Oosterveet and van Vliet, 2010). yet their inclusion in actual decision-making remains inconsistent. While roles and responsibilities are clearly defined in principle (Oosterveet & van Vliet, 2010; Lubega, 2019), in practice, the influence of international agreements and elite stakeholders has resulted in top-down policy design that frequently overlooks local priorities (Friis-Hansen et al., 2013; Ampaire et al., 2017).

Secondly, the multiple stakeholder structure in the policy design lays the groundwork for conflicts of interest. Given the high level of corruption in the country, coupled with the decentralized system, the decision has been made with a bias in support of the ideas of powerful stakeholders (Ampaire, et al., 2018; Ojamba, 2018). During implementation, the proliferation of overlapping policies often causes confusion at the district level, where capacity and resources for enforcement are limited (Atakunda, 2020).

All these conditions make policy implementation challenging, particularly on the local level. The policies that have been designed on the national level fall short for finding reflecting the local levels, especially when it comes to climate change-related policies (Friis-Hansen et al., 2013).

Most critically, even though the country has been operationalizing carbon projects for more than 20 years, there is still no policy framework that focuses just on the procedural side of the mechanism. Although carbon markets are referenced as a climate financing tool and resilience strategy in national policy documents, there are no clear guidelines for project development, approval, monitoring, or spatial allocation. Interview respondents noted that various ministries are currently working on carbon pricing and offset regulation frameworks (Int4, Int9), yet the date for formal adoption remains unclear (Int4). As a result, even after two decades of carbon project activity, Uganda continues to operate without a cohesive framework to govern the institutional, spatial, and social dimensions of the carbon offset mechanism.

4.2.Comparative case studies

Aiming to represent how the operationalization processes of carbon market projects in the Ugandan context, two contradictory case studies have been elucidated. The first, the KFP, is widely regarded as a top-down, externally driven initiative. The second, TGB, is often cited as a grassroots, participatory model. Together, they illustrate the diversity of governance structures and outcomes in Uganda's carbon market landscape.

KFP was initiated under the framework of Kyoto Protocol projects as a reforestation activity on degraded savannah land in 2006, through a collaboration between companies from Norway and Sweden. The project has been operated on land leased from the National Forest Authority, which was formerly classified as savannah land. However, its top-down implementation, land selection process, lack of inclusivity, and overall operationalization have been widely criticized, and the project has been described by scholars as a market failure (Oakland Institute, 2014, 2017, 2019; Carton & Edstedt, 2021). Although the project involved multiple stakeholders, including the UN, international actors, and government ministries, it excluded local authorities and communities from the decision-making process. To implement the project, local communities were displaced and lost access to their lands. The project site was fenced off, and entry was strictly controlled (Gebremichael, 2016; Edstedt, 2017; Carton & Edstedt, 2021). Furthermore, while the project had promised to create job opportunities and support biodiversity, its single-species plantation approach harmed biodiversity (Oakland Institute, 2014, 2019; Edstedt, 2017), and the limited employment options left many people in poverty (Edstedt, 2017; Oakland Institute, 2017, 2019). Some reports claim that the project brought economic benefits to the country by attracting foreign investment (Gebremichael, 2016; PDD, 2012; Edstedt, 2017), and argue that it displaced informal inhabitants rather than evicting formal residents (Oakland Institute, 2019; Edstedt, 2017; Carton & Edstedt, 2021). However, overall, the project has been widely criticized for the negative social and environmental outcomes it produced.

In contrast, TGB has been recognized as one of the strongest examples of carbon market projects in Uganda, thanks to its bottom-up approach and its positive impacts across environmental, social, economic, and policy domains. The project was initiated by a local NGO, EcoTrust, to reverse deforestation in vulnerable areas and support nature protection. TGB participants—mostly small-scale landholders—are paid based on the number of trees they plant on their land, which are then sold on the global carbon market ("Trees for Global Benefit", n.d.). The project began in a region of the country affected by frequent landslides, and over time, it has expanded with support from the UN and other international organizations such as the World Bank, WWF, and IIED (EcoTrust, 2013; 2020; Lee et al., 2016; Schreckenberg et al., 2013). Given the grassroots nature of the initiative, project design and management included local perspectives from the beginning. During implementation, regular meetings were held with community members, and land use and zoning plans were developed collaboratively (EcoTrust, 2020; Schreckenberg et al., 2013). As a result, the project has contributed to environmental protection by enhancing biodiversity, while also generating alternative income sources for participants. Additional benefits, such as improved social infrastructure, have supported better living conditions for local communities. In some districts, the project has even been incorporated into policy agendas as part of broader strategies for sustainable development (EcoTrust, 2024; Schreckenberg et al., 2013; Int9).

In conclusion, these two case studies demonstrate that carbon market projects are more likely to succeed and deliver justice when they are built on inclusive governance structures, active community engagement, and context-sensitive land use planning.

5.Discussion

Ugandan case study shows that the relationship between environmental justice, sustainable development, and spatial planning is highly connected, and in order to reach the optimum level, policy making and governance, stakeholder management and land management are crucial.

Even though numerous laws, regulations and other policy frameworks have been accepted, the country still lacks regulation about carbon pricing and carbon markets, which poses a big challenge for the management of existing and upcoming projects. Lack of integration between the policy framework and deficiencies for policy frameworks' reflection on the local levels are keystones in the governmental aspects, as well as, the weak institutional structure and lack of human capacity and financial support. Moreover, in the implementation processes of the projects, the decentralized structure of the government also held the country back from more efficient operationalization processes. The confusion created by the various policy frameworks, and lack of

guidelines for the local governments causes various practices that end differently at the local level, which in some cases worsen the injustices. In these terms, the urgent need for newly-baked policy frameworks for carbon pricing and operating carbon markets have been highlighted by the all respondents.

Moreover, the participation of different stakeholders have also been a problem in the operationalization processes of carbon market projects. Given the market-based nature of the system, while the market actors (project developers, investors, and so on) are superior in the processes, the governmental bodies and local communities are excluded. The projects show that even though the governmental authorities might be involved in the projects' management, it is very limited. Despite the fact that the local communities are the main groups that know the local characteristics best, excluding them from the processes affecting not only their well-being but also causes missing opportunities to conduct projects better. And enhancing community engagement in the project design processes and strengthening collaboration with governmental bodies can be one of the solutions for better operationalization processes (Oosteerveet and van Vliet, 2010). And, one of the reasons the projects lack inclusivity is the gap in the policy frameworks regarding the participatory approaches for the implementation of the projects.

Another important aspect for the operationalization of the projects is land management. Firstly, the land tenure system puts people's property in jeopardy since they do not have any formal ownership on the land, people were evicted from the places they lived for years (Edstedt, 2017) or they had to accept the projects' land use plan without consent (Edstedt and Carton, 2018; Oakland Institute, 2014;2017). Moving further from plot-based injustices, the lack of a planning mechanism also caused problems on different levels. Firstly, given the country's inefficient physical planning mechanism, the projects' locational distribution is not organized. And this situation deepens already existing inequalities between the regions (Fisher, 2012; Edstedt and Carton, 2018; Oakland Institute, 2014; 2017). Secondly, local development plans are either have not been prepared yet or have not integrated the carbon trading mechanism into their agenda. Therefore, the location of the projects is still mostly dominated by the market actors, rather than local experts and practitioners (Int3; Int8; Int9).

In these whole processes, as a part of the institutional organization and mechanism, the lack of land management and spatial planning mechanisms impact how the projects have been implemented. The cycle of capital accumulation enabled by carbon trading mechanisms—often intensified by neoliberal environmental policies—has been widely critiqued in the literature for exacerbating spatial and social inequalities (Bumpus & Liverman, 2008; Bachram, 2004; Carton et al., 2020). These markets reshape social and economic geographies through capital accumulation and spatial impacts (Bond et al., 2012; Bumpus & Liverman, 2008), aligning them closely with spatial planning discourse. Literature highlights that the most criticized aspects of carbon market operationalization include policy design (Bachram, 2004; Fogel, 2004; Michaelowa et al., 2019; Carton et al., 2020), stakeholder engagement (Fogel, 2004; Tramel, 2016), and project siting (While, 2008; Gonzalez, 2021)—all of which fall within the domain of spatial planning.

These problems are also clearly visible in the Ugandan context. The weak administrative organization, incoherence between policy frameworks, exclusion of communities, and underdeveloped land management systems have emerged as the most pressing challenges. Interviewees confirmed that these gaps significantly hinder the operationalization of carbon market projects. One of the main problems identified was the lack of alignment between existing laws and frameworks, which creates institutional confusion and leads to uncoordinated implementation across different administrative levels. Officials noted that although multiple policies exist, there are no clear procedural guidelines or coordination mechanisms that explain how carbon offset projects should be executed, monitored, or managed spatially. In addition, stakeholder participation, especially that of local communities, was seen as more symbolic than practical. Although consultation is often mentioned in project proposals and policies, in reality, communities are rarely involved in project planning or benefit-sharing decisions. This exclusion not only affects community wellbeing but also limits the long-term sustainability of the projects.

Despite these challenges, many interviewees expressed optimism about the role of spatial planning in improving project implementation.

They emphasized that integrating planning tools into carbon market mechanisms could support fairer land use decisions, better regional coordination, and more transparent governance. In their view, spatial planning can act as a bridge between global climate agendas and local needs by helping to direct projects to suitable locations, supporting land tenure clarity, and strengthening communication between institutions and communities.

Addressing environmental injustice requires complex policy-making across local, national, and global levels, particularly in systems involving multilevel governance and multiple stakeholders, such as carbon markets (Mohai et al., 2009; Bond et al., 2012). Spatial planning can enhance equity in carbon market implementation through three key contributions. First, its role in multilevel policy-making enables the integration of supranational frameworks into national and local governance. Second, as "knowledge keepers" (Janin Rivolin, 2012), planners can support inclusive stakeholder engagement by bridging knowledge gaps and facilitating dialogue across levels. Third, land use management and zoning, which is core spatial planning functions, can guide more just project siting and land allocation.

Given the alignment between carbon market challenges and spatial planning capacities, integrating spatial planners into climate finance governance could lead to more effective and equitable outcomes. This is particularly important in contexts where capacity-building and coordination are lacking (Okereke & Coventry, 2016). As supported by interview findings from Uganda, spatial planning can support implementation at national, regional, and local levels by directing project siting, enhancing institutional mechanisms, and connecting local stakeholders with decision-makers.

6.Conclusion

This paper has explored how carbon market mechanisms are operationalized in Uganda and what justice-related implications emerge in the process. Although carbon markets, particularly those introduced through the Kyoto Protocol and later through Voluntary Carbon Markets, are framed as tools to mitigate climate change and mobilize finance for climate-vulnerable countries, their implementation reveals a more complex and often problematic reality. Uganda, with its vast natural resources, decentralized political structure, and postcolonial legacies, offers a particularly illustrative case of how such mechanisms unfold on the ground.

The analysis has shown that the challenges in Uganda are not merely technical but deeply embedded in structural and governance-related issues. Fragmented policy frameworks, institutional weaknesses, and the absence of a regulatory structure specific to carbon markets have contributed to inconsistencies in project management and limited local benefits. Furthermore, land tenure insecurity and the weak spatial planning system have made it easier for private actors to access land for offset projects, often at the expense of local communities. Despite the existence of national policies that call for decentralization and public participation, these principles are not effectively practiced in carbon project governance.

The comparative case studies further illustrate this point. The Kachung Forest Project exemplifies how exclusionary, top-down approaches can lead to negative social and ecological outcomes, including displacement, biodiversity loss, and lack of community benefits. In contrast, the Trees for Global Benefit project demonstrates the potential of locally driven, participatory models to deliver positive environmental and socio-economic results, particularly when grounded in community engagement and collaborative land use planning.

These findings support broader critiques in the literature that argue carbon markets, in their current form, risk reproducing patterns of inequality and exploitation, often referred to as "carbon colonialism." As the interviews in this research confirmed, the lack of regulatory guidance, professional capacity, and coordination between national and local authorities only amplifies these risks.

Spatial planning, however, holds significant yet underexplored potential in addressing these issues. By facilitating multilevel coordination, guiding land allocation, and promoting inclusive governance, spatial planning can serve as a practical tool to operationalize climate justice on the ground. It can help ensure that carbon offset projects are not only technically sound but also socially equitable and locally responsive.

Looking ahead, integrating climate finance into spatial planning discourse, and particularly into carbon offset governance, could be a step toward bridging the gap between global climate goals and local realities. For Uganda

and other countries with similar vulnerabilities, doing so is not only a matter of efficiency but one of justice. Future climate action must not only aim to reduce emissions but also to challenge and transform the unequal structures that shape who benefits, who decides, and who bears the costs.

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Temporal-Spatial Distribution Characteristics of PM2.5 and Noise in the Under-Viaducts Space

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Abstract
As large cities grow in size and density, they come under increasing pressure for space and regeneration. Many under-viaducts spaces (UVSs) are being converted into open-air sports fields, but such spaces can cause air and noise problems for people playing sports. There is a lack of research on the pollution of the UVS. To fill this gap, this study selected a case area of an UVS in central Shanghai that has already been renovated into a sports field, and investigated the spatial and temporal distribution patterns of air and noise pollution and the factors influencing them. Based on site monitoring and data analysis, this study found that: 1) Air pollution in the UVS is significantly higher than the background levels, the higher the background levels, the greater the difference between the concentrations in the UVS and the surrounding area. 2) The noise intensity in the UVS is also higher than the background value with a more constant variation. 3) Air pollution is highly correlated with the built environment and traffic flow, while noise is more closely related to traffic flow and less so to the built environment, both of which have a negative correlation with temperature. This study provided valuable empirical evidence on the exposure to air and noise pollution in the sports space under viaduct in the micro-environment, which can help planners to adequately consider pollution reduction in the planning and management of urban renewal.

Key Words: Under-Viaducts Space, Noise, $PM_{2.5}$, Spatio-temporal distribution, Urban renewal, Shanghai

1.Introduction

With the rapid development of urbanization, there is an increasingly prominent conflict between limited land and high population density in major metropolitan areas. Elevated highways and viaducts have become essential solutions to traffic problems in many cities. The viaduct itself has public attributes [1], and the under-viaduct space (UVS) is regarded by scholars as a potential public space or site for activities [2]. In this study, the UVS was defined as the space covered by the orthographic projection under the viaduct and the surrounding neighbourhood space significantly affected by the viaduct. Effective utilization of the UVS is highly significant for urban renewal, but due to the relatively closed nature of the main space, the UVS has become an area where particulate matter pollution caused by traffic increases [3], resulting in its poor environmental quality. Noise pollution is also a major issue in the UVS [4], and the horizontal and vertical sound fields in the road space of the viaduct are greatly altered compared to ordinary roads, causing more severe noise pollution on both sides of the road [5]. Consequently, the impact of viaducts on the urban environment and the use of space around viaducts are receiving more and more attention in high-density cities.

1.1 $PM_{2.5}$ in the UVS

Air pollution caused by traffic is a major health hazard for urban dwellers worldwide [6]. Particulate matter with a diameter less than or equal to 2.5 microns ($PM_{2.5}$) is an essential criterion for determining air pollution [7]. Most $PM_{2.5}$ emissions in cities originate from transportation, especially diesel trucks and buses [8]. In Toronto, motor vehicle-related emissions account for about 40% of $PM_{2.5}$ [9]. Abu-Allaban et al. [10] found that the percentage contribution of motor vehicles to $PM_{2.5}$ at seven U.S. sites ranged from 20% to 76%. In London, the mean incremental traffic contribution to $PM_{2.5}$ near motorways can be as high as 50% [11]. $PM_{2.5}$ can also cause many adverse health effects [12]. Lelieveld et al. [13] found that outdoor air pollution, mainly $PM_{2.5}$, causes 3.3 million premature deaths each year. At the same time, short-term or long-term exposure to high $PM_{2.5}$ concentrations can elevate the risk of heart disease, while potentially triggering respiratory diseases, asthma and other diseases, and may also induce cancers such as lung cancer and increase the risk of mental disorders such as major depression [14,15,16,17].

The combination of surface roads and viaducts pollution can result in 1.6 to 4.5 times the amount of pollution compared to road surfaces alone [18]. Urban roads in the UVS have become priority areas for particulate pollution [19]. $PM_{2.5}$ concentration distribution of viaducts is attracting increasing attention, but there are still relatively few relevant studies. Most existing studies have focused urban roads, such as highways, roadsides, intersections and arterials (Table 1). The urban road spaces have high similarity with the UVS, so the experimental methods and results of the studies can be used as references. Around the 2000s, studies on the $PM_{2.5}$ concentrations of major roads became more frequent, and found that the closer to the road, the higher the $PM_{2.5}$ concentration and higher

than the background concentration [20,21]. In addition, some studies found that there is an attenuation effect of $PM_{2.5}$ concentration in the 200 meters range of highway [22,23]. Similar results were verified at intersections, where $PM_{2.5}$ concentrations at the downwind curb of the intersection were significantly higher than background values and were significantly higher during peak traffic hours [24,25]. Many studies have also focused on influencing factors, with traffic conditions such as traffic volume, meteorological conditions such as wind speed, local topography and surroundings, barriers or noise walls all affecting the distribution of $PM_{2.5}$ in road space [26,27].

Most studies on viaducts concentrate on the street canyons [28,29], and there are fewer studies on the horizontal distribution of $PM_{2.5}$ in the UVS. It is discovered that viaducts increase $PM_{2.5}$ concentrations in street canyons, particularly on the ground. Li et al. [30] utilized a mobile monitoring method to measure the space beneath three viaducts with different types of barriers in Xi'an, China and found that $PM_{2.5}$ concentrations have a single-peak decay trend in locations with noise barriers and combined barriers, meaning they initially increase then decrease to background levels within 300 meters. In Wuhan, China, Yin et al. [19] monitored 14 UVSs and 9 potential environmental parameters such as temperature to study spatial and seasonal differences in particulate matter like $PM_{2.5}$. They also found that $PM_{2.5}$ concentrations were related to the surrounding environment and that $PM_{2.5}$ concentrations in the UVS were higher compared to surrounding roads in winter, and vice versa in summer. The study contributes to understanding the factors influencing $PM_{2.5}$ concentrations in the UVS, but lacks spatial analysis at the microscopic scale. In summary, the realistic distribution pattern of $PM_{2.5}$ in the planar dimension and the influence mechanism of parameters are not clear, and further spatial and temporal studies are needed to guide the assessment and judgment of spatial reuse.

Table 1. Summary of research findings on $PM_{2.5}$ concentrations in road space.

Research Object		Monitoring Methods	Results	Sources
Road	Highway	Mobile monitoring	•Within 200m, $PM_{2.5}$ concentrations usually increase as the highway approaches. • $PM_{2.5}$ increases with the onset of peak hours and is strongly influenced by temperature changes in colder months.	Patton et al., 2014 [22]
			•Before sunrise and peak traffic volume, downwind concentrations are highest within 100-250m of the highway. • After sunrise, pollutant levels drop sharply and the gradient becomes less pronounced.	Durant et al., 2010 [31]
		Fixed monitoring	The reduction in urban traffic helps to reduce the concentration of particulate matter pollution.	Azhari et al., 2021 [32]
			Particulate concentrations decay exponentially with increasing distance within 100-150m from the road and return to background levels within a few hundred meters from the road.	Zhu et al., 2009 [23]
			Wind speed, prevailing wind direction, daily cycle of the atmospheric boundary layer and traffic density are the main influencing factors.	Charron & Harrison, 2005 [33]
	On-road & Roadside	Fixed monitoring	Higher $PM_{2.5}$ concentrations were observed in Madrid during the cold season.	Kassomenos et al., 2014 [34]
		Mobile and fixed-site monitoring	•$PM_{2.5}$ concentrations on the road are highly correlated with nearby roadside $PM_{2.5}$ concentrations in winter and summer. • Seasonal effects need to be considered, and short-term exceedances of particulate matter concentrations may occur in early spring.	Cheng et al., 2010 [35]; Lozhkina et al., 2016 [36]
	Intersection	Fixed monitoring	There was an overall decreasing trend in $PM_{2.5}$ concentrations with increasing distance from the roadside. The incremental $PM_{2.5}$ decreased by 75% between 5 m and 30 m from the road.	Mukherjee et al., 2020[37]
		Mobile monitoring high-flow gravimetric personal samplers	$PM_{2.5}$ concentrations are higher in the morning, decrease at noon, and rise in the early afternoon and are even higher in the evening. This phenomenon is related to the traffic activity in the surrounding area.	Kaur et al., 2005 [24]
		Fixed monitoring	• Roadside concentrations were higher than those simultaneously monitored at urban sites away from the road. • Average pollutant concentrations at downwind roadside stations are higher than at background stations. • $PM_{2.5}$ concentrations during peak traffic hours are higher than during off-peak hours.	Wang et al., 2018 [25]; Kinney et al., 2011 [38]
	Arterial	Fixed monitoring near-road continuous air monitoring station (CAMS)	•$PM_{2.5}$ concentrations are usually elevated close to roads. • Traffic-related $PM_{2.5}$ concentrations are usually highest at night, followed by the morning peak, evening peak and midday respectively.	Askariyeh et al., 2020 [39]
			$PM_{2.5}$ quality is more related to regional sources and meteorological conditions, with a limited role of traffic volume.	Kendrick et al., 2015 [40]
	Street canyon	Mobile monitoring	Street canyons have a significant impact on the accumulation of $PM_{2.5}$ concentrations on Hong Kong's roads.	Rakowska et al., 2014 [41]
		Fixed monitoring three heights (0.20 m, 1.0 m and 2.60 m)	The concentration decreases exponentially with increasing canyon height.	Kumar et al., 2008 [42]

Viaduct	Street canyon	Fixed monitoring	Particle mass concentrations in street canyons are negatively correlated with height, and particle mass concentrations in street canyons are negatively correlated with temperature.	Feng et al., 2015 [28]
			Viaducts increase $PM_{2.5}$ concentrations in street canyons and significantly affect airflow fields.	Zhi et al., 2020 [29]
	UVS	Mobile monitoring	$PM_{2.5}$ concentrations decay exponentially near the viaduct without any obstacle.	Li et al., 2021 [30]
		Mobile and fixed-site monitoring	•$PM_{2.5}$ concentrations in the UVS are lower in summer than in the adjacent road environment, but higher in winter. Meteorological factors, green structure, viaduct structure and surrounding built environment have a significant impact on $PM_{2.5}$ concentrations.	Yin et al., 2021 [19]

1.2 Traffic noise in the UVS

Road traffic noise is one of the main sources of noise pollution in urban areas and has become a global problem [43]. Traffic noise has harmful effects on health [44,45], including anxiety [46,47], sleep disturbance [48], and reduced cognitive performance in school-aged children [49] and an impact on cardiovascular diseases [50]. Traffic-related noise is one of the major environmental impacts of roads [51]. Therefore, the proper assessment of the noise impacts in urban traffic areas is crucial for the rational use of urban space and the preservation of human health.

At present, there have been numerous studies on the spatial and temporal analysis of traffic noise and its influencing factors in urban traffic spaces (Table 2). These studies indicate that noise levels in spaces along the main roads entering and passing through the city are relatively high and that the traffic noise increases during peak hours [52,53]. Some studies have found a positive correlation between urban density and traffic noise through software simulations [54] and between urban road network density and traffic noise [55]. At the same time, there is a strong inverse relationship between the area of green space on both sides of the traffic space and traffic noise [56]. In terms of space design, the height and shape of building facades on both sides of the street are closely related to the noise levels of the traffic space [57] and other aspects. These factors have varying effects on urban road traffic noise.

The results of existing studies are summarized in Table 2. However, relatively few studies have been conducted on the noise of the UVS and its associated temporal and spatial distribution patterns. Additionally, there is a scarcity of research on the effects of human activities under traffic noise exposure.

Table 2. Summary of research findings on noise concentrations in road space.

Research Object		Monitoring Methods	Results	Sources
Road	highway	-	For outdoor environment, sound barrier, low-noise pavement and soundproof window are the most common solutions to reduce the noise generated by main noise sources	WHO, 2018 [58]
	On-road & Roadside	Fixed monitoring	The address noise level along the main roads entering and passing through the city is the highest As the density increases, the street noise will also increase	Thacher et al., 2020 [52]
		Mobile and fixed-site monitoring	There is an inverse relationship between greening area and noise pollution	Lopez et al., 2018 [56]
		Mobile and fixed-site monitoring	Increased traffic noise pollution during peak hours The noise pollution in the space near the road is large	Shakya et al., 2019 [53]
	Arterial & Roadside	Mobile and fixed-site monitoring	The more urban activities, the more noise the street	Mohareb & Maassarani, 2019 [59]
	Arterial	Software simulation	There is a positive correlation between road network density and traffic noise	Wang et al., 2011 [55]
		Software simulation	The higher the urban density, the more important the noise insulation measures	Bouzir & Kang, 2017 [54]
	Street canyon	Fixed monitoring	Street canyon architectural design has a significant impact on street space noise	Sanchez et al., 2016 [57]

1.3 Monitor and analysing method review

Fixed monitoring and mobile detection are two types of effective methods for measuring air and noise pollution in urban environments. These methods have been tested by numerous scholars and have been proven to be successful. However, fixed measurements has limitations, such as the cost of equipment and maintenance for fixed-site air quality monitoring stations (AQMS) [60], which can make it challenging to accurately reflect pollutant distribution over short distances [61]. Mobile monitoring technology can help to overcome these limitations and provide a spatial map of population exposure in the micro-environment with higher spatiotemporal resolution [62]. Additionally, it is also an effective way to obtain noise data [63]. The specific methods include platforms such as instrumented cars and vans [60,64], public transportation such as trains and trams [62,65], bicycles [63], and backpack walking measurements [66,67,68]. In this study, backpack walking measurements were used to directly assess personal exposure to pollutants and noise in the traffic micro-environment.

The main methods of analyzing pollutants and noise include spatial analysis, temporal analysis, and correlation analysis of influencing factors. Spatial analysis is mainly divided into two categories: the differences in pollutant and noise distribution in different road spaces [35,66,69], and the continuous distribution characteristics of pollutants and noise in larger spaces, such as cities and districts [63,70], with insufficient attention given to small-scale horizontal space. Temporal analysis focuses on the differences in pollutant concentrations and noise levels during different seasons such as winter and summer [36], working and non-working days [41], and different time periods of the day [22,24,31]. The correlation analysis of impact factors includes meteorological factors such as temperature and humidity, road factors such as traffic volume, and built environment factors such as distance from the main road and height to width ratio [19].

In conclusion, there is a lack of research on the small-scale UVS, and most studies do not consider the combination of particulate and noise pollution in the same space. Many current studies focus on statistical analysis, with limited exploration of the spatial layout and potential for built-up space reuse.

To address these gaps, the research goals of this paper are as follows: 1) expand the scope of the study, and analyze the spatial and temporal distribution characteristics of particulate matter and noise under the viaduct and within a block or so (about 250m) of the surrounding space; 2) enrich the research objectives, and investigate the factors affecting particulate matter and noise in the UVS and further propose planning countermeasures for spatial reuse.

2.Data and methodology

2.1Study Area

The study area is the UVS of Tianmu Middle Road (31°14'32.7"N, 121°27'45.2"E), which is located on the south side of the intersection of Hengtong Road and Gonghexin Road in Jing'an District, Shanghai, China. As an international metropolis with a high population density and elevated roads throughout the city, Shanghai is representative in its exploration of the quality of the urban spatial environment. The city has carried out a lot of practices and explorations in the use of the UVS and has issued relevant policies and standards to guide the development and utilization. The study area is currently designed as a basketball court, with a large number of people exposed to the environment of the viaduct. Therefore, the area is of great practical importance in evaluating the fine particulate matter and noise environment under the viaduct.

The study area is located in the most prosperous centre of Shanghai, on the north side of the intersection of the North-South viaduct and the Suzhou Creek (Fig.1). The north side is close to the intersection of arterial roads, the south side is only separated from the Suzhou Creek by a branch road, and the east and west sides of the base are urban roads. The viaduct has 12 lanes and heavy traffic, while ground level has 2 lanes on either side of the space underneath the viaduct. The sports field is located under the main bridge of the North-South viaduct and consists of four basketball courts, which are sheltered on east and west sides are sheltered by the overhanging eaves of the viaduct deck. On the east side of the site there is a ramp departure point, and the degree of screening is less than on the west side. During weekday peak hours (7:00-9:00 and 17:00-19:00), slow and congested traffic is common, while road traffic is relatively smooth at other times. In summary, the study area was selected for analysis of the particulate and noise environment assessment of the UVS due to its good regional location, site shape, traffic characteristics, and pollutant sources.

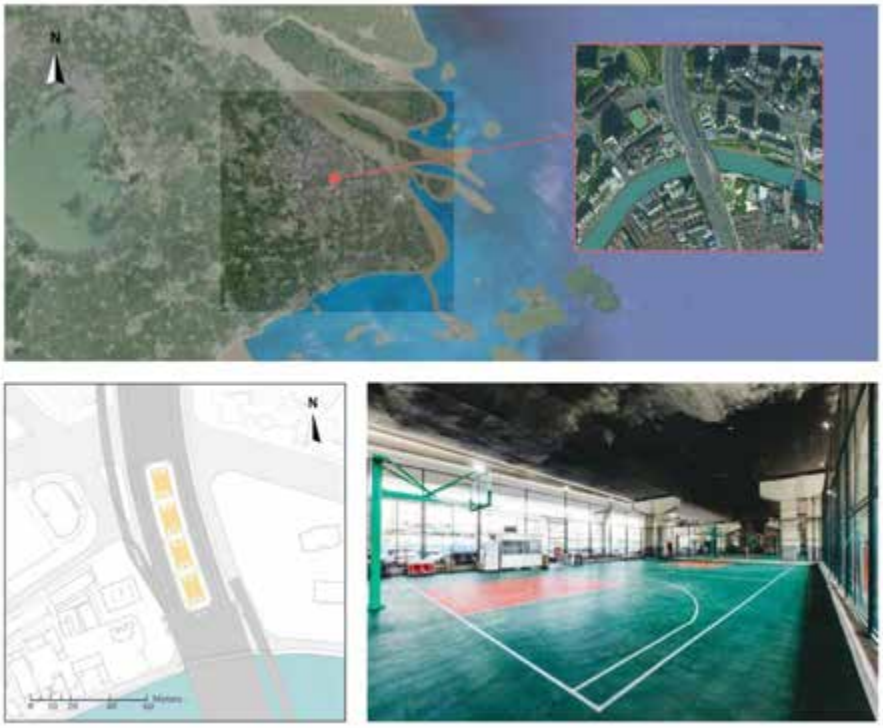

Fig.1 Sketch map and the general plan of the study area.

2.2Data preparation

2.2.1 Mobile site measurements

The mobile monitoring route covered the UVS and the surrounding space within 250 meters on both sides of it. The starting point of the route was a reference point used to measure background levels, which had no influence of pollution sources such as factories and parking lots within 50 meters of its surroundings, and no more than 3,000 vehicles pass through it per day (Hoek et al., 2002)[71]. Meanwhile, 32 measurement points were set up along on the route in sequence, and peripatetic measurements were performed at each point using handheld instruments. The clocks of all real-time instruments were checked for synchronization prior to the measurement. Points 3, 4 and 15-26 were located in the projected space of the viaduct, specifically indicated as the UVS-P. The remaining 18 points were peripheral spaces not covered by the viaduct and were set up to investigate the attenuation effects of pollutants and noise, specifically designated as the UVS-NP. There was a continuous wall interface on the east side of the viaduct, with green space in front of the interface (Fig. 2). The selection of this monitoring route was based on the following needs:

1) Since the site had different built environments in the north-south and east-west directions, the monitoring points were set up homogeneously in the UVS and in the road space around the viaduct respectively, to measure the distribution characteristics.

2) The viaduct had differences in the morphology of its eastern and western branches, so double rows of monitoring points were set up in the UVS to objectively reflect the numerical situation of pollutants, noise distribution and the various influencing factors. It was confirmed in advance that there were no industrial sources near the entire study area.

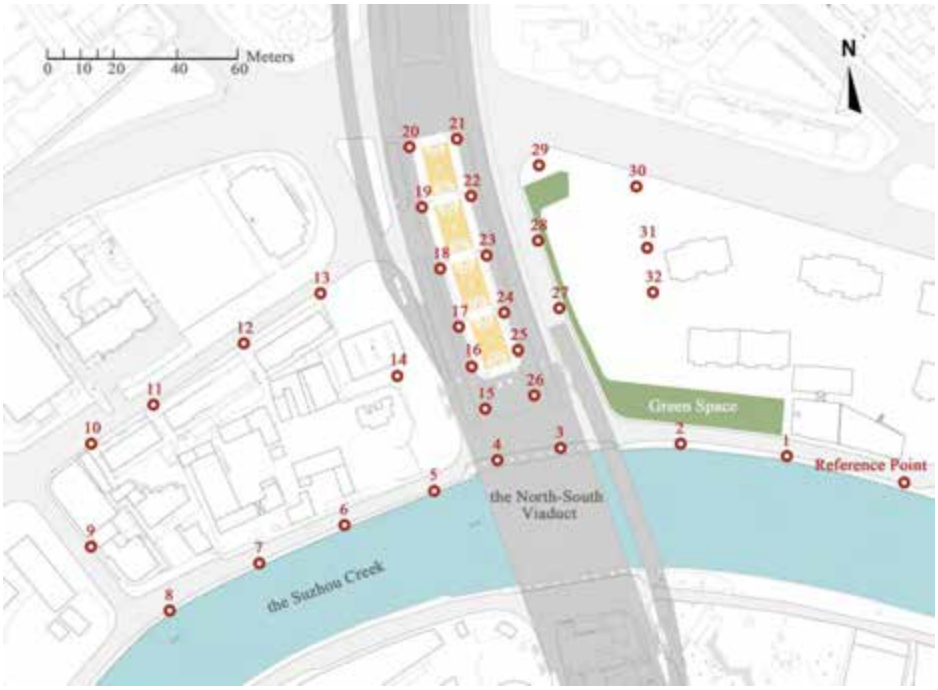

Fig.2 The locations of all the monitoring points set up on the route are numbered from small to large according to the sequence from the beginning to the end.

2.2.2 Data collection

According to previous studies [19,62,70], it is recommended to conduct environmental monitoring for more than 10 days, including both working and non-working days, to ensure the accuracy of the results. Therefore, our experiment was conducted over a 12-day period in winter (February 25th to March 8th, 2022), encompassing both working and non-working days, with 4 different time segments (8:00, 11:00, 15:00 and 18:00) per day. To prevent fatigue of the backpack walking monitoring experimenters from affecting the results, each experiment was kept to a total duration of less than 30 minutes [72] and each measurement point was monitored for 20 seconds

[73]. The portable sensors used to monitor environmental elements such as $PM_{2.5}$ concentrations, noise, and meteorological parameters, were deployed at a height of approximately 1.5 meters above the ground to ensure accurate correspondence with human activities [71].

Taking into account the specifics of the environment under the viaduct, the experiment data collected in this study included geographical data, pollution and noise data ($PM_{2.5}$ concentrations, equivalent sound level), and information about the factors that influence pollution and noise (temperature and humidity, distance from the viaduct, distance from the river, and traffic volume above and below the viaduct). Table 3 shows the various instruments used for data collection. The $PM_{2.5}$ concentrations data was collected using the PM: SidePak Aerosol Monitor AM520 air particulate experiment instrument, which is designed to provide accurate mass concentrations of particulate matter at 1-second intervals. To ensure the validity of the data, the $PM_{2.5}$ monitor was factory calibrated and further verified based on the configured standard method at an outdoor site in Shanghai prior to the study. The noise data was collected using the AWA6228 multi-function sound level meter instrument. Location and distance data were collected using Unistrong handheld GPS instrument and got GPS data. This study analyzed the relationship between $PM_{2.5}$ concentrations, equivalent sound level (Leq) and each of the influencing elements separately, and evaluated the suitability of exercising at the site with all the data.

Table 3. Summary of instruments and influencing parameters

Type	Parameter	Description	Instrument and model	Sampling resolution
Geographic information	GPS positioning data	Location of each data point (m)	Unistrong handheld GPS instrument	1s
Pollutant data	$PM_{2.5}$ concentration	The 20-s average data at the sample sites (μg/m³)	PM: SidePak Aerosol Monitor AM520 Air particle test instrument	1s
	Equivalent sound level (Leq)	The 20-s average data at the sample sites, representing the intensity of the noise (dB)	AWA6228 multi-function sound level meter instrument	1s
Influence factor	Traffic volume	Traffic volume data of the overall environment (up and down the viaduct) (vel/h)	Mobile phone recording 5 minutes of video	-
	Distance from the viaduct	Distance from the centerline of the viaduct (Fixed values, pre-measured) (m)	Unistrong Handheld GPS instrument	1s
	Distance from the river	Distance from river bank (Fixed values, pre-measured) (m)	Unistrong Handheld GPS instrument	1s
	Temperature	Average value of temperature (	HOBO Temperature and humidity recorder	1s
	Humidity	Average value of humidity (%ph)		

2.3 Data preprocessing and analysis method

2.3.1 Data preprocessing

The study retained high $PM_{2.5}$ concentrations (several hundred μg/m³ or higher) and Leq data (90 dB or higher) to represent real measurements in time and space [62,74]. During pre-processing, data affected by unusual weather conditions, such as strong winds and heavy rain, and the first 2 minutes of on-site monitoring data were removed to reduce errors. The corresponding average measurements of $PM_{2.5}$ concentrations, Leq, temperature and humidity were then calculated for each monitoring site by taking the arithmetic mean of the 20-second samples. Traffic volume data was obtained by averaging the measured data over a five-minute period at the beginning and end of each measurement, to obtain the two-way hourly motor vehicle throughput. The GPS data was imported into the GIS software for subsequent analysis. The final sample consisted of 1188 geographical

coordinates, 1188 $PM_{2.5}$ concentration data, 1188 noise data, 1188 temperature and humidity data, 36 traffic volume data and 66 distance data from the viaduct or the river.

2.3.2 Analysis method

After obtaining the monitoring data, this study conducted descriptive analysis, spatial analysis, temporal analysis, and correlation analysis with influencing factors for $PM_{2.5}$ concentrations and noise intensity respectively. First, a significance test was performed using SPSS Statistic 25.0 software to determine the overall distribution of pollutants and noise, and to assess the presence or absence of attenuation in the surrounding area. The Kriging interpolation technique was used to map the spatial distribution of pollutants and noise and to examine individual exposure within the site [75,76,77], which can be expressed as:

$$\mathbf{Z}^*(s_0) = \sum_{i=1}^{n} \lambda_i \mathbf{Z}(s_i)$$

where $Z^*(s_0)$ denotes the observation at point i; Δ_i is the unknown weight of the observation at point i, s_0 is the point to be estimated, and n is the total number of observations. The temporal analysis focused on the characteristics of $PM_{2.5}$ concentrations and noise intensity during working versus non-working days, as well as peak versus non-peak hours. Finally, a backward multiple stepwise regression model was used to quantify the relative contribution of influencing elements to the changes in $PM_{2.5}$ concentrations and noise intensity in winter. The prediction model can be expressed as:

$$Y = a + b_1X_1 + b2X_2 + b_3X_3 + \ldots + b_nX_n \ (n \leq 5)$$

where Y denotes $PM_{2.5}$ concentration or Leq; a is a constant; $b_1, b_2, \ldots b_n$ denote the coefficients of the independent variables; $X_1, X_2, \ldots X_n$ are impact factor parameters. In the specific comparative and correlations analysis of $PM_{2.5}$ concentrations, the relative exposure concentration (REC) was used to reduce the confounding effect of ambient concentration differences [74,78,79]. A positive concentration difference indicates that the $PM_{2.5}$ concentration in the UVS exceeds the background concentration and vice versa. The REC is defined as:

$$REC = C_{exposure} - C_{background}$$

where $C_{exposure}$ is the actual concentration measured at the monitoring site and represents the exposure of the active population in the UVS, and $C_{background}$ is the background concentration monitored at the background site.

3.Results

3.1Results of $PM_{2.5}$ concentrations in the UVS

3.1.1Statistical analysis of $PM_{2.5}$ concentrations in UVS

Figure 3(a) shows the objective fact that the sample data for $PM_{2.5}$ concentrations in the UVS are higher than the background values at an overall level. The background $PM_{2.5}$ concentrations are the measured values at the starting point of the route, with a mean value of 86.2 μg/m³. The UVS-P $PM_{2.5}$ concentrations are directly influenced by the viaduct, with a mean value of 107.0 μg/m³. While the UVS-NP $PM_{2.5}$ concentrations represent the monitored values at peripheral points not covered by the viaduct projection, with a mean value of 99.9 μg/m³. The mean UVS-P $PM_{2.5}$ concentration is the highest, approximately 7.1% higher than the mean UVS-NP $PM_{2.5}$ concentration and 24.1% higher than the mean background $PM_{2.5}$ concentration.

The sample data for particulate matter concentrations in the UVS varied significantly, with a maximum daily mean of 167.1 μg/m³ corresponding to a background concentration of 131.0 μg/m³, and a minimum daily mean of 52.2 μg/m³ corresponding to a background concentration of 46.3 μg/m³. This study found that the background concentration had a "magnifying effect" on the $PM_{2.5}$ concentration in the UVS, with the higher the background concentration value, the greater the difference between the UVS and the background value. The differences between the daily data in Figure 3(b) are also similar, reflecting a consistent distributional trend, except for 26 February and 28 February, when the variance of the data is relatively large.

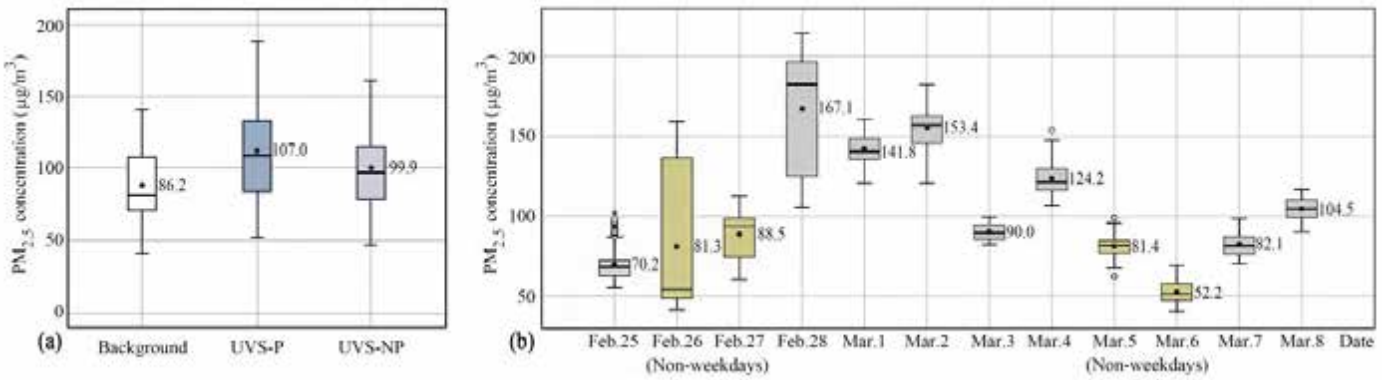

Fig.3 (a) Box plots of all $PM_{2.5}$ concentration data for background points, viaduct projection coverage, and non-viaduct projection surrounding space; (b) Box plots of $PM_{2.5}$ concentrations for each day of UVS. The dots in each box represent the mean (marked by numbers) and the solid line represents the median. Each box extends from the lower quartile to the upper quartile. Whiskers (error bars) below and above the boxes represent maximum and minimum values, and other circles represent outliers.

3.1.2 Spatial-temporal map

At the overall spatial distribution level, estimates of $PM_{2.5}$ concentrations at unmonitored sites were calculated by interpolation using GIS software. Figure 4 presents the 12-day map of mean $PM_{2.5}$ concentrations, which vary considerably between spatial sites, with differences in concentrations between monitoring sites as high as 15.4 μg/m³, accounting for up to 15% of the mean concentration of all sites. There is a discernible trend of significant attenuation from the viaduct to the east and west over a distance of approximately 210 meters along the road. The areas of high mean $PM_{2.5}$ concentrations occur to the north of the UVS-P, particularly at the intersection with the main road on the north side, with all values above 107 μg/m³. This indicates higher levels of pollutant exposure and more severe pollution in these areas. There were two areas of low $PM_{2.5}$ concentrations: one is in the green space between the viaduct and the buildings to the east, where a continuous wall of about 2m height between the building and the green space sharply reduces the pollutant concentration to about 99 μg/m³. The other area of low concentration is the space along the river, with a clear reduction seen, particularly in the section covered by the viaduct, where the mean $PM_{2.5}$ concentration drops to 98 μg/m³, a much lower value than in the north. This shows that urban water bodies can reduce $PM_{2.5}$ concentrations in nearby areas.

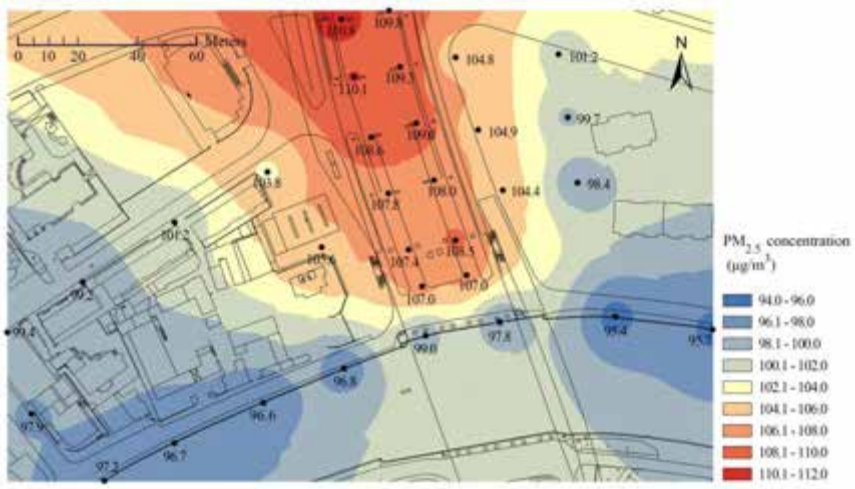

Fig.4 Map of mean $PM_{2.5}$ concentrations in the study area, black dots are actual sample locations, numbers are mean $PM_{2.5}$ concentrations at actual monitored location.

At the overall temporal level, Figure 5 shows that $PM_{2.5}$ concentrations are generally lower on non-working days than on working days. Overall, $PM_{2.5}$ concentrations at different times of the day also shows regular variations. The peak traffic periods tends to have the highest $PM_{2.5}$ concentrations of the day, especially in the evening peak period, while $PM_{2.5}$ concentrations are relatively low in the morning peak and off-peak periods. Sometimes the morning peak values are even lower than the midday off-peak values, presumably due to the difference in traffic volumes and the deposition of $PM_{2.5}$. This phenomenon is more pronounced on working days or when background $PM_{2.5}$ concentration is high.

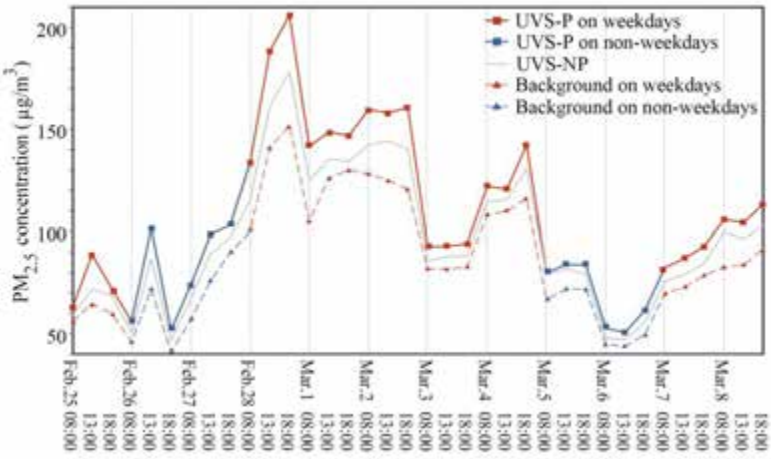

Fig 5. Mean value of $PM_{2.5}$ by time period.

On this basis, two typical days (27 February and 4 March) with similar meteorological backgrounds and traffic volumes are selected for detailed analysis of REC distribution characteristics for each time period between working and non-working days. Figure 6(a) shows that the overall REC values for the three periods on the typical non-working day are small. Figure 6(b) indicates that on a typical weekday the difference in REC between the two peaks and the midday period is greater. The trend of increasing REC towards viaducts and major roads and decreasing REC towards water bodies can be clearly seen in the morning and evening peaks. Two further findings are that 1) the distribution of $PM_{2.5}$ concentrations during a single period on a typical non-working day is more homogeneous and REC is smaller compared to the typical working day; 2) the range of high $PM_{2.5}$ concentrations on the typical working day has a wider impact, almost significantly affecting the area within 240m of the viaduct.

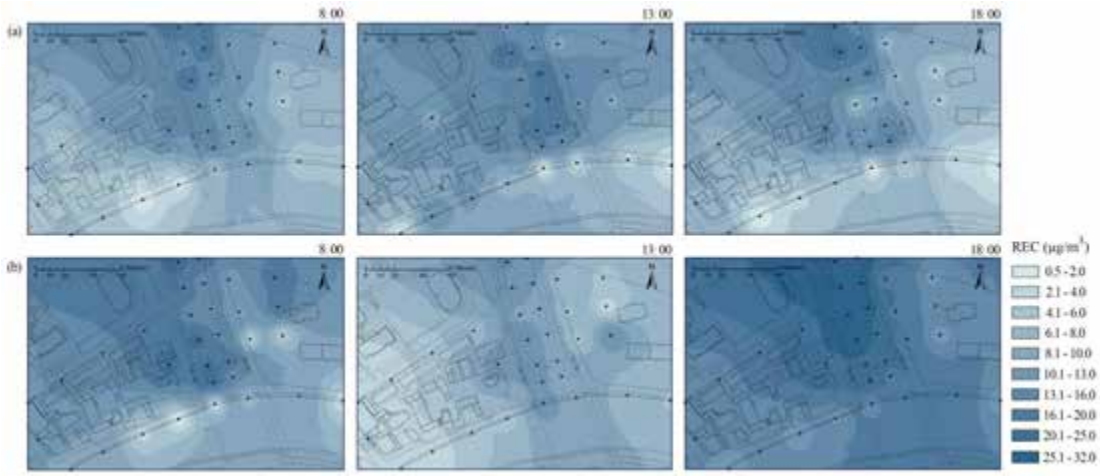

Fig.6 Spatial distribution of REC, black dots are measuring points. (a) includes values for three measurement periods on 27 February, representing non-working days. (b) includes values for three measurement periods on 4 March, representing working days.

3.1.3 Results of influencing factors

A multiple linear regression model (backward method) was used to investigate the effect of different influencing parameters on the distribution of REC in the UVS during winter. All the influencing variables listed in Table 4 have relatively small p-values (<0.05), indicating a statistically significant relationship between the predictor variables and the corresponding $PM_{2.5}$ concentrations. The standardization coefficient (beta coefficient) shows the relative contribution of different parameters to the change in REC. Furthermore, the adjusted R-squared of 0.573 indicates that the model has good explanatory power for the data.

REC is sensitive to changes in traffic, the built environment, and meteorological factors such as temperature and humidity. Among there, traffic volume has the greatest influence on REC, followed by temperature, with beta coefficients of 1.213 and -0.298 respectively. Distance to the viaduct and distance to the water body have no correlation with REC, but the ratio of the two is significantly correlated with REC. This suggests that sports venues should be located as close as possible to water and away from viaducts, and that people should choose times of high temperature, low humidity and low traffic volume to exercise.

Table 4. Regression analysis of the influencing parameters.

Variables	p-value	Beta [b]	
$PM_{2.5}$_TV	0.000	1.213	
$PM_{2.5}$_DD	0.000	0.225	**adjusted R^2**
$PM_{2.5}$_TP	0.013	-0.298	
$PM_{2.5}$_HM	0.041	0.121	0.573

Note: Beta [b] is standardized coefficient; $PM_{2.5}$_TV = traffic volume; $PM_{2.5}$_DD = the ratio of distance to viaduct and distance to river; $PM_{2.5}$_TP = temperature; $PM_{2.5}$_HM is humidity.

3.2 Results of traffic noise in the UVS

3.2.1 Statistical analysis of traffic noise in the UVS

Figure 7(a) shows that the measured equivalent sound level (Leq) of both the UVS-P and the UVS-NP is significantly higher than the background value. The background Leq has a mean value of 58.9 dB. The mean Leq of the UVS-P is 69.4 dB, which is 17.8% higher than the background level, while the mean Leq of the UVS-NP is also high at 63.2 dB, which is 7.3% higher than the background level, indicating that both are influenced by the viaduct.

Within a single day, there is a large difference in Leq, which can vary by about 10 dB (Figure 7(b)). This suggests that the noise intensity in the study area changes significantly throughout the day. Furthermore, while Leq is slightly higher on working days than on non-working days, the distribution trend is consistent, with median and mean values mostly varying in the range of 60-70 dB, and exceeding 70 dB in a few cases. Since the noise mainly comes from traffic and the activity behavior of the UVS, and the noise intensity from this type of source does not vary much from day to day, the Leq over the 12-day period varies less between single days, but varies considerably within a single day.

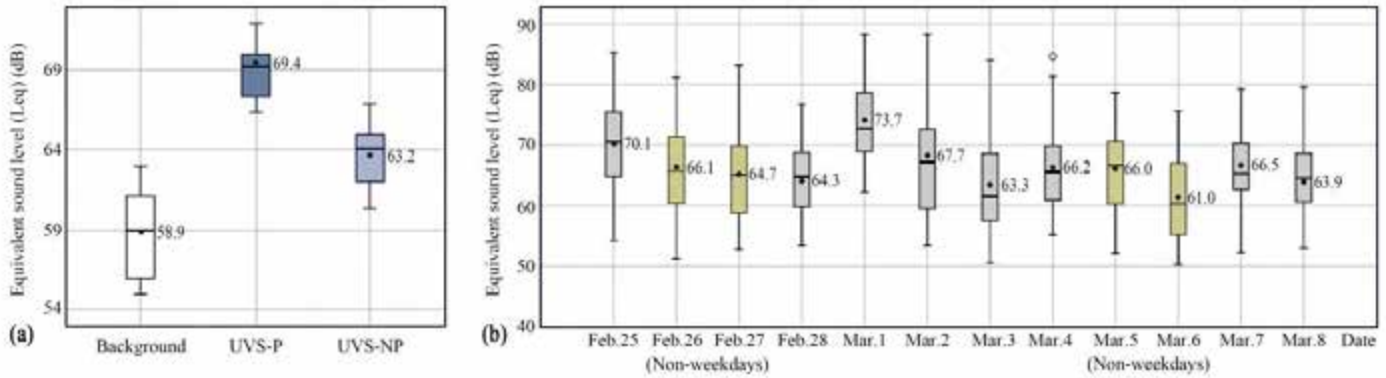

Fig.7 (a) Box plots of all Leq data for background points, viaduct projection coverage, and non-viaduct projection surrounding space; (b) Box plots of Leq for each day of the UVS. The dots in each box represent the mean (marked by numbers) and the solid line represents the median. Each box extends from the lower quartile to the upper quartile. Whiskers (error bars) below and above the boxes represent maximum and minimum values, and other circles represent outliers.

3.2.2Spatial-temporal map

At the overall spatial level, the mean noise distribution over 12 days was calculated using kriging interpolation with GIS software, and the results are shown in Figure 8. The noise levels vary widely across different spaces, with relatively high levels of Leq in the UVS-P, the north side road, and its surrounding areas, where it can reach over 70 dB. The noise levels also show a trend of gradual decay outward from high-traffic areas such as the viaduct and main road intersections. The Leq decreases sharply near the waterfront area on the south side away from the high-traffic area in the UVS-P. In addition, low Leq values appear in the waterfront area and on the west side of the viaduct, where the Leq remains at 59 to 63 dB. The noise is lower away from high-traffic areas and near the waterfront space on the south side, where the noise of the waterfront space remains around 60 dB. The existence of continuous greenery and walls on the southeast side of the viaduct allows the noise to dissipate more quickly.

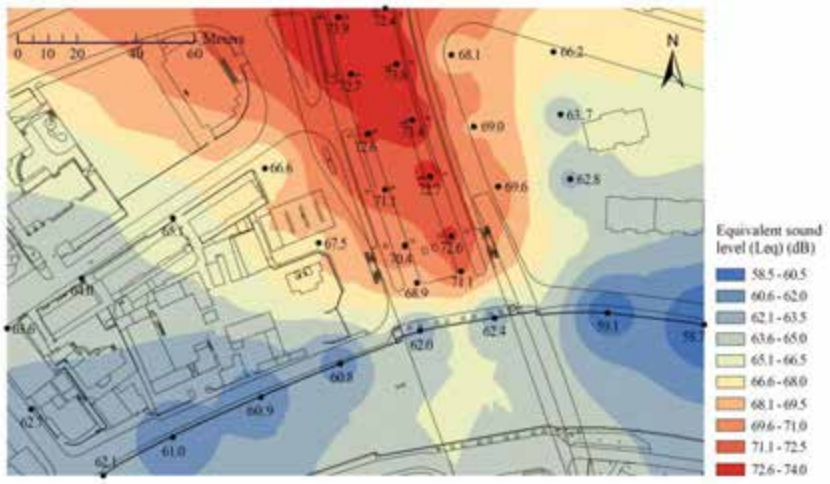

Fig.8 Map of mean Leq in the study area, black dots are actual sample locations, red numbers are mean Leq at actual monitored locations.

At the overall temporal level, the Leq of the UVS-P does not differ much between weekdays and non-weekdays, and is in a stable range of values that are about 10 dB higher than the background value for all time sections. The Leq of the UVS-NP is in the middle of the range. During the day, the Leq of the UVS-P in the morning and evening peaks is usually significantly higher than the midday value, and the difference between the former and the background values is greater than that between the latter and background values. This phenomenon is particularly evident on weekdays such as March 1st.

Overall, the Leq is higher in the morning and evening peak periods for most days, especially on weekdays. The Leq of the UVS-P basically appears as an amplification of the background value, while the Leq of the UVS-NP is in the middle.

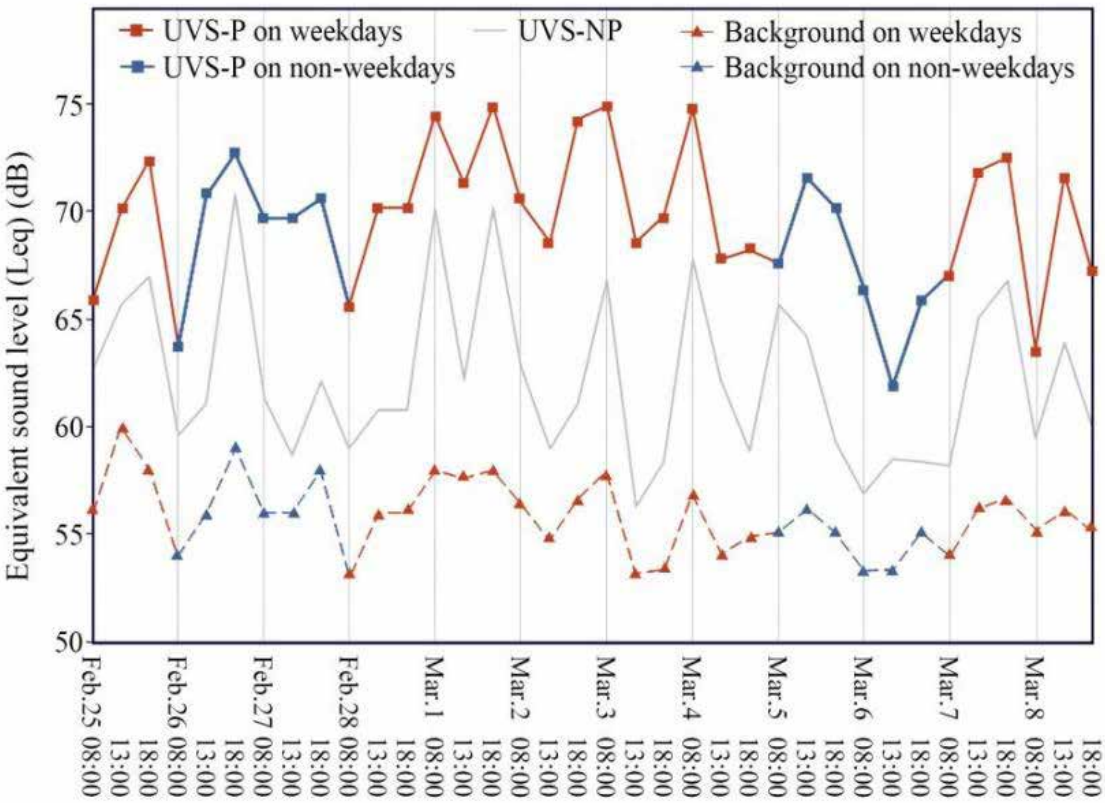

Fig 9. Mean value of Leq by time period.

Continuing with the selection of typical days above, the noise distribution characteristics of the three periods of working and non-working days are presented in Figure 10. In general, the Leq of the UVS-P is significantly higher than that of the UVS-NP and the background value in all time periods for both types of typical days, reflecting the inherent nature of noise under the viaduct. This may be due to the resonance and other characteristics of the viaduct itself, which amplify the traffic noiseΔK.W. NGAI et al., 2002Δ[80], and non-motorized Traffic vehicles and human activities, which also contribute to the noise pollution.

In addition, the overall difference between working and non-working days is less significant than the corresponding characteristics of $PM_{2.5}$ concentrations, with morning and evening peaks about 5-10 dB higher than normal. The Leq values at each point during the three periods of non-working days are similar, similar to the distribution characteristics of the midday period of working days. While the Leq of the UVS is still significantly higher during the working days peak period, the Leq of the UVS-P is 10-15 dB higher than the background value, indicating that the noise levels are still significantly influenced by the traffic flow. The range of noise attenuation is larger for working days (at least 50-100 meters), while the attenuation characteristics for non-working days are relatively small (between 20-100 meters). In addition, the noise attenuation effect of water bodies is not as obvious as for the $PM_{2.5}$ concentration, and it can be seen that the noise is relatively high at the monitoring sites along the river covered by the viaduct.

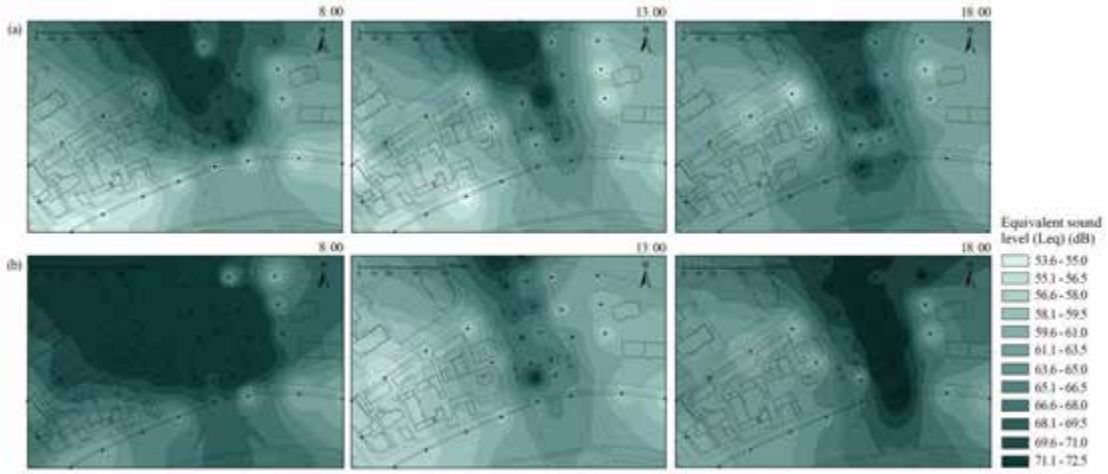

Fig.10 Spatial distribution of Leq, black dots are measuring points. (a) includes values for three measurement periods on 27 February, representing non-working days. (b) includes values for three measurement periods on 4 March, representing working days.

3.2.3 Results of influencing factors

In the case of traffic noise, the effect of different influencing parameters on the distribution of Leq in the UVS during winter was also investigated. Table 5 shows the p-values for various influencing variables, including traffic volume, humidity, and temperature. The p-values for traffic volume, humidity, and temperature are relatively small, with traffic volume having the smallest p-value. This indicates a significant relationship between these influencing factors and Leq. The adjusted R-squared value of 0.718 suggests that the model provides a good level of explanation of the data. The Leq data indicates a clear positive correlation with traffic volume, with a beta coefficient of 0.902, implying that traffic volume is the most influential factor on Leq. Additionally, it shows a negative correlation with winter temperature. This finding suggests that in order to reduce noise hazards, sports stadiums in the UVS should be located in spatial and temporal locations with low traffic flow and humidity.

Table 5. Regression analysis of the influencing parameters on traffic noise

Variables	p-value	Beta [b]	
Noise_TV	0.000	0.902	
Noise_DD	0.191	0.052	adjusted R^2
Noise_TP	0.106	-0.046	
Noise_HM	0.08	0.132	0.573

Note: Beta [b] is standardized coefficient; Noise_TV = traffic volume; Noise_DD = the ratio of distance to viaduct and distance to river; Noise_TP = temperature; Noise_HM is humidity.

4.Discussion

The $PM_{2.5}$ concentration and Leq data, as well as influencing factors in the UVS in central Shanghai, were collected based on mobile monitoring and used to analyze spatial and temporal distribution characteristics and factor correlations.

4.1 Contribution of $PM_{2.5}$ and noise distribution pattern

This study found and confirmed the spatial and temporal distribution characteristics of $PM_{2.5}$ concentrations and noise in the UVS, and also found similarities and differences between the two. Firstly, the spatial findings are as follows: 1) $PM_{2.5}$ concentrations and noise in the UVS-P are higher than the background case, consistently the highest values in the study area, and have some attenuation distance in the USP-NP. This is consistent with previous studies [19,22,31]. 2) Pollution levels along the river area are significantly lower and the water bodies

contribute to the reduction of $PM_{2.5}$ concentrations as well as noise, which is in agreement with the study finding that lake wetlands can significantly reduce PM concentrations within 300 meters [81]. Furthermore, urban open spaces, green spaces and roadside continuous walls can partially offset air and noise pollution from viaducts [82,83] and effectively reduce $PM_{2.5}$ concentrations and noise attenuation distances [19,56], although the influence on $PM_{2.5}$ is much higher than that on noise, suggesting that pollution can be optimized and mitigated through appropriate design measures.

The temporal findings are as follows: 1) $PM_{2.5}$ concentrations in the UVS and its surrounding space are significantly higher on working days than on rest days, which is not reflected in the noise, a side indication that the main factors influencing the two are different: traffic flow mainly influences $PM_{2.5}$ concentrations, while both traffic flow and crowd activity influence noise [84]. 2) $PM_{2.5}$ concentrations and noise in UVS and its surrounding space are basically higher during the morning and evening peak hours than during normal times of the day. In particular, $PM_{2.5}$ concentrations are more pronounced when the background concentration itself was higher, which is consistent with existing studies [24].

This study found that the enclosed environment of the viaduct significantly increased $PM_{2.5}$ concentrations and noise intensity in the UVS, both of which were significantly and positively correlated with traffic volume. Humidity was also positively correlated with the two pollutants. While there is a negative correlation between temperature and $PM_{2.5}$ concentrations, the negative correlation between temperature and noise is weaker, supporting previous microscopic studies [85]. Additionally, $PM_{2.5}$ concentrations are more sensitive to changes in the built environment, as its formation and dispersion are often influenced by urban buildings, floor area ratio and vegetation [86], while noise intensity is not significantly correlated with the built environment.

4.2 Contribution to policy

This study innovatively focuses on the characteristics of particulate matter and noise distribution in the sports space in the UVS, which is a less studied but important topic. Building on this, the study also selects the spatial quality of the UVS as the ultimate perspective to explore the appropriateness of reusing negative spaces in high-density cities. The results of this study have relatively high application value and provide an intuitive understanding of the changes in particulate matter and noise in the UVS microenvironment. This study is expected to provide theoretical support for the future development of the UVS spatial design and urban form optimization in large cities, represented by Shanghai. According to the spatio-temporal study, the overall $PM_{2.5}$ and noise pollution in the UVS in winter is more severe than in the surrounding areas, and there is attenuation. We recommend not placing open-air sports fields under the viaduct and in the surrounding space within 240 meters to avoid health damage to sensitive people. Noise and $PM_{2.5}$ have different attenuation characteristics and are less affected by the built environment, a difference that needs to be factored into future government decisions. Considering the influence of various factors, the exercise space around the viaduct should preferably be close to the water body, and people should be guided to exercise in places with appropriately high temperature, low humidity and low traffic flow to mitigate the adverse effects of these two types of pollution.

The space for sports under existing viaducts can be transformed into an enclosed indoor space, and mitigation measures can be taken for spaces under viaducts where transformation is difficult. Firstly, they can be converted into indoor spaces by adding spatial barriers to the road or greenery. Secondly, the airflow under viaduct spaces can be maximized by using new materials such as acoustic panels and mitigation measures for the viaducts [30], as well as enhancing the microclimate design of the UVS.

4.3 Limitation

This study only selected 12 days in winter to conduct the experiment, which lacks comparability to the summer season or to a full year's worth of data, and the limited timeframe may have had an impact on the correlation analysis. Secondly, as the dispersion of airborne particulate matter is influenced by aerodynamic mechanisms, the dispersion of polluting particulate matter in the UVS is the result of a combination of meteorological factors. Although this study avoided the effects of strong winds and rain, it did not specifically consider wind environmental factors such as wind speed and direction. In the future, more factors, such as the types of moving vehicles, need to be incorporated.

This study reveals the spatial and temporal characteristics and summarizes the influencing factors of particulate matter and noise pollution in a typical UVS in a high-density city through a field experiment with high accuracy. This provides an important basis for scientifically and effectively assessing the health and comfort of the UVS.

The study has both guidance and practical significance for the design of existing or new UVS, and provides more ideas and references for the concept of urban renewal in high-density cities.

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Consent for publication
All authors consent for publication.

Ethics approval and consent to participate
Not applicable.

Availability of data and materials
All data generated or analyzed during this study are included in this manuscript.

CRediT authorship contribution statement
Chao Liu: Conceptualization, Supervision, Project administration. **Ze-Yin Chen:** Writing – original draft, Investigation, Software, Visualization, Formal analysis. **Si-Ying Li:** Writing – original draft & reviewing & editing, Investigation, Software, Formal analysis. **Zheng Liu:** Data curation.

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Not applicable.

Data availability
The data that has been used is confidential.

Abbreviations
UVS under-viaducts spaces
UVS-P projected spaces of under-viaducts spaces
UVS-NP unprojected spaces of under-viaducts spaces
REC relative exposure concentration

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Agricultural landscapes and agrivoltaic systems: the key role of landscape planning

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Abstract
The spread of renewable energy sources (RES) is nowadays a key goal at European level, being "decarbonization" crucial to counterbalance climate change. However, current push towards energy transition is opening new questions, such as the need of balancing the positive environmental impacts arising from the spread of the RES and the landscape transformations it may entail. This contribution, with reference to the Italian context, explores the role of landscape planning tools in ensuring a proper balance between landscape quality and increase of energy generation from RES, with specific reference to agrivoltaic systems (APV), providing hints for their location, according to landscape quality, and criteria for designing APV. tailored to the peculiar features of the heterogeneous agricultural landscapes.

Keywords: agrivoltaic systems, landscape planning, agricultural landscapes

Introduction

Energy generation from renewable sources represents, nowadays, a primary goal at both European and national levels, being "decarbonization" one of the key solutions to counterbalance climate change. By 2030, the share of energy produced from renewable energy sources (RES) in the European Union is expected to reach 42.5% (binding) and 45% (indicative) with a key contribution from solar photovoltaics (European Commission, 2022). According to the data provided by Terna1, in 2024 energy produced by RES recorded the highest ever demand coverage level of 41.2 percent (up from 37.1 percent in 2023). This level is up mainly due to the increase in hydroelectric and photovoltaic production. With the Integrated National Energy and Climate Plan, Italy aims at achieving a target of 39.4% of gross final energy consumption from renewable sources in 2030 (Ministero dell'Ambiente e della Sicurezza Energetica, 2024).

In line with the European and national targets to 2030, the Italian Ministry of Environment and Energy Security, in July 2024, issued a Decree setting the distribution among Italian regions of the national target of additional power from renewable sources to be achieved by 2030. The same Decree also established the criteria for identifying unsuitable areas, leaving it up to the regions to identify eligible areas, maximizing the achievement of the assigned targets in terms of energy production from renewable sources.

However, a recent verdict issued in May 2025 by the Administrative Court of the Lazio Region, and namely by a competent judge for the matter whose decisions are valid for the entire national territory has cancelled the articles of the Decree specifically related to the identification of the suitable and unsuitable areas, forcing the Ministry of Environment and Energy Security to re-edit the criteria for identifying areas suitable and unsuitable for the installation of plants for energy generation from RES2.

Despite the significant uncertainty that characterizes current legal and regulatory framework, the push toward energy transition is opening issues related, first and foremost, to the need of balancing the positive environmental impacts of RES deployment with the territorial and landscape transformations that such deployment entails

1 TERNA manages the Italian Electricity Transmission Grid (NTG) and it is the largest independent grid operator (TSO) in Europe. Data are available at: https://www.terna.it/it/media/comunicati-stampa/dettaglio/consumi-elettrici-2024.
2 Sentence of the TAR Lazio n. 9155 of 13 May 2025

(Greco, Cresta, 2023). Although energy transition is nowadays an undisputed priority, also in relation to the goals set by Agenda 2030[3], the protection of landscape constitutes one of the fundamental principles of the Italian Constitution (Article 9), which has been more recently extended to the environment, ecosystems, and biodiversity.[4] Thus, some authors, considering energy generation from RES as a matter relevant to environmental protection, state that when two principles, such as landscape and environmental protection, represent both foundational constitutional values, a non-hierarchical priority is established between them (Ferraro, 2012). Others, emphasize the existence of a "clear separation between environment and energy", even in the case of energy generation from RES, highlighting the conflicts between environmental/landscape protection instances and wind and photovoltaic energy development policies (Calabrò, 2021).

Based on the above, the thesis here supported is that landscape planning tools could represent key tools for achieving a proper balance between the conflicting instances of landscape protection and enhancement and the current policies for the development of energy generation from RES. According to the Legislative Decree 42 of 2004 (Art. 145, paragraph 3), in fact, the forecasts of landscape planning tools cannot be derogated from by national or regional economic development plans, programs and projects. Moreover, they are binding for urban planning tools issued by municipalities, metropolitan cities and provinces as well as for sectoral interventions; their forecasts immediately prevail over any dissimilar provisions included in urban planning tools; they establish safeguard rules applicable pending the necessary revision of the urban planning tool.

Hence, this paper explores the role that landscape planning could and should play in ensuring a balance between landscape quality and the spread deployment of energy generation from RES, with specific reference to agrivoltaics systems (APV). In detail, this paper provides some hints to identify areas for the location of APV, based on landscape protection needs, and criteria to design APV tailored to the peculiar features of the heterogeneous agricultural landscapes.

Although APVs have a lower environmental impact than other types of RES, since they reduce the consumption of agricultural land and ensure a number of potential benefits to agricultural activities (shading, reduction of water demand, protection from extreme weather winds, etc.), their massive introduction can result in substantial transformations of agricultural landscapes, especially in regions characterized by a high extensions of agricultural land, also reducing the acceptability by local communities of APVs that are, in turn, carriers of innovation and fundamental tools towards a sustainable energy transition.

How to reconcile the location choices of APVs with the needs of landscape protection?
The latest generation of landscape plans in Italy has definitively marked the transition from a constraint-based approach towards a landscape plan intended as a tool to guide the sustainable transformation and enhancement of environmental, territorial and landscape heritage. It was precisely these plans that attempted to provide criteria and rules to guide both the localization and the landscape compatibility of renewable energy sources (Paolinelli, 2012; Magnaghi, 2016).

All the examined landscape planning tools (Apulia, Tuscany, Piedmont) recognize the significant changes to the landscape features that renewable energy production plants could cause and provide hints for their location and for minimizing their impact on landscapes. Nevertheless, most of them do not provide regulations specifically addressed to APV, focusing above all on wind farms and ground-based photovoltaic systems.

However, numerous European scholars have provided hints to determine suitable and unsuitable areas for APV, suggesting some useful landscape criteria. Among the latter, the studies aimed at assessing the agrivoltaics potential in Germany have to be mentioned (Rösch, Fakharizadehshirazi, 2024): they suggest, in detail, the widespread adoption of small-scale APV (<2.5 ha), privileging areas not easily visible and accessible, and minimizing visual impact through the planting of hedges. They also identify some typologies of areas in which the location of APV should be prohibited:

3 See in particular Goal 7 (Clean and Affordable Energy), which identifies increasing energy produced from RES and improving energy efficiency as key strategies for combating climate change.
4 https://www.riformeistituzionali.gov.it/it/la-legge-costituzionale-in-materia-di-tutela-dell-ambiente/

- biodiversity protection areas (nature reserves, national parks, biosphere reserves, landscape protection areas, natural parks, natural monuments, legally protected biotopes and Natura 2000 areas);
- water protection areas;
- floodplains;
- landscapes of special significance.

Finally, they identify as unsuitable areas for APV, the 200 mt. buffer zones around residential and commercial areas, to avoid visual interference with the most populated and frequently visited areas.

Similar studies have been conducted with reference to Sweden (Elkadeem et al. 2024): in this case, restrictive criteria for APVs' location include all protected areas, with a buffer zone equal to 1 km; water bodies, with a buffer zone of 100 mt. for rivers and 300 for lakes. In addition, with the aim of limiting the visual impact of installations, Elkadeem et al. consider a protected strip along roads equal to 50 mt. and a buffer value of 1 km with respect to urbanized areas.

Similar studies, carried out with reference to the Italian context, show some minor differences from those previously recalled, because they do not include, for example, the use of buffer zones, but provide similar exclusion criteria (Fattoruso et al., 2024):

- national and regional parks;
- areas included in the NATURA 2000 network;
- areas reserved for biodiversity conservation in European countries (established by the Habitats Directive) for the conservation of natural and semi-natural habitats and wildlife.

Fattoruso et al. provide also relevant insights into the heterogeneous regional distribution of the areas potentially suitable for agrivoltaics, that range from 12% of the total agricultural area in Apulia to 0% in Liguria and Valle d'Aosta. These data clearly underline the importance of adopting flexible criteria that can be adequately tailored to heterogeneity of landscapes that characterize at least the Italian regions.

In June 2024, a Ministerial Decree was approved in Italy to drive Regions in determining suitable and unsuitable areas for the installation of renewable sources energy plants. In detail, the Decree, in addition to establishing the regional distribution of the national 2030 target of an additional 80 GW of power from renewable sources compared to December 2020, asks Regions to identify:

a) suitable areas, where an accelerated and facilitated procedure is provided for the installation and operation of RES facilities and related infrastructure;
b) unsuitable areas, showing features incompatible with the location of specific types of RES;
c) ordinary areas, where ordinary authorization regimes set forth in Legislative Decree No. 28 of 2011 can be applied;
d) areas where the installation of photovoltaic systems with ground-based modules is prohibited.

According to the criteria set by the 2024 Decree, unsuitable areas are those included in the perimeter of properties subject to protection under Article 10 and Article 136, paragraph 1, letters a) and b) of Legislative Decree n° 42 of January 22, 2004. Such properties can be listed as follows:

- immovable assets having artistic, historical, archaeological or ethnoanthropological interest and distinguished by peculiar features of natural beauty or geological singularity;
- villas, parks and gardens of artistic or historical interest or distinguished by their uncommon beauty;
- all urban open spaces (streets, squares, etc. of artistic or historical interest); mining sites of historical or ethno-anthropological interest; rural architecture having historical or ethno-anthropological interest as evidence of the traditional rural economy.

The Decree provides Regions also with the opportunity to define as unsuitable all the areas included in the perimeter of other assets protected under the same Legislative Decree (n° 42, January 22, 2004). Regions can, therefore, exclude from suitable areas, additional areas, such as those protected by the article 142. Moreover,

Regions may establish a buffer zone, having different width depending on the type of plant and protected asset, from the perimeter of the protected asset up to a maximum of 7 kilometres, but only if this choice does not compromise the possibility of achieving the production targets set for each Region by the Decree.

Finally, Regions are required, following the identification of the suitable areas, to update all energy, environmental and landscape planning acts and any other regulations, programs, plans or legislation previously approved at the regional, provincial or municipal level. Hence, according to the Decree, the identification of suitable areas prevails on any previously made provision, including those referred to landscape protection.

In this sense, the 2024 Ministerial Decree entails a substantial reversal from Ministerial Decree 219/2010, aimed at providing Guidelines for the authorization of plants powered by RES. The latter assigned, in fact, to the Regions the task of identifying unsuitable areas, taking into account what already established in the landscape regional plan, and indicated a broader list of areas that for their sensitivity/vulnerability features could be identified as unsuitable for the location of specific types of plants.

It seems useful to remind that, according to current Italian legislation, the main task of landscape planning tools is the identification of necessary measures to ensure a proper integration in the different landscapes, of any intervention, with the aim to guarantee the compatibility between territorial development and the different recognized and protected landscape values, with particular attention to the preservation of rural landscapes and sites included in the UNESCO World Heritage List (Dlsg. 42/2004).

Moreover, as previously mentioned, the articles of the 2024 Decree related to the identification of suitable and unsuitable areas have been currently cancelled and will have to be re-edited.

Thus, despite the lack of certain regulatory references, it is here considered of paramount importance to identify unsuitable areas for the location of APVs, in compliance with the protection regimes and requirements already set by the landscape plans. Nevertheless, it is possible to identify some relevant landscape assets, whose quality could be altered by the installation of APVs, that were only partially included by the articles, currently eliminated, of the Ministerial Decree issued in 2024. In particular:

- landscape assets regulated by Articles 10 and 136 of Legislative Decree 42/2004;
- landscape assets regulated by Article 142 of Legislative Decree 42/2004;
- landscape assets as identified in accordance with Article 143, paragraph 1 (d) and (e) of the 2004 Legislative Decree ;
- areas included within the Natura 2000 network;
- wetlands falling under the Ramsar Convention;
- Important Bird Areas (I.B.A.);
- UNESCO sites;
- rural landscapes listed in the National Register of Rural Landscapes of Historic Interest, Agricultural Practices and Traditional Knowledge by the Ministry of Agriculture, Food and Forestry (Decree No. 17070, November 19, 2012).

Nevertheless, an adequate attention to the quality of landscapes does not imply only the exclusion of selected areas from the possibility of installing APVs; it requires, first and foremost, the definition of criteria aimed at guiding the design of APVs towards a greater attention to the features and quality of the agricultural landscape in which each AVP will be located (Toledo, Scognamiglio,2021; Fattoruso et al., 2023].

To this end, this contribution aims at providing some landscape criteria useful to guide the APVs' design towards a better understanding, and consequently to a greater respect, of the peculiarities of each agricultural landscape, especially in selected "*warning*" areas, where the compliance with detailed landscape criteria must be mandatory. The identification of these areas, which must be carried out within the framework of regional landscape plans too, can be based on some general criteria:

- presence of quality agricultural and food production;
- historical-testimonial value;
- presence of visual cones drawn from viewpoints located in scenically unsuitable areas and/or in historic centres or along roads, pedestrian or bicycle paths that have historical and/or scenic value;
- presence of protected areas of local significance.

In the "*warning*" areas, the potential for the location of APV has to be determined through detailed analyses at local scale, aimed at identifying areas that, due to their landscape-cultural value, relevance in the local agricultural tradition (traditional crops that currently survive only in limited portions of the regional territory), visibility from routes characterized by a high landscape value or from relevant points of the territory, cannot be considered suitable to the location of APV, falling into the category of unsuitable areas. Within all the other "*warning*" areas, the respect of landscape criteria in the design of the APVs must be considered always mandatory.

Figure 1 summarizes the suggested methodological path to ensure that both location and design of APVs are compatible with the features of the agricultural landscape they will be included in.

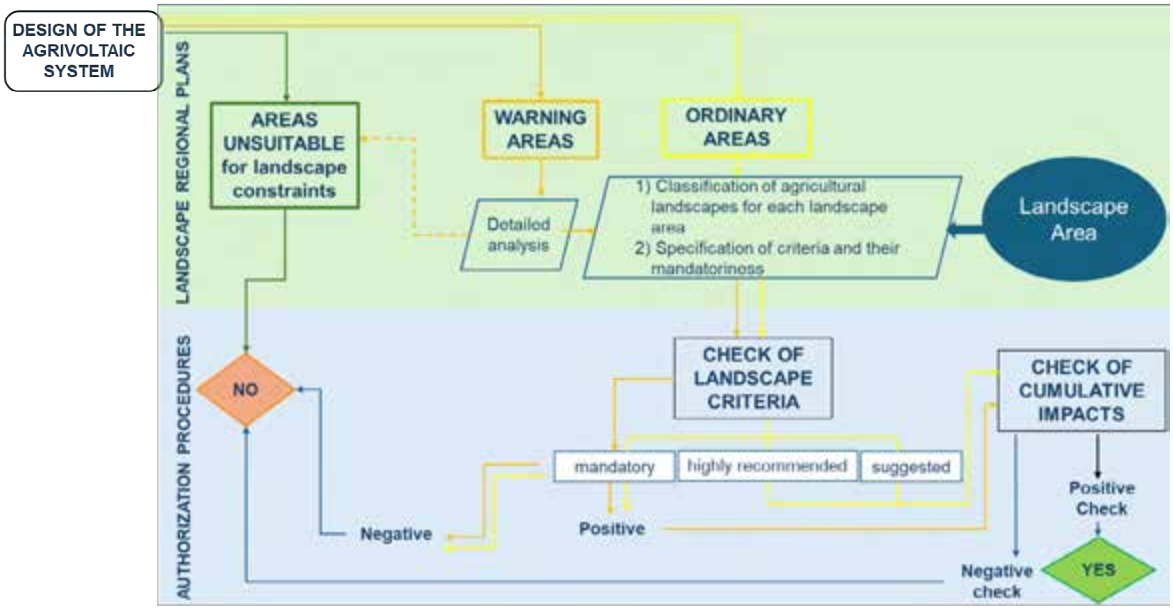


Figure 1 - *The methodological path to ensure localization choices based on landscape protection needs and an APVs' design tailored to the peculiar features of the different agricultural landscapes. Source: Authors' elaboration*

Landscape criteria to guide the design of agrivoltaics systems.
The definition of landscape criteria to guide the design of APVs has been the most challenging aspect of the research work, due both to the limited references in scientific literature, being this aspect a quite recent research field (Scognamiglio, 2016), and to the heterogeneity of agricultural landscapes that characterize, in particular, the Italian context.

Indeed, there are few studies aimed at providing criteria for designing an APV according to the peculiar features of agricultural landscapes. Most of them focuses on the visual impact of APV, which is considered particularly relevant because of the elevated structure of PV modules, which are clearly visible even from a significant distance, especially in flat areas. Some studies examine, in particular, issues related to visual openness, visibility, and relationships between PV modules and crop patterns (Sirnik et al., 2023); others underline the importance of considering both the view from inside the agricultural area where the PV modules will be located, and the visibility of the PV modules from the surrounding areas; other studies consider visual openness, i.e., the amount of space visible from a user located in the centre of the APV, and its visibility from valuable assets located in the surrounding area (Weitkamp et al., 2011). The same authors suggest the identification of a 10-m buffer, around

the perimeter of the area were the APV is located, and the check of the presence of valuable elements from which the system could be visible, regardless of the presence of infrastructural elements such as roads or pedestrian paths.

The few studies focusing on the relationship between the shape of agricultural plots and those of PV patches have identified three types of configurations: responsive, irresponsive, split, island, incidental (Figure 2) (Oudes, Stremke, 2021; Sirnik et al., 2023).

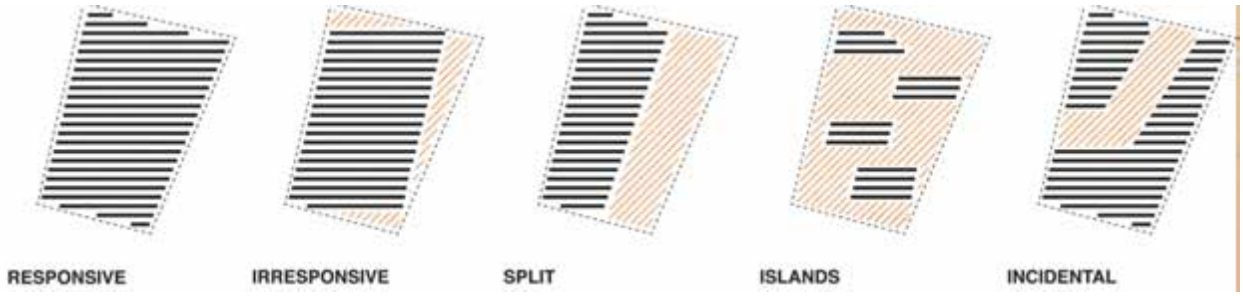


Figure 2 - *Geometric relationships between agricultural plots and PV patches. Source: Oudes, Stremke, 2021*

In the *responsive* configuration, the arrangement of PV patches conforms to the shape of the agricultural plot, covering its entire extent. This preserves the recognizability of both the shape and size of the agricultural plot.
In the *irresponsive* configuration, the arrangement of PV patches does not compare with the size and shape of the agricultural plot. As a result, there are residual spaces in the agricultural plot, but they do not reflect the shape of the plot itself.

In the *split* configuration, the arrangement of PV patches conforms to the shape of the agricultural plot, but they cover only partially the plot. The result is a subdivision of the agricultural plot that, however, does not alter the shape of the plot itself.

In the *island* configuration, only small parts of the agricultural plot are covered by the PV patches, with shapes completely independent of the plot itself.

In the *incidental* configuration, the arrangement of PV patches depends on the presence of specific elements, such as buildings or infrastructure.

Some scholars have also investigated the relationship between the orientation of the PV modules and that one of the crops: *so* far mainly related to optimizing energy performance, this relationship could be usefully varied, using criteria for consistency between crop and PV modules orientation, both in the case of vertical and inclined modules, to meet different objectives (Toledo, Scognamiglio, 2021).

Birò-Varga et al. (2024) carried out studies on the perception of different types of APV by those who enjoy a given landscape, using questionnaires. The authors, with reference to an overhead and a vertical interspace agrivoltaics power plant, examine the different perception of the two systems: in both cases the attractiveness of the landscape is considered lower, but it is perceived as drastically lower in the case of the overhead agrivoltaics power plant, Studies specifically aimed at providing criteria for better integration of APV into the landscape include the work of Fattorusso et al. (2023) who identified three general criteria related specifically to:

- the relationships between the size of APV and the size of other landscape elements;
- the relationships between the geometrical features of the PV modules and those of the landscapes' elements;
- the different densities between the PV pattern and the landscape pattern.

The study, based on the principles of *landscape ecology*, provides some metrics to quantify analyse the landscape structure (e.g., size and number of patches within predefined areas) and suggests the possibility of using these criteria to guide the integration of APV into the landscape.

However, the variety of agricultural landscapes requires careful consideration regarding the appropriateness of general criteria and metrics: the latter should be outlined, on the opposite, taking into account the morphological, geometric, cultural and contextual peculiarities of each landscape typology in which each APV has to be located. Therefore, a classification (certainly not entirely exhaustive) of the most widespread typology of rural landscapes, at least in Italy, has been outlined to define, for each typology, adequate landscape criteria, characterized by different levels of compulsoriness depending, above all, on the urbanization level of the considered agricultural area. In addition, some criteria for the assessment of cumulative impacts have been defined for each typology of agricultural landscapes.

Agricultural landscapes are composed of cultivated areas and their features depend on the peculiarities and different aggregation of some "structuring" elements"; in particular (Table 1):

- the morphology of the area;
- the agricultural plots;
- the type of crop;
- the presence of historical remains;
- the road network;
- the water network;
- the natural vegetation.

However, a correct classification of agricultural landscapes cannot disregard the complex relationships between agricultural areas and urbanization processes: the latter induced, in fact, significant changes in rural landscapes, especially in lowland areas, where there has been the greatest growth of both settlements and infrastructure. Data from the 7° General Census of Agriculture (ISTAT, 2021) show that in Italy, between 1982 and 2020, almost two out of every three farms disappeared, while the total agricultural area shrunk by more than 20%. Therefore, starting from the analysis of the recurring relationships between agricultural and urbanized areas, four typical contexts in which rural landscapes can be placed have been identified, as highlighted in table 2.

The different contexts identified in Table 2 are useful both for a better classification of agricultural landscapes and for assigning different levels of compulsoriness to the landscape criteria for the design of APV (Table 3). In areas where settlement pressure is very low, in fact, the adoption of landscape criteria in the design of APV must be mandatory, while such adoption can be only suggested, in case of APV to be located in agricultural areas enclosed or located in peri-urban areas, where the spread of APVs should be largely "favoured", being them useful to counteract the abandonment of agricultural activities and in promoting their multifunctionality.

Regarding the criteria useful to improve landscape compatibility of APV in different types of agricultural landscapes, also based on the available scientific literature, four categories of criteria were identified: morphological, dimensional, geometric and visual criteria (Table 4).

Table 1 - Structuring elements of agricultural landscapes. Source: Authors' elaboration

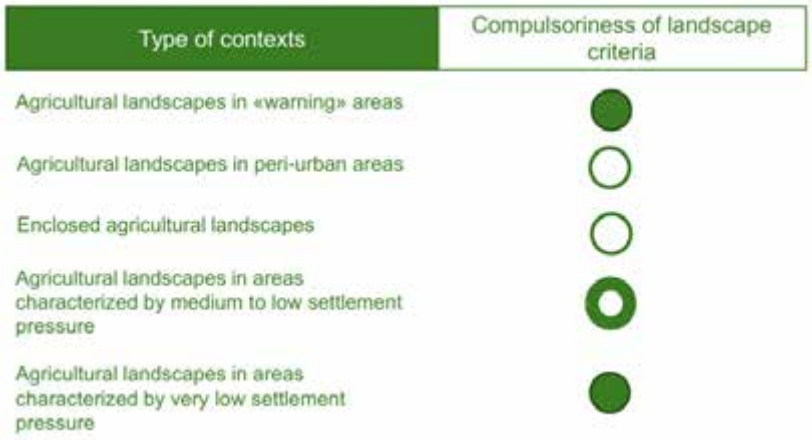
Elements	*Description*	
Morphology	Lowland or hillside landscapes have heterogeneous characteristics and determine distinct categories of agricultural landscapes, which are also decisive for the characterization of additional elements (plots, crops, etc.), as well as for different visibility conditions.	
Plots	Agricultural plots are highly dependent on the morphology of the site and area characterized by different shapes, sizes and type of aggregation. They also depend on the road network and on the type of cultivation, and show different geometries, more or less regular.	
Crops	The different crops can be distinguished into four macro-types: arable land, stable grassland, woody crops, arboriculture, and floricultural crops. The different crops result in variations in texture, size, grain, and colour, which are also very important in the characterization of agricultural landscapes.	
Remains	Traces of the historical stratification, which can be both buildings (e.g. historical farms, rural villages) or linear elements (such as historical tracks, or forms of organization of the agricultural territory, such as the Roman "centuriatio"). Other types of remains are, for example, the drystone walls, which were included in the UNESCO heritage list in 2018.	
Networks	Networks constitute decisive elements in the structuring of the agricultural mosaic: the main roads and the dense network of inter-modal roads, together with the possible presence of waterways and the more or less dense network of irrigation canals constitute fundamental elements in the design and characterization of agricultural plots.	
Natural vegetation	It is made up of the set of arboreal or shrubby elements bordering the field (hedges, isolated trees, tree patches or trees in rows) and plays a fundamental role from both a landscape and environmental point of view, representing elements with high ecological value within the cultivated areas.	

Table 2 - Different types of agricultural landscape contexts. Source: Authors' elaboration

Type of contexts	*Description*	*Images*
Agricultural landscapes in peri-urban areas	They are generally characterized by multiple uses, where agricultural tracks intersect with fragmented settlements, industrial areas, landfills, etc. and/or characterized by extensive urban *sprawl* and the presence of major infrastructure axes.	
Enclosed agricultural landscapes	Residual agricultural areas surrounded by densely built urban fabrics	
Agricultural landscapes in areas characterized by medium to low settlement pressure	Agricultural areas characterized by the presence of historically established rural settlements and more recent urban fabrics, generally concentrated along secondary road networks	
Agricultural landscapes in areas characterized by very low settlement pressure	Agricultural areas characterized by a very limited presence of settlements and a high presence of natural vegetation	

Finally, with exclusive reference to landscape aspects, some criteria to limit the cumulative impacts, resulting from the albeit desired spread of APVs, have been defined.

Table 3 - Types of contexts and level of compulsoriness of landscape criteria for the design of APVs. Source: Authors' elaboration



To date, apart from the guidelines provided by the Apulia Region in 2012 (Resolution of the Regional Council 2122/2012) for the assessment of cumulative impacts of projects for electricity production from wind and ground-mounted photovoltaic systems, which also explicitly consider cumulative impacts on landscape views, no guidelines specifically addressed to APVs are available.

Table 4 – Landscape criteria for APV design. Source: Authors' elaboration.

Criteria	Description
Morphological	These criteria refer to the coherence between the design of APV and the morphological features of landscape, determined by the morphology of the site and of the agricultural plots, by the organization of the networks (road, irrigation channels) and/or by presence of historical traces (centuriatio, paths, etc.). These criteria are also aimed at ensuring that the layout of PV modules does not induce a loss of continuity of non-crop vegetation networks (hedges, rows, swaths of spontaneous vegetation, wooded patches, etc.), ensuring that these elements can effectively play their role as ecological connections in contexts that are often already heavily artificialized.
Dimensional	These criteria are related to the "size" of the different elements that agricultural landscapes are made of. As highlighted by several scholars, a better integration of APV in agricultural landscapes requires that the size of the APV is consistent with the average size of the landscape elements, and namely of the agricultural plots, avoiding the so called out-of-scale effect, also relevant from a perceptual point of view. To this aim, metrics extremely common in landscape analyses, such as the average size of agricultural plots in the area affected by the APV, are suggested. Dimensional criteria can be also used to define buffers to be respected in the areas contiguous to the APV, useful to interrupt the continuity of the PV modules, especially in the selected "warning" areas.
Geometric	These criteria refer to the consistency between the orientation of PV modules and that one of agricultural crops, taking into account the possibility of using modules with such "mobility" characteristics as to maximize their sun exposure.
Visual relationship	These criteria are the most widely used in scientific literature, with reference to the visibility of both APV from surrounding areas and surrounding areas from APV. The key objective is to avoid that PV modules obstruct relevant views (e.g. landmarks) or alter the view of agricultural landscapes from viewpoints located in protected areas, along routes with high historical and landscape value or from centres or artifacts of historical-architectural importance.

Again, due to the heterogeneity of agricultural landscapes, it is not appropriate to provide unambiguous rules for all of them: while for some landscapes it is essential to avoid the "sprawl" effect, in fact, for others, a widespread presence of APV can be relevant to counteract settlement pressures and the increasing phenomena of land take and soil sealing, currently affecting numerous agricultural areas. These are two extreme cases: between them, some intermediate cases can be identified. For example, in agricultural landscapes falling into the "warning" areas or in areas with low settlement pressure and high presence of natural vegetation, it is essential to provide limits on the maximum extension of the total agricultural area that can be devoted to APV, as well as on the mutual distance between new APV and pre-existing or authorized ones, with particular attention to the portions of landscape perceptible from viewpoints located in areas and/or along roads of particular historical and landscape significance. Conversely, in peri-urban and enclosed agricultural landscapes, it seems relevant to maximize the presence of APV even as replacements for existing greenhouses.

The methodological path here briefly outlined was tested on the Campania Region, which to date has a Preliminary Landscape Plan, approved in 2019.

Specifically, from the 51 Landscape Areas identified by the Preliminary Plan, an Abacus of the agricultural landscapes in the Campania region was outlined. For each of the identified agricultural landscape types, a sheet describing their structuring elements (geometry and size of agricultural plots, crop type, etc.) and relationships with settlements (Figures 3a, 3b) was drawn up. These sheets also indicate the different levels of compulsoriness of the landscape criteria for the design of APVs. Finally, with reference to each type of agricultural landscape, a matrix of criteria to be adopted for guiding the design of APVs and for assessing the cumulative impacts has been developed (Figures 4, 5).

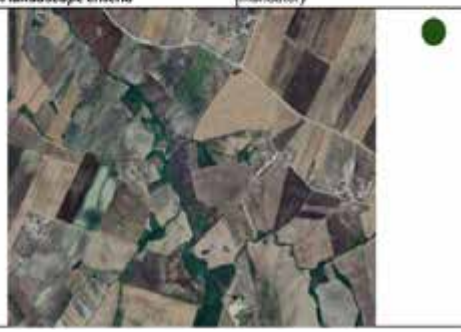
Concluding Remarks

The definition of criteria for improving the compatibility of APVs with agricultural landscapes represents a complex and meanwhile an unavoidable challenge to ensure a proper balance between the needs related to the sustainable energy transition and the equally relevant needs related to the protection and enhancement of landscape heritage.

APV represents, nowadays, an important innovation in renewable energy generation, enabling the coexistence of energy and agricultural production and, in many cases, allowing an increased agricultural productivity; nevertheless, the spread of APV, if not carefully planned and in the lack of landscape criteria guiding their design, could induce uncontrolled landscape transformations, with negative consequences both for the quality of agricultural landscapes and for the social acceptability of APV.

Therefore, landscape planning tools have been here identified as the most suitable tool to achieve a better balance between landscape quality and the spread of APV: these plans are, in fact, endowed with binding and prevalent effectiveness compared to other planning tools and they might guide both the location and design of APV through guidelines, tailored to the peculiarities of the heterogeneous regional landscapes.

LANDSCAPE AREA	
20-Ufita	
Rural system with cultural value	
B04_Ufita	
Type of agricultural landscape	
2. Irregularly meshed lowland arable land.	
Anthropogenic pressure/urbanization	low
Site morphology	plain
Shape of agricultural plots	irregular
Size of agricultural plots	0.5-8 ha
Type of crop	arable land
Geometry	random warps
Punctual historical traces	
Linear historical traces	historical road network
Road network	primary-secondary road network
Water network	
Network of natural vegetation	rows of trees
Context	*Area characterized by very low settlement pressure*
Compulsoriness of landscape criteria	*mandatory*



LANDSCAPE AREA	
20-Ufita	
Rural systems with cultural value	
B04_Ufita	
Type of agricultural landscape	
5. Complex peri-urban mosaic and enclosed agricultural areas.	
Anthropogenic pressure/urbanization	medium
Site morphology	plain
Shape of agricultural plots	irregular
Size of agricultural plots	1-7 ha
Type of crop	arable land with trees
Geometry	random warps
Punctual historical traces	
Linear historical traces	
Road network	primary-secondary road network
Water network	
Network of natural vegetation	rows of trees
Context	*Peri-urban area*
Compulsoriness of landscape criteria	*suggested*

Figures 3a, 3b – *Examples of agricultural landscapes: descriptive sheets. Source: Authors' elaboration*

Thus, based on the national and regional regulatory framework for the location of energy generation plants from RES, the state of the art of regional landscape planning in relation to energy and agricultural landscapes, and the scientific literature on the relationship between APV and landscape, this paper has outlined a methodological path to guide landscape planning tools in guiding:

- the location of APV through criteria for identifying unsuitable and warning areas;
- the design of APV, through morphological, dimensional, geometric and visual criteria tailored to different agricultural landscapes;
- the compulsoriness of these criteria, depending on the degree of urbanization of the context;
- the assessment of cumulative impacts.

The methodological path, tested on the Campania region, has led to outline specific Guidelines, useful to support the dissemination and application of the proposed methodology at national level. The Guidelines are addressed to different categories of end-users (regional and local administrators, landscape planners and people in charge of the authorization procedures of individual APV system) and are user-friendly, including numerous explanatory examples of the different steps of the methodology.

2. Irregularly meshed lowland arable land.	Dimensional	Morphological	Geometric	Visual relationships
LANDSCAPE ELEMENTS — *Site morphology*				APV must avoid obstructing relevant views
Shape and size of agricultural plots	APV must occupy an area ranging from 0.5 ha (minimum lot size) to 4.5 ha (average parcels' size). The area covered by the APV must have a buffer on each side equal to, at least, the largest dimension of the area occupied by the APV.	APV can fully or partially cover the agricultural parcel, preserving the recognizability of its shape.		In the first level visibility bands (500 mt), calculated from relevant viewpoints located in unsuitable or in warning areas, APVs are not allowed; in the second-level visibility bands (1200 mt), calculated from the same viewpoints, APVs are allowed on a maximum area of two hectares.
Type of crop			The warping of PV modules should be consistent with the warping of different types of crops.	The different elements of the APV system should be shielded with hedges or tree rows along the sides visible from roads, including inter-farm roads. The colors of the PV modules should harmonize with the predominant colors of the surrounding landscape.
Punctual historical traces				In case of presence of artifacts of historical-artistic-architectural value, the non-visibility, also through natural screens, of the different elements that make up the APV system for at least 100 m, from all accessible observation points, inside or outside the artifact, must be ensured.
Linear historical traces		In the presence of historical traces (e.g., Roman centuriatio), APV must ensure the legibility of these traces, respecting their geometries and proportions.		In case of presence of roads (vehicular or pedestrian) of historical significance, the non-visibility of the different elements that make up the APV system must be ensured, also through natural screens, for at least 100 m, from all accessible viewpoints, along the entire route.
Road network		In the presence of road networks (including inter-farm tracks), APV must ensure the legibility of these networks, respecting their geometries and proportions.		In case of presence of road routes of landscape significance, the non-visibility of the different elements that make up the APV system should be ensured, also through natural screens, along the entire route.
Water network		In the presence of water networks (canals, rivers, etc.), APV must ensure the legibility of these networks, respecting their geometries and proportions.		
Network of natural vegetation		In the presence of networks of natural vegetation (hedges, rows od trees, strips of spontaneous vegetation, wooded patches, etc.), APV must avoid the alteration or the loss of continuity of these elements, since these networks have a key ecological role		
CUMULATIVE IMPACTS	**1. In the second-level visibility bands (1200 mt) calculated from relevant viewpoints located in unsuitable or warning area, new are allowed up to a maximum cumulative limit of the 40% of the agricultural area visible from the viewpoint, taking into account any existing, authorized or pending permit energy production systems.** **2. In case of existing, authorized or pending permit energy production systems, new APVs must be located at a distance equal to at least twice a buffer zone established, on each side, according to the largest size of the area occupied by the APV.** **3. An adequate number of viewpoints must be identified along the routes crossing the first and second level visibility bands in order to evaluate the cumulative impact due to the simultaneous perception of the new APV with other energy generation systems located in the same area. Viewpoints must be even more numerous along elevated routes that have a wider view field**			

Figure 4 - The criteria matrix for the landscape type shown in Fig. 3a. Source: Authors' elaboration

5. Complex peri-urban mosaic and enclosed agricultural areas.	Dimensional	Morphological	Geometric	Visual relationships
LANDSCAPE ELEMENTS — *Site morphology*				
Shape and size of agricultural plots	The size of APV must be compatible with the maximum size of agricultural parcels in the area.	APV can fully or partially cover the agricultural parcel, preserving the recognizability of its shape.		
Type of crop			The warping of PV modules should be consistent with the warping of different types of crops.	Where APV affects areas characterized by low-lying crops (e.g., vegetables, flowers, etc.), the presence of its elements should be screened with hedges or tree rows along the sides visible from roads, including inter-farm roads.
Punctual historical traces				In case of presence of artifacts of historical-artistic-architectural value, the non-visibility, also through natural screens, of the different elements of the APV for at least 100 m, from all accessible observation points, inside or outside the artifact, must be ensured.
Linear historical traces		In the presence of historical traces (e.g., Roman centuriatio), APV must ensure the legibility of these traces, respecting their geometries and proportions.		In case of presence of roads (vehicular or pedestrian) of historical significance, the non-visibility of the different elements of the APV must be ensured, also through natural screens, for at least 100 m, from all accessible viewpoints, along the entire route.
Road network		In the presence of road networks (including inter-farm tracks), APV must ensure the legibility of these networks, respecting their geometries and proportions.		In case of presence of road routes of landscape significance, the non-visibility of the different elements of the APV should be ensured, also through natural screens, along the entire route.
Water network		In the presence of water networks (canals, rivers, etc.), APV must ensure the legibility of these networks, respecting their geometries and proportions.		
Network of natural vegetation		In the presence of networks of natural vegetation (hedges, rows od trees, strips of spontaneous vegetation, wooded patches, etc.), APV must avoid the alteration or the loss of continuity of these elements, since these networks have a key ecological role.		
CUMULATIVE IMPACTS	**In case of existing, authorized or pending permit energy generation systems, greenhouses and other landscape detractors, new APVs should be preferably located adjacent to such elements.**			

Figure 5 - The criteria matrix for the landscape type shown in Fig. 3b. Source: Authors' elaboration

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An Examination of the Environmental Impacts of Mega Projects on Rural Areas: A Case Study of Two Villages in the South Marmara Region of Türkiye

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Abstract
Mega projects are investments that make significant changes to land use structures and have the potential to cause major damage to the natural environment. Their impact is often discussed in relation to cities. However, they are much more fragile in rural areas. In Turkey, these projects are primarily located in the Marmara Region and encompass a series of initiatives aimed at creating a transportation corridor within the 'Golden Ring' framework and promoting the decentralisation of industry in the region.

The study will examine the rural areas of Yalova and Bursa in terms of the environmental impacts of mega projects. The reason for conducting the study in these rural areas is that the large investments are located at the intersection and focal point of these areas.

In this study, qualitative and quantitative data methods will be used in combination to concretely reveal how rural areas that are critical in economic, ecological and social terms have undergone a process of change over the last 10 years as a result of mega projects, and what effects this may have in the future.

Keywords: Mega Projects, Rural Areas, Sustainable Environment, Ecological Balance

Introduction

In recent years, increasing technological developments and innovations have brought about a rapid transformation process in both spatial and social structures. While the effects on the built environment are a subject of debate, the effects on the natural environment are much more fragile and irreversible. These effects in cities and natural areas are causing the social structure to disintegrate. Among the factors influencing this situation are mega-projects created to meet the needs of urbanisation and urban structures. In recent years, these projects have expanded beyond the boundaries of urban spaces and into rural areas. While this expansion benefits the projects, it causes damage to the natural environment. Research on this issue has generally focused on the urban scale. The ways in which rural areas are affected are explained within an urban context, and the visibility of the impact created by the projects on the natural environment is overlooked (Çalışkan, 2010; Ercan, 2020; Flyvbjerg, 2014; Flyvbjerg, Bruzelius, & Rothengatter, 2003; Keydal, 2021; Kızılay & Zorlu, 2020; Köksal & Öztürk, 2017; Özbay, 2019; Öztürk P. Ç., 2017; Sönmez, 2017).

This study aims to analyse environmental transformation in a multifaceted way by examining the environmental impacts of mega projects in the rural areas of Yalova and Bursa in Turkey's Marmara Region, together with social vulnerabilities. It aims to reveal the concrete reflections of the natural environment created by agricultural lands through land transformation analysis. Through thematic analysis, it seeks to support these analysis results and convey the social dimensions of environmental impacts in a comprehensive manner.

Results of the study. By presenting the environmental transformation process created by mega projects in rural areas in a multi-layered manner, including the social dimension of participation processes, it will serve as a guide for researchers and decision-makers.

Mega Projects and Their Environmental Impact on Rural Areas

Mega projects are projects that range from historically significant developments to large monumental structures. These projects have been followed by railways, infrastructure works and industrial developments (Söderlund, et al., 2017). Flyvbjerg (2014) defines mega projects as large-scale, complex ventures that typically cost a billion dollars or more, take years to develop and build, involve multiple public and private stakeholders, are transformative, and affect millions of people.

Mega projects are increasingly being preferred in many sectors. Examples of mega projects include railways, motorways, airports and industrial areas, among many other sectoral structures (Baysal, 2017; Flyvbjerg, 2014; Kızılay & Zorlu, 2020).

Mega projects should not be defined solely by their size, as this growth is steadily increasing. Although these formations, which were referred to as 'mega projects' in the 1970s, are now reaching giga and tera proportions, the term has remained largely unchanged (Flyvbjerg, 2014). However, the size of mega projects varies depending on the size of the areas they are located in. Both the areas covered by mega projects and their numbers are increasing (Baysal, 2017; Flyvbjerg, 2014). This quantitative growth also increases the risks involved and can have negative effects on cities in environmental, economic, social and cultural areas (Gellert& Lynch, 2003; Dündar, 2010). Projects of this scale can be large enough to change the spatial structure of cities (Aysev, 2022). For this reason, it has been emphasised that the resulting growth should be characterised as unpredictable and frenzied, and that it must be prevented (Ercan, 2020).

Regardless of geography, 90% of mega projects experience cost overruns. These cost overruns occur in both the private and public sectors. However, the benefits initially anticipated have generally turned into losses (Flyvbjerg, et al., 2003). Despite this loss, projects are increasing (Flyvbjerg, 2014). This inconsistency has been defined as a paradox by Flyvbjerg et al. (2003). It has been noted that cost overruns are sometimes considered insignificant in long-term investments, and that most monumental structures have suffered from cost overruns. However, the cost overruns of projects undertaken today are of such magnitude that they can affect the benefits and losses of all nations (Flyvbjerg, et al., 2003). For this reason, the time frame in which projects are evaluated is important (Söderlund, et al., 2017).

Despite the increase in their numbers and their growing influence in many areas, resources and management remain in the background in mega projects. In management processes, project officials tend to disregard all participation processes and leave civil society behind. In such cases, local communities and civil society organisations do not have the same say as other stakeholders. This situation leads to the public approaching projects with suspicion and certain negative developments emerging during the process (Flyvbjerg, 2014).

Mega projects are also uncertain and often do not turn out as planned, but can be used to serve various interests. This situation causes social and economic disruptions (MüllerMahn, et al., 2021). Such ruptures do not only appear in an abstract form, but also influence the shaping of the space and the city as a whole in a broader context (Robbins, 2014). When the studies are examined, it is seen that mega projects are generally emphasised for their significant impact on the shaping of urban spaces, but their impossible effects are also mentioned. In these studies, the effects on rural areas have been addressed mainly in relation to cities, and the direct changes and transformations they cause have been addressed to a limited extent (Çalışkan, 2010; Ercan, 2020; Flyvbjerg, 2014; Flyvbjerg, et al., 2003; Keydal, 2021; Kızılay & Zorlu, 2020; Köksal & Öztürk, 2017; Özbay, 2019; Öztürk, 2017; Sönmez, 2017; Tolunay, 2015;).

Mega projects located in city centres have gradually spread to rural areas due to land constraints. With the arrival of these projects in rural areas, rent formation has begun, and their attractiveness in rural areas has increased because they generate more economic profit than rural production (Özbay, 2019; Tekeli, 2014). Rural areas, which serve as the primary source of land resources, are undergoing uncontrolled urbanisation due to the expansion of cities and mega projects, resulting in the degradation and loss of rural lands (Çalışkan, 2010; Keydal, 2021; Özbay, 2019; Uysal & Albayrak, 2024).

Looking at the case studies examined, projects related to transportation and industry stand out (Arslan & Üzülmez, 2024; Debela et al., 2020; Döner, 2016; Kolukırık, 2016; Morshed et al., 2024; Mothorpe et al., 2013; Ramachandraiah, 2014; Robbins, 2014; Song et al., 2016; Uysal & Albayrak, 2024). These projects, which have a profound impact on the country and region, are generally constructed through tenders carried out by the public sector and through private sector investors. Although the public sector takes the lead in the decision-making and implementation processes related to the projects, the lobbies in the background are the biggest drivers of these projects (Robbins, 2014). At the same time, large-scale businesses in rural areas have benefited more, leaving individuals behind (Delphine et al., 2019; Ramachandraiah, 2014).

In most projects, it is known that certain external investors begin purchasing agricultural land and, in a sense, engage in land speculation at stages when the local community has no information, while planning and decision-making processes are still ongoing (Döner, 2016; Kolukırık, 2016). As the process continues, expropriations are carried out by the public sector, and compensation is paid to the local community. Typically, to prevent social opposition, efforts are made to maintain expectations that the project will create a high level of employment for the local community. However, it is argued that the employment generated by the investments will fall short of expectations once the projects are implemented. In this case, large businesses have benefited more, leaving individuals behind (Arslan & Üzülmez, 2024; Debela et al., 2020; Delphine et al., 2019; Döner, 2016; Kolukırık, 2016; Ramachandraiah, 2014; Rashid et al., 2024; Robbins, 2014; Song et al., 2016). However, while it is argued that these projects will have a significant economic impact on national and regional development, they exceed their own cost limits and place the existing system under a financial burden (Müller Mahn et al., 2021; Robbins, 2014).

With mega projects, agricultural areas have been opened up to residential areas, and the urban fabric has begun to shift towards agricultural land. With this situation, rural areas have been merged with each other and added to the borders (Debela et al., 2020; Mothorpe et al., 2013). Rural areas have been concretely affected by these projects through the loss of agricultural land and damage to natural areas. The loss of land has increased in the context of these projects (Arslan & Üzülmez, 2024; Morshed et al., 2024). The change in land affects many factors, including production quantities and types. Farmers whose income sources have changed have been unable to continue their production activities or have had to limit their activities. Farmers whose land has shrunk can only engage in irrigated or dry farming, depending on the nature of their expropriated land (Arslan & Üzülmez, 2024; Debela et al., 2020; Döner, 2016; Kolukırık, 2016; Ramachandraiah, 2014). At the same time, these projects have also damaged the natural structure and ecosystem. They have resulted in air pollution, water pollution, and noise pollution (Delphine et al., 2019; Döner, 2016; Morshed et al., 2024; Robbins, 2014; Song et al., 2016). Furthermore, it has caused the fragmentation of the landscape structure in rural areas and led to changes in land quality, resulting in the formation of new landscape patterns (Morshed et al., 2024; Song et al., 2016).

All these environmental and spatial impacts also have social and economic repercussions. Although the economic impacts of projects are sometimes seen as positive at the outset, they have led to changes in or the loss of livelihoods. In particular, the agriculture and livestock sectors have been severely affected (Debela et al., 2020; Delphine et al., 2019; Morshed et al., 2024; Mothorpe et al., 2013; Ramachandraiah, 2014; Robbins, 2014; Song et al., 2016). Socially, the sudden disruption of traditional lifestyles in rural communities, forcing them to change their ways of life and livelihoods, has increased individuals' concerns (Kolukırık, 2016)

Impacts of Mega Project Trends on Rural Areas within the Framework of the Golden Ring

When looking at the historical process of mega projects in Turkey, it can be seen that the intensity of the projects is concentrated in Istanbul (Çalışkan, 2010; Ercan, 2020; Keydal, 2021; Kızılay & Zorlu, 2020; Köksal & Öztürk, 2017; Özbay, 2019; ÖztürkP. Ç., 2017). The projects have spread from Istanbul to the Marmara region and other provinces in conjunction with the industrial sector and central government strategies in this context (Ercan, 2020; Köksal & Öztürk, 2017).

When examining Turkey's development plans for the last 20 years within the scope of mega projects, it is seen that large-scale projects began to be mentioned in the 8th Development Plan (2001-2005), with particular reference to incentives in the industrial sector. At the same time, the development of infrastructure works was also mentioned during this period ((DPT), 2000). 9. The development plan (2007-2013) includes policies related to creating a competitive environment that addresses technological developments. Improvements in other areas are also addressed. ((DTP), 2006). 10. When it comes to the development plan (2014-2018), it is seen that large-scale investments are mentioned more frequently and that projects and policies are developed in this context ((SBB), 2013). Along with this, mega projects that will have a significant regional and national impact on Istanbul have begun to emerge and their foundations have been laid in recent years. Subsequent development plans have focused on mega projects on a much larger scale than the national level. In the latest development plan, the concept of sustainability has gained greater prominence (SBB, 2019; SBB, 2023).

During and after the 10th Development Plan (2014-2018), which saw a particular concentration of mega projects, major transportation projects were carried out in the northern region of Istanbul, including the 3rd Bridge, 3rd Airport, Northern Marmara Motorway, Istanbul-Izmir Motorway, and the Osmangazi Bridge. During the

construction of the 3rd Bridge, 3rd Airport, and Northern Marmara Motorway, it was noted that the area contained dense ecological habitats, a fact that was either clearly stated in the Environmental Impact Assessment (EIA) reports or overlooked due to the inadequacy of the reports. The projects were located in the peripheral region, one of the few areas in Istanbul with rich natural structures that had not been opened up for settlement. The fact that these projects were implemented without undergoing a detailed analysis phase has created negative environmental impacts on the region (Tolunay, 2015). This process is also mentioned in the assessment of the EIA report submitted in the context of the 3rd Bridge. It is emphasised that the process will negatively affect natural areas and rural settlements in the northern region, which will come under pressure. At the same time, it is stated that the transport routes built in this context will increase this pressure. Although the EIA reports do not fully reflect the current situation, the project has disregarded the inconsistencies with these reports (Çalışkan, 2010). Due to the ecological richness of Istanbul's northern region, which extends to the Black Sea coast, it is insufficient to carry out applications and interventions solely under the name of protection. In addition to protection decisions, comprehensive plans and models are essential for this region (Altınok, 2023).

Projects in the northern region of Istanbul have spread beyond Istanbul's sphere of influence to neighbouring provinces and the Marmara Region. Projects such as the Osmangazi Bridge and the Istanbul-Izmir Motorway have been carried out within this scope. In this context, a line called the Golden Ring has been created with the aim of connecting Istanbul, Kocaeli and Bursa Metropolises with Yalova (Doğu Marmara Kalkınma Ajansı, 2012).

This line, which has also been reported in the news as the Marmara Ring (Milliyet, 2011), is 400 km long and surrounds the Marmara region. (Doğu Marmara Kalkınma Ajansı, 2012). The Golden Ring route, which begins with the 3rd Bridge and Northern Marmara Motorway project, continues with the Çanakkale Strait Bridge between Lapseki and Gelibolu, and continues with the Gulf Crossing-Istanbul-Izmir Motorway (Kural, 2014), reduces the time required to travel around the Marmara Region to 4 hours. (Doğu Marmara Kalkınma Ajansı, 2012).

It is emphasised that the Golden Ring line is important for easing Istanbul's current traffic and preventing transit traffic from outside the city from putting pressure on central traffic. However, the Istanbul-Izmir Motorway, which is part of the line, has facilitated transportation between important industrial cities (Haber, 2022; Karaca, 2019; Ünal, 2022). However, other news sources have noted that the project continues to advance destructive initiatives toward regions in northern Istanbul that include agricultural lands and other natural areas, creating irreversible environmental pressure (Kural, 2014; Sendika.Org, 2016). It is also described as a 'concrete shackle around the Marmara Region' (Kural, 2014).

The Golden Ring project in the region does not only include transportation projects; the industrial zones affected by these projects are also located in the area. It is stated that 58 new industrial zones have been established in the region in 8 years. The establishment of industrial zones along the Istanbul-Izmir Motorway route has had a particularly significant impact. This has accelerated the development of both transportation and the industrial sector in the region (Haber, 2022).

The concept of the Golden Ring is not found in literature. It is only mentioned in reports on cities' visions, etc. Although this concept is found on news websites, it has not been included in scientific articles and research, but has been discussed in the context of Istanbul's northern axis and other projects.

Materials and Methods

The study used both quantitative and qualitative research methods. Quantitative research methods included land use analysis, while qualitative research methods included thematic analysis, allowing for a multi-layered examination of the environmental impacts of mega-projects in rural areas.

Land change analysis was conducted using data from 2000 to 2025. Since CORINE land cover data for the period 2000-2018 and current data sets were not available, 2025 data were used, which were manually drawn using Google Earth. In the study conducted in Yalova (Çiftlikköy)-Kılıç village and Bursa (Karacabey)-Taşpınar village, the data were classified and analysed using the QGIS programme. The analysis results were calculated numerically and mapped. The analysis provides a concrete framework for understanding the environmental dimensions of land conversion.

Before the thematic analysis, field research was conducted in the villages identified. Semi-structured interviews were conducted with the local community during the research. In order to examine the environmental impact of mega-projects in a multi-layered manner, the study also considered the social impact dimension, with interviews conducted with 25 individuals (Table 5). The interviews were categorised into themes within the scope of the environmental, spatial, social, economic, and participatory dimensions of mega-projects. Relevant codes were created for each theme, and these codes were organised into a diagram (Figure 5).

Study Are

Kılıç and Taşpınar Villages

Kılıç Village is located in the Marmara Region of Turkey, in the Çiftlikköy district of Yalova province, while Taşpınar Village is located in the Karacabey district of Bursa province. Both villages are Muhacir settlements. Kılıç Village is located at the toll booth exit of the Izmir-Istanbul Motorway, on the border of the Yalova Machinery Specialised Industrial Zone. TEKNOSAB is located around Taşpınar Village, and the İzmir-İstanbul Motorway is located on its periphery. Kılıç Village has a population of 727 (TÜİK, 2024), while Taşpınar Village has a population of 229 (Vural, et al., 2020). The economic structure of the villages is largely based on agricultural activities.

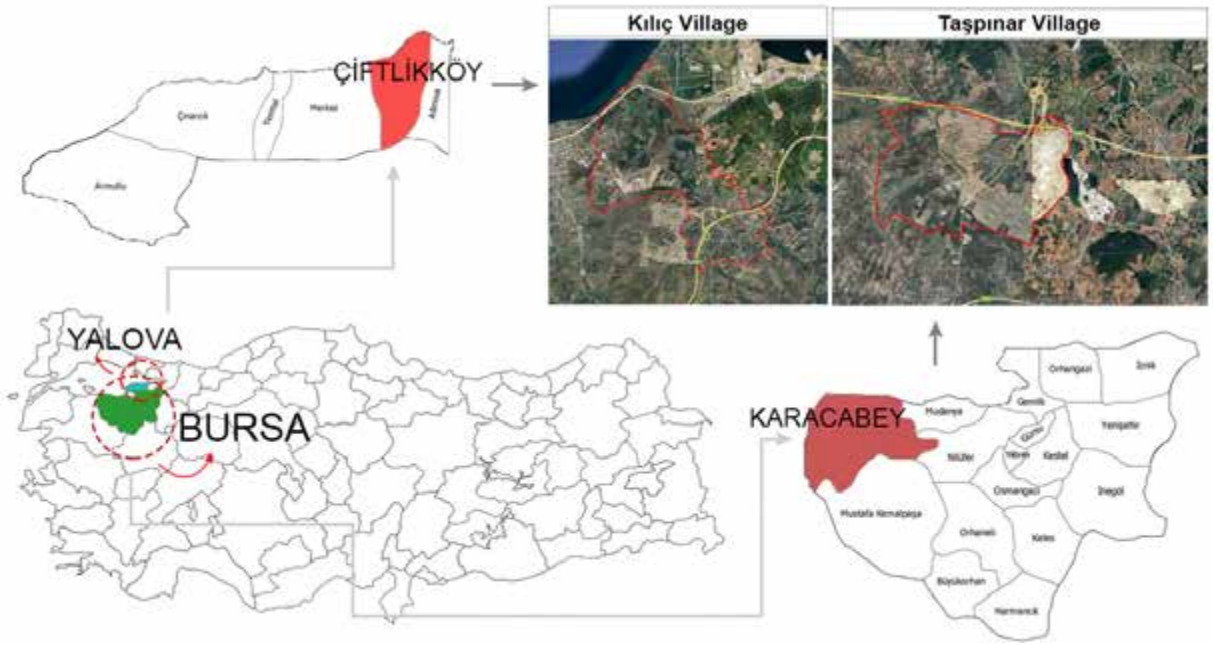

Figure 1. Study Area Location (Prepared by the author using Google Earth data)

Motorways and Industrial Areas

One of Turkey's largest transportation projects, the Izmir-Istanbul motorway, opened in 2019. The 426 km long motorway (Directorate, n.d.) passes through the villages of Kılıç and Taşpınar in the project area. The route of the highway has led to the establishment of industrial areas along its path (Ünal, 2022). The Yalova Machine Specialised Industrial Zone and TEKNOSAB area are examples of such industrial sites.

Yalova Machine Specialised Organised Industrial Zone (OSB) was established in 2017 and became operational in 2020. It was planned within the scope of the Green OSB model. The OSB, which was established on an area of 625 hectares, covers an area of 625 hectares. The settlement process has not been completed, and the occupancy rate is 20% (Çağlar, et al., 2022).

TEKNOSAB acquired legal personality in 2019, began infrastructure work in 2019, and commenced operations in 2021. The factories were constructed using a gallery reinforced concrete system, and the aim is to source a significant portion of the electricity from renewable energy sources (TEKNOSAB, n.d.).

Figure 2.Location of Mega Projects in the Field of Work (Prepared by the author using Google Earth data)

Findings

Land Cover Area Change Analysis

In this section, land change analysis was performed using CORINE land cover data for the villages of Kılıç and Taşpınar. Land use in the villages between 2000 and 2025 was calculated in hectares and percentages, and absolute and percentage changes in the area were analysed. The analysis was digitised in tables and visualised with maps.

Note: Since CORINE 2025 land cover data has not been published, data for 2025 has been manually generated based on Google Earth satellite imagery and project area data.

Table 1. Kılıç Village-Land Distribution Table by Year (Prepared by the author using CORINE data)

Code	Land Type	2000		2006		2012		2018		2025	
		ha	%	ha	%	ha	%	ha	%	ha	%
1.2.2.	Highways, Railways and Related Areas	0	0,00%	0	0,00%	0	0,00%	46,685	2,41%	46,685	2,41%
1.3.1.	Mining Areas	0	0,00%	0	0,00%	0,3004	0,02%	0,3004	0,02%	0,3004	0,02%
1.3.2.	Dumping Areas	0	0,00%	0	0,00%	0	0,00%	28,976	1,49%	28,976	1,49%
1.4.2.	Sports and Recreation Areas	65,43	3,37%	65,389	3,37%	66,651	3,44%	66,651	3,44%	66,651	3,44%

2.1.1.	Non-Irriga-ted Arable Land	527,13	27,17%	530,65	27,35%	577,06	29,74%	541,56	27,91%	541,56	27,91%
2.3.1.	Pasture Land	335,71	17,30%	241,57	12,45%	244,38	12,60%	243,1	12,53%	243,1	12,53%
2.4.2.	Mixed Agricultural Areas	367,29	18,93%	444,08	22,89%	442,17	22,79%	419,27	21,61%	419,27	21,61%
2.4.3.	Agricultural Areas with Natural Vegetation Cover	640,32	33,01%	556,48	28,68%	577,24	29,75%	561,25	28,93%	561,25	28,93%
3.2.4.	Plant Transition Areas	4,1748	0,22%	101,9	5,25%	31,997	1,65%	31,997	1,65%	31,997	1,65%
5.2.3.	Sea and Ocean	0	0,00%	0,2423	0,01%	0,5124	0,03%	0,5124	0,03%	0,5124	0,03%

Table 1 shows that agricultural areas accounted for 96.41% of the total land cover in 2000. However, agricultural areas with natural vegetation cover accounted for 33.01% of the total land cover, which was the highest land type. This was followed by non-irrigated arable land with 27.17%. In 2006, agricultural land types again accounted for the most land use at 91.37%. Marine and ocean areas accounted for a very low percentage of 0.01%. By 2012, artificial areas began to appear, and mining areas emerged as a new land use type, accounting for a very low percentage of 0.02%. In 2018, new land types emerged. Roads, railways, and related areas accounted for 2.41%, and disposal sites accounted for 1.49%. By 2025, the data from 2018 remained unchanged.

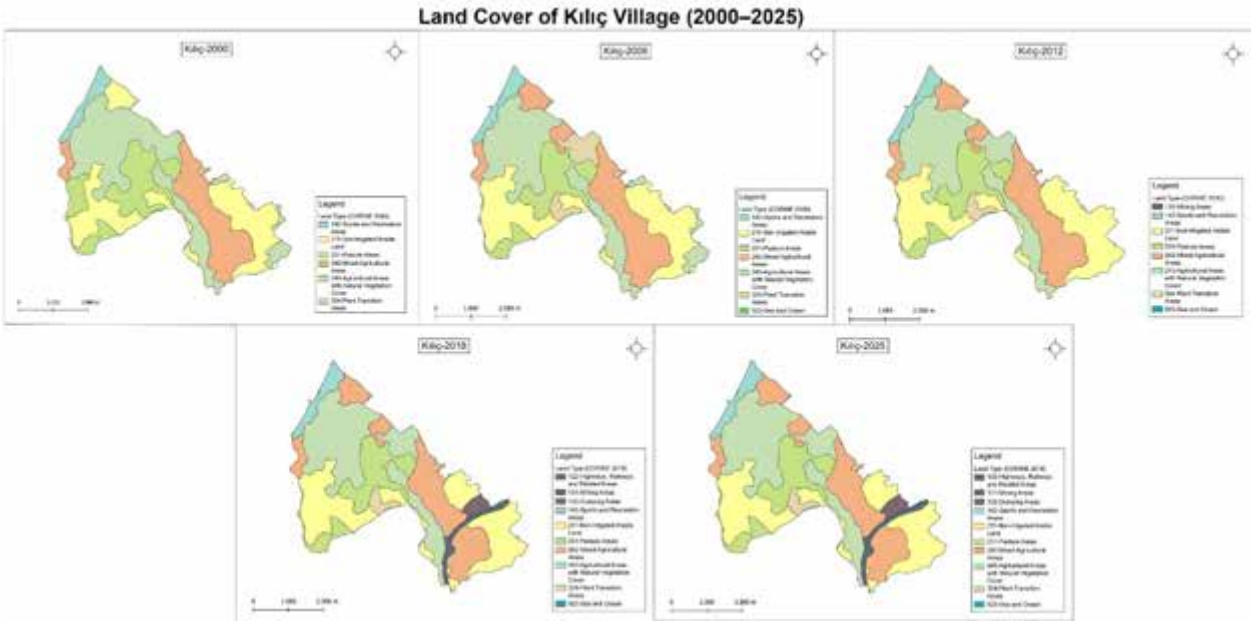

Figure 3. Kılıç Village - Land Distribution Map by Year (Created by author)

When examining the tables in Figure 1, it can be seen that agricultural areas in Kılıç village are spatially distributed over a wide area. Although artificial areas show limited growth, the general land structure of the area has not changed.

Table 2. Taşpınar Village-Land Distribution Table by Year (Prepared by the author using CORINE data)

Code	Land Type	2000		2006		2012		2018		2025	
		ha	%	ha	%	ha	%	ha	%	ha	%
1.1.2.	Discontinuous Urban Structure	47,403	2,51%	28,938	1,53%	28,937	1,53%	28,937	1,53%	28,937	1,53%
1.2.1.	Industrial and Commercial Units	0	0,00%	0,6599	0,03%	0,027	0,00%	0,027	0,00%	790,64	41,85%
2.1.1.	Non-Irrigated Arable Land	1649,4	87,31%	1686,3	89,26%	1687,5	89,32%	1687,5	89,32%	950,52	50,32%
2.3.1.	Pasture Land	190,78	10,10%	146,4	7,75%	146,04	7,73%	146,04	7,73%	94,231	4,99%
2.4.2.	Mixed Agricultural Land	0	0,00%	0,7763	0,04%	0,7665	0,04%	0,7665	0,04%	0,7665	0,04%
2.4.3.	Agricultural Land with Natural Vegetation Cover	1,5393	0,08%	0	0,00%	0	0,00%	0	0,00%	0	0,00%
3.2.4.	Plant Transition Areas	0	0,00%	26,042	1,38%	25,678	1,36%	25,678	1,36%	23,799	1,26%
5.1.2.	Water Bodies	0	0,00%	0	0,00%	0,2248	0,01%	0,2248	0,01%	0,2248	0,01%

Looking at Table 2, agricultural land accounts for 97.49% of the land use in Taşpınar village. The land type with the highest value is non-irrigated arable land, accounting for 87.31%. However, the settlement type included in artificial areas covers 2.51% of the land. In 2006, the land type with the highest land density was again non-irrigated arable land, accounting for 89.26%. At the same time, new land formations were observed. Industrial and commercial units accounted for a very low percentage of 0.03%, while plant change areas (scrub/semi-scrub, transition areas) accounted for 1.38% of new formations. Settlement areas covered 1.53% of the land. In 2012, the land structure remained similar. New formations were observed at a very low rate of 0.01%. In 2018, the land structure remained unchanged. By 2025, non-irrigated arable land will cover 50.32% of the area, while industrial and commercial units will cover 41.85% of the area. The ratios for other land types have remained largely unchanged.

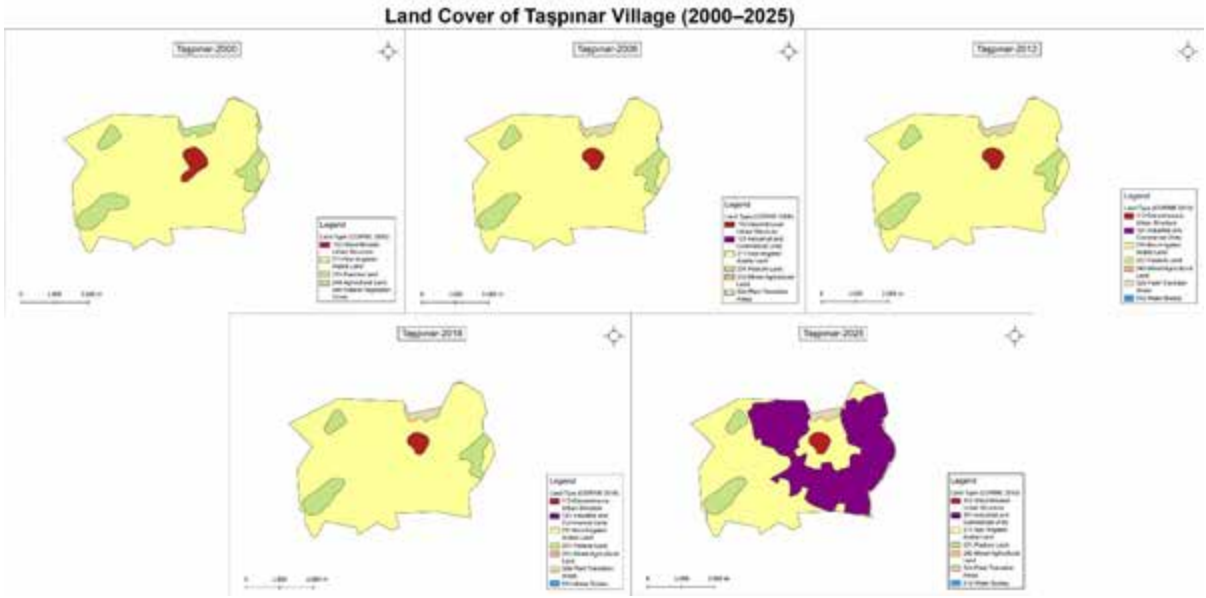

Figure 4. Taşpınar Village - Land Distribution Map by Year (Created by author)

When examining the tables in Figure 2, it can be seen that agricultural areas in Taşpınar village are spatially distributed over a wide area. However, newly formed areas have affected land use distribution. Industrial and commercial units have increased significantly and have come close to the proportion of non-irrigated arable land.

Table 3. Kılıç Village - Land Cover Change Table by Year (Prepared by the author using CORINE data)

Code	Land Type	2000–2006		2006–2012		2012–2018		2018–2025		2000–2025	
		Δha	%	Δha	%	Δha	%	Δha	%	Δha	%
1.2.2.	Highways, Railways and Related Areas	0	0,00%	0	0,00%	46,685	Newly occurred	0	0,00%	46,685	Newly occurred
1.3.1.	Mining Areas	0	0,00%	0,3004	Newly occurred	0	0,00%	0	0,00%	0,3004	Newly occurred
1.3.2.	Dumping Areas	0	0,00%	0	0,00%	28,976	Newly occurred	0	0,00%	28,976	Newly occurred
1.4.2.	Sports and Recreation Areas	-0,041	-0,06%	1,2626	1,93%	0	0,00%	0	0,00%	1,2214	1,87%
2.1.1.	Non-Irrigated Arable Land	3,519	0,67%	46,415	8,75%	-35,5	-6,15%	0	0,00%	14,434	2,74%
2.3.1.	Pasture Land	-94,14	-28,04%	2,8119	1,16%	-1,2836	-0,53%	0	0,00%	-92,61	-27,59%
2.4.2.	Mixed Agricultural Areas	76,788	20,91%	-1,915	-0,43%	-22,893	-5,18%	0	0,00%	51,981	14,15%
2.4.3.	Agricultural Areas with Natural Vegetation Cover	-83,84	-13,09%	20,755	3,73%	-15,984	-2,77%	0	0,00%	-79,07	-12,35%
3.2.4.	Plant Transition Areas	97,722	2340,76%	-69,9	-68,60%	0	0,00%	0	0,00%	27,822	666,43%
5.2.3.	Sea and Ocean	0,2423	Newly occurred	0,27	111,41%	0	0,00%	0	0,00%	0,5124	Newly occurred

Looking at the analysis results for Kılıç village, the greatest decrease in land types between 2000 and 2006 was observed in pasture areas, with a rate of 28.04%. The highest increase in land area was observed in plant change areas, with a very high rate of 2340.76%. Marine and ocean areas showed new formations. Between 2006 and 2012, mining areas showed new formations. While an overall increase was observed in agricultural areas, the mixed

agricultural land type decreased by 0.43%. At the same time, a significant decline occurred in plant change areas, with a decrease of 68.60%. The boundaries of sea and ocean areas within land boundaries expanded, showing an increase of 111.41%. Between 2012 and 2018, a decrease of 14.62% was observed across all agricultural areas. Meanwhile, 46,685 hectares of roads, railways, and related areas, and 28,976 hectares of disposal sites have emerged as new formations. Changes between 2018 and 2025 have remained constant.

Looking at the changes between 2000 and 2025 in general, new land formations are noteworthy. Here, roads, railways and related areas, mining sites and disposal sites, which have formed in a different way from the natural structure, have developed by changing the quality of agricultural land. At the same time, a decrease of 27.59% in pasture areas and 12.35% in agricultural areas with natural vegetation cover is noteworthy. Additionally, a significant increase of 666.43% has been observed in areas with vegetation changes.

Table 4. Taşpınar Village - Land Cover Change Table by Year (Prepared by the author using CORINE data)

Code	Land Type	2000–2006		2006–2012		2012–2018		2018–2025		2000–2025	
		Δha	%	Δha	%	Δha	%	Δha	%	Δha	%
1.1.2.	Discontinuous Urban Structure	-18,466	-38,95%	-0,0002	0,00%	0	0	0	0,00%	-18,47	-38,95%
1.2.1.	Industrial and Commercial Units	0,6599	Newly occurred	-0,6329	-95,91%	0	0	790,62	2929845,03%	790,64	Newly occurred
2.1.1.	Non-Irrigated Arable Land	36,915	2,24%	1,1412	0,07%	0	0	-736,93	-43,67%	-698,9	-42,37%
2.3.1.	Pasture Land	-44,389	-23,27%	-0,3585	-0,24%	0	0	-51,806	-35,47%	-96,55	-50,61%
2.4.2.	Mixed Agricultural Land	0,7763	Newly occurred	-0,0098	-1,26%	0	0	0	0,00%	0,7665	Newly occurred
2.4.3.	Agricultural Land with Natural Vegetation Cover	-1,5393	-100,00%	0	0,00%	0	0	0	0,00%	-1,539	-100,00%
3.2.4.	Plant Transition Areas	26,042	Newly occurred	-0,3646	-1,40%	0	0	-1,879	-7,32%	23,799	Newly occurred
5.1.2.	Water Bodies	0	0,00%	0,2248	Newly occurred	0	0	0	0,00%	0,2248	Newly occurred

Looking at the analysis results for Taşpınar village, the greatest decrease between 2000 and 2006 was in settlement areas, at a rate of 38.95%. This was followed by a 23.27% decrease in pasture areas. However, there was a 100% increase in agricultural areas with natural vegetation cover, and industrial and commercial units, mixed agricultural areas, and plant change areas showed new formations. Between 2006 and 2012, there was a slight decrease in agricultural and natural areas. However, there was a 95.91% decrease in industrial and commercial units. At the same time, water bodies showed new formations. The values between 2012 and 2018 remained constant. Between 2018 and 2025, a decrease of 86.46% was observed in agricultural areas and natural areas combined. However, there was a very high increase of 2929845.03% in industrial and commercial units.

Looking at the changes between 2000 and 2025 in general, new areas of development are noteworthy. Here, industrial and commercial units that have formed in a manner distinct from the natural structure have developed by altering the nature of agricultural land. At the same time, a decrease of -192.98% in the total agricultural area is noteworthy. Additionally, there has been a 38.85% decrease in residential areas, and water bodies have shown new formations.

Participant Profile

The participant profile is provided in Table 5. In the study, interviews were conducted with 11 people from Kılıç village and 14 people from Taşpınar village. The interviews addressed demographic variables such as gender, age, and occupation of the participants. While most of the interviews were conducted as in-depth interviews, some participants showed limited participation. Additionally, information provided by a village headman from a neighbouring village outside the study area was used in the study but was not included in the participant table.

Table 5. Demographic Distribution of Participants Interviewed in Kılıç and Taşpınar Villages (Created by author)

Code	Gender	Age Range	Occupation	Place of Residence	Type of Participation
P1	Male	30–40	Farmer (business owner)	Kılıç Village	Individual
P2	Female	70–80	Housewife (former village head)	Kılıç Village	Individual
P3	Female	40–50	Housewife	Kılıç Village	Individual – limited participation (general conversation)
P4	Male	40–50	Farmer (estimated)	Kılıç Village	Individual – limited participation (general conversation)
P5	Male	20–30	Farmer	Kılıç Village	Group interview
P6	Male	20–30	Farmer	Kılıç Village	Group interview
P7	Male	70–80	Retired farmer	Kılıç Village	Group interview
P8	Male	70–80	Retired farmer	Kılıç Village	Group interview
P9	Male	40–50	Village head	Kılıç Village	Group interview
P10	Male	60–70	Retired teacher	Kılıç Village	Group interview
P11	Male	60–70	Retired	Kılıç Village	Group interview
P12	Male	60–70	Retired farmer	Kılıç Village	Group interview
P13	Male	70-80	Retired farmer	Taşpınar Village	Group interview
P14	Male	60-70	Retired/Village headman	Taşpınar Village	Group interview
P15	Male	60-70	Retired/Private sector	Taşpınar Village	Group interview
P16	Male	50-60	Village headman	Taşpınar Village	Individual
P17	Male	10-20 (Age 19)	Student	Taşpınar Village	Group interview
P18	Male	50-60	Retired farmer	Taşpınar Village	Individual
P19	Male	70-80	Retired farmer	Taşpınar Village	Group interview
P20	Male	70-80	Retired/Private sector	Taşpınar Village	Individual
P21	Male	70-80	Retired farmer	Taşpınar Village	Group interview
P22	Male	30-40	Retired/Private sector	Taşpınar Village	Group interview
P23	Male	60-70	Retired farmer	Taşpınar Village	Individual (general discussion)
P24	Male	60-70	Retired farmer	Taşpınar Village	Individual
P25	Female	60-70	Retired/Private sector	Taşpınar Village	Individual – limited participation

Thematic Analysis Findings

In this section, a thematic analysis was conducted using data obtained from field research conducted in the villages of Kılıç and Taşpınar. As a result of the analysis, main themes were identified and supporting themes were created (Figure 5). The central themes, 'Loss of Natural Areas and Environmental Degradation' and 'Changes in Land Use,' form the basis of the environmental impacts of mega-projects. The conversion of agricultural and pasture lands into projects has led to multifaceted degradation in rural areas.

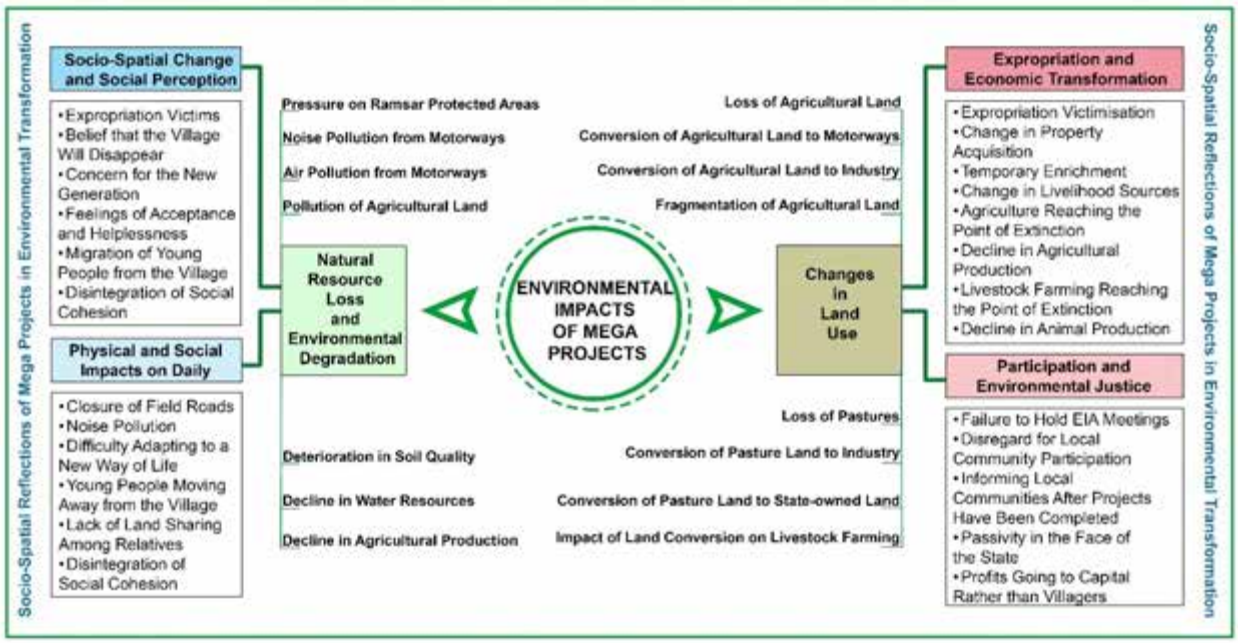

Figure 5 Themes and Related Codes Obtained Within the Scope of the Analysis (Created by author)

The themes on the periphery of the diagram reflect the environmental dimension of the transformation. The expropriation of agricultural and pasture lands has led to a change in their nature. At the same time, the inadequacy of EIA processes has led to environmental justice issues, and the lack of sufficient information provided to the public has left the participation process in the background. Furthermore, this has led to the emergence of effects such as the deterioration of rural community structures, migration, and a decline in production.

Theme 1: Natural Resource Loss and Environmental Degradation

The first theme that stands out in the study covers environmental degradation caused by the loss of natural resources. In particular, the conversion of agricultural and pasture lands into infrastructure projects such as industry and roads has increased environmental pressure.

Upon examining the codes, it was found that agricultural lands in the border region of the Ramsar protected area were expropriated for TEKNOSAB in Taşpınar village. The public believes that the remaining Ramsar areas will also be incorporated into industry through certain legislation and practices. One participant described the situation as follows:

"It didn't enter Ramsar, for example, the field was 10 acres, 5 acres were left for Ramsar. But it left the exact border. Now what will happen to these areas? Dry storage, water storage... Slowly, Ramsar will disappear." (P16)

Traffic caused by vehicles has reached an annoying level in both villages. Several people have stated that there is too much traffic and noise. Air pollution has also begun to be observed in Kılıç village due to the motorway. One user described the situation as follows: 'There is fog over the village in the mornings' (P1). This situation is also confirmed by the village headman of the neighbouring village:

'There is pollution from the motorway. Students from Istanbul came and took measurements, and it turned out to be polluted.' (Village Head)

Industrial waste has been dumped on olive groves in the village of Taşpınar. One participant described the situation as follows:

"The guy took the filth, there are olive groves here, and dumped it there. The factory said, 'Take it away, get rid of it.' So he did what he was told and dumped a truckload of filth on the olive groves." (P24)

The local population states that the agricultural land is very fertile, but that the quality of the agricultural land has been downgraded and expropriated for projects. One participant expressed this situation as follows:

'Whenever it suited them, they came and said, "agricultural land, barren land"; they took over our land.' (P15)

They also mention that water sources affecting agricultural land in Kılıç village have dried up. One group of participants stated:

"The land was expropriated, and our water disappeared. We had artesian water." (P10)

It has been noted that agricultural production has declined due to factors such as the loss of agricultural land, fragmentation of land, and water shortages.

Theme 2: Changes in Land Use
Another prominent theme in the study concerns changes in land use associated with the transformation of agricultural and pasture lands. The nature of the land has changed with the transformation of expropriated areas in the context of projects.

When the codes are examined, it is stated that a large part of the agricultural and pasture lands in both villages have been lost. It is stated that there is no land left in either village. In Kılıç village, the situation has been expressed many times as 'agricultural and wetland areas are gone' (P1, P2, P7). In Taşpınar village, it has been stated with expressions such as 'Our village had 30,000 acres of land; 3,000 acres of it was pasture. They took the pastures without paying' (P24) and 'The pasture business is over' (P23). Furthermore, with the conversion of pasture areas, there are no longer any areas available for livestock farming. Additionally, the nature of agricultural and pasture areas has been altered, with the highway in Kılıç village and the majority of the land in Taşpınar village being converted into TEKNOSAB. At the same time, agricultural lands have been fragmented, leading to the loss of their functionality and subsequent conversion. One participant described the situation as follows:

"Since half of the land is outside the border, the remaining agricultural land has become unusable. Instead of fertile land, the rightful owners were given infertile land on the edge of cliffs. Access to these areas is also impossible." (P5)

Theme 3-4: Socio-Spatial Change and Social Perception & Physical and Social Effects in Daily Life
These themes, which are both indicative of environmental impacts and supportive in nature, reflect not only the physical dimension of the transformation but also its social aspect and the perceptions of the local population. They also encompass the effects on the daily lives of local residents.

Upon examining the codes, it was revealed that agricultural and pasture lands in both villages were expropriated by force, leaving the local population feeling powerless. Participants expressed this situation with statements such as: "They seized our property here!" (P21), and "You cannot go against the state." (P2). Other reactions followed a similar pattern.

Due to the impact of mega projects, young people have migrated, and their ties with the village have weakened. One participant expressed this situation as follows:

There are no young people left. What would they even do here? There's no animal husbandry, farming is finished. A man is already 40 or 50 years old—what job could he possibly find? Even if he gets into a factory, what difference does it make? Everyone's life has been turned upside down." (P23)

In both villages, feelings of concern and hopelessness about the future are prevalent. Participants expressed this sentiment as follows:

"In the future, we'll be strangers in our own village—there's no land left. Every piece of land has been sold, and now outsiders hold power. Our land is gone, only the village centre remains. The water is gone—it's over." (P7)
As a result of the projects, particularly in Taşpınar village, there is a strong belief that the village will undergo complete transformation in the future. One participant stated, "If they open it for development, the village will be no more!"

With the introduction of these projects, especially in Taşpınar, some individuals have begun living in urban centres and only travelling to the village occasionally. This has led to a decline in social relations. One participant articulated the situation as follows:

"We used to have peace and comfort here. My own house... Look, my uncle is here, my maternal uncle is here. Now, when I sit in the café and look around—who's next to me? None of them." (P16)

The sale of land has also caused rifts within families. One participant described the situation as follows:

"My brother says, 'Brother, divide the fields with stone markers; divide them while our father is still alive...'" (P16)

Noise pollution is another disturbing factor, frequently mentioned in both villages. Participants voiced similar complaints, such as: "Traffic and noise have affected us greatly; now they're constant." (P9)

They also reported difficulties in accessing existing agricultural lands and pastures due to the projects implemented in the area.

Theme 5-6: Expropriation and Economic Transformation & Participation and Environmental Justice
Two additional themes reflecting the environmental impact, while also encompassing the social dimension, relate to economic transformation and the effects of participation processes.

An analysis of the codes reveals that in both villages, the expropriation of agricultural lands is frequently mentioned. As a result of these expropriations, the local population argues that their lands were sold below market value. They express that the lands acquired from them at low prices are now significantly more valuable. Participants note that the financial benefits of the land sales were granted to investors rather than the locals, and they also stated that there was nothing they could do about this situation. Participants expressed their frustration as follows:

"Most people's lands were sold at very low prices; those who didn't sell were forced to do so by the state. There was no other option. Our best lands were taken for nothing." (P7)

"What would happen if we objected? We are up against the state; everyone is intimidated." (P9, P10)
"The municipality is on their side anyway; whether you want it or not, they take it." (P15)

Due to land expropriation, a significant portion of the local population stated that they could no longer engage in agriculture or animal husbandry. Consequently, a sharp decline in production was reported. Participants described this situation as follows:

"They destroyed agriculture; dry and irrigated farming is over." (P9)

"They took the lands; farming declined, animal husbandry declined." (P13)

"It wiped out the young population, livestock farming, and agriculture." (P16)

"There used to be cattle in our village; now there's none left." (P25)

"Farming was affected by 90%. There's no farming anymore; there are no fields left." (P24)

It was stated in both villages that there was little to no prior information given before the projects began, and that they only became aware after the decisions had already been made. Moreover, Environmental Impact Assessment (EIA) meetings were held without properly informing the public, with only a few individuals being notified. Participants voiced their dissatisfaction with the participation process as follows:

"An EIA meeting was held, but it took place far from our village. In a way, people were deceived." (P9)

"No proper EIA meeting took place. A few people gathered at dawn; they handed out a couple of bagels and left." (P15)

On the other hand, the village headman (muhtar) of Kılıç village at the time of the projects claimed that the public was informed but chose not to participate in the meetings. The headman's statement is as follows:

"I was an expert witness in all of them. Everything was done; nothing happened without consulting the public. Why didn't anyone object? The industrial zone wasn't up to us; it wasn't even our land. It was built in an area with farms and private property. Still, no one asked us anything." (P2)

Finally, the sale of land brought temporary wealth to many individuals, enabling them to purchase homes, cars, and other assets. Particularly in Taşpınar, those who did not oppose the projects stated that farming no longer provided sufficient income, which is why they didn't resist much. Participants described this situation as follows: "The village became rich; everyone got a car after the expropriation." (P2)

"What did I do? I bought three houses and a car. Now we're struggling in the city, trying to survive. I used to be a respected man here; now I drive a taxi, trying to make ends meet." (P16)

"When the land was sold by presidential decree, everyone got their money — from Bursa, from Karacabey... Some bought taxis, others minibuses, some bought houses. The money is gone, and so is the land." (P24)

"Villagers were struggling to make ends meet; people were borrowing from their future. If you had a wedding or bought a tractor, you were already in debt for the next three years. When TEKNOSAB arrived, we all rushed to sell — just to get the money quickly. Everyone had kids renting in Bursa, weddings to pay for, already in debt. We all waited in line at the Provincial Directorate in Bursa for our payments." (P20)

Conclusion and Discussion

The findings of the study yielded results in two distinct analytical contexts. Firstly, looking at the results of the land use change analysis, it was found that agricultural areas constitute the majority of the land cover. When examining the changes over time, the motorway in Kılıç village emerged as a significant factor, passing along the edge of the settlement area and resulting in the loss of priority agricultural lands for the local population. Additionally, due to the village's proximity to the industrial zone, newly constructed industrial areas have also affected the agricultural lands.

Beyond this, the emergence of these artificial zones has caused environmental degradation by disrupting areas where agricultural and natural landscapes coexisted in a mixed form. In Taşpınar village, the recently constructed TEKNOSAB in particular has led to the loss of a substantial portion of the village's agricultural land. Together with the newly built motorway, it has also encircled the settlement area.

This transformation has led to significant destruction of the natural environment and has altered the environmental structure of the rural landscape. The analysis has clearly demonstrated the environmental transformation occurring in rural areas.

Alongside the land use analysis, thematic analysis has concretely revealed social, economic, and participatory dimensions in an inclusive manner. Upon examining the results obtained, the environmental and land transformations corroborate the findings of the land use change analysis. The indigenous population, who were actively engaged in production, have lost both their livelihoods and the natural environment in which they lived. However, unlike the land use change analysis, Kılıç village experienced less land loss relative to its existing land assets. Consequently, it was observed to be less affected than Taşpınar village. Furthermore, the village's more developed infrastructure has diminished the economic visibility of individual grievances. Nevertheless, the loss of fertile lands used for irrigated agriculture and water sources has led to the disappearance of some of the village's prominent characteristics.

In Taşpınar village, a substantial portion of the land has been expropriated for industrial purposes, causing a significant rupture in the community. The local population became aware of this situation rather late. Due to financial difficulties, they reluctantly accepted the situation, considering its economic dimension. However, the loss of their lands has led to various challenges in maintaining rural livelihoods. Lacking their own land, they have continued farming activities by renting fields, yet this constraint has resulted in competition among the locals. Additionally, in both villages, it was expressed that information dissemination was limited and that the views of the local people were largely ignored. The indigenous population frequently emphasised their lack of power to oppose decisions taken by the state.

From an environmental justice perspective, Taşpınar village, a rural settlement, has been encircled and constrained by an industrial zone of massive scale even by urban standards, without an adequate buffer zone, and bordered by a motorway. This has caused significant hardship for both the natural habitat and the local population. Similarly, although not within the boundaries of Kılıç village, the industrial zone at the edge of the settlement and the motorway crossing over the most fertile agricultural lands exert pressure on the natural environment and the lifestyles of the local inhabitants.

In both rural areas, environmental pressures arising from projects of a scale far beyond the local context and the social ruptures they have caused are clearly observed. Rural areas are not merely instruments for urban profiteering; they constitute the foundational pillars of sustainable development centred on production and host a diverse array of living beings within their complex, multilayered landscapes.

Accordingly, policies to be developed must carefully consider this fragile structure, incorporating the living organisms within it into the process, which is of critical importance.

By employing a multifaceted analytical approach, this study offers a holistic assessment that spatially and socially reflects the complex environmental degradations occurring in rural areas. Among the limitations of the study are the unavailability of up-to-date data, which introduces a margin of error—albeit not excessively large—in measurements and analyses. Future research conducted over broader temporal scales and with wider perspectives will enhance the significance of such studies.

In conclusion, mega projects primarily cause environmental degradation in rural areas. Although the destructive impacts of this environmental deterioration may not become immediately apparent in tangible terms, their reflections on social life are clearly evident.

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Deep Learning-Based Commercial Building Energy Consumption Prediction Model Considering Occupant Density Using Mobile Network Big Data: A Case Study of Seoul

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Abstract
This study proposes a multidimensional modelling framework to estimate annual energy consumption in commercial buildings across Seoul by integrating physical, environmental, economic, and behavioural variables. While previous research has predominantly focused on structural and environmental factors, this study addresses a critical gap by incorporating high-resolution spatial data and temporally disaggregated floating population variables derived from mobile network data, segmented into three time periods: late night, daytime, and evening. This enables a more refined representation of occupant dynamics in dense urban settings. Separate regression models for annual electricity and gas/heating consumption per unit floor area provide a contextual and scalable analytical approach. In the next phase of the research, a non-linear modelling technique based on a Multi-Layer Perceptron (MLP) will be implemented, along with SHAP (SHapley Additive exPlanations) analysis to enhance model interpretability. These advanced methods aim to capture complex interdependencies among variables and improve predictive performance. Ultimately, the proposed framework offers a robust foundation for data-driven energy policies and smart urban planning strategies in high-density metropolitan areas.

Keywords: Energy Consumption; Occupant Density; Commercial Buildings; Deep Learning; Prediction Model

1. Introduction

The building sector accounts for approximately one-third of global final energy consumption, making it a vital domain for achieving energy efficiency and climate resilience (IEA, 2022). Among various building types, commercial buildings located in dense urban areas represent key targets for sustainability interventions due to their high energy intensity and operational complexity. In highly urbanised contexts such as Seoul, energy consumption at the building level is shaped not only by structural and environmental characteristics but also by spatiotemporal variations in occupant density, especially in areas with high human mobility.

Traditional models of building energy consumption have typically emphasised physical variables such as gross floor area (GFA), building age, and structural type. While such models provide a basic analytical framework, they often fail to account for the behavioural dimension of energy use, particularly in cities where occupancy patterns fluctuate throughout the day. A comprehensive understanding of urban energy demand therefore requires a multidimensional modelling approach that incorporates physical, environmental, economic, and behavioural factors.

Recent advancements in spatial data infrastructure and mobile sensing technologies have made it feasible to integrate time-segmented floating population data into energy consumption models. Unlike static population indicators, these data capture dynamic occupant presence across three key time zones—late night (00:00–06:00), daytime (06:00–18:00), and night-time (18:00–24:00)—enabling more nuanced insights into the behavioural drivers of energy demand in commercial buildings.

In response to these developments, this study proposes a multidimensional analytical framework to estimate the annual electricity and gas/heating consumption of commercial buildings in Seoul. The model integrates four categories of explanatory variables: physical (e.g., GFA, building age, structural type), environmental (e.g., green space ratio, average temperature), economical (e.g., land price), and behavioural (e.g., floating population by time zone). The analysis begins with a set of multiple linear regression models to assess the explanatory power of each variable group, using energy consumption per unit of gross floor area as the dependent variable. In subsequent phases of the research, deep learning methods—Multi-Layer Perceptron (MLP) models—along with SHAP (SHapley Additive exPlanations) values will be applied to enhance prediction accuracy and interpretability.

Through the integration of high-resolution spatial datasets and advanced modelling techniques, this study aims to contribute both theoretically and practically to the understanding of urban energy demand.

The findings are expected to inform data-driven strategies in building energy management, policy development, and sustainable urban planning.

2. Literature Review

Building energy consumption has been widely studied across four major dimensions: physical attributes, socio-economic context, behavioural dynamics, and environmental factors.

Physical characteristics such as building age, structural system, and gross floor area (GFA) are frequently cited as key determinants of energy use. Empirical research indicates that newer buildings typically consume less energy due to improved insulation, efficient systems, and stricter building codes (An et al., 2014). Structural systems also significantly influence energy performance; for instance, reinforced concrete buildings tend to be more energy-efficient than masonry structures due to higher thermal mass and better envelope integrity (Kim, 2013). While GFA is often used as a proxy for operational scale, especially in commercial facilities, its explanatory power improves when paired with use type and occupancy characteristics that influence internal loads and activity schedules (Zhang et al., 2020).

Socioeconomic indicators help capture spatial and behavioural heterogeneity in urban energy consumption. Factors such as income level, land value, and population density have been used as proxies for energy service demand and urban activity intensity. In the Korean context, where income data is often limited at the building level, official land price has emerged as a practical proxy for economic intensity and urban development pressure (Kim et al., 2017; Shi et al., 2021). These variables provide important context for interpreting energy patterns within the built environment.

A growing body of research emphasises the importance of human activity and occupant dynamics. Traditional models often rely on static or assumed schedules, failing to capture the actual spatial and temporal variability in occupancy. To address this gap, recent studies have introduced floating population data derived from mobile communication networks as a spatially disaggregated and temporally sensitive measure of real-time human presence (Kim and Park, 2021; Chen et al., 2022). Such data is especially useful in commercial zones, where occupancy patterns fluctuate markedly across different times of day. Segmenting this data into discrete time periods—such as late night, daytime, and night-time—offers a more accurate behavioural input for urban energy models.

Environmental conditions also remain central to understanding energy demand. Temperature extremes significantly affect electricity and gas/heating consumption by increasing cooling and heating loads (Li et al., 2018; Jo et al., 2022). Furthermore, environmental features such as vegetation, green spaces, and water bodies can mitigate urban heat through shading and evapotranspiration, contributing to lower cooling energy needs, especially during summer months (Ewing and Rong, 2008; Ko, 2013).

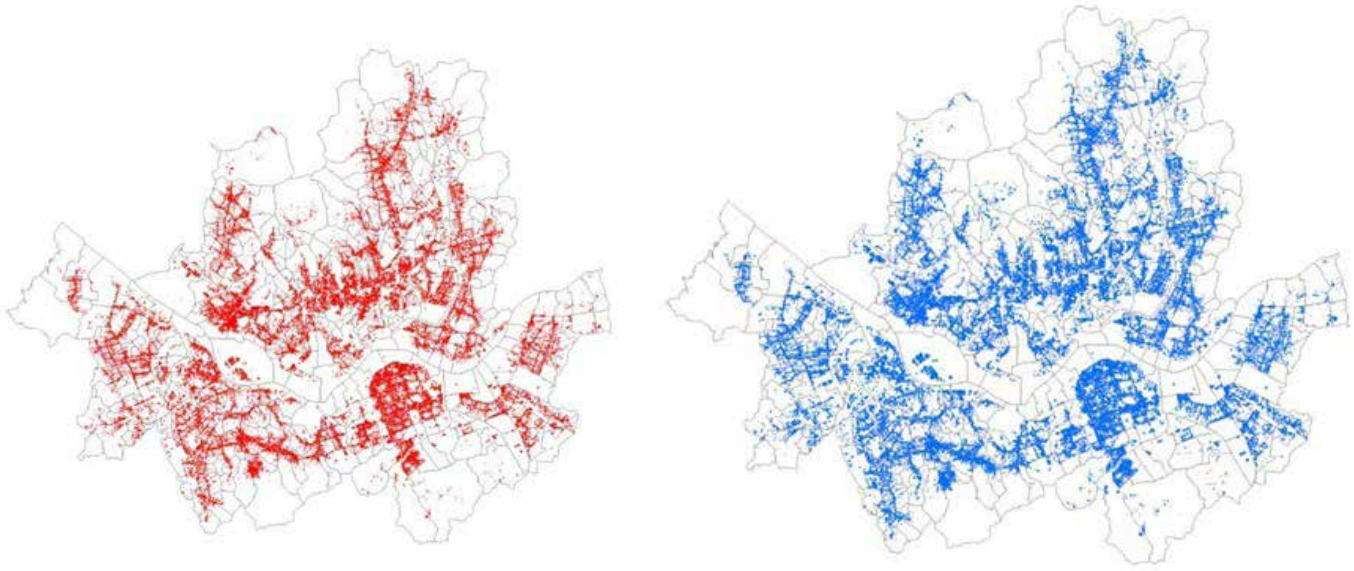
Despite these advances, many previous studies rely on aggregated spatial units—such as neighbourhoods or districts—which may mask variability at the building level. Moreover, the lack of high-resolution behavioural and environmental data has limited the explanatory power of many models. This study addresses these limitations by utilising a building-level dataset that integrates physical, environmental, economic, and behavioural indicators for commercial buildings in Seoul. Specifically, it incorporates mobile-based floating population data segmented by time of day to better reflect occupancy-driven variation in energy consumption. By doing so, the study aims to bridge the gap between temporal human activity and granular urban energy modelling, providing a more realistic and actionable framework for analysis.

3. Research Subject and Data

This study focuses on Seoul, the capital of South Korea, as the spatial and analytical unit for investigating commercial building energy consumption. As a highly urbanised and technologically advanced metropolis, Seoul is characterised by dense population clusters, a compact and heterogeneous building stock, and the availability of rich, high-resolution spatial datasets. These features make the city a particularly suitable case for building-level energy consumption analysis. The scope of the study is limited to commercial buildings, specifically those categorised as first- and second-class neighbourhood living facilities and office buildings. These building types were selected due to their wide spatial distribution, extended operating hours, and relatively high user intensity

throughout the urban landscape. The spatial distribution of valid energy data for electricity (a) and gas/heating (b) consumption is presented in Figure 1a and Figure 1b, respectively.

The study utilises two dependent variables to represent energy intensity: electricity consumption intensity and gas/heating consumption intensity, both based on data from the year 2023. These are defined as the natural logarithm of the total annual energy consumption (electricity or gas/heating) divided by the natural logarithm of the gross floor area (GFA), allowing for size-normalised comparisons across buildings. After data cleaning and preprocessing, the final sample consists of 88,293 buildings for electricity consumption and 67,918 for gas/heating consumption.



1a. 1b.

Figure 1a and Figure 1b: Spatial distribution of electricity (a) and gas/heating (b) consumption

To comprehensively reflect the determinants of urban energy demand, the independent variables are categorised into four analytical dimensions: physical, environmental, economic, and behavioural. Physical variables include the gross floor area, building age, structural type (classified as reinforced concrete, brick, or other), and usage function (office, first-class neighbourhood facility, or second-class neighbourhood facility). Environmental characteristics are measured through average annual temperature and the green area ratio within a 50-metre buffer around each building, derived from NDVI satellite imagery. Economic factors are represented by officially registered land price values, which act as proxies for development intensity and land-based economic value. Behavioural characteristics are captured through mobile network-based floating population data, segmented by three time periods—late night (00:00–06:00), daytime (06:00–18:00), and night-time (18:00–24:00)—as well as an overall daily average.

All variables used in this study were obtained from official government sources or authorised public data platforms. Annual energy consumption data were provided by the Ministry of Land, Infrastructure and Transport (MOLIT), while building characteristics were derived from the national spatial data platform V-World. Environmental indicators were sourced from the Seoul Metropolitan Government's S-DoT sensor network and Sentinel-2 satellite imagery. Official land price data were retrieved from the national land valuation registry, and floating population data were obtained from mobile network big data repositories. A summary of all variables, including definitions, measurement units, types, and data sources, is presented in Table 1. Because the study models electricity and gas/heating consumption separately, all statistical outputs and visualisations are reported accordingly to reflect the unique patterns of each energy type.

Table 1: Summary of variables and descriptions

Variable Name	Variable Type	Description	Unit	Data Source
elect_gfa	Dependent	Log-transformed electricity consumption per gross floor area (2023)	log(kWh/m²)	MOLIT (2023)/ V-World
gasheat_gfa	Dependent	Log-transformed gas and heat consumption per gross floor area (2023)	log(kWh/m²)	MOLIT (2023)/ V-World
GFA_log	Independent	Gross floor area	log(m²)	V-World
bldg_age	Independent	Age of the building	0	V-World
str_reinfo	Independent (Dummy)	Structural type: Reinforced concrete	0/1	V-World
str_brick	Independent (Dummy)	Structural type: Brick	0/1	V-World
str_others	Independent (Dummy)	Structural type: Others	0/1	V-World
bldg_use_1neigh	Independent (Dummy)	Use type: Type 1 Neighborhood Facility	0/1	V-World
bldg_use_2neigh	Independent (Dummy)	Use type: Type 2 Neighborhood Facility	0/1	V-World
bldg_use_office	Independent (Dummy)	Use type: Office Building	0/1	V-World
green_ratio	Independent	Proportion of green space within a 50-meter buffer around the building (NDVI)	%	Copernicus Data Space
temp_avg	Independent	Average temperature within a 50-meter buffer around the building (IDW)	°C	S-DoT Sensor Data
gongsi_jiga	Independent	Official land price of the parcel where the building is located	KRW/m²	MOLIT
avg_lifepop_tot	Independent	Annual average floating population (00:00–24:00)	Persons	Mobile Network Data
avg_lifepop_late	Independent	Annual average floating population (00:00–06:00)	Persons	Mobile Network Data
avg_lifepop_day	Independent	Annual average floating population (06:00–18:00)	Persons	Mobile Network Data
avg_lifepop_night	Independent	Annual average floating population (18:00–24:00)	Persons	Mobile Network Data

4.Methodology

The methodological approach of this study consists of three primary phases: data preprocessing and integration, statistical modelling using multiple linear regression, and the application of a deep learning-based prediction model in the form of a Multi-Layer Perceptron (MLP).

In the initial phase, datasets covering energy consumption, building characteristics, environmental variables, land value, and behavioural data were integrated spatially using unique building identifiers or geocoded addresses. This integration ensured both spatial alignment and content consistency across all records. Missing values were addressed using listwise deletion, and extreme outliers were removed by applying the interquartile range (IQR) method, with thresholds set at the 1st and 99th percentiles. These decisions were visually validated using boxplots.

Categorical variables, including structural type and building use, were transformed into dummy variables to enable their inclusion in the regression model. Additionally, natural logarithmic transformations were applied to electricity consumption, gas/heating consumption, and gross floor area to reduce skewness and improve interpretability. Other continuous variables, such as land price, temperature, and green area ratio, were retained in their original form. In all regression models, dummy variables were constructed for categorical features. Specifically, office buildings were set as the reference group for building use type, and others for structural type, enabling interpretation of coefficients relative to these baseline categories.

Environmental indicators were assigned at the building level using ArcGIS Pro. Average annual temperature was interpolated from point-based sensor data using the Inverse Distance Weighted (IDW) method. The green area ratio was calculated based on NDVI values within a 50-metre buffer surrounding each building. Floating population data, originally provided in a 50-by-50-metre grid format, were overlaid with building footprints. For each building, average values were computed from the intersecting grid cells corresponding to late night, daytime, night-time, and daily periods.

All preprocessing, spatial operations, and feature engineering tasks were conducted using Python, with relevant libraries including Pandas, GeoPandas, and Scikit-learn. Following data preparation, multiple linear regression models were estimated separately for electricity and gas/heating consumption intensities.

All explanatory variables from the four thematic categories were entered simultaneously to evaluate their joint and relative contributions to energy use.

In the subsequent phase of the research, a deep learning approach is planned to be implemented using a Multi-Layer Perceptron (MLP) model. The dataset will be randomly divided into training (70%), validation (15%), and test (15%) subsets. All continuous variables will be standardised, and the MLP architecture will include multiple hidden layers with ReLU activation functions. The model will be optimised using the Adam algorithm, with mean squared error (MSE) as the loss function. To mitigate the risk of overfitting, regularisation techniques such as dropout and early stopping will be employed. Model performance will be assessed using standard evaluation metrics, including R^2, root mean square error (RMSE), and mean absolute error (MAE), based on the test set.

To enhance transparency and interpretability of the deep learning models, SHAP (SHapley Additive exPlanations) analysis will be conducted to quantify the marginal impact of each explanatory variable on the prediction outcomes. All model results, performance evaluations, and SHAP visualisations will be presented separately for electricity and gas/heating, offering differentiated insights into the determinants of each energy type. This methodology enables a high-resolution, multidimensional analysis of urban energy consumption that incorporates spatial, temporal, and behavioural complexity.

5.Analysis Results

This study investigated the annual electricity and gas/heating consumption per unit of gross floor area in commercial buildings in Seoul through a series of multiple linear regression models, constructed separately for each energy type. The analysis utilised large-scale 2023 data, comprising 88,293 building-level observations for electricity and 67,918 for gas/heating. A five-stage modelling framework was adopted to evaluate the contribution of physical, environmental, economic, and behavioural variables, with a particular focus on the impact of time-segmented floating population data. The results reveal distinct determinants for each type of energy consumption and underscore the explanatory value of incorporating spatiotemporal population data.

In the case of electricity consumption, the baseline model includes fixed variables representing physical attributes (log-transformed gross floor area, building age, building use, and structural type), environmental factors (green area ratio and average temperature), and economic conditions (official land price). This initial model demonstrates relatively high explanatory power, with an adjusted R^2 of 0.584. Interestingly, the log of gross floor area shows a statistically significant negative coefficient, suggesting that larger buildings tend to consume less electricity per square meter, potentially reflecting economies of scale. Building age has a positive and significant effect, indicating that older structures are associated with higher energy use, possibly due to outdated equipment or insulation.

In terms of building use, neighbourhood living facilities consume less electricity compared to office buildings, while reinforced concrete structures display lower consumption than other structural types. Environmental variables exhibit notable effects: the green area ratio is positively associated with electricity use, possibly reflecting increased human activity in greener areas. Average annual temperature also contributes positively, likely driven by cooling demands during warmer periods. The official land price emerges as a statistically significant and positive factor, implying that buildings located in higher-value zones tend to consume more electricity, which may be indicative of more intensive building operations. (see Table 2 for regression results of Electricity Consumption per GFA).

Table 2. Regression Result of Model 1 of Electricity Consumption per GFA

Category	Variable Name	Coef.	Std.Err.	t-value	p-value	VIF
Physical	Building Age	0.000644	2.68E-05	24.07526	1.2E-127***	1.157005
	Gross Floor Area (log)	-0.16122	0.000679	-237.501	0***	1.907705
	Structural Type: Reinforced Concrete	-0.1244	0.002012	-61.8237	0***	2.842248
	Structural Type: Brick Masonry	-0.08187	0.002222	-36.8445	6.3E-295***	2.491508
	Use Type: Class 1 Neighborhood Facility	-0.04137	0.002282	-18.1293	2.54E-73***	5.116019
	Use Type: Class 2 Neighborhood Facility	-0.04245	0.0022	-19.2938	8.97E-83***	4.848605
Environmental	Green Area Ratio	0.000436	3.45E-05	12.61746	1.82E-36***	1.021823
	Avg. Temperature	-0.00083	0.000623	-1.32818	0.184122	1.013653
Economic	Official Land Price	4.5E-09	7.25E-11	62.02604	0***	1.148543

N=88293, Durbin-Watson: 1.6837, Adj. R-square: 0.584
* p < 0.05, ** p < 0.01, *** < 0.001

Dependent Variable: Annual electricity consumption per unit of gross floor area
Independent Variables: Physical, Environmental, and Economic Characteristics of Buildings

As floating population variables are introduced progressively in subsequent models, the explanatory power improves modestly. The final model, which includes late-night population density (00:00–06:00), achieves the highest adjusted R^2 value of 0.588 and the lowest Akaike Information Criterion (AIC), suggesting an improved model fit. This outcome highlights the role of 24-hour commercial activities or night-time operations—such as lighting, security, and maintenance services—in shaping electricity demand. All models yield Durbin–Watson statistics close to 1.68, indicating no significant autocorrelation. F-statistics and p-values confirm the overall statistical robustness of the models on Table 3.

Table3: Regression Results for Models with Floating Population on Electricity Consumption per GFA

Model	Variable	Coef.	t-value	p-value	Adj. R2	DW
Model 2	Average Total Population	0.000110404	19.80503643	4.17E-87***	0.5859	1.6835
Model 3	Late Night Population (00:00-06:00)	-0.000296387	-20.12045846	7.78E-90***	0.5878	1.6847
Model 4	Daytime Population (06:00-18:00)	0.000107928	4.846908526	1.26E-06***	0.586	1.6841
Model 5	Evening Population (18:00-24:00)	0.000501439	21.58245971	4.86E-103***	0.5881	1.6797

Durbin-Watson: 1.6837, * p < 0.05, ** p < 0.01, *** < 0.001

For gas and heating consumption, the baseline model including fixed variables explains 53.1% of the variance. Similar to the electricity model, the log of gross floor area is negatively and significantly associated with consumption intensity, reinforcing the view that larger buildings operate more efficiently. Building age once again exerts a positive influence, consistent with ageing infrastructure leading to increased energy usage.

In contrast to electricity, the effects of building use and structural type appear less pronounced in gas/heating models, suggesting that heating demand is more strongly governed by physical and climatic factors. Average annual temperature shows a strong and statistically significant negative effect, as expected in colder environments. However, the green area ratio is found to be statistically insignificant, possibly due to its limited relevance

to internal heating systems. As with electricity consumption, the land price variable remains a significant positive predictor. (see Table 4 for regression results of Gas/Heat Consumption per GFA).

Table 4. Regression Result of Model 1 of Gas/Heat Consumption per GFA

Category	Variable Name	Coef.	Std.Err.	t-value	p-value	VIF
Physical	Building Age	0.000218	4.08E-05	5.341784	9.23E-08***	1.186283
	Gross Floor Area (log)	-0.19464	0.000965	-201.675	0***	1.924024
	Structural Type: Reinforced Concrete	-0.1125	0.003159	-35.6173	2.7E-275***	3.470785
	Structural Type: Brick Masonry	-0.07384	0.003456	-21.3633	6.3E-101***	3.23347
	Use Type: Class 1 Neighborhood Facility	-0.10211	0.003137	-32.5453	1.5E-230***	5.255343
	Use Type: Class 2 Neighborhood Facility	-0.09747	0.00301	-32.3832	2.6E-228***	4.945725
Environmental	Green Area Ratio	0.000565	4.83E-05	11.7026	1.33E-31***	1.020019
	Avg. Temperature	0.001474	0.000844	1.746352	0.080754	1.010858
Economic	Official Land Price	2.16E-09	1.19E-10	18.24758	3.26E-74***	1.209314

N=67918, Durbin-Watson: 1.8720, Adj. R-square: 0.531
* p < 0.05, ** p < 0.01, *** < 0.001

Dependent Variable: Annual gas/heat consumption per unit of gross floor area
Independent Variables: Physical, Environmental, and Economic Characteristics of Buildings
Incorporating floating population variables leads to a modest increase in explanatory power, reaching an adjusted R^2 of 0.533. Notably, the model including late-night population data performs best in terms of model fit, exhibiting the lowest AIC value. This supports the interpretation that night-time human presence is linked to greater heating requirements, particularly in buildings with 24-hour occupancy or operational activities. Durbin–Watson values hover around 1.87, indicating no evidence of autocorrelation in the residuals. (Table 5 and Figure 3)

Table 5: Regression Results for Models with Floating Population on Gas/Heat Consumption per GFA

Model	Variable	Coef.	t-value	p-value	Adj. R2	DW
Model 2	Average Total Population	0.000129	16.9001	6.07E-64***	0.533	1.8736
Model 3	Late Night Population (00:00-06:00)	-0.00016	-7.5759	3.61E-14***	0.5334	1.8737
Model 4	Daytime Population (06:00-18:00)	0.000121	3.7243	0.000196***	0.5331	1.8739
Model 5	Evening Population (18:00-24:00)	0.000155	4.619	3.86E-06***	0.5332	1.8729

Durbin-Watson: 1.6837, * p < 0.05, ** p < 0.01, *** < 0.001

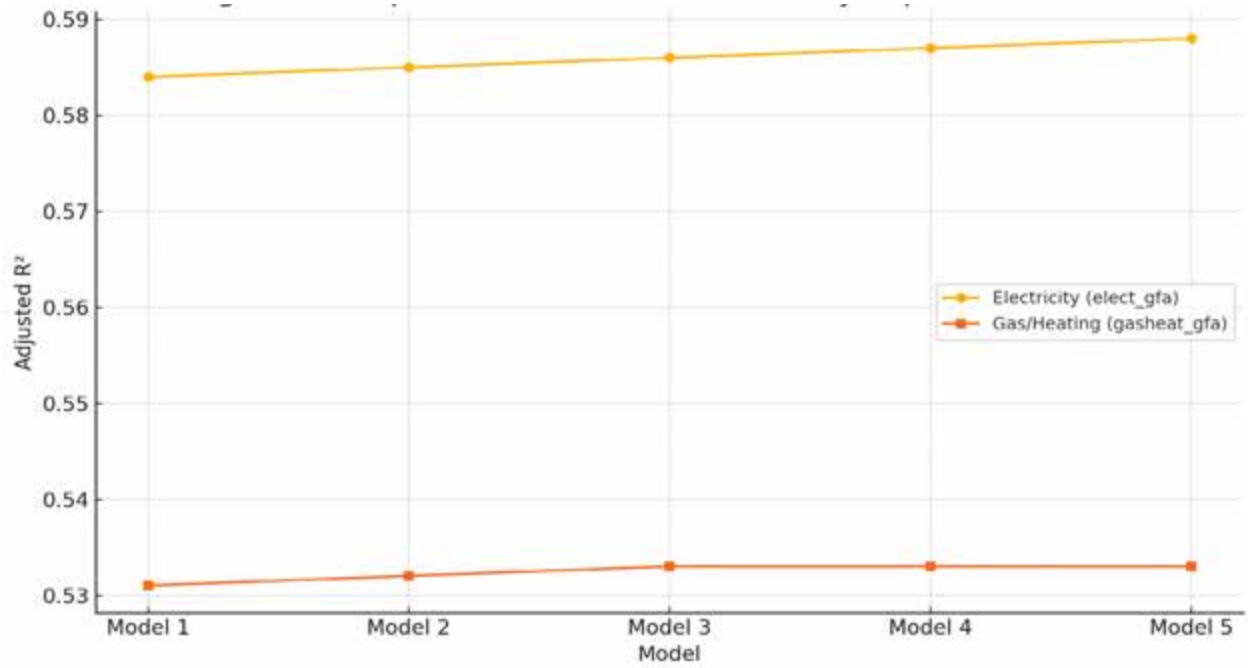


Figure 3: Comparison of Models Performance by Dependent Variables

6.Conclusion

This study proposes a multidimensional modelling framework to examine energy consumption in commercial buildings in Seoul by integrating physical, environmental, economic, and behavioural factors within a unified analytical structure. Separate regression models for electricity and gas/heating consumption reveal both shared and distinct drivers across energy types. Among the explanatory variables, temperature emerges as a particularly strong determinant of heating energy use, while official land price reflects patterns of energy demand in economically dense urban areas. Although floating population variables contributed modestly to the overall explanatory power of the models, they nonetheless provided valuable insight into the behavioural dimension of urban energy use.

The proposed framework enables a more comprehensive interpretation of energy consumption patterns by incorporating temporally segmented mobility data alongside building attributes and environmental indicators. Such integration allows for more context-sensitive predictions, especially in highly dynamic urban environments. In the subsequent phase of this research, a non-linear modelling approach using a Multi-Layer Perceptron (MLP) will be implemented to capture complex interdependencies that are beyond the scope of traditional linear models. The application of SHAP (SHapley Additive exPlanations) will further enhance model interpretability by quantifying the contribution of each input variable. Together, these methodological advancements aim to expand both the predictive power and the policy relevance of building-level energy models.

Overall, the findings underscore the importance of adopting a holistic perspective in urban energy modelling—one that accounts not only for physical infrastructure but also for the social and environmental dynamics that influence energy demand. The study contributes a scalable, data-driven approach that can inform future energy efficiency strategies, smart city initiatives, and evidence-based urban sustainability policies.

These findings carry several policy implications for energy-efficient urban development. First, retrofit programmes should prioritise ageing commercial buildings, particularly in areas with high official land values, where energy consumption is significantly elevated. Second, urban energy models should incorporate behavioural data, such as time-segmented floating population, to better reflect actual occupancy-driven energy demand. Third, planning authorities may consider expanding green infrastructure and optimising thermal environments to indirectly influence energy use patterns. Lastly, the integration of spatially granular data and advanced pre-

dictive models can support smarter zoning decisions, resource allocation, and the design of targeted energy policies in high-density urban contexts such as Seoul.

7.Discussion and Limitations

This study provides important insights by analysing the energy consumption of commercial buildings in Seoul within a multivariate analytical framework. However, several methodological and contextual limitations should be taken into account when interpreting the findings.

First, the analysis relies exclusively on cross-sectional data from the year 2023. This temporal limitation prevents the examination of seasonal fluctuations or longer-term trends in energy use. In practice, energy consumption is influenced by dynamic factors such as economic cycles, climate variability, and policy shifts. Future research could address this limitation by incorporating panel datasets or time-series analyses, allowing for a more robust understanding of temporal patterns.

Second, the study focuses solely on Seoul, a city with unique urban characteristics including high population density, advanced infrastructure, and extensive availability of digital data. These context-specific conditions enhance the resolution of the analysis but also constrain the generalisability of the findings. Comparative studies across different urban settings would be beneficial to assess the external validity of the proposed modelling framework.

Third, the behavioural variables in this study—namely, floating population indicators—are derived from mobile network data, which may contain inherent biases due to variations in data collection methodologies, coverage across providers, or limitations in capturing nuanced human mobility. Future work should consider integrating multiple data sources, such as public sensor networks or multimodal mobility datasets, to enhance measurement accuracy and behavioural representation.

Finally, the regression-based methodology employed in this study assumes linear relationships between variables. While useful for interpretability, this assumption may oversimplify the complex interactions that characterise real-world energy consumption. To overcome this limitation, the study outlines a plan to implement a deep learning-based approach using a Multi-Layer Perceptron (MLP), which can capture non-linear dynamics and improve prediction accuracy.

Despite these limitations, the study contributes meaningfully to the urban energy modelling literature by demonstrating how high-resolution, multi-source data can be operationalised within a consistent analytical framework. The proposed methodology supports both academic inquiry and practical decision-making in the pursuit of energy-efficient and data-informed urban environments.

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Accounting beyond boundaries: Exploring consumption-based carbon approaches in Paris and Gothenburg

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Abstract
This article examines how Paris and Gothenburg have integrated Consumption-Based Carbon Accounting (CBCA) into local climate governance. As cities increasingly confront emissions beyond their borders, CBCA offers a framework to address the carbon impacts of urban consumption. Through a comparative qualitative case study, the research identifies 16 enabling conditions for CBCA implementation, organized into four themes: (1) data transparency and accessibility, (2) institutional and technical capacity, (3) political legitimacy and stakeholder engagement, and (4) multi-level and cross-sectoral support. The findings reveal how different governance models - Paris's institutionalized approach and Gothenburg's pioneering model - can both foster CBCA adoption. This study contributes to understanding the political, institutional, and participatory dynamics that enable cities to engage meaningfully with consumption-based emissions.

Keywords: Consumption-based carbon accounting; Carbon neutrality; Climate governance

1. Introduction

As cities around the world increasingly commit to achieving carbon neutrality, they rely on greenhouse gas (GHG) inventories to assess their emissions and guide climate action. These inventories are typically structured around internationally recognized frameworks, such as the Global Protocol for Community-Sc ale Greenhouse Gas Emission Inventories (GPC) , that primarily rely on a production-based carbon accounting (PBCA) methodology (Harris et al., 2020). However, a growing body of academic literature and policy discourse has highlighted the limitations of PBCA, arguing that it captures only a partial representation of urban emissions (Balouktsi, 2020; Millward-Hopkins et al., 2017; Pellan et al., 2024). In particular, PBCA overlooks the substantial carbon footprint embedded in goods and services consumed by urban populations but produced outside city boundaries. On the contrary, consumption-based carbon accounting (CBCA) estimates the life-cycle emissions of goods and services consumed within a city's boundaries, regardless of where those emissions occur geographically offering a more comprehensive and equitable framework for addressing urban GHG emissions, incentivizing the adoption of policies that promote less carbon-intensive consumption (Grasso, 2016; Lombardi et al., 2017). The claim for the switch towards a more CBCA-focus framework is especially relevant in high-income cities in Europe and North America, where local production-based emissions have declined due to deindustrialization, while consumption-based emissions continue (Millward-Hopkins et al., 2017).

Despite its appeal, the implementation of CBCA remains limited and uneven. Most existing research focuses on methodological and technical challenges (i.e., data availability, input-output modeling), while the political and governance dimensions are mostly studied at the national level. Therefore, the governance dimensions of CBCA at the city level remain largely underexplored, particularly with regard to the political, institutional, and organizational conditions that enable its operationalization within local governments.

This article seeks to address this gap by asking the following research question: What are the governance conditions that enable cities to implement consumption-based carbon accounting and associated policies to reduce emissions?

To answer this question, the article conducts a comparative case study of two European frontrunner cities – Paris and Gothenburg - which have formally adopted CBCA approaches and integrated consumption-based targets into their climate strategies. By analyzing these two cases, the study identifies key enabling governance conditions, ranging from data systems and institutional capacity to political leadership and stakeholder engagement.

The article is structured as follows. Section 2 reviews the terminology and key concepts. Section 3 outlines the methodological approach, including the case selection and analytical framework. Section 4 presents the empirical findings, identifying five thematic clusters of governance enablers. Finally, Section 5 discusses the broader implications of the findings for climate governance and outlines directions for future research.

2. Definition and key concepts

It is essential to define the key terms used throughout this study, as terminology in the field of urban carbon accounting is often used interchangeably or inconsistently.

Most GHG reporting frameworks currently focus on territorial or production-based emissions (Harris et al., 2020). PCBA is a method for quantifying GHG emissions that attributes all emissions to the country, region, or organization where the emissions physically occur during the production of goods and services (Franzen & Mader, 2018). At city level, these emissions largely correspond to Scope 1 of the GPC – meaning emissions from industrial activity, transportation, energy use in buildings, and waste management (Balouktsi, 2020; Fan & Guan, 2025). However, PBCA overlooks the embodied emissions in imported goods and services, which can be considerable, particularly in high-consumption urban contexts with limited local production.

In contrast, CBCA allocates emissions to the final consumers of goods and services, regardless of where in the world those emissions occur along the supply chain. This approach accounts for all emissions generated throughout the supply chain, including production, transportation, and distribution (Volden, 2018). It closely aligns with what is considered Scope 2 and Scope 3 emissions under the GPC framework.

The GPC categorizes emissions as follows:

- Scope 1: Direct emissions from sources located within the city boundary (e.g., local transport, buildings, industry).
- Scope 2: Indirect emissions from the consumption of grid-supplied electricity, heat, steam, and cooling within the city.
- Scope 3: Other indirect emissions that occur outside the city boundary as a result of activities within the city

While Scope 3 provides the most comprehensive perspective on urban emissions, it remains largely optional and is often excluded from official city-level inventories or only partially addressed. As a result, most cities continue to focus on reducing production-based emissions, leaving a significant portion of their carbon footprint unaccounted for (Millward-Hopkins et al., 2017). This gap has crucial implications for the effectiveness of urban climate strategies, particularly in "consumer cities" such as those in Europe, where a significant share of emissions stems from imported goods and service (Harris et al., 2020). Furthermore, it is argued that integrating consumption-based accounting, and particularly Scope 3 emissions, into local governance is critical for developing more effective and equitable climate mitigation strategies. A full accounting of urban emissions - beyond territorial boundaries - enables better-targeted policies that reflect the real carbon emissions drivers in service-oriented urban economies.

To explore this shift, the article focuses on the governance conditions necessary to support the integration of CBCA into city-level climate policy. Governance here is understood in a broad sense, encompassing formal and informal norms, procedures, institutions, and instruments that structure decision-making and implementation processes (Grasso, 2016). As Grasso underlined in his study on the political feasibility of CBCA, governance mechanisms for consumption-based accounting may not yet be fully established or even conceptualized. In this study, governance will be analyzed as a multidimensional framework - including policies, institutional structures, political will, and administrative practices - that can either enable or hinder the implementation of CBCA.

3. Study framework

This study draws upon data originally collected in a broader comparative research project that analyzed the barriers to implementing consumption-based carbon accounting (CBCA) in 17 European cities. These cities were purposefully selected to ensure diversity in terms of geographical location, size, and climate policy maturity. Within this wider research effort, certain cities stood out as exemplary cases in integrating CBCA into their local climate governance frameworks. Among them, Paris and Gothenburg were identified as particularly progressive to advance CBCA and have been chosen for a more in-depth comparative study case study on the governance conditions. Drawing from the main study, the authors formulated a set of hypotheses regarding the political, institutional, and technical enablers necessary for successful CBCA integration. These hypotheses guided the subsequent research design and data analysis strategy.

3.1 Main hypotheses

Two principal hypotheses shaped the analytical framework of this study. The primary hypothesis argues that the successful implementation of CBCA at the city level is contingent upon a combination of enabling governance conditions. These include high institutional capacity, strong data transparency, stakeholder legitimacy, and effective multi-level coordination. The second hypothesis states that the successful implementation of CBCA at the city level is contingent upon a combination of enabling governance conditions. These include high institutional capacity, strong data transparency, stakeholder legitimacy, and effective multi-level coordination.

Each of these hypotheses is underpinned by theoretical and empirical insights from climate governance literature and were broken down into more specific analytical categories, as described below.

High institutional capacity

It is anticipated that cities advancing CBCA possess robust institutional capacity. This includes not only administrative competence and specialized staff, but also financial resources sufficient to develop and sustain complex policy instruments such as CBCA.

Data availability and transparency

An expected key enabling factor is the presence of mechanisms to gather, estimate, and communicate consumption-based emissions data. This may involve standardized methodologies, collaboration with national statistical agencies or academic institutions, and innovative approaches to address data gaps. Moreover, transparency in how data are collected and what they represent is considered essential for credibility and stakeholder engagement.

Political legitimacy

Successful implementation is also linked to the legitimacy of CBCA within the local governance ecosystem. Two factors are anticipated to support legitimacy, measurable targets and the active engagement of both internal and external stakeholders in shaping and delivering on the policy objectives.

Multi-level coordination and stakeholder engagement

Effective coordination across governance levels; horizontal (within municipal departments), vertical (with regional or national authorities), and cross-sectoral (with businesses and civil society), is assumed to be a central enabler. The engagement of diverse stakeholders is also crucial to reinforcing legitimacy and ensuring long-term policy durability.

3.2 Research design

From the broader dataset of 17 European city case studies, Paris and Gothenburg were selected for deeper qualitative analysis. The selection was guided by their advanced engagement with CBCA defined here as going beyond compliance with national or EU mandates. Another selection criterion was for the city to have a consumption-based emissions reduction goal that does not only encompass organizational emissions (i.e., from the municipality) but also include city-wide emissions in their climate targets.

Semi-structured interviews were conducted with key stakeholders involved in the climate governance of each city. Interviewees were initially identified through the NetZeroCities (NZC) platform and selected based on their role and knowledge of CBCA implementation. Complementary to the interviews, documentary analysis was conducted on municipal climate action plans, technical reports, and official data-sharing agreements. During the initial research, a codebook was developed. As this research was exploratory, an inductive coding approach was preferred to discover unexpected themes and patterns and limit researcher bias. These codes were then refined through an iterative validation process involving a second researcher, ensuring inter-coder reliability and interpretative coherence.

From the results of the coding of the main research data, an initial focus was placed on the codes that reflected governance enablers. This preliminary review made it possible to identify recurring patterns and key governance conditions necessary for the implementation of consumption-based carbon accounting (CBCA). These conditions form the analytical framework presented in the results section. Subsequently, a comparative analysis was conducted by reviewing all codes linked specifically to the interviews from Paris and Gothenburg. This step aims

to identify the concrete governance mechanisms present in these two cities, which are considered frontrunners in CBCA. Additional patterns that complemented the initial findings were identified through this city-specific review. Finally, a close re-examination of the interview transcripts for both cities was carried out to validate and deepen the analysis of the governance conditions that have facilitated progress on CBCA at the local level.

Table 1: Summary of Interviews Conducted in Paris and Gothenburg

City	Date	Duration
Paris	19-07-2024	45:58
Gothenburg	07-08-2024	53:28

The transcription of the interviews conducted in Paris and Gothenburg serve as the primary empirical basis for this study and directly inform the analysis of governance conditions for implementing consumption-based carbon accounting (CBCA). In addition to the interviews, several key documents provided by the municipalities were analyzed, including, the Paris Climate City Contract (CCC), the Paris Climate Action Plam, the Gothenburg CCC. Further desk research was also conducted to clarify specific aspects of local governance and policy context not directly covered in the interviews or official documents.

It is worth noting that, throughout the research process, the terms *consumption-based carbon accounting (CBCA)* and *Scope 3 emissions* were frequently used interchangeably by stakeholders. While technically distinct, in this context they were often treated as synonymous in practice and discourse.

3.3 Paris and Gothenburg case studies

Paris and Gothenburg were selected as case studies due to their advanced commitments to climate action, particularly regarding the integration of consumption-based carbon accounting (CBCA) into their urban climate strategies.

Table 2: Key Climate Commitments of Paris and Gothenburg

City	Covenant of Mayors adhesion	Date of CCC publication	Consumption based objectives
Paris	2008	2024	Achieve carbon neutrality, including consumption-based emissions, by 2050
Gothenburg	2009	2024	Reduce per capita consumption-based emissions to 1.9 tCO$_2$e by 2050

Paris emerged early in the research as a leading example, having set an ambitious carbon neutrality target that explicitly includes Scope 3 emissions. Its 2018 Climate Action Plan and subsequent strategies reflect a comprehensive approach, integrating both territorial and consumption-based emissions into its monitoring and objectives. As stated in the Plan:

> *"Through the Climate Plan, the City of Paris has set an ambitious objective to reduce its carbon footprint by 80%. In this way, it is going beyond the legal requirements by integrating indirect emissions that come mainly from aviation, the production of goods, and the food consumed in Paris. To attain this target, the City of Paris plans to encourage the aviation and food industries in particular to make their practices more sustainable"* (p.92)

Gothenburg also represents a strong case, albeit with a slightly less integrated approach than Paris. Nevertheless, it has set clear and measurable targets for reducing consumption-based emissions. The city aims to lower per capita consumption-based emissions to 3.3 tonnes by 2030, 3.5 tonnes by 2035, and 1.9 tonnes by 2050. These goals encompass all goods and services consumed by residents, regardless of where the emissions occur, and imply an annual reduction of approximately 7.6%.

4. Results

4.1 Initial Coding Results

The initial coding process based on the original codebook revealed several recurring governance conditions that enable the implementation of Consumption-Based Carbon Accounting (CBCA). This led to the identification of 16 enabling conditions, organized across four overarching themes: (1) Data transparency and accessibility, (2) Institutional and technical capacity, (3) Political legitimacy and stakeholder engagement, and (4) multi-level and cross-sectoral support. These enabling conditions are presented in the framework below:

Table 3: Enabling Governance Conditions for CBCA Implementation

Themes	Enabling Conditions	Explanation
Data transparency and accessibility	Standardized process	The city has established procedures for collecting and/or analyzing consumption-based emissions data
	Innovation	The city uses alternative data collection approaches where direct data is missing
	Data agreements	The municipality has institutional arrangements with external actors (e.g., private companies, agencies) for data sharing
	Open access	When working with an external stakeholder to collect the data, the city has access to the datasets and methodologies used
Institutional and technical capacity	Dedicated expertise	The municipality has in-house staff or department with expertise in CBCA
	Human and financial resources	The department in charge of the carbon accounting has sufficient technical, administrative, and financial resources
	Strategic cross-departmental collaboration	All relevant departments are being included in CBCA implementation
Political legitimacy and stakeholders' engagement	Strong political mandate	The political commitment goes beyond minimal compliance, supporting ambitious CBCA targets
	Clear communication	There are active efforts to explain CBCA logic and relevance to stakeholders
	Historic commitment	The city has a long-standing engagement in climate action
	City wide and multi-sectoral targets	The consumption-based emissions targets address a broad range of emission sources within the scope of the entire city
	Stakeholders' inclusion	The municipal strategy plans for the engagement of external actors (e.g., citizens, business)
	Clear framing of the objective	A numerical objective with a timeframe is set out from the reduction of consumption-based emissions. This objective is written in the Climate Plan.
Multi-level and cross-sectoral support	National level support	The national ecosystem is favourable of the implementation of CBCA
	Horizontal coordination	Formal agreements are being signed with other public or private organisations allows to enlarge the scope of committed actors

The following sections detail how each theme is manifested in the case studies of Paris and Gothenburg, with insights triangulated through case analysis and complementary data sources.

4.2 Data transparency and accessibility

Four factors have been identified as enabling conditions for CBCA implementation: (1) Standardized data collection and analysis, (2) Use of innovative methods to fill data gaps, (3) Existence of formal data-sharing agreements, (4) Open access and transparency in data communication.

Standardized data collection and analysis processes

A standardized data collection and analysis process appeared essential to strengthen the legitimacy of the accounting process. One the one hand, Paris utilizes the nationally standardized *Bilan Carbone* methodology developed by ADEME[1], ensuring consistency across French cities and reinforcing data legitimacy. The city also relies on INSEE[2] for robust demographic and economic statistics critical to emissions estimation, especially for sectors like food. Paris estimates average daily meal consumption based on residential and commuting populations to approximate food-related emissions. As expressed in the interviews, the existence of national level process allows to strengthen the legitimacy: "*It's good to have in France this "Bilan Carbone" methodology, because then every city would use the same rate for emissions. So, it gives more legitimacy as well for these figures.*"

Gothenburg, while lacking standardized local systems, leverages data provided by the Stockholm Environment Institute (SEI), which, for all cities in Sweden, broke down national data to postal code areas, using market segmentation and local adjustments. However, Gothenburg notes this approach is externalized and lacks sufficient clarity. They also work with a state-sponsored research institute to calculate the impact of food consumption. Therefore, Gothenburg relies on externalized processes, carried on by research institutions, and unified at a national level.

Innovative Approaches

Paris uses innovative methods for categories with data gaps. For example, freight emissions are estimated through regional surveys and applying proportional calculations to allocate emissions to the city. The city also calculates material usage based on construction waste data: "*We do the math from the waste to upstream, because we don't know the amount of materials purchased. So we estimate it from construction waste.*"

Gothenburg began with a bottom-up approach in 2008, assessing household consumption categories using available data, despite its fragmented nature. As exposed in the interview: "*We used like more of a bottom up approach that we looked at on various consumption categories and which day-to-day had available and tried to see how difficult the households in Gothenburg consumed and what the emissions were from the different groups*". Nowadays, this work still complements SEI's data.

Formal data-sharing agreements

These data sharing agreements appear to be particularly done with the air travel industry. Paris has a formal agreement with Aéroports de Paris (ADP), providing free annual data on air travel by Parisians, including departure and arrival information. On the other hand, Gothenburg previously received local air travel data from the airport, but this was discontinued due to political sensitivities, highlighting the fragility of this type of voluntary agreement.

Open access and transparency

In the case of Paris, getting the data from national institutions guarantees the transparency of the processes and access to the data sets. However, Gothenburg, while benefiting from SEI's mapping tools, notes that the opacity of the underlying model makes it hard to explain variations between areas, illustrating a trade-off between using relying on an external stakeholder and transparency; "*It's a little bit of a black box. It's a bit difficult to explain why some areas are higher in emissions and some are not*",

1 ADEME (Agence de l'environnment et de la maîtrise de l'énergie) : French Environment and Energy Management Agency
2 INSEE: French National Institute of Statistics and Economic Studies

4.3 Institutional and technical capacity
The institutional and technical capacity depends on 3 enabling factors: (1) Dedicated expertise within the municipality, (2) Human and financial resources, (3) Cross-departmental collaboration.

Dedicated expertise within the municipality
Paris also works with the Association Bilan Carbone (ABC) association, a national organization that trains professionals on carbon inventories and methodologies, ensuring the upskill process in French municipalities. Furthermore, the city also created a Department for Ecological Transition and Climate in 2022 to oversee its Climate Action Plan. This department monitors actions across administrative departments, conducts greenhouse gas emissions assessments. Gothenburg has a small, dedicated team, with one or two people focusing specifically on carbon accounting, led by a climate strategist responsible for monitoring emissions. "*We have people working with the carbon accounting, but it's not a big team. It's one or two people that are really working with this in detail.*"

Cross-departmental collaboration
Both cities are involving a large number of departments into the strategy to reduce consumption-based emissions. **Paris** promotes shared responsibility by involving various departments and external partners. Carbon accounting data is shared internally to build awareness and ownership: "*We try to involve all the stakeholders of the municipality. So we have different ways to raise awareness and to discuss with them*". **Gothenburg** collaborates with departments like transport and procurement, though it acknowledges that challenges remain: "*There is some collaboration with the transport department and with the procurement department, because their decisions have a big impact on emissions.*" The CBCA strategy is embedded in the normal environmental governance in Gothenburg: "*The City's climate goals are deeply embedded in its ordinary governance structures, notably outlined in the Environmental and Climate Program, backed by a broad political consensus. Central to this program is the aim for near-zero emissions, driving action across all municipal administrations*".

4.4 **Political legitimacy and stakeholders' engagement**
Seven enabling conditions emerged: (1) Strong political mandate, (2) Clear communication, (3) Historic climate commitment, (4) City-wide, cross-sectoral scope, (5) Inclusion of external stakeholders, (6) Legitimacy through leadership and continuity.
.
Strong political mandate
Both cities have a strong political support that goes beyond the mandatory obligations in terms of climate engagements, as highlighted in the interview: "*We have a very ambitious climate plan, and the mayor is very committed to including all emissions, not just the ones happening inside the city.*" Indeed, Paris's commitment to carbon neutrality by 2050 includes scope 3 emissions. The interviewees also highlighted the role of the COP21 Conference in Paris, and the mayor's leadership as a formal president of the C40 network, as key factors explaining Paris high-level commitment.

Gothenburg has robust, cross-party political support for its 2030 goal of near-zero carbon footprint, targeting both territorial and consumption-based emissions. "*The City's climate goal for 2030, 'a carbon footprint close to zero,' has robust support from a broad political majority, and is particularly highlighted by The Environment and Climate Programme for the City of Gothenburg 2021-2030.*" However, as underlined by the interviewee, it might be more complicated to get a political consensus about the methods to adopt to reach the emissions reduction objectives: " *It was quite universal support for these kind of goals, and there have been some discussions when it comes to like individual choices when it comes to like food or what politicians should not do when it comes to emissions related to citizens. But the goals in themselves and not so much discussion*".

In both cases, the cities are pushed by what could be called a moral obligation, as expressed by Gothenburg in the following quote: "*We thought we also have an obligation to see how we affect the other parts of the world through our consumption*".

Clear communication
Paris actively communicates the importance and methodology of CBCA to stakeholders, both inside and outside the municipality, to foster understanding and engagement:

"*We explain to them that it's not just about the emissions from buildings or transport in Paris, but also about what we consume, like food, clothing, and electronics.*"

"*We have meetings and workshops to explain the logic of including consumption-based emissions and why it's important for the city's climate goals.*" Gothenburg supports public participation, but less detail is available regarding structured communication campaigns.

Historic commitment:
The fact that both cities have been leading on climate action and consider as "champion" is perceived as a clear enabler, pushing cities to further extend their actions towards Scope 3 emissions. Paris has demonstrated a long-standing commitment to greenhouse gas accounting and climate action, reflected in the establishment of specialized departments and the use of standardized methodologies. The city began assessing the impact of its activities in terms of greenhouse gases as early as 2004 and published its first comprehensive greenhouse gas assessment in 2006, identifying key emitting sectors and establishing a knowledge base for further action. They were also calculating the carbon footprint of the city since 2004: "*We were already known as a leader on climate for for a long time, and that's what we want to still carry on*".

Gothenburg began measuring consumption-based emissions in 2008, integrating scope 3 in climate policy despite limited data at the time: "*We had our first time goal for the city, we chose to include the consumption emissions also, even though we had very little data or anything on it*". Initially, the city was separating between territorial and consumption-based emissions before adopting the scope 1, 2, 3 framework as part of their involvement with the Covenant of Mayors and other reporting schemes.

City-wide and cross-sectoral focus
Both Paris and Gothenburg have adopted climate strategies that extend well beyond municipal operations, encompassing a wide range of emissions sources, including those linked to citizen behavior, urban infrastructure, and procurement practices.

In Paris, the city's climate policy is explicitly designed to address emissions across all sectors - not just those occurring within city boundaries. This includes emissions from energy, transport, food, construction, and the consumption of goods and services by Parisians. As one official explains, "*The city's climate plan covers all emissions, including those from energy, transport, food, construction, and even the consumption of goods by Parisians.*" Another emphasizes the city's broader scope: "*We don't just look at what happens inside the city boundaries. We want to reduce the footprint of everything Parisians consume, even if it happens outside Paris.*" The ambition is clear and comprehensive: "*Our goal is to reduce all emissions by 100%, not just the ones we control directly.*"

Similarly, Gothenburg has adopted a wide-ranging climate objective that integrates both territorial and consumption-based emissions. As described by a city representative: "*The climate goal of the City of Gothenburg has a broader scope than required in the Mission. The goal targets emissions from both a territorial and a consumption-based perspective.*" At the organizational level, Gothenburg closely monitors emissions associated with municipal procurement. The city has conducted a detailed analysis of all its programmatic requirements, comparing them against a national emissions database that calculates greenhouse gas intensity per monetary unit. This allows the city to assess the carbon impact of everything it purchases: "*We did this analysis on all our programme requirements, checking them against the database that has data on emissions per krona or monetary unit in Sweden.*" As one official notes, this gives the municipality considerable influence: "*We have much more say in what we as a city consume and procure, and we can do much more with that.*"

At the citizen level, Gothenburg also aims to capture emissions associated with individual consumption. While recognizing limitations in influencing certain areas - such as the embedded emissions in imported goods - the city still exerts significant control through local systems: "*When it comes to what our citizens consume, we still have a lot of say in how our transport system is set up and our energy system within the city, but not so much when it comes to the cost of goods and services.*". To operationalize this broad approach, Gothenburg has developed a climate program structured around seven strategic focus areas - or "strategies" - that require radical transformation.

Stakeholders inclusion:
Both Paris and Gothenburg prioritize inclusive governance by actively engaging a wide range of stakeholders in their climate initiatives - from large corporations and public institutions to local associations and citizens.

In Paris, the city has developed a collaborative framework to bring together stakeholders from across sectors. One key initiative is the Pacte Action-Climat-Biodiversité (Climate Action–Biodiversity Pact), a publicly available charter that outlines stakeholder commitments and reinforces transparency. "*It's like a kind of charter that some actors and stakeholders agree to sign to say that they will work alongside the city to implement measures that have an impact on the carbon footprint of the city.*" The pact not only encourages joint action but also provides open access to information about partners and their objectives. Among the participating actors are major energy providers such as **GRDF** and **EDF**. As one official described, "*We have big energy companies like GRDF, EDF... the idea is to embark all of them and to share experience and good practices between all of them.*" This approach reflects a deliberate effort to keep institutionalizing cooperation and knowledge exchange across organizational boundaries.

In Gothenburg, a similarly inclusive approach is taken, particularly with local associations and community-based actors. The city provides targeted support mechanisms that encourage grassroots involvement in climate work. For instance, associations, including sports organizations, can apply for municipal grants to fund environmental initiatives. "*You can, as a sports association, ask the city for grants for doing that kind of work, and you can get access to the city's buildings*", explained one representative. Notably, these programs have been expanded to include organizations working on issues such as circular economy, allowing for greater diversity in the types of projects supported: "*We extended those programmes to associations that want to work with circular economy issues and things like that.*"

Clear objectives
The presence of clearly defined goals - particularly those that are quantitative and time-bound - plays a fundamental role in enabling consumption-based climate action (CBCA). These objectives serve not only as guiding principles but also as concrete benchmarks that drive prioritization, mobilize resources, and ensure accountability. In both Paris and Gothenburg, long-term climate ambitions are formally documented in strategic plans, providing an essential foundation for implementing CBCA measures.

In Paris, the city's objectives are explicitly articulated in the Climate Action Plan and the Climate, Air, and Energy Plan (PCAET). These plans commit Paris to reducing all local emissions - including both territorial and consumption-based - by 100% in the long term. More specifically, the city aims to cut total emissions (including consumption-based ones) by 40% by 2030 and by 80% by 2050, relative to 2004 levels: "*Paris established targets in its Climate Action Plan to decrease territorial and consumption-based emissions (the Paris carbon footprint) to 40% below 2004 levels by 2030 and 80% below 2004 levels by 2050.*"[3]

Similarly, Gothenburg has committed to a clear and ambitious consumption-based emissions reduction pathway. Its goals are both quantified and tied to a defined timeline, providing a strong political mandate for CBCA implementation. By 2030, the goal is to reduce consumption-based greenhouse gas emissions to 3.3 tonnes CO e per person per year, down from a baseline of 9.25 tonnes in 2017. This requires an annual reduction rate of at least 7.6%. The final goal is to reach 1.9 tonnes CO e per person per year by 2050.

4.5. Multi-level and cross-sectoral coordination
The successful implementation of CBCA depends significantly on coordination across multiple levels of government and sectors. This is enabled by two key factors: a supportive national governance system and a horizontal coordination across sectors and stakeholders.

National governance ecosystem
Paris benefits from a strong national framework that provides substantial institutional support for implementing CBCA. National-level entities - including government agencies, research institutions, and statistical offices - supply cities with the methodologies, data, and standards necessary for consumption-based carbon accounting. These tools not only strengthen the technical foundation of Paris's climate policy but also lend political legitimacy and

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coherence to local actions. In contrast, Gothenburg operates within a more fragmented national governance context. While it receives technical support from organizations such as the Stockholm Environment Institute (SEI) - which plays a crucial role in developing methodologies for CBCA - there is no formal governmental mandate or support at the national level for consumption-based accounting.

Horizontal coordination
Both cities also rely heavily on horizontal coordination, meaning collaboration across sectors and with various public and private stakeholders.

In Paris, this is exemplified by initiatives such as the Pacte Action-Climat-Biodiversité, an open, online charter where stakeholders voluntarily commit to actions aligned with the city's climate goals, as explained above. Similarly, in Gothenburg, CBCA is not the responsibility of a single department but is instead embedded across the city's governance structures. The Environment and Climate Program for 2021–2030 was adopted by a wide political majority and applies to all city departments and city-owned companies. This ensures that the goal of reducing consumption-based emissions is shared across the entire municipal apparatus.

5. **Discussion**
This study identifies two contrasting yet complementary models of consumption-based carbon accounting (CBCA) governance: Paris's institutionalized model and Gothenburg's pioneering approach. These cases illustrate that there is no singular pathway to implementing CBCA. Instead, diverse strategies - shaped by political cultures, institutional configurations, and external support systems - can all serve as viable routes to operationalizing this ambitious climate accounting framework.

5.1. Two different models: Institutionalized vs. Bottom-up CBCA Approaches
Paris advances CBCA within a highly institutionalized and nationally supported governance environment. It benefits from a structured ecosystem comprising national research institutions (e.g., INSEE, ADEME, ABC), legal mandates, and standardized methodologies, which provide a robust backbone for methodological consistency and policy legitimacy. CBCA is embedded within the city's broader climate strategy, supported by cross-sectoral coordination and formal target-setting. This reflects what Bulkeley and Kern (2006) describe as "governing through enabling," where higher-level institutions provide cities with tools and frameworks for climate action. In contrast, Gothenburg exemplifies a more bottom-up, pioneering approach. Despite the absence of strong national mandates or standardized frameworks, the city has pushed CBCA forward through close partnerships with expert institutions like the Stockholm Environment Institute (SEI), bottom-up data collection, and partnerships with local institutions. The reliance on external actors has enabled methodological innovation and credibility, though it also introduces potential vulnerabilities in terms of continuity, autonomy, and long-term data governance. Studies shows that, while introducing expertise and standardized methods, the reliance on external stakeholders also include challenges in maintaining consistent methodologies over time, risks of data discontinuity if external partnerships dissolve, and potential limitations on local autonomy and data ownership (Fünfgeld & McEvoy, 2012; Turnhout et al., 2016).

5.2 The Role of National Ecosystems
These two cases highlight the enabling role, but not deterministic function, of the national ecosystem. While Paris's success is deeply tied to a supportive national framework, Gothenburg demonstrates that local innovation can substitute for national direction. Paris thrives in an ecosystem with clear national institutions and policies that underpin CBCA, from macroeconomic data (INSEE) to methodological standards (ADEME). The relationship between national frameworks and local climate action is well documented in the literature. National institutions can provide essential data, methodological standards, and legitimacy, enabling cities to develop robust climate policies (Bulkeley & Kern, 2006; Kern & Bulkeley, 2009).

Conversely, research shows that cities can also innovate in the absence of strong national direction by leveraging local academic and technical expertise. For example, Gothenburg does not benefit from national institution data but draws on the academic expertise of the SEI. However, such innovation may be less stable or scalable without institutionalized national support (van der Heijden, 2019; Castán Broto & Bulkeley, 2013).

5.3 Political framing and target settings as a key enabler towards CBCA
A shared enabler in both contexts is the framing of CBCA through clear, time-bound targets embedded in official climate strategies. Paris aims to reduce territorial and consumption-based emissions by 80% from 2004 levels by 2050. Gothenburg targets a per capita reduction to 3.3 tonnes CO$_2$e by 2030. The literature demonstrates that setting ambitious and specific targets not only structures implementation but also acts as a powerful tool for political mobilization, stakeholder engagement, and accountability (Rogge & Reichardt, 2016; Hsu et al., 2020).

Closely tied to target-setting is the integration of CBCA across departments and sectors. Paris exhibits more formalized coordination through interdepartmental mechanisms and city-wide climate charters. Gothenburg relies on horizontal integration, embedding CBCA objectives across all departments and city-owned companies through its Environmental and Climate Program (2021-2030). This integration ensures that scope 3 data informs procurement, planning, and budgeting processes which are key for mainstreaming beyond symbolic commitments. The mainstreaming of CBCA objectives across municipal departments and city-owned companies, as seen in both Paris and Gothenburg, is also recognized as a best practice for effective climate governance (Bulkeley & Kern, 2006; Reckien et al., 2018).

5.4 The crucial role of stakeholder engagement
Stakeholder engagement is central to the legitimacy, operationalization, and sustainability of CBCA governance. In Paris, structured participation is institutionalized through the Pacte Action-Climat-Biodiversité, a publicly accessible charter that mobilizes actors across sectors, from energy companies to grassroots organizations. This charter formalizes commitments, ensures transparency, and reinforces co-responsibility. It embeds climate action within a network of shared governance, illustrating that a broad societal buy-in is needed in order to carry out actions to counter consumption-based emissions. Gothenburg mainly focus on society organizations, sports associations, and NGOs are encouraged to align with the city's environmental objectives through financial support and access to public infrastructure. This fosters bottom-up engagement and reflects a high-trust model of participatory governance. The city has expanded its collaborative programs to include circular economy initiatives, highlighting the dynamic evolution of stakeholder roles in CBCA. Such bottom-up approaches are shown to be effective in mobilizing local actors, fostering innovation, and ensuring that climate actions are contextually relevant and widely supported (Aylett, 2015; Arnouts et al., 2012).

5.5 Normative Framing and Cities as Global Climate Actors
The deliberate inclusion of consumption-based emissions in local climate plans reflects a normative redefinition of urban responsibility. Rather than limiting themselves to territorial emissions under their direct control, both Paris and Gothenburg embrace a broader ethical mandate that connects local governance to global sustainability. This shift positions cities not as passive implementers but as active shapers of post-territorial climate governance. This framing aligns with emerging literature on cities as global actors (van der Heijden, 2019).

Therefore, it can be argued CBCA equips cities with tools to address climate change systemically but also imposes new demands. Cities must negotiate responsibilities beyond their formal jurisdictions, build internal expertise, and ensure accountability for emissions they do not directly control. To succeed in this role, they require enhanced support - access to funding, methodological guidance, and platforms for international collaboration. The cases of Paris and Gothenburg reinforce the view that cities can lead in addressing global challenges when empowered with the right frameworks and coalitions. Their experiences suggest that CBCA is not just a technical exercise but a transformative approach to rethinking urban sustainability and governance in the age of climate crisis.

Conclusion
This article has examined the governance conditions of consumption-based carbon accounting (CBCA) through an in-depth comparison of Paris and Gothenburg, two cities that, despite distinct institutional contexts and levels of national support, each have advanced ambitious and pragmatic CBCA strategies. The findings reveal that while Paris operates within a highly institutionalized, nationally backed model and Gothenburg advances a more bottom-up, normatively driven approach, both demonstrate that local governments can lead on scope 3 emissions governance, even in the absence of a harmonized international framework.

The Paris case illustrates the strengths of a mature governance ecosystem where national institutions provide the methodological and legal infrastructure necessary to support robust CBCA integration. In contrast, Gothenburg shows that municipal innovation, when coupled with collaboration with expert institutions, can pioneer new methodologies and mainstream CBCA into city operations, even with limited national guidance. Across both cases, the success of CBCA governance is tied not only to technical capacity or institutional design, but also to the political and ethical reframing of urban climate responsibility. By choosing to include emissions beyond their direct territorial control, both cities expand the boundaries of local climate governance toward a more globally accountable model. Clear targets, cross-sectoral integration, and meaningful stakeholder engagement emerge as critical levers for embedding CBCA within policy and society. At the same time, the analysis underscores the fragility of such efforts when they rely too heavily on individual champions, external expertise, or voluntary mechanisms. To sustain and scale CBCA, cities need institutional safeguards such as binding mandates, integrated planning processes, and sustained national support.

Moreover, the broader governance landscape must evolve to recognize and support cities as global climate actors, providing the financial and technical resources needed to monitor, manage, and reduce consumption-based emissions.

Ultimately, the Paris and Gothenburg experiences show that CBCA is not only a technical tool but a political and ethical project. It calls for reimagining the role of cities in a globally interconnected carbon economy and for crafting governance arrangements that enable urban actors to lead climate action far beyond their borders. CBCA thus offers a vital lens through which to rethink both the responsibilities and the capabilities of cities in the age of planetary crisis.

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Social movements and collaborative climate adaption: the case of Campo do Bomba, in Duque de Caxias-RJ-Brazil

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Abstract
The sources discuss climate adaptation challenges in Brazil, noting that most municipalities lack capacity and plans. Local adaptation and community participation are crucial, especially in vulnerable settlements. Duque de Caxias, a flood-prone municipality, exemplifies these issues, marked by unregulated development and political resistance to public debate. The FORAS movement emerged, advocating for urban rights. A conflict centres on Campo do Bomba, a key floodplain, which the municipality wants for economic development despite its ecological role. FORAS mobilized, arguing its "sponge" function is its social function. Collaborating with academics, the community proposed the Quilombo do Bomba Ecological Park, featuring nature-based flood control, green areas, improved mobility, and community facilities. This case illustrates the struggle between economic interests and environmental/community needs

Keywords: climate adaptation, local government, community participation, vulnerable settlements;

Introduction

Addressing climate adaptation at the local level in Brazil represents a significant challenge due to the lack of institutional capacity and challenges in integrating sectoral policies. In Brazil, there are 5,570 municipalities. Data from the National Confederation of Municipalities indicate that between January 2013 and December 2024, a total of 5,279 Brazilian municipalities (95%) were affected by different kinds of disasters. Drought and excessive rainfall were the disasters that most affected Brazilian municipalities between 2013 and 2024 (Confederação Nacional dos Municípios, 2025) On the other hand, data from the AdaptaBrasil Platform indicate that more than 65% of Brazilian municipalities have low or very low capacity to adapt to natural disasters, such as heat waves, droughts and heavy rains.

The Rio de Janeiro Metropolitan Area (RMRJ) has twenty-two municipalities and only two of them have a Climate Change Mitigation and Adaptation Plan. Despite the Metropolitan Region of Rio de Janeiro (RMRJ) having an Integrated Urban Development Plan (PDUI) and a collegiate metropolitan governance body that brings together both local and state-level representatives, the urban actions that have been implemented remain fragmented, lacking a mitigating or adaptive approach to climate change. These projects are fragmented not only in their territorial scope but also in terms of the cross-sectoral integration of public policies.

Literature on climate change highlights the importance of cities and the local level in building adaptation strategies. The United Nations Development Programme (UNDP) highlights that climate adaptation is local in nature and that local governments should focus on adaptation activities and develop local strategies and action plans; the European Union's (EU) Strategy on Adaptation to Climate Change stress the importance of climate adaptation at the local level; the Global Commission on Adaptation (GCA) places an important emphasis on locally-led adaptation, which aims to shift "power to local stakeholders (OCDE, 2023). For Wannewitz and Garschagen (2023) adaptation is at least partly a communal task given that communities are in many ways bound together through infrastructure, geography, or resource management. They shared a common perception of hazard risk.

The authors propose a definition of collective adaptation "as actions of a group of individuals or subcultures collaborating according to shared rules to reduce their climate risk, exploit climate change opportunities and/or achieve additional common development objectives adopting a long-term perspective" (Wannewitz and Garschagen, 2023, p.2).

Peeling argues that adaptation agenda has local and global components and indeed national level action too. High level legal frameworks and voluntary agreements can support local action, but local level action is also a potential driver for higher level policy. But when this agenda is absent at higher levels, local action has the potential to be decisive in determining capacity and action and influencing the construction of a higher-level policy (Pelling, 2011).

Even if adapting to climate change is an important issue for the local environmental agendas, it is also a growing challenge for local communities, especially in marginalized informal settlements. Many informal settlements face high risks of floods and landslides a result of poor-quality buildings and a lack of infrastructure to prevent flooding, withstand heavy storms, and cope with heat waves (Wannewitz and Garschagen, 2023; Satterthwaite et al. 2020). The literature highlights the importance of social participation in the construction of adaptation strategies. Communities, and especially people who are marginalized, excluded, or especially vulnerable, must have some control over how their community will adapt (Adger et al. 2011).

But participation in adaptation strategies or policies at informal and vulnerable settlements is a complex issue. The question is if a vulnerable population has the political power – or political capability – to influence adaptation decisions, or if people most vulnerable to harm are politically capable of having control over their environment reveals opportunities to address the root causes of their vulnerability, as well as barriers to transformational outcomes. Informal communities often face a lack of political power, as their voices are marginalized in decision-making processes and their needs are overlooked by formal governance structures.

The local arena of environmental and climate adaptation politics includes elected officials and bureaucrats, as well as non-governmental actors, such as business entities, non-profit organizations, independent academics, political advocacy groups, and ordinary citizens who have a stake in climate adaptation decisions. It is a space where different interests are expressed and is therefore marked by conflict. Scientific expertise holds a privileged position in this arena. The privileged role of expertise can then function to diminish the voice and disregard the experience of those exposed to environmental harms (Ottinger 2013). Holland stresses the importance of alliances built by vulnerable or marginalized communities to enhance their capacity to be politically capable of shaping adaptation decisions, such as alliances with media or academics.

This paper addresses this topic through a case study in Duque de Caxias, a municipality in the Metropolitan Region of Rio de Janeiro that is severely vulnerable to flooding. Data on flood susceptibility indicate that 45% of households are in high-risk situations (Casa Fluminense, 2024). Focusing on the issue of social participation in discussions about climate adaptation projects and based on the definition of collective adaptation mentioned before, the paper focuses on a case study related to the protection of an area, Campo do Bomba, that has an important function in preventing floods. It highlights a community-driven project of sponge park, built from an alliance between the Urbanism Post-graduate Program at the Federal University of Rio de Janeiro and FORAS, an articulation of local social movements. The paper is organized into three parts in addition to this introduction. The first introduces the municipality of Duque de Caxias, its social characteristics, and its challenges concerning climate change and the local social movement, FORAS, which articulates the second proposal. The second section discusses the clash between the two proposals. The third focuses on the FORAS proposal and its development.

The case study area: Duque de Caxias and its vulnerabilities

Duque de Caxias is a municipality situated in the Metropolitan Region of Rio de Janeiro. The city has a population of 808,161 inhabitants (IBGE, 2022) and represents one of the major poverty areas within the metropolis. Regardless of this inequality scenario, the municipality holds the fourth largest GDP in the state (IBGE, 2021), with a per capita value of R$57,170.07. The industrial production at the Duque de Caxias Refinery (Reduc), operated by Petrobrás, accounts for 80% of Brazil's lubricant production, in addition to processing the largest volume of natural gas in the country. This generates significant revenue for the municipality through the collection of oil royalties.

Although Duque de Caxias ranks among the municipalities with the highest per capita tax revenue in the state, its Human Development Index (HDI) was classified as *Medium* in 2021, with a value of 0.711, placing it 49th in the state ranking—below the state median.

When considering the Income component of the HDI, the municipality ranks even lower, at 57th position.

Geographically, Duque de Caxias is in the Baixada Fluminense, at the foothills of the Serra do Mar, with a mangrove coastline bordering the Guanabara Bay. The municipality lies within the Guanabara Bay hydrographic region, the outlet for the main rivers that traverse the metropolis and is frequently affected by flooding.

The city is drained by three major hydrographic basins: Iguaçu-Sarapuí, Estrela, and São João de Meriti, in addition to other smaller continental catchments that drain directly into the bay. The rivers descending from the Serra do Mar do so along stepped gradients formed by fault lines. These rivers exhibit a torrential regime with significant erosive power. Upon reaching the lowlands, their flow becomes depositional, lacking an intermediate sediment transport phase between the slopes and the plains. The violently descending waters from the slopes encounter difficulty in draining across the plain due to the low terrain gradient, resulting in extensive flooded areas, such as swamps and marshes (Prefeitura de Duque de Caxias, 2017).

According to the diagnostic report prepared for the Municipal Sanitation Plan, the drainage difficulties in the municipality are primarily attributed to its geomorphological genesis. These natural conditions of floodplain formation are further compounded by unregulated urban development and a lack of basic infrastructure, which exacerbate the flooding issues. The soil sealing increases surface runoff, while the silting and obstruction of rivers with sediment and domestic waste diminish their drainage capacity. The frequent overflowing of watercourses is also affected by tidal fluctuations, thereby extending the duration of flood events (Prefeitura de Duque de Caxias, 2017).

The history of urban occupation in Duque de Caxias is closely tied to the establishment of petroleum-based industrial parks. The industry, by generating employment opportunities, attracted many low-skilled workers to occupy positions along the production chain. However, the strategy of locating industrial plants was not accompanied by a broader process of urban and regional planning to address housing and basic sanitation needs. This lack of integrated planning has contributed to the current scenario of pronounced social inequality.

According to Neves et al. (2019), between 2007 and 2016, Duque de Caxias experienced a significant expansion of its urban footprint, encroaching substantially upon areas of herbaceous vegetation. Beyond the direct suppression of vegetation resulting from urbanisation in Duque de Caxias, Neves et al. (2019) highlight a concerning trend: the direction of this urban expansion towards areas highly susceptible to flooding. This raises significant concerns regarding occupant safety, particularly given the region's known susceptibility to riverine flooding events (Britto, Quintslr and Pereira, 2019).

Despite environmental issues constituting the primary urban challenges in Duque de Caxias, the municipality's political and administrative culture continues to prioritise strategies for attracting industries at any cost, often without adequately assessing the associated benefits and drawbacks across various industrial sectors. Historically, public administration in Duque de Caxias has operated to serve the parochial interests of specific family groups, promoting ventures that have contributed minimally to the reduction of social inequality. Consequently, the socio-environmental outcomes in the region have generated hybrid risks, characterised by the superimposition of environmental threats such as floods, water and soil contamination from landfills and refinery leaks, atmospheric pollution originating from oil industry chimneys, and significantly substandard basic sanitation infrastructure.

By the early 2000s, the city was compelled to initiate an urban planning process, driven by Federal Law 10.257, known as the City Statute. The master plan was approved on 31st October 2006. In 2009, a study on the drafting process of the Municipal Urban Master Plan of Duque de Caxias highlighted that public participation was not adequately accommodated. It was observed that during over a six-month of plan elaboration, only 14 public meetings were held. Furthermore, some of these meetings were cancelled due to a lack of quorum.

One of the most flagrant indicators of inadequate participation was the fact that the Master Plan was voted upon without public presence and without the inclusion of amendments.

Nonetheless, Duque de Caxias has a set of social movements that were structured in the 1980s. In 1983, the Municipal Federation of Residents' Associations of Duque de Caxias (MUB) was created at a meeting attended by 27 residents' associations. The MUB emerged in a context in which several popular movements and community organizations were organized in the municipality, such as residents' associations, CEBs (Base Ecclesiastical Communities) and the Friends of the Neighbourhood Movement. These movements were organized during the military dictatorship, with their main causes being the fight for democracy, the right to health, basic sanitation, education and housing. A few other movements that also focused on environmental issues were also organized. However, the various local governments resisted the democratization of public management through participatory processes.

The process of the plan shows this local government unwillingness, demonstrating the extent to which the administration is refractory to the concept of planning and regulating the territory through public debate. Such planning typically reveals conflicts and establishes rules for reconciling different urban land uses. Without stringent regulation, any type of enterprise can establish itself in the municipality, which offers minimal or no restrictions on activities that could cause environmental damage. In the case of Duque de Caxias, there is a discernible lack of concern on the part of governmental authorities regarding whether new ventures embraced by the municipality as an economic strategy conflict with public health considerations.

The land-use zoning imposed by the Duque de Caxias Master Plan was not revised within the stipulated 10-year period for its renewal. Amendments to the Master Plan have been enacted through complementary laws whenever the administration deems it necessary to alter provisions to accommodate specific political projects. Between October 2006 and May 2025, the Master Plan's text has been subjected to 14 alterations. All these changes have specifically modified land use to permit the economic exploitation of areas that were frequently designated as areas of environmental interest or subject to occupation restrictions. Out of the 14 modifications to land use within the Master Plan enacted by the municipality, five pertain to the suppression or reduction of the delimitation of Special Environmental Interest Zones to accommodate Special Business Zones. Furthermore, two complementary laws relate to the intensification of land use in Controlled Occupation Zones, reclassifying them as urban expansion areas. This paper reports on the community mobilisation in São Bento concerning the land-use changes affecting a parcel of land. This area was decoupled from the São Bento Environmental Protection Area and subsequently reclassified as a business interest zone.

In 2014, faced with the imminent construction of a multi-activity complex that included a shopping centre, office towers, and an aparthotel planned for the last remaining green area in the central region of Duque de Caxias at the time, the local population, recognizing the scale of the initiative, organized in opposition, creating the Forum of Resistance to the shopping mall named FORAS.

From the perspective of promoting greater public participation in city management and pressuring municipal authorities to prioritize the interests and needs of the population, FORAS positioned itself against the construction. It denounced its various social, cultural, urbanistic, and environmental impacts of the project and proposed, instead, the creation of an urban park. This park would contribute, among other things, to preserving the city's memory.

The chosen format for organizing this initiative was a People's Forum—a space where various organizations and grassroots movements could participate without losing their unique identities. Institutions involved in this process included among others: local cultural associations, environmental movements, feminist movements, Federation of Residents' Associations of Duque de Caxias (MUB); the Forum of Communities Affected by the Petroleum and Petrochemical Industry near Guanabara Bay (FAPP-BG); the State Union of Education Professionals (SEPE); the Duque de Caxias Oil Workers' Union (SINDIPETRO-CAXIAS; the National Movement for Housing Rights (MNLM); the National Union of Black Men and Women in Duque de Caxias (UNEGRO) and Catholic Church leaders and members.

During the movement against the shopping mall, meetings were held with public authorities, workshops were conducted in schools, and participation in municipal participatory councils and conferences was emphasized. Other activities included publishing educational booklets, organizing public hearings, distributing pamphlets, graffiti campaigns throughout the city, and filing public civil actions. The Institute of Urban and Regional Planning and Research (IPPUR-UFRJ) was a key partner of FORAS, contributing activities to enhance public discourse, equipping activists with the technical knowledge necessary for effective dialogue and advocacy with local authorities.

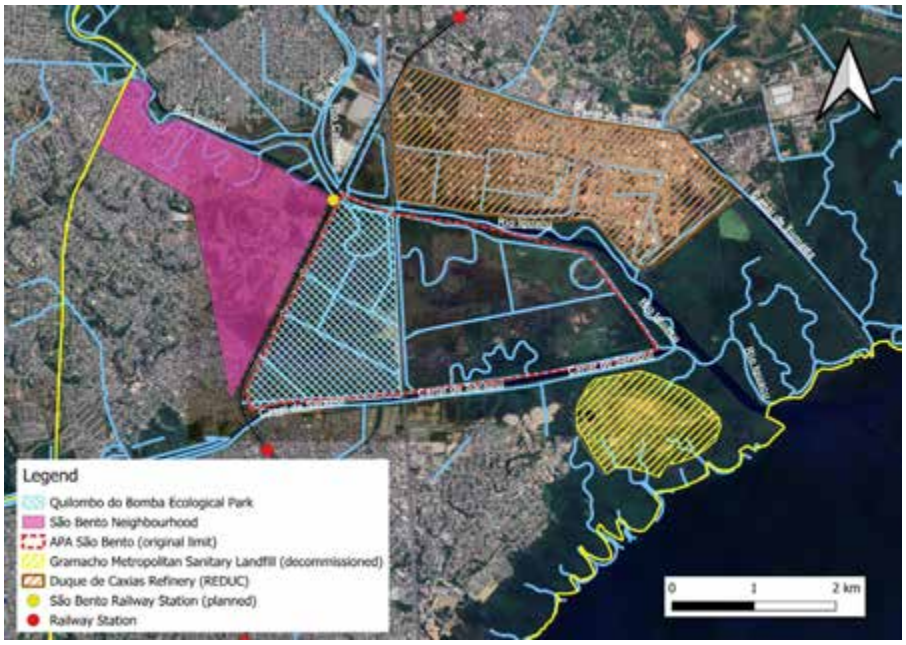
The movement organized by FORAS was victorious, bringing the conflict beyond the city's boundaries, to the extent that, to this day, the Central Park Caxias project has not been realized. In the process, FORAS established itself as a unifying force for major grassroots movements in the city, advocating for community libraries, protecting the city's historical heritage and the environment, and fighting for urban rights. Despite an unfavorable political climate in the city, FORAS members remained vigilant regarding new projects, denouncing the predatory occupation of public lands and deforestation.

Another critical moment of mobilization arose in response to the 2018 Metropolitan Urban Development Plan proposals for Duque de Caxias, which sought to promote logistics activities in the municipality, compromising environmental quality. One proposal that faced significant opposition involved an area known as "Campo do Bomba", in the São Bento neighbourhood, which will be explained in the following section.

The fight for Campo do Bomba preservation

The São Bento neighbourhood, situated between the estuaries of the Iguaçu and Sarapuí rivers, was historically part of the São Bento Farm. This land was transferred by the Ministry of Agriculture to the National Institute of Colonization and Agrarian Reform (INCRA) upon its establishment in 1970. A portion of this region now constitutes a Municipal Environmental Protection Area (APA de São Bento). The São Bento APA is divided into the eastern part and western part. The eastern part, under the possession and supervision of the Navy, has different communities settled by the Ministry of Agriculture, the State Government, social movements, and militia members who illicitly sold Union lands without the knowledge of the National Institute for Colonization and Agrarian Reform. The western contains archaeological and historical heritage sites and one of the last remaining fragments of the Atlantic Forest in close proximity to the municipality's urban centre (Figure 1)

On October 27, 2006, the then-mayor of Duque de Caxias enacted Law No. 2003/2006, which excluded the areas known as Campo do Bomba 1 and Campo do Bomba 2 from the São Bento Environmental Protection Area (APA). Together, these areas covered approximately 315 hectares. The justification for this exclusion was unclear.



São Bento neighbourhood has long been regarded as a metropolitan sacrifice zone, owing to its location adjacent to the Duque de Caxias Refinery (REDUC) and the former metropolitan landfill of Gramacho. The APA de São Bento is highly valued by the local population, serving as a natural barrier against atmospheric pollution emanating from REDUC and acting as a buffer zone against the risk of chemical leaks from the industrial area. Furthermore, it plays a critical role in the region's hydrological dynamics by absorbing a portion of the flow from the Iguaçu and Sarapuí rivers, thereby mitigating the effects of flooding in the Baixada Fluminense lowlands.

In 2017 Duque de Caxias government announced a project to build in the Campo do Bomba area a new State Central Supply Market (CEAERJ), and it requested INCRA to donate the land to the municipality. The Municipality initiated a process of landfilling the area, thereby suppressing native vegetation. Concerned by the potential consequences of this undertaking, FORAS initiated a political mobilisation against the project arguing the environmental role of the area, and the negative consequences of its occupation.

The municipal government's idea was to build the new State Central Market to replace the old one located in Rio de Janeiro suburb since the 70's. The Association of Ceasa Merchants were against the change. The decision concerning the relocation of CEASA was under the state government's responsibility, and the project from Caxias municipality wasn't approved. But the idea of giving an economic function to the area remained.

Between 2017 and 2018 the state government developed the Integrated Urban Development Strategic Plan for the Metropolitan Region of Rio de Janeiro (PDUI/RMRJ). Discussion groups were created to address different subjects, followed by integration discussion groups that consolidated scenarios and subsequently the proposals for priority actions included in the plan. One of these actions concerned the Campo do Bomba area.

The project was part of the subprogram "Living in the Metropolis," and it aims to mitigate flooding in the Iguaçu-Sarapuí River basin through macro-drainage interventions in the Campo do Bomba area. The metropolitan project was aligned to the municipal interests to give to this area an economic use. It aimed to install a canal between the Iguaçu and Sarapuí rivers to reduce the over flood of the two rivers. This canal would ensure the flood mitigation function, thereby allowing the remaining (3,000,000 m² of Campo do Bomba) to be utilized for industrial, logistical, and other purposes (Consórcio Quanta-Lerner, 2018).

The project mobilized FORAS that organized meetings to discuss the metropolitan plan projects to Duque de Caxias. But until then, the occupation of Campo do Bomba was only a non-developed project. The situation changed. With the approval of the guidelines included in the Metropolitan Plan, the government of Duque Caxias took up the project to give the area an economic purpose, now in the form of a logistics centre, similar to CEAERJ. A bidding process was conducted, and the area was granted to the territory's winning consortium—the sole bidder.

When the landfilling of the area began, in 2020, members of FORAS (researchers, environmentalists, lawyers and fishermen) began to meet every week to discuss strategies for action against the landfill. The dispute ended up in the Federal Public Ministry (MPF), which requested that the work be suspended and that studies be carried out to assess the impacts it could cause. The land is, in fact, owned by the National Institute for Colonization and Agrarian Reform (Incra), a federal agency, and ceded to the municipality. Due to the non-compliance with clauses of the donation agreement that conditioned the donation to a socio environmental project to the area, and the accomplishment of the social function of the land- a principle of Brazil's Constitution- the Federal Public Prosecutor's Office, ordered the reversal of the donation term.

Although the Public Prosecutor's Office successfully suspended any ongoing interventions by the municipality in the area, the local government maintained its agenda. In 2021, Duque de Caxias, presented a reformulated project, including a study for the channel between Iguaçu and Sarapuí river, elaborated by un expert in hydrology, which was responsible for the Iguaçu Sarapui River Basin Plan, elaborated within a contract with the state government's environmental agency (INEA).

In march 2021 a public hearing was conducted by the Federal Public Prosecutor's Office and mediated by Federal Prosecutor Júlio José Araújo Júnior. It included the participation of representatives from the Duque de Caxias municipal government, the Rio de Janeiro State Environmental Agency (INEA), the National Institute for

Colonization and Agrarian Reform (INCRA), the Public Defender's Office, and civil society—comprising teachers, residents, and individuals connected to social movements. The hearing was held remotely via the YouTube platform and streamed live. At that time, due to the health emergency caused by COVID-19, it was not possible to hold in-person public hearings to prevent the spread of the disease.

During the herring, the representative of the municipal government argued that Campo do Bomba wasn't fulfilling a social function and that there was a risk of the area becoming a "slum,". He states that economic development will prevent a disorderly occupation and will create about 50,000 jobs and an increase in tax revenue for the municipal administration. The municipality also emphasized the area's strategic location, adjacent to the Washington Luís Highway and near the Duque de Caxias petrochemical hub. The government's project shows a cluster of plots occupied by warehouses with highly waterproofing. The study conducted by the expert for the canal that will prevent the floods and allow a non-residential occupation of the area was not presented.

The proposal of the municipal representative was contested by FORAS members, who presented studies showing the importance of Campo do Bomba as a sponge site, absorbing water from flood water from rivers and preventing worsening flooding in the surrounding occupied area. The population living around Campo do Bomba considers that the site already fulfils its social function, which is its ecological function. The climate change impacts were highlighted. Sarapuí and Iguaçu rivers are silted up due to mud and trash, which hinders water drainage during rainfall. The progressive rise in sea level caused by climate change is expected to further worsen this situation because both rivers have a configuration highly prone to flooding. When it rains, the sea acts as a wall holding back the flow and preventing the floodwaters from receding. In the coming years, climate change could increase rainfall volumes by up to 30%.

To counter the potential occupation of Campo do Bomba, FORAS organized a petition to transform the area into a state-protected park. The document was presented to deputies in the Legislative Assembly of the State of Rio de Janeiro, leading to the proposal of a bill by a deputy who embraced FORAS's cause, presented in the Legislative Assembly in the end of august 2021.

In the process of the drafting of a bill, this representative organized three public hearings in 2021 at the Legislative Assembly, attended by representatives from the Caxias municipal government, FORAS, INCRA, the Federal Public Prosecutor's Office, and INEA, all of whom were given the right to speak. During the debate in the public hearing in September 2021 the representative of Duque de Caxias mentioned the project of the canal between the two rivers, but did not present it. The representative of the State Environmental Agency, INEA, stated that the area is highly complex and requires technical studies conducted by a multidisciplinary team to issue the Environmental Technical Opinion. These studies are necessary because the area involves an entire ecosystem, including fauna and flora; however, such studies have not yet been conducted by the state agency. It was emphasized that, due to the proximity of the Sarapuí and Iguaçu Rivers and its coastal location near Guanabara Bay, the region functions as a floodplain, it was important to conduct a more detailed study of the area's hydrological behavior.This study should outline the advantages and disadvantages of implementing the Duque de Caxias government project, as well as all environmental consequences. This instrument will then be reviewed by INEA, and after analysis by the technical team, a decision will be made regarding the area.

The Campo do Bomba's community planning

Concurrently, within the political discourse and community leadership mobilisation, Bill No. 4773/2021 was submitted to the Legislative Assembly in 2019, proposing the establishment of the Quilombo do Bomba State Park in the area. However, the bill remains under discussion, and the ultimate designation of the area is still uncertain. The name of the park was chosen by FORAS members because the site was also home to the Quilombo do Bomba. Quilombos are settlements established by escaped enslaved people (known as quilombolas) in Brazil during the colonial period. These communities were often formed in remote areas and served as places of resistance, refuge, and self-determination. Quilombo do Bomba was part of the most famous quilombo complex in Rio de Janeiro, known as the Hydra of Iguaçu, a reference to the mythical monster and the river that crossed the settlement. To this day, residents find ancient artifacts in the surrounding area. For researchers, building on Campo do Bomba is equivalent to permanently burying the memory of the place.

Given the local community's recognition that the land's social function should be maintained as an environmental protection area and considering the context of climate change and the already observed alterations in natural phenomena, the community has sought partnerships to assist them in developing an alternative proposal for the land parcel. Despite the existence of the Bill for park creation, the community fears that the proposed urban and landscape design may not adequately consider aspects they value. In this regard, a local effort was made to establish contact with the Federal University of Rio de Janeiro's Faculty of Architecture and Urbanism, seeking academic cooperation with residents in preparing a preliminary study for a viable park in the area.

Within the scope of the Professional Master's Programme in Landscape Architecture, a design studio course facilitated the development of a preliminary study for the Quilombo do Bomba Ecological Park. The professors and students implemented a participatory design process. Members of FORAS participated in all the studio classes and lectures on water sensitive cities and nature-based solutions. Field work and discussions with the community were held in numerous meetings.

As a result, the local population prioritised five key strategies to be integrated within the park's spatial framework.

Water Strategy
Given that flooding and sanitation are central issues in the neighbourhood, the population advocated for these problems to be primarily addressed with nature-based solutions. Initially, however, the completion of the unbuilt dikes from the Projeto Iguaçu and the expansion of polder areas along the Sarapuí and Iguaçu rivers were proposed. Recognising that urban occupation no longer permits the river's original meandering, engineering methods are necessary to ensure the local population's safety from floods.

In contrast to the landfilling proposed by the municipality, the community favoured excavating the area to create a large detention basin, allowing the interlinking of both rivers for promoting flow control in both river basins. Excavation would enable the construction of various cells at different elevations, which would be inundated as river levels rise. The objective is to retain this water during peak flow periods and gradually release it after the crisis subsides. Furthermore, the excavation aims to establish a constant water surface across a significant portion of the terrain for planting phytoremediation species, accelerating water purification processes.

For the neighbourhood, the installation of water distribution, sewage, and drainage networks is a key guideline. During this process, there is a strong demand for replacing asphalt with permeable pavements and installing rain gardens to reduce the volume of surface runoff from rainwater.

Green Strategy
The green strategy is intrinsically linked to drainage issues, particularly concerning the maintenance of dike structures and the role that vegetation plays in soil stability and permeability levels.

The project anticipates the restoration of riparian forests along the rivers through planting on dike slopes. The aim is for roots to stabilise the slopes while creating a continuous tree canopy along the dike to facilitate genetic material transit via fauna. The dike structure must also support the passage of dredging tractors, with accessible points to the river for maintaining the macro drainage channel.

In addition to the dike strategy, the Quilombo do Bomba Ecological Park area is traversed by Furnas' high-tension energy distribution infrastructure. The "non aedificandi" (no-build) zone beneath the power lines has the potential to be utilised as a strategy for promoting corridors to form a system of green areas and interconnect conservation units within the Baixada Fluminense.

Furthermore, part of the territory could also be used for establishing urban gardens, mitigating issues related to food security in the area.

Mobility Strategy
Considering the precarious conditions in the area, the widespread absence of private vehicle ownership in the neighbourhood, and the need for access to the job market, the São Bento population demanded accessible (physically and financially) public transport for the project. Research conducted by students, based on community

statements, revealed a historical plan for a train station within the neighbourhood at the perimeter of the Quilombo do Bomba Ecological Park. This proposal was subsequently incorporated into the preliminary study.

The devised strategy was to utilise the tops of the dikes that connect to the railway line as a large cycle path, allowing flow from the neighbourhood to the train station and the centre of Rio de Janeiro. This cycle path would reach other Baixada Fluminense municipalities, such as Belford Roxo and São João de Meriti, potentially increasing the use of urban trains, mitigating greenhouse gas emissions from bus use, and influencing a modal shift among car owners.

The dikes would be structured with appropriate paving and shaded by the planned riparian forest. Additionally, the station could be located on the banks of the Iguaçu River, which was historically navigable and has the potential to integrate with fluvial transport to Guanabara Bay. For the consolidation of bicycle use, residents highlighted the need for bicycle parking associated with the new station, as well as the implementation of shared bicycle stations for access by those who do not own one.

Mobility also encompasses the redesign of local streets, incorporating level, permeable, and shaded pavements.

Regional integration was also considered by incorporating the Park as a connecting route between the São Bento neighbourhood and the Pilar and Jardim Gramacho neighbourhoods, as well as with the Washington Luís Highway, through suspended walkways and viewpoints constructed at their intersections. In this sense, these walkways, which would also include cycle paths, would allow residents of São Bento and Pilar easy access to facilities such as the Federal Institute of Rio de Janeiro, located in Jardim Gramacho, an area currently "distant" due to various existing spatial fragmentation elements: the railway line, rivers, impenetrable land parcels, etc.

Social and Environmental Development Strategy
Throughout the discussions concerning the preliminary design of the Quilombo do Bomba Ecological Park, the need to integrate the area into the community's daily life was frequently highlighted, ensuring the space would not be occupied by housing or economic activities incompatible with the proposed model. To achieve this, the strategy would involve the urbanisation of the land's periphery as a mechanism to protect its ecological functions while simultaneously endowing the periphery with public uses necessary for the local community.

One frequently cited demand was for a creche (daycare centre). This is due to the high incidence of households headed by women in the area, and their need to secure childcare for young children to enable economic activity. The 2022 census indicates that the São Bento, Pilar, and Jardim Gramacho neighbourhoods have 52.40%, 51.75%, and 52.77% female-headed households, respectively.

In addition to a daycare centre, the necessity of a community centre for meetings of various organised groups lacking a formal meeting space was mentioned. This community centre could also host courses and lectures for the community and provide an area for exhibiting local artisanal production.

The periphery should also include leisure areas not hegemonically used by men and boys, as is often the case (e.g., multi-sport courts, skate parks). Instead, it should feature meeting areas for the elderly, spaces for caregivers adjacent to playgrounds, and playgrounds with specific equipment for different age groups.

The park's needs program also included the use of environmental education-promoting furniture, where air quality sensors, rain gauges, and anemometers could be installed, or which could narrate the local community's history. In this sense, the Quilombo do Bomba Ecological Park could be concretely integrated into residents' lives, reinforcing local identity.

Housing and Urban Infrastructure Strategy
While much of the discussion revolved around the preliminary design of the Quilombo do Bomba Ecological Park and the integration of this new space into local dynamics, reflection on the concrete reality of the population was recurrent and important for incorporating aspects related to residents' living conditions into the project guidelines.

To enable the strategies described previously, articulated action through housing policy is crucial. The population residing on top of the dikes, who are the primary victims of annual floods, must be relocated to new housing. Consequently, this housing must be within the neighbourhood's perimeter so that the population does not lose social ties with their neighbours or their solidarity network, nor lose the benefits of the park to be realised due to their own resettlement.

For the consolidated areas of the São Bento neighbourhood not within environmental risk zones, the guideline is the implementation of water, sanitation, and drainage infrastructures. As it is an INCRA area, the community's land regularisation process could also be initiated through a REURB-S process, where public investments would be directed towards installing this basic infrastructure.

Conclusions and Future Developments

This paper discusses how organized social participation can build alternative projects for climate adaptation. The literature analysed on the subject highlights the role of the local level in constructing adaptation agendas and the importance of social participation in shaping these agendas. However, it also underscores the challenges of participation in contexts of socio-environmental vulnerability, where social actors are deprived of power., and their capacity to influence decision-making remains a limiting factor. Government practice continues to be largely resistant to the demands of the population, as the local political arena for climate adaptation is a contested space where competing interests collide.

Urban and environmental projects that impact areas vulnerable to climate change and claim to mitigate these effects are often top-down initiatives, disregarding the experiences, knowledge, and interests of those living in these areas. One way to counter these projects is through the creation of collective adaptation projects, built by forming alliances.

The case study focuses on the municipality of Duque de Caxias, where the local government lacks both institutional capacity and political will to address the climate emergency. On the other hand, there are organized social movements in the region that address this issue and oppose government projects that negatively impact the environment and increase the local population's vulnerability to the effects of climate change.

Beyond mere opposition, these social movements strive to propose alternative projects to official initiatives, where climate adaptation becomes a crucial aspect. To achieve this, strategic alliances are formed to provide the projects with technical and political support. It is within these alliances and the articulation built in the territory that the concept of collective adaptation lies.

The paper analyses the construction of a collective adaptation project by social movements in São Bento, Duque de Caxias in alliance with progressive political actors, the Federal Public Prosecutor's Office, and the university. The project addresses a context where socioeconomic vulnerability combines with vulnerability to flooding. It emerged as a counterpoint to another project, driven by dominant economic interests and supported by municipal and state government spheres, which overlooked local demands.

Government's project prioritizes economic development in a narrow sense and seeks to promote the installation of large-scale logistics infrastructure. This would require landfilling an area that, until recently, was part of an environmental protection zone and which plays a critical ecological role, providing natural mechanisms for mitigating environmental impacts. On the other hand, there is the counterproject from the São Bento community, which values environmental preservation and integrated socio-environmental development. This vision is embodied in the proposal for the Parque Ecológico Quilombo do Bomba, a community-led plan that seeks recognition of the area's ecological function as its social function, using the site as a space for sustainable climate adaptation.

Despite social mobilization and legal actions, the legal status and fate of contested areas such as Campo do Bomba remain uncertain, depending on the outcomes of political and technical processes at various levels of government. There remains an urgent need for in-depth technical studies carried out by multidisciplinary teams. The future development of vulnerable areas such as Duque de Caxias will depend on the ability of social movements and communities to overcome local political resistance, foster public debate, and defend development models

that integrate climate adaptation, environmental preservation, and basic social needs — as opposed to models focused exclusively on unregulated economic growth.

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Addressing Climate Equity Through Community Engagement on Virginia's Eastern Shore

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Abstract
The Eastern Shore of Virginia (ESVA) is experiencing severe climate impacts, including sea-level rise, flooding, and groundwater salinization, which disproportionately affect its rural, resource-dependent, and underserved communities. The ESVA Climate Equity Project, funded by the National Science Foundation's Coastlines and People (CoPe) program, employs a participatory framework that integrates local knowledge with scientific modelling to co-develop a climate adaptation decision-support tool. Through community workshops, stakeholder interviews, and the guidance of a diverse Community Advisory Committee, the project fosters inclusive engagement, deepens local understanding of climate risks, and strengthens collective capacity. Findings highlight the importance of addressing structural barriers, investing in civic infrastructure, and embedding local priorities into adaptation strategies. The article offers practical lessons and policy recommendations for equitable climate resilience planning in similarly at-risk coastal communities.

Key words: climate equity; community engagement; rural coastal communities

Introduction

Coastal communities are on the front lines of climate change, facing mounting risks from sea-level rise, intensifying storm events, saltwater intrusion, and hydrological variability. Rural coastal regions, in particular, are highly vulnerable due to their dependency on natural resource-based economies, limited infrastructure investment, and geographic isolation (Bhattachan et al., 2018). These areas frequently contend with aging or inadequate public systems, declining population trends, and chronic underfunding—conditions that compromise their adaptive capacity in the face of escalating climate pressures (Vogel et al., 2007; Marino, 2015).

The Eastern Shore of Virginia (ESVA) exemplifies this intersection of physical exposure and socio-institutional vulnerability. Located between the Chesapeake Bay and the Atlantic Ocean, the Eastern Shore of Virginia is a narrow peninsula experiencing one of the highest rates of relative sea level rise along the U.S. Atlantic coast, due to both global sea level rise and localized land subsidence (Sweet et al., 2022). According to the NOAA Technical Report, the Mid-Atlantic region, which includes the ESVA, is projected to experience a relative sea level rise of approximately 10 to 14 inches (0.25 to 0.35 meters) by 2050 (Sweet et al., 2022). This rate is among the highest along the contiguous U.S. coastline. The region's low elevation, shallow aquifers, and rural character make it highly susceptible to coastal and inland flooding, groundwater salinization, and septic system failures (Walker et al., 2019; DeMaria et al., 2020). These environmental hazards are compounded by socio-economic disparities, limited access to scientific resources, and fragmented governance structures—factors that hinder cohesive, long-term planning (Jurjonas & Seekamp, 2018; Commonwealth of Virginia, 2020).

This article examines these challenges through the lens of the ESVA Climate Equity Project, a National Science Foundation (NSF)-funded project aimed at fostering participatory, equity-oriented climate resilience strategies in the region. Grounded in principles of co-production, the project integrates community engagement with environmental modelling to develop a Livability Tool that supports localized climate adaptation. This article, hence, contributes to growing scholarly and policy discussions on how participatory processes can enhance addressing equity issues in changing climate and produce more just and effective climate solutions in rural regions.

These environmental threats intersect with deep-seated social inequities. The region's rural character, socio-economic disparities, and fragmented governance limit the development and implementation of long-term resilience strategies (Jurjonas & Seekamp, 2018; Commonwealth of Virginia, 2020). In response to these challenges, a participatory, equity-centred framework for co-developing climate adaptation tools with and for the community was adopted by the Eastern Shore of Virginia (ESVA) Climate Equity Project.

This article examines how the project's participatory design—anchored in co-production and sustained community engagement—has helped identify climate priorities, foster trust, and inform the development of a "Livability Tool" for local decision-making. By situating this work within broader debates on inclusion and rural

adaptation, the article contributes to a growing literature on the transformative potential of collaborative, community-centred climate planning (Norström et al., 2020; Schlosberg et al., 2017, Edizel-Tasci and Evans, 2021).

Climate Challenges in the Eastern Shore of Virginia

The Eastern Shore of Virginia is experiencing the compound effects of climate change at both severe and chronic scales. Relative sea-level rise in the Chesapeake Bay region has been measured at approximately 3–5 mm per year—nearly twice the global average—due to a combination of land subsidence and global sea level trends (Boon et al., 2010). These changes increase the frequency and severity of both coastal and inland flooding, endangering transportation infrastructure, agricultural fields, and residential properties. In addition, the region's shallow aquifer systems are becoming increasingly saline due to saltwater intrusion, threatening drinking water supplies and farm irrigation.

Climate impacts in the ESVA manifest across multiple systems. Flooding events disrupt access to schools, health services, and employment centres, while declining groundwater quality strains the viability of domestic wells and small-scale agriculture. Many households rely on decentralized wastewater systems, such as septic tanks, which are increasingly vulnerable to saturation, failure, and backflow under rising water tables (Agbasi et al, 2025). These risks are unevenly distributed, with low-income and historically marginalized communities more likely to reside in low-lying areas, lack resilient infrastructure, or face financial barriers to adaptation (Kaufman & Williams, 2021). In this way, climate impacts amplify existing structural inequities and threaten basic livelihood systems (Chang et al., 2017, Edizel-Tasci and Evans, 2021).

The region's agricultural economy—anchored in poultry, soybeans, and vegetable production—is increasingly unstable due to shifting rainfall, saltwater intrusion, and declining water quality (Bhattachan et al., 2018). Meanwhile, the physical infrastructure (roads, bridges, culverts) is aging and often ill-equipped to handle extreme weather or stormwater, which undermines both economic mobility and emergency response systems.

Disruptions to water and transportation systems intersect with public health vulnerabilities. Children, elderly residents, and migrant workers are especially at risk, particularly during heatwaves, flood events, and disease outbreaks exacerbated by compromised sanitation. For example, blocked roadways can delay emergency medical services, while overcrowded or inadequate housing can intensify exposure to environmental stressors (Jurjonas & Seekamp, 2018; Walker et al., 2019). These cascading impacts highlight the interconnectedness of environmental and social systems and underscore the urgency of coordinated, equity-focused adaptation.

Disparities in Resilience

In rural coastal regions such as the Eastern Shore of Virginia (ESVA), exposure to climate-related hazards is unevenly distributed across communities. These disparities are shaped by historical land use patterns, demographic segregation, and unequal access to basic infrastructure and planning processes. Many of the region's most at-risk populations—including long-established African American communities and Latino farmworker groups—live in low-lying areas with poor drainage and limited stormwater infrastructure, often a result of historical exclusion from safer or better-serviced zones (Schlosberg et al., 2017; Kaufman & Williams, 2021).

These communities frequently face additional barriers: substandard housing, unreliable transportation, limited access to healthcare, and low political visibility. For migrant and seasonal farmworkers, for instance, overcrowded housing, limited mobility, and temporary work arrangements reduce access to reliable climate information or emergency support (Bhattachan et al., 2018). Language barriers and precarious employment further limit access to climate information or public support systems.

This dynamic reflects what Edizel & Evans (2017) describes as the spatial and institutional marginalization of underrepresented communities—where barriers to participation are embedded in both the physical environment and the formal processes of planning. Addressing these disparities requires more than technical solutions; it calls for participatory approaches that recognize lived experience, redistribute access to decision-making, and challenge dominant narratives about urban space.

As others have noted, adaptation efforts that do not attend to these underlying disparities may inadvertently reinforce the very vulnerabilities they seek to address (Schlosberg et al., 2017). Equitable resilience planning,

therefore, must attend to questions of who is most at risk, who is heard, and how systems can be restructured to deliver fairer outcomes.

Participatory Approaches in Climate Adaptation

Participatory approaches have become central to contemporary climate adaptation strategies, particularly in regions facing complex socio-environmental challenges. Over the past three decades, scholars and practitioners have developed a wide array of methods designed to involve communities in shaping the policies, practices, and infrastructures that affect their lives. As Beierle (2002) outlined, the goals of public participation often include educating and informing the public, incorporating local values into decision-making, enhancing the substantive quality of policies, building institutional trust, and reducing conflict.

These aims are especially relevant to climate adaptation, where scientific uncertainty, local variability, and contested values converge. Participatory methods—ranging from community mapping and deliberative workshops to scenario building and citizen science—enable residents to articulate lived experiences, prioritize risks, and shape policy solutions that are contextually meaningful (Few et al., 2007; Armitage et al., 2011).

A growing body of scholarship distinguishes between levels of engagement, emphasizing that meaningful participation goes beyond informing or consulting the public. Trench (2008) and Rowe & Frewer (2005) conceptualize public engagement along a continuum—from dissemination (one-way information flow), to dialogue (two-way consultation), to full collaboration or co-production (shared decision-making and mutual learning). Chang and Moore (2017) similarly stress the importance of designing enabling conditions that support inclusive processes—particularly those that shift power and resource control toward local communities.

In the context of climate resilience, co-production has gained traction as a framework that foregrounds equity, accountability, and situated knowledge. Norström et al. (2020) define co-production as an iterative process where power, knowledge, and responsibility are equitably distributed among actors. This is not merely a methodological choice but a normative stance—aimed at disrupting hierarchical knowledge systems that historically excluded marginalized voices. Edizel & Evans (2017) reinforces this perspective through her exploration of participatory mapping, highlighting how spatial practices can reveal embedded, often invisible forms of marginalization that shape both the physical and institutional landscapes—what she frames as the politics of representation and exclusion in planning processes.

In sum, participatory approaches in climate adaptation are most effective when they are designed not only to gather input, but to reshape power dynamics, institutional relationships, and governance outcomes. As the ESVA Climate Equity Project illustrates, co-production can serve as both a method and a political commitment—one that redefines how resilience is imagined, measured, and achieved.

Methodology

The ESVA Climate Equity Project adopts a participatory engagement framework rooted in principles of knowledge co-production. Rather than treating community engagement as a supplemental or extractive component of research, this project positions engagement as central to shaping research questions, methods, and outputs (Norström et al., 2020; Turnhout et al., 2020).

The project is supported by the National Science Foundation's Coastlines and People (CoPe) program, which supports interdisciplinary, place-based research to advance climate resilience in coastal communities. A core objective of the project is the development of an open-source data and visualization platform—referred to as the Livability Tool—that integrates scientific modelling with community knowledge. This five-year (2021-2026) collaboration between the University of Virginia, Old Dominion University, and regional community leaders aims to build local capacity for climate adaptation by foregrounding lived experience, historical context, and locally relevant priorities.

The project applies co-production as both a normative and methodological commitment, engaging diverse stakeholders in all stages of the research cycle. Drawing on the work of Lemos et al. (2018) and Howell and Wilson (2018), the research design emphasizes iterative feedback processes to ensure that outputs reflect the practical needs and values of the community. A core methodological focus of the project is the integration of

local knowledge—such as lived experience, oral histories, and cultural memory—with scientific tools including spatial modelling and hydrological analysis. For instance, flooding and groundwater models were developed and refined based on insights shared during workshops. Community members provided maps and narratives documenting salinization of wells, historical drainage patterns, and land use changes that would have been otherwise invisible in top-down datasets.

The project team is also advised by a Community Advisory Committee (CAC which serves as both a governance body and a bridge between the research team and broader community. The CAC includes 12 local leaders from education, public health, planning, nonprofit, and economic sectors, including representatives from public schools, community colleges, migrant advocacy groups, and social services. CAC members play a key role in shaping research questions, advising on engagement strategies, reviewing draft deliverables for accessibility, and supporting outreach and dissemination. Their guidance ensured that community voices were embedded in all stages of tool development and public engagement.Throughout the process, the research team met regularly with the CAC to refine outreach strategies and align engagement activities with evolving community concerns. This integrated, iterative approach aimed to strengthen trust, encourage local leadership, and embed community knowledge throughout the development of adaptation tools.

Stakeholder Identification and Outreach
Stakeholders were identified through a combination of network-based and snowball sampling methods, initiated through referrals from CAC members and extended via existing community relationships. Outreach efforts included targeted emails, local event tabling, word-of-mouth, and phone calls. This approach was designed to ensure representation from across the region's geographic, socio-economic, and institutional spectrum. Participants included elected officials, school staff, tribal leaders, public health professionals, nonprofit directors, small business owners, and civic volunteers. This diversity strengthened the relevance of the engagement process and contributed to the development of locally meaningful climate adaptation resources.

Community Workshops
Three in-person community workshops were held between January 2023 and August 2024, drawing a total of over 200 participants (67 in Winter 2023, 83 in Winter 2024, and 50 in Summer 2024). Each workshop was structured as an open-house event featuring 6–8 interactive stations. Topics were developed in collaboration with community members and included:

- Sea level rise and storm surge
- Septic system vulnerability
- Groundwater depletion and salinization
- Land use history and community memory
- Climate adaptation and planning scenarios

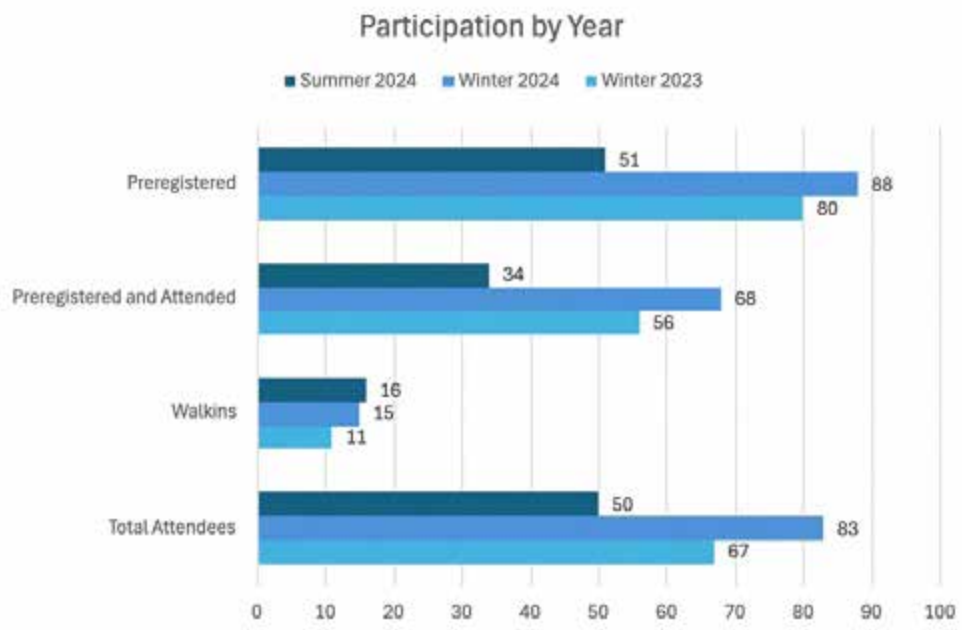

Figure 1: ESVA Workshop Participation Numbers by Years (2023-2024)

Each station was facilitated by a member of the research team. The format enabled participants to move freely, explore areas of interest, and engage in informal dialogue. Data collection methods included sticker voting, written comments, annotated maps, and structured conversation prompts (e.g., "What climate changes are you most concerned about?"). This iterative design supported multiple entry points for participation and fostered mutual learning among participants and facilitators.

Semi-Structured Stakeholder Interviews

Between September 2023 and May 2024, 20 semi-structured interviews were conducted with representatives from local government, education, public health, environmental NGOs, and media. Many of these interviewees were first introduced to the project through the workshops and later volunteered for follow-up discussions.

Interviews were designed to capture institutional perspectives on climate risk, planning processes, and community resilience needs. Each interview lasted approximately 60–90 minutes and was audio-recorded and transcribed for analysis. The interviews informed the framing of the Livability Tool and provided additional context for interpreting community engagement data.

Analysis and Discussion

The ESVA Climate Equity Project reflect a layered process of community engagement and knowledge co-production. The three community workshops—Winter 2023, Winter 2024, and Summer 2024—served not only as educational and participatory events but also as recruitment mechanisms for deeper engagement through interviews. During these workshops, community members were invited to sign up for follow-up interviews, which were conducted from September 2023 to May 2024. This sequential methodology ensured continuity between broad-based community feedback and more detailed institutional perspectives, enabling the project team to triangulate across qualitative inputs and refine project goals iteratively. The process also offers a grounded example of how participatory, equity-oriented climate research can generate meaningful insights, foster institutional trust, and support more just adaptation planning in socio-ecologically vulnerable regions.

1. Enhanced Community Understanding of Climate Risks

Throughout the engagement efforts, there has been an increase in community understanding of localized climate risks through iterative, station-based workshops and embedded institutional dialogue. The open-house format and use of visual tools (e.g., flood maps, story timeline boards) enabled participants to explore complex topics—such as groundwater salinization or septic vulnerability—in accessible and meaningful ways which emphasizes that tailored, place-based approaches foster greater comprehension and trust (Kahan et al., 2011; Lemos et

al., 2018, Edizel & Evans, 2017). Stakeholder interviews reinforced these insights, revealing how participatory activities informed internal agency conversations and community-level planning. For instance, concerns about septic system failures and saltwater intrusion—initially shared anecdotally in workshops—were later echoed by institutional actors who confirmed their growing salience in infrastructure and public health planning (See Table 1).

This convergence between community knowledge and institutional awareness aligns with Daniels and Walker's (2001) concept of Collaborative Learning, which highlights the importance of systems thinking, mutual learning, open dialogue, and constructive conflict resolution in support of adaptive decision-making. It further reflects Lemos et al.'s (2018) framing of *knowledge usability* as the central aim of co-production—emphasizing that knowledge becomes usable when it is not only credible and salient but also co-created through sustained relationships, iterative feedback, and contextual alignment with community needs. In this sense, the co-production process bridges technical expertise and lived experience, fostering actionable outcomes grounded in both scientific insight and local relevance.

Together, these participatory methods supported the ongoing calibration of scientific models with local experience and helped surface tensions between technical planning needs and lived realities. The iterative engagement strategy not only enriched the project's empirical base but also contributed to broader efforts to democratize climate adaptation. As Wyborn et al. (2019) and Fazey et al. (2014) argue, science must be co-shaped by communities if it is to advance meaningful and durable responses to complex social-environmental change.

Table 1: ESVA Resilience Priorities

Priorities identified by the Institutional Stakeholders	**Community Priority Questions Identified during the Workshop & CAC**	**Overview**
Water and Groundwater Management	How will septic systems, salinization of soils and groundwater be affected by land use change?	Stakeholders emphasized SLR's threat to infrastructure, such as the Chincoteague Causeway, and community displacement. Concerns included tourism, erosion, and uneven exposure.
Sea Level Rise and Coastal Resilience	How will sea level rise, flooding from storm surge, and intense rainfall affect ESVA communities and populations differently?	Interviewees raised concerns about septic system failures and saltwater intrusion, especially in Cape Charles and Chincoteague. Desalination is costly, and groundwater salinization threatens drinking water.
Agriculture and Land Use	What can our community do to mitigate and adapt to the effects of changes in land use and climate?	Changing rainfall patterns affect agriculture and water quality. Adaptive practices like regenerative agriculture were recommended.
Housing and Insurance Pressures	How can we create affordable retrofitting for homes and structures to withstand the increase of powerful storms and hurricanes?	Housing pressures include displacement due to short-term rentals, unaffordable insurance in flood-prone zones, and lack of affordable retrofitting options. These dynamics reflect broader vulnerabilities in coastal housing systems.
Public Health and Transportation Access	What can our community do to mitigate and adapt to the effects of changes in land use and climate?	Stakeholders advocated for mapping at-risk populations and improving rural healthcare access. Extreme heat, flooding, and lack of access to safe housing increase public health vulnerabilities were mentioned.
Community Engagement and Education	What practices would encourage and ensure input and collaboration from residents of underserved communities crucial to the planning process, and from local government officials vital to the implementation.	Stakeholders stressed the importance of youth education, decision-support tools, and inclusive processes. Initiatives aim to train residents in climate resilience.

The ESVA Climate Equity Project demonstrates how sustained engagement, shared governance, and co-production can lead to both more relevant science and more equitable adaptation outcomes. Both the workshops and interviews surfaced consistent climate resilience priorities across the community and institutional levels. The use of participatory methods to calibrate scientific models and scenario planning tools enhanced both the legitimacy and accuracy of project outputs. Rather than imposing static data products, the project adapted its design to community inputs—renaming the "Climate Equity Atlas" to the "Livability Tool," simplifying data visuals, and adding place-based filters. These changes underscore the value of participatory adaptation as not only an epistemic exercise but a procedural one that prioritizes responsiveness, relevance, and contextual sensitivity (Bremer & Meisch, 2017; Norström et al., 2020). Later workshops tested draft models, generating actionable suggestions such as clearer visuals, scenario planning, and localized data filters. Institutional interviews provided additional guidance on decision-making contexts and integration into existing planning workflows.

2. Trust-Building and Collective Action Outcomes

Trust-building emerged as both a goal and an outcome of the participatory process. In a region with a history of institutional disinvestment and marginalization, the opportunity for community members to express their perspectives and see them acknowledged served as a meaningful form of validation. The participatory nature of the project helped bridge historic divides between researchers and residents, government and underserved populations, and between institutions and lived experience. The project team's consistent responsiveness to community input—via workshops, interviews, and the advisory role of the Community Advisory Committee (CAC)—helped shift perceptions of research from extractive to collaborative.

Interviews with local leaders affirmed that consistent engagement, responsiveness to feedback, and the visible integration of community knowledge into the Livability Tool helped foster collective ownership. Trust, as defined by Leach and Sabatier (2005), is a necessary condition for collaborative capacity, particularly in politically fragmented or resource-constrained environments. These examples reflect the catalytic potential of inclusive engagement when paired with institutional alignment and sustained facilitation (Few et al., 2007; Wyborn et al., 2019).

Moreover, the project contributed to broader civic infrastructure by creating space for shared governance. The ESVA Climate Equity Project exemplifies the application of co-production in climate adaptation planning. Rather than positioning local stakeholders as passive recipients of expert knowledge, the project operationalized participatory methods through an iterative, multi-scalar design. This included the formation of a Community Advisory Committee (CAC), participatory workshops, and stakeholder interviews—all of which fed directly into the development of a Livability Tool that integrates both scientific data and community-defined priorities.

3. Barriers and Facilitators to Community Engagement

Despite success, the ESVA project encountered significant challenges associated with rural engagement: geographic isolation, transportation gaps, and uneven internet access. These barriers—identified by both community participants and institutional stakeholders—illustrate how infrastructure deficits can significantly undermine the effectiveness of otherwise well-designed participatory processes

The cross-cutting insights from workshops and interviews revealed systemic barriers to climate resilience, many rooted in long-standing inequities. For example, stakeholders noted how historical land use patterns left Black communities disproportionately exposed to flood risk, while limited transportation and digital connectivity constrain adaptation options for isolated residents. In response, the project's participatory model fostered pathways for both immediate input (e.g., through interactive workshop stations) and sustained dialogue (e.g., through advisory roles and interviews). Participants across both methods consistently emphasized the need for culturally relevant, economically accessible, and community-centred adaptation strategies.

Institutional silos posed another barrier, as many agencies struggled to coordinate across sectors (e.g., housing, health, water). However, the cross-sectoral design of the ESVA project—bringing together diverse actors in shared workshops and interviews—helped mitigate this fragmentation. As Chang and Moore (2017) note, enabling conditions for participation include institutional flexibility, relational trust, and distributed leadership, all of which were present in the CAC structure and workshop design.

Facilitators included strong local leadership, consistent CAC involvement, and the use of culturally resonant tools. By enabling participants to engage on their own terms—selecting stations, voting on priorities, and sharing experiences—the project lowered both cognitive and procedural barriers. This approach supported more inclusive engagement by fostering mutual understanding and shared meaning-making. Trench (2008) characterizes such interaction as symbolic of a participatory model of science communication—moving beyond unidirectional dissemination to emphasize reciprocal engagement, transparency, and co-constructed knowledge. By adopting this framework, the ESVA Climate Equity Project contributed to the ongoing evolution of public engagement practices, reinforcing the value of sustained dialogue and community agency in climate resilience planning.

4. Inclusive Participation Approaches for Underserved Populations

A central analytic contribution of the project is its emphasis on inclusion without dilution—ensuring broad participation while avoiding tokenism. The intentional recruitment of participants to overcome structural exclusions, as well as the CAC's diverse composition, helped counter structural exclusion.

Interviewees emphasized the importance of representation and access, noting that previously underrepresented groups now had a seat at the table—though challenges remain in sustaining participation over time. As Arnstein's (1969) classic "Ladder of Participation" model warns, engagement without real influence can breed cynicism. It also responds to the critique advanced by Schlosberg et al. (2017), who argue that adaptation must challenge the systemic marginalization embedded in planning processes themselves. The ESVA team addressed this by visibly integrating feedback into tool revisions and workshop themes.

Further, partnerships with educational institutions and local media outlets helped reduce language and accessibility barriers. The recognition that climate adaptation also requires investments in civic infrastructure—mentoring, training, and translation—demonstrates a mature understanding of participation as an ongoing process, not a one-time event (Tschakert et al., 2016; Wyborn et al., 2019).

Workshops employed a station-based open house format that invited reflection, discussion, and localized knowledge sharing. This format aligns with Edizel & Evans's emphasis on participatory mapping not just as a tool, but as a "relational and place-based practice" that strengthens community agency and makes structural inequalities visible. Similarly, Chang and Moore (2017) underscore the importance of relational trust, leadership, and institutional flexibility as enabling conditions for sustained participation—features that were embedded in the ESVA project design through continual feedback loops and collaborative decision-making.

Importantly, the project's participatory framework also addressed barriers to engagement, such as digital exclusion, transportation inequities, and language access. Rather than viewing participation as a one-off event, the project treated engagement as an ongoing process—responsive to community needs and grounded in transparency, accessibility, and respect. This echoes calls in the literature to move beyond technocratic, extractive engagement and toward dialogic, adaptive partnerships (Bremer & Meisch, 2017; Tschakert et al., 2016).

Conclusion

This paper demonstrates how participatory, place-based approaches can strengthen climate adaptation planning in rural, under-resourced coastal regions. Through community workshops, stakeholder interviews, and co-design of a decision-support tool, the project demonstrated that participatory methods are not only ethically necessary but also empirically effective in generating actionable, locally grounded adaptation strategies (Few et al., 2007; Norström et al., 2020). The integration of scientific models with community-defined priorities—facilitated through a Community Advisory Committee and iterative engagement—strengthened both the legitimacy and the usability of the Livability Tool. Beyond generating data, the project cultivated relationships, built institutional trust, and expanded the adaptive capacity of both community members and local institutions.

Policy Implications for Equitable Climate Adaptation

The ESVA experience underscores several key policy implications for equitable adaptation, particularly in underserved and rural communities:

- **Community-Driven Planning as Core Practice**: Meaningful engagement must go beyond consultation and involve co-decision-making structures. Embedding advisory committees or resident-led councils into governance processes increases legitimacy and aligns adaptation strategies with lived realities.
- **Data Democratization and Knowledge Co-Production**: Climate data must be transformed into usable formats that reflect local knowledge and priorities. Co-production frameworks support the design of tools that are both scientifically robust and socially relevant (van Kerkhoff & Lebel, 2015; Bremer & Meisch, 2017).
- **Cross-Sectoral and Multi-Level Coordination**: As seen in the ESVA case, siloed decision-making hinders effective adaptation. Adaptive governance requires cross-agency collaboration that bridges public health, housing, water, and transportation sectors (Adger et al., 2005; Armitage et al., 2011).
- **Civic Infrastructure as Climate Infrastructure**: Effective engagement depends on investments in civic infrastructure—such as translation services, facilitation training, and community organizing—not just in physical systems. Such support builds long-term capacity for adaptation (Chang & Moore, 2017).
- **Procedural and Distributive Fairness**: Without explicit mechanisms to address historical and structural marginalization, adaptation may reinforce existing inequities. Justice-oriented frameworks call for redistributive policies that prioritize frontline communities and expand access to adaptation funding and services (Schlosberg et al., 2017; Tschakert et al., 2016).

Lessons and Recommendations for Similar Coastal Communities

While climate risk is highly localized, the process lessons from the ESVA are widely applicable to other small, coastal communities grappling with sea level rise, water insecurity, and socio-economic vulnerability.

1. **Centre Community Priorities Early and Often**

Engage communities from the outset—not just to gather feedback, but to shape research questions, define engagement approaches, and guide outputs. This builds trust, legitimacy, and relevance (Reed et al., 2010). Tools like participatory mapping and story-based workshops can surface valuable localized knowledge that might otherwise be excluded (Edizel & Evans, 2017).

2. **Develop Long-Term Relationships, Not One-Off Consultations**

Avoid one-off or superficial engagement efforts. Build long-term relationships through advisory committees, recurring workshops, and feedback loops that allow communities to see how their input shapes outcomes. This fosters collective ownership and supports sustained civic capacity (Few et al., 2007).

3. **Address Structural Barriers to Participation**

Transportation challenges, limited internet access, language barriers, and institutional mistrust often block full participation. Engagement must be designed with these barriers in mind. Culturally resonant, locally hosted, and multi-lingual strategies increase accessibility (Chang & Moore, 2017; Tschakert et al., 2013).

4. **Embed Cross-Sector Collaboration**

Create engagement formats that convene stakeholders from multiple sectors—health, housing, environment, and education—together with residents. This promotes systemic understanding and supports more integrated, durable planning outcomes (Armitage et al., 2011).

5. **Treat Engagement as a Form of Adaptation Infrastructure**

Just as coastal communities invest in seawalls and drainage systems, they must also invest in the infrastructure of inclusion: facilitation, capacity building, digital access, and leadership development. These investments improve adaptive capacity and resilience over time (Lemos et al., 2018; Norström et al., 2020).

In summary, just and effective climate adaptation develops not only from scientific modelling or hazard mitigation, but also from the shared labour of co-producing knowledge, redistributing voice, and embedding equity in institutional practice. For other coastal communities seeking to navigate the complex terrain of climate change, this article offers a roadmap grounded in humility, collaboration, and the transformative potential of local leadership.

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Feminization of Energy Poverty in China: Contrasting Urban and Rural Experiences

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Abstract
Despite growing global interest in energy poverty and gender issues, limited research explores their intersection from a female perspective. This study examines the feminization of energy poverty in China, contrasting urban and rural experiences. Drawing on data from the China Family Panel Studies and applying mixed methods, the research finds that rural women face significantly higher levels of energy poverty than their urban counterparts. This disparity is linked to traditional Confucian gender norms, limited financial autonomy, and restricted access to education. Offering a feminist lens, the study enhances understanding of gendered energy disparities in China and proposes targeted strategies to support a more equitable and sustainable energy transition.

Keywords: Energy poverty; Gender bias; Urban-rural disparity; Confucian culture; China

1. Introduction

Promoting gender equality and access to affordable, reliable, sustainable and modern energy are two pivotal components of the Sustainable Development Goals (SDGs) outlined by the United Nations. Specifically, SDG7 calls for reducing dependence on biomass materials (carbon-based fuel like wood, leaves, straw, cow dung, coal, etc.) as the main source of cooking fuel. The progress toward achieving SDG7 has, however, been slow. As of 2023, around 2.3 billion households worldwide continue to suffer from energy poverty, lacking access to clean and efficient cooking solutions (International Energy Agency et al., 2023). Energy poverty is considered to have a woman's face (Sánchez et al., 2020). Earlier studies have revealed that the use of biomass in cooking imposes time, health, and environmental costs on households (World Economic Forum, 2022), with such costs often falling on women due to their traditional roles. For instance, Acheampong et al (2023) noted that using biomass fuels has disproportionately impacted women as they generally take on the more significant burden of household chores, including cooking and fuel collection. Moreover, energy poverty issues also affect women's well-being, as acquiring biomass fuels is time-consuming and often leads to indoor air pollution, posing significant health risks (Opoku, Kufuor, & Manu, 2021). In fact, the World Economic Forum (2021) has estimated that women are likely to spend close to 20 hours per week searching and collecting biomass fuels, whereas cooking with these fuels can take up to 4 hours per day. Furthermore, geographical inequalities in energy poverty further intensify these gendered burdens, particularly the urban-rural disparity. Research by Moniruzzaman and Day (2020) has underscored that rural woman, particularly in developing countries, face significant barriers to accessing clean and affordable energy, often due to limited infrastructure and low-income levels. These gendered responsibilities are compounded by the fact that rural communities, in comparison to urban areas, suffer from more frequent energy access disruptions, inefficient energy systems, and higher reliance on polluting energy sources (Revolve, n.d.). This phenomenon is rooted in the urban bias theory where social amenities provision and resource allocation (including energy access) disproportionately favors urban cities relative to rural communities. Moreover, rural women often have fewer opportunities for advocacy or policy engagement, leaving them more vulnerable to the negative impacts of energy poverty (Moniruzzaman & Day, 2020). As such, the urban-rural disparity in energy access not only deepens existing gender inequalities but also hinders progress toward energy justice, sustainable development, and human well-being (Scheier & Kittner, 2022).

China, as both the biggest developing economy and the world's largest carbon emitter, has committed to reducing energy poverty (Luan, Zou, & Huang, 2023). To address this issue, the Chinese government has launched a series of policy measures, such as the 'Household Biogas Project,' 'Photovoltaic Projects for Poverty Alleviation,' and 'Coal-to-electricity Project' (Shen et al., 2020). By 2013, China has achieved 100% access to electricity (World Bank, 2020), and the electricity consumption per capita has already surpassed the average level of the country's upper middle income (National Energy Administration, 2024). However, China is still facing serious challenges concerning energy accessibility, affordability, and service availability. According to Zhang et al. (2019), approximately 48.98% of Chinese households are still experiencing energy poverty, with over 400 million Chinese individuals relying

on traditional biomass and coal for cooking. The challenge is even more serious in terms of energy disparity. More than 75% of rural households primarily used coal and firewood as fuel sources (i.e., 17.1% and 58.6% with coal and biomass respectively), while 8.2% and 36.1% of households in urban and township areas used solid fuels for cooking (XX). Additionally, households using clean fuels accounted for 62.7% of the total townships, while the proportion was only 23.2% for rural areas. These facts indicate that the urban-rural disparity in energy poverty is still a pressing issue in China, which is one of the focal issues of this study.

Undoubtedly, gender inequality in the context of energy poverty is also a critical issue in China. This issue is particularly associated with the Chinese Confucian culture (Li, Leng, Hu, Cao, & Guo, 2023), which has long emphasized traditional gender roles and hierarchical social structures. As the core of traditional Chinese culture, Confucianism historically positions men as the primary decision-makers within the household, while women are largely restricted to domestic responsibilities (e.g., household chores and childcare). This cultural framework continues to influence contemporary societal norms, limiting women's access to energy resources and involvement in energy-related decisions, particularly in rural areas (Johnson et al., 2020). As such, households influenced by Confucian culture tend to exhibit gender bias and are more likely to experience energy poverty. Therefore, promoting gender equality in energy poverty requires not only an economic solution but also a deep understanding of the cultural norms that shaped gendered access to energy.

Despite the importance of gender inequality and geographical disparity in energy poverty, few studies have accounted for the geographical gender disparity and cultural norms' influence on women experience of energy poverty. We contend that such consideration is critical in ascertaining the fuller impact of energy poverty and to devise robust economic and social measures in countering the plights of women. Thus, the two main research gaps we seek to address include the following. Firstly, Gender Perspective: the general situation of women's vulnerability to energy poverty in China is still unclear, particularly the disparity in urban and rural area. Secondly, culture perspective, although the existing literature has explored the impact of culture on energy poverty, it has covered a wide range of cultures and has rarely focused on a country or region-specific culture.

Therefore, the aim of this study is to explore how energy poverty affects women in the Chinese context, with a specific focus on the disparities between urban and rural areas. It seeks to understand the risks women face in these settings and to examine how cultural norms (i.e. Confucian culture) shape women's experiences of energy poverty. By addressing these questions, this study may provide a nuanced understanding of the intersection between gender, culture, and energy poverty, contributing to more equitable energy policies and practices in China. This study contributes to the following aspects. First, this paper integrates feminization and energy poverty into a unified research framework. Accordingly, this paper can better analyze the factors of household energy poverty from the perspective of female. To the best of current knowledge, few studies have explored the situation regarding the feminization of energy poverty. Second, the possible factors (e.g., age, education level, financial status) concerning the feminization of energy poverty are captured. Third, the feminist approach can enhance our co. Therefore, this study adopts a feminist perspective while considering energy systems will establish the structure for creating a fair and equitable transformation in the energy sector. Understanding gender in energy concerns may help create alternatives to a more equitable and sustainable energy framework. The remainder of this study proceeds as follows. **Section 2** presents the background of this research, which includes a review of the relevant literature and the theoretical foundation guiding the study. **Section 3** introduces the data sources and empirical methodology. **Section 4** shows and discusses the empirical results of this study. **Section 5** offers further discussion based on qualitative data. **Section 6** concludes and provides policy implications.

2. Literature Review

2.1. Feminization of Energy Poverty

Research on energy poverty and gender dynamics, particularly in the Global South (Listo, 2018; Petrova & Simcock, 2019), highlights the specific vulnerabilities faced by women. While existing studies have recognized the feminization of energy poverty (Bartiaux et al., 2018), comprehensive evaluations remain limited, especially in Asian contexts. Wilson (2018) reframes feminization not as a purely feminist concept, but as a promising analytical lens to understand how gender shapes energy poverty, a perspective especially relevant in countries like China. The concept of feminization of energy poverty aligns with Chant's (1998, 2006, 2013) broader theory of feminization of poverty, which underscores women's lower income levels, their disproportionate burden as household heads, and their greater exposure to long-term poverty. These patterns are echoed in studies across both developing

(Sovacool et al., 2013; Winther et al., 2018) and developed countries (Fraune, 2015), reinforcing the need for gender-sensitive energy policies that prioritize care, health, and equity (Wilson, 2018; Bell et al., 2020).

Evidence shows that rural women are particularly affected. Cecelski (1995) and Bhattasali (2005) document the physical toll of traditional energy use, with women often walking long distances to collect firewood and facing severe indoor air pollution—comparable to inhaling the smoke of 20 cigarettes daily. These conditions underscore the urgency of integrating feminist perspectives in energy transition strategies, especially in rapidly developing nations like China.

2.2. Energy Poverty and Regional Disparities in China

Energy poverty in China exhibits pronounced disparities across urban-rural divides and regional geographies, with rural households and those in central and western regions disproportionately affected (Zhang et al., 2019; Cai et al., 2021; Zhao et al., 2022). For example, while 15% of urban families rely on solid fuels for cooking, the figure rises to 52% in rural areas. Moreover, recent studies underscore the growing regional divide in energy poverty levels, necessitating a more nuanced understanding of spatial variations (Lu et al., 2022; Wan et al., 2024).

Although much of the existing literature focuses on rural energy poverty, less attention has been given to identifying vulnerable groups across both urban and rural contexts (Zhang et al., 2023). This gap is particularly salient in light of China's unique geographical, climatic, and resource endowment differences, which shape its energy poverty landscape in ways distinct from other countries (Wang et al., 2017; Lin & Wang, 2020).

Cultural factors—especially those rooted in Confucian traditions—intersect with socioeconomic dimensions to exacerbate gendered energy poverty. Confucian norms, which historically restrict women's autonomy through principles such as the "three submissives" and "four virtues," limit female participation in decision-making, financial independence, and educational access (Tsai, 2006; Li et al., 2023). These constraints are particularly pronounced in rural areas, where Confucian influence is stronger, and women often bear greater childcare burdens, further limiting their income-generating opportunities (Mijnheer, 2023).

While urban women are not immune to gender biases, their relatively better access to education and employment enhances their economic agency and household decision-making power. Nonetheless, the broader link between Confucianism and energy poverty in China remains underexplored, representing a critical gap in the literature on culturally embedded energy inequalities (Chaudhry & Shafiullah, 2021).

2.3. Social Role Theory and Confucian Cultural Norms

This study employs social role theory, integrated with Confucian cultural norms, to examine how entrenched gender roles contribute to the feminization of energy poverty in China. Social role theory explains how gendered behaviors are shaped and sustained, particularly in rural households where Confucian values prevail (Tang et al., 2020). These values promote hierarchical family structures and the "three submissions" principle, which constrain women's agency and reinforce their economic dependency.

Confucianism assigns women primary responsibility for domestic tasks such as cooking and heating—activities that often rely on traditional, inefficient energy sources (Tsai, 2006). In rural areas, where modern energy access is limited and women have lower levels of education and financial autonomy, their exclusion from household energy decisions further increases their vulnerability to energy poverty.

Framing this within the feminization of energy poverty, the study highlights how the gendered division of labor and restricted decision-making power intensify women's energy-related burdens. By embedding Confucian values into the analysis, the framework reveals how cultural norms shape not only gender roles but also societal expectations around women's involvement in energy management. While urban women benefit from greater autonomy due to improved access to education and employment, rural women remain more constrained by tradition.

This combined framework—linking social role theory, Confucian culture, and feminization of energy poverty—offers a culturally grounded explanation for why rural women in China face disproportionate energy hardships. It supports the study's broader aim to identify socio-cultural drivers of energy poverty and inform policy interventions that promote gender equity and inclusive energy access.

3. Data and Methodology

3.1. Data sources

We collected data from two sources: a nationwide survey and in-depth interviews. The nationwide survey utilized in this study is the China Family Panel Studies (CFPS). CFPS is a nationally representative annual longitudinal survey that examines Chinese communities, families, and individuals, with a focus on the economic conditions and well-being of the population. The data covers economic activities, education outcomes, family dynamics and relationships, migration, and health for 25 provinces in mainland China (exclude Xinjiang, Tibet, Inner Mongolia, Ningxia, and Qinghai), which represent 95% of China's population. CFPS has been widely used to explore energy poverty in China, since it collects information on household fuel usage and energy expenditures related to heating, cooking, and other purposes (Li et al., 2023; Zhang, D., Li, J., & Han, P., 2019). For this study, we follow in the spirit of Li et al., (2023) and rely on the 2018 wave which is the most recent to construct our cross-sectional energy usage and gender disparities variables. The choice of 2018 wave is due to data availability and to align with our research focus (i.e. gender disparities in energy poverty), only data pertaining to women were retained for the analysis. Following the data filtering process, we ultimately employed a sample of 18,452 female-headed households.

In addition to the survey, we conducted a total of 43 in-depth, semi-structured, face-to-face interviews in Jiangsu, Zhejiang, and Shanghai between January and April 2024. The interview respondents include 20 women; 20 husbands of these women, and 3 related experts. Each interview lasted 60-100 minutes. We recorded and transcribed all the interviews. Data from the interviews were qualitatively coded using Atlas.ti, where we developed a coding framework and coded each interview.

The purpose of these interviews is to extend our quantitative findings by providing a more holistic understanding of energy poverty, considering the influence of socio-cultural factors that may not have surfaced in the statistical analysis but are crucial to addressing the issue comprehensively. This is indeed, lacking in the extant literature. We acknowledge that while these interviews may not be representative of the entire population of Chinese women, achieving representation was not our main goal. Instead, we hope to draw insight from this sample, which will be critical for comprehensive policy action towards tackling the gendered impact of energy poverty issues among rural women in China.

3.2. Variable selection

Table 1 outlines the definitions of the key variables used in this study. The dependent variable is energy poverty. Existing studies typically characterize household energy poverty based on energy accessibility and affordability (Li et al., 2023; Zhang et al., 2019; Llorca, Rodríguez-Álvarez, & Jamasb, 2020; Jayasinghe, Selvanathan, & Selvanathan, 2021). To effectively assess household energy poverty, we develop the following three proxy variables by integrating the dimensions of accessibility and affordability in the spirit of Zhang et al., (2019); Lloca et al., (2020); and Jayasinghe et al., (2021).

Energy accessibility is denoted as *EP1*, which reflects the type of fuel used for cooking by the respondents. Following Zhang et al. (2019), if a household primarily relies on solid fuels, such as firewood, coal, or charcoal, for cooking, it indicates limited access to modern energy sources. **Energy affordability** is measured as *EP2*, which captures the proportion of household income spent on energy. A commonly used threshold, known as the "Ten Percent Rule", categorizes households as energy-poor if their energy expenditure exceeds 10% of their total income (Zhang et al. (2019; Boardman, 1991). However, Hills (2011, 2012) argued that this rule could misclassify affluent households with high energy consumption as energy poor. To address this, Okushima (2016) proposed the adjusted Ten Percent Rule (aTPR), applying the 10% threshold to households within the bottom 30% of the income distribution. Another approach, known as After Energy Cost Poverty (AECP), defines energy poverty based on the household's remaining income after subtracting energy expenses. If the remaining income is less than 60% of the sample median, the household is considered to lack energy affordability (Hills, 2011). In this study, we adopt the AECP method to define energy affordability (*EP2*). Given that energy poverty in China reflects characteristics of

both developing countries (dependence on solid fuels) and developed countries (energy burden) (Wang and Lin, 2022), this study, following Zhang et al. (2019) and Luan et al. (2023), constructs a composite index (*EP*). We employ an equal-weight method to construct a multidimensional index by combining accessibility and affordability. Specifically, if a household has no issue with energy accessibility or affordability, *EP* is assigned a value of 1. If there is energy poverty in either aspect, *EP* is assigned a value of 2. *EP* is assigned a value of 3 for households experiencing severe energy poverty, defined as deficiencies in both energy accessibility and affordability.

Our independent variable captures the female population residing in both rural and urban locations, with the variable being represented as a dummy variable. The variable *urban_ruralfemale* is assigned a value of 1 if the female is in urban regions, and a value of 0 if she is not. Specifically, based on the person's identification and the identification of their respective families, the person was matched with the family, retaining only the data pertaining to females. For the control variables, we select age, schooling years, or education, which directly affect economic opportunities and knowledge of energy poverty following Wang and Lin, 2022; Luan et al., 2023). We also control for other socio-economic and demographic factors including personal income, total household assets, marital status and family harmony based on the literature (Dubois and Meier, 2016; Deller and Waddams, 2018; Llorca et al., 2020).

Table 1 Variable and their definitions

Variables		Label	Definition
Energy Poverty	Accessibility	EP1	Solid fuels (such as firewood and coal) for cooking, EP1 =1, others (such as gas/liquid, natural gas, solar energy, electricity) for cooking, EP1= 0
	Affordability	EP2	If remaining income after energy costs is < 60% of median income, EP2 = 1, others EP2 = 0
	Multidimensional	EP	EP = 1 if EP1 = 0 and EP2 = 0; EP = 2 if EP1 =1 or EP2 =1; EP = 3 if EP1 =1 and EP2 = 1
Locations of Female Householders		Urban_ruralfemale	1 = urban females, 0 = rural females
Age		Age	The age of the female householders. (years)
Education		Edu	The schooling years of the female householders. (years)
Personal Income		lnFincome	The individual's annual income generated from all personal sources, including wages, business profits, and other financial earnings. (in logs)
Total Asset of the Households		lnTotal_asset	The cumulative value of all assets owned by the households (real estate, vehicles, savings, investments, and other property). (in logs)
The Marital Status of the females		Marital_Status	The marital status of females, such as single, married, divorced, or widowed, rating from 1 to 5.
The Happiness of the females		Family_Harmony	The subjective happiness or harmony experienced by females within their family or household environment, rating from 1 to 5.

3.3. Descriptive statistics

The descriptive statistics for all variables are presented in Table 2 with a total of 17,004 households in our cross-sectional full sample. The average of EP (multidimensional Energy poverty proxy) is 0.278 with a standard deviation of 0.357, suggesting clear variability in the degree of energy poverty in the sample. EP1 (proxy for energy accessibility) and EP2 (proxy for energy affordability) show an average of 0.282 and 0.274 respectively with standard deviation of 0.450 for EP1 and 0.446 for EP2. These indicates that approximately 28.2% of households still rely on firewood or charcoal as cooking fuel mainly reflecting household energy accessibility concerns while at the same time, 27.4% of households face severe energy burdens, with their energy expenditures exceeding 10% of household income, reflecting energy affordability issues. Furthermore, approximately 49.1% of women live in

urban areas, while the rest reside in rural areas. This ratio is close to 1:1, indicating that the distribution of female samples in urban and rural areas is relatively balanced for the analysis. Given the dominant role of women in household energy use, this urban-rural disparity may have a significant impact on the two dimension of energy poverty. The average age of female householders is approximately 47.7 years, with a mean education level of 8.6 years. In terms of economic and social characteristics, the average personal income (fincome) is 10.955 with a substantial standard deviation, reflecting wide income disparities across the sample. Total household assets (total_asset) average 12.679 but exhibit high variability indicating large differences in household wealth levels. Marital status (Marital_Status) has an average value of 2.171, suggesting that a majority are married or in stable partnerships. Family harmony (Family_Harmony) has an average score of 4.657, showing relatively high levels of perceived family well-being among female respondents.

Table 2 Summary statistics

Variables	Samples	Mean	Min	Max	SD
EP	17004	0.278	0.000	1.000	0.357
EP1	17004	0.282	0.000	1.000	0.450
EP2	17004	0.274	0.000	1.000	0.446
Urban_ruralfemale	17004	0.491	0.000	1.000	0.500
Age	17004	47.673	10.000	100.000	18.039
Edu	7837	8.565	0.000	22.000	5.045
Age2	17004	2598.123	100.000	10000.000	1801.025
Edu2	7837	98.813	0.000	484.000	79.154
Ln(fincome)	17004	10.955	0.000	16.030	1.105
Ln(total_asset)	15712	12.679	0.000	17.737	1.392
Marital_Status	14989	2.171	1.000	5.000	0.934
Family_Harmony	14989	4.657	1.000	5.000	0.690

3.4. Identification strategies

This study aims to examine the association between feminization and household energy poverty and to further explore the internal mechanisms. Our empirical model can be expressed as follow:

$$\log\left(\frac{P(EP \le j)}{1 - P(EP \le j)}\right) = \theta_j - (\beta_1 urban_ruralfemale + \gamma control_variables) + \varepsilon$$

where EP is the explained variable, energy poverty; the explanatory variable *urban_ruralfemale* represents the location of residence of women, with urban-rural division being the part of the focus of this study. According to the social role theory of gender division of labor, women usually bear the main responsibility for household energy use, especially in the selection of cooking fuels. Therefore, the differences in the identity of urban and rural women may significantly affect the level of energy poverty in their families.

4. Empirical results

4.1. Correlation Analysis

The correlation analysis is shown in **Table 3**. The correlation coefficient between energy poverty (EP) and the urban-rural women variable (*urban_ruralfemale*) is -0.394, indicating a moderate negative relationship. This suggests that females living in rural areas are more likely to experience higher incidences of energy poverty compared to their urban counterparts. This preliminary finding aligns with Listo (2018) and Dutta and Sahu (2024) which have documented that rural populations, particularly women, tend to face higher energy poverty burdens than their urban counterparts due to limited access to modern cooking energy sources. We found the correlation coefficient between energy poverty and age and its squared term (age^2) to be close to zero (0.072), which indicates a weak linear relationship between age and energy poverty. This suggests that age alone may not be a significant predictor of energy poverty, and the role of age might be more complex, requiring the exploration of nonlinear or interaction effects to fully understand its impact. A significant negative correlation is found between energy

poverty and years of schooling (Edu), with a coefficient of -0.346. This finding indicates that individuals with lower levels of education are more likely to experience energy poverty, implying that education can play an important role in alleviating energy deprivation. Furthermore, the correlation between the squared term of education (Edu^2) and energy poverty is identical, which implies that the relationship between education and energy poverty may be non-linear, where increases in education levels may progressively reduce the risk of energy poverty. The positive correlation between the urban-rural women variable and education level (0.322) suggests that individuals in urban areas generally attain higher levels of education. This result is consistent with patterns in socio-economic development, where urban residents typically have greater access to educational resources and opportunities (Li et al., 2023). Additionally, the negative correlation between age and education level (-0.519) indicates that older individuals tend to have lower levels of education. This generational difference likely reflects varying access to education, with older cohorts having had fewer opportunities compared to younger generations, who benefit from improved educational systems. Income-related variables also show strong negative correlations with energy poverty: personal income (fincome) has a coefficient of -0.636, while total household assets (total_asset) show a coefficient of -0.494. These results indicate that households with higher incomes and assets are less likely to experience energy poverty, underscoring the critical role of financial resources in securing energy access (Bersisa, 2019). Lastly, the variables Marital_Status and Family_Harmony exhibit minimal correlation with energy poverty, with coefficients close to zero (-0.000 and -0.010, respectively). This suggests that these social factors may not have a direct impact on energy poverty as previously supposed, although they may still contribute indirectly through interactions with other socio-economic factors.

Overall, the correlation analysis reveals that urban-rural location, education, and economic resources are important variables related to energy poverty. Education, in particular, appears to be a key factor, as it is negatively correlated with energy poverty and positively associated with urban residency, which generally facilitates better energy access. While age shows a weak direct relationship, its interaction with education may provide insights into generational differences in energy poverty. These findings lay the groundwork for subsequent empirical analysis, where we employed an ordered logistic regression model to further investigate the specific impacts of these variables and their predictive power in explaining energy poverty.

Table 3 Correlation Analysis -- Spearman's rank correlation coefficients

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) EP	1.000									
(2) urban_ruralfemale	-0.394	1.000								
(3) age	0.072	-0.021	1.000							
(4) age2	0.072	-0.021	1.000	1.000						
(5) Edu	-0.346	0.322	-0.519	-0.519	1.000					
(6) Edu2	-0.346	0.322	-0.519	-0.519	1.000	1.000				
(7) fincome1	-0.636	0.311	-0.067	-0.067	0.370	0.370	1.000			
(8) total_asset	-0.494	0.391	-0.018	-0.018	0.347	0.347	0.592	1.000		
(9) Marital_Status	-0.000	-0.001	0.649	0.649	-0.334	-0.334	0.020	0.006	1.000	
(10) Family_Harmony	-0.010	-0.009	0.004	0.004	-0.016	-0.016	0.017	0.015	0.012	1.000

Spearman rho = 0.012

4.2. Baseline results

Table 4 presents the benchmark results based on the ordered logistic regression models, which progressively incorporate additional control variables to analyze their influence on energy poverty (EP). Column (1) includes only the main independent variable, urban_ruralfemale, while Columns (2) and (3) introduce demographic and socioeconomic variables to progressively adjust the model. In all models, the coefficients for the urban-rural female variable remain negative, and statistically significant at the 1% level ($p < 0.001$), with values of -1.6526,

-1.3534, and -1.2098 in columns (1), (2), and (3) respectively. This finding indicates that women residing in rural areas experience significantly higher levels of energy poverty compared to the urban groups. These results reinforce the previous correlation analysis, highlighting the profound impact of urban-rural disparities on energy poverty. To better visualize the impact of the urban-rural female variable on energy poverty, Figure 1 presents the predictive margins with 95% confidence intervals for the probabilities of experiencing different levels of energy poverty. As shown in the figure, the probability of avoiding energy poverty (red line) increases significantly while the probabilities of experiencing moderate (blue line) or severe energy poverty (green line) are substantially higher for rural females. This further supports our regression results, showing that women living in urban areas are less likely to face energy poverty.

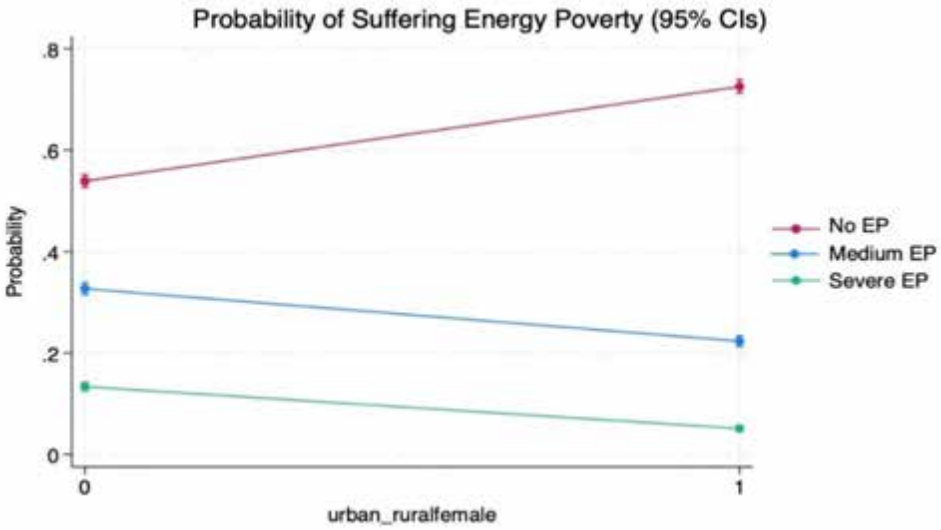

Fig.1 Marginalized plot for energy poverty and female in urban and rural areas

In column (2) we introduce age and education variables, along with their squared terms, to account for potential nonlinear effects. The coefficient for age is -0.0703 and statistically significant ($p < 0.001$), while its squared term (age^2) shows positive and statistically significant coefficient of 0.0006 ($p < 0.001$), indicating existence of a nonlinear relationship. This suggests that while energy poverty initially decreases with age, it begins to increase again as individuals grow older, potentially reflecting greater energy needs or financial constraints among older populations. Unlike most of the extant studies which found a more linear or straightforward impact of age on energy poverty, our results have shown that an inverse U-shape relationship might exist when one accounts for older age groups in energy poverty studies. Thus, our findings suggest a complex relationship between age and energy poverty, warranting further exploration of interaction effects or segmentation by age groups. Next, the Education level (Edu) also demonstrates a strong, and statistically significant negative association with energy poverty, with coefficients of -0.1546 and -0.1348 in columns (2) and (3) respectively ($p < 0.001$). This relationship suggests that higher education levels contribute significantly to reducing energy poverty, likely due to better economic opportunities or return on education and access to energy-efficient resources among educated individuals. Interestingly, the squared term for education (Edu^2) shifts from insignificant in column (2) to positive and significant (0.0027, $p < 0.05$) in column (3), indicating a more complex, possibly diminishing effect of education at very high levels. In column (3), we account for additional economic and social variables such as personal income (fincome) and total household assets (total_asset). Both variables show highly significant negative coefficients (-0.0000, $p < 0.001$), further affirming that economic stability and financial resources play a crucial role in mitigating energy poverty. More speficially, the results imply that households with higher incomes and assets are less likely to experience energy poverty, highlighting the importance of economic capacity in ensuring energy access and affordability. The variables Marital_Status and Family_Harmony do not show significant associations with energy poverty. This possibly suggests that, unlike economic factors, social dynamics may have a less direct impact on energy poverty.

The cut-off values (cut1 and cut2) provide thresholds for categorizing the levels of energy poverty. Each model iteration shows improvements in Pseudo R-squared, values, indicating a better fit as more control variables are

included. These improvements in model fit demonstrate that the inclusion of demographic and socioeconomic variables such as age, education, income, and assets significantly enhance the model's ability to capture variations in energy poverty. This progressive enhancement of fit metrics underscores the importance of a comprehensive set of control variables in accurately modeling the determinants of energy poverty among households. Overall, our baseline results emphasize the significant influence of urban-rural disparities, age, education, and financial resources on energy poverty. In particular, the complex relationships involving age and education suggest that addressing energy poverty may require targeted interventions based on age-demographic and economic characteristics.

Table 4 Benchmark results

	(1)	(2)	(3)
	EP	EP	EP
EP			
urban_ruralfemale	-1.6526***	-1.3534***	-1.2098***
	(0.0332)	(0.0536)	(0.0609)
age		-0.0703***	-0.0446***
		(0.0083)	(0.0094)
age^2		0.0006***	0.0004***
		(0.0001)	(0.0001)
Edu		-0.1546***	-0.1348***
		(0.0167)	(0.0184)
Edu^2		-0.0002	0.0027**
		(0.0011)	(0.0012)
lnfincome			-0.0000***
			(0.0000)
lntotal_asset			-0.0000***
			(0.0000)
Marital_Status			-0.0005
			(0.0439)
Family_Harmony			-0.0609
			(0.0383)
cut1	-0.4639***	-2.9893***	-4.3632***
	(0.0217)	(0.1990)	(0.2902)
cut2	1.3136***	-1.0927***	-1.9936***
	(0.0250)	(0.1967)	(0.2846)
Pseudo R-squared	0.0847	0.1382	0.2813
Chi2	2721.3265	1901.0797	3678.7069
log-likelihood	-14701.4660	-5925.4920	-4700.1492

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table shows the results of the baseline regression using an ordered logistic model to examine the determinants of energy poverty (EP) among households. Column (1) of this table shows the results of the first regression model, which only contains the independent variable urban_ruralfemale. Column (2) expands the model by incorporating demographic variables, specifically age and education, along with their squared terms to capture potential nonlinear effects. Column (3) further extends the model with additional economic and social control variables, including personal income, total assets, marital status, and family harmony. The coefficients for each variable represent their estimated impact on energy poverty, with negative coefficients indicating a reduction in the likelihood of experiencing energy poverty. The **Cut1** and **Cut2** are the threshold parameters for the ordered logit model. They separate the different categories of energy poverty (e.g., no energy poverty, moderate energy poverty, and severe energy poverty).

4.3. Robustness checks

To enhance the reliability of the empirical results, the robustness of the estimation results given below. It employs the ordered probit (***oprobit***) model as an alternative to the baseline ordered logistic (***ologit***) model. While both models are appropriate for analyzing energy poverty problem, they differ in their underlying statistical assumptions. Specifically, the ordered logistic model assumes a logistic distribution for the error term, whereas the ordered probit model assumes a standard normal distribution. These differences in distributional assumptions allow for a thorough test of the stability of the results. The findings of this robustness analysis are presented in **Table 5**.

The results indicate that the primary conclusions remain consistent across the two model specifications. The independent variable urban_ruralfemale retains its negative and statistically significant effect on EP, although the magnitude of the coefficient is smaller under the ordered probit model. The demographic control variables, including age and education level, exhibit similar results across the two models. It also suggests that elder and less educated female householders are more likely to experience energy poverty, though this effect could diminish at older ages as indicated by the positive coefficient of the quadratic term (age2, education2). Plus, the control variables related to economic state remain highly significant and negative in both models, highlighting the importance of household financial capacity in mitigating energy poverty problem. On the other hand, those related to social well-being continue to lack statistical significance, potentially suggesting limited influence on energy poverty, which is left to be further discussed in the next qualitative analysis section.

Regarding the fitness of the model, the R^2 values and log-likelihood statistics demonstrate comparable levels of explanatory power across the two different models. Slight improvements in the R2 values in the ordered probit model suggest a marginally better fit when using a normal distribution assumption. Additionally, the threshold parameters (Cut1 and Cut2) in the ordered probit model differ from those in the baseline model, which is consistent with the theoretical differences in the error term distributions. However, these differences do not alter the substantive interpretation of the results.

Table 5 Robustness Analysis

	(1)	(2)	(3)
	EP	EP	EP
EP			
urban_ruralfemale	-0.9901***	-0.7971***	-0.6643***
	(0.0192)	(0.0308)	(0.0351)
age		-0.0424***	-0.0170***
		(0.0048)	(0.0059)
age^2		0.0004***	0.0001*
		(0.0001)	(0.0001)
Edu		-0.0897***	-0.0788***
		(0.0096)	(0.0109)
Edu^2		-0.0002	0.0016**
		(0.0006)	(0.0007)
lnfincome			-0.6581***
			(0.0176)
lntotal_asset			-0.2129***
			(0.0147)
Marital_Status			-0.0160
			(0.0263)
Family_Harmony			0.0014
			(0.0245)
/			
cut1	-0.2724***	-1.7692***	-10.8590
	(0.0132)	(0.1153)	(.)
cut2	0.7719***	-0.6728***	-9.4019***
	(0.0142)	(0.1142)	(0.0283)
Pseudo R-squared	0.0855	0.1406	0.3142
Chi2	2745.2202	1933.2275	3960.3626
log-likelihood	-14689.5192	-5909.4182	-4322.6643

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: This table shows the results of the robustness analysis using an ordered probit model to examine the determinants of energy poverty (EP) among households. Column (1) of this table shows the results of the simplest model, which only includes the independent variable *urban_ruralfemale*. Column (2) expands the analysis by incorporating demographic variables, specifically age and education, along with their squared terms to capture potential nonlinear effects. Column (3) further extends the model with additional economic and social control variables, including personal income, total assets, marital status, and family harmony. The coefficients for each variable represent their estimated impact on energy poverty, with negative coefficients indicating a reduction in the likelihood of experiencing energy poverty.

The **Cut1** and **Cut2** are the threshold parameters for the ordered probit model, separating the different categories of energy poverty (e.g., no energy poverty, moderate energy poverty, and severe energy poverty). The pseudo R-squared values and log-likelihood statistics indicate improved model fit as additional variables are included across the results, which helps to confirm the robustness of the results.

In conclusion, the robustness analysis confirms that the key findings of the baseline ordered logistic model are not sensitive to the choice of model specification. The consistent direction, significance, and interpretation of the coefficients across both models provide strong evidence for the stability and reliability of the conclusions regarding the determinants of energy poverty. These results enhance the credibility of the baseline analysis and further support the role of demographic and economic factors in shaping household energy poverty outcomes.

5. Results and discussions

The quantitative analysis reveals that factors such as urban-rural residency, age, education, and financial resources significantly influence energy poverty among female-headed households, while socio-cultural variables like marital status and family harmony show no direct statistical impact. However, these factors may still shape energy-related behaviors and coping strategies in indirect ways. To capture these nuanced dynamics, the following qualitative analysis explores how cultural norms, household roles, and societal expectations affect women's experiences of energy poverty, offering a more holistic understanding that complements the quantitative findings.

5.1. Limited financial independency

Interviews reveal a consistent perception among participants: women experience and cope with energy poverty differently from men. This disparity is largely attributed to the gendered division of labor, where women disproportionately bear responsibility for childcare and domestic work. As a result, they spend more time at home and have reduced access to income-generating opportunities, increasing their exposure to energy poverty (Mijnheer, 2023). One respondent observed: "*Women persist in shouldering the primary obligation of caring for their kids... while their husbands chase careers.*" (Female respondent 03). These dynamics are further exacerbated in rural areas, where traditional Confucian cultural norms remain deeply entrenched. Principles such as the "three submissives" and "four virtues" restrict women's autonomy in household decision-making, especially concerning energy use (Li et al., 2023). Household energy decisions, particularly those related to fuel choices and appliance purchases, are often made solely by men. "*When I try to talk to my husband about our enhanced energy requirements... he reprimands me.*" (Female respondent 07) This reflects the broader gender hierarchy embedded in Confucian family structures (Van, 2019).

By contrast, urban households—where Confucian influence has diminished due to socioeconomic development and shifting gender norms—offer women greater participation in household energy management. Women in these contexts often have access to financial resources and information, facilitating more equitable decision-making. As one urban participant noted: "*When I talk to my husband... he listens and tries to understand... we could discuss together how to make our home more energy efficient.*" (Female respondent 11)

Rural women also reported significant health concerns related to traditional fuels, such as smoke inhalation and heat exposure. Many advocated for adopting safer alternatives, like electric rice cookers, which improve efficiency and reduce hazards. However, resistance from male family members—grounded in perceptions of tradition, cost-effectiveness, and skepticism toward change—remains a barrier. "*Smoke poses no issue... our mums used firewood... Why is she unable to do it?*" (Male respondent 08). Furthermore, intra-household dynamics, particularly the influence of in-laws, pose additional challenges. Women often lack support from their husbands, who prioritize familial harmony and parental authority over spousal concerns. "*Whenever I mention replacing the gas range... he ends up resenting me... he always prioritises making [his mother] happy.*" (Female respondent 02) Nevertheless, the study also finds evidence of transformation in urban areas. Women who contribute financially to the household tend to wield greater influence over energy decisions, and younger husbands are more open to shared decision-making, regardless of their wives' income status. These findings suggest that shifting gender norms, financial autonomy, and intergenerational change are gradually enhancing women's agency in energy management, offering a pathway toward more equitable outcomes in energy access and use.

5.2. Limited education opportunities

Confucian cultural norms have historically constrained women's access to education, particularly in rural China,

due to deeply rooted beliefs about women's intellectual inferiority (Tsai, 2006). These norms reinforced traditional gender roles by relegating women to the domestic sphere and discouraging formal education, resulting in long-lasting effects that continue to shape gendered vulnerabilities to energy poverty. Less-educated rural women often lack awareness of energy-efficient technologies and available support systems, leaving them particularly exposed to energy-related hardships. The insularity of rural communities further exacerbates these challenges. Many women remain unaware of external assistance mechanisms due to limited exposure and economic barriers such as consultation fees or transportation costs. These constraints discourage help-seeking behavior, reinforcing passivity in the face of energy deprivation. As one expert noted, "*I am aware of a collective of individuals who, due to feelings of shame or apprehension about incurring supplementary expenses, are reluctant to be linked with the issue of energy poverty... leaving us unable to assist them.*" (Expert 03)

Education plays a pivotal role in enabling women to adopt modern energy solutions. Studies show that women with limited educational backgrounds are less inclined to utilize technologies such as solar water heaters, improved cooking stoves, LED bulbs, or water purification systems—despite their proven effectiveness in reducing energy poverty (Paudel et al., 2018; Belmin et al., 2022). "*When I first heard about solar water heaters, I thought they were too complicated to maintain... why change now?*" (Female respondent 06)

The continued influence of Confucian gender roles further delays the adoption of modern views, particularly in rural areas. Li et al. (2023) found that less-educated female householders are more likely to retain traditional energy practices, reinforcing their energy vulnerability. National survey data supports this trend: between 2010 and 2016, use of modern cooking energy increased modestly in rural households (from 1.30% to 3.90%) and more substantially in urban households (from 23.43% to 30.02%) (Adusah-Poku & Takeuchi, 2019). These figures underscore the persistent resistance to change in rural communities, where Confucian values remain deeply embedded. "*My husband's mother still insists on using firewood, saying it's what she knows and trusts.*" (Female respondent 08)

This cultural inertia presents significant barriers to the uptake of modern energy practices. Women are expected to maintain traditional domestic routines, and without adequate education or decision-making power, many lack the confidence or means to initiate change. As one respondent shared, "*When I realized how much energy our old heater was wasting... I found a much more efficient model. I knew it would save us money in the long run, so we made the switc.*" (Female respondent 11). Such proactive behavior, however, remains uncommon in rural contexts.

In contrast, urban women generally benefit from higher educational attainment, broader access to information, and greater financial autonomy. These conditions foster a more proactive approach to energy management. Empowered by education, urban women are more likely to seek out and adopt energy-efficient technologies, thereby reducing their exposure to energy poverty. Nonetheless, the urban-rural divide in energy awareness persists. As an expert noted, "*We had a meeting in the village about switching to cleaner energy, but only a few of the women attended... They feel they're doing just fine with what they've always used.*" (Expert 05)

In sum, Confucianism's enduring emphasis on women's subordinate roles and limited education continues to influence patterns of energy poverty in rural China. Addressing this issue requires not only technical interventions but also culturally informed strategies. Promoting energy literacy and empowering women through targeted educational programs are essential steps toward disrupting the intergenerational cycle of energy poverty, particularly in areas where traditional values remain dominant.

5.3. Mental health impacts of both factors

The mental health of rural women in China is deeply affected by the intersection of energy poverty and limited educational opportunities, both of which are shaped by enduring Confucian cultural norms. Confucianism reinforces traditional gender roles and the subordination of women, confining them to domestic responsibilities and restricting access to education. Consequently, rural women are disproportionately affected by energy poverty, a condition that not only undermines physical health but also imposes significant psychological burdens. In rural areas, the reliance on inefficient and hazardous energy sources—such as firewood and biomass—exacerbates this vulnerability. Prolonged exposure to smoke and odors from these fuels harms physical well-being and contributes to chronic psychological stress. The responsibility for managing household energy within

tight constraints often leads to anxiety, especially as women are expected to uphold familial well-being without the necessary resources. Confucian values amplify these pressures, reinforcing women's perceived duty to the home while limiting their autonomy. One woman remarked, "*I never imagined that I would be stuck using these old methods to keep our home warm... It's as if I'm trapped in the past, with no way out.*" (Female respondent 16) The absence of educational opportunities further compounds women's sense of powerlessness. Many lack the knowledge and confidence to seek alternatives or access support, leaving them emotionally isolated. The mental toll intensifies when women feel they cannot meet familial expectations, particularly under constant criticism or blame. As one participant shared, "*If the electricity bill is too high, he blames me, even though I'm just trying to keep the house comfortable for the children. It's exhausting.*" (Female respondent 09)

This psychological strain often leads to reduced self-confidence and deep emotional distress, especially in cultural settings where failure to fulfill domestic duties is associated with shame. The risk of depression and other mental health disorders increases under these conditions. Cultural norms discourage women from discussing their struggles or seeking help, for fear of being perceived as weak. "*They don't want to be seen as unable to handle their household duties. It's this feeling of shame that often prevents them from seeking help.*" (Expert 01)

Confucian traditions also inhibit women's capacity to advocate for change or adopt new energy practices. In many cases, women internalize their culturally defined roles, adhering to outdated energy use practices despite the harm they cause. "*My mother-in-law insists that we keep using the old stove, saying it's what we know and trust. It's hard to convince anyone otherwise.*" (Female respondent 08)

These cultural and psychological pressures are further exacerbated by familial discord. Many women report feeling incapable of satisfying their husbands' expectations, leading to emotional fatigue and withdrawal. A lack of emotional and social support compounds this experience, impairing women's ability to respond proactively to their circumstances. "*This society has a way of making us women feel completely powerless... I occasionally use the air conditioning to keep my home at a comfortable temperature. My husband was pleased with it initially, but when he saw the electricity bill, he scolded me again. There isn't much to discuss.*" (Female respondent 09)

Ultimately, the psychological effects of energy poverty are not merely the result of material deprivation but are deeply entangled with cultural and educational barriers. Addressing these challenges requires more than just expanding access to clean energy technologies. It also necessitates efforts to confront and transform the Confucian cultural norms that restrict women's roles, discourage education, and suppress their voices. A culturally informed, gender-sensitive approach to both mental health and energy policy is essential to breaking this cycle of vulnerability and enabling rural women to regain agency over their lives.

6. Conclusions and implications

Based on China Family Panel Studies (CFPS) data, this study finds that rural women are significantly more affected by energy poverty than their urban counterparts. Energy poverty is measured through access and affordability, and benchmark regressions confirm that rural women, especially those with lower education and older age, face higher risks. The correlation analysis reveals that variables such as educational attainment, age, and geographic location influence women's exposure to energy poverty, with little evidence of multicollinearity in the models.

The findings suggest a strong link between limited education and increased energy poverty risk, highlighting education and financial resources as key factors for mitigation. Age shows a nonlinear relationship, indicating evolving energy needs over the life course. Urban women are generally more resilient due to greater autonomy and access to social and economic resources, while rural women remain disadvantaged by household responsibilities, lack of voice in energy decisions, and entrenched social norms.

The study also explores energy injustice, pointing to rural women's restricted access to renewable energy, their heavy domestic burden, and mental health challenges stemming from energy deprivation. These issues are compounded by Confucian cultural norms that limit women's decision-making power, especially in rural areas where gender roles are more rigidly enforced.

To address these challenges, a multidimensional policy response is required. First, expanding access to education and skills training for rural women can strengthen their capacity to engage in energy-related decisions and

improve their socio-economic status. Second, building localized support systems—such as community networks, NGOs, and government-led initiatives—can provide emotional support and practical guidance to women in energy-poor households. Third, implementing sustained and regionally tailored subsidy programs for low-income rural households can ease their transition to modern, clean energy sources while reducing long-term dependency on traditional fuels. Finally, broader societal change is essential: challenging deeply rooted gender norms through public awareness campaigns and institutional reforms can promote greater gender equity in both domestic and public spheres. These interventions, collectively, will be crucial for reducing gendered energy inequalities and advancing an inclusive, culturally informed energy transition in China.

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Simulating Urban Green Space's Cooling Impact on School-age Children' Sleep Quality Using Diverse Planning Approaches

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Abstract
Despite the widespread use of urban green spaces (UGS) as a climate change mitigation strategy, their cooling effects have not been thoroughly studied for public health benefits. This study, conducted in Guangdong Province, a subtropical monsoon region in China's Great Bay Area, assesses four UGS scenarios with different trade-offs regarding their impacts on school-age children's sleep health. Introducing around 2.5 to 2.7 km^2 of UGS significantly lowers temperatures by up to 1.13 °C monthly, benefiting populations with varying risk levels. Prioritizing small UGS yields the most profound benefits, especially investing in existing ones. Emphasizing large UGS has limited benefits, with constructing new ones the least effective. Careful planning and design highlighting social benefits and equity are crucial for addressing heat-related health risks under climate change.

Keywords: Urban green space; Heat exposure, Planning; Sleep health; Simulation

1 Introduction

The escalating climate change exposes individuals to greater health risks (Ebi et al., 2021), particularly in densely populated urban areas of subtropical and tropical regions (Dong et al., 2024), where the urban heat island effect (UHI) combined with high humidity increases the risks of heat stress (Ho et al., 2025), non-communicable diseases such as cardiovascular and respiratory diseases (Liu et al., 2022), sleep disorders and mental illnesses (Cianconi et al., 2020; Rifkin et al., 2017).

Having the potential to confer physical and psychological benefits, urban green space (UGS) has been increasingly adopted as a climate change mitigation strategy (Sugiyama et al., 2018; Zhang et al., 2022). Apart from bringing psychological relief and promoting physical activities and social contacts (Lachowycz and Jones 2013; Shuvo et al., 2020), research also indicates that UGS mitigates heat exposure, improve thermal comfort and thus improve public health (Markevych et al., 2017).

However, this specific cooling pathway remain largely underexplored, especially regarding its associations with public health benefits (Huang et al., 2025; Sadeghi et al., 2022). Current research on UGS's cooling effect lacks systematic perspective that positions UGS in an extensive urban landscape with various intricately-influencing factors (Aram et al., 2019), thus failing to offer constructive prescriptions (Zhang et al., 2017 a). Moreover, simulations seldom consider the real-world planning practices that are embedded in the urban land use system (Li et al., 2022), leading to a fundamental gap between theoretical results and practical guidance.

Therefore, using Guangdong Province as a case site, this study examines the health benefits of UGS's cooling pathway through assessing the performances of different UGS planning scenarios. Results from air temperature simulations are linked with a large-scale survey on school-age children' s sleep health status. How different planning approaches are influencing their sleep health is evaluated to shed light on the common trade-offs between small-large and new-old UGS. Section 2 reviews the established findings and remaining debates. Section 3 illustrates the research strategy. Section 4 presents the results, and Section 5 conveys discussions and policy implications.

2 Literature review

2.1 Heat exposure's impact on school-age children's sleep health

Sleep health is closely related with all kinds of mental disorders (Hudson et al., 2020; Scott et al., 2016), yet has received less attention than diseases and death in the realm of health research. Research indicates that global warming is leading to increased thermal discomfort, night sweats, breathing difficulties, and disrupted sleep patterns (Obradovich et al., 2017; Zheng et al., 2019), resulting in individuals worldwide losing around two weeks of sleep each year (Minor et al., 2022). Sleep efficiency decreased by 10% in temperatures between 25 °C and 30 °C (Baniassadi et al., 2023), and interruptions and awakenings significantly increased when ambient temperatures

exceeded 30 °C (Altena et al., 2023). Although air conditionings can mitigate outdoor heat exposure, they are typically used when temperatures rise to a relatively high degree; in their absence under mild and moderate exposure, indoor temperatures systematically surpass outdoor ones (Yan et al., 2022), causing significant sleep issues related to heat exposure (Lin and Deng, 2006).

Recently, the sleep issues of school-age children are receiving increasing attention, as the incidence of various sleep disorders among school-aged children, including sleep-related breathing disorders and circadian rhythm sleep disorders, may reach 30% to 40% around the world (Lim et al., 2023; Chen et al., 2021). School-age children are particularly prone to experiencing sleep disorders compared to adults, possibly due to their developing physiological and nervous systems that make them more sensitive to changes in thermal environment (Kansagra, 2020; Trosman and Ivanenko, 2024). Moreover, they are particularly sensitive to noise and artificial light (Wang et al., 2022) and indoor air quality (Fujii et al., 2015; Rahai et al., 2024), and the academic pressure they face may also make them more sensitive to the thermal environment (Qi et al., 2020; Steare et al., 2023). Since most current studies focus on vulnerable groups such as the elderly, the pregnant or outdoor workers (Baldwin et al., 2023; Gulia and Kumar, 2018), it holds theoretical and practical significance to examine the sleep health of school-age children and provide potential prescriptions.

2.2 UGS's health benefits and cooling capacity

UGS offers health benefits through various pathways, including emotional regulation, promoting physical activities and social contacts, as evident in extensive studies (McMahan and Estes, 2015; Lachowycz and Jones, 2013; Oliveira et al., 2014; Sallis et al., 2016). However, non-significant relationship between UGS and physical activities have also been reported (Triguero-Mas et al., 2015), partly due to some UGS's not being thermally comfortable or adequately designed for physical activities (Evenson et al., 2013). Additionally, UGS enhances air quality by absorbing, filtering, and decomposing harmful particles (Buccolieri et al., 2018; Ysebaert et al., 2021), yet concerns arise about the allergens and particles brought by UGS that may harm health (Osborne et al., 2017). Moreover, UGS confers public health benefits by reducing urban heat through evapotranspiration and shading[1](Probst et al., 2022; Wong et al., 2021). Research indicates that the temperature reduction contributed by UGS ranges from approximately 1 °C to 10 °C and even higher (Park et al., 2017; Rashid et al., 2014; Wu et al., 2012), further leading to profound decrease of air conditioning usage and promoting energy conservation (Zhang et al., 2014). Existing research has identified controversies regarding the size and layout of UGS. For example, some scholars highlight the extraordinary cooling effect of large UGS, pointing out UGS over 100 hectares can cool areas over several kilometers far (Du et al., 2017), while evidence also show that UGS as small as 0.49 to 2.04 hectares can generate a significant cooling effect of 1°C to 3 °C (Grilo et al., 2020). Some scholars highlight that a clustered pattern of UGS patches have greater cooling performances than a scattered pattern (Estoque et al., 2017; Rhee et al., 2014; Zhao et al., 2020), but there exist inconsistent findings (Zhou et al., 2011; Zhou et al., 2023). Some studies worry that UGS may increase humidity and thus hinder the cooling of the surrounding areas, yet studies from places such as Singapore and Malaysia have demonstrated UGS's profound cooling effect (Rashid et al., 2014; Shahidan et al., 2012).

However, current studies have not effectively linked UGS's cooling capacity to public health benefits through empirical investigations. Several gaps remain. First, Studies defining UGS boundaries often overlook the influence of the built environment, resulting in inaccurate definitions. Second, while some studies use simulation techniques to optimize UGS distribution for cooling effects (Zhang et al., 2017 b), they fail to include the real-world land use situations and leading to limited practical guidance. These ambiguities and gaps highlight the necessity of conducting location-based empirical research (Zhou et al., 2025).

2.3 UGS planning practices and equity debate

Recently, UGS has become a popular planning strategy aimed at improving public health (Sugiyama et al., 2018), as it is considered more economical in cost and can raise fewer concerns on environment and political sides than many other measures (Zhang et al., 2019). However, gaps remain between UGS research and planning practices. First, UGS is mainly provided by governments due to its competitiveness and non-exclusiveness as quasi-public goods (Chen et al., 2019) and thus less valued due to budget constraints (Chen and Hu, 2015; Lin et al., 2023; Wang,

1 Evapotranspiration reduces ambient air temperature through converting liquid water into water vapor and exchanging sensible heat for latent heat, while the shade created by plant canopies blocks heat transfer and contributes to lowering temperatures, especially in humid regions through delaying the peak air temperatures during the day.

2015), leading to UGS relatively small, not appropriately designed and suitable for recreational activities (Jiao et al., 2017; Wolch et al., 2014). Furthermore, compulsory demands from the higher-level governments regarding UGS have not prompted local governments to intricately plan UGS. Instead, they struggle to meet minimal quantity requirement2, disregarding spatial layout and interior design, as well as public participation (Miao, 2011; Yu and Padua, 2007). Additionally, that land developers placing high values of UGS construction turns them into private asses, exacerbating the inequalities in distribution and utilisation of UGS due to "green gentrification" (Liebelt et al., 2018; Shan et al., 2024). These practical obstacles embedded in the planning system hinder UGS from maximizing their potential to deliver comprehensive and equitable health benefits (Wang and Chan, 2019) and require more cautious planning interventions (De Haas et al., 2021; Kruize et al., 2019).

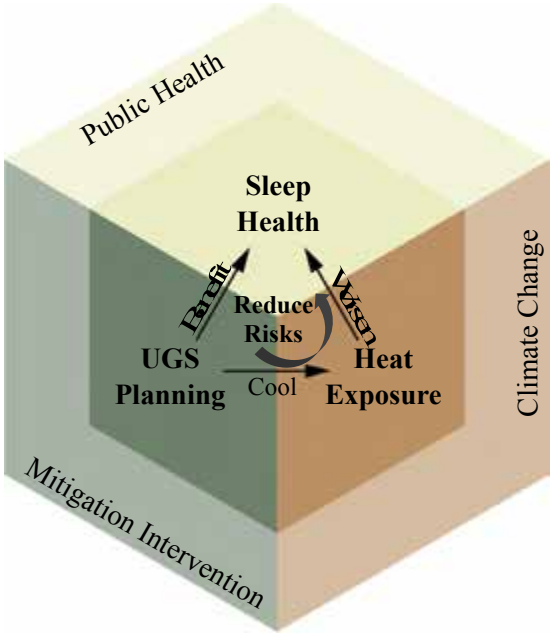

Figure 1 UGS's cooling pathway to mitigate climate change's impact on sleep health

3 Research strategy

3.1 Data source and research framework

This study focuses on Guangdong Province from the Great Bay Area of China, which features a subtropical and tropical monsoon climate zone (20°09'N to 25°31'N, 109°45'E to 117°20'E) with its average temperature between 19 °C and 23.5 °C and averagely over 30 °C during the summer, thus facing significant heat exposure-induced health issues (Ho et al., 2025).

Six cities from the Guangdong Province that cover both economically developed and developing cities were selected to conduct a survey of school-age children, including Guangzhou, Shenzhen, Foshan, Zhongshan, Zhuhai and Maoming **(Figure 2**). The six cities cover both the coastal and inland part, 41.50% of the impermeable area, 41.45% of the population, and 65.43% of the GDP of the entire Guangdong province3, representative regarding climate and population. A large-scale survey was conducted across almost all months from 2016 to 20184, obtaining information on sleep health, home address and family's socioeconomic status from 131,412 school-age children in 105 randomly-selected primary and middle schools. The average atmospheric temperature within 500 meters of the residence is matched according to students' home address and used to represent heat exposure (Venter et al., 2020).

2 For instance, Guangzhou does not provide detailed definition and calculation method for the different requirements of UGS. Shenzhen sets the rate of green space for each district, which is a different indicator compare to Guangzhou. The planning documents do not specify the calculation method as well.

3 These percentages are calculated based on the 30m resolution land use data from 2016 to 2018, the 100m resolution population and GDP density data in 2019. Detailed data sources are in Table 1.

4 The protocol was approved by the Sun Yat-sen University Institutional Human Ethics Committee (Ethics Approval Number: 026).

This study comprises three stages (**Figure 3**). The first models the link between air temperature and sleep health and explores whether UGS has the potential to mitigate heat exposure's exacerbating influences on sleep disorders, with sampled school-age children as a focused group. The second constructs a prediction model for air temperature based on various factors, including planning interventions that can be linked with different planning approaches. The third applies the four UGS scenarios representing different trade-offs regarding small-large and new-old to established models in the first two stages, evaluating their nuanced potentials in improving school-age children's sleep health.

Multiple factors are included in the second stage (**Table 1**), including climate and geographic factors such as precipitation, relative humidity, wind velocity, solar radiation and digital elevation model (DEM) (Cristóbal et al., 2008; Yang et al., 2017), socioeconomic factors such as population and GDP density (Shen et al., 2020; Sun et al., 2018). Normalized difference vegetation index (NDVI) and land cover data are also included to link with planning interventions in different scenarios. Air temperature better represent people's perception of temperature exposure (Bernhard et al., 2015), yet land surface temperatures (LST) are also included as factors as recommended (Hu et al., 2019; Janatian et al., 2017).

Figure 2 Research site5

5 The map of the Great Bay Area is from the Guangdong Provincial Department of Natural Resources, with review number Yue S (2022) No. 226, with the small islands on the sea omitted. The map of China is from the Ministry of Natural Resources, with review number GS (2023) No. 2765.

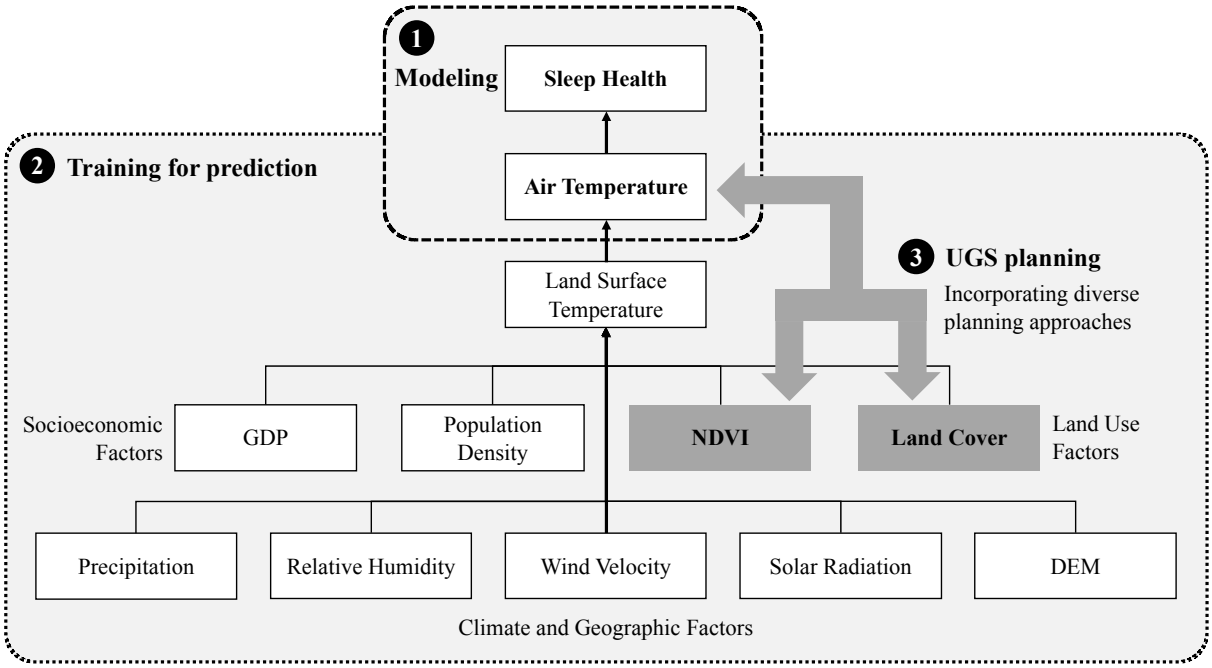

Figure 3 Research framework

Table 1 Source of data for heat exposure simulation

Data	Source	Spatial Resolution	Temporal Resolution
Air temperature	National Earth System Science Data Centre, National Science & Technology Infrastructure of China (http://www.geodata.cn)	1km	monthly
Precipitation		1km	monthly
Relative Humidity		1km	monthly
Wind Velocity		1km	monthly
Solar Radiation		1km	monthly
NDVI		1km	monthly
DEM	National Tibetan Plateau Data Centre (Tang, 2019)	1km	2000, stable across years
Land Cover	(Yang and Huang, 2021)	30m	yearly, using 2016-2018
Population Density	China Resource and Environmental Science Data Platform (Xu, 2017a; 2017 b)	100m	every five years, using 2019
GDP Density		100m	every five years, using 2019
Land Surface Temperature	NASA's Land Processes Distributed Active Archive Centre (Wan et al., 2015)	1km	monthly

3.2 Model setting

3.2.1 Model between air temperature and sleep disorders

A logistic model is utilized to examine the impact of heat exposure on sleep health, considering sleep disorder indicators such as overall sleep disorder (SD), disorders of initiating and maintaining sleep (DIMS), and sleep hyperhidrosis (SH). Covariates include age, gender, body mass index (BMI), exercise time, secondhand smoke exposure, household income level, housing area per capita, presence of mold at home, proximity to main road or factory, and average NDVI in the neighborhood.

$$Prob(Y_i = 1|X_i, Z_i) = \Phi(\beta_0 + \beta_1 T_i + \theta G_i + Z_i\gamma + \varepsilon_i) \quad (1)$$

where Prob(Y_i=1|X_i,Z_i) represents the probability of sleep disorders. R denotes the temperature exposure variable. G refers to the average NDVI of the surrounding neighborhood. Z represents the control variables.

A generalized structural equation model (GSEM) is used to test UGS's cooling pathway in mitigate heat exposure's adverse impact on sleep health. The formula (1) and (2) are estimated in a structed way (Yu et al., 2025).

$$T_i = \mu_0 + \mu_1 G_i + \varepsilon_i \quad (2)$$

If both μ_1 and Δ_1 are significant, UGS's cooling pathway in mitigating heat exposure's adverse impact on sleep health is significant. If both μ_1 and Δ_1 are not significant, product-of-coefficients tests are performed. If Δ is nonsignificant, the full mediating effect is further verified. Otherwise, there is a partial mediating effect.

A natural cubic spline (NCS) method is used to detect the nonlinear impact.

$$Prob(Y_i = 1|X_i, Z_i) = \Phi(\beta_0 + \beta_1 ns_1(T_i) + \beta_2 ns_2(T_i) + \beta_3 ns_3(T_i) + \beta_4 ns_4(T_i) + \theta G_i + Z_i\gamma + \varepsilon_i) \quad (3)$$

where $ns_1(T_i)$, $ns_2(T_i)$, $ns_3(T_i)$, $ns_4(T_i)$ indicate the functions generated using NCS method. Each disorder-specific model is determined using the lowest Akaike's Information Criterion (AIC) values that indicates the best fit across the three different knot specifications (Lee et al., 2020).

3.2.2 Model for predicting air temperature

A two-stage training approach using random forest method is adopted to construct an air temperature prediction model for each month across the survey time. UGS in this study is defined as all forest, shrub and grass within the "urban area"[6] (Sun et al., 2021) based on the land cover data of 30 m resolution (Yang and Huang, 2021), as employed by many other studies to exclude hard pavements and allow for the actual cooling effect from plants (Feltynowski et al., 2018; Kuang et al., 2021). The two-stage training method allows for the consideration of UGS impact on the environment through LST (Janatian et al., 2017), with marine areas omitted due to data unavailability. Urban areas and human habitats mostly situate to the southern area, allowing for the exclusion of the confounding effects from bordering regions. The importance of each factor and goodness of fit are reported in **Appendix Table 1**.

3.3 UGS scenarios

Four UGS scenarios are proposed based on the real-world practices and debates, including expanding current large UGS (s1), expanding current small UGS (s2), constructing new large UGS (s3), and constructing new small UGS (s4) (**Figure 4**). Expanding current UGS can be costly but beneficial for densely populated areas nearby. Building new UGS may be more feasible with lower costs, benefiting residents in the vicinity, although their impact may be limited if located in remote areas.

In China, local governments determine the UGS quota based on the total new urban land allocation set by higher

6 The urban area in this study is the minimum bounding rectangle based on the urban built-up area published by Sun et al. (2021) using the "Minimum Bounding Geometry" tool in GIS. This approach maximizes interconnected urban green spaces in close proximity while excluding rural and ecological conservation areas.

authorities, typically ranging from 5-30% of the annual new urban land. City-specific ratios between 5-30% is set for converting to new UGS, and the total amount of new UGS range from approximately 2.5 to 2.7 km^2, with the six sampled cities accounting for over 60% (**Table 2**).

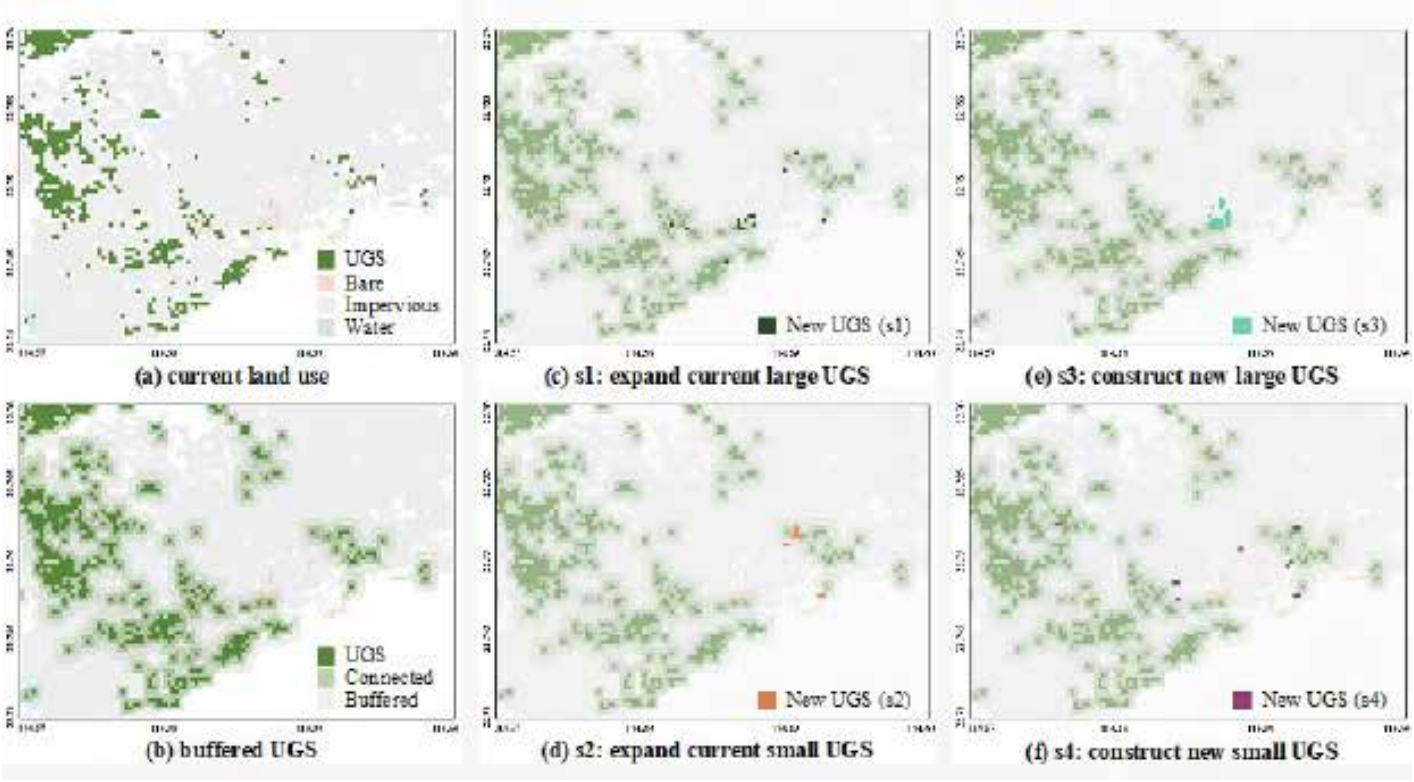

Figure 4 Simulation scenarios (Shenzhen example)

Table 2 The city-year-fixed total amount of new UGS (km^2)

	bare land			Increased UGS			Ratio
	2016	2017	2018	2016	2017	2018	
Foshan	4.028	4.193	4.233	1.209	1.258	1.270	30%
Guang-zhou	1.049	1.150	1.094	0.315	0.345	0.329	30%
Maoming	0.067	0.053	0.052	0.004	0.003	0.003	5%
Shenzhen	1.067	1.002	0.764	0.320	0.301	0.230	30%
Zhongshan	0.650	0.638	0.557	0.130	0.128	0.112	20%
Zhuhai	0.083	0.079	0.069	0.005	0.004	0.004	5%
Other	4.020	4.064	3.860	0.631	0.636	0.604	5-30%
Total	10.880	11.100	10.560	2.613	2.674	2.550	24%

4 Results

4.1 Modeling exposure-disorder relationship

Logistic models reveal that heat exposure significantly increases the risk of sleep disorders (SD, DIMS, SH) (**Table 3**, Model 1-3). lnNDVI significantly decreases of risks of sleep disorders. GSEM analysis examines the mediating role of UGS cooling effect on sleep health (**Table 4**), demonstrating a significant positive impact aligning with prior empirical evidence (Yu et al., 2025). The cooling pathway accounts for approximately 1% of the total effect using lnNDVI as a proxy.

The NCS method identifies the nonlinear impact of heat exposure (**Table 5**, Model 4-6). Each knot function shows significant estimated coefficients, especially ns(T)3 which falls around the moderate levels of exposure. The coefficients of lnNDVI are similar as those in normal logistic models. We focus on analyzing the predicted probabilities of experiencing sleep disorders rather than specific numerical results.

Table 3 Heat exposure's impact on sleep disorders using logistic egression

	Model 1 (SD)	**Model 2 (DIMS)**	**Model 3 (SH)**
T	0.013***	0.020***	0.017***
	(0.004)	(0.003)	(0.003)
lnNDVI	-0.539***	-0.448***	-0.506***
	(0.038)	(0.034)	(0.035)
Controls	Yes	Yes	Yes
N	108930	108930	108930
Pseudo R^2	0.019	0.013	0.061

Note: Robust standard errors are in the parentheses. * indicates statistical significance at the 0.1 level, ** indicates statistical significance at the 0.05 level, *** indicates statistical significance at the 0.01 level.

Table 4 UGS's cooling pathway in heat exposure's impact on sleep health

	SD	**DIMS**	**SH**
lnNDVI→T	-0.344***	-0.344***	-0.344***
	(0.036)	(0.036)	(0.036)
T→SLEEP	0.013***	0.020***	0.017***
	(0.004)	(0.003)	(0.003)
lnNDVI→SLEEP	-0.539***	-0.448***	-0.506***
	(0.038)	(0.034)	(0.035)
Indirect	-0.004***	-0.007***	-0.006***
	(0.001)	(0.001)	(0.001)
Total	-0.544***	-0.455***	-0.512***
	(0.038)	(0.037)	(0.034)
Indirect/Total	0.8%	1.5%	1.2%

Note: Robust standard errors are in the parentheses. * indicates statistical significance at the 0.1 level, ** indicates statistical significance at the 0.05 level, *** indicates statistical significance at the 0.01 level. All models included control variables.

Table 5 Heat exposure's nonlinear impact (NCS method)

	Model 4 (SD)	Model 5 (DIMS)	Model 6 (SH)
ns(T)1	0.882***	1.031***	1.005***
	(0.152)	(0.128)	(0.157)
ns(T)2	0.354***	0.410***	0.576***
	(0.126)	(0.097)	(0.128)
ns(T)3	1.497***	1.397***	1.903***
	(0.362)	(0.298)	(0.381)
ns(T)4	0.565***	0.564***	0.547***
	(0.132)	(0.089)	(0.118)
lnNDVI	-0.576***	-0.491***	-0.542***
	(0.040)	(0.035)	(0.036)
Controls	Yes	Yes	Yes
N	108930	108930	108930
Pseudo R^2	0.020	0.015	0.062

Note: Robust standard errors are in the parentheses. * indicates statistical significance at the 0.1 level, ** indicates statistical significance at the 0.05 level, *** indicates statistical significance at the 0.01 level. All models included control variables.

4.2 Simulating UGS's cooling potential

Figure 5 compares original and simulated temperatures in s1 within the built-up area, displaying monthly averages. The most significant cooling effect occurs in March and April, with a maximum decrease of 1.13 °C. Conversely, July and August show minimal cooling, with a potential increase of 0.04 °C, likely influenced by high humidity.

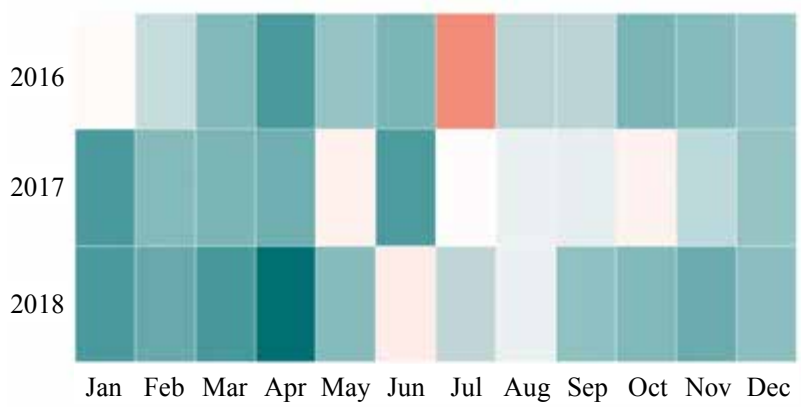

Figure 5 Temperature difference between the original and simulated (s1)

4.3 Simulating UGS's cooling impact on sleep health

Possibilities of developing sleep disorders are predicted based on the normal logistic and NCS models (Model 1-6). By incorporating simulated temperature exposures, new probabilities are generated for the four planning scenarios proposed in section 3.3. **Figure 6** presents the overall mean value and Gini coefficient. **Table 6** reports the t-test results of the mean value between four scenarios. **Figure 7** shows the decile-based probability changes, while **Table 7** reports the average risks of sleep disorders (measured using the NCS method) across different cities.

According to **Figure 6** and **Table 6**, Mean values from the NCS method are higher than those from normal logistic regression, with relatively lower Gini coefficients. Since prior research has highlighted that using a linear "exposure-response" relationship may underestimate health risks linked to high temperatures (Gasparrini et al., 2010), NCS results may provide a more reliable and accurate reflection of heat exposure's real-world impacts. The mean values in s2 are significantly lower than in s1 and s3 according to the NCS method), suggesting that enhancing large UGS may not provide substantial health benefits through cooling. In contrast, mean values in s2 are higher than s1 and s3 in normal logistic regression due to potential underestimation at high temperatures. Gini coefficients in s2 and s4 are lower than in s1 and s3, with s4 showing a more balanced distribution of sleep disorder risks compared to s2, indicating that focusing on small UGS improvements may lead to more equitable outcomes.

In **Figure 7**, blue indicates a decrease in the average probability of sleep disorders compared to the original situation in the simulated scenario, while yellow signifies an increase. An unpaired t-test between the original and simulated scenarios reveals a significant improvement in the first decile group in the NCS model of SD. Introducing UGS shows potential to enhance sleep health for populations at low and high-risk levels, but may not have the same effect for those with moderate risk levels due to increased humidity in some areas. The NCS results, considering nonlinear relationships, show greater improvements, underscoring UGS's ability to mitigate heat exposure's negative effects. UGS's cooling benefits are particularly advantageous for lower-risk groups (SD and SH), offering broad advantages across different risk levels. However, individuals in the extremely high-risk category (DIMS) may not experience significant improvements in sleep health, indicating complex factors beyond heat exposure may pose threats to DIMS.

In **Table 7**, the scenario with the lowest mean risk value for each city is highlighted in grey. Most cities show the greatest benefits from scenarios s2 and s4, with Foshan benefiting from scenario s4 across all three types of sleep disorders. Guangzhou and Zhuhai might derive the most benefit from scenario s1. Only a small number of cities appear to benefit from scenario s3.

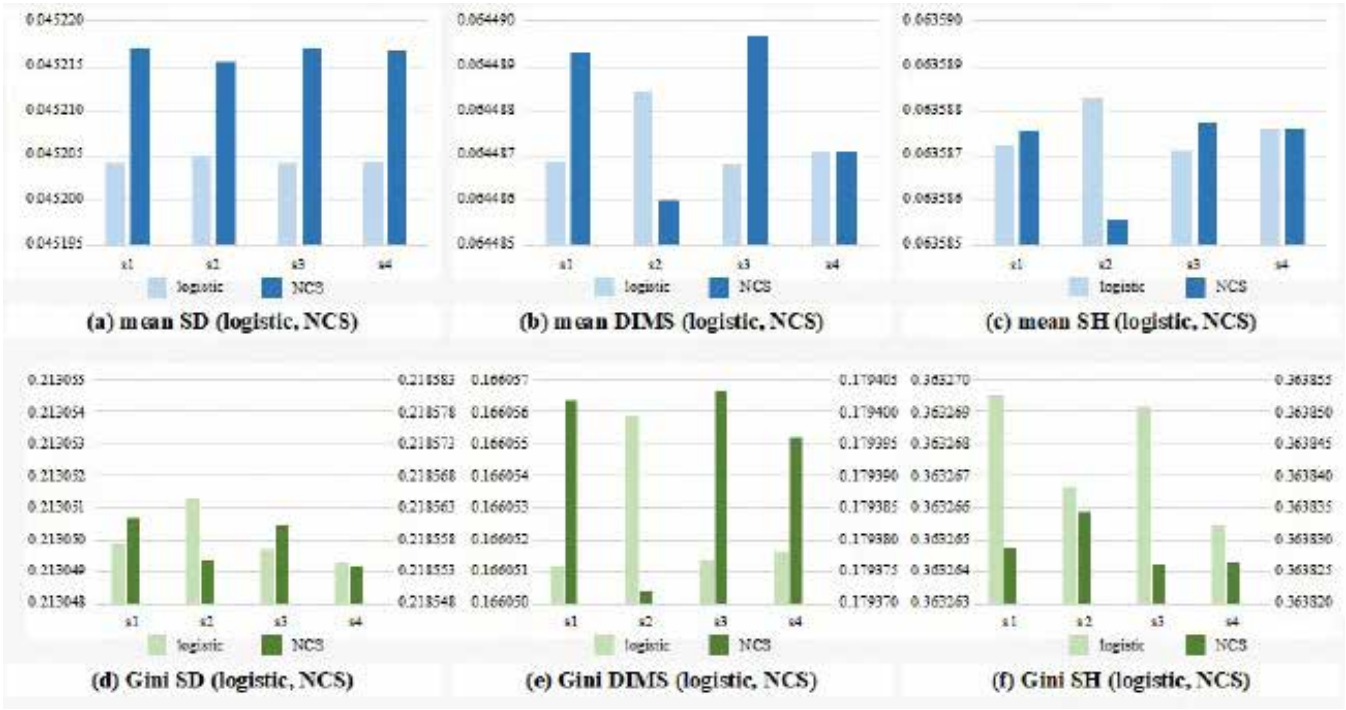

Figure 6 The mean and Gini coefficients of the risks of sleep disorders among four scenarios

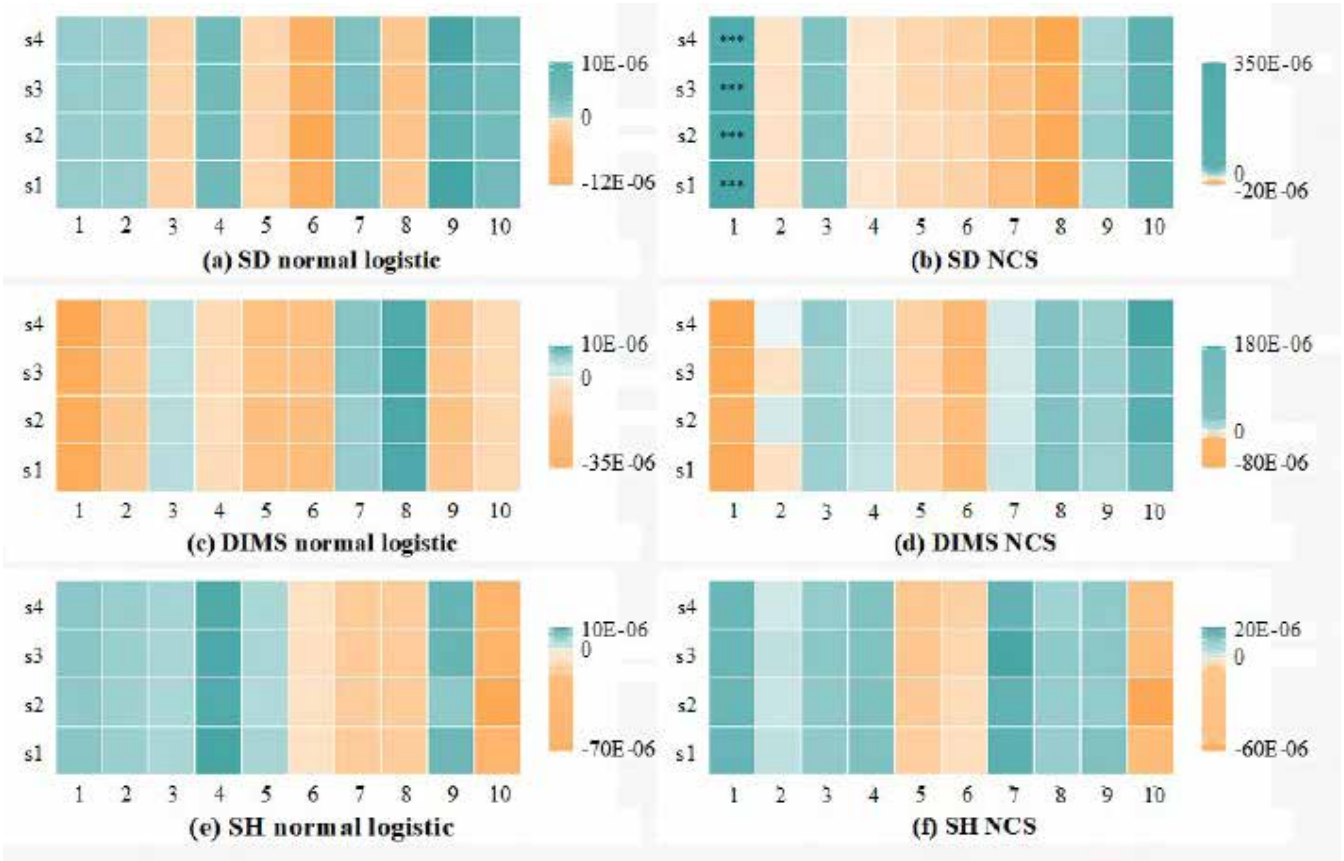

Figure 7 The differences between the current and simulated risks by levels among the four simulation scenarios

Table 6 T-test results of the risks of sleep disorders between the four simulation scenarios

group	l_sd	l_dims	l_sh	ns_sd	ns_dims	ns_sj
s1 - s2	-0.887***	-1.560***	-1.050***	1.600***	3.290***	2.000***
	(0.019)	(0.032)	(0.026)	(0.061)	(0.173)	(0.056)
s1 - s3	0.049***	0.070***	0.102***	0.044	-0.354***	-0.146***
	(0.007)	(0.013)	(0.010)	(0.027)	(0.080)	(0.022)
s1 - s4	-0.007	-0.030	0.076***	0.748***	2.030***	0.390***
	(0.011)	(0.019)	(0.017)	(0.040)	(0.117)	(0.035)
s2 - s3	0.936***	1.630***	1.150***	-1.560***	-3.640***	-2.150***
	(0.019)	(0.033)	(0.027)	(0.063)	(0.176)	(0.060)
s2 - s4	0.880***	1.530***	1.130***	-0.854***	-1.260***	-1.610***
	(0.018)	(0.031)	(0.026)	(0.063)	(0.176)	(0.057)
s3 - s4	-0.056***	-0.099***	-0.026*	0.704***	2.380***	0.536***
	(0.009)	(0.015)	(0.015)	(0.035)	(0.101)	(0.030)

Note: Due to the small numerical values, the reported results are shown after multiplying by , representing the key figures in scientific notation (E-06).

Table 7 The mean values of the risks of sleep disorders (NCS method) by cities

city	Foshan	Guangzhou	Maoming	Shenzhen	Zhongshan	Zhuhai
ns_sd						
p1	46032.8	46785.8	43376.2	44468.6	45425.2	43137.9
p2	46035.1	46786.6	43362.9	44467.9	45424.9	4 3137.8
p3	46031.3	46786.1	43377.4	44468.0	45425.0	43138.0
p4	46030.3	46785.7	43377.1	44467.9	45424.8	43138.4
ns_dims						
p1	65971.2	68181.4	67144.2	55384.2	63173.5	66310.5
p2	65978.7	68184.6	67111.9	55383.6	63172.8	66310.1
p3	65966.8	68183.6	67148.5	55383.4	63173.1	66310.5
p4	65963.3	68181.7	67138.7	55383.5	63172.7	66310.7
ns_sh						
p1	64160.4	56358.7	59075.8	75077.9	62735.7	73261.4
p2	64161.7	56359.2	59061.9	75077.5	62735.2	73261.2
p3	64160.0	56359.4	59076.9	75077.4	62735.4	73261.3
p4	64159.7	56359.0	59076.8	75077.3	62735.3	73261.9

Note: Due to the small numerical values, the reported results are shown after multiplying by , representing the key figures in scientific notation (E-06).

5 Discussion and policy implication

This study focuses on Guangdong Province which features a typical subtropical monsoon climate. Using a "marginal increase" approach, the research examines how UGS provide health benefits through cooling effects in the region. A monthly air temperature prediction model is developed, incorporating various factors and achieving a good fit above 0.95. Four UGS planning scenarios are proposed based on real-world practices. Simulation results are then used to assess the risks of three types of sleep disorders among school-age children in six sampled cities.

Results confirm that UGS serves as an effective strategy in mitigating climate change impacts on sleep health, and the cooling pathway significantly accounts for at least 1%. Introducing around 2.5 to 2.7 km^2 of UGS can effectively cool urban areas, with the most substantial temperature reduction of 1.13 °C in April 2018. Approaches highlighting small UGS have a more profound and significant positive effects on school-age children's sleep health than scenarios focusing on large UGS. Particularly, expanding existing small UGS in s2 shows the greatest potential for balanced and equitable outcomes. In contrast, s3 performs poorly in terms of health impact and equity.

Results indicate that UGS provides health benefits for population with both low and high risks, as shown in **Figure 7**. In other words, UGS not only serve to mitigate heat-related risks but also contribute to enhancing public health in a preventive way (Lachowycz and Jones, 2013; Zhang et al., 2022), emphasizing the importance of introducing and improving UGS to confer public health benefits. However, UGS may have negative impacts on populations with medium risk levels. In some cases, UGS in humid areas may increase humidity levels, impacting thermal comfort (Yu et al., 2025). The complex dynamics between humidity and temperature (Yang et al., 2024) jointly affect thermal comfort, and elevated humidity coupled with extreme high temperatures may exacerbate heat discomfort (Ho et al., 2025). UGS may not effectively mitigate risks at very high levels, highlighting the need for targeted investigations into factors beyond the thermal environment affecting sleep disorders.

The size of UGS matter a lot in planning practices. Contrary to the emphasis on large UGS in studies specifically focusing on the cooling effect (Shah et al., 2021), this study indicates that prioritizing small UGS may yield greater cooling-induced health benefits. Expanding and improving small UGS and creating new ones can provide broader access to cooling benefits for the population, consistent with previous findings (Yan et al., 2021). In contrast, expanding the large UGS in s1 shows limited health benefits, likely due to its placement in non-residential central urban areas (Aram et al., 2019). Similarly, constructing new large UGS in s3 is ineffective and unbalanced, as many remaining plots are in suburban areas, repurposed from factories, and far from residents, limiting their benefits. This study warns that practices in s3 may lead to underutilized UGS, wasting resources and should be avoided.

Although expanding small UGS may incur higher costs, its cooling and health benefits could be greater with better long-term social and economic outcomes. Instead of just "greening the city" (Wolch et al., 2014), it is highly recommended to implement strategic UGS placement and ongoing improvement of existing parks to maximize public health and ensure equity.

This study offers two main innovations. First, it integrates UGS's cooling capacity with public health benefits by quantitatively simulating the specific performances of UGS's cooling pathways. Second, the real-world quota-allocation practices in simulation scenarios are incorporated to compare the common trade-offs between large and small, new and old UGS, and thus provide constructive planning prescriptions. Limitations include non-random sampling, though participants are widely distributed across six cities. Moreover, due to data constraints, the spatial resolution is only 1 km. Future work aims to enhance accuracy and recommendations.

Appendix

Table 1 The importance of factors and goodness of fit for air temperature prediction models

Model	Precipitation	Humidity	Wind	DEM	Solar	GDP	POP	NDVI	Impervious	Water	Forest	Shrub	Grass	LST_day	LST_night	RMSE	R^2
201601	35363.94	43684.18	13424.62	125498.85	45718.74	218998.14	141624.08	15422.43	13309.03	4517.22	26662.74	961.07	1189.45	389790.23	148182.75	0.34	0.98
201602	16310.69	27920.15	9786.56	90532.63	39179.96	114464.10	48464.14	10196.53	4610.33	4454.43	18308.95	576.64	1039.13	271552.66	165117.24	0.32	0.98
201603	18292.19	40346.11	11996.80	193423.30	147938.25	87822.33	57716.45	11380.38	5318.96	4226.48	25172.44	706.26	992.73	48963.05	161734.56	0.34	0.98
201604	9199.94	12370.13	7095.24	78116.67	73401.34	24914.43	35873.24	6108.21	2357.79	1765.92	9760.67	491.24	686.61	26640.16	112754.93	0.34	0.97
201605	12472.40	13863.28	8467.91	131500.57	30474.93	28163.54	42348.30	7838.33	5533.29	2752.05	32023.33	651.12	886.85	31171.49	80592.10	0.32	0.96
201606	21645.90	15960.02	8887.78	115006.17	16644.14	16392.17	21265.87	11366.52	24761.30	2701.25	40342.21	732.72	912.86	21875.93	146323.68	0.34	0.96
201607	30851.60	11501.34	8658.54	92908.03	11979.96	18859.46	17586.64	13748.51	15273.86	3021.62	47347.42	1099.81	902.09	39356.29	180530.95	0.32	0.97
201608	22530.92	14980.69	8986.10	154277.60	17105.74	27522.31	39588.55	10134.15	7290.12	2989.30	31806.53	506.58	824.35	74665.74	134883.89	0.32	0.97
201609	20082.09	12331.22	9038.39	174488.71	20113.12	32779.10	26734.94	11097.87	11740.90	2906.36	49207.86	838.68	932.88	57383.75	137231.14	0.32	0.97
201610	18739.14	10721.12	9152.29	172468.58	27087.94	39938.77	56526.91	11075.62	8251.37	3974.55	39472.37	685.07	883.72	45220.17	90892.80	0.31	0.97
201611	11333.88	13779.81	9548.15	159384.35	137542.76	56770.09	154793.72	10976.55	9901.33	3600.00	20463.05	858.16	970.88	88261.08	116042.50	0.31	0.98
201612	16172.12	11967.01	7077.15	64573.26	31596.89	78807.30	96252.11	10663.17	5985.81	3975.06	21533.99	863.80	833.53	265450.35	407755.20	0.30	0.98
201701	15408.35	18853.97	8176.31	71798.39	55195.37	82970.98	46980.86	13530.92	8871.65	4484.19	16728.28	778.15	883.31	323424.62	176903.82	0.30	0.98
201702	12129.32	17063.68	7777.70	119544.93	46408.90	48404.75	55792.33	8846.88	6515.15	3695.82	19143.86	550.62	860.94	159689.82	205590.89	0.28	0.98
201703	30834.84	23617.34	14306.49	101626.71	185975.67	157993.65	244578.77	15086.65	7288.23	5080.66	23516.28	778.51	1086.56	150439.68	467201.61	0.32	0.99
201704	12576.18	13260.01	8324.72	157906.07	34129.87	57433.50	62565.13	8310.70	8705.37	2860.35	27651.06	721.70	768.58	57151.57	208497.19	0.28	0.98
201705	13253.38	11820.32	7785.82	137267.32	17566.92	23657.77	36572.98	8934.12	3726.58	3478.13	30299.38	709.72	882.51	33555.03	88876.23	0.31	0.96
201706	25274.65	11808.79	8996.60	74087.83	15512.69	23004.37	14829.88	8391.95	13010.55	3933.03	30692.97	550.69	870.66	15033.49	120632.85	0.38	0.95
201707	25189.83	19767.44	10382.29	107483.49	17817.81	22687.99	23268.05	22169.35	25975.38	2710.27	46220.85	701.83	829.46	21419.25	159529.28	0.34	0.96
201708	26104.16	15172.20	9759.19	139503.92	18059.31	34844.37	19714.15	25773.60	24454.64	3595.49	36555.13	863.60	934.05	55055.48	147046.02	0.32	0.97
201709	29364.18	10994.87	8122.21	148853.30	15803.18	27951.20	21860.34	17351.01	10713.27	2572.66	52679.06	704.48	911.59	42662.59	159217.55	0.30	0.97
201710	21818.96	10021.31	8697.40	180456.35	19713.64	34188.22	60620.58	11166.10	6062.99	4827.21	29394.63	855.09	875.44	62906.94	115435.91	0.31	0.97
201711	13012.98	15850.08	10530.59	125229.84	157519.67	55652.14	74489.74	11617.59	7954.31	3286.29	25432.00	1047.79	991.20	48688.36	197281.55	0.32	0.98
201712	16315.68	16260.96	8236.49	75852.12	40237.81	78470.52	68745.74	11737.13	7568.07	5681.33	13292.42	696.43	755.44	193824.26	421176.19	0.29	0.98
201801	23657.34	28493.27	11965.76	117832.81	104529.31	172583.19	126238.03	16719.29	5942.70	4087.38	28279.12	821.63	1155.07	135152.59	253793.52	0.33	0.98
201802	14574.70	20041.80	10530.51	119109.89	34425.23	93058.29	62011.02	11307.51	8943.92	2957.39	21600.50	566.94	832.99	81656.69	197288.41	0.31	0.98
201803	11047.04	15071.75	7928.69	182391.37	51255.06	74526.38	70537.28	10754.11	6019.40	2383.55	22624.47	499.69	723.27	146851.21	208413.59	0.27	0.98
201804	21032.61	19692.83	11786.22	165146.64	36321.38	40377.24	100268.02	16926.45	8389.24	3035.50	42690.06	1039.10	868.39	32222.78	121053.55	0.32	0.97
201805	39650.08	12473.18	9025.77	105845.40	16025.39	25619.09	16641.24	26456.78	13895.99	2768.13	52126.17	1138.29	920.93	21436.53	90539.90	0.35	0.95
201806	17774.68	12820.67	10473.76	159309.17	22942.07	22597.01	31965.23	15760.47	8921.36	3022.58	48556.20	1022.38	837.97	52279.72	180340.72	0.33	0.97
201807	16737.06	11612.05	9627.61	113620.83	15367.85	14944.71	21650.59	20625.22	18145.88	3138.64	29567.85	785.91	835.15	18408.09	108143.12	0.33	0.96
201808	36285.43	18166.92	18194.20	136684.36	22213.24	43693.76	30210.12	24837.88	27510.94	4121.60	61259.36	841.44	1127.33	37588.24	143804.58	0.42	0.95
201809	23308.35	10156.61	9250.09	176076.77	14592.48	31967.99	38389.07	27394.22	11632.96	2772.36	47380.46	887.99	832.56	25138.25	88686.10	0.32	0.97
201810	15247.43	9239.80	7118.63	155695.97	55143.62	47034.06	68741.16	13392.37	4817.60	3864.62	25387.07	697.69	786.12	55422.30	188148.06	0.30	0.98
201811	15327.92	14534.81	7467.25	86503.28	43681.16	68901.91	84686.50	9027.18	5213.19	2240.00	27365.38	541.70	754.90	192263.57	333902.23	0.29	0.98
201812	13326.98	13632.06	9143.38	64567.56	169642.39	94386.76	101507.52	11235.85	4494.81	2806.48	17205.33	793.37	831.75	371609.95	243380.54	0.30	0.99

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Using Participatory GIS for Sustainable Campus Planning: Insights from GreenHack Hackathon

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Abstract
Climate change is the principal global challenge demanding active community participation alongside governmental and corporate efforts. This article presents findings from GreenHack, a student hackathon at Istanbul Technical University (ITU), utilizing Participatory Geographic Information Systems (PGIS) to enhance campus sustainability. Participants developed creative PGIS-based prototypes addressing green space planning, waste management, water conservation, and energy economy, aligned with UI GreenMetric standards and ITU's Green Campus project. These applications demonstrated GIS technologies' ability to visualize data, engage users through gamification, and provide actionable insights. GreenHack showcases the potential of participatory hackathons to connect sustainability goals with community engagement, offering scalable, inclusive frameworks for sustainable design extending from campus environments to broader urban contexts.

Keywords: Campus sustainability; Climate change; Green campus; Public GIS; Hackathon

Introduction

Cities have become areas facing many interconnected problems such as the side effects of industrialization, population density, and unhealthy urbanization. The damage to the environment due to these problems requires the integration of technology and sustainability to address these issues and for society to take action. Universities and their campuses are important for this goal because their physical structures, technological infrastructure, and qualified student populations carry the potential to create collective awareness and perform environmentally beneficial actions. As centres of learning and innovation, university campuses are ideal environments for adopting new approaches. Their focused communities and infrastructure enable them to effectively test and demonstrate sustainability and technology initiatives that can inform and inspire change in the wider city. Thus universities can set an example for adopting a green and sustainable design approach and adapting to changing dynamics. Many universities have adopted UN sustainable development goals within their curriculums and campuses. Their local and international connections give these institutions the opportunity to be effective in achieving these goals at different scales. Istanbul Technical University (ITU) has already demonstrated significant progress in these areas. For instance, its commitment to a green campus has earned global recognition, with ITU ranking in the top 50 in the 'UI Green Metric' ranking in 2025. Furthermore, it achieved a top 100 placement in 'The Impact Rankings,' which assesses sustainable development goals, sharing first place in Turkey with METU. These achievements are underpinned by its robust technological infrastructure, including efforts to integrate GIS-based applications with 'ITU Mobil'. Such initiatives not only enhance environmental consciousness but also foster active participation, transforming the campus into a dynamic model for observable sustainable practices and digital transformation.

This paper focuses on the 'Istanbul Technical University GIS-Based User-Oriented Green Campus Application Alternatives Determination' (İTÜ CBS Tabanlı Kullanıcı Odaklı Yeşil Kampüs Uygulama Alternatiflerinin Belirlenmesi)

project, supported by the Scientific Research Projects (BAP) unit. This BAP initiative specifically aims to develop user-oriented pilot applications for ITU's Green Campus activities, leveraging GIS and mobile infrastructures. Within the scope of this project, the GreenHack hackathon, organized at Istanbul Technical University (ITU) from December 1st to 3rd, 2023, served as a key activity. The hackathon was designed to bring together students, planners, GIS experts, and other stakeholders to collaboratively develop integrated Participatory Geographic Information Systems (PGIS) application prototypes. This event directly supported the broader goal of the BAP project by fostering creative, user-cantered solutions for ITU's 'Green Campus' initiative and enhancing the university's standing in the UI Green Metric rankings.

The hackathon itself was a participatory activity, as students are key stakeholders in the campus ecosystem and they were directly involved in shaping its future. By participating in the event, students had the opportunity to voice their perspectives, share their ideas, and contribute to creating solutions that reflect their priorities and needs. This collaborative environment also enabled them to acquire new knowledge and essential skills in areas such as GIS, urban sustainability, and app prototyping, through seminars and hands-on experience. This collaborative approach not only generated innovative prototypes but also fostered a sense of ownership and responsibility among participants, strengthening their connection to the campus and its sustainability goals.

Building on the identified need for innovative and participatory approaches to sustainable urban development, particularly within academic settings, this paper seeks to answer key questions regarding the efficacy of the GreenHack hackathon as a transformative planning action within the framework of a BAP project. Specifically, this study explores: How can hackathons, specifically utilizing Participatory GIS (PGIS), serve as an effective mechanism for fostering collaborative and innovative solutions for sustainable campus planning within a university context, as exemplified by the ITU Green Campus initiative? What types of PGIS-based solutions, in this case, prototypes, emerged from the GreenHack hackathon, and what is their potential for applicability within the UI GreenMetric criteria and scalability for addressing broader urban sustainability challenges, offering a replicable approach for other institutions?

To address these questions, the paper is structured as follows: Section 2 provides a comprehensive theoretical framework, reviewing the literature on participatory planning, the role of universities as living laboratories for sustainability, the evolution and application of Participatory GIS (PGIS), and the emergence of hackathons as platforms for collaborative innovation. Section 3 outlines the methodology, detailing the case study approach cantered on the GreenHack hackathon, data collection methods including document analysis and participant observation, and the analytical framework applied to the hackathon's outcomes. Section 4 presents the GreenHack hackathon as a detailed case study, describing its context within ITU's BAP project and Green Campus initiative, its structure, key themes, and the characteristics of the developed prototypes. Section 5 elaborates on the findings and analysis, discussing the innovation and functionality of the solutions, the role of PGIS in empowering stakeholder participation, and insights from the jury's evaluation. Section 6 offers a discussion of the broader implications of the GreenHack model, exploring its replicability and potential for scaling participatory solutions from campus to wider urban contexts. Finally, Section 7 concludes the paper by summarizing key arguments and contributions, emphasizing the transformative potential of participatory, technology-driven approaches in addressing contemporary environmental challenges[BD02] .

Theory

From conventional, typically top-down, tactics to more sophisticated and diversified digital technologies, public involvement in urban planning has evolved significantly. Historically, public participation first surfaced in many industrialised nations in the middle of the 20th century when institutional planning frameworks were set up (Wilson and Tewdr-Jones, 2021). Early public participation mostly depended on representational democracy, when choices made by professional officials and elected politicians have less direct influence outside of local elections. Public criticism of expert-driven planning decisions intensified after the 1950s, which resulted in participatory democracy being more significant in planning choices (Campbell and Marshall, 2000). With the Skeffington report in 1969, which sought to change planning from something "done to people" to something "with people," this change was formalised in Britain. Arnstein's (1969) Ladder of Participation describes obstacles like incomprehensible technical and legal jargon, inflexible planning processes, and the over-representation of elite groups in participation, therefore showing how frequently early participatory attempts remained tokenistic despite these aims. With communicative and cooperative planning theories in the 1980s stressing public

involvement to oppose strong interest groups, the argument surrounding public participation changed (Forester, 1982). The notable transition to new technologies, referred to as the "digital turn," has commenced altering urban planning and public engagement in the planning process. Technology's impact on planning, including urban modelling and 3D visualisations, has been evident since the 1960s and 1970s to facilitate a scientific approach; however, its incorporation for public engagement is a more contemporary advancement. Planners initially exhibited reluctance in adopting the digital revolution, frequently perceiving it as beyond their area of expertise. The accessibility of digital technologies, especially through smartphones and social media, has significantly altered citizen interactions with government, impacting political discourse and campaigns (Batty, 2021). The increasing public demand, along with the constraints of conventional methods such as public hearings and written statements, has necessitated the development of more accessible and accountable planning processes. The COVID-19 pandemic expedited this transition, prompting local planning authorities to adopt digital working and engagement processes. During this digital transformation, various specific technologies have emerged. The Public Participation GIS (PPGIS) field has expanded considerably in the last ten years, acknowledging that GIS technologies possess both empowering and disempowering potential. PPGIS seeks to promote grassroots GIS applications through the integration of various local knowledge and participatory methods. This approach aims to modify GIS data structures to incorporate qualitative data, sketch maps, and images, in addition to quantitative data. This enhances the accessibility of complex spatial information. PPGIS techniques encompass collaborative mapping and community evaluation of spatial data (Sieber, 2000). The "SoftGIS" methodology in Finland serves as an internet-based PPGIS tool that gathers localised experiential knowledge from residents, including children. PPGIS has the potential to integrate expert and lay knowledge for mutual learning and is particularly effective in the early diagnostic phases of planning; however, challenges remain. The skills required and the significant financial and temporal costs associated with GIS use can exclude numerous individuals and groups. Concerns exist regarding the technology's tendency to prioritise quantitative and visual data, which may marginalise alternative forms of knowledge (Brown and Kyttä, 2014). Numerous PPGIS tools primarily offer information instead of promoting substantial engagement. The quality of spatial information gathered may be diminished if participants fail to allocate adequate time and effort to the mapping activity.

Mobile applications and social media platforms offer opportunities for "low-friction" and "in-situ" participation. Several apps have been designed to make people aware of proposed changes while they are physically in the built environment, allowing for quick, location-based comments and potentially influencing long-term planning policy. Social media serves as an informal platform for discussions related to place, reflecting individuals' lived experiences and providing a medium for commentary on observable changes (King and Brown, 2007). These platforms can expand discussions and engage individuals who are not typically involved in formal democratic debate (Twitchen and Adams, 2012; Wilson and Tewdwr-Jones, 2019). Exclusive reliance on applications and social media presents challenges, such as the digital divide and the potential exclusion of individuals who lack access to or confidence in using technology. Furthermore, many modern digital tools, similar to their offline equivalents, primarily facilitate one-way information distribution rather than fostering interactive dialogue (Conroy and Evans-Cowley, 2005). The speed and ease of participation, while beneficial for raising awareness and reporting issues, can sometimes undermine the quality and depth of comments, which may impede the acquisition of knowledge essential for long-term planning.

Approaches incorporating digital gaming and creative activities aim to encourage deeper, more reflective engagement. Technologies that allow people to express complex feelings and visions about their environment through drawing and talking provide a novel and tangible method for participation that moves beyond traditional text-based responses. These "serious games" are designed to make participatory processes more accessible and engaging by using game design techniques. Creative methods can allow a wider representation of people to include perspectives that digitized "traditional" technologies struggle to capture and help visual thinking about the future of places (Wilson and Tewdwr-Jones, 2019).Still, a major obstacle is bringing these innovative ideas into line with the formal, usually strict planning framework anchored in legal and procedural rules.

All things considered, digital technologies add extra complexity and reproduce certain current problems even if they provide chances to lower participation barriers and collect fresh points of view on urban development. Usually, the success of digital involvement depends on striking a balance between speed and efficiency with the depth and quality of interaction.Always in demand are a collection of solutions combining many digital and non-digital approaches aimed at certain planning activities and citizen needs.The ultimate aim is to produce citizen-

cantered involvement that guarantees that planning stays sensitive to the many experiences and ambitions of the people it serves and encourages significant communication.

The discussion on public participation in urban planning, particularly with the advent of new technologies, necessitates a deeper examination of 'equity' from both ethical and ecological perspectives. The historical evolution of planning participation reveals persistent issues of exclusion and unequal representation, where processes have often been "tokenistic" and dominated by specific, often more educated and affluent groups, or those with vested interests (Elwood, 2006) . This raises fundamental ethical questions about whose voices are heard and whose interests are served in planning decisions that affect a wide range of people. The planning system's traditional legalistic and technical language, coupled with its top-down, expert-driven nature, has historically disenfranchised many citizens, especially those in lower-income socio-demographic groups, ethnic minorities, and women, who are typically less involved in decision making (Arnstein, 1969; Forester, 1982). This inherent bias means that the rights of the minority often disappears once the majority has spoken. The input of these stakeholders can be omitted also due to dominant cultural norms and values that define legislation and planners' attitudes. From an ethical standpoint achieving genuine equity requires addressing these deeply rooted power imbalances and moving towards a more human-cantered approach that values diverse lived experiences and emotions, rather than solely focusing on the technical and procedural aspects of land use.

The concept of equity is also combined with ecological considerations especially within the broader discourse of sustainable development. While sustainable urban planning aims to create environments that are equitable, efficient, and resilient, there is often a tension between these goals (Wilson and Tewdwr-Jones, 2019). Particularly between economic growth and social equity or growth and environmental sustainability. For instance, the government may interpret "sustainable development" as economic growth and job creation, sometimes disregarding or minimizing important issues like climate adaptation, environmental protection, and resilience. Decisions on major projects such as airports or new housing often involve hard trade-offs between regional economic benefits, local quality of life and environmental costs. Achieving "environmental justice" requires that planners consider how their decisions may lead to inequitable distributions of environmental costs particularly for communities at risk. Therefore, a "just city" model emphasizes a collective identity that promotes diversity while supporting values such as democracy, equity, growth, and sustainability (Fainstein, 2005) ensuring that no single value is above others with equity being at the forefront.

From ethical as well as environmental perspectives, new technologies have a complicated and changing role in tackling equitable issues. Digital tools—including Public Participation GIS (PPGIS), applications, and social media—offer great chances to lower obstacles to participation by means of time and geographic restrictions, and by including those who do not usually engage in conventional planning procedures. PPGIS can locate cultural ecosystem services and social-ecological "hotspots" offering a geographical way to combine many values into environmental planning (Alessa et al, 2008). These technologies, however, can bring fresh ethical questions and potentially "exacerbate previously existing digital and representation disparities" (Wilson & Tewdwr-Jones, 2019, p. 161). Although technology presents a strong tool for increasing citizen involvement and openness, it needs careful design to guarantee inclusivity, balance various forms of knowledge and honestly empower communities to shape their surroundings in a more just and sustainable way, rather than just digitising current often unfair processes.

Increasingly acknowledged as effective citizen centred projects encouraging cooperation among many people to provide creative answers to public challenges are hackathons. These fast-paced, design-driven events unite people from several backgrounds—technical specialists, designers, and non-programmers—to turn ideas into real-world prototypes within designated timesframes (Falk Olesen and Halskov, 2020). While conventional crowdsourcing usually sees participants working independently on ideas, hackathons—especially those aimed at civic engagement—aim to encourage generative co-creation and collaborative discourse, whereby participants build upon each other's ideas to develop more complete solutions. This method leverages the "wisdom of people" and varied experience to provide a range of ideas that would not result from more expert led initiatives (Surowiecki, 2012). The objective is not just to produce plenty of ideas but also to deepen knowledge of issues and support original, creative solutions going beyond product innovation towards support of society impact.

Using hackathons to actively solve important environmental issues is under more and more importance. Combining end users, technological professionals, students, and citizens, these "green hackathons" address environmental challenges and support reflective practices and practical solutions (Adisa et al., 2023). Often functioning as "living laboratories," universities are very important in this regard as they use their people resources and capital to create test beds for Sustainable Development Goal (SDG) solutions (Purcell et al., 2019). Hackathons encourage multidisciplinary cooperation and inspire participants to create creative digital solutions that propel sustainable actions and environmentally friendly initiatives, including lowering CO2 emissions or supporting sharing economies, by tying academic knowledge with practical sustainability problems. These projects help to empower people economically and modify behaviour in addition to increasing sustainability consciousness and encouraging a green attitude among participants and society. By means of prototype creation, the group participation in local sustainability challenges emphasises the possibilities of hackathons to directly influence society well-being and hasten towards more general sustainable development objectives.

Method

This study employs a qualitative, in-depth case study approach to examine the GreenHack event as a model for participatory GIS (PGIS) in sustainable campus planning. In this research the GreenHack hackathon serves as the primary case. This approach allowed for an in-depth investigation into how participatory methodologies, specifically a hackathon utilizing PGIS, can empower stakeholders and generate actionable solutions for sustainable campus planning.

The research design for this paper centres on an in-depth case study of the GreenHack hackathon, held at Istanbul Technical University's Faculty of Architecture from December 1st to 3rd, 2023. The hackathon was specifically designed to support ITU's "Green Campus" initiative and enhance its standing in the UI Green Metric rankings by developing integrated PGIS application prototypes. The focus was on leveraging technology, creativity, and participatory design to contribute to environmental sustainability efforts at ITU.

The case study design enabled a comprehensive analysis of the hackathon as a "living lab" for sustainability, where students, as key stakeholders, were directly involved in co-creating solutions for their campus environment. This qualitative approach allowed for the exploration of the nuanced interactions between participants, the challenges they identified, and the innovative solutions they proposed within the specific context of ITU's sustainability goals. The dynamic nature of a hackathon, characterized by intensive collaboration and rapid prototyping, provided a unique setting to observe and analyse participatory innovation in action.

Data for this case study were primarily collected through two main methods: document analysis and participant observation.A comprehensive review of various official documents related to the GreenHack hackathon and ITU's sustainability initiatives was conducted. This included the GreenHack Booklet which provided detailed information on the event's concept, objectives, structure, themes (green spaces, waste management, energy efficiency, water conservation, participatory GIS), program flow, expected outcomes, key elements, evaluation criteria, jury composition, mentorship, and awards; the Jury Report which provided insights into the evaluation criteria and specific comments on the strengths and weaknesses of the submitted projects, particularly the three winning projects; BAP Project application and Progress Reports: These internal ITU documents provided the foundational rationale for the project, its objectives, planned methodologies, and updates on its progress.

The final part of the analysis focused on Project Submissions (Prototypes and Concept Descriptions). The outputs from the hackathon teams, including their PGIS application prototypes and detailed concept descriptions, provided concrete examples of the proposed solutions. Participants were instructed to use pseudocode and graphic narrative techniques (e.g., screen designs, diagrams, symbols, colours, animations) to present their prototypes, detailing the application's purpose, target audience, data and methods, and expected outcomes. They were also required to align their concepts with UI Green Metric criteria and ITU Green Campus objectives.

Findings

Istanbul Technical University (ITU) is actively committed to integrating environmental sustainability into its operations and campus design, a commitment underscored by its "Green Campus" initiative. This project aims to transform ITU's Ayazağa campus into an environmentally conscious, smart, and liveable space that prioritizes nature, conserves resources, and enhances the quality of life for its community. The ITU Green Campus initiative,

launched in 2008, emphasizes a respectful approach to both nature and people. Key features include preserving natural habitats, creating pedestrian and bicycle routes, and implementing solutions for individuals with disabilities, aligning with the "Accessible ITU" motto. Specific actions involve sustainable landscape design with high water permeability for hard surfaces, use of low-water-consuming and climate-appropriate vegetation, and optimized irrigation and lighting systems. Furthermore, the campus has increased its green area, developed a greenhouse gas inventory, expanded bicycle paths to a target of 6 kilometres, established a bicycle repair and sales shop, installed electric vehicle charging units, and implemented separate collection of rainwater for a campus pond.

ITU's dedication to sustainability is also reflected in its strong performance in global university rankings. In 2021 ITU ranked 31st among 100 universities in Europe and 57th globally out of 956 universities in the UI Green Metric ranking system. Nationally, ITU holds the leading position in green campus initiatives in Türkiye. The UI Green Metric established by Universitas Indonesia in 2010 evaluates universities' environmental performance and sustainability across six main criteria: Setting and Infrastructure, Energy and Climate Change, Waste, Water, Transportation, and Education and Research. In the 2020 UI Green Metric country rankings ITU excelled in education, transportation, and waste management categories. Beyond UI Green Metric, ITU also featured in "THE Impact Rankings," which assess universities' contributions to the UN Sustainable Development Goals. In 2021, ITU was ranked in the 101-200 range globally among 1117 universities in THE Impact Rankings, sharing Turkey's top position with Abdullah Gül University. The university's strategic plan (2017-2021) explicitly emphasizes ITU's transformation into a green campus, with specific goals such as reducing carbon footprint and achieving 100% UI Green Metric certification by 2020.

The GreenHack hackathon was an innovative event designed to promote student-driven solutions for campus sustainability. Held at the ITU Faculty of Architecture's Taşkışla Campus, the event aimed to bolster the "ITU Green Campus" initiative and improve the university's standing in the UI Green Metric rankings. The hackathon received applications from a total of eight student groups. Out of these, six groups actively participated in the hackathon and successfully submitted their projects in the required format. Participants were divided into interdisciplinary teams of 4-6 individuals, fostering a collaborative environment with diverse skills to address various facets of the challenge. The target audience for GreenHack included students from various ITU faculties, such as urban planning, architecture, and computer engineering.

The GreenHack hackathon was designed to foster civic engagement, encourage generative co-creation, and promote collaborative discourse among participants in developing sustainable campus solutions. The event, spanning three days from December 1st to December 3rd, 2023, at ITU's Taşkışla Campus, incorporated several key elements to facilitate this "wisdom of crowds" approach.

The initial phase, Day 0 (December 1st), began with a registration period, followed by a seminar focusing on Green Campus initiatives, Participatory GIS (PGIS), and mobile applications. This seminar served as an foundational element, providing participants with a common understanding of the core concepts and tools necessary for the hackathon's objectives. By equipping all teams with essential knowledge in GIS, urban sustainability, and app prototyping it ensured a baseline understanding upon which collaborative efforts could build. The next session for hackathon team introductions and a Q&A segment directly promoted initial interactions and the sharing of preliminary ideas among participants, laying the groundwork for collaborative discourse. The official kickstart of the 24-hour hackathon on the evening of Day 0 immediately immersed teams in an intensive co-creation environment.

Day 1 (December 2nd) was dedicated entirely to the core development phase, with the critical introduction of mentor participation. Mentors, experienced in GIS technology, urban planning, and app development, provided direct guidance and support, facilitating problem-solving and encouraging the refinement of ideas through expert feedback. This mentorship model allowed teams to benefit from diverse perspectives and build upon their initial concepts with informed input. Through informal breaks the event provided organic opportunities for inter-team discussion and sharing of ideas, contributing to the generative nature of the event.

The final day (December 3rd) featured a projects video sharing and award ceremony, which served as a platform for teams to present their developed solutions to a broader audience. This public presentation aspect is vital for civic

engagement, allowing for the dissemination of innovative ideas and fostering a sense of collective achievement. The subsequent networking session between teams, juries, and the project team further encouraged continued collaborative discourse and the potential for future development of the concepts generated during the hackathon. The overall structure of GreenHack, from foundational seminars to intensive collaborative development and public presentation, was designed to harness the collective intelligence of participants, leading to more comprehensive and actionable solutions for campus sustainability.

The GreenHack event was not only about technology and sustainability but also embodied these principles in its prizes and operational aspects, effectively "closing the loop" on its core themes. The prizes were strategically designed to reinforce the hackathon's dual focus. All winning team members received free registration for ESRI ArcGIS Pro training (face-to-face or online). This particular prize directly advanced technological skill development in GIS, a fundamental tool for sustainable planning, ensuring that the acquired knowledge from the hackathon could be further honed and applied in professional contexts. Furthermore, the event explicitly incorporated sustainability into its material outcomes. The hackathon featured a 3D work produced from waste materials. This contribution represented a technical innovation in the application of sustainable practices. It showcased an innovative approach to upcycling and material reuse, involving advanced design and fabrication methods for transforming discarded materials into a valuable, three-dimensional product. This initiative physically demonstrated the principles of a circular economy and waste reduction that the hackathon aimed to promote, moving beyond theoretical concepts to embodied, tangible solutions. By integrating this demonstration of sustainable production into the event, GreenHack reinforced the practical application of sustainable practices. All participating teams also received a Certificate of Participation, recognizing their contribution to an event dedicated to environmental sustainability. This comprehensive integration of tech-centric skill development and direct sustainability practices into the event's incentives and physical presence ensured that GreenHack served as a holistic demonstration of its central themes.

The Winning PGIS Entries

The intensive, collaborative nature of the hackathon facilitated interdisciplinary collaboration, motivating participants to develop innovative digital solutions aimed at driving sustainable actions and environmentally friendly initiatives on campus. The participants were tasked with developing PGIS application prototypes and concepts that could be integrated into the existing ITU Mobile application. This requirement specifically promoted the development of digital solutions that could seamlessly translate into real-world sustainable actions for ITU. The projects were evaluated based on their innovation, functionality, design, and impact, ensuring that the proposed solutions were not only creative but also practical and aligned with tangible sustainability goals.

Three winning prototypes emerged from the GreenHack hackathon, each offering a unique approach to enhancing campus sustainability through participatory GIS: Green Tracker (First Prize), BeeKe (Second Prize), and Green Bee Systems (Third Prize). These projects demonstrate how hackathons can connect academic expertise with real-world sustainability problems, encouraging innovative digital solutions that range from reducing waste and promoting sustainable mobility to fostering a sharing economy mindset. Each prototype included technical aspects, such as data collection, spatial analysis, and application development, in addition to social aspects by encouraging behavioural change, community engagement, and collaborative problem-solving.

Green Tracker: A Comprehensive Environmental Monitoring Tool

Green Tracker, the first-prize winning project, was designed to track and improve environmental sustainability efforts within the ITU campus. Its primary goal was to enhance the environmental consciousness of individuals residing in or using the campus and to encourage their active participation in sustainable practices. The project specifically targeted critical areas such as waste management, energy consumption, green space preservation, and air quality, enabling users to monitor and share their observations and proposed solutions. The project focused on the challenges of campus environmental management by providing a platform for real-time feedback and engagement. By focusing on data collection related to specific environmental parameters Green Tracker aimed to create a more transparent and accountable system for understanding and mitigating the campus's environmental footprint. This objective directly aligns with ITU's aim of becoming a greener university and improving its environmental performance.

Green Tracker used mobile application platforms and Geographic Information Systems (GIS) to integrate data from both campus users and the university's official sources. The prototype provided a user-friendly interface that facilitated map-based participation, allowing individuals to pinpoint and report environmental issues directly on a digital map of the campus. This spatial data collection mechanism is a core component of PGIS, enabling the visualisation and analysis of geographically referenced information. The application's design conceptually included pseudocode to detail the algorithmic steps for data input, spatial querying, and updating user scores based on their contributions. Graphic narrative techniques such as screen designs and diagrams, were used to illustrate how environmental observations, proposed solutions and activities would be visually represented within the application's interface. This dual approach ensured a clear communication of both the technical functionality and the user experience of the PGIS application.

The project was successful promoting active user engagement and participation which is a critical aspect that enables equity within campus sustainability initiatives. By employing gamification elements like a scoring and reward system Green Tracker promoted eco-friendly behaviours making participation accessible and appealing to a diverse range of campus users. The dual role of PGIS, helping as a technical instrument for data visualisation and spatial analysis while also functioning as a participatory mechanism that encourages stakeholders in shaping campus sustainability initiatives, was effectively illustrated through the GreenHack prototypes. This crowdsourcing approach democratizes environmental monitoring and problem identification enabling individuals from various backgrounds to contribute their local knowledge and perspectives, thus tapping into the "wisdom of crowds."

Green Tracker was recognized by the jury as innovative, effective in ensuring active user participation, and providing the most comprehensive and positive contribution to sustainable objectives. Its value proposition lies in offering a holistic tool for environmental monitoring and community-driven action, fostering a bottom-up approach to sustainability. The innovative use of gamification to drive civic engagement for environmental good sets a precedent for how digital tools can empower individuals to become active stewards of their surroundings.

BeeKe: Gamifying Sustainable Mobility

BeeKe, the second-prize winning project, was developed to significantly promote the use of bicycles and scooters within the ITU Maslak Campus. The initiative aimed to encourage campus residents, particularly students and academic staff, to adopt sustainable transportation modes, thereby contributing to a reduction in the campus's carbon footprint and fostering healthier commuting habits. The project promoted sustainable transportation adoption by introducing an engaging and rewarding incentive mechanism. By focusing on specific behavioural changes related to mobility BeeKe aimed to integrate eco-friendly choices into the daily routines of campus members moving beyond mere awareness to active participation in sustainable practices.

BeeKe used Geographic Information Systems (GIS) and Internet of Things (IoT) devices to contribute to making campus transportation greener and more sustainable. The application had a points system that incentivized sustainable mobility behaviours such as correctly parking bicycles. The project also included a feedback mechanism for bicycle paths, encouraging users to report issues or suggest improvements directly through the mobile application. The pseudocode for BeeKe outlined the logic for tracking bicycle and scooter usage, calculating points based on distance or compliant parking and managing the gamified reward system. The graphic narrative displayed the in-app interface for tracking rides, viewing accumulated points, and accessing a leaderboard, making the sustainable commuting experience interactive and competitive.

BeeKe's strength was its innovative use of gamification to drive user engagement in sustainable mobility. By providing a tangible reward system for eco-friendly actions, it aimed to make participation accessible and appealing to a broad spectrum of campus users, encouraging active adoption of sustainable transportation modes. The feedback mechanism for bicycle paths also allowed for direct user input on infrastructure improvements, fostering a sense of co-ownership in shaping the campus's sustainable mobility landscape and ensuring that the needs of all users were considered.

The jury found the project successful, acknowledging its innovative approach to promoting sustainable transportation through gamification. While its strong focus on mobility was noted, the effective use of a clear system algorithm and its impact on encouraging greener commuting habits were particularly appreciated.

The project's capacity to incentivize and engage users in real-time contributes to a more equitable and participatory approach to campus sustainability.

Green Bee Systems: A Social Platform for Sustainability

Green Bee Systems, the third-prize winning project was developed to support and enhance green and sustainable initiatives across the ITU Maslak Campus. Its core objective was to facilitate active participation from all segments of the ITU community including students, academics, administrative staff, student clubs, alumni, and retired faculty in sustainability-related data and projects.

The platform aimed to overcome information disconnect and foster a more connected and proactive campus community regarding environmental issues. By creating a centralized hub for sustainability efforts, Green Bee Systems aimed to empower individuals to contribute their observations, share their projects and collaborate on collective solutions to campus environmental challenges.

Green Bee Systems included a user-friendly platform, similar to a social media network, and utilized Geographic Information Systems (GIS) infrastructure alongside mobile and web platforms, data analysis, and visualization tools. A key technical feature was its ability to integrate official university data with location-based data provided by users. This hybrid data integration allowed for a comprehensive spatial understanding of sustainability initiatives on campus.

The project's design included features for data collection and input, mapping and visualization, community participation, and project collaboration development. Users could share their sustainability observations and projects through the platform and contribute to other ongoing initiatives. The pseudocode outlined the backend logic for managing user-generated content, linking it to spatial data, and facilitating communication and collaboration features, while graphic narratives illustrated the social feed, interactive map, and project pages.

The core strength of Green Bee Systems lay in its strong emphasis on community engagement and project collaboration, effectively creating a "social media platform" for sustainability. By enabling all ITU constituents to share observations and contribute to projects, it democratized access to sustainability initiatives and fostered a profound sense of collective action and ownership. This participatory approach is fundamental for ensuring that sustainability efforts are inclusive and genuinely reflect the diverse needs and priorities of the entire campus community, thus promoting equity by giving every stakeholder a voice in shaping the campus's future.

The jury commended Green Bee Systems for its well-designed information flow and database and its effectiveness in facilitating user communication. Its value proposition cantered on creating a centralized, interactive hub for sustainability initiatives, fostering a more connected and proactive campus community. The innovative integration of social media dynamics with PGIS offers a unique model for broad-based civic engagement in environmental protection.

SDGs

The winning prototypes from the GreenHack hackathon demonstrate a strong alignment with both the UI Green Metric criteria and the broader United Nations Sustainable Development Goals (SDGs), showcasing the university's role as a "living lab" for real-world sustainability solutions. Green Tracker, with its focus on waste management, energy consumption, and air quality, directly contributes to UI Green Metric's categories of Waste (WS) and Energy and Climate Change (EC). Furthermore, its objective to increase environmental awareness and encourage active participation aligns with SDG 12: Responsible Consumption and Production by fostering sustainable practices, and SDG 13: Climate Action by addressing energy and air quality. The project's emphasis on user observations and solution sharing also supports SDG 4: Quality Education by promoting sustainability literacy within the campus community.

BeeKe, by promoting bicycle and scooter use, directly addresses the UI Green Metric's Transportation (TR) criterion. This initiative directly contributes to SDG 11: Sustainable Cities and Communities by fostering sustainable transportation options, and indirectly to SDG 13: Climate Action by reducing carbon emissions associated with commuting. The gamified approach to encouraging behavioural change also touches upon aspects of promoting sustainable lifestyles under SDG 12. Green Bee Systems, functioning as a social platform for sustainability initiatives,

broadly supports all UI Green Metric criteria by enhancing awareness, facilitating collaboration, and integrating diverse data. Crucially, its emphasis on broad participation from all ITU constituents; students, staff, and faculty and directly reinforces SDG 17: Partnerships for the Goals, by building inclusive multi-stakeholder partnerships for sustainable development. Furthermore by providing a platform for sharing sustainability-related data and projects it contributes to SDG 4: Quality Education by disseminating knowledge and encouraging sustainability research and innovation. The prototypes collectively demonstrate how localized, technology-driven, and participatory solutions within a university setting can effectively advance global sustainability agendas.

Discussion

The GreenHack hackathon provided rich insights into the potential of participatory methodologies and GIS-based tools for addressing complex sustainability challenges within a university campus setting. The event successfully functioned as a "living lab," demonstrating how the collective intelligence of students, guided by academic and technical expertise, can generate innovative and actionable solutions.

The three winning prototypes: Green Tracker, BeeKe, and Green Bee Systems demonstrated innovation and functionality in addressing diverse sustainability challenges on the ITU campus. Green Tracker's approach moved beyond passive data reporting to actively incentivize and reward eco-friendly behaviours, thereby promoting a more proactive and engaged campus community in environmental monitoring and problem-solving. Its functionality revolved around intuitive data collection, sharing, and visualization, directly linking user actions to measurable sustainability impacts. BeeKe demonstrated innovation in sustainable mobility by gamifying bicycle and scooter usage. Their direct behavioural intervention, supported by a feedback mechanism for bicycle paths, aimed to shift commuting habits towards more environmentally friendly modes. Green Bee Systems, on the other hand, presented a broader social platform for sustainability. Its functionality focused on enabling wide-ranging participation from all ITU constituents in sustainability projects and data sharing, effectively serving as a social media-like hub for environmental initiatives. This platform's innovation lay in fostering collaborative project development and knowledge exchange, making sustainability a collective and highly interactive endeavour. Each prototype, while distinct in its primary focus, leveraged digital functionalities to make sustainability engagement more accessible, measurable, and engaging for the campus community. These ideas show how participatory design may effectively combine technical features with social interventions, therefore promoting not just technology innovation but also cultural and behavioural changes towards sustainability.

Participatory Geographic Information Systems (PGIS) proved to be a key element in empowering student participation and co-creation during the GreenHack hackathon. In GreenHack, students were provided with campus-related maps and land use data, transforming them from passive recipients of information into active contributors to a shared spatial understanding of campus sustainability. Green Tracker exemplifies this empowerment, allowing users to geographically pinpoint environmental issues and share solutions on a map, thereby democratizing the identification and visualization of campus challenges.

The requirement for prototypes to be compatible with ITU Mobile also meant that PGIS functionalities were designed to be user-friendly and widely accessible. This lowered the barrier to participation, enabling a larger segment of the student body to contribute their observations and ideas in a spatially intelligent manner. BeeKe's feedback mechanism for bicycle paths and Green Bee Systems' integration of location-based user data further highlight how PGIS empowered students to not only report but also actively shape and improve the physical and operational aspects of their campus environment. This direct engagement with geospatial data fostered a sense of agency among participants, aligning with the broader goal of democratizing spatial knowledge in planning processes.

Beyond the PGIS tools, the very structure and execution of the GreenHack event promoted the hackathon as a participatory process, focusing on student voices and fostering a deep sense of ownership. The event commenced with a comprehensive seminar that provided a common knowledge base on green campus concepts, PGIS, and mobile applications, ensuring that all participants were equipped to contribute meaningfully. This structure enhanced ownership and responsibility among participants, as students became partners of solutions, thus deepening their engagement with the campus's sustainability goals. This was critical for cultivating an environment where ideas could genuinely build upon each other, leveraging the "wisdom of crowds."

The inclusion of experienced mentors throughout the development phase was key in guiding participants and promoting the refinement of their ideas. This continuous feedback loop encouraged generative co-creation, where initial concepts evolved through expert input and inter-team discussions. As highlighted in a related social media article, "Hacking for Sustainability: How Students Are Redefining Our Future, One University Campus at a Time," the event's atmosphere fostered a collective drive, where students actively shaped solutions reflecting their priorities and needs, thus strengthening their connection to the campus's sustainability goals. The culminating video sharing and award ceremony served not only as a presentation platform but also as a celebration of this collective effort, further cementing a sense of ownership over the proposed innovations.

The jury's evaluation of the GreenHack prototypes provided crucial insights into the potential and pitfalls inherent in student-led innovation within a hackathon framework. The assessment criteria: Innovation, Functionality, Design, and Impact, were applied rigorously, highlighting both the strengths and areas for improvement in the submitted solutions. The evaluations also pointed to potential pitfalls. The insights from the jury underscore the balance required between innovative conceptualization and practical implementability, particularly regarding resource allocation and system integration, which are common challenges in transitioning hackathon prototypes to large-scale deployment.

The GreenHack hackathon, while specifically designed for the ITU campus, offers a model for scaling participatory solutions to broader urban contexts. The GreenHack model presents a highly replicable framework for participatory planning that extends beyond the university campus to wider urban settings. Its core strength lies in the synergistic integration of PGIS technology, the intensive hackathon format, and a deliberate focus on interdisciplinary collaboration. By providing foundational knowledge through seminars, offering continuous mentorship, and fostering a competitive yet collaborative environment, GreenHack effectively cultivated a space for generative co-creation. This approach, which actively engages end-users and diverse stakeholders in problem identification and solution development, directly taps into the "wisdom of crowds," generating solutions that are both innovative and locally relevant. The emphasis on developing digital prototypes (PGIS applications) ensures that the outputs are inherently scalable and can leverage existing mobile infrastructure, similar to ITU Mobile, for wider dissemination and impact.

The success of prototypes like Green Tracker, which uses map-based reporting and gamification for environmental monitoring, and BeeKe, which incentivizes sustainable behaviour, demonstrates that such user-cantered, technology-driven solutions are not limited to campus boundaries. These models can be adapted for city-wide waste management initiatives, public transport optimization, or urban green space planning. Green Bee Systems further highlights the potential for building community-wide social platforms for sustainability, fostering collective action across a diverse urban population. By systematically structuring the problem-solving process, providing necessary technical resources and guidance, and valuing direct citizen input, the GreenHack model offers a robust and adaptable framework for urban planners and policymakers seeking to implement more inclusive, effective, and scalable participatory planning initiatives for a sustainable future.

Conclusion

This research examines the GreenHack hackathon as a participatory framework for integrating digital technologies, especially Participatory Geographic Information Systems (PGIS), into sustainable campus design at Istanbul Technical University (ITU). The findings indicate that hackathons can be helpful in promoting community participation, innovation, and collaboration in addressing complex sustainability challenges. The three winning prototypes—Green Tracker, BeeKe, and Green Bee Systems—demonstrated how PGIS-based solutions can encourage active participation, promote environmentally responsible behaviours, and facilitate knowledge sharing across a diverse campus community.

The GreenHack event functioned not only as a technical exercise but also as a social and educational process, enabling students to become co-creators of their campus's sustainable future. Combining gamified digital tools, mentoring, and multidisciplinary cooperation, the hackathon succeeded in enabling participants to create meaningful solutions that meet UI Green Metric standards and help the United Nations Sustainable Development Goals (SDGs). Furthermore, the scalable nature of these digital prototypes emphasises the potential to apply such participatory strategies beyond the university into wider metropolitan environments.

In conclusion, GreenHack demonstrates that the integration of PGIS and participatory hackathons can bridge the gap between environmental objectives and community engagement, offering a replicable model for inclusive, innovative, and impactful planning practices. Involving students as participants of sustainability solutions enhanced their sense of ownership and strengthened their commitment to long-term environmental objectives. Future research could explore the long-term implementation of such prototypes and assess their effectiveness in driving sustainable behaviour and institutional change.

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Exploring the link between biodiversity, health, and climate action through the URBioPark project

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Abstract
The URBioPark project investigates the link between urban biodiversity, health, and climate action, promoting an integrated approach to sustainable planning. Coordinated by the University of Brescia and funded under the 2022 PRIN program with Next Generation EU resources, the project involves Italian universities and the National Research Council (CNR). Its aim is to assess the relationship between biodiversity in urban parks and the incidence of chronic diseases by integrating health and geographic data using GIS. Results will help identify critical areas, support re-naturalization efforts, and provide guidelines for urban planning. URBioPark contributes to reducing health inequalities, enhancing well-being, and offers a replicable model for other cities by combining scientific research, civic engagement, and territorial governance.

Keywords: biodiversity, climate change, resilience, urban green areas, public health

1. Introduction

Urban areas are at the forefront of environmental and public health challenges. Rapid urbanisation, combined with the accelerating effects of climate change, has intensified the demand for adaptive strategies that enhance urban resilience and sustainability. Among the tools available to city planners and policymakers, urban green spaces have emerged as multifunctional infrastructures that deliver a wide array of co-benefits. These include ecological services—such as carbon sequestration, temperature regulation, and habitat preservation—as well as social and health-related advantages, like improved air quality, stress reduction, and opportunities for physical activity.

Recent trends in urban planning reflect a growing emphasis on nature-based solutions (NBS) as cost-effective, inclusive, and sustainable alternatives to traditional engineering approaches. In this context, biodiversity is no longer seen only as an ecological resource, but also as a strategic asset for public health and social equity. The intersection of biodiversity, climate resilience, and health has therefore become a critical focus in the pursuit of sustainable urban development.

This paper presents the objectives, methodology, and preliminary findings of the URBioPark project—a multidisciplinary initiative designed to explore the correlations between urban park biodiversity and public health outcomes. Conducted in the city of Brescia (Italy), the project integrates spatial analysis, ecological fieldwork, and health data to support a replicable model of biodiversity-inclusive planning.

2. Background and theoretical framework

The positive effects of greenery on human health are well-documented in the literature. For instance, walking in a forest has been shown to lower anxiety levels (Li et al., 2016).

Increasing evidence links biodiversity to human health and ecosystem resilience: biodiversity enhances public health through multiple mechanisms, including exposure to diverse microbiota, improved air quality, opportunities for physical and recreational activity (Aerts et al., 2018), regulation of the immune system (Mills et al., 2017).

Green spaces, particularly in urban environments, have a wide range of positive impacts on human life. Areas with diverse plant and animal species offer consistent and beneficial outcomes for mental health (Carrus *et al.*, 2015; Sandifer, Sutton-Grier and Ward, 2015; Methorst *et al.*, 2021)selected on the basis of urban forestry expert criteria according to a 2×2 factorial design. The biodiversity level (low vs. high and a decrease in stress levels (Ward Thompson *et al.*, 2012)including stress reduction, but much pertinent evidence has relied on self-reported health indicators or experiments in artificially controlled environmental conditions. Little research has been reported using ecologically valid objective measures with participants in their everyday, residential settings. This paper describes the results of an exploratory study (n=25. The presence of urban greenery is positively associated with a reduction in the symptoms of many chronic diseases (Maas *et al.*, 2009) such as the type 2 diabetes (Astell-Burt, Feng and Kolt, 2014), cardiovascular (Giacinto *et al.*, 2021) and inflammatory diseases (Haahtela, 2019). In particular, the presence of greenery is positively associated with a higher chance of survival in ischemic stroke patients (Wilker *et al.*, 2014).

Urban biodiversity also plays a key role in reducing social inequalities in health. According to Becker et al. (2019), access to green environments is associated with lower public healthcare spending and better health equity. In addition, green areas that promote health contribute to reducing health inequalities associated with income (Mitchell and Popham, 2008)or so-called green space, has an independent effect on health and health-related behaviours. We postulated that income-related inequality in health would be less pronounced in populations with greater exposure to green space, since access to such areas can modify pathways through which low socioeconomic position can lead to disease.\nMETHODS: We classified the population of England at younger than retirement age (n=40 813 236.

The World Health Organization has formally recognised urban health as a central component of sustainable development, calling for stronger integration of health metrics into planning practices (Neira, 2015). In this context, biodiversity serves as both an ecological and socio-political determinant of health, being essential not only for the functioning of ecosystem but also for building resilient, equitable, and liveable cities.

3. Project description: URBioPark objectives

URBioPark is a multi-partner project funded by the 2022 PRIN programme and supported by Next Generation EU. The consortium includes the University of Brescia (coordinator), the National Research Council - Institute for BioEconomy (CNR-IBE) based in Florence, and the Universities of Padua and Verona.

The project aims to investigate the relationship between urban biodiversity and public health, focusing on the city of Brescia as a representative mid-sized European city actively engaged in sustainability and climate adaptation. Over the past decade, Brescia has launched several initiatives aimed at promoting environmental resilience, reducing emissions, and improving the quality of life for its residents. As part of its climate transition strategy, the city has expanded its green infrastructure, promoted sustainable mobility, and implemented nature-based solutions in urban planning. Brescia's participation in national and European climate networks further underscores its commitment to ecological transition. The relevance and potential impact of the URBioPark project have been recognized through formal endorsements by the Municipality of Brescia, Fondazione Cariplo, Urban Center Brescia, and AmbienteParco—key institutional and civic actors engaged in shaping the city's sustainable future. This strong local support highlights Brescia as an ideal case study for exploring how urban biodiversity can contribute to public health and territorial equity.

3.1 Project structure

The URBioPark project is structured around five interrelated Work Packages (WPs), designed to investigate and strengthen the link between urban biodiversity and public health, with a particular focus on the city of Brescia. The project will run over 24 months and follows a multidisciplinary and participatory approach.

The five WPs are as follows:

1. WP1 – Project coordination and management (UNIBS): Coordination of all research units, financial oversight, and risk monitoring through regular meetings and reporting.
2. WP2 – Brescia urban parks analysis (UNIBS): Mapping urban morphology, green space distribution, socio-economic and health data, and existing vegetation and soil characteristics using GIS and statistical tools. This package sets the baseline for the empirical research.
3. WP3 – Biodiversity and ecosystem services (CNR-IBE): Field and lab analyses on plant and soil biodiversity in selected urban parks. This includes microbial DNA sequencing, soil mesofauna identification, and eco-physiological plant assessments, to evaluate ecosystem services and health impacts.
4. WP4 – Good Practices Manual Development (UNIVR): Synthesis of research outputs to create actionable planning guidelines. These will support urban decision-makers in designing and managing biodiversity-friendly green spaces and integrating biodiversity into Strategic Environmental Assessments (SEA).
5. WP5 – Dissemination and Citizen Science (UNIBS): Stakeholder engagement through public events, citizen science activities (BioBlitz), and participatory surveys. The WP also includes educational actions and outreach in collaboration with local institutions to increase public awareness and co-design strategies with communities.

Each Work Package contributes to building an integrated, evidence-based framework for planning healthier, more biodiverse, and climate-resilient urban environments. By integrating diverse datasets and disciplinary approaches, URBioPark aims to develop practical guidelines and indicators that support biodiversity-inclusive urban governance, ensuring both scientific rigor and real-world applicability, and offering a replicable model for other cities.

Fig. 1. Actions of the URBioPark project. Source: Author's own elaboration

4. Methodology

The URBioPark project adopts a multidisciplinary methodology to explore the complex interrelations between urban green areas, biodiversity, and human health. The study combines ecological, environmental, socio-economic, and epidemiological data to produce a comprehensive framework for biodiversity-inclusive urban planning. The method used is structured in the following phases: 1) selection of the parks on which to carry out the survey; 2) analysis of the spatial context in which the parks are located and health assessment; 3) Socio-economic and health analysis; 4) Economic value of ecosystem services analysis.

In the first phase, the parks are selected based on criteria such as size, vegetation structure, accessibility, and heterogeneity of the surrounding urban context; a 500m buffer zone is then defined around each park.

In the second phase, the following indicators are calculated for each park and each buffer zone:

- Land Surface Temperature (LST)
- Sky View Factor (SVF), measuring sky visibility from ground level and indicating a location's ability to dissipate heat.
- Tree Canopy Cover (TCC), to quantify the extent of arboreal coverage. Areas with denser tree cover consistently exhibited lower surface temperatures, highlighting the cooling function of vegetation and the importance of canopy density in mitigating urban heat island effects
- NDVI (Normalized Difference Vegetation Index) and NDMI (Normalized Difference Moisture Index). These indices allowed to evaluate the vitality and moisture levels of vegetation, providing a more detailed understanding of the parks' ecological conditions

In the third phase, the vegetation and soil components of the selected urban parks are analysed through a detailed ecological assessment that examine plant species composition, soil characteristics, and the presence of soil microarthropods. The collected data are subsequently analyzed and integrated to develop biodiversity indicators, offering a comprehensive picture of the ecological status of the parks and their contribution to overall urban biodiversity.

In the fourth phase, consistently with the project's focus on health, it is investigated how the exposure to urban green spaces—particularly those with higher levels of biodiversity—can influence the physical and mental well-being of nearby residents. This analysis takes place by employing spatial and temporal statistical analyses using georeferenced socio-demographic data to define and classify the socio-economic profile of the areas surrounding the selected parks.

In the fifth phase, the economic value of the ecosystem services provided by urban parks is estimated, using a questionnaire-based survey. Since these services are not traded on the market and lack a clear reference price, a simulated market approach is adopted to evaluate citizens' willingness to pay for their maintenance or enhancement. The survey features a discrete choice experiment involving 500 participants and examines preferences for five possible interventions, each associated with a hypothetical tax. In addition to these choices, the questionnaire gathers information on socio-demographic characteristics, attitudes toward biodiversity, and patterns of park usage. An informational treatment is also included to assess how participants understand and incorporate information into their responses. The analysis identifies attitudinal clusters, investigates correlations with socio-demographic and spatial factors, and performs a cost-benefit analysis of the proposed interventions based on the current state of the parks.

5. First results

The first results obtained by the URBioPark project derive from the phases of urban and morphological analysis of the selected parks, supported by the integration of data relating to the health of the population and the socio-demographic characteristics of the surrounding areas. (phases 1, 2, 4). This multidisciplinary approach has permit us to collect valuable information that, although preliminary, offers a first picture of the interconnections between the physical structure of cities, the green infrastructures present in the urban fabric and the well-being of the population.

5.1 Park selection

Four parks in the city of Brescia — Parco Gallo, Parco Giffoni, Parco Croce Rossa, and Parco dei Poeti — were selected based on criteria such as size, vegetation structure, canopy density, accessibility, and heterogeneity of the surrounding urban context. Data for the four parks are included in Table 1.

Tab. 1. Surface data about the four sel ected parks in Brescia

Park	Area (m^2)	Permeable surface	Semi-permeable surface	Non-permeable Surface	Trees (number)
Parco Gallo	34701	85%	2%	13%	191
Parco Giffoni	18574	90,6%	0,2%	9,2%	198
Parco dei Poeti	28895	84%	15,6%	0,4%	549
Parco Croce Rossa	32989	97%		3%	883

Fig. 2. Location of the four selected parks in Brescia

5.2 Spatial analysis and vegetation assessment

A 500m buffer zone was defined around each park to analyse environmental conditions and health outcomes. Firstly, using GIS technologies, the following elements were mapped within each buffer: land use, building heights, and street networks. Secondly, key climate indicators, have neem derived from satellite imagery, including Land Surface Temperature (LST) and Sky View Factor (SVF) — the latter measuring sky visibility from ground level and indicating a location's ability to dissipate heat. The Tree Canopy Cover (TCC) was also calculated to quantify the extent of arboreal coverage. Areas with denser tree cover consistently exhibited lower surface temperatures, highlighting the cooling function of vegetation and the importance of canopy density in mitigating urban heat island effects.

Tab. 2. Data about the four buffer parks

Park buffer (500 m)	LST	SVF	TCC	NDVI	NDMI
Parco Gallo	39,3°C	0,71	18%	0,14	0,30
Parco Giffoni	34,9°C	0,83	18%	0,38	0,54
Parco dei Poeti	34,8°C	0,87	12,05%	0,13	0,55
Parco Croce Rossa	37,8°C	0,88	19,9%	0,47	0,50

In addition to these spatial analyses, parks' vegetation health was assessed using remote sensing indices such as the NDVI (Normalized Difference Vegetation Index) and NDMI (Normalized Difference Moisture Index). These indices allowed to evaluate the vitality and moisture levels of vegetation, providing a more detailed understanding of the parks' ecological conditions. In particular, NDVI for all parks is between 0.3 - 0.4, indicating low vegetation cover with low vigour or very low vegetation cover with high vigour. NDMI for Parco Giffoni and Parco dei Poeti is between 0.4 – 0.5; these values indicate medium-high vegetation cover with high water stress or medium vegetation cover with low water stress. Parco Gallo and Parco Croce Rossa have slightly higher NDMI values, between 0.5 and 0.6, indicating high vegetation cover and no water stress. NDVI and NDMI were also calculated for the buffers (see table 2). In particular, NDVI around Parco Gallo and Parco dei Poeti it presents very low values (between 0.1 and 0.2) indicating almost no vegetation cover.

Tab. 3. Parks vegetation assessment

Park	NDVI	NDMI
Parco Gallo	0,34	0,53
Parco Giffoni	0,31	0,48
Parco dei Poeti	0,33	0,48
Parco Croce Rossa	0,38	0,55

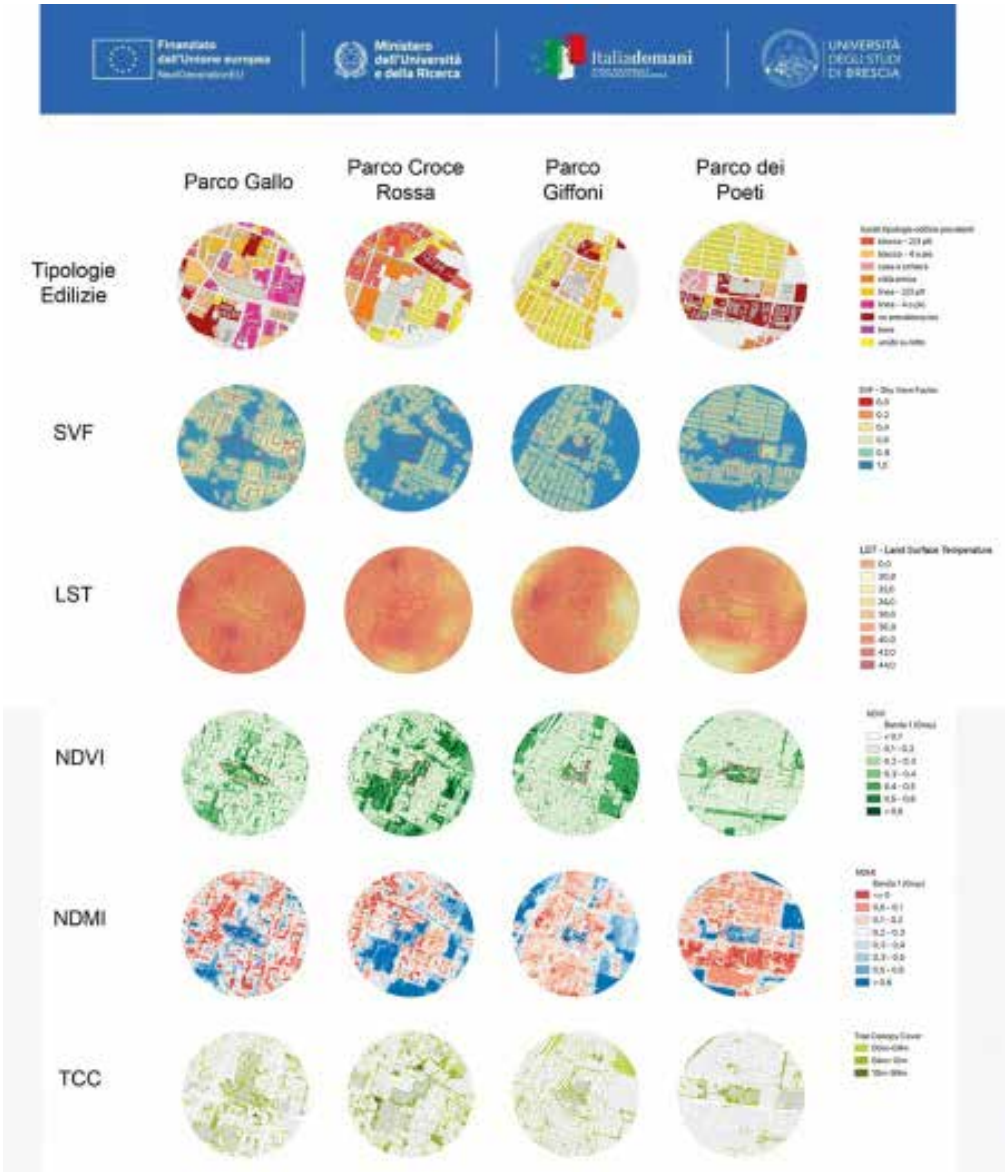

Fig. 4. Analysis of the urban fabric surrounding urban parks within a 500-meter buffer zone. Comparison of indices: Building Typologies, Sky View Factor (SVF), Land Surface Temperature (LST); Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDMI), and Tree Canopy Cover. Source: Author's own elaboration.

5.3 Socio-economic and health analysis

To identify potential correlations between health outcomes and both proximity to and use of green spaces, aggregated data on health conditions and medication have been used. The source is the health database (BDA) of the Brescia Local Health Protection Agency (ATS). To capture these dynamics, disease frequencies are calculated for residents living within two defined buffer zones—250 meters and 500 meters—around each park. For each area, the Standardised Prevalence Rate (SPR) is computed by comparing the number of observed cases of chronic diseases to the expected number based on citywide averages. This methodology enables a robust comparison across different neighborhoods and helps assess whether variations in health status may be associated with environmental and ecological conditions, including biodiversity levels.

Tab. 4. Chronic disease cases in the observed buffers

Park buffer	Observed cases	Expected cases	SPR
250 m			
Parco Gallo	520	542.67	0.96
Parco Giffoni	570	520.88	1.09
Parco dei Poeti	375	342.17	1.10
Parco Croce Rossa	322	280.42	1.15
500 m			
Parco Gallo	2,754	2,808.02	0.98
Parco Giffoni	1,484	1,404.49	1.06
Parco dei Poeti	1,522	1,480.75	1.03
Parco Croce Rossa	1,091	1,069.04	1.02

Tab. 5. Demographic characteristic of the population within the 250 m. buffers

Park buffer (250m)	Population	Females (%)	Foreigners (%)	Median Age
Parco Gallo	1,250	54.2	29.3	48,9
Parco Giffoni	1,178	53.2	18.8	50,0
Parco dei Poeti	766	54.2	13.8	51,5
Parco Croce Rossa	619	54.8	2.9	50,6
Brescia (total)	**192,322**	**51,9**	**19,9**	**48,8**

6. Discussion

The first results of the URBioPark project are based on the urban and morphological analysis of the selected parks and the integration of health and socio-demographic data. These preliminary findings provide an initial understanding of the relationships between urban structure, green infrastructure, and public health.

The ecological assessments related to vegetation and soil biodiversity—crucial for establishing detailed biodiversity indicators—are still ongoing. Their integration will offer a more complete picture of how different components of urban biodiversity contribute to residents' well-being and health outcomes.

Preliminary analyses conducted across the four selected urban parks in Brescia reveal insightful correlations between urban biodiversity, socio-demographic factors, and public health outcomes.

From a demographic standpoint, the population distributions in the four park areas are broadly comparable to the rest of the city in terms of age and male/female ratio. However, significant differences emerge in the percentage of foreign residents: for example, the area surrounding Parco Gallo shows a notably higher share (29.3%) compared to the city average (19.9%), while the Parco Croce Rossa area registers just 2.9%.

In terms of environmental indicators, parks with higher NDVI values and greater canopy density were associated with lower Land Surface Temperatures (LST) and improved microclimatic comfort. Notably, areas with low Sky View Factor (SVF)—indicating a denser urban form—still benefited from significant heat mitigation when supported by robust green infrastructure. These findings confirm the essential role of vegetation and tree coverage in regulating urban temperatures.

From a health perspective, results from the ATS Brescia database suggest emerging patterns. In the 250 m buffer zones, areas around Parco Croce Rossa and Parco Giffoni show a 15% and 9% higher prevalence of at least one chronic disease, respectively—though these increases are not statistically significant. When disaggregated by disease type (hypertension, diabetes, hypercholesterolaemia, cardiovascular and respiratory diseases), the frequencies are slightly above expected values in some areas but remain within non-significant margins.

However, the 500 m buffer analysis confirms a statistically significant 6% higher prevalence of chronic diseases around Parco Giffoni, alongside a 10% increase in hypertension and a 12% increase in cardiovascular conditions. Interestingly, the Parco Croce Rossa area shows a 20% lower prevalence of diabetes compared to the city average.

Regarding mental health, the use of antidepressant medication was also assessed. Slightly higher percentages of antidepressant prescriptions were recorded near Parco Croce Rossa and Parco dei Poeti, though again, not statistically significant. Further logistic regression analysis indicates that women over 65 of Italian nationality are the most frequent users, which may account for some of the geographic variation. When broken down by frequency—at least one vs. at least two prescriptions over three years—only Parco dei Poeti shows a confirmed excess (around +8%) for the higher threshold.

Complementing the quantitative health data, survey responses collected from residents reinforce the correlation between perceived green space quality, biodiversity awareness, and individual well-being indicators.

Residents living closer to greener, more biodiverse parks reported reduced symptoms of chronic stress, improved mental health, and increased physical activity.

Lastly, the data also highlight social and environmental disparities. Lower-income districts with reduced green coverage and fewer biodiversity features tend to exhibit higher rates of chronic disease and report lower satisfaction with environmental conditions. These findings underscore the importance of equitable access to biodiverse green spaces as a means to support both public health and climate resilience in urban environments.

7. Project objectives: towards integrated urban governance

A core objective of the URBioPark project is to generate knowledge and tools that inform urban governance by integrating biodiversity and health into planning and policy frameworks. The project aims to provide actionable strategies that can be adopted at multiple levels—urban design, public health, and community engagement—to foster healthier, more resilient cities.

URBioPark's results are intended to support the inclusion of biodiversity and health criteria within Strategic Environmental Assessments (SEA), masterplans, and local regulatory instruments. The project envisions the establishment of a shared governance model that unites urban planning, environmental management, and public health.

Key strategic recommendations include:

- Urban planning: introduce mandatory biodiversity-health impact assessments in zoning revisions and urban redevelopment projects.
- Green infrastructure: promote tree planting, canopy connectivity, and soil permeability, especially in socio-environmentally vulnerable areas.
- Health integration: develop partnerships with local health authorities to monitor and respond to environmental determinants of chronic disease.
- Citizen engagement: encourage participatory approaches through citizen science, enabling communities to contribute to biodiversity monitoring and park stewardship.
- Education and awareness: launch targeted campaigns and integrate ecological literacy into school curricula to promote awareness from an early age.

Through these actions, URBioPark also aims to establish an interdepartmental governance framework, bringing together expertise and policy from health, urbanism, and environmental sectors under a unified strategy for sustainable and inclusive urban development.

8. Conclusions and future directions

URBioPark project exemplifies how urban biodiversity can be leveraged as a cross-sectoral asset, capable of addressing climate resilience, health equity, and urban sustainability.

By linking scientific research with practical applications and policy recommendations, the project contributes to a paradigm shift in urban planning where nature and public health are integrated rather than treated as separate domains.

The project's outcomes will culminate in a manual of best practices to guide municipalities in biodiversity-sensitive planning. Moreover, its GIS-based methodology offers a powerful decision-making tool for identifying areas in need of intervention and monitoring the impacts of implemented actions.

Future steps include refining the biodiversity-health indicator set, expanding the study to other cities involved in the project (Verona, Padua), and establishing transdisciplinary training programmes for professionals involved in urban health and spatial planning.

URBioPark serves as both a research initiative and a policy incubator. By embedding biodiversity into the core of planning practices, cities can become healthier, more equitable, and more resilient in the face of future challenges.

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Between Walls and Water:
Technocratic planning of stormwater infrastructure and the reshaping of everyday life in flood-prone Mumbai

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Abstract
Mumbai has been experiencing an increasing frequency of extreme climate events that result in recurrent monsoon flooding. Challenging the prevailing view of flooding as an infrastructural crisis, this paper argues that flooding is instead an inevitable consequence of systemic failures in the city's technocratic planning regime. It critically examines the BRIMSTOWAD masterplan in developing the city's stormwater infrastructure. It attempts to understand how the absence of such infrastructure exacerbates existing spatial vulnerabilities, reshaping the everyday life of marginalised communities living in flood prone areas. Through a case study of the 2019 Malad wall collapse, the paper analyses how stormwater drainage, housing crisis, and regulatory planning practices intersect during a flood event, demonstrating that Mumbai's flooding crisis is deeply tied to its urban development model.

Keywords: stormwater infrastructure, technocratic planning, urban flooding

Introduction

The metropolitan city of Mumbai has been grappling with an increasing frequency of extreme rainfall events attributed to climate change and the subsequent flooding that follows them. Historian Miriam Dossal, narrating her observation of the city in 1990, wrote that 'water and drainage continue to be the bane of Bombay[1] and every monsoon the problems are aggravated' (Dossal, 1996). Today, even after two decades, her observations remain just as valid for Mumbai. In the period from 2000-2024, Mumbai has recorded 18 extreme rainfall events (greater than 204.5mm rainfall/day) and 11 very heavy rainfall events (115.6-204.4mm rainfall/day)(*IMD*). Based on IMD (Indian Meteorological Department) data (1985–2024), Mumbai's rainfall has become highly skewed and unevenly distributed, meaning a small number of extreme rainfall days contribute disproportionately to the total monsoon rainfall[2]. Every monsoon, heavy rains almost always wreak havoc in everyday life leaving several neighbourhoods inundated and residents struggling to adapt to the high waters. What should ideally be rare practices of coping have become an annual ritual making Mumbaikars habituated to regular flooding (Jamwal, 2017). Meanwhile, actions of the State have aimed at strategically deregulating environmental laws and policies meant to protect the city's riparian and coastal zones—which are vital socio-ecological systems actively sustaining livelihoods and mitigating flood impacts—for intensively constructing infrastructure and real estate projects aimed at the city's economic development (Indorewala, 2018; Menon et al., 2015; Nijman, 2002; Wagh, 2018; Wagh & Indorewala, 2025; Zope et al., 2015). Scholars and activists analysing the narratives of disaster and resilience of Mumbaikars expound that any city that regularly demands such a price for survival and such a toll on human life, is not unprepared for calamity – it is unprepared for normality (Indorewala & Wagh, 2018).

The response by the state's planning system to "fix" the problem of flooding has been highly technocratic—envisioned and implemented primarily through the augmentation of the city's stormwater drainage through mega infrastructural projects such as the BRIMSTOWAD (Brihan Mumbai Stormwater Drainage) masterplan (Gupta, 2007). Despite the massive investment of public funds into the building of stormwater infrastructure, 'technological-fixes' like the BRIMSTOWAD have been grossly ineffective in keeping majority of the city's areas from being water-logged and inundated during the monsoon, leaving its inhabitants with the perpetual daunting question: *why does Mumbai flood year after year?* Through this paper, I attempt to expound upon this seemingly simple yet fundamentally complex question of urban flooding by examining it through the lens of urban planning. Arguing against the mainstream notion that attributes flooding as an infrastructural crisis persisting due to "lack of planning", "corruption" or "non-implementation of infrastructure projects", I contend that flooding is a recurring symptom of the near-perfect implementation of a technocratic planning system—which produces infrastructural projects such as the BRIMSTOWAD—discriminately aimed at maximising the economic potential

1 The city's original name was changed from 'Bombay' to 'Mumbai' in 1995. The article will address the city as 'Bombay' while referring to contexts before the mid 90s, and 'Mumbai' while discussing contexts post the mid 90s.
2 Fewer than 5% of rainy days (approximately 4–6 days/year) deliver more than 50% of Mumbai's monsoon rainfall, with extreme events clustering in July and August. A single event accounts for 30-50% of the monthly rainfall in which occurred.

of Mumbai's land at the cost of systematically undermining the *socio-ecological* relationship between land and water. The paper explores the question of urban drainage within this paradigm by critically examining the role of technocratic planning in the development of stormwater infrastructure and its impacts on everyday life. It intends to understand how the 'constructed' presence or the 'planned' absence of formal stormwater infrastructure exacerbates existing spatial vulnerabilities specifically targeting marginalised classes and communities living in flood prone areas, and alters conditions of everyday life in the city particularly during flood events. In doing so, I seek to unravel the intersections between flooding and other connected urban crises pertaining to the city's built environment by studying how their relations shape the planning of the city's stormwater drainage and in turn get shaped by its outcomes.

The paper's theoretical framework delves into the critiques of technocratic planning in the development of public infrastructure for spatial water, layered by an engagement with perspectives of political ecology concerned with power relations underlying the practices that make and unmake such infrastructures. Furthermore, it synthesises insights from the socio-technical construction of infrastructural 'fixes' in planning literature and the socio-ecological construction of flooding within political ecology perspectives for building an analytical approach to unravel the material practices that shape everyday life. Discursively engaging with the notion of everyday life as the level where impacts of floods are observed, the paper explores how material practices, of both planning and the everyday, can serve as a lens to trace the linkages between stormwater drainage and the consequences of inter-related crises unfolding during flood events.

Guided by the theoretical framework outlined above, I address the research questions mentioned above by adopting a two-part methodological approach. The approach focuses on observing everyday practices of vulnerable inhabitants alongside state planning practices, revealing the complexities of stormwater drainage in Mumbai from its historical roots to its spatially uneven consequences. The first part (see section 3) critically examines Mumbai's BRIMSTOWAD (Brihan Mumbai Stormwater Disposal) project through a qualitative policy analysis, assessing its planning, implementation, challenges, and outcomes. In the second part (see section 4), I take the case of the 2019 Malad wall collapse, a disaster triggered by extreme rainfall that caused a periphery wall to collapse onto an adjacent settlement, resulting in significant loss of life and property. Taking this case, I empirically investigate the interplay between flooding and inter-connected compounding urban crises. Through this case study, the paper traces material practices of planning and everyday life to analyse living conditions before, during, and after the disaster. Using qualitative spatial analysis, the paper draws systemic linkages between flooding and other urban crises related as housing and environmental (de)regulation. The analysis is followed by a synthesis of its findings to understand how flood events do not merely expose but actively intensify these underlying compounding crises. In conclusion of the paper, I highlight the need to critically examine everyday life in cities to better frame the problem of flooding, and the urgency for reimagine stormwater drainage by prioritising the needs of marginalised communities in the city.

Theoretical framework

The planning of water in relation to the urbanisation of land has typically followed a modernist-technocratic infrastructural approach based on manipulating, modifying, containing and controlling water's accumulation and flow (Anand, 2017; Björkman, 2015; Kaika, 2005; Mathur & Cunha, 2009). Studying the historical flows of water in the various visions of city planning over the last century, Maria Kaika observes that as water became controlled, tamed, and domesticated, its presence and availability became "normalised" and taken for granted (Kaika, 2005). This is reflected in infrastructure planning dealing with water where practices have remained largely as rational, centralised, expert-driven systems up until the present, despite the planning regime becoming more socially oriented over the second half of the 20th century (Furlong et al., 2016). Critiques of technocratic approaches to stormwater planning have fundamentally challenged how urban planning as a discipline conceptualises and manages the relationship between water and land (Baviskar, 2017; Ranganathan, 2015). Over the second half of the last century, new directions in planning theory such as advocacy planning (Davidoff, 1965), communicative planning (Forester, 1980), and justice planning (Fainstein, 2010; Harvey, 2009; Marcuse et al., 2009) have sought to expose power relations latent within technocratic and rational planning practices, thereby challenging the institutional logics that prioritise certain interests over others. They have questioned and scrutinised the values, logic, ideals and power relations that underscore institutional processes and practices of technocratic planning, by asking—in whose interest are these practices undertaken, at what and whose cost, and aimed at what kind of environmental transformation? When combined with political ecology perspectives this critique from the

planning domain gains sharper focus, revealing how everyday injustices, from flood vulnerability to housing precarity, are not accidental outcomes but systemic consequences of planning paradigms (Henrique, 2023; Rusca & Cleaver, 2022).

Political ecology is concerned with the analysis of power in constituting of social and environmental conditions and how unequal power relations are often linked to conflicts over access to, and the use of, diverse environmental resources (Bryant, 1998). Comprehensive research on the political ecology of water has produced different knowledge perspectives—hydro-social territories (Boelens et al., 2016), social-hydrology (Liao & Schmidt, 2023; Linton & Budds, 2014), and waterscapes (Goh, 2019; Swyngedouw, 1999), to name a few—that look at water as a hybrid construct, emphasising its relational character with society, where technical representations of its economic, biophysical and engineering dimensions intersect with questions concerning social power and political economy (Karpouzoglou & Vij, 2017; Swyngedouw, 1999; Swyngedouw et al., 2002). These perspectives argue against the reductive logic—implicit in the technocratic usage of planning instruments such as land-use, zoning and built form regulations—that treats water as an external element to be contained and controlled through engineered solutions rather than as an intrinsic component of urban socio-ecological systems (Gandy, 2014; Swyngedouw, 1999; Swyngedouw et al., 2002; Wagh & Indorewala, 2025). They provide useful insights for understanding the ways in which water related problems may be socio-politically constructed and linked to other urban crisis, and how this process of social construction may facilitate the control of people and environments by powerful actors (Bryant, 1998). These perspectives enable us to interrogate why the state consistently frames flooding as an extrinsic problem stemming from natural forces, rather than acknowledging it as an intrinsic outcome of its own planning paradigms and interventions. To question the identification and framing of flooding as a problem and its intersections with other urban crises means considering the threatened livelihoods linked to altered social and environmental conditions that figure centrally in political ecology thinking (Bryant and Bailey, 1997). Feminist political ecologists further illustrates how situated material responses to everyday flood threats as well as organised practical resistance tactics emerge from everyday spaces (Henrique, 2023). Peter Marcuse's assertion that 'the city is the scale where questions of justice are felt concretely as part of everyday life' (Marcuse et al., 2009) underscores the need to examine how material practices shape lived experiences, especially during periods when multiple urban crises unfold simultaneously. In this paper, I employ 'material practices' as an analytical lens to integrate the aforementioned theoretical perspectives, enabling observation of how urban crises unfold simultaneously and how stormwater infrastructure impacts everyday life in Mumbai during flood events.

The BRIMSTOWAD masterplan and the transformation of stormwater infrastructure in Mumbai

The landscape of Mumbai has undergone extensive environmental transformation since the time it was acquired as 'Bombay island' (see Figure 1) in dowry by the English king Charles II, on his marriage to the Portuguese princess Catherine of Braganza in 1661 and subsequently leased to the East India Company (Dossal, 1996). In its growth as a metropolitan region, now spread across 4355 sq.km (see Figure 2), dealing with spatial water in all its hostile and distinct "natures"—which included coastal landscapes, tidal marshes, riparian areas, mangrove forests, and swamplands—was an inevitable task encountered in processes of reclaiming and expanding the colonial city (Indorewala & Wagh, 2022; Meera Kosambi, 1986). Most of the reclaimed lands in the city lie below the High Tide Line[3] whose outfall of stormwater is not naturally leading to the sea on the eastern and western shores (BMC, 2018; Dossal, 1996). Mastering stormwater drainage, therefore, has always been a prerequisite for making its urban landscape inhabitable, sanitary and healthy (Dossal, 1996; Indorewala et al., 2016).

3 The Town Hall Datum (THD), established at the historic Bombay Town Hall (now Asiatic Society) in Mumbai's Fort area, serves as the city's official vertical reference point for elevation measurements and is set at +3.658 meters above Mean Sea Level (MSL). The High Tide Line (HTL) is the highest elevation reached by seawater during spring tides In Mumbai (BMC, 2018).

Figure 1: The Bombay Group of Islands (Indorewala et al., 2016)

Figure 2: Map of Mumbai Metropolitan Region (MMR) (Indorewala et al., 2016)

Post the catastrophic 2005 mega flood, Mumbai's stormwater infrastructure has undergone significant transformation and expansion, radically reshaping the city's drainage patterns through engineered solutions for controlled water disposal. This comprehensive infrastructure is governed by the BRIMSTOWAD masterplan which regulates how rainwater percolates, accumulates, and ultimately drains across the urban landscape (Gupta, 2007). The Municipal Corporation of Greater Mumbai's (MCGM) Storm Water Drains (SWD) Department is responsible for the implementation of both the physical infrastructure and the operational practices that comprise this masterplan, from construction and maintenance to flood management protocols. The stormwater drainage system based on the BRIMSTOWAD masterplan is an integrated network of engineered and natural drainage pathways. The network comprises of constructed open/closed concrete drains which are in many places (particularly in parts of Greater Mumbai) connected to natural drains (nallhas, rivers, streams and creeks) for the purpose of channelling, discharging and releasing rainwater into the sea (BMC, 2018). It includes creating concrete embankments along the nallahs to contain outflows, and pumping stations near the mouth of estuaries to manage tidal backflow during heavy rains.

Despite significant public investment, Mumbai's BRIMSTOWAD masterplan has proven ineffective in flood prevention due to two fundamental shortcomings. The first lies in its outdated hydraulic design which was initially engineered to account for two events per year of 50mm/hour rainfall intensity, was recommended to account for 100mm/hr rainfall post the 2005 flood (Chitale, 2006). It, however, was not modified in plan and eventually revised slightly to accommodate 65mm/hour in few selected zones only (BMC, 2018; Chitale, 2006). This revision remains grossly inadequate, as historical rainfall data from the IMD for 1999-2004 demonstrates that peak intensities exceeded 72mm/hour rainfall 80% of the time, while contemporary climate extremes regularly surpass 100mm/hour rainfall (Gupta, 2007; *IMD*). The second, more fundamental flaw stems from its narrowly technocratic approach that conceptualises stormwater solely as excess to be disposed off, while completely disregarding its complex socio-ecological relationships with the city's landscapes and people (Chitale, 2006). This reductive engineering paradigm has produced multiple cascading failures: the concrete channelisation of natural drains and construction of embankments have displaced vulnerable informal settlements while protecting formal developments (Parthasarathy, 2009), degraded critical mangrove ecosystems and disrupted tidal flows in ways that ironically exacerbate flooding in certain suburban areas (Indorewala & Wagh, 2018), and institutionalised spatial inequities through disproportionate allocation of pumping stations to high real-estate neighborhoods in the south at the expense of northern suburbs dependent on gravity-based drainage. These systemic issues reveal the project's deeper contradiction where its intensive infrastructure conflicts with pressing needs for affordable housing and ecological conservation, while its implementation reflects and reinforces Mumbai's unequal political economy (Stecko & Barber, 2007). MMRDA's (Mumbai Metropolitan Region Development Authority) development of the Bandra Kurla Complex by landfilling 600 acres of the Mithi river (which flooded in 2005) is exemplary in this

case (Lewis, 2019). The resulting planning practices have not only proven exploitative in their execution but have also transformed flooding from a natural phenomenon into a techno-politically 'engineered' disaster.

Case study: Malad Wall Collapse, 2019

Mumbai recorded two extreme rainfall events on 29th June 2019 and 2nd July 2019 with the Santacruz observatory of the Indian Meteorological Department in the suburban city region recorded 234.8mm and 375.2mm of rain respectively, along with heavy showers observed on the night of 1st July 2019 as well[4] (*IMD*; "Monsoon Covers Ground," 2019) . At about 11.45pm on the night of 1st July, the 2.3km long (about 4-6m of varying height) periphery wall of the MCGM's Malad Hill Reservoir facility in Malad, Mumbai breached and collapsed at two points, in the adjoining settlements of Ambedkar Nagar and Pimpripada, a few hundred meters apart causing terrible devastation and loss of human life (Malad Wall Collapse, 2019). The wall collapse completely destroyed 140-160 houses in Ambedkar Nagar[5] and 65 houses in Pimpripada while flooding and damaging 80-95 houses in both areas. It resulted killing 31 people and leaving around 130 injured from about 86 families (Barnagarwala, 2019; Malad Wall Collapse, 2019; Marpakwar, 2021; Press Trust of India, 2019).

Figure 3: Photos of the uncollapsed wall (LEFT) and of the collapsed portions (MIDDLE and RIGHT) (Malad Wall Collapse, 2019)

Figure 4: Satellite imagery showing transect of the site with encircled locations of wall collapse

4 As per observations from the IMD, the Malad area in Mumbai received as much as 183 mm of rainfall in a short span of 3 hours between 10 pm on 30th June and 1pm on 1st July (IMD; Malad Wall Collapse, 2019).

5 As per survey conducted by Centre for Promoting Democracy (CPD) and Pani Haq Samiti (PHS) in July 2019 post the wall collapse event.

Methodology

This case study builds upon the observations and findings of the independent fact-finding committee's 2019 interim report titled 'Malad Wall Collapse: A state induced disaster' (Malad Wall Collapse, 2019). In this study, I employ an integrated methodological approach to examine the Malad wall collapse and its ongoing socio-spatial consequences. Through extensive fieldwork conducted during January-February 2025, I systematically documented the reservoir site and surrounding settlements using a transect-based spatial analysis framework. This approach enabled a critical examination of both the physical landscape of destruction and the lived experiences of affected communities, tracing how the disaster continues to shape everyday life along its path of devastation. The study combines archival investigation of historical news reports and relevant court cases with qualitative data gathered through semi-structured interviews and participatory walks along the transect with different actors including BMC engineers, municipal reservoir workers, and members of affected families. These techniques were used to corroborate and expand upon the fact-finding report. The transect-based spatial methodology functions as a critical analytical framework, bridging this study's theoretical foundations with empirical observations to systematically trace the interconnected relations of stormwater infrastructure to practices of housing and environmental regulation on site.

Consequences of 'constructed' presence and 'planned' absence of stormwater infrastructure

MCGM's Malad Hill Reservoir facility[6] is situated on the western edge of the Sanjay Gandhi National Park (SGNP) in Mumbai, spread across 46 acres—of which roughly half falls under forest land reservation—on a hilly terrain that's around 70-80m above mean sea level, with its boundary guarded on all sides by the high wall (Malad Wall Collapse, 2019). The observations from the fact-finding committee's interim report highlight significant deficiencies in the stormwater infrastructure, reveal a drainage system that is grossly inadequate in both design and maintenance inside the facility and completely absent in the adjoining settlements that lie downhill. My spatial documentation of the facility corroborates these observations, documenting a fragmented network of discontinuous drains and concrete culverts that remain obstructed by accumulated debris and unchecked vegetation growth. The facility's municipal workers interviewed on-site confirmed the absence of repair and maintenance efforts for the critical drainage infrastructure. Considering the topography of the site coupled with inefficient stormwater infrastructure inside the facility (see Figure 5), the boundary wall becomes a major obstruction to the natural drainage paths of rainwater that run downhill.

6 The facility constitutes of two water reservoir tanks, control rooms and housing for MCGM staff. Tank 1, which was renovated in 2017, has a capacity of 11 Million Gallon. Tank 2 is a smaller tank with a capacity of 4 Million Gallon, but remains under-utilised since it hasn't been repaired and is leaking from beneath due to its deteriorating condition (Data based on spatial documentation interviews of the facility's municipal workers and engineers conducted during field visit).

Figure 5: Satellite imagery of the site showing the boundary wall of the facility in red, overlaid with GIS based contour show direction of water flow (indicated with arrows), and natural drainage pathways in blue (Malad Wall Collapse, 2019)

The technical investigation committee (TIC), comprising of engineers and experts, constituted by the State to probe the event stated in its report that heavy rainfall coupled with holes in the wall blocked by the hutment dwellers resulted in the mishap (Ozarkar & Sharma, 2019). However, a closer inspection of the entire periphery wall through my spatial mapping—which is concurring with the investigations of the fact finding report—reveals that the wall itself is in fact technically flawed in its design and structure. It was constructed without any consideration for stormwater runoff, containing very few weep holes placed in a randomised manner scattered across some selective sections only. Unlike retaining walls, this wall was not built to sustain lateral pressures resulting from soil and rainwater accumulation (Malad Wall Collapse, 2019; Singh, 2019). This critical infrastructure led the adjoining housing tenements to be *walled against* a significant volume of water that had accumulated due to the heavy downpour of that night and the previous day. It was indeed built as *an infrastructure of containment, not protection* to shut out of sight and contain the adjoining dwellers who are perceived as "encroachers" by the state and judiciary, than protect them from landslides and flooding (Malad Wall Collapse, 2019). Except for the collapsed portions, the wall still stands the same way with no modifications or alterations made for drainage whatsoever even five years post the disaster. The Maharashtra State Government has in February 2025 approved a plan to build a protective wall along the entire periphery of the Sanjay Gandhi National Park to keep it from "encroachers" (Deshmukh, 2025). The building of such separation walls has, thus, become a normative planning practice in Mumbai's planning: containing people from "nature" by precariously walling them against its unstoppable forces.

Housing precarity and environmental regulation in Ambedkar Nagar & Primpripada

The areas of Ambedkar Nagar and Pimpripada abutting the boundary wall, lie downhill from the reservoir facility on a slope that's around 30-60m, and are a part of a much larger settlement that falls under the forest land of the Sanjay Gandhi National Park. As per environmental regulations, parts of the settlement that lie within the delimited extents of the forest land are not allowed to use permanent building materials to construct their tenements (Agarwal, 2002). Thus, the tenements closer to the wall have resorted to practices of constructing stone plinths out of loose random rubble and using skeletal bamboo frames covered with materials such as plastic/tarpauline sheets for their superstructure (see Figure 6 and Figure 7). These temporally fragile structures proved catastrophically inadequate when confronted with the force of the wall's collapse, which sent flood water and massive boulders cascading downhill.

The settlements have been denied and devoid of any formal infrastructure for managing stormwater drainage and depend almost entirely on ground water (sourced from an open well located downhill) for their domestic purposes. Following writ petitions and orders from the Bombay High Court in 1997, people living in this settlement—which is predominantly constituted by socio-economically marginalised groups of Dalits and

Muslims—were ought to be rehabilitated by the state government before evicting them from the forest land (Nivarra Hakk, 2000). Their rehabilitation has been pending ever since. However, the MCGM and forest department, in contempt of the court order, conducted forceful and violent demolitions in the settlement in 1999 and 2000 (Nivarra Hakk, 2000). Had the settlement residents been properly rehabilitated in compliance with court orders, their lives would not have been endangered on such hazardous terrain when the wall collapse in 2019. The resulting devastation was therefore not simply the consequence of rainfall-induced structural failure, but rather the direct outcome of deeply entrenched housing inequities and spatial injustice inflicted upon the urban poor belonging to marginalised communities who are forced to inhabit vulnerable and precarious conditions within the city.

Fig 6. Tenements on site (Photo by author)

Fig 7. Tenement on site and the periphery wall uphill in the background (Photo by author)

Stormwater drainage at the intersection of flooding, housing, and environmental deregulation

The case of the Malad wall collapse event indicates a much deeper urban crisis that weaves together issues of stormwater drainage, housing, exclusionary forms of material infrastructures, and environmental conservation. The wall collapse event brought to the surface the overlapping epistemic injustices, connecting questions of drainage to housing precarity and environmental regulation which otherwise lay dormant yet very much present in the everyday lives of the Ambedkar Nagar and Pimpripada residents. The wall (and its partial collapse in time) symbolises, both materially and ideologically, the exclusive nature of environmental regulations aimed at conservation where the urban poor are singled out as "encroachers" on contested eco-sensitive lands, the SGNP in this case. While land disputes and the notion of 'encroachment' surrounding SGNP have been widely analysed within environmental debates (Bhide, 2009; Parthasarathy, 2011; Sen & Pattanaik, 2015), this paper employs the case of the 2019 wall collapse to illuminate one of the many critical dimensions of SGNP's complex environmental conflicts. The incident reveals the fundamental tension inherent in SGNP's dual identity as both a protected forest land and a transient (albeit at times violent) waterscape that amplifies risks for marginalised communities inhabiting its lands, peripheries, and fringes. State planning mandates protective measures such as boundary wall construction to safeguard forest lands, reinforced by environmental regulations that impose restrictions on building practices of the informal albeit legal settlements within these areas. However, the park's hydrological system, comprising of rivers, runoff channels, and hillslopes, functions as an active catchment zone (Mapping Aarey, 2019) by disproportionately endangering precariously housed residents abiding by the state's planning mandates. The fundamental paradox of this condition lies in the state's imposition of "forest land" zoning which does not consider the temporal nature of water that flows within this land. While the planning forcibly restricts residents to precarious, makeshift housing constructed with temporary materials, it simultaneously authorises the state to erect permanent concrete structures—which often fail to meet basic structural and environmental standards, as demonstrated by the Malad case—such as boundary walls, tunnels for highways, concretised link-roads, and metro sheds on the very same terrain as projects for economic development, often overlooking the implications of these on the forest's social-hydrology (Mapping Aarey, 2019; MMRDA, 2015; Sen & Nagendra, 2019; Surve, 2023). This contradiction reveals how conservation zoning operates as a material practice of spatial injustice. It criminalises legal informal settlements as "encroachments" while legitimising state infrastructure that exacerbates flood risks (in this case, boundary walls that obstruct natural drainage and intensify flood vulnerability). By framing the land as inviolable forest land yet buildable for state

projects, the policy perpetuates a double standard that perpetuates urban marginalisation under the guise of technical necessities for environmental protection.

The persistent question for housing, prior to and post the Malad wall collapse, exposes the systemic injustices at the heart of Mumbai's housing crisis. This case compels us to treat housing and spatial justice as non-negotiable parameters in stormwater infrastructure planning, especially in flood prone areas. The actions of residents in Ambedkar Nagar and Pimpripada, of building and occupying precarious homes since 1997, must be recognised as everyday practices by those most marginalised of coping with state planning practices that endanger their living environments. The exclusion of informal settlements from municipal stormwater drainage networks, the inadequate construction and maintenance of stormwater infrastructure, and the collapse of infrastructures during extreme rainfall events must be understood not as planning failures or oversights, but as intrinsic outcomes of Mumbai's technocratic planning paradigm (Indorewala, 2018). This system is principally rooted in valuing land solely for its economic potential and, thus, through its practices, systematically undermines its vital socio-ecological relationships with water systems and communities, inevitably producing disastrous environmental consequences for the city.

Conclusion

The inferences drawn from the ineffectiveness of the BRIMSTOWAD masterplan to prevent flooding combined with an analysis of the Malad wall collapse, demonstrates that Mumbai's chronic flooding problem is not a planning failure but rather the inevitable consequence of a technocratic planning system that subordinates socio-ecological considerations of water to the economic development of its land. The BRIMSTOWAD infrastructure as a techno-fix, designed to withstand only 50–65 mm/hr rainfall despite evidence of intensifying monsoons, reveals a deliberate disregard for both hydrological science and environmental justice. The stormwater drainage system's challenges and inadequacies—whether in excluding informal settlements, degrading natural drainage channels, or dysfunctions under climate extremes—are not technical miscalculations but logical outcomes of a planning paradigm that treats land as a commodity and all stormwater as disposable excess. The 2019 Malad wall collapse event, which killed 31 residents of an informal albeit legal settlement, exposes how issues of stormwater drainage are linked to inter-connected urban crises concerning housing and environmental regulation, thereby furthering the marginalisation of vulnerable communities. Such marginalisation and spatial vulnerability is not accidental but engineered. It is a direct result of planning that uses material practices of environmental regulation to displace and dispossess the urban poor. The boundary wall of the Malad facility shares both ideological and aesthetic similarities with the embankment walls of the BRIMSTOWAD project. Both structures serve a containment function. The BRIMSTOWAD's walls are designed to control and contain stormwater, while the Malad reservoir's periphery wall effectively confines adjacent informal settlements. Though their stated purposes differ, stormwater remains the common thread. It is the explicit target in BRIMSTOWAD's engineering, but implicitly present in the periphery infrastructure shaping the vulnerability of communities living near the reservoir facility.

The lived experiences and practices of those navigating waterlogged homes, inundated streets, and collapsing infrastructure reveal what official plans obscure, that flood risk is not natural but engineered. This paper has attempted to problematise flooding and related urban crises through the material practices that shape planning and the everyday in Mumbai. Reflecting on these practices would help us to understand—as Lefebvre puts it—'how people live or how badly they live, or how they do not live at all' (Lefebvre, 2014). The task ahead is not to "fix" flooding but to dismantle the systems that produce it.

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The Legacy of Experience: Reflections on Climate Transition Strategies in Medium-Sized Italian Cities

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Abstract
This study examines Climate Transition Strategies in medium-sized Italian cities (Bergamo, Brescia, Mantua), funded by Fondazione Cariplo. It investigates how urban nature is conceptualized and integrated, and the impact of these strategies on urban planning instruments. Despite varying visions – from human-centered 'oasis cities' to technical performance and integrated eco-climatic planning – direct actions across the CTS converge on (re)naturalization, (re)forestation, depaving, maintenance, and extension in urban spaces. A key finding is the significant influence of CTS on urban governance, integrating climate objectives into planning instruments. Competitive funding catalyses these experimental approaches in resource-constrained cities. The research highlights a shift towards integrating urban nature but notes challenges like fragmented actions and the need to assess long-term socio-ecological effectiveness and equitable benefit distribution.

Keywords: Climate Transition Strategies; Urban Nature; Medium-sized Cities; Climate Adaptation; Climate Mitigation

Introduction

Human activity is the primary driver of global warming and climate change (CC), significantly contributing to the increase in extreme weather events (Lynas et al., 2021; IPCC, 2023). Globally, 2023 was the hottest year since 1961, and in Europe it ranked as the second warmest on record (SNPA, 2024). Italy experienced comparable trends, with 2023 being its second hottest year on record and marked by significant deviations in rainfall patterns compared to historical norms (SNPA, 2024). Particularly in the northern regions of Italy, there has been an uninterrupted rise in average annual temperatures, coinciding with strong fluctuations in monthly precipitation (SNPA, 2024). Urban areas are amongst the most vulnerable to the impacts of CC, due to their high population density. The consequences of climate change for urban life are numerous. These include rising temperatures, worsening air quality and an increased risk of flooding or intense rainfall (OECD/EC, 2020). Consequently, there is an increasing need to develop effective strategies for climate mitigation and adaptation (Tang, 2024), as well as identifying mechanisms to finance the climate transition (WEF, 2025). A notable category of interventions involves Nature-based Solutions (NbS), which rely on natural processes to address specific challenges while delivering multiple co-benefits (Sowińska-Świerkosza & García, 2022). Despite the capacity of NbS to produce social, environmental, and economic value (Bockarjova et al., 2022), the concept of 'naturalness' has the poten tial to perpetuate a dichotomy between the natural and artificial, thereby diverting attention from their genuine functionality and effectiveness (Osaka et al., 2021).

Nature has played an integral role in shaping urban environments, particularly through the presence of natural green spaces. The discipline of urban planning has historically sought to reintroduce a natural environment into urban settings, thereby reflecting ongoing efforts to define the relationship between humans and green spaces. The role of nature has been subject to evolution since the late 19th century, as evidenced by the Barcelona Extension Plan (Urban, 2016), the Garden City movement (Howard, 1902), and more recent climate-focused projects. Early urban interventions were primarily concerned with public health and sanitation (Benevolo, 1971). In contrast, contemporary planning acknowledges the integration of cities with natural systems, with the objective of achieving goals such as biodiversity, climate regulation, stormwater management, and recreation. Recently, a growing number of European cities have adopted new planning approaches to support the climate transition. The overarching objective of these strategies is to rethink urban-nature relations and promote sustainable practices. Approximately 60% of Europe's population inhabits small to medium-sized cities (with 10,000–250,000 inhabitants) (Selada et al., 2010), which frequently encounter climate-related challenges with constrained financial

and human resources. For these cities, external funding – frequently obtained through competitive calls from public or private institutions – can provide vital support. Strategic plans that emerge from such funding are integrated into municipal planning frameworks with a view to promoting sustainability and climate resilience, while also outlining concrete actions. These strategies, particularly the ones originating from competitive funding programmes, frequently resort to experimental approaches (Broto and Bulkeley, 2013). Nevertheless, such approaches are not without critical issues (Caprotti and Cowley, 2017), and it becomes essential to evaluate both their social-ecological effectiveness and their influence on urban governance. The study draws on the concept of Social Nature (Castree and Braun, 2001) to investigate how different ideologies, imaginaries, and objectives shape the framing of nature. It highlights how climate strategies produce a 'socionature' (Swyngedouw, 1996) – a hybrid of social and ecological processes.

The present research focuses on the legacy of strategic climate plans, evaluating both the implementation outcomes and their impact on planning instruments. The present study explores varying interpretations of nature's role in Climate Transition Strategies developed under a shared funding framework and tailored to local contexts. The study considers the commodification of natural elements, their use in city branding, and their potential to redefine the relationship between people and the environment. Moreover, it explores the process through which global climate agendas are adapted to local contexts in order to facilitate the conservation, regeneration, and functional integration of nature in urban planning. The study is divided into three sections. The first section introduces the Climate Transition Strategies that have been promoted by Fondazione Cariplo. The second part of the study explores a selection of Climate Transition Strategies experiences enabled by this initiative, highlighting their visions and nature-oriented interventions. The third section of this study examines how these strategies have influenced urban planning instruments.

Climate transition strategies

The '*F2C - Fondazione Cariplo per il Clima*' project was initiated in 2019. The initiative has been promoted by Fondazione Cariplo (FC) and is in alignment with the European and national climate policies that gave rise to the European Green Deal (EC, 2019), the Next Generation EU and the National Recovery and Resilience Plan (PCM, 2021). The objective of the project is to implement CC mitigation and adaptation interventions within the Lombardy Region. Furthermore, the objective is to enhance the level of institutional and public understanding of CC. One of the F2C call is the call for ideas *Strategia Clima* [Climate Strategy]. The objective of this initiative is the realisation of Climate Transition Strategies (CTS), with the identification of a partnership necessarily composed of a lead municipal administration (with limits for the number of residents), an organisation managing a naturalistic area of high importance for the protection of biodiversity and a private non-profit organisation with experience in involving citizenship in environmental sustainability. In the context of this second project, Fondazione Cariplo is committed to providing technical assistance during the implementation phase of the CTS, as well as financing a share (up to 60%) of the expenditure related to each intervention.

The competitive call for ideas proposed by Fondazione Cariplo for the Climate Strategy Call for Ideas is composed of three phases (F2C, 2020): (i) Call for ideas: collection of project ideas related to the Climate Transition Strategy. In this phase, a high degree of detail is not required with regard to the proposals for action, but the application must mandatorily contain a number of well-defined areas (e.g. support to the revision of urban planning instruments of public bodies, adaptation and mitigation to CC). However, the necessity to influence public administration decision-making mechanisms from a policy and resource allocation perspective is emphasised. (ii) Provision of technical assistance for co-design: this is only available for ideas that have been selected during the initial phase. This phase is characterised by the elaboration of project ideas. The Fondazione Cariplo may provide direct support for the implementation of specific actions, prioritising those that have demonstrated effectiveness and can be implemented promptly (Quick win/No regret actions) and in social contexts where the consequences of CC are most pronounced. At the conclusion of the second phase, financial contributions are also determined. (iii) Effective implementation of interventions by the partnership. The terms of these agreements are to be defined in writing between the partners and Fondazione Cariplo.

The CTSs developed in this process must have two main objectives: (i) mitigation and adaptation to CC of vast

territorial areas, intervening on climate-altering emissions, impacts of extreme weather phenomena and increase in natural capital; (ii) intervention to improve public knowledge and awareness of CC, both by supporting scientific research and by promoting cultural and dissemination activities.

The territories and actions

The 2020 edition of the Climate Strategy encompasses four projects, each pertaining to a distinct Lombard territory. Of these four projects, three are the focus of this analysis: (i) 'Cli.C. Bergamo!', spearheaded by the Municipality of Bergamo in collaboration with the Parco Regionale dei Colli di Bergamo, Legambiente Lombardia, and ERSAF. The involvement of the Regional Park is instrumental in facilitating the project's extensive area of action. Within the designated area, encompassing a total of nine municipalities, the park's plan supersedes the urban planning instruments of the local authorities. This indirect influence enables the Cli.C. Bergamo! project to extend its intervention to areas beyond the municipal boundaries of Bergamo (Comune di Bergamo et al., 2020). (ii) 'Un Filo-Naturale', led by the Municipality of Brescia in partnership with Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), AmbienteParco, Parco delle Colline di Brescia (Comune di Brescia et al., 2020); (iii) ACE3T - CLIMA, spearheaded by the Municipality of Mantua in collaboration with multiple municipalities, namely Curtatone, Marmirolo, Porto Mantovano, San Giorgio Bigarello, Parco del Mincio, Unione Colli Mantovani, and Alkémica Cooperativa Sociale (Comune di Mantova et al., 2020). The territorial extension of the intervention possibilities is variable for the three cases. Starting from the most limited, the Un Filo-Naturale project envisages interventions only within the municipality of Brescia. Conversely, the Cli.C. Bergamo! initiative delineates interventions within the lead municipality and, in a secondary manner, in the territory of nine other municipalities within the Regional Park. The final case, designated ACE3T - CLIMA, involves a total of six municipalities in addition to the primary municipality, thereby enabling direct intervention in the designated territory.

The three territories under consideration present different characteristics. The geographical area of Cli.C. Bergamo and Un Filo-Naturale are distinguished by their similarity in terms of urbanisation levels and topographical characteristics, specifically the presence of foothill zones. Conversely, the area of ACE3T - CLIMA pertains to a heavily irrigated and agricultural lowland context. The repercussions of CC accentuate phenomena deemed pivotal by the three projects: the hydraulic and flooding risk, and the escalation in temperature, in conjunction with the urban heat island phenomenon. However, the distinct local characteristics translate into further specific territorial criticalities. The first two territories highlight problems related to hydrogeological instability while the final territory is distinguished by diminished soil quality and reduced water availability.

The vision of each strategy is defined based on the territorial cognitive framework and the criticalities identified. The Cli.C. Bergamo! programme identifies five objectives: preventive adaptation and reactive adaptation to climate change; containment of the expansion of urbanised areas, including processes of depopulation and renaturalisation; strengthening of social cohesion for a new urban welfare; attribution of a relevant role to green areas and vegetation, including the creation of a green belt; and safeguard and enhancement of agricultural areas. Un Filo-Naturale, commencing from specific objectives, summarises them with three key words: oasis city (creating shade and coolness for human wellbeing, improving the urban microclimate and increasing urban biodiversity), sponge city (restoring space, time and quality to water) and city for people (with beautiful and liveable spaces guaranteeing rights such as health, slow mobility, meeting and inclusion). The vision of ACE3T-CLIMA is predicated on three fundamental pillars: firstly, blue permeability (the transformation of hydraulic risk into a resource, with concomitant improvements in safety, environmental quality and the adaptability of the territory to the effects of CC); secondly, green inclusion (the overcoming of the separation between natural and anthropic systems, with a view to favouring biodiversity, human wellbeing and the sustainability of productive and agricultural systems); and thirdly, resilience and decarbonisation of territorial systems (the energy efficiency which improves the quality of life and the sustainable management of resources from a fossil-free perspective)., The semantic structure of the strategies' objectives is different. Un Filo-Naturale employs a vision narrative, synthesising the advantages associated with the term 'city' and emphasising the robust 'urban' character of the strategy. ACE3T-CLIMA articulates the objectives by integrating them with the strategies of eco-climatic planning of the territory, thereby establishing a nexus between rural and urban contexts. It appears that Cli.C. Bergamo! employs a more technical approach, with a focus on the performance of the actions. The objectives of the vision are then translated into specific actions aimed at resolving the critical issues identified. All the actions, as explicitly requested by the call, fall into one of the following categories: governance actions/application for funding; support for the revision of urban planning tools; CC adaptation; CC mitigation; monitoring systems and

networks; capacity building and training of municipal technicians; territorial animation and communication.

The number of planned actions ranges from 20 in ACE3T - CLIMA to 30 in Un Filo-Naturale. Highlighting only the direct actions, that involve physical modification of the territory, Cli.C. Bergamo initiative entails 11 direct actions, constituting a proportion of the total 23 planned initiatives. All 11 of these direct actions pertain to mitigation or adaptation strategies. Un Filo-Naturale present only 11 direct actions, all in the adaptation category. In this STC, mitigation is achieved through actions that do not involve land modifications but are based on citizen participation and involvement. ACE3T - CLIMA incorporates a total of nine direct actions, exclusively those pertaining to CC adaptation. Despite the heterogeneity of strategies and the partiality of territorial criticalities, all direct actions can be ascribed to five families: (re)naturalisation, (re)forestation, depaving, maintenance and extension. Each action falls within a specific typology of space: wetlands, urban or suburban forests, green and blue infrastructure, urban parks, parking areas and draining plazas, water network, roof gardens, rain gardens, slow mobility paths.

The Influence of CSTs on Planning Instruments
The call expressly requires CTS to directly influence the planning instruments of the territories.

The CTS Cli.C. Bergamo! provides for four actions to 'review of urban planning instruments'. These four actions aim to address four CC mitigation objectives, two CC adaptation objectives, four governance objectives for the implementation of the CTS, and three objectives for participatory processes and co-design.

Action 1, 'mapping the climate risk index', has the following objectives: capacity building for public entities involved in the management, implementation and monitoring of the CTS; raising awareness of the impacts of CC among stakeholders and citizens. It involves correlating CC manifestations with the morphological and socio-economic characteristics of the territory in order to assess exposure and vulnerability. The mapping is carried out in stages: characterisation of the local climate through analysis of historical data series; investigation to characterise future climate scenarios; in-depth analysis of environmental, demographic and socio-economic matrices and the relationships between them to investigate the vulnerability and resilience of the territory; risk assessment consists of relating the potential direct and indirect impacts to the characteristics of the territory. The expected results include the creation of a Climate Risk Map to guide climate change adaptation and mitigation policies, the identification and study of the main climate-related threats and issues, and an analysis of the degree of exposure, vulnerability and adaptability of the territory.

Action 2, 'River contract for the Morla and its tributaries - how it flows between the hills and the city of Bergamo', will be described in detail below.

Action 3, 'Increasing resilience through planning choices in the new *Piano di Governo del Territorio*[1] (PGT)', has several objectives: disseminating CC mitigation policies in territorial governance choices; integrating CC adaptation and mitigation policies into urban choices and transformations; capacity building for public entities involved in the management, implementation and monitoring of the CTS. The Municipality of Bergamo is revising its PGT to respond to socio-economic and regulatory changes, with the aim of promoting sustainable and regenerative urban development. The new PGT pays particular attention to environmental and climate protection, integrating actions for climate change mitigation and adaptation, such as the enhancement of urban green spaces, sustainable water management and the limitation of land consumption. In this context, the CTS is a tool for guiding urban policies towards resilience, contributing to the definition of structural and non-structural interventions capable of reducing the city's environmental vulnerabilities. The CTS also supports the creation of new ecosystem services, urban forestry and renaturalisation, strengthening the integration between planning and sustainability. The expected results include the construction of a resilient city capable of coping with climate change and environmental risks in the long term. The development of organisational and management strategies geared towards prevention is envisaged, through both preventive adaptation tools – to reduce hazards and

1 The Piano di Governo del Territorio (PGT) is the overarching urban planning instrument to which all Lombardy municipalities are obliged to adhere in order to regulate land use, urban and territorial development, and environmental and landscape protection. The plan is composed of three primary documents: the Documento di Piano, which outlines the development strategies and general objectives; the Piano dei Servizi, which identifies the necessary equipment and public infrastructures; and the Piano delle Regole, which regulates the admissible uses and transformations of the territory.

vulnerabilities – and reactive tools to respond effectively to extreme events such as heat waves, droughts and floods.

Action 4 'from PAES to PAESC' involves the transition from the *Piano d'Azione per l'Energia Sostenibile*[2] (PAES) to the *Piano d'Azione per l'Energia Sostenibile e il Clima*[3] (PAESC). The objectives are manifold: dissemination of CC mitigation policies in land management decisions; reduction of climate-changing gas emissions through energy efficiency; integration of CC adaptation and mitigation policies into urban planning and transformation; capacity building for public entities involved in the management, implementation and monitoring of the CTS. The Municipality of Bergamo has begun developing its new PAESC. This process is part of the commitments made under the Covenant of Mayors, which Bergamo joined in 2009. After two monitoring cycles of the previous PAES, the municipality now intends to align itself with the new European targets: -55% CO$_2$ by 2030 and climate neutrality by 2050. The new SEAP will include mitigation actions to reduce emissions and adaptation actions to strengthen the city's resilience to climate change. The plan will be divided into three main parts: emissions inventory and risk analysis, decarbonisation plan and adaptation plan. The process will involve public participation, biennial monitoring and the sharing of good practices with other European cities through a network.

The CTS Un Filo-Naturale for the Brescia area provides for two actions to 'revise urban planning instruments', which aim to respond to one CC mitigation objective, one CC adaptation objective, two governance objectives for the implementation of the CTS, and one objective for participatory processes and co-design.

Action 1.1 of the CTS Un Filo-Naturale 'support for the revision of urban planning instruments' will be described in detail below.

Action 1.2 'analysis of local climate variability' has as its main objectives improving awareness of CC and capacity building for public bodies, citizens and stakeholders. The Municipality of Brescia wants to integrate the analysis of local climate variability into the process of revising urban planning tools. The aim is to identify the main past and future climate challenges to plan targeted adaptation measures. The analysis is based on internationally recognised climate indicators, calculated both from historical data (last 30 years) and future projections based on climate scenarios. This analysis makes it possible to define the current state of the climate and the potential risks arising from future changes, providing a scientific basis for planning local adaptation strategies and assessing climate risk. The expected result is the development and study of local climate variability.

ACE3T - CLIMA for the Mantua area provides for a single action of 'mainstreaming and revision of urban planning tools': action 2 'revision of urban planning instruments'. The objective of the action is to reorient the actions of municipalities in local and supralocal government decisions to include adaptation and mitigation to CC in urban planning instruments and processes. Some of these instruments are mandatory, others optional. The action plans to integrate the following tools with specific guidelines:

- *Piano Triennale delle Opere Pubbliche*[4]: definition of public intervention standards to contribute to resilience.
- *Regolamento del Verde Pubblico e Privato*[5]: identifying native plant species with high environmental

2 Piano d'Azione per l'Energia Sostenibile (PAES) is a strategic instrument developed by municipalities under the Covenant of Mayors, a European initiative focused on climate and energy. The SEAP delineates objectives and specific actions aimed at mitigating greenhouse gas emissions, encompassing initiatives pertaining to energy efficiency, renewable energy, and sustainable mobility.

3 Piano d'Azione per l'Energia Sostenibile e il Clima (PAESC), represents the evolution of the PAES and signifies the strategic instrument through which municipalities adhering to the new Covenant of Mayors commit themselves not only to reducing CO2 emissions, but also to addressing the impacts of climate change through adaptation measures. The strategy delineates an integrated approach to achieving European decarbonisation targets, promoting energy efficiency, the utilisation of renewable sources, and fortifying territorial resilience.

4 The Piano Triennale delle Opere Pubbliche is a planning document that every Italian municipality is required to draw up in order to plan, over a three-year time horizon, the implementation, maintenance and adaptation of public works of economic importance. It includes, for example, schools, roads, public buildings, sports facilities, road and environmental infrastructure.

5 The Regolamento del Verde Pubblico e Privato is a regulatory instrument adopted by municipalities for the purpose of protecting, managing and enhancing the public and private urban plant heritage. The document establishes criteria and procedures for the design, maintenance, felling and replacement of plants, with the overarching objectives of promoting biodiversity and

effectiveness; redeveloping public green spaces in relation to heat islands; considering CC in the design criteria for urban green spaces; promoting the adoption of municipal or inter-municipal green space plans.

- *Regolamento Edilizio*[6]: defining specific rules to increase adaptation and mitigation capacity in new construction and renovation projects and defining an index to increase the response to heat waves and urban flooding.
- *Documento di Piano*[7]: consider scenarios and critical issues arising from CC; integrate objectives and strategies with adaptation and mitigation elements and promote agriculture and rural land management, considering ecological networks, the promotion of biodiversity and the contribution of ecosystem services.
- *Piano delle Regole*[8]: promote urban regeneration by encouraging adaptation to CC; encourage environmental sustainability and urban resilience with new standards and criteria to minimise carbon emissions, improve drainage and the urban microclimate, create green infrastructure, mitigate heat islands; reduce hydraulic risk and de-impermeabilisation;

Action 2 of the CTS Cli.C. Bergamo! involves signing a River Contract (RC) for the Morla river basin, a 14 km watercourse considered to be Bergamo's river. From the start of its course within the city, the Morla is heavily artificialised. The RC is a voluntary planning instrument negotiated between several municipalities, which aims to protect water resources, improve their management and contribute to safeguarding against hydraulic risk. The RC can also help to integrate and guide local planning, while improving subordinate planning. The RC '*Il Morla e i suoi affluenti*' (The Morla and its tributaries) has the specific objective of restoring the watercourse and the surrounding area, both in terms of its naturalness and its historical and identity value. The stages indicated by the CTS for the implementation of the RC, which were then actually implemented, included: the drafting of a document of intent containing the reasons for the creation of the RC, its objectives and methodology; a fact-finding analysis of environmental, social and economic aspects; the mapping of potentially interested public and private entities and stakeholder; the implementation of participatory processes to share intentions among the entities and stakeholder; the development of a shared medium- to long-term strategic scenario; the definition of a three-year Action Programme, indicating objectives, actors (with obligations and commitments), timelines, implementation methods, and the necessary human and economic resources; the signing of the River Contract. Specifically, the Memorandum of Understanding was signed on 2 December 2022, while the actual River Contract was signed on 8 February 2024.

With regard to 2024, the first year of the RC, various interventions were carried out within the river basin: unsealing of a section of the stream; restoration of a drainage ditch; cleaning and redevelopment of the banks; conservation of tree vegetation; training meetings for technicians and professionals; development of a GIS database; updating of the areas of environmental enhancement within the PGT of the municipality of Bergamo. The year 2025 will be characterised by five themes: green space regulations, environmental compensation for investments and infrastructure, river routes, environmental education, and communication.

Action 1.1 of the CTS Un Filo-Naturale 'support for the revision of urban planning instruments' aims to update and integrate land management tools with objectives and actions strategically geared towards climate transition. The action therefore consists of updates and additions to reports, regulations, project guidelines, maps, procedures and regulations for planning tools that are currently in force or being implemented. The activities follow two coordinated lines: the first involves the introduction of new support tools to guide and prescribe interventions in the territory, improving resilience to climate change; the second line involves direct or indirect interventions

defining the responsibilities of citizens and entities in the care of green areas.

6 The Regolamento Edilizio constitutes a municipal regulatory instrument, the function of which is to govern the processes of construction, renovation and maintenance of buildings within the municipal territory. The overarching objective of the plan is to establish a set of rules that, if adhered to, will ensure safety, urban quality, environmental sustainability and respect for the local context. It is integrated with the PGT.

7 The Documento di Piano constitutes the strategic element of the PGT. It delineates the objectives of urban and territorial development for a medium-long term time span. It identifies the needs of the territory, guidelines for urban transformation, environmental, social and economic policies, and demographic and settlement forecasts.

8 The Piano delle Regole constitutes one of the three constituent components of the PGT. It is the regulatory component, the function of which is to regulate land use and the transformation of the existing territory. The document under consideration comprises the regulations that govern the construction and town planning interventions permitted within the various areas of the municipal territory. It identifies the agricultural areas, the landscape, historical or environmental assets to be protected, and the parts of the urban fabric where restructuring, replacement or building conservation is permitted.

on areas and buildings aimed at urban regeneration and the creation of interconnected green infrastructure. In detail, the CTS provides for interventions on specific urban planning instruments. Within the PGT, the main municipal-level tool is expected to:

- Introduce new annexes: climate variability analysis and municipal study for flood risk management.
- Updating documents and maps: urban redevelopment areas with direct and indirect interventions; areas for hanging gardens and green roofs; areas for tree planting and permeability; pilot interventions for water retention basins; areas for new woods and habitats in urban areas; retrofitting areas.
- Introducing a procedure for participatory processes in urban transformation interventions.

In addition to the PGT, the CTS also intends to intervene on other instruments such as the *Regolamento Edilizio*, the *Piano Urbano della Mobilità Sostenibile*[9] (PUMS), the PAESC, the *Piano Comunale del Verde*, and the Multi-Year Plan for the PLIS of the municipality of Brescia. New planning instruments are also planned: the de-paving implementation plan, the strategy for the spread of green roofs, the forestry action plan, and guidelines for the extension of the district cooling pilot project.

Worthy of note is the new municipal green plan, called the 'Green and Biodiversity Plan of the Municipality of Brescia'. The introduction presents the CTS and analyses of climate change scenarios. It highlights air pollution, heat islands and hydrogeological risk as specific vulnerabilities of the Brescia area. It then explores the benefits of ecosystem services such as carbon sequestration and the removal of air pollutants, temperature regulation, protection from hydrogeological risk, etc. Just as the CTS summarises the objectives in three visions for the city, this tool also has the same structure: the healthy city (inspired by the One Health principle), the spring city (to restore the central role of water), and the city for people (with public space and community at its heart). Finally, the plan's implementation tools include the NbS abacus, organised into three sections: the first section introduces the functions and benefits of NbS; the second relates NbS to the project areas of the city of Brescia, listing the appropriate NbS for each area; the last section brings together the NbS fact sheets, outlining guiding principles and ecosystem services.

Discussion

The present study investigates the role of urban nature within Climate Transition Strategies, which is funded by Fondazione Cariplo, in medium-sized Italian cities. The analytical framework utilised in this study focuses on the Climate Transition Strategies that have been developed by the municipalities of Bergamo, Brescia and Mantua. The primary objectives are twofold: firstly, to comprehend the manner in which diverse ideologies, imaginaries and objectives influence the conceptualisation and integration of nature within urban contexts; and secondly, to critically evaluate the impact of these strategies on urban planning instruments.

The semantic structures employed in the objectives of each strategy reveal distinct approaches to framing urban 'natures'. The 'Un Filo Naturale' project is an ambitious undertaking that aims to create an 'oasis city,' a 'sponge city,' and a 'city for people.' This vision, in which human society is placed at the centre, synthesises the benefits of urban nature with broader concepts of human well-being and liveability, positioning nature as an intrinsic component of an ideal urban environment. The 'ACE3T-CLIMA' initiative articulates its objectives through the integration of established ecoclimatic planning strategies for the territory, thereby establishing a nexus between rural and urban contexts through concepts such as 'blue permeability' and 'green inclusion'. The 'Cli.C. Bergamo!' project adopts a more technical approach, with a focus on the measurable performance of actions related to preventive and reactive adaptation or containment of urban sprawl. The manifestation of these disparate conceptualisations as discrete 'socionatures' (Swyngedouw, 1996) in action illuminates the multifaceted manner in which social and ecological processes are hybridised and negotiated within these climate strategies. The conceptualisation of nature, whether as a functional apparatus, a provider of ecosystem services or a source of human well-being, exerts a direct influence on the cultural approach to urban nature and the language employed to communicate its value.
Despite these divergences in vision, there is convergence regarding the direct actions proposed in the three CTS.

9 The Piano Urbano della Mobilità Sostenibile (PUMS) is a strategic planning instrument adopted by municipalities to design efficient, safe and environmentally friendly mobility systems. The objective of the initiative is to enhance the quality of life in urban areas by reducing pollution, traffic congestion and greenhouse gas emissions. It delineates integrated interventions to promote sustainable transport modes, including public transport, cycling and walking, shared mobility, and the utilisation of environmentally friendly vehicles.

These actions, which are designed to induce physical changes to the urban territory, can be categorised into five distinct families: (re)naturalisation, (re)forestation, depaving, maintenance and extension. These interventions target a variety of urban spaces, ranging from wetlands and urban forests to green and blue infrastructure and urban parks. The 'Cli.C. Bergamo!' initiative integrates climate mitigation and adaptation into direct actions, whilst 'Un Filo-Naturale' and 'ACE3T – CLIMA' focus their direct interventions on adaptation strategies. The mitigation objectives in 'Un Filo-Naturale' are chiefly pursued through initiatives centred on citizen participation and involvement. One of the key findings of this study is the influence of CTS on existing and developing urban planning instruments, demonstrating a systemic change in urban governance frameworks. In accordance with the stipulations of the call, all three projects under consideration have been designed to incorporate their respective climate objectives into the existing urban planning instruments.

The 'Cli.C. Bergamo!' project is an initiative that proposes a series of actions with the objective of revising urban planning tools. These include the creation of a detailed Climate Risk Map, the integration of climate policies into the TMP, and the adoption of a PAESC. The River Contract for the Morla basin in Bergamo serves as a case study in multi-municipal strategies for ecological restoration of natural watercourses, illustrating a direct and quantifiable impact on land management practices and environmental enhancement within the broader TMP framework. The contract under discussion is indicative of a shift towards collaborative governance models that transcend administrative boundaries, a key element for effective action against climate change. In a similar manner, the Brescia 'Un Filo-Naturale' project endeavours to modernise and amalgamate prevailing urban planning instruments. The development of a new 'Green and Biodiversity Plan', based on the visions of a 'healthy city', a 'spring city' and a 'city for people', together with the creation of an NbS abacus, represents an approach to integrating climate resilience directly within urban planning. This process underscores a transition from ad hoc projects to systematic policy integration.

The findings indicate that competitive funding programmes, such as those administered by Fondazione Cariplo, function as catalysts for medium-sized cities to adopt experimental approaches and integrate climate strategies into their spatial planning. This is of particular significance when considering the financial and human resource limitations experienced by these cities. This research study lends further credence to the integration of 'natural systems' in urban areas, a concept that has gained significant traction in contemporary planning discourse. However, this raises questions regarding the long-term sustainability and scalability of these experimental approaches, underlining the need to evaluate their socio-ecological effectiveness and their influence on urban governance (CIT). The potential for the commodification of natural elements in urban branding further underscores the necessity for a more profound and critical examination of how these emerging strategies are reshaping the relationship between urban populations and their environment. In addition, an evaluation of the potential equity concerns is necessary, as well as an assessment of whether the advantages derived from these 'greening' initiatives are distributed uniformly across all demographic groups within the urban population.

Conclusion

This study provided a comprehensive analysis of climate transition strategies in medium-sized Italian cities, revealing both promising progress and critical areas for improvement in local climate action. The results of the study indicate a paradigm shift in the way urban nature is conceptualised and integrated into planning. The cases of Bergamo, Brescia and Mantua exemplify different and functional approaches to exploiting NbS for climate change adaptation and mitigation, reflecting different narratives adapted to local specificities. Despite the integration of urban nature being substantial within planning instruments, the analysis also highlights certain challenges. A fundamental concern pertains to the absence of a systemic and strategic approach to climate action. The individual direct actions promoted by CTSs appear to be fragmented and independent, with no internal coordination or external alignment with other ongoing projects. This underscores the necessity for a systemic approach that acknowledges the variability of climate change effects, transitioning from isolated interventions to coordinated strategies.

A further distinction is to be drawn between the ways in which 'old' and 'new' nature are addressed. The concept of 'old nature' frequently serves as the focal point for conservation, control, exploitation, or removal interventions, largely attributable to the perceived risks associated with it. Conversely, the concept of 'new nature' (Tononi, 2025) is predominantly evaluated based on its immediate benefits for human well-being and the natural system. The incorporation of socio-nature mapping, encompassing elements such as wasteland, forgotten spaces,

and groundwater, could facilitate the development and implementation of more effective climate strategies. The strategy for planning tools demonstrates a commitment to institutionalising climate resilience, ensuring that these efforts become lasting urban development rather than 'experimental' phases (Broto and Bulkeley, 2013; Caprotti and Cowley, 2017). However, further investigation is required into the long-term socio-ecological effectiveness of these changes, in order to assess the impact on biodiversity, ecosystem service provision and the general well-being of urban populations. It is also necessary to investigate how these strategies can redefine the relationship between urban populations and their environment, fostering a sense of connectedness and responsibility. It is therefore essential to explore the distribution of environmental benefits across different socioeconomic groups and the potential of these initiatives to address existing urban inequalities.

Addressing these implications and conducting further comparative studies on different funding mechanisms and governance structures will facilitate the identification of best practices and improve the transferability of successful models. This, in turn, will promote a climate-resilient, nature-positive and socially just urban future.

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Reintroduction of health impact assessment in Bulgarian city planning – why and how?

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Abstract
Bulgaria has established practices in Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), yet the integration of applied. Health Impact Assessment (HIA) research findings in the practice of urban planning, governance, and development is limited or absent. This study highlights the pressing need for reintroduction of HIA in the Bulgarian spatial planning system and proposes how that can be accomplished without excessive regulatory burden to city authorities, planning and design experts, (re)developers, and citizens. Drawing on local Bulgarian and international research experience with HIA-based urban planning, the present study conducts a comparative analysis of HIA regulations, provides an overview of health related SEA content, recent exposure studies for the 5 biggest cities in Bulgaria, and ultimately attempts to conceptually reframe HIA in the urban development practice.

Keywords: city planning; urban environment; health impact assessment; exposures; decision framework

Introduction

Urban environments shape human health through a range of direct and indirect pathways involving exposure to stressors, behavior modification, and salutogenic influences building resilience (Mueller et al., 2021). Compact and densely populated cities often amplify exposure to air pollutants, noise, artificial light at night, heat islands in summer seasons, and result in limited availability or inaccessible green space, exacerbating both physical and mental health disorders (Dyer et al., 2024). The means of production and consumption, shaped by political-economic systems of governance and spatial development configurations, influence air quality, the acoustics environment, energy dynamics, viewsheds, food availability, mobility modes, and physical activity among other characteristics of the living environment affecting health and quality of life (Barton & Grant, 2006; EEA, 2010; Krefis et al., 2018; Mouratidis, 2021). Historical waves of deindustrialization have left a legacy of unequal spatial development, often concentrating health risks in socioeconomically disadvantaged areas (Hajat, Hsia & O'Neil, 2015). Mixed use services oriented redevelopment and reindustrialization offer various opportunities for urban regeneration while technological and organisational advancements such as the smart city and circular economy concepts may optimize and prevent excessive energy and resource use. Nevertheless, all of these good intentions in cities' development may provoke new pressures and add specific adverse cumulative effects due to unbalanced patterns of spatial development relations and rebound effects (Parrique et al., 2019; Castro et al., 2022). The structural health-determining patterns and the future opportunities call for integrated public health-oriented urban design strategies that not only mitigate risks but also foster equity and resilience in the endless quest for sustainable cities.

Urbanization in Bulgaria is shaped by a post-socialist legacy, characterized by uneven development, deteriorating infrastructure, and persistent environmental issues. Many urban areas still bear the imprint of industrial pollution (e.g. Varnagglomeration, Burgas, Pernik) or newly emerging consumption externalities, especially in cities like Sofia and Plovdiv, where PM10 and PM2.5 levels regularly exceed the World Health Organization air quality guideline limits standards (European Environment Agency, 2023), while NO2 levels are often not in the spotlight that stay hidden from the official monitoring systems although there is confident evidence that it is an important issue (Popov & Hlebarov, 2021). This contributes to non-communicable disease respiratory and cardiovascular morbidity and mortality, disproportionately affecting mostly children and the elderly (Health Effects Institute, 2024). Despite its membership in the European Union and its current application for OECD accession, Bulgaria has recorded the highest mortality rate in the EU, with a crude death rate of 15.7-22.9 deaths per 1,000 inhabitants between 2019-2023 compared to the EU average of 10.4-11.9 (Eurostat, 2025). This reflects the combined impact of demographic shrinkage, population aging, chronic disease prevalence, underfunded health systems, and socioeconomic stress.

Health Impact Assessment (HIA) has emerged as a key tool for making health a visible and accountable component of urban planning and the parallel ex-ante and ex-post evaluation instruments (Mueller et al., 2021, 2023). The WHO's Healthy Cities movement provides a flagship guidance on the overall policy and tools, promoting governance

models that embed health into municipal decision-making via a series of indicators, such as health, health services, environment and socio-economic conditions oriented ones (Webster & Sanderson, 2012). HIA complements other legislatively established evaluation tools such as Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), offering more detailed insight into local health status and projected outcomes. While SEA and EIA focus generally on environmental and ecological impacts, HIA places explicit emphasis on population health, wellbeing, and social equity and thus is helpful in bridging societal and environmental aspects with people in the focus. Incorporating high quality HIA into these broader environmental assessment frameworks at the strategic planning and the project level ensures that health benefits are not seen as a byproduct but a central consideration in the different scales of urban development policy and decision making.

Integrating HIA helps identify co-benefits and trade-offs early on in planning processes and drive and orient, inform or strongly support planning and decision-making approaches, alternatives and choices. The gradually improving local evidence and global understanding of health - urban environment relations make HIAs more relevant and with higher resolution thus increasingly helpful for the targeted design of urban level solutions.
The present study addresses two main points:

1) The pressing need for reintroduction of more advanced and robust HIA in the Bulgarian spatial planning system.
2) The feasible implementation of HIA without an excessive regulatory burden to city authorities, planning and design experts, (re)developers and citizens.

Materials and methods
Drawing on experience from one pilot (UBSP, 2025) and three research projects (CES, 2025; SU, 2025; MUP, 2025) as well as other related actual studies carried out by the authors, conducted in major Bulgarian cities, this paper proposes a framework for reintroducing and improving the quality of evidence-based HIA in the country. The study offers insights by drawing on three qualitative analysis approaches:

1. A comparative analysis of international regulations and the current state of HIA practices at the urban level in Bulgaria as well as stakeholder analysis and survey;
2. An overview of urban environment - public health interactions and exposure patterns across Bulgaria's five largest cities, with a particular focus on Sofia, highlighting some of the key urban exposures such as air, noise, and light pollution, alongside the characteristics of green spaces and their accessibility;
3. A conceptual reframing of approaches to address urban environmental pressures and develop balanced strategies for creating healthier urban environments in Bulgaria in the near future.

We first review existing international standards, EU regulations, and nationally adopted legislation regarding monitoring, screening, mapping, programming, and action planning in the urban environmental domain. The comparative analysis of international regulations and the current state of HIA practices at the urban level in Bulgaria covers WHO and selected national recommendations and their application, the EU acquis transposition in relations to SEA and EIA. Next a brief overview of the variety of procedural and content oriented norms in selected countries and the differences in capacity, that is scientific, professional, and political will for evidence-based decision making is presented as well as an overview of Bulgarian regulations and analyses of the SEA-related content of the general spatial development plans of the cities of Sofia, Plovdiv, Varna, Burgas and Ruse. As part of one of the studies on joint effects on urban health, a purposive sample of stakeholders using the Delphi method is compiled and surveyed. The initial iterative discussion process went through several stages of defining specific aspects of social or natural phenomena in the urban environment - health nexus, identifying individuals, groups or organizations affected and/or that may have an impact on the urban planning and management decisions and thus prioritizing participants to be invited. The output of the stakeholder analysis is represented as initial findings.

We then present an overview of the urban environment - public health relationship and discuss exposure patterns in Bulgaria's capital and other large cities. In particular, we draw on the projects mentioned above and represented in more depth later in the text with short 'nicknames' as follows:

1) **Urban Standard** or originally "Set an **Urban Standard** - Creation of a Standard for Evaluation and Monitoring of the Quality of the Urban Environment" (UBSP, 2025);
2) **URBiNAT** or originally "**URBiNAT** - Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS" (CES, 2025);
3) **Methodology for air and health assessment** or originally "Development of a **methodology for air** quality **and** human **health** risk **assessment** in urban areas";
4) **Joint effects** or originally "**Joint effects** of exposures to natural and built environments – informing healthy and sustainable urban development".

More information about the sets of methods and results are described and compared in 3.2. Additional references are included in terms of important screening studies in this knowledge base review - outlooks and compilations of the Health Effects Institute (2022, 2023), the EXPANSE, UBD Policy Horizon 2020 projects. The latter combines resources with the Methodology for air and health assessment and the Joint effects projects in order to bring the research experiences with Sofia to a higher level (Khomenko, 2025).

The exposures of interest here include air pollution, traffic noise, artificial light at night, greenery and urban health islands. Particular focus is on Sofia, the capital city of Bulgaria.
The conceptual reframing of HIA in Bulgarian urban planning practice is made on the basis of definitions and principles stemming from the outlined gaps and the compact review of the international regulations, national practice and stakeholders' survey, as well as the accumulated research evidence.

Results

3.1. A comparative analysis of regulations of health impact assessment practices at the urban level in the EU

The comparative analysis of regulations regarding HIA is represented by an unfolding matrix of procedural and substantive issues. The comparison includes neighboring countries of Bulgaria (Romania and Greece), countries of similar population size (Denmark, Ireland, Austria), and other influential or role model ones in the urban development domain (The Netherlands, Germany, France, Spain, Italy, Poland). As in most cases in Europe, HIAs are part of the SEA and EIA content, so an overview of the legislative framing of both is shown in Table 1.

Table 1 Types of national legislation transposing the SEA Directive in selected EU countries (based on EC, 2025)

Type of legislation	SEA legislation	Integrated legislation		
Country		Environmental code / protection act	EIA legislation	Sectoral legislation
Austria				Δ(federal level and in some provinces)
Bulgaria	Δ(by-law)	Δ	Δ(by-law)	
Denmark	Δ(SEA and EIA together)			
France		Δ		
Germany	Δ		Δ	Δ
Greece	Δ			
Ireland	Δ			

Italy		Δ		
The Netherlands			Δ	
Poland		Δ	Δ	Δ
Romania	Δ			
Spain	Δ(SEA and EIA together)			

The Environmental Protection Act (EPA) in Bulgaria regulates the obligation to carry out a strategic environmental assessment or as it is called "ecological assessment" of policies, plans and programs, and an environmental impact assessment (EIA) of investment design projects in order to prevent, reduce or compensate for harmful effects of planned activities on nature and human health. The SEA related ordinance (CMRB, 2020) further defines the procedures and criteria for carrying out EAs.

The main focus is on the systematic assessment of likely significant impacts, including the ones on human health.

Table 2 Comparative analysis of regulations of health impact assessment at the urban level in selected countries (EU, 2001; EC, 2019a,b; 2025)

Country and responsible regulative bodies	Key regulatory acts and complimentary documents	Themes - factors and indicators	Evaluation cycle steps and health considerations	Urban planning related requirements
European Union				
European Parliament Court of Justice of the European Union European Environmental Agency	Directives 2001/42/EC (SEA) and Directive 2011/92/EU (amended by 2014/52/EU) (EIA) as well as guidance documents	Biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage, landscape and the interrelationship between the factors	Screening, Scoping, Reporting, Consulting, Decision making, Monitoring Para 1, Annexe I (f) and II (2)	Health impacts considered as part of the assessment of significant environmental impacts of plans and programs via SEA and EIA
Bulgaria				

Ministry of Environment and Water Executive Environmental Executive Agency Regional Inspectorate of Environment and Water Regional Health Inspectorate	Environmental Protection Act (EPA), 2002 and later amendments; (SEA) Ordinance on the conditions and procedure for carrying out an environmental assessment of plans and programmes, 2004 and later amendments; (EIA) Ordinance on the conditions and procedures for carrying out environmental impact assessment, 2006	Components: atmospheric air, atmosphere, waters, soil, subsoil, landscape, natural sites, mineral diversity, biological diversity and its elements; Factors: natural and anthropogenic substances and processes; waste; risky energy sources - noise, vibrations, radiation, GMO (Art.4, EPA)	Screening, Scoping, Reporting (assessment of the alternatives through comparison of planning options with), Consulting (a prolonged Aarhus convention case for Bulgaria regarding both the information and environmental justice aspects (UNECE, 2025)), Decision making (elaboration of reasoning and criteria for selection of the best alternative), Monitoring (setting of indicators for post-approval monitoring and control of the implementation)	Urban planning not explicitly addressed, overall implications for spatial planning. The state of health affected by the state of environmental components, or via them by the factors, actions and measures (Art. 19, EPA); The report must assess impacts on health among the other aspects (Art. 86, para. 3, pt. 6, EPA) Considerations of the objectives, territorial scope, level of detail related to investments, location, characteristics, scale, and impacts of plans in general and general spatial development or detailed urban design plans in particular (Art. 81, para. 3 and Art. 85, para. 1&4, EPA; Art. 8a, para. 2 SEA Ordinance)
Other EU countries (Romania, Greece, Italy, Spain, France, Netherlands, Germany, Austria, Danmark, Ireland)				
Various, e.g. ministries (Greece), inspectorate (France), commission (Netherlands)	Single (e.g. Greece, Romania) to many acts, based on sectoral distribution of issues and/or hierarchy of acts (e.g. France), federal divisions of legal responsibilities (Germany, Austria)	Most notably air quality and noise, as well as a number of other themes similar to the ones described in the EU SEA and EIA directives and other specific themes highlighted in the national context	Adherent to the EU directives, including Screening, Scoping, Reporting, Consulting, Decision making, Monitoring Various guiding documents on separate steps of the process (e.g. Poland, Austria, Netherlands)	Additional procedural and content support such as urban planning guidance (e.g. France), GIS environmental sensitivity mapping portals and tools (e.g. Romania, Ireland)

Compared to other countries, Bulgaria has a well-developed legislative base, both SEA and EIA related, although more generic in terms of the HIA specific implications, methodological and technical and in the urban planning and geospatial field. The health protection is included in the EPA as well as in the Health Act, and there is synchronization in procedural terms but content of HIAs is not comprehensively addressed.

Content analysis of SEAs with focus on the HIA related content

Further on an exhaustive review of available health related assessments is presented drawing on the content of Strategic environmental assessments in the 5 biggest cities in Bulgaria.

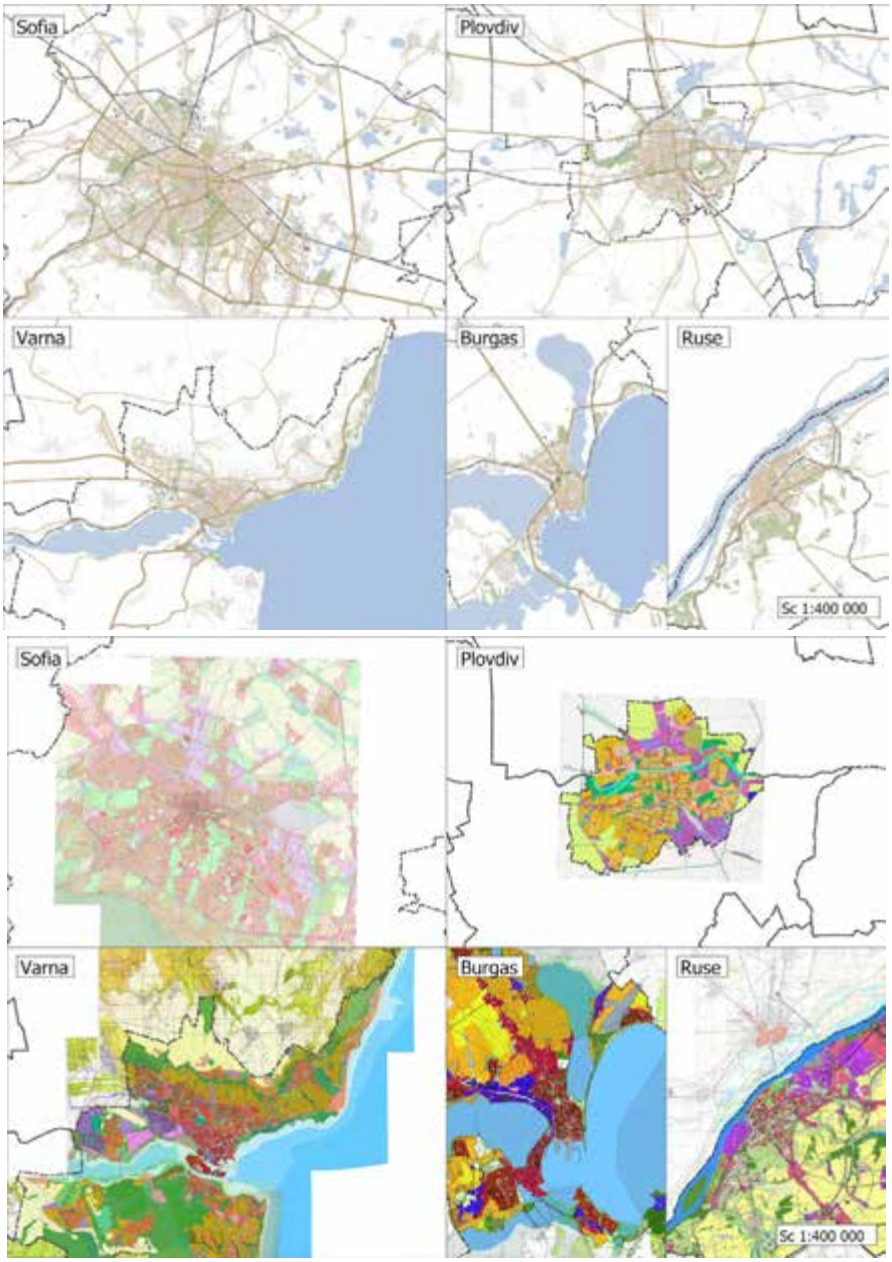

Figure 1 The 5 biggest cities (2023), their basic shape and the actual masterplans

The SEA content reviewed includes the available profiles in the official registry of the Ministry of Environment and Water (MEW). Additional sources like municipal portals are also used where older assessments are available, especially for the case of Sofia, whose spatial development plan and its SEA are preceding the creation of the registry (Sofiaplan, 2025). The selection of cities is based on their population size until 2023 when the last survey, part of the Joint effects project, was implemented.

Table 2 Review of SEA's health related content of the 5 biggest cities until 2023 in Bulgaria (Sofiaplan, 2025; MEW, 2025)

<table>
<tr><td>Health related content - quantity (number of mentions of the health word root) and quality (paragraphs with concentration of the root word)</td><td>Overall evaluation of the HIA aspects in terms of health data, statistics and geospatial data metrics used for impact assessment</td></tr>
<tr><td colspan="2">Sofia (SEA built upon preceding EIA but much lighter in tune with the SEA directive and national legislation) (Sofiaplan, 2025)</td></tr>
<tr><td>Quantity - 1 procedure, 269 mentions in Volume II of the SEA from 2008</td><td>Moderate amount of regional (equal to local level) health data used thanks to the overlapping of the regional district and the metropolitan municipality</td></tr>
<tr><td rowspan="2">Quality - pp. 556-559, 560-567, 573-600
describing conditions and state of health related factors; pp. 615-632 description of expected impacts mostly associated with climate, air quality and noise; 637-641 methodological description for the component and factor analyzes; annexes with prescription of mitigation and abatement measures</td><td>Health statistics are cited and descriptively analysed and projected by expert judgement on the basis of trends analyses and first tier modeling of components and factors</td></tr>
<tr><td>Geospatial data metrics are neither cited, analysed or applied due to lack of available data (though the preceding EIA of the draft version of the plan from 2002 included such a pilot interdisciplinary attempt thanks to intensive field work with district clinics and processing of analogous data)</td></tr>
<tr><td colspan="2">Plovdiv (SEAs) (MEW, 2025)</td></tr>
<tr><td>Quantity - 2 procedures, 41 mentions in the SEA from 2007, no health related SEA content from the amendment in 2020</td><td>Low amount of health data used</td></tr>
<tr><td rowspan="2">Quality - pp. 53-54 describing conditions and state of health related factors; pp. 72-74 prescribing mitigation measures against the expected impacts mostly associated with air quality, noise and water quality</td><td>Health statistics are neither cited nor analysed</td></tr>
<tr><td>No geospatial data metrics cited, analysed or applied</td></tr>
<tr><td colspan="2">Varna (SEA) (MEW, 2025)</td></tr>
<tr><td>Quantity - 1 procedure, 67 mentions in the SEA</td><td>Moderate amount of health data used</td></tr>
</table>

from 2009	
Quality - pp. 31-32 describing conditions and state of health related factors; pp. 60-65 prescribing mitigation measures against the expected impacts; pp. 65-85 prescribing mitigation measures against the expected impacts mostly associated with air quality, noise and water quality (incl. bathing waters)	Health statistics are cited and descriptively analysed
	No geospatial data metrics cited, analysed or applied
Burgas (SEAs) (MEW, 2025)	
Quantity - 6 procedures, 172 mentions in the last SEA from 2022, 84 mentions in the first SEA from 2007, the interim amendments of the plan are not directly related to health issues	Moderate amount of health data used
Quality - 2007 SEA, part 2 pp. 101-103 describing conditions and state of health related factors, part 3 with consistent methodology for multiple environmental issues; 2022 SEA of a partial amendment, pp. 34-40 and 96-100 describing conditions and state of health related factors	Health statistics are cited and analysed, interpretative and data based impact evaluation matrices is used
	Geospatial data metrics cited, analysed or applied through modeling of pollutants (e.g. atmospheric)
Ruse (SEA) (MEW, 2025)	
Quantity - 1 procedure, 150 mentions in the SEA from 2018	Low amount of health data used
	Health statistics are cited and analysed
Quality - distributed paragraphs across the descriptive and prescriptive parts	No geospatial data metrics cited, analysed or applied

The HIA related content is too general, except for Sofia and Burgas cities. Most of the initial plans were elaborated more than 15 years ago and the monitoring of their implementation is missing. Amendments are avoided due to procedural fears and the ones present avoid more thorough HIA, while consultations provide demand and proposals for more emphasis on the health effects.

Juxtaposing the regulative comparison and the content analysis we provide evidence that the health aspects are broadly mentioned in the Bulgarian legislation but the HIA guidance and planning and decision support tools are missing, while the content in the SEAs where such assessment usually has to take place is too vague and outdated. Much more is needed in order to address this pressing issue, given the exposure evidence and the related health risks in the Bulgarian cities and among its vulnerable population.

Stakeholder analysis

A purposive sample of stakeholders was surveyed to collect information on their self-assessments of awareness, interest, influence, knowledge of the major settlements; identification and prioritization of current issues of urban environment associated with health; as well as their opinions on the necessary actions/decisions; barriers and opportunities to overcome those, experience in evidence-based approaches and preferences as well as anticipated future problems and expected benefits for the urban quality of life. The initial consensus sample comprised 354 individuals associated with 136 organizations representing international, national and local institutions, political, governmental, business and non-governmental organizations, academia and professional communities, etc. invited to take part in the on-line survey. Results were obtained from 108 respondents from the 5 major cities in Bulgaria who were well familiar with the urban environment of more than one city – the highest rate being 79% (n=85) for Sofia, 48% (n=52) for Plovdiv, respectively 40% (n=43) for Burgas, 30% (n=32) for Varna and 13% (n=14) for Ruse overall comprising 32% (n=35) governmental/central authorities and national institutions or agencies, NGOs accounted for 19% (21), 16% (n=17) members of academia, researchers and experts, followed by business stakeholders 13% (n=14) and active citizens - 10% (n=11).

Respondents' professional roles are predominantly policy enforcement and planning ones and the scope of expertise is regionally and locally oriented for most of the half (fig. 1). Perceived ability to influence urban health decisions differed significantly and was highest for Sofia - 66% (n=61) while for Plovdiv and for Burgas it was respectively 25% (n=23) and 24% (n=22) and much lower for Varna - 10% (n=9), and Ruse at 8% (n=7), aligning with Sofia's role as a policy and decision-making hub.

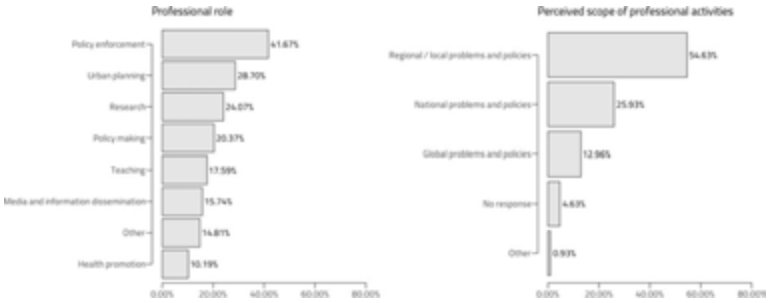

Figure 2 Professional role and activities of respondents

The priority challenges stated by the respondents are led by the urban air pollution, followed by issues related to the capacity and compactness of the city and the quality of green spaces, almost equally prioritized with the noise pollution (fig. 2).

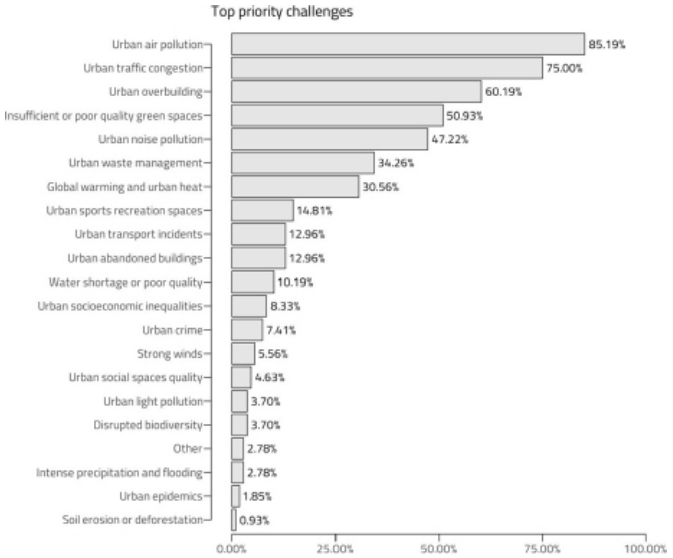

Figure 3 Priority challenges for health in the urban environment

Respondents awareness levels were high with urban environment issues having a profound personal significance for the stakeholders - 57% (n=61) reported being affected "very much" and in 39% (n=42) being "quite affected" and 44% (n=48) claiming expert knowledge of urban planning and evidence-based decision making supporting the idea of a well-informed respondent pool.

Policy preferences for tangible, high-impact interventions aligned closely with identified urban environment issues and policies targeting improvement of urban air quality were endorsed by 74% (n=80), followed by enhancing mobility and transport connectivity in 55% (n=59), improving green spaces quality and/or quantity in 42% (n=45).

Expected direct QoL benefits when effectively addressing urban challenges were mainly health related - improved public health indicators in 78% (n=83) associated with improved air quality, resulting in increased citizen satisfaction (77%, n=82) but also reduced noise levels (51%, n=54) and increased physical activity by 44% (n=47). Improved socioeconomic status and reduced social inequality ranked lower underscoring a primary focus on environmental and health outcomes.

Consistent with the self-evaluations of stakeholders' abilities to exercise influence were the reported barriers to sustainable urban development pointing poor coordination and alignment of decisions and policies as major challenge (44% n=47), along with conflict of business and public interests in 43% (n=46), as well as lack or insufficient political support in 39% (n=42), followed by poor or inadequate capacity and understanding of research evidence (38%, n=41), general public awareness (36%, n=39) and underfunding (35%, n=38) revealing major systemic governance and engagement challenges.

The prevailing opinion was that local authorities (90%, n=97) were the most effective agents in advancing sustainable urban development and health, along with communities (71%, n=77) while 48% (n=51) acknowledged the role of national and centralized policy decision making.

Overall results of the survey provided insight into deficiencies limiting effectiveness in urban health management and stakeholders' opinions favouring access to high-quality health-related research evidence to foster active engagement of both public and professional bodies thus providing rationale for validating the concept for reframing integrative HIA approach for sustainable urban development.

An overview of urban environment - public health interactions and exposure patterns across major Bulgarian cities

The overview of the interactions between urban environment and public health as well as the mapping and modeling of exposure patterns clarifies the current data and evidence base. This overview is focused on five of the largest cities, with a particular emphasis on Sofia. We highlight some of the key urban exposures such as air, noise, and light pollution, alongside the characteristics of green spaces and their accessibility.

One of the experiences drawn here together with others is the pilot project "Set an **Urban Standard** - Creation of a Standard for Evaluation and Monitoring of the Quality of the Urban Environment", funded by the "Europe" Program by Sofia municipality in 2017 in which the healthy urban environment was defined as one of the five major thematic spheres for high quality urban environment.

Another flagship experience reflected here, the project "**URBiNAT** - Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS" was funded by the EU Horizon 2020 program and provided ground from 2018 for natural experiments of healthy urban environment co-creative regeneration through nature based solutions in the form of green corridors, one of them implemented in Sofia by 2024.

A more focused and thorough approach in the project "Development of a **methodology for air** quality **and** human **health** risk **assessment** in urban areas" that is supported by the Bulgarian National Science Fund from 2021 onwards, helps to build the bridges between multiple disciplines in the sake of more robust air pollution modeling and assessment of its health impacts in terms of current status and future impacts from urban development alternatives.

The project "**Joint effects** of exposures to natural and built environments – informing healthy and sustainable urban development" as part of the "Strategic research and innovation program for the development of Medical University – Plovdiv" and as part of the Establishment of a network of research higher schools via the National plan for recovery and resilience is financed by the European Union – NextGenerationEU. It is a primary effort of all the authors of this paper to dive into the complex and intertwined urban environment - health relations in the major urban areas in Bulgaria.

Additional references made in terms of important screening studies in this knowledge base review are outlooks and compilations of the Health Effects Institute (2022, 2023), the EXPANSE, and UBD Policy Horizon 2020 projects. The latter combines resources with the Methodology for air and health assessment and the Joint effects projects in order to bring synergy in the research efforts for Sofia city.

Table 3 Overview of the HIA evidence for large cities in Bulgaria generated by selected research projects

Type of research / Characteristics	Previous local research - e.g. **'Urban standard'** project (Burov et al., 2023; UBSP, 2021)	Recent international urbanism, social sciences and other interdisciplinary research - e.g. **URBiNAT** project (Tasheva-Petrova et al., 2021; Cardinali, 2024a,b,c; Burov & Tasheva-Petrova, 2025)	Ongoing national multidisciplinary research - e.g. **Methodology for air and health assessment** project (Burov & Brezov, 2022; Brezov & Burov, 2023; Dzhambov et al., 2023; Velizarova et al., 2024; Dimitrova et al., 2025)	Ongoing epidemiological and multidisciplinary research - e.g. **Joint effects** project (Helbich et al., 2024a,b, 2025; Dzhambov et al, 2025a,b)	Recent and ongoing broader EU and comparative case studies epidemiological and multidisciplinary research - e.g. **UBD Policy** project (Iungman et al., 2024; Khomenko et al, 2025)

Studied interactions between urban environment and public health	Comprehensive demonstration in Sofia (several neighborhoods) Health as part of 5 strands of a 4 tiers taxonomy considering indicators representing components and factors for healthy urban environment at the lowest tier and at plot, street segment and quarter level	Co-creation action research in Sofia (Nadezhda district) as well as other EU cities Self-reported health before and after small physical and supportive participatory, social and solidarity nature based solutions (NBS) interventions along green healthy corridor in real scale	Multidisciplinary focus on air pollution as the major environment al risk factor along with other prominent health-relate d exposures in Sofia Dispersion modeling of air pollution and investigating health outcomes, scenario simulations at micro scale	In-depth and multilayered pictures of exposures of 5 biggest cities in Bulgaria Exposure-response functions, socio-economic and spatial disparities in health effects, studied at high resolution	Overall and multilayered picture linking multi city comparative analysis and several cities case studies, one of them Sofia, studied at high resolution neighborhoo d scale
Mapping and modeling and/or evaluation methods and techniques	Rapid assessment based on available data, information and knowledge	Mixed methods and acquisition of self-rated health data together with mapping and geospatial analysis	Focused multilevel air pollution and multi exposure modeling assessment filling gaps, cross-sectional survey for acquisition of self-reported health data	Integrated and focused various pollution and multi-exposure modeling assessment filling gaps, cross-sectional survey for acquisition of self-rated health data	Data science geospatial analysis, synthesis, case study multi-exposure investigation with specific sets of models adapted to every case study

Measured and modeled exposure patterns, thresholds, limits	Available secondary datasets collection, field surveys, geospatial analysis of air quality, noise, greenery, waste, light, water according to national regulations	Available secondary datasets collection, field surveys, behavioral mapping, ex-ante and ex-post cross sectional surveys, geospatial analysis, Structural Equation Modeling (SEM) and other mixed methods with foci on greenery and air quality (PM10, PM2.5, NO_2, and SO_2)	Own inventory, mapping, traffic, emission and dispersion models of air pollution: PM10, PM2.5, NO_2, etc. compared to national, EU and WHO thresholds. Additional co-exposure s such as: noise (road, rail and air traffic noise) from secondary sources; green space: access within 300m of residences.	Official noise measurements based land-use regression and explainable machine learning models compared to European Noise Directive maps with exposure-response curves assessed. Nighttime Light Pollution exposure based on VIIRS satellite data. Air Pollution based on own NO_2 measurements and EXPANSE air pollution data. Greenspace within buffers and via tree cover, NDVI and public spaces. Blue space within buffers.	Air pollution: PM2.5, NO_2) Noise: Road traffic noise levels range from 45-80 dB(A), exceeding WHO guidelines of 53 dB Lden and 45 dB Lnight. Green space: 77% of Sofia's population lacks sufficient greenspace access within 300m of residences. UHI: Average summer UHI effect of 2.5°C Temporal patterns: NO_2 peaks during rush hours (8 a.m. and 5-6 p.m.), with lower concentrations on weekends.
Health burden	Not explicitly addressed but with implicit references	Not explicitly addressed but with implicit references	To be addressed in the final round of well validated dispersion modeling	Health burden estimates of noise for the 5 big cities and others under consideration	Health burden estimates of Sofia with PM2.5, NO2, noise, green and UHI (Khomenko, 2025)
Health promotion, prevention and protection guidelines	Comparison s of (un) favourable exposure, particular urban development , planning and design recommendations, guiding and localisation of public space improvements	Air pollution mitigation by green corridors to improve air quality. Physical activity by accessible green spaces with sports facilities and walking paths. Community engagement by educational programs on environment al stewardship and healthy lifestyles	Measures like low emission zones (LEZ) and traffic reduction (20%) to significantly decrease pollution concentration levels in critical episodes. Integration of green wedges, cycling infrastructure, and transit-oriented development to reduce environmental stressors.	Upcoming set of recommendations based on the exposures and health effects found in each of the 5 cities	Policy briefs and scenarios to be developed as part of overall health promotion guidelines for Sofia

Concept for reintroduction of health impact assessment in Bulgarian cities

In order to enhance the general understanding of the healthy urban environment and its implications in the planning process and content a more holistic definition of its related qualities is needed in the primary EPA and/or in the Health Act along with more specific principles, requirements, capacity arrangements, etc. in a future edited version of the newly proposed by-law. Thus HIAs can become more clearly interpreted against the constitutional rights for healthy environment and wellbeing at a more collective level. Also, healthy aspects of urban planning, design and development can be more clearly treated in the judicial practice in this domain in order to resolve both types of cases under the umbrella of the civil and administrative law. Part of the small gaps can be filled by guidelines, standards and other supportive tools, but due to the contested nature of urban development neither laws nor guidelines are enough. Well targeted and well informed communication can be the key to reintroduction of health and HIAs in the urban arena of knowledge and action, as a cornerstone around the building of the very needed resilient and sustainable communities.

The conceptual model attempts to reframe and propose improvements of existing policies, regulations, tools, and measures. It further attempts to provide grounds for balancing trade-offs between urban development and health protection, by proposing a circular path to safeguarding the wellbeing of Bulgarian city dwellers (Fig. 4). The model is based on a set of definitions, principles and recommendations as follows:

A. Defining „healthy urban living environment“

At the level of the specific legislation - the Environmental protection and Health acts, the concept proposes a definition of “healthy urban living environment” in both legislative texts in order to serve as the basis for urban development policies and principles in this domain. The spirit of the definition proposed is embodied in the notion that “Healthy urban environments do not harm physical health and well-being and promote health-enhancing behaviors and resilience”. Additional proposal is to include in the definition the “Protective characteristics” that limit risk factors, reduce social inequalities, create access to green space and public spaces, support active travel, and promote sustainable resource use leading to overall satisfaction with environmental qualities”.

B. The concept for HIA reintroduction at the bylaw level implies adopting a set of principles:

- The use of sound scientific data and city specific knowledge building as a base;
- Formulation of health-based indicators adapted to the local environment;
- Targeted surveys and consultations with potentially influenced citizens and involved experts;
- Assessment of the needs of vulnerable groups and respect for socio-economic dimensions;
- Adherence to WHO, other international and EU guidelines
- Definition of national norms, thresholds for harmful and targets for protective urban environmental qualities.

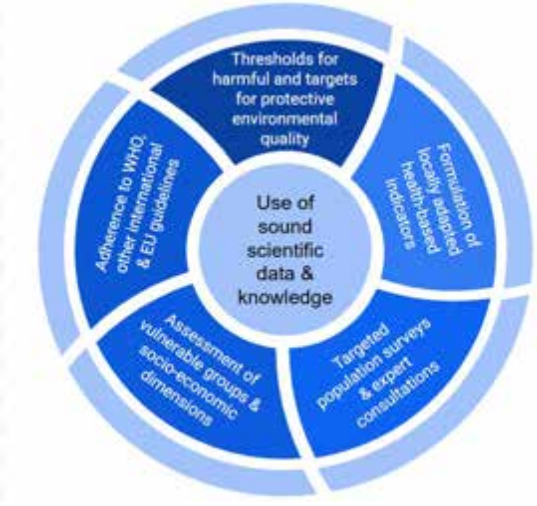

Figure 4 A circular path of HIA reintroduction principles

C. Furthermore, development of instructions is proposed, as well as methodological guidelines and technical standards based on scientific evidence and good practice.

Improved understanding of multidisciplinary issues and provision of references and resources for health protection is a more soft emphasis which could be implemented by the National Centre for Public Health and Analyses and the Regional Health Inspectorates in partnership with academia and professional organizations.

D. It is highly recommended that regulations and plans are updated regularly, and their implementation is monitored and controlled more closely.

Additional synchronisation of the HIA regulations with other environmental and development regulations and differentiation of the levels of complexity in the elaboration of spatial plans are also important aspects that can better direct the implementation of healthy urban planning and evaluation efforts at the appropriate level of initiative, mandate and competence.

Conclusion

Healthy urban planning should be both a goal ensuring the well-being and civilized continuity of urban life and a procedural mechanism driven by actual evidence and enhanced participatory governance. Advanced tools like geospatial analytics, mixed-method approaches, machine learning, and natural language processing enhance the capability of HIA to provide timely, context-sensitive insights and feedback loops, improving communication, saving time and providing precision of urban (re)development endeavors. Efficient procedures and equitable frameworks are essential for delivering health-promoting environments, particularly in post-transitional and contradictory contexts with many external and internal players like Bulgaria.

The proposed revitalized HIA agenda may support cities in staying livable and becoming more inclusive, resilient, and health-supportive spaces for current and future generations. Thus HIA can be a crucial instrument for avoiding the double spending of financial resources, time, energy and resource input as well as human efforts to overcome critical urban health issues while observing processes of urban decay.

Stimulating a wider and deeper discussion on the key principles for healthy and sustainable development of the urban living environment as well as the health support systems in decision making affecting urban development, planning and design is a necessity for Bulgaria. These decision making systems can benefit from a set of tools and interlinkages including qualitative and quantitative assessment of the expected impact, from planned development and regeneration, on public health in terms of morbidity, mortality and well-being, as well as associated socio-economic burden. Emerging platforms for sharing recent knowledge base and data spaces combining spatial data infrastructure and various services can help give confidence in HIA in times of multilevel challenges to our cities.

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SimulSoil: Ecosystem Service Modelling for Sustainability-Oriented Planning in the Metropolitan City of Turin"

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Abstract
Mountain territories provide essential ecosystem services (ES) to metropolitan areas, yet their contributions are often overlooked in spatial planning. This paper presents an updated application of the open-source SimulSoil plugin to model two key ES—Carbon Storage and Habitat Quality—in the Metropolitan City of Turin, a complex mountain-metropolitan system in northern Italy.

Using the high-resolution 2023 Land Cover Piemonte dataset, the models were applied across 11 Homogeneous Zones to map ES distribution and ecological asymmetries. Results show that mountain areas act as "ecological donors", offering critical services to densely populated urban zones.

This study demonstrates how spatially explicit ES analyses can support rebalancing-oriented governance. The updated models provide actionable knowledge for integrating ecological functions into territorial planning and reveal the need to address spatial imbalances and territorial justice.

Keywords: Metro-mountain Interdependencies, Ecosystem services, SimulSoil Modelling; Metropolitan governance, Spatial planning

1. Introduction

In recent years, ecosystem services (ES) integration into spatial planning has gained increasing attention among scholars and practitioners aiming to reorient territorial governance toward sustainability and climate resilience (Mosso, Nino and Salata 2025). Ecosystem services—broadly defined as the benefits humans obtain from nature—have emerged as a conceptual and operational framework for bridging ecological processes with human well-being (MEA, 2005; TEEB, 2010; (Egegard *et al.*, 2024). Despite this growing interest, the effective operationalisation of the ES paradigm in planning remains a significant challenge, especially in multi-scalar, ecologically diverse, and institutionally fragmented contexts such as metropolitan areas.

Urban and metropolitan areas are often perceived primarily as population, consumption, and economic activity centres. However many such areas—particularly across southern and alpine Europe—include extensive mountain systems within their territorial boundaries. While often peripheral in terms of infrastructure and political attention, these upland areas are critical suppliers of key ecosystem services such as carbon sequestration, biodiversity conservation, water regulation, and landscape stability. Recognising this role requires a conceptual shift in understanding metropolitan systems (Dematteis, 2018 and 2020): not as urban-centric spaces but as socio-ecological territories shaped by complex interdependencies between human settlements and natural ecosystems.

The Metropolitan City of Turin (CmTo) offers a compelling case for exploring this shift. Located in northwestern Italy, the CmTo encompasses 312 municipalities across a spatially diverse territory that extends from the densely

urbanised plain surrounding the city of Turin to the sparsely populated Alpine valleys to the west and north. This includes over 50% of its territory, classified as a mountain area. The institutional structure is based on 11 Homogeneous Zones (HZs), designed to facilitate territorial coordination, yet significant disparities in population, economic capacity, and ecological functionality remain.

Within this mountain-metropolitan system, the provisioning of ecosystem services is highly uneven. Mountainous municipalities contribute disproportionately to ecological regulation—through forested land, protected areas, and low-intensity land use—yet they often lack the institutional power and financial resources to influence metropolitan planning processes.

Conversely, lowland and urban municipalities concentrate demand for ES, infrastructure investment, and political representation while contributing relatively little to ecological functions. This asymmetry reflects a broader challenge in contemporary spatial planning: recognise and govern ecological interdependencies across heterogeneous territorial systems. The CmTo has taken up this challenge by basing the vision of its third Metropolitan Strategic Plan 2024-2026 on the this vision, incorporating elements from the Metropolitan Agenda for Sustainable Development and focusing on a new polycentric and "metromountain" development model. In this model, urban and mountain areas contribute to the competitiveness and attractiveness of the entire territorial ecosystem (Città metropolitana di Torino 2024).

One promising avenue lies in spatially explicit modelling tools that visualise ES flows and highlight ecological performance across territorial units.

This paper addresses this challenge by applying an updated version of the open-source SimulSoil plugin. Originally developed within the EU LIFE SAM4CP Project (http://www.SAM4CP.eu), SimulSoil integrates biophysical models from the InVEST software suite with locally adapted land use and ecological data (Barbieri&Giaimo, 2015; Giaimo&Barbieri, 2018; Giaimo, Barbieri&Salata, 2019). The project aimed to promote local-scale, sustainability-oriented models of land governance by providing tools to assess the costs and benefits of the free ecosystem services provided by soil; SimulSoil allows for the analysis of specific ecosystem services across planning-relevant spatial units, offering outputs compatible with strategic planning and governance frameworks.

We focus on two services: Carbon Storage and Sequestration (CS) and Habitat Quality (HQ) selected for their high relevance to climate and biodiversity goals, their mappability using available data, and their capacity to reflect underlying ecological conditions. CS and HQ serve as proxies for broader regulatory services and provide insight into the spatial logic of ecological provision in the CmTo.

Our objectives are threefold: i) to generate spatialised evidence of ES provision in the CmTo using updated and locally calibrated models; ii) to interpret the spatial patterns of CS and HQ across the 11 HZs and assess territorial imbalances in ES supply; iii) to reflect on how such evidence can inform rebalancing-oriented planning, particularly by recognising the role of mountain territories as ecological donors within the metropolitan system. The paper is structured as follows. Section 2 presents the regional context of the CmTo and discusses key socio-ecological characteristics of the HZs. Section 3 introduces the SimulSoil plugin, tracing its development and recent updates to data sources and model assumptions. Section 4 describes the methodology used to operationalise the InVEST Carbon Storage and Habitat Quality models within SimulSoil. Section 5 presents and interprets the modelling results, while Section 6 critically examines limitations of the approach and identifies potential avenues for integration into planning practice. The final section offers conclusions and policy recommendations.

This study makes three main contributions by applying updated ES models to a mountain-metropolitan case. First, it provides empirical evidence for the ecological centrality of upland territories within a metropolitan context. Second, it illustrates how open-source tools can be adapted and applied to produce planning-relevant outputs. Third, it contributes to debates on spatial justice by highlighting the need to account for territorial imbalances in ES supply and demand. Ultimately, we argue that ecosystem service modelling, when grounded in local data and critical territorial interpretation, can serve not only as a technical aid, but as a transformative planning lens—one capable of advancing ecological transition and promoting a more equitable distribution of responsibilities, resources, and recognition across metropolitan landscapes.

2. Case study: The Metropolitan City of Turin and Its Mountain-Metropolitan System

The Metropolitan City of Turin, located in the northwestern region of Piedmont, Italy, is a paradigmatic example of a mountain-metropolitan system where ecological, socio-economic, and institutional dynamics intersect. Established in 2015 as part of Italy's metropolitan reform (L. 56/2014), the CmTo replaced the former Province of Turin and is one of the ten metropolitan cities officially recognised by the Italian state. Its territory encompasses 312 municipalities, making it one of Europe's most fragmented metropolitan areas. This region's spatial heterogeneity poses challenges and opportunities for the governance of ecosystem services and territorial sustainability.

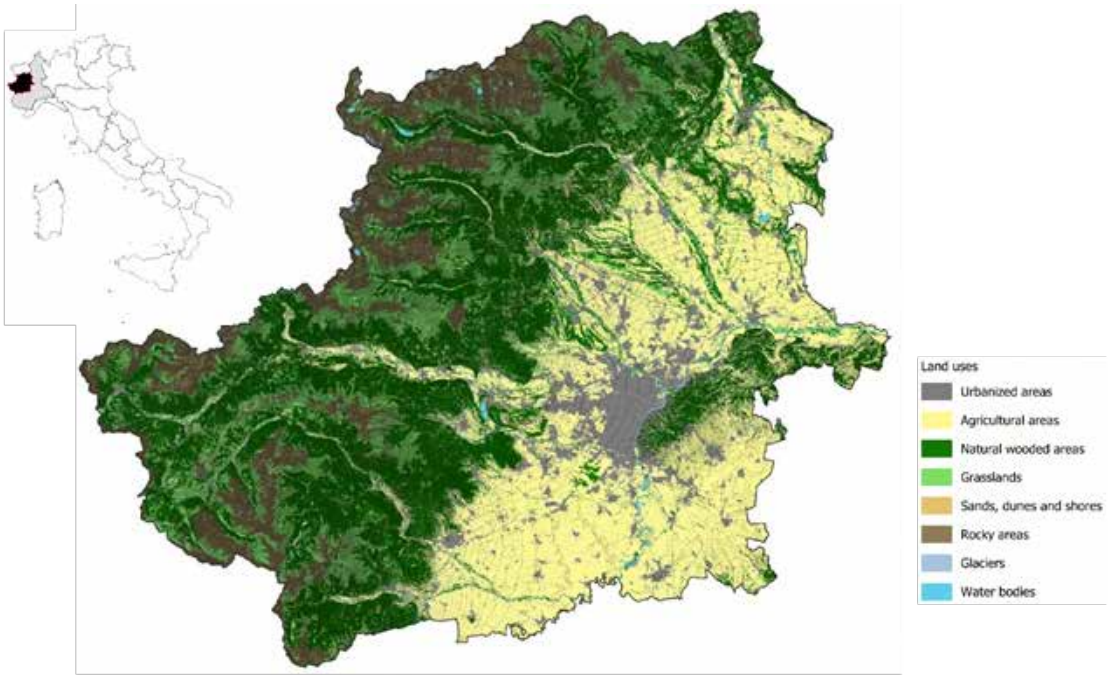

Figure 1 The Metropolitan City of Turin. Framing and Morphological-Settlement Structure (source: authors' elaboration)

Covering an area of approximately 6,800 square kilometres, the CmTo is geographically diverse and climatically varied. More than half of its territory is classified as mountain or upland area, with the western and northern parts defined by prominent alpine systems such as the Graian Alps, Cottian Alps, and the Lanzo, Susa, Chisone, and Pellice valleys. These mountain regions border France and include several national parks, protected areas, and Natura 2000 sites, collectively representing critical ecological infrastructure for carbon sequestration, biodiversity conservation, and climate regulation (Città metropolitana di Torino, 2021).

In contrast, the central and southeastern portions of the CmTo composed mainly of plains and hilly terrain, forming part of the upper Po Valley. This area hosts the urban core of Turin and its surrounding municipalities, where economic activities, transport infrastructures, and residential development are heavily concentrated. As such, the CmTo encapsulates a marked spatial asymmetry: mountainous zones are low-density, ecologically rich, and institutionally peripheral; lowland zones are high-density, socio-economically dominant, and ecologically stressed.

To foster more effective and participatory management of municipalities in metropolitan governance and government, the CmTo has adopted an internal subdivision into 11 Homogeneous Zones (HZs), each grouping municipalities with shared geographical and functional characteristics. This sub-metropolitan geography is not merely statistical but plays a role in policy coordination, funding allocation, and planning. For such reason it also serves as a practical framework for applying ecosystem service models and interpreting their results regarding planning relevance.

Figure 1 illustrates the spatial configuration of the CmTo and the major physical features of the area, including mountain ridgelines, river basins, and urban concentrations. The figure highlights the metropolitan region's concentric structure, with Turin's urbanised core surrounded by progressively more natural and mountainous belts. This spatial organisation is central to understanding the flows and gradients of ecosystem services across the territory.

Within this spatial framework, mountain territories' ecological functions are vital and under-recognised. Forests and semi-natural landscapes in the alpine valleys represent key carbon sinks and habitats of high ecological integrity. Due to limited land transformation, low-intensity agriculture, and restricted infrastructure development, these areas maintain high ecosystem service provision capacity, particularly in Carbon Storage and Habitat Quality. Simultaneously, they face socio-economic pressures such as population decline, ageing, service retrenchment, and low institutional capacity—factors that undermine their visibility and influence in metropolitan governance (Alberti et al., 2019).

Conversely, the lowland and peri-urban areas concentrate anthropogenic pressures, including land sealing, habitat fragmentation, pollution, and transportation emissions. Urban expansion into formerly agricultural land has reduced the plain's ecological connectivity, while the intensity of land use has diminished both carbon sequestration and habitat potential. While dominant in population and economic terms, these zones are ecologically dependent on the surrounding uplands for regulatory functions such as flood control, temperature moderation, and air quality improvement.

This functional asymmetry reinforces the concept of mountain municipalities as "ecological donors" in the metropolitan system, providing environmental benefits that are largely consumed elsewhere. Despite this role, ES-based reasoning is not yet institutionalised within the CmTo's planning practice. The General Metropolitan Territorial Plan (GMTP), though still in development, has only partially integrated ecological indicators, and coordination among HZs remains uneven. From a policy standpoint, the fragmentation of administrative competencies across municipalities creates obstacles to coordinated ES management. While the CmTo provides a metropolitan umbrella, actual planning competences are still largely exercised at the municipal level, with variable technical capacity and resources. This poses challenges for the integration of ES modelling tools, which require a shared vision, consistent data, and inter-institutional cooperation.

In this context, updating SimulSoil offers a valuable opportunity to visualise and quantify ecosystem services at the HZ level, providing empirical support for more equitable and sustainability-oriented planning strategies. The selection of Carbon Storage and Habitat Quality as focal ESs reflects their relevance to territorial resilience and the data availability within the regional land use framework.

The recent availability of the 2023 Land Cover Piemonte (LCP) dataset—developed by Regione Piemonte—has significantly improved the region's thematic resolution and reliability of land use information. This dataset enables a more accurate representation of forest types, agricultural mosaics, and anthropogenic land cover, essential for ES modelling. By integrating this dataset into the SimulSoil plugin, we achieve a more context-sensitive representation of ecological processes and service provision potential.

Moreover, using the HZs as the primary units of analysis allows for a better alignment between ES outputs and institutional planning scales. It helps overcome the disconnect between ecological data and planning implementation, a gap frequently highlighted in the literature on landscape governance (Primmer et al., 2015.

In sum, the Metropolitan City of Turin provides a relevant and rich case study for exploring ecosystem service dynamics in a mountain-metropolitan setting. Its territorial heterogeneity, administrative complexity, and ongoing planning reform processes make it an ideal laboratory for testing tools like SimulSoil. By linking spatialised ES modelling to institutional geography, this study aims to demonstrate how planning can move beyond urban-centric logic and embrace more ecological and equitable understandings of metropolitan space.

3. The Open Source SimulSoil Plugin: Origins and How to Update

SimulSoil is an open-source plugin for the QGIS (version 2.18.15) software, developed to support the qualitative and quantitative assessment of soil's ecosystem services. The tool aims to make mathematical and statistical models accessible to non-expert users by automating the complex calculation algorithms of the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) software.

SimulSoil provides access to repositories and databases that enable the mapping of the biophysical performance of soils at a spatial scale, as well as the identification of quantitative biophysical parameters that measure the potential of soils to deliver ecosystem services. It is achieved by relying on scientific literature and the availability of shared map bases. Additionally, the software enables the measurement of changes in ecosystem balance at the municipal scale through the simulation of alternative scenarios. The simulator was developed based on the assumption that constructing a cognitive framework for mapping ES would support more informed and shared decision-making processes regarding soil, spatial planning and management.

The tool includes eight ecosystem models selected by InVEST. This U.S.-based, open-source software uses computational models to map and assess ecosystem goods and services in biophysical and economic terms, quantifying their contribution to meeting essential human needs (Costanza *et al*., 1997; MEA, 2005). SimulSoil leverages QGIS capabilities for managing raster and vector data, integrating WMS/WFS services and using base maps (e.g. Google Maps, OpenStreetMap) to provide an intuitive, user-friendly interface. Its modular architecture and the open-source nature of the data facilitate adoption and continuous enrichment by a large, diverse user community.

SimulSoil aims to contribute developing methods and tools for integrating the ES paradigm into land-use governance activities by spatialising new knowledge on the distribution and flows of ecological and environmental performance. This methodology enables the development of a multi-scalar approach to be developed, allowing local applications to assess urban transformation scenarios and conduct spatial analyses to explore the complex interrelationships related to ecosystem flows, thus supporting decision-making processes (Corrado *et al*., 2019). It enables to prioritise scenarios in which investment in natural capital can balance human development and ecosystem conservation (Natural Capital Project, last accessed 27/05/2025).

The models produce map outputs in raster format with a pixel size of 5x5 metres, wich constitute valuable cognitive tools for studying the performance of ecosystems in soils.

At the local level, a significant potential application of the SimulSoil simulator lies in its use within the Strategic Environmental Assessment (SEA) process, a mandatory procedure for spatial planning. Analyses of ES associated with land use and land cover classes represent a concrete opportunity to quantify the impacts generated by ex-ante plan choices as well as using ES calculation models through SimulSoil allows alternative scenarios to be evaluated by modifying the cartographic input data that defines land uses and land cover.

At the scale of the metropolitan area, studying ecological and environmental performance supports spatial governance in distinct and evolving ways. For instance, studying ecological and environmental performance can address the need to consider and implement policies affecting the entire metropolitan area, which is characterised by significant morphological and settlement heterogeneity. In this context, SimulSoil is a valuable tool for analysing the exchanges and flows of ecosystem services between different spatial contexts, from the most peripheral municipalities to those close to the capital, highlighting the interdependent relationship between plains and mountains in particular. It allows to recognise the relationships between ecosystem demand and supply, identifying areas of provision and beneficiaries. Mountain territories play a strategic role in this system: they represent the entire metropolitan area's ecosystem pull, compensating for the impacts generated by the more densely urbanised lowland areas. Mountain areas provide essential regulatory services, demonstrating that ecosystem performance stems from spatial patterns generating a system of spatial interdependencies that are functional for the well-being of the entire metropolitan area.

Compared to the previous version of Simulsoil, which included eight ecosystem models, the ongoing update process aims to release a new version of the application consisting of five models: Carbon Sequestration (CS), Habitat Quality (HQ), Agricultural Production (CPR), Wood Production (TPR) and Sediment Retention (SDR). As these

ecosystem models all require Land Use Land Cover (LULC) mapping as their main input data, the update process began with revising this mapping. Additionally, the update to SimulSoil will enable it to be used with QGIS versions 3.0 and above, making it more accessible to users and allowing them to take full advantage of the latest software features.

With reference to mapping, the Piedmont Region periodically produces updates to this cartographic base under the name 'Land Cover Piemonte' (LCP). As SimulSoil was developed using the available LCP base dated 2010, one of the first activities conducted as part of its update was to check how to integrate the latest version of the LCP base 2023 and study their contents to ensure consistency with the previously used LCP base for automating SimulSoil's calculation models.

The LCP 2023 database contains more geometric and descriptive detail than its predecessor, moving from a four-level classification system with 74 classes to a five-level system with 99 classes. Due to this increased detail, we decided not to use the original input data from the SAM4CP project (2014–2018) directly, as this project relied on the 2010 LCP legend. A notable example of this change is the classification of urbanised areas intended for residential use. The 2010 LCP divided these into 8 classes based on building density criteria made explicit through qualifying adjectives (e.g. continuous and dense, medium dense, discontinuous and sparse). The 2023 version, on the other hand, adopts a classification based on zones that are differentiated through percentage thresholds of soil sealing (>80%, 50-80%, 30-50%, 10-30%, <10%) and a specific class for isolated residential areas. The improved detail of the 2023 map base allows for a clearer distinction between input values associated with LULC classes. Despite the advantages of geometric accuracy and descriptive detail, the new LCP base map has some critical structural issues. Notably, despite being derived from high-resolution sources such as the Piedmont Entities Spatial Reference Database (BDTRE), the mapping does not distinguish between buildings and contiguous spaces. This limits the ability to associate specific input values with certain land use types. Additionally, while the adopted LULC classification is inspired by Corine Land Cover (CLC), it introduces descriptive language that partially diverges from the 2010 version. This necessitates the reconstruction of input repertoires. (Giaimo, Pantaloni and Farina, 2025). The update also involved revising the reference geometries and enriching them with thematic information from various sources, such as the Forest Map, the Regional Landscape Plan, the Agriculture Census, Copernicus data, Piedmont Remote Sensing data and ISPRA land consumption data. We integrated all of this information into the parcels of the Mosaic Cadastral Survey. While this combination of sources enabled the creation of a more robust mapping base, it also necessitated substantial adaptation of the SimulSoil models in terms of content and data structure. In summary, adopting the new LCP base was a pivotal step in ensuring the continuity and reliability of the ecosystem service assessment models implemented in SimulSoil, though it did require significant work to harmonise and update the input data.

4. Methodology: updating the Habitat Quality and Carbon Storage and Sequestration models

This study employs two ecosystem service models—Habitat Quality (HQ) and Carbon Storage and Sequestration (CS)—from the InVEST software suite, integrated into the open-source SimulSoil simulator.

Carbon Storage and Sequestration refers to two distinct regulatory ES, which describe the processes by which carbon is sequestered and stored in soil, subsoil, and surface vegetation. These processes play a crucial role in balancing atmospheric greenhouse gases (Nowak&Crane, 2002). Specifically, the sequestration model quantifies the amount of carbon dioxide removed from the atmosphere by terrestrial ecosystems, while storage indicates the amount of carbon retained in organic form until the plant dies (Larcher, 1975). Therefore, Carbon Storage is linked to the entire life cycle of vegetation, whereas sequestration is generally assessed on an annual basis, corresponding to a single seasonal growth phase (McPherson&Simpson, 1999).

Habitat Quality is a life-supporting ecosystem service and a key indicator for assessing the ecological and environmental status of habitats (Assennato *et al.*, 2018). The ecosystem quality index reflects the extent to which biological and genetic diversity, and the evolutionary processes that underpin the regulatory, provisioning and cultural functions of ecosystems, are preserved. Assessing HQ at a local level is essential for understanding the ecological condition of urban areas and identifying critical areas and spaces with potential for increasing vegetation biodiversity. The latter is defined as the variability of all living organisms in terrestrial, aquatic, and marine ecosystems, as well as the ecological complexes of which they form part (ISPRA-CATAP, 2012). In the

literature, HQ is recognised as a key proxy value for representing regulatory ecosystem services. Assessing HQ in urban areas is particularly important because the interactions between living organisms and the physical environment generate functional relationships that determine the resilience of ecosystems, their conservation status and their ability to provide other ecosystem services (ISPRA-CATAP, 2012). This issue is becoming increasingly important in European metropolitan areas, where the ability to adapt to climate change is closely linked to the state of ecosystems and their biodiversity. Indeed, high biological diversity increases species' resilience to new environmental conditions induced by climate change (National Biodiversity Strategy, 2010).

In detail, the CS model proposed by the InVEST software and updated within the SimulSoil simulator provides quantitative estimates of the amount of carbon sequestered in soil. The model is based on associating predefined sequestration capacity values with LULC categories. Specifically, the model requires five types of input data in order to provide an output of the quantity of sequestered carbon expressed in tons/pixels. The first input is the map base, which spatially represents the different land uses and land covers. Four values representing the Carbon Storage capacity of the main reservoirs, namely litter, hypogean phytomass and epigeal phytomass, must be associated with the LULC classes. As the model is based on a direct association between these values and LULC classes, it can be considered static, as interactions between different habitats do not influence the output. Consequently, the output represents a strong simplification of the carbon cycle, as neither the plant component nor soil management is considered (Giaimo, Pantaloni and Farina, 2025): for example, agricultural processes that involve ploughing. Therefore, the model's goal is to provide shared and common parameters useful for recognising changes in LULC, rather than absolute data.

The HQ model is also based on LULC base mapping; each class is assumed to represent a different ecosystem. Unlike the CS model described above, the HQ output value calculation algorithm is more complex. The latter assesses the naturalness of land uses according to the spatial distribution of threats to them, such as infrastructure, agricultural areas and built-up areas, by cross-referencing LULC data with information on threats to habitats, including land-use changes, sealing, urbanisation, compaction, salinisation and invasive alien species, which lead to degradation, dystrophy, and the alteration of eco-biological processes. This results in a reduction in ecological resilience and ecosystem fragmentation (Seto *et al*., 2012; Romano&Zullo, 2014). The model operates dynamically, assessing interactions between different habitats and threats, which are also spatially defined within the range of LULC classes available. In detail, the input values needed by the model are seven as follows: the cartographic base of Land Use and Land Cover (on which habitats are defined); the level of naturalness, expressed by a 0-1 index, referred to each habitat; threat factors (LULC classes that determine threat to habitats); the sensitivity value of habitats to recognised threats (0-1 index); the weight associated with each threat (0-1 index); the maximum distance of interaction between threat and habitat (expressed in km); and the decay function of the threat factor in the interaction area (linear or exponential). These input values interact in a complex way to generate a parametric indicator associated with each pixel of the base map. This indicator has a value between 0 and 1 and provides a useful reference for identifying areas that are more or less prone to hosting biodiversity.

The CS model benefits from the higher quality of the updated map base in 2023, as its outputs depend on Carbon Storage values being directly associated with LCP classes. The research team chose to update the Carbon Storage values according to the new classification proposed in the LCP 2023, rather than changing the calculation algorithms proposed by the InVEST software on which Simul Soil relies. Therefore, the methodology adopted in the LIFE SAM4CP project was retraced and, where possible, the input values were updated through literature research. It should be noted that the 2023 LCP classification, particularly with regard to urbanised land, required a more substantial update to the input values concerning the storage data of the four carbon pools. Specifically, no useful bibliography could be found to define such biophysical values for urbanised territory. Consequently, a proxy storage value was adopted for the Meadows LULC class (ISPRA, 2024). This value was weighted by averaging the imperviousness threshold values derived from remote sensing data (Copernicus Sentinel-2), which define and differentiate the various urbanised classes. This is a significant revision, as in the previous version of SimulSoil, it was assumed that all urbanised land was incapable of storing carbon.

The data used to determine the carbon pools in agricultural and natural areas were searched in the bibliography. This update was based on the most recent national and regional databases, which allow Carbon Storage values to be associated with each LULC class.

As for CS, only the input data of HQ model were revised, without modifying the original algorithm. In fact, as previously described, the 2023 LULC base differs from the 2010 version in terms of both geometric accuracy and descriptive content. Consequently, the new LULC base was substituted for the one previously used by SimulSoil. The other input data required for statistical processing by the model were also revised, both to adapt to the new mapping base and to update them in light of new knowledge brought to light by the scientific literature.

5. Results and interpretation of the outcomes

The HQ and CS models produce raster maps which can be represented adopting a colour ramp, ranging from red to green, to display soil ecological and environmental performance levels. These maps therefore offer quantifiable, spatially explicit information, identifying areas, administrative boundaries, and minimum ecological and environmental units.

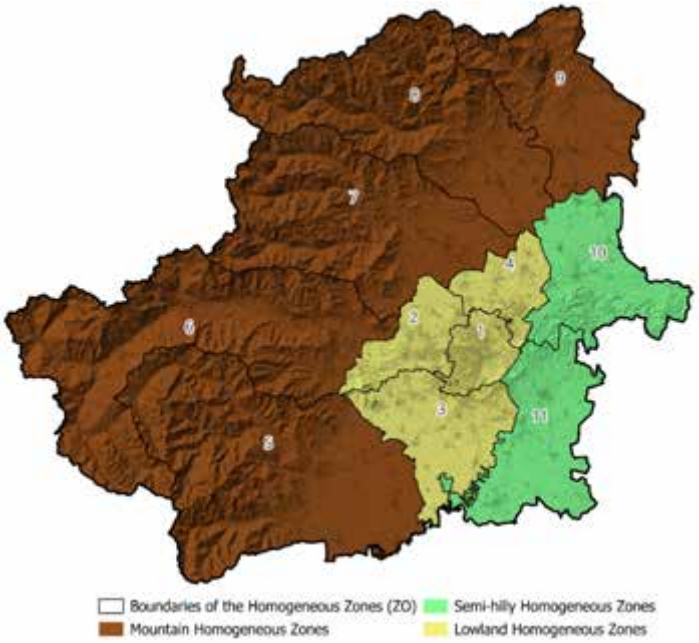

Figure 2 The 11 Homogeneous Zones. Morphological-settlement classification (source: author's elaboration).

Starting from these cartographic outputs, values expressing the average ecological-environmental performance of each OZ has been collected, both for CS and HQ ecosystem services. Doing that, the 11 OZ has been , divided into mountainous, hilly, and plain areas (Figure 2), and the mean ecological value has been compared with the one calculated considering the entire metropolitan territory.

The data illustrated in the two graphs (Figure 3) highlight that mountainous areas are the principal contributors to the ecosystem performance of the CmTo, with semi-hilly and lowland zones playing secondary roles. Among these zones, the highest value was observed in the one that includes the Turin Hill and a complex system of territorial parks and natural areas, with a relatively limited presence of heavily anthropised land uses and covers. In fact, comparing the biophysical values of HZ with those of CmTo helps us recognise which areas of the metropolitan territory contribute most to the territory's overall positive environmental performance. Furthermore, the positioning of the HZ values within the graphs shows that, although the same Land Use And Land Cover have a different contributing capacity in the provision of the two ecosystem services investigated, mountain territories constitute areas where the values recorded are always the highest, as they contain the largest amount of CmTo's natural capital.

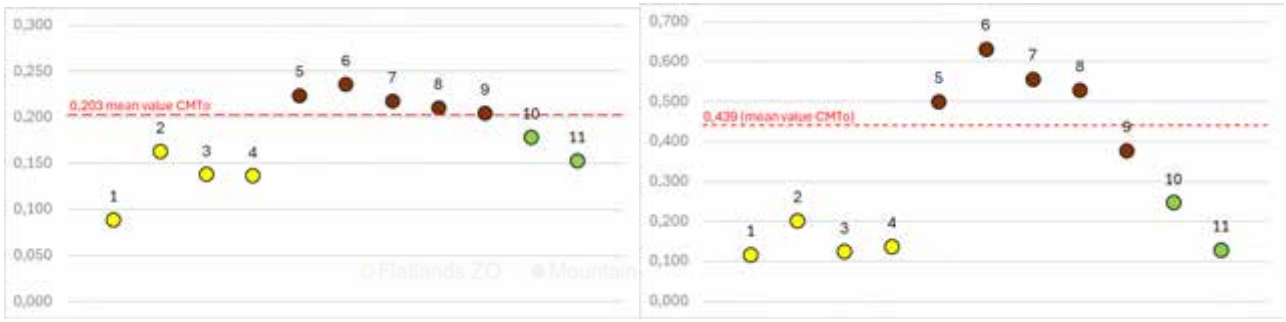

Figure 3 From left: average Habitat Quality value per Homogeneous Zone; average Carbon Sequestration value per homogeneous zone (authors' elaboration).

Considering that, the mountainous component of the metropolitan area plays an essential ecosystem role, providing most of the ecological and environmental benefits. However, this does not mean that areas in hilly or flat contexts cannot deliver significant ecological and environmental performance. Nevertheless, analysis at this scale suggests that anthropogenic pressures and the strong presence of urbanised soils in flat and hilly HZs lead to lower ecological and environmental performance being identified. A notable example is HZ number 11, which, despite including part of the Turin hills, exhibits ecosystem values comparable to those in the HZs of the flat terrain.

This example illustrates how both the morphological and settlement structure, as well as the spatial interaction between ecologically functional soils and anthropogenic pressures, shape the ecosystem values observed across the different Homogeneous Zones (HZs).

Importantly, the ecosystem values recorded in the hilly and lowland areas of the CmTo should not be interpreted solely as indicators of environmental degradation. Ecosystem service assessment requires a multi-scalar approach that allows for more nuanced interpretation of results. When analysed at a finer spatial scale, each HZ may reveal sub-areas with varying capacities to deliver ecosystem services.

In this light, the interpretation of biophysical data and maps can provide valuable insights for enhancing ecological connectivity or guiding the restoration of degraded areas.

The results of this study contribute to raising awareness of the critical role of ecosystem services in supporting sustainable metropolitan governance and planning. By applying updated biophysical models within the SimulSoil platform to the Metropolitan City of Turin, we have demonstrated how spatially explicit mapping and analyses of CS and HQ can generate valuable insights into ecological performance and territorial asymmetries. These insights are especially pertinent in a context such as the CmTo, where natural systems, demographic dynamics, and administrative fragmentation intersect in complex ways.

A key contribution of this research lies in its empirical demonstration of the functional dualism between mountainous and lowland areas in terms of ES provision and demand. The analysis shows that mountain territories act as ecological "donors" within the broader metropolitan system, supplying essential regulatory services that are largely consumed or degraded in more urbanised, lowland zones. This spatial imbalance has been acknowledged in the literature but is rarely documented through high-resolution, model-based evidence at the metropolitan scale. In this sense, the study bridges a gap between theoretical insights on territorial interdependencies and applied planning knowledge.

Moreover, the research adds methodological value by demonstrating how open-source tools such as SimulSoil, when appropriately updated and contextualised, can operationalise the ES paradigm in a practical and locally adapted way. While many studies rely on global or standardised model parameters, we show that region-specific data and assumptions can significantly enhance the relevance and credibility of outputs. This contributes to the ongoing debate on the scalability of ES modelling frameworks in diverse planning contexts.

Another important dimension is the articulation of the models with planning-relevant spatial units—namely, the 11 Homogeneous Zones (HZs) defined by the CmTo. By structuring the analysis according to these institutional geographies, we facilitate a potential alignment between ecological knowledge and decision-making boundaries. This is particularly relevant in metropolitan governance contexts marked by fragmentation and asymmetry, where the absence of shared spatial frames often undermines cooperation. Our results suggest that ES assessments can function not only as technical tools but also as discursive instruments for framing territorial challenges and negotiating shared priorities.

Nonetheless, the discussion of results also highlights certain challenges. The models employed, while useful for quantifying ecological functions, do not fully capture the socio-political realities that mediate ES access, governance, and valuation. As such, they must be interpreted as partial representations of complex socio-ecological systems. There is a risk that planners may overestimate the neutrality and objectivity of model outputs, or fail to integrate local knowledge and stakeholder perspectives into subsequent decision-making processes. For this reason, we stress the importance of combining model-based assessments with participatory approaches and qualitative investigations.

From a broader perspective, this study reinforces the relevance of ES-based planning in the face of global challenges such as climate change, biodiversity loss, and socio-territorial inequalities. Mountain regions, often peripheral in administrative and political terms, emerge here as central actors in ecological resilience and territorial sustainability. Recognising this role has profound implications for how resources, responsibilities, and planning competences are distributed across metropolitan systems.

This discussion underscores both the promise and the limits of ES modelling in metropolitan planning. The evidence presented here supports the call for more integrated, systemic, and evidence-based approaches, while also recognising that such transitions are not purely technical but institutional and political. The path forward will require not only better models but also new forms of governance, interdisciplinary collaboration, and shared ethical commitments to territorial equity and ecological integrity.

6. Limitations and potential of ES models and updating

Although the SimulSoil tool—based on updated InVEST models—represents a promising methodology for mapping and analysing ES in metropolitan contexts, it is important to acknowledge a number of limitations that constrain its current effectiveness and applicability. A critical appraisal of these issues is essential not only for scientific transparency but also to pave the way for future refinement and operational use of the tool in planning practice. A first limitation concerns the quality, classification criteria, and temporal resolution of the land use and land cover (LULC) datasets used as input. The 2023 LCP dataset represents a substantial improvement over previous versions, particularly in terms of thematic detail and spatial resolution. However, several issues persist. Certain land cover categories remain too generalised to capture the heterogeneity of real landscapes. For example, the classification of "forest" does not distinguish between mixed deciduous forests, coniferous stands, or agroforestry systems—each of which has different ecological functions and capacities for Carbon Storage or biodiversity support. Similarly, cropland areas are treated as homogeneous blocks, even though the ecological impact of monoculture maize fields differs markedly from that of organic or polyculture farming.

Moreover, the data used represent a static snapshot in time. The ES models assume that the landscape remains unchanged throughout the analytical period. This limitation may lead to distortions in dynamic contexts where land use is rapidly evolving—whether due to urbanisation, abandonment, natural succession, or policy-driven transformations (e.g., greening subsidies, forest incentives, agricultural zoning changes). As such, the outputs should be interpreted with caution when applied to medium- or long-term planning decisions.

Second, while the visual outputs of the models are spatially detailed and potentially useful for communication and decision-making, their uptake into planning and governance frameworks remains limited. Most municipal planning offices, particularly in smaller or mountainous areas, lack the technical skills, GIS infrastructure, or staff capacity needed to interpret and operationalise model results. Furthermore, the legal and procedural frameworks that govern spatial planning in many regions—including Piedmont—do not yet mandate or structurally integrate ES consideration. Without institutional anchoring, the models risk being perceived as optional or academic exercises, rather than as actionable tools.

Third, the models operate under assumptions that may not hold in every local context. For example, the InVEST Habitat Quality model assumes that all threats act linearly and that their impacts diminish with distance according to fixed decay functions. In complex urban-rural landscapes, these relationships may be more nuanced: some infrastructure corridors may have disproportionate ecological impacts due to edge effects or barrier functions, while others may support biodiversity if managed appropriately (e.g., green railway verges or low-traffic rural roads). Customising these decay functions and threat-response parameters requires detailed local knowledge and empirical data, which are not always available or incorporated.

Despite these limitations, the updated SimulSoil framework also exhibits substantial strengths and potential. From a technical standpoint, its open-source architecture allows for continuous improvement, localisation, and user-driven modification. The model is compatible with most GIS environments, can be run on ordinary hardware, and does not require proprietary software licenses—making it particularly suited for application in low-resource settings. The use of regionally specific data and parameterisation increases its contextual relevance, while its transparent structure enhances scientific credibility and reproducibility.

From a policy perspective, the tool offers several advantages. It enables planning authorities to move beyond abstract sustainability goals and base their decisions on spatially explicit evidence. For example, the model can be used to identify ES-rich zones that should be protected, or to detect ecological deficits in peri-urban areas where restoration is needed. It supports inter-municipal dialogue by offering a shared visual language and baseline for territorial coordination. Furthermore, by making the spatial interdependencies between upland ES providers and lowland beneficiaries visible, the model can support the development of compensation mechanisms, ecological fiscal transfers, or co-management agreements.

7. Conclusions

The results of this study confirm the strategic ecological role of mountain territories in the Metropolitan City of Turin, particularly in their capacity to provide Carbon Storage and habitat-related ecosystem services. The updated implementation of SimulSoil, based on high-resolution land cover data and spatially explicit modelling, has proven to be an effective tool for supporting evidence-based planning in complex metropolitan contexts.
The case study demonstrates that digital tools and open-access geospatial datasets can significantly improve the quality and accessibility of ecosystem service assessments. However, their integration into institutional planning processes remains limited. Bridging the gap between knowledge production and governance requires embedding these models into planning instruments through legislative frameworks, technical guidelines, and training for local authorities.

The ecosystem services paradigm offers a robust lens through which to understand ecological conditions and flows across heterogeneous territories. Importantly, this approach does not replace other forms of territorial analysis, but complements them by providing a shared methodological foundation based on data produced by institutional actors such as Regione Piemonte and the Metropolitan City of Turin. In this sense, the continued updating and application of SimulSoil is not only useful but necessary, ensuring that planning tools remain aligned with current land use dynamics and ecological knowledge.

Furthermore, this study shows that Homogeneous Zones (HZs) should not be interpreted as rigid ecological units, but rather as functional subdivisions that allow for tailored, site-specific planning responses. Their use supports a more integrated reading of metropolitan space, accounting for both ecological function and administrative relevance.

A key insight emerging from this work is the importance of spatial scale. Ecosystem service provision and demand are not evenly distributed, and assessments must be sensitive to variable geographies and territorial configurations. The revised models provide a framework for interpreting such patterns and for informing governance strategies aimed at improving ecological conditions and rebalancing flows between service providers and beneficiaries.

Ultimately, the application of SimulSoil in this context demonstrates the potential of ecosystem service modelling to enhance strategic planning. By offering spatially explicit, scientifically grounded information, this approach contributes to more sustainable, equitable, and context-sensitive territorial governance—particularly in metropolitan regions facing environmental and climatic transitions.

Acknowledgements
It should be noted that in October 2022, the Directorate-General for the Environment of the European Commission sent an official letter of appreciation to the Metropolitan City of Turin (CmTo) for the results achieved through the LIFE SAM4CP project, with particular reference to the SimulSoil tool. The Commission encouraged the continued use and promotion of the tools developed by the project, recognizing their value in supporting land-use planning and management.

In 2023, LIFE SAM4CP was included in the "Knowledge Platform" developed by the Department for Sustainable Development of the Italian Ministry for the Environment and Energy Security, as an example of good practice for the environment and climate, and as an experience to be widely disseminated at both national and local levels.

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Urbanization, Biodiversity, and Ecosystem Services in Norway: Challenges and Strategies for Sustainable Land Use

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Abstract
Urban areas are complex systems where urbanization affects vegetation and land use, leading to biodiversity loss and fragmented green-blue spaces. Understanding urban biodiversity is essential for maintaining ecosystem services (ES), but assessing land-use changes remains difficult. There's growing interest in restoring and integrating nature into cities to support climate regulation, food production, recreation, health, and more. In Norway, "Area neutrality" (Arealnøytralitet) promotes a municipal land-use management system that prioritizes nature protection in urban development and extends the net-zero philosophy to nature loss. This article explores how urbanization in Norway impacts biodiversity and ES, and which planning tools can help bridge science and policy to address land-use and climate challenges. It emphasizes the need for local knowledge, citizen science, and policies to better integrate ES into urban planning.

Introduction

Nature is essential for human existence and good quality of life but is not often distributed equally across space and time and among different segments of society. There are often trade-offs in the production and use of nature's contributions (IPBES, 2019). The negative trends in biodiversity and ecosystem functions are projected to continue or worsen in many future scenarios in response to indirect drivers such as rapid human population growth, unsustainable production and consumption. According to Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019) societal goals, including those related to food, water, energy, health and human well-being for all, mitigating and adapting to climate change and conserving and sustainably using nature, can be achieved in sustainable pathways through the rapid and improved deployment of existing policy instruments and new initiatives that more effectively enlist individual and collective action for transformative change.

Biodiversity creates the unique variety of life on our planet that provides multiple benefits derived from ES, such as clean air and water, food, health and recreation. Nature is as important for our mental and physical wellbeing as it is for our society's ability to cope with global change, health threats and disasters (EC, 2020). Nature is in crisis. Anthropogenic land use, resource overuse, climate change, pollution, and invasive species have eroded biodiversity, pushing many species toward extinction. Wildlife populations have dropped 60% in the last four decades, with nature in steep decline globally. *Global Assessment Report on Biodiversity and Ecosystem Services* (IPBES, 2023) identified land-use change as the first direct driver of biodiversity loss for terrestrial and freshwater ecosystems, and sea-use change as the second direct driver for marine ecosystems.

Urban areas are dynamic and complex landscapes, where urbanization effects on vegetation are influenced by socio-ecological processes across multiple scales (Ernstson et al., 2008). Urban areas have become increasingly important for ecosystem services (ES) and biodiversity management as more than 50% of the world's population now lives in cities; a share that is estimated to reach 70% by 2050 (UN DESA, 2009). Under current processes of densification of urban areas, the alteration in land use is likely to be a major driver of changes in the distribution of ES (Eigenbrod et al., 2011). Sustainable urban development strives for an optimal relationship between built (grey) and green infrastructure. Increase of buildings, roads, and industrial areas often corresponds to the increase of impervious surfaces and decrease of green areas. The combined effect of increasing population and loss of permeable surfaces is likely to result in greater and more frequent floods and also loss of habitat for biodiversity due to fragmentation of natural habitats and drastic and persistent alteration of habitats (Ahrne et al., 2009). Further, the delivery of urban ecosystem services (ES) depends on the spatial structure of ecosystems (Alberti, 2005). The TEEB-Report for Cities (TEEB, 2010) suggests that ES could be used as a tool; thus, cities can make positive changes, saving municipal costs, strengthening local (green) economies, enhancing quality of life and securing livelihoods. There is renewed interest in reconnecting, restoring, and designing nature into the built environment to provide a wide suite of benefits for urban residents, infrastructure, and economies, which

include climate-change regulation, local food production, recreation, human health, and many other benefits. Many recent reports, (e.g.IPBES, 2023, the World Economic Forum,2022), have emphasized the importance of such an approach and encourage the implementation of nature-based solutions around the world. There is a need to develop place-based empirical knowledge, citizens' science and to define appropriate measures/policies for better integrating generation of ES into spatial planning (Kaczorowska et al., 2015).

Area neutrality

In Norway, "Area neutrality" (Arealnøytralitet) is promoted as a municipal land use management system that prioritizes the protection of nature in urban development (McCormack et al., 2022). This framework calls for first avoiding nature destruction, then reducing nature loss, and finally "replacing" natural lands that are developed for human use by restoring other areas. In effect, it extends the net-zero philosophy to the loss of nature.

Current research on nature and land use management emphasizes the need for holistic strategies that integrate ecological, social, and spatial planning considerations. This approach recognizes that biodiversity loss and ecosystem degradation are complex issues requiring collaboration across multiple fields, such as ecology, urban planning, environmental policy, and sociology as well as involving and mainstreaming to stakeholders at various levels. Institutional innovation can ensure more involving urban transformations (Nilssen & Hanssen, 2022). The complexity of today's societal challenges, such as political and economic instability, threat of war, climate change, loss of nature and alienation to nature, requires a greater ability for coherent thinking, reflection and a unified political direction. There is the importance of coordinating natural, technological, and socio-economic systems when designing, planning, and managing urban nature-based solutions to enable optimal social-ecological outcomes (McPaerson et al., 2022). Overall, interdisciplinary research underscores the need for comprehensive strategies where ecological preservation, policy design, and community development intersect to achieve sustainable land use and biodiversity conservation.

In the context of Norwegian urbanization, this paper presents how systems-based, interdisciplinary planning approaches—leveraging area neutrality, ecosystem services, and participatory methods—can bridge the science–policy gap to address land use, biodiversity loss, and climate adaptation.

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Exploring Two Interpretative Models of Eco-cities in the United Arab Emirates: Masdar City and The Sustainable City Dubai

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Abstract
Since the early 2000s, eco-cities have emerged as a key urban paradigm. As an umbrella concept, the eco-city encompasses diverse models aiming to address urban sustainability through environmental and socio-economic dimensions. However, a lack of consensus and context-sensitive variations has led to multiple "interpretative models." This paper explores two eco-city projects in the United Arab Emirates—Masdar City and The Sustainable City Dubai—revealing contrasting approaches shaped by local challenges such as oil dependency, car-centric urbanism, and extreme climate. Drawing on inductive research, the study highlights how differing visions—technology-driven versus community-centered—embody the flexible nature of the eco-city ideal. It contributes to understanding eco-cities as context-specific laboratories for sustainable urban futures.

Keywords: eco-city ; interpretative models ; UAE ; Masdar City ; The Sustainable City

1.Introduction

Phenomenon

Over the past two decades, we have witnessed a global proliferation of urban initiatives branded as "eco-cities", evolving in parallel with the rise of other future-oriented urban models such as smart cities and knowledge-based cities (Ingallina, 2019). Among these, the eco-city – or ecological city – has emerged as a key manifestation of sustainable urbanism, increasingly promoted by policymakers and planners – making it a new "paradigm" (Nguyen & Vu, 2023) or a "global phenomenon" (Joss, 2010, p. 242). In his global survey made in 2009, Joss (2010) identified 79 eco-city initiatives spanning various continents. This number has since increased to include new and ongoing projects, especially in Global South emerging countries such as Morocco (Zenata Eco-City) or Laos (Amata Smart & Eco City Natuey), to give few examples.

Literature review

The origins of ecological urban development projects can be traced back to the 1970s and 1980s, with the emergence of eco-neighbourhoods in countries of the Global North—particularly in Germany, the United Kingdom, and Scandinavia—largely initiated by grassroots associations. This phenomenon arose in response to global dynamics observed since the 1970s, a period marked by the rise of widespread *environmental consciousness*. This awareness was shaped by the growing visibility of ecological disasters through mass media, alongside the burgeoning body of scientific literature highlighting the human impact on the biosphere. One notable institutional milestone was the launch of UNESCO's *Man and the Biosphere* (MAB) Programme in 1971, aimed at understanding and managing the complex relationships between humans and natural ecosystems on a global scale. This initiative gave rise to one of the earliest known formulations of the eco-city concept, notably articulated by the Soviet sociologist Oleg Yanitsky, who defined it as "a human settlement of the future in which social and ecological processes are harmonized in the best possible way" (1982, p. 470). Over time, a growing number of international initiatives were launched in support of environmental protection, among which the publication of the *Limits to Growth* report in 1972 by the Club of Rome stands out as a major milestone. This report warned against the pursuit of unlimited economic growth in light of the planet's finite resources, thereby reinforcing the urgency of ecological considerations in urban and global policy frameworks.

Gradually, these small-scale European initiatives were paralleled by the emergence of large-scale urban development projects—designed to accommodate several thousand inhabitants—in the Global South. These projects aimed to address the urgent demand for housing while adhering to the principles of sustainable development, which had become a global paradigm following the publication of the Brundtland Report in 1987. Indeed, countries in the Global South are those experiencing the fastest demographic growth and are simultaneously the most exposed to the multifaceted impacts of climate change. These conditions characterise the Anthropocene—a new geological epoch in which human activity has become a dominant force disrupting ecological and planetary systems.

This shift marks a transition from the logic of eco-districts to that of eco-cities, a broader and more encompassing framework used to describe a diverse range of spatial interventions—from compact neighbourhoods to newly built megacities. Despite their differing scales and forms, these projects share a common objective: to ensure socio-ecological balance in an era of increasingly urgent climate warnings (Bibri, 2020; Joss, 2011).

In light of these challenges and the goals it sets out to achieve, the eco-city model is increasingly regarded as a meaningful response to the pressing issues of the 21st century. Urban areas are currently responsible for approximately 70% of global CO emissions associated with energy consumption (Dasgupta, Lall, & Wheeler, 2022), with transport alone accounting for one-fifth of total global emissions (Ritchie, 2020). These figures present a significant challenge for policymakers and urban practitioners, particularly given that the United Nations projects a global population of 9.7 billion by 2050, with two-thirds—over six billion people—expected to live in urban areas, compared to 4.61 billion in 2023 (World Bank, 2018). This demographic trajectory implies an intensification of urbanisation, primarily driven by rural-to-urban migration in developing countries.

To meet international climate mitigation targets—such as those outlined in the Paris Agreement—and to reduce the global carbon footprint, it is essential to address the urbanisation process itself, which has a direct and proven link to global warming (Helbling & Meierrieks, 2023).

Within this context, the development of more ecologically responsible cities—eco-cities—appears to be a relevant and timely strategy for tackling these multidimensional challenges. Such an approach aims to promote socio-ecological sustainability by striving for a balanced coexistence between human and non-human ecosystems. Cities of the future are thus expected to embody greater efficiency, sustainability, and resilience (Kohlhase, 2013).

Theoretical problem

These expectations have fostered a substantial body of literature surrounding the concept of the eco-city, particularly since the early 2000s. However, this literature remains characterised by conceptual ambiguity (Rapoport, 2014). Indeed, the concept is still polysemous, vague, and lacks a shared definition within the scientific corpus. This absence of consensus does not concern the ultimate goal of the eco-city—namely, sustainability in its broadest sense—but rather the means and forms through which it is to be achieved. Beneath the apparent unity of the term "eco-city," which functions as a catch-all expression, lie multiple divergent visions regarding how such projects are conceived and operationalised.

Within this conceptual vagueness, a comparative approach has frequently been favoured by scholars, who endeavour to assess projects against often technical and environmental criteria. Nevertheless, this comparative methodology can prove limiting, particularly in urban planning, given that urban projects are deeply embedded within the contexts in which they emerge—be they geographical, legal, socio-economic, or environmental. Consequently, it is challenging to compare projects located in different geographical settings and responding to diverse socio-political dynamics; moreover, the "urban project" is, by nature, bespoke (Ingallina, 2001).

It is therefore necessary to move beyond this comparative framework and adopt a more interpretative stance aimed at understanding the "meaning" attributed to the urban project. This approach seeks to elucidate the internal logics underpinning these projects and the spatial translations of these logics.

Research question

To better apprehend this diversity, this article proposes to investigate the interpretative frameworks at work within each project through the following question: What interpretative models of the eco-city can be identified through the analysis of eco-city projects? Furthermore, how do these models reveal differentiated visions of eco-sustainability?

Research motivation

This paper seeks to document the multiple interpretations attributed to the concept of the "eco-city," highlighting the intrinsically polysemous nature of the model. Aware of the absence of a single, unified definition, we argue that this lack of consensus should not be regarded as a weakness, but rather as a significant indicator of the plurality of approaches underpinning urban projects labelled as "eco-cities."

Accordingly, rather than aiming to establish a single definition of this urban model, the objective of this paper is to embrace this diversity and examine it through a "project-centred" reading employing an inductive methodology, detailed below.

On this basis, we explore how different eco-sustainable urban projects are shaped by varied project dynamics—ranging from the ideation phase through to operational implementation (Yanitsky, 1982). We thus introduce the notion of "interpretative models," understood as analytical constructs that capture the underlying logics of action, reference frameworks, and socio-spatial translations at work within projects designated as eco-cities. These models are not intended to constitute a fixed typology, but rather to reflect the diversity of visions and practices embedded within projects grouped under the eco-city label. Ultimately, we seek to understand how various actors conceive and operationalise the eco-city—despite their shared commitment to environmental sustainability—thereby revealing the multiplicity of urban projects encompassed by this designation.

Roadmap
The following section outlines the methodology of this research. Subsequently, two eco-cities developed in the United Arab Emirates are presented. The third section presents the conclusive findings emerging from the highlight of these two interpretative models.

Methodology

Research context
This paper presents preliminary findings from an ongoing doctoral thesis in urban planning, initiated in 2022, which investigates the "interpretative models" of eco-sustainable cities, collectively referred to under the umbrella term "eco-city" (Ingallina, 2019 ; Joss, 2010). This doctoral thesis adopts an international perspective, analysing urban projects located in three different countries: France, Morocco, and the United Arab Emirates. Within this framework, the present article focuses on two case studies in the UAE—Masdar City and The Sustainable City Dubai—which constitute the empirical field sites selected for this portion of the research.

Data collection and analysis
Within the framework of this inductive doctoral thesis, we employ the notion of the "urban project" (Ingallina, 2001) as an analytical lens through which to examine the cities under study. This choice is grounded in its capacity to systemically integrate the various constituent elements of the dynamics at play around the project, as well as the project itself. Unlike sectoral or thematic approaches, which are often compartmentalised, the urban project approach enables a comprehensive understanding of the complex relationships between territorial context, political ambitions, the processes of development and implementation, and the evolving trajectories within which these projects are located.

This article draws upon a body of empirical data collected between 2023 and 2025 as part of this research. To ensure a clear and structured analytical reading, we have deliberately chosen to organise the collected data into three categories: (i) the historical context of the project's emergence, (ii) its ambitions, and (iii) its spatial manifestations. These three interpretative keys guide the analysis of the two Emirati cities presented herein. For each category, we detail its scope and the types of data utilised to inform the analysis.

Historical context
Urban projects are embedded within specific historical and political contexts and are developed to provide a bespoke response tailored to the territory in which they are situated: "*The urban project is not simply the application of generic principles devised elsewhere to a particular place. It must emerge from local dynamics*" (Rémy, 1998). The motivations driving an urban project are manifold and stem from diverse political imperatives aimed at linking several themes: socio-economic transition, quality of life, strategic positioning, among others. Understanding this context allows for the identification of the political and strategic conditions underpinning these projects. This first axis employs a genealogical reading (Foucault, 1971) to uncover the processes leading to the formulation of the projects, incorporating planning documents, the strategic agendas of states or metropolitan authorities, and prior territorial transformations. This analysis is based on the examination of official documents, press sources, and interviews with key stakeholders.

Ambitions
Following the analysis of the historical conditions that gave rise to the project, attention is turned to the ambitions and objectives articulated through the urban project. This section draws on official documents (notably planning materials), interviews, and project websites.

Spatial translations
Finally, the stated ambitions and discourses must be confronted with the urban forms produced, the design choices made, and the concrete modes of implementation. This third axis examines the spatial translations of the project—that is, the manner in which the declared objectives are materialised within the urban fabric, infrastructure, morphology, and programming. This analysis relies on site observations, press coverage, official documentation, and interviews.

Case studies
For this article, we have chosen to focus on two urban projects located in the United Arab Emirates (UAE): Masdar City (Abu Dhabi) and The Sustainable City (Dubai). This selection is justified by the UAE's pioneering role in experimenting with so-called sustainable urban models in the Arabian Peninsula. As early as 2008, with the launch of Masdar City in Abu Dhabi, the UAE established itself as a key player in ecological urban transition, both in the Gulf region and globally. Indeed, the project represented the first eco-city to achieve tangible development following the abandonment of the world's first planned eco-city in Dongtan (China). Although still under construction, Masdar stands as the first large-scale attempt to realize an eco-city in a desert environment.

This project aligns with a broader national strategy aimed at supporting the country's energy transition—historically reliant on hydrocarbons—toward diversifying its energy sources by significantly increasing the share of renewables, primarily solar power, in its energy mix. It forms part of ambitious state-driven transformation plans, such as the Energy Strategy 2050 and the UAE Net Zero by 2050 Strategic Initiative, which position sustainability as a key pillar of the Emirates' long-term trajectory (United Arab Emirates, n.d.).

Beyond this pioneering role, the Emirati context also exhibits several characteristics that make it a relevant case study for analyzing eco-cities. The UAE serves as a veritable laboratory, as the country already faces constraints that the rest of the world is striving to mitigate or avoid. These include extreme environmental conditions – particularly its hyper-arid climate (Böer, 1997) – along with automobile dependency (Ochieng & Jama, 2015), urban sprawl (Elessawy, 2021), among other challenges.

Masdar City (Abu Dhabi)

Project's history
Abu Dhabi, the capital of the United Arab Emirates (UAE), has undergone profound urban transformation since the mid-20th century, triggered by the discovery of oil in 1958. In 1939, the settlement was a modest fishing village of approximately 10,000 inhabitants. The city's significant expansion began in the late 1960s under the leadership of Sheikh Zayed bin Sultan Al Nahyan. Upon becoming ruler of Abu Dhabi in 1966, and later founding the UAE in 1971, Sheikh Zayed initiated an ambitious modernization strategy through the creation of the Abu Dhabi Planning Council (Government of Abu Dhabi, n.d.). Breaking away from the austere policies of his predecessor Sheikh Shakhbut—who preferred to conserve oil revenues to maintain a tribal and Bedouin lifestyle—Sheikh Zayed reinvested oil wealth into public infrastructure. This included the rapid development of schools, hospitals, housing, and road networks, aimed at improving the quality of life for Emirati citizens (Davidson, 2010).

This moment marked Abu Dhabi's entry into modernity, characterized by a functionalist approach to urban planning (Bani Hashim, 2019). Under Sheikh Zayed's leadership, Abu Dhabi quickly transformed into a "boomtown", fuelled by successive waves of migrant labour necessary for large-scale construction efforts. These migratory flows were instrumental in the Emirate's rapid demographic growth. The first federal census in 1975 recorded a population of 211,812 across the Emirate, which would continue to expand rapidly in subsequent decades (UAE National Bureau of Statistics, n.d.).

To manage and anticipate this demographic surge, Abu Dhabi commissioned numerous master plans designed by international firms. These plans—closely supervised by Sheikh Zayed—sought to shape Abu Dhabi into a modern,

green city equipped with all essential infrastructures. At this stage, development efforts were overwhelmingly supported by oil revenues, as the emirate had not yet embarked on a transition toward a business-oriented economy.

The death of Sheikh Zayed in 2004 marked a significant turning point in the trajectory of Abu Dhabi. His successor, Sheikh Khalifa bin Zayed Al Nahyan, assumed leadership and ushered in a new development paradigm—one that was distinctly more business-oriented than oil-oriented. This shift in economic strategy, underpinned by efforts to reduce dependence on oil revenues, had far-reaching urban implications (Bani Hashim, 2019). In collaboration with Sheikh Mohammed bin Zayed, Crown Prince of Abu Dhabi from 2004, Sheikh Khalifa promoted economic diversification. This new strategic direction was formalised with the launch of the *Abu Dhabi Policy Agenda 2007–2008*, a foundational roadmap that defined the government's core priorities. The agenda aligned closely with Sheikh Khalifa's entrepreneurial vision to position Abu Dhabi as a robust and globally competitive economy. The ultimate objective was the establishment of a "sustainable knowledge-based economy", which entailed a dual ambition:

"*Sustainable here meant continual economic growth (as distinct from environmental sustainability), which in turn implied profit-making enterprises operating over the medium to long term. The emphasis on knowledge building meant high-skilled, high-wage rather than low-wage, low-productivity areas*" (Rossiter & Yates, 2025).

This vision became the foundational pillar for two subsequent strategic frameworks: the *Abu Dhabi Economic Vision 2030* and the *Abu Dhabi 2030 Urban Structure Framework Plan*. Together, these served as key policy instruments for aligning the Emirate's economic transformation with spatial and infrastructural development. The Urban Structure Framework Plan in particular articulated the principles and spatial strategies needed to position Abu Dhabi as a global economic hub by aligning its urban development with international standards (Samarrai, 2016, p. 112). The plan called for the enhancement of public spaces, improved mobility systems, and the strengthening of the city's global image to secure its success amid intensifying global urban competition.
As part of this broader diversification agenda, the Government of Abu Dhabi, through its majority ownership of Mubadala Development Company, launched the Masdar Initiative. Known as *Masdar* (meaning "source" in Arabic), the project embodied the Emirate's dual objectives: to foster new business ventures and to advance the transition away from oil through investment in clean technologies and alternative energy solutions. This strategic alignment of ecological innovation and economic diversification positioned Masdar as a flagship project in Abu Dhabi's entrepreneurial urban agenda.

The Masdar Initiative was founded with four primary objectives (Embassy of the UAE in Washington, 2009) :

- To help drive the economic diversification of Abu Dhabi;
- To maintain – and expand – Abu Dhabi's position in evolving global energy markets;
- To help Abu Dhabi become a developer of technology;
- To make a meaningful contribution to sustainable human development.

In this context, Masdar City was established as a demonstrator of these ambitions, embodying in its planning and development Abu Dhabi's broader diversification objectives. From 2014 onwards, the city became one of Masdar's four operational units: Masdar Capital, Masdar Clean Energy, Masdar Special Projects, and Masdar City (Griffiths & Sovacool, 2020).

Ambitions

Initial ambitions
Masdar City was conceived as a Special Economic Zone (SEZ), intended to serve as a commercially viable model for sustainable living. From the outset, its design was strategic: by offering the advantages of a free zone, the development aimed to attract international firms to Abu Dhabi. This economic incentive proved effective, drawing major companies such as Siemens and Saint-Gobain to establish a presence in the city. This approach aligned with Abu Dhabi's broader agenda of economic diversification, seeking to reduce reliance on oil revenues by fostering innovation-led sectors.

Beyond its economic ambitions, Masdar was also envisioned as a prototype for sustainable urban life in extreme desert conditions. The project thus combined environmental aspirations with a high-profile development strategy, seeking to demonstrate that sustainability could be both livable and profitable.

A cornerstone of Masdar's early phase was the creation of the Masdar Institute of Science and Technology, a graduate-level research university established in partnership with the Massachusetts Institute of Technology (MIT). The Institute not only brought the city's first residents—students—but also anchored Masdar in a research-driven, innovation-oriented trajectory. These students were envisioned as co-developers of the city's technological infrastructure, actively contributing to the advancement of solutions that would be deployed in Masdar itself.

In its initial configuration, Masdar operated as a Porterian cluster, concentrating government bodies, private enterprises, and academic institutions within a single geographic area to foster innovation and economic development. This strategic co-location laid the groundwork for what would later be conceptualized as a 'green knowledge-based city' (Ingallina, 2019; Carlotti & Alaoui Aziz, 2025), defined by the pursuit and deployment of eco-technological innovations (Ingallina, Park, & Carlotti, 2025).

A hallmark of the project was its bold ambition to become the world's first zero-carbon, zero-waste, and car-free city. This aspiration received widespread media attention, albeit often critical, particularly in light of the paradox that the initiative was spearheaded by a government whose economy remained heavily dependent on oil revenues—accounting for approximately 70% of GDP at the time.

To enhance the project's global visibility and symbolic value, Masdar engaged the renowned architecture firm Foster + Partners. The involvement of a starchitect reinforced the city's image as an iconic, high-tech experiment, positioned to elevate Abu Dhabi's standing on the international stage. This move echoed broader efforts by the emirate to diversify its global identity—not only economically but also culturally, architecturally, and environmentally—as evidenced by parallel initiatives like the Cultural District on Saadiyat Island.

Changing ambitions

Initially scheduled for completion in 2015, the Masdar City project experienced significant delays, particularly following the subprime mortgage crisis, which had substantial repercussions for the United Arab Emirates—Abu Dhabi included—notably in terms of the funding allocated to the project itself. This financial downturn compelled a strategic reorientation of Masdar City, prompting its leadership to broaden its vision beyond purely environmental goals to encompass economic sustainability, with an emphasis on the commercial viability of its operations as a means to ensure continued development. As noted by Masdar City officials:

"Abu Dhabi was not immune to the effect of this crisis. Under such an economic environment, a shift in the direction of Masdar City was about to take place. This shift marked a pivotal moment in Masdar City's evolution. Whereas the earlier focus was solely on environmental sustainability, the new focus was on economic sustainability in the form of commercial viability, but at the same time upholding environmental stewardship" (Masdar City, n.d. a).

The subprime mortgage crisis also had the effect of tempering the project's initial ambitions. Masdar City was compelled to soften its objectives, shifting from a 'zero-carbon' model—where no carbon dioxide emissions occur within the city's boundaries—to a 'net-zero carbon' model. This latter approach permits certain carbon emissions, provided that an equivalent amount is removed or offset, resulting in no net increase in atmospheric COΔ In an interview conducted with a Masdar City official, it was acknowledged that while the goal of achieving zero-carbon was unattainable at the time, it served more as a global message—an aspirational statement of ecological ambition underpinning the entire project:

[...]. *Also, you may have a brand that the big aspirations back then were net zero. This is something that, that most are called out in 2006, much to a lot of criticism and ridicule saying it's impossible and all that. And in many ways, in 2006, that was impossible. But we didn't set out to do what was possible in 2006. The goal was to have this as a kind of a driving factor to aim very high and actually push and develop the technologies within the city to achieve that. (interview, March 2024)*

Today, the project has refocused its efforts around the pursuit of net-zero carbon in alignment with the UAE's Net Zero 2050 Strategy, which targets net-zero emissions by mid-century across six key sectors: energy, industry, transport, buildings, waste, and agriculture. Masdar City now commits itself to the following targets (Masdar City, 2023):

- Reducing the energy use intensity (EUI) of its real estate portfolio by 45% by 2025, relative to the ASHRAE baseline;
- Achieving net-zero carbon emissions by 2050 across Scope 1, 2, and 3 emissions;
- Limiting the embodied carbon of concrete structures to less than 550 kgCOΔe/m² across all new developments;
- Diverting 80% of operational waste from landfills by 2030, across all waste streams.

Spatial translations

Masdar City is a planned urban development situated in the Emirate of Abu Dhabi, encompassing an area of 6 km². Conceived to host approximately 47,500 residents and accommodate 1,500 businesses—with an estimated 50,000 daily commuters—the project represents one of the most ambitious urban sustainability initiatives in the Middle East. According to the development programme, Masdar City will ultimately offer a total gross floor area of 3.7 million square metres, of which 57% is allocated to residential use, 38% to commercial activities, and 10% to community and retail functions. As of today, the city houses over 15,000 residents who both live and work within its limits, and it has established itself as a growing economic hub, hosting more than 1,000 local and international firms registered within the Masdar City Free Zone.

The master plan, designed by the British architectural practice Foster + Partners, is structured around a compact, pedestrian-oriented urban form intended to reduce energy consumption and encourage sustainable modes of mobility. Central to this design philosophy is the principle that all key services and amenities should be accessible within a maximum walking distance of 200 metres (Foster + Partners, n.d.). This contrasts markedly with the car-centric, low-density urbanism that characterises much of the Gulf region, and particularly Abu Dhabi.

Figure 1. *Masdar City master plan (Masdar City, n.d. c)*

Masdar's spatial logic draws heavily upon the morphological and climatic strategies of traditional Arab cities, particularly those of historic settlements such as medieval Cairo (Hassan, Lee, and Yoo, 2015). These influences are evident in the city's narrow, shaded streets, internal courtyards, and public plazas, all of which are employed to mitigate heat gain and enhance thermal comfort in the public realm. The compact urban fabric and building orientation optimise shading and natural ventilation, aligning with vernacular architectural practices adapted to arid environments.

Figure 2. From left to right: Masdar Park, Masdar Institute, and Masdar City Wind Tower *(personal pictures)*

Furthermore, the city's SE–NW grid alignment is strategically oriented to reduce exposure to the prevailing hot desert winds. This bioclimatic approach reflects a deliberate effort to integrate environmental responsiveness into the physical layout of the city.

Vehicular access to the inner city is strictly limited. Private cars are not permitted within the core of Masdar City, a policy designed to prioritise pedestrian circulation and reduce air and noise pollution. Instead, the city promotes sustainable mobility through a multimodal transport strategy that includes electric shuttles, autonomous vehicles, and extensive cycling and pedestrian infrastructure.

Key examples

Masdar City presents a paradigmatic shift in urban development models within the Gulf region through its explicit integration of cutting-edge technologies, high-performance architecture, and environmental design rooted in local climatic adaptation. Distinguished by a concentration of technologically advanced infrastructure and buildings, the city functions as a demonstrative site for green innovation and experimental sustainable urbanism (Pandita et al., 2024). Numerous scholarly works have analysed the performance metrics of individual buildings within Masdar, demonstrating the extent to which architectural prowess and engineering ingenuity have been mobilised to achieve ambitious energy efficiency goals (AbiSaad et al., 2014; Boyer et al., 2010).

One of the emblematic examples is the Masdar Institute of Science and Technology (now part of Khalifa University), the first completed building in the city, designed by Foster + Partners. The Institute is equipped with smart shading devices, passive design strategies, and a high-performance façade system that collectively reduce cooling loads by up to 70% compared to conventional buildings in the UAE. The integration of photovoltaic panels, wind towers, and optimised building orientation exemplifies the city's ambition to combine architectural excellence with energy consciousness. The Institute thus serves both as a research hub and as a living laboratory for sustainable architecture.

Another flagship development is the Siemens Middle East Headquarters, which achieved LEED Platinum certification and is often cited as one of the most energy-efficient office buildings in the region. The structure features a distinctive façading system that allows for natural daylighting while minimising heat gain, alongside advanced HVAC systems powered in part by renewable energy sources. With an Energy Use Intensity (EUI) far below regional averages, the building symbolises the operational translation of net-zero objectives at the individual parcel scale.

Other large-scale projects have been implemented or are currently planned:

Table 1. *Selected High-Performance Developments in Masdar City (made by the authors, with sources on this table)*

Project	Masdar City Square	The Link	Net-Zero Energy Mosque
Expected Completion	Scheduled for 2025	Scheduled for 2025	Completed (Date not specified)
Primary Function	Cluster of 7 commercial buildings	Mixed-use development (offices, residential areas, co-working spaces, recreational activities, visitor center, multi-use hall)	Religious facility
Sustainability Certifications (targeted)	• Targeting LEED Platinum, WELL Gold • Estidama 4 Pearl PBRS • Zero Energy certification	• LEED Platinum • WELL Gold • Estidama 4 Pearl, • Parksmart Silver for sustainable mobility integration	Targeting Estidama 4 Pearl Rating
Energy Strategies and Technologies	• Extensive photovoltaic panel installations designed to meet 100% of the project's annual energy needs • Shaded walkways to reduce solar gain	• 131% estimated annual savings • 40% light power reduction • Net-zero energy Co-Lab Building powered entirely by renewable sources, incorporating advanced HVAC systems, real-time energy monitoring, and high-efficiency appliances	• 35% reduction in energy consumption relative to conventional mosques • 1,590 m² of photovoltaic panels integrated into the roof system so it can produce 100% of the energy it needs over the course of a year • 55% reduction internal water consumption • 100% of its recycled water used to irrigate outside gardens
Sources	WFES (2025), Masdar City (n.d. b)	WFES (2025), Masdar City (n.d. d)	WFES (2025), ARUP (n.d.)

The Sustainable City (Dubai)

Project's history

Dubai, the largest city in the United Arab Emirates (UAE), has progressively positioned itself as a global city through a rapid and ambitious process of urban transformation. Originally a modest fishing and pearling settlement, Dubai experienced limited economic activity until the decline of the pearl industry in the 1930s. Over the course of the twentieth century, however, the city underwent dramatic changes following the discovery of oil in 1966.

Under the visionary leadership of Sheikh Rashid bin Saeed Al Maktoum, the city invested its initial oil revenues in foundational infrastructure—constructing ports, airports, road networks, and basic utilities to modernise its urban fabric.

Yet it was from the 1990s onward that Dubai's trajectory took a decisive turn, as the Al Maktoum ruling dynasty actively pursued a strategy of economic diversification to reduce dependency on finite hydrocarbon resources. This vision gave rise to a globalised urban identity rooted in leisure, finance, commerce, and large-scale real estate development (Pagès-El Karoui, 2021). Landmark projects such as the Burj Al Arab (1999), the Palm Jumeirah (early 2000s), and the Burj Khalifa (2010) not only redefined the city's skyline, but also projected an image of Dubai as a global city.

As part of this internationalisation and diversification agenda, Dubai enacted *Law No. 7 of 2002* (the Dubai Property Ownership Law), enabling foreign nationals to acquire freehold property in specific areas. Within this regulatory framework, two entrepreneurs founded Diamond Developers in 2003. Between 2004 and 2013, the company engaged in conventional real estate ventures aligned with the prevailing urban logic of the time. These included the Marina Diamond towers, situated near the Palm Jumeirah, and the Diamond Views residential complexes in Jumeirah Village Circle—a popular, family-oriented district that appealed particularly to an international clientele seeking affordable and secure housing within the emirate.

However, the 2008 global financial crisis—driven by the collapse of subprime mortgage markets—prompted a strategic reorientation for the company. In an environment of investor mistrust and depreciating property values, sustainable real estate products were perceived as less volatile and more resilient in times of economic downturn, according to one manager in an interview. It was within this context that the founders of Diamond Developers identified an opportunity to innovate. Moving beyond superficial 'green' add-ons such as photovoltaic panels, they embraced a more holistic understanding of sustainability, one which integrates environmental responsibility, social cohesion, and economic viability. As one of the firm's urban planners explained in an interview, the objective was not simply to construct energy-efficient buildings, but to design entire communities aligned with long-term socio-ecological values.

Ambitions

According to an interview conducted with one of Diamond Developers' urban planners, the company's ambition in the aftermath of the 2008 financial crisis was to demonstrate that an alternative, more resilient model of urban development could indeed be viable. Rather than pursuing high-risk speculative ventures, the objective was to secure a stable return on investment by appealing to prospective homeowners seeking assets perceived as economically low-risk—namely, properties grounded in sustainability principles. Diamond Developers thus adopted a cost-efficiency-driven approach, selecting technologies with a proven track record, such as photovoltaic solar panels. These technologies, while environmentally beneficial, were above all seen as reassuring features for buyers: durable, reliable, and capable of substantially reducing long-term utility costs.

The project's development was therefore underpinned by a strategic philosophy based on six interconnected domains: Food, Energy, Water, Products, Mobilities, and Waste. These six pillars formed the conceptual backbone of the master plan (see after), establishing the foundation for a self-sufficient urban model that contrasted sharply with the typical, resource-intensive developments seen elsewhere in Dubai. By integrating pragmatic solutions into each of these domains, the developers sought to achieve a high degree of sustainability that could respond effectively to the city's harsh climatic and environmental conditions.

Spatial translations

General presentation

TSC Dubai represents the first fully operational sustainable urban community in the Middle East (The Sustainable City Dubai, n.d.). Developed by Diamond Developers, construction began in 2014, with the first residents moving in by 2015. Located on a 46-hectare site (113 acres) and comprising 500 residential villas designed to accommodate approximately 3,000 inhabitants, the project amounted to an investment of USD 354 million.

The master plan is structured around six pillars—Food, Energy, Water, Products, Mobility, and Waste—that articulate the project's holistic approach to sustainability. Central to the design is a "green spine", a linear, pedestrian-friendly corridor running through the development. This spine, accessible to all residents within a five-minute walk, incorporates biodomes, recreational facilities (e.g. swimming pools, sports fields), and community gardens. The biodomes are designed to meet 100% of the residents' caloric needs by supplying free, locally grown fruits and vegetables. The residential clusters—five in total—are oriented northward to maximise thermal massing and reduce heat gain, enhancing passive cooling strategies. Each villa is equipped with rooftop photovoltaic panels, and the cumulative solar infrastructure enables the community to generate 150% of its total energy demand. Internal combustion engine vehicles are banned from the site; mobility within the city is exclusively ensured through electric buggies and soft modes of transport. TSC also adheres to the principles of the "15-minute city", whereby all daily services—including shops, clinics, schools, and a central market square—are within a 15-minute walking radius from any residence.

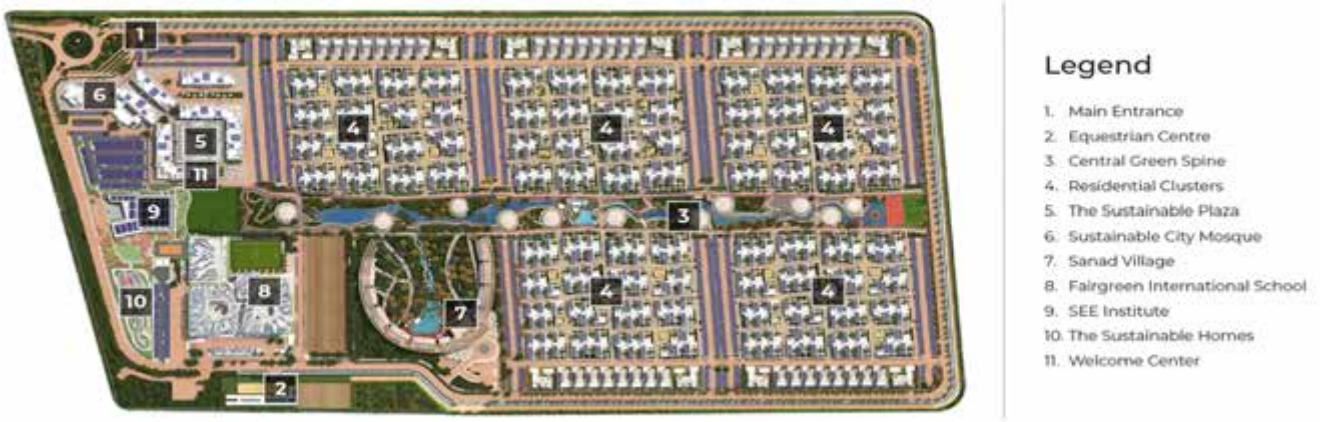

Figure 3. *The Sustainable City Master Plan (The Sustainable City, n.d.)*

Figure 4. From left to right: the farm ; one biodome ; villa *(personal pictures)*

Key benefits
The developers of TSC Dubai have based the city's development on 6 pillars:

Table 2. *The Six Sustainability Pillars of The Sustainable City Dubai (made by the author)*

Pillars	Implemented Solutions	Expected Benefits
Food	• Biodome greenhouses • Community-based urban agriculture using hydroponics	• Enhanced food security • Reduction in greenhouse gas emissions • Nutritional education
Energy	• Rooftop photovoltaic panels • Passive energy-efficient building design	• 100% renewable energy supply • Reduced utility costs • Lower carbon footprint
Water	• Greywater recycling systems • Measures to reduce water consumption	• Minimised water waste
Products	• Use of sustainable and recycled materials • Low-carbon architecture • Promotion of local supply chains	• Waste reduction • Strengthened local economy • Reduced ecological footprint
Mobility	• Electric vehicles only • Pedestrian and cycling infrastructure (20-minute city model)	• Zero local emissions • Improved public health • Reduced noise and traffic congestion
Waste	• On-site composting systems	• Decreased landfill waste • Organic waste valorisation • Support for circular economy

Findings
Despite being developed within the same national context and underpinned by overarching sustainability goals, Masdar City and TSC Dubai illustrate two markedly different interpretations of the eco-city paradigm, even if they take place in the same Gulf context. Two core findings emerge from this comparative analysis:

(i) Each city articulates a distinct conceptualisation of the eco-city model partly based on governance and actor rationalities;
(ii) And each follows a different operational logic—community-based adaptability in one case, and technological disruption in the other—while both ultimately converge towards similar sustainable development objectives.

Two eco-city types in the UAE
As previously discussed, the eco-city model is inherently protean and subject to diverse interpretations. In the context of the United Arab Emirates, Masdar City and The Sustainable City (TSC) Dubai offer compelling illustrations of this plurality by embodying two contrasting visions of what is often framed as the "city of the future." Like all urban projects, these initiatives are deeply shaped by their historical and geographical contexts—in this case, the unique political economy and developmental trajectory of the UAE. Each project has generated singular responses to the challenges of sustainable urbanism, reflecting the situated nature of their emergence. Their respective trajectories—sometimes diverging, sometimes complementary—can be largely attributed to distinct governance logics and actor rationalities, which significantly influence the projects' underlying philosophies, spatial configurations, and operational frameworks.

Masdar City, for its part, represents a complex and long-term endeavour embedded within a state-led strategic vision. Initiated by Masdar in close partnership with the Government of Abu Dhabi, the city is conceived as the physical manifestation of the Emirate's broader economic diversification agenda, particularly its efforts to pivot away from oil dependence through investments in renewable energy and ecological transition. As previously outlined, this agenda is closely linked to the production of new and bold urban landmarks—such as the Cultural District on Saadiyat Island—designed to brand Abu Dhabi as a global centre for business, leisure, and culture. Within this broader assemblage, Masdar City operates as a new pillar of Abu Dhabi's soft power strategy, projecting an image of environmental consciousness and technological sophistication. This strategy has become particularly visible at the national level, notably during the UAE's hosting of COP28 in Dubai in 2023, where Masdar City was prominently featured and promoted as a national showcase of sustainability.

In this context, Masdar aligns with and extends ambitious national and regional strategic visions. It stands out not only for its philosophical ambition but also for its formal innovation, displaying an architectural futurism emblematic of the UAE's broader approach to urban spectacle, often mobilising renowned starchitects to underscore the project's boldness. As such, Masdar City functions as what Arab (2007) describes as an "operational vector of metropolitan ambitions and urban policies," articulated within larger territorial development frameworks. Its public-private governance configuration further distinguishes it from other eco-city models such as TSC Dubai. Crucially, Masdar's trajectory has been subject to external contingencies—most notably the slowdown following the 2008 global financial crisis—demonstrating the project's need to adopt a more adaptive and phased implementation strategy.

On the other side, The Sustainable City Dubai is a private development by a private developer that took the subprimes crisis as a springboard to promote a more sustainable vision of urban planning in the Dubai context. By being a private-led project, the city is exclusively relying on the developer ambitions which should be market-aligned to sustain a demand. This city fits into what Arab (2007) defines as a Type B project—primarily private-sector-driven, contained within a delimited area, and usually delivered over a relatively short timeframe.

A high-tech disruptive model vs. a modular community-based model

Masdar City: A disruptive high-tech urban model
Masdar City forms an emblematic disruptive urban project—one that seeks to redefine the very boundaries of sustainable design through the integration of cutting-edge technologies, renewable energy systems, and experimental urban form. This ambition is clearly expressed in publications such as *The Future of Energy* (World Future Energy Summit, 2025), where the city is variously marketed and described as a "global model", "greenprint", "sustainable energy-efficient urban space", and "global laboratory" (pp. 14–21). These varied designations reflect the project's experimental and future-oriented character, marking it as a high-tech flagship of eco-urbanism.

The Sustainable City Dubai: A modular, Scalable and replicable model
By contrast, The Sustainable City offers a more grounded and pragmatic model of eco-urbanism—one that prioritises the implementation of proven, low-risk solutions over the development of novel high-tech innovations. Rather than investing in experimental technologies with high costs and uncertain returns, TSC focuses on practices that have already demonstrated effectiveness, thereby fostering buyer confidence and limiting financial and technical risk. Visually and spatially, the development adopts what could be described as a 'conventional' urban morphology, yet it is optimised to deliver tangible socio-ecological benefits.

These benefits manifest, first and foremost, in the creation of a vibrant community, centred around recreational and communal facilities—such as farms, swimming pools, playgrounds, and a local marketplace. This configuration fosters social interaction, especially through the self-sufficient nature of the development, which reduces the need for residents to leave the city for daily necessities. This dynamic was particularly evident during our field observations, where residents' daily routines were interwoven with informal encounters and collective activities. Secondly, TSC's planning principles demonstrate a clear commitment to environmental sustainability—both through the integration of extensive green spaces and the use of photovoltaic solar panels to power the neighbourhood.

What is particularly distinctive about TSC, in contrast to Masdar City, is its character as a replicable urban prototype. It functions as a scalable and modular template for sustainable development, with clear and measurable outcomes that facilitate adaptation across different contexts. Its design logic can be easily transferred to new sites, with flexibility for local adjustments depending on land characteristics, territorial specificities, and regulatory frameworks. Having acquired significant experience and credibility with its first operation in Dubai—which achieved full occupancy—Diamond Developers have been able to replicate and extend the model with greater ease and reduced risk. This modular quality proves to be a strategic asset: as the developers themselves claim, "*The Sustainable City is a resilient, scalable, and replicable working model*" (The Sustainable City, n.d.).

This approach significantly reduces the time required for both conceptualisation and implementation in subsequent projects. It allows for both upscaling and contextual adaptation, enabling each new iteration to refine and build upon the previous version. Such a logic is currently evident in the developer's expansion projects in Sharjah, Abu Dhabi, and particularly Oman, where the core layout—comprising public plazas, leisure centres, and equestrian facilities—is maintained while incorporating substantial improvements. This replicability and modularity stand in marked contrast to a complex urban experiment like Masdar City, which must navigate a distinct set of constraints and respond to broader state-driven strategic imperatives.

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From Vulnerability to Resilience: Coastal Heritage as Environmental Infrastructure

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Abstract
The contribution investigates the key-role of coastal cultural heritage in a strategic approach to address environmental and climatic vulnerabilities in mid-Adriatic coastal areas. The research hypothesis that coastal heritage can act as resilience factor is considered and tested within the framework of the PRIN 2022 COSTA | Med project. Focusing on two case studies along the mid-Adriatic coast of Abruzzo (Pineto-Silvi and Fossacesia-Vasto), it explores the potential of heritage as environmental infrastructure to support adaptive strategies against climate risks. Through a research-by-design approach, the paper combines vulnerability mapping with design strategies, highlighting the regenerative capacity of existing and latent heritage assets. The study aims to outline planning agendas that integrate ecosystem services, socio-spatial dynamics, and infrastructure transformations, fostering resilience in complex land-sea interfaces.

Keywords: Land-sea, coastal heritage, environmental infrastructure, vulnerability mapping, design strategies.

1 | Introduction

Coastal territories represent a particularly intricate and vulnerable interface between socio-ecological systems (Adger et al., 2005). Significant anthropogenic transformations, climate pressures and cultural stratification are found in this variable-width strip, generating unprecedented challenges for the governance of coastal space (Hoegh-Guldberg et al., 2019). Land-sea interfaces, characterised by intense human occupation and high environmental variability, offer favourable conditions for experimenting with systemic approaches in response to the effects of ongoing climate change. In this framework, Mediterranean coastal areas are particularly vulnerable to a range of environmental challenges, including erosion, hydro-geomorphological fragility, excessive soil sealing, sea level rise, saltwater intrusion, increased surface and water temperatures, loss of biodiversity, marine pollution from plastics, chemicals and eutrophication, extreme weather events, flooding, and subsidence. These issues are further compounded by the presence of a significant concentration of cultural heritage values (Reimann et al., 2018; Bonazza et al., 2018). It is therefore well established in the relevant literature that the analysis of risks associated with climate change cannot be limited to the observation of physical processes alone but must also consider the interactions between the natural and anthropogenic environments (Bruno et al. 2016). This necessitates a departure from conventional risk mapping, which is predominantly relying on the superimposition of layers of information. In lieu of this, there is a requirement for alternative models that can reflect the conditions of vulnerability which emerge from the interaction between environmental pressures and the specific characteristics of places (Turner et al., 2003). In the context of land-sea interface, the risk levels at the "friction points" between anthropogenic uses and naturalistic and ecological values are of particular relevance. In such contexts, systemic assessment becomes crucial for interpreting the dynamics at play and guiding integrated planning processes.

The contemporary urgency of mitigation and adaptation has contributed to a gradual shift in focus from sectoral approaches to systemic perspectives able to address the complexity of territorial interactions (O'Brien and Sygna, 2013). This paradigm change is of particular significance in coastal areas, where the accelerated pace of transformation necessitates active and coordinated responses in terms of integrating environmental and cultural protection. From this standpoint, cultural heritage can only be recognised in its evolutionary dimension, generated and renewed by those who care for it and nourished through continuous interactions with society (Magnaghi, 2020), thus overcoming the static approach that considers it exclusively in reference to its monuments. A systematic analysis of these values necessitates the incorporation of at least two primary categories. The first of these is manifest heritage, which is represented by real estate and tangible cultural assets, protected areas and landscape values. These are bound, protected and recognised not only by the community but also by law. The second component encompasses latent heritage, comprising cultural practices, traditional knowledge systems, human and animal migration patterns that have historically characterised these regions, and maritime

uses. It also incorporates virtuous approaches that have emerged through the historical interplay between human societies and their environments (Lenzerini, 2011). This dual focus enables the identification of heritage resources, including those that are not formally recognised, but which have significant potential to contribute to the resilience of coastal contexts. In recent years, several studies have emphasised the value of Mediterranean identity heritage as a key component of integrated coastal zone management systems (Daire et al., 2012; Khakzad et al., 2015). However, most approaches are anchored in risk mitigation strategies that treat cultural heritage as a vulnerable asset to be protected, rather than as an active infrastructure for territorial adaptation (Fatorić and Seekamp, 2017).

The present paper illustrates the line of research that falls within this framework. It recognises the potential of systemic analysis – both of heritage values and associated risks – alongside the identification of design and transformation strategies. These strategies aim to enable interventions on both tangible and intangible heritage that actively contribute to reducing the vulnerability of coastal areas. The themes mentioned are at the centre of the applied research conducted in recent years by the Department of Architecture of Pescara on the Adriatic coast[1], and in particular the ongoing research project PRIN 2022 – *COSTA | Med: Catching Opportunities for Strategic Transformation and Adaptation of Mediterranean Coasts*[2] – dedicated to the development of methodologies for the analysis of coastal areas to support strategic transformation and adaptation to climate change in the Mediterranean. The research activity in Pescara focuses on experimenting with innovative ways of recognising and enhancing coastal cultural heritage as a strategic tool for observing coastal transformations and designing degrees of resilience. The central Adriatic coastline of Abruzzo has been identified as a case study of particular interest, with reference to two specific contexts that are distinguished by the specificity of their urbanisation processes and socio-economic and cultural dynamics. However, these contexts are united by the relevance and density of existing heritage values.

The research addresses several key issues, including multiscale mapping of vulnerability levels, identification of the tangible and intangible heritage values that characterise the study areas, and exploration of design scenarios and approaches for risk reduction. Accordingly, particular attention is paid to the ways in which coastal heritage interacts with risk levels, with the aim of guiding the integrated design and planning of coastal areas, providing guidelines that can be transferred and scaled to other Mediterranean coasts.

The contribution specifically focuses on the analysis of selected Adriatic coastal stretches as case studies, and on conceptual reflections regarding the definition of heritage as a resilience factor for reducing vulnerability, with particular attention to design approaches aimed at restoring environmental connectivity.

2 | Territorial Context and Case Studies

2.1 The linear Adriatic city: a fragile and stratified settlement system

The Abruzzo coastal area constitutes a component of the extensive system of the so-termed linear Adriatic city, a settlement pattern spread across the regions of Emilia-Romagna, Marche and Abruzzo, extending into a portion of Puglia. This dense and stratified urban-infrastructural continuum is characterised by the pervasiveness of urbanisation processes and the pressure they exert along land-sea spaces. The coexistence of high building density, linear infrastructure and tourist flows has resulted in a particular configuration of the territory that has attracted considerable critical attention within the relevant disciplinary field. This critical attention began with the definition of the 'medium-Adriatic city' as the result of post-war transformations linked to the construction of the railway line and State Road 16 (Bianchetti, 2011).

The intricacies of this territorial system are not solely attributable to anthropogenic influences, but also to substantial morphological, landscape, socio-economic, and cultural factors. The proximity of anthropogenic and natural landscapes, coupled with the historical interactions between land and sea, has contributed to the definition of settlement patterns along the coast, thereby fuelling the relational dimension of the cultural heritage of these places.

1 The comparative research propositions guiding the reflections of the PRIN COSTA | Med research are the outcome of activities carried out in recent years within the framework of teaching (master's theses), doctoral research, and university third mission initiatives, conducted in the Department of Architecture, coordinated by prof. Matteo di Venosa.

2 More information is given in the Acknowledgements section; further details are available at: https://costamed.uniroma3.it/

However, this relational richness is now confronted with growing environmental pressures manifested through land consumption, the reconversion of tourism and production systems, and the effects of the climate crisis.

The result is a fragile geography where multiple critical conditions converge (including the aforementioned coastal erosion, hydrogeological risk, flooding, ecosystem fragility, etc.) associated with seasonal anthropogenic pressure and building densification (Zullo et al., 2015). Linear urbanisation processes have increased soil sealing, resulting in a progressive disconnection between coastal and inland hill ecosystems, thereby interrupting important environmental flows and compromising the resilience of the entire territorial system (Ricci, 2018). ISPRA data (2024) confirm that land consumption rates along the Abruzzo coastline remain at significant levels, contributing to increased territorial vulnerability to extreme weather events.

The intersection of urbanisation dynamics and environmental vulnerability thus engenders a particularly intricate management and planning scenario (di Venosa, 2023), rendering the Adriatic case study emblematic for the examination of settlement dynamics and the manifold levels of risk that typify Italian coastal landscapes. In this context of widespread fragility, the PRIN 2022 *COSTA | Med* research identifies two contexts representative of the morphological and settlement characteristics and environmental issues found along the Abruzzo coast: the Silvi-Pineto context (C1) in the north and the Fossacesia-Vasto stretch, known as the Trabocchi Coast (C2) in the south. The density of heritage values they share, together with the different spatial configurations, recent transformations, and evolutionary potential expressed by the selected contexts, provides a complex picture of the challenges and opportunities within the land-sea interface.

The contexts mentioned represent two distinct models of coastal urbanisation: the first characterized by continuous development and high levels of artificialisation, the second distinguished by an alternation of fragmented built environments and preserved natural areas. This divergence is evident not only in the spatial layout but also in the types of cultural heritage present and in the adaptive strategies developed over time by local communities. As highlighted in studies on cultural landscapes, such settlement patterns give rise to differing forms of vulnerability and resilience, thereby requiring differentiated management approaches (Antrop, 2005).

2.2 The Silvi-Pineto system: urban continuity and ecological fragility

The Silvi-Pineto context (C1), which is bordered by the Vomano river to the north and the Saline river to the south is characterised by an almost uninterrupted coastal urban continuity (Figure 1). The littoral system under examination is a narrow, compact strip consisting of a succession of parallel lines extending from the water towards the mainland. These include the sea defences at Silvi, the shoreline, the Abruzzo section of the Adriatic Cycle Route, the railway corridor, the SS16 state road and the A14 Bologna-Taranto motorway. The most significant physical and perceptual barrier is the Adriatic railway, which separates the historic town of Silvi, located on a hill, from the waterfront settlement. This reflects a pattern typical of many municipalities in Abruzzo, where the main urban nucleus is distinct from the marina, with a relatively differentiated development of the built environment. The urban fabric of Silvi Marina, which alternates with the infrastructure system, has become denser especially since the 1960s. This phenomenon can be attributed to the predominantly flat terrain and early development linked to tourism and seaside resort growth. This has led to a high degree of seasonal specialisation. This spatial expansion has resulted in a progressive loss of functional and visual connections with the hinterland, a condition exacerbated by the construction of north-south infrastructure corridors, which have disrupted the continuity of ecological networks. This territorial fragmentation has contributed to the formation of a spatial system marked, ultimately, by multiple disconnections: between the sea and the hills, between the historical core and coastal development, and between ecological and anthropic systems.

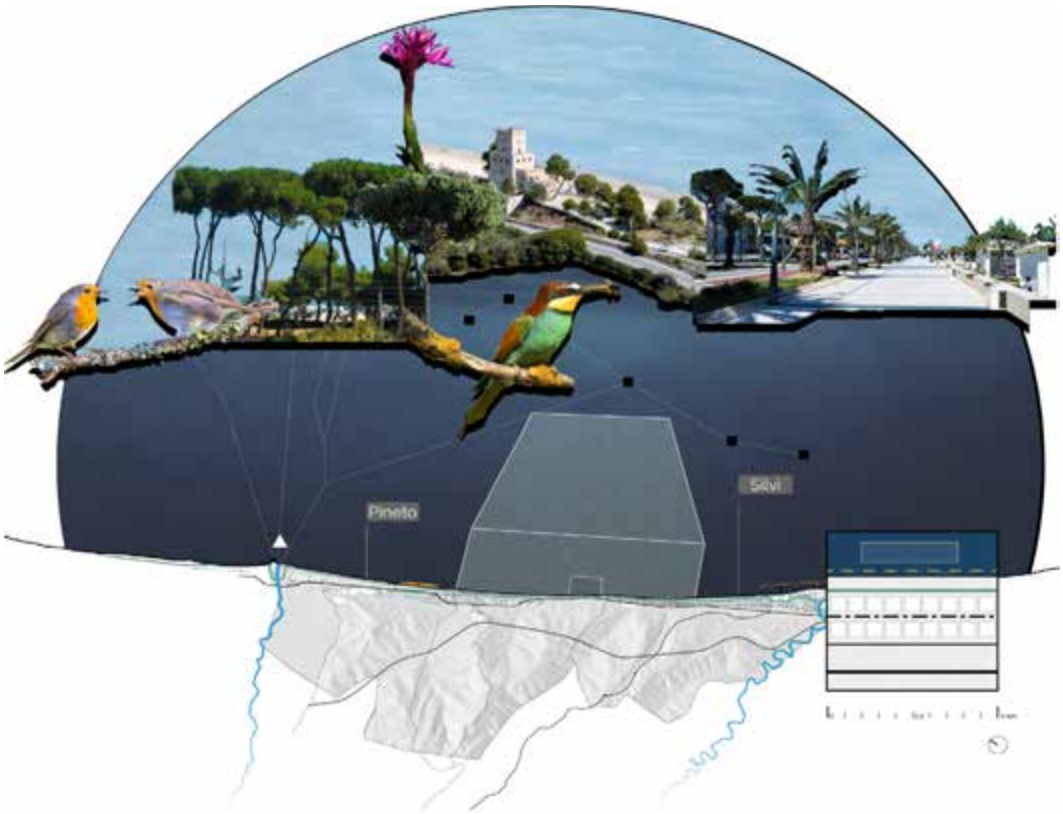

Figure 1: The Silvi-Pineto context (C1). The image illustrates the continuous urbanisation along the narrow coastal strip, punctuated by infrastructure systems and key heritage features: coastal pine forests, the Torre del Cerrano Marine Protected Area, the seafront promenade, and selected elements of local flora and fauna.

The pressure of construction, the functional rigidity of the urban system and the scarcity of open spaces render these areas more vulnerable to current climate dynamics. ISPRA data (2021) indicates that a considerable number of coastal segments between Silvi and Pineto are experiencing structural retreat, resulting in a substantial loss of natural sediments and, consequently, a compromise to the morphological resilience of the coastline. Furthermore, the rigid defence measures adopted in recent decades, such as groynes and breakwaters, have often proved ineffective or even counterproductive in the medium term, with a negative effect on the landscape and the coastal hydrodynamic balance (CIESM, 2012).

Despite the critical issues outlined above, the C1 context evinces elements of historical, landscape and naturalistic value of considerable interest, four of which are particularly noteworthy.

The first is the Torre del Cerrano Marine Protected Area (MPA), one of the few MPAs along the central Adriatic coast, which was established to protect a complex and interdependent ecological system comprising dunes, the coastal zone and the open sea (Ministero dell'Ambiente, 2009). Within the reserve, which covers approximately 37 square kilometres, the Torre del Cerrano plays a central role: an ancient coastal tower dating back to the viceregal era (1568), which has now been transformed into a narrative device illustrating the relationship between land and sea. The Museo del Mare (Sea Museum), located within the tower, features an exhibition dedicated to the Adriatic ecosystem, which progresses from the depths of the seabed to the sea surface, thereby facilitating a vertical and immersive interpretation of the underwater and coastal landscape, articulated across the various floors of the building. This symbolic narrative serves to reinforce the link between cultural heritage, historical memory and ecological perception, thereby positioning the Tower as a physical and conceptual hinge between the terrestrial and marine environments (AMP Torre del Cerrano, 2023).

The second is the system of coastal pine forests dating back to the 19th century, including the Catucci and Filiani Pine Forests. These vegetative formations, originally planted to stabilise the coastal dunes, have now become

significant reservoirs of biodiversity and ecological corridors within the urban landscape (Stanisci et al., 2014). The third comprises the remains of historic agricultural and industrial buildings, some of which have been partially incorporated into urban development. These bear witness to the functional relationships between the coast and hinterland prior to the rise of tourism.

Finally, the fourth consists of a few 20th-century accommodation facilities and traces of social tourism associated with Italy's "holiday culture", including examples of notable architectural quality (Fiadino and Zucconi, 2020).

In recent years, the area has been a fertile ground for experimenting with climate adaptation strategies and coastal regeneration processes, thanks to the implementation of co-management programmes and European projects. The participation of the Torre del Cerrano Marine Protected Area in the MPA NETWORKS project has strengthened the collaborative dimension of local governance, contributing to the adoption of integrated and multi-level approaches to planning (MedPAN, 2020). These initiatives proffer an alternative interpretation of coastal vulnerability, transcending a purely physical and morphological assessment in favour of a more systemic vision.

This approach is exemplified by the planning and management initiatives undertaken by the Municipality of Pineto in recent years. Through integrated policies focused on sustainable tourism, slow mobility, and the enhancement of coastal pine forests, the area has consolidated its role as a laboratory for innovation at the intersection of environmental conservation and local development. The establishment of the Zone 30 coastal area along the Teramo coast – which stretches from Martinsicuro to Silvi, constituting the largest initiative of its kind at national level – is an example of this (Eco dalle Città, 2023).

2.3 The Trabocchi Coast: intermittent landscapes and vulnerability in transformation

The second study context (C2) corresponds to the southern coastal stretch that includes the municipalities of Fossacesia, Torino di Sangro, Casalbordino and Vasto, part of the so-called Trabocchi Coast (Figure 2). In contradistinction to the Silvi-Pineto coastal system, this context exhibits a discontinuous settlement pattern, characterised by alternating promontories, coves and small coastal plains, where natural features still maintain a significant territorial presence.

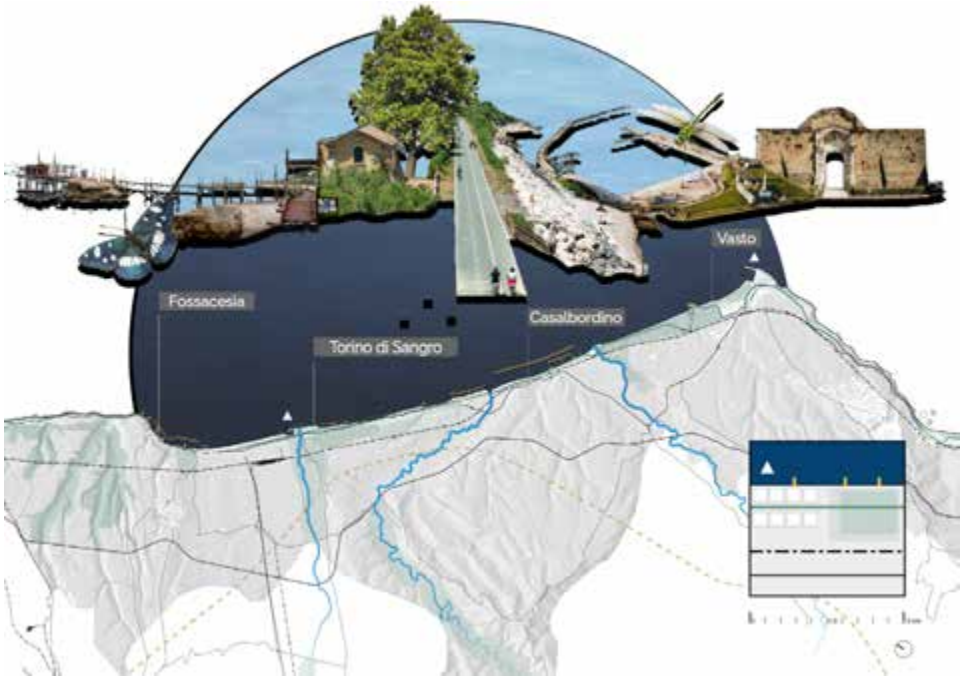

Figure 2: The Trabocchi Coast context (C2). The image highlights the coexistence of fragmented built environments and extensive preserved natural areas. Key features include: the trabocchi fishing structures, the *Via Verde* with its disused railway stations, the port of Vasto and historical traces, along with elements of flora and fauna typical of the Special Conservation Areas of this stretch.

Here, the orography of the terrain has historically influenced the processes of anthropisation, leading to a lower degree of building pressure and a greater preservation of environmental values in comparison to the northern section of the Abruzzo coast. This is evidenced by the fact that significant parts of the coastal area maintain a high degree of natural characteristics (Stanisci et al., 2014).

Indeed, this particular stretch is distinguished by intermittent natural "episodes" of high value, which are interspersed with infrastructure, industrial areas and seasonal settlements. From north to south, Special Conservation Areas (Habitat Directive 92/43/EEC) have been designated, including the Lecceta di Torino di Sangro, Punta Aderci - Punta Penna, and Marina di Vasto, in addition to two regional nature reserves. However, the restrictions and legal protection measures have not been sufficient to prevent actions with a significant environmental impact, such as the creation of the industrial area of the Port of Vasto or the post-war coastal settlements, sometimes built within 300 metres of the coastline, where building is strictly prohibited according to the Code of Cultural Heritage and Landscape (2004).

In addition to its rich natural heritage, the regional identity of the area is characterised by the distinctive trabocco system, which consists of ancient fishing machines built on stilts. This unique cultural heritage has recently become the focus of tourism and identity enhancement processes (Barone, Marino and Pignatelli, 1999). These structures are an emblematic example of anthropic adaptation to the morphological and hydrodynamic conditions of the coast, bearing witness to a history of symbiosis between humankind and the marine environment through construction techniques handed down through generations. The trabocchi are an embodiment of a living heritage that extends beyond their monumental value, representing a synthesis of technical and cultural expertise that has enabled local communities to devise adaptive strategies in a changing and occasionally hostile coastal environment (Cuzzucoli Crucitti, 2018).

In fact, the Trabocchi Coast is increasingly vulnerable due to the interaction between morphogenetic processes and anthropogenic pressures, particularly in river mouth areas. The most recent data demonstrate an intensification of coastal erosion and hydrogeological risk, with numerous stretches of the coastline being classified as "highly vulnerable" (ISPRA, 2022a). The risk of flooding and landslides is increasing, both in terms of extent and frequency of events, with a progressive expansion of the areas at risk compared to previous surveys (ISPRA, 2022b; ISPRA, 2023a). The area surrounding the mouth of the Sangro River has already been identified as one of the Italian coastal zones most exposed to flood risk by 2100 in the absence of adequate adaptation measures (ENEA, 2018). In recent years, this area has shown growing signs of criticality, particularly due to the increasing frequency and intensity of extreme weather events recorded over the past five years (ISPRA, 2023b).

The C2 context has gained increasing relevance due to recent territorial transformations, particularly the decommissioning of the Adriatic railway line and its conversion into a coastal cycle and pedestrian path. The *Via Verde of Trabocchi Coast* project, launched in 2009 and largely completed by 2020, has redefined the relationship between accessibility and the coastal landscape, offering new perspectives for the appreciation and enhancement of local natural and cultural heritage (Agenzia per la Coesione Territoriale, 2020). The repurposing of the railway corridor has created an opportunity to rethink the interplay between infrastructure and landscape, promoting a model of soft mobility aimed at valorising environmental resources and enhancing territorial resilience – although the latter still struggles to find effective implementation. Moreover, the increased tourist appeal generated by the new infrastructure has accelerated certain dynamics of change that require careful monitoring in terms of environmental impact and human pressure. The growing demand for tourism-related services and facilities along the route risks compromising the very landscape qualities that constitute its main attraction, introducing further elements of vulnerability into an already ecologically sensitive setting. In this light, the *Via Verde* may be understood not only as a sustainable mobility corridor, but also as a strategic infrastructure equipped to reconnect fragmented ecological networks and supporting adaptation strategies. However, to fully realise this potential, it is vital to move beyond conventional sector-based planning approaches and embrace integrated strategies that address the ecological, cultural, and socio-economic complexities of the coastal landscape (Clemente and Nanni, 2024).

In the preparatory studies for the coastal risk assessment of Abruzzo (AnCoRa Research, 2017)[3], the exposure analysis considered demographic data, building density, infrastructure, and the presence of environmental and cultural assets. However, in the final evaluation concerning the Trabocchi Coast – the region's most naturalistic stretch – these aspects were often secondary to geomorphological vulnerability alone. This methodological imbalance serves to confirm the necessity for integrated approaches to risk assessment, able to capture vulnerability as a combination of sensitivity and adaptive capacity (IPCC AR5, 2014), proposing reading categories suitable for restoring the complexity of local contexts.

3 | Heritage as environmental infrastructure

3.1 Two coastal landscapes, a common challenge

In both contexts (C1-C2), the conflictual relationship between processes of anthropisation and environmental values clearly emerges, exacerbated by the transformations associated with ongoing climate change. The land-sea interface is configured as a space of tension and opportunity, where critical issues related to environmental emergencies intersect with the potential for transformation and regeneration of the settlement system (Manigrasso, 2023).

The presence of significant heritage elements offers an opportunity to rethink adaptation strategies from an integrated cultural perspective, where the memory of place and the transmission of traditional practices become resources for imagining resilient futures.

In this regard, the selected case studies provide a significant experimental setting in which to test innovative design approaches, grounded in the recognition of heritage value as a strategic lever for reducing coastal vulnerability.

The *design testing phase* carried out in the described contexts, as part of the research undertaken, represents a significant methodological step aligned with the *research by design* approach. This phase aims to identify recurring conditions and design guidelines that can be transferred and scaled to other areas, while maintaining close attention to the specific characteristics of each site and its territorial and community vocations. The experimental phase, developed through educational initiatives, applied research activities, and meetings with experts and stakeholders, highlights the value of design as an exploratory investigative tool. It allows for the description of the conditions and resources that can be activated within a given territory (Marchigiani, 2022), functioning as a cognitive practice in which hypotheses, intuitions, and interpretations are tested and brought into tension (Pasqui, 2017). In line with these considerations, within the framework of the PRIN research project, scenarios and design guidelines were derived through an inductive approach from the experimental activities (see note 1), abstracting the outcomes and emphasizing strategic approaches that are particularly relevant in relation to the evolving dynamics and risk conditions of the coastal contexts under investigation.

3.2 Environmental infrastructure: reconnecting ecological and cultural matrices

With reference to the multiplicity of interactions between risk levels and coastal cultural heritage, as well as to the richness of landscape and natural values found along the examined coastal stretches, this contribution aims to highlight the significant role that design strategies can play in supporting and promoting natural regeneration, restoration, and the enhancement of ecological networks, starting from the reconnection of existing environmental matrices. The literature concerning the definitions and terminology of green infrastructures identifies a key aspect in overcoming the notion of infrastructure or network as a mere sum of elements or parts, which, in order to provide benefits, must be adequately connected. This is not merely a matter of physical-functional connection, but of strengthening and enhancing the networks and the services they can provide (EEA, 2011). The advantages associated with the "stitching together" and "recomposition" of ecological matrices and networks underline the importance of moving beyond sectoral approaches that limit the scope of action to isolated interventions, without recognizing their strategic and structural impacts on ecosystem and territorial balances (Sargolini, 2009).

3 In 2017 AnCoRa research project (Risk Analysis of the Coastal Area of the Abruzzo Region) was developed as part of an agreement between the Abruzzo Region and Univaq - DICEAA. The results are available online at: https://www.regione.abruzzo.it/content/analisi-e-documenti-propedeutici/

Therefore, the conceptual and operational background is broader than the framework defined by the narrative of landscape ecology, which focuses on the functioning of environmental systems and emphasizes the description of natural processes while continuing to implicitly separate "natural" from "cultural" heritage (Cevasco, 2007). From the perspective adopted here, natural and human-made ecosystems cannot be understood as separate components; the benefits associated with the functioning of continuous ecological matrices and capillary environmental networks should not be assessed solely in terms of human needs or advantages. Although ecosystem services, as defined by the Millennium Ecosystem Assessment (2005), are anthropocentrically interpreted as the benefits humans derive from ecosystems, it is now clear that they serve as an interpretive tool for understanding the relationships between natural processes and the uses and activities of society (Franchina, 2018).

These very ecosystem services underpin the definition of green infrastructures, conceived as a key system for interpreting the health and well-being of ecosystem components (water, soil, organisms). Accordingly, this contribution adopts a definition of green infrastructure as a system of elements and parts capable of creating conditions and enabling opportunities – an "assemblage" whose functions may vary, but whose entirety can become structure, support, and a base for implementation. In this view, green infrastructures are understood not only as environmental networks, but also as carriers of identity, historical-cultural connections that underscore slow processes of decoding and interpreting places. This perspective informs the research reflections aimed at addressing the fragmentation of environmental matrices, whose spatial configuration in Adriatic coastal systems is associated both with natural edges – currently discontinuous – running longitudinally along the waterline, and with a dispersed distribution linked to interstitial spaces within the linear urban fabric.

Considering heritage as environmental infrastructure – as a strategic approach to reducing vulnerability – brings to the forefront of contemporary planning debate and tools the role of soil itself, which is currently described and indexed in terms of uses that increase its profitability or productive capacities. This is consistent with the territorialist definition of heritage adopted in this research, which goes beyond a merely conservative vision. It recognizes the processual and incremental dimension of heritage, encompassing the identity features of landscapes and grounded in the dynamic interactions between local communities and the "natural" heritage (Magnaghi, 2020). It is not only a matter of material elements and sites, but also of traditions and collective imaginaries of coastal communities. This approach shifts the focus to relational spaces – buffer zones where overlapping and transitions of land-sea uses occur – thus variably defining the range of influence of land-sea interactions.

The heritage dimension is therefore expressed in land-use practices, in the innovation of architectural and urban solutions, as well as in the transformations of production systems in response to diverse environmental conditions. Reactivating these mechanisms through design means recovering adaptive approaches that are still traceable in some indigenous contexts, where social, cultural, and productive dimensions are deeply integrated into ecological practices of natural resource management and use.

However, exploring the potential of heritage as an infrastructure capable of mitigating vulnerability in a complex system such as the coastal one requires that communities once again be placed at the center of territorial transformation processes – as active agents in the very processes of patrimonialisation. Enhancing heritage as infrastructure, in fact, requires the active contribution of communities that resume responsibility for the care of the territories they inhabit through practices of management and maintenance. This is not only about caring for soil as a functional base of the natural and built environment, but also about recovering and transmitting the relationship with the land on which cities are established and continue to evolve (Pileri, 2015). This is the core of what cultural heritage represents: the progressive accumulation of material and immaterial sediments, nourished by continuous exchange with society, which shares its value and transmits it to future generations.

4 | Conclusions

The research presented in this contribution highlights the strategic potential of coastal cultural heritage in supporting adaptive responses to climate and environmental risks within the complex land-sea interface of the mid-Adriatic. By adopting a research-by-design approach and focusing on the coastal systems of Silvi-Pineto and the Trabocchi Coast, the study aims to demonstrate how heritage – both manifest and latent – can be reinterpreted as an active infrastructure, capable of informing and guiding resilience-oriented territorial strategies.

The comparative analysis of the two case studies reveals that heritage values, far from being static or merely preservable assets, constitute dynamic resources embedded in socio-ecological processes. These resources offer interpretive and operational frameworks to reconfigure spatial fragmentation, support ecological connectivity, and strengthen local adaptive capacity. In this regard, the reconceptualisation of green infrastructure as a system of relations – ecological, cultural, and infrastructural – emerges as a critical perspective for moving beyond sectoral planning logics and embracing a more integrated, place-based approach.

Importantly, the study underscores the role of communities as co-producers of resilience. The transition from a protection-oriented vision of cultural heritage to one that frames it as a living infrastructure requires both a conceptual shift and the reactivation of social processes of care, maintenance, and transmission.

The research outputs derived from the design testing phase contribute to formulating transferable planning agendas and strategic design guidelines, which may inform other Adriatic coastal territories experiencing similar dynamics of pressure and change. Ultimately, the integration of heritage and environmental infrastructure perspectives fosters a more nuanced understanding of vulnerability, not as a static condition but as a relational state shaped by history, identity, and the capacity to adapt. In a context marked by accelerating climatic change and territorial fragility, this approach offers a valuable contribution to the development of adaptive planning paradigms, capable of sustaining the ecological and cultural integrity of coastal landscapes over time.

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Author contributions

The contribution is the result of a shared reflection by the authors. However, the following paragraphs were written by Lia Fedele: 3 | Heritage as environmental infrastructure; 4 | Conclusions. Angelica Nanni was responsible for: 1 | Introduction; 2 | Territorial Context and Case Studies. Angelica Nanni was also responsible of the graphic elaboration of the figures included.

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Track 6

URBAN CULTURES AND LIVED HERITAGE

Reimagining Postgrowth Urbanism: Adaptive Reuse of Industrial Heritage for Sustainable Futures

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Abstract
Amid escalating planetary crises, postgrowth urbanism emerges as a critical paradigm shift, challenging traditional planning models by prioritizing ecological balance, social equity, and community well-being over relentless economic expansion. This paper investigates the adaptive reuse of industrial heritage as a transformative tool for advancing sustainable urban futures. Focusing on regions shaped by extractive industries, such as West Texas and the MENA region, the study examines how these legacy sites can be reimagined to address today's environmental, social, and cultural challenges.

Keywords: postgrowth urbanism, adaptive reuse, industrial heritage, resilience, sustainable development

1.Introduction

The escalating environmental crises and socio-economic inequalities of the 21st century have prompted a critical reevaluation of traditional urban development paradigms. Conventional growth-centric models, which prioritize economic expansion often at the expense of ecological and social well-being, are increasingly being challenged. In response, the concept of postgrowth urbanism has emerged, advocating for urban development strategies that emphasize ecological balance, social equity, and community resilience over relentless economic growth (Eizenberg & Jabareen, 2017).

Within this paradigm shift, the adaptive reuse of industrial heritage sites presents a compelling strategy for sustainable urban transformation. Industrial heritage, encompassing defunct factories, warehouses, and other industrial infrastructures, often occupies significant urban spaces. Repurposing these sites not only preserves cultural and historical values but also mitigates the environmental impacts associated with new constructions (Mehan & Stuckemeyer, 2023). Moreover, adaptive reuse can catalyze community engagement, foster local economies, and contribute to the creation of inclusive urban environments.

This paper explores the potential of adaptive reuse of industrial heritage within the framework of postgrowth urbanism. Focusing on regions shaped by extractive industries, such as West Texas and the MENA region, the study examines how these legacy sites can be reimagined to address contemporary environmental, social, and cultural challenges. Through a comparative analysis of exemplary adaptive reuse initiatives, the research aims to identify actionable strategies that bridge the gap between theoretical aspirations and practical implementation, fostering a more inclusive and resilient urban future.

The urgency of reimagining urban development models is underscored by the increasing frequency and intensity of climate-related disasters, resource depletion, and social unrest. Traditional urban planning approaches, rooted in the pursuit of economic growth, have often failed to address these multifaceted challenges adequately. Postgrowth urbanism offers an alternative framework that prioritizes sustainability, equity, and resilience, aligning urban development with the ecological limits of the planet and the well-being of its inhabitants (Raco & Street, 2012).

Adaptive reuse of industrial heritage aligns seamlessly with the principles of postgrowth urbanism. By repurposing existing structures, cities can reduce the environmental impact of new construction, preserve cultural heritage, and revitalize communities. This approach not only conserves resources but also fosters a sense of place and identity, contributing to social cohesion and community empowerment (Barthel-Bouchier, 2013).

The transformation of industrial sites into functional spaces for contemporary use also presents opportunities for economic diversification. By integrating green industries, cultural institutions, and community services into these repurposed spaces, cities can stimulate local economies and create employment opportunities that align

with sustainable development goals (Mehan, 2022). However, the implementation of adaptive reuse projects is not without challenges. Structural issues, regulatory constraints, and financial limitations can hinder the successful transformation of industrial heritage sites. Addressing these obstacles requires innovative policy frameworks, interdisciplinary collaboration, and community engagement to ensure that adaptive reuse initiatives are both feasible and beneficial (Mehan & Mostafavi, 2024).

This study aims to contribute to the discourse on sustainable urban development by examining the intersection of postgrowth urbanism and adaptive reuse of industrial heritage. Through a comparative analysis of case studies from West Texas and the MENA region, the research seeks to identify best practices, challenges, and strategies for leveraging industrial heritage in the pursuit of inclusive, resilient, and sustainable urban futures.

2. Literature Review

2.1 Postgrowth Urbanism: A Paradigm Shift

Postgrowth urbanism represents a transformative approach to urban development, challenging the traditional emphasis on economic growth as the primary indicator of progress. Instead, it advocates for development models that prioritize ecological sustainability, social equity, and community well-being (Raco & Street, 2012). This paradigm shift is rooted in the recognition that perpetual economic expansion is incompatible with the finite nature of planetary resources and the need for equitable social structures.

Adaptive reuse significantly contributes to environmental sustainability by minimizing the need for new construction materials and reducing demolition waste. By repurposing existing structures, cities can lower carbon emissions associated with building processes and conserve natural resources. This approach aligns with circular economy principles, emphasizing the reuse and longevity of materials. Moreover, adaptive reuse projects often incorporate energy-efficient systems and sustainable design elements, further enhancing their environmental performance. For instance, the integration of green roofs, solar panels, and natural ventilation systems in repurposed buildings can lead to substantial energy savings and reduced urban heat island effects. These environmental benefits underscore the role of adaptive reuse as a practical strategy for cities aiming to achieve sustainability goals and mitigate climate change impacts.

The principles of postgrowth urbanism align with the concepts of degrowth and steady-state economies, which call for the downscaling of production and consumption to achieve ecological sustainability and social equity (Barthel-Bouchier, 2013). In the urban context, this translates to planning and development strategies that focus on resource efficiency, community resilience, and the preservation of cultural and natural assets (Kozlowski et al., 2020).

The implementation of postgrowth urbanism requires a reorientation of urban planning practices to prioritize long-term sustainability over short-term economic gains. This involves integrating environmental considerations into land-use planning, promoting mixed-use developments, and enhancing public transportation systems to reduce carbon emissions and improve quality of life (Eizenberg & Jabareen, 2017). Furthermore, postgrowth urbanism emphasizes the importance of participatory governance and community engagement in the planning process. By involving residents in decision-making, cities can ensure that development projects reflect the needs and values of the community, fostering a sense of ownership and accountability (Mehan, 2024a; 2024b).

Adaptive reuse projects have the potential to strengthen social cohesion by providing spaces that reflect and serve the needs of diverse communities. Repurposed industrial sites can be transformed into community centers, cultural venues, or affordable housing, addressing local needs and fostering a sense of belonging. Engaging community members in the planning and design processes ensures that the outcomes resonate with local identities and aspirations. Such participatory approaches can build trust, empower residents, and promote social equity. Moreover, preserving historical structures through adaptive reuse can reinforce community narratives and collective memory, contributing to a shared sense of history and place. These social dimensions highlight the importance of inclusive strategies in adaptive reuse initiatives.

The successful implementation of adaptive reuse projects relies on supportive policy frameworks and effective governance structures. Governments can facilitate adaptive reuse by offering incentives such as tax credits, grants, or streamlined permitting processes. Establishing clear guidelines and standards for the preservation

and modification of historic structures ensures that adaptive reuse projects maintain architectural integrity while meeting contemporary needs. Interdisciplinary collaboration among urban planners, architects, policymakers, and community stakeholders is crucial for addressing the complex challenges associated with adaptive reuse. By fostering a regulatory environment that encourages innovation and sustainability, policymakers can unlock the full potential of adaptive reuse as a tool for sustainable urban development.

2.2 Adaptive Reuse of Industrial Heritage: Definitions and Benefits

Adaptive reuse refers to the process of repurposing existing buildings for new uses while retaining their historic features. In the context of industrial heritage, this involves transforming obsolete industrial structures into functional spaces that serve contemporary needs, such as cultural centers, residential units, or commercial establishments. This approach offers multiple benefits, including the conservation of cultural heritage, reduction of construction waste, and revitalization of urban areas (Mehan, 2024c). Moreover, adaptive reuse contributes to environmental sustainability by minimizing the need for new construction materials and reducing urban sprawl. It also fosters social sustainability by preserving the historical identity of communities and providing spaces that can accommodate diverse social activities (Mehan, 2020).

Beyond environmental considerations, adaptive reuse serves as a catalyst for economic revitalization in urban areas. Transforming obsolete industrial sites into functional spaces can attract investment, stimulate local economies, and create job opportunities. These projects often become hubs for innovation, entrepreneurship, and cultural activities, drawing both residents and tourists. The revitalization of such sites can lead to increased property values and enhanced tax revenues for municipalities. However, it's essential to implement policies that ensure the economic benefits of adaptive reuse are equitably distributed, preventing displacement and promoting inclusive growth. By fostering economic development while preserving cultural heritage, adaptive reuse projects can contribute to resilient and vibrant urban communities.

Economic benefits of adaptive reuse include cost savings on construction, increased property values, and the attraction of tourism and investment. By revitalizing underutilized spaces, cities can stimulate local economies and create employment opportunities in construction, design, and cultural sectors (Mehan & Mostafavi, 2024). Adaptive reuse projects also serve as catalysts for community development, providing venues for social interaction, education, and cultural expression. These spaces can enhance social cohesion and contribute to the overall well-being of residents (Barthel-Bouchier, 2013).

2.3 Challenges in Adaptive Reuse of Industrial Heritage

Despite its benefits, adaptive reuse of industrial heritage faces several challenges. These include structural and environmental issues, such as contamination and degradation of materials, as well as regulatory and financial barriers. The complexity of retrofitting old structures to meet modern building codes and standards can also pose significant obstacles (Mostafavi et al., 2024). Furthermore, the success of adaptive reuse projects often depends on effective stakeholder engagement and community participation. Without inclusive planning processes, such projects risk marginalizing local communities or failing to meet their needs, thereby undermining the social sustainability objectives of postgrowth urbanism (Eizenberg & Jabareen, 2017).

Financial constraints can also impede adaptive reuse initiatives, as the costs associated with renovation and compliance with regulations may exceed those of new construction. Securing funding and investment for such projects requires innovative financing models and public-private partnerships (Mehan, 2022). Regulatory frameworks may not always support adaptive reuse, with zoning laws and building codes often favoring new developments. Reforming these regulations to accommodate the unique requirements of adaptive reuse is essential for the successful implementation of such projects (Barthel-Bouchier, 2013).

2.4 Integrating Adaptive Reuse into Postgrowth Urbanism

Integrating adaptive reuse into postgrowth urbanism requires a holistic approach that considers environmental, social, and economic dimensions. This involves developing flexible policy frameworks that support adaptive reuse initiatives, providing financial incentives, and fostering interdisciplinary collaborations among architects, planners, policymakers, and community members (Barthel-Bouchier, 2013).

Successful examples of adaptive reuse within postgrowth urbanism demonstrate the potential of this approach to create resilient and inclusive urban environments. These cases highlight the importance of context-specific strategies that respect the historical and cultural significance of industrial heritage while adapting to contemporary urban needs (Mehan & Stuckemeyer, 2023). Furthermore, integrating adaptive reuse into urban planning can contribute to the achievement of broader sustainability goals, such as reducing greenhouse gas emissions, conserving resources, and promoting social equity. By aligning adaptive reuse projects with these objectives, cities can enhance their resilience and adaptability in the face of environmental and socio-economic challenges (Raco & Street, 2012). In conclusion, the adaptive reuse of industrial heritage offers a viable and sustainable strategy for urban development within the framework of postgrowth urbanism. By addressing the challenges and leveraging the benefits associated with this approach, cities can transform obsolete industrial sites into vibrant, inclusive, and resilient urban contexts.

3. Methodology

This study employs a qualitative, comparative case study approach to investigate the adaptive reuse of industrial heritage sites within the context of postgrowth urbanism. The research focuses on two distinct regions: West Texas in the United States and the Middle East and North Africa (MENA) region. These areas were selected due to their rich industrial histories and ongoing efforts to repurpose obsolete industrial infrastructures for sustainable urban development.

Data collection involved a comprehensive review of academic literature, policy documents, and project reports related to adaptive reuse and postgrowth urbanism. Additionally, site visits and semi-structured interviews with stakeholders, including urban planners, architects, and community members, provided insights into the practical challenges and successes of adaptive reuse projects.

The analysis framework is grounded in the principles of postgrowth urbanism, emphasizing ecological sustainability, social equity, and community engagement. Each case study was evaluated based on criteria such as environmental impact, economic viability, cultural preservation, and community involvement.

By comparing cases from different geographical and cultural contexts, the study aims to identify common strategies and unique adaptations that contribute to the successful integration of adaptive reuse within postgrowth urban development models.

4. Case Studies

4.1 West Texas: The Transformation of the Seaholm Power Plant, Austin

The Seaholm Power Plant, originally constructed in 1951, is a notable example of Art Moderne architecture and served as Austin's primary power source until its decommissioning in 1989. Recognizing the site's historical significance and potential for urban revitalization, the City of Austin initiated a comprehensive redevelopment plan in the early 2000s. The adaptive reuse project, completed in 2016, transformed the decommissioned power plant into a vibrant mixed-use development encompassing residential units, office spaces, retail establishments, and public green spaces. This redevelopment not only preserved the industrial character of the original structure but also integrated modern sustainable design elements, such as a 325,000-gallon rainwater harvesting system for landscape irrigation.

A significant aspect of the Seaholm redevelopment was its emphasis on community engagement and public accessibility. The project included the creation of open public spaces and pedestrian pathways that connect the development to the adjacent Lady Bird Lake and downtown Austin. By fostering walkability and providing communal areas, the redevelopment aligns with postgrowth urbanism principles that prioritize ecological balance and community well-being over relentless economic expansion. Furthermore, the Seaholm Power Plant redevelopment serves as a catalyst for sustainable urban development in Austin. The project is part of the Seaholm EcoDistrict, one of ten projects in North America participating in the EcoDistricts Pilot Program, which aims to create sustainable and resilient neighborhoods. By integrating adaptive reuse with sustainable urban planning, the Seaholm redevelopment exemplifies how industrial heritage can be leveraged to foster inclusive and regenerative urban spaces.

The success of the Seaholm project has inspired similar adaptive reuse initiatives in Austin and beyond, demonstrating the potential of such projects to contribute to urban revitalization, heritage preservation, and sustainable development. By reimagining obsolete industrial sites as vibrant, multifunctional urban spaces, cities can address contemporary challenges related to sustainability, community engagement, and economic diversification.

Image 1: Seaholm Power Plant Redevelopment, Austin, Texas

Caption: The Seaholm Power Plant, a decommissioned Art Moderne-style facility in Austin, Texas, has been transformed into a vibrant mixed-use development. This adaptive reuse project integrates residential units, office spaces, and retail establishments while preserving the industrial character of the original structure. The redevelopment emphasizes sustainability through features like a 325,000-gallon rainwater harvesting system and contributes to the revitalization of Austin's downtown area. Source: Guide to Austin Architecture. Seaholm Power Plant Redevelopment

4.2 MENA Region: The Revitalization of the Gasworks in Cairo, Egypt

In Cairo, Egypt, the adaptive reuse of a former gasworks facility into a cultural and community center exemplifies the potential of industrial heritage transformation in the MENA region. The project involved the restoration of historic industrial buildings and the introduction of new public spaces for art exhibitions, workshops, and community events. This initiative not only preserved the architectural integrity of the industrial site but also provided much-needed cultural infrastructure in a densely populated urban area. The project demonstrates how adaptive reuse can address urban challenges such as the scarcity of public spaces and the need for cultural amenities, contributing to the social sustainability goals of postgrowth urbanism.

A key component of the Cairo gasworks redevelopment was its focus on community involvement and cultural engagement. By transforming the industrial site into a hub for artistic and educational activities, the project

fostered a sense of ownership and pride among residents. This participatory approach aligns with postgrowth urbanism principles that emphasize inclusivity, social equity, and community-driven development.

The adaptive reuse project also incorporated sustainable design strategies to enhance environmental performance and resilience. Efforts included the implementation of energy-efficient systems, the use of locally sourced materials, and the integration of green spaces within the urban fabric. These measures contribute to the broader goals of environmental sustainability and climate adaptation in urban redevelopment projects.

The revitalization of the Cairo gasworks serves as a model for similar initiatives in the MENA region, highlighting the potential of adaptive reuse to address urban challenges while preserving cultural heritage. By reimagining industrial sites as vibrant community spaces, cities can promote sustainable development, enhance social cohesion, and celebrate their unique historical identities.

Image 2: Adaptive Reuse Project in Historic Cairo, Egypt

Caption: In Historic Cairo, Egypt, adaptive reuse initiatives have revitalized former industrial sites into cultural and community centers. These projects involve restoring historic buildings and introducing public spaces for art exhibitions, workshops, and community events. By preserving architectural integrity and providing much-needed cultural infrastructure, such initiatives address urban challenges and contribute to the social sustainability goals of postgrowth urbanism. Source: Zawya. How adaptive reuse transforms communities

4.3 Comparative Analysis

Both the Seaholm Power Plant in Austin and the Gasworks in Cairo exemplify the transformative potential of adaptive reuse in urban settings. While differing in context and execution, these projects share common goals of preserving industrial heritage, fostering community engagement, and promoting sustainable development.

In Austin, the Seaholm Power Plant's redevelopment into a mixed-use complex has revitalized a once-dormant area, integrating residential, commercial, and public spaces. This project not only preserves the architectural integrity of the original structure but also incorporates sustainable design elements, such as a 325,000-gallon rainwater harvesting system for landscape irrigation. The success of this redevelopment has spurred further

investment and development in the surrounding Seaholm EcoDistrict, reinforcing the city's commitment to sustainable urban growth.

Conversely, the adaptive reuse of the Gasworks in Cairo focuses on cultural preservation and community development in a context where public spaces are scarce. The transformation of this industrial site into a cultural and community center addresses the need for accessible public spaces and cultural amenities in a densely populated urban area. By restoring historic industrial buildings and introducing spaces for art exhibitions, workshops, and community events, the project contributes to the social sustainability goals of postgrowth urbanism.

Despite their differing approaches, both projects underscore the importance of context-sensitive strategies in adaptive reuse. They demonstrate how industrial heritage can be leveraged to meet contemporary urban challenges, whether through economic revitalization and sustainable development, as seen in Austin, or through cultural preservation and community engagement, as exemplified in Cairo. These case studies highlight the versatility of adaptive reuse as a tool for creating inclusive, sustainable, and resilient urban environments.

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Understanding the cultural potential of rural history: A conceptual framework of cultural capital development

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Abstract
As the process of globalisation accelerates, cultural diversity is receiving unprecedented attention. As the international community continues to explore sustainable development models for traditional communities, the value of culture in shaping local identities, transforming resource values and enhancing economic competitiveness has become increasingly important. Peasant Life in China: A Field Study of Country Life in the Yangtze Valley opens a window for the international community to understand the Chinese countryside, and the history and cultural resources of the classic case study of Kaixingong Village in the new era. In the context of the new era, the cultural resources of Kaixiangong Village have undoubtedly become an excellent example for exploring the transformation mechanism and sustainable development path of rural cultural resources. Borrowing Bourdieu's concept of cultural capital, the study chooses a village in Suzhou, China Kaixingong Village, and explores the ways and mechanisms of transforming rural cultural resources into cultural capital through field surveys, semi-structured interviews and questionnaires. The study finds that: 1) The transformation of cultural resources involves the synergy of the government special team, the village committee and the enterprise group. The rural governance structure under the scale reorganisation promotes the development of rural regionalisation and the overall planning of cultural resources. 2) The village committee plays the role of coordinating all parties in the process of transforming cultural resources, making use of the social base of rural acquaintances, storing villagers' unused houses, and overlaying the policy benefits to guarantee the group's market operation in the countryside. 3) The group and the village enterprise, as the terminal of transforming cultural resources, maximise the economic value of cultural resources through rural operation. Maximise the economic and social benefits of cultural resources, transform them into value-added cultural capital, and give them capital attributes. At the same time, the passive impact on villagers during the transformation of cultural resources requires the establishment of an effective communication mechanism in the subsequent development of the village to ensure the sharing of benefits and sustainability. The study aims to accurately analyse the capitalization mechanism of rural cultural resources, deeply explore the positive role of rural historical and cultural potentials in contemporary socio-economic development, further expand the application dimension and feasible path of cultural capital in rural revitalization practice, and contribute innovative and referential Chinese wisdom and solutions to the effective development and utilization of global rural cultural resources.

Key words :cultural capital Kaixiangong Village Peasant Life in China Government special team

1. Introduction

Since 2000, culture and heritage have been recognised as the fourth pillar of sustainable development in European and international policy research. The rise of culture as a solution to urban social and economic 'diseases' has received unprecedented attention(Sabatini, 2019, Dinardi, 2015). However, research on culture-led development strategies has focussed mainly on large cities and metropolitan areas, with less attention paid to villages and small towns(Bell and Jayne, 2010, Lysgård, 2019). So far, the link between rural development and culture has been dominated by tourism, which may have exacerbated existing problems while promoting economic development(Ghahramani et al., 2020). Cultural policy in the countryside is limited and related to the urban culturally dominated policy discourse(Lysgård, 2016). Despite this lack of attention, cultural resources can be a valuable driver of revitalisation in rural areas and a major contributor to social cohesion and civic engagement(Thurley et al., 2015). In rural areas, culture mainly refers to landscape management and conservation, traditional social practices, customs and lifestyles, etc. Established research narratives on rural culture also mainly refer to natural capital and tourism-related benefits, neglecting other rural resources and capital(Egusquiza et al., 2021).

Indeed, culture shapes access to other forms of capital and is itself an indispensable form of capital(Daskon and McGregor, 2012). We believe that rural areas will benefit from culture-led revitalisation opportunities, and that traditional or vernacular culture has been recognised as a key resource and an important variable in the survival and sustainability of villages. Rural villages beyond culture itself and heritage-related tourism can access additional resources by utilising the power of higher levels of government and business, but the transformation of cultural resources driven by different agents has rarely been studied. To address the existing research limitations, this study uses Bourdieu's concept of cultural capital, aiming to understand the ways of accumulation of

cultural resources in the countryside, the transformation pathways and the impact of cultural capital on rural development. A rural village in Suzhou, China is empirically selected to explore the process of realising rural cultural capital and the key elements involved in the process. The main contribution of the study is the introduction of a new transformation theory model that describes the transformation mechanism of cultural resources. The study aims to contribute to the study of rural cultural capital by furthering the understanding of rural cultural values and the factors that may influence participants' cultural capital.

2. Literature review

2.1 Capitalisation of cultural resources

Culture is a highly ambiguous concept that is difficult to define. Broadly speaking, culture can be divided into three categories: material, institutional and spiritual. Generally speaking, the capitalisation of cultural resources refers to the transformation of all kinds of industrially exploitable cultural resources owned by a society into value-added cultural capital with the goal of maximising economic and social benefits, and endowing them with the attribute of capital. Resources, as the sum of all means of production that can promote the progress of the cultural cause, play an important role in cultural identity, power cohesion and economic competition, and prompt the corresponding cultural capital to participate in cultural production activities, thus generating new cultural resources(Ma et al., 2021). Resources are not capital in themselves, but only have potential value before they are transformed. Moreover, not all cultural resources can be transformed into cultural capital, only those that can be developed under the existing conditions and have market potential can be transformed into capital. Therefore, Bourdieu believes that cultural resources and cultural capital have a dependent relationship, and cultural capital is the cultural resources that are activated and utilized. Sotheby's believes that cultural resources are the cultural products of labour value accumulation, and only the cultural commodities that can be circulated and generate new benefits in consumption can be called cultural capital, and they tacitly agree that cultural products are the basis of cultural capital, which raises the starting point of classification of cultural resources. Therefore, the essence of capitalisation of cultural resources is the process of activation and utilisation of static cultural resources, which is also the essence of cultural capital.

In rural areas, the material dimension of cultural resources is embodied in the products that people create and their longstanding ways of producing them, including the specific tools, processes and technologies used to produce goods. The institutional dimension consists of the moral and ceremonial norms established over time to maintain stability and social order in rural societies. The spiritual dimension reflects the shared psychological structure and emotional response patterns, often expressed in villagers' personalities, values and outlook on life(Daskon and McGregor, 2012). Cultural resources provide opportunities for other forms of capital to be shaped in the process of capitalisation, as assets that represent the strengths or weaknesses of actors, such as natural, physical and financial capital, and profoundly influence villagers' upgrading decisions and standards of living(Lewis, 2005). There is a consensus among researchers that cultural resources must undergo a series of developmental transformations and market operations before they can finally be transformed into chemical capital. However, for the capitalisation process of cultural resources, or the transformation mechanism of cultural resources, more studies focus on the cross-section results of cultural resources into cultural capital. Fewer studies have explored the capitalisation process and effectiveness of cultural resources from the time series dimension.

2.2 Cultural capital and rural development

When cultural resources are transformed into cultural capital, they become a kind of assets that can be transferred from one generation to another in the social field over time. The concept of cultural capital we are discussing nowadays is mostly derived from Bourdieu's theory of cultural capital, in which he believes that cultural capital is the appropriation of certain cultural resources by actors, including their dress and behaviour, aesthetic preferences, cultural qualities, educational diplomas, and so on(Apple et al., 2009). Cultural capital is the accumulation of the value of cultural labour in the field of production, which can evolve into a class structure of continuous intervention, the capital power of resource distribution, and is expressed as a method and adaptive capacity, which provides human society with the possibility of using and transforming the natural environment(Berkes and Folke, 1992). Correspondingly, cultural capital possesses three forms: concrete, physical and institutionalised. Concrete cultural capital is dependent on the inherent cultural skills and cultivation of individuals; physical cultural capital is the form of material presentation under the action of subjective initiative; and institutionalised capital is the form of officially sanctioned institutionalisation. The three forms of existence complement and influence each other, and play the roles of regulating, structuring and safeguarding in the 'field' on which the

theory of cultural capital is based. cultural capital theory has developed the following characteristics under the continuous expansion of researchers: 1) cultural capital (1) Cultural capital can bring economic value, which is in essence a kind of 'attention economy'. (2) With the help of certain real carriers, cultural capital has the form of materialisation. (3) Cultural capital can be accumulated through time, which needs to be inherited by people. (4) Cultural capital can be accumulated and reproduced. Cultural capital can be accumulated and reproduced, and its essence is the continuous expansion of the value system.

Bourdieu leaves a lot of space for the study of cultural capital, which is both determined by the social structure and reproduced through the continuous practice of the subject, and the concept of cultural capital can be interpreted in the broader social context of the city and even the countryside. The countryside can be regarded as 'a history of accumulation', or even a way of existence in which culture and capital are organically combined. This gives rise to the concept of rural cultural capital, which is an umbrella term for those historical or contemporary, traditional or modern, material or immaterial, dynamic or static, tangible or intangible rural production and lifestyles that have been created under the dual role of agricultural and industrial civilisations. Rural cultural capital is based on in-depth excavation of rural cultural resources, through a variety of ways to carry out the optimal allocation of resources and effective operation, so as to promote the progress of cultural productivity, and achieve the maximisation of the economic and social benefits of cultural capital. In the process of transforming such resources into capital, a benign interactive cultural construction can be formed, which becomes the productivity and competitive advantage of the countryside and drives the development of rural industries(Daskon and McGregor, 2012). Through the intensive use of cultural resources in the countryside, it can optimise the industrial structure of the countryside, change the mode of economic development and promote the development of the tertiary industry. At the same time, it can also bring back the labour force, adjust the population structure, and revitalize the countryside(Radcliffe and Laurie, 2006). Some studies have extensively discussed the impact of rural cultural capital on rural livelihoods(Ma et al., 2021), or linked rural cultural capital with rural tourism and cultural festivals, and discussed the relationship between culture and labour, resources and social capital(Rossetti and Quinn, 2021). However, these studies are more at the level of phenomenon association, and have not explored in depth the transformation process, mode and conditions of cultural resources, and lack of application-oriented transformation strategies. This study focuses on the transformation mechanism of cultural resources, and explores the impact of cultural resources on rural governance structure and spatial planning, so as to realise the transformation into economic benefits. The integration process of cultural resources, the way they are transformed into cultural capital, and the key details of the transformation will be fully investigated.

3. Research design

3.1 Case study

A village in Suzhou, China, Kaixiangong Village, one of the representative economically developed areas in Southern Jiangsu Province, was selected for the study, Figure 1. Kaixiangong Village consists of five natural villages: Kaixiangong, Lotus Bay, Xicaotian, Tianzixuwei, and Sifangxuwei. The village area has a total area of 4.5 square kilometres, with 25 villagers' groups, 752 households, a resident population of 3,020, 2,965 acres of arable land, 45 acres of mulberry land, 2,920 acres of paddy and mulberry land converted into fish ponds, and 1,400 acres of water surface in the outer swings.

The accumulation of cultural resources in Kaixiangong Village comes from Mr Fei Xiaotong's Peasant Life in China, which analyses the economic system, social structure and cultural ecology of Kaixiangong Village in depth, and constructs a complete and academically valuable narrative framework for the village. This is not only an objective record of Kaixiangong Village's specific stage of development, but also gives authority and uniqueness to the village's cultural resources, constituting the core and dominant part of Kaixiangong Village's accumulation of cultural resources.1938, when Fei Xiaotong was studying at the University of London in England, he relied on a study of the village's economic system, social structure, and cultural ecology. In 1938, while studying at the University of London, Fei Xiaotong wrote his doctoral thesis, Peasant Life in China, based on his research in Kaixiangong Village, which documented the process of rural industry in China, and he visited Kaixiangong Village a total of 26 times. Since then, Kaixiangong Village has become a research base for the international sociological community to study the Chinese countryside and establish long-term academic ties.

Figure 1 Location map of Kaixiangong Village
Source: Self-drawn

3.2 Research method

In order to fully discuss the transformation mechanism of Kaixiangong Village cultural resources, this study adopts a combination of quantitative and qualitative research methods. A one-week field survey of the village was conducted in July 2023, with short semi-structured governmental, village committee, enterprise group leaders, and villagers field interviews (N=20). The interviews were semi-structured and included open-ended questions that allowed respondents to answer questions in their own way, independent of the researcher. All interviews were transcribed verbatim and thematic analysis techniques were used to identify key themes and conceptual issues. Secondly, questionnaires were administered to the villagers and 150 valid questionnaires were collected. In addition, Kaixiangong Village's planning atlas related to cultural resources, statistical data, and information about development projects by outside companies were collected. Although, a case study can never form a generalisable sample, this study can be partially replicated and can shape the design of future studies.

4. Capitalisation of cultural resources

4.1 Accumulation of cultural resources

The study systematically combed and statistically analysed the specific content of Mr Fei Xiaotong's 26 visits to Kaixiangong Village, Figure 2, quantifying the material, spiritual and institutional levels of cultural resources respectively. We divided the sequence of visits into three stages, the first stage is from the 1st visit to the 9th visit (1935-1985), which is mainly the accumulation of cultural resources in the material level. The second stage is

from the 10th visit to the 19th visit (1985-1996), in which the accumulation of cultural resources shifted from the material level to the spiritual and institutional levels, and the accumulation of cultural resources was relatively balanced in the three levels. In the third stage, from the 20th visit to the 26th visit (1996-2002), the accumulation of cultural resources was mainly at the spiritual level, with the material level decreasing and the institutional level increasing.

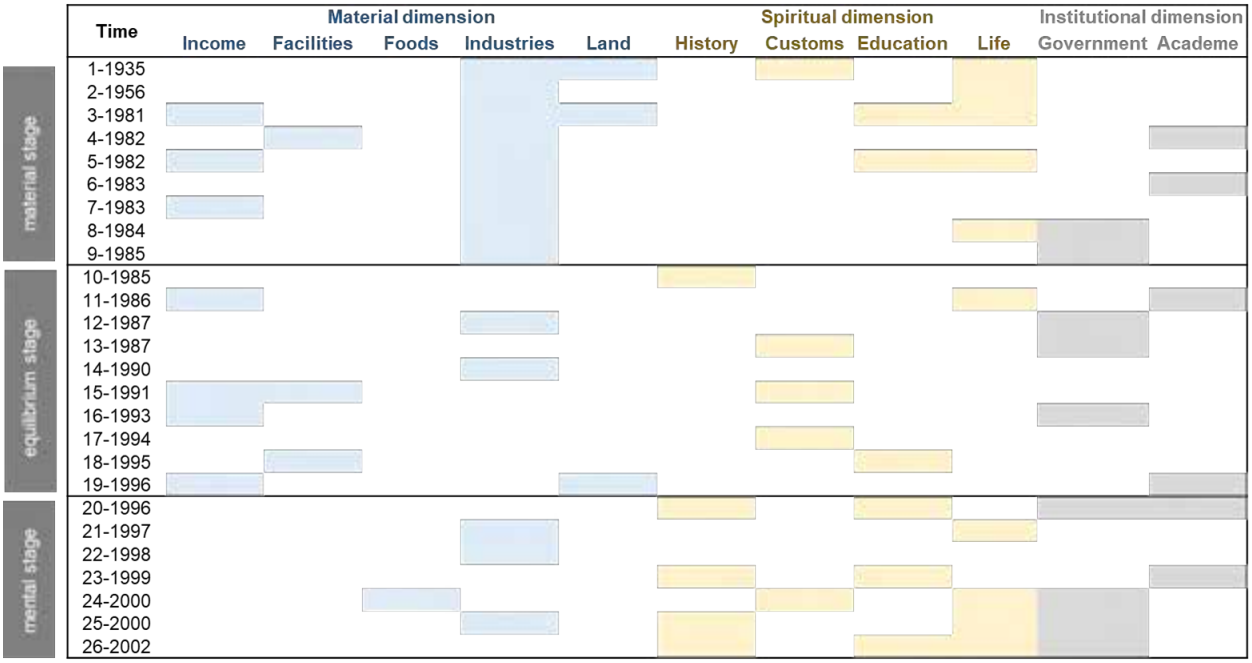

Figure. 2 A compendium of Fei Xiaotong's 26 visits
Source: Self-drawn

We further screened the content frequency of the 26 visits to the countryside to determine the main content of each stage of the visit, in order to identify the process of accumulation of elements of cultural resources, and to provide a basis for the subsequent transformation of resources, Figure 3. In the material stage, industrial labour and land use, as the main accumulation of cultural resources at the material level, not only create the material products needed for life and satisfy the basic needs of rural residents through specific production and practical activities and the development of land space, but also lay a solid material foundation for subsequent academic research, and their embedded economic value and physical presence form the material foundation of cultural resources. The economic value and physical existence of these products constitute the core elements of the material foundation of cultural resources in the countryside. In the equilibrium stage, economic income and infrastructure at the material level, local customs at the spiritual level, and academic research at the institutional level mutually empower each other, and the optimisation and upgrading of economic income and infrastructure provide material support and dissemination platforms for the inheritance and display of local customs, while the unique local customs attract more attention and feed the economic development. Meanwhile, academic research at the institutional level provides theoretical basis and scientific guidance for the first two, ensuring that cultural resources in the countryside achieve all-round, sustainable and balanced development in the process of accumulation, and jointly promoting the advancement of rural cultural capital to a higher level. In the mental stage, the focus of cultural resources accumulation is shifted to the spiritual level of historical accumulation and cultural education. Deep historical deposits have injected rich connotations into rural culture, while cultural education plays a key role in the process of inheriting and promoting these cultural elements. This process not only promotes intergovernmental exchanges at the institutional level and the deepening of academic research, providing policy support and theoretical guidance for the development and utilisation of cultural resources in the countryside, but also, with the help of various channels of communication, vigorously promotes the widespread dissemination of rural cuisine at the material level and enhances the overall influence of rural culture.

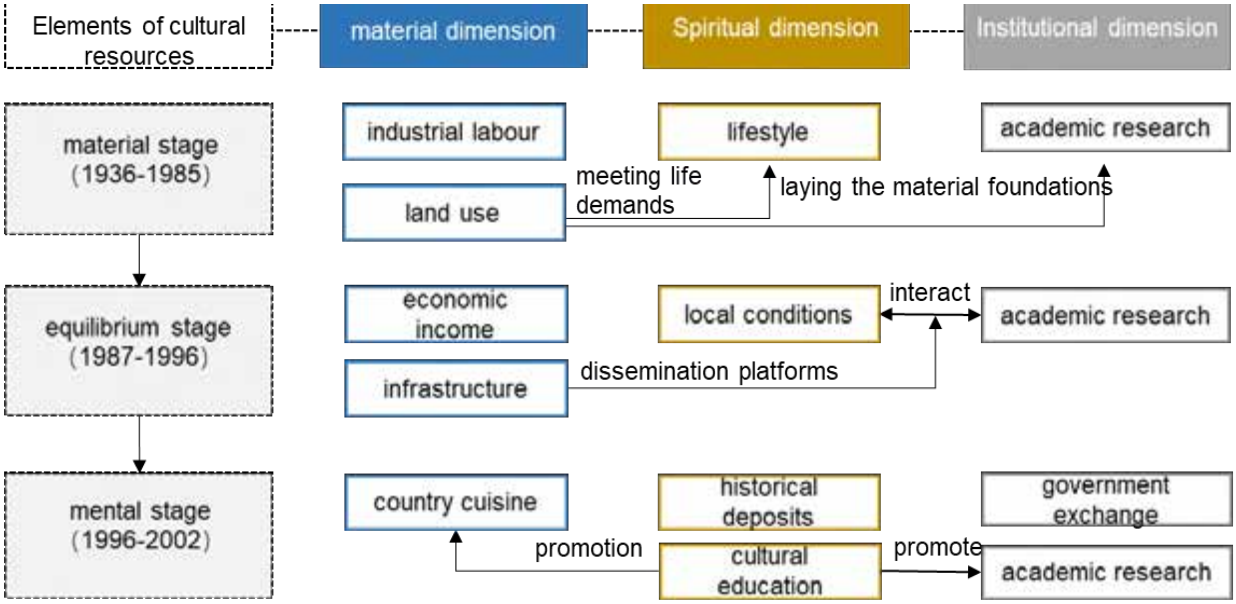

Figure 3 Cultural resources element accumulation
Source: Self-drawn

4.2 Transformation of cultural resources

4.2.1 Transformation path 1: government special team under scale reorganisation

The uniqueness of China's villages lies in the vertical depth and grassroots intervention of the governance system. Unlike the bottom-up governance model in Western countries, Chinese villages are governed by an informal administrative body, the village committee, which is an extension of state power and is indispensable for most village development, capital introduction, and project attraction, but when the influence of the village extends beyond its boundaries and attracts cross-regional investment, large-scale project resources or complex policy coordination needs, the limited resources and coordination capacity of the village committee alone are often insufficient to cope with the situation. However, when the influence of the village extends beyond the village, attracting cross-regional investment intentions, large-scale project resources, or facing complex policy coordination needs, it is often difficult to cope with the limited resources and coordination capacity of the village committee alone, and a cross-scale reorganisation of the government special team becomes a necessary and efficient response. In Kaixiangong Village's cultural resources capitalisation process, a government special team was set up to coordinate the development of the hyper-village, and work with the village committee to promote the transformation of cultural resources and the dissemination of the 'Jiang Village' IP, Figure 4. In addition to the valuable academic cultural resources left behind by Mr Fei Xiaotong for Kaixiangong Village, in the context of China's rural revitalisation strategy, Suzhou City has established the 'China Jiang Village' rural revitalisation demonstration zone in 2020, which is officially recognised at the municipal level. Institutionalisation. In the same year, Wujiang District, a subordinate district of Suzhou, built a project command department for Kaixiangong Village, and started to organise government personnel across administrative scales to form a special team. The mayor of Wujiang District acted as the head of the command department, linking up various departments of agriculture and rural areas at the district level, and correspondingly, Qidu Township set up a special comprehensive rural upgrading task force and deployed township staff to work in the village, which has been in place since then.

The establishment of the government special team in Kaixiangong Village has led to a systematic transformation of the village, laying the institutional foundation for the creation of the 'Jiang Village' cultural brand. On the one hand, the special team continues to promote the excavation of village culture, and on the other hand, it works with the village committee to assist in village planning and the development of introduced projects. As Director Shen of the government special team said:

'At the beginning of the establishment of the task force, the overall planning of the village was to build a cultural development corridor centred on Kaixiangong Village, and around Kaixiangong Village North, Kaixiangong Village South and Lotus Bay Village, we built the Jiang Village 1936 North Garden, Taihu Crab Garden, Jiang Village 1936

South Garden, and Jiang Village 1936 Landscape Mulberry Field. Now all of them, except the North Garden, have been completed and are open for business.'

At this point, cultural resources have been transformed into institutionalised capital. The cultural capital of Kaixiangong Village exists in an 'institutionalised state' in the form of social identity, which is officially recognised, legal and socially accepted. Kaixiangong Village's cultural resources, both material and spiritual, are preserved, inherited and disseminated more widely through the vehicle of the government special team.

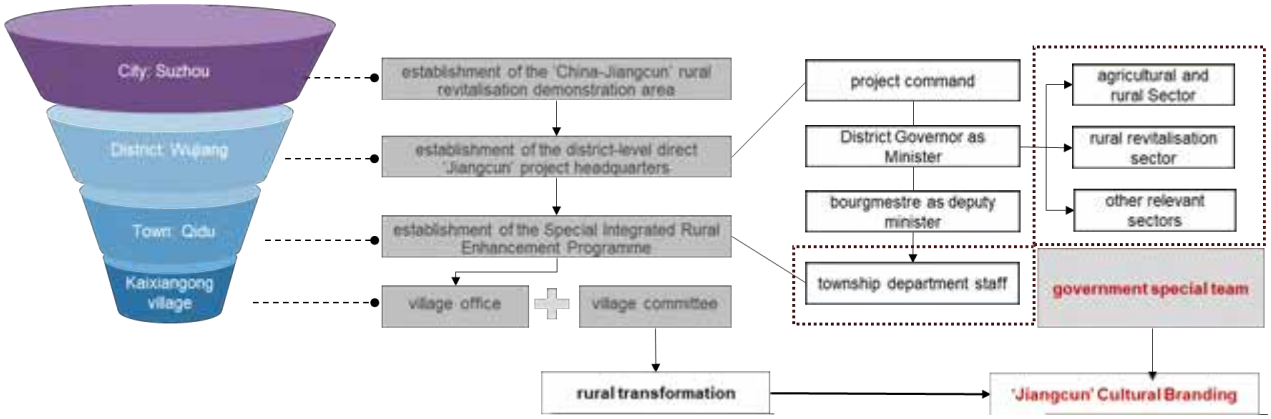

Figure 4 Institutions under scale reorganisation cultural capital
Source: Self-drawn

4.2.2 Transformation Path 2: Internal and External Symbiosis of Rural Public Cultural Space

The co-governance between the government special team and the village committee has led to the materialisation of Kaixiangong Village cultural resources, creating new values in the production field through the introduction of projects, promoting the reproduction of cultural space, and storing it in an 'objective state' in the concrete material. Through the investment and introduction of projects, new values are created in the production field, and the reproduction of cultural space is promoted, which is stored in the concrete material in an 'objective state'. In order to revitalise and utilise cultural resources, a series of rural public cultural spaces have been created, Figure 5, and with the development of urbanisation and rural revitalisation, rural operating companies with cultural service skills have become the dominant factor in intervening in the development of the countryside, and the traditional endogenous space and the new exogenous and modern space have appeared to be mixed and symbiotic. In Kaixiangong Village, we see two different paths of cultural resources being transformed into public space under the intervention of capital. Firstly, there is the entry of the village sage enterprises. Kaixiangong Village's Shanshui Mulberry Field, South Park Carnival and Taihu Crab Bank are all invested by the village sages, who have returned to their hometowns with their deep feelings for their hometowns and their familiar industrial fields, and have given back to their hometowns through their practical actions. Compared with foreign enterprises, the sages deeply understand the value of their hometown culture, show a high degree of cultural identity and cultural self-awareness, and integrate regional cultural characteristics into industrial development, which not only promotes local economic growth, but also promotes the inheritance and innovation of rural culture. As the director of government special team, Mr Miao, said:

'In the beginning, we also negotiated co-operation with larger foreign companies and groups, but their understanding of the culture of Jiang Village was not that deep. Instead, my local entrepreneurs were able to sense what we wanted, what we wanted to do for the villagers, what we wanted to do for this village.'

Secondly, in order to further expand the influence of the 'Jiang Village' cultural brand, the village has introduced a village operation company (Blue City Group), which cooperates with the government in rural revitalisation projects. For example, Kaixiangong Village's Jiang Village Hall, Market, Council Chamber and Cultural Gallery are all public cultural spaces funded by the company during its operation of the village. Compared to the direct economic benefits generated by the mulberry fields, crab gardens and carnivals, the functional attributes of these public spaces are more integrated into the lives of the villagers and attract foreign tourists to learn about village culture. Integration of fragmented cultural resources and further formation of cultural capital will lead to the development of diversified industries.

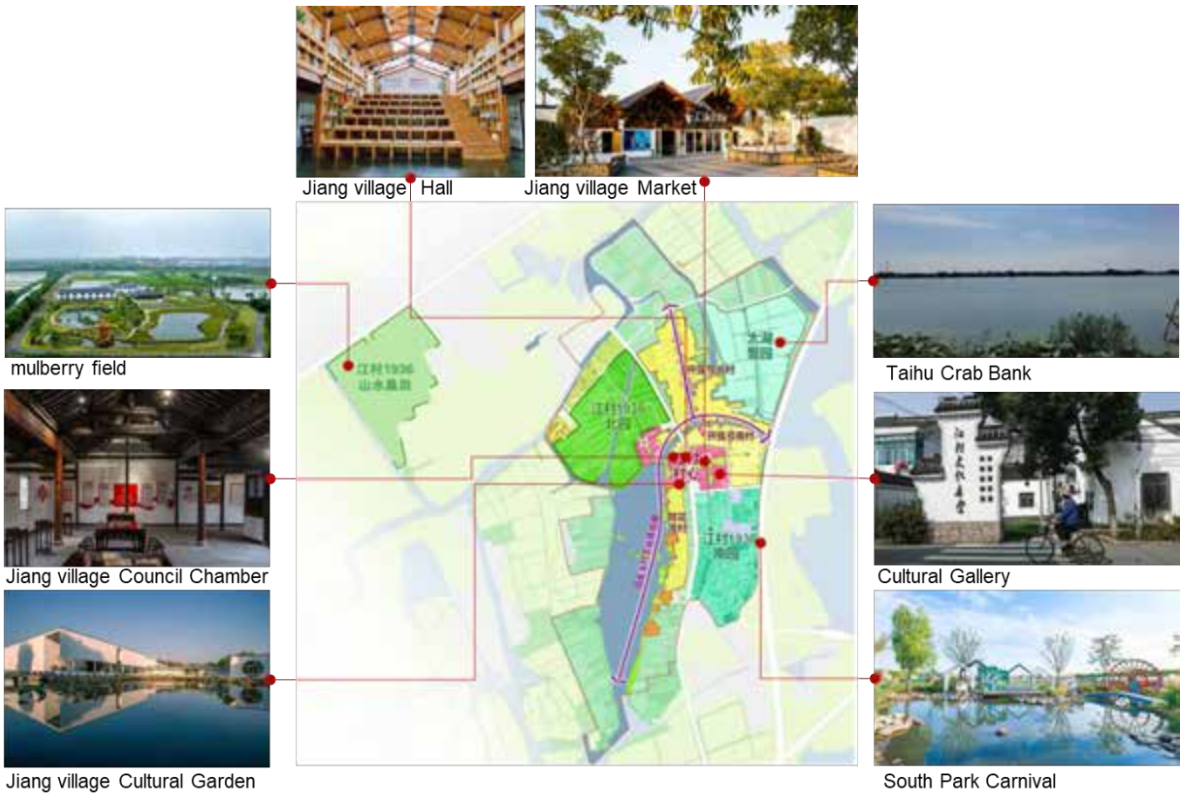

Figure 5 Public cultural spaces in villages
Source: Provided by the village

4.2.3 Transformative pathway 3: Participatory research and learning activities

In the process of capitalising cultural resources, in addition to institutionalised and materialised forms of storage, Kaixiangong Village also has an educational and cultural dissemination value of study activities. This includes village social surveys and academic exchanges between scholars from home and abroad at the beginning, as well as a wide range of research experiences for students at the present time. The unique cultural features and connotations of the villages, such as historical deposits, local customs and lifestyles, have been internalised over time into the unique spiritual qualities of Kaixiangong Village. Research activities have expanded the scope of dissemination of this cultural capital, and its audience has shifted from scholars to a wider public. The participatory nature of this spiritual transformation of cultural resources is very important. Therefore, the promotion of research activities and the target groups are the main considerations for Kaixiangong Village in shaping its cultural capital. Through research and interviews, our research team concluded that study activities are mainly classified into task-type, spontaneous-type, and education-type, Figure 6. Specifically, task-type study activities are usually carried out by government staff as the main body to carry out collective activities, mainly to learn from the village's governance model of multi-party participation, the government's experience of linking social capital and villagers' assets for economic development, and the experience of tapping into the countryside cultural resources to create a village cultural brand. Resources to create a rural cultural brand model. Spontaneous research activities refer to the researchers' independent decision to go to the countryside for research based on their own research interests and research directions. Their research includes the social structure change, economic transformation, and cultural inheritance of Kaixiangong Village. Through interviews, observations, questionnaires, etc., they dig into the first-hand data, and dedicate themselves to contributing innovative results to the field of academic research. Educational study activities are agricultural experience activities organised for primary and secondary school students to participate in, based on the rural agricultural production environment, integrating agricultural knowledge learning and practical experience in depth. Through field visits to farmland, participation in agricultural operations, observation of the growth process of crops and other forms, primary school students are guided to broaden their horizons of knowledge in real agricultural scenes, and to understand the basic process and importance of agricultural production.

The interactive process of research activities further promotes the capitalisation of cultural resources and gives participants unique cultural capital experiences, for example, participants can buy cultural goods, develop skills and learn about local cultural history. Of course, there are scholars who believe that people participate in study activities just for fun, not for the development of cultural capital in villages. However, from the actual development of Kaixiangong Village, the high frequency of study activities has been effective in spreading culture. Participants have attracted more social resources to invest in them, further helping the village to carry out more cultural projects, so that the culture of the Jiang Village can be cohesive in Kaixiangong Village, which is worth preserving and passing on, and sharing with a wider range of people and regions.

Figure 6 Three Types of Research Activities
Source: Provided by the Village Council

5. Discussion and conclusions

5.1 Mechanisms for the formation of cultural capital

The analysis of the research results shows that the process of cultural resources capitalisation is complex, and the relationships between different subjects are intertwined, and they play different roles and have their own interests in the process of cultural resources capitalisation. Therefore, this study provides a conceptual model of cultural capital development and related dominant actors, Figure 7, which includes the direction and interrelationships of different actors in the process of cultural resources transformation, as well as the forms of cultural capital that are formed under the role of these actors. Firstly, the transformation of cultural resources involves the synergy of government special team, village committee and enterprise group. In the case of Kaixiangong Village, cultural resources were the first to be officially recognised, and the legitimacy of the social identity was the strategic basis for a series of business projects. The reorganisation of the village governance structure has facilitated the regionalisation of the village and the development of the cultural concept of 'Extensive Jiang Village', which has facilitated the overall planning of Cultural resources. The government's function is to attract investment and bring in external resources and capital. Secondly, village committee plays the role of coordinating all parties in the process of transforming cultural resources, making use of the social basis of village acquaintances, storing the idle houses of villagers, and overlaying policy preferences to guarantee the market operation of the group's enterprises. In addition, the group and the village committee, as the end point of cultural resources transformation, maximise cultural resources and social benefits through village operations, transform them into value-added cultural capital and give them capital attributes.

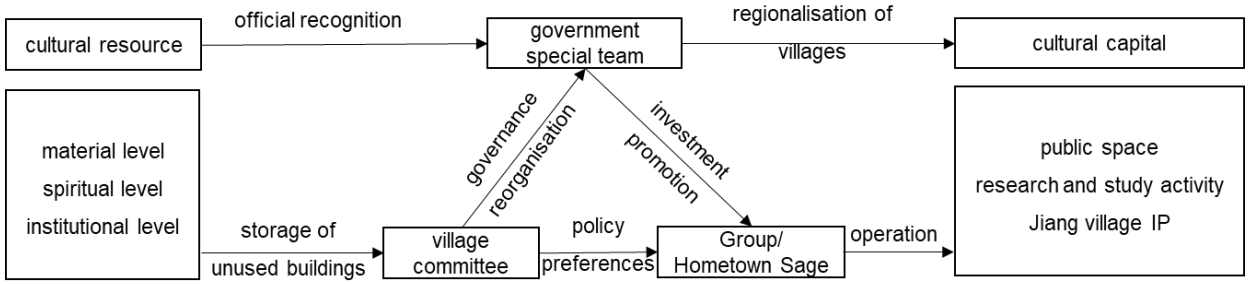

Figure 7 Cultural resources transformation mechanism
Source: Self-drawn

5.2 Response of villagers to passive participation

In the case of Kaixiangong Village, we see that the government, village committees and enterprises are actively involved in the dissemination, transformation and transmission of cultural resources in the villages, but the villagers living in the villages are involved in a passive way. In our research questionnaire, we found the unequal distribution of benefits in the relative deprivation theory and the information asymmetry in the knowledge gap hypothesis. More than 24% of the villagers are indifferent to the development of the cultural industry in the countryside, and 27% of the villagers think that the current public cultural space attracts insufficient and does not have a positive impact on their lives. This shows that the value-added of cultural capital has not yet fairly benefited all villagers, and villagers fail to get direct economic and social benefits from it, then their interest and support for these changes will be reduced. Second, villagers only see the external changes in the villages superficially, and differences in access to information further widen the knowledge gap between different groups. Villagers do not understand the specific process and long-term significance of the transformation from cultural resources to cultural capital, and therefore cannot feel the positive impact of this transformation.

The reason for this is the lack of participation in the project and the lack of sustainability, which leads to the perception of group differences in the process of transforming cultural resources. This also requires that the government, enterprises and village committees pay more attention to the actual needs and opinions of the villagers in the subsequent development of the countryside, and promote the active participation and support of the villagers through the establishment of an effective communication mechanism, ensuring the sharing of benefits and respecting and integrating the local cultural characteristics, as well as the provision of the necessary education and training. In addition, the government and village committees need to pay more attention to the actual needs and opinions of villagers by establishing effective communication mechanisms, ensuring benefit sharing and respect for and integration of local cultural characteristics, and providing the necessary education and training, so as to promote villagers' active participation and support. At the same time, there is a need to formulate long-term plans to ensure that the process of transforming cultural resources into cultural capital is sustainable and can bring about substantial improvements.

5.3 Conclusion and prospect

The main purpose of this study is to further understand the transformation paths and mechanisms of rural cultural resources, which provides theoretical explanations and case sharing for the study of the adaptive use of rural cultural resources. Based on a study of a rural village in Suzhou, China, a new theoretical model of cultural capital is proposed, including the relaxation of the accumulation of cultural resources, transformation pathways and impacts. The study reveals three forms of cultural capital storage in villages, the interactions between different actors and the passive responses of villagers. The study highlights the dominant role of the scale-restructured village governance structure in the formation of cultural capital, the coordinating role played by village committees in the process of resource transformation, and the value-added role in the operation of group enterprises.

Clearly, this is an exploratory study and conclusions relying on one case alone are not broadly generalisable. Rural culture is significantly territorial, and future research could carry out a larger survey of villages. Attention should also be paid to how rural cultural capital can be beneficial to participants on an individual level.

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The inheritance mechanism of rural living heritage in China based on the model of "rural governance - policy supply - protective activation"

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Abstract
This paper studies the triadic dialectics of "rural governance - policy supply - protection and activation", builds a theoretical influence model of the three, and puts forward the views that rural governance is the tool, policy supply is the guarantee, protection and activation is the purpose.

Taking rural governance as the starting point, this paper analyzes the protection and utilization of cultural heritage in the process of rural evolution in Zhongshan under the influence of policy supply since 2018. It also proposes five suggestions for establishing the mechanism: improve the regional resource survey mechanism, strengthen the design of top-level protection and activation policies, enhance the Role of Village Collectives through Governance-Oriented Mechanisms, improve the dynamic protection-update feedback mechanism, establish a supervision and inspection mechanism.

Keywords: rural governance; policy supply; protection and activation; rural lived heritage

The countryside is an important space for carrying the culture[1] and an indispensable part of heritage protection[2]. However, since the reform and opening up in 1978, rapid urbanization has had a significant impact on China's rural areas. Rural heritage generally faces two major situations. First, urbanization in some areas is based on the annexation of rural areas, and many traditional villages have been completely demolished. Second, there is a large loss of population, the backwardness of village infrastructure, and serious damage to rural buildings and landscapes. Rural heritage protection is urgent. For a long time, China's rural heritage protection has been a continuation of urban policies (such as demarcating protected areas and listing cultural relics/historical buildings), which has played a good role in single-point static protection of heritage, but has insufficient dynamic activation of the entire region. From the endogenous characteristics of Chinese villages, it is a highly autonomous clan society and is independent of the "central-provincial-municipal-county" administrative agencies. This determines that the protection and renewal of villages needs to rely on rural governance. However, as a strong government society, China's rural self-revitalization ability is not strong, and the protection and utilization of rural cultural heritage cannot be separated from policy supply.

Therefore, it is particularly important to achieve dynamic protection of rural heritage through comprehensive policy supply and rural governance tailored to local conditions. It is necessary to systematically sort out the relationship between "rural governance-policy supply- protective activation ", re-understand the connotation and characteristics of rural governance, and then think about the impact of policy supply on the protection of rural living heritage.

1. Research review

1.1 Rural lived heritage related research

The New Oxford Dictionary's definition of heritage includes "unspoilt countryside" . The Venice Charter of 1964 points out that "rural setting" is also a monument that bears witness to history. The Charter on the Built Vernacular Heritage of 1999 points out that rural heritage plays an important role in human emotions and pride. It is informal, orderly and has use value, the focus of life in an era and a record of social history. The Guidelines for the Protection of Chinese Cultural Relics and Historic Sites proposes hat historical and cultural villages and cultural landscapes are still closely connected with contemporary life, reflecting specific cultural significance and possessing "living characteristics".

Foreign scholars have long recognized that rural heritage includes all tangible and intangible systems and spaces[3], and is the product of the coupling of people, society and ecosystems[4][5]. The authenticity and effectiveness of rural heritage protection are closely related to local policies[6]. Establishing a good relationship with local residents is conducive to the protection of rural cultural heritage[7]. In summary, the protection of rural heritage deeply depends on policy support and rural governance.

Chinese scholars' understanding of the living characteristics of rural heritage involves aspects such as rural historical stratification[8], rural landscape[9], and living traditions[10]. They also start from multiple dimensions such as architecture, geography, economics, sociology, and management to study topics such as traditional dwellings[11], rural cultural heritage systems[12], rural heritage protection paths[13], and rural heritage landscapes[14]. It can be seen that the protection and inheritance of rural living heritage has received more and more attention from Chinese scholars, and has become an important supplement to the research on urban and rural heritage.

1.2 Rural governance related research

Mr. Fei Hsiao-Tung mentioned in "Rural China" that the origin of Chinese society is rural, and the rural society regulates everyone's behavior through close and long-term common life. "Governance" has been running through the entire process of rural development since ancient times. The research on rural governance is mainly divided into two aspects. On the one hand, scholars have realized that under the background of rapid urbanization, the social structure of villages has become increasingly atomized, the ability of rural governance has gradually weakened[15], the lack of villagers' subjectivity has led to governance difficulties[16], and it is difficult for a single government to meet the diversified needs of public goods[17]. On the other hand, scholars have also proposed that the action strategies and governance capabilities of village communities play a key role in rural construction and protection[18]. Rural governance is needed to achieve coordination of village affairs and build consensus[19], promote rural protection and development[20], and then play a role in promoting policy transmission, industrial development, cultural protection, and common prosperity for rural revitalization[21].

1.3 Rural policy related research

There are relatively few studies on rural policy mechanisms. Scholars point out that the flexibility of public goods supply policies, the organizational mobilization capabilities centered on village cadres, and the group governance capabilities constitute the policy organizations and social foundations for activating autonomy[22]. The establishment of policy supply mechanisms such as village creation and financial incentives plays a certain role in mobilizing village enthusiasm and social participation[23]. However, in the traditional rural policy system, villages lack the autonomy to make project decisions, supervise and evaluate, and use funds. Rural grassroots organizations lack the necessary financial resources, and their space and autonomy for action are limited[24]. Strengthening the design and research of policy mechanisms plays an important role in ensuring the implementation of plans[25].

1.4 Summary of research review

Overall, rural governance, policy supply, and rural living heritage are attracting more and more attention from scholars, but existing research focuses on a single content, and there is little research on the relationship between the three. There is insufficient research on how policy supply affects the protection of rural living heritage and what role governance plays in it.

2. Research framework

2.1 Research on the Institutional Framework for Rural Heritage Protection in China

Heritage protection in China has always been directly affected by policy system, and can be roughly divided into three stages. The first stage was the "cultural relics protection unit" period, which was mainly single-point protection. The second stage was the "historical and cultural city" period (1982 to present). The third stage was the "whole-region heritage protection" period (2003 to present). Up to now, relevant ministries and commissions have successively launched historical and cultural villages (a total of 487 from 2003 to 2014), the list of traditional Chinese villages (a total of 8,155 from 2012 to 2014), and provinces and cities have successively issued policy documents to protect rural heritage. It can be seen that China's rural heritage has gradually received attention from the central and local governments. In 2025, the CPC Central Committee and the State Council's "Notice on Strengthening the Protection of Cultural Heritage" clearly stated that "in the process of urbanization, we must effectively protect the historical and cultural environment, and make outstanding vernacular architecture and other cultural heritage an important part of the urbanization development strategy."

At present, the framework of China's rural living heritage protection and inheritance system mainly includes three aspects: legal documents, top-level policies, and listing certification. First, legal documents, including "the Cultural Relics Protection Law" and "the Regulations on the Protection of Historical and Cultural Cities, Towns and Villages", stipulate that local governments at or above the county level must provide necessary financial support for the protection of historical and cultural villages, propose development intensity and construction

control requirements based on the traditional pattern and historical style of the village, and formulate a phased implementation plan for the protection plan. The second is the listing certification, which mainly clarifies the protection requirements through the list of famous historical and cultural towns and villages in China, the list of traditional Chinese villages, the list of cultural relics protection units and the list of historical buildings issued by the Ministry of Housing and Urban-Rural Development, the Ministry of Culture and Tourism, the Ministry of Finance, etc. The third is the top-level policy. Since 1978, a total of 26 "Central Document No. 1" (1982-1986, 2004-2024) have mentioned the issue of rural development and protection. The programmatic documents issued by the State Council in recent years, such as the "Rural Comprehensive Revitalization Plan (2024-2027)", have also put forward new requirements for the protection and inheritance of traditional villages and the cultural empowerment of rural development.

It can be seen that most rural protection policies are issued by the central government and its ministries, as local governments just play a supporting role. The top-down policy mechanism has played an important role in the protection of rural living heritage, but the content is mostly directional guidance, and there is often a big gap between policies and implementation[12]. The national-level protection system can only play a bottom-line protection role for villages with listed identities, while a large number of rural cultural heritage with protection value but not included in the protection system are facing the risk of demolition. This requires, on the one hand, strengthening the vertical extension of the mechanism, paying more attention to local policy, strengthening control, and focusing on implementation. On the other hand, strengthening the horizontal expansion of the mechanism, promoting the continuation of the use function, cultural expression, social connection, and management and care of rural cultural heritage, and truly realizing the "living up" of heritage.

2.2 Connotation of rural governance in China

In recent years, with the decentralization of power and the influx of capital into villages, rural interest groups have become more diverse, and the rural self-organization governance system that has lasted for thousands of years has been impacted. The key role of rural governance in the protection of living heritage is reflected in some fields. First, it is the participation of multiple subjects. The government's public power guarantees the bottom line of heritage protection and seeks a balance between heritage protection and revitalization. The village collective strengthens the cultural identity and internal integration of the village through the guidance of local sages, forms a "community of thought", builds a "protective wall" of collective consciousness, and promotes the implementation of protection measures. Corporate investment in the social field is an important supplement to rural governance and an important support for the revitalization of rural heritage, as the villagers are the real users and conservators of rural heritage. Second, there is continuous collaboration throughout the protection process. Heritage protection and revitalization is not a single physical space repair, but a whole process of planning, construction, management, and operation. Third, the whole work is dynamic and sustainable. The complexity of rural population, industry, and economy determines that the protection and revitalization of rural heritage is a dynamic process, which must be promoted continuously and effectively. This requires exploring village development empowerment, operation transactions, and income distribution mechanisms on the basis of protection and revitalization to stimulate the "self-generating" ability of villages.

2.3 Construction of theoretical model based on institutional perspective

Mr. Hok-Lin Leung proposed in "Policy Planning and Evaluation Methods" that policies are achieved through a series of means, and the policy process includes "value selection-determination of goals-clarification of means-policy results". It is generally believed that the government formulates policies based on public value, and its implementation requires the use of governance tools that take into account both policy attributes and social attributes, and ultimately improves the policy implementation path through policy results. There is often a certain deviation between the protection of rural heritage with long-term value and the short-term economic interests of the village collective, which leads to the implementation of policies must rely on the power of rural governance. Therefore, the efficient unification of policy, governance, and protection has become the key to rural development.

Therefore, firstly, this paper proposes to construct a theoretical model of "rural governance-policy supply-protection and activation" from the perspective of theoretical understanding. Policy is a means to actively mobilize various resources, promote rural heritage protection, and achieve institutional and mechanism innovation; governance is a capability, which is an important driving force behind the effectiveness of heritage protection and

an important angle for evaluating whether policy supply is effective; rural heritage protection and activation is a carrier, an object of observation and an object of action. Ultimately, the three interact with each other to promote the sustainable protection and utilization of rural living heritage (Figure 1).

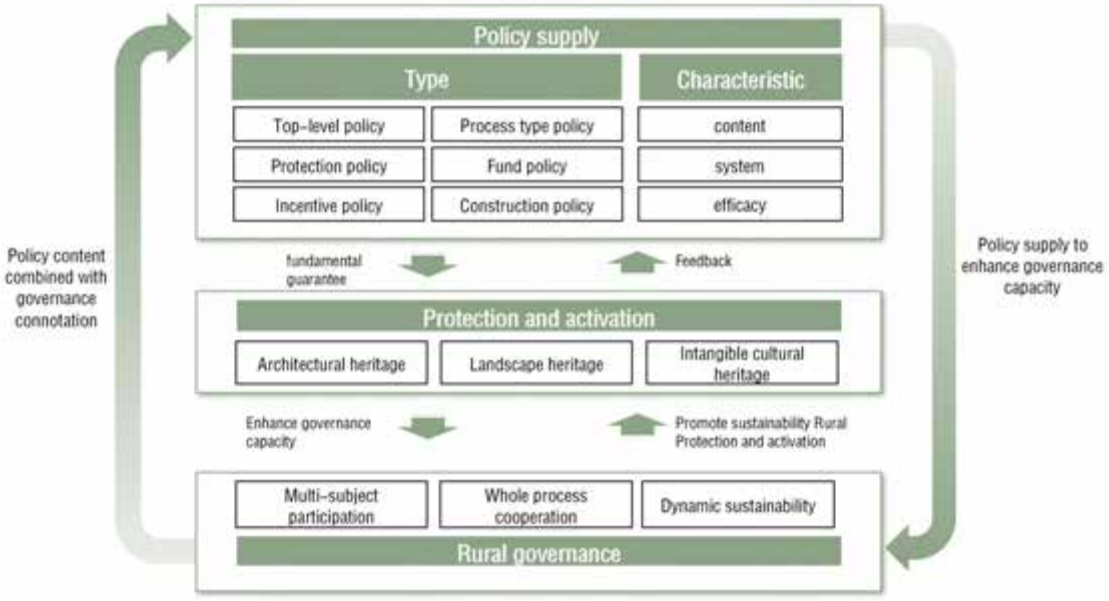

Figure 1: Dialectical relationship of "policy supply - rural governance - rural construction"
Picture source: self-drawn by the author

Secondly, we respond to the theory from the perspective of case practice. We explore the impact of policy supply on the protection and revitalization of a traditional Chinese village since 2018 , study the role of rural governance in protection and revitalization, and propose suggestions on how to accurately match policies and promote efficient governance in the protection and revitalization of rural living heritage.

3. The practice of rural living heritage inheritance in Yungmark Village, Zhongshan City

Established in the Southern Song Dynasty, Zhongshan's villages have gathered a large number of buildings that combine Chinese and Western styles, nurtured Mr. Sun Yat-sen and many celebrities, and witnessed half of China's modern history. Among 900 villages, more than 300 have typical cultural values, and have formed a rural heritage circle around Wugui Mountain in space (Figure 2). The historical and cultural value of Yungmark Village includes: Yungmark is the hometown of Zheng Guanying, the "first person to open his eyes to the world" in the late Qing Dynasty. Yungmark is the place where Deng Xiaoping proposed " never walk backwards " during his southern patrol, an important witness to reform and opening up, and the first village in mainland China to open up to the outside world. Yungmark is a window for Sino-Western exchanges, a typical hometown of overseas Chinese, and rich in historical and cultural relics. Yungmark is the geographical center of Zhongshan, Zhuhai and Macau, and a strategic place for ancient transportation and coastal defense.

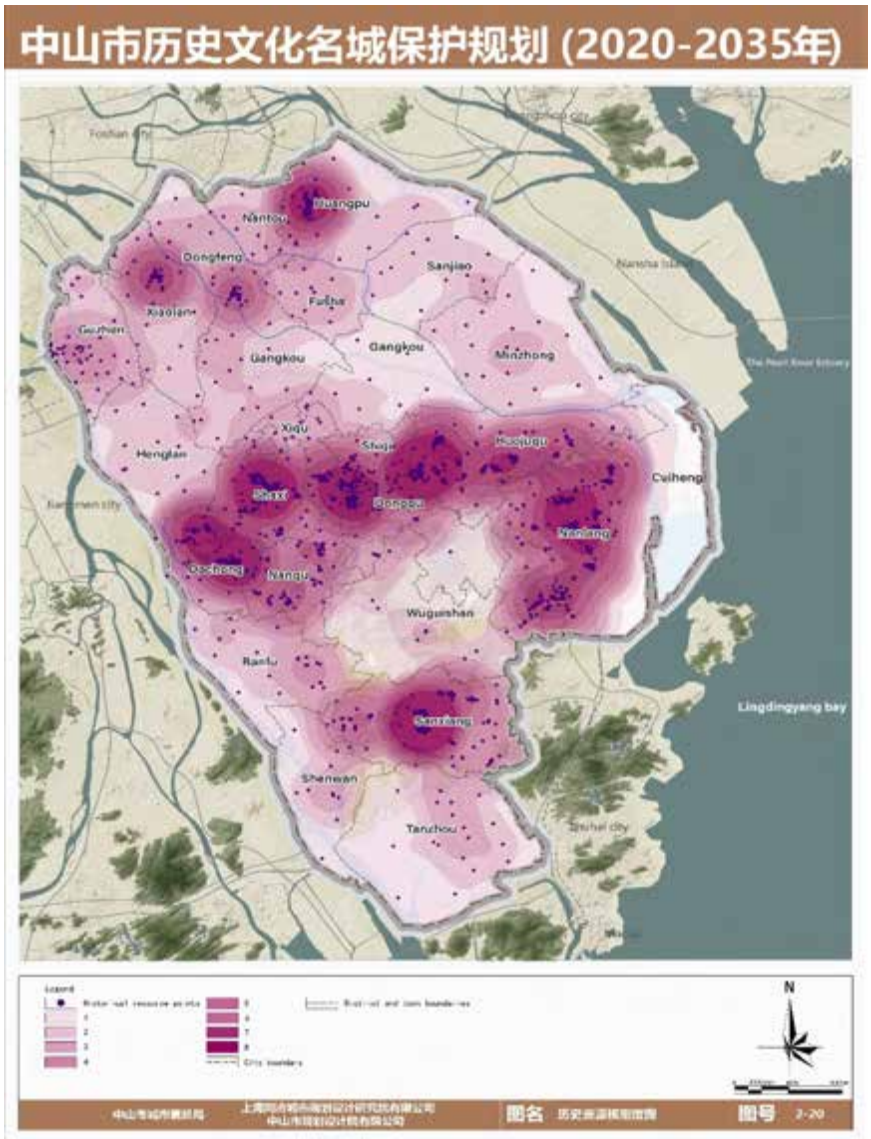

Figure 2: Distribution map of historical resources in Zhongshan City
Picture source: self-drawn by the author

3.1 Types, effectiveness and problems of policy supply

3.1.1 The type of policy supply

Since 2018, Zhongshan City has successively published dozens of policies related to rural revitalization and protection, which can be divided into seven categories (Table 1). Top-level design policies clarify the outline of rural revitalization and lay the foundation for the promulgation of subsequent detailed policies. Protection policies clarify that urban-rural renewal must carry out historical and cultural protection evaluations and strengthen financial subsidies for the protection and repair of historical buildings. Process policies simplify the process of small construction projects, promoting the rapid implementation of protection and repair projects with a total investment of less than 2 million yuan, as well as single projects with an investment of less than 1 million yuan. Funding policies focus on the management of special funds, and propose the scope of fund use, project reserves, fund allocation, use management, project acceptance, performance evaluation and other contents, which are the core policies to ensure the implementation of protection and revitalization projects. Incentive policies include city leaders taking charge, evaluation of human settlement environment improvement, etc., which mobilize the collective will of villages through a healthy competition mechanism. Construction policies ensure that rural architectural styles and forms are appropriate through guidelines, positive and negative lists, etc. Talent policies mainly strengthen the management of craftsmen who repair traditional buildings.

Table 1: List of rural revitalization policies in Zhongshan (2018-2024) Source: Zhongshan Municipal Agriculture and Rural Affairs Bureau Government Affairs Website and Zhongshan Municipal Natural Resources Bureau Official Website Compiled by the author

Types	Name
Top-level design	"Zhongshan City's Implementation Plan for Promoting Rural Revitalization Strategy"
	"Zhongshan City's Implementation Plan for Promoting Rural Living Environment Improvement and Building Ecologically Livable and Beautiful Villages in the Whole Region" (Zhongshan Office [2018] No. 15)
	"Zhongshan City's Action Plan for Implementing the "Thousand Villages Demonstration, Ten Thousand Villages Improvement" Project"
	"Zhongshan City Rural Human Settlement Environment Improvement and Improvement Five-Year Action Plan"
	"Zhongshan City Action Plan for Promoting Rural High-quality Development"
Protection policies	"Zhongshan City Urban Renewal Historical and Cultural Protection Evaluation Report Preparation Work Guide"
	"Zhongshan City Historical Building Protection and Repair and Historical and Cultural Protection Area Protection and Renewal Subsidy Fund Management Measures"
Process policies	"Zhongshan City Simplified Rural Small Construction Project Process Guidance Opinions"
	"Zhongshan City Simplified Rural Small Construction Project Process Guidance Opinions" (revised version)
Funding policies	"Zhongshan City "One Village One Product, One Town One Industry" Construction Fund Management Rules (Trial)"
	"Zhongshan City "Hundred Counties, Thousands of Towns and Tens of Thousands of Villages High-quality Development Project" Twenty Fiscal Policy Measures"
	"Zhongshan City Rural Revitalization Strategy Construction (Rural Human Settlement Environment Improvement) Special Fund Management Measures"
Incentive policies	"Zhongshan City Leaders' Contact with Characteristic and High-quality Demonstration Village Creation Work Plan"
	"Zhongshan City Characteristic and High-quality Demonstration Village, Beautiful and Livable Demonstration Village Construction Project Database Implementation Work Guide" (Central Committee Agricultural and Industrial Office Letter [2020] No. 9)
	"Zhongshan City Rural Living Environment Improvement Comparison and Learning Evaluation Plan"
	"Zhongshan City Beautiful Countryside Index Evaluation Work Plan"
Construction policies	"Zhongshan City 2019-2021 Beautiful Rural Construction Project Positive and Negative List" (Central Committee Agricultural and Industrial Office Letter [2022] No. 16)
	"Zhongshan City's "Ten Dos and Ten Don'ts" for Rural Construction"
	"Zhongshan City Rural Revitalization Construction Guidelines (Trial)"
	"Zhongshan City's "14th Five-Year Plan" Rural Toilet Revolution Implementation Plan" (Zhong Nong Nong [2022] No. 6)
Talent policies	"Zhongshan City Agricultural and Rural Special Talents Implementation Rules"
	"2023 Zhongshan City Rural Craftsmen Professional Title Evaluation Reform Implementation Plan" (Zhong Ren She Fa [2023] No. 49)

3.1.2 The characteristics of policy supply

In terms of content, the first is administrative guidance. The 2021 "Zhongshan City Leaders' Contact with Characteristic and High-quality Demonstration Village Creation Work Plan" clearly states that characteristic and excellent villages are contacted by city leaders. Under the influence of administrative effectiveness, the villages have formed comparative advantages in heritage protection, financial rewards and subsidies, etc. The second is healthy competition, policy supply tends to villages with good basic conditions and strong willingness to revitalize. Strong villages will first invest funds to carry out ancestral hall repairs, cultural building conservation, etc. to express their own willingness and organizational capabilities. Townships are more willing to recommend villages with strong initiative and high execution to strive for funds. The third is third-party evaluation. Starting from 2022, the Municipal Agriculture and Rural Affairs Bureau will entrust a third-party organization to randomly select villages and communities to conduct rural beauty index evaluation every year, and reward and subsidize the top 8 townships in the monthly evaluation to promote healthy competition in village construction. The fourth is to implement supervision, establish a rural environmental improvement inspection mechanism, report on villages with poor assessment results, and provide additional financial rewards for villages with outstanding achievements.

In terms of system, policy supply is continuously upgraded throughout the life cycle of rural construction, including encouraging the transition from "individual village heritage protection" to "rural heritage belt conservation". Emphasis is placed on correcting the implementation effect, and the "Zhongshan City 2019-2021 Beautiful Rural Construction Project Positive and Negative List" and "Zhongshan City's "Ten Dos and Ten Don'ts" for Rural Construction"" are promulgated to strengthen the management of design units and construction units, and clarify the contents of the positive and negative lists such as protection and repair, protection technology, and farmhouse style control.

In terms of effectiveness, high-effectiveness policies include financial subsidies, process simplification, leadership appointments, protection policies, etc. Medium-effectiveness policies include assessment, fund management, positive and negative lists, etc., which cannot play a decisive role, but have a certain promotion effect on rural construction. Low-effectiveness policies are mainly special policies and talent policies. This type of policy is difficult to directly affect the village level, takes a long time to be effective, and has a low degree of impact.

3.1.3 The problem of Policy supply

On the one hand, rural construction is mainly funded by government investment, and policy supply focuses on the improvement of public space and the protection and repair of public buildings. However, there are insufficient policies on how to mobilize villagers to carry out the renovation of their own traditional buildings, and the operation of houses after repair is insufficient. On the other hand, with the government's continued investment but low returns, Zhongshan City requires that rural construction and heritage protection should focus on self-balancing funds. This has led to the fact that although most villages are facing problems such as imperfect infrastructure, poor architectural style, and heritage in urgent need of rescue repairs, it is difficult for people's livelihood investment to directly generate economic benefits, so the funds for rural revitalization have been greatly reduced, which has also affected the confidence of social capital to be injected into the countryside, resulting in insufficient motivation for rural construction and protection.

3.2 The influence of policy supply on the lived heritage in Yungmark Village

Funding policies are the basis for the protection and revitalization of rural heritage. From 2018 to 2021, Yungmark Village received 55 million yuan in central special funds, 30 million yuan in municipal funds, 15 million yuan in town fiscal funds, 3.6 million yuan in village collective funds, and 650,000 yuan in donations from local elites and villagers, making it the most funded village in the city, and directly promoting the implementation of hundreds of small projects.

Protection policies have laid the foundation for rural heritage protection. Under the guidance of the "Zhongshan City Sanxiang Town Yungmark Village Traditional Village Protection and Development Plan", it is proposed to protect the "mountain-village-field" pattern in an integrated manner to maintain the natural and cultural heritage of the village. In the village, an overall protection framework of "cultural relics (20) + historical buildings (14) + traditional style buildings (16) + historical streets (55) + environmental elements (ancient trees, ancient wells, ancient roads, ancient springs, etc.)" is constructed.

Process policies have improved the efficiency of heritage protection and repair. Based on the simplification of rural small-scale project processes, Yungmark Village has repaired two cultural relics protection units represented by Zheng Guanying's former residence, and Dongxuan Zhenggong ancestral hall, three general immovable cultural relics, five historical buildings, and 40 traditional buildings. It has also rectified more than 40 inharmonious buildings around cultural relics and historical buildings, renovated 17 historical lanes, improved six public spaces represented by Yungmark Art Square, built a new tourist parking lot, and rectified two water systems, Zhongzhu Sewage Channel and Qianyang River (Figure 3). As they felt the benefits brought by the improvement of the implantation of business functions, some villagers began to change their mindsets and agreed to renovate their houses, which in turn pushed governments to increase investment in rural construction. Eventually, the village collective invested in Zhongshan Yonghui Cultural Tourism Investment Co., Ltd. and Zhongshan Yonghe Cultural Tourism Development Co., Ltd., promoting the entry of social capital and forming a virtuous circle.

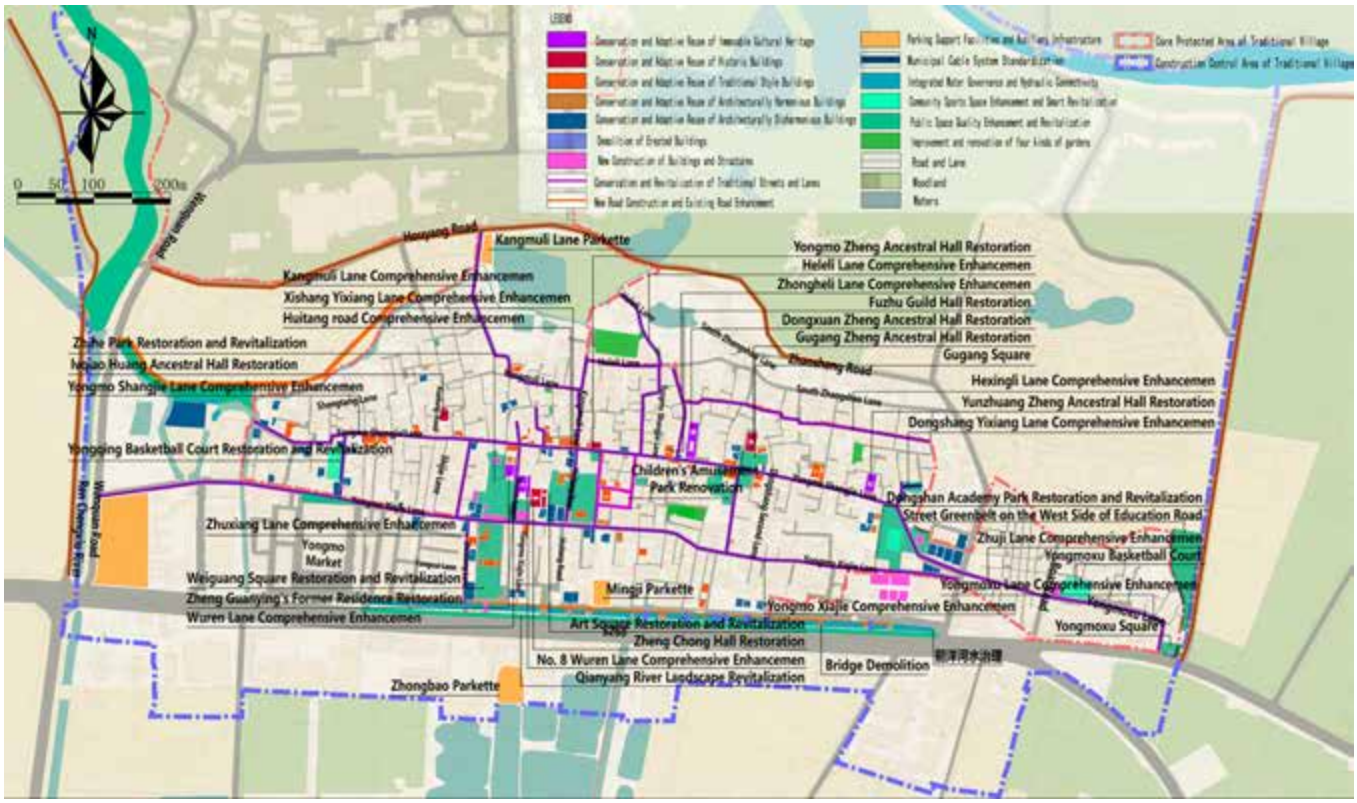

Figure 3: Distribution map of construction Project in Yongmo Village
Picture source: self-drawn by the author

Incentive policies played a guarantee role. Through the appointment of the then municipal party secretary and the appointment of the leaders of the municipal/town agriculture and rural bureau as the village's first secretary, Yungmark Village opened up a communication channel directly from the village to the municipal level, effectively ensuring the implementation of funds and the advancement of project review.

3.3 The effect of protection and inheritance of lived heritage in Yungmark Village under rural governance

3.3.1 Multi-subject participation: to achieve multiple governance of "co-consultation, co-operation, co-management"

"Co-consultation" is to build a village-level discussion platform for the government, village committee, enterprises, designers, villagers and other parties. Through a multi-party co-discussion meeting, the protection and renovated project will not be started until the villagers all agree. "Co-operation" is to encourage social groups to participate in the promotion and operation of Yungmark. Since 2018, Yungmark Village has held more than 200 art performances, Cantonese opera cultural evenings, etc., vigorously promoting the cultural card of village. "Co-management" is to implement rural house style control for buildings that have not been included in the protection system, and put forward the five styles of rural house style guidelines to provide design guidance for

villagers to renovate their houses by themselves (Figure 4). The mechanism has greatly promoted the continuation of the "use function-cultural expression-community connection" of living heritage.

Figure 4: The five styles of rural house design style guidelines
Picture source: self-drawn by the author

Continuation of the use function: the renovation of the Yungmark ancestral hall is a typical case. Before the renovation, the ancestral hall had been vacant and abandoned, and part of it was demolished and occupied by villagers. Whether from the perspective of heritage or life, the function and space conversion should be given priority. To this end, the renovation took the following measures: 1) The village collective negotiated with the villagers who occupied the ancestral hall to demolish the houses and formulated a proper resettlement plan. 2) Encourage villagers to donate money to achieve "self-repair of the ancestral hall ", which guaranteed the funding needs. 3) According to historical photos, the ancestral hall was repaired to reproduce the damaged and covered historical information to continue the original function, continue the functional positioning of the ancestral hall as a public space in the village, and transform it into a cultural space that is currently lacking in rural areas (Figure 5).

Figure 5: Before-and-after comparison pictures of the Yungmark ancestral hall 's renovation
Picture source: Photographed by the author

Continuation of cultural expression: The changes in heritage include tangible and intangible parts. The former is the material space, and the latter is festivals, customs, and beliefs. The two are interdependent as a unified whole. The renovation of the surrounding area of Zheng Guanying's former residence well presents the process of cultural transformation and derivation: with the concept of "amber", the historical deposits of each stage are protected, including the restoration of the private school (Xiaoxi Zhenggong ancestral hall) based on the old photos provided by the villagers in 1980, and the preservation of some of the interior walls and corridors of the Yungmark Primary School classroom. The memory of the old and middle generations is continued (Figure 6).

Figure 6: Before-and-after comparison pictures of the renovation
of the surrounding area of Zheng Guanying's former residence
Picture source: Photographed by the author

Community connection and continuation: The Nara Authenticity Document states that the responsibility and management of heritage should belong to the heritage community. The residents of the heritage site and their communities are both creators and users of heritage. The restoration of the Fengshui Pond in front of the Overseas Chinese Building embodies this spirit. The vacant land on the south side of the Overseas Chinese Building was originally planned to be transformed into a village square, but during the construction process, the surrounding villagers proposed to change the design based on their childhood photos and memories of the "pond" and "pondside granite". In the end, the design party, the construction party, and the village collective adjusted the plan on site to restore the old pond environment and realize the connection between the site and the villagers' memories (Figure 7).

Figure 7: Before-and-after comparison pictures of the restoration of the Fengshui Pond
Picture source: Photographed by the author

3.3.2 Whole process coordination: "planning-design-construction-operation" overall coordination
The rural revitalization chain is improved through four steps. At the planning level, the short-term and long-term implementation plans for the protection and revitalization of village heritage are clarified from the perspective of the entire region and all time periods, the bottom line of protection is formulated, and the recent project library is delineated. At the design level, the villagers are encouraged to design together, and designs are carried out for the urgent problems of the villagers. At the construction level, the design party and the construction party visit local old craftsmen and use traditional craftsmanship to repair the ancient village. At the operation level, it is to mobilize the villagers to combine self-operation with the introduction of social capital. At present, the repaired traditional style buildings have introduced rural operation formats such as "Winter Melon Pastry", "Macau Bakery", and "Yungmark Pub ".

3.3.3 Dynamic sustainability: Improving the value realization mechanism of rural heritage resources
The residential houses, ancestral halls, streets, squares, and farmlands formed by the spontaneous growth of villages are important components of rural heritage resources. The positive cycle of "rural heritage → rural assets → rural capital → rural funds → reintegration of rural heritage" promotes the dynamic sustainability and spiral rise of rural heritage protection. However, as a highly autonomous self-growing settlement, the property rights of houses in the village are mostly dispersed among the villagers, which makes it particularly difficult to transform rural heritage into rural assets. The degree of realization is highly related to the collective willingness and governance capacity of the village collective. In the practice of Yungmark Village, the village collective first counted the "rural resource list", including village collective properties, long-term rented private houses, overseas Chinese houses that can be managed, and farmlands that can be operated. Secondly, the village head led the team to carry out house collection and storage. This process involves multiple aspects such as ownership determination, transfer of use rights, resale of operating rights, and agreement on income rights. In the end, nearly 40 dilapidated houses and ownerless houses were collected and stored. The rural heritage resources collected within a certain period of time were packaged again, and rural assets were formed through joint ventures/self-operation. The capital income generated after the capital entered the market was reinvested in the next round of resource integration. This cycle process ensures the asset appreciation of rural heritage and obtains the support of villagers.

4. Relevant suggestions on improving the protection and inheritance mechanism of China's rural living heritage
4.1 Improve the regional resource survey mechanism
At present, rural heritage listed in the framework of historical and cultural villages, traditional villages, cultural relics protection units, and historical buildings is strictly protected by law, but there are still a large number of rural heritages with typical value not included in the list. Take Zhongshan City as an example. Among the 300 villages with protection value, there is only one national historical and cultural village and seven national traditional villages. This has led to the possibility that other villages may be demolished during the urbanization process due to the lack of a protection system.

First, the survey mechanism needs to be improved. Through the joint efforts of multiple departments, use remote sensing, drones and other technologies to form a digital record chassis to take stock of the village's architectural style, property ownership, and intangible cultural heritage. Secondly, the property rights mechanism also needs to be improved. Villages with better property rights collection are similar to "rural clean land", which makes it easier to carry out asset confirmation, transfer of operating rights and income distribution, and reach a consensus. It is necessary to strengthen the relevant policies on property rights collection and land preparation, and provide policy guarantees for the participation of multiple subjects. Finally, the survey conclusions will be used as an important reference for the revision of the protection plan, and according to the principle of "protecting everything that should be protected", the work from resource surveys to resource protection will be effectively promoted.

4.2 strengthen the design of top-level protection and activation policies

On the one hand, firstly strengthen the bottom line protection. Under the institutional framework of "historical and cultural city-historical and cultural town-historical and cultural village", add the "Historical village" level, including villages that do not meet the conditions for inclusion in the historical and cultural village but have relatively rich heritage into the "traditional village". The protection and development of " Historical village" should formulate special contents for historical and cultural protection, delineate historical and cultural protection lines, and clarify positive and negative lists. In recent years, Zhongshan City has promulgated 79 traditional villages, promoting the protection of rural areas throughout the city at the overall level. Secondly, Improve the listing mechanism, promote the implementation of the "rural traditional architecture" system, and "rural traditional architecture" will be listed by the village collective to protect the village from the bottom up. Taking Yungmark Village as an example, a total of 52 traditional buildings in Yungmark Village have been listed, and has promoted the formation of village cultural cognition community.

On the other hand, strengthening heritage revitalization requires vigorously promoting the supply of rural operation policies, stimulating multiple participating entities to jointly operate rural heritage through a diversified policy package, and improving the construction of rural asset operation mechanisms. From the experience of Yungmark Village, although state-owned enterprises have carried out rural heritage operations, the operating quota accounts for a relatively low proportion of the overall asset, and rural operations are difficult to become a key area of concern for state-owned enterprises. Instead, they are more about completing administrative tasks in accordance with municipal requirements, which leads to insufficient innovation in rural operations, insufficient flexibility, and difficulty in making dynamic adjustments to the operation content according to actual conditions. Although villagers actively participate, their operational capabilities are not strong, their sensitivity to the market is not high, and there is a lack of preferential policy support to encourage private capital investment. In addition, the policy mechanism for investment promotion and operation is not sound. Public welfare projects such as the Zheng Guanying Life and History Museum invested by the government are operating well, but there is no clear business access list and attraction mechanism for the architectural heritage that is rented out to the public, making overall operation difficult.

4.3 Enhance the Role of Village Collectives through Governance-Oriented Mechanisms

First, reconstruct the dominant position of village collectives. Strengthen the organizational capacity of village collectives in heritage protection, such as establishing a compilation team led by the collective, organizing villagers to participate in the compilation of oral history and the collection of old objects, and activating the enthusiasm of villagers to participate in governance. Clarify the legal responsibilities and rights of village collectives in heritage protection, such as giving village collectives the right to supervise the repair of traditional buildings, and requiring them to cooperate with the government to complete the heritage census and registration, forming a power and responsibility system of "government guidance and village collective implementation".

Second, formulate protective village rules and regulations, incorporate heritage protection into the framework of villagers' self-governance. Taking Yungmark Village as an example, the government timely incorporated the village appearance management requirements into the village rules and regulations, and regulated the control of building height and volume, maintenance of public facilities and green environment, protection of natural resources and cultural heritage, control of building style and parking management, etc., to improve the self-supervision and self-management level of villagers' self-built houses.

Third, realize the multi-governance of city-town-village planners-public. incorporate village collectives into the assessment system for protection effectiveness, evaluate their organizational capabilities, villagers' participation and other indicators through third-party institutions, and link the results with policy support.

4.4 Improve the dynamic protection-update feedback mechanism

The inheritance and development of rural living heritage is a continuous evolutionary process, which requires policies to respond to actual rural problems and stage goals in a timely manner and establish a dynamic response mechanism. A policy evaluation action group should be established to track the entire process of policy implementation, build a rural construction implementation indicator system, and conduct policy implementation evaluations at half-yearly time nodes. Provide timely feedback on areas where policy implementation effects are not as expected or even have negative effects, and formulate the direction of policy adjustments. For policies with good feedback, trace the specific paths of policies to promote rural construction, explore whether they have universal value and the possibility of being promoted to more villages. Key issues should be discussed through villager discussions, expert consultations, and other methods to explore solutions and fill policy gaps in key and difficult areas.

It is also necessary to realize that the inheritance and development of rural living heritage is not a campaign-style behavior that can be achieved overnight, and policy supply must be consistent and sustainable. The effectiveness of policy supply cannot be measured solely by investment returns. Rural protection and development is a long-term incubation process that needs to respect its objective laws. Rural policy supply should also play a long-term leading, corrective and supervisory role.

4.5 Establish a supervision and inspection mechanism

Firstly, emphasize the self-supervision of the village collective and villagers. The village collective assumes the daily supervision responsibility, organizes villagers to participate in heritage protection inspections, coordinates conflicts of interest among multiple parties, and improves the self-supervision and self-management level of villagers' self-built houses.

Secondly, improve the incentive and accountability mechanism. Responsibility binding: link the supervision results with the performance evaluation of village cadres, and clarify the statutory responsibilities of the village collective in heritage protection. Villager participation incentives: encourage villagers to actively participate in supervision through the points system, honorary awards, etc., and enhance their subject awareness. The third is to improve the supervision methods and technical means. Digital monitoring: Use remote sensing, drones and other technologies to establish a digital monitoring platform to record the status of heritage protection in real time.

5. Conclusion

Based on the inheritance of rural living heritage, this paper constructs a theoretical model of "rural governance-policy supply- protective activation ", and conducts an empirical study using Yungmark Village in Zhongshan City as an example. The study found that the protection and revitalization of rural heritage is driven by both the external influence of policy supply and the internal role of rural governance. The integration of rural heritage protection and revitalization into the rural governance helps the effective implementation of policies. First, as a top-down intervention, policy supply is prone to "failure" when facing villages with endogenous logic and governance order. It is necessary to fully respect the contractual spirit and clan ties of Chinese villages, consider the important role of collective economic organization relations in rural governance, give play to the core role of village collectives in rural building property rights identification, village rules and regulations, and building repair coordination, and formulate policies from the perspective of activating the endogenous organizational strength of villages. Secondly, protective activation is a dynamic maintenance process, which requires multiple dimensions such as improving the heritage survey mechanism, improving the protection mechanism, and establishing a supervision and inspection mechanism to achieve heritage protection throughout the life cycle.

Compared with cultural relics and historical sites, China's research and practice on the protection of rural living heritage is still in its infancy. The key lies in how to coordinate the collaborative relationship between the government, village collectives, and villagers in heritage protection. Limited by the research object, this article focuses on the practical content of the protection of the material space of Yungmark Village. Further follow-up

observation is needed on how to further enhance the social autonomy of villagers and form sustainable heritage management. At the same time, given the significant differences in heritage characteristics and protection conditions in various parts of China, existing protection experience and methods may not be applicable to other regions. Therefore, how to establish an effective demonstration promotion mechanism and form a heritage protection system suitable for China's national conditions needs further discussion. observation is needed on how to further enhance the social autonomy of villagers and form sustainable heritage management. At the same time, given the significant differences in heritage characteristics and protection conditions in various parts of China, existing protection experience and methods may not be applicable to other regions. Therefore, how to establish an effective demonstration promotion mechanism and form a heritage protection system suitable for China's national conditions needs further discussion.

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A Critical Ethnographic of Ziddi Feminist Socio-Spatial Practices in a Modern-Mohalla of Islamabad

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GLOSSARY OF TERMS

The following is a list of terminologies and their meanings used for this research, which stem from my mother tongue, Urdu.

Abbu- father
Bazaar - marketplace
Biryani - local Pakistani food
Behn-chara – sisterhood
Chacha - uncle
Chitai – floor mat
Chut – rooftop
Dhaba – informally built tea stall/shop
Gaon - village
Ham saygi- neighbourly relations
Islamabadi – belonging to the city of Islamabad
Jirga – elderly tribal group
Katchi gali – unbuilt footpaths
Mohalla – neighbourhood, community
Mohalla Dari – neighbourly relations, communal ties
Nalkiyan – thread reels
Pashtun/Pathan – people from the province of Khyber Pakhtoon Khawa in Pakistan
Purdah – privacy maintained by Muslim women
Punjabi – people from the province of Punjab in Pakistan
Quran Khwani- a Muslim traditional ceremony marking the completion of the recitation of the Holy Quran.
Saalan – curry
Sehn – courtyard
Urdu Speaking – people from the province of Sindh in Pakistan.
Ziddi – to be stubborn

Abstract
This research conceptualizes the "Modern Mohalla" in a post-independence Pakistan to explore the interrelatedness of feminist 'Mohalla-Making practices' and formal urban planning in Islamabad's G-9/2 Government Housing Quarters. The study investigates the lived experiences of subaltern women through a critical ethnographic methodology, including interviews and visual translations of spatial practices. The research addresses the systemic exclusion of women from the design process of Islamabad and the Government Housing quarters, feminist spatial discourse, and archival data about feminist lived experiences. By engaging with Doxiadis' theory of Ekistics, the study further interrogates its potential alignment with feminist Mohalla-making practices. Ultimately, the research aims to develop a historiographical feminist dialogue that highlights unacknowledged female communal networks within a socially stratified and patriarchal urban context.

Keywords: Informality, Modern Mohalla, Mohalla-making practices, feminist spatial practices.

Introduction

At the turn of the mid-20th century in Pakistan, in between the post-war era of 1965 and the two-decade-long rush of the Great Partition, which occurred in 1947, Islamabad came into being as a modern bespoke metropolitan city designed by a foreign architect, Doxiadis. Planned, seemingly clean, and equipped with an organized infrastructure and abundant recurring green spaces amidst a strictly orthogonal street grid, Islamabad post-independence was designed on the concept that symbolized unfettered growth. As Hull (2012) explains, while designing the communal structure of Islamabad, Doxiadis believed in the homogenizing of neighbourhoods

based on their income brackets, thereby employing a bureaucratic approach of socially stratifying the city. This research examines how this approach has impacted the socio-cultural construct of neighbourhoods in Islamabad today by exploring the community's spatial practices within a socially stratified Class-IV low-income[1] 'Modern Mohalla' in the Government Housing Quarters of G-9/2, Islamabad. It seeks to investigate this theme by identifying and studying female lived experiences and their informal 'Ziddi' socio-spatial appropriations in this neighbourhood.

As this research is grounded in the absence of female representation in a communal structure, it examines the lack of designed feminist spaces within a Mohalla of Islamabad that have inevitably given an impetus to 'radical' Mohalla-making practices as recorded via the oral testimonies of the female participants as a part of the research methodology. Introvert spaces that are reflective of the Islamic cultural construct of feminist spaces in a Mohalla, since the time of the Mughals within the subcontinent, in the form of interior courtyards, rooftops, and balconies, are studied as unrealized spaces of the Modern Mohalla. Therefore, addressing this absence of feminist spaces and their reclamation by establishing a deeper ethnographic dialogue with the 'other', as Madison (2020) suggests, the concealed spaces of feminist appropriation that are being explored in this research are imperative to comprehend the complex socio-spatial structure of the Mohalla. The research further grounds itself in De Certeau's (1984) theory of 'strategies', which is associated with Doxiadis' role as the omniscient master planner of Islamabad's communities versus the innate 'tactics' developed as a response by the female residents of the Modern Mohalla. This research seeks to explore this hypothesis while reflecting on the oral testimonies of the female participants as a part of the research methodology.

When one explores Islamabad's existing literature and archival history to address this research inquiry, one notices a glaring gap in the documentation of its people's rich and complex lived histories, particularly women, and their relation with the built environment through their communal practices. Historians and academics like Doxiadis, Daeschel (2015), and Hull (2012) have focused on Islamabad's urban design and policymaking, often highlighting statistical aspects of the city's master planning process. Other scholars, such as Moffat (2024), examine housing communities like Anguri Bagh in Lahore but overlook the female lived experience. Similarly, female author Moatasim (2023) discusses informal slum settlements in Islamabad but fails to capture the role of women in shaping these informal urban spaces, particularly concerning their communal norms. This research fills in this gap by aiming to highlight and call out the paradoxical situation where female representation and their lived experiences in these important informal urban spaces are completely hidden in formalized modernist settlements. By revealing the informal feminist spatial practices of the women in the 'Modern Mohalla' of G-9/2 as an acknowledgment of the female presence in Islamabad's communal structure, which is otherwise buried beneath the profession of their spouses, this research aims to highlight and record the unrecorded qualitative aspect of the female contribution to the community's socio-spatial relationships as a part of the Mohalla culture.

Furthermore, this research examines how Doxiadis' urban planning for Islamabad, specifically in the Modern Mohalla of G-9/2, manifests in the neighbourhood. While the city is considered well-planned, the study reveals that true community diversity is only evident through the women's oral histories. It questions the impact of Doxiadis' design on fostering mixed communities and explores how women's roles in the Mohalla contribute to feminist practices in a patriarchal context. This study, due to time constraints, will not be studying Islamabad as a whole but will focus on one 'Modern Mohalla'/neighbourhood in G-9/2 to investigate how Doxiadis' designs are manifested at that level. It also explores the Modern Mohalla's untold realities by examining its historical formation in the South Asian context by linking Doxiadis' Ekistics theory to the communal structure in G-9/2. It highlights gaps in feminist representation in the original planning and how women's lack of participation has influenced informal Mohalla-making practices. Analysing these practices through Hook's (2021) 'Homeplace' theory, this study looks at how women celebrate 'Behen-chara' (sisterhood) while reinforcing their roles in a patriarchal society. The research also views these feminist practices as a post-colonial space for marginalized women, aiming to bring attention to their previously overlooked lives within the Modern Mohalla's socio-urban fabric.

As its research methodology, this research engages with an ethnically diverse set of women living in the Government Housing Quarters of G-9/2 via interviews to develop a critical ethnography of their lived histories

1 Doxiadis classifies this neighbourhood as Community Class IV. A systemic classification of communities was established for Islamabad where 20,000 to 40,000 people of the same income bracket in the government sector dwell together.

as drawings supported by calligraphic commemorations of their oral testimonies. By applying Tayob's (2018) methodology of drawing as a research tool to study and portray subaltern feminist Mohalla-making practices, this methodological approach seeks to respect their privacy and maintain their anonymity, which is an integral part of their Islamic culture. The oral testimony of the female participants is collected, which informs this research inquiry of how the historical socio-spatial values are at risk of being lost and can be recovered by deciphering their Mohalla-making practices. Drawing as a tool for ethnographic research is used to shed light on the absence of female subaltern representation within the archival and critical historiographical forefront of Islamabad. This methodological approach illustrates the role of women, namely **Umaima and Laiba[2],** in this Modern Mohalla as historical actors, communal leaders, and autonomous social visionaries. Drawing as a research tool in this research paper foregrounds the participants' privacy under Glissant's theory of opacity, whereby the documentation of feminist lived experiences does not need to be seen via the Western lens of explicit transparency.

The History Of Mohallas And Their Rite Of Passage Into Islamabad

This section discusses the intersectionality between Mohallas and modernist planning principles in post-independence Islamabad. It underlines the historiographical context of the Mohalla in the context of South Asia and proceeds to examine how Mohallas exist today in Islamabad as an innate means of informal spatial appropriations within a modernist built environment. To trace the Mohalla's rite of passage into the planned city of Islamabad as a socio-spatial concept, understanding its relationship with Rawalpindi is integral, as they are like 'two peas in an urban pod'. This chapter explores the intersectionality between Islamabad and Rawalpindi and how the latter acts as a permeable membrane for the conceptual diffusion of a Mohalla as a spatial practice in Islamabad's modernist neighbourhood structure.

The concept of the Mohalla, a community space rooted in Pakistani culture, has persisted since before the 1947 Partition and remains a significant socio-spatial practice. It originated from Muslim immigrants who carried these traditions to Pakistan, reflecting a shared history with pre-partition India. Historically, Mohallas evolved through different regimes, including the Mughal and Colonial eras, shaping subaltern communities' social, cultural, and economic dynamics. Originally autonomous, family-centred, and grounded in Islamic practices, Mohallas now appear as 'cloaked' neighbourhoods in modern cities. They balance private family life and the public sphere, with a focus on social celebrations and communal activities, especially observed during the Delhi Sultanate. The legacy of Mohallas is seen as a form of traditional social cohesion across generations. In Islamabad, the influence of modern planning as implemented by Doxiadis reshaped the Mohalla structure via informal Mohalla-like spaces, persisting particularly among migrants from Rawalpindi. This research explores whether these spaces are a result of deliberate urban planning or a continuation of historical socio-spatial practices. Existing literature about post-independence Islamabad conceptually situates the rite of passage of Mohallas into Islamabad by analysing its complex relationship with Rawalpindi (Figure 1), a much older and colonized city by the British. When designing Islamabad, Doxiadis' initial study about the science of the human settlement in Islamabad can be argued to have been from a broader perspective, where Hull (2012) explains he was required to treat Islamabad and Rawalpindi as a dual force that progressed simultaneously. However, the reality was far from different as Islamabad was designed and actualized in complete isolation from Rawalpindi for not only making administration and surveillance convenient but, also formulating a city that had a tailored, modernist, and socio-economic hierarchal approach regarding its master planning and was thus not similar in its outlook to the dense and complex layout of Rawalpindi. Daeschel (2013) expands on this further by explaining that Islamabad was conceived as a prototype of a subjective 'vernacular modernism' through a Westernized lens, whereby the previously discussed Islamic identity of its residents was sidelined. Thus, this resulted in spaces that locals were not acquainted with, and so they appropriated them as per their needs. For Doxiadis, this was an innate quality that could be preserved by the community members autonomously on a micro-level, which is the argument this research paper seeks to make through the feminist Mohalla-making practices and spatial appropriations in the Government Housing community of G-9/2.

2 All names of participants for this research have been anonymized.

Figure 1. View of the Mohalla settlement around the main Murree Road in Rawalpindi. Source: Pindi Heritage Tours

As shown in the archival images below (Figures 2 and 3) Daechsel (2013), concerning the Master plan of Islamabad, writes about how it was intended to project a dynamic growth amidst three distinct areas demarcated in the city i.e. 'the new capital' which was roughly triangular and sat at the base of the iconic Margalla Hills, the Capital Park area which runs north-east to the main Islamabad-Rawalpindi Highway also demarcating the southern end of Islamabad and thirdly planning its expansion alongside Rawalpindi. However, Daechsel (2013) argues that this expansion was not thought of in terms of how it could be a complementary relationship between both cities, therefore revealing a displacement of the socio-spatial practices that reflect the city's modernized communal structure intermixed with their informal practices. Islamabad's physical and historical connection with Rawalpindi is relevant to mention as it conceptually grounds Mohallas and their spatial translation into the socio-cultural fabric of the neighbourhoods designed in Islamabad through the practices of its residents. Accordingly, it is important to question how the Mohalla culture was appropriated into the modernist city through the residents' practices. Even if one assumes that Doxiadis recognized the intricate relationship between Islamabad and Rawalpindi's shared socio-cultural heritage, the absence of implementing it within the actualized master plan of Islamabad is observed through the informal feminist spatial practices revealed further.

Figure 2: Model Projection of Islamabad based on Doxiadis plan (conceptual)
Sourced from CADA: Archive Files: 17666 as found in Daechsel, Markus. Islamabad and the Politics of International Development in Pakistan. Cambridge: Cambridge University Press, 2015.

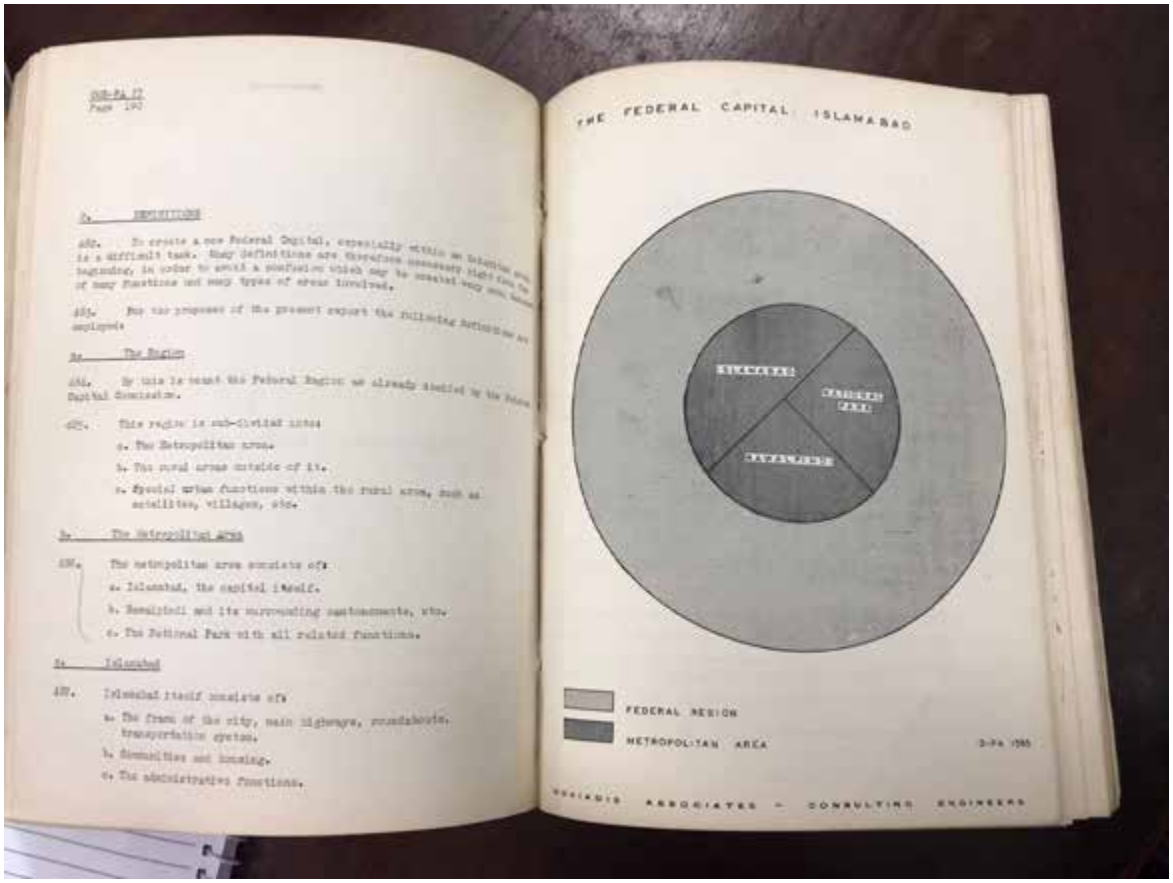


Figure 3: This image is from my visit to the Capital Development Authority Library's informal archives, which exist in the basement of the Water and Tax Revenue building in Islamabad. As the diagram in this image shows (RHS), Islamabad was meant to be conceived as a whole with Islamabad and Rawalpindi in geographical proximity, but was never actualized. Source: Doxiadis Associates Reports Developed for Islamabad Master Planning Project: DOX-PA 77, pp.190-191.

Despite this strategic separation, the idea of a Mohalla has been carried forward to Islamabad by the residents of Rawalpindi and other rural regions of the country who have migrated to Islamabad. As they keep commuting to Rawalpindi to purchase goods and visit families settled there, the socio-spatial practices are migrating between the two cities through the movement of the people. Doxiadis organized each residential sector with a sense of hierarchy in Islamabad, as illustrated in Figure 4 below, showcasing a strict modernist iron grid in which the communities were allocated based on their income and profession, of about 20,000 to 40,000 people. This modular and utilitarian design was focused on achieving quick and better visual results, not resembling the informality of a Mohalla, especially those of Rawalpindi, that the state leaders felt necessary to exhibit for the Western Powers who had invested in this project, namely the USAID and the Ford Foundation (Daeschel, 2013). In contrast, the so-called 'Ballet of the Street', which Jacobs describes as the surfacing of ethnically vibrant communities in homogenous neighbourhoods, is now observed within the spatial zoning of Islamabad, thereby anchoring the stark visual differences within the formal and informal urban spaces that are a by-product of complex unplanned communal structures of its people.

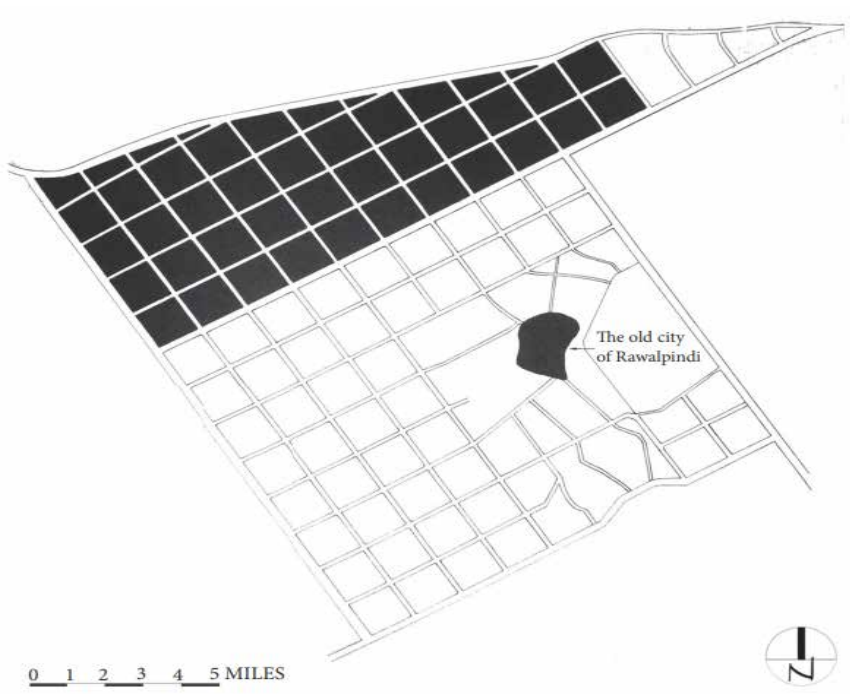


Figure 4: Conceptual plan for the iron-grid development/master planning for Rawalpindi (in white), which was meant to coincide with the planning scheme for Islamabad (in black) but never actualized. Sourced from Moatasim, Faiza. Master Plans and Encroachments: The Architecture of Informality in Islamabad. Philadelphia: University of Pennsylvania Press, 2023

Figure 5: Elevation of the Government Building Blocks from the courtyard. Source: Author

The Government Housing Quarters were one of the first building typologies within Islamabad that were proposed by the Capital Development Authority to be built separately from the surrounding residential zones of their respective sectors[3]. The government housing quarters in G-9/2 were constructed in the early 80s, a little after Islamabad was established. With sixteen of these apartment blocks in the vicinity, they house a hundred living quarters each, where six to ten family members reside in one living quarter on average. The Government Housing Quarters in G-9/2 portray a socially stratified community of low-income families of government servants who reside here based on their income bracket (Community Class IV[4]) as predetermined by Doxiadis via his spatial zoning for the city. This planned stratification, as explained by Yanagisawa and Funo (2018), is reflective of the historical practice of formulating the social structure of the Mohalla based on the caste of its residents, an administrative practice originating from the Delhi Sultanate. Similarly, this is also observed as a modernist urban principle of social planning pertinent within the Mohalla of G-9/2, whereby the creation of a community, as Moatasim (2023) explains, is accomplished via the spatial bundling of low-grade government servants in a mid-rise vertical building exclusively. The socio-economic indicator of the residents in a vertical settlement here is being given precedence as a factor in establishing a neighbourhood demographic rather than dealing with intermixed communities based on their religion or ethnicity. As Daeschel (2013) explains, the insulation of the government servants from the wider society, despite being an issue that had been present since the colonial regime and even in Rawalpindi, posed itself as a newfound socio-spatial issue for Doxiadis. To avoid this issue, lower-income families were mainly housed in the rectilinear G sectors of Islamabad due to their proximity to their workplaces (industrial and government workers). It can be suggested that this was done to preserve the social stratification and keep at bay the potential ties of kinship between neighbourhoods that could otherwise consequentially threaten the social and bureaucratic hierarchies (Hull, 2012) that Doxiadis was asked to maintain categorically while designing Islamabad independently from Rawalpindi, as discussed earlier. The Government

3 The whole metropolitan area is subdivided into sectors, called Communities Class V, each for about 20,000-40,000 people and each according to the income group it will serve. The sub-division of the metropolitan area into sectors resulted from the adoption of a pattern of principal roads placed 2,200 yards apart in both- directions.

4 Each sector in Islamabad is named after an alphabet with subsequent subsectors denoted by numerals. So for Sector G, subsequent sectors are G-9/2 onwards.

Housing Quarters in G-9/2 on the surface level appear as the act of 'ghettoising of civil servants' in a designed colony of Islamabad. On the contrary, this act of 'ghettoisation' has further sparked an informal Mohalla-esque character that seems to remain imbibed inherently within the practices of the women of these government quarters in G-9/2 and is thus further explored through the documentation of female lived experiences.

Radical Rooftops

This section, through the lived experiences of the female participants, explores how their Mohalla-making reveals informal socio-spatial relations in a modernist housing community that has not been documented before. Their oral testimonies depict the rich and paradoxically heterogeneous nature of the communal fabric within the formal modernist built environment they reside in. As a post-colonial city planned on modernist design principles that did not aim to spatially replicate the essence of a Mohalla within its master plan or modernist housing complexes realized later, the memories and oral histories of the female participants in this research being collected seek to substantiate the argument that a Mohalla is indeed an intrinsic socio-spatial propeller of cultural relations in the modern-day neighbourhood of Islamabad.

Figure 6: A Kameez, which Umaima has tailored and brought to the interview. Source: Author

' I stitch for the women here... I also have clients from Rawalpindi, my previous home... Sania's *Libas*...I made it for her.'

Umaima is the Mohalla seamstress. She has the gift of creating a tangible product, i.e., Libas (Figure 6), that marks the intangible heritage of the shalwar kameez, the national Pakistani dress. As a housewife with a family of five living in a two-bedroom apartment, she migrated from Rawalpindi to these government living quarters with her husband.

'...Rawalpindi was nice... but too busy... people were too nosy. I like it here...'

For Umaima, migrating from Rawalpindi to Islamabad has been a breath of fresh air. She feels content with the order that the Mohalla brings to her lifestyle. The complexity of the Mohalla in Rawalpindi, where she resided previously, was far too overwhelming for her.

'...it is easy, commuting by foot instead of hiring a taxi for menial everyday tasks such as purchasing groceries

or buying my *'nalkiyan'* (stitching supplies) from the *'Bazaar'*.. it is across the block, so it is convenient for me...'.

She recalls the richness of the Mohallas of Rawalpindi. Still, she feels more secure in a modernist environment with infrastructure. She has created an introverted yet unconventional feminist node on her building's rooftop, which she can visit anytime without being questioned.

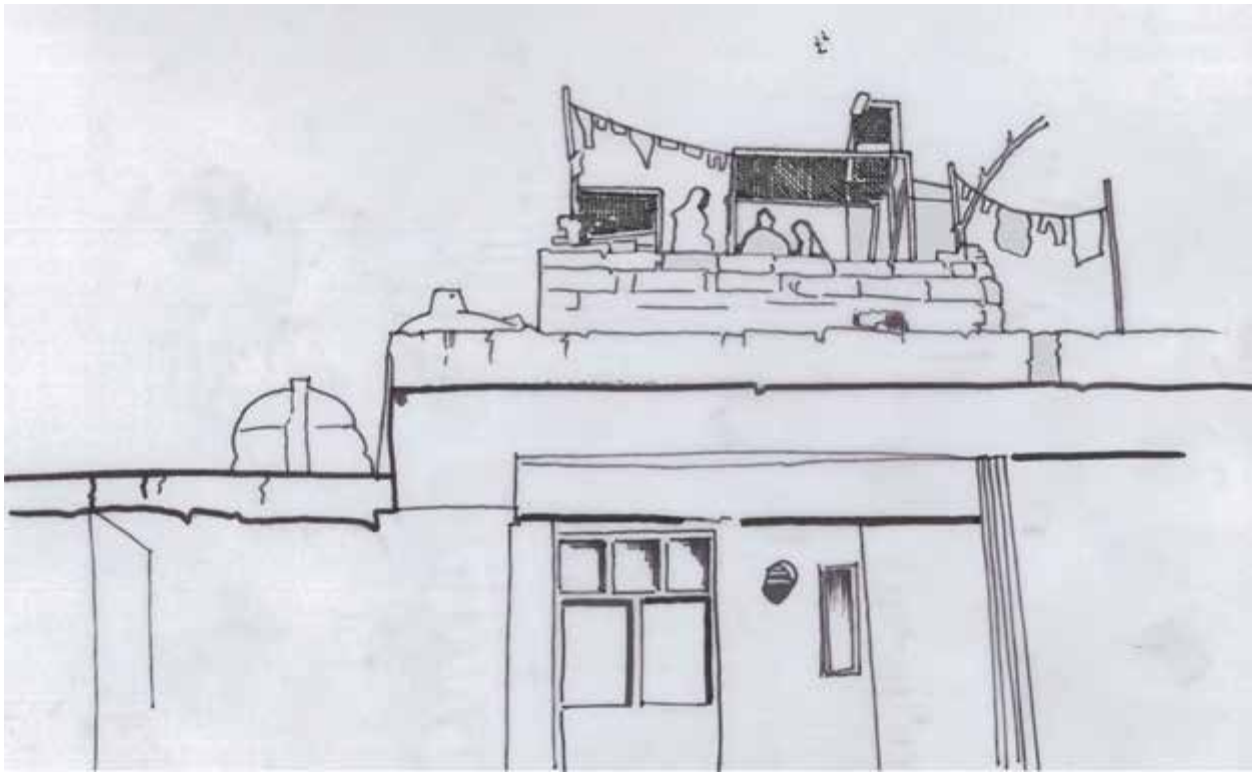


Figure 7: A platform for a 'stickier' social practice in the Mohalla. Source: Author

'...we cannot go freely in public spaces... rooftop was left... so I use the stepladder... my husband doesn't even have a problem...my friends and I get together and go...'

The symbolic approach towards the 'Chut' (rooftop) as communal spaces in Mohallas has been present in the subcontinental region during the Mughal and Colonial periods and also post-partition (1947 onward) in Rawalpindi where rooftops (Yanagisawa and Funo, 2018) were understood to be spaces of congregation that supported commotion, community, and privacy for women.

'...The rooftop for this building block serves the sixteen families who live here, but also draws in women from neighbouring building blocks...'

However, regarding the Government Housing Quarters of G-9/2, rooftops were not designed as inhabitable social spaces, let alone as spaces for women. Due to its concealed accessibility, which is only viable from inside the building via a flimsy stepladder, it gives the women of the Mohalla the freedom to socialize without the 'male gaze', much to the consent of their husbands. Again, one observes the female struggle to secure a space to freely socialize as a radical exercise of feminist communal appropriation, reeling in Hook's (2021) argument of women redefining the domestic realm as an act of social emancipation, yet decrying that this is an act of forced labour for them.

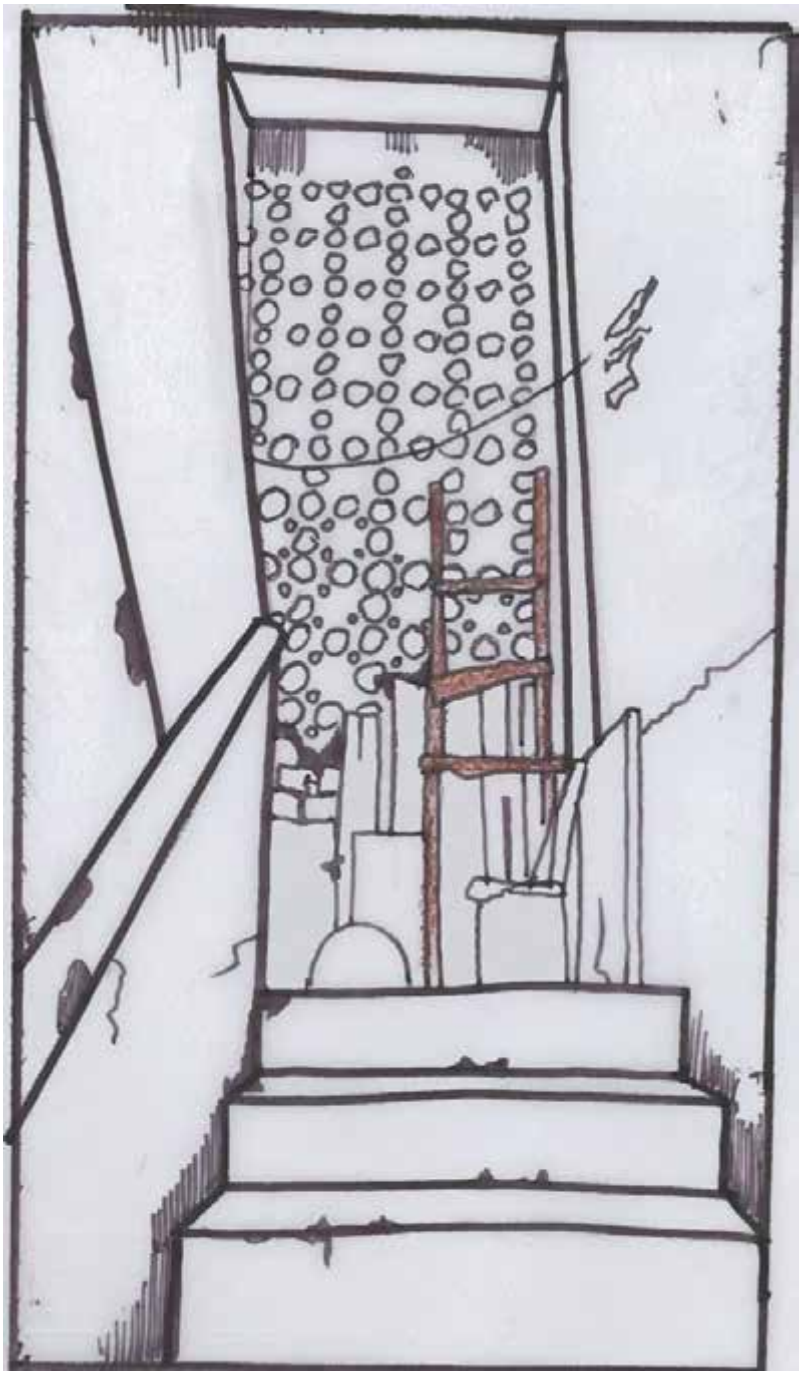


Figure 8: The stepladder used by the women to access the rooftop from inside the building block. This stepladder demonstrates that the roof was not meant to be used in the first place. Source: Author

'...We, the women, gather here in the warm summer evenings and crisp winter mornings... talk about our daily routines, cut vegetables, and babysit... we also have a Quran Khwani[5] here...'.

The association Umaima and her cohort of women living in this neighbourhood have developed with the rooftop while maintaining a sense of purdah through a vertically detached means of communal bonding can be seen as an attempt to reinvent the idea of a Mohalla from Rawalpindi via rooftops, a recurring theme in the majority of the oral testimonies collected. As Gosh (2014) suggests in her scholarly work regarding vertical communities, this

5 A local celebration where people of the Mohalla gather to celebrate a child completion's of reciting the Muslim's book i.e. the Holy Quran.

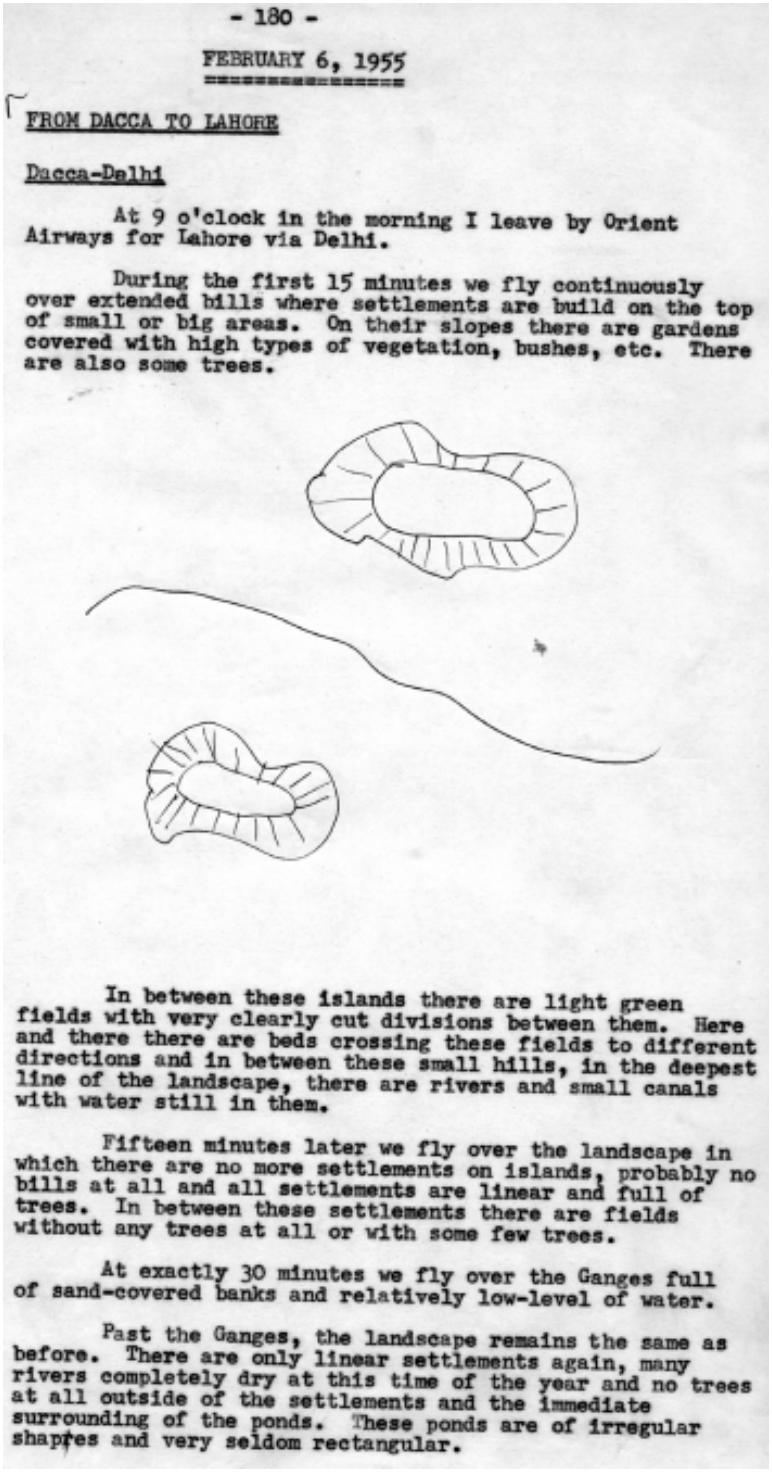
indicates how the Mohalla found its way conceptually into the communal fabric via a collective social practice in newfound spaces, thereby developing a feminist 'stickier dependence' (Gosh, 2014). As shown in Figure 7, the rooftop has been collectively transformed by Umaima and the women of the Mohalla as a usable space, which otherwise was an abandoned building cover.

'We- the women living in this block- get together every month and clean the entire rooftop together... I consider it an exercise for myself...women living on the ground and first floors socialize on the ground level, whereas women living on the second-floor level and above usually visit the rooftops...'

This phenomenon of feminist salvation of rooftops as an act of Mohalla-Making has further enhanced the dynamic and fluid nature of the everyday lives of the women within a Modern Mohalla spatially. This has birthed a unique solidarity among them as the communal exercise of having to clean the rooftop together, lay down a 'Chitai'(mat) to sit on, and then use it to cut vegetables or even counsel each other commemorates the act of coming together in a unique space that is solely for women.

Dissecting Umaima's oral testimony alongside Doxiadis' ideology behind communal arrangements of neighbourhoods in Islamabad, rooftops as feminized nodes in Mohallas are a reflection of the architect/planners 'gaze' that applied aerial visual decoding as a design tool to understand the local culture, as mentioned by Daeschel (2015). As a triptych of vantage points, i.e., De Certeau, Doxiadis, and Umaima, one observes that the authoritative figure envisaging everything from an aerial view can ultimately be challenged through subaltern feminist Mohalla-making practices, even unintentionally. Daeschel (2015) mentions how Doxiadis' surface-level approach to understanding the vernacular cultural context of Islamabad gets lost in translation. This is because, as an architect for a post-colonial city who came across as a 'gora sahab', i.e., white man, Doxiadis, as a Westernized Pakistani planner, planning from above, physically and metaphorically (Figure 9), was seldom challenged by the local Pakistani. Can one suggest that the unforeseen feminist spatial appropriation of rooftops symbolizes a shift in the power dynamic between the makers of 'strategies' and enactors of 'tactics' as an act of feminine spatial resistance?

What is important to acknowledge here is that this unique shift in the standardized relationship between strategies and tactics as defined by De Certeau (1984) has transformed into a radical perspective where women of an Islamabadi Mohalla manage their way up to the rooftops, unintentionally, as the Mohalla-makers of 'strategies' within a community where female appropriation of spaces was not even acknowledged as a part of the overall communal structure. It is an ironic yet critical feminist action to document as it redresses the image of female subaltern identity within the built environment of Islamabad. This intersectionality between the repression and expression of Islamabad's inhabitants and their communal structure today not only transforms the modernist design principles employed by the master planners and architects but also creates diverging poles of interpretation of feminist lived experiences.



- 180 -

FEBRUARY 6, 1955

FROM DACCA TO LAHORE

Dacca-Delhi

At 9 o'clock in the morning I leave by Orient Airways for Lahore via Delhi.

During the first 15 minutes we fly continuously over extended hills where settlements are build on the top of small or big areas. On their slopes there are gardens covered with high types of vegetation, bushes, etc. There are also some trees.

In between these islands there are light green fields with very clearly cut divisions between them. Here and there there are beds crossing these fields to different directions and in between these small hills, in the deepest line of the landscape, there are rivers and small canals with water still in them.

Fifteen minutes later we fly over the landscape in which there are no more settlements on islands, probably no hills at all and all settlements are linear and full of trees. In between these settlements there are fields without any trees at all or with some few trees.

At exactly 30 minutes we fly over the Ganges full of sand-covered banks and relatively low-level of water.

Past the Ganges, the landscape remains the same as before. There are only linear settlements again, many rivers completely dry at this time of the year and no trees at all outside of the settlements and the immediate surrounding of the ponds. These ponds are of irregular shapes and very seldom rectangular.

Figure 9: The romance of aerial surveillance. Aerial topography was sketched and interpreted by Doxiadis in his diary en route from Dacca to Lahore. Seen as a planning 'strategy' used by Doxiadis, this is from one of his diary entries, which demonstrates how he addressed the challenge of master planning in Islamabad from a literal aerial view. Source: CADA: Pakistan vol.4, Diary DOX-PP 40, Jan.–Feb. 1955, p.180 (Archive Files 23556)

Courtyards And Feminized Aerial Occupation

This section discusses the Mohalla's most obvious spatial feature, i.e., 'Sehn' (courtyards), due to its massive scale, amidst an aerial entanglement of washing lines. Courtyards, which have been a symbolic architectural element for Muslim neighbourhoods, in the context of the site, were not intentionally designed for Mohalla-making in

this neighbourhood of G-9/2. They were pieces of barren land connecting the building blocks. Through the lived experiences being studied in this section, one observes how the practice of feminist Mohalla-making redefines the modernist and homogenous socio-spatial construct as well.

The courtyards, or 'Sehn', in the government living quarters of G-9/2 (Figure 10) are key architectural features, historically central to Muslim design for their space, ventilation, and ability to create introverted environments, particularly for women. Each residential block, housing sixteen families, is linked by a large courtyard, serving as a communal area for various activities like weddings, funerals, cooking, and laundry. While courtyards traditionally offer privacy, in this case, they transform into extroverted public spaces, reflecting an unconventional approach to Mohalla-making that encourages communal interaction across blocks.

Figure 10: Aerial view of the Mohalla in sector G-9/2, Islamabad, with courtyards in between housing blocks. Rectangles shown in the middle represent the courtyards in between the housing blocks. Source: Google Maps

Figure 11: The Washing Line Phenomenon of the Modern Mohalla, i.e., the pulley system. Source: Author

Laiba, a Pashtun woman, and her family of six moved to the government quarters from Kohat, Peshawar, when her husband secured a job as a driver for the Capital Development Authority in Islamabad.

'...back in the village, there were open spaces, and the houses were very spacious. My home is much smaller here...'

Her migration to the city has been for the sake of the three holy necessities that she deems as 'electricity, gas,

and water'. She enjoys the richness of this Modern Mohalla with its infrastructure, which was absent back in Kohat. Laiba's chronicle commences with her narration regarding the aerial reclamation of space via 'washing line clusters' and the formation of micro communal friendships based on this. ,

'...These washing lines in the Mohalla are spaces of interaction for us... It is our routine in the morning, after our husband leaves for work, we used to go down to the courtyards... women who put their clothes in the same area... children go to school...we run the machine...also have to put clothes out to dry today...'

The drying of laundry itself is an act of Mohalla-making by the women, illustrating the rich ethnic blend of its residents, where women of all ethnicities congregate to dry their laundry based on which floor they reside on. What adds to the character of this social space within the Mohalla is the authority that different residents from the surrounding blocks exert on the courtyards surrounding the building blocks concerning drying their laundry.

'...We leave our kids with each other and ask for *saalan* (food) from each other.. we cook for each other.. we clean each other's homes (shared spaces like the central staircase and main entrance of the building)...also look out for each other's laundry, we don't fight for space on the washing lines. We don't throw away other neighbours' clothes to dry our own...sometimes it is a problem, so my husband made this for me...'

For Laiba, living on the second floor is problematic. She mentions that the families living on the ground floor feel more entitled to use the space for their laundry compared to the other residents residing on the upper levels. Due to this conflict, many families, like Laiba's and Umaima's, have installed a pulley system from their living room window where they hang their washing lines thereby introducing an alternative 'modern' practice of drying laundry in the Mohalla that transcends the traditional drying occurring at ground level in the courtyards and relieves the 'laundry load' on ground level.

'...my husband does not like me putting our family's clothes on public display in the courtyard downstairs, so he fixed this pulley from my living room window... See, I will show you... Now I hang my clothes here and we do not need to wait for other families like we did before on the ground...'

Umaima's narrative concerning the aerial retrieval of space to avoid conflict with other residents of the Mohalla shows a means of facilitating socio-spatial hierarchies through the Sehn, which is translated as a feminist socio-spatial agency that can assimilate into the aerial space as well.

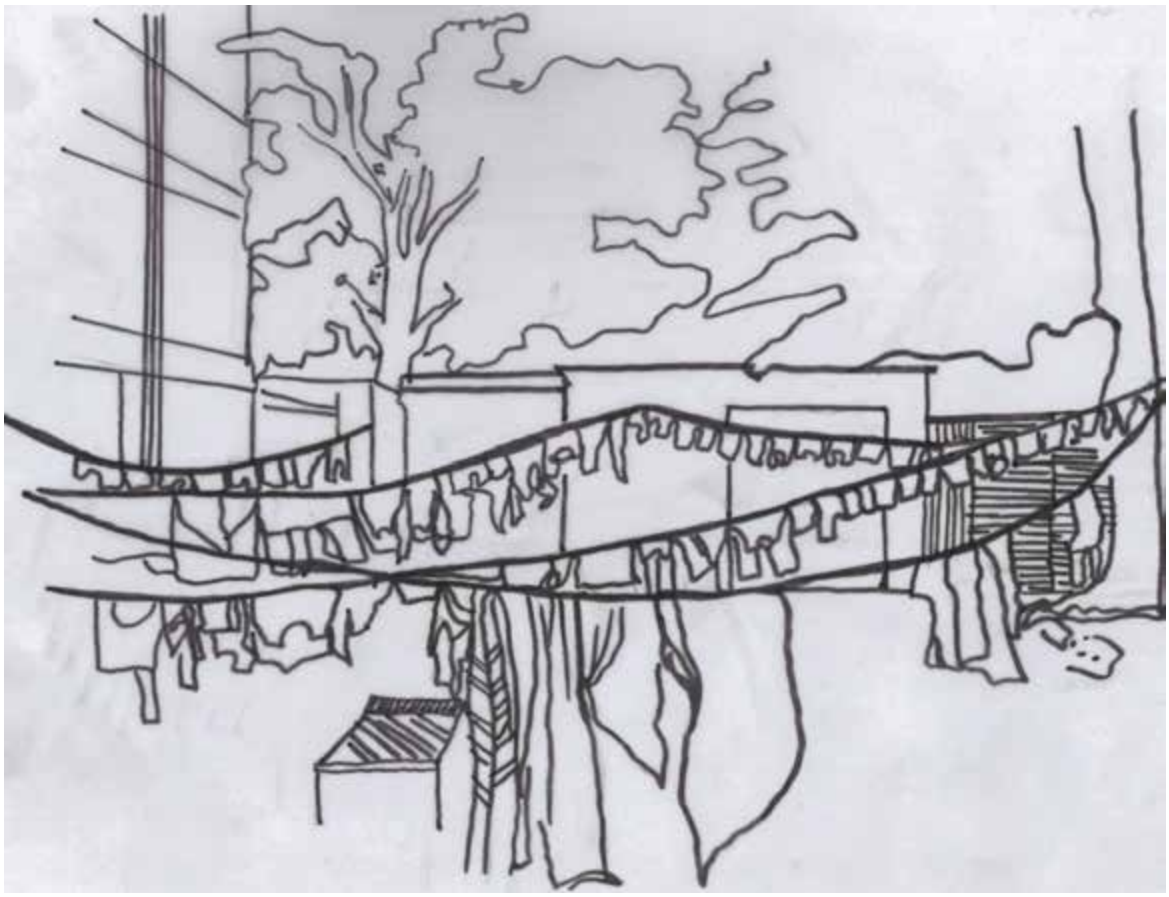


Figure 12: Drying laundry on ground level (in the courtyard) is a Mohalla-making practice versus the aerial pulley system that is illustrated in Figure 10. Source: Author

'...we usually go here (as written in Figure 13)**, to the playground... my kids enjoy it. We go there in the evenings as it is summer now... we go early morning in the winter...'**

As a woman of Pushtun descent, Laiba explains that her Mohalla-making activities vary distinctly from women of different ethnicities around her. Pashtun women are expected to be introverted, and the men expect their women to observe purdah and avoid public spaces of gathering. However, in Laiba's case, the aforementioned unique situation is observed by her interaction in the public realm within the Modern Mohalla of G-9/2, which is ironically propelled by her youngest children, a set of twins, who regularly visit Mohalla Park, i.e., the courtyard readapted into a playground. It must be noted that the adaptation of the courtyard into a playground was not a part of the original design plan for the housing block.

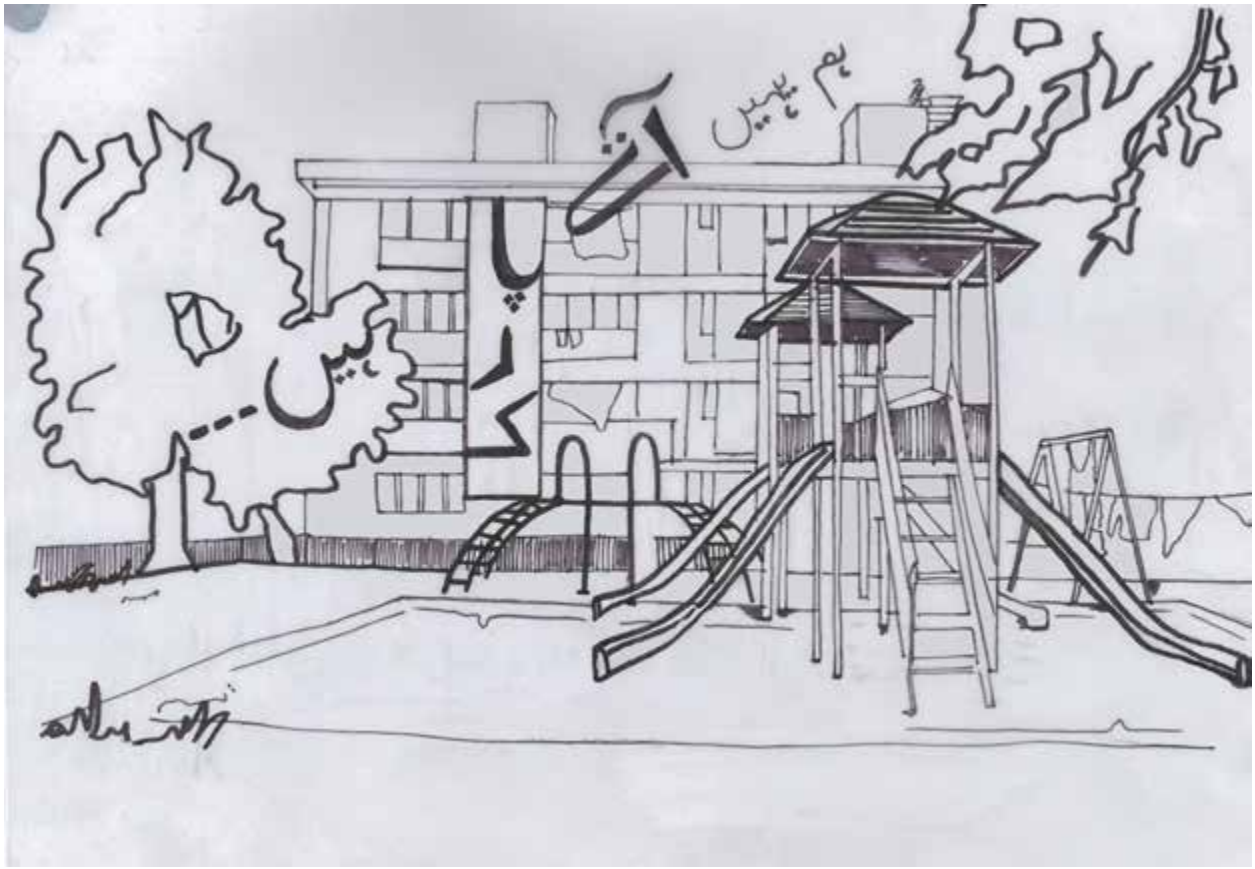


Figure 13: The transformative nature of the Mohalla courtyard, now a playground, serves as a means of social interaction for the Mohalla mothers.

Laiba visualizes a Mohalla as a playground where mothers of the community, together with their children, can socialize freely. In contrast to the women who socialize on the rooftop, Laiba and her cohort of women do not visit the rooftops because their husbands do not see the space for women as 'socially appropriate' i.e., they prefer their women to be using conventional spaces for communal gatherings, the idea of a rooftop is strange to them.

'...it is preferable to see children playing in the park on a ground level where they can also be seen from their kitchen or living room windows...'

'...This is where we come, the park is within walking distance from my house... only takes us five minutes... it has fences around so it is safe for children to play while we talk...'

Questioning how efficiently the park is designed and to what extent it satisfies the needs of its users, it is important to point out that it is not a green space. It comprises some playground items fixed onto a barren courtyard inside a sand pit lined with bricks. The park is more of an informal playground that serves as a recreational facility for the women and children of the Modern Mohalla. As discussed further, parks are a design element of the original communal structure that Doxiadis planned in his archival illustration (Figure 15), however, Laiba's testimony illustrates this space as an afterthought brought to the forefront through the feminist appropriation of courtyards as play areas for their young rather than the design process itself.

Laiba defines the idea of a Mohalla as an 'act (s) of caring' that she appropriates to a play area, as that is where she embodies the concept as a tangible space. Facilitating her children's and her social needs through a playground is an act of Mohalla-making that can be carried through for generations. As shown in the written calligraphic image of Figure 13, 'this is where we come', courtyards, despite their extroverted nature, are seen as spaces used by women like Laiba, who otherwise belong to an introverted culture where using public spaces for Pashtun

women is not the norm. Therefore, Laiba's Mohalla-making is seen as a socially reformative act where women like her can identify and meet their communal needs by informally establishing newfound Mohalla-making traditions in a modernist urban setting.

By reflecting on the oral testimonies of Umaima and Laiba, the theme of socio-spatial interrelatedness becomes more apparent as the idea of a Modern Mohalla and its physical manifestation via their unconventional practices of Mohalla-making can be traced to their consistent intangible communal practices linked to their lifestyles before migrating to Islamabad from Rawalpindi and Peshawar, respectively. As such, a trajectory of concepts regarding traditional spatial formations is seen in a modernist built environment, a requirement that Doxiadis blanketed under the homogenous zoning as a part of his master planning exercise. This is further explored in the next section, where Doxiadis' theory of Ekistics is studied as a facilitator for feminist Mohalla-making in Islamabad.

Islamabad And Ekistics: How Does Ekistics Facilitate Mohalla-Making?
This section investigates Doxiadis' theory of Ekistics and how it impacts the structure of a community in Islamabad and ultimately Mohalla-making. It addresses the research inquiry of how the Mohalla-making practices of women are facilitated by Doxiadis' illustration of a communal structure. Viewing this research inquiry through a post-independence lens and Doxiadis' theory of Ekistics, questions whether female representation was a consideration during the design process of Islamabad's neighbourhoods and whether feminist spaces were conceived as a part of the overall communal structure of Islamabad and the site of study in particular.

Doxiadis defines Ekistics as the understanding of social interaction between and within human groups and societies. Doxiadis uses his science of human settlements to develop a coherent social structure of how neighbourhoods should be designed in Islamabad, thereby shaping their future social practices. Concerning the layout of communal structures, Doxiadis grounds his theory of Ekistics on the following units, which are sourced from his archival works (Doxiadis, 1972): Nature, which is the site on which settlements are built, Man who creates and inhabits them, Society which is formed within them via people and whose social Networks allow people to grow, and lastly Shells which are translated as the built environment housing the other three elements (man, society, and networks). By connecting these units as building blocks of a community, this research examines how they collectively impact the structure of a neighbourhood in Islamabad and consequently the Mohalla-making practices of the women in the Modern Mohalla of G-9/2.

The structure of a community is integral to understanding the investigation of the Modern Mohalla. As a living quarter that is a modernist vertical building, it is not a customary building typology for its inhabitants, who have migrated from non-modern communities to the city for a better lifestyle. Yet their communal practices permeate the modernist built form and birth new informal spatial appropriations as studied via the feminist oral traditions and drawings. Islamabad was a culmination of Doxiadis' vision for a city that operated on multiple fronts, which he believed made a city embody the principles of autonomous growth (Kreutzmann, 2013) while catering to the daily needs of its residents. However, it was not realized particularly via a feminist lens of utility. The entire process of Doxiadis' appointment and the master planning of Islamabad was seen as a bureaucratic strategy that Moatasim (2023) explains envisioned the city according to the modernist ideals of its administrators and patrons rather than its people's intangible or gendered cultural practices. Most academics who have written about Islamabad from a post-independence lens omit the qualitative aspect of documenting the lived experiences and feminine participation as a part of Islamabad's inception because there wasn't any to document in the first place. The female presence as a part of this research is felt as an 'otherly' subject, which Madison (2020) describes, with which a critical dialogue has yet to be made. This 'otherly' characteristic is deeply felt because even more than seventy years after Islamabad's birth, there is no archival record of feminist representation regarding community planning and dwelling design as a part of Islamabad's establishment.

One focuses on the archival evidence of Doxiadis' work titled The Human Community Project (Doxiadis, 1965), a project launched in 1961 in Athens, ironically coinciding with Islamabad's creation, to study the human community level and prescription of relevant communities at a local district level per their social needs as an attempt to situate an informed strategic decision regarding community design. However, despite having a systemic observational technique, one notices the lack of its implementation within the design of Islamabad, especially during its preliminary stages when Doxiadis was attempting to understand the social structure of Islamabad. For whatever reason, this may not have been executed, had The Human Community Project been used

as a participatory socio-spatial tool to understand the sensitive social structure of the neighbourhood culture in Islamabad, their presence today would be mainstream and more cognizant of women's spatial practices on an urban level.

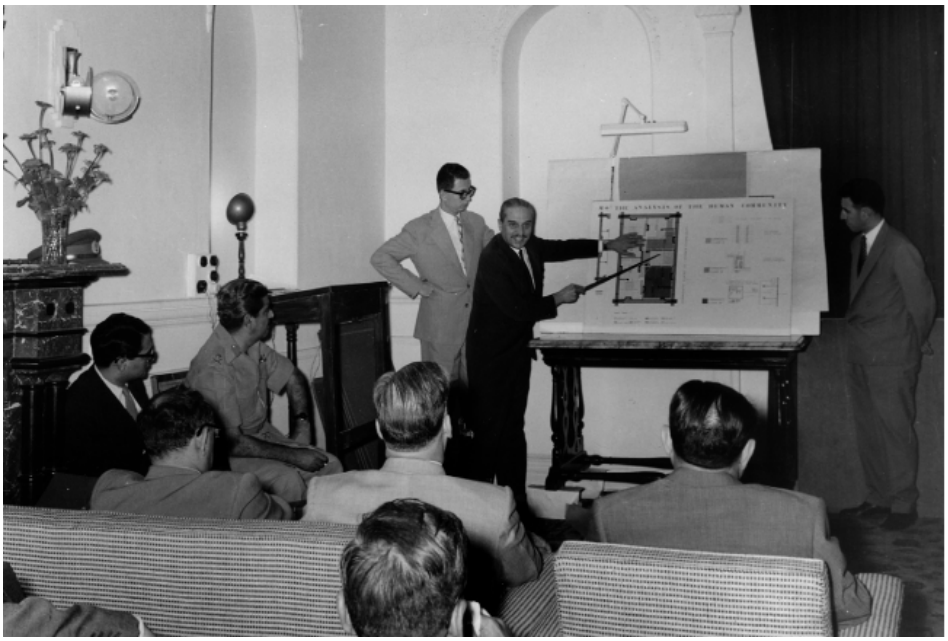


Figure 14: Two images show only male representation during Islamabad's design process. The first image shows Doxiadis presenting aspects of his master plan for Islamabad to the Capital Development Authority, Rawalpindi, in May 1961. A lack of female representation in the meeting is observed. Source: CADA: Photographs No. 30917. The second image shows a meeting in Athens between Doxiadis and General Azam Khan who was Doxiadis; the most powerful supporter in Pakistan and influenced his success in securing Islamabad as a design project. Source: CADA: Archive Files 28557.

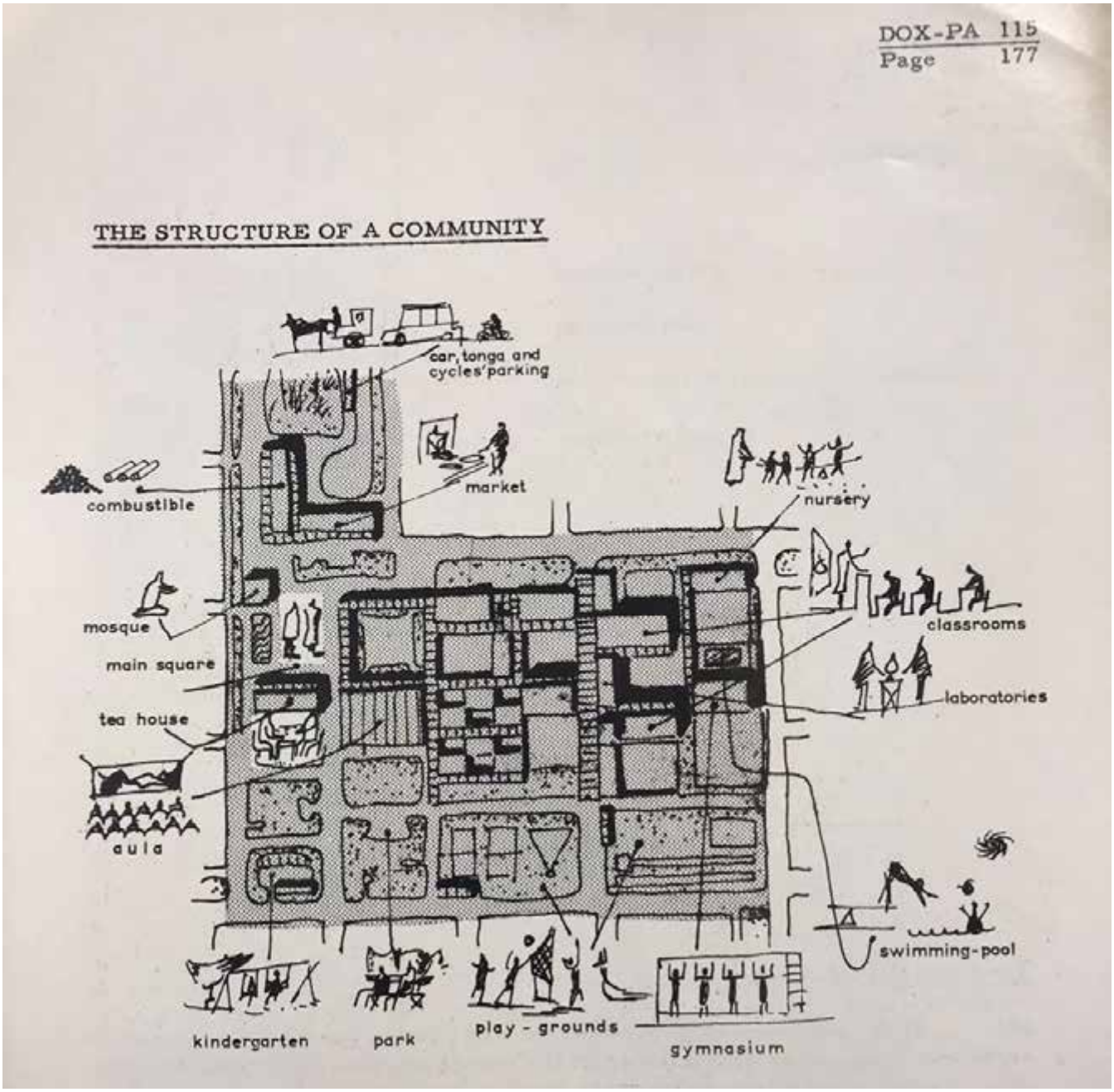


Figure 15: The structure of a community, illustrated by Doxiadis. Source: Capital Development Authority, Islamabad. Doxiadis and Associates- DOX-PA 115.

Stitching together Doxiadis' theory of Ekistics with his illustration of a communal structure, as a modernist master planner (Figure 15), each spatial relation reflects his vernacular interpretations. The spatial typologies assigned by Doxiadis have been translated and transformed by the inhabitants as per their lifestyles, driven by their traditions today. Once again, we notice that this illustration (Figure 15) depicts the socio-spatial relations of a neighbourhood from an aerial view, a recurring theme in Doxiadis' planning approach. When this 'strategy' of Doxiadis is observed via my site visit, on a street level, and through the feminist lens of lived experiences, the Mohalla-making 'tactics' of the residents are noticeably different. For instance, spaces demarcated as 'tea-house' exist informally as 'dhabas'(pop-up tea stalls), cobblers, or fruit vendors, as shown in Figure 16. Can one suggest that Ekistics envisioned Mohalla-making for the locals from a top-down approach? If so, this research argues that this top-down approach is contested through the feminist re-appropriations of his canonized theory of human settlements, another act of feminine resilience that can be connected with Hooks' (2021) proposition of

women doing the work only because they are expected to do so to create alternatives for themselves when none are available. This is explored further via Figure 17, which is seen again but from a feminist lens of occupying communal spaces.

Figure 16: Local fruit vendor's informal stall in the Government Housing Modern Mohalla. These spaces are primarily used by men.

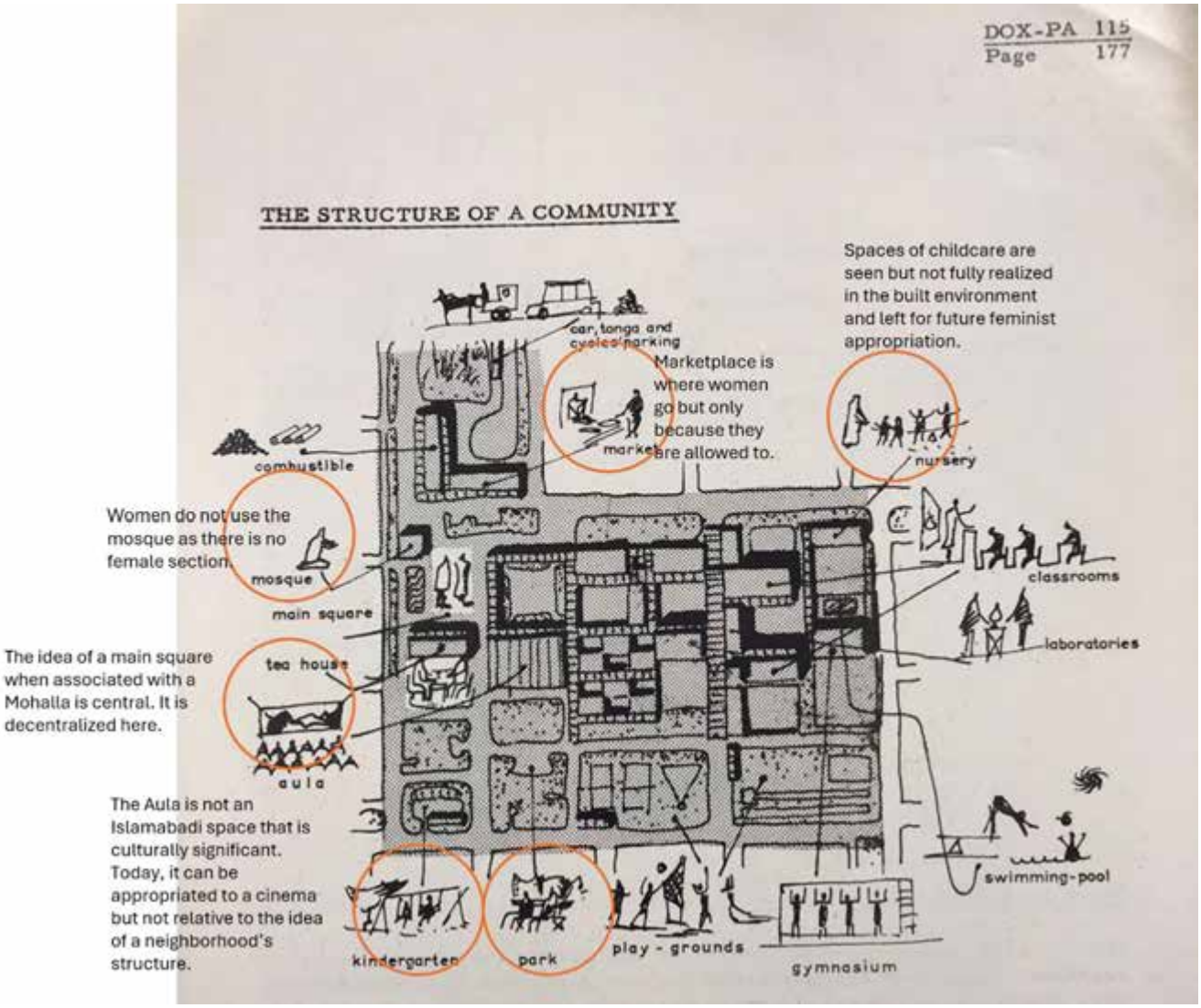


Figure 17: The structure of a community designed by Doxiadis revisited via a feminist lens of Mohalla-making practices.

The extroverted nature of the spaces shown in Figure 15 highlights a disconnect between Doxiadis' urban planning approach and the introverted, culturally specific needs of the community in Islamabad, particularly for women. Doxiadis' designs, such as the 'Aula' (a modern screening area or swimming pool), reflect a Westernized, extroverted vision, which does not align with the introverted Mohalla culture, particularly in terms of feminist spaces and the concept of 'purdah' (female segregation). The absence of women in the planning process of the 1960s and their lack of representation in public and communal spaces (such as mosques) is noted as a significant issue in Doxiadis' illustrations. This research, therefore, explores unique spatial appropriations of retaining privacy by women for women. It focuses on how women navigate and appropriate space to maintain privacy, via oral testimonies revealing that the practical realities of vernacular socio-spatial practices differ from Doxiadis' vision, emphasizing a need for more context-sensitive urban design that acknowledges these socio-cultural nuances.

Conclusion

This interdisciplinary research explores the lived experiences of women in the Modern Mohalla of G-9/2, Islamabad, emphasizing their "Ziddi feminist Mohalla-making practices". The study frames the Modern Mohalla as a space of urban informality where women actively redefine their socio-spatial roles within a post-independence, modernist Islamabad. It portrays the women being studied as independent, radical agents of change, whose contributions to community-building extend beyond traditional roles tied to their spouses' income, asserting their presence in a space that was never designed with them in mind. With my interpretation of a Mohalla's socio-spatial

construct as shown in Figure 18, one of the findings is how the communal life in a Modern Mohalla indicates an unconsciously conceived feminist prototype of dynamic cultural customs as a collective response to the modernist planning principles implemented by Doxiadis. This study is unique because it highlights a paradoxical situation of the qualitative lived experiences of the women as residents of formal settlements practicing informal urban practices. The collected feminist lived experiences in the Modern Mohalla are an unintentional antithesis of the communal structural stratification for government servants that Doxiadis designed, since feminist spaces were not realized as a part of his study, to begin with.

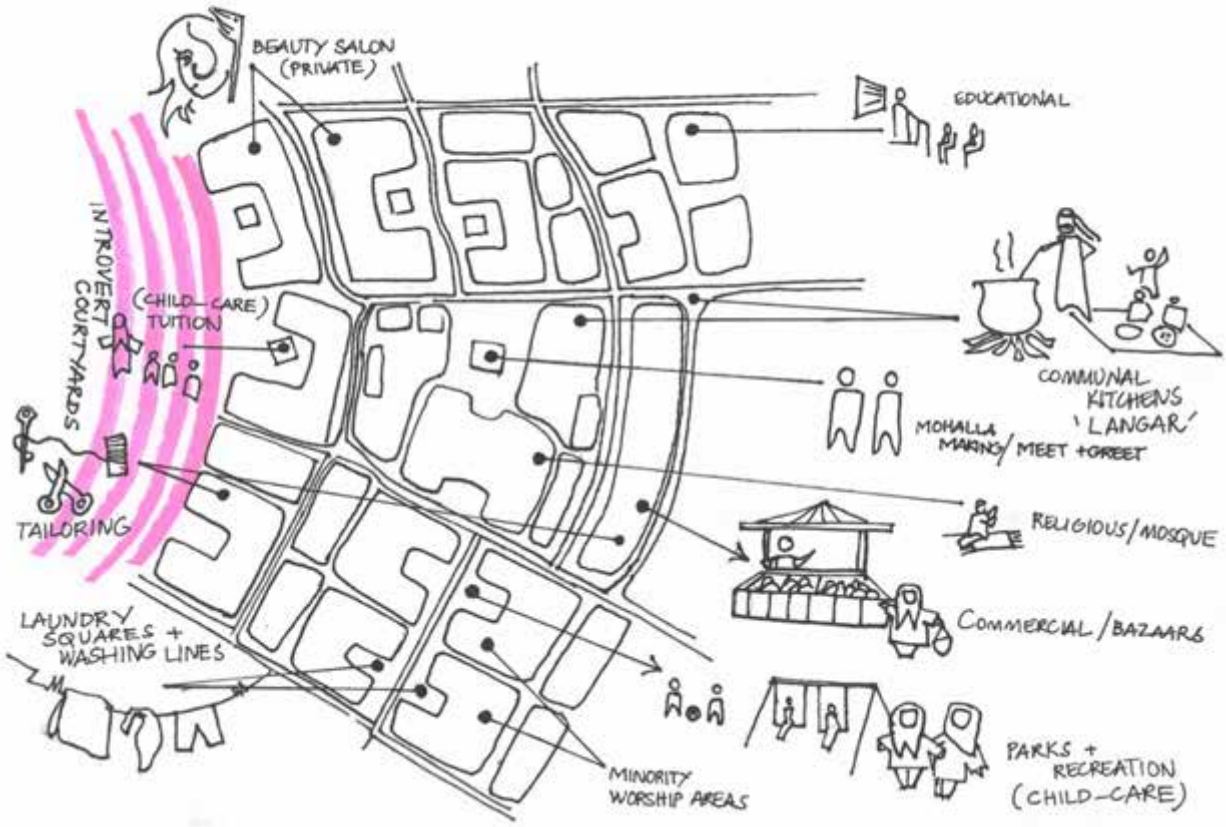


Figure 18: An interpretation of how a Modern Mohalla could be structured if it were seen via a feminist lens of participatory engagement after my site visit. The intersectionality between the formal nature of the built environment and the informal nature of the feminist Mohalla-making practices thrives through a dense interrelated network of streets and buildings as an ephemeral concept of socio-spatial relations.

The approach shown in Figure 17 challenges the rigid, ungendered zoning proposed by Doxiadis, which treats public spaces (market, mosque, square) as functional areas that do not limit women's social interaction. Instead, by reimagining the neighbourhood as a complex web of historical, socio-cultural, and feminist influences, blending private and public spaces, the study envisions a more emancipated communal structure. The Modern Mohalla manifests itself as a hub of intangible socio-spatial relationships passed down through generations, evolving within a modernist framework. As a female Islamabadi researcher focusing on the feminist lived experiences of the Government Housing Quarter of G-9/2, this research explores my role in uncovering and documenting their often-overlooked stories to address their "triple absence" in critical feminist socio-spatial discourse within Islamabad's neighbourhoods. Writing about the architectural history of my hometown as a Pakistani woman is itself a radical act, as it advocates for incorporating feminist spaces into urban design, something that has not been previously considered. By examining the complex Mohalla-making practices, the study allows the researcher and audience to engage with the once-overlooked experiences of these communities. It opens the door to further inquiry, questioning "What more is there to know?" about Modern Mohallas in Islamabad, especially with the low-income government servants and their ghettoised communal structures influenced by feminist practices that

remain largely unexplored.

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The Intersection of National Image, Urban Development, and Civic Life: A Study on the 70-Year Evolution of Large-Scale Sports Architecture Heritage in Beijing

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Abstract
Under the guidance of Sustainable Development Goals, Olympic legacy is defined as the long-term benefits of major sporting events for residents and cities. As a key component of event legacies, large-scale sports architecture(stadium) has become a significant urban research topic. Capital sports architecture serves as a carrier of national identity, embodying symbolic urban imagery and enriching urban cultural landscapes. This study employs longitudinal and comparative analyses to examine the evolution of Beijing's stadiums over the past 70 years, systematically exploring their construction context, design concepts, architectural features and public activities. The findings aim to summarise trends, provide insights for stadium development, and promote sustainable growth. These outcomes ensure that these iconic venues continue to represent national identity and connect the past, present, and future.

Keywords: Beijing; Sports architecture heritage; national image; urban development; comparative study

Under the guidance of the goal of Sustainable Development Goals, Olympic legacy is defined as the long-term benefits that the Olympic Games or major sports events bring to residents and cities(Han & Xie, 2020). Effective reuse of 'Olympic legacy' has become a critical focus for modern Olympic Games. Therefore, the construction, development and reuse of 'Olympic legacy' represented by large-scale sports buildings has become an important research topic in global academic circles and planning practices. Stadiums are the most important type of sports buildings and a key urban landmark. Stadiums are one of the places where national and city sports events and activities are held. National and world-class high-level games and events, such as the Olympic Games, National Games, World Cup, etc., have great international influence and are the medium for the country to enhance its international image. Because of its natural functionality, agglomeration and openness, the stadium is not only the venue for these competitive sports, but also the venue for the opening ceremony and other events, and more importantly, the venue for some commemorative meetings, cultural performances and other national celebrations. The capital stadium, more important, as a national and international activities held in the place, is to show the strength of the country, reflecting the dignity of the country's important window, excellent stadiums on the development of the city has a positive role in promoting. The stadium architecture is also the expression of the image of the capital and the image of the country, so it is of great research value to analyze the architectural development changes, style concept changes, and urban spatial relations of the capital stadium.

1. Status of research and scope of content

1.1 Status of research

Currently, the research on Beijing stadiums focuses on the construction and use of stadiums: function and utilization, building structure and construction, building form and external spatial relationship, energy consumption analysis and optimization; and the cultural level: protection of sports heritage buildings, sports buildings and humanities analysis, most of which are focused on the consideration of single buildings or stadiums, and less on the study of 'capital city' within the scope of the stadiums. There are few studies on the stadiums within the scope of 'capital city', and there are few comparisons of the changes of the capital city stadiums in both vertical and horizontal dimensions, and fewer of them focus on the correlation between the stadiums and the image of the country.

1.2 Content and scope of the study

Stadium for all kinds of games sports buildings, according to the 'Architectural Design Sourcebook 6 (third edition)' interpretation, the stadium is able to outdoor track and field and soccer and other sports buildings, can also be called track and field or integrated stadium, which is mainly by the field area (including track and field and soccer field), grandstand area, auxiliary rooms and facilities and other parts of the composition(Architectural Society of China, 2017). According to the China provisions of the 'Sports Building Design Code' (JGJ 31-2003), the stadium's official competition venues should include a 400m perimetre of the standard circular track for track and field events, a standard soccer field and various field events. Specialised soccer stadiums can also have only standard soccer fields without a loop track and field events. According to the code, stadiums with more than 60,000 seats

are considered mega, 40,000 to 60,000 seats are considered large, and 30,000 to 40,000 seats are considered medium.

As the capital stadium with a certain influence that can show the dignity of the country is inevitably large, high level and wide range of services, so the important stadiums in Beijing involved in the study are the Xiannongtan Stadium, Workers Stadium, Olympic Sports Centre Stadium, National Stadium and the new Workers Stadium (a professional soccer stadium). Small stadiums such as college stadiums or non-special grade and Grade A stadiums are not included in the scope of this study.

2. Reviewing the 70-Year evolution of stadiums in Beijing

Modern sports architecture and culture originated from the Greek Olympic, and the prototypes of modern sports stadiums also came from the stadiums and colosseums of ancient Greece and Rome. Modern sports in China began with the sports of Westerners in the concession and trading ports, and Western sports buildings under the colonial regime began to be constructed in China(Hou, 2020). Under the passive importation of the West and the active fusion of the local community, modern stadiums modeled on Western modern venues were gradually built.

The earliest formal stadiums in Beijing were the Huiwen Shuyuan Stadium and the Xiehe Shuyuan Stadium(Hui, 2023). According to the time division, the construction of major stadiums in Beijing can be roughly divided into 5 Stages, corresponding to the background characteristics and urban development needs of different eras, namely, the Early Development stage (EDS)(1936-1958), the Construction Start-up stage (CSS) (1959-1978), the Asian Games stage (AGS) (1979-1990), the Olympic Games stage (OGS) (1991-2008), and the Post-Summer Olympics Stage (PSOS) (2009-present). which has lasted for more than 70 years since Beijing became the capital of new China.

Figure 1: Study cases and location relationships

2.1 Early Development stage (1936-1958)

The main stadium of this Stage was the Xiannongtan Stadium, built in 1937 and originally called the 'Peking Public Stadium'. In 1936, in preparation for the 19th North China Games (not held), the design of the Xiannongtan Stadium in Beijing was completed by Guan Songsheng of the Kwan, Chu and Yang Architects & Engineers (KCYAE). Since there was no precedent to follow from the traditional building activities in China, domestic sports buildings of this stage were often modeled directly on modern Western venues. Before taking over the public stadium in Peking, KCYAE had already had experience in building stadiums, therefore, the design is inherited from the Nanjing Central Stadium, under the core of the 'Western Stadium', set up the enclosed grandstand, the long axis of the stadium conforms to the axis of the Xiannongtan (Agricultural god temple), set up an end gate tower as the entrance on the north side, and the exterior design is integrated into the palace form, so as to achieve the integration of the traditional Chinese architectural style.

Stadium was equipped with a 400m runway, with a capacity of 4,000 spectators, and is the only large-scale public stadium in Beijing before and after the liberation. After the peaceful liberation of Peking, Stadium took over many political and cultural events. The 28th anniversary of the founding of the Communist Party of China and the Beijing Municipal People's Sports Congress were held here. In the 1950s, Stadium was expanded twice, increasing the number of spectators to nearly 30,000(Shaoyi, 2004). Prior to the construction of the Workers Stadium, almost all of China's major competitions were held at the Xiannongtan Stadium, which was nominally the 'National Stadium'.

Figure 2: Xiannongtan Stadium Design

Figure 3: Aerial view of the stadium

2.2 Construction Start-up Stage (1959-1978)

The main stadiums built during this stage were the Workers Stadium and the renovation of the Xiannongtan Stadium. The main construction opportunity was the First National Games (1959).

In the early years of the founding of the PRC, Beijing was very short of stadiums, and there were no large stadiums except for the Xiannongtan Stadium mentioned above. As the capital city, Beijing often hosted visits by foreign athletes, and due to the lack of relevant facilities, the venues for various competitions were very simple, which did not match the temperament of the capital city of new China. Taking the opportunity of the 10th anniversary of the founding of the People's Republic of China and the first National Games in 1959, one of the '10 major projects of the National Day', the Workers Stadium, was completed in the eastern suburb. The Workers Stadium has a geometrically regular group layout, with the stadium at its core. The Workers Stadium north-south length of 282m, east-west length of 208m. ring depth of 40m for the grandstand, the ring for the competition venue. The grandstand is divided into two levels, the highest place in the ground above 22m(Youming, 1959). The total area is 80,000 m^2 and can accommodate 80,000 spectators. The whole building adopts the whole cast reinforced concrete frame orange structure.

The facade of the building is treated under the guidance of the architectural policy of 'applicable, economical, and pay attention to the aesthetics under the possible conditions', with generous, open and bright large glass windows together with the light and powerful columns(Beijing Municipal Planning Bureau Design Institute Sports Farm Design Team, 1959), the design is simple, with the practical characteristics of socialist architecture, and the window patterns on the outer wall of the stadium are the traditional Chinese style. 13 sculptures of workers and athletes are arranged around the building, which is very characteristic of the times. The Workers Stadium became the de facto national stadium, taking over from the Xiannongtan Stadium, which hosted the first National Games in the year of its completion, and later hosted many important competitions; in the 1960s it became a 'political stadium'(Dongming, 2008), with more functions such as parades and rallies.

Figure 4: Opening Ceremony of the First National Games

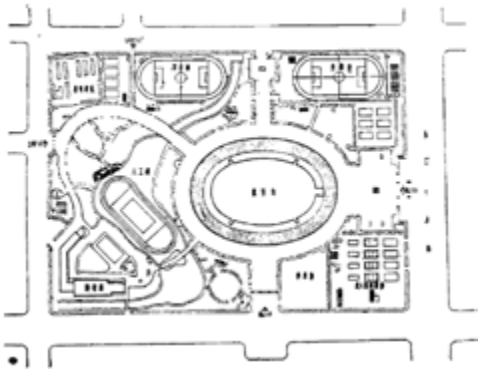

Figure 5: Site-plan of Workers Stadium

2.3 Asian Games Stage (1979-1990)

The main stadiums built during this Stage were the Olympic Sports Centre Stadium, as well as the reconstruction of the Workers Stadium and the restoration of the original site of the Xiannongtan Stadium. The construction opportunity of this Stage was the 11th Asian Games (1990).

The Asian Games was the first large-scale comprehensive international games held in China, and it was also an important opportunity for China to show its dignity and image to the outside world. To host the Games, a new National Olympic Sports Centre was chosen to be built in the northern suburbs of Beijing. The National Olympic Sports Centre was planned and designed as an integrated whole, with a total of three large sports buildings, 'one stadium and two gymnasiums', for which Ma Guoxin was the chief architect. In this area, the northern part of the building is used as the first phase of the venue to serve the Asian Games, and the overall planning takes grid and curve as the design elements, and draws on the group combination treatment of Beijing's traditional city to form the overall design, and the centre is planned to open to the public as a sports park after the games. The centre is planned to be opened as a sports park for all after the games. The stadium of the Olympic Sports Centre is located on the main east-west axis, with a floor area of 30,000 m^2, a design capacity of 20,000 people, and reserves in the north and south, and is planned to be converted into a football stadium with a capacity of 40,000 people in the later stage. The podium is located in the West Stand and has a technical special box. The top of the west stand has a 20m wide, 100m long overhanging translucent canopy(Ma, 1990).

Since 1986, the first large-scale renovation of the Workers Stadium was carried out in preparation for the 1990 Asian Games. The Workers Stadium had been damaged by 30 years of wind and rain. The stadium was reinforced, a torch platform was added, the comfort of the seats in the stands was improved (reduced in number), and the top was covered with a large canopy, with the canopies of the east and west stands cantilevering inwards by up to 18 m. The restored Workers Stadium successfully hosted the opening ceremony and matches of the 11th Asian Games, and celebrations for the return of Hong Kong to China and other festivities. At the same time, in order to meet the Asian Games, Xiannongtan Stadium was demolished and rebuilt in 1986, and the new Xiannongtan Stadium became a 30,000-seat modern stadium in line with the modern track and field and football stadiums(Beijing No.2 Municipal Engineering Company, No.1 Team of No.2 Work Area, 1985).

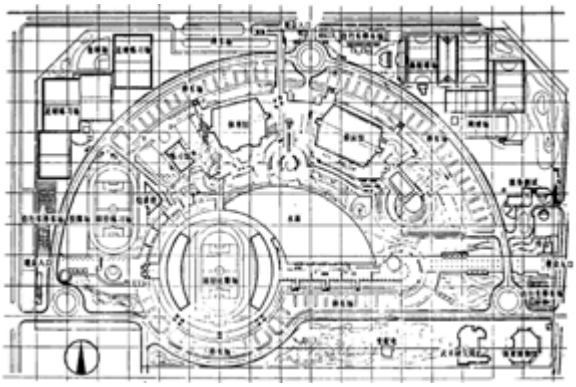

Figure 6: Site-plan of Beijing Olympic Sports Centre

Figure 7: Beijing Olympic Sports Centre Stadium

2.4 Olympic Games Stage (1991-2008)

The main stadiums built during this Stage were the National Stadium and the renovation of the Olympic Sports Centre Stadium and the Workers Stadium. The opportunities for construction were the 21st World University Games (2001) and the 29th Beijing Olympics (2008). Since Beijing lost the bid for the 2000 Olympics, it retreated to bid for the Universiade, but the main target event for this stage was the Olympics, so this stage is categorised as the Olympics phase.

The China National Stadium (Bird's Nest), designed by the China Academy of Architectural Design Institute (CAADI) in conjunction with Herzog & de Meuron, was the main venue for the 2008 Beijing Olympic Games. After the completion of the stadium, it officially succeeded the Workers Stadium as the National Stadium. The shape of the stadium is an ellipse with a north-south length of 333 m and an east-west width of 298 m, with a maximum height of 69 m and a minimum height of 40 m; the middle opening has a north-south length of 182 m and an east-west width of 124 m. The main steel structure forms an integral giant large-span, crosswise rotating braided structure, and the stadium grandstand is a bowl-shaped structure supported by a reinforced concrete frame(Li, 2008) . The National Stadium is a design from the inside out, where the structure is the appearance, forming a woven structure like the 'Bird's Nest', a perfect unity of structure and appearance due to function.

Figure 8: Floor plan of the China National Stadium

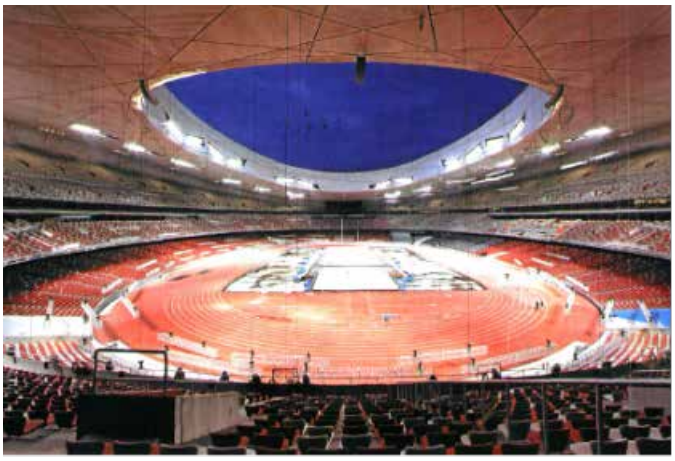

Figure 9: Inside China National Stadium

Figure 10: Site-plan of the China National Stadium

Meanwhile, the Workers Stadium also saw two important renovations during this stage. In 2000, the Stadium was renovated for the second time to meet the Universiade. The stadium was partially reinforced, with the construction of high-standard lounges and a press centre. In 2006, the third renovation of the Workers Stadium was carried out. The most significant change in its appearance was the installation of the overhead light frame cable structure. After a comprehensive renovation of the Workers Stadium, can accommodate 62,000 spectators, the field facilities fully meet the technical standards of the Olympic Games football match requirements. The Olympic Sports Centre Stadium has also undergone related alterations, removing the ring road, reconstructing the east and west awnings and expanding its capacity to 40,000 while reinforcing the structure to meet the requirements of the Olympic Games.

2.5 Post-Summer Olympics Stage (2009-present)

The main stadiums built during this stage were the restoration of the Workers Stadium (New Workers Stadium) and the renovation of the National Stadium. The construction opportunities are diverse, mainly for the Beijing 2022 Winter Olympics and the AFC Asian Cup.

The Workers Stadium has undergone four renovations, reaching its design life of 50 years after the Olympics, and was partially renovated in 2010, transforming it from a comprehensive stadium into a professional football stadium. However, as an important stadium building in Beijing, its external environment as a whole presents a messy and disordered, therefore, in order to make effective use of the stadium, coinciding with China's opportunity to host the 2023 Asian Cup (Stadium was originally scheduled to serve as the main venue for the Asian Cup, but was abandoned due to an epidemic), under the basic principle of 'three constant' -- the elliptical shape remains unchanged, the facade form remains basically unchanged, and the style remains basically unchanged, the way of dismantling and reconstructing was finally determined, and the concept of 'traditional appearance, modern arena' was put forward. Workers Stadium ushered in the opportunity of nirvana rebirth(Du song & Wang, 2023).

Figure 11: New Workers Stadium

Figure 12: Inside New Workers Stadium

With a floor area of 380,500 m^2 and 68,000 seats, the new stadium meets the highest standards of FIFA, with the pitch sunk to 11m below ground to form a sunken professional football stadium. The 4-tier grandstand is designed and integrated into 2 tiers on the north side to create a 15,000-seat super grandstand for home fans. The first row of spectator seats is only 8.5m away from the lawn to enhance the sense of intimacy. The sports reconstruction retains the original architectural style as much as possible(Sheng et al., 2021), such as restoring the original eaves and ring bands and other architectural features. For special historical memory construction, such as the old gymnasium outer wall window patterns, reliefs and peripheral sculptures, etc., three-dimensional laser scanning technology and 3D printing technology are also used to repair and reproduce(Wang et al., 2023). Up to now, the new Workers stadium has been put into use for more than two years, as the home stadium of Beijing Guoan in the Chinese Football Super League.

In the design of the space around the stadium, the sparse urban space form of 1959 is restored, a large area of greenery is added, and the water space is upgraded and improved to provide the public with a high-standard space for sports activities. The underground space introduces the concept of integrated operation of underground and business, and actively creates the Greater Sanlitun Business Circle in the form of 'TOD+Block+Mall', providing the city with a new integrated space for sports, culture and business(Du S. et al., 2023).

In the post-summer Olympic Stage, the National Stadium also hosted the 2015 World Athletics Championships, and in 2019, for the opening and closing ceremonies of the Beijing Winter Olympic Games, the National Stadium followed the 'green, sharing, open, clean' concept of running the Olympic Games, the main energy-saving performance of the building to regulate the transformation to meet the sustainable development needs. After the renovation, the 'Bird's Nest' officially opened a new mode of energy saving, low carbon and intelligent service. After the renovation, a large-scale cultural performance to celebrate the 100th anniversary of the founding of the Communist Party of China was held in the National Stadium.

Figure 13 Opening Ceremony of the Beijing Winter Olympics

Figure 14 Large-scale Cultural Performance to Celebrate the 100th Anniversary of the Founding of the Communist Party of China

Table 1: Summary of Beijing Stadiums by Stage

Name	Year	Location	Seating Capacity	Purpose	Architectural Features	Main Activities
Early Development Stage						
Xiannongtan Stadium	1938	Urban South (Xiannongtan)	4,000	The 19th North China Games*	Traditional Chinese Style	Celebrations for the 28th Anniversary of the Founding of the Communist Party of China, etc.
Construction Start-up Stage						
Workers Stadium	1959	Eastern Suburb (Sanlitun)	80,000	The 1st National Games	Socialist Characteristics, Simple and Plain	The 1st to 4th National Games, Mass Political Gatherings, etc.
Asian Games Stage						
Olympic Sports Centre Stadium	1989	Northern Suburb (Beitu Cheng)	20,000	The 11th Asian Games	Modernist Architecture	The 11th Asian Games
Workers Stadium (Renovated)	1986	-	70,000	The 11th Asian Games	Reinforcement, Modern Renovation, Addition of Torch	Main Venue for the 11th Asian Games, Celebration of Hong Kong's Return, etc.
Xian Nong Tan Stadium (Reconstructed)	1986	-	30,000	The 11th Asian Games	Modernist Architecture	Asian Games Events, Jia-A League Matches
Olympics Games Stage						
National Stadium	2008	Urban Nouth (Olympic Park)	80,000 (11,000 temporary)	The 29th Summer Olympics	Technology, Oriental Aesthetics, Olympic Spirit	Opening and Closing Ceremonies of Beijing Olympics and Competitions
Workers Stadium (2nd Renovation)	2000	-	70,000	The 21st Universiade	Reinforcement, Addition of Restrooms and Press Centers	Opening and Closing Ceremonies of Beijing Universiade and Competitions.
Workers Stadium (3rd Renovation)	2006	-	62,000	The 29th Summer Olympics	Reinforcement, Meeting Requirements for Olympic Football Matches	Football Matches of Beijing Olympics, CSL Matches, etc.
Olympic Sports Centre Stadium (Renovated)	2007	-	40,000	The 29th Summer Olympics	Addition of Stands, Renovation of Canopies, etc.	Related Competitions of Beijing Olympics
Post-Summer Olympics Stage						
New Workers Stadium	2023	Original Site	68,000	2023 AFC Asian Cup*	three constant Principles, Integration of Technology and Culture	Opening Ceremony of the 2023 CSL, Chinese Football Super League
National Stadium (Renovated)	2021	-	-	The 2022 Winter Olympics	Green and Low Carbon Sustainable Development	Opening and Closing Ceremonies of the Winter Olympics, etc.

Note: * indicates not held

3. The wave of stadium construction orientated to tournament celebrations: from the region to the world

The development of the stadiums in the capital of China was orientated towards celebrations, with the construction and renewal of the stadiums being associated with major sporting events. After 1978, the stage of stadium construction was even divided on the basis of the dates of sports events. The construction of stadiums in most foreign capitals is also similar to this, with the Olympic Games, the World Cup and other opportunities for stadium construction. China's special characteristics are: the level of the event is gradually increased, the scope of influence of the event is gradually increased, and the importance of the event is gradually enhanced. We have experienced a progressive trajectory in stadium development, evolving from domestic regional games to national-level competitions, followed by Asian-level multisport events, and ultimately culminating in world-class comprehensive games. This progression has also expanded to encompass a wide range of global-scale sporting and cultural activities.

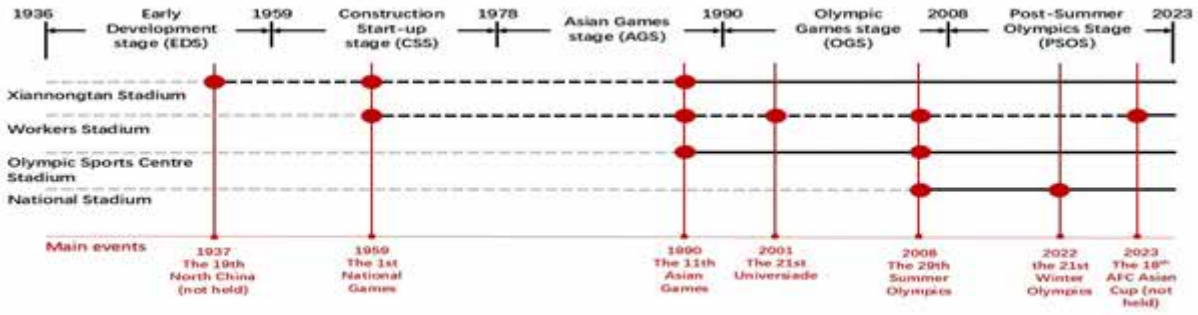

Figure 15: The Development of Capital Stadium Construction under the Orientation of Tournament Celebration

Before the founding of new China, China's social instability, economic foundation is weak, but also unable to hold international events, so this Stage of the country's cities in the construction of the opportunity are all the local games, such as the North China Games. North China Games is also China's modern sports history of the greatest influence, the longest duration of the regional games, held a total of 18 sessions, and then cancelled due to the outbreak of the WWII. For a period of time after the founding of New China, the construction of sports buildings in the capital city was also dominated by simple venues, with a number of simple stadiums built in urban areas in combination with parks and green spaces, and the main events were held in the Xiannongtan Stadium. 1952, after participating in the Finnish Olympic Games for the first time, decision-makers realised that sports performance was related to international status, and therefore vigorously promoted sports during the 'First Five-Year Plan'. During the 'First Five-Year Plan', the construction of sports buildings was vigorously promoted, and after the Great Leap Forward, the Workers Stadium was built to celebrate the 10th anniversary of the National Day of New China and to welcome the first National Games. At this time the country has been on track after ten years of construction, the overall national strength has been improved, the construction of stadiums, held the National Games is a new China's national strength show. There were 24 friendly countries participating in the National Games, which was an expression of the image of the new China and a manifestation of the dignity of the country.

After the reform and opening up in 1978, China sought to organise comprehensive international sports competitions to reflect China's new image and provide new opportunities for international exchanges and economic development. In 1984, Beijing started to organise the 11th Asian Games in 1990, with 'based on the Asian Games, with an eye on the Olympics' as the main construction goal for this Stage, and through this organisation, the Workers Stadium reached the level of advanced stadiums at that time, and new buildings such as the Olympic Sports Centre were built with an eye on the Olympics. Through this preparation, the Workers Stadium Stadium also reached the level of advanced stadiums at that time, and the Olympic Sports Centre and other buildings were newly built 'with an eye to the Olympics', which made the number and level of Beijing's sports facilities greatly improved. After the Asian Games, Beijing declared for the 2000 Olympic Games, but unfortunately failed. In order to gain practical experience in organising international high-level sports events, and to lay a good foundation for further bidding for the Olympic Games(Hou, 2020), Beijing hosted the 21st Universiade, which was the first time that China held a world-class comprehensive sports event, and took this opportunity to upgrade and update the sports buildings in Beijing.

In 2001, Beijing's bid for the Olympic Games was successful, and the related sports stadiums were gradually put on the agenda. By 2008, China had been reforming and opening up for 30 years, and its comprehensive national power had been greatly enhanced. The Bird's Nest, as a unique and unprecedented landmark building, was a renewal of China's image and a demonstration of its national power in the new millennium. After the Olympic Games, Beijing stepped into the Stage of transformation and operation to protect and make use of the Olympic legacy. After the Olympic Games, in addition to hosting the Winter Olympics, the country is seeking the comprehensive development of all kinds of sports events, and hopes to host major events such as the Asian Cup and the World Cup, etc. At this time, the renewal of the capital city's sports buildings is to take these

activities as an opportunity for the balanced, dynamic, highly efficient use of the construction and management of sustainable development.

4. Changes in Architectural Style and Philosophy in the Context of the Times: From Western Learning to Parallel Development

Since the beginning of the last century, the capital stadium has been influenced by the sports, styles, concepts and cultures of different eras in the course of a century, showing colourful and varied changes. Similarly, the social background of China as well as sports and architectural undertakings have gone through different stages of development since the modern times, which have also shaped the soil of the development of the capital stadium. From the background of different Stages, we compare the architecture of the capital stadium with that of foreign countries in the same Stage, and explore the causes of the changes in the architectural style and concept of the capital stadium.

4.1 Early Development Stage: Study of the West and Formal Collage

In this stage, China was in a stage of transformation of the social system under the external war and internal revolution, and the main sports and architectural undertakings were also dominated by the activities of Westerners. Therefore, the stadium construction in China was still in the process of learning from the West and imitating the Western sports architecture, and after absorbing a certain amount of Western experience, it was gradually tracing the traditional Chinese form from the style. A stadium from the same Stage as the Xiannongtan Stadium was the Olympiastadion (Reichssportfeld) in Berlin, Germany, in 1936.

Berlin was again awarded the right to host the Olympic Games in 1931, and the German government decided to remodel the stadium in Charlottenburg, west of Berlin, as the main venue. The Olympiastadion was completed in 1936 with an east-west layout and a double-decker grandstand that could accommodate 110,000 spectators. The stadium was built in expensive materials such as granite, and its form is predominantly Fascist, with a symmetrical layout, soaring vertical rows, and dehumanising superscales to create a solemn atmosphere. The two stadiums are similar in form, controlled by axes and ceremonial at the ends, but the Xiannongtan Stadium is too small, with a capacity of only 4,000 spectators in the early days. Considering the social turmoil and weak industrial economy at that time, the stadiums were out of reach of the West in terms of both the scale of the stadium buildings and the creation of spatial order, and were in the position of learners.

Figure 16: Olympiastadion

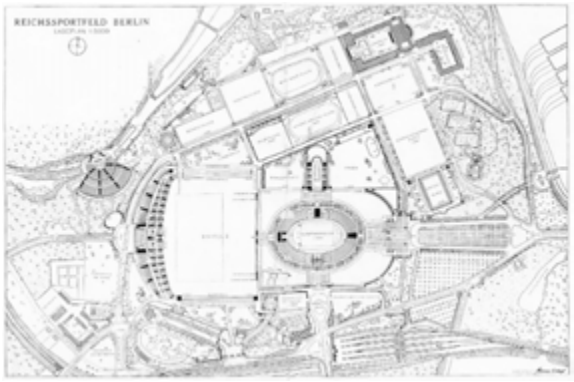

Figure 17: Site-plan of Olympiastadion

4.2 Construction Start-up stage: Soviet Influence and Simplicity and Economy

In the beginning of the construction stage, from 1949 to the Reform and Opening Up, China basically followed a foreign policy of 'alliance with the Soviet Union and opposition to the America', and basically drew its modern architectural nourishment from the Soviet Union. In the early 1950s, the Soviet Union began to provide large-scale construction assistance to China, and the architectural creations were deeply influenced by the Soviet Union ideology, and 'socialist content and national form' became the supreme guidance in architectural creations. After the Great Leap Forward, economic savings itself became a necessary requirement for architectural construction, and reflection on national forms also became the mainstream architectural thinking, at this time, the designers

could not take the 'capitalist' road of modernist architecture, so they could only weaken the attention to architectural forms as much as possible, and reduce the architectural features in form.

The Soviet Union was also in the midst of the Khrushchev era, and after 1955, the Soviet Architectural Society under Stalin was abolished, abandoning the 'Stalinist' aesthetic and replacing it with an architectural style aimed at pursuing high efficiency and economic benefits. The Central Lenin Stadium, built before the Workers Stadium, bears a strong resemblance to it. Built in 1956, Luzhniki Stadium (Стадион 'Лужники'), known as the Central Lenin Stadium before the collapse of the Soviet Union, is located on the banks of the Moscow River in the south-west of the city, and was the national stadium of the Soviet Union (also Russia), as well as the largest stadium, which was constructed for the purpose of hosting the Spartak Games of the Soviet People in 1956. Built under the direction of Alexander Vlasov, it has a total of 80,000 seats. The stadium's architectural style is simple and frugal, and it has undergone a number of alterations and extensions in later years.

The two buildings, the Workers Stadium and the Luzhniki Stadium, are similar in form and volume, and show the same architectural style and compositional features, and the buildings of the capital city in this Stage were deeply influenced by the Soviet architectural style. Among them, the biggest difference between the Workers Stadium in terms of elevation is that the Luzhniki Stadium emphasises vertical composition, with robust and powerful columns with vertical bar windows and designed with curved porticos, while the columns of the Workers Stadium are thinner, and the horizontal bar windows emphasise the horizontal composition in a more minimalist way. The completion of the Labour Stadium not only demonstrates that China has the ability to build mega stadiums after 10 years of development, but also assumes more political meanings, its name is closely related to the historical position of the working class and the main theme of the times, which emphasises the development of the country's national strength and the awakening of the country's will, and at the same time, swears to the independence of the country from the cultural and spiritual level.

Figure 18: Central Lenin Stadium

Figure 19: Site-plan of Stadium

4.3 Asian Games stage: Catching up with the West and Connecting with the World

After the reform and opening up in 1978. Lifting the political burden, sports architecture began to get rid of the limitations of national sentiment, the formal thinking of sports architecture quickly turned to modernism, and domestic sports architecture designers began to learn from the experience of advanced Western venues. Under the background of internal reform and opening up to the outside world, Chinese sports architecture also began to connect and catch up with advanced western sports architecture. In this Stage, the planning of a large sports centre appeared for the first time in the capital. The overall planning of the Olympic Sports Centre is people-oriented, and it is the first large-scale sports park in China to achieve the separation of pedestrian and vehicular traffic and a barrier-free environment for the whole field(Ma, 1990). In terms of building technology, the Olympic Sports Centre stadium is the first in China to adopt the canopy technology of steel pipe space mesh shell.

A similar foreign building to this phase is the Stadium of France (Stade de France), built in 1998. Located in the north of Paris, the Stadium of France is the national stadium of France and the home of the national football

team, and was built for the 1998 FIFA World Cup with a seating capacity of 80,000 people. The design idea is 'open, transparent and fluid', and its architectural image consists of a vertical facade and a horizontal ring (roof) suspended above the stadium. The curved steps give the building a sense of movement, while the roof discs 'floating' above the city symbolise the dexterity of movement(Hu & Zhang, 1998). The Stade de France was characterised by 'high technology', with its suspended circular roof and mobile stands being the most advanced designs of the time. Comparing with the high technology, high efficiency, adaptable and changeable development direction of Stadium of France in the same Stage, although some new technical means have been applied in the Olympic Sports Centre Stadium, it is still in a catching-up stage compared with it in all aspects.

4.4 Olympic Games stage: Parallelism and Cultural Expression

After the new millennium, China's political situation has stabilised, its economic level has greatly improved, and the society has developed in a comprehensive and harmonious manner; sports architecture has also faced multiple development opportunities and has developed rapidly. International competitions for sports buildings have provided opportunities for foreign design organisations, and a large number of advanced design ideas and technologies have been conveniently introduced into China, directly promoting the progress and development of Chinese architectural design. The National Stadium, as a co-operation work between a foreign firm and a Chinese design institute, not only reaches the world advanced level in overall planning, structural technology and functional layout, but also contains 'the oriental aesthetic thought of order and introspection' and 'the perfection of a single object'. It combines Chinese oriental aesthetics and humanistic style with contemporary art and Olympic sportsmanship(Li, 2008).The design of sound, light, heat and drainage fully embodies the concept of Green Olympics.

The London Olympic Stadium ('London Bowl'), which was completed 4 years later, has a different architectural character from the 'Bird's Nest'. Located in the Stratford district of East London, the stadium is designed for 80,000 people. Since the London Olympics began with the themes of 'sustainability' and 'economy', the concept of 'sustainability' has been incorporated into the design, with the stadium being constructed as a lightweight frame with a steel composite base. The main structure of the stadium is a lightweight frame, with a basic steel hybrid structure forming the main body of the stadium. Plans to demolish the upper levels after the games to reduce the size of the stadium to a permanent 25,000-seat venue did not materialise and the stadium is now used as the home of West Ham United of the Premier League. Compared to the two stadiums, the 'Bird's Nest' focuses more on appearance and practicality, and is a display of national culture, national image and national strength. As London itself has large stadiums such as Wembley Stadium, the 'London Bowl' focuses more on practicality and economy. The difference between the two venues is a reflection of the economic and cultural background of the two countries.

Figure 20: Stadium of France

Figure 21: London Olympic Stadium

4.5 Post-Summer Olympics Stage: Cultural Confidence and Low Carbon Sustainability

In the post-Olympic era, China's economic development has undergone a historic and substantial change, entering

the stage of 'adjustment, optimisation and upgrading', and industrialisation, specialisation, and a balanced focus on competitive and popular sports have driven the development of the sports industry. In the construction industry, the design and construction of buildings return to the rational road, iconic no longer become the only pursuit, green ecological and sustainable construction has become an important way out of the development. In the context of cultural self-confidence and national rejuvenation, cultural heritage, respect for tradition and integration of science and technology became the mainstream of design in this Stage.

The capital stadium in this Stage is represented by the New Workers Stadium. As a professional football stadium, the new stadium has a high degree of integration of technology and culture, reproducing the simple appearance of the old stadium with the technique of fair-faced concrete. The canopy adopts the creative concept of 'national prosperity and people's peace, gold purlins', and uses the rib-supported single-layer arched shell structural system to present the classic composition of "'San Jiao Liu Wan' (Three Crossings and Six Rays) decorative motif" window lattice(Sheng et al., 2021). The canopy also integrates the functions of sun shading, lighting, siphon drainage, snow melting, photovoltaic power generation and acoustic noise reduction, which maximally realises the sustainable concept of the whole life cycle to reduce the energy consumption of the building and practice the concept of green and low-carbon.

A similar project from the same Stage was the Santiago Bernabeu Stadium (Estadio Santiago Bernabéu) in Madrid, Spain. Located in the north of Madrid, the stadium is an iconic landmark in Madrid and is one of the home stadiums of Real Madrid FC and the Spanish national team. The stadium has a capacity of 81,000 people. Due to new demands for use, the stadium, built in 1947, will be remodeled in 2020, using high-tech elements to create a new experience for fans(Gmp Architects, 2024). The renovation project will cover the building's unified image with a softly curved surface formed by metal louvres, and a translucent curtain wall that connects the inner and outer scenes, enriching the view of spectators and pedestrians, and giving a unique spatial quality to the public environment around the stadium. At the same time, the design takes into full consideration of the surrounding urban space, and will include additional viewing corridors, movable roofs, commercial complexes and other service facilities. A sense of technology, integration with the urban space, humanised experience, and the addition of commercial operations characterise the stadium's architectural design in this new era.

On the basis of 'sustainability', the New Workers Stadium actively integrates into the city, and adopts the concept of integrating metro and commercial operations in the underground space for operation and maintenance, which is very similar to the design concepts of technology, commerce, humanity, and localisation of Madrid's Bernabeu Stadium, but with more respect for tradition and cultural expression.

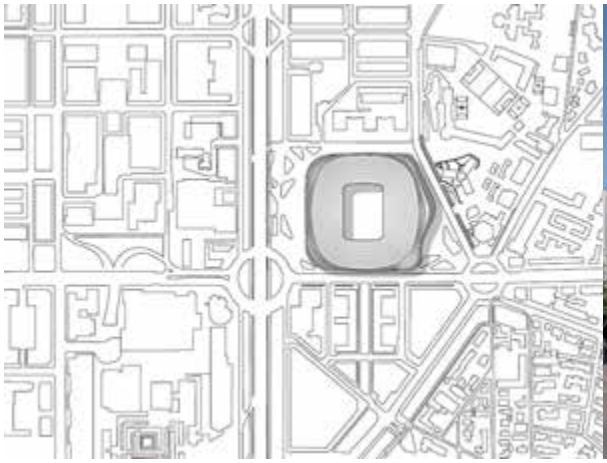

Figure 22: Site-plan of Bernabeu Stadium

Figure 23: Bernabeu Stadium

In conclusion, within the broader historical and cultural context, the stylistic evolution of China's capital stadiums has undergone a complex trajectory, transitioning from an initial phase of Western influence and appropriation, through a Stage marked by eclectic formal collages and Soviet-inspired models, towards a convergence

with international architectural trends. This developmental path ultimately culminated in a dynamic shift characterised by growing cultural confidence, alongside an increasing emphasis on low-carbon and sustainable design principles.

Table 2: Comparison of Capital Stadium buildings from different stages

Stage	New Building	Time	Scale/Capacity	Architectural Features
1 EDS	Xian Nong Tan Stadium	1936	Medium /30,000	Traditional Chinese style, modern sports
2 CSS	Workers Stadium	1959	Mega /80,000	"Soviet-style", frugal and economical
3 AGS	Olympic Sports Centre	1986	Large/40,000	Modernist architecture, new structural systems
4 OGS	National Stadium	2007	Mega /80,000	Technology, Oriental aesthetics, Olympic spirit
5 PSOS	New Workers Stadium	2023	Mega /68,000	Fusion of technology and culture, sustainability

Table 3 Comparison of backgrounds from different stages

Stage	Social	Architectural	Political	Economic
1 EDS	Transformation of social systems amidst external wars and internal revolutions	Western-dominated activities, beginning of modern architecture	Internal and external turmoil	Low level
2 CSS	Exploration of socio-political structures centred on political forms	Establishment of architectural systems, influenced by the Soviet Union and politics	Internal exploration	Low level
3 AGS	Economic reform and opening up with a focus on economic development and societal progress	Flourishing architectural theories and technological advancements	Stability	Initial development
4 OGS	Economic advancement and societal openness under globalisation influences	New developments in architectural theory, industry liberalisation and institutionalisation	Openness	Rapid development
5 PSOS	Emphasis on economic quality and low-carbon humanism post-rapid development	Continuous advancement in building science and technology, embracing new urban design concepts	Inclusiveness	Quality development

Table 4: Comparison of other countries' stadiums in different stages

Stage	Other Country Stadium	Time	Scale/Capacity	Architectural Features
1 EDS	Germany - Berlin Olympic Stadium	1936	Mega /110,000	Super-scale, solemn
2 CSS	Soviet Union - Luzhniki Stadium	1956	Mega /80,000	Frugal and economical

Stage	Other Country Stadium	Time	Scale/Capacity	Architectural Features
3 AGS	France - Stade de France	1998	Mega /80,000	High-tech, adaptable
4 OGS	United Kingdom - London Olympic Stadium	2012	Mega /80,000	Sustainable, economical
5 PSOS	Spain - Santiago Bernabeu Stadium	2024	Mega /81,000	Technological, humanised

5. The Changing Relationship between Stadium Architecture and the City: Connecting History, Present and Future

5.1 Trend towards the convergence of stadium siting

In the site selection of the stadium building in the capital, it presents the characteristics of siting in the peri-urban area of the city boundary and moving outward with the development of the city. In 1936, the vicinity of Xiannongtan was a peri-urban area, and the stadium was 3.8 km away from Tiananmen Square(city centre); by the end of the 1950s, the urban area of Beijing was gradually expanded, and Youth Lake in the eastern suburb was chosen as the site of the Workers Stadium, which was 4.8 km away from Tiananmen Square, and the site of the Olympic Stadium Centre in the 1980s was even further to the north, which was 8.4 km away from the Tiananmen Square; after the new millennium, due to the development of the city, the construction of a mega stadium was not suitable for the south side of the Olympic Stadium Centre. After the new millennium, due to urban development, it was not suitable to build a mega-stadium on the south side of the Olympic Stadium, so the National Stadium was even further north, with a distance of 9.5 km from the centre; in the post-Olympic era, the city has reached its limit of development, and the location of the Workers Stadium has changed from a suburban area to the core area of the city, so the restoration of the stadium will enable it to be better integrated into the city to serve it. Compared with other national stadiums, Berlin Olympic Stadium is the furthest away from the city centre, located 11 km to the west, while Madrid Bernabeu Stadium is the closest, only 4.2 km away, and most of the other stadiums are between 6 and 8 km away. It can be seen that the sites of the capital stadiums, after moving outwards to their limits, will gradually stop moving and will instead be invested in the renewal of the existing stadiums, forming a spatial core that is constantly integrated into the city.

5.2 Trend towards composite stadium functions

In the overall planning of the Capital Stadium, it can be seen that the overall presentation of the small venues to large single venues, to sports centres, sports parks and then to urban parks, culture, tourism and business integration space of the development of the transformation, which reflects the capital stadium venues layout more intensive and organic, venues function gradually composite integration, the construction of more flexible mode of operation, the public participation continues to enhance the characteristics of the stadium.

In terms of venue categories, it can be seen that integrated stadiums such as the Bird's Nest, London Bowl, Luzhniki Stadium and other integrated stadiums are often used as one of the buildings of the sports centre, forming a cluster effect with other venues to better serve large-scale integrated tournaments, while professional football stadiums such as the New Workers Stadium, Stade de France and Bernabeu Stadium are mostly operated and maintained as independent stadiums in the city's core area, which are also more flexible in terms of the number of events and activities held in the stadiums. This is also more in line with its main activities such as football tournaments. The introduction of commercial, leisure, cultural and tourism businesses in the New Workers Stadium and the new Bernabeu has enabled the stadium to become a city landmark, cultural and sports business card, and a centre of vitality. The attention to urban spatial integration and infrastructure compensation will further drive the overall improvement of the surrounding environment, making the stadium a sports complex in the city, and contributing to the new pattern of 'stadium-region' integrated and linked development in the city.

5.3 Trend towards the adaptive reuse of sports architectural heritage

Major stadiums in capital cities, as events or Olympic legacies, are not only static buildings but also dynamic cultural vehicles. In response to the multiple challenges of tourism, gentrification and climate change, the capacity of the stadiums should be continuously upgraded in order to redefine their social function and cultural

significance. In this regard, it is important to enhance the sustainability of the building, for example, by retrofitting it with a new energy recovery system, enhancing the connectivity of the urban space, for example, by optimising public transport connections, increasing public participation, for example, by utilising NGOs to organise events and implementing a policy of free admission, integrating the land around the building, integrating the renovation and development of the building, revitalising the space, utilising the intensity of the use of the venue by means of an innovative investment and financing model, and enhancing its spatial relevance to the urban environment. And enhance the spatial correlation with the urban environment. This will strengthen their role in improving the quality of life of urban residents and stimulating urban vitality.

6. Conclusion

Beijing stadium architecture, especially the national stadium, is the window and embodiment of the national image and national culture. This paper takes vertical and horizontal comparison as the main vein to analyse the construction background, building scale, construction concept and architectural image of the capital stadium architecture in different periods. At the same time, it also compares the stadiums of other countries in the same period horizontally, explores the unique temporal characteristics behind the stadiums, sums up their architectural features and concepts, and finally concludes that 'The wave of stadium construction orientated to tournament celebrations: from the region to the world' and 'Changes in Architectural Style and Philosophy in the Context of the Times: From Western Learning to Parallel Development'. It provides new ideas for the construction of stadiums in the capital city and other cities and the display of national dignity. We also summarise the urban development characteristics of stadiums in terms of their relationship with the city, and propose optimisation strategies that not only enhance public participation and promote the synergistic and sustainable development of architecture and urban space, but also ensure that these iconic stadiums continue to play a key role as important carriers of the national image, connecting history, the present and the future.

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Challenges and outlooks of incremental historic urban district renovation in China – take Beijing Hutong Dongsinan case as an example

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Abstract
Incremental historic urban district renovation has emerged as a political consensus and trendy research field in China. However, intertwined challenges have made sustainable incremental renovation an increasingly demanding job. Evaluating incremental HUD renovation and exploring the potentials and limitations of such incremental approaches have become key topics in contemporary research. This paper proposes a theoretical and technical framework to evaluate HUD renovation processes and results regarding sustainability principles. With this framework, the paper evaluates the DSN quarter in Old Peking—one of the most representative cases of incremental urban renewal in China. Based on this evaluation, the paper identifies the key strengths, potentials and challenges of this emerging pattern, offering learnings towards sustainability for historic urban districts in and beyond Beijing Hutong.

Key words: Incremental historic urban district renovation; Beijing Hutong; evaluation; sustainability

1. Introduction

Incremental renovation, an urban renovation/redevelopment/renewal approach that "does not resort to wholesale demolition" and occurs without large-scale displacement (Shih, 2017; Wu, Zhang and Liu, 2022)derived from and defined by local entrepreneurial governance. However, changing state politics, in particular national political mandates, has not been adequately addressed. Through examining variegated practices, this paper understands how the changing national political context affects or redefines local redevelopment projects. These cases reflect local responses to the national campaigns for rural vitalisation and "Beautiful China", heritage preservation and "incremental regeneration" (weigaizao, has been long considered as a scholarly consensus among urban planners and scholars in China as well as a recommendation for historic urban district (HUD) renewal. Wu Liangyong, one of the most influential figures in this discourse, created "organic renewal theory") based on the Ju'er Hutong renovation project in the inner Peking. Wu advocated for a metabolic renovation process to achieve "sustainable development," applying different policies – such as conservation, demolition, etc. -- depending on the physical quality and the cultural significance of individual courtyards in HUDs. (Wu, 1994, pp. 63–69) Since the turn of 21st century, as China joined the WTO in 2000 and successfully bid for hosting the 2008 Olympics in 2001, the country has been further engaged in world industrial division and cultural exchange. Heritage conservation and cultural branding have been increasingly vital in the context of inner city renovation in China's urban development, especially in major metropolitan areas such as central Beijing (Tang and Zhang, 2021). In response, a growing number of scholars and local citizens have criticized the large-scale HUD demolition and replacement, once the "mainstream" mode of redevelopment since the late 20th century, for their adverse effects on urban conservation and social justice. (Fang, 2000) However, "dull-dozer redevelopment" remained to be in dominance in the 2000s driven by profit-oriented objectives under the joint control of local governments and real estate developers.

Incremental renovation became a widely-accepted political consensus (Ni, Zhang and Huang, 2017) and a popular trend (Wu, Zhang and Liu, 2022)derived from and defined by local entrepreneurial governance. However, changing state politics, in particular national political mandates, has not been adequately addressed. Through examining variegated practices, this paper understands how the changing national political context affects or redefines local redevelopment projects. These cases reflect local responses to the national campaigns for rural vitalisation and "Beautiful China", heritage preservation and "incremental regeneration" (weigaizao in China in the early 2010s, especially in HUD renewals. The shift was largely driven by central government's strong will and commitment (Wu and Zhang, 2022) to heritage conservation and community construction as deepening the "all-round reform." (China Daily, 2013) In addition to the top-down effort, the growing instability of the financial mechanisms underpinning large-scale "bulldozer" redevelopment programs further accelerated the transition toward incremental approaches in the late 2010s. Compared to bulldozer redevelopment, incremental HUD renovation with limited demolition and replacement, has been widely considered to be more sustainable

regarding economic, social, and cultural dimensions. It can contribute to preserving the spatial framework of the old city, the texture of the historic district, traditional architecture, traditional craftsmanship and customs, etc. (Ni, Zhang and Huang, 2017; Chen, 2021, p. 152; Wu, Zhang and Liu, 2022)derived from and defined by local entrepreneurial governance. However, changing state politics, in particular national political mandates, has not been adequately addressed. Through examining variegated practices, this paper understands how the changing national political context affects or redefines local redevelopment projects. These cases reflect local responses to the national campaigns for rural vitalisation and "Beautiful China", heritage preservation and "incremental regeneration" (weigaizao. It can also help to maintain local social network and collective memory, enhancing residents' sense of community belonging. (Chen, 2021, pp. 156–161; Wu, Zhang and Liu, 2022)"publisher":"China Architecture & Building Press","publisher-place":"Beijing","title":" (The Research of Protection Renewal and Regeneration of Historic District: The Case of Three Blocks and Seven Alleys Historic District in Fuzhou Moreover, incremental renovation allows for "flexible social capital investment influx" and helps to "avoid market risk" (Fang, 2000; Chen, 2021, pp. 165–166), making it a resilient strategy for sustainable urban regeneration.

This study focuses on incremental renovation in Chinese HUD renovation by raising up the following research questions: Can the incremental HUD renovation modes in China align with sustainability principles? What are the potentials and limits of the current incremental approaches? By evaluating a typical Beijing Hutong case -- Dongsinan (DSN) renovation -- against a sustainability-based framework, the study will offer reflections and recommendations on incremental HUD renovation practices in China. Section 2 will develop an evaluation framework grounded in sustainable principles. Section 3 will introduce the case site, outline the major challenges of Hutong development and conservation, and introduce the data collection methods. Section 4 will present the evaluation results, while Section 5 will provide reflections and discussions informed by the findings especially on the potentials and limits of the current incremental renovation mode.

2. Sustainability principles in incremental HUD renovation

2.1 Literature review on sustainability

"Sustainability" has emerged as a prominent global discourse in the 21st century. (Li, 2025) The concept highlights integrity across multiple dimensions, encompassing environment, social development, economy, and culture. (Strezov, Evans and Evans, 2017; Sabatini, 2019; Zhao, Zhao and Hui, 2021; Najjar, 2022; Li, 2025)comprising Change in Wealth Index (CWI It also features both intergenerational and intragenerational "justice" among diverse actors. (Neugebauer, 2014, pp. 69–74) As urban heritage has been recognized among "central components" towards sustainable urban development (UNESCO, 2016, p. 22), understanding and interpreting "sustainability" principles in the HUD renovation contexts provide a basis for evaluating renovation cases and generating learnings from past experiences.

"Sustainability" in the HUD renovation refers to both sustainable processes and sustainable results. (Li, 2025) With regard to sustainable HUD renovation processes in response to the increasingly complex and intertwined challenges with uncertainties, a body of literature highlights the importance of a strategic approach. Such an approach highlights both integrity -- integrative vision, inclusive participation, and integrative governance and institution design – as well as adaptiveness, which requires both consistency and flexibility in the course of time and varying scenarios. An integrated and adaptive strategic thinking, offering "a set of concepts, procedures, and tools" towards fixed objectives or open visions (Wiechmann, 2007), can contribute to organising thinking, setting direction, focusing on effort, defining organization, providing consistency, and reducing ambiguity. (Mintzberg, Ahlstrand and Lampel, 2005, pp. 15–17) It can play a crucial role in addressing the complexities and uncertainties in HUD renovation. Carter and Roberts (2017, p. 50) identified a set of key features of a sustainable strategic approach drawing on extensive theoretical research on urban issues. They highlighted the importance of recognizing the inherent complexities involved, maintaining consistency of objectives under a long-term vision, and facilitating broad-based participation of both "bottom-up" and "top-down" interests throughout the entire process. They also underscored strategic adaptiveness, highlighting the need for creating a self-sustaining system open to ongoing adjustment and refinement, alongside regularly monitoring and evaluation. Other key principles included building consensus creation under a shared strategic vision as well as ensuring transparency in information dissemination. The HUL Guidebook (WHITRAP et al., 2016, p. 13) outlines a six-step methodology for strategy development, highlighting comprehensive survey and mapping, participatory planning for consensus building, integrated value and vulnerability assessment, action prioritization, and partnership establishment.

As HUD renovation has been increasingly incremental and emergent, strategic approaches are required to incorporate "embedded flexibility" (Van Karnenbeek and Janssen-Jansen, 2018) in response to the complex urban systems. Since the renovation results may be "provisional and contingent," (Dovey, 2014) in recent decades emphasis has been turned to institutional design—or "the rules of the games" (North, 1990)—by a number of scholars, including D.A. Jelincic and Y. Mansfeld (2019) and Dovey (2014). In addition, an adaptive development model featuring "gradual adjustment of routines as a reaction to the dynamic environment" grow out of "collective learning" has been proposed in addition to the traditional linear, fully-formulated, and "from ends to means" strategy model (Wiechmann, 2007).

As for sustainable results, the expected and un-expected outputs, outcomes, and impacts of HUD renovation actions should be taken into account. A comprehensive understanding of sustainability in HUD renovations requires the integration of multiple dimensions—typically environmental, economic, social, and cultural. Scholars have developed a variety of multicriteria assessment methods and indicator systems to evaluate sustainability, either holistically (Neugebauer, 2014; Kou et al., 2018; Lin et al., 2021) or from specific disciplinary perspectives. There is also a growing body of literature on Impact Assessment (IA), such as Heritage Impact Assessment (Ashrafi, Neugebauer and Kloos, 2022), Environmental Impact Assessment (Glasson and Therivel, 2013), and Social Impact Assessment (Sairinen and Kumpulainen, 2006; Yung, Chan and Xu, 2014, 2015), providing detailed discussions and criteria for different (potential) impacts of the renovation efforts in ex-ante and/or ex-post contexts. All these studies contributes to a comprehensive understanding of how to describe, assess, and evaluate the multifaceted outcomes of HUD renovation projects.

2.2Incremental HUD renovation evaluation framework on sustainability

Based on the literature view on "sustainability," the study proposes an evaluation framework of both sustainable HUD renovation process and results. In evaluating the renovation process, sustainability is interpreted through four key dimensions: integrated vision, justice, adaptiveness, and robust institutional support. An integrated vision involves both integrative value interpretation and comprehensive strategic objective or direction setting. Justice mainly refers to the fair participation among different actors, especially the local communities and the experts since in China the party-state can always be in a dominant position in HUD related issues. Adaptiveness should also be highlighted in an incremental and emergent process in the course of time. Last but not least, robust institution design, or game rules design, such as resource allocation and negotiation system, can be essential for guiding ongoing, open-ended renovation efforts and achieving long-term strategic goals. With regard to the outcomes, a comprehensive assessment should consider the impacts across environmental, economic, social, and cultural dimensions. Figure 1 and Figure 2 list the key evaluation criteria derived from the literature, which will subsequently be applied to the case of the DSN Hutong renovation by evaluating to what extent the DSN case is in line with sustainability.

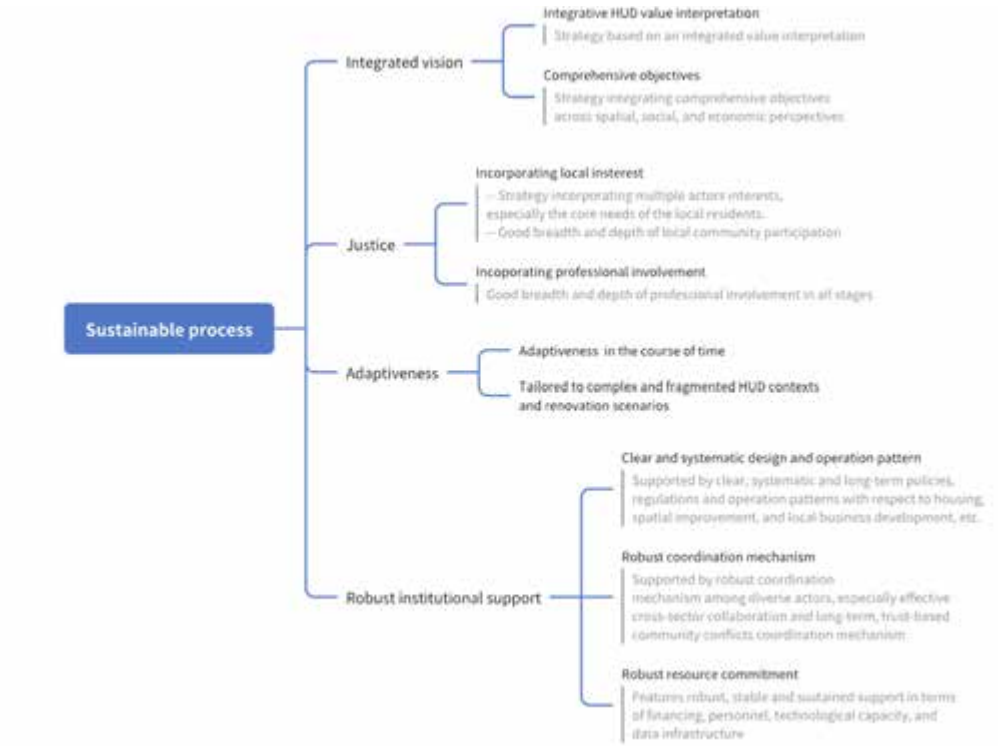

Figure 1: Criteria for sustainable processes (key reference: (Carter and Roberts, 2017; Li, 2025))

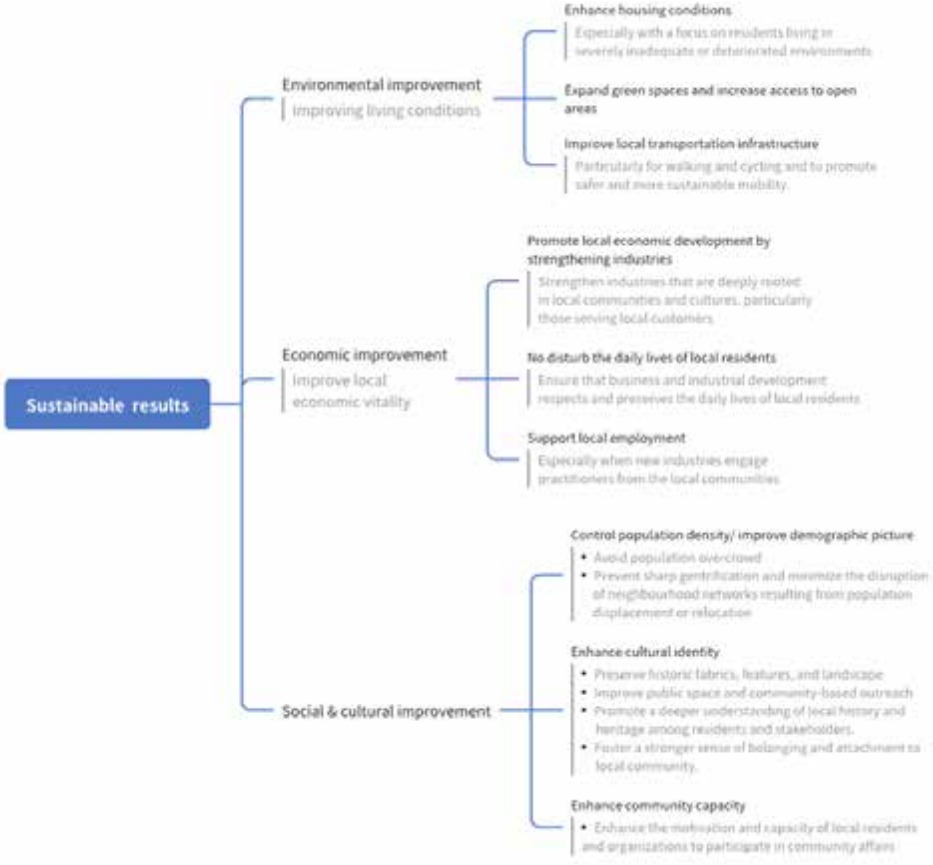

Figure 2: Criteria for sustainable results (key reference: (Neugebauer, 2014; Shi, Bian and Ge, 2015; Lin et al., 2021; Li, 2025))

3. Case study: DSN Quarter in Beijing Hutong

3.1 Key challenges for Hutong renovation

Beijing Hutong quarters are typically residential and commercial-residential HUDs in China, located in the central area of the city. These quarters feature a traditional spatial pattern of Hutong (narrow alleys) – siheyuan (courtyard houses). A Hutong (alley) refers to a narrow alley lined by the exterior facades of courtyard residences, while siheyuan, also known as a Chinese quadrangle, typically consists of inner yard enclosed by one-story houses. Historically, a single Siheyuan was often inhabited by an extended family; however, in contemporary times, these courtyards are usually shared by multiple households. Beijing Hutong quarters possess significant historical, social, and economic value. They exemplify traditional Chinese urban planning principles and embody the cultural philosophy of rites and order. However, in the recent decades, Beijing Hutong and its associated renovation efforts have faced a range of complex and pressing challenges.

Figure 3: Beijing Hutong (DSN Quarter), photoed in Nov 2023 (left) and June 2024 (right)

First, the Hutong quarters suffer from population-space conflicts. Accommodating a large population within spatially constrained environment has resulted in the limited living space, informal self-built additions within the yards, and encroachment on public and semi-public areas[1] with their personal items, which further undermines the historical spatial pattern and landscape, adds to the difficulties in improving local residents' living conditions, and may even exacerbate tensions among residents when competing for limited shared space. (BUT Research Team on Dashilar, 2019) Second, the Hutong quarters feature spatial and social fragmentation. There can be considerable differences among different courtyards in terms of property right management, courtyard neighbourhood relations, and households' willingness to engage in relocation or renovation processes in Hutong Quarters. (Shi, 2022, pp. 159–184) Therefore, a uniform approach or "one-size-fits-all" policy is unlikely to be effective. Renovation efforts need to take into account the diverse preferences and conditions of individual households featuring flexible and context-sensitive strategies tailored to different scenarios.

Third, the Hutong quarters remain insufficiently robust in terms of grassroots management. As the Danwei-allotment system in the planned economy time collapsed in the late 20th century, an institutional vacuum emerged regarding the grassroots management. Though local Neighbourhood Committees,[2] Street Offices[3], and certain

1 The "semi-public" space here mainly refers to the yard space inside the courtyards, usually shared by multiple families.

2 Neighbourhood Committee is the fundamental local-based organization in urban China featuring a dual character of both residents' self-governance organization at the grassroots level and quasi-state administrative agency.

3 Street Offices, or "街道办" in Chinese, is the administrative agency of the district-level governments. They are always the lowest formal state governance agency in urban China.

local community organizations have taken on responsibilities in local management, grassroots management are still suffering from unclear delineations of rights and obligations among different actors, limited local resources and power, and authority fragmentation among sectors. The weak local management institution construction has posed challenges for effective community participation and interdisciplinary collaboration in HUD renovation processes.

Last but not the least, local Hutong communities have limited capacity for sustainable product production and consumption. It can be difficult for local residents, especially the underprivileged, to "generate their own blood." In addition, due to the increasingly stringent control of commercial and tourism developments in HUDs in Beijing (BMBCT, 2021), the "rent gap" (Smith, 1979) in these areas has been reduced, limiting opportunities for economic revitalization and capital inflow into the Hutong quarter.

3.2 DSN Renovation

DSN Hutong quarter is located in the Dongcheng District of Central Beijing. It retains a historical spatial pattern of Hutong alley-courtyard, though now a single courtyard has often been shared by multiple families. Since the early 20th century, the quarter has attracted a number of educational and administrative institutions and has become a favoured residential and gathering place for prominent figures in literature, education, and modern science. (BMCPNR, 2021) The quarter spans around 1,24 km^2 and holds around 40, 000 long-term residents. (Chen, 2020, p. 29) Like many other Peking Hutong quarters or HUDs in China, DSN quarter faces intricated challenges towards sustainable development.

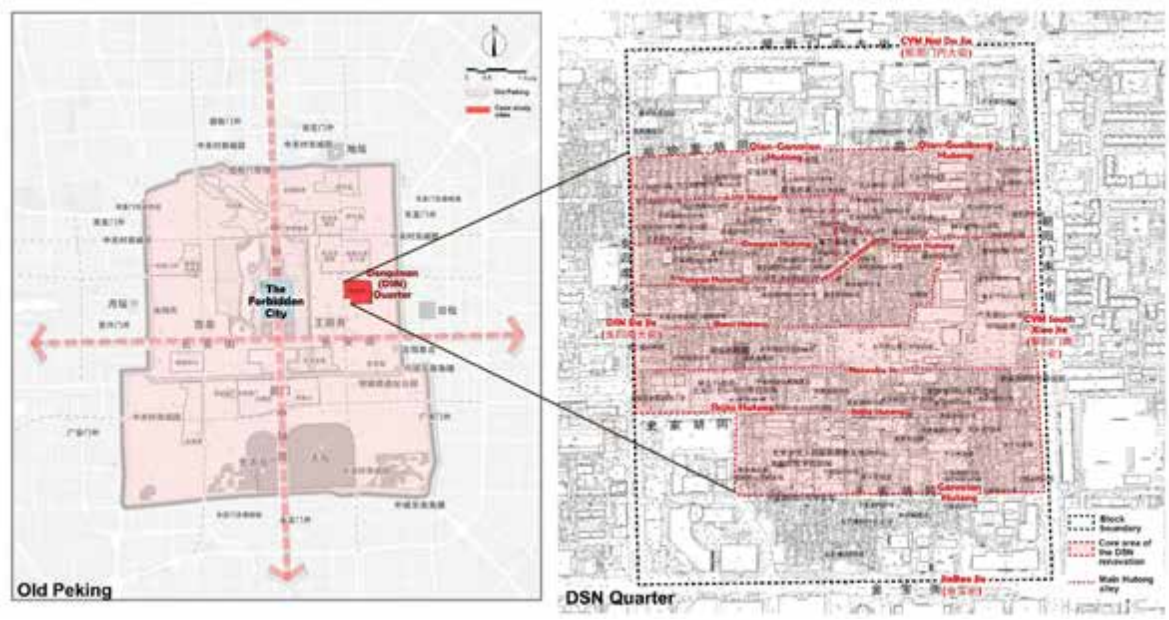

Figure 4: DSN quarter (base map of the left: (BMCPNR, 2018); base map of the right(BMCPNR, 2021))

DSN renovation is one of the most representative incremental HUD renovations in China. Initiated in 2010, it remains an ongoing process till today. Instead of following a linear trajectory, DSN renovation features open-ended development towards comprehensive community building and renovation. The renovation can be categorized into three phases: an incubation phase (2010–2013), characterized by tentative strategy-making through community workshops and the pilot renovation of Shijia Hutong Museum (SHM); a phase of institutional development (2014–2018), focused on community-based institutional construction and renovation efforts led by the Shijia Hutong Style and Feature Conservation Association (SHSFCA)[4], a local organization established in 2014; and a phase of comprehensive exploration (2018–present), marked by the development of long-term responsible planner cooperation and the creation of a collaborative management platform, known as "DSN Platform" for short, DSN renovation come to a new period, featuring multiple series of cooperative across the Quarter.

4 SHSFCA is composed of local residents, property-right danwei, local party state members, experts from universities and planning institutes. (Feng et al., 2020, p. 3)

Up till now, DSN renovation has accumulated experience in developing local organization institution and has established several renovation patterns for incremental spatial improvements exemplified by round-by-round residential courtyard improvement, historic courtyard rehabilitation, and micro-public space renovation. Additionally, it also highlights cultural outreach and capacity building.

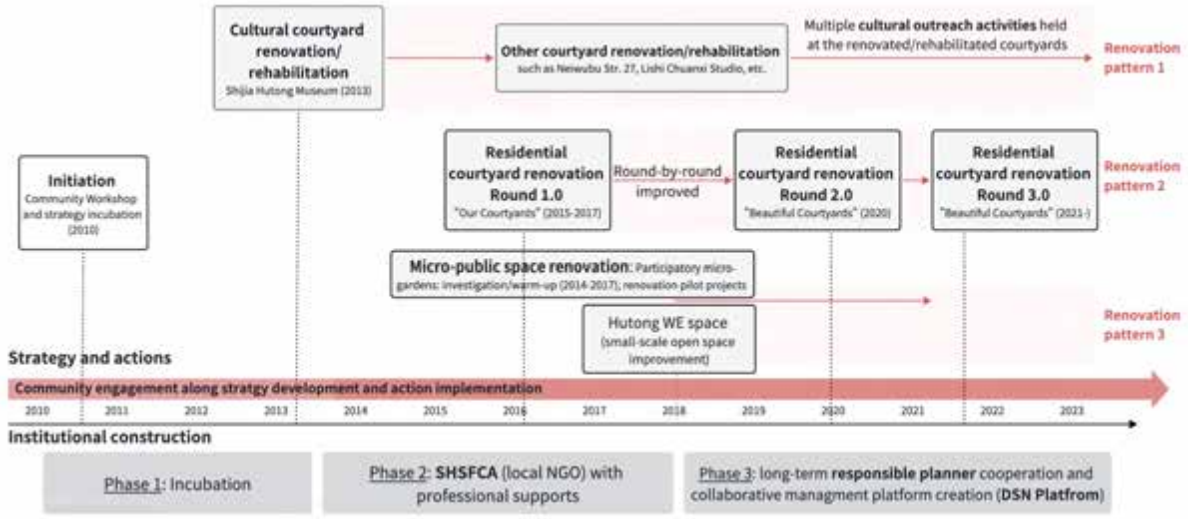

Figure 5: DSN renovation procedure (Li, 2025)

3.3 Data Collection

In order to assess and evaluate DSN renovation processes and results against sustainability, data were collected through three primary methods: (1) literature review; (2) direct field observation in the field trip; and (3) semi-structured interviews.

The literature review draws upon a wide range of sources, including governmental notices and documents, academic publications (books, journal articles, theses, etc.), community bulletins, newspapers, and official media outputs. Field observations were conducted during site visits to the DSN Quarter in November 2023 and June 2024, covering most of the public spaces within the HUD. During these visits, careful measures were taken to minimize the influence of the researcher's presence on the observed environment. Semi-structured interviews were conducted from November 2023 to June 2024 with a range of key stakeholders, including experts directly involved in the renovation process, members of local Neighbourhood Committees (NCs) representing the resident communities, and representatives of NGOs and guest performers engaged in community outreach. All interviewees were informed of the study's purpose in advance, and notes or audio recordings were made with their prior consent.

4. Results

Based on the literature review, field observations, and interviews, the study presents preliminary evaluation results referring to the framework and criteria on sustainable HUD renovation processes and results.

Table 1: Process evaluation of the DSN case

Criteria		Assessment and Evaluation
Integrated vision	Integrative HUD value interpretation	Mostly in conformity (For) The strategy is grounded in an integrated HUD value interpretation, especially the social and cultural values. (Against) However, there is still a long way to go to create "value consensus" and clear bottom lines among different actors.
	Comprehensive objectives	Fully in conformity (For) The strategy addresses multiple objectives regarding spatial, social and cultural perspective with a long-term vision.
Justice	Incorporating local interest	Partly in conformity (For) The renovation is relatively open to local residents engagement, especially compared with the non-incremental HUD renovation cases in China. (Against) The strategy can be limited regarding housing condition improvement, which is the residents' primary concern (Shi, 2022, p. 226) Resident participation mainly stay in the level of tokenism according the citizen participation ladder (Arnstein, 1969) and still limited in terms of genuine decision-making power.
	Incorporating professional involvement	Mostly in conformity (For) The renovation features "responsible planners" system and exhibits good depth and spectrum of professional participation in the entire process. (Against) The power and working scope of the responsible planners can be depended on the altitude of local street office.
Adaptiveness	Adaptiveness with consistency in the course of time: Tailored to diverse and complex renovation scenarios	Mostly in conformity (For) The strategy adopts an incremental, step-by-step approach, allowing for continuous adaptation based on feedback, thus balancing consistency with flexibility over time. The strategy features small steps at a time and tailored to the fragmented HUD courtyard contexts. The strategy features wide-range cooperation with third parties, enhancing its ability to respond effectively to different scenarios when coming across various challenges. (Against) Many of the incremental operation patterns remain experimental and vulnerable to uncertainties.

Robust institution support	Clear and systematic design and operation pattern	Partly in conformity (For) The renovation provides valuable explorations on institutional infrastructure design and game rules making regarding incremental small-scale actions supported by the local-based collaborative platform, exemplified by the round-by-round courtyard renovation pattern. (Against) Limited regulations and operation patterns have been developed regarding population and housing management and housing condition improvement, which is the core challenge and concern of the local community. The courtyard renovation operation pattern has still suffered from high transaction costs and lack of long-term maintenance
	Robust coordination mechanism	Partly in conformity (For) Creating the collaborative platform contributes to inter-sectoral and interdisciplinary cooperation, though the impacts have been gradual rather than transformative. Facilitating small-scale cooperation and consensus building in community activities or renovation actions as well as utilizing endogenous interpersonal structure and leadership to contribute to long-term trust-based community conflicts coordination mechanism. (Against) The coordination mechanism is not robust enough in the face of serious disputes, especially those involving core interests or occurring in courtyards without strong endogenous leadership.
	Robust resource commitment	Partly in conformity (For) Instead of relying solely on local government, the renovation draws on multiple resource sources and creates its resource pool to support renovation and community building. (Against) Current resource commitment are not stable and robust enough to provide continuous support for a broad range of initiatives.

Table 2: Result evaluation of the DSN case

Criteria		Assessment and Evaluation
Environmental improvement	Improving living conditions	Partly in conformity (For) Spatial improvements have been made in several courtyards through cultural outreach rehabilitation and round-by-round residential yard enhancement. Spatial improvements have been made regarding creating small public space and green space (Against) Only a limited number of courtyards have undergone renovation. No or limited improvement in housing conditions, (semi-)public space encroachment, and local walking, cycling, and parking system
Economic improvement	Improve local economic vitality	Partly in conformity (For) DSN has attracted a few self-sustainable organizations providing cultural and welfare-related services to local residents (Against) Limited improvements on local employment. An increasing influx of tourists has begun to disturb the everyday life of the local community

Social and cultural improvement	Control population density and improve demographic picture	No or limited in conformity No specific strategies or actions—either direct or indirect—addressing population density have been identified in the renovation plans
	Enhance cultural identity	Fully in conformity (For) Historic fabric and landscape conservation and rich community-based outreach activities have enhanced local heritage understanding and cultural identity.
	Enhance community capacity	Partly in conformity (For) Community activities and thematic seminars have created opportunities for some Hutong residents to develop a more open and proactive attitude toward local participation. The development of trust and emotional connections among local residents, on-site professionals, and NGO workers—alongside the accumulation of professional experience—has contributed to strengthening local community capacity. (Against) The depth and the scope of community participation as well as the capacity of local residents require further improvement.

5. Discussions

The evaluation results of the DSN renovation highlight both its potential and its challenges in terms of sustainability. One key advantage is that incremental HUD renovation like the DSN case allows for a long-term, gradually-improving strategy, fostering institutional design and the development of an operational model that balances consistency and adaptability. This approach is particularly valuable in addressing the growing complexities and uncertainties of current HUD renovation and instrumental in evolving institutional procedures from an experimental, easily initiated, and community-inclusive phase into a well-structured, mature framework. For instance, in the DSN case, the operational model for residential courtyard renovations has undergone three rounds of refinement. Improvements have been made regarding the establishment of the "pilot courtyard pool," courtyard selection processes, collaborative design, and renovation plan confirmation, and the early experimental efforts of the Round 1.0 courtyard renovation in 2015–2016 have gradually evolved into a more structured and well-designed series by Round 3.0 in 2021. Furthermore, the DSN renovation case also suggests that in order to guarantee the long-term strategy with consistency, adaptiveness, integrity, it is important for the local authorities and professionals stay in an open mind and provide long-term commitment, as well as to create long-term local-based collaborative institutions alongside professional support systems.

In addition, the DSN case also indicates the great potential in social capital accumulation in the incremental HUD renovation process, which will reduce transaction cost in the negotiation and cooperation and benefit long-term spatial improvement and community capacity building. "Social capital" refers to resources embedded in "social network accessed and used by actor for actions" (Lin, 2001, p. 25) or "the good will that is engendered by the fabric of social relations and that can be mobilized to facilitate actions." (Adler and Kwon, 2002, p. 23) The DSN case indicates that long-term local-based cooperation can enhance trust and emotional connection between the local residents and the community urban planners or the NGO workers and facilitate smoother collaboration. Moreover, it is also an important learning that we should not neglect endogenous structure and leadership shaped by the kinship, prestige, tenancy relationship, and long-term gaming among residents themselves. Supporting individuals with endogenous leadership roles can be important in facilitating cooperation and decision-making within the local community.

Apart from the advantages and potentials, incremental HUD renovation, as demonstrated in the DSN case study, also reveals limitations. In particular, this approach struggles to address situations involving severe conflicts of interest or the absence of endogenous leadership. In addition, the current DSN renovation does not touch one of the primary concerns of local residents: housing condition improvement. Critical issues such as expanding residential space and upgrading basic amenities (such as the kitchen facilities) remain insufficiently addressed, especially for underprivileged groups living in substandard conditions. Instead, it focuses more on semi-public and public spaces, such as shared courtyards and the open green space. Therefore, the DSN renovation falls short of tackling one of the fundamental challenges of sustainable HUD development -- managing population pressure within limited space – and results in limited explorations regarding the housing policy studies, property right clarification, etc. It also means that the derivative issues of population-space conflicts -- such as the self-additions in the courtyards spoiling the historical landscape and the encroachment into the public areas, courtyards neighbours conflicts on using the limited shared space, etc. -- can hardly be adequately assessed. Further explorations are still required with respect to a more holistic and resident-centred approach and taking population pressure management and housing policy improvement into consideration, supported by strengthened resource support and institutional frameworks.

Based on the above discussion, Table 3 summarises the potential advantages and limits of incremental renovation models, as exemplified by the DSN case. In further cases, the table may serve as a useful tool for determining whether the incremental renovation approach is appropriate for specific contexts. It is also important to note that the analysis in Table 3 is situated within the specific context of China and may not be directly applicable to other settings. In the future, the incremental approach requires further enhancements on improving its local-based capacity in addressing more challenging residents concerns with party-state and third-party supports as well as community capacity building, especially with respect to population density control and housing conditions improvement.

Table 3 Limits and potentials of incremental renovation models exemplified by the DSN case

Well-suited to these conditions	Inappropriate for these conditions
- Not suffering from severe population pressure or critical housing condition issues	- Suffering from severe population pressure or critical housing condition issues
- Featuring a certain degree of endogenous structure and emotional connection accumulation that favouring negotiation within the local community	- Featuring a poor degree of endogenous structure and emotional connection accumulation that favouring negotiation within the local community
- Featuring a relatively strong potential for long-term collaborations with local experts and emotional connection	- Featuring a poor potential for long-term collaborations with local experts and emotional connection
- Facing limited political pressure to produce immediate, visible, and remarkable results	- Facing great political pressure to produce immediate, visible, and remarkable results

6. Conclusion

This study investigates the current exploration of incremental HUD renovation with a particular focus on its current strengths and weaknesses on sustainability. It develops a comprehensive evaluation framework on both sustainable HUD renovation processes and results based on literature review and applies this framework to assess and evaluate one of China's most representative cases—the DSN Quarter renovation in Beijing's Huong.

The case study and evaluation indicate the dual nature of incremental renovation at current stage in China: on one hand, it allows a long-term, gradually-improving strategy with consistency and adaptability and it demonstrates the potential for social capital accumulation, thereby reducing transaction costs in negotiation and collaboration over time. One the other hand, the findings also underscore existing challenges. Specifically, further exploration is needed to advance a more holistic and resident-centred approach that integrates population pressure management and housing policy reform. These insights may contribute to enhancing the sustainability of future incremental HUD renovation efforts.

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Abbreviations

BMBCT: Beijing Municipal Bureau of Culture and Tourism

BMCPNR: Beijing Municipal Commission of Planning and Natural Resources
BUT: Beijing University of Technology

HUL: Historic Urban Landscape

SHSFCA: Shijia Hutong Style and Feature Conservation Association

UNESCO: United Nations Educational, Scientific and Cultural Organization

WHITRAP: World Heritage Institute of Training and Research for the Asia and the Pacific Region under the auspices of UNESCO

Lived Heritage through the Changing Gaze: A Views and Vistas Analysis for Valletta

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Abstract
This paper investigates the transformative potential of urban planning by presenting the process through which a comprehensive Views and Vistas Analysis for Valletta World Heritage City was drawn up. The theoretical background is presented through key themes related to Urban Cultures and Lived Heritage. We explore how space is a relational concept and present a critical understanding of the changing gaze in its regard to the city. The methodology for the analysis is then presented, this based on identifying key visual elements within the city, assessing their aesthetic and symbolic importance, determining optimal viewing positions and analysing the visual composition of the views. The analysis resulted in a set of key principles for good governance in the interpretation and application of Maltese spatial planning policy.

Keywords: Community, Ritual, Spatiality, Views, Visual Integrity

Lived Heritage through the Changing Gaze: A Views and Vistas Analysis for Valletta

1. Introduction

Valletta was conceived by the Knights of St John as a Renaissance city with the rather grandiose duty of serving as a 'bulwark of Christendom'. Striking while the iron is hot, as the saying goes, the Grandmaster appealed to the Pope to fund a new city in Malta following the Knights' successful survival of the Great Siege in 1656. Faith and military prowess thus intertwined, Valletta was inaugurated as Malta's capital city in 1571 and has remained so to this day. It was inscribed on the UNESCO World Heritage List in 1980 under criteria (i) and (vi) and is currently the subject of several studies being undertaken to draw up a Management Plan for the city. A Views and Vistas Analysis has thus been completed and submitted to the World Heritage Committee (MHAL, 2023), the methodology for which is described in this paper. The Analysis underscores the significance of visual perception within the historical and cultural fabric of Valletta, a point echoed by the reflections of Italian author Italo Calvino. He observed that the eye is perhaps the most existential organ of the body and hence the most important one (Calvino, 2010).

Calvino's observation was particularly inspired by the existential philosophy of Martin Heidegger so preponderant at the time, who in his 1927 magnum opus 'Being and Time' dwelt considerably upon the 'throwness' of Being, and hence the 'situatedness' of existence (Heidegger, 1962). According to Heidegger, there is little that has to do with choice when it comes to our existence; we find ourselves 'thrown' in the world, and the world is always a situation that has already been worked out. One could say that we are not only born in a determined time and space, but, perhaps more important, we are also 'born in language'. By language it is understood a system of signs and signification, of symbols and their meaning, of an ordering of the world that provides us with an understanding of it. This paper shall delve into such an understanding of Valletta by taking a theoretical and practical journey through the assignment of significance and meaning to our changing gaze of the city.

2. A Theoretical Lens on Views and Vistas

To continue upon Calvino's astute observation, the eye is not merely a biological organ but is also a linguistic (and thus an existential) phenomenon. Through the gaze, the act of seeing, we understand where we stand in the world, because the eye is never a naked organ, but an organ dressed in the livery of meaning. The act of seeing is not a natural act but an educated (or informed) act; we learn how to see, what to see and where to put that which is being seen within the order of meaning.

This has a profound impact on our understanding of space. Space is therefore always relational to our gaze. We never look at space with a naked, neutral eye. Ours is an informed eye, and therefore even before the act of

seeing we already have expectations, assumptions, values that will impact what we see and how we will relate to it. To a certain extent we see what we prepare ourselves to see and overlook pretty much else. This explains why, for example, many tourists experience heightened emotions in front of such monuments as the Great Pyramid of Giza, but then those emotions are significantly less strong in front of, say, the step pyramid in Saqqara projected by Imhotep – ignoring the fact that the quantum leap in the structuring of burial mounds occurred in Saqqara rather than in Giza. The tourist, whose gaze had already been armed by the expectation of wonder and grandeur, finding himself standing in front of the Great Pyramid, is further awed by sheer size, and therefore, the already informed eye not only finds confirmation of its expectations but the relationship in size experienced first-hand only fuels further the sense of awe and wonder.

The impact of a foreign set of eyes can also work the other way round. An expectant pair of eyes, on the lookout for things of interest, can also serve to open the eyes that have got used to the gaze to see new things. In the Maltese experience, it was the eyes of the foreigner that first noticed the strange formation of boulders on land used by the locals for foraging. Once the area around them was excavated these boulders proved to be the remaining menhir of stone age temples now recognised as World Heritage Sites. In the historical field, travel diaries left us accounts written through foreign eyes of customs, fashions, monuments, that many times their authors misunderstood – precisely because theirs was a foreign gaze – but which in the long run left us with precious details that did not necessarily hold the same value or importance with the locals.

For the purpose of our journey to understand the changing gaze vis-à-vis Valletta, this theoretical standpoint implicates that any analysis of views and vistas will always depart from an already informed eye. In the case of Valletta, the inward views and vistas (looking from outside viewing points towards Valletta) were influenced by three different gazes, which in themselves are not mutually exclusive: a) the 'local' gaze; b) the 'touristic' gaze; and c) the 'technical' gaze. What we are calling 'the local gaze' is influenced by the symbolic meaning that Valletta has for the Maltese people. Given that such symbolic meaning changes over time, it is significant to point out that there was a resurgence as to the value of Valletta, not merely as a capital - political - administrative city but as an architectural, cultural and social phenomenon, during the past twenty years in Malta. During the 1980s and especially the 1990s, the local gaze was more directed towards more modern areas and developments as the country was experiencing an unprecedented wave of modernisation and economic expansion. Valletta was a remnant of a decaying past, eyed with a sense of detachment, as the new high-rises in Sliema and St Julians' most prominently provided a view towards a prosperous future to a fast growing, considerably affluent middle-class. Valletta was rediscovered by the Maltese when that same growing economy brought towards the island archipelago wealthy European foreign executives whose 'foreign eyes' saw an opportunity to invest in elegant baroque palaces either as their private residences, offices or the hospitality industry. Restoration – including a widespread rehabilitation programme by the Maltese Government prior to Valletta becoming European Capital for Culture in 2018 – and commercial development, especially in the food and beverage sector, together with more cultural activities taking place within the city walls, made the Maltese fall back in love with their capital city.

The 'touristic gaze' is based on the narrative by which Valletta is 'sold' to the tourist that visits Malta. It is what one could alternatively call 'the iconic gaze'. The most prominent of these is the view of Valletta from across Marsamxetto Harbour, with prominence given to the skyline marked by the spire of the Anglican Proto-Cathedral of St Paul and the massive cupola of the Carmelite Church constructed in 1955. It is quite ironic that the most prominent elements of this most iconic view are the two elements appearing to sit on the original bastions built by the Knights of St John that were not in the 'ideal' original plan of the city and were not built by the Knights. On the other side, the viewpoints from Cottonera, exalt the beauty of the Grand Harbour, and bring to prominence the garden element of Valletta, since both Barrakka Gardens are on the eastern side of the city.

Perhaps the viewpoint that remains closest to the original intended gaze of Valletta is the one from the sea where at the tip of the peninsula rests Fort St Elmo. The Knights of St John were profoundly aware of the visual impact that Valletta was intended to leave upon anyone approaching it from the sea. It was not just a military statement. The imposing fortifications, St Elmo at the forefront curtained by multiple layers of bastions, was not just meant to send a message of military might to an approaching enemy. They were also the Order's calling card – a symbol of affluence, modernism, and cultural refinement. In an age where wars are fought by drones and digital technology, this is the least obvious gaze to the uninformed eyes and the details that make up the big picture tend to escape the attention not just of the tourist but sometimes to the modern planner too.

The 'technical gaze' of the expert is informed by the study of the historical development of Valletta. It is a gaze that must often find balance between the 'ideal' city and the 'real' one. The Knights themselves had to veer from their 'ideal' plans for the city for various reasons, perhaps the most notorious being the Manderaggio, where originally they planned to have an enclosed bay for their galleys but due to difficulties during excavations they had to abandon their plans and the empty quarry ended up taken over first by workers migrating from the countryside and then eventually degenerating into a slum area, until it was finally cleared and new housing units were constructed in the 1950s. During the late baroque period the Knights further altered the original plans for the city to make way for new developments along the fashion of the times. The British period also brought about various changes, especially after the devastations of the Second World War. Other significant changes happened following Malta's independence in 1964, the last most significant one being the construction of a new Parliament and City Gate in 2015. Although elements of the 'ideal' city remain, sometimes masked behind alterations from later periods, these 'traces' (as Walter Benjamin would call them) are not enough to construct a credible narrative of the actual city.

The 'real' city is a lived city, that has undergone numerous transformations, some of them at the hands of political-administrative authorities, but other mutations are simply the result of the local community's lived experience. On the eastern side of Valletta, to take an example that divides expert opinion, on the coastline, against the walls of the city, over a period of time certainly dating back to the nineteenth century several boathouses were constructed by the locals. These had (and still have, at least a number of them) the function of housing the boats of Valletta fishermen. However, they are also used during the summer months for recreational purposes, where the owners host their families and friends when they want to spend a day by the sea or have an evening barbeque. The question facing experts is: should the 'real' city, that includes these inelegant constructions that hide a good part of the walls on that side, make way for the 'ideal' city to stand out? Or should the 'real' city prevail, and the routine that has shaped the livelihood of those families be considered as part of a lay ritual that has become endemic to the city itself?

Here we would like to make a small digression in favour of a certain historical consideration. We would like to argue against a static view of history in favour of a dynamic understanding of history as a state of becoming (Deleuze and Guattari, 1977). History is a continuous process and today, as we stand here, history is still being written. There is never a final history. If for planning or conservation purposes we understand history as 'what it was' or 'how it was originally conceived', in order words if we seek comfort in the 'ideal' city, we overlook the lived experience of the city. The city is not a plan designed on paper, and it is beyond the physical or monumental dimension. It is a human and humanised space, and beyond its physical it also has a meta-physical, symbolic dimension (Lowenthal, 1998). The experience of living in the city means that the communities that somehow meet within the city alter not just its physical dimension but also its symbolic qualities. Living also entails adaptability. For example, considering the challenges posed by climate change in our age, to what extent should the implementation of rooftop gardens and further greening be prioritised in Valletta, even though this might bring some changes to the idealised views of the city? Would the benefits that urban greening can bring to the air and sea quality, as well as the reduction of temperature, benefit the conservation and preservation of the city in the long run?

When it comes to the outward views and vistas (from Valletta looking out or within Valletta itself) the three gazes used for the inwards views and vistas still hold. However, in addition, one has also to consider the Valletta community more closely. It has been estimated that over 55,000 people cross the streets of Valletta every day. The include employees (especially in the public sector), tourists, shoppers and customers, service providers and school children. On special occasions such as public events of a religious and cultural nature, most notably carnival, Good Friday, New Year's Eve celebrations, concerts and political mass events, this number increases exponentially. In comparison, the community of Valletta residents is small, close to six thousand souls. It is a small population, mostly living in the lower part of Valletta, and ageing. They are increasingly besieged by tourism, commercial development, and a sense of alienation even from basic services. Their gaze has progressively become more nostalgic and what used to be a very worldly population (as a port city Valletta, together with Cottonera, used to be the cradle of Maltese intelligentsia and enlightenment) has become with the steady dwindling of its numbers more inward looking and pessimistic.

The element of nostalgia, with its characteristic element of remembering only selective fragments that create

a romanticised ideal narrative, now characterises the symbolic value of different areas in the city. Thus, Strada Stretta, a narrow street that cuts across Valletta from north to south and which used to be known by sailors across the Mediterranean as The Gut for the poverty, crime, prostitution and sordid entertainment that characterised it, has been sanitised and idealised as an emblem of a presumed golden age for Valletta. This narrative is often used to contrast with modern entertainment outlets that operate nowadays in the same street, even though in reality there is no comparison to the squalor of the past. These narratives attached to different locations, idealised as they might be, are also a community's way of resistance at the face of extinction. In fact, during the past few years, the Valletta community has become more sensitive and more vocal with regards to certain public occasions, such as religious rituals and festivities, as a way to reclaim – even if only for the duration of the event – public spaces that they feel were stolen from them especially by the commercial community. In the gaze of the Valletta community, therefore, the presence of churches, places where the community gathers – or used to gather – local shops owned by Valletta residents, informal meeting spaces along the waterfront, and other places that hold a historical significance to the history of the city as home to the local community hold paramount importance. One might even argue that for the Valletta community, its interest lies almost exclusively within the city walls and their gaze rarely ventures outside – to what surrounds the city. This is often in contrast with the attitude of the general Maltese gaze, which looks at Valletta mostly from the outside, and is more concerned about the impact of outside elements upon the city, than it looks at Valletta from the inside. Perhaps this is the case because their trips to Valletta are usually motivated by something other than Valletta itself and therefore in their gaze Valletta never really emerges from being in the background.

As fundamental as the gaze of the Valletta community is for an adequate understanding of the city, one must not forget that Valletta is also the capital city of Malta and therefore certain of its elements hold national symbolic importance. If one had to trace a line from the Mall in Floriana to Fort St Elmo on the northernmost tip of the Valletta shoreline, it is one long road going from the monument for Independence, to the monument for the Eucharistic Congress of 1913, to the Triton Fountain, to City Gate and all down Republic Street (previously known during the British Period as Kingsway) it is all one road to the sea at the horizon, mostly pedestrian. It is for the Maltese people a national symbol, a place where lay rituals are held, where all important Events of State pass including State Funerals and the first public outing of prime ministers and Presidents of the Republic. In Republic Street is also the former palace of the Grand Masters, now the palace of the President of the Republic of Malta, fronting St George's Square, the former piazza d'armi where the most important public and State events are held.

Just before St George's Square is Republic Square, however the Maltese still know it as Pjazza Regina (the Queen's Square), because of the statue of Queen Victoria that still dominates this public space. The presence of the statue in the square, right in front of the National Library, has long been the subject of controversy within the context of post-colonial debate, since it is often regarded as an imposition of British colonial authority. Some argue that it should be removed, but till now a consensus still has not been reached, largely the result of divergent views about colonialism and its impact on the Maltese islands. The same square, the space of which is nowadays divided between umbrellas, tables and chairs from different food and beverage outlets, used to house two historic cafeterias – Cordina, which is still running, and Premier, which has been turned into the offices of the Valletta Local Council. The former Premier site still forms part of the nostalgic gaze in Valletta because of its past ties to the Maltese Jazz golden age during the first half of the twentieth century and later in the late 1960s and 1970s in association with the Maltese literary movement called Moviment Qawmien Letterarju.

The act of seeing in fact, is not always the act of seeing 'what is there', but seeing 'what was there', or even 'what could have been there', and this alters the symbolic value what is being seen. We often find ourselves in a place that elicits memories and consequently the value we attribute to that place is intrinsically linked to those memories and similarly could be said to aspirations that we might have had for that place and did not materialise. As in the case with Premier, the gaze towards the past, towards 'what has been', tends to shape the gaze of the present, with nostalgia and possibly even resentment, for those who still hold memories from when Premier still existed. The Valletta community can provide many other examples of artisan workshops, the homes of notorious citizens, and community spaces that nowadays have either been completely transformed or are no longer existent. In contrast with the narrative about Strait Street, these have not become subject to a narrative of resistance perhaps because their existence was never in itself transgressive enough to become a symbol of defiance. One can sense this element of resistance even in the pride that some Valletta residents take in identifying themselves as coming from certain areas that were held in ill repute in the past, such the Mandraġġ, Kamrata or Diju Balli.

For younger generations these considerations have no value, and for them, Pjazza Regina is a square like any other, which in summer provides the perfect spot to quench your thirst whilst watching the world go by like a true flaneur. Indeed, side streets, especially those narrow staired streets that were traditionally given lesser importance – many of which used to be characterised by empty buildings in a bad state of conservation, have since been rediscovered by commercial outlets, especially in the food and beverage sector, become meeting spaces for younger generations and flourishing even touristically. Their quaintness, enhanced by street decorations, and often by their views of the port, have made them much sought after not just for entertainment but also as a visual spectacle in themselves. A look at social media would immediately indicate that they are amongst the most photographed by tourists visiting Malta. Looking outwards from the streets of Valletta, on the eastern side the views are dominated by the sight of the port waters and Cottonera on the other side including Fort St Angelo and the Drydocks, depending on from which side street you are viewing from. For the Maltese gaze, looking westwards is where perhaps the most controversial views are. The westwards outwards gaze from Valletta is characterised by the high rise buildings in Sliema and Gżira. This is, in our opinion, a perfect example of a conflicted gaze.

On the one hand, the Sliema-Gżira development is very much symbolic of economic affluence and success within the context of a globalised free-market economy. It is aggressive and dominating, aesthetically rooted in global-capitalist urban aesthetics very much removed from the Mediterranean characteristics that even British colonialist architecture and spatial dynamics had incorporated within its style. The Sliema-Gżira area is home to a multi-national, multi-ethnic population, mostly working within the offices and establishments of trans-national corporations that made the same area their regional hub. For this reason, that same economic success and expansion can be considered equally symbolic of a loss of national identity by some, an imposing reminder of the might of corporate power and money. The preservation of the views and vistas to and from Valletta, alongside the World Heritage Status of the city, often becomes a political argument tainted with a blend of nationalist-nostalgic discourse whereby Valletta becomes a symbol of national identity and (misunderstood) authenticity juxtaposed with the unrestrained development and greed symbolised by nearby mega-developments on either side of the peninsula. Such arguments often pose Valletta as an 'idealised' city neglecting the complex realities of the lived city. It is indeed the minority view that the Sliema-Gżira developments and those at Xgħajra need not be necessarily alien to Valletta despite the obvious visual difference that characterise them. Such differences can in fact be interpreted as two different facades of modern Malta, at once rooted in its long history but also moving forward with the modern world.

3. Methodological Considerations of the Views and Vistas Analysis

The way in which the Views and Vistas Analysis of Valletta unfolded is one typical of spatial planning policy - the rationality of logic pitting itself against the vagrancies of politics. These two contending bedfellows define the process that was undertaken to understand the context of the policy, to carry out the analysis, and to ratify the measures that were eventually recommended. Over the course of several years and numerous collaborations, a multidisciplinary team of heritage professionals strove to understand the meaning of a World Heritage context, the responsibilities that the designation entailed, and the considerations related to the development control of tall buildings within this context. Malta has a strong regulatory background, with several targeted policies in place for the safeguarding of strategic views to and from Valletta. A significant weakness lies however in the application of such policies, when faced with development pressure and land-based commitments for the construction of major development projects and tall buildings, as shall be discussed.

An easy trap to fall into is to consider Valletta only within the immediate context of the Grand Harbour, or even within the national context of the Maltese Islands. As a World Heritage Site, matters of international significance come into play, based on the criteria for which the city is inscribed onto the World Heritage List, and specifically its Outstanding Universal Value (OUV). Another key consideration was obsolescence, used here as a term to define the relevance of the city, both in the physical sense - its morphology and building typologies, and in the socio-economic sense – its administrative and commercial role. In this, heritage policy plays a crucial role, both from a national and international perspective. These matters guided the identification of the view value during the analytical stage of the Views and Vistas Analysis. To define such a view value however, a meticulous process of investigation was embarked upon. To begin with, the Operational Guidelines for the Implementation of the World Heritage Convention (UNESCO, 2021) were thoroughly consulted, to understand the requirements of the World Heritage Committee and therefore, the remit of such a study. The Recommendation on the Historic

Urban Landscape was an influential reference, stating that "the urban area [is] understood as the result of a historic layering of cultural and natural values and attributes, extending beyond the notion of 'historic centre' or 'ensemble' to include the broader urban context and its geographical setting" (UNESCO, 2011). This definition allowed us to consider the city in its totality, both tangible and intangible, as opposed to the more traditional understanding of the city as a receptacle for monuments large and small.

The team was now well-set to place heritage value at the centre of the study and could continue shaping the methodology. To assist, best practice methodologies were identified, searching specifically for similar studies on World Heritage Sites which are Mediterranean cities, towns or historic centres in a dense urban context, located in proximity to a port or riverside. Ratified UNESCO Management Plans were helpful in this regard, that recently drawn up for the Historic Centre of Florence World Heritage Site (Municipality of Florence, 2022) standing out amongst the many relevant case studies from Albania, Croatia, France, Greece, Italy, Morocco, Portugal and Spain. Though some of these case studies did not offer much in terms of a methodology for the assessment of views and vistas, they all have a defined buffer zone which was studied for its relationship to the OUV of the World Heritage Site to which it appertains. This served to forge a strong link between the assessment of the view values for different strategic viewpoints to and from Valletta, and the delineation of a proposed buffer zone for the city, in line with the requirements of the World Heritage Committee for each inscribed site. Since Valletta is the core of Malta's Principal Urban Area (PUA), as defined in the Strategic Plan for Environment and Development (SPED) (MEPA, 2015), ratifying such a buffer zone has historically been a policy minefield. Development pressures abound within an urban context that is one of the densest globally, with high rise buildings and mega-projects taking centre stage in the drive to modernise Malta's economic model. Nevertheless, Valletta's peninsular topography and the historic cities of the Cottonera to the south-east have protected the city somewhat from such development within its immediate environs, despite the density of the urban environment. The environs to the north-west are however another matter entirely, as shall be discussed.

A seven-point methodology was subsequently devised for the Views and Vistas Analysis and the eventual delineation of the proposed buffer zone for Valletta, as follows:

1.Understand the SOUV for Valletta and extract key view-based indicators.
2.Identify the features of Valletta that have visual amenity, based on the key indicators.
3.Discuss the visual and symbolic merit of the features identified.
4.Define viewing positions from which visual assessments of the features can be made effectively.
5.Analyse important visual compositional characteristics of the views from these viewpoints.
6.Summarise the compositional attributes of the background, middleground and foreground.
7.Outline measures for protecting the visual integrity of the features from the viewpoints.

Once these methods were successfully implemented, a visual sphere of influence around Valletta was defined, within which the proposed buffer zone was to be delineated. This served as a springboard for discussion as to where the actual regulatory boundary was to be placed, since it shall become an important spatial planning policy tool to be used in development control mechanisms for the region. Prior to undertaking this exercise however, an assessment of the relevant local spatial planning policies and guidance documents was necessary to understand the protective measures already in force. There are several strong measures in favour of protecting the OUV of Valletta, specifically targeted to the retention of the skyline and views towards the city. The challenge was therefore to understand why such measures were not being as effective as one would expect them to, considering their status within the hierarchy of spatial planning policy for the Islands.

Let us therefore delve briefly into which the relevant policies for the purposes of the Views and Vistas Analysis are. From an internal perspective, the most pertinent documents are the Resolutions on the Conservation of Smaller Historic Towns, 1975 (ICOMOS, 1975), the Xi'an Declaration on the Conservation of the Setting of Heritage Structures, Sites and Areas, 2005 (ICOMOS, 2005), and the Australia ICOMOS Charter for the Conservation of Places of Cultural Significance, 2013 (The Burra Charter) (ICOMOS, 2013). Cumulatively, these documents make the case for a sensitive approach to development both within the heritage site and within its setting or visual sphere of influence, as we have chosen to call it. They repeatedly mention the cultural significance of a heritage site and the need to respect both tangible features and intangible aspects of the site, the latter including views and other sensory indicators that contribute an integral part of the heritage value of the World Heritage property.

Nationally, the SPED sets out policies for cultural landscapes in Thematic Objective 8, referring to the need for "Re-appraising the value of the character, amenity and distinctiveness of designated areas and sites for their built heritage value" (MEPA, 2015). Valletta is recognised a cultural landscape since it is a designated Urban Conservation Area (UCA), as ratified in the Grand Harbour Local Plan 2002 (Government of Malta, 2002). The city thus benefits also from the protection of other SPED policies, specifically Urban Objective 2, which mentions "a context driven approach to the control of building heights within Urban Conservation Areas" and that "[d] evelopment within historic sites is to be carried out in such a manner as to ensure that the historic sites' skyline is not adversely affected."

Furthermore, the Grand Harbour Local Plan 2002 designates an Area of High Landscape Value (AHLV) which encompasses the Grand Harbour Fortifications, of which Valletta forms part; and the North Harbour Local Plan 2006 (Government of Malta, 2006) designates Strategic View Corridors (NHSE07), with the aim to protect "the settings of key landscapes, landmark buildings, Urban Conservation Areas and the Valletta World Heritage Site." Considering guidance documents which form part of Malta's hierarchy of plans, we find the Development Control Design Policy, Guidance and Standards, 2015 (DC15) (Malta Environment and Planning Authority, 2015), the Planning Authority Circular 3/20 - Assessing and Determining development Applications in the Setting of Scheduled Buildings and Monuments, 2020 (Planning Authority, 2020), the Planning Policy Guide on the Use and Applicability of the Floor Area Ratio, 2014 (FAR) (Malta Environment and Planning Authority, 2014b), the Height Limitation Adjustment Policy for Hotels, 2014 (Malta Environment and Planning Authority, 2014a) and the Height Limitation Adjustment Policy for Retirement Homes, 2017 (Planning Authority, 2017). These numerous documents set out an agenda for sensitivity towards heritage contexts, including key considerations related to the visual impact of development on rooftops and at exposed rides within and in the context of heritage sites, the appropriateness of increased height for specific types of development, and crucially the siting of tall buildings in relation to the impact of such landmarks on views to and from heritage sites.

Once the policy context was sufficiently understood, a photographic analysis was carried out to serve as a visual baseline for determining the view value of each strategic viewshed. The take-off points for a series of photographs were carefully chosen to represent ubiquitous views of the city, and from the city, therefore including belvedere along the imposing Grand Harbour fortifications and picturesque waterfronts on either side of the Valletta peninsula. Within the city, the photographic take-off points highlighted the undulating streets parallel to the main thoroughfare, Republic Street, and public spaces off this street. The views were characterised based on a methodology developed by DEGW to assess London's Skyline, Views and High Buildings (DEGW, 2002), defining each Viewing Experience as a sum of the Viewing Place and View Type. Three viewing places were identified for Valletta and its environs – the High Point, the Open Space and the Axial Route. The viewing types were consequently characterised as a Panorama, a Contained Prospect and a Linear View respectively. The sum of these definitions thus led to three Viewing Experiences, namely:

1. A wide view looking towards or outwards from the city.
2. A broad view with a clearly defined edge.
3. An unfolding, changing view along major routes.

In parallel, a formula for defining a set of View Enhancement Criteria was developed, based on the sum of the View Value, the Compositional Quality and the Landmark Impact. Having set out these parameters to frame the analysis of the views, each was critically described in terms of the composition quality of the background, middleground and foreground features that are visible at the time of the study and making sure to describe the landmark impact of key features. Subsequently, a technical analysis for each view could be carried out, focussing on a detailed description of each View Experience in relation to its perceived visual and symbolic value, and the ultimate delineation of a set of View Enhancement Criteria based on the preservation and enhancement of the views to and from the city. The exercise culminated in a set of guiding principles for the protection of views to and from Valletta (MHAL, 2023).

4. Deconstructing the Changing Gaze in Valletta's Visual Narrative

A more detailed description of the view value is warranted here, since this sets the scene for a later outline of the ensuing guiding principles. The view value can be described under three headings, firstly considering the foundational aspects of Valletta that can still be appreciated, thereby referring to the criteria under which

the city is inscribed on the World Heritage List – "an ideal creation of the late Renaissance" that "is irrevocably affiliated with the history of the military and charitable Order of the Knights of St John of Jerusalem" (UNESCO, 2023). Secondly, we consider the defining characteristics of the fortified city itself, rising high above flanking harbours. Finally, we consider the dense urban context that characterises the setting of the city on either side of the peninsula.

To begin with, let us recall that the first impression of many visitors to Valletta prior to mass air travel was by sea, arriving at one of the city's heavily fortified maritime gates and walking up St John Street towards the eponymous Co-Cathedral with its distinctive twin belfries. This route is visible today by following a dip in the saddleback skyline of the city when viewed from across the Grand Harbour. Thus, although the visual landscape of Valletta and its approaches has changed drastically, there is much charm in its skyline, and in the strong line of fortification walls of the city. This places much value on keeping the waterfronts free of unsympathetic accretions at the base of the fortifications, and the same goes for the spaces above the numerous bastions and curtain walls, all of which warrant ongoing restoration to ensure their continued appreciation within and around the World Heritage Site.

Within the city, the undulating streets lead the eye along a picturesque route lined by honey-coloured stone façades that often culminates in the blue waters of the two harbours and beyond. Unsympathetic rooftop development can easily mar the uniqueness value of these streets by failing to mirror the topography at street level. Such development also has an impact on the aesthetic value of the city's skyline, since it can obscure the view of key monuments that attest to its history, both from its early years such as the various belfries and cupolas of Baroque churches, and from later alterations such as the definitive cupola of the church of Our Lady of Mount Carmel and the spire of St Paul's Anglican Cathedral. From beyond the city walls, one can appreciate the mammoth undertaking that the entire system of harbour fortifications once was, as well as the impact of many centuries of development that the harbour region attracted. The still visible gap between the Valletta and Floriana land-fronts attests to this continuous change and provides a visual clue as to the boundary of the World Heritage Site. Around both harbours, the fortifications that line the foreshore in an almost unbroken line are a visually appealing reminder of the military nature of Valletta in its earliest attestation, and proof of the heritage value that countless generations have imbued these sites with. As a culminating observation that attests to the Islands' scale, the Mdina promontory rises in the far distance view viewed from many places around the harbour cities, another valuable visual cue attesting to the relationship between the former and current capital cities of Malta.

A series of guiding principles has ensued from the detailed consideration of the view values pertaining to Valletta, with the foremost referring to the need to responsible governance in applying spatial planning policy, harking back to the point made earlier about planning as both a rational endeavour and a political practice. Note however that although several relevant policies for the safeguarding of the views exist, they are not universally applied when deciding upon whether to grant or refuse applications for development permission that may have an adverse impact of the World Heritage Site. Considering the principles that apply to the foreground views, these pertain primarily to the immediate visual experience of Valletta, when it comes to applying appropriate textures, materials, colours and even forms. Here we observe the jarring effect of large, glazed areas, exposed party walls created by developments higher than their context, and the cumulative impact of rooftop extensions within the city. Visual clutter too plays a part, this including redundant wiring and signage, as well as paraphernalia erected for outdoor catering areas.

Continuing to the middleground views, the principles focus on fostering urban attractiveness within and around the city, and especially within the proposed buffer zone. Good design takes centre stage when considering appropriate building height, form and rooftop design, recognising that the overall massing of new developments significantly influences views to and from Valletta. Recalling the OUV of the city, the morphological characteristics of the grid-iron plan and the topographical characteristics of the undulating streets must be respected during redevelopment projects, as this will protect the visual dominance of existing landmarks that are a key aspect of the iconic skyline of the city. This applies also to development that may obstruct seascape views from within Valletta, a picturesque feature that evokes memories of a time when this city was the maritime hub of the Mediterranean. As guiding principles for background views, the analysis proves that tall buildings visible from Valletta must showcase sensitive architectural techniques that allow them to meet the sky gracefully, such as

tapering upper levels or incorporating translucent elements to create a smoother visual transition, drawing inspiration from both exemplary modern designs and the traditional Maltese skyline adorned with church spires and cupolas. Protected viewshed gain much significance here, since they serve to outline locations where tall buildings are acceptable or otherwise and emphasise the importance of determining a height envelope within the visual sphere of influence of Valletta to enable development control to serve as a protective measure for the visual and symbolic value of the city.

The synthesis of the visual sphere of influence into a proposed buffer zone for Valletta was heavily prejudiced by the consideration of previously made land commitments and the vested interests of influential lobby groups. The blue waters of the Mediterranean Sea lapping at the albeit heavily contested foreshore of the Valletta peninsula, act as perhaps the strongest deterrent to overdevelopment in the immediate vicinity of the World Heritage Site. An initial proposal for the buffer zone, submitted to the World Heritage Committee for consideration, incorporates Marsamxetto Harbour and the Grand Harbour, the latter with its many creeks on either side of the Ricasoli, Kalkara and Cottonera peninsulas. The entire urban area within this zone is incorporated into the proposed buffer zone, as is Floriana, Manoel Island and Fort Tigne. These are all historic places that have been intimately tied to the history and development of Valletta over the centuries and are therefore well-suited to be offered the additional protection that the buffer zone may provide.

5. Conclusions

To conclude, through the analysis of views and vistas in and around Valletta, we have sought to highlight the critical importance of visual perception in understanding and safeguarding the city's lived heritage, within the scope of its significance as a World Heritage Site. The analysis forms a key component of the city's Management Plan, which though yet to be ratified, considers Valletta's urban fabric and its susceptibility to change. Through the reflections of thinkers such as Calvino and Heidegger, we have accentuated the importance of the gaze in shaping our experience and understanding of place, specifically heritage places that are fundamentally imbued with values both tangible and intangible. Therefore, we posit that the way we see and interpret Valletta is deeply intertwined with its historical and cultural significance in a fluid and dynamic manner that requires ongoing valorisation.

The proposed buffer zone emerges as a crucial policy mechanism for safeguarding Valletta's visual integrity in the light of its position within Malta's dense conurbation. Here, the city's visual landscape is pitted against land commitments and vested interests that pose a threat to strategic views to and from Valletta, thus potentially undermining the experience of the city for those who look upon it. The maritime boundary of the natural harbours at either flank of the peninsula on which it is built provide an inherent protection that sets the city at a distance for its built environs, however short this may be. Thus, the Views and Vistas Analysis aids in the strategic implementation of essential steps that are required to ensure that Valletta's visual and symbolic value endure for future generations to appreciate, recognising the profound connection between lived heritage and the ever-evolving gaze.

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Measuring Cultural Participation: A Comprehensive Study in Kayseri

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Abstract
This study investigates cultural participation in Kayseri, a secondary city in Türkiye with rich historical heritage yet persistently low levels of cultural engagement. Drawing on a quantitative survey conducted with 166 residents, the research identifies key barriers to participation, including socio-economic constraints, limited accessibility, and low awareness of cultural opportunities. The study is situated within the theoretical frameworks of cultural capital and socio-spatial inequality, emphasizing how demographic and geographic factors shape engagement with cultural life. The findings point to uneven distribution of cultural resources and highlight the need for localized, inclusive policy interventions. By offering data-driven insights into cultural behavior and access patterns, the study aims to inform municipal and institutional strategies and contribute to broader efforts for equitable cultural development in non-metropolitan urban contexts.

Keywords: cultural participation, access to culture, cultural policies, cultural capital, arts and culture

1. Introduction

Cultural participation has increasingly become a critical domain for examining spatial, social, and policy-related dimensions of urban life. As cities attempt to promote inclusive development, the question of who participates in cultural life—and who is excluded—remains a persistent challenge. Particularly in the context of secondary cities with rich cultural heritage but low levels of cultural engagement, such as Kayseri, Turkey, understanding the dynamics of cultural participation is essential for designing more equitable and responsive urban cultural policies.

Kayseri, a historically significant city located in central Anatolia, possesses a wealth of tangible and intangible cultural assets. Despite this potential, cultural participation rates remain considerably low, and access to cultural resources is unevenly distributed across socio-economic and spatial lines. The lack of comprehensive, data-driven assessments of cultural participation in such cities limits the capacity of local stakeholders—municipalities, cultural institutions, and civil society organizations—to develop inclusive strategies that ensure broader cultural access and engagement.

In Türkiye, regional disparities in cultural engagement remain a persistent issue. While metropolitan areas such as Istanbul, Ankara, and Izmir have experienced diversification in cultural offerings and the emergence of participatory policy frameworks, mid-sized cities like Kayseri often struggle to establish sustainable cultural ecosystems. Limited institutional support, insufficient cultural infrastructure, and a lack of locally grounded cultural policies contribute to these persistent gaps. As a result, secondary cities remain peripheral in the national cultural landscape, despite their significant historical and demographic presence.

This study aims to fill this empirical and policy gap by conducting a comprehensive analysis of the cultural participation landscape in Kayseri. The research investigates who participates in cultural life, what barriers inhibit participation, and how strategies can be developed to foster inclusive and equitable access to arts and culture. By addressing both the structural inequalities embedded in cultural participation and the experiential realities of local residents, this research contributes to a more nuanced understanding of culture-led urban development.

The study is framed within broader theoretical and policy debates on cultural capital (Bourdieu, 1984), socio-spatial inequalities in cultural access (DiMaggio & Useem, 1978; Stevenson et al., 2017), and participatory cultural governance (UNESCO, 2012). It responds to recent calls in European and Turkish literature for more localized, bottom-up assessments of cultural engagement, especially in regions outside major metropolitan centers.

2. Theoretical Framework

Cultural participation is increasingly understood as a multi-layered phenomenon shaped by intersecting social, spatial, and institutional dynamics. Rooted in classical sociological traditions yet evolving through contemporary critiques and policy discourses, scholarly debates on cultural participation interrogate not only who participates in cultural life, but also how, why, and under what conditions such engagement occurs—or fails to occur. A foundational reference point remains Pierre Bourdieu's conceptualization of cultural capital, wherein cultural consumption is understood as a form of distinction that reflects and reproduces social inequalities (Bourdieu, 1984). In this framework, participation in "legitimate" cultural forms—such as museums, concerts, or theatre—is closely aligned with educational attainment, occupational prestige, and class-based dispositions acquired through socialization. DiMaggio and Useem (1978) further argue that educational systems and cultural institutions contribute to this stratification by privileging certain tastes and competencies, rendering high culture more accessible to dominant groups while alienating others.

Yet, Bourdieu's determinism has been critically revisited in light of empirical research suggesting more fluid and hybrid modes of cultural consumption. The "cultural omnivore" thesis posits that high-status individuals increasingly engage with diverse forms of both highbrow and popular culture, reflecting an eclecticism that transcends rigid class boundaries (Peterson and Kern, 1996). Studies from Flanders support this view, revealing new consumption clusters that blend traditional and contemporary cultural preferences (Vander Stichele and Laermans, 2006). These findings underscore the need for analytical approaches that accommodate evolving patterns of engagement shaped not only by class, but also by generation, urban context, and cultural hybridity (Bennett et al., 2009).

At the same time, critical policy scholars have drawn attention to the structural barriers that inhibit participation, especially in secondary cities or marginalized communities. European cultural policy often constructs non-participation as a "problem" to be solved, legitimizing top-down strategies that fail to address deeper socio-economic exclusions (Stevenson et al., 2017). The cultural sector's tendency to promote narratives of success while ignoring systemic failures has also been critiqued, with calls for more reflexive and inclusive models of cultural governance (Jancovich and Stevenson, 2023). These critiques resonate in the context of cities like Kayseri, where formal cultural policies often lack embeddedness in everyday lived experiences, and where community needs and alternative cultural expressions remain underrecognized (Finkel et al., 2019).

Feminist and relational approaches further underscore the importance of intersectionality and social networks in shaping cultural access. Cultural participation—particularly among women—is strongly influenced by the diversity and density of social ties, with exclusion often emerging from time poverty, caregiving responsibilities, or absence of supportive networks (Kane, 2004; Chan et al., 2008). These insights complicate traditional models and call for an understanding of participation that is attuned to both structural and interpersonal constraints.

Building on this relational turn, the concept of "classed cognition" has been proposed to describe how cultural policy initiatives often fail to recognize the ways in which class-based experiences and perceptions mediate engagement (Roaldsnes, 2025). When participation is framed as a universally attainable goal, cognitive and affective exclusions shaped by classed experiences are often overlooked. Cultural institutions are thus urged to shift from instrumental rationality to more dialogical, value-centered models of cultural legitimacy (Holden, 2006).

In parallel, the contribution of cultural participation to subjective well-being and quality of life has attracted growing attention. Regular engagement in cultural activities can enhance emotional resilience, life satisfaction, and social cohesion, although these outcomes depend on the accessibility, form, and frequency of participation (Reyes-Martínez et al., 2020; Galloway, 2006). Galloway cautions against reductive, instrumentalist interpretations and instead advocates for frameworks that capture the experiential and symbolic dimensions of cultural life, particularly in urban contexts marked by uneven access and identity-based exclusions (Grogan, 2021).

Globally, the measurement of cultural participation has been systematized through UNESCO's Framework for Cultural Statistics, which defines participation as encompassing attendance, creation, access, and digital engagement (UNESCO, 2009; 2012). This approach views participation as both a right and a public good, essential for inclusive development and cultural sustainability. However, critics highlight the limits of universal metrics and emphasize the importance of contextually grounded indicators that reflect diverse cultural practices and

infrastructural conditions (Tomka, 2013; Schuster, 2007). Recent scholarship further stresses that digital divides—often shaped by socio-cultural rather than merely technological gaps—have become increasingly significant in determining access to cultural participation (Selwyn, 2004; Heikkilä and Sassi, 2021).

Altogether, this theoretical framework positions cultural participation as a site where social stratification, institutional design, symbolic boundaries, and subjective meaning converge. By drawing on classical theory, post-Bourdieusian perspectives, policy critiques, and international frameworks, the study constructs a conceptual foundation capable of interrogating the uneven landscape of cultural engagement in Kayseri and advancing grounded insights for equitable cultural policy-making. Culture must be read as "a web of significance" through which social life is interpreted and made meaningful (Geertz, 1973).

3. Methodology

This study employs a quantitative, exploratory research design to investigate the patterns, motivations, and barriers of cultural participation among residents of Kayseri, Türkiye. Developed as a pilot study within the scope of a scientific research project funded by Erciyes University, the research constitutes a preliminary empirical inquiry into cultural participation in mid-sized Anatolian cities. The study aims to test the local applicability of UNESCO's (2012) cultural participation framework and generate baseline insights for future, more comprehensive investigations.

The survey consisted of 38 structured questions divided into four thematic sections:

• Demographics:

Age, gender, education level, household income, employment status, and neighborhood.

• Cultural Participation Behavior:
- Frequency of engagement with cultural activities (e.g., theater, museum, festivals, concerts)
- Preferred cultural formats (physical attendance vs. digital participation)
- Frequency of participation (never, rarely, occasionally, frequently)

• Barriers to Participation:

Participants were asked to evaluate potential obstacles such as:

- Economic factors (ticket prices, transportation costs),
- Physical and spatial barriers (venue accessibility, distance),
- Informational barriers (lack of knowledge about events),
- Sociocultural reasons (lack of interest, cultural mismatch).

• Perceptions and Attitudes:
- The perceived importance of cultural life,
- Role of the municipality in promoting culture,
- Suggestions for improving access and relevance of cultural services.

All questions were either multiple-choice, Likert-type scale (1–5), or single-answer categorical variables.

Data collection took place between March and May 2025 using both digital and paper-based formats to ensure inclusivity. Approximately 60% of the responses were gathered via Google Forms, while the remaining 40% were collected in-person in locations such as university campuses, community centers, and public squares. The sampling strategy was non-probabilistic and purposive, designed to reach individuals from different age groups, income brackets, and neighborhoods across Kayseri. This dual-mode approach helped include digitally marginalized or older populations who are often underrepresented in online surveys.

The final dataset comprised responses from 166 participants. Descriptive statistical methods were employed to analyze the data, including frequency distributions, percentages, and mean scores. Cross-tabulation techniques

were used to explore relationships between cultural participation levels and demographic indicators such as age, gender, education level, and income. Data analysis was conducted using Microsoft Excel and SPSS, and analytical categories were structured in alignment with UNESCO's typology of "active," "occasional," and "non-participant" cultural users.

As a pilot study, the research is subject to limitations, particularly concerning the representativeness of the sample and the generalizability of the findings. While the study offers valuable initial insights, the conclusions should be interpreted as indicative rather than definitive. These results are intended to inform the design of future studies utilizing probabilistic sampling methods and more robust inferential statistical techniques.

All participation was voluntary and anonymous. Prior to survey administration, respondents were briefed about the purpose of the research, and verbal consent was obtained. The study was conducted in accordance with the ethical protocols of Erciyes University, ensuring confidentiality and the responsible handling of data throughout the research process.

4. Findings

This section presents the core empirical findings of the study, organized thematically to reflect the main dimensions explored through the survey. These include the sociodemographic characteristics of participants, patterns of offline and digital cultural engagement, perceived barriers to participation, attitudes toward cultural life, improvement expectations regarding municipal cultural services, and everyday conceptions of "culture." The analysis integrates both descriptive statistics and thematic coding to highlight how structural factors, personal dispositions, and spatial conditions intersect in shaping cultural participation in a mid-sized Anatolian city.

4.1. Socio-Demographic Profile of Respondents

The survey collected responses from 166 participants residing in Kayseri. Of these, 51.8% identified as female and 48.2% as male, indicating a relatively balanced gender distribution. In terms of age, the 25–34 age group constituted the largest share of respondents, followed by the 35–44 and 18–24 cohorts. Participants aged 45 and above were less represented, suggesting a skew toward younger, working-age adults in the overall sample. Table 1 provides a comprehensive overview of the percentage distribution of respondents across gender, age, education level, employment status, and monthly income brackets, offering a demographic snapshot that contextualizes the cultural participation patterns explored in this study.

Table 1. Sociodemographic profile of respondents (%)

Gender (%)	F (51.8)	M (48.2)				
Age (%)	18-24 (17.5)	25-34 (41)	35-44 (20.5)	45-54 (12)	55-64 (5.4)	65+ (3.6)
Education Level (%)	Prim. (9.6)	Sec. (22.9)	BA (53)	MA (13.9)	PhD (0.6)	
Employment Status (%)	Public (19.3)	Private (28.9)	Self-employed (6)	Student (18.7)	Unemployed (23.1)	Retired (3)
Monthly Income (TRY, %)	0-20.000 (34.3)	20.001-40.000 (22.3)	40.001-60.000 (14.5)	60.001+ (13.3)	Prefer not to say (15.7)	

In terms of educational attainment, the majority of respondents held bachelor's degrees (53%), followed by secondary education (22.9%), master's degrees (13.9%), and primary education (9.6%), while less than 1% reported holding a doctoral degree. This indicates a participant pool that is largely composed of individuals with tertiary-level qualifications, with approximately 67% holding at least a bachelor's degree.

Regarding employment status, the largest group of respondents were employed in the private sector (28.9%), followed by individuals who reported being unemployed (22.9%), working in the public sector (19.3%), and students (18.7%). A smaller portion identified as self-employed (6%), retired (3%), or homemakers (1%), indicating a diverse labor force composition within the sample. In terms of monthly income levels, 34.3% of participants reported earning between 0–20,000 TRY, followed by 22.3% in the 20,001–40,000 TRY range, and 14.5% between 40,001–60,000 TRY. Notably, 13.3% reported earning above 60,000 TRY, while 15.7% preferred not to disclose their income. These figures reflect a concentration in lower- to mid-income brackets, with a significant number of respondents indicating financial constraints that may affect their access to cultural activities.

4.2. Patterns of Cultural Participation

4.2.1. Offline Participation: Frequency and Preferences

Respondents reported relatively low-to-moderate engagement with cultural events in the past year. 40.4% attended 1–2 events, and 24.1% attended 3–5 events, while only 15.7% reported participating in more than five events (Figure 1). This suggests a modest but non-negligible level of cultural engagement.

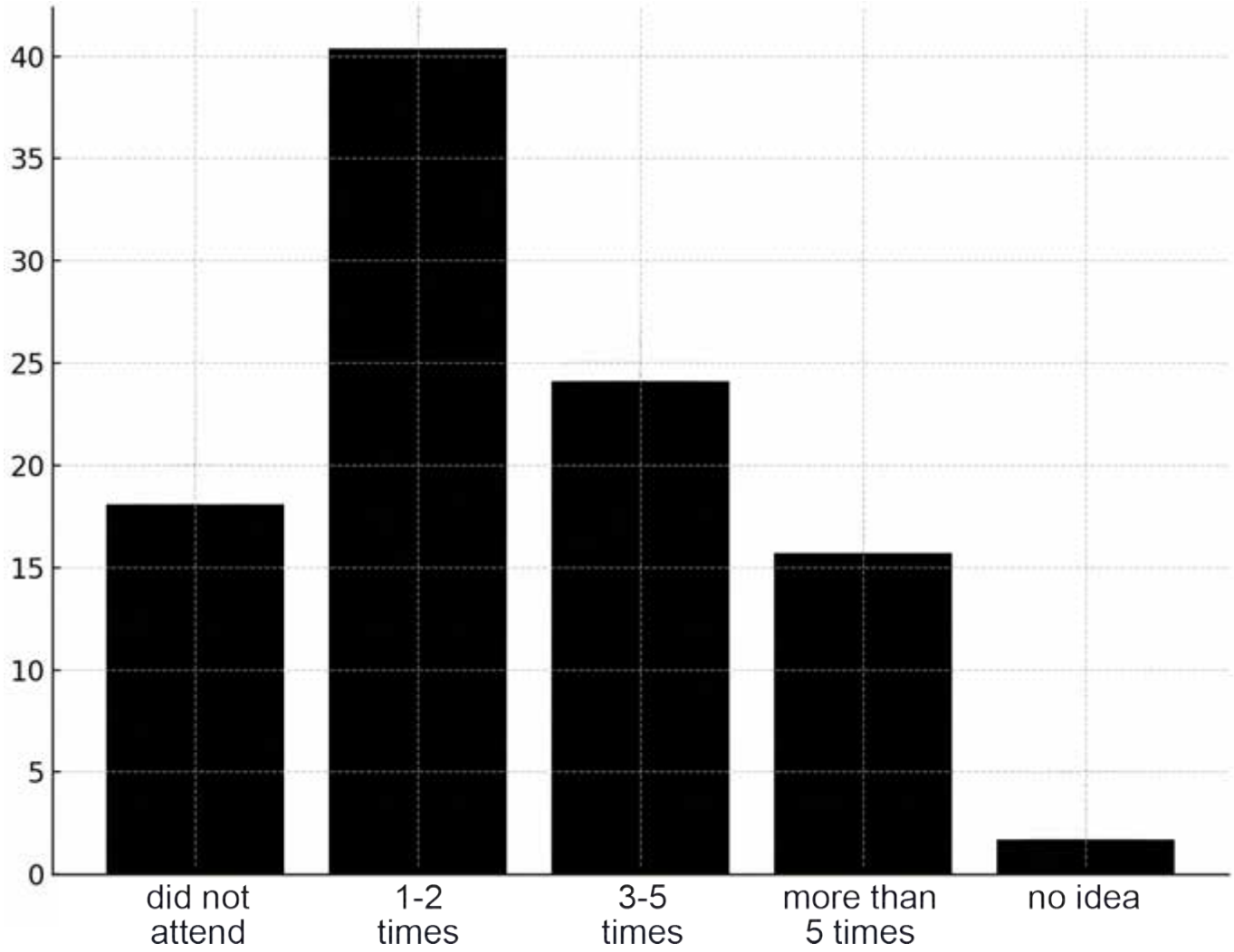

Figure 1. Frequency of cultural participation in the past year (%).

Figure 2 illustrates the distribution of respondents' most recent cultural event participation, grouped into broader thematic categories. The most commonly attended events were concerts and musical performances, followed by cinema and film-related activities. Theater and performative arts also had a notable share, reflecting continued interest in live artistic expression. Museum visits, exhibitions, and literary events constituted a smaller but significant portion. The "Other" category includes responses such as traditional ceremonies, religious gatherings, local fairs, educational panels, and family-oriented social events. This diversity suggests that while mainstream cultural formats dominate participation, respondents also engage with a wide range of community-based and informal cultural expressions, highlighting the importance of recognizing alternative forms of cultural engagement in policy and planning frameworks.

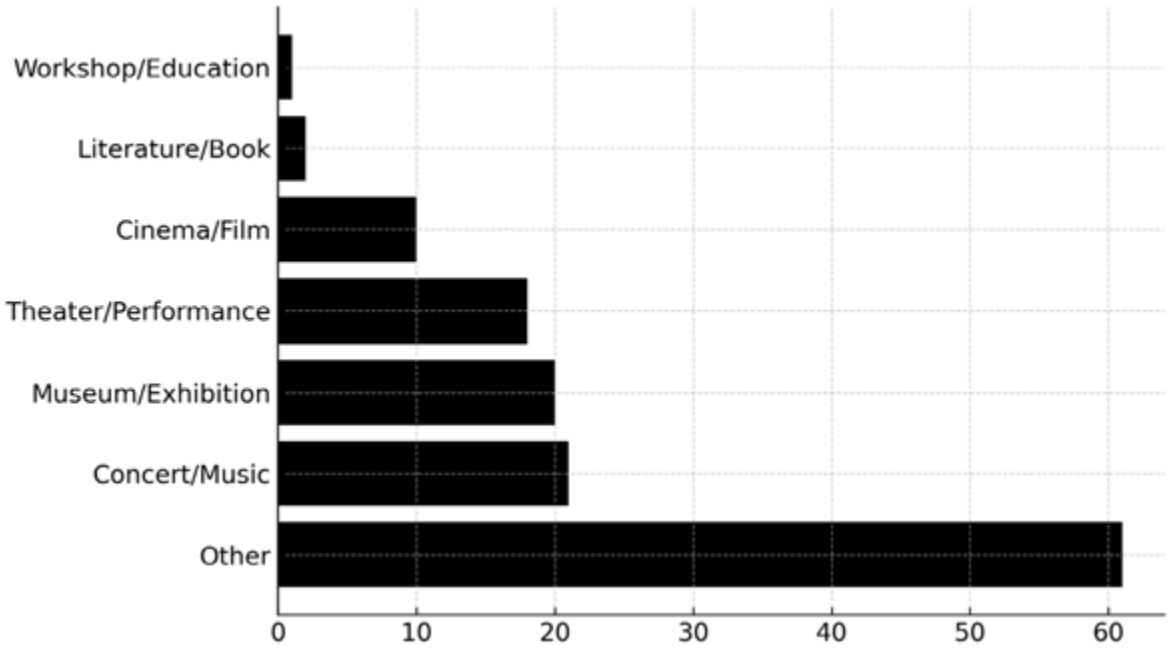

Figure 2. Types of most recently attended cultural events (%).

Based on the data visualized in Figure 3, respondents demonstrated a clear preference for certain cultural formats they would like to see more frequently organized by local authorities. Music and performing arts ranked highest, selected by 71.1% of respondents, followed by historical and cultural excursions (59%), and visual arts and exhibitions (42.8%). Workshops and educational activities also garnered significant support (41.6%), indicating a strong public interest in participatory and skill-based formats.

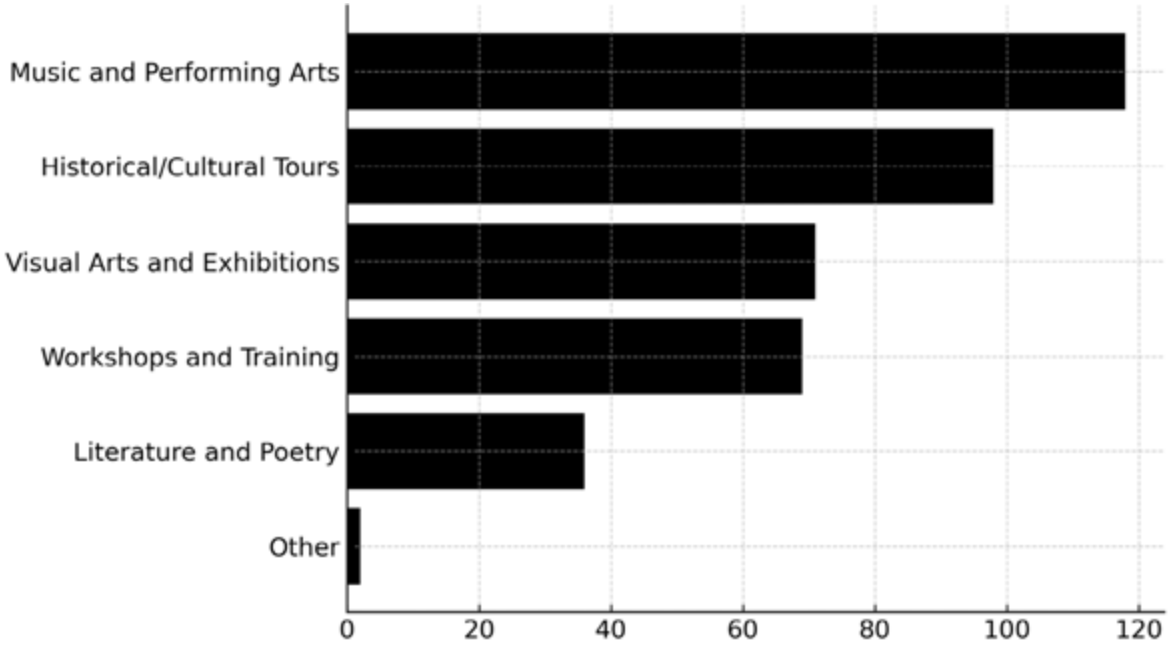

Figure 3. Preferred cultural event formats desired from local authorities (%).

Although mentioned less frequently, literature and poetry events (21.7%) still reflect a notable cultural demand among a segment of the population. These preferences suggest that residents of Kayseri expect municipalities

to go beyond conventional event programming and adopt a more proactive and inclusive cultural strategy. The results support the broader argument that diversifying and expanding cultural offerings—especially through accessible and experiential formats—can act as a catalyst for deeper and more widespread cultural participation.

4.2.2. Digital Participation: Platform Use and Activity Types

Survey findings reveal that digital cultural participation is highly shaped by platform preferences and content accessibility. As shown in the first chart, a substantial majority of respondents (77.7%) reported using social media platforms (e.g., Facebook, Instagram, Twitter) to engage with cultural content. In contrast, culture-specific applications such as YouTube, Netflix, or Spotify were used by 27.7%, and only 9% reported engaging with cultural events through online platforms like Zoom or Teams. Additionally, 15.7% indicated that they do not use any digital platforms for cultural participation, suggesting the presence of a digitally disengaged segment.

When asked about the types of digital cultural events they had attended, the most common response was online education and workshops (43.8%), followed by online theater/cinema screenings (32.8%), digital exhibitions or virtual museum visits (20.4%), and online concerts (16.1%). These preferences indicate a tendency toward more structured or performative formats, though overall participation rates remain modest.

The third chart, which illustrates the frequency of participation across five types of online activities over the past year, shows a clear variation in engagement. Film and series streaming stood out as the most frequent activity, with a large number of participants reporting 10 or more viewings. However, participation in online education, e-book reading, and virtual museum tours was considerably lower. In each of these categories, the most frequent response was no participation at all, indicating limited uptake of more cognitively or culturally intensive formats.

Overall, the findings suggest that digital engagement is widespread primarily through social media and entertainment platforms, while educational and heritage-related content remains underutilized. These patterns point to gaps not only in digital access but also in content relevance and awareness. Enhancing digital cultural participation will require targeted communication strategies and inclusive programming that reflect the diverse needs and digital habits of the local population.

4.3. Barriers to Cultural Participation

The survey findings confirm that a significant portion of respondents face obstacles to full cultural engagement. While nearly half (48%) stated they cannot participate in cultural activities as much as they would like, an even higher proportion (68%) reported that there are specific cultural events they wanted to attend but were ultimately unable to. These responses underline the presence of a consistent gap between cultural interest and realized participation.

When asked to elaborate on the reasons behind their inability to attend cultural events, respondents identified a diverse set of barriers (Figure 8). The most frequently cited issue was lack of time, selected by 52.6% of participants, followed closely by economic limitations (40.1%) and the absence of such events in Kayseri (40.9%). This indicates that both structural deficits in event availability and personal constraints significantly shape participation patterns.

Additional barriers included a lack of events suitable for families (10.9%), insufficient awareness or communication about events (22.6%), and the inadequacy of event content with respect to quality or relevance (24.8%). Social constraints also emerged: 8% reported not having someone to attend with. Practical challenges like difficulty in accessing tickets (5.8%), transportation problems, and family responsibilities—such as recent parenthood—were cited by a smaller but important portion of respondents.

These results reaffirm that cultural non-participation in Kayseri is shaped not merely by individual disinterest but by overlapping constraints across time, cost, access, relevance, and social support. Addressing these complex layers will require coordinated efforts to enhance both the infrastructure and inclusivity of the cultural environment.

4.4. Attitudes Toward Cultural Engagement

Although actual levels of participation in cultural activities remain relatively modest, respondents' attitudinal profiles reveal a more complex and hopeful picture. As illustrated in Figure 4, a majority of participants (57.2%) regard cultural activities as either "important" or "very important" in their daily lives. This normative appreciation is further supported by the fact that nearly three-quarters (74.7%) have attended at least one free cultural event—an encouraging indicator of public interest, even when structural limitations exist.

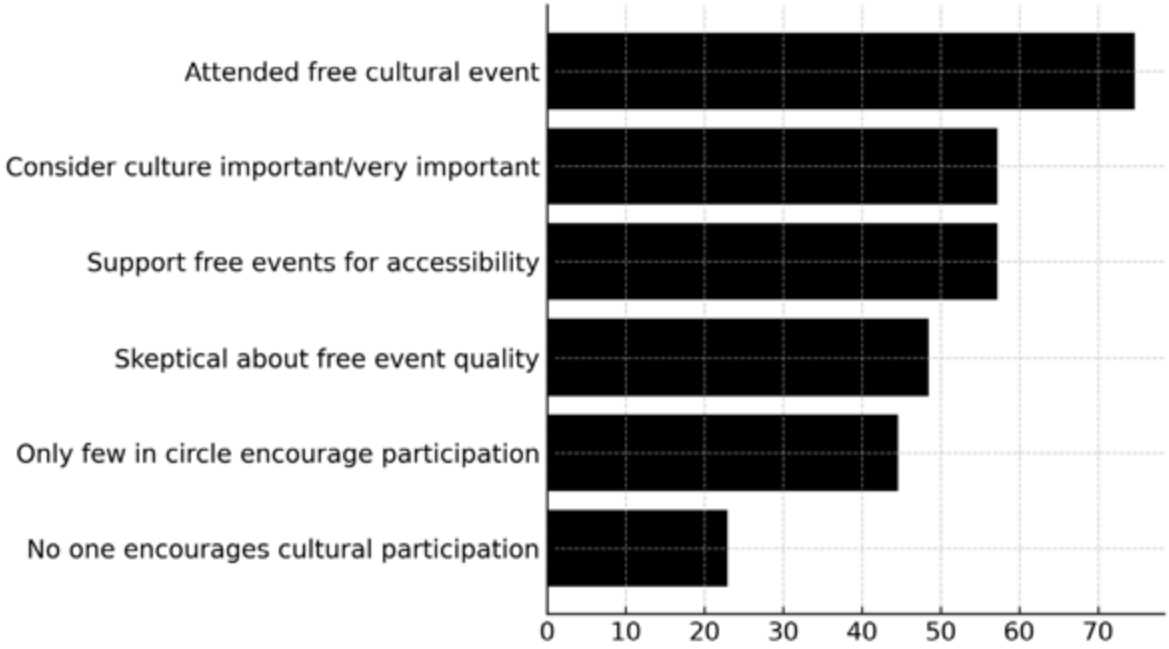

Figure 4. Key indicators of cultural engagement attitudes (%).

However, the presence of such interest does not automatically translate into widespread participation. The same figure shows that 48.5% of respondents expressed skepticism about the quality of free cultural programming, suggesting a perceived trade-off between accessibility and content richness. Additionally, 57.2% agreed that free events play a vital role in broadening access to culture, yet this support was tempered by ambivalence regarding their qualitative merit.

Social dynamics also appear to influence participation: while only a minority (13.9%) reported having a highly encouraging peer network, a significant portion (44.6%) noted that only a few people in their social circles support or promote cultural engagement. Meanwhile, 22.9% stated they lack any such supportive network entirely. This indicates that social encouragement remains unevenly distributed and may act as a hidden barrier, particularly among younger or more isolated individuals.

Taken together, these findings suggest that while cultural value orientations are largely positive, their impact is moderated by perceptions of quality, affordability, and social support. Strategic interventions should therefore go beyond merely increasing event quantity or lowering costs—they must also address content curation and community-building to convert positive attitudes into active participation.

4.5. Expectations for Cultural Development in Kayseri

When asked about their expectations for the improvement of cultural activities in Kayseri, respondents highlighted several priority areas (Figure 5). The most frequently expressed expectation was the diversification of event types, with a clear demand for a broader range of cultural programming that appeals to different age groups, interests, and artistic forms. This was closely followed by the need for enhanced communication and promotional strategies to ensure that cultural opportunities are widely known and accessible. Respondents also emphasized the importance of lowering ticket prices or expanding the availability of free events, reflecting economic concerns as a major constraint to participation.

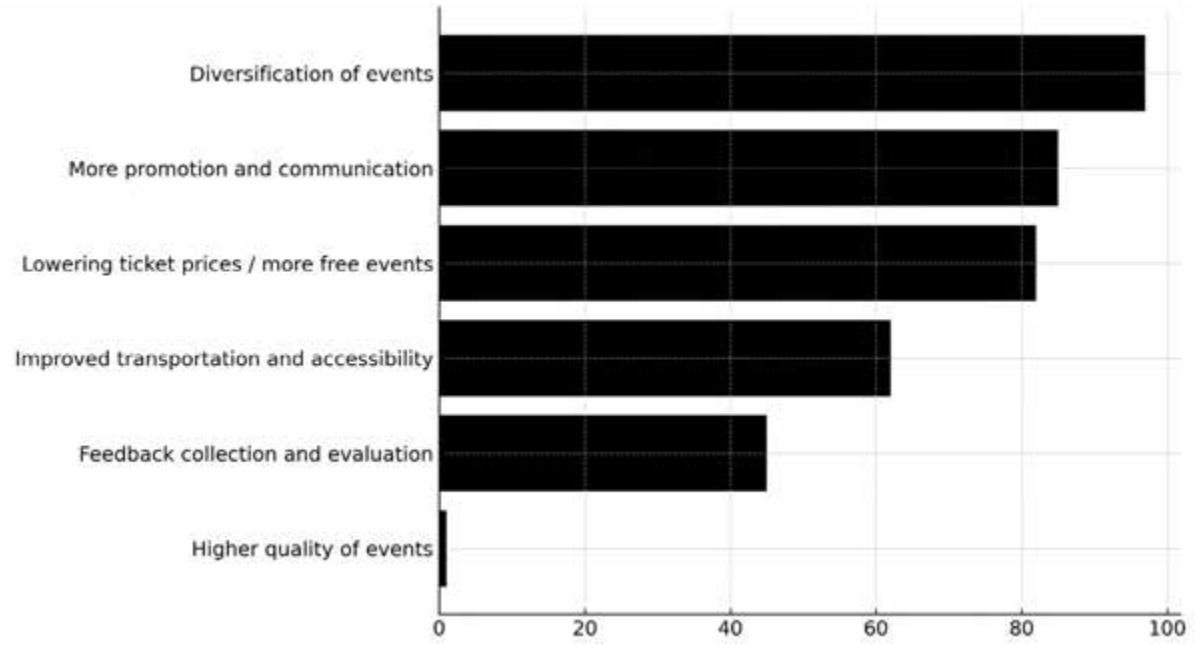

Figure 5. Public Expectations for Improving Cultural Life in Kayseri (%).

Transportation and spatial accessibility also emerged as key themes, with participants calling for easier access to venues and improved mobility, particularly for those living in outlying areas. In addition, a significant portion of respondents expressed a desire for their feedback to be considered in the planning and evaluation of cultural activities, indicating a preference for more participatory and responsive cultural governance practices.

These expectations signal a strong public demand for a more inclusive and responsive cultural ecosystem in Kayseri. Participants envision cultural services that are not only affordable and accessible but also better tailored to community interests. As such, policy responses should aim to diversify programming, enhance outreach, reduce financial barriers, and integrate resident feedback into cultural planning and delivery. Taken together, these improvements could contribute to a more vibrant and equitable cultural life across the city.

4.6. Perceptions and Meanings of Culture

In addition to measuring participation behavior, the survey asked respondents an open-ended question: "What comes to mind when you hear the word 'culture'?" Thematic analysis of these responses—coded and aggregated from 166 participants—offers insight into how individuals conceptualize culture in their everyday lives. The results reflect a rich and multidimensional understanding of culture that goes beyond institutional or elite associations.

The most frequently mentioned concept was "gelenek" (tradition), followed by "sanat" (art), "tarih" (history), "yemek" (food), and "müze" (museum). This distribution indicates that participants associate culture both with intangible heritage and artistic expression, as well as with material spaces and everyday practices. Notably, food and museums serve as symbolic anchors, connecting the personal and the institutional dimensions of cultural memory. These associations align with UNESCO's (2003) expanded definition of culture as encompassing "ways of living together, value systems, traditions, and beliefs", alongside creative and artistic output.

The prominence of tradition and history points to a conception of culture that is grounded in continuity and collective memory. At the same time, art and museum-related references indicate that respondents also perceive culture as something cultivated and displayed—tied to aesthetics, curation, and public representation. The mention of food reveals the extent to which culture is also seen as embodied and experiential, embedded in daily life rather than restricted to high-cultural institutions. These findings resonate with anthropological perspectives that frame culture as a "web of meaning" (Geertz, 1973) and with contemporary sociological accounts that

emphasize culture as both structure and practice (Swidler, 1986).

Importantly, the variety of associations suggests that respondents do not view culture as static or monolithic, but rather as plural, layered, and context-dependent. This is consistent with studies highlighting the increasingly hybrid and localized definitions of culture emerging in non-metropolitan urban contexts (Moulin, 2021). In the context of Kayseri, the data points to a public imaginary where culture is simultaneously communal and curated, lived and learned—a framework that offers fertile ground for inclusive, place-based cultural policy development.

Digital Cultural Participation by Age and Income The analysis of average participation frequencies in digital cultural activities across age and income groups reveals distinct generational and socio-economic divides. Younger participants, particularly those aged 18–24 and 25–34, exhibit the highest engagement across nearly all digital cultural forms, especially in film and series streaming and online education. Conversely, engagement levels decline steadily with age, with respondents aged 45 and above reporting significantly lower frequencies of participation—particularly in e-book reading and virtual museum tours.

Income-based variations further underscore disparities in cultural access. Respondents in higher income brackets (e.g., 40,001–60,000 TRY and above) tend to engage more frequently in diverse online cultural formats. Notably, those earning below 20,000 TRY still demonstrate high engagement in film/TV streaming, likely due to the relative affordability and accessibility of such platforms. Participants who opted not to disclose their income generally exhibited lower participation levels, especially in educational and literary content.

These findings point to both generational and economic factors shaping patterns of digital cultural consumption. They also suggest that streaming services may play a crucial compensatory role for lower-income groups, while digital educational and heritage-oriented offerings remain underutilized among older and economically disadvantaged populations.

4.7. Perceptions of Kayseri's Cultural Capacity

In addition to behavioral patterns and barriers, the survey included specific items aimed at gauging how residents perceive the city's overall cultural infrastructure and institutional responsiveness. The results, summarized in Figure 6, reveal a generally critical but nuanced public assessment.

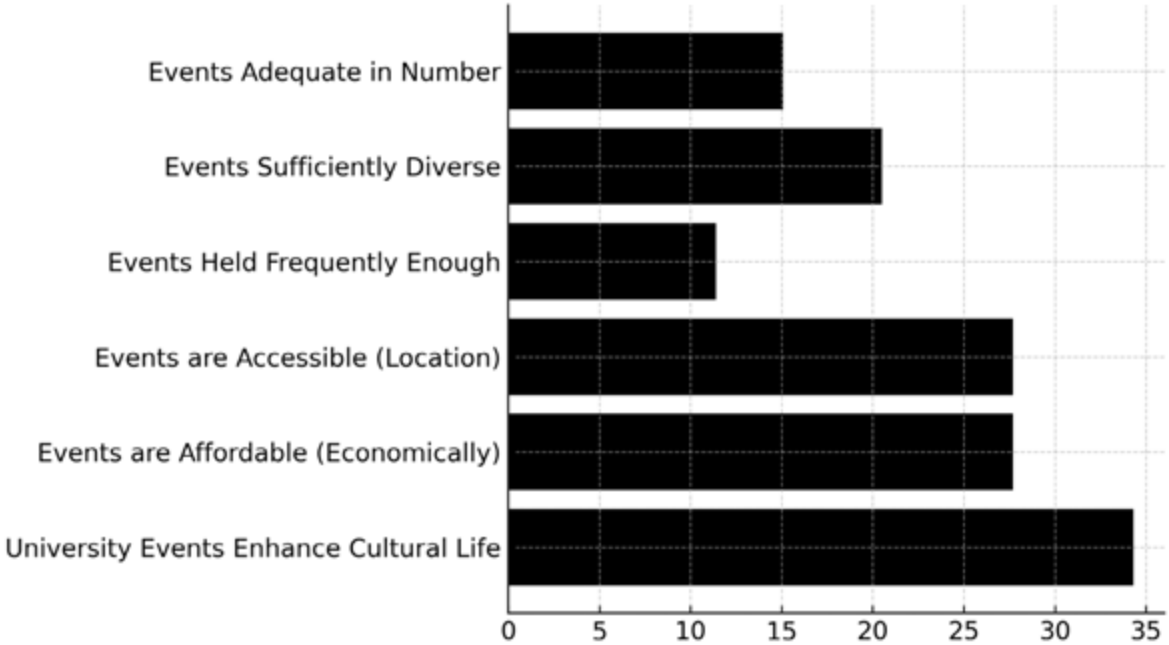

Figure 6. Overall perceptions of cultural infrastructure and participation opportunities in Kayseri (%).

Only 15.1% of respondents believe that cultural events in Kayseri are adequate in number, and an even lower share (11.4%) think they are held frequently enough. This highlights a perceived scarcity in both volume and continuity

of cultural offerings. Diversity also appears to be lacking, with just 20.5% agreeing that events reflect a sufficient range of interests and formats.

More encouraging responses were recorded for spatial and economic accessibility: 27.7% of participants found event locations to be reasonably accessible, and an equal percentage stated that cultural events are economically affordable. These figures suggest that while physical and financial access remains a challenge for many, there is a partial recognition of ongoing municipal efforts in these areas.

Notably, the most positive result emerged in relation to universities: 34.3% of respondents agreed that university-led cultural activities contribute meaningfully to the city's cultural life. This points to the prominent role higher education institutions may play in compensating for broader gaps in public cultural provision.

Together, these findings indicate that Kayseri's cultural ecosystem is perceived as limited in diversity, frequency, and scale, yet with modest successes in affordability and location, and with universities emerging as key cultural actors. These perceptions underscore the need for coordinated municipal-university partnerships and expanded efforts in event programming, frequency, and outreach to enhance cultural vitality across the city.

5. Discussion

The findings of this study reveal a persistent pattern of uneven cultural participation in Kayseri, driven primarily by socio-economic, spatial, and informational barriers. These results corroborate long standing theoretical arguments emphasizing the role of cultural capital, educational attainment, and social positioning in shaping access to cultural life (Bourdieu, 1984; DiMaggio, 1982). Despite Kayseri's wealth of cultural heritage and infrastructure, participation remains limited, particularly among lower-income groups, women, and youth with limited exposure to institutionalized culture. The survey results indicate that affordability, awareness, and accessibility are the most frequently cited barriers—each mapping onto broader structural dynamics that inhibit inclusion.

These empirical patterns resonate with recent critiques of cultural policy discourse in Europe, which problematize non-participation without sufficiently addressing the socio-structural conditions that produce it (Stevenson et al., 2017; Jancovich & Stevenson, 2023). In the context of Kayseri, the absence of participatory planning mechanisms and the dominance of top-down cultural programming result in a limited responsiveness to local needs. This reinforces symbolic boundaries and maintains a disconnection between formal cultural institutions and the everyday cultural practices of residents.

Moreover, the findings reveal that cultural participation in Kayseri is not merely a matter of personal interest but is closely tied to place-based factors such as proximity to venues, urban transport connectivity, and neighborhood-level social networks. These insights align with intersectional and network-based approaches, which highlight the role of relational infrastructures in enabling or constraining cultural engagement (Kane, 2004). In this light, cultural participation must be understood not only as an outcome of individual choice, but also as a relational and spatial practice embedded within urban inequalities.

The results also raise critical questions about the universality of cultural metrics. While this study draws upon UNESCO's Framework for Cultural Statistics (2012) to guide the design and interpretation of survey instruments, the application of such frameworks in secondary cities like Kayseri reveals key limitations. Standardized indicators may obscure context-specific dynamics and overlook alternative, informal, or non-institutional forms of cultural expression that are vital to local identities. In line with Roaldsnes (2025), this study underscores the need to attend to the spatial-temporal embeddedness of participation—how seasonal rhythms, municipal planning calendars, and local traditions mediate cultural engagement in context-specific ways.

These findings collectively indicate that increasing cultural participation in Kayseri will require multi-level interventions that not only address structural barriers, but also recognize and integrate local cultural practices. This necessitates a shift in cultural policy toward inclusive, participatory planning that reflects the lived realities of diverse populations in secondary cities.

This study provides a comprehensive exploration of cultural participation patterns in Kayseri, a city that possesses significant cultural heritage yet continues to exhibit relatively low engagement levels. The findings confirm that while many residents value culture and express a desire to participate, structural and symbolic barriers often inhibit their ability to do so. This phenomenon echoes broader scholarly debates on cultural inequality, wherein participation is shaped not solely by individual preferences but by socio-economic, spatial, and informational asymmetries (Bourdieu, 1984; DiMaggio & Useem, 1978).

One of the study's most striking revelations lies in the discrepancy between attitudinal support for culture and actual engagement. Despite nearly two-thirds of respondents deeming culture "important" or "very important," only a minority regularly attend cultural events. This gap reinforces prior claims that positive dispositions alone do not guarantee participation in the absence of enabling conditions (Miles & Sullivan, 2012). Instead, our data suggest that participation is mediated by an ecology of access, where economic hardship, time poverty, limited spatial mobility, and informational deficits intersect.

The strong presence of economic and temporal constraints—identified as the most significant barriers—resonates with cultural access literature that foregrounds cost and time as recurrent inhibitors (Chan et al., 2008; Stevenson, 2013). In the Kayseri context, ticket prices, transportation costs, and competing responsibilities among working-age adults represent core challenges. Moreover, the urban geography of cultural provision remains highly centralized, limiting access for residents in peripheral districts—an issue corroborated in spatial justice and cultural planning literature (Grogan, 2021; Finkel et al., 2019).

The findings also point to substantial informational and social barriers. The prevalence of late or inadequate announcements, limited outreach through digital or local channels, and a lack of event diversity reflect an ongoing misalignment between supply and demand. This is consistent with Holden's (2006) argument that cultural institutions must evolve from traditional producer-consumer models toward dialogic, audience-responsive frameworks. Furthermore, the lack of a supportive peer environment for cultural engagement—reported by nearly half of the respondents—suggests that cultural participation is not only an individual act but a socially embedded practice, often shaped by networks of encouragement and belonging (Bennett et al., 2009).

The digital dimension of cultural engagement in Kayseri also reveals significant disparities. While social media use for cultural content is high, more substantive formats such as online workshops or virtual museum visits remain underutilized. Age and income were found to be major predictors of digital participation, confirming findings in other studies highlighting the digital divide in cultural access (Selwyn, 2004; Heikkilä & Sassi, 2021). These disparities underscore the need for inclusive digital strategies that move beyond passive content delivery to foster interactive and meaningful online experiences.

Finally, respondents' open-ended definitions of culture demonstrate a pluralistic and hybrid understanding that encompasses both tangible heritage and lived practices—aligning with UNESCO's broader definition of culture (2003) and anthropological perspectives that frame it as a "web of meaning" (Geertz, 1973). The prominence of food, tradition, art, and museums as cultural referents suggests that policies should not limit themselves to high-cultural institutions but instead embrace everyday and community-based expressions.

6. Conclusion and Policy Recommendations

This study offers a comprehensive analysis of the structural and experiential dimensions of cultural participation in Kayseri. Through the use of a standardized survey grounded in UNESCO's (2012) methodology, the research identifies both the scope and limitations of cultural engagement in a historically rich yet under-researched secondary city. The findings underscore that cultural participation is not evenly distributed across the urban population and is shaped by a complex interplay of economic, educational, spatial, and symbolic barriers (Bourdieu, 1984; DiMaggio, 1982).

Despite Kayseri's wealth of tangible and intangible cultural assets, participation remains limited, particularly among lower-income groups, women, and youth. Barriers such as affordability, lack of awareness, and restricted physical access align with broader structural conditions, highlighting the embedded nature of cultural exclusion. These findings resonate with critiques of European cultural policy discourses that often individualize non-participation while neglecting systemic inequalities (Stevenson et al., 2017; Jancovich & Stevenson, 2023).

In response, this study proposes a series of policy recommendations aimed at fostering a more inclusive and equitable cultural environment:

• Adopt Participatory Cultural Planning Cultural institutions and local authorities must adopt participatory mechanisms that actively involve underrepresented groups in decision-making processes. This includes co-designing cultural programs with local residents and diversifying content to reflect plural identities, needs, and interests.
• Develop Targeted Outreach and Awareness Strategies Informational gaps should be addressed through strategic communication efforts, particularly in peripheral neighborhoods. These efforts must be complemented by improved transportation infrastructure and the establishment of decentralized cultural hubs embedded in residential areas.
• Recognize Informal and Everyday Cultural Practices Cultural policy in Kayseri should shift from a supply-driven model toward a needs-based, place-sensitive approach that acknowledges informal and everyday cultural practices as legitimate forms of participation. This reframing requires the integration of cultural access into broader urban and social policy frameworks, linking it to education, mobility, and social cohesion.
• Adapt Standardized Metrics to Local Contexts While UNESCO's cultural statistics framework offers a valuable starting point, its application in secondary cities like Kayseri reveals limitations. Standardized indicators may obscure local dynamics and overlook non-institutionalized forms of expression vital to community identities. In line with Roaldsnes (2025), the study calls for the development of culturally sensitive, spatially embedded, and temporally attuned metrics that reflect local patterns of engagement.
• Expand Research Methodologies Future research should complement quantitative surveys with qualitative methods such as interviews, focus groups, or ethnographic observation to capture the lived experiences and cultural meanings of participation. Longitudinal and comparative studies across cities in Türkiye would further enrich the evidence base for inclusive cultural policy-making.

By shedding light on the local dynamics of cultural participation, this study not only contributes to academic debates on culture-led urban development but also provides actionable insights for policymakers, planners, and cultural actors. Advancing inclusive cultural governance in secondary cities like Kayseri demands both structural reform and a reconceptualization of participation that values diversity, everyday practices, and the co-production of cultural life.

While future research should expand the empirical base through longitudinal and comparative studies, this investigation provides a foundational step toward rethinking cultural participation in Türkiye's secondary cities. By positioning cultural engagement as both a right and a process, policymakers can begin to build more just, inclusive, and resilient cultural ecosystems.

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Metropolitan Cities as Living Monuments: Resilient Territories between Culture, Justice and Innovation

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Abstract
The text redefines the concept of the monument within metropolitan conservation, shifting from a static object to an active, antifragile device that generates values and behaviours over time. Conservation becomes a dynamic design process aligned with societal sustainability and evolving heritage, rather than mere material preservation. At the metropolitan scale, cities are seen as living monuments—relational infrastructures fostering cultural continuity and innovation. They catalyse social and environmental transformation, translating local knowledge into adaptive strategies. Case studies introduce the idea of eco-centrality as a node of territorial resilience, where new forms of living, producing, and governing emerge. These places integrate sustainability, spatial justice, and care for the commons, offering a forward-looking model of urban development rooted in cultural vitality and collective agency.

Keywords: Antifragile heritage; Metropolitan resilience; Eco-centrality

Heritage as an engine for localising the SDGs: culture, metropolitan policies and sustainable connections

The territorialisation of the Sustainable Development Goals (SDGs), known as 'localisation of the SDGs' (Senatore, Bellabarba, 2021), is a key element in implementing a sustainable development strategy. This approach is based on multi-level governance and the involvement of territories, civil society, and non-state actors in the policy cycle, from planning to monitoring and evaluation.

There are four vectors of sustainability: planning and design for sustainability, policy coherence, culture and participation in sustainable development.

In particular, culture promotes training, information, and communication to strengthen governance and encourage population involvement. It also develops the capacity to closely observe contextual factors to identify what needs exploration in order to improve the quality of life for metropolitan populations.

In our research at the MSLab of the Politecnico di Milano, we asked ourselves whether humanity's quality of life remains the central reference for any consideration. Our reflection runs through the transformation of cities driven by emancipated and multi-ethnic societies shaped by technological progress.

Indeed, with the evolution of technology, geopolitical changes, and the expansion of cities into rural areas, there is a need to integrate non-linear urban realities by merging elements of ultra-modernity with fragments of neo-archaism. Modern metropolises, once deeply connected to the bodies of their inhabitants and urban spaces, now struggle to re-establish this relationship. Critical issues arise, such as the integration of historic and peripheral areas into the urban fabric and the need to design policies for metropolitan spaces that can engage with the local physical context, which has shifted in scale while maintaining its own identity to avoid producing a generic city (Koolhas, 1995). Areas emerging from the destruction of war or natural disasters deserve special attention.

Our research focuses on implementing a strategic framework to guide the transformations necessary to overcome the negative impacts of the metropolitan scale. Furthermore, in line with the new European Green Deal, we emphasise the central role of sustainability in evaluating metropolitan-scale policies that require introducing the cultural component of local populations.

In this context, ecological and social transitions are intertwined in an integrated and cooperative transformation process. The final objective is to present examples of local cultural resistance actions that influence decision-making processes at the metropolitan scale for the development of inclusive public spaces and new metropolitan typologies, with a specific focus on metropolises' grey-green infrastructure and its impact on the individual and collective behaviour of 'conservative' and 'futurist' inhabitants.

The link between the localisation of the SDGs and culture underlines the crucial role of territories and their knowledge in promoting metropolitan sustainable development projects and policy coherence. Integrating the 2030 Agenda into horizontal metropolitan and vertical local planning processes relies on the meaningful engagement of various metropolitan and local agents.

A combination of culture and civil society movements is essential. Artistic practices can create a discontinuity with the past through an emotional rupture. However, this remains momentary and didactic if the wedge of mobilisation does not widen and if we stay anchored to a vision of art limited to individual emotion. Instead, they must be capable of leaving a mark of permanent value, contributing to constructing a collective landscape, producing a shared experience, and defining and recognising a community.

Millions of people, frightened and distressed by a significant rise in inequality, must be provided with a convincing alternative: a radical realignment of public governance to the collective interest and the right to their own 'lifestyle'. We would like to present proposals and experiments on this approach formulated by the MSLab of the Politecnico di Milano, particularly in Latin America.
That requires efforts to change the prevailing common sense, i.e. the mental predispositions, beliefs and attitudes that guide our decisions. Once again, science, history, knowledge, and local culture, which exist in the ashes, show us the way. We need a combination of two ingredients: culture and civil movements.

The new idea of a monument
According to the Venice Charter (ICOMOS, 1964), the notion of monument includes the architectural work and the urban/landscape environment.

I would replace this definition with that of a monument as an architectural sign that establishes a virtuous behaviour that is valid for a period of time (Choay, 1992).

That means that any significance of value we attach to an architectural fact is not linked to a 'then', but because it is recognised as valid today as it was then.

Thus, we can point to a value of time that does not focus on permanence but on duration, that is, on that which persists because it has determined lasting relationships with the context to which it belongs.

The relationship between past and present makes the past meaningful insofar as it can activate the reasons for today, and conservation is authentic if, after conservation, society can remain alive. With the extinction of society and, consequently, of subjective time, there is no longer any meaning or value in conservation; therefore, we can define that the sustainability of action is linked to its strong relationship with the survival of human society. Sustainability, thus, must be considered in the light of a temporality understood in its variance that requires an understanding of the meaning of the common sense, and of the accidental event that breaks into the metaphysical dimension of principles. The question is the value relationship between what we now consider eternal and accidental, temporary and consumable.

The theme of consumption encourages us to reflect on the relationship between human beings and nature, which has been profoundly transformed. This transformation carries philosophical, ethical, and practical implications that have shaped our understanding of the natural world and our role within it. It is linked to three interdependent concepts: freedom, constraint, and the secularisation of nature.

If we consider the metropolitan dimension, we can argue that the 'metropolitan commons'- that which today's generation must preserve for future generations as the mark of cultural value to leave as a testimony to its understanding of the world of this era and its society- is precisely what we can still call the cultural landscape, within which nature also lies, since it is no longer possible to distinguish human history and its preservation from that of the planet. Dipesh Chakrabarty, in his The Climate of History: Four Theses (2009), leads us to look at the entanglement between culture and nature as an extreme attempt in the age of the Anthropocene to save the planet.The concept of entanglement, also proposed by the New European Bauhaus, is the eye of the storm from which to understand the current condition and to comprehend what the culture of nature means today, i.e. the entanglement between culture, technology, and the biosphere that is the unprecedented phenomenon of the current era.

That is where the discussion on the monument comes in. In our Western tradition, the monument serves as the warning that each generation entrusts to the next. But can every warning become a monument? No. A monument becomes a monument only when it elevates itself to a universal rule, a shared obligation, a secular sacred that binds all. In this sense, the monument is metaphysical sacredness made immanent.

This translation of the sacred into immanence is realised in heritage: a heritage that cannot exist only as a warning but takes shape in the collective expectation of leaving a mark of value to future generations, consolidating itself through law and intention.

Today, what gives the warning the status of the monument stems from an inverse process compared to the past, when the sacred deity sanctioned the law. Today, sustainable human behaviour towards nature has become a necessity, a spontaneous form of self-confinement. It is the detachment from the idea of a religious metaphysics, a vital and unavoidable act, to be handed down to those who will come after us as a universal condition and rule, binding for the very survival of humanity.

If heritage is not only a legacy of the past but also an engine of change, a hope, it is a strategic resource for shaping sustainable urban futures. As cities work to localise the Sustainable Development Goals (SDGs), cultural and natural heritage becomes crucial to integrate policies across sectors, linking water, agriculture, food, mobility and social equity.

Heritage, serving as a bridge between tradition and innovation, conservation and transformation, underlies the New Urban Agenda's emphasis on strengthening the links between city and country through the definition of Urban-Rural Linkage Patterns, which are an integral and fundamental part of the new metropolitan landscapes (Contin,2021).

Achieving the sustainability goals of our metropolitan cities enshrined in SDG 11 requires moving beyond isolated interventions to integrated metropolitan policies that address climate adaptation, resource efficiency and social inclusiveness while strengthening local identity. European frameworks such as the Green Deal (European Commission, 2019) and the Digital Agenda (European Commission, 2010) emphasise the alignment of heritage with green and digital transitions. However, systemic change requires adaptive governance and flexible institutions that respond dynamically to evolving challenges.

Metropolitan landscapes are complex ecosystems in which heritage plays a vital role in maintaining regional equilibrium; incorporating heritage into planning processes is key to addressing socio-economic inequalities and environmental degradation. The Mombasa Swahilipot Hub (https://www.swahilipothub.co.ke/) demonstrates how youth culture, digital innovation and heritage entrepreneurship can challenge traditional patterns of preservation, transforming metropolitan heritage into a catalyst for economic growth and highlighting the need for strategies that integrate heritage into spatial development.

Even more, the Quintuple Helix Model (Contin, Sona, Pesci, Porreca, Pandolfi, Yang, Koike, 2025, p.253) includes the environment among the stakeholders and offers a governance framework that balances economic, environmental, and social factors. This approach is particularly strategic in conflict-affected areas, such as Gaza.

War erodes the protection of human rights and leads to the destruction of cultural heritage.

War is abhorrent because it also erases the complexity and dynamism of cultural heritage. It erases the multiplicity of human existence, cultural spaces, and shared meanings. It erases the possibility of crossing cultural boundaries and learning from others who appear different. UNESCO should have the courage to declare that the war in Gaza is destroying people's right to their Memory and History.

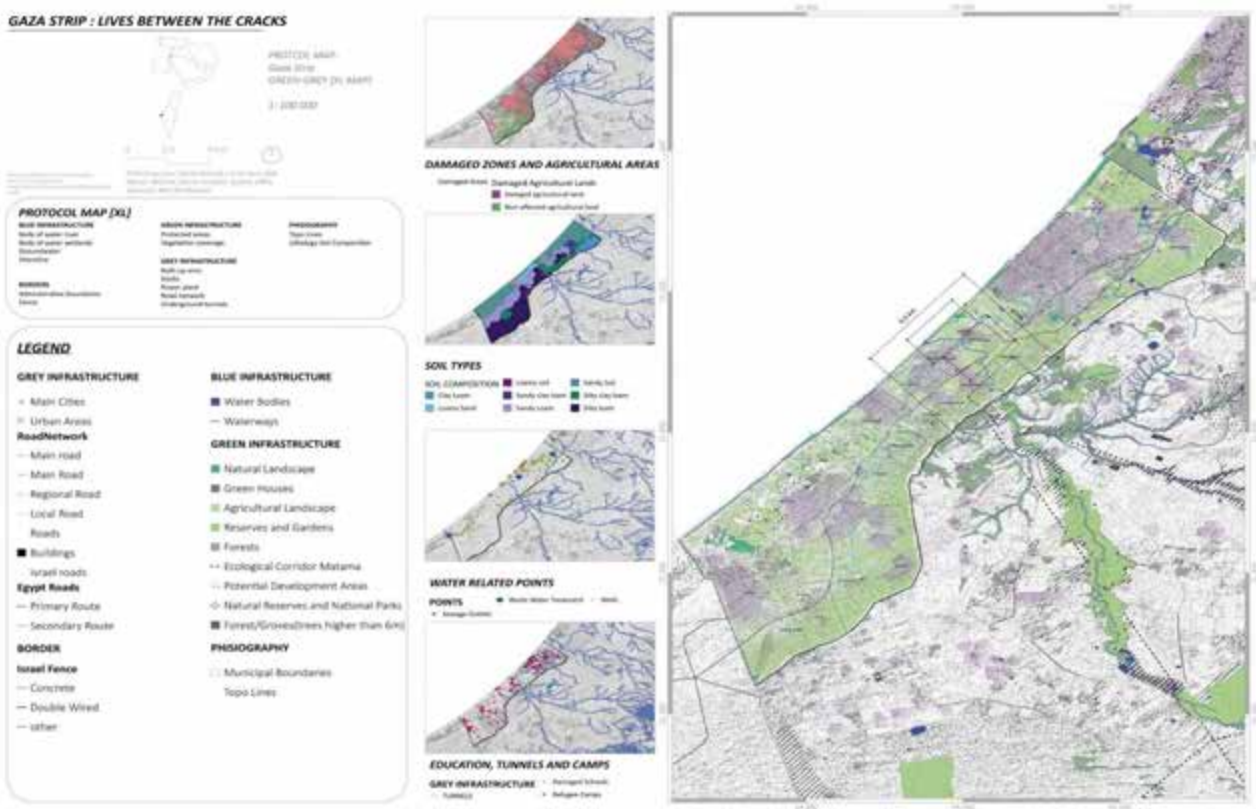

Figure 1. Metropolitan Cartography. Gaza Strip- XL Protocol Map.Credit: MsLab Polimi & Aktas E., Gandevikar K., Tsang W.C., Chen J.

Our study of the autumn semester 2024/2025 at the Politecnico di Milano was based on research and academic collaboration between the GLA programme, Birzeit University, An Najah National University and Gaza students enrolled in the online educational programme at the aforementioned Palestinian institutions, AUB in Lebanon and the Politecnico di Milano. The semester's intervention took place in the Gaza Strip, Palestine, focusing on the landscape of emergencies in the territories in transition. Students and teachers explored the concept of landscape in conflict and related planning for socio-environmental justice in a war-torn territory, Gaza, Palestine.

Landscape results from a dynamic interaction between a community and its environment, demonstrating how landscape architecture can foster socio-environmental justice by linking heritage conservation to resilience and recovery efforts.

This is why we have argued that urban resilience is no longer about survival but about anti-fragility. We use crises as opportunities to rethink governance and planning. This approach encourages urban planners, architects, and politicians to see heritage as an active force in transitions towards sustainability.

Urban planning in fragmented territories such as the Gaza Strip and the West Bank is not only a response to systemic oppression but also a profound act of resistance and resilience. Our Master Studio Project demonstrated that by integrating nature- and culture-based solutions through metropolitan mapping (Contin, Galiulo, 2022) and participatory design interventions, it is possible to reimagine urban landscapes as spaces of equity, connectedness and sustainability.

The case studies and strategies presented, such as the reconversion of fragmented empty spaces into agricultural networks and rehabilitating coastal areas in Gaza to foster shared spaces that promote cultural identity, emphasise the transformative potential of urban design in addressing human and ecological needs. These projects exemplify how participatory design processes can counter systemic fragmentation by promoting ownership, solidarity, and collective action. These efforts align with the philosophy of 'Sumud', which embodies perseverance in the face of adversity, sustaining cultural memory and ecological balance (Massad, El-Astal, and Thabet, 2018).

Mapping the damage, segregation, and ecological disruption within Gaza highlights the critical role of cartography as a tool to visualise spatial injustice and imagine alternative futures. By exposing the mechanisms of fragmentation and proposing integrative strategies, the maps presented in this study allow us to transform boundaries into opportunities, gaps into centres and blockages into avenues for collaboration and restoration.

Ultimately, the projects emphasise that resilient urban planning must go beyond survival to envision hopeful, inclusive, and decolonial futures. They invite architects, planners, landscape architects, and policymakers to fuse local culture with global solidarity, creating spaces that resist erasure and support justice, sustainability, and equity. By bridging gaps between people, places, and ecosystems, design becomes a catalyst for healing fragmented territories, promoting lasting coexistence, and building infrastructures of resistance.

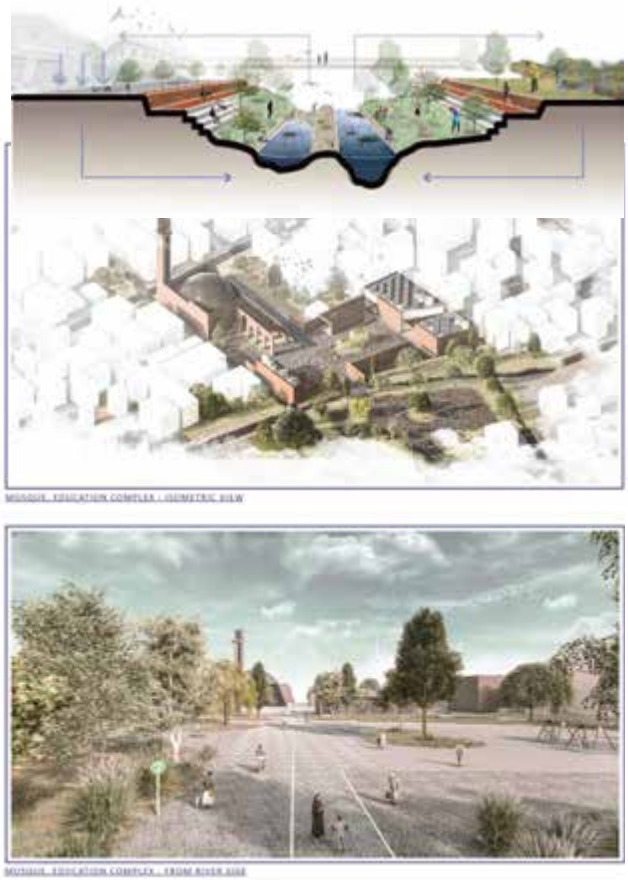

Figure 2a.Gaza Strip. Graded distribution basins flooded after heavy rains. Reduces flood risk while recharging groundwater and providing water for agriculture.Credit. MSLab & 2024Idll MersIn, Lynne Nabha, Jingrui Yang, Jialu Li

Figure 2b. Gaza Strip. Detailed section and water system management. Credit. MSLab & 2024Idll MersIn, Lynne Nabha, Jingrui Yang, Jialu Li

Figure 2c. Gaza Strip. Mosque, education complex - isometric view. Credit. MSLab & 2024Idll MersIn, Lynne Nabha, Jingrui Yang, Jialu Li

Finally, the Heritopolis Society (https://heritopolis.org/), a UN-Habitat initiative within the Korean Ministry of Culture, positions itself at the intersection of cultural identity, adaptive management and policy innovation, promoting cross-sectoral metropolitan connections.

By linking research and practice, as well as past and future, we aim to implement the habitat's local and sustainable cultural landscape. We consider heritage a fundamental pillar for localising the SDGs (Sustainable Development Goals) and constructing more just, resilient, and inclusive metropolitan territories, integrating other knowledge of local communities (Hale, Lynn Stephen, 2014) in current metropolitan projects and policies. It is time to move beyond static notions of heritage. Blood and territorial identity must be dismantled if we are to reconcile conflicts, thereby transforming the identity value of heritage to embrace a new, albeit ancient, idea of democracy.

The metropolis as heritage

The heritage debate revolves around two crucial issues: determining which heritage elements should be permanent and balancing conservation with community growth.

We argue that the definition of cultural heritage is inherently subjective. Traditions play a crucial role in maintaining heritage, but events such as the COVID-19 pandemic have demonstrated how disruptions can alter perceptions of time and cultural continuity. Furthermore, we suggest shifting the focus to fringe events and alternative manifestations to revitalise heritage, emphasising the need for individuals to actively engage with cultural heritage as creators and users, shaping cultural appropriation.

The modern debate recognises the challenge of maintaining cultural heritage while allowing communities to evolve. A successful balance preserves key cultural elements such as street layouts and commercial activities. It also means emphasising the importance of branding cities while permitting the creative reinterpretation of historical heritage. Expanding the definition of heritage includes emerging technologies and creative expressions, arguing that heritage should not be confined to traditional monuments but evolve alongside societal changes.

For this, we must emphasise the transformative role of technology in discovering new aspects of cultural heritage (iHERITAGE, or the 'UNESCO Mediterranean ICT Platform for Cultural Heritage'). Digital tools can redefine the way we perceive cities and experience urban culture. However, we must emphasise the importance of responsible digital information management as it significantly influences our understanding of heritage. Future challenges include integrating technological advances to enhance cultural appreciation without diluting its authenticity (Buragohain, Meng, Deng, et al. 2024).

If we interpret heritage as an infrastructure capable of transporting values/resources, we highlight its dynamic nature. Traditions and recognisable elements ensure continuity, but the anti-fragile approach (Blečic, Cecchini, 2019) makes it sustainable in a changing urban context. The key lies in fostering participation, welcoming creative and counter-thinking reinterpretations, and harnessing technology to enrich the cultural experience, without sacrificing responsible preservation practices.

Our field of research is the Metropolis of the Second Modernity. In the ecological era (Khan, Vandevyvere, & Allacker, 2013), we need to focus on the paradigm of anti-fragility (Taleb, 2014) and de-risking that concerns contingent, fluid, and emergent structures and relations. The metropolis, therefore, in its dimension of bioregion (Barbanente, Fanfani, 2023), represents a 'different nature', a worldview in which nature overflows through its categories and touches culture (and vice versa) and in which human beings do not possess external characteristics that guarantee them a privileged viewpoint on things.

The Metropolis of the Second Modernity must be rethought from the demand for sustainability as a place where the soil, transformed with low environmental impact, becomes a critical node in the metropolitan processes that drive development and determine anthropological, social, technological, economic and managerial mutations. The consumption of energy, materials and, above all, soil must, therefore, be understood as the consumption of a rare commodity within a metabolic approach that calls into question a generational responsibility. For the new generations, it is a matter of building a life-cycle project that puts ecological issues at the centre. We must, in fact, consider the impact of metropolitanisation as a generational threshold: a transition that, in a short time, has

radically altered the lifestyle of local communities.

The coexistence of different places and their communities is typical in metropolitan societies.

The need to consider the metropolis as a cultural issue stems from the fear of losing due to the immeasurable size of the city today, our understanding and control of the spaces we inhabit, and the certainty of our social identities. This anxiety makes the conservative perspective on change extreme and exclusive, even though change is an undeniable reality. The issue of radicalised identities can lead to indifference to the dangers of obsolescence or disinvestment, and conflict intensifies with the rapidity of change. Conversely, there is hope for the future, but sometimes, an uncritical belief in its benefits often overshadows the past as we strive to look only ahead.

In this scenario, various cases of inequality and vulnerability are attributed to the inability to recognise and appreciate the value of cultures other than one's own and the consequent failure to include these cultures in a new metropolitan cosmopolitan culture; the loss of the plurality of different cultures and knowledge results in a resultant monotony of values, with risks of homogenisation and uniformity.

Cultural identity risks becoming a failed project if not conceived as a system of different resources. Moreover, it would be necessary to govern the dynamic transitions of processes and epistemologies, turning them into resources for designing new territories and lifestyles.

The metropolitan structure is based on a systemic approach: the metropolitan scale was chosen as the privileged dimension to observe, with greater precision, the gaps in local knowledge, particularly concerning the know-how of the territorialisation of the twin transitions and their impact on the SDGs.

The Metropolis of the Second Modernity is a system of places constituting its region, an alliance of multiple decision-makers and heterogeneous populations.

In the opening of a path of convergence between macro and micro scales, local intelligence intertwines with global dynamics, becoming a strategic axis.

Recognising the local languages of common sense and the earthworks that inhabit metropolitan areas is necessary. From these elements, we must be able to extract systemic resources that are treated as invariant data on a metropolitan and national scale.

Only then will a metropolitan architecture project be able to return these enhanced values to the territory, strengthening its local identity through conscious regeneration processes.

Resilient territories: Dialogues between city and country
In the past, in many culturally relevant areas, the lack of infrastructure drastically compromised the quality of village life, leading to the exodus of younger generations and triggering a demographic decline that reduced the availability of local labour.

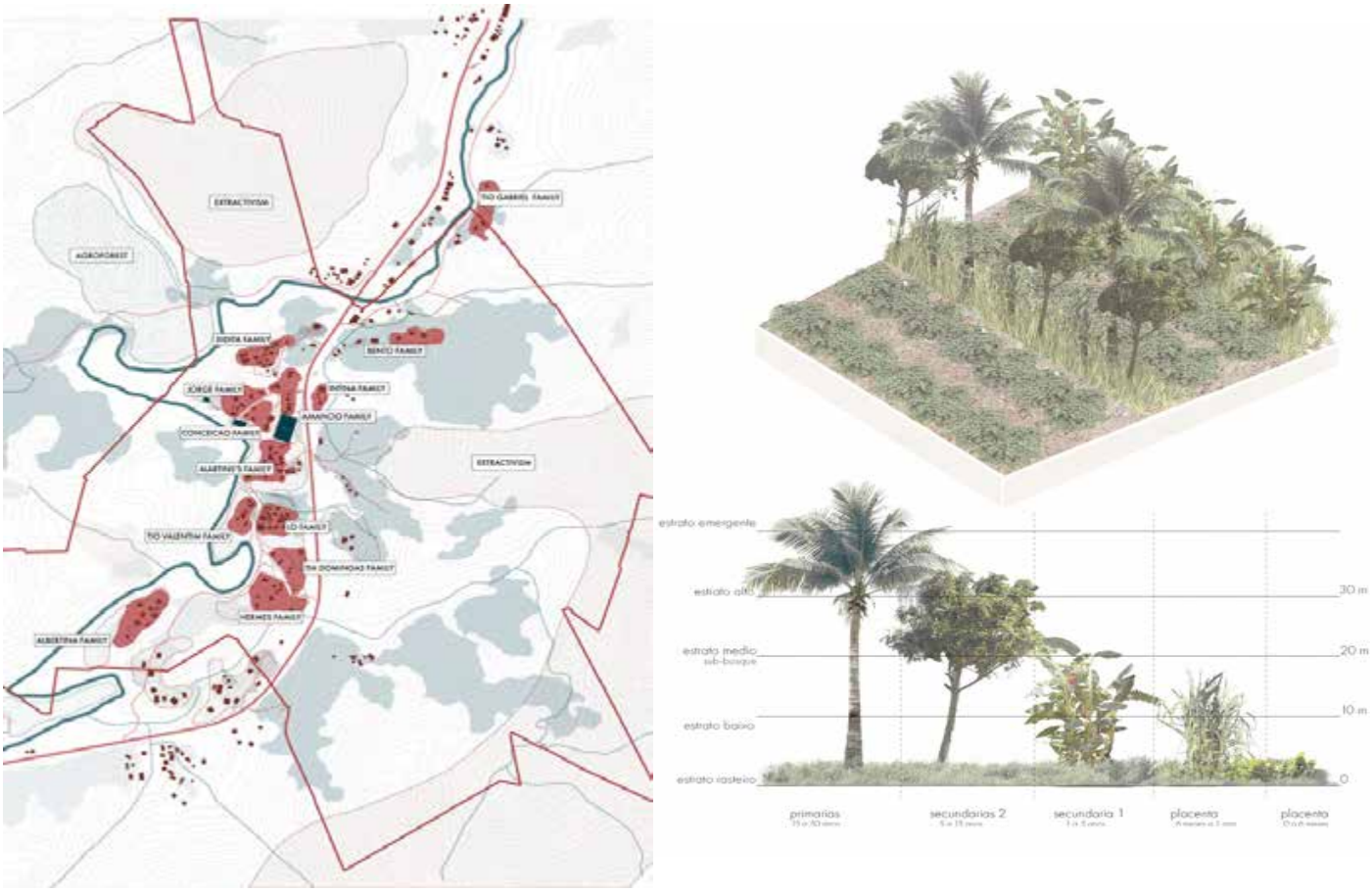

Figure 3. The perimeter of the Quilombo defined by the Palmares Foundation encompasses the areas of 13 family plots, and Agroforest type. Credit. MSLab & Erika Nataly Amidati e Francesca Cisaria.

Today, in those same areas, the increasing influx of tourists has generated a progressive shift from the traditional agricultural economy to the tourism industry, narrowing the range of employment opportunities and reducing the diversity of jobs available.

This shift manifests itself on spatial, economic and socio-cultural levels.

However, alongside these material transformations, there have also been intangible losses: local knowledge - the legacy of practices and skills linked to the land - has gradually been supplanted by a tourist economy that, while bringing new flows, has eroded the fabric of the local economy and disarticulated traditional social structures.

Of course, geography is also instrumental in shaping the divisions between rural and urban areas. Topographical features, including mountains and rivers, as well as policies and regulations, have played a role in the clear separation of areas. This zoning has profoundly influenced the population, and its effects are visible in various places, from economic disparities to social differences.

The fragmentation of rural and urban areas results from a combination of geography, politics, and history, and its effects are still lasting and significant.

In the project Paraty-Quilombo do Campinho (Contin, 2025), we investigate how local knowledge and cultural landscapes can become active agents of change in the face of the most pressing global challenges: climate

change, inequality, and poverty. We propose that new ecocentres, through the strength of their living culture, can play a central role in building resilient and antifragile communities capable of adapting, transforming and thriving in contexts of uncertainty and pressure.

Protecting the natural reserve is crucial for preserving the region's biodiversity. Some areas have been safeguarded to maintain the delicate ecological balance and ensure the continuity of native species. The reserve served as an ecological and cultural barrier at one time, establishing clear boundaries between valleys and fostering settlement agglomerations with distinct morphologies and identities.

In our intervention, we recognised the existence and value of traditional villages, working to enhance the quality of public spaces within a broader heritage conservation project. The objective was to find a balance between the needs of the local populations and the need to protect the fragility of their cultural landscape. We thus decided to activate agroforestry processes in the capoeira areas that had remained inactive due to the cyclical nature of production. In some of these spaces, agroforestry has hosted an experiment in urban-rural linkage: housing units built according to local indigenous techniques have sprung up, revealing new ways of living integrated into the ecological cycle.

In parallel, we proposed revising the UNESCO boundary for the protected area: indigenous building expansion was pushing dangerously towards the Atlantic forest. The design hypothesis was to extend the boundary through reforestation to agroforestry. This strategy, inspired by the theories of David Gouverneur (2015), generated more collective spaces in an ecologically sensitive area and helped turn the Quilombos into active custodians of natural and cultural heritage. Attractive activities and welfare nuclei have accompanied this - true stem cells of the project - that testify to the institutions' presence, care and shared responsibility.

Thus, more living and usable spaces within a protected area can be a driving force for improving the inhabitants' quality of life and offering new opportunities for truly sustainable development and participatory heritage protection.

The gap between urban and rural areas remains significant and requires new strategies of connection and cooperation. Our research in Guadalajara (Mexico) aims to explore metropolitan dynamics capable of building an urban-rural continuum through a multi-scalar approach that enhances the role of small and medium-sized cities and rural service centres, generating new models of connection and complementarity between territories.

At the core of the analysis is the strengthening of local agricultural identity, integrated into the Guadalajara metropolitan region's green and grey infrastructure systems. In this context, rethinking food systems and prioritising environmental care in public policies are strategic tools to address complex challenges related to employment, mobility, access to services, poverty and social cohesion.

Since the second half of the 20th century, the development of the State of Jalisco has been intensely concentrated in the Guadalajara metropolitan area, which is now home to approximately 60 per cent of the State's population. This trend reflects a global process of urbanisation, which risks widening the gap between rural areas, which are often disadvantaged in terms of quality of life and opportunities.

Today, the relationship between cities and the country is no longer defined by clear boundaries. Daily interactions, the mobility of people and goods and functional interdependencies shape new relational geographies. Increasingly interconnected cities operate as nodes of complex networks embedded in specific ecological and spatial contexts.

Figure 4. Eco-centrality and Settlement Concept. Acatlan de Juarez - Guadalajara (Messico). Credit: MSLab & Valerio Rigamonti.

In this scenario, rapid urbanisation requires a rethinking of metropolitan governance. Urban dynamics now go beyond traditional administrative boundaries and require holistic strategies that integrate planning, sustainability and inclusion. It is within this framework that the role of Acatlán de Juárez emerges.

Officially integrated into the Guadalajara Metropolitan Area in 2019, Acatlán - although not yet physically connected to the consolidated urban fabric - acts as an intermediate city, facilitating dialogue between urban and rural contexts along a strategic axis for regional balance. Its location and potential make it a key node for experimenting with innovative models of territorial interaction, promoting a balance between development and cohesion. The MSLab project investigates the potential of an urban-rural connection, already observed in Far Eastern contexts, by importing and reinterpreting the concept of the Desakota region (McGee, 1991). In metropolitan environments characterised by rapid urbanisation - driven by industrial expansion and population pressure- the landscape has fragmented into a constellation of urban, peri-urban, and rural areas, often disjointed. The concept of Desakota, a fusion of Desa (village) and Kota (city), accurately represents this intermediate and blurred condition: a hybrid space where agricultural, residential, and productive elements coexist, forming a complex and interdependent territory. Starting from McGee's analysis and observing the evolutionary dynamics at work in the Guadalajara metropolitan region, the project proposes a systemic approach that activates synergies between rural and urban areas through a network of metabolic relationships. The system is considered a connective tissue in which integrating green and grey infrastructures becomes a fundamental lever to build a resilient, adaptive and learning metropolitan model.

Through a new infrastructural and landscape gradient, the project fosters an urban-rural connection that recognises and enhances the specific identity of each territorial fragment. This strategy mends existing discontinuities and activates a new morphogenetic layer in the metropolis's DNA, creating a capillary weave of coexistence and transformation. Local nodes thus become catalytic devices, generators of meaning and form, capable of triggering systemic regeneration dynamics throughout the entire metropolitan structure.

A theory for metropolitan city culture and a cartographic tool to explore the local sustainable habitat.
Context matters and, in the end, context always wins. That is ultimately the true definition of sustainable culture.

To discuss culture seriously, we must first clarify its operational meaning: culture is the living link between what we know and how we know it. It is knowledge that becomes action. It is not an abstract concept but a reality that guides choices and defines priorities.

We also need a clear definition of the objective. However, targets - especially those with high abstraction - often lose their meaning precisely because they are taken out of context. Take, for example, SDG 11, the urban goal: Where is poverty? Where is inequality? Where is productivity? These are key words for understanding the urban environment, yet they do not appear. We can talk about cities without addressing the issues that define them.

What are we trying to improve with SDG 11 if we examine it from the perspective of the role of local culture in the sustainability of metropolitan landscapes? Does it make sense to discuss urban heritage without recognising that this heritage is embedded in contexts marked by deep inequalities, widespread poverty, low productivity, and high unemployment? It is one thing to speak about urban heritage in a poor African country and quite another in Italy: possibilities change, priorities shift, and the meaning of intervention evolves.

We cannot monitor changes in territory without considering the local economy, ecology, cultures (both formal and informal), institutions, and hierarchies. The local context is always interconnected. Without a theory of the city and an understanding of how urban space is constructed and transformed, we cannot grasp metropolitan culture, let alone comprehend how human behaviour influences urban spaces.

It must be stated emphatically to address a culture-related urban objective. Otherwise, the fundamental questions remain unanswered: How can we improve the living conditions of the majority of urban residents? How can we prevent poverty and inequality from increasing while tourism productivity grows for the few?

These are not abstract considerations; they are concrete problems affecting millions and billions of people. Urban policies must begin by analysing territories, vulnerabilities, and the relationships between local and metropolitan scales. Furthermore, they must adopt a less simplistic and less linear vision.

The World Bank speaks of 'global knowledge, local results. ' However, the most crucial issue is the lack of local knowledge. Knowledge from the territories recognises specificities and lends meaning to action.

Even the word 'commitment', often used in the SDGs, remains empty if it is not based on a vision. Without an urban theory, the mechanisms of cause and effect cannot be explained. There is no social justice. There is no ethics. It is just a list of good intentions, but without the why.

The New Urban Agenda must serve this purpose: to build a vision, choose priorities, and use vulnerabilities as starting points for conscious, concrete, and coherent action.

We cannot solve problems without understanding the conditions that created them. For this, we need a comprehensive, integrated vision. Once again, we must start from the context.

The context influenced the tools, but the tools also reinforced the definitions of the contexts.

The master plan served as the context. Everything that was 'outside the plan' was truly outside and not taken into account. In many urban areas, what was outside the plan was, by definition, illegal and, therefore, subject to demolition by public authorities.

Policies and regulations guide urban behaviour, allocating resources through projects and strategic investment plans. In recent years, there has been a progressive shift of focus towards expected outcomes - what must necessarily be - under the assumption that those involved adhere, almost by nature, to codes of behaviour in design, construction, and use. The central question, therefore, revolves around identifying which rules can steer urban actors in specific directions and what the enabling conditions are for the emergence of that collective intelligence capable of recognising the metropolitan common good as a shared value and resource. That intelligence is necessary to achieve results that are not only formal but also transformative.

However, this is where the limitations of policy instruments emerge: the lack of institutional capacity to effectively implement policies, resulting in a disconnect between strategy and execution. In particular, market-oriented policies—especially in their application to the tourism sector—represent a crucial variant of this scenario. The issue lies not only in directing the actions of individual actors but also in attempting to shape the systemic

behaviour of society, intervening in common sense, shared representations, desires, and value mechanisms, both individual and collective.

In this framework, context refers to the dynamic set of spaces, sites, flows, and interactions between agents, which define the balance between supply, demand, and price. The instruments of stimulus packages - first and foremost, government spending - fit into this logic as typically Keynesian devices for stimulating the production of goods and services, injecting liquidity, and sustaining consumption (Keynes, 1936).The speed of public spending directly affects the pace of the creation of new demand and, thus, the trajectory of economic recovery. Nevertheless, how does this mechanism relate to the operating culture (Salazar, 2023)? How can the economy generate truly widespread forms of prosperity? What values and contradictions does the tourism industry generate for the world culture (Shepherd, 2002)?

The metropolitan architecture projects (Contin, 2015) were designed to translate, through principles of sustainability and interscalarity, the physical objectives of the plan into constructed forms: housing, infrastructure, and social services. The possibility was tested that values and resources linked to operational culture could act as active tools against poverty, inequality and low productivity, improving the quality of life. As a spatial and non-verbal narrative, Metropolitan Cartography (Contin, Galiulo, 2020) recognises and names these values, identifying them as resources to be translated into factual indicators capable of nourishing transformative and measurable processes in the dimension of urban reality.

In this context, the metropolitan architecture project (Contin, 2015) assumes a strategic role: it is configured as a tool to physically formalise values and resources from the operational culture, not as a theoretical abstraction, but as a set of living practices, behavioural codes, and local languages. Through these spatial devices, an accurate collective intelligence capable of recognising the metropolitan common good can be activated beyond institutional rigidities and the limits of normative planning. As a non-verbal narrative, metropolitan cartography makes it possible to identify and translate into measurable indicators those shared values that escape the logic of standardisation and rent. It does not merely represent the territory but traverses it, codifies it, and returns it as a relational space where culture becomes infrastructure and is no longer just symbolic heritage. In this perspective, urban planning must open up to the plurality of languages, recognising in situated behaviour and local practices - even where written law is absent - a generative heritage capable of guiding development, even in opposition to dominant economic interests.

Conclusions and openings: The reactivation of the 'culture of care'; the role of cultural and creative industries in promoting knowledge and education; why conserve?
The proposed project represents an innovative theory for the culture of the Metropolitan City, centred around a large-scale cultural enhancement strategy that focuses on creating an integrated model for utilising cultural heritage. This model, characterised by its unique dimensions and functions, aims to enrich local communities' knowledge and attract interest from non-regional audiences by leveraging the region's significant cultural, natural, and environmental heritage.

The proposal is based on a visionary project that sets the territory in motion, creating a connection between a physical path and an imaginary one: a transgenerational strategic plan project capable of promoting innovative functions for a green and digital economy that can attract new categories of entrepreneurs and users into the territorial system.

A vision that serves as a framework for the new common and public space of relations, acting as a figurative cornerstone and a tool for constructing a memorable yet everyday image to recognise the identity of the new agro-urban reality. This reality recovers knowledge of the environment through innovative mapping methodologies and modern communication technologies that refunctionalize industrial archaeology. It also reactivates the urban fabric by replacing certain features while respecting specific dimensional and formal considerations. However, it must identify a strategic cultural reason for its preservation.

It is necessary to consider supply chains that create a new economic dimension around which to 'do agriculture' and 'do handicrafts', starting from the understanding of the territory as a resource and analysing the data constructed by the citizens themselves. Synergy will be the keyword: between municipalities and their territories,

between hoteliers and tourists passing through, and between hoteliers, entrepreneurs, and schools.

Starting from a project as an engine for the renewed hydration of cultural energies within the identified urban system, a project that recognises its value concerning the three ecosystem services of supply, regulation, and culture (which are crucial today in light of the recent flooding phenomena), we aim to list areas and themes that can be subjects of a process of innovation and social evolution:

1. Urban-rural areas: The sociology of agriculture and the urban park;
2. Built city: mapping and diagnostics, common and public spaces (the sponge of the urban fabric), green areas reclaimed from built-up areas, the relationship between land use and water system management (the city as a source of quality water);
3. Neighbourhoods: maintenance, development and transformation. The recovery plan and innovative solutions;
4. New citizenships: cultural start-ups, inclusion (second-generation migrants), diffuse tourism.

The project identifies two approaches: one is based on molecular re-appropriation of the territory, promoting local values to create relationships between territory and settlement; the other aims to work on the nodes of interchange between regions and cities, viewing territories as archipelagos and networks of sustainable activities, with cities seen as systems composed of a web of networks and nodes, understood as dynamic and interconnected networks of relationships (Castells, 1996) that connect urban and rural actors, facilitating the exchange of knowledge, cultural practices, and forms of resistance (Srinivasan, 2017).

This network is expressed through social, economic, and cultural connections beyond classical spatial separations, generating a mutual and sustainable interaction between city and countryside (Ananthasubramaniam et al., 2022). The active nodes of this network - the hinge points - function as connection (web) hubs: points of tension and contact that, as in a web, spread and multiply these relations in the territories, traversing what Shane (2005) calls body of space, those 'spaces in between' dense with potential, friction, and transformation (see: https://www.myvillages.org/index.php).

By fostering the sustainability of agricultural areas through the creation of synergistic production circuits (agriculture, production-transformation of natural resources in a sustainable manner), a new model of territorial system is established that views agriculture as 'the other part of the city, but city', integrating it through the introduction of new functions and a new concept of supra-municipal public space.

To counter the dissipation of our heritage, which the new urban scale could induce, we need to refine the concept of sustainability: how is regeneration sustainable? We aim to honour the identity dimension of the context, where stagnation presently prevails instead of development. Agriculture is essential for the city, contributing to sustainability like a spring by safeguarding water and alternative energies linked to local waterways and the surrounding context. It is vital to envision supply chains that create a new economic dimension centred on 'doing agriculture' and 'doing handicrafts'. Synergy will be the key term for the project's structural component, while communication will be the second key term.

A pilot project, *City of Muses*. The arts of the city and metropolitan landscapes
In his text, The Image of the City, Kevin Lynch (1960) explicitly aims to control the production of the urban image by elaborating a visual plan for the city, promoting a reordering of public mental images of the urban environment to foster greater integration of citizens with their places of residence and work. Lynch's approach seeks to reveal a possible order beneath the chaotic appearances of the urban landscape, emphasising it through increased figurability, i.e., the individuality and visual evidence of forms.

Lynch's project, which we would like to support, aims for an urban figurability of the metropolitan dimension that is intended to manifest in a visual plan not confined to the aesthetic realm but also focused on the well-being and psychological safety of urban users. This state of 'feeling adequate' is closely associated with the ability to orient oneself: figurability is, therefore, the clarity of visual matrices.

The intention is to design a shared public mental image of the city and its metropolitan landscapes through the recognition of the profound identity of the selected places: a portrait that combines spatiality and the arts,

particularly music and images. In this context, the architectural project becomes a salient expression of the city, contributing decisively to its mental image.

The proposal - as already outlined by Tschumi in 1981 - is understood here as a network of stem cells or connection nodes (web) scattered throughout the new metropolitan landscapes. It aims to initiate a reflection on the relationships between architecture, cities, landscapes, and the arts, establishing a dialogue between architectural and urban design, technologies, and art. The ultimate goal is to enhance the quality of urban space, providing art with significant opportunities to communicate rhythms, sounds, sociality, and well-being. In particular, we intend to explore the relationship between art and urban space concerning the redevelopment of places through traditional and innovative devices activated by 'ephemeral architectures' capable of introducing an augmented sensorial experience in public areas through music and images.

The project supports a vision of the analysis, interpretation, and design of metropolitan urban interiors through forms that cannot be traced back to Euclidean geometry, capable of generating spatiality through the support of music and images. The aim is to envision structures that can be realised with inexpensive, durable, and sustainable materials. Among the areas of research explored is the use of 3d printing and solar concentrators (Müller, Zastrow, 2015), with the intention of developing a system that can be modelled during assembly using parametric digital tools. Experimentation also involves interactive technologies in design, architecture, and robotics, utilising physical computing systems, which are understood as environments capable of perceiving and reacting to stimuli from the surrounding environment.

If the project anticipates the subsequent deconstruction of the installations, it is configured as a permanent transformative action of the public space, which is enhanced both in the collective imagination and in the virtual dimension created ad hoc. The latter, reconstructed using sophisticated software and archived online, will host all data related to the places, allowing the installations to be revived and reapplied elsewhere.

A metropolitan urbanity project is outlined through a series of installations that experiment with innovative materials, augmented reality, and responsive interactions. Utilising new technologies opens up a new way to map the city, allowing urban values to be communicated on a different level. The installations interpret space in relation to sound, light, and sustainability, establishing profound connections with historical places and urban art, which are rediscovered and recognised through a spatiality where music, images, and narratives merge. The intention is to trace an itinerary capable of rewriting the narrative of the city and its suburbs, guiding citizens and users to discover an unprecedented historical and future heritage.

The elliptical itinerary will have a beating heart. It will construct a new narrative of the city that accounts for its past, recent history, and urban, rural, and natural contexts, laying the foundations for future perspectives that enhance a new metropolitan identity. Each landscape will tell its own story and serve as a treasure chest to be discovered, engaging in dialogue with other places through diffuse installations. With its scenic effects, technology will connect citizens with music, the city, its networks, and its forgotten or hidden landscapes.

The operation not only connects the mother city with its most precious objects, but also acts in the opposite direction by bringing the city into other hinge points of the metropolitan landscapes. The images, photographs, and videos of the places and their history conveyed by the installations will construct a new urbanity as part of the metropolitan landscapes. Just as in ancient times, large-scale event apparatuses were built to embellish the city, today, the urban landscape will be broken down into its most beautiful parts and distributed in forgotten places.

The route will be accessible both physically and through a dedicated mobile application. New technologies prove to be fundamental in creating innovative landscape settings that encompass historical, agricultural, and natural heritage. Responsive technologies are transformed into educational and informational tools capable of transmitting and archiving multimedia content. The reactivated places once again communicate the strong message of the city of the past, projecting it into the future.

The project aims to reinterpret the metropolitan city, fostering a new territorial awareness and a strong cultural identity for a sustainable future. It also seeks to integrate the cultural sector with tourism, research, innovation,

and education, identifying key locations for valorisation, cultural animation, dissemination, and training activities.

The interaction between new technologies and regenerated public spaces represents an opportunity to connect the metropolitan city's most prestigious institutions in an articulated system of places, knowledge, and visions capable of regaining an authoritative position in the global city network.

The metropolitan city of the second modernity is configured as an integral fusion of biosphere, water, and soil, which we call the critical zone (Latour, 2004). It requires regenerative agricultural techniques and a profound synergy between culture and science. This intertwining - the entanglement - strengthens the resilience of the natural system and places society at the centre of protecting this fragile but potential heritage.

In the Urban-Rural Linkage Patterns project, the network of hotspots- junction points, such as the metro-world web- functionally and symbolically interconnected, becomes a design element and socio-spatial device. These can activate resources and build ecological narratives and forms of environmental governance. In this context, we propose constructing an abacus of patterns of network hotspots, which will be included as recognisable elements in the metropolitan structural plan, along with defining information layers to create localised maps using open-source data.

The project is configured as a precise cultural enhancement strategy through an innovative and integrated model of heritage use. It is aimed at both the local public and external users, attracted by the widespread cultural, natural, and environmental excellence. The expected repercussions on the territory are multiple: a greater dissemination of knowledge of the heritage, an improvement in the quality of life, an increase in tourist flows and employment opportunities, as well as an enhancement of the image and local development. The project actively involves the local population, especially young people, through workshops and educational activities, while externally targeting users interested in exclusive, innovative and immersive cultural experiences. The ultimate goal is to expand the use of immersive virtual reality, moving it from mere entertainment to a cultural and academic sphere, opening the doors of museums and historical sites to the world in an accessible, detailed, interactive and deeply personal experience.

Through an application, each citizen will be able to experience and relive these spaces, creating individual mental maps and forging a new relationship with the city and its landscapes. This will be supported by effective, engaging communication that can reactivate the lost urban narrative. The City of Muses is not just a project: it is a system, a generator of art, innovation, economy, and future.

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Study on evaluation of liveliness level and promotion strategy for Intangible Cultural Heritage in Qinghai Province

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Abstract
The shift towards living heritage protection necessitates robust evaluation systems. This study constructs a quantitative assessment model using the Analytic Hierarchy Process (AHP), integrating four dimensions: carrier transmission, policy support, social engagement, and production efficacy. Empirical analysis of Qinghai Province reveals: (1) moderate overall vitality with marked internal disparities; (2) hierarchical dimension performance—carrier transmission excels while policy support lags; (3) traditional crafts and folk customs demonstrate stronger vitality through effective dissemination, contrasting with marginalised traditional sports. Proposed strategies encompass liveliness inventory management, spatial carrier development, and 'Integrating Intangible Cultural Heritage' integration strategies. The model transcends conventional qualitative paradigms, providing a theoretical-practical framework for optimising living heritage mechanisms.

Keywords: Intangible Cultural Heritage; Liveliness level; Evaluation system; Promotion strategy

0. Introduction

Under the background of the transformation of world cultural heritage protection from "emergency preservation" to "liveliness inheritance", the protection concept of intangible cultural heritage (hereinafter referred to as "ICH") has changed, gradually shifting from "cultural remnants" to "liveliness" protection. The Convention for the Safeguarding of the ICH, officially adopted by the 32nd session of the UNESCO General Conference, clearly states that "safeguarding" refers to all measures aimed at ensuring the viability of ICH, including its identification, documentation, research, preservation, protection, promotion, transmission (especially through formal and non-formal education), and revitalization. The protection of ICH should focus on its "liveliness inheritance process" rather than merely preserving it as a static cultural specimen. However, current ICH protection practices generally face two major problems: the contradiction between cultural authenticity and modern adaptability, and the dilemma of ambiguous protection subjects and insufficient inheritance motivation. How to scientifically assess the liveliness survival level of ICH and formulate precise improvement strategies has become a focus of both academic and policy circles.

As a convergence point of diverse cultures on the Qinghai-Tibet Plateau, Qinghai Province possesses six representative works of human ICH, including the Thangka Art and the Epic of King Gesar, as well as over a hundred national and provincial-level ICH projects. Its ICH is characterized by ethnic diversity, ecological vulnerability, and the threat of extinction. Despite the government's efforts in strengthening protection through legislation and establishing protected areas in recent years, some ICH still face the crisis of "museumization" due to issues such as inheritance gaps, limited dissemination, and lagging industrialization.

Against this backdrop, constructing a quantitative evaluation model to analyze the liveliness state of ICH, identify its development shortcomings, and propose differentiated strategies not only provides a theoretical tool for regional ICH protection but also has practical significance for maintaining cultural ecological balance and promoting sustainable development in ethnic areas. This study, through literature analysis and the Delphi method, deconstructs the "Four Forces Model" of ICH liveliness state (inheritance force, dissemination force, innovation force, and vitality force), aiming to provide a scientific basis for the protection and development of ICH in Qinghai Province.

1. Research Progress and Theoretical Framework

1.1 Review of Domestic and Foreign Research on the liveliness Protection of ICH

After the United Nations Educational, Scientific and Cultural Organization (UNESCO) proposed the concept of "all living cultures" in 1994, the term officially entered policy documents. The release of the Convention on the Protection and Promotion of the Diversity of Cultural Expressions in 2005 marked that "liveliness" has become a key theme in the field of cultural heritage protection and a central goal of cultural heritage protection actions. In 2009, the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM)

systematically proposed the “Living Heritage Approach” (LHA), emphasizing the liveliness continuation of the cultural value of heritage.

Abroad,(Jia, L. ,2024) related research focuses on the following aspects: In terms of legal guarantee systems, the European Union established a hierarchical protection system through the European Heritage Law, incorporating the protection of ICH into a unified legal framework and strengthening the enforcement effect through regional collaboration. France’s Heritage Protection Law pioneered the concept of “cultural space”, combining the material carriers of ICH with liveliness practices, promoting adaptive protection by law for liveliness inheritance. Japan’s Cultural Properties Protection Law established the “Living National Treasure” certification system, encouraging inheritors to participate in liveliness practices. In terms of community participation models, Mexico’s “Day of the Dead” festival achieved the liveliness renewal of ICH through community self-organization, and its experience was summarized as a three-stage model of “festival empowerment - skill regeneration - economic feedback”. (Table 1)

Table 1 Topics and Contents of Overseas Research on ICH

Research Topic	Author	Year	Research Content
Sustainable Development of ICH	Giliberto	2020	How cultural heritage projects implemented in the MENA region promote environmental sustainability through ecotourism and sustainable agriculture.
Community Participation in ICH Research	Sheila Watson	2010	Community-led conservation measures tend to be more sustainable, and ICH projects can better reflect the uniqueness and diversity of local culture.
Cultural Landscape Heritage and ICH	Daniel	2013	The relationship between cultural landscapes and local identity, how local cultures are preserved and displayed through heritage landscapes in the context of globalization.
Digital Research on ICH	Bonacchi	2019	Through digital museums, virtual exhibitions, etc., the display and dissemination of ICH have become more convenient and extensive.

In the domestic academic circle, there has been a consensus that ICH is regarded as a living culture with its own liveliness attributes. Based on this, the calls for and academic exploration of liveliness protection have been deepening. (Qi,Q.F. ,2009) clearly proposed the viewpoint that the fundamental purpose of protecting ICH is to preserve the "living inheritance". He believed that all protection methods conducive to the preservation of the living inheritance of ICH are reasonable. (Liao W.J. ,2013) argued that ICH has both cultural value and market value, and the transformation from recognition to practical implementation of living protection is a necessary issue for the inheritance and industrial development of ICH. (Qi A.M. ,2017) constructed an institutional system for the liveliness protection of inheritance schools, and institutionalized the concept of liveliness protection of ICH. (Huang Z.Z. ,2024) proposed that "livelinessization" is a practical path connecting the historical value of ICH with current needs, emphasizing the need to highlight the people-oriented, contemporary, and national nature of ICH through liveliness protection, and avoiding it from becoming static exhibits. Current research mainly focuses on external factors of living inheritance and protection, such as government management, market operation, legislative guarantee, school education, and ecological museum construction.

1.2 The Essence of the Liveliness level of ICH

The concept of "living attitude of ICH" refers to the comprehensive degree at which a specific ICH maintains its vitality during the liveliness process of inheritance through the maintenance of its essence, adaptation to the environment, and transformation of value. The living space centered on ICH and serving as its carrier is linked by the inheritors, connecting the physical and spiritual spaces where the heritage exists. The embodied knowledge, experience, skills, and folk beliefs formed in this way are perfected through the inheritance mechanism in

contextualized teaching and practice, and are continuously refined into a shareable knowledge form in the process of practical application, thereby enabling the knowledge and culture related to ICH to be recognized and orderly inherited, and reflecting the vitality of ICH.

This paper studies its connotation and includes four core dimensions: the degree of carrier inheritance centered on ICH, manifested as the completeness of the inheritance lineage and the intergenerational continuity of skills and knowledge; the policy support degree based on systems, covering the levels of legal protection, the intensity of financial investment, and the effectiveness of restoration of inheritance space; the social exchange degree driven by interaction, manifested as the breadth of public participation, the depth of media dissemination, and the intensity of cultural identification; the production adaptation degree oriented by innovation, reflecting the conversion efficiency and market vitality of ICH resources into the modern economic system. The characteristics of the "living attitude of ICH" can be perceived from aspects such as carrier characteristics, expression form characteristics, cultural characteristics, and activation characteristics. An example analysis using six projects from the Representative List of the ICH of Humanity of Qinghai Province is provided, as shown in the Table 2.

Table 2 The characteristics of the Liveliness level of ICH

Name	Carrier Feature	Form Feature	Activation Feature	Illustration
Thogon Art	With Tangka, murals, sculptures, etc. as carriers	integrating Tibetan Buddhist culture and folk art elements, featuring bright colors and rigorous composition.	Business value	
Flowers	Presented through folk song performances	The melody is high-pitched and melodious, the lyrics are simple and natural.	Video and audio	
Gesar	Presented through epic singing	It is of a grand scale, with a rigorous structure, vivid language, and rich imagination.	IP development	
Tibetan Opera	Presented through theatrical performances	It integrates various art forms such as music, dance, and performance.	Festival format	
Chinese Shadow Puppetry	Presented through the use of carved human silhouettes made of animal skins or paper	During the performance, the silhouettes are projected onto the screen using light, accompanied by singing and music.	Cultural performance	
Tibetan Medicine Bath Therapy	It uses natural minerals and plant medicines as the bathing agents	It acts on the human body through methods such as soaking and fumigation.	Health preservation concept	

2. Construction of the Evaluation Model for ICH Liveliness level

2.1 Evaluation Method

This study adopts a combination of the Delphi method and the Analytic Hierarchy Process to construct the evaluation model for ICH live attitude. The Delphi method conducts multi-round anonymous expert consultations to screen and revise the rationality of the evaluation indicators for the live activation of ICH, ensuring the scientificity and authority of the indicator system; the Analytic Hierarchy Process constructs a hierarchical indicator structure,

constructs a judgment matrix, and conducts consistency tests to quantify the relative importance of each indicator, ultimately determining the weight distribution. The combination of these two methods avoids the one-sidedness of subjective experience judgment and realizes the collaborative optimization of qualitative analysis and quantitative calculation, providing methodological support for the liveliness evaluation of ICH Liveliness level.

2.2 Selection of Evaluation Indicators

When constructing the evaluation model for the live attitude of ICH, the scientific selection of the indicator system should be based on the liveliness essence of live inheritance, follow the core principle of "ensuring the vitality of ICH" in the Convention for the Safeguarding of the ICH, and respond to the practical needs of sustainable governance of cultural space in the context of China's new urbanization. This study constructs an evaluation framework from four dimensions: carrier inheritance degree, policy support degree, social exchange degree, and production efficiency degree, forming a multi-dimensional coupled and positively and negatively balanced indicator system. Finally, 4 criteria, 12 subcategories, and 28 minor categories are selected to construct the evaluation indicator system for the Liveliness level of ICH, as shown in the Table.3below.

Table 3 Evaluation Index System and Weights for the Liveliness level of ICH

Target Layer	Criterion Layer	Weight	Sub-criterion Layer	Weight	Indicator Layer	Weight	Nature
Innovative Liveliness level Evaluation Index System A	Carrier inheritance degree B1	0.5340	Inheritance Holder Scale C1	0.2453	Heritage Holder LevelD1	0.0238	Positive
					Number of Heritage Holders D2	0.0571	Positive
					Age of Heritage Holders D3	0.1643	Positive
			Project scale C2	0.0787	Project Category D4	0.0245	Positive
					Project LevelD5	0.0176	Positive
					Project Quantity D6	0.0366	Positive
			Inheritance risk coefficient C3	0.2100	Natural Reduction Rate of Heritage Holders D7	0.1343	Negative
					Inaction of Heritage Holders D8	0.0377	Negative
					Risk of Skill Distortion D9	0.0381	Negative

Policy Support degree B2	0.1872	Policy and Regulation C4	0.0967	Number of Policies D10	0.0239	Positive
				Policy Implementation Rate D11	0.0728	Positive
		Capital investment C5	0.0689	Investment Amount D12	0.0363	Positive
				Reward Mechanism D13	0.0326	Positive
		Policy implementation deviation C6	0.0216	Incidence of Violations D14	0.0042	Negative
				Impact of Violations D15	0.0174	Negative
Social exchange degree B3	0.2176	Activity scale C7	0.0966	Activity Frequency D16	0.0142	Positive
				School Education D17	0.0718	Positive
				Number of Participants D18	0.0106	Positive
		Media Index C8	0.0287	Number of Propagations D19	0.0123	Positive
				Search Popularity D20	0.0164	Positive
		Social Identity Crisis C9	0.0924	Cognitive Deviation Index D21	0.0680	Negative
				Cultural Heritage D22	0.0244	Negative

Production efficiency degree B4	0.0612	Tourism Development C10	0.0262	Proportion of ICH Tourism Income D23	0.0056	Positive
				Tourist Experience Conversion Rate D24	0.0206	Positive
		Production efficiency C11	0.0207	ICH Cultural Products D25	0.0050	Positive
				ICH Employment D26	0.0157	Positive
		Developed overload C12	0.0142	Expansion Degree of Homogeneous Production D27	0.0099	Negative
				Invasion Index of Heritage Holding Scenarios D28	0.0044	Negative

Due to significant differences in the units and magnitudes of the evaluation indicators (for example, the number of inheritors is an absolute value, and the policy implementation rate is a percentage), the incomparability needs to be eliminated through normalization. This paper uses the range method to standardize the original data.

Positive indicators (the larger the value, the better):

$$I_{ijk} = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

Negative indicators (the smaller the value, the better):

$$I_{ijk} = \frac{X_{\max} - X}{X_{\max} - X_{\min}}$$

2.3 Determine the weights of evaluation indicators

Inviting 10 experts in the field of ICH protection (including cultural policy researchers and project managers of ICH) and ICH inheritors to form an expert group, based on the hierarchical structure of the "Evaluation Index System for the Live Attitude of ICH" shown in the figure, construct a judgment matrix, and conduct pairwise comparisons of the evaluation indicators belonging to the same criterion level. Using the Saaty 1-9 scale method to quantify the expert judgments. That is, the ratio of the importance of the i-th indicator to the j-th indicator under the same indicator level can be expressed as aij. Generally, it is assigned a value using a 1-9 proportion scale. When aij is assigned 1, 3, 5, 7, or 9, it indicates that the importance of the two indicators compared pairwise is equally important, slightly important, relatively important, very important, or absolutely important. When aij is assigned 2, 4, 6, or 8, it indicates that the importance of the two indicators compared pairwise is between the adjacent important scales. Using software such as Spssau and Yaahp to analyze it, the matrix score results of each expert are obtained respectively. The consistency ratio CI of the judgment matrices of all experts is all <0.1. The results of the expert scoring matrices that pass the consistency test are geometrically averaged to obtain the mean

judgment matrix, and then the weights of each indicator are calculated, as shown in Table 3.

2.4 Define the comprehensive evaluation criteria

In order to evaluate the live attitude of ICH as a whole, it is necessary to calculate the total of each indicator of the live attitude of ICH. This paper selects the multi-objective comprehensive evaluation method and constructs the comprehensive evaluation function of the live attitude of ICH, the mathematical formula is:

$$M = \sum_{i=1}^{n} \left(\sum_{j=1}^{n} I_j \times R_j \right) \times W_i \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

In the formula, M represents the total score of the live attitude evaluation of ICH; Ij represents the score of the individual indicator j of the live attitude of ICH; Rj represents the weight of the individual indicator j of the live attitude of ICH; Wi represents the weight of the evaluation criterion.

Based on the comprehensive evaluation score of ICH, ICH is classified into five levels: extremely poor live attitude, poor live attitude, average live attitude, good live attitude, and excellent live attitude (Table 4).

Table 4 Evaluation Criteria for the Liveliness level of ICH

Evaluation index	<0.20	0.20-0.40	0.40-0.60	0.60-0.80	>0.80
Evaluation criterion	Range	Poor	Average	Better	Good

3. Empirical Analysis on the Evaluation of ICH Approaches in Qinghai Province

3.1 Case Selection and Data Sources

Based on the statistics from the five batches of the "National ICH Representative Projects List" published by the State Council from 2006 to 2021, Qinghai Province currently has 88 national-level ICHs, covering ten major categories such as folk literature, traditional music, traditional dance, traditional drama, folk art, traditional sports and games, traditional art, traditional skills, traditional medicine, and folk customs(Table 5) .From 2006 to 2023, Qinghai Province has announced 335 provincial-level ICH items. Among them, national-level ones are mainly traditional music, while provincial-level ones are mainly traditional skills. From the spatial distribution of each city and prefecture in Qinghai Province, the spatial distribution characteristics of ICH representative projects are as follows: They are mainly concentrated in Xining City, Haidong City, and Yushu Tibetan Autonomous Prefecture, accounting for nearly 60% of the total number of projects, forming a core distribution area; while Hainan Tibetan Autonomous Prefecture and Guoluo Tibetan Autonomous Prefecture have the fewest distribution numbers, accounting for about 10%, forming a low-density area(Figure 1).

Table 5 Statistics of Representative ICH Projects in Qinghai Province

Category	Number of National-level Projects (items)	Number of Provincial-level Projects (items)	Number of UNESCO Representative List of the ICH of Humanity Projects (items)	Total
Folk literature	9	39	1	49
Traditional music	15	32	1	48
Traditional dance	9	31	——	40
Traditional drama	3	12	2	17
Traditional sports, games and acrobatics	3	17	——	20
Traditional craftsmanship	11	90	——	101
Traditional medicine	6	17	1	24

Folk customs	17	61	——	78
Oral art	4	10	——	14
Traditional fine arts	11	26	1	38
In total	88	335	6	429

(Note: National-level includes 6 projects listed in the UNESCO Representative List of the ICH of Humanity)

At the same time, Qinghai Province has 88 national-level representative inheritors and 343 provincial-level representative inheritors. There are 3 national-level cultural ecological protection (experimental) zones (Hotong Culture, Gesar Culture (Goluo), and Tibetan Culture (Yushu)) and 3 provincial-level cultural ecological protection (experimental) zones (Tu Ethnic Group (Huzhu), De Du Mongolian (Haixi), and Xunhua Salar Ethnic Group) for ICH. 33 ICH (Qingxiu) employment workshops, 5 national-level ICH production protection demonstration bases, 7 provincial-level ICH production protection demonstration bases, and 27 provincial-level ICH inheritance bases have been established.

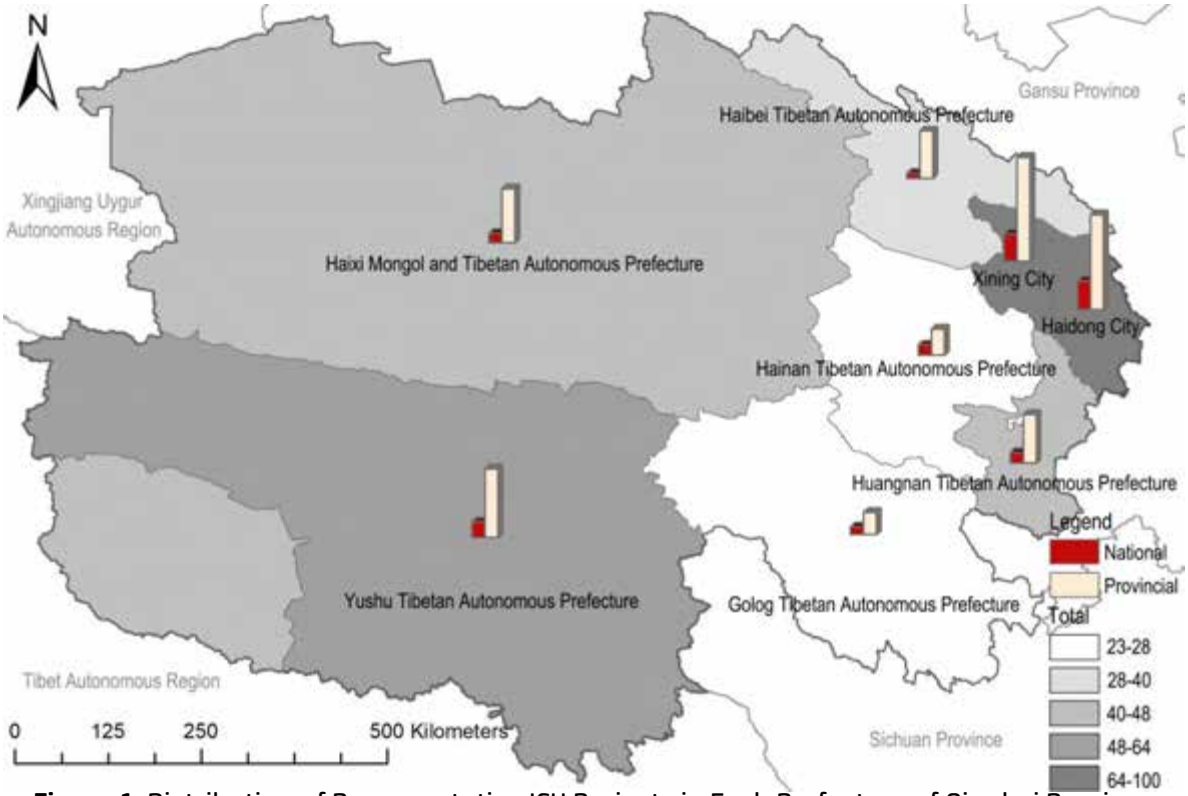

Figure 1: Distribution of Representative ICH Projects in Each Prefecture of Qinghai Province

This research was based on the "Qinghai Province ICH List", "Qinghai Province Cultural Statistical Yearbook (2018-2024)", the list of ICH representative projects, information on inheritors, and policy texts such as the "Qinghai Province ICH Regulations". It integrated the data on cultural heritage protection funds investment from 2018 to 2024, quantified policy support indicators. Through on-site research from July to August in 2024, interviews with inheritors of 6 ICH representative projects such as Hotong Art and Gesar Epic were conducted to record the frequency of skill transmission and innovative practices. Participatory observation methods were used to collect audience interaction data from 15 ICH performance activities such as the Tarsar Monastery Butter Sculpture Exhibition and the Yushu Horse Racing Festival. Data on the degree of social exchange was derived from the dissemination data of topics related to "Qinghai ICH" on platforms such as Douyin and Weibo from 2018 to 2024, and public awareness and consumption behavior were analyzed. Data on the degree of production efficiency was quantified through the sales revenue of ICH workshops, the scale of employees, and product development

cases (such as Snow Leopard Culture).

3.2 Evaluation Results

After comprehensive calculation, the overall score of the ICH (ICH) in its living form in Qinghai Province is 0.44. According to the living attitude grading standard (0-1 range, divided into five levels: extremely poor, poor, average, good, and excellent), the overall score falls within the critical range between "poor" (0.3 - 0.4) and "average" (0.4 - 0.5), indicating that the current overall living inheritance of ICH in Qinghai Province is in the transitional stage from a low level to a medium level.

From the perspective of the living attitude scores of various categories of ICH in Qinghai Province, the living attitude of traditional skills (0.75), folk customs (0.70), and traditional fine arts (0.60) are at a good level, with leading scores and obvious advantages in living attitude; the living attitude of traditional dance (0.46) and traditional music (0.45) are at a general level, and there is still room for improvement in the living inheritance ability; the living attitude of traditional medicine (0.38), traditional drama (0.37), folk art (0.29), and folk literature (0.23) are at a poor level, with low scores and facing a systemic inheritance crisis; the living attitude of traditional sports, games, and acrobatics (0.17) is at an extremely poor level, and is at risk of breaking the living inheritance.

Based on the scores of the four criteria(Figure 2), in terms of the degree of inheritance of the carriers, traditional skills received the highest score, benefiting from the dual promotion of the ICH workshops (such as the Silver and Copperware Making Training Institute) and the construction of digital archives; traditional drama received the lowest score, due to the lack of training venues (such as the Qinghai Pingxian Opera, with only 2 fixed performance venues remaining). In terms of policy support, traditional skills received the highest score,reflecting the tilt of policy resources (such as the provincial ICH special funds accounted for 42% from 2021 to 2023); traditional sports, games and acrobatics received the lowest score,lacking special support policies (accounting for only 3.5% of the total funds) and regular management mechanisms. In terms of social exchange, folk customs received the highest score,achieving high-frequency public participation through festival activities (such as the Tarsar Temple Lantern Festival, the Hotong June Festival); traditional medicine received the lowest score,limited by the single market-oriented channel (over 90% relying on local clinics for sales) and weak dissemination. In terms of production efficiency,folk customs received the highest score, as the cultural tourism integration projects (such as the Tujia Ethnic Folk Tourism) brought economic benefits; traditional medicine received the lowest score, with a low degree of industrialization (no large-scale production enterprises) and a lack of innovative products (only 3 patent registrations).

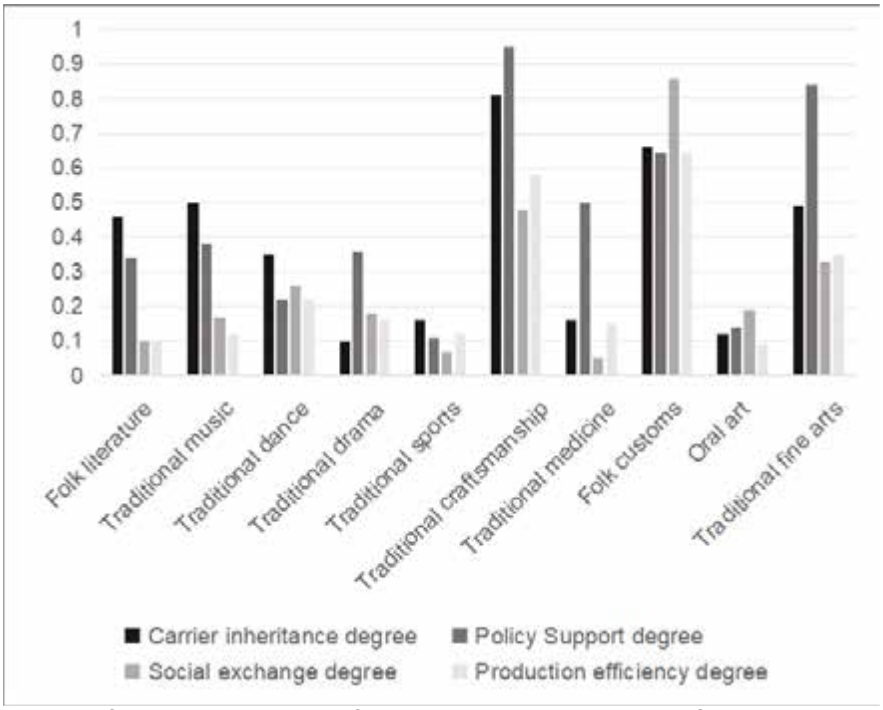

Figure 2 Score of the criterion layer for the top ten categories of ICH in Qinghai Province

3.3 Result Analysis

Traditional skills, folk customs and traditional art, positive driving forces from policy support and industrialization; The number and level of inheritors show a good active attitude. Traditional skills (such as Huangzhong Silver and Copper Ware, Jiaoya Tibetan Blanket) and folk customs (such as Hotong June Festival, Tu Ethnicity Naonong Festival) are the benchmark areas for the protection of ICH in Qinghai. The policy support is strong, the industrialization level is high, and the social participation is extensive. Traditional skills achieve economic transformation through the development of cultural and creative products (such as snow leopard-themed leather embroidery, Qing embroidery pendants) and large-scale production, while traditional art relies on the high-end art market of Hotong Thangka and pile embroidery to form a stable industrial chain. At the same time, the model of ICH workshops drives employment for farmers and herdsmen, and the production efficiency is good.

Traditional dance and traditional music, coexistence of cultural tourism integration and inheritance bottlenecks; Traditional dance and music face problems such as aging of inheritors and insufficient participation from young groups, and the coverage of digital recording is low. Policy resources are concentrated on handicrafts, while non-performance art ICHs lack special support. For example, the construction of traditional drama training venues lags behind, and traditional dance and music attract tourists through scenic area performances (such as the ICH performances in Taichang Ancient City), but there are insufficient regular activities and rely on short-term festival exposure. Cultural tourism integration brings economic benefits, but the industrialization path of traditional dance and music is single and relies on ticket revenue, with low added value.

Traditional medicine, traditional drama, folk art, and folk literature are facing a crisis in systematic inheritance; the digital protection of traditional medicine and folk literature is weak. For instance, the Tibetan medicinal bath method only has basic archives but lacks a platform for liveliness display. There are insufficient venues for traditional drama transmission, and the genre of folk art relies on oral transmission, which makes it prone to loss due to the absence of a continuous line of inheritors. The policy coverage is uneven; traditional medicine and drama have not been included in the key support list, and the investment is insufficient. The marketization ability is weak; traditional medicine lacks e-commerce channels; folk literature, due to the lack of innovative expression (such as adaptation to short videos), is difficult to attract young people. The commercialization path of the genre of folk art is single (such as tea house performances), and the income is unstable.

Traditional sports, games, and acrobatics are on the verge of losing their liveliness inheritance; there are no venues for transmission (the number of folk art troupes is decreasing year by year), and they lack special support and have not been included in the mainstream promotion system of national fitness. The activities are mostly carried out based on festivals for short periods and have insufficient regular participation; the commercialization path is single (such as the archery association relying on a small group of enthusiasts), and the market appeal is low. The economic transformation ability is weak, and there is a lack of cultural and creative development (such as no social fire theme study tours), making it difficult to form a scale effect(Table 6).

Table 6 Analysis of Live Evaluation Data for the Top Ten Categories of ICH

Liveliness level score	Reason analysis	Indicator analysis
0.6-0.8	Driving Factors and Advantages	Key Support
Traditional craftsmanship	Outstanding production efficiency: mature industrialization	the proportion of ICH creative products in D25 accounts for 35%
	Precise policy support: 40% of the national-level production-oriented protection demonstration bases	annual average growth rate of fiscal input: 18% (D12)
Folk customs	Vigorous social exchanges: Frequent festival activities	The frequency of D16 activities is the highest in the province
	High degree of cultural and tourism integration: The Na Ton Festival and the June Festival will become cultural and tourism IPs	The revenue from D23 tourism accounts for 28%
Traditional fine arts	The intergenerational transmission is relatively balanced: 25% of the inheritors are young people	The average age of the D3 inheritors is 50 years old
	Digital dissemination leads the way: Digital Tibetan painting collections reach over 10 million yuan in transaction volume	D20 search popularity grows by an average of 45% annually
0.4-0.6	Bottleneck issues and potential	Main problem areas
Traditional dance	Performance scene contraction: Traditional ritual spaces have decreased by 70%	D18 Annual participation rate has dropped by 12%
	Insufficient innovation: Dance choreography homogeneity rate exceeds 60%	D27 Homogenization expansion degree is 0.58
Traditional music	Audience aging: The proportion of listeners over 60 years old is 65%	D21 Cognitive deviation index is 0.42
	Single dissemination form: Digital music works account for less than 10%	D19 New media dissemination accounts for 8%
0.2-0.4	System crisis and root causes	Intuitive risks
Traditional medicine	Inheritance Gap: Only 6 national-level inheritors, with an average age of 68 years old	D7 Natural Decrease Rate: 7% (the highest in the province)
	Policy Support Mismatch: Funds are biased towards tourism development, and the integration rate of the medical system is less than 5%	D13 Reward Mechanism Coverage Rate: Only 12%
traditional drama	Loss of Young Audience: The audience under 35 years old accounts for less than 15%	D16 Annual Average Decrease in Activity Frequency: 20%
	Digital Absence: Online performances account for less than 5%	D19 Digital Communication Investment Ratio: 3%
folk art	Lack of Training Funds: County-level inheritors' subsidies coverage rate is 10%	D14 Violation Rate: 22% (the problem of fund misappropriation is prominent)
	Disappearance of Performance Venues: Traditional tea houses have decreased by 70%	D28 Scene Occupation Index: 0.65
folk literature	Oral Inheritance Crisis: There are only 5 young inheritors of the Gesar Epic	D9 Risk Level of Skill Distortion: 4.2 (evaluated by experts)
	Insufficient Modern Transformation: Lack of IP development and digital narrative	D25 Cultural and Creative Industry Output Ratio: Less than 1%
<0.2	At risk of breaking and analysis	Core weakness
Traditional sports, games, and acrobatics	The traditional scenes are disappearing: traditional events such as horse racing and archery have decreased by 90%	D2 inheritors is only 23 (the lowest in the province)
	Policy neglect: There is no dedicated protection fund or event planning	The penetration rate of D17 school education is 0%

Meanwhile, the status of ICH preservation in each prefecture of Qinghai Province was statistically analyzed (Table 7), and spatial visualization was conducted (Figure 3) to facilitate the formulation of targeted strategies based on the prefectures. Among them, the ICH preservation status in Xining City, Huangnan Prefecture and Haidong Prefecture was at a good level, while that in Haibei Prefecture, Yushu Prefecture was at a medium level, and that in Hainan Prefecture, Haixi Prefecture and Guoluo Prefecture was at a poor level.

Table 7 Evaluation of the living attitudes of ICH in each prefecture of Qinghai Province

Ranking	Provinces /Counties	Carrier inheritance degree	Policy Support degree	Social exchange degree	Production efficiency degree	Overall score	Liveliness level
1st	Xining City	0.82	0.78	0.75	0.68	0.79	Better
2nd	Huangnan Prefecture	0.76	0.65	0.70	0.55	0.72	Better
3rd	Haidong City	0.68	0.60	0.65	0.50	0.65	Better
4th	Haibei Prefecture	0.53	0.48	0.56	0.26	0.54	Generally
5th	Yushu Prefecture	0.55	0.45	0.60	0.30	0.53	Generally
6th	Hainan Prefecture	0.40	0.35	0.38	0.15	0.38	Poor
7th	Haixi Prefecture	0.38	0.30	0.35	0.20	0.34	Poor
8th	Goluo Prefecture	0.25	0.20	0.28	0.10	0.24	Poor

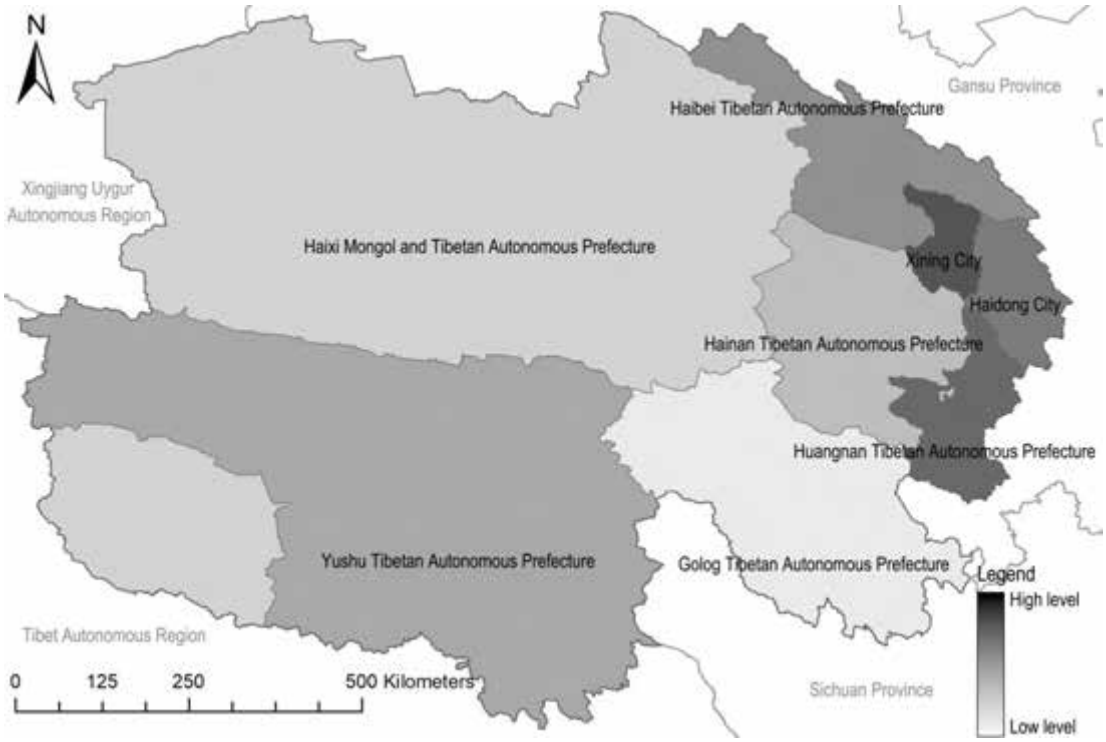

Figure 3 The spatial distribution of the ICH across various cities and counties

4. **Strategies for Enhancing the liveliness Transmission of ICH in Qinghai**

4.1 liveliness Addition Mechanism

Although Qinghai Province has established a four-level ICH list system at the national, provincial, municipal (city), and county (district) levels, the current list management still has several prominent problems such as high data isolation, insufficient public participation, and lagging liveliness updates. The national and provincial lists are generally announced by government documents, making it difficult for the public to obtain comprehensive data on ICH in Qinghai. The public has a low level of awareness of basic information such as the categories of ICH projects and the distribution of projects by cities and counties. The subjective initiative for bottom-up addition is weak. At the same time, the protection measures for the list have long relied on static management and failed to achieve liveliness adjustment based on the evaluation results of the living attitude (such as the disappearance of inheritors or the extinction of the environment). As a result, some endangered projects are difficult to be promptly included in the key protection category. Therefore, it is urgent to establish a "data-driven, public participation, and hierarchical response" liveliness addition mechanism.

In response to the relatively fixed protection situation of existing ICH projects and the lack of a digital and public platform for liveliness addition(Song, J.H. ,2015). The Qinghai Provincial Department of Culture and Tourism can collaborate with the Qinghai ICH Protection and Smartization Center and the digital management platform "Qinghai ICH Map" jointly created by Baidu. This platform integrates the data resources of the four-level list in the province, publicly displays core information such as the map of ICH projects, the distribution of inheritors, and training venues, and opens functional modules for public application, evaluation, and supervision. By real-time access to liveliness evaluation indicators (such as the frequency of D16 activities, D25 cultural product output), the platform can automatically identify low-living attitude projects (if the rate of inheritance of the Lozhou Gezarsa Epic is 7%) and endangered categories (such as traditional sports, games, and acrobatics ICH in Haixi Prefecture <0.2), triggering warnings and promoting the management department to initiate emergency addition procedures according to risk levels.

4.2Construction of ICH Spaces

There is an imbalance in regional development in the construction of ICH spaces in Qinghai Province. Currently, the three national-level cultural ecological protection areas (Thorgon Culture, Gesar Culture, and Tibetan Culture) and the three provincial-level protection areas (Tuo Ethnic Group, De Du Mongolian, and Xunhua Salar Ethnic Group) are concentrated in the eastern regions such as Huangnan and Yushu. Meanwhile, the 72 production-based bases (including 5 national-level, 7 provincial-level demonstration bases, and 33 Qingxiang embroidery workshops) also exhibit a "dense in the east and sparse in the west" pattern, resulting in weak capacity for the liveliness transformation of ICH spaces in the western regions such as Haixi and Guoluo.

At the level of cultural ecological protection areas, (Dai, X. ,2020)we can leverage the advantage of the Thorgon Cultural Ecological Zone (in Huangnan Prefecture) in the abalone painting industry cluster to collaborate with 33 Qingxiang embroidery workshops to create a "ICH production - cultural tourism experience" complex. By adopting the "front store-back workshop + e-commerce live streaming" model (Dai Xin, 2020), we can enhance the efficiency of the production-based bases and promote an annual output value exceeding 800 million yuan. In response to the shrinking inheritance scenarios in the Gesar Cultural Ecological Zone (in Aba Prefecture), we can rely on 27 provincial-level inheritance bases to build a digital narration center, restore traditional ritual spaces such as horse racing and shooting festivals, and cover low-density areas with "village-based mobile workshops" to alleviate the crisis of spatial discontinuity. At the same time, we can upgrade the 5 Qingxiang embroidery workshops in the Tuo Ethnic Cultural Ecological Zone (in Huzhu County) into a "ICH study and tourism + folk customs tourism" hub, design the chain of "homestay experience - festival performance - handmade creation", and strengthen the degree of cultural and tourism integration (D23 indicator).

4.3 "Integrating ICH"

The integration of "ICH" in Qinghai Province should be based on the regional resource endowment and the differences in the attitude towards life. It needs to break through the current bottlenecks such as "domination by cultural and tourism integration, with insufficient penetration in other fields" and "single high-scoring regional models and ambiguous low-scoring regional paths". Combining with the research by Chen Wei and Yang Lianjiao (2020) on the spatial differentiation characteristics of ICH in Qinghai, the ICH across the province presents a spatial differentiation pattern of "eastern cultural and tourism type, central production type, and western ecological

type". It is necessary to construct a "tailored to local conditions, integrating ICH" integration system based on the different attitude levels of different prefectures and cities (Xining, Huangnan, Hedong are "better", Hainan, Haixi, and Guoluo are "poor") and the characteristics of ICH categories.

High-scoring areas (Xining, Huangnan, Haidong): Centered on “ICH (ICH) + tourism”, extend the chains of “ICH + cultural creation” and “ICH + technology”. Xining City, leveraging the ICH clusters such as Hotong Tangka and Huangzhong Silver and Copper Ware (with an annual output value of over 1 billion yuan), promotes the linkage of “ICH workshops, theme scenic areas, and city IPs”, drawing on the “urban ICH complex” model (Chen Wei et al., 2020), to create immersive ICH districts (such as Tangka Digital Art Museum), develop digital cultural products like “ICH limited edition boxes” and “Yuanzuo Collection”, and increase the proportion of D25 cultural industry output to 40%; Huangnan Prefecture, relying on the Hotong Cultural Ecological Protection Area, deepens the integration of “ICH + festivals”, embedding folk activities such as the June Festival and Tibetan Opera Performances into the Qinghai Lake tourism route, and designing an “ICH Experience Points System” (tourists can exchange cultural products by participating in training activities), enhancing social exchange rate (the annual average increase in activity frequency is 15%); Haidong Prefecture, leveraging the folk customs of the Tu ethnic group, promotes “ICH + study tours”, building an ICH study camp in Huzhu County,and jointly developing “ICH handicraft courses” with the Qingxi Embroidery Workshop,attracting young audience (the proportion of participants under 35 years old has increased to 50%).

Low-scoring areas (Hainan,Haixi,Guoluo): Taking “ICH + ecology” and “ICH + medical care” as breakthrough points,activate marginalized ICH categories. Hainan Prefecture,addressing the low attitude towards traditional medicine (score 0.38) and the singleity of market channels,promotes “ICH + health care”,introducing business models such as hot spring therapy and medicinal bath experiences at the Tibetan Medicine Heritage Base (such as Guinan County Tibetan Hospital),developing “Tibetan Medicine Health Tourism Packages”,and promoting the integration rate of the medical system (from <5% to 20%);Haixi Prefecture,relying on the De'udu Mongolian Cultural Ecological Protection Area,pilots “ICH + ecological compensation”, integrating Mongolian epic training and traditional horse racing activities into the national park system, extracting 3 yuan of ecological funds for each ICH experience by tourists.

5. Conclusions and Outlook

This study focused on the liveliness inheritance of ICH in Qinghai Province. Addressing the common issue in current ICH protection, which is "emphasizing static preservation while neglecting liveliness development", a liveliness evaluation index system based on the Analytic Hierarchy Process (AHP) was constructed. This system quantitatively assessed the liveliness level of ICH projects from four dimensions: carrier inheritance degree, policy support degree, social exchange degree, and production efficiency degree. The scientificity and applicability of this system were verified by taking Qinghai Province as an example. The research results showed that the comprehensive score of ICH livelinesss in Qinghai Province was 0.44, indicating that it was in the transitional stage from a low level to a medium level. However, there were significant differences among different categories and regions: traditional skills, folk customs, etc., scored ahead due to their advantages in industrialization and cultural tourism integration (0.6 - 0.75), while traditional medicine, folk arts, etc., fell into a systemic crisis due to the lack of inheritance continuity and policy support (scores < 0.4). Based on this, the study proposed strategies such as liveliness supplementation mechanism, spatial network reconstruction, and "ICH +" integration, aiming to promote ICH protection from "passive rescue" to "active adaptation" through digital platforms, resource elasticity allocation, and cross-border collaboration. This study hopes to promote the return of ICH protection from "cultural specimens" to "life practice", injecting vitality into the creative transformation and sustainable development of outstanding traditional cultures worldwide.

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The Mountain of Gargano
Where the Sacred Dwells in the Forms of the Earth

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Abstract
The Gargano promontory in southern Italy constitutes a sacred landscape where archaic, arcane, sacred, and daimonic dimensions converge within a living geography of pilgrimage and revelation. This study examines key sanctuaries as spatial archetypes that articulate the dialogue between architecture, ritual, and terrain. Through archival research, cartographic analysis, and field surveys, it explores how sacralisation has shaped both physical forms and cultural practices. The sanctuaries emerge as infrastructures of meaning, sustaining territorial identity while facing challenges such as environmental degradation and overtourism. The paper proposes an integrated strategy of active conservation; where walking, ritual, and silence reactivate sacred presence. Ultimately, the sacred mountain is presented as a regenerative palimpsest: a landscape where spiritual heritage and ecological care entwine in a dynamic equilibrium between memory and transformation.

The Archaic, the Arcane, the Sacred, the Daimonic

"And he said, Draw not nigh hither: put off thy shoes from off thy feet, for the place whereon thou standest is holy ground"[1]

A fruitful path toward a conscious and profound appropriation of architecture and place restores meaning to its condition of necessity, refocusing on the generative elements of place by drawing on multiple, mutually enriching modes of thought. This stance, simultaneously hermeneutic and metaphorical, celebrates rootedness, continuity, resistance, and persistence. It nurtures a vital tension: a disposition and aspiration that reach beyond form, uncover the root embedded in things, and invite continual renewal.

Grasping the richness of this critical posture requires a transdisciplinary itinerary that honours the term in its most precise sense while exploring the diverse meanings it gathers across the fields in which the concept finds application. Archaic, Arcane, Sacred, and Daimonic flow through mythic imagination as four interlaced forces. In the pages that follow, each lemma reveals its linguistic root at the moment of emergence, allowing word history and conceptual movement to rise together, like breath animating meaning.

The pulse of the archaic refers to a primordial layer of human experience and culture – the ancient, foundational mode of thought and world creation. In a philosophical sense, it evokes the original archē or "beginning", the creative depth from which later symbols and institutions emerge. Mythically, the archaic resonates with ancestral gods and the primal Cosmos: it is the time of gods and heroes when the structures of reality were first cast in archetypal form. In this view, natural phenomena and social norms are not mere accidents but sacred patterns inherited from the "time before time." As Mircea Eliade observed, "for archaic man, reality is a function of the imitation of a celestial archetype[2]": to know a thing's origin is to grasp its essence. Thus, the archaic dimension emphasises origin and power in beginnings – a world where knowing the origin of a river, a ritual, or a clan name confers magical competence.

Practically, the archaic resides in cultural memory; it endures in myths, symbols, and landscape names that connect us to a mythic past. Hesiod invokes Gaia and Ouranos. It also underpins a mythopoetic mode of thinking in which ancestral spirits animate the world, linking one's existence to primordial mysteries. In Aboriginal Australian traditions, sacred landscapes are crossed by "songlines"[3]—paths sung by ancestral beings that shape the land and its meaning. In Japan, Mount Fuji is a sacred presence, honoured as a living spirit or kami. In symbolic geography, an archaic sensibility may emerge in reverence for prehistoric sites or in the concept of "deep time," whereby a sacred mountain or river is perceived as an unbroken thread linking present-day people to primordial events. The Ganges River, for instance, is both a river and a goddess. It connects today's people with ancient, divine origins. Mountains carry this weight of memory. Mount Sinai is the place of divine law in Jewish tradition,

1 Ex 3:5
2 (Eliade, 1949)
3 (Chatwin, 1988)

and Mount Hira in Islam is where the Prophet received the first revelation. These places remain spiritually active, not merely historical. By turning to the archaic, cultures affirm a link to a sacred beginning[4]. The Palatine Hill in Rome, where Romulus is said to have founded the city, has retained its sacred role even in later centuries. These spaces hold meaning because they are seen not just as old but as originating—they give shape to time and belief.

The arcane denotes the mysterious and hidden aspects of reality – secret knowledge, esoteric practices, and the concealed logic of the cosmos. Its root, from Latin arcanus (hidden), suggests what is closed or kept from ordinary sight. In intellectual terms, the arcane refers to wisdom or traditions accessible only to initiates, such as the hidden symbolism of temple rites, alchemical formulas, or secret texts. Culturally, arcane knowledge is often woven into rituals, mysteries, or mythic lore, promising insights, or powers beyond the common understanding.

The arcane dimension imbues certain landscapes and rituals with a potent sense of enigma. It neither conceals arbitrarily nor mystifies for effect; instead, it withholds meaning in a manner that demands interpretative patience, symbolic literacy, and spiritual receptivity. In this way, it stands in contrast to profane clarity: the arcane is not merely hidden—it is hidden to be revealed, but only to those adequately prepared to receive it. Landscape features such as caves, labyrinths, or remote peaks frequently become vessels of arcane power precisely because they defy immediacy; they necessitate passage, descent, or ritualised approach. A case in point is the adyton of the Delphic temple[5], where the Pythia, seated above a chasm, pronounced her ambiguous oracles under the influence of sacred vapours. The oracular cave functions as both a literal fissure and a metaphysical one—a breach in rational knowing through which divine utterance filters. Similarly, the Buddhist monument of Borobudur in Java presents a mandalic labyrinth that encodes spiritual ascent in stone. Pilgrims progress through levels of iconography and architectural symbolism, not towards spectacle, but towards a central void—a sunyata that is both physical and ontological. The arcane is not confined to architecture.

The ritual of the whirling dervishes, for example, exemplifies an embodied arcane practice. Their movement traces a cosmology of inward return, where the body becomes a compass and gesture a theological glyph. This arcane grammar of movement mirrors another site of veiled revelation: Plato's cave, whose darkness shelters not ignorance but latency. The shadow-world requires a conversion of vision, not the abandonment of place but its transfiguration through ascent. Initiatory traditions heighten the arcane by codifying silence. The difficulty of access, the echoing darkness, and the visceral imagery combine to form a space where myth, matter, and motion converge. Here, the arcane is not a category of thought but a mode of presence: an atmosphere wherein the visible and the invisible coil around one another.

In each case, the arcane enriches cultural geography not through abstraction, but through embodied difficulty: meaning is earned. This mode of symbolic withholding opens up space for imagination, mythic elaboration, and sacred secrecy to function as formative forces. The landscape becomes not merely a backdrop, but an interlocutor—silent, yes, but suggestive; opaque, but resonant. In this tension between what is shown and what is withheld, the arcane offers not obscurity, but depth.

The sacred designates that which is elevated and set apart, a domain marked by divine or numinous presence. It evokes notions of sanctity, reverence, and ultimate significance. In religious traditions, the sacred emerges in specific spaces—such as temples, groves, and mountains—as well as in designated times, including festivals and mythic epochs, and in beings that carry a transcendent dimension, including gods and saints. Rudolf Otto's seminal analysis defines the core of sacred experience as the numinous, an encounter with the Holy that transcends rational comprehension. He characterises this experience as mysterium tremendum et fascinans: a wholly other mystery that provokes awe and trembling while simultaneously drawing the individual into a state of wonder. The tremendum evokes a majestic dread and overwhelming intensity, while the fascinans conveys grace, attraction, and the marvellous (mirum), which together generate a condition of profound spiritual receptivity.[6]

Mircea Eliade advances this phenomenological understanding through the concept of hierophany, the manifestation of the sacred within the fabric of the ordinary. For Eliade, the sacred serves as the ontological foundation of meaning in space, time, and human orientation. In The Sacred and the Profane, he affirms that the sacred

4 (Ravasi, 2001)
5 (Kerényi, 2015)
6 (Otto, 2020)

"manifests itself as a reality of a wholly different order from 'natural' realities"[7]. Such a manifestation opens a fissure in the continuity of profane space and introduces an axis around which experience may be ordered. Stones, rivers, trees, or mountains can emerge as axis mundi, vertical connectors through which the divine engages and reconfigures the human world.

Rather than inventing sacred space[8], homo religiosus[9] identifies it—recognising its pre-existing power and ritually reaffirming its role as a cosmic centre. Sacred geography takes shape through the resonance of mythic origin. The mountain summit, for instance, assumes meaning not only through its elevation but also by its symbolic link between heaven and earth. It replays the act of creation, becoming a condensed image of cosmogony. The sacred mountain thus functions both as a symbol and as a generative medium of revelation. While the profane may unfold as a dispersed or disoriented field, sacred space concentrates presence, renews orientation, and intensifies awareness. The sacred affirms an experience of the real that remains deeply rooted in the origin and animated by presence.

Eliade emphasises the significance of ritual repetition and reactualisation in religious life. Rites do not merely refer back to a mythic past; they re-enact the original event, collapsing ordinary chronology into the primordial illud tempus—the time of beginnings. This cyclical orientation revitalises the sense of the mirum, enabling lived experiences of sacred time. Religious festivals, pilgrimages, and architectural structures contribute to this rhythm. They offer not representation, but the incarnation of sacred presence. As Eliade puts it, "religious man feels the need to live in a sacred time and in a sacred space," thereby re-establishing contact with origins and reinforcing his existential stability.

The sacred affirms a condition that both elevates and deepens human experience. It inspires reverence for divine majesty and reveals the gracious allure of the Holy. Sacred places—mountains, temples, sanctuaries—draw their power from this dual intensity: they awaken awe and cultivate devotion. Their atmosphere unites proximity and transcendence in a manner that roots human presence while opening it towards the beyond. This convergence endows sacred geography with formative power, enabling it to organise perception and facilitate transformation.

Every sacred encounter manifests as an event of revelation, a moment when the world becomes transparent to a deeper order. When a pilgrim ascends a mountain and feels a surge of sanctity, this experience signifies more than emotional elevation—it initiates a hierophanic breakthrough. The mountain transforms into a liturgical site, where presence deepens and silence speaks. Otto's mirum captures the aesthetic wonder of such encounters[10], where the divine does not merely overwhelm but also radiates beauty in strangeness. Eliade reinforces this vision by affirming that this beauty belongs intrinsically to the sacred order itself: "the sacred is saturated with Being"

To witness it is to enter a field where meaning is unveiled rather than invented, and where reality becomes luminous with presence.

What Socrates himself said about his daimonion, the "inner voice" that gave him advice, we do not know[11]. The daimonic pertains to the realm of daimons or spirits—beings that bridge the human and divine, inspiring, or compelling us. In Greek thought, a daimon (as Plato taught) is a guiding spirit or intermediary; modern psychology (via Jung) redefined it as a numinous psychic force. Jung described the daimon as an "autonomous psychic content"—a kind of inner presence that has its own momentum, "something alien from the unconscious... an archetype or numinous imperative" with authority beyond our intellect. He likened it to a god within us, giving creative energy or demanding action: "There lives a creative being inside all of us," he noted, that will give no peace unless he is obeyed. This daimonic influence is neutral: it can drive outstanding achievements or cause inner turmoil, depending on its alignment with the conscious will.

7 (Eliade, 2013)
8 (Dematteis, 1994, p. 31)
9 (Eliade, 2013)
10 (Otto, 2020, p. 40)
11 (Luck, 2006, p. 233)

Mythologically, the daimonic finds vivid expression in figures like Pan – the horned, goat-legged god of rustic nature – and in angels or celestial messengers. Pan embodies the wild, instinctual side of the daimonic. He is "the goat-God," a personification of untamed nature with "hairy, phallic, roaming and goatish" energy. Modern interpreters (Hillman among them) point out that Pan was demonised as the Christian Devil, but originally he symbolised the raw, life-affirming force of nature. In this way, Pan represents the earthy daimonic – the instinctual libido, creativity, and passion that possess us if we neglect them. Conversely, the angelic side of the daimonic represents the luminous guiding spirit – the Platonic "daemon" of destiny or the guardian angel of some traditions. Angels, angels' apparitions, and other bright daemons signify the daimonic as inspiration and moral illumination.

Thus, we may say that the daimonic is the mediating breath between the mortal and the immortal: it can manifest in dark, bestial form (Pan, daemonic possession) or angelic, visionary form. In both cases, it works beneath or within the self to call forth transformations. Jung and Hillman emphasise that personal destiny or creative vocation is guided by such a daimonic presence – an unconscious genius or archetype urging one towards fulfilment. In every age, the daimonic has been illustrated by figures who hover at the boundary of the human and the divine, reminding us that the psyche is enlivened by spiritual forces beyond ordinary reasoning.

According to the opening words of the chronography of being, God "created the heavens and the earth"[12], and this division of all of creation has always been regarded as foundational. Likewise, in the profession of faith, we call upon God as "the Creator of all things visible and invisible"[13], the maker of what can be seen and, equally, of what cannot. These two realms—the visible and the invisible—indeed touch, yet their difference is so profound that one cannot help but question the nature of the boundary where they meet: a threshold that both separates and unites them. How should this be understood?[14] It may be that the sacred mountain softens the threshold, offering a place where distance gives way to nearness, and the intangible begins to take form—where the mystery of the unseen quietly emerges within the contours of the world.

A sacred mountain is an archetypal locus where the archaic, arcane, sacred, and daimonic converge. Mountains have been universally regarded as natural pillars or axis mundi, connecting Earth and sky[15]. (fig.1) As Edwin Bernbaum notes, the highest sites "form natural links between heaven and earth, the sacred and the profane." In other words, peaks serve as natural thrones for the gods and stages for revelation. When the transcendent momentarily touches our world ("hierophany"), it often occurs on a mountain that acts as "an absolute fixed point, a centre" in the homogeneous expanse of profane space. At such sites, all four dimensions can unfold: the archaic echoes in the primaeval rock and legendary origins of the place; the arcane dwells in hidden grottoes or concealed pathways; the sacred manifests in visions of the divine; and the daimonic appears through spirit-figures or the mountain's own numinous presence.

Consider Mount Sinai, where Moses received the Law. In Exodus, the peak is enveloped by storm, fire, and cloud – theophany at its most dramatic. Smoke and flame streak across Sinai's summit as the divine hierofany unveils itself. Here, the sacred is explicit: the trembling, silent presence of God is both "terrifying and wonderful," matching Otto's tremendum et fascinans. Sinai also embodies the archaic (it is perceived as ancient earth consecrated by God's words) and the daimonic (the divine commandment is delivered by a transcendent spirit in the storm). Its height and isolation designate it as a liminal centre of the world, fulfilling Eliade's notion of sacred space as a fixed point in the cosmos.

Mount Olympus in Greek imagination embodies a profound convergence. As the legendary abode of Zeus and the gods, Olympus represents sacred geography. Heroes and mortals who ascended or glimpsed Olympus confronted both the divine and the daemonic: gods in council, nymphs, and Pan in hidden woods, oracles in caves. A mortal's journey up Olympus would carry the archaic aura of Homeric myth (the age of heroes) and the arcane mystery of pagan ritual (sacred groves and unknown rites). Even today, climbers on Olympus can discover wild, uncanny places (e.g., the Cave of the Sleeping Nymphs) that preserve a sense of secret power.

12 Gn, 1, 1
13 Col, 1, 16
14 [Trad. by Author] (Florenskij, 2024, p. 1)
15 Cfr. (Daumal, 2020)

In the Christian East, Mount Athos – literally "Holy Mountain" – exemplifies these dimensions through monastic life. Athos has been continuously inhabited by monks since the Byzantine era, making it a lasting channel of sacred tradition. The archaic reverence is found in the strict traditions and ancient chants still preserved; the arcane in the disciplined, hermetic practices of hesychasm (inner prayer) and its cloistered terrain. Pilgrims who ascend its slopes speak of an intense presence, as though the entire mountain is imbued with the prayer and asceticism of centuries. Athos serves as both a geographic promontory and an imaginal high point where earth and heaven converge in liturgy.

On the Italian side of the Adriatic, Monte Sant'Angelo (Mount Gargano) epitomises the convergence of the daimonic and the sacred (fig.2). In late antiquity, the Archangel Michael appeared repeatedly on this mountain's windswept summit, instructing that a grotto there be a place of Christian worship. These angelic visions made the site a significant pilgrimage centre. The rocky cave beneath the peak became a physical symbol of arcane depth – the hidden cave of revelation – while the archangel's fiery sword rendered the peak itself the axis mundi of Western Christendom for a time. It stands today as a reminder that even in the Christian era, the daimonic (angels, visions) and archaic magic (mountain cult, sanctuary) coexist in the sacred landscape.

Sacred mountains are both geological forms and living symbols. Climbing a mountain has always represented a symbolic ascent —a movement from the human realm toward the divine. As one ascends, the four dimensions interact with each other. One might find oneself re-enacting an archaic myth (hearing echoes of the hero's journey), decoding arcane omens (unfamiliar flora, mysterious lights), and experiencing a cleansing of the profane through awe. The summit ceremony – whether a priest's liturgy, a tribal dance, or a solitary prayer – becomes a theophany in miniature, a moment when the sacred cleaves through space. In that instant, Pan and angel alike seem near: the wild life-force of Earth and the luminous grace of heaven unite.

Thus, in the mythopoetic geography of the sacred mountain, the archaic endurance of Earth's origins, the arcane secrets hidden in stone and sky, the overwhelming sacred presence of the divine, and the daimonic guardians of fate all converge. On such peaks, earth and heaven kiss, and the four dimensions – archaic, arcane, sacred, and daimonic – are felt as one.

The Geographies of Hierophany in the Sacred Landscape of the Gargano

The Gargano massif, in Apulia, emerges as a geographical structure of extraordinary symbolic intensity, whose relationship with the plain — understood both as the land of the Capitanata and the Adriatic Sea — expresses a profound spatial dichotomy, reflecting the opposition between two domains of differing ontological order. Here, hierophany — literally "manifestation of the sacred" — is embodied in caves, on summits, in forests and across liminal thresholds, delineating a topography that articulates a hierarchy of places capable of transcending the horizontal continuity of plains and waters (fig.3). While the plain and the sea appear as open and undifferentiated spaces, the mountain rises with vertical force, dominating the landscape through a system of reciprocal visibility and positioning itself to be recognised as an axis mundi, a symbolic and spiritual pivot of the world. Within this scenario, Mircea Eliade's distinction between the sacred and the profane becomes manifest: the sacred bursts into the fabric of the landscape, punctuates it, interrupts it, leaving signs and revelations that alter its continuity. Similarly, Rudolf Otto's concept of the numinous conveys the emotional ambivalence these places evoke: trembling and wonder, distance, and desire. One of the earliest ways in which human beings began to understand the relationship between the sphere in which they moved and far more extended horizons was, in fact, through an essentially visual approach to geography[16]. In the Gargano, as in many Mediterranean landscapes, pilgrimage routes — including the Via Francigena — trace a rhythm of sacred manifestations, structuring space through deeply significant places. Such places are elective, sites chosen by culture and faith to host the presence of the divine.

In the Mediterranean, the richness of rocky outcrops and hydrographic channels along the coastline — that is, the morphological fragmentation of geographic contexts — has favoured the formation of perceptual fields, punc-

16 [Trad. by Author] The reference here is to the "chain of fires" bridging the physical and symbolic distance between Troy and Mycenae in Aeschylus's Agamemnon, as studied by Tracy and cited in (Horden & Purcell, 2000, pp. 119-120)

tuated by visual and symbolic landmarks. This condition has fostered a diffuse character of visibility[17], grounded in both the forms of the land and a network of reciprocal observation, which constitutes one of the fundamental traits of sacred manifestations and settlement patterns in the Gargano.

Indeed, starting from the natural condition, humans progressively visualised[18] these elective places, commenting on and reinterpreting the physical forms of the landscape through the construction of increasingly complex artificial structures. Earth metaphors and archaic imagery reveal the sacred dimension of sites such as Santa Maria di Stignano, San Matteo, San Michele Arcangelo at Monte Sant'Angelo, the Santissima Trinità on Monte Sacro, and Santa Maria di Pulsano, interpreted through mythopoetic spatial categories such as the cave, the summit, the forest, and liminal landscapes.

These sacred places embody archetypal meanings and foster a profound dialogue with the natural and cultural context that surrounds them. Within them, one encounters a deep-seated tension between panoramic elevation and primordial terror, between vision and vertigo, between "panorama" and "panic" — a contrast that becomes inscribed in the very body of the sacred mountain, shaping its most intimate and enduring symbolic experience. Otherwise, Nature has no language or signs but simply 'is'. Nature is an essence to which we attribute feelings that exist solely within us. Architecture, on the other hand, is language; it is a convention of signs. However, Cave Architecture imposes linguistic connotations on Nature; geological formations and landforms are selected as existing forms of Architecture and become part of a project. The material: spatial continuity between the cavern and its lithic matrix thus proposes the ambiguity between inside and outside, between Architecture and non-architecture, between Nature and artefacts, between language and essence. Hermitic monasteries are an extraordinary example of how Architecture can create relationships with the forms of the land on which it is grafted. In these places, the discrepancy is attenuated, leaving free space for communication and interpretation of forms. The relationship between interior and exterior becomes the focal point of this dichotomy, which confronts Architecture with a dilemma: to oppose the land or conform to its form, adapting to it. The Nature-Architecture theme develops in the monastic context in three distinct variants: development orthogonal to the terrain; polar development of secondary modules; development parallel to the ground. This image refers to an "uninterrupted body of myths"[19].

The possibility of identifying places with a strong symbolic value - true topoi of the sacred landscape - depends on an intense interpretative operation, activated in the representation and design, of the multiple units that make up the mountain landscape. In this process, iconemes[20], elementary signs of spatial perception, play a key role. they orient the gaze, structure the vision and allow an overall cognitive grasp of an intrinsically hybrid and heterogeneous environment, such as that of the mountains. in this sense: the anacrusis, the meander, the daimon, the echo and the counterpoint, (fig.4) help to describe the forms and metaphors of the interactions between Architectures and Earth.

Anacrusis and Meander

The pilgrim's journey to the mountain begins in the valleys below – the liminal, in-between land where the earth constricts and guides the way. Two convents near San Marco in Lamis exemplify this anacrusis and meander before the ascent of the mountain.

The origin of the magnificent Church of Saint Mary in the Valley of Stignano is recorded in the divine book of God, aimed at the salvation of humanity, who should seek Him through the Blessed Virgin Mary, His glorious Mother.
A 19th-century manuscript on the sanctuary's history starts with these words, and similarly, I would like to clarify that this is not meant to be an anonymous historical account. Instead, it serves as a journey through the events and devotions of the men and women who have traversed this valley for centuries, where the Supreme and Good God, alongside His Mother, narrates the "History of Salvation."
The Gargano's history is marked by the lack of historical documents, leading to the rise of many sacred and profane legends over the centuries. These tales include stories of kings and queens, sailors and pirates, disreputable

17 (Horden & Purcell, 2000, pp. 118-134)
18 (Norberg-Schulz, 1981, p. 17)
19 [Trad. by Autor] (Hillman, 1972)
20 (Turri, 2023, p. 19)

women, dragons, devils, brigands, witches, sorcerers, hidden treasures, hermits, monks, wandering shepherds, sprites, and various other figures from the rich imagination of the people. However, among the "creators" of these legends are some pseudo-scholars who, from the slightest evidence, think they can discern "lu trajòne"[21] oblivious to the fact that illusions and mirages can mislead them. With these fantasies, they seek to reconstruct history as if it were merely about "the deeds of men."

The Valley of Stignano is among the most legend-filled and evocative places in the Gargano. One such tale holds that Saint Francis of Assisi, en route to the cave of the Archangel Michael, passed through the Valley of Stignano and was enraptured by the beauty of the landscape and the kindness of its people. It is said that, in gratitude for the charity he received from the inhabitants—and even from the animals, who brought him food—he blessed the fruits of this valley. Though clearly a legend, it is important to recall that Stignano is a land of blessings as well as of legends, and also of sorrowful and dramatic events.

The convent of Stignano (fig.5) is located at the entrance to the broad valley that opens to the north-east of the great Tavoliere plain, where the road begins to climb; the sanctuary stands as the northern gateway to the sacred territory of the Gargano. Some have proposed that this was the path of the Via Sacra Langobardorum, or the Way of the Angel, or more precisely, the Via Francesca or Via Peregrinorum. However, I shall not dwell on the route of the road, leaving to future studies the investigation of the possible pilgrim paths to the Gargano.

From this natural threshold, one enters the Gargano Sanctuary, the very heart of the sacred mountain, making a stop at this sanctuary imbued with the deepest Marian and Franciscan spirituality.

The entire Tavoliere plain and the mountainous zone of the Gargano have been inhabited since prehistoric times. There is extensive evidence of human presence dating back to the Palaeolithic and Neolithic periods. The whole piedmont and lowland area was cultivated in the ancient Daunian period, throughout the era of Magna Graecia, and during the Roman age. The numerous archaeological sites, settlements, and tombs provide ample confirmation of this.

The Valley of Stignano is a vital part of the enduring human journey. Serving as a prelude (anacrusis) to the sacred path, it represents the instant when pilgrims bid farewell to the ordinary plains: the land constricts, and the soul is urged to look within.

The valley stretches from San Matteo to Stignano is known as Valle la Iana.

"This name appears as such in the Tavolario Pugliese... and in the public land registries, it is still referred to as Ponte di Iana, or, more precisely, as Ponte di Giano (Bridge of Janus)..."[22]

Ciavarella, meanwhile, notes:

Via Iana, which branches from Vico della Pace and leads to Via Lungo Iana, is a street name that originated in 1907, formerly known as Vico 1 Santa Chiara. Via Lungo Iana (which runs from Via Roma to Piazza Gramsci) also received its name in 1907. The name is thought to be derived from Giano (Janus), leading to the entire ravine of San Marco, situated between the convents of San Matteo and Stignano, being referred to as Valle la Iana; Torrente Iana, the small stream that flows down from the cliffs of the Difesa di San Matteo into the settlement below; and Ponte di Iana, the bridge that was once built at the location where the road Ponte le Grazie would later be constructed."[23]

Thus, the valley begins not with a declaration but with a constriction — a folding of the land that draws the pilgrim inward. It's not a threshold one crosses but rather a space into which one is gradually received, as the plains recede and the earth's contours tighten into significance. The Valle la Iana, named in honour of Janus, the god of dual faces and sacred passages, stretches between Stignano and San Matteo like an antechamber shaped by time and reverence. The earth does not immediately reveal its sacredness; it demands approach, attunement — a descent that, in reality, prepares one to ascend.

21 F. P. Borazio, Lu trajòne, poem in the Sammarche vernacular
22 [trad. by author] (Giuliani, 1846, p. 6)
23 [trad. by author] (Ciavarella, 1982)

The sacred begins softly, in quietude. The Stignano sanctuary, nestled against the valley's side, does not elevate but instead envelops. Its flatness signifies not a lack of height, but a liturgical calm — a gesture of gathering, a maternal embrace. The church remains still, surrounded by trees, as if the forest itself has learned to pray. There is no grand reveal here; the sacred surfaces through the earth's natural rhythm, where the land curves to create space for worship. The structure wraps around, its energy centripetal — a basin of memory, shelter, and blessing.

The Sanctuary of St. Matteo (fig.6) is perched on its small peak at the foot of Monte Celano (871 m). The first Benedictine foundations were developed here in the 11th century, becoming a centre for pilgrims on their way to the Gargano[24]. Topographically, San Matteo is located on a knoll emerging from a mixed oak and hornbeam forest (the Bosco Difesa). The meandering condition alludes to the winding pilgrimage path leading there, or perhaps to the meandering river shape of the valley. To arrive at St Matthew's is to follow the bend in the valley: to stop on a ledge of land that, at the same time, offers a view of the town and the passage. The sanctuary of St Matthew is a ledge, marking the passage. St Matthew's could be said to be the first 'peak' of the Gargano pilgrimage, albeit on a modest scale: a promontory reflecting the pilgrim's path from below. a constructed 'peak' that completes the natural knoll.

The entire valley serves as an anacrusis — it's not yet the mountain's peak, but already hints at it. The pilgrim cannot yet see the sanctuary of the Archangel, yet the mountain is weaving its language into the landscape's gestures. A fold, a rise, a ledge, a curve: these are the expressions the earth communicates through stone and shadow, and the pilgrim learns to interpret them with their steps.

Sound quiets in this place. The bells do not chime but float away. Silence is not merely an absence; it takes form, resembling the pause before a prayer, like the instant when a breath is held right before it transforms into a chant. This is not mere location; it is a liturgy made of stone. The landscape is not merely traversed but engaged with as a text. The sacred does not come from above; it lies dormant in the earth, waiting to be stirred by the one who walks through it. There exists a particular geography of silence in this place: as one steps into the valley's confined walls, sound ceases.

Cave and Daimon

At the summit of the promontory rests Monte Sant'Angelo, crowned by the Sanctuary of San Michele. This Romanesque basilica encloses the renowned Grotta di San Michele, a natural cave long revered as a sacred site (fig.7). According to legend, around the year 490, Bishop Lorenzo of Sipontum witnessed flaming apparitions of the Archangel Michael on this very rock[25], commanding that the grotto be consecrated to Christ and Michael. Yet the rocky cave and its subsequent chapels do not invite vertical ascent but rather a descent—a stooping of the body and spirit—as pilgrims enter the womb of the mountain. This subterranean space functions simultaneously as womb and tomb, a threshold between realms, charged with symbolic ambivalence and eschatological weight. The tangible darkness, the dripping stone, the echoing ventilation: all contribute to a vastness that overwhelms the senses—a felt tremendum. And yet, locals say that no winter storm ever disturbs its entrance, suggesting a protective, even maternal, aura. It is here, in this mineral hollow, that the Gargano daimon resides: not only the Archangel Michael, but also the latent spirits and healing forces that animated the mountain long before Christianity.

Indeed, the cave, one of the most ancient and sacred forms of natural architecture, embodies dual principles of concealment and emergence, evoking powerful imagery across cultures and cosmogonies. Functioning as both womb, symbolising genesis and gestation, and tomb, marking withdrawal and finality, it serves as a primordial site for transformation—where birth and death, vision, and silence, converge. In Greek mythology, caves were revered as the cradles of gods: sites of incubation, refuge, and revelation. In Eastern traditions, they function as thresholds towards inner enlightenment. Described by some as "a uterine space of regeneration," the cave

24 (Villani, 2023)

25 AA.VV., Il Santuario di San Michele sul Gargano dal VI al IX secolo. Contributo alla storia della Langobardia meridionale, edited by C. Cadetti and G. Otranto, Bari 1980; hereinafter referred to as 'Atti Monte Santangelo'. The volume contains essays by a group of scholars from the Institute of Ancient Christian Literature of the University of Bari (C. Colafemmina, C. D'Angela and M. Salvatore, in addition to the editors) who worked on the monument in close collaboration with scholars from other universities: M.G. Arcamone, M. Cagiano de Azevedo, C.A. Mastrelli, A. Quacquarelli.

offers a distinct spatial condition: rather than raising the gaze upwards toward celestial light, it draws the self downwards, into the hidden depths of being.

At Monte Sant'Angelo, this archetype finds its fullest theological expression. The sanctuary is believed to have been revealed rather than built, underscoring the precedence of divine presence over human intervention. Bishop Maiorano, upon witnessing the miracle, chose not to consecrate the grotto, deeming it already sanctified by the Archangel's epiphany. This refusal articulates a profound conception of non-mediated sacredness: a holiness that emerges from the land, not from ecclesiastical rites. Here, sanctity is inherent—ontological—rather than conferred. The descent into the cave becomes a katabatic liturgy, a ritual of immersion into the earth's psyche and one's own unconscious, evoking what Mircea Eliade called "the chthonic mode of the sacred": a form of holiness rooted in instinct, earth, and the raw vitality of life.

This sensibility finds symbolic resonance in the figure of Pan, the archaic nature-daemon whose presence intensifies the perception of the landscape, transforming it from a neutral background into a psychological mirror of human desire, terror, and wonder. The grotto becomes not only a setting for religious action but also a topography of the soul, wherein the sacred does not descend from above but erupts from within—from rock, root, and echo. "The sacred," Eliade writes, "reveals itself as phàinesthai": a coming-into-appearance that precedes rational understanding, causing a trembling of perception, a reverence for being itself.

The Apparitio Sancti Michaelis[26] in Monte Gargano, the foundational text of the site's cult, situates the sanctuary within its topographical and spiritual context. After anchoring the city of Siponto within its landscape, it recounts three emblematic apparitions of the Archangel, including the vision in which Michael prophesies the victory of the Beneventans and Sipontines—Lombard groups—over the Byzantine Neapolitans. The text subsequently shifts from visionary narration to a detailed natural description, portraying the rocky sanctuary, its surrounding environment, and the early practices of pilgrimage, devotion, and miracle-working (fig.8).

At the time of its historical emergence, the cult of Michael showcased a fundamentally therapeutic and naturalistic character. The Apparitio recalls that the Archangel healed fevers through a miraculous water (stilla) that sprang directly from the rock within the cave[27]. This healing force, inseparable from the materiality of the place, resonates with earlier mythological traditions: the site was previously linked to iatric-divinatory figures such as Calchas and Podalirius, whose presence prefigures Michael's functions. Thus, the sanctuary inherited not only its physical location but also a deeper archetypal role as a site of visionary incubation and bodily healing.

The presence of elemental forces—water, stone, forest, altitude—converges to create a landscape infused with sacral density. These features define the symbolic grammar of sacred space in the Gargano throughout the Middle Ages, shaping liturgical imagination and practices. The cave, referred to in medieval sources as both crypta and domus angulosa, remains irregular and tactile: walls protrude with jagged edges; the ceiling varies dramatically in height; the floor descends in stages, guiding the body through spatial modulation. Outside, the dogwood forest (cornea silva) encircles the summit, sheltering the sanctuary before it opens onto a vast plateau.

For the medieval pilgrim, the experience is not only topographical but also existential. The act of entering the cave serves as an initiation. In Greek, daimon refers to a guiding spirit[28] or genius loci[29]. Michael, in this context, becomes both guardian and revealer, governing not from above but from within. Inscriptions within the cave suggest a practice of incubatio—sleeping in the sacred space to receive dreams and prophecies—echoing ancient rites that were later reinterpreted in Christian terms. The votive tablets and banners preserved in the sanctuary reflect centuries of pilgrimage and protection, extending from battlefields to the thresholds of death.

Within the grotto, even sound behaves differently: footsteps echo like liturgical bells; prayers are absorbed into the stone with muted resonance. As one moves inward, the light grows dimmer, and silence acquires texture.

26 La Memoria agiografica di san Michele sul Gargano. Testo critico, traduzione e commento a cura di A. Lagioia, prefazione di G. Otranto, Bari 2017.

27 (Aulisa, 2021)

28 (Richer, 1989)

29 (Norberg-Schulz, 1981)

Then, at the threshold, a sudden opening reveals the Gargano ridge sloping towards the sea, evoking a sacred panorama—not an image, but an event of perception. The cave of Monte Sant'Angelo does not merely contain the sacred. It is the sacred, in its most primordial, unmediated form: an archetypal hierotopy[30], a cleft in the world through which the supernatural discloses itself—not in spite of the earth, but through it.

Counterpoint

Opposite the Carbonara Valley, in relation to the Sanctuary of San Michele, lies the Abbey in Monte Sacro (Mattinata), the ruins of which indicate an even older sacred heritage. At its peak are the remnants of a Benedictine abbey dedicated to the Holy Trinity, founded in the 11th century. However, archaeology and legend suggest this was once Monte Dodoneo – a mountain associated with Zeus Dodoneus. Giuseppe Piemontese notes that a temple of "Giove Dodoneo" stood here until the 5th century, echoing the cult of the Dodona oracle. An ancient inscription remarked "to Janus or to the door," but the name Dodoneus truly originates from Dodona in Epirus. Bishop Lorenzo, the same bishop who built the church at Monte Sant'Angelo, is reputed to have diminished the pagan oracle and consecrated the site to the Trinity. From that moment on, it was known as Monte Sacro, "the sacred mountain par excellence" of that area. Ongoing archaeology around the abbey continues to reveal Hellenistic temple foundations (fig.9).

The body of the building itself is entrusted with the task of meeting life and interacting with its manifold forms and infinite expressions. In order to define the meaning of this art of building, Bernard refers to two decisive and precise terms: rigour and dispossession. Building is essential, but not exhibiting, because the true construction must, paradoxically, be invisible. It is no coincidence. At the same time, in the clearing in which it usually stands, the ensemble of the abbey is like the soul of the land, of a body that would have remained dead without the effort of the men that arose it from its torpor. «As in the soul, in fact, maintained by all the humours that flow through the human body – and it, in turn, entrusts to the body warmth and life – in the dwelling – wher e in an e fervescence of light the riches, still dark, that the stimulated earth produces are consumed – resides the motor of every action»; through memory, reason, will.[31]

In Gargano's thematic geography, Santissima Trinità serves as a counterpoint to San Michele. While St. Michael's location is described as "high, fast, glorious" (a soaring beacon), the site of Monte Sacro is more stately, solstitial, and perhaps more connected to the earth. Both locations are significant for gods associated with thunder and sky (Zeus and Michael) on parallel ridges, apparent to each other and to pilgrims traversing the gulf. The ancients were aware of their relationship: Mattinata's carbonate spring (the Altheno river) noted by Strabo in the context of the Podalirius cult, flows from the base of Monte Sacro. Thus, Podalirius's healing waters were located at Monte Sacro's foot, while Calcante's oracle resided atop Monte Sant'Angelo. Christianity intertwined these sites by erecting Michael's church on the summit and the Trinity church (which continues the legacy of Jupiter) on the adjacent peak.

Now a dilapidated convent, Monte Sacro vividly embodies Otto's notion of the numinous. Visitors report feeling "caught up in the mystery" of walls that have become "prey to the assaults of the vegetation." The remaining arches and cells are "gripped by giant ivy," haunted by "the spirits of the forest" – as nature reclaims the sacred space. An unsettling aura pervades the site, as the legend of a treasure-guarding demon "does not seem so unfounded." In these instances, Monte Sacro unmistakably feels "wholly other" and profoundly awe-inspiring – a true "mysterium tremendum et fascinans," both daunting in its power and captivating in its beauty.

The mountain insists on the liveliness of nature: the forest reappropriates stone and altar, allowing ethos and environment to merge. The image takes us back to the original condition, to nature 'within.' Every ivy-covered arch and every fallen pillar resonates with an archaic, numinous quality. In the desolate splendour of Monte Sacro, the sacred, the demonic and the arcane intertwine in the lived landscape, leaving the visitor with a sense of wonder at the ancient mystery of the place. Monte Sacro remains a place of arcane wonder, where the archaic and the numinous converge in tangible form. A place where Homer[32] would say the Nymphs live, "personifications of those filaments and banks of mist suspended over the valleys, the mundane walls and springs, veiling

30 (Lidov, 2008, pp. 9-12)
31 Zermani, P. (2018) "La struttura interiore" in Firenze Architettura
32 Odissea, VI, 123.

the waters and dancing above them"[33].

The Echo: Forest Hermitages of Santa Maria di Pulsano

Descending again towards the foothills of the Gargano, the landscape wrinkles - the southern terraces - where silence and echoes of solitude, of the monastic desert, prevail. Perched on a rocky spur dominating the coast between Monte Sant'Angelo and Mattinata is the Abbey of Santa Maria di Pulsano[34], founded in the 6th century (according to tradition by Pope St Gregory) and re-established in the 12th century by St John of Pulsano. Here the echo manifests itself both acoustically and spiritually. Rocky spurs envelop the abbey complex; small hermitages cling to the cliffs below, where monks once led a composite life[35]. Human existence is realised only in the composite life, that is, in the cooperation of the active life with the contemplative life (fig.10). As St. Gregory teaches:

"when a good program of life involves a transition from the active to the contemplative life, then it is often helpful for the soul to return to the contemplative life to the active, causing the flame of contemplation kindled in the heart to give all its perfection to industriousness thus the active life must lead us to contemplation, but contemplation [...] must lead us back to action"[36].

The landscape visible from Pulsano is not a passive view but rather a visual architecture that establishes the way of looking at and inhabiting space. The panorama generates orientation, establishing both a vertical and a horizontal axis: the former connects the cave to the vault of heaven, while the latter links the hermitage to the sea and the plain below. The place does not merely open itself to view; it demands a conscious gaze that permits it to be traversed by light and time. Here, what Gernot Böhme calls the "aesthetic atmosphere" is activated—namely, an affective quality of the landscape that shapes perception and establishes an existential dimension.

The landscape extends beyond mere visual observation; it encompasses light, sound, air, and the body's position. The monastic liturgies performed within the abbey found their spatial counterpart in the landscape: every canonical hour and chant coincided with shifts in the coastal light, breezes from the gulf, and a deepening silence. As a result, the landscape is shaped into an expansive liturgical space, where heaven and earth engage in the rite, positioning man not as a mere observer but as an active participant in this sacred tableau.

The expanse of the panorama induces a feeling of internal growth akin to what James Hillman[37], a perceptual broadening that links the individual to the entirety. The Gargano landscape, viewed from Pulsano, conjures the essence of Pan not in its frightening aspect, but in its rich, natural, and inherent quality. This vision transforms into a tangible experience, enhancing the connection with the world and granting access to an ancient form of knowledge that integrates humans with their surroundings, creating a unified living web.

Thus incarnates the geography of silence. It contrasts vividly with the grand panorama it overlooks: here is both altar and amphitheatre for contemplation. Modern commentators note how a visitor "stops and gazes at the boundless horizon, moved by the signs of the distant, tenacious Christian tradition of Santa Maria di Pulsano." It is this echo of history – a thousand years of solitary prayer inscribed on stone – that gives Pulsano its mythopoetic charge. As at Stignano, the site is an "elective place": not for crowds, but chosen by pilgrims seeking interiority.

33 [Trad. by Autor] (Hillman, 1972, p. 103)

34 (Cavallini, 1999)

35 Human existence is realised only in the composite life, that is, in the cooperation of the activa life with the contemplative life. As St. Gregory teaches: "when a good program of life involves a transition from the active to the contemplative life, then it is often helpful for the soul to return to the contemplative life to the active, causing the flame of contemplation kindled in the heart to give all its perfection to industriousness thus the active life must lead us to contemplation, but contemplation […] must lead us back to action". [Trad by Author] (Han, 2023, pp. 113-114)

36 Alois M. Haas, Die Beurteilung der Vita contemplativa und activa in der Dominikenermystik des 14. Jahrhudnderts, in B. Vickers (Hrsg.), Arbeit Musse Meditation, Verlag der Fachvereine, Zurich 1985, pp. 109-131

37 "Panic is no longer seen as a physiological defense mechanism or an inadequate reaction or abaissement du niveau mental, but would instead be seen as the right response to the numinous. precipitous flight becomes a breach out of protected safety into the 'mysterious wild regions of elemental existence.' Panic will always exist because it is rooted in human nature as such so even to govern it says Brinkmann will need to follow a mythological ritual procedure of gestures and music." [Trad. by Autor] (Hillman, 1972, pp. 68-69)

Calvino, valuing lightness, would point out how here the world is rendered thin – one is suspended between sky and rock. In Otto's terms, the place is no less tremendum, for the soul feels the scale of eternity in the "smisurato orizzonte" (boundless horizon) and the weight of solitude. In short, Pulsano is the echo chamber of the Gargano, where the sacred reverberates in empty space as much as it did in carved chapel walls (fig.11).

An Active Conservation of the Sacred Landscape

A sacred landscape needs to be reactivated, reinhabited, and maintained through ritual. Its sacredness exists in the stone, gestures, silences, and rhythms. A landscape is considered sacred not when it is merely observed, but when it is practised[38].

In this way, conservation is viewed not as an act of immobilisation but as a continuity: a sacred ecology of care. To maintain sacred sites, it is essential to provide attention that rejuvenates gestures, upholds rhythms, and nurtures our presence in relation to the land's shape and time. Monte Sant'Angelo exemplifies this principle by maintaining form alongside liturgical gestures, where structure is inextricably tied to spiritual orientation. Its strength is rooted in the lasting connection between sacred vision and the ritual path. The divine is etched into the physical space and the temporal layers of the land—its accumulated expressions of gesture and devotion.

Central to this valorisation is the practice of walking. Pilgrimage, understood as embodied liturgy, reactivates terrain as a revelation space. The Cammino di San Michele retraces an arc from Mont Saint-Michel to Jerusalem through Monte Sant'Angelo, linking sacred sites across time and geography.[39] This gesture aligns with the ethics of slow tourism: decentralisation, ecological awareness, and temporal openness. Micro-sites such as Santa Maria di Pulsano, Santa Maria di Merino, and the eremitic clearings of the Foresta Umbra become nodal points in a sacred network. The landscape re-emerges as a reticulum—an interconnected web of presences held by pilgrimage and prayer.

Valorisation, however, risks degradation when it shifts to consumption. "The sacred cannot be consumed; it demands a pact." The landscape is thus man-made. In the Gargano region, this results from prioritising the infinite over the finite[40] - While the effects of an urbanised landscape are clear, they require our focus eyes[41].This principle underscores the importance of sacred maintenance through acts of discretion and reverence. Voice, gesture, and rite must be preserved before presenting the artefact. Infrastructures remain discreet, and access flows are ritualised. The grotto is not simply a scenography; it retains its voice.

Equally important is the revitalisation of place through everyday actions. Ancient mule paths are restored, and dry-stone terraces are revitalised using agroecological methods. Forest trails are ceremonially cleared again. These actions do not merely enhance the sacred; they uphold its rhythm. They embody forma del patto—acts that reaffirm the bond between the land and those who inhabit it. The Eremo di Pulsano illustrates this approach. Reoccupied by a lay monastic community, it combines ascetic living, spiritual sharing, and landscape care. Pilgrims experience a renewed presence instead of a mere static heritage. Its architecture comes alive. What happens here is not a programme—it is a rite: a commitment to the space and its sacred evolution.

At the core of this philosophy lies a dialectic: the sacred landscape flourishes through responsiveness to rhythm rather than being tethered to rigid form. Sacred landscapes embody layers of time, serving as venues where various durations coalesce. Rather than imposing design, architecture should be attuned to the cycles of seasons, rituals, and the paths taken by pilgrims. Engaging with such an environment invites collaboration in its revelation. Projects ought to resemble liturgies rather than mere products, concentrating on the place instead of superimposing a design. To appreciate Monte Sant'Angelo is to engage in its continual manifestation of the divine—by hearing the whispers of its stones, respecting the patterns of approach, and nurturing the echoes of revelation[42].

38 Cfr. (Han, 2023, pp. 113-114)

39 Cfr. A. Cardone. Il paesaggio incolto nel Gargano. Un primo esame di contesti in abbandono. In Congresso Il patrimonio culturale pugliese. Ricerche, applicazioni e best practices - Bari, 28-30 settembre 2022

40 (Venturi Ferriolo, 2002)

41 Cfr. (Assunto, 1995, pp. 218-221)

42 The paper is part of mine PhD research in Mediterranean Archaeological, Historical, Architectural and Landsca-

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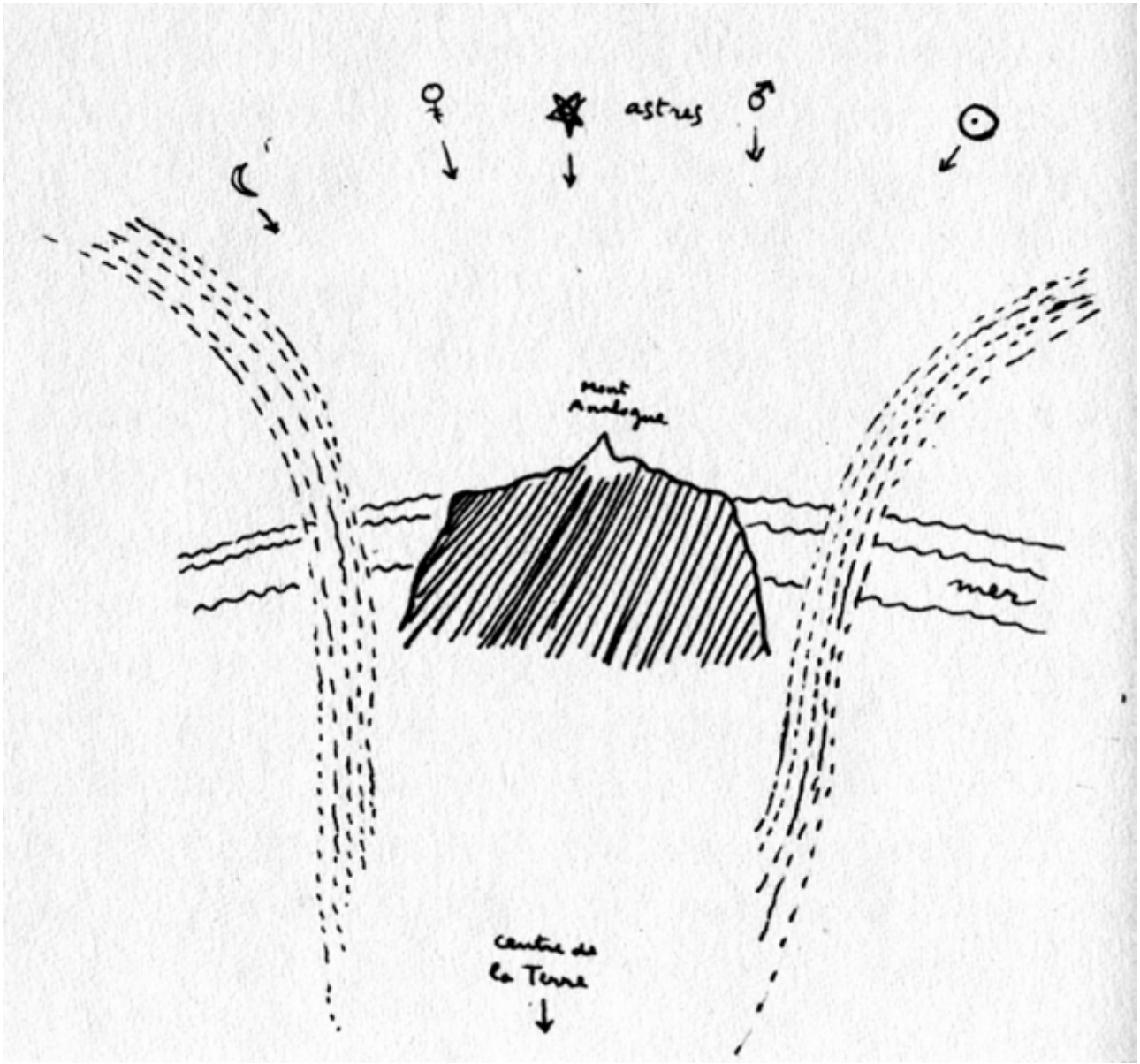

Figura 1 – Illustration by Renè Daumal, The Mount Analogue

Figura 2 - Lucano da Imola, Il monte Gargano e la città di Siponto (1550; Bergamo, San Michele al Pozzo Bianco)

Figura 3 – The Geography of the south Sacred Mountain of Gargano (elaborated by the Author)

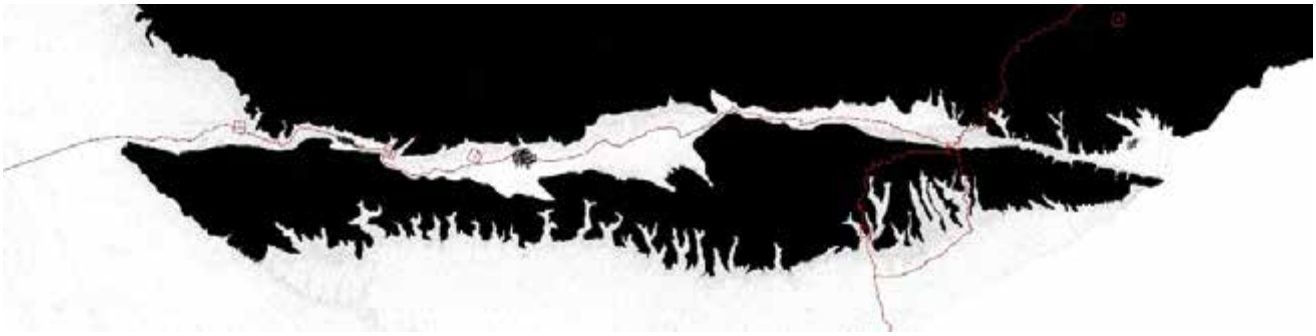

Figura 4 – The Via Francigena and sanctuaries across the south sacred Mountain of Gargano (elaborated by the Author)

Figura 5 – sanctuary of Saanta Maria di Stignano before restoration work

Figura 6- Sanctuary of San Matteo

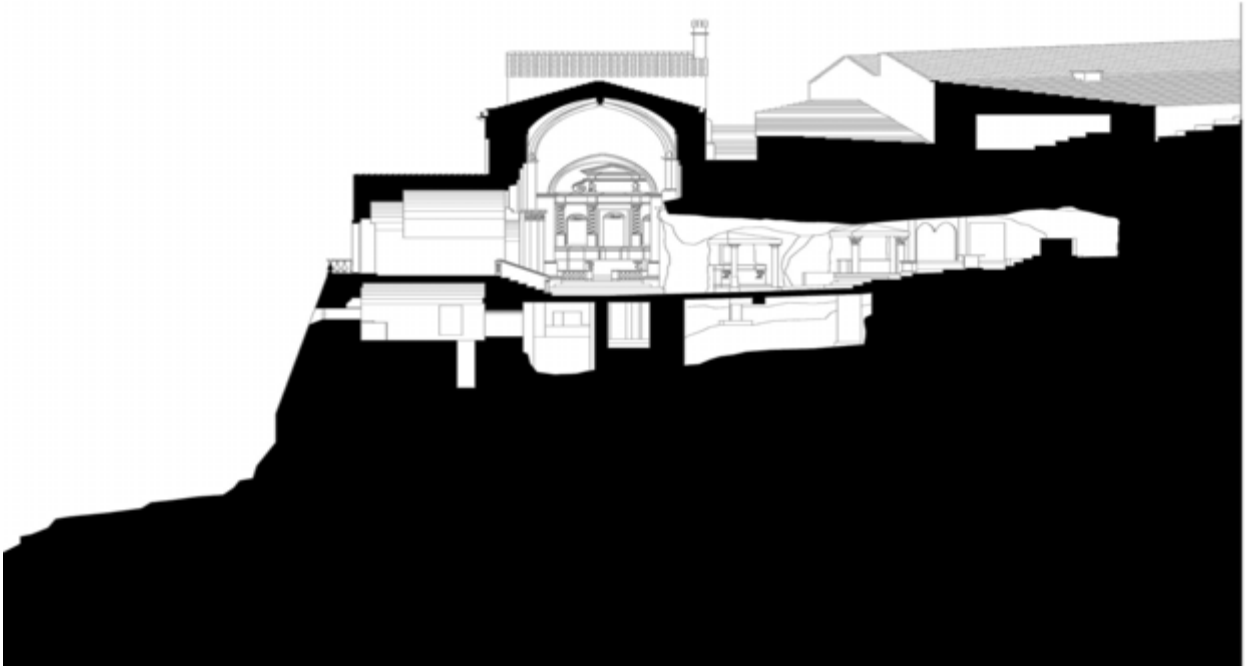

Figura 7 – Cave of Sanctuary of San Michele Arcangelo (drawing by the author)

Figura 8 - the gaze of the contemplator (photos of the author)

Figura 9 – Abbey of SS Trinità in monte Sacro. Photos by Arthur Haseloff, 1907

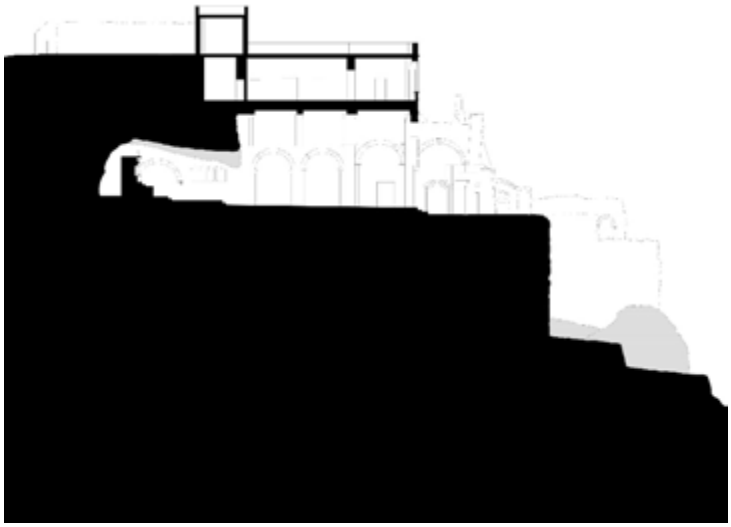

Figura 10 – sanctuary of Santa Maria di Pulsano (drawing and photos by the author)

Figura 11 – Panoramic view by Pulsano

(Re)Production of Urban Space through Cultural Events: Legacy of the Bergama Festival

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Abstract
This study explores how planned events temporarily reshape public spaces while permanently transforming their form, function, and meaning. Focusing on the Bergama Festival, it examines the shift from a region-wide celebration across the Bakırçay Basin to a city-centred event held in modern and historical public spaces. The research primarily relies on archival analysis of past events and the spatial mapping of these findings to trace the transformation of public spaces. While the festival enhances cultural vitality and public engagement, its increasing commercialisation and spatial compression risk marginalizing residents and diminishing inclusivity. By analysing the socio-spatial dynamics of event spaces, the study contributes to debates on public space, cultural heritage, and urban equity, offering insights for planners and policymakers to create more inclusive and resilient urban environments.

1.Cultural Events as Urban Agents: Rethinking Festivals in the Public Space

Cultural events, particularly festivals, have increasingly come to be understood as significant urban agents that contribute to the social, spatial, and symbolic reproduction of public space. Drawing on Habermas's (1989) concept of the public sphere, planned cultural events can be seen as arenas where individuals express opinions, engage in dialogue, and contribute to the construction of public discourse and communal life. However, the extent to which these events strengthen the public sphere depends on their underlying intentions whether they cultivate civic engagement or serve primarily commercial or entertainment-driven goals.

From a sociological perspective, Castells (2000) identifies public spaces as contested terrains where collective identities are formed and negotiated. In this context, festivals and other cultural events provide crucial platforms for these expressions. Similarly, Bourdieu (1990) emphasizes that the organization and experience of planned events reflect cultural practices and underlying power relations, revealing how spatial transformations are shaped by, and in turn shape, social dynamics.

The performative aspect of public events is further illuminated by Goffman's (1959) concept of the "presentation of self," which highlights how individuals use events to navigate and negotiate public identities. Massey's (1991) work on the "global sense of place" complements this view by challenging static definitions of place, instead emphasizing the interplay of global processes, local dynamics, and personal experiences in shaping public space. From this perspective, events are not merely activities situated in space but symbolic expressions that actively transform it (Sennett, 2017).

Lefebvre's (1991) spatial triad, conceived, lived, and perceived space, provides a critical theoretical framework for understanding the multifaceted role of events in urban life. Within this framework, events are understood as "celebrated moments of time and space" that shape and mediate the relationship between society and the urban realm (Elden, 2004). Festivals thus serve as temporal articulations of the spatial dialectic, making visible both the physical and symbolic layers of public life.

In recent decades, there has been a growing shift from enclosed venues to open public spaces as preferred locations for cultural events. Richards and Wilson (2004) argue that the private sector increasingly uses public space as a stage for promoting events, while local governments utilize festivals as tools to "stage the city" in global inter-urban competition (Colomb, 2012). Smith (2016), however, pushes this discourse further by advocating for event planning that reflects the dynamics of the city and its inhabitants a transformation from the notion of "city as stage" to "city as staged."

Jakob's definition of a planned event as the "deliberate organization of an elevated emotional and aesthetic experience" underscores the aesthetic and affective dimensions of public events. Stevens (2007) views such events as choreographed moments that enrich the streetscape, while Montgomery's (1998) Form-Activity-Meaning (FAM) model provides a concrete framework for assessing their impact. According to this model, festivals and similar events activate public space through diverse uses, enhance social interaction, and create meaningful, memorable experiences. However, the commercialization or imposition of such events can alienate

users and diminish the inclusiveness and democratic potential of public space.

Urban thinkers such as Jane Jacobs and Jan Gehl offer valuable insights into how cultural events can align with principles of vibrant and inclusive public space. Jacobs advocates for diverse, people-oriented spaces where social life can flourish. Within this framework, events such as street festivals and community markets can transform underutilized areas into active hubs of social life, exemplifying Jacobs' notion of "eyes on the street." Gehl's distinction between necessary, optional, and social activities similarly helps articulate how planned events can enrich public life by intersecting with different types of spatial engagement.

Crucially, the management and governance of public space are vital in supporting or undermining the success of cultural events. Carmona (2010) emphasizes the importance of designing accessible, active, and socially engaging spaces. Effective event planning must not only address physical design but also ensure that public spaces remain open, inclusive, and meaningful in both everyday use and during special occasions.

Finally, Smith (2016) categorizes the transformative impacts of festivals into three spatial dimensions. First, formal and monumental public squares can be animated and democratized through participatory cultural events. Second, parks often subject to restrictive control can be temporarily reactivated as open, communal spaces. Third, by closing streets to vehicular traffic, festivals reclaim urban space from privatization and consumerism, fostering communal experiences and spatial justice.

Taken together, these perspectives demonstrate that cultural events when thoughtfully conceived and inclusively implemented are not merely spectacles but critical instruments in the social production and transformation of public space. Through their temporal nature and symbolic richness, they hold the potential to sustain urban vitality, foster civic identity, and reinforce the democratic life of cities.

2.Layers of Heritage and Change: Tracing the Historical Trajectory of the Bergama Festival

The Bergama Kermesi, Turkey's one of the first local festival held continuously for 89 years and initiated under Atatürk's leadership with the aim of promoting local values, has been selected as the field site for this study due to its diverse and multi-dimensional character. The festival comprises a variety of events, including cultural and artistic performances as well as sports activities, taking place across the city's public open spaces over the course of a week. The kermes supports Bergama's international visibility and tourism, fosters the marketing of local products and economic revitalization, and facilitates encounters between villagers and townspeople, locals and tourists, and citizens and artists

With its rich historical, cultural, and natural assets, Bergama was inscribed on the UNESCO World Heritage List in 2014 under the title "Pergamon and its Multi-Layered Cultural Landscape." In addition to its tangible heritage, comprising successive layers from the Hellenistic, Roman, Byzantine, and Ottoman periods, Bergama's intangible cultural heritage has also been formally recognized and registered in line with UNESCO's principles. A prominent example is the Bergama Festival (Bergama Kermesi), held annually since 1937 in response to Mustafa Kemal Atatürk's directive: "An opportunity should be provided to promote this exceptional corner of our country through a fair or festival for its people.". As one of the oldest festivals in Turkey, the Bergama Festival now in its 89th edition, represents a vital expression of the city's living heritage.

Today, the term kermes, used to describe this week-long local festival, refers, according to the Turkish Language Association (TDK), not only to festivities, holidays, and fairs, but also to collective events organized for the public good, such as communal efforts and fundraising events. In its first 15 years, the Bergama Kermesi was organized entirely by civic initiative, specifically by the "Bergama'yı Sevenler Derneği" Later on, the responsibility for organization and funding was assumed by the Bergama Municipality, with contributions from the public, the district governorate, and the Bergama Foundation for Culture and Arts (BERKSAV) (Eriş, 2011).

The poster archive offers a valuable clue for understanding the shifting approach to how the Bergama Festival has been presented over time (see Figure 1). In its early years, graphic designs prominently featured traditional folk dances and the city's rich historical heritage. However, these representations gradually faded into the background. Notably, following the rise of neoliberal influences in the post-1980s period, the poster for the 54th festival included the logo of a global beverage company that sponsored the event, a clear indication of commercialization. In the

posters from the 2010s onward, elements of Bergama's local identity are largely absent. Instead, the focus shifts to promotional images of performing artists scheduled to give concerts during the festival. This transformation in the visual language of the posters alone reveals that the festival, originally intended to highlight local values and represent the place, has increasingly been compelled to forfeit its authenticity in the face of global dynamics, evolving into an event more focused on chasing popularity than celebrating local heritage.

Figure 1: Posters of the Bergama Festival from 1938 to 2024

This situation demonstrates that the event has gradually shed its original character of representing, promoting, and reproducing the space. Instead, it has assumed a new role that contributes to the consumption of space. Rather than fostering new cultural expressions or sharing what is unique to Bergama, the festival increasingly mirrors mainstream popular culture. In doing so, it drifts away from its initial function as a platform for the articulation of local identity, becoming a stage where imitation replaces authenticity and commodification overshadows cultural rootedness.

Cultural policies in Turkey have undergone significant transformations since the early Republican period. With the establishment of community centres "Halkevi" in 1932, cultural activities such as theatre, music, literature, and folk dance were institutionalized, positioning "Halkevi" as central venues for local festivals and artistic expression. The transition to a multi-party-political system in 1950 led to a partial decentralization of cultural initiatives, encouraging private sector involvement. In 1958, the closure of Halkevleri marked a turning point, as municipalities and private actors took over the organization of public cultural events. During the 1960s and 1970s, rapid urbanization and cultural pluralism saw the diversification of events in major cities, while popular culture flourished in informal settlements.

The 1980 military coup brought increased censorship and repression in the arts. Between 1983 and 2000, neoliberal policies contributed to the commercialization of cultural events, with international festivals emerging in big cities. The 1990s witnessed the rise of global cultural forms in Turkey, including music festivals, independent theatres, and biennials. In the 2000s, metropolitan municipalities like Istanbul and Ankara began to exert greater influence over cultural policy. By the 2010s, cultural events held in public spaces were increasingly shaped by security, profit-driven motives, and urban transformation agendas. The 2013 Gezi Park protests underscored the central role of public space in cultural production, sparking alternative forms of cultural expression. However, growing concerns include the homogenization of event programming and venues, the suppression of spatial diversity, overcapacity, and cultural degradation.

The Bergama Festival, with its nearly nine-decade history, stands as a unique cultural formation that encapsulates the evolving dynamics of Turkey's cultural policies, urban transformations, and local identity politics. Initially conceived as a celebration of Bergama's rich cultural heritage and a civic act of local representation, the festival once offered a platform for promoting both tangible and intangible assets of the city. However, as revealed through the changing actors, aesthetics, and spatial strategies of the event, the Bergama Festival has undergone a significant transformation from a place-based, community-oriented expression of heritage to a commodified spectacle shaped by neoliberal imperatives. While it continues to attract attention as a cultural attraction,

the shift toward a popularity-driven and commercially influenced format undermines its potential to act as a generator of cultural continuity and urban meaning. This transformation signals not only a detachment from the festival's founding ethos but also a broader struggle for authenticity, inclusivity, and cultural memory in the face of global and local pressures. Understanding this trajectory is vital not only for reclaiming the cultural integrity of the Bergama Festival but also for informing more equitable and place-sensitive cultural policy frameworks that prioritize collective memory, local participation, and spatial justice.

3.Shrinking the Festive Geography: From the Bakırçay Basin to the City Core

Located in the northern part of İzmir Province, Bergama has long held a central role as a cultural and commercial hub in Western Anatolia (see Figure 2). As the modern inheritor of ancient Pergamon, the town's unique archaeological wealth, layered historical fabric, and diverse natural landscapes have positioned it as a key tourism destination within the region. This potential has been further amplified since Bergama's inscription on the UNESCO World Heritage List, which has brought greater national and international recognition. In this context, the Bergama Festival (Bergama Kermesi), held annually since 1937, plays a critical role in both the promotion of the city's tangible and intangible cultural heritage and the active reproduction of urban life. Serving as a bridge between past and present, the festival not only invites residents and visitors to engage with the city's legacy but also transforms Bergama into a space of collective celebration and memory.

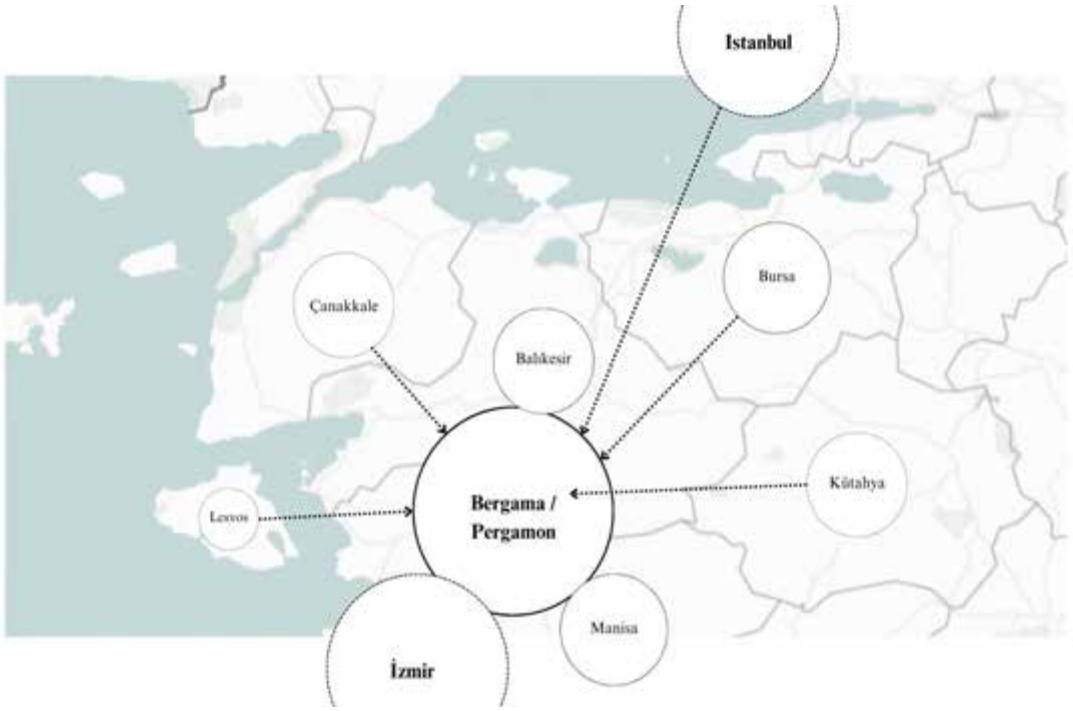

Figure 2: Bergama's regional position with surrounding settlements

In its foundational years, the festival was envisioned as an event that connected the urban and rural, drawing on the full geography of the Bakırçay Basin, from the coastal settlements of Çandarlı and Dikili to the forested heights of the Kozak Plateau and the agricultural plains of Göçbeyli and Kınık (see Figure 3). Through this expansive geography, the festival embraced a diverse array of local identities and practices. Seaside festivities along the Aegean coast, sports competitions in the forests, and folkloric performances, particularly the traditional "Bengi" dances of the plain villages collectively reflected the rich and pluralistic cultural identity of the wider basin. In this sense, the festival functioned as a powerful agent of territorial representation, producing a spatial narrative that connected nature, history, and cultural expression across multiple settlements.

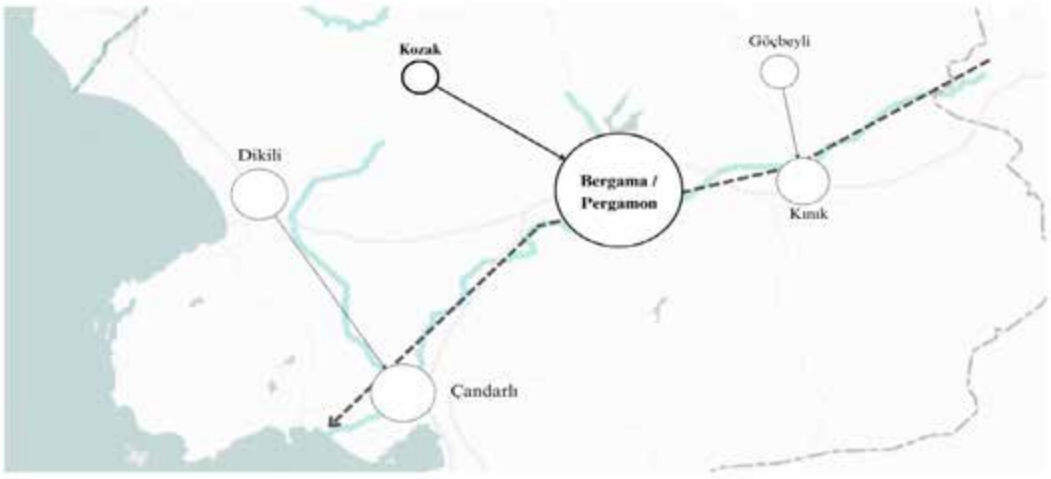

Figure 3: The geography of the festival spread in the Bakırçay Basin

However, over time, structural shifts in administrative boundaries and governance frameworks have significantly reshaped this geography. With the transition of Bergama into a district of the İzmir Metropolitan Municipality and the redefinition of local government jurisdictions, the festival's spatial scope has gradually narrowed. Practical considerations such as transportation, security, visibility, and institutional control have contributed to the centralization of festival activities within the historic core of the city. As a result, key venues now include symbolic urban spaces such as Cumhuriyet Square, Atatürk Boulevard, and historical sites like the Red Basilica, Asklepieion, and the Arasta district. While these locations lend prestige and cultural depth to the event, they also signal a marked shift: from a basin-wide, inclusive celebration of shared rural-urban identity to a centralized, curated spectacle within the city's core.

The only remaining trace of the festival's once expansive geography lies in the final-day celebrations held in the Kozak Plateau, a symbolic gesture toward its rural roots. Yet even this tradition faces the risk of becoming a ritualized performance rather than a genuine extension of the festival's original ethos.

The contraction of the festival's geography mirrors broader trends in urban governance, cultural commodification, and spatial politics. What was once a decentralized celebration fostering territorial belonging and collective identity across the Bakırçay Basin has been reconfigured into a more controlled, urban-centred event. While this shift may offer advantages in terms of visibility and logistical management, it raises critical questions about authenticity, inclusivity, and the politics of cultural representation. As public events become increasingly embedded in strategies of city branding and tourism promotion, there is a growing need to revisit the spatial logic of festivals like the Bergama Kermesi, not merely as performances in space, but as active instruments in the production of space, identity, and memory.

4.The Power of Bergama Festival to (Re)produce Urban Space

Public festivals have long been recognized as influential tools in shaping the spatial, social, and symbolic dimensions of cities. In this context, the Bergama Festival (Bergama Kermesi) offers a compelling case for understanding how recurring cultural events can participate in the (re)production of urban space. Since its inception in 1937, the festival has not only functioned as a celebratory ritual rooted in local heritage but has also played an active role in redefining the spatial narratives and practices within the city. Through its varied programming, from parades and performances to exhibitions and street activities, the festival temporarily transforms Bergama's urban fabric, reactivating public spaces, reassigning symbolic meanings to historical sites, and creating new rhythms of urban life. More than a reflection of cultural identity, the Bergama Festival becomes an agent in the production of space, mobilizing collective memory, political narratives, and everyday encounters.

Although the festival has become largely confined to the city centre, limited to its historical and modern public spaces, it retains significant power to (re)produce urban space. This potential is most evident in the spatial

diversity of event venues, which collectively form a unique urban event landscape. The festival activates a wide range of spatial typologies, including historical sites, parks, squares, streets, public buildings, and natural areas (see Figure 4). While central squares serve as stages for concerts and large public gatherings, parades and ceremonial processions animate the main boulevard, creating temporary flows of movement and spectatorship. Elevated parks located on the city's dominant hills provide scenic vantage points, transforming into collective viewing platforms that extend the experiential field of the events. At the same time, Bergama's layered historical environment, comprising archaeological landmarks and cultural heritage sites, offers an evocative backdrop, enriching the festival's spatial atmosphere and reinforcing the symbolic connection between past and present. Thus, the festival reclaims, reconfigures, and reinvests meaning into these spaces, temporarily reshaping the city's spatial rhythms and enhancing its public life.

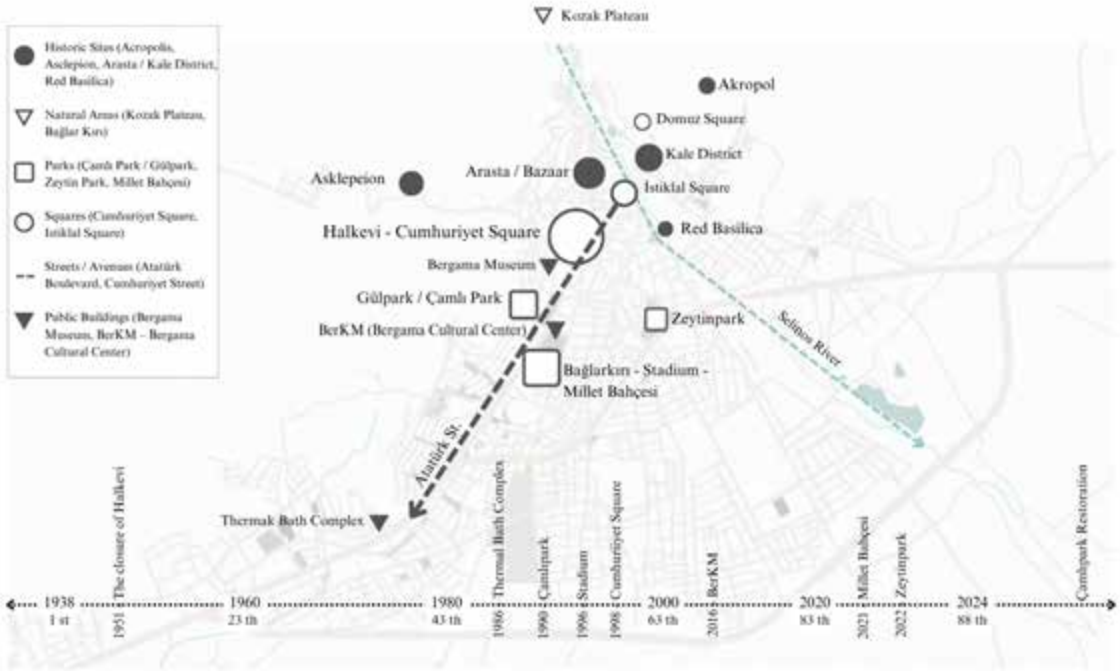

Figure 4: Distribution of the Bergama Festival across different urban space typologies

This spatial reconfiguration is most clearly embodied in Cumhuriyet Square, which has become the epicentre of the festival's urban imprint. Originally the garden of the Halkevi (Community House), the square has undergone multiple transformations aligned with broader political and cultural shifts in Turkey. While its earliest traces go back to the early Republican period, shaped by ideals of Westernisation and civic identity, the space has been continuously redefined through successive interventions. The most decisive transformation took place in 1998, when celebrated architect Cengiz Bektaş redesigned the square with a vision centred on spatial experience and collective memory, explicitly to accommodate festival activities. Since then, Cumhuriyet Square has functioned as the primary venue for major performances, including folk-dance shows, opening ceremonies, award distributions, and especially evening concerts that draw large crowds. During the most recent edition of the festival (2–8 September 2024), this site hosted the highest concentration of events, temporarily reshaping both the functional logic and symbolic meaning of the space.

In addition to the square, various public spaces, such as Atatürk Street, Arasta, and Çamlı Park, are temporarily defunctionalized during the festival, as their everyday uses are suspended in favour of programmed activities. The transformation also extends to historically and culturally significant sites such as the Acropolis, Asklepeion, Red Basilica (Kızıl Avlu), and the ancient theatre, whose accessibility is reconfigured to allow large-scale gatherings, performances, and public engagement. While this strategy increases the visibility of Bergama's cultural assets and expands the festival's experiential landscape, it also risks overexposure and commodification. Particularly since the 2000s, neoliberal influences have prompted a gradual shift in festival content, increasingly favouring

popular cultural acts to attract broader and often external audiences. This trend has amplified the appeal of the festival but has simultaneously narrowed its connection to local cultural practices and community identities. As a result, the festival becomes more consumption-oriented, and urban spaces, particularly central ones, are pushed to accommodate excessive demands, which may displace everyday users, diminish local belonging, and alienate long-term residents from their own city spaces.

In recent years, a growing institutional fragmentation has begun to constrain the symbolic impact and spatial potential of the Bergama Festival. While the event itself is organized and embraced by the local municipality, many of the city's most significant historical sites such as the Asklepeion and the Acropolis are managed by the central government through the Ministry of Culture. This divide has led to a disconnection between the festival and these emblematic locations, reducing the festival's ability to activate historically and spatially meaningful venues. This is particularly striking given that both the Asklepeion and the Acropolis include amphitheatres, making them naturally suited for performances and collective gatherings.

In addition to this institutional tension, evolving spatial interventions in the city have also influenced the festival's capacity to reproduce urban space. A key example is the area known as Bağlarkırı, which in the early years of the festival served as a major venue and host site. Over time, Bağlarkırı was transformed first into a stadium and later into a "Millet Bahçesi", thereby losing its function as a festive space. This shift illustrates how urban development decisions can sever historical continuities in public event geographies. Nevertheless, the city has also seen the emergence of new public venues that are being integrated into the festival landscape, such as Zeytinpark and the Bergama Cultural Centre (BerKM). These additions suggest that while certain traditional spaces are lost or repurposed, new possibilities for cultural expression and spatial activation are still being created. This tension between spatial loss and renewal encapsulates the broader challenge of sustaining the festival's urban role in a rapidly changing cultural and political environment.

Public space emerges as a dual entity within this context. On the one hand, festivals enliven and democratize urban environments, offering opportunities for collective memory, cultural performance, and temporal reappropriation. On the other, they intensify spatial pressure, potentially marginalizing everyday users and transforming public domains into semi-exclusive eventscape. The Bergama Festival thus represents both an opportunity and a challenge in terms of urban policy: it revitalizes and redefines space yet simultaneously contributes to spatial inequalities. This study contributes to broader debates on urban space and cultural event policy by critically examining the mechanisms through which festivals shape the physical and symbolic dimensions of cities. By highlighting the spatial consequences of shifting festival geographies, it offers insights for planners and policymakers seeking to balance visibility, accessibility, and inclusivity in the use of public space, especially in heritage-rich, yet socioeconomically fragile, urban settings like Bergama.

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Heritage Perception and Identity Construction Among Residents in Industrial Community Transformation: A Case Study of National Creative Park, Nanjing, China

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Abstract
In the context of China's deindustrialization, the redevelopment of industrial heritage sites has become central to urban transformation strategies. This study examines the regeneration of Nanjing National Creative Park (NCP), tracing its evolution from a major Qing-era factory to its closure in 2011 and subsequent conversion into a creative industry park. Using a qualitative approach, the research analyzes dominant narratives over different historical periods. In addition, in-depth interviews were conducted with various community residents to assess heritage perception and identity construction. The findings formed an unofficial "community narrative." This study reveals the dynamic interaction between dominant narratives and community narratives in the redevelopment of Chinese industrial heritage sites. It highlights the complexity of local residents' perceptions and argues that these perspectives should be incorporated into the framework of industrial heritage conservation. Moreover, the study emphasizes the importance of considering community voices in ensuring the sustainable development of heritage sites.

Keywords: Industrial Heritage; Dominant Narratives; Community Narratives; Urban regeneration; Place identity

1 Introduction

1.1 State-led redevelopment of industrial heritage sites

Post-industrialization and urban regeneration have become key global trends in urban governance and spatial transformation. While sharing similar drivers, their mechanisms and narrative practices differ significantly across contexts (Harvey, 2007). Industrial heritage has emerged as a site of cultural narration and identity construction. In China, as the world's largest manufacturing nation, post-industrial redevelopment is shaped by a unique socialist governance model and land regime. Under this context, state-led redevelopment and cultural re-narration have reshaped industrial heritage. Sites like Nanjing's National Creative Park (NCP) have been reframed through discourses of "creative industry parks" in planning texts, policy discourse, and curated exhibitions. Unlike the overt political expressions of working-class resistance in the West, China's former industrial community residents often respond to dramatic spatial and social restructuring through subtle, depoliticized forms of "silent resistance" and negotiated identity (Zhao and Nichols, 1996; Bray, 2005).

1.2 Industrial Heritage Communities under Divergent Policy and Cultural Contexts

In recent years, researchers have begun to highlight the "north–south divide" in China's industrial heritage landscapes. Similar to well-studied cases like Germany's Ruhr Valley, northern Chinese cities (e.g. Shenyang, Tianjin) typically exhibit single-industry clustered communities, where heritage regeneration primarily focuses on addressing systemic community decline (Zhang et al., 2023). In contrast, cities like Nanjing feature small-scale industrial sites embedded within existing neighborhoods, where heritage overlaps heavily with residential life. Here, urban regeneration is entangled with multiple pressures—historic preservation, industrial restructuring, and everyday livelihoods. Spatially and socially, such mixed-use heritage areas differ significantly from traditional "industrial satellite towns," which were once highly unified in terms of work and living arrangements.

In these hybrid heritage districts, residents are not limited to former industrial workers, but may include indigenous households, relocated residents, tenants, and homebuyers. This "internal heterogeneity" challenges the conventional class-based frameworks of identity and calls for analytical tools based on narrative negotiation. Studying the regeneration processes in these areas can therefore enrich our understanding of how identities are shaped across diverse social groups.

This paper applies critical discourse analysis (Fairclough, 1995), three-level positioning framework (Bamberg, 1997), and narrative structural approach (Riessman, 2008) to analyze how different types of residents engage with policy discourse, spatial change, and cultural reinterpretation. It examines how narrative positions are chosen, senses of belonging evaluated, and social roles reconstructed. Responding to the emerging academic focus on narrative governance, this study argues for pluralistic and dialogic mechanisms in heritage-led urban regeneration, providing insights into more inclusive approaches to community renewal.

Specifically, it addresses the following questions: In the face of transformation, how do residents from different backgrounds within hybrid industrial communities perceive their neighborhoods and construct their identities? Under the control of China's socialist institutional system, how can industrial heritage sites undergo a social transformation from "industrial relics" to cohesive "heritage communities" in the process of deindustrialisation?

2 Literature Review

2.1 Narrative Contestation in Post-Industrial Urban Regeneration

In the context of post-industrial urban regeneration, the reproduction of space is frequently accompanied by struggles and negotiations among narratives. Urban space becomes a site of multi-actor narrative competition (Jensen, 2007). Amid industrial transformation, heritage reuse, and community renewal, governments, developers, indigenous residents, and cultural actors engage in discursive battles over how the city should be remembered, represented, and envisioned for the future (Raco & Henderson, 2009). Such contestation reflects conflicts over historical legitimacy, cultural identity, and social spatial justice, often involving the restructuring of power and the marginalization of alternative knowledge systems (Lees, 2008).

Mainstream narratives, underpinned by policy language, development strategies, and capital logic, dominate through urban branding, spatial aesthetics, and elite discourse production (Balibrea, 2001). However, these narratives frequently neglect or marginalize the voices of vulnerable communities, particularly in terms of their sense of loss and displacement, resulting in what Lees (2008) terms "narrative silencing." The emotional energy and historical significance embedded in post-industrial ruins are often sanitized or instrumentalized under official discourse (Emery, 2019).

In response, residents, local actors, and critical scholars have developed "counter-narratives" that challenge elite representations and reassert local history and identity (Till, 2005). These alternative narratives are grounded in memory, affective landscapes, and lived experience, emphasizing locality and a "sense of historical presence." In China's socialist and post-socialist context, narrative contestation exhibits unique characteristics. First, the regeneration process is highly centralized, with limited community participation. Second, the functional and symbolic values of industrial heritage are explicitly embedded within national economic development agendas (Sun & Chen, 2023).

Narratives are not static but continuously negotiated through multi-actor interaction. Fairclough (1995) highlights the process of "selective recontextualization," where dominant narratives absorb, alter, or discipline individual voices—a phenomenon especially pronounced in post-industrial heritage settings. Thus, narrative contestation in post-industrial urban regeneration concerns not only cultural reproduction but also has profound implications for identity formation, spatial belonging, and civic participation.

2.2 Identity in Heritage Discourse

The reconfiguration of heritage spaces not only reshapes urban landscapes but also directly impacts residents' identities and sense of place (van Knippenberg & Boonstra, 2024). Studies indicate that functional changes in space often accompany symbolic reconstructions. For instance, transforming former labor sites into commodified exhibition spaces or art districts can impose a certain cultural narrative, leading residents to adopt new "identity frameworks" associated with the redefined "locality" (Mathur, 2014).

Residents' identities in industrial heritage spaces are often shaped by both official mainstream narratives and grassroots local discourses. Mainstream narratives, through institutional frameworks, planning contexts, and cultural reinterpretations, often shape residents' identities based on institutionalized discourses rather than personal experiences or grassroots collective memories. Zhang et al. (2023) argue that local identity has been "cultural symbolized" by dominant discourses, reducing it to an object of passive reception. In contrast, community narratives are articulated through personal and collective experiences and memories.

Preece (2020) introduces the concept of "biographies of belonging," highlighting how individuals in working-class communities construct identities through emotional and experiential connections to local spaces. These narratives not only reflect personal self-understanding but also maintain the historical continuity and collective memory of communities. Such participation is crucial for forming a sense of spatial belonging (Jones & Leech, 2015). For example, community-led redevelopment models are more likely to preserve residents' familiarity

and intimacy with spaces, thereby enhancing their sense of belonging. Conversely, neglecting or marginalizing residents' narratives can exacerbate their sense of spatial alienation (Preece, 2020).

While existing research acknowledges the importance of incorporating residents' narratives into industrial heritage renewal processes, discussions have primarily focused on the emotional memories and historical experiences of the working class. However, industrial heritage communities often have diverse demographic structures. The perceptions and emotional attachments of other types of residents to heritage renewal have been marginalized in current research. Moreover, existing literature has yet to reveal how narratives serve as mediating forces in shaping place perceptions and community identities amidst the interplay of multicultural and social structures.

3. Study Area

The Nanjing Creative Park (NCP), located in the heart of Qinhuai District, Nanjing, occupies a site historically used by two significant institutions: the Jiangnan Mint (formerly responsible for coin casting during the Qing Dynasty) and later the Nanjing No. 2 Machine Tool Plant, a major manufacturing base in the early industrialization of the People's Republic of China. In response to national deindustrialization policies, the site has undergone a series of transitions, including factory relocation, property restructuring, industrial heritage designation, and both park and community redevelopment. Its role has shifted from a self-contained industrial unit to a mixed-use urban precinct (Fig. 1, Fig. 2). Although now positioned as a creative industry park, NCP is spatially and socially interwoven with adjacent residential neighborhoods, making it a key case for understanding policy-driven transformation and community integration.

Figure.1. A photograph of a public space in this residential community), photo by Wenjing Dong

Figure.2. A photograph of houses in this residential community (Lai Feng Xin Cun), photo by Wenjing Dong

Surrounding areas such as Lai Feng Li, Ling Jiao Shi, and Lai Feng Xin Cun, many former workers and their families, who represent important community voices in this research (Fig. 3). Following the closure of the factory, these residents experienced institutional detachment, employment insecurity, and identity dislocation. Conversely, the commercialization has created new interactions for residents with no prior connection to the industrial past. The NCP thus exemplifies the dynamic interplay between dominant state narratives and plural community discourses in the context of heritage-led urban regeneration.

Figure.3. Location of NCP community, author self-painted.

4. Methodology

4.1 Research Design

This qualitative study investigates narrative construction and identity formation in the redevelopment of NCP. Two stages were conducted: (1) critical discourse analysis of policy texts, and (2) narrative analysis of resident interviews, aiming to explore the interaction of spatial discourse, place attachment, and identity.

4.2 Data Collection

Two datasets were used: (1) 10+ planning documents, exhibition texts, and media sources (1900s–2024), capturing official narratives of transformation; (2) 32 semi-structured interviews (Sept 2024–Jan 2025) with residents categorized as "old" and "new". "Old residents" include former No. 2 Machine Tool Plant workers and their family members ("worker group" and "worker family group"), as well as long-term dwellers with no direct factory affiliation—such as original inhabitants, relocated households, and residents assigned housing from other work units ("other old residents"). "New residents" refer to homebuyers and renters who moved in after the park's redevelopment. Interviews focused on memory, experience, attachment, and heritage perception. All were anonymized and transcribed.

4.3 Data Analysis

Official texts were analyzed via Fairclough's (1995) CDA model to uncover discursive mechanisms legitimizing redevelopment. This involved examining language use, discourse production, and the underlying ideologies. Special attention was given to keywords such as "industrial revitalization" and "heritage activation" to uncover how official narratives construct heritage discourse. Resident narratives followed Bamberg's (1997) identity positioning framework and Riessman's (2008) narrative structuring, examining how individuals negotiate identity and space in response to policy and change.

By comparing the structures and strategies of two narrative logics, this study aims to present a tension-filled context of industrial heritage redevelopment, revealing how personal memory and policy planning intersect, conflict, and negotiate within local narratives.

5 Official Narratives: Functional Transformation and Discursive Reconstruction

5.1 Functional Narratives in Spatial Transformation

The origin of Nanjing Creative Park (NCP) is closely tied to state-led policies. Initially established in the early 20th century as the Jiangnan Mint under the Qing court, the site was later transformed into the Nanjing No.2 Machine Tool Plant after the founding of the People's Republic of China (Xu, 2012) (Fig. 4, Fig. 5). In 2012, under the "retreat of secondary industry and advancement of tertiary industry" strategy, the plant began its industrial transformation. By December 2013, under the guidance of the Nanjing Industrial Heritage Protection Plan, the site was redeveloped into a national innovation and entrepreneurship hub (Li & Chen, 2022).

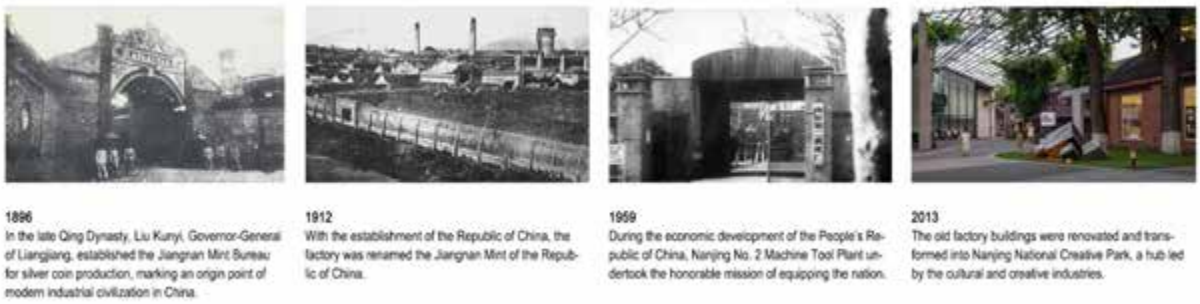

Figure.4. NCP during the different historical stages, author self-painted.

Figure.5. The spatial extent of NCP, author self-painted.

Currently, guided by the strategic goals of constructing a "national all-area tourism demonstration zone," building an "innovation-driven city," and promoting "high-quality development," NCP has become a key node in the spatial restructuring of Qin Huai District (Qin Huai District Development and Reform Commission, 2019). According to the mid-term evaluation report of the 13th Five-Year Plan, the old southern city area has been designated a national cultural demonstration zone (Qinhuai District Government, 2018). In this narrative of "all-area tourism," industrial heritage sites like NCP are framed as cultural and tourism assets.

Multiple policy documents indicate that the NCP's identity has undergone a shift from "industrial relic" to a hub for "cultural and creative industries" and the "digital economy." In this transformation, the park is no longer regarded solely as a historical site but reimagined as a complex industrial space symbolizing innovation and integration (Qinhuai District Government, 2019a).

The official narrative strongly emphasizes NCP's economic function, especially its roles in cultural industries and tourism. On one hand, the park is promoted as a cultural IP incubator and a key site for implementing the "Ten Measures for Cross-border E-commerce in Qin Huai." On the other hand, it is integrated into tourism strategies like "Night Stay in Qin Huai," aimed at fusing industry and tourism consumption experiences (Qin Huai

District Government, 2019b). This narrative logic reflects a systemic embedding of the "production–exhibition–consumption" chain into the traditional industrial community.

5.2 Shifting Policy Subjects and the Redistribution of Discursive Power

An analysis of policy texts across different historical periods reveals a significant shift in the subject of NCP's official narrative from the "working class" to "enterprises," "investors," "park managers," and "tourists." This semantic shift reframes the park not as a site of industrial production, but as a spatial tool for project implementation, resource aggregation, and productivity enhancement. For instance, the Qin Huai District Bureau of Commerce (2025) emphasizes supporting enterprises' global expansion and building a cross-border export ecosystem, highlighting a "park–enterprise–government" cooperation model. Similarly, the Qin Huai District Government (2019a) stresses the creation of a full industrial chain for IP development, with the operative subjects being park operators and tenants. This discursive strategy restructures the actor network of the park and reallocates discursive power to new entrants.

Driven by these dominant narratives, NCP has redefined its institutional identity. First, it is positioned as a key platform for cultural display, technological innovation, and industrial upgrading, and as a model for policy implementation. Second, while policies highlight the roles of government and enterprises, local residents are largely absent from these texts, with little attention to their emotional needs, lifestyle shifts, or identity struggles. Third, policies do not offer pathways for former residents to engage with or reestablish roles in the transformed park. Thus, while the official narrative facilitates spatial and functional renewal, it simultaneously neglects the reconstruction of local identity and community continuity, transforming the park from a "social space" into a purely "functional space."

5.3 Fractures Within the Dominant Narrative

The official narrative, which centers on an integrated framework of "technology, culture, tourism, consumption," has effectively repositioned NCP within Nanjing's high-quality development discourse. However, this narrative model also exposes certain limitations, particularly its unidirectionality and closure. While emphasizing "innovation driven" development and a "showcase city" image, it tends to overlook the social fractures and cultural exclusions that may arise during redevelopment. The de-contextualization of daily life, the fading of historical memory, and the weakening of place-based identity present latent challenges behind the polished official discourse. This analysis provides a critical foundation for subsequent examinations of community narratives and lays the groundwork for exploring the dynamic between policy frameworks and lived experience.

6 Community Narratives and Place Identity in Industrial Heritage Redevelopment

6.1 Emotional Narratives and Identity Reconstruction among Former Workers

Interviews with former workers revealed diverse and emotionally charged narratives. These accounts not only addressed physical spatial changes but also reflected nostalgia for industrial identity, cognitive dissonance toward urban transformation, and emotional responses to shifting social status.

Some retired workers retained strong place attachment. Long-term residents of former factory housing described frequent visits to the site (Fig. 6), calling it a place "with feelings," often using collective terms like "we workers" to affirm historical bonds—demonstrating group cohesion. Such narratives carried implicit loss. When discussing deindustrialization and relocation, one respondent expressed alignment with official discourse: "National policy comes first," indicating both trust and resignation. When asked whether the redevelopment had affected his life, one respondent replied, "Now it's the young people in there," and "preserving the site allows us to reminisce," acknowledging the historical retreat of the worker community. He also noted that the redeveloped NCP "can boost consumption," suggesting not hostility but an attempt to understand its economic rationale. These responses represent a "compliant-adjustive identity," shaped by dominant narratives of reform and development.

Figure.6. A photograph of the former factory housing (Lai Feng Li), photo by Wenjing Dong

Others, especially laid-off workers, expressed sharper criticism. One respondent explicitly rejected the redevelopment: "It was not good! Workers were laid off with nothing to eat," signaling forced identity loss and resistance to mainstream discourse. These "protest narratives" reveal emotional rupture and identity crisis among marginalized groups.

Some older workers exhibited silent acceptance. One elder noted, "We're too old to go there," showing emotional distance and disengagement. This "withdrawal narrative" reflects the exclusion of elderly residents from heritage reuse processes.

In sum, worker narratives are emotionally complex and heterogeneous, combining memory, belonging, grievance, and disengagement, offering insight into contested identity reconstruction.

6.2 Domestic Narratives and Collective Belonging among Workers' Families

Elderly women, particularly as wives or mothers of former workers, expressed strong place attachment despite not working in the factory themselves. Their narratives reflect a shared memory of household life under the "work-unit system" (housing, employment, and welfare were tightly bound to one's workplace). and highlight a gendered experience of spatial cohabitation. As one group of elderly women noted, "This whole row was factory's dormitories," constructing a sense of spatial belonging through the nested relationship of house and family. Although most had not worked in the factory themselves, phrases like "our husbands and sons were in the plant" enabled indirect identity formation and reinforced their narrative legitimacy as members of worker families.

Compared to workers, these family members tended to view redevelopment more positively. One respondent commented, "The renovation is nice; I go for walks in the evening," and participates in volunteer activities. Their narratives focus on everyday spatial use and temporal rhythms rather than political loss or class identity, representing a pragmatic, life-oriented mode of storytelling.

6.3 Marginalised Narratives and Functionalist Tendencies among Other Old Residents

An analysis of narratives from "other old residents", including original inhabitants, relocated households, residents assigned housing through other work units, and those who moved in through marriage, reveals a pattern of structural marginalization, especially when compared to the identity-secure and memory-rich narratives of former factory workers. Although these individuals have lived long-term in the area surrounding the original factory, their lack of affiliation with the "work-unit system" has largely excluded them from dominant historical narratives and cultural identity frameworks. Many respondents clearly distanced themselves from the factory's legacy, stating "I wasn't part of the factory" or "it has nothing to do with us." While some acknowledged the reputation of NCP as a "good unit," their accounts emphasized practical belonging, such as "we've lived here for a long time" or "we're used to it", but without emotional or historical resonance. As institutional "outsiders"

inhabiting shared spaces, they experience a tension between spatial inclusion and narrative exclusion. These non-worker residents tend to frame their narratives around everyday concerns such as convenience, social ties, and housing stability. Their recognition of NCP reflects a utilitarian orientation.

Their narratives often focused on everyday concerns like convenience, housing stability, and neighborhood ties, reflecting a utilitarian mode of place identification. Many expressed functional approval of the redevelopment, noting the area's walkability, food options, and livability, while deliberately withholding affective attachment.

Some, however, voiced strong disaffection. One resident, resettled in the 1990s, strongly rejected any association with community life, describing the area as "dirty," "expensive," and "annoying," and dismissing both the present and historical identity of the NCP. She expressed no sense of belonging: "I don't join activities" "I don't like living here". This group, resettled through policy-driven arrangements, remains excluded from prevailing community narratives, revealing a structural contradiction: spatial embeddedness without socio-cultural inclusion.

In sum, this group experiences dual marginalization, which excluded from both institutional memory and cultural representation, highlighting the need for inclusive heritage regeneration that embraces diverse social identities and lived experiences.

6.4 Instrumental Narratives and Cultural Reception among New Residents

Within the newly formed community structure following NCP's transformation, new residents constitute a key variable in identity dynamics. Their sense of place attachment often increases significantly with the length of residence. Younger tenants with shorter residency often display an instrumental narrative orientation, viewing the site primarily in terms of amenities like dining or leisure, showing little emotional connection or historical awareness.

Longer-term homeowner residents, though lacking direct historical involvement, gradually establish a connection to the site through everyday use and begin to develop interest in its history and culture. Those with even longer residence accumulate a strong sense of belonging through daily engagement. One interviewee, for instance, demonstrated a shift from functional engagement to cultural reflection by actively discussing the relationship between industrial heritage preservation and public education, suggesting that new residents can become potential agents in the transmission of industrial heritage.

Narratively, this group tends to follow a trajectory of "relocation, engagement, usage, and understanding," with role positioning evolving from "user" to "identifier." While situated on the cultural periphery of NCP's legacy, they possess strong potential for discursive integration. Though new residents are not directly involved in memory construction, they are actively shaping the contemporary meanings of industrial heritage.

7 Discussion

7.1 Selective Interaction Between Dominant and Community Narratives

During the redevelopment of NCP, dominant narratives have been actively constructed through policy documents, media representation, and exhibition spaces, emphasizing themes such as "industrial heritage renewal" and the clustering of "cultural and creative industries." These future-oriented discourses serve to reframe the post-industrial transformation in a positive light. In contrast, community residents' memories of the former factory, their attachment to the work-unit system, and their experiences of cultural disconnection and identity marginalization throughout the redevelopment process form an unofficial counter-discourse. Rather than directly opposing the official narrative, these local stories engage in an "interactive dynamic". Policymakers have selectively incorporated elements of community narratives, particularly those with positive emotional value, into heritage and tourism storytelling. However, this selective integration tends to marginalize expressions of loss, skepticism, and resistance, constituting what can be described as a state-led "curated fusion." In the Chinese socialist context, where the working class is valorized in official ideology, the identity of working-class residents is shaped differently depending on whether it is viewed through the lens of political propaganda or social reality (Xin & Xiaofan, 2020). While individuals may outwardly conform to dominant narratives, they also demonstrate active support for aspects that align with their class interests. This reflects a characteristic interplay between dominant and individual narratives in socialist systems, where conformity coexists with pragmatic negotiation.

7.2 The Complexity of Community Narratives and Narrative Aphasia

Former workers of the No. 2 Machine Tool Plant often articulate emotions marked by a mixture of pride and sorrow. Their narratives reflect both a sense of dignity rooted in their industrial past and grief over its loss. Family members of workers, particularly women in domestic roles, focus their narratives on the everyday spatial transformations, expressing a strong attachment to the worker community. Other long-term residents, such as original inhabitants or resettled households, have undergone a shift in identity from peripheral observers to engaged participants, due to the influence of industrial heritage discourse. In contrast, new residents primarily engage with the community through ownership or economic interest, reflecting a more instrumental orientation in their narratives.

A significant number of residents exhibit what may be termed "narrative aphasia" in the face of media interviews or official surveys. This silence does not stem from an inability to speak, but from a lack of appropriate discursive space within the dominant narrative. Some former residents expressed sentiments like "no one listens when we speak" or "we don't understand what is written," revealing a broader "loss of narrative agency." In other words, residents lack the authority to define or reinterpret the place they inhabit.

This discursive marginalization is rooted in structural constraints. Many residents share the belief that they have no control over their living environment. Although many are dissatisfied with their conditions, few are willing to voice complaints or seek change. A key reason lies in property rights: residents often possess only the right to renovate their interior living spaces, while control over streets and public infrastructure remains with government authorities. Another contributing factor is the enduring influence of collectivist ideology. As former dominant actors in the community, the working class and their families have long internalized a trust in and compliance with state policies, much like their acquiescence during deindustrialization. Meanwhile, other residents, marginalized for nearly 80 years, lack both the power and the confidence to articulate their concerns.

This exclusion from discourse is not merely an individual issue but a reflection of how narrative positions are stripped away through interactions with dominant discourses. These fragmented and non-mainstream narratives reveal the deep entanglement of historical trauma, identity anxiety, and cultural discontinuity.

7.3 Integrating Individual Narratives into Dominant Discourse to Enhance Community Belonging

Although the dominant narrative of NCP emphasizes "historical and cultural regeneration," it remains largely focused on the visual reproduction of space (Fig. 7), with limited incorporation of residents' collective memory. While some industrial artifacts have been preserved, the individual voices of the working class have been intentionally overlooked. This "depersonalized" approach to heritage transformation has led to a sense of disconnection and weakened identity attachment.

Figure.7. Factory structures preserved within NCP, photo by Wenjing Dong

Systematically incorporating individual narratives into dominant discourse constitutes a form of cultural justice. Resident narratives should not merely serve as resources for cultural tourism but ought to be embedded within spatial redevelopment, policy formulation, and participatory governance. Such integration can disrupt the unidirectional narrative dynamic of "government planning—resident compliance," and instead foster a co-creative, co-governed, and co-shared model of spatial governance. Moreover, narrative pluralism may alleviate intra-community tensions, strengthen social cohesion, and promote the transformation of industrial heritage sites into inclusive "heritage communities."

8 Conclusion

This study focuses on the narrative practices surrounding the transformation of NCP within the broader context of urban regeneration and industrial heritage redevelopment. Employing an interpretive qualitative approach, it uncovers the dynamic interaction between official narratives and individual community accounts, and explores how local identities are continuously negotiated and reconstructed through spatial restructuring and cultural reproduction.

Findings reveal that individual narratives are selectively excluded from official discourse. Both long-term and recent residents exhibit complex emotions regarding identity positioning and place attachment. This divergence highlights the heterogeneity of narrative positions and the risks of narrative silencing faced by marginalized groups within institutionalized discourses.

The study argues that incorporating diverse personal narratives into mainstream heritage discourse enriches cultural meaning and enhances community belonging and intergenerational continuity. It calls for a more inclusive "narrative governance" framework in heritage-led urban regeneration. Theoretically, the research extends the application of narrative identity theory to post-industrial spatial contexts, demonstrating that identity is actively constructed through individual responses to space and policy. Practically, it advocates for dialogic planning processes that recognize resident experiences as a source of heritage value. Furthermore, studying mixed-type industrial heritage can offer globally relevant perspectives, especially for cities undergoing industrial restructuring, demographic shifts, and cultural hybridity.

It is important to note that the study is based on a single case, which limits the generalizability of its conclusions. Future research could benefit from cross-regional comparisons to explore how residents engage with industrial heritage spaces in varied socio-spatial contexts. Additionally, integrating spatial analysis and participatory ethnography would further illuminate the mediating role of narrative in urban heritage landscape reconstruction.

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Research on Cultural Adaptation Mechanisms of the Duku Heritage Corridor Based on Heritage Ecosystems

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Abstract
The Duku Heritage Corridor is known as "China's Most Beautiful Highway",represents the the essence of the Tianshan World Heritage Scenic Byway. The 14th Five-Year cultural development Plan from China's central govemment emphasizes the importance of systematically protecting and utilizing historical and cultural heritage. Cultural adaptability plays an important role in achieving this balance by fostering harmony between cultural heritage and ecosystems. Through the creation of adaptive landscapes, integrating "ecological restoration - health restoration - cultural restoration - economic restoration", it is possible to ensure both preservation and sustainable use of heritage corridors.The Duku Heritage Corridor erves as a valuable case study for exploring how these principles can be implemented effectively.By analysing the "production space", "living space",and "ecological space" along the corridor, the research provides insights into how these spaces can coexist and support each other. The findings inform the development of a culturally adaptive management model that can guide route planning, infrastructure design, and conservation strategies. Ultimately, the proposed model offers a comprehensive framework for understanding the unique cultural and natural heritage of the Duku Heritage Corridor.

Keywords: Heritage ecosystems; Duku heritage corridors; multiple values; cultural adaptation mechanisms; digital management

1 Introduction

Since the promotion of the strategy of 'Tourism Development of Xinjiang' and the implementation of the project of 'Culture Runs Xinjiang', the regional government has made every effort to promote the development of Xinjiang's tourism industry. 2019, in order to promote the vigorous development of the new industry pattern of 'Transportation + Tourism In 2019, in order to promote the 'transport + tourism' new mode of vigorous development, the implementation of the regional party committee '1 + 3 + 3 + reform and opening up' for the precise poverty alleviation, rural revitalisation and vigorously develop the tourism industry deployment of the 'traffic and tourism exemplary project', in response to the traffic and transport In 2024, General Secretary Xi made an important instruction on tourism work, stressing that efforts should be made to improve the modern tourism system and accelerate the construction of a strong tourism country, promote the high-quality development of tourism to make a steady progress [1], shape the tourism with the culture, highlight the culture with the tourism, and protect the cultural heritage and ecological resources. By promoting the construction of 'full-time' tourism along the Dokku route and driving the development of the regional economy, it will help multi-ethnic areas to fight poverty.

Fig. 1 The Duku Heritage Ecosystem

The Dushanzi-Kuche Highway starts in the Dushanzi district of Karamay City in the north and connects with the city of Kuche in the Aksu region in the south, crossing the Tianshan Mountains in the north and south, with a total length of 561 kilometres. More than half of this part of the road crosses high mountains and canyons, connecting many ethnic minority areas; snow-capped mountains, canyons, lakes and grasslands cover nearly all of Xinjiang's topographical features. The Duku Heritage Corridor, a landmark natural-cultural landscape route in Xinjiang, is taken as the object of study to address the practical issues of strengthening infrastructure construction along the route, upgrading the quality of services, enhancing regional cooperation in the heritage corridor, and focusing on the sustainable development of the heritage ecosystem.

Emphasis is placed on the construction of ecological protection zones and cultural heritage protection zones [2], the use of big data, cloud computing, artificial intelligence and other modern information technologies to promote intelligent tourism, enhance the intelligent level of culturally-adapted management and services, strengthen tourism safety management, enhance security and emergency response systems, and undertake the mission of the times to promote the cultural adaptability of the Duku heritage ecosystem.(Fig. 1).

2 Related concepts

2.1 Adaptation of heritage ecosystems

In 2025, the Gunma Declaration introduced the concept of 'heritage ecosystems' [3], which aims to deepen the understanding of heritage by emphasising the interconnections between tangible and intangible, cultural and natural heritage. Adaptive heritage ecosystems emphasise the ability to respond to environmental change and the ability of ecosystems to repair and renew themselves. Through the creation of adaptive landscapes, integrating 'ecological restoration - health restoration - cultural restoration - economic restoration', it is possible to ensure the conservation and sustainable use of heritage corridors. Cultural adaptation of heritage ecosystems plays an important role in achieving a balance between cultural heritage and ecosystems by fostering harmony between them. Cultural adaptation of heritage ecosystems emphasises the integration of cultural heritage into modern life and sustainable development in a dynamic and changing social environment through living heritage, community participation, value transformation and institutional innovation, while maintaining its originality.

Adaptability requires the integration of heritage into modern life to avoid becoming 'museum specimens', and emphasises the need to maintain the authenticity and original protection of core cultural values of heritage in the process of adaptation. Cultural adaptation relies on the subjective status of the heritage-holding community, such as community empowerment. The right to information, participation and benefit-sharing of indigenous people in heritage management is clarified. Holistic conservation and systematic management break through the single heritage ontology and focus on the synergy of cultural ecosystems, whose adaptability ultimately serves cultural continuity and identity construction. Therefore, the cultural adaptability of the heritage ecosystem is essentially the resilience of guarding the cultural genes in the midst of changes: it is necessary to abide by the bottom line of originality and innovate the inheritance path; it relies on the endogenous dynamics of the community as well as the exogenous support of the system and science and technology. The ultimate goal is to make cultural heritage a 'living tradition' through dynamic balancing, so as to continuously nourish the national spirit and modern civilisation.

2.2 Discriminating between resilience and adaptability

The Duku Highway Cultural Landscape Corridor is a major transport route connecting the north and south of the Tianshan Mountains, and its mode of protection should be resilience and sustainable management. The word 'resilience' (resilience), meaning 'recovery to the original state' is divided into three dimensions, namely: resistance (Resistance), recovery (Recovery) and evolution (Renewal). The main purpose of the project is to assess the cultural landscape of Duku. The main focus is on the adaptation of living conservation, the stabilisation of holistic conservation, and the promotion of regenerative conservation of the Duku cultural landscape corridor. Fabrizio Aimar explored the possibilities of cultural landscape resilience in his book Cultural Landscape Resilience: a Perspective on UNESCO World Heritage Sites, where the study emphasised the necessity of building an integrated management system and a heritage space that is more capable of responding to continuous change, and proposed the need to build an integrated management system and a heritage space that is more capable of responding to continuous change, as well as to build an integrated management system, and proposes a resilience management model with multidimensional synergistic enhancements [4].

Therefore, in the context of the Dokku Heritage Corridor, cultural adaptability is reflected in the 'adaptability' of communities and herders along the route to respond to external changes in the tourism economy brought about by the opening of the highway, and to take the initiative to adjust their economic models, such as the operation of B&Bs, service modes, or forms of cultural display; and cultural resilience emphasises the 'ability to maintain and rebuild' the ecological outlook of these communities after experiencing the impacts, Cultural resilience [5], on the other hand, emphasises the ability of these communities to maintain their core values such as ecological outlook, identity, traditional festivals or key rituals, and social structures to resist dissolution, maintain stability and achieve innovative inheritance after experiencing impacts . In short, adaptability is about 'how to change flexibly in order to adapt to new environments', while resilience is about 'how to protect and revitalise the core in the face of change'.

3 Adaptive mechanisms for the Duku Heritage Corridor

3.1 Mechanism for the Integration of Tourism

With the continuous promotion of the strategy of 'Tourism to Develop Xinjiang' and the in-depth implementation of the project of 'Culture to Run Xinjiang', the regional government is making every effort to promote the rapid development of tourism in Xinjiang. Since 2019, the regional party committee has put forward the '1+3+3+Reform and Opening Up' work deployment, aiming to promote poverty alleviation and rural revitalisation as well as the further development of tourism through the development of tourism. In order to implement this deployment and promote the development of the new industry of 'transport + tourism', the regional government has launched the 'Transport and Tourism Exemplary Project'. The project aims to respond to the support of transport to the development of culture and tourism [6], and at the same time expects the development of culture and tourism to feed back to transport, so as to achieve the positive interaction and common prosperity of the two. As an important corridor connecting the northern and southern parts of the Tianshan Mountains in Xinjiang, the Duku Heritage Corridor, with its unique geographical location and spectacular natural scenery, has become a typical example of the deep integration of transport and tourism. It has become a typical representative of promoting the deep integration of transport and tourism.

3.2 Mechanism of cultural and tourism integration

The cultural and tourism integration value of the Duku Heritage Corridor mainly consists of 'minority cultural value + tourism' and 'red cultural value + tourism', which fully embodies the functional value of guaranteeing ancient social and economic development, contemporary military defence and cultural exchange. The history of Duku Highway can be traced back to the ancient Mengkede Road at K625 Road Marker, as the predecessor of Ili section of the original Duku Highway, there are still traces of the national defence and war preparation highway that had been constructed in April 1964, when Chairman Mao issued the instruction of 'activating the Tianshan Mountain', and the road, which started from Dushanzi in the north and went to Kuche in the south, was completed and opened to traffic in September 1983, in order to communicate with the traffic along the north and south of the border. In order to communicate with the north and south of the border and increase the unity of the various ethnic groups along the route, during the many years of arduous road construction, 168 PLA soldiers were killed in avalanches [7], mudslides and other causes, and were buried in the Chorma Martyrs' Cemetery along the route, and a Dokoukou Highway Museum was built to commemorate this epic piece of road-building culture (Fig. 2).

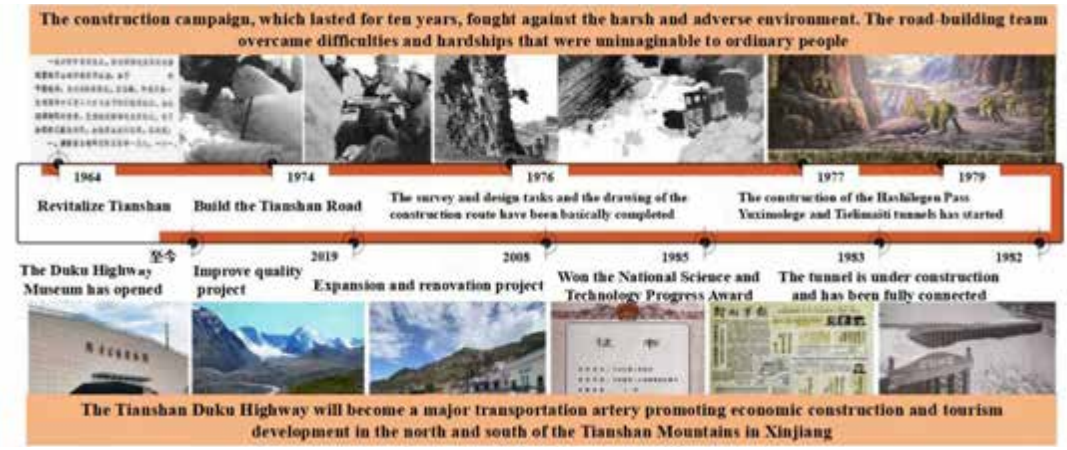

Fig. 2 History of the Duku Highway

In addition, Duku Cultural Landscape Corridor presents the most significant minority cultures as Donggui culture, Guzi culture, monuments, Ovoo, grottoes, murals and other cultural relics witnessing the diversity of roadside culture, while shouldering the responsibility of protecting, managing and demonstrating the use of the roadside cultural relics of the times.

3.3 Mechanism of production and tourism integration

The value of industry-tourism integration of the Duku Heritage Corridor lies in the sustainability of resource protection and management along the route, which improves the regeneration of the heritage sites, nature reserves, characteristic landscape nodes and parking spots in the road area, thus enhancing the effectiveness of the production space along the route. The translation value of its production and tourism integration value consists of the resource utilisation value and the socio-economic value brought by tourism, which can be broken down into the tourism resource value and the industrial resource value [8].

Duku Highway also has a very high value of tourism resources, and the natural and humanistic scenic spots along the way, such as Narathi Grassland Scenic Area, Jorma Scenic Area, Big and Small Dragon Pools, Bayinbruk Grassland and so on, have attracted many tourists from home and abroad for sightseeing and travelling, which brings the social and economic value and the popularity of the transport-tourism linkage. Duku Highway along the rich industrial resources, including tourism, including animal husbandry, mineral resources, water conservancy and hydropower resources, emerging industries and other industrial resources value, while the industry empowers the protective development of resources along the Duku Highway to promote the maximisation of socio-economic value, and together to create the 'Corridor Economy' of the value of the integration of the industry and tourism.(Fig. 3).

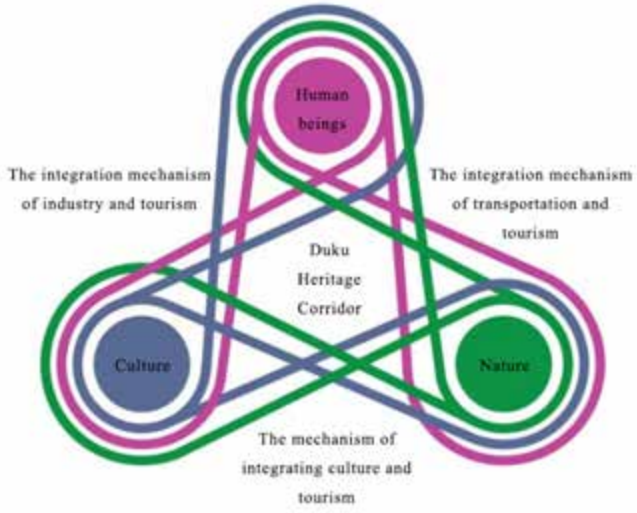

Fig. 3 Adaptive mechanisms for the Duku Heritage Corridor

4 Heritage Ecosystem Utilisation Pathways in the Duku Heritage Corridor

4.1 Zoning protection for ecological restoration-healthy recovery

The Duku Heritage Corridor Plan divides the Duku Highway into six regions based on the principles of resource similarity, cultural uniqueness, and regional coordination, including the Kuiduwu Area, the Qorma-Tangbra Area, the Nalati-Gongnaix Area, the Bayinbruk-Bayin Goleng Area, the Dalongchi -Yanshigou Area, and Baicheng County-Kuche County Area.

(1) Rational development of regional tourism resources

Tourism resources such as landforms, forests, scenic spots, water conservancy, humanities, wetlands, etc., should be reasonably developed and used, and all kinds of material and non-material resources with tourism and sightseeing value should be reasonably developed and utilised and perpetually used. Develop red tourism resources rich in local characteristics.

(2) Drive the tourism service industry, catering and accommodation industry, tourism equipment and other industries

Invest and operate in scenic spots, develop speciality tourism commodities, and turn local specialties into tourism commodities; use intangible cultural heritage as a carrier to develop a strong experience, entertainment and playability.

(3) Create a favourable atmosphere conducive to private tourism investment

Vigorously publicise national policies and the State Council's preferential policies and initiatives on encouraging, supporting and attracting the development of private capital, and vigorously promote and publicise the positive role and contribution of private capital in increasing the supply of tourism, meeting the needs of tourists, optimising the industrial structure, and enhancing the strength of economic development.

(4) Developing various types of tourism products along the route

Cultivate eco-tourism, forest tourism, trade tourism, study tourism and other tourism products according to local conditions, cultivate tourism products such as 'Nongjiale' and leisure farms, and actively cultivate leisure and tourism tourism products. Within the scope of the Duku Scenic Byway, except for the ecological conservation area, scenic restoration area and scenic excursion area, all other areas are the development control area. Within the development control area, the original land use pattern can be retained, and locally suitable tourism facilities and projects can be arranged for the orderly production, operation and management of the area; however, the scale and intensity of all facilities should be controlled, and be compatible with the environmental carrying capacity of the scenic area, and the three-level protection is implemented [9].

Through the zoning protection of the Duku scenic area, it forms a regional cycle of development and promotes regional tourism development, and has a positive demonstration and promotion effect on the construction of the Duku National Park Road.

Fig. 4 General road map of the Duku Highway
Photo credit: Author's own drawing

4.2 Segmental revitalisation of health restoration and cultural restoration
Through the G217 Dushanzi to Kuqa section of the highway 'traffic + tourism' service quality improvement project, a tourism corridor from the icebergs to the grassland is formed, displaying the natural landscape, history and culture and ethnic customs.(Fig. 4).

Create a high-quality demonstration highway with national influence, a model in Xinjiang and an industry leader in the integration of 'traffic+tourism'; create a world natural cultural heritage tourism highway (because of the Bayinbruk natural cultural heritage along the route, it is recommended to build a world natural heritage scenic road), the first red tourism highway to show the spirit of road building (because of the Qorma martyrs along the route), and the first red tourism highway to show the spirit of road building (because of the Qorma martyrs along the route). (because of the combination of five scenic spots: the scenic beauty of Tianshan Mountain, the scenic beauty of rivers and lakes, the scenic beauty of the countryside, the scenic beauty of canyons, and the scenic beauty of Yadan, Xinjiang's first tourism highway is proposed), the cultural card of showcasing the regional flavour of the Dukui Highway, and the provision of a smooth, safe, comfortable and beautiful driving environment and infrastructure (Tab. 1).

Tab. 1 Cultural Interpretation of Overall Line Sections

county and city	Pre-designed points for road space	Road elevation	cultural interpretation	Heritage ecosystem use pathways
Dushanzi District (starting point)		H0.75 km	The Red Heritage	Realising the integration of transport and tourism + cultural tourism

Wusu city in Xinjiang		H3 km	Geology Expo	Realising the integration of transport and tourism + cultural tourism
Nilka County		H2.26km	The Red Heritage	Realising the integration of transport and tourism + cultural tourism
Xinyuan county		H1.8km	natural landscape	Realising the integration of transport and tourism + agri-tourism
Hejing County		H2.25km	(Natural Landscape) Donggui Culture	Realising the integration of transport and tourism + agri-tourism
Baicheng County		H1.025km	Geology Expo	Realising the integration of transport and tourism + cultural tourism
Kucha City (end point)		H1.05km	(Geological Expo) Guzi Culture	Realising the integration of transport and tourism + cultural tourism

4.3 Multi-point enhancement of cultural and economic recovery

The Duku Highway connects many ethnic minority settlements and always puts the improvement of highway safety in the first place. In the near future, it mainly improves the safety and accessibility of the Duku Highway, and focuses on the treatment of road diseases that can be implemented at present and have an important impact on the improvement of the access conditions; it also strengthens the function of tourism services, and improves the sightseeing stops, signage systems, service areas, parking areas and other ancillary service facilities in suitable areas along the route; and it also improves the road appearance and the road environment to beautify the highway tourism environment. Improve the road appearance and road environment, and beautify the highway tourism environment. The medium- and long-term goals can be summarised as strengthening itself, promoting integration and leaving interfaces [10]. On the basis of guaranteeing the safe passage of highways and upgrading the quality of road surfaces, we will focus on the development of traffic+tourism integration into the industrial system, actively create the form of traffic+tourism industry, and build a high-quality highway for the integration

and development of 'traffic+tourism'.

5 Conclusions and Implications

5.1 Rationalisation of thematic mountain landscapes for travelling through the seasons

Due to the special climatic conditions and unique topography, four-season access to the Duku Highway is not yet possible. AI can process and analyse a large amount of environmental monitoring data, such as temperature, humidity, light, etc., so as to detect potential risk factors in time and prevent the risk of damage to the Duku Heritage Corridor. By analysing and monitoring data through machine learning algorithms, AI can predict the maintenance needs of heritage corridors and help managers plan maintenance work in advance to extend the life of the heritage. The term 'Digital Intelligent Conservation' [11].usually has two meanings: one is to make physical conservation more scientific through digital technology and intelligent management, such as better detection of diseases, more accurate identification of roadblocks and deformation of roadbeds, etc.; and the other refers to the fact that we use modern digital intelligence technology to digitise the heritage corridor itself and even the road environment and the view-scope landscape in a complete and holistic manner. Secondly, through modern digital intelligence technology, we can collect, reconstruct and present the heritage corridor itself and even the road environment and the landscape within the line of sight in a complete and full-fledged way, and save it as 'data' permanently. At the same time, the AI system can provide decision-making support for managers based on historical data and real-time conditions, such as emergency response strategies under extreme weather conditions, real-time broadcasting of the tour theme of the road section in front so as to make the heritage corridor culturally activated, on-site, and scenario, and thus promote the effective development of the construction of the 'all-time' tourist sites along the Duku Heritage Corridor.

The Duku Heritage Corridor is a 'full-time' tourist destination. With the development of modern science and technology, intelligent monitoring management system and computer network technology has been further optimised and improved. The construction of highways has also entered the era of intelligent transport, and intelligent service areas with higher service levels and more personalised functions have also emerged. Therefore, the digital intelligent management of heritage corridor is a systematic project covering many aspects, involving data collection, analysis and processing and application implementation. In concrete implementation, it is necessary to combine modern information technology, such as artificial intelligence, big data analysis, cloud computing and other technical means, to achieve effective protection and rational use of heritage corridors.

5.2 Systematic cognition of cultural landscape corridors of heritage world heritage sites

The core of the cultural landscape corridor as a world heritage site is to focus on the historical and human resources along the route, and the organisation of traditional festivals and events to bring economic benefits and brand economic benefits. With the development of artificial intelligence and machine learning technology, the accuracy of image recognition has increased dramatically, allowing for the automatic identification of past image data of the heritage corridor and its restoration. Using digital twin technology, panoramic 3D modelling and other technologies, the collected data can be transformed into virtual models, providing intuitive and accurate information support for management. Acquire high-precision images and 3D models of various types of natural-cultural heritage in the heritage corridor and accurately digitally record them, and provide support for the restoration of complex heritage corridor environments through the establishment of high-precision 3D models.To support this analysis, advanced methods such as digital footprint and user-generated content (UGC) from social media are utilized to capture and evaluate public interactions with the heritage corridor (Fig. 5).

The implementation of intelligent heritage and cultural corridor details and purposes can fully mobilise the enthusiasm of all stakeholders in the region along the route - including local government departments and other community groups of non-government organisations, increase the overall economic income of the region through the development of the regional economy of the road section, and enhance the attention and participation of all sectors of the community in the digital management of the heritage corridor. Enhance the community's interest and participation in the digital management of heritage corridors. Establish a digital archive of the heritage corridor for long-term preservation of heritage information to facilitate historical research and comparison of data for future restoration. Using the Internet platform, the results of the digital restoration will be shown to the public in the form of a virtual exhibition, so as to expand the dissemination of the culture of the Duku heritage corridor.(Fig. 6).

Fig. 5 The Duku heritage corridor is rich in multiculturalism

Fig. 6 The Cultural Inheritance Base of the Duku heritage corridor Area

5.3 Digital restoration of exemplary national parkways with Chinese characteristics

In addition to this, VR/AR technology is utilised to provide the public with an immersive experience of touring the heritage corridor, enhancing their knowledge and understanding of the cultural heritage. Introduce interactive technologies [12], such as intelligent guide systems and interactive exhibitions, to bring the stories of the exhibits to life and enhance the visitors' experience. Carry out monitoring and big data analysis of important historical and cultural heritage sites, nature reserves, special viewpoints, parking spots, etc. in the road area to monitor the status of the heritage in real time and carry out preventive protection of the heritage corridor. Comprehensively improve the supporting service facilities such as sightseeing stops, signage systems, service areas, parking areas and other facilities at suitable locations along the Duku; intelligent car park management system, road safety monitoring system, cable broadcasting management system, road traffic signal transmission and guidance system, WiFi network hotspot coverage management system, and high-definition bayonet anti-evasion management system. Developing intelligent systems for automated diagnosis, comprehensively applying modern information technology means, starting from data collection, management, display, dissemination, research, monitoring and other aspects, automatically identifying damages and diseases in the natural-cultural heritage, and improving the relevance and efficiency of regular segmented restoration work, as well as using robots to fine tune restoration operations in high-risk or manpower-intractable areas, such as high-altitude tunnels, traffic site areas. It is also necessary to consider factors such as regulatory and policy support, financial and human resources protection, etc., to comprehensively improve the systematic protection and digital intelligent management level of the Duku Heritage Corridor, gradually realise the digital transformation of the whole road section and the whole network of heritage sites, to form a provincial intelligent heritage corridor system, to promote the development of an intelligent restoration management system of the heritage sites, to let the public understand the importance of digital restoration, and to enhance the public's cognition of the multifaceted value of heritage protection and the national Parkway construction participation.

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A Study on the Evolution Characteristics of the Spatial Layout of The Mountain Fortress System of Sichuan and Chongqing in China during the Song and Yuan Wars

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Abstract
The Song-Yuan Mountain Fortress System in the Sichuan-Chongqing region of China emerged from the 13th-century conflict between East Asian agrarian and nomadic civilizations. Preserving military engineering relics from both the Song and Yuan dynasties, it reflects the historical evolution of diverse civilizations in the region. This study employs GIS tools and knowledge graph technologies to analyse the mountain fortress system, identifying key value elements and their interconnections. By examining the socio-economic context of Sichuan, China, during the Song-Yuan wars, the research explores the factors and internal logic shaping spatial pattern evolution, aiming to support the comprehensive preservation of the system in the Sichuan-Chongqing region.

Keywords: Song-Mongol (Yuan) Wars; Mountain Fortress Defence System; Value Elements; Spatial Patterns; Holistic Conservation

1 Introduction

1.1 Background

Military cultural heritage is a product of history, with historical value reflecting its intrinsic nature. It encompasses the remains, artifacts, and the entire historical evolution formed by successive generations through military activities, as well as the comprehensive development process of these activities[1]. With the continuous advancement of international concepts for historical and cultural heritage conservation, holistic and integrated protection has gradually become the mainstream approach, and the types of heritage preservation have increasingly diversified. Against this backdrop, military heritage has emerged as a significant topic in the global field of heritage conservation, garnering growing attention from professionals in the discipline. Military heritage not only holds profound historical value but also plays an indispensable role in shaping national cultural identity and preserving historical memory.

The Southern Song Mountain Fortress Sites in Sichuan, China, or the "Sichuan-Chongqing Song-Yuan Mountain Fortress Sites," is the collective designation for the remnants of a system of mountain fortresses—combining newly planned administrative cities and military fortifications—entirely reconstructed in the Sichuan theater during the late Southern Song period amid the Song-Yuan wars[2]. These Sichuan-Chongqing Song-Yuan Mountain Fortresses represent the most intact ancient administrative urban system preserved in China, exemplify the historic use of mountainous and riverine landscapes to establish cities and regional defenses via land and water routes, and constitute the finest material evidence of the Song-Yuan conflicts in China's Sichuan-Chongqing region.

1.2 Overview of the Study Area

Geographically, "Chuan-Yu" denotes the broad region centered on China's Sichuan Basin, extending into southern Shaanxi, western Hunan and Hubei, northern Yunnan and Guizhou, and lying east of the Hengduan Mountains along the Jinsha River. This area corresponds to the territories administered by Ba, Shu, Hanzhong, and the various Nanzhong commanderies during the Qin and Han dynasties. Surrounded by mountain ranges—the Daba and Micang Mountains to the north, the Dalou Mountains to the south, the Hengduan Mountains to the west, and the Wuling Mountains to the east—the Sichuan Basin forms a relatively enclosed geographic unit[3]. Its periphery comprises the Three Gorges of the Yangtze River to the east, the Yunnan–Guizhou Plateau to the south, the Qinghai–Tibet Plateau to the west, and the Daba Mountains to the north, while its basin floor is divided into the eastern Sichuan parallel ridge-valley system, the central Sichuan hills, and the Chengdu Plain in western Sichuan (Figure 1).

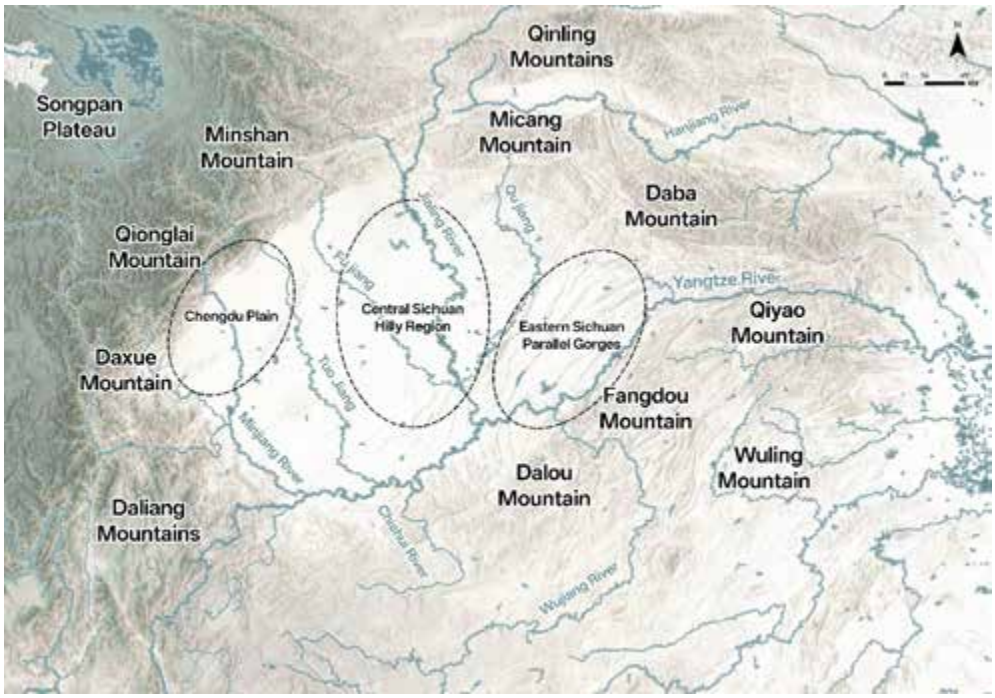

Figure 1 Geographical Division of China's Sichuan Basin (Source: the author)

In the fourth year of the Xianping era during the Northern Song Dynasty (1001 AD), the imperial court divided the former Ba-Shu region into four administrative circuits: Yizhou (present-day Chengdu, China), Zizhou (present-day Santai, China), Lizhou (present-day Guangyuan, China), and Kuizhou (present-day Fengjie, China). Collectively known as the "Four Lu (Circuit) of Chuanxia" or the "Sichuan Lu (Circuit)," these regions later gave rise to the abbreviated name "Sichuan." During this period, official positions such as the Sichuan Pacification Commissioner and Sichuan Military Commissioner were established. Historically, the water-rich Jianghuai region of China was easily defensible and difficult to attack. Northern campaigns to conquer the south, such as Emperor Wu of Jin's subjugation of Wu, Emperor Wen of Sui's destruction of Chen, and Emperor Taizu of Song's pacification of the Southern Tang—all involved first seizing Sichuan to control the Yangtze River, then advancing eastward along its flow. The strategists within the Mongol army likewise held this view[4].

1.3 Literature Review

Recent years have witnessed scholarly research on the Song-Yuan Mountain Fortress System in the Chuan-Yu region of China. For instance, Peng Feng's "Fortifying Cities to Hold Ground" and "Mutual Support between Jing and Shu": Adjustments in Late Southern Song Sichuan Defense Policies and Their Impact analyzes strategic shifts in the Southern Song's defensive policies before and after the Battle of Diaoyu Fortress, exploring their profound influence on the overall defensive framework of Chuan-Yu[5]. Wang Zhejun's Administrative and Economic Operations of the Mountain Fortress System in Sichuan During the Song-Mongol (Yuan) War investigates the economic and political characteristics of the region during the conflict[6]. Li Zhen's Characteristics of the Southern Song's Anti-Mongol Mountain Fortress Defense System in the Upper Yangtze from a Cultural Landscape Perspective examines the correlation between the fortress system layout and major transportation networks through spatial distribution and site selection[7]. Collectively, academic research has made progress in understanding the policies, economic conditions, defensive morphology, and spatial patterns of the Chuan-Yu region of China during the Song-Yuan wars. However, studies on defensive spaces largely remain confined to the "Eight Pillars of Sichuan" framework, lacking regional or holistic perspectives. Furthermore, research on the evolving spatial patterns and characteristics of fortresses across different phases remains inadequate.

Regarding GIS and knowledge graph technologies in heritage conservation, Hu Mingxing's Application of GIS Technology in Historical Neighborhood Conservation Planning establishes a GIS-based methodology for surveying, protecting, and planning historical districts[8]. Zhan Qingming's Suitability Analysis of Heritage Corridors Based on GIS and RS develops a landscape resistance evaluation system to assess corridor viability[9]. Xie Yongjian's

Knowledge Graph Construction for Shanghai's Outstanding Historical Buildings creates an associative network for 150 historic buildings, enabling single-attribute and cross-conditional searches while exploring shared traits and latent patterns[10]. Liu Yanchao's Digital Knowledge Graph for the Central Axis' Artistic Value Based on Neo4j proposes an AI-powered approach to excavate and interpret heritage values, using Beijing's Central Axis to reveal traditional Chinese philosophical essence across four dimensions[11]. Overall, domestic GIS applications in heritage conservation prioritize risk management and data mapping, with limited spatial feature analysis. Knowledge graph research in this field remains scarce, predominantly focusing on historic architecture or summarizing trends via CiteSpace, lacking urban/regional-scale studies and failing to reflect spatial distribution and evolution across historical periods.

Therefore, this study will apply emerging technological means to understand the spatial evolution characteristics of the Song and Yuan Mountain Fortress System in the Sichuan-Chongqing region of China. By using GIS tools, the coupling relationship between the mountain fortresses and ancient roads, water systems, and mountains in the Sichuan-Chongqing region during the Song and Yuan Dynasties will be explored. The distribution of mountain fortresses and the defense focus in different historical stages will be analyzed, and the spatial distribution characteristics of the mountain fortresses in the Sichuan-Chongqing region during the Song and Yuan Dynasties in each historical period will be summarized. Moreover, by combining knowledge graph technology, relevant historical materials and documents will be sorted and summarized, and the political and economic environment of the mountain fortresses in different stages in the Sichuan-Chongqing region during the Song and Yuan Dynasties, as well as the interrelationships among the mountain fortresses, will be revealed through visualized graphs.

2 Methodology

2.1 Research Objects

2.1.1 Sichuan-Chongqing Song-Yuan Mountain Fortress System

The Song-Yuan Mountain Fortress System in the Sichuan and Chongqing region of China is the most direct and intense product of the conflict between agricultural and nomadic civilizations in East Asia in the 13th century. It preserves the military engineering remains of both the Song and the Yuan (Mongol) sides, providing a complete witness to the conflict, exchange, and continuous integration between the two civilizations. The ideas of city defense system construction, military governance models, and engineering facilities reflected by it are the concentrated embodiment of outstanding military thoughts in ancient China in military engineering. At the same time, it also shows the confrontation and confrontation between the two sides of the war based on different military guiding thoughts in terms of offensive and defensive strategies, tactical methods, and engineering construction techniques. From the purity of the construction reasons, the particularity of the social environment at that time, the readability of the existing sites, as well as the war results and far-reaching influence, the Song-Yuan Mountain Fortress System in Sichuan and Chongqing is the most representative military heritage discovered so far, which can comprehensively reflect the historical evolution pattern of different civilizations in East Asia in the 13th century.

2.1.2 Sichuan-Chongqing Song-Yuan Mountain Fortresses

In the late Southern Song period, the Mongol army launched a massive invasion and occupied half of the territory, including Chengdu, the capital of Sichuan, China. The defensive system originally established by the Song dynasty along the mountainous edges of the Sichuan Basin collapsed. The Southern Song-controlled areas in Sichuan, China, found themselves in a situation devoid of natural defenses. To secure Sichuan as a strategic upper-reach shield of the dynasty's remaining territory, the Southern Song court intensified its defensive arrangements in the region. It began to construct fortifications by taking advantage of the natural barriers formed by mountains and rivers. Mountain fortresses and naval stockades were built at strategic points along the three major north-south rivers within Sichuan—namely, the Jialing River, the Tuo River, and the Min River—as well as along the east-west Yangtze River, which forms after the confluence of the three. Existing prefectural and county seats, which lacked sufficient natural defenses, were relocated to these mountain fortresses and water-based strongholds to counter the tactical superiority of Mongol cavalry. As a result, a defense system was formed that combined mountain and river fortifications as strategic nodes and used rivers as connecting lines, creating a coordinated network of mutual support between points and lines[12].

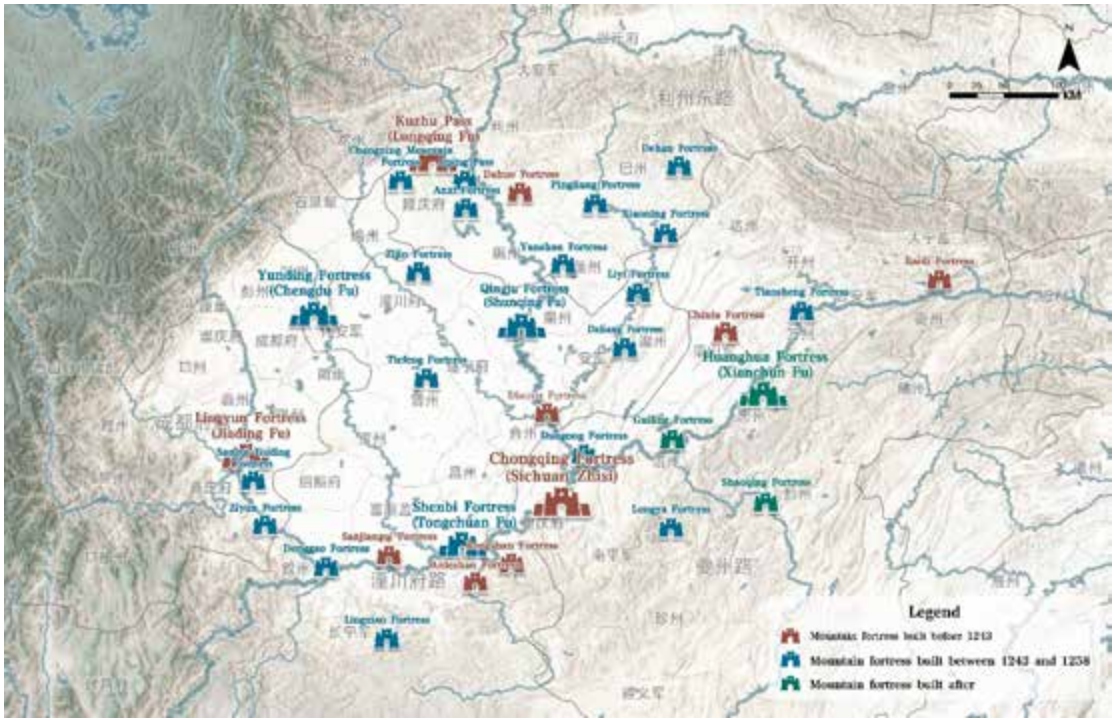

Figure 2 Distribution Map of Mountain Fortresses Built by the Song Military in Different Periods (Source: the author)

The Song Dynasty implemented a three-tier administrative system comprising Lu (Circuit), Fu/Zhou/Jun/Jian (Prefecture, Subprefecture, Military districts), and counties (Xian). Additionally, it also established overarching positions such as Xuanfushi (official positions in ancient China) or Anfu Zhizhishi (official positions in ancient China) to supervise multiple Lu. During the Southern Song period, the strategic demands of resisting northern invasions led to the progressive expansion of the Anfu Zhizhishi's authority in Sichuan, China. This elevated the role into a chief administrator overseeing military affairs, civil governance, and fiscal administration across all Lu. Consequently, Sichuan's mountain fortresses during the Song-Yuan War were organized into four administrative tiers aligned with this structure: Zhishi (overseeing the military affairs of a theater of war), Lu, Fu/Zhou/Jun/Jian, and county (Figure 3).

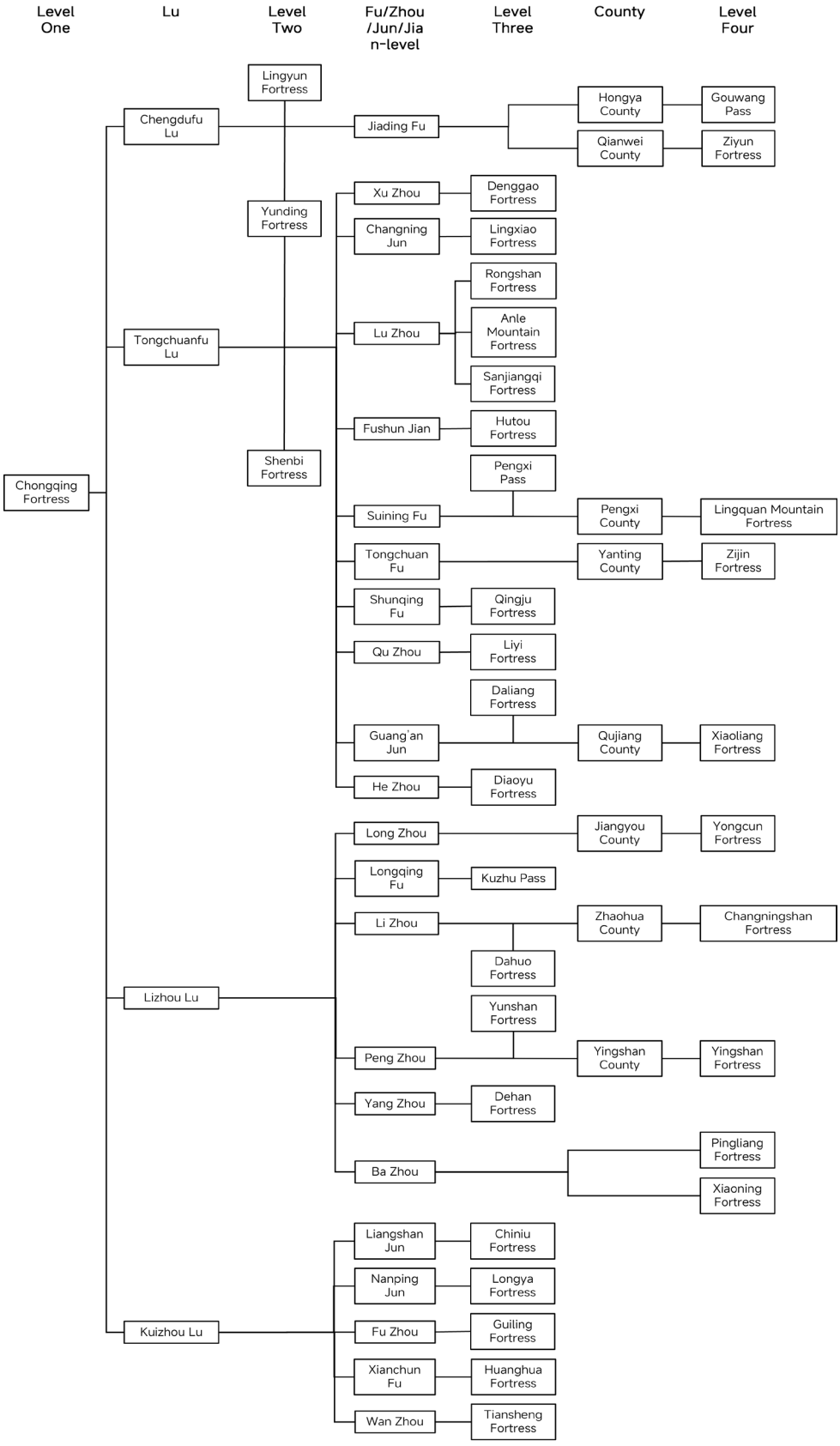

Figure 3 Administrative Hierarchy and Jurisdictions of Mountain Fortresses (Adapted from Zhou Siyan, 2017)

According to archaeological field investigations, no fewer than twenty identifiable Southern Song Mountain Fortress Sites remain within the Sichuan region of China[14]. Almost without exception, these mountain fortresses were constructed atop steep and rugged mountain peaks. After the conclusion of the Song-Yuan wars, administrative centers were relocated back to plains or gently sloping areas, resulting in minimal subsequent urban development that might have caused damage to these sites. As a result, the architectural structures of these mountain fortresses have been largely preserved, with many Song-era city walls still clearly visible today. Notably, nine city gates from the Song dynasty have survived, providing invaluable physical evidence for contemporary research into the history of the Song-Yuan wars, urban development, mountain fortress architecture, and the regional history of the areas where these fortresses are located[2].

2.2 Materials and Methods

2.2.1 Research Materials

This study draws upon archaeological literature, contemporary scholarship, and field investigations, utilizing materials including the History of Song, History of Yuan, and local gazetteers. Research materials were sourced through multiple channels such as library collections, CNKI (China National Knowledge Infrastructure), and Web of Science. An extensive review of domestic and international literature concerning military site research, the formation and development of the Song-Yuan Mountain Fortress System, and spatial morphology analyses of individual fortresses was conducted to comprehend current research trends and findings. Primary sources comprise the History of Song, History of Yuan, and Comprehensive Historical Events of Song, supplemented by local chronicles, publications on Chinese military history, and relevant academic papers. Through documentary analysis, the historical trajectory of the Song-Yuan conflicts in the Chuan-Yu region and the developmental stages of the Song Mountain Fortress System were systematically examined, laying the groundwork for subsequent GIS analysis and knowledge graph construction.

Figure 4 Related Reference Texts (Source: the author)

2.2.2 Geographic Information System

A Geographic Information System (GIS) represents an integrated information technology encompassing disciplines including geography, surveying, and computer science[15]. It constitutes a technical framework operating under computer hardware and software support for capturing, storing, managing, processing, analyzing, displaying, and describing geographically distributed data across the Earth's surface and near-surface atmosphere.

Within China's cultural heritage sector, GIS applications primarily focus on three domains: heritage conservation management platforms, visualization research for archaeological information, and disaster risk assessment of cultural assets[15]. Simultaneously, GIS facilitates spatial data management through capabilities for storing, editing, querying, and symbolizing historical heritage data, thereby providing geospatial support for knowledge graph construction. Leveraging GIS spatial analysis functions enables the identification of proximity and connectivity among geographical entities, revealing spatial distribution patterns of historical heritage.

2.2.3 Knowledge Graph

The concept of the knowledge graph was originally proposed by Google as a semantic network that describes relationships between entities. Knowledge graphs can be categorized into general knowledge graphs and domain-specific knowledge graphs based on their usage and scope. General knowledge graphs have broad coverage but limited depth of research. In contrast, domain-specific knowledge graphs focus on particular fields, requiring more rigorous data schemes and enabling deeper exploration. A domain-specific knowledge graph consists of a schema layer and a data layer and utilizes domain ontology technologies to transform unstructured data into structured data[16]. Within this framework, nodes are composed of entities, such as concepts, people, or objects, and form a network through interconnections defined by relationships and attributes.

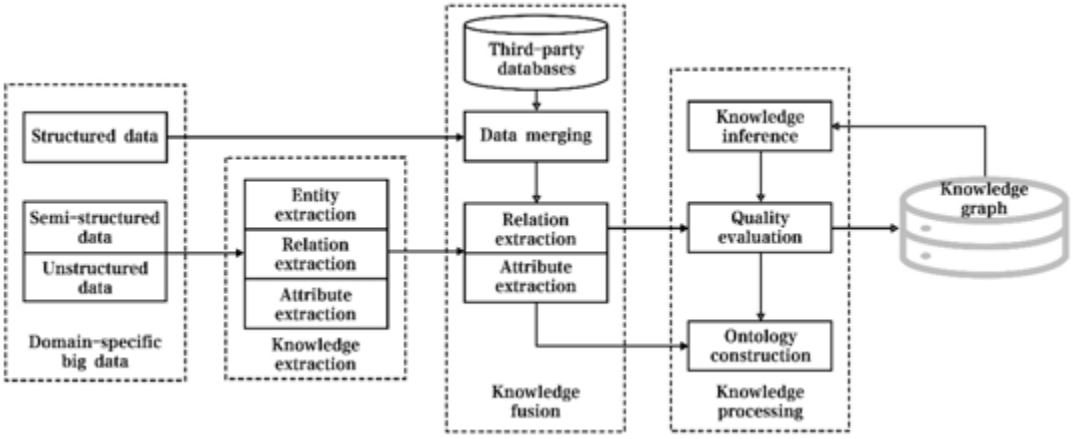

Figure 5 Architectural Framework of Domain-Specific Knowledge Graphs (Adapted from Liu, Y.C., 2020)

In a domain-specific knowledge graph, an ontology refers to a formalized framework that provides explicit definitions of entities and the relationships between them, serving as an abstract model for representing the objective world. The methods for constructing ontologies vary according to the needs of different domains and are mainly divided into bottom-up and top-down approaches. The bottom-up approach extracts entities, relationships, and attributes directly from underlying data before integrating them, and is more suitable for general knowledge graphs. The top-down approach involves constructing a domain ontology first, which then constrains and guides the structuring of data. Typically, domain-specific knowledge graphs adopt a combination of top-down and bottom-up approaches to meet the requirements for depth and accuracy within a specific field.

3 Spatial Evolution Characteristics Analysis of the Sichuan-Chongqing Song Army Mountain Fortress System Based on GIS

3.1 Kernel Density Analysis of Mountain Fortresses

The Kernel Density tool in ArcGIS calculates the density of point features around each output raster cell, aiming to identify areas of concentrated density and variations in distribution. In this study, 46 mountain fortresses with relatively well-defined geographic coordinates were selected based on historical documents and relevant local gazetteers. Combined with analytical results and the geographical division of the Sichuan Basin of China, it can be observed that Song Military Mountain Fortresses in the Sichuan-Chongqing region of China were primarily concentrated at the junction of the Jialing River and the Qinling-Daba Mountains, along the Jialing River, at the confluence of the Jialing River and the Yangtze River, along the Min River, and at the junction of the Yangtze River and the Wushan Mountains.

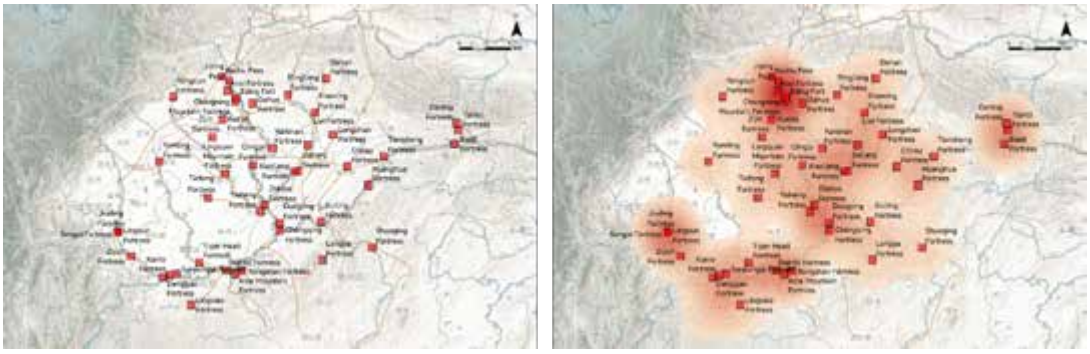

Figure 6 Kernel Density Analysis of the Song-Yuan Mountain Fortress System (Source: the author)

The ancient Qin-Sichuan route connected the Guanzhong Plain with the Sichuan Basin, organically linking most of the historical towns in the Shaanxi region of China. The distribution of historical and cultural relics along the Shu Roads, as well as the spatial patterns of historical towns, can be categorized into five major historical and cultural regions based on administrative divisions: the Guanzhong region, the Hanzhong region, the Guangyuan region, the Chengdu region, and the Chongqing region. As a historical cross-section, the system of Song-Yuan Mountain Fortress sites serves as a significant entry point for studying the military defense system along the ancient Shu Roads, the dynamic relationship between transportation and regional control, the integration of diverse cultures, and contemporary heritage conservation[17].

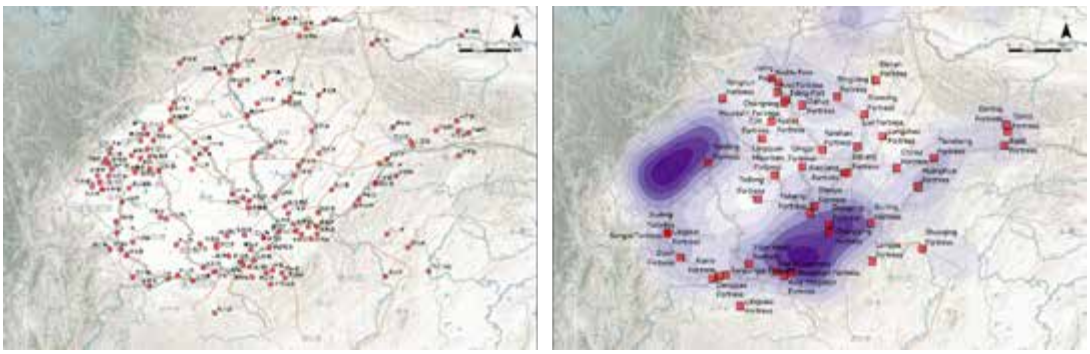

Figure 7 Kernel Density Analysis of Historical Settlements in the Sichuan-Chongqing Region of China (Source: the author)

By conducting a kernel density analysis of 155 historically significant settlements along the Qin-Sichuan route and overlaying it with the kernel density analysis map of the Song-Yuan Mountain Fortress system, it is evident that the overall distribution of mountain fortresses generally aligns with that of ancient settlements. The only notable exception is the Chengdu Plain of China, where numerous settlements are present, yet few mountain fortresses were constructed to guard Chengdu. This may be attributed, first, to the relatively flat terrain of the Chengdu Plain, which lacks natural defensive barriers, prompting the Song military to focus on controlling the upper reaches of the Jialing River to block the Mongol army's advance toward Chengdu, or to station troops in the Jiading area to slow the enemy's progress and provide timely reinforcement to Chengdu when necessary. Second, during the Song-Yuan wars, the Song military's deployment appeared more inclined toward the defense of the Chongqing region, resulting in a spatial distribution of mountain fortresses that was notably denser in the east than in the west, and more concentrated in the south than in the north.

Using the Sichuan Basin of China as the study area, five evaluation factors—elevation, slope, aspect, water availability, and soil texture—were selected for analysis. Single-factor evaluations were conducted using ArcGIS, and the weights of each factor were calculated using the Analytic Hierarchy Process (AHP)[18]. These single-factor evaluation maps were then subjected to spatial overlay analysis based on the evaluation model, resulting in a thematic map of arable land suitability levels and ultimately generating a spatial distribution map of arable land suitability across the Sichuan Basin.

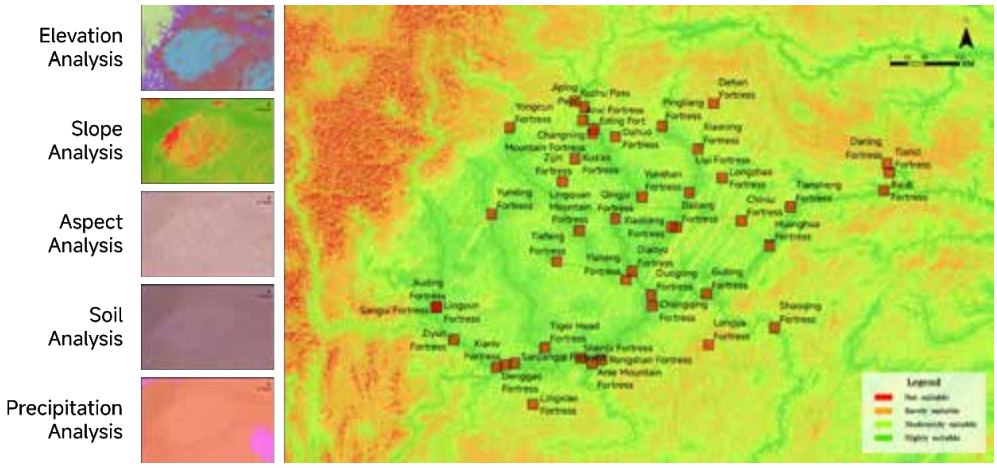

Figure 8 Map of Mountain Fortress Distribution and Agricultural Land Suitabil ity Assessment in the Sichuan Basin of China (Source: the author)

According to the results of the agricultural land suitability evaluation, the Sichuan Basin of China is generally highly suitable for cultivation, with the Chengdu Plain of China in particular standing out as an extensive area of high-quality arable land. By overlaying the distribution map of Song military mountain fortresses during the Song-Yuan wars, it can be observed that these fortresses were generally located in areas with fertile soil and adequate precipitation, which were highly suitable for farming. This pattern aligns with the overall operational model employed by the Song during the Mongol invasion, wherein local populations relocated a masse into mountain fortresses during periods of military threat and resumed agricultural activities in the surrounding areas once the Mongol forces had withdrawn. However, this also reveals that following the Mongol occupation of Chengdu, much of the high-quality farmland in the Sichuan Basin of China fell under threat from Mongol forces. Consequently, the continued functioning of the entire Sichuan-Chongqing Mountain Fortress system became heavily reliant on support from the Jinghu region.

3.2 Contour Analysis of Construction and Fall Times

The construction of the Song-Yuan Mountain Fortress System can be roughly divided into three phases, each corresponding to the growing military threat posed by the Mongol forces. Mountain fortresses built prior to 1243 mainly consisted of pre-existing fortresses as well as those constructed spontaneously by local military and civilian groups in the Sichuan-Chongqing region of China in response to evolving circumstances. Although limited in number, these fortresses occupied key transportation routes and played significant roles in subsequent military engagements. The mountain fortresses constructed between 1243 and 1259 were largely completed during the administration of Yu Jie. Following the large-scale invasion of the Sichuan-Chongqing region by Ögedei Khan, the Song military adopted the advice of strategic advisors and initiated the construction of a substantial number of mountain fortresses. This period witnessed the greatest number of fortress constructions, with a spatial distribution characterized by a higher concentration in the east than in the west. After 1259, the fierce offensives led by Möngke Khan resulted in the near-total collapse of the Song defensive system north of the Yangtze River within the Sichuan-Chongqing region. During this final phase, the number of newly constructed mountain fortresses was minimal, and their primary purpose was to reinforce the Yangtze River defense line and protect Chongqing.

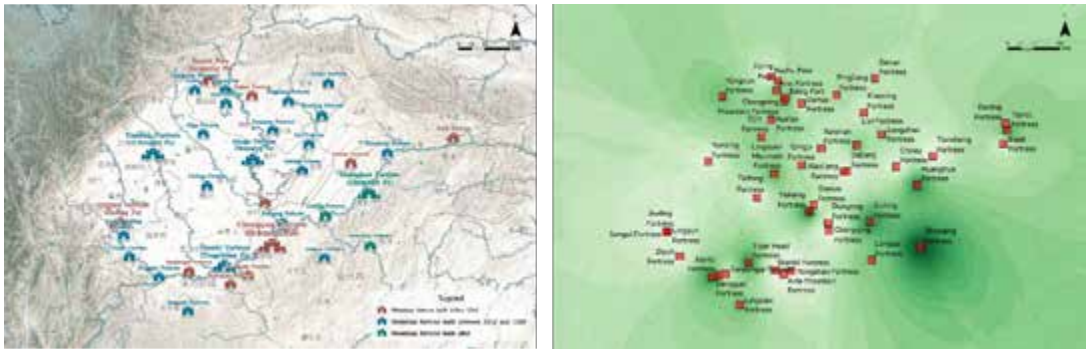

Figure 9 Analysis of Construction Timelines for Mountain Fortresses in the Song-Yuan Fortress System (Source: the author)

The Inverse Distance Weighted (IDW) interpolation method calculates weighted values based on the distance between interpolation points and sample points, considering only the distances between the interpolation point and its neighboring points during the interpolation process. It is commonly used in the construction of Digital Elevation Models (DEM)[19]. By applying the IDW method to analyze the construction dates of the Song-Yuan Mountain Fortresses (Figure 9), it is observed that the earliest-built mountain fortresses during the Song-Yuan wars were scattered throughout the Sichuan-Chongqing region of China. Subsequently, defensive efforts gradually intensified in three directions: northwest, southwest, and southeast. This pattern may be related to the late-stage Mongol occupation of Dali and the loss of Song fortresses in the upper reaches of the Jialing River, which forced the Song military to contract their defensive line to the Yangtze River area and strengthen defenses in the southwest.

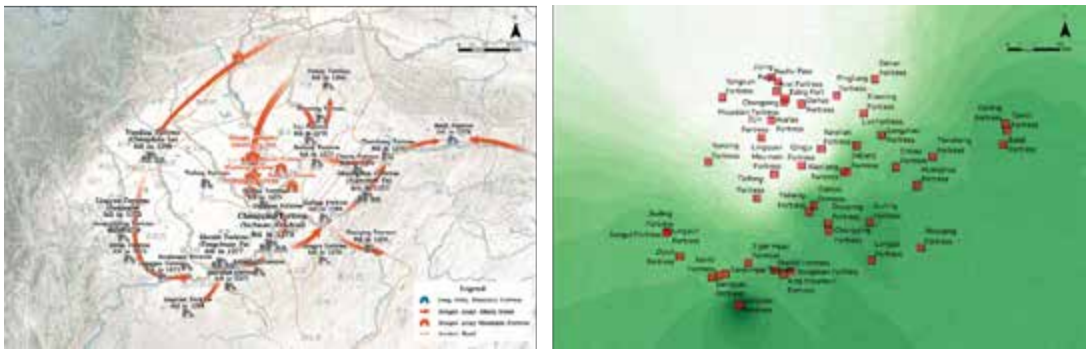

Figure 10 Analysis of Fall Timelines for Mountain Fortresses in the Song-Yuan Fortress System (Source: the author)

By analyzing the fall times of the Song-Yuan Mountain Fortresses using the Inverse Distance Weighted interpolation method (Figure 10), two distinct phases of fortress collapse become apparent. This pattern reflects the spatial contraction of the Song military defense in the Sichuan-Chongqing region of China from the upper reaches of the Jialing River to the main course of the Yangtze River. In 1258, the Mongol Great Khan Möngke personally led a three-pronged campaign against the Song, successfully breaking through the Song Mountain Fortresses around the Jialing and Min Rivers and advancing to the foot of Diaoyu Fortress. Although Möngke died at Diaoyu Fortress in 1259, during this period the Mongols also began constructing mountain fortresses themselves, utilizing the captured Qingju Fortress to establish several forward outposts north of Diaoyu Fortress. This development deprived the Song forces of any ability to reclaim lost territory and is likely the primary reason for the pronounced phased pattern in the fall times of the Song Mountain Fortresses.

3.3 Analysis of Mountain Fortress Defense Priorities Based on GIS

Since the Qin and Han dynasties, with the increasing strategic importance of Sichuan, China, the development during the Three Kingdoms, Wei-Jin, Southern and Northern Dynasties, and especially the Sui and Tang periods laid the foundation for the transportation routes in Sichuan during the Song dynasty[20]. The Shu Roads are divided into northern and southern sections, with the southern section comprising three main routes: Jinniu Road, Micang Road, and Litchi Road, among which the Litchi Road served as the key connection between the Sichuan Basin of

China and the Central Plains of China. Waterway transportation was the primary mode of travel in Sichuan at the time, with the Min River–Yangtze River system being an important channel for cargo and passenger traffic. The sites of the Song-Yuan Mountain Fortresses were all located near major water and land transportation routes in Sichuan. The mountain fortresses adjacent to land routes played a crucial supplementary role in resisting the Mongol invasion, jointly supporting the effectiveness of the anti-Mongol defense system.

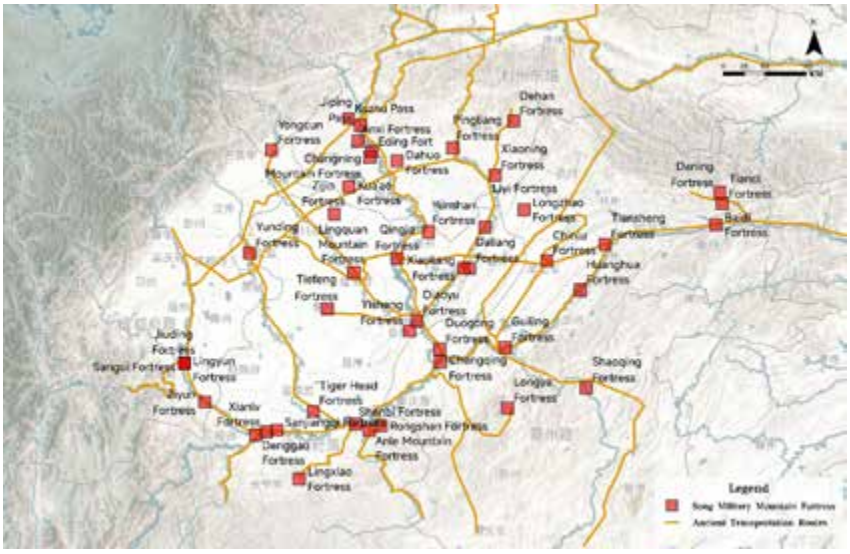

Figure 11 Map of Transportation Routes in the Sichuan-Chongqing Region during the Song-Yuan Wars (Source: the author)

Meanwhile, the defensive characteristics of the mountain fortress, formed jointly by fortification facilities and the terrain and landforms, together with the administrative functions transferred to the mountain fortress during wartime and its convenient access to both water and land transportation, collectively determined the regional defensive capability possessed by an individual mountain fortress within the entire Song-Yuan Mountain Fortress System.

The Analytic Hierarchy Process (AHP) is an objective analytical method that organizes and synthesizes subjective judgments. It is a systematic and hierarchical approach that effectively combines subjective and objective, qualitative and quantitative analyses[21]. Scores were assigned based on the mountain fortress's accessibility, defensive capability, administrative level, and terrain conditions, and AHP was employed to assess the relative importance of each evaluation factor. By comparing the significance of these factors, the weights (w) of the evaluation factors—accessibility (B1), defensive capability (B2), administrative level (B3), and terrain conditions (B4)—were determined, resulting in the construction of the evaluation matrix as shown in Table 1.

Table 1 Mountain Fortresses Defense Priority Judgment Matrix Table (Source: the author)

A	B1	B2	B3	B4	
B1	1	5	3	5	0.5579
B2	1/5	1	1/3	1	0.0963
B3	1/3	3	1	3	0.2495
B4	1/5	1	1/3	1	0.0963

To verify matrix consistency, the consistency index was calculated (n=4, CI=0.0145). Referencing Saaty's random consistency index (RI) table derived from 1,000 simulations, RI=0.90 for a 4th-order matrix yielded a consistency ratio , confirming matrix validity.

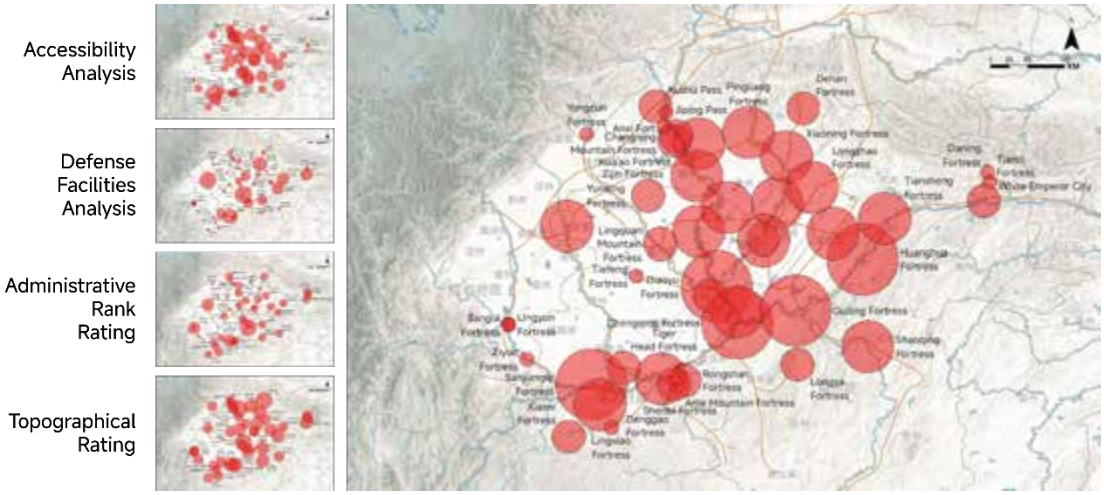

Figure 12 Evaluation of Regional Defense Levels for Song and Yuan Mountain Fortresses in the Sichuan-Chongqing Region of China (Source: the author)

Based on OD cost matrix analysis in GIS, the traffic accessibility of the mountain fortresses was evaluated using an ancient marching speed of 30 li (ancient Chinese unit of length equivalent to approximately 360 meters) per day as a reference, generating the accessibility analysis map shown above (Figure 12). Combining the evaluation results of the defensive capability, administrative level, and terrain conditions of the Song military mountain fortresses in the Sichuan-Chongqing region of China, and using the evaluation factor weights derived from the Analytic Hierarchy Process, a regional defense level evaluation map of the Song-Yuan mountain fortress system was produced. Among these, Chongqing Fortress, Diaoyu Fortress, Guiling Fortress, and Huanghua Fortress were classified as the first tier, possessing prominent regional defensive capabilities. While ensuring their own defensive strength, they were also able to effectively coordinate with surrounding mountain fortresses. Yunding Fortress, Qingju Fortress, Shenbi Fortress, and Yunshan Fortress were classified as the second tier, serving as important regional defensive strongholds capable of effectively resisting Mongol attacks. The third and fourth tiers of mountain fortresses generally functioned as supplementary defenses, reinforcing connections between mountain fortresses or filling gaps within the fortress system. Overall, a defense hierarchy was established with Chongqing City and its surrounding mountain fortresses as the first tier, mountain fortresses along the main road and waterway networks of the Sichuan-Chongqing region as the second tier, and third- tier and fourth-tier mountain fortresses providing supporting layers.

3.4 Summary of GIS Section

GIS-based spatial evolution analysis of the Southern Song Mountain Fortress System in the Chuan-Yu region reveals a high degree of coupling between its distribution patterns and geographical environments, military strategies, and transportation networks. The system exhibits an east-dense, west-sparse distribution pattern along strategic waterways, predominantly concentrated at tactical junctions including the Jialing River corridor, Yangtze mainstream-tributary confluences, with particular density clusters in the upper Jialing River defensive group and the Chongqing peripheral fortress complex. Kernel density analysis confirms spatial correlation between fortress locations and historical settlements, while the Chengdu Plain of China manifests a distinct "dense settlements but sparse fortresses" phenomenon—reflecting the Song military's strategic withdrawal from plains to mountainous terrain, prioritizing defense lines along the Jialing and Yangtze rivers.

Temporally, fortress construction demonstrates marked phasic characteristics. Early strongholds guarded the Shu Roads; mid-phase development under Yu Jie's governance established large-scale defensive networks; late-phase construction contracted to the Yangtze corridor. This spatiotemporal trajectory mirrors Mongol offensive pathways. Spatial differentiation in capture timelines reveals strategic shifts in defensive focus: after losing upper Jialing fortresses, the Song rebuilt defenses along the Yangtze anchored by core strongholds like Chongqing and Diaoyu Fortress. Analytic Hierarchy Process indicates hierarchical regional defense capabilities, with primary-tier fortresses (e.g., Chongqing Fortress, Diaoyu Fortress) forming command nuclei that integrated administrative control and military functions through multi-level, water-land coordinated networks.

Collectively, the fortress system established a tri-tiered defensive hierarchy (core-node-supplement) through its "mountaintop fortifications and waterside defenses" spatial configuration. This design leveraged synergistic terrain-fortification effects while maintaining strategic resilience through control of agricultural hinterlands and transportation arteries. Such a spatial defense paradigm represents both an evolution of traditional Shu Roads defensive frameworks and a concentrated manifestation of geo-military ingenuity under specific historical conditions, providing critical empirical insights into the spatial logic of ancient mountain warfare systems.

4 Spatial Evolution Characteristics Analysis of the Sichuan-Chongqing Song Army Mountain Fortress System Based on Knowledge Graph

4.1 Analysis of Defense Policy Association Graph Characteristics

The Southern Song Dynasty placed great emphasis on the defense and management of Sichuan and Chong regions of China. After Emperor Gaozong of Song fled south, pacified various bandits, and stabilized the regime, he devoted himself to constructing the defense system in Sichuan and Chongqing. Subsequent Southern Song monarchs also attached great importance to the defense of this region[5]. Overall, the defense policies of the Southern Song in the Sichuan-Chongqing area during the Song-Yuan wars can be roughly divided into three stages: the period of Mongke Khan Ögedei (1236–1243), the period of Yu Jie and Mongke Khan (1244–1259), and the period of Kublai Khan (1260–1288).

By extracting data from selected literature corpora, the obtained information units were categorized into periods, policies, key figures, mountain fortresses, and strategic positioning. The reclassified information was input into Gephi software to generate a knowledge graph, and modularity analysis was applied to produce the modular association diagram shown below (Figure 13). This association graph can be roughly divided into five categories: the collection of mountain fortresses initially constructed during Ögedei Khan's period, the collection of mountain fortresses forming the defensive system built during Yu Jie and Mongke Khan's period, the collection of mountain fortresses built during Yu Jie's offensive against Xingyuan Fu (Prefecture), the collection of mountain fortresses defending the southern border during Kublai Khan's period, and the collection of mountain fortresses maintaining the defensive system during the late stage of the Song-Yuan wars.

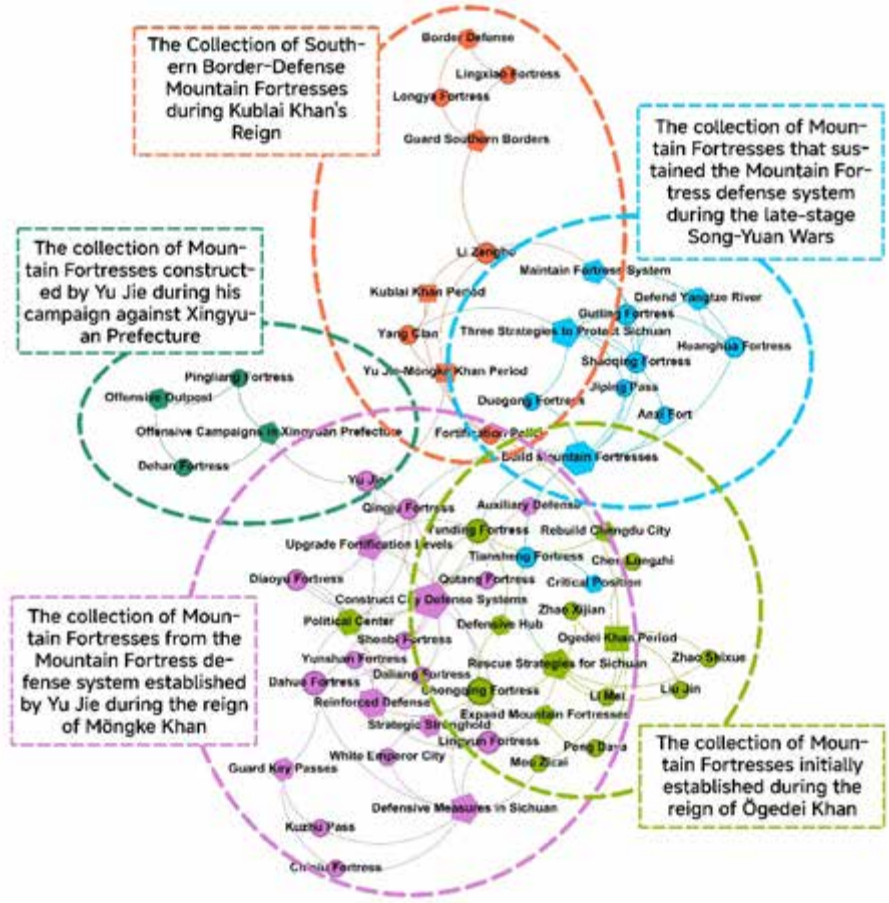

Figure 13 Modular Clustering Analysis of Policies and Mountain Fortress Construction in the Sichuan-Chongqing Region of China During the Song-Yuan Wars (Source: the author)

Based on the analysis of the modular knowledge graph, it can be observed that the construction policies of Song military mountain fortresses exhibited distinct characteristics during different historical periods. During the period of Ögedei Khan, the Song army built mountain fortresses primarily to support the court's strategy to rescue Shu, serving as emergency defensive measures following the Mongol army's first large-scale invasion in 1239. The majority of mountain fortresses were constructed during the period of Yu Jie and Mongke Khan, mainly to establish a defensive system of mountain fortresses for the Song army in the Sichuan-Chongqing region of China. It was also during this historical period that the Song forces still had the capacity to establish several forward offensive bases and launched large-scale attacks on Xingyuan Fu (Prefecture). During the Kublai Khan period, the Mongol forces expanded their territorial control to the southern borders of the Sichuan-Chongqing region of China, and the Song-Yuan Mountain Fortress System suffered severe damage following the battle with Mongke. Consequently, mountain fortress construction during this period was primarily aimed at maintaining the defensive system and guarding the border.

4.2 Analysis of Mountain Fortress Site Association Graph Characteristics

Analysis of existing archaeological evidence indicates that Southern Song Mountain Fortresses in the Chuan-Yu region during the Song-Yuan conflicts preserved not only military remnants but also numerous civilian and religious sites serving military and civilian populations. Through extraction and modular analysis of relevant documentary information, the modular association diagram presented below was constructed (Figure 14). Its nodes primarily form three clusters: living facilities sites, military facilities sites, cultural facilities sites and administrative facilities sites.

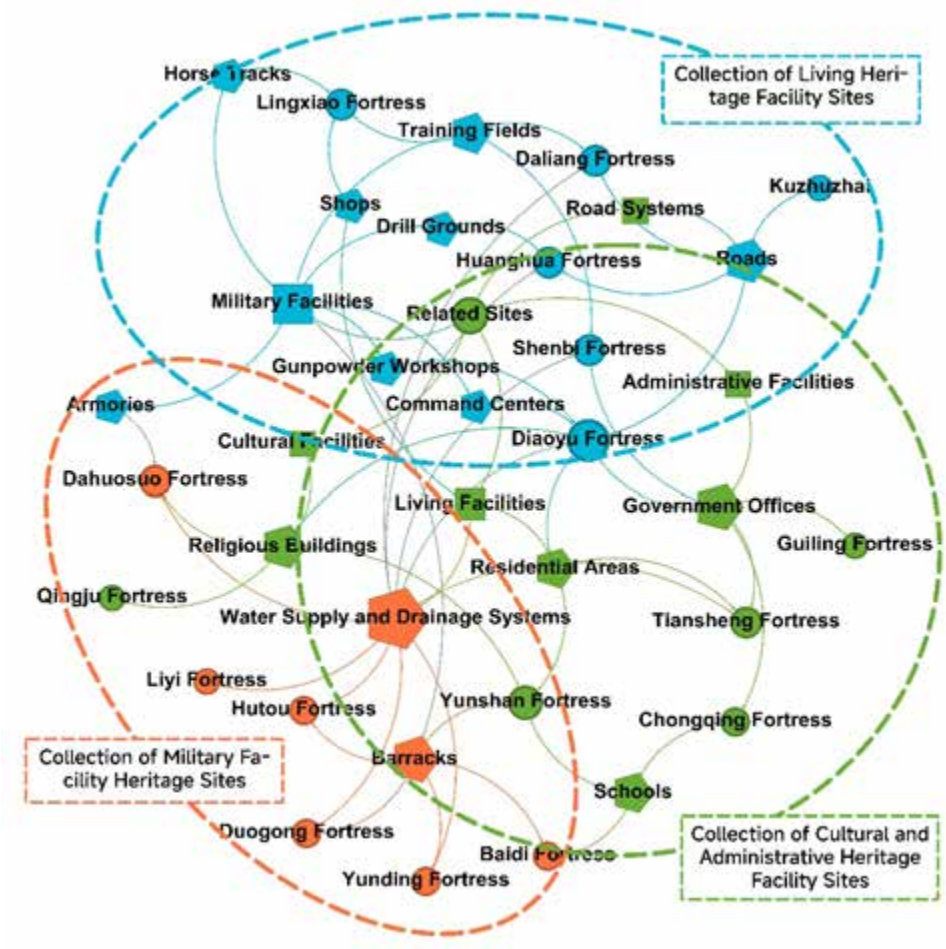

Figure 14 Modular Clustering Analysis of Mountain Fortress Archaeological Facility Sites in the Sichuan-Chongqing Region of China During the Song-Yuan Wars (Source: the author)

Based on the above modular analysis results, numerous sites related to military facilities, cultural facilities, living facilities, and administrative facilities of the Song army's mountain fortresses remain in the Sichuan-Chongqing region. This largely corresponds to the era's characteristic practice of relocating governing institutions and surrounding civilians into well-defended mountain fortresses. It also indirectly reflects that the daily life and agricultural activities of the Song military and civilians in the Sichuan-Chongqing region of China were severely hindered by the threat posed by the Mongol forces, restricting the entire region's productive and living spaces to the strategically prominent mountain fortresses.

4.3 Analysis of Historical Event Association Graph Characteristics

Recognizing repeated Mongol incursions into Sichuan, China, the Song court deemed the "upper Yangtze critically vulnerable," prioritizing Sichuan's defense as urgent since the river's strategic dominance relied entirely on Sichuan's security. Consequently, a strategic defense doctrine was established: securing the lower reaches required holding the upper reaches; defending the Yangtze necessitated controlling the Huai and Han River basins. Implementing this policy, the court empowered three theater commanders (Lianghuai, Jinghu, and Sichuan) with unified military authority over their jurisdictions. Repeated directives mandated fortifying strategic strongholds across theaters, while imperial decrees emphasized coordinated mutual support: "Sichuan's emergencies require Jinghu's aid; Hexian and Chaoxian's crises demand assistance from the Yangtze Command; Zhenjiang and Taizhou's perils necessitate relief from the Huaixi Command"[4].

Based on extant historical sources, events related to the Song-Yuan conflicts between 1223 and 1274 were systematically cataloged, with information specific to Chuan-Yu extracted to examine the region's economic, political, and military conditions during the reigns of Ögedei Khan, Yu Jie-Möngke Khan, and Kublai Khan. Modular analysis of this compiled data generated the knowledge graph presented below.

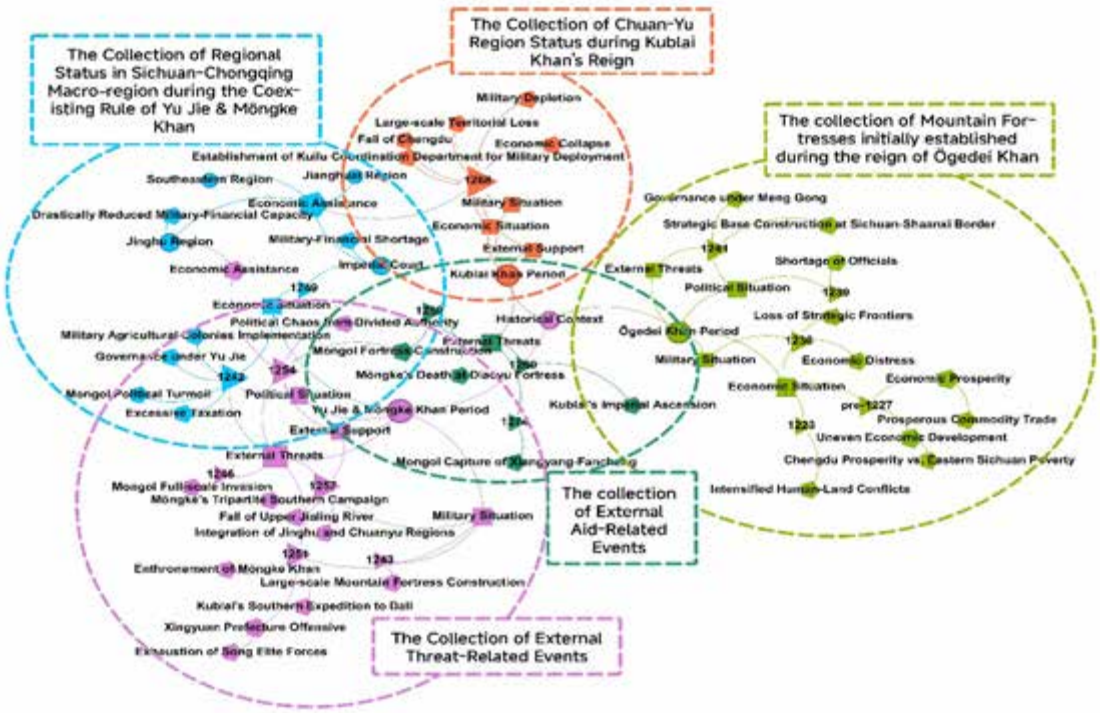

Figure 15 Modular Clustering Analysis of Historical Events in the Sichuan-Chongqing Region of China During the Song-Yuan Wars (Source: the author)

Based on the above modular analysis results, the historical event nodes related to the Song-Yuan war in the Sichuan-Chongqing region of China can be roughly divided into five sets: the status quo of the Sichuan-Chongqing region during the Kublai Khan period, the status quo during the Ögedei Khan period, the status quo during the Yu Jie–Möngke Khan period, events related to external assistance, and events related to external threats. Throughout the entire historical period of the Song-Yuan war, prior to the loss of Xingyuan Fu (Prefecture) by the Song army in 1227, the Sichuan-Chongqing region of China enjoyed relatively developed economic conditions, albeit exhibiting an unbalanced pattern characterized by the wealth of Chengdu and the poverty of the Qutang Gorge. The primary advanced economic system at the time was centered on commodity trade. As the Mongol forces gradually intensified their offensive against the Song army in Sichuan-Chongqing, the fertile Chengdu Plain became a focal point for Mongol plundering, and the region's commodity trade steadily declined amid prolonged warfare. Consequently, the economic situation in Sichuan-Chongqing deteriorated from prosperity to distress and even collapse. On the other hand, as the Sichuan-Chongqing economy became unable to sustain itself, it increasingly relied on the Jinghu region economically, and the Southern Song court made efforts to integrate Jinghu with Sichuan-Chongqing. However, continuous warfare severely depleted the military and financial resources of the Jinghu region of China, and the division of authority led to political chaos, laying hidden dangers for the later period in Jinghu.

4.4 Connections Between Mountain Fortresses

During the Song-Yuan conflicts in the 13th century, the Southern Song Mountain Fortresses in the Chuan-Yu region of China constituted an extensive and systematic "mountain fortress strategic defense system." These strongholds formed mutually responsive relationships through geographical positioning, military coordination, and resource complementarity. Leveraging the rugged terrain surrounding the Sichuan Basin, Song forces constructed fortresses on commanding heights along the Yangtze, Jialing, Tuo, Min, and Qu rivers, establishing a defense network that controlled strategic corridors through nodal points. Each mountain fortress provided

mutual support through waterways and land routes, forming a regionally interconnected network that functioned as complementary flanks, coordinating defenses and constructing a three-dimensional defensive system that operated with seamless precision.

This study selected representative Song fortresses with relatively precise geographical coordinates in the Chuan-Yu region to analyze their interrelationships in administrative division, collaborative defense, military assistance, and transit routes. Utilizing the Geo Layout plugin in Gephi software for geospatial positioning, modular clustering analysis of the constructed nodal network generated the knowledge graph association network illustrated (Figure 16). The resulting nodal network comprises four primary clusters: the Jialing-Qu River Defense Group, Eastern Sichuan Defense Group, Tongchuanfu Lu (Circuit) Defense Group, and Chengdufu Lu (Circuit) Defense Group.

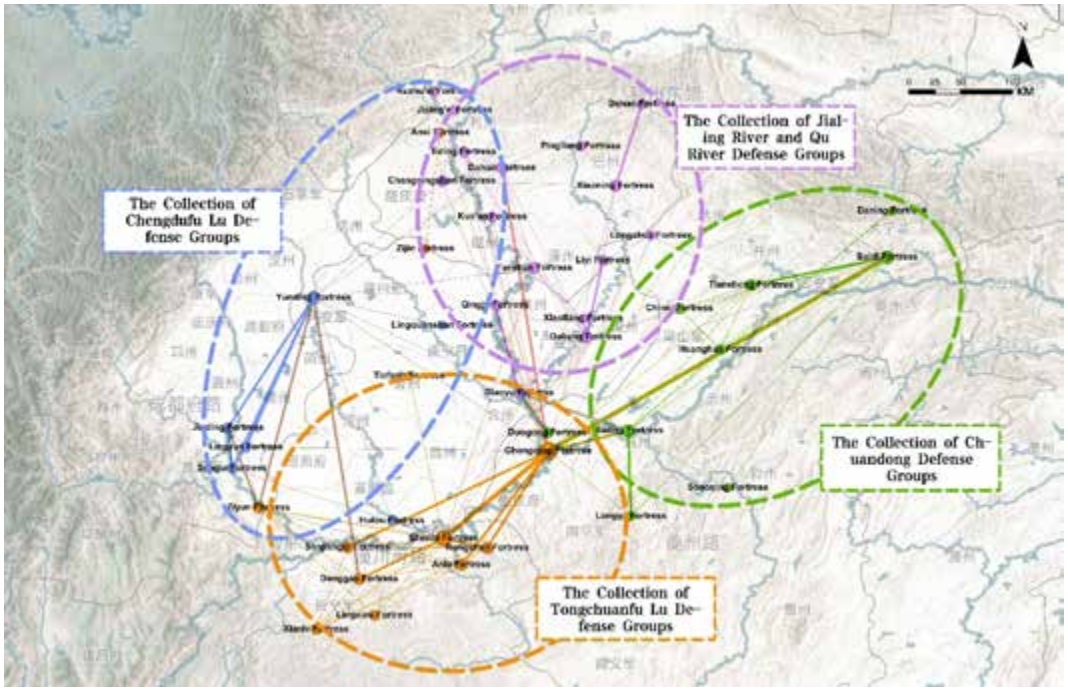

Figure 16 Modular Clustering Analysis of the Song Army's Mountain Fortresses in the Sichuan-Chongqing Region of China (Source: the author)

The size of each node in the relational network is determined by its eigenvector centrality. Eigenvector centrality is a metric used to measure the importance of nodes within a network. It considers not only the number of direct connections of a node (i.e., degree centrality) but also the importance of the nodes to which it is connected. Chongqing Fortress exhibits the highest centrality, reflecting its role as the strategic nexus of the system, functioning as both the military command hub and primary contested stronghold. Yunding, Shenbi, and Baidi fortresses demonstrate secondary centrality, serving as circuit-level administrative centers responsible for coordinating regional defenses. Fortresses such as Dahuo, Xiaoning, Yunshan, and Guiling represent the next tier, occupying critical tactical positions as pivotal nodes within the regional defense framework.

The clustering results derived from the modularized relational network reflect the regional defensive coordination among Song military mountain fortresses in the Sichuan-Chongqing region of China. According to the network analysis, during the Song-Yuan War, the Song mountain fortresses in this region can be categorized into four primary defensive clusters: one constructed around the Jialing and Qu rivers; one centered on the Chengdu Plain; another formed along the Tuo River and the upper reaches of the Yangtze River, known as the Tongchuanfu Lu (Circuit) cluster; and a final one established in eastern Sichuan, east of Chongqing. Within each cluster, the mountain fortresses maintained relatively complete systems of mutual support, collectively forming a coherent and interlocking defensive network that constituted the overall mountain fortress defense system of the Song military in the Sichuan-Chongqing region of China.

4.5 Summary of Knowledge Graph Analysis

Analysis of the knowledge graph association network reveals that the spatial evolution of the Southern Song's Mountain Fortress System in the Sichuan-Chongqing region of China during the Song-Yuan wars exhibited phased progression, hierarchical organization, and regional coordination. As Mongol offensives escalated, Southern Song defense policies transitioned through three distinct phases: emergency deployments under Ögedei Khan's incursions, systematic construction during Yu Jie's governance, and strategic contraction in the Kublai Khan era. Yu Jie's "mountain fortress defense system," centered on the "Eight Pillars of Sichuan," formed four defensive clusters along the Jialing and Yangtze waterways: the Jialing-Qu River cluster controlled eastern Sichuan's land-water junctions with Chongqing Fortress as the strategic nucleus; the Chengdufu Lu (Circuit) cluster maintained remnant plains defenses via strongholds like Yunding Fortress; the Tongchuanfu Lu (Circuit) cluster anchored by Shenbi Fortress dominated the upper Yangtze; and the Eastern Sichuan cluster shielded the Three Gorges gateway through Baidi Fortress. Within each cluster, fortresses established integrated "point-line-area" networks through waterway coordination and resource complementarity, while cross-regional command was facilitated by administrative hierarchies.

The spatial layout of this system was profoundly constrained by the wartime situation and economic changes. As the Mongol forces continued to devastate the prosperous areas, the defensive focus in the Sichuan-Chongqing region of China gradually shifted southward, ultimately forming a mountain fortress defense system centered on Chongqing and reliant on external support from the Jinghu region of China. The coexistence of military, residential, and cultural facilities found in archaeological sites confirms that the mountain fortress served both as a wartime stronghold and a place of survival. Although the coexistence of military and civilian populations enhanced the capacity for prolonged warfare, it also led to economic decline and social spatial tension within the region. Ultimately, the Mongol army compressed the living space of the Song forces by employing a strategy of "mountain fortress against mountain fortress." Coupled with the overall strategic retreat of the Southern Song, this defensive system—steadfast for nearly half a century—collapsed amid spatial fragmentation and resource depletion. Nevertheless, its regional defense concepts and mountain fortress defense system remain an important paradigm in ancient Chinese military engineering.

5 Conclusion and Outlook

5.1 Conclusion

This analysis, employing GIS and knowledge graph technologies, systematically reveals the spatial interconnections and structural features of the Song-Yuan Mountain Fortress System in China's Sichuan-Chongqing region. The fortress network exhibits a "dense in the east, sparse in the west, and strategic along the rivers" spatial pattern, relying on the Jialing and Yangtze River systems to form a three-tiered "core–pivot–supplement" defense framework. Core strongholds such as Chongqing City and Diaoyu Fortress coordinated via waterways and land routes to construct a multilevel, three-dimensional defense network, enabling regional cooperative operations. In both time and space, mountain fortress construction unfolded in three phases: an early stage of dispersed deployments along the ancient Shu Roads; a mid-stage of large-scale, systematic construction under Yu Jie's administration; and a late stage of contraction to the Yangtze corridor—reflecting the profound influence of wartime dynamics and economic transformations on the system's spatial layout. The Sichuan-Chongqing Song-Yuan Mountain Fortress System not onSly capitalized on the Sichuan Basin's interleaved mountains-and-rivers terrain but also reinforced strategic resilience by controlling key transport arteries and economic hinterlands, exemplifying the systematic and dynamic nature of ancient military geographic wisdom.

The collaborative analysis employing GIS and knowledge graph technologies provides a multidimensional theoretical foundation for the study of the distinctive values of Sichuan's Mountain Fortresses in China. Through kernel density analysis and the Analytic Hierarchy Process, GIS establishes a three-tiered "core–pivot–supplement" defensive framework, thereby quantifying the strategic significance of each mountain fortress. Meanwhile, knowledge graph technology captures the evolving wartime dynamics and economic transformations, illustrating the roles that individual mountain fortresses played within the Song military defense system amid the tides of history. These findings offer a scientific basis for uncovering the differentiated values of each mountain fortress and elucidating their historical significance and functions.

The integration of GIS and knowledge graph technologies can also provide critical support for the construction of heritage corridors for China's Sichuan-Chongqing Mountain Fortresses and their nomination for World Heritage status. By coupling kernel density maps with transportation network analysis, the structural framework of heritage corridors along the Jialing River and the main course of the Yangtze River has been precisely delineated, establishing protection priorities for core nodes such as Chongqing City and Diaoyu Fortress. The relational network derived from the knowledge graph further elucidates the systemic coherence of the mountain fortress network across administrative hierarchies, military coordination, and cultural transmission, thereby laying the foundation for the development of cross-regional collaborative preservation strategies.

5.2 Limitations and Prospects

This study acknowledges certain limitations. First, severe deterioration from age and natural erosion at some Song fortress sites in Chuan-Yu region of China, compounded by uncertain original locations, creates analytical gaps in reconstructing comprehensive defensive layouts. Second, interpretations of defensive patterns and structures at certain fortresses rely heavily on indirect archaeological inferences, where historical layering (e.g., later reconstructions or damages) may introduce biases in understanding Song-era military characteristics. Additionally, precise reconstruction of ancient Shu Road routes and historical waterways remains challenging due to geographical transformations.

Future research could advance in three directions: First, integrating Mongol offensive routes with Song-Yuan military technologies (e.g., siege engines, defensive structure iterations) to examine the system's adaptability to warfare modalities and reveal its strategic logic. Second, conducting granular studies of well-preserved exemplars like Diaoyu Fortress and Chongqing Fortress through archaeological excavations and 3D modeling technologies to validate defensive hierarchies and spatial configurations from military-geographical perspectives. Third, assessing natural disaster risks (e.g., landslides, floods) to develop GIS-based risk zoning and conservation strategies, thereby advancing preventive heritage protection. Furthermore, synthesizing multi-source historical materials with emerging technologies (e.g., remote sensing, artificial intelligence) to construct dynamic, high-precision historical-geographical databases holds potential for enhancing research rigor and optimizing heritage management efficacy.

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Drawn City: the effects of women's graffiti in public spaces of Rio and Barcelona through cartography

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Abstract
There are manifestations of graffiti in various places throughout the contemporary city. The drawings created by female graffiti artists can present different themes as a means of the consolidation of identities. However, does graffiti made by a woman symbolically influence public space? Focusing on the neighbourhoods of Santo Cristo in Rio de Janeiro and Poblenou with Provençals del Poblenou in Barcelona, this article proposes a methodological reflection on how to identify these actions and understand their cultural effects in a global phenomenon. In order to comprehend the impacts of these graphic expressions, a methodology based on a cartography was developed. Mapping graffiti created by women can be carried out in other cities and asserts the female presence as part of the occupation of public space.

Keywords: urban cultures, street art, cultural landscapes, critical cartography, right to the city

Introduction

The contemporary city presents layers of everyday graphic interventions carried out by different agents through multiple forms of expression. The urban landscape is in constant transformation, shaped by the creative and communicative capacities of citizens through their drawings and writings. In this context, urban public spaces are regarded as platforms for the expression of various groups, ranging from institutional organisations to popular forms such as graffiti. Graffiti raises questions about hegemonic power and brings artistic expression to the urban fabric; for this reason, it is relevant to the consolidation of identities and reinforces people's sense of belonging.

However, the artistic movement is predominantly male and female graffiti artists face difficulties in being accepted and have few records (Pabón-Colón, 2018), raising the question: why do female graffiti artists not receive the same visibility as their male counterparts? Authors such as Silvia Federici (2017) argue that realities like these reflect the social pressures of the patriarchal capitalist system[1]. According to Federici, the transition from the feudal system to capitalism caused a reconfiguration of power relations: to maintain power for men and in an attempt to compensate for the expropriated lands, women began to be treated as property under the imposition of social roles. Even so, this oppressive structure of objectification of women was not uncontested.

This history also includes women's struggles for the right to the city (Lefebvre, 2016). Some creative initiatives of place appropriation provide new perspectives on inhabiting cities based on women's own lived experiences. In this way, despite obstacles, they participate in urban development (Muxí, 2019) and in shaping the image of a place.

Given this context, it is necessary to identify where the interventions are located and what their messages are in order to understand the symbolic effects of graffiti on the landscape. Considering these issues, it is worth asking: can graffiti created by a woman transform the landscape of a city? To reflect on this question, this article focuses on analysing the impacts on public space caused by graffiti created by women.

The research employs critical cartography as a tool to understand the graphic-symbolic effects of graffiti as a global phenomenon with local specificities. Furthermore, it aims to develop a reproducible methodology for graffiti studies applicable in different cities to advance theoretical and methodological frameworks. Through an interdisciplinary approach combining Urban Planning, History of Art, Design and Geography, the study also seeks to reflect on the hypothesis that urban voids in a city are the spaces most sought after by female graffiti artists

1 Silvia Federici's (2017) study focuses on the period of the Middle Ages in Western Europe.

in pursuit of freedom of expression.
Focusing on urban voids, the research seeks to compare the Santo Cristo neighbourhood in Rio de Janeiro (Brazil) with Poblenou and Provençals del Poblenou[2] in Barcelona (Catalunya, Spain). These locations are recognised for their significance in graffiti history, offering an opportunity to build international networks. The neighbourhoods share similarities as they are currently experiencing predatory real estate development, resulting in fenced-off plots featuring interventions by female graffiti artists.

In order to analyse graffiti interventions made by women in these places in 2024, this article proposes a reflection on the methodology based on cartographic production. Cartography is a way to highlight artistic diversity in public space, showing how female graffiti artists form part of the cultural landscape and enabling the discovery of new graphic representations of the city.

Drawing as a Tool for Urban and Human Transformation
Historically, graffiti is considered a cultural movement in the United States and its purpose "is primarily an invitation to encounter and dialogue" (Gitahy, 2012, p. 16). The initiative originated from young black and Latino Americans living in the suburbs, who saw artistic expression as a way to denounce public authorities' neglect through codes and provocations in public spaces. The U.S. core of the artistic movement gained strength in the 1980s, consolidating its relationship with Hip Hop through initiatives in drawing, music and dance. In the same decade, the style spread internationally, sparked political clashes[3], was appropriated by art galleries[4] and challenged urban art (street art), which proposes focusing more on the end result on the street over the cultural process.

Although graffiti has gained acceptance among young people worldwide, Jessica Pabón-Colón (2018) points to the relative erasure of women in these narratives. The author states that female graffiti artists have existed from the beginning, with participants such as Eva62, Barbara62, Kivu 181, Lady Pink, and others, but records have predominantly focused on men. Challenging this situation, the increase in the number of women involved in graffiti was noted in the 1990s and expanded in the 2000s due to digital media. The female presence brought some changes to the style. They managed to form more collectives, introduce their perspectives in debates, magazines and studies to encourage other women in graffiti (Amorim, 2022).

Similarly, women's struggle for greater prominence is evident in other fields, as Urban Planning. Authors like Zaida Muxí (2019) share their professional experiences in municipal organisation to highlight the complexity of a woman's insertion into public administration, although they believe in the possibility of urban change through their participation. Supporting this view, Silvia Federici (2017) argues that the inclusion of women in power structures is part of the refusal of the 'disciplining of the body', as historically patriarchy controls cities, and women's involvement in urban life can be seen as a catalyst for creative initiatives questioning the hegemonic system.

Furthermore, artistic expressions also take place in public spaces, revealing that these urban fabrics are important "places of activism for most social and political movements of the past two centuries" (Kern, 2021, p. 160). The presence of women in these spaces is a way to strengthen social struggles through the dissemination of their debates and also symbolises resistance (Kern, 2021). While reality exposes accumulations of violence, women continue to resist through their artistic work and projects, such as female graffiti artists who use drawing as a tool for expression. Some artists prefer to remain anonymous for safety reasons, but their marks reaffirm the diversity of themes, techniques and styles.

Walking through the streets, it is possible to find graffiti on walls, construction fence, signs, and other surfaces. It becomes a challenge to understand the messages of these interventions within an environment with intense sensory stimuli. Thus, recognising whether a graffiti piece created by a woman is even more complex, because doesn't exist a pattern. According to Gilles Deleuze (1999), it may be possible to identify if the drawing was made

2 According to the Ajuntament de Barcelona (2024), Poblenou and Provençals del Poblenou are neighborhoods in the district of Sant Martí and are part of the 'traditional Poblenou'.
3 Debates about the legality of graffiti only intensified in the 2000s (Amorim, 2022).
4 Galleries primarily embraced the style through the works of Jean-Michel Basquiat and Keith Haring.

by an women artist through their style. For the author, personal style resides in the act of creation, in which the subject understands their experiences and produces a unique and non-transferable style. Therefore, each female graffiti artist has an identity and a style that provides a diversity of colours, themes and materials.

Thus, it can be said that there is no 'universal style of graffiti made by women' and creativity together with the act of drawing has added graphic layers to the landscape and transformed places. According to Henri Lefebvre (2016), inhabiting the city is a negotiation between powers. For this reason, citizens' creativity is a way of appropriating environments, a claim for the right to the city. Artistic action can subvert hegemonic control, especially as "art has resisted the meaning of the work; it offers multiple figures of times and spaces" (Lefebvre, 2016, p. 125). In other words, women can also act collectively in environments and their graffiti reinforces the power of drawing in the constitution of a drawn city.

A graffiti intervention can bring political debates, criticism, greater access to art, playful and popular representations, as well as codes of complex legibility into the public space. However, for the movement, beyond the result in the environment, the act of drawing itself is essential. The process incorporates shared experiences between artists, can create emotional bonds with places, enables communication with society and maintains the collective memory (Halbwachs, 2003) of an urban cultural tradition. These layers may be considered symbolic marks in the city, as even if they are not easily recognisable, they carry the weight of urban history and are part of the landscape.

With this context in mind, authors such as Denis Cosgrove (1989) argue that the construction of cultural and symbolic landscape takes into account the contribution of social groups that also create graphic markings on walls, revealing their varied understandings of urban life—just as happens with graffiti made by women. These artistic manifestations can heighten levels of communication. However, "to understand the expressions written by culture in the landscape we must know the 'language' used: the symbols and meanings alongside the culture" (Cosgrove, 1989, p. 125). Therefore, to deepen knowledge of the urban landscape, it is important to decode the drawings present and analyse the mutability of space.

Understanding the landscape as an envelope in constant formation through graphic elements is also central for Joy Till (2014), who states that "every city is, fundamentally, a human relational environment, a vast medium" (Till, 2014, p. 56). According to the author, the city gives rise to multiple forms of visual communication, enhancing a landscape built upon the layering of graphic productions. Thus, images created by citizens contribute to a graphic landscape and foster the individual's sense of belonging in place.

Considering that female graffiti is another graphic layer in shaping the contemporary city's landscape, one might ask: is it possible to locate graffiti created by women? To investigate this, mapping is used as a tool for research and representation of their presence, which may be expressed in different territories. Therefore, the cartographic methodology should be applied across various cities to reflect the diversity of urban interventions and demonstrate how the act of graffiti by women is a global phenomenon. With the intention of confirming these potentials, the territorial focus is on the neighbourhoods of Santo Cristo in Rio de Janeiro and Poblenou with Provençals del Poblenou in Barcelona.

Urban and Cultural Dialogues between Rio de Janeiro and Barcelona

To speak of the relationship between Rio de Janeiro and graffiti is to speak of the pioneering spirit of certain groups in the 1980s. The city played a significant role in the emergence of the first collectives, such as the FleshBeck Crew, who were influenced by the provocative phrases written by the figure known as Profeta Gentileza[5] in the port zone. In 2004, Latin America's first all-female graffiti group, TPM Crew, was also formed in Rio (Pabón-Colón, 2018). Since then, the number of female graffiti artists in the city has continued to grow. Their interventions can mainly be found in areas such as the city centre and the port area, particularly in the neighbourhood of Santo Cristo.

Santo Cristo, with approximately 9,936 residents[6], is one of the foundational areas of the city. It preserves its industrial past, shelters the favelas of Morro da Providência and Morro do Pinto, safeguards historic warehouses

5 José Datrino (1917–1996) became immortalised in the memory of Rio de Janeiro's residents through his panels bearing messages of love and peace.

6 Information obtained by IBGE (Instituto Brasileiro de Geografia e Estatística), 2022.

and sheds, and has become a highly sought location for many female graffiti artists. After years of urban transformation, the area is currently marked by urban voids[7]. Due to its strategic location near the sea and the administrative centre of the city, along with institutional political projects such as Porto Maravilha and Porto Maravalley, it has been significantly reshaped by the real estate market since 2024. Construction companies foresee major changes to the landscape, with the planned development of six new residential buildings and the arrival of an estimated 15,000 new residents[8].

The presence of graffiti in the area can be seen on walls, hoardings and within urban voids. It is believed that female graffiti artists choose these locations due to the relatively low level of policing, allowing them to appropriate the space for an indefinite period. However, as the neighbourhood undergoes transformation and its residents experience the effects, the presence of popular female graffiti in these areas takes on further symbolic layers: the resistance of presence and the preservation of graffiti's contestatory culture.

Like Rio, Barcelona is also a cosmopolitan city with a significant history tied to graffiti. Since the 1980s, symbolic graffiti murals have existed there[9], though the relationship with the municipal authorities has not always been harmonious. In the 1990s, graffiti was declared illegal. In the 2000s, however, artists' efforts to gain cultural recognition for the movement spurred initiatives to distance it from vandalism, instead valuing urban art more aligned with aesthetic expression than subversion. As a result, legalised spaces for graffiti were inaugurated, such as the park of Les Tres Xemeneies, and the city gained the title of capital of urban art (Bou, 2023).

Nevertheless, spontaneous graffiti continues to appear on ephemeral surfaces, especially in neighbourhoods like Poblenou and Provençals del Poblenou. Located in the district of Sant Martí, the have approximately 34,151 residents[10] and is historically significant for Catalunya's industrial heritage. It also features tourist, artistic and cultural landmarks[11] and has been similarly impacted by fast real estate development. Due to its proximity to the beach and the quality of local infrastructure, as well as institutional projects such as Plan 22@[12], the area has attracted property developers, leading to rising housing costs and an increase in urban voids destined for new construction.

Walking through its streets, one can observe a variety of landscapes within the same neighbourhood. There are areas marked by large warehouses, constructions that recall the industrial past, corporate skyscrapers, residential condominiums and ongoing building works. Even so, it is possible to find graffiti by women that asserts their presence and signals places where there is a relative sense of popular dissatisfaction regarding the state of local maintenance and the future of the neighbourhood. These interventions are most visible on the temporary hoardings surrounding vacant plots.

Considering the context of Santo Cristo in Rio de Janeiro and Poblenou with Provençals del Poblenou in Barcelona, it becomes clear that both are significant in the local and international history of graffiti. These areas were selected for the study precisely because they highlight urban voids as spaces desired by female graffiti artists. Despite undergoing radical urban transformations, these neighbourhoods have a vibrant urban life, which confirms the presence of women in the construction of the urban landscape.
In order to carry out the methodological exploration in these areas, a mapping-based methodology was applied. Cartography not only suggests a valorisation of the territory but also becomes a tool for visualising the networks among artists and documenting the process. Moreover, it is a practice that establishes spatial representations of the graphic marks and proposes another dimension of time and graphical depiction of the sites. It can be said

7 The basis regarding urban voids is found in the book "Vazios urbanos: percursos contemporâneos", by Andréa Borde (eds.), 2012.
8 Data obtained from the City of Rio de Janeiro through Invest.Rio, 2024.
9 Such as Keith Haring's mural, "Todos juntos podemos parar el SIDA" (1989), in Barcelona.
10 Data obtained from the Ajuntament de Barcelona, 2024.
11 Key sites include Parc del Centre del Poblenou, La Escocesa, La Torre, among others.
12 An institutional project aimed at transforming the industrial territory into a hub for innovation and technology. Based on "¿Del Manchester Catalán al Soho Barcelonés? La renovación del barrio del Poblenou en Barcelona y la cuestión de la vivienda" by Isaac Marrero Guillamón (2003).

that mapping the landscape also constitutes a way of recording alternative modes of occupying and inhabiting the city from the perspective of female graffiti artists.

Methodological Paths: Studying Graffiti Space Between Walls and Maps

Mappings are laden with interpretations and bring to light realities that were previously invisible or unimaginable. Considering the technological advances in mapping, authors such as Gilles Deleuze and Félix Guattari (2021) regard cartography as a framework that assists in understanding the transformation of things in the world. For the authors, "the map does not reproduce an unconscious closed upon itself; it constructs it. It is part of the rhizome. The map is open and connectable in all of its dimensions" (Deleuze, G.; Guattari, F.; 2021, p. 30).

With this in mind, mapping is understood as an activity that may be guided by the method of becoming, in a non-linear process of learning-by-doing. The cartographic practice allows for the representation of layers of the contemporary city that are in constant transformation and, throughout its execution, new knowledge is produced. In this sense, this article proposes the creation of a map of graffiti made by women, based on the belief that cartography contributes to better visualisation of the public space where interventions are found and that it can be constantly updated — just as graffiti is created daily.

However, in order to assess whether the proposed methodology contributes to the study of the subject, this article is an exercise in methodological experimentation. With the aim of understanding the impacts of graffiti by women on the urban landscape in different cities, a comparative analysis is conducted between the neighbourhoods of Santo Cristo in Rio de Janeiro and Poblenou with Provençals del Poblenou in Barcelona. Among the procedures are mappings and the creation of a database, organised in five stages.

The initial step is to identify who the female graffiti artists active in these spaces are and to establish contact with them. These artists can often be found within artistic circuits and through their social media profiles, where it is possible to discover names and strengthen connections. The second stage involves visiting the sites of previously identified graffiti interventions. This phase is ideal for exploratory walks, which may begin at a starting point or specific piece of graffiti but are intentionally flexible. Here, the practice of drifting[13] through the city helps to uncover new places, artists, and works in unfamiliar urban settings, while also constructing a mental map of the territory. During fieldwork, each piece of graffiti should be documented through photographs and notes.

With some graffiti locations recorded, the third stage entails mapping these interventions by women. Regardless of the two territorial case studies, the process proceeds through digital mapping using Google My Maps, which enables swift registration of images and collected data. This platform can also serve as a basis for other visual representations, such as hand-drawn cartographies. Through intentional and critical drawing, it becomes possible to create a map that is not only objective and communicative but also aesthetically engaging — serving as both an analytical tool and a prompt for formulating new questions about public space.

The fourth stage runs parallel to the third and consists of processing the data gathered through mapping. Given the complexity of information associated with each graffiti work, it is essential to develop a database that organises specific details such as authorship, theme, style, date of execution, among others. This stage also offers the opportunity to experiment with visual formats such as diagrams and infographics, which can enhance the readability and accessibility of the data.

The final stage concerns how the research is shared. Most of the dissemination takes place online via social media, inviting diverse audiences to engage in conversations about how female graffiti shapes everyday landscapes. Creating an Instagram profile, for example, allows the project to connect the research, cities, artists and individuals across different locations. Furthermore, documenting interventions in digital format contributes to the preservation of their memory. Nevertheless, this space comes with its own challenges, such as shifting algorithms and uncertain longevity (Lanier, 2018). While acknowledging that such tools are not permanent, they are still employed due to their current relevance.

Given this methodology, the aim is to identify and document the presence of graffiti created by women in urban

13 The Situationist drift, grounded in psychogeography, is an exploratory form of walking that embraces the unexpected in urban contemplation.

public spaces. Applying this investigative framework across different cities may demonstrate its reproducibility and signal that the act of graffiti by women is part of an international phenomenon. One might say that mapping graffiti also offers an opportunity to spatialise the artworks and understand how certain women appropriate spaces through creative and artistic initiatives. Accordingly, this methodology was applied to the two case studies and produced significant results and analyses.

Results

Initially, the identification of female graffiti artists and their styles in the Santo Cristo neighbourhood was conducted through social contact with cultural centres, collectives and art schools. With this foundation, walking through the streets became a routine process of photographic documentation. Following these experiences, digital mapping was carried out, including metadata for each piece of graffiti and some charts were also created. The resulting map, photographs and specific details of the interventions facilitated contact with new artists and led to the discovery of additional graffiti works.

The mapping of Poblenou and Provençals del Poblenou began with a key challenge: how to apply this process in an unfamiliar territory? It was necessary to immerse oneself in and study the local culture, land use and other layers that informed attentive walks. Discovering art schools and cultural centres made it possible to connect with female graffiti artists and enabled the photographic documentation of some of them and their work. For the cartography, an independent file was created in Google My Maps. The process remained similar to that in Rio de Janeiro, but particular emphasis was placed on hand-drawn maps. Beyond offering alternative cartographic representations, these were essential for developing spatial familiarity and for valuing creative psychomotor work.

The execution of the procedures led to the identification of 23 graffiti pieces created by 12 female artists in the Santo Cristo neighbourhood of Rio de Janeiro, as illustrated in Figure 1. The number of women involved suggests a diversity of agents active in the streets. It can be said that the artists have appropriated underused spaces, construction hoardings and some of the main roads of the area, with one or more interventions each. According to the findings, the majority of the artworks bear signatures — making it easier to identify authorship — and are created on a human scale. Furthermore, in terms of visual content, the themes tend to revolve around playfulness, typography and critical commentary.

Figure 1: Map of graffiti made by women in the Santo Cristo neighbourhood (Rio de Janeiro), 2024. Source: Author's elaboration (2025).

In Poblenou and Provençals del Poblenou, seven graffiti works by seven different female artists were recorded, as

illustrated in the map in Figure 2. These pieces are strategically located in busy areas such as parks, technology and innovation hubs, art galleries, as well as in abandoned buildings or vacant lots. It was observed that the closer one gets to the residential zones, the fewer instances of female graffiti are found. Moreover, the artists — most of whom are Latin American or from other European countries — tend to create medium-scale pieces with themes related to typography, gender and playfulness.

Figure 2: Map of graffiti made by women in Poblenou and Provençals del Poblenou (Barcelona), 2024. Source: Author's elaboration (2025).

From the cartographic analysis of both locations, it was possible to identify some similarities and differences in how female graffiti artists operate. In terms of themes, artists in Santo Cristo tend to adopt a more activist stance, taking advantage of the visibility of certain areas — such as vacant lots earmarked for new developments — to assert their presence through character illustrations or typographic designs. In contrast, the work found in Poblenou and Provençals del Poblenou reveals a stronger concern with the aesthetic and technical aspects of graffiti, as illustrated in the mosaic in Figure 3. Furthermore, it can be argued that public space itself influences both the themes and styles of the graffiti. In both neighbourhoods, parks and artistic centres feature graffiti with symbols that reference the local context.

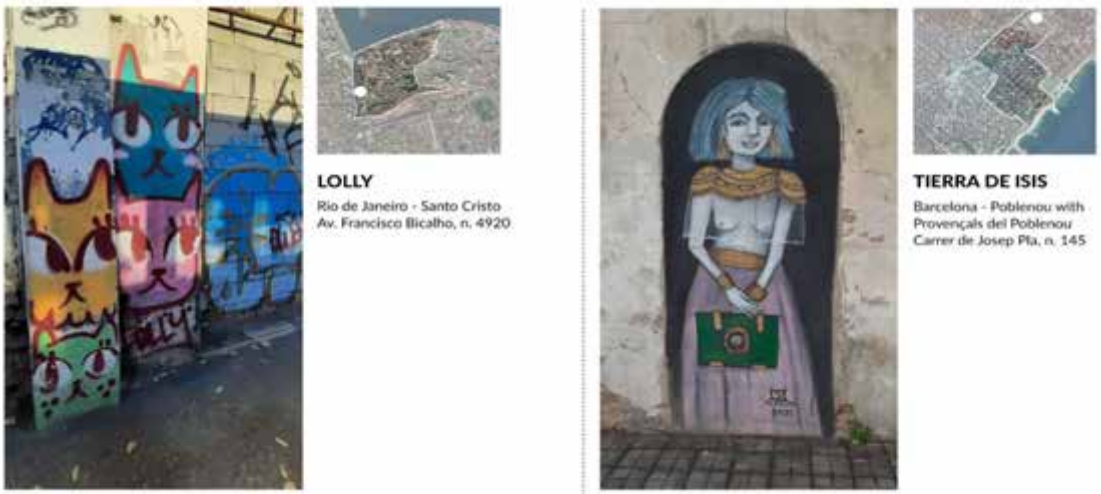

Figure 3: From left to right, graffiti by Lolly in Santo Cristo and work by Tierra de Isis in Poblenou with Provençals del Poblenou, with their locations. Source: Author (2025).

It is important to highlight that squares, playgrounds and skate parks not only convey cultural codes but also emphasise the significance of these spaces for urban life. These social spaces serve as invitations for gathering, contemplation and the creation of socio-spatial bonds. Because of this characteristic, it can be understood that some female graffiti artists feel encouraged to appropriate these environments. Another similarity between the cases is the type of surface on which the graffiti is found. The interventions are predominantly on large obsolete industrial facilities, underutilised and deteriorating buildings, and on metallic temporary fence around construction sites (see Figure 4), consolidating their ephemeral identities.

Figura 4: From left to right, graffiti by Las, Pam and Bia in Santo Cristo, and work by Mida in Poblenou with Provençals del Poblenou, with their locations. Source: Author (2025).

Similarly, it is interesting to point out the bond among the female graffiti artists, which strengthens friendships and fosters international exchange, as they leave their marks in other places with the help of colleagues. Looking at a mural with various graffiti, it is possible to distinguish that some were created at the same time (through use of the same paint or theme), but the artists are recognised by their individual styles. Thus, graffiti is not merely the final product, but rather the social relationships within the process. Observing the case studies, one can say that this global phenomenon is driven by women's search for belonging and their desire to be part of the

urban landscape. Consequently, public spaces with urban voids also become canvases for these interventions, influencing how the artists communicate with the contemporary city.

Conclusion

Bearing in mind the historic social oppressions faced by women, their participation in graffiti highlights struggles for the democratic right to inhabit the city. Since graffiti is based on experimentation and critique of hegemonic power, women have the opportunity to assert their existence in the world through their distinct codes and symbols. The trace left by a female graffiti artist on the street is also the construction of new graphic layers within public space. Thus, documenting the artists and their work contributes to the collective memory of urban culture — the graffiti movement — and to the cultural landscape.

From the methodological essay conducted in the Santo Cristo neighbourhood in Rio de Janeiro (Brazil) and Poblenou with Provençals del Poblenou in Barcelona (Catalunya, Spain), the rapid advance of the real estate sector in these territories was also evident. Both areas share a relatively deactivated industrial and port past, resulting in deteriorated buildings, urban voids and public spaces with poor maintenance by local authorities. With growing real estate market interest, new developments are underway, with noticeable impacts on rising living costs and landscape transformation. In this context, graffiti signals historically neglected spaces that might become the next real estate targets, becoming a popular code of dissatisfaction towards radical urban transformations.

Furthermore, it is clear that questioning whether graffiti made by women can symbolically transform the landscape is insufficient without considering the spatiality of these interventions. The methodology based on mapping proved helpful in this study. Fieldwork, graphic representations and direct contact with the artists demonstrated how lived experience and cartographic drawing walk hand in hand. It was confirmed that this methodology can be replicated in different cities.

Consequently, the comparative study allowed connections between the two cities and strengthened expressive drawing as a cartographic tool. It identified that urban voids are sought out by female graffiti artists due to low surveillance and the provision of ephemeral surfaces such as hoardings, which offer greater freedom of expression. The presence of similar themes across different contexts also reveals a global phenomenon where women resist and continue to engage in graffiti, connecting local identities through international dialogues. Therefore, graffiti interventions by women add symbolic meaning to public spaces and are part of the construction of the cultural landscape.

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The Dilemma of Authenticity: The Conservation and Reconstruction of Traditional Residences in China —Taking Pingyao, Shanghai and Suzhou as Examples

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Abstract
Thirty years after the release of the Nara Document on Authenticity, the concept of authenticity still faces many difficulties in its localization in China, which are manifested in three aspects: the contradiction between absolutization and relativization, materiality and spirituality, and authority and popularization. In China's historic cities, there are a large number of traditional residences, which constitute the background of the "authenticity" of urban heritage. However, due to the traditional wooden construction in China, these traditional residences have undergone nearly a century of historical changes and suffer from problems such as structural aging and long-term disrepair. Unlike the legally protected historical buildings in China, which are maintained by the state, most traditional residences are protected by individuals, and often encounter difficulties such as lack of funds and high maintenance costs during the conservation process. To a considerable extent, there are also calls for demolition and reconstruction among the public. How to maintain the authenticity of traditional residences? This paper takes three historic cities in China - Pingyao, Shanghai and Suzhou - as examples to explore three different conservation models caused by the different aspects such as construction history, construction scale, land values: comprehensive conservation, limited conservation, and "Three Original" conservation. It also discusses the similarities and differences in the attitudes of the government, experts and the public towards the protection of traditional residences, and how they maintain a delicate balance like walking on a tightrope to the greatest extent possible to preserve the authenticity of traditional residences.

Keywords: Authenticity; Dilemma; Traditional dwellings; Conservation; Reconstruction

After the release of the Nara Document in 1994, there was more attention and discussion on the adaptability of the concept of "authenticity" in the field of international heritage conservation to different civilizations around the world. The concept of "authenticity" originated from the cosmology and spatial-temporal view of Western civilization, and is significantly different from the concept of "authenticity" in ancient Chinese cosmology and spatial-temporal view. Firstly, analyze how to express "authenticity" in traditional Chinese construction culture, then discuss the challenges faced by the concept of "authenticity" in the contemporary Chinese context, and finally illustrate the way of "authenticity" in the field of Chinese heritage conservation through three cases of traditional residential protection in historic cities.

1. The concept of "authenticity" in traditional Chinese construction culture

In the traditional organic holistic cosmology and cyclic space-time view of China, humans and nature, matter and spirit, are a unified whole and are in eternal change, known as the "turning the tide and bringing prosperity" and "the movement of the opposite path". The construction of urban architecture should conform to the reflection of the " the Tao of Heaven " in the human world, that is, it should conform to the "ritual system" and "feng shui". Architecture is a dwelling place for "people "in the present world. Compared to the material existence of "eternity", the Confucian emphasis is more on the spiritual inheritance of "eternity ", which is known as the "Three Immortals " of "Set Moral Examples, Perform Great Deeds, and Spread Noble Ideas ". Architecture does not pursue eternity through "solidity ", but expresses the path of eternity through "replacement and reconstruction ".

1.1 Organic holistic cosmology

The ancient Chinese organic holistic cosmology believed that humans and nature form an inseparable whole, jointly adhering to the principles of heaven and ethics. Human beings are a part of nature, and architecture is also a part of nature. The highest level of architectural aesthetics is" although created by humans, like Heavenly". People or buildings dissolve into nature to achieve "eternity", rather than standing in nature and resisting nature to achieve "eternity".

1.2 cyclic space-time view

The concept of cyclic space-time in China originated from the Book of Changes, which established " No plain is not followed by a slope; no advance is not followed by return" as the fundamental law governing the operation of all things in the universe. The Yin Yang Eight Trigrams diagram in the Book of Changes originates from the

observation and setting of the 24 solar terms in nature by ancient people (Figure 1), emphasizing the cyclic and changing laws of yin and yang energies. Yuanjie Lin 2023) Buildings standing in the universe also follow this law without exception. The use of wood in ancient architecture, based on the characteristics of wood decay, can be consistent with the laws of the circulation of all things in the universe.

Fig 1. The 24 Solar Terms

The 24 solar terms are Start of Spring, Rain Water, Insects Awaken, Spring Equinox, Clear and Bright, Grain Rain, Start of Summer, Grain Buds, Grain in Ear, Summer Solstice, Minor Heat, Major Heat, Start of Autumn, The End of Heat, White Dew, Autumn Equinox, Cold Dew, Frost's Descent, Start of Winter, Minor Snow, Major Snow, Winter Solstice, Minor Cold, Major Cold.

1.3.Expressing the Way of Eternity through Maintenance and Reconstruction

The ancient Chinese imperial palace had a complete maintenance system. Taking the Forbidden City, which has been in existence for 600 years, as an example, it has a precise maintenance system of annual repair (regular maintenance), major repair (periodic reconstruction), and special repair (post disaster restoration). Establishing a royal timber factory to store the golden nanmu needed for the construction of the imperial palace, setting up a golden brick kiln in Suzhou to produce glazed golden bricks, and passing down the eight master craftsmen's systems of painting, tile making, and woodworking from generation to generation. The standard methods are fixed in the "Rules of Engineering Practice" to ensure the continuity of traditional construction techniques. Over the course of 600 years, the Hall of Supreme Harmony suffered from lightning strikes, wars, and burning, and underwent 4 reconstructions. (Figure 2-3) The maintenance system of folk architecture integrates patriarchal ethics and traditional craftsmanship, utilizing the winter agricultural off-season for maintenance and ensuring the reuse of old materials.

Fig 2. The Hall of Supreme Harmony

The Hall of Supreme Harmony in the Forbidden City is located in the Palace Museum in Beijing. It is the largest of the three outer halls of the Forbidden City and also the largest palace in the Forbidden City. Commonly known as the "Golden Luang Hall" among the people, it is located in a prominent position along the north-south axis of the Forbidden City. Built in the 18th year of the Yongle reign of the Ming Dynasty (1420).

Picture source: The official website of the Palace Museum https://www.dpm.org.cn/building/talk/224412.html

2.The dilemma faced by the concept of "authenticity" in the contemporary Chinese context

The concept of "authenticity" in the field of urban heritage conservation originated from Western civilization and has a strong Western cultural color. The concept of "authenticity" has had a significant impact on the field of heritage conservation in China since its introduction, but to this day, it still faces many contradictions in the process of "sinicisation".

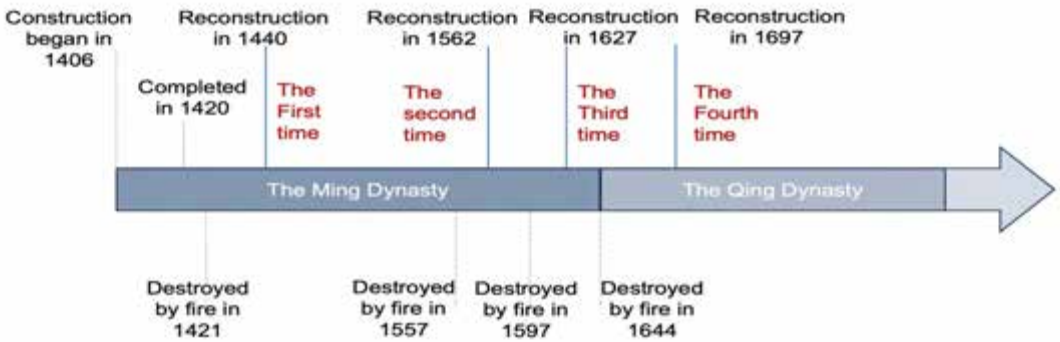

Fig 3. Over the course of more than 600 years, the Hall of Supreme Harmony has undergone four reconstructions
Diagram source: Drawn by the author of this article

2.1.The contradiction between absolutization and relativization
There are still a large number of traditional residential buildings in use in China, and these urban heritages are essentially dynamic, influenced by the passage of time and constantly changing cultural customs. However, the concept of authenticity in the field of international heritage protection often fails to adapt to changes and prioritizes preserving a fixed "absolutized" historic moment. In fact, authenticity should not be limited to a static "snapshot", but should reflect the cultural changes that are taking place, which give meaning to urban heritage.

2.2.The contradiction between materiality and spirituality
Chinese urban heritage is often full of profound spiritual significance, which cannot be expressed solely through material attributes. An important contribution of the Nara Authenticity Document is its recognition of the importance of intangible values. However, this intangible spiritual value challenges the traditional standards used to evaluate authenticity. The spiritual value in heritage is often marginalized, excluded, or misunderstood due to considerations of authenticity, even though it is crucial for the cultural identity of the heritage. Chritina Cameron 2024)

2.3.The contradiction between authoritarianism and popularization
The origin of the concept of "authenticity" in Western civilization is not a subjective evaluation, but comes from institutional authority, law, religion, or scientific rationality. Authenticity is often invoked as a method of social control or a mark of power relations: once something is defined as authentic, it is no longer questioned. (Jones, S. ,2010) The Nara Authenticity Document broadens the evaluation criteria for authenticity, emphasizes the importance of communities in interpreting and assessing authenticity, and recognizes them as the primary guardians of cultural heritage. However, the voices of local communities are still often marginalized, and experts and governments tend to prioritize material protection over community values and the views of local residents.

3.Cases of Traditional Residential Conservation in Three Historic Cities: Pingyao, Shanghai, and Suzhou
Pingyao, Shanghai, and Suzhou are three famous historic and cultural cities in China, which still retain a large number of traditional residential buildings that are still in use. These traditional dwellings, distributed in large patches, constitute the background of the authenticity of urban heritage. Traditional Chinese wooden architecture is a reflection of the traditional concept of cyclical time, emphasizing human habitation in the "present world" and reconstruction is a common occurrence. At present, most of these traditional dwellings suffer from problems such as structural aging and long-term disrepair. Unlike historical buildings in China that have legal protection status and are maintained by the state, most traditional dwellings are protected by individuals, often facing difficulties such as funding shortages and high maintenance costs during the protection process, and to a considerable extent, there are calls for reconstruction among residents. Experts have also raised questions that these wooden buildings, which have existed for a hundred years or even longer, have lost their maintenance. "What is the significance of completely preserving the dilapidated reality of these houses for the contemporary development of the city? Since conservation is for the inheritance and development of culture (Abdul Huq, S., Puthuvayi, B. 2024), will the purpose of contemporary historical and cultural protection be reversed by being limited to such static reality?" (Bing Zhang ,2011) How to better maintain the "authenticity" of traditional dwellings, while improving the quality of life of residents and raising their awareness of actively protecting traditional dwellings, is a problem that needs to be carefully considered. Pingyao, Shanghai, and Suzhou have provided different answers based on their own history and actual situations.

3.1.Government led + Resident autonomy - Pingyao
3.1.1.Strict and orderly courtyard model
Pingyao Ancient City has a history of 2700 years. The existing Pingyao Ancient City was formed in the 14th century and is an outstanding example of the Ming and Qing dynasties in China. It fully preserves the spatial sequence of traditional Chinese ritual architecture and was recognized as a World Cultural Heritage site by UNESCO in 1997. The entire ancient city covers an area of 2.25 square kilometers and has nearly 4,000 traditional residential courtyards, of which 90% are buildings from the Ming and Qing dynasties, and about 20,000 households live in them.

The traditional residential buildings in Pingyao Ancient City adopt the traditional Chinese solemn and orderly quadrangle courtyard model. There are clear axis lines, symmetrical left and right, and distinct primary and

secondary in the planar layout. Large courtyards are often composed of two or three courtyards, forming a "日" and "目" shape. (Figure 4)

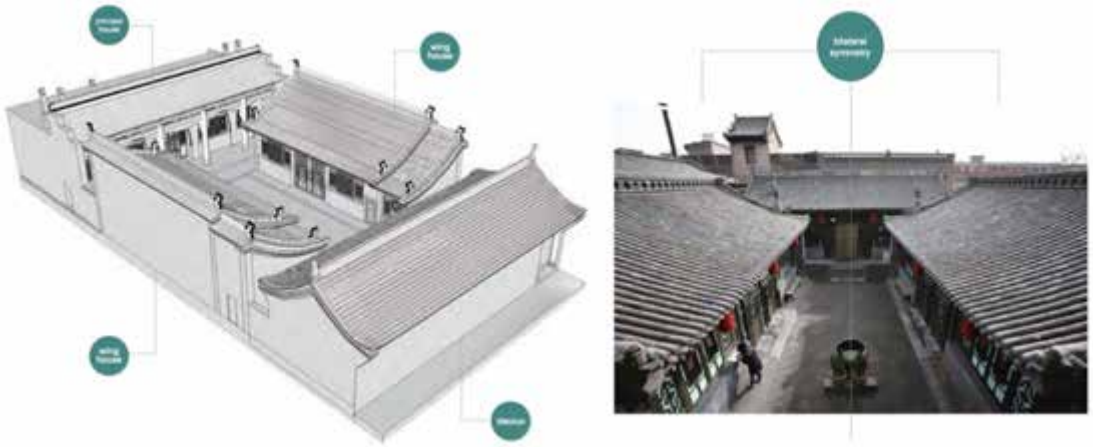

Fig 4. Typical Traditional Residential Courtyard in Pingyao Ancient City

There are various types of courtyard combinations in traditional residential buildings in Pingyao. The main courtyard is mostly a narrow quadrangle courtyard, while the auxiliary courtyards include chariot and horse yards or study courtyards.

Picture source: " Practical Conservation Guidelines for Traditional Courtyard Houses and Environment in the Ancient City of Pingyao "

During the Ming and Qing dynasties, a courtyard was the private property of a household. After two rounds of "private house socialist transformation" in 1958 and 1962, by 1966, more than 10,100 houses belonging to over 1,000 households in the ancient city had become "economic rental houses", and their property rights had changed from private property to public property. (Feng Tian, Wenzheng Shi, Junqing Wen, etc ,2016) Some courtyards have formed a mixed situation of public and private property, and residents have a low willingness to autonomous maintenance. Due to the low rent, the housing management office is unable to use the rent for house maintenance, resulting in widespread housing decay.

3.1.2.Comprehensive Conservation Policy

Since the 20th century, the tourism industry in Pingyao Ancient City has become increasingly developed, bringing about changes in courtyard functions and alienation of environmental landscapes. Traditional dwellings lack protection systems and financial support, and a large number of traditional dwellings have long lacked maintenance, resulting in poor living conditions. The traditional craftsmanship of restoration also needs to be adapted to modern protection concepts, lacking scientific and technical guidance. As early as 2010, the Global Heritage Fund (GHF) in the United States sponsored a pilot project for residential renovation in Pingyao. At that time, the concept of GHF was to use a courtyard as a model for renovation, providing reference standards and technical guidance for local residents.

The Pingyao County Government promulgated the "Implementation Measures for Financial Subsidies for the Conservation and Restoration of Traditional Residential Buildings in Pingyao Ancient City" in 2012, which was revised, improved, and implemented in 2013. The property owner shall submit an application to the county planning bureau and provide proof of property rights, original photos, restoration drawings, budget and other materials, which shall be reviewed and posted of the public notice by the government before being issued. Supervisors are composed of government deputies to the National People's Congress and members of the Chinese People's Political Consultative Conference, as well as experts, scholars, and social figures who love the protection of ancient cities. At the same time, the "Conservation Management Guidelines for Traditional Courtyard Houses and Environment in the Ancient City of Pingyao " and the " Practical Conservation Guidelines for Traditional Courtyard Houses and Environment in the Ancient City of Pingyao " were jointly initiated by UNESCO and the Pingyao County People's Government. The Shanxi Provincial Department of Housing and Urban Rural Development and Tongji

University jointly began to develop them, providing guidance for government management departments and residents' traditional residential building restoration and protection. (Figure 5) From the completed courtyards, government subsidies can basically account for one-third of the total project cost. On February 28, 2025, the Pingyao County Administrative Approval Service Management Bureau officially approved the "Pingyao Ancient City Historical and Cultural Block Renovation Project", planning to invest over 250 million yuan to inject new vitality into the protection and development of the ancient city. The funding source is 55.9471 million yuan from the county-level finance and 200 million yuan from the central finance application.

Fig 5. "Conservation Management Guidelines for Traditional Courtyard Houses and Environment in the Ancient City of Pingyao " and " Practical Conservation Guidelines for Traditional Courtyard Houses and Environment in the Ancient City of Pingyao "
Developed by the Shanxi Provincial Department of Housing and Urban Rural Development and Tongji University (2012-2016)

3.2.Government led + market participation - Shanghai
3.2.1.Joint layout of courtyard model
Traditional residential buildings in Shanghai, also known as Shikumen Lilong, are a combination of Chinese and Western architectural forms, built by foreign real estate developers or Chinese businessmen. Shikumen Lilong originated during the Shanghai Concession period in the 1870s and was built on a large scale in the 1910-1930s. The Shikumen architecture has the traditional form of a two-story courtyard or quadrangle courtyard in the regions south of the Yangtze River, with an overall layout following the Western style of row houses. (Figure 6-7)

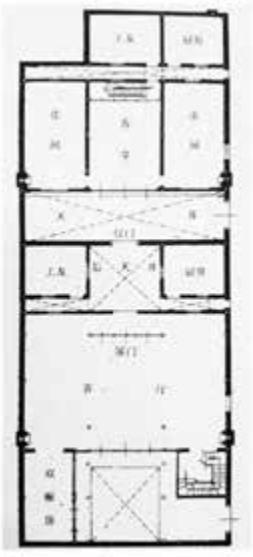

Fig 6. Shikumen Lilong Residences and the urban texture in old Shanghai.
Picture source: Collection of Shanghai History Museum (part of the original picture).

Fig 7. The plan of early Shikumen Hongdeli. Picture source: Qing Chang (2023)

Due to its construction during times of war, the land in the concessions was precious, and the opening and area of Shikumen buildings were greatly reduced compared to traditional residences. In 1949, 3 million people were squeezed into an 82.4km2 urban area. At that time, there were a total of 17.115 million square meters of new and old style lilong buildings in Shanghai, accounting for 72.5% of the total residential area. (Compiled by the Shanghai Residential Construction Chronicles Compilation Committee ,1998).

There are both a small number of high-end villas and mansions in Shikumen Lilong, as well as small courtyard houses in new-style lilong. Most of these high-quality lilong have protected identities and are maintained by the government or property owners. In addition, due to the real estate development method of renting land to build houses in Shanghai at the beginning of the 20th century, with a lease term of only 20-30 years, a large number of low-quality Shikumen residential buildings were also constructed. These residences, which experienced a wave of social movements from the 1950s to the 1970s, often had complex relationships between housing attributes and residency rights, crowded living conditions, inadequate living facilities, and safety hazards. They have long been referred to as "old-style lilong". Due to the lack of identity protection or the ambiguity of identity protection, the preservation of such old houses is often in a state of controversy. By the end of 2000, there were 14.1199 million square meters of old-style lilong in the central urban area of Shanghai center, which had been reduced to 8.13 million square meters in 2017, nearly half of which was secondary old-style lilong. By the end of 2018, there were still 2.38 million square meters of secondary old-style lilong in the central urban area of Shanghai center, with more than 100,000 residents.

3.2.2.Limited Conservation Policy

Faced with the protection and development of traditional residential buildings on such a large scale in Shanghai, as well as such complex historic relics, the principle of "authenticity" in the field of international heritage protection cannot be used for general comparison, because the scarcity of heritage is no longer comparable. (Qing Chang ,2023) Some experts believe that for the Shikumen architectural complex, active protection should be taken, but there is also a degree of protection. Not everything can be protected, and needs to be protected to its original state. When determining the scale, standards, structure, and degree of protection (architectural form, economic format, social ecology), except for cultural relics protection units, the principle of comprehensive authenticity may not necessarily be followed (protection units can only reflect the authenticity at the material level), and specific issues need to be analyzed case by case. (Yong Wan, Jianxiong Ge ,2011)

Since the 1990s, with the rapid development of Shanghai's economy and the soaring of land value and real estate prices, large-scale reconstruction of the old urban areas in the centre of Shanghai has been carried out. Shikumen Lilong is located in the central area of the city, facing the dual pressure of urban functional layout adjustment and land development intensity, which is intensifying. The government led mechanism for the renovation of old urban areas, with market access and "development plot ratio rewards" as its core features, quickly took over the dominant position, and the current social and material spaces began to be completely eliminated. Under the temptation of the real benefits brought by large-scale demolition, the government and market forces directly intervened in large-scale spatial reconstruction, thus forming an urban redevelopment model characterized by "large-scale demolition and construction, separation of people and land". (Gang Liu ,2016) (Figure 8-9)

Fig 8-9. "Xiesan Base" turned into Haihua Garden,1992-1994

On January 25, 1992, Shanghai signed a contract for the first phase of the "Xiesan Base" in Dapuqiao, the first old district renovation site to utilize foreign investment. Two years later, the site was built into a high-rise residential area called Haihua Garden. From then on, land leasing was fully implemented in various districts of Shanghai, marking the beginning of large-scale urban renewal in the city.

Picture source: [Memory of the city] "Xiesan Base"-a milestone in the history of Shanghai's old reform, News and Publicity Center of Shanghai Municipal Commission of Housing and Urban Rural Development

In recent years, the old district renovation model of "large-scale demolition and construction" has become unsustainable, and the concept of "urban renewal" based on stock development has gained more expectations. In 2017, the Shanghai Municipal Party Committee and Government proposed to adjust the renovation method of old districts from "demolition, renovation, and retention, with demolition as the main focus" to "retention, renovation, and demolition, with preservation and conservation as the main focus", and emphasized "allowing the city to retain memories and people to remember their homesickness". The renovation of old buildings in Shanghai has roughly gone through three stages, from "large-scale demolition and construction" to "demolition, renovation, and retention", and then to "retention, renovation, and demolition", with a greater emphasis on the conservation of historical features and urban texture. Due to the high investment and low return ratio of the renovation of old buildings, the government and state-owned enterprises have become the main sources of funding, and the participation of social capital in the renovation is relatively small. Since 2019, Shanghai has gradually explored the old and new system and operation mode of "urban cooperation and government enterprise cooperation", hoping to more effectively attract social capital participation. The new round of old area renovation projects will be implemented through the "housing expropriation" method, with monetary compensation as the main form of expropriation and physical resettlement as a supplement. For historic buildings that require conservation and preservation, renewal and functional reuse will be implemented after the completion of house expropriation, in order to achieve the goal of "people leaving the house and not demolishing it" for historic buildings. (Jingyun Xu, 2023) (Figure 10,11)

Fig 10-11. Zhangyuan before and after renovation,2018-2024

Zhangyuan is the largest and most well preserved representative of the Shikumen architectural complex in Shanghai. Before the protective expropriation of Zhangyuan, about 280 residents living here did not have independent bathrooms in their homes, and the internal space of the building was arbitrarily divided and overloaded. The aging, damage, and destruction of the building were serious, and the residents' desire to improve their living conditions became increasingly strong. In order to improve the quality of life of residents and continue the urban context, the Zhangyuan area will be renovated using the method of "expropriation without demolition", fully preserving the texture of the neighborhoods and alleys. After the expropriation is completed, the historic buildings will be protected, preserved, renovated, and reused according to the planning requirements.

Picture source: Taken by the author of this article on February 22, 2023

3.3.Government led + Resident autonomy + Market participation - Suzhou

3.3.1.The courtyard model of living by the water

Suzhou has a 2500-years history of city construction, and most of the existing traditional dwellings were built during the late Ming, Qing, and Republic of China periods. The ancient city of Suzhou still maintains a dual chessboard pattern of rivers and streets, and traditional residential buildings mostly reflect the layout characteristics related to rivers. Suzhou residential buildings are often center-courtyard model, with "one-entrance gate courtyard" as the basic unit of residential buildings. Large residential buildings are composed of two to multiple entrance gate courtyards. (Figure 12,13)

In the 1950s, in order to solve the housing problem of residents, public-private partnerships were implemented, and traditional houses in the ancient city of Suzhou were rented out to residents in the form of contracts, with the whole old houses being separated and inhabited. In the 1990s, the permanent population of 142,000 square kilometers living in the ancient city of Suzhou was 342,000. Crowded living, lack of supporting facilities, complex property rights, aging building structures, and damaged building appearances are all challenges to the Conservation and renewal of traditional residential buildings in Suzhou.

Fig 12-13. Typical Traditional Residences in the Ancient City of Suzhou

Traditional Suzhou houses are arranged in groups horizontally or vertically, forming a continuous group of alleyway houses. The overall layout of residential buildings is closely related to the river channel. This high-density layout allows each household to occupy the smallest amount of riverbank and alley sections, compact the land area, and achieve convenient water and land transportation.

Picture source Ancient Charm of Jiangnan - Suzhou Residential Architecture Culture Ancient Architecture in China

At present, there are about 1.95 million square meters of traditional residential buildings in the ancient city of Suzhou, with 43,000 households living in them. In traditional residential buildings, there are approximately 840,000 square meters of private houses and 19,000 households, with an average area of approximately 44.21 square meters per household; Directly managed public housing covers an area of approximately 1.11 million square meters, with around 24,000 households and an average household area of approximately 46.25 square meters per household. Both public and private houses are unable to meet the basic living needs of 60 square meters per household, and many directly managed public houses face difficulties in being fully integrated.

3.3.2."Three Original" Conservation Policy

In the 1980s, Suzhou's economy began to develop rapidly, and urban expansion led to the demolition of traditional dwellings and the reconstruction of modern buildings in the ancient city, resulting in the destruction of the city's appearance. In 1982, Suzhou was listed as one of the first batch of Chinese historic and cultural cities, officially beginning the process of ancient city conservation. In order to maintain the integrity and authenticity of the layout and style of the ancient city, the 1995 Suzhou Urban Planning Regulations proposed that "the urban area of Suzhou should protect the style of the ancient city", explicitly stating that "within the protection scope of the

ancient city, it is not allowed to construct buildings (structures) that do not conform to the style and features of the ancient city". In 2003, the "Measures for the Conservation of Historical and Cultural Cities and Towns in Suzhou City" further refined the regulations, stating that "the form, volume, height, and color of buildings within the protection scope of the ancient city should maintain the inherent characteristics of moderate volume, light shape, elegant color, and especially the white walls and black tiles of Suzhou buildings, reflecting the traditional style of Suzhou ancient city." In 2011, the Suzhou Planning Bureau formulated and issued the "Regulations on the Planning and Management of Private Housing Construction for Residents in Suzhou City," which clarified that the renovation of "dilapidated houses" in traditional residential buildings in the ancient city should maintain the "original area, original height, and original style", abbreviated as the "three original" principle.

Before 1998, the number of approvals for the renovation of traditional residential buildings was about 100 per year. After the promulgation of the "Regulations on the Planning and Management of Private Housing Construction for Residents in Suzhou City", the planning and management of private housing construction for residents has been strengthened, and the number of approvals for traditional residential reconstruction has been reduced to 20-30 per year. After 2020, the number of approvals for traditional residential construction has increased to about 50 per year, and is showing a trend of increasing year by year. On September 1, 2022, Gusu District held a special conference on the participation of social capital in the revitalization and utilization of traditional residential buildings, exploring new paths for introducing social capital to participate in the collection and revitalization of traditional residential property rights, and providing greater strength for the protection and renewal of the ancient city. Whether it is residents' independent reconstruction or the activation and utilization of social capital, the "Three Original" principle is still a rigid principle that cannot be exceeded.

The "Three Original " principle embodies the concept of combining "protection priority" with "organic renewal", by limiting the area and height, thus controlling the development intensity and avoiding excessive high-rise and commercialization of the ancient city; By preserving the texture of streets, courtyards, and architectural styles, the ancient city style has been continued; Under the premise of protection, residents are allowed to carry out modernization of the interior, thereby improving the living environment and balancing the needs of people's livelihood. (Figure 14-15)

Fig 14-15. An example of the renovation of a traditional residential building located on Shantang Street in the ancient city of Suzhou 2024
Picture source: DEKONG STUDIO

This is an independent residential renovation project. The space of the original building has been re planned and the height of the floor slabs has been adjusted. By appropriately staggered levels (ensuring the height

of the main space and reducing the height of the auxiliary space), a new attic space has been obtained. Due to the partial decay of the original roof wooden structure, the entire roof was renovated by adding insulation and waterproof layers. In order to obtain a larger span, steel structures were locally added. The staircase was designed as a hollow staircase and skylights were added, making the staircase a lighting well and solving the problem of insufficient lighting in the original house.

4.Conclusion and Discussion: How to Understand Authenticity in the Chinese Context?

How to understand the "authenticity" of a large number of traditional residential buildings that are in disrepair and lack identity conservation in the contemporary context of China? How to renovate the buildings in traditional Chinese cities, mainly consisting of brick and wood structures, in order to maintain their "authenticity"? Maintaining the materiality and authenticity of traditional architecture is certainly important, but can the continuation of traditional urban functions and sense of place also be understood as maintaining the "authenticity" of historic sites? Looking back at the three historic cities of Pingyao, Shanghai, and Suzhou, Pingyao has adopted a comprehensive protection policy due to the small scale of traditional residential buildings and the relatively intact preservation of courtyards, which are funded and maintained by the government; Due to the large scale and varying quality of traditional Shikumen Lilong in Shanghai, a limited protection strategy has been chosen to preserve some of the Lilong; The scale of traditional residential buildings in Suzhou is in the middle, and the ancient city's water and land double chessboard pattern has been well preserved for thousands of years. Therefore, the "Three Original" principle of "small-scale gradual" preservation of urban texture and allowing residents who meet regulations to rebuild independently has been adopted. Table.1

Tab.1 Comparison of the Conservation of Traditional Residences in Pingyao, Shanghai, and Suzhou

	Traditional Residences in Pingyao	Traditional Residences in Shanghai	Traditional Residences in Suzhou
Construction History	During the Ming and Qing dynasties	From the late Qing Dynasty to the Republic of China period	From the late Ming Dynasty to the Republic of China period
Construction scale	The ancient city covers an area of 2.25 k and has nearly 4,000 traditional residential courtyards	In 1949, 3 million people were crowded within an 82.4k area of Shanghai's urban area, with a total of 17.115 million square meters of Shikumen Lilong and residential buildings. In 2017, the area decreased to approximately 8.13 million square meters	The ancient city of Suzhou covers an area of 14.2 k and has approximately 1.95 million square meters of traditional residential buildings, with 43,000 households living in it
Is it a World Heritage City	Listed in 1997	no	Suzhou Gardens as a World Cultural Heritage Site (1997, 2000)
Is it a historic and cultural city	Second batch (1986)	Second batch (1986)	First batch (1982)
Real estate prices	¥5,000-7,000 /square meter	About ¥120,000 /square meter in the central urban area	About ¥26,000 /square meter in Gusu District
Government conservation tendency	Comprehensive conservation policy	Limited conservation policy	"Three Original" conservation policy
Market participation situation	Less	More	Medium
Residents' willingness	Repair after applying for government subsidies	Looking forward to receiving the demolition compensation after the government's unified expropriation*	Prefer to rebuild or construct independently
Expert advice	Continue the "authenticity" of the World Cultural Heritage	Question the damage to "authenticity" caused by the early government's "large-scale demolition and construction" and the current "gentrification" process	Hoping that the government will introduce policies to encourage residents to carry out self-repair instead of reconstruction, so as to maintain the "authenticity" as much as possible.
Present situation	Keep almost completely	Collage-style retention	Continue the texture and style of the ancient city

Table source: Drawn by the author of this article

* If residents choose to stay, they can enjoy the potential appreciation of the house in the future after its restoration, but it also means they still have to live in the old house and continue to endure various inconveniences. However, by choosing to leave, residents can directly vacate their old houses. This not only enables them to get rid of the poor living conditions as quickly as possible, but also allows them to immediately obtain the benefits of expropriation and relocation, or by purchasing and exchanging for new houses, they can gain the potential appreciation of their properties in the future. Many people are not averse to lilong life, but under the influence of opportunity cost, they still choose to leave. (Jing Yu, 2024)

Regardless of the principle of protection, the attitude, function, and role of the government in preserving or rebuilding traditional dwellings are highly noteworthy. In addition to considering the continuation of traditional culture and the preservation of cultural memory, the government also needs to take into account economic benefits such as tourism consumption income, economic benefits from reconstruction, and the cost of demolition and resettlement for residents. The higher the land prices in historic urban areas, the more inclined the local government is to promote the reconstruction of traditional dwellings, and the more motivated market capital is to participate; For residents, this often means that they can receive a large amount of compensation for

demolition and substantial improvement in their living conditions (except for the unfavorable factor of needing to leave the city center); Heritage conservation experts are more inclined to restore and preserve traditional dwellings, opposing the "gentrification" process of historic urban areas and calling for the preservation of the material and spiritual "authenticity" of traditional dwellings. However, reality is often complex. As the number of traditional dwellings that can be preserved has greatly decreased, the overall trend in various historic cities is to prioritize protection over reconstruction (small-scale autonomous reconstruction, or government and market forces led demolition and reconstruction). After all, these cultural memories representing a nation should not be roughly erased.

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Exploring Spatial Evolution of Traditional Settlement Landscapes in the Southern Taihang Region of China: A Study on Cultural Ecosystem Dynamics and Reconstructive Strategies

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Abstract
As spatial manifestations of human–environment relationships, traditional village landscapes are increasingly challenged by industrialization, urbanization, and globalization. This study focuses on the southern Taihang Mountains in China and applies a cultural ecology approach to construct a process-oriented model of settlement evolution. It systematically analyzes how agrarian culture shapes spatial forms across technological, institutional, cognitive, and practical dimensions, and reveals the transformation of settlements from ecological adaptation to spatial reconstruction under external disturbances. Integrating Holling's adaptive cycle theory, the research delineates four evolutionary stages of traditional settlements and employs network analysis to build a cultural ecosystem network, highlighting mechanisms of multi-scalar spatial restructuring. Based on this, a holistic protection strategy is proposed—from node activation and cluster coordination to regional network optimization. The study offers theoretical support for the dynamic reintegration and systemic revitalization of traditional settlements in the southern Taihang region, while providing a reference framework for adaptive protection of cultural landscapes globally.

Keywords Traditional Settlement Landscapes; Cultural Ecology; Evolutionary Mechanisms; Southern Taihang; China

Introduction

As a fundamental material basis of human civilisation, villages serve an irreplaceable function in preserving historical memory and transmitting cultural heritage-Barrientos et al.,2021-. Nevertheless, the rapid advancement of industrialisation and urbanisation, alongside profound socio-economic transformations, has posed significant challenges to rural settlements globally, manifesting in depopulation, functional decline, and even the complete disappearance of some villages-Mu and Aimar, 2022; Li, Westlund and Liu, 2019-. In the context of China's rural revitalisation strategy, traditional villages constitute a critical spatial unit. They not only facilitate the modernisation of rural areas and enhance the living standards of local populations but also play a pivotal role in sustaining regional cultural identity and ensuring social cohesion.Since the initiation of systematic protection efforts in 2012, China has implemented a six-phase listing programme (2012–2023), encompassing 8,155 traditional villages and thereby establishing the most comprehensive agricultural heritage conservation framework globally -Cheng et al., 2024-. Furthermore, starting in 2020, the Ministry of Finance and the Ministry of Housing and Urban-Rural Development have successively promulgated the Model Work Programme for the Intensive and Continuous Conservation and Utilisation of Traditional Villages. This initiative targets persistent issues such as spatial homogenisation and limited revitalisation pathways in traditional village development -Zhao et al., 2024-.Against this backdrop, an in-depth exploration of the spatial characteristics and generative mechanisms of regional traditional villages has become essential. Such inquiry is vital for addressing the fragmentation in current conservation practices, unlocking cultural and ecological potentials, and advancing both theoretical understanding and practical implementation of holistic settlement preservation and cultural system reconstruction.

Research on the spatial morphology of traditional settlements has undergone a progressive evolution of theoretical paradigms, gradually forming a composite explanatory system that integrates natural, social, and cultural dimensions. In its early stages, the dominant perspective was functionalism, which highlighted the interdependence between settlements and natural geographical conditions, yet largely overlooked cultural and institutional dynamics -Li and Zhang, 2012-. Later, central place theory introduced a hierarchical logic of settlement distribution and functions, advancing the modelling of spatial systems -Hill, 2003; Pacione, 1984-. Concurrently, cultural landscape theory underscored the notion that spatial forms are shaped by cultural choices, thereby integrating cultural behaviours into spatial analysis-Sauer, 2008-.Within the structuralist tradition, Rossi's theory of architectural typology interpreted settlements as material representations of collective social cognition -Rossi, 1984-, while Hillel's spatial syntax elucidated the organisational logic of space and human behaviour through topological structures-Yamu, Van Nes and Garau, 2021-. In recent years, interdisciplinary approaches have gained

prominence, fostering closer integration between theoretical inquiry and practical application. However, most existing studies still lack a systematic framework capable of explaining the dynamic generative mechanisms behind settlement morphology, particularly those shaped by long-term interactions among ecological, cultural, and institutional forces.To address these limitations, this paper introduces the theoretical perspective of the cultural ecosystem and proposes a four-dimensional analytical framework encompassing: technology–ecology, cognition–concept, organisation–institution, and practice–strategy. This approach aims to overcome the current fragmentation and unidirectional interpretations in traditional settlement research, offering a more holistic understanding of their spatial evolution.

As scholarly inquiry deepens, empirical research on the spatial morphology of traditional settlements has gradually matured across several dimensions, including research subjects, scale frameworks, analytical methods, and variable construction. A foundational analytical pathway has emerged, characterised by the sequence of "pattern identification – typological classification – factor analysis." Most existing studies concentrate on nationally recognised villages or prominent regional cases -Liu et al., 2022-, such as Guizhou Province -Yan et al., 2021- and ethnic minority areas-Chen, Xiao and Liu, 2024-. While such research has elucidated macro-level distribution patterns, it tends to overlook marginal regions and atypical cases, thereby constraining the generalisability and applicability of findings.In terms of scale, a widely adopted three-tier analytical framework—macro, meso, and micro—is typically employed, corresponding to spatial distribution evolution, typological differentiation, and intra-settlement structural analysis, respectively-Lin, Liang and Liu, 2024-. Common methods include kernel density estimation-Bi et al., 2024-, cluster analysis, and space syntax modelling-Qin et al., 2023-. With regard to variable construction, most indicators are derived from natural, social, cultural, and institutional dimensions. However, the analytical techniques employed are predominantly linear, such as regression analysis and structural equation modelling-Yuan et al., 2024-, which often fail to capture the complex nonlinear interactions and coupling mechanisms among variables.Despite notable progress, current research continues to exhibit limitations, including inadequate identification of spatial phenomena and insufficient integration of cultural-ecological dimensions. Moving forward, it is essential to optimise indicator systems and refine analytical approaches under robust theoretical guidance, in order to achieve a more systematic and comprehensive understanding of the evolutionary mechanisms underpinning the spatial morphology of traditional settlements.

Situated within the transitional geographic zone between the Central Plains and North China, the South Taihang region represents a typical mountainous and hilly terrain bridging the eastern edge of the Loess Plateau and the North China Plain. Characterised by its fragmented topography and ecological diversity, the region has nurtured a wide spectrum of traditional settlement forms. Embedded within this landscape is a convergence of diverse cultural lineages, including agrarian traditions, mountain-based defence systems, and nomadic frontier influences. These have collectively shaped distinctive village morphologies—such as fortress-type, trade route-based, and mountain-adapted settlements—rendering the region highly representative and of considerable academic interest.In recent years, however, the acceleration of urbanisation and the deepening reconstruction of rural spatial structures have triggered profound transformations in these traditional settlements. Their embedded cultural and ecological frameworks are experiencing significant disruption, thereby necessitating timely institutional responses to safeguard their evolutionary continuity and guide appropriate conservation strategies.

Accordingly, this study pursues two primary research objectives: (1) to elucidate the historical trajectories and spatial evolution patterns of traditional settlements in the South Taihang region; and (2) to develop a protection and reconstruction pathway grounded in the cultural ecosystem perspective. Through this, the study seeks to offer a theoretical foundation and strategic guidance for the systematic conservation of traditional settlements in complex mountainous landscapes.

Research Methods

Overview of the Study Area

The Taihang Mountains extend through central North China, with the South Taihang section located in Henan Province, spanning approximately 150 kilometres from north to south. This region is predominantly mountainous and hilly, and it hosts a rich array of traditional villages whose residential and architectural forms exhibit pronounced mountainous settlement characteristics-Duan et al., 2023-. However, the rapid pace of urbanisation and tourism development has resulted in the hollowing out and commodification of many villages. Concurrently,

land use transformations and ecological degradation have posed severe threats to their sustainable development. Existing conservation efforts tend to concentrate on individual villages, often overlooking broader regional dynamics, including inter-village interactions, resource flows, and spatial functions.To address this gap, the present study selects 43 representative traditional villages—each recognised at or above the provincial level—located in the South Taihang mountainous region as the research sample (Fig. 1). These villages are characterised by long-standing histories, relatively intact preservation, and high cultural landscape value.

Fig. 1 Map of the study area of South Taihang in northern Henan Province

Data Sources

The data utilised in this study were derived from multiple authoritative sources to ensure comprehensiveness and reliability. Geographic information, including 30×30 m resolution digital elevation model (DEM) data, was obtained from the China Geospatial Data Cloud Platform (http://www.gscloud.cn/). Administrative boundary data at the provincial, municipal, county, and village levels were sourced from the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences (http://www.igsnrr.ac.cn/). Official lists of traditional villages were acquired from the Ministry of Housing and Urban-Rural Development of China and the Henan Provincial Department of Housing and Urban-Rural Development. GDP and population statistics were also retrieved from the Institute of Geographic Sciences and Natural Resources Research. Cultural heritage data were collected from the Ministry of Culture and Tourism of the People's Republic of China (https://www.mct.gov.cn/) and the Henan Provincial Cultural Relics Bureau (http://wwj.henan.gov.cn/). Additionally, Point of Interest (POI) data, along with information on the shortest travel time and distance between locations, were obtained from the Gaode Open Platform (https://lbs.amap.com/). To complement these secondary sources, field investigations were conducted to collect primary data on village profiles, infrastructure, architectural characteristics, as well as population and economic conditions.

Analysis Framework and Research Ideas

Evolutionary Mechanism Model of the Cultural Ecosystem in Traditional Villages

Traditional settlements are not merely historical accumulations of material space; they also represent the evolving outcomes of cultural ecosystems shaped by the dynamic interplay between natural, social, and cultural forces. Drawing on the principles of cultural ecology, human societies have developed a "culture-driven core" under resource constraints and institutional regulation, from which three major cultural dimensions—material, institutional, and spiritual—have emerged-Chen, Xie and Li, 2020; Shao, Cui and Zhang, 2024-(Fig. 2). These dimensions are systematically translated into spatial expressions through four structural levels: technology–ecology, organisation–institution, cognition–concept, and practice–strategy, forming the intrinsic mechanism underlying the spatial evolution of settlements.

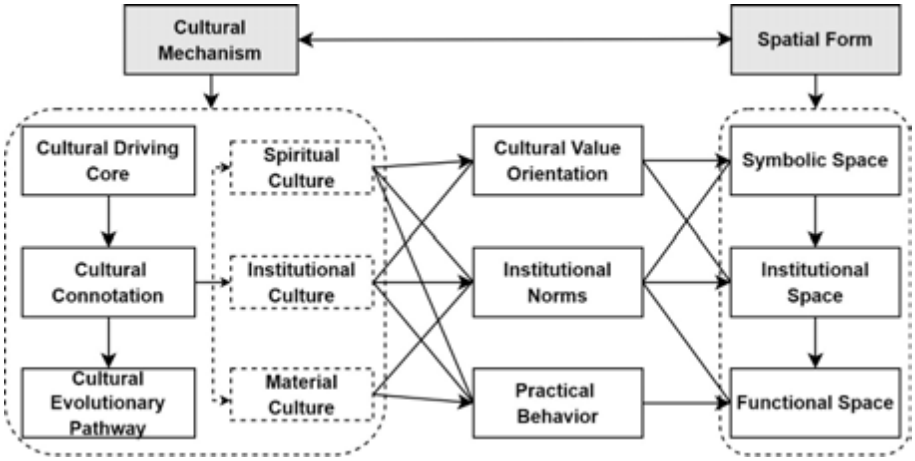

Fig. 2 Conceptual Framework of Cultural Mechanisms Driving the Formation of Spatial Forms in Traditional Settlements

To capture the temporal dynamics of this evolution, this study adopts Holling's adaptive cycle theory-Holling, 2001-, which conceptualises evolution in four phases: exploration, conservation, release, and reorganisation. This framework reveals how the culture-driven core undergoes phases of stabilisation, disintegration, and restructuring. Spatially, this process is embodied in a nested path of "culture-driven core—cultural connotation—spatial representation", leading to the construction of a three-tiered spatial network comprising nodes, clusters, and regions. This tripartite structure spans macro-regional scales, meso-level agglomerations, and micro-level settlement nodes. Overall, the proposed mechanism model demonstrates that cultural ecological spaces evolve through a dynamic process of variation–adaptation–integration, driven by self-organisation and network coupling under multiple external disturbances.

Construction of the Cultural Ecological Network of Traditional Villages

To uncover the patterns of cultural-spatial interaction among traditional villages in the South Tai hang region of northern Henan, this study constructs a cultural ecological network system. This system integrates cultural development indicators, applies the gravity model as its analytical logic, and employs social network analysis (SNA) as its methodological tool. First, a set of 16 specific indicators was developed across five criteria: historical and locational background, tangible and intangible cultural heritage, infrastructure, industrial activity, and economic status-Wang et al., 2023-, aiming to comprehensively assess the cultural development level of each village. These indicators were standardised using the extreme deviation method, and weighted through the entropy method-Chen, Zhong and Li, 2023-, yielding a composite cultural development score ranging from 0 to 1. This score serves as a proxy for the village's cultural attractiveness. Next, the traditional gravity model-Wang et al., 2025- was modified to incorporate both the composite cultural development scores and the shortest travel time between villages, thereby quantifying the intensity of cultural-spatial linkages. Based on this, a spatial cultural ecological network was established. Finally, SNA was employed to analyse the centrality of network nodes, the overall network topology, and to explore patterns of core–periphery differentiation, cohesive subgroups, and mechanisms of spatial interaction -Liu, Hao and Xia, 2024-.

Results

Stages in the Evolution of the Cultural Ecosystem of Traditional Villages

Agricultural Inception: The 'Livelihood–Adaptation' Phase of the Cultural Ecosystem

During the Ming and Qing Dynasties, traditional villages in northern Henan began to emerge and gradually coalesced into stable settlement systems. This period marked the initial formation of a cultural ecosystem grounded in agriculture as the primary mode of subsistence and ecological adaptation as the core dynamic. Although the spatial scale of these villages remained limited and their internal structures relatively loose, the foundational coupling of people–land–culture began to take shape. In response to challenges such as frequent Yellow River flooding, cold and arid climatic conditions, and scarcity of arable land, early settlers gradually constructed a preliminary yet stable cultural ecosystem. This was achieved through livelihood-based adaptation, conceptual reconstruction, organisational experimentation, and practical accumulation, laying a critical foundation for the

institutionalisation and networked evolution of traditional settlements.

Deconstructing the Intrinsic Mechanism: Origin and Adaptive Logic of the Cultural Ecosystem

In the formative stage of cultural ecosystem development, traditional agrarian settlements in northern Henan demonstrated a spatial logic rooted in livelihood adaptation.At the technology–ecology level, villages were typically situated along the seasonal water belts at the margins of the Yellow River alluvial fan. These locations enabled the construction of ridge-and-border farming systems well-suited to dryland agriculture. Productivity was enhanced through the use of agricultural tools such as waterwheels and ploughs, and small-scale settlements were spatially distributed according to topographic features.At the cognition–concept level, cultural consciousness was shaped by reverence for natural forces and adherence to agricultural seasonality. Symbolic spaces—such as land shrines and communal temples—emerged as centres of collective belief and practice, embodying the villagers' perceptual and spatial responses to ecological rhythms.

At the organisation–institution level, early village life was governed primarily by neighbourly cooperation and customary norms, with formal clan systems still in embryonic form. Nonetheless, the emergence of ancestral halls and sacrificial fields signalled the nascent development of institutional frameworks for communal organisation.At the practice–strategy level, villagers adopted a diversified risk-coping strategy involving small-scale mixed farming, crop rotation, and household-based handicrafts. They enhanced settlement resilience through cooperative practices such as ditch construction, flood control, and collective labour mobilisation. Simultaneously, early forms of interaction with local administrative structures were established, initiating the villages' gradual integration into broader regional governance networks.

Together, these four structural mechanisms—technological, cognitive, institutional, and strategic—constituted the spatial and functional basis of the early cultural ecosystem, establishing the point of departure for the sustained evolution of traditional settlements in northern Henan.

Spatial Representation: Prototypical Construction of Agricultural Settlements and Ecological Dependency Structures

In the early stages of development, agrarian settlements in northern Henan were predominantly situated along natural water systems—rivers, canals, shallow floodplains, and wells—forming a distinct ecological dependency structure that integrated agricultural production and daily living within a unified spatial context. These villages were generally small in scale, with vague or fluid boundaries, and the layout of dwellings reflected a terrain-responsive logic: houses were scattered based on topographical conditions, forming a proto-structural pattern centred around nuclear families, with miniature plots of farmland encircling the residential core.At this stage, internal functional zoning remained rudimentary, and the spatial structure was largely defined by a few critical nodes. Elements such as land shrines and wells served multifunctional roles, acting as centres for communal gathering, ritual worship, and local trade. The residential form was characterised by compact courtyard-style housing, where living and productive activities were highly integrated (Fig. 3), reflecting the underlying spatial principle of "life as livelihood."

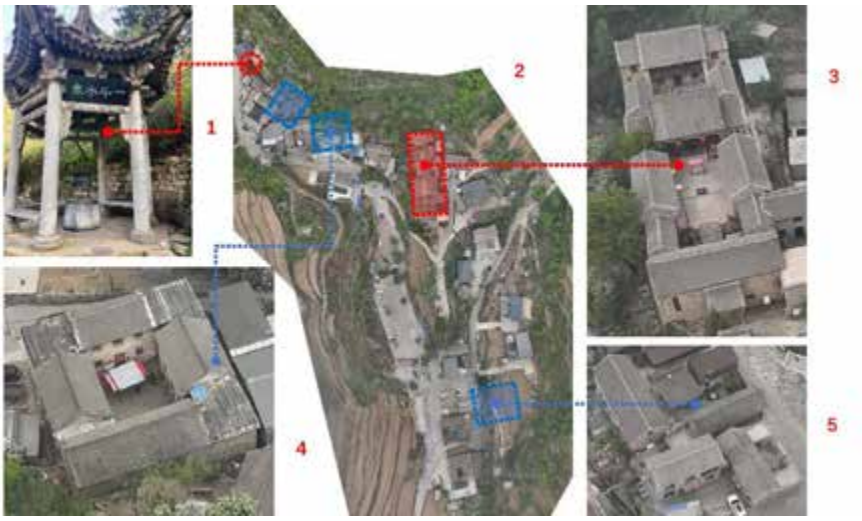

Fig. 3 Spatial features of Yidoushui Village in the 'Livelihood–Adaptation' phase of the cultural ecosystem: (1) the ancient spring well that served as the origin of settlement; (2) aerial view of the current village layout; (3) Guandi Temple, a spiritual and institutional cultural core; (4) courtyard dwellings providing commercial services during the early stage of development; (5) representative enclosed courtyards adapted for early trade and residence.

With the gradual stabilisation of agricultural cycles and the emergence of rudimentary institutional interventions, certain villages began to exhibit axial symmetry and defined residential base boundaries, marking a shift towards more organised spatial order. Simultaneously, the path system evolved into a functional network that linked residences, farmlands, and water sources—a configuration here referred to as the "house–field–water" network. This spatial transformation signified a critical transition from settlements based purely on ecological adaptation to those shaped by cultural organisation, thereby laying the structural groundwork for the subsequent institutionalisation and networked evolution of the traditional settlement system.

Agricultural Heyday: The 'Stabilisation–Adaptation' Phase of the Cultural Ecosystem

During the agricultural heyday, the advancement of agricultural technologies in northern Henan significantly enhanced human–land relations, ushering traditional villages into a phase of stabilisation-oriented evolution within the cultural ecosystem. In this stage, ecological constraints were no longer the primary limiting factors. Instead, cultural, institutional, and social dynamics emerged as the dominant shaping forces, steering the evolution of village spatial structures toward systematic organisation, functional differentiation, and networked synergy.

Deconstruction of Intrinsic Mechanism: Multi-Layered Homeostatic Synergy in Agrarian Cultural Ecosystems

At the technology–ecology level, northern Henan's geographic position—spanning both plains and hills—provided a favourable foundation for dry farming. From the Ming and Qing Dynasties onward, the widespread adoption of agricultural tools such as ploughs and waterwheels, coupled with improvements in water conservancy infrastructure, led to the development of an integrated "field–village–road" system. This structure linked irrigation networks with tributary channels, effectively boosting agricultural productivity and enhancing the external connectivity of settlements.At the cognition–concept level, ancestral halls and family temples became the spiritual and spatial axes of the village. The Confucian ideology of ritual-based governance) became deeply embedded in land allocation, residential spatial arrangements, and settlement planning. Ethical values centred on filial piety and ancestor reverence reinforced spatial hierarchies within the settlement and fostered the stable evolution of axial and enclosed spatial layouts.

At the organisation–institution level, village covenants, ancestral codes, and clan regulations—driven by lineage-based governance—effectively maintained collective order. Systems of centralised land management and collaborative farming strengthened the endogenous governance capacity of the village. Moreover, the nested interaction between formal administrative institutions (e.g., the bailiwick system) and informal clan

self-organisation provided a high degree of institutional resilience and governance flexibility.At the practice–strategy level, daily activities remained highly synchronised with agricultural seasonal cycles. Interactions across seasons, the establishment of market trading hubs, and the development of regional road networks promoted functional connectivity between villages. Additionally, Qing Dynasty rural policies—such as the establishment of marketplaces, patrolling mechanisms, and inspection systems—contributed to the institutionalisation of spatial nodes and facilitated the construction of inter-village cooperative networks.

Spatial Representation: Network Structure of Farming Villages under Institutional Embeddedness and Functional Synergy

The synergy of multi-level cultural ecosystem mechanisms during the agricultural heyday is spatially manifested in farming settlements characterised by systematic organisation, functional clarity, and enhanced network connectivity. Village layouts were typically centred around arable land and water resources, forming a spatially cohesive "cultivation–residence–ancestral shrine" structure. Within these settlements, the ancestral hall functioned as the spiritual and symbolic core, around which residential zones were organised—reflecting a spatial logic founded on the trinity of land, kinship, and faith (land–family–belief).Beyond the settlement core, roads, canals, and market access routes facilitated the construction of a rural spatial network linking adjacent villages. The implementation of market-day systems introduced a regular rhythm to local socio-economic life, transforming marketplaces into intermediary nodes for both economic exchange and cultural interaction. This system encouraged the evolution of villages from isolated spatial units into a networked and coordinated rural system, defined by multi-layered interactions and cooperative functions.

Overall, the spatial morphology of farming villages in this phase reflects the organic integration of natural, institutional, and cultural elements within a stabilisation-dominated cultural ecosystem. This period is marked by the typical features of institutional embeddedness, functional complementarity, and spatial hierarchy (Fig. 4). The resulting spatial network not only enhanced the resilience and adaptability of the settlement system but also laid a robust foundation for the future development of regional collaboration and cultural integration.

Fig. 4 Spatial Characteristics of Beizhu Village in the 'Stabilisation–Adaptation' Phase of the Cultural Ecosystem: (1) Village master plan with old village boundary (blue dashed line); (2) Bird's-eye view of fortress-like courtyard houses; (3) Clan ancestral hall as the core of spiritual and institutional culture; (4) Enclosed traditional courtyard with defensive spatial layout; (5) Main entrance and façade of a preserved residential courtyard.

Agricultural Decline: The 'Disturbance–Imbalance' Stage of the Cultural Ecosystem

Since the 20th century, driven by rapid industrialisation, urbanisation, and population mobility, the cultural ecosystem of traditional farming villages in northern Henan has entered a phase of "disturbance–imbalance". The core of cultural motivation has been severely disrupted, institutional mechanisms have disintegrated, spiritual order has collapsed, and the once-stable system has undergone fragmentation. This stage is marked by

structural dispersion and a marked weakening of spatial functionality.

Deconstruction of the Internal Mechanism: Systemic Imbalance in Traditional Cultural Ecosystems

At the technology–ecology level, the traditional agricultural system—once aligned with natural seasonal rhythms—has been supplanted by modern agricultural practices. While mechanisation and the use of chemical fertilisers and pesticides have increased productivity, they have also contributed to the degradation of soil and water resources, destabilising the ecological foundation. A significant portion of farmland has been abandoned, converted to non-agricultural uses, or left fallow, resulting in its redefinition as an inefficient and fragmented resource field.At the cognition–concept level, the societal shift toward urban employment has rendered the farming profession increasingly unattractive. Traditional cultural values such as "honour through cultivation and scholarship" and "ancestral reverence and filial piety" have weakened, leading to the erosion of cultural identity structures. The once-vibrant practices of faith-based rituals, seasonal festivals, and ancestral worship have faded, plunging village spiritual life into a state of low identification and low participation.

At the organisation–institution level, the introduction of the household contract responsibility system has restructured land-use relations, diminishing intra-village cooperation and weakening clan-based collaborative networks. Ancestral codes, clan regulations, and other traditional governance frameworks have largely become symbolic or obsolete. Grassroots village administration often persists in form but lacks substance, with governance systems existing without cultural legitimacy or communal recognition—a condition encapsulated in the notion of "the system is present, but the identity is absent."At the practice–strategy level, the collapse of seasonal agricultural rhythms and collective living practices has led to the decline of community rituals, such as temple fairs, neighbourly assistance, and village markets. The simultaneous outmigration of younger populations and aging-in-place of the elderly has critically undermined local organisational capacity. As a result, traditional settlements are increasingly reduced to spatial containers of low-frequency use, wherein everyday life becomes decoupled from spatial form, and the functional meaning of space deteriorates into obsolescence.

Spatial Characterisation: Decoupled Variation and Dysfunction of Settlement Structure

The collapse of cultural and ecological mechanisms is spatially reflected through significant distortions at three interrelated levels:First, the failure of ecological adaptation systems has led to the de-agriculturalisation of village peripheries. Farmland surrounding settlements has been increasingly abandoned, built upon, or repurposed for rental uses. These processes have disrupted the traditional "cultivation–residence–irrigation" spatial configuration, resulting in the blurring of settlement boundaries and fragmentation of functional zoning. Second, the degradation of symbolic cultural spaces has accelerated. Traditional spiritual landmarks—such as ancestral halls, temples, and sacrificial platforms—have lost their communal functions, becoming abandoned, repurposed, or neglected. These symbolic spatial nodes, once central to collective identity, have become cultural voids. Ancestral residences and study halls have been converted into storage sheds and barns, while public spaces have lost their ritualistic and integrative functions, transforming from centres of cultural life into static physical remnants.Third, the institutional spatial order has undergone disintegration. Unregulated housing expansion, ambiguous residential boundaries, and the juxtaposition of old and new structures have disrupted previously coherent axial or enclosed layouts. Former institutional nodes—such as council halls, well platforms, and clan assembly spaces—have lost their governance and symbolic roles. The result is a transformation from an orderly and synergistic spatial system to one marked by de-nucleation, decentralisation, and spatial disintegration.

Additionally, the collapse of communal living practices has further hollowed out the spatial vitality of traditional settlements. Streets and alleys lie deserted, public spaces remain unused, and the overall frequency of spatial engagement is extremely low. The proliferation of roadside construction, oriented with houses "facing away" from communal space, has produced a "back-to-the-road" layout, emblematic of spatial disengagement. Consequently, traditional settlements have fallen into functional silence, with a complete rupture in the cultural life network.In summary, the spatial pattern of settlements at this stage is characterised by structural fragmentation, functional dislocation, and cultural degradation (Fig. 5). These patterns reveal the disintegration logic of the cultural ecosystem in conditions of systemic imbalance, offering critical insights into the spatial evolution trajectory and mechanisms underlying rural decline.

Fig. 5 Spatial characteristics of traditional villages during the 'Disturbance–Imbalance' stage of the cultural ecosystem:(1) Overall spatial layout of Hankou Village: the core traditional settlement area (red dashed boundary) shows a dense and organically grown morphology with curved paths and compact buildings, contrasting sharply with the surrounding grid-like new development zones;(2) Aerial view of the core traditional zone in Hankou, showing decaying buildings and landscape disintegration;(3) Overall spatial pattern of Huanghou Village: buildings with dark roofs indicate preserved traditional houses, while blue roofs mark updated or reconstructed structures;(4) Aerial view of the inner central courtyard cluster in Huanghou, illustrating enclosed residential morphology;(5) Aerial view of edge-zone dwellings in Huanghou, representing transitional spaces undergoing functional and morphological fragmentation.

Eco-Capital Transformation: The 'Integration–Regeneration' Stage of Cultural Ecosystems

Following prolonged phases of institutional disintegration, population outflow, and functional decay, certain traditional villages in northern Henan have begun to explore new mechanisms for reconstructing their cultural ecosystems through the lens of eco-capital transformation. Distinct from earlier phases that relied primarily on endogenous resilience and passive recovery, this stage is driven by an integrated dynamic of ecological value recognition, institutional reshaping, cognitive renewal, and behavioural reactivation. Together, these four dimensions enable the simultaneous regeneration of both cultural systems and spatial structures.

Reconstruction of Intrinsic Mechanism: Pluralistic Activation of the Cultural System under the Logic of Ecological Capital

At the technology–ecology level, village ecological assets—including arable land, forests, mountains, water bodies, and courtyards—have been systematically evaluated and incorporated into a "resource–asset–capital–product" transformation chain. This is realised through digital mapping and suitability assessments, which facilitate the spatial integration of these assets into new development platforms such as "pastoral complex zones" and "eco-cultural tourism districts", enabling a shift from traditional agricultural spaces to composite ecological production landscapes.At the cognition–concept level, ecological resources have been reinterpreted as both "green wealth" and "cultural imagery." Through strategic mechanisms such as "nostalgia narratives" and "rural aesthetics", villages construct renewed cultural identities grounded in ecological memory and cultural symbolism. Spatially, this shift is embodied in the emergence of new cultural nodes, including agricultural heritage schools, festival plazas, and eco-exhibition halls, which enhance cultural attractiveness and reinforce a localized sense of place.

At the organisation–institution level, the implementation of land and resource rights confirmation reforms has clarified the ownership and usage boundaries of key ecological resources, such as mountains, forests, and waterways. This has laid the foundation for multi-party collaborative governance mechanisms, involving villages, communities, governmental entities, and private capital. Spatial governance has evolved from traditional self-organising models to platform-based, networked coordination, with newly delineated functional zones for culture, education, habitation, and ecological industry.At the practice–strategy level, villagers are no longer solely cultivators, but have transformed into "ecological stewards." Their daily practices now include eco-agriculture,

cultural tourism, community festivals, and participatory initiatives, forming an integrated "ecology + culture + participation" model of community life. In this transition, the village is redefined from a static residential unit into a dynamic cultural production and experiential space, simultaneously supporting ecological sustainability and cultural regeneration.

Reorganisation of Spatial Structure: A Mechanism for the Re-Scenarioisation of Settlements Driven by Ecological Value

Driven by the logic of ecological capital, the spatial structure of traditional villages has undergone a significant transformation, shifting from a single-function agricultural landscape to a multifunctional and synergistic spatial system. Former agricultural spaces have been reorganised into diversified zones, including ecological corridors, cultural districts, and shared public nodes, promoting the evolution of settlements towards forms characterised by block-based synergy and structural clarity. Cultural imagery and institutional networks are deeply embedded within these reorganised spaces, while everyday practices such as ecological farming, cultural tourism, and communal events revitalise spatial functions. This transformation generates a new spatial logic comprising three interrelated dimensions: platform-based governance operations, cultural expression as a symbolic axis, and scenario-based participation as a mechanism for community engagement. Overall, this phase reflects the trajectory of the cultural ecosystem through a process of system imbalance, structural reorganisation, and mechanism regeneration. It marks a critical shift from elemental dispersion to functional integration, achieving the dual transformation of spatial functionality and cultural revitalization (Fig. 6). By embedding ecological values into both material and symbolic space, this stage offers a practical paradigm for the holistic protection, adaptive reuse, and sustainable regeneration of traditional settlements.

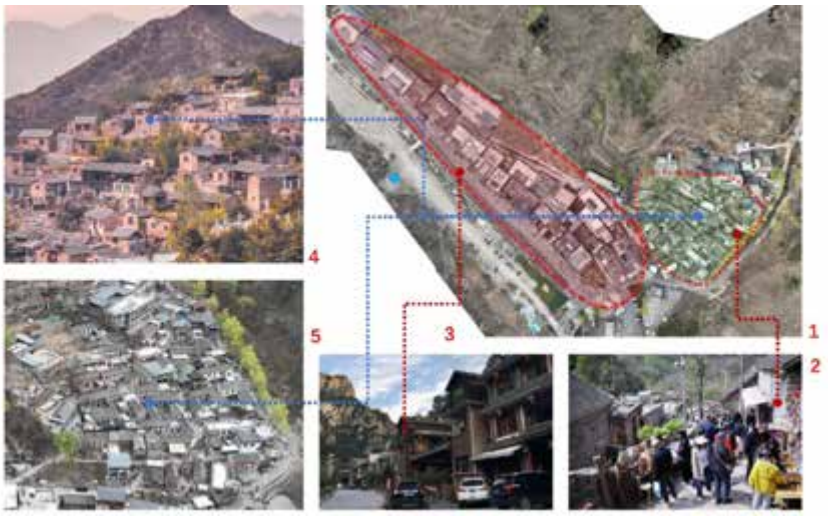

Fig. 6 Spatial reconstruction of Guoliang Village under the logic of cultural ecological capital activation: (1) current spatial layout, with the red strip representing newly developed areas and the green zone indicating the historical village core; (2) commercial landscape and streetscape in the traditional area; (3) newly constructed commercial street zone; (4) historical architectural form during the mature stage of village development; (5) current internal spatial transformation within the traditional village.

Characteristic analysis of traditional village cultural and ecological network structure

Characteristics of Network Individual Levels

Analysis of the cultural and ecological network structure of traditional villages reveals distinct patterns at the individual node level. Degree centrality results indicate that villages such as Xixiangping, Shijiagou, Wangjiatan, and Shuangmiao occupy central positions within the network (Fig. 7), with degree values significantly above the mean. These nodes demonstrate strong capacities for regional coordination and resource diffusion, functioning as key hubs. In contrast, villages such as Judeo and Lihe exhibit low degree centrality, signifying weak spatial connectivity and marginal positions within the network—factors that impede the overall network's cohesion and integrative potential.In terms of closeness centrality, villages like Xideng, Hankou, and Shijiagou possess high levels of accessibility, allowing them to quickly interact with other nodes. Their strategic spatial locations position

them as critical service hubs and network actors within the broader regional structure. Conversely, villages such as Xianmagou and Wenpo are characterised by low closeness centrality, reflecting their relative spatial isolation and reduced influence.

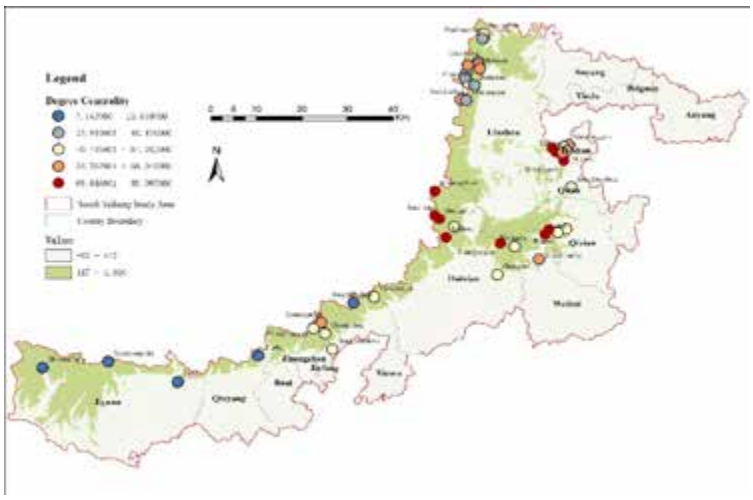

Fig. 7 Spatial Distribution of Degree Centrality of Traditional Villages in the Southern Taihang Region

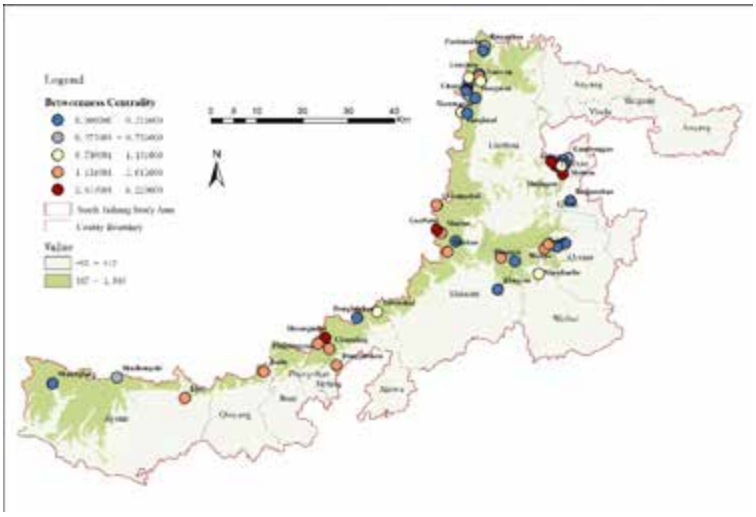

Fig. 8 Spatial Distribution of Betweenness Centrality of Traditional Villages in the Southern Taihang Region

Further, betweenness centrality analysis reveals that approximately 39.5% of villages function as bridges or intermediaries within the network, predominantly located in the central and southern subregions. These nodes exhibit strong capabilities in pathway control and resource intermediation, facilitating inter-cluster flow of information and functions. However, a subset of villages exhibits zero betweenness centrality, indicating a lack of transit or brokerage function, which restricts their role in fostering collaborative development and undermines network efficiency.Collectively, the traditional village network in the South Taihang region displays a multi-core spatial structure, characterised by core–periphery differentiation and centralised dominance. These structural features provide a critical foundation for subsequent network optimisation and the formulation of targeted conservation and revitalisation strategies.

Characteristics of Network Clusters

The spatial association network of traditional villages in the study area reveals distinct clustering patterns based on cohesive subgroup analysis, resulting in the identification of four primary network clusters. Subgroup I consists of eight villages, including Xiding and Wangjiatan, primarily concentrated in the northern area of Hebi City within the central part of the region. Subgroup II includes twelve villages, such as Xixiangping and Chefogou, encompassing all surveyed villages within Anyang City in the northernmost area. Subgroup III comprises thirteen villages, including Guoliang and Liyu, spanning ten villages in Xinxiang City and three in the southern part of Hebi City, thereby forming a central-southern transitional cluster. Subgroup IV includes ten villages, such as Donglinghou and Yidoushui, distributed across seven villages in Jiaozuo and three in Jiyuan, representing the southern part of the study area.

To further examine the relational dynamics among these subgroups, a network density matrix was constructed. Using the overall network density value of 0.531 as a threshold, intra- and inter-group densities above this value were assigned a value of 1 to represent strong linkages, while those below were assigned a value of 0, indicating weak or absent connections. This binarisation yielded a transmission relationship matrix that illustrates the potential paths of interaction and influence between clusters. The resulting structural pattern not only reflects the territorial proximity and administrative boundaries of the villages but also highlights the spatial logic of cultural exchange, ecological cooperation, and functional interdependence. These findings provide an empirical basis for promoting regionally adaptive conservation strategies and enhancing cross-cluster synergy in the holistic governance of traditional villages.

Discussion

Spatial Mechanisms Driven by the Evolution of Cultural Ecosystems

Current scholarly approaches to traditional settlement spatial studies generally follow two predominant theoretical trajectories. The first is the "taxonomy of cultural landscapes", which focuses on the classification and generalisation of settlement forms and cultural traits. While this path has yielded rich typological insights, it often remains confined to static descriptive analysis, lacking explanatory depth regarding the dynamic cultural mechanisms underlying spatial transformation-Duan et al., 2025-. The second trajectory draws on Lefebvre's theory of spatial production, which underscores the formative role of power relations and institutional structures in the production of space-Hu et al., 2019-. Although Lefebvre's "spatial triad" framework offers strong explanatory power in urban and abstract spatial contexts, its adaptability is limited when applied to ecologically, culturally, and historically intertwined traditional villages, where spatial form emerges from the long-term interplay of environment, culture, and collective practice.

To address these limitations, this study proposes an alternative analytical mechanism: the "culture-driven core – cultural connotation – spatial representation" chain-Qiao et al., 2022-. This framework integrates the logic of cultural and ecological evolution with the structural dimensions of spatial practice-Steward, 1972-, and further introduces a four-layer analytical model encompassing technology–ecology, cognition–concept, organisation–institution, and practice–strategy. This model not only clarifies the intrinsic logic of settlement spatial evolution, but also establishes a systematic framework amenable to quantitative methods such as geographic modelling and network analysis.The theoretical contributions of this study are threefold: first, it advances cultural landscape research by shifting from typological description to mechanistic interpretation; second, it offers a theoretically grounded and empirically operable paradigm for understanding the evolution of regional settlement systems, through the integration of cultural ecosystem theory and spatial network analysis; third, it promotes the deeper integration of cultural geography and rural spatial studies, enriching interdisciplinary dialogue and providing robust tools for analysing and guiding the sustainable transformation of traditional village landscapes.

Holistic Protection Path of the Regional Cultural Ecological Network

To achieve the holistic protection of traditional village cultural ecosystems, a hierarchical activation strategy should be established across the node–cluster–region scale. At the node level, functional typologies can be identified using network centrality indicators. Villages exhibiting high degree centrality (e.g., Xideng, Shijiagou) should be designated as cultural engines, serving as pilot areas for the integration of cultural heritage and tourism development. Villages with high closeness centrality may be developed as cultural dissemination hubs, facilitating regional cultural transmission. Those with high betweenness centrality can function as cultural corridors, enhancing inter-village connectivity and information flow. In contrast, peripheral nodes should focus

on revitalising endogenous cultural potential through resource re-evaluation and the reconstruction of local traditions and folklore practices.

At the cluster level, the cultural ecological network exhibits differentiated cohesion strengths among its four subgroups. Subgroups I to III, characterised by dense internal connections, should prioritise co-construction of shared resources, institutional collaboration, and the formation of integrated cultural ecological zones. In contrast, Subgroup IV, which demonstrates relatively weak connectivity, requires the cultivation of organisational systems and the construction of a "cultural bridge" to enhance its interaction with core clusters. The identity and linkage among subgroups can be further strengthened through initiatives such as "itinerant exhibitions of intangible cultural heritage", which foster inter-regional cultural recognition and cohesion.

At the regional level, a "core–linkage–periphery" spatial framework should be implemented to optimise the synergistic integration of cultural and ecological systems. This includes delineating a cultural protection red line in coordination with the existing landscape ecological patterns, thereby reinforcing the spatial co-evolution of culture, ecology, and landscape. Furthermore, the establishment of a multi-level co-governance mechanism—led by government coordination, supported by village self-governance, and enhanced through multi-stakeholder participation—can facilitate the transition of the cultural ecosystem from mechanism integration to systemic regeneration, ultimately contributing to the sustainable and dynamic revitalisation of traditional rural spaces.

Conclusion

This study focuses on the traditional villages in the South Taihang region of northern Henan Province, integrating cultural ecology theory with Holling's adaptive cycle model to construct a systematic analytical framework for understanding the evolutionary mechanisms of spatial morphology and the structure of the cultural ecological network in traditional settlements. The main conclusions are as follows:

(1) The spatial form of traditional villages represents the material expression of the long-term evolution of cultural ecosystems. Elements such as material culture, institutional arrangements, and spiritual beliefs, guided by the culture-driven core, are deeply embedded within settlement space, forming an interlinked chain of "culture–mechanism–space."

(2) Based on Holling's adaptive cycle theory, the evolution of settlement systems can be categorised into four stages: exploration, conservation, release, and reorganisation. Each stage reflects a shifting cultural core—ranging from agricultural subsistence to clan-based governance, defensive adaptation, and commercial transformation—alongside corresponding spatial characteristics that evolve from centralised to fragmented, and ultimately to composite and restructured forms. This progression reveals the non-linear, multi-causal interaction mechanisms that drive the spatial transformation of traditional villages.

(3) In terms of cultural network construction, the study introduces a multi-dimensional cultural development index system, and employs a modified gravity model combined with social network analysis (SNA) to uncover a "centre–periphery–bridge" network structure. This structure is anchored by villages of high cultural value, exhibiting spatial synergy and functional differentiation, and offering a new perspective for understanding rural cultural connectivity.

Theoretically, this study transcends the limitations of static typologies and isolated case analysis by proposing a "culture-driven → four-dimensional mechanism → evolutionary stage" model. By incorporating network analysis, the research achieves a paradigm shift from fragmented conservation to systematic spatial governance, thereby enriching the interdisciplinary dialogue between cultural geography, ecology, and human geography. Practically, the findings offer a solid basis for the classification, spatial optimisation, and policy-making of traditional villages. Stage-based typology enables the precise identification of settlement evolutionary phases, while network-based analysis facilitates the construction of cross-village collaborative mechanisms, supporting the transition from "point-based conservation" to "network-oriented governance" -Yuan et al., 2025-. Future research may extend this framework through cross-regional comparative studies and further develop dynamic modelling and mechanism validation for the evolution of cultural ecosystems.

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Reversing cultural marginality in inner peripheries: the key role of community mapping

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Abstract
The marginality of inner peripheries – related to the chronic depopulation and abandonment - fosters the sense of subalternity of communities living in these areas. Nevertheless, inner peripheries' heritage still has an important transformative potential, acting both as a resource and as a catalyst for change and community empowerment. According to the Faro Convention, heritage goes beyond physical artefacts to encompass values, practices and meanings that define collective identities and can serve here as a powerful counter-narrative. This paper explores potential and limitations of community mapping in strengthening relations between heritage and community and discusses the first outcomes of a participatory process developed in a small town of the Tammaro-Titerno area (South Italy). The process highlights the deep historical stratification and the interplay between human practices and physical environment that contributed to shape the territorial heritage.

Introduction

Across Europe, inner peripheries (ESPON, 2017) are increasingly struggling with marginalization shaped by spatial, socio-economic, political, and symbolic dynamics (Schmidt, 1998; Kühn, 2015; Rodriguez-Pose, 2018). From a cultural perspective, marginalization manifests itself as geographical isolation, characterized by limited access to cultural centers and infrastructure, such as museums, theatres, and universities. This isolation reinforces perceptions of exclusion, while socio-economic trends, such as the emigration of young people, further deprive these areas of innovation and creativity. Moreover, the disconnection between local and global cultural networks, the limited influence on policy-making processes and persisting global urban-centered development models further exacerbate the sense of subalternity of communities living in inner peripheries. As a result, marginal territories are perceived as "places of elsewhere" (Membretti et al., 2022), distant from the values and dynamics of cultural production. This symbolic marginalization fosters a negative self-image within communities, reinforcing narratives of cultural subalternity and isolation. On the other hand, the main risk is that policies aimed at enhancing these territories are based on a romanticized imaginary of rural life in subordination to urban lifestyles, on the 'musealization' of historical centers and on the occasional leisure-time use (Coppola, 2023).

Despite these challenges, cultural heritage offers significant transformative potential for inner peripheries, acting both as a resource and as a catalyst for change and community empowerment (Duxbury, 2020).

According to the Faro Convention (CoE, 2005), heritage goes beyond physical artefacts to encompass values, practices and meanings that define collective identities, and it is intrinsically linked to community recognition. The latter is crucial for preserving and activating heritage as a resource.

This perspective is particularly relevant in inner peripheries, where cultural subalternity often arises from a lack of both internal and external recognition (Schmidt, 1998). Heritage can serve here as a powerful counter-narrative. Bottom-up approaches to the enhancement of cultural heritage can reverse the perceptions of marginality, fostering new visions and opportunities for local development.

Active relationships between a community and its environment are the basis for sustainable living (Magnaghi, 2010), envisioning trajectories of place-based enhancement (Barca et al., 2012). Many scholars (Wilson and Sanyal, 2013; Carrosio et al., 2018; Pappalardo and Sajia, 2020) recognize the active involvement of communities as an effective way for activating revitalization strategies to counterbalance the progressive abandonment of places

and their legacy. Reconnecting communities with their territories starts with awareness of local heritage. The Faro Convention (CoE, 2005) defines two fundamental concepts: cultural heritage and heritage community. Since the heritage community "consists of people who value specific aspects of cultural heritage which they wish [...] to sustain and transmit to future generations" (CoE, 2005, art.2 b), heritage goes beyond the institutional status attributed to the relevant places and extends to any place to which a community attributes a collective value. Cultural heritage is what people identify as "a reflection and expression of their constantly evolving values, beliefs, knowledge and traditions. It includes all aspects of the environment resulting from the interaction between people and places through time" (CoE, 2005, art.2 a).

In the context of inner peripheries, even more than in cities, both human–place relationships and the traces of the practices that have shaped them over time remain recognizable (Magnaghi, 2010; Ferraresi, 2012), (Magnaghi, 2010; Ferraresi, 2012), despite the risk of losing both heritage and its collective memory.

This contribution explores an ongoing process of community mapping a trigger for reviving the relationships between community and its local heritage and contributing to outline new trajectories for a place-based strategy beyond urban-centric models.

Losing the heritage of rural areas in Italy: the inner areas between abandonment and musealization
In Italy the term "Inner areas" was firstly introduced by the National Strategy for Inner Areas (Barca et al. 2014), and referred to the municipalities located significantly far from the supply centers of essential facilities (education, health, and mobility). According to the inner areas' classification updated in 2020[1], about half of the Italian municipalities can be classified as inner areas, hosting less than a quarter of the national population. These mostly hilly and mountainous villages face several interconnected problems resulting from long-term migration to cities: decreasing and aging of population, lack of accessibility, economic marginality, lack of job opportunities and higher education, physical abandonment of the architectural and infrastructural heritage, political and cultural marginality. Depopulation dynamics result in the loss of both tangible and intangible heritage. Indeed, heritage is what people identify as expression of their values, beliefs, knowledge and traditions. Therefore, such dynamics, altering or even breaking the relationships between people and places, often result into a loss of local culture, traditions, practices as well as changes in how inhabitants relate to the territory.

Moreover, inner and peripheral areas play a crucial role in ensuring the provision of ecosystem services at the territorial and regional scale (Borghi, 2017; Galderisi and Limongi, 2024). These territories own the major reserve of natural resources, biodiversity, and agricultural areas; hence, they play a role of paramount importance in regulating ecological balances and providing services for the entire population, including urban centers. However, the long-term provision of ecosystem services cannot be ensured by a relationship of mere and passive dependence for the multiple benefits they provide. An active and sustainable relationship between local communities and their territorial heritage entails shared responsibility and care. According to Magnaghi (2020), while ecosystem services are grounded in the objective value of nature for humans, eco-territorial services are grounded in the subjective and cultural value of territorial heritage. They depend on the mutual relationship between people and places and are essential for activating sustainable and place-based practices. Eco-territorial services go beyond the logic of extraction and foster a regenerative and place-based approach to territorial development. This applies for all the components of the territorial heritage (nature, architecture, culture, practices, etc.)

As a result, reversing the chronic processes of depopulation and abandonment requires reviving the relationships that have shaped territorial heritage over the years.

Reviving the relationship between community and local heritage to outline place-based and shared strategies.
The path towards a new place-based development strategy goes through a process of effective and sustained community engagement (Buuren, 2009; Cook and Nation, 2016). Communities must be largely involved in both the exploration of local potential and the design of actions to take. The starting point is establishing a dialogue with key local stakeholders (institutions, associations, active citizens, etc.): researchers must forge relationships with both the place and the community, develop a critical analysis of the internal dynamics that have eroded traditional ways of living, while identifying latent resources and values that could inspire new development trajectories.

The participatory process is structured around two main phases: co-exploration and co-design. The co-exploration phase is devoted to the collective construction of territorial knowledge based on the recognition by the community of its own values and resources, trying to identify links and potentials. Researchers act as mediators guiding the exploration of local histories, memories, and landscapes. Their role is to connect the existing cultural, social, and ecological values of the territory with emerging opportunities, helping communities rediscover the meanings embedded in their everyday spaces. Community mapping is especially valuable in this phase: it helps visualizing local assets – natural, historical, and cultural – and allows linking places with intangible heritage – memories, rituals, etc. This is particularly relevant to foster a renewed sense of shared responsibility for places. Community maps are not only descriptive tools but also political paths to express collective needs and spatialize potential transformation pathways (Perkins, 2007). The process can reactivate community cohesion, strengthen organizational capacity, and revive a culture of care toward the territory as a common good. It sets the stage for a transition toward a local self-determined development.

The community mapping process requires two fundamental preliminary steps: the establishment of a group of active citizens responsible for collecting materials and identifying other interested citizens to be involved in focus groups; the definition of thematic focuses to explore and map starting from brainstorming and clustering. Thematic focuses help the collection of data, materials, and information. Also, during the co-exploration phases relationships between thematic focuses and priority interests emerge. While the thematic focuses help concentrating common interests to collect available materials, the brainstorming favour the intersections between different interests, facilitate mutual exchange and create dialogue. The co-exploration and co-design phases are not clearly distinguishable. It is a cyclical process that is based on retroactivity. However, the parallel setting between Community-Spatial-Knowledge and Technical-Spatial-Knowledge (Larrain & McCall, 2019.) allows systematizing the results of each session from time to time and allows the initial frame to be updated.

Technical-Spatial-Knowledge includes both the neutral assessment of local resources and gaps, spatial dynamics, and future projections and the structured outcomes of insights generated by community through interviews, participatory workshops, walks, and storytelling.

Building upon the foundation laid in the co-exploration phase, co-design focuses on translating shared knowledge and values into strategies and actions. The phase has to be anchored in a collective vision of the future, place-based and collectively endorsed by the community. Researchers guide and support the design process by supporting the outlining of objectives, prioritization of actions, and alignment of strategic axes with the identified local potential. They introduce best practices, facilitate synthesis, and ensure scientific accuracy to the process, while also leaving the room for local creativity and ownership. In particular, when the co-exploration phase is primarily focused on mapping, the subsequent co-design phase benefits from a clearer spatialization of ideas, allowing the discussion to concentrate on areas with significant heritage value and on areas that are most in need—and most suitable—for enhancement.

This approach proves especially relevant in inner and rural areas where capacity building may be weaker due to depopulation, abandonment, and marginality. While the presence of researchers can facilitate the transfer of knowledge and best practices, effective empowerment requires that the community is willing and adequately equipped to independently lead and sustain the process and translate it into the capacity to organize actions around shared goals.

The co-design phase can be developed starting from a SWOT analysis, leading to the definition of general and shared goals, around which the focus groups are formed. Then, general goals can be further detailed in specific goals and actions and a territorial strategy can be outlined by answering three key questions: who? where? when? That is, subjects who might promote an action are identified, places that could be catalysts of transformation are mapped (Wilson and Sanyal, 2013), priority actions and their timeline are established, also by discussing the links with the other actions and the potential barriers to their implementation. As a result, the co-design phase becomes a launchpad for self-sustained development, driven by a community that has regained the sense of responsibility toward the future of its own territory.

The two-stage process briefly outlined is characterized by a cyclical nature and generates a spiral effect involving the community. The two main phases are closely related and intertwine with each other; moreover, community

engagement is not limited to the initial identification of the key actors but expands over time feeding both phases (Figure 1). This cyclical process also allows internal evaluation of the work through participant debate, influencing both the method and the outcomes.

An ongoing experience in Campania region: first outcomes and possible insights

The outlined methodological path is being currently tested on the municipality of Guardia Sanframondi, in the inner area Tammaro-Titerno, one of the NSIA project areas identified in the Campania region for the Province of Benevento (Figure 2).

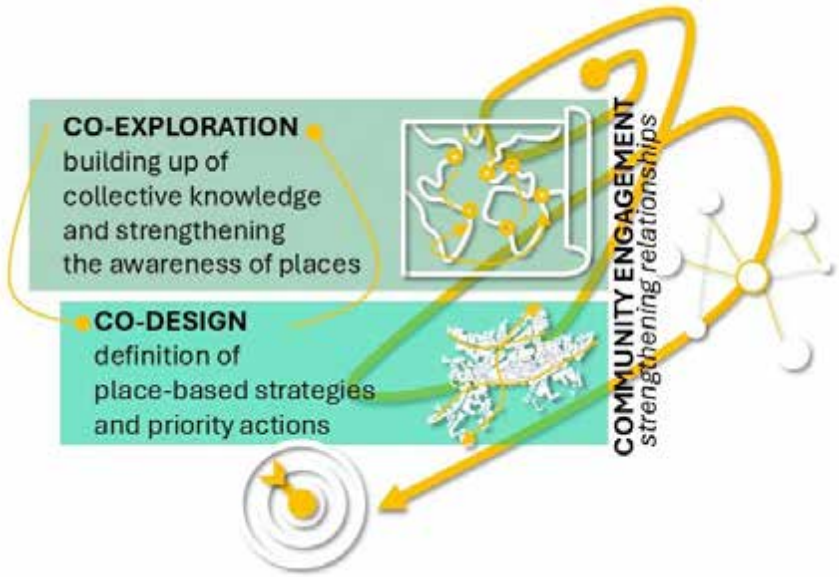

Figure 1. The methodological path
Source: Authors' elaboration

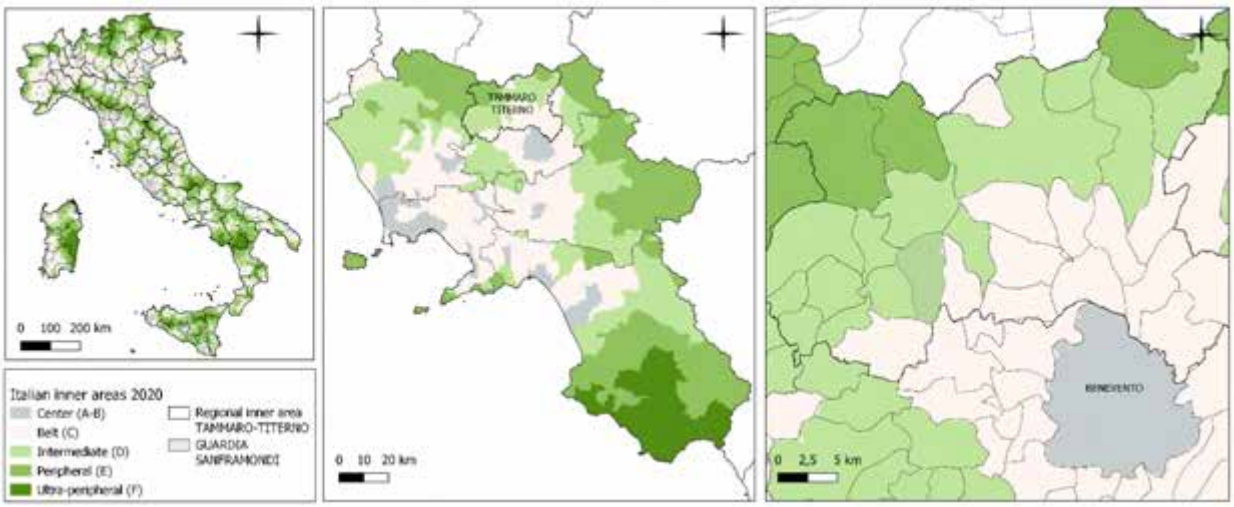

Figure 2. The Italian classification of Inner areas, the Tammaro-Titerno inner area in the Campania Regione and the Municipality of Guardia Sanframondi in the province of Benevento.
Source: Authors' elaboration

Guardia Sanframondi hosts a population of about 5,000 inhabitants and suffers from a chronic depopulation, like almost all the municipalities of the Tammaro-Titerno area. The municipality is characterized by a valuable, but almost totally abandoned, medieval center and a widespread presence of wine yards, olive groves, and other crops, being agriculture the main income source of the inhabitants.

The work started with the identification of an initial group of stakeholders to investigate the main problems of the place. In particular, the main concern is about the advanced state of abandonment of the historical center, shared both by the community and local institutions. Meanwhile, onsite inspections and desk analysis of demographic and territorial dynamics were started by the research group. The first active citizens already involved during the numerous onsite visits, representatives of local associations and the Mayor were invited to the kick-off meeting. The project was presented, and the main topics of interest were identified to start the co-mapping. After the first meeting, the others took place in small groups in relation to the topics of interest. The co-mapping was accompanied by informal interviews, walks, collection of materials such as photos, testimonies, local bibliography, and labs with high school students. As the knowledge of places and community's dynamics progressed, the meetings were more focused on specific insights and on the involvement of new citizens. The activities specifically focused on co-exploration lasted about six months. At the end, another general meeting officially launched the co-design phase. It should be emphasized that the two phases were not clearly distinct: during the first phase there were many references to possible strategies for the future, in particular for the revitalization of the historic center, and during the second phase the materials collected during the community mapping was further enriched with information especially regarding the places with a great heritage value for the community but underrepresented. However, despite the concerns about the critical issues related to depopulation and physical abandonment, co-exploration activities have attracted much more interest than co-design activities. Even about the involvement of heterogeneous groups of citizens, they welcomed the exchange of ideas in the co-exploration activities better than in the co-design ones, where the work carried out with small, already consolidated groups was more fruitful.

The process itself allowed the understanding of the main barriers for each group of citizens: they partly depend on their age and partly on their way of living the place. Young people show great pride about the history of the place and enthusiasm for a future revitalization, but they hardly think about long-term strategies for living there in the future.

The elderly have less confidence in the possibility of reversing current trends, but they are more open to outline strategies for the future. In general, intergenerational dialogue is difficult. In addition, a large community of foreigners, especially from the United States, lives in the historic center for a few months a year, some of whom have moved permanently. Despite this interesting migratory dynamic, the repopulation of the historic center is not such as to attract sociality. The new inhabitants also promote initiatives for the community, but dialogue with locals is limited by the language barrier.

As an initial reflection on the partial results of the ongoing research, it is worth highlighting the effectiveness of co-mapping tools in both phases of the process. The spatialization of narratives and the shared identification of heritage across the territory not only provided a comprehensive overview of the assets involved, but more importantly, enabled the collective recognition of relationships among places and between places and community. This approach significantly facilitated also the co-exploration phase, helping participants move beyond a focus on isolated physical interventions toward a more integrated territorial strategy, where each place and action is interconnected within a broader, cohesive framework.

Conclusions

The still ongoing research work already allows some considerations both regarding the effectiveness of the adopted methodology and the results for the case study area.

Guardia Sanframondi hosts a huge tangible and intangible heritage made up of natural resources, agricultural practices, traditions and religious rites, works of art, and literature. Therefore, the choice of rooting a possible revitalization strategy in renewing the relationships between local community and their own heritage is useful not only to provide the community with tools to support a sustaining process of revitalization, but also to strengthen these relationships in a proactive logic and not only in the safeguarding of the past. Also, the choice to accompany the co-exploration phase with co-mapping tools allows the spatialization of both tangible and intangible heritage and facilitate the identification of possible hotspots to trigger a revitalization strategy.

This is important especially for the specific case study because the place does not fully reflect the vitality of the inhabitants, the lively activism, the numerous cultural initiatives, although scattered, promoted by locals, new

inhabitants, university students, artists and scholars, the strong and transgenerational sense of belonging and the widespread knowledge of the past value of places.

An indirect effect of this process, perhaps more important than the outcomes of the two phases, is the reawakened awareness of some involved groups of being direct agents of change, who seized the opportunity and continued their activities independently of the research project.

Finally, it should also be noted that reinforcing the link between heritage and community can promote the effectiveness of public action in facing significant challenge such as securing significant portions of the historic centre.

Nevertheless, public interventions to redevelop buildings risk being ineffective unless they assume a role recognised by the community.

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Silent evidence.
On nuclear mounds, craters and caves

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Abstract
This essay focuses on three sites – the Niagara Falls Storage Site, NY, the Nevada Test Site north of Las Vegas, NV, and the Waste Isolation Pilot Plant, near Carlsbad, NM – where the ground still shows the scars of atomic testing and where nuclear waste is stored, shielded by artificial mounds or in deep underground caves. Sites that following the categorization proposed by Alois Riegl in his fundamental text on the cult of monuments would be defined as unintentional monuments.

The mounds, craters and caves that punctuate these sites, along with others dispersed both through the US and other countries that experienced nuclear testing and activity, testify of the great sacrifices that were inflicted upon territories that, realistically, will never return to their original condition.

Keywords: Atomic power, nuclear testing, nuclear waste, landscape, monument.

A new era

Dealing with the heritage of the Manhattan Project does not simply mean expressing one's position as being against or in favor of nuclear weapons or nuclear energy for civil use. Either we like it or not, and whether we accept it or not, the Trinity test held on July 16, 1945, ushered humankind into a new era (Figure 01).

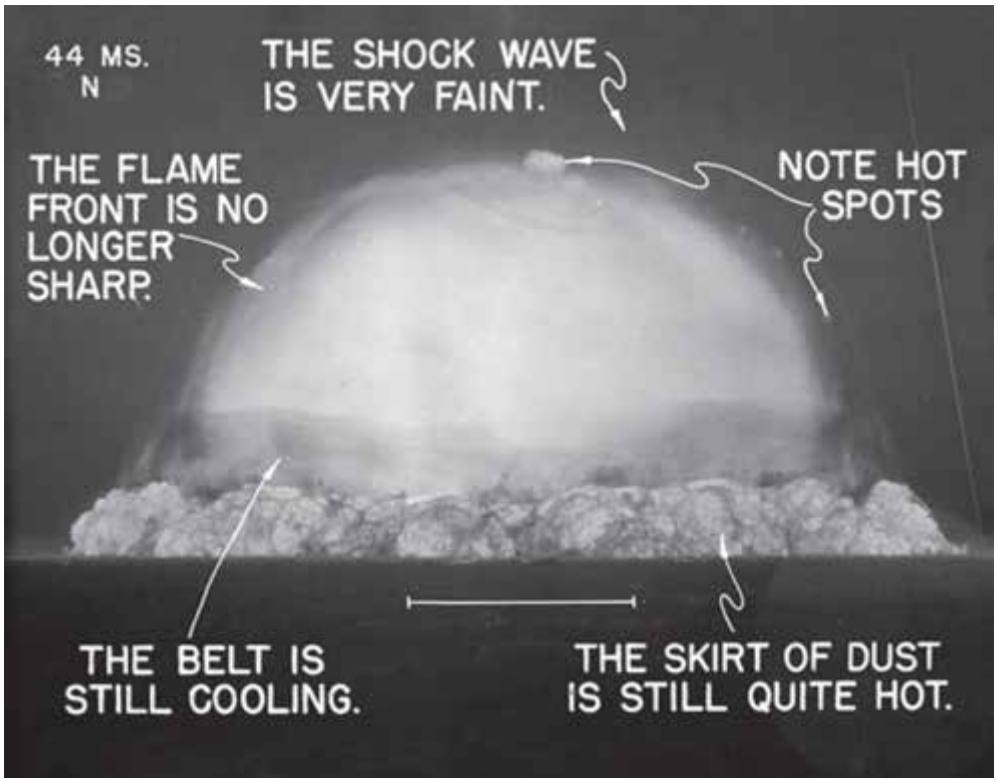


Figure 01: Annotated photograph of the Trinity test. Courtesy of Los Alamos National Laboratory.

We cannot pretend it never took place; we cannot simply go back to pre-atomic life. We should be aware that, as Günther Anders has stated, "we entered the Atomic Age in 1945 not because we fabricated three atomic bombs, but because we possessed the recipe for producing countless more."[1] We have to remember, and understand,

1 " . . . nicht dadurch sind wir 1945 in das atomare Zeitalter eingetreten, dass wir drei Atombomben fertiggestellt hatten, sondern dadurch, dass wir das nicht-physische Rezept für zahllose andere besassen" (Anders 1980, 37, auth. trans.).

what happened. Doing this is essential if we want to understand the world we live in today and avoid repeating the mistakes of the past, especially when it comes to the handling and disposal of nuclear waste and the safeguarding of the future of countless generations to come.

While historian Donald Worster has asserted that the Age of Ecology began with the Trinity test (1977, 339), philosopher Peter Sloterdijk (2002) further developed Anders's point of view, declaring that over the course of the twentieth century we have been led to question the man's existence as a Being in "breathable" space due first to poisonous gas and then to atomic bombs, for these offered means that could bring about a complete destruction of the environment human life requires. Arthur Koestler expressed a similar concept: "From the dawn of consciousness until 6 August 1945, man had to live with the prospect of his death as an individual; since the day when the first atomic bomb outshone the sun over Hiroshima, mankind as a whole has had to live with the prospect of its extinction as species" (Boyer, 2009, 3).

Unintentional monuments

If Alois Riegl had written his fundamental text on the cult of monuments today (Riegl, 1903), he would certainly see the test sites and mounds of nuclear waste as fascinating and exceptional examples of what he defined as unintentional monuments. Riegl made clear that it is we who define the value of unintentional monuments, and that there is a subtle and mutable threshold that divides what we want to preserve from what we allow to be destroyed. As Kurt W. Forster would remind us, for Riegl the very idea of the monument proved to be at once historically determined and relative to the values of each era. The Swiss historian has underlined that "Riegl's patient study of historic monuments raised issues other than scholastic distinctions [. . .] At the heart of the matter beats the destructive force of time; and beneath it, like a murmur of the Heart, the mortality of culture itself" (Forster, 1982, 31).

And while the historical value of a monument, which is based on scientific criteria and perceived through reason, is defined by a mutable threshold determined by the people and culture of a specific period, the age-value of monuments is more universal and enduring, touching the masses, regardless of their experience or education in the same manner as religious feelings do (Riegl, 1903). We should also remember that "Riegl had entitled his essay the modern cult of monuments. Under Riegl's dry prose one can find a belief that heritage in a secular society will fill the void left by religion. The cult of heritage would turn into a mass-movement that ignored borders and national identities" (Arrhenius, 2012, 103). Shifting from European theory to an American context, one could link the kind of religious feeling Riegl evokes to what David Nye has defined as the experience of the technological sublime (1994, XIII), something

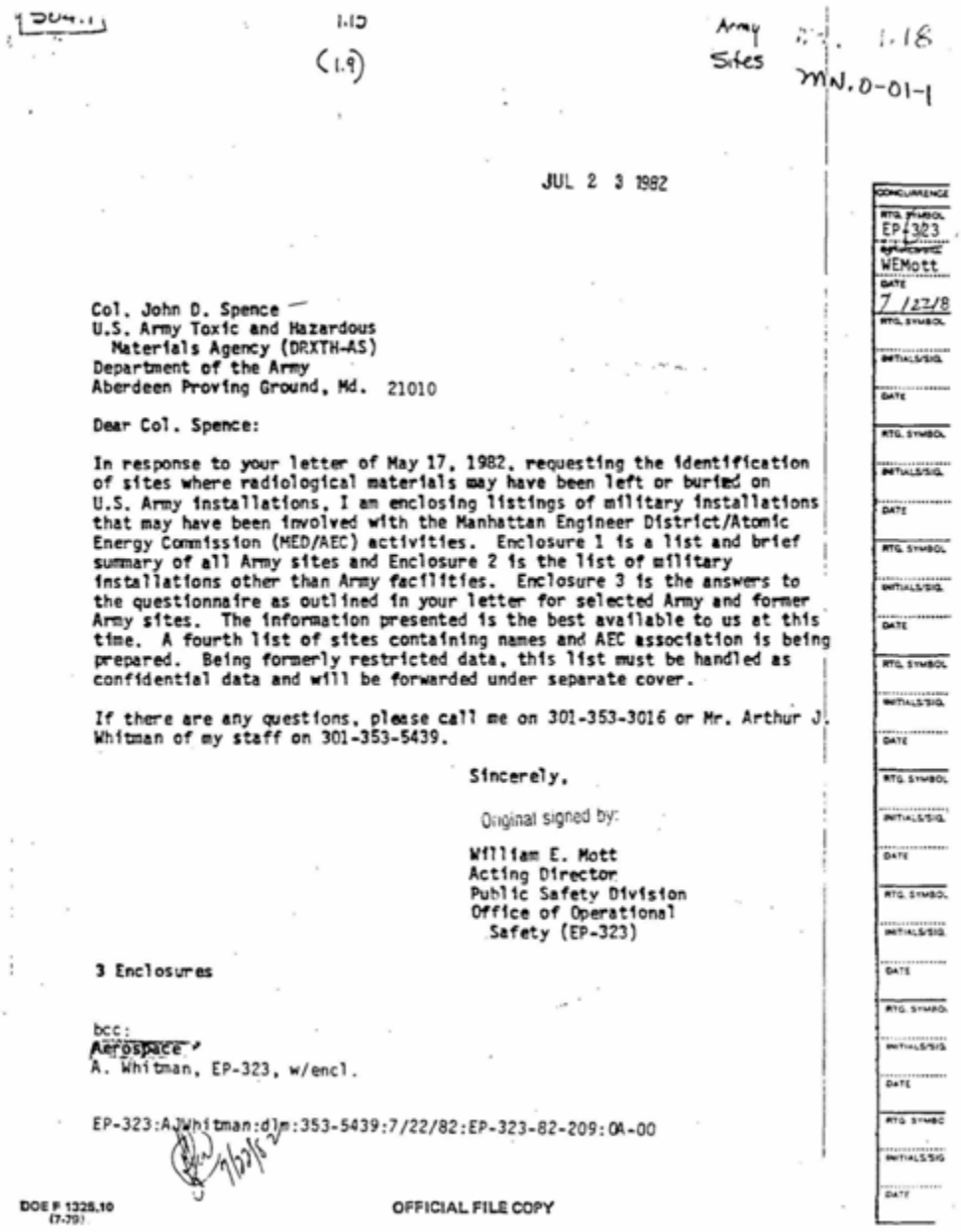
that taps into fundamental hopes and fears [. . .] an essentially religious feeling, aroused by the confrontation with impressive objects [. . .] an integral part of collective consciousness [. . .] In a physical world that is increasingly desacralized, the sublime represents a way to reinvest the landscape and the works of men with transcendent significance.

It should come as no surprise that Nye himself mentions the Manhattan Project and the atomic tests in his work (1994, 224–56).

This essay focuses on three sites – the Niagara Falls Storage Site in Lewiston, NY, the Nevada Test Site north of Las Vegas, NV, and the Waste Isolation Pilot Plant, near Carlsbad, NM – where the ground still shows the scars of atomic testing and where nuclear waste is stored, shielded by artificial mounds or in deep underground caves. Following the fact that the nuclear waste will remain active for thousands of years, Riegl's notion of age-value is pushed to its limit, evoking a future so distant that our limited sense of time as human beings can barely grasp it.

Niagara Frontier mounds

In response to Colonel John Spence's request in 1982 for a list of where "radiological materials may have been left or buried on U.S. Army installations", Department of Energy public safety division director William Mott sent him a letter with several attachments (U.S. Department of Energy, 1982). Mott's reply indicates that forty years after the beginning of the nuclear program, even the U.S. Army did not know where all of the radioactive materials produced had been buried (Figure 02).



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Army Sites 1.18
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JUL 2 3 1982

Col. John D. Spence
U.S. Army Toxic and Hazardous
Materials Agency (DRXTH-AS)
Department of the Army
Aberdeen Proving Ground, Md. 21010

Dear Col. Spence:

In response to your letter of May 17, 1982, requesting the identification of sites where radiological materials may have been left or buried on U.S. Army installations, I am enclosing listings of military installations that may have been involved with the Manhattan Engineer District/Atomic Energy Commission (MED/AEC) activities. Enclosure 1 is a list and brief summary of all Army sites and Enclosure 2 is the list of military installations other than Army facilities. Enclosure 3 is the answers to the questionnaire as outlined in your letter for selected Army and former Army sites. The information presented is the best available to us at this time. A fourth list of sites containing names and AEC association is being prepared. Being formerly restricted data, this list must be handled as confidential data and will be forwarded under separate cover.

If there are any questions, please call me on 301-353-3016 or Mr. Arthur J. Whitman of my staff on 301-353-5439.

Sincerely,

Original signed by:

William E. Mott
Acting Director
Public Safety Division
Office of Operational
Safety (EP-323)

3 Enclosures

bcc:
Aerospace
A. Whitman, EP-323, w/encl.

EP-323:AJWhitman:dlm:353-5439:7/22/82:EP-323-82-209:OA-00

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Figure 02: Cover letter typed by William E. Mott introducing the List of Army sites that have or may have handled nuclear materials for the AEC or MED, 1982. Courtesy of U.S. Department of Energy.

While Mott declared with certainty that activities related to the Manhattan Project, and later to the Atomic Energy Commission, had taken place in specific locations, the information available about others—such as the Picatinny Arsenal, Dover, NJ, or the Twin Cities Army Ammunition Plant, New Brighton, MN—was either vague or conflicting. The list shared by Mott included several sites in Western New York State. This included the Lake Ontario Ordnance Works in Lewiston, NY, that along with the Linde Ceramic plant, located in the nearby city of Tonawanda, was among the facilities in the Niagara Falls area that made a significant contribution to the Manhattan Project. In fact, the abundance of hydroelectric power facilitated an unusually intense concentration of electrochemical plants in the area, including those of Union Carbide, Hooker Chemical, Carborumdum, Linde Air, and U.S. Vanadium. These

companies contributed to the uranium enrichment process and the production of other materials necessary for the construction of the atom bomb.
A few companies in particular, namely Linde Ceramics in Tonawanda and Bethlehem Steel in Lackawanna, played particularly key roles in the production process that led to the realization of the first atomic bomb. While this program did significantly boost the local economy at the time, it has left behind a serious and enduring threat, for it resulted in the creation of polluted areas and facilities that remain such for centuries to come.

Within this framework, the story of the Lake Ontario Ordnance Works is of particular interest, something Kevin Lynch acknowledges by mentioning it in his analysis of the waste we produce in his book Wasting Away (1990, 75). Originally conceived as a TNT production plant, from 1944 to 1952 the Manhattan Engineer District and the Atomic Energy Commission used the site as a radioactive waste deposit that later became known as the Niagara Falls Storage Site.

Looking at excerpts from local newspapers that refer to the Lake Ontario Ordnance Works site, it is revealing to see how in just a few months' time, the information printed in newspapers about this site went from being clear and transparent—as in the lengthy article on the TNT plant that had been located there since 1942 (Garnish, 1943)—to being vague and misleading, as is evident in the short article of October 1943 (Courier-Express Niagara Falls Bureau, 1943), stating that the TNT plant had been shut down and the land was to be returned to the farmers, when in reality the area was going to be transformed into a landfill for the burial of the radioactive remains generated by New York state's nuclear activities in Buffalo, Tonawanda, and Rochester, such as research byproducts from the Strong Memorial Hospital. In fact, from 1944 to 1952, first the Manhattan Engineer District and then the Atomic Energy Commission deposited radioactive waste in three areas at the Niagara Falls Storage Site, formerly the Lake Ontario Ordnance Works. In the years that followed, the Army Corps of Engineers consolidated the nuclear waste in a single area to allow the cleanup and repurposing of the rest of the site. In 1980, nearly twenty-five years after the intervention by the Army Corps of Engineers, the Department of Energy built an Interim Waste Containment Structure designed to work efficiently for a minimum of twenty-five and a maximum of fifty years (Figure 03).

Figure 03: The mound covering the Interim Waste Containment Structure designed by the Army Corps of Engineers to consolidate the nuclear waste from the Linde plant. Courtesy the author.

In the past decades, several landfills containing various types of domestic waste have been located around the

containment facility. The gas produced by the decomposition of waste is collected and used to heat some large greenhouses built in the vicinity. The greenhouses are particularly used to grow tomatoes that are sold across the state and probably beyond. Not far from the Niagara Falls Storage Site, 15 miles south as the crow flies, the Linde Ceramic plant processed uranium ore for the Manhattan Project. The radioactive remains of the building are now buried under a mound named Ashland site, enclosed by a fence and facing the Niagara River (Figure 04).

Figure 04: The Ashland site mound covered by a snow cap. Courtesy the author.

Desert scars

The U.S. conducted 1,054 nuclear tests from July 1945 to September 1992. Some of these were run by the Los Alamos scientists, some by the military, and others by the Atomic Energy Commission, which was established in 1946. Of these tests, 904 were carried out at the Nevada Test Site, 106 in the Pacific Ocean, 3 in the South Atlantic Ocean, and 17 in other U.S. locations (U.S. Department of Energy, 2000). The Trinity test, the first test run on July 16, 1945 in a remote desert area of New Mexico that was then part of the Alamogordo Bombing Range (today the White Sands Missile Range), was an atmospheric one. After this event and the release of the nuclear bombs on Hiroshima and Nagasaki in August 1945, the U.S. government decided to conduct over a hundred atmospheric and underground tests far from home in the Pacific Ocean—at the Marshall Islands, Johnston Atoll, and Christmas Island—as well as over the South Atlantic Ocean. This series of tests began in June 1946 and ended in November 1962.

Already in the early 1950s a sum of different factors, including the Cold War climate, the Korean War, and the logistical complications of carrying out atomic testing in the Pacific Ocean, pushed the U.S. government to select an alternative site. The location chosen was eighty miles northeast of Las Vegas and came to be known as the Nevada Test Site (NTS). The large majority of tests—both atmospheric and underground—carried out by the U.S. government between January 1951 and July 1962 were conducted at the NTS. From 1962, all experimentation was conducted underground, again mostly at the NTS, although some tests were also run at the Nellis Air Force Range, on Amchitka Island off the coast of Alaska, in central and northwestern Nevada, and in Mississippi, Colorado, and New Mexico.

Following the 1963 signing of the Limited Test Ban Treaty, which prohibited all but underground nuclear blasts, a series of tests was carried out to open the way for the civilian use of nuclear weapons. Military seismic tests were

run—first on the NTS and then all over the country—in order to distinguish natural earthquakes from underground nuclear tests. The Plowshare Program, terminated in 1975, foresaw the use of nuclear weapons for engineering projects, such as creating canals and harbors (Figure 05).

Figure 05: A permanent stable cavity formed by one of the underground nuclear tests as part of Operation Plowshare in 1961. Courtesy of Los Alamos National Laboratory.

The Sedan Crater, produced in 1962 as part of the Plowshare Program, measures nearly four hundred meters in diameter and is a hundred meters deep (Figure 06). The fallout generated by the explosion that created the crater exposed more than ten million people to radiation, raising serious doubts about the legitimacy of the program.

Figure 06: Sedan Crater. Courtesy of Los Alamos National Laboratory.

After decades of atmospheric tests that dramatically polluted large swathes of American soil with radioactive contaminants, the 1963 treaty accidentally could have served as the basis for underground pollution too, such as the diffusion of radiation through cracks in the earth and observation conduits in a gaseous form and the

contamination of groundwater and workers. Just imagine what would have happened if Project Gasbuggy, the first commercial application of nuclear explosions for natural gas stimulation (Zavattaro, 2005, 24), had led the way to nuclear fracking. Luckily, the high levels of radioactivity in the process's final product and the high cost of production halted further experimentation.

A nuclear oasis

A four-lane road wide enough to accommodate special trucks carrying transuranic nuclear waste[2] was built in the late 1990s in southern New Mexico (Lippard, 2014, 20). Since then, these trucks have used it to travel to the Waste Isolation Pilot Plant (WIPP), which was officially inaugurated in 1999 near Carlsbad, a city famous for both the Carlsbad Caverns (a part of the National Parks System) and Project Gnome.[3]The WIPP is a deep geological repository designed for the permanent disposal of transuranic radioactive waste—in other words, for ten thousand years (Figure 07).

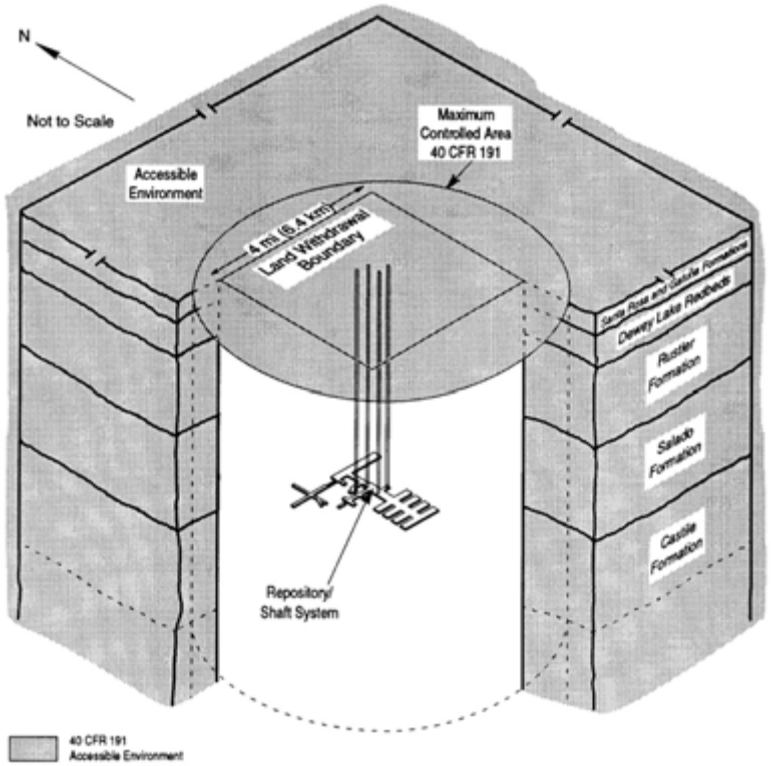

Figure 07: Artist's concept of the WIPP disposal system showing the controlled area and accessible environment tor 40 CFR 191, Subpart B, and the repository/shaft system. The repository/shaft system scale is exaggerated. On the land surface, the land-withdrawal boundary is shown at the same scale as the maximum extent of the controlled area. From Trauth et al. (1993).

The WIPP is one of what Andrew Blowers (1999) has named nuclear oases, often peripheral and remote landscapes

2 All stages of the nuclear cycle—the mining of radioactive ore, enrichment, fuel fabrication and reprocessing, the production of energy and the management of waste—involve risk. The radioactive life of spent fuel varies from thousands to several hundred thousand years, depending if it was generated by reprocessing (High-Level Waste [HLW]), reactor operations (Intermediate-Level Waste [ILW]), or different sets of routine operations (Low-Level Waste [LLW]). When the nuclear plants are decommissioned, several decades are usually required for the site's clean-up and restoration, as well as for the management of the waste it produced. Transuranic, or low-level, waste remains radioactive for approximately twenty-five thousand years. It usually consists of materials that have come into contact with uranium, plutonium, or other radioactive elements in the production of nuclear weapons or fuel, such as tools, gloves, and machinery.

3 The Gnome detonation, which was a part of Operation Plowshare, took place on December 1, 1961. A three-kiloton nuclear device buried in sedimentary salt was detonated before the physicist Edward Teller and more than five hundred other observers. Even if it had been planned as a fully contained explosion, radioactive smoke and steam quickly began to rise from the shaft and leaked out into the atmosphere. In the explosion cavity, the intense radiation created by the blast turned the salt shades of green, blue, and violet. It was only in 1977—sixteen years later—that the Department of Energy began the site decontamination process.

struck by economic marginalization and environmental degradation whose inhabitants are imbued with a sense of powerlessness and a culture of acceptance, thereby offering the ideal place for managing nuclear waste. These oases also became the places where conflicts over the future of the nuclear industry arise. Blowers divided the sites dealing with nuclear reprocessing and waste management into two groups: those that have been operating for several decades, such as the nuclear military reservations of Hanford, Washington, and the plant at Savannah River, South Carolina; and those he defines as "greenfield" locations, economically vulnerable areas where the nuclear industry is introduced for the first time generating patterns of spatial inequality, such as the WIPP itself, or the proposed deep disposal facility at Yucca Mountain, Nevada.[4]

Since 2014, when twenty-one workers at the WIPP were exposed to doses of plutonium sufficient to lead to cancer after an explosion, which caused an airborne release of radiological material, there are growing concerns about the safety of the repository. The safety of the facility was also a focus of studies carried out in the 1990s by the Sandia National Laboratories entitled Expert Judgment on Markers to Deter Inadvertent Human Intrusion into the Waste Isolation Pilot Plant (Trauth, Hora, and Guzowski, 1993). As Van Wyck has underscored,
for the WIPP, no one was particularly concerned that the interred waste be recoverable; the main concern was that the geological matrix be predictably stable over a (very) long period of time. The EPA [Environmental Protection Agency], which became responsible for the oversight of any nuclear waste disposal, subsequently added a layer of complexity to the decidedly material problem of stability and (relative) permanence. They decreed that any waste repository must be marked with signs—the "most permanent markers"—the purpose of which would be to deter "inadvertent human intrusion" into the repository for a regulatory period of ten thousand years (2012, 66).

The problem was not simply dealing with the enduring nature of the hazardous materials, or that of the structure of these markers. Rather, it was one regarding semiotics, signs, and memory, and concerned how best to transmit to future generations an awareness and understanding of the presence of the deadly materials buried in the underground repository—even in a future so remote that none of the languages spoken around the world at the time might still be comprehensible.[5] In the 1990s Michael Brill and Safdar Abidi conceived a variety of proposals – named respectively "Landscape of Thorns", "Spike Field", "Spikes Bursting Through Grid", "Leaning Stone Spikes", "Menacing Earthworks", "Black Hole", "Rubble Landscape", "Forbidding Blocks" (Trauth, Hora, and Guzowski 1993, F59–F75)– for a "monument to waste" that "perform[s] the threat that lies beneath" (Van Wyck 2004, 150). At the time of writing, none one of them has yet been realized.

Landscapes of Risk
The nuclear industry, whether put to civil or military use, represents a cornerstone of today's techno-scientific society, which Ulrich Beck defined in his book Risk Society: Towards a New Modernity (1992). According to Beck's thinking, we are individually unable to face or deal with nuclear activities and yet we collectively accept in a fatalistic way the consequences it brings.[6] What Beck articulates is not a recent phenomenon, namely the fact that nuclear energy has made mankind less free and more interdependent, and that nuclear energy's potential had to engender a race to military power was clear from the very beginning of the Atomic Age, as proven by books such as No Place to Hide.[7] The writer William Kittredge noted that the greater environmental awareness that came at the end of the twentieth century allowed us to understand that during the Cold War
we felt great destructiveness was permissible in defense of ourselves and our people . . . Great sacrifices were regarded as absolutely necessary, including the devastation caused by nuclear testing, and even the lives of luckless citizens who turned up downwind. Gonna bake a cake, gotta break some eggs. The Cold War was an

4 The deep disposal facility at Yucca Mountain was designed to contain seventy thousand tons of spent fuel. After an investment of ten billion dollars and many years of study that encountered irresolvable geological, environmental, and design problems, President Barack Obama canceled the program in 2010.

5 See Lynch (1990, 77).

6 Andrew Blowers has further elaborated on the role of nuclear industry in Beck's Risk Society: Towards a New Modernity: "Risk Society provides grand generalization on the mega risks which threaten to engulf us all. But, and again the nuclear oases make the point, risk is uneven, likely to be experienced by some communities more than others [. . .] Risk Society clearly identifies the nuclear industry as a key example, it is concerned with the problems of risk at the broad, abstract societal level rather than with the specific problems of risk facing local communities" (1999, 257).

7 See Bradley (1948).

orgy of mutual distrust and paranoia, and it was hard to think of a response, once we were in it, other than gearing up to defend ourselves. Now history has moved on and we are no longer compelled to maintain such vast military forces. But nothing has changed. (1997, 8)

It could be said that a good number of the great sacrifices that Kittredge referred to were inflicted upon territories that, realistically, will never return to their original condition. In the case of sites associated with the Manhattan Project and its legacy, aesthetic considerations permeated with nostalgia are much less important, considering that many of these landscapes are hostile or deadly to forms of life, and will continue to be for millennia to come. What scientists, engineers, and experts have been trying to do since the second half of twentieth century is "clean up" these territories, which means achieving the stabilization, removal, and long-term containment of the radioactive byproducts that have rendered them threatening. These efforts can prove satisfactory interventions when the initial level of radioactivity is low, but when the level is higher, we rarely have solutions to the dramatic environmental problems it poses, or at least, a properly in-depth cleanup with the means we do possess would prove prohibitively expensive. It also goes without saying that the only funding available for the cleanup of areas polluted with nuclear waste is public while it is usually private corporations that run the plants and create the pollution, making money in the process.

Considering the kind of impasse we are at today when it comes to dealing with atomic energy's byproducts, we might agree with Jacques Derrida's identification of nuclear energy as the most extreme pharmakon (1981; 1984), a type of substance that can both injure and be a remedy; we must not forget the contributions of nuclear medicine and the diagnostic abilities it affords. At the same time, we must recognize that we live in a society in which the threats generated by scientific development and technological innovation cannot be managed confidently (Anders, 1956; 1980), for it is now capable of exposing us to unprecedentedly large-scale and enduring environmental-pollution phenomena. In this respect, one need only call to mind the Three Miles Island, Chernobyl and Fukushima accidents, as well as the Manhattan Project's own dangerous legacy at sites such as Hanford. In the meantime, mounds, craters and caves that punctuate the US landscape in sites as the Lake Ontario Ordnance Works, the Nevada Test Site and the Waste Isolation Pilot Plant stand as silent evidence of the new era opened by the discovery of atomic power.

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From Large-scale Modernist Planning to Small-scale Urban Blocks: Spatial Transformation Experiments in China's Large Gated Communities

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Abstract
This study reconsiders large-scale gated communities in China shaped by modernist planning, which often lead to spatial inefficiency, social isolation, and unsustainability. Drawing on the theory of "urban cells," it explores spatial densification through theoretical analysis, case studies, and a design experiment in Shanghai's New Jiangwan Town. The proposed design restructures urban form through fine-grained grids, mixed-use blocks, and redefined plot hierarchies, enhancing both vibrancy and permeability. It also examines challenges of property adjustment and stakeholder coordination. The findings demonstrate the feasibility of transforming gated communities into open, sustainable urban fabrics. The study offers a transferable model with strategic implications for rapidly urbanizing regions across the Global South.

Keywords: Modernist planning; Large-scale gated communities; Urban cells; Scale optimization; Densification

1. The Prevalence of Large-Scale Residential Areas in China's New Towns

1.1 Emergence of a Homogenized Urban Model

Since the 1990s, Chinese cities have experienced unprecedented challenges brought by rapid urbanization. In response, extensive new town developments were launched across the country. Nearly all of these new towns adopted a standard model characterized by wide arterial roads, large-scale interchanges, superblocks, low-density land use, and generous spatial allocations. This formulaic approach has resulted in a repetitive spatial pattern across cities—manifested in new urban centres comprised of major roadways, expansive green landscapes, large gated residential enclaves, industrial parks, and mega commercial complexes (Sha, 2010, p. 3) These urban forms starkly contrast with the fine-grained fabric of traditional city centres, yet ironically appear highly similar to one another across different urban contexts.

This study focuses on one of the most representative units within this model——the large-scale gated residential community (Figure 1). First defined by Blakely and Snyder in 1997, gated communities are privatized residential areas enclosed by walls or fences, where services and amenities are internally managed and restricted to residents (Blakely and Snyder, 1997). In the Chinese context, these communities are often structured as "superblocks" characterized by functional monotony and structural uniformity. They reflect the spatial logic of modernist urban planning while exposing a growing disconnect between spatial form and contemporary urban lifestyles.

Figure 1. *Typical Large-Scale Gated Residential Community Module*

1.2 Structural Origins and Multidimensional Issues

The persistence of this urban form can be traced to two fundamental dimensions. Conceptually, it is a direct result of modernist urban planning principles, especially the concept of functional zoning, which promoted the separation and concentration of urban functions, leading to vast, single-use residential areas. Operationally, China's response to rapid urbanization relied on a real estate–driven model guided by regulatory detailed planning. Under this framework, urban plots tend to be oversized and isolated from each other, with planning and design focused on intra-parcel configurations while neglecting public space formation and the integration

of urban systems.

Although this model has supported rapid urban expansion and short-term economic gains, it has simultaneously generated interrelated problems in three critical areas: sustainability, quality of urban life, and social-cultural cohesion.

In terms of sustainability, these communities rely on a "wide-road, sparse-network" structure, which reinforces automobile dependency. Their spatial segregation and functional exclusivity reduce walkability and mixed-use potential, frequently necessitating long-distance travel for everyday needs—thus aggravating traffic congestion and obstructing efforts toward sustainable mobility.

In relation to quality of life, the most significant issue brought by this development model is the lack of urbanity. Professor Pu Miao from the University of Hawaii famously likens oversized gated blocks to "tumors," highlighting their destructive impact on urban space (Miao, 2004). These large gated communities are divided by wide roads and interchanges, forming isolated "islands" with limited connection to each other and to the broader city. As a result, urban vitality struggles to emerge. The streets between them are oversized, poorly defined, and functionally limited. Lacking human-scale design and everyday amenities, they fail to support active, livable public life.

At the socio-cultural level, this model diminishes the city's cultural identity. Modernist, copy-paste-style residential designs turn housing into industrialized products, producing uniform "new heritage" landscapes that erode regional uniqueness. The physical and social enclosures further intensify social segregation, hinder neighborhood interaction, and reinforce class divisions—posing serious challenges to social equity and integration.

1.3 The Need and Potential for Redevelopment

As urban development in China enters a more stable phase, the spatial, functional, and social shortcomings of large gated communities have become increasingly evident. With growing societal expectations for high-quality urban life, the traditional residential model can no longer accommodate the demand for diverse, open, and adaptable urban living environments. A transition toward more urban and resilient residential forms is urgently required (International Panel on Social Progress, 2018).

Despite their limitations, modernist planning legacies retain a degree of spatial plasticity. Their low-density, large-scale structure presents opportunities for transformation. With thoughtful planning and design, these inherited urban forms can be reconfigured to align with contemporary needs, unlocking both spatial potential and renewed social value.

2. New Jiangwan Town: Lifeless Streets and Living Units

2.1 Site Selection

This study takes New Jiangwan Town in Shanghai as its primary design site (Figure 2). As a representative of new residential areas within the central urban area, it exemplifies the broader urban issues previously discussed—despite its location within the inner ring, the district suffers from a lack of urban vitality. Its challenges and potential for transformation hold valuable insights and relevance for similar urban contexts.

Figure 2. *Status of New Jiangwan Town*

Located in the northeastern part of central Shanghai, New Jiangwan Town was developed on the former site of Jiangwan Airport—once known as "an ecological oasis in the city". In the early 2000s, the municipal government envisioned the area as a model "garden city" and ecological residential zone for the 21st century, oriented toward middle- and upper-income residents within a knowledge-based, international community (Figure 3).

This design research focuses on a 29.2-hectare site bounded by Zhengqing Road and Songhu Road, with Yinhang Road as its central axis. The site, measuring approximately 780 by 510 meters, encompasses the New Jiangwan Town metro station, ensuring convenient accessibility. It also reflects common issues of large gated communities, making it an ideal site for studying residential urban transformation. (Figure 4).

Figure 3. *Planning Context: Spatial Structure, Functions, and Transport Networks*

Figure 4. *Design Focus and Existing Site Issues*

2.2 Absence of Urbanity and Cultural Life

Despite ts designation as a "town," New Jiangwan Town lacks the spatial and cultural attributes expected of urban life. Influenced by modernist planning principles, its spatial organization is disconnected from everyday use, with limited continuity and permeability. In terms of spacial scale, wide roads and superblocks undermine human-scale connectivity; streets lack spatial enclosure, and elongated block edges create monotonous and fragmented pedestrian experiences. In terms of spacial form, residential compounds are developed independently with minimal attention to urban frontage. In pursuit of optimal orientation and floor-area ratios, buildings turn inward, and streets are flanked by blank walls or landscaped setbacks, lacking the spatial conditions needed for street life. Functionally, the area is dominated by residential use, with commercial and cultural facilities sparsely and unevenly distributed. workplaces and cultural institutions are virtually absent. As a result, urban diversity and the informal rhythms of everyday life are missing. New Jiangwan Town presents an urban façade but fails to perform as a true urban environment, functioning instead as a closed residential enclave devoid of socio-cultural depth.

esembles an urban form in appearance but functions as a mono-functional residential enclave—devoid of collective memory and civic culture.

The Yinhang Road site, for example, includes five gated residential communities, with an average building coverage of just 12.65%. The distance between buildings along main roads ranges from 65 to 91 meters, while secondary streets such as Ruida Road remain disproportionately wide. This functional monotony and disordered spatial form undermine both urban vitality and cultural expression (Figure 5).

Figure 5. *Analysis of Existing Site Problems*

2.3 Analysis Through the Lens of Urban Cells

To further understand the disconnection between space and culture, this study adopts the concept of the "urban cell" as a medium-scale analytical framework. The concept of urban cells, derived from biological metaphors, refers to the basic spatial unit of a city. Each cell is defined by its boundaries (walls, facades) and internal structure (courtyards, paths), which jointly determine its spatial performance and cultural capacity (Cai, Xu, Zhang and others, 2018).

In traditional urban forms, such as Beijing's siheyuan or Shanghai's lilong, urban cells are compact (typically 50–100 meters), fostering dense, permeable street networks and mixed-use environments (Cai and Xu, 2021). By contrast, modernist planning transforms these cells into isolated "functional warehouses," disconnected from their surroundings. New Jiangwan Town exemplifies this new urban cell typology, marked by two key deficiencies:

1-Oversized Cells: The excessive scale of residential blocks lead to functional fragmentation, low traffic efficiency, and weak social interaction.
2-Inactive Boundaries: The compound walls and adjacent buffer zones function merely as physical separators. While they provide basic spatial division, they offer little depth, serve no additional functions, and ultimately fail to sustain urban life. As a result, the street spaces between these cells remain lifeless and underutilized.

These two core issues correspond to two main transformation goals:
1-Optimizing the scale of urban cells to rebuild spatial and social connectivity.
2-Restructuring interstitial and boundary spaces to enhance street quality and activate public life.

2.4 Site Potential

At the macro level, New Jiangwan Town holds strong redevelopment potential. Its central location, robust public transit, and diverse population offer strategic, economic, and cultural advantages. Rich ecological resources further support high-quality, sustainable urban living.

At the site level, the existing low-density pattern leaves ample room for densification. Underutilized spaces between buildings and streets create opportunities to reconfigure urban cells, implement open community models, and revitalize street edges.

3. Research Objectives and Methodology

Despite extensive critique and revision of modernist urban planning concepts within academic discourse, practical applications for transforming large-scale and low-density residential areas remain scarce (Wu, Yang, Xu, Zhang and Antwi-Afari, 2021). This study seeks to bridge that gap by translating theoretical insights into actionable design methods, addressing the prevalent challenges faced by new residential areas in China.

Through theoretical analysis, case studies, and a spatial transformation design experiment in the core area of Shanghai New Jiangwan Town, this study investigates the theoretical significance and practical approaches to spatial transformation in contemporary large-scale communities.

At the design research level, this study focuses on the prevalent large-scale gated residential model in China's new towns. Taking the Yinhang Road area of New Jiangwan Town as a testing site, the core objective is to transform it from a large-scale, low-density, mono-functional residential zone into a network of small-scale, mixed-use, and street-oriented urban blocks that support greater urbanity. Importantly, the term urbanity here extends beyond physical form or centrality. It refers to the holistic spatial quality of the built environment, characterized by human-scale dimensions, legible urban form, programmatic diversity, and vibrant public life.

4. Theoretical Framework

This chapter establishes the theoretical foundation for the design strategies proposed in subsequent sections. It first traces the historical and cultural roots of gated community patterns in China, unpacking their spatial logic and sociopolitical underpinnings. It then reviews contemporary urban theories that advocate for openness, integration, and human-scale development. Together, these perspectives form a critical lens through which the challenges and potentials of reconfiguring New Jiangwan Town can be understood.

4.1 Historical Roots of Enclave Patterns in Chinese Housing

4.1.1 A Brief History of Residential Transformation in China

China's urban housing has undergone multiple stages of transformation, deeply shaping today's urban form.

During the planned economy period (1950s–1970s), residential development was primarily state-led, resulting in the widespread emergence of "danwei compounds" —enclosed residential blocks controlled by work units. In the absence of private property rights, walls served to delineate administrative boundaries, laying the groundwork for today's gated community model.

Since the late 1970s, reform and opening-up restored private property rights and introduced market-driven housing. Real estate developers emerged as dominant players, and under the influence of modernist planning paradigms, gated communities became the mainstream model emphasizing order, security, and property value.

In the 21st century, regulatory detailed planning became the dominant development mechanism, further entrenching the gated community model. However, this approach has been increasingly questioned. In response, the concept of open communities has gained attention, with pilot projects like Changde's Berlin International Community have shown the feasibility of fence-free designs in China (Wang, 2023).

4.1.2 Cultural DNA and the Shanghai Experience

Traditional Chinese housing has long favored inward-facing, enclosed environments, reflecting values of privacy and order (Deng, 2011). This is evident in the "lifang" system of ancient cities and residential types like Beijing's siheyuan or Shanghai's lilong. This spatial logic underpins contemporary acceptance of gated communities.

In Shanghai, a migrant city shaped by both indigenous tradition and Western modernism, hybrid housing forms such as "shikumen lilong". These typologies combined the privacy of Chinese courtyards with the density of European row houses. Their "closed outside, open inside" spatial logic fostered vibrant alleyway life and strong neighborhood cohesion, becoming a key element of the city's collective memory.

In older urban areas, mixed-use configurations like "shopfront-residence" and "store below, residence above" created high-functionality environments within walkable neighborhoods. By contrast, contemporary gated communities, though superficially resembling traditional forms, often lack the scale, form, and programmatic richness needed to sustain urban life, losing not just permeability, but also the cultural depth rooted in everyday spatial practices.

4.2 Spatial Strategies of Re-Urbanization

4.2.1 The Open Block Model

At the turn of the 21st century, French architect Christian de Portzamparc proposed the "Open Block" concept in Paris's Rive Gauche project, highlighting the street as the core of urban life (Portzamparc, 2015). He emphasized that the key principles of open blocks included small block size, mixed functions, and open circulation to foster accessibility and social interaction. In China, the Green Neighborhood Standard echoes these principles, promoting integration of public space and civic functions into residential areas. Unlike gated compounds, open communities aim to create lively, inclusive, and adaptable urban environments.

4.2.2 Small Blocks and Dense Streets Networks

The 2016 State Council Guidelines marked a paradigm shift by stating that new residential developments should adopt a block-based model and avoid constructing enclosed communities. It promoted the "narrow streets, dense networks" urban pattern.

The model generates a series of interrelated benefits. By subdividing large parcels and introducing shared street rights-of-way, it facilitates multimodal mobility and improves overall connectivity (Zhuo, Wu and Xu, 2017). Enhanced permeability and activated street frontages contribute to a more articulated and adaptable urban form. Simultaneously, the model fosters social integration by aligning with human-scale spatial perception and promoting frequent, informal interactions within the neighborhood context.

Nonetheless, the model poses design and operational challenges. Smaller blocks may reduce development flexibility and increase management costs. Perimeter block layouts may limit solar access, while denser street grids can increase noise and pollution (Zhuo, Wu and Xu, 2017). Therefore, local adaptation and site-specific strategies are essential.

4.2.3 Mixed-Use Development Theory

As a critique of functional zoning, mixed-use theory promotes integrating residential, commercial, educational, and recreational functions within walkable urban areas.

Mixed-use development promotes proximity, diversity, and efficiency by integrating varied urban functions within a compact spatial framework. It shortens spatial distances between living, working, and service activities, enhances temporal vibrancy through overlapping uses, and optimizes land and infrastructure utilization. By countering spatial segregation and curbing urban sprawl, it also reinforces socio-spatial sustainability (Jacobs, 2011).

Yet, the approach also demands careful spatial balancing. Conflicts in privacy, noise, and circulation must be resolved through refined architectural and programmatic design to harmonize vibrancy with livability.

5. Case Studies

Building on the theoretical framework, this chapter investigates representative urban spaces and residential areas to clarify the spatial logic of "Plot-Building-Block-District" and identifies the key characteristics of vibrant, sustainable districts. Furthermore, by examining cases of urban space reconstruction, the study explores densification strategies for spatial transformation and categorizes specific operational patterns.

5.1 Urban Blocks in Classic Cities

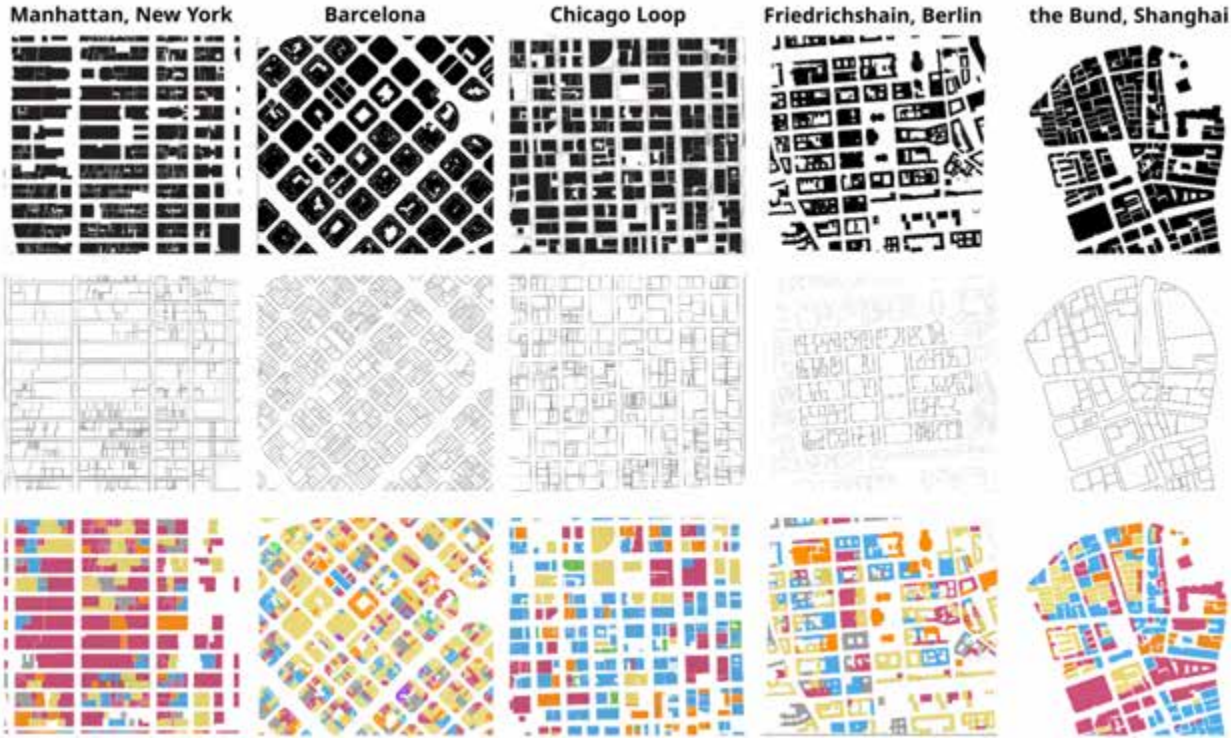

Figure 6. *Case Study of Urban Blocks*

This section examines 1 km² urban blocks in New York, Chicago, Barcelona, Berlin, and Shanghai's Bund to identify shared spatial traits (Figure 6). Comparative analysis of figure-ground patterns, parcel divisions, and functional layouts reveals a common logic: small blocks (70–160 m) within a coherent street grid, continuous frontages, fine-grained and flexible parcels, and diverse functions at the block scale. Together, these elements form a model of urban vitality marked by legibility, human scale, morphological richness, and integrated uses.

5.2 Urban Living blocks: The Case of Chuangzhifang

Located in Shanghai's Yangpu District, Chuangzhifang exemplifies the localized application of "small blocks" and "mixed-use" urbanism. The project integrates spatial, mobility, functional, and governance strategies to promote urbanity within a formerly underused area.

5.2.1 Spatial Construction: Small Blocks and Public Space

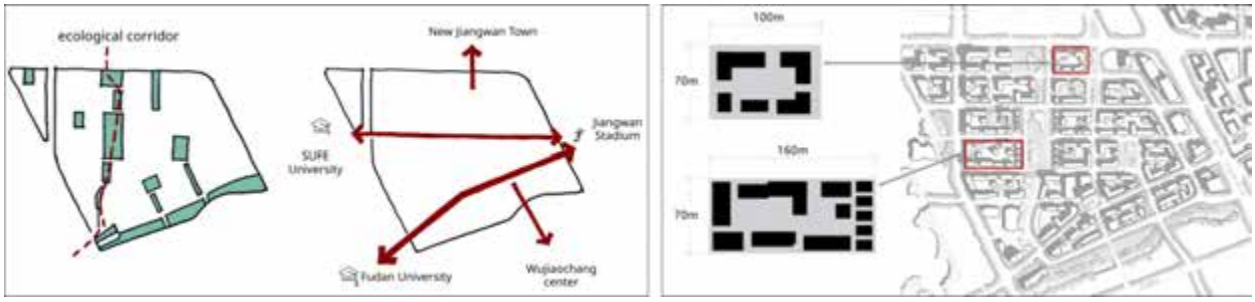

Figure 7. *Spatial Structure and Block Analysis of Chuangzhifang*

Figure 8. *Public Space and Building Height Analysis of Chuangzhifang*

The street grid is structured by a clear north-south ecological corridor and east-west urban axes (Daxue Road and Weikang Road), which connect key urban anchors including Fudan University, Shanghai University of Finance and Economic and Jiangwan Stadium, establishing a coherent spatial framework. Blocks adopt a compact scale (70–160 m), aligning with traditional urban grain and enabling seamless connection to surrounding neighborhoods. Public spaces are strategically placed at key intersections, with moderately scaled plazas (e.g., 40 × 50 m) that balance capacity with spatial intimacy (Qian, 2017). High near-line rate contributes to the integrity of the block form. Public space is closely tied to commercial functions, supporting a variety of events such as weekend markets and pedestrianized zones, enhancing spatial adaptability and user engagement (Figure 7, Figure 8).

5.2.2 Traffic Organization: Dense Networks and Pedestrian Priority

The district adopts a "narrow street, dense network" model, with open, shared streets seamlessly integrated into the city's broader traffic system (Yin, 2007). 8-meter-wide sidewalks are subdivided into outdoor dining, pedestrian, and furnishing zones, stimulating outdoor commerce and active street life. Tight corner radii (3–5 m) reduce vehicle speed, fostering a safer pedestrian environment (Figure 9).

Figure 9. *Street Layout, Sidewalk Zoning, and Road Section of Chuangzhifang (Qian, 2017)*

5.2.3 Functional Mix: Multi-Dimensional Integration
Functions are mixed across horizontal, vertical, and temporal dimensions. Horizontally, Plots are primarily mixed-use. Commercial functions line the main street while residential and office functions occupy interior plots. Residential units are preferentially arranged along north-south orientations, while non-sunlit areas are repurposed for offices (Wang, 2023). This horizontal integration is illustrated in the spatial organisation of Chuangzhifang. Vertically, buildings combine shops with "SOHO" (Small Office/Home Office) units, residences, or offices above, supporting ground-level activity without compromising livability (Figure 10). Temporally, LOFT-style SOHO units support dual-use functionality, accommodating shifts between daytime work and nighttime dwelling, exemplifying adaptable spatial design (Wang, Wang and Huang, 2023).

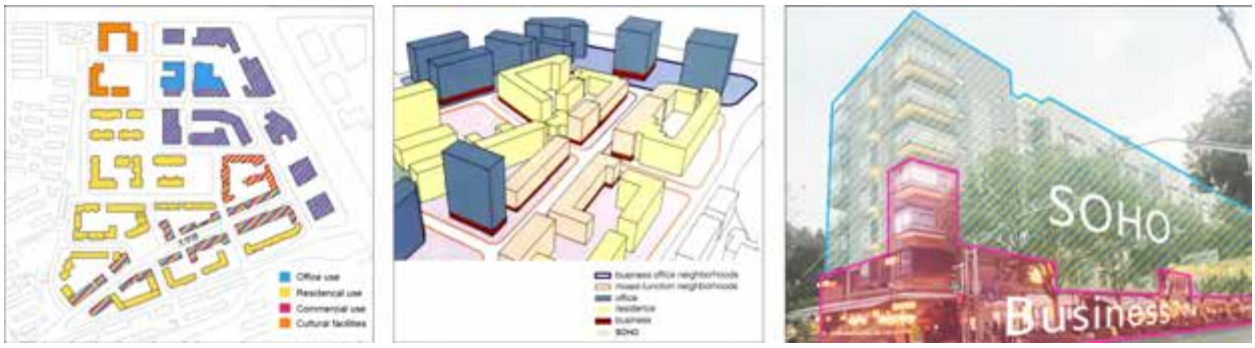

Figure 10. *Functional Mix Analysis of Chuangzhifang (Qian, 2017)*

5.2.4 Management Model: Flexible Governance through Subdivision
The district employs a decentralized governance model, subdividing the area into seven independently managed gated sub-blocks. Although this approach entails higher management costs, it enhances operational flexibility and security. In addition, these sub-blocks are physically and functionally integrated into a cohesive "super-block" through shared underground infrastructure, effectively balancing spatial openness with governance efficiency.

5.3 Densification: Strategies for Urban Block Transformation
In *Urban Transformations and the Architecture of Additions*, De Arce identifies three primary modes of urban transformation: extensive expansion, demolition-based reconstruction, and spatial densification (de Arce, 2014). In the context of land scarcity and rising demands for urban renewal, spatial intensification has emerged as a key strategy to activate existing urban fabrics and improve spatial efficiency. This section explores the mechanisms of densification at both the urban and residential scales.

5.3.1 Urban-Scale Densification
The fundamental strategy involves the insertion of new blocks into underutilized spatial voids without altering existing buildings, thereby preserving the original urban typologies. Based on Léon Krier's idea of urban space as composed of figure elements such as monuments and landmarks, and ground elements that form the spatial fabric of daily life, (Krier and Thadani, 2009) (Figure 11), this method overlays new "ground" elements onto modernist figure-dominated environments, resulting in a form of additive spatial repair.

For instance, de Arce's intervention in Chandigarh introduces 50m×50m blocks into the administrative district. These additions respect the axial order and iconic architecture while enclosing new communal spaces that enhance livability (Figure 12). Similarly, Rob Krier's interventions in central Stuttgart reinforce street edges and public squares through carefully placed infill (Figure 13), while Léon Krier's work in the Luxembourg suburbs re-establishes block perimeters and fine-grain urban texture, restoring spatial coherence at the human scale (Krier, 2010) (Figure 14).

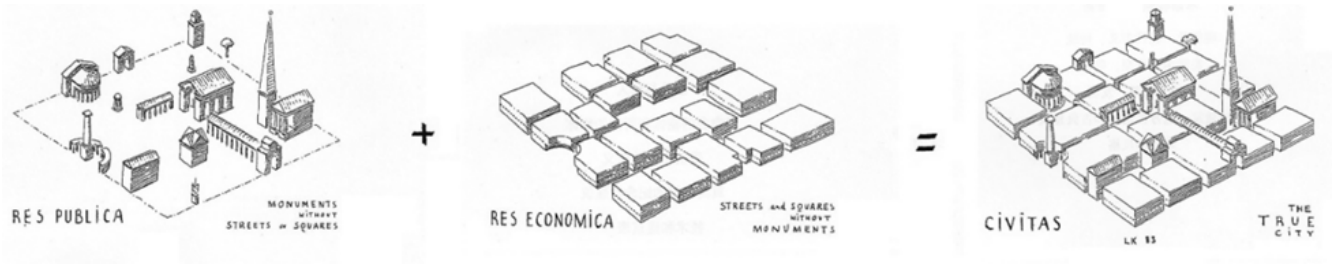

Figure 11. Typological Logic of Urban Spatial Structure (Krier, 2010)

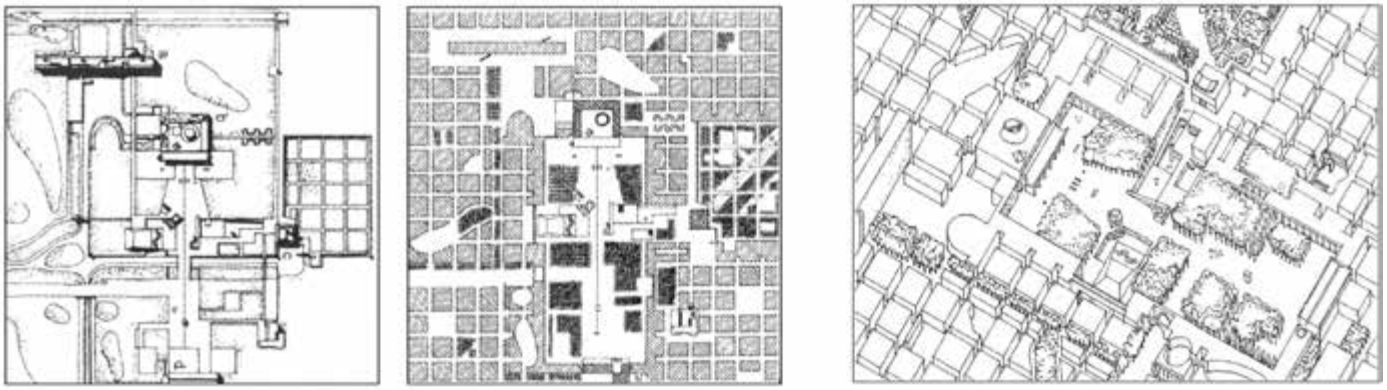

Figure 12. *Spatial Densification in Chandigarh New Town (Zhang, 2022)*

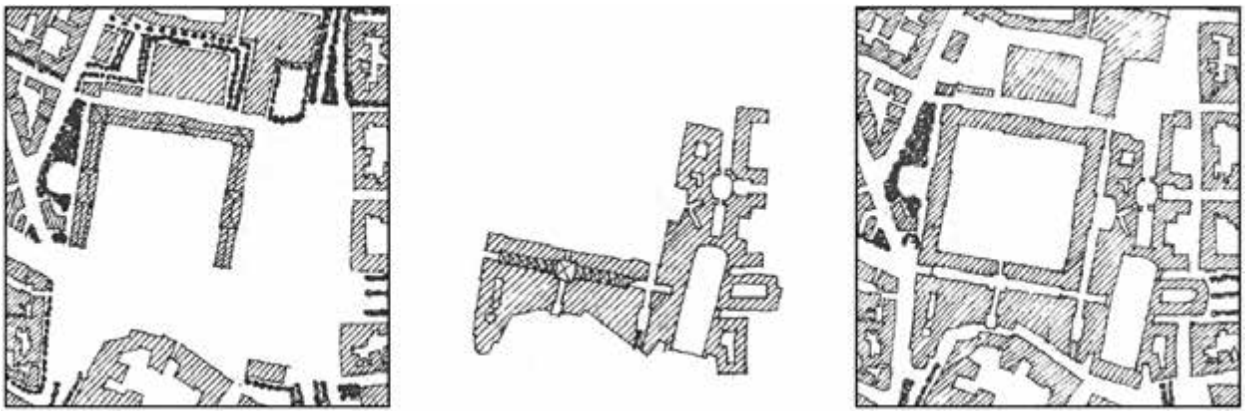

Figure 13. *Spatial Densification in Central Stuttgart (Krier and Thadani, 2009)*

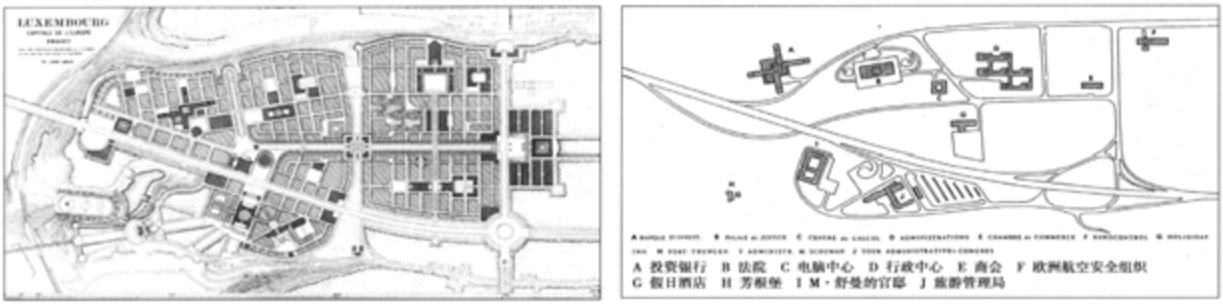

Figure 14. *Spatial Densification in the Suburbs of Luxembourg (Krier, 2010)*

5.3.2 Typological Transformation through Densification

Another strategy involves transforming existing building typologies through new additions. In the case of the Parliament Complex, de Arce's design infills street-facing volumes, converting isolated towers and slabs into a "enclosing block + tower" hybrid form (Zhang, 2022). This typological shift enhances enclosure, scale, and interface continuity, producing a more legible urban form (Figure 15). Such transformation represents a structural redefinition of urban form through densification.

This approach is echoed in Rob Krier's work in Runcorn New Town and Léon Krier's interventions in suburban Florence, where additions create cohesive and human-scaled urban environments through collaborative interplay between new and existing buildings (Figure 16).

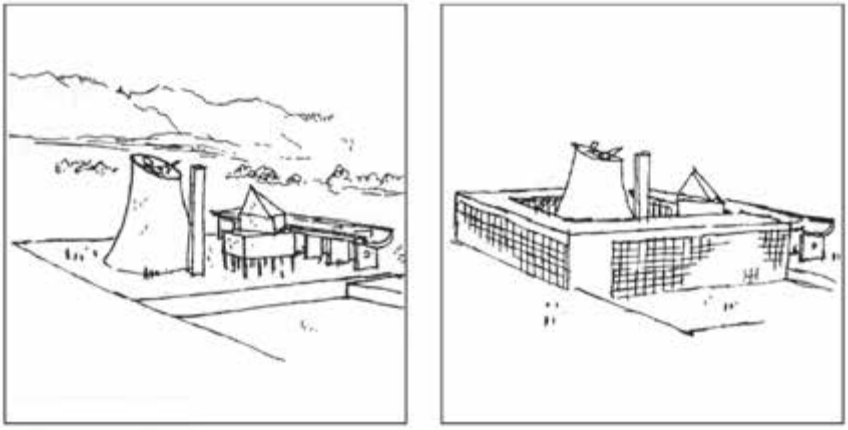

Figure 15. *Transformation of the Parliament Complex Into a Hybrid Form (Zhang, 2022)*

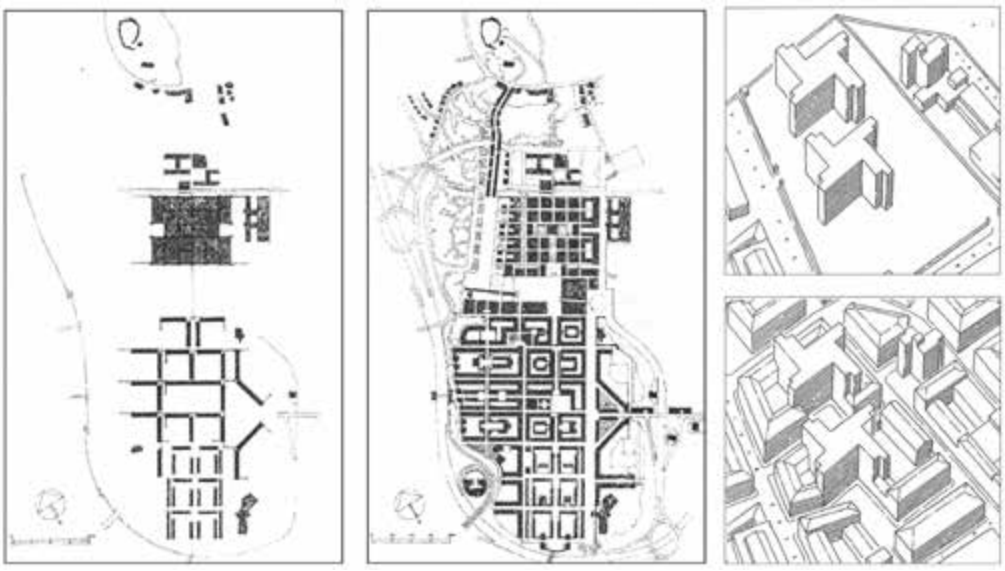

Figure 16. *Densification Strategies in Runcorn New Town (Krier and Thadani, 2009) and Suburban Florence (Krier, 2010)*

5.3.3 Residential Densification: A Prototype

While real-world examples of low-density residential densification remain limited, Léon Krier's experimental proposal for the St. Louis–Laurent Torres neighborhood offers a compelling model. In this scheme, formerly privatized land is re-parceled into traditional urban plots, reducing the public space ratio from 80% to 32% (Krier and Thadani, 2009). New low-rise additions (2–3 stories) are carefully integrated into the existing fabric, introducing housing, gardens, and civic amenities, while repurposing ground floors for mixed uses. This strategy of "small-scale accretions" demonstrates a viable approach to restructuring low-density environments by layering new spatial and programmatic complexity onto largely preserved built forms (Figure 17)

Figure 17. *Spatial Densification of the St. Louis-Laurent Torres Neighborhood (Krier, 2010)*

6. Design Experimentation

Building on the preceding analysis, this study proposes a strategic redevelopment of the core area of New Jiangwan Town. The design focuses on adjusting the scales of urban cells and their interstitial spaces, using spatial densification as a tool to restructure the urban framework and cultivate vibrant, resilient block patterns.

6.1 Three "Basics"

The design framework is anchored in three core aspects—Basic Task, Basic Strategy, and Basic Principle—which establish the foundation for targeted and responsive interventions.

6.1.1 Basic Task: Scale Adjustment

The design intervention addresses scale optimization at both the block and street levels, aiming to improve spatial functionality and social cohesion. At the macro scale, the current superblocks significantly exceed the optimal urban dimensions. Studies suggest that block sizes between 50 and 150 meters per side are most conducive to pedestrian accessibility and everyday convenience in central urban areas (Huang and Sun, 2012). However, all four study plots surpass this range, indicating the necessity of subdividing and reopening existing gated communities.

From a social standpoint, the household scale of residential clusters plays a crucial role in fostering neighborhood cohesion. Psychological research indicates that groups of 5–10 households encourage mutual support, 50–150 households cultivate a sense of belonging, while clusters exceeding 500 households tend to weaken interpersonal ties (Zhang, 2015). With current residential clusters exceeding 400 households, the need for finer subdivisions and more intimate social units becomes evident.

At the street level, the existing road network is characterized by excessive widths that undermine walkability and spatial articulation. The proposed design introduces strategic infill to reduce roadway dimensions, reconstruct fine-grain street interfaces, and enhance overall urban permeability.

6.1.2 Basic Strategy: Spatial Densification

Spatial intensification is the core design strategy. Studies show that vibrant urban districts typically achieve a built density of around 50% (Zhang, 2022), whereas the current average in New Jiangwan Town is only 12.65%, underscoring the need for densification development.

Following principles of spatial hierarchy, the site is divided into zones of differentiated intensity: The southern Wujiaochang node, designated as a city-level core, accommodates high-density, mixed-use development. The Yinxing Road area, identified as a community-level centre, is moderately densified to activate communal functions. The remaining sectors function as basic neighborhood units, subject to limited or deferred interventions.This gradient-based strategy seeks to produce a balanced urban fabric that integrates open space and functional intensity, aligning development with varying urban roles and scales.

6.1.3 Basic Principle: Contextual Adaptation

A critical challenge lies in integrating new interventions within the existing built fabric. The design adopts a strategy of contextual adaptation, in which existing structures inform the alignment, function, and articulation of new additions. Rather than imposing a uniform order, the approach leverages the irregularity of the current fabric to generate spatial variation within a coherent morphological logic. In this way, new and old elements co-produce block structures that are both legible and adaptive.

6.2 Spatial Reconstruction

At the structural level, the design introduces a reorganized framework to reshape the macro spatial logic of the site. To address the traffic and environmental burdens of Yinhang Road posed by the oversized scale, the design introduces a primary “urban vitality loop” that weaves through the site, interconnecting residential clusters. This loop extends westward to Ruida Road, integrating with the existing road network to establish a multi-dimensional street system. Additionally, a north-south ecological corridor is introduced to connect the waterfront edges on both sides of the site, forming a continuous green infrastructure. City-level public nodes are distributed along the primary loop, while secondary community-level nodes are embedded within residential clusters, forming a hierarchically structured public space network (Figure 18).

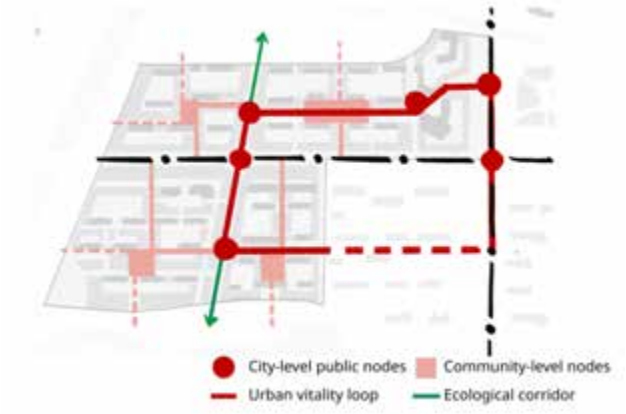

Figure 18. *Overall Spatial Structure Plan*

Building upon the structural reconfiguration, the macro-level strategy focuses on optimizing spatial scale and transforming gated communities into open urban blocks. This is achieved by dismantling and reorganizing the oversized, monolithic urban cells, introducing a finer-grained street network (Figure 19).

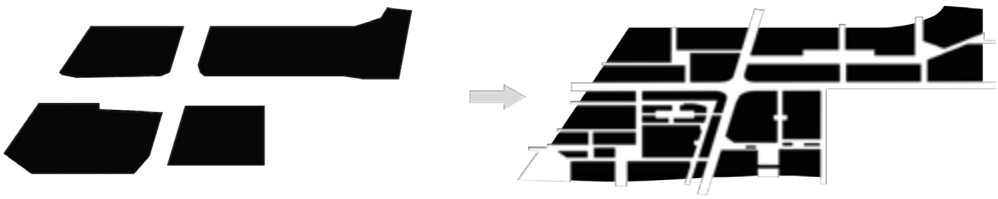

Figure 19. *Macro-Level Strategy: Before-and-After Comparison of Open Spatial Morphology*

At the micro scale, spatial infill is implemented through strategic insertions of new buildings that engage with existing structures to define new block perimeters and public interfaces. Three primary relationships are identified:

1-Full Intersection: New volumes overlap with existing buildings, often requiring ground-floor adaptation or replacement.

2-Partial Intersection: Including four subtypes—short-side intersection, inner long-side alignment, outer long-side alignment, and interlocking. Short-side contact entails minimal intervention, while the others require context-sensitive ground-floor modifications.

3-No Intersection: Including buffered spacing, enclosure, and juxtaposition, offering the least impact on existing structures.

These relationships are systematically categorized in a typological summary that guides design interventions (Figure 20). Based on these typologies, the design adopts a context-sensitive approach where new 3–4 story buildings are inserted in response to existing conditions. As a result, the district transitions from traditional slab-type blocks to a new hybrid model of “enclosing blocks + towers”, enabling dynamic dialogues between new and existing structures in terms of both scale and form.

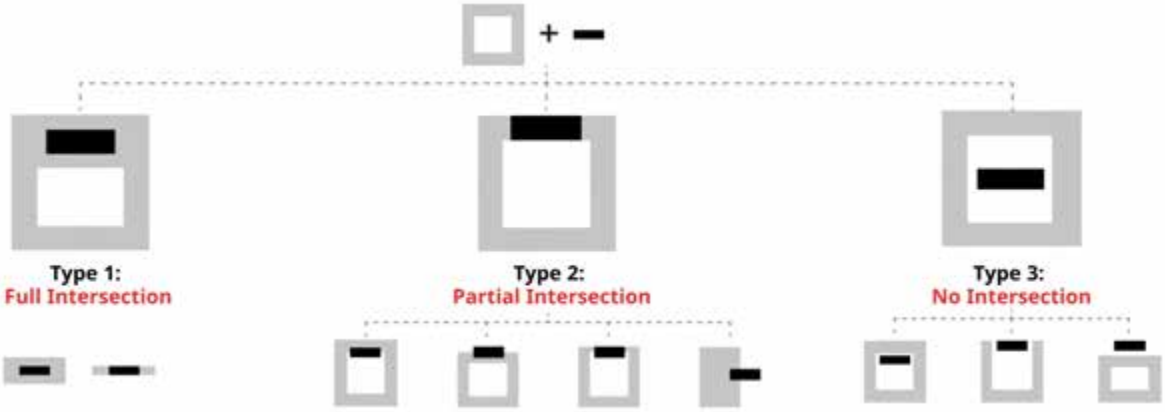

Figure 20. *Typological Summary of Spatial Relationships Between New and Existing Buildings*

The visual transformation of block morphology is illustrated through a series of before-and-after black-and-white diagrams, revealing changes in spatial structure and permeability (Figure 21). Building on a spatial hierarchy of "Plot–Building–Block–Cluster–District," the design introduces a multi-tiered public space system including city-scale nodes, community-scale nodes, and semi-enclosed courtyards embedded within blocks. This framework generates an "inward courtyard, outward street" configuration that transitions gradually from quiet and private to vibrant and public, accommodating diverse behavioral and psychological needs. Additionally, variations in building layout, height, and façade are used to shape and enrich spatial nodes, enhancing the overall experiential quality of the public space (Figure 22).

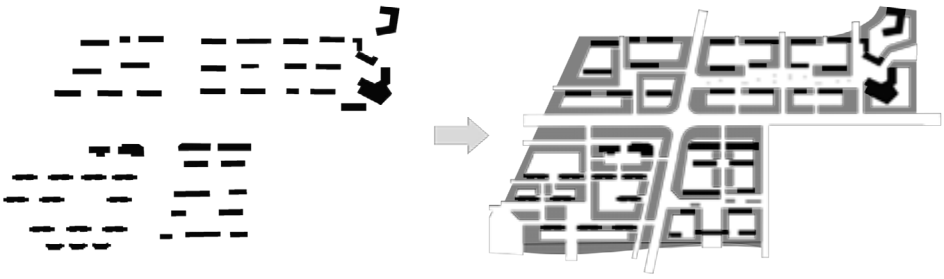

Figure 21. *Before-and-After Figure–Ground Comparison*

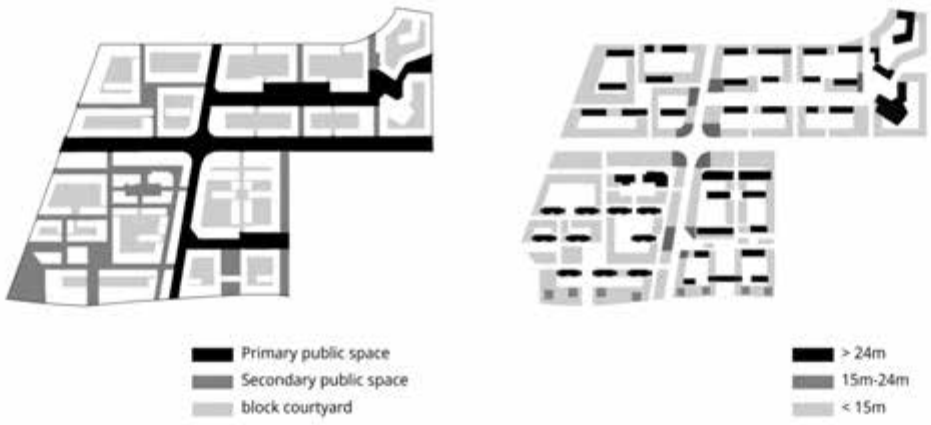

Figure 22. *Public Space Hierarchy Diagram (Left) and Building Height Control Diagram (Right)*

6.3 Traffic Reorganization

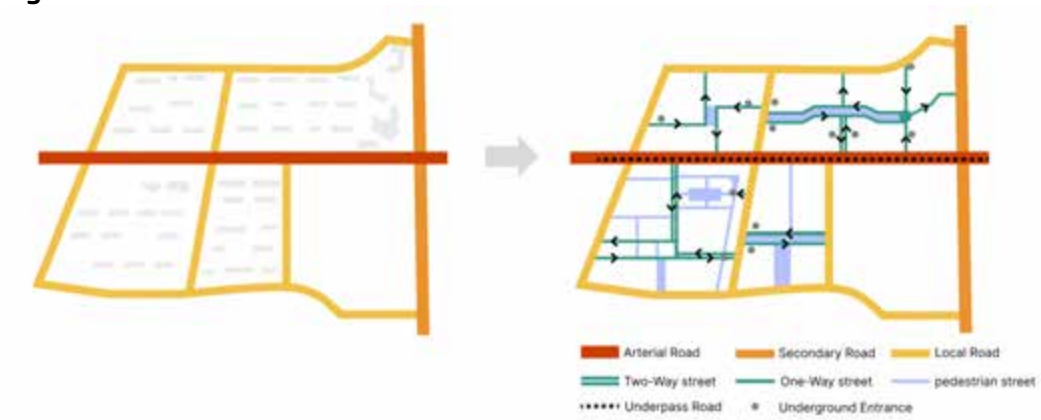

Figure 23. *Before-and-After Traffic System Comparison*

The reorganization of traffic operates at two levels: dealing with the existing urban road network and designing new intra-block circulation systems. The focus lies in coordinating the internal slow-mobility network with the external vehicular system while maintaining a clear distinction between the two (Figure 23).

For the external system, existing urban roads are retained as the foundational framework. While maintaining the primary traffic function of Yinhang Road, its scale and spatial form are optimized. A partially sunken traffic strategy is employed to redirect a portion of vehicular flow underground, thereby reducing the surface roadway width and significantly improving pedestrian spatial quality.

Internally, the newly introduced circulation system prioritizes pedestrian and low-speed traffic. In contrast to the external arterial roads, internal streets are narrower, consisting primarily of one-way lanes and pedestrian streets, with selective sections upgraded to two-way streets to ensure connectivity. To minimize disruption at points of integration, buffer lanes are added along both sides of major roads, alleviating the impact of the denser internal grid on regional traffic performance.

To further protect the residential environment, the design incorporates traffic-calming strategies, drawing from precedents such as Shanghai's Anting New Town. These include reducing vehicular lanes, introducing curved alignments, implementing one-way traffic patterns, installing roundabouts, and selectively closing intersections, thereby discouraging through-traffic and enhancing neighborhood tranquility.

6.4 Functional Supplementation

To transform the mono-functional residential area into a vibrant urban district, the design incorporates a mix of residential, commercial, and office functions into the newly inserted blocks. Drawing from mixed-use urban residential blocks in cities such as Berlin, where commercial functions generally occupy between 5% and 20% of the gross floor area (with up to 20% in central districts like Mitte and Kreuzberg), the proposed program the new buildings are assigned an approximate distribution of 55% residential, 30% office, and 15% commercial and community services. This ensures a residentially-oriented urban environment while differentiating from the regional commercial centre of Wujiaochang.

Functional layout is carefully aligned with the public space hierarchy. Continuous commercial and office frontages are positioned along the primary loop, forming a vibrant urban corridor comparable to the character of Daxue Road in Chuangzhifang. Community-scale public spaces are framed by smaller retail, cultural, and service facilities that support everyday life within each cluster. Along Yinhang Road, office functions dominate to strengthen its identity as a commercial corridor.

Functionally and spatially, the district adopts both horizontal and vertical integration strategies. A base typology emerges—commercial units at the ground corners, offices at middle levels, and residences above—offering flexible adaptation based on site-specific needs (Figure 24). This layered integration not only enhances daily

convenience and street-level vitality, but also positions the district for a gradual shift toward a more mixed-use, urban character, without compromising its residential identity.

The urban block adopts a both vertical and horizontal mixed-use typology, with a foundational model of "commercial units at the ground corners, offices at middle levels, and residences above" This model is flexible and adaptable to specific needs while maintaining a coherent logic.

Through this integrated approach, the design reinforces New Jiangwan Town's residential character while gradually transitioning it toward a more urban, multifunctional neighborhood.

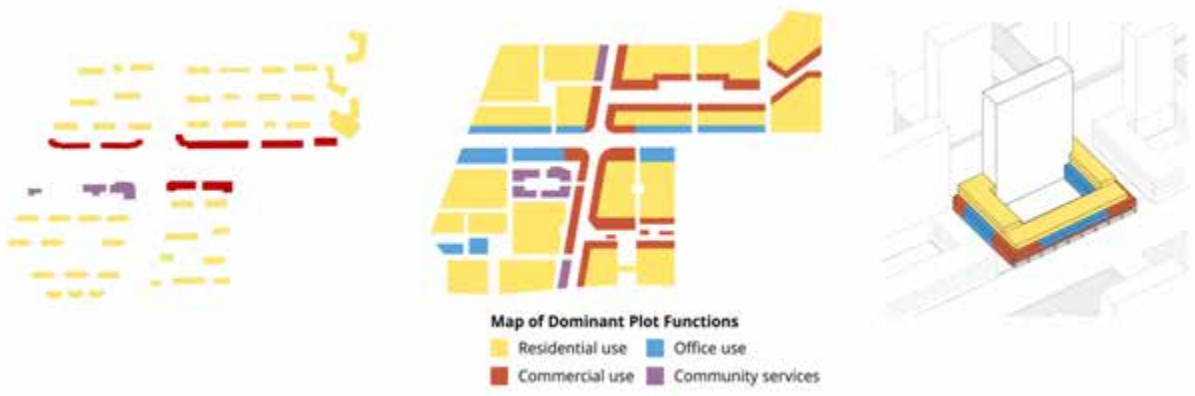

Figure 24. *Functional Layout: Before-and-After Comparison and Vertical Mixed-Use Typology*

6.5 Spatial Diversity Strategies

The creation of urban diversity is guided by a balance between spatial order and variation. At the urban design scale, new buildings align with existing structures while introducing articulation through axes, plazas, and T-intersections. These elements generate a rhythm of compression and openness, encouraging interactions across multiple scales (Figure 25).

At the block and cluster level, spatial patterns respond to both function and contextual character. Western clusters adopt inward-facing layouts for residential quietness, while eastern clusters open toward the urban edge to foster vibrancy. Northern clusters favor an ordered and structured layout to ensure clarity, whereas southern clusters use looser, fragmented patterns to create maze-like spatial experiences. These contrasting strategies collectively enrich the spatial texture of the district.

At the architectural level, future interventions will introduce further variation at a finer grain. Designers are encouraged to employ diverse architectural expressions, including pitched roofs, setbacks, arcades, and varied façade treatments, combined with a rich palette of materials. This flexibility supports architectural individuality while maintaining overall coherence, contributing to a layered and engaging urban environment.

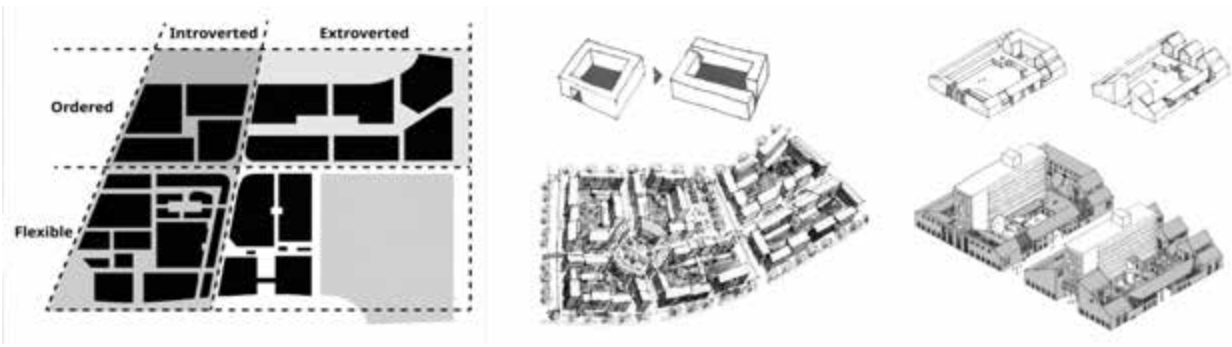

Figure 25. *Spatial Diversity Strategies*

7. Technical Challenges

The transformation from gated compounds to open communities involves not only physical spatial restructuring but also complex negotiations at the operational level such as land ownership, residential privacy, and socioeconomic equity. This chapter analyzes key technical challenges encountered in the implementation process.

7.1 The Change of Land Ownership

Extending urban streets into residential compounds and adjusting the scale of peripheral roads inevitably requires a reconfiguration of land ownership and plot boundaries. The design must therefore directly address how spatial densification strategies impact plots subdivision and property rights (Figure 26). Two primary approaches are identified:

Approach 1: While the primary loop inevitably subdivides the original parcel, other internal streets remain within existing property boundaries. These streets, though publicly accessible, are not designated as municipal roads and remain under community ownership. This minimizes legal transformation and avoids conflicts with current regulations, but may compromise long-term public governance.

Approach 2 designates all newly introduced roads as urban infrastructure, subdividing parcels into smaller units and requiring more extensive adjustments to land rights. Although more demanding in terms of implementation, this approach offers greater clarity in urban form and block structure. As a forward-looking urban design strategy, the second approach is considered as a more future-oriented and structurally coherent solution.

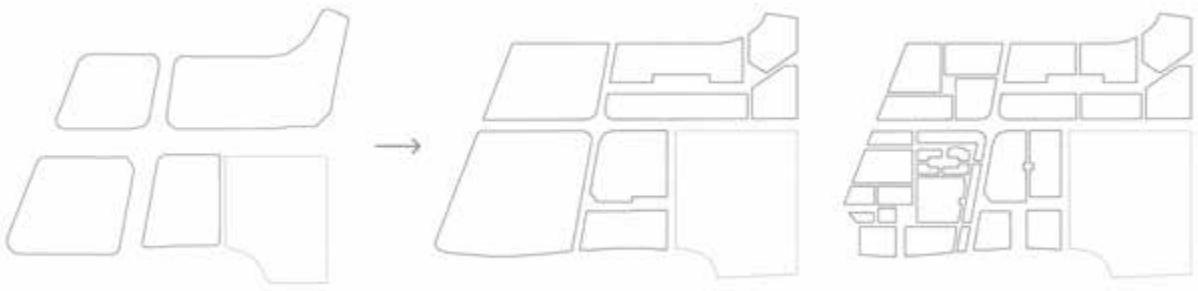

Figure 26. Before-and-After Parcel Subdivision Comparison

7.2 Avoidance: Negotiating New–Old Building Interfaces

While the design is guided by the principle of contextual adaptation, its technical implementation must address potential physical conflicts between new and existing structures, particularly with regard to residential buildings' needs for light and ventilation. To mitigate these impacts, the location and height of new additions are carefully controlled through staggered massing, spatial offsets, and deliberate gaps (Figure 27).

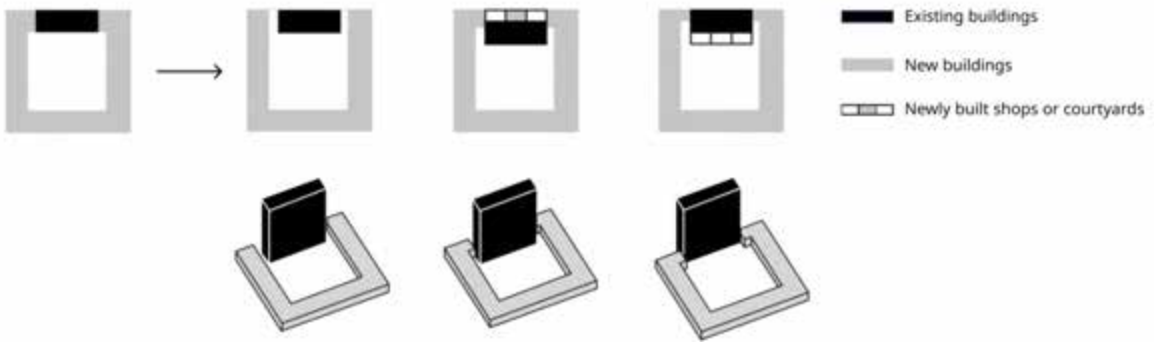

Figure 27. *Strategies for Managing Conflicts Between New and Existing Buildings*

7.3 Balance: Ensuring Privacy and Safety in Open Communities

To preserve privacy in a more open, mixed-use urban environment, the design incorporates spatial buffers such as building setbacks, ground-floor retail and courtyards (Figure 28). These elements create gradual shifts from public to private space. Although open communities inherently offer less privacy than gated compounds, the improved spatial quality and lifestyle afford greater long-term appeal .

Regarding safety, the scheme follows Jane Jacobs' principle of "eyes on the street." Active ground-floor commercial frontages replace blank compound walls, enhancing natural surveillance. The blocks become the fundamental unit of communal defence, contributing to both social cohesion and environmental security.

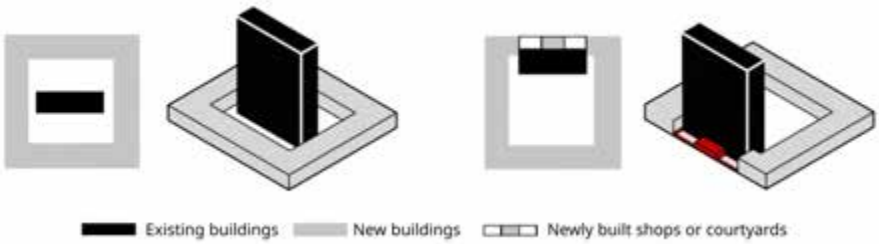

Figure 28. *Privacy Enhancement Strategies in Open Communities*

7.4 Compensation: Economic Viability and Social Equity

The proposed densification strategies may generate friction through shadowing, view obstruction, or reduced privacy, especially those living on lower floors. It is therefore essential to establish a multidimensional compensation framework. Compensation could be economic or spatial. Economic compensation refers to direct financial reimbursement. Spatial compensation can take the form of private gardens, balconies, or retail opportunities offered to affected residents within the new developments. Additionally, residents may be relocated to high-quality new housing units.

Beyond resident-level responses, a broader framework must define responsibility and benefit: who invests, who builds, and who gains. A public-led, multi-stakeholder renewal model is recommended to manage investment and ensure equitable value distribution. Additional floor area from densification should be used to generate returns that are reinvested locally, forming a closed-loop of value regeneration. This framework underpins not only financial feasibility, but also social acceptance and long-term sustainability.

8. Conclusions

Within the context of China's urban regeneration, this study critically examines large-scale gated residential communities shaped by modernist planning principles, directing the urban design perspective toward spatial quality and sustainable development.

Using New Jiangwan Town in Shanghai as a case study, it employs the concept of urban cells to examine the technical feasibility of transforming closed compounds into open communities. Through scale optimization and functional integration, the study demonstrates the feasibility of this transformation, offering a flexible and operable design framework. The spatial densification approach is shown to have broad applicability in urban regeneration.

Beyond its local context, the study contributes to the evolving discourse on urban renewal in comparable global contexts. It offers insights into redefining urban heritage and reconstructing public life, with strategic implications for Global South cities seeking sustainable approaches to legacy transformation.

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The Manifestation of Patterns and the Reconstruction of Meaning: The Reproduction of Spatial Patterns and Role Interpretation Along Xi'an's Historical Urban Axis

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Abstract:
The layering of historical spaces in Xi'an has led to the preservation and renewal of historical forms being maintained through the underlying structural control logic of residual forms,such as growth patterns along axes,partitioning relationships along enclosed structures,and isomorphic textures derived from fractal structures.As a representative of such historical cities,Xi'an's spatial text further reveals that the significance of architectural ruins as elements within the urban framework determines the linguistic structural characteristics of their formal value.

Based on the renewal cases of Xi'an's axial spatial morphology,this study explores how architectural forms,as extensions of urban morphology,rely on urban morphological research to sustain their historical significance in contemporary layered historical spaces,as well as the value continuity of East Asian urban heritage's unique morphological composition in the rewriting of contemporary urban forms.

Keywords: Typology, Xi'an, Historical axis, Urban morphology, Urban palimpsest, Architecture and city, Systemic transformation, Site rewriting

1. Architectural Fragments in Systemic Transformation

As urban forms evolve structurally over long historical periods, architectural elements from the previous era's structural system often face being captured and reorganized by the new structural system in the construction of a new layer of urban material text. These buildings or groups of buildings continuously integrate into the writing of the new urban fabric. The study of morphological typology becomes an indispensable premise for site research in architectural design during the renewal of such multi-layered, superimposed historical cities. It provides necessary systematic contextual analysis for architectural sites along the two dimensions of diachrony and synchrony, emphasizing the study and generation of architectural forms as linguistic elements of the urban morphological typology system through a textual organizational model. In terms of textual linguistic elements, context expresses the relationship between the whole and its parts, which only have complete meaning when understood as a whole. (Pezzetti, 2025) Whether surviving or renovated historical buildings or building clusters, or urban structural information hidden in city blocks and archaeological strata, they can be understood at the fragment or system level as layers of historical information within this overall superimposed collection that urgently need to be revealed and organized. It is worth noting that for traditional Chinese urban settlements: in the context of changes in urban morphological structure, buildings are not always subordinate to the urban structural system; rather, with structural evolution, most building forms continuously participate in or even determine the fractal occurrence and operation of urban structures at different fractal levels. For example, the architectural forms of city walls, gates, and towers themselves mark the same level of urban enclosure structure, while the forms of city towers and the centrally located bell tower arise from the urban axial spatial structural system. These buildings' "symbolic forms" are woven by a multidimensional systemic whole and are not fundamentally determined by themselves. Moreover, they do not participate in the adjustment of synchronous morphological relationships as "individual building" entities in relation to the continuously changing "residential fabric." Caniggia and Maffei, 2008 Rossi, 1966 This differs significantly from the European structural system, where streets and public spaces divide and juxtapose urban building plots, and at the level of architectural form operation. Compared to the expression of architectural form itself, the vast majority of important buildings in Chinese urban history have architectural significance because their form types reveal urban-level patterns. A typical example is the Xi'an Bell Tower, which, after urbanization, serves as the center of a road roundabout with a "symbolic form." Its representative construction form is unrelated to timekeeping functions or commemorating any event; it purely acts as a nodal element integrating the city and geographical environment structure. This nodal element is gradually integrated by urban cultural construction into a form of urban structural morphology; it strengthens the architectural form types of the same-level related elements to provide a reference system for

marking multi-level macrostructures in the urban landscape dimension.This also brings difficulties for Chinese historical urban renewal in borrowing European experiences.

The tremendous transformation of Chinese urban architectural typologies and site structural types has forced traditional architectural linguistic elements to continue in the contemporary urbanization context, where they have lost their systemic linguistic significance. In the capital-driven planning practices where linguistic elements lose their systemic function and the system context is completely segmented by plots, the traditional Chinese urban architectural typology, which originally spanned systems, can only be reduced to a convenient mode of "style experiments" decorating city streets as a subsidiary context for architects to choose from.

The classical Chinese city, whose urban system structure determines the architectural form types, has lost the cognitive context of architectural form types and the holistic connection of formal operations in the contemporary urban modernization movement; the typological combinations that lost control at the architectural dimension have been dismantled. While the classical language frees itself from typological constraints, it imitates the classical symbols competing under Western commercial trends, which in turn leads to the smearing and concealment of the city's deep historical structure in the preserved fragments carrying certain historical information. The superficial behavior that seemingly strives to reveal a certain historical layer's characteristics instead severely weakens the typological features of the remaining authentic historical form information. In 1985, Rossi described Japanese cities with characteristics similar to those of China: "I find it difficult to distinguish past civil buildings, religious buildings, and community buildings. Similarly, some more refined contemporary buildings are the same. My first impression of their reality is typological, that is, the principles followed by usually very different architectural structures."

2. The Transformation of the Site Context of Xi'an Urban Architecture

The continuous layering and superimposition of Xi'an's historical urban space have led to the preservation and renewal of historical forms being maintained in each era through the morphological control logic of the residual form's underlying structure. However, the morphological structure of the Chinese urban context has been in flux: what changes is the segmentation form of residential and commercial building land at the end of the macro-structural system (such as the transformation from "lilong" to "hutong alleys"); what remains unchanged is the mutually reinforcing relationship between the structural system and architectural form types, namely the typological organization of architectural forms and the construction of meaning (such as the gate tower system and city gate system). This unchanging control logic of urban form types, from top to bottom, from mountains and rivers to buildings, thoroughly creates the typical characteristics of East Asian layered historical cities as "rewritten editions." These characteristics include: fractal growth patterns of courtyard units along axial directions, division relationships along enclosed structures, and isomorphic textures derived from fractal structures(Miu, 1990).These typical structures of East Asian urban forms collectively define the attributes and form types of buildings and courtyards within the spatial framework. This cultural landscape information, formed by the synergy of interior and exterior spaces, is hidden in the "remnants" of the city's historical landscape and has a multi-level nested logic completely different from modern cities that emphasize the split relationship between buildings and road networks. This exacerbates the accelerated dilution of these historical landscapes at the morphological level and further dissolution at the structural level within the contemporary urban structural system.

3. Architectural Design's Revelation of the City's Historical Pattern

As a representative of this type of historic city, Xi'an's spatial text further reveals the significance of architectural sites as elements within the urban framework, determining the linguistic structural characteristics of their formal value. Since the beginning of this century, driven by urbanization efficiency, Xi'an's important historical sites have faced reorganization within the contemporary urban structure, generating new urban forms along their stratified historical axes. These new forms of spatial restoration not only attempt to reinterpret the historical significance of the site under a certain cultural construction but also provide buffering and self-protection mechanisms for the "important heritage" facing urbanization pressures; on the other hand, the axial forms of remnants at various levels in the city signify structural growth that goes far beyond the "symmetry" of architectural form and volume, existing within an environmental system beyond the "important heritage," and have long served as a control system for architectural types evolving with history. While new urban architecture plays a role in cultural narrative, it cannot avoid the systemic structural context revealed by these "important heritage" sites

as partial fragments of a potential historical whole. From the perspective of urban renewal, this excavation of renewal conditions determines the strategic direction of new architecture rewriting the historical structure of the urban dimension; from the perspective of heritage conservation, this awakening of design principles precedes architects' subjective formal experiments and their coincidental alignment with cultural narratives Rogers, 199 Through the analytical study of the evolution of Xi'an's urban historical morphology, within the urban pattern centered on axes, the axis serves as the main principle organizing the growth of architectural interior and exterior spatial layers through courtyard patterns. Architectural forms developed around this system are woven, concealed, repaired, or even dispersed within the stratified layers of the city's historical text. The architectural creation sites around urban heritage areas strictly accept the allocation of contemporary urban land, with historical axes being captured by the land-use logic of contemporary urban architecture, causing misleading misinterpretations and evasions in understanding the site's historical axes. The continuation of axes in new architecture related to ruins or historic buildings often stops at the inheritance of superficial symbols, leading to systemic isolation. In the formal strategies of such architectural designs, truly understanding and deeply conveying the value and significance of the city's historical structure, revealing the connotations of the site's multilayered system, generally relies on the following three experimental steps, here still exemplified by the architectural continuation of the historical axial pattern:

1) Morphological Analysis: Focus on the evolution process of the axial spatial forms in these areas, using the diachronic evolution of the figure-ground relationship of group buildings as an analytical element of the urban historical landscape system. The relational patterns of synchronic structures from various eras serve as the analytical basis for the diachronic evolution of architectural forms. In the East-West heritage value contest, respect the stratification process of the existing texture (including diachronic structural evolution and synchronic structural collage), dissecting the morphological texture of new architecture to organize and reveal opportunities to uncover hidden historical structures while respecting the existing complex structural system.

2) Site Decoding: Explore how architectural forms, as extensions of the urban landscape in contemporary stratified historical spaces, maintain historical significance through morphological studies, as well as the value continuity of East Asian urban historical landscapes in contemporary rewriting. Decode the spatial grammar of the site's historical stratification through morphological analysis and typological research.

3) Structural Verification: The fractal growth logic embedded in the axial structure constitutes the texture of Xi'an's urban historical landscape. Following the architectural volume under this structure naturally achieves its typological significance in form.

4. Practical Research on Interpretive Rewriting of Historical Axes

As a typical example of this type of site condition, the spatial text of Xi'an, represented by the Beilin Historical District, further reveals the significance of architectural landscape relics as elements woven into the hierarchical system of the city's historical landscape, as well as their linguistic structural characteristics that determine their formal value. The first case involves repairing the relationship between the new and old buildings of the Beilin Museum through landscape design. Since modern times, urban construction forms dominated by Soviet-influenced architectural entities have gradually interfered with the renovation and renewal of traditional neighborhoods originally dominated by courtyard patterns, under the pretext of seeking higher indoor utilization rates. The ancient inscription museum located in the core area of Xi'an's old city—the Xi'an Beilin—shares a historical texture similar to that of most Chinese and even East Asian cities, which unfold layer by layer along the north-south axis. Within it, vague pattern sequences and scattered individual buildings are submerged in the increasingly dense and morphologically changing urban fabric. Modern heritage workers, drawing on Western models of protecting individual buildings and groups of buildings, have allowed these remaining historical fragments to continue the traces of ancient civilization in the urbanization process by gradually expanding isolated individual buildings. Although this model formally repairs and continues the ancient texture, it causes a serious loss of the informational and value significance of these individual historic buildings at the group level of courtyard patterns. The newly completed north-side annex, half-embedded underground, continues this model in its strategy for updating the city's environmental historical information, despite the building's own design offering a new typological interpretation of the individual buildings housing the steles. The organizational structure of courtyard axes in ancient East Asian cities determines and constitutes the typological derivation of individual buildings; as nodes that "segment" the city's axial pattern, their significance usually precedes the

formal meaning of the buildings themselves. The new museum's repeated emphasis and focus on the typological interpretation of the building's own historical form instead intensifies its opposition to the city's contextual system. The limited landscape design task needs to structurally transform the axis and the spatial pattern of its two wings between the new and old buildings while connecting the traffic and evacuation routes of the new and old museums. (Figure 1)

1) Morphological Analysis: The design first organizes the basic logic of urban spatial segmentation by hierarchical levels. It then compares several courtyard generation methods based on "segmentation" as a spatial generation principle to assess their patching effect on the existing courtyard sequence and evaluate the opportunities revealed by this patching for the pattern to which the historical individual relics belong. The "preview" action of the new museum's building wall logic can simultaneously serve as the finishing and tidying of the preceding historical space dominated by courtyards. Thus, the "plaza" in front of the new museum building is understood as the "cross street" following the Confucius Temple courtyard at the end of the old venue. While organizing vertical circulation of the historical terrain, the landscape wall controls people's bidirectional understanding of the north-south structure as they stand between it.

2) Site Decoding: The new wall, matching the materials of the new and old venues, stands independently between the new and old buildings, constituting a linguistic type of "ruins" in the nostalgic sentiment of ancient Chinese literati. The converging and dispersing walls penetrate the grid between the new and old buildings, becoming an intermediate mediator that treats the new and old buildings—systems of different kinds—as exhibits to each other. Within the movement lines defined by the walls that are at once near and far, the perspective images of the new and old building landscapes complete the camera's transitions and edits through the organization of scene fragments.

3) Structural Verification: The landscape design on both wings around the axis forms spatial extensions adapted to the historical terrain under a symmetrical relationship, maintaining the growth of the courtyard axis at different levels. The Xi'an Beilin Museum complex, submerged in two different types of urban structures from ancient and modern times, transforms from an ambiguous and unclear structural relationship into a conclusion of the historical structure and a "camera transition" between the old and new Beilin through landscape mediation here. It realizes the originally mixed but overall museum and ancient temple complex, shifting from the single and strict whole of "Beilin as Confucius Temple" to a woven system of two opposing yet unified forms of "Beilin and Confucius Temple overlapping out of alignment." The city itself is a fabric formed by multiple systems layered through history. This both separates the historical venue from the new venue in terms of morphological type and maintains the structural integrity of the historical venue as a "historical building complex" heritage attribute.

The museum's landscape renewal ultimately respects the existing historical building complex by implanting a new "wall system" as a frame of reference for the historical space, organizing and integrating the scattered courtyard spatial sequence, highlighting the courtyard-dominated urban spatial order, and revealing the courtyard relationships to which individual building remains belong. At the same time, it also achieves the new venue building's own persistence and focus on formal innovation based on a certain historical type.

5. Conclusion: Structural Writing of This Time and Place

The "design site" in historical urban renewal activities is based on the standpoint of urban architecture, adapting both to the planning logic of contemporary Chinese urban renewal building land and serving as a meso-level research object for tuning the continuation of urban context on important urban heritage sites within a rapidly changing and complexly layered historical urban morphological environment. The Chinese character for "site" itself provides an accurate explanation of the synchronic and diachronic research dimensions of the historical attitude toward design land, representing a dynamic spatiotemporal concept of "this time and place." It signifies respect for the systemic meaning behind its own temporal condition and spatial state. The research emphasizes the principles and recognition patterns of architectural design interventions on the urban heritage landscape of the area but does not necessarily rely on strong intervention strategies involving urban architectural body conflicts. This intervention approach involves: revealing, protecting, and marking the core grammatical structure of the historical landscape; transitional buffering methods with morphological continuity research; and interpretive spatial language for contemporary interventions. The study shows that heritage landscape renewal in East Asian historic cities represented by Xi'an should establish a dynamic interpretive mechanism

while studying and continuing the deep structural genes of historical forms. Through typological experiments simulating the inherited urban context system, it comparatively discusses the reweaving and renewed contest of the urban structural systems in the area. This allows the city's "rewritten edition" to provide a readable formal sorting and structural inheritance for historical landscape fragments through the "site rewriting" model, enabling them to integrate into the future urban heritage system with dignity.

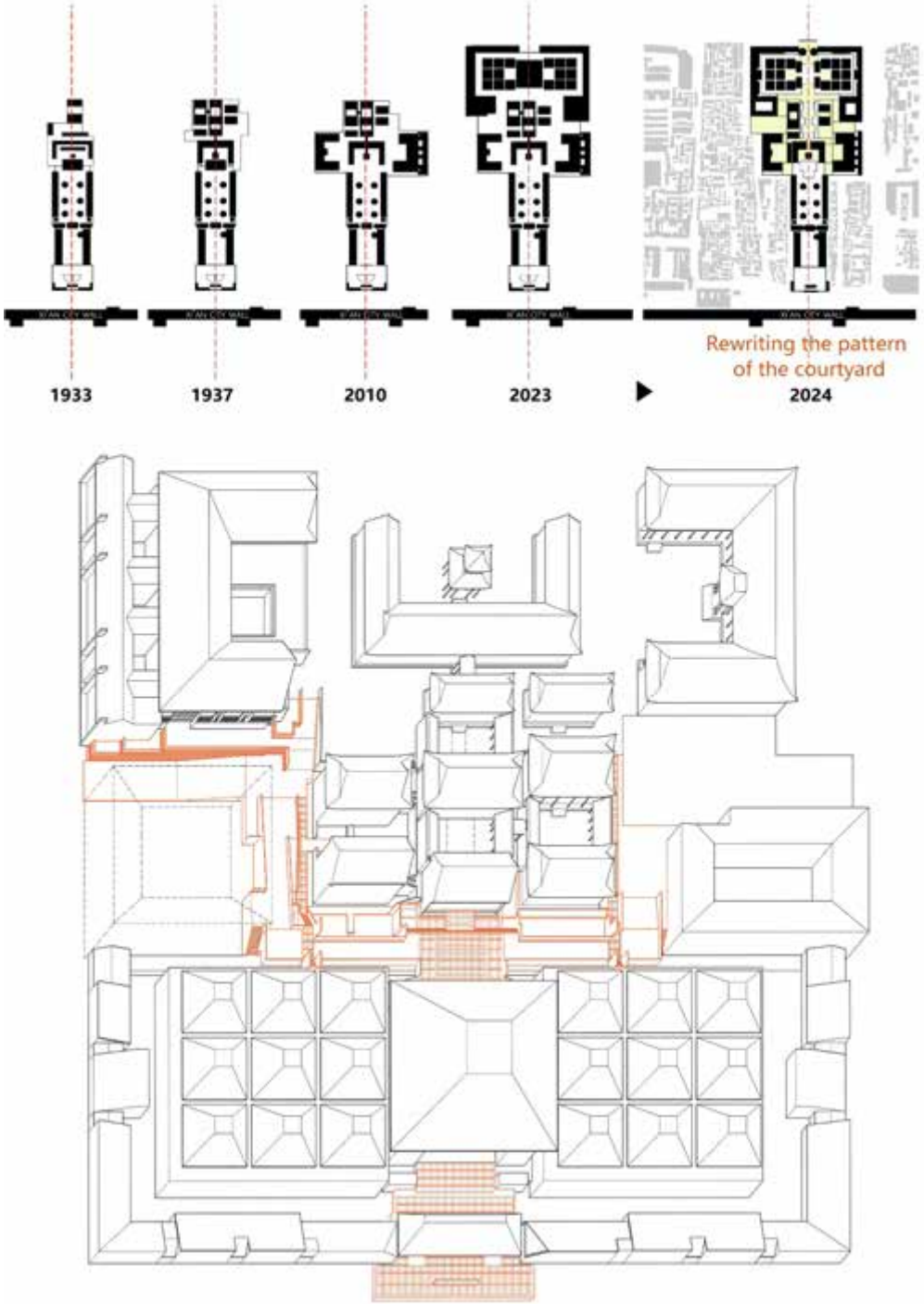

Figure 1: Landscape integration design of the new and old building complexes at Xi'an Beilin Museum, Designers: Liu Kecheng, Li Xinfei

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Overlapping urban processes: Research by design experiences in a Sarajevo city central military campus

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Abstract
This paper investigates the interplay of urban cultures, heritage, and spatial transformation through the case of the former Marsala Tito Barracks in Sarajevo, now redeveloped as the University of Sarajevo Campus. Developed within a research collaboration between the Universities of Ferrara and Sarajevo, it frames urban design as a critical lens for examining tensions between global urbanisation and local cultural identities. Challenging static conceptions of heritage, the study advocates for a dynamic, negotiated understanding shaped by evolving social relations. It highlights the complexities of reconciling heritage preservation with contemporary development in a post-conflict, multicultural city. The transformation of the Marsala Tito site exemplifies how urban interventions become contested arenas of memory and identity, calling for more inclusive, context-sensitive strategies that respond to both local narratives and global urban pressures.

Keywords: Post-Conflict Urbanism, Multicultural City, Urban Transformation Processes, Overlapping Urban Narratives

1.Theoretical and Methodological Framework

1.1 Introduction

The city of Sarajevo, the capital of Bosnia and Herzegovina, stands as a deeply stratified urban environment shaped by centuries of imperial, socialist, and post-conflict transformation. As a city at the crossroads of East and West and the *locus* of multiple modern conflicts — including the 1992–1996 siege during the Bosnian War — Sarajevo is more than a post-conflict city: it is a complex and unique urban palimpsest (Machado,1976). Each layer of its history remains legible, yet overlaid with subsequent uses, narratives, and ideologies. The city's contemporary condition is emblematic of the intersection of trauma, resilience, and re-imagination in the context of cultural heritage and urban regeneration.

In such a context, heritage is not simply an object of conservation: it is a medium of contested meanings. In Sarajevo's post-Dayton configuration, the politicization of urban planning and memory practices is embedded in fragmented governance and ethnic territorialization (Pickering, 2007). Projects like the transformation of the Marsala Tito Barracks into the University of Sarajevo Campus must be understood within this matrix of spatial symbolism and institutional negotiation.

Originally constructed in the Austro-Hungarian period and serving military functions through the Yugoslav era, the Marsala Tito Barracks were abandoned in the post-war years. They were later appropriated as the site for a civic and educational transformation — a shift from closed, military urbanism to an open, knowledge-driven environment. This evolution is the focus of a collaborative academic research effort between the University of Ferrara and the University of Sarajevo, initiated through the Erasmus+ program (2019-1-IT02-KA107-061336), which framed architectural design as a research tool and critical medium for understanding spatial transformation in complex, multicultural contexts.

This paper investigates three core research questions:
- How can urban heritage be understood not as static but as dynamic, particularly in post-conflict urban settings?
- What methodologies are suitable for reading and intervening in sites marked by overlapping historical, social, and architectural layers?
- How can transnational academic collaborations contribute to more inclusive and culturally sensitive urban development practices?

1.2 Conceptualizing Urban Heritage

Conventional approaches to heritage — especially those aligned with conservation charters and institutional frameworks — tend to prioritize tangible assets and monumental structures. These "authorized heritage discourses," as defined by Laurajane Smith, risk reifying the past and detaching it from lived experience. In contrast, critical heritage studies emphasize heritage as a dynamic, processual phenomenon, continuously constructed and reconstructed through social practices and spatial interventions (Harrison, 2013).

This shift is particularly relevant in cities like Sarajevo, where memory is politically charged and layered across ethnic, religious, and temporal axes. (Haidar, 2006). The Marsala Tito Barracks, for example, symbolize different things to different actors: to some, a relic of Yugoslav unity and military order; to others, a void awaiting reinvention. The act of transforming this site into a university campus involves not only physical redevelopment but also symbolic reinterpretation.

The concept of the urban palimpsest is instrumental here. As Rodolfo Machado (1976) argued in his seminal essay, the palimpsest represents a city where successive layers coexist, interfere, and reveal traces of prior occupations. Such layering does not imply a neat historical chronology but a complex, often conflictual assemblage of spatial meanings. In Sarajevo, the palimpsest condition includes Ottoman mosques, Austro-Hungarian boulevards, socialist apartment blocks, war ruins, and emergent neoliberal enclaves.

Solà-Morales further elaborates on this concept through his notion of "terrain vague," referring to ambiguous, residual urban spaces that resist definitive categorization. These spaces, often overlooked, hold the potential for new interpretations and interventions that acknowledge their layered histories. Engaging with these spaces thoughtfully, and avoiding aggressive impositions that erase their inherent complexities, is fundamental to promoting an effective and sensitive approach to urban and architectural design. (Solà-Morales, 1995).

Moreover, the importance of acknowledging the fragmented and layered nature of urban memory, advocating for interventions that respect and engage with the existing historical and cultural contexts rather than overwriting them, erasing them somehow (Haidar, 2006)

At the scale of the Marsala Tito Barracks, this palimpsest condition is especially visible. The barracks' architecture, planning geometry, and residual militarized landscape stand in tension with the civic and educational programs being projected onto them. The transformation project, as explored 3 years in a row by architectural and urban design students, does not seek to erase these traces but to integrate them critically within new urban narratives.

Importantly, this reconceptualization of heritage aligns with broader discourses on planetary urbanization, as theorized by Brenner and Schmid (2015). In an increasingly globalized urban system, local identities and cultural specificities are often subsumed by standardized development logic. Redevelopment projects risk producing homogenized spaces unless they are grounded in situated, culturally sensitive approaches. The work presented in this paper advocates for a model of heritage practice that resists such flattening — one that sees value in complexity, contradiction, and negotiated transformation.

1.3 Methodological Approach

The methodology employed in this research combines architectural design, critical heritage theory, and transdisciplinary pedagogy. At its centre is the overlapping methodology, developed within the design studios and workshops coordinated by the University of Ferrara in Sarajevo. This approach was articulated by Elena Guidetti in the context of LAP3 Architectural Design Studio as a "dual-paced didactic framework" designed to accommodate both synchronic readings of the present city and diachronic interpretations of its historical and cultural layers.

Overlapping refers to the simultaneous engagement with multiple temporal, spatial, and cultural layers in both analysis and design. It is opposed to reductionist models of urban intervention that seek clarity or linear solutions. Instead, it embraces ambiguity and contradiction as inherent qualities of real urban environments. In Sarajevo, this meant working with the existing barracks structures — not as obsolete relics to be replaced, but as active participants in shaping new spatial narratives.

Methodologically, the process was structured into two interconnected phases:

(1) Analytical Layering: students and faculty began with immersive site investigations, including photographic surveys, historical mappings, programmatic inventories, and spatial ethnography. The aim was to generate a multi-dimensional reading of the Marsala Tito site, incorporating both formal properties (geometry, structure, materiality) and informal dynamics (use patterns, social meanings, perceptual layers). These investigations culminated in visual "overlaps" that combined different timeframes and thematic perspectives on the site.

(2) Design as Inquiry: building on this analysis, students developed architectural and urban proposals that did not resolve the site into a single vision but instead allowed for multiple, often conflicting, interpretations. The design strategies — such as graft, box-in-the-box, parasite, and platform — were chosen for their capacity to negotiate between presence and absence, memory and innovation, stasis and transformation.

This iterative process was supported by collaborative critiques, guest lectures from Sarajevo-based scholars and public exhibitions that encouraged feedback from stakeholders. Importantly, the method emphasized pedagogical reciprocity: Italian and Bosnian students worked in mixed teams, producing knowledge across cultural and disciplinary boundaries. This not only enriched the design output but also enacted a model of shared authorship and mutual learning, crucial for operating in contexts of contested heritage (Guidetti, 2020).

The significance of this approach lies not only in its academic merit but also in its capacity to model a more inclusive, culturally grounded form of urban practice. The method produced a form of critical storytelling that respects the multiplicity of voices and spatial histories embedded in the site. Rather than imposing a single narrative, the designs allowed for overlapping meanings to be read, inhabited, and modified over time (Gardini, 2020).

Finally, the application of the overlapping methodology within LAP3 workshops resulted in more than 60 student design proposals and two major exhibitions in Sarajevo. These projects were not intended for direct implementation, but as speculative instruments that could provoke dialogue, critique existing paradigms, and suggest alternative futures for the Marsala Tito Barracks and similar urban sites. In this sense, design was mobilized not only as a tool of production but as a method of thinking-through-making, a way of generating knowledge about the urban condition through material and spatial speculation.

However, this design exercise sees the confrontation with the reality of urban transformation and planning. The project developed for this site and the current situation is still open to future transformations.

2.Case Study – Marsala Tito Barracks Transformation
2.1 Historical Significance of the Site
Overview of the Marsala Tito Barracks' military and political history.
Its symbolic and cultural relevance in the urban fabric of Sarajevo.

2.2 From Military Zone to University Campus
Description of the masterplan by ARUP London.
Phases of physical transformation: demolition, preservation, adaptation.
Integration with city planning and public space networks.

2.3 Actors and Stakeholders
Roles of architects, planners, local communities, and institutions.
Analysis of power dynamics and decision-making processes.
Tensions between preservation, redevelopment, and commercialization.

2.4 Urban Identity and Everyday Use
How the new campus is perceived and used by students, staff, and residents.
Shifts in social practices and spatial meaning.

Figure 3: Historical and current site plans of the Marsala Tito Barracks area?

Figure 4: Project image-other

Critical Reflections and Broader Implications
3.1 Heritage in the Age of Planetary Urbanization
How global urban models (e.g., neoliberal planning, university-driven gentrification) impact local heritage.
Homogenization vs. cultural specificity in post-socialist urban spaces.

3.2 Contested Memories and Narratives
Memory politics in Sarajevo and its role in shaping heritage discourses.
The site as a locus of competing narratives: reconciliation vs. erasure.
The role of critical storytelling and urban pedagogy.

3.3 Conclusion
Summary of key insights from the case study.
Reaffirmation of the need for nuanced, dynamic approaches to urban heritage.
Future research directions.

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A Study on the Identification of Historical and Cultural Resource Carriers Oriented by Value: A Case Study of the Taihu Lake Basin

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Abstract
China's heritage protection system faces gaps as many historical resources remain outside legal frameworks due to inadequate classification standards. This study addresses legislative deficiencies by establishing systematic criteria to identify non-statutory cultural resources (e.g., place names, intangible skills). Combining international standards with domestic practice, it prioritizes conservation through value-based assessment—focusing on cultural genetics, intergenerational transmission, and regional identity. Using the Taihu Lake Basin as a case study, resources are analyzed across political, economic, social, technological, and geographical dimensions. The proposed recognition system clarifies resource value, enables timely protection, unlocks potential, and maintains cultural integrity within dynamic urban contexts. This approach sustains heritage significance while enhancing urban cultural resilience and exchange.

Keywords: historical-cultural value; urban dynamic development; historical-cultural resource conservation; element identification

Introduction

The 21st century has witnessed China's urbanization transition profoundly from quantitative expansion to qualitative advancement, elevating the imperative to preserve "collective memory" and cultural roots in urban-rural development. However, rapid urbanization has revealed a critical challenge: vast resources bearing historical memory and cultural genes—excluded from legally protected heritage categories (encompassing cultural relics sites, historic districts, and historic cities/towns/villages)—now face severe conservation gaps (Dong, 2022). These invaluable resources suffer from compartmentalization and fragmentation, undermining their integrity. Despite UNESCO's establishment of an Outstanding Universal Value (OUV)-based global assessment framework through the 1972 World Heritage Convention and its 2015 integration of sustainable development principles, China's conservation efforts confront persistent deficiencies. Current systems predominantly prioritize monumental ancient heritage with tangible forms, while inadequately addressing intangible elements (e.g., toponymic culture, traditional crafts) and dynamic cultural landscapes (e.g., polder systems, canal networks). This results in ineffective identification and preservation mechanisms (Wang et al., 2023). Value assessment remains reductive, overemphasizing the "antiquity" and "architectural integrity" of physical remains while neglecting the contemporary adaptability of cultural DNA and derivative values such as ecological wisdom.

The Taihu Lake Basin exemplifies these tensions. As the cradle of Wuyue culture and China's economic core since the Southern Song Dynasty, its networked aquatic settlements, engineered polder landscapes, and canal relics embody multidimensional historical, cultural, economic, and ecological values. Yet rigid classification frameworks and limited value recognition impede systematic identification and integrated governance.

Addressing these issues necessitates a value-oriented, dynamically integrated identification framework for historical-cultural resources. This requires transcending the material/non-material dichotomy and examining resources through dual analytical lenses: diachronic (temporal layering) and synchronic (spatial-network interactions) (Dong, 2022). Such an approach aligns with the holistic mandate of "spatial comprehensiveness, element inclusivity, and integrated conservation-transmission chains" in China's territorial spatial planning paradigm.

China's heritage conservation has evolved beyond adopting international models to develop distinctive frameworks. Since the 1982 Historic City System, a tripartite protection structure (cultural relics sites → historic districts → historic cities/towns/villages) has expanded to include industrial and agricultural heritage (Lü, 2008). The 2015 revision of China Principles for the Conservation of Heritage Sites marked a milestone by augmenting traditional "historical, artistic, scientific" values with "social" and "cultural" dimensions, emphasizing heritage's role in fostering contemporary identity (Lü, 2015). Recent policy directives, notably the CPC Central Committee's Opinions on Strengthening Historical-Cultural Conservation in Urban-Rural Development, explicitly advocate "spatial comprehensiveness and element inclusivity," demanding systematic integration from individual

structures to intangible cultural heritage (ICH).

Domestic scholars have pioneered context-specific methodologies: Shao (2019) proposed a "stratification-integrity-pluralism" assessment model, analyzing the Taihu water system to reveal spatiotemporal layering from the Tang-Song to Ming-Qing periods, and developed a stratified framework ("hydraulic base → ancient site → settlement → modern layers") for heritage integration. Jiang et al. (2024) employed a "value-characteristic correlation metric model" to quantify interactions among political, economic, social, technological-cultural, and geographical dimensions. Dong's (2022) "National Historical-Cultural Space" theory advocates integrated management through a "production-living-ecology" nexus.

Nevertheless, three interrelated challenges persist:
1.Coverage deficits: Material-focused registries overlook the Taihu Basin's polder systems, water-town networks, and intangible resources (e.g., toponyms, craft techniques).
2.Reductive valuation: Conventional "tripartite values" frameworks cannot accommodate cultural DNA's contemporary adaptability (e.g., silk craftsmanship in circular economies) or derived ecological wisdom.
3.Administrative fragmentation: Jurisdictional boundaries obstruct the formation of continuous cultural corridors (e.g., Taihu-Yangtze historic clusters), impeding holistic conservation. While Dong's (2022) theoretical framework provides direction, its implementation remains constrained by inadequate cross-regional coordination and limited community engagement.

Literature Review
(1) Theoretical Paradigm Shift in International Cultural Heritage Conservation
International cultural heritage conservation theory has undergone a paradigm shift from material-object preservation to value-based dynamic system governance. Early foundations emerged from the 1964 Venice Charter, which established "authenticity" and "integrity" principles emphasizing the transmission of civilizational memory through physical remains (Lü, 2008). The 1972 World Heritage Convention introduced six "Outstanding Universal Value" (OUV) criteria, framing heritage as testimony to shared human experience. While reinforcing authenticity and integrity, early implementation prioritized static conservation of tangible assets, overlooking intangible elements and dynamic interconnections. Evolving perspectives contextualized authenticity within cultural frameworks through the 1994 Nara Document on Authenticity and 2005 Xi'an Declaration, validating local knowledge systems (Lü, 2015). A pivotal advancement came with UNESCO's 2011 Recommendation on the Historic Urban Landscape (HUL), proposing "stratification" to balance heritage conservation and urban development. The 2015 revised Operational Guidelines for the World Heritage Convention further integrated Sustainable Development Goals, marking a transition from "freezing history" to "living heritage transmission."

ICOMOS's HUL methodology advocates multidisciplinary integration of natural-human elements. Cultural landscape theory conceptualizes natural substrates and cultural practices as symbiotic entities, exemplified by the Hani Rice Terraces' "forest-village-terrace-water" system (Jiao, 2002). The 1999 Charter on the Built Vernacular Heritage introduced "living heritage" principles, emphasizing synergistic conservation of traditional lifestyles and material spaces—providing theoretical foundations for protecting Taihu Basin's polder systems and Zisha pottery techniques. France's "Architectural, Urban and Landscape Heritage Protection Zones" (ZPPAUP) and Carl Sauer's cultural ecology theory further illuminate heritage-geography symbiosis (Shao, 2019). Australia's Ballarat Goldfields demonstrates "participatory change management" for functional regeneration, offering a global methodological framework.

(2) Characteristic Development and Challenges of China's Conservation System
China has developed a localized "national-provincial-municipal" tripartite conservation framework by synthesizing international experience. The 1982 Historic City System evolved into a three-tier structure (cultural relics sites → historic districts → historic cities/towns/villages), later expanded to include industrial and agricultural heritage (Lü, 2008). The 2015 revised China Principles for the Conservation of Heritage Sites augmented traditional "historical, artistic, scientific" values with "social" and "cultural" dimensions, emphasizing heritage's contemporary identity-building function (Lü, 2015). The CPC Central Committee's Opinions on Strengthening Historical-Cultural Conservation mandates "spatial comprehensiveness and element inclusivity," requiring integrated conservation from individual structures to intangible cultural heritage.

Domestic scholars propose innovative models: Shao's (2019) "stratification-integrity-pluralism cognition" framework deciphers the spatiotemporal layering of Taihu hydraulic systems from the Tang-Song to Ming-Qing periods; a four-tier system ("hydraulic base → ancient site → settlement → modern layers") integrates Jiaxing's heritage; Jiang et al.'s (2024) "value-characteristic correlation metric model" quantifies interactions among political, economic, social, technological-cultural, and geographical dimensions. However, three contradictions persist:

- Insufficient coverage: Statutory registers prioritize material heritage, neglecting intangible resources (e.g., toponyms, traditional crafts), leaving Taihu's polder systems and water-towns underprotected;
- Reductive value cognition: Overreliance on the "tripartite values" framework ignores cultural DNA's modern adaptability (e.g., silk craftsmanship in low-carbon economies) and derivative ecological wisdom (Dong, 2022);
- Fragmentation: Administrative boundaries impede holistic cultural corridor formation in the Taihu-Yangtze region. Dong's (2022) "National Historical-Cultural Space" theory proposes integrating natural-cultural resources via a "production-living-ecology" network, yet implementation faces cross-regional coordination and community participation deficits.

(3) Value-Oriented Theory Adaptation in the Taihu Lake Basin
As the core region of Jiangnan culture, the Taihu Basin pioneers localized innovations through value reconfiguration, technical integration, and governance synergy. Its heritage manifests multidimensional dynamics: governance wisdom in Southern Song tribute transport networks, global influences via silk trade, clan-structured water-town organizations, and hydraulic innovations in Lingang polder systems—collectively forming a "political-economic-social-technological-geographical" value matrix.

A three-dimensional framework ("cultural gene value-era-transmission value-territorial identity value") enables multidimensional identification:
- Cultural gene value focuses on core civilizational symbols (e.g., polder ecological wisdom), supported by diachronic analysis methodologies (Li, 1994);
- Era-transmission value emphasizes functional adaptation (e.g., low-carbon retrofitting of traditional architecture), aligning with UN Sustainable Development Goals (2015);
- Territorial identity value strengthens cohesion through festivals (e.g., Fishing Commencement Ceremony), guided by "cultural gene decoding" theory (Luo, 2023).

To counter fragmentation, dual integration strategies are implemented:
- Vertical: Cultural corridors (e.g., Grand Canal) link wharves and granaries;
- Horizontal: "Wetland-settlement-industry" ecosystems integrate polders and mulberry-dyke fishponds (Yang, 2016).

Technologically, the "Regional Correlation Metric Model" quantifies inter-element value relationships. Governance innovations include: dynamic tourist-capacity monitoring via digital platforms; revitalization of traditional silk-reeling techniques as cultural IP; intergenerational transmission of rituals (e.g., Silkworm Deity Worship) reinforcing identity (Han, 2024). These practices resolve the "conservation-development" paradox and establish a networked "natural-cultural ecological patch" system, contributing Chinese solutions to global living heritage transmission.

(4) Research Gaps and Innovations
Persistent limitations include:
1.Absence of classification standards for non-statutory heritage (e.g., toponyms, intangible techniques), delaying conservation of Taihu's polder systems;
2.Inadequate attention to adaptive evolution during urbanization (e.g., authenticity erosion in Zhouzhuang's tourism commercialization);
3.Cross-regional coordination deficits in the Taihu-Yangtze cultural zone.

This study innovatively proposes:

- A "five-dimensional value model" integrated with the HUL concept to establish a "cultural gene-spatial carrier-contemporary function" dynamic identification framework;
- Bottom-up pathways (e.g., specialized regulations for toponym conservation) complementing statutory systems;
- An "eco-conservation transmission" model combining "primitive ecological display" and "quasi-ecological inheritance" (Liu, 2022), demonstrated through intergenerational practices like Gaochun's Dongba Horse-Lantern Festival.

These innovations address gaps in dynamic landscape analysis (e.g., seasonal agrarian rituals) and offer globally transferable Chinese approaches to heritage conservation.

Framework Development for Historical-Cultural Resource Identification

Contemporary cultural heritage conservation confronts systemic deficiencies wherein resources embodying core cultural genes, adaptive continuity, and territorial recognition remain inadequately safeguarded due to fragmented protection frameworks. The dissolution of Beijing's historic hutong toponyms and jurisdictional ambiguities surrounding Southern Song shipwrecks in the South China Sea exemplify fundamental contradictions in non-systematic conservation: isolated interventions sever organic connections across temporal stratification, spatial systems, and multi-subject dimensions. This precipitates not only physical degradation but also ruptures in cultural gene transmission. Fragmented conservation undermines heritage's intrinsic value as integrated "structure-function-meaning" entities. Resolving these systemic challenges necessitates paradigm reconstruction through:

1.Dynamic correlation (dialectical unity of diachronic stratification, synchronic systems, multi-subject dimensions)
2.Value-oriented approaches (tripartite assessment of structural stability, functional adaptation, meaning cohesion)

$$(\text{RI}=0.58)\quad CR = \frac{CI}{RI} = \frac{0.0025}{0.58} = 0.0043$$

This study advances a dual-core theoretical framework integrating dynamic correlation with value orientation, structured through three weighted dimensions: cultural gene value (50%), era-transmission value (25%), and territorial identity value (25%). Quantitatively validated via Analytic Hierarchy Process (AHP; CR<0.1), this system establishes hierarchical metrics for assessing stratified, systemic, and pluralistic resources, targeting "comprehensive spatial coverage and inclusive element protection."

Dynamic correlation operationalization:
1.Diachronic stratification: Recognizes evolutionary patterns in cultural genes while establishing evaluation mechanisms accommodating continuity and adaptation.
2.Synchronic systems: Examines heritage embeddedness within geographical and socio-structural matrices to decipher natural-human interdependencies.
3.Multi-subject dimensions: Decodes coexistence logics of polycultural symbols across heterogeneous carriers.

Value-oriented architecture transcends static paradigms through tripartite assessment:
1.Structural dimension: Reveals historical-logical integrity beyond material persistence (e.g., Lingang polder system's Song-era "bamboo fencing–watercourses–sluice gates" technological chain preserving hydrological wisdom).
2.Functional dimension: Prioritizes adaptive regeneration (e.g., Lihu Wetland's restoration of traditional purification networks increased avian biodiversity by 100% through synergistic ancient-modern hydrology).
3.Meaning dimension: Activates cultural cohesion (e.g., Wuzhong's silvopastoral system transforming agricultural heritage into identity symbols via Hu sheep conservation centers).

Synthesizing dynamic correlation principles (dialectical integration of stratification, systemicity, multi-subjectivity) with value-oriented theory (structure-function-meaning assessment), we establish a three-dimensional framework centered on cultural gene value (50%), era-transmission value (25%), and territorial identity value (25%). AHP-quantified (CR<0.1) and hierarchically structured, this model enables integrated cognition through "historical stratification–systemic correlation–subject interaction" operationalization.

Weight Allocation Model of Three-dimensional Value Framework Based on AHP

1.Constructing a Hierarchical Structure Model

- Objective Layer (O): Maximization of Historical and Cultural Resources Value
- Criterion Layer (C):Cultural ($\Phi = \alpha \cdot S_{gene} + \beta \cdot I_{function} + \gamma \cdot D_{meaning}$ Identity Value (C3)
- Index Layer (P): 9 core indicators

2.Constructing Judgment Matrices

Using Saaty's 1-9 scale method for pair-wise comparisons to form judgment matrices. Take the criterion layer as an example:

	C1	C2	C3
C1	1	3	3
C2	1/3	1	1
C3	1/3	1	1

3.Weight Calculation and Consistency Test

Calculating Eigenvectors	$W_i = \sqrt[n]{\prod_{j=1}^{n} a_{ij}}$(Geometric Mean Method)	
Normalization Processing		
Consistency Verification	Maximum Eigenvalue	$\lambda_{max} = \sum \frac{(AW)_i}{nW_i} = \frac{1.803}{3 \times 0.600} + \frac{0.605}{3 \times 0.200} + \frac{0.605}{3 \times 0.200} = 3.005$
	Consistency Index	$CI = \frac{\lambda_{max} - n}{n-1} = \frac{3.005 - 3}{2} = 0.0025$
	Random Consistency Ratio	RI=0.58

4.Weight System of the Three-dimensional Value Framework

Value Dimension	Weight	Core Indicators	Sub-weight	Composite Weight
Cultural Gene Value	50%	Historical Stratification	40%	20%
		Civilizational Continuity	30%	15%
		Pluralistic Symbiosis	30%	15%
Time Inheritance Value	25%	Modern Adaptability	30%	7.5%
		Living Heritage Inheritance Ability	50%	12.5%
		Innovation and Transformation Ability	20%	5%
Regional Identity Value	25%	Geographical Relevance	40%	10%
		Ethnic Community Awareness	35%	8.75%
		Regional Representativeness	25%	6.25%

5.Priority Determination Equation for Cultural Heritage Protection, used to quantitatively assess the urgency of resource protection:

Φ	Priority Index
α	Weight coefficient of cultural gene breakage risk
S_{gene}	Cultural gene breakage risk
β	Weight coefficient of functional chain integrity
$I_{function}$	Functional chain integrity
γ	Weight coefficient of meaning production activity
$D_{meaning}$	Meaning production activity

Judgment Matrices of the Index Layer

	Historical Stratification	Civilizational Continuity	Pluralistic Symbiosis
Historical Stratification	1	2	3
Civilizational Continuity	1/2	1	2
Pluralistic Symbiosis	1/3	1/2	1

	Living Heritage Inheritance Ability	Modern Adaptability	Innovation and Transformation Potential
Living Heritage Inheritance Ability	1	2	3
Modern Adaptability	1/2	1	2
Innovation and Transformation Potential	1/3	1/2	1

	Geographical Relevance	Ethnic Community Awareness	Regional Representativeness
Geographical Relevance	1	1/2	2
Ethnic Community Awareness	2	1	3
Regional Representativeness	1/2	1/3	1

Formula for Historical Stratification:

$$D_t = \frac{1}{n}\sum_{i=1}^{k} \delta_i T_i$$

(δ_i is the stratum weight,is the chronological span)

Cultural Element Diversity: Calculated by the Shannon-Wiener diversity index to measure the coexistence degree of multi-ethnic symbols:

$$H = -\sum (p_i \ln p_i) \geq 1.5$$

Three-dimensional Value	Core Indicators	Quantification Criteria	Evaluation Method
Cultural Gene Value	Historical Stratification	Chronological Span: Number of historical stages covered by resources. Superimposition Density: Physical superposition layers of remains from different periods.	Combining archaeological reports, historical geography maps, and 3D modeling techniques (e.g., digital stratification analysis of Liangzhu Ancient City).
	Civilizational Continuity	Technical Iteration Cycle: Evolution frequency and span of key technologies (e.g., ceramic firing, water conservancy projects). Institutional Sustainability: Duration of institutional heritage.	Analyzing institutional texts through bibliometrics, combined with physical verification of technical archaeology.
	Pluralistic Symbiosis	Cultural Element Diversity: Number of coexisting multi-ethnic/cultural symbols. Interaction Frequency: Record density of cross-cultural exchange events in historical documents.	Based on ethnographic fieldwork and multi-source data fusion (GIS spatial overlay analysis).
Time Inheritance Value	Living Heritage Inheritance Ability	Intangible Heritage (ICH) Practice Frequency: Annual number of traditional festivals and craft activities. Inheritor Generational Span: Integrity of ICH inheritance and existing generational numbers.	Sociological statistics (questionnaire surveys) and oral history records of inheritors.
	Modern Adaptability	Functional Conversion Rate: Proportion of functional reuse of heritage spaces. Community Usage Rate: Daily usage frequency of heritage by contemporary communities.	Evaluation method: Spatial behavior big data analysis (WiFi hotspots, crowd flow heat maps).
	Innovation and Transformation Potential	Digital Coverage: Completeness and access volume of heritage digital archives. Cultural and Creative Economic Contribution: Annual sales of heritage-derived products.	Economic statistics models and intellectual property database analysis.

Three-dimensional Value	Core Indicators	Quantification Criteria	Evaluation Method
Regional Identity Value	Geographical Relevance	Landscape Coupling Degree: Spatial matching index between heritage and natural elements (water systems, terrain). Ecological Service Value: Contribution of heritage to regional ecosystems.	Landscape ecology models (e.g., InVEST) and remote sensing image interpretation.
	Ethnic Community Awareness	Number of Multi-ethnic Collaboration Cases: Quantity of historical and contemporary multi-ethnic co-construction projects. Cultural Identity Index: Community's recognition degree of the "Chinese Nation Community".	Ethnographic research and psychological statistics analysis.
	Regional Representativeness	Symbol Communication Breadth: Media exposure and online search volume of heritage as a local symbol. Economic Dependence: Contribution rate of heritage to local GDP.	Media big data crawling and economic input-output models.

Value-Oriented Identification of Historical and Cultural Resource Carriers: A Case Study of the Taihu Lake Basin
In the process of constructing a value assessment system for historical and cultural resource carriers, this study takes the Lougang water system in the Taihu Lake Basin as an empirical object. Through the quantitative application of a three-dimensional value framework, it systematically demonstrates the operational pathway and evaluation efficacy of value-oriented identification methods in practice. As a typical cultural-geographic unit in the Taihu Lake Basin, the Lougang water system's evaluation process fully reflects the organic integration of cultural gene inheritance, responsiveness to contemporary needs, and regional identity construction.

Based on the previously established evaluation model, the research team conducted multi-dimensional data collection and value decomposition of the Lougang system. In the dimension of cultural gene value, archaeological evidence and cross-referenced historical documents reveal that since the Song Dynasty's "longitudinal pujiang and transverse tang" water network formation, the system has undergone technological iterations through the Ming and Qing dynasties, culminating in the "one longitudinal pujiang every seven li and one transverse tang every ten li" weir system. The historical stratification is vividly demonstrated by the stratigraphic relationship between Song Dynasty wooden pile cofferdams and Ming-Qing stone embankments discovered at the Daxianlou site in Wuxing. The technological evolution trajectory confirms the millennium-long continuity of civilizational genes—from Song Dynasty bamboo-wood permeable dams to modern ecological hydraulic facilities—while the "Mulberry-Dike-Fish-Pond" system's wetland agricultural productivity, exceeding traditional cultivation by 200%, underscores the symbiotic wisdom of natural-human systems.

In assessing contemporary transmission value, field research and statistical yearbook analysis reveal modern adaptive features of traditional hydraulic functions: of the 62 existing waterways, 12 still maintain core irrigation and flood control functions, while Wujiang Pingwang Town's transformation of weir grids into modern ecological units has reduced nitrogen-phosphorus load by 42%. However, indicators of living heritage transmission show a 72% decline in traditional ritual frequencies over the past decade, reflecting practical challenges in intangible cultural heritage preservation. Notably, the 340% growth in silk cultural and creative industry output over eight

years demonstrates the economic potential of cultural gene innovation.

The quantitative analysis of regional identity value focuses on spatial correlation and cultural recognition. GIS spatial parsing indicates that the "waterway-settlement-weir field" tripartite spatial organization formed through water level regulation is perfectly exemplified in linear settlements like Yigao Village. The spatial distribution density of "Xu"-prefixed place names along the Xu River corroborates the waterway's historical role as a cultural exchange axis, while the agricultural proverb "When Suzhou and Huzhou thrive, the empire is fed" maintains 78% recognition among local residents as a regional economic identifier.

Through AHP analytic hierarchy process integration of third-tier indicator weights, the Lougang system received composite scores: 77 for cultural gene value, 62 for contemporary transmission value, and 76.5 for regional identity value. Core strengths lie in technological evolutionary continuity and spatial organizational integrity, though declining vitality in living heritage transmission warrants attention. These results directly informed dynamic adjustments to conservation priorities: urgent provincial-level intangible heritage rescue initiatives were launched given only seven living practitioners of the Mulberry-Dike-Fish-Pond techniques; smart monitoring systems were fully deployed in Wuxing sections with 68% hydraulic facility integrity; and cultural memory preservation platforms were constructed around dragon boat races attracting 23,000 annual participants.

This case validates the systemic efficacy of the three-dimensional value framework in resource inventorying, dynamic analysis, and conservation decision-making. By integrating historical stratification parsing, modern functional adaptation assessment, and regional identity construction within a unified evaluation framework, it avoids cultural fragmentation from static preservation while preventing value erosion through over-development. The methodology refined through Lougang evaluation—incorporating "technological gene continuity identification, spatial functional adaptability assessment, and regional network integrability construction"—provides replicable quantitative tools for similar heritage conservation efforts. Particularly within the context of integrated cultural heritage governance in the Yangtze River Delta, its trans-regional cooperation mechanisms and spatial integration enhancement strategies demonstrate innovative pathways for synergistic development between cultural preservation and regional sustainability.

Conclusion and Prospects

This study establishes a dynamic value-oriented identification framework for historical-cultural resources, advancing methodological approaches to systemic heritage conservation challenges. The synergistic integration of a five-dimensional value model (political, economic, social, technological-cultural, geographical) and three-dimensional value framework (cultural gene value, era-transmission value, territorial identity value) reveals heritage's multidimensional essence:

- Cultural gene value traces diachronic stratification of core civilizational symbols and technological evolution;
- Era-transmission value enables creative functional adaptation in contemporary contexts;
- Territorial identity value sustains community cohesion through living practices.

This system addresses critical gaps in conventional frameworks by:

1.Resolving cognitive blind spots regarding intangible resources and dynamic landscapes

2.Enabling comprehensive coverage through scientific identification of "implicit heritage" (e.g., toponymic traditions, artisanal techniques).

The validated multi-scalar protection strategy (cultural clusters corridors networks) offers transferable solutions to heritage fragmentation:

- Micro-scale: Precision identification of cultural clusters (e.g., settlement-ecological complexes) ensures unit integrity;
- Meso-scale: Linear heritage corridors (canals/ancient routes) integrate dispersed resources into functional systems;
- Macro-scale: Spatial integration of natural-cultural patches with industrial corridors forms regional cultural-ecological networks.

This hierarchical integration significantly enhances spatial connectivity and sustainable governance efficacy, transforming historical contexts from static artifacts into regenerative drivers of urban-rural development.

Future advancement requires tripartite innovation:
1.Theoretical: Machine learning-powered predictive modeling of value evolution to dynamically optimize identification criteria
2.Methodological: Integration of ecological resilience metrics and sociological community capital theory to quantify adaptive capacity
3.Practical: Transnational comparative studies (Taihu Lake Basin vs. Rhine/Mekong regions) to distill universal principles for living heritage transmission in hyper-urbanized contexts

Through integrated innovation—theoretical dynamization, transdisciplinary technologies, and collaborative governance—China's heritage conservation transitions from passive rescue to proactive stewardship, offering scientifically robust and culturally attuned solutions for global civilizational continuity.

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Public emotions and visual perception of historic district : An AI approach using social media data

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Abstract
Historic districts possess unique visual landscape features that can influence public emotional experiences. Advances in artificial intelligence, particularly multimodal large models, enable integrated analysis of image and text data, offering new possibilities for understanding the complex relationship between visual environments and emotions. This study focuses on Nanluoguxiang, a historic district in Beijing, using 2,851 text reviews and 13,553 associated images collected from the social media platform Dianping between January 2024 and January 2025. An AI-based emotion analysis framework was developed, and XGBoost was applied to examine the associations between seven types of visual scenes and emotional responses. Results indicate that joy dominates public sentiment; commercial scenes are highly perceived; and architectural and streetscape elements are linked to positive emotions, while storefronts correlate with negative emotions.

Keywords: historic districts: public emotions: visual perception

1. Introduction

Historic districts can offer positive emotional experiences to the public, enhancing well-being, place attachment, and psychological restoration (Bornioli et al., 2018; Scopelliti et al., 2019; Reece et al., 2022). Among the various factors that influence such experiences, visual perception plays a particularly important role, as it represents one of the most immediate and intuitive ways through which individuals engage with urban heritage environments. Therefore, the visual landscape characteristics of historic districts—such as architectural forms, streetscapes, commercial elements, and natural features—may significantly shape how people feel in these settings.

However, existing research often treats emotional responses and visual landscape features as independent topics, lacking a unified framework that links the two. In particular, while numerous studies have examined either the aesthetic value of urban heritage or the restorative potential of urban spaces, the specific influence of visual landscapes in historic districts on public emotional responses remains underexplored.

Recent advances in Artificial Intelligence (AI), especially in the domains of computer vision, natural language processing, and multimodal learning, provide new opportunities to examine this relationship. AI techniques are capable of extracting detailed visual features from images and detecting emotional content in text, making it possible to systematically analyze large-scale user-generated data. Accordingly, this study proposes to construct an AI-based analytical framework to explore the relationship between visual landscape characteristics and public emotional experiences in historic districts. By leveraging multimodal social media data and interpretable machine learning models, this research aims to bridge the gap between environmental perception and emotional response in the context of heritage planning.

2. Case study

2.1 Study area

Nanluoguxiang is a renowned historic district in Beijing, China, known for its well-preserved siheyuan (courtyard residences) dating back to the Ming and Qing dynasties. It holds a prominent position in the field of world heritage studies. Following multiple rounds of conservation and renewal efforts, Nanluoguxiang now features a mix of commercial, residential, and cultural functions. Whether the current spatial form and its visual perception are beneficial to the public's emotional experience is an important issue for policymakers to consider.

2.2 Social media data on NLG

The review data for Nanluoguxiang on the Dianping platform is relatively high in both quality and quantity. As a well-known tourist destination in China, Nanluoguxiang has accumulated a large volume of social media reviews across various platforms, including Xiaohongshu, Weibo, Dianping, and Ctrip. However, platforms such as Xiaohongshu and Weibo contain a significant number of promotional accounts and non-authentic user comments, which may not accurately reflect the public's genuine emotional responses, and were therefore excluded from this study. Although Ctrip is one of China's major travel platforms, the volume of available data on

Nanluoguxiang is comparatively limited. Considering factors such as data volume, the proportion of authentic users, and content quality, Dianping was selected as the primary data source for this research.

This study collected all publicly available reviews of Nanluoguxiang from Dianping between January 1, 2024 and December 31, 2024, including text reviews, associated images, and timestamps. A total of 2,818 text reviews and 13,986 images were initially gathered. After data cleaning, the final dataset comprised 2,460 valid text reviews and 12,770 images. The average length of a review was 106.8 characters (standard deviation: 86.7), with a median length of 105 characters. Notably, approximately 25% of the reviews exceeded 126 characters, indicating that users were generally willing to provide detailed narratives, thus offering a strong semantic foundation for emotion analysis.

3. Methodology

3.1 Overview

Text reviews from social media help understand people's emotional experiences with the built environment (Ghahramani et al., 2021; Park et al., 2020), and images voluntarily shared on social media serve as a rich resource for understanding people's visual preferences for environments (Chen et al., 2020). Although some studies have attempted to qualitatively explore the relationship between visual perception and emotional experience (Yang & Zhang, 2024), no quantitative analysis framework for this relationship has been established. In this study, we use Nanluoguxiang, a typical historic district in Beijing, as a case study. This study develops a multimodal deep learning framework to examine the impact of 6 environmental scenes in historic districts on public emotional experiences.

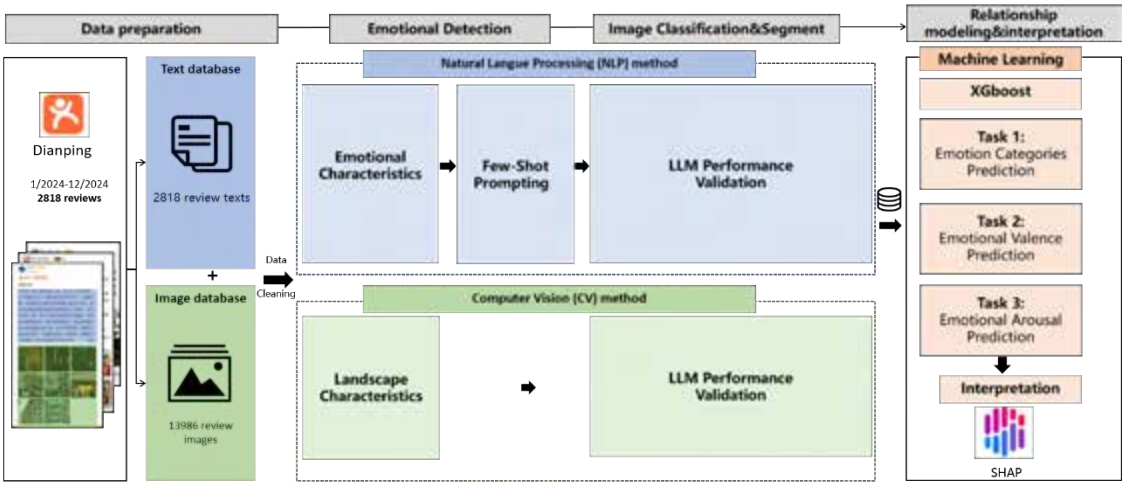

Fig. 1 Research Overview

3.2 Emotion Analysis Method

Aspect-Based Sentiment Analysis (ABSA) aims to identify specific spatial or managerial elements mentioned in user comments and determine their associated emotional tendencies. ABSA is a highly valuable technique in text analysis, as it allows the evaluation of sentiment across multiple dimensions within a single comment (Mehra, 2023; Viñán-Ludeña & Campos, 2024). Compared to overall sentiment classification, integrating ABSA into machine learning or regression models has been shown to significantly improve predictive performance (Li et al., 2023).

Based on the key dimensions typically emphasized in the conservation and renewal of historic districts, this study includes six analytical aspects:

- Material Form: Refers to the physical environment, including street surface design, street interfaces, and spatial morphology (e.g., sidewalks, building facades, architectural styles, and maintenance conditions).
- Commercial Functions: Encompasses commercial uses such as restaurants, entertainment, and retail businesses.
- Service Facilities: Includes public service amenities such as visitor centers, restrooms, parking areas, signage systems, and accessible infrastructure.
- Natural Environment: Covers elements such as vegetation, green spaces, water features, garden landscapes, and animals. Note: This does not include weather or air quality.

• Cultural Identity: Reflects the user's subjective appraisal and emotional identification with the district's historical value, cultural heritage, and ethnic character, including feelings of resonance, pride, and familiarity linked to heritage preservation and regional identity.
• Governance Mechanism: Relates to management practices such as crowd control, sanitation, shared bicycle regulation, ticketing systems, and public safety. ABSA enables fine-grained analysis and offers substantial value by providing insights for urban governance and decision-making.

In terms of emotional classification, this study draws on the basic universal emotions framework proposed by psychologist Paul Ekman, who identified seven core emotional categories: joy, sadness, anger, fear, surprise, disgust, and neutrality (Ekman, 1992). In this study, emotions are categorized into seven types: joy, pride, calmness, disappointment, fear, dissatisfaction, and mixed.

• Joy is defined as positive emotions such as happiness, relaxation, excitement, and satisfaction.
• Pride refers to expressions of admiration and identification with the district's historical or cultural background.
•Calmness indicates an absence of strong emotional fluctuation, often reflected in objective or neutral descriptions.
• Disappointment is characterized by a clear gap between expectation and actual experience.
• Fear involves concerns related to personal safety or social order.
• Dissatisfaction includes feelings of indifference, rejection, resistance, or negative judgment.
• Mixed emotion is used only when both positive (e.g., joy, pride) and negative (e.g., disappointment, fear, dissatisfaction) emotions are clearly expressed in the same comment with comparable intensity, making it difficult to determine the dominant emotional tendency.

3.3 Image Feature Extraction

Landscape type refers to the perceptual distinctions between one area and another, emphasizing the contextual differences that define distinct environments. Human perception responds more to holistic situations than to isolated elements, making landscape types—understood as cognitive situational units—more aligned with how people observe and experience their surroundings. Based on the principles of historic district conservation and renewal, and considering the typical scenes found in such areas, this study classifies visual landscape types into seven categories: historic architecture, streetscape, storefront façade, natural environment, signage and facilities, goods, and human activities.

In this study, a Mask2Former-based image segmentation model was employed to identify the visual landscape types embedded in user-generated images from social media. Mask2Former is a universal image segmentation framework capable of handling semantic segmentation, instance segmentation, and panoptic segmentation tasks (Cheng et al., 2022). The model was pretrained on the ADE20K dataset, which contains 150 categories of urban and natural scenes and broadly covers neighborhood elements and environmental features. ADE20K has been widely applied in studies of urban space recognition, landscape ecology, and visual perception (Zhou et al., 2019; Zheng et al., 2021; Zhao et al., 2023).

Compared with conventional convolutional neural network models such as U-Net or DeepLab, the key advantage of Mask2Former lies in its Transformer-based feature aggregation mechanism, which enables simultaneous modeling of both local details and global contextual relationships. This is particularly beneficial for interpreting images of historic districts, where spatial structures are complex and visually layered. In multi-label visual scenes, traditional models often struggle to differentiate highly co-occurring elements such as buildings, roads, and vegetation. Mask2Former, however, allows for fine-grained segmentation and accurate category recognition, thereby enhancing the detection of compositional structures in visual landscape types.

Accordingly, Mask2Former was selected for the interpretation of visual landscapes in historic districts. In this study, we extracted the top five segmented labels for each image, representing the dominant visual landscape types, and further analyzed their potential associations with emotional expressions identified in the corresponding textual comments.

3.4 Analytical Approach: Machine Learning Modeling and Explainability Techniques

In this study, XGBoost and SHAP were employed to analyze the relationship between emotional features and visual landscape characteristics. To investigate how users' emotional responses relate to the structural features of historic districts captured in images, we adopted Extreme Gradient Boosting (XGBoost), an ensemble learning method based on gradient-boosted decision trees. XGBoost is a supervised learning algorithm known for its strong capability in handling nonlinear relationships, robustness with high-dimensional sparse data, and high computational efficiency. It has been widely applied in urban research, affective computing, and geospatial data analysis, making it particularly suitable for modeling heterogeneous data that include image-derived landscape classifications and emotional variables.

To further interpret the contribution and directionality of each landscape feature in emotion prediction, we integrated the SHAP (SHapley Additive exPlanations) method. Rooted in game theory, SHAP assigns each feature a Shapley value, representing its marginal contribution to a particular prediction. It is widely recognized for its consistency and local accuracy in model interpretation. By applying SHAP analysis to the output of the XGBoost model, we identified key image-based structural features—such as the proportion of architectural elements, vegetation coverage, and frequency of human presence—that significantly influence emotional responses. Furthermore, SHAP enabled us to discern the positive or negative direction of each feature's impact on emotional outcomes.

4. Results

4.1 Overall Emotional Characteristics

The public's overall emotional experience in Nanluoguxiang is predominantly positive. Notably, the emotion of joy accounts for 68.7%, indicating that this historic district is generally successful in eliciting pleasant and satisfying emotional responses from visitors. However, negative emotions are still present to a certain extent. The proportion of dissatisfaction reaches 18.64%, followed by disappointment (5.89%) and calmness (5.44%). Emotions such as pride (0.97%) and fear (0.36%) appear infrequently and can be considered peripheral.

Monthly breakdowns of emotional distribution reveal notable seasonal variations. Joy remains consistently high during spring (March–May) and autumn (September–November), ranging from 67% to 73%. In contrast, its proportion drops significantly in the summer, reaching a yearly low of 61.24% in July. This decline is inversely correlated with a peak in dissatisfaction, which reaches 28.09% in the same month. This pattern may be attributed to increased tourist volumes during the summer holiday season, leading to greater spatial crowding and disruption of visitor rhythms, thereby influencing emotional perceptions.

By comparison, the milder climate and moderate foot traffic of spring and autumn provide more favorable spatial experiences, contributing to more positive emotional responses. These findings suggest that urban planners and tourism managers should pay particular attention to the emotional consequences of seasonal peaks in historic districts. During summer, strategies such as visitor flow control, enhanced service facilities, and spatial buffering may help alleviate the sense of overcrowding and emotional fatigue, ultimately improving emotional satisfaction and overall visitor experience.

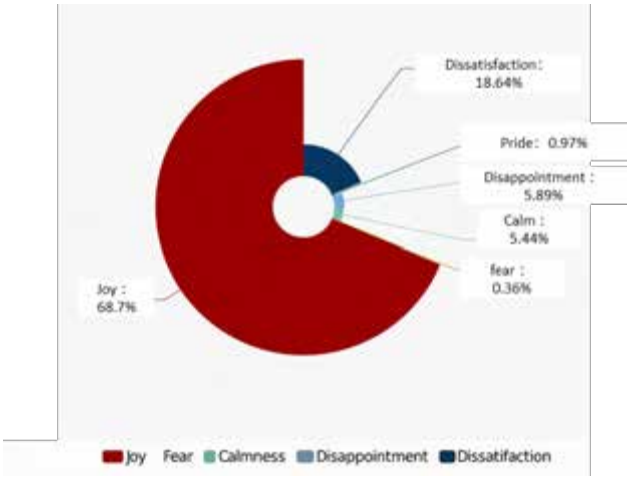

Fig.2 Distribution of Public Emotion Types in Nanluoguxiang

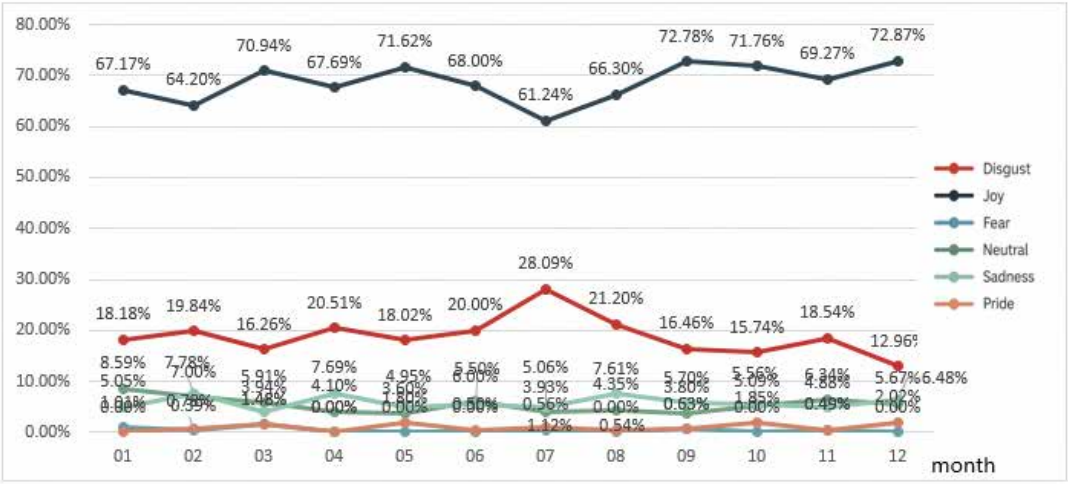

Fig.3 Annual Distribution of Public Emotion Types in Nanluoguxiang

4.2 Aspect-Based Emotional Characteristics

Overall, joy dominates across most aspects, reaching its highest proportion in the natural elements dimension (91.3%), followed by service facilities (82.5%) and functional formats (62.5%). This suggests that these aspects tend to elicit more positive emotional responses from the public. However, in the dimensions of management mechanisms and cultural identity, positive emotions are significantly diminished. The proportion of joy drops to 26.0% and 66.9%, respectively, in these two categories.

Notably, dissatisfaction accounts for as much as 52.0% under management mechanisms, the highest across all aspects, and considerably higher than its proportion under cultural identity (11.8%) and functional formats (24.8%). This indicates that institutional arrangements, regulatory measures, or managerial actions are more likely to provoke negative emotions among visitors. In addition, calmness also reaches a relatively high level under management mechanisms (18.8%), which may reflect a sense of passive acceptance or emotional neutrality among some visitors.

Among the less frequent emotions, disappointment is primarily associated with functional formats (5.5%) and cultural identity (4.8%). Pride appears slightly more often under cultural identity (11.8%) than in other aspects, suggesting that cultural elements can trigger a sense of emotional affiliation or resonance. Overall, this chart reveals substantial variation in emotional composition across different aspects, highlighting the need for differentiated optimization of landscape, functionality, and governance in historic districts based on their specific

emotional effects.

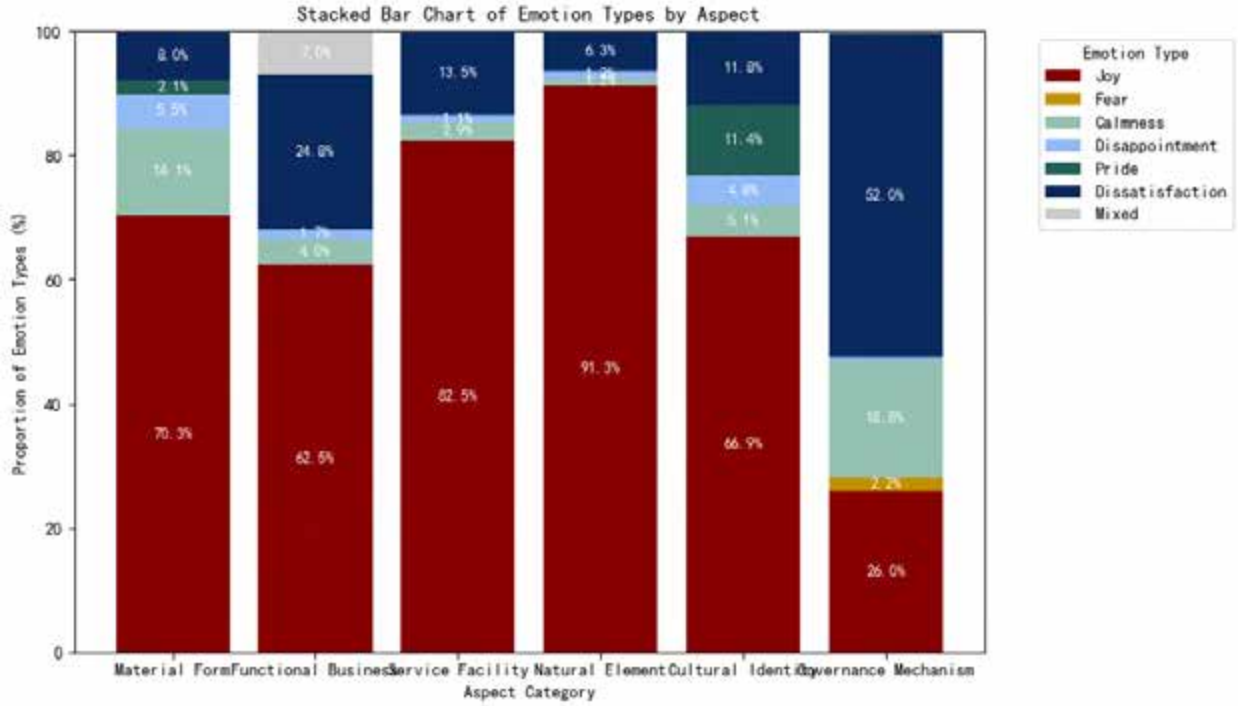

Fig.4 Aspect-Level Emotion Type Analysis

4.3 Visual Landscape Type Characteristics

Among the six categories, **commercial landscape** occupies the largest share at **48.5%**, suggesting that commercial scenes such as storefronts, signs, and retail displays are the most frequently photographed elements in this historic district. **Architectural landscapes** account for **23.7%**, indicating that built heritage and spatial enclosures remain important visual elements.

Streetscapes represent **15.2%** of the image content, while **facilities and signage** (8.7%) and **natural landscapes** (3.7%) appear less frequently. The **human activities** category accounts for only **0.3%**, implying either limited visible social interaction in the captured images or potential underrepresentation due to model classification limitations. Overall, the radar chart reflects a highly commerce-oriented visual landscape in Nanluoguxiang, with relatively low visibility of natural and sociocultural elements.

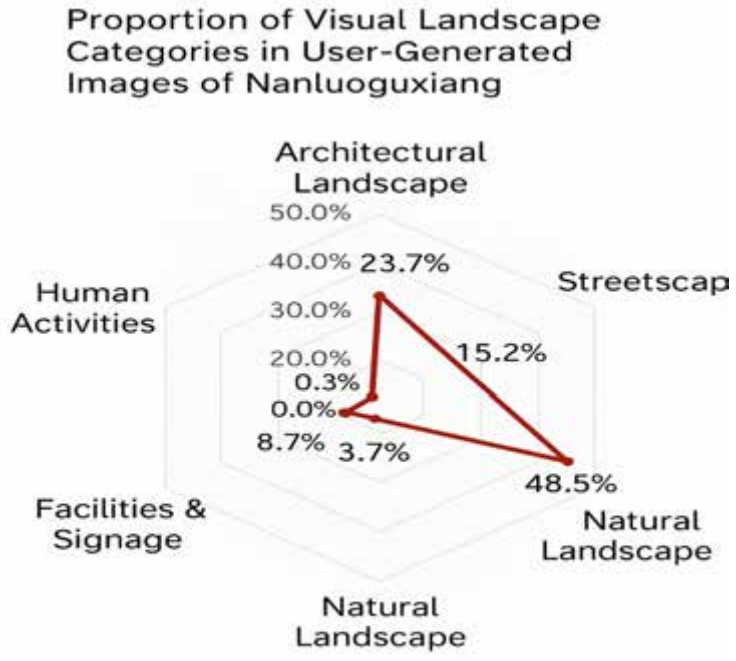

Fig.5 Proportion of Visual Landscape Categories in Nanluoguxiang

4.4 Relationship Between Emotional Characteristics and Visual Perception Types

The results are derived from an XGBoost (Extreme Gradient Boosting) model trained to predict public emotional responses based on visual landscape features extracted from images. To interpret the contribution of each feature to the model's output, SHAP (SHapley Additive exPlanations) values were employed. SHAP provides a theoretically grounded and visually interpretable method to quantify the marginal impact of each input variable on the prediction outcome.

Among the seven features, **Human Activities**, **Streetscape**, and **Historic Buildings** exhibit the widest spread of SHAP values, indicating they have the greatest influence on model output. High values of **Human Activities** and **Streetscape** (shown in red) are generally associated with positive contributions to the prediction, while higher levels of **Storefronts** and **Signage & Facilities** often reduce the predicted emotional positivity.

By contrast, **Natural Environment**, **Commercial Goods**, and **Signage & Facilities** show relatively narrow SHAP ranges, implying limited influence in the current model context—either due to low prevalence in the data or weaker emotional associations. This visualization provides a transparent global view of model interpretability, highlighting which physical elements in historical streetscapes are most strongly tied to emotional outcomes.

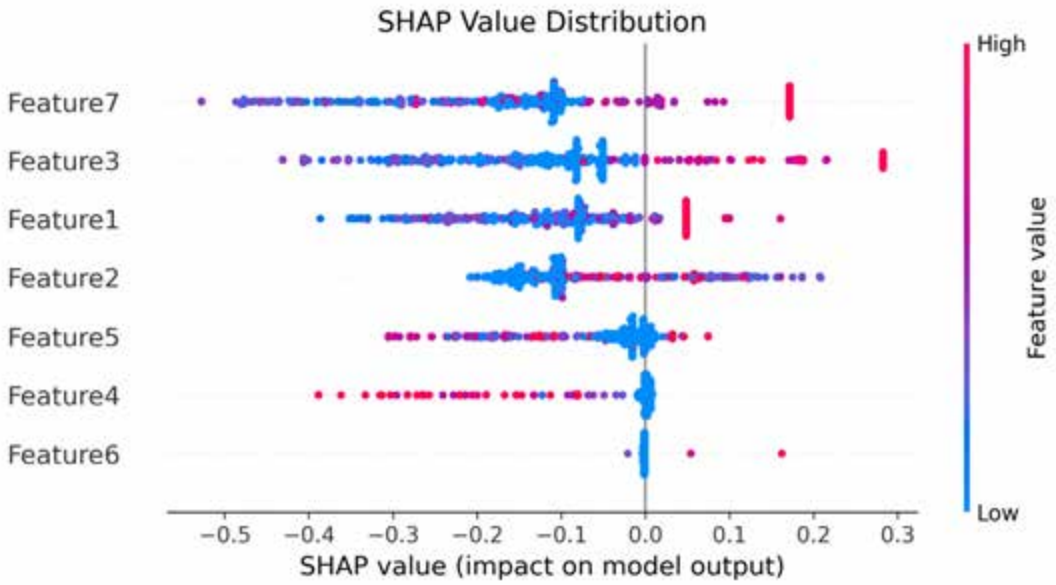

Fig.6 SHAP Value Distribution for Feature-Level Impact on Emotion Prediction Model

5. Discussion

This study demonstrates that text-based user comments and their accompanying images from social media platforms can serve as a valuable form of multimodal data for investigating the emotional effects of urban spaces. By integrating textual and visual content, the research reveals how public emotional responses are embedded within both narrative expressions and visual representations of historic districts.

Moreover, the findings highlight the potential of artificial intelligence (AI) in detecting and analyzing emotional experiences associated with urban environments. In particular, the AI models employed in this study were able to classify six distinct types of emotional responses with a relatively high degree of accuracy and consistency, illustrating their applicability to emotion analysis tasks in the urban and heritage planning context.

This research further confirms that it is feasible to integrate large language models (LLMs), computer vision techniques, and machine learning algorithms to jointly observe emotional signals and spatial landscape characteristics from social media data. Such integration enables a more comprehensive and scalable approach to understanding how people perceive and emotionally respond to historic urban spaces in real-world, user-generated contexts.

Nevertheless, certain limitations remain. A key constraint lies in the inherent biases of social media data. These datasets typically lack information on users' socioeconomic attributes, such as age, income, education level, or residential background, which may influence how different groups emotionally experience the same space. To address this limitation, future studies could incorporate experimental or survey-based methods to supplement and validate findings from digital trace data. Such triangulation would enhance the robustness and generalizability of emotion-oriented urban research.

6. Conclusion

This study is based on user-generated content (UGC) from the social media platform Dianping, using Nanluoguxiang (NLG), a representative historic district in Beijing, as a case study. It collected text reviews and associated images to construct an AI-driven framework for emotional analysis. Using XGBoost, the study investigates the relationship between six types of visual environmental scenes in the historic district and visitors' emotional experiences. The results reveal that specific visual scene types within historic districts have significant effects on public emotions. Meanwhile, the proposed multimodal framework proves effective in predicting the emotional impacts of visual

landscapes in historic district settings.

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The Spatial Dynamics of Cafés as Everyday Urban Spaces: Exploring Socialscapes through Streetscapes

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Abstract
Cafés have emerged as vital cultural and social anchors in contemporary cities, increasingly located in alleyways and residential neighbourhoods rather than traditional commercial centres. Focusing on Seoul's Hongdae district, this study uses semantic segmentation and deep learning applied to Street View Images to examine how streetscape attributes—both visual (e.g. enclosure, openness) and perceptual (e.g. liveliness, beauty)—influence café location patterns. Results reveal a shift away from conventional accessibility-based location towards environments that offer sensory richness and walkable appeal. These findings underscore the evolving role of cafés as everyday cultural spaces shaped by experiential consumption and image-based sharing. Accordingly, urban planners should consider streetscapes as active elements of lived heritage and place identity, rather than passive infrastructure.

1.Introduction

Modern consumer culture has expanded beyond the consumption of goods to encompass the commodification of space, emphasising the image and aesthetic distinctiveness of retail environments. Brands have adopted experience-oriented retail strategies, such as flagship stores and pop-up stores, or employed omni-channel approaches that integrate online and offline platforms. Offline stores, in particular, are being restructured as spaces where consumers can engage with brand identity and share their experiences with others. These experience-centred spaces have become a key foundation for consumer engagement, enabling them to share information through online communities or social network services (SNS), and visit cafés based on recommendations from others. Furthermore, location-based information on social media enables consumers to indirectly experience places they have not yet visited (Yuksel et al., 2016), thereby influencing their spatial preferences and consumption behaviour. In South Korea, retailers are making strategic location decisions that prioritise residential neighbourhoods over commercial centres, largely due to lower rents and improved access to spatial information. This tendency reflects a growing interest in individual consumer preferences, sense of place, and spatial experiences. Previously overlooked places and cafés have started to attract attention from consumers. Some of these areas—though not originally designed as commercial zones—are gradually recognised as commercial spaces, while others actively contribute to enhancing the perceived attractiveness of their surrounding urban space.

Among business sectors, the food and beverage (F&B) industry—particularly cafés, restaurants, and pubs—clearly exemplifies these spatial and cultural shifts. Cafés, in particular, are relatively easy to open with limited capital and preparation time, and are perceived as carrying lower risks compared to other food-related businesses, leading to greater locational flexibility. Moreover, as the millennial generation increasingly values experience and social sharing (Ryu et al., 2022), cafés are gaining recognition as places for unique experiences and social interaction. In South Korea, the café industry has expanded rapidly since the entry of the global franchise Starbucks in 1999. In Seoul, the number of operating cafés doubled from 8,638 in 2010 to 17,721 in 2019, making it one of the most active sectors for new business openings. Additionally, cafés are often among the first establishments to enter neighbourhoods undergoing a commercialisation process—including those associated with gentrification—and are known to attract external visitors, thereby demonstrating pronounced shifts in spatial distribution. With their rapid proliferation and flexible locational behaviour, cafés have thus played a leading role in shaping new commercial geographies across urban space.

While geographic location remains an important factor in retail location decisions, cafés have recently demonstrated patterns that diverge from traditional retail location models. In the past, cafés were typically concentrated in areas with high physical accessibility, such as near subway stations or along major boulevards. In contrast, newly opened cafés tend to be smaller in scale and more locally situated. Unlike conventional stores, these cafés position themselves as places offering distinctive experiences, enabling consumers to perceive their surroundings as unique and appealing, thereby overcoming less favourable locational conditions. This phenomenon is difficult to explain using traditional retail location theories, such as Christaller's (1933) central place theory, which suggests that new spatial patterns may emerge—patterns that are not solely based on conventional economic-geographic factors such as accessibility, land price, agglomeration, or population

density, but are instead shaped by changing consumer behaviours. However, most of the previous literature on café locations has focused on these traditional indicators (Gautama Himawan and Rahadi, 2020; Kim et al., 2015; Ko and Chiu, 2006; Sevtsuk, 2014; Zhao et al., 2023), often overlooking the influence of experiential attributes and visual appeal on location decisions.

In urban space, cafés have established themselves not merely as providers of food and beverages, but as everyday places of social and cultural interaction. They serve as places for optional activities (Gehl, 2013), and contribute to the vitality of public space (MacCormac, 1983). Zukin (1998) interpreted cafés not as simple consumption spaces, but as symbolic places that represent a new form of urban lifestyle. Similarly, Banerjee (2001) argued that public life becomes more enriched in third places such as cafés. According to Oldenburg (1999), third places refer to diverse public spaces beyond the domains of home and work, where people voluntarily and informally gather with the expectation of enjoyment. In South Korea, cafés have become representative examples of spatial consumption, functioning not as venues for the physical acquisition of goods at a specific moment in time, but as experiential places consumed and possessed through use. In this sense, cafés enable consumers to indirectly express their personal tastes and lifestyles through experiential consumption. Increasingly, people visit cafés not for the products themselves, but for the atmosphere of the surrounding area or the store. Ultimately, consumers have come to pay attention not only to the physical attributes of a place, but also to the emotional atmosphere and image it conveys.

Pedestrians' perceptions of place are shaped by the physical environment of the streetscape and the interactions among individual storefronts. Environmental elements that constitute the street function as part of the service setting that supports better customer experiences and contributes to the overall atmosphere of a café. At the same time, they offer personalised experiential spaces, allowing consumers to perceive a distinctive and appealing ambiance. A favourable service environment experienced at the time of use can trigger consumer behaviour and enhance customer satisfaction (Koo et al., 2023b). This, in turn, can attract potential customers, making it essential to understand the role of streetscape and walkability in shaping the attractiveness of commercial spaces in relation to café locations. Accordingly, this study examines the spatial dynamics of café location shifts in an area where traditional and emerging retail districts coexist, and analyses the influence of streetscape and walkability. Furthermore, it aims to assess the limitations of traditional theories in explaining café location decisions and to explore the evolving role of cafés in urban space.

The structure of this study is as follows. Section 2 reviews the relevant literature and theoretical background. Section 3 outlines the study area, data, and methodology. Section 4 presents the spatial patterns and influencing factors of café location shifts. Section 5 discusses the empirical findings, and Section 6 concludes the study.

2.Literature review

2.1.Retail location theories

Traditional retail location theories assume that retailers make location decisions that minimise transportation costs for consumers while maximising proximity to both competing and complementary stores. For example, Christaller (1933), in his central-place theory, posited that each retail store is equidistant from others selling the same goods and that stores offering more diverse products possess market areas of varying sizes. Later, Lösch (1938) modified this framework by excluding the concept of product range and instead focusing on the minimum market area required to maximise production value. In contrast, Hillier (1997) introduced the concept of movement in his movement-economic theory, emphasising that the fundamental logic of urban structure lies in movement itself. Ultimately, he emphasised that spatial advantages—such as streets with high pedestrian or vehicular traffic—are inherently more valuable.

More recently, the rising rents that often accompany commercial revitalisation have driven retailers to make location decisions in areas with relatively lower physical accessibility to reduce operational costs. In this context, producers increasingly choose locations with lower rents compared to commercial centres, thereby seeking greater economic efficiency. From this perspective, Smith (1979) proposed the rent-gap theory, suggesting that commercialisation occurs when disparities in rent emerge, even among areas with similar accessibility. Ley (1997), on the other hand, argued that when artists move into low-rent areas, they foster a consumption culture centred on aesthetic value.

Today, retail locations are increasingly chosen by consumers based not only on convenience but also on the unique characteristics of a district and the physical environment and atmosphere surrounding the store. Walkable streets provide positive sensory stimuli, contributing to more enjoyable and satisfying service experiences (Koo et al., 2023b). Building on this idea, Bitner (1992) introduced the concept of the 'servicescape', combining service and landscape to describe the physical environment in which the service experience takes place. The servicescape includes both the interior and exterior of a facility, as well as its surroundings, allowing consumers to indirectly perceive service quality and product value even prior to direct service engagement (Turley and Milliman, 2000).

2.2.Walkability and retail location

The built environment of a retail district plays a crucial role in attracting potential consumers, making walkability a key factor in determining the location and operation of retailers (Duncum, 2007; Handy et al., 2002). Streets serve not only as corridors for movement but also as social spaces that connect buildings and human activities (Carmona, 2021). Streets with high connectivity or those designed to encourage pedestrian movement tend to experience greater levels of foot traffic, which in turn contributes to drawing potential consumers (Sevtsuk, 2020).

Previous studies examining the built environment of retail districts from a street network perspective have employed Urban Network Analysis (UNA) to demonstrate that street-level accessibility and connectivity significantly influence the location and performance of retailers (Jeong and Yoon, 2017; Kang, 2016; Sevtsuk, 2014). For example, Sevtsuk (2014) analysed pedestrian accessibility from surrounding facilities and highlighted the importance of network-based measures such as the gravity index for public transit and building-level expected betweenness. Kang (2016) demonstrated that in pedestrian accessibility, betweenness and straightness are key predictors of retail sales in Seoul. From the perspective of urban spatial structure, Harvey et al. (2017) investigated cities such as Boston, New York, and Baltimore to explore how built features—such as street width and length—can be used to evaluate streetscape structure. Streetscapes enclosed by buildings or walls were found to contribute to perceived safety and imageability, offering more immediate stimuli for pedestrians and enhancing the effect of visual complexity.

2.3.Streetscape and retail location

Most literature on streetscape and retail location has primarily measured walkability from the perspective of pedestrian accessibility. However, walkability extends beyond accessibility to encompass pedestrians' perceived safety, aesthetic quality, and enjoyment of the environment at the landscape level (Koo et al., 2023b; Shields and Gomes da Silva, 2023). The architectural organisation of streetscape influences how pedestrians experience and perceive the space, contributing to increased safety, comfort, and enjoyment. Specifically, previous studies have assessed streetscape characteristics based on elements such as enclosure (Ewing and Handy, 2009; Harvey et al., 2017), openness (Ewing et al., 2013), and greenery (Li et al., 2018; Zhang et al., 2018). These micro-scale streetscape characteristics of walkability directly or indirectly influence pedestrian perception and emotion, shaping a human-scale environment that supports commercial activity by enhancing pedestrians' feelings of safety and comfort (Hahm et al., 2019). In previous literature, these features have been quantified through two-dimensional GIS-based analyses or extracted from street-level images using qualitative methods to identify visual factors (Ewing et al., 2006; Harvey et al., 2017; Hong et al., 2010; Purciel et al., 2009).

More recently, urban planning research has increasingly turned to machine learning techniques using street-level imagery, such as Google Street View, to estimate walkable environments from a human-eye perspective. Compared to two-dimensional GIS-based methods, Street View Images (SVIs) provide a more accurate representation of the built environment as it is experienced by pedestrians (Koo et al., 2022). For example, several studies have used semantic segmentation techniques to identify visual components of the streetscape from the perspective of pedestrian perception (Kim and Woo, 2022; Koo et al., 2023a; Lee et al., 2022). Common models include PSPNet, UPerNet, and HRNet, which have been applied in various studies to classify fine-grained visual features of the street environment. Furthermore, Dubey et al. (2016) proposed a Convolutional Neural Network (CNN)-based deep learning model that predicts six emotional responses to urban environments using the Place Pulse 2.0 dataset provided by MIT. This dataset contains 110,998 images collected from 56 cities across 28 countries and includes over 1.17 million pairwise comparisons evaluating six dimensions of perceived streetscape quality: Safe, Lively, Beautiful, Wealthy, Depressing, and Boring (Figure 1). Using this dataset, it becomes possible to identify how different SVIs elicit varying perceptions among pedestrians. In addition, Zhang et al. (2018) developed a deep learning model to predict emotional responses to streetscapes in specific study areas such as Beijing and

Shanghai. They examined the relationship between qualitative perceptual evaluations derived from image-based predictions and quantitative visual attributes obtained through semantic segmentation.

Figure 1. Example of Place Pulse 2.0 data collection

2.4.Café location

Cafés have been considered both spaces for community engagement (Ferreira et al., 2021) and indicators of gentrification (Zukin et al., 2009). Accordingly, previous studies on café locations have primarily focused on factors related to business performance, such as accessibility, economic viability, competitiveness, demographic characteristics, and store characteristics (Gautama Himawan and Rahadi, 2020; Kim et al., 2015; Ko and Chiu, 2006; Sevtsuk, 2014; Zhao et al., 2023). Table 1 provides an overview of these studies.

Table 1. Literature on café locations

Authors (Year)	Key variables	Findings related to location
Ko and Chiu (2006)	Accessibility, Physical characteristics	Key factors influencing customer satisfaction, ranking professional service, reasonable pricing, food quality, environment, other food drink, and promotion.
Sevtsuk (2014)	Accessibility, Competitions, Demographics, Store characteristics	Spatial clustering is a key determinant of retail location patterns, with restaurants exhibiting a tendency to be situated near similar stores. Additionally, proximity to subway stations is a significant positive factor influencing the store's location.
Kim et al. (2015)	Accessibility, Economic conditions, Competitions, Demographics, Store characteristics	Retail sales benefit from closer proximity to subway stations and a higher density of similar stores. Higher sales are observed in locations with lower footprint area but greater building volume.
Gautama Himawan and Rahadi (2020)	Accessibility, Physical characteristics	The built environment and ambiance of a café strongly influence customer satisfaction and revisit intention. Location and accessibility are critical factors in customers' choice of a particular café.
Zhao et al. (2023)	Accessibility, Economic conditions, Competitions	In Beijing's major urban centres, cafés tend to cluster in central business districts or along high streets.

However, today's consumers are increasingly willing to visit cafés with a desirable atmosphere, even if the locations are not physically accessible. As a result, the widespread use of digital platforms such as social media has brought about noticeable shifts in location patterns, even for stores situated outside traditionally optimal areas. Based on these insights, this study aims to examine how micro-scale environmental factors enhance the perceptual quality of streetscape while simultaneously making the pedestrian experience more enjoyable. In particular, aesthetic streetscapes increase the attractiveness of the walking experience and thus play a critical role in encouraging pedestrian flows. Given that such flows often translate into consumer footfall, it is essential

to investigate how walkable and visually distinctive streetscapes are associated with café location decisions.

Accordingly, this study explores the shifting patterns of café locations and investigates the role of streetscape and walkability in this process. Specifically, it employs a deep learning model to objectively evaluate physical streetscape conditions while also incorporating subjective pedestrian perceptions. By analysing new patterns in café locations, this study contributes to understanding not only the spatial transformation of retail districts and urban form but also the socio-cultural shifts driven by experiential consumption.

3.Methodology

3.1.Study area

This study focuses on the Hongdae retail district, one of the major commercial centres in Seoul, South Korea (Figure 2). The study area encompasses seven administrative districts (dong): Seogyo-dong, Seogang-dong, Hapjeong-dong, Mangwon-1-dong, Mangwon-2-dong, Seongsan-1-dong, and Yeonnam-dong. The term 'Hongdae' refers to the area surrounding Hongik University, which has developed into a central retail district around the campus. Covering an area of 8.15 km², the district includes six subway stations along two lines: Hongik University, Hapjeong, Mapo-gu Office, Mangwon, Sangsu, and Gwangheungchang. The district is characterised by human-scale streetscapes and a mixture of residential and commercial zones, which allows for the observation of retail activity not only within designated commercial zones but also in adjacent residential zones.

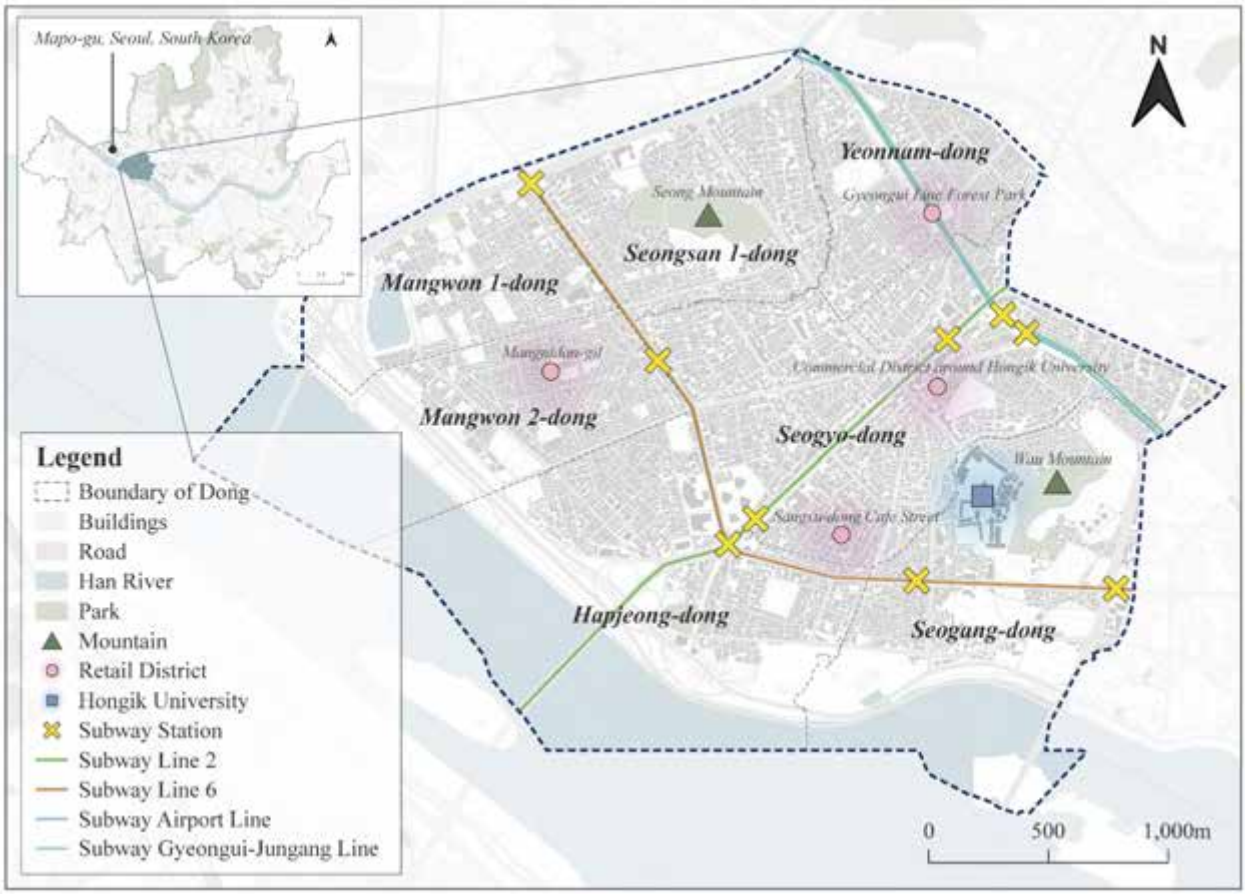

Figure 2. Study area

The Hongdae retail district began to take shape in 1955 with the establishment of the College of Fine Arts at Hongik University. As studios and galleries catering to art students began to cluster in the area, it gradually evolved into a culturally significant street. Over time, the area experienced continued retail growth as small shops became concentrated, and commercial businesses gradually penetrated residential zones, giving rise to newly developed retail districts (Hahm et al., 2017).

In the 2000s, foot traffic increased significantly due to two major factors: the 2002 Korea–Japan World Cup and the implementation of the Walkable Street Development Project, part of the broader Street Environment Improvement Project. These developments led to an influx of cafés, pubs, and restaurants into the university-centred retail district, solidifying its position as a central commercial district. In the early 2010s, the opening of new subway lines such as the Incheon Airport Railroad and Gyeongui Line improved accessibility from other cities such as Incheon and Gimpo. As a result, the area experienced gentrification driven by rising rents, which forced many young artists to relocate to nearby neighbourhoods such as Hapjeong-dong. This migration led to the emergence of new street-level retail districts, such as the so-called 'Sangsu-dong Café Street'.

In 2015, the Gyeongui Line Forest Park, an urban regeneration project that transformed an abandoned railway line into a linear park, was completed near Yeonnam-dong. It has been popularly dubbed 'Yeontral Park'—a reference to New York City's Central Park—due to its central location and the perceived improvement it brought to the surrounding residential and retail environment. The development of this green space contributed to another wave of retail expansion along the park corridor. That same year, the Beautiful Signage Street Project, a signage improvement initiative, was implemented to enhance the visual aesthetics of streets near the retail district. In 2016, the western part of Mangwon-dong—adjacent to the Mangwon Market—gained popularity and has been labelled as 'Mangnidan-gil'. The name was inspired by Gyeongnidan-gil, a well-known street-level retail district in South Korea. As the area attracted increasing attention on social media, it began to emerge as a new hotspot for younger consumers and independent retailers.

More recently, the broader Hongdae retail district has seen a rapid increase in foreign visitors, prompting the launch of the Cultural Tourism Destination Development Project for Walkable Street, a tourism initiative aimed at enhancing pedestrian-friendly cultural attractions. Figure 3 illustrates the spatial transformation of the study area over time.

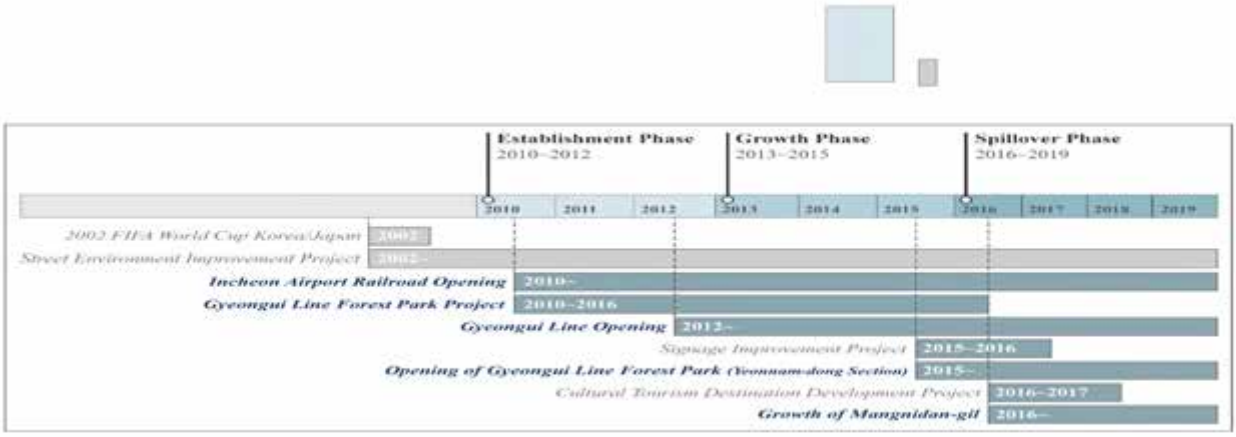

Figure 3. Evolution of study area

3.2.Definition of analysis periods

Due to limitations in the availability of SVIs prior to 2010, and in order to exclude the economic disruptions caused by COVID-19, the temporal scope of the analysis was set from 2010 to 2019. To examine the spatial shifts in café locations, it was necessary to define specific phases that reflect the evolution of spatial and commercial dynamics. This periodisation also helps to control for potential outliers in the annual opening data of cafés.

Based on the evolution of the Hongdae retail district, the study defines three distinct analytical phases. The Establishment Phase (2010–2012) corresponds to the initial formation of café clusters centred in Seogyo-dong, adjacent to Hongik University. The Growth Phase (2013–2015) is characterised by spatial expansion into surrounding areas along the edge of the core, while the Spillover Phase (2016–2019) captures the transformation

of retail activity extending beyond major boulevards into previously overlooked alleyways.

3.3.Measuring network-based walkability using UNA

The built environment that influences retail location decisions includes two key forms of accessibility: proximity to public transportation and specific facilities, and network-based accessibility derived from the street structure. In this study, three indicators were calculated using UNA: accessibility to subway station exits, accessibility to parks, and betweenness. UNA is a network-based spatial analysis method that incorporates buildings into the analytical framework; in this study, it was implemented using Rhinoceros 3D.

The Gravity Index quantifies accessibility by incorporating spatial resistance between origins and destinations. It captures the cumulative gravitational pull that destinations exert on a given origin within a specified network radius. The index assumes that accessibility increases when more destinations are located within the radius, when those destinations have greater weights (e.g. size or attractiveness), and when the network distance to them is shorter (Sevtsuk, 2020). The formula is given as follows:

$$Gravity[i]^r = \sum_{j \in G-i; d[i,j] \leq r} W[j]^{\alpha} / e^{\beta * d[i,j]} \quad (1)$$

where *W[j]* is the weight of destination *j*, indicating its size or attractiveness; *d[i,j]* is the shortest distance between origins *i* and destination *j* within the network radius r; α is a parameter that adjusts the influence of destination weight; and β is the distance decay coefficient that determines how accessibility decreases as distance increases.

The Betweenness measures the degree to which a building lies on the shortest paths between other buildings. A higher betweenness value indicates greater accessibility and ease of movement. As a probabilistic measure of how often a specific location is traversed within the street network, it serves as a proxy for estimating pedestrian flow (Figure 4). The formula is defined as follows:

$$Betweenness[i]^{r,dr} = \sum_{j,k \in G-i; d[j,k] \leq r*dr} (n_{jk}[i]/n_{jk}) W[j] \quad (2)$$

where n_{jk} [i] is the total number of shortest paths from origin j to destination k that pass by observer building i, $n_{jk}$is the total number of shortest paths from origin j to destination k, W[j] is the weight of origin j, and dr is the detour ratio, allowing for slight deviations from the shortest path, with j and k located within the network radius r of one another.

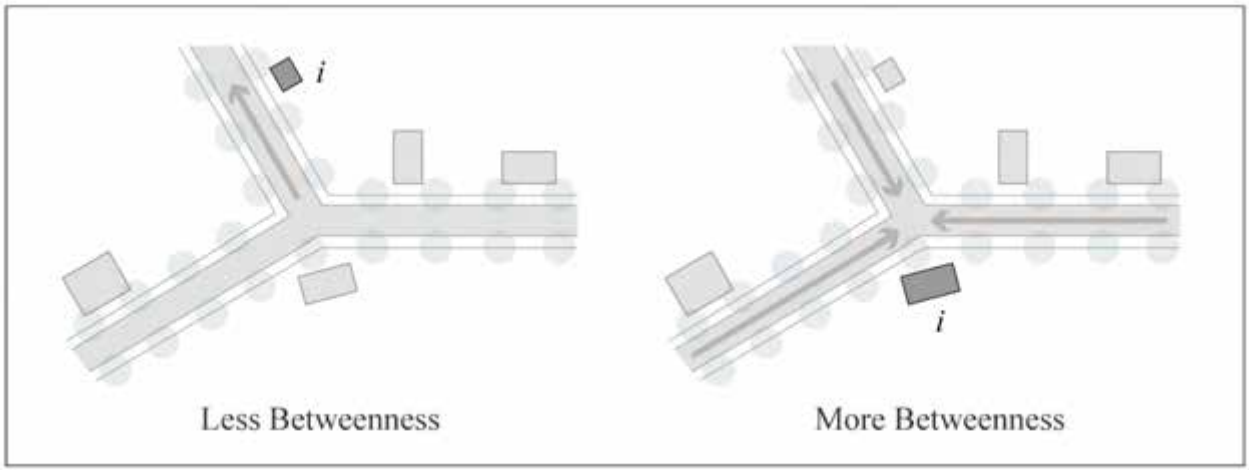

Figure 4. Example of betweenness (Adapted form Sevtsuk, 2014)

For the calculation of the Gravity Index, the network radius was set to 600 metres, which corresponds to a typical walking distance of 5–10 minutes. The distance decay coefficient was set to 0.00217, following the walking

distance-based value reported in Handy and Niemeier (1997). Betweenness was computed based on the full network of buildings within the study area. To account for differences in building size within the Hongdae retail district, each building was weighted by its volume. Accordingly, the resulting Betweenness values reflect the estimated volume of movement associated with each building, assuming that larger buildings generate more pedestrian flow than the smaller ones (Sevtsuk, 2014).

Given that urban structures such as roads and buildings tend to evolve gradually over long periods (Casali and Heinimann, 2019), it was assumed that the spatial configuration remained relatively stable during the analysis period. Therefore, spatial network data from 2019 were used for all time periods. For subway accessibility, changes were incorporated starting from the Growth Phase to reflect the opening of the Gyeongui-Jungang Line at Hongik University Station in 2012.

3.4. Measuring streetscape characteristics using SVIs

This study employed SVIs to extract streetscape characteristics as perceived by pedestrians. SVIs enable the quantification of pedestrians' subjective perceptions of the physical environment (Lee et al., 2022; Seo et al., 2021; Yin and Wang, 2016). This approach reduces statistical distortions and data biases, thereby improving measurement precision and enhancing the generalisability of results.

SVIs for the study area were collected using the Naver Street View (NSV) API. Naver is a leading Korean internet portal that provides both mapping and Street View services. In this study, a total of 21,101 panoramic 360° images were collected by generating points at 20-metre intervals along the road network in the study area. For visual attributes, full 360° panoramic images were used to assess the overall street environment. For perceptual attributes, only the front-facing portions of the panoramic images were extracted, as these reflect the visual field most relevant to pedestrians and were used as input for streetscape perception modelling (Figure 5). The SVIs used in the analysis correspond to the years 2010, 2014–2015, and 2016–2017. NSV data for the year 2013 were not available, as imagery for that year was not provided by the platform. In addition, the 2015 and 2017 images were included to supplement spatial gaps left by incomplete coverage in earlier years.

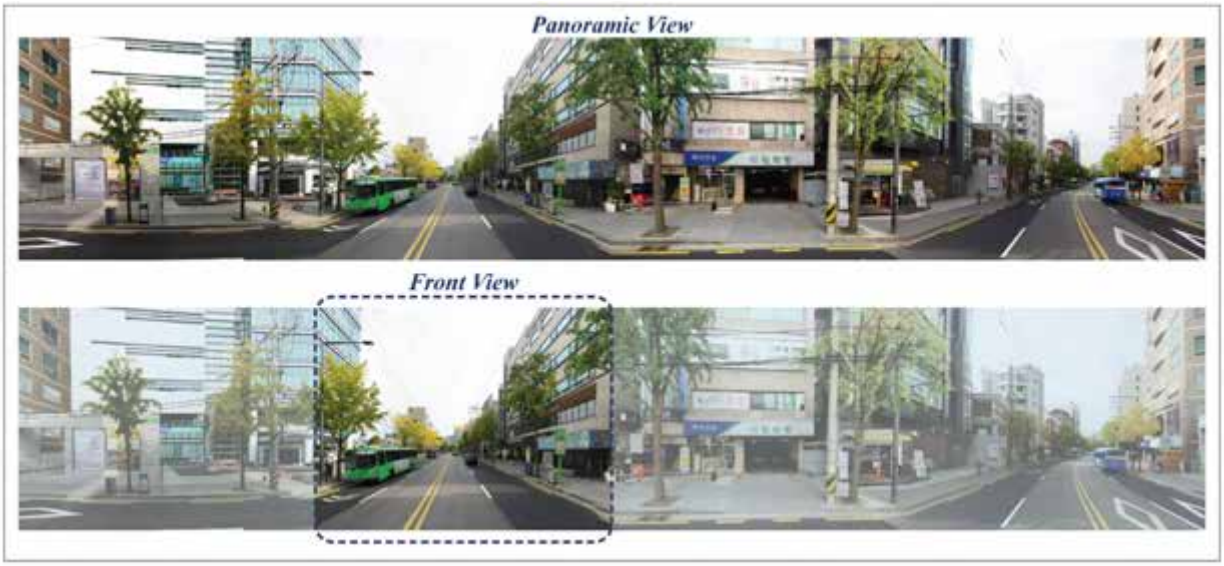

Figure 5. Example of a panoramic and front views extracted from SVIs

To extract the visual attributes of streetscape characteristics, this study employed a computer vision technique known as semantic segmentation. Semantic segmentation is a pixel-wise image classification method that distinguishes between multiple categories—such as buildings, trees, and sky—within a given dataset. We used the HRNet-V2-W48 model pre-trained on the ADE20K dataset to apply this technique. The pixel proportions of physical streetscape elements identified in each image were adopted as visual attributes perceived by pedestrians. Four indicators were ultimately computed: Enclosure, Openness, Pavement, and Greenness. Enclosure refers to the proportion of buildings and walls relative to roads; Openness indicates the proportion of sky area; Pavement reflects the proportion of sidewalks relative to road area; and Greenness quantifies the proportion of visible

greenery such as trees, grass, and plants (Figure 6).

Figure 6. Visual attributes extracted from a SVI using semantic segmentation

To measure pedestrians' perceptions of the streetscape, we trained a CNN model to predict perceptual attributes based on SVIs. In this study, we adopted VGG16 and applied transfer learning using a model pre-trained on the ImageNet dataset. For training data, we used the Place Pulse 2.0 dataset, a large-scale visual perception survey conducted by MIT Media Lab, which captures people's impressions of urban environments via an online platform. From the Place Pulse dataset, we extracted three positive perceptual dimensions—Safe, Lively, and Beautiful—as quantifiable street scores for each image. Other perceptual labels were excluded to ensure objectivity and reliability. First, the Wealthy dimension was excluded, as it tends to reflect high-income residential zones or areas with large boulevard-style street trees, which are not easily generalisable in typical retail districts. Second, the Depressing and Boring dimensions were excluded as negative emotional attributes, which may conflict with the selected positive attributes. Moreover, these mental health–related indicators are less applicable in the South Korean context, and difficult to interpret within retail environments.

Each variable was calculated as the average value of images within a 100-metre radius, to reflect the contextual streetscape characteristics of the surrounding area. During this process, 86 samples lacking image coverage within the 100-metre buffer were removed from the analysis due to missing data. Figure 7 illustrates the three stages of the machine learning–based analysis using SVIs conducted in this study.

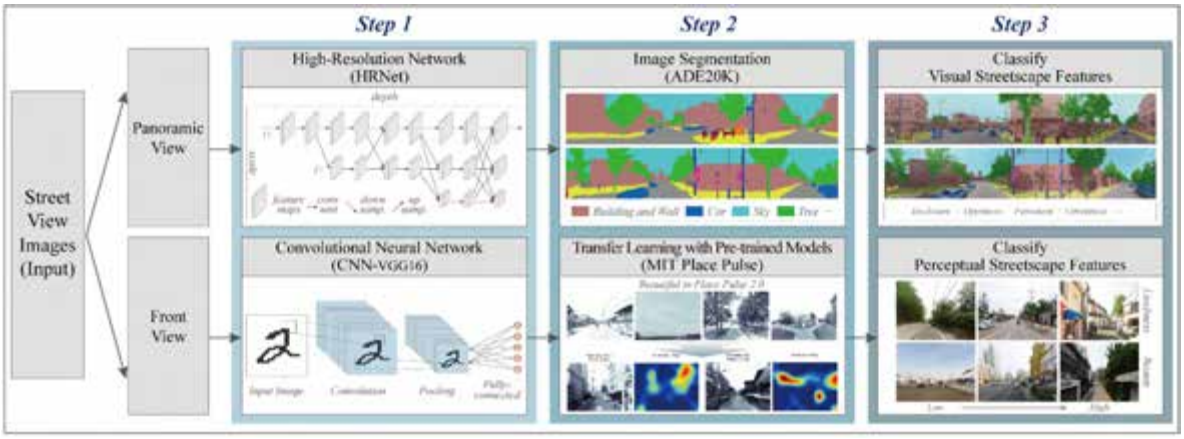

Figure 7. SVI-based process for classifying visual and perceptual streetscape features

3.5.Data

Point-of-interest (POI) data on cafés from 2010 to 2019 were collected from the Statistical Geographic Information Service (SGIS) using Python-based web crawling. From these data, we identified store openings, closures, and operational status for each year to construct the dependent variable: a binary indicator of store opening (0 or 1). Store opening was operationally defined as the appearance of a café in year t that did not exist in year t–1 (Figure 8).

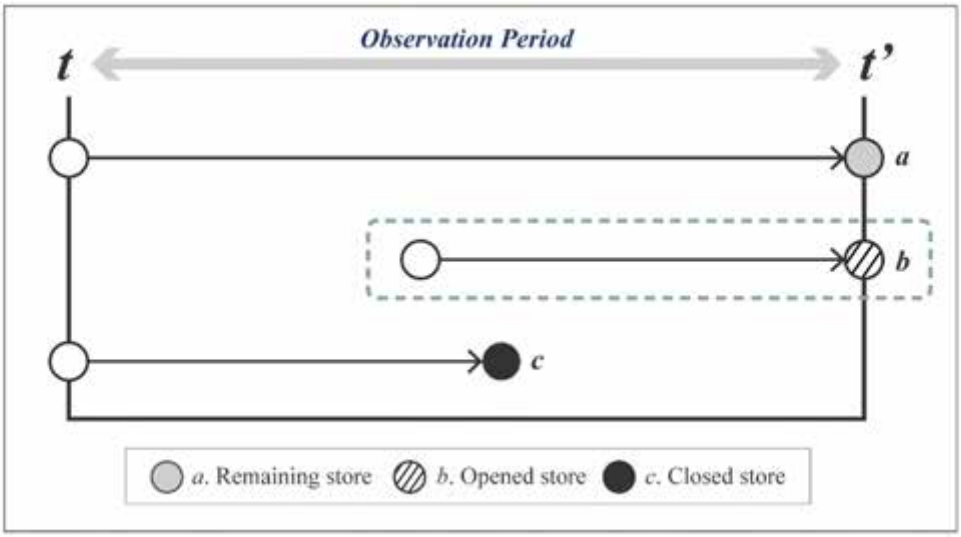

Figure 8. Classification of store status

To assess the prior presence of stores and café clustering before the time of opening, we used POI data from 2010, 2013, and 2016. Clustering was calculated using UNA with a network radius of 100 metres to capture the degree of competitive clustering as experienced by pedestrians.

Additional data on location factors were collected from various sources commonly used in previous studies. Information on building characteristics—including building footprint, building volume, building height, and parcel area—was obtained from the Ministry of Land, Infrastructure and Transport (MOLIT). Average land prices were collected from the Seoul Open Data Plaza and averaged for each analysis period. Population density and the number of millennial residents were retrieved from SGIS. Because population data prior to 2015 were only available in 5-year intervals, data for the Growth Phase were collected based on the 2015 census. Definitions of all variables used in the analysis and their data sources are summarised in Table 1.

Table 2. Description of variables

Variable				Description of variables	Source
Dependent variable			Open	Binary variable indicating whether a café newly opened (1=Yes; 0=No)	SGIS
Independent variable	Walkability characteristics		Subway	Spatial accessibility to subway entrance in the radius (gravity, r=600m)	MOLIT
	Park		Spatial accessibility to park in the radius (gravity, r=600m)		
	Betweenness		Connectivity between all buildings in the radius (r=n, weighted by volume)		
	Road width		Width of the road adjacent to the building (m)		
	Streetscape characteristics	Visual attributes	Enclosure	Average ratio of building and wall area to road in the radius (r=100m)	NSV
			Openness	Average ratio of sky area to road in the radius (r=100m)	
			Pavement	Average ratio of sidewalk area to road in the radius (r=100m)	
			Greenness	Average ratio of tree and plant area to road in the radius (r=100m)	
		Perceptual attributes	Safe	Average perceived level of safety of streetscape in the radius (r=100m)	
			Lively	Average perceived level of liveliness of streetscape in the radius (r=100m)	
			Beautiful	Average perceived level of beauty of streetscape in the radius (r=100m)	

Control variable	Store characteristics Agglomeration	Occupied	Binary variable indicating whether the store was already occupied in the previous year (1=Yes; 0=No)	SGIS
		Spatial proximity to other operating cafés in the radius (gravity, r=100m)		
	Built environment characteristics Building height	Building footprint	Footprint area of the building (m^2)	MOLIT
		Height of the building (m^2)		
	Parcel area	Area of the land parcel (m^2)		
	Land price	Average land price during the analysis period (won)	SODP	
	Demographic characteristics Millennials Employees	Residents	Residential population density in the census district	SGIS
		Number of millennials (aged 20–39) in the census district		
		Number of workers in the census district		

3.6.Research methods

To investigate the spatial distribution of café locations, we employed Kernel Density Estimation (KDE), a point pattern analysis method. KDE is a non-parametric technique that estimates the probability density of point distributions across space using point data. Unlike statistical clustering methods such as K-means, KDE accounts for spatial dependence and is particularly effective for identifying the spatial diffusion of events and visualising clusters of point features (Anderson, 2009; Węglarczyk, 2018). Due to its strengths, KDE has been widely used in various fields, including traffic accident and crime hotspot analysis, as well as studies of spatial utilisation patterns (Cai et al., 2013; Chainey et al., 2008; Xie and Yan, 2008; Yu et al., 2015). In this study, KDE was applied to the opening data of cafés during the Establishment, Growth, and Spillover Phases to examine spatial shifts in location patterns over time.

Subsequently, a binary logistic regression model was used to identify the determinants of café openings for each phase. Logistic regression is one of the simplest probabilistic modelling techniques and is used to estimate the likelihood of a binary outcome based on a set of independent variables. Rather than predicting whether an event will occur, it estimates the probability of its occurrence (Jin and Lee, 2017). The predicted value of the dependent variable is expressed as a probability between 0 and 1. If the predicted value exceeds a threshold (typically 0.50), the event is considered likely to occur. The logistic function is formulated as follows:

$$\ln\left(p\left(y=1\middle|x_1,\cdots,x_p\right)/\left(1-p\left(y=1\middle|x_1,\cdots,x_p\right)\right)\right)=\beta_0+\beta_1x_1+\cdots+\beta_px_p \quad (3)$$

where ln *ln(p/(1-p))* represents the logit, *p/(1-p)* is the odds, β_p is the regression coefficient, and x_p is the independent variable.

$$Odds=p_i/(1-p_i)=\exp(\textstyle\sum_{j=1}^{k}\beta_jx_{ij})=\exp(\beta_1x_1)\exp(\beta_2x_{i2})\cdots\exp(\beta_kx_{ik}) \quad (4)$$

where p_i represents the probability that event *i* occurs, β_k is the regression coefficient, and x_{ik} is the independent variable.

The odds indicate the ratio of the probability that an event occurs to the probability that it does not. When an independent variable x_{ik} increases by one unit, the odds ratio (OR) is given by exp(β_j), which quantifies the multiplicative change in odds. If the coefficient β_j is negative, the OR will be less than 1, indicating a decrease in odds as the independent variable x_{ik} increases. Based on this model, we examined the factors influencing café openings across the three temporal phases, thereby analysing the spatial dynamics of location shifts in the Hongdae retail district.

4.Results

4.1.Shifting patterns of café locations

Figure 9 presents the KDE results for café openings in the Hongdae retail district and reveals a pattern of spatial diffusion over time. During the Establishment Phase, openings were concentrated around Hongik University and Hongdae Station on Subway Line 2. Densely clustered openings appeared along Wausan-ro and the 'Walkable Street' near Hongdae, which had already established themselves as central commercial districts by the early 2000s. Several openings also occurred along higher-order boulevards such as Yanghwa-ro and Dongmak-ro.

In the Growth Phase, new openings emerged primarily around Hapjeong Station (Line 2) and Sangsu Station (Line 6). In particular, the alleyways adjacent to Hongdae Solnae-gil and the 'Sangsu-dong Café Street'—located roughly one block away from major boulevards—saw an increase in activity. This spatial relocation may reflect displacement due to commercial saturation or gentrification.

In the Spillover Phase, a significant increase in opening density was observed in the residential area of Yeonnam-dong near the Gyeongui Line Forest Park, suggesting a newly emerging location pattern. Additionally, opening density rose around Mangnidan-gil, indicating the expanding boundary of the Hongdae retail district. Notably, opening clusters during the Growth and Spillover Phases exhibited a linear pattern along the street network, suggesting that retail development and relocation tend to follow the structure of the street grid. Unlike the earlier phases, openings in Yeonnam-dong and Mangwon-dong extended beyond boulevards and into inner-block alleyways, highlighting the spatial shift into non-central areas.

The KDE results across the three temporal phases demonstrate an evolving spatial distribution of café locations. Unlike earlier periods, when cafés were concentrated in core commercial centres, recent openings have increasingly occurred in non-commercial or decentralised locations. These findings suggest a shift in the preferred locational attributes of cafés. To further investigate this trend, we apply binary logistic regression to quantify the factors that influence location decisions.

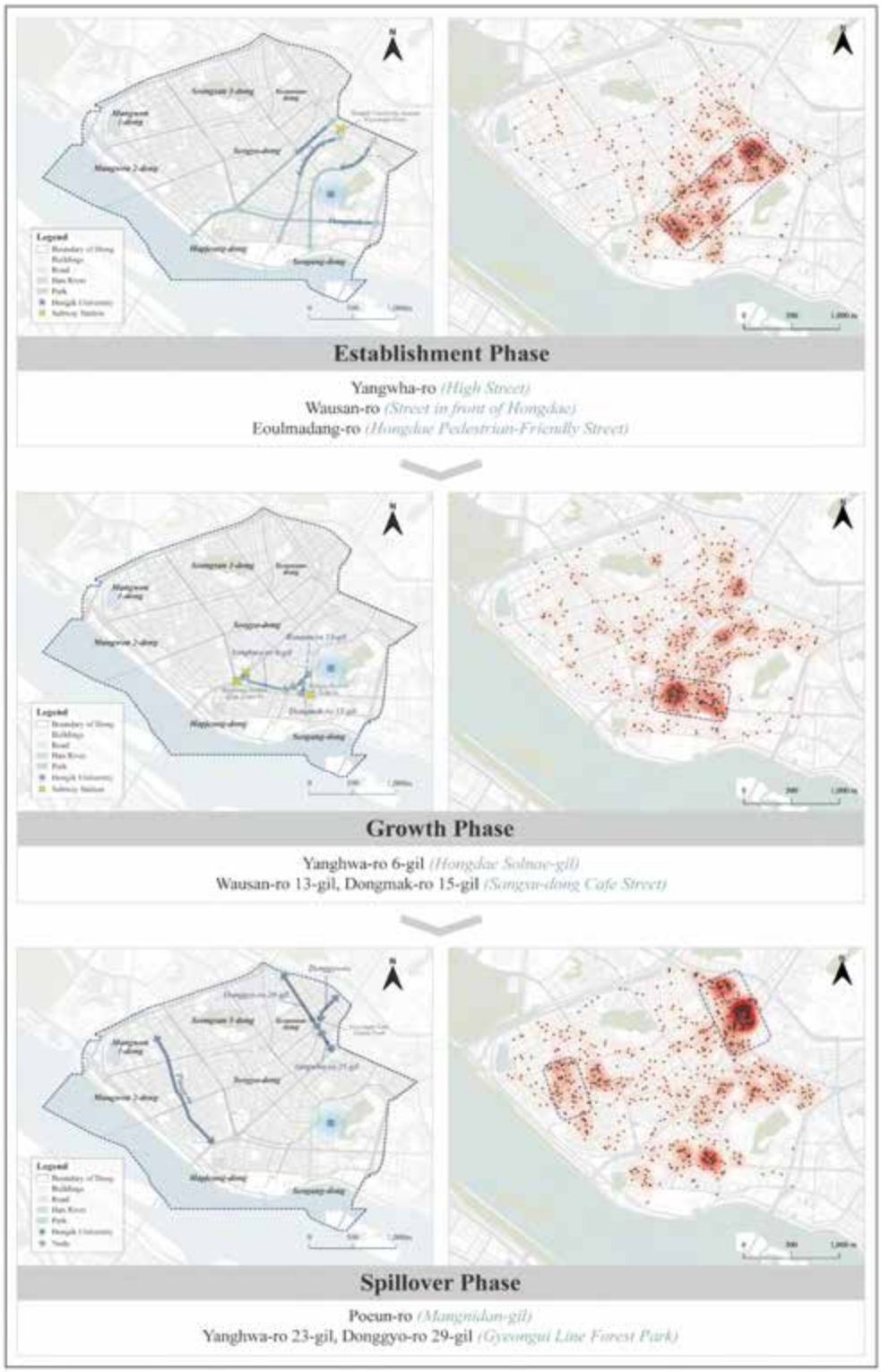

Figure 9. KDE of café openings by phase

4.2.Descriptive statistics

Descriptive statistics for the dependent and explanatory variables used in the binary logistic regression models are presented in Table 2. The unit of analysis is the individual building, and all variables were aggregated accordingly. Buildings deemed unsuitable for retail district analysis—such as apartments, schools, gas stations, and parking lots—were excluded from the sample. The final dataset includes a total of 13,439 buildings. Some variables were log-transformed or rescaled to improve normality prior to analysis.

Table 3. Descriptive statistics

	Model 1		Model 2		Model 3	
Variables	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Dependent variable						
Open	0.03	0.17	0.03	0.18	0.05	0.22
Independent variables						
Walkability characteristics						
Subway (gravity, 600m)	0.93	1.08	1.13	1.25	1.13	1.25
Park (gravity, 600m)	1.14	0.47	1.14	0.47	1.14	0.47
Betweenness (weight=building volume, r=n, log)	11.97	1.16	11.97	1.16	11.97	1.16
Road width	6.06	4.46	6.06	4.46	6.06	4.46
Streetscape characteristics						
Visual attributes						
Enclosure (r=100m)	838.96	564.68	742.79	287.71	835.18	299.62
Openness (r=100m)	17.99	3.97	16.10	3.49	15.28	3.32
Pavement (r=100m)	26.00	24.45	25.43	8.54	26.05	8.35
Greenness (r=100m)	7.19	4.43	10.23	5.31	9.80	4.94
Perceptual attributes						
Safe (r=100m)	0.26	0.09	0.40	0.11	0.38	0.09
Lively (r=100m)	0.74	0.10	0.80	0.08	0.81	0.07
Beautiful (r=100m)	0.16	0.07	0.23	0.09	0.22	0.08
Control variables						
Store characteristics						
Occupied	0.03	0.16	0.05	0.21	0.06	0.24
Agglomeration (gravity, r=100m)	0.87	1.78	1.42	2.29	1.88	2.37
Built environment characteristics						
Building footprint (log)	4.69	0.55	4.69	0.55	4.69	0.55
Building height (log)	2.43	0.55	2.43	0.55	2.43	0.55
Parcel area	14.84	0.36	15.00	0.37	15.37	0.36
Land price (log)	269.86	601.76	269.86	601.76	269.86	601.76
Demographic characteristics						
Residents	11.06	0.72	10.97	0.76	10.94	0.79
Millennials	71.33	46.58	58.27	25.31	60.21	27.88
Employees	6.26	1.78	6.34	1.81	6.60	1.70
Observations	13,439		13,439		13,439	

Note: Model 1 corresponds to the Establishment Phase (2010–2012), Model 2 to the Growth Phase (2013–2015), and Model 3 to the Spillover Phase (2016–2019).

4.3.Factors influencing café location choices

The Log Likelihood Ratio (LR) test results indicate that all three models are statistically significant ($p<0.001$). The Nagelkerke R^2 values were 0.23 for the Establishment Phase, 0.15 for the Growth Phase, and 0.11 for the Spillover Phase. However, it is widely recognised that R^2 values in logistic regression tend to be relatively low and vary depending on the distribution of the dependent variable (Cohen et al., 2009). Moreover, the Nagelkerke R^2 should not be interpreted in the same manner as R^2 in Ordinary Least Squares (OLS) regression, as the two statistics are not directly comparable (Azen and Traxel, 2009; Hu et al., 2006). To further assess the goodness-of-fit of the models, the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values were also examined. Table 3 summarises the overall model accuracy.

Table 4. Model fit statistics for the three phases

Statistic	Model 1	Model 2	Model 3
Log likelihood	-1,405.53	-1,741.58	-2,413.44
LR chi^2(df)	746.58(20)***	538.98(20)***	491.43(20)***
Nagelkerke R^2	0.23	0.15	0.11
AIC	2,853.05	3,525.15	4,868.88
BIC	3,010.68	3,682.78	5,026.50
*: p<0.1, **: p<0.05, ***: p<0.01			

The binary logistic regression results for the Establishment Phase are presented in Table 4. All variance inflation factor (VIF) values were below the conventional threshold of 10, indicating that multicollinearity was not a concern. Neither walkability nor the visual attributes of streetscape characteristics had a statistically significant effect on the probability of café openings.

By contrast, among the perceptual attributes of the streetscape, Lively—reflecting pedestrian perception of vibrancy—was negatively associated with the likelihood of opening (OR = 0.18). Regarding traditional location factors, both prior presence of cafés (OR = 9.49) and agglomeration (OR = 1.13) were positively associated with the odds of opening. In terms of building characteristics, larger footprint was associated with lower opening probability (OR = 0.79), while greater building height (OR = 1.38), larger parcel (OR = 1.00), and higher average land price (OR = 2.72) were associated with increased odds of opening. As for demographic factors, higher population density (OR = 1.44), larger millennial population (OR = 1.00), and higher number of employees (OR = 1.21) all significantly increased the likelihood of café openings. These results align with previous findings suggesting that the complementary relationships among similar stores contribute to agglomeration economies, and that building characteristics and population-based retail demand are critical for the efficient operation and location decisions of retailers (Porter, 1996; Sevtsuk, 2014; Small and Song, 1994; Teller et al., 2016; Um et al., 2009; Wu et al., 2021).

Table 5. Binary logistic regression results for the Establishment Phase

Variables	Model 1 (Establishment Phase)		
	OR	**z**	**VIF**
Constant	4.40e-11***	-7.85	-
Dependent variables			
Walkability characteristics			
Subway (gravity, r=600m)	1.09	1.64	1.39
Park (gravity, r=600m)			
1.24			
1.59			
1.12			
Betweenness (weight=building volume, r=n, log)	1.02	0.42	1.33
Road width	1.01	1.22	1.27
Streetscape characteristics			
Visual attributes			
Enclosure (r=100m)	0.99	-0.69	5.49
Openness (r=100m)	1.00	0.21	1.63
Pavement (r=100m)	1.00	0.28	4.48
Greenness (r=100m)	0.99	-0.00	3.47
Perceptual attributes			
Safe (r=100m)	4.24	1.12	3.67
Lively (r=100m)	0.18*	-1.77	2.59
Beautiful (r=100m)	0.13	-1.12	4.41
Control variables			
Store characteristics			
Occupied	9.49***	15.48	1.14
Agglomeration (gravity, r=100m)	1.13***	5.33	1.61
Built environment characteristics			
Building footprint (log)	0.79**	-2.11	1.46
Building height (log)	1.38***	2.73	1.31
Parcel area	1.00**	2.17	1.27
Land price (log)	2.72***	6.17	1.88
Demographic characteristics			
Residents (log)	1.44***	2.89	1.86
Millennials	1.00***	2.73	1.41
Employees (log)	1.21***	2.99	2.24
Number of observations	13,439		
Log likelihood	-1,405.53		
LR chi^2(df)	746.58(20)***		
Nagelkerke R^2	0.23		
AIC	2,853.05		
BIC	3,010.68		

*: p<0.1, **: p<0.05, ***: p<0.01

The logistic regression results for the Growth Phase are presented in Table 5. All VIF values were below the threshold of 10, indicating no multicollinearity issues. Compared to the Establishment Phase, the Growth Phase revealed a notable shift in the influence of locational factors, particularly in terms of walkability and streetscape characteristics.

Café openings were more likely to occur in areas with greater accessibility to subway stations (OR = 1.11) and nearby parks (OR = 1.27). Among the visual attributes of streetscape characteristics, higher Enclosure was associated with a slight decrease in opening probability (OR = 0.99), while higher Greenness also reduced the likelihood of opening (OR = 0.95). Conversely, a higher Pavement had a positive effect on opening probability (OR = 1.02). These findings support the interpretation that micro-scale visual streetscape factors enhance pedestrian visual preferences, thereby increasing the attractiveness of retail locations, in line with the results of Koo et al. (2023b).

Among the perceptual attributes, Lively continued to show a negative association (OR = 0.13), whereas Beautiful exhibited a strong positive association with café openings (OR = 9.89). In contrast, several traditional location factors—such as building footprint, parcel area, and millennial population—lost their statistical significance during this period. This suggests that, as the retail district expanded, large-scale parcels and fixed demographic groups such as young adult residents became less influential, while other commercial and spatial factors emerged as more influential in location decisions.

Table 6. Binary logistic regression results for the Growth Phase

	Model 2 (Growth Phase)		
Variables	**OR**	**z**	**VIF**
Constant	1.22e-09***	-6.40	-
Dependent variables			
Walkability characteristics			
Subway (gravity, r=600m)	1.11**	2.59	1.59
Park (gravity, r=600m)	1.27**	2.06	1.10
Betweenness (weight=building volume, r=n, log)	0.95	-1.01	1.32
Road width	0.99	-0.68	1.27
Streetscape characteristics			
Visual attributes			
Enclosure (r=100m)	0.99**	-2.10	3.35
Openness (r=100m)	0.99	-0.38	1.75
Pavement (r=100m)	1.02**	2.45	1.68
Greenness (r=100m)	0.95*	-1.96	4.62
Perceptual attributes			
Safe (r=100m)	0.86	-0.12	7.01
Lively (r=100m)	0.13*	-1.79	3.04
Beautiful (r=100m)	9.89*	1.69	6.16
Control variables			
Store characteristics			
Occupied	4.64***	11.74	1.16
Agglomeration (gravity, r=100m)	1.05***	2.76	1.72
Built environment characteristics			
Building footprint (log)	0.97	-0.30	1.47
Building height (log)	1.48***	3.69	1.31

Parcel area	0.99	-0.71	1.17
Land price (log)	2.17***	4.79	2.18
Demographic characteristics			
Residents (log)	1.45***	3.13	2.09
Millennials	1.00	1.59	1.16
Employees (log)	1.31***	4.38	2.39
Number of observations	13,439		
Log likelihood	-1,741.58		
LR chi^2(df)	538.98(20)***		
Nagelkerke R^2	0.15		
AIC	3,525.15		
BIC	3,682.78		
*: p<0.1, **: p<0.05, ***: p<0.01			

The binary logistic regression results for the Spillover Phase are summarised in Table 6. All VIF values were below 10, indicating no multicollinearity concerns. While the influence of traditional retail location attributes remained similar to the previous phase, the impact of walkability and streetscape characteristics shifted notably.

Accessibility to subway entrances (OR = 0.89) and wider roads (OR = 0.98) were associated with decreased probabilities of café openings. This suggests that improved access to spatial information has weakened the traditional locational advantages of highly accessible central areas. Meanwhile, higher Enclosure (OR = 1.27) and higher Openness (OR = 1.09) were positively associated with opening likelihood, whereas higher Pavement was negatively associated (OR = 0.98). These findings align with Nasar's (1990) study, which argued that people prefer open spaces with clearly defined boundaries, rather than simply wide-open areas.

In addition, Lively, one of the perceptual attributes of streetscape, was positively associated with café openings (OR = 14.15). This reflects the fact that areas with slower pedestrian speeds and frequent foot traffic—such as alleyways with small-scale spatial units and multiple storefronts—are perceived as more vibrant (Gehl, 2013; Kickert and Talen, 2022; Yun and Choi, 2013), and play a crucial role in retail operation and location decisions. Overall, these results suggest that under the rise of experiential consumption, consumers increasingly value the emotional and aesthetic appeal of surrounding environments. As a result, visually and perceptually attractive areas—as experienced by pedestrians—are becoming more important in café location decisions.

Table 7. Binary logistic regression results for the Spillover Phase

	Model 3 (Spillover Phase)		
Variables	**OR**	**z**	**VIF**
Constant	1.25e-09***	-6.73	-
Dependent variables			
Walkability characteristics			
Subway (gravity, r=600m)	0.89***	-2.88	1.57
Park (gravity, r=600m)	1.17*	1.73	1.08
Betweenness (weight=building volume, r=n, log)	0.99	-0.10	1.33
Road width	0.98*	-1.91	1.27
Streetscape characteristics			
Visual attributes			
Enclosure (r=100m)	1.00***	4.89	3.21
Openness (r=100m)	1.09***	5.78	1.67

Pavement (r=100m)	0.98**	-1.97	2.08
Greenness (r=100m)	1.01	0.79	5.56
Perceptual attributes			
Safe (r=100m)	0.42	-0.79	5.51
Lively (r=100m)	14.15**	2.42	3.25
Beautiful (r=100m)	2.89	0.77	7.42
Control variables			
Store characteristics			
Occupied	6.10***	16.60	1.13
Agglomeration (gravity, r=100m)	1.06***	3.49	1.76
Built environment characteristics			
Building footprint (log)	0.89	3.37	1.47
Building height (log)	1.30***	-0.92	1.32
Parcel area	0.99	-1.28	1.16
Land price (log)	1.73***	2.96	2.42
Demographic characteristics			
Residents (log)	1.38***	3.17	1.98
Millennials	1.00	0.53	1.23
Employees (log)	1.14***	2.73	2.53
Number of observations	13,439		
Log likelihood	-2,413.44		
LR chi^2(df)	491.43(20)***		
Nagelkerke R^2	0.11		
AIC	4,868.88		
BIC	5,026.50		

*: p<0.1, **: p<0.05, ***: p<0.01

5.Discussion

The spatial shift in café locations in the Hongdae district reflects the evolving nature of urban consumer culture and highlights the growing influence of streetscape quality and place perception on location preferences. Figure 10 illustrates the streetscape characteristics of areas that satisfied the preferred locational conditions for each phase. In the early stages, location decisions were primarily shaped by traditional characteristics of commercial centres, such as accessibility and centrality. However, as the core area became increasingly saturated and experiential consumption gained prominence, new locations—such as surrounding alleyways—emerged as preferred sites. These findings align with previous research suggesting that during commercialisation, retail districts tend to expand into adjacent areas with relatively lower rents or land prices once the core becomes saturated (Ley, 1997; Smith, 1979; Zukin, 1987). Furthermore, beyond traditional location characteristics, spatial features closely tied to consumers' experiences of place should be considered as increasingly important in café location decisions.

More specifically, the results can be interpreted in two ways. First, the relationship between café locations and walkability differed by phase. During the Growth Phase, openings were concentrated near subway stations and parks, reflecting a continued preference for traditional commercial centres with high transit accessibility and public amenities. These results align with prior studies that emphasise the positive impact of public transportation on retail activity by serving as anchors of pedestrian flow (Lee and Kwon, 2016; Wu et al., 2021; Yoshimura et al., 2021) and highlight how parks attract consumers and generate synergies with surrounding businesses (Sim, 2019). However, in the Spillover Phase, locations with lower subway accessibility and narrower street widths became more favoured. This suggests that café location decisions were no longer dependent on minimising

distance to a fixed destination or locating in walkability-optimised central areas.

Second, the visual and perceptual quality of streetscapes had a significant influence on café location decisions, and this influence varied by phase. During the Establishment Phase, cafés tended to locate along major boulevards with relatively low perceived vibrancy. As the retail district expanded, new openings increasingly concentrated along pedestrian-friendly streets and eventually shifted towards narrower, human-scale alleyways. In particular, during the Spillover Phase, vibrant and visually attractive streets—as perceived by pedestrians—became preferred locations for café openings. While wide streets may appear empty even when populated, narrow streets with clear visibility of building facades are perceived as more active. Cafés located along such streets not only contribute to perceived safety and imageability (Harvey et al., 2017), but also enhance the spatial appeal by encouraging optional activities such as lingering and spending time (Gehl and Svarre, 2013). This shift in location—from closed boulevards with limited social interaction to open alleyways that support informal encounters—ultimately contributes to neighbourhood transformation and strengthens the vitality of the broader urban space. Moreover, as cafés begin to cluster along pedestrian-friendly and aesthetically pleasing streets, the resulting streetscapes can promote gradual urban growth and enhanced vibrancy (Cox and Streeter, 2019; Jacobs, 1961; Kickert and Talen, 2022). Outdoor cafés that utilise terraces in highly walkable areas, or shops embedded in alleyways that foster active interaction with the street, serve as extensions of public space (Montgomery, 1997; Sim, 2019). These findings suggest that urban planners should aim to improve the streetscape environment and encourage small-scale commercial activity in alley-based retail districts.

While traditional location attributes have long been considered important in café location decisions, their influence has diminished over time. This result underscores the limitations of traditional location theories and highlights the need for ongoing monitoring of consumer preference shifts—particularly by incorporating streetscape-oriented locational trends.

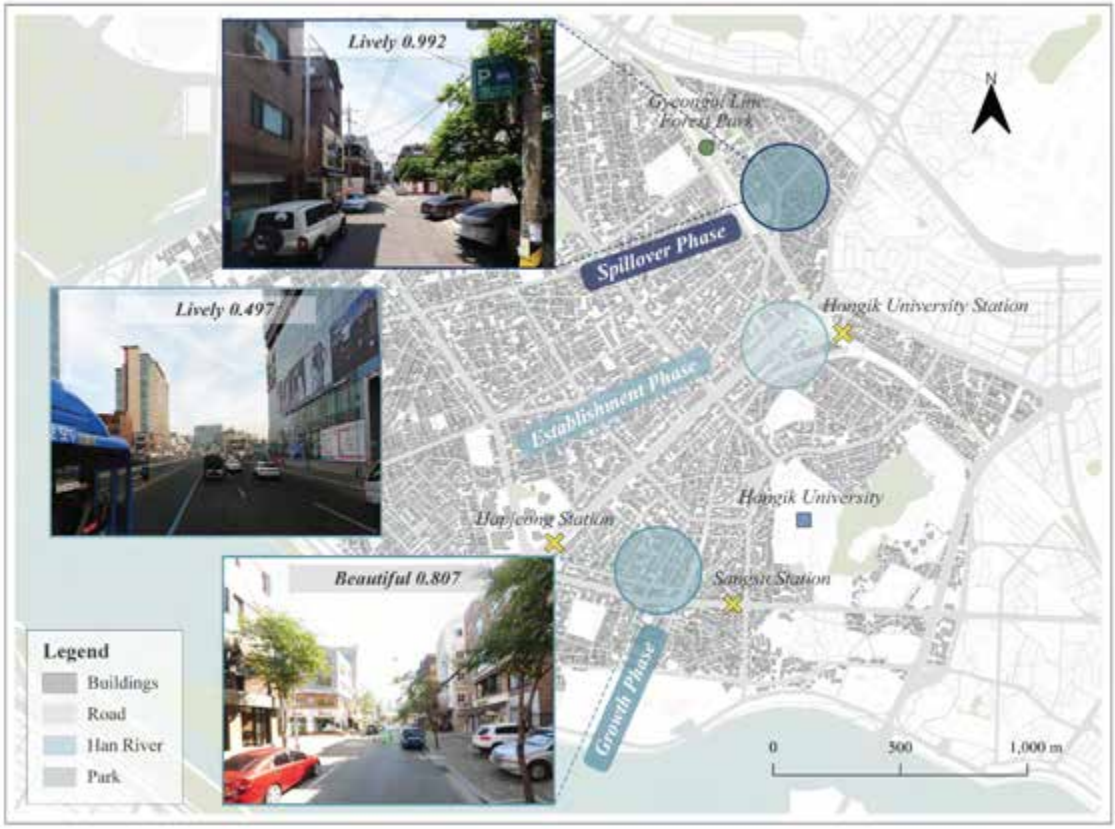

Figure 10. Locational preferences and streetscape indicators by phase

6.Conclusion

This study empirically demonstrates the complex interaction between café location decisions and urban spatial conditions, particularly emphasising the significance of streetscape quality. It highlights the dynamic and

interrelated processes through which sense of place, urban culture, and everyday heritage evolve. In the Hongdae retail district, traditional commercial location characteristics were more influential during the Establishment Phase, while walkability became more important during the Growth Phase, and visual and perceptual streetscape characteristics were emphasised during the Spillover Phase. Historically, small-scale retailers such as cafés have tended to locate in highly visible areas—physically central streets with heavy pedestrian and vehicular traffic—to benefit from agglomeration economies or gain competitive advantage. However, in contemporary urban consumer culture, consumption has evolved towards everyday life, and cafés have become key social spaces where individuals share in one another's daily routines (Horton and Kraftl, 2013). Place, as Carmona (2021) notes, is constructed through lived experience; it becomes meaningful as individuals, communities, and societies attach emotions and memories to space. These social activities are embedded in the street, where the streetscape becomes a medium for memory, experience, and emotional resonance.

Moreover, the rise of small-scale experiential spaces, omni-channel retail, and social media has made it possible for people to indirectly experience spaces without physically visiting them, thereby increasing the importance of the environment surrounding a store. User-generated content and information sharing on social media platforms can shape the identity and attachment to place (Farrelly, 2017). In particular, with the growing culture of image-based sharing, users now actively tag locations and upload images in real time, even from lesser-known alleys or newly discovered destinations (Lee et al., 2018). From this perspective, streetscapes that facilitate visual engagement and offer sensory experiences provide retailers with new opportunities to attract consumers (Kickert and Talen, 2022). Therefore, urban planners are encouraged to cultivate a localised sense of place in retail districts by designing environments that offer differentiated experiences for consumers within the everyday urban landscape.

This research not only assesses the continued relevance of traditional commercial location theories, but also highlights the overlooked connection between recent shifts in café locations and streetscape characteristics—an aspect that has received limited attention in previous research. The findings emphasise that, in determining retail locations, the perceived quality of the surrounding service environment has become increasingly important for consumers. Specifically, the study shows that preferred location conditions have changed over time, from both the retailer's and the consumer's perspectives. These results point to the need for long-term monitoring of spatial changes in retail districts to support sustainable commercial operations. Notably, considering the role of cafés in enhancing quality of life and contributing to urban vibrancy, the findings suggest that streetscapes should be viewed not as passive elements, but as active components in evaluating and promoting urban vitality. In this sense, the study offers insights into retail dynamics driven by evolving consumption patterns and the changing role of cafés, moving beyond a mere examination of locational shifts.

There are some limitations that need to be explored in future research. First, as this study focuses on a single case study area, the generalisability of the findings is limited. Future research should expand the analysis to include multiple cities. Second, to ensure consistency across the dataset, the SVIs used in the analysis were collected by vehicle-mounted cameras, meaning that the images were captured from a driver's perspective. In streets with clearly separated roads and sidewalks—such as boulevards—this may lead to discrepancies from the pedestrian point of view. As such, there may be subtle differences between the visual perception captured in the SVIs and the streetscape as experienced by pedestrians. Addressing this limitation in future studies may help to more precisely capture changes in how urban spaces are subjectively perceived.

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Research on the Tourism Development Path of Human-Habitat World Heritage from the Perspective of Space Production: A Case Study of Pingyao Ancient City

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Abstract:
Human-Habitat World Heritage, as a form of living heritage, embodies dual attributes of "heritage" and "habitat." Driven by economic restructuring and urbanisation, it is transitioning from "everyday residential use" to "tourism-driven development," facing challenges of conservation and development. This study, based on Pingyao Ancient City, employs the triadic dialectics of spatial production alongside policy analysis, historical archives, field surveys, and oral histories to construct its transformation narrative. Findings reveal that Pingyao achieved physical space reproduction through planning and business adjustments, strengthened cultural identity via conservation policies and cultural festivals, and expressed social space through community participation and visitor interaction. This process has enhanced cultural and social values while driving sustainable development. Through Pingyao's practical paradigm, this study establishes a theoretical framework for balancing conservation and development, offering insights for managing similar heritage sites globally.

Key words: space production; human-habitat world heritage; living heritage; Pingyao Ancient City; tourism development

1 Introduction

Pingyao Ancient City, located in Shanxi Province, China, was built in the 14th century and inscribed on the World Heritage List in 1997. It is a quintessential example of Human-Habitat World Heritage, possessing dual attributes of "heritage" and "habitat." First, its heritage characteristics are significant, featuring abundant tangible and intangible heritage. It preserves a traditional urban layout, streets, and architectural remains, reflecting over five centuries of evolution in Han Chinese urban architectural styles and planning (Centre). Additionally, it embodies traditional spatial organisation principles, materials, structures, and construction techniques, as well as traditional aesthetics, folklore, religious practices, political systems, commercial culture, and production methods (Shao et al., 2016). Second, its habitat characteristics are evident; historically, it served as a living space and continues to accommodate daily life, undergoing constant development and change (Shao, Hu, and Xu, 2019). These dual attributes underscore its "Outstanding Universal Value" at the global level" ('Convention concerning the protection of the world cultural and natural heritage', 1973) and highlight its significance for stakeholders (Li and and Su, 2020), heritage communities, and cities at the local level. The interplay between traditional spaces and lifestyles illustrates the wisdom of addressing "human-place relationships" in traditional urban planning, offering unique value (Shao et al., 2016).

With the progression of urbanisation in China and economic restructuring, Pingyao Ancient City has witnessed rapid tourism development in recent decades. Commercial activities and spatial forms within the city have diversified, improving and advancing the local economy (Long, 2016). However, the form and function of the heritage site have been irreversibly affected (Rezaei, 2017). The deepening connection and escalating conflict between visitors and indigenous residents have driven Pingyao's transformation from an "everyday residential" model to a "tourism-oriented" one. Overuse and excessive demand on the heritage site have revealed issues unanticipated during its construction (Li, Wu and Cai, 2008). Heritage conservation faces dual challenges: safeguarding the authenticity and integrity of the heritage, respecting the material spatial authenticity and lifestyle of indigenous residents, while promoting tourism and modern livelihoods to drive tourism-induced spatial and economic transformation (Wang, 2012). The Protection and Revitalisation Plan for Pingyao Ancient City was approved in 2014, with the overarching goal of enhancing heritage conservation and livability while fostering sustainable social and economic development (Centre). The conservation, preservation, reconstruction, and management of Pingyao have evolved from a "material-centric" approach focused on architectural restoration and tourism to a "people-centred" model of community co-creation (Sun and Nakajima, 2023).

Current research on the governance of Pingyao Ancient City, a Human-Habitat World Heritage site, primarily focuses on analysing its intrinsic value and conservation methods, as well as its development from the

perspective of heritage tourism. Studies on intrinsic value and conservation methods encompass value assessment and characteristic evaluation(Shao, 2018), conservation management mechanisms(Miao, 2014), spatial and morphological studies(Tao, He and Jiang, 2014; Xie, 2015), comparative analyses of ancient urban planning concepts and urban expansion through conservation and planning(Li et al., 2022), and research on the protection and analysis of street facade spaces (Li and Wang, 2015).From the perspective of heritage tourism, research covers spatial-functional analyses (Liao et al., 2022), resident and community participation(Ju, 2022; Liu et al., 2022; Sun and Nakajima, 2023; Liu et al., 2023; Cui, Cheng and Shang, 2024), stakeholder framework studies (Li and and Su, 2020), application frameworks for urban historical landscapes(Hu, 2011; Wang and Gu, 2020), tourism industry analyses (Gao et al., 2017), sustainable development assessments(Weng et al., 2019), and visitor data tracking(Li et al., 2024).In summary, there is limited focus on the spatial production and renewal mechanisms of Pingyao Ancient City. Few studies adopt a comprehensive framework to integrate and analyse the relationships among the material, social, and spiritual dimensions.

This study focuses on the spatial patterns and production processes of Pingyao Ancient City as a Human-Habitat World Cultural Heritage site, employing Lefebvre's triadic dialectical framework of spatial production for a narrative construction of its transformation pathway. Lefebvre's theory views urban space as both a product and a means of production, shaped by social and interpersonal relationships (Fuchs, 2019). It conceptualises urban space as a triad: (1) Spatial practice (perceived space); (2) Representations of space (conceived space); (3) Representational space (lived space) (Lefebvre,1991). Through historical-sociological analysis and spatial investigation, this study aims to construct a comprehensive framework of spatial production. It analyses the interplay among material space (buildings, streets, districts), planning and policy frameworks (conservation plans, relevant policies), and everyday life and values (local culture, resident experiences). The objective is to elucidate the processes and outcomes of spatial production and heritage governance during the tourism transformation of Pingyao, thereby offering valuable theoretical and practical paradigms for the humanistic tourism development of Human-Habitat World Heritage sites.Specifically, this research seeks to address the following questions:

1.How have the material, social, and spiritual spaces of Pingyao Ancient City changed under heritage tourism?
2.How do stakeholders and key policies collectively influence and shape the spatial production of Pingyao Ancient City?
3.What integrated strategies can be identified to guide the tourism transformation of Human-Habitat World Cultural Heritage sites?

2 Literature Review

2.1 Human-Habitat World Heritage and Living Heritage

Human settlement refers to all types of inhabited aggregations and their environments, including rural areas, towns, cities, and regions. It encompasses five key elements: nature, society, humans, dwellings, and supporting networks. Human settlement consists of two main components: firstly, humans, including individuals and the societies they form; secondly, the tangible settlements and their surrounding environments composed of natural or artificial elements (Wu, 2014). Research on Human-Habitat heritage sites began in the late 1990s ('The spatial coupling and its influencing mechanism between rural human-habitat heritage and key rural tourism villages in China', 2025) and is interdisciplinary, covering both tangible and intangible heritage (Su, 2011; Wang, 2016; Amit Cohen and Sofer, 2017). The inheritance and development of Human-Habitat heritage sites demonstrate continuity (Poulios, 2011), with an emphasis on the functional role of "habitat" where residents, as key participants, continuously engage in shaping heritage spaces (Chapagain, 2013). Heritage sites and communities are closely interconnected, forming a form of "living heritage" (Zhang and Lu, 2025).

Academic literature on Human-Habitat World Heritage emphasises the concept of "living heritage", focusing on its sustainable development (Landorf, 2011; Weng et al., 2019). The heritage management process has shifted from a centralised, exclusionary approach to a participatory and holistic one, with "community", "residents", and "co-creation" becoming key terms in heritage governance (Li et al., 2020). A "community co-creation" governance model has been developed to address conflicts in living heritage, particularly the tensions between modern socio-economic development and the daily needs of local heritage communities (Ju, 2022; Sun and Nakajima, 2023). Additionally, conflicts among stakeholders have become a major focus in heritage tourism research, prompting the proposal of frameworks to resolve such disputes (Li and and Su, 2020). Furthermore, tailored

assessment frameworks have been established to evaluate China's management practices in promoting community participation in cultural heritage (Li et al., 2020).

2.2 The Applicability of the Theory of Spatial Production

The theory of spatial production originated from Marxist sociology, with Henri Lefebvre as its founding figure. Lefebvre posited that "space is a product of social relations," emphasising that social space is produced through social practices. He categorised the production of space into three dimensions: spatial practice, representations of space, and representational space (Lefebvre, 1991).

In recent years, the theory of spatial production has been increasingly applied to research on cultural heritage sites and industrial heritage. In the context of industrial and urban heritage renewal, scholars have employed the perspective of spatial production in analysing cases of Chinese industrial heritage and urban redevelopment. For example, Song Yongyong, Zhang Tongyu, and others investigated urban old industrial zones, analysing their renewal mechanisms and pathways within the framework of spatial production theory (Song et al.). The theory has also been introduced into the protection and governance of historic urban districts. The conservation of inhabited heritage must balance heritage value with the needs of residents' daily lives. Ma Xiaowen and Li Bin analysed the renewal process of Qingdao's Zhongshan Road Historic District within the theoretical framework of spatial production and place-making (Ma and Li, 2024). Moreover, spatial production theory has been applied to heritage spaces in tourism contexts. Wang Mingfeng and Zhou Yuan studied the production and evolution of Shanghai's Tianzifang as a creative tourism space (Wang and Zhou, 2022).

For Pingyao Ancient City, as an inhabited World Heritage Site, Henri Lefebvre's theory of spatial production offers a valuable perspective. The triadic dialectics of spatial production organically integrate the physical, social, and mental dimensions. This theory facilitates an understanding of how state-led conservation plans (conceived space) interact with tourism-driven market forces (social space) and cultural attachment (lived space).

3 Materials and Methodology

This study examines the transformation pathway of Pingyao Ancient City, a World Cultural Heritage Site, through methods such as policy review, historical archive analysis, field surveys, and oral history collection. Using Henri Lefebvre's triadic dialectics of spatial production as a theoretical framework, it analyses the spatial production mechanisms of Pingyao Ancient City.(Figure 1)

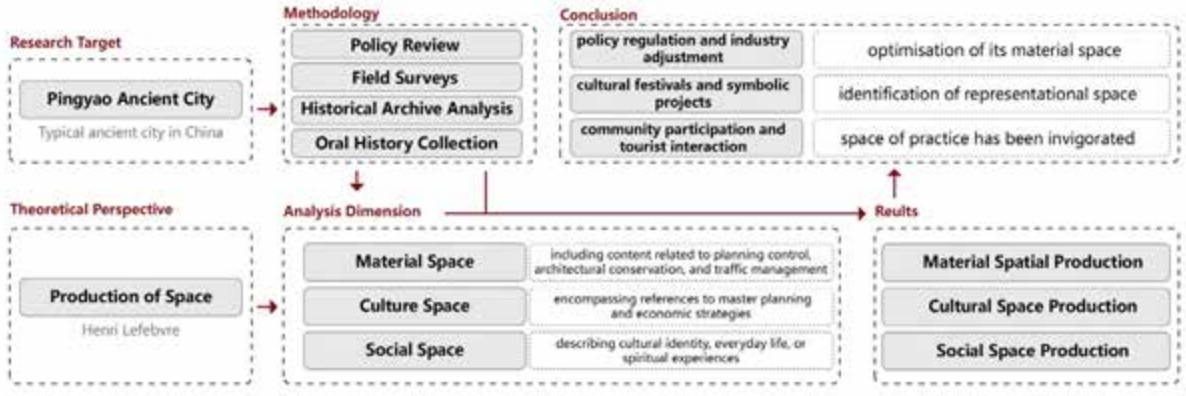

Figure 1.Research Framework

3.1 Study area

3.1.1 Pingyao Ancient City

Pingyao is located on the central plains of Shanxi Province, adjacent to the Fen River, the region's principal waterway-Figure 2-. Pingyao Ancient City lies in the northwest of Pingyao, covering an area of 2.25 km². The protected zone encompasses "one city and two temples"—Pingyao Ancient City and the nearby Zhenguo Temple and Shuanglin Temple. Within the city, there are over 20 ancient temples and nearly 4,000 historical residential units. Built in the 14th century, Pingyao Ancient City is one of the four well-preserved ancient cities in China,

reflecting Han cultural characteristics(Su, 2018; Tang, Zheng and Ng, 2019). Its urban fabric illustrates five centuries of evolution in Chinese imperial architectural styles and urban planning, with its "piaohao" buildings, associated with banking, being a distinctive feature.

Pingyao City is shaped like a turtle poised to move but remaining still-Figure 2-. The "turtle's" head points south and its tail north, with its four gates on the east and west symbolising the turtle's legs. Outside the southern gate, there were originally two wells, metaphorically representing the turtle's eyes. This configuration has led to the city being colloquially referred to as the "Turtle City," symbolising eternal life, perpetual youth, unyielding strength, and everlasting stability (Government, 2015).

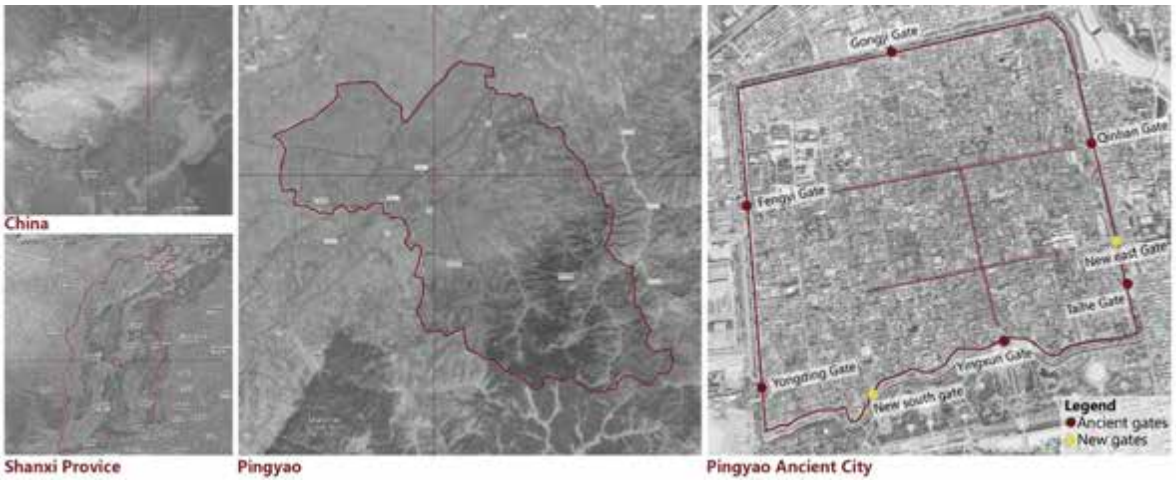

Figure 2. Location and the plan of Pingyao

The functional layout within the ancient city of Pingyao exemplifies the typical characteristics of a traditional county town in the Central Plains region of the Han ethnic group. On the left is the Chenghuang Temple, while the county office is on the right; the Confucian Temple is located to the left and the Martial Temple to the right. The Qingxu Taoist Temple is situated on the eastern side, and although the Jifu Buddhist Temple on the western side no longer exists, the City Tower remains centrally positioned, creating a symmetrical functional distribution. Pingyao's street network is renowned for its "Four Main Streets, Eight Minor Streets, and Seventy-Two Winding Lanes." Most streets and lanes are organised in straight north-south or east-west alignments, with distinct hierarchies and systematic organisation. Particularly prominent is the inverted "干" shaped primary commercial street system formed by South Street, East and West Streets, Chenghuang Temple Street, and County Office Street, whose scale far exceeds that of typical traditional county towns(Xie, 2015). Flanking the main streets are historical shop buildings dating back to the 17th to 19th centuries. The well-preserved architectural ensembles vividly illustrate the historical urban landscape and commercial cultural heritage of Pingyao Ancient City.

3.2 Research design

3.2.1 Theoretical Framework

Henri Lefebvre's core triadic dialectical structure of spatial production consists of: (1) Spatial Practice, which refers to the material practices in production and everyday life, such as daily activities and social reproduction processes. (2) Representations of Space, denoting the conceptualised space created by ruling classes, planners, and professionals, including urban planning, architectural design, and maps. (3) Representational Space, indicating the lived space characterised by people's subjective experiences and symbolic meanings, encompassing cultural imagination and symbolic inscriptions. (Lefebvre, 1991). These three dimensions are dialectically interconnected: spatial practice reproduces space through social actions, representations of space shape spatial forms via planning and design, and representational space reflects people's utilisation and emotional investment in space. Within this framework, Lefebvre asserts that every social formation exhibits this "triadic dialectical" structure(Lefebvre, 1991).

3.2.2 Analytical Dimensions

Using Lefebvre's triadic dialectical theory of spatial production, the surveyed texts are categorised according to the spatial dimensions they reflect, specifically: (1) material space, including content related to planning control, architectural conservation, and traffic management; (2) cultural space, encompassing references to master planning and economic strategies; and (3) social space, describing cultural identity, everyday life, or spiritual experiences. The analysis results are further integrated to form a comprehensive examination of Pingyao's spatial production process, revealing how the material, social, and spiritual dimensions interact under the influence of various stakeholders and policies to collectively shape the spatial characteristics of the heritage site.

3.3 Data and methods

This study employs a combination of qualitative research and case study methods, supplemented by policy and historical document analysis, on-site observations, and semi-structured interviews. To visually present the findings, the study uses tables to illustrate the research content: Table 1 lists the major policies of Pingyao Ancient City, and Table 2 marises the timeline of significant events, providing historical and policy context for the study.

Heritage tourism projects involve numerous stakeholders, and existing literature presents different models of relevant stakeholders across various cases (Aas, Ladkin and Fletcher, 2005; Sheehan and Ritchie, 2005; Cheng et al., 2012). However, there are still shared and overlapping stakeholder groups. Local residents, governments, tourists, tourism entrepreneurs, non-governmental organisations, and mass media are identified as key and indispensable stakeholders in heritage tourism projects (Communicating heritage – a handbook for the tourism sector, 2011) .-Figure 3-This study's oral history interviews involved five categories of key stakeholders: government officials and planners, local residents within the ancient city, tourism entrepreneurs, and visitors. The interviews were structured around the following themes: living conditions, perceptions of heritage value, views on the benefits and costs associated with tourism, and understanding of conservation policies. All interviews were conducted in Mandarin.

Figure 3-Stakeholders and Their Interrelations

4 Empirical Analysis of Spatial Production in Pingyao Ancient City

4.1 Pingyao Ancient City

Pingyao is located on the trade route between Beijing and western China, serving as a longstanding administrative and market centre (Wang and Gu, 2020). Its historical evolution encompasses three morphological periods: the pre-industrial period (before 1949), the socialist period (1949–1997), and the recent development period (post-1997). Each period represents a distinct cultural-historical phase, marked by the emergence of unique spatial configurations and forms that adapted to the socio-economic demands of their time (Conzen, 1960; Conzen and and Whitehand, 2012; Wang and Gu, 2020).

Before 1949, Pingyao Ancient City experienced a period of trade prosperity, even emerging as a financial centre of China. During this time, historic buildings were subjected to repurposing, such as the conversion of the Confucian Temple into a modern school in 1904 and the use of Qingxu Taoist Temple for military purposes in 1926. Additionally, key traditional structures suffered damage during wartime (Wang and Gu, 2020).

Between 1949 and 1997, the development of Pingyao Ancient City was shaped by socialist policies, leading to the construction of industrial-related buildings such as factories and staff dormitories within the ancient city

(Wang and Gu, 2020). Additionally, modern structures like prisons, police stations, and juvenile detention centres emerged, which contrasted sharply with the traditional architecture (Su, 2018). During the late 1970s, a team from Shanghai Tongji University conducted multiple field surveys and mapping projects in Pingyao, strongly advocating for the preservation of the ancient city. They appealed to the local government to halt demolition activities, marking the beginning of Pingyao's heritage conservation efforts (Ruan and Pan, 2019). In 1986, Pingyao Ancient City was designated as a National Historical and Cultural City. By 1997, the city, including its "ancient city walls," "government offices," "markets," "residences," and "temples," was inscribed as a unified entity on the World Heritage List. Recognised as a "living specimen" for studying the development of Chinese politics, economy, culture, arts, and religion.

After 1997, the local government prioritised tourism as a key focus for the conservation and development of Pingyao Ancient City. Over years of planning and implementation, the ancient city gradually evolved into an isolated landmark within the urban area. (Li et al., 2022). The local government's objectives for urban conservation and heritage development included: first, restoring the historical features of the walled city; second, reducing population density within the city walls; and third, creating an ideal environment for tourists (Wang, 2012). By the time this study commenced in 2005, the local government had largely achieved these goals. Historical buildings within the city walls had been restored, and functional transformations had been completed to serve tourism purposes. (Wang and Gu, 2020).

4.2 Dimension of Material Spatial Production

The "spatial practice" within the dimension of material spatial production constitutes its primary level, with production outcomes manifested as tangible and perceptible spatial forms. The incorporation of tourism attributes into the spatial fabric has become a key aspect of the tourism development process in Pingyao Ancient City. The intervention of tourism elements has led to significant transformations in the material spatial morphology. External driving forces, represented by the government and planning experts, have gradually replaced the endogenous impetus based on the natural development of the local community, thereby assuming a dominant role in the production of heritage tourism space (Zhang and Li, 2024). As a model of cultural heritage conservation in China, Pingyao Ancient City has realised a spatial transformation from a traditional town to a cultural tourism destination through functional relocation, business adjustment, restoration of traditional residences, and the introduction of cultural industries. The urban pattern has undergone a diachronic evolution from the "Ming and Qing layout" to a "tourism pathway", while spatial functions have experienced a topological reconfiguration from "residential and productive" to "commercial and cultural."

Functional relocation and spatial vacancy have provided the spatial foundation for the transformation of the ancient city. Prior to the World Heritage nomination, the ancient city housed approximately 45,000 residents. Following the successful inscription, the county government, originally located in the old county yamen, was the first to relocate outside the city walls. Subsequently, schools, hospitals, public security, prosecution, and judicial institutions—functions less related to the cultural context of the ancient city—were gradually moved out. The resident population within the city decreased to about 20,000 permanent inhabitants (Wang, 2012; Wang and Gu, 2020). This measure not only alleviated spatial pressure within the ancient city but also freed up space for cultural exhibitions and activities. It furthermore provided opportunities for the restoration and conservation of historic buildings occupied by institutions.

The reshaping of commercial functions and the optimisation of the landscape constitute important means for the transformation of the ancient city. The production of material space in Pingyao Ancient City is profoundly influenced by policies and planning at international, national, and local levels. The restoration and conservation of the city walls and the strict planning of traffic in historic districts have resulted in the core area becoming a pedestrian zone, with motor vehicles restricted to peripheral circulation to reduce environmental impact on the heritage site. The adjustment of commercial functions centred on South Street is a key example of spatial functional reproduction, where shops originally serving local residents were relocated, and the core street was transformed into a tourism-oriented commercial district themed around cultural antiques, calligraphy, paintings, and intangible cultural heritage (Wang, 2012). Through the restoration of courtyards, revival of traditional styles, and establishment of intangible cultural heritage exhibition centres, this area has become a spatial node of both cultural and economic value. Infrastructure within the ancient city has been repaired, and some private residences have been converted into tourist-oriented guesthouses, boutique hotels, and restaurants (Whitehand and Gu,

2007; Wang et al., 2022). In this process, traditional spaces have been redefined as venues for cultural display and consumption. However, this phenomenon is distinctly marked within the ancient city, where buildings on main streets and heritage nodes have been restored and revitalised, whereas backstreets and peripheral areas receive comparatively less attention, revealing an uneven distribution of resources during heritage conservation and spatial redefinition.

Non-profit restoration and industrial innovation have injected vitality into the production of material space. Under the guidance of policies such as the "Control Plan" and "Management Rules," the restoration of traditional residences, the rehabilitation of significant historical buildings, and the functional adjustment of industrial buildings and land have further reinforced the cultural display function of the ancient city (Government, 2015; Regulations on the Protection of the Ancient City of Pingyao in Shanxi Province). The non-profit restoration of residential buildings in Pingyao Ancient City has achieved remarkable results, with restoration funding jointly undertaken by the Pingyao County Government, the Global Heritage Fund, and property owners. Meanwhile, some industrial and warehouse lands that have been relocated were repurposed for cultural exhibition and creative industry functions, providing venues for the presentation of intangible cultural heritage and cultural research activities, such as lacquerware decoration techniques and Sha Ge opera performers.

The spatial transformation of Pingyao Ancient City demonstrates a policy-driven model of heritage conservation and tourism development. Through the combination of functional relocation, targeted restoration, and innovative cultural industries, it illustrates that heritage sites can achieve a balance between cultural preservation and economic vitalisation.

4.3 Dimension of Cultural Space Production

The second dimension of spatial production is the "representation of space," that is, the production of cultural space. Its outcome is manifested in conceived and symbolised spatial forms that carry specific knowledge and ideology. Building upon the embedding of material tourism elements, the interpretation and reinterpretation of heritage values endow the physical space with spiritual and cultural connotations, which is key to emphasising the heritage attributes and their value significance (Zhang and Li, 2024), thereby promoting the incorporation of cultural connotations and the spirit of place into heritage tourism spaces. Cultural festivals, artistic activities, and symbolic architecture in Pingyao Ancient City are critical carriers of this dimension.

Cultural interpretation and policy implementation constitute the foundational controls ensuring the reliability of spatial representation. The central and local governments of China have successively issued multiple policy documents that provide clear guidance for the preservation of Pingyao Ancient City's spatial pattern, restoration of its historic appearance, and environmental improvement, with strict enforcement at the implementation level (Shao et al., 2016). For instance, in 1998, Pingyao initiated the "blue brick and grey tile" renovation project, removing incongruous colourful buildings to restore the traditional visual characteristics of the ancient city. In 2017, the local government further implemented the "illegal construction removal, disorder rectification, and quality enhancement" campaign, clearing over incompatible building materials such as coloured steel sheets and polycarbonate panels, thereby improving the overall visual impression of the ancient city. The "Management Regulations for the World Cultural Heritage Pingyao Ancient City" strictly specify the renovation styles and procedures for traditional residences (Sun and Nakajima, 2023).

Cultural festivals and narrative reconstruction have deepened the cultural expression of Pingyao's spatial environment. Pingyao Ancient City realises the reproduction of cultural space through festival activities. These include representative events such as the Pingyao Chinese New Year, Pingyao International Photography Festival, Pingyao International Film Festival, and Youjian Pingyao Performance (Again See Pingyao) (Li et al., 2022), which integrate traditional culture with contemporary art, thereby reshaping the city's cultural imagery (Sun and Nakajima, 2023). These cultural projects and festive celebrations not only enhance the attractiveness of Pingyao Ancient City but also inject new narrative dimensions into the city, strengthening public recognition of the heritage site's cultural value.

The demands of different stakeholders have shaped the cultural spatial representation of Pingyao Ancient City. Around 1994, Pingyao proposed the "Three-City Plan," aiming to establish a "Tourism City," "Film and Television City," and "Commercial City." In 1995, the local government introduced a "Private Sector Strategy," seeking to enhance

the cultural spatial value through market-based approaches by encouraging private capital to participate in the renovation of South Street, transforming it into a cultural district themed around "antique trading." The government further reinforced the cultural value of the ancient city through symbolic naming, for instance, in 2017, roads near Pingyao Ancient City were renamed as Ruan Yisan Road and Zheng Xiaoxie Road, commemorating experts who contributed to the heritage conservation efforts. Additionally, the establishment of the "See You Again in Pingyao" theatre exemplifies the heritage management's control over cultural space production, as well as the driving role of private capital and creators. This representational space combines traditional narratives with contemporary art to provide visitors with a unique cultural experience, while simultaneously reinforcing the heritage's contemporary value.

The cultural spatial production of Pingyao Ancient City reflects an organic integration of policy and practice. On one hand, the government provides strong assurance for the cultural conservation of the ancient city through the implementation of policy documents and concrete measures. On the other hand, cultural festivals, symbolic architecture, and narrative activities serve as key carriers that enrich the cultural connotation of the ancient city and enhance public heritage recognition.

4.4 Dimension of Social Space Production

The third layer of spatial production is the "representational space," referring to the production of social space, whose outcome combines both reproducibility and authenticity in spatial form. As a space of practical living, experience, and engagement, its primary producers are the local residents and visiting tourists of the heritage site. During the transformation of heritage tourism, local residents often occupy a passive position due to relatively weak discourse power (Sun and Nakajima, 2023). With the dominant intervention of power holders, heritage communities typically undergo a process of resistance, adaptation, and eventual acceptance (Su, 2018). Ultimately, through participation in tourism services and heritage education, they gradually identify practical fields for intervention in spatial production, thereby personalising and normalising the power-led spatial representations and the spirit of place, resulting in a perceivable representational space with distinctive local community cultural characteristics (Zhang and Li, 2024). In Pingyao Ancient City, heritage serves both as a material carrier and a reproduction of living narratives, with community participation and tourist experience forming the core of this dimension.

Community spatial participation and social feedback enhance the vitality and cohesion of heritage communities. Residents of Pingyao Ancient City are deeply engaged in building renovation and commercial operations, achieving a win-win situation for heritage conservation and economic development through the synergistic guidance of private capital and government policies. For example, the former site of the Rishengchang Draft Bank was transformed by private capital into the "China Draft Bank Museum," which not only fully preserves its historical and cultural characteristics but also effectively stimulates the local economy, injecting endogenous dynamism into the heritage area. Many residents have converted private residences into guesthouses, shops, or exhibition venues, actively participating in the city's operation through commercial means. Under a "government-led + resident self-help" model, community members have completed the restoration of privately owned courtyard houses, gradually becoming key actors in heritage space management and operation (Sun and Nakajima, 2023). Furthermore, intangible cultural heritage such as Pingyao lacquerware decoration techniques is widely exhibited within the heritage zone, revitalising traditional craftsmanship and effectively addressing employment issues for some local youth (Sun and Nakajima, 2023). Heritage community residents also participate in local governance through roles such as "grid members," contributing to the administration of the ancient city community.

Tourist experience and the reproduction of representational space. Tourists, as perceivers and participants of heritage representational space, shape their unique heritage narratives through heritage education, cultural experiences, and subjectivised evaluations (Su, 2018). Various guided tours, cultural activities, and heritage education programmes provide tourists with opportunities for an in-depth understanding of the cultural significance of Pingyao Ancient City. Modern technological means, such as digital light shows, museum development, and intangible cultural heritage transmission, reproduce the ancient city's culture within virtual spaces, creating novel visitor experiences. The diversified interpretations of heritage by tourists enrich the cultural connotation of the heritage and simultaneously raise new spatial production demands for heritage managers and local communities, thus forming a dynamic balance between heritage conservation and tourism development.

As a World Cultural Heritage site, Pingyao Ancient City has established a dynamic and interactive social space between the community and tourists. The community achieves self-empowerment through active participation and social contribution, while tourists inject new narrative dimensions into the heritage through their experiences and reproduction.

5 Conclusion

This study attempts to reveal the heritage revitalisation of ancient city heritage with distinctive Chinese traditional cultural characteristics through the protection and transformation practices of Pingyao Ancient City. From Lefebvre's perspective, it analyses the dynamic interweaving and mutual shaping of material space, space of representation, and representational space within heritage sites: through policy regulation and industry adjustment, the ancient city has achieved optimisation of its material space; by leveraging cultural festivals and symbolic projects, the city has strengthened the identification of representational space; and through community participation and tourist interaction, the space of practice has been invigorated. This virtuous cycle not only injects sustainable development momentum into the heritage site but also provides a referential model of spatial production for other heritage sites (Figure 4).

From the perspective of spatial practice, political power, professionals, capital, and non-governmental organisations have been deeply involved in the remaking of Pingyao's space: government planning and financial investment have shaped tangible spaces such as the city walls, roads, and utility networks (including the continuous removal of illegal constructions and the construction of underground corridors); market forces have introduced modern tourism functions, promoting the synchronous development of pedestrian districts within the ancient city and the surrounding areas (for example, guiding private capital to renovate South Street). Social strata and various interest groups have also played a role in this process: the authorities have constructed Pingyao as a site to exhibit Jin merchants' culture and emphasised the protection of indigenous residents' rights by positioning them as the "remaining residents of the old city"; meanwhile, investors and external developers pursue tourism profits, leading to a reconstruction of commercial space content, but this has also resulted in inappropriate "false prosperity," raising concerns about the authenticity of the space.

At the level of representational space, the preservation blueprint designed by the government and experts has provided guidance for the transformation of the tangible space: the official policy's principle of "minimal intervention" and the subsidy mechanism have directed conservation and repair practices; cultural and creative projects along with promotional narratives have reconstructed the public's interpretative understanding of Pingyao's spatial significance.

At the level of spatial representation, the interaction between residents and tourists endows the ancient city's space with multiple cultural significances: it is both a historical relic and a modern living environment. The community progressively strengthens its role through active participation in management, education, and governance, while tourists, through their experiences and reinterpretation of the heritage, inject new cultural narratives and meanings into the site.

The spatial production of Pingyao Ancient City is a complex process involving multiple actors and layers: national policies and planning establish the baseline for protection and development positioning; capital investment presents challenges. Lefebvre's framework reminds us to focus on the contestation among different forces in the process of spatial production. The transformation practice of Pingyao Ancient City demonstrates that through the integration of government, capital, and community, alongside a protection-prioritised approach, these conflicts can be mitigated to some extent, providing a valuable reference for the management and planning of similar heritage sites worldwide.

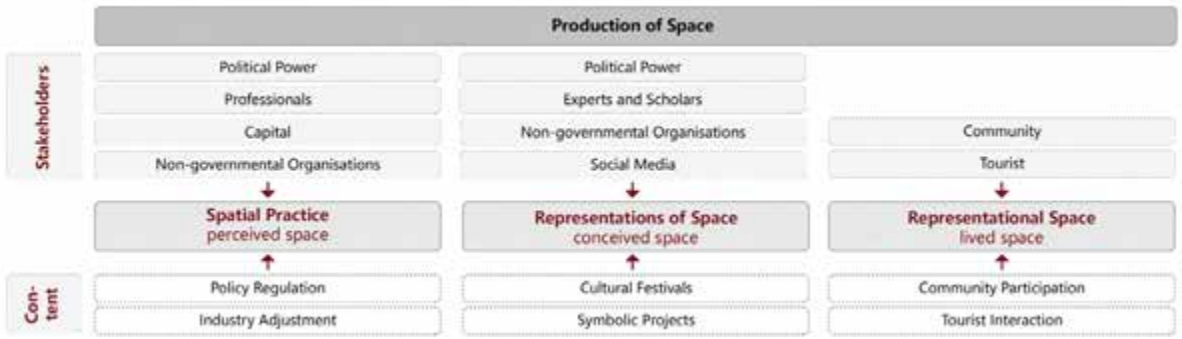

Figure 4-Framework Model

Based on the present study, future research could be further expanded in the following directions:
(1)The balance mechanism between heritage authenticity and commercialisation: Conduct in-depth analyses of the impact of commercialisation on the cultural value of heritage during the production of heritage space, and explore regulatory approaches through policies and management methods to maintain the authenticity and sustainability of heritage sites.

(2)Collaborative heritage conservation models involving multiple stakeholders: Investigate the modes of collaboration and power distribution among government, capital, and community in the spatial production of heritage sites, with a focus on the evolving roles and dynamic relationships of each stakeholder in heritage protection and utilisation. Further exploration should be made on the long-term mechanisms of multi-stakeholder collaboration for sustainable heritage development.

(3)Strategies to enhance visitor experience and cultural identification: From the visitor's perspective, examine the relationship between heritage spatial representation and visitor cultural identification, analysing how cultural experiences and narrative construction influence visitors' understanding and attitudes towards heritage, thereby providing new insights for the future development of heritage tourism.

(4)Comparative heritage management from a cross-cultural perspective: Through comparing the conservation and management practices of Pingyao Ancient City with other cultural heritage sites, especially under different national and cultural contexts, explore universal principles and localisation strategies for heritage site management in a global context.

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Appendices

Table 1 . Main Policies

Year	Level	Leading Organisations	Policy / Convention Title
1972	International	UNESCO	Convention Concerning the Protection of the World Cultural and Natural Heritage
2013	International	UNESCO	Operational Guidelines for the Implementation of the World Heritage Convention
1964	International	International Conference of Architects and Technicians of Historic Monuments	International Charter for the Conservation and Restoration of Monuments and Sites (Venice Charter)
1987	International	International Council on Monuments and Sites (ICOMOS)	Charter for the Conservation of Historic Towns and Urban Areas (Washington Charter)
1994	International	International Council on Monuments and Sites (ICOMOS)	The Nara Document on Authenticity
2005	International	UNESCO	Hoi An Draft — Asia's Best Practice in Heritage Conservation
2004	China	ICOMOS China	China Principles for the Conservation of Cultural Relics
2007	China	National People's Congress of the People's Republic of China	Cultural Relics Protection Law of the People's Republic of China
2008	China	National People's Congress of the People's Republic of China	Urban and Rural Planning Law of the People's Republic of China
2008	China	State Council of the People's Republic of China	Regulations on the Protection of Famous Historical and Cultural Cities, Towns and Villages
2024	China	Ministry of Housing and Urban-Rural Development, National Development and Reform Commission	Construction Guidelines for Protection and Enhancement Projects of Historical and Cultural Cities and Districts (Trial)
2022	Local	Shanxi Provincial Government Office	Action Plan for Strengthening Protection and Development of Pingyao Ancient City as an Internationally Renowned Tourist Destination
2018	Local	Shanxi Provincial People's Congress	Shanxi Province Pingyao Ancient City Protection Regulations
2015	Local	Pingyao County Government, UNESCO, China Huaxia Cultural Heritage Foundation, Global Heritage Fund, Tongji University	Guidelines for Protection, Restoration and Environmental Governance of Traditional Residences in Pingyao Ancient City
2009	Local	Shanghai Tongji Urban Planning and Design Institute	Management Rules for World Cultural Heritage Site Pingyao Ancient City
2015	Local	Pingyao County Government, UNESCO, China Huaxia Cultural Heritage Foundation, Global Heritage Fund, Tongji University	Practical Guidelines for Protection, Restoration and Environmental Governance of Traditional Residences in Pingyao Ancient City
1987	Local	Pingyao County Government, Shanxi Urban-Rural Planning and Design Institute	Protection Planning for Pingyao Historic and Cultural City
1999	Local	Pingyao County Government, Shanxi Urban-Rural Planning and Design Institute, Tongji University	Overall Planning for Pingyao County Town
2013	Local	Pingyao County Government, Shanghai Tongji Urban Planning and Design Institute	Detailed Control Plan for Protection of Pingyao Ancient City
2012	Local	Pingyao County Government	Implementation Measures for Financial Subsidies for the Protection and Restoration of Traditional Residences in Pingyao Ancient City

Table 2. Main Events

Year	Main Participants	Event Description
1963	Dong Jianhong, Ruan Yisan (Tongji University)	Conducted a survey of Pingyao
1976	Pingyao County Construction Bureau	After the Reform and Opening-up, Pingyao was designated as a small to medium-sized city focusing on light textile and machinery industries
1981	Pingyao County Government, Tongji University	Surveyed and formulated the Overall Plan for Pingyao County; new urban area developed outside the old town; Pingyao was designated as a nationally protected tourist county with a complete ancient cityscape
1986	State Council of the People's Republic of China	Listed as the second batch of national historical and cultural cities
1992	Ministry of Construction, UN-Habitat	Organised training courses on ancient city protection planning
1994	National Committee of Historical and Cultural Cities	Passed a proposal to support the prompt nomination of Pingyao as a World Cultural Heritage Site
1997	UNESCO	Officially inscribed Pingyao Ancient City along with Shuanglin Temple and Zhenguo Temple on the World Heritage List
2006	Global Heritage Fund, Pingyao County Government	Jointly funded and completed the overall conservation plan and residential repair projects in Pingyao
2011	Pingyao Jiucheng Cultural Tourism Investment Co., Ltd., Wang Chaoge Team	Youjian Pingyao Performance (Again See Pingyao) designated as a benchmark project; Pingyao Film Festival became a signature event
2017	Jia KezhangdirectorPingyao International Film Festival Co., Ltd.	Pingyao Crouching Tiger Hidden Dragon International Film Festival
Since 2019	State Administration of Cultural Heritage, Shanxi Provincial Bureau of Cultural Heritage	Conducted protection and repair of heritage units; constructed public service spaces; implemented operational regulation
Since 2020	Pingyao County Government	Implemented infrastructure improvement and renovation projects in Pingyao Ancient City

Digital Platform for Accessibility and Cultural Enhancement of Inner Areas in Italy

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Abstract
Heritage plays a central role in territorial cohesion and development policies, as well as in the activation of urban transformation processes. This interdisciplinary project experiments with a virtual platform to explore small historic centres, enhancing cultural and landscape heritage and promoting inclusive accessibility. The objective is to guarantee the right to know and share this minor heritage, eliminating accessibility barriers and serving as a shared archive for local communities. Focused on Stigliano (MT) in Basilicata, the project aims to preserve memory and local identities in areas affected by depopulation and hydrogeological risk. It also aims to promote cooperation between different levels of government and local actors, also through virtual interactions, and to encourage potential investments. The platform becomes a tool for cultural regeneration, stimulating dialogue on the future of these communities.

Keywords : Inner areas, cultural heritage, digital tools, public engagement, accessibility.

1. Introduction

More than 60 percent of Italy's territory is made up of fragile and poorly accessible rural territories, i.e., inner areas, yet they are home to less than a quarter of the national population and continue to depopulate. These figures are indicative of a clear territorial imbalance impoverishing cultural continuity and integrity, especially in rural areas.

European policies have increasingly focused on social cohesion and cultural enhancement to strengthen these marginalised contexts. Public debates reflect a shift from static conservation to dynamic place-based development, in which cultural and natural heritage – both tangible and intangible – acts as a driver of territorial cohesion and sustainable growth. In Italy, 'inner areas' are defined as areas far from service centres, characterised by systemic inequalities that lead to progressive demographic decline, accelerating depopulation and the impoverishment of local economies (Barca et al., 2014). This weakens the bond between inhabitants and their territory, also threatening the survival of cultural and historical-architectural heritage – a legacy of stratified histories, vernacular architecture, and landscape elements now at risk (Vigotti, 2020).

While the importance of developing services that address the essential needs of the inhabitants of inner areas is well known, there is also a growing recognition of the need to initiate processes of knowledge-building, conservation, and enhancement of territorial capital in its various dimensions – material, cultural, and cognitive – in order to define effective intervention strategies. The Hangzhou Declaration (2013) already addresses the contribution of culture to the social, environmental, and economic pillars of sustainable development, as well as its role in creating sustainable cities and building resilient societies. Although not explicitly stated, the cultural aspect is underlying, transversal, and implicit in all the actions of the 17 goals and 169 targets of the 2030 Agenda. This is because each pillar – environment, society, and economy – has a cultural dimension. Some scholars claim that this lack of explicit recognition has led many conservation-focused projects to concentrate efforts and resources on physical preservation, often at the expense of cultural, social, and intellectual drivers of sustainable management (Vandesande, 2021), and that this approach has frequently proven ineffective. As a result, public participation, community involvement, and civil society engagement are increasingly promoted in the context of heritage interventions to ensure the long-term sustainability of management, valorisation, and development processes (Faro Convention, 2005; Tomka, 2013). In this sense, digital technologies can foster cultural innovation and participation, considering deeper forms of participation that go beyond mere interaction

with predefined content. The idea of democratising heritage (Taylor, Gibson, 2016) through digital access has promoted a number of Europe-wide initiatives and funding programmes for the digitisation of cultural heritage (European Commission, 2019).

In Italy, in line with the Faro Convention and the European Framework for Action on Cultural Heritage, the National Recovery and Resilience Plan (NRRP) of the Ministry of Culture includes, among its investments under Mission 1 (Digitisation, Innovation, Competitiveness, Culture and Tourism) - Component 3 (Tourism and Culture 4.0), a specific measure for the implementation of 'Digital Strategies and Platforms for Cultural Heritage'. These developments represent a valuable opportunity for fragile and marginalised territories, in continuity with what was already envisaged by the National Strategy for Inner Areas (SNAI) during the 2014–2020 programming period. Information management through open and interoperable platforms provides valuable tools for decision-making and heritage monitoring. Indeed, by offering data and digital content to a wide range of users, these platforms promote collaborative networks between stakeholders and open new possibilities for knowledge sharing and cultural innovation. Digital tools allow both physical and virtual accessibility, which is also functional in promoting sustainable forms of cultural tourism; sustainable cultural tourism is indeed one of the pillars for the local development of inland areas, as highlighted by various scholars (Bizzarri, 2024).

The aim of this contribution is to explore how digital resources can significantly support the understanding, protection, and enhancement of cultural heritage, through the conceptualisation and first experimentation of a digital platform in a real case study, i.e. the Italian small town of Stigliano (MT) – leading municipality of the action plan for the inner area "Montagna Materana" – characterised by a rich cultural landscape but also by strong environmental fragility due to hydrogeological instability. The article is structured as follows: Section 2 presents a literature review and a selection of best practices related to the use of digital platforms for the enhancement of cultural heritage, with a focus on inner areas and minor historical centres; Section 3 illustrates the methodological framework for the development of a virtual platform, enabling its replicability, and an initial experiment in a pilot area of Stigliano; Section 4 discusses open issues, including feedback obtained from the pilot case application, implementation possibilities, and the structural limitations identified. Finally, Section 5 reflects on how the experimentation fits into a broader public and scientific debate, as well as on the future scalability and replicability of the research.

2. Literature review and best practices on social digital tools for inner areas

There are several examples of experimentation and application, both institutional and non-institutional, that use digital platforms to enhance cultural heritage and promote sustainable cultural tourism. Although most of these good practices refer to medium-to-large urban contexts or specific heritage institutions (art collections, museums, etc.) and are focused on particular sites (monuments, archaeological areas, historic buildings, rural areas, museums), some experiments address marginal territories and smaller historical centres – together with their tangible and intangible heritage – in a more integrated way, including through the involvement of so-called "heritage communities" (Faro Convention, 2005). The experiences presented below, at European, national, and local levels, were selected for their methodological similarities and alignment of objectives: they all involve the development or use of digital tools and platforms for the valorisation of cultural heritage, both tangible and intangible, in marginal and underrepresented areas, with the active involvement of local communities in the various stages of the knowledge and management process. Digital platform thus becomes a 'space' for exercising shared responsibility in the protection, enhancement, and promotion of collective memory and heritage (Longo et al., 2020), also through virtual interaction between users and the digital environment, as well as among users themselves. Furthermore, some of these initiatives focus on expanding the concepts of accessibility and inclusiveness in smaller historic centres through virtual reality or digital twins (Bacci et al., 2021; Lombardo et al., 2023). However, awareness of the actual effectiveness of these initiatives in producing tangible transformations in public space remains limited (Caselli et al., 2025).

At the European level, the Horizon 2020 Programme has promoted numerous projects in which digitisation, and the enhancement and sharing of cultural, environmental, and social heritage, served as key drivers for reducing territorial and social inequalities, with a focus on rural, mountainous, and peripheral areas. One example is the REACH project (Re-designing Access to Cultural Heritage for a Wider Participation in Preservation. Reuse and Management of European Culture, 2017-2020), a European initiative aimed at creating a Digital Social Platform. Its purpose was to bring together a wide range of stakeholders and audiences and offer meaningful participatory

experiences through pilot projects. One of these focused on rural heritage in Spain, exploring participatory approaches to its conservation, particularly in relation to historical irrigation systems and rural areas affected by change or natural disasters. The project continues the work begun by the FP7 MEMOLA project (Mediterranean Mountainous Landscapes, 2014-2017), which led to the development of a collaborative map of historical irrigation systems[1]. The resulting dataset, now available online, is presented to the public as a map; registered users can contribute new entries and comment on existing ones. This approach not only constitutes an example of active community involvement in the process of knowledge production and subsequent "maintenance" of heritage but also highlights the importance of using open online platforms to ensure the visibility and usability of data collected through research projects. It also facilitates collaboration between researchers and civil society in the collection and validation of data, opening new opportunities for cooperation (Toscano, 2018).

In Italy, the National Plan for the Digitisation of Cultural Heritage (PDN) for the five-year period 2022-2026, sub-investment 1.1 of the NRP Culture, defines a platform as "any hardware and software system used to host applications or services and serves as a basis for the development or management of other applications, processes or technologies [...] and may be equipped with different interfaces both for the display of data and for interchange with other platforms". This includes applications designed with different interfaces and structures to ensure access to cultural heritage and to enable any user to participate in, experience, interact with, disseminate, and reuse public cultural assets. Forms of participation are often activated through online crowdsourcing of ideas, memories, personal stories, and other data (Ridge, 2014), depending on the thematic focus of each initiative. Such is the case, for instance, of the "Archivio Atena" community archive and the "Qui Val di Fiastra" project[2]. The former aims to digitally archive the architectural and cultural heritage of the historic centre of Atena Lucana (SA), to trigger processes of adaptive reuse and urban regeneration by leveraging socio-spatial relationships. The process is based on mutual participatory learning between experts and community members, with the goal of co-identifying shared values through the spatial, social, cultural, and environmental dimensions of the context (Rocca et al., 2023; Somma et al., 2024). The latter project seeks to revitalise the social, economic, and cultural fabric of the municipalities of Ripe San Ginesio, Loro Piceno, and Colmurano (MC) through an integrated strategy of social and cultural regeneration and the creation of a Digital Valley Ecosystem (Giacomelli, Calcagni, 2022). The initiative includes 15 interventions concerning the development of Territorial Infrastructures (networks for slow mobility and enhancement of socio-cultural services), Intangible Infrastructures (an interactive web platform and museum network), Cultural Activation and Events, and the Narrative of the Valley. This reflects a broader intent to promote more inclusive forms of cultural tourism. Nevertheless, such experiences demonstrate that mapping information and making it widely accessible – e.g. through GIS tools – is a way to operationalise and make use of it, both for the sake of knowledge and to stimulate planning that considers local identity and memory. Moreover, these experiences address the need to work on the encoding of heritage, especially intangible heritage. While digital interaction (such as interpretation or expression of values) during the decoding phase has become increasingly polyvocal, the decision about what constitutes "heritage" and what is selected for digitisation (encoding) is not necessarily part of this democratisation (Taylor, Gibson, 2016).

3. Testing a metodological framework for a virtual platform on the pilot case of Stigliano

Within the broad framework of the experiences summarised above, the national research project "GO-IN! Digital Platform for Inner Areas" (funded by Next Generation EU in the framework of the Italian NRRP) explores the application of new digital technologies to the cultural heritage of small historical centres in inner areas for the enhancement of local resources, supporting innovative approaches in tourism, housing, and sustainable mobility (Savi, 2019).

The main objective of this inter-university and interdisciplinary research project is to assess the potential of

1 The collaborative map of historical irrigation systems has the primary goal of making both these productive landscapes and the irrigation communities that manage them visible. This initiative was born in collaboration with the European FP7 MEMOLA project and the Association of Historical and Traditional Irrigation Communities of Andalusia. To support this effort, we have received funding from the Spanish Foundation for Science and Technology (FECYT) within the framework of the participatory science program. https://regadiohistorico.es/

2 "Archivio Atena" and "Qui Val di Fiastra", are a winning projects of the public notice, "Attractivity of the villages", part of the National Recovery and Resilience Plan (PNRR M1C3) financed by the Next Generation EU.
Web site Archivio Atena: https://archivioatena.com/ (last accessed: 13/05/2025)
Web site Qui Val di Fiastra: https://www.quivaldifiastra.com/ (last accessed: 13/05/2025)

3D reality-based models integrated into GIS environments and virtual platforms for the enhancement and conservation of small historical centres in vulnerable contexts. The project aims to develop an innovative and replicable methodological protocol for the creation of a 3D GIS databases and an interoperable virtual platform (Figure 1). The protocol also focuses on evaluating the technical and economic feasibility required for managing and implementing digital systems in contexts that typically lack resources, personnel, and digital skills within public administrations.

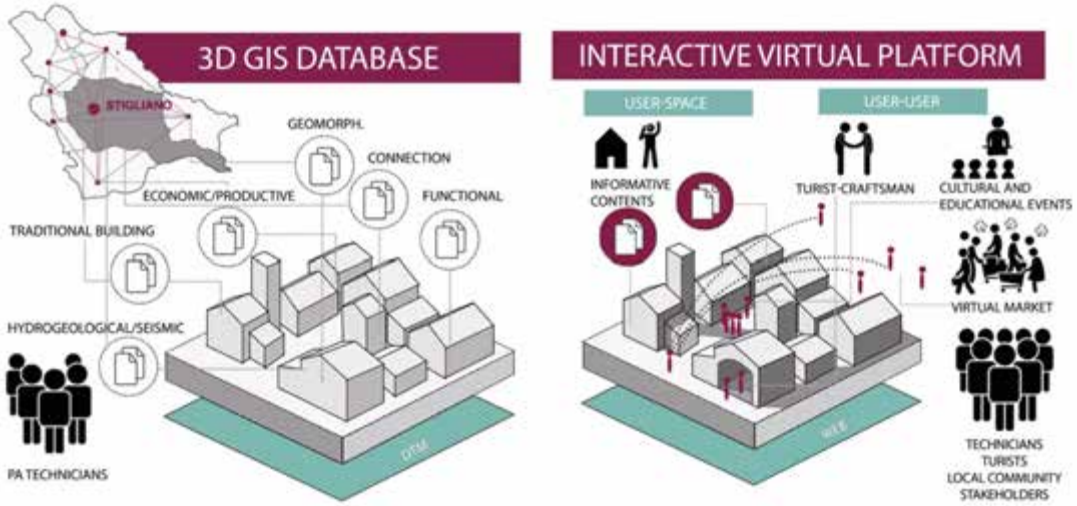

Figure 1. Graphic diagram summarising the objectives of the GO-IN! project. On the left, the 3D GIS database targeted to technicians of the Municipality of Stigliano; on the right, the interactive virtual platform addressed to scientific and non-scientific community. Image produced by DAda Lab, University of Pavia.

This contribution focuses on the development of the interoperable virtual platform, which include a photorealistic 3D model made publicly available online through the project website. The concept is developed starting from the case study of Stigliano, which had been thoroughly documented in the first stages of the GO-IN project.

The platform enables the archiving, processing, and visualisation of open and interoperable data available in various formats (3D models, images, texts, videos, interactive contents, etc.) and collected from diverse sources (traditional archives, digital libraries, real-time content, open dataset databases, open-access research data repositories of scientific results, social networks, etc.). Users, including tourists, will be able to navigate the digital environment, interact with virtual content, and engage with other users. The platform helps guarantee the right of access to culture by removing barriers to accessibility – both physical and informational.

3.1 Contextual Analysis of Stigliano and the Montagna Materana inner area

The experimentation of the virtual platform focuses on the case study of Stigliano (MT) in Basilicata. The region, characterised mainly by small municipalities, comprises four inner areas designated by the SNAI: Montagna Materana, Mercure - Alto Sinni - Val Sarmento, Marmo Platano, and Alto Bradano. Of these, the inland area "Montagna Materana", of which Stigliano is the leading municipality, is described by SNAI as an archipelago of eight "landscape towns"[3] : Accettura, Aliano, Cirigliano, Craco, Gorgoglione, Oliveto Lucano, San Mauro Forte, and Stigliano (Figure 2). All eight municipalities are considered ultra-peripheral, and the main demographic indices confirm the typical symptoms of demographic contraction, accompanied by a rapid ageing of the population (Figure 3). This leads to a progressive erosion of the everyday infrastructure (Coppola et al. 2021), and of the material and immaterial resources of these areas. Further exacerbating this condition of territorial fragility are widespread forms of hydrogeological instability, which in some municipalities have led to the relocation of parts of the settlement at

3 Area Strategy, pilot project 'Montagna Materana'. Website: www.agenziacoesione.gov.it/strategia-nazionale-aree-interne/regione-basilicata-aree-interne/montagna-materana/ (last accessed: 03/06/2024)

risk to newly built areas, amplifying “dispersions, slights, pains, fractures, dissensions, forms of resistance” (Teti, 2024).

Urban/connective criteria (conditions of isolation from reference service centres), morphological criteria (conditions of geological or hydrogeological risk), and cultural criteria (presence of tangible and intangible cultural heritage) were particularly influential in identifying the case. But that is not all. Among all of them, the municipality of Stigliano was certainly the one that best lent itself to experimentation, because although it is among the municipalities most affected by ageing and by a constant rate of decline – in the last 19 years it has lost 14% of its population – it is still the most demographically significant, with 3,586 inhabitants (as of 1 January 2023). Moreover, although since 2017 Stigliano, together with the other municipalities in the inland area, has signed a convention for the associated exercise of activities and services with the delegation of functions to be exercised in a coordinated manner, it still has a more solid administrative apparatus, with the management of urban and building planning at the municipal level as well as participation in territorial planning at the supra-municipal level. Technical-administrative capacity was considered an essential condition for achieving the objectives that the project had set and for hypothesising possible future developments and further activations.

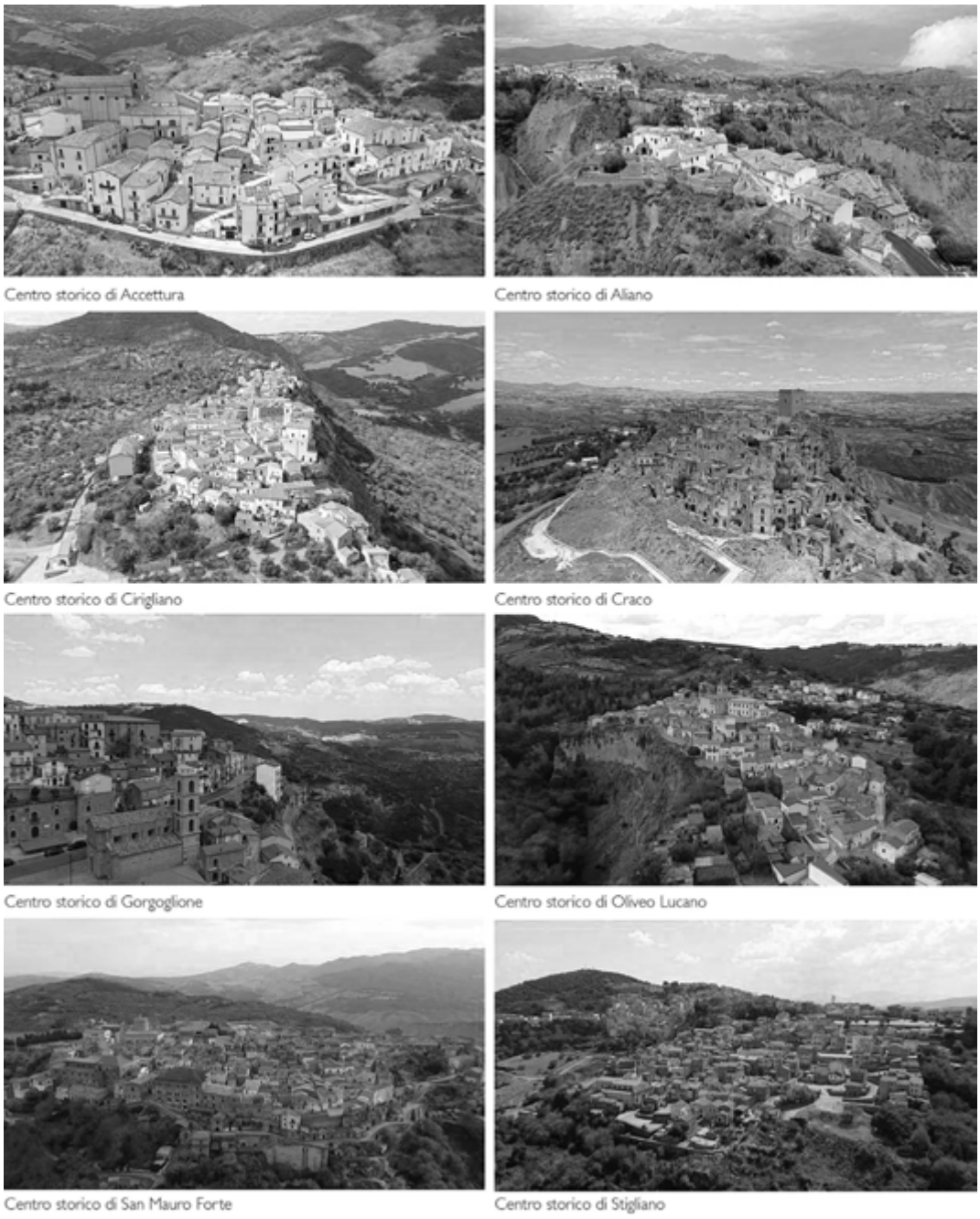

Figure 2. Aerial photos of the eight municipalities that make-up the 'Montagna Materana' inner area. Authors' elaboration.

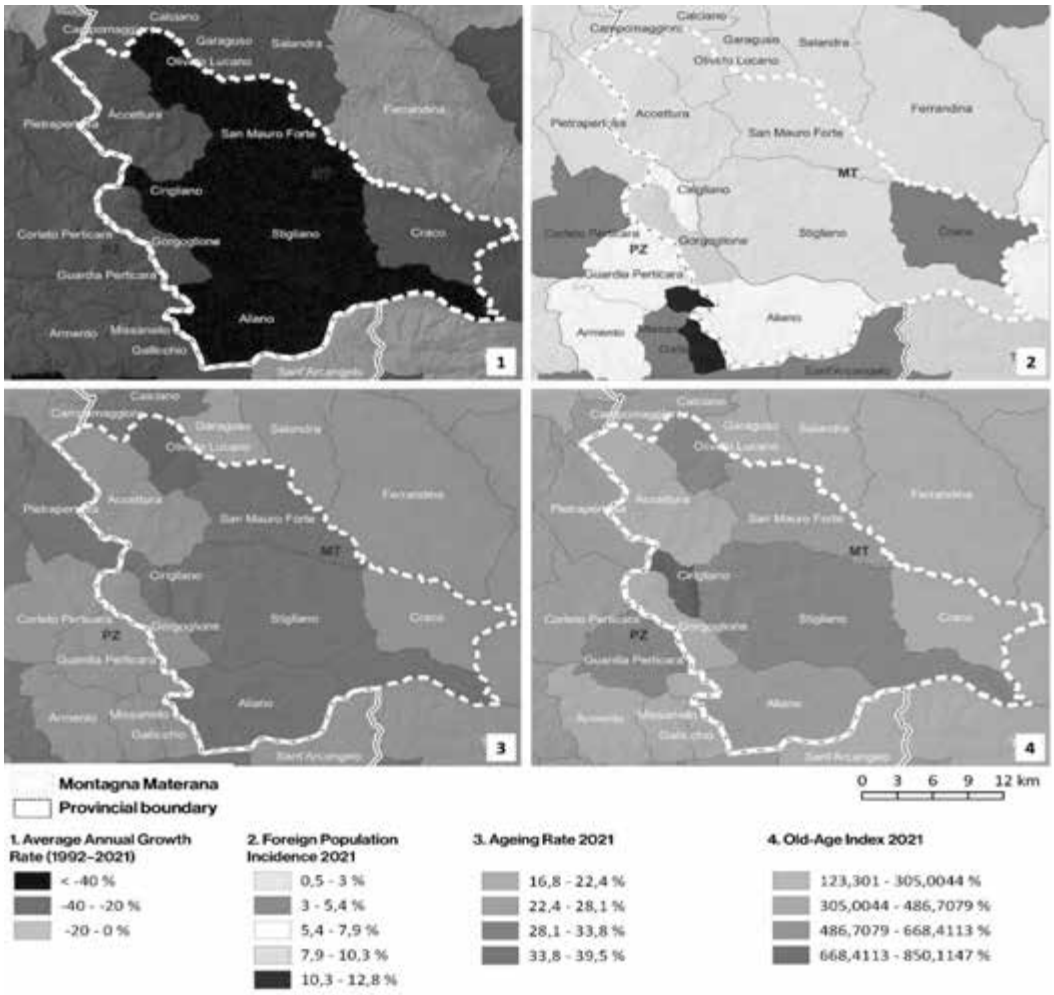

Figure 3. Main demographic indicators: growth rate, incidence of the foreign population, ageing rate, and old-age index. Original elaboration based on Istat data, Statistical Atlas of Municipalities 2021. Authors' elaboration.

In this framework, the experimentation for the GO-IN virtual platform focuses on the portion of the historic centre of Stigliano included in the perimeter of the "Transfer Plan" following the disastrous flood of 1973 and the identification of an area subject to high hydrogeological risk. The area coincides with the oldest part of the settlement, the Rione Terra known as "Chiazza", in which there are sections with severely degraded units that are no longer habitable, including buildings of considerable historical and architectural value (Figure 4). The "Transfer Plan", which has been in force in the area for more than fifty years, prevents any hypothesis of functional recovery/reconversion, consigning the buildings to progressive erosion, accelerated by preventive demolition interventions carried out for public safety reasons.

Figure 4. Collage of photos depicting the Chiazza district of Stigliano. The Mother Church of Santa Maria Assunta stands out within the urban fabric, which is mostly made up of minor historic architecture. The urban voids visible in some of the photos are a direct consequence of preventive demolitions. The historic center overlooks the badland landscape of the Basento valley. Authors' elaboration.

The exposure of historical-artistic artefacts, as well as cultural landscapes, to calamitous environmental events – aggravated by anthropic intervention – highlights the need for new forms and policies for the protection of cultural heritage, both tangible and intangible, and opens up experimentation with new tools for the preservation of knowledge and memory, also taking into account the possibility that this heritage may disappear over time (Parrinello et al. 2024). The project has developed digital documentation of tangible and intangible heritage, analysis of the state of conservation of buildings and open spaces, a census of services and territorial resources, as well as an update of hydrogeological and geomorphological vulnerability assessments. Part of these data will also be included in the virtual platform currently under construction in the framework of the GO-IN project, which will allow their free use.

3.2 The methodological framework for a Virtual Platform

The identification of site-specific needs and resources of the inner area Montagna Materna, Stigliano and the chosen historic neighbourhood helped the conceptualisation of the virtual platform whose main objectives, as

already mentioned, are to integrate and disseminate knowledge on historical and architectural heritage; make information on territorial resources easily accessible; promote a network that connects environmental landscape and cultural assets, small businesses, associations, and local cultural initiatives.

The methodological approach is therefore based on an in-depth, multi-scalar knowledge of the study area and on the principles of making the platform accessible - with freely available content - scalable and reproducible. The proposal involves the creation of a web interface that enables access to digital documentation and interactive contents including a 3D model of the selected historical neighbourhood of Stigliano designed to establish connections and networked routes at multiple scales. This strategic 'node' thus act as a catalyst, trying to extend its impact across a wider territorial extension.

The conceptualisation of the platform is given in the following subsections, which present four main strategic axes, accompanied by a description of the main objectives of each axis, expected results and main tools and procedures to be adopted.

3.2.1 3D digital reconstruction and participatory mapping

The interactive 3D model represents the main innovation of this proposal. This is integrated into an easily navigable web interface, enriching it with informative content and narrative elements that make navigation more engaging. The process starts with a digital survey and 3D modelling, in parallel with designing data architecture – supported by the digital documentation of the site through heritage mapping and cataloguing – multimedia and user interaction methods.

The use of an integrated data acquisition campaign involving both range-based technologies (terrestrial and mobile laser scanners) photogrammetry and image-based tools improves the accessibility of user-digital interaction once the model is published online because the model can be enjoyed from different pint of views: 2D map, 3D perspective, street-level with the guidance of a 2D navigator.

The implementation of the model into a software for the management of interactive 3D models - i.e. 3DVista – allows users to navigate the online space and interact with "hotspots" located on specific objects or areas. The interactive hotspots consist of multimedia content related to the area's cultural and touristic heritage. These contents can be collected through different collaborative mapping tools, as well as, structured and semi-structured interviews.

This phase is preceded by an exploratory effort aimed at engaging different stakeholders and, as much as possible, the local community, in order to identify and bring to light shared, plural, and cultural values. These values may serve as key elements both in shaping visitor itineraries and in constructing a community archive.

3.2.2 Community Digital Archive

The construction of community archives, as previously mentioned, can represent a significant advantage in terms of active involvement in urban regeneration processes (La Rocca et al., 2023). The goal in this case is the construction of an open and evolving archive, accessible online, built together with the community, to document and preserve the cultural heritage of a small town in the internal areas. The process of community involvement and activation begins with the planning of meetings, participatory workshops and focus groups, during which themes and values recognized as shared emerge and are "mapped", subjects bearing knowledge and "interest" for the construction, maintenance and implementation of this tool. The tools used to collect material on the identified themes include the use of more or less structured interviews, the use of questionnaires, participatory mapping and participatory GIS (PGIS), integrating top-down and bottom-up approaches. The database produced is digitized and uploaded to the platform, where it will be freely available for consultation and download. It can be expanded over time by users through forms of online crowdsourcing, subject to appropriate moderation processes. Through the implementation of this system with interactive features such as forums, surveys and the integration of mobile apps for data collection, it can constitute an opportunity not only in terms of memory preservation and support for urban and territorial planning, but also in stimulating the birth of innovative startups, social enterprises, local networks and associations engaged in the territory.

3.2.3 Tourism interaction and immersive storytelling

Mapping this information and making it accessible to all is a way of operationalizing it – making it available not only for general knowledge but also as a tool to support planning efforts, particularly within the framework of cultural-based tourism promotion.

This approach aims to enhance even lesser-known places, creating alternative routes to mainstream circuits. The archive thus becomes an active resource for the development of thematic itineraries that require a methodological framework capable of integrating both expert knowledge and knowledge rooted in the local context. Building on these principles, intangible heritage – such as rituals, dialects, oral histories, and culinary traditions – was also "mapped" through the collection of images and testimonies. To ensure ease of interpretation, the data were organized into thematic clusters and integrated into the 3D model. The grouping follows either a logic of spatial proximity or one of conceptual continuity: in the first case, it is directly highlighted on the model through interactive hotspots; in the second, it is organized within a dropdown menu. The selected thematic layers activate a selective display of hotspots, guiding their exploration according to a defined sequence – either linear or open-ended. The 3D platform includes virtual tours (of both indoor and outdoor spaces) created using 360° photographs, allowing users to immerse themselves and interact with public spaces, historic buildings, handcrafted objects, and artefacts. In this context, the platform will be integrated with physical systems connected to multimedia content (such as QR codes, information panels, and visitor centers), acting as a tool to promote and connect local guides and interactive experiences (e.g., community-recorded audio guides, participatory tours, thematic festivals).

The itineraries may also engage small accommodation facilities, farms, and local producers, helping to create a hybrid network – both physical and digital – that offers immersive experiences, including those related to the region's traditional products. With the aim of promoting virtual forms of interaction – between user and space, and between users themselves – that also have a tangible impact on the physical world, remote experiences will be developed to complement in-person ones (such as virtual markets, educational events, and outreach activities). This is made possible by activating crowdcasting methods of interactive live streaming, enabling people to participate remotely in live events and interact through text comments and reactions via social media platforms (e.g., YouTube Live, Facebook Live, Instagram Live) or through video conferencing software and interactive remote workshops (Rodriguez-Gil et al., 2018). To enhance interaction with the 3D model, encourage community participation during crowdsourcing phases, and stimulate learning and recognition of this heritage among new generations, the platform can also be integrated with gamification tools (such as hotspots with game logic).

3.2.4 Open digital infrastructure and local governance

The Platform, if conceived as a dynamic digital ecosystem, must ensure the active involvement of the community, particularly in terms of the continuous updating and enrichment of its contents over time. For this reason, it is essential to define in advance the management model to be adopted – one that is as sustainable as possible in relation to the technical, economic, and human capacities of those responsible for its operation. In contexts such as inner or marginal areas, the most sustainable model is one that brings together and fosters dialogue between public administration and local stakeholders – associations, third sector organizations, and community-based actors. On the one hand, it is crucial for a local public authority – either independently or in partnership with others – to take responsibility for the platform's operational, technical, and legal management, formally recognizing it as part of its institutional digital services and territorial information systems. On the other hand, placing the full burden of management on such small-scale administrations risks quickly slowing down platform updates and development processes. An integrated management model – shared between public, private, third sector, and local community actors – can instead ensure the presence of dedicated and skilled personnel, enhancing the capacity to access funding through national (e.g., PNRR, Borghi, Cultura Digitale) and European programs (e.g., Creative Europe, Interreg, Erasmus+). This approach leverages complementary expertise and the ability to adopt new tools and languages. However, an integrated model also requires a strong coordination structure to avoid dispersing efforts and to mediate between stakeholders whose interests may not always align.

3.3 Pilot application on the case of Stigliano.

Regarding the pilot application in the case of Stigliano, work is still ongoing. The web interface for the 3D platform has been completed, the photogrammetric model has been optimized for remote access and use, and the

selection and insertion of informational content has begun.

More specifically, with respect to the 3D modeling of the site, an integrated data acquisition campaign (Picchio et al., 2024) was conducted, involving both distance-based technologies (terrestrial and mobile laser scanners) and image-based tools (portable reflex cameras, 360-degree cameras, and UAV systems – DJI Phantom Pro and Mavic Mini). After appropriate metric verification and scaling, photogrammetric altimetric data were produced and further decimated using CloudCompare. These data form the basis of the virtual 3D platform. The model was then imported into the 3DVista software and enriched with multimedia content related to the cultural and tourist heritage of the area. This content was collected through collaborative GIS mapping (ArcGIS Survey123 and Field Maps) and semi-structured interviews with local stakeholders.

The GO-IN website (www.goinprin2022.com) was configured as a multidimensional interactive platform designed to provide access to a variety of multimedia content (some of which is available for download) related to the cultural and tourist heritage of the pilot area. It is accessible from smartphones or tablets without the need to download specific applications and is available in both Italian and English. The content is organized into three sections: Home, Resources, and 3D Platform. The 3D Platform is the main component of the website and consists of a 3D model that functions as an interactive interface: by selecting areas, points of interest, or itineraries, users can directly access contextualized content (Figure 5). The platform demo has currently identified five thematic clusters: Historical Architecture, Murals, Rural Culture, Historical Itinerary, and Online Market. In this case, the design of cultural itineraries and the identification of key themes have benefited from the work of the research group at the University of Basilicata in the Montagna Materana area. For many years, this group has carried out research projects involving the active participation of communities, institutions, cultural operators, and citizens. Through workshops, laboratories, and meetings, values, themes, and places linked to collective memory and community identity have been jointly identified.

The inclusion of a dedicated "online marketplace" cluster allows for the networking of local producers, small artisans, and creatives, fostering the creation of shared itineraries, narrative paths, and showcases designed to promote local creativity and diverse forms of cultural and experiential tourism.

Figure 5. 3D Virtual Platform with thematic interactive hotspots visible on the model; on the side, an example of an interior virtual tour – Museum of Rural Life – and an information sheet from the Architectural itinerary. Developed by Metaheritage srl.

4. Discussion on application in the pilot case

The pilot application, although still under development, already provides valuable insights into the opportunities and limitations of implementing a virtual platform in a peripheral and internal area such as Stigliano.

One of the most significant opportunities is the ability to document and preserve a fragile heritage through digitalization – particularly in contexts where material and immaterial cultural assets are at risk of erosion. Building on this premise, initial demonstration tests of the prototype – conducted with the involvement of the municipal administration and both internal and external technical experts – have shown that interactive features are capable of generating renewed curiosity and engagement with a heritage often "unseen" or unrecognized even by the local community. To further enhance this engagement, particular attention has been paid to the integration of game dynamics and an exploratory dimension within the 3D model. The possibility of creating gamified narrative tours, virtual/physical treasure hunts, thematic quizzes, and collective challenges opens up new educational opportunities and fosters intergenerational interaction. These features facilitate connections between traditional knowledge holders and younger generations, helping to create meaningful bridges across age groups. As a result, new actors and stakeholders emerge at both local and territorial levels, including schools, libraries, educators, and students. In parallel, another promising development lies in the creation of a network of local producers and artisans. Within the platform, these stakeholders can narrate the deep connection between land, people, and production – using tools such as historical documentation and digital storytelling, and providing links to their commercial activities. This fosters an integrated vision of cultural and productive heritage.

However, to draw more robust conclusions, further testing will be conducted once the platform is complete. These tests will involve a broader and more diverse user base – students, tourists, and residents of all ages – to assess the clarity, emotional engagement, and overall usability of the digital narratives. The feedback gathered will be integrated into an iterative refinement process, enabling continuous improvement and contextual adaptation of the platform (Camarda, 2021).

That said, the success and longevity of the platform rely heavily on meaningful community involvement through structured participatory and co-design processes. Without this, there is a risk that the outcomes achieved during the research phase may fade at the end of the project. Participation must therefore be designed in relation to the community's actual capacities, with attention to overcoming a variety of structural and social barriers – including limited human, financial, and infrastructural resources; latent conflicts and misaligned interests among stakeholders; and a general distrust toward time-consuming or politically-driven processes.

In this regard, the choice of participatory techniques and tools for data collection and archiving becomes crucial. When tools are overly technical or not truly collaborative, they may discourage community participation and compromise the platform's future sustainability – particularly its ongoing maintenance and content updating by local stakeholders.

To address this challenge, and to ensure long-term sustainability, the virtual platform and website will be formally handed over – after testing and evaluation – to the technical department of the Municipality of Stigliano, or to other local, regional, or national bodies. Recognizing the digital skills gap that emerged during the project, a series of tailored training programs is planned for municipal staff, professionals, cultural operators, and young people in training. These courses aim to create a local pool of digitally competent individuals capable of maintaining, enriching, and managing the platform, as well as facilitating participatory content creation and knowledge sharing.

5. Conclusions

The use of digital platforms and systems to revitalize inner and peripheral areas through the enhancement and promotion of their cultural and environmental heritage, as well as their cultural and creative scenes, is becoming increasingly widespread and structured. It has demonstrated a strong potential to stimulate new forms of entrepreneurship.

The ongoing pilot in Stigliano fits within a local context that shows certain potential. The historic center, in fact, receives a moderate influx of tourists only during the summer period, mainly due to cultural promotion activities organized by the public administration and local associations (for example, "AppARTEngo" https://www.appartengo.com/). However, these initiatives alone are not sufficient to counter the depopulation trend. It is necessary to connect these cultural realities with others operating at the local, national, and even international levels – actors that can act as external enablers (Milone, Paolucci, 2025). The new opportunities that could emerge would benefit both the local community and potential external stakeholders.

At the core of the GO-IN project lies the idea that, through the replicability of the model proposed for Stigliano, it is possible to activate collaborative networks among neighboring territories that are historically interconnected through shared landscape, social, and economic systems. To achieve this, it will be essential to build alliances with the ecosystem of projects, organizations, and cultural programs that have flourished across the region – especially following Matera's designation as European Capital of Culture in 2019, which gave both the city and the region significant international visibility and strengthened their identity as a prominent cultural destination. Moreover, in a broader multi-scalar perspective, this pilot initiative could also contribute to and integrate with a national network of villages aimed at improving economic, ecological-environmental, and welfare systems.

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The Value of Suqian Water Culture heritage from the Perspective of Cultural Landscape

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Abstract
The perspective of cultural landscape echoes the trend of regionalization, holistic, and dynamic protection of cultural heritage. From this perspective, this study constructs a value cognition framework based on three dimensions, aiming to explore the water culture value of Suqian area. According to history, Suqian formed its unique water network and field patterns under different human-water relationships. Therefore, the value of the water cultural heritage can be distilled into four aspects: the evolutionary history of the coexistence and integration between villages and water, the formation of characteristic water networks and conservancy, the witness of the iteration of modern rural governance and the spirit of water management. Finally, this article proposes strategies providing experience for the protection and revitalization of Suqian area.

Keywords: cultural landscape; Water cultural heritage; Value; Suqian area

1. Introduction

In recent years, the concept of international heritage protection tends to be regionalized, holistic and complex. From the first attention paid to the connection between individual heritage sites and their surrounding environment in the Venice Charter, to the concept of historic towns and urban areas proposed in the Nairobi Recommendation and the Washington charter, and then to concept of cultural landscape, rural landscape and cultural routes proposed in the 1990s, the focus of international heritage protection gradually shifted from individual sites to the whole, and the scope of protection gradually expanded. Meanwhile, the natural and cultural complex heritage has attracted much attention, and the elements of heritage protection are constantly superimposed.

Since the 19th century, the West has carried out extensive investigation and Research on landscape, forming the branch fields as landscape geography and human geography, and laying the foundation for cultural landscape(Xu&Han,2016). Among them, Ratzel systematically expressed the concept of cultural landscape with the word "historical landscape" for the first time, providing an early framework for the studies of cultural landscape(Tang&Jin,1998). In the 1920s, American geographer Carl Sauer created the theory of cultural landscape, claiming that cultural landscape is the result of culture acting on nature, and emphasising the systematic interaction between natural and human society, which formed the core theory of cultural landscape(Sauer,1925). In 1992, the 16th meeting of the UNESCO World Heritage Committee was held in Santa Fe, the United States. The word "cultural landscapes" was proposed for the first time, making it formally different from the cultural and natural heritage, and becoming one of the world cultural heritage types. The word "cultural landscape" was written into the Convention Concerning the Protection of the World Cultural and Natural Heritage(UNESCO World Heritage Centre,2019).

Conceptually, cultural landscape is a complex of the natural landscape and human activities attached to it. It encompasses the overall characteristics within the region, such as the site selection, form and distribution of settlement groups, providing a basis for the regionalization and holistic protection of rural heritage. In terms of value cognition, cultural landscapes emphasize the integration of nature and humanity, and pay attention to the comprehensive value of heritage in multiple aspects such as ecology, culture and society, which can provide a framework for the multi-dimensional value identification of rural heritage. Therefore, taking Suqian area as an example and water culture as a clue, this paper studies the exploration of heritage value from the perspective of cultural landscape. It is of great significance for the regional value identification of general village remains (village clusters without characteristic resources), and is conducive to the implementation of contiguous protection and utilization work of villages.

Based on the current research and literature review, although experts and scholars have long proposed the necessity and urgency of the regional holistic protection and utilization of rural heritage, the protection theories

and methods at the regional scale have not yet formed a universal system, especially in terms of value identification. There is a lack of universally applicable and operational guidance. In the research on heritage protection at the rural regional scale, there are a relatively large number of studies conducted with cultural landscapes as the entry point. The research contents mainly involve the formation mechanism and evolution mechanism of village cultural landscapes, gene identification and map construction of village cultural landscapes, and research on the protection and development strategies of cultural landscapes. For example, Hao Naiyi took the tea culture landscape of traditional settlements in Zhejiang as the research object. Through the analysis of its geographical environment characteristics, such as hilly terrain, humid climate, tea culture activities, traditional architecture centered on courtyards, and beautiful environment, she deduced the formation and evolution process of the local tea culture landscape(Hao,2024). Zheng Wenwu proposed the concept of landscape group genes based on the theory of cultural landscape, identified the common characteristics of traditional villages in Hunan Province through clustering, and constructed a gene map(Zheng,2021). However, the objects of these studies mainly focus on national and provincial key protected villages, and general villages not included in the protection system are rarely involved. Therefore, the conclusion could be drawn that in the vast rural areas of China, villages that have not been included in the protection and inheritance system are rarely studied. Furthermore, most of these villages have remnants rather than heritage. With no value exploration been carried out, the heritage value has not been identified, and few protection and utilization measures have been taken. This further explains the necessity of conducting research on the general village of Suqian in this paper.

In addition, the research on the heritage value system from the perspective of cultural landscapes is relatively detailed. Studies tends to be combined with issues such as comparisons among landscape heritages of the same category, heritage protection and sustainable development. The discussions on its heritage value focus on material aspects such as mountain terrain, water systems, farmlands, and residential settlements, as well as intangible resource elements such as production techniques and folk culture. For instance, Wang Lin pointed out that the constituent elements of the Longji Terraced Fields cultural landscape heritage include topography and landforms, air, unique mountain microclimate and characteristic cuisine(Wang,2009). Shen Xiuying conducted the research on Settlement cultural landscape area. By means of disciplinary methods such as geography, biology and anthropology, she identified and extracted elements including topography, climate, ethnic identity, production and lifestyle, religious beliefs, customs and conventions, building materials and aesthetic concepts and establishing the genetic map of cultural landscapes of different regional settlements.(Shen,Liu&Deng,2006) Spencer JE summarized the heritage elements of agricultural cultural landscapes into six aspects, namely the psychological elements of environmental perception, the political elements of land resource allocation, the historical elements of ethnicity, religion and customs, the technical elements of the ability to utilize land, the agronomic elements of varieties and cultivation, and the economic elements such as the law of value(Spencer,1963). These studies provide a good theoretical and methodological basis for this paper to construct the cognitive framework of heritage value from the perspective of cultural landscape, and help clarify the angles and dimensions of the analysis. This study will construct the framework of value cognition on this basis.

Finally, regarding the research on water cultural heritage, relevant scholars from disciplines such as water conservancy engineering and landscape architecture have respectively explored the value and protection and utilization of water cultural heritage in recent years. Chen Haiying explored the connotation and value of water cultural heritage from the perspective of tourism discipline(Chen et al,2019). Wang Cheng fang explores the value of Guangzhou's waterway cultural heritage from the perspective of spatio-temporal integration and constructs an overall protection system for heritage interpretation(Wang,Wu&Zhang,2021). Kong Fan'en studies the differences in the quantity and type distribution of water cultural heritage in different regions around the world and analyzes its value from the disciplinary perspective of landscape architecture(Kong&Liu,2022).These studies have sorted out and analyzed the value of water cultural heritage in terms of form and culture, but their research objects mainly focus on ancient water conservancy projects. There are relatively few studies and protection practices related to modern and contemporary water conservancy projects, and there is still a research gap.

In conclusion, this paper selects Suqian area as the research object. Firstly, through the analysis of historical archives and the translation of historical maps, combined with field investigation, this study sorts out the

historical evolution of the human-water relationship in Suqian area, especially the historical turning point of water management in modern times. Then, it attempts to construct a value cognition framework from the perspective of cultural landscape. Under this framework, the material space, social governance and Spiritual and culture dimension values can be recognized, along with corresponding carriers of water culture heritage in Suqian area. Finally, based on the above results, this paper proposes strategies for the protection and utilization of contiguous areas. On the one hand, this paper expects to take Suqian as a template, providing an empirical analytical framework for the exploration, protection and utilization of the heritage value in general villages. On the other hand, as the research on modern time water cultural heritage in China is still incomplete at present, it is hoped that this research can supplement and expand the systematic understanding of water cultural heritage in China's cultural heritage protection system. This is also of positive significance for regional ecological protection and the healthy development of the human living environment.

2. The Value Cognition Framework from the Perspective of Cultural Landscape

UNESCO has proposed that cultural landscapes represent the "combined works of nature and of man", and have dynamically evolved along with human activities, witnessing the evolution process of human settlements under the constraints and influence of the natural environment(UNESCO World Heritage Centre,2019).The perspective of cultural landscape emphasises the continuous interaction between human and nature and the regional protection scope. Reflected in the representation of village clusters, it can reflect the common value attributes of villages within the region from three dimensions: material space, social governance and spiritual culture, which enables general villages to be identified, protected and inherited as a cultural landscape as a whole. It constitutes the basic framework of regional value cognition from the perspective of cultural landscape (Fig. 1.).

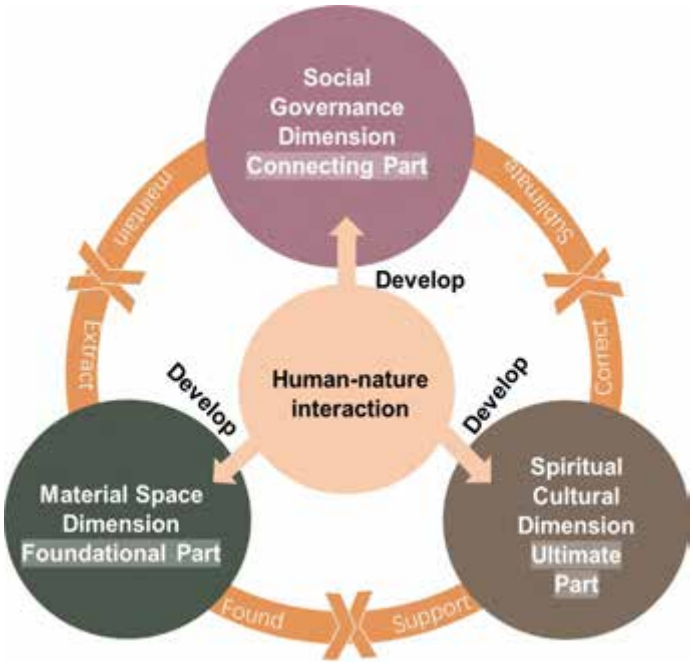

Fig. 1. The Value Cognition Framework from the Perspective of Cultural Landscape. Using a circle to explain the interrelationships among the three dimensions. The value of each dimension is generated due to the interaction between human beings and nature. On the surface, it is the development of material value into social governance value and then into spiritual value. In fact, both social governance value and spiritual value will have a feedback effect on material value.

2.1 Material Space Dimension

The material space dimension is the surface value of the villages. The carriers are usually various material

elements of the village. On the one hand, it includes the characteristics and evolution of the natural environment and settlement forms. On the other hand, it also includes the material interaction between human beings and nature. Such as water network systems, land use patterns, technologies and measures for life, production and ecology which adapted to local conditions (ANTROP,2005). These two aspects above constitute the value of material space dimension.

Furthermore, when constructing the value cognitive framework of general village clusters, in addition to emphasising the value of the human-land relationship, attention should also be paid to the collaborative value of general village clusters from a regional perspective, which focuses on regions with roughly the same cultural characteristics (Wu,1999). On the one hand, the regional perspective identifies the consistency or integrity of the spatial structure, resource environment, and even the cultural structure of villages. On the other hand, it can also grasp the structural relationship of "village-unit-region" in the village cluster. Through the spatial scale division of regions, units and specific villages, it recognizes the consistency or integrity at the regional scale level and the differentiation of the village structure at the unit scale level(Zhang,2015).The value in the material space dimension is the most foundational. On this basis, the value of social governance, as well as spiritual and cultural dimension can be further explored.

2.2 Social Governance Dimension

Based on the material space, with the development of society and the conduct of social activities, people carries out the spatial governance on nature and villages, which has formed the second level of value——the value in the dimension of social governance. The value of this dimension is generally reflected in carriers such as the social governance system, economic and social policies, production models, and social organizational relations. The spatial governance of rural areas is not only the key to maintaining the material interaction between human and nature, but also an important component of the local knowledge system. The human-land interaction in this dimension not only can maintain or correct the value of the material space, but also serve as the basis for extracting spiritual and cultural values.

2.3 Spiritual and Cultural Dimension

The spiritual and cultural value of a village is the cultural and spiritual significance bestowed upon nature and society by human beings in their interaction with nature. Village clusters take cultural commonalities as the main line, by integrating resources, they connect scattered cultural carriers and clarify the ambiguous cultural context. From the perspective of cultural landscape, the value cognition of the spiritual and cultural dimension of ordinary villages carries the regional place identity, cultural identity and ethnic identity. It is a significant part of maintaining community cohesion and pride, and also the basis for community support for the protection of rural landscape(Walker&Ryan,2008).

3. The History of Water Culture in Suqian

3.1 Before the Ming and Qing Dynasties: thrived and declined due to water

In ancient times, with dense water network and numerous rivers and lakes, Suqian was a fertile place suitable for farming, fishing and hunting and living. Ancient cities such as Sizhou City were born due to the Sishui waterway and the Southern Canal.

In 1194, the Yellow River burst its banks in Yanghwu, Henan Province, and changed its course to the southeast, divert the way towards the Huai River.Later, the Yi River flowed into the Yellow River and accumulated to form the Luoma Lake, which was almost unable to discharge floodwaters normally. Therefore, the bottom of the lake gradually silted up and overflowed to the downstream areas, causing disasters. The "Yellow River's diversion of the Huai River" has completely changed the original pattern of the water systems in the Huai and Si River basins, causing the siltation of rivers and the rise and fall of lakes. This has led to soil desertification and alkalization, along with significant changes in the structure of rice crop cultivation. Frequent floods and drought occurred, making the once fertile land turning into a flood-stricken-area. The folk sayings such as "Afraid of both flood and drought, nine out of ten years without harvest" and "If there is rain, there will be flood; if there is no rain, there will

be drought" have become the true portrayal of Suqian.

3.2 From the Ming and Qing Dynasties to the founding of the People's Republic of China(1949): The predicament of water control

During the Ming and Qing Dynasties, the rulers were constantly striving to construct water conservancy projects, hoping to solve the long-standing flood drainage problem. In 1644, the Ma Ling Mountain Ridge was excavated to the north of Suqian County, allowing the water of Luoma Lake to be discharged. It was thus named the Lanma River. In1680, the general governor of the river, Jin Fu, presided over the construction of six dams on the Lanma River. It was thus named the "Liutang River", which serves as the main flood discharge outlet for the Luoma Lake. During the reigns of Emperor Kangxi and Emperor Qianlong, they paid particular attention to the water-control projects in Suqian and both made six Tours of investigation. Emperor Kangxi inspected the projects of the Yellow River, Huai River, Grand Canal, Luoma Lake and Hongze Lake for several times. He went to the sites to measured the water levels in person and discussed water-control strategies with his ministers. Emperor Qianlong issued hundreds of river engineering orders and conducted many projects. It can be seen that during the Ming and Qing dynasties, the rulers played an important role in water-control projects. These deeds also became the poetry of Suqian and formed a part of the local water culture.

In conclusion, From the Ming and Qing Dynasties to 1949, although the Chinese government had initiated some water conservancy projects, due to the limitations of social technology and scientific levels, it was unable to fundamentally solve the problems of floods, waterlogging and droughts. During this period, there were 32 major floods in Suqian, averaging once every four years. Moreover, due to the inability to store and utilize rainfall, only drought-resistant crops could be grown, which was with low and unstable yields. In the event of floods or droughts, the government is powerless, and the common people can only resign themselves to fate and fight against water.

3.3 After the founding of the People's Republic of China(1949): Two peaks of water control laid the foundation for the water network and farmland pattern

After the founding of the People's Republic of China, a wave of water-control campaign has swept across the country. In April 1951, under the leadership of the county committee, the heroic people of Suqian launched the vigorous "Guiding Yi river and regulating Shu river" project. Centering on flood problem, they opened up the New Yi River, a channel for the flood of Luoma Lake to flow into the sea, and built the south embankment of Luoma Lake and the Zaohe Control Gate, Zaohe Small Boat Gate, Yanghetan Gate, forming the first-line flood-control barrier of Luoma Lake (Zaohe Control Line). It became the first large-scale water-control battle of the country after the founding of the People's Republic of China. Since 1957, the government has led the construction of water-control projects of the Middle Canal and the Liutang River, and extended the south embankment of Luoma Lake to the west and north, basically completing the large-scale control project in Suqian. This was the first water-control campaign under the leadership of the government initiated by Suqian people after1949. Centering on flood-control and security, a water-control engineering system was established to solve the flood problem of Luoma Lake. The five major engineering systems and layouts of flood control, drainage, irrigation, waterlogging reduction and water supply in Suqian were basically formed. The human-water relationship also shifted from defense to governance. In addition, the people of Suqian have renovated the old river channels, excavated new rivers for flood drainage, and carried out supporting projects for branch rivers as well as large, medium and small ditches. They have built a cascade river network that is interconnected and coordinated with the ditch network, laying the foundation for the water network system in the Suqian area.

After the flood problem was solved, aiming to address the food issue, government of Suqian made the decision of " Conversion of dry fields to paddy fields "projects, developing irrigation agriculture to increase agricultural output and the living standards of farmers. From the winter of 1958 to the spring of 1959, Suqian gathered more than 100,000 farmers to dig the Second main Canal, the Third main Canal, as well as the first and second branch canals in the Lailong Irrigation District. They carried out meticulous and dense river network construction to transform farmland water conservancy and used lake water for gravity irrigation.Since then, the area of paddy

fields in the region has expanded rapidly, the basic construction of farmland has been improved rapidly, and the number of major agricultural producers has increased. The dry fields in rural areas have been transformed into high-yield and stable fields that guarantee harvests in both drought and flood.This is the second peak of water-control campaign in Suqian. Centering on the transformation from dry land to paddy fields and the construction of irrigation and drainage areas, it developed irrigation agriculture, and laid the foundation for the water system and field pattern in the rural areas of Suqian. Through unremitting efforts to transform nature, the human-water relationship have shifted from people struggling with water to people coexisting with it, from managing water to utilizing it.

Based on the utilization of water, Suqian people have further adjusted their industrial structure around agriculture and industry through the renewal of governance measures. They drew on outstanding cases across the country and attempted the "all-round contract" program in agriculture, starting to grow economic crops mainly including mulberry, and using the silk industry to drive the adjustment of the agricultural planting structure. In industry, the "Gengche Model" was created, where township enterprises led communities and family workshops to develop together, promoting social and economic progress(Fig. 3.).

Fig. 3. The different stages of water history in Suqian area. In Figure a, Suqian has experienced the Yellow River's diversion of the Huai River and the accumulation of Luoma Lake. In Figure b, during the Ming and Qing dynasties, the general managers of the Yellow River dug the Middle Canal and the Liutang River under the emperor's order, attempting to divert the floodwaters. Figure c shows that after the founding of the People's Republic of China, Suqian area experienced two peaks of water control campaigns. Therefore, Suqian gradually formed a tiered water network, laying the foundation for the current water network pattern and farmland layout.

4. The Value and Carriers of Water Cultural Heritage in Suqian

From the perspective of cultural landscape, the human-water relationship in Suqian area is a dynamic process from defense to governance and then to utilization. In this interactive relationship, they jointly constitute the value and carrier system of the village cluster in Suqian area(Fig. 2.).

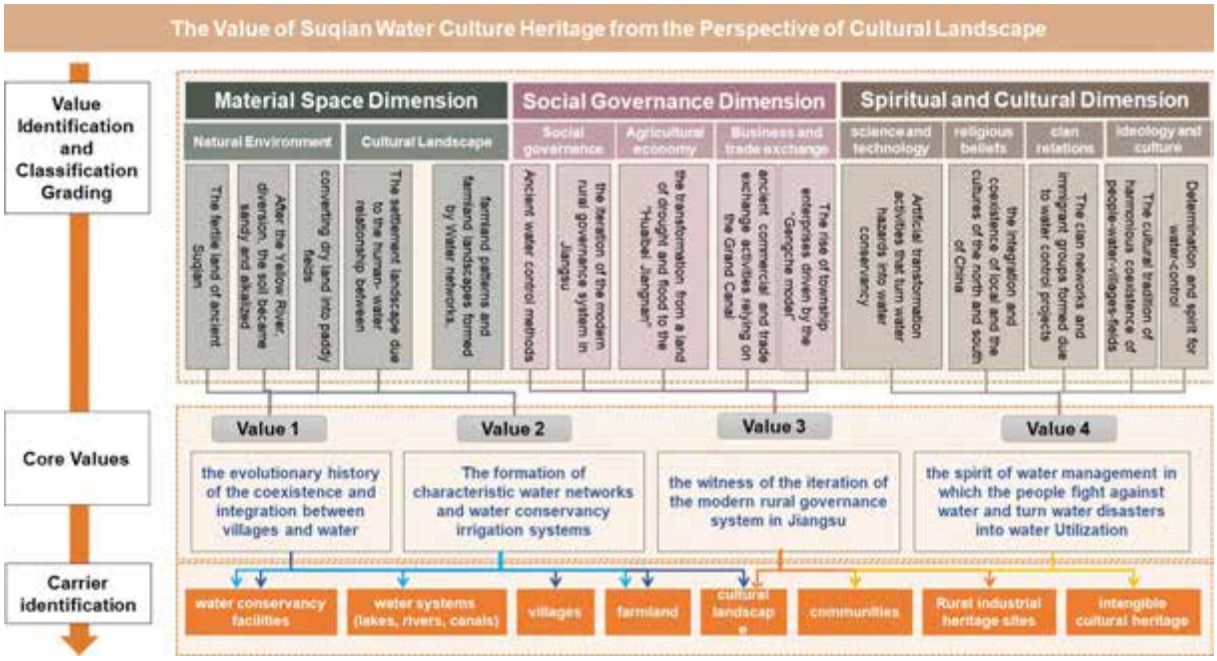

Fig. 2. The Value of Suqian Water Culture Heritage from the Perspective of Cultural Landscape. By classifying and grading the three dimensions, the value of Suqian area in each dimension is comprehensively expounded, and through refinement, the three core values are ultimately determined

4.1 Material Space Dimension: The evolution history of the coexistence and integration between villages and water

In ancient Suqian area, the natural background with its dense water network and fertile land, gave Suqian an thrive in agricultural. At this time, the relationship between people and water in Suqian area was harmonious. The settlements were built along the water and gradually developed into ancient cities. After the Yellow River's diversion, the soil in Suqian rapidly became sandy and alkaline. Coupled with frequent floods and droughts, the people began to fight against water, mainly by excavating the river course to promote the diversion of water from the river. For instance, the Lanma River and the Middle Canal was dug to divert water from the Yellow River system. At this time, due to the tense relationship between people and water, most settlements were distributed in farmlands and forests, maintaining a certain distance from rivers to reduce the losses caused by floods.

After the founding of the People's Republic of China, the relationship of struggle between humans and water continued. However, due to the increasingly improved scientific level, it gradually shifted from defense to governance. Not only did the people continue to excavate for flood diversion, but they also constructed a flood control engineering system with new technologies. In addition, converting dry land into paddy fields and developing irrigation agriculture around Luoma Lake have significantly increased agricultural output, and the relationship between humans and water has further evolved towards utilization and symbiosis. At this time, the newly established settlements showed a trend of distribution along water, which is banded distributed and divided by water systems, forming a settlement landscape where water and villages blend, demonstrating the harmonious coexistence of human and water relations.

Therefore, in the material form dimension, the changes in river systems and the evolution of villages connect different historical periods, witnessing the human-nature interaction and the changes in the human-water relationship, as well as the evolutionary history of the coexistence and integration of villages and water.The carriers of this part of the value mainly fall into two categories. One is the water system in Suqian area, including lakes, rivers and canals. Another category is aquatic cultural landscapes, that is, farmlands and villages that emerged and changed because of water.

4.2 Material Space Dimension: the formation of characteristic water network and water conservancy irrigation system

In this regard, the heritage value of Suqian area mainly lies in the formation of a distinctive water network and water conservancy irrigation system, whose carriers are mainly the water conservancy facilities, artificial water network systems and drainage and irrigation areas after the founding of the People's Republic of China. In Suqian area, a water network system composed of large and small rivers, canals and reservoirs has been artificially excavated, and branch rivers, branch canals and large, medium and small ditches have been artificially divided in the farmland. The water from Luoma Lake is drawn through a tiered water network to serve as Irrigation water source, which was transformed by regular and dense farmland water conservancy in the field. Thus, the water network system and farmland complement each other in the process of human transformation of nature. They not only form a regular grid-like pattern of water system, field pattern and farmland landscapes, but also demonstrate the material interactive value in terms of production technology in the process of human transformation of nature.

For instance, in the Lai Long Irrigation District, before its construction, the land within the district was compacted and alkalized, allowing only drought-resistant crops to be grown, and the people's lives were extremely poor.In 1958, under the leadership of the county government, the broad masses of the people built channels, constructed culverts and sluices, leveled fields and prepared land, and began to switch to growing rice. And through the engineering support, the Yanghetan Gate draws water from Luoma Lake for gravity irrigation. One year later, the rice and crops in the irrigation area gradually increased, and the average annual agricultural output value reached 35 million yuan.

4.3 Social Governance Dimension: Witness to the Iteration of the modern governance System in rural area of Jiangsu

After water control, the material utilization of nature gradually stabilise. People of Suqian established social interaction and began to update and innovate the governance system, pursuing development. This is the value of Suqian's water culture history and its remnants in the dimension of social governance, witnessing the iterative process of the modern governance system in Jiangsu's rural areas.

On the one hand, as for agriculture, Suqian has implemented an "all-round contract" program based on the existing paddy fields, carried out agricultural structure adjustment, by planting economic crops like mulberry. In the industrial field, Suqian has created the "Gengche Model", which has driven the development of township industries through a group and serialized operation mode at the township, village and household levels, witnessing the history of exploring modernization in Jiangsu's rural areas. The main carriers are the industrial sites of the "Gengche model", such as Xiaodian Winery, Daxingchao Silk Factory, Suqian Glass Factory , as well as the related Caoji People's Commune and Xinzhuang People's Commune.

On the other hand, Suqian has merged scattered natural villages and administrative villages based on the renovated water network, and transformed them into new rural communities. Based on the common memory of water control, these natural villages and administrative villages have similar farmland cultivation history and folk cultures. By utilising the cohesion generated by water culture, villagers can well adapt the transformation from different villages to the common rural community shared together. Furthermore, through the joint management of village cadres and community social organizations, combined with the innovative grid-based management approach, the community guaranteed the collaborative governance of multiple subjects.This transformation has facilitated the transformation from traditional villages into new rural communities, highlighting the social governance value of updated models and system based on Suqian's water culture. The main carriers are emerging rural communities such as Liyuanwan Community and Shuangheli Community. This also the important manifestation of Suqian's implementation of the national rural revitalization strategy

4.4 Spiritual and Cultural Dimension: The water-control spirit of Suqian people during their struggle against water and their efforts of turning water disasters into water conservancy

In terms of the cultural and spiritual dimension, the water culture history of Suqian demonstrates values in various aspects such as science and technology, religious beliefs, clan relations, and ideological and cultural categories.

In terms of science and technology, in the face of the floods caused by the Yellow River's diversion of the Huai River, Suqian people have reshaped the water network through projects such as "Guiding Yi river and regulating Shu river" and " Conversion of dry fields to paddy fields ", transforming the threat of floods into irrigation resources, demonstrating the spirit of transformation and the wisdom of technology .

In terms of religious beliefs, since ancient times, the Grand Canal and the well-developed north-south canal transportation have not only generated the circulation of goods and materials, but also facilitated the integration of dialects, folk customs and skills, giving birth to an open and inclusive cultural mindset and cultural genes.In the belief system of Suqian people, they not only Revere the Mazu belief introduced from Fujian, but also worship the canal god of wealth, Guandi, which was brought from Shanxi. All these belief are closely related to water culture. In addition, waterfront customs such as the Zaohe Temple Fair, Dingzui Donkey Running, and Daxing Boat, are also the intangible cultural heritage created in the integration of local cultures and cultures from northern and southern regions of China. They embody the unique personality and character of Suqian region, demonstrate the cultural identity and common beliefs that the people have gathered because of water.

In terms of clan relations, early Suqian predominantly consisted of traditional Chinese villages organized along kinship ties.After the founding of the People's Republic of China, due to the large-scale water control project, the Luoma Lake Mass Migration Incident occurred. The migrants around Luoma Lake settled in communes such as Lailong community, Caoji community and Xinzhuang community, which prompted the collaboration between the clan organizations and the immigrant groups. People build collective identity within water management and establish a new social collaboration network with water as the bond. This not only enhanced the cohesion and sense of belonging of the village clusters in Suqian area, but also enriched the local clan network in Suqian, which was reflected in the names of the roads, factories built at that time.

In terms of ideology and culture, with the continuous changes in the human-water relationship, Suqian area has gradually formed a layout of "ponds-canals-fields-villages", achieving a sustainable cycle between water, fields and people, and solidifying the ecological concept of respecting nature and harmonious coexistence that has been passed down from generation to generation. In addition, throughout the long history of water control, from the 180,000 voluntary labor in the "Guiding Yi river and regulating Shu river"Project in 1951, to the migrants of Luoma Lake who Abandoning their own house to build a reservoir in 1958, not to mention the ten years of continuous efforts in the " Conversion of dry fields to paddy fields "project. Suqian people have never stopped their efforts to transform nature in the struggle against water, showing their determination of making sacrifices and contributions.This indomitable spirit of resistance has become a spiritual symbol of collective resistance against nature, as well as the cornerstone of the spiritual culture of Suqian people.

These spiritual and cultural values are not only the survival wisdom of Suqian people in dealing with natural challenges, but also the core driving force for uniting the community and carrying forward traditions.

5. Strategies of Concentrated and Contiguous Protection

Based on the analysis of the value of Suqian area and its carriers, the strategies are proposed from the perspectives of human-water relationship and village governance, aiming for the concentrated and contiguous protection and utilization of Suqian area

5.1 Reorganizing the water-control cultural routes in the river basin

Taking the history of water control as the clue, a cultural route with the theme of "Transforming water hazards into water utilization " could be constructed in the Lailong Irrigation District. Relying on the water network system of "Lake (Luoma Lake Reservoir)-River (Zhongyun Canal Liutang River)-Canal (Ergan Canal)", the historical story of the development and evolution of the relationship between humans and water will be told in sections. Along the Liutang River to the Second Main Canal, from the starting point of water-control, to the water-control predicament of the Ming and Qing Dynasties, and finally to the two peaks of water-control campaign. Water-control cultural landscape nodes could be set up based on the remaining relics and the main line of historical narrative.

At the micro-scale level, in combination with cultural routes, water-control theme activities can be set up. For instance, water management cultural parks can be created by integrating the remains of water conservancy facilities such as water conservancy heritage parks. River-digging experience activities can be carried out in conjunction with the farmland water conservancy in villages, and related science popularization and education can be conducted. Moreover, water management history exhibition halls can be set up based on new agricultural communities built along water. Showcase and explain the history of water-control in Suqian District and the fighting spirit during the years. In addition, as for villagers, through water pollution control and ecological transformation of ditches and rivers, the original hard revetments can be classified and softened to create various types of waterfront platforms and riverside walkways, recreating the harmonious interaction scene between humans and water, and also providing activity venues for waterfront folk customs during special festivals.

5.2. Jointly building a governance system

Continue to optimize the governance system of the community. From the flexible governance dimensions such as behavioral norms and cultural inheritance, guiding farmers to transform from the traditional geographically oriented village identity and familiar society action model to the modern community citizen behavior model. In this process, the improvement of villagers' self-governance ability and identity empowerment should be guided. It is also necessary to Lay a psychological foundation and provide flexible guarantees for the reconstruction of governance order in new rural communities. Furthermore, through the integration of clan etiquette and legal norms, the governance system of the new rural community has become more practical. While conforming to the humanistic traditions of the settlement, it can also operate in a coordinated and efficient manner.

6. Conclusion

Based on the trend of the regionalization, holistic and complexity of international heritage protection, this paper introduces the perspective of cultural landscape to construct a value cognition framework based on three dimensions: material space dimension, social governance dimension, as well as spiritual and cultural dimension, hoping to expand the focus of heritage protection from individual and typical villages to general village clusters in the region.

Under this framework, this article takes water culture as the clue, sorting out the history of the Suqian area along with the evolution of human-water relationship, and identifies the common values and their carriers in four aspects of the Suqian area, which can be distilled into four aspects: firstly, the evolutionary history of the coexistence and integration between villages and water; secondly, The formation of characteristic water networks and water conservancy irrigation systems; thirdly, the witness of the iteration of the modern rural governance system in Jiangsu; fourthly, the spirit of water management in which the people fight against water and turn water disasters into water Utilization. On this basis, this paper proposes concentrated and contiguous protection strategies such as reorganizing the water-control cultural routes in the river basin and Jointly building a governance system.

The value cognition system constructed in this paper provides a universal method for the value identification of general villages from a regional perspective, and has enlightenment for the protection and revitalization of vast rural areas. Based on this study, more specific regional protection planning methods and technical paths still need to be discussed on a thematic basis in subsequent studies, such as the demarcation of protection areas and so on.

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Research on the Revitalization Modes and Mechanisms of Historical Buildings in High-density Cities: A Case Study of Hong Kong

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Abstract
The conservation and revitalization of historic buildings constitute a critical challenge for high-density cities in balancing urban development with cultural continuity. Hong Kong's practice in this domain offers paradigmatic insights. This study systematically examines the evolutionary trajectory and defining characteristics of heritage revitalization in Hong Kong, identifying three prototypical modes through the analytical framework of multi-stakeholder interest coordination. This study reveals that negotiable interest commonality serves as the inherent driver shaping these differentiated models, with governance processes involving interest concession, value co-creation, and benefit-sharing mechanisms. Hong Kong's experience provides actionable references for Asian megacities undergoing urban regeneration, such as integrating differentiated incentives with rigid protection, synthesizing cultural inheritance with innovation, and strengthening whole-process public participation to forge preservation consensus.

Key words: Revitalization; historical buildings; Benefit coordination; Diverse entities; Hong Kong

1 Introduction

As non-renewable resources in cities, historical buildings' conservation and adaptive reuse yield economic, socio-cultural, and environmental benefits (Gražulevičiūtė and Urbonas, 2011). However, urban central areas in high-density cities frequently confront acute land scarcity (Wang et al., 2015). Conserving historical buildings may reduce government revenue, limiting its ability to allocate resources for other policies (Liu and Tang, 2014), and also restricts land development rights. Thus, historical buildings are often demolished under high development pressure (Yung and Chan, 2016). Hong Kong exemplifies such urban contexts, where historical neighborhoods in Hong Kong Island and Kowloon Peninsula—key development zones—operate under severe land constraints (Ye, 1998). Therefore, how to maximize their socio-spatial value and regenerate aging urban districts remains a pressing scholarly inquiry, particularly regarding balancing conservation imperatives with developmental necessities, thus constituting a critical research imperative.

Hong Kong's historic building regeneration operates within a demolition-redevelopment paradigm, where conflicts arise among governments, developers, and the public over competing conservation and revitalisation agendas. Urban renewal, predominantly driven by real estate interests and governmental land reclamation needs, subjects heritage revitalization to dual pressures of capital accumulation and political prioritization (Xu et al., 2022). Transferring urban development rights to conservation initiatives inevitably diminishes potential economic returns from market-driven redevelopment (Urban Renewal Authority, 2008). Thus, achieving equilibrium between demolition and adaptive reuse fundamentally hinges on institutionalized interest coordination among stakeholders. This positions interest coordination as the critical nexus for resolving revitalization dilemmas in land-constrained metropolises, where optimized institutional arrangements mediate tensions between heritage integrity and urban growth imperatives.

Existing studies predominantly address socio-political dimensions of heritage conservation in Hong Kong, such as public engagement awareness and urban renewal conflicts (Yung et al., 2015). However, systematic examinations through an interest coordination framework remain scarce, particularly regarding dynamic interplay among governmental, market, and societal actors in resource allocation, as well as the stakeholder interest configurations underlying diverse revitalization models. Institutional barriers hinder social institutions' resource access and decision-making participation (Chan and Yung, 2004), while market-driven revitalization exacerbates developer-community conflicts (Lee and Chan, 2008). Community-led initiatives often require external interventions to establish interest equilibrium due to weak endogenous capacities(Ng, 2002), resulting in superficial project evaluations that inadequately dissect power dynamics and resource distribution inequities.

Present research also pays insufficient attention to the operation phase, predominantly centering on preliminary planning and transformation (Langston et al., 2008) but overlooking the dynamic operational processes. Critical issues like functional compatibility of revitalized historical buildings gradually emerge during this stage, yet lack

systematic scrutiny, undermining long-term impact assessments and practical guidance. Moreover, Eurocentric studies on low-density urban contexts inadequately address Hong Kong's high-density specificities. As a typical high-density city, Hong Kong faces unique challenges, such as functional hybridization driven by land scarcity (Cheung and Chan, 2014), complex community networks fostering competing interests (Yung et al., 2014), and necessity for context-specific conservation technologies (Yung and Chan, 2012), which existing studies have inadequately addressed.

From a lens of stakeholder engagement, this study employs a tripartite methodology integrating case studies, in-depth interviews, and documentary analysis to systematically examine core interest coordination mechanisms in historic building revitalization within Hong Kong's urban renewal context. It particularly investigates how institutional configurations mediate interactions among the government, market, and societal actors, elucidating pathway formation processes for balancing multi-stakeholder interests. Based on the interest-balancing logic of different stakeholders, it proposes optimization strategies for high-density cities, aiming to solve the dilemma of historical building protection and urban development coexistence.

2 Revitalization of Historical Buildings in Hong Kong: Evolution and Overview

2.1.Evolution of Historical Building Revitalization in Hong Kong under Urban Renewal Context

Hong Kong has evolved through four stages, reflecting the dynamic interaction of urban renewal and cultural awareness. 1)The Inception Stage (Before 1970). Hong Kong, dominated by economic development and pragmatism, focused on infrastructure and housing construction due to the post-1894 plague demolition and post-war housing shortages. As a borrowed place (Gallagher, 2021), weak public place attachment and an underdeveloped local identity (Lin, 2015) marginalized conservation concerns. 2)The Scattered Conservation Stage (1970–2000). During rapid economic growth, the Land Development Company was established to drive urban renewal, with demolition and new construction becoming the norm. The release of the Antiquities and Monuments Ordinance in 1976 and the formation of related committees marked the government's conservation efforts, but commercial interests still led to widespread demolition of historical buildings, with only limited preservation due to public conservation struggles. 3)The Reflection and Adjustment Stage (2000–2010). Demolition-dominated renewal caused housing rights conflicts(Wu, 1996) and community network disruption(Lai et al., 2018). In 2001, the Urban Renewal Authority (URA) replaced LDC and introduced the 4R strategies, including Redevelopment, Rehabilitation, Preservation and Revitalization, integrating conservation into policy. Post-SARS public resistance to high-density development (Lin, 2015)and conservation movements at places like Wan Chai's Lee Tung Street and Queen's Pier(Audit Commission, 2013) prompted the government to launch the Revitalising Historic Buildings Through Partnership Scheme (Revitalisation Scheme, R-Scheme) in 2008 and the Central Conservation Plan in 2009, significantly enhancing public conservation awareness. 4)The Pro-Active Inheritance Stage (Post-2010).The Hong Kong 2030+ plan established goals of Sustainable Development and Cultural Inheritance. The government explored Conservation through Design and Development strategies (Development Bureau, 2012; Legislative Council, 2011). Projects like the Blue House Cluster and Tai Kwun, winning UNESCO awards, proved conservation-revitalization and economic-development compatibility. By setting up conservation funds and cultural activities to encourage public participation (Development Burea, 2025), society's perception of historical buildings has shifted from physical elements protection to social-cultural inheritance, creating a diverse development pattern with the government, community, and NGOs working together.

This evolution shows Hong Kong's transformative journey from initial neglect of historical buildings to valuing conservation due to social conflicts and public awakening, and then achieving a preservation-development balance via policy innovation. It offers a paradigmatic case study for cultural continuity in high-density cities. Overall, Hong Kong's urban renewal focuses on historical conservation after large-scale demolition and redevelopment. Within this context, Hong Kong's historical building conservation and revitalization reflects a sustained negotiation to balance socio-cultural values under a strong economic-interest orientation.

2.2 Historical Building Revitalization in Hong Kong

In Hong Kong, historical buildings are categorized as Declared Monuments and Graded Historical Buildings. The first is protected under the Antiquities and Monuments Ordinance[1]. The Antiquities Advisory Board (AAB) assesses

1 This legal designation enables the Authority to prohibit any alterations to the monument or, at its discretion, impose conditions that must be complied with when alterations are made, ensuring statutory protection measures are enforced for the protection of the monument.

historical buildings using six criteria: historical, architectural, group, rarity, social and regional values, and integrity (Antiquities and Monuments Office, 2005), grading them into Grade 1, 2, or 3[2]. These graded buildings lack legal protection, and owners can demolish them (Gallagher, 2021). From Hong Kong's published list of 1,444 historical buildings (Antiquities Advisory Board, 2025a) and supplementary list (Antiquities Advisory Board, 2025b), over 70% are privately owned.

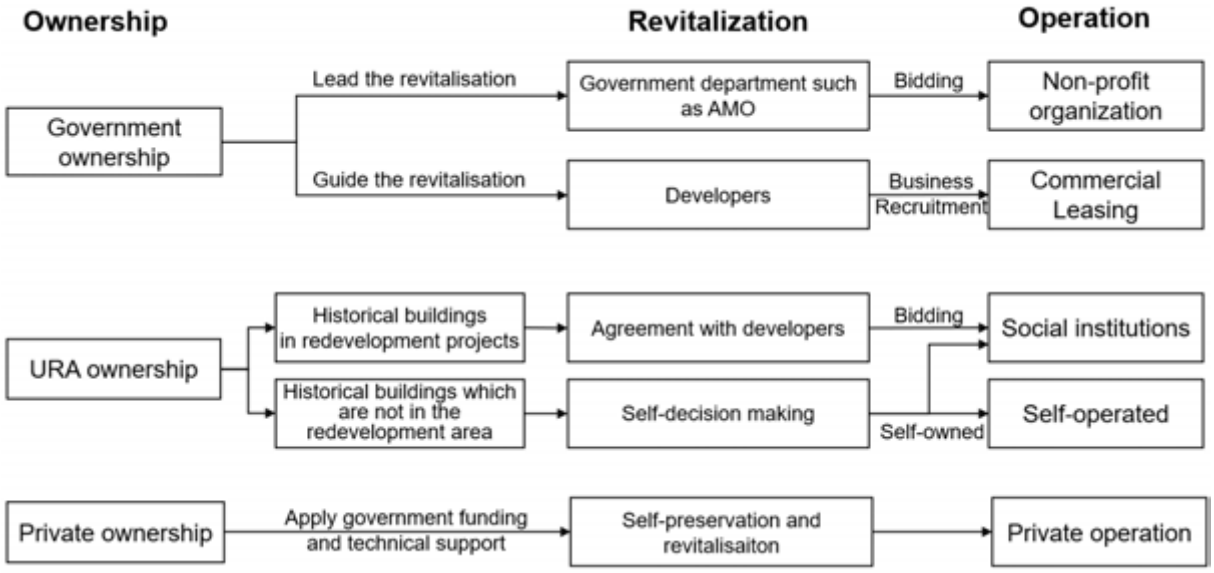

Figure 1. The Revitalization Pathways of Historic Buildings in Hong Kong
Source: By author

Hong Kong's historical building revitalization operates through three property-rights frameworks, forming multiple revitalization paths based on government, URA, and private ownership (Figure 1). Government-owned buildings are revitalized through the R-Scheme, where non-profit organizations are introduced to create public cultural spaces. For buildings with commercial potential, market capitalization is brought in via public bidding. The former Marine Police Headquarters (1881 Heritage) exemplifies heritage-commercial integration, transforming cultural assets into commercial value (Rong et al., 2017). Additional strategies include adaptive reuse as public museums (e.g., Kom Tong Hall as Dr. Sun Yat-sen Museum) or governmental offices (e.g., Old Supreme Court Building as Court of Final Appeal), ensuring functional continuity.

URA-owned buildings are managed with ownership control. Tenant compensation follows district-based property valuation standards(Urban Renewal Authority, 2024), and special projects (e.g., Wing Lok Street) get targeted subsidies like the Home Improvement Allowance (Press Release, 2010). URA executes two typologies: Preserved Buildings in Redevelopment Projects, i.e, contextual conservation integrating heritage elements within redevelopment zones, and Pure Preservation and Revitalisation Projects. From now on, URA has preserved over 60 buildings (Urban Renewal Authority, 2025)through self-operated or leased cultural and commercial programs.

In privately owned historical buildings, owners can revitalise cultural heritage through independent functional transformation. For instance, the Grade III historic residential building at 11 Yuk Sau Street was converted into the F11 Poto Museum, focused on photographic art. The Nan Fung Cotton Mills, an industrial heritage site, was revitalised into an experiential retail and textile art complex. Owners of graded buildings can apply for the Financial Assistance for Maintenance Scheme on Built Heritage with a maximum of HKD 6 million per project. However, grantees must commit to not demolishing or transferring ownership during repairs and allow reasonable public access (Commissioner for Heritage's Office, 2024).

2 Grade 1: Buildings of outstanding merit, for which every effort should be made to preserve if possible. Grade 2: Buildings of special merit; efforts should be made to selectively preserve. Grade 3: Buildings of some merit; preservation in some form would be desirable and alternative means could be considered if preservation is not practicable.

As historical buildings are bundles of cultural heritage, economic resources, and living spaces, their revitalization involves conflicting interests of the government, markets, residents, and civil society. These conflicts manifest in tripartite value contests: authenticity preservation, economic viability, and community equity (Aigwi et al., 2021). Thus, regardless of revitalization pathways, core challenges stem from divergent stakeholder interests and their dynamic interplay. In Hong Kong's high-density context, land scarcity intensifies the conflict between conservation and development. Market-led commercialization can cause gentrification and squeeze public cultural rights (Yung and Chan, 2016). Top-down planning, lacking participatory mechanisms, often disconnects from communal cultural aspirations (Ng, 2018). Mandatory public access requirements in privately-owned heritage spark private-public domain boundary disputes over residential privacy and usage restrictions(Luo and Wen, 2025). These tensions not only hinder revitalization but also undermine social consensus, highlighting the urgency of establishing interest-coordination mechanisms among different entities. Moreover, the long-term sustainability of historical building revitalization requires full-cycle investment, yet high costs deter market, social, and resident participation (Fang and Wu, 2025). Therefore, only by using interest coordination as a starting point and identifying the root of conflicts among entities can we protect cultural authenticity while accommodating diverse interests. This can transform historical buildings from conflict arenas to symbiotic value platforms, ensuring sustainable revitalization of cultural heritage in high-density cities.

3 Revitalisation Modes Under Different Interest Coordination Mechanisms and Case Studies

From the perspective of interest coordination, Hong Kong has established three typical stakeholder collaboration modes in the historical buildings revitalization: the government-social institution collaboration mode, the market-led with benefit recirculation mode, and the community-engaged co-creation mode. These modes balance the demands of multiple stakeholders, achieving coordinated conservation and development.

3.1 The Government-Social Institution Collaboration Mode

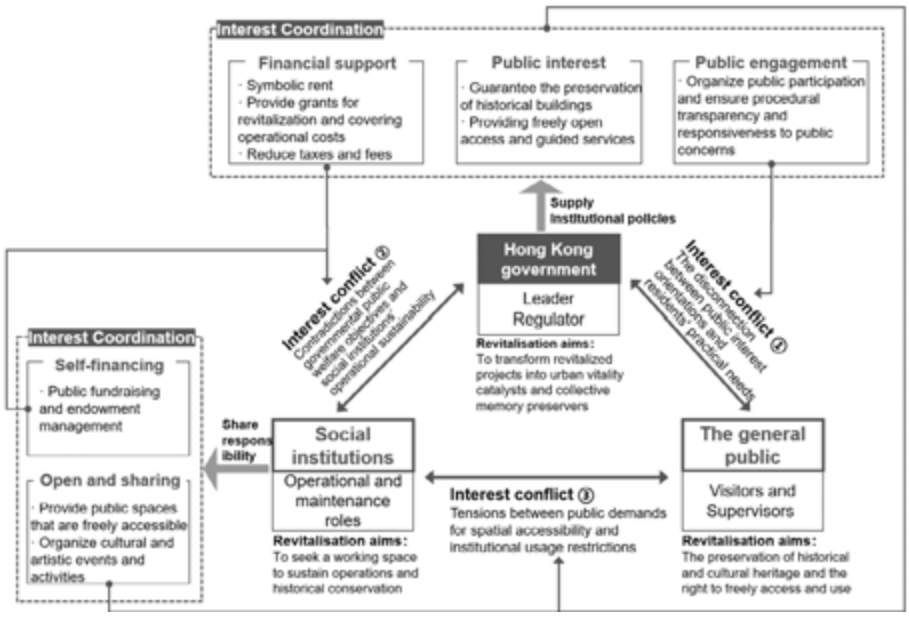

Figure 2. Operational mechanism of the government-social institution collaboration mode Source: By author

This mode is commonly applied in revitalizing government-owned historical buildings. As illustrated in Figure 2, this mode prioritizes government funding and policy-driven initiatives, focusing on public domains such as cultural exhibitions and community services while strictly limiting commercial development. Within this framework, the government assumes the leading role in overseeing and regulating the revitalization process, aiming to transform

revitalized projects into urban vitality catalysts and collective memory preservers. Social institutions, such as non-profit organizations (NPOs), assume operational and maintenance roles, seeking a working space to sustain operations and architectural conservation. The general public, as the visitors and supervisors of these projects, is mainly concerned with the preservation of historical and cultural heritage and the right to freely access and use the spaces. Divergent stakeholder interests arising from distinct roles often trigger three types of conflicts, including contradictions between governmental public welfare objectives and social institutions' operational sustainability, tensions between public demands for spatial accessibility and institutional usage restrictions, as well as the disconnection between public interest orientations and residents' practical needs. To address these, the government coordinates the interests of different parties through institutional arrangements. It offers symbolic rent and tiered financial support to NPOs, such as providing grants for revitalization projects and covering operational costs for the first two years (Commissioner for Heritage's Office, n.d.). The government also implements stringent application reviews and supervision mechanisms to guarantee reasonable preservation, freely open access and guided services. Furthermore, the government organizes public participation to ensure procedural transparency and responsiveness to civic concerns. Selected social institutions collaborate with the government to fulfill obligations, alleviating financial burdens through public fundraising and endowment management while proactively opening historical buildings. In this way, a collaborative mechanism that balances the interests of all stakeholders is established.

The Former Explosives Magazine(Asia Society Hong Kong Center)

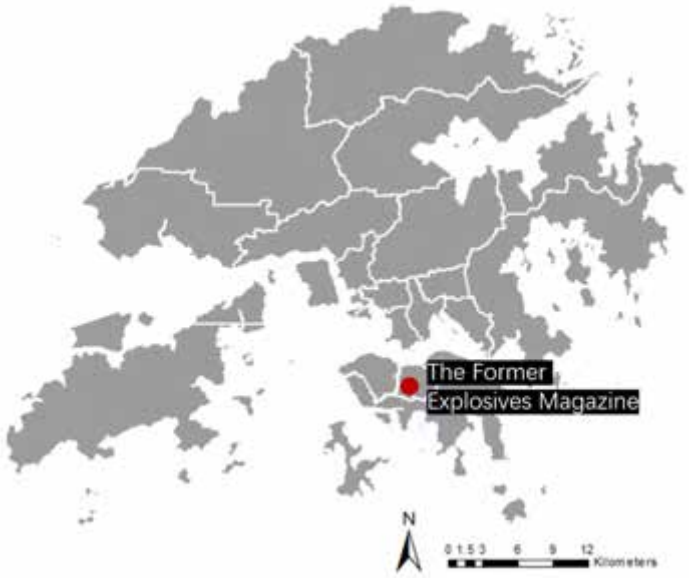

Figure 3. The location of The Former Explosives Magazine
Source: By author

The Former Explosives Magazine, located in Admiralty, Hong Kong Island(Figure 3), is part of the Victoria Barracks, one of Hong Kong's oldest military camps. It comprises four historical buildings, three of which are Grade I and two are Grade II[3]. In 2002, the Hong Kong Government, in collaboration with the non-profit Asia Society Hong Kong Center, leased the former depot site via Private Treaty Grant[4] at a nominal rent of HKD 1,000 to revitalize it

3 A mid-19th century explosives magazine (Magazine A, Grade 1 historic building), an early 20th century explosives magazine (Magazine B, Grade 1 historic building), a mid-19th century laboratory complex (Old Laboratory, Grade 1 historic building), and a 1930s military barracks (the GG Block, Grade 2 historic building).

4 Private Treaty Grant: Land allocation in Hong Kong primarily occurs through public auction for private residential and commercial developments. Under exceptional circumstances, specific projects aligning with established policies and contributing to Hong Kong's socio-economic needs may obtain land through private treaty grants. https://www.landsd.gov.hk/en/land-disposal-transaction/land-transaction/private-treaty-grant.html

as the Asia Society Hong Kong Center's headquarters and a cultural museum. After formally taking possession of the site in 2005, the Asia Society initiated the revitalization project in 2006, completing it in 2012(Figure 4). In the adaptive reuse of these buildings, A and B Warehouses were converted into an exhibition hall and a 100-seat multifunctional theater. The old laboratory was repurposed into meeting rooms and offices. GG Barracks became the administrative office space for the center. To meet modern functional requirements, the project added new service buildings and linked the historical structures with a contemporary bridge (Figure 5), merging old and new elements into a cohesive cultural space.

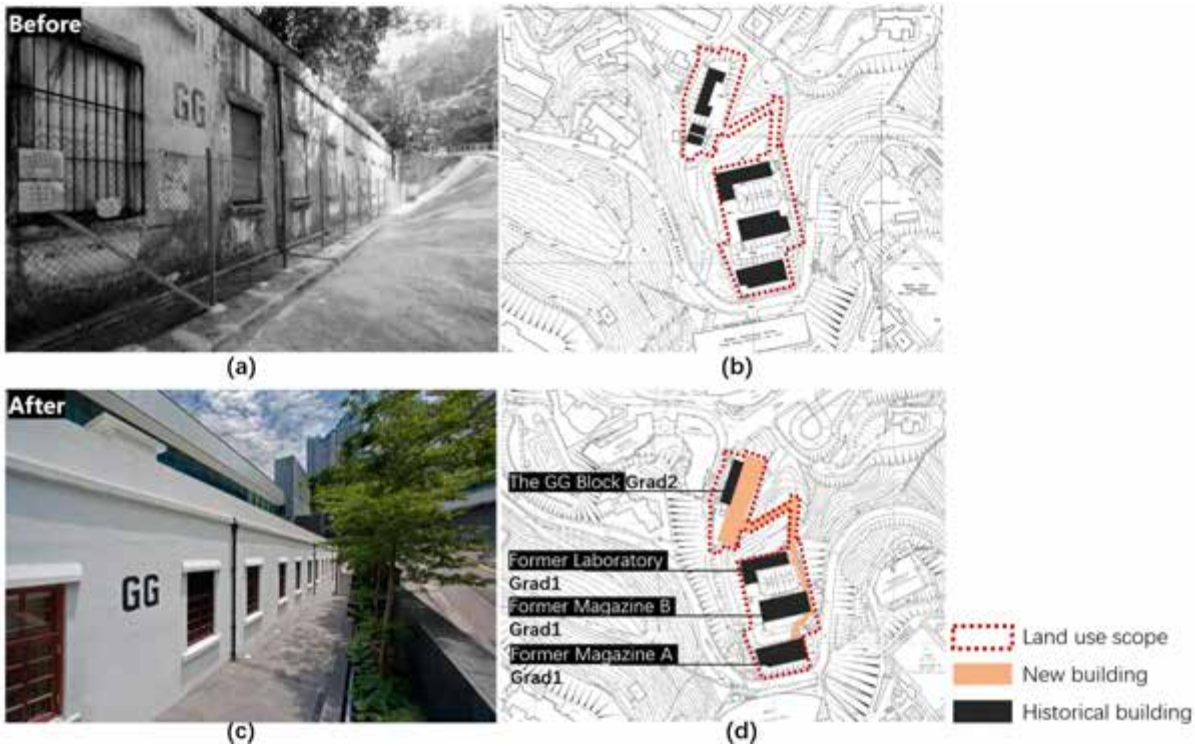

Figure 4. The Former Explosives Magazine before and after revitalization
Source: (a)(c)Asia Society Hong Kong Center;(b)(d)by author

Examining the Asia Society Hong Kong Center revitalization project through the lens of interest coordination reveals a dynamic interplay of competing demands and reconciliation mechanisms among multiple stakeholders. Initial conflicts primarily arose from public and conservation groups concerned about potential compromises to the historical authenticity of the ordnance depot and its ecological context (The Conservancy Association, 2002). These objections delayed project implementation, extending the timeline from the 2002 agreement to a 2005 groundbreaking, prolonging the construction period to 13 years. Concurrently, the budget doubled from HKD 200 million to 400 million, with sustained high operational costs (HKD 30-40 million annually), exposing resource allocation challenges for social institutions in heritage revitalization (Cummer, 2021). The government's symbolic lease arrangement (HKD 1,000 for a 21-year term) and the Asia Society's reliance on philanthropic donations drew public criticism as elitist, perceived as creating a private club for Hong Kong's elite (Chan, 2016).

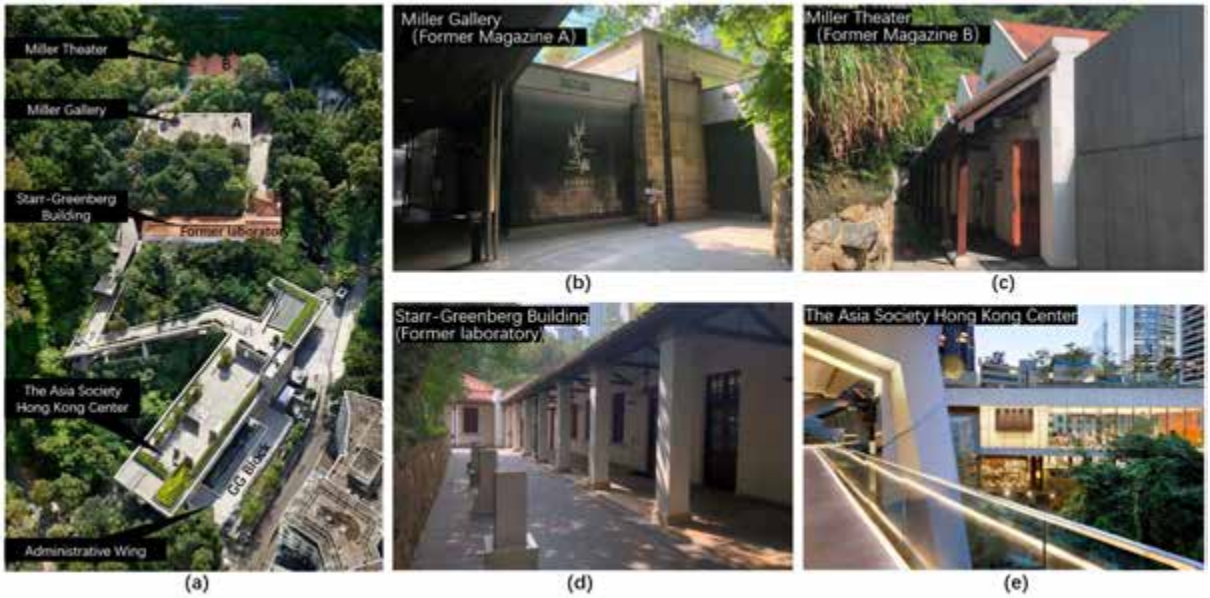

Figure 5. The revitalized former explosives magazine has become the headquarters of the Asia Society Hong Kong Center
Source: (a) K.Cummer;(b)(c)(d)(e)Asia Society Hong Kong Center

Facing initial public skepticism, the ASHKC later eased tensions through multi-dimensional cooperation. Financially, it established a mechanism led by social capital with government support. All HKD 400 million construction funds came from private donations, including HKD 102.5 million from the Hong Kong Jockey Club (Legislative Council, 2005). The government only offered maintenance subsidies in 2023-2024 via the Historic Buildings Maintenance Sponsorship Scheme, reinforcing the non-profit mandate by allocating all revenues to operational upkeep and enhancing resource allocation transparency. In terms of space use, the Center implemented inclusive measures such as complimentary guided tours(Asia Society, 2023) and public art exhibitions, transforming the revitalized heritage site from an elite enclave to a socially shared space, thereby gradually dispelling public distrust. The adaptive reuse of the Former Explosives Magazine, including the conversion of Buildings A/B into exhibition halls and a theater, achieved a balance between historic preservation and contemporary cultural functionality. This approach garnered professional acclaim, demonstrating practical value in reconciling philanthropic funding, governmental oversight, and public demands.

3.2 The Market-Driven with Benefit Recirculation Mode

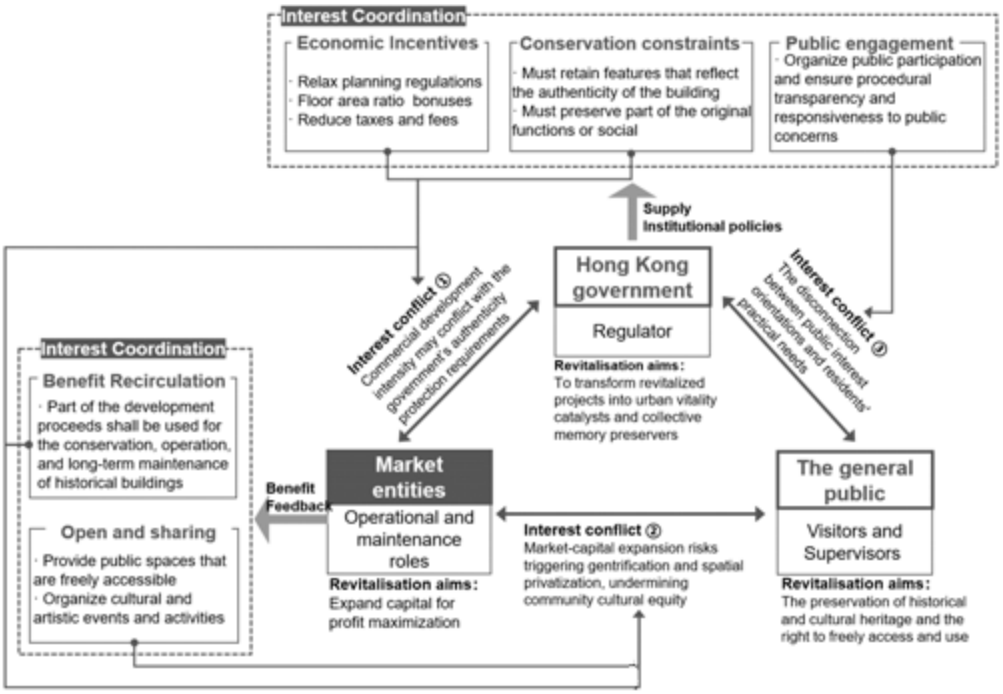

Figure 6. Operational mechanism of the market-driven with benefit recirculation mode
Source: By author

This mode is primarily applied to private historical building revitalization, a developer-led process. As Figure 6 shows, market entities, as operators and maintainers, leverage the building's cultural value to expand capital space for profit maximization. The government assumes a regulatory role, enforcing conservation obligations while promoting these projects as new urban vitality drivers. The public, as users and supervisors, prioritizes heritage continuity and equitable access to revitalized spaces. This mode also faces multiple stakeholder conflicts. Market-capital expansion risks triggering gentrification and spatial privatization, undermining community cultural equity. Commercial development intensity may conflict with the government's authenticity protection requirements, potentially degrading historic fabric through over-renovation. Insufficient profit margins may deter market participation, compounded by misalignments between regulatory efficacy, public expectations, and functional mismatches with community needs. To reconcile these conflicts, the government implements dual regulatory mechanisms. Policies like floor area ratio (FAR) bonuses and relaxed planning regulations reduce revitalization costs and enhance commercial feasibility. Technical conservation guidelines limit development intensity, enforce adaptive reuse standards, and embed authenticity protection in plans. Concurrently, a portion of commercial revenues must be allocated for building maintenance, with designated public access zones to mitigate the impact of capital expansion on public interests. Market entities reciprocate by reinvesting profits into conservation, environmental improvement, and public cultural services, fostering a symbiotic cycle where commercial operations sustain conservation efforts, which in turn enhance commercial viability.

The former headquarters building of CLP (CLP Pulse)

Figure 7 The location of CLP Group Headquarters
Source: By author

The former headquarters of China Light and Power Company (CLP), situated on Argyle Street in Kowloon (Figure 7), was originally constructed in 1940 and embodies profound urban historical significance. This three-story reinforced concrete building features brick-patterned ceramic tile cladding, exemplifying distinctive Art Deco architectural motifs. In 1959 - 1968, two adjacent residential buildings were converted into offices (Figure 8) and linked to the headquarters, expanding the complex. The building's clock tower once served not only as a critical public timekeeping facility but also as a local landmark, silently bearing witness to Kowloon's developmental trajectory. Historically, residents frequently paid electricity bills on-site, forging an enduring connection between the building and community life, thus solidifying its role as a living repository of collective urban memory (am730, 2023).

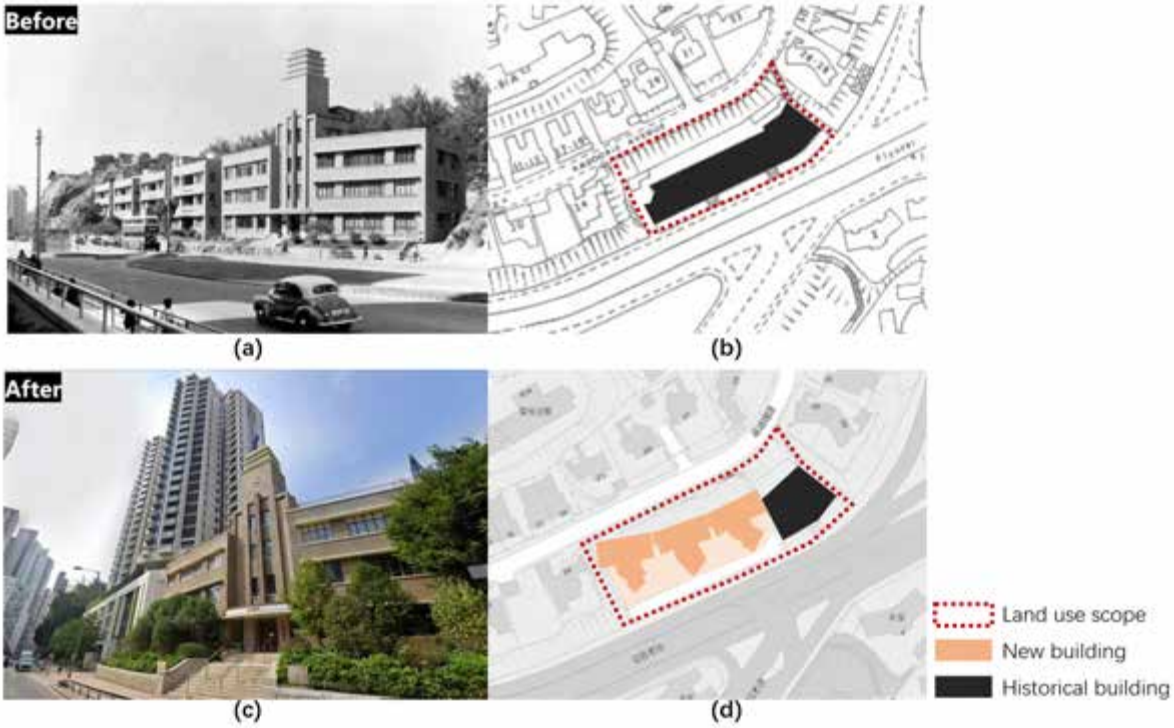

Figure 8. The former headquarters of CLP before and after revitalization
Source: (a)CLP Pulse;(b)(d)by author; (c)Google Street Map

From the lens of interest coordination, the revitalization of CLP Group's former headquarters has been marked by conflicts and coordination among multiple stakeholders. The initial contradiction between redevelopment returns and cultural preservation emerged when the government-approved 43-story residential redevelopment plan (2001) directly clashed with authenticity preservation demands following the building's proposed Grade 1 heritage designation in 2009.CLP contested the heritage status based on commercial priorities, suspending the redevelopment plan. In 2011, CLP provided a proposal for partial conservation with partial redevelopment, sparking new disputes. Local residents raised concerns that three residential buildings, forming a 70-metre-long and 100-metre-high screen wall, might cause canyon effects and trap vehicle exhaust fumes (Green Sense, 2011), highlighting tensions between high-density development and environmental rights. Conservation groups insisted on preserving the entire building and opposed only keeping the clock tower, criticizing the fragmented protection approach (Oriental Daily, 2011), exposing fundamental disagreements over commercial development intensity versus authenticity preservation.

In response to these conflicts, the government facilitated interest balancing through policy adjustments. Development rights were transferred to market entities. The Town Planning Board approved CLP's partial demolition plan, relaxing building height restrictions from 80 meters to 100 meters and increasing the FAR to 5.5 (Oriental Daily, 2012). These measures compensated for floor area losses due to heritage retention, incentivizing corporate conservation participation. Simultaneously, conservation clauses enabled a 23% reduction in land premium payments for China Light and Power in 2018 (Ma, 2018), further motivating market engagement through fiscal concessions. CLP reciprocated by fulfilling social responsibilities through functional adaptation. The clock tower was revitalized as a cultural center (Figure 9), hosting free public exhibitions such as Power World and Humanity & Intangible Heritage, alongside multilingual guided tours (English, Cantonese, and Mandarin). This transformation established a hybrid space for historical interpretation, cultural education, and community interaction. By reallocating commercial profits to public cultural services, the company addressed demands for equitable cultural access, demonstrating responsiveness to civic rights.

Figure 9. After revitalization, the former headquarters of CLP has been transformed into a public space integrating historical display, cultural education, and community interaction
Source: CLP Pulse

3.3 The Social-Engaged and Community Co-Creation Mode

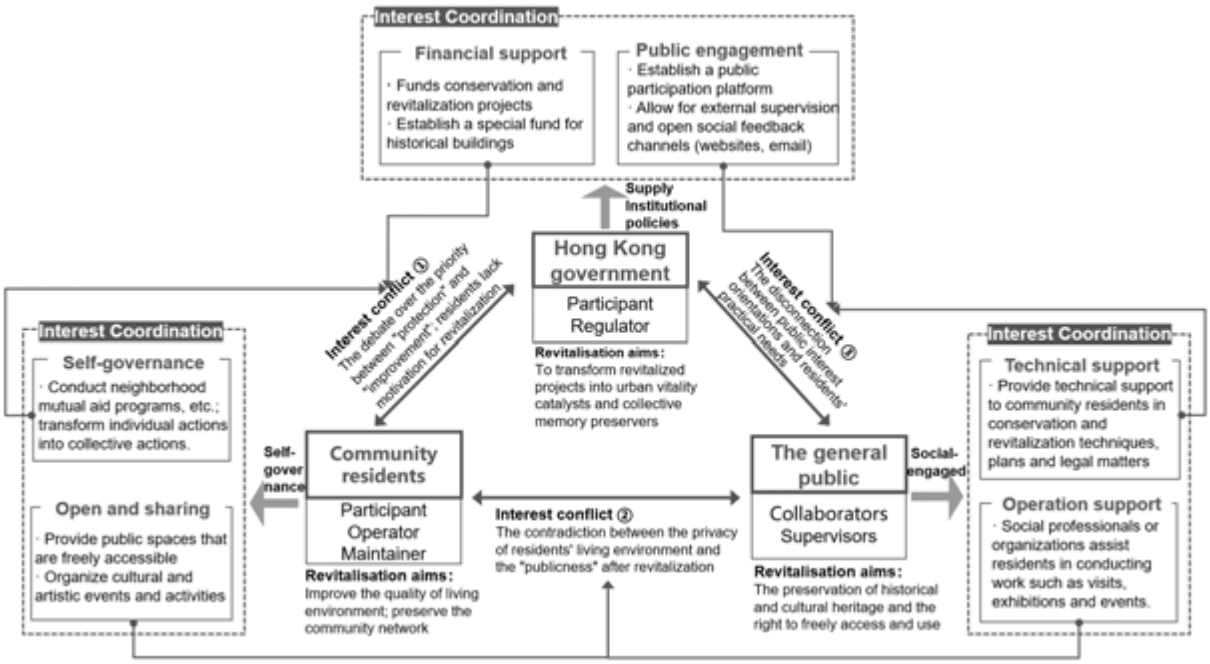

Figure 10. Operational mechanism of the social-engaged and community co-creation mode
Source: By author

In this mode (Figure 10), residents, merchants, and tenants within historic buildings serve as core participants who act as both operators and maintainers of revitalization projects. Their primary objectives involve improving residential environmental quality while preserving their essential social networks (Ng, 2018). The public transitions from traditional users to co-creation participants, while the government assumes dual roles as both participant and coordinator, striving to stimulate new dynamics for regional development while preserving urban historical and cultural heritage. Key conflicts of interest manifest in four dimensions: 1) the tension between residents' privacy requirements and the post-revitalization publicization of buildings; 2) the divergence between governmental prioritization of historical environmental authenticity and residents' practical needs for environmental improvements; 3) diminished participation incentives due to high revitalization costs; and 4) cognitive disparities between governmental revitalization objectives and public perceptions regarding resource allocation and participatory rights. To reconcile these conflicts, the Hong Kong government has implemented institutional support through financial mechanisms and public engagement strategies. This includes direct funding for conservation projects and the establishment of special funds to alleviate residents' economic burdens. Residents, tenants, and merchants engage in co-construction through neighborhood mutual assistance and community self-governance, while appropriately opening shared spaces to facilitate public access to historical-

cultural resources. Social stakeholders, including experts, scholars, and professional institutions, provide technical support in revitalization strategies, design solutions, and legal consultation. They assist in organizing cultural activities such as guided tours and exhibitions, fostering collaborative efforts between residents and social forces to establish a "living community" that achieves integration of historic building preservation, community quality enhancement, and cultural inheritance.

Staunton Street/ Shing Wong Street(H19)

Figure 11. The location of Staunton Street/ Shing Wong Street(H19) Source: By author

The Staunton Street and Shing Wong Street community, located in the Central District, Hong Kong Island (Figure 11), traces its origins to mid-19th century commercial development. Initially evolving into an international lower and middle class settlement where Chinese-Portuguese labor families established roots, Staunton Street gradually developed into 30 tenements, namely Tong Lau (唐樓)[5], by the late 19th century. These buildings collectively formed the culturally and historically significant landmark known as Thirty Houses (卅間). During the early 20th century, Dr. Sun Yat-sen frequented the area, which became a significant hub for Hong Kong's early educational institutions, revolutionary networks, and newspaper industry, marking its critical role in the city's printing history. Post-World War II reconstruction transformed it into a vibrant community characterized by wet markets, restaurants, and close-knit neighborhood ties. Since the 1990s, urban road planning initiatives have enhanced community vision, preserving historical heritage while elevating community identity(SVhk, 2019). As such, this neighborhood embodies not only layered historical narratives but also a cultivated cultural distinctiveness (Figure 12).

5 Tong lau were historically inhabited only by Chinese people, hence they are commonly referred to as "tong lau". This architectural style was quite common in towns and cities of southern China during the 19th century.

Figure 12. H19 before and after revitalization
Source:(a)(c) URA; (b)(d)by author

Examining the H19 community revitalization project through the lens of interest coordination, its progression demonstrates a characteristic trajectory of conflict eruption, multi-stakeholder negotiation, and mode innovation. Intense conflicts of interest emerged since its launch. The 2003 commercial-residential redevelopment plan proposed by URA triggered dual opposition from residents and conservation advocates. Residents demanded fair compensation (referencing property appraisal values in the same district), tenant rights protection, and transparent communication mechanisms, citing severe building dilapidation and prolonged project stagnation due to litigation (Legislative Council, 2004). Concurrently, civic groups and conservation organizations advocated preserving the historical fabric and community culture embodied in this tenement community (Press Release, 2010), directly challenging URA's initial high-density oriented redevelopment. The 2010 film Echoes of the Rainbow, using Wing Lee Street as its backdrop, amplified public demands for preserving urban memory (Lui, 2022), exposing fundamental contradictions between commercial development and cultural conservation, as well as between residents' livelihood rights and urban renewal efficiency.

To reconcile the interests of all parties, the government and the URA adjusted the plan and introduced community-engagement initiatives. URA abandoned the original high-density development scheme, reducing the plot ratio from 8 to 4.5 (Press Release, 2010). Aligned with the revitalization policy for the former Hollywood Road Police Married Quarters, Wing Lee Street was rezoned as a Comprehensive Development Area in 2011 and further designated for cultural-historical community use in 2020, shifting from demolition-redevelopment to preservation of historical-cultural ambiance(Legislative Council, 2012).In terms of implementation, URA introduced a community-engagement mode in 2019, commissioning Social Ventures Hong Kong (SVhk) to establish a multi-stakeholder platform integrating residents, conservation groups, and professional institutions. Through sustained dialogue, this collaborative process developed an inclusive revitalization framework(SVhk, 2019). The plan transformed tenement buildings into mixed-functional complexes featuring "co-living units + retail units + community-making units," preserving the terrace-style urban fabric while providing housing improvement options.. Socio-culturally, residents' self-organized activities, such as community nurseries and plant-sharing programs, strengthened neighborhood bonds. Intergenerational integration was fostered through youth-elderly co-working spaces, while economic sharing concepts revitalized community vibrancy (Figure 13). Concurrently, URA implemented a building rehabilitation program with owners' associations to enhance environmental quality, and commissioned professional organizations to manage co-living projects. This approach achieved multidimensional progress encompassing physical restoration, social network cultivation, and cultural value regeneration.

Figure 13. After revitalization, H19 has become a community shared space.Source: Co-living Unit and Community farm, URA; Community-making units,by author

4 Discussion

4.1 The comparison of the three modes

Hong Kong's three interest coordination modes for historic building revitalization in high-density urban contexts demonstrate distinct strategic responses to revitalising costs and public interest preservation, with marked operational divergences in practice. The government-social institution collaboration mode, as a top-down public welfare approach, leverages government-owned property rights through symbolic rents, fiscal subsidies, and policy instruments to enable non-profits delivering cultural exhibitions and community services. While ensuring authentic preservation and safeguarding public accessibility under governmental stewardship, this mode's heavy reliance on public financing raises sustainability challenges in balancing non-profit operational costs against their social missions. The market-driven with benefit recirculation mode, operating through public-private bundling mechanisms, centers on developers, receiving planning incentives, such as FAR bonuses and planning concessions, to integrate heritage conservation with commercial projects. Exemplified by the CLP Clock Tower's conversion into a free cultural venue, this approach effectively mobilizes private capital while mandating profit-sharing for conservation. However, its commercial orientation risks gentrification and privatization of communal spaces (Yung and Chan, 2016), frequently triggering community dissatisfaction regarding benefit distribution. Contrastingly, the social-engaged and community co-creation mode initiates bottom-up revitalization through multi-stakeholder negotiation, exemplified by URA's acquisition-based community making in the H19 project. While effectively preserving cultural identity and achieving high social acceptance (Yung et al., 2015), it requires sustained governance to reconcile immediate livelihood improvements with long-term conservation goals.

In the three modes, the government dynamically shifts from a leader to a regulator and then to an enabler, yet it remains the defender of historical buildings' public attributes. Across all paradigms, governments employ institutional frameworks encompassing funding regulations, conservation mandates, and participatory mechanisms to safeguard core objectives of cultural continuity and public accessibility against commercial encroachment or individual interests. Concurrently, authorities bear ultimate regulatory responsibilities through controlling commercial development intensity and monitoring fiscal subsidy allocation, thereby mitigating risks of authenticity erosion and benefit inequity during revitalization processes. Notably, URA, with a semi-governmental and semi-market identity (Zhang and Wang, 2024), leans differently in various modes. In market-led, benefit-feedback revitalization, its market role dominates, and its governmental role weakens, as seen in the Johnston Road Project (J Residence) involving the revitalization of 60 - 66 Johnston Road and Woo Cheong Pawn Shop (URA, 2008). Conversely, its governmental identity prevails in community co-creation initiatives through programs like H19, where market considerations become subsidiary to participatory governance.

The resolution of stakeholder conflicts fundamentally lies in innovative institutional designs for interest concessions and benefit-sharing mechanisms across different modes. In government-social institution

collaborations, this mode reconciles contradictions through public resource transfers. The government relinquishes historical building usage rights via symbolic rents and directly funds initial revitalization costs, such as covering restoration works and two-year operational expenses in revitalization schemes, thereby addressing high conservation expenditures. Social institutions then assume public service delivery through nonprofit operations. The market-led benefit-recirculation mode resolves funding constraints through development profit redistribution. Market entities gain planning concessions (e.g., plot ratio incentives) and commercial premiums from heritage cultural value (Licciardi and Amirtahmasebi, 2012), while contractually reinvesting partial profits into public space enhancement or conservation. The government essentially "purchases" conservation outcomes through regulatory incentives, achieving a commercial-public interest exchange. The community-engaged co-creation model establishes community value co-creation scenarios where residents sacrifice short-term redevelopment profits in exchange for improved living environments, community identity preservation, and social network maintenance, establishing shared value co-creation (Zheng et al., 2020). Governments and social institutions transform heritage conservation into tangible quality-of-life enhancements through community placemaking initiatives.

4.2 Revitalization Policy Optimization and Implications

To address existing challenges across these modes, the Hong Kong government should refine heritage conservation policies through four dimensions: funding system construction, economic incentive design, balanced rigid-flexible governance, and deepened public participation.

Funding system construction

The government should establish a multi-stakeholder funding framework. This requires expanding support for public education, academic research, and maintenance projects within existing heritage conservation funds while strengthening the coordinating role of heritage trusts to enhance fiscal efficiency. Concurrently, a dedicated heritage revitalization fund should be established to support vulnerable groups' adaptive transitions during revitalization processes(Yung et al., 2015). Policy instruments like tax incentives and honorary recognition should channel social capital from corporate donations and lottery surpluses into heritage conservation (Liu and Tang, 2014). NPOs should be encouraged to manage government-owned historic buildings through social enterprise models (Antiquities Advisory Board, 2014), permitting revenue reinvestment from low-impact commercial operations, such as cultural experiences and creative retail. This approach would ultimately form a sustainable financial ecosystem integrating fiscal allocations, social capital, and project-generated income, ensuring economic viability for revitalisation.

Economic incentives design

The government should integrate policy instruments (Antiquities Advisory Board, 2014), establishing a transparent tiered incentive system. Based on evaluations of historical significance and adaptive reuse potential, differentiated incentives, such as maintenance subsidies and plot ratio concessions, should target high-adaptability projects to enhance market participation (Langston et al., 2008). Concurrently, mandatory benefit-reinvestment rules must institutionalize profit-sharing clauses in redevelopment agreements, requiring market entities to proportionally allocate value-added benefits from rental premiums and asset appreciation to heritage maintenance, public space enhancement, or community services. This ensures commercial developments reciprocally replenish public interests while securing economic returns, fostering a virtuous cycle between conservation efficacy and developmental benefits.

Governance System Optimization: Balanced the rigid-flexible

Governance frameworks must reconcile mandatory conservation requirements with adaptive management. The government should legislatively mandate compulsory public access provisions for revitalization projects (Lang et al., 2018), resident retention incentives, and social obligations like public space allocation ratios (Yung and Chan, 2012). Collaborative governance with social institutions necessitates strengthened procedural oversight, requiring periodic submission of visitor statistics (Audit Commission, 2013), long-term viability assessments, and dynamic adjustments to funding caps(Audit Commission, 2020) to safeguard the public attributes of historic buildings. Meanwhile, policy adjustments should relax overly restrictive modern regulations (e.g., fire safety codes) on heritage buildings by exempting non-critical safety standards. Technical adaptations should enable flexible integration of conservation techniques with contemporary functionalities (Yung and Chan, 2012). Local service priority clauses must further ensure community welfare, requiring commercial tenants to

prioritize neighborhood employment and services (Cheung and Chan, 2014). This hybrid governance framework institutionalizes both regulatory safeguards and adaptive flexibility, addressing heritage-specific operational challenges while maintaining public accountability.

Public Participation and Educational Innovation

The government could innovate heritage education through digital platforms such as QR-code-guided tours and virtual reality experiences, enhancing owners' awareness of timely maintenance while leveraging public engagement to constrain excessive commercialization (Yung and Chan, 2016). Participation channels should be expanded via District Councils and NGOs, incorporating resident consultation mechanisms for functional needs during planning phases(Lam et al., 2022). Operational agreements should embed free community workshops and multilingual revitalization documentation (Cheung and Chan, 2014), with independent heritage management bodies facilitating bottom-up participatory planning to optimize transparency in balancing diverse interests. A tiered public access policy should be implemented: government-owned historic buildings maximize physical accessibility, while private properties adopt 3D archival sharing as a non-intrusive alternative to onsite visits (Antiquities Advisory Board, 2014). This approach safeguards cultural rights while respecting owner privacy, forming a comprehensive public engagement network spanning education, planning consultation, operational involvement, and access management.

5 Conclusion

This study deciphers three core revitalization modes through the lens of interest coordination, elucidating governance logics for multi-stakeholder equilibrium in high-density cities. These modes institutionalize negotiable interest commonality by translating development profits, cultural preservation, and community well-being into tradable governance metrics, establishing a "benefit concession, value co-creation and outcome sharing" governance cycle. This framework offers localized references for cities like Shenzhen and Shanghai to address challenges of exorbitant conservation costs, development conflicts, and weak public engagement. However, limitations arise from the exclusive focus on Hong Kong's singular context, insufficient analysis of adaptive mechanisms under divergent property regimes, such as mainland China's land tenure system, and inadequate exploration of latent factors like quantified community identity assessments and social capital allocation efficiency. Future research should extend comparative analyses to Tokyo, Singapore, and other high-density cities, prioritizing dynamic interest mediation mechanisms in multi-actor negotiations. Integrating surveys and benefit models could empirically evaluate the efficacy of these models across dimensions like cultural continuity, resident satisfaction, and commercial sustainability.

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Exploring Policy Frameworks for Cultural Heritage in Climate Adaptation and Disaster Risk Management: A Cross-Case Comparison

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Abstract
We examine the integration of cultural heritage into climate adaptation and flood risk governance through comparative case studies in Norway and Italy, undertaken within the AGREE project. Using a relational analytical framework to assess the policy portfolios connecting these fields, we analyse how heritage is framed in adaptation and risk policies, how vulnerability is conceptualised, and how integration unfolds across sectors and scales. Norway provides formal definitions and planning tools for heritage vulnerability, yet implementation remains inconsistent. Italy demonstrates diagnostic awareness of heritage risk, but operational integration is lacking. Our findings highlight persistent gaps in vertical and horizontal policy alignment, while identifying entry points for transformative change. Reframing cultural heritage in terms of its relational capacities may support more integrated, adaptive, and resilient approaches to climate risk governance.

Introduction

Flood protection is a growing priority in local adaptation strategies across Europe (Cumiskey et al., 2019). Over the past two decades, urban flooding has intensified due to shifting precipitation patterns and temperature fluctuations (Bueno Rubial et al., 2024). Extreme rainfall events, although statistically rare, are becoming more frequent and severe, posing increasingly significant risks to cities. Regional climate projections indicate these trends will intensify by century's end, especially in Norway and Italy (Amundsen & Dannevig, 2021; Vitale et al., 2022), underscoring the rising importance of flood risk management (FRM) in climate change adaptation (CCA).
While technological innovations have improved hazard control and set safety standards, FRM has evolved beyond a technical field. It increasingly intersects with governance, spatial planning, and societal concerns. Risk-based approaches emphasize reducing exposure and vulnerability (IPCC, 2022); however, the practical integration of spatial policies into FRM remains limited.

Meeting today's climate challenges requires transformative adaptation—structural shifts in governance logics, regulatory norms, and institutional values (UNFCCC, 2024). Climate risk management (CRM) frames this as a long-term, non-linear process that addresses the root causes of vulnerability across scales, from communities to national regimes (Deubelli & Mechler, 2021). Although promising, this transformation remains difficult to operationalise due to entrenched policy silos and institutional inertia (Hölscher et al., 2019).

CCA measures, such as water reservoirs and flood infrastructure, rely on multi-level governance (Termeer et al., 2017) and diverse policy instruments (Cumiskey et al., 2019) This mix of policies also presents significant governance and implementation challenges. Their inherent complexity, stemming from multiple, often conflicting goals and instruments across sectors and governance levels, can result in fragmentation, redundancy, or institutional lock-in. The variation of policy mechanisms to address CCA and increased climate risks often evolves incrementally rather than through deliberate design, complicating optimization and integration (Lesnikowski et al., 2019). Additional challenges include blurred responsibilities, inconsistent policy timeframes, and difficulties in aligning spatial and administrative boundaries (Nilsson & Persson, 2003). Thus, we analyze the policy mixes employed at national, regional, and local levels according to a policy-mixes structured approach to understanding how governments combine various goals and instruments. Examining how these two cities integrate CCA and cultural heritage conservation policies amidst escalating flood risk offers valuable insight into the complexities of policy frameworks and the challenges of systemic and landscape-based cross-sectoral integration.
Adaptation strategies require coordinated policy mixes across levels of government. Local actions are shaped by broader institutional frameworks, and practical strategies often combine instruments such as spatial planning,

infrastructure standards, and financial incentives (Cumiskey et al., 2019). Yet this complexity can lead to fragmentation and institutional lock-in, especially when policy instruments evolve incrementally (Lesnikowski et al., 2019), or when responsibilities and spatial jurisdictions are poorly aligned (Nilsson & Persson, 2003).

This paper analyses policy mixes for CCA and FRM across national, regional, and local levels. We focus on how governments combine diverse instruments and goals, and how these combinations impact the integration of cultural heritage. Examining how two cities—Lillehammer in Norway and Moncalieri in Italy—navigate climate adaptation and heritage conservation amidst increasing flood risks offers valuable insight into the challenges of systemic, cross-sectoral governance.

The AGREE (Advancing Cultural Heritage Governance for Resilient Climate Adaptation) project investigates the intersection of FRM and cultural heritage management—two domains where adaptation is often operationalised. It asks: What is the role and effectiveness of cultural heritage governance frameworks in advancing climate action across countries and governance levels? We compare two contrasting governance contexts: Italy's centralized, sector-based model with strong civil protection traditions, and Norway's decentralized, participatory planning model that emphasizes vulnerability assessments (Amundsen & Dannevig, 2021). Despite these differences, both countries face intensifying flood risks to heritage, creating a shared ground for comparison.

Moncalieri, in the Piedmont Region, is part of Turin's metropolitan area and lies along the Po River. The city has experienced several flood events, notably in 2000, revealing systemic vulnerabilities linked to ageing infrastructure and fragmented governance. Lillehammer, in Norway's Innlandet region, has a long history of floods, including the devastating "Storofsen" flood of 1789 and another major event in 1995 that severely affected heritage areas. Both cities illustrate complex interdependencies between water systems, urban development, and historic environments.

To assess how adaptation and heritage objectives interact within policy discourses, we combine policy-mix and discourse analysis. We map the portfolios of planning, regulatory, and capacity-building instruments for FRM and heritage management, then analyse how they frame climate risk, resilience, and heritage values. This approach uncovers discursive misalignments or synergies and helps identify capacities and gaps that shape cross-sectoral coordination. Applying this to Turin and Lillehammer reveals how climate adaptation is—and is not—being integrated with cultural heritage governance in flood-prone urban areas.

Theoretical Framework

Sustainability transformations require a shift in how we conceptualise relationships between humans, nature, and governance systems. West et al. (2020) call for a relational turn in sustainability science, arguing that dualistic thinking—such as the separation of nature and culture—hinders our capacity to address complex socio-ecological challenges. Relational approaches instead view systems as dynamic and co-constituted, shaped by continuous interactions. This shift enables more inclusive and transformative governance by emphasising the relationships and processes that underpin decision-making and lived experience.

This relational perspective offers a foundation for addressing climate risks to cultural heritage. It moves beyond siloed, asset-based approaches and recognises heritage as a socially embedded and evolving element of place, memory, and identity—capable of contributing to climate adaptation, not just requiring protection.

Recent convergence between landscape and heritage discourses reflects this shift. Both emphasise place-based, long-term stewardship and promote participatory, cross-sectoral governance (Galan et al., 2023). Landscapes are increasingly understood not only as physical environments but also as cultural and emotional infrastruc-

tures—deeply embedded in how communities relate to place (López Sánchez et al., 2020).

The Historic Urban Landscape (HUL) approach embodies these principles. It seeks to embed heritage management within wider territorial development goals (Bandarin & van Oers, 2012), moving away from static conservation towards adaptive governance models that integrate ecological, social, and cultural values (Veldpaus & Pereira Roders, 2017). HUL thus supports systems thinking in heritage governance, aligned with broader adaptation agendas.

This convergence prompts key questions: How is cultural heritage framed in adaptation and risk policy? How can relational approaches like HUL inform governance mechanisms that integrate climate, heritage, and spatial planning? To answer these, we apply an analytical framework combining three interrelated lenses: (1) cultural heritage as a relational actor in policy discourse; (2) climate risk management (CRM); and (3) policy integration (PI).

Cultural Heritage as a Relational Actor in Policy Discourse

We build on Guzman (2025), who proposes a framework for analyzing how cultural heritage is conceptualized and operationalized within national climate policy portfolios. This analytical framework serves to trace discursive shifts, from portraying heritage as a vulnerable asset to recognising it as a relational actor that contributes to adaptation processes. This repositioning opens new roles for heritage in enabling cross-sector collaboration, adaptive planning, and inclusive decision-making.

Through discourse analysis as defined by (Hajer, 1993), this framework examines how policy narratives shape the framing of heritage, define policy problems, and legitimise governance responses. It identifies three key dimensions through which cultural heritage becomes integrated in adaptation governance:

- Paradigm shifts: how heritage discourses evolve from preservation to adaptation;
- Policy cycle integration: whether heritage is addressed from planning to implementation and monitoring;
- Collaborative governance: How heritage facilitates coordination across sectors.

This approach allows us to examine not only whether heritage is included in policy, but how it is framed—as passive or active, static or dynamic, vulnerable or adaptive. It also highlights heritage's potential to mediate between technical systems and lived experiences of place and change.

Framing heritage as a relational actor thus repositions it as more than a sectoral concern. It becomes a vehicle for transformative change, capable of mobilising shared values, institutional innovation, and context-sensitive knowledge. This conceptual shift aligns with recent calls in adaptation and heritage literature to treat cultural assets not as isolated monuments, but as embedded within evolving socio-spatial systems that both shape and are shaped by climate risks.

Climate Risk Management (CRM)

The second lens builds on climate risk management as a governance framework that integrates climate adaptation and disaster risk reduction. CRM moves beyond reactive, hazard-based models typical of traditional disaster risk management (DRM), and instead emphasises proactive, systemic approaches that address the root causes of vulnerability (Leitner et al., 2020).

CRM recognises that risk is shaped not only by exposure and hazard, but also by governance responses. Poorly

designed interventions may inadvertently increase risk, particularly when they ignore social values, historical context, or community capacities (Andrews et al., 2023). For cultural heritage, this highlights the importance of engaging with the meanings of place, identity, and continuity in climate strategies.

By applying CRM to cultural heritage, we extend beyond technical assessments of material degradation. This lens highlights how vulnerability is socially constructed and historically situated, and how heritage can serve as a resource for building resilience, particularly when planning frameworks acknowledge its symbolic, experiential, and adaptive dimensions.

CRM thus reinforces the relational framing of heritage. It calls for integrated, long-term planning approaches that consider cultural systems as both at risk and part of the solution. In the context of this study, CRM provides a means to assess whether risk policies adequately account for the multifaceted nature of heritage vulnerability and whether heritage is being effectively activated in building adaptive capacity.

Policy Integration (PI)

The third lens addresses policy integration as a strategy for overcoming fragmentation between cultural heritage, spatial planning, climate adaptation, and disaster risk management. Following Lafferty and Hovden (2003) and Tosun and Lang (2017), we adopt a dual perspective: horizontal integration examines the extent to which cultural heritage is linked to climate and environmental sectors through regulatory, planning, and institutional instruments. It asks whether heritage is treated as a cross-cutting concern or confined to sectoral mandates. Additionally, vertical integration examines whether heritage-related adaptation objectives are consistently addressed across different scales and whether feedback mechanisms exist between national frameworks and subnational implementation. Inconsistent integration across these levels can undermine both climate resilience and heritage protection.

Effective PI supports mutual reinforcement of policies and enhances collaboration between actors. It also enables cultural heritage to function as a bridge between technical planning, institutional structures, and community-based knowledge.

This is particularly relevant in flood risk governance, where overlapping responsibilities, divergent planning cycles, and fragmented data systems often challenge implementation. Policy integration can help align adaptation and heritage goals, reduce duplication, and open space for transformative governance approaches.

By combining the lenses of CRM and PI with the discourse-oriented analysis of heritage as a relational actor, we aim to assess not only whether and where heritage appears in policy, but also how it is conceptualised and what capacities it brings to governance systems.

This framework enables a more nuanced evaluation of whether heritage is positioned as a passive object of protection or as an active contributor to resilience and systemic adaptation. Together, the three lenses provide the conceptual foundation for our comparative analysis of how cultural heritage is integrated into climate adaptation and flood risk planning in Norway and Italy.

Methodology

This study adopts a qualitative, comparative case study approach to examine how cultural heritage is conceptualised and integrated into climate adaptation and risk frameworks across governance levels in Italy and Norway. The analysis focuses on multi-level governance arrangements, flood risk management, and the degree of policy

integration—both vertical (across scales) and horizontal (across sectors). Case selection is based on the AGREE project's empirical focus on urban heritage historically exposed to flood hazards, situated within distinct planning cultures, institutional architectures, and heritage governance frameworks.

Data sources

The empirical analysis draws on a broad set of policy documents related to climate adaptation, disaster risk management, flood risk planning, and cultural heritage management at national, regional, and municipal levels in Italy and Norway. To structure the document collection, we applied the policy portfolio framework developed by Hurlimann et al. (2024), which includes two main components:

- A policy instrument typology, covering laws, regulations, strategies, and guidelines;
- A built environment policy setting, capturing the institutional and spatial contexts in which instruments are deployed across cultural heritage, CCA, and CRM (including DRM).

This framework provided a systematic basis for identifying and comparing the planning and governance instruments that influence the positioning of cultural heritage within climate and risk policies.

Coding and Analytical Procedure

The policy portfolio framework provided the foundation for targeted content retrieval. A structured codebook, aligned with the three conceptual dimensions—heritage as relational actor, climate risk management (CRM), and policy integration (PI)—was optimised using Large Language Models (LLMs), specifically NotebookLM.

Drawing on Guzman (2025), the analysis applies prompting techniques to extract, cluster, and refine relevant text segments from a large volume of documents. These prompts guided the identification of both explicit and implicit framings of cultural heritage, climate risk, and vulnerability. They also supported the mapping of institutional responsibilities, coordination mechanisms, and cross-sectoral linkages.

This hybrid method, combining structured policy mapping with AI-assisted discourse analysis, enabled a systematic comparison of the coherence, effectiveness, and transformative potential of national and subnational policy portfolios. Thematic synthesis and interpretation were manually verified to ensure analytical rigour and contextual sensitivity. The resulting insights contribute to understanding how cultural heritage governance can support more transformative approaches to climate adaptation and flood risk planning according to the cases' policy context (Fig 1).

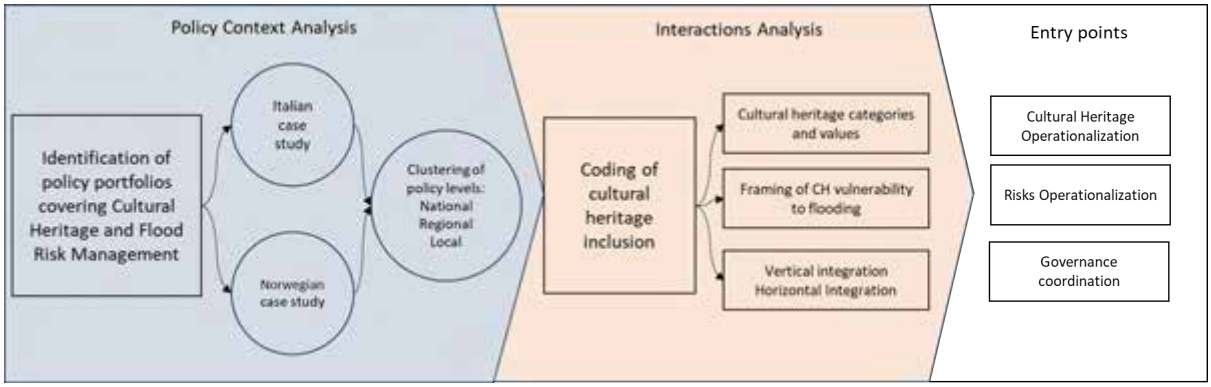

Figure 1. Methods overview for case study analysis.

Case Study Analysis

Lillehammer, Innladet region in Norway

The Norwegian policy portfolio (figure 2) for cultural heritage management (CHM), climate change adaptation (CCA), and flood-related disaster risk management (DRM) comprises 38 documents: 26 at the national level, 5 at the regional level, and 7 at the municipal level. These span regulatory, planning, and guidance instruments relevant to heritage in the context of climate risk.

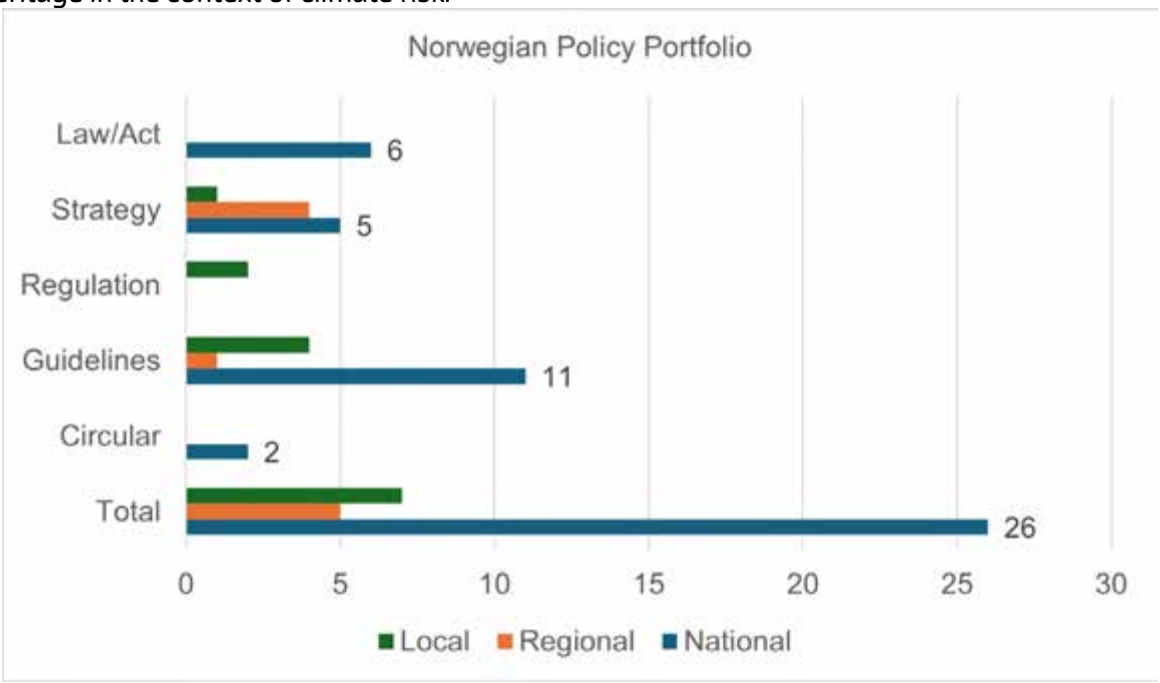

Figure 2. Norwegian policy portfolio for cultural heritage in FRM for CCA and DRM

National policy documents

Nationally, key responsibilities are defined by the Planning and Building Act (2008), the Water Resources Act, and the Civil Protection Act. The Norwegian Water Resources and Energy Directorate (NVE) leads on flood hazard mapping, spatial planning guidance, and emergency coordination. The Directorate for Civil Protection (DSB) oversees broader disaster preparedness. Within the Risk and Vulnerability Analysis (ROS) framework, cultural heritage is explicitly identified as a vulnerable asset. Vulnerability is defined in terms of a cultural environment's capacity to retain value under prolonged stress, encompassing physical degradation, symbolic and institutional fragility, and threats from climate-driven hazards such as flooding, erosion, and biological decay.

Regional policy documents

Innlandet County translates national priorities into spatial strategies via mandatory four-year Regional Planning Strategies and supporting thematic plans. The county's FylkesROS (Regional Risk and Vulnerability Analysis) incorporates cultural heritage under the categories of "Nature and Environment" and "Material Values." This framework uses scenario-based assessments to identify indirect flood impacts on heritage sites, such as water infiltration, soil saturation, and erosion.

Although this value-based risk framing elevates heritage within the regional discourse and encourages the preparation of emergency plans, its application remains mainly generic and advisory in nature. Cultural heritage is treated as an asset at risk rather than as a contributor to adaptive spatial planning. Its role is referenced in environmental and emergency strategies but is not embedded in instruments that guide spatial decision-making or long-term resilience planning.

Local policy documents

At the municipal level, Lillehammer integrates cultural heritage into risk governance through planning instruments such as the Municipal Master Plan and binding Zoning Plans, as well as its municipal ROS (Risk and Vulnerability Analysis). These tools consider cultural heritage among long-term risks and apply concepts such as "sensitivity requirements" and "tolerance thresholds" to regulate development and conservation activities.

Despite this formal inclusion, flood-related heritage risks are typically rated as "very small," reflecting low perceived urgency and limited consideration of evolving climate dynamics. While regulatory mechanisms safeguard heritage against inappropriate development, they do not consistently address climate-induced risks or promote proactive adaptation. Design standards and oversight processes remain focused on static protection rather than anticipatory or systemic responses to future climate impacts.

Table 1. Cultural Heritage Vulnerability in Flood Risk Governance – Norwegian Case Study

Comparative Point	National level	Regional (Innlandet)	Local (Lillehammer municipality)
Formulation of Vulnerability	Focused on material and structural susceptibility to climate parameters (moisture, temperature, rainfall).	• Part of broader sectoral/territorial assessments (FylkesROS); • highlights exposure and emergency preparedness gaps.	• Embedded in land use plans and heritage protection strategies (Kommundelplan); • expressed through tolerance and sensitivity criteria.
Focus of Vulnerability	Physical degradation of heritage due to site-specific climate conditions and structural/material weaknesses.	Emphasis on hazards like flooding and landslides and their potential to damage heritage.	Emphasis on architectural character, cultural landscape features, and urban form coherence.
Mechanism / Approach	Uses scientific data, national registers (Askeladden), risk matrices, and expert-based assessments.	• Integrated into ROS analyses; • focuses on qualitative assessment of exposure and event-based risk.	Planning tools define acceptable change thresholds (scale, structure, terrain, form) and guide development to protect heritage significance.
Types of Heritage Considered	Mostly listed and mapped heritage assets, including buildings, archaeological sites, and landscapes.	Includes settlements, infrastructure, and sectoral assets, often aggregated into risk categories.	Broad inclusion: historic buildings, gardens, walls, paths, and visual experience of heritage environments.

Vulnerability Dimensions Addressed	Primarily physical/material dimensions.	Some institutional and preparedness dimensions included in civil protection planning.	Focuses on morphological, experiential, and aesthetic dimensions of vulnerability.
Integration in Risk Planning	Partial – addressed in sectoral strategies and adaptation studies; generally limited to state-owned or protected heritage.	• Present within ROS frameworks, but not always heritage-specific; • often generalized within infrastructure or building risk.	Stronger integration in planning documents and municipal regulations; less in hazard-specific risk assessments.
Quantification / Monitoring	Lacks comprehensive quantitative indicators; knowledge base relies on expert input and fragmented registries.	• Risk often qualitatively graded; • lacks specific vulnerability metrics for cultural heritage.	Uses qualitative tolerance definitions and design prescriptions rather than measurable vulnerability indicators.
Limitations / Gaps	Cultural heritage vulnerability is largely framed as a technical conservation issue, with less emphasis on systemic or societal dimensions.	• Heritage is not consistently or specifically disaggregated in risk data; • Limited technical detail.	• Emphasis on planning compliance rather than climate resilience; • No systematic tracking of climate-related vulnerability at the site or community level.

Turin, Piedmont, Italy

National policy documents

Italy's FRM system spans multiple levels of government and integrates civil protection, environmental planning, and water governance. The legal framework is long-established and supported by technical experience in hydrogeological risk management. The national policy portfolio comprises 37 documents relevant to cultural heritage management (CHM), CCA, and DRM, with a particular focus on FRM. Policy documents (shown in fig.3) include nine national-level instruments (laws, strategies, and programmes), 16 regional documents, and 12 at the municipal level, reflecting Italy's hierarchical structure and the division between strategic planning and regulatory implementation.

Despite the availability of planning tools such as Flood Risk Management Plans (FRMPs) and hazard maps, cultural heritage is not systematically integrated into national or basin-scale FRM strategies. While risks to heritage, particularly in historic centres, underground assets, and coastal or archaeological sites, are increasingly recognised, they are typically addressed in isolated assessments. Diagnostic studies often explore material sensitivity, environmental conditions (e.g., fluctuating water tables), and anthropogenic stressors such as neglect or tourism. However, these insights are not yet embedded into FRM protocols, early warning systems, or emergency preparedness plans. Although the 2023 National Adaptation Plan (PNACC) acknowledges the vulnerability of heritage, it has yet to produce enforceable mandates or mechanisms for implementation.

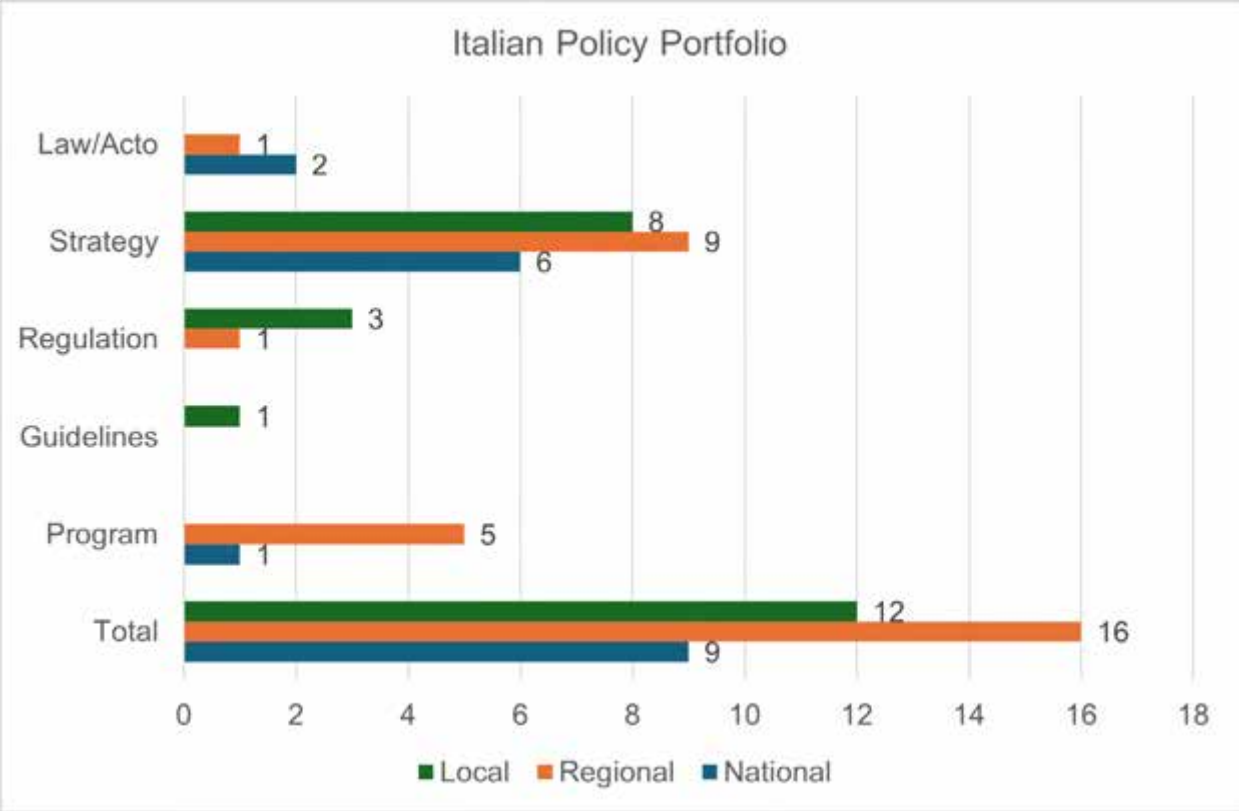

Figure 3. Italian policy portfolio for cultural heritage in FRM for CCA and DRM

Piedmont region policy documents

Following constitutional reforms, Italian regions such as Piedmont have gained significant autonomy in spatial planning and civil protection. Flood risk governance is integrated into Territorial Coordination Plans (PTRC/PTCP), supported by a Regional Functional Centre that collaborates with the national Department of Civil Protection (DPC) on real-time hazard monitoring, early warning, and prevention strategies. River Basin Authorities provide hazard maps that inform regional land-use restrictions and guide planning in areas prone to risk.

Despite the formal embedding of flood risk planning into regional governance, cultural heritage remains largely absent from these instruments. Historic centres, subterranean structures, and culturally significant landscapes are visibly exposed to hydrological hazards, but this exposure is rarely reflected in risk assessments, hazard mapping, or emergency planning.

Where heritage is considered, the regional approach reflects a multi-dimensional view of vulnerability. Physical risks arise from degradation, ground instability, and maintenance deficits. Institutional fragilities include fragmented mandates, weak coordination, and the lack of strategies linking heritage protection and promotion. Territorial inequalities persist, particularly in inland and mountainous areas, alongside chronic capacity gaps, underfunding, and outdated infrastructure that limits adaptive reuse. However, these issues are mostly recognised in assessments and reports, rather than operationalised in governance instruments.

Moncalieri municipality and Turin metropolitan area policy documents

Municipalities and provinces are responsible for local risk governance. Each municipality must prepare a Piano Comunale di Protezione Civile (Municipal Civil Protection Plan), which outlines hazard scenarios, such as floods and landslides, and sets out emergency procedures and guidance for citizens. Mayors act as the highest civil protection authorities in emergencies. The Metropolitan City of Turin coordinates among municipalities, supports planning, and consolidates local risk data.

Land-use restrictions in flood-prone areas are enforced through municipal planning instruments based on hazard maps from regional and national sources. Functions such as drainage and local water management are often delegated to land reclamation consortia, reflecting Italy's decentralised implementation model.

Cultural heritage is acknowledged within civil protection and urban planning frameworks but lacks dedicated risk methodologies. It is referenced in Strategic Environmental Assessments (VAS) under general environmental or landscape categories, without clear criteria for vulnerability or exposure. The Cultural and Environmental Assets Observatory in Turin improves data availability by cataloguing and mapping heritage assets and constraints. However, its use in vulnerability assessment or flood risk planning remains limited.

Table2. Cultural Heritage Vulnerability in Flood Risk Governance – Italian Case Study

Comparative Point	National Level	Regional Level (Piedmont)	Local Level (Turin)
Formulation of Vulnerability	Generic and implicit in FRMPs; heritage vulnerability is not methodologically defined	Multi-dimensional diagnosis covering physical, institutional, territorial fragilities	Implicit in civil protection and environmental assessments; not heritage-specific
Focus of Vulnerability	Damage to exposed assets; heritage seen as one of many sectors	Sectoral fragilities and systemic weaknesses across institutions and landscapes	Emergency impact on heritage assets; indirect inclusion in urban planning
Mechanism / Approach	General guidance in FRMPs and civil protection policies	Diagnostic assessments in regional plans; preliminary integration in spatial and adaptation planning	Strategic Environmental Assessments (VAS); local protection plans; civil protection frameworks
Types of Heritage Considered	Broad: monuments, archaeological sites, landscape heritage (not disaggregated)	Historic buildings, archaeological sites, rural landscapes	Cultural and environmental assets, including archives and museums
Vulnerability Dimensions Addressed	Physical exposure; limited institutional or societal framing	Physical, institutional, societal, infrastructural, and data-related vulnerabilities	Exposure to hazard; infrastructural and data constraints; societal access barriers
Integration in Risk Planning	Limited; cultural heritage weakly embedded in FRMPs or hazard maps	Partial; not systematically translated into FRM or adaptation instruments	Fragmented; planning tools acknowledge heritage but lack targeted vulnerability assessments
Quantification / Monitoring	Minimal; no dedicated indicators or recovery protocols	Economic valuation and scoring tools used diagnostically; not linked to FRM	Observatories and asset mapping exist, but not integrated with risk assessment
Limitations / Gaps	Weak operational link between heritage and FRM; fragmented responsibility	No formal mechanism for integrating heritage in hazard mapping or emergency preparedness	No dedicated methodologies for heritage-specific vulnerability; underutilized data systems

Comparative Discussion

This section compares the integration of cultural heritage into flood risk and climate adaptation governance in Norway and Italy. While both countries acknowledge heritage vulnerability, they differ in how it is framed, operationalised, and linked across governance levels.

Norway adopts a formal and multi-dimensional definition of vulnerability, embedded in national civil protection and planning tools. Cultural heritage is explicitly included in the ROS (Risk and Vulnerability Analysis) framework and reflected in spatial planning regulations. However, this framing is not always translated into practice at the local level, where climate-specific risks to heritage are often rated as low.

In contrast, Italy is showing an increasing awareness of heritage vulnerability, particularly at the regional and municipal levels. Diagnostic assessments in Piedmont, for example, highlight physical, institutional, and territorial fragilities. Yet, this knowledge is not systematically integrated into national FRM instruments, emergency planning, or spatial policies. To consolidate the comparative insights across key governance dimensions, Table 3 summarises the main findings:

Table 3 Comparative Summary – Cultural Heritage in Flood Risk and Adaptation Governance

Analytical Dimension	Norway	Italy
Heritage Categories & Values	Tangible assets (e.g. buildings, sites); some recognition of functional and experiential value in planning tools.	Focus on tangible heritage (monuments, archaeology); limited articulation of social or functional roles.
Vulnerability Framing	Defined nationally (ROS); includes physical, symbolic, and institutional aspects.	Diagnosed regionally; multi-dimensional but lacks national methodology.
Operational Integration	Heritage included in national tools; local uptake limited, risks often downplayed.	Heritage rarely integrated into FRMPs; awareness growing but not formalised.
Vertical Integration	National frameworks guide subnational levels; implementation varies.	Weak vertical coherence; local and regional efforts not fully supported.
Horizontal Integration	Some coordination between heritage, planning, and risk sectors.	Institutional silos persist; limited cross-sectoral governance.
Transformative Potential	Emerging in discourse; heritage recognised as a potential resilience asset.	Seen largely as a passive asset; not yet activated in resilience strategies.

Conclusions

This study examined the integration of cultural heritage into climate adaptation and flood risk governance in Norway and Italy. While both countries recognise heritage vulnerability, integration remains limited and uneven. Norway benefits from clear national frameworks, but local uptake is inconsistent and often downplays climate risks. Italy demonstrates growing diagnostic awareness at regional and municipal levels yet lacks operational tools and formal mechanisms for integration.

In both contexts, heritage is still largely framed as a passive asset at risk, rather than an active contributor to resilience. Policy integration—both vertical and horizontal—remains weak, constrained by fragmented mandates, limited coordination, and underdeveloped methodologies for heritage-specific risk assessment. These findings point to the need for relational governance approaches that see heritage not just as an object to protect, but as a medium for connecting people, places, and institutions. Advancing this perspective can support more inclusive, adaptive, and systemic responses to climate risk.

Within the AGREE project objectives, we will further explore how integration unfolds in practice by engaging with the actors and institutions shaping adaptation and heritage governance on the ground.

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Appendices

Norwegian policy portfolio

Code	Instrument title: National documents	Policy Type	Year
LI.10	Guidelines for risk and vulnerability assessment method for Cultural environments	Guide-lines	09.06.2024
LI.12	Act concerning the cultural heritage	Law/act	1978
LI.13	Meld. St. 13 (2020–2021) Report to the Storting (white paper) Norway's Climate Action Plan for 2021–2030	Strate-gy-Plan	08.01.2021
LI.14	Natural Damage Compensation Act	Law/act	01.01.2017
LI.15	The Civil Protection Act	Law/act	ACT-2010-06-25-45
LI.16	Guide to comprehensive risk and vulnerability analysis in the municipality - Revised 2022 - version 1	Guide-lines	01.10.2022
LI.17	The Planning and Building Act – PBL	Law/act	01.07.2024
LI.18	Guidelines: How to take climate change into account in planning?	Guide-lines	31.10.2019
LI.19	Regulation on municipal preparedness duty	Law/act	05.07.1905
LI.20	State planning guidelines for climate and energy planning and climate adaptation	Law/act	28.09.2018
LI.21	National expectations for regional and municipal planning 2023–2027	Strate-gy-Plan	20 June 2023
LI.22	New goals for Norway's cultural environment policy — Meld. St. 16 (2019–2020) Report to the Storting (white paper)	Strate-gy-Plan	17.apr.20
LI.24	DSB GUIDES Community safety in the municipality's spatial planning Method for risk and vulnerability analysis in planning	Guide-lines	2017
LI.25	National and significant regional interests in the environmental area - clarification of the environmental administra-tion's objection practice	circular	17.02.2021
LI.26	Handbook on impact assessment of climate and environment | M-1941 Create a plan and study program	Guide-lines	n.d.
LI.27	Handbook on impact assessment of climate and environment | M-1941 Method of investigation	Guide-lines	n.d.
LI.28	Social security in planning and construction case processing Circular H-5/18	circular	17.10.2018
LI.29	Climate strategy for cultural environment management 2021-2030	Strate-gy-Plan	01.08.2021
LI.30	Strategy and Professional Recommendations for Urban and Rural Development	Strate-gy-Plan	14.02.2025
LI.31	Regulations on Environmental Impact Assessments	Regula-tion	01.07.2017
LI.32	The Climate Helper: A guide on how to ensure public safety and climate adaptation in planning according to the Plan-ning and Building Act	Guide-lines	2015
LI.33	Safety against floods Investigation of flood risk in zoning plans and building applications	Guide-lines	des.22
LI.34	Guide: Sea level rise and high-water levels	Guide-lines	June 2024
LI.35	Risk Analysis of Rain-Induced Flooding in Cities	Guide-lines	2019
LI.37	Guide for the County Governor's work with risk and vulnerability analyses (fylkesROS) version 4	Guide-lines	mar.20
LI.38	Regulations on mandatory registration of ground surveys and natural hazard assessments	Regula-tion	18.12.2024

Code	Instrument title: Regional documents	Policy Type	Year
LI.8	Regional Strategy for Sustainable Development	Strate-gy-Plan	ND
LI.9	Regional Plan for Climate, Energy and Environment	Strate-gy-Plan	06.13.2023
LI.11	Regional Plan for Social Security Innlandet Region	Guidelines	31.10.2022
LI.23	County Risk and Vulnerability Assessment Inlandet 2022-2026	Strate-gy-Plan	
LI.36	Lågen plan Regional Plan for Gudbrandsdalslågen with tributaries - Measures to reduce flood and landslide damage	Strate-gy-Plan	29.jun.21

Code	Instrument title: Local documents	Policy Type	Year
LI.1	Area Policy for Future Lillehammer. Municipal Plan's Areal Part - Provisions and Guidelines 2020-2023 (2030)	Regula-tion and Guideline	26.03.2020
LI.2	Municipal Plan Lillheammer City Town Plan - Provisions and guidelines 2022-2023 (2030)	Regula-tion and Guideline	26.03.2020
LI.3	Complete risk and vulnerability assessment Lillehammer	Guidelines	01.01.2019
LI.4	Emergency plan Lillehammer municipality	Guidelines	ND
LI.5	Storm water plan for Lillehammer municipality Thematic plan	Strate-gy-Plan	2024
LI.6	Flooding in smaller tributaries - preparedness 2024	Guidelines	22.03.2024
LI.7	R-01 Measures report Åretta River	Guidelines	07.02.2019

Italian policy portfolio

Code	Instrument title: National documents	Policy Type	Year
TU.29	National Recovery and Resilience Plan	Strategy	2021-226
TU.30	National Prevention Plan	Strategy	2020-2025
TU.33	Integrated National Energy and Climate Plan	Strategy	2019-2030
TU.34	National Plan for Adaptation to Climate Change	Strategy	2023
TU.35	Norms for the development of green urban spaces	Law	2013
TU.41	Cultural Heritage Code	Law	2004

Code	Instrument title: Regional documents	Policy Type	Year
TU.10	Regional Strategy for Sustainable Development	Strategy	2022
TU.11	Regional Strategy for Climate Change – 1st phase	Strategy	2022
TU.12	Regional Territory Plan	Strategy	2024 (updated in 2011)
TU.13	Regional Landscape Plan	Strategy	2017
TU.14	The Unitary Strategy Document	Strategy	2021
TU.15	Finance and Economy Document	Strategy	2022
TU.16	Management Plan of the Po River Hydrographic District	Strategy	2010
TU.17	Hydrogeological Planning Plan – Po River	Strategy	2001
TU.18	Water Protection Plan	Strategy	2007 (updated in 2021)

TU.19	Triannual Program of Culture	Program	2022
TU.20	Adhesion of the Piedmont Region to the Memorandum of Understanding to gather the commitment of sub-national governments in reducing global emissions, 'UNDER 2 MOU' Subnational Global Climate Leadership Memorandum of Understanding	Program	2015
TU.22	MaB UNESCO Biosphere Reserve Po Hill	Program	
TU.23	Report on the state of the environment	Program	2023
TU.25	FESR Regional Programme of Piedmont for the programming period 2021-27	Program	2022
TU.27	Identification of the interventions related to the enhancement of the natural and cultural heritage of the Piedmont Region, originally planned within the framework of the POR FESR 2014-2020 programming	Regulation	2024
TU.28	Coordinated provisions in the field of culture	Law	2018
TU.31	Flood Risk Management Plan	Strategy	2016 (updated 2021)
TU.32	Water Balance Plan	Strategy	2016 (updated 2021)
TU.38	Area plan of the Piedmontese Po River belt	Program	2009

Code	**Instrument title: Local documents**	**Policy Type**	**Year**
TU.1	Climate Resilience Plan	Strategy	2020
TU.2	Metropolitan Agenda for Sustainable Development	Strategy	2022
TU.3	Metropolitan Agenda for Sustainable Development – Work Plan for the System Actions	Strategy	2023
TU.4	Metropolitan Strategy Plan 2021-2023	Strategy	2021
TU.5		Strategy	2020
TU.6	Territorial Plan of General Metropolitan	Strategy	2023
TU.7	Acquisition, management, and enhancement of real estate assets.	Regulation	2021
TU.8	Governance of public urban goods in the City of Turin	Regulation	2019
TU.9	Provincial-Territorial Coordination Plan	Regulation	2011
TU.39	Civil Protection Plan Moncalieri	Strategy	2022
TU. 40	Piano Regolatore Comunale di Moncalieri – Norme tecniche di attuazione	Strategy	2000
TU.44	Climate Resilience Plan	Guideline, Programme	2020

Exploring the Emotional Dynamics of Beyoğlu's Transformative Urban Atmosphere Through Music Ecosystems

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Abstract
This study traces how music-related everyday practices have shaped Beyoğlu's affective atmosphere in the wake of spatial changes since the 1990s. Although emotions began gaining ground in urban research in the early 2000s, they had long been excluded or marginalised. Empirical research has often relied on methods that objectify emotions, rather than engaging with their embodied and affective dimensions. Drawing on field observations, in-depth interviews and sensory methods, this study proposes an approach that treats subject and method as an integrated whole—treating emotions as spatially entangled and grounded in embodied ways of knowing. Addressing a gap in the local context, it offers a case from Turkey and contributes both theoretically and methodologically to the expanding field of affective geographies.

Keywords: Emotions, Atmosphere, Beyoğlu, Music, Sensory Methods

<This research is conducted as part of the author's ongoing doctoral thesis supervised by Prof. Dr. Murat Cemal Yalçıntan at Mimar Sinan Fine Arts University.>

1. Introduction

The relationship between individuals and places is inseparable from emotions. Emotions may be conceptualized as a connective tissue that integrates the embodied geographies of the self with broader social and spatial formations. Emotions have long been marginalized in urban studies. Within the framework of Cartesian dualisms and modern scientific conventions, emotions were framed as irrational, subjective, and incompatible with value-free knowledge production (Bondi, 2009; Thien, 2005; Thrift, 2004). This perspective has been sharply criticized by those who argue that it replaces the complex nature of social relations in space with a logic of reproduction necessary for the survival of the system (Lefebvre, 1994; Hochschild, 2012). The emergence of literature on concepts such as sense of place and place attachment marked an early attempt to engage with the emotional relationships people form with their environments (Proshansky, 1978; Altman and Low, 1992). However, tended to reduce rich conceptual insights frequently falling short of capturing the full complexity of such relationships (Manzo, 2003). Since the early 2000s, however, a growing body of scholarship, frequently described as emotional geographies, has challenged previous assumptions (Anderson and Smith, 2001; Davidson and Milligan, 2004; Davidson, Bondi, and Smith, 2007), calling for approaches that "take emotions seriously" (Bondi, Davidson and Smith, 2007) not only as content but also as method. Responding to this call, this study traces how music-related everyday practices have shaped Beyoğlu's affective atmosphere in the wake of spatial transformations since the 1990s.

Atmosphere is conceived as a space that mediates between emotion and affect or integrates them; and serves as a central analytical tool for exploring how place is affectively charged (Riedel, 2019; Anderson, 2009). In a similar vein, this study does not take sides in the conceptual divide between 'emotion' and 'affect', but instead uses the term 'emotion' to refer to relational, embodied, and spatially situated experiences that co-constitute place. Applied to the case of Beyoğlu, the term affective atmosphere allows the study to trace how emotional relationships to place are shaped and transformed through music-related everyday practices, particularly within the context of spatial and cultural change. In doing so, it offers a situated contribution to emotional geographies by showing how space, affect, and emotion co-produce one another through embodied urban life.

Viewed through the lens of emotions and affective atmosphere, Beyoğlu offers a rich and complex field of research. Despite the district's layered history; its central role in Istanbul's cultural, social, political life and its prominence in studies on urban change, nightlife, and music; research addressing the role of emotional and sensory dynamics in shaping people's relationships to place is still limited (Ural, 2017; Öz and Özkaracalar, 2021; Türkün, 2021). Focusing on the period following the 1990 pedestrianization of İstiklal Avenue this research examines how music-related everyday practices have shaped and been shaped by the affective atmosphere of Beyoğlu. Pedestrianization of İstiklal Avenue initiated a period of cultural revitalization in which idle spaces were reclaimed by art institutions, bars, and civic organizations (İBB, 2023; Türkün, 2021). During this period, the district emerged as a major hub of musical and artistic activity. This period catalyzed the formation of the district's contemporary cultural memory and atmosphere, while simultaneously triggering processes of gentrification, spatial privatization, and intensified state intervention in cultural life. These shifts deeply affected the district's music spaces—its venues, informal performance zones, recording studios, artists' homes as spaces of both production and recreation, among others—reshaping music-related practices in everyday life. More importantly, they disrupted the functioning of numerous actors both within and beyond the music sector, and signaled profound transformations in the city's musical culture. These transformations not only call for a deeper understanding of how emotions are entangled with urban change, but also underscore the importance of studying space through its affective and sensory dimensions, alongside its physical or institutional shifts. In this research, the focus is on Beyoğlu not as defined by the boundaries of the district municipality, but rather as the area commonly evoked in contemporary debates and everyday personal narratives—an axis beginning at Gezi Park, passing through Taksim Square, Galatasaray Square, and Tünel Square, and ending at Galata Square, along with its many branching side streets.

This study addresses that gap by offering both a theoretical and methodological contribution to the growing field of emotional geographies, and by providing a locally situated perspective on the interplay between affective atmospheres and place. This research adopts an ethnographic approach, combining in-depth interviews, field observation, and sensory methods to understand how urban space is lived not only cognitively, but affectively. This article is part of a multi-layered research project conducted within the scope of my doctoral dissertation, carried out under the supervision of Prof. Dr. Murat Cemal Yalçıntan.

2. Literature Review

The marginalization of emotions in urban studies is by no means a new concern. Around half a century ago, a conceptual distinction between space and place began to take hold—one that emphasized meaning, affect, and emotional relationships with place (Tuan, 1974; 1977; Relph, 1976; 1985; Buttimer and Seamon, 1980). Nearly two decades have passed since emotional geographies emerged as a field committed to exploring how emotions are entangled with spatial processes (Anderson and Smith, 2001; Davidson and Milligan, 2004; Davidson, Bondi, and Smith, 2007; Bondi, Davidson and Smith, 2007). Still, many of the foundational questions remain unresolved.

As the literature on emotional geographies has expanded, the growing dissatisfaction with representational approaches has led to a conceptual division between 'emotion' and 'affect' (Parr, 2014), often presented as a theoretical and methodological rupture. Emotions are typically seen as nameable, conscious states tied to individual subjects, while affect refers to pre-personal, non-cognitive intensities that circulate between bodies, spaces, and materials (Pile, 2010). This distinction emerged largely from non-representational theory's critique of the limits of language, reflexivity, and cognition in capturing embodied experience (Anderson, 2015; Anderson and Harrison, 2010; Thrift, 2004). This research resists such an ontological split. Instead, it approaches emotion and affect as entangled registers of experience, co-produced through bodily and sensory encounters that unfold within specific spatial and social contexts. Within this framework, the concept of affective atmosphere offers a way to rethink emotion and affect not as phenomena located within bounded individuals, but as dynamics that emerge across bodies, environments, and relations.

The term atmosphere predates its introduction into recent debates by Anderson (2009). In human geography, affective atmospheres are conceived as emergent, relational, and collectively sensed—hovering between subjects

and spaces, never fully subjective nor entirely external (Anderson, 2009; Böhme, 1993; Thibaud, 2014). Importantly, affective atmospheres resist reduction to either stable emotional categories or abstract affective forces (McCormack, 2008; Anderson, 2009; Riedel, 2019). They are registered through movement, rhythm, material presence, and bodily orientation—shaping how space is sensed and lived without always being linguistically captured (Bissell, 2010; Pink and Mackley, 2015; Sumartojo and Pink, 2019; Riedel, 2019). This study draws on the concept of affective atmosphere not merely as an interpretive tool, but as a central analytical lens through which the emotional and affective texture of urban transformation is examined. Rather than treating affect as pre-cognitive intensity or emotion as representational expression, it explores how these registers operate together in shaping everyday spatial experience. Affective atmosphere as a concept provide a way of attending to the dynamic, ambiguous, and often ineffable qualities of the change in Beyoğlu—especially as it unfolds through music-related practices with space.

Riedel (2019) highlights a parallel between atmospheres and musical experience, highlighting their rhythmic, mereological, and immersive qualities. A number of recent works that approach music practices and space through the concept of atmosphere (Riedel and Torvinen, 2020; Tan, 2023; Järviluoma and Murray, 2023) shed light on both the relational nature of musical practices and their affective dimensions. There is a growing body of research on the spatial, social, cultural, and economic contributions of music to cities (Behr et al., 2014; Martin, 2017; Van der Hoeven et al., 2022; 2023). Recognized as tools within international development and resilience agendas (UN-Habitat 2020; United Nations General Assembly, 2016), they play a role in city branding (Botta, 2008; Wynn ve Yetis-Bayraktar, 2016; Brunow, 2019) and contribute to urban economies (Florida ve Jackson, 2010). But one should not ignore the fact that while music-led development can foster urban revitalization (Kronenburg, 2020; Gibson and Homan, 2004; Jakob, 2013; Seman, 2010), it may also render urban spaces more exposed to market-driven dynamics and economic pressures (Bennett, 2020; Brown et al., 2000; Flew, 2008). When legitimized solely through its economic benefits, it may lead to problems such as gentrification and displacement (Gibson and Homan, 2004; Holt, 2013; Lobato, 2006). Literature increasingly emphasizes the need for urban policies, legal frameworks, and planning tools to address such outcomes (Brown et al., 2000; Flew, 2008; Grodach, 2012; Hitters and Mulder, 2020; Homan, 2010; 2017; Lobato, 2006; Martin, 2017). Although the gentrifying power of culture has been well documented, some studies offer comparative examples of legal and planning mechanisms that mediate the positive and negative outcomes of music in urban contexts. In the case of Beyoğlu, the failure of policymakers to implement protective strategies led to the loss of the district's character.

3. Methodology

Incorporating emotion and affect into social, cultural, and spatial research necessitates a shift in methodological approaches. Beyond conventional frameworks, the integration of perspectives such as empathy, reflexivity, and sensory or embodied ways of knowing into fieldwork has been widely emphasized. Edited volumes that aim to bring together theoretical foundations and empirical studies on emotional/affective methodologies (Flam and Kleres, 2015; Knudsen and Stage, 2015) also stress the importance of conceptual, methodological, and epistemological alignment. A range of conventional methods have been employed in empirical research, including surveys (Hubbard, 2007; Korpela and Hartig, 1996; Hernandez et al., 2007), mapping (MacKian, 2004; Lazarenko, 2020), discourse analysis (Ural, 2016; 2017; Bennett, 2013), narrative analysis (Tokdoğan, 2018; 2019), and interviews (Demirkol, 2023; Karmann et al., 2023; Tang, 2021; Bissell, 2010). Alongside this diversity, most studies focus on interviews to access emotions, drawing on participants' or researchers' observations. A significant portion of these studies adopts an ethnographic approach (Boğaç, 2020; Navaro, 2009; 2016; Ellington, 1998; Korjonen-Kuusipuro and Marilainen-Hyvaranen, 2016; Laurier vd., 2012). Given that ethnography can encompass multiple methods, its use in studies exploring emotions in space may offer advantages through its potential to integrate diverse research practices. Since this study aims to explore aspects of emotional experience that lie beyond what can be verbally articulated, the chosen methodology is expected to be capable of capturing atmospheres as spatially non-representable affects and spatial ambiguities. In line with similar concerns, visual (Duru, 2019; Wilson et al., 2020; Lorimer, 2010; Pink and Mackley, 2015) and sensory methods (Bingley, 2003; Wise, 2010), which foreground emplacement, reflexivity and embodied experience, will form the methodological basis of this research.

The design of my research on Beyoğlu, which adopts visual/sensory methodologies, is grounded in the principle that visual ethnography is inherently multisensory rather than merely visual, as emphasized by Pink (2001), adopts visual/sensory methodologies. There is now an extensive body of literature on empirical visual research (Grimshaw ve Ravets, 2005; Knowles ve Sweetman, 2005; Pink vd, 2004; Bates, 2013; Laurier ve Philo, 2006). In recent years, sensory methods have been increasingly integrated into spatial empirical research (Adams ve Guy, 2015; Crang, 2003; DeFazio, 2011; Garrett ve Hawkins, 2000; Low, 2015; Paterson, 2009; Urry, 2003). These studies are grounded in the idea that visual methods have a capacity to encompass embodied/sensory research.

As previously stated, this paper covers the part of a broader research project—my doctoral dissertation—that I have carried out so far, along with its preliminary findings. In my dissertation, I propose a research design that enables a bidirectional perspective—from today to the past and from the past to the present. The comprehensive study involves conducting ethnographic interviews with individuals from Beyoğlu and deepening these interviews through the photo elicitation method, using photographs selected from their personal archives to access the past; while to approach the present from today, I designed a participant observation process. At the intersection of these two methods, I aimed to create a space for re-articulating emotions related to these sites by walking through the streets of Beyoğlu with the interviewees and spending time together. The preliminary findings presented in this paper are based solely on the participant observation and ethnographic interview phases of the research. While the participant observation process spans the last year, my personal relationship with Beyoğlu dates back to the 1990s, and these past experiences have contributed significantly to developing insights into the space and making sense of my observations.

During this process, I made periodic visits to the spatial contact points, tracing them backward from the present, while also conducting general observations on the current state of Beyoğlu. I conducted ethnographic interviews with individuals who have longstanding ties to Beyoğlu, using various audio-visual materials related to specific places, times, and events. In these interviews, I recorded not only verbal expressions but also affective components such as facial expressions, gestures, and moments of silence, using both audio and video. During my visits, I focused on documenting the sensory qualities of Beyoğlu through my own embodied experience. I collected and analyzed all these data using MAXQDA, a data analysis software that allows for the systematic coding, analysis, and visualization of not only textual but also visual, audio, and video data in qualitative and mixed-methods research. I chose this software because it allowed me to evaluate my field and interview notes together with other types of data.

4. Beyoğlu

Since its emergence as the new center of Istanbul in the 19th century (Üstdiken, 1994), Beyoğlu has been a space that has continually transformed under the influence of ideological, political, and economic dynamics, marked in every era by an atmosphere distinct from tradition. Beyoğlu has established a strong connection with the culture, arts, and food and beverage sectors, evolving alongside them and undergoing transformations over time.

In the decades preceding the 1990s, Beyoğlu underwent significant transformations due to political unrest and military interventions, leading to the loss of its formerly vibrant, energetic and multicultural atmosphere. The 1942 Capital Tax, Istanbul Pogrom, curfews, military rule, and ongoing national tensions lead to a significant decline in interest toward restaurants, taverns, and other dining venues, many of which consequently shut down. In the 1980s, Istanbul's urban spaces underwent significant transformation as part of neoliberal renewal campaigns aimed at integrating the city into global networks. In 1988, following mass demolitions, Tarlabaşı Boulevard was officially opened. Subsequently, İstiklal Street was pedestrianised in 1990 in order to increase the area's attractiveness for both the business sector and tourists.

The identity of Istiklal Street has changed significantly since the pedestrianisation. Although İstiklal Street was pedestrianised in 1990, it was still not a preferred area for many, its lower rents compared to other central neighborhoods in Istanbul began to attract "bohemian" individuals once again, who started opening cafés, bookstores, and stationery shops (Türkün, 2021). This movement signaled the beginning of a new period of revival

for Beyoğlu. The multicultural and multi-layered composition has resurfaced with the co-emergence of different actors (Erkut and Shirazi, 2014; Tekin and Gültekin, 2017). One of the more ironic and symbolically rich moments in İstiklal Street's transformation from the 1980s to the 1990s was the impromptu Sun Ra Arkestra concert performed atop a moving truck in 1990. Taking place shortly after the pedestrianisation of the street, the performance marked an early cultural intervention in an area that had not yet regained its former vibrancy (Url1). Through such interventions, İstiklal Street slowly began to evolve from a space of transition and abandonment into a renewed cultural axis.

In the 1990's, notable urban planning decisions included designating Beyoğlu as a conservation area, and classifying various parts of it as Tourism Development Zones (Güney, 2015). These policies contributed significantly to the revitalization efforts of that period and laid the groundwork for the developments seen in the 2000s. From the second half of the decade onwards, new types of cafés, bookstores, and music venues that were particularly popular among high school and university students began to emerge (Türkün, 2021). The revival of cultural and high-quality commercial activities on Istiklal Avenue also accelerated the gentrification of nearby residential areas like Cihangir and Galata, known for their historic building stock (Türkün, 2021).

Throughout the 1990s, Beyoğlu emerged as a key hub for both independent music scenes and institutionalized cultural production. Performance venues such as Hayal Kahvesi, Jazz Stop, Kemancı, Peyote, Roxy, and—toward the end of the decade—Babylon, became central to the city's diverse musical landscape (url3). At the same time, art institutions funded by private companies, such as Aksanat and Borusan Sanat, contributed to the area's cultural diversification on a more institutional level. Istanbul Jazz Festival played a crucial role in bringing contemporary music to the city, with most concerts at the time taking place in and around the Taksim area. The backstreets of Beyoğlu were rediscovered. During this transitional period, streets intersecting or running parallel to Istiklal Avenue witnessed the coexistence of workshops, cabarets, rock bars, and pubs. The transformation of Mis Street in the 1990s became an important symbol of the broader changes in Beyoğlu. Venues offering cheap beer operated side by side with artist-frequented cafés, maintaining a vibrant, mixed-use environment. Rock music and rock venues became nearly mainstream on Istiklal Avenue (Akay et al., 2021).

In the 2000s, Beyoğlu's popularity increased significantly (url3). This decade marked also a sharp increase in rental and property values. There was a notable diversification in dining, entertainment, and cultural activities. One of the most striking developments of the 2000s was the revitalization of the area between Galatasaray and Tünel. This area began to attract higher-income groups (Eder and Öz, 2015). The transformation of Asmalı Mescit, marked by the emergence of more upscale retail and dining establishments, drew many from the middle and upper classes to Beyoğlu (İnce, 2011). During this period, Istiklal Avenue experienced its peak in terms of tourism. In response, large-scale urban projects targeting these areas were promoted under the local government's vision (Adanalı, 2011).

Within the framework of Istanbul's selection as the 2010 European Capital of Culture in 2006, developments in tourism and the cultural sector accelerated. It has been observed that the policies implemented during this time triggered a rapid gentrification process along Istiklal Avenue (Türkün, 2021). As the tourism sector expanded and inflation rates—previously high due to the 2001 economic crisis—dropped, the real estate market in Beyoğlu began to flourish, leading to a sharp rise in property values. This, in turn, deepened the gentrification process, and many businesses were forced to close due to rising rents (Eder and Öz, 2015). The years following 2010 marked a turning point for the fate of many venues in Beyoğlu. A series of events —including changes in the district's vision, the release and subsequent annulments of the 2011 zoning plan, bans on outdoor seating, the enactment of the Turkish Code of Obligations No. 6098 in 2012 (implemented in 2014), the Gezi Park protests of 2013, the terrorist bombing in 2016, and the economic crisis—collectively triggered Beyoğlu's decline.

During the COVID-19 pandemic, Beyoğlu underwent one of the most dramatic periods of silence and inactivity in its recent history. Following the announcement of Turkey's first official case, a series of nationwide closures and restrictions were imposed, severely impacting the district's vibrant ecosystem of restaurants, bars, nightclubs,

and cultural venues. İstiklal Street, once known for its round-the-clock activity, became nearly deserted, with most businesses—including those offering delivery services—shutting down. Entertainment venues were particularly hard-hit, as establishments with bar and nightclub licenses were not permitted to reopen even during phases of controlled normalization. Iconic spots such as Zencefil, Leb-i Derya, Anahit permanently closed, while others relocated or changed ownership. The collapse of this cultural infrastructure deeply affected musicians within the nightlife economy, many of whom lacked access to government support mechanisms. Reports of widespread financial hardship and even suicides among musicians revealed the depth of the crisis.

Since the early 2000s, Turkey has been governed by the Justice and Development Party (AKP), and during this period, Beyoğlu was consistently administered by AKP-affiliated mayors. Especially over the last fifteen years, the transformations discussed in this section were largely shaped by interventions jointly implemented by the central government and the local municipality, often reflecting a shared political vision. In the 2024 local elections, a notable shift occurred when the district was won by İnan Güney, the candidate of the opposition Republican People's Party (CHP). This political change was interpreted by many people of Beyoğlu as a sign of emerging expectations for a different model of local governance, one that might be more responsive to the area's cultural diversity and civic demands. Post-election celebrations, including street parties and widespread engagement on social media, pointed to a renewed public interest in Beyoğlu's potential and a hopeful re-engagement with its urban life.

5. Belonging, Creativity, and Cultural Continuity in Beyoğlu: Everyday Practices, Musical Spaces, and Affective Memory

Participant narratives reveal that the sense of belonging to Beyoğlu is not solely constructed through frequency of visits or physical proximity, but rather through everyday practices, emotional orientations, and social encounters. Especially during high school and university years—when daily responsibilities were minimal—Beyoğlu emerged as a space that was repeatedly visited, intuitively navigated, and eventually felt "like home." Expressions such as "the place I spent the most time outside home," "more than at home itself," or "like my own neighborhood" positioned Beyoğlu as an extension of everyday life. A participant whose actual residence was neither located within the administrative boundaries of Beyoğlu nor in a neighborhood typically associated with proximity to İstiklal Avenue nonetheless described the area as "very close to our home," referring to it as "like our street." This account illustrates how strong affective attachments can reshape spatial perception, producing a sense of proximity that is emotionally rather than geographically grounded. The statement "we would sit and drink beer in front of one of its apartment buildings" illustrates a strong sense of spatial appropriation. The same participant recalled, "I once left saying I was going to the corner shop, but ended up just going there, wandering around in my flip-flops and shorts. We wouldn't do anything. We'd go there for the sake of going." This non-instrumental orientation was further articulated through the analogy: "It's like going home—you don't know exactly what you'll do in which room, but you go anyway."

Experiences of Beyoğlu often lacked clearly defined spatial boundaries. While İstiklal Avenue appeared as a shared axis, participants' spatial practices extended into surrounding side streets and informal gathering spots. "We spent a lot of time on the streets... the streets were much freer," one noted. Spaces such as the steps near the Galatasaray public bath, in front of TRT, or the backstreets were remembered not as places of consumption but of lingering, inhabiting, and informal interaction. Social ties were sometimes formed with those working in these venues: "We would go to places because people working there became our friends." The sense of belonging varied across micro-locations in Beyoğlu. The Tünel–Asmalımescit area was often perceived as "posh" and associated with adulthood, whereas the axis between Taksim Square, Galatasaray High School, and Odakule felt more comfortable and familiar. The presence of "our people" in certain areas—an expression used by the participant—was a strong determinant of emotional attachment, reinforcing a form of socially coded spatial orientation.

Beyoğlu was not only a place for socializing but also for solitude, self-reflection, and escape from daily routine. Visits to Beyoğlu were often spontaneous and purposeless. The metaphor of "going home without knowing

what you'll do there" illustrates how the attachment was grounded in a habitual rhythm. Encountering someone familiar or remaining alone were equally plausible outcomes, and this ambiguity did not weaken one's sense of place. Activities described as "aimless wandering" or "going to loiter" positioned Beyoğlu as a space of open-ended potential, not limited to consumption. Participants described their navigations as shaped by an embodied familiarity: "knowing where to look" or "having nowhere else to go." The social encounters forged in this context often transcended the immediate moment, reemerging in later life phases and shaping enduring personal or romantic relationships. Shared memories of Beyoğlu, its venues, and the people within them acted as a unifying emotional reference point, even long after the spatial context had changed.

Another affective tone is the sense of safety. However, this sense of security did not stem from institutional infrastructure or formal policing, but from familiarity and emotional resonance with the space. "I never had any problems—I didn't even consider that I might," one participant remarked. While participants did not deny that negative incidents occurred, they generally framed them as exceptions rather than generalizations. Words like "my people were there" described a social landscape composed of familiar, unnamed faces. One participant referred to a man known by many as "Sedat Abi," a homeless figure who was widely recognized in the neighborhood and affectionately described as "everyone's Sedat Abi." He was nonetheless attentive to others, once asking the participant if something was wrong when they appeared upset. This anecdote exemplifies a horizontal form of care and social cohesion grounded in everyday familiarity and mutual recognition. For individuals with non-normative appearances or lifestyles, Beyoğlu functioned as a rare zone where their presence was not policed: "If you went to Ümraniye dressed like a punk, people would stare or say things, but in Beyoğlu you could express yourself freely." In this sense, safety was not just about avoiding harm, but about the right to be seen without judgment. In a similar vein, Beyoğlu also served as a site of personal formation. It functioned as a "laboratory" for experimenting with tastes, interests, and identity orientations. One participant described themselves as "formless," initially attracted to "a bit of an 'apaçi' aesthetic," underscoring Beyoğlu's role in processes of aesthetic and social discovery. Yet this process of "finding oneself" was never purely individual—it was shaped by spatial affordances and limitations. The participant noted, "you need to find the part that includes you," suggesting that inclusivity was not evenly distributed. Places like Asmalımescit were never experienced as accessible or welcoming, revealing the classed and culturally coded exclusions that coexisted within the broader inclusivity of Beyoğlu. Over time, this spatial learning led to a form of confidence—knowing "where to go, what to do there, and what I liked"—which reflected not only a stable relationship with place, but also a solidified relationship with the self.

All these layers of experience converge in a distinction participants make between merely "being in Beyoğlu" and "truly going there." The latter implied not a momentary or instrumental visit but a sustained, repetitive, and immersive engagement with the space. This pattern, often interrupted by life changes such as relocation or the pandemic, was most severely disrupted by the shrinking diversity of venues and increasing inaccessibility. Participants mourned the loss of spontaneity and mobility between venues, noting that today's Beyoğlu often resembles "a tunnel of memories." The shift from lived to remembered experience coincided with the gentrification of previously accessible spaces. Venues once defined by low cost and openness had either closed or been replaced by fine-dining restaurants and boutique shops. "Many places feel like souvenir shops now," one participant said, underlining the transformation from dynamic, relational space to commercial spectacle.

Within this broader context, music emerges as a particularly powerful medium through which cultural engagement and personal transformation were made possible. Participant narratives reveal that Beyoğlu was not merely a space where music was consumed as a listener, but also a site where music production, creative expression, and personal transformation were directly experienced. Particularly during high school and university years, practices such as renting studios went beyond casual engagement and evolved into collective forms of production. These studios were not simply rental spaces offering technical equipment; they functioned as expressive environments where observational learning, and the right to make noise were actively explored. Statements such as "We did everything there—someone would play guitar, someone else would just sit in the corner, but we were there" emphasize the value of being present, spending time together, and learning collectively just as much as producing music itself. Participants noted that the development of similar musical tastes occurred

through shared aesthetic preferences and the places they frequented together. The expression "We used to go there not knowing who we might run into" underscores the culturally generative nature of Beyoğlu's encounter regime, which was not only social but also directional. The relatively low cost of studio rental, the shared nature of expenses, and the accessibility of music production rendered Beyoğlu an inclusive space not only physically, but also economically and affectively. Participants' recollections highlight how Beyoğlu once offered not only physical but also economic inclusion. Moreover, the density of opportunities for spontaneous encounters directly shaped individual musical orientations. Listening to similar genres was not merely an aesthetic preference but was enabled by shared spatial trajectories and a broader regime of encounters. These moments—whether a spontaneous street interaction with Harun Tekin, an unposed photograph taken by Ara Güler, or an unexpected meeting with a musician in a studio—were not simply memories, but affective and cultural inflection points that contributed to the formation of identity and orientation. Over time, however, these dynamics began to shift. Processes of gentrification, genre transformations, institutionalization, and rising economic thresholds rendered these spaces more exclusive, more expensive, and less accessible. Although emotional attachments to the past persist, participants noted that spontaneous encounters and unplanned creative production have diminished. In this context, Beyoğlu continues to exist not only as a former site of cultural creation but also as a cultural potential that persists in memory.

The types of music participants connected with were shaped by the diversity of genres and styles that Beyoğlu made accessible. Particularly in their youth, connections with punk, rock, metal, and other alternative subgenres were formative in shaping both individual identities and interactions within social groups. Participants reported that their musical preferences evolved over time, often in parallel with shifts in their spatial circulation and vice-versa.

These experiences contributed to a shared spatial memory of venues that left collective traces: places like Yeni Melek, Haymatlos, GarajIstanbul, Karınca, Klan, Ağaç Ev, Ghetto, and Dorock were not only concert spaces, but also stages for everyday socializing, relationships, discovery, and the formation of belonging. Some venues, such as Klan—where high schoolers gathered on Fridays, surrounded by film posters and drinking banana-flavored instant coffee—offered tangible expressions of "alternative" identities in everyday life. Participants' continued emotional connection to the songs they once listened to—felt with the same intensity today—demonstrates that their musical engagement was not limited to personal taste. Rather, it was grounded in spatial, cultural, and affective continuity. This continuity persists, even as spaces themselves change, sustained by the power of memory and the affective force of remembering.

6. Conclusion

This study has explored how the emotional and sensory dimensions of everyday musical practices shape and are shaped by the transforming urban atmosphere of Beyoğlu. By foregrounding the role of emotions not only as content but also as method, it contributes to the expanding field of emotional geographies with a situated, multisensory perspective. Through participant observation and ethnographic interviews, it becomes evident that Beyoğlu has functioned not merely as a spatial backdrop, but as a relational and affective environment where belonging, identity formation, and cultural expression are co-produced.

Participants' narratives reveal that musical engagement in Beyoğlu operated as a mode of spatial appropriation, emotional continuity, and collective meaning-making. As informal musical encounters, studio practices, and venue-based interactions became increasingly constrained by gentrification, economic pressures, and political interventions, the district's affective atmosphere also shifted—moving from a lived, inclusive openness toward a more fragmented and nostalgic terrain. Yet, the persistence of affective memory, and the emotional intensity associated with past spatial rhythms, indicates that place continues to exert influence even after its physical and social textures have changed.

Methodologically, this research demonstrates the value of integrating sensory and visual approaches in capturing the elusive qualities of urban transformation. The concept of affective atmosphere—neither wholly repre-

sentational nor entirely pre-cognitive—proves to be a productive lens for tracing how emotions circulate through bodies, places, and practices.

In sum, Beyoğlu's musical past is not simply remembered; it is felt, embodied, and enacted through emotional orientations that endure beyond spatial loss. The findings not only illuminate how music and place co-construct affective geographies, but also underscore the need for urban scholarship to engage with the ephemeral, affective, and embodied layers of spatial experience—particularly in contexts marked by cultural displacement and contested memory.

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Participatory living heritage planning in practice: Lessons from Balıkçıköy, Istanbul

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Abstract
This study examines the participatory process of an ongoing conservation-oriented urban planning initiative in Balıkçıköy, a registered cultural heritage site in Maltepe Istanbul, through the conceptual lens of the living heritage approach. Drawing on in-depth interviews with local residents and planning professionals, it investigates three interrelated dimensions: the acknowledgment of local values, the translation of community knowledge into planning decisions, and the equity of representation across the process. Although a range of participatory tools was employed, the findings indicate that participation largely remained at a consultative level, with limited influence on strategic outcomes. While local values were documented, their integration was constrained by expert-driven frameworks. Rather than evaluating final outputs, the study focuses on participatory dynamics, arguing that meaningful heritage planning requires transparent dialogue, shared authority, and a sustained commitment to co-producing decisions with communities.

Key words: Heritage planning, community participation, knowledge integration, conservation planning, urban governance

1. Introduction: From material- and value- based conservation to the living heritage approach

After World War II, approaches to cultural heritage conservation became institutionalised, leading not only to technical advancements but also fundamentally transforming knowledge production, accuracy criteria, and decision-making authority. A brief analysis of cultural heritage conservation in a historical context suggests three distinct periods, first defined by Poulios, 2014: positivist–materialist period (1960-1980s), interpretivist–evaluative period (1990-2000s), and participatory–community-oriented period (post-2000s). Understanding these periods with their differences and shifts is important to describe the living heritage approach, which is the main topic of this study.

During the positivist–materialist period, conservation was framed as a scientific-technical field. The 1964 Venice Charter established this approach by emphasizing the documentary value of heritage and endorsing scientific methods as the sole valid basis for intervention. Knowledge was seen as measurable, objective, and universal. Authenticity was defined through material components, applying uniform criteria regardless of cultural or geographic context. Although UNESCO's concept of the "common heritage of mankind" (1972) and the "integrated conservation" approach of the 1975 Amsterdam Declaration expanded the focus from individual monuments to urban areas, the core paradigm remained unchanged (Muñoz Viñas, 2005). Material authenticity continued to dominate (Jokilehto, 1999), and decisions were led by experts. This approach was criticized for forcing cultural diversity into a uniform model.

By the 1990s, the limitations of the earlier one-dimensional approach had become evident. UNESCO's development of the concept of Outstanding Universal Value shifted the focus of conservation from purely physical attributes to the values embodied in heritage (Bortolotto, 2015). Beyond aesthetic and historical dimensions, social, economic, symbolic, and spiritual meanings began to be considered. A turning point came with the 1994 Nara Document on Authenticity, which emphasised that authenticity must be understood within its cultural context—marking a shift from a Eurocentric to a multicultural perspective. Similarly, the 1999 Burra Charter restructured the conservation process into the stages of understanding–deciding–intervening, centred on the notion of cultural significance.
During this period, knowledge production became more multidisciplinary, and stakeholder perspectives started

to be acknowledged. Yet, value assessments continued to be shaped primarily by expert opinion, and meaningful community participation remained limited. Smith (2006) critiqued this value-based approach through the concept of authorized heritage discourse, arguing that experts tend to prioritise certain values while marginalising others. This highlights how heritage definitions remained constrained within a narrow framework and how genuine public involvement was still largely absent.

The growing emphasis on locality, shaped by globalisation and post-colonial critiques (Poulios, 2014; Ndoro and Wijesuriya, 2015), challenged the expert-dominated conservation paradigm (Waterton and Smith, 2010). These critiques revealed that conventional conservation theory relies on hegemonic knowledge systems and often disregards local cultural contexts. In the emerging paradigm, valid knowledge derives not only from technical expertise but also from the real-life experiences and everyday practices of local communities (Wijesuriya et al., 2013).

As Harrison (2013) argues in his notion of dialogical heritage, the pluralistic nature of heritage values necessitates democratic conservation processes. Decision-making has thus evolved into a multi-actor practice involving experts, community members, managers, and users. This community-oriented paradigm positions local communities as key stakeholders in heritage conservation (Wijesuriya, 2015; Labadi and Gould, 2016) and views change as a sign of vitality rather than a threat (Poulios, 2014).

ICCROM's 2015 People-Centred Approaches document provides a structured framework for translating the emerging principles of living heritage into practical strategies (ICCROM, 2015). As dialogical, community-driven heritage practices gained prominence, the document offered concrete methodologies to support inclusive, locally grounded conservation efforts. By reframing conservation as a collaborative and continuous process of 'living together,' it foregrounds local agency, values, and capacities, and supports the shift toward participatory and pluralistic governance. In line with Healey's (1997) communicative planning theory, which emphasises inclusive dialogue and the co-construction of meaning in spatial governance, the document contributes tools to facilitate negotiation and mutual understanding among diverse heritage actors.

2. Making living heritage participatory: potentials and challenges

2.1. The importance of the community-oriented perspective brought by the concept of living heritage

The concept of living heritage, which enabled the transition to a community-oriented conservation paradigm, brought about a fundamental shift in perspective for conservation practice. The main contribution of this perspective is to change the ontological definition of heritage: Heritage is no longer a static 'object' to be preserved, but a dynamic 'process' that is constantly reproduced in the everyday life practices of communities (Wijesuriya, 2015). This ontological shift is driving fundamental changes in conservation practice. As Waterton and Smith (2010) emphasise, heritage is no longer understood as a collection of physical objects, but as the social practices and value systems constructed around them. The shift from passive beneficiary to active subject, as described by Jigyasu (2015), highlights how communities are now positioned as central actors in the conservation process.

The continuity–change balance, as conceptualised by Poulios (2014), provides the operational framework for the living heritage perspective. This approach redefines change not as a threat to heritage, but as a sign of its vitality. It asserts that decisions about what kinds of change are acceptable can only be made by the communities that sustain the heritage. In response to Smith's (2006) critique of authorized heritage discourse, this perspective centres the value systems, priorities, and meaning-making practices of communities within conservation processes. Heritage is thus no longer viewed as static objects to be preserved and displayed, but as dynamic spaces where collective memory is sustained and social dialogue is fostered.

This community-oriented perspective brought about by the concept of living heritage makes participatory approaches in planning processes mandatory. This necessity stems from the nature of the living heritage perspective and manifests itself in three main dimensions. The need for knowledge production stems from the definition of living heritage as a process. Heritage knowledge, continually reproduced through the lived practices of

communities, can only be accessed from within those practices. In this context, Healey's (1997) communicative planning theory is crucial: without integrating diverse forms of knowledge, the dynamic nature of heritage cannot be reflected in planning. This renders the traditional 'informing' and 'consulting' levels of Arnstein's (1969) ladder of citizen participation insufficient. Instead, a co-production of knowledge becomes a necessity rather than a choice. The need for inclusive decision-making arises from the fact that the continuity–change balance cannot be maintained through external interventions. Since this balance emerges from lived practices, only the communities that sustain these practices can manage it. Fishkin's (2009) deliberative democracy models highlight the importance of democratic dialogue in such decision-making. Similarly, Ostrom's (1990) co-management approach emphasises that the ongoing processes of maintenance, reproduction, and adaptation essential to heritage survival require genuine community ownership. On another note, the legitimacy imperative stems from the institutional need highlighted in Harrison's (2013) concept of dialogical heritage. If heritage is constantly renegotiated, such negotiation must occur under democratic conditions. Fairclough's (2009) notion of democratic heritage stresses that these processes are essential for ensuring social legitimacy.

The living heritage perspective faces a key paradox in practice. While community knowledge and participation are essential, existing institutional structures often limit this involvement. This gap reflects an underlying interest in preserving existing power relations. Chitty's (2017) community-based heritage management approach addresses this paradox by enhancing community autonomy and control over heritage. It offers a way to reconcile the democratic participation required by living heritage with institutional sustainability. This highlights three key questions for implementing participatory living heritage planning: How do communities assess their heritage, and how can these assessments be systematically integrated into planning? How should participatory planning processes be designed and conducted? What are the main barriers to implementation, and how can they be addressed? The following literature review examines existing research and theoretical frameworks that address these questions.

2.2. Transferring community knowledge to the planning process

Recognising the role of community attitudes in sustaining living heritage raises a core question: How can the diverse values that communities assign to heritage be systematically integrated into planning? Transferring community-centred heritage knowledge into planning requires systematic data collection and participatory methods. Community-based mapping combines local knowledge with expert cartography by visualising spatial perceptions. Focus groups enable comparison across demographic groups' heritage views. Participant observation reveals how communities engage with heritage in daily life. Oral history captures the lived knowledge of older generations and supports intergenerational transfer. Digital ethnography and social media analysis explore younger groups' heritage perceptions and content production. Crowdsourced inventories, social media mapping, and virtual reality tools complement traditional methods. Online platforms offer access for those unable to join in person—such as remote communities, the elderly, disabled individuals, or working parents—though digital exclusion risks must be addressed. Community-based inventories promote local involvement in identifying, classifying, and prioritising heritage. Narrative research and storytelling workshops help communities express their heritage through their own concepts. Defining the role of community knowledge through procedural transparency is essential. It ensures that how community insights shape planning outcomes is traceable and supports the sustainability of participatory governance.

Sustainable participatory living heritage planning depends on three key conditions. First, capacity building (Simpson, 2008): strengthening communities' technical knowledge, organisational skills, and leadership. Second, flexibility (Brown et al., 2013): establishing regular evaluation and adaptation mechanisms. Third, egalitarian power sharing (Logan, 2012): ensuring balanced decision-making where no single stakeholder dominates. When these conditions are met, participatory planning becomes a responsive and effective tool that aligns with both community needs and the dynamic nature of heritage. Urban cultural heritage sites offer examples of these principles in action. In Barcelona's El Raval neighbourhood, inclusive representation brought together residents, artisan groups, municipal actors, and conservation experts on equal footing—preserving the historic fabric while preventing social exclusion (Degen and García, 2012).

2.3. Implementation challenges to participatory heritage planning

The implementation of participatory heritage planning, despite its theoretical appeal, encounters various practical barriers. Research examining real-world applications has identified recurring challenges that limit the effectiveness of participatory approaches.

Participatory heritage planning faces several interconnected challenges, particularly within institutional and legal frameworks. As Taylor (2016) points out, heritage institutions are often shaped by traditional, expert-led models. Conflicts between conservation boards and local governments, stemming from overlapping authority, can obstruct the implementation of community-driven projects. Ndoro and Wijesuriya's (2015) research in Africa shows that colonial-era institutional structures continue to limit community participation. In many site management plans, community input remains consultative, while decision-making power is retained by expert boards.

Power imbalances and issues of representation also hinder meaningful participation. In traditional neighbourhood meetings, older men tend to dominate discussions, while the voices of women and youth are often sidelined. Ethnic and religious minorities similarly face structural barriers to being heard. Cooke and Kothari's (2001) concept of the "tyranny of participation" highlights how such processes may reproduce existing hierarchies. For example, when dominant community actors or interest groups claim to speak for the entire community, the perspectives of tenants and other less visible groups often go unrepresented.

A lack of resources and capacity further complicates participation. Chirikure et al.'s (2010) study in Africa shows that communities often lack the technical knowledge and financial means required for heritage management. They may be unfamiliar with traditional repair methods or conservation project planning. Even basic needs—such as organising meetings, hiring facilitators, or securing venues—may remain unmet, deepening dependence on experts and limiting community control.

Conflicts of interest and diverging priorities also create challenges. As Logan (2012) notes, heritage stakeholders often have conflicting goals. For example, the tourism sector may push for increased visitation, while residents raise concerns about noise and congestion. Similarly, luxury real estate projects can clash with tenants' fears of displacement. Short-term, project-oriented funding models also undermine participatory continuity. As Leask and Fyall (2006) highlight, heritage initiatives often rely on time-limited funding. Community committees formed during 2–3-year EU projects are usually dissolved once the project ends, leading to the abandonment of participatory mechanisms and loss of social capital. Cultural and contextual differences further complicate implementation. Caftanzoglou (2001) and Landorf (2009) show that participatory approaches face distinct challenges across settings. In some cases, traditions that prioritise elder authority may conflict with egalitarian participation models.

Systematically understanding and adapting these challenges to local contexts is essential for effective participatory living heritage planning. How such universal challenges manifest within Turkey's institutional structure and social dynamics must be examined within the framework of the local planning system.

3. A brief review of the local planning system: Turkey's legislative capacity for participatory living heritage

After identifying key challenges in implementing participatory living heritage planning, it is essential to assess how well Turkey's current planning system supports the participatory processes this approach requires in order to effectively understand the case study context.

Turkey's cultural heritage planning system is grounded in Law No. 2863 on the Protection of Cultural and Natural Heritage (1983), supported by additional laws such as No. 5366 and 6306. However, this legal framework shows limited alignment with the three core principles of the living heritage approach: integrating community knowledge into decision-making, power sharing, and democratic legitimacy. The practical implications of these limitations arise not only from legal texts but also from complex dynamics, including institutional structures,

professional culture, participation practices, and political priorities. Articles 6 and 7 of Law No. 2863 require "necessary examinations and investigations" in identifying and registering protected areas, yet these procedures rely solely on technical expert assessments. The law includes no provisions for systematically incorporating community knowledge. Conservation Boards base their decisions on technical reports and plans, excluding the experiential knowledge of local communities. Although Annex Article 2 envisions consulting relevant institutions, NGOs, and property owners during the area management plan process, this remains limited to a consultative level. Moreover, the regulations lack binding procedures for systematically collecting and processing community knowledge.

The most explicit participation provisions appear in the Conservation-Oriented Development Plan (CODP) process. While the 2005 regulation required public meetings, a 2019 amendment made them optional—held only "when deemed necessary." This shift weakened public influence in decision-making. Similarly, Law No. 5366 on the Conservation by Renovation and Utilization by Revitalization of Deteriorated Historical and Cultural Properties, and Law No. 6306 on Transformation of Areas under Disaster Risk contain no explicit participation requirements, leaving implementation to central authorities. This undermines the living heritage principle of "managing change with the community" and enables rapid, investment-driven planning.

In Turkey, participation remains at the "information" and "consultation" levels of Arnstein's (1969) ladder of citizen participation, lacking the legal and institutional foundations needed to support equal public involvement in decision-making. Conservation Board members are appointed solely by the Ministry, with no institutionalised mechanisms for local citizen representation, social balance, or civil oversight. Also, while legislation defines the framework for participatory planning, differences in practice cannot be explained by legal texts alone. The emergence of varied practices across cities under the same laws reflects the influence of institutional, professional, and social factors. In Turkey, planning and conservation education and practice remain largely technical and physically oriented. This limits experts' engagement with community knowledge and creates distance from participatory methods (Kayasü and Yetişkul, 2014).

The capacity of municipalities—in terms of staff, expertise, and budget—shapes the quality of participatory processes. Well-resourced municipalities can support more meaningful engagement, while others conduct participation superficially. The success of such processes also depends on local communities' organisational strength and prior experience. Some neighbourhoods mobilise effectively, while others lack this capacity. In areas under tourism, investment, or redevelopment pressure, participation is often side-lined. Cases like Tarlabaşı, Sulukule, and Fener-Balat show how economic priorities have overridden community needs (Kuyucu and Ünsal, 2010).

4. Methodology

This study evaluates the effectiveness of the participatory planning process conducted in Balıkçıköy urban conservation area located in the Maltepe District of Istanbul, during the preparation of the Balıkçıköy CODP. Balıkçıköy was selected because the planning process explicitly aimed to implement participatory methodologies in heritage conservation, providing an opportunity to critically examine the application of participatory principles within Turkey's institutional context.

A qualitative methodology was adopted, structured through a two-stage data collection process. The first stage involved content analysis of participation reports and documents to examine how community inputs were recorded, framed, and who was involved. In the second stage, semi-structured interviews were held with local residents and planning experts to explore their experiences and perceptions in depth. Data were analysed thematically using MAXQDA software. Coding followed an inductive approach, informed by literature on participatory heritage planning and spatial practices.

Purposive sampling was used to reach individuals residing in Balıkçıköy who were involved in the participatory planning process. A total of seven interviews were conducted: four with local residents and three with planning experts. Resident selection considered age, gender, occupation, and length of residence to capture diverse social

profiles and experiences. Participants ranged in age from 37 to 67 and included artisans, journalists, and others. Their ties to the area varied from lifelong residents to artisans with 25 years of experience. Planning experts were selected based on institutional roles—such as coordinator, assistant branch manager, and project staff—and experience with participatory planning.

Interviews with local residents focused on three main themes:

1. Translating community views into planning decisions: Participants were asked about opportunities to participate, how their views were reflected in the plan, the clarity of communication, integration of community demands into decision-making, and the existence of feedback mechanisms.
2. Representation of neighbourhood values: Questions explored perceptions of Balıkçıköy's cultural and historical values, how these were conveyed to planners, the role of everyday experiences in the planning process, representation of intangible heritage, and the balance between conservation and change.
3. Inclusiveness of the participation process: Participants evaluated how accurately their views were reflected in reports, whether participation barriers were addressed, if diverse opinions were equally considered, and whether outcomes were shared transparently.

Institutional interviews were structured around five core questions, addressing:

1. identification of cultural values,
2. participatory planning methods used,
3. criteria for evaluating community input,
4. diversity and inclusiveness of participants, and
5. recommendations for improving future participatory processes.

The raw interview data were first reviewed to identify common themes and outliers, followed by discourse analysis of the coded content. The three main themes aligned with the question sets developed through field observations and were further broken down into secondary categories (Table 1). Observation notes from the researcher's open participation were incorporated where relevant. Finally, findings from the literature review and case study were evaluated together to revisit the research questions and overall topic.

Table 1. Coding themes

Main Themes	Sub themes
Local values and patterns of daily life	• Physical environment and structural memory • Spatial memory and identity construction • Social practices and collective rituals
Transforming local people's views into planning decisions	• Disconnect between demand and decision • Technical knowledge and local knowledge and experience • Institutional complexity and jurisdictional ambiguity
Representation of all views	• Participant composition and demographic diversity • Temporal and spatial dynamics of participation • Information sharing and process traceability

5. Results

5.1. The Balıkçıköy conservation area and its planning process

The case area is located in Yalı Neighborhood, Maltepe district, Istanbul, lying between the E-5 (D100) Highway and

Turgut Özal Boulevard, bordered by the E-5 to the north, the coastal road to the south, Hasan Polat Stadium to the east, and Orhangazi City Park to the west (Figure 1). Originally a traditional fishing settlement with strong ties to the sea, its coastal connection weakened after the construction of the coastal road in the 1970s, resulting in a spatial structure increasingly disconnected from the shoreline.

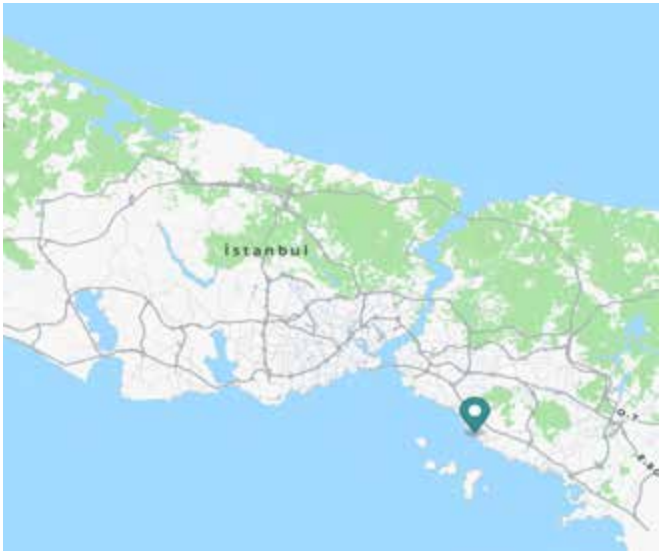

Figure 1: Location of the planning area in Istanbul (Source: Istanbul Metropolitan Municipality, 2024a)

Key features of the area include Beşçeşmeler Square, İskele Square, Feyzullah Mosque, traditional houses, and narrow streets, which together define its distinctive urban character (Figure 2). Beşçeşmeler serves as both a functional hub and a symbolic focal point. The organic street layout reflects typical coastal settlement patterns, but growing development pressure and functional changes have led to a gradual deterioration of the urban fabric.

Figure 2: Balıkçıköy Urban Conservation Area (Source: Istanbul Metropolitan Municipality, 2024b)

The area was designated as an Urban Conservation Area in 1990 by Istanbul Cultural and Natural Heritage Conservation Board No. II. It covers a total of 12.5 hectares, including the protected zone and its buffer area (Figure 3). The 1/500 and 1/5000 scale Conservation Plans approved in 1998 remain in effect. The plan revision process began with a 2019 decision by the Regional Conservation Board.

Figure 3: The boundaries of the planning and urban conservation area, (Source: Istanbul Metropolitan Municipality, 2024b)

In 2021, the 1/5000 scale Balıkçıköy Conservation-Oriented Revision Master Plan received presidential approval from the Istanbul Metropolitan Municipality (IMM). Later that year, following the transfer of planning authority from the district municipality to the IMM, the 1/1000 scale Implementation Plan was also approved. By early 2022, the planning process actively commenced, with opinions sought from relevant institutions. Analyses on natural structure, land use, built environment, transportation, and technical infrastructure were conducted based on 2022 data and made available digitally. Between 2022 and 2023, analysis–synthesis studies, conservation zoning plans, and the Urban Design Guide were completed with input from institutional stakeholders, fieldwork, and participatory processes. In 2023, the plan was approved by the IMM Assembly and submitted to the Regional Conservation Board in 2024. That same year, the plans were returned with revision requests, and revision efforts are currently ongoing.

The Balıkçıköy CODP implemented a participatory planning methodology based on six core principles.

- Transparency ensured openness from start to finish, with all activities shared publicly;
- Objectivity promoted equal and fair treatment of all participants;
- Inclusiveness aimed to represent diverse social groups and foster dialogue;
- Needs assessment focused on identifying and discussing stakeholders' on-the-ground needs;
- Deliberation encouraged open discussion of conflicting views and expectations;
- Feasibility emphasized evaluating proposals in light of their practicality and public benefit.

Various data collection methods were employed to operationalise the participatory approach. Public meetings supported information sharing, awareness raising, and consultation. Surveys, spatial marking exercises, and a participation desk were used to gather input from local residents, shopkeepers, and visitors. Additional methods included focus group meetings, one-on-one interviews, city councils, and exploratory walks to sustain dialogue and consultation throughout the process (Figure 4). The following activities were carried out as part of the participatory planning process:

- Balıkçıköy introductory forum (June 9, 2022): An open-air forum was held in Beşçeşmeler Square, where residents, shopkeepers, and users were informed about the conservation area, planning process, and urban design guide. A Q and A session followed.
- Cultural centre meetings (June 23–25, 2022): Over three days, meetings were held with five neighbourhood cultural centres to discuss street revitalisation through cultural functions, public space improvements, infrastructure needs, and ways to enhance social interaction.
- Participation desk and spatial marking: One-on-one interviews were conducted at a participation desk in Beşçeşmeler Square, while participants marked problems and suggestions on a digital map via an online tool.
- Urban design guide meeting (September 9, 2022): Held at the Chamber of Architects, this meeting presented the draft urban design guide. Alternative scenarios for square and street layouts were evaluated through design criteria.
- Interviews with local actors (March 9, 2022): Representatives from BEKSED and the Katılımcı (Participatory) Maltepe Newspaper were consulted to gather views on local challenges, opportunities, and recommendations.

Figure 4: Participatory planning activities by IMM (Source: Istanbul Metropolitan Municipality, 2024b)

5.2. Local values and daily life patterns

Physical environment and structural memory

Local participants perceive Balıkçıköy's physical environment as a strong anchor of collective memory. Old buildings are associated with personal memory cues such as "the coffee left by the Greeks," "tandoori smells," and "Communist Kenan's house," reflecting both the area's multicultural past and the spatial grounding of individual memories (İ, 67, local resident). Beşçeşmeler, in particular, is identified as a key focal point with both nostalgic and symbolic significance (N, 43, NGO representative; M, 64, local journalist).

Expressions like "silently being demolished" and "abandoned to its fate" reflect widespread concern over the loss of physical heritage. Participants associated the street texture with a past characterized by low-density, gardened, countryside living. The transformation over time was voiced critically through remarks such as "it was a summer place" and "now we cannot see the sea."

In planners' discourse, the physical environment is framed primarily as a site of technical intervention. Tools such as registration fiches, 3D models, façade arrangements, and circulation schemes are used to enhance the visibility and accessibility of historic buildings (Planner M; Planner N). References to Beşçeşmeler focus on functionality rather than emotional meaning. Emphasis on circulation and visual continuity reflects a technical optimisation of the street texture, with limited attention to its cultural significance.

Spatial memory and identity construction

Interviewee narratives indicate that local identity in Balıkçıköy is shaped not only by the physical environment but also by personal histories and shared community memory. A sense of belonging is reinforced through long-term residence and being born and raised in the neighbourhood, transforming the place into a carrier of biographical identity. İ's (67, local resident) remark, "we are the ones who have the real say," reflects a claim to legitimacy grounded in both historical continuity and lived experience. Beyond daily use, this sense of belonging is deeply tied to individual and collective memories. N's (43, NGO representative) remark, "we used to play on

these streets," reflects the spatial imprint of childhood, while M's (64, local journalist) statement, "this fountain connects me to life," shows how physical elements become emotional anchors. Temporally, participants idealise the past, constructing a "golden age" narrative with expressions like "it was like Bodrum" and "it was a tourism town." These narratives express both criticism of current changes and a sense of loss, marking ruptures in the experience of belonging.

Local identity in Balıkçıköy is shaped by both micro-level personal references and macro-level historical narratives. Phrases like "Communist Kenan's house" and "Hacı Kahve's house" reflect how individual memory is embedded in the physical fabric of the neighbourhood, while statements such as "this is where Maltepe was born" emphasise the historical depth of collective identity (İ, 67, local resident; G, 46, shopkeeper). In planners' narratives, belonging and memory are often treated as externally observed behaviours or data sources for planning. Planner E's remark that "a protectionist attitude was observed among the participants" reflects an understanding of belonging as an object to be identified, rather than a lived experience. Similarly, Planner N's statement "citizens shared their memories and we tried to reflect this in the planning decisions" suggests that memory-based inputs are mediated through a planning lens. From this perspective, identity tends to be shaped through physical interventions, supported by tools such as pedestrian connections, public focal points, and façade arrangements.

Social practices and collective rituals

Local participants describe Balıkçıköy's social fabric through past neighbourhood relations, shared rituals, and daily practices. Statements like "everyone knew each other," "you couldn't go home without having tea at 5 p.m.," and "there was a culture of helping each other" reflect sustained forms of social interaction (İ, 67, local resident; N, 43, NGO representative). Among ritual practices, the Turkish Republic Day celebrations stand out. Narratives such as "local dances used to be played" and "people walked around in war costumes" highlight both the vibrancy of the tradition and its spatial requirements (M, 64, local journalist). However, this continuity has been disrupted, as expressed by G (46, shopkeeper): "the square cannot accommodate it in its current form." Social belonging is said to persist in small-scale spaces such as modest cafés, street conversations, and fountainheads. These places strengthen individual and collective bonds, as reflected in expressions like "it connects me to life" and "we are on very good terms with the shopkeepers" (M, 64, local journalist).

Planners tend to view social practices as sources of observation and data. The decline of rituals like the October 29 celebrations is attributed to spatial issues, such as "winter gardens blocking public space." The lack of playgrounds and inadequate public gathering areas were noted in reports under the category of social needs. Past social practices—such as the "tavern and raki culture"—were treated by planners as historical references derived from observation and archival sources, rather than as lived local experiences (Planner M). However, most local residents noted that the tavern culture in Beşçeşmeler Square is not a unique value of the area's past. Overall, official correspondence and institutional opinions appear to have been the primary sources guiding the planners during the process.

5.3. Transforming the insights of local people into planning decisions

Disconnect between demand and decision

During the Balıkçıköy planning process, local participants were able to share their demands in meetings and engage directly with planners. While they acknowledged that their views were noted and recorded, there was little clarity on how much these inputs influenced actual plan decisions. N (43, NGO representative) reflected a sense of limited impact with the remark, "even if we object, not much changes. Planner N stated that data collection was systematic, with field observations and meeting notes analysed thematically. However, she did not clarify how this information was communicated or shared with local stakeholders.

The tension between local demands and planning objectives is clearly reflected in the debate over winter gardens. Shopkeepers defended them for their economic value, while residents complained that they limited access to the square. In response, the planning team recommended their removal, citing disruption of public space continuity and obstruction of historic buildings. Planner E's remark— "the frequency of requests was important, but

public interest was also taken into account"—indicates that while local demands were considered, final decisions were ultimately guided by the principle of public interest.

Technical knowledge vs local knowledge-experience

The planning process reveals an asymmetry between technical expertise and local experience. In Balıkçıköy, technical knowledge largely shaped decision-making, while local knowledge was primarily used during data collection. Planners noted that input from residents was categorised under thematic headings in plan documents (Planner E). However, how this information was translated into specific decisions and shared with stakeholders remained unclear. Local participants noted that they were able to share their experiences, but were unsure whether this input influenced outcomes. Statements like "we told them, but the decision is still the Board's" (N, 43, NGO representative) and "I attended the meeting, but we couldn't see what happened afterwards" (M, 64, local journalist) highlight a disconnect between participation and decision-making.

Planners explained that the process relied on institutional opinions, archival records, registration slips, and technical analyses by BİMTAŞ (Planner M; Planner N). These sources, drawn from official documents, were directly incorporated into the planning materials. Local knowledge—such as neighbourhood memory, usage patterns, and oral narratives—was included only after being filtered through technical evaluation. The presentation of technical information also limited access. Although plan documents were made available online, this was insufficient for users with low digital literacy. M (64, local journalist) noted that she accessed the documents through her own efforts, while other participants struggled to obtain them. The complexity and technical nature of the language used also emerged as a barrier. M (64, local journalist) remarked, "I had difficulty understanding some parts," while N (43, NGO representative) described the participation desk as "like a touristic place," criticising the information as superficial. Planner E acknowledged this issue, noting that efforts were made to simplify terms—for example, saying "zoning" instead of "Master Plan" to improve understanding.

Institutional complexity and ambiguity of authority

The Balıkçıköy planning process involved multiple actors, including the Conservation Board, Istanbul Metropolitan Municipality, and Maltepe Municipality, all exercising overlapping authority. Most local participants viewed the Conservation Board as the final decision-maker. N (43, NGO representative) expressed this perception, though the quote was incomplete in the original input—please feel free to provide the rest if you'd like it included.

Institutional authority conflicts were made tangible by the failure to implement an approved project. G (46, shopkeeper) noted that a project developed by the artisans' association was approved by the Conservation Board but not implemented by Maltepe Municipality. The lack of clearly defined institutional responsibilities left local residents without a clear point of contact, resulting in unresolved expectations. İ (67, local residents), M (64, local journalist), and G (46, shopkeeper) stated that despite collecting numerous signatures to pedestrianize Küçükyalı Street, they received no definitive response from any authority. Some participants remarked, "the Metropolitan Municipality has the authority, but we're left dealing with the local municipality." Participants noted their exclusion from the Urban Design Guide process. N (43, NGO representative) stated, "we were not invited to some technical meetings," while M (64, local journalist) remarked that technical experts deliberately avoided involving local residents, which led to their exclusion.

5.4. Representation of all insights

Participant composition and demographic diversity

Participants offered varied reflections on the demographic composition of stakeholders involved in the Balıkçıköy planning process. İ (67, local resident) remarked, "I was the only local," highlighting the underrepresentation of long-term residents. Regarding age groups, Planner M noted, "children could have been worked with, and the night population could have been interviewed," indicating limited inclusion of children and evening users. Socio-economic and interest group disparities were also evident. Commercial actors—especially shopkeepers—were well represented, likely due to debates over winter gardens. In contrast, the voices of non-commercial users, such as families, public space users, and recreational visitors, were less visible. Planner E acknowledged

this imbalance, stating, "the diversity of participants could have been wider," suggesting that institutional actors were aware of representational gaps.

Temporal and spatial dynamics of participation

Several observations were made about the timing and spatial organisation of participation activities. Planner E noted that "the area becomes more crowded in the evening," suggesting that scheduling meetings primarily in the morning may exclude evening users and the working population. Concerns were also raised about how meetings were announced. N (43, NGO representative) stated, "we found out later that some meetings were held," while İ (67, local resident) recalled, "suddenly a crowd came to the square, and when I saw there was a plan meeting, I joined." These accounts highlight how the timing and communication strategies of participation events can unevenly affect access for different user groups.

Information sharing and process traceability

Participants reported contributing to the process but receiving little information about the final outcomes. İ (67, local resident) noted, "we did not see the final version of the plan," while N (43, NGO representative) stated, "we participated but no one informed us afterwards." G (46, shopkeeper) highlighted the lack of traceability with the remark, "no feedback was given." Some participants said they were unaware of the plan's approval status and were only told it had been uploaded online. M (64, local journalist) pointed to digital inequalities, saying, "I was able to access it, but not everyone can." From the institutional side, Planner E emphasised the timing of feedback, observing that "if it is not responded to in a short time, belief decreases."

6. Discussion and conclusions

The participatory living heritage planning process in Balıkçıköy drew attention for its methodological variety and institutional involvement. Despite this, it faced key limitations regarding the influence of participation on decision-making and its perceived legitimacy among the community. Various tools—such as introductory forums, cultural centre meetings, participation desks, online mapping, thematic public meetings, and design guide workshops—were employed to create a formally inclusive model. Yet, participants often questioned whether these tools led to meaningful participation or shaped actual planning decisions. For instance, many participants were unclear about how activities like the participation desk in Beşçeşmeler Square or the mapping of local issues influenced planning outcomes. Remarks such as "We participated, but then no one provided any information" (N, 43, NGO representative) and "We couldn't see the final version of the plan" (İ, 67, local resident) highlight a lack of feedback and process transparency. These concerns indicate that participation was largely limited to data collection and aligned more with the "consultation" level in Arnstein's (1969) ladder of participation.

Although the process followed participatory principles, the integration of local knowledge into planning decisions was limited. This is especially relevant to the study's second theme: how community knowledge informs decision-making. While local input was included in planning documents, it was filtered through technical frameworks, and the details of this transformation were not communicated back to the community. In cases like the exclusion of winter garden proposals for "public interest," technical priorities prevailed over community demands. This reflects the reproduction of what Smith (2006) terms 'authorised heritage discourse,' where local knowledge served a supplementary rather than central role.

Participant narratives reflect not only information but also expressions of identity and belonging. Statements like "This fountain connects me to life" (M, 64, local journalist) and "We are the real decision-makers" (İ, 67, local resident) illustrate that spatial memory and local values imply both physical and social ownership. This aligns with the study's first theme: local values and everyday life patterns. However, in the planning process, these values were often reduced to functional elements, stripped of their cultural context within the technical discourse. According to Healey's (1997) communicative planning approach, such values should inform decisions, yet in Balıkçıköy they remained largely illustrative rather than operative.

The third main theme, "representativeness and equality," becomes central when examining participant experi-

ences. Access to meetings, the selection of invited groups, and the ability to follow the process directly shaped the inclusiveness of participation. Comments such as "I was the only local person there" (İ, 67, local resident) and "some meetings were held in the morning, so workers couldn't attend" (N, 43, NGO representative) reveal how temporal and social constraints limited representation. Although planners acknowledged that "participant diversity could have been broader," this issue was not addressed through structural changes.

At the institutional level, the involvement of multiple actors—such as the Istanbul Metropolitan Municipality, the district municipality, and the Conservation Board—created confusion and weakened participants' focus on solutions. Comments like "the Board approved it, but the municipality did not" or "we went to the local municipality, but the authority lies with the metropolitan municipality" illustrate a lack of clarity in the chain of authority. This ambiguity reduced public motivation to engage. According to Healey's governance-based model of participation, this case highlights the need to strengthen both horizontal and vertical communication mechanisms.

When these findings are evaluated through the lens of Court and Wijesuriya's (2015) three-stage cyclical participation model in living heritage planning, the Balıkçıköy planning process appears to have been relatively effective in the first phase, "Discovery and Understanding." A variety of tools were employed to explore community perceptions, local values, and priorities; rich qualitative data were collected through activities such as community forums, participation tables, and online mapping. However, during the second phase, "Visioning and Strategy," the integration of this local knowledge into decision-making processes remained limited, as the planning vision was primarily shaped by expert-driven definitions. In the third phase, "Implementation and Monitoring," the absence of participatory feedback mechanisms and the inadequate dissemination of the final draft plan outcomes to the public hindered the development of a cyclical and adaptive planning process. This indicates that participation was largely confined to an initial data collection exercise, falling short of the principles of continuous learning and shared governance central to the living heritage approach. The Balıkçıköy case thus highlights the importance of not only engaging communities in the discovery phase, but also ensuring inclusive collaboration throughout strategy development and implementation in order to fulfil the transformative potential of living heritage planning.

In conclusion, while the Balıkçıköy planning process adhered to formal participatory principles, it fell short in key areas such as influence on decision-making, the integration of local values, and equitable representation. Technical tools alone were insufficient to establish democratic legitimacy. The process underscored the need for deeper structural changes—particularly in decision-making authority, information transparency, and representational balance. Taken together, the findings reveal structural tensions between participatory ideals and practical implementation in the Balıkçıköy case. The study's three core themes—(1) recognition of local values, (2) the link between information and decision-making, and (3) representational inequalities—offer a valuable lens for evaluating the transformative potential of participatory planning, not only in Balıkçıköy but across other protected areas in Turkey. Future research should assess the long-term impacts of these dimensions through broader case studies to determine whether participatory mechanisms function as effective tools for equitable governance or remain constrained within procedural boundaries.

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Digital platforms, regulatory planning and heritisation: Airbnb and discourses around courtyard houses in the medina of Tunis (2011 to 2024)

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Abstract
This paper is concerned with historic houses in the old city or médina of Tunis as sites of memory. We take three case studies of courtyard houses (diyar, sing. dar) which were restored or adapted for use as guest accommodation in the 2010s. While the sample is small allows us to explore some of the main features of the discourses of belonging developed around the historic house in old Tunis. Such guest accommodation can now be seen across the world thanks to digital service platforms like AirBnB. Our interviews with guesthouse owners suggest a strong intellectual and emotional commitment is present in the restoration and reuse of a history property. While digital platforms are importants as sites via which individuals can communicate ideas about the built heritage of a city, there are other important discourses underlying the veneer. The paper thus reveals how family pasts are important in a form of activist engagement with a particular city's past.

Key words: heritisation, urban conservation, guesthouses, urban memory, médina of Tunis

This paper is concerned with historic houses in the old city or médina of Tunis as sites of both memory and forgetting. We take three case studies of courtyard houses (diyar, sing. dar) which were restored or adapted for use as guest accommodation in the 2010s. The sample is small but in the short space of an oral conference paper, it allows us to suggest some of the main features of the discourses of belonging developed around the historic house in old Tunis. Such guest accommodation can now be seen across the world thanks to digital service platforms like AirBnB. We suggest that such platforms are growing in importance as sites on which individuals can communicate ideas about the built heritage of a city, to an extent competing with or even weakening the discourse of public institutions. While we believe that actors providing tourist services play an increasingly important role in the historic built environment, we are not sure how this might be measured. Its impact is certainly clear in numerous cities where residents are driven out by rising rents and the general decline in deep rooted urban ways of living which occurs as tourism expands.

In this short study on old Tunis, we hope to show something of the way in which houses are made appealing, displaying historic features and playing a part in narratives of the old city. Such narratives are developed – at least for the houses discussed here – by individuals with a strong sense of the value of Tunis' historic architecture and of their place in the scheme of the city's past.

Both the authors of this paper are concerned with questions of regarding the heritisation of urban space, housing and planning. Iman Batita is the author of a doctoral thesis on the different users who have restored houses in the médina of Tunis for different uses; Justin McGuinness, having originally worked on planning for precarious social groups in multi-occupancy housing is interested in the techniques used in the transformation of historic homes and in the planning frameworks for médinas in North Africa.

The old city of Tunis has been the focus of conservationist discourse since at least the 1920s when two central areas whose architecture was held to require special protection were defined (Ammar 2010, p.116). The details of the development of heritage planning from that decade onwards are well covered by Jellal Abd el-Kafi in his La Médina de Tunis, espace historique. Since the late 1960s, the historic urban fabric has had a place in Tunisia's national political discourse. The médina has also been the object of numerous professional interventions by

architects and urban planners, for the most part working for an unusual body, the Association de sauvegarde de la Médina de Tunis, established in 1967. The more distinctive spaces of the old city have also proved attractive to entrepreneurs in the tourism and hospitality industries, a turning point being the opening of a high-quality restaurant in 1989, the Dar el-Jeld. A further turning point in the old city's trajectory was the completion of a major public realm project in the north-west section of the Médina, one of the areas with a particularly high concentration of historic buildings, religious, residential and educational. Through a subtle series of interventions on façades and sometimes on whole buildings, this project, completed in 2010 and often referred to as le Circuit, rendered several kilometres of streetscape far more 'historic' – and certainly more attractive thanks to the careful selection of colours and materials. Arguably this project 'primed the pump' for private investment for tourist activity in the western médina. The route from the Zitouna Mosque through to the rue du Tribunal had become immensely more pleasing to both residents and visitors. Note that actors in the tourist industry comprise individuals and businesses ranging from the highly professional to the amateur.

Since the 1980s, the medina has been subject to a specific town planning code that the municipality was able to enforce fairly effectively until the Jasmine Revolution – as it was often dubbed in the media – of 2011. Façade improvement operations like le Circuit continued in the early 2010s while a municipal programme to improve owner-occupied private housing continued over the same period. However, the control by the municipality over building use and new build / restoration works weakened considerably after 2015. Notably, the wholesale trade in imported garments, footwear and accessories gained considerable ground in a large swathe of the south-eastern central médina. This phenomenon has yet to be studied in detail either by researchers or by the municipality's services. There are several reasons which may account for the lack of investigation here, the most important one being the instability of municipal government since the 2011 Revolution. For a long period, municipal councils across the country operated under a special régime; there being no municipal elections, caretaker city councils were put into place. Short of funds and without strong leadership, such councils were unable to undertake any major decisions on the future of the built environment.

Methodological framework: discovering discourses of the house as site of meaning

Indispensable to human survival in settled areas, the material forms of the house are strongly invested with meaning. This has been explored by numerous theorists and a reflection of the contemporary debates about the question of the house can be found in journals like Home Cultures. The present paper draws on the authors' work on houses in Tunis, and notably on Batita's doctoral thesis which was based on numerous direct interviews with the actors of the heritage and tourism sectors in Tunis. In order to build her knowledge of the functioning of guesthouses, Batita also undertook short stays in several of them, giving her work a particular level of nuance.

McGuinness worked on the trajectories of precarious, low-income households during his doctoral research in the early to mid-1990s. Between 1992 and 2000 he lived in a nineteenth century house in the Bab Menara district. Through his network of friends and acquaintances, he has been able to follow the changes in a number of historic homes, some of them which are now used as guest accommodation. He is also well aware of the challenges and unforeseen hurdles of historic house restoration, having undertaken ethnographic work in that area in Fès – where he also restored a house.

Such familiarity with this particular aspect of the médina's functioning is not easily acquired. Some informants are prolix, to say the least, in a discussion of the médina. Others whom one would have expected to have much to say are not interested in the researcher's themes. But it is an old truism of ethnography that good insights are not always to be found where one would expect them – and that a discussion with informants will necessarily take a hoped-for direction. But this is all part of generating insights into a world with which the researcher may only have limited familiarity.

Before moving on, the authors recognise that the business of researching other people's homes can be sensitive. The informants who provided material for our case studies are in a sense public figures, either by dint of their interventions on the Web or by their professional activity which is based on the provision of well run short-stay

accommodation.

Changes in residential patterns in the médina, 1960 to 2000

In terms of residential use, the Medina underwent major changes, starting in the 1950s. Fleeing the poverty of the countryside, large numbers of rural migrants settled in the old city. As of the 1960s, elite families began to move out of the old city to settle in neighborhoods vacated by departing French, Italian and Tunisian Jewish families. There was a change in meaning and ways of living apparent in the Medina. Old Tunisois (beldi) families whose jobs and aspirations were tied up with the country's drive to modernity longer no wanted to live as part of extended families in the labyrinthine courtyard houses.

It became difficult for such families to live alongside the rural folk who were living in historic houses where rooms were rented out to individual families. The beldia found the northern coastal suburbs to be more congenial for a middle-class 'modern' family and they began to live in their summer residences all year round. There was a definite mimicry here.

When a family moved out, the old courtyard houses faced two options: abandonment or rental through agents as rooming houses (oukala-s). Architecturally important houses like Dar Belhassen and Dar Hedri on rue du Trésor, just a few minutes' walk away from the central Zitouna Mosque, were left to crumble. As certain individualism took root in the extended families, it became impossible to finance the maintenance, generally costly and often complex, of a typical large médina dar. The rental of rooms to families desperate for somewhere to live in the city was a stop-gap solution which became permanent.

Nevertheless, in some neighborhoods, the old ways of life continued to an extent into the late 1990s. In that decade, a number of families – the Baccouches and the Bou Hajbas, along with members of the Bayram and Lakhoua families were still resident in the Bab Menara district. Even today there are old beldi families living on the rue Sidi Ben Arous. One such family, the Belhaouanes, were the very first to transform their home on this street into the médina's first guest house, the Dar el-Médina, which opened in 2005.

The 1990s also saw artistically minded artistically minded folk, both Tunisian and foreigners, acquiring historic properties in the central Medina. The Algerian artist Rachid Koreïchi restored a house. The restoration of a fine seventeenth century courtyard house, just off Rue de la Kasbah, was conceived by the London-based Minimalist architect John Pawson. This house has featured on several occasions in decoration magazines like Nest and Architectural Digest (Withers 2008, Tomasini 2024). By about 2000, the possibility of the médina becoming a place where a relatively wealthy person might have a tasteful retreat, restored so as to preserve and enhance its original architectural features, was circulating among a handful of architecturally minded Tunis residents. That the médina might become a place where old houses were upgraded to function as guest houses – as was the case in Marrakech from the mid-1990s – did not seem likely, however. (By 2000, that city had at least three agencies specialised in the purchase, restoration, rental and management of upgraded historic houses).

The development of the *maison d'hôte*: obstacles and opportunities

As just mentioned, the first fully functioning guesthouse was the Dar el-Médina on the Rue Sidi Ben Arous. We discuss this case in detail because it provides a base-line from which to discuss the factors enabling the phenomenon of individually owned guest houses to develop. (Not least of these was Web 2.0)

Originally the family home of a family close to the Tunisian nationalist movement, Dar el-Médina opened in 2005. All family members had agreed that a guesthouse was an appropriate use for the home. The restoration project saw a skilled architect with years of experience in working on historic buildings reinforce the house's character with the careful insertion of extra rooms and the judicious addition of decorative features.

Nevertheless, few other families in the early 2000s were ready to make the leap. The question of indivision (Muslim law lays down scrupulous rules for the division of an inheritance) can stymie a project should there be absent

part-owners or a family member unwilling to sell their share to the promoters of a project for a house. Then there is the question of cost. To put in the fluid and electric networks is a costly job, as is the construction of new rooms to give a house the number of rooms – generally considered to be seven – necessary for a guesthouse to be cost effective. The city planning regulations are stringent on security and on quality requirements for utility networks.

Despite a major delay due to a shortage of funds, Dar Belhaouane was opened as the city's first officially authorised guesthouse and continues to function as such today.

The Belhaouanes had seen a business opportunity. Familiar with developments in Morocco, they had realised the potential of their home. Because the other elements necessary (available loans, a good architect and suitable contractors) were present, they were able to move forward. Many other projects for guesthouses and small hotels remained at embryonic level, however, for reasons not always clear. Some of the most ambitious projects, launched by major business figures simply stalled, seemingly from lack of interest.

European buyers were also few – a major difference with Morocco and other Mediterranean countries. The Tunisian State requires that foreigners buying property outside designated tourist zones obtain an authorisation to purchase. The procedure for obtaining this document from the regional authorities (governorate) is slightly opaque in character and would seem to have discouraged individual foreigners from buying property and eventually moving into the guesthouse business.

The market for property with historic character and potential as tourist accommodation thus remained dominated by Tunisian buyers. So it was that when the digital travel platforms appeared in the 2010s, there was an opportunity for individuals and families with attractive houses to reach a global market for their newly created guest accommodation. The Revolution of 2011 saw people taking liberties with municipal regulations in a way which would have been unthinkable during the years of the Ben Ali regime (1987-2011), not least of which through the construction of new rooms on roof terraces or the transformation of street-facing rooms into shops or depots. While the Revolution may have not ushered in a new republic firmly based on respect for the rule of law, it did open up opportunities in various areas where regulations were unclear or had yet to be drafted on a new activity, i.e. the family-run guesthouse.

To return to our theme, in this short paper, we are exploring the discourse around three well-known maisons d'hôte, namely the Dar Jellouli, La Chambre bleue and Dar Ben Gacem. All are in the central médina, all are well known in one way or another. Located on Rue du Riche, the first-floor patio apartment of Dar Jellouli was occupied by one of the Médina's most emblematic figures, Si Ahmed Jellouli, a true dignitary of the city whose home was a point of call for many a diplomatic visitor. La Chambre bleue, situated on Rue du Divan, was established by a Tunisian couple, descendants of an old Tunis family, both of whom had studied abroad. One was a dancer and actress, the other a university lecturer. Located on the Rue du Pacha, our third example, Dar Ben Gacem, is run by a woman entrepreneur of a family of the same name. This family has no historic ties to the médina.

All these maisons d'hôte are centrally located. We take them each to be representative of a certain approach to presenting the life of the médina – and to making a narrative of the past and the city's culture available to the foreign visitor. In Dar Jellouli, the family once resident in the house is explained through references to a prestigious lineage. La Chambre bleue is a conversion with a strong contemporary aesthetic charge; at least one of the owners is always present. The owners of Dar Ben Gacem grew up abroad, and had restoration works conducted by an experienced architect. This is the most heavily promoted guesthouse of the three. Owner Leïla Ben Gacem's good works in the médina have been the subject of many a media article; she appears to be the main force in a private-sector initiative, Tunistoric, promoting the sale and restoration of historic houses.

We propose now to examine more closely the discourses produced around different elements in these restoration projects. How did their owners establish a relationship with their houses – and through them, with the city's past?
Motivations. What makes couples or families decide to set up a *maison d'hôte*?

As indicated earlier, the present authors are both well aware of the vicissitudes of historic house restoration. The process is rarely smooth. A building may have unforeseen defects; appropriate materials may be in short supply or extremely expensive; a suitable contractor can be unavailable without explanation. In the light of these factors, we should turn to our small selection of guest-houses, first providing brief descriptions of their character before turning to the thinking which led the owners to take on restoration projects.

All three guest houses are at least two and half centuries old. Dar Jellouli is mentioned in 'the Revault' (1978, p.140) on account of its striking main entrance framed in the dressed stone so typical of the Tunis streetscape. However, only a small part of the house is used – or was used in the early 2000s – for guest accommodation. The main patio, referred to in the family as Dar et-Talyana ('la Maison de l'Italienne') was in multi-occupancy until recently. Similarly, the Chambre bleue is in fact the guest quarters of the much larger Dar Bel-Cadhi (Revault 1978, pp.347-348). Dar Ben Gacem, on the other hand, is a full courtyard house which may go back as far at the seventeenth century. All these houses have the decorative features so typical of buildings in old Tunis: polychrome wall tiles, marble or cut-stone floor paving, painted ceilings and carved stucco.

To go into depth regarding Dar Jellouli, this house was the Tunis residence of a family originally from Sfax. The Jelloulis were involved in corsair activity, a form of legalised piracy practiced in the Mediterranean in the seventeenth and eighteenth centuries. As of the nineteenth century, the family provided administrators for the Beylicate of Tunis (see Binous 2001, pp.62-69). The last of these figures, Si Ahmed Jellouli, was a well-known figure in the Médina. After his death in 2011, his apartments on the first floor of Dar Jellouli were preserved as he left them. It was here that he would receive, in an unofficial capacity, important visitors to the city. Family members' respect for Si Ahmed had allowed him to continue to enjoy the use of the upstairs apartment; the question of indivision was not evoked.

Given the cost of maintaining the property, two of Si Ahmed's relatives started a small-scale guest room operation on AirBnB. One of the present writers (I.B.) stayed in the house and was struck by the extent to which a visitor was immersed in the family's story. At least in the first decade after Si Ahmed's death, members of the family felt invested by a mission to conserve the memory of the family and its place in Tunisia's history. But the revenue generated through the rental of a guest room was inadequate to cover the cost of maintaining the house. In 2025, it seemed that Dar Jellouli was for sale.

In the case of the Chambre bleue, the relationship with the house was different. Sondès and Marouan Ben Miled, the couple who acquired the property at the Rue de l'Aga end of Rue du Divan knew that they wanted to live in the Médina. They had the advantage that Marouane's father had restored a property and that an uncle, Tarik Ben Miled, is a highly respected architect in Tunis, aware of the difficulties of restoration. The motivation was more diffuse than in the case of the owners of Dar Jellouli. There was a strong attraction to the ways of life still present in the médina; Sondès felt a need to hand on the house to future generations. But as works proved expensive for the couple, medium term rentals became a way of generating some extra income to help cover costs. Eventually, this activity turned into short stay holiday rentals which Marouane Ben Miled manages extremely effectively – as is illustrated by comments on the Chambre bleue's AirBnB page. A will to transmit a feel for old Tunis to clients, both in the spaces and through the food prepared for guests, is strong in this guest house.

In contrast, in the case of Dar Ben Gacem, the motivation for restoring the house is more definitely commercial. Possibly because she is not from Tunis and does not actually live on the premises, the owner has had to put effort into developing a discourse which demonstrates her affective link with the house. This can be discerned in the promotional booklet, Dar Ben Gacem, the Story, where much is made of the 'noble' origins of the Anun family, the original owners of the house. (The connotations of the term 'noble' as used in European languages cannot be easily applied in a city like Tunis). Arguably, in the case of Dar Ben Gacem, the business of selling accommodation in a beautifully restored house is linked to a desire for recognition.

Thus our three guesthouses, partly through their striking décor and interesting locations, but also through their

owners' affection for the medina and their sense of responsibility, can be described through the metaphor of a deeply felt 'rootedness' in the city's long history. To move further theoretically, these owners, heritage activists as they are – without ever using that term about themselves - are people who have succeeded in creating places where certain qualities of old Tunis are presented and even enhanced. One cannot doubt their sincerity in this task. The récits of the city are an essential part of their practice. After all, anecdotes please; one cannot just say here is a stone-flagged courtyard with four rooms.

What does a guest house mean?

Through a small number of cases – to be expanded upon further in the fuure, this short paper illustrates the way in which the Tunisois courtyard house, that most intimate of dwellings, has shifted from being the living space of extended families to a place for receiving a regular flow of short-stay visitors. While similar mutations in the function of housing have taken place in thousands of historic neighbourhoods across the world, in the case of Tunis – and Arab-Muslim cities like it - the shift marks a major break with the deep-rooted cultural practices, in the meaings of place. While the owners of some houses work to generate income allowing the built fabric to survive, in other cases the house is very much a place to purvey commodified 'experiences' of an old way of living. Below the (extremely agreeable) veneer of the heavily restored courtyard house, the profit motive is at work. That said, there are different degrees with respect to this motive.

To return to our closing question, 'how do guest houses mean?', there is much more than immediately meets the eye on the Internet when discovering these Tunisois homes through images and the flow of comments on a digital platform. Both the Belhaouane and Ben Miled families had a deep-rooted commitment to the broader life of Tunis. The grandfather of the owner of the Chambre bleue was one of the city's first European-trained Tunisian doctors and a public figure, as was his grandmother. The uncle of the Belhaouane brothers who set up Dar el Médina in the early 2000s, Ali Belhaouane (d.1958) was a figure in the Tunisian independence movement. The nuances of such pasts are not easily explained to the short-stay visitor. But for those who are curious, further tales of the city are there.

The historic *dar*'s place in the processes of heritisation – and commercialisation

In this paper, we have attempted to bring out the discourses which are part of the general fabric of meaning offered by our three emblematic guesthouses. In future work, we would like to situate them firmly in the broader processes at work in residential life. The récits offered by the owner-promoters of these guest houses are lucky in a sense that their homes are both aesthetically pleasing and are part of strong traditions in public life.

Encouraged with technical advice provided by trained architects sensitive to the qualities of the Tunisois house, sometimes assisted financially by local government, these entrepreneurs are actually just a handful of people among the numerous actors at work buying, selling, transforming property in the médina. Praiseworthy as they are, central to the revitalization of the city's historic building trades, such initiatives are a small part of the broader pattern of urban change – the médina's population is declining, the residential function is being driven out by pressure from garment wholesale businesses, the centre of Tunis gravity has moved north-east to new suburbs.

But via digital platforms, the guesthouse owners – and the guests through their comments - offer a particular take on the historic house. In effect, the house is used to state who the owner is and above all what their attitude to the material traces of the past are.

But there are other 'house-stories' to be seen in historic Tunis: the early twentieth century apartment stone-built immeuble, entirely demolished, replaced by a concrete frame low-rise building. There are the houses which go back to the seventeenth century, completely abandoned; for those who knew them before the family left, they are still imbued with memories. And there are the shrines and mausolea, every year a little more decayed after the heavy September rains – and mostly far off the tourism industry entrepreneur's radar. And there are the fine houses on key streets – rue Sidi Ben Arous, rue des Andalous, for example – where works were started on ambitious restoration projects, only to stall for years. To take a normative stance, these are worthy of the

researcher's gaze, given their place in the unique texture of the city. They will certainly need attention should stringent conservation plans be put into place.

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Canal Imperial de Aragón, the functionality of a water infrastructure and the inheritance of a traditional agriculture landscape in Spain

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Abstract
Canal Imperial de Aragón is one of the most significant hydraulic infrastructures in Europe and probable one of the most ambitious projects in the history of Aragón region. This work analyzes the main elements that characterize this infrastructure, including symbolic constructions such as locks and historic buildings, to provide objective reasoning of how these elements have shaped the region's cultural heritage. In addition, this study reconstructs the hierarchy and topological dependencies of the elements that comprise the canal's current irrigation network. The findings contribute to clarify the canal's role as a cultural and territorial asset, while also identifying current actions aimed at ensuring balanced water management without compromising this peri-urban landscape.

Keywords: Agricultural landscapes; GIS; Hydraulic infrastructure; Traditional Irrigation; Aragón

1. Introduction

The Imperial Canal of Aragon — Canal Imperial de Aragón in Spanish — is not only a major hydraulic infrastructure but also one of the main cultural heritage assets of the city of Zaragoza. Water-related assets hold deep cultural significance for the entire region of Aragón, especially for the Ebro River valley, where vast arid areas require the development of large-scale infrastructure to harness the river and its tributaries. The canal was initially conceived to bypass the meanders of the Ebro River in its middle course, making it navigable and providing a connection to the sea for the exchange of agricultural products. It was integrated with existing irrigation canals and extended their reach. Its role as a transportation route became obsolete with the development of railways. Today, the canal is no longer used for navigation; instead, it serves purposes such as irrigation, urban water supply, and electricity generation (CHE, 2025a). Its geographical trajectory is shown in Figure 1.

Figure 1: Geographical location of the Imperial Canal of Aragon in Spain. The map shows the trajectory of the canal and its irrigated region, which runs from the region of Navarre to Aragon, in parallel to the Ebro River, within the northeastern quadrant of the Iberian Peninsula.

1.1 History and Tradition of the Canal

Since ancient times, the use of water resources has played a central role in the development of the Ebro Valley. At least two dams from the Roman Imperial period are known in this area (Beltrán Lloris & Willi, 2012). The dam at Almonacid, on the Aguasvivas River—a tributary of the Ebro—has considerable dimensions and must have been capable of irrigating a vast area between the present-day towns of Quinto and Belchite. Moreno Gallo (2022) believes that the abandonment of the Celsa colony in 70 AD was due to the early failure of this dam, likely caused by rapid siltation. As a result, Caesar Augusta, now Zaragoza, replaced it as the most important city in the region. Of course, it also had a major hydraulic infrastructure for irrigation. In this case, a dam was built on the Huerva River, in Muel. Thus, the availability of irrigation water shaped both the settlement and development of the region.

There is even evidence of irrigation activity prior to the founding of Caesar Augusta. A bronze plaque found in Botorrita, known as the Tabula Contrebiensis, records the first documented legal dispute on the Iberian Peninsula, and the subject of contention was none other than water channeling rights, disputed by the inhabitants of Alaun and Salduie, the two Iberian settlements that once occupied the areas of present-day Alagón and Zaragoza (Giusto, 2006). Dated to 87 BC, it demonstrates, on one hand, the importance of irrigation water in the region since ancient times, and on the other, the extent of Roman resource management, which led them to arbitrate disputes between local populations. Later than this bronze plaque is the so-called lex rivi hiberiensis—the law of the Ebro canal—which documents a similar dispute in the 1st century AD and refers to a canal used jointly by several communities in the valley (Beltrán Lloris, 2006).

During the period of Islamic rule, which lasted for four centuries in this region until the conquest of Zaragoza by the Christian kingdom in 1118, irrigation systems and water channels were also developed. These infrastructures were of a smaller scale than those established by the Roman Empire, yet they left a significant cultural legacy. The invaders brought hydraulic technologies and new crops. Even today, most Spanish terms related to irrigation and water channeling originate from Arabic (Roldán Cañas, Moreno Pérez & del Pino, 2008). For instance, cisterna—like in Latin—means water tank, but when referring specifically to irrigation water, the word aljibe, from the Hispano-Arabic al úbb, is preferred. This is just one example of the Arab legacy in the culture of water and irrigation. They also influenced management practices, administrative systems for water rights, and many other aspects of irrigation activities.

To properly discuss the history of the Imperial Canal of Aragon, starting with its direct antecedents, we must go back to the year 1125, when Alfonso I the Battler, who had reconquered Zaragoza for Christendom, began granting irrigated lands to various knights. Thus, a new network of noble estates and large landholdings began to emerge as part of the colonization of the newly conquered territory (Laliena Corbera, 2011). Other irrigation channels are also known to have existed during the 12th century (Bosque Maurel, 2011: 112). As for the city of Zaragoza, the earliest surviving documents that mention them date from 1184, in which Alfonso II grants the Templars custody of the Celtén Canal—now called Centen.

Zaragoza had undergone significant growth and, by the early 16th century, had become a wealthy Renaissance city. Some texts from the period refer to it with terms alluding to its opulence (Bas Carbonel, 1999: 138). Spain was experiencing a period of splendor in technology, art, and culture, driven by the voyages to the Americas. Advances in navigation and cartography stimulated technological innovation, modern thinking, and the ambition that fostered grand projects. It was in this context that a faction of Zaragoza's municipal leaders, the Jurados, petitioned King Ferdinand the Catholic in 1510 for authorization to divert a navigable and irrigational canal from the Ebro River.

That project formally began in 1528, when Charles I of Spain—also known as Charles V, Holy Roman Emperor—commissioned three architects to study the diversion dam for the canal. The proposal by Gil de Morlanes was selected, recommending the dam be built at Fontellas, in the neighboring Kingdom of Navarre. Construction began in 1529, resulting in the El Bocal dam, but the canal never reached Zaragoza, halting just 15 kilometers from the city. This canal, known as the Acequia Imperial (Imperial Ditch), encountered numerous operational and maintenance issues. Among them, the original design included a large siphon to cross the Jalón River, which caused leakage and sedimentation problems and had to be replaced with an aqueduct supported by massive walls (Gallardo Pérez, 2024: 104). The challenges were so severe that King Philip II demanded a loan from Zaragoza for its upkeep (CHE, 2025a). The project was ultimately abandoned when a flood from the Ebro River destroyed the dam.

After several failed attempts to launch a new project to replace the Acequia Imperial, responsibility for overseeing the construction of a new one was entrusted in 1772 to Ramón de Pignatelli, with Pedro Herranat appointed as chief engineer (Fernández de Córdoba, 1791). This marked the beginning of the construction of the present-day Imperial Canal of Aragon, which remains in operation to this day.

This project also faced serious challenges during its execution. However, unlike the Acequia Imperial, all of them were ultimately overcome, and it can be regarded as a success in civil engineering. Initially, the canal's diversion dam was to be located upstream of Tudela, but due to technical issues, the new dam was ultimately built slightly higher than that the previous one. A remnant of this early attempt still survives: the ruins of a palace known as Casa de la Obra, constructed near Tudela to serve as the project's headquarters (Carrasco Navarro, 2013). The greatest risk of failure came when a flood from the Ebro River cast doubt on the project's viability. In 1784, engineer Agustín de Betancourt was appointed to inspect the site and evaluate the project. His report was highly favorable, and work resumed. Nevertheless, public opinion had begun to see the canal as a doomed venture. The failure of the earlier Acequia Imperial and the recent destruction of part of the works were seen as ominous signs.

When the water finally reached Zaragoza, Pignatelli ordered the installation of a monumental fountain near the mill and the San Carlos locks. A stone plaque was affixed to it with the inscription INCREDULORUM CONVICTIONI ET VIATORUM COMMODO (For the conviction of the incredulous and the relief of travelers). Today it is known as the Fountain of the Incredulous (Fuente de los Incrédulos). Shortly thereafter, Pignatelli died, having extended the canal beyond Zaragoza. He was succeeded in the project by the Count of Sástago, Vicente Fernández de Córdoba, who did not fulfill the dream of reaching the sea. Ultimately, the canal ends at the Ebro River near the town of Fuentes de Ebro. The Count of Sástago's contribution to the project was less significant, as the major works and engineering feats had already been completed. However, he left behind a highly valuable document: a detailed report on the canal and its construction, containing extensive information on the engineering solutions that had been implemented (Fernández de Córdoba, 1791).

Not long after, the canal and its bridges in Zaragoza became part of the front lines. The sieges that the French army inflicted upon the city in 1808 and 1809 caused damage to the canal infrastructure. Further destruction occurred during the French retreat in 1813. The 19th century was a time of reorganization and restructuring for the canal. In 1813, the Junta del Canal Imperial was established to manage and maintain it. From that point on, the administration and oversight of this hydraulic infrastructure remained under public authority. Since 1985, the Ebro River Basin Authority (Confederación Hidrográfica del Ebro) has been its managing body. Water users, organized into irrigation communities, form the General Community of Users of the Imperial Canal of Aragon. These two entities are today responsible for the infrastructure's maintenance, management, and the allocation of water quotas.

1.2 The Imperial Canal today

The 108 kilometers of the canal's course run parallel to the Ebro River along its right bank. At its origin, the intake dam has a flow capacity of 30 m^3 per second, diverted through eleven sluice gates installed beneath the large building known as San Carlos, which has remained operational since the 18th century. Approximately 265 km^2 (around 65,500 acres) of land are irrigated using this infrastructure. For this purpose, more than 300 water intakes are assigned to irrigation communities, each feeding one of the main ditches (CYA, 2025).

In terms of productive use, irrigation is primarily dedicated to extensive herbaceous crops (alfalfa, maize, cereals, etc.), although there are also areas devoted to fruit and vegetable cultivation (artichokes, cauliflower, onions, etc.). The average annual water demand for irrigation is 417 hm^3. Although most of the canal remains unlined earth, a hydrological plan has been approved that includes the modernization of several sections among other improvements (CHE, 2025).

The numerous intakes for irrigation and other services are supplemented by additional infrastructure. Two aqueducts allow the canal to cross the Jalón and Huerva rivers, both tributaries of the Ebro, near Zaragoza. Additionally, a diversion near Gallur channels water to the La Loteta reservoir, which is also fed by other watercourses (Lafuente Dios, 2004).

Regarding hydropower, four plants operate along the canal. In Gallur, where the elevation difference with the river exceeds 20 meters, 20 GWh are generated annually. In Zaragoza, the drop at the Casablanca lock was originally used as a mill in the 19th century. In 1901, a Kaplan turbine was installed in its place, enabling the generation of 650 kW, and it is still used today as an auxiliary system. This small power plant made Zaragoza the first city in Spain—and the second in Europe—to receive high-voltage alternating current. The other two power stations in operation are the Jalón plant, producing 3 GWh annually, and the Valdegurriana plant, near Zaragoza, generating 1.1 GWh.

The total elevation drops along the entire length of the canal is 125 meters. Since it was originally designed for navigation, the gradient of all sections is only 0.08%. The elevation is overcome by a system of lock groups installed in three locations on the outskirts of Zaragoza, although one of these areas has since become a highly developed urban neighborhood. This reflects how the rest of the canal's route successfully bypasses the natural terrain

using well-engineered valleys and aqueducts. The first group, located in the Casablanca neighborhood, consists of two locks known as the San Carlos locks. Adjacent to them is the sluice house, which diverts water toward the urban center of Zaragoza. It is also at this location, taking advantage of the drop in elevation, where the first hydroelectric power station was installed. Eight kilometers downstream lies the Valdegurriana lock group, situated in the Torrero hills. These are imposing oval-shaped locks, built with ashlar masonry and flanked by stone staircases. The final group is the Torrecilla locks, which overcome a vertical drop of 9.75 meters. Due to the abandonment of navigation and lack of maintenance, they had fallen into disrepair. Currently, a system of four sluice gates has been installed to allow navigation once again, serving as a replacement for the original locks.

2. Canal Elements and Cultural Heritage

2.1 Architecture and Engineering

Most of the buildings and major engineering works of the Canal have been preserved. As expected for an infrastructure that has remained in continuous use for 225 years, many of these elements have been modernized or adapted. Only those components dedicated to navigation have suffered significant general deterioration, in some cases reaching total ruin. This is also understandable after more than a century of neglect of that activity. Nevertheless, especially in recent years, restoration efforts have been undertaken to recover what is now a recognized and highly emblematic cultural heritage site for the region.

All elements of the canal —locks, guardhouses, ditches— form part of an integrated system, whose coherence is not only hydraulic but also topological. Their spatial and functional interdependence allows the infrastructure to be understood and managed as a network, with upstream and downstream relationships that reflect both physical flow and institutional coordination. This systemic logic can be mapped and studied using GIS and historical cartography, offering tools not only for conservation, but also for maintaining operational continuity in the face of change. This network logic becomes especially evident when analyzed using Geographic Information Systems (GIS), which allow mapping the hierarchy and interconnections of primary and secondary ditches, sluices, and intake points. Understanding these dependencies is essential for both conservation and adaptive management, particularly in times of increasing climate uncertainty and regulatory demands. The canal is not a linear infrastructure, but a spatially distributed and functionally interlinked system, shaped by both hydrological and social flows.

The list of elements we present here to highlight the legacy of the Canal is based on information gathered by the authors during numerous visits to the facilities and analysis of three key documentary sources. First, the document prepared by the Count of Sástago (Fernández de Córdoba, 1791) is undoubtedly the most detailed description of the Canal at the time, including highly precise technical and graphic information. The second source is primarily visual: in 1833, a collection of landscape engravings of the Canal was published by order of King Ferdinand VII, accompanied by a descriptive text of the construction project and its uses (Blanchard & Alexis, 1833). It includes 37 plates, showing the state of the facilities and buildings during the first third of the 19th century, each with an explanatory caption. The most recent source is a publication offering a detailed account of the Canal's current elements (Pallarés Jiménez, 2011).

The Casa de la Obra is a palace built as the Canal›s headquarters at the start of the project, when the dam was initially planned to be located upstream from Tudela. Although this location was ultimately abandoned, some structures remain at the site (Carrasco Navarro, 2013). The palace is considered one of the finest examples of Baroque architecture in the city of Tudela. Its imposing facade adorned with noble coats of arms and its interior with carved stone columns reflect the magnitude of the project. This is one of the so-called Canal Palaces. The term also refers to two large buildings that can be admired at El Bocal dam, both of which are well preserved. The so-called Palacio de Carlos V was the seat of the Acequia Imperial, home to its governor and the access point to the dam's four sluice gates. Built in the 16th century, it was renovated in the early 19th century. Of Aragonese style, it combines ashlar masonry on the ground floor with Mudéjar brickwork on the upper two floors and side towers. It forms a complex with other structures, such as the neoclassical Chapel of San Carlos Borromeo (Pinilla Gonzalvo, 2022). A few meters upstream, the Palacio de Compuertas is the building associated with the current Canal dam.

The El Bocal dam includes additional buildings, and an important settlement developed around it at the beginning of the Canal's construction. Families of the construction workers settled in the area, which still retains residential buildings, a school, and workshops maintained and periodically restored by the Ebro River Basin Authority (CHE, 2022).

Less monumental than the palaces but no less important as heritage is the San Carlos Mill in Casablanca. Today, Casablanca is a district within the city, and its name—meaning the white house—derives from this building, which was coated and painted white. A visual comparison of its historic and current state is provided in Figure 2. The mill serves multiple functions. It houses the Community of Users of the Imperial Canal of Aragon (CYA) and was formerly part of the Canal›s management infrastructure. Located next to the dock and locks, it also served as the administrative house for these facilities. It harnessed the water drop to grind wheat and today contains a small hydroelectric plant. Beneath the building, a structure of large ashlar blocks forms the sluice gates that once supplied Zaragoza with water—its only source for many years. The building also has significant historical value: it was here that the capitulations of the city of Zaragoza were signed in 1809, ending the second siege during the Peninsular War against Napoleon›s army. Currently, the building also houses a Canal museum featuring historical artifacts and interpretive models. Next to it is the Fountain of the Unbelievers.

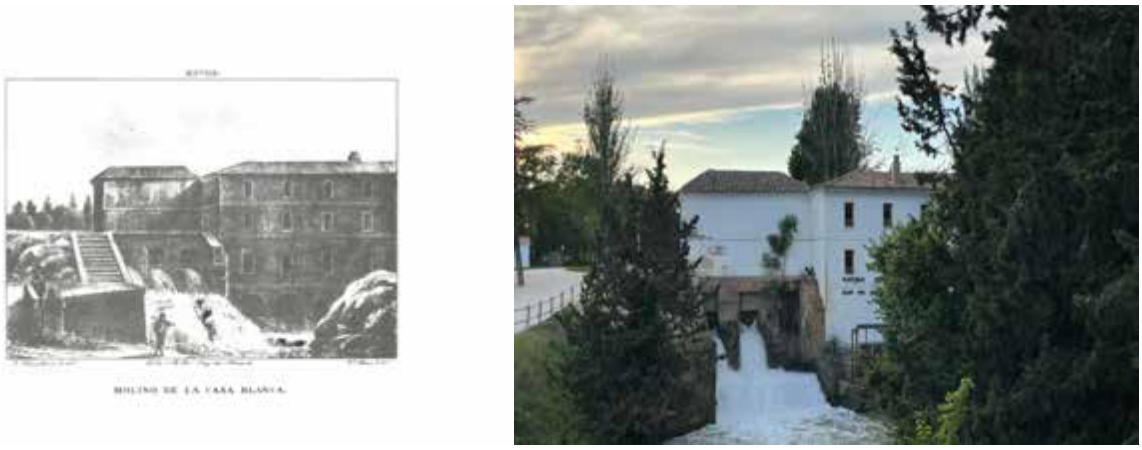

Figure 2: Historical and current view of the San Carlos Mill. Comparison between an archival image and a contemporary photograph of one of the key buildings linked to the Canal's infrastructure, located in the Casablanca district of Zaragoza. Sources: archival print (Blanchard & Alexis, 1833); authors' photography.

Currently, the Canal has 300 sluice gates that divert water into irrigation ditches. Initially, there were fewer, and the oldest ones feature access buildings used to manage the infrastructure. Twenty of these structures, known as almenaras, are preserved along the Canal. As the water has been spordically used for industrial projects, industries powered by water can be found at its side. The most important are the Imperial Flour Mill of Zaragoza and the Imperial Ceramics of Ribaforada.

2.2 Landscape and Cultural Heritage

Both Zaragoza's population and public institutions are increasingly aware of the value of the Canal's facilities as cultural heritage. In recent years, significant efforts have been made to restore all the locks to make navigation possible once again (CHE, 2025b).

Along the Canal, historical bridges built from various combinations of ashlar masonry, brick, and concrete are still preserved. Some stand out for their elegant arches, such as the Formigales Bridge, Cortes Bridge, and Clavería Bridge in Garrapinillos. Some bridges remain incomplete or in ruins, often because they had wooden decks, sometimes temporarily constructed. A good example is the Jubo Bridge in Pinseque, which preserves only its side plinths. These old bridges are an essential part of the Canal's landscape, as shown by their inclusion in the

1833 collection of picturesque views (Blanchard & Alexis, 1833).

Also notable are the aqueduct segments. In the section crossing the Jalón River, the Canal runs elevated over a monumental ashlar wall known as Las Murallas de Grisén (The Walls at Grisén). Nearby is a natural area called El Caracol, where tourism is encouraged to enjoy the landscape formed by the immense aqueduct, a large tower with a spiral staircase that leads to the elevated Canal, and the slender gate San Martín almenara, which, being on the elevated canal, rises like a tower on the horizon. The water flowing from it cascades down a stepped channel. These visible walls conceal earlier ones built for the Acequia Imperial that provided access to the siphon (Saenz Ridruejo, 2004: 356). The nearby crossing over the Jalón River, with the large openings of the aqueduct, is also part of this setting. Other elevated aqueducts on large walls exist in Zaragoza, such as the Barranco de la Muerte.

Elsewhere, the Canal's contribution to the landscape is less monumental but no less significant. Its route through Zaragoza is especially visited where it integrates with the city's large park. In this area, it crosses the Huerva River via another elevated aqueduct known as El Ojo del Canal (the eye of the Canal). Less integrated into the city is the linear PLAZA park, a newly created green space bordering a large industrial and business area, where the Canal plays a key role in shaping the park's landscape.

The Canal's contribution to the urban landscape goes beyond parks. As mentioned earlier, the Casablanca district grew around the Canal's facilities. Another major urban district, Torrero, is also closely tied to the Canal. The large América Bridge connects this district with its southern area and the rest of Zaragoza. Torrero's initial growth was driven by Canal-related construction. Pignatelli commissioned the construction of a large church for the workers, the Church of San Fernando. Today, located within a military compound, the 19th-century district was then connected to the city only by a rural road. The church marked the consolidation of this new population center and it features a large dome and two towers, reflecting the importance of the growing community. The commission for the interior paintings went to Francisco de Goya y Lucientes (Marías et al., 1984). During the sieges of Zaragoza, French troops looted the church, and the paintings were lost. However, Goya's preparatory sketches are still preserved.

The ecological value of the Canal is indisputable. It has helped sustain a vast irrigated area on the southern side of the Ebro River. Although irrigation has existed since ancient times, the Canal's infrastructure and steady flow ensures the ecosystem's maintenance. Notably, the water serves as a reservoir for endangered species such as Margaritifera auricularia, a rare freshwater mussel also known as the river pearl (Araujo & Ramos, 2000).

As presented, the Imperial Canal of Aragón is a cultural asset of special significance for the region due to its connection with the water culture, a recognized part of the region's identity. In such an arid area of Aragón, yet rich in difficult-to-access water resources, it is no surprise that the region closely identifies with its rivers and canals. This water and irrigation culture, inherited from Romans and Arabs, survives in local traditions affecting both irrigation techniques and water governance. For instance, in a town near Zaragoza, an ancient system of irrigation rights allocation known as El Trallo is still in use. It involves throwing a bundle of plants into a ditch and depending on which direction they take at a fork, water is allocated to one village or the other (Pérez Viñuales, 1989).

The Imperial Canal traverses a highly dynamic peri-urban area where rural practices, metropolitan expansion, and ecological values intersect. This landscape is not a passive buffer but a space of tension, where different land uses and temporalities coexist —productive agriculture, infrastructural heritage, and urban transformation. The canal, by sustaining agricultural activity and offering ecological continuity, becomes a structural element of resilience in this context. Its preservation is not only a matter of heritage, but of territorial balance and environmental justice as well.

Zaragoza, as the regional capital, embraces and promotes this legacy. In 2008, it hosted an International Exposition whose central theme was water and sustainable development. The event addressed the challenges of water under climate change and its role as a shared resource, while supporting a landscape intervention and

management project that has contributed to improving the city's environmental quality (Alday, Jover y Dalnoky, 2009). Today, Zaragoza has a vast riverside park dedicated to water and water resource issues often shape the region's political discourse. The Imperial Canal of Aragón remains one of the most cherished assets, representing Aragon's heritage of traditional and responsible water use.

3. Challenges to traditional practices amidst Peri urban dynamics

The irrigation system is managed through a shared institutional structure. While the physical infrastructure is owned and maintained by the Confederación Hidrográfica del Ebro (CHE), the distribution and operational management of water is carried out by the user community, represented by the Canal Imperial de Aragón entity (CYA). CYA is the organisational body that brings together the various irrigation syndicates along the canal, coordinating the use of water resources and ensuring compliance with the regulatory framework established by the CHE. Within this model, CYA is responsible for implementing irrigation schedules, mediating local governance, and maintaining the traditional practices that structure daily water management. The main structure of this irrigation system and its extent can be seen in Figure 3.

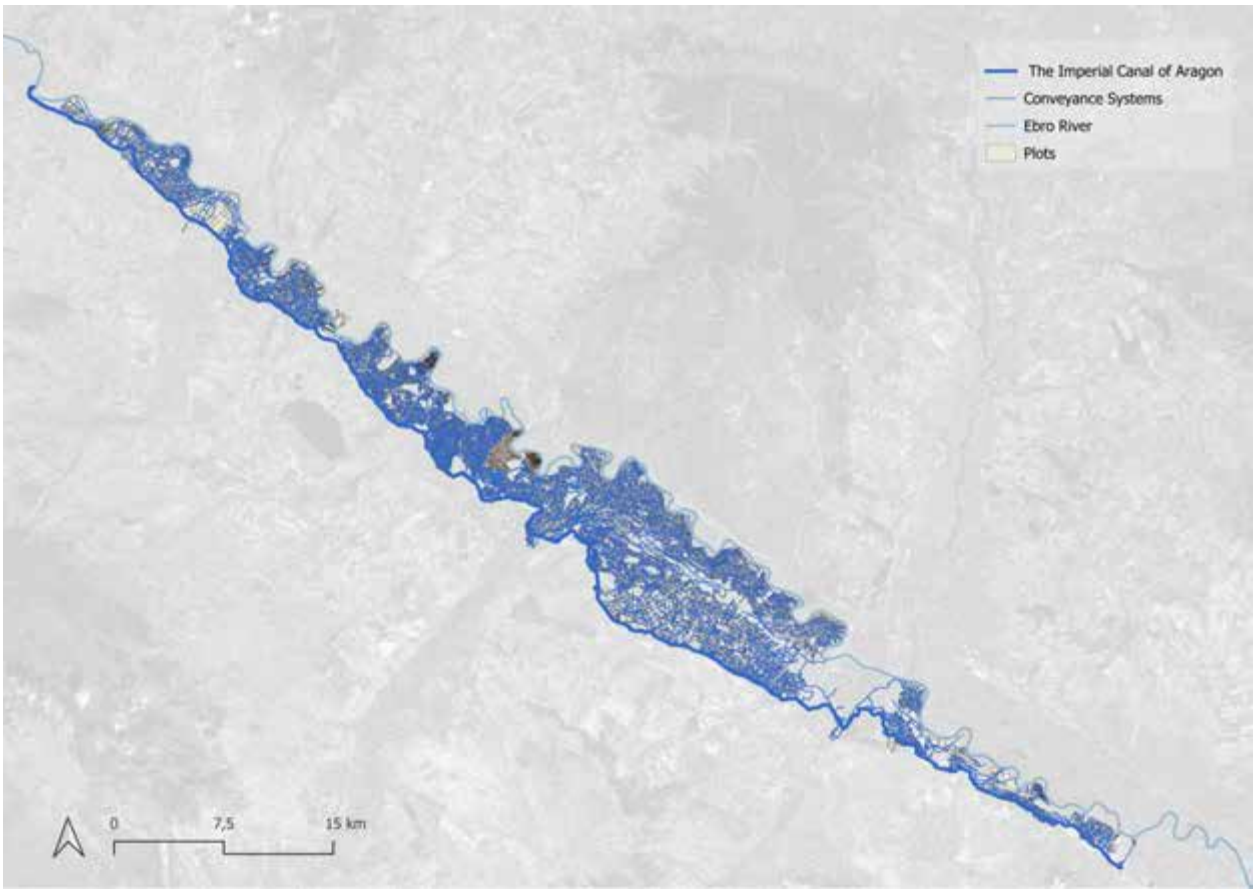

Figure 3: Irrigation infrastructure of the Imperial Canal of Aragon. The map shows the main canal, the network of conveyance systems, and the agricultural plots it serves. This layout reflects the extensive spatial organization of the irrigated area.

The uniqueness of CYA lies not only in its technical scale but in its organisational model. Governed by communities of irrigators, grouped into irrigation syndicates (sindicatos de riego), the system operates according to a set of practices developed through centuries of shared use. At the heart of these practices is the notion of equity, embedded in a rotation-based method of distribution—known as adores—that assigns water to users in a cyclical and public manner. Each day, the head canal guard oversees water distribution, records which plots have received water, and ensures compliance with the schedule. This structure has generated a strong sense of

collective responsibility and reciprocity, contributing to the social resilience of the communities that depend on the canal.

This model of self-managed irrigation, developed long before the rise of contemporary resource governance theory, provides an exemplary case of what Elinor Ostrom termed a "common-pool resource institution" (Ostrom, 2002). It is governed by rules devised by the users themselves, enforced through mutual monitoring, and adapted to environmental fluctuations. Yet, despite its adaptability and effectiveness, the CYA system is increasingly seen as insufficient from the perspective of modern water management standards and regulations.

3.1. The Need for Water Consumption Management

Across Europe and other parts of the world, the discourse on water governance has shifted significantly over recent decades. The focus has moved from access and equity toward efficiency, accountability, and technological innovation. This transition is linked to broader concerns over climate change, water scarcity, and environmental sustainability. Under new regulatory frameworks, irrigation communities are now expected to provide detailed data on consumption, report crop types and schedules, and demonstrate improvements in water use efficiency. These expectations arise from both legal requirements —such as the EU Water Framework Directive— and growing public pressure to justify the use of shared natural resources.

In this context, the traditional operational logic of CYA appears increasingly out of step with institutional demands. Water is not allocated based on volumetric measurement or per capita quotas. Instead, distribution is guided by historical entitlements associated with plots of land, and turns are coordinated through informal negotiations and routine practices. While this system has ensured equitable access over centuries, it offers limited capacity for real-time monitoring or precise accounting.

The disconnect between traditional logic and regulatory expectations poses both technical and political challenges. From a technical standpoint, it becomes difficult to evaluate the relative performance of CYA in terms of water efficiency or productivity. Statistical comparisons with pressurised or automated systems often favour the latter, especially when data availability is unequal. From a political perspective, the lack of data can be interpreted as a sign of opacity or inefficiency, reinforcing the notion that traditional systems must be replaced or overhauled to meet contemporary standards.

Yet, such assumptions overlook the complexity and functionality of systems like CYA. Despite its informality, the canal's distribution mechanism operates with remarkable precision, guided by generations of experience and local knowledge. The guards responsible for opening and closing the main gates often know each plot, user, and ditch intimately. Their role, though rarely digitised or standardised, ensures the system's daily operation and reflects a form of expertise that cannot be reduced to sensor readings or remote monitoring dashboards.

The need to manage water consumption more effectively is not denied within the community. Many users and administrators of CYA recognise that the pressures facing the system today are different from those of the past. They are aware of the demands for transparency, the importance of sustainability, and the necessity of adapting to a changing climate. However, they also argue that solutions must be adapted to the context. What works in drip irrigation schemes or highly mechanised farms may not apply to a flood irrigation system rooted in collective action and territorial history.

Moreover, the scale and heterogeneity of the CYA system further complicate the implementation of standardised monitoring tools. The network of ditches and secondary canals is complex, and many plots receive water from more than one intake point, depending on the topography, the time of day, and the specific irrigation cycle. The idea of installing a flow meter at each individual gate is not only financially unfeasible, but also socially disruptive, as it would alter the balance of trust that underpins the existing order.

In this scenario, the goal is not to reject the call for better water management, but to reframe it in ways that

respect the system's cultural and operational integrity. What is needed is a form of adaptive governance that improves data availability and reliability without undermining the principles of collective management. Such an approach would seek to enhance, rather than replace, the mechanisms already in place, and to work from within the system's logic instead of imposing an external model.

The adoption of new tools and methods must be aligned with the principle of subsidiarity—where decision-making is kept as close as possible to the local level. This means recognising the guard's observations as valid inputs, structuring the existing libros de adores (ador logbooks) in ways that allow for systematic analysis, and combining this information with basic hydrological models that account for the physical characteristics of the network. In doing so, CYA could generate more accurate estimates of water consumption while maintaining the community-led structure that has sustained it for centuries.

3.2. Challenges of Measurement in Traditional Systems

The traditional structure of the CYA irrigation network presents inherent limitations for measuring water consumption using conventional technical tools. Unlike modern irrigation systems that rely on pressure lines, digital meters, and automated control, CYA operates entirely through gravity-fed flow, distributed via open ditches of varying construction types and dimensions. This complexity is illustrated in Figure 4, which shows the dense conveyance system and the parcel fragmentation. The physical configuration of the network, along with the rotational logic of water allocation, makes precise and continuous measurement a difficult task.

Each intake along the main canal diverts water into a local conveyance system, which then branches into numerous ditches and ultimately reaches individual plots through gates operated manually by irrigators. These gates are not fitted with meters or sensors, and their opening levels are rarely recorded with engineering precision. Instead, guards and users rely on experience, visual inspection, and habitual knowledge to manage the distribution. This results in a system that is functionally effective, yet difficult to capture in standardised data formats.

Water losses between the canal intake and the destination are significant and variable. They depend on several factors, including the material and age of the ditches, the slope and distance of the flow path, and weather conditions that affect evaporation. Conveyance losses are generally assumed to be high —sometimes exceeding 40%— (Serra, 2016) but no direct measurements are made on a daily basis. The inability to account accurately for these losses complicates efforts to assess how much water each plot receives.

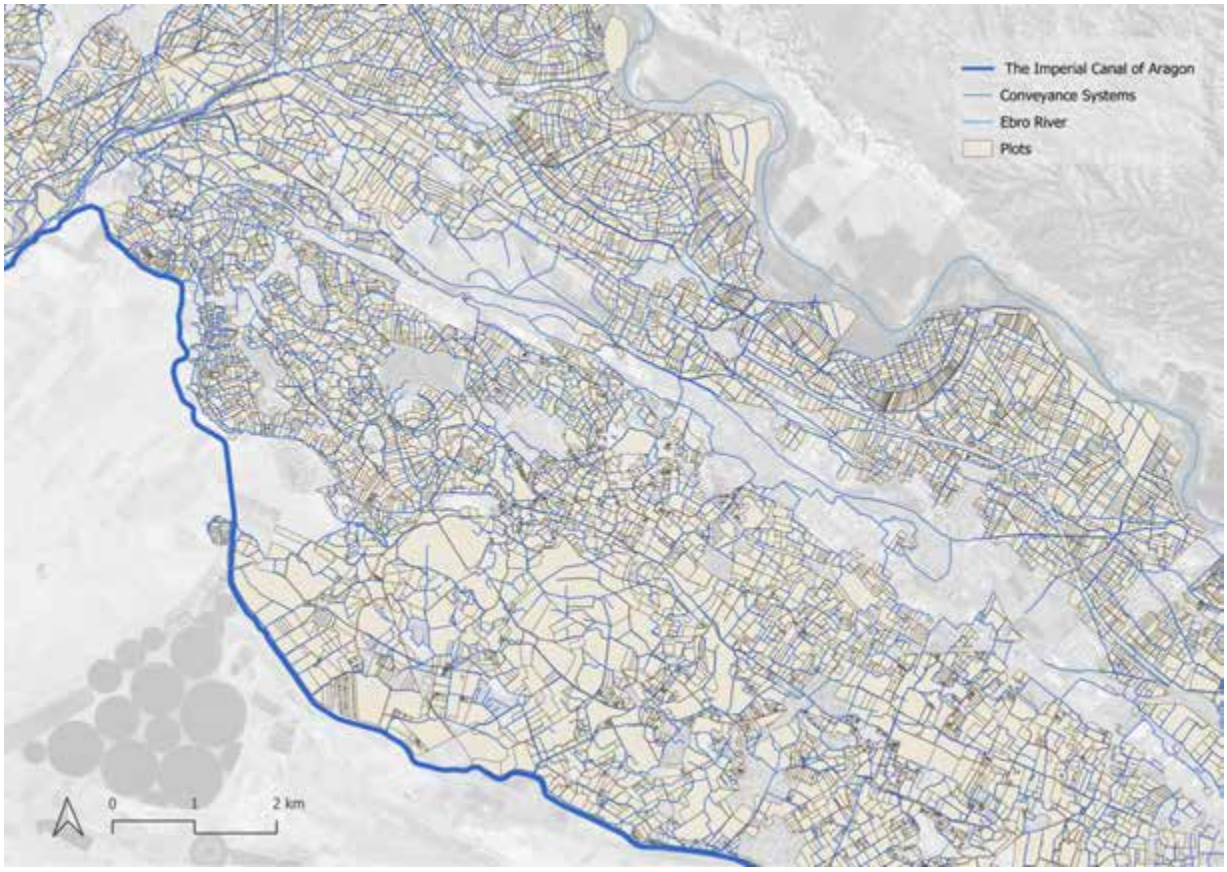

Figure 4: Detailed partial view of the irrigated area. The image illustrates the high density and complexity of the conveyance system and the parcel fragmentation.

Another issue is the temporal dimension of flow. Because of the slow movement of water through the ditch system, there is always a delay between the moment water exits the main canal and the moment it reaches the plot. This delay, known as conveyance time, can range from 90 minutes to over two hours, depending on distance and conditions. As a result, any time-stamped measurement at the canal level does not immediately correspond to what happens downstream. Synchronising flow data with plot-level activity requires not only physical modelling but also reliable information on irrigation schedules—information that, in the CYA context, resides primarily in the daily notes of the guards.

The adores logbook is the only consistent record of water distribution in the system. It is maintained manually, often with limited detail, and varies from one syndicate to another in structure and style. Despite this, it offers valuable insights into how water is used: which plots were irrigated, in what order, and for how long. However, because the data is subjective, based on observation or user reports, and not standardised, its reliability for estimation purposes is variable. Some entries are precise, while others may be incomplete or rely on assumptions. The lack of systematic archiving or digital transcription further reduces its analytical potential.

The core issue concerns the coexistence of two distinct approaches to managing irrigation. One is based on lived experience, observation, and collective coordination; the other relies on measurement, standardisation, and external monitoring. Bridging these perspectives requires not just methodological innovation but also institutional awareness of the system's cultural and operational specificities. Traditional data should not be dismissed as unreliable, but rather understood in its context and translated into forms that can inform practical decision-making. Ultimately, the goal is not to quantify every detail, but to generate sound and consistent estimates of water consumption—estimates that reflect both the physical dynamics of the system and the way it is used and governed.

CYA presents a powerful case for rethinking how we define and measure water use. It invites a broader reflection on the role of tradition in contemporary water management, and on the need to adapt our tools to the systems we are working with, not the other way around.

3.3. Heritage Dimensions and Pathways for Protection

Beyond its operational challenges, the CYA irrigation system must be understood as part of a broader cultural and territorial heritage. Its ditches, gates, pathways, and guardhouses form part of a historical landscape shaped by centuries of interaction between people and water. The rules of rotation, the figure of the guard, and the communal management model are all expressions of intangible heritage that reflect a collective memory and a shared sense of belonging.

These dimensions are often overlooked in conventional water policy, which tends to favour efficiency over continuity and data over meaning. Yet, safeguarding traditional irrigation systems is not only about preserving old techniques. It is about recognising the value of a way of managing land and resources that remain socially relevant and ecologically adapted. Systems like CYA have persisted precisely because they respond to the complexities of their environment with flexibility, embedded knowledge, and low-cost operation.

However, this heritage is increasingly under threat. Regulatory frameworks rarely account for the specificity of traditional systems, and funding programmes for irrigation modernisation often prioritise technical upgrades that are ill-suited to the logic of collective governance (OECD, 2006). Meanwhile, generational renewal is limited. Young people are less involved in farming and less connected to the values and practices that sustain traditional water management. Without targeted support, much of this knowledge may be lost within a generation.

To address this risk, heritage protection should be redefined to include not just monumental structures or historic canals but also living practices and institutional arrangements. Recognising the ador rotation system, the adores logbook, and the figure of the guard as heritage assets could open new possibilities for institutional support. This recognition does not mean freezing the system in time. On the contrary, it involves empowering communities to adapt their practices while maintaining their identity. It also involves documenting existing knowledge, promoting intergenerational transmission, and creating spaces for dialogue between users, researchers, and policymakers.

The future of CYA depends on the capacity to evolve without losing its core. Protecting the system means more than preventing physical decay. It requires creating conditions for social, institutional, and technical continuity. Only then can the canal continue to irrigate not only crops, but also the cultural and civic fabric of the territory it sustains.

Striking a balance between technological innovation and traditional knowledge is essential. Maintaining the canal's use should not imply transforming it into a mechanised or hyper-technified system at the cost of its ecological and cultural integrity. Rather, adaptation must work within the system's own logic, respecting the territorial and environmental values that give meaning to its operation. The canal is not only an infrastructure. It is a socio-ecological ecosystem shaped by collective practices and historical memory. Any modernization strategy must recognize this complexity and avoid interventions that might simplify or fragment it. Protecting this equilibrium is the real challenge of contemporary water governance.

4. Conclusion

The Imperial Canal of Aragón constitutes a unique case of territorial continuity, where an infrastructure designed in the 18th century remains both operational and socially embedded in the contemporary landscape. Heritage, ecology, and agricultural functionality intersect in the peri-urban fringe. Its hybrid nature —as both a functioning irrigation system and a cultural-historical landscape— challenges conventional modernization approaches that often prioritize technical metrics over historical resilience and socio-ecological integration.

The peri-urban context of Zaragoza plays a crucial role in this complexity. As urban pressures intensify, the canal landscape has become a buffer zone between agricultural persistence and urban expansion. This spatial tension must be addressed not only through land-use regulation, but also through policies that recognize the cultural, ecological, and social functions of traditional irrigation landscapes.

Efforts to modernize water management must be carefully adapted to these specific contexts. Rather than imposing volumetric control through high-tech systems, governance frameworks should pursue compatibility with the collective, experience-based logic of flood irrigation. Adaptive models that integrate community records, observational practices, and targeted monitoring can improve accountability without dismantling historically grounded practices.

Protecting the canal requires more than preserving its physical elements. It demands a commitment to maintaining the social fabric that gives it life: the irrigation communities, the guards, the rotation schedules, and the lived knowledge embedded in each ditch and gate. These are not relics, but assets of a flexible, robust, and living rooted system.

In a time of climate uncertainty, biodiversity decline, and urban sprawl, infrastructures like the Imperial Canal offer a roadmap for ground sustainability. It demonstrates that resilience can be built not only through innovation, but also through memory, reciprocity, and rootedness in territory. It stands as evidence to how infrastructure, tradition, and landscape can coexist in dynamic balance. Recognizing and supporting these qualities will be key to ensuring their continuity into the future.

Acknowledgements
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Heritage and Community. Strategies for a sustainable change of the mid-Adriatic coastline

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Abstract
The study analyzes the coastal landscape of the mid-Adriatic coast of Abruzzo, from Pineto to Vasto, interpreting the heritage processes connected to the dynamics of territorial transformation. The focus is on new forms of development aimed at enhancing the coastal heritage, understood as an accessible resource.

The research deals with heterogeneous territories: the Adriatic city, squeezed between the coastline and the infrastructure that crosses the Adriatic dorsal of the country, and the Costa dei Trabocchi, where the rural landscape clashes with the pressures of urbanization and tourism.

The coastal heritage, consolidated and in need of reinterpretation, is understood here as an environmental infrastructure and a laboratory for experimenting with policies to mitigate the risks posed by climate and social change, capable of developing sustainable enhancement strategies.

Keywords: Trabocchi coast, tangible and intangible heritage, heritage community, mid-Adriatic coastline, Coastal Landscape.

Introduction

The coastal areas of the Mediterranean are currently undergoing profound environmental, social, and territorial transformations, triggered by intense urbanization, climate change, and increasing pressure from tourism.

In this scenario, the stretch of the mid-Adriatic coast of Abruzzo between Pineto and Vasto represents an emblematic laboratory for investigating the tensions between development and conservation, between heritage and innovation. The study focuses on the mid-Adriatic coast of Abruzzo, interpreted as a privileged space of connection between cultures, economies, and emerging territorial dynamics. Abruzzo now plays a strategic role as a gateway to the eastern coast of the Adriatic Sea, strengthening its vocation as a bridge to the Balkan peninsula, which is currently undergoing economic, cultural, and social upheaval.

The study aims to analyze the coastal landscape of the mid-Adriatic coast of Abruzzo, interpreting the processes of heritage preservation linked to the dynamics of transformation currently underway. The goal is to identify new forms of sustainable development capable of protecting and enhancing heritage, understood as a living and shared resource.

The Costa|Med research, conducted by the research unit of the University "G. d'Annunzio" Chieti-Pescara, aims to create a cognitive atlas of the mid-Adriatic coastal heritage, focusing on the coastal heritage of Abruzzo to create a territorial analysis tool that can provide a comprehensive picture of the characteristics and potential of this specific geographical area. The research is part of the PRIN 2022 project "COSTA | Med – Catching Opportunities for Strategic Transformation and Adaptation of Mediterranean Coasts," which involves the research units of Roma Tre University and the University "G. d'Annunzio" Chieti-Pescara.

The paper is divided into four main sections. The first section presents the theoretical and methodological context of the research. The second section describes the study area, highlighting the specific characteristics of the Abruzzo coastline between Pineto and Vasto. The third section illustrates the results of the territorial analysis and the atlas as a tool for reading and studying the territory. Finally, the fourth section looks at the impacts of climate change and some good practices.

The Mid-Adriatic between identity and transformation

The Adriatic Sea, with its qualities and history that have defined the characteristics of the peoples inhabiting the territories bathed by its waters, is one of the basins of the Mediterranean Sea that has perhaps contributed most to our understanding of the Mediterranean world, its dynamics, and its events. This is despite the historical complexity of the basin and its "marginal" position, with which we are accustomed to identifying it today.

This basin, defined by Franco Farinelli (2024) as "the sea of domesticated complexity," encompasses three of the main civilizations of the contemporary world, identified by Samuel P. Huntington: Islamic, Orthodox, and Western civilizations, which together make up the soul of the Adriatic.

The work of the research unit at the University "G. d'Annunzio" Chieti-Pescara fits into this context rich in communities and tangible and intangible heritage, where geographical proximity has fostered processes of exchange, comparison, and cultural hybridization. The activity is developed within the Costa|Med project, focusing on the stretch of the mid-Adriatic coast of Abruzzo, along the western coastline.

The macro-context of the research is part of a much larger geographical context that extends for about 400 km, covering an area that stretches from Emilia-Romagna to Molise, crossing the Marche and Abruzzo regions. These regions share similarities in their urban and social characteristics along their coasts, such that the mid-Adriatic can be considered a single territorial entity.

The territory is structured as an urban filament that runs continuously along the entire coastal strip (Pignatti, 2014). In its components, which will be described in more detail below, the mid-Adriatic manifests itself along this strip of land, intersecting perpendicularly with the valleys. These natural, urban, and infrastructural intersections give rise to the characteristics and "situations" that shape the identity of the central Adriatic territory.

This coastal landscape, including the Abruzzo coastline, is a vacation destination par excellence, an identity for which it is famous abroad, generating substantial tourism from Europe. It is characterized by endless rows of beach umbrellas which, like the urban fabric, seem to stretch uninterrupted along the mid-Adriatic coast. This is a tourist image that over time has become a distinctive feature of the mid-Adriatic landscape, an identity that today, however, threatens the very existence of this territory. The Abruzzo coastline under consideration is in fact subject to strong expansionist pressure from tourism, which threatens the territories, the communities that live there, and their tangible and intangible heritage.

Coastal heritage as environmental infrastructure: sustainable development of the mid-Adriatic coast of Abruzzo

The coastal heritage is interpreted here as environmental infrastructure (di Venosa, et al. 2022), alive and dynamic, overcoming the traditional static view to embrace a perspective that recognizes it as an active resource, capable of redefining itself through social practices of enhancement. It thus takes the form of a value-generating resource, through its daily use by the communities that inhabit it, through practices capable of keeping it alive and mitigating the risk factors that threaten its existence.

This dimension is particularly important in the coastal areas of the mid-Adriatic region of Abruzzo, where traditional practices, from fishing along the Trabocchi coast to settlement patterns and relationships with the territory, now constitute an intangible heritage that manifests itself through places and rituals. This is the same heritage that local artists have always represented, such as the painter Francesco Paolo Michetti and the "circolo michettiano" with their evocations of everyday life in Abruzzo.

These testimonies show how heritage in its various forms is articulated in complex relationships between the natural and built environment, knowledge, and traditions, where landmarks such as the trabocchi or the more recent oil and gas extraction platforms take on the value of identity symbols capable of guiding territorial development.

Heritage is constructed through the adoption of social practices of attribution of meaning, a particularly fruitful perspective for coastal heritage, where transformations require a continuous renegotiation of meanings and values. The European Landscape Convention introduces a democratic concept of landscape, defining it as "a specific part of the territory, as perceived by the population" and emphasizing that "landscape is a key element of individual and social well-being." This link between quality of life and landscape is a fundamental principle, particularly significant for coastal areas where environmental quality is a factor of attractiveness and a resource for the well-being of communities.

Coastal heritage must be seen as a privileged laboratory for policies to combat climate crises, a territory where innovative and sustainable solutions can be tested that effectively integrate heritage protection with contemporary environmental challenges.

The Faro Convention (2005), and in particular its Article 8 on "Environment, heritage, and quality of life," provides the theoretical and operational framework to support this project vision. The article establishes the importance of using all dimensions of cultural heritage to enrich development processes and promote an integrated approach to policies concerning cultural, biological, and landscape diversity. Heritage enhancement is achieved through the ability to understand the virtuous link between heritage itself, improvement of quality of life, and sustainable development.

The concept of "heritage communities" therefore takes on a central role, identifying groups of people who value specific aspects of cultural heritage and wish to support and pass them on to future generations. This approach does not replace institutional logic, but promotes structured collaboration between public institutions and heritage communities, creating the conditions for participatory governance of coastal heritage that can respond to the needs of conservation as well as those of climate adaptation and sustainable territorial development.

It is important to highlight some fundamental aspects of the Convention that are essential for research and its future developments. The first concerns democratic participation, which provides for the active involvement of communities in decisions relating to the cultural heritage of their territory. This is followed by the integrated approach, according to which heritage protection must be considered across all sectors of public policies, recognizing the strong connection between heritage and development. Finally, shared responsibility establishes that the identification, study, protection, and conservation of cultural heritage do not belong exclusively to institutions but are a collective responsibility of citizens.

To paraphrase Alberto Magnaghi, in this perspective, designing means creating a "stable home", i.e. establishing virtuous relationships between the settled community, the environment and the territory. Building the future means reconnecting differences, where diversity becomes a resource rather than a source of fragmentation. At the heart of this vision, the community is not just a social aggregation, but becomes the active subject of territorial transformation, capable of imagining and building concrete alternatives.

The prospects for the mid-Adriatic coast of Abruzzo in this research are outlined through the integration of these theoretical dimensions into operational strategies capable of enhancing the existing heritage, orienting transformations towards environmental and social sustainability.

Characteristics of the coastal urban fabric between Pineto and Vasto

The stretch of coast between Pineto and Vasto is an emblematic fragment of the so-called linear Adriatic city, where the urban fabric is continuous along the coastline, intertwining with transport infrastructure and the local landscape. The urban morphology of this area is the result of a predominantly recent and widespread development, in which medium-sized urban centers, such as Pescara, Ortona, and Vasto, alternate with smaller towns.

This sequence of settlements is characterized by a dual nature: on the one hand, heavy anthropization along

the coastline, reflecting a process of urbanization that alternates between residential areas, beach resorts, and tourist infrastructure; on the other hand, a significant presence of agricultural and coastal landscapes, residual green areas, and portions of territory that still reflect a more direct relationship between the community and the natural environment.

The Adriatic sea, defined by Matvejević (2006) as the "sea of intimacy", has played a crucial cultural role in the formation of these settlements, not only as a route for trade and connection, but as a fundamental element of identity. If we were to look at Europe from above at night, we would immediately notice that "the two coasts of the Adriatic show an irreducible diversity. "On one side, the dense layer of lights" (Bianchetti, C. 2002) that highlight the western part, dotted and illuminated by the conurbation of the linear Adriatic city, and on the other side, "a black border in a Mediterranean full of lights" (Bianchetti, C. 2002). A sort of exception, decipherable from the landscape and history.

The medium-sized western Adriatic cities that dot this coastal strip, often with between 50,000 and 200,000 inhabitants, are now central nodes in the redefinition of sustainable urban development models. According to the reflections of A. Rodríguez-Pose (2018), these cities, once considered "places that do not matter," are acquiring a new prominence, demonstrating a capacity for resilience and innovation that large metropolises struggle to maintain.

In the section between Pineto and Vasto, the urban fabric significantly expresses the tension between consolidation and transformation. This segment of the so-called linear Adriatic city is a complex landscape, where established infrastructure and new coastal centers intertwine. The Trabocchi coast, with its architecture suspended over the water, coexists with tourist and industrial ports such as those of Pescara and Vasto, while protected areas of nature, such as the Torino di Sangro holm oak forest, offer an ecological counterpoint of great importance. In this scenario, the interaction between settlements, infrastructure, and landscape provides a privileged observatory for interpreting territorial transition processes and imagining a new development paradigm based on the integrated enhancement of cultural, environmental, and built heritage.

The Trabocchi coast: natural landscape and development processes

Along the Adriatic coastline, between land and sea, ancient structures stand out, their roots sinking into the water: the trabocchi, bearers of a deep local history and authentic symbols of the genius loci of the mid-Adriatic. It is no coincidence that the 42 km stretch of coastline between Ortona and Vasto has been named the Trabocchi coast, in recognition of their central role in redefining the collective imagination and the specificity of the Abruzzo region.

These fishing machines on stilts, built entirely of wood and anchored to the rocks by long arms that support the nets, are widespread along the central Adriatic coast and represent a unique architectural and engineering feat, skillfully modeled on the irregular morphology of the coastline. At once vernacular, evocative, and fragile (Cambi, C. et al. 2017, Di Mascio, D. 2009, Carolis, D. 2020), trabocchi embody traditional technical knowledge deeply rooted in local culture and the millennial relationship between man and the sea. According to some studies, their origins date back to the Phoenician era, but it was mainly between the 18th and 19th centuries that trabocchi established themselves as a means of subsistence for coastal communities, enabling them to fish even in adverse weather conditions.

The Trabocchi Coast, an emblematic stretch of the mid-Adriatic coastline, is a cultural landscape in which the natural and anthropic dimensions merge in a delicate but meaningful balance, representing not only an architectural and functional asset, but above all a symbol of identity rooted in the collective memory and local maritime culture. The heritage value of this coastline lies in its heterogeneous morphological composition: rocky promontories, sandy coves, protected natural areas, and stretches of spontaneous vegetation coexist in a continuum that conveys an image of a coastline that is still authentic, despite anthropogenic and tourist pressures. In this context, the perception of the landscape takes on an affective and relational character, as

recognized by the European Landscape Convention and, more recently, by the amendment to Article 9 of the Italian Constitution, which explicitly includes the protection of the environment, biodiversity, and ecosystems among the duties of the Republic.

The landscape of the Trabocchi Coast has been transformed over time from a marginal and productive area to a place of cultural and tourist rediscovery, where the trabocchi have been restored and reinterpreted as heritage sites, often converted into restaurants or exhibition spaces. This process, however, is not without its contradictions: on the one hand, there is a strengthening of the sense of belonging among local communities and an appreciation of intangible heritage; on the other hand, there is a risk of turning the landscape into a museum or triggering tourist consumption dynamics that distort its original value.

The recent development of the "Greenway" cycle path, a cycling route built on the dismantled track of the Adriatic railway between Ortona and Vasto, represents an emblematic example of sustainable and heritage oriented territorial regeneration. The intervention not only restored accessibility to the coastline, reconnecting urban centers to the littoral, but simultaneously transformed landscapes, trabocchi, and historic stations into heritage assets to create slow and conscious tourism. This type of cultural infrastructure, which integrates with a historic landscape matrix, contributes to consolidating the understanding of heritage as a living resource, capable of generating economic development and social cohesion, in line with the principles of the Faro Convention.

The Greenway is configured today as a strategic resource for experimenting with integrated development models, based on environmental sustainability, heritage enhancement and the involvement of local communities. However, even in this case some critical issues emerge: while on one hand territorial identity is strengthened and a virtuous model of enjoyment is promoted, on the other hand the project implementation methods did not pay full attention to the environmental context in which it was inserted. In particular, the coastal strip within 300 meters of the shoreline is subject to landscape constraints and, in some cases, to absolute construction prohibitions, which would have required greater design caution and more careful evaluation of impacts.

Ultimately, the Trabocchi coast presents itself today as a laboratory of territorial practices in which environment, identity and development intertwine. Its protection cannot ignore an integrated vision that considers the landscape not only as an asset to be protected, but as a lived space, in which local communities play an active role in transformation processes.

Cognitive Atlas of the mid-Adriatic Abruzzo Context

The coastal stretch of the mid-Adriatic Abruzzo region constitutes a territory of extraordinary complexity, characterized by a rich interweaving of landscape, environmental and cultural values that today confront the growing pressures arising from climate change and ongoing anthropogenic transformations.

The objective in this phase of the research is to identify, map and enhance the different forms of heritage present, highlighting their potential in mitigating risk factors related to climate and social change.

The project is based on a mixed methodological approach, which integrates qualitative analysis of readings, attributed meanings and interpretations of the territory that come from local communities with quantitative analysis of environmental, territorial and socio demographic data.

Through this methodology, a multilevel reading of the mid-Adriatic coastal stretch is enabled, which relates the physical, social and cultural aspects of the territory under examination.

The atlas is therefore configured as a multi scalar knowledge tool, articulated on three levels of analysis:
1 - mid-Adriatic macro-context: a large scale vision of the Abruzzo coastal territory and its main environmental, morphological and settlement characteristics;
2 - in depth contexts: the first context (C1), the northern one with the municipalities of Pineto and Silvi and the

southern one (C2) with the municipalities of Fossacesia, Torino di Sangro, Casalbordino and Vasto;
3 - a synthesis of the critical issues and opportunities identified within the previous study levels, with the construction of a risk map interpolated with the environmental and socio demographic factors identified, which will allow the construction of design scenarios in the analyzed areas.

In this reference framework, the research aims to highlight the knowledge necessary to make it possible to re heritage the coastline, understood as an active resource for sustainable territorial development.

Specifically in the mid-Adriatic Abruzzo stretch, heritage manifests through heterogeneous forms, which are the result of a multitude of settlement histories, urban and infrastructural transformations.

The two contexts taken into analysis in their heterogeneity, when compared, fully manifest the territories that can be encountered along the Abruzzo coast.

To the north, in the territorial area of the municipalities of Pineto and Silvi, the presence of a compact urban fabric is evident, a typical expression of the so called "Adriatic city". This settlement model develops between the coastline and the infrastructural bundle that runs longitudinally along the Adriatic dorsal, composed of railway, highway and state road. In an apparently paradoxical way, this urban density has favored the conservation of original and identity characters in the municipalities located beyond this infrastructural bundle. This linear system, while on one hand representing a strategic resource for regional and national mobility, on the other hand significantly affects the continuity and accessibility of the coastline.

The southern context includes the municipalities of Fossacesia, Torino di Sangro, Casalbordino and Vasto, which together represent that natural and rural landscape that composes the Trabocchi coast area, a territory that represents an environmental heritage of great landscape value.

The atlas proposes to map in an ecosystemic manner the coastal territories of this region, identifying the characterizing elements, today subjected to strong pressures due to rapid urbanization and seasonal tourism.

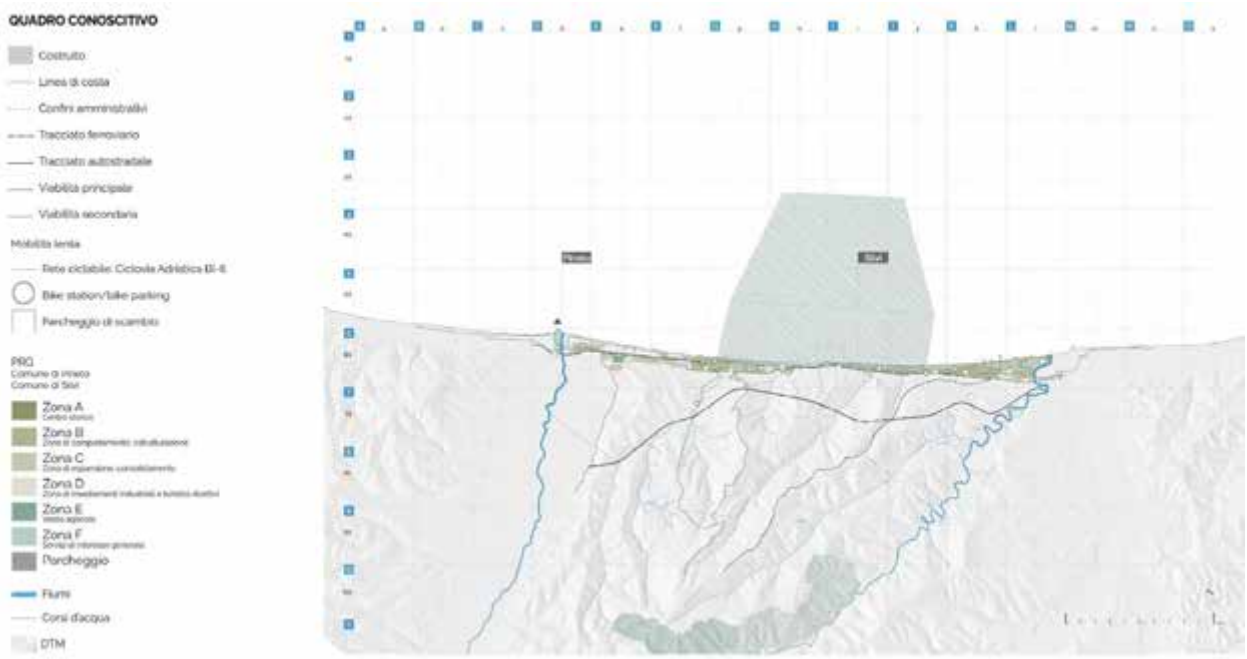

Figure 1. C1 - Pineto and Silvi area's cognitive framework designed by Andrea Di Cinzio, Angelica Nanni

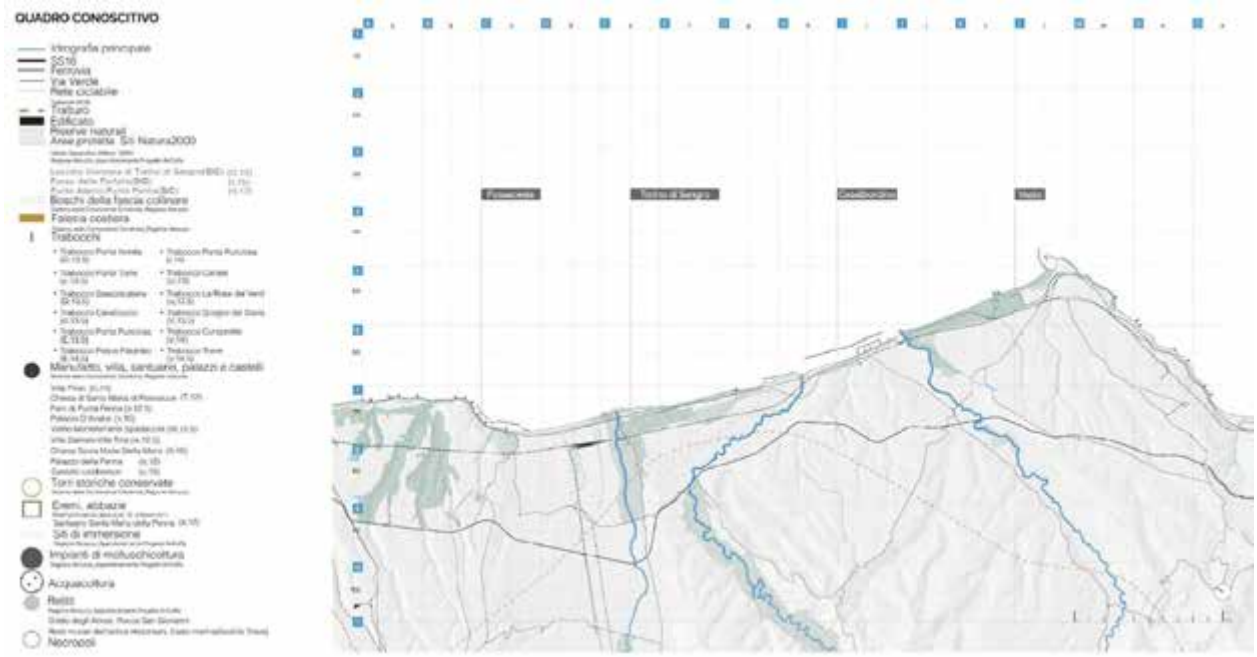

Figure 2. C2 - Fossacesia, Torino di Sangro, Casalbordino, and Vasto area's cognitive framework designed by Sirjia Spiritoso, Francesca Maria Santobuono

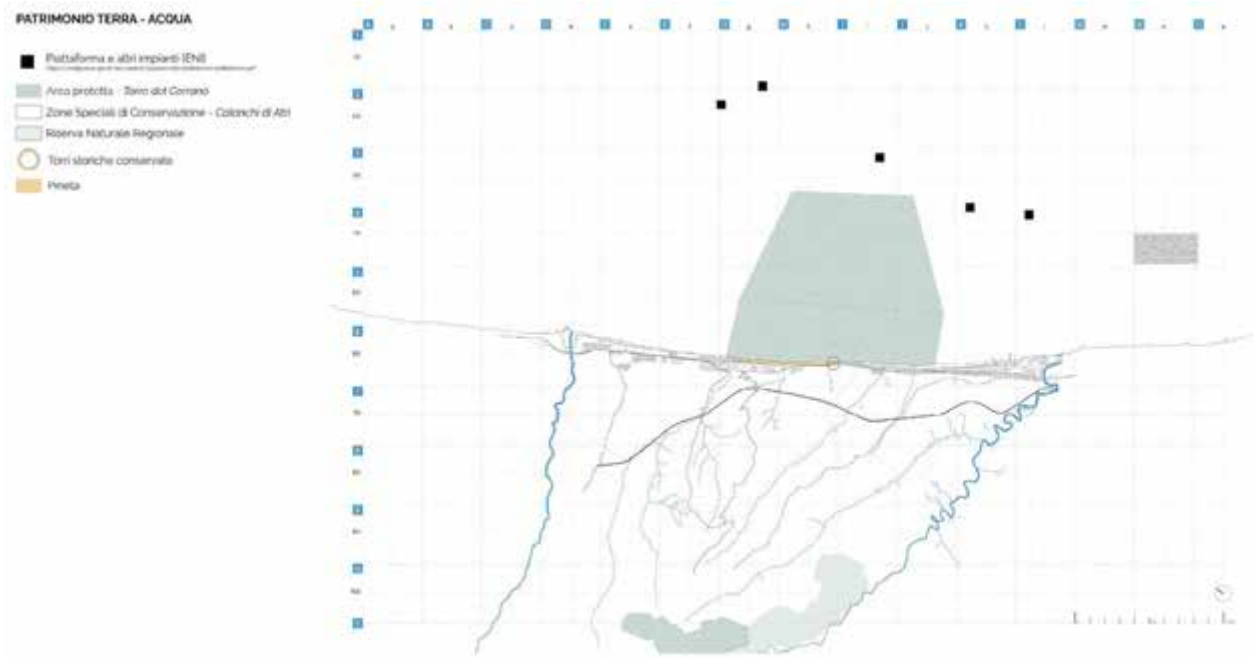

Figure 3. C1 - Pineto and Silvi area's Heritage designed by Andrea Di Cinzio, Angelica Nanni

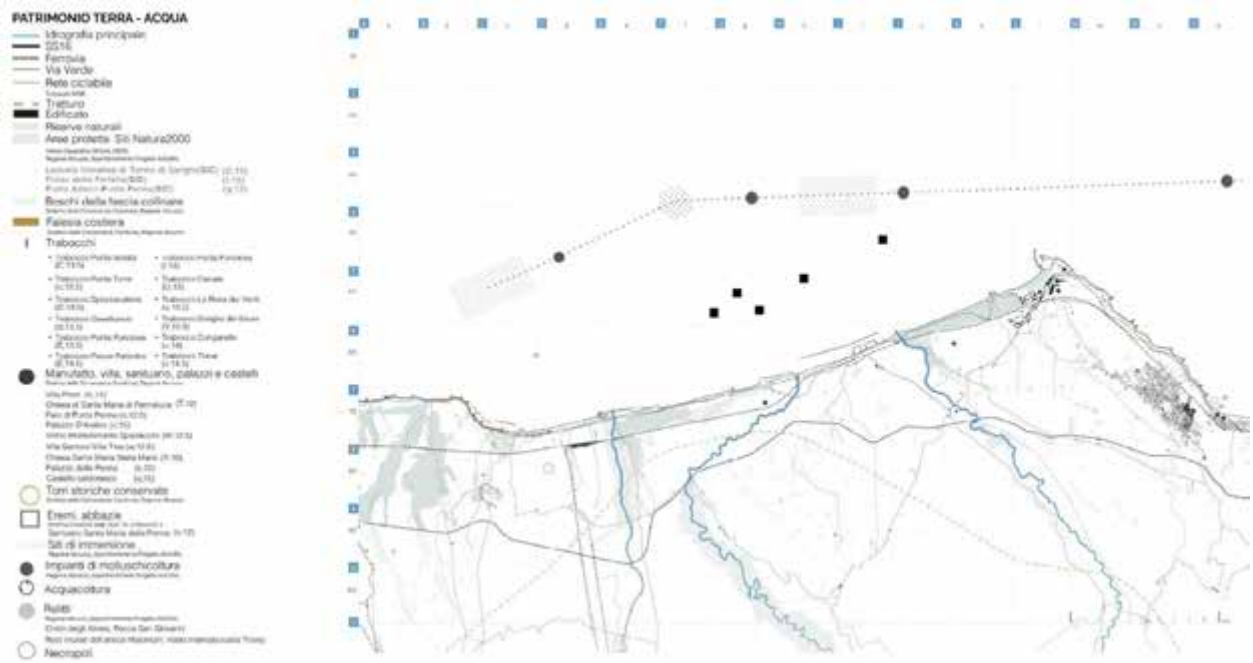

Figure 4. C2 - Fossacesia, Torino di Sangro, Casalbordino, and Vasto area's Heritage designed by Sirjia Spiritoso, Francesca Maria Santobuono

Towers, Platforms and Reserves: Anatomy of a Coastal Landscape
In this delicate and complex scenario, the mid-Adriatic Abruzzo coastal heritage is characterized through different interconnected dimensions.

The atlas, through territorial analysis, studies hydrogeological and climatic vulnerabilities. The integration of this data with social vulnerabilities allows for the construction of a complex and dynamic framework of relationships between human and environment, useful for guiding management and territorial enhancement plans and policies.

The context analysis is oriented toward an integrated reading of territories that start from the hinterland, cross the coastline and extend into the sea. This research emphasizes the necessity of considering all these environments to obtain a complete understanding of the mid-Adriatic Abruzzo stretch, since the coastal territory requires a holistic approach to be effectively understood and enhanced.

The built coastal heritage is distinguished by the stratification of elements belonging to different eras, which function as distinctive landmarks and which, as previously observed with the trabocchi structures, define the identity of the littoral landscape. An emblematic example of these territorial signs is represented by the Torre del Cerrano, located between the municipalities of Silvi and Pineto within the homonymous marine protected area. This ancient fortification, dating back to the Kingdom of Naples period, constituted a strategic node of the extensive network of coastal towers designed to counter Turkish and Saracen incursions coming from the sea.

From the summit of the historic tower it is possible to glimpse the ENI oil and gas extraction platforms that today characterize the Adriatic maritime panorama. These industrial structures, which appeared along the Abruzzo coast starting from the 1970s until the first decade of the 2000s, represent a new generation of landmarks that defines the marine horizon, often positioned within 12 miles from the coast.

The presence of these infrastructures in the mid-Adriatic stretch configures an emblematic scenario that solicits reflections on possible paths of reconversion and innovative reuse. The critical analysis of these industrial artifacts opens questions about their transformative potential: from extractive elements with controversial environmental impact, they could evolve into spaces dedicated to new cultural, scientific or eco touristic functions. Such transformation would contribute to the construction of a contemporary narration of the coastal landscape, capable of integrating historical memory and future projection in a sustainable vision of the territory.

Exposed to strong pressures and anthropic impacts, the natural heritage in the mid-Adriatic Abruzzo instead is composed of green infrastructures that also in this case want to be read, preserved and enhanced through a bidirectional reading from the hinterland to the sea and vice versa.

Representative in this case is the Natural Reserve of the holm oak forest of Torino di Sangro which, with its approximately 180 hectares of surface, connects the Abruzzo coastline to the hinterland and represents one of the few testimonies of natural forest still present in the Mediterranean area. Within it is contained an extraordinary biodiversity that needs to be preserved and enhanced: from sea level it reaches up to 115 m of altitude, collecting flora and fauna in some cases unique in the world, as in the case of the terrestrial turtle population (*Testudo hermanni*), symbol of the reserve.

A little further south we find yet another example of natural heritage in the context of the mid Adriatic Abruzzo: the Punta Aderci Natural Reserve. With an area of approximately 285 hectares that reaches 400 hectares counting the external protection area, it extends from the beach of Punta Penna to the mouth of the Sinello river. Within it shows some peculiarities to preserve such as the dune environment or some bird species like the Kentish plover (*Charadrius alexandrinus*), which also in this case has been chosen as the symbol of the reserve.

The atlas, therefore, collects this and much other fundamental information to construct a complete knowledge framework of the territory, allowing for the mapping of significant places and knowledge and distinguishing those consolidated from those that need reinterpretation. This analysis offers the basis for developing operational tools aimed at territorial enhancement, through an integrated vision of heritage capable of requalifying and restoring value to the coastline.

Climate Change Impacts on Coastal Heritage. The Vulnerability of the Mid Adriatic Abruzzo Coast

In 2014, the Trabocco Turchino, following a storm surge, collapsed. One of the symbols of Abruzzo coastal heritage was damaged by extreme events. The Abruzzo coast hosts elements of great cultural and landscape value, such as the trabocchi, today exposed to the growing effects of climate change. More intense and frequent weather marine events are already having tangible impacts on heritage: “climate change has, already today, visible impacts in terms of damage to cultural heritage” (Mascitelli, A. et al. 2023). This emblematic case demonstrates how phenomena such as sea level rise, coastal erosion and marine storms represent concrete threats to coastal assets. Recent studies on the mid-Adriatic stretch highlight “significant changes in recent decades, which pose a serious threat to cultural heritage due to climate change (sea level rise, erosion, storms, floods and salinization)” (López Campos, L. I. et al. 2024). Faced with such risks, it becomes crucial to integrate heritage protection into climate adaptation strategies, ensuring management that considers new weather climatic scenarios.

The Abruzzo coast between Pineto and Vasto presents marked geomorphological vulnerability, particularly regarding erosive processes. Studies conducted on the coastal stretch between Pescara and Ortona report an advancement of erosion due to scarce sedimentary input and intense anthropization of the littoral zone. (Tarragoni et al., 2015) Detailed analyses confirm how the Abruzzo Region falls among the Italian coastal areas most exposed to erosion phenomena and hydrogeological risk. (Cavuta et al., 2018, Zullo et al., 2022). In the Italian context, beach erosion increased by 63% between the 1970s and 2000, with Abruzzo showing one of the highest rates at the national level (Zullo et al. 2022). The coastalization of the coast and the loss of dune systems – today severely reduced – have altered natural sedimentary dynamics, contributing to the intensification of the erosive phenomenon.

Beyond erosion, the mid-Adriatic littoral is subject to local hydrogeological instabilities, with cliffs and coastal slopes unstable in some points. For example, along the Chieti coast there are landslides and ground movements that threaten infrastructures and settlements on the littoral edge (López Campos, L. I. et al. 2024). Accessibility also suffers from these critical issues: in the past the presence of coastal railway and industrial areas limited access to the sea, while today erosion reduces the usability of some beaches and imposes costly periodic beach nourishment. Beyond erosion, the coastal stretch is subject to landslides and hydrogeological instabilities linked to intense weather events and the fragility of the hills behind. An emblematic case concerns the extreme rains that occurred in 2007, 2011 and 2012, which caused strong erosion phenomena of surface coverings on Abruzzo hillsides, with average values between 0.8 and 3.1 cm per event (Piacentini et al., 2018).

These multiple vulnerabilities highlight the necessity of integrated planning and sustainable coastal management measures, capable of balancing environmental protection, territorial safety and public use of the littoral.

Adaptation and Mitigation Strategies: Design Examples and Practices

On the adaptation front, diversified approaches are being experimented along the Abruzzo coast. "Traditional" coastal engineering interventions remain important in some critical areas: for instance, new defense works such as groynes, breakwaters and submerged barriers are being designed to protect the most exposed points of the Costa dei Trabocchi (Mascitelli, A. et al. 2023). However, there is consensus that solutions must not be limited to rigidly contrasting phenomena, but rather accommodate them intelligently. "All proposals must adapt to the problem and not go against it. The keyword is adaptation: adapt the affected areas, make them resilient, adjusting to environmental changes" (Mascitelli, A. et al. 2023).

From this perspective, nature based solutions are gaining importance. For instance, the restoration of coastal dunes and backdune wetlands is promoted to reactivate natural defenses against storm surges and flooding, as well as to conserve littoral biodiversity. In non urbanized areas, the possibility of retreating or relocating infrastructures away from erosion risk zones (the so called strategic retreat) is evaluated, avoiding fighting the sea where it is not sustainable to do so in the long term. Territorial planning increasingly incorporates these approaches: the new Trabocchi coast plan, for example, prescribes considering different scenarios of sea level rise and increased hydrogeological risk, estimating the potential costs of damages associated with each scenario. This denotes a growing institutional awareness of future uncertainty and the necessity to pre adapt territorial transformations.

Even at the European level there are virtuous examples of coastal adaptation from which to draw lessons. In the Netherlands, where low coasts are particularly exposed, the innovative Sand Motor project was implemented. This is a gigantic artificial sediment nourishment implemented in 2011 along the Delfland littoral, which formed a hook shaped sandy peninsula destined to be gradually distributed by wave motion on surrounding beaches. This intervention, equivalent to about 20 years of traditional beach nourishment concentrated in a single solution, "has formed a peninsula to protect the coast, mitigate sea level rise and create recreational and ecological spaces... is achieving its objectives of coastal conservation, habitat creation and recreational opportunities" (Climate ADAPT, 2022). The Sand Motor is considered a successful example of the Building with Nature approach, in which one works with natural processes rather than against them, obtaining coastal protection together with environmental and social benefits.

Parallel to adaptation measures, mitigation remains a fundamental pillar of territorial climate strategies. Reducing climate altering emissions in Abruzzo means, for example, promoting sustainable mobility, energy efficiency and renewable sources. The transport sector, in particular, can contribute significantly through green interventions from the hinterland to the coast and vice versa and along it: such as the transformation of the former railway route into a cycle pedestrian path; incentivizing the use of soft mobility and enhancing rail mobility. This would help reduce both local atmospheric pollution and the carbon footprint of tourism.

Conclusions

The Atlas has brought to light, through the reading of the land water heritage and the construction of an articulated knowledge framework, a complex system of heritage, environmental, cultural and settlement values, which are configured today as a territorial laboratory of great interest for experimenting with enhancement and sustainable adaptation strategies. The articulation of its landscapes, the richness of natural and cultural heritage and the presence of rooted communities make it an ideal context for reconnecting protection instances with those of sustainable transformation.

The research highlights how the coast, if reread in an ecosystemic key, can become a strategic area for experimenting with alternative development models capable of integrating environmental resilience with the quality of life of settled communities. The coastal heritage, consolidated but in need of reinterpretation, thus proposes itself as environmental infrastructure and active laboratory for adaptation policies, where heritage communities, understood as collectivities that preserve and transmit stratified territorial knowledge, become active protagonists in the co design of sustainable enhancement strategies, transforming the memory of the place into a resource for adaptive innovation.

Furthermore, the integration of adaptation and mitigation measures results in a further essential action: it is necessary to adapt to impacts now underway, protecting coastal heritage and local communities, but at the same time act to limit the extent of future changes. Only through coordinated strategies on both fronts will the mid Adriatic Abruzzo coast be able to successfully face the climate and social challenges of the coming decades, transforming potential crises into opportunities for innovation and sustainable development.

The future of Costa|MED research will be further articulated along three main operational directions. The first will concern public restitution and completion of the knowledge Atlas, through validation of collected data, integration of new territorial information and dissemination of results to communities, local authorities and professionals. The second direction aims at the construction of climate and sustainable development scenarios, capable of anticipating coastal territory transformations and orienting adaptation policies on local and territorial scale, integrating environmental data with socio economic dynamics. Finally, the third direction provides for the elaboration of a design guidelines agenda, structured as an operational tool for administrations and designers, aimed at guiding future interventions in a resilient, participatory and regenerative key.

In this perspective, the mid-Adriatic coast is no longer only a fragile margin to be preserved, but is configured as a strategic space for the contemporary project: a habitable, sensitive and adaptive territory, in which environmental challenges can be transformed into opportunities to rethink the relationship between heritage, communities and innovation.

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Complex System Conservation Technology for Spatial Cultural Heritage Networks: A Case Study of Qinghai Province, China

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Abstract
Qinghai Province, on the Qinghai-Tibet Plateau, hosts 517 national/provincial heritage sites across 720,000 km², with spatial dispersion challenging conservation. Shifting from single-site models, current research stresses interconnectedness and systemic risks but lacks dynamic modeling and value quantification. This study uses ArcGIS, spatial syntax, and AI-driven multidimensional models (cultural value, environmental vulnerability, social connectivity) to analyze spatial distributions. For the first time, we identify hierarchical structures and vulnerability patterns, yielding three outcomes: (1) a five-tier vulnerability classification framework; (2) a "Three Cores, Three Belts" conservation network; and (3) pathways for heritage activation. These findings advance UNESCO's "Cultural-Natural Symbiosis" agenda, addressing plateau conservation challenges through an integrated technical system (spatial analysis, risk simulation, decision support), positioning Qinghai as a potential International Demonstration Zone for plateau heritage conservation.

Keyword: Cultural Heritage Spatial Network: Cultural Value Index: Synergistic Conservation: Qinghai Province, China

Introduction:

Qinghai, a multi-ethnic province, has accumulated a rich tapestry of historical and cultural heritage shaped by generations of diverse ethnic groups. These assets serve as critical pillars for fostering a sense of shared identity among the Chinese nation and safeguarding national ecological security.

As an integral component of China's pluralistic civilization, Qinghai's cultural heritage embodies both distinctive ethnic characteristics and ecological fragility. The province boasts 1 National Historical and Cultural City, 1 National Historical and Cultural Town, 5 National Historical and Cultural Villages, 4 Historical and Cultural Blocks, and 183 Chinese Traditional Villages—ranking first among China's five northwestern provinces. It also houses 51 national-level protected sites, including the Sakyamuni Pagoda in Sangnang and the Gyasa Monastery, along with 466 provincial-level sites such as the Zhujiazhai and Hanzhuangzi ruins. Many of these cultural treasures suffered catastrophic damage during the 2010 Yushu earthquake, with nearly 100% of immovable cultural relics impacted, exposing the vulnerabilities of traditional conservation models. Current challenges in cultural heritage protection include:1 Simplified Value Assessment: Overemphasis on physical carriers while neglecting intangible cultural dimensions.2 Reactive Risk Management: Predominantly post-disaster rescue rather than proactive mitigation.3 Fragmented Conservation Strategies: Lack of systemic coordination and holistic planning.

Complex system theory offers a novel approach to overcome these limitations. By conceptualizing cultural heritage as a dynamically interconnected system, this theory analyzes node relationships to reveal inherent structural patterns—a methodology widely applied in micro-scale spatial layout studies such as community public spaces. This study innovatively applies complex network theory at the provincial scale, examining the spatial distribution of cultural heritage through a network topology perspective. Utilizing data on heritage sites, road networks, and points of interest (POIs), we establish a five-tier vulnerability classification system for Qinghai's historical and cultural heritage network. By integrating historical information, spatial coordinates, and fuzzy boundary processing, we construct a multi-layered heritage typology framework that interweaves points, lines, and planes. This framework provides a reference for heritage conservation, transmission, and adaptive reuse. While international applications—such as resilience assessments for Italy's cultural heritage corridors—exist, this study represents the first practical implementation in China's plateau regions, filling a critical research gap.

1 Study Area Overview and Research Methodology

1.1 Study Area Overview

Qinghai Province, located in northwest China (89°35′–103°04′ E, 31°9′–39°19′ N), spans 720,000 square kilometers (7.5% of China's territory) with an average elevation exceeding 3,000 meters. Bordering Gansu to the east, Sichuan to the south, Tibet to the southwest, and Xinjiang to the northwest, it serves as a transitional zone between the Qinghai-Tibet Plateau and the Loess Plateau, as well as a historical crossroads of the Tang-Tibet Ancient Road and the Henan Corridor of the Silk Road. Dubbed the "Water Tower of China," it is the birthplace of the Yangtze, Yellow, and Lancang rivers, and hosts Qinghai Lake (China's largest inland saltwater lake) and hundreds of salt lakes. The province's topography is defined by the "Three Mountains, Two Basins" configuration: the Kunlun Mountains traverse its center, the Qilian Mountains guard its northern flank, and the Tanggula Mountains dominate the south. As one of the cradles of Yellow River civilization, it nurtures the Hehuang cultural complex—centered in Haidong City—which blends Central Chinese agrarian, steppe nomadic, and Western regional commercial traditions into a "pluralistic integration" cultural model, earning designation as a national cultural ecosystem conservation zone.

The province boasts a robust intangible cultural heritage (ICH) system, with 2,361 entries across four protection tiers, including 88 national-level items (e.g., Regong Thangka, Hua'er folk songs, Huangzhong Duiu embroidery) and 238 provincial-level items, supported by 3,160 designated bearers. Its tangible heritage is equally remarkable, comprising 6,411 immovable cultural relics (51 national-level, 466 provincial-level protected sites), 1 national historical and cultural city, 1 national historical and cultural town, 5 national historical and cultural villages, 123 Chinese traditional villages, and 1 archaeological site park. The province's 41 registered museums and memorials safeguard 310,000 movable cultural artifacts.

1.2 Research Methodology

1.2.1 Kernel Density Analysis

This study employs kernel density analysis to process the POI data of cultural heritage sites in Qinghai Province. As a widely adopted non-parametric estimation method, kernel density analysis calculates density values within spatial point/line element domains to simulate continuous density distributions. The mathematical expression for the conventional kernel density estimator is:

$$f_n(X) = 1/N\pi/^{2} \bullet \sum_{j}^{n} =_1 k_j(1 - D_{ij}^2 \ /h^2)^2$$

Here, K denotes the kernel function; *h* represents the bandwidth of the selected region; D_{ij} signifies the distance between spatial point *i* and study object *j*. Even with a relatively small *h*, sufficient sample capacity ensures adequate data points for probability density calculation. The optimal bandwidth relationship is defined as $h=c \cdot N-1/5$, where c=1.05 under normal distribution conditions.

1.2.2 Quantitative Evaluation Framework

The integrated quantitative evaluation methodology combines single-factor assessment with comprehensive density analysis, forming a hybrid evaluation technique that merges independent single-element analysis with spatial aggregation characteristics. This framework is applicable to cultural heritage conservation, environmental assessment, and regional planning. Its core logic involves:Single-Factor Evaluation: Independent quantification of critical impact factors (e.g., heritage value, ecological sensitivity, social engagement) using standardized scores within a 0-1 range:

$$S_i = \frac{X_i - X_{min}}{X_{max} - X_{min}}$$

where S_i is the standardized score for factor *i*, X_i denotes the actual value, and X_{min} /X_{max} represent the minimum/maximum values within the evaluation scope.

1.2.3 Comprehensive Resistance Model Analysis

The comprehensive resistance model (CRM) evaluates a complex system's capacity to maintain functional stability under internal/external disturbances. Originally proposed by Dutch ecologist Knappen for species dispersion studies, this model has been extended to ecological conservation and landscape pattern analysis. By quantifying "resistance" generated by internal structures, external environments, and their interactions, CRM identifies systemic vulnerabilities and optimizes resilience strategies. The Minimum Cumulative Resistance (MCR) calculates the minimum energy expenditure or cumulative cost for movement from "sources" through heterogeneous landscapes:

$$MCR = \int_{\min} \sum_{j=n}^{i=m} (D_{ij} \times R_i)$$

where *MCR* represents the minimum cumulative resistance, D_{ij} is the distance from heritage site *j* to landscape element *i*, and R_i denotes the resistance value of location i for heritage corridor development. Higher resistance indicates lower corridor suitability, and vice versa.

1.2.4 Application of Complex Network Theory in Cultural Heritage Conservation

Rooted in the principles of system science—including holism, hierarchy, openness, teleology, stability, mutability, self-organization, and irreversibility—and governed by fundamental laws such as structure-function correlation, information feedback, competitive synergy, fluctuation-induced order, and optimization-driven evolution, systemic principles exhibit universal applicability to the material world. Systems permeate all facets of human society, encompassing entities of varying scales, natures, and attributes. Cultural heritage networks exemplify such complex systems, integrating social, cultural, and natural dimensions. These networks comprise foundational natural ecosystems, anthropogenic structures, and the socio-economic activities of local communities and visitors, encompassing aspects such as neighborhood social interactions and regional cultural bearing capacity. The material spaces shaped by temporal-spatial evolution, regional cultural bearing capacity, and environmental factors demonstrate significant overlap and integration, with ubiquitous complex interconnections existing among elements and hierarchical levels within the system. Alterations in one system element trigger cascading effects across interconnected components, collectively shaping the system's holistic behavior. By treating historical sites as complex adaptive systems and employing systems thinking to investigate dynamic interactions among system, environment, and elements, this approach enables targeted analysis of specific system components to address emergent practical challenges.

Complex network theory elucidates systemic complexity through node-edge topological relationships. In cultural heritage contexts:Nodes represent individual heritage entities.Edges encode spatial connections, cultural lineages, or functional dependencies between heritage elements.

Recent methodological developments highlight two research trajectories:Network Resilience Analysis: Identification of critical heritage nodes through centrality metrics (e.g., degree centrality, betweenness centrality). Multi-Layer Network Integration: Emergence of coupled network models, such as Italy's hybrid framework overlaying sacred architecture networks with tourist mobility patterns for proactive risk management.

2 Multi-level analysis of cultural heritage in Qinghai Province

2.1 Three Principles for Cultural Heritage Conservation in Qinghai

(1) Authentic and Effective Protection of Historical and Cultural Resources

Adopting a value-oriented approach, this principle emphasizes the implementation of scientific methods and appropriate strategies to safeguard the authenticity of historical and cultural resources. Destructive practices such as demolishing authentic heritage to construct replicas or engaging in fraudulent restorations are strictly prohibited. Emergency conservation and repair measures are promptly undertaken for historical and cultural resources facing severe deterioration or existential threats.

(2) Holistic Conservation of Resource Entities and Landscape Patterns
This principle underscores the integrated preservation of historical and cultural resources, their associated landscape patterns, natural vistas, and cultural environments. It encompasses the protection of ecological elements such as mountains, rivers, ponds, and pastoral landscapes. Conservation efforts must avoid altering the topography surrounding heritage sites, refrain from felling ancient trees, and preserve morphological contours, street networks, architectural textures, axial sightlines, and spatial landmarks that reflect indigenous construction wisdom. Exploration of river-basin and corridor-style regional heritage conservation approaches tailored to Qinghai's geographical context is actively encouraged, emphasizing holistic and systemic preservation.

(3) Systematic Conservation of Historical and Cultural Resources Across Eras
This principle advocates for the harmonious coexistence of historical and cultural resources from different periods, opposing the overshadowing of diverse cultural information by singular thematic or stylistic representations. It emphasizes understanding the evolutionary trajectories of heritage assets, integrating their temporal stratification and spatial interconnections. Conservation strategies should ensure continuity and legacy across spatial configurations and physical heritage entities, vividly preserving historical traces and collective memories from various epochs.

2.2 Evolution of Cultural Heritage Conservation Policies in Qinghai
The policy framework for heritage conservation in Qinghai has undergone continuous refinement. In 2022, the provincial government enacted the Regulations on the Identification of Historical and Cultural Cities, Towns, Villages, and Districts in Qinghai. Subsequently, in 2023, it designated 4 cities, 9 towns, and 33 villages as the first batch of provincial-level historical and cultural entities. An additional 3 historical and cultural districts were added to the reserve list in 2024, establishing the foundational structure of the provincial heritage conservation system. Key legislative milestones include the Regulations on the Protection of Intangible Cultural Heritage in Huangnan Tibetan Autonomous Prefecture (February 27, 2025), alongside the formulation of the Qinghai Provincial Urban-Rural Historical and Cultural Conservation and Inheritance System Plan and the Huangnan Prefecture Concentrated Conservation and Utilization Special Plan. The Approval Regulations for Conservation Planning of Qinghai's Historical and Cultural Cities, Towns, Villages, and Districts have been implemented, with all national-level conservation plans having secured provincial government approval. Collaborative efforts with the Provincial Publicity Department and relevant bureaus have resulted in the 2024 Key Tasks for Urban-Rural Historical and Cultural Conservation and Inheritance, alongside the issuance of standards such as the Qinghai Provincial Guidelines for Village Appearance Enhancement and the Qinghai Provincial Standards for Traditional Village Conservation and Utilization. A comprehensive regulatory mechanism has been established through the introduction of identification protocols, management regulations, accountability measures, planning approval procedures, inspection systems, and expert advisory committee frameworks, supplemented by annual assessments, patrol inspections, and public interest litigation initiatives. This multi-pronged approach has engendered a deterrent effect against heritage damage, ensuring robust protection and oversight.

2.3 Spatial Distribution of Cultural Heritage in Qinghai
2.3.1 Regional Distribution of Cultural Heritage
Table 1 summarizes the distribution of cultural heritage sites across Qinghai's 8 prefecture-level cities. Based on administrative boundaries, Haidong City holds the highest count of both national and provincial-level protected sites, while Golog Tibetan Autonomous Prefecture has the fewest. Huangnan Tibetan Autonomous Prefecture is home to Qinghai's sole national-level historical and cultural city, while Haidong City contains the province's only national-level historical and cultural town and the majority of traditional villages.

Aggregating all categories, Xining City boasts 98 heritage sites; Huangnan Prefecture, 62; Golog Prefecture, 30; Hainan Prefecture, 81; Haidong City, 245; Haixi Prefecture, 43; and Yushu Prefecture, 106. The ranking of prefecture-level cities by heritage site quantity is as follows: Haidong City, Yushu Prefecture, Xining City, Hainan Prefecture, Huangnan Prefecture, Haixi Prefecture, and Golog Prefecture.

Table 1 Administrative distribution of cultural heritage in Qinghai Province

order number	City	Cultural heritage sites		settlement						
		National Geopark	Provincial tourism	National historic city	A provincial historical and cultural city	A famous historical and cultural town in China	Provincial historical and cultural town	A famous historical and cultural village in China	Provincial historical and cultural villages	Traditional Chinese villages
1	Xining City	1	72	0	1	0	2	0	4	23
2	Tibetan Autonomous Prefecture of Huangnan	4	55	1	1	0	1	1	4	24
3	Tibetan Autonomous Prefecture of Golog	3	13	0	0	0	1	1	1	0
4	Tibetan Autonomous Prefecture of Hainan	7	43	0	1	0	2	0	0	0
5	Haidong City	16	139	0	0	1	2	1	10	19
6	Hainan Mongolian and Tibetan Autonomous Prefecture	2	27	0	0	0	1	0	0	0
7	Tibetan Autonomous Prefecture of Haibei	4	26	0	0	0	0	0	0	0
8	Tibetan Autonomous Prefecture of Yushu	7	65	0	1	0	1	2	3	22
9	total	51	440	1	4	1	11	5	24	107

Figure 1 spatially locates cultural heritage sites in Qinghai Province using ARC GIS geographic information data, revealing distinct geographical distribution patterns between cultural resources and natural landscapes within the region.

Historical and cultural cities, towns, villages, and traditional villages predominantly cluster in basin and valley regions. The Hehuang Basin exhibits particularly high density, while valley areas along the Tongtian River (Yangtze River), Yellow River, and Zhaqu River (Lancang River) also serve as critical settlement zones for these heritage communities.

Protected cultural relics similarly concentrate in basin and valley terrain, with the Hehuang Basin remaining the most densely populated area. Substantial numbers of protected sites also line the river valleys of the Tongtian River, Yellow River, and Zhaqu River.

Scenic areas demonstrate strong correlation with mountainous and fluvial geomorphology, typically following mountain ranges and river courses. The Yellow River corridor hosts exceptionally high concentrations of scenic sites, with additional significant clusters in the Qilian Mountains and Kunlun Mountains regions.

The Qinghai section of the Silk Road cultural belt primarily extends through valley and basin zones, with the Hehuang Basin constituting its core distribution area and the Qaidam Basin serving as another key component.

The Qinghai-Tibet Railway cultural belt predominantly follows basin areas and railway corridors, maintaining high density in the Hehuang Basin while also exhibiting significant resource distribution along the Qinghai-Tibet Railway route.

The Tang-Tibet Ancient Road cultural belt similarly favors basin and valley topography, with the Hehuang Basin as its densest concentration zone and valley areas along the Tongtian River, Yellow River, and Zhaqu River forming additional critical distribution regions.

Other heritage remains broadly distribute across basin, valley, and transportation corridor zones, showing highest concentration in the Hehuang Basin while also appearing in valley areas along the Tongtian River, Yellow River, and Zhaqu River, as well as along the Qinghai-Tibet Railway.

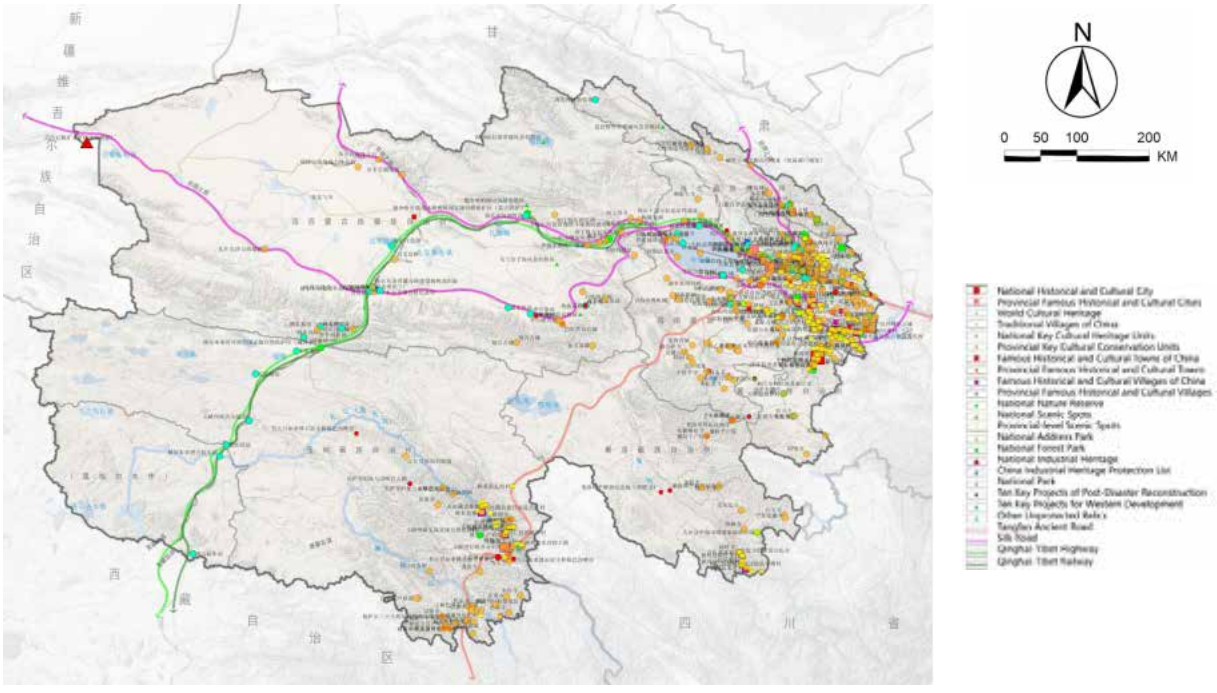

Figure 1 Distribution Map of Historical and Cultural Heritage Sites in Qinghai Province

2.3.2 Analysis of Cultural Heritage Conservation and Utilization Efficiency in Qinghai Province

An integrated analytical framework for historical and cultural heritage conservation-utilization efficiency was developed by synthesizing: (1) An integrated resistance surface model incorporating natural factors (elevation, slope, land use type, road proximity, river proximity) (2) Specialized assessments of heritage site vulnerability, environmental threats, and management efficacy.This framework enables the demarcation of five vulnerability tiers and the formulation of tiered conservation strategies.

Single Factor	Category	Grade	Weight
Elevation (m)	1500	1	0.1
	2750	2	
	4000	3	
	5250	4	
	Above 5250	5	
Slope (°)	3	1	0.1
	8	2	
	15	3	
	25	4	
	Above 25	5	
Land Use Type	Unused Land	1	0.5
	Construction Land	2	
	Forest Land	3	
	Grassland	4	
	Cultivated Land, Water System	5	
Distance to Road (m)	300	1	0.25
	1500	2	
	5500	3	
	10000	4	
	Above 10000	5	
Distance to River (m)	300	1	0.05
	500	2	
	800	3	
	1000	4	
	Above 1000	5	

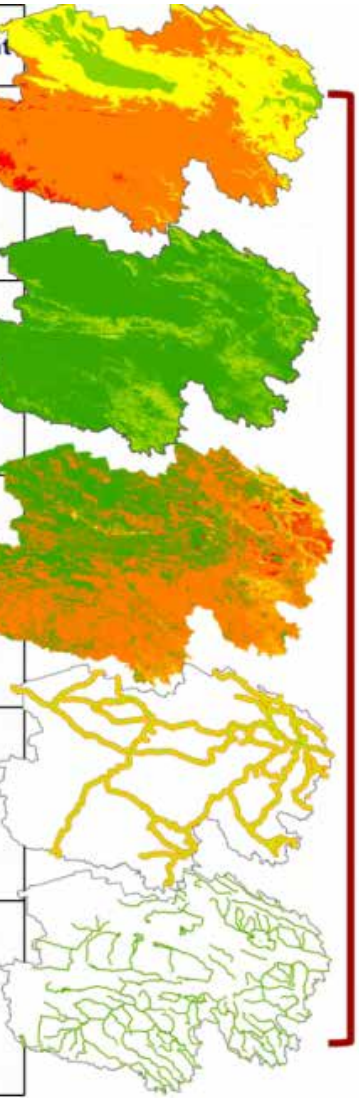

Figure 2 Comprehensive resistance surface model diagram

(1) Cultural Heritage Vulnerability Assessment and Tier Classification

Through the integration of natural factor resistance surfaces with specialized assessments (heritage asset vulnerability, environmental risks, management performance), a five-tier vulnerability classification system for Qinghai's cultural heritage sites was established (Table 2). This tiered structure clarifies conservation priorities and management focuses across different vulnerability levels.

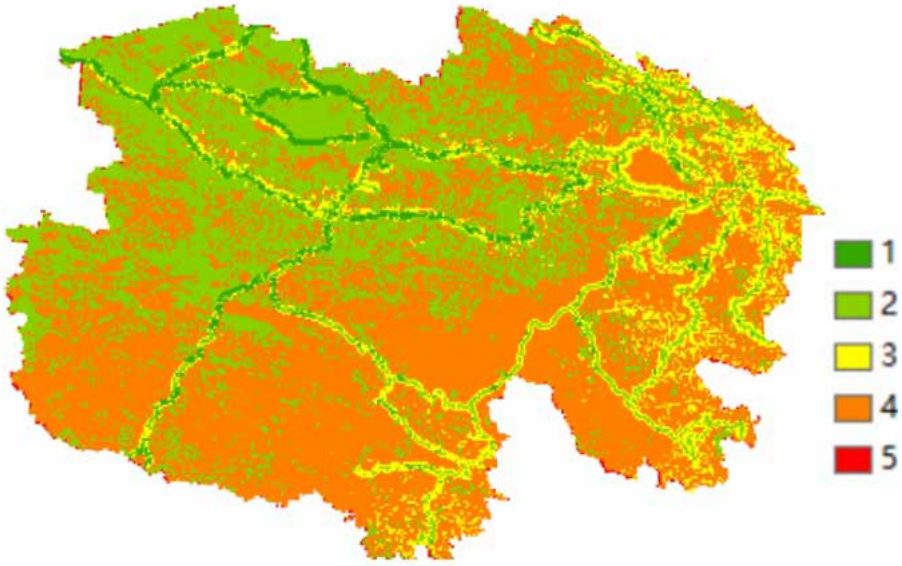

Figure 3 Cultural Heritage Vulnerability Assessment and Grading Diagram

Vulnerability Level	Natural Resistance Characteristics	Preservation Status of the Object	Environmental Threat	Management Efficacy	Typical Case
Level I (Slightly Vulnerable)	Low-resistance area	The object is intact, with a disease rate <5%	Low risk of natural disasters, weak human activity interference	High protection level, monitoring coverage >90%	Dongguan Mosque in Xining, Zhenda Temple
Level II (Mildly Vulnerable)	Lower-resistance area	Slight disease (5%-15%)	Relatively low risk of natural disasters, controllable human activity interference	Relatively high protection level, monitoring coverage 70%-90%	Kumbum Monastery murals in Haidong
Level III (Moderately Vulnerable)	Medium-resistance area	Structural stability decline (disease rate 15%-30%)	Moderate risk of natural disasters, significant human activity interference	General protection level, monitoring coverage 50%-70%	Zongri Site in Hainan Prefecture
Level IV (Severely Vulnerable)	Higher-resistance area	Endangered state (disease rate >30%)	High risk of natural disasters, strong human activity interference	Low protection level, monitoring coverage <50%	Jia Mani Stone Carvings in Yushu Xinzai
Level V (Extremely Vulnerable)	High-resistance area	Urgent need for rescue protection (disease rate >50%)	Extremely high risk of natural disasters, severe human activity damage	No effective management measures	Red Army Long March Inscription in Golog

(2) Integrated Conservation-Utilization Analysis

Superimposing cultural heritage vulnerability tiers onto the integrated resistance surface model reveals spatial patterns of conservation-utilization efficiency, categorized into five levels:

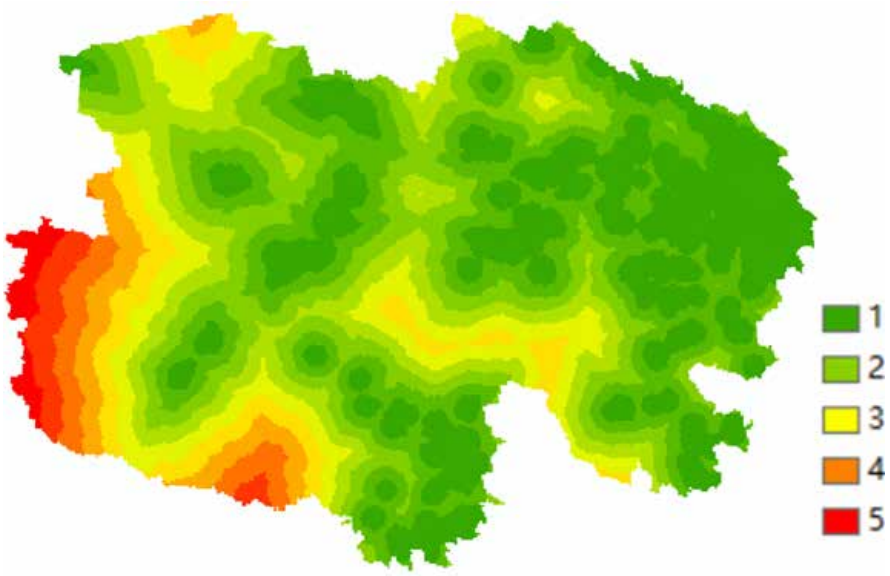

Figure 4 Comprehensive protection and utilization degree analysis diagram

Priority Conservation Zones (Tiers I-II): Predominantly located in the Hehuang Valley and eastern agricultural regions characterized by low natural resistance and minimal-to-mild heritage vulnerability. Strict in-situ preservation measures and development controls are mandatory.Stringent Conservation Zones (Tier III): Concentrated in the Loess Plateau-Qinghai-Tibet Plateau transition zone with moderate natural resistance and medium heritage vulnerability. Visitor capacity limits and enhanced monitoring/maintenance protocols are required.Conservation-Oriented Utilization Zones (Tier IV): Dispersed across the Three-River Source core zone and periphery, marked by high natural resistance and severe heritage vulnerability. Limited cultural experience projects may be permitted under stringent construction intensity controls.Moderate Development Zones (Select Tier V Areas): Restricted to rare areas with extremely low natural resistance and extreme heritage vulnerability. Digital exhibition formats represent potential conservation modalities.

Cautious Development Zones (Most Tier V Areas): Characterized by high natural resistance and extreme heritage vulnerability, these zones prohibit development in principle, restricting access to scientific research and emergency conservation activities.

(3) Spatial Adaptability and Management Recommendations
Qinghai's cultural heritage conservation-utilization efficiency exhibits a spatial pattern of "concentrated protection in the east, prudent utilization in the west," necessitating differentiated management strategies aligned with regional realities.

① Hehuang Valley: Living Heritage Preservation in Cultural Hubs
As Qinghai's most densely populated heritage region, the Hehuang Valley hosts national-level protected sites like the Lajia Ruins and Machangyuan Ruins, alongside intangible heritage such as Regong Arts and Hehuang Hua'er folk songs. Conservation priorities include:Living Heritage and Community Engagement: Transitioning from isolated preservation to mass participation, as demonstrated by the Huangzhong District "Eight-Petal Lotus" ICH Experience Center. Programs like Xining's "ICH in Schools" initiative (recognized as a national best practice) enhance community involvement.

Ecomuseum Model: Expanding the Regong Arts Ecological Protection Zone concept across heritage-rich areas, integrating cultural landscapes, traditional villages, and natural environments while resisting over-commercialization.

Digital Conservation and Dissemination: Leveraging digital technologies for heritage documentation and exhibition, exemplified by digital archives for 128 historic structures and traditional villages, coupled with online ICH dissemination platforms.

② Three-River Source Region: Ecological-Cultural Synergy
As China's "water tower," this region's heritage intertwines with alpine ecosystems (e.g., Qumalai alpine nomadic systems, Gesar epic traditions). Conservation strategies emphasize:Eco-Friendly Utilization: Balancing heritage preservation with ecosystem integrity, such as Qumalai County's integration of pasture resources through ecological livestock cooperatives, merging traditional nomadism with modern management to restore grasslands.

Traditional Knowledge Databases: Documenting nomadic cultural lexicons, proverbs, and ecological ethics (e.g., "The grassland is our mother; livestock are our children") to strengthen cultural identity through educational outreach.

Eco-Management Integration: Incorporating heritage conservation into the Three-River Source National Park's ecological management framework, training herders as dual cultural-ecological stewards through "cultural ranger" positions.

③ Southern Qinghai Plateau: Emergency Conservation in High-Vulnerability Zones
Regions like Golog and Yushu face challenges from high natural resistance and management difficulties (e.g., fading Red Army slogans, aging Gesar epic custodians). Interventions include:Emergency Documentation and Restoration: 3D scanning of endangered rock art and stone inscriptions, coupled with conservation laboratories for weathered artifacts.

Custodian Support Programs: Increasing stipends for ICH custodians and offering subsidies for apprenticeship training (e.g., Qinghai's ¥10,000 annual grants to provincial-level custodians).

Cross-Regional Collaboration: Joint protection mechanisms with Tibet and Sichuan for trans-regional heritage (e.g., Gesar culture), including shared databases and cooperative frameworks.

④ Policy and Institutional Safeguards
Regulatory Enhancement: Revising the Qinghai Provincial Intangible Cultural Heritage Protection Regulations to clarify rights/responsibilities and strengthen enforcement.Dynamic Monitoring System: Establishing a heritage spatial database for real-time environmental (seismic, flood) and anthropogenic threat monitoring, with vulnerability tiers subject to dynamic adjustment.Diversified Funding: Supplementing fiscal allocations with social capital participation, such as ICH protection funds and heritage lottery programs.

2.3.3 Kernel Density Analysis of Cultural Heritage and Spatial Network Construction for Heritage Conservation in Qinghai
(1) Kernel Density Analysis of Heritage Distribution
Based on the spatial distribution characteristics, significance, and internal relationships of historical and cultural heritage, kernel density analyses were conducted for six categories: historical and cultural cities, towns, and villages; traditional villages; protected cultural relics; scenic areas; revolutionary heritage sites; and cultural route heritage sites. These analyses revealed the comprehensive spatial distribution patterns of provincial historical and cultural resources. Key findings include: an absolute concentration zone in the Hehuang Basin, which benefits from favorable natural conditions and transportation accessibility; secondary density belts along

the valleys of major rivers such as the Tongtian River, Yellow River, and Zhaqu River; aggregation zones along transportation corridors (e.g., Qinghai-Tibet Railway, historical Silk Road Qinghai section, Tang-Tibet Ancient Road) and connected basins like the Qaidam Basin; and a distinct distribution pattern for scenic areas, which primarily align with mountain ranges (Qilian Mountains, Kunlun Mountains) and river courses, particularly the Yellow River. Overall, basins, valleys, and transportation arteries are identified as the three critical geographic factors shaping Qinghai's cultural heritage spatial structure.

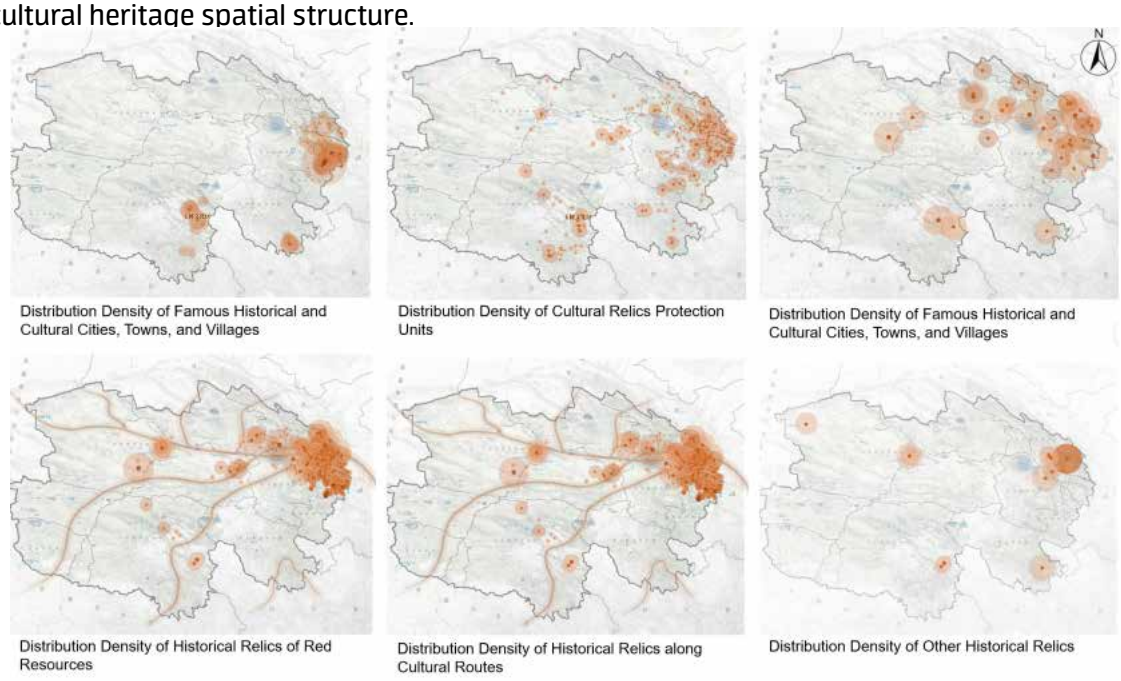

Figure 5 Analysis diagram of kernel density by type

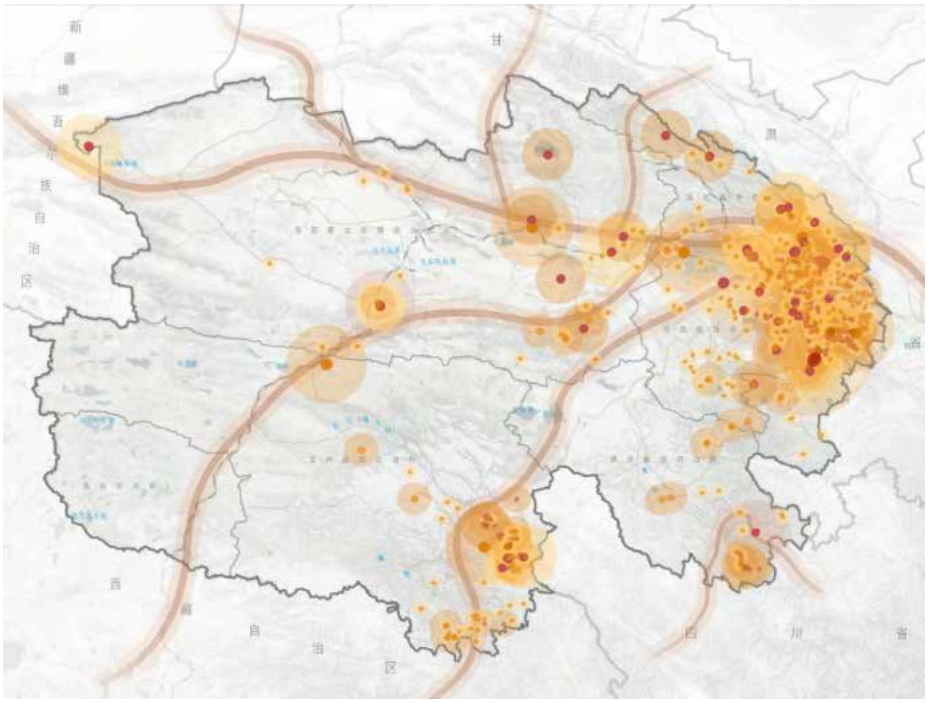

Figure 6 General diagram of nuclear density analysis

(2) Construction of the "Three Cores, Three Corridors" Heritage Conservation Spatial Network
Based on kernel density analysis results and the intrinsic connections among heritage sites, a spatial conservation network was constructed.

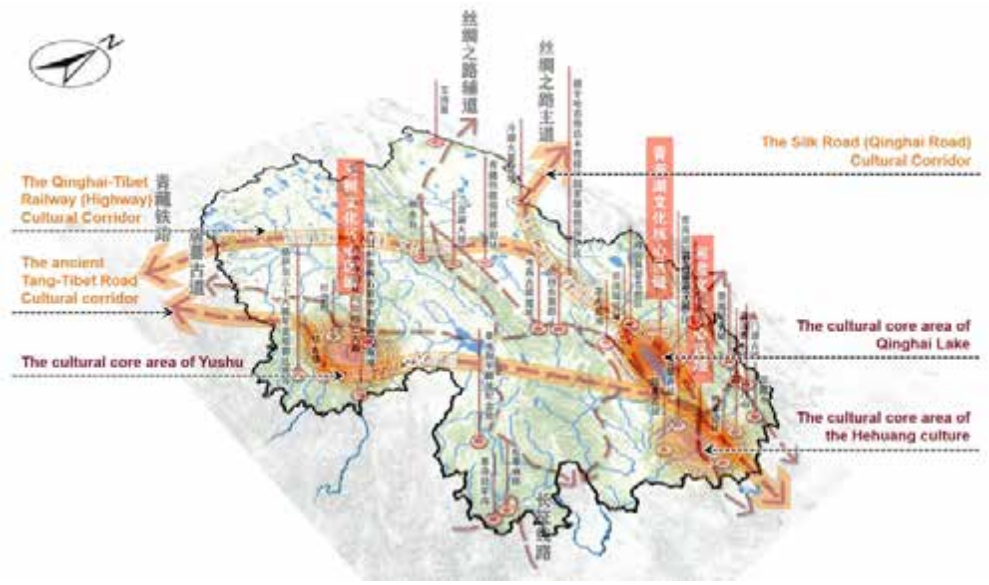

Figure 7 Spatial network structure diagram for Heritage protection

This network integrates the natural and cultural geographic patterns, historical and cultural context elements, and provincial heritage value priorities. It comprises three cultural cores and three cultural corridors: the three cores include the Hehuang Cultural Zone (encompassing Xining, Haidong, Haibei, and Huangnan prefectures), the Qinghai Lake Cultural Zone (including Haiyan, Gonghe, Tianjun, and Gangcha counties), and the Yushu Cultural Zone (covering Yushu Prefecture); the three corridors include the Tang-Tibet Ancient Road Cultural Belt (along National Highway 214), the Qinghai-Tibet Railway Cultural Belt (along National Highway 109), and the Silk Road (Qinghai Route) Cultural Belt (along National Highway 315).

3 Cultural Heritage Conservation Strategies for Qinghai within Complex Systems

For a prolonged period, the field of historic urban conservation has been trapped in a monolithic mindset, excessively focusing on conservation methodologies themselves while relentlessly pursuing technical perfection and flawless planning outputs. However, insufficient attention and research have been directed toward understanding the fundamental attributes and inherent operational mechanisms of historical-cultural heritage carriers. This fragmented approach has hindered our ability to comprehensively examine conservation and development issues within historic cities under the macroscopic framework of spatial complex systems.

In practical implementation, these limitations manifest prominently. During urban renewal processes, drastic demolition-and-reconstruction approaches have severely disrupted the traditional urban fabric, gradually eroding historical values and cultural functions. Conversely, when formulating conservation plans, an overemphasis on preservation controls often neglects the developmental and renewal needs of historic cities, resulting in planning frameworks that struggle to adapt to evolving realities and urban growth dynamics.

Confronting this dilemma, the heritage conservation community faces a critical challenge: how to respect the fundamental characteristics of historic cities while adhering to general urban development patterns, thereby identifying viable pathways for their conservation and evolution. Fortunately, this discourse is gaining increasing global attention.

The 2005 Vienna Memorandum offers valuable insights, particularly through its exploration of World Heritage conservation and historic landscape preservation amid rapid urbanization—a document commended by the 29th session of the World Heritage Committee. It explicitly identifies the paramount challenge of balancing modern development, urban transformation, and socio-economic harmony when introducing new constructions into historic environments. The memorandum underscores the necessity of prioritizing cultural and historical factors in such contexts, ensuring the integrity and authenticity of heritage structures while achieving synergistic outcomes for both conservation and urban advancement.

The 2011 UNESCO Recommendation on the Historic Urban Landscape further deepens our comprehension of historic city conservation, asserting that historic urban areas represent humanity's richest and most diverse cultural heritage expressions—critical testaments to collective human endeavors and aspirations. Simultaneously, urban heritage constitutes not merely social, cultural, and economic assets but also bridges connecting past and future. That same year's Valletta Principles for the Conservation and Management of Historic Cities, Towns and Urban Centres positions heritage as a vital component of urban ecosystems, emphasizing that conservation entails not only preservation, protection, reinforcement, and management but also harmonious integration with contemporary life.

These international instruments provide crucial theoretical frameworks and practical guidance for exploring effective models of historic city conservation and development. Moving forward, deeper inquiry into the fundamental attributes and intrinsic mechanisms of historic cities is essential to adopt a more holistic, scientific perspective in addressing conservation and development challenges.

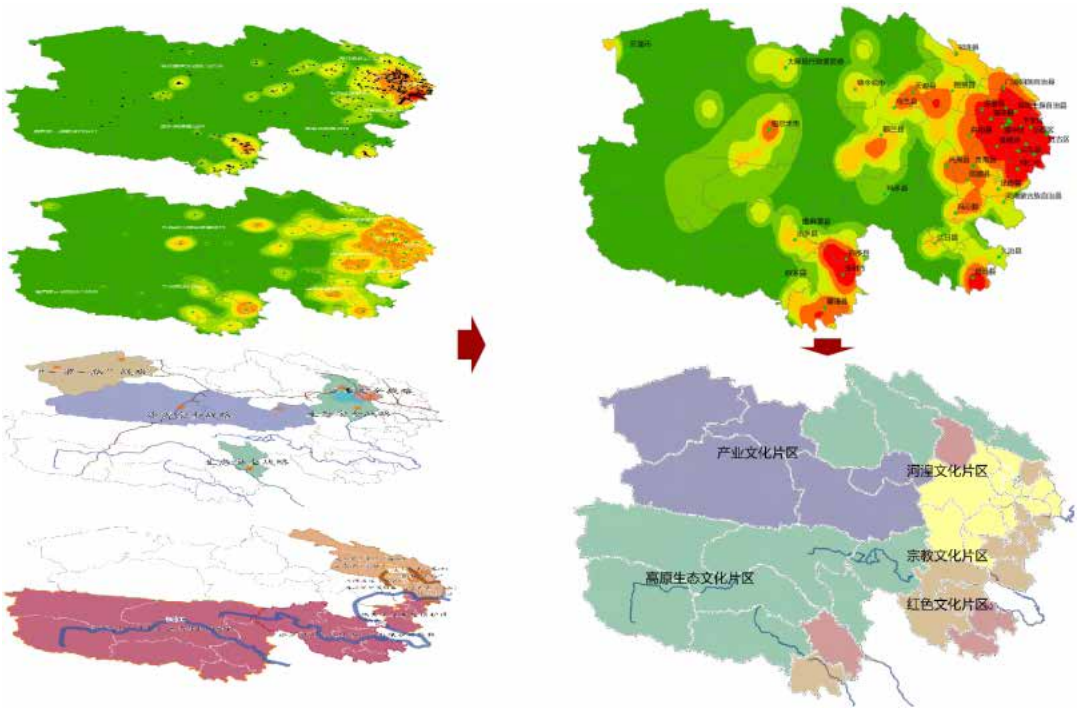

Figure 8 Path of revitalization and utilization of cultural heritage

4 Conclusions

The integrity of protection and transmission urgently needs strengthening. The work of protecting and transmitting urban and rural historical culture lacks overall provincial coordination and vertical linkage. A

provincial-level historical and cultural value system has yet to be established, resulting in unclear direction and focus for protection and transmission efforts. A collaborative protection mechanism between the province and cities/counties is absent, leaving the specific responsibilities, missions, and priorities of different cities and counties undefined, preventing the formation of a unified provincial effort ("playing chess as one province").
The coverage of protection work urgently needs expansion. Currently, Qinghai Province possesses only 1 National Famous Historical and Cultural City, 10 Famous Chinese Historical and Cultural Towns/Villages, and 4 Historical and Cultural Districts, significantly lagging behind other provinces. In reality, many urban and rural heritage sites bearing important historical and cultural value remain unlisted for protection. Heritage resources reflecting historical memories and values from key periods like the 100th anniversary of the CPC, the 70th anniversary of the PRC, and the 40th anniversary of Reform and Opening-up have not been fully explored or protected. Cross-regional and cross-jurisdictional historical and cultural corridors and routes, such as the Tang-Tibet Ancient Road and the Qinghai-Tibet Railway, lack integrated protection.

The scientific rigor and rationality of protection and transmission urgently need enhancement. There is a widespread tendency to focus on protecting individual heritage buildings or historical structures while neglecting the preservation and continuity of the overall urban/rural landscape pattern, traditional regional character, and cultural environment. In some urban construction projects, the destruction of original topographic features and the overall setting of historical and cultural heritage has occurred, damaging the protection of overall townscape, height control, and visual corridors, resulting in "bonsai-style" protection (isolating relics from their surroundings). Protection and renewal efforts in some historical and cultural districts or areas have severed the original social fabric and living networks.

In the contemporary era, urban and rural cultural heritage, as a vital component of a complete cultural ecosystem, is experiencing continuous expansion and deepening of its connotation and extension. It is no longer confined to singular cultural elements or physical carriers but extends to the complex interactions between different cultures, and between culture and the natural environment, along with their profound impacts. This comprehensive expansion endows urban and rural cultural heritage with diversified values, encompassing profound historical value, unique cultural value, captivating aesthetic value, significant social value, and potential economic value, among other dimensions.

Given the richness and complexity of urban and rural cultural heritage values, protective actions have far surpassed the scope of traditional cultural relics preservation, evolving into a complex social systems engineering project involving multiple domains such as politics, economy, society, culture, and management. This necessitates comprehensive, multi-level expansion and exploration in our protection efforts.

Cognitively, we need to re-examine the value and significance of urban and rural cultural heritage, deepening our understanding of its cultural essence and ecological value.

Theoretically, a more robust theoretical system for the protection of urban and rural cultural heritage should be constructed to provide scientific guidance for practice.

Technically and methodologically, innovative conservation techniques and methods must be continuously developed to enhance the scientific rigor and effectiveness of protection work.

In terms of implementation and strategy, long-term, systematic protection plans need to be formulated to ensure the continuity and stability of conservation efforts.

Simultaneously, the protection of urban and rural cultural heritage must transcend the singular concept of space and be considered within a broader cultural-ecological context. This implies a shift from specialized technical fields towards integrated domains where society, economy, politics, and culture intersect, requiring interdisciplinary and cross-sectoral collaboration.

To achieve this goal, we need to conduct comprehensive and in-depth integrated surveys and assessments of value, current status, and management, accurately grasping the situation and challenges of urban and rural cultural heritage. Based on this, establish a core-value-based protection system for urban and rural cultural heritage to ensure targeted and effective conservation work.

Furthermore, urban and rural cultural heritage protection should emphasize a people-oriented philosophy, focusing on strengthening the formulation and implementation of public policies. By establishing coordination mechanisms involving multiple departments and public participation, we can fully mobilize the initiative and proactiveness of all stakeholders – government, enterprises, social organizations, and the public – fostering a positive atmosphere of collective participation and protection. Only in this way can we steer urban and rural cultural heritage protection towards a dynamic, proactive, inclusive, and diverse path of sustainable development.

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Track 7
INCLUSION

Spatial Development Strategies and Policy Recommendations for Social Development in Shenzhen

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Abstract
This paper examines the current challenges in the spatial dimensions of our city's social construction efforts, including the low level of resource allocation efficiency, inadequate expression of urban characteristics, and shortcomings in management systems. It offers reflections on the issues and underlying causes affecting social construction in our city. Drawing on successful practices in social construction from both domestic and international contexts, the paper proposes relevant spatial strategies aimed at activating existing spaces, expanding incremental development, prioritizing community engagement, supporting vulnerable groups, enhancing citizens' well-being, and innovating institutional mechanisms.

Keywords: Social Development; Spatial Strategy; People-Oriented; Sense of Well-Being

Looking back at the history of Shenzhen's reform and opening up over the past 40 years, economic construction has always been the centre of development, while the development of social construction has lagged , becoming a 'bottleneck' that further restricts Shenzhen's sustainable economic and social development. As a pioneer city of China's reform and opening up, Shenzhen has long faced challenges in integrating economic development with social construction, as the lack of effective synergy has led to high property prices, congested traffic and increasing social pressure, seriously affecting the sustainable development of Shenzhen. Urban planning, as a tool for regulating urban development and construction, plays an important role in guiding coordinated economic and social development. Looking at developed cities at home and abroad, all of them give full play to the comprehensive, macroscopic and holistic role of urban planning to promote the sustainable development of cities.

1. The top-down social construction model is difficult to adapt to the requirements of Shenzhen's transformation and development

In the 40 years since the establishment of the Shenzhen Special Economic Zone, while creating a world miracle of economic development, urban social construction has also made remarkable progress. However, in terms of spatial support for social construction, it is basically a big deal for the government, and there is still a gap between its top-down spatial allocation model and that of advanced cities, which is mainly reflected in:

1.1 Spatial resource allocation for social construction needs to be optimised

There is a shortage and a waste of spatial resources for social construction. There is a shortage of community-level service facilities compared with the relatively well-developed urban-level service facilities. Shenzhen has highlighted some of its large-scale facilities, completing the construction of public facilities with a high starting point and high standards, such as the Shenzhen International Convention and Exhibition Centre, the Universiade venues and the Shenzhen Concert Hall. However, there is a relative shortage of community-level service facilities compared to urban-level facilities. The population served by social service centres in Bao'an District, Luohu District and Longhua New District, where community population density is high, is 2-3 times that of other districts, and the service carrying capacity of community facilities is relatively weak. The network of grass-roots cultural and sports facilities is not yet complete, with only seven districts having cultural centres and two streets having cultural stations; cultural centres and libraries outside the original Special Administrative Region are not up to standard, and the construction of grass-roots sports facilities needs to be stepped up.

On the other hand, existing facilities, whether in education, health care, elderly care or housing, are being used inefficiently and resources are being wasted to varying degrees. Concerning medical and health facilities, large and medium-sized hospitals are overcrowded and operating at excessive capacity. Primary healthcare facilities, on the other hand, are cold and quiet, and are even struggling to survive. With regard to elderly care facilities,

the total occupancy rate of institutional elderly care facilities is only 49.3%, with the occupancy rate of privately-run elderly care facilities at 18.9%, and a large number of facilities and equipment lying unused; whereas the total number of elderly people on the waiting lists of the Luohu Welfare Centre and the Nanshan District Welfare Centre at the end of 2023 amounted to 1,700, and the distribution of beds does not match the distribution of the elderly population. Social welfare facilities such as social welfare homes for vagrant mental patients and children are lacking. With regard to cultural and sports facilities, the efficiency of the use of some of the large cultural and sports facilities is generally low, such as the low utilisation rate of the Universiade venues, the yearly number of visitors to the Guanshanyue Museum of Art in Shenzhen is around 100,000, and the annual number of visitors to the Hexiangning Museum of Art is no more than 80,000, for example.

1.2 Social construction needs to be elevated

The current social construction is based on the protection of people's basic needs, and it is difficult to meet people's ever-increasing material and cultural needs. Aristotle once said: 'People gather in the city in order to live, in order to live better in the city.' People living in cities not only need to solve the basic problems of food, clothing, housing and transport, but also need to live a happy and joyful life.

However, Shenzhen's urban space shaping has yet to fully reflect the characteristics of a coastal city and multiculturalism, and residents lack a sense of belonging and identity. As a coastal city with a long coastline in the east and west, Shenzhen has good conditions for building a coastal eco-city. However, these natural conditions have been neglected in the development process, resulting in the distance of the sea, the reduction of mountains and the pollution of rivers. The proportion of living shoreline is low. Shenzhen has a total of 260.5 kilometres of shoreline, of which about 63 kilometres are living shoreline, accounting for only 24%. Referring to the proportion of public shoreline to the main waterfront shoreline in advanced cities (regions) in the world, Chicago is 68.9% and Sydney is 36.3%, which are both over 30%. Shenzhen's multi-cultural characteristics are not fully perceived by the public. Firstly, history and culture are not sufficiently visible, and protection and utilisation are fragmented. Shenzhen has 1600 years of urban history in Dongguan County and Bao'an County, and 600 years of castle history in Nantou and Dapeng. Although the protection of historical and cultural resources is increasingly important, but the government passively delineates the purple line for strict protection, and can not fully realise the value of historical and cultural resources. The combination with the cultural and creative industries is not high, and in the end, but is not conducive to the protection of cultural resources themselves. Secondly, the implementation of the reform and opening-up culture is less content. At present, the culture of reform and opening up is mostly protected through museum exhibitions; this static and single way of protection can not be a comprehensive display of the reform and opening up of the culture of Shenzhen.

1.3 Institutional mechanisms for social construction need to be improved

There is no clear distinction between the responsibilities and roles that the Government and the market can assume. At present, in the area of social construction, the Government 'takes care of everything', with all types of social resources being allocated by the Government from the top down. In terms of construction and investment channels, the government's financial resources are predominant. Social capital, especially social organisations and charitable organisations, does not have good channels for donating funds and land for the construction of various welfare facilities. In social organisation management, the slow development of private organisations has made it impossible to effectively alleviate the social contradictions brought about by the sharp increase in social pressure and the imbalance in income distribution.

There is a lopsided emphasis on disaggregating and implementing responsibilities, and there is a lack of platforms for effectively integrating resources and coordinating interests. As the city's social construction is dispersed among various functional departments, the implementation of vertical 'article management', each grassroots community hangs dozens of signs, the community more from the perspective of meeting the requirements of the assessment of the higher level of government rather than from the perspective of meeting the actual needs of the community to carry out the various tasks. The lack of effective coordination among various functional departments makes it difficult to form synergies, and public properties completed often lack follow-up management and supervision; various departments are unable to share resources, and the public has no way of understanding the social facilities around them. Inadequate mechanisms for acceptance and supervision,

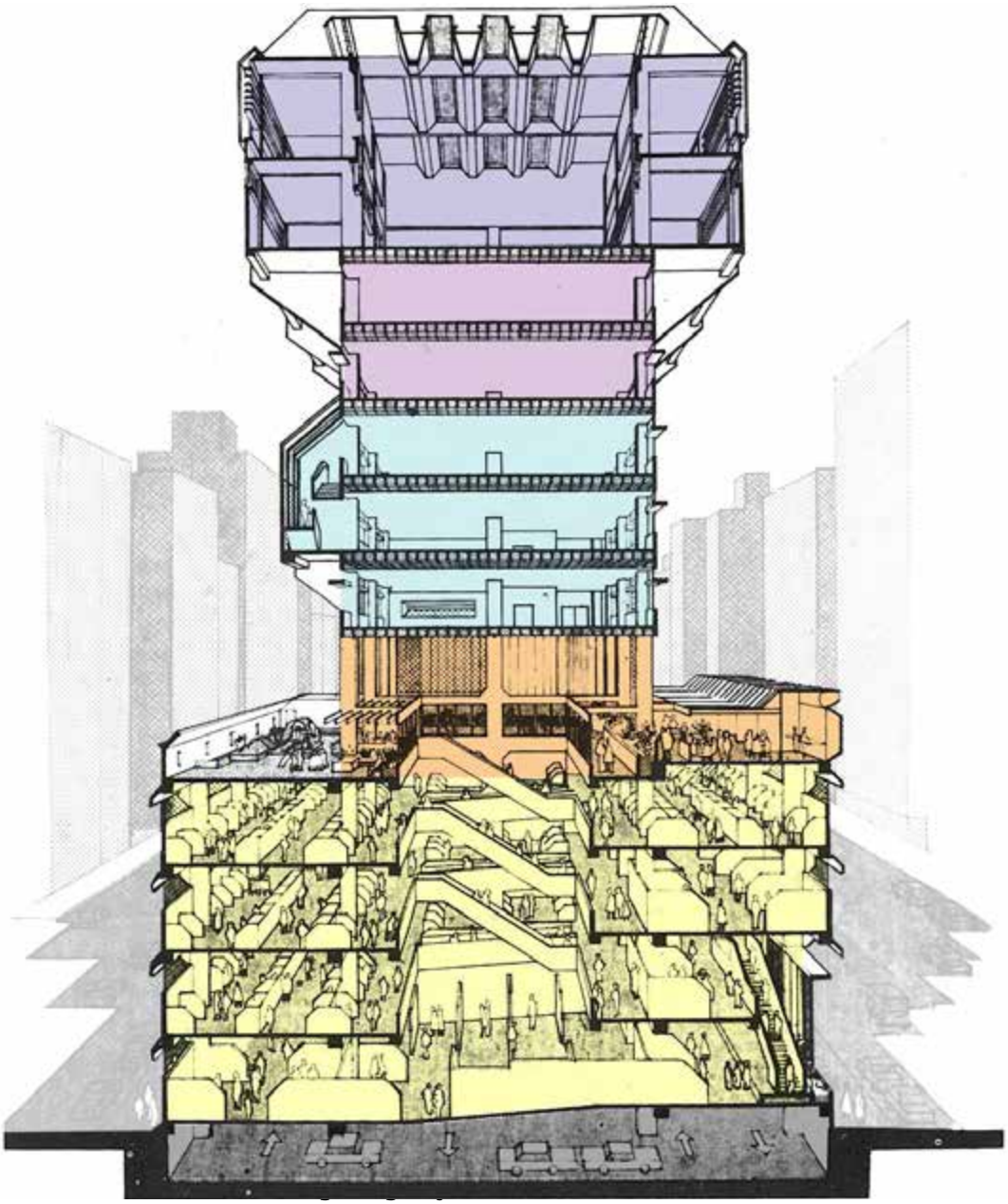
which require the participation of multiple departments, have made it difficult to implement planning for social facilities. Mainly reflected in the completion of the transfer of the community, community public facilities are not in accordance with the requirements of the planning and construction, or do not meet the requirements of the sectoral industry norms, resulting in the phenomenon of 'goods do not match the board', resulting in low utilization of social facilities, problems also have no feedback or accountability. Existing public welfare facilities, due to mismanagement or being in the hands of developers, are privately contracted for closed operations, losing their original public welfare purpose and becoming 'tasteless. For example, the Starlight Home for the Elderly has been converted into a mahjong teahouse in many communities.

2. Successful explorations in the field of social construction both at home and abroad have centred on 'human development' to organise all kinds of social resources.

Although Shenzhen's social construction is in a leading position in the country, there are still certain gaps in terms of space, level and institutional mechanism. Strengthening social construction is an important part of Shenzhen's construction of a modern, internationalised and advanced city, and is also a basic guarantee for the social and urban transformation that Shenzhen is facing. We must look to the developed countries and regions and learn from their successful experience, focusing on human needs and organising all kinds of social resources around human development.

2.1 Efficient and Intensive Spatial Allocation for Social Construction - One-Stop Service in Hong Kong's Municipal Services Buildings

The Hong Kong Municipal Services Building (HKMSB) is a multi-purpose integrated municipal building in Hong Kong, which generally comprises a loading and unloading yard on the basement level, a market on the ground and first floors, a cooked food centre on the first floor, a public library on the third floor, a swimming pool from the fourth floor to the fifth floor, and a gymnasium on the sixth and seventh floors. The LCSD and the FEHD now manage some of the facilities separately. At present, there are 39 municipal services buildings in Hong Kong. Vibrant municipal services buildings not only accommodate a wide range of social activities and provide diversified choices for the community, they are also valuable historical monuments in their own right. At least one community cultural complex is encouraged to be provided in each urban living cluster, where the basic needs of life, such as markets, catering, libraries, activity rooms, and so on, are concentrated in a single building, so that residents can enjoy diversified and multi-level as well as 'one-stop' services without having to go out of their neighbourhoods.



2.2 High Starting Point, Forward-looking Social Construction Service Model - The Mature Senior Living Community Model in the US

Retirement communities in the United States are generally divided into five categories: Active Adult Retirement Communities, Self-Care Communities, Assisted Living Communities, Special Care Communities, and Mixed Continuing Care Retirement Communities. Active Adult Retirement Communities are primarily for active, healthy seniors between the ages of 55-70 years old. This type of retirement community basically eliminates the need for medical care, but does allow for the use of third-party-provided services such as housekeeping, sanitation, and health care. The amenities that go along with them are more dynamic and include gyms, swimming pools, and golf courses. Self-care communities are for seniors aged 65-80 who do not need assistance with daily living, but do require medical care. The services required are mainly catering, housekeeping and cleaning services, with supporting facilities such as gyms, swimming pools and libraries. The occupants of assisted living communities are mainly elderly people aged 75 and above who need help. The level of medical care required is higher, requir-

ing three meals, bathing, toileting, medication reminders, physical rehabilitation training, etc. Activity rooms, libraries, exercise and rehabilitation centres are required. Special care communities provide the highest level of medical care, including medically prescribed professional rehab, and 24-hour emergency care. Supporting facilities are primarily recreational facilities, exercise and rehabilitation centres, and physical therapy rooms. Hybrid Continuing Care Retirement Communities are a combination of the previous types of retirement communities.

Elderly communities in the United States are already very mature, with different types of elderly communities for different ages and different self-care abilities of the elderly, as well as different modes of management and profitability. This model of community care for the elderly, which is truly considered from the perspective of different needs, is worth learning from.

A schematic diagram of a Continuing Care Retirement Community in the US
source from Research: Learning from the middle class pension model in the United States

2.3 Shared and transparent mechanisms for the management of socially constructed space

2.3.1 Anhui Wuhu 'Tree of Life' social service management innovation road

Wuhu City, Anhui Province, has proposed the creation of a 'tree of life' information management system, that is, the integration of information resources required in social activities during the different life cycles of human beings, through the establishment of basic databases co-ordinated by various departments, and the initial construction of three-level convenient service enquiry systems for districts, neighbourhoods and communities, with several functions such as household registration management and address management, and at the same time At the same time, information on house ownership, social security, civil affairs, etc. is gradually integrated into the basic database, and several application sub-systems are established, so that all community work is integrated into information management. Information-sharing platforms for all urban and rural communities in the city are gradually being established and covered.

This innovative management model for social services establishes an information platform whereby all sectors of society can more easily grasp information on all types of social services, and government administrations can provide public services more effectively.

2.3.2 Operation of Public Properties by the Government Property Agency of the Hong Kong Government

The Government Property Agency (GPA), a department under the Financial Services and the Treasury Bureau of the Hong Kong Government, was set up in 1990 to consolidate the management of government properties, which at that time were scattered in the Chief Secretary's Office, the Lands Department and the Rating and Valuation Department, into a single department. Its core objective is to manage government properties efficiently and cost-effectively. Its main activities include the construction, acquisition or leasing of public properties to optimise the use of government, agency and community land through the reservation of land, the release of under-utilised government land where appropriate, and the vetting of bureaux and departments' office and

accommodation requirements.

As the government's industrial coordination and management department, it participates in the supply, planning, construction, operation, supervision and management of the city's public welfare properties, and coordinates the management of the city's public welfare properties in an all-around way. For private organisations in need of acquiring and leasing properties, it provides more convenient and favourable application conditions that are open and transparent.

3.Strengthening spatial integration to build a people-centred social construction system

The successful exploration of advanced cities at home and abroad in the field of social construction embodies humanistic care everywhere. Their spirit and philosophy of focusing on human development and putting people first, as well as their successful practical experience, have brought valuable lessons to Shenzhen. Given the existing situation in Shenzhen and some of the problems in social construction, we propose six spatial strategies to cope with social construction, taking space as the entry point:

3.1 Activate the stock of space and encourage the mixing of functions and flexible transformation within the social service space

Ensure the efficient recycling of facilities by converting them to the most needed use of the moment when appropriate. Maximise the value of socially constructed space by adapting, optimising and overlaying internal functions over time. Based on the functional access guidelines, the land use of buildings or public spaces at different times of the day can also be used for different purposes, to achieve the purpose of realising as many uses as possible on the smallest possible plot of land. For example, sports and recreational facilities in primary and secondary schools can be conditionally opened to the community during holidays. Surplus office and conference space in the public sector can be opened up to the community when it is not in use, so that it can be converted into a venue for the activities that the community needs most.

Existing public welfare facilities are encouraged to renew and renovate themselves and increase their floor area ratios in order to expand the space available for use. As the level of urban construction and quality of life continue to improve, when the original public welfare facilities in terms of quality and quantity have gradually failed to meet the needs of residents, in the case of the surrounding land can not be further expanded, can be guided by the planning premise, by applying for the use of the government property maintenance fund or the public-private partnership model, undertake demolition and reconstruction or addition of the existing public welfare facilities in order to expand the use of space, so that they can independently complete the renewal and revitalisation. In this regard, the Government will continue to assist these facilities to enable them to complete their renewal and revitalisation on their own.

3.2 Enlarge the incremental space and release more space for social services in multiple ways

By focusing on internal potential, the government can encourage the reuse of idle or abandoned land or non-construction land for social service facilities. Guiding public participation in the supervision and management of idle or abandoned land suitable for development, and formulating preferential policies to encourage its reformation and utilisation as places or facilities needed by society. In urban landscape zones, green areas and other urban green open spaces under certain conditions, the government takes the lead in designing public facilities and public open spaces that are easily accessible and usable by the public. Encourage the construction of temporary outdoor activity facilities such as tennis courts and football pitches, and revitalise existing non-construction land resources.

Encourage owned buildings to provide public space after the renewal of the building, as well as the surrounding environment through policy instruments such as floor area ratio (FAR) incentives. Further increase efforts to support the transformation of old factory buildings, encourage urban renewal to provide public space, and encourage old factory buildings and other buildings to contribute more public facilities through such means as the distribution of land proceeds, land-price adjustments, and the transfer of plot ratios.

3.3 Focus on the community level and promote social service facilities at the community and grassroots levels

Optimising the scope of community management and services. Explore the establishment of basic community statistical units, and set up a system of basic community statistical units linking professional departments such as planning, land, property, statistics, public security, education and health. Change the statistical system in which each unit works separately and does not interfere with each other, integrate information on spatial and social management resources such as healthcare, culture and sports, education, population and public services, and implement a comprehensive and all-encompassing community statistical system. Integrate various types of statistical units, including those of planning, public security, education and other departments. Allocate social service facilities according to the actual population size. Break down the traditional community boundaries based on administrative boundaries, and determine the scale and type of various types of facilities according to the size of the actual population living in the local area, and establish a service-oriented mechanism for the allocation of community spatial resources. Under a market-based mechanism, the scale and structure of community service personnel of all types are configured around the needs of the community in accordance with factors such as the size of the population served and the carrying capacity of the community, and community boundaries are dynamically adjusted to form a scientifically reasonable physical community boundary for community management services.

Strengthening the provision of grass-roots facilities such as community-level sports and cultural facilities and medical facilities. For example, in response to the shortage of sports venues, increase the construction of community-level simple basketball courts, simple fitness facilities and other grounded, fast-acting and inexpensive cultural and sports facilities. Ensuring the availability of community-level service facilities. Appropriate policy preferences will be given in terms of supporting land for community service facilities outside the original Special Administrative Region or in short supply. Open a 'green channel' for the approval of land for community-level facilities, and simplify the content and procedures for the approval of land for community facilities, so that they can be put into use within the shortest possible time. A multi-sectoral acceptance system has been established to ensure that community facilities meet the normative requirements and practical needs of various sectors.

3.4 Care for the disadvantaged and provide diversified spaces and services for different people in the city

Through differentiated spatial strategies, different groups of people in the city can have their own place and enjoy themselves. Improving the living space for low- and middle-income groups in urban villages and other cities. To address the housing problems of low-income groups, broaden the supply of secure housing by actively promoting urban renewal modes such as conversion of industrial buildings into residential buildings and renewal of allotments, and make good use of the self-renewal mechanism of urban villages. In such a densely populated place as Haisha Village, where water cannot be splashed in, a new underground car park of several thousand square metres has been built, and the decoration of shops on the ground floor of the streets of Shuiwei Village is becoming more and more fashionable. Give some time and policies to allow urban villages to gradually renew themselves; extract some of the buildings to create public activity spaces in urban villages. Perhaps more important than old age reform is to make urban villages more livable. Compared with uprooting, acupuncture-type therapy is more effective.

Real scene of 1368 block in Shuiwei Village (Photo by the author)

To open up space for entrepreneurship among low- and middle-income people, such as the Civic Centre Square as a flea market, and regulating its management by fixing its opening time, location and types of commodities, and so on. The Civic Centre Plaza is grand and empty, with no facilities for public recreation, and not well divided and designed, with a large scale and a lack of vitality. The elevated plaza on its north side and the car park on its south side are very underutilised. We can make the Civic Centre Plaza an ideal place for various urban activities and festivals, so that the Civic Centre Plaza can really become a 'citizens' plaza'. At the same time, an appropriate fee reduction and exemption policy can be implemented, the level of social security for the informally employed can be gradually raised, and the training of the informally employed can be strengthened and improved.

Enhancing accessible design. Tailor humane spaces for women, children and the elderly to enhance the inclusiveness of cities. Improve people-centred barrier-free urban design, provide rehabilitation services or facilities for people with disabilities, adopt universal design, and implement a system of accessibility co-ordination managers and accessibility directors. To address the mobility problems of the elderly, barrier-free facilities such

as handrails have been placed in public activity areas, walkways and even the interior of housing in neighbourhoods, and attention has been paid to the elderly in the smallest detail through refined design.

According to the differences in the self-care abilities of the elderly, various types of retirement communities, such as active adult retirement communities, assisted living communities and special care communities, will be fostered. In response to the trend of aging in Shenzhen, we will focus on cultivating 'residential area + retirement' type of elderly communities in the future, with architectural designs specially designed for the elderly, giving full consideration to the dual needs of the elderly both physically and mentally, and targeting the planning of recreation, arts and culture as well as the main body of recreational living space, to create an image of a rich and personalised residential area, and to respond to the diversified needs of elderly groups in a flexible and changeable way, and to comprehensively promote the community elderly social community. Flexible and changeable ways to respond to the diversified needs of the elderly groups, and comprehensively promote the socialised service mode of community elderly care. There are different types of retirement communities for different age groups, with different management and profit models.

3.5 Enhance citizens' sense of well-being and shape the characteristics of a city of mountains and seas and a diversified city

Create a strong subtropical coastal city character and improve the quality of life of citizens. Insist on creating high-quality ecological space, and create urban clusters with suitable scales, complete support facilities and balanced jobs and housing; accelerate the establishment of the city's ecological protection and compensation system, and explore a variety of ways, such as eco-community planning, government leasing, and transferring the right to development in ecological areas, so as to realise the protection of resources with the mindset of development; and accelerate the adjustment of the function of the shoreline to increase the proportion of public shoreline. In Shenzhen's 260.5 kilometres of coastal zone co-ordination planning, increase the proportion of the original living shoreline of 25% to 35%; enhance the permeability of the coastal space to the service hinterland, so that the public in their daily activities are more close to the coastal space; cultivate more waterfront space, so that the public can see the mountains, look at the water, get close to the sea, forming an open, pleasant mountain and sea city cityscape; in the streetscapes, park landscapes, architectural styles and sculptural vignettes to reflect the characteristics of the coastal city everywhere.

Shenzhen Coastal Corridor (Photo by the author)

Strengthening the 'diversified and inclusive' urban culture and spirit of the city, enhancing the citizens' sense of belonging and happiness in their city, and improving the city's cultural competitiveness. On the basis of the diversified cultures of Lingnan culture, marine culture, reform and opening-up culture and immigrant culture that have already been formed in Shenzhen, learn and absorb the cultural development strategies of world-class cities, and, according to Shenzhen's strategic concept of 'establishing the city with culture', reflect the diversity of the city's cultures in the organisation of urban space, layout of facilities, and architectural design, so as to enhance the inclusiveness and cohesion of urban development. To enhance the inclusiveness and cohesion of urban development. Actively promote the protection of ancient villages and the transformation of historic districts. Different protection and utilisation methods will be adopted for different types of ancient villages, so as to achieve 'original protection' and 'functional regeneration', and to ensure that ancient villages regain their vitality and vigour while retaining urban memory. Regulations on the management, protection and repair of ancient villages should be formulated, and adequate compensation and incentives should be offered in terms of renewal and upgrading, as well as investment in the renovation of municipal facilities. Shape humane and characteristic urban public spaces. Use acupuncture to create a vibrant and interesting Shenzhen, starting from the 'point'. Use different buildings, places, facilities and vignettes to fully express the spirit of innovation and design. Advocating the small-scale transformation of urban villages, creating public courtyard spaces by removing part of the building; taking into account Shenzhen's climatic conditions, creating all-weather promenades, urban bridges, etc.; and proposing the combination of urban locations and urban activities, such as the Binhai Avenue Bicycle Race and the Civic Centre Festivals.

"original appearance protection" + "function regeneration" of Shenzhen Dapeng Fortress source from sznews.com

3.6 Innovative institutional mechanisms and the gradual establishment of a working mechanism for sharing resources across sectors

The Shenzhen Public Property Management Agency was created as the government's industry co-ordination and management department to participate in the supply, planning, construction, operation, supervision and management of public property throughout the city. The Public Property Management Agency is mainly responsible for the operation and management of government and other public welfare properties in the city, and coordinates the supply of land, planning and construction of new development programmes in response to the demands of various functional departments for land for public facilities. Through conversion or renovation, purchase or lease, it flexibly provides housing for social construction services and, where appropriate, vacates underutilised government properties to ensure that the city's public property land use efficiency is maximised.

Developing a 'one account' information network platform at the municipal, district and community levels. Integrate information on healthcare, culture and sports, education, population, and public service space and social management resources, and unify and publish them on the livelihood facilities supply information platform, which will be dynamically updated and maintained according to the use of the facilities, and gradually promote the sharing of public resources managed by different departments. All sectors of society can more conveniently grasp the latest information on the use of social construction space, and apply to public property management organisations on the platform to rent space, as well as apply for the construction or acquisition of certain properties for specific projects.

Open up channels to guide individuals, enterprises and charitable organisations to contribute facilities and services to society. Gradually relax the restrictions on social organisations entering the field of social construction, study and formulate a variety of incentives such as relevant land prices, plot ratios, taxes, etc. to support the entry of private capital into the social sector, and encourage social capital to participate in the construction of

livelihood-type facilities through various modes such as BT and BOT. Encourage individuals to contribute to society by transforming land or buildings in their hands into public facilities and open spaces such as parks, squares and promenades for charitable purposes. A professional operation mechanism of contribution-assessment-distribution-management has been established to respond quickly to current public needs.

Improving mechanisms for the participation of all of society in social construction. Reinforcing the participation of relevant authorities in civil affairs, education, health and human rights, culture and sports in the entire process of social construction projects, including the entire process of planning, approval, acceptance and management, will make it easier for the competent authorities to improve their own sectoral plans promptly and to promote the construction of relevant facilities in due course. Gradually establish a mechanism for teachers, doctors, lawyers, planners and other professionals and technicians related to social construction to share their professional knowledge and serve in social construction. In conjunction with the community planner system, a counselling and service platform for professional and technical personnel has been established in the community to provide a full range of services to community residents regularly.

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Gender-Responsive Approaches in Post-Disaster Temporary Settlement Planning: Insights from Malatya and Adıyaman

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Abstract
The earthquakes that struck southeastern Türkiye on February 6, 2023, caused massive destruction and displaced thousands to temporary shelters. This study examines the applicability of the UN Women Turkey Gender-Responsive Settlement Model (GRSM) in the cities of Adıyaman and Malatya. Using a GRSM-based checklist, the research evaluates temporary shelter areas and identifies the need for modifying the criteria to allow for more nuanced, scalable assessments. Data were collected through online surveys, field observations, unstructured interviews, and an expert workshop. Content analysis of the findings supports the development of locally adaptable, gender-sensitive settlement design principles. Addressing safety, accessibility, services, participation, and economic opportunity, the GRSM aims to guide local authorities in sustainable, inclusive post-disaster planning.

Key Words: Gender; Temporary Settlement; Post-disaster; Türkiye.

In a world of increasing uncertainty and complexity, enhancing urban resilience is becoming increasingly complex but critical. In particular, global impacts such as climate change, natural disasters, and large migration movements affect vulnerable groups more profoundly, making addressing their needs in a local context imperative. However, in the existing literature and urban policy practices, resilience mainly focuses on physical infrastructure. It does not adequately address the needs of vulnerable groups and their role in post-disaster recovery processes (Vale & Campanella, 2005). Urban planning practices, while central to post-disaster reconstruction and resilience-building, also often fail to integrate the socio-spatial needs of vulnerable populations, particularly women.

This narrow focus on physical infrastructure overlooks how inequalities are embedded in space and reproduced through standard planning responses to crises. As Moser (1993) highlights, women and girls, among the most fragile and disadvantaged groups, face compounded challenges during and after disasters stemming from socially constructed gender roles. These dynamics shape not only how risks are experienced but also how recovery unfolds across different social groups. Therefore, the authors hypothesize that localizing gender-responsive design criteria in temporary post-disaster settlements, where women and girls face intersecting vulnerabilities, can enhance not only social resilience but also the long-term adaptive capacities of communities.

Based on the "Gender Responsive Settlement Model" guidance manual prepared for UN Women Turkey, this paper analyzes local contexts with different social, geographical, and cultural characteristics via the cases of Malatya and Adıyaman. These provinces were selected not only because they were among the most affected by the earthquake, but also because these regions have multi-layered social, economic, and cultural backgrounds due to their strong historical structures.

The existing guide must be tailored to adapt to different geographical and cultural local contexts rather than providing a generic design approach. Thus, the findings of the research in Malatya and Adıyaman are expected to lead to a discussion to point out that considering local characteristics in the design of temporary settlements

will both increase pre-disaster urban and social resilience and strengthen the adaptation capabilities of people in post-disaster recovery and reconstruction processes. This contribution aims to localize a global and generic model and advance the conceptual integration of gender responsiveness within urban resilience policies.

Literature review

Critiques of Technocratic and Infrastructure-Centric Resilience Models

Resilience is a multi-layered concept defined in different ways in different disciplines. Defined as elastic strength and ability to recover in engineering (Chelleri, 2012), resilience is associated with the ability of an individual to cope with difficulties throughout life in psychology (Rutter, 1987). In this transition from the individual and physical level to the societal scale, Adger (2000) defines social resilience as the ability of communities to adapt to environmental and political stresses. While traditional approaches interpret resilience within the framework of "returning to equilibrium" or "maintaining stability," ecological systems theory (Holling, 1973) and complex systems thinking have explained resilience with the capacity for transformation, multiple equilibrium states, and self-organization principles (Levin et al., 1998). The social-ecological systems approach emphasizes that resilience should be addressed not only with the capacity for recovery but also with the capacity for adaptation and transformation (Berkes & Folke, 2003).

Although the concept of resilience is increasingly present in planning and policy discourses, Davoudi (2012) argues that the technocratic treatment of this concept often reduces it to a managerial discourse of "bounce-back-ability." Davoudi (2012) makes a distinction between engineering resilience (the speed at which the system returns to its former state) and evolutionary resilience (the capacity to adapt and transform). This distinction is crucial in the post-disaster context, as returning to a pre-disaster "normal" state can often mean reproducing the same vulnerabilities. Therefore, the integration of resilience into planning should be rethought not only in terms of efficiency and stability but also in terms of justice, power relations, and inclusiveness. However, this technocratic framing of resilience also overlooks how structural gender inequalities shape access to resources, recovery trajectories, and coping capacities, especially for women, caregivers, and marginalized populations.

In parallel with the concept of resilience being interpreted in different ways in different disciplines and diversifying over time into a complex framework, considering the necessity of addressing urban systems as a whole with their social and economic dimensions, gender equality, the role of vulnerable groups in recovery processes and consideration of local contexts have become integral components of current resilience approaches. However, this multi-layered understanding of resilience remains incomplete unless it includes the different vulnerabilities of social groups. In particular, ignoring social resilience weakens post-disaster adaptation capacity and further deepens social inequalities (Sezgin Hatipoğlu & Ersavaş Kavanoz, 2024).

The evolution of resilience across disciplines and time shows that while early resilience approaches focused more on physical infrastructure and technical capacities, current approaches emphasize the central role of social resilience. Social resilience refers to the capacity of individuals and communities to overcome crises and reorganize, adapt, and transform in response to these crises. Therefore, social resilience includes the capacity to survive and prepare for future risks (Smyth & Sweetman, 2015).

Communities contain many social groups, and these groups have different levels of resilience to crises. Resilience should cover risks that vary according to gender, age, and socioeconomic status (Buckle, Mars & Smale, 2000). Gender constitutes one of these different vulnerability parameters. Traditional engineering-based resilience approaches often ignore structural inequalities and render these vulnerable groups invisible (Meerow, Pajouhesh & Miller, 2019). This situation may cause the concept of resilience to function as a 'status quo protector' that reproduces inequalities (Davoudi, 2012; Chelleri et al., 2015). Ignoring social resilience in planning and post-disaster recovery processes may lead to reproducing or deepening existing social inequalities (Sezgin Hatipoğlu & Ersavaş Kavanoz, 2024). Especially in contexts where gender-based inequalities are intense, the absence of community-based strategies limits an inclusive recovery and transformation process.

Therefore, to understand urban resilience holistically, social resilience needs to be addressed, especially in its relationship with gender, care work, and informal solidarity networks.

Gender as a Dimension of Social Resilience

Traditional resilience discourse often celebrates coping strategies developed at the "community" or "household" level but fails to question the social inequalities upon which these strategies are built. Smyth and Sweetman (2015) argue that to address the concept of resilience effectively and fairly, invisible but determining dynamics such as gender roles, power relations within the household, and care work must be taken into account as well. When these elements are ignored, resilience discourse can become a framework that naturalizes and reproduces the unequal burdens on women and girls.

Theis, Bryan & Ringler (2019) argue that most resilience strategies used in social policy and development programs offer a "one-size-fits-all" solution and therefore homogenize social vulnerabilities. Such approaches render inequalities faced by different social groups, such as women, the elderly, migrants, or caregivers, invisible. This can not only result in the needs of these groups not being met but also in the deepening of their risks. Gender-based resilience strategies should not be limited to post-disaster physical shelter or livelihood opportunities. Increasing women's participation in decision-making processes, socializing care work, and reducing time poverty experienced by women directly impact long-term resilience outcomes (Theis, Bryan & Ringler, 2019). Therefore, women should be positioned as "recipients of assistance" and active agents of resilience.

Building on these critiques, a growing body of research emphasizes the need for resilience frameworks that are not only sensitive to structural inequalities but also transformative. In this context, gender-sensitive planning approaches are not only a corrective tool that aims to compensate for existing deficiencies; they are also a call for a fundamental rethinking of how the concept of resilience is defined, measured and implemented. In the context of post-disaster reconstruction, this approach recognizes that states of vulnerability are socially produced and spatially embodied. These vulnerabilities become particularly evident in disaster contexts, as the design of settlements and the distribution of services either reduce or deepen existing inequalities. Therefore, resilience strategies need to take into account the spatial experiences of women and other marginalized groups, along with dimensions such as access, security, care work and participation.

This growing body of feminist and critical resilience literature underscores the necessity of post-disaster planning frameworks that are both intersectional and sensitive to spatial, social, and institutional inequalities. Together, these insights underscore the necessity of rethinking resilience planning through intersectional and locally grounded frameworks.

As earthquakes of February 6, 2023 caused widespread destruction in the southeast of Turkey, spatial and social problems experienced by vulnerable groups have become more visible. Problems such as basic infrastructure deficiencies, security risks and injustice in access to services became apparent in temporary shelter areas established during the crisis. This situation necessitated the rethinking of post-disaster temporary settlements not only as physical shelters but also as places of social resilience and social recovery.

The Gender Responsive Settlement Model (GRSM) (Oğuz Çevik, 2023), developed for the UN Women Turkey Office, provides a holistic framework for planning and designing post-disaster settlement areas with a gender responsive perspective. This model is based on the integration of the specific needs of women, girls, the elderly, the disabled and other vulnerable groups into settlement design. This is particularly evident in Türkiye, where empirical findings after February 6 Earthquakes further validate the critical need for gender-responsive and locally adaptable frameworks.

In Türkiye, studies conducted after the February 6 Earthquakes show how disasters reveal social vulnerabilities (see Altıok, Arıcı & Özüçelik, 2025; Duruel & Avşar Arık, 2023; Tüzün, 2023). These studies demonstrate that the concept of social resilience should be redefined inclusively by focusing on the experiences of different vulnerable groups, such as children, the elderly, and immigrant women. These studies also emphasize that post-disaster interventions should consider the chronic problems that existed before the disaster and the needs of vulnerable groups. Social resilience is not only an individual's adaptation capacity, but it is also closely related to their social support networks. Duruel and Avşar Arık's (2023) study with elderly individuals in Hatay highlights the protective role of solidarity networks over individual strategies. In other words, disaster fragility

is determined by the social system and power relations rather than the disaster itself. The fact that post-disaster social policies are generally based on "one-dimensional" interventions also deepens gender-based vulnerabilities (Altıok, Arıcı Özüçelik, 2023). For example, the focus of public support on uniform and temporary interventions has ignored the needs of migrant women. Thus, post-disaster social policy practices have increased the vulnerability of these groups by making existing inequalities invisible. These findings not only support the theoretical underpinnings of GRSM but also point to the urgent need for planning frameworks that move beyond standard templates to engage with situated experiences of vulnerability and recovery.

The Gender Responsive Settlement Model (GRSM) emerges as a vital planning tool that both responds to and reshapes the conceptual debates on resilience. Rather than treating gender as a secondary consideration or an add-on, the model places it at the centre of post-disaster recovery processes. By foregrounding lived experiences, local dynamics, and care responsibilities, especially those disproportionately shouldered by women, the model offers a transformative vision of resilience that is deeply embedded in place and social relations. It challenges the default technocratic approaches that focus solely on physical reconstruction and instead calls for a paradigm shift: from infrastructure-led to justice-centred planning. In this regard, GRSM bridges the gap between theory and practice by translating feminist and intersectional insights into spatial design principles and policy interventions.

Moreover, the model's adaptability across different local contexts offers a replicable and flexible approach for other disaster-affected regions. By engaging with the specific socio-cultural characteristics and institutional capacities of each locality, GRSM does not impose a one-size-fits-all template but encourages co-production of knowledge and participatory planning processes. It enables communities not just to recover, but to transform in ways that reduce future vulnerabilities and redistribute social risks more equitably. This localized and inclusive perspective aligns with the evolving understanding of resilience as not merely about 'bouncing back' but about building forward with justice, care, and collective well-being at the core. Therefore, the Gender Responsive Settlement Model contributes to an emerging planning paradigm that reframes resilience through gender justice and spatial equity.

In operationalising this vision, the GRSM includes a Gender Equality Self-Assessment Checklist specifically designed for newly established permanent settlements. This tool guides planners and decision-makers in identifying and addressing potential gender inequalities across various domains, including safety, housing, mobility, education, healthcare, employment, governance, and public space. Far from being a static instrument, the checklist is meant to be context-sensitive and adaptable to the unique social, cultural, and spatial dynamics of each locality. It fosters inclusive and equitable communities by integrating the perspectives of women and marginalised groups throughout planning and implementation processes. In doing so, the checklist not only enhances the responsiveness of recovery efforts but also anchors gender-sensitive social resilience within urban design and policy. As climate-induced and socio-political disasters become more frequent and more complex, planning responses must evolve accordingly. GRSM provides a framework for that evolution, one that resists the normalization of inequality in crisis response and instead reimagines post-disaster recovery as an opportunity for structural transformation.

Data and Methodological Approach

This research investigates the applicability of a model developed for designing and managing gender-responsive temporary settlements in different socio-cultural contexts. It is supported by the Scientific Research Projects Coordination Unit of Gebze Technical University. The main objective is to provide an adaptation framework that localises the Gender-Responsive Settlement Model developed by the United Nations Entity for Gender Equality and the Empowerment of Women (UN Women). The research is conducted in temporary shelter areas established following the earthquakes centred in Kahramanmaraş on 6 February 2023, selecting Malatya, Gaziantep, Kahramanmaraş, and Adıyaman provinces as case study areas. The choice of these cities stems from their direct and profound experience of the disaster's destructive impact as well as their social and cultural diversity, which allows the observation of varied experiences and needs within the context of gender.

This research employs a qualitative research approach through a multiple-case study method, as systematised

by Yin (2018). This method facilitates a comparative analysis of how a particular phenomenon manifests across different contexts. By observing the same phenomenon in diverse social, spatial, and institutional environments, it enhances both the validity and generalisability of the findings. Moreover, this approach enables the examination of the intersection between gender and disaster across different countries and contexts. Complementing the multiple-case study design, this research also employs the Grounded Theory approach to conduct an in-depth analysis of the data and to develop theoretical concepts. Grounded Theory, developed by Glaser and Strauss in the field of sociology, is a method that systematically constructs theoretical models based on qualitative data (Glaser & Strauss, 1967; Charmaz, 2014). This approach particularly facilitates the generation of original theoretical frameworks from field data without relying on predetermined hypotheses, making it suitable for understanding social processes, experiences, and complex human relationships. Given the multifaceted nature of women's experiences, needs, and gender dynamics in post-disaster temporary settlements, the flexible and data-driven analysis offered by Grounded Theory provides an appropriate method to reveal the detailed and authentic realities of the field.

The semi-structured interviews, observations, and field notes collected in the study were analysed using the constant comparative method. Through this process, codes and themes were developed to construct key concepts related to gender-sensitive settlement design. This approach provided a critical foundation for enhancing theoretical sensitivity and questioning the adaptability of existing models within the local context (Strauss & Corbin, 1998; Charmaz, 2014). Moreover, Grounded Theory facilitated the reciprocal development of the core "Gender-Sensitive Settlement Model" with the field data. This method went beyond merely defining a phenomenon; it also contributed to understanding the structural and social challenges women face in post-disaster contexts and supported the development of more inclusive and sensitive policies. Researchers such as Gaillard et al. (2017) and Enarson and Meyreles (2004) also emphasise the importance of supporting gender-based approaches in disaster settings with field-based analyses. Accordingly, the Grounded Theory method enriched the study's theoretical depth while enabling the formulation of robust, locally appropriate recommendations for practical application.

The case studies presented in this paper were conducted within a general framework in the provinces of Malatya and Adıyaman. According to Report of Presidency of Strategy and Budget (2025), the earthquakes centred in Kahramanmaraş on 6 February 2023 affected more than 14 million people across an area of 120,000 square kilometres. A total of 53,737 people lost their lives, 107,213 were injured, and more than three and a half million people had to be evacuated from the region. Following the earthquake, the Ministry of Environment, Urbanisation and Climate Change conducted damage assessment studies, which revealed that 102,825 housing units in Malatya and 64,456 in Adıyaman were classified as moderately or severely damaged. In Malatya city centre, there are 75 container settlements currently housing 112,686 people. In Adıyaman, 55 container settlements have been established, accommodating 118,150 people.

Before the case studies commenced, preliminary meetings were held to establish collaboration with active civil society organisations, local and central government institutions, and research organisations operating in the field. Based on these preliminary meetings and document reviews, initial impressions were gathered regarding the provinces of Malatya and Adıyaman, where the fieldwork would take place. Guided by these insights and the partnerships established, the fieldwork was conducted in temporary shelter sites. These temporary shelter sites were directly observed, and on-site assessments were made through photographs and videos. Additionally, semi-structured interviews were conducted with disaster-affected and/or refugee women, NGO staff, and local officials from public institutions. The scope and content of the semi-structured interviews were designed based on the UN Women's gender-sensitive settlement model and tailored with questions appropriate to each target group. The interviews were recorded via audio and/or detailed note-taking, then transcribed and analysed using thematic analysis.

Following the completion of the Malatya case study, the checklist developed within the framework of the Gender-Sensitive Settlement Model was transformed into an online survey form to ensure broader participation and data collection, informed by insights gathered from the field. The aim of the survey is to collect information on temporary settlement areas that could not be accessed during fieldwork due to time constraints and permission limitations. The survey is disseminated using a snowball sampling method, expanding through the trust and collaborations

established during fieldwork. This approach aimed to capture the experiences and perspectives of different social groups. It was deliberately chosen to facilitate rapid and effective access to the lived realities encountered in the field.

In contrast to the Malatya field study, the Adıyaman fieldwork was conducted in collaboration with Adıyaman University through the organisation of the Expert Consultation Workshop on Gender-Sensitive Temporary Settlements. The workshop was designed both to introduce the model and to collect data through participants. Participants included container city residents, local government employees, representatives of public institutions, women-focused NGOs, and academics. During the workshop, themes such as housing, security, infrastructure, access to social services, and livelihood opportunities were examined in the context of Adıyaman's temporary accommodation sites and the post-disaster process. The scope and adaptability of the Gender-Sensitive Settlement Model were discussed specifically within the Adıyaman context.

All field studies, along with their data collection and analysis methods, aimed to contribute to the effective localisation of the Gender-Sensitive Settlement Model and the development of gender-sensitive policy recommendations for post-disaster temporary settlement design. The collected data not only tested the model's practical applicability but also enabled the identification of the unique needs of diverse gender identities and social gender groups experiencing post-disaster conditions. This integrated approach offers a holistic understanding of how gender-responsive strategies can be more effectively designed, implemented, and institutionalised within disaster recovery frameworks.

Findings

Based on interviews and field visits conducted in the provinces of Malatya and Adıyaman, the findings obtained through the testing of the Gender-Responsive Approaches in Post-Disaster Temporary Settlement Planning model are presented below. The analysis first focuses on province-specific conditions, followed by a comparison of the current state of temporary living environments in both locations, and the identification of shared problems and needs. This comparative assessment is structured around the key components of the model. These components are used to comprehensively examine the spatial, social, and administrative dynamics observed during the fieldwork, and to evaluate the model's applicability and adaptability to local contexts.

Evaluation of Temporary Settlements in Malatya

Fieldwork conducted in Malatya revealed that temporary settlements were not designed in accordance with gender-responsive principles. Observations showed that the specific needs of women, girls, and other vulnerable groups were not adequately considered during the planning processes. Significant deficiencies were identified in core GRSM (Gender-Responsive Settlement Model) areas such as safety, privacy, access to services, and participation.

In the visited settlements, each household was typically allocated a single 21-square-meter container (Fig. 1). However, these units failed to provide an interior layout suitable for the age, gender, and care needs of household members. In most cases, no separation of sleeping spaces for women, men, and children was possible, leading to breaches in privacy. Containers were placed in very close proximity, blurring the boundaries of personal space and disrupting daily routines. The lack of proper lighting and inadequate locking systems on container doors posed particular safety concerns for women, especially at night. The separation of sanitary facilities from living units further hindered access to basic needs.

Figure 1. Container Unit. Rönesans 1 Temporary Settlement Area, Malatya.

Security practices varied significantly between container sites and lacked a consistent implementation model. For instance, while some sites allowed unrestricted entry and exit, others were subject to control by law enforcement. No specific protective mechanisms were in place for cases of harassment or violence against women and girls, and survivors were often forced to remain in the same physical environment. Although legal and psychological support was available through civil society organizations, the lack of enforcement authority limited their effectiveness.

Regarding WASH (Water, Sanitation, and Hygiene) services, there were notable shortcomings in meeting basic hygiene needs. Health services specifically for women — including prenatal care, family planning, and reproductive health — were either limited or entirely absent in many of the areas. Psychosocial support services were also found to be irregular and inadequate. Considering the widespread trauma following the earthquake, these gaps are particularly critical.

Although some temporary solutions were implemented in the education field, significant continuity problems were reported. While certain civil society initiatives aimed to uphold the right to education for both girls and boys, public educational facilities remained spatially inadequate. Some NGOs provided play areas, study rooms, and digital equipment spaces, yet the reach of these services remained limited (Fig. 2).

Figure 2. Social areas for Children. Samanköy Temporary Settlement Area, Malatya.

Overall, there were very few safe and inclusive public spaces where women, men, and children could come together. Existing social infrastructure was not designed with a gender-sensitive perspective, and failed to address the distinct needs of women, the elderly, and children.

Evaluation of Temporary Settlements in Adıyaman

Fieldwork conducted in Adıyaman revealed structural and operational problems similar to those observed in Malatya; however, notable differences emerged in administrative practices and the presence of civil society actors. When assessed through the framework of the Gender-Responsive Settlement Model (GRSM), it becomes evident that gender-sensitive planning principles have only been partially implemented in Adıyaman.

Unlike Malatya, Adıyaman's urban fabric has undergone a different set of spatial transformations in the aftermath of the earthquake. Whereas temporary settlements in Malatya were dispersed throughout the city center, in Adıyaman they are primarily concentrated in the urban periphery. Although this spatial arrangement has facilitated the centralized delivery of services, the scale and isolation of these areas have generated challenges for daily life—particularly for women and girls.

Housing typologies in Adıyaman are more diverse. In addition to container-based settlements, prefabricated structures are also commonly used (Fig. 3). In some areas, hybrid settlements composed of both containers and prefabricated units were observed. While prefabricated units offer larger interior spaces and may benefit larger households, their monolithic construction and internal layouts pose disadvantages in terms of privacy and safety. For families with five or more members, the increased floor area does not necessarily translate into improved privacy per capita. Therefore, while spatial expansion may contribute positively to perceptions of security—particularly among women and girls—it does not fully resolve concerns regarding privacy.

Figure 3. Prefabricated Unit. Vartana Temporary Settlement Area, Adıyaman.

Another distinctive feature of Adıyaman's temporary settlements is the spatial differentiation based on social profiles. For example, settlements near the eastern part of the city, especially around hospitals, were designated for healthcare personnel, while those near the university accommodated academic staff. Larger families were predominantly located in the southern Vartana region, within mixed (container-prefabricated) settlements. Conversely, marginalized groups such as the Dom community were placed in segregated settlements in the northeastern parts of the city. These patterns suggest a partial spatial profiling of temporary accommodation, though such arrangements were not consistently applied across all sites.

In terms of WASH (Water, Sanitation, and Hygiene) infrastructure and lighting, conditions were broadly similar to those in Malatya, yet significant variation was observed between settlements. For instance, in areas supported by private sector actors or charitable organizations, infrastructure was generally more developed, while others faced acute deficiencies. City-wide interruptions in water and electricity supply disproportionately affected those residing in temporary settlements, with women and girls bearing the brunt of these disruptions.

Access to education and social activities also revealed deep inequalities across sites. Earlier-established settlements benefited from a broader range of NGO-provided services, whereas newer settlements had more limited access to such resources (Fig. 4). The absence of a systematic and equitable distribution mechanism further exacerbated these disparities.

Figure 4. NGO-Provided Services Units. K-6 Temporary Settlement Area, Adıyaman.

Over time, the withdrawal of NGOs and the reduction of external support have led to significant gaps in healthcare services. Civil society organizations had played a crucial role in addressing the physical and psychological needs of women, girls, and adolescents. However, their diminished presence in the field has resulted in severe service interruptions, leaving these vulnerable groups increasingly unsupported.

Common Challenges and Needs

Field research conducted in Malatya and Adıyaman revealed that temporary settlement areas in both cities exhibit similar shortcomings in terms of gender-responsive planning principles. Common problem areas were identified at both the physical and administrative levels, particularly in relation to the core pillars of the GRSM model: safety, accessibility, participation, access to services, and resilience.

Shelter, Physical Infrastructure, and Safety

In both cities, women and girls report a low perception of safety in temporary settlement areas. In Malatya, this perception is linked to container material quality, spatial design, and layout. In Adiyaman, the issue stems from the location of settlements in large, isolated areas. While centrally located and small-scale settlements in Malatya, integrated into the urban fabric, positively influence perceptions of privacy and safety through greater social interaction, the prefabricated units in Adiyaman offer improved material quality and larger capacity, mitigating some safety concerns.

Urban Planning, Infrastructure, and Transportation

Differences in water, sanitation, and hygiene (WASH) services between the two cities are rooted in the performance of their infrastructure systems post-disaster. Malatya's infrastructure sustained comparatively less dam-

age, whereas in Adiyaman, water provision has been irregular, with scheduled outages during the week and formerly potable tap water becoming non-drinkable. These disruptions have a more severe impact on vulnerable groups, particularly women and girls, for whom hygiene is essential to daily functioning.

Psychosocial Impacts and Mental Health

Psychosocial and mental health support services in both cities are predominantly provided by civil society organizations. However, these services are not equitably distributed, and some units have withdrawn over time. In Malatya, smaller, more integrated settlements such as those outside Samanköy and Teknokent facilitate normalization and trauma recovery, especially for adolescents and children who have easier access to urban activities. In contrast, the larger-scale settlements in Adiyaman complicate coordination and contribute to fragmented service delivery, slowing psychosocial recovery.

Gender and the Status of Women

Although gender-related issues are similar in both cities, women's everyday roles are impacted differently depending on the shelter typology. In Malatya, standardized container units, regardless of household size, intensify domestic responsibilities for women. In Adiyaman, while container areas face similar challenges, prefabricated units with more flexible and spacious layouts provide relatively better conditions for women. Furthermore, Adiyaman features more visible support for women's labor participation through NGOs and women's cooperatives.

Education and Child Rights

The provision of education in both cities lacks standardization. While some areas offer on-site preschool and primary education, others rely on nearby public facilities. These differences are influenced by the settlement's location and development timeline. Similarly, educational support by NGOs is uneven; older settlements host multiple active organizations, whereas newer ones often lack any support mechanisms. In Malatya, public services provide relatively more comprehensive access to education, unlike in Adiyaman where such access is limited.

Social Fragmentation and Discrimination

Temporary settlements in Malatya and Adiyaman demonstrate distinct manifestations of social fragmentation and discrimination. In Malatya, dispersed settlements within the urban fabric foster greater interaction with the host community, which may support integration but also expose residents to exclusionary practices. In Adiyaman, large, homogeneous settlements located on the urban periphery contribute to spatial segregation and feelings of exclusion. The assignment of marginalized groups, such as the Dom community, to separate areas exemplifies institutionalized spatial discrimination.

Social Capital and Societal Change

In both cities, social capital plays a dual role in fostering resilience and reinforcing limitations. In Malatya, the proximity of settlements to pre-disaster neighborhoods has supported the preservation of social networks. In Adiyaman, earlier-established settlements maintain stronger neighborhood ties, while newer ones show weaker social cohesion. Group homogeneity within settlements enhances internal solidarity but restricts intergroup interaction. While women support one another in caregiving, daily tasks, and information exchange, socio-spatial disconnection threatens the sustainability of these networks. Additionally, newly emergent norms—such as refraining from going out at night or interacting with strangers—reproduce traditional gender roles.

Participation, Institutional Capacity, and NGOs

In both cities, participation in the management of temporary settlements is minimal. Decision-making processes are largely centralized, and women's involvement tends to be symbolic. While some NGOs in Malatya operate in a more systematic and institutionalized manner, those in Adiyaman function on a project-based and often fragmented basis. The weak coordination between local authorities and civil society actors negatively affects the continuity and inclusivity of services.

Rights, Access, and Perceptions of Justice

Women in both Malatya and Adiyaman expressed similar dissatisfaction regarding access to basic rights and perceptions of justice. Inequities in public service provision and spatial organization are key contributors to this sentiment. In Malatya, differences in service quality among container settlements were frequently mentioned.

In Adiyaman, the allocation of certain groups to better-equipped areas reinforced the perception of unequal resource distribution. Limited access to legal aid, psychosocial support, and healthcare has led many women to feel excluded from the system, significantly hindering both individual and collective empowerment.

Conclusion

This study aimed to examine the applicability of the Gender Sensitive Settlement Model (GRSM) in the context of post-disaster reconstruction in southeastern Türkiye, as well as its localization requirements. Preliminary findings based on fieldwork conducted in Malatya and Adıyaman provinces confirmed that GRSM offers an inclusive framework based on gender responsiveness but revealed that this model needs to be reinterpreted in a way that is sensitive to local contexts.

Common problems, including security concerns, limited access to care services, lack of participation in decision-making processes, and the neglect of women's or care workers' needs in spatial planning processes, were observed in both cities. This supports the importance and applicability of the basic principles of GRSM. However, at the same time, local differences, such as the spatially dispersed structure of services in Malatya and the stronger informal community networks observed in Adıyaman, indicate that the model cannot be applied uniformly in every context and needs to be adapted according to local socio-spatial dynamics.

Since the research is not yet complete and a fully localized version of GRSM has not been presented, a final model is not proposed in this study. However, the findings in Malatya and Adıyaman provide strong indications of how the model may evolve in the future. In this context, the need to develop participatory, flexible, and process-sensitive adaptation mechanisms, rather than fixed and centralized models, is emphasized for the planning of post-disaster settlements.

In conclusion, this study once again demonstrates the critical importance of integrating gender sensitivity and principles sensitive to social vulnerabilities in the design and governance of post-disaster settlements. Planning frameworks, such as GRSM, should be considered as non-static tools shaped by local realities, power relations, and daily life practices.

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The Role of Spatial Alienation in the Journey of Existence as an Actor in Contested Urban Areas: The Case of Kasımpaşa, Istanbul

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Abstract
Although alienation represents the arche of Marxist theory, it has also key role in the field of urbanism. In parallel with people's labour, their own life and alienation of human to human, the aggressive policies of production-oriented relationships in cities trigger the alienation of people from the city. This research investigates the levels and types of alienation produced by neoliberal urban policies in Kasımpaşa, one of the most chaotic neighbourhoods of Istanbul. A questionnaire survey was conducted with employees of Istanbul Metropolitan Municipality's located in Kasımpaşa, a group chosen due to their institutional responsibility in urban policies. The findings reveal the levels and processes of alienation experienced by this group within the context of Kasımpaşa while also analysing the urban interventions contributing to spatial alienation.

Keywords: Alienation, Gentrification, Being Actor, Borders, Neoliberal Urbanisation

1. Introduction

Alienation comes to the forefront as one of the main issues discussed in philosophy, sociology, psychology, political science and perhaps most importantly in urbanism. It is inevitable that this concept should be defined by various disciplines, and that this concept should be the product of an interdisciplinary discussion, as there can be a physical alienation with the built environment as well as socio-cultural layers of alienation (Sahan, 2021). What separates people from the environment they live in is the loss of their sense of belonging to that environment; The disappearance of memories of that environment with physical, social and cultural impositions creates a great story of disconnection from space. One of the crucial reasons for this break is that capital's own interests are produced through urban space, and moreover, space becomes a part of the production process. In that case, it is important to analyse the policies of capital on space and to discuss the views of Marxist and post-Marxist theory on alienation in order to understand the processes of breaking up from urban space.

Although the definition of Marx's concept of alienation as alienation from one's own labour continued for many years, it began to take a different form with Lefebvre. The French school and Lefebvre tried to create a synthesis of the concept of city and alienation, which Marxist literature ignored for a long time. Lefebvre (1991) speaks alienation was defined as the separation of human from life blessed with primitive fragility, joy and wisdom: "The human, stripped bare and projected outside of itself, was and remains at the mercy of forces which in fact come from the human and are nothing but human—but torn apart and dehumanized" (Lefebvre 1991, p.276). And it points to the relations of production as the basis of this alienation. Monetary policies have formed the basis of class and social divisions and these policies have revealed a deep alienation. Such a transformation stemming from the internal dynamics of the relations of production denied the existence of the urban dweller as an actor on the street (Lefebvre 2003), redefined it as a commodity and transformed it into individuals who only pass by, do not wait, and do not have a deep relationship with the space.

With the destructive interventions created by neoliberal economic policies on urban space, the increase in crime rates, irregular urbanisation, increase in urban violence and, in parallel, the increase in the control of neoliberalism in the city triggers urban rupture and alienation (Geis&Ross 1998). Alienation is the product of a set of neoliberal policies and gentrification efforts in the areas of cities that are subject to conflicts, causing the deep

relationship between the city and the urbanite to be damaged. In developing or unconsciously developed cities like Istanbul, where alienation is felt at such an aggressive level, the attitude of the local government is at the centre of the problem in the parameters that cause alienation. Therefore, it is necessary to emphasize the importance of local governments and, moreover, the planning departments in local governments in understanding the trends and policies underlying the problems that cause alienation and in solving the problems that arise. Thus, understanding the alienation process of Kasımpaşa from the perspective of the employees of the Istanbul Metropolitan Municipality, which has an aggressive construction area in the region, constitutes the key point of this study. The process and degree of alienation of local administrators provides deep and meaningful conclusions about the spatial alienation of residents. Therefore, this study aims to understand the level of alienation of municipal employees from the environment they live in and the types of alienation they are exposed to and seeks answers to the following questions: To what extent do the commodification processes of neoliberalism affect the physical, cultural and social alienation between urban dwellers and space? Which type of alienation has a deeper relationship with wrong urban policies and chaotic urban space? To what extent does alienation affect the ontological existence of the individual in urban space?

2. Anatomy of Alienation

Marx(1844/2016) says that alienation has many layers, and the first stage of it begins with economic alienation due to the inability to access what one's own labour produces. The object produced by labour appears to man as a foreign substance that does not belong to her/him. In the end, the worker relates to the product of her/his own labour as if she/he was communicating with a foreign object. Therefore, the more labour the worker exerts, the more alien her/his attitude towards the product she/he produces. In addition to the alienation of the worker from the object produced by her/his labour power, Marx also speaks of the alienation of the process of production, that is, the process of activity. The production process is a process in which the workers are active, in which their body, mind, abilities work. The workers' alienation from this process of activity ultimately leads to their alienation from own self. According to Marx (1844/2016), human beings, as a species, turn the activity of their lives into an object of their own consciousness. The human being's life is a conscious activity, and this is the most significant feature that distinguishes it from other animals. The human beings are a conscious being and therefore their life is also their purpose. However, with alienation, man's own life activity ceases to be a goal and becomes a means of her/his essence. The detachment of human beings from their species-being and purpose of life leads to their alienation from others—ultimately, from fellow human beings (Marx 1844/2016). Healy explains the process as follows: "When we are denied control and use over the product of our labour, when it becomes alienated from us, appearing to have power over us, we are in effect alienated from our own species-being; alienated from our own humanity and from the world we inhabit (Healy 2020, p.15)."

In Marxist theory, the process of alienation (Marx 1844/2016) is fundamentally rooted in the worker's labour power (Figure 1). Labour power constitutes the foundation of capitalist production and serves as the primary determinant of the production process. Within this system, the worker is compelled to sell her/his labour to the capitalist in exchange for a wage. The capitalist class, holding private ownership of the means of production, maintains control over the productive assets necessary for labour. Although the worker engages with and activates these means through her/his labour, she/he remains perpetually excluded from ownership, regardless of the intensity of her/his work — a dynamic that generates surplus value (Marx 1867/1990). Consequently, the worker becomes alienated from the product of his labour, as her/his wages are insufficient to purchase the very commodities she/he produces. While the products circulate globally as part of international trade, they largely remain inaccessible to the worker, symbolising his profound alienation from the outcomes of her/his own productive activity. As a result of alienated labour man actually alienates her/his essence. Creativity is inherent in man, and man is essentially a practical being. With the alienation of these creative activities from himself/herself, man loses self-worth. The human being who maintains the purely individual existence of the generic self-worth by working continuously and continuously ceases to be a human. Man's alienation from own essence leads to a direct result: man's alienation from other people (Figure 1). Every relationship that a person establishes with herself/himself finds expression in her/his relationship with other people. In that case, the person who is alienated from herself/

himself becomes alienated from other people and the person who is social by nature turns into an asocial being (Petrović, 1963).

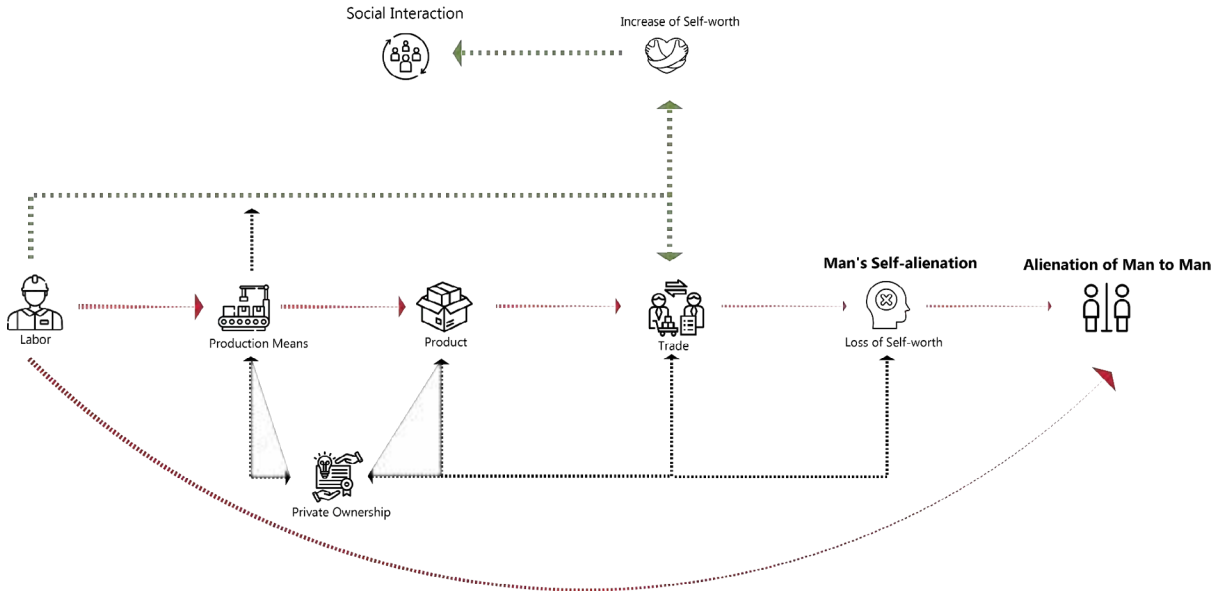

Figure 1: Alienation Process in Marxist Theory (Marx, 1844/2007; Petrović, 1963).

Marx's concept of alienation can be defined as a social and economic process that starts with the alienation of objects as a product of labour, alienates from one's own essence, and ultimately results in alienation from human to human. The main subject of this research is to analyse the alienation of social and physical space to human and human to social and physical space. In this context, analysing an intellectual synthesis of the concept of urban alienation and Marx's concept of alienation will form the basic theoretical framework of this study. Based on Marx's theory of alienation of labour, we first see the integration of space into alienation. Starting from the alienation of objects as products of labour, Lefebvre extends the concept of alienation to the dimension created by capitalism in the production of space and social relations. That is to say, capitalism has transformed cities into centres of production; moreover, it has commodified space itself, eliminating the classifications based on the historical, social, cultural, and natural values that space holds, and replacing them with classifications based on use value. Just as the private ownership of the means of production leaves the labour with the product it produces, the private ownership of the urban land alienates the city dweller from the city both subjectively and objectively (Diaz-Parra and Jover 2021). Right to the city (Lefebvre 1971), one of the most important concepts written by Lefebvre, claims that spatial alienation must be eliminated in order to people for claiming their environment. Ownership also includes the residents taking an active role in the construction of the city. Residents create the city, transform it on a conscious level, transfer their own culture and lifestyle to the city and subsequently shape their own personalities (Lefebvre 1971).

Although the policy of the citizen to build the city directly was common for the pre-capitalist cities, which transformed into places where capital only produced as a commodity tool and moreover, the centre of production. Capitalist institutions, private property, and the expansion of the land market have obliterated the pre-capitalist form of the city. The commodified product (including the space itself) replaces urban structures, the living space replaces the settlement, and alienation is imposed. Thus, while the inhabitants of the city are alienated from the city they have produced and transformed, they are actually expelled from the centres of the city. As city centres

are centres of production, only the working population begins to concentrate in the centre of the city. The commodification, displacement and gentrification processes of historic city centres are at the root of modern urban alienation. For instance, Lefebvre defines the profound interventions and changes that Haussmann created in Paris as the product of these alienation processes. Haussman's intervention is clearly a series of projects that undermine the organizing power of the proletariat, displacing them and further alienating them from the environment in which they live. For this reason, Lefebvre refers to the re-enactment of workers in urban centres as an important part of the right to the city. (Diaz-Parra and Jover 2021).

While capitalism commodifies the city itself and subject it to a deep and concrete change, it tries to abstract all its policies in order to prevent the perception of these concrete changes. Lefebvre expresses this fact that capitalism has tended to transform the space into an abstract space by removing the diversity, vitality and life-recognizing structure of the space, placing it in an abstract context. Capitalism is in an effort to separate space from the real thing and isolate it in order to cover up the urban reality, the struggle for life in the urban slums, the class war and its contradictions. The space of capitalism is an abstract space. As for capitalism, the exchange value is important, not the concrete use of space. For this reason, neither the historical production and use of space nor the social values it represents have a value in itself for capitalism. They are only important to the extent that they contribute to the exchange value of the space in question. What makes one of the two different historical places more valuable than the other - for the capitalists - is the high trade-off value (Lefebvre 2003). Due to the that fact, capitalism wants to commodify the vitality of the space, the life that continues in the space, and the common values, and to ensure that the masses are alienated from these values. With modernist urbanism urban space has become commodified, and standardization has become the basic principle instead of diversity that constitutes the spirit of that space. Lefebvre's criticisms of Le Corbusier's street imagination as the pioneer of modernism are actually based on this basis. According to Lefebvre, street is not only a place where people pass by and move without stopping. The street is the place where people meet, socially exist and interact with each other, connecting places such as cafes, theatres, reading clubs, and moreover providing a continuous relationship amongst these places. The street is a spontaneous theatre, and sometimes a person who was just a spectator suddenly becomes an actor, occupies the street, and turns the street into a battle for her/his unheard voice to be heard. For this reason, the street is a place where people, who tend to be one as a species, are together and establish meaningful relationships with the other (Lefebvre 2003, p.22).

The lack of control over the production process itself exposes the individual to alienation and ultimately leads to alienation from the workplace/street where the individual spends the majority of her/his daily time. The individual's inability to control or predict the consequences of her/his own behaviour ultimately undermines her/his relationship with space. While the behaviours of the individual find themselves in the relationship with the other, the inhibition of these behavioural patterns by alienation detaches them from social life itself. The fact that the rules of the society and social environment she/he lives in are based on the morality of commodities disrupts the semantic integrity of the individual's relationship with others and space. Moreover, when the social norms determined by the world of commodities clash with the individual's value judgments, a social isolation may result. The class culture of the bourgeoisie, such as consumer culture, individualization, globalization, gentrification, elitism, and more importantly, the individual's rebellion against these cultural norms, which are necessary for the uninterrupted continuation of the capitalist production system, also pushes her/him into alienation. In the end, the individual is not only alienated from the society and social environment, but also from the space itself where all these processes take place and continue.

As a catalyst of urban alienation, rapid, unconscious and aggressive urbanisation policies, vandalism, drug use, lack of safety regarding criminal issues have profound effects on the individual's relationship with space. In contemporary urban landscapes shaped by neoliberal capitalism, aggressive urbanisation policies not only exacerbate economic inequalities but also produce conditions of social abandonment, where marginalised groups are increasingly pushed towards acts of vandalism, drug dependency, and violent resistance against the alienating environment (Madden and Marcuse 2016; Rolnik 2019; Watt 2021).Vandalism contributes to the deterioration of shared urban spaces, eroding residents' emotional attachments to their environment and fostering a sense of alienation

(Taylor 2011). Similarly, the prevalence of drug use in urban areas accelerates social fragmentation and generates an atmosphere of distrust, undermining individuals' sense of belonging within the city (Sampson 2012). An increase in criminal activities further compromises residents' feelings of safety, leading to a withdrawal from public spaces and intensifying experiences of urban alienation (Jacobs 1961). Collectively, these dynamics expedite the process of detachment from urban life and weaken the identity bonds individuals form with their cities (Wacquant 2008).

Wirth (1938) argues that increasing urbanisation weakens the connection with place and this triggers spatial alienation. One of the most important reasons triggering urban alienation is the destruction of local ties and neighbourhood relations as a result of complex urban living. Aggressive urbanisation, moreover, the transformation of space into a commodity that is produced and consumed, pushes the limits of control over the environment in which the urban dweller lives. The urban dweller's loss of control over the environment leads to a loss of a sense of belonging and as a result, social isolation emerges (Massey 1996; Geis and Ross 1998). According to Simmel, the chaotic sights and sounds of the city, crowds and noise are the main factors in the deterioration of social control (Simmel 1969). Increasing negative stimuli in cities create an uncontrollable perception of physical environment on citizens. As a result, people living in the city learn that they cannot control the social and physical environment in which they live. This whole experience results in helplessness, that is, the loss of their sense of belonging. Massey argues that spatial alienation is mostly a result of economic relations. He concludes that poverty, especially concentrated at the scale of neighbourhoods, is effective in the deterioration of public order, which in turn triggers the process of alienation. Contrary to many other urban sociologists, he states that this alienation starts at the neighbourhood scale, not at the city level, and that the physical and social environment has a direct impact on people. He claims that the demographic structure of the people living in the neighbourhood; ethnicity, gender, income status shape social life and have a profound impact on alienation (Massey 1996). In line with Massey's view, the necessity of a neighbourhood-scale analysis to understand urban alienation is among the conclusions reached through the literature research. In this context, Kasımpaşa, as one of the most controversial neighbourhoods of Istanbul, has been the focus of this study.

6. The Study Area: Kasımpaşa Neighbourhood

The historic neighbourhood of Kasımpaşa is located in Istanbul's Beyoğlu district. It was an important hub for naval operations throughout the Ottoman era, especially in the 18th and 19th centuries. The neighbourhood had a commercial and military organization throughout this time. The population of Kasımpaşa increased significantly throughout the Industrial Revolution, making it one of Istanbul's most significant residential areas (Çelik 2019). As the economic structure changed in the 20th century, problems including poverty and rapid urbanisation started to appear.

Kasımpaşa has had a swift urban transformation and gentrification trend in recent years. Although the historic fabric of the neighbourhood is at risk, this process has also attracted significant investments and the development of high-end homes and offices (Taşan 2020). Real estate prices have significantly increased due to its close proximity to Galata and Beyoğlu which have high land values. The original residents of the neighbourhood, especially those from lower-income groups, have been displaced as a result of the significant socioeconomic divide brought about by urban transformation (Karaman 2017).

Throughout this process, civil society organizations (CSOs) like Beyoğlu Kent Savunması (Beyoğlu City Defense) and İstanbul Kent Savunması (Istanbul City Defense) have vigorously campaigned against the detrimental impacts of urban transformation while promoting the rights of the locals. These organizations have called for a more equitable transition process and have opposed displacement and the loss of cultural identity (Yılmaz and Kaya 2018). The Union of Chambers of Turkish Engineers and Architects, or TMMOB, has contributed knowledge and oversight to Kasımpaşa's urban transformation initiatives, guaranteeing that urbanisation is executed in a safe and healthy way.

Considering the current situation of Kasımpaşa, the relationship of these new projects with the urban identity and context should be expressed. Istanbul Metropolitan Municipality Kasımpaşa Additional Service Building is

one of the urban interventions in Kasımpaşa (Figure 2). Among the notable uses in the area are Istanbul Bilgi University and Arter Art Gallery, representing the significant educational and socio-cultural interventions in Kasımpaşa. In addition, the first phase of the Piyalepaşa Mass Housing projects created a deep physical boundary between the neighbourhood and the other part of the city. The urban policies of the neoliberal economy try to isolate the city of space by breaking the city out of its real and concrete context, evaluating it as a commodity according to its use value and breaking the solid bond with the city dweller. In this respect, the real relationship between the concrete space and the human being is taken out of its context and it eliminates the possibility of the urban dweller to live as a social being in the space, to be an actor. The removal of many ethnic groups like Romani citizens from their homes for the second phase of the Piyalepaşa Mass Housing project is also the product of such policies. At the same time, the construction of new hotels and office buildings that are disconnected from the identity of the city are similar activities of these policies. The main reason why Kasımpaşa was chosen as the study area was that the ruptures, social isolation, cultural clusters, differences and various urban functions frequently mentioned in the literature were experienced. Although the gradual decrease in the presence of open and wide green areas as a product of aggressive urbanisation is seen in Kasımpaşa, it is still possible to talk about the existence of some large parks. Sururi Park and Hacı Ahmet Cinderesi Park are the two largest neighbourhood parks of Kasımpaşa. (Figure2).

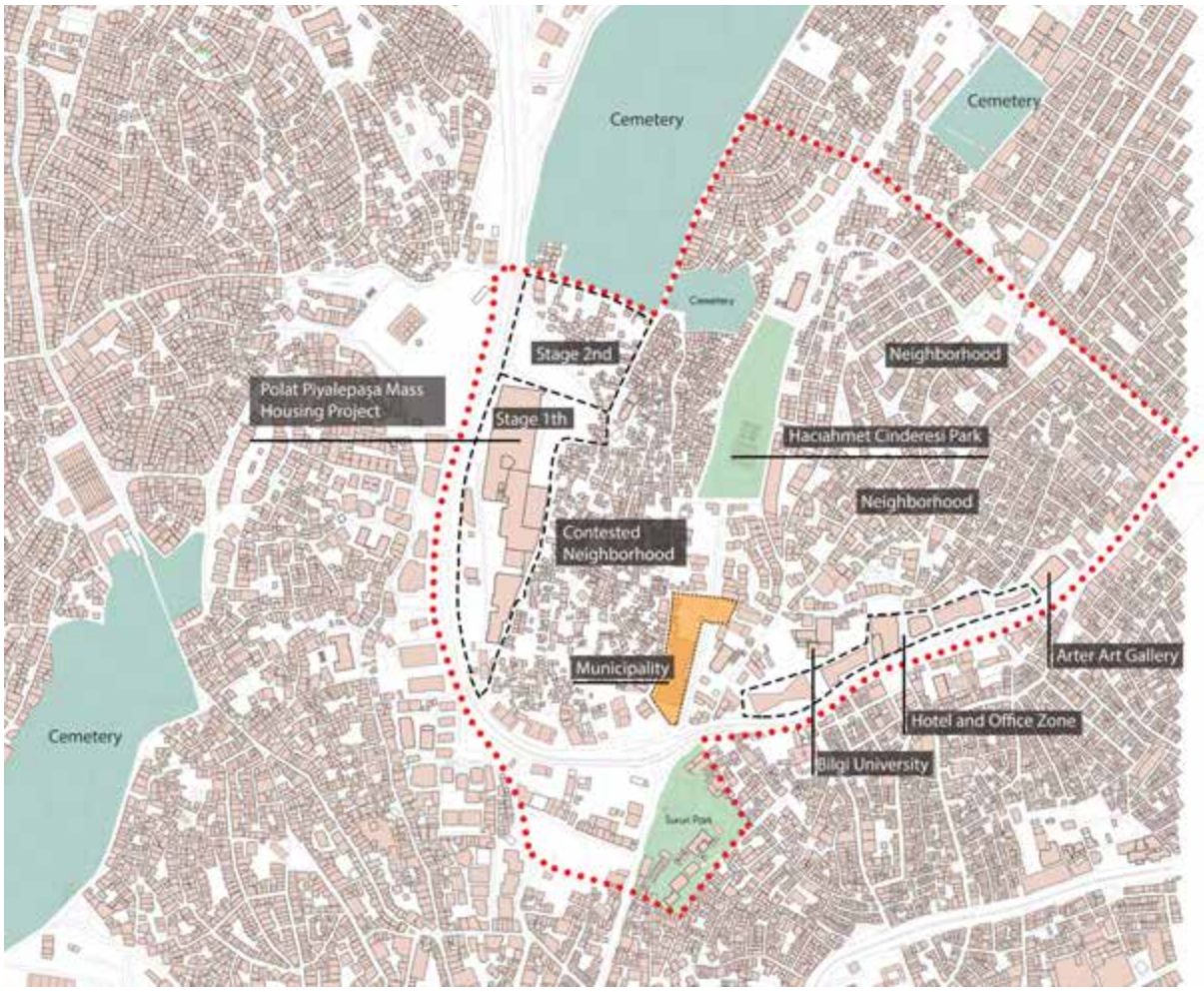

Figure 2: Existing Functional Urban Areas in Kasımpaşa

The first photo seen in Figure 3 and 4 depict the modern exterior façade of the municipal building. The photo on the right, taken from the roof of the municipal building, reveals the chaotic structure of the neighbourhood. On one hand, neglected wooden and concrete buildings stand out, while on the other, high-rise apartment blocks illustrate the picture of unplanned urbanization.

Figure 3: Municipality Building and overhead view of the neighbourhood

Figure 4: An overhead view of the neighbourhood

The photos in Figure 5 illustrate a typical scene of gentrification. The newly completed housing area has been constructed with a façade style that reflects a highly parametric design approach, creating an evident contrast with the surrounding buildings. While it would be inaccurate to describe the existing building stock as structurally sound, it can still be stated that the new developments are incompatible with the existing architectural identity (Figure 5). The photos in Figure 6 reveal the gentrification process at a deeper level. Along Kurtuluş Deresi Street, one side features wealthy, well-maintained, and ornate hotel and office façades, while directly across from them stand small workshops and old buildings with neglected façades—exposing a striking paradox (Figure 6). Figure 7, once again, presents a striking image of Kasımpaşa, featuring small auto repair workshops and commercial units set against a backdrop that is both historical and chaotic (Figure 7).

Figure 5: An overhead view of the neighborhood

Figure 6: On one side, gentrification; on the other, the old urban texture

Figure 7: An image reflecting the chaotic urbanization of Kasımpaşa

"The Arter Art Gallery continues to exist in Kasımpaşa as part of the gentrification process. A pool, constructed as a decorative element at the gallery's entrance, acts as a physical and symbolic barrier between the gallery and the city (Figure 8). On one side of the pool lies art; on the other, Kasımpaşa in all its raw reality. Photographs taken from within the gallery reveal the historic and chaotic urban fabric of the neighbourhood just behind it—historic façades, bay windows, and wooden and brick buildings. Another striking photograph depicts Kasımpaşa as a grim reality behind an abstract work of art (Figure 9).

Figure 8: A photo from in front of Arter Art Gallery

Figure 9: A view of the city from the inside of Arter Art Gallery

6.1. Methodology

The aim of this study is to understand the process of alienation in Kasımpaşa from the perspective of the residents living in the area. One of the dominant subjects of the region is undoubtedly the employees of Istanbul Metropolitan Municipality (IMM). The social and spatial relationships, sense of belonging, and alienation processes of IMM employees with their surroundings were analysed using a questionnaire survey. Due to the ongoing security problems in the neighbourhood, the existence of introverted groups, and the security problems experienced at the entrances and exits to the all part of the neighbourhood, this study could not address the other dwellers of the neighbourhood as a sample group. However, municipality employees are a useful sample group in many contexts to measure alienation. This group both experiences the urban space due to their long working hours

and carries out direct works on public spaces. In this context, municipality employees are considered to have opportunities in terms of measuring alienation. The concepts that emerged as a result of the literature review have been a guide in the preparation of the survey questions. In the table below, we can see the relationship between the concepts that are part, cause, and result of the alienation process and the survey questions (Figure 10).

The literature states that security, vandalism, aggressive urbanisation, gentrification, loss of physical and social control established with the urban environment due to various reasons are the indicators that trigger alienation. As a result of alienation, urban dwellers turn into individuals who cannot socialize in their environment and others with poor communication and put them in social isolation. In that case, the questions trying to understand the relationship between the citizen and the environment he lived in and being an actor were also the subject of the survey. The survey results were subjected to Principal Component Analysis, and mean values (see appendix for the descriptive statistics) were presented to illustrate the overall evaluation of the relevant components grouped under each extracted factor across the sample.

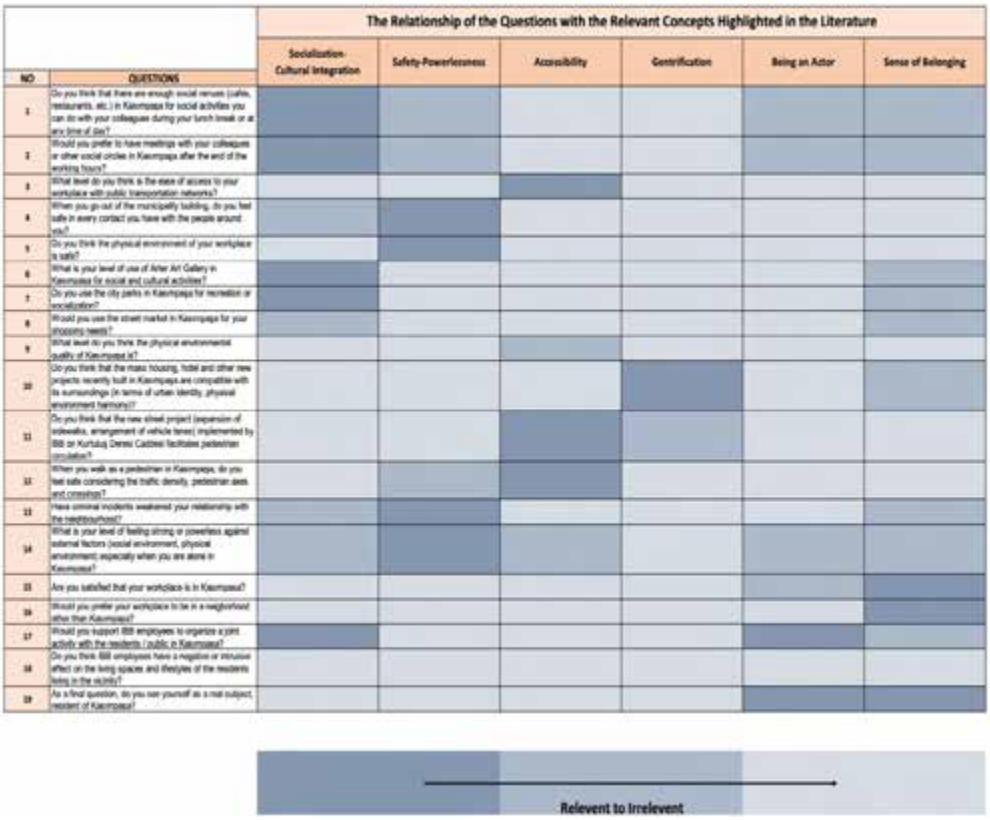

Figure 10: Relation level of the survey questions to some parameters triggered the alienation.

6.1. Interpretation of Results

The level of participation in the survey consists of 156 people. The first four questions aim to obtain information about the demographic structure of the participants. It is seen that the majority of the participants are female (Figure 11), but there is not a deep difference between the proportion of female and male participants. The majority of the participants have at least a bachelor's degree, although there are a few participants with primary and high school education (Figure 11). Although there are participants from almost every age group, the results show that the most intense age group is 31-40 (Figure 11). When we look at the occupational distribution of the participants, we encounter a very cosmopolitan view. Although it is seen that the participants belonging to professions such as Architecture, Landscape Architecture and Urban and Regional Planning, which are prominent in the field of urbanism, are dense, there are also participants from Civil Engineering and other engineering branches and professions with a wide variety of perspectives such as art historian, archaeologist, film director, restorer, cinema writer (Figure 12).

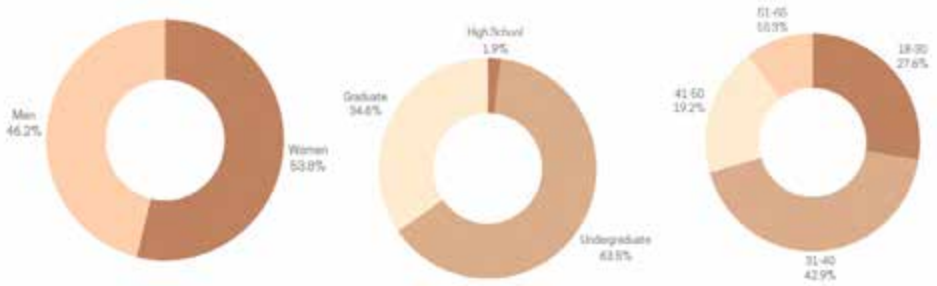

Figure 11: Gender, Education Level and Age Group of Participants

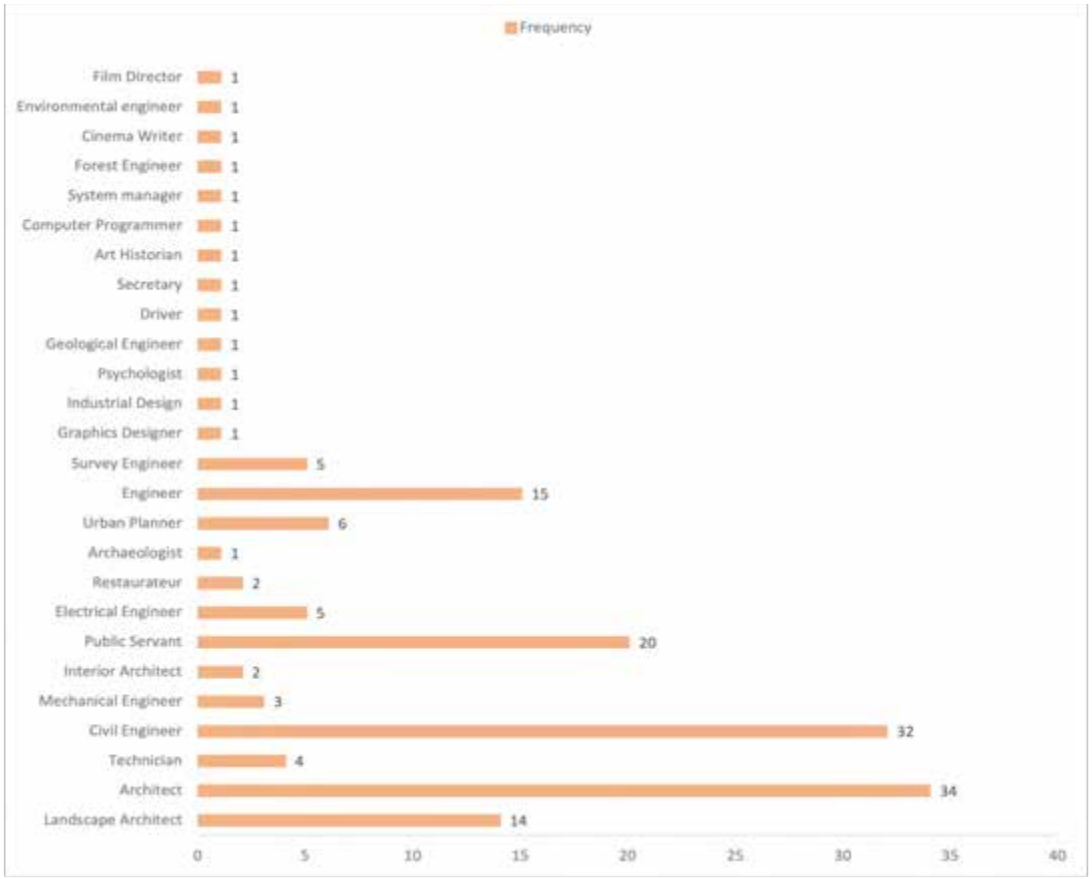

Figure 12: Occupations of Participants

The survey questions were evaluated in two separate sets, and two distinct Principal Component Analyses (PCA) were conducted. The first set of questions aimed to measure respondents' evaluations based on their perceptual evaluations and experiences within the neighbourhood. These questions addressed aspects such as integration into neighbourhood life through use social and cultural facilities, feelings of safety and powerlessness, evaluations of accessibility, and the effects of gentrification processes. The PCA, applied to 14 questions from the first set, revealed five factors that together explain 64,92% of the total variance. These factors reflect urban alienation, related to the use of social and cultural facilities, socialization, sense of safety, environmental quality, accessibility, compatibility of newly developed projects with the urban identity, gentrification, and spatial integration.

Accordingly, the following factors were identified to assess the levels of spatial alienation (Table 1). The first factor is titled "**Inclusion Through the Use of Social Facilities and Infrastructure & Physical Environmental Quality Assessment**" and explains the largest proportion of the variance. This factor consists of includes questions measuring respondents' frequency and tendency to use recreational and social opportunities and shopping facilities in Kasımpaşa after work and during leisure time, as well as their evaluations of physical environment quality and accessibility in the neighbourhood. The average value measuring whether users consider the socialization spaces in the area, such as cafes and restaurants, to be sufficient was recorded as 2.36. When asked whether they use these spaces for socialization outside of work, the average usage level was quite low at 1.75. Similarly, despite the presence of two large parks and green spaces near the municipal building, the results indicate that these parks are rarely used (mean value: 1.69), even though they could be ideal recreational spaces during lunch breaks. There are two large parks close to the town hall. Although one of these parks, Hacıahmet Cinderesi Park, is closer to the municipality and more accessible, when the participants who said that they use the parks were asked which park they use more frequently, Sururi Park, which is less accessible, was predominantly answered as Sururi Park. In parallel, street markets, which are among the most common and fundamental urban functions in Turkey, are set up twice a week in Kasımpaşa. While these markets are considered an essential part of everyday urban life, the responses regarding their usage frequency, although relatively more positive, do not indicate a wholly favourable outcome. In this regard, it can be concluded that the frequency of use of street markets in Kasımpaşa is relatively low. The responses to questions about the accessibility of the municipal building and the overall environmental quality of Kasımpaşa were recorded at 2.35 and 1.71, respectively.

Another factor with a high contribution to the total explained variance has been titled **"Perceived Safety and Powerlessness"** This factor includes questions that assess respondents' feelings of safety both in the immediate vicinity of their workplace and in the broader Kasımpaşa area, as well as the perceived impact of this sense of safety on their relationship with the neighbourhood. The responses to whether municipal employees feel safe in their daily interactions with people in the surrounding area had a low average value of 1.99. Similarly, responses to the direct question of whether Kasımpaşa is perceived as a safe environment yielded a low average score of 1.94. Responses to whether users feel empowered or powerless in relation to environmental factors were relatively more positive, with an average value of 2.62.

The third factor, which has a moderate level of explanatory power, is titled **"Assessments for Pedestrian Experience"** It is composed of two questions: one that evaluates perceived safety during pedestrian movement, and another question that assesses the impact of recent street upgrading projects on pedestrian accessibility. When asked about the effects of the pavement and road lane improvement project on pedestrian accessibility along Kurtuluş Creek Street, one of the main axes of the region, the response of the participants was very positive. However, despite this, responses regarding whether they feel safe as pedestrians when walking or using crosswalks were relatively negative, with an average score of 2.23.

The fourth factor, titled "**Assessment of Spatial Integrity and Inclusiveness of New Urban Interventions**" is based on a single question. It measures respondents' evaluations of whether recently implemented projects in Kasımpaşa — such as mass housing, hotels, and other developments — are compatible with the surrounding area's physical and social characteristics and overall urban identity. When asked about the integration of new urban projects (such as hotels and office buildings that can be considered as part of the gentrification process) with the existing urban identity and built environment, the average of the answers given by the users remained at a low level with 1.94. The fifth factor, titled "**Inclusion Through Use of Cultural Facility**" also consists of a single item and refers to the use of the Arter Art Gallery, which is a prominent cultural and architectural component of the study area. The respondents' level of engagement with this facility represents a distinct dimension of social inclusion (Table 1). The average of the answers given to the question about the frequency of visits to the Arter Art Gallery is below average with 2.25.

Table 1. Principal component analysis results for alienation related to concepts of socialization cultural integration, accessibility, safety powerlessness, gentrification

		1	2	3	4	5
Factor 1: Inclusion Through the Use of Social Facilities and Infrastructure & Physical Environmental Quality Assessment	*Would you prefer to have meetings with your colleagues or other social circles in Kasımpaşa after the end of the working hours?*	0,648				
	What level do you think is the ease of access to your workplace with public transportation networks?	0,63				
	Do you use the city parks in Kasımpaşa for recreation or socialization?	0,71				
	Would you use the street market in Kasımpaşa for your shopping needs?	0,58				
	Do you think that there are enough social venues (cafes, restaurants, etc.) in Kasımpaşa for social activities you can do with your colleagues during your lunch break or at any time of day?	0,499				
	What level do you think the physical environmental quality of Kasımpaşa is?	0,643				
Factor 2: Perceived Safety and Powerlessness	*When you go out of the municipality building, do you feel safe in every contact you have with the people around you?*		0,665			
	Do you think the physical environment of your workplace is safe?		0,721			
	Crime incidents have not weakened my relationship with the environment.		0,723			
	What is your level of feeling strong or powerless against external factors (social environment, physical environment) especially when you are alone in Kasımpaşa?		0,797			
Factor 3: Assessments for Pedestrian Experience	*Do you think that the new street project (expansion of sidewalks, arrangement of vehicle lanes) implemented by IBB on Kurtuluş Deresi Caddesi facilitates pedestrian circulation?*			0,833		
	When you walk as a pedestrian in Kasımpaşa, do you feel safe considering the traffic density, pedestrian axes and crossings?			0,747		
Factor 4: Assessment of Spatial Integrity and Inclusiveness of New Urban Interventions	*Do you think that the mass housing, hotel and other new projects recently built in Kasımpaşa are compatible with its surroundings (in terms of urban identity, physical environment harmony)?*				0,841	
Factor 5: Inclusion Through Use of Cultural Facility	*What is your level of use of Arter Art Gallery in Kasımpaşa for social and cultural activities?*					0,887

Kaiser–Meyer–Olkin measure of sampling adequacy: 0,775 and Bartlett's Test of Sphericity sig.: .000
Each variable comprises an evaluation by the respondent made on a Likert scale where 1 is "completely disagree" and 5 is "completely agree"

In the second set of questions, which included five items, a separate PCA identified three distinct factors explaining 77.9% of the variance. These factors relate to respondents' alienation through dimensions such as workplace preference and satisfaction, intention for social integration and sense of belonging, and perceived intrusiveness

in local life (Table 2). The first factor, **"Workplace Preference and Satisfaction from the Workplace Neighbourhood"** explains 33.18% of the variance individually and consists of questions that assess respondents' satisfaction with working in Kasımpaşa (mean value is 2.62) and their willingness to relocate their workplaces elsewhere (mean value is 3.95).

The second factor, titled **"Intention for Social Integration & Feelings of Belonging"** comprises items that evaluate respondents' willingness to take part in a joint activity with local residents as representatives of Istanbul Metropolitan Municipality (IMM), and the extent to which they perceive themselves as genuine members or residents of Kasımpaşa. Both items capture aspects of alienation in terms of belonging and the perception of oneself as a social actor within the neighbourhood. When the participants were asked about their willingness to participate in a joint activity with the neighbourhood, the average value of the answers given is 2.64, which is a relatively low tendency. The answer to the question about whether the municipality employees consider themselves as a real subject of Kasımpaşa expresses one of the lowest levels with an average value of 1.63.

The final factor, **"Perceived Intrusiveness in Local Life"** includes the question: "Do you think IMM employees have a negative or intrusive effect on the living spaces and lifestyles of the residents living in the vicinity?" This question measures perceived social distance and the potentially disruptive role of institutional actors in everyday neighbourhood life (Table 2). The average value of the answers to the question is 2.25, which is quite neutral.

Table 2: Principal component analysis results for alienation related to concepts of sense of belonging and perception of oneself as an actor

		1	2	3
Factor 1: Workplace Preference and satisfaction from the workplace neighbourhood	*Are you satisfied that your workplace is in Kasımpasa?*	*0,846*		
	Would you prefer your workplace to be in a neigborhood other than Kasımpaşa?	*-0,894*		
Factor 2: Intention for social integration & feelings of belonging	*Would you support IBB employees to organize a joint activity with the residents / public in Kasımpaşa?*		*0,913*	
	As a final question, do you see yourself as a real subject, resident of Kasımpaşa?		*0,577*	
Factor 3: Perceived Intrusiveness in Local Life	*Do you think IBB employees have a negative or intrusive effect on the living spaces and lifestyles of the residents living in the vicinity?*			*0,979*

Kaiser–Meyer–Olkin measure of sampling adequacy: 0,537 and Bartlett's Test of Sphericity sig.: .000
Each variable comprises an evaluation by the respondent made on a Likert scale where 1 is "completely disagree / lowest satisfaction" and 5 is "completely agree / highest satisfaction"

7. Conclusion

Neoliberal urbanisation, where space is considered as a commodity that can be bought and sold, strives to distance space from the concrete realities of society. The concrete reality of everyday life, real problems, emotions, ideas and being a real subject are the most valuable parameters that shape space as human. However, capitalism endeavours to remove the urbanite from real problems and to create masses who can be free only within the confines of their own homes, not on the street. In this respect, spatial alienation can be the product of capitalism's efforts to abstract urban space, as well as its tool.

Kasımpaşa is one of the oldest but also most chaotic neighbourhoods of Istanbul. The scale of the neighbourhood sets an important boundary for understanding and deepening the effects of alienation. This boundary is not only a physical boundary but also a social and emotional one. Kasımpaşa is the living space of various ethnic groups such as Romani people, immigrants, who are the weighty subjects of the neighbourhood. The cosmopolitan character of the neighbourhood has further deepened with the addition of new structures such as the municipal building, art gallery, university campus, large-scale housing complexes, hotel, and commercial facilities.

The cosmopolitan structure of Kasımpaşa acts as a catalyst for spatial alienation in the face of aggressive urban development and transformation. Ultimately, the results of the Principal Component Analysis (PCA) have allowed us to obtain concrete indicators of this alienation. The emergence of five distinct components from the PCA applied to the first set of questions demonstrates that alienation is not a one-dimensional experience; rather, it involves multiple layers such as spatial usage, sense of safety, compatibility of spatial interventions, and cultural integration. This reveals that individuals' relationships with the urban environment—or the lack thereof—should be understood in a multidimensional way.

That the strongest factor relates to the use of recreational, social, and commercial spaces shows how everyday spatial practices shape individuals' feelings of belonging or alienation. If individuals do not engage with these spaces, they may not feel emotionally or socially connected to them, even if they are physically present. This finding aligns with Henri Lefebvre's view that space is produced and experienced through everyday practices. Public space, as a disrupted yet integral part of daily life, becomes a crucial tool in making sense of individuals' existence as social beings in the city. Sometimes a person is an observer; other times, an actor. However, the individual—alienated first from their labour, then themselves, then their ontological existence, and finally from others—also experiences a deep rupture in their relationship with space.

In the case of Kasımpaşa, the predominantly negative responses regarding the frequency, willingness, or motivation to use public spaces indicate a growing spatial alienation. The emergence of "Perceived Safety and Powerlessness" as a distinct and strong dimension highlights how critical the subjective feeling of safety is in fostering a sense of urban belonging. The sense of safety influences how individuals experience the city, how they relate to others, and whether they form emotional connections with their environment. Conversely, the feeling of powerlessness reflects a lack of agency, which is a powerful indicator of alienation—particularly in the context of gentrification or rapid transformation processes.

The factor concerning the compatibility of new spatial interventions—such as mass housing or hotels—with the local urban fabric reflects the tension between development and continuity in the city. That this factor emerges as an independent dimension indicates that participants are highly aware of the spatial identity mismatch and its relation to alienation. Notably, the factor related to the use of a cultural institution like Arter emerges independently, suggesting that cultural participation functions as a bridge that enhances spatial belonging—perhaps even more effectively than physical infrastructure. This provides a meaningful insight into how symbolic spaces (e.g., galleries) affect individuals' feelings of inclusion, visibility, participation, or exclusion.

The second PCA confirms that alienation is not only spatial but also institutional and emotional. The three resulting dimensions—job satisfaction, social integration, and perception of intervention—show that:

- Some individuals may feel alienated despite being satisfied with their jobs;
- Others may feel excluded due to a lack of social or emotional integration;
- A separate group (e.g., municipal employees) may perceive themselves as intervening forces, even if that was not their intention.

Notably, the fact that nearly half the participants acknowledged this intervention as a reality provides significant empirical insight. These findings reflect the multilayered nature of urban space undergoing transformation. Public employees may be physically present in the area, yet their levels of social and symbolic integration vary. Spatial interventions like infrastructure projects or gentrification shape individuals' emotional and perceptual boundaries within the city. Emotions such as safety, participation, and authenticity play a decisive role in whether individuals feel inside or outside the urban system.

To conclusion, this study shows that there is spatial alienation in Kasımpaşa as a result of neoliberal urbanisation. The alienation experienced in Kasımpaşa prevents the physical, social, emotional, artistic and cultural existence of the individual.

Although this study focuses on a significant and well-established sample group — municipal employees — the inability to reach the Romani community, who have been the historical subjects of the neighbourhood for centuries but are now marginalized, due to various safety concerns, constitutes a major limitation of the research. A further, long-term study involving a separate survey with the Romani residents, employees in nearby commercial areas, and staff from art gallery would be necessary for a comparative analysis of the levels of urban alienation among all neighbourhood stakeholders.

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Appendices
Descriptive statistics:

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
What is your gender?	156	1,00	2,00	1,4615	0,50012
What is your education level?	156	2,00	4,00	3,3269	0,51007
What is your age?	156	1,00	4,00	2,1218	0,93217
What is your occupations?	156	1,00	27,00	6,8462	5,90806
Are you satisfied that your workplace is in Kasımpasa?	156	1,00	5,00	2,6218	1,18780
Would you prefer your workplace to be in a neigborhood other than Kasımpaşa?	156	1,00	5,00	3,9551	1,03077
Do you think that there are enough social venues (cafes, restaurants, etc.) in Kasımpaşa for social activities you can do with your colleagues during your lunch break or at any time of day?	156	1,00	5,00	2,3654	1,11925
Would you prefer to have meetings with your colleagues or other social circles in Kasımpaşa after the end of the working hours?	156	1,00	4,00	1,7051	0,78055
Do you use the city parks in Kasımpaşa for recreation or socialization?	156	1,00	5,00	1,6987	0,95323
If your answer is positive, which of the following parks do you prefer?	72	1,00	2,00	1,0556	0,23067
Would you use the street market in Kasımpaşa for your shopping needs?	156	1,00	5,00	2,2500	1,28828
What is your level of use of Arter Art Gallery in Kasımpaşa for social and cultural activities?	156	1,00	5,00	2,2500	1,33743
What level do you think is the ease of access to your workplace with public transportation networks?	156	1,00	5,00	2,3590	1,04695
What level do you think the physical environmental quality of Kasımpaşa is?	156	1,00	3,00	1,7179	0,62004
Do you think that the mass housing, hotel and other new projects recently built in Kasımpaşa are compatible with its surroundings (in terms of urban identity, physical environment harmony)?	156	1,00	5,00	1,9487	0,84849
Do you think that the new street project (expansion of sidewalks, arrangement of vehicle lanes) implemented by IBB on Kurtuluş Deresi Caddesi facilitates pedestrian circulation?	156	1,00	5,00	3,1218	0,95946
When you walk as a pedestrian in Kasımpaşa, do you feel safe considering the traffic density, pedestrian axes and crossings?	156	1,00	4,00	2,2308	0,93565
Would you support IBB employees to organize a joint activity with the residents / public in Kasımpaşa?	156	1,00	5,00	2,6410	1,18566
When you go out of the municipality building, do you feel safe in every contact you have with the people around you?	156	1,00	5,00	1,9936	0,95375
Do you think IBB employees have a negative or intrusive effect on the living spaces and lifestyles of the residents living in the vicinity?	156	1,00	5,00	2,2500	1,06937
Do you think the physical environment of your workplace is safe?	156	1,00	5,00	1,9487	0,93529
Are there any criminal (theft, extortion, violence, etc.) incidents you have witnessed in Kasımpaşa?	156	1,00	2,00	1,4295	0,49660
If so, do you think these events weaken your relationship with the region?	125	1,00	5,00	3,8800	1,08211
What is your level of feeling strong or powerless against external factors (social environment, physical environment) especially when you are alone in Kasımpaşa?	156	1,00	5,00	2,6218	0,88968
As a final question, do you see yourself as a real subject, resident of Kasımpaşa?	156	1,00	5,00	1,6346	0,82764
Valid N (listwise)	63				

Multiculturality in Lisbon: Migration, Integration Policies, and Urban Space

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Abstract:
Migration is an urban reality closely tied to multiculturalism, an evolving set of political strategies requiring rethinking immigrants' social and spatial integration. In Portugal, over 9% of the population are foreign nationals, reaching 11% in Lisbon, where inclusion poses unique challenges. Lisbon, with its rich multicultural history, aims to become an inclusive city, ranking first in the European Council's Intercultural Cities Index in 2014 and 2018. Its 2023–2027 strategy emphasizes citizen participation through budgeting and councils, yet spatial integration policies need deeper analysis. While traditional integration focuses on employment, housing, and rights, spatial justice for less-privileged migrants remains under-addressed. This study examines participatory urban projects like Martim Moniz and Almirante Reis to assess who is included in these processes. Findings highlight a design focus and overrepresentation of Portuguese voices, urging reflection on urbanists' role in fostering inclusive spaces.

Keywords: multiculturality; public space; participatory process; migration; spatial integration

1.Introduction: Rethinking Multiculturalism in Urban Contexts

Despite its widespread use, the concept of the multicultural city remains ambiguous. It has been described as a term that encompasses a range of overlapping yet distinct meanings, such as demographic trends, political agendas, institutional frameworks, and ideological commitments (Vertovec, 2010). In most interpretations, the presence of racially, ethnically, and culturally diverse groups is often taken as the defining indicator of multiculturalism in cities (Qadeer, 2014). However, this presence alone does not guarantee inclusion. As Wise and Velayutham (2009) argue, multiculturalism is not just about demographic diversity but about how such diversity is negotiated, recognized, and lived through everyday interactions. When talking about multiculturality, the right to difference must be actively acknowledged and supported through urban life and spatial practices (Sandercock, 2003).

Urban planning has increasingly been shaped by these dynamics. Since the mid-20th century, multiculturalism has influenced both national and local policy agendas (Fleras & Elliott, 2002) and has become central to planning discourses across Western contexts (Sandercock, 1998; Vertovec, 1998; Amin, 2002; Beebeejaun, 2012; Burayidi, 2015; Fincher et al., 2014; Barbarino & Seydel, 2024). In the 21st century, multiculturalism has taken on a more dynamic character, emphasizing intercultural dialogue, the right to the city, and active citizenship within a shared public sphere (Sandercock, 2003). Cities such as Barcelona (with its Intercultural Plan) or Berlin (through inclusive neighborhood planning initiatives) offer examples of ongoing intentional approaches to discuss an intercultural urbanism.

While multicultural planning has evolved from early assimilationist models to more participatory and pluralist approaches (Burayidi, 2015), critiques persist regarding its limitations. Scholars argue that even contemporary planning often fails to accommodate the real diversity of urban life, prioritizing abstract notions of the public good over the specific needs of marginalized groups (Amin, 2013; Sennett, 1992). This can lead to what Ahmed (2000) terms repressive tolerance, a scenario in which difference is celebrated symbolically but controlled or excluded in practice. Moreover, despite calls for inclusive frameworks such as communicative planning, just city theory, and new urbanism (Harper & Stein, 2015), urban policy has at times commodified diversity, using multiculturalism as a marketing tool rather than a means of empowerment (Moghadam, 2024; Torino, 2021). Such instru-

mentalization reduces ethnic and cultural diversity to aesthetic or economic assets, contributing to what some scholars describe as the urban governmentality of multiculturalism, where multicultural rhetoric masks deeper exclusions and inequalities (Moghadam, 2024). In this context, the description of an urban space as "multicultural" can obscure its fragmentations and contradictions, reinforcing its inherently incomplete and contested nature (Sandercock, 2003).

In Portugal, particularly Lisbon, this issue is pressing. Lisbon provides a compelling case for examining how multiculturalism plays out in spatial terms. The city's multicultural character is shaped primarily by recent waves of migration, driven in part by Portugal's aging population and demographic decline. In 2023, the country recorded the highest number of permanent immigrants in a decade, 189,367 people, according to data from the National Statistical Institute of Portugal (INE, 2024). The Lisbon Metropolitan Area absorbed nearly half of this increase, hosting around one-third of Portugal's entire migrant population. With over 9% of the national population and 11% of Lisbon's residents being foreign nationals (with an increasing trend over the past five years), the city is a significant site for exploring inclusion. Although Lisbon has a rich multicultural history and has been recognized for its innovative inclusion practices, such as topping the European Council's Intercultural City Index in 2014 and 2018, it still faces challenges in translating these efforts into spatial realities. The participatory urban policy tool BIP/ZIP[1] that launched in 2011 by Lisbon City council and the policies such as participatory budgeting and local citizen councils are steps forward, yet a deeper analysis is needed to assess their impact on urban space and everyday life.

Migration is a defining feature of contemporary urban life, making multiculturalism an unavoidable political and spatial issue in many cities. However, multiculturalism is not a fixed policy framework; it consists of dynamic, often incomplete strategies that differ by context and evolve over time. For urban planners and designers, this demands a rethinking of how immigrants are socially and spatially integrated into cities and how cities can become shared spaces for diverse populations. As Lisbon's experience shows, the translation of the integration ideals into spatial strategies and inclusive urban design is not always straightforward. Lisbon's migrant communities are far from homogeneous. The term "migrant" spans a spectrum of socio-economic positions, from elite professionals and middle-class expatriates to precarious and marginalized groups. Certain central neighborhoods, which attract more affluent foreigners, project a sanitized image of multiculturalism, while other districts, often inhabited by less-privileged migrant groups, experience increasing exclusionary narrative, surveillance, and social tension.

Therefore, this paper specifically centers on the experiences of less-privileged migrant communities, whose spatial and social integration remains most at risk of being overlooked in mainstream urban policies and multicultural narratives. For instance, in a recent urban regeneration program in the historical Mouraria neighborhood at the city center, the multiculturality of the area is advertised with the slogan "visiting the world without leaving Lisbon" and followed by several urban interventions from public space regenerations to city-scale events. Despite contributing to the area's touristic attractions, these methods neither precisely address nor solve the socio-spatial needs of the foreign populations living there. Today, there are several examples of participatory design activities for public space requalifications. Still, not all the dimensions of spatial justice such as distributive, recognitional and procedural aspects are met. Moreover, as xenophobic policies persist, public spaces predominantly used by migrants have increasingly become the targets of hostile actions and police controls sparking significant public backlash and highlighting the growing urgency of this issue.

2. Policy vs. Practice: Gaps in Spatial Integration

Integration is a central theme in global migration policy, aligned with the 2030 Agenda's goal to "leave no one behind." While definitions vary by context, integration is broadly understood as the process by which migrants become part of society (IOM, 2011). Ager and Strang (2008) outline four key dimensions of integration: access to services (employment, housing, education, health), legal and civic rights, social connections, and barriers such as language or cultural differences. Integration is closely linked to social inclusion (active participation in all aspects

1 https://bipzip.cm-lisboa.pt/

of society) and social cohesion (anti-discrimination and mutual understanding) (IOM, 2017). Portugal has taken notable steps in this area. It was the first UN member to adopt a National Plan for the Global Compact on Migration. Earlier, its 2007 ministerial resolution emphasized integration through improved access to culture, language training, housing, health, and education. Spatially, this has included measures like cultural exchange spaces in libraries, expanded social housing, and public internet access. The 2015 Strategic Plan for Migration aimed to align migration governance with national development and EU priorities, reflecting an evolving approach to a more diverse society.

Portugal performs above the European average on migrant integration indicators, ranking among the top ten in the 2020 MIPEX index. However, gaps remain in labor market access, family reunification, and anti-discrimination efforts (Tsagkroni, 2024; Citron & Gowan, 2004; Niessen et al., 2007). Lopes (2014) views Portugal's integration model ,focused on labor mobility, education, citizenship, and anti-discrimination, as relatively successful, even amid economic strain. Lisbon has played a leading role in integration policy by being the was the first Portuguese city to formally recognize ethnic minority issues, establishing the Municipal Council of Migrant Communities in 1993, which evolved into the Municipal Council for Interculturalism and Citizenship (CMIC) in 2007. Successive National Plans for Immigrant Integration, starting in 2007 and extending through 2022, have guided municipal actions. These efforts are shaped by both national agendas and international expectations and are supported by Lisbon's institutional infrastructure (Juzwiak, 2014).

Despite a generally positive policy climate, recent shifts raise concerns. In June 2024, the government introduced a new immigration law aimed at curbing "excessive abuse" and signaling a "new beginning," as stated by Prime Minister Luís Montenegro. Against this backdrop, the integration policy document analysis show how integration is framed in policy documents and strategies especially in relation to urban space. Traditional integration policies, focusing on employment, housing, health, education, and citizenship, form the backbone of national and municipal strategies. Lisbon has adopted a range of these measures, employing both policy tools and digital technologies to ease bureaucratic integration. However, when it comes to spatial integration, particularly for marginalized or underprivileged migrant groups, the picture becomes less clear. Public spaces play a key role in daily social interaction and identity formation, but many integration efforts fail to fully address the social and spatial justice principles necessary for inclusive urban everyday life and space.

Integration, understood as the strengthening of social ties and institutions (Heckmann, 2004), is a complex and dynamic process shaped by interdependent relationships between people and activities (Asselin et al., 2006). This complexity raises a key question for urban planning: how can "spatial integration" be conceptualized and implemented when migrants are not merely recipients of urban policies, but active agents in shaping the city? Participatory planning and design processes offer valuable insights into this question, particularly in contexts where there is an effort to shift away from top-down governance models. These participatory initiatives provide important grounds for observing how underrepresented groups are included, or excluded, in urban decision-making. They also reveal how cities respond to these groups and how, in turn, the groups engage with participatory opportunities. As such processes aim to promote cities made both for and with people, they are essential for understanding spatial integration not only as a matter of infrastructure and planning, but also in terms of everyday life, social interactions, and the lived experience of urban space.

3. Case Studies: Who is included in participatory design processes?

The area stretching from Martim Moniz northward along Avenida Almirante Reis is widely recognized for its multicultural character (Figure 1 and 2), shaped by diverse commercial activities, services, and products associated with ethnic consumption (Mendes, 2012 in Felix, 2017) Martim Moniz and Almirante Reis have long attracted immigrant populations due to the availability of affordable commercial spaces. Shopping centers built in the 1980s, although not originally intended for such use, gradually became hubs for wholesale businesses operated predominantly by immigrants from former Portuguese colonies, many of whom arrived in the 1970s. This commercial dynamic expanded further with the arrival of Chinese, Indian, and other South Asian communities, which have since become integral to the area's identity. In the parish of Arroios, where much of Almirante Reis is locat-

ed, foreign residents make up approximately 23% of the 33,302 inhabitants, with the largest groups originating from Nepal and Bangladesh. As early as 2004, around 200 shops in the area were identified as being operated by immigrant entrepreneurs (Bastos in Mendes, 2012).

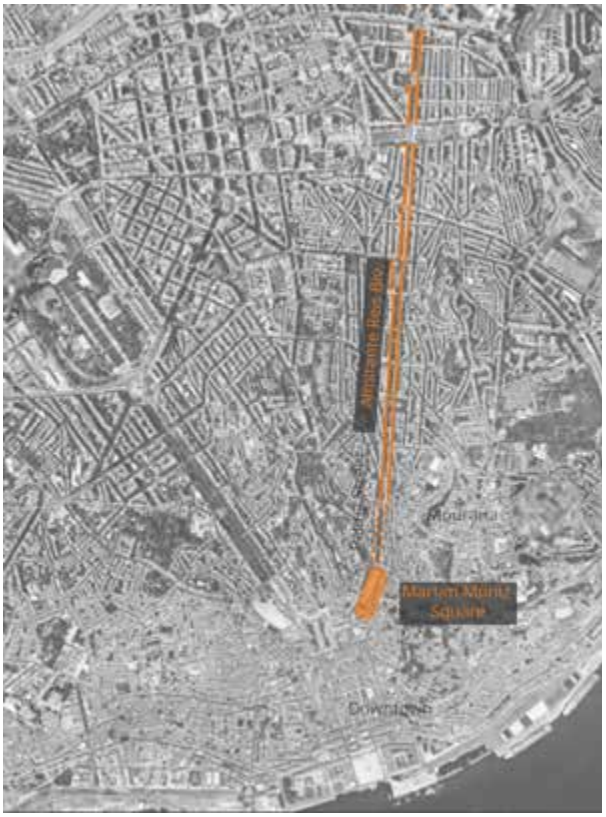

Figure 1. The Location of Case Sites in Lisbon

Figure 2. The photos from the site (Resource: 1:Almirante Reis Blv. https:// amensagem.pt/2023/02/24/most-populated-block-lisbon-portugal-1-room-for-8-stores-neighborhood-life/

2. Martim Moniz Square: Personal Archive, 2024)

Despite this well-documented socio-cultural diversity along the Almirante Reis axis, it was not meaningfully reflected in the participatory urban design processes conducted by the municipality in 2023. Two recent participatory planning initiatives, Martim Moniz Square and Avenida Almirante Reis, serve as case studies in this research. While both aimed to revitalize public spaces through community engagement, critical questions remain regarding the actual impact of these processes and the extent to which they reflect the area's demographic and cultural diversity. This study investigates how such participatory approaches to public space planning in Lisbon engage or overlook different community groups, with particular attention to patterns of inclusion and exclusion.

Figure 3. The Call for Martim Moniz Participatory Process

(Resource: https://martimmoniz.lisboaparticipa.pt/martimmoniz)

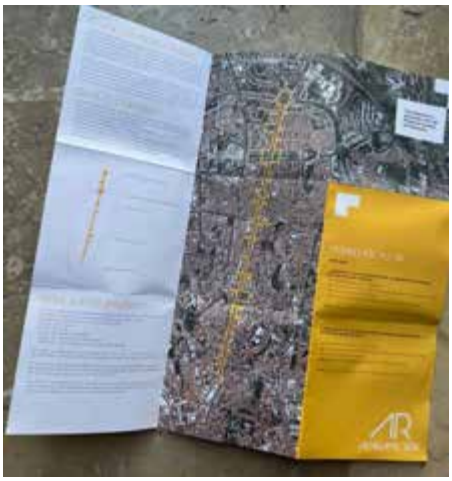

Figure 4. The booklet fort he call for the participatory process in Almirante Reis

Resource: https://informacao.lisboa.pt/en/dossies-tematicos/eixo-almirante-reis/entry

"The future of Martim Moniz"

Martim Moniz Square, situated at the intersection of multiple social and ethnic flows in central Lisbon, has long been associated with the city's multicultural identity. Historically, the area has been home to various immigrant communities. Martim Moniz, a historic figure from the 1147 Siege of Lisbon, is remembered for his legendary sacrifice, holding the castle doors to enable the Christian conquest of the city from the Moors (Arabs). After this conquest, Lisbon's Moors were resettled in Mouraria, initially a segregated suburb that evolved into a multicultural enclave where Moors, Jews, and Christians lived side by side. Today, Martim Moniz Square is both a symbolic and functional landmark at the junction of Lisbon's historic center and Almirante Reis Boulevard, a key urban artery. However, Lisbon's ongoing housing crisis and precarious labor market create significant barriers for newly arrived migrants, especially those without stable resources. The square reveals these realities, functioning less as a celebrated "outdoor living room" and more as a collective refuge where marginalized groups adapt public space to meet survival needs, from informal shelters during cold months to social gathering spots and makeshift street markets. This fragmented use underscores the limits of symbolic multiculturalism and calls for participatory planning that addresses structural inequalities.

In recent years, the square became the focus of a participatory urban regeneration project launched by Lisbon Municipality (Figure 3), intended to reimagine the space through inclusive public input. The participatory planning process for Martim Moniz Square, launched in 2021 by Lisbon City Council, followed a structured, multi-phase approach aimed at community involvement and transparent decision-making. It began with a public consultation and exhibition (Jan 2021), followed by the publication of a participatory report outlining key inputs. In May 2021, the report and its proposed intervention principles were unanimously approved by the council. A co-design phase in June 2021 further engaged residents in shaping the project vision. The process continued with the approval of terms for a public design competition (Oct 2022), officially launched in March 2023. A clarification period (April-May 2023) allowed for open communication with applicants, leading to the submission of proposals in June. The final evaluation and selection took place between July and October 2023, concluding with a public exhibition and announcement of the winning design in November 2023, followed by the commissioning of the selected

team for execution planning. Although "multiculturality" emerged as a defining concept among 920 surveyed participants, the process failed to equitably represent the area's diverse user base. Only 11% of the 1,009 total participants were non-Portuguese, and participation from key migrant communities around the site such as Bangladeshi, Nepali, and Pakistani residents was minimal, often limited to a single respondent per group.

This imbalance reflects deeper issues in Lisbon's participatory frameworks. While participatory urban initiatives promote inclusivity on paper, they seem to fall short in engaging marginalized communities meaningfully and participation is frequently instrumentalized. The disconnect became more evident in the design competition's jury process. Despite an inclusive participatory phase in 2021, the 2023 jury included only professionals, architects, engineers, and municipal officials, without representatives from the earlier community engagement phase (Câmara Municipal de Lisboa, 2023). This exclusion reflects what Falanga describes as the "institutional limits of participation," In a space like Martim Moniz, characterized by its ethnic and cultural diversity, such shortcomings risk reinforcing the very inequalities participatory design is meant to address[2].

"The New Avenue Almirante Reis"

The participatory process for Almirante Reis Boulevard[3]was notably comprehensive and multi-faceted (Figure 4), engaging Lisbon's population through various methods. An online survey open to the entire city attracted 2,252 responses, reflecting broad public interest. Additionally, 74 contributions were collected through physical participation boxes placed at key local points such as neighborhood councils and markets, ensuring input from residents who may prefer offline engagement.The process also involved targeted focus groups with 67 invited stakeholders representing security forces, public transport workers, local associations, schools, health professionals, and merchants, fostering dialogue with key community actors. Four "World Cafés," open to all and requiring prior registration, engaged 51 participants in informal yet structured discussions. Lastly, recognizing the importance of including youth voices, the initiative ran four "Urbanist for a Day" session, a marathon of ideas conducted with schoolchildren, where 90 children from 4th and 6th grades contributed their perspectives during guided walks.

Despite the scale and diversity of participation, questions remain about who was truly included and how the input from marginalized groups, particularly migrant communities, shaped the outcomes. Similar to the Martim Moniz case, it is essential to critically assess whether this participatory approach goes beyond city branding or image-making, to genuinely address the socio-spatial needs of all users of Almirante Reis Boulevard. The Lisbon Municipality presented the process as the most participatory ever for a public space in the city. This is correct in terms of final number od particioants. Yet, 93% of respondents were of Portuguese nationality, and only marginal participation came from other nationalities such as Brazilian, Italian, Spanish, or French. The call for the participatory process stated "Almirante Reis with people for people" and the resulting announcement similarly states: Almirante Reis: Made with everyone[4].

2 For more information, please see the final report on the participatory process on Martim Moniz: https://informacao.lisboa.pt/fileadmin/informacao/dossies/mmoniz_requalif/documentos/Relatorio_4a_fase_Martim_Moniz_-_Imagens_-_Ilustracoes.pdf

3 For more information, please see the final report on the participatory process on Almirante Reis: https://informacao.lisboa.pt/fileadmin/informacao/dossies/areis/relatorio_AAR_maio_2024.pdf)

4 https://informacao.lisboa.pt/en/dossies-tematicos/eixo-almirante-reis/entry

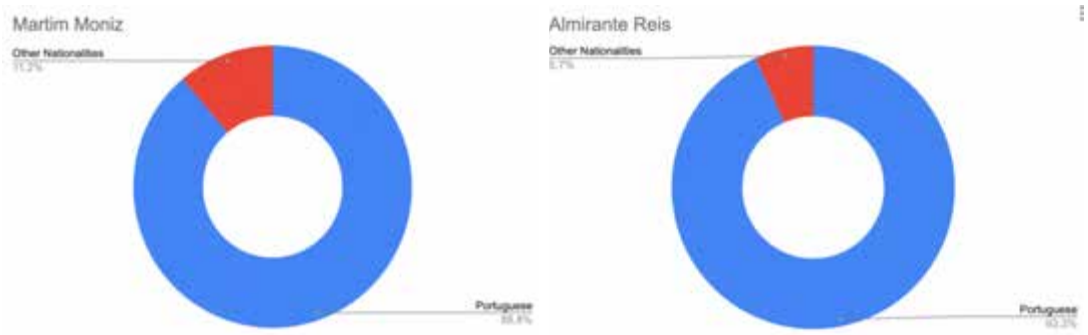

Figure 5. The ratio of participation according to portuguese and other nationalities in both processes

While the process focused on themes like mobility, safety, and the environment with proposals centering on public transport, bike lanes, and green infrastructure, it seems to overlook the area's cultural dimension and the lived experiences of its diverse populations. Given that public space is shaped by all who use it, the area's diverse population represents a missed opportunity to foster a more inclusive and meaningful participatory process. As Félix (2018) argues, understanding public space demands attention to how different cultures perceive and appropriate the urban environment: "Two individuals from different cultures, when placed in the same space, will not extract the same information or feel the same, because they inhabit different sensory worlds" (Hall, 1966). A truly inclusive approach in Martim Moniz and Almirante Reis (Figure 5) would require integrating these layered cultural perceptions into both participatory methods and design outcomes.

4. Discussion and Conclusion

The Lisbon case reveals both the promises and limitations of multicultural urban planning. Despite being recognized for progressive policies and participatory mechanisms such as participatory budgeting, citizen councils, and urban regeneration projects, the translation of these initiatives into spatial equity remains uneven. As this study shows, the celebratory language of diversity often masks the lack of genuine socio-spatial inclusion. In practice, public space design tends to prioritize aesthetics and formal outputs over inclusive processes, leading to a gap between representational success and lived experience. This disconnect is especially evident in the Martim Moniz and Almirante Reis areas, where migrant communities remain underrepresented in participatory processes despite their demographic and cultural presence. While initiatives like the BIP/ZIP program and the redesign of Martim Moniz Square demonstrate some efforts to engage diverse populations, these mechanisms often fall short in meaningfully involving marginalized voices.

The Martim Moniz case illustrates how participation can be instrumentalized more as a symbolic gesture than as a transformative tool for spatial justice. Although steps were taken to include diverse groups, the process ultimately highlighted the difficulty of sustaining procedural inclusion. As Falanga (2023) notes, participatory processes have the potential to open new dialogues in policymaking, but only if deliberate efforts are made to include the most excluded.This study argues for a clearer distinction and stronger connection between spatial integration and social inclusion in urban planning. Urban space must not only be accessible and culturally recognizable but must also support everyday participation and democratic involvement. For this, urban governance must move beyond one-off consultations and invest in long-term, justice-oriented planning models. Planners, urbanists, and researchers play a key role in shaping inclusive cities, not by designing for communities, but by designing with them through these framing recommendations:

- Prioritize process over form: Urban planning must move beyond aesthetic representations of diversity to prioritize inclusive and transparent processes that meaningfully involve marginalized communities.

- Institutionalize inclusive participation: Develop frameworks that embed co-creation and long-term community engagement at all stages of planning and design, not just during consultation phases.
- Recognize migrants as active (city-making) agents: Inclusion should not be symbolic, migrants must be recognized as co-authors of urban space, with real influence over decisions that affect their lives.
- Design for adaptability: Public spaces should be flexible, allowing for cultural appropriations and evolving uses that reflect the shifting dynamics of urban life.
- Embrace interdisciplinary methods: Integrating urban design with social research can better capture the complex socio-spatial realities of diverse populations and inform more responsive planning.

This research presents the critical role of public space in fostering urban justice and inclusion, particularly for immigrant communities. It highlights the need for culturally visible, accessible, and inclusive urban environments that reflect the diversity of their users. To achieve this, urban planning must adopt participatory design processes that actively involve local voices, especially in multicultural neighborhoods Ultimately, achieving spatial integration as a lived reality requires more than policy, it demands a rethinking of how cities are made, for whom, and with whom. Lisbon's experience offers valuable lessons not only about the limitations of current practices but also about the possibilities of building genuinely inclusive urban futures.

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Inclusive Renovation Strategies for Aging Residential Communities — A Case Study of Daguan Subdistrict in Hangzhou

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Abstract
With rapid urbanisation, many aging communities in China face deteriorating infrastructure and limited spatial functionality, impacting vulnerable groups such as the elderly, disabled, and children. This study argues that renewal efforts must go beyond physical upgrades to include multifunctional spaces, barrier-free design, and community cultural integration. Focusing on Daguan Subdistrict in Hangzhou, the paper analyses issues such as spatial deficiency, fragmented environments, and inadequate services. It proposes inclusive renovation strategies to enhance living quality, address diverse user needs, and support sustainable development. The study offers a systematic framework for inclusive community renewal, serving as a reference for similar urban regeneration projects. As urbanisation advances, continual refinement of design approaches is vital to building more inclusive, equitable, and resilient neighbourhoods.

Keywords: Aging Residential Communities, Inclusive Design, Urban Renewal; Sustainable Development, Hangzhou

1. Introduction

As China's reform and opening-up policy deepened in the late 20th century, the country entered an unprecedented phase of rapid urbanisation and socio-economic transformation. Particularly since the late 1980s, urban development has been driven by market-oriented reforms and an explosive expansion of the real estate sector. During this period, large numbers of residential communities were built to accommodate a growing urban population. However, many of these early developments, especially those constructed prior to the 2000s, now suffer from aging infrastructure, inefficient spatial layouts, and single-function designs that no longer align with contemporary urban lifestyles and demands. These aging residential communities, once considered vital assets during earlier stages of urban growth, are now becoming spatial and social liabilities. They often lack modern amenities, barrier-free accessibility, and adequate public services, creating significant challenges for vulnerable groups such as the elderly, persons with disabilities, and children (Gehl, 2011). According to national statistics, there are nearly 160,000 aging residential communities across China, affecting over 42 million households and covering an estimated total built area of approximately 4 billion square metres. These figures highlight not only the sheer scale of the issue but also its profound implications for urban governance, equity, and sustainability.

Improving the living standards and environmental quality of these communities has thus become a priority in China's urban agenda. In recent years, both central and local governments have issued a series of top-down policy initiatives to address this challenge. A major milestone occurred in December 2019, when the Central Economic Work Conference formally launched nationwide pilot programmes for the regeneration of aging residential communities. This move signified a strategic shift in urban policy—from growth-driven expansion to inward-looking regeneration. In 2020, the General Office of the State Council released the Guidelines on Advancing the Comprehensive Renovation of Aging Urban Communities, setting forth clear goals, tasks, and principles for such efforts. The guidelines emphasised the need for improving infrastructure, enhancing community functionality, and promoting resident participation. These directions were reaffirmed and expanded upon in the 14th Five-Year Plan (2021–2025), which explicitly calls for accelerating urban renewal as a means of improving quality of life, reducing inequality, and fostering resilient cities.

Within this policy and planning framework, inclusive design has emerged as a key conceptual and practical approach. Rooted in the values of social equity, human-centred development, and universal accessibility, inclusive design seeks to create environments that meet the needs of all population groups, regardless of age, ability, or socio-economic background (Imrie, 2012). In the context of aging residential communities, inclusive design implies more than technical retrofitting or cosmetic improvements—it calls for the transformation of public spaces, housing layouts, and community facilities to support interaction, dignity, and autonomy for diverse residents

(Carmona, 2019). Particularly important is the focus on populations that are often underserved in conventional urban development—elderly individuals navigating mobility decline, people with disabilities who face barriers in everyday life, and children who require safe, accessible play environments. Inclusive design provides a framework to not only accommodate these needs but also promote intergenerational interaction, mental wellbeing, and social cohesion (Dempsey, Brown & Bramley, 2012). It supports the vision of a more humane and democratic urbanism.

This paper takes the aging communities of Daguan Subdistrict in Hangzhou as a representative case for exploring how inclusive design principles can guide community renewal. Located in the city's urban core, Daguan comprises multiple residential compounds built in the late 20th century, many of which exhibit typical problems of spatial disconnection, infrastructure decay, and social fragmentation. Through a combination of field surveys, demographic analysis, and comparative case studies, this research identifies the core barriers to inclusivity in these neighborhoods and offers targeted design and policy strategies to enhance spatial functionality, community resilience, and urban equity. By rooting the analysis in real-world conditions and integrating international design principles with local socio-cultural contexts, the study aims to contribute both theoretically and practically to the broader discourse on inclusive urban regeneration. In doing so, it also responds to the national call for innovation in community governance, sustainable urban development, and people-oriented planning.

2. Core Concepts

2.1 Inclusive Design

Inclusive design is an evolving design philosophy and methodology that aims to create products, services, and environments accessible and usable by the widest possible range of users, regardless of age, ability, socioeconomic status, or cultural background (Mace, Hardie & Place, 1991). Its foundational premise is that exclusion often results not from personal limitations, but from environmental, institutional, and attitudinal barriers embedded within the built and social environments. Historically, inclusive design has been closely aligned with the needs of individuals with disabilities (Mitrović, 2024). This association has led to significant advancements in accessibility, such as barrier-free entrances, tactile wayfinding, and universal signage. However, the scope of inclusive design has significantly expanded over the years. Today, it addresses a much broader spectrum of human diversity—including cognitive differences, language proficiency, cultural practices, gender identities, and generational experiences. These factors profoundly influence how individuals perceive and interact with physical spaces and social systems.

Inclusive design is not a stylistic feature or a one-time technical fix; it is a holistic, life-cycle-oriented approach. It encompasses all stages of the design process—from user research and conceptual development to prototyping, implementation, and post-occupancy evaluation. The goal is not to design for the "average" user, but to embrace variability as a norm and embed flexibility, adaptability, and equity into the core of design solutions (Ma'rof, Noor & Xiang, 2023). In architectural and urban contexts, inclusive design manifests through a variety of spatial strategies: adaptable floor plans, step-free circulation paths, age-friendly landscapes, multilingual wayfinding, and participatory design processes. It encourages designers and policymakers to question default assumptions and to centre marginalised voices during planning and implementation.

Importantly, inclusive design also intersects with broader social values such as human rights, public health, and environmental justice. In the face of aging populations, climate change, and widening inequality, inclusive design offers a framework for creating resilient, dignified, and equitable living environments. In the context of aging residential communities, it enables the transformation of outdated, exclusionary urban spaces into welcoming, multi-generational places that foster wellbeing and belonging for all residents.

2.2 Renovation of Aging Residential Communities

The renovation of aging residential communities refers to a systematic and multidisciplinary process aimed at upgrading the physical, social, and environmental quality of residential areas that were built during earlier stages of urban development. These neighbourhoods, typically constructed in the 1980s and 1990s—or even earlier—now face growing issues of obsolescence, functional inadequacy, and social disintegration. As such, their renewal is not only an infrastructural concern, but a key urban policy imperative tied to broader goals of livability,

inclusiveness, and sustainability.

The core aims of such renovation efforts include: upgrading deteriorated infrastructure (e.g., water, electricity, waste systems), improving building safety and energy performance, enhancing the availability and quality of public services and amenities, and integrating smart technologies and digital governance tools to modernise community operations. Importantly, these interventions must be carefully tailored to preserve local identity, architectural heritage, and cultural memory. Blind demolition and reconstruction—common in earlier waves of urban renewal—are increasingly replaced by organic, incremental, and participatory models that value history and local context.

However, the renovation of aging communities presents substantial challenges. Many of these areas were built with minimal regulatory oversight, and suffer from outdated design standards, cramped spatial configurations, and poor environmental performance. Property ownership is often fragmented among residents, government units, and enterprises, leading to legal ambiguity and coordination difficulties. Moreover, many communities lack formal property management structures, and financial mechanisms for long-term maintenance are either weak or entirely absent (Obermuller, 2024). These institutional and governance gaps often result in neglect, where aging communities fall into states of disrepair, characterised by crumbling infrastructure, inadequate waste management, and a decline in social capital. Residents may experience not only physical discomfort but also social exclusion, particularly those who are economically disadvantaged or mobility-impaired.

Thus, the renovation of aging communities must be understood as a complex socio-spatial process, involving not only physical upgrades but also legal reform, financial innovation, stakeholder collaboration, and capacity-building. It requires a shift from top-down, engineering-driven interventions to integrated and inclusive renewal strategies that centre the needs of residents, promote social equity, and align with broader urban development frameworks.

3. The Evolution of Aging Community Renewal in Hangzhou

3.1 Initial Exploration Phase (2000–2012)

Between 2000 and 2012, Hangzhou entered the initial phase of aging community renewal, characterised by government-led pilot projects aimed at improving basic infrastructure. At the time, the primary goal was to address the most visible and urgent physical problems faced by aging neighbourhoods (Gong et al., 2025). These included outdated roads, inadequate drainage systems, poor lighting, and unsafe building conditions. Renovation efforts focused on functional upgrades to restore basic services and improve residents' immediate living environments.

During this period, the Hangzhou municipal government launched a series of targeted interventions. Notably, 2,721 back alleys (urban lanes known for congestion and poor sanitation) were refurbished, and comprehensive infrastructure upgrades were carried out in 1,048 communities. These projects addressed critical urban utilities—such as water supply, sewage systems, electricity, and gas pipelines—and helped stabilise physical conditions in densely populated urban areas.

However, these efforts were primarily engineering-oriented and reactive in nature, focusing on technical fixes rather than long-term transformation. Funding was sourced mainly from municipal and district-level government budgets, with little involvement from residents or external stakeholders. Strategic urban planning integration was minimal, and interventions were often fragmented, conducted on a case-by-case basis without a unified vision. As a result, while physical conditions improved in many communities, issues of social fragmentation, spatial disconnection, and ageing governance systems remained largely unresolved.

3.2 Deepening Reform Phase (2013–2016)

After 2013, Hangzhou's approach to community renewal began to shift from isolated infrastructural fixes toward more holistic, resident-oriented renovation strategies. This transformation was largely influenced by national policy signals advocating for more inclusive and sustainable urban development. During this phase, renovation efforts started to incorporate not only physical improvements but also the wellbeing, cultural life, and participatory rights of residents (Irawati et al., 2025). A key development was the diversification of funding sources. The city began experimenting with public-private partnerships (PPPs), social capital investment, and resident

co-financing models to reduce dependency on government funds and increase financial sustainability. Property management services were reformed to promote standardisation and professionalisation, and new models of community governance were tested, emphasising shared responsibility among stakeholders.

Physically, the renovation scope expanded to include public space enhancement, community landscaping, and the construction of small-scale amenities such as senior activity rooms, fitness areas, and children's play zones. The integration of landscape architecture, community art, and cultural heritage protection emerged as new thematic pillars. The city also began to recognise the role of green infrastructure in improving microclimates and fostering public life. This phase marked the transition from technical repair to spatial and social regeneration. Community renewal initiatives began to align more closely with residents' lived experiences and aspirations. Projects were guided by the principle of "improving quality of life," with more emphasis placed on user feedback, community engagement, and local identity. Importantly, the renewal process began to be seen not just as a government task, but as a collaborative process requiring the co-creation of value by government, market, and society.

3.3 Systematic Renovation Phase (2017–2020)

Beginning in 2017, Hangzhou entered a new stage of systematic and comprehensive urban renewal. With the national implementation of the 13th and 14th Five-Year Plans, cities across China were called upon to accelerate the transformation of aging urban spaces, prioritising human-centred planning, environmental sustainability, and efficient governance. In this context, Hangzhou developed a series of strategic, measurable action plans to complete the transformation of all residential communities built before 2000 by the end of the planning cycle.

During this phase, renovation moved beyond surface-level fixes to embrace urban design, integrated infrastructure planning, and digital transformation. Upgrades included expanded public spaces and pocket parks, new underground utilities, fire safety improvements, universal accessibility features such as ramps and elevators, and traffic reconfiguration to separate pedestrian and vehicular flows.

Crucially, this stage saw a strong emphasis on cultural and historical preservation. Hangzhou, with its rich architectural and cultural heritage, began to take a more nuanced approach to balancing development with conservation. Where possible, historic buildings, architectural features, and vernacular styles were preserved or restored, transforming communities into living archives of the city's evolution. Additionally, the "Smart Community" concept gained traction (Camellato, 2024). Pilot programmes introduced digital platforms for community management, real-time monitoring of energy usage, intelligent lighting, and online resident feedback systems. These technologies aimed to modernise the governance and service delivery mechanisms, making them more responsive, efficient, and transparent.

This phase also featured cross-departmental collaboration between planning bureaus, transportation agencies, environmental departments, and community associations, signalling the maturation of inter-agency coordination and urban governance in Hangzhou.

3.4 Future Community and Organic Renewal Phase (2021–Present)

Since 2021, Hangzhou has embraced a new frontier in urban renewal, defined by the concept of the "Future Community" (Weilai Shequ). This model promotes organic, context-sensitive regeneration over wholesale demolition and reconstruction. It calls for "micro-renewal", whereby each community is assessed based on its unique history, demographics, and spatial potential, and then renovated using flexible, tailored interventions.

This phase reflects a significant philosophical shift: from top-down planning to bottom-up participation, from infrastructure-led growth to people-oriented design, and from hardware improvements to emotional belonging and lifestyle enhancement (Zhou, 2024). The Future Community model incorporates nine core elements—health, education, employment, elderly care, childcare, mobility, architecture, community governance, and smart services—aiming to construct a comprehensive and adaptive ecosystem for urban life. In the wake of the COVID-19 pandemic, this model was further reinforced by the notion of "community as the basic unit of life." Hangzhou invested heavily in improving public health infrastructure, epidemic response systems, and digital integration. Communities became more self-sufficient, data-driven, and resilient.

Sustainability and inclusivity are also key themes (Triggiano, 2024). Green building standards, low-carbon design strategies, shared mobility systems, and intergenerational public spaces have been integrated into new renovation projects. Moreover, the city is emphasising spatial continuity and ecological connectivity, ensuring that revitalised communities are not isolated nodes but part of a larger, cohesive urban ecosystem.

This latest phase has also pioneered new financial and legal frameworks. Incentives were created to attract private capital, banks were encouraged to offer low-interest community redevelopment loans, and regulatory tools were adapted to allow incremental land use changes (Leite, Reis & Correia, 2024). Meanwhile, community participation was institutionalised through resident councils, participatory budgeting, and digital consultation platforms.

In summary, Hangzhou's evolution in aging community renewal reflects a progressive, multi-dimensional, and adaptive transformation. What began as simple infrastructure repairs has evolved into an integrated urban regeneration strategy grounded in inclusivity, sustainability, and innovation. Through diversified funding, policy experimentation, and the application of inclusive design principles, the city has created a model that balances heritage and modernity, growth and equity, government leadership and civic participation. Hangzhou's experience demonstrates how aging community renewal can serve as a strategic entry point for broader urban transformation—not only revitalising neighbourhoods physically, but also reimagining urban governance, strengthening community identity, and enhancing the quality of life for diverse populations.

4. Current Conditions of Daguan Subdistrict

4.1 Location and Historical Context

Daguan Subdistrict, located in the northern part of Hangzhou, represents one of the city's most concentrated clusters of aging residential communities. It occupies a strategically significant urban zone, bounded by Daguan Road to the north, the historic Shangtang River to the east, Shangtang Road to the west, and Shihuiba to the south. The area's name—"Daguan"—derives from the ancient Beixin Customs Gate ("Beixin Guan"), reflecting the district's longstanding role as a key point of commerce and trade during imperial times.

Covering approximately 1.6 square kilometres, Daguan Subdistrict encompasses eight administrative communities—Dongyi, Dong'er, Xiyi, Xi'er, Desheng, Cuiyu, Nanyuan, and Xiangji—and consists of 30 residential neighbourhoods, 29 of which are classified as aging or under-serviced communities, with only one built as modern commodity housing. The concentration of older developments makes Daguan an archetypal case for studying community decline and regeneration in the context of rapid urbanisation in China.

With the progression of urban modernisation in the 21st century, Hangzhou has experienced extensive transformations in land use, transportation systems, and urban design. Daguan Subdistrict, once peripheral, has now become a semi-central area integrating residential, commercial, and service functions. Yet this evolution has exposed the limits of its outdated residential infrastructure. Many buildings constructed during the 1980s and 1990s lack the spatial and technical capacity to meet current demands for comfort, accessibility, and resilience. The consequences include deteriorated environments, weak service provision, and rising dissatisfaction among long-term residents—making urban regeneration an urgent priority for local authorities and planners.

Figure 1. Location of Daguan Subdistrict – Source: Drawn by author

4.2 Demographic Structure and Needs Analysis

The demographic structure of Daguan Subdistrict reveals both stability and tension. According to the 2020 Seventh National Census, the subdistrict's permanent population stands at 42,036. Among these, 5,488 are children aged 0–14, 29,060 are working-age residents (15–64), and 11,059 are aged 60 or above, with 7,488 of them over 65 years old. This means that approximately 26% of the total population is elderly, exceeding the national average and confirming the district's ageing profile.

This demographic structure reflects two simultaneous trends. On one hand, Daguan is home to a stable base of long-term residents who have lived in these communities for decades. Many of them are retired workers or elderly citizens with deep social ties to the area. On the other hand, the subdistrict's strategic location and strong transport connectivity have attracted a substantial floating population, including young professionals, migrant workers, and university students who rent temporary accommodations.

The coexistence of ageing residents and a transient, youthful demographic creates complex service demands and urban management challenges. While older residents require enhanced accessibility, healthcare facilities, and public resting areas, younger residents seek flexible spaces for leisure, study, and socialising. Community planning must therefore address intergenerational coexistence, catering to both long-term attachment and short-term dynamism.

Notably, infrastructure in many aging communities is mismatched with the evolving demographic needs. For example, elevator access is scarce in walk-up buildings, posing barriers to elderly mobility. There is a shortage of daycare and rehabilitation services, and recreational spaces for seniors often double as storage or parking areas. Without targeted upgrades, these mismatches may continue to erode the wellbeing and autonomy of vulnerable groups.

4.3 Land Use Analysis

Land use in Daguan Subdistrict is dominated by residential zoning, with limited functional diversity and fragmented spatial organisation. Although the subdistrict is urban in character, it lacks the land-use efficiency seen in more contemporary mixed-use districts. Green space, in particular, is in short supply and poorly distributed, primarily confined to narrow riverbanks or dispersed in disconnected green strips between buildings.

Much of the public open space is residual—formed as by-products of outdated planning rather than intentional urban design. These spaces often suffer from poor maintenance, single-use layouts, and minimal ecological or social function. Their low quality undermines opportunities for physical activity, community interaction, and visual relief in a dense urban setting. The functional disconnect between land parcels further compounds the issue. Residential blocks are often physically and perceptually isolated from nearby amenities, schools, and transit nodes. The absence of clear spatial hierarchies (e.g., between private, semi-public, and public zones) diminishes legibility and weakens residents' spatial belonging.

Given the high population density and limited expansion potential, internal spatial optimisation is crucial. Renovation efforts should focus on: reclaiming underused plots for community gardens or seating areas, integrating greenery into pedestrian corridors, and reshaping residual lands into multifunctional, climate-responsive micro-environments. When reimagined thoughtfully, internal green spaces can serve not only as lungs of the community but as anchors for social resilience and environmental health.

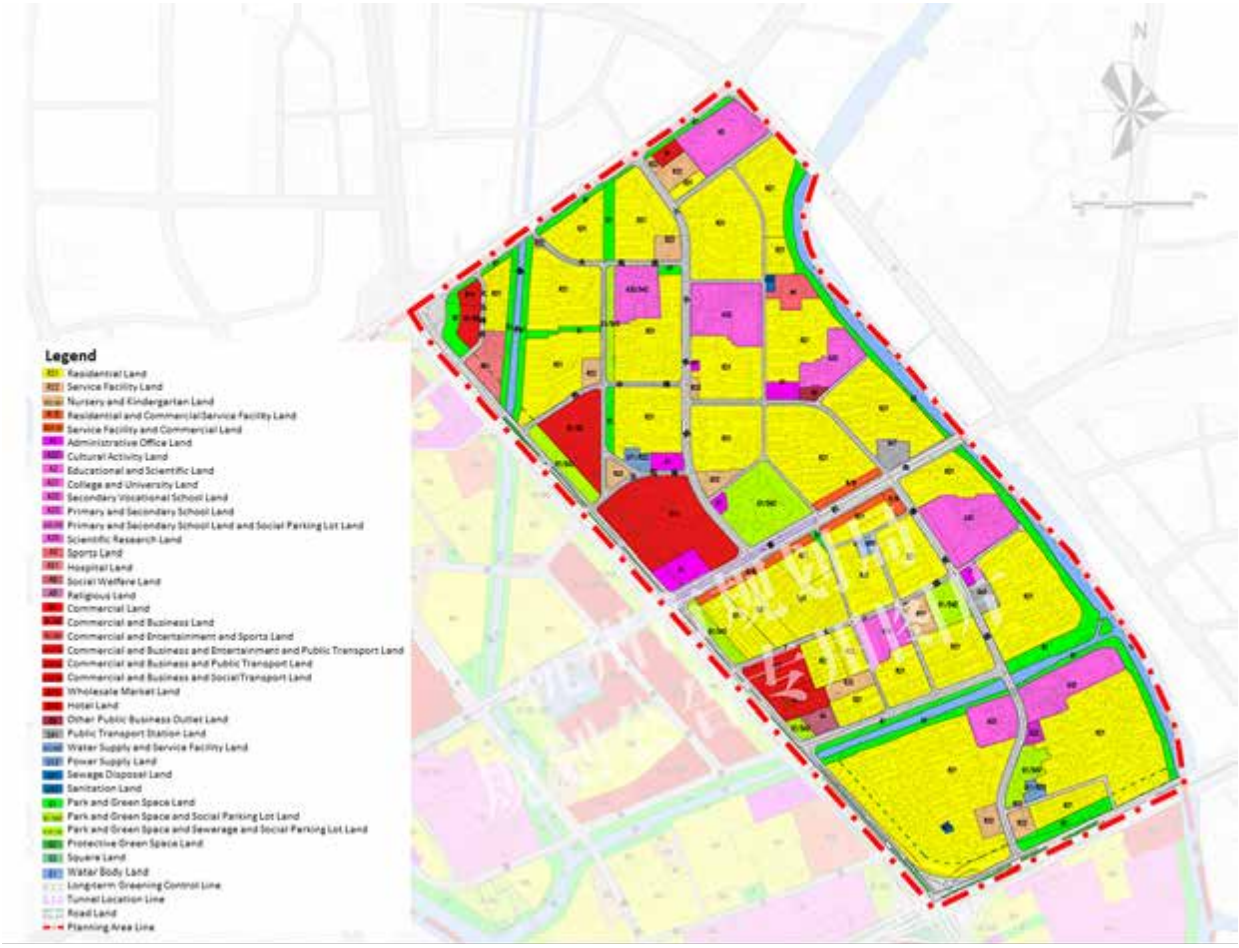

Figure 2. Current Land Use in Daguan Subdistrict – Source: Revised Regulatory Plan for Daguan Unit, Gongshu District, Hangzhou

4.4 Summary of Inclusivity Challenges in Aging Communities

Despite incremental improvements, aging communities in Daguan continue to face a host of barriers to inclusive living. These are structural, spatial, and institutional in nature, and can be grouped into three key domains:

(1) Lack of Functional Public Space

The aging residential compounds in Daguan were largely constructed during the 1980s and 1990s—before the concept of inclusive design was widely adopted in China. Consequently, many public spaces are limited in function, physically degraded, and socially underutilised. For example: 1) Most buildings lack elevators, making upper floors inaccessible to elderly or disabled residents. 2) Entrances typically have steps without ramps, and corridors are too narrow for wheelchairs or walkers. 3) Shared courtyards, when present, are often used for car parking or storage, leaving little room for social gathering or play. These physical limitations isolate vulnerable populations and restrict informal interactions that are vital for mental health and community cohesion. Moreover, women, children, and disabled individuals often experience the most acute forms of spatial exclusion, given the lack of flexible, safe, and accessible environments.

Figure 3. Problems of Functional Deficiency – Source: Drawn by author

(2) Fragmented Spatial Environment

Another critical challenge lies in spatial disconnection and poor environmental integration. Many internal road networks in Daguan's communities are incoherent, with dead-end lanes, non-continuous sidewalks, and inadequate signage. These conditions undermine walkability and deter residents from engaging in outdoor activities. Green infrastructure is similarly fragmented. Landscaped zones, if present, are often isolated patches with minimal ecological layering. Tree species are few, shrubs are scarce, and flowerbeds are replaced by concrete or tiles. This lack of biodiversity and spatial continuity reduces environmental benefits such as shade, air purification, and stormwater absorption. Furthermore, fragmented spaces impair social legibility—residents have no clear sense of where communal life should occur, and visual monotony diminishes aesthetic engagement. Addressing this issue requires a deliberate design strategy that reconnects circulation routes, consolidates fragmented green areas, and creates coherent spatial hierarchies that support everyday life.

Figure 4. Spatial Fragmentation Problems – Source: Drawn by author

(3) Inadequate Community Services
Community services in Daguan are insufficient in both quantity and quality. Most aging communities were developed as open-access neighbourhoods without enclosed management or comprehensive service provision. Although some property management companies have since been introduced, many operate with limited capacity, resulting in: inconsistent sanitation, poor facility maintenance, and unreliable security services. Specialised services such as elderly care centres, daycare for children, rehabilitation clinics, or community kitchens are scarce or entirely absent. Services that do exist are often difficult to access or operate with restricted hours and staffing. Governance mechanisms also remain weak. Communication between government agencies, property managers, and residents is often sporadic or unidirectional. Resident engagement in decision-making is minimal, and co-governance structures are still in a formative stage. This limits the community's capacity for self-management and constrains the long-term success of renovation efforts. In sum, the lack of coordinated services and participatory governance undermines the inclusiveness and resilience of Daguan's aging communities.

Figure 5. Deficiencies in Community Services – Source: Drawn by author

5. Inclusive Renewal Strategies for Aging Communities in Daguan Subdistrict

5.1 Multifunctional Integration and Barrier-Free Design

One of the most pressing spatial challenges in Daguan's aging communities is the lack of multifunctional and inclusive public space. Many of these communities were built during an era when design focused primarily on basic shelter and infrastructure, neglecting the broader social and behavioural dimensions of urban life. As a result, public spaces today are often narrowly functional, underutilised, and devoid of flexibility.

Addressing this issue requires a paradigm shift in design thinking—from static and single-purpose environments to dynamic, adaptable, and multi-use spaces that support a broad range of activities across different age groups and daily time cycles (Ferraro, D'Andria & Fiore, 2024). Designers should adopt an integrated, systems-level approach that reimagines courtyards, alleyways, and transitional spaces as opportunities for interaction and activation. For example, vacant lots or underused corners of the community could be retrofitted with: intergenerational playgrounds that combine fitness equipment for the elderly with safe zones for children, modular seating areas that can be rearranged for gatherings or quiet reading, or seasonal installations that support community events, cultural exhibitions, or pop-up markets.

Such interventions must go beyond decorative beautification. True multifunctionality is achieved through responsive programming, modular infrastructure, and participatory planning processes that reflect actual resident needs and habits (Douka, Mazzoli & Benedetti, 2024). By aligning spatial function with behavioural rhythms, public areas become not just "spaces" but catalysts of community vitality.

Additionally, inclusive spaces should foster social equity, ensuring accessibility for all, particularly for those historically excluded from public life. This includes elderly residents, persons with mobility impairments, visually impaired individuals, and caregivers with strollers. Spatial configurations must therefore anticipate diverse mobility and sensory experiences. Barrier-free design is central to this vision. Renovation plans should include the retrofitting of: step-free entries, standard-compliant ramps and handrails, lift installations in multi-storey walk-up buildings, tactile paving and auditory signals for wayfinding. These elements are not "special" features but essential components of universal usability. Importantly, they must be integrated aesthetically into the urban fabric—not as appendages, but as intentional design choices that dignify rather than stigmatise users. Inclusive environments enable all residents to navigate their neighbourhoods confidently and independently, thus enhancing community cohesion and emotional security.

Ultimately, by reconfiguring spatial hierarchies, enriching functional layers, and embedding accessibility into the design DNA, aging communities can transform shared spaces into "second living rooms"—warm, inclusive, vibrant domains where everyday life unfolds with dignity and joy.

Figure 6. Renovation Vision: Multifunctional Integration and Accessibility – Source: Internet

5.2 Spatial Connectivity and Green Environment Reconstruction

The fragmented spatial structure of Daguan's aging communities poses significant obstacles to everyday mobility, social interaction, and environmental performance. Decades-old planning models prioritised car access or isolated block layouts, resulting in poor connectivity, disjointed pathways, and underperforming green zones.

To restore spatial logic and ecological coherence, community renewal must begin with the reconstruction of internal circulation networks. This includes improving pedestrian flow, eliminating "dead-end" roads, and creating continuous, legible pathways that prioritise walkability (Pang & He, 2025). Such networks should include permeable pavement materials for sustainability, be shaded by vegetation for climate comfort, and include resting

spots, lighting, and signage to support safe and intuitive use, especially for seniors and children.

Small but impactful changes—like converting former fire lanes into green corridors or opening gated barriers between blocks—can substantially improve spatial integration. While large-scale road reengineering may be constrained by high density and ownership issues, tactical urbanism (small-scale, low-cost interventions) offers a pragmatic way forward. Temporary pilot projects and community feedback loops can gradually build consensus for more permanent restructuring.

Equally critical is the reimagining of green infrastructure. Presently, most greenery in Daguan is fragmented and ornamental. Green zones are either leftover marginal lands or mono-functional lawns with minimal social or ecological value.

Future-oriented design should treat green spaces as multifunctional ecological-social infrastructure. Proposals may include biodiverse gardens with medicinal herbs and native species, community farming plots to promote food literacy and intergenerational engagement, stormwater-absorbing rain gardens that reduce urban heat and flooding risk (Harde, 2025). Vertical greening on façades, rooftop gardens, and tree-lined boulevards can expand the green footprint without competing for scarce horizontal space. Vegetation layering is especially important: low shrubs and grasses enhance ground-level visibility and microclimate regulation, while avoiding excessive shading of lower residential units.

Moreover, green environments must be inclusive and programmable. Spaces should cater to diverse rhythms—quiet reflection, physical activity, group celebration—and offer physical, visual, and symbolic relief from urban density. This shift from fragmented green patches to connected green systems will not only improve environmental performance but also anchor communities in a renewed relationship with nature and place.

Figure 7. Renovation Vision: Connectivity and Green Environment Reconstruction – Source: Internet

5.3 Improved Service Facilities and Co-Governance

High-quality service infrastructure is foundational to inclusive communities. In aging neighbourhoods like Daguan, many public services—such as elderly care, health clinics, childcare, and cultural venues—are either outdated or entirely absent. To ensure long-term sustainability, community service systems must be adaptive, modular, and co-created with users.

Facilities should be designed for transformation: e.g., a classroom can function as a community cinema in the evening; a medical outpost can host wellness workshops; a vacant commercial storefront can become a shared tool library or repair station. This multifunctionality extends the lifecycle of limited resources while adapting to evolving demographic needs.

In response to the growing proportion of elderly residents, planners should incorporate ageing-in-place strategies. This includes establishing satellite elderly care centres, installing telehealth kiosks, expanding access to barrier-free toilets and rest areas, and integrating volunteer support networks into the formal service system

(Correia, Leite & Reis, 2024). At the same time, services should support young families and mobile workers through flexible coworking areas, parent-child activity rooms, and after-school tutoring spaces. This inclusive mix not only meets diverse demands but encourages cross-generational solidarity.

On the governance side, community renewal must shift from service delivery to co-production. Rigid top-down management systems must give way to collaborative governance models where government departments, property managers, and residents act as joint stakeholders (Antona, 2024). Practical strategies include: resident assemblies or participatory budgeting platforms, mobile apps for reporting maintenance issues and providing feedback, and rotating volunteer boards that help oversee public facilities. Such approaches democratise planning, increase transparency, and foster a sense of ownership. Empowered residents are more likely to maintain public assets, resolve disputes constructively, and cultivate a resilient social fabric.

Finally, capacity-building programmes for both residents and community managers—covering topics such as digital literacy, participatory planning, and conflict resolution—can enhance administrative professionalism and inclusivity. Over time, these models contribute to a governance culture rooted in trust, shared responsibility, and mutual support.

Figure 8. Renovation Vision: Service Improvement and Co-Governance – Source: Internet

6. Conclusion

This study has examined the Daguan Subdistrict of Hangzhou as a representative case for understanding how inclusive design principles can guide the renewal of aging residential communities. Against the backdrop of accelerating urbanisation, the demand for human-centred, equitable, and sustainable living environments has become more urgent. Many older communities, particularly those built in the late 20th century, now face multifaceted challenges stemming from deteriorating infrastructure, outdated planning paradigms, and fragmented service systems. These conditions compromise not only the quality of life for residents but also the social cohesion and ecological resilience of the broader urban fabric.

Through a comprehensive assessment of Daguan's spatial structure, demographic composition, land use, and service provision, this study identified a series of structural problems that hinder inclusivity. These include a lack of functional and flexible public spaces, insufficient barrier-free infrastructure for elderly and disabled residents, fragmented pedestrian and ecological networks, and limited or underperforming community services. These issues are further compounded by institutional and governance constraints, such as limited resident participation and weak coordination among stakeholders. Together, they paint a picture of communities that, while rich in historical value and social memory, are increasingly mismatched with the needs and expectations of contemporary urban life.

In response to these challenges, the study proposed a set of context-sensitive and adaptable design strategies grounded in the principles of inclusive urbanism. These include: restructuring and activating public spaces for multi-generational use, implementing barrier-free design standards to promote mobility and autonomy, en-

hancing green space continuity and ecological performance, and strengthening community services through co-governance models and flexible facility programming. These interventions are not isolated technical solutions but form part of a holistic renewal framework that views aging communities as living systems—embedded within complex social, environmental, and governance networks. As such, inclusive design must be understood not merely as an aesthetic or functional upgrade, but as a strategic and ethical commitment to creating urban environments where all individuals—regardless of age, ability, or socioeconomic background—can participate fully and equally in public life.

Importantly, the strategies developed for Daguan are scalable and replicable, offering practical insights for other urban districts across China and beyond that face similar challenges. By rooting the design process in empirical research, local specificity, and participatory dialogue, the framework balances universal accessibility principles with place-based adaptations, thus enhancing its transferability and long-term impact. Looking ahead, the success of inclusive community renewal efforts will depend on cross-sector collaboration, integrating the knowledge and resources of government institutions, urban planners, architects, community leaders, and residents themselves. Policy support must be coupled with design innovation, financial tools must support long-term maintenance, and participatory mechanisms must be institutionalised rather than ad hoc.

Moreover, future research should explore the development of quantitative metrics for evaluating inclusivity in community renovation projects, as well as post-occupancy studies to track the lived impacts of design interventions. Expanding the analytical lens to include digital inclusion, environmental justice, and care infrastructure will also be vital in adapting to emerging urban challenges—especially in the context of climate change, demographic ageing, and post-pandemic urban life.

In conclusion, the inclusive regeneration of aging residential communities is not only a spatial or technical project but also a moral imperative for equitable and sustainable urban development. Through targeted design strategies, institutional reforms, and a culture of shared responsibility, it is possible to reimagine older urban areas not as sites of decline, but as resilient and inclusive neighbourhoods that reflect the values and aspirations of a just and future-ready city. Only through such shared vision and multi-stakeholder commitment can we ensure that the urban environments we build today remain welcoming and liveable for generations to come.

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A Capital-Based Assessment of the Livelihood Vulnerability of Syrian Refugees

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Abstract
This study assesses the livelihoods of Syrian refugees in Konak District, İzmir, exploring their livelihoods and their context based on a capital framework, and vulnerability dimensions determined by the Intergovernmental Panel on Climate Change (IPCC). It employs household surveys, the Livelihood Vulnerability Index (LVI), and qualitative analyses with Syrian refugees and non-governmental organisations. The research questions seek the most effective capitals and dimensions for the LVI and the LVI-IPCC, and strategies affecting capital distribution and reproduction in refugee-dense areas. The study reveals a high-level LVI for Syrian refugees, especially due to financial capital. The LVI-IPCC indicates moderate vulnerability, with exposure as the main contributing factor. Specific capitals are vulnerable to varying extents. Urban planning should develop supportive strategies to reproduce capital and regulate distribution.

Keywords: Vulnerable Syrian Population, Refugee Crisis, Livelihood Capital.

1. Introduction

The livelihoods of refugees have recently attracted attention, as they are increasingly affected by and related to major global transitions in climatic, economic and social systems. In particular, the examination of the livelihood vulnerability of refugees is necessitated by human-made disasters and mass migrations. The United Nations' 2030 Sustainable Development Goals adopt a livelihoods approach to emphasise capital assets that reflect people's adaptive capabilities and sensitivities. The ability to sustain a livelihood in a manner that is both sustainable and viable is predicated upon the maintenance of resources and the reproduction of capital assets, thus ensuring resilience in the face of adversity and stress. According to United Nations reports, the Syrian Civil War is one of the largest refugee crises in the world, causing the forced displacement of approximately 10 million people (Izmir Mülteci Çalışmaları Ağı, 2021). This migration from Syria defined by the Syrian Crisis by the United Nations High Commissioner for Refugees (UNHCR) due to its rapidity and scale. According to the United Nations High Commissioner for Refugees (UNHCR), Türkiye has approximately 3 million Syrian refugees, making it the world's largest host country for Syrian refugees (UNHCR, 2025). The scale and rapidity of the mass migration also defines a crisis for Türkiye, the host country. The consequence of such actions is an imbalance in the distribution and reproduction of livelihood capitals, as well as a deterioration in interrelationships between capitals. Consequently, threats to livelihood sustainability result in livelihood vulnerability.

This study contributes to the extant literature by addressing a gap in research on livelihood vulnerability assessments at the household level for Syrian refugees in Türkiye. This study adopts a livelihood capital approach to improve Syrian refugees' ability to adapt to hazards, increase risk awareness, and develop urban policies for both host communities and refugees. It draws attention on livelihood vulnerability rather than only social vulnerability, which includes a social capital dimension (Quandt, 2018), because a livelihood vulnerability analysis provides a more comprehensive assessment of all types of livelihood capital. The aim of this study is to assess the vulnerability of Syrian refugees' livelihoods based on a capital framework and vulnerability dimensions (exposure, vulnerability and adaptive capacity) determined by the Intergovernmental Panel on Climate Change (IPCC) definition of vulnerability. Syrian refugees have been identified as a particularly vulnerable group in light of the Syrian Civil War and the subsequent forced displacement of their population. The challenges faced by this group are numerous and significant. In this study, the variables specific to the vulnerable group will be identified according to the extant literature and preliminary interviews. The variables will then be analysed with a multidimensional approach by grouping them according to capital types and dimensions that contribute to vulnerability, and livelihood vulnerability will be evaluated by creating a Livelihood Vulnerability Index (LVI) to capture socio-economic problems, the presence or absence of diverse forms of capitals, and problems of organisation or balance among these capital types. For a comprehensive evaluation of the sensitivities and adaptive capacities of the Syrian refugees, interviews with both Syrian refugees and non-governmental organisations (NGOs) will be conducted, encompassing a wide range of perspectives on social, human, financial, physical, and natural capital

types. Thus, both place-specific and community-specific disadvantages, advantages, needs and potentials for sustainable development through a livelihood vulnerability assessment of Syrian refugees. This study seeks to answers these research questions are as following:

- What is the level of LVI of Syrian refugees, and what type of capitals make it more or less vulnerable?
- What dimension of vulnerability is more effective on vulnerability?
- How should planning strategies regulate the distribution and reproduction of capitals in refugee-dense areas?

2. Literature Review

Chambers and Conway (1992) define livelihood as the process of accumulating assets and resources, encompassing both material and social capital, in addition to capabilities. The Sustainable Livelihoods Approach is centred on five categories of household assets, referred to as "livelihood capitals," which encompass natural, social, financial, physical (infrastructural), and human capital assets (Chambers and Conway, 1992). Livelihood capital assets, as an essential component of the livelihood system, have the capacity to effect change in structures and processes that are subject to 'disturbances'. However, these assets may be constrained by structural transformation and social processes within the system (Quandt, 2018; Glavovic et al., 2003). The livelihood approach has been demonstrated to be particularly efficacious at the community level (Hahn et al., 2009; United Nations General Assembly, 1997). Scoones (1998) also defined natural, physical, financial, human and social capital as livelihood resources. It is hypothesised that maintaining a balance of these five capitals is essential for the sustainability of adaptive capacity and well-being (Quandt, 2018; Jacobs et al., 2015).

According to Bourdieu (1986), capital is defined as a self-sustaining force with the capacity to generate profit and the ability to reproduce itself. The structure of the distribution of capital into different types reflects the social world at a given time, revealing constraints, opportunities and the success of practices (Bourdieu, 1986). As Gkartzios et al. (2022) emphasised, the interaction between the forms of planning and forms of capital is of paramount importance. Planning has been demonstrated to play a pivotal role in both the reproduction and the deterioration of capital. In accordance with the aforementioned framework, capitals are to be classified into different categories. However, the forms of capital do not explicitly differentiate between these categories, as they are interrelated. Gkartzios et al. (2022) further draw upon the concept of spatial energy, which is predicated on the interaction of capitals.

Human Capital

Human capital refers to conditions such as good health, good nutritional conditions, ability to work, knowledge and skills. It is similar to Bourdieu's definition of cultural capital. Due to insufficient income in crowded families, the division of parental attention with children, and too many responsibilities, household size and the age of the head of the household, who is the decision-maker, are determinant in the development of human capital of generations (Rahman et al., 2018). Zhang and Fang (2020) used occupational diversity to assess human capital as formal or informal skills provide diversity in livelihood capital assets. It also has a strong relationship with economic capital by expressing the socio-economic status of individuals.

Physical Capital

Physical capital relates to the conditions of built-up areas and urban infrastructures. This type of capital refers to the proportion of built-up area, safe shelter and buildings, affordable housing and transport, energy access to information, distance to areas offering education, health and market opportunities (Rahman et al., 2018). Gkartzios et al. (2022) considered physical capital as built capital. Rahman et al. (2018) used the term manufactured to refer to physical capital.

Financial Capital

Financial capital includes savings, loans, remittances, wages, pensions, salaries, other government transfers, subsidies and monthly expenditures (Rahman et al., 2018). Economically, it refers to livelihood goals, assets and regular income (Zhang and Fang, 2020).

Natural Capital

Natural capital includes natural resources such as land services, water, soil quality, crop diversity and air. Although natural capital was not defined by Bourdieu, Gkartzios et al. (2022) used the term land-based capital to refer to stocks of natural resources. Natural capital refers to the extraction of social and economic value from natural resources and the effects of natural capital on social structure. Urban areas suffer from a lack of natural ventilation and intensive industrial activities (Aygün Oğur, 2023). This shows that land uses and their location choices, which are physical capital, can have detrimental effects on natural capital.

Social Capital

Social capital is the resources derived from institutionalised or non-institutionalised networks of relationships, connections, group memberships such as family, class, workplace or neighbourhood (Bourdieu, 1986). These connections, trust and exchange in relationships can be used to facilitate access to resources and increase resources, support and opportunities (Bourdieu, 1986). The volume of social capital depends on the size of the social network. It represents solidarity and collective action. It is the establishment of communication paths and social relations that facilitate the acquisition of power and access to capital.

As a result, there are trade-offs between types of livelihood capitals (Quandt, 2018; Obrist et al., 2010). Moreover, the trade-off between capital assets has been demonstrated to generate income, enhance capacity and promote adaptability (Rahman et al., 2018; Chambers, 1989; Scoones, 1998). The capital-based approach facilitates the incorporation of context-specific and community-specific variables associated with Syrian refugees, in addition to variables commonly utilised in vulnerability assessments.

Urban planning is concerned with the field as a social space in which people interact and compete for capital. In both theoretical and practical contexts, the concepts of planning and capital are mutually reinforcing. In circumstances where capital is distributed unequally across a given field, said field becomes a source of specific capital-related effects. The aforementioned effects include power and profit as dominant forces within the field, with the result that laws are imposed which regulate the most effective mechanisms for the reproduction of capital (Bourdieu, 1986). This statement underscores the significance of not only the presence or absence of capital, but also the equilibrium between distinct forms of capital, in determining the reproduction of capital. Planning develops convenient practices and strategies to reproduce capital and regulate its distribution. However, in doing so, planning also functions as a transformative factor by supporting the spatial energy arising from the relations between types of capital (Gkartzios et al., 2022). It is also observed that different types of capitals frequently function in coordination with one another. It is therefore vital to understand the balance or relationship between these capitals in order to develop effective planning strategies (Gkartzios et al., 2022).

Dimensions of Vulnerability

Vulnerability is a concept which can be conceptualised as comprising three dimensions or contributing factors. These are exposure, adaptive capacity, and sensitivity. These are determined by the Intergovernmental Panel on Climate Change (IPCC).

Exposure results from environmental, social and economic uncertainties or rapid changes. It is also based on governmental causes, such as civil conflicts and extreme economic fluctuations. Geographical location poses risks but reflects population density and types of habitat in an area. Duration and degree of hazards and disasters refer to climate variations including high temperatures and precipitation (Lottering et al., 2021, Feyissa et al., 2018). Human density and conflict can also result in exposure to hazards.

Sensitivity is a risk factor. It is the responsiveness of a system to changes in social, economic and climate change. It is more closely related to inadequacy and lack of resources. Groups vulnerable to change are highly sensitive or responsive to rapid changes. Sensitivity and adaptive capacity vary according to circumstances including country, society and time (Aygün and Baycan, 2018).

Adaptive capacity is the ability of a system to deal with sudden social and economic changes and the impacts of natural changes, like climate change. It depends on access to resources. Literature on climate adaptation highlights the adaptive role of capital assets (Rahman et al., 2018). A system with more adaptive capacity is less

vulnerable. Reduced adaptive capacity due to poverty, education, social norms, health-economic policies and governance can cause increased sensitivity and exposure.

Roles of Non-Governmental Organisations and Intergovernmental Agencies in Livelihood Vulnerability Reduction
In consideration of the increasing number of refugees, the role of NGOs and intergovernmental agencies in fostering bridging social capital through inter-community activities is of crucial importance. It is asserted that these activities have the potential to foster social cohesion and facilitate refugees' integration into the national system and relations with the host community (Zihnioğlu and Dalkıran, 2022). The establishment of social ties within each particular community is imperative in order to decrease livelihood vulnerability and improve social capital (Zhang and Fang, 2020). The establishment of contact is of paramount importance in the process of deconstructing prejudices and fostering a culture of coexistence. According to United Nations statistics from previous refugee crises, the perception of foreignness or otherness should be eliminated in the integration of refugees (İzmirde Suriyeli Mültecilerle Dayanışma Derneği, 2020). The social concept of inclusion is proposed in lieu of integration (İzmirde Suriyeli Mültecilerle Dayanışma Derneği, 2020). The underlying rationale for this approach is to underscore the reciprocal relationship between the host nation's citizens and the refugee population. However, significant constraints exist with regard to the integration and sustainability of relationships between refugees and host communities, including language barriers (Zihnioğlu and Dalkıran, 2022).

A bottom-up approach is imperative in advocating for the rights of vulnerable groups, including refugees, children and women. A concerted effort by local governments, academics, non-governmental organisations, and private sectors is necessary to develop strategies and policies to reduce the vulnerability of refugees (İzmirde Suriyeli Mültecilerle Dayanışma Derneği, 2020). The government, as the primary policy maker, has a significant influence in reducing the vulnerability experienced by refugees. The government is responsible for the equitable distribution of aid to both the host and refugee communities. However, the collaboration between the government and non-governmental organisations is also crucial in order to achieve this objective.

All NGOs and official intergovernmental agencies, such as the UN, play vital roles in supporting populations worldwide. They work in many areas, including development, population planning, access to human rights, poverty reduction, health, education and crisis response, to address the refugee crisis and reduce the vulnerability of vulnerable groups. In particular this study, the UNHCR states that the Konak district of Izmir works with 10 implementing partners and 10 supporting agencies for Syrian refugees.

3. Based on Community and Context Scope of the Study

3.1. Vulnerable Group

This study aims to evaluate the effects of the refugee crisis based on livelihoods of Syrian refugees in the Konak district. Since 2011, Türkiye has hosted around 7 million Syrians, including returnees and those settled in third countries (UNHCR, 2024). According to data from the General Directorate of Migration Management (n.d.), with the end of the Syrian civil war and the start of returns, the number of Syrians under temporary protection is approximately 2.8 million in Türkiye and 111,374 in Izmir as of 10 April 2025. Izmir is the ninth city in Türkiye with the largest Syrian population and is defined as an ancient city of migration, having been a transit or destination city for migrants throughout history (Kurtarır et al., 2023). In this study, Syrians will be referred to as refugees due to their mass forced displacement and social circumstances. Historically, civil wars and tensions following the Second World War led to a refugee crisis in Europe.

Subsequently, Türkiye signed the 1951 Geneva Convention, the first international legal instrument to define refugee status and the obligations of states. However, Türkiye only granted refugee status to those coming from Europe (Al Munajed and Ekren, 2020; Chatty, 2016). Syrians do not fit the geographical definition of refugee. Therefore, they are granted temporary protection status. This status is a practical, complementary solution developed to provide urgent responses to mass migration events. It is applied within the framework of states' obligations to prevent individuals from being returned to situations of risk, thereby avoiding delays to the individual assessment of their international protection status (General Directorate of Migration Management, n.d.). Although Syrians in Türkiye are not legally recognised as refugees, they experience the social conditions associated with refugee status without being subject to geographical restrictions. However, since social recognition does not

include legal recognition, they do not have the same legal rights as refugees (Yükseker, Kurtuluş, Tekin and Kaya Erdoğan, 2023). Syrian refugees are a powerless group due to their lack of capital. They develop spatial strategies to increase their capital and maintain their presence in the city. Consequently, the role of immigrant communities in producing space, and the way they express the social logic of space, are important factors in spatial development.

3.2. Study Area

The geographical area selected for the study is the most commonly known as Basmane, Agora and Kadifekale neighbourhoods of Konak District, which is one of the districts with the highest refugee density in Izmir (Figure 1). Actually, the study area covers 22 neighbourhoods in Basmane Region in Konak: Alireis, Süvari, Faikpaşa, Yeni, Tuzcu, Ülkü, Altay, Kadifekale, Etiler, Ballıkuyu, Akarcalı, Kocakapı, Mirali, Kubilay, Pazaryeri, Sakarya, Kurtuluş, Altınordu, Yenigün, Hurşidiye, Akıncı and Namazgah. With the exception of Tuzcu, Ülkü, Ballıkuyu, Kurtuluş, Yenigün, Hurşidiye and Akıncı, all other neighbourhoods in the study area are closed to foreigners under temporary protection or international protection due to the high proportion of foreigners (Presidency of Migration Management, 2022). Due to its geographical location, the study area functions as a transit city or a destination city for numerous refugees, beyond those fleeing Syria. However, the fact that Izmir is a transit point to Europe for many refugees is one of the important factors for them to come here. In this study, spatial analyses will be conducted throughout Konak district, while qualitative analyses will focus on Basmane district, where a high concentration of Syrian refugees has been recorded. Konak district has an ageing population, with a persistent decline in population and an increase in the average age. It is important to note that, whilst all other districts in Izmir have experienced population growth, Konak district has undergone a decline. This highlights the need for a review.

According to the Avcan study (2024), the biggest population loss in the period 2009-2023 is -40.75% in the region called Kadifekale and -36.80% in the region called Basmane. These regions include neighbourhoods covered by the study. It is also emphasised that these neighbourhoods are the most socio-economically undeveloped and have a high population of migrants, refugees and asylum seekers.

The Basmane district is one of the most deprived areas in the city centre, characterised by poor physical conditions, inadequate infrastructure and social insecurity. Consequently, it provides affordable housing and facilitates access for a significant number of economically disadvantaged migrants and refugees, thereby enabling them to establish themselves in the community and cultivate social networks. In addition to the aforementioned points, it is important to note that employment opportunities are also available in and around Basmane in a variety of sectors. These sectors include, but are not limited to, the textile industry, the wedding and fashion industries, and the leather industry. The Kemeraltı Historical Bazaar, archaeological sites such as Agora and Kadifekale, hotels, restaurants and other shopping venues also serve tourism, bringing vitality and mobility to the study area (Oner et al., 2020).

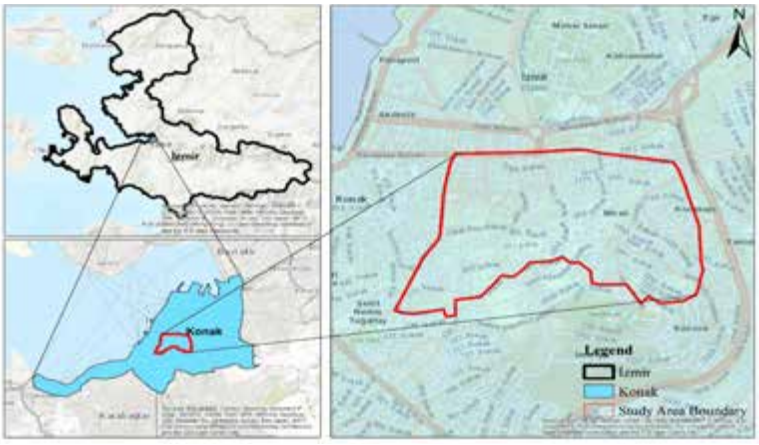

Figure 1: Study Area

4. Data and Method

A mixed method was employed by including both qualitative and quantitative analyses to maximise the reliability of the research. The capital-based livelihood approach is based on five types of capital: human, social, financial, physical and natural. Syrian refugees were selected as a vulnerable group due to the difficulties they face as a result of the Syrian Civil War and forced displacement. The literature review, field visits, discussions with vulnerable Syrian refugees, and in-depth interviews with non-governmental organisations, and household surveys were employed in order to grasp their needs, perspectives, and experiences. The study primarily relied on data derived from household surveys exploring or gaining a more nuanced understanding of complex issues related to livelihood vulnerability.

The employment of a mixed-method approach in the present study will facilitate a more nuanced interpretation of the quantitative and qualitative analyses, thereby enhancing the study's validity and its ability to discern similarities and differences in terms of the vulnerability of livelihood capitals. The determination of vulnerability variables was informed by a comprehensive literature review and insights from civil society organisations engaged in work with Syrian refugees.

First of all, based on previous studies of vulnerability indices such as refugee vulnerability, social vulnerability, and livelihood vulnerability, seventeen indicators and seventy-two variables have been selected. The seventeen indicators, which include the following variables, are: family structure; age; gender; education; employment; occupation; socio-economic status; housing tenure (ownership); livelihood strategies; minority/language; health; food; settlement/infrastructure; social safety; population growth; climatic variability; and hazards (natural and human). The table below shows the indicators and relevant variables used, how these variables affect vulnerability, and the relevant references (Table 1).

Table 1: Selection and Rationales for LVI Indicators of Syrian Refugees for Basmane Region

Indicators	Variables	Effect on Vulnerability	Justification
Family Structure	percentage of large families (more than 6 members)	increases	Arab Water Council and World Food Programme (2022), Mukherjee and Siddique (2020), Rahman et al. (2018), Frigerio et al. (2018)
	percentage of single parent households	increases	Arab Water Council and World Food Programme (2022), Lottering et al. (2021), Berchouxa and Hutton (2019)
	percentage of households with orphans	increases	Hahn et al. (2009)
	percentage of households with positive change in women's role/position in family after arrival in Türkiye	decreases	developed within the scope of research
Age	percentage of age 65+ in a household percentage of age ≤ 5 in a household number of children in a household	increases	Gerçek and Güven (2023), Mitra and Kumar Mandal (2023), Arab Water Council and World Food Programme (2022), Lottering et al. (2021), Fucile-Sanchez and Davlasheridze (2020), Zhang and Fang (2020), Frigerio et al. (2018), Duman Yuksel (2014)
	percentage of age of household head < 18 or > 65	increases	Arab Water Council and World Food Programme (2022), Rahman et al. (2018)

Gender	percentage of women in a household	increases	Gerçek and Güven (2023), Mitra and Kumar Mandal (2023), Fucile-Sanchez and Davlasheridze (2020)
	percentage of female-headed households	increases	Gerçek and Güven (2023), Mitra and Kumar Mandal (2023), Arab Water Council and World Food Programme (2022), Lottering et al. (2021), Fucile-Sanchez and Davlasheridze (2020), Mukherjee and Siddique (2020), Hahn et al. (2009)
Education	percentage of households with less than high school education	increases	Mitra and Kumar Mandal (2023), Arab Water Council and World Food Programme (2022), Lottering et al. (2021), Fucile-Sanchez and Davlasheridze (2020), Zhang and Fang (2020), Quandt (2018), Frigerio et al. (2018)
	percentage of households who participate in vocational training	decreases	Zhang and Fang (2020)
	percentage of households who can not afford education expenses	increases	developed within the scope of research
Employment	percentage of unemployed family members	increases	Arab Water Council and World Food Programme (2022), Fucile-Sanchez and Davlasheridze (2020), Frigerio et al. (2018)
	percentage of employed women	decreases	Berchouxa and Hutton (2019), Frigerio et al. (2018)
	percentage of employed children (age < 15)	increases	developed within the scope of research
	percentage of households who have a work permit	decreases	developed within the scope of research
Occupation	percentage of households with weather-exposed workers (agriculture, forestry, fishing, and hunting; mining; construction; manufacturing; and transportation and utilities)	increases	EPA (2021), Graff Ziven and Neidell (2014)
Socio-economic Status	percentage of households where members had any formal or informal skill	high decreases; low increases	Mitra and Kumar Mandal (2023), Arab Water Council and World Food Programme (2022)
	per household income monthly	high decreases; low increases	Arab Water Council and World Food Programme (2022), Rahman et al. (2018)
	percentage of households owning private or permanent land in any location that is usually used as a dwelling	decreases	Rahman et al. (2018)
	percentage of households with no vehicle	increases	Fucile-Sanchez and Davlasheridze (2020)
	percentage of households using technological devices (fridge, electric heater, fan, washing machine, computer)	decreases	developed within the scope of research
	housing quality (comfortable living conditions (e.g. indoor plumbing, and hot showers) (scale of good to bad)	**good** decreases; bad increases	Zhang and Fang (2020)
Housing Tenure (ownership)	percentage of renter households	increases	Arab Water Council and World Food Programme (2022), Fucile-Sanchez and Davlasheridze (2020), Quandt (2018)

Livelihood Strategies	percentage of earning member in a household	high decreases; low increases	developed within the scope of research
	percentage of households with members working for the government	decreases	Zhang and Fang (2020)
	percentage of households who took loan in the past 5 years	increases	Mitra and Kumar Mandal (2023), Zhang and Fang (2020)
	percentage of households that reported at least one family member worked outside the community to earn a wage	decreases	Mitra and Kumar Mandal (2023), Mukherjee and Siddique (2020), Hahn et al. (2009)
Minority/Language	language proficiency	**good** decreases; bad increases	developed within the scope of research
	percentage of households who participate in language course	decreases	developed within the scope of research
	percentage of households who have language problems with their children	increases	developed within the scope of research
	years when refugees are in Türkiye	high decreases; low increases	developed within the scope of research
	percentage of households who have a residence permit	decreases	developed within the scope of research
Health	percentage of households registered another province (in this case, they do not benefit from health services)	increases	developed within the scope of research
	percentage of households with chronically health difficulties	increases	Mitra and Kumar Mandal (2023), Mukherjee and Siddique (2020), Hahn et al. (2009)
	percentage of households with disabled people	increases	Mitra and Kumar Mandal (2023)
	percentage of households who not visiting doctors during illness	increases	Mukherjee and Siddique (2020)
	percentage of households who cannot afford medical expenses	increases	Zhang and Fang (2020)
Food	average number of months households struggle to obtain food for their family	increases	Mitra and Kumar Mandal (2023), Hahn et al. (2009)
	distance to market	high increases; low decreases	Zhang and Fang (2020)

Settlement/ Infrastructure	access to evacuation routes and/or assembly areas	decreases	Gerçek and Güven (2023)
	normal and rainy season road conditions (scale of good to bad)	**good** decreases; bad increases	Quandt (2018)
	percentage of households using the Internet	decreases	Mukherjee and Siddique (2020)
	percentage of households using unsafe water for drinking, cooking, bathing and washing	increases	Zhang and Fang (2020), Mukherjee and Siddique (2020)
	percentage of households who do not have toilet facilities	increases	Mitra and Kumar Mandal (2023), Mukherjee and Siddique (2020)
	distance to medical establishments and services	high increases; low decreases	Mitra and Kumar Mandal (2023), Arab Water Council and World Food Programme (2022), Mukherjee and Siddique (2020), Quandt (2018), Hahn et al. (2009)
	distance to schools	high increases; low decreases	Quandt (2018)
	percentage of households who cannot afford transportation expenses	increases	developed within the scope of research
	built-up area rate	increases	Frigerio et al. (2018)
	the amount of open and green areas per capita	decreases	Aygün and Baycan (2018)
Social Safety	percentage of households without access to information on health systems (getting disability report, appointment system, or language assistance)	increases	developed within the scope of research
	percentage of households who participate in adaptation events	decreases	Quandt (2018)
	percentage of households aware of vulnerabilities of the becoming refugee (e.g. social exclusion)	decreases	developed within the scope of research
	relationship with Turkish neighbours (scale of strength to weak)	**strength** decreases; weak increases	Quandt (2018)
	percentage of households with difficulty accessing daily information	increases	Zhang and Fang (2020)
	percentage of households who do not get awareness of hazards	increases	Mitra and Kumar Mandal (2023), Mukherjee and Siddique (2020)
	percentage of households who have opportunities to work outside the community using personal networks	high decreases; low increases	Rahman et al. (2018)
	percentage of households who receive assistance from a social network and other sources (NGOs) in the last 5 years	decreases	Mitra and Kumar Mandal (2023), Zhang and Fang (2020), Mukherjee and Siddique (2020), Hahn et al. (2009)
	percentage of households who do not receive assistance from the Government in the last 5 years	increases	Mitra and Kumar Mandal (2023), Fucile-Sanchez and Davlasheridze (2020), Zhang and Fang (2020), Mukherjee and Siddique (2020), Hahn et al. (2009)
Population Growth	average annual growth rate of refugee population	high increases; low decreases	Arab Water Council and World Food Programme (2022), Duman Yuksel (2014)

Climatic Variability	percentage of households reporting changes in livelihood due to climate change	increases	Mitra and Kumar Mandal (2023)
	both summer and winter temperature change (%) in the last 10 years	increases	Mitra and Kumar Mandal (2023), Duman Yuksel (2014)
	both summer and winter precipitation change (%) in the last 10 years	increases	Mitra and Kumar Mandal (2023), Duman Yuksel (2014)
Hazards	percentage of households exposed to increased frequency and intensity of natural hazards (inland floods or heat waves) in the last 10 years	increases	Mitra and Kumar Mandal (2023), Mukherjee and Siddique (2020), Hahn et al. (2009)
	percentage of households who have members injured or died as a result from human-induced hazards in the last 10 years	increases	developed within the scope of research
	percentage of households who have members injured or died as a result from natural hazards in the last 10 years	increases	Zhang and Fang (2020), Mukherjee and Siddique (2020), Hahn et al. (2009)
	percentage of households that have experienced damage to their property	increases	Mukherjee and Siddique (2020)
	percentage of households that have experienced a loss of their property	increases	Zhang and Fang (2020), Mukherjee and Siddique (2020)
	percentage of households that did not receive a warning about the pending natural disasters	increases	Mitra and Kumar Mandal (2023), Lottering et al. (2021), Mukherjee and Siddique (2020) Hahn et al. (2009)
	percentage of households who know how to turn off the installations in your home after any disaster	decreases	Demirci (2021)
	average air quality values of PM_{10}, $PM_{2.5}$, SO_2, NO_2 in the last 5 years	high increases; low decreases	Duman Yuksel (2014)

The following table illustrates the indicators according to the vulnerability dimensions (Table 2).

Table 2: Indicators by IPCC contributing factors to vulnerability

IPCC contributing factors to vulnerability	**Indicators**
Exposure	Occupation
	Population Growth
	Climatic Variability
	Hazards
Sensitivity	Family Structure
	Age
	Gender
	Health
	Food

Adaptive Capacity	Education
	Employment
	Socio-economic Status
	Housing Tenure (ownership)
	Livelihood Strategies
	Minority/Language
	Settlement/Infrastructure
	Social Safety

A livelihood assessment matrix was created by placing the relevant variables in the matrix with vulnerability dimensions on the horizontal and livelihood capitals on the vertical (Table 3). The variables were categorised under five types of livelihood capital (human, physical, financial, social, natural), and under three contributing factors to vulnerability.

Table 3: Variables by Livelihood Capitals and Vulnerability Dimension

Livelihood Capitals Dimensions of Vulnerability	Exposure	Sensitivity	Adaptive Capacity
Human Capital	**12.** percentage of households with weather-exposed workers (agriculture, forestry, fishing, and hunting; mining; construction; manufacturing; and transportation and utilities)	**1.** percentage of large families (more than 6 members)	**10.** percentage of households with less than high school education
	25. percentage of households who have members injured or died as a result from human-induced hazards in the last 10 years	**2.** percentage of age 65+ in a household	**11.** percentage of households where members had any formal or informal skill
	26. percentage of households who have members injured or died as a result from natural hazards in the last 10 years	**3.** percentage of age ≤ 5 in a household	**13.** percentage of unemployed family members
		4. number of children in a household	**14.** percentage of employed women
		5. percentage of women in a household	**15.** percentage of employed children (age < 15)
		6. percentage of female-headed households	**16.** percentage of households who have a work permit
		7. percentage of age of household head < 18 or > 65	**17.** language proficiency

Human Capital		**8.** percentage of single parent households	**18.** percentage of households who participate in language course
		9. percentage of households with orphans	**19.** percentage of households who participate in vocational training
		20. percentage of households registered another province (in this case, they do not benefit from health services)	**24.** percentage of households who do not get awareness of hazards
		21. percentage of households with chronically health difficulties	**27.** percentage of households who know how to turn off the installations in your home after any disaster
		22. percentage of households with disabled people	
		23. percentage of households who not visiting doctors during illness	
Physical Capital	**4.** housing quality (comfortable living conditions (e.g. indoor plumbing, and hot showers) (scale of good to bad)	**2.** percentage of households using unsafe water for drinking, cooking, bathing and washing	**1.** percentage of households using the Internet
	10. percentage of households that did not receive a warning about the pending natural disasters	**3.** percentage of households who do not have toilet facilities	**5.** distance to medical establishments and services
	11. built-up area rate	**9.** normal and rainy season road conditions (scale of good to bad)	**6.** distance to schools
			7. distance to market
			8. access to evacuation routes and/or assembly areas
Financial Capital	**13.** percentage of households reporting changes in livelihood due to climate change	**2.** per household income monthly	**1.** percentage of earning member in a household
	14. percentage of households that have experienced damage to their property	**5.** percentage of households who cannot afford medical expenses	**3.** percentage of households who took loan in the past 5 years
	15. percentage of households that have experienced a loss of their property	**6.** percentage of households who cannot afford education expenses	**4.** percentage of households that reported at least one family member worked outside the community to earn a wage
		7. percentage of households who cannot afford transportation expenses	**8.** percentage of renter households
		12. average number of months households struggle to obtain food for their family	**9.** percentage of households owning private or permanent land in any location that is usually used as a dwelling
			10. percentage of households with no vehicle
			11. percentage of households using technological devices (fridge, electric heater, fan, washing machine, computer)
			16. percentage of households who receive assistance from a social network and other sources (NGOs) in the last 5 years
			17. percentage of households who do not receive assistance from the Government in the last 5 years

Social Capital	**12.** average annual growth rate of refugee population		**1.** years when refugees are in Türkiye
			2. percentage of households with members working for the government
			3. percentage of households who have opportunities to work outside the community using personal networks
			4. percentage of households who have language problems with their children
			5. percentage of households who participate in adaptation events
			6. percentage of households who have a residence permit
			7. percentage of households without access to information on health systems (getting disability report, appointment system, or language assistance)
			8. percentage of households aware of vulnerabilities of the becoming refugee (e.g. social exclusion)
			9. percentage of households with positive change in women's role/position in family after arrival in Türkiye
			10. relationship with Turkish neighbours (scale of strength to weak)
			11. percentage of households with difficulty accessing daily information
Natural Capital	**1.** percentage of households exposed to increased frequency and intensity of natural hazards (inland floods or heat waves) in the last 10 years		**5.** the amount of open and green areas per capita
	2. both summer and winter temperature change (%) in the last 10 years		
	3. both summer and winter precipitation change (%) in the last 10 years **4.** average air quality values of PM_{10}, $PM_{2.5}$, SO_2, NO_2 in the last 5 years		

Household survey comprising 63 questions used to obtain primary data on Syrian refugees. The survey was conducted in Turkish and Arabic with 250 Syrian household representatives. Snowball method was used to identify participant households. In some regions, a household survey was conducted through random selection and then continued with the snowballing technique.

Secondly, in the qualitative method, livelihood vulnerability was explored through in-depth interviews with both Syrian refugees and NGOs. In the collection of data from Syrian interviewees, snowball method was used to facilitate the identification of the interviewees. The interviews averaged about 10-20 minutes in length. In order to explore the role of NGOs and intergovernmental organisations in reducing livelihood vulnerability, in-depth interviews were conducted with relevant parties. A series of semi-structured in-depth interviews were conducted with eight representatives or managers of organisations or associations related to refugees.

The interviews, comprising a total of 14 questions, were conducted in the workplace of non-governmental organisations. The duration of each interview was between 20 and 50 minutes. The fact that the majority of these organisations working with refugees are in close contact with refugees, as most of them are located in the field of work, provides direction to the study. The interviewed NGOs provided information about their activities and

their perspectives on the problems, needs and potential of refugees. The assessment of why Syrians choose the Basmane, Kadifekale, Agora and around and their social and economic relations, which will inform the spatial structure, is based on the results of interviews with Syrian refugees. Representatives or leaders of associations and networks on refugees were interviewed to assess social inclusion and integration policies from the perspective of the host country and refugee beneficiaries.

4.1. Creating Livelihood Vulnerability Index

The maximum and minimum values for these variables, based on community characteristics, were determined using the dataset resulting from a survey of 250 households. The normalisation of values measured on different scales is necessary to resolve incompatibility and imbalanced weighing (Gerçek and Güven, 2023). The min-max method was employed for data normalisation of all values, which provides dimensionless range between 0 and 1 (Ajtai et al., 2023) (please see Table A1). The normalization is conducted using Equation (1) for variables positively related to vulnerability, and Equation (2) for variables negatively related to vulnerability.

$$index\ V_{(positively)} = \frac{v - vmin}{vmax - vmin} \quad (1)$$

$$index\ V_{(negatively)} = \frac{vmax - v}{vmax - vmin} \quad (2)$$

where V is the normalized value of the variable, v is the original (raw) value of the variable, vmin and vmax are the minimum and maximum values, respectively, for each variable, and V [0, 1].

The related variables were averaged using Equation (3) in order to calculate the value of each indicator (please see Table A2).

$$Indicator = \frac{\sum_{i=1}^{n} index\ V_i}{n} \quad (3)$$

The calculation of livelihood capital specific vulnerability value will be adapted above formula with capital related variables. The same process was followed to calculate the capital-based values (4).

$$Livelihood\ Capital = \frac{\sum_{i=1}^{n} index\ V_i}{n} \quad (4)$$

Equation (5) demonstrates overall LVI calculation. The weights are included that all variables contribute equally to the overall LVI (Hahn et al., 2009; Sullivan et al., 2002). In this study, LVI is scaled from 0 (least vulnerable) to 0.60 (most vulnerable).

$$LVI = \frac{\sum_{i=1}^{5} w_{livelihoodcapital\ i}\ Livelihoodcapital_i}{\sum_{i=1}^{5} w_{livelihoodcapital\ i}} \quad (5)$$

To find LVI-IPCC, firstly values are calculated through Equation (6) for each vulnerability dimension or contribution factor to vulnerability. Then, Equation (7) presents LVI-IPCC.

$$CF = \frac{\sum_{i=1}^{n} w_{livelihoodcapital\ i}\ Livelihoodcapital_i}{\sum_{i=1}^{n} w_{livelihoodcapital\ i}} \quad (6)$$

where CF is an IPCC-defined contributing factor to vulnerability (exposure, sensitivity, or adaptive capacity), Livelihoodcapitali are the five types of the livelihood capital indexed by i, wlivelihoodcapital i the weights of each livelihood capital, and n is the number of livelihood capitals in each contributing factor.

$$LVI - IPCC = (e - a) * s \quad (7)$$

where LVI-IPCC represents LVI based on IPCC vulnerability framework, e represents computed score of exposure, a represents computed score of adaptive capacity, and s represents computed score of sensitivity. The LVI-IPCC scale varies between - 1 (least vulnerable) to 1 (most vulnerable) (Table 4).

Table 4: Levels of Livelihood Vulnerability for This Study arranged from (Islam and Ghosh, 2024) based on the IPCC (2007) and Hahn et al. (2009)

LVI	Range	LVI-IPCC	Range
Not vulnerable	0 - 0.20	Very less	(-1) - (-0.61)
Vulnerable	0.21 - 0.40	Less	(-0.60) - (-0.20)
Highly vulnerable	0.41 - 0.60	Moderate	(-0.19) - 0.20
		High	0.21 - 0.60
		Very high	0.61 - 1

5. Results

A total of 250 household surveys were carried out. The resulting data set comprised 1,373 Syrian refugees, with an average stay of 10 years in Türkiye. 49% of Syrian refugees are women. The average family size is 5.5, with the largest family consisting of 15 individuals. Family size refers to the number of people who sleep and eat in a household. 51% of Syrian refugees are under 18, while the family with the most children has 9 children. Language is a barrier for Syrian refugees, which is assessed by language proficiency. While 30% of Syrian refugees stated that their language proficiency is good, 60% chose intermediate proficiency. Among those who chose this level, some cited the presence of Turkish and non-Turkish speakers. Another variable is Syrian refugees' occupations or the sectors they work in. According to the household survey, the top 5 occupations (Figure) are textile manufacturer (33%), construction worker (19%), recycling employee (10%), tailor (5%) and repairman (5%), respectively. It is clear that Syrian refugees work most in textiles. 4% of the Syrian households stated that they were not registered in Izmir, although they had difficulty answering due to their hesitation.

As illustrated in Table 5, the table demonstrated the contribution value of each indicator to livelihood vulnerability. The indicator indices range from 0, representing no contribution to vulnerability, to 1, representing the maximum contribution to vulnerability. In the exposure factor, the highest value is attributed to both occupation and hazards.

In relation to sensitivity dimension of vulnerability, it has been demonstrated that food is the principal factor in the enhancement of livelihood vulnerability.

It is evident that the factor of adaptive capacity, which is a contributing element to vulnerability, is a highly effective measure in the context of livelihood vulnerability.

Table 5: Indices of IPCC contributing factors to vulnerability

IPCC contributing factors to vulnerability	Indicators	Indices of Indicators
Exposure	Occupation	**0.47**
	Hazards	**0.47**
	Climatic Variability	**0.41**
	Population Growth	**0.23**
Sensitivity	Food	**0.54**
	Gender	**0.33**
	Family Structure	**0.32**
	Health	**0.28**
	Age	**0.15**
Adaptive Capacity	Housing Tenure (ownership)	**1.00**
	Education	**0.78**
	Livelihood Strategies	**0.68**
	Socio-economic Status	**0.59**
	Minority/Language	**0.58**
	Settlement/Infrastructure	**0.51**
	Social Safety	**0.49**
	Employment	**0.46**

Human Capital of Syrian Refugees

The present study examines human capital through indicators of gender, age, family structure, health, education, socio-economic status, minority/language, occupation, employment, and awareness of hazards, losses related to hazards, and social safety. The importance of human capital lies in its role in the reproduction of social and financial capital, as well as the acquisition of advantages. This highlights that Syrian household have a large family and increasing demands for livelihoods, children are forced to work and are falling behind in their education. Also, Association of Konak Refugee - Konak Refugee Centre said that:

> "Most Syrians have completed primary school and there is a problem with enrolment in education. There are working children."

Furthermore, the lower socioeconomic status that characteristically typifies single-parent households renders them particularly susceptible to disaster. This is due to the fact that the responsibility for daily care and education of children is shouldered exclusively by the parent. In response to the question regarding the most vulnerable demographic, a Syrian woman whose husband had emigrated abroad provided the following answer:

> "People without a spouse, fatherless children and disabled people are in dire need."

Human capital has 0.44 exposure value, whereas 0.21 sensitivity value. Adaptive capacity with value of 0.41 helps to decrease livelihood vulnerability.

Physical Capital of Syrian Refugees

Physical capital refers to tangible infrastructure and urban services. The Syrian refugee

Considering the physical structure of the Basmane Region where Syrian refugees live, the study area has a high rate of built-up area, poor infrastructure, a lack of open and green spaces, which may allow to residents' physical, psychological and social amenities to the residents, and in some places, an excessive distance to school. These are interpreted as a lack of human and social capital due to capital relations, indicating that the study area is facing the challenge of being a deprived place that lacks the means and capacity to cope with economic struggles.

An Anonymous Nongovernmental Organization in Basmane District explained circumstances of the study area as follow:

> "There are many people of both Syrian and African nationalities. The number of roads that can be accessed by vehicle is fewer, surveillance and control are limited and low, and they can hide easily. There are many irregular migrants in this area. There are illegal workers, sex workers and laboured children. ***The vulnerability caused makes them more vulnerable.*** For example, it is difficult for a disabled Syrian living in there..."

Association for Monitoring Equal Rights expressed their insights about municipal services in the study area:

> "If there is a building stock in a region, it should be within the framework of the municipal services, there should be planning including transport, playgrounds, public spaces should be for women and children. The municipality withdraws itself to avoid being close to the Syrians. The growing hatred towards them has led to the withdrawal of the services provided by the municipality."

Lack of physical capital increases their exposure level to disasters. Therefore, natural hazards can cause disaster for people due to lack of physical capital. Syrian respondents mentioned the most common disasters they have experienced in the household survey. These include flooding, leaking toilets, water leaking from the roof and no electricity. This is due to building conditions and infrastructure deficiencies in the Basmane Region. Most Syrian households live in poor physical conditions. Many share a single dwelling, which may adversely affect the progress and consequences of a possible disaster.

According to index results, the exposure, sensitivity and adaptive capacity values of physical capital are 0.65, 0.32 and 0.48, respectively.

Financial Capital of Syrian Refugees
Households in Syria have suffered financial losses as a result of the ongoing conflict. During the course of the household survey, 73% of respondents indicated that they had been dispossessed of their houses, workplaces and vehicles. The provision of financial assistance to refugees is typically facilitated by government entities or family members. Syrian households have reported the provision of material and social support from relatives, neighbours and NGOs.

Additionally, they receive assistance from non-governmental organisations in the form of rights, such as education and healthcare. Moreover, access to employment opportunities is facilitated through language and vocational courses provided by NGOs. The Konak Refugee Centre has asserted that the absence of financial capital exacerbates the vulnerability of Syrian refugees, as articulated in the following statements:

> "Economic conditions are the most decisive factor, the most influential factor on everything. If there is a regular flow of money, you will feel comfortable both psychologically and in terms of access to your needs."

In the context of the dimensions under consideration, the value of exposure is identified as the highest, with a value of 0.58. It is evident that the value of adaptive capacity is 0.39, which has the effect of reducing livelihood vulnerability.

The variable pertaining to the percentage of households that have experienced damage to their property has a value of 0.77. The variables that contributed most significantly to enhancing adaptive capacity were as follows: the percentage of households that had previously taken out a loan within the last five years, and the percentage

of households that used technological devices. The value of the contribution was 0.95.

Social Capital of Syrian Refugees
Social capital is defined as connections with both internal and external parties at local and global levels. Furthermore, it was related to the social environment, which shapes the cognitive capacities of communities.

The subject, a 25-year-old female, articulated her experiences and challenges in her social environment and in her daily life as follows:

> "Sometimes I'm afraid for my children. I want to go out. If I were Turkish, I would not have to go through this. The salary is not enough. My landlord behaves very badly. I cannot answer. I keep quiet so that my children will not be harmed. The thing I want most is to get out of this house."

Moreover, Association of Konak Refugee - Konak Refugee Centre stated power of thinking of Syrian refugees in this way:

> "Their power of thinking is shaped by social environment. In the process, they spontaneously learn culture and education. In addition, the social environment has a great influence on behaviour. For example, tensions between both foreigner and domestic people in need rise when the person in need cannot get what they need."

Besides to social challenges, Syrian refugees have strong relationship with Turkish neighbours, and (Man, 18) stated this as follows:

> "I have no problem with the Turks. I am sincere with my Turkish customers, there is no discrimination."

(Man, 60) emphasised a different dimension for the relations between refugees and host communities:

> "Solidarity among Syrians may hinder their integration with Turks."

The percentage of households with positive change in women's role/position in family after arrival in Türkiye measures human agency and the power of thinking of Syrian refugees. This reveals the consequences of their habitus. Association of Solidarity with Syrian Refugees in Izmir highlighted the positive change in roles or position of Syrian women in the family after coming to Türkiye.

> "There has been a notable shift in their understanding, thoughts, attitudes, and roles. Women have changed in a positive way; they do not stay closed. Especially, 80 % of women in Halep do not go out of the house. Women can now go out alone because of the difficulties and needs of life. They help their families by carrying out tasks such as shopping, paying bills and going to hospital."

In addition to above statement, Syrian interviewee (Woman, 29) expressed the changing and developing structure of thought in terms of women after coming to Türkiye as follows:

> "Women in Syria are very limited. We cannot even go to the shops because of the shame. Former Syrians are very restrictive. We get married at a very young age. But you need to go to school, you need to learn a profession, I learned these things in Türkiye."

In the Basmane region, Çorakkapı Mosque, Hatuniye Mosque and Hatuniye Square, Anafartalar Street and Agora Park are areas where Syrian refugees socialise and engage with members of the local community. These spaces offer them the opportunity to rest, meet and shop, and communicate with the host community, but this contact is limited due to the density of refugees.

The exposure level is low with a value of 0.23 and the adaptive capacity of social capital is high with a value of 0.51.

Natural Capital of Syrian Refugees
Natural and physical capital affect each other. The study area, in Konak District of Izmir, is one of the oldest settle-

ments in the region. It is characterised by a high concentration of built-up area and urban infrastructure that is both old and poor-maintained. The primary challenges faced by the district include high population density, the presence of an unregistered population resulting in an uncertain demographic profile, and a severe lack of green and open spaces. High population density triggers human-induced air pollution. These issues have a detrimental effect on air quality. Furthermore, The findings indicate that the extent of open and green space per capita exerts an increasing influence on vulnerability, as evidenced by its negligible effect on the development of adaptive capacity, with a value of 0.22. The exposure level, as determined by 0.48 in terms of natural capital, is influenced by increased frequency and intensity of natural disasters, temperature and precipitation variation, and air quality values. Lastly, 47% of Syrian households have workers exposed to the weather, with temperature and precipitation variation having a significant impact. 32% of households have experienced increased natural hazards in the last 10 years. During surveys, respondents provided information on disaster experiences.

Finally, as demonstrated in Table 6, exposure is the most significant contributing factor to livelihood vulnerability, with a value of 0.50. Conversely, sensitivity is the least significant contributing factor, with a value of 0.31. Nevertheless, it is crucial to acknowledge the sensitivity multiplier effect on LVI-IPCC identification, as this value has the potential to exacerbate livelihood vulnerability. The Syrian refugee population has been found to demonstrate an adaptive capacity of 0.44. Moreover, findings indicate that physical, financial and natural capitals are the most effective in increasing livelihood vulnerability. Conversely, the possession of social capital has been demonstrated to contribute to the reduction of livelihood vulnerability through the enhancement of adaptive capacity. The study emphasised that Syrian refugees demonstrated notable social resilience and adaptability to change.

Table 6: Capital Specific and Overall Values of Vulnerability Dimensions

Livelihood Capitals	Exposure	Sensitivity	Adaptive Capacity
Human Capital	0.44	0.21	0.41
Physical Capital	0.65	0.32	0.48
Financial Capital	0.58	0.55	0.39
Social Capital	0.23		0.51
Natural Capital	0.48		0.22
Overall	**0.50**	**0.31**	**0.44**

The table compares LVI and LVI-IPCC values of each capital (Table 7). Human capital is found to be in a vulnerable position, whereas other capitals have high vulnerability level of livelihood vulnerability.

LVI is 0.48, indicating high livelihood vulnerability. Social capital is less vulnerable, while human, physical and financial capitals are moderately vulnerable, and natural capital is highly vulnerable. Overall LVI-IPCC is 0.02, indicating moderate livelihood vulnerability.

Table 7: Comparing Capital Specific and Overall Values of LVI and LVI-IPCC

Livelihood Capitals	LVI-Capital based*	LVI-IPCC
Human Capital	0.39	0.01
Physical Capital	0.50	0.06
Financial Capital	0.59	0.10
Social Capital	0.46	-0.29
Natural Capital	0.51	0.26
Overall	**0.48**	**0.02**
Reference range*	0 < LVI < 0.60	
Reference range	-1 < LVI-IPCC < 1	

6. Discussion

The concept of livelihood capitals encompasses the physical, natural, social, human and financial dimensions of communities. It introduces strategies and policies that address the absence, deficiencies and assets of these capitals within the context of urban planning. Despite the existence of numerous international literature studies on LVI, no studies have been found in Türkiye. The present study draws chiefly upon the research conducted by Pandey et al. (2017) and Zhang and Fang (2020) with regard to capital-based implementation. In this study, the assessment of livelihood vulnerability was conducted through the utilisation of a multifaceted approach, encompassing five distinct types of capital. An investigation was conducted into each type of capital, with particular reference to exposure, sensitivity and adaptive capacity. In addition to calculating overall livelihood vulnerability values, this study calculates both capital-specific LVI and LVI-IPCC based on capital-specific vulnerability dimensions. This approach facilitates the formulation of strategies and policies that are tailored to the specific livelihood vulnerabilities of each capital and each dimension of vulnerability. This study is therefore useful in reducing the increasing divergence in favour of vulnerability in dimensions of vulnerability, such as high levels of exposure or sensitivity and low adaptive capacity, and imbalances among types of capital and the distribution and reproduction of capital assets. In a similar vein, Rahman et al. (2018) employed varied methodologies for the organisation and combination of livelihood capital assets. This study uses more indicators (17) and variables (72) than other LVI studies. Also, compared to both similar and different studies in terms of different contexts, vulnerable groups and disasters, the study's level of livelihood vulnerability is higher than others.

Furthermore, if variables in adaptive capacity increase vulnerability, these should be inversely normalised to calculate the LVI-IPCC, since the value of adaptive capacity is included in the LVI-IPCC calculation. This causes errors in the LVI and LVI-IPCC calculations. This study used a different approach to calculate adaptive capacity to get more accurate LVI-IPCC results. Other studies have ignored this. Some studies use different methods for adaptive capacity (Pandey et al., 2017; Zhang and Fang, 2020).

Zihnioğlu and Dalkıran (2022) highlighted gaps in the literature regarding refugee-related topics such as NGOs, integration and human rights, and the lack of empirical studies with NGOs. NGOs, intergovernmental agencies and the media may help to reduce discrimination and hate towards refugees. This study is different from previous research because it includes in-depth interviews with relevant NGOs, including refugee-led organisations working with Syrians, foreigners, citizens and people with other statuses. Interviewed NGOs have provided information

about their activities and their perspectives on the problems, needs and potential of refugees.

7. Conclusion

The mass displacement of Syrians due to man-made disasters is the largest displacement on record and shows how shocked Syrians and host communities are about the loss and alienation of livelihoods, the reproduction and distribution of livelihood capital, and protracted displacement. This study focuses on the livelihood vulnerability of Syrian refugees in the Konak District's Basmane and around region of Izmir. İzmir is a transit point to Europe, which is an important incentive for many refugees. The Basmane region is one of Izmir's neglected areas, characterised by poor physical conditions and inadequate infrastructure and social insecurity, but providing cheap housing and easy access to many poor migrants or refugees, allowing them to settle and develop social networks. Syrian refugees face many challenges, including forced displacement, and lack of access to human and labour rights.

Syrian refugees are highly vulnerable in terms of physical, financial, social and natural capitals, and moderately vulnerable in terms of human, physical and financial capital, but less vulnerable in terms of social capital. Syrian refugees are the most exposed in terms of physical capital with a value of 0.65, financial capital is the most sensitive with a value of 0.55 and natural capital has the lowest adaptive capacity with a value of 0.22. Syrian refugees have the highest adaptive capacity value in social capital with 0.51.

NGOs contact refugees one to one and they have chance to observe due to their locations. The most effective capitals on livelihood vulnerability are financial and social capital according to NGOs. Syrian refugees believe that orphaned children, women and people with disabilities are the most vulnerable groups besides the refugees themselves. NGOs also state that social capital has a positive effect on the development of Syrian refugees' capacity and ability. Poverty is a common factor affecting both parties, host community and refugees. This commonality unites them. Examining the dynamics of the local economy, economic circulation and diversity of livelihoods in the study area through the income-earning activities of Syrian refugees can develop and sustain their livelihoods.

Livelihood vulnerability in areas heavily populated by refugees can be reduced and/or eliminated through a sustainable livelihoods approach. This study allows for the identification of capital-specific, context-specific and vulnerability dimension-specific problems, revealing the potential and making planning decisions to reduce livelihood vulnerability of both the vulnerable group and the host community to stressors and hazards. It provides sustainable livelihood opportunities for future generations.

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Appendices

Table A1: Raw Values of Variables and Data Ranges

Indicators	Types of Livelihood Capitals	Variables	Units	Raw Values	Max Values	Min Values
Family Structure	HC	**1.** percentage of large families (more than 6 members)	Percent	**23**	100	0
	HC	**8.** percentage of single parent households	Percent	**22**	100	0
	HC	**9.** percentage of households with orphans	Percent	**6**	100	0
	SC	**9.** percentage of households with positive change in women's role/position in family after arrival in Türkiye	Percent	**24**	100	0
Age	HC	**2.** percentage of age 65+ in a household	Percent	**0.01**	0.5	0
	HC	**3.** percentage of age ≤ 5 in a household	Percent	**0.14**	0.6	0
	HC	**4.** number of children in a household	Percent	**2.82**	9	0
	HC	**7.** percentage of age of household head < 18 or > 65	Percent	**2**	100	0
Gender	HC	**5.** percentage of women in a household	Percent	**0.48**	1	0
	HC	**6.** percentage of female-headed households	Percent	**19**	100	0
Education	HC	**10.** percentage of households with less than high school education	Percent	**78**	100	0
	HC	**19.** percentage of households who participate in vocational training	Percent	**9**	100	0
	FC	**6.** percentage of households who can not afford education expenses	Percent	**66**	100	0
Employment	HC	**13.** percentage of unemployed family members	Percent	**2**	100	0
	HC	**14.** percentage of employed women	Percent	**4**	100	0
	HC	**15.** percentage of employed children (age < 15)	Percent	**1**	100	0
	HC	**16.** percentage of households who have a work permit	Percent	**15**	100	0
Occupation	HC	**12.** percentage of households with weather-exposed workers (agriculture, forestry, fishing, and hunting; mining; construction; manufacturing; and transportation and utilities)	Percent	**47**	100	0

Socio-economic Status	**HC**	**11.** percentage of households where members had any formal or informal skill	Percent	**58**	100	0
	FC	**2.** per household income monthly	Turkish Lira (thousand)	**20.81**	120	0
	FC	**9.** percentage of households owning private or permanent land in any location that is usually used as a dwelling	Percent	**49**	100	0
	FC	**10.** percentage of households with no vehicle	Percent	**89**	100	0
	FC	**11.** percentage of households using technological devices (fridge, electric heater, fan, washing machine, computer)	Percent	**95**	100	0
	PC	**4.** housing quality (comfortable living conditions (e.g. indoor plumbing, and hot showers) (scale of good to bad)	Percent	**17**	100	0
Housing Tenure (ownership)	**FC**	**8.** percentage of renter households	Percent	**100**	100	0
Livelihood Strategies	**FC**	**1.** percentage of earning member in a household	Percent	**0.25**	1	0
	SC	**2.** percentage of households with members working for the government	Percent	**1**	100	0
	FC	**3.** percentage of households who took loan in the past 5 years	Percent	**5**	100	0
	FC	**4.** percentage of households that reported at least one family member worked outside the community to earn a wage	Percent	**7**	100	0
Minority/Language	**HC**	**17.** language proficiency	Percent	**30**	100	0
	HC	**18.** percentage of households who participate in language course	Percent	**20**	100	0
	SC	**4.** percentage of households who have language problems with their children	Percent	**16**	100	0
	SC	**1.** years when refugees are in Türkiye	Years	**9.55**	15	1
	SC	**6.** percentage of households who have a residence permit	Percent	**15**	100	0

Health	**HC**	**20.** percentage of households registered another province (in this case, they do not benefit from health services)	Percent	**4**	100	0
	HC	**21.** percentage of households with chronically health difficulties	Percent	**37**	100	0
	HC	**22.** percentage of households with disabled people	Percent	**23**	100	0
	HC	**23.** percentage of households who not visiting doctors during illness	Percent	**32**	100	0
	FC	**5.** percentage of households who cannot afford medical expenses	Percent	**44**	100	0
Food	**FC**	**12.** average number of months households struggle to obtain food for their family	Months	**4.16**	12	0
	PC	**7.** distance to market	Minutes	**7.60**	10	1
Settlement/ Infrastruc-ture	**PC**	**8.** access to evacuation routes and/or assembly areas	Percent	**11**	100	0
	PC	**9.** normal and rainy season road conditions (scale of good to bad)	Percent	**13**	100	0
	PC	**1.** percentage of households using the Internet	Percent	**89**	100	0
	PC	**2.** percentage of households using unsafe water for drinking, cooking, bathing and washing	Percent	**5**	100	0
	PC	**3.** percentage of households who do not have toilet facilities	Percent	**5**	100	0
	PC	**5.** distance to medical establishments and services	Minutes	**18.76**	31.25	3
	PC	**6.** distance to schools	Minutes	**11.34**	31.25	2
	FC	**7.** percentage of households who cannot afford transportation expenses	Percent	**50**	100	0
	PC	**11.** built-up area rate	Percent	**100**	100	0
	NC	**5.** the amount of open and green areas per capita	m^2/popu-lation	**3.44**	12.63	0.86

Social Safety	**SC**	**7.** percentage of households without access to information on health systems (getting disability report, appointment system, or language assistance)	Percent	**41**	100	0
	SC	**5.** percentage of households who participate in adaptation events	Percent	**37**	100	0
	SC	**8.** percentage of households aware of vulnerabilities of the becoming refugee (e.g. social exclusion)	Percent	**98**	100	0
	SC	**10.** relationship with Turkish neighbours (scale of strength to weak)	Percent	**85**	100	0
	SC	**11.** percentage of households with difficulty accessing daily information	Percent	**30**	100	0
	HC	**24.** percentage of households who do not get awareness of hazards	Percent	**90**	100	0
	SC	**3.** percentage of households who have opportunities to work outside the community using personal networks	Percent	**32**	100	0
	FC	**16.** percentage of households who receive assistance from a social network and other sources (NGOs) in the last 5 years	Percent	**61**	100	0
	FC	**17.** percentage of households who do not receive assistance from the Government in the last 5 years	Percent	**92**	100	0
Population Growth	**SC**	**12.** average annual growth rate of refugee population	Percent	**2**	43	-10
Climatic Variability	**FC**	**13.** percentage of households reporting changes in livelihood due to climate change	Percent	**23**	100	0
	NC	**2.** both summer and winter mean temperature change (%) in the last 10 years (years: 2013-2023) (reference years: 1981-2010) Summer	Percent	**0.04**	6.09	1.32
		Winter	Percent	**0.15**	51.26	-18.16
	NC	**3.** both summer and winter total precipitation change (%) in the last 10 years (years: 2013-2023) (reference years: 1981-2010) Summer	Percent	**1.62**	405.01	33.21
		Winter	Percent	**-0.03**	54.38	-70.19

Hazards	**NC**	**1.** percentage of households exposed to increased frequency and intensity of natural hazards (inland floods or heat waves) in the last 10 years	Percent	**32**	100	0
	HC	**25.** percentage of households who have members injured or died as a result from human-induced hazards in the last 10 years	Percent	**65**	100	0
	HC	**26.** percentage of households who have members injured or died as a result from natural hazards in the last 10 years	Percent	**20**	100	0
	FC	**14.** percentage of households that have experienced damage to their property	Percent	**77**	100	0
	FC	**15.** percentage of households that have experienced a loss of their property	Percent	**73**	100	0
	PC	**10.** percentage of households that did not receive a warning about the pending natural disasters	Percent	**12**	100	0
	HC	**27.** percentage of households who know how to turn off the installations in your home after any disaster	Percent	**82**	100	0
	NC	**4.** average air quality values in the last 5 years (years: 2019-2024) PM_{10}	Mikro-gram/m^3	**44.49**	50	1.25
		$PM_{2.5}$	Mikro-gram/m^3	**22.45**	25	0.08
		SO_2	Mikro-gram/m^3	**7.92**	20	3.19
		NO_2	Mikro-gram/m^3	**9.09**	40	6.03

Table A2: Indexed Values of Each Variable and Overall Value of Indicators

Types of Livelihood Capitals	Variables	Indexed Values	Indicators	Overall
HC	**1.** percentage of large families (more than 6 members)	**0.23**	**Family Structure**	**0.32**
HC	**8.** percentage of single parent households	**0.22**		
HC	**9.** percentage of households with orphans	**0.06**		
SC	**9.** percentage of households with positive change in women's role/position in family after arrival in Türkiye	**0.76**		
HC	**2.** percentage of age 65+ in a household	**0.03**	**Age**	**0.15**
HC	**3.** percentage of age ≤ 5 in a household	**0.24**		
HC	**4.** number of children in a household	**0.31**		
HC	**7.** percentage of age of household head < 18 or > 65	**0.02**		
HC	**5.** percentage of women in a household	**0.48**	**Gender**	**0.33**
HC	**6.** percentage of female-headed households	**0.19**		
HC	**10.** percentage of households with less than high school education	**0.78**	**Education**	**0.78**
HC	**19.** percentage of households who participate in vocational training	**0.91**		
FC	**6.** percentage of households who can not afford education expenses	**0.66**		
HC	**13.** percentage of unemployed family members	**0.02**	**Employment**	**0.46**
HC	**14.** percentage of employed women	**0.96**		
HC	**15.** percentage of employed children (age < 15)	**0.01**		
HC	**16.** percentage of households who have a work permit	**0.85**		
HC	**12.** percentage of households with weather-exposed workers (agriculture, forestry, fishing, and hunting; mining; construction; manufacturing; and transportation and utilities)	**0.47**	**Occupation**	**0.47**
HC	**11.** percentage of households where members had any formal or informal skill	**0.42**	**Socio-economic Status**	**0.59**
FC	**2.** per household income monthly	**0.83**		
FC	**9.** percentage of households owning private or permanent land in any location that is usually used as a dwelling	**0.51**		
FC	**10.** percentage of households with no vehicle	**0.89**		
FC	**11.** percentage of households using technological devices (fridge, electric heater, fan, washing machine, computer)	**0.05**		
PC	**4.** housing quality (comfortable living conditions (e.g. indoor plumbing, and hot showers) (scale of good to bad)	**0.83**		

FC	**8.** percentage of renter households	**1**	**Housing Tenure (ownership)**	**1.00**
FC	**1.** percentage of earning member in a household	**0.75**	**Livelihood Strategies**	**0.68**
SC	**2.** percentage of households with members working for the government	**0.99**		
FC	**3.** percentage of households who took loan in the past 5 years	**0.05**		
FC	**4.** percentage of households that reported at least one family member worked outside the community to earn a wage	**0.93**		
HC	**17.** language proficiency	**0.70**	**Minority/Language**	**0.58**
HC	**18.** percentage of households who participate in language course	**0.80**		
SC	**4.** percentage of households who have language problems with their children	**0.16**		
SC	**1.** years when refugees are in Türkiye	**0.39**		
SC	**6.** percentage of households who have a residence permit	**0.85**		
HC	**20.** percentage of households registered another province (in this case, they do not benefit from health services)	**0.04**	**Health**	**0.28**
HC	**21.** percentage of households with chronically health difficulties	**0.37**		
HC	**22.** percentage of households with disabled people	**0.23**		
HC	**23.** percentage of households who not visiting doctors during illness	**0.32**		
FC	**5.** percentage of households who can not afford medical expenses	**0.44**		
FC	**12.** average number of months households struggle to obtain food for their family	**0.35**	**Food**	**0.54**
PC	**7.** distance to market	**0.73**		

PC	**8.** access to evacuation routes and/or assembly areas	**0.89**	**Settlement/Infrastructure**	**0.51**
PC	**9.** normal and rainy season road conditions (scale of good to bad)	**0.87**		
PC	**1.** percentage of households using the Internet	**0.11**		
PC	**2.** percentage of households using unsafe water for drinking, cooking, bathing and washing	**0.05**		
PC	**3.** percentage of households who do not have toilet facilities	**0.05**		
PC	**5.** distance to medical establishments and services	**0.56**		
PC	**6.** distance to schools	**0.32**		
FC	**7.** percentage of households who can not afford transportation expenses	**0.50**		
PC	**11.** built-up area rate	**1**		
NC	**5.** the amount of open and green areas per capita	**0.78**		
SC	**7.** percentage of households without access to information on health systems (getting disability report, appointment system, or language assistance)	**0.41**	**Social Safety**	**0.49**
SC	**5.** percentage of households who participate in adaptation events	**0.63**		
SC	**8.** percentage of households aware of vulnerabilities of the becoming refugee (e.g. social exclusion)	**0.02**		
SC	**10.** relationship with Turkish neighbours (scale of strength to weak)	**0.15**		
SC	**11.** percentage of households with difficulty accessing daily information	**0.30**		
HC	**24.** percentage of households who do not get awareness of hazards	**0.90**		
SC	**3.** percentage of households who have opportunities to work outside the community using personal networks	**0.68**		
FC	**16.** percentage of households who receive assistance from a social network and other sources (NGOs) in the last 5 years	**0.39**		
FC	**17.** percentage of households who do not receive assistance from the Government in the last 5 years	**0.92**		
SC	**12.** average annual growth rate of refugee population	**0.23**	**Population Growth**	**0.23**

FC	**13.** percentage of households reporting changes in livelihood due to climate change	**0.23**	**Climatic Variability**	**0.41**
NC	**2.** both summer and winter mean temperature change (%) in the last 10 years (years: 2013-2023) (reference years: 1981-2010) Summer	**0.46**		
	Winter	**0.48**		
NC	**3.** both summer and winter total precipitation change (%) in the last 10 years (years: 2013-2023) (reference years: 1981-2010) Summer	**0.35**		
	Winter	**0.54**		
NC	**1.** percentage of households exposed to increased frequency and intensity of natural hazards (inland floods or heat waves) in the last 10 years	**0.32**	**Hazards**	**0.47**
HC	**25.** percentage of households who have members injured or died as a result from human-induced hazards in the last 10 years	**0.65**		
HC	**26.** percentage of households who have members injured or died as a result from natural hazards in the last 10 years	**0.20**		
FC	**14.** percentage of households that have experienced damage to their property	**0.77**		
FC	**15.** percentage of households that have experienced a loss of their property	**0.73**		
PC	**10.** percentage of households that did not receive a warning about the pending natural disasters	**0.12**		
HC	**27.** percentage of households who know how to turn off the installations in your home after any disaster	**0.18**		
NC	**4.** average air quality values in the last 5 years (years: 2019-2024) PM_{10}	**0.89**		
	$PM_{2.5}$	**0.90**		
	SO_2	**0.28**		
	NO_2	**0.09**		

Exploring Environmental Perception, Cognition, and NIMBY Sentiments Toward Psychiatric Hospitals: A Spatial Planning Perspective

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Abstract
This study through the Semantic Differential scales explores how spatial planning and design influence perceptions of psychiatric hospitals in Taiwan. Preliminary findings of the study show that hospitals situated within vibrant urban environments and possessing indistinct spatial boundaries are perceived as less 'lifeless' or 'dark'. Moreover, if the residents near the hospital with accurate knowledge of hospital departments and the patient the hospital services report lower levels of negativity. These results underscore the significance of environmental stimuli and cognitive familiarity in shaping public attitudes, suggesting that integrated spatial planning and enhanced transparency may mitigate stigma and facilitate community acceptance of psychiatric facilities.

Keywords: psychiatric hospital; psychiatric institution; NIMBY; perception

1. Introduction

The term 'deinstitutionalisation' first appeared in the 1950s in Europe and the United States, in the hope of removing the closed and institutionalised management of institutions and attempting to transform them into part of the community, with the right of patients in stable condition to live independently and be included in the community (UN Committee on the Rights of Persons with Disabilities, UN CRPD, 2021). In 2017, an international expert review of the Committee on the Rights of Persons with Disabilities (CRPD) also recommended the closure of large organisations in Taiwan.

However, in the process of promoting deinstitutionalisation in Taiwan in recent years, the emergence of community psychiatric rehabilitation, psychiatric nursing homes, and other places for the integration of people with mental disorders into community life has often led to a backlash from residents in the surrounding areas. For example, in 2019, residents of Zhoumei objected to a local group home for people with mental disorders due to concerns about safety and the impact on the quality of life, demonstrating that psychiatric facilities are still regarded as 'NIMBY facilities'.

The concept of mental healthcare has been introduced in Taiwan since the Japanese colonial period (1895-1945), but initially the psychiatric hospitals were still based on surveillance and management, and they were mostly located in the urban periphery. After the end of World War II, Taiwan's government attitude towards mental healthcare institutions changed from 'confinement and shelter' to 'therapy and care', but some urban planning land-use zoning regulations still kept psychiatric hospitals separate from medical institutions, restricting them from appearing in urban areas or new towns. Under the influence of historical context and spatial planning, the location of psychiatric hospitals has long been regarded as a space that 'should be located in remote areas.' This study explores whether spatial characteristics contribute to public perceptions, NIMBY sentiments, and the reinforcement of psychiatric stigma and spatial exclusion.

Therefore, this study aims to understand how the spatial planning of psychiatric hospitals affects people's attitudes, perceptions, and feelings about psychiatric hospitals by comparing the surroundings of psychiatric hospitals respectively in the 'urban frontier' and 'urban centre' regions. By understanding the exclusionary nature of spatial location for specific groups and its impact on facility perceptions and NIMBY sentiments, we propose recommendations for inclusive planning for disadvantaged groups, in the hope that spatial planning can help prevent the reproduction and deepening of stigma against disadvantaged groups.

2. Literature Review

2.1 Psychiatry hospitals (psychiatric institutions) in Taiwan

Mental health resources for mental disorders, as classified by Taiwan's Ministry of Health and Welfare, are broadly divided into three categories: 'psychiatric hospitals', 'psychiatric rehabilitation institutions', and 'psychiatric nursing homes', and established regulatory standards. This study focuses on 'psychiatric hospitals' that have been certified by the Ministry of Health and Welfare's Department of Mental Health through the 'psychiatric hospital accreditation' or 'psychiatric teaching hospital accreditation' and remain valid before the year 2027. However, the term 'psychiatric hospitals' only emerged in modern times, making it challenging to distinctly classify 'psychiatric hospitals', 'psychiatric rehabilitation institutions', and 'psychiatric nursing homes' in historical contexts. Therefore, the term 'psychiatric institutions' is used hereafter to refer to the aforementioned facilities in this study.

2.1.1 The Development of Psychiatric Institutions in Taiwan

'Yōkōdō', which was founded in 1929 by Professor Nakamura Yuzuru, is the earliest psychiatric institution in Taiwan, established from a medical treatment perspective. However, in 1930, the Taiwan Daily News reported incidents such as a patient smuggling firewood into a ward and setting a mosquito net ablaze, causing the second and third floors of the building to burn down, and another patient killing a nurse with a hammer in July. These events led the Governor-General's Office to take the social issues caused by mental disorders seriously, resulting in the establishment of the first public psychiatric hospital, 'Yōshin-in', in 1934 (Ko Yi-Ching, 2021).

During the Japanese colonial period, psychiatric institutions built in Taiwan included the 'Aigoryō' in Tainan (1929), 'Yōkōdō' in Taipei (1929), 'Xikou Yōshin-in' (1934), and 'Jōwa Hospital' in Taichung (1936). These institutions, regardless of their capacity, were mostly located on the outskirts of cities or in rural areas. Shen Xiancheng (2003) speculated on two possible reasons: first, in the 19th century, rural environments away from cities were considered ideal for patient recuperation, a common planning approach in Western countries at the time; second, influenced by the repeated relocations of Matsuzawa Psychiatric Hospital in Japan due to urban neighborhood rejection, the selection of remote hospital sites aimed to achieve isolation.

After World War II, U.S. aid became the main source for medical projects. In 1958, the Xikou Sanatorium (formerly 'Yōshin-in') added 200 beds, and the establishment of the Provincial Kaohsiung Sanatorium was also related to U.S. aid. Subsequently, with the World Health Organization's mental health programs, the invention of new medications, and the promotion of therapeutic environments, psychiatric hospitals gradually shifted from 'custodial' to 'therapeutic' models (Lin Xian, 1987, cited in Shen Xiancheng, 2003). However, when the Yuli Veterans Hospital was established in 1957, the concept of 'deinstitutionalsation' in Western psychiatry was emerging, but due to Taiwan's political and economic context at the time, psychiatric hospitals development still leaned towards 'institutionalisation' and geographical 'marginalisation'. To prevent patient escapes, hospitals and nursing homes were often enclosed by walls and situated on isolated blocks. During this period, stigmatisation still heavily influenced society. It wasn't until the lifting of martial law in 1987 that more opportunities were given to disadvantaged groups, indirectly leading to the legislation of the 'Mental Health Act' in 1990.

In the 1980s, the government successively completed facilities such as the Bali Psychiatric Center, Tsaotun Psychiatric Center, and the Daliao Branch of Kaohsiung Kai-Syuan Psychiatric Hospital. These facilities were mostly located in suburban areas with large land areas and included 'community-based' rehabilitation institutions within the hospitals. However, unlike the large sanatoriums in early Western countries, they still provided 'rehabilitation environments based on hospitals'. Hospitals like the Bali Psychiatric Center and the Daliao Branch of Kaohsiung Kai-Syuan Psychiatric Hospital were located in sparsely populated neighborhoods, even near some NIMBY facilities like landfills; indicating their peripheral positioning. Due to the strong negative connotations associated with psychiatric institutions, they are not considered desirable elements of a community's image. After 1990, 90% of institution operators indicated that communities still had low acceptance of these facilities (Shen, 2003).

Since 2000, the Executive Yuan has passed a series of mental health system restructuring plans, including strengthening social psychiatric rehabilitation resources and referral mechanisms after discharge, along with multiple amendments to the 'Mental Health Act', aiming to promote patients' integration into community life

after treatment. However, despite policies advocating for community-based and deinstitutionalised approaches, in practice, there is still strong opposition from residents to the establishment of psychiatric institutions in residential areas, such as 'community psychiatric rehabilitation' and 'psychiatric nursing homes.' For example, in 2000, the Recovery Friends Association's attempt to establish a full-day care institution faced protests from nearby residents, and in 2019, the Wenlin Home faced opposition from residents of the Zhoumei community, indicating that integrating psychiatric institutions into communities remains challenging even today.

2.1.2 Environmental Planning and Design for Mental Healthcare Institutions

Psychiatric institutions are often associated with 'isolation' and 'exclusion' (Gawlak et al., 2025), a perception that can be traced back to the historical perspective of psychiatry. Early psychiatric hospitals, as institutions for 'managing' patients, often featured physical barriers from the outside world, such as gates, high walls, fences, forests, or wilderness. Goffman (2012) referred to these as 'total institutions', categorising psychiatric hospitals as one such type. Due to the unique spatial requirements of psychiatric hospitals, they were designed to treat or care for patients while preventing their unpredictability from affecting external groups. However, overemphasis on management and surveillance functions in hospital planning and design, while neglecting actual users, can lead to cold and unwelcoming spaces. This sense of confinement is a significant reason why the public generally finds psychiatric medical institutions unapproachable (Ko Yi-Ching, 2021).

Over the past 30 years, numerous case studies on hospital environments have led to an increasing emphasis on 'evidence-based design (EBD)'. EBD involves using scientific evidence as a foundation for design, assessing the impact of the built environment on users' physical and mental health, and considering their experiences within the environment. The introduction of EBD concepts can enhance patient well-being during treatment and reduce stress for healthcare workers (Elisa et al., 2018; Szymańska et al., 2025). For instance, research by Mohamed and Roslinda (2010) indicated that diverse colours, natural elements (such as the sound of flowing water, plants, and vibrant gardens), and factors like homely, bright, and well-ventilated environments can effectively promote the caregiving environment for both healthcare workers and patients.

In terms of hospital locations, urban and rural hospitals can offer different therapeutic characteristics. According to a systematic literature review by Szymańska et al. (2025), urban hospitals can provide inpatients with more social stimulation, reducing feelings of social isolation. However, potential risks include safety concerns regarding interactions between patients and external individuals, necessitating environmental planning to ensure hospital security and alleviate nearby residents' fears of patient escapes. Rural hospitals, with generally larger spaces, allow for more flexible planning of suitable landscapes and buildings, meeting patients' needs for interaction with nature during treatment. However, transportation convenience becomes a barrier for patients without private vehicles. The study concluded that architectural planning and design can help improve public perceptions of psychiatric hospitals, summarising two influencing factors: 'locating hospitals in urban areas to promote shared green spaces with nearby residents' and 'using gentle materials and designs in hospital spaces to significantly impact spatial perception and cognition' (Szymańska et al., 2025).

However, as reviewed in the previous section, early psychiatric institutions in Taiwan were mostly located on the outskirts of cities or in rural areas. Even today, certain urban planning land-use zoning regulations continue to reflect this tendency. For example, the amended 2021 Taipei City Land Use Zoning District conditions allow for the use of psychiatric hospitals with more stringent standards than general hospitals, and the Tainan City Central and Western District Plan (Chinatown and Canal Diamond Area), which was released and implemented in 2016, avoids locating psychiatric institutions in the urban core area.

From the above literature, it is evident that past research on the environmental planning and design of psychiatric hospitals has primarily focused on 'patient treatment', 'patient safety', 'external personnel safety', and 'staff management', with few studies exploring how spatial planning indirectly affects residents' perceptions of psychiatric hospitals; early establishments on urban outskirts and current restrictions on setting up mental health care facilities in urban centers may stem from early construction habits or planners' perceptions of psychiatric institutions' environments, leading to the reconstruction of environmental perceptions through urban planning controls.

2.2 Not In My Back Yard

Not In My Back Yard (NIMBY) refers to facilities that are socially necessary but elicit negative emotions among local residents when sited nearby. NIMBY facilities can generally be categorised based on the nature of the rejection into three types: pollution-related, risk-clustering, and psychological dismay. Pollution-related facilities include sewage treatment plants and highways, which are opposed due to their direct environmental impacts; risk-clustering facilities are high-risk but low-probability facilities such as nuclear power plants; psychological dismay facilities include psychiatric hospitals, funeral parlours, and cemeteries—facilities that do not directly affect physical health but evoke long-term psychological rejection (Zhang et al., 2022). The psychiatric institutions explored in this study tend to fall under the category of psychological dismay NIMBY facilities.

When NIMBY facilities are constructed involuntarily by the surrounding residents, when they are beyond their control, provide no benefits to them, and are associated with fearful, adverse, or irreversible outcomes, a heightened perception of risk is often triggered. This may give rise to strong emotions such as worry, anger, anxiety, fear, and hostility, affecting individual attitudes and behaviours (Covello et al., 2001). These emotions are usually rooted in concerns over property values, personal safety, and quality of life (Dear, 1992). Chiu and Lo (2011), through interviews with key personnel from institutions serving people with intellectual and psychiatric disabilities, found that, unlike pollution-related NIMBY facilities, the resistance towards disability institutions is mainly linked to the 'facility users' themselves. Reasons for protest include damage to the landscape and feng shui, impact on air and water quality, concerns over child development (fear of imitation), personal safety concerns (fear of being frightened or of crimes committed by persons with disabilities), traffic safety or congestion, and declining property prices. These findings broadly align with Dear's (1992) summary of public concerns towards NIMBY facilities.

Regarding the formation mechanism of psychological dismay-type NIMBY emotions, Yu et al. (2022), in their literature review, cited Xu and Jing (2020), who found through qualitative research that community conflict over an elderly care centre in Wuhan in 2015 originated from 'psychological resistance', which gradually developed into heightened 'risk perception', eventually evolving into 'behavioural resistance.' Through an online questionnaire, they found that superstition, NIMBY attitudes, and perceived risk had a positive correlation with opposition to elderly care facilities in the community, while perceived knowledge and perceived benefits were positively correlated. These results indicate that NIMBY attitudes and risk perception greatly influence public support for elderly care facilities. In terms of attitude, Moon (1984) believed that aside from attitudes and beliefs, personal positive or negative experiences with psychiatric patients or care facilities also affect acceptance. However, to explore the entire community's NIMBY sentiment towards psychiatric institutions, broader structural factors such as social, economic, and political elements must be included, revealing differences between individual and community perspectives in understanding the formation of NIMBY sentiment.

3. Materials and Methods

3.1 Research Framework

Through literature review, it was found that psychiatric institutions in Taiwan have long been located in rural or urban fringe areas throughout their historical development. Therefore, this study uses questionnaires to investigate, within equal residential distances, whether residents of urban fringe areas and city centre areas differ in spatial familiarity with psychiatric hospitals, and whether the overall spatial locations and environmental planning create different spatial perceptions. Furthermore, the study seeks to identify the causes of these differences to understand how the spatial characteristics and surrounding environments of psychiatric hospitals influence the emotional perceptions of the public. The variable relationships in this study are shown in Figure 1.

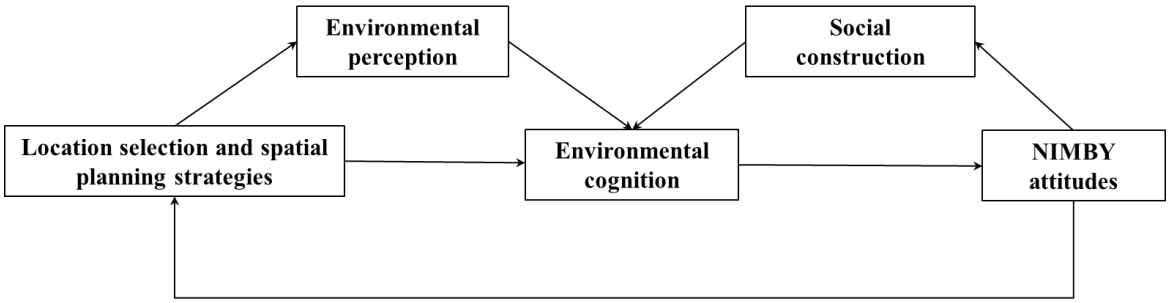

Figure 1 Relationship diagram of research variables

In terms of research locations, the study selected the two largest psychiatric hospitals in Tainan and Kaohsiung—Jianan Psychiatric Center in Tainan and Kai-Syuan Psychiatric Hospital in Kaohsiung. Jianan Psychiatric Center is situated on the border between East District and Rende District of Tainan City and has long been in an urban fringe area, with only recent developments in the past 30 years due to the Huwuiliao readjustment area (Figure 2). Kai-Syuan Psychiatric Hospital is located in the city centre of Lingya District, Kaohsiung, near the Kaohsiung Cultural Centre and National Kaohsiung Normal University, with relatively dense residential and commercial development in its surroundings (Figure 3).

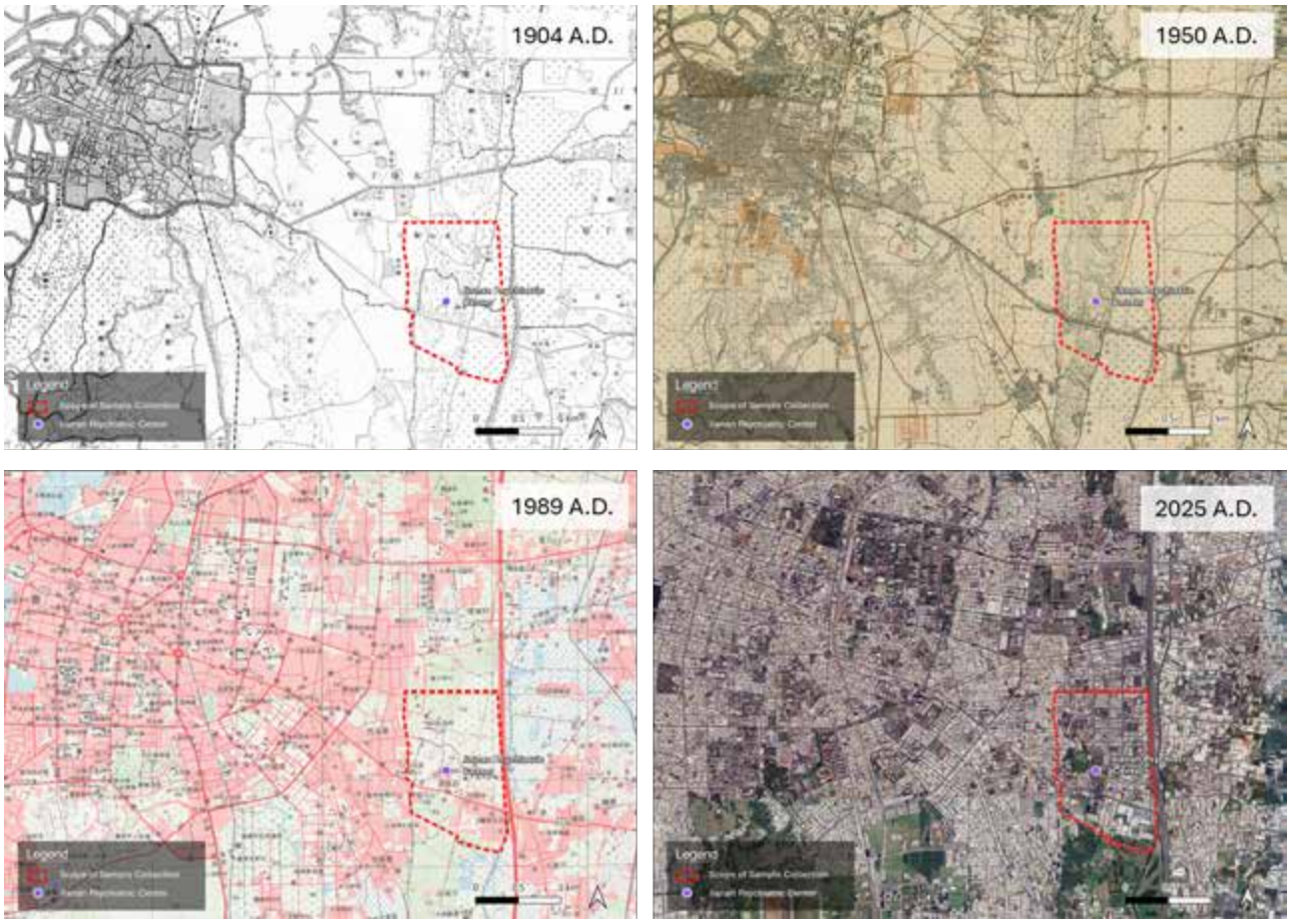

Figure 2 Urban development in Tainan City and around Jianan Psychiatric Centre

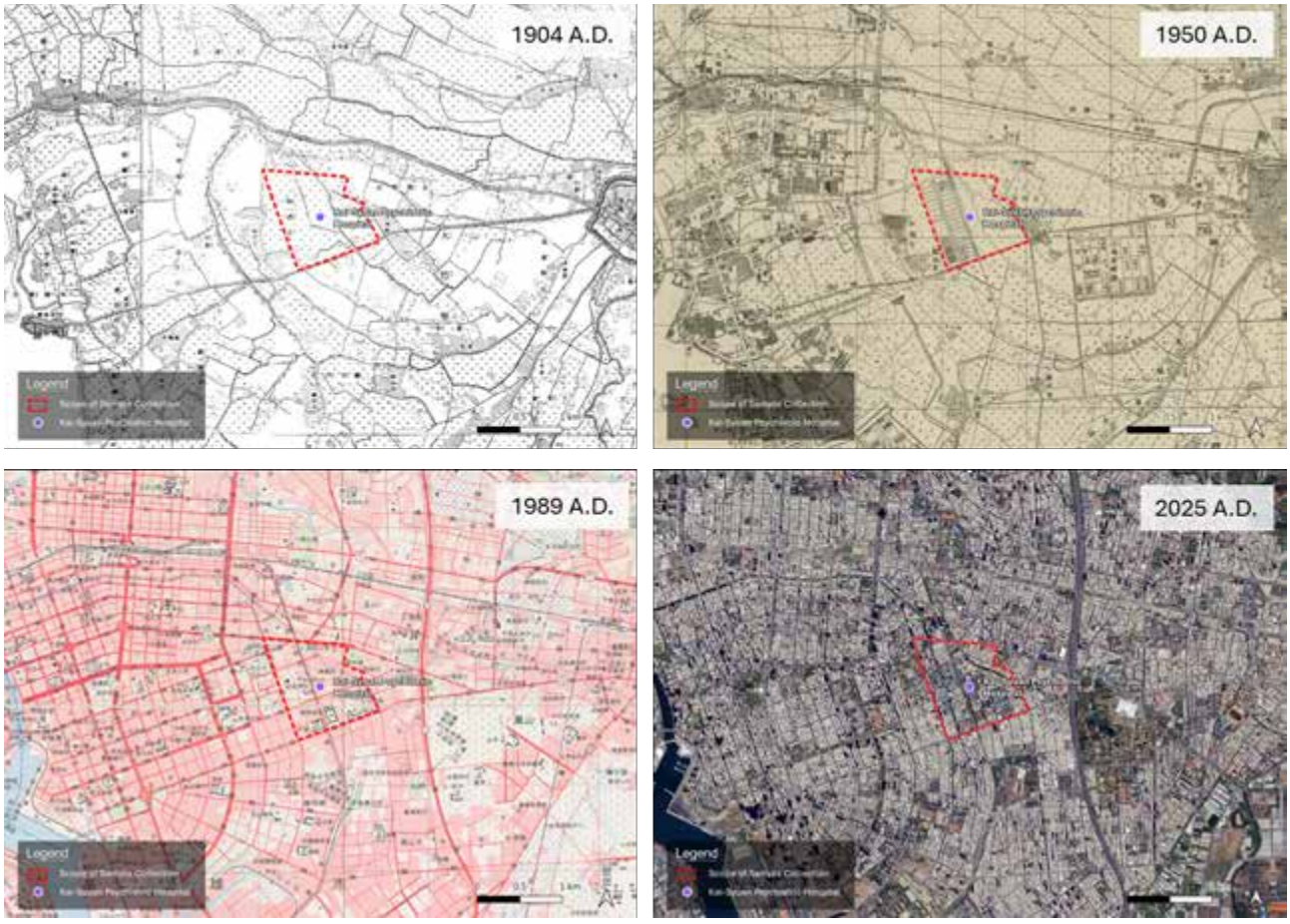

Figure 3 Urban development in Kaohsiung City and around Kai-Syuan Psychiatric Hospital

3.2 Research Methods

The purpose of this study is to use a questionnaire survey to understand the actual emotional perceptions of the public towards psychiatric hospitals and to compare whether NIMBY sentiments differ under different surrounding environmental conditions. To avoid over-focusing on the hospitals and thus losing authenticity, the questionnaire is divided into three parts:

The first part investigates the spatial images within about 500 metres of Jianan Psychiatric Center and Kai-Syuan Psychiatric Hospital, from the perspective of local community residents, to gain preliminary insight into impressions and perceptions of psychiatric hospitals in comparison to other spaces within the community.

The second part applies the Semantic Differential (SD) Scale to examine residents' emotional responses towards the hospitals within their block areas, and their perceptions of how the hospital environment reflects characteristics of its users (primarily the patients).

The third part is based on the premise that residents fully understand that both hospitals are psychiatric institutions and asks residents about their views on the relationship between psychiatric hospitals and the community and whether they consider them NIMBY facilities.

Through these three parts of the questionnaire, this study compares differences in overall spatial perceptions shaped by hospitals located in different communities and further explores whether spatial planning influences the public's NIMBY perceptions of psychiatric facilities.

4. Results

4.1 Current Conditions of the Research Sites

4.1.1 Kai-Syuan Psychiatric Hospital

Kai-Syuan Psychiatric Hospital is located in Lingya District, Kaohsiung City, in the city centre. The hospital site covers approximately 2.65 hectares and includes the main hospital, a psychiatric nursing home, and a community rehabilitation centre.

To the north of the site lies Fucheng Street, with the Kaohsiung City Department of Health located across the road. To the west is Kai-Syuan 2nd Road, a 20-metre-wide road with a light rail transit (LRT) line. The hospital entrance directly faces the Department of Health Station. To the south is Lane 189, Fude 3rd Road, lined with approximately 50-year-old residential townhouses. To the east is Zoujie Art Park, a neighbourhood park. The surrounding area is predominantly residential, with a large elderly population and relatively low traffic on the northern and southern roads. As a result, many residents take walks or engage in recreational activities in Zoujie Art Park, as well as along Fucheng and Fushou Streets in the evening.

Figure 4 Kai-Syuan Psychiatric Hospital Surrounding Environment

4.1.2 Jianan Psychiatric Center

Jianan Psychiatric Center is located in Rende District, Tainan City, on the urban fringe of the metropolitan area, adjacent to the southeastern side of the East District. The site covers approximately 5.3 hectares and includes the Chest Hospital under the Ministry of Health and Welfare, which is the only psychiatric teaching hospital in the Yunlin-Chiayi-Tainan area.

To the north of the site are wooded, unused lands and hospital car parks. To the west is Yuzhong Road, along which about ten new townhouses have been constructed over the past five years. Current land use in this area includes industrial, storage, and residential functions. To the south is the Chest Hospital, and to the east is Gong-Er-3 Park, which is adjacent to the hospital's rear entrance.

Figure 5 Jianan Psychiatric Center Surrounding Environment

4.2 Public Perceptions of the Community Environment Surrounding the Hospitals

As this stage involved pilot testing of the questionnaire, the sample size collected was insufficient for statistical analysis. Therefore, the following paragraphs will provide descriptive statistics to summarise the public's views on the areas surrounding the hospitals.

4.2.1 Kai-Syuan Psychiatric Hospital

A total of 5 questionnaires were collected in the area around Kai-Syuan Psychiatric Hospital. All respondents were former students who had attended senior high school or university in this area. Consequently, the 'most familiar place' was consistently identified as the surroundings of National Kaohsiung Normal University; the 'least familiar places' were typically Fudong Elementary School and Linjing Park, which are further away from the school. Two respondents mentioned Kaixuan Road and the hospital itself as places they were least familiar with. The 'least safe areas' were described as the dim alleyways and tree-lined boulevards.

According to the questionnaire's content, respondents did not express significantly more negative emotions towards Kai-Syuan Psychiatric Hospital compared to other areas. They did not spontaneously describe the area around the hospital using terms such as 'dangerous' or 'frightening', which are typical of NIMBY sentiments. Moreover, the field observations revealed that the layout of the roads, the proximity of the hospital to the park, and the absence of clear boundary walls encouraged many nearby residents to walk or engage in recreational activities in the park and along Fucheng Street. They did not deliberately avoid the hospital. Some shop owners even mentioned that the hospital and nearby medical facilities are important sources of business.

4.2.2 Jianan Psychiatric Center

A total of 9 questionnaires were collected in the area around Jianan Psychiatric Center, with all respondents having lived there for over ten years. 'Most familiar places' included major community parks such as Wensheng Park and areas surrounding primary schools. Three respondents identified the area around the Chest Hospital and Jianan Psychiatric Center as the 'least familiar', while four mentioned areas south of Zhongshan Road. Areas perceived as the 'least safe' were predominantly around the Chest Hospital and Jianan Psychiatric Center, mainly

due to lower pedestrian activity. One respondent mentioned that although they live near the hospital, their daily activities are centred in the east-side Huwuiliao readjustment area. The hospital's surroundings, being largely undeveloped, have little connection to their everyday life.

4.3 Public Perceptions of the Hospital Environment

This stage mainly sought to understand 'people's feelings when passing by the hospital' and 'the perceived atmosphere of the hospital itself'. Residents near Jianan Psychiatric Center generally described their feelings when passing the hospital as 'serious', without experiencing significant emotional burden or threat. However, the hospital atmosphere was perceived as 'quiet', 'gloomy', and 'lifeless'. Similarly, residents near Kai-Syuan Psychiatric Hospital also expressed a 'serious' and somewhat 'heavy' feeling when passing the hospital. The atmosphere was similarly seen as 'gloomy' and 'lifeless', but described as noticeably more 'dark' than that of Jianan Psychiatric Center.

4.4 Public Cognition of the Hospital

In this analysis, none of the five respondents near Kai-Syuan Psychiatric Hospital did not understand the hospital's departments or the patients they serve, making it difficult to assess how the hospital's presence influenced their understanding of psychiatric institutions. In contrast, five out of nine respondents near Jianan Psychiatric Center did understand the hospital's departments and the patients they serve.

During this stage, five respondents near Jianan Psychiatric Center were invited to 'recall the appearance and environment of the hospital, and describe their imagined image of the patients it serves. All five associated the patients with adjectives such as 'depressed' and 'controlled'. However, when asked whether they were concerned about being affected by the hospital's service users or whether they rejected psychiatric outpatient services, all respondents expressed little concern or rejection.

Comparing residents who 'understood' versus those who 'did not understand' the hospital's departments and the patients the hospital serves, it was found that those who lacked such understanding were more likely to perceive the hospital as 'threatening', 'dark', 'lifeless', and 'cold.' This suggests that the physical appearance and surrounding environment of a hospital can provide informational cues to the public, particularly for those unfamiliar with the hospital's function. Residents who understood the hospital showed fewer negative descriptions of the atmosphere, which may also reflect a lower level of stigma towards psychiatric hospitals.

5. Conclusion

Through the review of the literature, we can find that psychiatric hospitals were often initially sited on the urban periphery, and that conflicts arose during deinstitutionalisation between psychiatric facilities and surrounding residential areas. This study used semantic differential scales to explore how community residents perceive and accept psychiatric hospitals, aiming to test whether such peripheral siting influences public cognition and acceptance.

Preliminary results indicate that in terms of the physical environment, Jianan Psychiatric Center is located in a relatively remote area with fewer residential neighbourhoods, limited pedestrian activity, and primarily through traffic. Residents rarely pass by the hospital unless they have medical needs. They often described the area as 'unsafe', 'dark', and 'gloomy' due to its 'low flow of people' and abundance of 'vacant land'. In contrast, the area surrounding Kai-Syuan Psychiatric Hospital benefits from proximity to parks and daily amenities. The hospital has no boundary walls or clear separation from nearby residences, leading to perceptions of the hospital as 'gloomy' but not necessarily 'threatening'. Residents are more likely to engage in activities nearby. A comparison of the interface between each hospital and its surrounding residential areas shows that Jianan Psychiatric Center's layout and functions are more spatially separated from the community, resembling the spatial planning of 'total institutions' (Goffman, 2012), characterised by physical isolation, which gives rise to stronger feelings of 'darkness', 'insecurity', and 'threat', making the hospital less approachable. This suggests that the physical interface between psychiatric facilities and their surrounding neighbourhoods significantly influences public perception.

In terms of the residents' cognition about the hospital, long-term residents near Jianan Psychiatric Center had

a higher understanding of the hospital's function and the types of patients it serves, and demonstrated greater acceptance. Compared with those who did not understand the hospital's attributes, informed residents gave more neutral descriptions of the hospital and rated it lower in terms of 'coldness', 'darkness', and 'lifelessness.' On the other hand, although Kai-Syuan Psychiatric Hospital is located within the city and forms part of a medical cluster alongside the Kaohsiung City Department of Health and other institutions, it remains functionally detached from residents' daily routines. The medical area's circulation routes are separated from the community, which has not notably enhanced public familiarity or acceptance. Public understanding of the hospital remains limited. This phenomenon may reflect the findings of the research of Xu and Jing (2020), which found that perception knowledge significantly influences support for psychologically stigmatised NIMBY facilities.

Moreover, most respondents near Jianan Psychiatric Center were from small households living in newly developed residential areas from the past 30 years. In contrast, respondents near Kai-Syuan Hospital were mostly university students from the National Kaohsiung Normal University. A comprehensive comparison of community-wide NIMBY sentiments towards medical institutions requires consideration of broader structural factors such as social and economic status (Moon, 1984). This presents a future direction for refining questions and analyses.

Therefore, future research will further explore spatial layout and residents' daily interactions, focusing on the challenges and potential of integrating small-scale psychiatric care facilities (e.g., community psychiatric rehabilitation) into neighbourhoods amid the shift towards deinstitutionalisation. Key questions include: why do these community-based facilities, despite their proximity to residents' lives, still face psychological rejection or suspicion? Are these reactions linked to unfamiliarity with people with mental illness and limited spatial interaction? By comparing perceptions and attitudes under different facility and spatial conditions, future research will examine how urban planning might act as a mediator, designing spaces that foster understanding and inclusion—making it more natural for the public to engage with psychiatric service users and enabling patients to live more comfortably within the community.

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A Model for Measuring and Assessing Social Sustainability: Ankara Dikmen Valley Case Study

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Abstract
During the transformation of cities, the concept of sustainability has been incorporated into political discourse. Due to the emphasis on environmental and economic aspects of sustainability in urban interventions, issues of social inequality, insufficiency, insecurity, social exclusion, and a lack of social unity have been highlighted. Since the primary purpose of urban interventions is to improve the spatial structure, enhancing and maintaining social structure is essential in ensuring spatial sustainability. This paper focuses on measuring and assessing social sustainability before and after urban interventions. This paper presents a model that defines the key issues and criteria of social sustainability, the objectives and sub-objectives for achieving social sustainability, and the indicators to measure and evaluate them. The universal model is based on a holistic approach that can be applied to all urban areas and scales.

1. Introduction
In the ongoing process of urban transformation, the concept of sustainability has increasingly been integrated across various disciplines, primarily due to the widespread impact of human activity on all systems, including cities. As sustainability emerges as a key framework for addressing global challenges, it has gained prominence in both theoretical discourse and practical applications. Although the need to evaluate the three fundamental components of a sustainable society—environmental, economic, and social—became more widely acknowledged after the 1980s, urban renewal efforts have primarily focused on the physical and economic revitalization of existing urban areas to meet evolving urban demands (Colantonio and Dixon, 2009).

This focus has often led to the neglect of the social dimension of sustainability, resulting in increased inequality, inadequacy, and insecurity within urban spaces. As cities face limitations imposed by their physical and economic structures, a holistic approach that simultaneously considers environmental, economic, and social aspects becomes essential. Such an approach is necessary not only to achieve social sustainability but also to lay the groundwork for building resilient and sustainable cities in the face of changing conditions.

From this perspective, this research focuses on measuring and assessing social sustainability before and after urban interventions. This paper presents a model that defines the key issues and criteria of social sustainability, the objectives and sub-objectives for achieving social sustainability, and the indicators to measure and evaluate them. The universal model is based on a holistic approach that can be applied to all urban areas and scales. Ankara Dikmen Valley has been selected as a case study for implementing the model. The Dikmen Valley Housing and Environmental Development Project is the first multi-purpose urban development project in Turkey; in other words, it is an urban regeneration project for slum areas and squatter settlements. Dikmen Valley was chosen as the implementation area as it has been inhabited for more than 5 years.

2. Concept of Social Sustainability
Although there is no universally accepted definition of social sustainability, its theoretical framework varies depending on factors such as scale, spatial characteristics, subject matter, and the disciplinary perspectives of

researchers. Compared to the environmental and economic dimensions, the development of social sustainability has been relatively slow, mainly because it has historically received less attention and interest (Woodcraft, 2015). Early definitions of social sustainability primarily aimed to clarify and legitimize the concept within broader sustainability discourse. However, since the 2010s, more comprehensive explanations and in-depth analyses have emerged, reflecting a growing recognition of the importance of the social dimension in achieving truly sustainable urban development.

The fundamental key of social sustainability is described as the equitable access to resources for all residents of a region and the provision of fair opportunities for well-being (Murphy, 2012). Social sustainability is most broadly defined as the maintenance and enhancement of the well-being of current and future generations (Chiu, 2003) and the fulfilment of the fundamental social needs of all communities (Eizenberg and Jabareen, 2017). From an urban living perspective, the process of creating sustainable and prosperous places that enhance well-being involves understanding what people need from the spaces in which they live and work. Social sustainability 'integrates the design of physical space with the design of the social world' (Woodcraft, 2015).

More detailed definitions of social sustainability emphasize its nature as an integrated relationship between the physical environment, individuals, and the broader social structure.

In addition to approaches that examine the concept of social sustainability from different perspectives, there are also holistic and multi-layered approaches. The concept of social sustainability can be further expanded when considering basic needs, culture, well-being, and the continuation of the human species (Littig and Griessler, 2005). In this context, according to Cuthill (2010), social sustainability is shaped by principles such as well-being and quality of life, incorporating concepts including health, participation, needs, social capital, economy, ecology, and, more recently, happiness—all grounded in the core values of equity and democracy.

Colantonio and Dixon (2009), who argue that urban regeneration efforts can yield potential outcomes across various dimensions of social sustainability in cities, define these dimensions as follows: demographic change (ageing, migration, and mobility), education and skills, employment, health and safety, housing and environmental health, sense of belonging, place identity and culture, participation, empowerment and achievement, social capital, social mixing and cohesion, well-being, happiness, and quality of life. Underpinning all these concepts—including social exclusion, social inclusion, and social capital—is the premise that individuals in society must interact and collaborate to ensure social Sustainability (Bramley and Power, 2009).

In its broadest sense, social sustainability refers to the existence of equal, fair, and equitable living conditions in the built environment and its components for all segments of society. While equity and justice are at the heart of the concept, they must be considered in conjunction with other key issues, including population, accessibility, education and skills, health, housing, safety, belonging, participation, social capital, social cohesion, diversity, and satisfaction. Social sustainability can thus be defined as systems in which equity and justice are central values, where population distribution and economic welfare are balanced, equal access to basic services is ensured, opportunities necessary for individual and societal development are available, fundamental needs such as health, housing, and security are met, individuals feel a sense of belonging to their community and environment, public participation in governance is realized, and where social capital, cohesion, and satisfaction with quality of life are achieved (Atalay, 2023).

3. Definition of The Model For Measuring And Assessing Social Sustainability

In developing countries, particularly within urban contexts, there appears to be a lack of a comprehensive system or model capable of assessing and evaluating the extent to which the sustainability of the social structure is ensured as a component of achieving spatial sustainability. Based on this premise, the present study proposes a model specifically tailored to the Turkish context, designed to facilitate the assessment and evaluation of social sustainability within the field of urban planning. The proposed model constitutes an integrated measurement and evaluation framework that identifies the mechanisms through which the social fabric may be sustained in urban environments. The primary objective of the model is to identify the key dimensions and criteria of social sustainability, articulate the corresponding objectives necessary to ensure its realization and establish a set of

measurable indicators for evaluating these objectives. Designed to be universally applicable, the model adopts a holistic perspective and is intended for implementation across diverse urban settings and at varying spatial scales.

As part of the literature review conducted for this study, a comprehensive analysis was undertaken of publications by international organizations, academic books, peer-reviewed articles, and project reports, with a specific emphasis on methodologies and frameworks related to the measurement and evaluation of sustainability, particularly social sustainability. Each study reviewed in the literature has been systematically analyzed based on its respective criteria, and a comprehensive matrix encompassing all identified criteria and indicators has been constructed through synthesis. This matrix served as a methodological tool for selecting relevant social sustainability criteria and indicators based on their recurrence and frequency across the literature while also taking into account the spatial planning framework.

Utilizing this approach, ten principal criteria have been defined to constitute the thematic framework of the indicator system designed to assess social sustainability. These include demography and employment, accessibility, education and skills, health, housing, safety, sense of belonging, participation, social capital and social cohesion, and urban life quality, satisfaction, and adequacy of services (Figure 1).

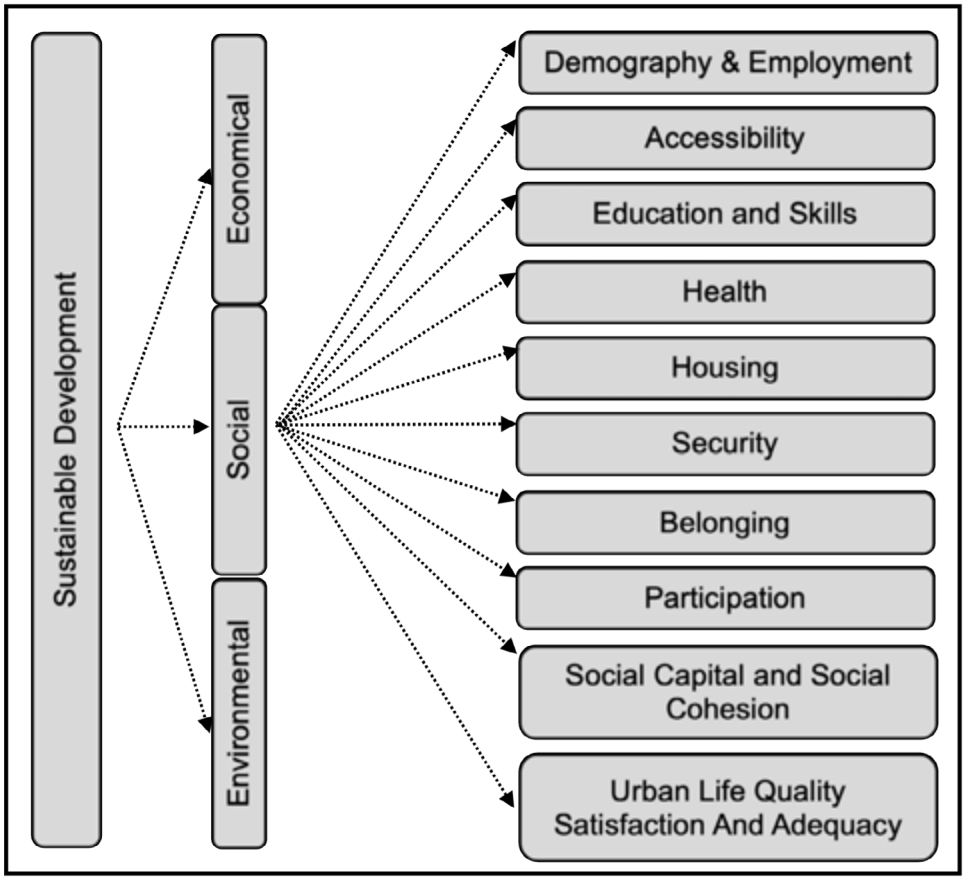

Figure 1. Criteria of the measuring and assessing social sustainability model

Within the scope of the social sustainability measurement and evaluation model, a total of 12 strategic objectives and 24 subordinate targets have been formulated concerning the ten core criteria (Table 1).

Table1. Targets and sub-targets of the social sustainability model

Criteria's	Targets	Sub-Targets
A.Demography & Employment	TA(1) Ensuring a Balanced Distribution of the Population	TA(1.1) Ensuring a Balanced Distribution of the Population by Birthplace
	TA(2) Ensuring the Balance of the Economic Well-Being of the Population	TA(2.1) Poverty Prevention
		TA(2.2) Provision of Employment Opportunities
		TA(2.3) Ensuring Productivity in Employment
		TA(2.4) Ensuring Gender Equality in Employment Opportunities
B.Accessibility	TB(1) Ensuring Equality of Access to Basic Urban Services	TB(1.1) Ensuring Equality of Access to Social Infrastructure, Open Green and Urban Working
C. Education and Skills	TC(1) Individual and Social Education, Raising and Promoting The Level of Development	TC(1.1) Raising literacy and education level
		TC(1.2) Promoting Participation in Vocational Education
		TC(1.3) Promoting Participation in Talent Development Education
D. Health	TD(1) Ensuring the Adequacy of Health Services	TD(1.1) Ensuring the Adequacy of Health Services
E. Housing	TE(1) Ensuring Housing Conditions for All	TE(1.1) Ensuring Increasing Housing Capacity
		TE(1.2) Improving the Physical Condition of Housing
F. Security	TF(1) Ensuring Individual Safety	TF(1.1) Ensuring Security in Public Spaces and Private Areas
G. Belonging	TG(1) Ensuring the Acquisition of Social, Spatial Belonging, Urban Image, and Heritage Values	TG(1.1) Ensuring Social and Spatial Belonging
		TG(1.2) Creation of Urban Image Awareness
		TG(1.3) Creating Awareness of Conservation of Heritage Values
H. Participation	TH(1) Promoting Public Participation in Management, Planning Processes, and Works Related to Municipal Services	TH(1.1) Ensuring Participation in Country and Local Government
		TH(1.2) Ensuring Public Participation in the Planning Process
		TH(1.3) Ensuring Transparency in Works Related to Municipal Services
I. Social capital and social cohesion	TI(1) Ensuring The Level of Social Development and Social Interaction	TI(1.1) Increasing Social Development
		TI(1.2) Level of Social Interaction
	TI(2) Ensuring Diversity and Cultural Integration	TI(2.1) Ensuring Cultural Diversity and Cultural Integration
L. Urban Life Quality Satisfaction And Adequacy Of Services	TL(1) Ensuring Local Residents' Satisfaction with Their Living Environment and the Adequacy of Provided Services	TL(1.1) Ensuring Satisfaction with Urban Quality of Life
		HL(1.2) Ensuring the Adequacy of Urban Services

4. Applying the Measuring And Assessing Social Sustainability Model: A Case Study of Dikmen Valley

4.1 General Overview of Dikmen Valley and Its Urban Development Project

Since the 1950s, internal migration from rural to urban areas in Turkey has led to a substantial increase in urban populations, particularly within metropolitan centres. This demographic shift has led to the proliferation of informal and unauthorized housing areas—commonly referred to as gecekondu settlements—across many cities (Gülersoy Zeren, 2003). One such area is the Dikmen Valley, located in Ankara, which was previously characterized by unregulated and illegal residential structures.

Dikmen Valley is situated within the Çankaya district of Ankara and encompasses the neighbourhoods of Ayrancı, İlkadım, Güzeltepe, Metin Akkuş, and İlker (Figure 2).

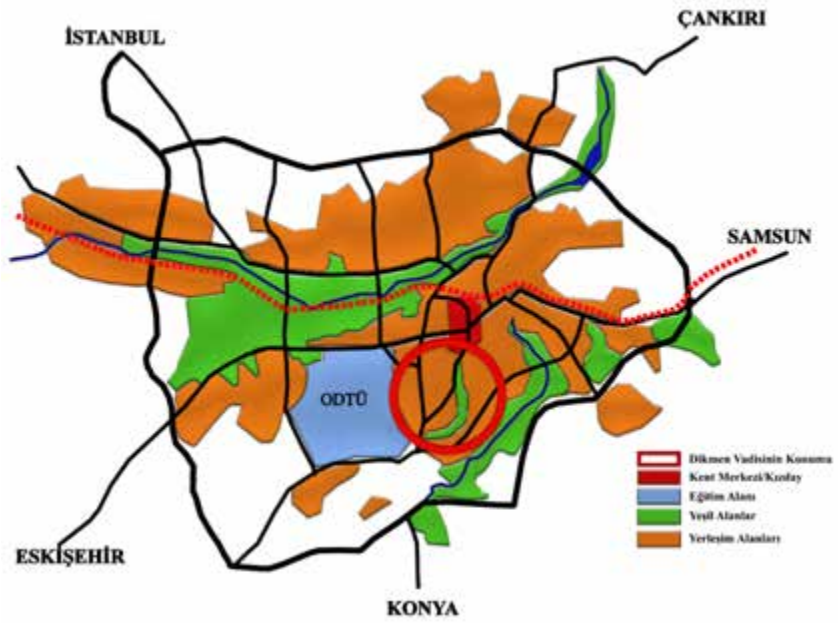

Figure 2: The Location of Dikmen Valley within Ankara (Adapted from Ankara Metropolitan Municipality et al., 1999).

In the aftermath of the 1989 local elections, the Ankara Dikmen Valley Housing and Environmental Development Project was initiated as a comprehensive intervention aimed at addressing this informal settlement. The project constitutes Turkey's first multi-functional urban development initiative, specifically an urban transformation project designed to regenerate informal housing areas. Its overarching aim was to enhance the living environment and improve the quality of life for the resident population and rightful stakeholders within the valley.

Crucially, the planning and preparatory stages of the project deviated from conventional top-down urban planning practices. Instead, a participatory planning approach was adopted, actively involving property owners and other stakeholders in the decision-making process. This inclusive and context-sensitive methodology renders the project a particularly salient case study in the field of urban regeneration.

Accordingly, the implementation of the proposed social sustainability assessment model has been spatially confined to the geographical boundaries encompassing Phases I, II, and III of the Dikmen Valley Housing and Environmental Development Project, as illustrated in Figure 3.

Figure 3: Boundaries of the Study Area

4.2. Scope and Limitations of the Study

For the implementation of the proposed model, the study area was defined as the spatial extent encompassing Phases I, II, and III of the Dikmen Valley Housing and Environmental Development Project. To conduct face-to-face household surveys within this area, separate verbal and written communications were initiated with apartment managers, site administrators, and security personnel.

Despite providing comprehensive information regarding the aim, scope, methodology, and disciplinary relevance of the study, several site and apartment administrations—particularly in Phases I and II—responded unfavourably to the survey request. However, following repeated efforts, access was granted by the management of Çankaya Evleri in Phase I, as well as Çankaya Park Evleri and select homeowner units in Phase II.

Although a formal written request was submitted following an in-person meeting with Phase III management, permission to administer the survey was ultimately denied.

The research sample is composed exclusively of homeowners and tenants residing within the defined study area. No data was collected from individuals outside the project boundary. The survey was administered in four sub-areas: Çankaya Park Evleri, Çankaya Evleri, Yeşil Vadi Street, and Zone 4, which are indicated in Table 2 and Figure 4.

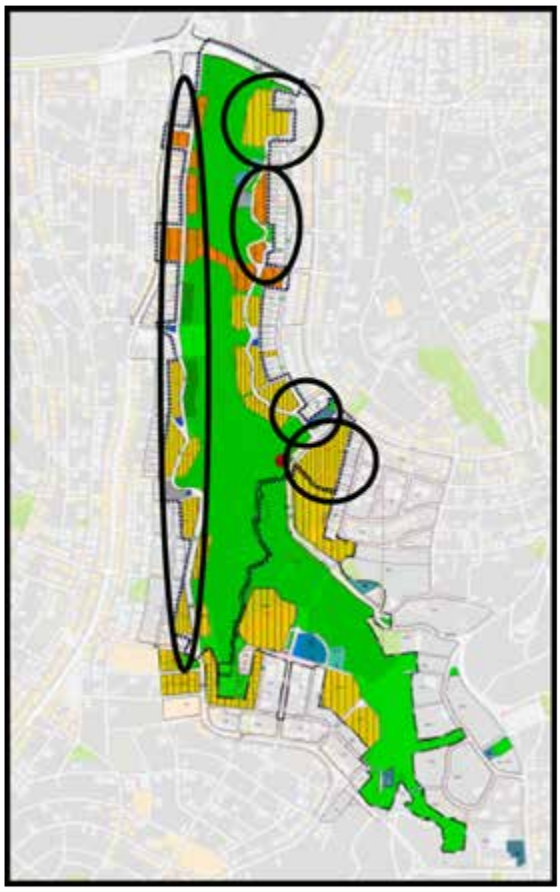

Figure 4: Distribution of Surveys by Area

Table 2: Distribution of Surveys by Area

Area	Number	Percentage
Çankaya Evleri	23	26,7%
Çankaya Park Evleri	32	19,2%
Yeşil Vadi Sokak	41	34,2%
4. Bölge	24	20,0%
Total	120	100,0%

4.3. Methodology

Method for Measuring Social Sustainability in Dikmen Valley

Within the framework of the Social Sustainability Measurement and Evaluation Model, both quantitative and qualitative research methods were employed to assess the indicators developed to achieve the defined criteria, objectives, and sub-objectives of social sustainability. The data used to measure social Sustainability in Dikmen Valley primarily consists of primary sources. These include spatial data, responses collected through household surveys, and insights obtained from in-depth interviews. A mixed-method data collection approach was adopted in the study.

Secondary data were also utilized to contextualize the findings. These include general household statistics from the Turkish Statistical Institute (TURKSTAT) about Ankara Province and Çankaya District, where Dikmen Valley is located, as well as data extracted from existing literature and prior studies conducted on Dikmen Valley.

The face-to-face survey was conducted between May 2018 and October 2018. During this period, 870 individuals were contacted. Of the completed questionnaires, 120 survey forms that were fully and accurately filled out were included in the final evaluation.

Evaluation Method for Measuring Social Sustainability in Dikmen Valley

To determine the demographic characteristics of survey respondents, a nominal scale was utilized, while a five-point Likert scale was applied to assess perceptions of adequacy regarding various social sustainability indicators. The survey forms included both closed-ended and open-ended questions. Where more detailed insights were needed, open-ended questions were used to support responses to closed-ended items.

During the data collection phase, a Computer-Assisted Personal Interviewing (CAPI) technique was employed. In this approach, the questionnaire was digitized and deployed via tablet devices using specialized software to facilitate real-time data entry and minimize errors. The data obtained through the surveys were processed and analyzed using SPSS version 22.0.

All quantitative and qualitative data derived from spatial assessments and face-to-face interviews were quantified on a five-point Likert scale, assigning scores ranging from 1 to 5. These data were then incorporated into the indicator tables developed for each criterion defined in the proposed model. For each criterion, the average scores of the corresponding objectives and sub-objectives were calculated to determine the level of achievement.

The achievement levels were categorized as follows based on average scores:

- 1.00–1.49: Very Poor
- 1.50–2.49: Poor
- 2.50–2.99: Below Average
- 3.00–3.49: Average
- 3.50–3.99: Above Average
- 4.00–4.49: Good
- 4.50–5.00: Very Good

In the final stage of the model's implementation, a comprehensive synthesis was conducted. This included spatial analysis results, survey data, and findings from in-depth interviews with various stakeholders: professionals involved in the project implementation process, current residents who remained in the area following the completion of the Dikmen Valley Housing and Environmental Development Project (DVHEDP), former residents who were relocated after the project, and community activists.

The assessment of social sustainability across the application area—which encompasses Phases I, II, and III of the DVHEDP—was conducted by evaluating the extent to which the objectives and sub-objectives outlined in the Social Sustainability Measurement and Evaluation Model were achieved.

4.4. Implementation of the Social Sustainability Indicator System in the Context of Dikmen Valley

The measurement and evaluation of social sustainability within the implementation area, encompassing Phases I, II, and III of the Dikmen Valley Housing and Environmental Development Project, are conducted by assessing the extent to which the objectives and sub-objectives defined in the Social Sustainability Measurement and Evaluation Model have been achieved. Within this framework, the indicator system criteria are as follows:

A. Demographics and Employment

B. Accessibility

C. Education and Skills

D. Health

E. Housing

F. Safety

G. Belonging

H.Participation

I. Social Capital and Social Cohesion

L. Urban Life Quality, Satisfaction And Adequacy Of Services

4.4.1. Demographics and Employment

In addition to revealing the general population profile of Dikmen Valley, the Demographics and Employment criterion is significant in relation to other model criteria, particularly regarding population dynamics, demographic change, development trends, and employment conditions. The objectives defined for this criterion are as follows (Table 3):

- TA(1.1) Ensuring a Balanced Distribution of the Population
- TA(1.2) TA(2) Ensuring the Balance of the Economic Well-Being of the Population

Table 3: Performance Scoring Table: Demographics and Employment

TA(1.1)) Ensuring a Balanced Distribution of the Population by Birthplace			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I(1) The level of distribution of the population by birthplace	The level of distance from the birthplace of the population to the ageing area	4.4	4.4
		TA (1) Mean	**4.4**
TA(2) Ensuring the Balance of the Economic Well-Being of the Population			
TA(2.1) Poverty Prevention			
I(2) Income level distribution of the population	The proportion of the population living below the poverty line	2.0	3.4
	The proportion of the population with a monthly income below the minimum wage	4.7	
TA(2.2) Provision of Employment Opportunities			
I(3) The level of employment of the population	I(4) The level of employment of the population	4.9	4.6
	The proportion of the working population	4	
	The proportion of the working population over 65	5	
TA(2.3) Ensuring Productivity in Employment			
I(4) The level of productivity of employment	Duration of Employment within the Same Organization	2.3	3.2
	Professional Skill Level	4	
TA(2.4) Ensuring Gender Equality in Employment Opportunities			

I(5) Gender equality level in employment opportunities	The ratio of the number of female employees to the number of male employees	1.9	3.6
	The ratio of average women's wages to male wages	4	
	The ratio of the number of unemployed women to the number of unemployed men	5	
		TA (2) Mean	**3.7**
		General Mean	**4.1**

Within the social sustainability indicator system, the achievement level of these two objectives is assessed based on five sub-targets, five indicators, and one indicator definition (Table 3).

According to the research findings, the sub-objective TA(1.1): Ensuring a Balanced Distribution of the Population by Birthplace was fulfilled at a score of 4.4, indicating a good level of achievement. Although the sub-objective TA(2.1): Poverty Prevention received an average score of 3.4 (moderate level), the specific indicator measuring the proportion of the population living below the poverty line was scored at 2.0, indicating a poor and inadequate level of performance. The sub-objective TA(2.2): Provision of Employment Opportunities was found to be fulfilled at a perfect level with a score of 4.6. While the sub-objective TA(2.3): Ensuring Productivity in Employment received an average score of 3.2, the indicator for Level of Tenure at the Same Workplace was rated at 2.3, which falls within the poor level. The sub-objective TA(2.4): Ensuring Gender Equality in Employment Opportunities was scored at 3.6, indicating a good level of achievement; however, the ratio of female to male employees was rated 1.9, corresponding to an upper-moderate level of achievement. Overall, objective TA(1), Ensuring a Balanced Distribution of the Population, was achieved at a reasonable level with a score of 4.4, while objective TA(2), Ensuring the Balance of the Economic Well-Being of the Population, was rated at 3.7, corresponding to an upper-moderate level (Table 3)

4.4.2. Accessibility

The second criterion of the Social Sustainability Measurement and Evaluation Model—Accessibility—serves not only to assess access to basic services but also to evaluate individuals' ability to meet essential needs and access relevant information. Accessibility is a crucial factor in enhancing social interaction and promoting positive social change and development. The objective defined for the Accessibility criterion is as follows:

- TB(1) Ensuring Equality of Access to Basic Urban Services

Within the social sustainability indicator system, the achievement of this objective is assessed through one sub-objective, one indicator, and five indicator definitions.

According to the research findings, the sub-objective TB(1.1) Ensuring Equality of Access to Social Infrastructure, Open Green and Urban Working, under the Accessibility criterion, was achieved with a score of 4.3, indicating a good level of fulfilment. Although the overall objective and sub-objective of the Accessibility criterion were met at a perfect level, the specific accessibility to healthcare facilities was found to be at a poor and insufficient level, with a score of 2.3 (Table 4).

Table 4: Performance Scoring Table: Accessibility

TB(1) Ensuring Equality of Access to Basic Urban Services		
TB(1.1) Ensuring Equality of Access to Social Infrastructure, Open Green and Urban Working		
Indicators	**Indicator Definitions**	**Score**
I(6) Access level to social infrastructure areas	Level of access to educational facilities	4.6
	Level of access to health facilities	2.3
	Level of access to cultural facilities	4.5
	Level of access to religious centres	4.9
	Level of access to green spaces	5
	General Mean	**4.3**

4.4.3. Education and Skills

The third criterion of the Social Sustainability Measurement and Evaluation Model—Education and Skills—is a key factor in enhancing societal capacity by improving the overall level of education, developing knowledge and competencies, and increasing employability. The objective defined for the Education and Skills criterion is as follows:

- TC(1) Individual and Social Education, Raising and Promoting The Level of Development

Within the social sustainability indicator system, the achievement of this objective is evaluated through three sub-objectives, five indicators, and five indicator definitions (Table 5).

Table 5: Performance Scoring Table: Education and Skills

TC(1) Individual and Social Education, Raising and Promoting The Level of Development			
TC(1.1) Raising literacy and education levels			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I(7) Literacy level	Adult literacy levels	5	4.5
I (8) Level of education	Latest graduated school levels	3.4	
I (9) Spatial adequacy level of educational facilities	The level of competence of the current situation is according to the standards of educational facilities that should be according to the population	5	
TC(1.2) Promoting Participation in Vocational Education			
I (10) Level of participation in vocational courses	Level of participation in existing vocational courses	1.0	1.0
TC(1.3) Promoting Participation in Talent Development Education			
I (11) Level of participation in talent development courses	Level of participation in existing talent development courses	1.0	1.0
		General Mean	**2.2**

According to the research findings, the sub-objective TC (1.1)- Raising literacy and education levels, under the Education and Skills criterion - was found to be at an outstanding level, with an average score of 4.5. However, the sub-objectives HC(1.2): TC(1.2) Promoting Participation in Vocational Education and HC(1.3): Promoting Participation in Skills Development Programs were both scored at 1.0, indicating an inferior level of achievement. Accordingly, the overall objective HC(1): TC(1.3) Promoting Participation in Talent Development Educations was

found to be at a poor level, with an average score of 2.2, indicating that the objective was not achieved (Table 5).

4.4.4. Health

The fourth criterion of the Social Sustainability Measurement and Evaluation Model—Health—is a critical component for maintaining both individual and societal quality of life, as well as the continuity of community-level activities. The objective defined for the Health criterion is:

- TD(1) Ensuring the Adequacy of Health Services

Within the social sustainability indicator system, the achievement level of this objective is assessed through one sub-objective, two indicators, and three indicator definitions (Table 6).

According to the research findings, the objective TD (1), Ensuring the Adequacy of Health Services, was found to be at a poor and insufficient level, with an average score of 2.05 (Table 6).

Table 6: Performance Scoring Table: Health

TD(1) Ensuring the Adequacy of Health Services			
TD(1.1) Ensuring the Adequacy of Health Services			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I(13) Spatial adequacy level of health facilities	The level of adequacy of the current situation is according to the standards of health facilities should be according to the population	1.3	1.3
I(14) Level of access to healthcare	The level of access of local people to health services	3.8	2.8
	The distance level of the health institution to the area that the local people access when they have health problems	1.8	
		General Mean	**2.05**

4.4.5. Housing

The fifth criterion of the Social Sustainability Measurement and Evaluation Model—Housing—is a vital component for sustaining individual and collective daily life activities, as well as for ensuring the continuity of social capacity.

The objective defined for the Housing criterion is:

- TE(1): Ensuring Adequate Housing Conditions for All

Within the social sustainability indicator system, the achievement of this objective is assessed through two sub-objectives, three indicators, and three indicator definitions (Table 7).

According to the research findings, the sub-objective TE(1.1): Increasing Housing Capacity was rated at 3.75, indicating an upper-moderate level of fulfilment.

Similarly, the sub-objective TE(1.2): Improving the Physical Condition of Housing Units received a score of 3.95, also reflecting an upper-moderate level. Accordingly, the main objective TE(1), Ensuring Adequate Housing Conditions for All, was fulfilled at an upper-moderate level with a score of 3.85, indicating that the objective was successfully achieved (Table 7).

Table 7: Performance Scoring Table: Housing

TE(1) Ensuring Housing Conditions for All			
TE(1.1) Ensuring Increasing Housing Capacity			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I (15) Property status of the houses	The ratio of homeownership to tenancy	5	3.75
I (16) The level of affordability of rents with household income	The ratio of average housing rent to average household income	2.5	
HE(1.2) Improving the Physical Condition of Housing			
I (17) Physical condition of the houses	Building status levels of houses	3.95	3.95
		General Mean	**3.85**

4.4.6. Safety

The sixth criterion of the Social Sustainability Measurement and Evaluation Model—Safety—is a crucial component for maintaining both individual and societal life activities, as well as for the continued and safe use of urban space.

The objective defined for the Safety criterion is:

- TF(1): Ensuring Individual Safety

Within the social sustainability indicator system, the achievement level of this objective is evaluated through one sub-objective, three indicators, and seven indicator definitions (Table 7).According to the research findings, the sub-objective TF (1.1): Ensuring Safety in Public and Private Areas was found to be fulfilled at a satisfactory level, with an average score of 4.1. Consequently, the main objective, TF(1): Ensuring Individual Safety, was determined to have been successfully achieved (Table 8).

Table 8: Performance Scoring Table: Safety

TF(1) Ensuring Individual Safety			
TF(1.1) Ensuring Security in Public Spaces and Private Areas			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I (18) Level of security in housing	Level of feeling safe in residences during the day	4.45	4.4
	Level of feeling safe in residences at night	4.3	
I (19) Level of security in public spaces	Level of feeling safe walking on the road during the day	4.25	4.0
	Level of feeling safe walking on the road at night	3.7	
	Level of feeling safe in public spaces during the day	4.05	
	Level of feeling safe in public spaces at night	3.85	
I (20) Level of trust in neighbourly relationships	Level of trust in neighbours	4.1	4.1
		General Mean	**4.1**

4.4.7. Belonging

The seventh criterion of the Social Sustainability Measurement and Evaluation Model—Belonging—is a key component that strengthens individual, spatial, and societal responsibility. It plays a crucial role in establishing and reinforcing connections between people and the places and communities they inhabit, thereby supporting social sustainability. The objective defined for the Belonging criterion is:

- TG(1): Ensuring the Acquisition of Social and Spatial Belonging, Urban Image Awareness, and Cultural Heritage Values

Within the social sustainability indicator system, the achievement of this objective is evaluated through three sub-objectives, four indicators, and six indicator definitions.

According to the research findings, the sub-objective TG(1.1): Ensuring Social and Spatial Belonging was rated at 3.5, reflecting an upper-moderate level of achievement.

The sub-objective TG(1.2): Creation Urban Image Awareness scored 3.95, also indicating an upper-moderate level. In contrast, the sub-objective TG(1.3): Creating Awareness of Conservation of Heritage Values was rated at 1.7, which reflects an inferior and insufficient level. As a result, the main objective, Ensuring the Acquisition of Social and Spatial Belonging, Urban Image Awareness, and Cultural Heritage Values (HG (1)), was found to be achieved at a moderate level, with an average score of 3.05 (Table 9).

Table 9: Performance Scoring Table: Belonging

TG(1) Ensuring the Acquisition of Social, Spatial Belonging, Urban Image, and Heritage Values			
TG(1.1) Ensuring Social and Spatial Belonging			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I (21) The level of belonging of local people to the society they live in	The level of local people's feeling like part of society	4.0	3.5
I(22) The level of the local people's sense of belonging to the area where they live	The level of life expectancy in the area	2.4	
	The level of feeling of belonging to the place they live	4.0	
TG(1.2) Creation of Urban Image Awareness			
I (23) Awareness level of local people about the changing conditions of the area	The level of desire for the area to improve its urban image	3.9	3.95
	The level of thinking that the urban image of the area has improved with the project	4	
TG(1.3) Creating Awareness of Conservation of Heritage Values			
I (24) Level of activities that contribute to the conservation of heritage values	Level of awareness of activities related to the protection of natural heritage in the area of living	1.7	1.7
		General Mean	**3.05**

4.4.8. Participation

The eighth criterion of the Social Sustainability Measurement and Evaluation Model—Participation—is a vital component of social sustainability, as it enhances individual, spatial, and societal responsibility and supports the establishment and integration of relationships between people and their living environments. The objective defined for the Participation criterion is:

- TH(1) Promoting Public Participation in Management, Planning Processes, and Works Related to Municipal Services

Within the social sustainability indicator system, the achievement of this objective is assessed through three sub-objectives, six indicators, and seven indicator definitions.

According to the research findings, the sub-objective TH(1.1) Ensuring Participation in Country and Local Government received a score of 4.8, indicating a very high level of achievement. However, the sub-objective TH(1.2) Ensuring Public Participation in the Planning Process was rated 1.0, and the sub-objective TH(1.3) Ensuring Transparency in Works Related to Municipal Services was rated 1.1, both reflecting an inferior level of performance. Consequently, the overall objective TH(1) Promoting Public Participation in Management, Planning Processes, and Works Related to Municipal Services was found to be not achieved, with an average score of 2.3, corresponding to a poor level of fulfilment (Table 10).

Table 10: Performance Scoring Table: Belonging

TH(1) Promoting Public Participation in Management, Planning Processes, and Works Related to Municipal Services			
TH(1.1) Ensuring Participation in Country and Local Government			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I (25) Level of participation in the country's administration	Level of participation of local people in general elections	4.8	4.8
I (26) Level of participation in local government	Level of participation of local people in local elections	4.8	
TH(1.2) Ensuring Public Participation in the Planning Process			
I (27) Level of public participation in the project design process	Level of participation of local people in the project design process	1	1
I (28) Level of public participation in the completion of the final project	Level of participation of local people in the completion of projects	1	
I (29) Level of public participation in the monitoring process of the project	Level of participation of local people in monitoring of projects	1	
	The level of ability of local people to influence the decisions made in the area where they live	1	
TH(1.3) Ensuring Transparency in Works Related to Municipal Services			
I (30) Level of knowledge of local people about municipal works	Level of informing the local people about the municipal work	1.1	1.1
		General Mean	**2.3**

4.4.9. Social capital and social cohesion

The ninth criterion of the Social Sustainability Measurement and Evaluation Model—Social Capital and Social Cohesion—is a key element of social sustainability. It reflects individuals' sense of belonging to their community, their involvement in local initiatives, participation in collective social efforts, and engagement with others in their environment. The objectives defined for the Social Capital and Social Cohesion criterion are:

- TI(1) Ensuring The Level of Social Development and Social Interaction
- TI(2) Ensuring Diversity and Cultural Integration

Within the social sustainability indicator system, the achievement of these objectives is evaluated through three

sub-objectives, five indicators, and eight indicator definitions.

According to the research findings, the sub-objective TI(1.1) Increasing Social Development was found to be at an inferior level, with an average score of 1.0. The sub-objective TI(1.2) Level of Social Interaction received a score of 2.8, indicating a lower-moderate level. Consequently, the main objective, TI(1) Ensuring the Level of Social Development and Social Interaction, was not achieved, with an overall average of 1.9, corresponding to a poor level.

Additionally, the sub-objective TI(2.1) Ensuring Cultural Diversity and Cultural Integration was rated at 1.4, indicating a very poor level, and the main objective TI(2) Ensuring Diversity and Cultural Integration was also found not to be achieved (Table 11).

Table 11: Social capital and social cohesion

TI(1) Ensuring The Level of Social Development and Social Interaction			
TI(1.1) Increasing Social Development			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I(31) Level of participation in information studies	Level of participation in the information studies organized about the area of living	1	1
I (32) Level of participation in social awareness studies	Level of participation in social awareness studies	1	1
	Level of voluntary involvement in any association/non-governmental organization (NGO)	1.1	
	Level of involvement in an association related to the Dikmen Valley Housing and Environmental Development Project (DVHEDP	1	
		TI (1.1) Mean	**1**
TI(1.2) Level of Social Interaction			
I(33) Level of interaction in public space	Level of going to public space	1.6	2.1
	Level of communication with neighbours in public space	2.6	
I(34) Level of social interaction by gender	The ratio of men who go to the public space to women who go to the public space	3.5	3.5
		TI (1.2) Mean	**2.8**
		TI (1) Mean	**1.9**
TI(2) Ensuring Diversity and Cultural Integration			
TI(2.1) Ensuring Cultural Diversity and Cultural Integration			
I(35) Level of the interaction of people of different cultural structures	Level of collaboration with people of different ethnic backgrounds/identities	1.4	1.4
		TI (2) Mean	**1.4**
		General Mean	**1.7**

4.4.10. Urban life quality satisfaction and adequacy of services

The tenth criterion of the Social Sustainability Measurement and Evaluation Model— Urban life quality satisfaction and adequacy of services—is a critical element of social sustainability, as it contributes to individual and societal well-being, happiness, equity, and a sense of sufficiency.

Table 12: Social capital and social cohesion

TL(1) Ensuring the Satisfaction of the Local People in the area they live in and the Adequacy of the Services Provided			
TL(1.1) Ensuring Satisfaction with the Quality of Urban Life			
Indicators	**Indicator Definitions**	**Score**	**Mean**
I(36) Level of satisfaction with environmental quality	Level of satisfaction with the quality of the natural environment	3.8	3.8
	Level of satisfaction with the quality of the built environment	3.8	
I(37) Level of satisfaction with housing and living conditions	Level of satisfaction with the standard of housing	4.3	4.2
	Level of satisfaction with the residence	4.2	
	Level of satisfaction with living conditions	4.2	
I(38) Level of satisfaction with social areas	Level of satisfaction with open and green areas	4.1	4.0
	Level of satisfaction in sports areas	3.7	
	Level of satisfaction in the religious areas	4.0	
I(39) Level of satisfaction with economic opportunities	Level of satisfaction with employment opportunities	3.6	3.6
I(40) Level of satisfaction with safety conditions	Level of satisfaction with personal security	4.0	4.0
I(41) Satisfaction level of participation in decision-making processes related to the area of living	Level of participation in decision-making processes and planning related to the area of living	3.3	3.3
		TL(1.1) Mean	**3.8**
TL(1.2) Ensuring the Adequacy of Urban Services			
I(42) Adequacy level of educational services	Adequacy level of educational services	3.5	3.3
	Adequacy level of cultural facilities	3.4	
	Adequacy level of library services	3.0	
I(43) Adequacy level of recreation areas	Adequacy level of entertainment areas and areas for spending time	3.6	3.6
I(44) Adequacy level of economic opportunities	Adequacy level of employment opportunities	3.4	3.4
I(45) Adequacy level of social services	Adequacy level of social services	3.5	3.5
		TL(1.2) Mean	**3.5**
		General Mean	**3.6**

The objective defined for this criterion is:

- TL(1) Ensuring the Satisfaction of the Local People in the area they live in and the Adequacy of the Services Provided

Within the social sustainability indicator system, the achievement of this objective is evaluated through two sub-objectives, ten indicators, and seventeen indicator definitions.

According to the research findings, the sub-objective TL(1.1), Ensuring Satisfaction with the Quality of Urban Life,

was scored 3.8, and the sub-objective TL(1.2), Ensuring the Adequacy of Urban Services, was scored 3.5, both corresponding to an upper-moderate level of achievement. Consequently, the main objective TL(1), Ensuring the Satisfaction of the Local People in the area they live in and the Adequacy of the Services Provided, was determined to be achieved, with an average score of 3.6, indicating an upper-moderate level of fulfilment (Table 12).

4.4.10. Result and Discussion

According to the research findings, within the implementation area of the Dikmen Valley Housing and Environmental Development Project (DVHEDP), the criteria of the social sustainability indicator system were evaluated based on their average scores. The criteria of Demographics and Employment (4.1 points), Accessibility (4.3 points), and Safety (4.1 points) were found to be at a reasonable level, with average scores exceeding 4.

The criteria of housing (3.85 points) and urban life quality satisfaction and adequacy of services (3.6 points) were determined to be at an upper-moderate level.

The Belonging criterion scored 3.05, corresponding to a moderate level. In contrast, the criteria of Education and Skills (2.2 points), Health (2.05 points), Participation (2.3 points), and Social Capital and Social Cohesion (1.7 points) were identified as being at a poor level of achievement (Figure 5).

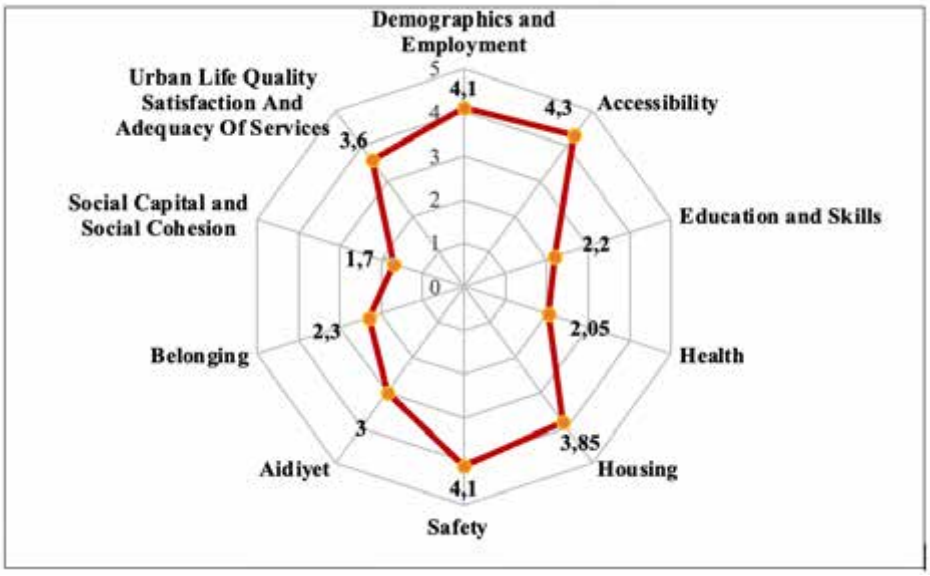

Figure 5: Assessment Scores of the Social Sustainability Indicator Framework

According to the research findings, within the implementation area of the Dikmen Valley Housing and Environmental Development Project (DVHEDP), the criteria of Demographics and Employment, Accessibility, and Safety achieved high average scores. They were determined to be at a reasonable level, indicating that the corresponding objectives and sub-objectives were successfully met.

In terms of Demographics and Employment, it was found that before the implementation of DVHEDP, the area was an informal settlement. Following the project, the original right holders began residing in planned housing, which resulted in a homogeneous population structure in terms of population balance and economic welfare, with limited heterogeneity.

For the Accessibility criterion, the integration of social infrastructure within the project's planning boundaries and surrounding areas ensured that the population's needs were met within walking distance.

The Safety criterion was also met, mainly due to the presence of security personnel in building complexes and gated areas developed under DVHEDP, as well as the restriction of unauthorized access to these zones.

Regarding Housing and Urban life quality satisfaction and adequacy of services, the criteria were found to be at an upper-moderate level. All buildings in the area were newly constructed as part of the DVHEDP, leading to an improvement in their physical condition. High homeownership rates contributed to achieving housing capacity objectives. The findings for Urban Quality of Life and Services reflect satisfaction with environmental quality, housing and living conditions, recreational areas, and safety—demonstrating the spatial benefits of the DVHEDP.

Although the Sense of Belonging criterion met its objectives and sub-objectives at a moderate level, the lack of awareness regarding the preservation of heritage values within the area was identified as a shortcoming. Given the valley's natural and ecological significance, it is necessary to increase residents' awareness and engagement in preserving the area.

The criteria that failed to achieve the defined objectives and sub-objectives in terms of social sustainability include Education and Skills, Health, Participation, and Social Capital and Social Cohesion, each scoring poorly.

For Education and Skills, despite the relatively low number of employed women in the area, participation in vocational and skill development programs was almost non-existent. This harmed the overall level of personal and community development. Promoting participation in such programs is essential to improving this criterion.

In the Health criterion, the lack of sufficient health facilities within the effective service radius and the distant location of existing health institutions from the population were the primary reasons for failing to meet health-related objectives. Although new facilities were proposed in the DVHEDP master plan, they were not implemented. Ensuring the construction of appropriately scaled facilities is essential for fulfilling the criteria's goals.

Under the Participation criterion, while residents were found to engage in national and local governance, they did not actively participate in neighbourhood-related planning processes. Therefore, the sub-objectives related to citizen involvement in planning and transparency in municipal services were not achieved. Encouraging and enabling participation in these processes is a key requirement for social sustainability.

Lastly, Social Capital and Social Cohesion were the weakest-performing criteria, with none of its sub-objectives being met. Actions aimed at enhancing social development interaction and promoting cultural diversity and integration are urgently required to strengthen this dimension.

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Rethinking Social Inclusivity. The Case of Urban Villages in Delhi

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Abstract
This study analyses the socio-spatial inclusion and exclusion of Delhi's urban villages under the framework of inclusive and safe urban development. Unlike slums, urban villages receive limited policy attention, despite their important role in housing rural migrants and supporting local economies. Their exclusion from official planning makes them vulnerable to marginalisation or gentrification. Using a qualitative technique, the study combines policy analysis with comparative case studies of Hauz Khas and Zamrudpur. Findings reveal a gap between policy intent and implementation, facilitated by fragmented governance, dated planning regulations, and inadequate finance. The two cases illustrate distinct outcomes driven by selective planning, political influence, and administrative neglect. The paper recommends for a context-sensitive, participatory planning acknowledging unique characteristics of urban villages, along with inclusive, localised policy reform.

Keywords: Socio-Spatial Inclusion; Urban Village; Gentrification; Marginalisation; Inclusive Planning Policies; Participatory Planning

Introduction

Urban Village Exclusion: A Global Issue

In the recent years, urban villages—former rural villages now encroached by cities, have garnered increased attention in urban studies, notably in cities in global South (Wang, 2022). Found predominantly in India, China and other Southeast Asian countries, urban villages are often viewed as informal settlements, arising from rapid urbanisation (Banerjee, 2021, Chen et al., 2023, Kochan, 2015, Tong et al., 2021, Wang, 2021) and large scale rural-to-urban migration (Al, 2023, Zhang, 2021, Tan et al., 2019). These settlements exist at the intersection of rural and urban systems and are typified by dense mixed-use development (Banerjee, 2021, Islam, 2023, Lin and de Meulder, 2011) with dark and narrow streets (Al, 2023, Qu, 2020, Zhang, 2021), inadequate infrastructure, and substandard rental housing (Wang, 2022, Tong et al., 2021, Spreeuwers, 2014). Given these physical characteristics, urban villages and their residents often face socio-spatial segregation within broader urban fabric.

In addition to their physical characteristics, urban villages experience socio-economic marginalisation. Many urban villagers, particularly rural migrants, lack recognition as "citizens," limiting their access to economic, social, political, and cultural spheres, making their integration into cities difficult (Cappo, 2002). This is further aggravated by internal stratification among urban villagers, which increases existing social disparities. According to He et al. (2010), rural migrants who make up for a significant portion of the urban village population are at the bottom of the social structure, while indigenous villagers who own land assume the role of petty landlords, benefitting from rental income. Furthermore, existing research have documented socio-economic exclusion of urban villagers, particularly rural migrants, who incur structural barriers across multiple domains. Their access to legal housing is limited (Lin et al., 2015) due to the lack of formal employment opportunities as a consequence of low education levels (Yu and Wu, 2021, Zhang, 2021). Furthermore, their political representation is overlooked, often hampered by discriminatory institutional systems (Li and Sun, 2021, Ren, 2018, Wong et al., 2018).

While socio-economic exclusion is well-documented, the spatial exclusion of urban villages remains an equally pressing issue. Despite being an important part in the local economy and offering affordable housing (Islam, 2023, Liu et al., 2018, Chen et al., 2023, Spreeuwers, 2014), urban villages are systematically excluded from formal urban planning frameworks (Banerjee, 2021). This exclusion is perpetuated by urban governance structures that either neglect these areas or impose restrictive planning controls. Bureaucratic inefficiencies, such as time-con-

suming land title registration (Tong et al., 2021), further hamper their integration. Discriminatory practices like China's hukou or household registration system limits rural migrants' access to formal housing and services, aggravating urban villages' marginalisation (Chen et al., 2023, Zhang, 2021). Wu et al. (2020) underscore that despite urban villages falling within the city or the officially designated urban growth boundary (UGB) they are excluded from the urban service boundary (USB), which defines the extent of municipal service provision. This deliberate exclusion reinforces a cycle of informality, socio-spatial inequality and constant marginalisation. Market-driven urban redevelopment strategies further compound the problem, prioritising financial benefits over social inclusion and often resulting in the displacement of vulnerable populations (Liu et al., 2018). Gentrification processes, spurred by urban renewal projects, frequently transform urban villages to attract wealthier demographics while alienating lower-income residents (Davidson and Lees, 2005, Song et al., 2008). This phenomenon underscores the increasing overlap between social and spatial exclusion, emphasising the need for integrative planning approaches to mitigating urban inequalities.

Role of Planning in Exclusion

In many Global South cities, urban planning frameworks fail to integrate urban villages into formal urban development strategies. Strategic planning measures for their inclusion are either poorly articulated or entirely absent from master plans (Thinh et al., 2024). Zoning and planning regulations play a pivotal role in shaping urban villages (Wu et al., 2022), often determining whether they are integrated or excluded from the broader urban fabric. As a top-down regulatory framework, zoning governs land use through bureaucratic controls such as restrictive land-use conditions, complex planning permissions, and rigid development bylaws. These mechanisms are embedded in urban governance instruments, including development plans, building codes, deed restrictions, and transferable development rights (Geyer, 2024). However, in many Global South nations, zoning laws have been inherited from colonial-era planning systems with minimal adaptation to contemporary socio-economic contexts. Many African and Asian countries, including India, continue to rely on outdated master planning and zoning frameworks introduced during colonial rule (Watson, 2009). These rigid regulatory structures fail to accommodate the needs of marginalised urban populations, limiting their access to tenure security and formal economic opportunities (Devas, 2001).

Instead of promoting inclusion, zoning and planning rules often displace vulnerable groups, prompting them to informal settlements such as Brazil's favelas, Bogota's barrios, India's jhoppad-pattis, functioning beyond the regulations (Mangin, 2014, Nel, 2016). Once zoning regulations are enforced in these areas, residents face costly and impractical regularization measures that further deepen socio-economic inequalities (Geyer, 2024, Pennington, 2000). The exclusionary nature of these policies necessitates a critical reassessment of how zoning and planning mechanisms impact urban village development. Policymaking plays a decisive role in determining whether urban villages are included or excluded from formal urban systems. When zoning laws and planning regulations are designed with inclusion in mind, however, they can facilitate tenure security, improve infrastructure provision, and support social mobility for marginalised communities. Conversely, exclusionary policies reinforce urban iequalities by limiting access to public services, employment hubs, and civic participation. Addressing these systemic challenges requires a paradigm shift in urban governance—one that prioritises inclusion over market-driven imperatives (Lens, 2022).

In the light of the above challenges, this study aims to bridge the identified gaps by examining the central research inquiry: How do existing regulatory tools and planning policies influence the socio-spatial inclusion and exclusion of urban villages within the broader urban fabric? The specific objectives addressed include: (1) analysing policy gaps in existing regulatory tools and planning policies governing urban villages; (2) identifying key stakeholders and their role in shaping urban villages; (3) assessing policy outcomes that contribute to socio-spatial exclusion of urban villages; and (4) proposing policy recommendations for fostering integration of urban villages through inclusive zoning, planning and urban governance mechanisms. To achieve these objectives, this study employed a systematic policy review and comparative case study approach to inform inclusive policy reforms that enhance urban governance and integrate urban villages.

Methodology

This study used a two-phase method that combined a policy review with comparative case study approach (Yin, 2009) to analyse the planning policies and regulatory tools that impact urban village's socio-spatial inclusion. In India, urban villages, often occur in grey areas of urban planning systems, experiencing exclusionary planning practices that impede their inclusion into formal city frameworks. The study aimed at understanding how urban planning instruments, such as master plans and zoning regulations affect these communities. The first phase included a thorough analysis of 'pre-textual sources' (Morgan, 2022), like land-use policies, government documents, and planning policies pertaining to urban villages in Delhi NCT. A systematic search method was utilised to collect policy papers from official government websites, with an emphasis on policies that have historically and now governed urban villages. The second phase included a comparative case study (Bartlett and Vavrus, 2017, Yin, 2009), concentrating on two urban villages in Delhi: Hauz Khas Village (HKV), a gentrified neighbourhood, and Zamrudpur, a marginalised village. The case study sites were chosen for their distinct socio-spatial, economic, and cultural qualities, which provide insights into how similar regulatory frameworks result in disparate outcomes in urban integration. This comparative analysis sought to emphasise the influence of planning strategies in either reinforcing or alleviating urban inequality.

The study employed the Institutional Analysis and Development (IAD) framework (Kiser and Ostrom, 1982, Polski and Ostrom, 1999) an analytical tool for data analysis (Figure 1). This paradigm is intended to help researchers better understand the interplay between governance, actors, and the external factors that influence policy outcomes. It focuses on the "action arena," where policy decisions are made and influenced by three external variables: biophysical conditions, community characteristics, and rules in use. For this study, the bio-physical conditions refer to characteristics of urban villages, rules-in-use are formal planning policies and regulations governing urban villages. The action arena is the urban village policymaking, where policies are formulated, and decisions are made by key actors or decision-makers. The pattern of interactions has been revised to stakeholder interactions, to understand the relationships and differences between key actors, which can aid in identifying management gaps. Finally, the outcomes of these policies were assessed through comparative case study approach, by analysing baseline reports, and other grey sources discussing the implications and effectiveness of these regulatory tools. Based on the assessment, policy reforms were recommended aimed at modifying the exogenous factors like rules-in-use, to reshape the action area i.e., policymaking landscape to enable inclusive and effective policy enforcement for Delhi NCT's urban villages. In conclusion, the adoption of IAD framework helped in identification of policy gaps, stakeholder interactions and interests hindering inclusion of urban villages. The IAD framework was used during both the policy review and comparative case study phases. The study followed a qualitative thematic analysis using NVivo software for data coding. The study revealed reoccurring themes, sub-themes, and gaps in policy implementation. Thematic analysis was carried out using Braun and Clarke (2006) six-phase approach: data familiarisation, code creation, theme search, theme review, theme definition, and reporting findings. This method enabled a thorough understanding of how policies reinforced exclusion or promoted inclusion in urban villages.

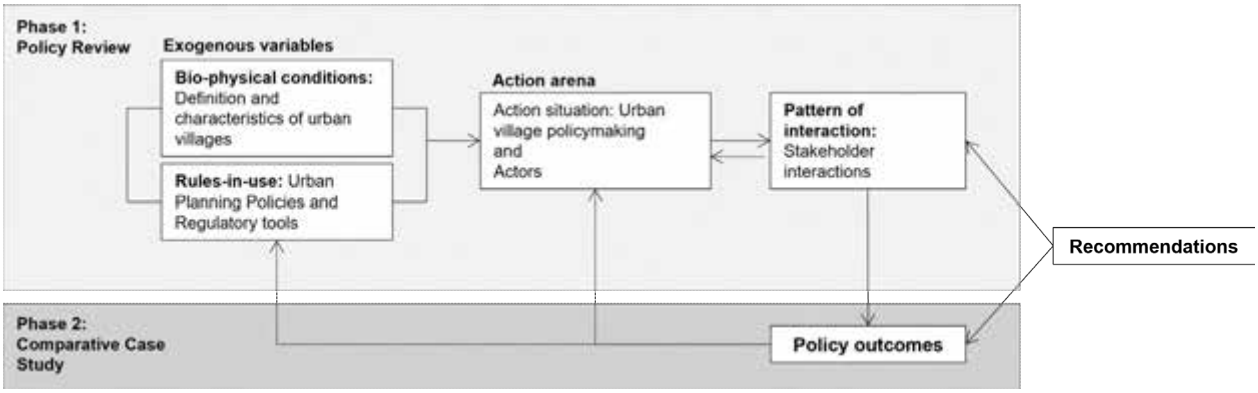

Figure 1 The IAD framework for structuring policy review.
(Source: Adapted from Ostrom (2005); grey square added by Author).

Findings

India's urban planning system is structured as a hierarchy of statutory and non-statutory plans that are developed in response to evolving planning needs, legal mandates, and traditions (TCPO, 2015). These include the Perspective Plan, Regional Plan (RP), Development Plan (e.g., Master Plan, City Development Plan), and Local Area Plan (LAP), which operate at various spatial levels and increase in detailing with descending hierarchy (Kundu et al., 2019), as illustrated in Figure 2. Perspective Plans establish long-term objectives at the national, state or regional level, whereas Regional Plans combine state and national resources at the metropolitan or district level. Development Plans address city-wide policies, while Zonal Plans and LAPs govern zones and neighbourhood-level planning. Furthermore, Special Area or Purpose Plans address context-specific issues, while Annual Plans developed by local bodies assist in project implementation and budget allocations (TCPO, 2015). In accordance with this hierarchy, this study reviewed important regulatory instruments influencing Delhi's urban villages. These were the NCR Regional Plans, the Delhi Sub-Regional Plan, the Delhi Master Plan, and the Zonal Development Plans, as highlighted in blue in Figure 2. Special Area Plans and frameworks tailored to each urban village were also considered. This multi-tiered policy research sought to identify policy flaws, operational gaps, and socio-spatial impacts affecting the inclusion or exclusion of urban villages in Delhi's overall planning framework.

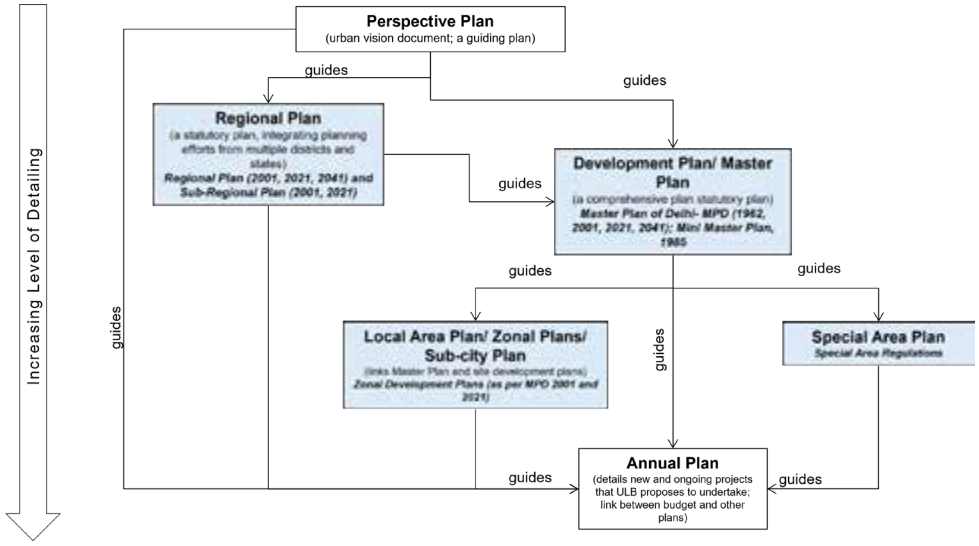

Figure 2 Types of plans and their inter-relationships in India (Source: Author's compilation).

Variable I: How are Urban Villages Discussed within the Existing Rules-in-Use?

Within the existing rules-in-use, Delhi's urban villages are often classified as unplanned settlements in legal documents like the MPDs and ZDPs, suffering from inadequate infrastructure, low housing quality, and a lack of regulatory control (DDA, 2021b, DDA, 2007a, DDA, 2011). These settlements have emerged from the British-era Lal Dora notification, which exempted them from building regulations with the intention of preserving rural identity, in unregulated development and spatial separation from adjacent urban areas (MoUD, 2007). Today, 135 urban villages in Delhi are centres for affordable housing, predominantly housing labour migrants. They also serve as hub for small-scale businesses, yet these villages are politically ignored and excluded from mainstream urban development (MoUD, 2007, GNCTD, 2024).

Variable II: The Rules-in-Use: Key Planning Instruments and Policies

The Foundational Planning Frameworks: Regional, and Sun-Regional Plans

The examination of Delhi's planning tools found several policy gaps, particularly in terms of socio-spatial integration. The NCR Regional Plans, which serve as the foundation for urban planning in the National Capital Region (NCR), only briefly address urban villages. The Regional Plan-2001 focused on regional development but disregarded urban villages, classifying them as rural (NCRPB, 1988). The following RP-2021 made minor attempts to incorporate urban villages by focusing on infrastructure improvements through public-private partnerships (PPP) modes but without planning strategies for their development or integration (NCRPB, 2005). The latest plan, RP-2041, explicitly acknowledged the existence of urban villages , and suggested redevelopment and conservation measures tailored to their distinct needs and characteristics, such as heritage preservation and environmental considerations for communities in sensitive locations like riverbed (NCRPB, 2021). However, these plans did not effectively address these communities' socio-spatial, and cultural dynamics, limiting the potential for significant urban transformation.

At the sub-state level, the Sub-Regional Plans (SRPs), developed under the NCRPB Act, 1985, serve as an intermediate plan translating the objectives of Regional Plans (RPs) into feasible proposals. The NCR Planning Board mandates all participating states to develop SRPs to integrate planning efforts with the larger objective of balanced regional development (DDA, 1994a). In Delhi NCT, the SRPs were prepared by DDA (NCR Planning Cell), aligned with the objectives of the Regional Plans 2001, and 2021, respectively. The SRP-2001 aimed to relieve the capital's urbanisation pressures by projecting its demands into the larger Regional Plan, consequently influencing the Master Plans and SRPs of neighbouring NCR states (DDA, 1994a). Like RP-2001, SRP-2001 did not acknowledge urban

villages' existence. The plan had primarily concentrated on the urban and rural areas, ignoring the transitional and informal characteristics of urban villages, thereby excluding them from formal planning document (DDA, 1994a).

In contrast, the SRP-2021 conformed with the aim of RP-2021, acknowledged the urban villages, particularly in the context of demographic shifts. Between 1991 and 2011, Delhi experienced decline in rural population from 11% to 2%, this can be attributed to reclassification rural villages as urban as per Master Plan-2021. Also, with land pooling scheme in pipeline, the plan anticipates all existing villages will become urban villages (DDA, 2021a). Despite their official recognition in SRP-2021, substantial policy and data gaps persists. The plan did not provide population data or socio-economic profiles for urban villages, unlike its detailed treatment of slums and unauthorised colonies[1]Furthermore, the plan stereotyped urban villages as one of the sources for encroachment, and unplanned development near heritage precincts like Shahjahanabad, Mehrauli, and Tughlaqabad, highlighting negative perceptions and lack of inclusion DDA (2021a). Overall, while SRP-2021 marked a change toward acknowledging urban villages in planning debate, it fell short of providing a viable framework for their growth. Both Regional and Sub-Regional Plans lacked a comprehensive knowledge of how urban villages fit into Delhi's urban framework. Their continuing marginalisation, whether through omission or unfavourable portrayal, highlighted a persistent gap between planning strategy and ground realities.

Provisions under Master Plans: Evolution of Urban Village Policies

The Master Plan Delhi (MPD) have gradually addressed urban villages, with each update reflecting changes in administration, urbanisation, and policy objectives. These urban villages, which are frequently viewed as marginalised pockets, have undergone substantial transformations in both policy discourse and urban planning practice, but in inconsistent ways. The following describes the evolution of provisions for urban villages in several Master Plans, aligning with broader Regional and Sub-Regional Plans, highlighting key issues and developments.

The First Master Plan for Delhi formulated in 1962 (or MPD 1962) was designed to control the city's expansion in response to the population influx post-partition. The goal was to guide urban expansion using land use zoning and spatial consolidation for an estimated population of 5 million by 1981 (DDA, 1962). The plan divided Delhi into eight planning zones, with an additional zone for rural areas in Outer Delhi. It emphasised on large-scale land acquisitions, structured zoning, and infrastructure development to meet projected population growth. However, the MPD 1962 overlooked urban villages, regarding them as rural areas, and sites for non-polluting industries and rural trades like dairy and cow farming (DDA, 1962). In the following year 1963, an exemption notification by the MCD, permitted urban village residents to develop structures without legal authorisation from governing agencies. This resulted in unchecked growth, congestion, and increased migration, altering the socio-economic and spatial landscape of urban villages (MoUD, 2007).

In 1985, the Government of National Capital Territory of Delhi (GNCTD), drafted a Mini Master Plan for the planned development of rural areas, including 135 urban villages. The strategy aimed to prevent unregulated expansion and promote the orderly development of urban villages by abolishing the Lal Dora system and requiring the adoption of municipal regulations for construction activities (GNCTD, 1985). It advocated incorporating urban villages into the Delhi Development Authority's (DDA) development limits, as well as the introduction of land use policies to regulate the villages' increasing industrial activity. Furthermore, the plan also proposed a gradual redevelopment strategy for urban villages, with a focus on infrastructure upgrades, integration with adjacent planned areas, and the implementation of village-specific building codes (GNCTD, 1985). However, a lack of regulatory clarity and a failure to apply the suggested building regulations resulted in the prolonged neglect and marginalisation of urban villages. The intended policy framework was left in uncertainty, and urban villages were excluded from the larger urban transformation effort.

1 Unauthorised colonies refer to residential areas in Delhi that have developed in violation of the city's master plan regulations.

MPD 2001: A Shift in Acknowledgment of Urban Villages

The Second Master Plan-2001 (MPD 2001) identified urban villages in a more structured way, including them into the larger framework of the Delhi Metropolitan Area (DMA) (DDA, 1990). The MPD attempted to address the housing needs of informal settlements, including urban villages, and encompassed a variety of planning zones, such as heritage zones and periphery rural areas. The plan focused on physical infrastructure, health, and education services in certain regions, while also acknowledging the need for transforming urban communities and preserving their traditional lifestyles (DDA, 1990). However, the rules for urban villages in the MPD 2001 were ambiguous and lacked clear planning guidance. The plan advocated for 'sensitive treatment' and the provision of new amenities while retaining cultural identity, but it did not offer tangible solutions for integration. Urban villages were left with few alternatives for planning, particularly in places with inconsistent land ownership, dense built form, and insufficient infrastructure.

MPD 2021: A Progress Toward Integration

The Third Master Plan (MPD 2021) aimed to transform Delhi into a global metropolis and a world-class city. This version of the plan identified urban villages as crucial components of Delhi's urban fabric, highlighting their distinct socio-economic and spatial qualities. It permitted small-scale businesses within villages, encouraged mixed-use regulations, and relaxed group housing standards to accommodate the compact, organic structure of urban villages. Furthermore, the plan established requirements for public facilities, enabling the efficient supply of services in limited spaces (DDA, 2007a). The plan designated the urban villages and its extension areas under residential zones, even though they did not fall under the standard land-use classification. Furthermore, it identified pedestrian-friendly commercial streets, and mixed-use corridors, highlighting the vital role of urban villages in supporting local economies (DDA, 2007a). The plan additionally recommended the Land Pooling Model for land assembly and infrastructure development, highlighting a move towards more inclusive and adaptive urban planning. However, MPD-2021 had certain implementation flaws. While the master plan developed foundations for integrating cities, their implementation remained aspirational, slowed by policy formation delays and regulatory uncertainty. The plan indicated a trend toward acknowledging the urbanity of Delhi's urban villages, but it failed to transform these objectives.

MPD 2041: Shift towards Sustainable Development and Heritage Integration

The MPD 2041, which was implemented in 2021, sought to make Delhi a sustainable, liveable, and vibrant city. Several elements of previous plan MPD 2021 were maintained in this plan, notably the residential character of the urban villages. It also highlighted the regeneration of urban villages, particularly those with heritage significance, and regarded them as sites for high-end retail and cultural activities (DDA, 2021b). The plan aimed to improve physical infrastructure, safety standards, and overall quality of life in these villages, and solve the issues of integrating urban villages into the city. Still, MPD 2041 failed to explicitly state regeneration implementation methods, and a lack of specificity about important stakeholders and regeneration techniques left many anticipated actions unresolved. Despite acknowledging the socio-economic potential of urban villages, MPD 2041's policy shortcomings underscored the persistent issue of bridging the gap between planning and execution.

Zonal Development Plans: The Micro-Level Plans (2001 to 2021)

Zonal Development Plans (ZDPs), which bridges Master Plans and neighbourhood or layout plans, have addressed urban villages haphazardly across planning periods. Urban villages received divided attention in the ZDPs under MPD-2001. For example, zones A, B, and C ignored urban villages (DDA, 1994b, DDA, 1994c, DDA, 1994d), while Zones D and F identified urban villages primarily due to presence of heritage monuments, recommending 'conservative surgery' approach for heritage villages like Nizamuddin (DDA, 1988). Whereas zone F emphasised unsuccessful redevelopment attempts and allowed restricted mixed-use until formalisation (DDA, 1998). Other zones, like zone K highlighted infrastructural deficiencies, indicating ongoing planning negligence (DDA, 1992).

Under the framework of MPD-2021, ZDPs experienced a partial policy shift with the Village Redevelopment

Schemes, promoting infrastructural upgrades, mixed-use zoning, and re-densification. Villages in Zones A, C, and F were classified as 'Special Areas' to foster context-sensitive development (DDA, 2007b, DDA, 2010f, DDA, 2010c). Some were also permitted to develop small-unit housing opposing planned developments (DDA, 2010b, DDA, 2010e, DDA, 2010f). Zones K-II and O (DDA, 2010a, DDA, 2010d) indicated a rising but limited sensitivity to heritage and the ecological environment, with Zone K-II mandating heritage protection, emergency access, and social services. Despite these improvements, implementation remained patchy. Formal integration was hampered by regulatory constraints.

ZDPs under MPD-2041 are still pending, indicating a procedural gap between strategic vision and local planning. This delay denies urban communities timely development recommendations, maintaining their socio-spatial marginalization (DDA). Overall, a review of Delhi's planning instruments demonstrates a recurring gap between strategic objective and execution, resulting in the socio-spatial exclusion of urban villages. Although regional and sub-regional plans eventually acknowledged urban villages, they were presented as unfavourable pockets of the city with few integration approaches. While Master Plans progressed from neglect in MPD-1962, to gradual recognition in MPD-2001 and MPD-2021, and regenerative goals in MPD-2041, implementation delayed due to legal ambiguity and a lack of stakeholder transparency. Zonal Development Plans reflected this inconsistency, with selective attention and delayed modifications. In conclusions, urban villages continue to be neglected by inclusive urban development because of fragmented, and inconsistent planning strategies.

Actors in the Urban Village Policymaking: Their Interests, Goals, and Conflicts

Ostrom (2005) describes the action situation as a 'conceptual space' or setting where actors interact on a particular issue—in this context urban village policymaking resulting in a shared outcome. It is structured by institutions or rules-in-use and is also influenced by exogenous variables. Also, during the interaction process, the actors respond in a certain way that enable them to achieve goals, preferably based on their interests, goals, mandates, and benefits. For this study, the key actors and their interactions in the urban village policymaking (action situation) were identified through the assessment of urban planning policies and regulations (rules-in-use).

Delhi's urban village governance is influenced by a multi-scalar, fragmented structure including multiple institutional players with overlapping mandates and frequently competing interests (Figure 3). Although urban development is theoretically a state responsibility, Delhi's governance is divided between the central and state governments, which adds to administrative ambiguity (GNCTD, 2024, NIUA, 2020a, NITI Aayog, 2021).

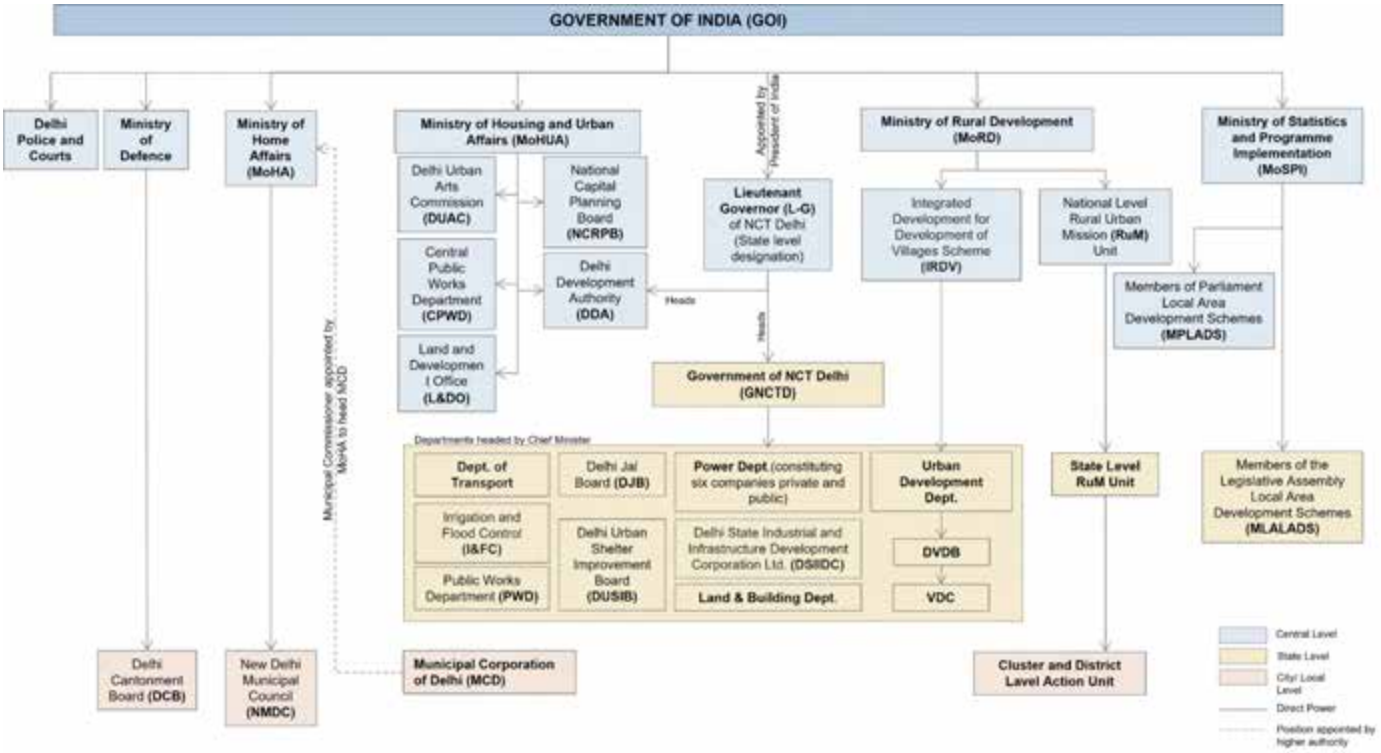

Figure 3 Key actors and their interactions in urban village planning and governance. Solid lines show administrative hierarchy; dashed lines indicate appointments by higher authorities (Source: Author's compilation).

Statutory planning is driven by key central institutions such as the Delhi Development Authority (DDA) and the National Capital Region Planning Board (NCRPB), which use regional and master plans. However, early NCRPB plans lacked specific solutions for urban villages, instead focusing on infrastructure through public-private partnerships that ignored socio-spatial issues (NCRPB, 2005). Only RP-2041 proposed mechanisms such as TDRs, higher FAR, and GIS-based land titling, but implementation remained limited (NCRPB, 2021). At the subregional level, SRP-2001 failed to identify urban settlements at all, whereas SRP-2021 recognised them but supported their integration but lacked socioeconomic data (DDA, 2021a). On the implementation front, institutions like DDA, MCD (Urban Local Body), and state departments like DJB, PWD, and DVDB have been pursuing infrastructure targets with little coordination (GNCTD, 2024, GNCTD, 1985). This institutional distribution has resulted in service gaps and unfulfilled growth in urban communities.

Meanwhile, informal actors such as private developers, NGOs, heritage organisations, and local leaders add to the complexity of governance. While commercial developers profit from high-density redevelopment, NGOs and historic organisations such as ASI and INTACH frequently have contradictory missions and lack a single heritage database (NIUA, 2020b). Residents of urban villages seeking tenure security, service access, and cultural preservation continue to be caught between regulatory complexity and policy neglect because of outdated rules and inaccurate land records. These competing interests and fragmented responsibilities have exacerbated socio-spatial exclusion, highlighting the importance of coordinated, context-sensitive governance anchored in local reality.

Assessing Policy Outcomes through Comparative Case Study Analysis

This study assessed the local, case-specific outcomes by conducting a desktop-based comparative case studies of HKV and Zamrudpur villages, situated in Zone F. The zonal level proposals and regulations specific to urban villages were compared to current state of identified sites. Doing so, enabled identification of effectiveness of

these rules-in-use, and addressing local-level gaps, particularly how policies are planned, governed, and implemented. Utilisation of the IAD framework encouraged this assessment of effectiveness of urban planning policies and regulations (Heikkila and Andersson, 2018), and how these rules hinder or foster socio-spatial inclusion of urban villages in Delhi. Data for the analysis was gathered from zonal plans, policy documents, official government websites, grey literature, blogs, and media sources, resulting in thorough, case-specific insights into these villages. Before conducting the comparative studies, the review first identified key provisions for urban village provisions in zone F (Table 1). These key themes where then assessed against the existing conditions of the two urban villages under investigation.

Table 1 Urban Village Zonal Development Plan Provisions for Villages in Zone F.

Zonal Plan Provisions	As per MPD-1962 (DDA, 1962)	As per MPD-2001 (DDA, 1998)	As per MPD-2021 (DDA, 2007b)
Land Use Classification and Zoning	Classified as rural use with agricultural activities	Acknowledged urban villages; permitted residential use and potential for mixed-use under Urban Renewal Scheme	Identified as 'Special Areas' with special regulations; compatible mixed-use permitted provided it is compatible with the surrounding residential areas
Mixed-Use and Commercial Development	Not specified	Mixed use was conditionally permitted under conditions	Identified mixed-use zones and pedestrian commercial streets in village
Building Regulations and Development Control Norms	No village specific provisions; bylaws relaxed to allow sub-standard housing	No provisions; highlighted weak enforcement of bylaws leading to substandard growth	Village Redevelopment Schemes proposed with stricter controls aligned with Special Area Regulations
Infrastructural Improvement and Provisions	Encouraged basic improvements to support village economies	Recognised need for upgrades; implementation remained inconsistent	Infrastructure improvement prioritised with redevelopment, mixed-use and conservation
Urban Village Planning and Integration Approaches	Proposed village-specific master plans for conservation, rehabilitation, and redevelopment	No provisions; some redevelopment plans were prepared but poorly implemented	Mandated Village Redevelopment Schemes with infrastructure upgradation to foster integration
Heritage Management	Heritage not addressed	Prioritised conservation of ASI protected monuments; mandated conservation measures under the Ancient Monuments and Archaeological Sites and Remains Act, 1958, and special building controls ; proposed landscaping strategies near monuments and improvement of basic services recommended	Emphasised on heritage conservation; HKV monuments (10) under ASI and five tombs under state government (GNCTD) ; highlighted conservation schemes through local authorities or designated organisations

Institutional Mechanisms	Not specified	No clear enforcement or monitoring highlighted	Role of local authorities and designated agencies for implementation of redevelopment and conservation initiatives

Case Study I: Hauz Khas- The Gentrified Enclave

Hauz Khas Village (Figure 4), formerly a rural settlement mainly inhabited by the Jat[2] community, exhibits the gentrification trajectory of Delhi's urban villages. The DDA designated it an 'urban village' in 1962, and large land acquisitions in the 1960s provided the groundwork for future change. HKV's transformation began in the late 1980s, when a well-known designer built a shop, attracting Delhi's elite and sparking its transformation into a cultural and commercial hub (Negi and Taraporevala, 2018, S, 2019, Ramesh et al., 2023). Low rents, closeness to heritage monuments, and important roadways all encouraged this transition. By the 2000s, HKV had surpassed markets such as Defence Colony and Khan Market, becoming a thriving hub of cafés, galleries, and boutiques (Gupta, 2024, Bernroider, 2015). However, rising property values, speculative development, and commercialisation have displaced many original residents, and exacerbated socio-spatial disparities, drawing uneven policy attention.

Figure 4 Location of Hauz Khas Village (Source: OpenStreetMap).

Case Study II: Zamrudpur- The Marginalised Village

Unlike the highly commercialised Hauz Khas Village, Zamrudpur (Figure 5) in South Delhi is an urban village that has received little policy attention or urban integration. Zamrudpur, located near the affluent neighbourhoods of Greater Kailash-I and Kailash Colony, has typical urban village features such as congested, haphazard development, narrow streets, and deteriorating infrastructure (Prakash and Sharma, 2021, Memories, 2016, Justtripping, 2021). Despite its rich cultural legacy, the village has been continually neglected in Delhi's planning narratives, with little investment from both the government and market actors. Zamrudpur, which is predominantly inhabited by migrants and service workers who support neighbouring affluent areas, demonstrates the systematic marginalisation that many urban villages in Delhi NCT face when governance frameworks fail to address their developmental demands (Prakash and Sharma, 2021, O'Leary, 2014). While both HKV and Zamrudpur fall within Zone F (South Delhi) of Delhi's Master Plan, their divergent outcomes reveal deep-rooted inequalities in planning implementation across the city.

2 Jat (also Jaat or Jatt) are traditional agrarian community found in Northern India and Pakistan. Today, they are prominent landowning farmers and key contributors to India's food grain production.

Figure 5 Location of Zamrudpur Village (Source: OpenStreetMap).

Evaluating Policy Implementation to Outcomes

The systematic comparison of policy outcomes is structured across six key themes: (1) land use, zoning, and mixed-use development, (2) building regulations and development control failures, (3) urban village planning and governance, (5) heritage management and commercialisation, and (6) planning and institutional gaps (Table 2).

Land use, Zoning, and Mixed-Use Development

HKV, which was previously a rural community, has evolved into a premium business and residential hub mostly through informal and market-driven mechanisms (Gupta, Negi and Taraporevala, 2018). Initially designated as an "urban village" by the Delhi Development Authority in 1962, it was not subject to conventional zoning regulations, allowing for substantial commercialisation (Ramesh et al., 2023). This regulatory loophole, which was reinforced by the NCTD Amendment Act of 2017, encouraged the expansion of unlicensed cafes, boutiques, and bars that violated land-use restrictions (Darji, 2018, Jeelani, 2018)Gulam</author></authors></contributors><titles><title>How Delhi's urban villages turned into 'no plan land'</title></titles><dates><year>2018</year></dates><publisher>Hindustan Times</publisher><urls><related-urls><url>https://www.hindustantimes.com/delhi-news/how-delhi-s-urban-villages-turned-into-no-plan-land/story-wI6PqbrcETuM3eqnZ59xWP.html</url></related-urls></urls></record></Cite></EndNote>.The outcome has been the fast commercialisation of residential plots with no formal planning control, displacing long-term residents and accelerating gentrification (Bernroider, 2015, Gupta, 2024, Verma and Modi, 2024). Property values in HKV have skyrocketed, with 3-4 BHK flats ranging from 1600 to 2000 sq. ft. costing more than INR 5 crores and renting for INR 50,000 to INR 110,000 per (Grovy India Limited, Royale Realtors India, 2025). Market-driven growth has transformed HKV into a high-value enclave that combines heritage and modernity, aided by its green surroundings, cultural activities, and central location (Ramesh et al., 2023).

Zamrudpur, in contrast, operates as an informal low-income rental zone surrounded by affluent neighbourhoods while remaining outside of official land-use plans and policy frameworks (Menon and Varma, 2019). Despite housing five neglected Lodi-era tombs, the region is not included in formal urban documentation, resulting in spatial fragmentation and unregulated development (Prakash and Sharma, 2021). According to limited real estate data, Zamrudpur's rental market mostly caters to hostels and paying guests, with monthly fees ranging from INR 6000

to 10,000, depending on occupancy and access to amenities (Magicbricks). Financial institutions continue to market urban villages like Zamrudpur as affordable home zones, using exemptions from building codes that allow for unregulated construction without municipal approval (Bajaj Finserv, Godrej Properties Limited, 2023).

Unlike HKV, which has been integrated into Delhi's economic framework through informal commercialisation, Zamrudpur is still institutionally excluded and functionally invisible in the planning regime.

Building Regulations and Development Control Failures

Failures in building regulation are obvious in both villages but emerge in different ways. HKV business facilities frequently operate often without license, fire safety clearances, or other legal permissions (Gupta et al., 2022, Darji, 2018). Height violations, insufficient setbacks, and small, narrow streets endanger emergency access and fire safety (Betigeri, 2013, Press Trust of India, 2020). Political intervention, particularly during elections, frequently undermines regulatory enforcement (Singh, 2013) . Multistorey rental structures flourish in Zamrudpur without permits, and congested layouts with exposed electrical wire demonstrate a lack of commitment to development rules (Justtripping, 2021, Memories, 2016). In all cases, planning officials failed to enforce or monitor building codes, exposing residents to long-term risks.

These inequities are also evident in infrastructure development. HKV's physical infrastructure has not kept up with its commercial growth (Darji, 2018). Sewer lines, solid waste management, and streets are still inadequate, resulting in frequent water logging and poor sanitation (Bernroider, 2015, Ramesh et al., 2023). Despite requests for modifications in redevelopment plans, execution remains inconsistent and disjointed (Guerrieri, 2017). Zamrudpur, in contrast, lacks even basic amenities: open drains, inconsistent water supply, mismanaged garbage, and dangerous electrical systems are frequent (Prakash and Sharma, 2021). Streets as narrow as three meters limit access for municipal or emergency vehicles. Despite its strategic location near metro lines and educational institutions, the town is excluded from most urban service plans, furthering its marginalisation.

Urban Village Planning and Governance

Furthermore, the governance structures in both villages are fragmented and ineffective, but the impacts differ significantly. Villages such as HKV and Zamrudpur were historically excluded from Delhi's formal planning processes. HKV benefited due to location, while others remain marginalised (Negi and Taraporevala, 2018). HKV's transformation proceeded in the absence of a coordinated planning framework, facilitated by political inertia and inadequate administrative control (Gupta, Jeelani, 2018, Negi and Taraporevala, 2018). Initial efforts to exempt such villages from planning laws have backfired, resulting in ad hoc urbanisation (Ramesh et al., 2023). Although strategies like Local Area Plans (LAPs) attempted to fill this gap, entrenched landownership and resource scarcity have slowed implementation (Bernroider, 2015). HKV benefits from its accessibility to key metro routes and universities, but the community's institutional capacity to manage change remains low (Betigeri, 2013). However, participatory planning procedures, such as consultations between local organisations and stakeholders, are theoretically possible and can aid in the balance between development and cultural protection (Guerrieri, 2017).

In contrast, Zamrudpur exemplifies institutional neglect. It lacks a single agency responsible for development or heritage preservation. Outdated land records and a lack of socio-economic databases lead residents to perform their own surveys (Menon and Varma, 2019, Prakash and Sharma, 2021). This fragmented governance has resulted in extended exclusion from planned urban structures. Despite its proximity to major metro line and educational institutions, Zamrudpur remains absent from formal master plans and socio-economic databases (Prakash and Sharma, 2021). This neglect from formal planning and census documents perpetuates exclusion from municipal infrastructure services and larger redevelopment initiatives, leaving basic service provision ad hoc and unplanned.

Heritage Management and Commercialisation

The treatment of heritage further reflects contrasting forms of policy failure. HKV's architectural legacy, particularly the Hauz Khas Complex, is integral to its identity, although it has been commercialised to some extent (Beyondbombay, 2021, Madan, 2015). The built heritage serves as a visual background to cafes, and pubs (Bernroider, 2015, Gupta et al., 2022). Despite tourism-related conservation measures, the shift toward aesthetic consumption threatens the area's historical integrity (Guerrieri, 2017). In comparison, Zamrudpur is home to five Lodi-era tombs of archaeological significance, the sites are not on the ASI's protected list in Zone F, and relevant agencies have allowed them to decay (Menon and Varma, 2019). Today, they serve as temporary shelters and dumping places. The lack of conservation plans, or heritage-zoning restrictions has made these structures vulnerable to encroachment and irrevocable heritage loss.

Planning and Institutional Gaps

Both villages have revealed how institutional gaps in planning, regulation, and enforcement can produce radically different yet equally problematic urban outcomes. The HKV's current state demonstrates institutional fragmentation and ineffective enforcement. Weak oversight has enabled illegal operations to thrive while lawmakers struggle with coordination and regulatory clarity (Ramesh et al., 2023). Political challenges, particularly from strong real estate and corporate interests, restricts implementation of building and zoning rules (Jeelani, 2018). Although participatory planning frameworks exist, their implementation is sparse (Guerrieri, 2017). Zamrudpur represents this inefficient through a severe governance gap. With no official planning agency or protected status, the village operates informally. The lack of institutional engagement has resulted in it being excluded from municipal records, diminishing responsibility and capability for integrated development (Prakash and Sharma, 2021). As a result, both settlements represent distinct manifestations of institutional failure: one of laissez-faire overdevelopment, the other of continued neglect. For the assessment of Zamrudpur village, limited data was available online, with most focusing on existing conditions of heritage tombs rather than overall urban village. Based on the data analysed from media sources, blogs, and a few articles, the analysis reveals that there is a lack of effective land use planning, heritage conservation, infrastructure development, and governance mechanisms in Zamrudpur.

Table 2 Overview of Policy Intent versus Outcomes.

Category	Hauz Khas Village	Zamrudpur
Land Use and Zoning	Uncontrolled commercialisation due to exemptions and unclear zoning regulations (Gupta, Negi and Taraporevala, 2018, Ramesh et al., 2023)	Primarily residential; neglected from all sources (Menon and Varma, 2019, Prakash and Sharma, 2021)
Building Regulations and Development Controls	Widespread violations of building controls; unauthorised vertical growth; no fire NOCs (Darji, 2018, Gupta et al., 2022, Press Trust of India, 2020)	Unregulated constructions; unsafe development; no building permits (Justtripping, 2021, Memories, 2016)
Urban Village Planning and Integration	Some efforts like LAP were attempted buy inconsistently implemented (Gupta, Negi and Taraporevala, 2018, Ramesh et al., 2023, Jeelani, 2018)	No efforts made towards village integration, excluding from city and local planning initiatives (Prakash and Sharma, 2021)
Heritage Management	Heritage driven development, due to presence of ASI protected monuments, but largely commodified; tourism focused (Beyondbombay, 2021, Gupta et al., 2022, Madan, 2015)	Existing heritage monuments neglected by state government; lack of conservation efforts (Menon and Varma, 2019)

Mixed-Use and Commercial Development	Unregulated commercialisation: cafes, pubs, and boutiques dominate (Bernroider, 2015, Guerrieri, 2017, Gupta et al., 2022)	No commercial development, remains as a low-income residential enclave (Prakash and Sharma, 2021)
Infrastructural Development	Strained infrastructure due to commercialisation (Bernroider, 2015, Guerrieri, 2017, Gupta et al., 2022, Ramesh et al., 2023)	Lack of basic services (Prakash and Sharma, 2021)
Institutional Mechanisms	Fragmented governance; political influence; market-driven inclusion (Betigeri, 2013, Guerrieri, 2017, Jeelani, 2018, Ramesh et al., 2023)	Institutional neglect; total policy neglect (Prakash and Sharma, 2021)

Discussion

The analysis of policies through IAD framework, provided a comprehensive overview of the urban village policy planning, implementation and its outcomes. The primary goal of this research was to examine existing policy gaps and their impact on socio-spatial inclusion and exclusion of urban villages. Based on the coding, the review identified five inter-related themes perpetuating socio-spatial exclusion of urban villages at city level: (1) political influence and erosion of community rights, (2) institutional fragmentation and regulatory ambiguity, (3) neglect of informal economies and socio-cultural transitions, (4) spatial exclusion and built environment neglect, and (5) transparency and administrative accountability.

Political Influence and Lack of Community Rights

Land reform and development policies, particularly the Delhi Land Reforms Act, fragmented land acquisition processes, and land pooling mechanisms, have adversely impacted rural livelihoods while providing little or no compensation to displaced populations (Datta, 2004, Mehra, 2005, MoUD, 2007). These efforts have disproportionately benefited corporate investors and politically associated actors, directing urban village development toward political gain rather than community need (Sheth, 2017, MoUD, 2006, MoUD, 2007). The adoption of public-private partnerships (PPPs) and selective regularisation procedures has resulted in uneven infrastructure provision and increased land commodification, marginalising original landowners and reducing local governance capacity (MoUD, 2006, Tyagi and Vats, 2020). Absorbed by neighbouring wealthy neighbourhoods, urban villages have not benefited from integrated development (GNCTD, 1985), leading to a system of spatial outcomes. The extension areas of urban villages have often been misused due to speculative development under the guide of community development (GNCTD, 1985). These practices have therefore resulted in scepticism towards planning and administrative organisations by the urban village residents.

Institutional Fragmentation and Regulatory Ambiguity

Institutionally, urban villages function within a fragmented structure characterised by overlapping mandates, inefficient inter-agency coordination, and lax enforcement. The lack of co-ordination among key planning and managing authorities—such as the DDA, MCD, GNCTD—has led to significant administrative and policy gaps (MoUD, 2006, Singh, 2024, GNCTD, 1985). These fragmented duties, coupled with the lack of a dedicated planning and management cell for urban villages, have hindered the urban village integration. Furthermore, the incomplete implementation of previous redevelopment plans, demonstrate administrative stagnation (GNCTD, 1985). A regulatory void has existed between the formal declaration of urbanisation and the execution of applicable regulations under the Delhi Municipal Corporation (DMC) Act, allowing unregulated building to spread unabated (GNCTD, 1985). Additionally, the breakup of village council (gram sabhas) and the failure to apply land mutation standards have increased legal uncertainty, limiting access to municipal services, credit systems, and secure tenure (Tyagi and Vats, 2020). These institutional flaws not only push informality but also limit meaningful community participation in planning processes (Singh, 2020, Singh et al., 2024). The overall administrative system of Delhi is widely viewed as overly fragmented (MoUD, 2006), preventing the integration of

urban villages into larger city frameworks. Furthermore, statutory planning documents such as Master Plans and Zonal Development Plans have consistently failed to account for the tangible and intangible qualities of urban villages, making them almost invisible in official spatial development strategies (Rewal, 2014, Sheth, 2017)

Neglect of Local Informal Economies and Socio-Cultural Transitions

Urban villages have been transformed into essential hubs of affordable housing and informal economic activity, but changes to laws have not kept pace. Existing regulatory frameworks do not provide for inclusive zoning, livelihood integration, or acknowledgment of informal rental and commercial networks (Mehra, 2005, DDA, 2007a). As a result, populations, particularly marginalised, landless, and migrants, continue to be excluded from social services, inheritance rights, and financial services (Tyagi and Vats, 2020). The lack of property documentation perpetuates informality, exacerbating inter-class disparities, and undermining community cohesion. Informal businesses face a constant danger of penalties, while regulatory neglect undermines social mobility, gender fairness, and long-term socioeconomic resilience (Singh et al., 2024, Govinda, 2013).

Spatial Exclusion and Built Environment Neglect

Despite their 'urban' status, many villages experience chronic infrastructural neglect and spatial exclusion. Inadequate building regulatory implementation, redundant land record systems (e.g., single-khasra or plot no.), and prolonged sanctioning processes enabled for unregulated growth and unplanned mixed-use development (Harikrishanan, 2021, GNCTD, 1985). Aggressive enforcement measures, such as sealing and demolition, focus on the tangible signs of informality rather than the underlying socio-economic conditions (Singh, 2020). Redevelopment projects continue to be elite-driven, with little participatory processes or context-sensitive design, alienating residents further (Tyagi and Vats, 2020). The lack of planned public infrastructure, municipal services, and open space perpetuates slum-like conditions (Bernroider, 2015, Prakash and Sharma, 2021, Ramesh et al., 2023) . These findings suggest that urban villages are symbolically included through over-regulation but functionally excluded by inadequate funding, prolonging cycles of socio-spatial injustice (Sheth, 2017, Datta, 2004)

Transparency and Administrative Accountability

Administrative transparency has exacerbated these inefficiencies. Residents are usually unaware of the documents required for permits, and critical information—such as sanctioned layouts, ownership records, and building codes—is neither accessible nor proactively supplied (Prakash and Sharma, 2021). The lack of digitised and publicly available information reinforced reliance on informal brokers and brokers, delaying legal recognition, and exacerbating animosity between communities and institutions (GNCTD, 1985, NCRPB, 2005).

What Approaches Can Integrate Urban Villages and Promote Socio-Spatial Inclusion?

Existing studies presents several alternative planning and policy approaches that challenge traditional top-down urban planning frameworks for urban villages. Prakash and Sharma (2021) have highlighted on Bottom-up Jugaad [3]based placemaking approach, which promotes community ownership and tangible outcomes. Furthermore, they also argue for moving away from the traditional PPP model to more inclusive People-Public-Private Partnership (PPPP) model. This new framework empowers locals to identify local needs, choose experts, and contribute to resource mobilisation, while public and commercial stakeholders assist with implementation (Prakash and Sharma, 2021). WRI India (2020) provided actionable recommendations like the Urban Village Development Plan (UVDP), a gradual planning framework for phased, local-level planning. The UVDP prioritises eight principles, including stakeholder engagement, transparency, and accountability, context-sensitive design, and linkage with larger urban planning policies and zoning regulations (WRI India, 2020). This framework assures that village development is both locally relevant and institutionally consistent.

3 Jugaad in Hindi language refers to an innovative, and creative idea offering a quick, alternative way—often cost-effective—of solving problems using readily available materials and resources.

Harikrishanan (2021) established the Shared Responsibility Model, which bridges the gap between top-down and bottom-up approaches by encouraging residents and the state to collaborate. This concept brings together adaptive reuse of built heritage, catalytic pilot interventions, and conservation incentives. It is built on enabling reforms including flexible master planning, digitised land records, and incentive-based land pooling to promote long-term spatial and socioeconomic integration. Gupta (2025) suggested for the integration of urban villages through neighbourhood-level planning frameworks, stating that their exclusion causes spatial disintegration, land misuse, and speculation. He further advocated for equitable distribution of surplus land value, infrastructural provisions, participatory methods, and employment-oriented planning. By addressing residents' lived realities, such initiatives can help to promote inclusive urban government, reduce socio-spatial disparities, and improve the incorporation of urban villages into metropolitan growth processes.

Conclusion and Future Suggestions

This study analyses the persisting policy gaps affecting urban villages in Delhi, India, using the IAD framework to investigate the drivers and consequences of socio-spatial exclusion. A comparative case study of Zamrudpur and Hauz Khas Village reveals a gap between planning discourse and implementation. Urban villages, while symbolically mentioned in policy documents, are functionally excluded from formal development due to political influence, institutional fragmentation, disregard of informal economy, spatial marginalisation, and inadequate administrative transparency. This selective integration exacerbates urban inequality and maintains socio-spatial imbalances. In theory, the study strengthens our understanding of how planning tools and governance institutions lead to urban exclusion. In practice, it provides guidance to urban planners and lawmakers by advocating for collaborative, integrated, and context-sensitive strategies. Recommendations include updating outdated land and zoning regulations, promoting bottom-up governance, recognising informal economies, ensuring transparency, and integrating urban villages into larger planning frameworks. Future study should investigate comparative case studies across Indian cities, socio-cultural dynamics within urban villages, the effectiveness of participatory planning, and novel finance mechanisms and public-private partnerships for urban village redevelopment. Such research will help to advance inclusive urban policies that address exclusionary actions and empower communities at large. Overall, the study adds to the greater issue of urban inclusion by providing a structured socio-spatial policy analysis. It highlights the necessity of hybrid governance models in which inhabitants collaborate to build development visions that are supported by public and commercial institutions, ultimately achieving the objective of equitable, inclusive cities.

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A Study on the Spatiotemporal Patterns and Influencing Factors of Urban–Rural Integrated Development: A Case Study of the Chengdu Plain Economic Zone

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Abstract
Urban-rural integration is essential for China's modernization, aiming to bridge the urban-rural divide and promote common prosperity. The Chengdu Plain Economic Zone, accounting for 63.2% of Sichuan's GDP, faces challenges such as a 39.3 percentage point urbanization gap and industrial homogenization. This study assesses integration from 2012 to 2021 across economic, social, spatial, and demographic dimensions, using the entropy method and geographical detector model. Results reveal an 8.65% annual growth in integration, with a spatial pattern of "high in the center, low in the southwest." Chengdu leads consistently, while De yang and Mian yang progress via industrial upgrades; Ya an and Leshan lag due to geographical constraints. Key drivers include urbanization rate (q=0.62), per capita GDP (q=0.58), and income gap (q=0.45). The proposed policy framework advocates multi-center collaboration, industrial complementarity, infrastructure connectivity, and talent sharing to achieve "value symbiosis," providing a model for less-developed regions in Western China.

Keywords: urban-rural integration; spatio-temporal patterns; geographical detector; multi-center collaboration

1. Introduction
Urban-rural integration is a central issue in China's modernization process, aiming to dismantle the urban-rural dual structure, promote bidirectional factor flows, and achieve balanced and coordinated socio-economic development between urban and rural areas. As a key growth pole for high-quality development in Western China, the Chengdu Plain Economic Zone encompasses eight prefecture-level cities, including Chengdu, Deyang, and Mianyang. In 2021, it accounted for 63.2% of Sichuan Province's GDP, with an urbanization rate of 56.16%, making it one of the most densely populated and economically vibrant regions in Western China. However, significant regional imbalances persist: Chengdu, the core city, boasts an urbanization rate of 79.5% and an urban-rural income ratio reduced to 2.01, while peripheral areas such as Ya'an and Ziyang face challenges including widening urban-rural income gaps (Ya'an's urban-rural income ratio was 2.35 in 2021), pronounced industrial homogenization, and inadequate infrastructure connectivity. Against this backdrop, studying the spatio-temporal evolution patterns and driving mechanisms of urban-rural integration in the Chengdu Plain Economic Zone not only responds to the policy demands of China's 14th Five-Year Plan for Urban-Rural Integration but also addresses the practical need to optimize regional resource allocation and promote coordinated development across the region.

Theoretically, current research on urban-rural integration predominantly focuses on developed eastern regions such as the Yangtze River Delta and Pearl River Delta, with relatively limited dynamic analyses of Western economic zones. Moreover, existing evaluation systems often overemphasize singular economic dimensions, neglecting multifaceted aspects such as social equity and spatial balance. This study constructs a four-dimensional indicator system encompassing economic efficiency, social equity, spatial coordination, and population mobility. By integrating the entropy method and the geographical detector model, it seeks to address the paucity of empirical studies in Western China and provide methodological advancements to urban-rural integration theory. Practically, the findings offer scientific evidence to support differentiated policymaking and cross-regional resource collaboration in the Chengdu Plain Economic Zone. For instance, a "core city radiation–secondary center absorption" model could mitigate Chengdu's "siphon effect," while optimizing transportation networks could narrow the development gap in the southwestern peripheral areas.

Focusing on the Chengdu Plain Economic Zone and utilizing statistical data from 2012 to 2021, this study addresses two key questions: (1) how to scientifically quantify the level of urban-rural integration, and (2) the spatio-temporal patterns and core driving factors of regional disparities. Methodologically, the entropy method is employed to construct a comprehensive evaluation model to analyze the temporal evolution characteristics of urban-rural integration. ArcGIS spatial analysis techniques are used to delineate the "high in the center, low in the southwest" spatial differentiation pattern. The geographical detector model identifies key influencing factors such as urbanization rate and per capita GDP. The innovation of this study lies in proposing a composite framework of "static indicator weight allocation + dynamic spatial attribution analysis," which overcomes the limitations of traditional studies confined to a single spatio-temporal dimension.

2. Theoretical Foundation and Literature Review

The theoretical evolution of urban-rural integration has consistently paralleled deepening understandings of urban-rural relationships. Early scholars often analyzed urban-rural dynamics from an "opposition-coordination" perspective. For instance, Ebenezer Howard's "Garden City" theory, proposed in 1898, advocated for planned integration of urban economic vitality and rural ecological value to achieve functional complementarity [1], laying a cornerstone for subsequent urban-rural integration studies. In the mid-20th century, Arthur Lewis's "dual economy structure theory" elucidated the economic roots of urban-rural segmentation in developing countries [2], emphasizing that the transfer of surplus agricultural labor to industrial sectors is essential for resolving urban-rural divides. However, its "urban-biased" perspective was critiqued by scholars like Michael Lipton, who argued that overly urban-centric policies lead to rural resource depletion and exacerbate urban-rural inequality. Lipton's concept of "balanced urban-rural development" marked a significant shift in the field [3].

Since the 21st century, with the acceleration of globalization and informatization, urban-rural integration theories have expanded to encompass multidimensional interactions across spatial, social, and ecological domains. John Friedmann's "core-periphery" theory highlighted the radiating influence of central cities on surrounding areas [4], while Michael Storper's "new regionalism" advocated for institutional innovation and local governance to facilitate the free flow of urban-rural factors [5]. Chinese scholars, building on Western theories and adapting to national conditions, have proposed localized interpretations. For example, Liu Yansui introduced the concept of "urban-rural equivalence," advocating for equalized public services and industrial linkages to narrow the quality-of-life gap between urban and rural areas [6]. Lu Dadao, from the perspective of "human-land relationships," emphasized the need to balance resource and environmental carrying capacity with socio-economic development demands in urban-rural integration [7]. These theories provide critical support for constructing the "economic-social-spatial-demographic" four-dimensional analytical framework in this study.

Empirical research on urban-rural integration, both domestically and internationally, exhibits a pattern of "eastern focus and methodological diversity." Early international studies were predominantly qualitative, such as T.G. McGee's exploration of the "Desakota" (urban-rural transition zone) model in Southeast Asia, which revealed the unique role of informal economies in transitional areas [8]. In recent years, quantitative modeling has gained prominence; for instance, J. Van den Bergh used spatial econometric methods to verify the role of infrastructure connectivity in promoting urban-rural income convergence [9]. In China, early studies focused on policy interpretation and case descriptions. After 2010, with improved statistical data, scholars began developing comprehensive evaluation systems. Liu Rongrong's team constructed an indicator system based on economic, social, and environmental integration, finding that urban-rural integration levels in the Yangtze River Delta urban agglomeration followed a "center-periphery" declining pattern [10,11]. Che Bingqing's study on the Huaihai Economic Zone identified topographic complexity and policy implementation capacity as key factors influencing urban-rural integration [12,13]. However, existing indicator systems often prioritize economic dimensions, with insufficient quantification of social equity (e.g., accessibility to public services) and spatial justice (e.g., ecological resource allocation). Moreover, dynamic spatio-temporal analyses targeting less-developed economic zones in Western China remain scarce.

Existing studies provide important insights for this research but exhibit three main limitations. First, at the theoretical level, most studies reduce urban-rural integration to "gap narrowing," overlooking the deeper logic of functional complementarity and value symbiosis between urban and rural areas. Second, at the methodolog-

ical level, static cross-sectional analyses predominate, with insufficient tracking of the dynamic evolutionary pathways of urban-rural integration. Third, at the regional level, there is inadequate attention to the unique and complex characteristics of Western China, particularly the influence of factors such as topographic barriers and ethnic diversity, which have not been fully incorporated into analytical frameworks. This study seeks to advance the field in the following ways: (1) constructing a composite indicator system encompassing economic efficiency, social equity, spatial coordination, and population mobility to address the multidimensional nature of urban-rural integration; (2) utilizing a decade-long time-series dataset to reveal the staged characteristics of the integration process in the Chengdu Plain Economic Zone; and (3) employing the geographical detector model to identify the interactive effects of natural conditions and institutional factors on the spatial differentiation of urban-rural integration, thereby providing a basis for differentiated policy design in less-developed regions of Western China.

3. Study Area Overview and Data Methods

3.1 Study Area Overview

The Chengdu Plain Economic Zone is located in the western Sichuan Basin, spanning a geographical range between 28°28'–33°02'N and 101°56'–106°59'E. It encompasses eight prefecture-level cities: Chengdu, Deyang, Mianyang, Leshan, Meishan, Ziyang, Suining, and Ya'an, covering a total area of 86,400 square kilometers. As a core component of the Chengdu-Chongqing Economic Circle, the region had a permanent population of 42.141 million in 2021, accounting for 50.3% of Sichuan Province's total population, and a GDP of 3.29 trillion yuan, contributing 63.2% of the province's economic output. This makes it one of the most densely populated and economically dynamic regions in Western China. However, internal development disparities are pronounced: Chengdu, with less than 20% of the region's land area, contributes 46.7% of the economic zone's GDP, and its urbanization rate (79.5%) is nearly double that of Ya'an (40.2%). Although the urban-rural income gap has gradually narrowed (from an urban-rural income ratio of 2.57 in 2012 to 2.01 in 2021), challenges such as insufficient rural public service provision and lagging infrastructure connectivity remain prominent in peripheral areas.

3.2 Data and Methods

The research data primarily come from the Sichuan Statistical Yearbook (2012–2021), the China City Statistical Yearbook, and statistical bulletins on national economic and social development from the respective prefecture-level cities. For missing data (e.g., county-level fiscal expenditures in certain years), linear interpolation was applied, and raw data were standardized to eliminate dimensional differences. The indicator system was constructed based on principles of "systematicity, operability, and policy orientation," selecting 16 indicators across four dimensions: economic integration, social integration, spatial integration, and population integration (Table 3-1). Economic integration focuses on urban-rural production efficiency and income equity (e.g., per capita GDP, non-agricultural industry share). Social integration emphasizes public service accessibility and consumption equity (e.g., medical insurance coverage, urban-rural consumption expenditure ratio). Spatial integration measures infrastructure and ecological coordination (e.g., highway density, green coverage rate in built-up areas). Population integration reflects labor structure and mobility (e.g., urbanization rate, non-agricultural employment ratio). Indicators are classified as positive or negative: for example, a smaller urban-rural income ratio (negative) indicates higher integration, while a larger per capita GDP (positive) reflects superior development levels.

Table 3-1 Evaluation Index System for the Level of Urban-Rural Integration in the Chengdu Plain Economic Zone

Dimension	Indicator	Indicator Calculation or Description	Attribute
Economic Integration	Per Capita Regional GDP	Per capita regional GDP (Yuan/person)	Positive
	Proportion of Non-Agricultural Industries in GDP	Proportion of secondary and tertiary industry added value in GDP * 100 (%)	Positive
	Proportion of Agricultural Expenditure in Total Expenditure	Agricultural fiscal expenditure / total fiscal expenditure * 100 (%)	Positive
	Urban-Rural Per Capita Disposable Income Ratio	Urban per capita disposable income / rural per capita disposable income	Negative
	Dual Production Efficiency Ratio	(Primary industry added value / primary industry employees) / (secondary and tertiary industry added value / secondary and tertiary industry employees)	Positive
Social Integration	Education Expenditure as a Proportion of GDP	Education expenditure / GDP * 100 (%)	Positive
	Basic Medical Insurance Coverage Rate	Insured population / total population * 100 (%)	Positive
	Hospital Beds per 10,000 People	Number of hospital beds in medical institutions per 10,000 people (beds/10,000 people)	Positive
	Urban-Rural Per Capita Consumption Expenditure Ratio	Urban per capita consumption / rural per capita consumption	Negative
	Urban-Rural Engel Coefficient Ratio	Urban Engel coefficient / rural Engel coefficient	Negative
Spatial Integration	Regional Urban Greening Rate	Green space area / construction land area * 100 (%)	Positive
	Highway Network Density	Highway operating mileage / total land area (km/km²)	Positive
	Proportion of Built-Up Area	Built-up area / total land area * 100 (%)	Positive
Population Integration	Population Urbanization Rate	Permanent urban population / total population * 100 (%)	Positive
	Proportion of Non-Agricultural Employed Population	Number of employees in secondary and tertiary industries / total employees * 100 (%)	Positive
	Urban-Rural Population Interaction Degree	Total urban-rural population migration rate (‰)	Positive

The entropy method was employed to determine indicator weights, avoiding biases from subjective weighting. First, raw data were standardized using the range method, and the information entropy and redundancy of each indicator were calculated to derive weight values. Next, a weighted sum formula was applied to compute the comprehensive urban-rural integration score, with values ranging from [0, 1]; higher scores indicate superior integration levels. Spatial analysis was conducted using the ArcGIS 10.2 platform, employing the natural breaks method to classify integration levels into five categories (low, medium-low, medium, medium-high, high). Standard deviational ellipse and hotspot analysis were used to reveal spatial differentiation patterns. The geographical detector model was utilized to identify key driving factors by calculating the explanatory power (q-value) of each factor, with q-values ranging from [0, 1]; higher q-values indicate greater contributions to spatial differentiation.

4. Spatio-Temporal Patterns and Evolution of Urban-Rural Integration in the Chengdu Plain Economic Zone

4.1 Measurement and Classification of Integration Levels

To evaluate the urban-rural integration levels in the Chengdu Plain Economic Zone from 2012 to 2021, this study applied the entropy method to measure the weights of each indicator. Subsequently, a specific computational formula was used to derive the comprehensive urban-rural integration score for the economic zone, serving as the benchmark for assessing the degree of integration. These comprehensive scores are detailed in Table 4-1, providing a foundation for subsequent in-depth analysis.

Table 4-1 Comprehensive Score for Urban-Rural Integration Level in the Chengdu Plain Economic Zone, 2012–2021

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average for each city
Chengdu City	0.502	0.537	0.570	0.594	0.626	0.716	0.742	0.731	0.719	0.782	0.652
Deyang City	0.275	0.295	0.294	0.333	0.321	0.331	0.368	0.376	0.423	0.443	0.346
Mianyang City	0.234	0.262	0.330	0.351	0.351	0.365	0.412	0.403	0.449	0.497	0.365
Meishan City	0.210	0.236	0.251	0.305	0.286	0.316	0.320	0.325	0.366	0.408	0.302
Leshan City	0.225	0.224	0.258	0.308	0.301	0.295	0.331	0.339	0.366	0.406	0.305
Ziyang City	0.215	0.228	0.247	0.277	0.328	0.334	0.341	0.364	0.390	0.414	0.314
Suining City	0.347	0.302	0.302	0.370	0.351	0.358	0.390	0.395	0.469	0.517	0.380
Ya'an City	0.186	0.191	0.185	0.226	0.235	0.224	0.280	0.307	0.367	0.389	0.259
Average	0.274	0.284	0.305	0.346	0.350	0.367	0.398	0.405	0.444	0.482	
Average growth rate %		3.692	7.121	13.418	1.266	5.002	8.336	1.759	9.537	8.650	

Building on the practical context of urban-rural integration in the Chengdu Plain Economic Zone, combined with national policy orientations, Sichuan Province's urban-rural development plans, and various comprehensive factors, this study thoroughly analyzes the spatio-temporal evolution characteristics of urban-rural integration levels in the region. The analysis reveals not only temporal progression but also significant spatial differentiation and variation. To comprehensively and accurately assess urban-rural integration levels, ArcGIS 10.2 software was utilized to conduct detailed hierarchical processing of the comprehensive urban-rural integration scores for the eight prefecture-level cities in the Chengdu Plain Economic Zone.

Adhering to the concept of high-quality urban-rural integration development, this study employed the natural breaks method to classify the comprehensive scores into five levels, sequentially named "high-level integration zone," "medium-high-level integration zone," "medium-level integration zone," "medium-low-level integration zone," and "low-level integration zone." Table 4-2 provides a detailed breakdown of the number of prefecture-level cities included in each level, offering valuable reference for in-depth research and strategy formulation for urban-rural integration in the Chengdu Plain Economic Zone.

Through this comprehensive analysis, the evolutionary trends of urban-rural integration levels can be more fully understood, providing robust data support and strategic guidance for future sustainable development strategies.

Table 4-2 Statistics on the Number of Prefecture-Level Cities at Various Levels in the Chengdu Plain Economic Zone by Urban-Rural Integration Level, 2012–2021

Year	Relatively high level	Relatively medium high level	Relatively medium level	Relatively medium low level	Relatively low level
2012	1	1	1	4	1
2013	1	2	1	3	1
2014	1	3	1	2	1
2015	1	2	3	1	1
2016	1	2	2	2	1
2017	1	2	3	1	1
2018	1	2	1	3	1
2019	1	2	2	2	1
2020	1	2	3	1	1
2021	1	3	2	1	1

4.2 Temporal Evolution of Urban-Rural Integration Levels

4.2.1 Overall Characteristics of Temporal Evolution

As shown in Table 4-1 and Figure 4-1, from 2012 to 2021, the urban-rural integration levels in the Chengdu Plain Economic Zone generally exhibited an upward trend. Chengdu City maintained a relatively high urban-rural integration score throughout the period, displaying steady growth, while the integration scores of other cities showed varying degrees of increase.

(1) The overall urban-rural integration level in the Chengdu Plain Economic Zone shows a fluctuating upward trend.

The comprehensive urban-rural integration score increased from 0.274 in 2012 to 0.482 in 2021, reflecting an overall increase of 0.208 over the decade. This indicates significant improvement in urban-rural integration levels during this period. Data on annual growth rates reveal fluctuations in the pace of growth. The growth rate was relatively high between 2014 and 2015, reaching 13.418%, but it slightly declined between 2019 and 2020 to 1.759%. Nevertheless, the average annual growth rate remained positive, demonstrating a steady upward trend. Between 2018 and 2019, the annual growth rate was 1.759%, while it increased to 8.65% from 2020 to 2021. This suggests notable progress in urban-rural integration efforts in the later stages, with an accelerated growth rate. Significant disparities in integration levels exist across regions. For instance, Chengdu City consistently achieved high comprehensive scores, whereas Ya'an City recorded relatively low scores. These differences may be influenced by factors such as regional economic development levels and the extent of policy support.

(2) The urban-rural integration level in the Chengdu Plain Economic Zone has risen from relatively medium-low to relatively medium-high levels.

From 2012 to 2021, the number of prefecture-level cities with relatively high integration levels remained stable, with only one city (Chengdu) consistently at this level each year. This indicates that Chengdu has achieved notable success in urban-rural integration and maintained a relatively high level. The number of prefecture-level cities with medium-high integration levels fluctuated but showed an overall increasing trend. From 2014 to 2018, the number of such cities steadily increased, peaking in 2021. This may reflect relatively stable and positive development in urban-rural integration in these areas. The number of cities with medium integration levels also exhibited an overall increase from 2012 to 2021, with significant growth between 2014 and 2017, reaching a peak in 2020. These regions likely made some progress in urban-rural integration, but their development levels still require further improvement. The number of cities with medium-low integration levels showed a fluctuating downward trend, decreasing from four in 2012 to one in 2021. These regions may face challenges in urban-rural integration, necessitating greater policy support and resource investment. The number of cities with low integration levels remained stable from 2012 to 2021, with one city (Ya'an) consistently at this level each year. This suggests that Ya'an is a region with persistently low urban-rural integration levels, requiring intensified reform efforts and policy support to enhance its integration.

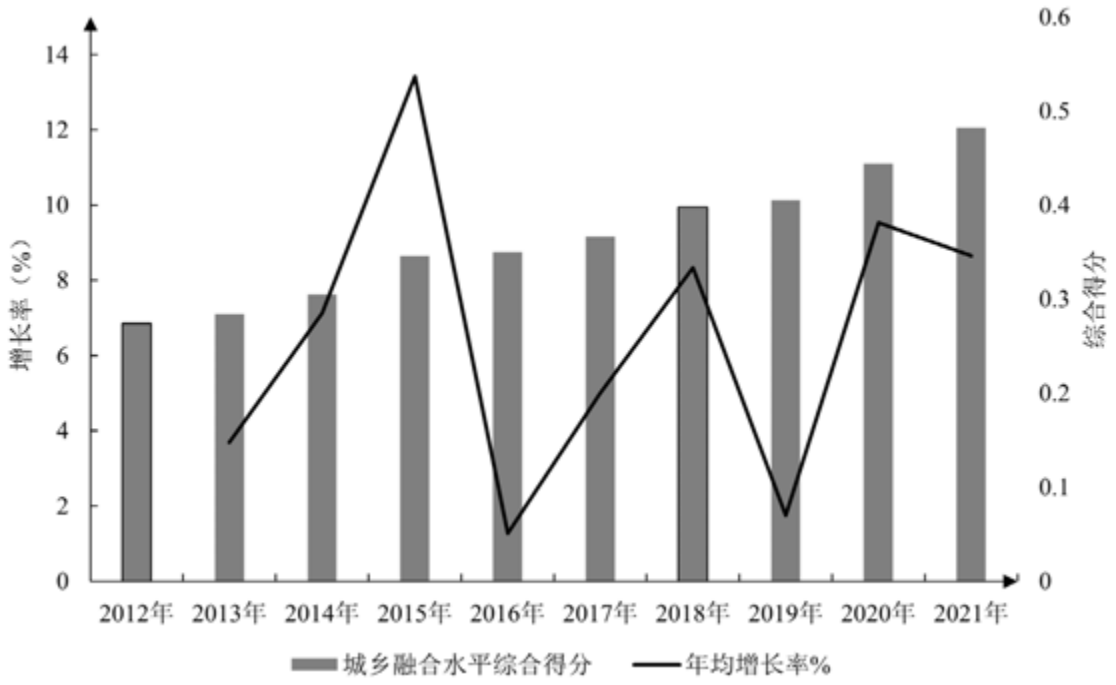

Figure 4-1 Comprehensive Score Trend for Urban-Rural Integration Level in the Chengdu Plain Economic Zone (2012-2021)

4.2.2 Temporal Variation Characteristics of Each Dimension

Based on the urban-rural integration indicator data for the Chengdu Plain Economic Zone from 2012 to 2021, this study employed the entropy method to calculate comprehensive scores for the four key dimensions: economic integration, social integration, spatial integration, and population integration. These scores are presented in detail in Figure 4-2 and Table 4-3, providing a comprehensive and in-depth understanding of the urban-rural integration levels in the Chengdu Plain Economic Zone.

As shown in Figure 4-2, the comprehensive score for urban-rural economic integration exhibited a steady upward trend from 2012 to 2021, increasing from 0.620 in 2012 to 1.106 in 2021, a growth of approximately 78.7%. From 2012 to 2015, the comprehensive score grew relatively slowly, with an increase of 0.181. During this period, constraints such as urban-rural development disparities and industrial structure transitions likely contributed to uneven economic development, slowing the progress of urban-rural integration. From 2016 to 2021, the comprehensive score increased more significantly, by 0.486. This may be attributed to accelerated urbanization, enhanced government policy support, and notable progress in industrial structure optimization and regional economic output growth.

The comprehensive score for urban-rural social integration showed a gradual increasing trend from 2012 to 2021, rising from 0.570 to 1.016, a growth of approximately 78.6%. Based on the magnitude of growth, this period can be divided into two phases: from 2012 to 2015, the comprehensive score grew slowly, with an increase of 0.237. This may have been influenced by issues such as widening urban-rural income gaps and imbalances in access to basic education and healthcare resources. From 2016 to 2021, the comprehensive score increased more noticeably, by 0.446. This is likely due to increased government investment in infrastructure, improvements in social security systems, and enhanced public service levels, which helped narrow the urban-rural social development gap.

The comprehensive score for urban-rural spatial integration demonstrated a steady upward trend from 2012 to 2021, increasing from 0.549 to 0.920, a growth of approximately 67.0%. From 2012 to 2015, the comprehensive score grew slowly, with an increase of 0.036, possibly due to issues such as inadequate transportation and

lagging infrastructure. From 2016 to 2021, the comprehensive score increased more significantly, by 0.371. This may be attributed to improvements in urban planning and transportation network development, which reduced spatial distances between urban and rural areas and strengthened their connectivity.

The comprehensive score for urban-rural population integration exhibited a fluctuating upward trend from 2012 to 2021, rising from 0.455 to 0.813, a growth of approximately 78.7%. From 2012 to 2015, the comprehensive score grew slowly, with an increase of 0.175, likely constrained by factors such as household registration (hukou) restrictions and limited urban-rural population mobility. From 2016 to 2021, the comprehensive score increased more significantly, by 0.358. This may be driven by household registration system reforms and increased absorption of rural populations into urban areas, facilitating greater population mobility and reducing urban-rural population disparities.

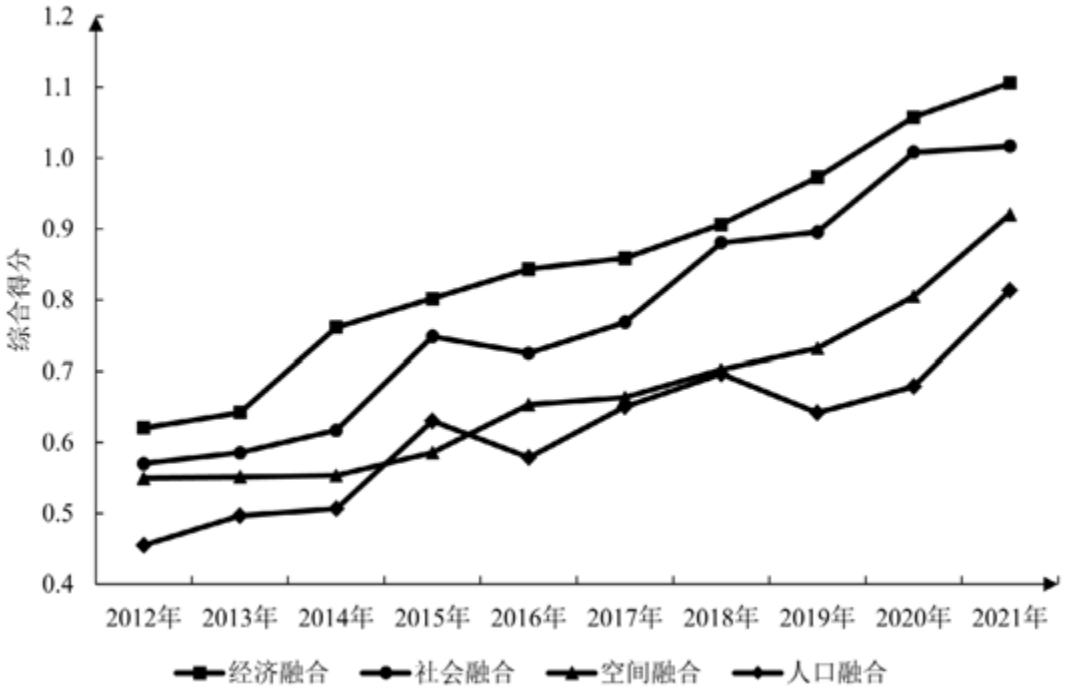

Figure 4-2 Comprehensive score trends for various indicators of urban-rural integration in the Chengdu Plain Economic Zone (2012-2021)

Table 4-3 Comprehensive Scores for Each Indicator Level of Urban-Rural Integration in the Chengdu Plain Economic Zone from 2012 to 2021

Year	Economic integration	Social integration	Spatial integration	Population integration
2012	0.620	0.570	0.549	0.455
2013	0.642	0.585	0.551	0.497
2014	0.761	0.617	0.553	0.506
2015	0.801	0.748	0.585	0.630
2016	0.843	0.724	0.653	0.579
2017	0.858	0.768	0.663	0.650
2018	0.906	0.880	0.702	0.696
2019	0.973	0.895	0.732	0.642
2020	1.058	1.008	0.805	0.679
2021	1.106	1.016	0.920	0.813

4.3 Spatial Patterns and Evolution of Urban-Rural Integration

4.3.1 Overall Characteristics of Spatial Patterns

Using the ArcGIS 10.2 platform, the spatial differentiation patterns of urban-rural integration levels in the Chengdu Plain Economic Zone were examined based on the average annual comprehensive scores of its eight prefecture-level cities from 2012 to 2021. The results (see Appendix Figure 4-3) reveal distinct spatial characteristics in the urban-rural integration levels of the Chengdu Plain Economic Zone: Chengdu City, located in the central region, exhibits the highest development level, followed by the northeastern areas, while the southwestern regions show lower levels of urban-rural integration, with significant internal spatial differentiation overall.

Within the Chengdu Plain Economic Zone, Chengdu, as the central city, plays a pivotal leadership role, exerting substantial influence across the entire region. This area displays a clear pattern of radiating outward from the center, forming a typical core-periphery structure. As a sub-provincial city and one of China's national central cities, Chengdu benefits from unique resource conditions and policy advantages that other cities in the region cannot match. Consequently, Chengdu's socio-economic development level is generally high, resulting in relatively weaker competitive capacity in other areas of the Chengdu Plain Economic Zone.

Regarding the overall spatial differentiation within the study area, Deyang, Mianyang, and Suining exhibit relatively high comprehensive scores for urban-rural integration, classifying them as medium-high-level integration zones. As secondary central cities within the Chengdu Plain Economic Zone, Deyang and Mianyang have slightly lower development levels compared to Chengdu. However, they are actively promoting urban-rural integrated development by improving infrastructure, adjusting industrial structures, enhancing rural living environments, and advancing the equalization of urban-rural public services. These efforts aim to narrow urban-rural development gaps and achieve regional development and shared prosperity. Although Suining may hold a relatively smaller position compared to Deyang and Mianyang, its economic development is more balanced and stable, with relatively high rural economic development levels, contributing to a favorable degree of urban-rural integration.

Meishan and Leshan, located in the mountainous regions of Sichuan Province, are geographically remote with rugged terrain. The mountainous topography results in lagging transportation and infrastructure development. Compared to the main cities in the Chengdu Plain Economic Zone, Meishan and Leshan have relatively lower economic development levels. Weak economic foundations lead to sluggish rural economic growth and significant urban-rural development disparities, resulting in medium-low levels of urban-rural integration.

Ya'an City, situated in northwestern Sichuan Province, is characterized by mountainous terrain and inconvenient transportation, which hinders connectivity between urban and rural areas and restricts the flow of resources

and industries. Ya'an's economy is predominantly agricultural, with relatively weak industrial and service sectors. This leads to uneven urban-rural development, with rural areas suffering from inadequate infrastructure and low levels of public services, resulting in significant urban-rural disparities. Furthermore, Ya'an's infrastructure development lags behind, and population outflow is severe, contributing to its persistently low level of urban-rural integration.

Figure 4-3 Spatial pattern of urban-rural integration in the Chengdu Plain Economic Zone

4.3.2 Spatial Characteristics of Each Dimension

Based on the average annual comprehensive scores for economic integration, social integration, spatial integration, and population integration across the eight prefecture-level cities in the Chengdu Plain Economic Zone from 2012 to 2021, the spatial characteristics of the four dimensions of urban-rural integration were analyzed using the data visualization capabilities of ArcGIS 10.2. The results are presented in Figure 4-4.

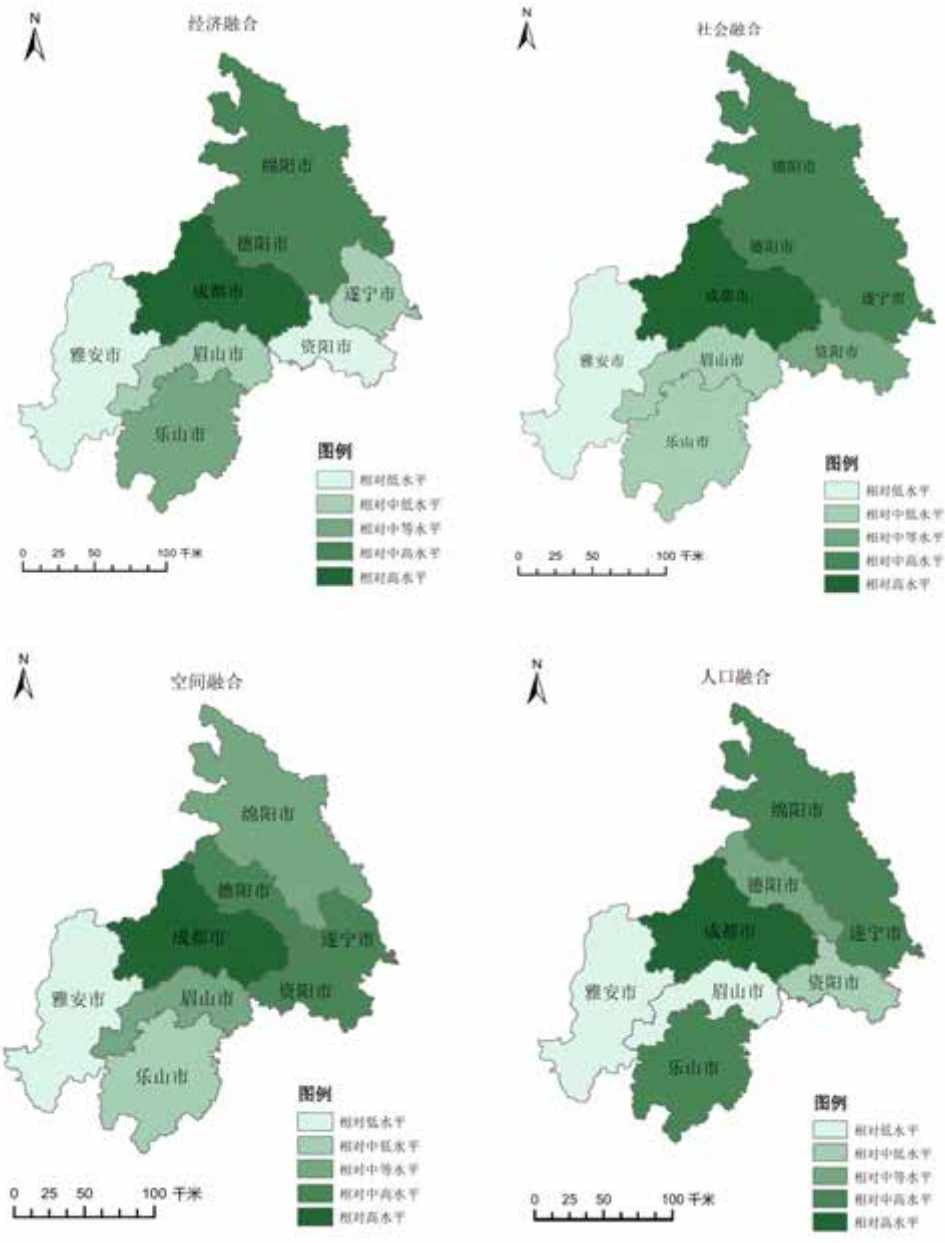

Figure 4-4 Spatial pattern of urban-rural integration levels in various dimensions of the Chengdu Plain Economic Zone

The urban-rural integration in the Chengdu Plain Economic Zone exhibits significant spatial differentiation and dynamic evolution characteristics. In the economic dimension, Chengdu, as the core city, leverages its diversified industrial structure and national strategic positioning to lead regional coordinated development. Deyang and Mianyang, relying on equipment manufacturing and aerospace industries, form secondary growth poles. Leshan depends on tourism resource development but has a lower industrial level, while Ya'an and Ziyang face integration lags due to isolated transportation and singular industrial structures. In the social dimension, Chengdu promotes social equity through high-quality public services and infrastructure. Deyang and Mianyang maintain medium levels through balanced resource allocation, while Meishan and Leshan are constrained by shortcomings in education and healthcare. Ya'an, with significant urban-rural consumption gaps and deficiencies in public services, remains a low-performing area. In the spatial dimension, Chengdu achieves urban-rural spatial inte-

gration through efficient road networks and ecological planning. Deyang and Suining facilitate factor flows via transportation hubs, whereas Leshan and Ya'an are limited by topographic constraints and unplanned expansion, resulting in weaker spatial integration. In the population dimension, Chengdu's high urbanization rate and non-agricultural employment advantages create a strong agglomeration effect. Deyang and Suining optimize labor structures through industrial upgrading, while Leshan attracts population settlement through cultural and tourism resources but with low conversion efficiency. Ya'an and Meishan, hindered by economic lag and transportation barriers, face population outflow and weak urban-rural interactions. The regional pattern overall displays a gradient differentiation of "core polarization–secondary emergence–peripheral decline," necessitating targeted policies to address the dual constraints of natural conditions and institutional barriers in peripheral areas.

4.3.3 Characteristics of Spatial Pattern Evolution

Based on detailed data from 2012 to 2021, this study conducted a comprehensive assessment of urban-rural integration levels in the Chengdu Plain Economic Zone. Using ArcGIS software and the natural breaks method within standard classification techniques, the comprehensive urban-rural integration scores were meticulously categorized. The study specifically focused on the comprehensive scores for the key years of 2012, 2016, and 2021, integrating these with vector maps of the Chengdu Plain Economic Zone to create spatial pattern evolution maps of urban-rural integration levels for these three years.

Building on these results, the study further analyzes and explores the evolutionary characteristics of the overall spatial pattern of urban-rural integration levels in the economic zone, aiming to provide robust data support and theoretical reference for future strategic planning of urban-rural integration.

Analysis of Figure 4-5 (see Appendix) reveals that in 2012, the urban-rural integration levels in the Chengdu Plain Economic Zone exhibited a spatial distribution pattern centered on Chengdu, radiating outward, with lower levels in the southwest and higher levels in the northeast. As the core city of the Chengdu Plain Economic Zone, Chengdu plays a leading and driving role. Its urban-rural integration development is at a relatively high level, characterized by close integration between urban and rural areas. Chengdu's development serves as a "pacesetter," exerting a radiating effect on surrounding areas. Suining City ranks at a relatively medium-high level of urban-rural integration. Although its development level is slightly lower than Chengdu's, it still has a certain radiating and driving effect, contributing to the integration development of neighboring areas. Deyang City's urban-rural integration level is at a relatively medium level. While it ranks at a medium level within the Chengdu Plain Economic Zone, its performance in urban-rural integration remains relatively stable, serving as a bridge connecting Chengdu with other regions. The remaining five cities maintain medium-low to low levels of urban-rural integration, with significant gaps compared to Chengdu. These disparities may be related to factors such as economic development levels, infrastructure development, industrial structures, and policy support in these regions.

Figure 4-5 Spatial pattern of urban-rural integration in the Chengdu Plain Economic Zone in 2012

In 2016, the significant improvement in urban-rural integration levels in the Chengdu Plain Economic Zone reflected the region's positive achievements in advancing urban-rural integrated development. First, Chengdu City, as the core city of the economic zone, continued to play a leading role, maintaining a relatively high level of urban-rural integration and demonstrating its advantages in economic, social, and cultural domains. Second, Mianyang City, an important component of the economic zone, achieved a notable increase in its urban-rural integration level, likely benefiting from the city's sustained efforts in urbanization and rural reform policies. Additionally, Ziyang City's urban-rural integration level advanced from a medium-low to a medium level, reflecting progress in infrastructure development and public service provision. These positive changes indicate that various regions within the Chengdu Plain Economic Zone have made significant strides in urban-rural integration, gradually narrowing urban-rural disparities and laying a solid foundation for comprehensive regional socio-economic development. (See Appendix Figure 4-6)

Figure 4-6 Spatial pattern of urban-rural integration in the Chengdu Plain Economic Zone in 2016

In 2021, the urban-rural integration level in the Chengdu Plain Economic Zone further improved, demonstrating a positive and upward development trend. However, the spatial distribution pattern of "low in the southwest, high in the northeast, and highest in the center" persisted. Within this pattern, Chengdu City remained the only region with a relatively high integration level, continuing to lead in urban-rural integration performance. Additionally, Deyang City saw a significant improvement in its urban-rural integration level, emerging as a new force in the medium-high-level integration zone. Meishan City progressed from a relatively low level to a medium level, indicating a positive trend in the development of its urban-rural integration. Overall, the urban-rural integration level in the Chengdu Plain Economic Zone exhibited a strong development trajectory in 2021, with all regions actively working to address urban-rural development imbalances and advance urban-rural integration to higher levels. (See Appendix Figure 4-7)

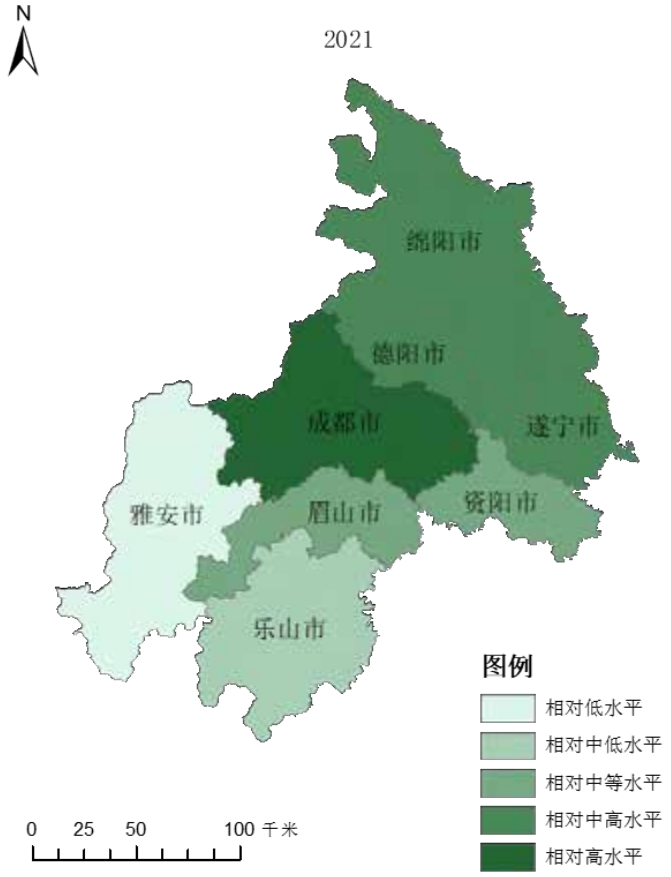

Figure 4-7 Spatial pattern of urban-rural integration in the Chengdu Plain Economic Zone in 2021

5. Influencing Factors of Urban-Rural Integration Levels in the Chengdu Plain Economic Zone

5.1 Variable Selection and Data Sources

5.1.1 Variable Selection

To explore the comprehensive influencing factors of urban-rural integration development levels, this study conducted a thorough review of relevant literature and studies, identifying six key dimensions: economic development level, population structure, policy investment, natural conditions, social conditions, and information development level. Subsequently, eight representative variables were carefully selected under these dimensions to comprehensively analyze how these variables influence and constrain the overall level of urban-rural integration. The selection of these variables not only enriches the dimensions of the study but also enhances the accuracy and comprehensiveness of the analysis.

5.1.2 Data Sources

The dependent variable data used in this chapter are derived from the comprehensive evaluation scores for the four dimensions of urban-rural integration—economic, social, spatial, and population—calculated using the entropy method in Chapter 4. The data for the explanatory variables primarily come from multiple sources, including the Sichuan Statistical Yearbook, statistical yearbooks of individual cities, the China City Statistical Yearbook, and the China Regional Economic Statistical Yearbook. This study focuses on the eight prefecture-level cities in the Chengdu Plain Economic Zone, covering the period from 2012 to 2021, to thoroughly examine the dynamics of urban-rural integration development in this region.

5.2 Construction of the Indicator System for Influencing Factors

The spatio-temporal evolution of urban-rural integration levels in the Chengdu Plain Economic Zone results from the combined effects of multiple influencing factors. Drawing on existing research and considering the actual conditions of urban-rural integration development in the economic zone, an indicator system for the influencing

factors of spatial differentiation in urban-rural integration levels was constructed, as shown in Table 5-1.

Table 5-1 Spatio-temporal Evolution of Factors Influencing the Level of Urban-Rural Integration in the Chengdu Plain Economic Zone, 2012–2021: Indicator System

Variable factors	symbol	Specific indicators	Explanation of indicators
Level of economic development	X1	GDP per capita	GDP/total land area (10,000 yuan/km²)
	X2	Ratio of non-agricultural to agricultural workers	Number of people employed in non-agricultural industries/number of people employed in agriculture
Population structure	X3	Urbanization rate	Urban population/total population
Policy investment	X4	Per capita fiscal expenditure	Fiscal expenditure/total population
Natural conditions	X5	Green space ratio	Statistical data
Social conditions	X6	Ratio of disposable income between urban and rural areas	Per capita disposable income in cities/per capita disposable income in rural areas
	X7	Ratio of Engel's coefficient between urban and rural areas	Engel's coefficient in cities/Engel's coefficient in rural areas
Level of information development	X8	Limited radio and television penetration rate	Number of cable TV users/total population*100

Building on the previous discussion of the spatio-temporal evolution characteristics of urban-rural integration patterns in the Chengdu Plain Economic Zone, this study selected the years 2012, 2016, and 2021, and comprehensively compiled data on relevant influencing factor indicators for these years. Subsequently, the geographical detector model was employed to analyze the influencing factors of urban-rural integration levels in the economic zone, aiming to explain its spatial distribution characteristics.

5.3 Analysis of Influencing Factors

5.3.1 Main Influencing Factors

According to the detection results presented in Table 5-2, the urban-rural integration levels in the Chengdu Plain Economic Zone across the eight single factors varied in 2012, 2016, and 2021. Based on the average q-values over multiple years, the main influencing factors can be categorized into different tiers. Urbanization rate, per capita GDP, urban-rural disposable income ratio, and the ratio of non-agricultural to agricultural employment rank at the top in terms of average q-value influence, with mean q-values of 0.927, 0.925, 0.922, and 0.907, respectively. The second tier includes the urban-rural Engel coefficient ratio and per capita fiscal expenditure, with mean q-values of 0.643 and 0.521, respectively. The third tier comprises the penetration rate of cable television and the green coverage rate, which have relatively smaller q-values. Overall, the q-values of the second and third tiers are relatively low, indicating their weaker influence on the spatial differentiation of urban-rural integration in the Chengdu Plain Economic Zone.

Observing the changes in the q-values of the influencing factors, the spatial differentiation influence of per capita GDP, the ratio of non-agricultural to agricultural employment, the urban-rural disposable income ratio, and the urban-rural Engel coefficient ratio on urban-rural integration levels in the economic zone shows an increasing trend. This suggests that the differences in these factors across different years have a progressively stronger impact on urban-rural integration levels. Conversely, the influence of green coverage rate and cable television penetration rate on the spatial differentiation of urban-rural integration levels exhibits a decreasing trend. This implies that the impact of changes in these two factors across different years on urban-rural integration levels is gradually weakening, or that the influence of other factors is increasingly dominant.

Table 5-2 Detection results of influencing factors of urban-rural integration in Chengdu Plain Economic Zone

Factor Index	2012		2016		2021		Average	
	q	p	q	p	q	p	q	Average q Value Ranking
Land GDP per Unit Area	0.858	0.414	0.965	0.096	0.951	0.224	0.925	2
Ratio of Non - Agricultural to Agricultural Personnel	0.816	0.578	0.972	0.073	0.934	0.221	0.907	4
Urbanization Rate	0.888	0.33	0.974	0.071	0.919	0.308	0.927	1
Per Capita Fiscal Expenditure	0.234	0.935	0.97	0.07	0.36	0.881	0.521	6
Greening Rate	0.655	0.652	0.451	0.825	0.35	0.911	0.485	8
Ratio of Urban - Rural Disposable Income	0.848	0.458	0.977	0.055	0.94	0.215	0.922	3
Ratio of Urban - Rural Engel Coefficients	0.414	0.83	0.569	0.694	0.945	0.196	0.643	5
Cable TV Penetration Rate	0.84	0.484	0.492	0.77	0.192	0.975	0.508	-

5.3.2 Temporal Variation Characteristics of Main Influencing Factors

Based on the multi-year average values of the eight detection factors, the top four factors were selected as the primary determinants of spatial variation in urban-rural integration levels within the Chengdu Plain Economic Zone for temporal change analysis. The results show:

The multi-year average q-value for urbanization rate in the Chengdu Plain Economic Zone is 0.927, indicating that it is the most significant factor influencing the spatial differentiation of urban-rural integration levels. From 2012 to 2021, the q-value for urbanization rate increased from 0.888 to 0.919, while the p-value approached 0, indicating a significant enhancement in its influence. This change in the degree of influence reflects adjustments in the region's urban-rural development strategies and shifts in its economic structure. On the one hand, the government has implemented a series of policy measures during the urbanization process, such as increasing investment in urban infrastructure, optimizing urban planning and layout, and improving the level of urban public services, to accelerate the urbanization process. These measures have attracted a large number of rural residents to migrate to cities, thereby driving the growth of the urbanization rate. On the other hand, as the urbanization process has advanced, the economic structure of the Chengdu Plain Economic Zone has also undergone changes, shifting toward sectors such as services and high-tech industries. Meanwhile, rural areas have also transitioned toward diversified industrial development, prompting more people to migrate from rural areas to cities, further increasing the urbanization rate. Therefore, the influence of the urbanization rate on the spatial differentiation of urban-rural integration in the Chengdu Plain Economic Zone has gradually strengthened.

The second major factor influencing the spatial differentiation of urban-rural integration levels in the economic zone is GDP per unit of land area. Its multi-year average q-value is 0.925. Between 2012 and 2021, the q-value

of GDP per unit of land area rose from 0.858 to 0.925, while the p-value approached 0, indicating a significant increase in its influence. In the Chengdu Plain Economic Zone, the influence of GDP per unit of land area as a key factor in the spatial differentiation of urban-rural integration has gradually increased for multiple reasons. First, the regional economy has continued to grow. Through measures such as technological innovation, industrial upgrading, and optimized resource allocation, the Chengdu Plain Economic Zone has continuously improved production efficiency and economic benefits, thereby driving the growth of GDP per unit of land area. Second, the government has implemented proactive urban-rural integration policies, strengthened infrastructure construction, promoted industrial structure optimization, and accelerated urbanization, further fostering balanced regional economic development and elevating the level of GDP per unit of land area. Additionally, strengthened urban-rural exchanges and accelerated talent mobility have injected new momentum into regional economic development, further enhancing the influence of GDP per unit area. Therefore, the growing influence of GDP per unit area in the Chengdu Plain Economic Zone reflects the combined effects of sustained regional economic development, proactive government policies, and strengthened urban-rural exchanges.

Over the years, the multi-year average q-value of the urban-rural disposable income ratio has been 0.922, making it one of the key factors influencing the spatial differentiation of urban-rural integration levels within the economic zone. Between 2012 and 2021, this indicator rose from 0.848 to 0.940, while its p-value continued to decline, indicating that the significance of spatial differentiation is increasing. In the process of urban-rural integration, the influence of the urban-rural disposable income ratio as a key factor has gradually increased, for various reasons. First, the optimization of the economic structure has driven this trend. By promoting industrial upgrading, strengthening rural economic development, and providing more employment training, economic ties between urban and rural areas have become closer. Second, the government has implemented proactive urban-rural integration policies, including more in-depth infrastructure development, improved public service levels, and the formulation of more comprehensive urban-rural integration plans. The implementation of these policies helps to further narrow the urban-rural income gap, reflecting greater fairness and balance in economic and social development, enhancing overall social stability and sustainable development, and thereby strengthening the influence of the urban-rural disposable income ratio. Additionally, the widespread adoption of information technology and improvements in transportation networks have provided urban and rural residents with broader employment and income opportunities, further driving the increase in the urban-rural disposable income ratio. Overall, the gradual increase in the influence of the urban-rural disposable income ratio reflects the adjustment and optimization of the economic structure, the comprehensive implementation of government policies, and the combined effects of multiple factors such as information technology.

The average Q-value for the ratio of non-agricultural to agricultural workers over the years is 0.907. From 2012 to 2021, the Q-value increased from 0.816 to 0.934, with the P-value continuously decreasing, indicating a significant increase in the influence of spatial differentiation. As urban-rural integration progresses, the more balanced allocation of social resources has brought about multiple impacts. First, the balanced development of education, healthcare, and science and technology has enhanced the overall quality and skill levels of urban and rural residents, making them more capable and competitive in non-agricultural industries. Second, fairer distribution of social resources has promoted talent cultivation and attraction in rural areas, reducing cities' reliance on migrant labor and thereby increasing non-agricultural employment opportunities and income levels. These factors collectively contribute to the rise in the ratio of non-agricultural to agricultural workers. Urban-rural exchanges facilitate the cross-regional dissemination of technology and management experience, enabling rural laborers to access more advanced technical knowledge and management expertise, thereby enhancing their capabilities and proficiency in non-agricultural industries. Additionally, rural talent also has the opportunity to enter urban areas through urban-rural exchange and participate in urban economic activities, thereby increasing the number of non-agricultural workers. This flow of technology and talent promotes complementary development between urban and rural economies, driving the growth of the ratio of non-agricultural to agricultural workers. These factors collectively enhance the influence of the ratio of non-agricultural to agricultural workers on urban-rural integration.

6. Research Conclusions and Policy Recommendations

6.1 Research Conclusions

The integrated urban-rural development of the Chengdu Plain Economic Zone exhibited significant regional differentiation and dynamic evolution from 2012 to 2021. From a temporal perspective, the comprehensive score for integrated urban-rural development in the region increased from 0.274 to 0.482, with an average annual growth rate of 8.65%, but internal gradient differences persisted. Chengdu, as the core city, has consistently remained in the high-level integration zone, with its economic agglomeration effects and policy advantages driving efficient allocation of urban-rural resources; cities in the northeastern region such as Deyang and Mianyang have gradually risen to the medium-high level through industrial upgrading and population aggregation; while cities in the southwestern peripheral regions such as Ya'an and Leshan have long remained at the medium-low level due to geographical barriers and lagging infrastructure. A dimensional analysis indicates that economic integration and population integration are the fastest-growing areas, with the increase in the proportion of non-agricultural industries and the growth in urbanization rates contributing the core driving forces. However, spatial integration is constrained by insufficient expansion of transportation networks, resulting in relatively slow growth. Geographic detector results show that urbanization rates (q=0.62) and GDP per unit of land area (q=0.58) are the primary factors driving spatial differentiation in urban-rural integration, followed by urban-rural income gaps (q=0.45) and non-agricultural employment structures (q=0.38), confirming the dual logic of "economic efficiency-driven" and "population aggregation-driven" development.

6.2 Policy Recommendations

Based on the above conclusions, policy design should focus on three key directions: regional coordination, factor mobility, and functional complementarity. First, a "core-secondary-peripheral" coordinated development network should be established to enhance the industrial reception capacity of secondary central cities such as Deyang and Mianyang. This would guide the outward expansion of Chengdu's high-tech industries to Deyang's high-end equipment manufacturing base and Mianyang's science and technology Transfer Pilot Zone, while providing targeted support for peripheral regions such as Ya'an and Leshan. Infrastructure projects such as the Chengdu-Ya'an high-speed rail double track and the Leshan-Xichang expressway should be implemented to reduce spatial-temporal distances, and the ecological compensation mechanism should be leveraged to explore a "green industry + rural tourism" integration model. Second, reforms to facilitate the two-way flow of urban and rural resources should be deepened. Pilot programs for the entry of collectively-owned operational construction land into the market should be launched in Chengdu's suburban areas to activate the value of rural land assets. In peripheral regions, the "rural homestead land swap for urban housing" policy should be implemented to promote the urbanization of agricultural populations. Concurrently, a cross-regional talent sharing network should be established to encourage flexible talent mobility through the "weekend engineer" model, and mechanisms for cross-regional social security coordination should be improved to lower barriers for non-resident populations to access public services. Finally, efforts should be made to promote complementary urban-rural functions and shared value creation. The metropolitan area should focus on developing high-end industries such as research and design, and financial services, while peripheral counties should take on labor-intensive industries such as agricultural product processing and logistics warehousing, forming a "research in the city, production in the countryside" industrial chain. At the same time, local cultural resources such as the Sichuan Western Forest Villages and Qiang-Tibetan villages should be explored to create a "intangible cultural heritage workshops + digital tourism" brand, using cultural identity to promote spiritual integration between urban and rural areas, to achieve a profound transformation from "spatial integration" to "value integration."

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Transformation of Consumption Space in Urban Regeneration: Spatial Characteristics and Influencing Factors of Youth Subcultural Consumption Space

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Abstract:
Multicultural demands and spatial transformations have fostered emerging consumption spaces, particularly youth subcultural venues in Chinese cities. Focusing on Nanjing's historic urban core, this study utilizes Dianping POI data to examine the spatial distribution patterns of youth subcultural spaces and their influencing factors within a multicultural context. GIS analysis reveals a "single-core with three subcentres" spatial configuration and point-axis development structure. SLM spatial lag models identify key agglomeration determinants: commercial density, catering density, cultural facility density, landmark density, and residential density. These spaces facilitate autonomous renewal of traditional commercial areas while creating inclusive social environments for youth, representing a transformative trend in urban consumption space evolution.

Keywords: multiculturalism; youth subculture; consumption space; inclusiveness; Nanjing

0. Introduction

Driven by the rapid development of the cultural economy, China is transitioning from the industrial era to the information era, from the mechanical age to the creative age, and from growth-oriented development to sustainable development. Urban development is gradually shifting from functional cities to cultural cities [1]. However, certain urban challenges have emerged, including the disconnection between cultural consumption spaces and consumption values, an emphasis on construction over operation, and the separation of production, living, and consumption—collectively termed as new urban maladies. In historical districts, the encroachment of commercialised spaces has triggered a cultural crisis in urban spaces[2]. Excessive commercialisation has eroded the original cultural identity, historical memory, authentic architecture, and folk customs, replacing them with homogenised dining streets, Yiwu commodity markets, tourist souvenirs, and globalised fast-consumption symbols.Cultural consumption plays an increasingly vital role in urban economic life. Cities, functioning as entertainment machines, continuously create diverse spaces to meet the growing demand for cultural consumption. A key challenge for many cities is how to cultivate vibrant cultural consumption spaces.

The evolution of urban spatial demands and qualitative upgrading of consumption patterns have expanded cultural consumption beyond material acquisitions (e.g., purchasing audiovisual products and printed materials) to encompass experiential dimensions (e.g., exhibition visits and cinema attendance), while subcultural groups increasingly engage in identity-driven consumption (e.g., live music venues, Pop Mart collectibles, and tattoo culture) for emotional value and social recognition.This diversification further stimulates the upgrading of cultural consumption and revitalises underutilised spaces. Nanjing, a renowned historical and cultural city in China, has witnessed a surge in youth-oriented subcultural consumption spaces amid the new consumption wave[3]. Against this backdrop, examining the spatial distribution patterns and influencing factors of youth subcultural consumption spaces holds significant implications for systematic research on consumption spaces and their transformation in urban renewal.

1. Research Context

The acceleration of globalization has intensified the flow and collision of cultural elements within urban spaces, transforming cities into dynamic carriers of multicultural coexistence, stratification, and evolution. Existing studies have adopted interdisciplinary approaches to analyze the plurality of urban cultural landscapes, systematically deconstructing their spatial characteristics through layered frameworks. For instance, research on Southeast Asian cities has employed macro-, meso-, and micro-scale analysis to examine the temporal evolution of urban morphology, street networks, and iconic architectural features[4], establishing an analytical model for understanding multicultural urban landscapes in coastal cities[5].Scholars have also applied the Historic Urban Landscape (HUL) approach to investigate how cultural diversity influences the development of urban historical spaces and heritage[6]. A notable example includes studies on the port city of Qingdao, where the organic integration of

maritime culture, foreign influences, and indigenous traditions has played a sustainable role in shaping the city's unique identity. During the urban regeneration phase focused on enhancing quality and efficiency, the inclusive capacity of public open spaces to accommodate multicultural interactions has emerged as a critical factor in improving spatial vitality. Empirical research in Macao—a multicultural hub—has examined the congregation patterns of migrant domestic workers in public spaces, analyzing their spatial distribution, underlying factors, and formation mechanisms[7]. Preserving the authenticity and continuity of multicultural expressions not only fosters social well-being but also unlocks economic potential. Multicultural neighborhoods, with their inherent complexity and diversity, contribute significantly to urban vitality and economic resilience[8]. This body of research underscores the need for integrated approaches that balance cultural preservation with sustainable urban development[4].

The rise of youth subcultural consumption spaces has occurred within the broader context of experiential consumption and the transformation of consumption spaces. Within Chinese academic discourse, the concept of 'youth subculture' is generally understood to represent cultural paradigms and typologies that diverge from dominant social culture while gaining popularity among youth demographics. The post-Birmingham School interpretation of subcultural circles has effectively deconstructed the traditional binary opposition between subculture and mainstream culture[9].

Core characteristics manifest in three dimensions:

(1)Identity Attributes: Exclusivity and Social Enclaving

Centreed on youth cohorts, these spaces coalesce around distinct subcultural interests and identity formations. Through curated symbols, behaviors, vernaculars, sartorial codes, and musical practices, subcultural groups demarcate collective identities, forging insulated social enclaves that consciously diverge from mainstream culture. This interactive boundary-making enhances spatial stickiness, transforming locales into physically demarcated territories with high identifiability.

(2)Functional Attributes: Placemaking and Symbolic Consumption

These spaces manifest a cyberspace-to-physical transition—exemplified by offline venues like trendy collectible stores—where "cool" and "edgy" elements materialize digital tribal cultures into tangible environments saturated with subcultural ethos. Functioning as urban cultural strongholds, they typically anchor commercial hubs, creative districts, or neighborhood nuclei, evolving into symbolic urban landmarks. For instance, subcultural malls in metropolitan trend zones form distinctive cultural circuits that become integral to city identity. Beyond commercial venues, they serve as epicentres for cultural praxis and collective identification.

(3)Cultural Attributes: Commodification-Culture Hybridity

Defined narrowly, these spaces inherently possess dual characteristics: commercial viability through sales of subcultural merchandise/services/experiences, and cultural authenticity as vessels of youth expression. Crucially, subcultural meaning remains contingent on relational frameworks—absent referential systems, subculture defies definition.

Based on these attributes, youth subcultural consumption spaces are identified through a tripartite lens:①Youth-dominant participation;②Cultural consumption orientation;③Provision of goods/experiences bearing subcultural symbolic value. Here, consumption extends beyond products/services to encompass spatial embodiment itself—patrons engage with tangible/intangible subcultural commodities while inhabiting meaning-charged environments. Through spatial praxis, participants experience multilayered subcultural immersion, forge social networks, and enact identity construction. This transcends mere transactional fulfillment, constituting instead deep cultural performance, social ritual, and identity-forming agency.

Accordingly, this study defines youth subcultural consumption spaces as purpose-built physical venues in urban environments that cater specifically to distinct youth subcultural groups. These spaces fulfill consumers' demands for identity affirmation, cultural experience, and community engagement through the commercialisation of subculture-specific merchandise and the creation of immersive spatial experiences.

International scholarship addressing youth subcultural consumption spaces remains fragmented, with most research confined to theoretical examinations of youth subculture from an urban sociological perspective, focusing primarily on associated social phenomena and issues[10-12]. Chinese academic inquiries into subculture have predominantly engaged with concepts including micro-media youth, cultural capital, ACG (animation, comics, and games) culture, and stereotype formation, with particular emphasis on the social impacts of subculture on youth development and detailed analyses of specific subcultural groups' behavioral characteristics across both online and offline platforms[13-16].

The current academic landscape reveals significant gaps in research from urban planning and human geographical perspectives, particularly regarding the interaction mechanisms between youth subcultural groups and physical environments, as well as detailed case studies focusing on specific demographic groups. Existing studies, such as those investigating urban and community influences on youth culture formation[16], comparative analyses of international youth fashion districts from cultural perspectives[17], and examinations of the 'Smarti' phenomenon's spatial distribution patterns within urbanisation processes[18], generally lack comprehensive analytical frameworks. While subsequent empirical research has explored the evolutionary processes of culturally hybrid consumption spaces exhibiting transnational subcultural characteristics[19], substantial research opportunities remain concerning the comparative spatial distribution relationships between youth subculture and mainstream culture in urban consumption landscapes, the spatial translation mechanisms of youth subculture within urban consumption space transformations, and the spatial distribution patterns and influencing factors of youth subcultural spaces.

2. Research Data and Methodology

2.1 Data Sources and Processing

2.1.1 Youth Subcultural Consumption Spaces

As one of China's first cohort of National Famous Historical and Cultural Cities and a UNESCO Creative City of Literature, Nanjing possesses profound historical heritage and abundant cultural resources. In recent years, the city has facilitated the unleashing of cultural consumption momentum through advancements in culture, tourism, and MICE sectors. Consequently, the typology of youth subcultural consumption spaces within Nanjing's Old City has been continually enriched. [20].

This study focuses on youth subcultural consumption spaces within Nanjing's Old City as its primary research object. The foundational research data comprise Point of Interest (POI) data and spatial vector datasets sourced from the Amap (Gaode) and Dianping platforms. Specifically, POI data pertaining to youth subcultural consumption spaces were extracted from the Dianping platform during April 2024. Following comprehensive data cleaning and filtering procedures, a refined dataset of 1,333 valid entries was obtained. Through rigorous random sampling validation, the processed data achieved an accuracy rate of 95%.

Currently, the academic community lacks a consensus regarding the precise definition of youth subcultural consumption spaces. Fundamentally, these spaces do not constitute a specific category of space per se, but rather represent consumption venues intentionally designed for specific youth subcultural groups and their associated cultural practices. Consequently, this research adopts a systematic classification framework grounded in the "National Economic Industry Classification (GB/T 4754-2017)" standard and the POI categorization coding system of the Dianping platform. Youth subcultural consumption spaces are thereby defined and classified into three mutually exclusive categories: 1) Artistic Creation Spaces, 2) Creative Retail Spaces, and 3) Leisure & Socialization Spaces(Table 1).

Table 1 Typology and Specific Formats of Youth Subcultural Consumption Spaces

Category	Content Description	Sub-category	Quantity (count)
Artistic Production	Renting studios or compact venues for subcultural art production	Street Dance Studios, DIY Workshops, Tattoo Parlors, Independent Recording Studios	226
Creative Retail	Providing commodities associated with specific subcultures	Designer toy boutiques, anime derivative merchandise stores, alternative fashion boutiques, vintage clothing shops, import goods specialty stores, record and music merchandise retailers, and skateboard specialty shops	227
Leisure Socialisation	Preferred Social Venues of Subcultural Groups	Punk bars, live music venues, comedy clubs, internet cafés, arcades, VR experience centres, escape rooms, murder mystery parlors, and alternative markets	880

2.1.2 Influencing Factors

The spatial distribution pattern of youth subcultural consumption spaces emerges as a complex outcome shaped by multiple interacting factors. A comprehensive review of literature examining determinants of consumption space distribution reveals that transportation factors, commercial factors, and socioeconomic factors consistently constitute common quantitative variables in empirical research[21-24]. Given the distinctive cultural attributes characterizing youth subcultural consumption spaces central to this investigation, cultural factors were deliberately integrated into the analytical framework. Guided by data availability constraints, this study operationalized variable selection by employing bus stop density, metro station accessibility, and road network density to represent transportation factors; shopping mall density and catering facility density to characterize commercial factors; school accessibility, cultural facility density, and scenic spot density to quantify cultural factors; and residential density alongside housing price levels to capture socioeconomic dimensions. This multi-factorial approach facilitated systematic analysis of influences governing the spatial distribution of youth subcultural consumption spaces within Nanjing's Old City, ultimately yielding four overarching influence categories—Transportation, Commercial, Cultural, and Socioeconomic—comprising ten explanatory variables (Table 2). To model spatial heterogeneity, a grid-based analytical approach was implemented wherein comparative model fitting analyses evaluated grid sizes standardized at 100-meter, 500-meter, and 1000-meter resolutions, accounting for both the physical extent of the Old City and the characteristic service radius of consumption spaces. Model performance metrics substantiated the optimality of the 500 × 500 meter grid resolution, consequently delineating 238 standardized analytical units across the study area. Prior to spatial econometric analysis, comprehensive data preprocessing was conducted, including multicollinearity diagnostics performed through multiple linear regression analysis using IBM SPSS Statistics 27 software. The computed Variance Inflation Factor (VIF) values for all independent variables remained consistently below the critical threshold of 3, confirming the absence of significant multicollinearity and thereby validating the mutual independence of explanatory variables for subsequent integration into spatial regression equations.

Table 2 Determinants of Youth Subcultural Consumption Space Distribution

Category	Factor	Variable Description	Data Source
Transportation	Bus stops	Number of bus stops per research unit (count)	Amap POI data
	Metro stations	Distance to nearest metro station (m)	Amap POI data
	Road network	Road length per unit area (km/km²)	Nanjing road vector data
Commercial	Shopping malls	Number of shopping malls per unit (count)	Amap POI data
	Restaurants	Number of catering establishments per unit (count)	Amap POI data
Cultural	Schools	Distance to nearest school (m)	Amap POI data
	Cultural facilities	Number of cultural venues per unit (count)	Amap POI data
	Tourist attractions	Number of scenic spots per unit (count)	Amap POI data
Socioeconomic	Residential areas	Number of residential communities per unit (count)	Amap POI data
	Housing prices	Average housing price per unit (¥/m²)	Beike second-hand housing data

2.2 Research Methods

This study employs a systematic suite of spatial correlation analysis models to comprehensively investigate the determinants and operational mechanisms governing the distribution of youth subcultural consumption spaces. The analytical framework progresses from global patterns to local variations, capturing both overarching trends and spatial heterogeneity, thereby providing an empirical grounding for evidence-informed urban spatial planning and youth cultural policy formulation. Prior to regression modelling, spatial autocorrelation diagnostics were conducted using Global Moran's I and Local Moran's I indices applied to youth subcultural consumption space distribution data. The Global Moran's I ascertains whether the data exhibit clustering or dispersion tendencies across the entire spatial domain, whilst the Local Moran's I identifies specific regional agglomeration characteristics. This dual-index approach determines the presence of spatial autocorrelation and informs subsequent model selection. Should significant spatial autocorrelation be observed, spatial econometric models become methodologically requisite.

Predominant methodologies for spatial correlation analysis encompass Ordinary Least Squares regression (OLS), spatial regression models (Spatial Lag Model/Spatial Error Model, SLM/SEM), and Geographically Weighted Regression (GWR). The OLS approach proves suitable under idealised scenarios devoid of significant spatial autocorrelation, whilst SLM/SEM models—contingent upon spatial weight matrices—are routinely employed in investigations of complex spatial mechanisms. GWR is particularly apt for examining localised spatial variations in influencing factors. An initial OLS model was constructed to provisionally estimate determinants of youth subcultural consumption space distribution. Rigorous diagnostic testing for multicollinearity, heteroscedasticity, and residual normality was undertaken to evaluate model suitability and robustness. Where substantial multicollinearity, heteroscedasticity, or non-normal residual distributions were detected, variable transformations or corrective methodologies were applied to ensure estimative validity.Subsequent to confirming spatial autocorrelation presence, both SLM and SEM specifications were implemented to discern whether spatial dependence operated predominantly through lagged-dependent or error-correction mechanisms. These three modelling frameworks—OLS, SLM, and SEM—were systematically deployed to analyse influencing factors, with comparative evaluation identifying the optimally fitted specification. Within this analytical architecture, youth subcultural consumption space density served as the dependent variable, whilst ten independent variables representing transportation, commercial, and cultural dimensions were operationalised[25]. Model selection adhered to established econometric criteria: higher R^2 and Log-Likelihood (Log L) values denote superior statistical significance,

whilst diminished Akaike Information Criterion (AIC) and Schwarz Criterion (SC) values indicate enhanced explanatory power. Following comprehensive assessment, the Spatial Lag Model (SLM) was retained for primary inference due to its demonstrable explanatory coherence and empirical verifiability.

Following the identification of the optimal global spatial econometric specification, the Geographically Weighted Regression (GWR) model was employed to interrogate the locally varying effects of individual determinants on the morphological configurations of youth subcultural consumption spaces. Through calibrated bandwidth parameterisation and kernel function selection, locally adaptive regression equations were formulated, facilitating the derivation of spatially distributed coefficient estimates for each influencing factor. Subsequent analysis examined inter-regional disparities in coefficient magnitude, directional effects, and statistical significance—thereby elucidating spatially heterogeneous patterns governing the distributional dynamics of youth subcultural consumption spaces.

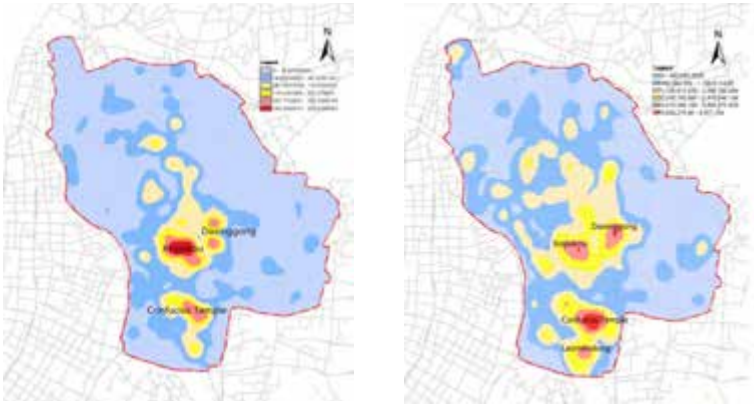
3. Macroscopic Distribution Characteristics of Youth Subcultural Consumption Spaces

Initially, the spatial autocorrelation analysis tool (Global Moran's I) within ArcGIS was employed to examine whether statistically significant spatial clustering exists in the distribution of youth subcultural consumption spaces within Nanjing's Old City. The results yielded a Moran's I index of 0.57, with a p-value < 0.001 and a Z-score of 15.51, strongly indicating the presence of significant positive spatial autocorrelation—demonstrating pronounced clustering effects among youth subcultural consumption spaces across the Old City.

Youth subcultural consumption spaces within Nanjing's Old City manifest a distinct polycentric agglomeration pattern, characterised by a primary central nucleus and three secondary clusters radiating through the urban fabric(Figure 1-a). This spatial configuration demonstrates pronounced concentration within both the historic commercial core and southern cultural districts, where high-density commercial-cultural hybrids have coalesced into identifiable subcultural quarters through complex socio-spatial processes.The central nucleus, anchored by the Xinjiekou-Daxinggong corridor, constitutes the traditional commercial heart of Nanjing. Here, premium retail complexes such as Deji Plaza and Central Mall have transcended conventional consumption functions through strategic cultural programming, including avant-garde art exhibitions and limited-edition brand activations specifically designed to attract fashion-conscious youth demographics. Adjacent to this, the 1912 precinct exemplifies successful heritage commodification, where Republican-era architecture has been adaptively reused to house concentrated subcultural venues - from craft cocktail bars to designer pop-up stores - creating a distinctive nocturnal economy. This area's exceptional accessibility, deriving from its pivotal position at the intersection of Metro Lines 1 and 2 supplemented by extensive bus networks, ensures sustained pedestrian flows that underpin the commercial viability of these specialised retail ecosystems.Among the secondary clusters, the Confucius Temple (Fuzimiao) district has leveraged its deep historical capital to cultivate immersive traditional cultural experiences. Specialist operators offer hanfu costume rentals for photogenic heritage exploration along the Qinhuai riverscape, complemented by hands-on workshops demonstrating Nanjing brocade weaving and other intangible cultural heritage techniques. This synthesis of tradition and youth culture has been further enhanced through deliberate urban interventions, particularly the Mendong Historic Quarter redevelopment, where carefully curated independent retailers - ranging from avant-garde bookshops to micro-roasteries - have established a culturally-anchored consumption node. These spaces simultaneously preserve architectural heritage while fostering contemporary creative expression, creating a palimpsest of historical and modern cultural layers.

Nanjing's Old City exhibits a pronounced polarisation in its cultural consumption landscape, with Xinjiekou emerging as a dominant central 'polar core' while peripheral areas demonstrate negligible agglomeration effects. This spatial configuration indicates an advanced stage of centralisation that warrants caution regarding potential regional development imbalances stemming from excessive resource concentration(Figure 1-b). Xinjiekou's longstanding status as Nanjing's civic centre has afforded it unparalleled advantages in cultural infrastructure development. The district boasts an integrated cultural ecosystem encompassing premium cinemas within major retail complexes such as Nanjing New Century and Central Mall, complemented by specialised venues including the People's Assembly Hall and Cultural Arts Centre. Together these facilities create a comprehensive cultural consumption spectrum ranging from popular entertainment to highbrow artistic experiences.

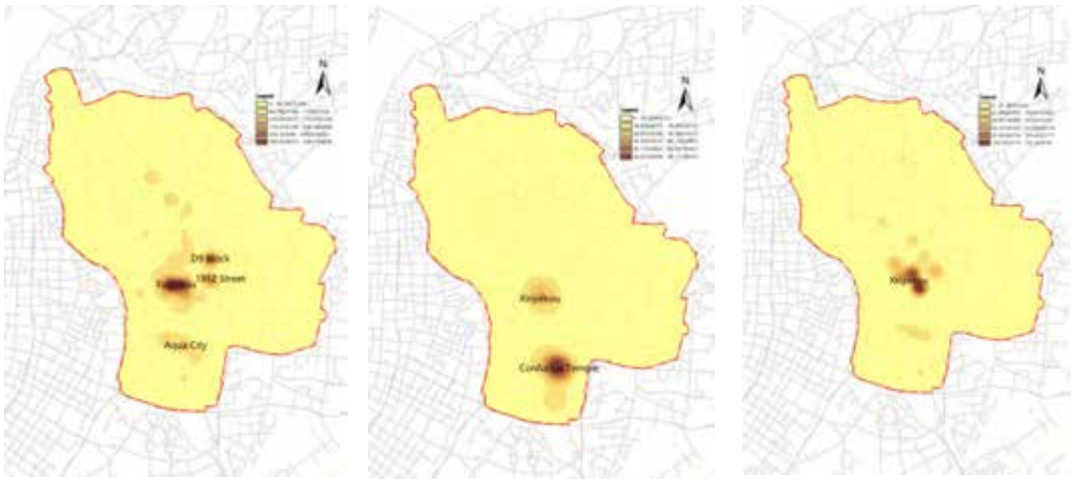
This concentration has been systematically reinforced through targeted policy interventions, including preferential funding for cultural infrastructure and the strategic allocation of major cultural events, thereby cementing Xinjiekou's position as the city's undisputed cultural nucleus.Conversely, peripheral zones within the Old City manifest significantly underdeveloped cultural consumption provision. The western districts exemplify this disparity, where historical planning priorities emphasised residential functions while neglecting cultural infrastructure. Limited commercial development has further compounded this imbalance, creating an environment inhospitable to major cultural enterprises and resulting in sparse, monotonous cultural offerings that fail to generate meaningful agglomeration effects.This polarised spatial structure presents dual challenges: Xinjiekou contends with the negative externalities of over-concentration, including chronic traffic congestion and market saturation, while peripheral residents face constrained access to diverse cultural consumption opportunities. Such asymmetrical development threatens the balanced growth of Nanjing's cultural economy and may engender self-reinforcing cycles of central accumulation and peripheral deprivation.



1-aYouth Subcultural Consumption Spaces

1-bCultural Consumption Spaces

Figure 1 Typology of Cultural Consumption Spaces



2-a Artistic Production

2-b Creative Retail

2-c Leisure Socialisation

Figure 2 Typology of Youth Subcultural Consumption Spaces

The kernel density analysis reveals that all three types of youth subcultural consumption spaces exhibit clustered distribution patterns, forming preliminary complementary spatial development clusters in both the central and southern parts of the historic urban core. Leisure and social spaces account for the largest proportion (approximately 66%), primarily comprising bars, live music venues, comedy clubs, internet cafés, and gaming arcades, with main concentrations in central areas including Xinjiekou, 1912 Pedestrian Street, and D9 Block (Figure 2-a). Creative retail and artistic production spaces constitute 16% and 17% respectively, where creative retail spaces (dominated by designer toy stores and anime derivative shops) mainly cluster around the Fuzimiao historic cultural district (Figure 2-b), while artistic production spaces (primarily street dance studios, DIY workshops, and tattoo parlors) predominantly concentrate in the Xinjiekou central area (Figure 2-c).

The leisure-socialisation youth subcultural consumption spaces (Figure 2-a) exhibit pronounced clustering within Nanjing's historic city centre, a spatial pattern fundamentally shaped by the area's vibrant commercial ecosystem, exceptional transport connectivity, and concentrated youth demographics. Xinjiekou, as the city's premier commercial district, accommodates upscale retail complexes including Deji Plaza and Central Mall, which have strategically diversified their offerings by incorporating bars, live music venues, and comedy clubs alongside conventional retail establishments. Deji Plaza exemplifies this trend through its sophisticated cocktail bars and regular musical performances that consistently attract fashion-conscious young patrons. Adjacent to this, the 1912 pedestrian precinct capitalises on its distinctive Republican-era architectural heritage to cultivate a thriving nocturnal economy, where atmospheric bars and cafés create compelling social destinations after dusk. Meanwhile, the D9 Block has emerged as a creative entertainment hub, integrating gaming arcades and internet cafés within its mixed-use development. This agglomeration is further facilitated by Xinjiekou's unparalleled accessibility as the interchange station for Metro Lines 1 and 2, supported by an extensive bus network that ensures sustained visitor flows essential for these leisure-socialisation businesses.

Creative retail subcultural spaces (Figure 2-b) demonstrate a distinct spatial logic, with approximately 16% concentration around the Confucius Temple historic district. These specialist retailers, including designer toy stores and anime merchandise shops, leverage the area's cultural capital and substantial tourist footfall to develop niche product lines that incorporate local heritage motifs. Innovative examples include collectible items featuring artistic interpretations of Qinhuai River scenery and Nanjing landmarks, which simultaneously cater to youth preferences for distinctive goods while promoting regional cultural narratives.

The precinct's mature tourism infrastructure, characterised by pedestrianised streets and public squares that regularly host creative markets, provides an ideal ecosystem for these ventures to flourish. Artistic-production spaces (Figure 2-c) display a 17% concentration in Xinjiekou, benefiting from the district's unique confluence of educational institutions and commercial vitality. Street dance studios, tattoo parlours, and DIY workshops thrive in this environment by drawing upon the abundant student populations from nearby Nanjing University and Southeast University, who serve as both primary consumers and potential practitioners. The district's robust commercial ecosystem enables innovative hybrid business models, exemplified by craft workshops that collaborate with consumer brands to produce customised merchandise. Furthermore, Xinjiekou's status as an information hub facilitates continuous exposure to emerging trends, fostering an environment of constant innovation that reinforces its agglomeration advantages.

This tripartite spatial configuration emerges from several interconnected urban processes: the strategic co-location of complementary subcultural businesses that create critical mass; high-capacity transport infrastructure enabling metropolitan-scale accessibility; synergistic relationships between cultural heritage and contemporary youth practices; and concentrated demographics with disposable income and cultural capital. The case offers valuable insights for urban planners seeking to cultivate vibrant youth cultural ecosystems while preserving historic urban character, demonstrating how careful spatial policy can mediate between commercial development and cultural sustainability in post-industrial cities. The organic formation of these specialised clusters illustrates the potential for creating dynamic interfaces between traditional urban forms and emergent youth cultures, suggesting pathways for other historic cities undergoing cultural-economic transitions.

4. Influencing Factors of Youth Subcultural Consumption Space Distribution

4.1 Analysis of Influencing Factors

The results of the three spatial econometric models are presented(Table 3). Regarding goodness-of-fit, the spatial lag model (SLM) (R^2=0.79601; Log L=-757.445706; AIC=1536.89; SC=1575.09) and the spatial error model (SEM) (R^2=0.794118; Log L=-756.318; AIC=1536.64; SC=1578.3) demonstrate comparable explanatory power for the distribution mechanisms of youth subcultural consumption spaces, with both outperforming the ordinary least squares (OLS) regression model. However, the SLM exhibits superior significance levels in its independent variables and, while having identical AIC values, shows slightly higher SC values than SEM, making it more suitable for subsequent mechanistic analysis of influencing factors. In conclusion, the SLM results prove more verifiable and interpretable, and thus this model is selected for the regression analysis of influencing factors.

Table 3 Comparative Results of Global Regression Models with Youth Subcultural Consumption Space Density as the Dependent Variable

Variable	OLS			SLM			SEM		
	Coefficient	t-value	t-value	Coefficient	z-value	t-value	Coefficient	z-value	t-value
	Constant -0.18221 -0.13181		0.89525	-0.12263	-0.08027	0.93602	-0.45693	-0.35109	0.72552
Bus stops	-0.55094	-1.38162	0.16845	-0.52891	-1.44267	0.14911	-0.76156	-2.00801	0.04464*
Metro stations	0.000479	0.310414	0.75652	0.000126	0.067855	0.9459	0.000915	0.628948	0.52938
Road network	-0.00265	-0.27124	0.78645	0.000009	0.001082	0.99914	-0.00167	-0.18091	0.85644
Shopping malls	2.10432	3.67549	0.0003***	2.1093	3.91852	0.00009***	2.02415	3.75241	0.00018***
Restaurants	0.132175	16.1686	0.000000***	0.125407	15.3723	0.000000***	0.11776	13.9925	0.000000***
Schools	-0.00015	-0.06236	0.95037	-0.0002	-0.06838	0.94548	-0.00072	-0.30629	0.75938
Cultural facilities	0.277169	3.33065	0.00101**	0.243271	3.00119	0.00269**	0.20114	2.50354	0.0123*
Tourist attractions	0.078244	2.40455	0.01699*	0.103218	3.16611	0.00155**	0.069942	2.25862	0.02391*
Residential areas	-0.28196	-3.41533	0.00075***	-0.24863	-3.14729	0.00165**	-0.28551	-3.67059	0.00024***
Housing prices	-0.20753	-0.81471	0.4161	-0.20402	-0.8213	0.41148	-0.1735	-0.72293	0.46972
R^2	0.778366			0.79601			0.794118		
Adjusted R^2	0.768603								
LogL	-763.896			-757.445706			-756.318		
AIC	1549.79			1536.89			1536.64		
SC	1587.99			1575.09			1578.3		

Note: *p<0.1, **p<0.01, ***p<0.001

Table 4 Influence Levels of Determinants on Youth Subcultural Consumption Spaces

Category	Factors	Directionality	Significance Level
Commercial	Shopping malls	Positive effect	***
	Restaurants	Positive effect	***
Cultural	Cultural facilities	Positive effect	**
	Tourist attrac-tions	Positive effect	**
Socioeconomic	Residential areas	Negative effect	**

Note: *,**and***indicate significance at the 5%, 1%, and 0.1% levels, respectively.

The SLM model results indicate that the primary factors influencing the agglomeration of youth subcultural consumption spaces are shopping mall density, restaurant density, cultural facility density, tourist attraction density, and residential area density. Among these, shopping malls, restaurants, cultural facilities, and tourist attractions exert positive effects, whereas residential areas demonstrate negative effects (Table 4).

First, commercial service facilities such as shopping mall density and restaurant density exert positive effects on the spatial distribution patterns of youth subcultural consumption spaces. The supply of commercial facilities like shopping malls and restaurants attracts consumers, expands consumer scale, and consequently promotes the agglomeration of consumption spaces to a certain extent, broadening customer acquisition channels for youth subcultural consumption spaces. The high-density human flow in these commercial spaces creates public spatial fields that provide low-cost venues for youth-dominated subcultural consumer groups, thereby facilitating rational spatial planning that maintains an elastic balance between commerce and diverse cultural formats.

Second, cultural facility density and tourist attraction density also demonstrate significantly positive effects on the distribution of youth subcultural consumption spaces. As spatial anchors for urban cultural tourism development, these facilities attract large numbers of non-local visitors and traveling youth, whose diverse demands present new spatial requirements and challenges to mainstream cultural facilities. On one hand, cultural facilities utilise media like books and exhibitions to serve as spatial platforms for disseminating youth subcultures within diverse cultural systems. On the other hand, through spatial translation of culture, independent artists are commissioned to create wall paintings and graffiti at tourist sites, creating inclusive spaces that facilitate equal dialogue between mainstream culture and subcultures. This collision and exchange of diverse cultures generates positive feedback effects for the composite development of cultural spaces.

Finally, residential density exhibits a significantly negative effect on the distribution of youth subcultural consumption spaces. Residential clusters are typically located in urban land price peak zones, where priority is given to mainstream cultural facilities such as libraries and sports stadiums. According to Alonso's bid rent theory, the payment capacity of youth subcultural businesses cannot compete with high-value-added industries like finance, upscale retail, and mainstream cultural media, leading to spatial squeeze effects on youth subcultural venues. Additionally, residential areas impose specific safety requirements for living environments, and some residents exhibit resistant attitudes due to stereotypical perceptions of youth subcultures. This negative influence reveals inherent conflicts between residential efficiency priorities and cultural diversity values in urban renewal processes.

4.2 Spatial Distribution Characteristics of Influencing Factors

A Geographically Weighted Regression (GWR) analysis was applied to the factors influencing youth subcultural consumption spaces previously identified through the Spatial Lag Model (SLM), enabling further exploration of how these five categories of factors shape such spaces. Visualization of the GWR regression coefficients effectivly captures the spatial heterogeneity of each factor's influence (Figure 3). The results reveal that, overall, the five influencing factors exhibit highly differentiated spatial clustering patterns. Their magnitude and direction

of influence display varying degrees of dispersion and equilibrium across different spatial extents within Nanjing's Old City, forming distinct clustered zones. This reflects significant spatial variations in the intensity of each factor's impact across urban districts.The influence of shopping mall density and catering density on youth subcultural consumption space distribution progressively diminishes from the central Old City toward its periphery. This pattern correlates with the Ming Palace area and its surroundings, where high concentrations of cultural heritage protection units and military zones result in lower commercial density and consequently reduced vitality of commercial services. Furthermore, large shopping malls and distinctive commercial streets are primarily distributed along Zhongshan South Road, Zhongshan North Road, and within the Confucius Temple (Fuzimiao) and Laomendong (Old East Gate) districts. In contrast, peripheral areas of the Old City feature fewer shopping malls and generally underdeveloped commercial and catering sectors.The influence of cultural facility density and scenic spot density decreases gradually from the southern Old City toward the north. The spatial extent of scenic spot influence corresponds directly to their distribution within the Old City. The southern districts possess abundant cultural facilities and densely concentrated scenic spots; this high saturation of historical and cultural resources contributes positively to increased density of youth subcultural consumption spaces. The influence of residential density diminishes from the northeastern periphery toward the northern Old City. Residential population density is lower in the northeastern periphery compared to the southern Old City. Areas with lower population density exhibit a stronger influence of this factor on youth subcultural consumption space distribution, consistent with the identified negative correlation associated with residential density.

Development priorities and trajectories diverge significantly across different regions of Nanjing's Old City. Historically dominated by factories and dense urban villages, the northern Old City has undergone large-scale regeneration in recent years, aiming to establish a model zone for industry-city integration within a megacity context. Conversely, the southern district of Qinhuai focuses on historical preservation and cultural-tourism integration. These differing historical paths and functional orientations have fostered pronounced north-south disparities in cultural diversity. The southern Old City exhibits vibrant cultural consumption, with cultural tourism driving district development. Over the past two years, youth subcultural consumption spaces have integrated with numerous traditional commercial spaces in the south, undergoing spatial renewal and business diversification, thereby infusing new vitality into the area's cultural consumption landscape. Meanwhile, regeneration efforts in the north prioritize the revitalization of traditional cultural corridors along the Yangtze River waterfront. The variation in regeneration priorities and levels of cultural inclusivity across these districts inevitably influences the locational attractiveness for youth subcultural consumption spaces. Effectively integrating urban multiculturalism with cultural consumption spaces thus constitutes a critical focus for contemporary urban regeneration strategies.

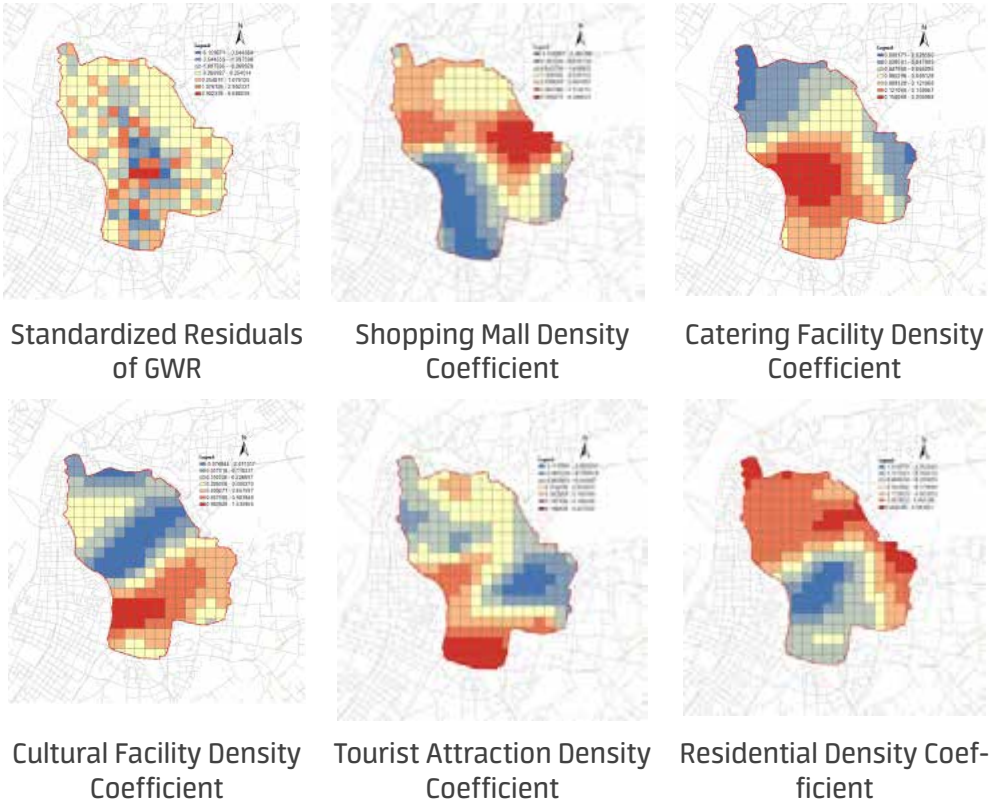


Figure 3 Spatial Heterogeneity of Influencing Factors for Youth Subcultural Consumption Spaces: A Geographically Weighted Regression (GWR) Analysis

5 Conclusions and Prospects

5.1 Key Findings

This study focuses on the macroscopic distribution characteristics and influencing factors of youth subcultural consumption spaces within Nanjing's historic urban core, with key findings as follows:

(1) At the interdisciplinary level of multiculturalism and urban consumption space research, this study constructs a youth subcultural consumption space framework at the macroscopic scale. Differing from previous studies that categorised these spaces into artistic creation spaces, creative retail spaces, and leisure-social spaces, youth subcultural consumption spaces represent an emerging typology within the urban cultural consumption system, constituting a critical subject for investigating consumption space transformation during urban renewal.

(2) Building upon the systematic framework of youth subcultural consumption spaces, this study focuses on analyzing their distribution patterns and influencing factors at the macroscopic scale, establishing an indicator system across four dimensions: transportation, commercial, cultural, and socioeconomic factors. The results demonstrate that youth subcultural activities in Nanjing's historic urban core exhibit vibrant spatial concentration, primarily clustering in the central and southern districts with high-density distributions centreed around modern commercial and cultural hubs. Specifically, shopping malls, restaurants, cultural facilities, and tourist attractions exert positive effects, while residential density shows negative impacts.

(3)The agglomeration of youth subcultural consumption spaces exhibits pronounced spatial heterogeneity in its driving factors across Nanjing's Old City. The clustering dynamics manifest distinct spatial dependencies wherein cultural facilities and tourist attractions exert stronger agglomerative forces in the southern districts, residential density emerges as the dominant driver in northern sectors, and commercial determinants—particularly concentrations of shopping malls and catering establishments—predominate in the central core area. This

centre-periphery differentiation further reveals that proximity to Xinjiekou, the metropolitan commercial nucleus, renders spatial aggregation predominantly responsive to commercial variables, whereas peripheral zones demonstrate heightened sensitivity to non-commercial influences including cultural facilities, scenic sites, and residential density. Such documented spatial divergence in formative mechanisms fundamentally illuminates the disparate logics governing cultural consumption space distribution, thereby providing an empirical foundation for designing spatially-targeted interventions to rectify developmental imbalances while simultaneously addressing a critical theoretical gap in consumption geography research through its context-sensitive explanatory framework.

5.2 Discussion and Prospects

This study systematically examines the role of youth subcultural consumption spaces in Nanjing's urban regeneration process, revealing their multifaceted value and operational mechanisms. Through empirical investigation and theoretical analysis, the research identifies four key functions these spaces perform in facilitating urban transformation, collectively constituting an integrated urban renewal promotion system.

(1) Cultural Agency as Spatial Catalyst: Activating Transformations in Existing Urban Fabric

Youth subcultural consumption spaces provide sustained cultural momentum for urban regeneration through unique cultural translation and spatial reconfiguration mechanisms. The study identifies two predominant transformation models: complete spatial renewal (e.g., the comprehensive conversion of Haishanghai Department Store into an anime-themed youth space) and partial functional adaptation (e.g., the introduction of trendy youth-oriented retail in Fashion Lady, Xinjiekou). These models demonstrate successful implantation of subcultural semiotics into physical spaces, facilitating cultural capital reproduction while reshaping place identity and spatial justice. Notably, this cultural transformation process often involves intergenerational cultural dialogue, preserving urban historical memory while infusing contemporary cultural significance. This study empirically validates the positive impact of shopping malls on the agglomeration of youth subcultural consumption spaces, providing theoretical underpinnings for the redevelopment of underutilized commercial assets in urban contexts. From a spatial economics perspective, malls generate synergistic agglomeration effects through intensive physical clustering, thereby reducing spatial fragmentation of subcultural consumption scenes and achieving a "1+1>2" multiplier effect that aligns with youth demands for diversified experiential consumption. Practically, renovating aging retail infrastructure not only revitalizes inefficient commercial properties but also facilitates cultural value reproduction within urban public spaces. Exemplary cases such as Shanghai's TX Huaihai and Chengdu's ACG Plaza demonstrate how integrating subcultural formats—including collectible art toys, ACG (Anime-Comics-Games) culture, and guochao (national trend) elements—significantly enhances their appeal to Generation Z demographics, catalyzing the transformation of commercial spaces from monofunctional retail venues into integrated cultural-social complexes. However, current revitalization initiatives face persistent challenges including homogenized competition and insufficient cultural depth, where some projects merely engage in superficial stacking of trendy formats without excavating subcultural essences, consequently resulting in consumption scenes with ephemeral appeal.

(2) Cultivating Cultural Habitats: Multicultural Inclusivity and Human-Centreed Urbanism

The construction of "cultural habitats" through multicultural inclusivity constitutes a profound practice of reshaping urban humanistic values via spatial empowerment. Youth subcultural consumption spaces serve as convergence fields integrating diverse cultures, populations, spatial configurations, and behavioral patterns, wherein leisure-socialization spaces embody principles of egalitarian interaction, creative-retail environments manifest self-expressive freedoms, and artistic-creation zones signify cultural pluralism. This symbiotic relationship between youth subcultural spaces and broader urban consumption landscapes intrinsically reflects the core values of human-centreed cultural habitats. Urban regeneration initiatives must therefore strategically leverage the catalytic capacity of these spaces to advance urban consumption ecosystems, delivering inclusive spatial provisions and functional services responsive to diverse cultural needs.As polycultural aggregators, youth subcultural spaces and their synergistic coexistence with mainstream consumption arenas epitomize the humanistic logic underpinning cultural habitat development: leisure-socialization spaces dissolve social hierarchies through equitable encounters; creative-retail venues empower individual agency through personalized

expression; artistic-creation domains embrace cultural heterogeneity through radical openness—collectively forming a microcosm of urban multicultural inclusivity. Nevertheless, persistent value disjunctures in integrating these spaces within mainstream urban fabrics reveal significant challenges: certain redevelopment projects prioritize commercial imperatives to the extent of commodifying subcultural spaces into mere traffic-generating instruments, thereby neglecting their essential cultural articulation and community-building functions; simultaneously, spatial planning frequently fails to accommodate differentiated group needs, creating disconnects between subcultural consumption scenes and residents' quotidian realities. These contradictions fundamentally manifest the tension between humanistic values and economic logics in urban spatial production, necessitating urgent recalibration through integrated institutional frameworks and transformative spatial praxis to achieve sustainable equilibrium.

(3) Negotiating Institutional-Spatial Dialectics: Elastic Coordination in Urban Regeneration
The interplay between institutional frameworks and spatial production manifests pronounced regional differentiation within Nanjing's Old City renewal initiatives. In the northern sectors, the industry policy-driven spatial production paradigm—while facilitating technology-oriented subcultural consumption scenarios through developments like data industrial parks—suffers from functional mismatches stemming from rigid industrial land conversion mechanisms and lagging commercial infrastructure planning. Conversely, the southern districts leverage culturally-grounded governance policies to cultivate flexible institutional environments. Through instruments such as intangible cultural heritage protection ordinances and adaptive reuse of culturally protected buildings, these frameworks enable symbiotic integration between subcultural expressions and historical settings.This institutional design achieves dual objectives: preserving spatial cultural memory while fostering structured growth of subcultural consumption scenes through regulatory control over business typologies. Such configurations empirically validate how institutional elasticity positively correlates with spatial diversity and inclusivity. However, both northern and southern practices reveal an inherent tension: the contradiction between institutional inertia and spatial innovation demands. The north's excessive reliance on industrial policies constrains spatial vitality, while the south's stringent cultural governance potentially inhibits subcultural experimentation and boundary-pushing innovation.

Research on youth subcultural consumption spaces constitutes a strategic implementation of national cultural industry development policies. This study elucidates macro-scale spatial distribution patterns and their determinants within Nanjing's Old City, while acknowledging that meso-micro level empirical investigations remain underdeveloped. Future scholarship should prioritize strengthening theoretical-empirical integration through quantitative analysis of spatial agglomeration dynamics across diverse subcultural business formats, thereby establishing standardized revitalization assessment frameworks for aging retail infrastructure. Concurrently, research must explore synergistic pathways between subcultural spaces and urban cultural ecosystems by facilitating their convergence with localized intangible heritage and collective memory—achieving equilibrium between cultural continuity and commercial innovation. The transformative potential of emerging technologies warrants rigorous examination, particularly regarding blended reality environments leveraging metaverse platforms and AI-driven immersion to reconfigure consumption experiences. Policy formulation requires enhanced regulatory frameworks addressing copyright protection, safety protocols, and operational standards to ensure sustainable sectoral development. Crucially, the integration of underutilized commercial assets with youth subcultural elements may catalyze urban transformation and consumption upgrading—a phenomenon demanding sustained scholarly attention given its profound socioeconomic implications for urban futures.

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The Demand-Supply Measurement of Youth Development-Oriented Cities Based on the Characteristics of Generation Z: A Case Study of Shanghai, Nanjing, and Hangzhou

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Abstract
This study examines Generation Z's (born 1997-2012) demand patterns and urban development alignment in Shanghai, Hangzhou, and Nanjing. As key drivers of urban innovation and economic growth, Gen Z exhibits atomized lifestyles and self-actualization tendencies. A demand-supply evaluation framework is developed across three tiers: basic growth, relational cohesion, and developmental leap. Empirical analysis reveals supply-demand mismatches: Shanghai and Hangzhou excel in employment ecosystems and recreational infrastructure, while Nanjing achieves higher youth satisfaction despite weaker supply capacities. Findings highlight Shanghai's lag in leisure services, Hangzhou's deficiency in cultural amenities, and Nanjing's need for entrepreneurship support. The study advocates policy optimization to bridge gaps in youth-oriented urban development, emphasizing tailored strategies to enhance productivity and social integration for this generation.

Keywords: Youth Development-Oriented Cities,Demand-supply matching,Generation Z,development evaluation

Introduction

As China's demographic dividend begins to wane, major cities across the country are increasingly recognizing the vital role that young people play in driving high-quality development across economic, social, and urban domains. In response, national and local governments have introduced a range of youth-oriented policy initiatives—ranging from improving talent attraction mechanisms to enhancing urban appeal for young residents. In April 2017, China released its first national-level plan dedicated to youth development: the Medium and Long-Term Youth Development Plan (2016–2025) (hereafter referred to as the Youth Development Plan), which provided clear guidance on education, employment, and entrepreneurship for young people (China, 2017). Later, in April 2022, the National Development and Reform Commission, along with 16 other ministries, jointly issued the Opinions on the Pilot Construction of Youth Development-Oriented Cities, advocating for the creation of cities that meet young people's needs in housing, employment, health, and education (NDRC et al., 2022).

Amid the growing trend of youth migration to urban areas, cities in economically advanced regions such as the Pearl River Delta and the Yangtze River Delta have seen increasingly concentrated youth populations. First-tier cities like Beijing, Shanghai, and Guangzhou, along with emerging cities such as Hangzhou, Nanjing, and Chengdu, have become the primary destinations for young people, offering abundant employment opportunities, high-quality healthcare and education services, and appealing living environments (Dou et al., 2023). In line with national strategies to build youth-friendly cities, many regions have prioritized creating high-quality spaces for youth production, living, and ecological wellbeing. Cities such as Shanghai, Hangzhou, and Nanjing have actively undertaken various youth development-oriented city-building initiatives.

However, despite the richness of these policy practices, a corresponding theoretical framework for youth-friendly urban spatial development remains underdeveloped in the academic realm. At the macro level, some scholars have proposed evaluative frameworks for youth development-oriented cities. For instance, Zheng et al. (2022) developed a four-dimensional assessment model—"livability, employment, vibrancy, and potential"—based on the characteristics of Generation Z. Xu et al. (2020) utilized multi-source big data to build digital profiles of youth groups, supporting evaluation efforts with empirical tools. Liu et al. (2021) constructed an assessment framework for youth-friendly cities using Zhuhai as a case study and offered policy suggestions accordingly. Other studies have focused on policy evaluations, assessing the effectiveness of housing support, spatial inclusivity, employment protection, and administrative services in pilot cities (Zhu, 2018; Wu and Zhou, 2023), or using methods such as fuzzy-set Qualitative Comparative Analysis (fsQCA) and the PMC index model to evaluate talent policy (Li and Zhang, 2023).

Scholars have also examined spatial needs, identifying the typologies and characteristics of youth-friendly spaces (Li, 2023), and proposing spatial configurations based on youth demand (Wang et al., 2023; Yin et al., 2021). Internationally, research has mainly focused on the relationship between cities and youth employment, often incorporating negative externalities brought by rapid urbanization (Zhu et al., 2019). In countries such as the United States, Canada, Poland, and Germany, cities have developed youth-friendly public policies and urban strategies centering on employment and community life. For example, the American Institute for Economic Research (2016) released a ranking of the best U.S. college destinations, evaluating cities' appeal to youth through demographic features, quality of life, and economic development. Similarly, Youthful Cities, a Canadian strategy consulting firm, identified key characteristics of youth cities—connectivity, dynamism, growth, novelty, and creativity—and developed an urban youth index accordingly (Youthful Cities, 2023). Some scholars have also addressed youth vulnerability, highlighting socio-economic and spatial inequalities faced by marginalized urban youth (Sriskandarajah, 2021).

In sum, current academic research either focuses on the interaction between youth populations and urban development—exploring evaluation systems and development pathways—or investigates spatial configuration through an analysis of youth behavior and needs. Yet, within the discipline of urban planning, such studies remain exploratory. There is a lack of attention to the dynamic coupling between evolving youth needs and urban spatial responses. Quantifying the multidimensional development needs of Generation Z youth and constructing a precise "demand-supply" matching mechanism has become a critical breakthrough for implementing national strategies and invigorating urban youth. This calls for deeper theoretical inquiry to support the development of urban spaces conducive to youth innovation and entrepreneurship.

1. Research Foundation for Youth Development-Oriented Cities

1.1. Homo-Urbanicus Theory

The Homo-Urbanicus Theory is a human-centered planning framework proposed by Liang Heren, which emphasizes that urban residents make rational choices regarding their settlement locations to balance their material needs with spatial interaction needs. Liang (2012; 2019) defines Homo Urbanicus as a composite identity, wherein an individual may simultaneously possess multiple urban roles. In the context of this study, the Homo Urbanicus identity of youth in industrial communities is shaped by life stage, age, gender, occupation, job position, and family roles.

Building upon the humanistic logic of "self-sufficiency and co-existence balance" embedded in the Homo-Urbanicus Theory, domestic scholars have begun to construct planning evaluation methodologies that reflect Chinese characteristics. For example, Wei Wei of Wuhan University has attempted to develop an assessment framework for urban public service facilities based on this theory. He positions public facilities as carriers of spatial interaction opportunities and argues that their spatial distribution should strive to fulfill both individual and collective needs—emphasizing full coverage, equalization, and equitable access to opportunities within regions. This forms the basis for a planning evaluation model from the perspective of Homo Urbanicus (Wei et al., 2018; 2020; 2022).

1.2 Constructing a Demand–Supply Evaluation Framework

According to the Homo-Urbanicus Theory, planners aim to achieve an optimal match between "typical urban residents" and "typical habitats" by analyzing both ends of the urban experience. The attributes of "typical urban residents" are defined by demographic characteristics (such as age and gender) as well as contextual elements like life stage, socio-economic status, and cultural background. Meanwhile, typical habitats refer to urban spatial units that provide opportunities for spatial contact.

In this study, youth residing in industrial communities are identified as the demand side—"typical urban residents" in search of spatial interaction—while the industrial community, as an integrated unit of production and living, serves as the supply side, i.e., the "typical habitat." Based on this logic, the study proposes an evaluation pathway for industrial communities by assessing the demand characteristics of Homo Urbanicus and the spatial supply capacity of the habitat. The aim is to enable optimal matching between human needs and spatial opportunities, thereby fostering youth development (Fig 1).

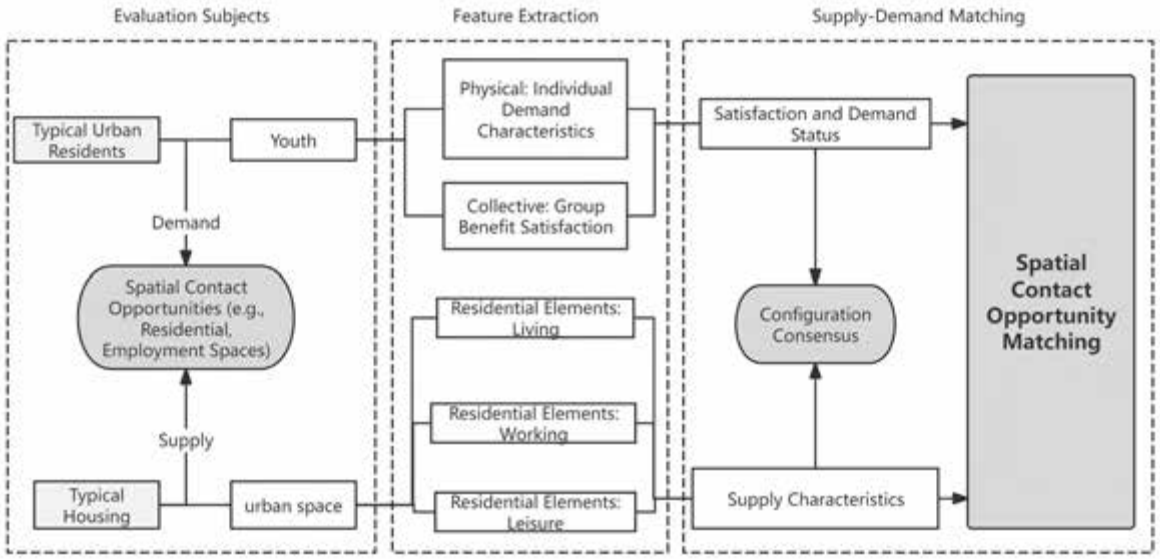

Fig 1 Construction of evaluation pathways for youth development-oriented cities

2.Construction of the Demand–Supply Evaluation Indicator System for Youth-Oriented Cities

Establishing an evaluation system for youth-oriented cities provides a scientific tool to promote their construction and sustainable development. The assessment of youth-oriented cities must adhere to a human-centered approach, using quantitative methods to measure the comprehensive effectiveness of science and technology innovation (STI) industrial communities in meeting the multidimensional needs of contemporary youth, stimulating regional innovation vitality, and optimizing spatial efficiency. This study evaluates the effective demand–supply matching of spatial resource allocation in youth-oriented STI industrial communities from both demand and supply perspectives.

2.1 Analysis of Generation Z Youth Demand Characteristics

Based on the 2021 China Social Status Comprehensive Survey (CSS) data, this study selects urban youth born between 1994 and 2003 who have entered the workforce. [Given that most industrial communities are located in areas with high urbanization rates, rural populations were excluded for research purposes.] The intergenerational characteristics of this cohort are analyzed to summarize youth group traits and development demand preferences, providing the "demand-side" direction for selecting evaluation indicators for youth-oriented industrial communities.

1) High Educational Attainment

According to the CSS data, urban youth generally possess high educational backgrounds(Fig 2), with approximately 68.2% having attained college education or above, including 34.8% with a bachelor's degree and 4.6% with a postgraduate degree. A comparison across generations reveals that, due to increased emphasis on higher education and demand for highly skilled talents, Generation Z exhibits a significant educational advantage over previous generations. This high educational attainment not only broadens employment options for Generation Z but also facilitates access to higher-paying jobs and promotion opportunities.

	Not enrolled in primary school	Primary school	Junior high school	High school	Technical secondary school	Vocational high technical school	Junior college	Undergraduate	Graduate student
1974-1983	1.18%	8.43%	28.99%	11.69%	9.47%	1.92%	15.53%	19.67%	3.11%
1984-1993	0.16%	2.66%	18.91%	10.78%	6.09%	2.19%	24.53%	28.59%	6.09%
1994-2003	0.00%	0.00%	11.48%	8.20%	8.85%	3.28%	28.85%	34.75%	4.59%

Fig 2 Statistical analysis of educational attainment across intergenerational cohorts

2) High Degree of Atomization
Influenced by the one-child policy and the fast-paced modern era, Generation Z youth display a marked degree of atomization. Compared with cohorts born between 1974–1983 and 1984–1993, the proportion of only children among Generation Z is higher by 26.5 and 9.7 percentage points, respectively, with a rate of 43.6%. Regarding marriage and fertility, 2021 data indicate nearly 75% of Generation Z youth are unmarried and childless, with only 11.8% having children.

3) Virtual and Fragmented Socialization
With rapid advances in information technology and the popularization of social media, Generation Z exhibits virtual and fragmented socialization characteristics. They prefer online platforms for information acquisition, business/work communication, and social relationship building, rather than traditional face-to-face interaction. Over 80% of Generation Z maintain diverse virtual social circles, including family groups, friend/classmate groups, workplace colleague groups, community groups, hometown groups, and interest groups. While this facilitates the formation of virtual networks, it weakens their real-life social connections. Due to fast work rhythms and life pressures, they often struggle to participate in community activities or develop deep interpersonal ties, which further intensifies atomization and fragmentation.

4) Coexistence of Enjoying Life and Self-Actualization
In terms of consumption, Generation Z emphasizes personalized life experiences and enjoys traveling, artistic creation, fitness, or novel consumption experiences such as immersive theater and escape rooms. They also exhibit strong self-actualization awareness, valuing not only material needs but also spiritual satisfaction and growth. They tend to seek positions and enterprises that are challenging, innovative, and development-oriented. Additionally, they focus on personal growth and learning, willingly investing time and effort in training and educational activities to enhance their overall quality and competitiveness, and enjoy engaging in culturally enriching activities such as visiting museums and art galleries.

2.1.1 Demand Hierarchy Characteristics of the Youth Group

In 1943, American psychologist Abraham Maslow proposed a hierarchy of needs theory based on motivation theory, which includes five basic needs: physiological needs, safety needs, love needs, esteem needs, and self-actualization needs, as well as cognitive needs related to knowledge and understanding, totaling six main domains of needs (Maslow, 1943). The priority of these needs differs between levels; higher-level needs only emerge after the more fundamental needs are adequately satisfied. In further discussions, Maslow suggested that for dif-

ferent personality types, there are variations in the hierarchy of needs, showing different tendencies. In 1954, Maslow elaborated this theory in his work Motivation and Personality, dividing the hierarchy into seven levels (Fig 3), where aesthetic and cognitive needs represent higher levels (Maslow, 2021).

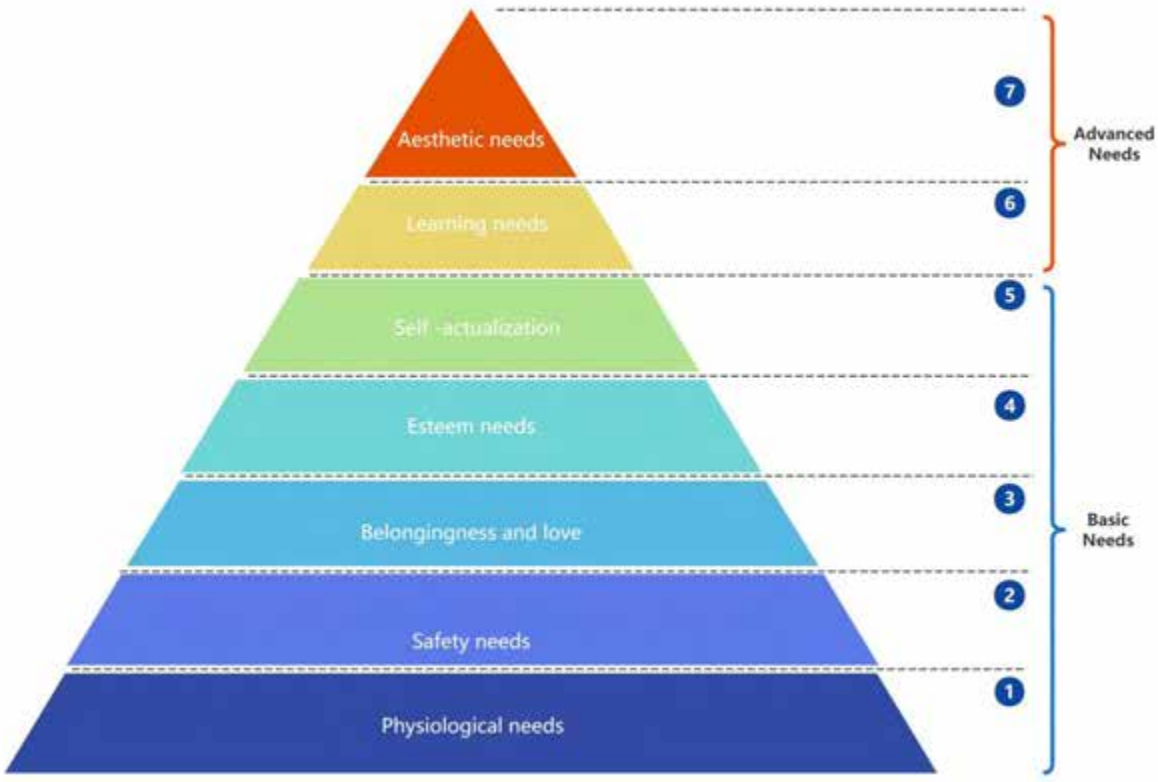

Fig 3 Seven-stage hierarchical model of Maslow's needs theory

Following the introduction of Maslow's hierarchy of needs theory, it has been widely applied and further developed. Clayton Alderfer, a scholar at Yale University, conducted extensive empirical research and revised the traditional hierarchy, proposing the ERG theory of needs (Alderfer, 1969). In his paper An Empirical Test of a New Theory of Human Needs, Alderfer argued that Maslow's five needs did not show clear distinctions and that there was overlap between love, esteem, and self-actualization needs. Therefore, he condensed the five needs into three types: Existence needs, Relatedness needs, and Growth needs. Existence needs include material and physiological desires such as food, salary, and physical working conditions. Relatedness needs reflect the human desire for interaction with others, including positive and negative emotions. Growth needs refer to the desire to influence oneself and the surrounding environment. This categorization avoids internal overlap among different need types. The ERG theory retains the concept of need hierarchies but emphasizes that the levels are not strictly sequential and highlights the reality of individual differences in needs (Shen, 2010).

This study divides the youth group's needs into three main levels: existence needs, relatedness needs, and growth needs, with existence needs further divided into three key areas: housing, employment, and living. As shown by the treemap analysis (Fig 4), employment is the area of highest concern for youth, followed by housing and living, while attention to self-improvement is greater than to consumption and social interaction. Employment is the core focus of young people because it directly relates to their economic independence, social status, and future career prospects. Therefore, youth who have just entered society tend to prioritize local employment opportunities and work environments. Housing conditions are closely linked to quality of life; choices such as renting or purchasing, housing location, and transport accessibility directly impact life quality, making it an important concern. After satisfying basic needs, youth tend to pursue personal growth and self-improvement rather than

invest excessive energy in consumption and socializing. Limited resources lead them to prioritize activities that enhance competitiveness by balancing time, money, and effort, emphasizing long-term self-investment. Meanwhile, consumption and social activities remain important ways for youth to regulate life pace and enhance satisfaction, though they receive slightly less overall attention than self-improvement.

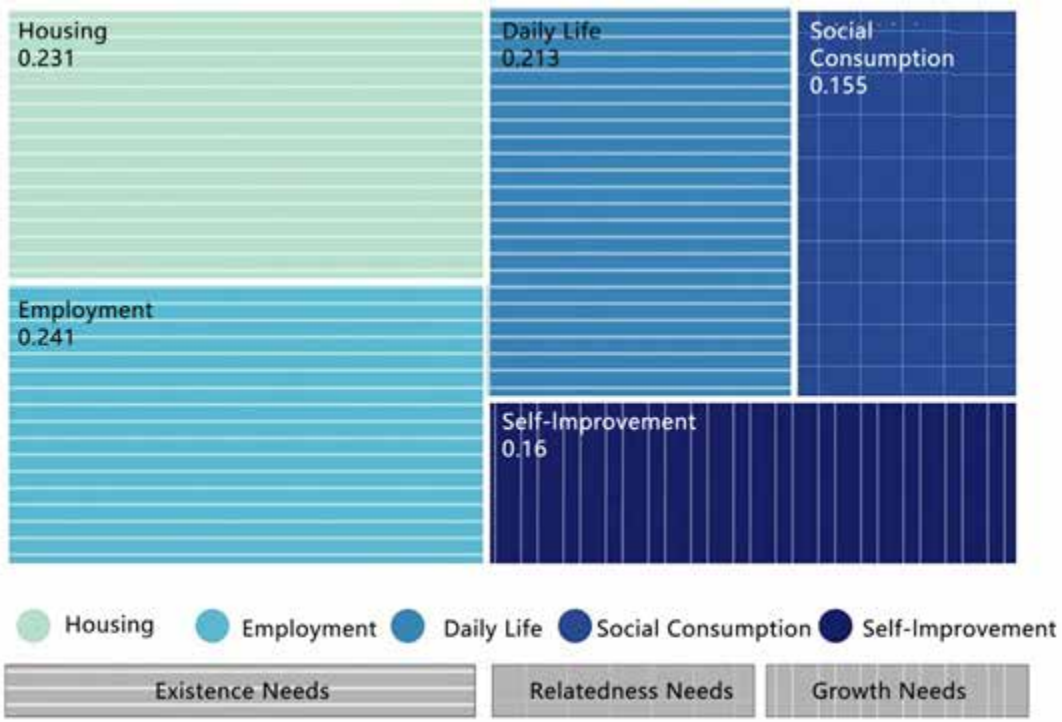

Fig 4 Hierarchical Treemap Analysis of Youth Needs

The division of these five levels and their relative attention can be further explained by ERG theory. These levels interact dynamically: on one hand, after satisfying lower-level needs such as existence and relatedness, youth tend to pursue higher-level needs; on the other hand, unmet higher-level needs can cause individuals to focus more on lower-level needs as a compensatory mechanism, resulting in a frustration-regression effect. For self-improvement needs, increasing satisfaction does not weaken demand but rather enhances it, showing a satisfaction-enhancement effect. This also explains why youth in industrial communities pay more attention to self-improvement needs than to relatedness needs (Fig 5).

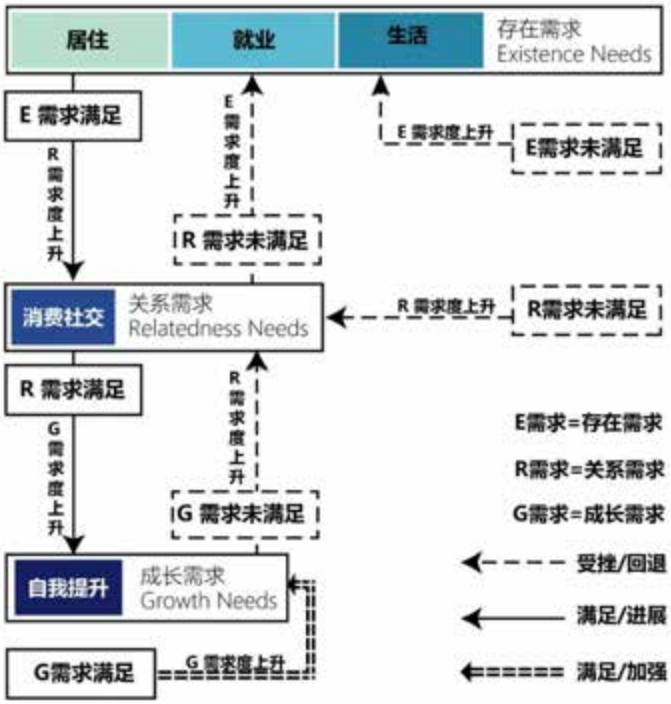

Fig 5 Interactive Mechanisms of Gen Z's Need Hierarchies

2.1.2 Analysis of Youth Development Needs

Based on the characteristics and hierarchical needs of youth, this section summarizes the development needs of the youth group:

Existence needs include housing, employment, and basic living needs related to material security, serving as the foundation for personal development. Regarding housing, the "high atomization" characteristic of Generation Z youth leads to greater attention to rental housing and employer-provided talent housing, with a strong demand for affordable and flexible rental models. In terms of employment, Generation Z youth typically have higher educational attainment and thus exhibit a stronger desire for economic independence and financial freedom. They seek income and career prospects that match their educational qualifications and tend to pursue meaningful and fulfilling work, placing emphasis on opportunities for innovation, entrepreneurship, and career development pathways (Fig 6). For daily basic living, Generation Z has a high demand for online consumption; ordering takeout and purchasing daily necessities or medicines online have become integral parts of their everyday life.

Fig 6 Occupational Value Systems of Generation Z
Data Source: TTI Gen Z Workplace Expectations Report 2024

Relatedness needs reflect the importance of socialization for Generation Z youth, who satisfy their sense of belonging and interaction needs through social activities and community participation. Growing up in the internet era, Generation Z is adept at using digital media platforms for communication, yet they also have a strong desire for offline interactions, especially deep social connections based on shared interests and values. They tend to join communities aligned with their interests and beliefs, emphasizing individual uniqueness and contributions within groups. By providing creative social spaces, multicultural interaction platforms, and supporting interest-based clubs and public welfare activities, industrial communities can foster richer social participation and cultural exchanges among youth.

Self-growth needs refer to individuals' demands for potential development, value realization, and long-term growth, representing advanced needs for Generation Z youth. Influenced by fast-paced lifestyles and social competition, they place high importance on mental and physical health, investing significantly in fitness, body shaping, and wellness. Moreover, Generation Z values personalized development and unique cultural expression, favoring art, design, and new media forms for self-expression. They pursue continuous knowledge updating and skill enhancement, aiming to access educational resources at any time to adapt to the rapidly changing society.

2.2 Composition of Supply Subject Elements

The city is analyzed as an integrated system (Fig 7). According to human settlement environment theory, it can be considered a system unit at the "community" level within the five hierarchical levels of human settlement environments: global – regional – city – community – building. This system contains five subsystems: population (man), society, shell, support network, and nature. These five subsystems collectively form the supply elements of youth development-oriented science and technology innovation industrial communities and correspond respectively to three types of capital in overall system analysis: human capital = population system + social system; structural capital = shell + support network; natural capital = various environments and resources. The specific interpretation of each subsystem in youth development-oriented science and technology innovation industrial communities is as follows:

Population Subsystem: This subsystem mainly targets the user populations within the industrial community, including employment groups, residential groups, and community managers.

Social Subsystem: This subsystem includes economic, socio-cultural, and government management aspects. Economically, it focuses on labor and employment, market trade, production, and consumption. In terms of socio-cultural and government management, it encompasses social medical and educational security, cultural activities organization, community management, and party-building activities.

Shell Subsystem: This includes spatial support systems such as housing, shops and malls, administrative offices, industrial facilities, and cultural and entertainment facilities, providing venues for human activities.

Network Subsystem: This refers to infrastructure networks such as water and electricity supply systems and transportation networks, linking various independent shells and forming the basic spatial organizational framework of the science and technology innovation industrial community.

Natural Subsystem: Serving as the "foundation" for the other subsystems, this includes natural resources such as land, water bodies, and vegetation. It should be noted that natural resources like water bodies and vegetation may be artificially modified and optimized through human activity, for example, by constructing artificial lakes and green parks.

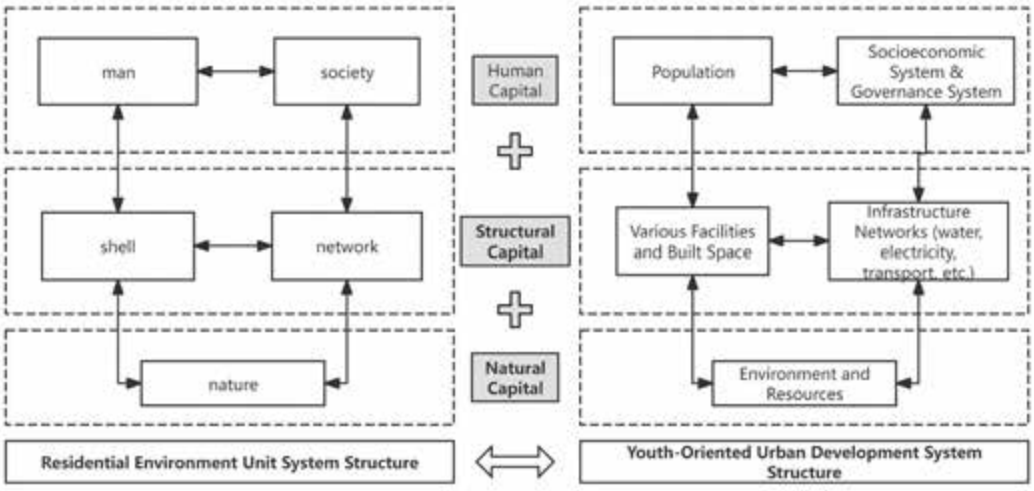

Fig 7 Schematic Diagram of Youth Development-Oriented City System Framework

2.3 Construction of the Evaluation System

The evaluation indicators are divided into three hierarchical levels: the goal layer, the criterion layer, and the implementation layer. The goal layer includes two main dimensions: the demand side and the supply side, referring respectively to youth's demand satisfaction and the urban supply level from the perspective of youth development. The criterion layer is classified in accordance with Maslow's hierarchy of needs theory, divided into five aspects: housing, employment, living, entertainment and consumption, and self-improvement. The criterion layer indicators on the demand side correspond one-to-one with those on the supply side. The selection of evaluation indicators at the implementation layer is based on the characteristics of youth development-oriented cities, youth demand preferences, and relevant academic studies on youth development city evaluation indicators, integrating these factors to construct a comprehensive indicator system (Table 1)

Table 1 Integrated Evaluation Index System

Goal Layer	Criterion Layer	Implementation Layer Indicator	Indicator Evaluation Standard
Supply Side	Work-Living Level	Commuting Convenience	Average Commute Time
		Housing Affordability and Friendliness	Average Income-to-Housing Price Ratio
		Career Development Level	Average Graduate Salary
	Daily Life Level	Medical Supply Level	Number of Tertiary Hospitals
		External Traffic Convenience	Cities Covered in 1-Hour High-Speed Rail Circle
		Online Shopping Supply Level	Coverage Rate of Express Stations / Food Delivery
		Daily Dining Supply Level	Convenience Store Coverage Rate
	Social Vitality Level	Shopping and Consumption Facility Supply Level	Commercial Area Foot Traffic
		Public Social Space Supply Level	Coverage Rate of Coffee / Milk Tea Shops
		Leisure and Entertainment Facilities Supply Level	Coverage Rate of Cinemas, KTVs
		Youth Activity Organization Supply Level	Frequency of Various Cultural and Entertainment Events
	Self-Improvement Level	Sports and Fitness Facilities Supply Level	Number of Sports Venues
		Cultural and Artistic Venue Supply Level	Coverage Rate of Specialty Bookstores
		Park and Green Space Development Level	Quality of Green Spaces
Demand Side	Work-Living Level	Commuting Satisfaction	Satisfaction Survey Results
		Housing Cost Satisfaction	
		Career Development Satisfaction	
	Daily Life Level	Medical Support Satisfaction	
		Traffic and Travel Satisfaction	
		Online Shopping Satisfaction	
		Dining Facility Satisfaction	
	Social Vitality Level	Shopping and Consumption Satisfaction	
		Public Social Space Satisfaction	
		Leisure and Entertainment Satisfaction	
		Youth Activity Organization Satisfaction	
	Self-Improvement Level	Sports and Fitness Satisfaction	
		Cultural and Artistic Venue Satisfaction	
		Park and Green Space Satisfaction	

2.4 Weights of Evaluation Indicators

To scientifically determine the relative importance of indicators at each level in the youth development-oriented city evaluation system, this study employs an interactive weighting method. Using a digital questionnaire platform, a multi-dimensional weight allocation was implemented, with a dynamic matrix slider weighting mechanism designed to allow respondents to systematically allocate weights within a bounded rationality framework. The weight results of each indicator are shown in Table 2. The weights for the demand side and supply side indicators correspond to each other, each accounting for 50% of the total.

Table 2 Comprehensive Evaluation Indicator System Weight Results

Goal Level Indicator	Weight	Criterion Level Indicator	Weight	Implementation Level Indicator	Weight
Supply Side / Demand Side	0.5	Employment & Residence Level	0.173	Commuting Convenience / Commuting Satisfaction	0.048
				Housing Affordability / Housing Cost Satisfaction	0.071
				Career Development Level / Career Development Satisfaction	0.053
		Daily Life Level	0.128	Medical Service Availability / Medical Service Satisfaction	0.027
				External Transportation Convenience / Transportation Satisfaction	0.033
				Online Shopping Availability / Online Shopping Satisfaction	0.04
				Daily Dining Availability / Dining Facilities Satisfaction	0.027
		Social Vitality Level	0.111	Shopping Facilities Availability / Shopping Satisfaction	0.031
				Public Social Space Availability / Public Social Space Satisfaction	0.033
				Leisure & Entertainment Facilities Availability / Leisure & Entertainment Satisfaction	0.031
				Youth Activity Organization Availability / Youth Activity Organization Satisfaction	0.017
		Self-Improvement Level	0.089	Sports & Fitness Facilities Availability / Sports & Fitness Satisfaction	0.028
				Cultural & Artistic Venue Availability / Cultural & Artistic Venue Satisfaction	0.029
				Park & Green Space Development Level / Park & Green Space Satisfaction	0.032

3. Empirical Evaluation: Taking Shanghai, Hangzhou, and Nanjing as Examples

3.1 Research Scope and Basic Situation

This study selects Shanghai, Hangzhou, and Nanjing as empirical evaluation targets. As core cities of the Yangtze River Delta, these three cities exhibit significant and typical structural characteristics in their youth populations. Shanghai, as a mega-city, had youth aged 14–35 accounting for 29% of its population in 2022, concentrating 19% of the nation's innovation and entrepreneurship enterprises, thus forming a "high-level employment – high-density agglomeration" characteristic. Hangzhou, relying on its digital economy ecosystem, had a youth population aged 14–35 reaching 5.13 million by the end of 2022, accounting for 34.6% of the city's total population, showing a resonance of "industrial youthfulness – population youthfulness." Nanjing, known for its strong higher education advantages with over 900,000 university students, also has a youth population proportion exceeding the national average in all three cities.

3.2 Evaluation Results

3.2.1 Supply Side Evaluation Results

Through an in-depth analysis of supply-side implementation-level indicators in Shanghai, Hangzhou, and Nanjing, differentiated characteristics and optimization pathways of urban youth development efficiency are revealed(-Fig 8). The comprehensive evaluation results show Hangzhou ranked first with a score of 11.88, followed closely by Nanjing (11.60) and Shanghai (11.51), with less than a 3% difference among the three cities, reflecting a trend of homogenized youth service supply in the Yangtze River Delta urban cluster. Specifically, Hangzhou leverages the deep penetration of the digital economy, leading in seven indicators including shopping and consumption facilities supply, daily dining density, cultural and artistic venue availability, and leisure and entertainment facilities. Nanjing excels in livelihood services, with comprehensive advantages in housing affordability and online shopping supply, but its youth activity organization supply (0.430) is only 43% of Shanghai's, revealing weaknesses in community operation capacity. Shanghai maintains the lead in hard resources such as career development level, medical resource supply, and external transportation convenience, but the housing cost pressure far exceeds that of Nanjing and Hangzhou, urgently needing to resolve the "high-level resource – high-cost" development paradox.

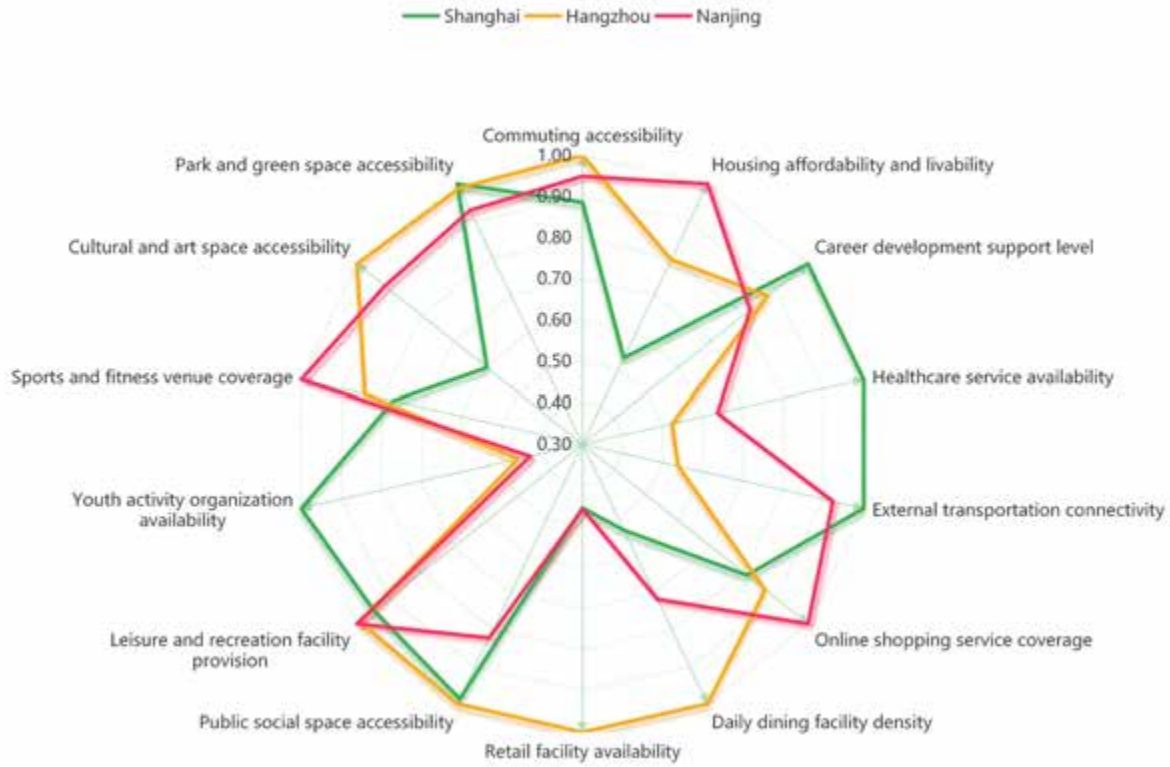

Fig 8 Shanghai-Nanjing-Hangzhou Tri-City Supply-Side Evaluation Results

3.2.2 Demand Side Evaluation Results

Based on empirical data analysis of youth development satisfaction in Shanghai, Hangzhou, and Nanjing, the study finds differentiated characteristics in youth development quality across the Yangtze River Delta urban cluster(Fig 9). From the overall average score, Nanjing ranks first with 3.258, followed by Hangzhou (3.200), and Shanghai lags behind at 3.001, reflecting the transformation pressures faced by mega-cities in youth development.

In the dimension of basic survival quality, housing cost and commuting efficiency are critical constraints. Housing cost satisfaction in all three cities is below the 3.0 benchmark, showing a "Yangtze River Delta youth housing anxiety belt" phenomenon, with Shanghai experiencing the most severe housing pressure (2.52), 8.3% lower than Nanjing. Relying on innovative affordable housing policies, Nanjing achieves a significant advantage with a survival quality score of 3.07. Shanghai faces the diminishing marginal benefits of its mega-city commuting network, with a transportation satisfaction of 3.12, significantly lower than Hangzhou (3.44) and Nanjing (3.43), exposing risks of service quality degradation due to rail transit over-saturation.

Public service supply shows gradient differentiation. Benefiting from its rich cultural capital, Nanjing leads in cultural and artistic venue satisfaction (3.64) and park green space (3.33), verifying the spatial empowerment effect of historic heritage revitalization. Driven by digital technology innovation in public services, Hangzhou's youth activity organization satisfaction reaches 3.71, forming an advantage in social vitality, with leisure and entertainment indicators 41.6% higher than Shanghai, highlighting the spillover benefits of the digital entertainment industry cluster. Although Shanghai maintains its traditional advantage in career development potential (2.88), its fragmented public social spaces (3.24) reveal community alienation issues during modernization.

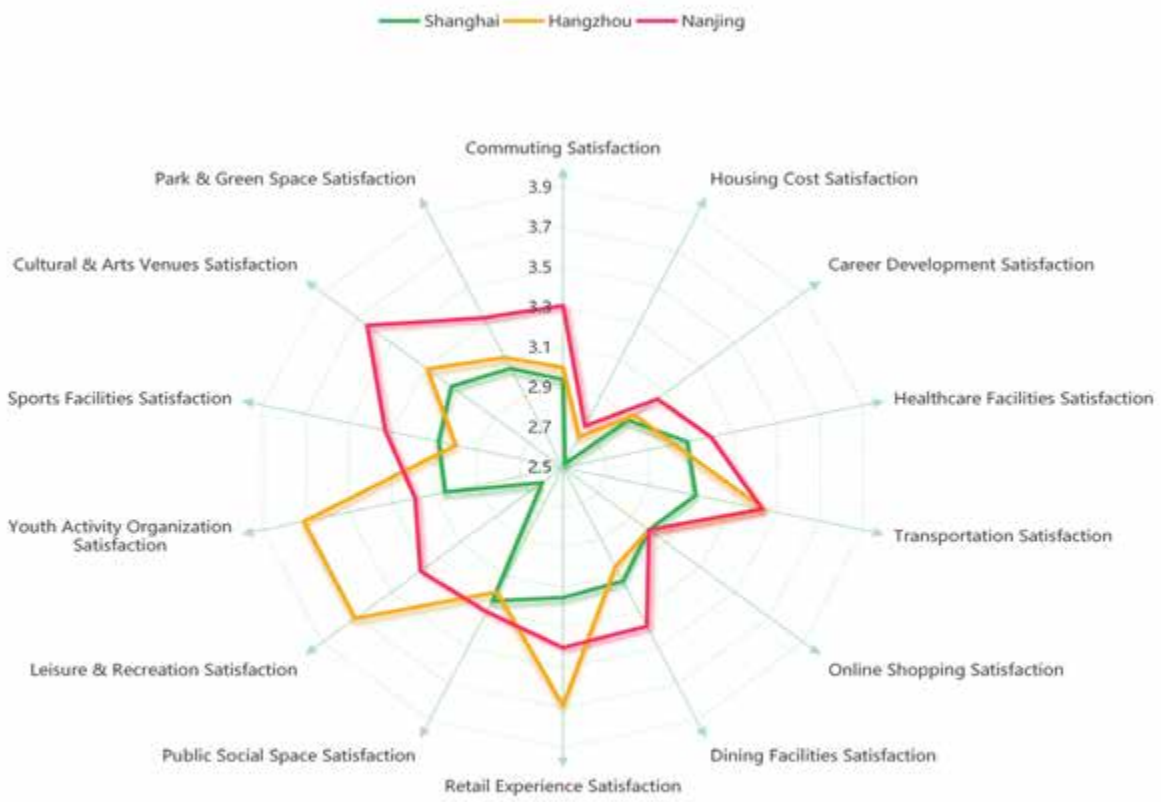

Fig 9 Shanghai-Nanjing-Hangzhou Tri-City Demand-Side Evaluation Results

3.2.3 Comprehensive Supply-Demand Analysis Results

The evaluation indicates varying degrees of supply-demand mismatch across Shanghai, Nanjing, and Hangzhou-Fig 10 A deeper analysis of youth development dynamics in these three Yangtze River Delta cities reveals differentiated characteristics. Hangzhou demonstrates the strongest alignment with Generation Z demands, achieving the highest congruence between urban resource supply and youth needs through optimized spatial planning

and resource allocation. In contrast, Shanghai exhibits relatively abundant supply-side resources but lower demand-side satisfaction among youth, indicating deficiencies in the targeting and precision of spatial elements and service provision. This necessitates enhanced supply orientation and adaptability to better accommodate the diversified needs of young populations. Nanjing presents a reverse pattern, with higher demand-side satisfaction but insufficient supply-side capacity, reflecting proactive attention to youth demands yet persistent shortages in critical supply elements such as housing, employment, and public services.

Fig 10 Supply-Demand Alignment Assessment in the Shanghai-Nanjing-Hangzhou Tri-City Region

The core cities of the Yangtze River Delta exhibit distinct youth attraction profiles shaped by their functional positioning and developmental trajectories. As a global metropolis, Shanghai holds clear advantages in public service provision and transportation infrastructure. Its tertiary hospital system and international healthcare networks form a robust health security framework, while high-speed rail hubs enable a two-hour connectivity circle within the Yangtze River Delta, facilitating cross-regional mobility for young populations. However, urban expansion has intensified spatial contradictions, with escalating housing costs and prolonged commutes in central areas creating compound pressures that undermine residential stability for youth.

Hangzhou leverages its digital economy-driven innovation ecosystem to foster unique advantages in youth social network development. Internet industry-enabled diversified social platforms and innovative professional communities provide nontraditional pathways for self-improvement. The integration of natural landscapes with digital economic features creates hybrid work-life spatial models. Yet, industrial structure homogeneity reduces labor market inclusivity, where technical thresholds may constrain career development opportunities for certain youth groups.

Nanjing demonstrates multidimensional equilibrium in its youth support system. The geographic integration of higher education resources and industrial parks establishes an industry-education-research collaboration model. Coordinated spatial planning between rail transit networks and employment centers maintains reasonable commuting durations. The synergistic evolution of historical cultural heritage and modern industrial systems cultivates an urban environment balancing cultural identity and professional growth. However, limited capacity in aggregating international high-end resources due to city-tier constraints may affect long-term retention of high-caliber young talent.

Conclusion

This study constructs an evaluation system for youth development-oriented cities based on spatial supply and demand theory, aiming to provide relevant authorities with scientific and reasonable criteria to accurately assess the progress of youth development city construction. The empirical analysis results of Shanghai, Nanjing, and Hangzhou reveal certain mismatches between supply and demand in the construction process of youth development-oriented cities. In future development, it is necessary to further integrate the characteristics and needs of the youth population to explore and form a sustainable and targeted model for building youth development-oriented cities.

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Just smart?
A Preliminary Study on the correlation of Smart City Infrastructure and Gentrification

Sin Yu Wang & Tzuyuan Stessa Chao

Abstract
This study uses Kaohsiung City as an example to explore whether smart city infrastructure leads to gentrification. Smart cities aim to improve quality of life and competitiveness, but they may attract high-income groups and force low-income residents to relocate. The study categorizes types of smart city infrastructure and employs Hedonic Price Method to analyze the relationship between the benefits of smart infrastructure and gentrification indicators, aiming to understand the impact of smart cities on spatial equity and propose policy recommendations for achieving inclusive and sustainable development.

Keyword: smart city; gentrification; sustainability

Introduction

In recent years, global urbanization has been on the rise, and urban issues are often inextricably linked to economic, social, environmental and governance issues. Smart cities are seen as one of the solutions that can address these issues (Micozzi and Yigitcanlar, 2022). However, as smart city policy advances and develops, there is no international consensus on its definition, which varies according to the target audience and influences policy making, except for the consensus on information and communication technology (ICT) as a core component of the infrastructure (Micozzi and Yigitcanlar, 2022). There is also no international consensus on how to define a smart city and what conditions a smart city should fulfill, but smart cities can be broken down as a combination of human capital, social capital and ICT infrastructure(Chang and Smith, 2023).

While past smart city research has focused less on quality of life and resident-centered issues, issues and challenges are beginning to emerge as smart cities are used as a means of solving all aspects of development. Infrastructure provision should be oriented towards improving the quality of life of the residents and moving towards sustainable development(Chang and Smith, 2023). Smart city infrastructure development emphasizes the need to balance the efficiency of urban infrastructure with the quality of urban life, and to identify priority areas for development, understand smart city needs, and integrate economic, social, environmental, and spatial domains(Grochulska-Salak and Wężyk, 2021).

With urban development, gentrification has begun to occur in a variety of contexts and areas. Gentrification, first used by Ruth Glass in 1964, describes a process of socio-economic change in urban areas caused by multiple factors (Johnson-Schlee, 2024), which is intuitively manifested by the loss of local residents' homes and the rise in real estate prices, with the middle and upper classes replacing the local residents in the community(Johnson-Schlee, 2024). The state of gentrification can be correlated with the amount of investment and infrastructure upgrading (Lees, Slater and Wyly, 2013).

Therefore, the construction of smart city infrastructures changes the local infrastructure pattern, improves the overall efficiency, and increases the local investment. Currently, there are fewer academic and practical studies on whether the upgrading of smart city infrastructures results in local gentrification. In this study, we will select a region as a site to discuss the changes in the various facets of a smart city as a result of the local government's policy and resource inputs.

In recent years, there has been growing discussion about the impact of investments in various smart city facilities on residents' quality of life and well-being. To provide better infrastructure, smart cities are increasingly intervening in data collection and utilization, integrating data into spatial applications. However, the collection of data that is private, widespread, and long-term has posed challenges to the autonomy of individuals and groups, blurring the boundaries between public and private domains, and gradually leading to the emergence of digital gentrification(Gstrein, 2024). In fact, when smart city projects are officially launched, signs of this phenomenon have already begun to emerge. The acceptance of smart infrastructure, from the overall residential area to the

individual level, should be incorporated into smart city governance.

The types of smart city infrastructures will cover four forms, namely technical and road infrastructure, social and service infrastructure, communication and data management infrastructure, and ecosystem infrastructure (Grochulska-Salak and Wężyk, 2021). It can be generalized into hard and soft infrastructure, where hard infrastructure refers to all types of buildings, equipment, space, facilities, etc., and soft infrastructure refers to education, applications, cloud systems, local norms, etc. Because most of the enhancements to the gentrification infrastructure are hard facilities, and that it is difficult to assess the impact of soft facilities on the price of housing and the local community when they are applied to the physical space, the study will focus on the hard infrastructure.

The study will focus on the following issues:

(a) Does smart city infrastructure cause changes in local housing prices?

(b) Is there a gentrification effect of the smart city infrastructure?

Study area

Kaohsiung City is in the southern region of Taiwan, with a large hinterland with an international commercial port and an international airport, is the political, cultural and industrial core of the south, and is one of the six Special Municipality in Taiwan, with 38 administrative districts, and is also the promotion area of the Asia New Bay Area 2.0 Intelligent Technology and Innovation Park.

The urban development policy has brought great changes to Kaohsiung's space and industries. Since the 1960s, Kaohsiung has been a major industrial center for Taiwan's heavy industry and light industry for processing and exporting, with rapid industrial development. 1980s, the major industries gradually dominated the city, shifting to low energy consumption, low pollution, and high value-addedness; in 1990s, Industrial Park and science park were established, and the townships possessed very high industrial intensity, with the industrialization level reaching its peak; it was not until 2000 that the type of industries changed and industries upgraded, with tertiary service industries gradually replacing some of the industrial industries. Since 2000, the industrial type has changed and the industry has upgraded, and the tertiary service industry has gradually replaced part of the industrial industry, and later joined the WTO(WU, 2011); since 2015, the smart city policy has been gradually implemented; in 2020, the Kaohsiung Smart City Promotion Committee was established, which is a team that combines industry, government, and academia, and combines the use of wisdom to drive the sustainable development of the city and the transformation of industries; and in 2021, the national program Asia's New Bay will be launched. Promote the 5GAIoT New Innovation Park Project in Asia's New Bay Area, a national-level project (Information Industry Council, 2021).

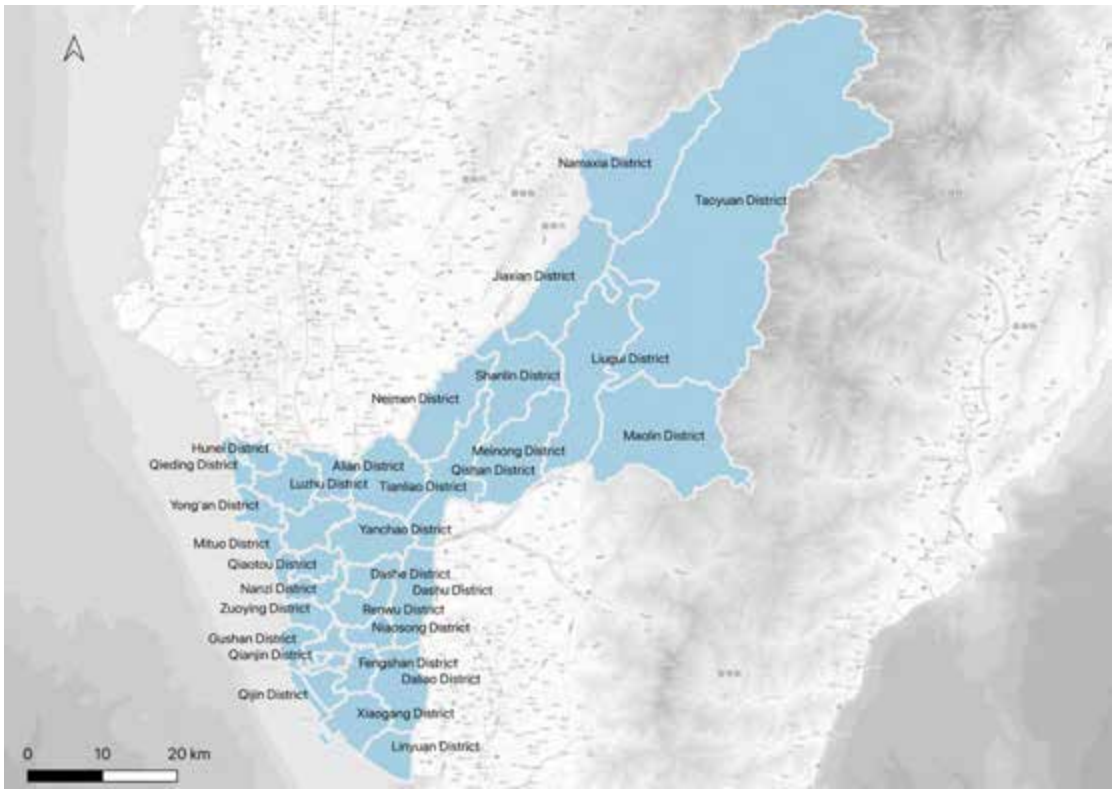

Figure 1 Kaohsiung City

Materials and methods

In this study, the hedonic property value method is used to understand which projects are the main influencing factors. Therefore, it is necessary to first select case areas, collect their smart city infrastructure construction plans or policies, compile infrastructure projects, and then conduct project screening. After eliminating soft infrastructure projects, the remaining hard infrastructure projects will be subject to the next round of screening, and then the facilities that are too small in scale or have a timeliness will be eliminated. Next, the representative year of the case area was selected, and the average price of housing in the area was used as the information of housing price in the area by collecting the price of housing in the area according to the year. After the data collection and processing, the information is analyzed by the hedonic property value method. Figure 2 the filtering process and the analyzing process shows the filtering process and the analyzing process.

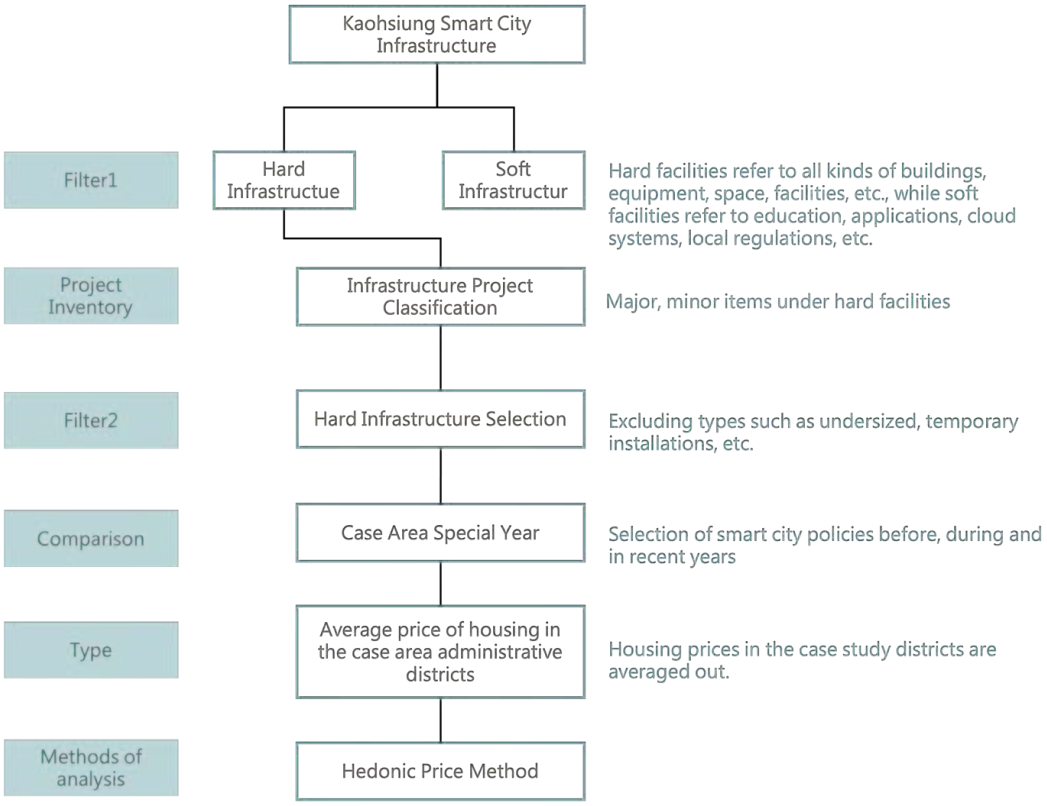

Figure 2 the filtering process and the analyzing process

Since 2015, smart city-related programs have been gradually implemented in Kaohsiung, and the types of smart city infrastructure are categorized according to nine major categories in the Kaohsiung Smart City Promotion Platform Project Achievement Zone: smart Mobility, smart living, smart healthcare, smart governance, smart security, smart tourism, smart education, smart energy, and smart agriculture. After counting the projects that have been implemented and will be implemented soon, the development of smart mobility, smart security, smart healthcare, and smart governance is the main focus, and the preliminary statistics of the main projects include software level and hardware level, and the 2025 Smart City Exhibition promotes the newest policies with healthcare, transportation, and life as the main axes (Kaohsiung Smart City Promotion Platform, 2025).Table 1 Unifying the Kaohsiung Smart City Infrastructure Buildings Table 1Categories, projects, and program listings (Kaohsiung Smart City, 2025).

Table 1 Kaohsiung City Smart City Infrastructure Project Statistics

Category	major projects	Number of Projects	Description of Projects
Smart Mobility	7	21	Kaohsiung Light Rail Transit (LRT), Kaohsiung Transportation Mobility Service Program (MeNGo), etc.
smart living	10	11	Kaohsiung Net Zero House and Intelligent Building Promotion Program (regional design principles and standards), Smart Public Housing (Smart building system), etc.

smart healthcare	6	7	Physical Medicine Specialized Hospital 5G Intelligent Safe Care System (iSafe, iCure), etc.
smart governance	11	18	Smart Kaohsiung AI Lighthouse Project (city-level sovereign AI platform), 3D pipeline data integration application project, etc.
smart security	12	21	Smart Water Resources Monitoring and Networking Platform, Climate Change Adaptation Promotion Platform (Disaster Alert System, Climate Change Disaster Risk Mapping Platform, Adaptation Enforcement Program Reporting System), etc.
smart tourism	3	3	Kaohsiung Fun Card Intelligent Tour, Seeing Greater Kaohsiung (5G XR Smart Tour System), etc.
smart education	2	2	E-game U generation island learning paradise, Net Zero Academy
smart energy	5	6	Fishery and electricity symbiosis , etc.
smart agriculture	3	3	Kaohsiung Farmer's Newsletter, Kaohsiung Plant Doctor's Help, Livestock Manure and Urine Water Irrigation and Farming Reuse Adopting and selecting from (Kaohsiung Smart City Promotion Platform, 2025)
available at: Kaohsiung Smart City 2025			

STEP1

This study conducts the first classification of smart city infrastructure types in Kaohsiung City, Taiwan, distinguishing infrastructure types into soft and hard infrastructure categories. The selection is based on whether the infrastructure exists in a physical space. Considering the characteristics of hard and soft infrastructure, this study focuses on hard infrastructure to examine its impact on surrounding property prices. Infrastructure types, based on the aforementioned characteristics, can be categorized into hard domains, soft domains, and hybrid domains (Albino and and Dangelico, 2015. "Hard" domains include buildings, energy grids, natural resources, water management, waste management, mobility, and logistics, where ICT can play a decisive role in system functionality. "Soft" domains include education, culture, policy innovation, social inclusion, and government, where ICT applications are typically not decisive (Senatore and Sessa, 2023). Hybrid smart city implementation projects are composed of both soft and hard infrastructure, initially classified as hard infrastructure, with subsequent spatial impact assessments conducted.

After screening, preliminary selections were made based on hardware infrastructure, and projects with little relevance to housing or housing prices were excluded based on actual application scenarios. Smart city infrastructure that does not directly impact housing prices, such as facial recognition at daycare centers, physiological monitors in hospitals, and tunnel detection systems, were excluded. Only hardware infrastructure with housing price impacts were presented. The detailed list is shown in Table 2.

Table 2 Step 1: Kaohsiung Smart City Hard Infrastructure

category	Scope of influence	Facility projects	Description of the facility	Sources:
Smart Transportation	Within 800 meters of each station along the light rail line	Light rail transit system	There are no overhead lines on the whole line, 100% low floor of the carriage, vibration and noise suppression track system	(Yu and Hsu, 2025)

Table 2 Step 1: Kaohsiung Smart City Hard Infrastructure

category	Scope of influence	Facility projects	Description of the facility	Sources:
Smart Transportation	Within 300 meters of a highway ramp	Important intersections around national highway ramps within the jurisdiction of the city	Taking national highway ramps and flat roads as the planned scope, 5G and AI image recognition were introduced, and real-time traffic flow detection modules and road network-based instrumentation and control strategies were established	The Impact of Transportation on the Real Estate Prices in Taipei City
Smart living	There is no clear scope	6-year 1.25GW plan	The roof is equipped with a solar photovoltaic system, a ground row and a water surface photoelectric system	-
Smart living	It is usually a single building	Intelligent building systems	Centralized setting of smart water meters, smart electricity meters and microcomputer gas meters, and centralized information management system	Exploring the Future Real Estate Market and Industry Development Trend from the Planning Concept of Smart City (Lai Zongyu|2018)
Smart living	It is usually a single building	Central monitoring system	Intelligent security and disaster prevention, waterproof and anti-theft systems, intelligent public facilities management, renewable energy equipment and monitoring systems	(Bagheri and Shaykh-Baygloo, 2021)
Smart governance	It is usually a single building	Carbon and water footprint monitoring and analysis of buildings	Smart water meters and smart meters are installed in buildings to collect water consumption and electricity consumption, and timely control the peak and off-peak power consumption and water consumption of buildings	(Bagheri and Shaykh-Baygloo, 2021)

Table 2 Step 1: Kaohsiung Smart City Hard Infrastructure

category	Scope of influence	Facility projects	Description of the facility	Sources:
Smart security	There is no clear scope	Charging disaster prevention mechanism	Promote the construction of a friendly charging environment for electric vehicles, promote a four-fold disaster prevention mechanism, including thermal imaging cameras, intelligent automatic notification systems, low-pressure water mist fire-fighting equipment, as well as special fire blankets and fire-fighting measures for electric vehicles, and a total of 738 charging piles have been set up in 121 public parking lots	-

STEP2

From the literature, understand whether the introduction of smart facilities has improved the performance of existing facilities, enhanced quality of life, and attracted highly educated individuals. Collect data on the types of facilities that have had an impact, focusing on changes in room availability between 2023 and 2024, and concentrate on the administrative districts where these facilities are located. Examine the annual changes in property prices registered in the real estate price registration system for these administrative districts. This study utilizes publicly available data from the Real Estate Transaction Case Actual Information System, focusing on residential buildings and facilities in the surrounding areas. After confirmation, the locations of smart city infrastructure are primarily concentrated in seven administrative districts: Qianjin District, Lingya District, Yantian District, Gushan District, Zuoying District, Sanmin District, and Fengshan District.

Result

This study aims to investigate the impact of smart city infrastructure types on housing prices. Taking Kaohsiung City as a case study area, the study takes an inventory of nine major categories and their projects, namely, smart mobility, smart living, smart healthcare, smart governance, smart security, smart tourism, smart education, smart energy, and smart agriculture, which have been promoted in recent years, in order to further explore the changes in the overall housing prices before, during, and after the promotion of the smart city. It is expected that by identifying the types of infrastructures with significant impacts and describing their spatial status, the results of this study can help to address the issues of spatial inequality and social inclusion in smart city infrastructures, and also serve as a reference for subsequent studies across different spatial scales or long-term changes.

Research Limitations

In terms of gentrification and smart cities, it can be seen that the formation factors of gentrification are quite diversified, and housing prices are only one of the forms of presentation, and there is a lack of discussion and exploration of local population migration in the study, so it may only serve as an illustration of the extent of the impact of smart city infrastructures on local housing prices. Secondly, the types of smart city infrastructures constructed do not have the same spatial scale of impact, and although the concept of smart cities has been around for a number of years, the actual time for improvement and construction has not been long, so it is not easy to see the obvious state of affairs in the short term. In addition, as the infrastructure of smart cities is widely oriented, this study only focuses on the hard infrastructure and does not include the soft infrastructure. Ultimately, because the case study area is an administrative district, different facilities, land types, and other influencing factors in each administrative district are neglected; and the average price of housing also leads to a lack of precision, and the price of housing varies with multiple factors such as the facilities of the lot, the land,

the building, and the quality of life. Therefore, as a preliminary study on the impacts of smart city infrastructure and gentrification, this research attempts to explore the relationship between the two.

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Unveiling travel communities of people with disabilities using smart card data: A case study of Nanjing

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Abstract
Mobility barriers for people with disabilities remain a critical issue in many cities, especially in developing countries. This study uses metro smart card data from Nanjing, China, to explore the spatiotemporal patterns and network-based community structures of metro travel among disabled individuals. Results show a distinct "dual-peak" travel pattern and a "core-periphery" spatial structure, with higher network centrality during peak hours. Community detection reveals four types of travel clusters—commuting-oriented, residence-dominated, mixed-function, and special-node—each shaped by both travel purpose and urban functions. Spatial regression analysis highlights transit accessibility and land-use mix as key factors influencing travel flow. These findings offer insights for promoting transport equity and optimizing accessible transit planning.

Key words: Spatial-temporal patterns travel communities people with disabilities smart card data

1. Introduction

In recent years, the mobility challenges faced by people with disabilities (PWDs) in urban environments have attracted increasing scholarly and policy attention worldwide, especially in rapidly urbanizing developing countries where infrastructure development and social inclusion often lag behind economic growth (Guo et al., 2022; Liu et al., 2018). According to the latest report from the World Health Organization (WHO), over 1.5 billion people worldwide—nearly 20% of the global population—live with some form of disability. In China alone, official statistics from the China Disabled Persons' Federation (CDPF) indicate that approximately 85 million individuals, accounting for 6% of the national population, are classified as disabled. This sizable demographic represents a critically underserved group whose urban mobility constraints significantly restrict their access to essential services, economic opportunities, and social participation. Consequently, improving transportation equity for PWDs has emerged not only as a matter of human rights and social justice but also as a key indicator of urban sustainability, inclusivity, and resilience (Liu et al., 2018).

Despite substantial efforts and investments in barrier-free infrastructure, including ramps, elevators, tactile paving, and auditory guidance systems, there remains a pronounced disconnect between the provision of accessible facilities and the lived travel experiences of PWDs. Existing research has often emphasized infrastructural availability or static accessibility indices, which inadequately capture the complexity and dynamism of disabled individuals' mobility behaviors (Ma, 2023). Such approaches risk oversimplifying the multifaceted barriers PWDs encounter—ranging from physical environment constraints, psychological apprehensions, to temporal variability in travel demand and purpose. Without a comprehensive understanding of actual travel patterns and their spatial-temporal heterogeneity, urban planners and policymakers face challenges in designing truly inclusive transport systems that accommodate diverse needs effectively.

As a vital backbone of urban public transport systems, metro networks offer inherent advantages of safety, speed, reliability, and weather protection, making them an increasingly preferred mode of travel for many PWDs in dense metropolitan areas (Zheng et al., 2024). The rapid expansion of metro systems in Chinese cities provides a valuable opportunity to leverage detailed smart card transaction data to examine mobility patterns at an unprecedented granularity. However, most extant studies focus primarily on aggregated station-level indicators—such as boarding/alighting volumes or accessibility scores—without delving into the dynamic, directional flows that connect different nodes in the network (Chen et al., 2023; Kolkowski et al., 2023). This station-centric perspective neglects the underlying network topology and the interdependencies among stations, which are essential for revealing the functional structure of travel behavior.

Particularly underexplored is the application of complex network theory and community detection algorithms

to model and interpret the travel flows of PWDs. Considering that PWDs often exhibit more regularized and constrained travel patterns due to physical limitations and environmental barriers, their mobility networks may reveal distinct spatial clusters or "mobility communities" that differ fundamentally from those of the general population (Wei et al., 2024). Identifying these communities and their temporal dynamics is critical for detecting underserved areas, optimizing resource allocation, and tailoring targeted interventions to enhance the equity and efficiency of accessible transport services (Liu et al., 2024). Such an approach transcends traditional accessibility measures by incorporating the relational and flow-based characteristics of urban mobility.

To fill these research gaps, this study employs metro smart card data from Nanjing, China, integrating network analysis with temporal community detection techniques to investigate the spatiotemporal characteristics of metro travel flows among people with disabilities. Specifically, this research aims to answer three key questions: (1) What are the spatiotemporal travel patterns of PWD metro users across different times of day and week? (2) How do the underlying network structures and community configurations evolve temporally, and what does this reveal about the organization of disabled mobility? (3) Which built environment and socio-spatial factors influence travel behaviors within the identified mobility communities? By addressing these questions, this study contributes a novel analytical framework and empirical insights to the growing discourse on urban transport equity, thereby supporting evidence-based policy formulation to promote inclusive, accessible, and resilient urban transport systems.

2. Methodology

2.1 Study area and data

Nanjing, the capital city of Jiangsu Province in eastern China, encompasses a total area of approximately 6,587 square kilometers and had a permanent resident population of about 9.28 million as of 2019. For the purpose of spatial analysis, the study area is delineated into two primary concentric zones (Figure 1): the Central Urban District (CUD) and the Suburban and Urban Distant (SUD) zone. The CUD comprises most parts of Gulou, Qinhuai, Xuanwu, and Jianye districts, alongside sections of Yuhuatai, Qixia, Jiangning, and Pukou districts. This zone represents the city's core urban fabric, characterized by dense residential, commercial, and institutional land uses. In contrast, the SUD zone includes the peripheral districts of Liuhe, Lishui, and Gaochun, which are relatively less urbanized and often represent the city's suburban fringe and outlying rural-urban transition areas. According to the latest Nanjing Statistical Yearbook, the city is home to approximately 595,000 people with disabilities, accounting for 6.4% of its total population, reflecting a substantial demographic group whose mobility needs are critical for inclusive urban development.

In recent years, Nanjing has witnessed rapid expansion and modernization of its urban rail transit system. The metro network now comprises 10 operational lines, servicing a total of 159 stations dispersed across the urban and suburban areas. This expansive metro system has become an increasingly vital mode of transportation for the city's residents, especially for people with disabilities, as a result of continuous improvements in barrier-free infrastructure such as accessible station designs, elevators, tactile guidance paths, and inclusive mobility policies aimed at reducing travel barriers. These efforts have positioned the metro as a backbone of accessible urban mobility, facilitating safer, more reliable, and convenient travel for PWDs within a sprawling metropolitan environment.

This study utilizes smart card data provided by the Nanjing Metro Group Co., Ltd., covering 315,685 metro trip records made by people with disabilities over 20 weekdays and 8 weekend days in 2019. Built environment data were collected from multiple sources: building and land-use data from the Nanjing Planning Bureau, point-of-interest (POI) data from AMap, and transportation facility vector data from OpenStreetMap. Given the average walking speed of people with disabilities (approximately 0.8 m/s), a 15-minute walking distance (equivalent to a 480-meter radius) is adopted as the service buffer threshold around each metro station.

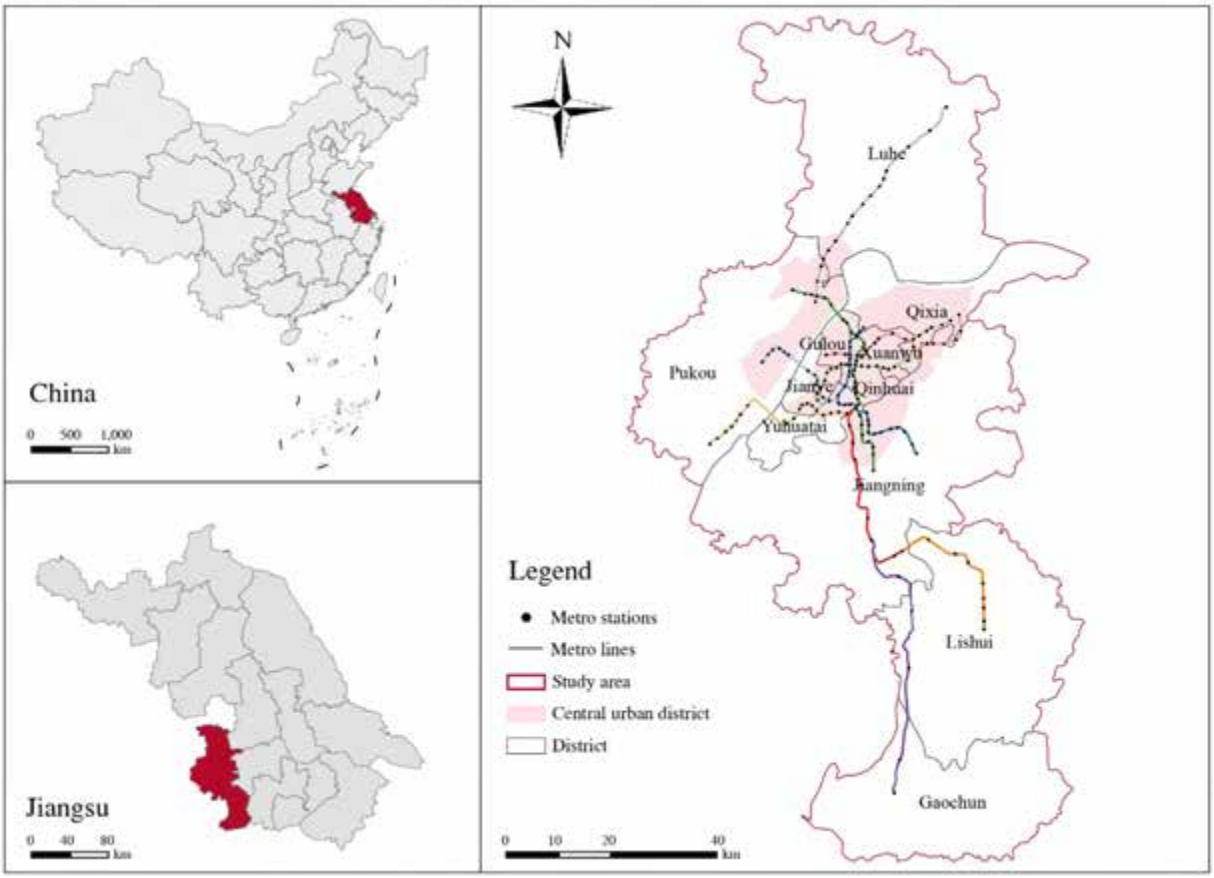

Figure 1 Study area.

2.2 Measurement of Time-Specific Travel Networks

Based on metro smart card data, this study first extracted the daily sequence of entry and exit times for each trip. By analyzing temporal fluctuations in ridership, three representative periods were identified: morning peak, off-peak, and evening peak hours. These periods serve as key time windows for analyzing the commuting-related travel behavior of people with disabilities. For each period, the origin and destination stations of individual trips were extracted. Metro stations were treated as network nodes, and travel flows between stations were represented as directed weighted edges, thereby forming a directed and weighted metro travel network. To characterize the structural properties of these networks, we calculated basic topological metrics such as number of nodes and edges, node degree, and weighted centrality (J. Liu et al., 2023), revealing the spatial structure and connectivity patterns of disabled individuals' metro travel.

2.3 Community Detection Based on Travel Flows

To uncover latent structures within the travel network, we adopted the Leiden community detection algorithm, which has been shown to outperform traditional methods in terms of computational efficiency and partition quality (Chang et al., 2023). This approach enables the identification of functional "mobility communities" by maximizing modularity, a measure that captures the strength of within-group connections. Unlike conventional methods based on administrative boundaries or individual station attributes, community detection allows for a more behaviorally grounded analysis, capturing actual spatial associations and functional regions formed through disabled travelers' movement patterns. By analyzing the size, spatial distribution, and internal flow characteristics of these communities, the study further identifies inter-community differences and group-specific mobility preferences.

2.4 Exploring the Determinants of Travel Flows: Regression Modeling

To examine the factors influencing metro travel flows across different communities, we constructed spatial regression models using average hourly metro ridership of people with disabilities (during weekdays) as the dependent variable. Independent variables included a set of built environment indicators surrounding each metro station, such as land-use mix, road network density, facility accessibility, and the number of disability-specific service facilities .Given the over-dispersion observed in the dependent variable, Poisson regression models were employed. Data subsets were constructed for three key weekday periods—morning peak, midday, and evening peak—and further stratified by mobility community for group-wise modeling. This approach accounts for both temporal variation and spatial heterogeneity in travel behavior across different community types. The modeling outputs include regression summaries and coefficient tables for each group, allowing for comparative analysis of the determinants shaping travel flow intensity across spatiotemporal units.

3. Result

3.1 Spatial-temporal characteristics of metro ridership of people with disabilities

Figure 2 illustrates the temporal distribution of metro trips made by people with disabilities on weekdays and weekends. On weekdays, the travel pattern exhibits a clear "dual-peak with off-peak differentiation" structure, with distinct morning (7:00–9:00) and evening (16:00–18:00) peaks. Travel volumes during off-peak hours are considerably lower. In contrast, weekends show a smoother dual-peak curve, reflecting non-commuting, leisure-driven travel behavior. In addition, notable differences are observed in the average hourly ridership across metro stations in central urban districts and suburban areas, indicating that the metro trips of people with disabilities are primarily concentrated in the urban core. Given the significant reduction in average trip volumes during weekends, this study focuses on weekday travel patterns, and classifies daily metro flows into three periods for further analysis: morning peak (7:00–9:00), noon off-peak (9:00–16:00), and evening peak (16:00–18:00). This classification enables a detailed comparison of travel flows and network structures across different time windows.

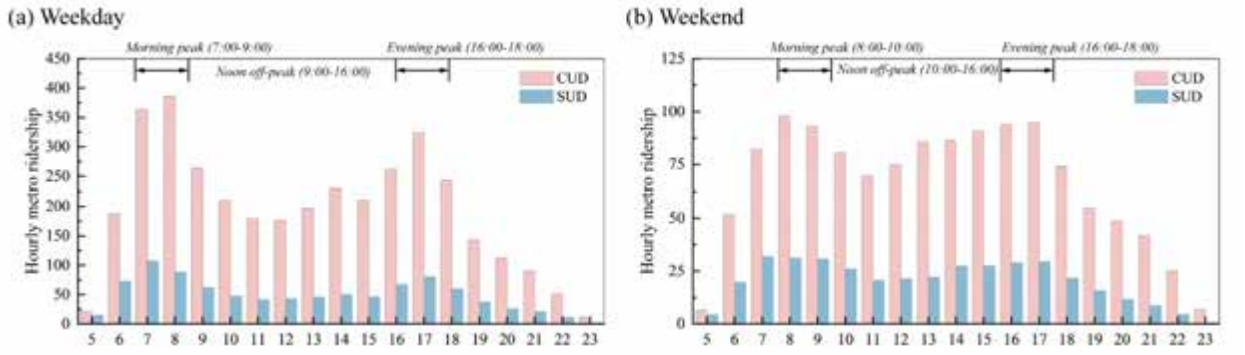

Figure 2 Temporal distributions of hourly metro ridership during weekdays and weekends.

Figure 3 illustrates the spatial and temporal differentiation of metro travel flows and station-level ridership of people with disabilities during weekdays. In the morning peak period, the OD flow pattern shows a strong centripetal tendency, with the highest observed hourly flow reaching 526 trips from Maigaoqiao to Gulou. Notably, 70% of the top 10 OD pairs represent commuting flows from suburban areas to the urban core. During the noon off-peak period, travel flows become more bidirectionally balanced, exemplified by the Maigaoqiao-Gulou link, where flows in both directions remain around 400 trips per hour. In the evening peak (T3), a clear centrifugal pattern emerges, with flows shifting from central areas to the periphery. The flow from Xinjiekou to Maigaoqiao reaches a peak of 421 trips per hour, marking a 22.3% increase over the same direction during the morning peak. Furthermore, aggregated station-level ridership across all time periods highlights a consistent core–periphery disparity. Metro stations in central urban districts exhibit significantly higher passenger volumes than those in suburban areas. In particular, Xinjiekou and Gulou serve as peak flow nodes during rush hours, a pattern closely

associated with the high density of employment centers, public services, and superior metro accessibility in these areas.

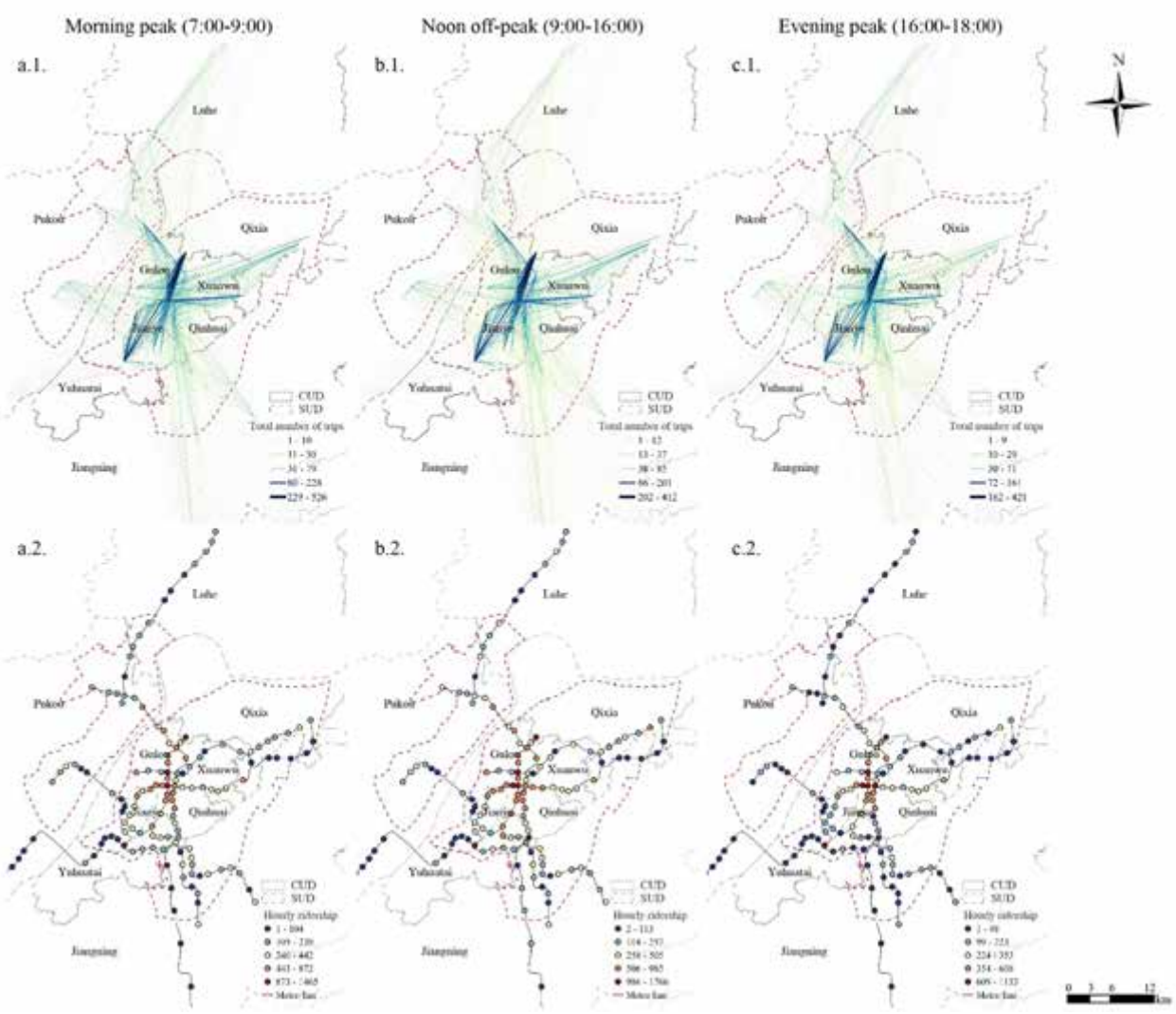

Figure 3 Spatial temporal variations of metro ridership on weekdays.

3.2 Network characteristics analysis

This study conducted a time-segmented analysis of node importance in the metro travel network of people with disabilities using the weighted degree centrality metric. The results reveal significant temporal variations in network structure. During the morning peak, stations such as Maigaoqiao, Difangqiao, and Gulou serve as critical hubs within the disabled passengers' travel network. In the noon off-peak period (T2), the overall network centrality decreases slightly (ranging from 0.003 to 0.041). However, the relative dominance of high-centrality nodes becomes more pronounced, with the maximum centrality increasing by 5.1% compared to the morning peak. For instance, Xinjiekou Station's centrality rises sharply to 0.0410, surpassing Maigaoqiao as the most important node. Meanwhile, Shanghai Road and Gulou stations maintain high centrality scores, highlighting the growing importance of commercial centers during non-commuting hours. In the evening peak, the network centrality strengthens markedly, with the distribution shifting upward (range: 0.004 to 0.047). Xinjiekou Station reaches a daily peak centrality of 0.0466, while Maigaoqiao Station, located at the urban fringe, regains its status as a secondary core node. Together with Difangqiao, these stations form a dual-core structure in the evening peak travel network. Overall, these spatiotemporal dynamics further illustrate the "core–periphery" structure of the metro

travel network for people with disabilities, with higher network concentration observed during peak hours. The most central stations are predominantly located in the historic urban core, whereas peripheral stations exhibit significantly lower importance in the daily travel network of disabled passengers.

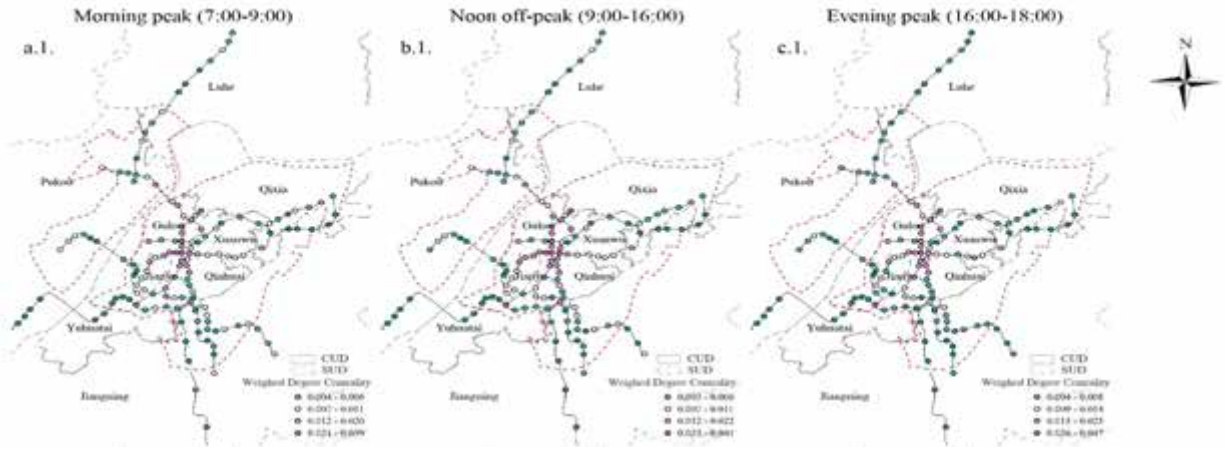

Figure 4 Spatial distribution of weighed degree centrality during the different period

3.3 Community detection analysis

Using a complex network community detection algorithm, this study analyzed the community structure of the metro travel network for people with disabilities across different time periods (Figure 5). The results reveal a high similarity between the morning and evening peak travel networks, whereas distinct differences emerge when comparing peak periods with the noon off-peak period. During peak hours, four prominent communities (C1–C4) are identified, each showing a significant alignment with the metro lines' spatial layout. Specifically, Community 1 (C1) is primarily concentrated along Metro Lines 2, 10, and the S3 line, exhibiting clear line homogeneity. Community 2 (C2) is mainly distributed along the north–south oriented Lines 3 and S8. Community 3 (C3) covers the interchange section between Lines 1 and part of Line 4. In contrast, Community 4 (C4) centers on the Yuhuatai and Jiangning districts, encompassing the S1 line and reflecting the suburban commuting network's relative independence, likely corresponding to a residentially oriented, single-function area. During the noon off-peak period, community structure shows stronger line intermixing with the number of communities reduced to three. Stations from different lines increasingly cluster within the same communities, indicating that the diversified travel purposes during non-commuting hours weaken spatial differentiation.

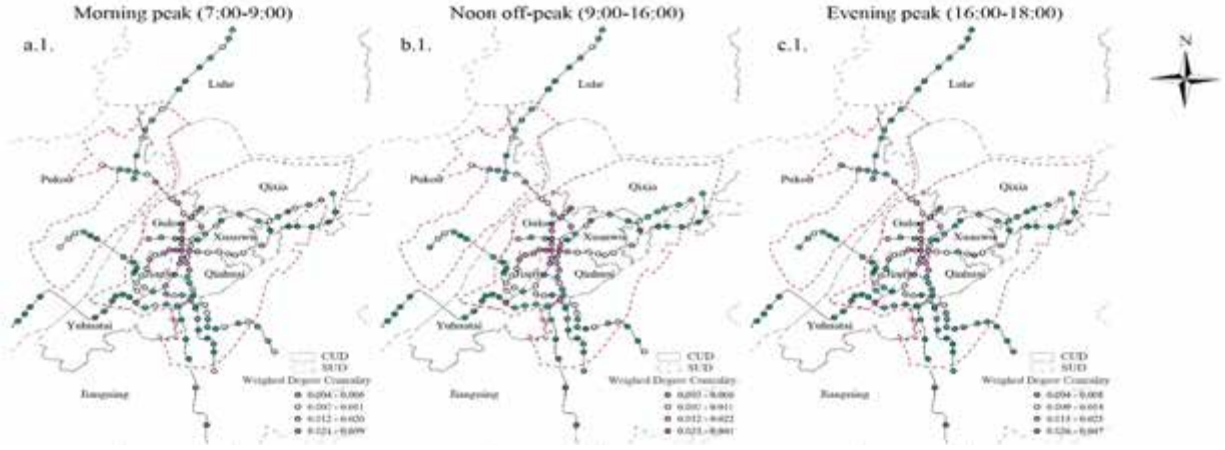

Figure 5 Detected communities for people with disabilities during different period

3.4 Potential Factors Influencing Community Formation

To better understand the formation of these community structures and the differences in travel activity patterns among communities, this study focuses on the morning peak travel network on weekdays, where community differentiation is most pronounced. We statistically analyzed the built environment characteristics of the four identified communities (Figure 6) and further explored the relationships between travel flows and urban built environment features within each community (Table 1).

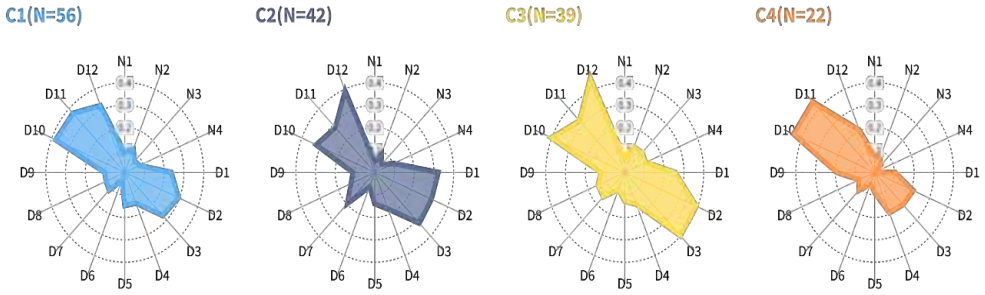

Figure 6 Indicator visualization results for each community during morning peak hours.

The study identified four distinct community types with differing built environment influences on disabled individuals' metro travel flows. Cluster 1, the commuting-oriented community (35% of total), exhibited a significant transportation-commercial synergy, where metro connectivity (β = 0.666*) and bus accessibility (β = 1.812*) combined with commercial facilities (β = 0.811*) to drive travel volume. Travel demand decreased by 1.576 units per kilometer from the CBD ($p < 0.01$), confirming the effectiveness of the traditional TOD model. Cluster 2, the residence-dominated community (26%), displayed typical "bedroom city" characteristics, with leisure facilities (β = 2.398*) and medical resources (β = 0.641*) as main attractors, while enterprise presence (β = -2.002*) and functional mix (β = -2.239*) exerted significant inhibitory effects, indicating spatial job-housing imbalance. Cluster 3, the mixed-use community (25%), reflected balanced development, with medical services (β = 1.792*) and bus coverage (β = 1.351*) as core drivers and minimal impact from distance variables, highlighting the effectiveness of the "15-minute city" concept. Cluster 4, the special-node community (14%), showed pronounced monopolar characteristics, where metro connectivity (β = 264.413*) and medical resources (β = 60.169*) had extraordinary impacts, but road network density (β = -6.840*) strongly suppressed travel, revealing its role as a specialized regional hub. Overall, transportation accessibility consistently underpinned all communities (all D12 coefficients $p < 0.01$), while differences in functional composition constituted the key dimension of community differentiation.

Table 1 Results of factors impacting metro ridership across different communities based on Poisson regression model.

Variables	Morning peak			
	Cluster_1	Cluster_2	Cluster_3	Cluster_4
Intercept	4.609***	6.077***	4.952***	5.594***
Node features				
Metroline(N1)	0.666***	-0.308***	0.101*	264.413***
NumBFAF(N2)	-0.208***	-1.232***	-0.288	-439.975***
NumBFIF(N3)	-0.172	1.122***	0.798***	172.118***
NumBFSF(N4)	0.133**	0.117	0.107	0.000***
Density				
FAR(D1)	0.501***	-0.163*	-0.117	-3.434***

DensRoad(D2)	0.142**	-1.232***	0.874***	-6.840***
DensPop(D3)	1.322***	1.419***	-0.650***	5.542***
Diversity				
POI Mix(D4)	-1.946***	-2.239***	0.213	10.700***
Parks(D5)	0.366***	0.367***	-0.426***	4.929***
Medical services(D6)	0.524***	0.641***	1.792***	60.169***
Shopping facilities(D7)	0.811***	0.136**	0.264***	-16.371***
Recreational facilities(D8)	-0.199	2.398***	0.823***	-12.679***
Companies(D9)	-0.067	-2.002***	-0.306**	1.148
Distance				
Distance to CBD(D10)	-1.576***	-5.702***	-0.301***	360.984***
Distance to sub center(D11)	0.848***	3.896***	-0.062	-365.035***
Availability of bus stop(D12)	1.812***	0.840***	1.351***	1.860***
Statistics				
Pseudo_R2	0.790505961	0.656166405	0.844541082	0.89870978

Note.
*: Significant at the 0.1 level; **: Significant at the 0.05 level; ***: Significant at the 0.01 level.

4. Discussion and conclusion

4.1 Key findings

This study reveals the community structure within the metro travel network of people with disabilities and systematically explores the potential factors influencing travel volumes within each community across different time periods. The findings highlight significant temporal and spatial variations in travel patterns, network characteristics, community structures, and their driving factors between peak and off-peak periods. Methodologically, this research integrates transit card data analysis, complex network modeling, and community detection algorithms, establishing a replicable analytical framework that contributes to urban transport equity research and offers valuable insights for meeting the daily travel needs of people with disabilities, optimizing accessible infrastructure, and promoting transport fairness.

From a temporal perspective, metro travel on weekdays exhibits a typical "double-peak" commuting pattern, with passenger volumes significantly higher during morning and evening peaks compared to off-peak periods, reflecting the rigid travel demands associated with employment or scheduled services for some people with disabilities. Weekend travel patterns are comparatively flatter, indicating that leisure-oriented trips dominate while commuting demands sharply decline. Spatially, travel activities of people with disabilities are highly concentrated in central urban areas, especially in employment-dense and service-rich zones. This concentration correlates closely with the accessibility level of the urban built environment, suggesting that despite rapid expansion of the metro network, people with disabilities tend to favor activity in resource-intensive core areas.

Topological analysis of the travel network shows a typical "core-periphery" structure. Network centralization significantly increases during peak hours, with a few core stations such as Xinjiekou, Maigaoqiao, and Gulou serving as critical hubs. This reflects the concentration of travel destinations during commuting periods and reveals spatial imbalance in metro system service capacity, with peripheral stations showing relatively weaker connectivity and attractiveness. During off-peak hours, the network structure is more dispersed, and the centrality of certain nodes increases, indicating that travel during service- or medical-oriented periods relies more on individual preferences and functional orientation rather than large-scale commuting flows.

Further community detection results identify distinct differences among the metro travel communities of people with disabilities during peak hours and their association with the built environment. The four identified commu-

nity clusters show pronounced heterogeneity in spatial structure, metro line orientation, and functional attributes. The commuting-oriented community (Cluster 1) is closely linked to the urban core and main metro lines, demonstrating the spatial influence of TOD patterns; the residential-dominated community (Cluster 2) is mainly distributed in urban peripheries, reflecting spatial contradictions of job-housing imbalance and mono-functionality; the mixed-function community (Cluster 3) embodies the phased achievements of the "15-minute living circle" planning, where balanced layouts of transportation and service facilities reduce sensitivity to distance; and the special-node community (Cluster 4) shows extreme hub characteristics, revealing the strong attraction of certain medical and special facilities to people with disabilities. These findings indicate that community structures are shaped not only by commuting behaviors but also by the interplay of diverse travel purposes and the functional spatial organization of the city.

4.2 Limitations

Due to data availability constraints, this study has several limitations. First, the smart card data used only cover metro travel, which may overlook trips made by other modes of transportation. Future research should consider incorporating multi-source travel data to provide a more comprehensive understanding of the daily travel behaviors and spatiotemporal network characteristics of people with disabilities. Second, although this study explored built environment factors influencing intra-community travel flows, it lacks causal inference and does not examine other potential longitudinal factors such as weather conditions or policy changes. Future studies could further investigate these key determinants affecting public transit use by people with disabilities to offer stronger insights for urban planning interventions (Kim, 2018).

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What kind of shrinkage differences do urban agglomerations at different stages of development lead to in the era of negative population growth?

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Abstract
Currently, the phenomenon of localized urban contraction has brought challenges to the high-quality development of the region. Based on the study of urban contraction in the Chinese context, we explore the phenomenon and characteristics of contraction in the city clusters of the Yangtze River Delta and the middle reaches of the Yangtze River, comparatively analyse the contraction patterns, temporal and spatial patterns and other changes presented by city clusters with different development processes. It also explores what kind of contraction differences mature and developing city clusters show in their respective development stages, taking the Yangtze River Delta city cluster and the city cluster in the middle reaches of the Yangtze River as examples.

Keywords: negative population growth, urban shrinkage, urban agglomeration, development process, regional differences

0 Introduction

The phenomenon of urban contraction first appeared in Western countries and gradually became a worldwide socio-economic problem (Fernandez C, Audirac I and Fol S, et al., 2012; Döringer S, Uchiyama Y and Penker M, et al., 2020). Currently, in the process of China's rapid urbanization, urban contraction is a phenomenon emerging from urban development mainly characterized by population loss, accompanied by negative externalities such as inefficient use of land resources, housing vacancy, and economic downturn (Guo, Li, 2019), which brings impacts and challenges to the traditional paradigm of growth-oriented thinking (Sun, 2022). China is in the parallel stage of rapid urbanization and urban contraction (Sun, 2022), and in 2019, the National Development and Reform Commission (NDRC) issued the "Key Tasks of New Urbanization Construction in 2019", which mentioned "shrinking cities" for the first time, and explicitly required shrinking small and medium-sized cities to slim down and strengthen their bodies, strictly control incremental growth, and revitalize the stock, which was mentioned in the "New Urbanization Construction and Urban Integration Development in 2020". In the "Key Tasks of New Urbanization Construction and Urban-Rural Integration Development in 2020", the development demands of shrinking cities are also emphasized. The phenomenon of urban contraction has become a key topic of concern at the current stage of emphasizing high-quality development.

Based on the research of foreign scholars, relevant domestic studies start from the introduction of foreign experience to carry out the "China Shrinking Cities Research Network", which researches the connotation (Sun, 2022), identification (Zhang, Shan and Zheng et al., 2019), development path (Zhou, Qian, 2015), and influence mechanism (Sun, Zhang and He, 2022) of shrinking cities. From the perspective of the object, northeastern cities, third-tier cities, resource-based cities are the main ones, and the phenomenon of local contraction within the metropolitan area and city clusters has gradually attracted the attention of scholars. Current research mostly considers the identification of cities with population contraction and the analysis of influencing factors, with less consideration of social and economic factors, and insufficient research on the differences in urban development brought about by contraction. In this paper, we adopt the population census data from the fifth to the seventh census to reflect the population loss of cities in a more comprehensive and real-time manner; at the same time, we select two city clusters of the Yangtze River Delta and the middle reaches of the Yangtze River, and conduct a comparative research on different types of city clusters to better reflect the characteristics and differences in the occurrence of the phenomenon of urban contraction; and based on the different directions and degrees of urban contraction, we will further put forward optimization suggestions.

1 Research Methods

1.1 Research object and data

The study selects the Yangtze River Delta city cluster and the city cluster in the middle reaches of the Yangtze River, considering that both of them have certain types of characteristics in the development of city clusters (Table 1), are located along the Yangtze River Economic Belt, adjacent to each other, the Yangtze River Delta city cluster is in a relatively mature stage of development, and the city cluster in the middle reaches of the Yangtze River is more inclined to be a cultivation period and a developmental type of city cluster, and its comparative study is a reference for the city clusters in different stages of development. Considering the administrative factor of zoning, the phenomenon of city contraction and its causes are analyzed from the prefecture-level city level.

Table 1 Comparison of city clusters in the Yangtze River Delta and the middle reaches of the Yangtze River

Research target	Yangtze river delta city cluster	Mid-Yangtze river city cluster
Geographical position	Yangtze river economic belt (east end)	Yangtze river economic belt (central)
Distributional characteristics	Coastal, open to the outside world	Inland, central hub
Developmental stage	Mature city cluster	Developmental city clusters
Development goal	High-quality integration	Cooperative development

The GIS analysis and visualisation were carried out using the Chinese standard map with review number GS(2020)4619, with the geographic coordinate system GCS_Beijing_1954 and the projected coordinate system China_Lambert_Conformal_Conic. demographic data were the data of the fifth, sixth and seventh censuses from 2000 to 2020, and the resident population of selected prefectural cities was selected for the change trend study; economic data were the GDP data of each city from the statistical yearbook of the local statistical bureau; spatial data were obtained by integrating DMSP-OLS and SNPP-VIIRS data after correction. The population data are the 2000-2020 VP, VIP and VIIP data, and the resident population of prefecture-level cities is selected to study the trend of change; the economic data are the GDP data of each city from the statistical yearbooks of local statistical bureaus; and the spatial data are corrected nighttime lighting data from 2000 to 2020 obtained by integrating the data of DMSP-OLS and SNPP-VIIRS (Chen, Yu and Yang et al., 2021).

1.2 Technical route of research

Starting from the three dimensions of 'population-economy-space', we select the indicators of urban agglomerations in the past years to conduct uni-dimensional, bi-dimensional and multi-dimensional contraction research and judgement, and at the same time analyse the paths and characteristics of urban contraction, discuss the spatial and temporal dynamics of the contraction of different urban agglomerations, and then put forward the corresponding suggestions and optimization strategies for different types of contracting cities, see Figure 1.

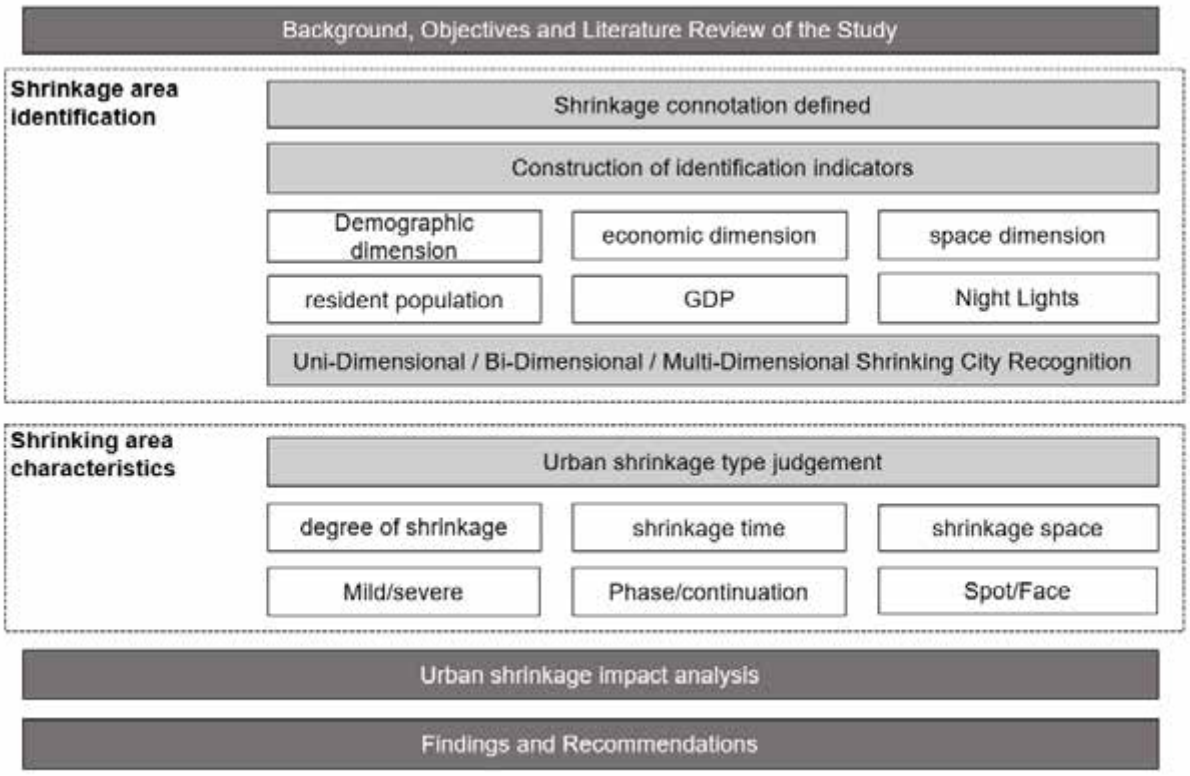

Figure 1 Research pathway framework

2 Shrinkage identification from multi-dimensional perspective

Shrinkage city identification is carried out using prefecture-level cities in city clusters as the division scale; the Yangtze River Delta city cluster includes Shanghai, Jiangsu, Zhejiang and Anhui provinces, totalling 41 cities, and the city cluster in the middle reaches of the Yangtze River includes Hubei, Hunan and Jiangxi provinces, totalling 31 cities. See Table 2 and Table 3 for details.

Table 2 Composition of the Yangtze River Delta Urban Agglomeration

The Yangtze River Delta city cluster contains prefecture-level cities (41)	
Shanghai	Shanghai
Jiangsu Province	Suzhou, Nanjing, Wuxi, Nantong, Changzhou, Xuzhou, Yancheng, Yangzhou, Taizhou, Zhenjiang, Huai'an, Lianyungang, Suqian
Zhejiang Province	Hangzhou, Ningbo, Wenzhou, Shaoxing, Taizhou, Jiaxing, Jinhua, Huzhou, Quzhou, Lishui, Zhoushan
Anhui Province	Hefei, Wuhu, Ma'anshan, Anqing, Chuzhou, Fuyang, Bengbu, Suzhou, Xuancheng, Lu'an, Bozhou, Tongling, Huainan, Huaibei, Chizhou and Huangshan.

Table 3 Composition of urban agglomerations in the middle reaches of the Yangtze River

City cluster in the middle reaches of the Yangtze River including prefecture-level cities (31)	
Hubei Province	Wuhan, Huangshi, Ezhou, Huanggang, Xiaogan, Xianning, Xiantao, Qianjiang, Tianmen, Xiangyang, Yichang, Jingzhou, Jingmen
Hunan Province	Changsha, Zhuzhou, Xiangtan, Yueyang, Yiyang, Changde, Hengyang, Loudi

Jiangxi Province	Nanchang, Jiujiang, Jingdezhen, Yingtan, Xinyu, Yichun, Pingxiang, Shangrao, and some counties (districts) in Fuzhou and Ji'an (Fuzhou and Ji'an were all delineated at the time of the study)

The term 'urban contraction' is used to emphasise the fact that this social problem exists in multiple economic, demographic, geographic, social and physical dimensions, rather than a simple linear process. Therefore, the study starts from a multi-dimensional perspective, taking demographic, economic and spatial indicators into account, and draws on the concept of 'one body, two wings and three dimensions' put forward by Zhang Wei and others (Zhang, Shan and Zheng et al., 2019). Drawing on the concept of 'one, two wings and three dimensions' of shrinking cities proposed by Zhang Wei and others (Figure 2), the study considers the dominant factors of city shrinkage under different scenarios from a multi-perspective perspective. Through three-dimensional identification and judgement, we can more accurately define the type, degree and status of urban contraction, and provide strategic benchmarks for urban regulation and development response.

Fig. 2 One body, two wings and three dimensions of shrinking city concept

2.1 Population contraction

Population contraction, as the main feature of urban contraction, is a key indicator for defining urban contraction. Classifying the data from the three censuses and calculating the rate of change in the resident population of each region from 2000 to 2010 and from 2010 to 2020 respectively, cities with a rate of change in population of less than -3% are identified as shrinking cities (Sun, Wang, 2021; Zhang, Liu and Lv, 2016; Gong, Zhang and Wang, 2022).

Table 4 shows that in 2000-2010, the Yangtze River Delta urban agglomeration mainly faced light to medium contraction, and the city agglomeration in the middle reaches of the Yangtze River existed in light to heavy contraction; in 2010-2020, the contracting cities of the Yangtze River Delta urban agglomeration decreased but the degree of contraction further deepened, with heavy and medium contraction predominating, and the contracting cities of the city agglomeration in the middle reaches of the Yangtze River increased but shifted to medium contraction more often.

Table 4 Identification of cities with shrinking populations

	2000-2010		2010-2020	
shrinkage strength	Yangtze River Delta (12)	Middle reaches of the Yangtze River (8)	Yangtze River Delta (6)	Middle reaches of the Yangtze River(15)
>20% (severe shrinkage)	——	Xiantao (1)	Anqing, Lu'an (2)	——

10%-20% (general severe shrinkage)	——	Tianmen, Huanggang (2)	——	Tianmen, Yiyang, Xiaogan (3)
5%-10% (moderate shrinkage)	Fuyang, Lu'an, Yancheng, Suqian (4)	Jingzhou, Xianning (2)	Huaibei, Yancheng, Huaian (3)	Qianjiang, Changde, Jingzhou, Jingmen, Yueyang, Hengyang, Fuzhou, Ji'an, Yichun (9)
3%-5% (mild shrinkage)	Bengbu, Bozhou, Xuancheng, Taizhou, Nantong, Huaian, Xuzhou, Lianyungang (8)	Qianjiang, Jingmen, Xiaogan (3)	Chizhou (1)	Xiantao, Xiangyang, Huanggang (3)

In terms of the number of cities with different degrees of contraction (Figure 3), between 2000 and 2020, the number of cities in the YRD with mild contraction is decreasing, moderate contraction is decreasing, and severe contraction is increasing; and in the middle reaches of the Yangtze River, there are no change in the number of cities with mild contraction, moderate contraction is increasing, more severe contraction is increasing, and severe contraction is decreasing.

Overall, the YRD has more contracting cities during 2000-2010, decreasing but further intensifying during 2010-2020; the middle reaches of the Yangtze River have fewer contracting cities during 2000-2010 and more during 2010-2020, but to a relatively slower extent.

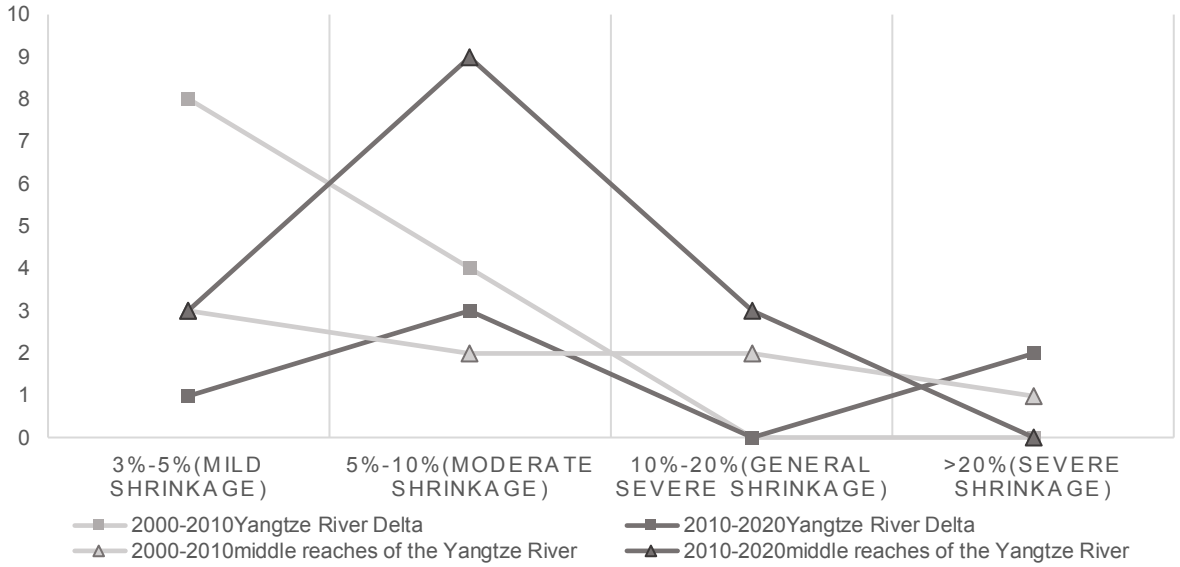

Figure 3 Comparison of cities with shrinking populations

2.2 Economic Contraction

Economic contraction mainly analyses the rate of change of GDP of regional gross domestic product of each city from 2000 to 2020, according to the data of statistical yearbook of each region (Table 5), the Yangtze River Delta has 4 cities with economic contraction phenomenon in the period of 2000-2010, and there are 3 cities in the period of 2010-2020, of which, Huainan is the only city with economic contraction phenomenon in two consecutive years; the middle reaches of the Yangtze River have 5 cities with economic contraction phenomenon in the period of 2000- 2010 period there were five cities that experienced economic contraction, and 2010-2020

excluding the impact of the 2020 epidemic, three cities were considered to have economic decline.

Table 5 Identification of economically contracting cities

Yangtze River Delta		Middle reaches of the Yangtze River	
2000-2010(4)	2010-2020(3)	2000-2010(5)	2010-2020(3)
Fuyang, Ma'anshan (2001) Wuhu (2001, 2006) Chuzhou (2005)	Lu'an (2010) Huainan (2014-2015) Tongling (2019)	Jingzhou, Jingmen, Xianning, Huanggang, Xiaogan (2005)	Pingxiang, Xinyu and Jingdezhen (2018)

2.3 Spatial contraction

Using night lighting data to reflect the spatial vitality of the city, taking into account China's unique 'population loss - land expansion' characteristics and did not choose the built-up area to identify the contraction of the land area, take the city in 2000, 2005, 2010, 2015, 2020 night lighting data to carry out the study in the gis to show the table partition. Statistics, when the average intensity change rate is less than 0, the city will be identified as a spatial contraction city.

The average nighttime light intensity in the Yangtze River Delta region is in a growing trend and basically has no contraction; the cities with contraction in the city cluster in the middle reaches of the Yangtze River are mainly Xiantao, Pingxiang, Yichang, Yiyang, Loudi, Changde, Yueyang, Changsha, Xiangtan, Zhuzhou, Yichun, Huanggang and Xiaogan.

2.4 Multi-dimensional contraction

By integrating the trends of the cities in the city cluster in terms of population, economy, and space, the analysis leads to the shrinking cities under the multi-dimensional perspective. In the Yangtze River Delta city cluster, Fuyang City and Lu'an City belong to the population-economy contraction, because the Yangtze River Delta region basically shows an upward trend in the spatial dimension, and the contraction phenomenon is more in a certain degree of shrinkage in population and economy. In the city cluster in the middle reaches of the Yangtze River, Xiangyang , Jingzhou , Jingmen , Xianning , Huanggang , Xiaogan belong to the population-economic contraction, Xiantao , Yiyang , Changde , Yueyang , Yichun , Huanggang , Xiaogan belong to the demographic-spatial contraction, and comprehensively Huanggang , Xiaogan belongs to the 3D contraction city, and the phenomena of contraction such as a certain degree of population reduction and economic decline exist to a certain extent in many aspects.

3 Evolutionary characteristics of population contraction

From the results of urban contraction research, population contraction is relatively more reflective of the real state of urban contraction, subject to relatively few external uncontrollable factors, based on the population contraction data to analyse the spatial and temporal characteristics of the two major urban agglomerations in the local contraction, and to discuss the contraction of the urban agglomerations in the degree and time of the trend of change.

3.1 Degree of contraction

The contraction of the Yangtze River Delta urban agglomeration in 2000-2010 mainly occurred in the north, Jiangsu and Anhui periphery, presenting a band form; to 2010-2020, the contraction mainly occurred in the east of Jiangsu and the west of Anhui, presenting a relative distribution of points, relatively speaking, the contraction of the city there is a significant reduction, but the degree of contraction from the previous general light to moderate to Medium-heavy. Analysis in the Yangtze River Delta integration to promote more coordinated and balanced development of cities in the urban agglomeration, their own city economy to drive employment growth, reducing

the phenomenon of urban contraction. However, there are also local areas that are relatively lagging behind in development, and neighbouring cities have more attractive resources, leading to a polarisation effect in the degree of contraction and increased wastage.

The city cluster in the middle reaches of the Yangtze River contracted mainly in the centre of Hubei Province in 2000-2010, and in 2010-2020, the phenomenon of piecemeal contraction will occur in the western and southern parts of the entire city cluster, with an increase in the number of contracting cities and a relative slowdown in the degree of contraction. Considering the uneven development of Hubei Province in the early stage, the development of neighbouring cities is relatively lagging behind, the capital city of Wuhan is too high to attract the population of neighbouring cities to gather here, resulting in a high degree of population loss in several neighbouring cities; then, with the gradual development of the neighbouring cities, a number of polarization centres appear in the city cluster in the middle reaches of the Yangtze River, and the economic development of Wuhan, Changsha, and Nanchang, etc., is faster than that of the neighbouring cities, and the resources of these cities are more superior, resulting in the emergence of neighbouring areas. The more superiority of the city leads to a greater range of population movement phenomenon in the peripheral areas, and the contraction further expands at the city level.

3.2 Time of contraction

By considering the overall contraction in 2000-2020, the time characteristics of the contraction of the city cluster are defined, if there is no population loss in both time stages judged as no contraction; if there is a contraction in Stage 1 and none in Stage 2, it is judged as a stage contraction; if there is no contraction in Stage 1 and there is a contraction in Stage 2, it is judged as a potential contraction; and if there is a contraction in both stages, it is judged as a sustained contraction.

Accordingly, comparing the Yangtze River Delta city cluster and the city cluster in the middle reaches of the Yangtze River in terms of contraction time con, it can be seen that from 2000 to 2020, 22% of the cities in the Yangtze River Delta city cluster are in stage contraction, 7% are in potential contraction, and 7% are in sustained contraction; and in the middle reaches of the Yangtze River city cluster, 3% of the cities are in stage contraction, 26% of the cities are in potential contraction, and 23% of the cities are in continuous contraction.

The Yangtze River Delta city cluster has a better advantage in regional integration and coordination, overall the development of each region is relatively balanced, in the face of the problem of urban contraction there is a better basis for coping with the problem, more is to seize the development of local areas to drive, higher quality to achieve regional integration; the middle reaches of the Yangtze River city cluster is still in the stage of cultivation and development, the polarity between the cities is relatively serious, and the differences in regional development are obvious, resulting in the emergence of a large proportion of cities or there is a risk of contraction, and more cities are in the stage of potential contraction. Or there is a risk of contraction, more to regional synergistic development to promote the promotion of the central city to drive the employment and economic development of the surrounding areas, to reduce the phenomenon of underdeveloped areas of the outflow of population.

4 Shrinkage causes and countermeasures analysis

4.1 Causes of contraction

From the current city contraction structure, the Yangtze River Delta city cluster and the city cluster in the middle reaches of the Yangtze River belong to the ‘core expansion - peripheral contraction’ type of contraction mechanism, in which the core city or the central city of the city cluster is attracted by the international co-operation and policies, and the introduction of resources is constantly growing, and the city governance ability

is relatively high and the advantage of innovation-driven development is obvious, attracting the population and industries of the surrounding small and medium-sized cities to gather in the centre. In the city cluster, the core city or the central city is attracted by international cooperation and policies, and continues to grow and bring in resources, from transportation, industry, facilities and social security, and has relatively high urban governance capacity and obvious advantages in innovation-driven development, which attracts the population and industry of the surrounding small and medium-sized cities to the centre, and all kinds of factors gradually tend to develop in the central region, leading to the contraction of the peripheral cities of the city cluster.

The Yangtze River Delta city cluster is a typical case of integrated development with the metropolis of Shanghai as the core, and the development strength of several leading central cities is very considerable, with more people flocking to the several central cities for further development and livelihood, which brings about a lack of sufficient innovative attraction and industry to retain the population in the surrounding small and medium-sized cities, leading to local contraction problems.

The city cluster in the middle reaches of the Yangtze River has a relatively low degree of integration and development, and is still the central city of several provinces in the driving force, the flow of factors between the region tends to converge to a few central nodes, and the nodes around the urban areas are also prone to the proximity of resources leading to the flow of factors, the essence of the spatial resources to the region of the higher level of energy and more promising areas of the development of the tilt brought about by the demographic tendency to be from the economic tendency to the contraction of the phenomenon as the phenomenon of contraction, as an unavoidable aspect of rapid urban development in the process of urbanisation, and the growth of cities present a situation of mutual pull, and the cities in the region are constantly pulling between 'contraction-growth', and the factors are constantly redistributed in space under the perspective of factor flow, which brings about the dynamic evolution and development of the region.

4.2 Planning Countermeasures

For the Yangtze River Delta and the city cluster in the middle reaches of the Yangtze River, the city contraction is dominated by population contraction, accompanied by economic contraction and slowing down of spatial vitality.

As a mature urban agglomeration, the Yangtze River Delta is now mainly characterised by population contraction, with more cities contracting in the northern region and a high degree of contraction in the western region, and contraction in recent years has mainly focused on some cities in the peripheral regions. The overall development of the Yangtze River Delta city cluster is more powerful and mature, and the contraction is mainly due to the loss of population from the peripheral cities to the core, and the contraction should be considered as the main mitigation, relying on the development of the power to transform the regional competitive relationship into the centre, and improve the configuration of the regional economic factors through the policy and planning (Peng, Luo and Liu et al., 2023), and effectively ease the transfer of the functions of the central urban areas to the periphery.

The city cluster in the middle reaches of the Yangtze River as a developmental city cluster, from uni-dimensional to multi-dimensional contraction type is more diverse, the contraction shows the trend of expansion and spreading, and is dominated by potential contraction and continuous contraction. Compared with the Yangtze River Delta City Cluster, which has a stronger development drive, most of the cities in the Middle Reaches of the Yangtze River cluster are contracting because of the disordered development caused by the loss of labour force and the depletion of resources, the limited role of the central city in radiating and driving the small and medium-

sized cities in the vicinity, and the lack of a regional network hierarchy due to the unbalanced development of the cities, which makes it difficult to form an effective linkage and collaboration. Based on economic activities, it is considered to cultivate secondary cities that are closely connected to each other to buttress the metropolitan area and radiate and drive the population flow and economic development of the contracting cities (Yu, 2024).

In terms of the type of contraction, for the phenomenon of population contraction in the city cluster, it is necessary to resist population loss in the early stage, improve urban development, promote the division of labour and cooperation in order to integrate into the regional development system, and drive its own development with developed cities. When the contraction continues to be severe, we should consider appropriately reducing the size of the city and promoting the development of a leaner and stronger city. For the phenomenon of 'population-economy' double contraction, the development positioning and effective development scale of cities in the urban agglomeration should be clarified, and the support of major industries should be appropriately increased to promote the economic development of the cities, and at the same time, the adjustment and optimisation of the industrial structure should be considered, as well as the comprehensive coordination of the spatial distribution of industries and the development of the population. Facing the phenomenon of 'population-space' double contraction, which mainly lies in the reduction of spatial vitality brought about by population exodus, we should control the scale of cities, optimise the land use structure, and adapt to the needs of urban development. For the multi-dimensional contraction phenomenon of 'population-economy-space', the adaptation contraction strategy is the main one, and the 'small and beautiful' development of the city should be realised through spatial resource integration and redistribution within the limited resources and space. Planning should take into account the type and degree of urban contraction and time, and make differentiated decisions on the response strategies to urban contraction.

From the perspective of urban agglomeration, the analysis of urban contraction strategy suggests that it is necessary to grasp the key points of regional integration and development, strengthen the internal integration and flow of factors such as labour, technology, capital and information within the region, enhance the synergy of regional development, and buttress the external cycle of the region. Taking 'population' as the root, we should guide the matching of population increase and employment, pay attention to changes in population size and age structure, encourage births moderately, and increase the introduction of talents to promote the inflow of young and strong people into the cities. With 'economy' as the driving force, we will optimise the regional industrial division of labour, adjust the industrial structure, introduce high and new technologies to upgrade traditional industries, promote the extension and integration of closely-connected industries, and create competitive alternative industrial clusters. On the basis of 'spatial vitality', the construction of regional spatial networks should be strengthened, and an attractive urban environment should be created to support the coordinated development of the region (Yu, 2024).

5 Summary

This paper identifies the contraction of the two major urban agglomerations of the Yangtze River Delta and the middle reaches of the Yangtze River from 2000 to 2020 through the multi-dimensional perspective of 'population flow - economic output - spatial vitality', and further analyses the spatial and temporal dynamics of urban contraction based on the main population contraction, and explores the spatial characteristics of the two types of urban agglomerations under the background of contraction, with the following main conclusions. The main conclusions are as follows:

Firstly, from the multi-dimensional identification of population-economy-space, it can be seen that the shrinking cities of the Yangtze River Delta urban agglomeration show the spatial characteristics of 'more in the north and less in the south, higher in the west and lower in the east', while the shrinking cities of the city agglomeration in

the middle reaches of the Yangtze River show the characteristics of 'more in the west and less in the east, higher in the north and lower in the south'. In terms of the distribution of bi-dimensional or multi-dimensional shrinkage cities, the Yangtze River Delta region is mainly located in the periphery, while the middle reaches of the Yangtze River tends to be distributed in the vicinity of the regional centre cities.

Secondly, analysing the time dimension, the contraction trends of the YRD urban agglomeration and the city agglomeration in the middle reaches of the Yangtze River show an opposite trend. In the time periods of 2000-2010 and 2010-2020, the number of shrinking cities in the YRD urban agglomeration decreases and intensifies, while the number of city agglomerations in the middle reaches of the Yangtze River increases and decreases, which is related to the fact that the two urban agglomerations are at different stages of development.

Thirdly, in terms of the type of contraction, the Yangtze River Delta Urban Agglomeration shows a 'periphery-core' structure, with population loss from the peripheral areas to the central cities occurring within the scope of the urban agglomeration, which mostly belongs to the type of phased contraction. The city cluster in the middle reaches of the Yangtze River shows a 'point-circle' structure, with the provinces as the scope of the phenomenon of circle contraction around the regional central city, and the population loss from the peripheral areas to a number of node cities, which is more of a potential contraction type.

For the two major city clusters in the context of contraction of different performance, targeted optimisation proposals: the Yangtze River Delta city cluster has basically entered the stage of integrated development, regional synergy is better, the future more consideration for the relative backwardness of the peripheral areas to further pull and boost, tendency to innovation, the introduction of talent and other policy guidance. The city cluster in the middle reaches of the Yangtze River is still in the stage of their own development, the three provinces have not yet reached the regional synergy drive, consider the core city of each province to make joint efforts, from independent development to the regional joint, to strengthen the competitiveness of the differences between the various regions of the city, and promote the balanced allocation of resources. As for the contraction of small cities caused by the overdevelopment of large cities, the governance means are more inclined to optimise the spatial layout of small cities, promote the fine development and smart contraction of small cities, cultivate their own characteristic industries and localisation, improve basic public service facilities, and promote the 'slimming and strengthening' of urban development.

The urban growth model is no longer applicable to the sustainable development of all cities and regions, and the planning discipline needs to reconsider the multidimensional impacts of urban contraction and urban regeneration strategies in practice, as well as the need to expand the current research paradigm of urban planning from 'growth' to 'growth and decline', as interconnected and interrelated. The current research paradigm of urban planning needs to be expanded from 'growth' to 'growth and decline' as interrelated urban development processes (Fernandez C, Audirac I and Fol S, et al., 2012). The phenomenon of city contraction in urban agglomerations brings more thoughts on regional synergy and integrated high-quality development: based on the metropolitan area to control over-concentration of population and inhibit the spread of contraction; shifting from factor accumulation to improving economic efficiency and promoting the implementation of bottom-up security policies; and different cities exploring location advantages and core competitiveness to promote balanced regional development. Urban contraction is a process of continuous change and adjustment, and dynamic assessment of the effectiveness of shrinking cities and the implementation of improvement measures to promote the refined development of cities is the focus of further research on the realisation of urban slimming and strengthening.

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Equity of pediatric diagnosis and treatment hospital allocation from the perspective of supply and demand: a case study from Shanghai, China

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Abstract
It has become a consensus to promote a balanced and equitable distribution of regional medical and health facilities, and hospitals that provide paediatric care are an important place and the last line of defence in safeguarding children's health. However, problems such as uneven distribution of medical resources and poor accessibility to nearby services are common. In order to understand whether there is equity in the allocation of paediatric hospitals, from the perspective of 'supply and demand', taking into account the spatial distribution and supply of hospitals, as well as the distribution of children and their demand, to explores whether there is an imbalance between the supply and demand for resources in different regions.

Keywords: Supply and demand balance, social justice, vulnerable groups, pediatric hospitals

1 Introduction

There is currently widespread concern about social issues related to children's health, and ensuring that the need to safeguard children's healthy development is not overlooked has become an important consideration in facility planning. Hospitals, as key venues for safeguarding children's health, serve as the last line of defence for their physical and mental well-being. This study examines the distribution of children's healthcare facilities from a supply-demand perspective to investigate how hospital layout impacts children's access to nearby services and the balance between supply and demand, thereby providing planning recommendations for the allocation of medical resources.

The urban-rural dichotomy has led to issues such as uneven distribution of medical facilities between urban and rural areas (Ni et al., 2025). Therefore, many scholars have conducted research on the distribution and accessibility of medical facilities. Existing studies have used various research units, including counties (Cheng et al., 2016) and townships/subdistricts (Zhong, Yang and Chen et al., 2016), and common measurement methods include the proportional model method (Kong, Li, and Zhang et al., 2008), the minimum distance model (Fan et al., 2017), the two-step moving search method (Deng et al., 2015), and the potential model (Wu et al., 2017). This study comprehensively considers the spatial distribution of the research subjects, as well as supply and demand factors, to analyse the differences in the supply and demand of children's healthcare resources across different regions.

2 Data and Methods

2.1 Research area and subjects

Shanghai Municipality was selected as the study area. Chongming Island was temporarily excluded from consideration due to its geographical isolation. The study scale was based on the administrative divisions of towns and sub-districts in Shanghai (Fig. 1). The population aged 0–14 years in each sub-district was considered the demand side, while hospitals providing paediatric care were considered the supply side. The study analysed the proximity of paediatric healthcare services, supply-demand balance, and facility competition, and proposed an evaluation of the layout of paediatric care hospitals in the city.

Fig. 1. Administrative divisions of Shanghai municipalities (excluding Chongming Island).

2.2 Data Sources and Processing

(1) Child Population Data.

The number of children aged 0–14 in each subdistrict of Shanghai was extracted from the seventh national census to serve as the demand volume for healthcare services. The centroid of each subdistrict was used as the location for healthcare service demand, with a total of 202 subdistrict demand points.

(2) Paediatric Hospital Data.

Referring to the Shanghai Municipal Government's 'List of Major Medical Institutions Providing Paediatric Medical Services in Shanghai,' paediatric care-providing hospitals were selected from Shanghai's medical POI data, including both general and specialised hospitals, as the locations of healthcare providers. The actual number of available beds at each hospital was queried as the supply volume of healthcare providers. Due to the inclusion of branch hospitals under the main hospital, a total of 84 hospital supply points were extracted.

2.3 Research Methods

Considering that medical institutions are public welfare facilities, the study first employs service area analysis to examine their proximity service capacity. It then uses the moving search method and two-step moving search method to analyse their supply-demand relationships. Finally, the Huff model is applied to analyse the influence ranges of each hospital, reflecting a certain degree of facility competition, thereby proposing evaluations and recommendations for the current distribution of paediatric hospitals.

3 Results and Analysis

3.1 Distribution of the Child Population and Paediatric Healthcare Facilities

First, the data was visually analysed using graded symbols to indicate the number of people aged 0–14, divided into ten categories based on natural breaks. As shown in Fig. 2 (a), children and adolescents are primarily distributed in suburban areas, with significant concentrations in districts such as Baoshan, Minhang, Pudong, and Putuo. In central urban areas, the distribution is densely concentrated, but each neighbourhood has a relatively small population.

From Fig. 2 (b), which shows the distribution of paediatric hospitals and the number of beds, it can be seen that hospitals in the central urban areas are generally larger in scale. This is likely because comprehensive hospitals are typically headquartered in the central urban areas, resulting in a higher number of beds. For example, Huangpu and Jing'an districts have several large medical institutions offering paediatric care. In peripheral areas, each district generally has one or two large medical institutions, with some smaller affiliated hospitals distributed around the periphery to meet local healthcare needs.

(a) Population aged 0–14 each subdistrict. (b) paediatric hospitals and number of beds.

Fig. 2. Spatial distribution of research subjects in Shanghai.

3.2 Proximity Service Analysis

Proximity services primarily consider the spatial relationship between supply points and demand points. Starting from a customer-oriented perspective, the nearest supply point for each demand point is determined. Due to the large spatial scale, Euclidean distance is used for calculation. Through GIS nearest neighbour analysis, the hospitals closest to each subdistrict demand point are identified. Figure 3 shows the number of times each hospital is the nearest facility. It can be seen that some hospitals are the nearest hospitals for five surrounding subdistricts demand points, while others are not the nearest hospitals for any demand point, indicating an uneven spatial distribution.

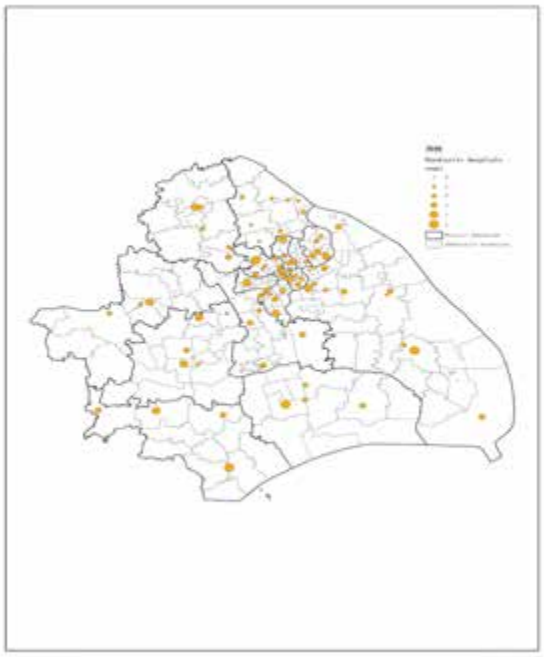

Fig. 3. Number of paediatric diagnostic and treatment hospitals in Shanghai as the nearest facility.

Secondly, from a facility-oriented perspective, buffer zone analysis (Fig. 4) shows that within a 5 km service radius of the hospital, i.e. a 15-minute commute, the central urban area is basically fully covered, but there are still a large number of demand points in the suburbs of Shanghai that are not covered. Within a 10 km service radius, i.e., a 30-minute commute, only a few demand points remain unaccounted for, and within a 15 km radius, all townships are within the service area. From a facility-oriented perspective, the central urban area is highly concentrated, making medical travel very convenient, while medical travel for children in suburban areas generally requires a longer time.

(a) 5km buffer (b) 10km buffer (c) 15km buffer

Fig. 4. Coverage of 5km, 10km and 15km service radius of Shanghai paediatric diagnostic and treatment hospitals.

3.3 Supply-Demand Balance Analysis

Supply-demand balance analysis primarily considers the capacity limits of facilities. The mobile search method is employed to simultaneously account for proximity-based service provision and supply-demand balance. As hospitals are public welfare facilities, the mobile search method is suitable for calculating the maximum service capacity available at each demand point. Given that paediatric healthcare facilities must achieve full coverage, and based on the '1560' healthcare circle planning in Shanghai, which stipulates that a tertiary hospital must be reachable within 60 minutes, a distance threshold of 15 km was selected for this study.

Figure 5 shows the maximum likelihood of obtaining services at each demand point, visualised using geometrical intervals. The supply-demand ratios in the central urban areas are relatively high, with supply fully meeting children's needs. Some townships in Baoshan District, Songjiang District, Minhang District, and Pudong New Area are also close to hospitals, with relatively high supply-demand ratios. However, some townships in the outer suburban areas have very low supply-demand ratios, with significant supply-demand imbalances observed in the northwestern and southeastern suburban areas.

Fig. 5. Ratio of supply and demand of hospitals for children in subdistrict of Shanghai.

Furthermore, the two-step moving search method is employed to consider scenarios where supply points serve multiple demand points simultaneously. The two-step moving search method analyses the accessibility of facilities through supply-demand relationships, ensuring that the supply-demand ratio within the search threshold range adequately accounts for both supply and demand (Zong et al., 2021).

As shown in Fig. 6, when considering the simultaneous provision of services at supply points, the central urban area has the highest service accessibility, while the southern suburban area has relatively improved medical accessibility, mainly because there are fewer demand points sharing the same hospital in the surrounding areas, allowing hospital resources to better serve local children. However, the current suburban areas of Qingpu and Jiading still face issues of poor accessibility. Spatial connectivity better reflects the supply-demand balance of paediatric healthcare facilities, with better conditions in the central urban area and southwestern suburban areas, and poorer conditions in the northwestern and eastern peripheral regions of Shanghai.

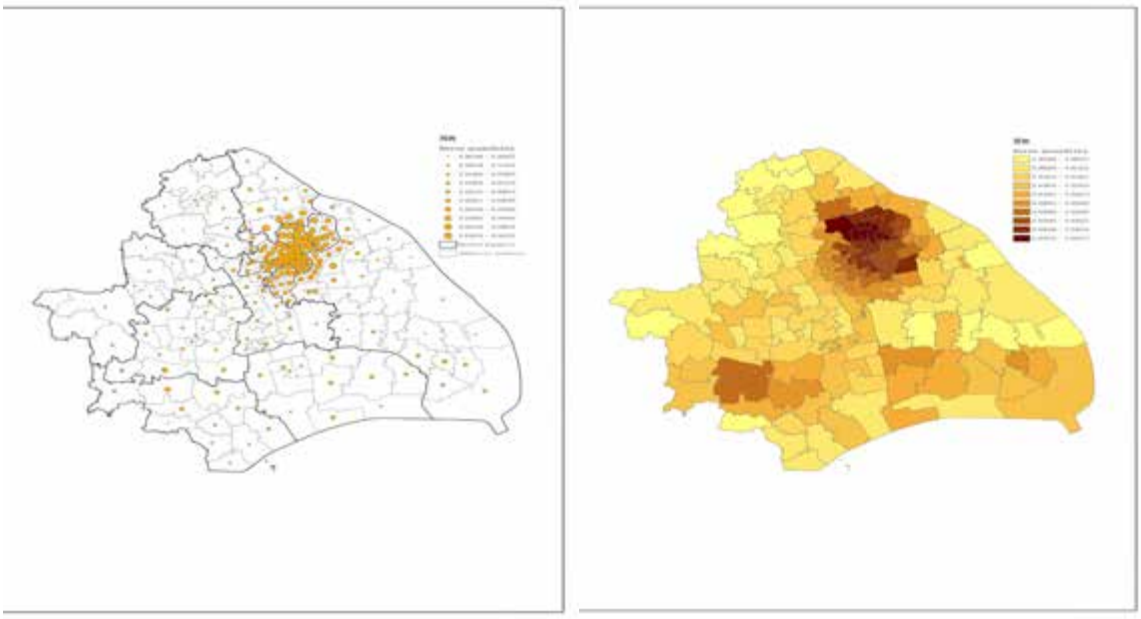

Fig. 6. Accessibility of children's medical services each subdistrict in Shanghai.

3.4 Facility Competition Analysis

There is also an issue of patient preference for hospitals. Although hospitals are public service facilities, it is necessary to consider competition between different hospitals. The aforementioned supply-demand relationship reflects the opportunities for children to choose hospitals, while facility competition reflects their preferences. The Huff model from the interaction model is selected, with hospital grading (Grade A > Grade B, Grade 3 > Grade 2) as the basis for determining attractiveness. with attraction increasing sequentially from Grade 2 Grade B to Grade 3 Grade A, and the power function distance decaying with a coefficient of 2. The maximum potential of each demand point is calculated (Fig. 7). Hospitals in suburban areas generally have greater potential in district centres, as medical institutions tend to be located in district centres to better serve the surrounding areas.

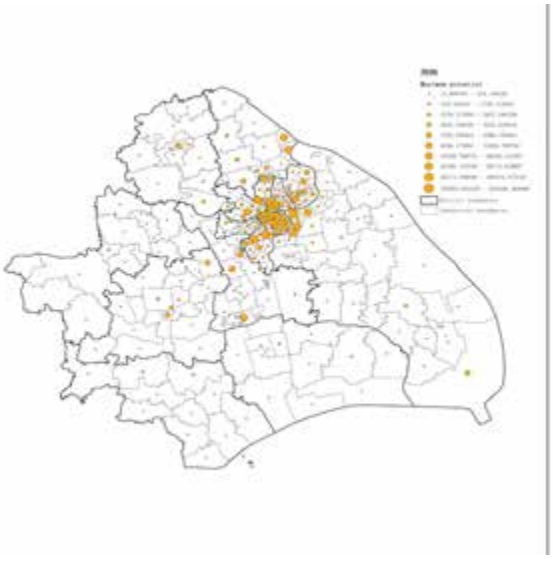

Fig. 7. Maximum potential of children's medical treatment in Shanghai.

From the sphere of influence (Fig. 8), it can be seen that under certain attraction settings, paediatric hospitals have their own main service areas. Competition is fierce in the central urban areas, with each hospital basically occupying one subdistrict. The suburbs are relatively loose. Based on attraction and distance, some hospitals need to serve the medical needs of children in a larger area. Overall, the further out the hospital is, the more subdistricts and townships it serves, but it is also relatively balanced, with each hospital serving several areas.

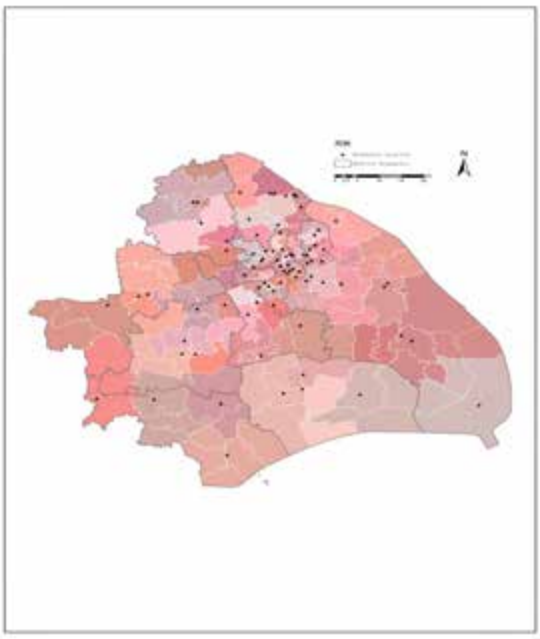

Fig. 8. Areas of influence of paediatric hospitals in Shanghai.

4 Summary

4.1 Conclusions

(1) From the perspective of spatial distribution characteristics, children and adolescents are primarily concentrated in the northern part of Shanghai, with a higher concentration in districts such as Baoshan, Jiading, and Pudong. Hospitals providing paediatric healthcare services are predominantly located in urban centres, with relatively balanced distribution in outlying areas, and each district has its own leading hospital.

(2) From the perspective of spatial proximity, hospitals located in district centres provide more services and are the nearest facilities to a higher number of demand points.

(3) From the perspective of spatial supply and demand, the central area has significantly higher supply and demand, while the central parts of Pudong, the southern part of Jinshan, and the central parts of Qingpu and Songjiang have relatively lower supply and demand. Considering the constraints on simultaneous supply capacity, the northwestern and eastern parts of Shanghai have poorer supply and demand, as these areas have a large number of children but fewer hospitals.

(4) From the perspective of hospital quality appeal and distance, the central urban area, Baoshan District, and Minhang District all have significant medical potential. From the perspective of influence distribution, hospitals in the outer suburbs serve the paediatric healthcare needs of more sub-districts, with relatively balanced distribution across corresponding sub-districts and towns.

4.2 Recommendations

Based on the above conclusions, the study proposes the following recommendations: (1) Overall, from a supply and demand perspective, Pudong, Qingpu, and Jiading districts have relatively insufficient paediatric hospitals. It is necessary to further supplement local medical resources and establish more hospitals specialising in paediatric care. (2) In terms of quality, Pudong has a higher concentration of attractive hospitals, while Qingpu and Jinshan districts lack sufficient hospital appeal. The penetration of tertiary hospitals, including service quality, lags behind other regions. It is necessary to further decentralise high-quality resources to local areas and build higher-quality paediatric hospitals.

Hospitals providing paediatric care serve as a crucial line of defence for ensuring children's healthy development. They should achieve full coverage within the region and maximise accessibility for children seeking medical care, thereby reducing the time required to reach a hospital. From the current layout of paediatric care hospitals, the supply-demand balance and accessibility in Shanghai's central urban areas are at a relatively high level, while suburban areas exhibit varying degrees of disparity in supply-demand balance and accessibility. In the future, it is recommended to adopt medical consortiums and resource sharing to drive the development of local paediatric hospitals. For example, medical consortiums can be used to integrate and reorganise the talent, technology, and information resources of medical institutions at all levels (Chen, Li and Zeng et al., 2018), optimise their supply and demand structure, promote the downward flow of high-quality medical resources, and provide more high-level hospitals for the treatment of children's diseases in a wider area, thereby driving the high-quality coverage of medical resources across the entire region.

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Grassroots Organization and Informal Economy: Learnings from Hawker Sangram Committee

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Abstract:
The informal sector, characterized by unregulated economic activities, dominates the contemporary global economy and supports about 80% of all employed individuals in India. Grassroots Organizations (GROs) play a crucial role in legitimizing and supporting the informal sector, particularly when formal means are unavailable. The GRO, Hawker Sangram Committee (HSC) in Kolkata, India, has united hawkers' unions across the city, state, and country, formed the National Hawker Federation, and passed the 2014 Street Vendors Act, legalizing street hawking and vending in the country. This study presents the roles and practices of such GROs in legitimizing informal workers through interviews with HSC members and union leaders, focus group discussions with street hawkers, and photo documentation. As the informal sector is expected to grow with global urbanization, recognizing GROs' roles in supporting marginalized individuals can provide useful policy insights to governments, practitioners, and scholars across nations.

Keywords: Hawker Sangram Committee, Informal Economy, Grassroots Organization, Global South, Kolkata, India

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1. Introduction

1.1. Street Vending: A Quintessential Form of Informal Economy

The informal economy, more popularly known as the informal sector (Bhowmik, 2010), comprises a wide range of unregulated economic activities and provides jobs for almost two billion (61%) of the world's workers today (ILO, 2019). The informal sector refers to unincorporated enterprises not affiliated with government authorities or managed by legal entities but owned by individuals (ILO, 2019). In informal employment, workers are typically self-employed individuals, unpaid family workers, and wage workers with no written contract, social insurance, or protection (World Bank, 2015). The absence of strict adherence to national legislation, income taxation, social security, and employment benefits makes this economy prone to injustice, violation of human rights, and straying away from labor moralities.

In India, almost two-thirds of the workers are in the informal sector; 88.2% of such workers reside below the poverty level, and 79% live in cities (ILO, 2019). While the informal sector dominates the world's employment and the nature of urbanization, it also creates challenges to comprehend and control informality, especially in developing countries. As these nations continue to urbanize, informal economies like street vending[1], also often referred to as hawking, question their legitimacy and future sustainability. Due to a dearth of initiatives by formal regimes, informal grassroots organizations (GROs) have taken the lead in formalizing the informal. This paper investigates the roles of GROs in the informal economy by scrutinizing the actions of the Hawker Sangram Committee (HSC) in legalizing street vending and hawking in India. The goal is to understand when, why, and how GROs like HSC operates and facilitate grassroots actions. The paper argues that GROs, like HSC, play crucial roles in both the macro- and micro-levels of government structures and civic bodies, blurring the conventional boundaries of formal and informal.

1 The 2014 Street Vendors Act of India defines street vendor as "a person engaged in vending of articles, goods, wares, food items or merchandise of everyday use or offering services to the general public, in a street, lane, sidewalk, footpath, pavement, public park or any other public place or private area, from a temporary built up structure or by moving from place to place and includes hawker, peddler, squatter and all other synonymous terms which may be local or region specific."

Street vending is one of India's most popular forms of informal self-employment, especially in urban areas (Bose and Mishra, 2013). It is a crucial source of income for many as the organized sector cannot employ all of the working population, leaving a significant part still reliant on the unorganized sector (Banerjee and Ghosh, 2019). Many street vendors are migrant workers who immigrate from neighboring countries like Nepal, Bhutan, and Bangladesh or rural areas of the country, owing to the poor economic conditions of their native places. Most of these migrants are unskilled, have low literacy, and struggle to secure jobs in the formal economy (Anjaria, 2006). Some may have had work experience in the formal sector, such as factories, but had turned to street vending due to the decline of industries in India (Bhowmik, 2005). Despite the low income and uncertainty, street vending is a viable option as it requires low investment and a bare minimum skillset (Morales, 2000; Bhowmik, 2007; 2010; Tucker & Devlin, 2019). In India, it is estimated that street vendors share 2.5% of the urban population, but the actual number exceeds 10 million (Bose and Mishra, 2013). The average daily income of a street vendor is estimated at 65 rupees. Street vendors can earn up to 150 rupees, which is higher than the income of daily wage laborers (Anjaria, 2006; Shah, Joshi, & Gopinathan, 2023). Street vending generates hundreds of thousands of jobs in major metro areas, wherein each area, street vendors and hawkers contribute approximately 12,000 million rupees annual turnover (Bose and Mishra, 2013, pg. 167). However, in most cases, these incomes go undocumented and untaxed due to a lack of government initiatives to manage street vending.

The growing number of street vendors poses a challenge to urban development, especially in urban governance (Rafieian & Kianfar, 2023). Street vending creates spatial conflicts over the use of sidewalks and other vital public spaces in the dense cities of India. The Indian government has only been recently active in addressing the issue. However, the laws passed by the state and local governments have mostly been against the welfare of these vendors and hawkers. Moreover, due to the lack of government interventions, mobile and stationary vendors and hawkers have used unregulated make-shift stalls, thus creating visual pollution and leading to the common notion of being eyesores to the middle and upper classes in the city. Street vendors mostly support the urban poor by providing food, clothing, utensils, and other necessities at affordable prices. They also provide the middle classes with the convenience of shopping at the door front. However, the constant struggle of a city to maintain its "image" as a brand in the milieu of globalization and development has rendered informality undesirable (Kamalipour and Dovey, 2019). The undesirability of the street vendors by the upper cohorts and the government has led to attempts to evict them from the country's urban landscape, also known as spatial purification movements. As a reaction to these movements, the formalization of informal vendors began at the grassroots level with the formation of the HSC, a GRO in Kolkata. Their relentless efforts to legitimize street vending and hawking in India brought about the passing of the 2014 Street Vendors Act, which legalized street vending in the country.

Figure 1: *Street Vendors and Hawkers in Kolkata*

1.2. Kolkata and its Street Hawkers:

Kolkata is the capital of the state of West Bengal and was founded in 1686 with the conglomeration of three villages – Sutanuti, Govindopur, and Kalikata, by the East India Company as the colonial capital for the expansion of the British Raj. Today, the city houses a population of around 4.5 million, and the Kolkata Metropolitan Area has a population of around 14 million (Census 2011). The city has a population growth rate of 4%, owing to the migrants from neighboring states and countries like Bangladesh, Nepal, and Bhutan. Almost 23% of the city's population resides in informal settlements, such as slums, 19% of the population is below the poverty level, and more than 20% are unemployed. Of the total workers in the city, around 52% are migrant workers. Almost 65% of such migrant workers stay in the city for more than ten years, residing in slums or other informal settlements and earning livelihood through informal commercial activities, like street vending. In India, approximately 2.5% of the urban population is engaged in street hawking and vending, contributing to around 10 million street hawkers and vendors. Being India's third largest metropolitan city post-independence, especially following the huge migration from Bangladesh in the 1970s, Kolkata observed an influx of street vendors who opted for this mode of income as their only way of survival. Today, the streets of Kolkata are filled with hawkers and vendors who occupy portions of the sidewalks and vehicular roads to sell a wide range of fresh and prepared food items, stationeries, clothes, shoes, books, furniture, and whatnot. Most vendors sell from temporary stalls, shades, or even mobile carts. Their vending areas are typically fixed, except for mobile hawkers who roam around different parts of the city. A recent survey conducted by the Kolkata Metropolitan Corporation (KMC) identified 59,085 street hawkers in various hawking zones of all 144 wards of the city (Kolkata Municipal Corporation, 2024). However, these numbers only represent the "genuine" hawkers who have a valid vending license with the KMC and do not account for "ghost" ones who sell illegally (Ray, 2024). Regardless of their genuineness, hawkers pay around Rs. 265 crore (31.6 million USD) a year, almost 3% of their annual turnover, as bribes to various agencies, signifying a lack of management

and the prevalence of corruption in the hawking business in Kolkata (Ganguly, 2006). Figure 1 shows a variety of street vendors and hawkers in Kolkata and their vending styles.

1.3. Spatial Purification Movements:

In the mid-1990s, major metropolitan cities in India witnessed "spatial purification" movements to eliminate street dwellers, vendors, and hawkers – mostly immigrants from rural areas and neighboring countries (Sibley, 1995). These movements were led by the city governments orchestrating brutal approaches of excluding unwanted cohorts of society from its public spaces. Several such instances include "Operation Pushback" in New Delhi in the 1990s, designed to force illegal immigrants from Bangladesh out of the city who were mostly residing as slum dwellers (Ramachandran, 2002). Around the same time, in Mumbai (formerly known as Bombay), various neighborhoods undertook grassroots social and spatial purification movements by deploying cleanup projects to purge the poor and homeless out of their neighborhoods. Most of these initiatives were patronized by the local governments and law enforcement. For example, "the former Sheriff of Bombay had a vision of tree-lined boulevards, fountains, and playgrounds. There will be no slums. The streets will be clean, with wide pavements unencumbered by hawkers. People will stroll through pedestrian plazas. The night will be brilliant with majestic buildings and fountains" (Seabrook, 1996, pg. 48). The Brihanmumbai (Greater Mumbai) Municipal Corporation (BMC) employed several regimes to prohibit vending and begging on the beaches and gardens of the posh areas of the city, limiting the use of quality public spaces by the urban elites (Fernandes, 2004). This instigated the relocation of the hawkers and beggars to other parts of the city, creating further revolts among several middle-class residents and citizens' organizations challenging the BMC's legal zoning plans to prevent these relocations to their neighborhoods (Devidayal, 1998). Civic organizations, such as the Citizens for the Protection of Public Space, are examples of the rising conflicts between the bourgeoisie and the proletarians in many cities of India attempting to keep the 'ugly' occupants off 'their beautiful urban spaces.' Kolkata experienced similar forms of spatial purification movements in the 1970s and 1990s. In 1975, Kolkata saw an extreme rise in street hawkers due to the influx of immigrants from rural parts of West Bengal and neighboring countries like Bangladesh, Nepal, and Bhutan. The congestion and inconvenience caused by these informal workers to the public life of the streets motivated the city government to undertake active eviction actions. "Operation Hawkers" in 1977 and "Operation Sunshine Drive" in 1996 were two mass-scale eviction projects executed in Kolkata. "Operation Sunshine Drive" recruited around 10,000 policemen who forcefully demolished around 7,000 street vending stalls from major informal commercial corridors of the city (Dell and Ghose, 2009).

1.4. The Hawker Sangram Committee in Kolkata:

HSC was founded in August 1996 as a reactionary measure to the spatial purification actions witnessed in Kolkata. The organization became renowned and most vocal after Operation Sunshine (OS) Drive on November 24th, 1996, led by the Kolkata Metropolitan Corporation (KMC) and the Kolkata Police. The committee was formed by a coalition of 36 street hawkers' unions. Before OS, a smaller committee of four unions was in place in reaction to the 1981 Sealdah Flyover hawkers' eviction project, the first documented case of eviction and political protest. HSC works towards the welfare of street hawkers and protects the "pavement economy" and human rights from the pressures of global growth and development (HSC Constitution, 2022). HSC acts as a 'collective resistance' against the eviction of street hawkers post-OS (Bandhopadhay, 2016). The committee's mission is to unionize, organize, and unite street hawkers and existing hawker unions to protect and legitimize street hawking in West Bengal and India. They can be conceptualized as an umbrella organization of the hawker unions and categorized as "a voluntary, non-sectarian, non-profit making organization" (HSC Constitution, 2022). HSC also facilitated the formation of the National Hawkers Federation (NHF) in May 2001 – an association of Street Vendors across 28 States, with 1,188 Unions, including 11 Central Trade Unions and over 20 International Trade unions abroad. The committee operates under the leadership of Saktiman Ghosh, the HSC and NHF general secretary, and manages 132 hawker unions of KMC and neighboring Bidhannagar and New Town areas. The current members are a group of leaders of the unions affiliated with HSC. The HSC members represent unions registered under the United Trade Union Congress, the Indian Federation of Trade Unions, the All India Central Council of Trade Unions, the All India Trade Union Congress, the Indian National Trade Union Council, the Trade Union Coordination Committee, unions with the Socialist Unity Centre of India, and few other unregistered unions (Lahiri, 2022).

The main source of funding for HSC is from membership fees and donations. The organization collects around 50,000 INR (around 600 USD) annually through member union subscriptions and donations. These funds are used for expenses incurred towards prints and stationery items, meetings, travel, festivities, office electricity charges, rallies and processions, audits and renewals, newspapers and magazines, social welfare programs, disaster reliefs, and other miscellaneous expenditures. The list below shows the operations HSC run on a regular basis:

- issuance of identity cards to new hawkers; creating new unions based on need and interest
- monitoring affiliation and legitimacy of existing member unions
- organizing monthly meetings with member unions to address concerns and issues
- communicating with KMC's Mayor in Council of Hawkers Rehabilitation Plans, State Government, Central Government, and other government bodies for policy implementation and validation
- organizing annual rallies and processions, such as the International Hawkers' Day on May 26 and Operation Sunshine Day on November 24
- facilitating protests against pressing government policies and actions against hawkers' welfare
- representing and communicating hawkers rights to local, state, regional, national, and international conferences
- connecting national and international stakeholders, such as United Nation bodies and Ministries of Development and Poverty Alleviation in India and in Southeast Asia
- engaging in intellectual and scholarly discussions through workshops and seminars
- developing policies, design guidelines, and acts for hawkers' welfare
- organizing periodic workshops to train and educate hawkers on hawking rules and practices
- staying vigilant about illegal hawking in HSC affiliate member union areas and in the city in general

1.5. What roles does GRO play in the Informal Economy?

A few studies, like Lahiri, 2022; Bandyopadhyay, 2009, 2011, 2014, and 2016, have researched HSC's actions in passing the 2014 Street Vendors Act, but their role as a GRO is yet to be analyzed. This study aims to understand how GROs work and their roles in legitimizing the informal when formal means are unavailable by analyzing the case of HSC. While it is widely accepted that GROs play crucial roles in solving local-level issues (Uphoff, 1993; Brown & Ashman, 1996; Ostrom, 2004; Hilmi, 2012; Recio, 2015), their approach to solving such issues is not scrutinized enough, especially from the perspective of their contribution to the informal economy. GROs like HSC have often been observed to organize themselves in a scenario that emerges as an immediate response to the cause, in this case, to stop the evictions of the hawkers. However, very little is known about how they organize themselves without any training or assistance from a formal organization. This research attempts to investigate such modes of operation by understanding HSC's roles in formalizing and managing the informal street hawkers and vendors. The study emphasizes the importance of GROs in the sustainability of informal street hawkers and vendors in India (and the Global South). The study also highlights possible coalitions between GROs and formal organizations, such as city corporations and planning departments, that can foster better ways to manage urban informality.

2. GROs and Informal Economy:

2.1. Defining GROs:

Organizations are typically associated with the sector of society they belong to or represent. For example, public agencies represent the state sector and corporations belong to the market sector ((Brown & Ashman, 1996). In such categorization, GROs are considered the basic local building blocks of society and are typically recognized as organizations serving at the local, communal, and group levels of decision-making and activity for development (Uphoff, 1993). Although there are many ways to understand grassroots, most scholars consider them as local organizations that are comprised of and benefit local people (Uphoff, 1993; Brown & Ashman, 1996; Ostrom, 2004; Hilmi, 2012; Recio, 2015). They are clearly distinguished from national or regional organizations that remain distant from the local community for whom they work and provide benefits. GROs are also considered different

from Non-Governmental Organizations or NGOs. NGOs represent the civil society sector but may or may not comprise or work for the grassroots (Brown & Ashman, 1996). Grassroots are characterized by the purpose they serve in society. For example, in defining grassroots innovation, Hilmi considers that GROs are formed "at the bottom of the pyramid, usually due to necessity, hardship, and challenges" (Hilmi, 2012, p.g. 2). GROs solve local problems often overlooked or ignored by formal organizations or due to the absence of relevant formal institutions (Bhaduri and Kumar, 2011). GROs can also be defined as the byproducts of collective actions exercising human agency that requires more than one individual to contribute to an effort to achieve a certain outcome (Ostrom, 2004; Recio, 2015). GROs are associated with the "ungovernable" cohorts of the population (Recio 2015) and are referred to as the fringe stakeholders of urban development and processes (Chowdhury, Kourula, & Siltaoja, 2018). With these notions, HSC qualifies as a GRO created at the grassroots level by informal street hawkers and vendors to prevent their eviction representing the grassroots agency.

2.2. Urban Informality:

Urban informality is an idiom of urbanization and a logic through which differential spatial value is produced and managed (Roy and AlSayyad, 2004). Informality is "a sphere of unregulated activities that exist outside the formal order of urbanization" (Roy, 2010, pg. 98). It is a "mode of production of space, expression of class power and have the ability to command infrastructure, services, and legitimacy" (Roy, 2011, pg. 233). In planning terms, informality represents "a state of deregulation" (Roy, 2009, pg. 80), as public land management, use, and ownership cannot be controlled by established or "formal" laws and regulations and exists due to open and multiple interpretations of laws and regulations in the Global South (Berry, 1993; Holston, 2008). Urban informality exists due to inadequate formal infrastructure, but the complexity of urbanism in Indian societies and the Global South lies in the diffused boundaries between formal and informal. As Mehta (2019, pg. 239) points out, "by viewing informality as the "other' and through the lens of the formal, we cannot fathom and appreciate these processes and the benefits they entail." Therefore, urban informality can be understood as the coexistence of the formal and the informal in terms of activities, legitimacy, regulation, institutionalization, and production/ reproduction of space and interaction between the formal and the informal by means of everyday resistance, survival strategy, conflict and resolution, and expression of class power (Mahato, 2020). In the societies of the Global South, including India, urban informality contributes in two ways. Firstly, increasing differences between the two extremes of society give rise to structural adjustments favoring the elites and middle classes – forcing the marginalized population to seek refuge in informal means of living and occupation. Informality as a process of providing shelter to the undesirables of society is preferred because of its nature of negotiation between legality and illegality, legitimacy and illegitimacy, and authorized and unauthorized, and acts as a "logic of resource allocation, accumulation, and authority" (Roy, 2009, pg. 83). Secondly, informal institutions and relations provide power and existential purpose to the grassroots – an alternative means of solving urban issues. Informality challenges the conventional socio-spatial structure of developing societies and is increasingly being institutionalized out of necessity.

2.3. Role of GROs in Urban Informality:

GROs are increasingly being associated with the informal sector, especially in establishing agencies for the informal population (Lindell, 2010; JumaAgaya, Ungaya, & Okuto, 2021). In recent years, we have seen the "institutionalizing informality" in India and other countries of the Global South through the standardization of labor relations and commodity chains within the informal economy and affiliation of informality through unionization (Ustyuzhantseva, 2015; Bandyopadhyay, 2016; Schoenecker, 2023). GROs play important roles in such institutionalization. With the absence of formal means of managing and controlling informal activities and population, urban informality has sought refuge to self-help through grassroots in many instances. It is widely assumed that informality exists because the poor are politically passive groups – therefore, marginalized or informalized (Bayat, 2000). However, the notion of the passive poor is being challenged to become increasingly active and powerful. They are becoming mainstream, giving rise to a new social class – the "precariat" who, as informal and marginalized populations, continuously reclaim their place in society through grassroots initiatives (Schierup et al. 2015). Informality is the survival strategy where marginalized groups opt for informal ways to counter unemployment or inflation and demonstrate everyday resistance or micropolitics through protests among subaltern groups due

to the dearth of collective action (Bayat, 2000; Butcher, 2021). Organized political practices are often seen to herd and feed such survival politics of the poor (Chatterjee, 2004). GROs contribute not only to the survival strategies of the poor but are also an involuntary part of the formal political structure and advocates of the marginalized (Mitlin, 2001; Roy, 2009). Castells (1983) defines these forms of grassroots insurgency as "urban populism," which occurs in day-to-day activities. GROs instigate the urban territorial movement by supporting urban informality's claim over urban space (Chatterjee, 2004) and advocate to mark informality not to be marginalized but integrated into the urban society (Bayat, 2000). The spatial purification movements are such urban territorial movements and their counter-movements by the informal sectors that showcase the advancement of the informal into formalized society through grassroots. A grassroots social movement is a group-level phenomenon initiated and maintained by an umbrella organization that unites fragmented groups for collective action (Bettencourt, 1996). GROs maintain coalitions and leadership between groups and provide basic resources and technology.

2.4. Conceptualizing HSC as a GRO:

The case of HSC presents the tension between the governed and the government, showcasing the complex urban dynamics of subaltern urbanism. These dynamics of civil society have been studied and conceptualized in various ways in the discourse concerning subaltern urbanism witnessed in Indian cities. Chatterjee (2004) discusses a unique aspect of politics known as "political society," which involves the entanglement between the elite and subaltern politics in rights, security, and welfare issues. Political society provides the space for negotiation and contestation with the governmental agencies for population groups that organizations like HSC represent (Chatterjee, 2004). The efforts of HSC also resonate with what Appadurai (2019) calls "deep democracy." Deep democracy reframes the movements of the urban poor to the rights of citizenship that signify new modes of mediation for reclaiming urban space from the urban elites. Non-governmental actors, like the hawkers in this case, are ubiquitous parts of global governance and local democracy, and hence, they give rise to a new form of democracy that connects similar actors across the globe (Appadurai, 2009, p. 31).

Scholars bring forth many non-traditional aspects of HSC's success in the hawkers' movement of Kolkata. The hawkers forced themselves to be archived as a legitimate part of society, a tactic for marginalized groups that Bandyopadhyay (2011) calls the "politics of archiving" to establish themselves as a visible category of the public. HSC's actions in Kolkata and its larger impacts on India's hawking culture also negate the traditional ways of understanding cities as motions of urban infrastructure. Bandyopadhyay (2017; 2022) reimagines the hawkers' movement in Kolkata as the politics of "'durable obstruction' that 'spatialized motion' or distributed motion across spaces" through the "organized encroachment of the sidewalks by hawkers" (2022, p. 206). HSC's movements can also be understood through the lens of the "politics of inclusion," coined by Roy (2009), to explain the ways GROs "seek to construct and manage a civic realm" (p. 160). The efforts to be included in civil society by the marginal groups represent "civic governmentality," "a spatialized regime" that uses tools of mediation, knowledge production, and self-norms by the marginalized population (Roy, 2009, p. 160).

This paper positions itself around these critical discourses on the processes of the subaltern to gain rights in civil society by conceptualizing HSC as a GRO for various reasons. Firstly, HSC is constituted by grassroots actors for grassroots needs and acts at the grassroots level. This character distinguishes HSC from other union groups in Kolkata and India, which historically have been affiliated with political parties in contrast to HSC's non-political aspirations. Secondly, the formation of HSC was a departure from the traditional protest against the hawker evictions by individual hawkers and unions to a more organized protest that involved the community for human rights beyond just hawkers' interests. Thirdly, HSC acts more as an umbrella organization of hawkers and hawker's unions than a union or association itself. This calls for an understanding of the workings of HSC as a grassroots agency rather than a union body. Finally, the expansion of HSC's efforts to local, regional, national, and international levels resonates with the concept of deep democracy and calls for understanding how grassroots actions connect global grassroots actors in the neoliberal globalization processes. This characterization of HSC leans more towards the qualities of GROs than traditional union bodies whose realms typically remain localized. This paper, thus, presents the case of HSC as a success story of a GRO that has multi-level roles addressing issues of informal and marginalized economic actors beyond the scope of unions or associations.

3. Methods:
The study uses a multi-method approach to understand the role of HSC in formalizing the informal street hawkers and vendors in India. This includes an archival study of old newspaper articles and working documents of HSC, interviewing HSC board members and selected union leaders, focus group sessions with their member hawkers, and observation and photo documentation of HSC and hawkers' daily operations, protests and rallies, and their hawking and vending practices.

3.1. Archival Study
Due to the unavailability of online or published materials, the study relied on the archives of the HSC office located in Central Kolkata. The office has a collection of historical documents, including past newspaper articles on the eviction of hawkers across India, court cases fought by HSC, their meeting agendas and minutes, action plans, budget and spending calculations, documents on past workshops and events, action plans, proposals for vending and hawking space and stall designs, HSC strategic planning reports, and their constitution. The archives relevant to the study were scanned and converted to PDF for analysis. An archival study was conducted, and conversations with the HSC general secretary helped in understanding the history of the HSC and its roles, along with the dialogues it engages in with the government and the hawkers. Additionally, some published materials on rights and regulations about street hawkers in India were found on the website of the National Association of Street Vendors of India.

3.2. Interviews
The study organized a total of 36 semi-structured interviews in October 2022. These interviews included meetings with the HSC General Secretary, Vice President, and union leaders. The research also interviewed the Kolkata Corporation Mayor in Council and conducted a focus-group meeting of fifty hawkers representing the eight studied hawkers' unions. The interviews aimed to listen to the past, current, and future initiatives of the HSC governing board members who have been involved with the organization since its inception and the hawkers' and their union leaders' current challenges and future needs.

3.3. Observations and Photo Documentation
Following the interviews, the research conducted field visits to the vending locations of the interviewed hawkers' unions to capture their actions and behavior. The aim was to observe the hawkers' use of public spaces, understand the types of goods they sell, learn about their interactions with customers, and deal with authority personnel like the police. Short videos were recorded while walking through the streets where hawkers were present, and relevant still images were extracted from these videos. The research also photo-documented the annual Operation Sunshine Day procession of 2022, attended by thousands of hawkers' in the city, and the speeches offered by HSC leaders and other union leaders. The speeches were especially useful in gauging current issues of hawking and vending, ongoing actions, and future aspirations.

3.4. Data Analysis
The interviews, originally in Bengali, are first translated and transcribed into English. Personal information found in the recorded audio is not included in the transcriptions. All the transcriptions are then imported into NVivo, a software used for qualitative analysis. Content analysis is done for the transcriptions using codes. The transcriptions are carefully read line by line, and each small idea is coded as one code. A total of approximately 270 different open codes are identified, followed by selective coding by unifying ideas. A set of selective codes is further grouped into themes to understand the roles of HSC at macro and micro levels, as described in the findings. Figure 1 shows an example of the coding process, depicting how raw interview data were used to generate themes that helped identify HSC's macro- and micro-level roles, such as its role as an arbitrator.

RAW DATA	OPEN CODING	SELECTIVE CODING	THEME
Yes, the Hawkers in Kolkata know about the union. When they face any issues they contact us and we go there so solve it.	Hawkers can address local concerns to Unions	Conflict resolution at local level	Role of an Arbitrator
We sort out that to allocate hawkers can where they can sit, what to say to the police.	Unions addressing conflicts with police		
Now they (police) have realized no one can remove them if they (the hawkers) are under any hawker's committee.			
We have to go out and look for instances of illegal hawking.	Unions looking out for illegal hawking		
Now, maybe there is political help, but we don't want to take that help because, in that case, we need to do a lot of favors for them.	No need for doing favors for any party	Non-political affiliation	
The plus point was that it was non-political platform, no personal need shall be there, so that there could be proper fight for the welfare of the society.	Welfare of hawkers is the main priority		
	No personal gains		
As far as I know what the central government is thinking or doing for the hawkers is done by the hands of this HSC. In this way, we do not have to rely on any political party	No reliance on any local political party		

Figure 2: Sample Coding Process

4. Findings:

HSC's efforts to formalize and legitimize informal street hawkers in Kolkata and India have been unique, unprecedented, and revolutionary. Their struggle for equal rights was ultimately rewarded by the central government's passing of the 2014 Street Vendors Act. Although the actual implementation of the Act is still underway, HSC's journey since its inception tells the story of how GROs operate to address grassroots social issues, in this case, to stop the eviction of the hawkers (Figure 3). Adapting Lahiri's (2022) interpretation of HSC's political strategies, this paper classifies HSC's role in formalizing the informal hawkers into macro and micro levels (Figure 4). The macro and micro level roles position HSC in the spectrum of the two extremes of the political society – the formal or established institutions versus the informal or marginalized groups. The study finds that GROs like HSC stand in between the formal and informal dichotomy and, in many ways, blur the boundaries between the state and civic. As Roy (2009) talks about the informality of India's planning regime characterized by deregulation, ambiguity, and exception, HSC's macro and micro-level roles give a perspective of ways GROs can take advantage of an informalized government structure to solve grassroots issues.

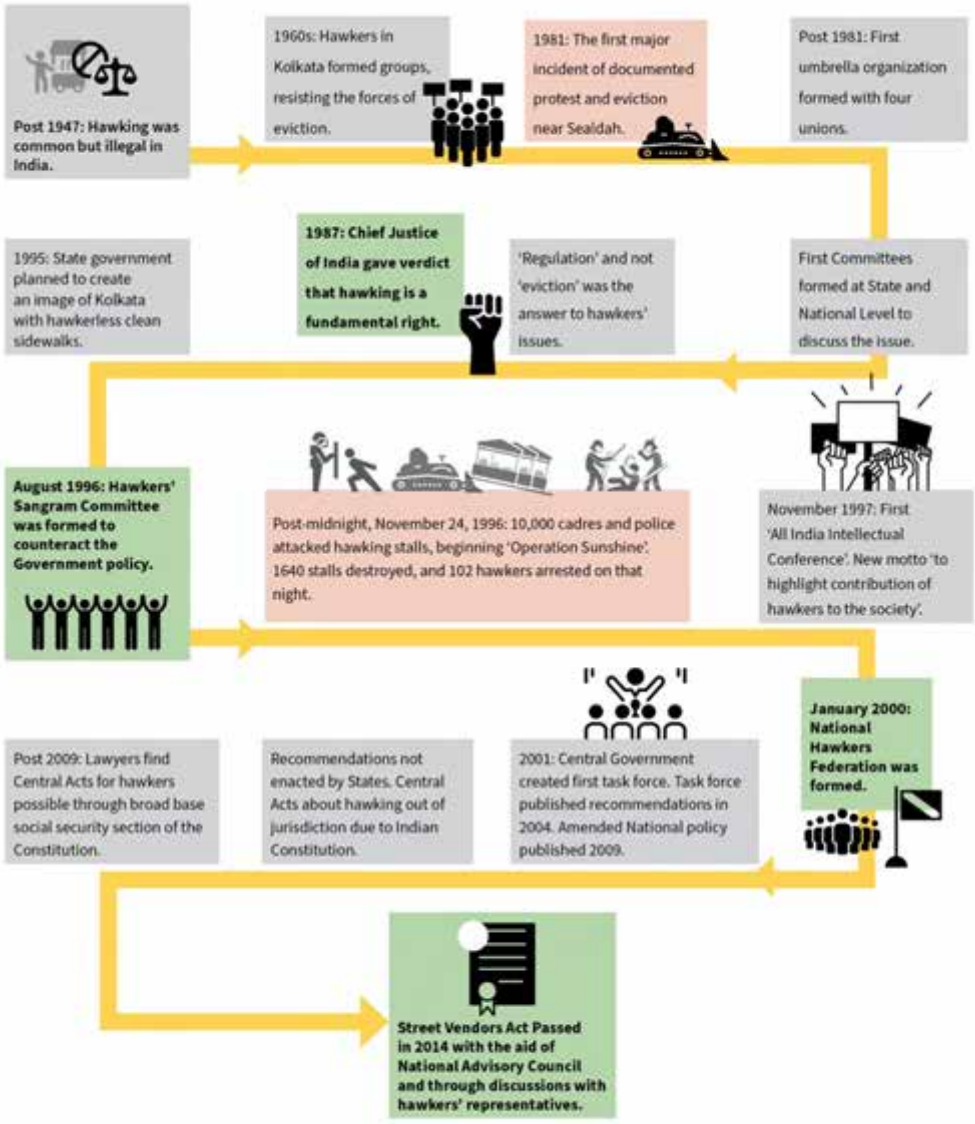

Figure 3: The Hawker Sangram Committee's Actions to Legalize Street Vendors in India

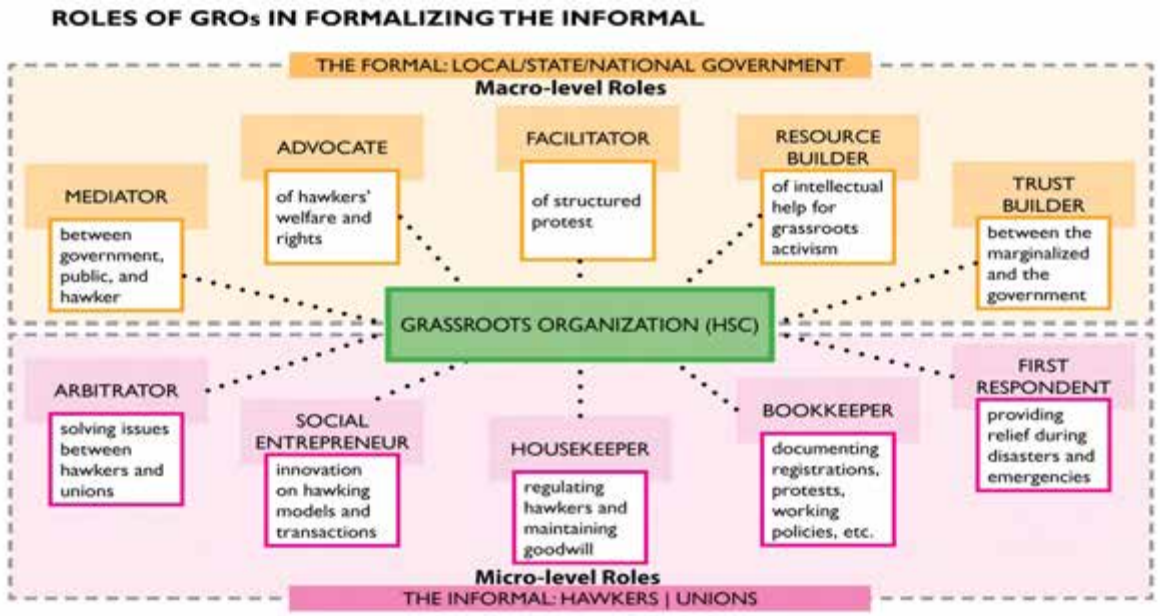

Figure 4: The Macro- and Micro-level Roles of GROs in Formalizing the Informal

4.1. Macro-level Roles:

Macro-level roles of HSC are carried out through its relationship with the formal sector at the municipal, state, and national scales. HSC takes crucial initiatives to present local grassroots issues to higher authorities that can provide more permanent and universal solutions. While the HSC was initially formulated to protest an eviction issue in central Kolkata, over the years, HSC has facilitated the formation of state and national-level GROs that eventually resulted in the passing of the 2014 National Vendors Act. The multifarious roles played by the HSC at the macro level can be defined as that of a mediator, an advocate, a facilitator, a resource builder, and a trust builder.

4.1.1. Mediator

HSC acts as a mediator between the government, the public, and the hawkers when hawkers' needs are beyond the scope of HSC or the unions and, therefore, require government interventions. Vending zones create conflicts among pedestrian users and hawkers as the Vendors' Act allows only 1/3 of the sidewalk width for vending, which is difficult to enforce in narrow sidewalks of older parts of the city. HSC works on finding alternate vending designs/plans and better vending zones that will resolve such conflicts. HSC also mediates conflicts over the relocation of vendors, which often affects customer access to hawkers. In many such relocations, major thoroughfares create barriers because of the lack of adequate pedestrian infrastructure like crosswalks, pedestrian signals, subways, or foot overbridges. Other needs for mediation include creating parking spaces near big natural markets and involving hawkers in the relocation plans to identify suitable locations for hawkers in case displacement is necessary for valid development purposes. HSC's major act of mediation has been the inclusion of a Town Vending Committee (TVC) in each city in the 2014 Act to increase grassroots representation in the government. TVC is to be composed of 40% hawkers, 10% NGOs, and the rest members of the city council with an aim to keep a directory of hawkers, issue hawking licenses controlling their numbers up to 2.5% of the total population, and demarcate vending and non-vending zones to avoid encroachment issues of street vending. TVC works for the welfare of the hawkers and the city government or the public and has been the first-ever attempt to create a formal and informal coalition. Organizing annual rallies and protests also form an important role of the HSC in reminding the government of their presence and solidarity among the associations, as pointed out by the Secretary of the Ballygunge Hawkers Association: "I think they are very important. To have the organization working and keep it strong, these gatherings are vital. These are the 'tactics.'"

4.1.2. Advocate

HSC advocates for the welfare and rights of hawkers. Although TVCs are responsible for the facilities and benefits of hawkers, the committee is not yet fully functional. In its absence, HSC advocates for the needs and demands of its member unions and hawkers to the KMC. HSC presents proposals to alleviate hawkers' working conditions, including access to basic infrastructure, healthcare, financial benefits, and better vending zones and structures. Basic infrastructure, such as access to drinking water, electricity, and toilets, especially for women hawkers, is a dire need for many hawkers. "There is no problem with water, but the toilet is a problem. This problem is very common here." (Secretary of the Kalighat Vivekananda Hawker committee). The Calcutta Electric Supply Corporation (CESC) is reluctant to provide electricity to the shops for fire risks due to the use of combustible materials like plastic in the shops. The inability to afford electricity forces some hawkers to run businesses only in daylight or to borrow electricity connections from nearby big shops and residential homes at higher prices. HSC also urges KMC to provide durable, sustainable, safe, and aesthetically pleasing shops and stalls for the hawkers to diminish environmental and fire hazards and elevate the city's beauty and has provided concept designs of stalls by partnering with a food service equipment company (Congas). Other issues HSC advocates for are government-led awareness workshops and health camps for hawkers, access to existing social benefits like health insurance cards and student credit cards, newer policies for bank loans for hawkers, and office spaces for the unions like other government employees.

4.1.3. Facilitator

Without formal initiatives to legalize hawking and vending, the HSC acted as the facilitator of the legalization of street hawkers in India. Hawkers' unions existed before the formation of HSC but operated in fragments in their respective geographic areas. The unions hardly interacted or worked together due to the absence of a unifying body. HSC provided a structure for hawkers' fight against displacement by uniting the fragmented hawkers' unions of the city under one umbrella, facilitating a common platform for expression. "This platform had given right to the hawkers and also gave the place so that they can be united. Many people who cannot share their problems got a platform to share and raise their voice against all the odds," explained the General Secretary of HSC. With the help of HSC, the unions and their hawkers could stand in solidarity to fight against the government and be more powerful than remaining siloed in their respective unions. HSC also structured the revolution by conducting organized protests and processions, slowly gaining momentum from the local level to the state level and then to the national level. HSC also facilitated the creation of a hierarchical structure for organizing the street vendors and hawkers by forming the NHF. NHF worked for the unification of hawkers from other states and spearheaded the hawkers' protests of eviction at state and national levels. The 2014 Act was possible owing to the unified nature of the protest and the systematic way grassroots actions were taken to the national level. Currently, NHF is led by the Central Secretariat, and state leaderships represent hawkers' unions across the states.

4.1.4. Resource Builder

Hawkers need intellectual help in their fight for equal rights. The hawkers, union leaders, and HSC leaders did not have the capacity in terms of education, skill, or power to materialize their strategies to prevent the eviction of hawkers. They seek help from the "face of the society" to support their cause, gain public attention, and contribute through their expertise. HSC held an intellectual conference where they brought together big personalities like film stars, singers, poets, social activists, lawyers, scholars, teachers, and even ministers. "In 1997 we organized an 'intellectual conference'. There was no intellectual in West Bengal who did not attend" (HSC General Secretary). These pioneers of the society brainstormed strategies, slogans, and action plans to modify the perception of hawkers. The intellectuals' involvement helped them modify their "motto of the revolution from fighting against eviction to studying the contribution of hawkers in society," stated the HSC General Secretary. It is also important to note that initially, the Spatial Purification Movements, like OS, were glorified by poets and singers to uplift the aesthetics of the city. Hence, it was even more important to include prominent personalities who could be insistent against such glorifications and make a case for the hawkers on humanitarian grounds. Intellectuals like lawyers were an integral part of their success as they helped them win court cases against the government, helped formulate policies into laws, and laws into acts. The current president of the NHF is a veteran

lawyer who assists in passing hawking and vending laws nationwide. HSC also collaborated with local scholars to find national and international research articles and case studies about the rights of informal hawkers and their legitimization process to legitimize their claims for hawking and vending rights in the country.

4.1.5. Trust Builder

The past eviction events made hawkers distrust the government's willingness to help the marginalized. HSC was crucial in reinstating that trust between the hawkers and the city officials. This was achieved through efforts on multiple fronts. HSC maintains a non-political status by operating on neutral grounds, avoiding political patronage, and attaining its objectives through systematic and democratic means. Historically, hawkers and unions were affiliated with political parties and used for political agendas as vote banks. However, during the spatial purification movement, the political parties supported the evictions regardless of their connection with the unions. Historically, informal hawkers have earned their livelihood by paying bribes to the police and being exploited by political leaders to find ways into the workforce. Periods of despair and ignorance instigated a sense of distrust toward authority and government. An organization concerned for its true welfare seemed surreal to them. HSC gained this trust by employing hawkers as union members and leaders. Similarly, HSC leaders belong to the working class and lead a lifestyle similar to the hawkers. This was unlike previous instances of politically patronaged hawkers' unions where union leaders were often political party members, aspiring to become ministers and leading a fancier lifestyle than their member hawkers. Being apolitical helped the HSC, as stated by a union representative from Kalikapur Hawkers' Association, "The plus point was that it was a non-political platform, no personal need shall be there so that there could be a proper fight for the welfare of the society. Gaining public trust by highlighting hawkers' contribution to society is another major achievement of HSC. As many residents, especially the middle and upper cohorts, deemed hawkers as eyesores of cities, a way to gain their support was to take human rights ground and showcase the contribution of the hawkers to society. Hawkers run a parallel economy that alleviates poverty, helps with unemployment, creates a huge economic turnover, and provides shopping convenience at the doorstep. HSC encourages its member unions to maintain goodwill with the residents of the neighborhoods where they vend and hawk, ask reasonable prices for their goods, provide services like product return options and home delivery opportunities when needed, and have "eyes on the street" for the area's safety.

4.2. Micro-level Roles

GROs like HSC are vital community support for the grassroots population. In addition to communicating the grassroots' needs to local, state, and national authorities, HSC has taken several steps to address the micro-level needs of the unions and the hawkers. These are local needs that can be resolved by HSC and do not always need to be brought to the government. At the micro-level, HSC performs the roles of an arbitrator, a social entrepreneur, a local problem solver, a housekeeper, and a bookkeeper.

4.2.1. Arbitrator

Issues with informal hawking exist at multiple levels and on multiple scales. While some issues need interventions from higher authorities, such as dealing with court cases, stopping evictions, or formulating acts, other trivial issues are left under the unions' jurisdiction. Unions deal with minor hawker-related issues, such as managing vending and hawking zones, illegal hawking, police interference, or other local issues. The president of the All-India Women's Hawkers Federation stated, "We sort out that to decide where the hawkers can sit... what we can tell the police, all these things." The individual unions are responsible for employing rules and policies and regulating hawking in their respective geographic areas. If a conflict or an issue arises locally, the area's union leader is first to be approached. The union leaders make the first attempt to resolve the conflict. If the issue cannot be solved at the union level or is beyond the union's scope, the union leaders present the issue to HSC during their monthly meetings. HSC here acts as a body for arbitration. It is important to maintain the hierarchy and mode of operation to address grassroots issues. HSC holds neutral ground for being non-political and not having any vested interest in individual hawking and vending areas. The hawkers always respect HSC decisions as they appreciate the organization's and its leadership's benevolence, which has been fighting for hawkers' rights. Also, as most union

leaders are vendors or hawkers, their opinions may sometimes create conflicts of interest. HSC possesses no such conflicts. The issues mostly brought to HSC concern new hawkers' registration or spatial conflicts between two street vendors. Since the number of hawkers in existing vending zones is limited, HSC typically sends the new vendors and hawkers to a new market area that can accommodate newcomers. Union leaders do not have the authority to assign a hawker to a zone and, therefore, resort to HSC for such arbitration needs.

4.2.2. Social Entrepreneur

The modes of commerce are constantly changing in the contemporary world. As grassroots individuals like street hawkers and vendors do not have the resources to adapt to that change, GROs like HSC must act as social entrepreneurs to help them with new and innovative ways of vending and hawking to keep up with other shops and retailers. Many hawkers reside below the poverty level and have limited access to modern technology for economic transactions, such as smartphones, online banking, or mobile banking. This limits their ability to cater to younger generations and middle and higher economic groups of customers who often prefer to use such transaction modes for convenience over cash transactions. Hawkers' livelihoods are also threatened by online shopping giants like Amazon, Flipkart, Swiggy, Zomato, and others, which steal their customers, especially the tech-savvy young population. While addressing such shortcomings needs more formal initiatives, hawkers and union leaders rely on HSC for innovative ways to compete with the changing economic environment. One of the ways HSC tackles the situation is to encourage hawkers to match or sell at lower prices than online vendors with options for return and refund. Alongside this, HSC has been organizing workshops to train hawkers to use Paytm and other forms of cashless transactions. These transactions require hawkers and vendors to have bank accounts, online access, and smartphones, which many of them, especially those from rural areas, do not have. HSC has created a working relationship with local banks as guarantors for creating bank accounts and online banking options for their hawkers. In addition, HSC planned to establish an online association with hawkers as suggested by a union representative, "We once decided to take an initiative to open a website named hawkerbajaar.com - where the hawkers themselves would deliver the things and essentials at the doorsteps." However, this initiative was affected by the advent of the COVID-19 pandemic.

4.2.3. Housekeeper

With the lack of government initiatives, HSC continues to perform housekeeping tasks to regulate in-house hawkers and maintain their goodwill to society. In the absence of the TVC, the HSC manages new union formations, existing union affiliations, and new hawker registrations with the KMC. When a group of hawkers is interested in forming a union under the affiliation of HSC, the committee hears their appeal and sends them the constitution to be adopted and followed. The HSC General Secretary stated, "We identify a set of leadership positions among them like a president, a secretary, a working president, a treasurer, and working committee members." HSC then sets a fee structure and defines norms, such as having meeting minutes, taking decisions unanimously, and, when required, taking decisions through voting. Any new union under HSC is reported to the NHF and included in a national list of unions. HSC requires the union leaders and their hawkers to attend HSC meetings, conferences, and other assemblies, pay dues and comply with the HSC-defined constitution to maintain their affiliations. HSC and individual union leaders look after preventing illegal hawking in their respective jurisdictions. Another major housekeeping task for HSC is ensuring its member unions maintain goodwill in the community.

4.2.4. Bookkeeper

Without the TVC, the HSC performs the bookkeeping tasks for all its member unions and hawkers. Even before passing the 2014 ACT, HSC strategized to document the protest process systematically so that it could be used to present an authentic claim locally, regionally, nationally, and even internationally. HSC archived and kept records of each meeting, conference, rally, procession, eviction action, court case, and notable event, including news articles on hawkers' evictions. Since there was no official log of the street vendors and hawkers in the city, an important aim of bookkeeping was to survey hawkers and keep records. HSC kept a count of the number of hawkers in the city, the types of items they sell, hawking and vending modes, and vending zones. This was important to manage and organize the hawkers during protest rallies. Bookkeeping also helps HSC oversee where hawkers need to be unionized or reach out to unions not affiliated with HSC. In addition to keeping records, HSC surveyed

the conditions of their member hawkers and vendors and published regular reports on their socio-economic profiles. They also published conference and academic papers, newspaper articles, proformas, and memorandums and kept minutes of meetings to organize their efforts. Since its inception in 1996, HSC has maintained and archived files in its small office in Central Kolkata. Due to space limitations, they have been working since 2018 on digitizing the documents and making them available to the public through the NHF website. As TVC is not active yet, HSC oversees managing vending licenses and hawker registrations. HSC bookkeeping also maintains a dossier of member unions, leadership, and hawker information. Earlier, the hawkers did not have identity cards. "That time, we didn't have cards. We used to give pictures and signatures according to our post (Secretary of the Ballygunge Hawkers Association). The HSC issues hawkers' identity cards, collects membership dues, and maintains funds to run regular activities. Since 2020, they have been able to computerize and expedite the registration process. This has been an important achievement for the HSC. Since the number of hawkers in the city is increasing, it has been difficult to maintain physical records. Nonetheless, HSC hopes that TVC will take over this job soon, as HSC operates with limited staff, most of whom are hawkers and can only participate in HSC activities part-time.

4.2.5. First Responders

Unlike formal shopkeepers or business owners, informal street hawkers and vendors are more vulnerable to natural calamities and other disasters. As government reliefs in such events do not reach these informal cohorts, HSC performs as first responders on such occasions. Both before and after the passing of the 2014 Act, HSC has been the "go-to" place for local hawkers and vendors. The street vendors and hawkers mostly use temporary and cheap building materials like plastics, tin shades, and bamboo structures, which are prone to destruction during storms, cyclones, heavy rain during the monsoon season, and fire. These disasters have economic consequences since they do not have business insurance, often leading to total business loss. Street vendors and hawkers have relied on HSC's help to recover from such downfalls without any other means of revival. During many such disasters, including the recent COVID-19 pandemic, HSC collected donations, food and sanitation items, clothing, and stationeries and provided them to the hawkers whose livelihoods were affected. On the occasion of the unfortunate deaths of hawkers, HSC offers their vending rights to immediate family members to support them in times of turbulence.

5. Conclusion:

Even though the 2014 Act legitimized hawking in India, a full formalization of street vending and hawking is yet to be accomplished. A decade after the Act was passed, the formation of a TVC in Kolkata and many other cities is still in process. Formal authorities tend to be reluctant to meet the needs of the informal population (Bhowmik, 2000; Joshi, 2018), as is apparent in the case of street vending in India. The demands for equal rights, permanent shops, and basic facilities are deemed unnecessary or are not prioritized by the authorities. The demand for permanent and durable vending stalls is ignored, with the perception that "hawkers should remain hawkers and not try to be shop owners," as expressed by the mayor of the Council of KMC when interviewed. The Act also requires KMC to survey the current hawkers in the city to monitor their numbers, vending zones, and items they sell. The survey was recently finished but created immense unrest among the hawkers due to several aspects of illegality and associated corruption. Interviews with the hawkers revealed that the Act has not fully gained their trust and reliance on the government. They consider the HSC, especially their general secretary Shaktiman Ghosh, their "savior" and sole means to deal with the government. The police and political leaders are the "opportunists" who help the hawkers for their own benefit. The decade-long hiatus of the actual implementation of the Act, especially the skepticism of TVC's workings, has rekindled the long-held distrust and hatred against the government among the informal street hawkers.

It is apparent that the major issue of street hawking is encroachment, which is allowed by politicians and the police in exchange for bribes from hawkers. In some recent "anti-encroachment" and "hawker pushback" drives by KMC to clear off city streets from hawkers, clashes occurred between the law enforcement officers and the hawkers who demanded that they were allowed to sell in those locations by the authorities (Zeeshan, 2024). The current chief minister of the state criticized these actions, supporting hawkers' claim, saying, "I do not believe in first allowing encroachers and then using bulldozers. I want restrictions to be imposed from the beginning,"

and warned the authorities, declaring, "Politicians who incite hawkers will be arrested, regardless of their party affiliation, and police officers supporting them will either be arrested by their superiors or removed from their positions" (Ghosh & Banerjee, 2024). In the interviews, many hawkers revealed the chief minister's party's endorsement of their welfare. They also expressed their distrust of the previous government, which initiated the spatial purification movements in the 1970s and 1990s. Similar issues of hawking politics can be observed in other Indian cities, such as Mumbai, where a similar eviction drive has invoked the questions of hawkers' rights and legality (Pinto, 2024). Nevertheless, marginalized populations like street vendors are significant voting assets for politicians and are often manipulated for political gain (Bandyopadhyay, 2024).

GROs like the HSC are the backbone of the informal population and economy, with or without the brace of formal institutions. Street vendors and hawkers would not have thrived or survived without their support, let alone been legalized. GROs are the missing link in the overlapping, often conflicting spheres of the formal and the informal. In polarized societies like India, the formal and the informal lie at the extreme ends of the population cohort. Their interdependency and interrelationship are full of friction, which, perhaps, can only be lessened by means of GROs. The HSC was formed to stop eviction, but its role and importance did not stop after inhuman evictions were stopped and hawkers became legal in India. It continued to exist even more actively because of the limitation of formal institutions in effectively attending to the needs and demands of the marginalized.

In a country where the neoliberal economy is channeled by the pressure of development forces to create neoliberalizing middle classes and the new rich (Fernandes, 2004), the informal economy supports the urban poor. With patterns of political and climate migrations around the world, the informal economy has been and will remain the lifeline of immigrants (Mingione, 1999; Rodgers, Shahid, & Williams, 2019). Since formal institutions do not have any vested interest or benefit from the informal economy (Huang, Xue, & Wang, 2019), GROs like HSC will continue to be the lifeline of the informal population. Street vending and vendors have thrived, not just in India but worldwide, through the changing epochs of society and the economy (Morales, 2007). The challenges that vendors encounter in India may be unique. However, issues such as bribery, harassment, lack of licensing, confiscation of goods, and eviction drives are problems that vendors face in almost every city worldwide. As political, social, and economic variables change, hawkers and vendors innovate and improvise to adapt. This research sheds light on one of the many such ways the actors of the informal economy perform. A universal generalization of the informal economy is unreasonable (Williams & Round, 2007), and therefore, the case of HSC may be unique and not the only way grassroots continue to exist and excel. Perhaps a comparative analysis of other cases around the world will provide a holistic insight into the ubiquitous relationship between the GROs and the informal economy
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Floating Population Structure in Shrinking Area of Shanghai Metropolitan Area: An Urban-Rural Mobility Network Analysis

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Abstract
With the advancement of urbanization in China, urban and rural areas are experiencing different trends and structural changes in population mobility. In particular, some shrinking areas exhibit diverse and complex migration patterns. However, few studies have examined these areas from the perspective of spatial mobility networks. This paper employs an urban-rural population mobility network analysis to explore the structural characteristics and movement patterns of the floating population in the shrinking areas of the Shanghai metropolitan area. It identifies the key factors influencing population structure and provides new insights for local governments to promote regional and urban-rural integration and to formulate effective policies for managing shrinking areas.

Keywords: Population structure; Floating population; Shrinking area; Network analysis; Shanghai metropolitan area

1. Introduction

China's long-standing planning practices have been dominated by a growth-oriented development paradigm, leading to the neglect of urban shrinkage. However, with the intensification of low fertility and population aging, the country is entering a stage of overall population decline. As policies promoting regional integration and urban-rural fusion take effect, the siphoning effects of central cities have led to varying degrees and types of shrinkage across many urban agglomerations and metropolitan areas. While Chinese scholars have mainly focused on urban shrinkage in the Northeast due to long-term reliance on resource-based industries, less attention has been paid to shrinkage in economically developed regions such as the Yangtze River Delta and Pearl River Delta. Yet, research has already identified signs of shrinkage in parts of cities like Shanghai and in certain counties and small towns within cities like Taizhou, Yancheng, Nantong, Jiaxing, and Wuxi. As a result, China's traditional growth-driven urbanization model may no longer be applicable, marking the arrival of a post-growth era in urban development.

Current research on shrinking areas primarily focuses on cities, with relatively little attention given to shrinking towns. However, towns are often typical areas experiencing population loss, aging, and hollowing out during China's urbanization process, facing the dual challenges of natural population decline and out-migration. Population structure has profound implications for regional economic development and long-term competitiveness, which in turn determines whether regional shrinkage is temporary or long-term. Martinez-Fernandez (2013, p. 303-308) suggested that from the perspective of global urban networks and spatial mobility networks, shrinking cities may experience a weakening or even severing of their connections to global flows. However, empirical studies testing this hypothesis remain limited. Compared to research on urban networks, studies focusing on urban-rural network characteristics are scarce. Therefore, this study aims to explore the characteristics of shrinking areas within metropolitan regions from the perspective of spatial network linkages, emphasizing the population agglomeration capacity of towns. Unlike Western countries, China's ongoing urbanization has made population loss less pronounced in cities. Urban shrinkage in China is not only a result of internal urban factors but also of regional and spatial interactions. Thus, examining shrinking areas through the lens of factor flows provides a more effective way to assess their future development trajectories.

This study focuses on all towns within the Shanghai metropolitan area, an area characterized by frequent economic interactions and distinct network connectivity. First, traditional demographic data are used to calculate population changes in each town, providing a preliminary identification of shrinking towns. Next, massive mobile phone mobility data are utilized to construct urban-rural and rural-rural population flow networks within the metropolitan area. By analyzing population travel profiles—including flow volumes and demographic attributes

such as age and gender—this study examines the population mobility and structural characteristics of shrinking towns. It identifies key influencing factors, ultimately proposing optimization strategies. By adopting the novel perspective of population mobility networks, this study offers a new analytical framework for understanding shrinking areas in metropolitan area and provides valuable insights for promoting regional coordination, urban-rural integration, and the development of targeted policies for managing shrinking areas in China.

2. literature review

At present, the definition of shrinking areas is primarily based on population change and involves multiple dimensions such as demographics, economy, and time. However, due to differences in national development contexts and statistical standards, there is no unified measurement criterion. Moreover, the phenomenon of shrinkage in China's urbanization process has unique characteristics, and changes in population size alone may not objectively reflect regional shrinkage.

Existing studies on shrinking cities tend to focus on descriptive analysis. However, with the ongoing processes of economic globalization and regional integration, the traditional "place-based economy" rooted in comparative advantages of resource endowments is gradually being replaced by a "flow-based economy" centered on capital, technology, markets, and innovation, with flow space becoming the mainstream paradigm. In economics, some scholars have begun using total factor productivity combined with econometric methods as criteria to determine regional shrinkage or growth (Yang, 2022). Wu (2021) utilized a unique dataset on intercity investment flows in mainland China to demonstrate a significant positive correlation between network centrality of investment and population change, revealing a link between urban shrinkage and the loss of external investment. Sun (2022) proposed that urban shrinkage reflects a relative or absolute decline in a city's "regional capacity to agglomerate development factors" within regional linkages, leading to the "relocation" of population and other key development factors—a market-driven behavior, with population outflow being merely a manifestation. With the emergence of flow space theory, research on spatial networks has deepened, and advances in information technology have enabled the use of mobile signaling data and Internet app-generated big data to track various flows. These data, supported by increasingly mature algorithms, are widely applied in studies of urban agglomeration and metropolitan spatial structures, thus making it increasingly feasible to analyze shrinking areas from the perspective of element flows.

The identification of shrinking cities has primarily relied on static data analysis, lacking dynamic analysis from the perspective of network connectivity and an essential understanding based on the outflow of development factors. Overall, current methods for identifying shrinking cities are mostly population-centered, using statistical and spatial data to construct multi-dimensional indicator systems. With technological advancement, simulation-based models have also begun to emerge (Liu, 2016). While prefecture-level cities remain the main unit of measurement, studies identifying shrinkage at the district, county, and township levels are increasing.Some scholars have proposed that, from the perspective of global urban networks and spatial flow networks, shrinking cities may also exhibit a weakening or even severance of their connections to global flow spaces—particularly in terms of knowledge and information flows (Martinez-Fernandez, 2014). The inequality between cities and regions integrated into global networks and those excluded from them is intensifying. Cities connected to global networks are the "winners," while others struggle to maintain ties and survive in global economic competition. Cities bypassed by global networks may fall into what Castells termed the "black holes" of globalization—isolated from or disconnected from global growth engines. Therefore, shrinking cities can also be analyzed through their association with urban factor networks. By constructing regional factor networks based on factor flows, areas with weak or disrupted connections to other parts of the region can be identified, thereby detecting cities with shrinkage tendencies.

Research on population structure has mostly relied on static statistical analysis, with limited focus on how population structures evolve in shrinking cities. Demographic structure is often only used as an indicator for identifying shrinkage, rather than as a subject of study in itself. There is a lack of systematic investigation into how population structures change in shrinking cities and how these changes in turn affect urban population,

economic, and social development. Yet demographic shifts can profoundly influence regional economic growth. Therefore, integrating the study of mobile populations with population structure is crucial for understanding the socioeconomic impacts of population decline (Chen, 2025).

3. Methodology and data

3.1 Research area and data source

The Shanghai Metropolitan Area, located in eastern China, is a key component of the Yangtze River Delta. In 2022, the governments of Shanghai, Jiangsu Province, and Zhejiang Province jointly released the "Shanghai Metropolitan Region Spatial Coordination Plan", which aims to advance the national strategy of integrated development in the Yangtze River Delta. The planned area includes the administrative regions of nine cities: Shanghai, Wuxi, Changzhou, Suzhou, Nantong, Ningbo, Huzhou, Jiaxing, and Zhoushan—referred to as the "1+8" city cluster. The Metropolitan Area features diverse patterns of population agglomeration and, as the most functionally concentrated and economically advanced area within the Yangtze River Delta, it is characterized by a high degree of economic clustering and rapid development. With multiple interconnected centers and a strong need for close collaboration, the region plays a pivotal role in driving coordinated regional development. Therefore, integrated urban-rural development holds particular importance for the Shanghai Metropolitan Region.

This study takes the Shanghai Metropolitan Area as the research area, dividing the nine cities into 913 sub-city administrative units at the street (township) level. Based on the "Statistical Compilation Rules for Administrative Division Codes and Urban-Rural Division Codes" (index no. 410A03-1201-201708-0006) issued by the National Bureau of Statistics, each administrative unit was classified by its urban-rural attribute using the first digit of its urban-rural classification code: 1 for urban areas and 2 for rural areas. In total, 404 urban streets and 495 townships were identified.

This study primarily uses statistical data and mobile signaling data. Population statistics are derived from China's Sixth Population Census (2010) and Seventh Population Census (2020), both providing resident population data at the street and town levels. The mobile signaling data consist of weekday origin-destination (OD) travel data from October 2022. Users' movements were located using cell tower grids, and their residence and workplace locations were identified by the longest stay during nighttime and daytime, respectively. The population flow analysis in this study focuses mainly on work-related commuting based on residential origins.

3.2 Research approach and methodology

Compared with traditional studies that explore the characteristics of shrinking areas using static statistical data, this research aims to examine the features of shrinking regions within metropolitan areas from the perspective of regional spatial network linkages, focusing on the population agglomeration capacity of towns. Therefore, this study first adopts the conventional but crucial indicator of population change by calculating population growth rates to identify areas with significant population decline. Next, based on large-scale population mobility data, a population flow network is constructed for the Shanghai Metropolitan Area. This network is analyzed at two levels: urban–rural and rural–rural population flows. These levels respectively represent the connections between shrinking towns and both urban subdistricts and neighboring towns, and can reflect, to some extent and in a timely manner, the ability of shrinking towns to attract and retain population development factors. Based on the constructed networks, the structural characteristics of mobile populations in shrinking towns are statistically analyzed in both urban–rural and rural–rural networks. This analysis is of great significance to promoting urban-rural integration and coordinated development in the Shanghai Metropolitan Area.

The first step involves identifying shrinking towns. Although there is no consensus in academia on how to define shrinking areas, negative population growth remains a key criterion. Given the continued urbanization in China and its significant impact on rural populations, this study follows relevant methodologies (Wang and Xue, 2016; Cheng, Zhang and Liu, 2021) by first selecting towns with negative population growth between 2010 and 2020. Then, the average population change rate is calculated for all townships in Jiangsu Province, Zhejiang Province, and Shanghai. By computing the relative population change rates that exclude the impact of urbanization,

townships within the metropolitan area that still exhibit negative relative growth are defined as shrinking towns.

The second step focuses on analyzing the population mobility network. Using mobile signaling data, the subdistricts and towns are treated as network nodes, and the total bidirectional commuting trips between them are used as the measure of network connection strength. This enables the construction of an urban–rural and rural–rural commuting population network within the metropolitan region. Commuting flows reflect labor force mobility and indicate the degree of productive economic collaboration between regions. Based on this, statistical analyses are conducted on the gender, age, and other characteristics of the mobile population in shrinking towns.

4. Results and discussion

4.1 Distribution characteristics of shrinking towns

Based on the calculation of town-level relative population change rates after excluding the impact of urbanization, a total of 135 shrinking townships were identified in the Shanghai Metropolitan Region. In terms of quantity, Shanghai and Nantong have the highest number of shrinking townships, with 31 and 33 respectively, mainly concentrated in Chongming District (Shanghai) and Rudong County (Nantong). Suzhou, Wuxi, and Changzhou have fewer shrinking townships, each in the single digits, while Zhoushan, Ningbo, Jiaxing, and Huzhou each have around 15.

In terms of spatial distribution, the shrinking townships in the Shanghai Metropolitan Region show a combination of localized clustering and a perforated pattern, mainly concentrated in peripheral areas of the metropolitan region and the border zones between cities. Overall, although current research using cities or districts as the statistical unit does not indicate significant population decline within cities in the Shanghai Metropolitan Region, a more detailed analysis at the township level reveals varying degrees of shrinkage within cities. This better reflects the unique development characteristics of different areas. For example, towns in the Suzhou-Wuxi-Changzhou area maintain stable population levels due to a solid industrial base and balanced internal economic development. In contrast, the areas surrounding Shanghai are affected by the strong siphoning effect of the central urban core and related policies, leading to frequent population mobility in towns. (Figure 1)

Given the limitations of traditional population statistics, shrinking towns in different regions should be further categorized and analyzed. Big data sources such as population mobility data can dynamically reflect the current development status of towns.

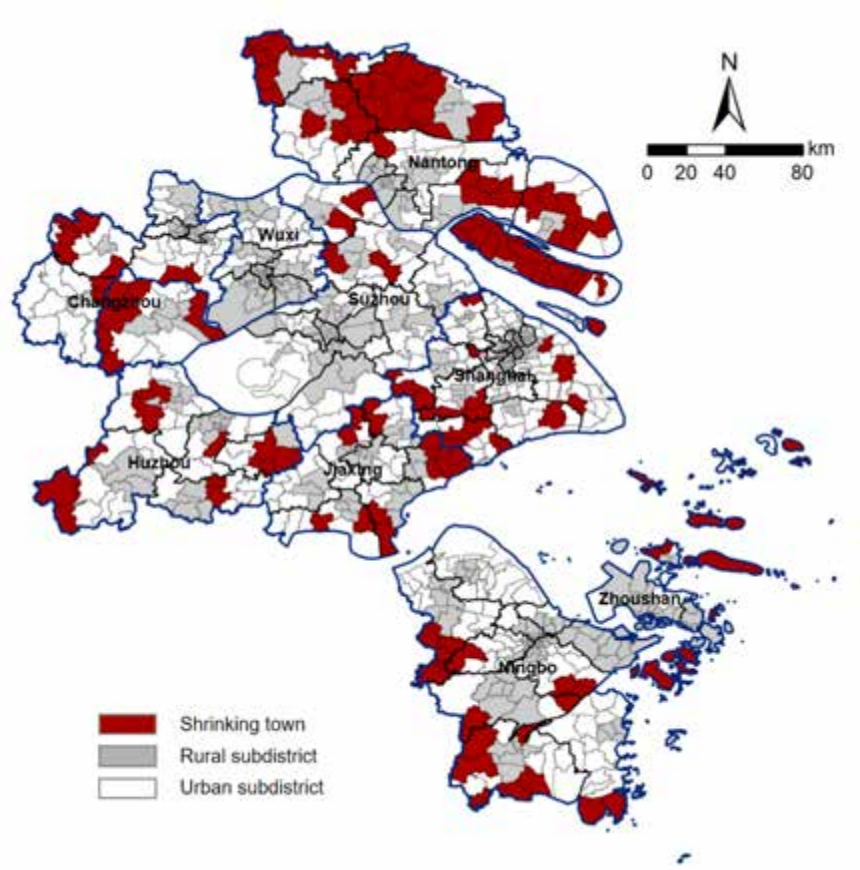

Figure 1. Location, urban-rural classification and shrinking towns layouts of Shanghai metropolitan area

4.2 Connection characteristics of shrinking towns

The travel connections of shrinking townships were filtered and visualized . In both the urban–rural and rural–rural networks, shrinking townships show stronger internal connectivity within their respective districts or counties, indicating the significant constraint imposed by administrative boundaries. However, cross-boundary connections are more prominent in the rural–rural network, suggesting that inter-township interactions are less influenced by administrative borders.

Among the 2 types of networks, shrinking townships in Shanghai, Suzhou, and Jiaxing exhibit higher overall connection volumes, while those in Ningbo, Zhoushan, and Huzhou generally show lower levels of external connectivity. This may be due to topographical constraints such as the Siming Mountains and Tianmu Mountains. In the urban–rural network, shrinking townships are not only closely linked to urban subdistricts within their counties but also maintain functional connections with central urban areas. In the rural–rural network, the connections between shrinking townships and other rural areas appear more evenly distributed.**(Figure 2)**

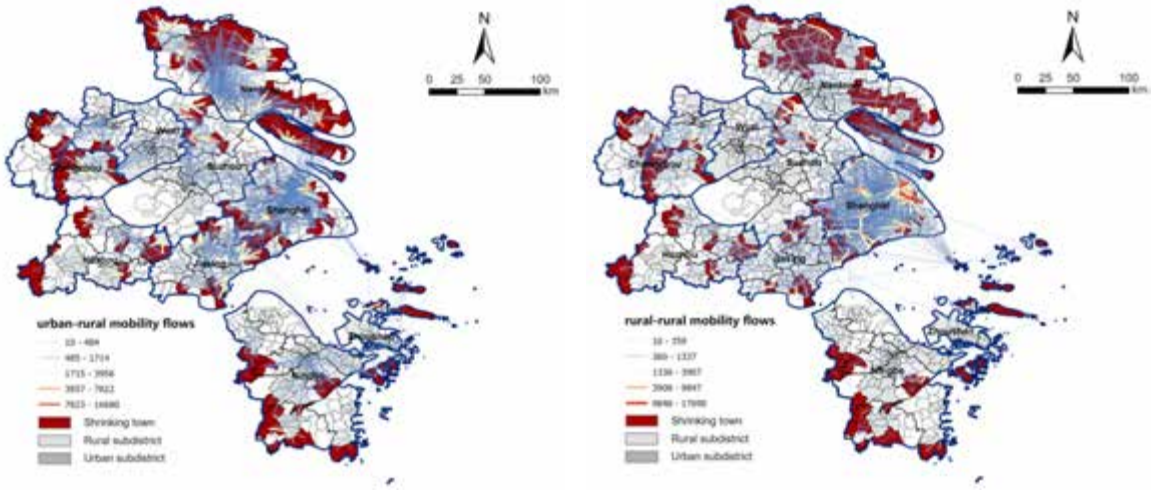

Figure 2. Characteristics of urban - rural population flow network in shrinking towns of Shanghai metropolitan area

4.3 Structural characteristics of the floating population in shrinking towns

The structural characteristics of the floating population in shrinking towns are analyzed from five key aspects: gender, age, education level, income, and consumption level. By comparing the characteristics and differences of the floating population between rural–rural and urban–rural flows, this study conducts a comparative analysis of the overall development trends and internal disparities within the shrinking towns.

4.3.1 Gender characteristics

In both rural–rural and urban–rural population mobility networks, the proportion of males is higher than that of females, which is closely related to the development characteristics of townships. As the main labor force, men are typically the primary source of household income in these areas. In the rural–rural mobility network, the gender imbalance is more pronounced, with a male-to-female ratio of approximately 1.4:1. This indicates that in township labor distribution, men are mainly engaged in labor-intensive industries such as construction and logistics, while women are more likely to migrate through marriage or work in the service sector.

In the urban–rural mobility network, the gender ratio is more balanced at 1.1:1. This suggests that urban–rural labor flows are more likely to involve couples working together or seeking nearby employment opportunities, reflecting a trend of "family-based migration." **(Figure 3)**

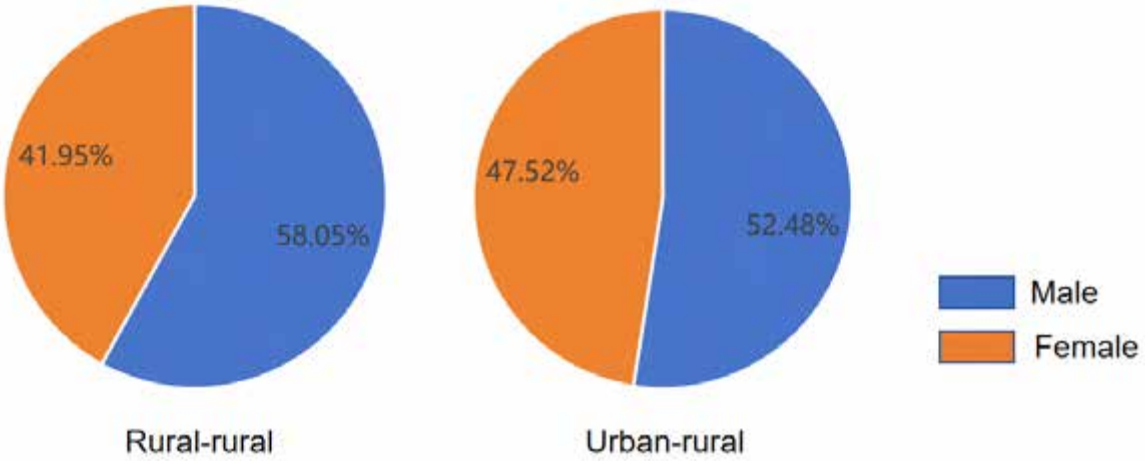

Figure 3. Gender characteristics of floating population in Shanghai metropolitan area

4.3.2 Age characteristics

Among the mobile labor population in shrinking townships, young and middle-aged individuals aged 16–35 remain the main force. In the urban–rural mobility network, this age group accounts for a higher proportion—up to 70.19%—reflecting the strong demand for young labor in urban labor-intensive industries and physically demanding jobs, which attracts more people to engage with urban areas.

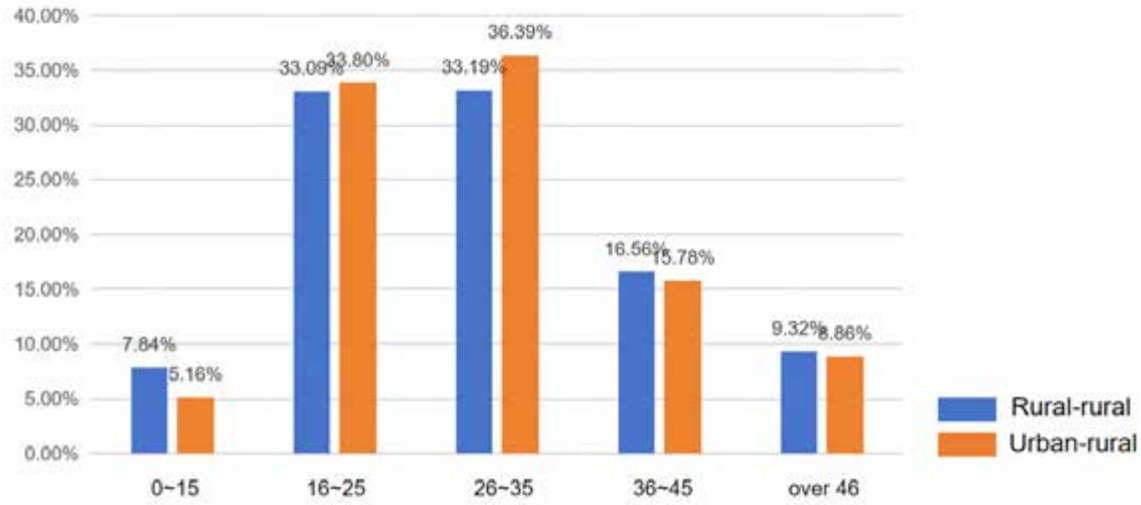

Figure 4. Age characteristics of floating population in Shanghai metropolitan area

In contrast, the proportions of elderly and youth within the mobile population are relatively low, showing a polarized distribution. In the rural–rural mobility network, the proportions of youth and middle-aged or elderly individuals are slightly higher, indicating that these groups tend to move over shorter distances between townships **(Figure 4)**.

4.3.3 Educational attainment

The education level of the mobile labor population in shrinking townships is categorized into three types: high (associate degree and above), middle (high school or vocational school), and low (junior high school and below). The educational attainment of this population shows a polarized pattern, with a predominance of individuals with higher education levels. This differs from internal rural–rural mobility and suggests that those leaving the townships tend to be more highly educated, which is often associated with skill advantages and higher income levels.

Among the urban-rural mobile population, the proportion of individuals with higher education is significantly greater. This indicates that, in addition to some medium- and low-educated laborers, there is also a group of well-educated and skilled professionals. This trend aligns with the industrial structure of the Shanghai metropolitan area, where the secondary and tertiary sectors dominate, and agriculture holds less competitive advantage-resulting in a labor force with relatively higher education levels.

In contrast, the rural-rural mobile population has a higher proportion of individuals with lower education levels. This group is likely engaged in agricultural work, basic manufacturing, or service-sector jobs that require minimal skills.**(Figure 5)**

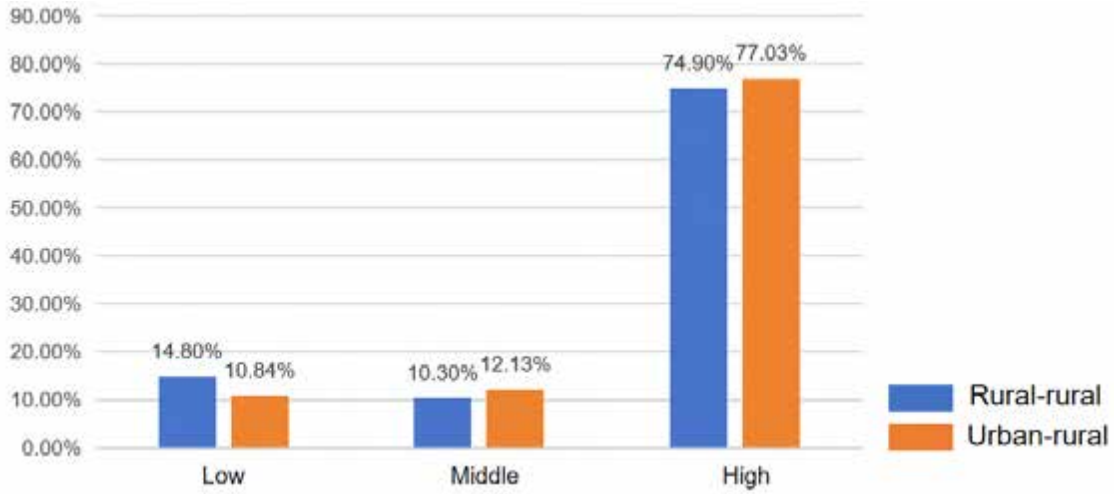

Figure 5. Educational attainment characteristics of floating population in Shanghai metropolitan area

4.3.4 Income and consumption level

In terms of income and consumption levels, both types of mobile populations-urban-rural and rural-rural-are primarily characterized by low income and low consumption, which is closely related to the overall level of development in townships. For township residents, incomes tend to be unstable and grow slowly. Consumption is generally low, focused on basic needs such as food and clothing, with relatively limited spending on housing, education, healthcare, and other areas.

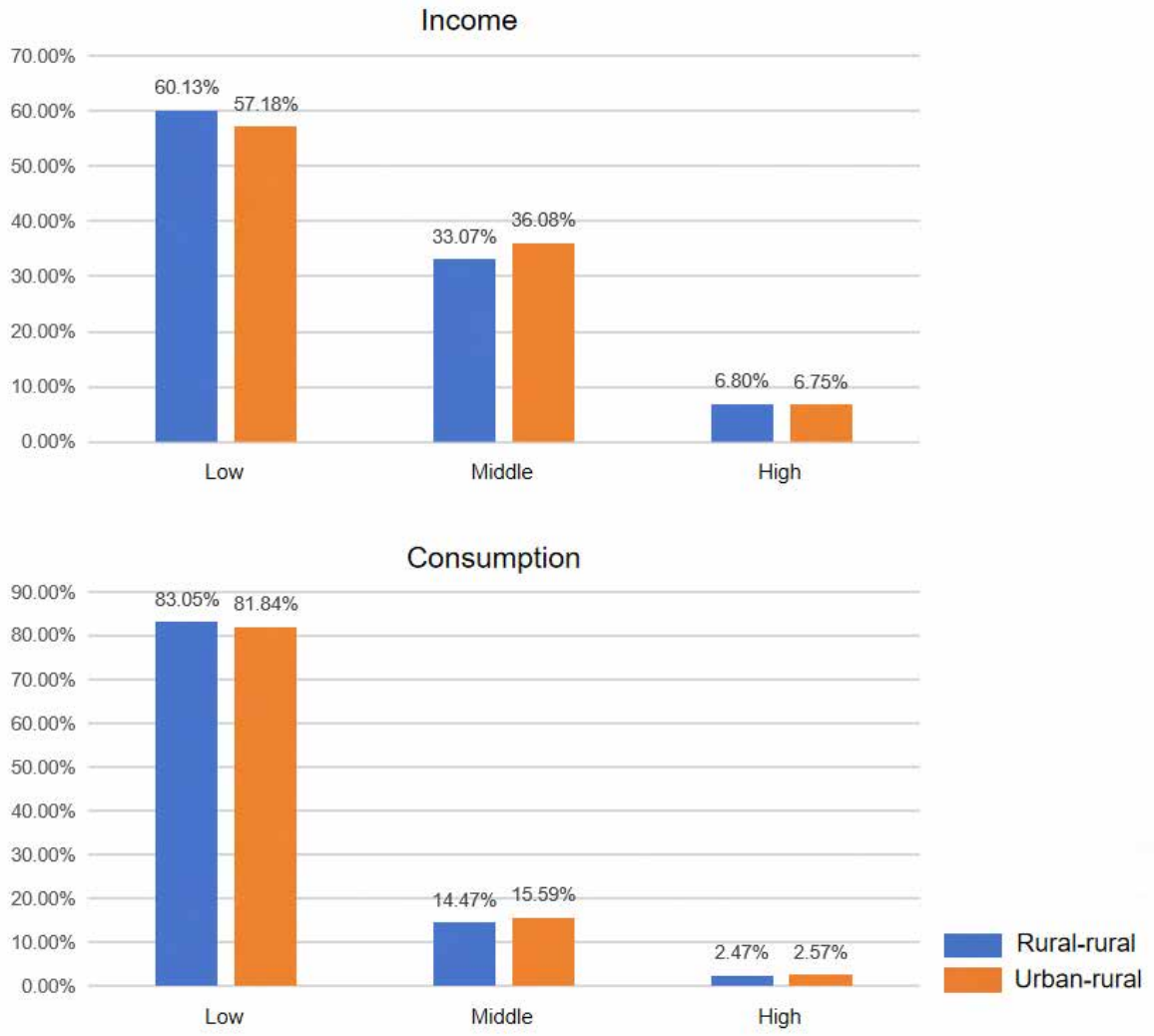

Figure6. Income and consumption characteristics of floating population in Shanghai metropolitan area

However, among the urban-rural mobile population, the proportion of individuals with medium income and consumption levels is higher than that of the rural-rural group. This suggests that urban-rural migrants may have additional sources of income, such as urban savings or investment returns. Consequently, their consumption in townships tends to be at a higher level-not only meeting basic living needs, but also including expenditures on housing improvement, children's education, and cultural or recreational activities.

Overall, for shrinking townships, both urban-rural and rural-rural mobile populations exhibit similar structural characteristics, but also reveal internal heterogeneity. This heterogeneity brings diverse development dynamics and demands, but may also lead to social conflicts and challenges, such as interest coordination among different groups and the differentiated provision of public services. Therefore, it is essential to propose targeted strategies based on these influencing factors.**(Figure 6)**

4.4 Influencing factors of floating population structure in shrinking towns

Based on the distribution, connectivity characteristics, and migrant population structure of shrinking townships in the Shanghai metropolitan area—and in light of current development conditions—the formation of their population structure is primarily influenced by a combination of economic development, geographic location, policy and institutional frameworks, and sociocultural factors.

Firstly, the impact of economic and industrial development: The Shanghai metropolitan area is dominated by the secondary and tertiary sectors, with agriculture playing a less prominent role. As a result, workers in agriculture-related industries tend to have relatively higher educational attainment. Among urban–rural migrants, there is a higher proportion of well-educated and skilled individuals who are more likely to migrate to cities or peri-urban townships to engage in jobs associated with the secondary and tertiary industries. The overall economic development level of the townships is relatively low, with unstable and slow-growing incomes, resulting in a predominantly low-income and low-consumption mobile population. Among urban-rural migrants, some individuals accumulate significant wealth through employment in cities, resulting in relatively higher income and consumption levels. In contrast, rural-rural migrants tend to have lower income and consumption levels overall.

Secondly, the influence of geography and spatial conditions: Shrinking towns are mostly located in the outer regions of the metropolitan area or in intercity border zones (such as Chongming in Shanghai and Rudong in Nantong), where the radiation effect of the central city is weak. In areas like Ningbo, Zhoushan, and Huzhou, geographical barriers such as the Siming and Tianmu Mountains limit external connectivity. Rural–rural mobility networks exhibit more cross-boundary connections due to geographic proximity, while urban–rural networks are more constrained by administrative boundaries. The convenience of transportation also influences the direction and frequency of population mobility—areas with better transportation tend to attract more inflows, whereas poorly connected regions see less movement. These spatial differences also lead to variations in the structure of the mobile population.

Thirdly, the role of policies and institutions: Shrinking towns generally maintain strong internal connections within their respective districts and counties, with administrative barriers exerting significant influence. However, cross-boundary connections are more apparent in rural–rural networks, indicating that township-level interactions are less constrained by administrative borders. Policy plays a crucial role in shaping population flows. The siphoning effect of central urban areas and associated policies can draw population toward cities or peri-urban townships. Under the hukou and land systems, rural–rural migrants are often limited by land transfer regulations, leading them to engage primarily in seasonal or temporary work. By contrast, urban–rural migrants benefit from urbanization policies, which often grant them more stable living conditions.

Lastly, sociocultural influences: Men, as the primary labor force and income earners in households, have higher mobility rates. In urban-rural migration, “family-based migration” is common, with couples working together or choosing jobs nearby, leading to a more balanced gender ratio. Women are more likely to migrate into townships through marriage and are typically employed in services or household-related work-a trend more prominent in rural–rural migration. Public services in town-s-particularly in education and healthcare-are relatively underdeveloped, which contributes to higher internal mobility among lower-educated populations. Conversely, individuals with higher education and specialized skills are more inclined to migrate to cities or peri-urban townships in search of better educational and healthcare resources.

In summary, the population structure of shrinking townships in the Shanghai metropolitan area is shaped by the combined effects of economic positioning, policy guidance, geographic conditions, and sociocultural factors. The internal heterogeneity of these townships calls for policies that can accurately identify the needs of different groups. Through industrial restructuring, optimization of public services, and institutional innovation, shrinking townships can be guided to shift from passive decline toward a model of “smart shrinkage.”

5. Conclusions

This study analyzes the characteristics of two types of mobile populations: urban-rural and rural-rural migrants, in shrinking townships within the Shanghai metropolitan area. It summarizes key structural features including gender, age, educational attainment, income, and consumption levels, and identifies their primary influencing factors. Based on the current development status of these shrinking townships, the following development recommendations are proposed:

First, to address regional development imbalances, the siphoning effect of central urban areas and industrial hollowing in peripheral townships should be mitigated through **"differentiated county-level economic positioning." For example, peripheral townships in Shanghai could focus on health and wellness services or cultural and tourism functions, while Suzhou, Wuxi, and Changzhou could strengthen support for manufacturing industries.

Second, to resolve disparities in public service provision, mechanisms for the sharing of education and healthcare resources within counties should be improved to serve rural-rural migrants, while urbanization-related support services should be enhanced for urban-rural migrants.

Third, to address mismatches between skills and industrial needs, a "dual-track training system combining education and vocational skills" should be established to align with the demands of industrial upgrading in townships.

Lastly, population management should be stratified: entrepreneurial support should be provided to highly skilled urban–rural migrants, while employment security and the formalization of informal economies should be strengthened for low-skilled rural-rural migrants.

By employing a population mobility network analysis approach, this study explores the characteristics and patterns of migrant populations in shrinking areas from spatial, mobility, and structural perspectives. The findings provide valuable insights for local governments to formulate targeted population policies, optimize resource allocation, and enhance regional development potential.

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Transformative Planning for Sustainable Futures: Bridging Global Goals and Local Actions through Adaptive Frameworks

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Abstract

Planning plays a transformative role in addressing global crises such as climate change, biodiversity loss and inequality. This study emphasizes the integration of environmental considerations into urban and regional planning, rather than prioritizing economic benefits alone. It explores how planning can bridge the gap between global sustainable development goals and local implementation, especially in rapidly urbanizing areas. Using an interdisciplinary approach including case studies, spatial analysis and participatory workshops, this study examines governance innovation, community empowerment and adaptive infrastructure. The findings suggest that transformative planning can foster collaboration, integrate sustainability into decision-making, and support equitable development. The proposed adaptive planning framework promotes flexibility, inclusiveness and systems thinking and provides guidance for addressing complex global challenges and advancing the sustainable development goals.

Key words: Transformative Planning; Adaptive Framework Sustainable Development Goals

1.Introduction

Contemporary societies face a variety of global crises, including climate change, biodiversity degradation, socioeconomic inequalities, forced migration, demographic change, and political instability. These challenges are unevenly distributed, disproportionately affecting marginalized populations, exacerbating existing inequalities, and placing increasing pressure on urban systems around the world. With the acceleration of urbanization and the increase in the frequency and intensity of climate-related shocks, traditional planning approaches are no longer adequate.

Mainstream urban and regional planning paradigms are often centered on technology and growth and are not well suited to complex socio-ecological transformations.These approaches tend to marginalize the voices of the most affected groups - migrants, women, people with disabilities, and low-income groups - while exacerbating spatial inequities through top-down interventions and a narrow view of public goods.

In this context, transformation planning has emerged as a compelling alternative. It aims to combine global sustainable development agendas such as the United Nations Sustainable Development Goals (SDGs) with locally based, socially inclusive and practical planning approaches.Change-making shifts the focus from largely technical solutions to critical shifts, democratic participation, and distributive justice. The importance of incorporating a variety of ideologies and traditional knowledge is highlighted in establishing versatile frameworks.

How are the social, cultural, and economic factors that cause disillusionment and action addressed effectively in transformative planning? This research draws on the lived experience of vulnerable features and the co-production of gathering information to create a theory and practice that are both resilient and future-oriented, fair and interactive.

2. Theoretical Framework: Adaptive and Inclusive Planning

The theoretical framework developed in this assessment incorporates findings from adaptive planning, various urbanisation, and significant management plans. According to the idea behind adaptive planning, confusion and modification are natural characteristics of social-ecological items. It prioritises scenario-based techniques, adaptive feedback loops, and continuous decision-making (Walker et al., 2004; Wilkinson, 2011)[1]. This perspective is required to address social change, population movement, and climate change issues.

Various studies also highlight the essential responsibility marginalised groups play in developing technologyudies. It examines well-known power relationships and politicians for spatial justice using deliberative democracy, feminist planning, and rights-based frameworks. In this environment, cooperation is seen as both a legal

requirement for formal cooperation and a pressing need for the inclusion of different expertise and lived experience in decision-making strategies.

In favour of context-based, historically integrated approaches, the framework draws on postcolonial urban theory and Southern epistemologies (Parnell & Pieterse, 2016) [2]. These tenets emphasise range, directness, and understanding how different common systems, civil society, and condition players interact.

This review incorporates transformative planning as a system-thinking, justice-focused training with roots in network thinking and functional resilience. It challenges democratic forms of knowledge and power based on power and prediction, in contrast to supporting co-evolutionary techniques, collective learning, and social forms of knowledge and power. While hard strength and prediction-dominated reasoning emphasise co-evolution, collective learning, and multi-agent talk. The article's factual and analytical components are built on this philosophical base.

3. Methodology

This study utilizes a multi-method qualitative research approach, combining comparative case study analysis, spatial ethnography and participatory action research. Methodologically, the study is based on the understanding that "knowledge is co-produced and contextualized",requiring planners to work with different participants in an iterative and context-sensitive manner.

3.1 Case Selection And Comparative Design

Two urban environments were purposely chosen for this study because of their very different institutional setups and planning cultures - Chengdu, China and Rotterdam, the Netherlands. This comparative design helps to explore how transformative planning manifests itself in different governance systems and socio-political environments.

3.2 Data Collection Methods

Primary data collection methods included in-depth, semi-structured interviews with planners, local government officials, community organizers, and residents (N=28), as well as participant observation during planning workshops and community meetings. We also analyzed spatial data, including GIS-based land use maps, socio-demographic overlay maps, and mobility patterns to support an understanding of context.

3.3 Participatory Planning Tools

Participatory tools include mapping exercises, digital narratives, visioning sessions, and AI-assisted scenario modeling. These tools aim to democratize the planning process by visualizing complex trade-offs and integrating non-expert knowledge (Brown & Kyttä, 2014)[3]. Special attention is paid to power dynamics in participatory settings to ensure equitable inclusion and avoid elite capture .

3.4 Analytical Framework

Analytical Framework Data analysis combined grounded theory and critical discourse analysis, allowing the recognition of repeating designs, changing habits, and core strength relationships that power planning processes and outcomes. To increase the study's resilience, this study used validation from various data sources, including conference transcripts, research notes, and natural materials.

This multi-method approach to survey preparation study uses reflexivity and social consciousness as key components. A critical analysis of transformative planning strategies ' potential and limitations in various social settings also emphasises the value of creative data production.Process event studies undergo a large change.

4. Case Studies: Inclusive Transformation in Practice

4.1 Case 1: Revitalization of Older Neighborhoods in Chengdu, China

Chengdu, one of China's oldest towns, was revitalised. Thee Chengdu Municipal Government in China put forth several neighbourhood regeneration ideas in the early 2010s to handle the state's decaying situations, including the ageing community, daily financial activities, and poor housing conditions. The process employed a phased on-site recovery system based on participatory planning guidelines, in contrast to the conventional method, which focused on large-scale death.

Residents, generally old tenants and remote-to-industrial American families, were properly engaged through participatory mechanisms like gathering workshops, participation monitoring, and discussion forums.(Liqing Yang,2023)[4].These engagements directly affected decisions regarding planning for public spaces and service enhancements.

The development of energetic group services, the improvement of discharge systems, and the addition of cranes to buildings were some of the actions taken by Chengdu, such as placing commissions and other important intermediaries between government entities and society stars. These initiatives prioritised the protection of historical and cultural recollection, social mobility, parent unity, and material development.

By combining standard assembling tools with native knowledge systems, the Chengdu work demonstrates the viability of communicative planning in a hybrid governance framework. Because the court's people actively participated in the healing process while maintaining their regional independence, the occasion strongly connects to the "right to the city" approach. The occasion demonstrates how well-designed, complex interventions can promote equity and develop long-term resilience in rapidly changing business environments.

4.2 Case 2: Climate Migration Planning in Rotterdam, the Netherlands

As a lower-lying close place, Rotterdam, the Netherlands, has excellently positioned itself as a captain in the weather version. In 2010, Rotterdam expanded its speech method to have recruitment- gentle planning in response to the growing problem of climate migration and the potential for population movement in flood-damaged regions. A multi-agency working group was established to organise work on housing, present, social inclusion, and software development.

The Design for Resilience programme, which brought up local partners, foreign companies, and professional designers, was a key component of this method. The project used interactive workshops and cutting-edge model tools to make prototypes for a nature-based problem safety equipment, assess projected action flows, and choose the best locations for affordable housing. The main objectives of the position were to lower the risk of climate gentrification and to ensure that speech investment would benefit both clear refugee groups and already-vulnerable areas.

The Rotterdam method adheres to effective governance principles and engaging route planning reasoning. It further demonstrates how powerful polycentric governance and lateral institutional collaboration are at resolving complex business problems. The event demonstrates using interesting, forward-looking practices and diverse organisational structures to reorient technology-driven resilience planning toward funds and additional resources.

In conclusion, Rotterdam and Chengdu demonstrate the potential of transformative planning by including the global sustainable development approach into socially acceptable, equitable, and flexible methods despite their firmly different political and cultural contexts. Both situations provide valuable insight into how to account for statistical shifts, geographical disparities, and social vulnerability.

Case Comparison: Chengdu vs Rotterdam

Category	Chengdu, China	Rotterdam, Netherlands
Planning Goal	Revitalize old neighborhoods and protect historical culture	Prepare for climate migration and plan for adaptation
Governance Structure	Hybrid: state + community coordination	Multi-center: multi-institutional collaboration
Target Groups	Elderly, migrant families, low-income tenants	Displaced migrants, vulnerable communities
Participatory Tools	Community mapping, workshops, forums	Scenario modeling, digital simulations
Infrastructure Focus	Accessibility upgrades, social spaces	Nature-based flood protection + housing
Equity Strategy	Right to stay, localized inclusion	Avoid climate gentrification
Planning Philosophy	Communicative, heritage-rooted	Anticipatory, resilience-focused

5. Key Findings and Discussion

According to the findings of this study, the effectiveness of move planning depends on how well it integrates many theories, how well it can join many theories, and how effective the current governance structures are. Three main components are necessary for its action: community empowerment, governance innovation, and the production of adaptive infrastructure.

5.1 Governance Innovation:

Governance Innovation: Both functional reports emphasise the value of multi-level coordination and functional skills in implementing innovative preparation. In order to promote shared role in the organising process, China's hybrid governance framework encourages power sharing between state and community organisations. In comparison, Rotterdam adopts a polycentric governance view that favors ahead- looking mix- business engagement. These governance arrangements abandon traditional prepared models and promote institutional resilience and managerial diversity by redistributing energy and broadening the range of reasonable stars, including illegal institutions and civil society organisations. (Ansell & Gash, 2008)[5].

5.2 Community Empowerment:

The independence of marginalised and resilient activities is a prerequisite for a proper plan to improve socially acceptable and appropriate results. Both occasion studies demonstrate how successful real-world creative processes are in promoting regional ownership, strengthening administrative beliefs, and creating local interventions that work better than local needs. Similar plans exist for "rebel organising" and "deep democracy," which promote fairness and support localised, frequently uncertain knowledge systems. Contrary to the frequently used "displacement" discussion of market-oriented expert maintenance, the position in Chengdu, China, illustrates how planning does prevent the "right to help" of low-income people and older occupants.

5.3 Co-creation of Adaptive Infrastructure:

A socio-technical assembly that embraces and reproduces cultural norms, power relationships, and social priorities should not be seen as only material. Technology organising is embodied in both case studies as a co-productive and incremental process that incorporates natural problems, cultural names, and investment goals. Using affordable accommodation and personality-based crisis protection methods in Rotterdam demonstrates how resilience can be redefined to encourage social inclusion. Progressive but carefully targeted therapies like

modifications to open space and convenience demonstrate Chengdu's worth of resident-centred, community-based strategies for promoting long-term industrial resilience.

These problems challenge conventional making types that promote technical rationality and economic productivity over democratic participation and distributive justice. Instead, they provide factual justification for a brand-new, democratic, and energising model that emphasises long-term socio-ecological change (Davoudi et al., 2012)[6]. Additionally, transformative planning gives the potential for conflicting corporate risk (related to age, disability, action place, or anxiety) a lot of thought. Planning is reframed as a political and ethical training in this environment, emphasising officials as agents, officers, and co-learners in social industrial change techniques, rather than being seen as technical specialists or regular managers.

6.Conclusion

In order to solve the interconnected problems of demographic transition, people action, social injustice, and climate change, transformative planning is a required model change, according to this analysis. Cities may move beyond expert treatments to more built-in and tough business prospects by incorporating versatile logics into participatory, equitable, and justice-oriented planning systems.

How diverse management structures and co-created recognition can be used to promote structural change is illustrated by the examples of Chengdu and Rotterdam. As evidenced by China's community-focused approach to revival, the urban renaissance is grounded in social capital, cultural heritage, and standard practice. In comparison, Rotterdam's predicted management model demonstrates how managers can adjust their strategies to address unplanned issues like climate-induced movement while upholding the rights and well-being of underprivileged groups.

The planner's transition from analyst to an educator, arbitrator, and embedded co-learner is at the heart of both situations. This change aligns with popular desire for more meditative, grounded, and understated planning methods. The selection of how to arrange hypotheses is broadened due to the focus on intersectionality and intellectual variety. It underscores the need for equitable urbanisation strategies that embrace a range in companies and ideas and knowledge systems.

Applying this design calls for long-term investments in the account system, official recognition of peaceful and aboriginal information, and the development of open, flexible, and reliable operational frameworks. In addition to regularly fundamental planning goals, distributing resources, and identifying options, it calls for developing geographical characteristics that help marginalised groups.

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Equity-Oriented Optimisation of Public Space Supply-Demand in Ageing Communities: A Behavioural Perspective on Elderly Residents

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Abstract
China's urban renewal reveals persistent mismatches between formal public spaces and the heterogeneous behavioural needs of an ageing population. Employing a Multi-Group Huff Three-Step Floating Catchment Area model, this study quantifies age-stratified accessibility in Shanghai's Yinhang community, where elderly residents constitute 48% of the population (n = 1,016). Incorporating subgroup-specific walking distances and visitation frequencies demonstrates that conventional single-group models overestimate accessibility in 70% of residential compounds, disproportionately disadvantaging the oldest-old. Low formal accessibility significantly predicts the emergence of informal gathering nodes, indicating a compensatory bottom-up mechanism. Integrating behavioural heterogeneity and informal spatial practices into urban planning frameworks can thus enhance equity and efficiency in public-space provision for rapidly ageing cities.

Keywords: Two-step floating catchment area; Improved model; Equity; Accessibility

1. Introduction

The global demographic transition towards an ageing society is accelerating, with the proportion of individuals aged 60 and above projected to increase from 12% in 2020 to 22% by 2050 (World Health Organisation, 2024). China exemplifies this trend, with its elderly population expected to reach 39.9% by 2050, including a significant proportion (10.5%) aged 80 and above (Textor, 2023). As ageing progresses, the mobility of elderly residents declines, leading to a growing reliance on proximate public spaces within communities for daily activities (Wang, 2009) Informal public spaces, often spontaneously formed near residential entrances, small shops, and temporary structures, serve as critical everyday venues for elderly residents due to their proximity, familiarity, and ease of access.

Despite this, existing planning studies predominantly focus on formal public spaces, such as community parks and street green spaces, and often neglect the functional significance of informal public spaces. Moreover, current planning frameworks tend to generalise elderly residents as a homogenous group, failing to acknowledge behavioural distinctions across age cohorts. This homogenisation results in a spatial mismatch between standardised public space configurations and the differentiated needs of elderly residents, particularly the oldest-old. This leads to the underutilisation of formal spaces and the growing reliance on informal alternatives.

The Two-Step Floating Catchment Area (2SFCA) method has become a prominent tool for measuring public space accessibility, particularly in health care, green infrastructure, and elderly care (Tao and Cheng, 2016). However, conventional 2SFCA models assume uniform behavioural characteristics, ignoring variations in walking range, activity frequency, and spatial preference across elderly subgroups. This study introduces an enhanced model (Song, Kong and Cheng, 2024), the Multi-Group Huff Three-Step Floating Catchment Area (MGH3SFCA), incorporating age-specific behavioural parameters to overcome the limitations of conventional accessibility measurements. The objectives are threefold:
(1) Quantify behavioural differences in space usage across elderly age groups;
(2) Assess the impact of age-differentiated behaviours on accessibility measurements;

(3) Examine how accessibility deficits contribute to the emergence of informal public spaces.

2. Materials and Methods

2.1 Model Framework

The proposed MGH3SFCA model introduces three principal improvements to the conventional two-step floating catchment area (2SFCA) method. First, it incorporates a Gaussian distance-decay function (Liu, Chen, Xiang et al., 2024) to reflect the declining likelihood of accessing a facility as travel distance increases. Second, it employs the Huff probability model (Luo, 2014) to account for competitive interactions among alternative public spaces. Third, the model integrates age-specific behavioural parameters, including activity frequency and walking distance, and applies differentiated search radii according to the spatial scale of public space supply (Zhang et al., 2019). Larger-scale facilities are assumed to serve multiple residential clusters, whereas smaller spaces primarily cater to the immediate vicinity. The model operates in the following three steps.

(1) Estimating the Probability of Visiting Public Spaces

This step defines public space j and residential compound i as supply and demand nodes. Their geographic centroids are extracted for spatial calculations. The probability that residents in unit i will visit public space j is denoted as $\mathrm{Huff_{ij}}\mathrm{Huff_{ij}}$, calculated using Equation (1). Specifically, S_jS_j denotes the area of public space j, $d_{ij}d_{ij}$ represents the network distance between units i and j, and $G\left(d_{ij},d_0\right)G\left(d_{ij},d_0\right)$corresponds to the Gaussian distance-decay function defined in Equation (2).

$$\mathrm{Huff_{ij}} = \frac{S_j G\left(d_{ij},d_0\right)}{\sum_{k\in\{d_{kj}\le d_0\}} S_k\, G\left(d_{kj},d_0\right)} \quad (1)$$

$$G\left(d_{ij},d_0\right) = \frac{e^{-\frac{1}{2}\times\left(\frac{d_{ij}}{d_0}\right)^2} - e^{-\frac{1}{2}}}{1-e^{-\frac{1}{2}}} \quad \left(d_{ij}<d_0\right) \quad (2)$$

(2) Calculating the Supply-to-Demand Ratios

A first-step search is performed around each public space j within a predefined distance threshold $d_{0*}d_{0*}$. The supply-to-demand ratio R_jR_j is calculated using Equation (3), representing the relationship between the facility's supply capacity and the total weighted demand from elderly residents within its catchment area. Specifically, P_kP_k indicates the older adult population of a given age group in residential compound k, $f_{kj}f_{kj}$ reflects the frequency coefficient for visits from k to j, and $\mathrm{Huff_{kj}}\mathrm{Huff_{kj}}$ denotes the visit probability. These parameters jointly determine the composite demand weight for space j.

$$R_j = \frac{S_j}{\sum_{k\in\{d_{kj}\le d_{0*}\}} \mathrm{Huff_{kj}}\, f_{kj} P_k} \quad (3)$$

(3) Assessing Accessibility by Age Group

A second-step search is conducted around each residential compound i within the same distance threshold d_0d_0. Using the calculated supply-to-demand ratio, the age-specific accessibility (A_iA_i) of elderly residents in unit i to public space j is determined via Equation (4).To capture behavioural heterogeneity, the older adults population P_kP_k in each residential compound is divided into three subgroups: young-old $P_{kM1}P_{kM1}$, middle-old $P_{kM2}P_{kM2}$, and oldest-old $P_{kM3}P_{kM3}$. Group-specific accessibility scores are first computed and then aggregated into a composite multi-group accessibility index ($A_{i(multi-group)}A_{i(multi-group)}$) for each residential compound through weighted integration, as outlined in Equation (5).

$$A_i = \sum_{j \in \{d_{ij} \le d_0\}} Huff_{ij}\, G(d_{ij}, d_0) R_j \quad (4)$$

$$A_{i(multi-group)} = \frac{\sum_{M_1}^{M_n} A_{iM_n} f_{kj(Mn)} P_{kM_n}}{\sum_{M_1}^{M_n} f_{kj(Mn)} P_{kM_n}} \quad (5)$$

2.2 Study Area

Yinhang, located in the northeastern sector of Shanghai's Yangpu District, is the study site. Spanning 7.98 km², the community hosts approximately 194,100 residents, with nearly 47.7% of the population aged 60 or above. Among them, the proportion of elderly residents in poor health reaches 12.6%, compared to the municipal average of 9.7%; similarly, the share of functionally dependent elderly (i.e., unable to care for themselves) exceeds 4.7%, significantly higher than the Shanghai average of 3.2% (National Bureau of Statistics of China, 2021). These figures indicate that Yinhang exhibits a higher-than-average burden of ageing-related health limitations. The community comprises 66 residential compounds and a diverse public space system, including formally planned and spontaneously formed informal public spaces (Figure 1).

Figure 1. Location of Yinhang Community in Shanghai

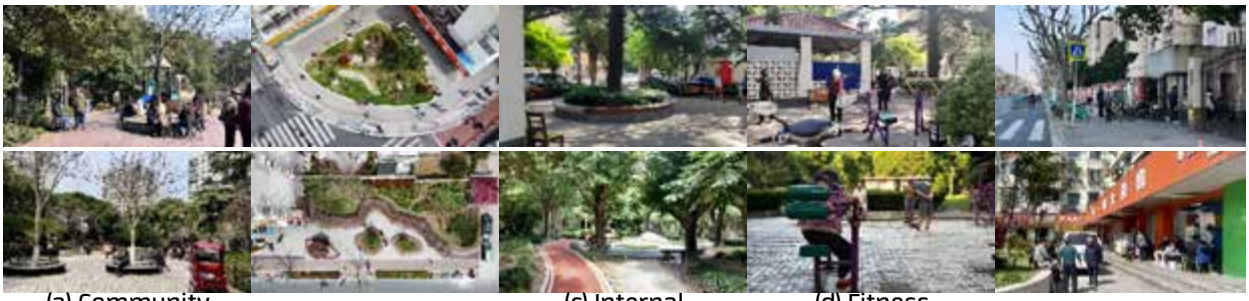
2.3 Data Collection and Processing

(1) Elderly Residents' Demand

Residential population data directly reflect the spatial distribution and quantity of potential public space users, while age structure provides a critical demographic basis for evaluating differentiated deman (Wang, Wu, Gao et al., 2021). The smallest unit of analysis is the "residential compound" ('xiaoqu'), a prevalent housing type in Chinese cities. Population data were derived from the Seventh National Population Census of China (2020–2021) and were classified into three age cohorts: young-old (60–69 years), middle-old (70–79 years), and oldest-old (80 years and above). Walking distances were defined by observed gait speeds: 5-, 10-, and 15-minute walks equate to 180–300 m, 360–600 m, and 540–900 m, respectively. These demographic layers were integrated with spatial data using ArcGIS to support the demand-side component of the model.

(2) Public Space Supply

Public spaces within a 500-m radius of the Yinhang community were identified using a combined approach that included point-of-interest (POI) annotation from online maps and on-site field investigations conducted in March 2024. A total of 95 formal public spaces were delineated and classified into four types according to their functional role and designated service radius: community parks (J1), street green spaces (J2), internal parks (J3), and fitness stations (J4). The assignment of service radii, ranging from 300 to 1000 meters, followed the guidelines outlined in China's Urban Green Space Planning Standards (GB/T 51346–2019). All spatial locations were geocoded in ArcGIS to construct the supply-side spatial database. Additionally, 24 informal public spaces were identified through a structured, week-long behavioural observation period. These locations exhibited consistent patterns of elderly gathering and were equipped with basic amenities such as benches, shade structures, or handrails. Based on these characteristics, they were defined as Spontaneous spaces (J5) and incorporated into the model's supply-side dataset. (Figure 2)



(a) Community Park (b) Street Green Space (c) Internal Park (d) Fitness Point (e) Spontaneous Space

Figure 2. Examples of Public Space Types (J1–J5

(3) Behavioural Data

A structured questionnaire survey targeting residents aged 60 and above was conducted in Yinhang community from March to July 2024. The survey was administered during clear daytime periods (08:00–18:00) across all days of the week to account for variability in behavioural patterns. The questionnaire comprised two parts: personal demographics (age, health status, and mobility condition) and public space usage behaviours (frequency, duration, type of activity, and mode of travel). Only respondents who reported walking directly from home to a public space were included in the modelling. Actual walking distances were computed using the Origin-Destination (OD) matrix function in ArcGIS. The resulting dataset informed the behavioural weights used in the MGH3SFCA model, particularly in estimating frequency coefficients and mobility thresholds across age groups.

3. Results

3.1 Age-Specific Differences in Behavioural Activities

A total of 1,525 questionnaires were distributed, yielding 1,405 valid responses. Walking emerged as the dominant mode of travel among elderly residents (84.9%), followed by non-motorised vehicles (11.5%) and public buses (0.9%). Among respondents, 87.6% reported walking directly from home to their activity destinations, while only 8.3% indicated detouring through other activities. The final sample included 1,049 elderly residents who reported walking directly to a public space. (Table 1)

Table 1. Age Distribution of Elderly Residents by Public Space Type

	Young-old	Middle-old	Oldest-old	Total
Community Park (J1)	136 (37%)	172 (47%)	57 (16%)	365
Street Green Space (J2)	129 (46%)	94 (34%)	56 (20%)	279
Internal Park (J3)	81 (43%)	71 (38%)	37 (20%)	189
Fitness Point (J4)	44 (53%)	20 (24%)	19 (23%)	83
Spontaneous Space (J5)	54 (41%)	52 (39%)	27 (20%)	133
Total	444	409	196	1049

Note: Percentages in parentheses represent the proportion of each age group within the corresponding public space type.

Chi-square tests (Table 2) revealed significant age-related differences in health status and mobility. The proportion of individuals with chronic illness increased from 18% in the young-old group to 36% in the oldest-old group ($p < 0.01$). Meanwhile, the share of residents with unimpaired walking ability dropped from 91% to 53% across the same age ($p < 0.01$). These age-related health and mobility declines significantly influence public space use patterns and walking range.

Table 2. Chi-Square Test Results of Behavioural Characteristics by Age Group

	Young-old	Middle-old	Oldest-old	Total	χ^2	p
Health status						
With chronic disease	18%	33%	36%	27%	35.928	0.000**
Without chronic disease	82%	67%	64%	73%		
Mobility status						
Normal walking	91%	78%	53%	79%	143.622	0.000**
Slow walking	9%	20%	33%	17%		
Cane assistance	1%	1%	12%	3%		
Wheelchair assistance	0%	1%	3%	1%		
Walking distance (m)						
< 213.39	24%	27%	19%	24%	20.334	0.002**
213.39–322.76	20%	28%	29%	25%		
322.76–620.43	26%	25%	27%	26%		
> 620.43	30%	20%	26%	25%		
Visit frequency						
Occasionally	3%	2%	1%	2%	20.435	0.025*
Once a week	2%	1%	2%	2%		
Multiple times a week	23%	15%	15%	18%		
Once a day	48%	52%	60%	52%		
Twice a day	20%	25%	19%	22%		
Three times a day	4%	4%	3%	4%		
Activity intensity						
Low	50%	44%	58%	49%	20.64	0.008**
Medium	48%	54%	41%	49%		
High	2%	1%	1%	2%		
Activity status						
Group activity	42%	41%	45%	42%	0.838	0.658
Independent interaction	58%	59%	55%	58%		
Single activity duration (h)						

< 0.33	21%	24%	21%	22%	3.13	0.792
0.33–0.50	12%	11%	9%	11%		
0.50–0.67	23%	23%	22%	23%		
> 0.67	45%	43%	48%	45%		
Daily activity duration (h)						
< 1.00	45%	43%	48%	45%	3.13	0.792
1.00–1.50	12%	11%	9%	11%		
1.50–2.00	23%	23%	22%	23%		
> 2.00	21%	24%	21%	22%		

Note: * p < 0.05; ** p < 0.01. Significant results are marked accordingly in the respective rows.

(1) Age Differences in Walking Distances

Figures 3 and 4 present the distribution of walking distances and visit frequencies across various types of public spaces, stratified by the three age groups of the elderly. The young-old group exhibits the strongest walking ability, with a broad range of spatial activity across all space types. In particular, the median walking distances to community parks (J1) and street green spaces (J2) range from 400 to 600 metres, with some individuals walking more than 1,000 metres, indicating extensive mobility. In contrast, the middle-old and oldest-old groups show a progressive decline in walking ability. Their median walking distances are generally shorter, especially in internal parks (J3) and fitness stations (J4), where most visits occur within a 300-metre radius. This reduction is most pronounced among the oldest-old, whose median distances fall below 300 metres across all space types, reflecting a high dependence on nearby spaces. Notably, in spontaneous public spaces (J5), the differences among age groups are much smaller. This suggests that informal public spaces are significant for the oldest-old, as their proximity effectively accommodates the mobility limitations of this subgroup.

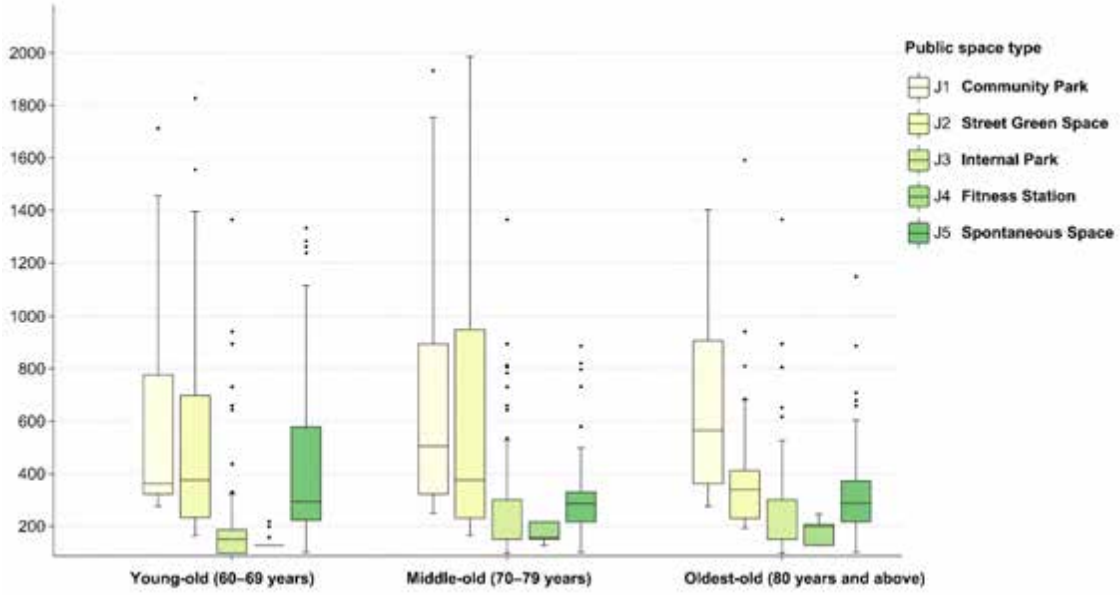


Figure 3. Walking Distance to Public Spaces by Age Group

(2) Age Differences in Visiting Frequency

Regarding visit frequency, community parks (J1) and street green spaces (J2) exhibit relatively stable usage across all age groups, with an average of once per day. Internal parks (J3) and fitness stations (J4) exhibit a moderate decline in visitation among the middle-old and oldest-old groups, possibly due to smaller spatial scale or higher use thresholds. In contrast, spontaneous public spaces (J5) maintain consistently high visitation frequencies

across all age groups. This trend is particularly pronounced among the oldest-old, with a median visit frequency of one to two times per day, and some individuals reporting up to three visits per day. These findings highlight residents' substantial reliance on informal public spaces, particularly among those with mobility constraints. In summary, walking distance and visit frequency demonstrate age-related stratification and marked differences across space types. Formal public spaces (J1–J4) are more likely to attract the young-old for medium- to long-distance, low-frequency use. In contrast, informal public spaces (J5) support high-frequency, short-distance daily activities among the oldest-old due to their proximity, flexibility, and accessibility.

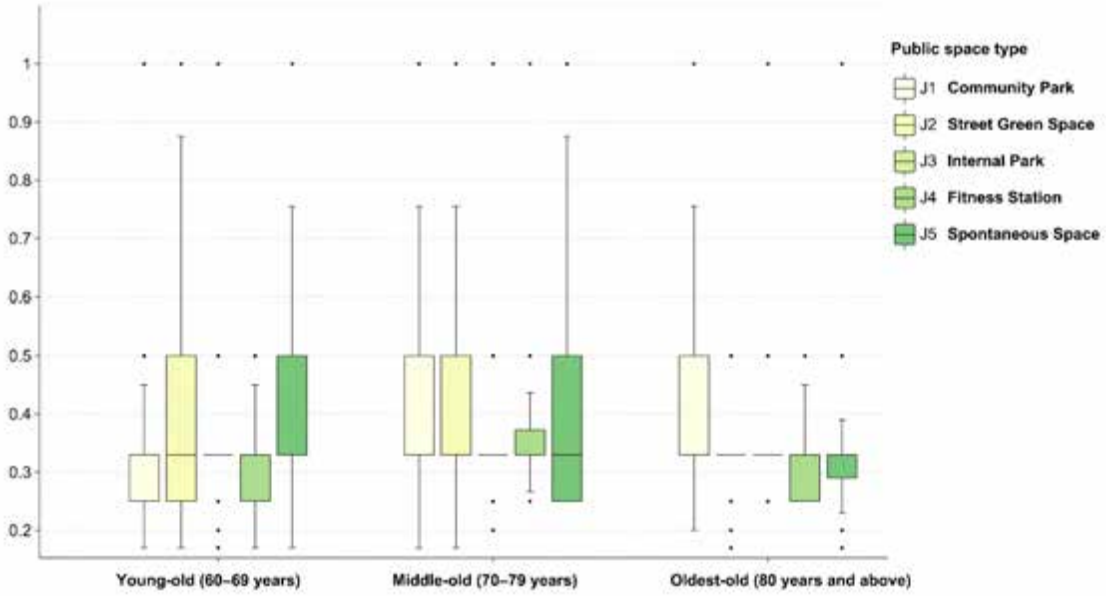
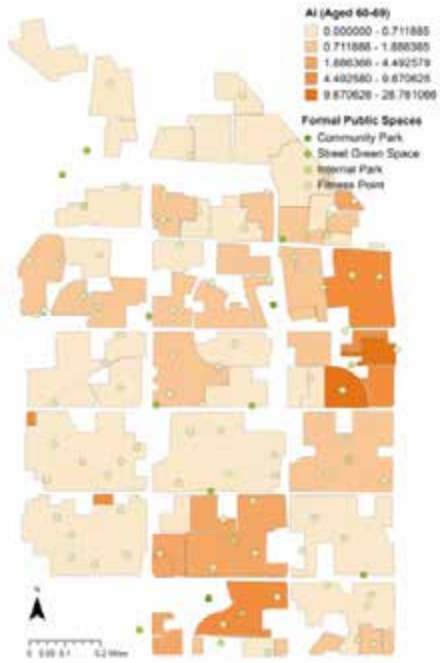


Figure 4. Visit Frequency to Public Space Types by Age Group

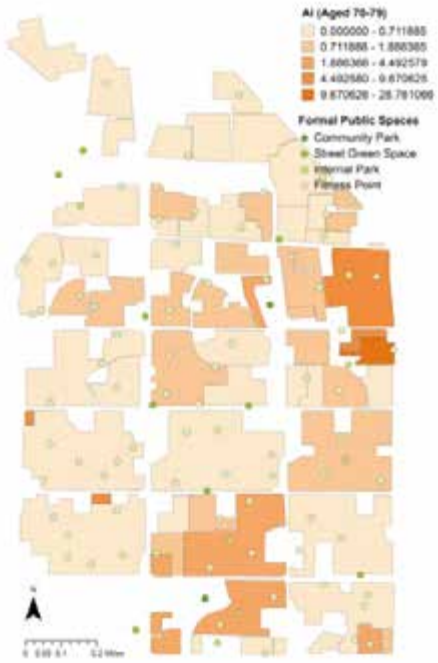
Note: Visit frequency codes: 0.17 = occasional; 0.20 = weekly; 0.25 = several times/week; 0.33 = daily; 0.50 = twice/day; 1.00 = three times/day.

3.2 Accessibility Results of Single vs Multi-Group Models

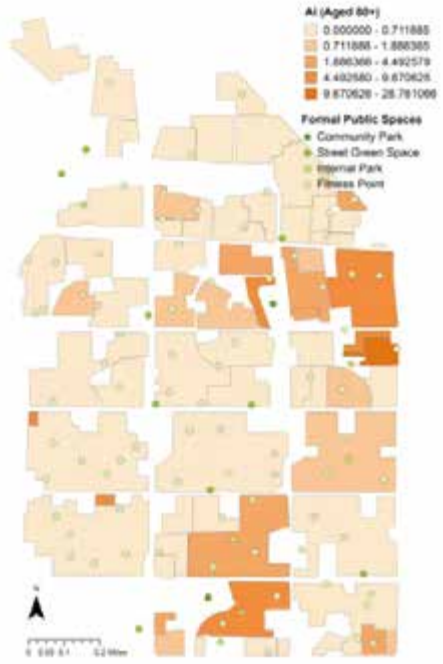
Based on MGH3SFCA model outputs, public space accessibility was calculated for each age group across residential compounds. Values were categorised into five levels using ArcGIS natural breaks: very high, high, medium, low, and very low (Figure 5a–5c). Results show that the single-group model consistently overestimates accessibility compared to the age-specific model. Around 70% of residential compounds exhibited overestimation, with an average margin of 15.9% (Figure 5d). This disparity is most evident in units rated 'very high' by conventional models, where the oldest-old residents still face limited effective access. The findings highlight the importance of incorporating intra-group behavioural variation in accessibility planning.



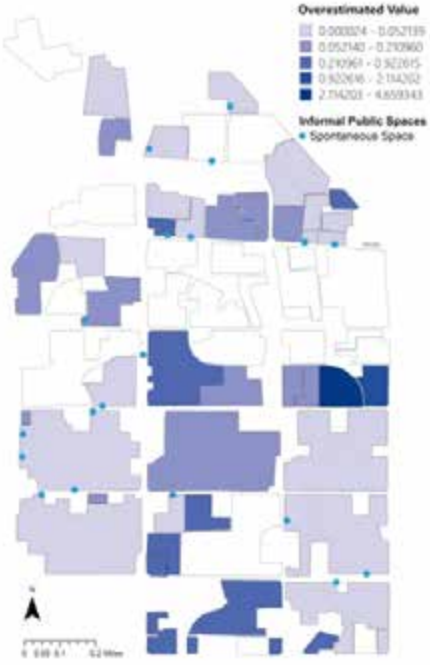
(a) Accessibility for Young-Old Residents



(b) Accessibility for Middle-Old Residents



(c) Accessibility for Oldest-Old Residents



(d) Spatial Distribution of Accessibility Overestimation

Figure 5. Multi-Group Accessibility Modelling Results

3.3 Correlation Analysis of Accessibility and Informal Public Space Distribution

In the Yinhang community, informal public spaces formed through the spontaneous gathering of elderly residents are predominantly located near the entrances of residential compounds, which have zero or low comprehensive accessibility, particularly in communities with a high proportion of residents aged 80 and above. For example, although Guohe No. 2 Community and Shiguang No. 2 Community are relatively limited in spatial scale, they effectively accommodate the needs of elderly residents for nearby social interaction and daily leisure activities. Moreover, even in communities with relatively well-organized formal public spaces, informal gatherings are often observed beneath the eaves of street-facing shops, such as those located at Lane 590 and Lane 296 on Yinhang Road. These spatial patterns indicate that elderly residents, particularly those in the oldest-old group, tend to choose locations with high pedestrian traffic and open visibility, such as traffic intersections or commercial frontages, to engage in social interaction activities, including conversation and chess. This behavioural preference reflects a conscious strategy to increase the likelihood of informal social encounters and to mitigate the sense of isolation often experienced in daily routines.

To further quantify the relationship between comprehensive accessibility and the distribution of informal public spaces, this study employed a binary logistic regression model to examine the correlation between accessibility levels and the presence or absence of informal public spaces, using residential compounds as the unit of analysis. Additionally, a negative binomial regression model was employed to examine the impact of accessibility on the number of informal public spaces. The results indicate a significant negative association between the comprehensive accessibility of elderly residents and the emergence of informal public spaces (Table 3). Specifically, for every 0.1 unit decrease in comprehensive accessibility, the probability of informal public space formation increases by approximately 24.6% (odds ratio = 0.059, p = 0.011), while the number of such spaces increases by roughly 20.4% (incidence rate ratio = 0.102, p = 0.011). These findings suggest that when formal public space provision fails to accommodate the behavioural capabilities of senior residents, they are more likely to create alternative spaces within the community spontaneously. This pattern reflects a spatial equity feedback mechanism, whereby informal public space formation emerges as a compensatory response to deficiencies in formal accessibility.

Table 3. Influence of Accessibility on Informal Public Space Formation

	Model 1: Presence (0/1)	Model 2: Count (Number)
Regression method	Logistic regression	Negative binomial regression
Exp(B)	0.059	0.102
95% CI	[0.007, 0.527]	[0.018, 0.595]
p-value	0.011*	0.011*
Sample size (n)	66	66
Model fit	McFadden R^2 = 0.316	Pearson χ^2/df = 0.570

Note: * p<0.05; ** p<0.01.Model 1 estimates the probability of informal public space presence; Model 2 estimates its quantity.

4. Discussion

4.1 Deficiencies in Conventional Accessibility Planning

With the accelerating ageing process, differences between younger-old and oldest-old residents can surpass those between elderly and non-elderly populations (Neugarten, 1974). Nevertheless, current urban planning often treats older adults as a single group, using average walking capacity to define service radii for public spaces, which fails to address the age-specific needs of this population. In Shanghai, the Beautiful Homes Three-Year Action Plan (2021–2023) was implemented as part of the broader 15-Minute Community Life Circle initiative, aiming to improve community environments through micro-scale renewal (Liu, Qian, Huang and Zhou, 2020). However, many newly built formal public spaces remain underutilised, while informal areas such as residential entrances and street-facing shopfronts attract frequent use by elderly residents.

Empirical findings further demonstrate that the walking distance of the oldest-old group is significantly shorter than that of the young-old. However, current planning practices overlook this disparity, resulting in a systematic overestimation of formal public space accessibility for the senior population. Moreover, formal public spaces often exhibit homogenisation in scale, spatial layout, and functional design, with limited adaptation to the specific needs of senior residents, such as provisions for short-distance resting or enhanced visual safety (Sun et al., 2020). This misalignment between spatial supply and actual behavioural demand drives elderly residents to frequent informal public spaces near residential entrances and street-facing shops. Variations in accessibility among different housing units primarily reflect disparities in the spatial provision of housing. In contrast, disparities among elderly age groups within the same unit reveal deeper issues related to equity in the allocation of public space.

4.2 Informal Public Space as a Behavioural Adaptation

The theory of everyday urbanism emphasises that the production of urban space is shaped not only by top-down planning and design but also by residents' routine behaviours and spatial practices. Informal public spaces emerge spontaneously through micro-scale actions by elderly residents, such as placing chairs or installing pergolas. These spatial practices complement formal spaces and reflect overlooked equity demands of elderly residents (Torres and Cao, 2019). The formation and spatial distribution of informal public spaces exhibit apparent regularities, with concentrations typically observed in highly accessible locations such as entrances of residential compounds and areas beneath the eaves of street-level shops. This spatial pattern is shaped by the combined influence of physiological limitations and psychological needs among elderly residents. Proximity to residential buildings ensures that these locations remain reachable even for individuals with reduced mobility. At the same time, such areas often offer open sightlines and steady pedestrian flows, which enhance the perceived safety of outdoor activities and provide opportunities for social interaction and incidental encounters with acquaintances, fulfilling essential psychological and social needs. In contrast, although physically open, marginal spaces such as street corners, the peripheries of enclosed green areas, or the backs of public facilities, are rarely used by elderly residents. These areas lack sufficient accessibility, visibility, and pedestrian presence, and are often devoid of environmental familiarity. These findings suggest that the formation and utilisation of informal public spaces are not solely determined by physical attributes, but reflect active spatial choices made by elderly individuals within the constraints of their physical capabilities. Such preferences underscore a perceived demand for environments that offer both safety and opportunities for social interaction.

4.3 Strategies for Integrating Informal Public Spaces into Planning Frameworks

Although formal public spaces can theoretically achieve optimal spatial allocation through rational planning and design, their implementation is often constrained by limited land availability and high construction costs. These constraints hinder formal spaces' ability to fully meet the diverse activity needs of senior residents, particularly in communities with high population ageing. In this context, informal public spaces serve an essential compensatory role due to their flexibility, convenience, and proximity to residential areas. With appropriate guidance and moderate planning intervention, these spontaneously formed spaces can be gradually integrated into the formal public space system. Such integration can effectively address the limitations of formal planning and enhance the overall equity and responsiveness of urban public space provision (Sikorska et al., 2020).

The strategic incorporation of small-scale public spaces at spontaneous gathering sites can effectively respond to the diverse needs of elderly residents in ageing communities where spatial resources are limited. First, modest physical improvements at residential entrances and exits, including surface paving, ground levelling, and installing seating, shading structures, and handrails, can transform these locations into formally accessible areas for rest and social interaction. Second, residual spaces beneath shop eaves can be utilised by providing simple benches or small activity platforms, thereby encouraging elderly residents to gather in a safe and orderly manner within the street environment. When immediate physical upgrades are not feasible, community-led services such as regular health consultations, social activities, or chess games can activate these spaces and incorporate them into routine community management. Through the coordinated advancement of physical

micro-renewal and service provision, informal public spaces can be gradually integrated into the broader public space system. This process not only addresses the differentiated needs of elderly residents across age groups but also improves spatial utilisation, promotes resident engagement, and enhances the overall quality of life in ageing communities.

5. Conclusion

This study highlights the importance of behavioural heterogeneity in assessing public space accessibility for elderly residents. The MGH3SFCA model, which integrates age-specific walking distances and activity frequencies, reveals that conventional approaches substantially overestimate accessibility. The spatial emergence of informal public spaces in low-accessibility areas further reflects bottom-up compensatory behaviours driven by unmet needs. Two policy implications can be drawn. First, accessibility models should differentiate between elderly subgroups to avoid systemic misestimations. Second, informal public spaces should be considered essential for ageing-supportive urban systems. Behaviour-sensitive modelling and inclusive spatial design collectively provide promising strategies for achieving more equitable and effective public space provision in ageing societies.

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Inclusive Urban Planning Based on Time-Use Analysis: A Markov Chain Approach Across Family Life Cycles

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Abstract
As China's urbanization shifts from rapid expansion to quality-oriented development, understanding the dynamics of time use across different stages of the family life cycle is essential for designing more inclusive and targeted urban planning strategies. Time, as a key indicator of quality of life, is profoundly influenced by family structure, social roles, and the living environment. However, existing studies on time pressure and behavioral dynamics lack a systematic life-cycle perspective. Drawing on the 2018 Shanghai time-use survey, this study identifies weekday activity structures and high time-pressure periods across typical life stages and applies a Markov chain model to construct activity-state transition matrices. Through this, we uncover critical spatiotemporal stress points at each stage and propose planning strategies for inclusive cities. Key findings include: (1) Time-use patterns evolve from a "work-oriented" structure to a more complex "care–work–leisure" interplay as families progress through life stages, with the childcare phase showing the most acute time pressure. (2) Entropy-based fragmentation metrics highlight morning and evening peaks as the most stressful periods. (3) Markov models reveal frequent activity transitions within these pressure zones: work-centric paths dominate during the pre-nesting phase; dual cores of employment and family responsibilities emerge during the nesting phase; childcare years exhibit the most complex and fragmented chains; post-child phases shift toward work and leisure; and the dissolution phase focuses on health care and rest. (4) Based on these insights, we propose differentiated spatial strategies aligned with family life cycles, including nighttime leisure facilities, parenting support spaces, and age-friendly infrastructure. This research contributes to a deeper understanding of dynamic time-space behaviors and offers data-driven insights for building age-inclusive and socially equitable cities.

Keywords: Time use; Family life cycle; Markov chain; Time pressure; Inclusive urban planning

0. Introduction

Identifying differences in residents' time use across various life stages is crucial for advancing inclusive urban planning. Time is not only a constraint on daily activity participation but also a central indicator of quality of life and lifestyle (Jiao & Wang, 2021). With the advancement of activity-based approaches, spatiotemporal behavior research has deepened, and concepts such as time-space prisms and potential path areas have provided a theoretical foundation for linking time use with life quality.

The family life cycle offers a critical perspective for understanding the evolving stages of family development, encompassing processes such as marriage, childbearing, child-rearing, children leaving home, and elder care (Wang & Liu, 2024). In recent years, China's family structures have become increasingly diverse, with a rise in aging populations, nuclear families, and empty-nest households, accompanied by a continuous restructuring of internal family roles. In Shanghai, for instance, people aged 60 and above make up 23.4% of the population, and grandparents are responsible for 31.7% of childcare for children aged 0–3 (Ma et al., 2023), highlighting the prevalence of "active aging." At the same time, young adults face challenges such as flexible employment and economic dependence on parents(Wang, 2024), with intensified workloads and parenting responsibilities leading to time poverty and declining life satisfaction (Jiao et al., 2023).

While prior research has addressed the impacts of aging, family transformation, and employment pressures on well-being, systematic time-use studies from a family life cycle perspective remain limited. This gap constrains our understanding of the mechanisms behind quality of life and hinders the formulation of evidence-based urban policies.

This study draws on the 2018 Shanghai residents' time-use survey to classify five stages of the family life cycle and extract twelve major categories of daily activities. It summarizes time-use patterns across life stages, identifies high time-pressure periods using fragmentation entropy, and applies a Markov chain model to extract

typical behavior transition pathways. By uncovering the distinctive time-pressure characteristics and behavioral mechanisms of each life stage, the study offers targeted recommendations for inclusive urban planning.

1. Literature Review

The family life cycle is a theoretical concept that describes the developmental stages a family undergoes from formation to dissolution. First introduced by sociologists Sorokin, Zimmermann, and Galpin in 1931, the framework outlines key life events such as marriage, childbirth, children leaving home, and the death of family members (Sorokin et al., 1931). Building on this foundation, Paul C. Glick (1947) proposed a more systematic classification, dividing the family life cycle into the formation, expansion, stability, contraction, empty-nest, and dissolution stages—each corresponding to critical family milestones like marriage, child-rearing, children becoming independent, and spousal loss (Glick, 1955). This framework has proven valuable for understanding evolving family needs and behavioral shifts across stages, and it has been widely applied in sociology, economics, demography, and urban planning.

In recent years, scholars have localized and refined the family life cycle theory to better reflect China's social realities. For example, Guo Jingjing and Chai Yanwei (2014) examined suburban residents' lifestyles and leisure preferences, emphasizing how leisure activity types and time allocation vary by life stage. Du Xiaojuan et al. (2017) further subdivided the "full nest" phase into distinct stages such as infancy, preschool, school age, and adult children, offering a more nuanced view of parenting-related transitions, particularly in consumption preferences and shopping behavior. Mao Yaqian and Li Jiuquan (2020) focused on the elderly and multigenerational households, identifying diverse living arrangements such as empty-nest single living and co-residence with children. Their work expanded the applicability of the life cycle framework by incorporating the perspective of intergenerational family support.

The family life cycle not only shapes individual behavior but also deeply influences urban spatial practices. Research shows that life stages significantly affect housing decisions (Pan, 2024), spatial settlement preferences among migrant populations (Yang et al., 2024), and willingness to participate in the renewal of aging neighborhoods (Xiao et al., 2022). Thus, detailed segmentation of the life cycle offers critical insights into understanding modern household spatial needs, aligning urban services, and informing policy interventions. In particular, it serves as a guiding framework for inclusive urban planning and housing policy in the face of population aging and increasing multigenerational living arrangements.

Time Use Surveys (TUS) serve as high-resolution tools for recording individuals' daily activities and time allocation. Now conducted in over 100 countries worldwide, TUS data are widely applied across disciplines such as sociology, economics, gender studies, and the built environment (Osman & Ouf, 2021). A time use pattern refers to the structure of activity types, sequences, and time distribution over a given period, encompassing key life dimensions such as work, domestic chores, leisure, and commuting (Song et al., 2023). These behavioral patterns involve both static attributes—such as activity type, location, and social role—and dynamic temporal sequences.

In recent years, growing attention has been paid to the relationship between individual time use and subjective well-being. For instance, Zhao Hong (2023), using China's 2017 national TUS data, estimated that the "optimal work duration" for employees is 6.25 hours per day. Similarly, Jiao Jian et al. (2023) introduced a "time poverty" threshold, defining it as 60% of the median free time, and suggested that workers in Shanghai should have at least 2.72 hours of discretionary time daily.

Amid the twin challenges of population aging and digitalization, researchers have also focused on time-use patterns among specific groups. These include studies on older adults' travel time (Sen et al., 2022), sedentary behavior (Perchoux et al., 2023), and the use of leisure and screen time (Sturm & Cohen, 2019). Such research is increasingly important for identifying disparities in life satisfaction and addressing equity in public service provision, particularly for vulnerable populations.

From the perspective of dynamic behavioral modeling, the Markov Chain has become a widely used tool in studies of life cycle, health, employment, and mobility due to its structural capability to model state transitions (Xia et al., 2023). Its foundational assumption of "memorylessness"—where the probability of transitioning to the next state depends solely on the current state—makes it ideal for modeling evolving behavioral trajectories. In the context of family studies, Han et al. (2020) applied Markov models to explore pathways of family structure evolution, identifying typical transition chains and influencing factors between different life stages. When integrated with time use data, Markov Chain models can be used to construct activity time sequences and capture the structural dynamics of daily behaviors, thereby offering quantitative insight into how families reallocate time and adjust behaviors over the course of the life cycle.

Based on this foundation, the present study adopts the following analytical framework (Figure 1). First, using 2018 Shanghai TUS data, we focus on residents' time use during workdays and summarize time-use patterns across different stages of the family life cycle. Second, we apply entropy-based fragmentation metrics to identify high time-pressure periods for each stage. Third, using these high-pressure intervals as analytical windows, we calculate transition probability matrices via the Markov Chain model to reveal the most frequent activity shifts for each life cycle stage. Finally, we propose differentiated strategies for optimizing time-space resource allocation tailored to the unique spatiotemporal challenges of each stage.

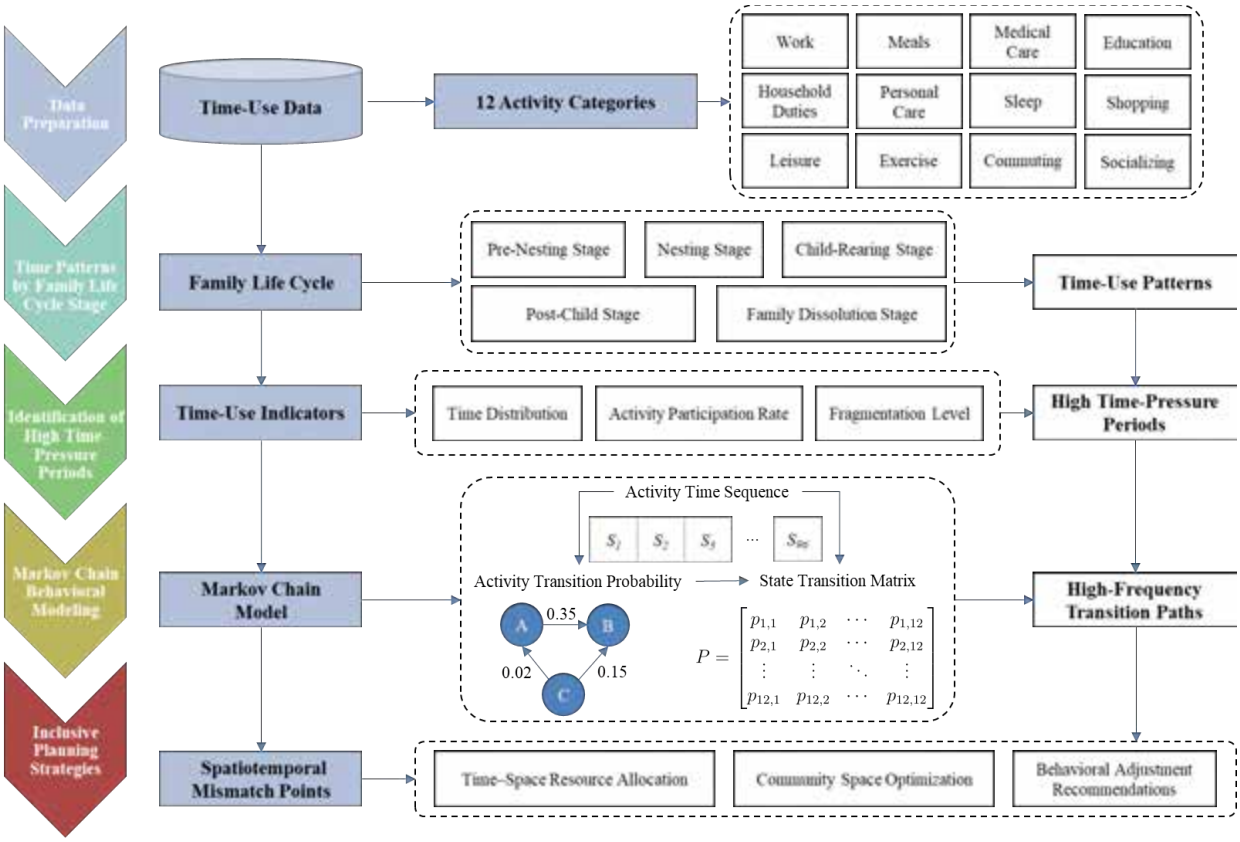

Figure 1. Technical Framework of the Study

2. Research Data and Methods

2.1 Time-Use Data

This study draws on data from the 2018 Shanghai Time Use Survey, which employed a stratified sampling approach and collected responses from 1,351 households, comprising a total of 3,297 individual samples. The survey captured comprehensive information on individual demographics, household composition, and time-use behaviors, documenting specific activities in 15-minute intervals over the course of a single day.

The raw data were cleaned and standardized, with all time entries converted into 96 uniform 15-minute segments per day to form a continuous time series. To simplify the analysis, 48 original detailed activity categories were consolidated into 12 broader activity types (Table 1). These categories represent the individual's activity status at each time point and serve as the basis for constructing the Markov transition model in subsequent stages of the research.

Table 1. Classification of Time-Use Activity Types

Category	Included Activities
Work	Full-Time Work, Part-Time Work, Agricultural Work, Non-Agricultural Business, Job Training, Vocational Training, Job Search
Household Duties	Household Management, Caregiving, Daily Care, Child Pick-Up/Drop-Off, Laundry and Cleaning, Cooking, Pet Care, Playing With Children
Leisure	Tea Drinking, Fishing, Board Games, Cultural and Media Activities, Web Browsing, Arts, Tourism, Smoking
Meals	Breakfast, Lunch, Dinner, Other Eating Activities
Personal Care	Grooming, Washing, Using the Restroom
Exercise	Fitness Training, Health Management
Medical Care	Medical Treatment, Doctor Visits, Accompanying Someone to The Doctor, Beauty Services
Sleep	Night Sleep, Rest Breaks, Naps
Commuting	Personal Transportation
Education	Formal Education, Adult Education, Homework, Tutoring, Waiting for Classes, Internships
Shopping	Buying Goods, Purchasing Services
Socializing	Social Visits, Companionship, Conversations, Volunteer Work

2.2 Classification of Family Life Cycle Stages

To systematically analyze structural differences in time-use patterns across life cycle stages, this study develops a tailored classification framework (Table 2), drawing on demographic and sociological theories of the family life cycle and incorporating the lived realities of Shanghai residents.

The classification is based on both the logical progression of household development and the intergenerational composition of family members. On one hand, five primary stages are defined according to changes in household structure and role transitions: Pre-Nesting, Nesting, Child-Rearing, Post-Child, and Family Dissolution. On the other hand, to reflect generational composition, the Child-Rearing stage is further divided into two subtypes: Nuclear Families (households composed of only parents and their children) and Multigenerational Families (households where three or more generations live together).

Table 2. Family Life Cycle Stage Statistics

Family Life Cycle Stage	Stage Description	Households
Pre-Nesting	Adult individuals who are single, unmarried, and childless, living independently. They have minimal family responsibilities, with daily activities centered around work and personal routines.	N = 105
Nesting	Married or cohabiting couples without children. These households are in stable partnerships, take on limited domestic responsibilities, and are not yet engaged in childrearing.	N = 127
Child-Rearing	Households with children aged 0–18 or grandparents caring for grandchildren in the same age range. Includes both nuclear and multigenerational families. Typically face heavy caregiving and domestic responsibilities.	N = 406
Post-Child	Households where children have reached adulthood or are attending university (18+), but still reside with parents or grandparents. While caregiving burdens are reduced, intergenerational cohabitation requires continued resource and space coordination.	N = 208
Family Dissolution	Households where children have fully left home, or where the family structure has undergone reorganization (e.g., divorce, widowhood, empty nest). These households are typically composed of older adults or grandparents living with adult children. Time autonomy is high, but issues such as health concerns, loneliness, or spatial mismatch may arise.	N = 505

2.3 Markov Chain Model

2.3.1 Time Distribution and State Definition

On the temporal dimension, each 24-hour workday is divided into 96 discrete time intervals, each representing a 15-minute segment. For each interval, the individual's primary activity is recorded and treated as a discrete state, denoted as S_t. This produces a daily activity-state sequence of length 96 for each individual:

$$\{S_1, S_2, \ldots, S_{96}\}$$

According to the classification system outlined in Table 1, all activities are grouped into 12 major categories. Each category is defined as a unique state, forming the complete set of possible activity states:

$$S=\{S_1, S_2, \ldots, S_{12}\}$$

This state set captures the primary behavioral types that make up residents' daily routines and serves as the foundation for the subsequent Markov chain-based behavioral modeling.

2.3.2 Activity Participation Rate

At the aggregate level, to assess the prevalence and temporal patterns of different activity types across family life cycle stages, this study introduces the indicator of activity participation rate. This metric reflects the proportion of individuals engaged in a specific activity during a given time interval, relative to the total sample size at that time. It is used to identify the temporal concentration and peak periods of particular behaviors.

The participation rate is calculated using the following formula:

$$P_{a,t} = \frac{N_{a,t}}{N_t} \times 100\%$$

Where: $P_{a,t}$ represents the participation rate of activity a at time t; $N_{a,t}$ is the number of individuals engaged in activity a during that time interval; and N_t is the total number of individuals in the sample at time t.

2.3.3 Fragmentation Entropy Calculation

During periods characterized by frequent transitions between activity states, individuals are more likely to experience elevated time pressure. To capture the degree of time-use fragmentation, this study employs the Shannon entropy index. Based on each individual's full-day activity sequence, the proportion of time spent on each activity category is calculated, and the corresponding fragmentation entropy is computed as follows:

$$H = -\sum_{i=1}^{n} p_i \log_2 p_i$$

Where: p_i represents the proportion of total daily time spent on activity category i, and $n = 12$ is the total number of activity categories. A higher fragmentation entropy indicates that the individual engages in a greater variety of activities, with more frequent transitions and a more dispersed time distribution throughout the day.

In addition, this study also calculates group-level fragmentation entropy at each time point. Specifically, for a given life cycle stage, the activity distribution $p_i(t)$ across all individuals during a specific time interval is used to compute the Shannon entropy. This value reflects the behavioral diversity of the group at that particular moment in time.

2.3.4 Identification of High Time-Pressure Periods

By plotting the average fragmentation entropy curve across the 96 daily time intervals for each family life cycle stage, this study identifies periods marked by sharp increases in entropy and significant behavioral diversity. These intervals are defined as high time-pressure periods. Such periods often correspond to peak commuting hours or times when multiple household responsibilities converge, characterized by frequent activity switching and heightened time constraints.

2.3.5 Markov Modeling and Transition Matrix Construction

After identifying the high time-pressure periods, the activity-state sequences of individuals within these intervals are extracted for each family life cycle stage. A first-order discrete-time Markov chain model is then constructed, where the state transition is defined as follows:

$$P(S_{t+1} = j \mid S_t = i) = p_{ij}$$

Where: p_{ij} represents the probability that an individual currently in state *i* transitions to state *j* in the next time interval. For each family life cycle stage, all observed transitions during the high time-pressure periods are aggregated and normalized to construct the state transition probability matrix:

$$P = \begin{bmatrix} p_{1,1} & p_{1,2} & \cdots & p_{1,12} \\ p_{2,1} & p_{2,2} & \cdots & p_{2,12} \\ \vdots & \vdots & \ddots & \vdots \\ p_{12,1} & p_{12,2} & \cdots & p_{12,12} \end{bmatrix}$$

This matrix captures the internal structure of behavioral switching within each life cycle stage. It serves as the basis for identifying typical high-frequency behavioral pathways and uncovering structural differences in time allocation and daily rhythms across different family types.

3. Time-Use Patterns Across Family Life Cycle Stages

3.1 Weekday Time Allocation in Representative Family Life Cycle Stages

The time-use survey data clearly illustrate the full-day structure of individual schedules, patterns of household division of labor, and spatial activity chains. Representative households from each family life cycle stage were selected from the sample, and 24-hour weekday activity timelines were constructed for all household members (Figure 2).

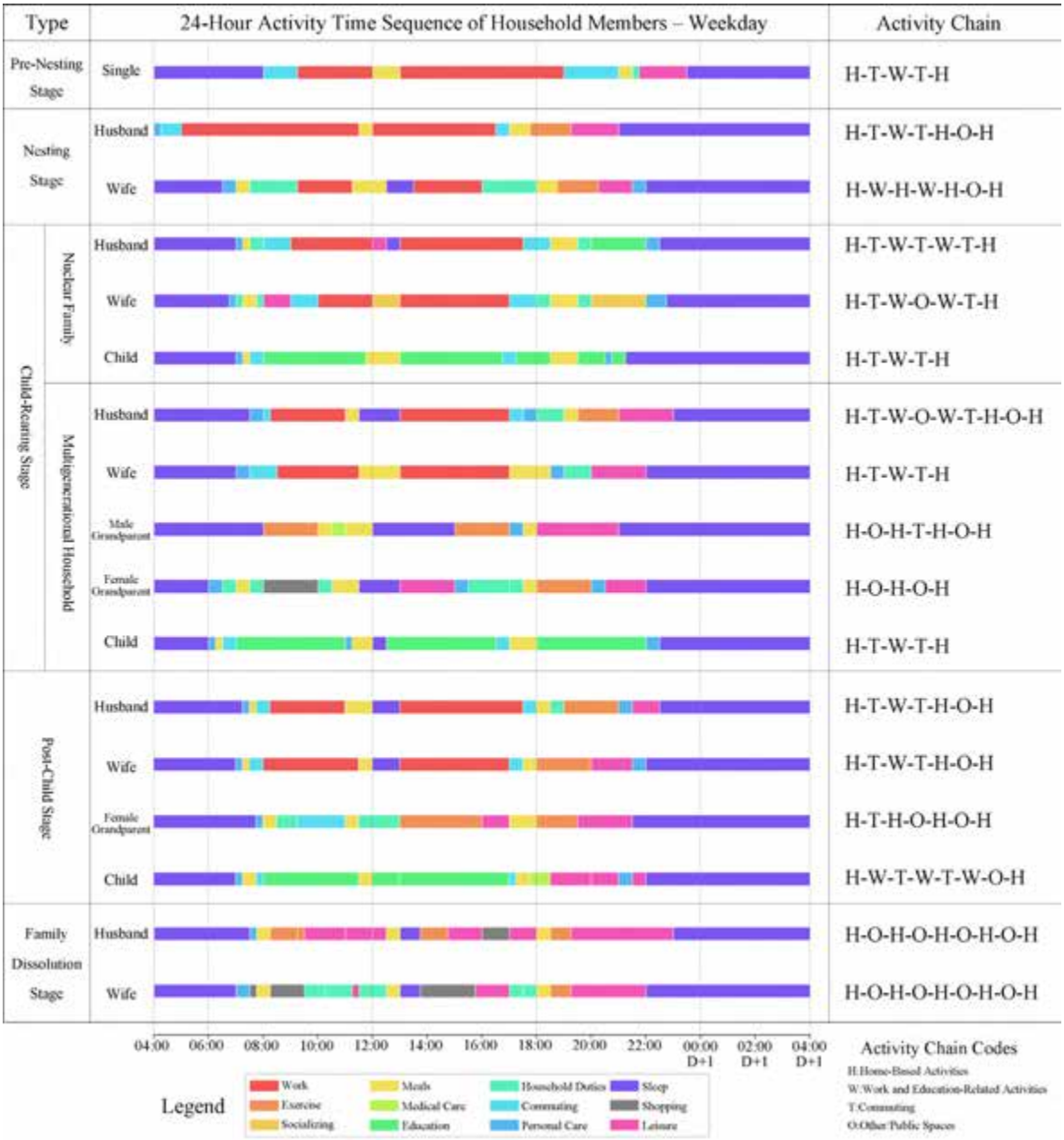

Figure 2. Time-Use Distribution on Workdays Across Typical Family Life Cycle Stages

1. Pre-Nesting Stage: The household consists of a single adult male or female. The daily activity pattern follows a streamlined "Work–Commute–Leisure–Sleep" cycle. The activity chain is highly simplified, with strong personal control over time and no interference from household responsibilities, reflecting a typical pattern of autonomous time use.

2. Nesting Stage: The household is composed of a husband and wife, both primarily engaged in professional work, with generally synchronized daily rhythms. In addition to the basic commute–work loop, their activity chains include connections to non-residential spaces such as commercial areas or fitness facilities, reflecting expanded engagement in leisure and personal services. The wife assumes household responsibilities before and after meals, indicating the early formation of an internal division of labor.

3. Child-Rearing Stage (Nuclear Family): Both the husband and wife maintain work-centered schedules, but with additional responsibilities related to caregiving and education, reflecting the time pressure experienced by dual-earner households balancing employment and parenting. Children follow a "Study–Rest" structure.

Child-Rearing Stage (Multigenerational Family): Compared to nuclear households, some caregiving responsibilities are shared with grandparents. These older family members typically follow short-loop activity chains (e.g., Home–Outside–Home), centered around shopping, caregiving, and meal preparation, thus providing auxiliary parenting support. As a result, both the husband and wife enjoy more leisure time than in nuclear families. Children still follow a study-oriented routine, forming a clear model of intergenerational division of labor and cooperative caregiving.

4. Post-Child Stage: The husband and wife continue to work, while their children are in college. Household caregiving demands are significantly reduced, with noticeable increases in time spent on fitness and leisure activities. Their activity chain shifts from the previously intense "Commute–Work–Caregiving" mode to a more relaxed "Work–Leisure/Fitness" structure.

5. Family Dissolution Stage: Most household members are empty-nest elderly individuals. Daily routines center around non-work activities such as leisure, exercise, and shopping. The activity chain is highly flexible with minimal repetition, and the time structure is loose, indicating a high degree of autonomy and a lifestyle characterized by "non-commuting, non-working" patterns.

3.2 Time-Use Patterns Across Family Life Cycle Stages

Figure 3 presents the average weekday duration of each activity category across the five family life cycle stages, highlighting the overall influence of life stage on time-use patterns—particularly in the allocation of time to work, household duties, and leisure.

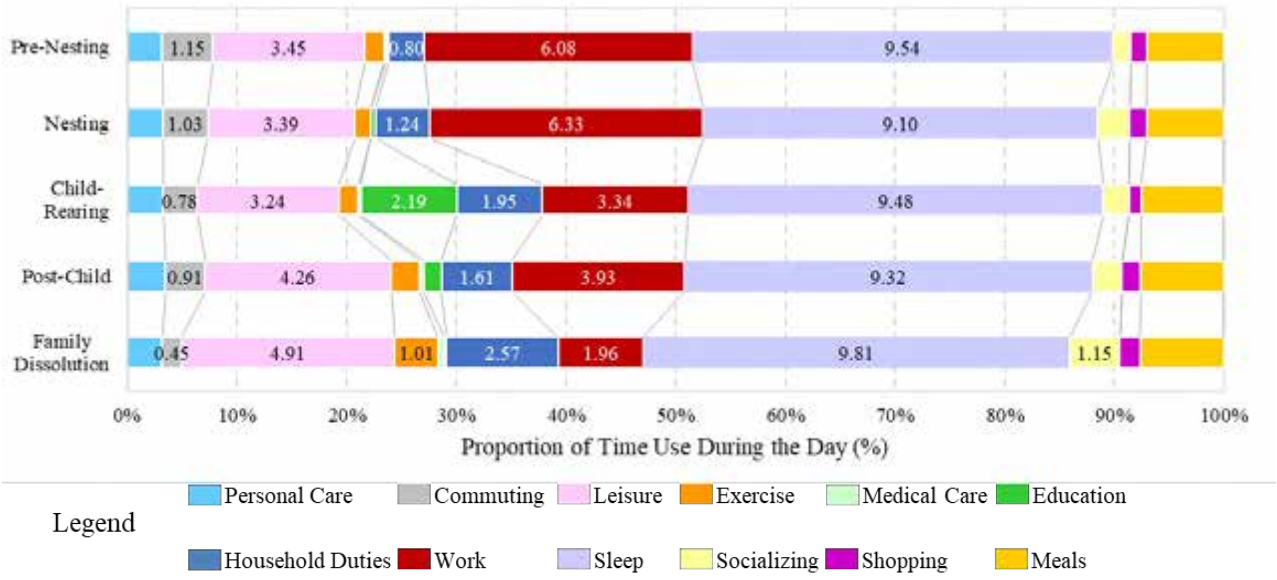

Figure 3. Average Daily Activity Duration by Family Life Cycle Stage

First, work hours exhibit an overall inverted U-shaped pattern. During the career-intensive stages of the Pre-Nesting and Nesting phases, average work durations reach 6.08 and 6.33 hours per day (h/d), respectively. As families enter the Child-Rearing stage, work time becomes compressed due to increased caregiving responsibilities, though both husbands and wives continue to spend substantial time working. In the Post-Child and Family Dissolution stages, work duration gradually declines to 3.93 h/d and 1.96 h/d, respectively—reflecting a restructuring of daily schedules in the context of retirement.

Second, household responsibilities and educational activities peak during the Child-Rearing stage. Individuals in this stage spend an average of 2.19 h/d on education-related tasks and 1.95 h/d on household duties—significantly higher than in any other life stage. This suggests that family members are simultaneously managing both caregiving and educational support, making it one of the most time-pressured phases of the life cycle.

Third, leisure and physical exercise time increases at both ends of the life cycle. Residents in the Pre-Nesting, Post-Child, and Family Dissolution stages each report more than 3.4 h/d of leisure time. In the Family Dissolution stage specifically, individuals also spend about 1 h/d on exercise and socializing, resulting in nearly twice as much discretionary time as those in the Child-Rearing stage. This shift reflects greater time autonomy and a slower, more flexible daily rhythm.

In contrast, sleep duration remains stable across all life stages, with average sleep time exceeding 9 h/d in each category. This consistency underscores sleep as a basic physiological necessity, largely unaffected by changes in life stage.

Finally, commuting time is most prominent during the Pre-Nesting, Nesting, and Child-Rearing stages, indicating that commuting is closely tied to employment. The time squeeze becomes especially acute when individuals must balance full-time work with active parenting responsibilities.

Further, Figure 4 illustrates the full-day activity participation rates on weekdays across the five family life cycle stages, revealing the stage-specific influence of family life progression on individual time rhythms and allocation patterns.

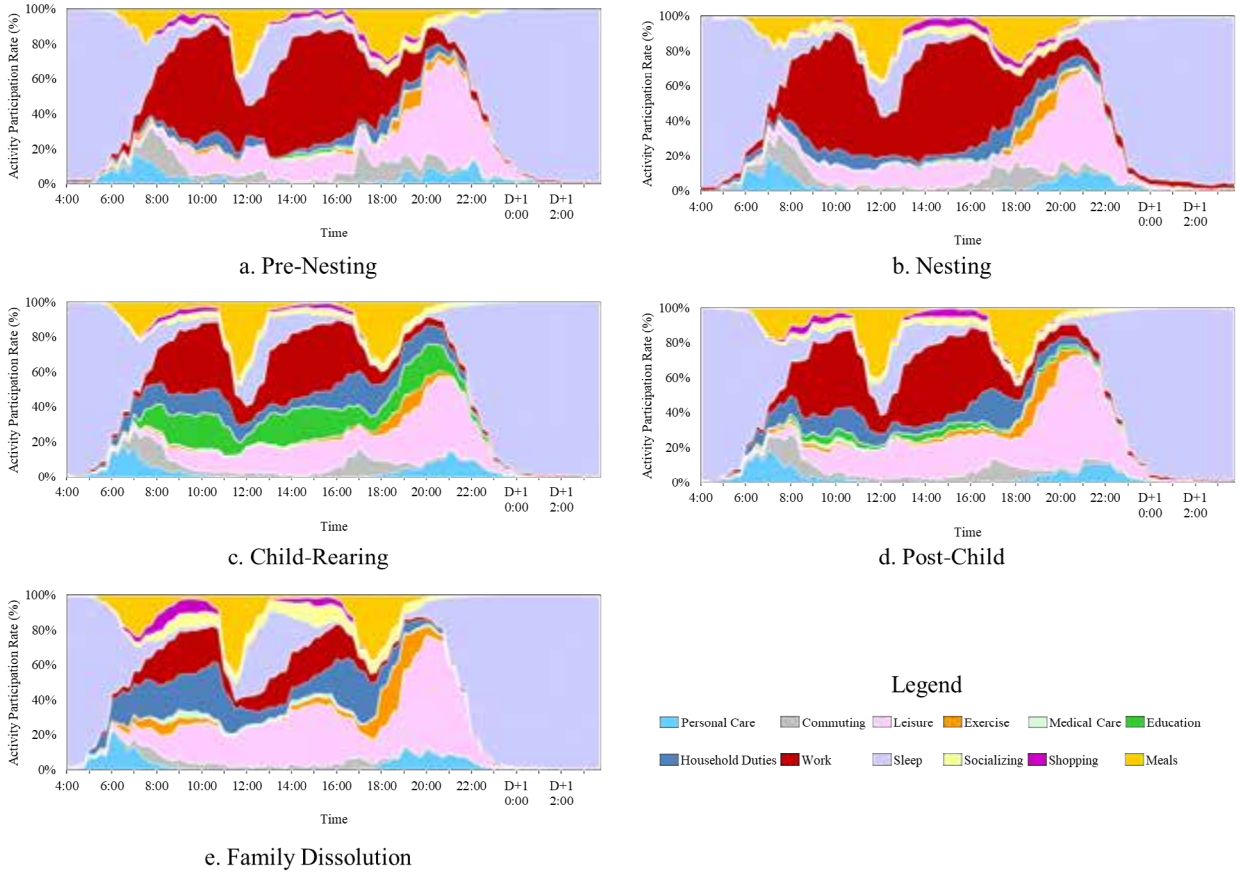

Figure 4. Activity Participation Rates Throughout the Day by Family Life Cycle Stage

1. Pre-Nesting Stage: Time-use rhythms are highly concentrated and autonomous. Work-related activities form a clear double peak between 9:00–12:00 and 14:00–18:00, while commuting peaks appear around 8:00 and 18:00, reflecting an intensive "commute–work" cycle. After 19:00, leisure becomes dominant—particularly virtual forms of leisure—with participation rates approaching 60%, indicating a high level of temporal freedom.

2. Nesting Stage: Daily rhythms are strongly work-centered, exhibiting clear synchronization between partners and emerging patterns of household coordination. Work participation remains high from 9:00 to 17:00, with pronounced commuting peaks that slightly extend earlier and later than in the Pre-Nesting stage. Participation in household duties, shopping, and exercise rises during early morning and evening hours, suggesting the early formation of internal role division and shared domestic routines.

3. Child-Rearing Stage: This stage shows the most complex distribution of activities, with a fragmented time-use pattern driven by the interplay of employment and caregiving. Work and educational activities remain high between 9:00 and 17:00, while commuting peaks occur from 7:00–8:00 and 16:30–17:30. Household duties and meals are concentrated in the morning, midday, and evening, highlighting the pressure of managing multiple roles—work, caregiving, and domestic tasks. In multigenerational households, grandparents also participate in household responsibilities and shopping during morning and afternoon hours. Leisure and exercise are mostly confined to nighttime, often squeezed out by other obligations.

4. Post-Child Stage: Daily activities shift toward leisure and personal development. While employed household members continue to follow standard work routines, work and commuting participation rates decline compared to the Nesting stage. Participation in leisure, exercise, and social activities increases significantly, indicating a growing emphasis on quality of life outside of work. Household responsibilities remain stable and relatively minimal.

5. Family Dissolution Stage: The structure of daily activity participation shifts strongly toward non-work and self-care routines. Participation in work and commuting drops sharply, while leisure, exercise, and socializing become the primary components of the day. Household duties and shopping are distributed across the morning and afternoon hours, and the overall daily rhythm is more relaxed—reflecting the increased time autonomy of older adults.

4. Time Pressure Identification and Markov Chain Behavioral Modeling

4.1 Identifying High Time-Pressure Periods

On weekdays, different family life cycle stages exhibit distinct patterns of time fragmentation. To identify high time-pressure periods across family types, this study uses fragmentation entropy as an indicator of activity-switching frequency and temporal discontinuity. A higher entropy value indicates more frequent activity transitions and greater behavioral dispersion within a given time interval, reflecting heightened tension in time management.

Following the approach of Shi et al. (2022), we adopt a fragmentation entropy threshold of 2.8 to define high time-pressure periods, based on the following rationale: (1) Across all life cycle stages, the value of 2.8 falls within the upper quartile of entropy distributions, indicating relatively intense time fragmentation; (2) As shown in earlier analyses, when entropy exceeds this threshold, behavioral patterns typically involve rapid transitions between work, household duties, and commuting—hallmarks of time fragmentation overload. Therefore, 2.8 is used as the dividing line between routine daily rhythms and high time-pressure conditions.

Figure 5 presents the fragmentation entropy curves for weekdays across different family life cycle stages, along with the identified high time-pressure periods.

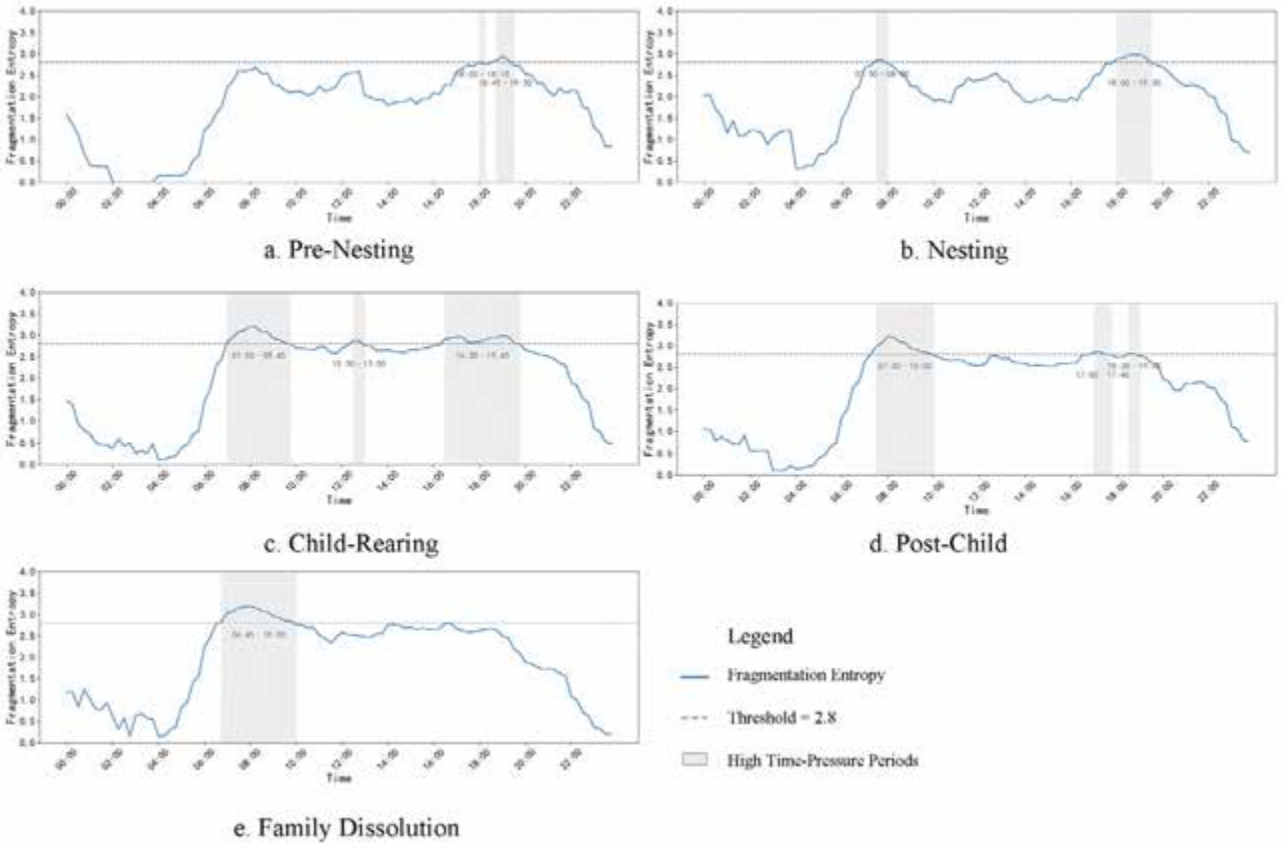

Figure 5. Intraday Variation of Time Fragmentation Entropy Across Life Cycle Stages

1. Pre-Nesting Stage: Entropy levels remain stable throughout the day, briefly exceeding the threshold only between 18:00 and 19:30. This suggests a generally manageable time rhythm with minimal scheduling stress.

2. Nesting Stage: Notable entropy spikes occur during two commuting peaks—7:30–8:00 and 18:00–19:30—highlighting time pressure arising from transitions between commuting, work, and emerging household responsibilities.

3. Child-Rearing Stage: Displays a clear "three-phase" structure of time pressure, with elevated entropy from 7:00–9:45 (morning commute and school drop-off), 12:30–13:00 (midday rest and domestic chores), and 16:30–19:45 (evening caregiving and household tasks). Entropy remains high for extended periods, marking this as the most prolonged and intense stage of time pressure.

4. Post-Child Stage: While the early morning (7:30–10:00) and evening (17:00–19:00) still show noticeable increases in entropy, the overall fluctuation is more moderate, reflecting reduced caregiving burdens and a partial alleviation of time stress.

5. Family Dissolution Stage: Elevated entropy appears only during 6:45–10:00, after which the daily rhythm stabilizes. This reflects a typical post-retirement pattern—high autonomy with concentrated morning activity followed by a slower, more relaxed pace throughout the day.

4.2 Identifying High-Frequency Behavioral Transitions Using Markov Chains

To further uncover behavioral patterns during high time-pressure periods across different family life cycle stages, Markov transition matrices were constructed based on the previously identified high-fragmentation time windows. These matrices model the weekday activity transitions for each of the five life cycle stages under time pressure. The matrices capture the probability of shifting from one activity to another, while the bar charts above each matrix (Figure 6) display the inflow probability of each activity type.

Overall, the structure of activity transitions under time pressure varies significantly across life stages, reflecting two key dimensions: the functional concentration of behavioral pathways and the complexity of transitions.

1. Pre-Nesting Stage (Figure 6a): The transition structure is relatively simple, with work remaining the central activity during pressure periods. The dominant transition pathways include Work - Commuting, Commuting - Meals, and Meals - Leisure, indicating a focused routine with few competing demands.

2. Nesting Stage (Figure 6b): Work and household responsibilities coexist, forming a dual-core transition structure. In addition to the work-centered transitions, notable pathways include Household Duties - Meals (0.34) and Leisure - Household Duties (0.21), suggesting an emerging division of domestic labor between partners.

3. Child-Rearing Stage (Figure 6c): The transition matrix is highly complex and densely connected, reflecting a multi-centered, high-pressure behavioral landscape. Prominent pathways include Education - Meals (0.19), Household Duties - Meals (0.21), Shopping - Household Duties (0.19), and Medical Care - Household Duties (0.21). These transitions form a dual-loop structure of education and caregiving, indicating the need for frequent multitasking. Notably, the inflow probability for Sleep is relatively high, highlighting a strong demand for restorative activities among residents in this stage.

4. Post-Child Stage (Figure 6d): Behavioral transitions shift back toward work and leisure. While work-related pathways remain visible, they appear more compressed. Commuting remains a burden, though household responsibilities begin to ease. Leisure activity sees an increase in inflow probability, suggesting a growing emphasis on personal time.

5. Family Dissolution Stage (Figure 6e): The transition network becomes significantly simplified, centering on a loop between self-care, household duties, meals, and leisure. Core pathways include Medical Care - Leisure (0.21) and Leisure/Exercise - Household Duties (0.23), reflecting a rhythm of health maintenance and relaxed daily living. The inflow probability for work-related activities drops sharply, underscoring a non-productive, high-autonomy time-use structure typical of older adults.

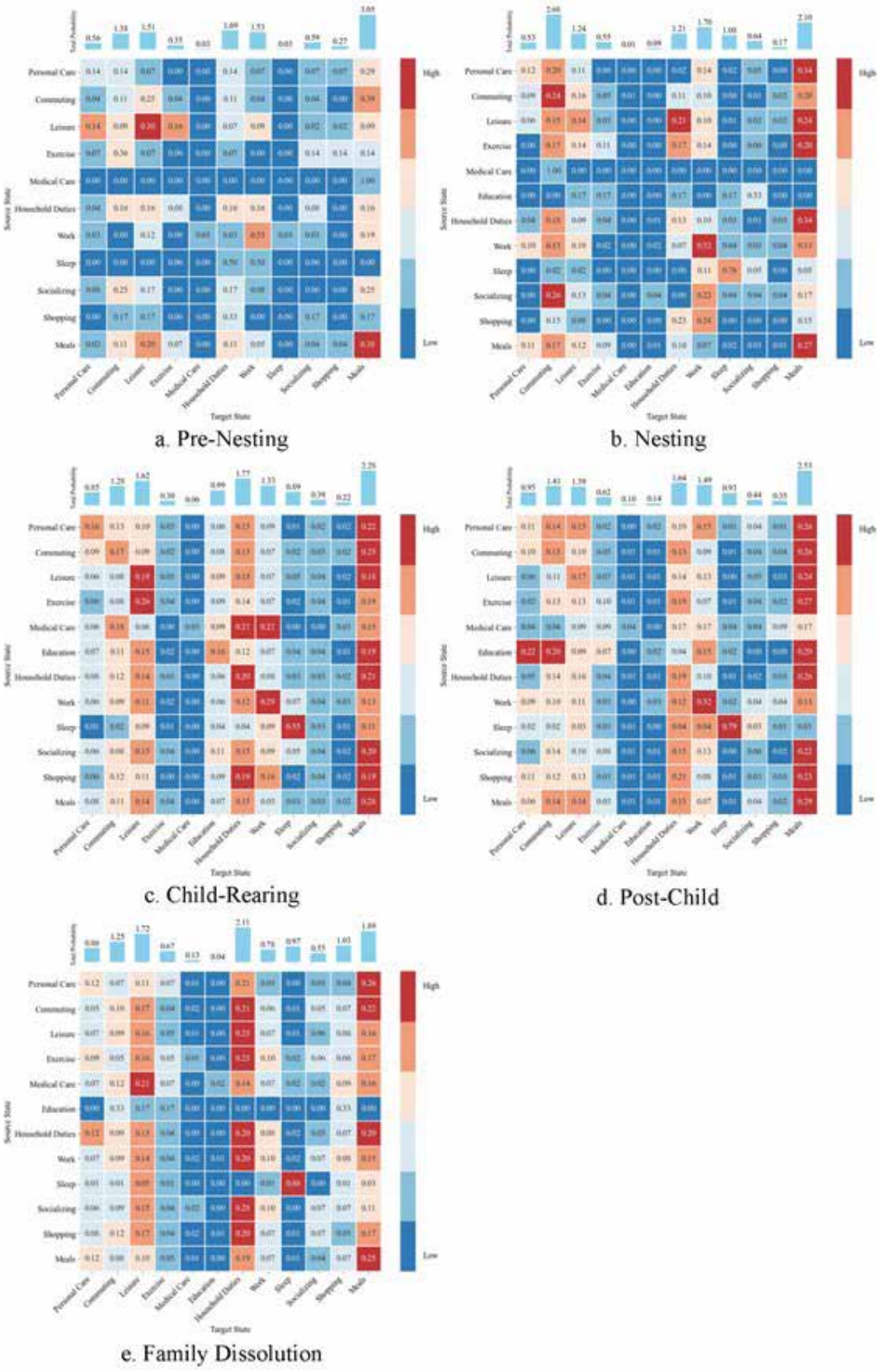

Figure 6. Markov Transition Matrices and Inflow Probabilities by Family Life Cycle Stage

5. Spatiotemporal Needs and Recommendations for Inclusive Urban Planning

5.1 Life Cycle–Oriented Spatiotemporal Matching Needs

With the integration of the family life cycle perspective, residents' time-use behaviors and spatial activity needs exhibit distinct stage-specific differences. Drawing on the earlier identification of high time-pressure periods and Markov-based behavioral transitions, we can pinpoint the unique time constraints, high-frequency activity pathways, and spatial stress points at each life cycle stage (Table 3).

Traditional urban planning—centered around a binary "residence–work" model—struggles to accommodate the complex, multi-role, multi-task, and multi-node behavioral patterns that emerge within family structures. This calls for a fundamental shift toward a spatiotemporal supply–demand framework that balances employment, caregiving, leisure, and aging needs. From the perspective of the family life cycle, spatial resources must be more flexibly adapted at the neighborhood scale. This provides a foundation for developing inclusive urban planning strategies that are responsive to the evolving demands of residents across different stages of life.

Table 3. Time-Pressure and Spatiotemporal Stress Points Across Family Life Cycle Stages

Family Life Cycle Stage	Time-Pressure Periods	High-Frequency Behavioral Pathways	Key Spatial Mismatches
Pre-Nesting	18:00-19:30	Work – Commuting – Meals – Leisure	Urban spatial design remains poorly aligned with the post-work evening routines of single young adults, with a lack of integrated online–offline options for nighttime dining and leisure.
Nesting	07:30-8:00 18:00-19:30	Commuting – Work Work – Household Duties Household Duties – Meals	There is limited last-mile connectivity between residential areas and public transit stations. Morning peak commuting is burdensome, and community-based convenience services need to be strengthened to help absorb household responsibilities.
Child-Rearing	07:00-9:45 12:30-13:00 16:30-19:45	Commuting – Work Work – Household Duties Education – Meals Household Duties – Meals Shopping–Household Duties	Spatial connectivity between education, dining, and shopping facilities is weak, creating overlap between commuting and caregiving demands. Community-level infrastructure for temporary childcare, midday rest, convenient pick-up/drop-off, and last-mile delivery requires optimization.
Post-Child	07:30-10:00 17:00-19:00	Work – Commuting – Meals Household Duties – Leisure	Commuting pressure remains significant, and there is a lack of diverse leisure spaces near residential areas tailored to the needs of middle-aged adults.
Family Dissolution	6:45-10:00	Household Duties – Meals Leisure – Household Duties Errands – Household Duties Medical Care – Leisure	Age-friendly upgrades are urgently needed in residential communities to support older adults' morning access to food and shopping. Additional public spaces for senior socialization, fitness, and wellness activities are also needed.

5.2 Recommendations for Inclusive Urban Planning

To address the spatial needs of different family life cycle groups during high time-pressure periods, urban planning and community renewal efforts should adopt more inclusive and differentiated service strategies:

1. Pre-Nesting Stage: Encourage the development of the nighttime economy in employment hubs and central commercial districts by supporting extended hours for dining and entertainment venues. Introduce digitally integrated leisure spaces—such as live-streamed night markets and immersive social platforms—to meet the post-work needs of single young adults for dining, entertainment, and social interaction.

2. Nesting Stage: Provide shared mobility services and last-mile connection infrastructure between residential areas and public transit stations, and improve multimodal commuting systems. Within neighborhoods, incorporate convenient service modules such as domestic help, community kitchens, and centralized laundry facilities to help ease the burden of household responsibilities.

3. Child-Rearing Stage: In response to the overlapping spatial demands of commuting, school drop-off, employment, and caregiving, establish neighborhood-level family service centers. These should integrate midday childcare stations, after-school care facilities, community kitchens, and parent–child activity spaces. Additionally, expand last-mile delivery access points for online shopping to reduce time pressure and caregiving costs.

4. Post-Child Stage: Encourage communities and business parks to provide flexible leisure spaces, such as social cafés and hobby workshops, to help alleviate the mental fatigue associated with balancing career and evolving family roles among middle-aged adults.

5. Family Dissolution Stage: Promote comprehensive age-friendly upgrades to communities, including the addition of accessible, pleasant small-scale shopping venues and senior meal stations. Develop senior-friendly greenways for exercise, social spaces, and smart assistive infrastructure to support physical activity and social participation among older adults.

6. Conclusion and Future Directions

This study, grounded in a family life cycle perspective, draws on the 2018 Shanghai Time Use Survey to examine how time-use patterns vary across different stages of the family life cycle. By identifying high time-pressure intervals and high-frequency behavioral transitions, the study proposes inclusive urban planning strategies that respond to stage-specific needs.

The findings reveal that individuals in the Pre-Nesting stage exhibit a work-oriented time structure characterized by high autonomy and strong engagement in nighttime leisure. The Nesting stage is defined by a dual-core structure balancing professional commitments and emerging household responsibilities. The Child-Rearing stage presents the most complex time structure, with family members engaging in frequent multitasking across work, caregiving, education, and domestic duties—making it the stage with the highest time pressure. In the Post-Child stage, time use shifts back toward a work-led structure with a gradual transition to leisure. Finally, the Family Dissolution stage is marked by a non-productive, highly autonomous daily rhythm.

Using fragmentation entropy and Markov chain modeling, the study identifies the peak pressure periods and dominant behavioral pathways for each life cycle stage, revealing the underlying time allocation mechanisms and corresponding spatial needs. Based on these insights, the research puts forward family life cycle–oriented recommendations for inclusive urban planning, including the creation of nighttime leisure environments for young adults, improved commuting buffers and caregiving infrastructure for families with children, and age-friendly spatial upgrades to support social participation among the elderly.

This study offers both a micro-level lens on residents' everyday spatiotemporal behaviors and practical guidance for building age-inclusive, caregiving-supportive cities. Nonetheless, certain limitations remain. The analysis relies primarily on cross-sectional data and does not yet incorporate multisource spatiotemporal information. Future research should integrate longitudinal time-use surveys with GPS-based spatial data to support higher-resolution analyses and more robust spatial intervention strategies.

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Neighborhood walkability for older adults and their travel — Shanghai Anshan area case study

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Abstract
As population ageing accelerates, safeguarding older adults' mobility is vital to promoting their physical health, mental well-being, and social inclusion. Given their reliance on walking within neighbourhoods, walkability is a key factor influencing mobility behaviours. This study refines existing walkability index by incorporating empirical data on older adults' travel characteristics, including walking speeds, gathered via surveys. Using Shanghai's Anshan area—a community with a high proportion of older residents—as a case study, a fine-grained (50 m × 50 m) grid-based analysis was conducted. The modified index reveals spatial disparities in walkability and delineates essential travel patterns within a 15-minute community life circle. Findings inform practical recommendations for age-friendly neighbourhood renewal, offering valuable insights for policy adjustments in the context of rapid demographic ageing.

Keywords: Walkability Index; Older adults; Daily Travel; Community Planning

0. Introduction

The global trend of population ageing is accelerating, with China—owing to its large population—undergoing an especially pronounced demographic shift. As of 2024, individuals aged 60 and above account for 22% of the national population, while those aged 65 and above comprise 15.6% (China National Bureau of Statistics, 2025). In light of the universal reality that "every family has an elder, and everyone will eventually age," the mobility and safety of older adults have emerged as critical societal concerns. As a major global city, Shanghai also faces substantial challenges related to population ageing. Advancing age is often accompanied by a decline in mobility, reduced social engagement, and diminished quality of life among older residents. Therefore, it is essential to investigate the factors influencing the travel frequency and mobility limitations of older people, in order to guide the planning and renewal of age-friendly communities.

Shanghai's "15-minute community life circle" initiative, although instrumental in enhancing residential environments, has yet to fully incorporate design principles tailored to the specific needs of older adults. Common issues such as pedestrian spaces being occupied by parked vehicles and suboptimal configurations of public facilities remain prevalent (Chen et al., 2016; Huang et al., 2022). This underscores an urgent need to optimise neighbourhood environments through an elderly-centred lens. While existing walkability indices serve as important tools for evaluating pedestrian-friendliness, they exhibit notable limitations. These include a failure to distinguish between types of destinations frequently visited by older adults, and a neglect of their subjective experiences and

perceptions (Wei et al., 2024; Weng et al., 2019). Most existing studies tend to focus on correlations between the built environment and physical health, with comparatively limited attention paid to mobility challenges as perceived by older adults themselves.

Furthermore, there remains a need to enhance the interpretability of research methodologies. Traditional investigations have predominantly relied on linear regression models to examine direct, linear relationships in travel behaviour. However, the emergence of machine learning techniques has enabled researchers to uncover more complex, non-linear patterns and threshold effects in mobility dynamics (Shi et al.,2022; Wu et al., 2021).

To address these methodological and conceptual gaps, this study proposes an analytical framework for evaluating walkability within community life circles, specifically tailored to the needs of older adults. Drawing upon a comprehensive literature review and empirical fieldwork—centred on the daily living requirements (e.g., shopping, leisure) and travel behaviours of elderly residents—this study refines facility weightings and correction coefficients embedded in conventional walkability indices, thereby formulating an improved, age-friendly walkability assessment system. Older residential neighbourhoods characterised by both a high concentration of ageing populations and mature built environments are selected as case studies. By calculating walkability indices for these areas, the study evaluates the influence of various spatial and environmental factors on accessibility for older adults, offering a theoretical foundation for the regeneration and transformation of urban communities. This study not only provides a robust scientific basis for the development of age-inclusive neighbourhoods but also represents a conceptual advancement in ageing studies—shifting the analytical focus from a singular emphasis on the built environment towards a multi-dimensional, integrated perspective. In doing so, it contributes to the broader societal objective of ensuring that older adults may age with dignity, adequate support, and enhanced quality of life.

2 Methodolody

2.1 Study area and data

The survey area is situated in the Anshan Xincun neighbourhood of Shanghai (Figure 1). Located within Yangpu District and adjacent to Tongji University, Anshan Xincun encompasses an area of approximately 1.51 km². In 1952, four major workers' neighbourhoods were developed to the north of Kongjiang Road, with Anshan Xincun being one of them, forming a large-scale residential community. As a product of Shanghai's transitional period of urban development (Zhigang and Fulong, 2006), Anshan Xincun represents a typical workers' neighbourhood. Its spatial configuration resembles that of traditional alleyways, though it is not entirely open, with service facilities arranged along the main streets. Following the establishment of these residential areas, a substantial number of workers moved in and settled permanently. Today, Anshan Xincun is characterised by high residential density and a deteriorating built environment, serving as a representative example of older urban districts within central Shanghai. The pronounced level of population ageing in the area further renders it a suitable site for investigating the travel behaviours of the elderly.

Figure 1 Location of Anshan Xincun

This study was conducted in three stages, each focusing on the mobility patterns of older people. The first stage comprised semi-structured interviews, each lasting approximately 30 minutes, and aimed at investigating the travel preferences, challenges, and daily mobility needs of older adults. The second stage involved a questionnaire survey, informed by existing literature, to gather data on travel preferences, frequency of travel, and key influencing factors. These data were subsequently used to refine the weighting of facilities within the walkability index. The third stage entailed tracking the travel trajectories of a selected group of older residents in order to determine their average walking speed, thus enabling the definition of a neighbourhood activity radius tailored to their mobility characteristics.

2.2 Walkability index

Empirical research examining the relationship between the built environment and walking behaviour has primarily concentrated on the computation of walkability indices (Cheng et al., 2019; Fonseca et al., 2022; Nagel et al., 2008) with the majority of such studies conducted in Western contexts(Aghaabbasi et al., 2018; Cubukcu et al., 2015). However, many of the indicators employed—such as facility weights and adjustment coefficients—are designed specifically for Western urban settings and may not be well suited to cities such as Shanghai, where the urban morphology differs considerably. Nonetheless, the methodological framework underpinning walkability indices remains a valuable instrument for evaluating walkability at the regional scale, as it encompasses both the spatial distribution of facilities and the pedestrian-friendliness of the built environment. This renders it particularly appropriate for assessing the travel environments of older adults, who are often more vulnerable in terms of mobility.

Mainstream approaches to calculating walkability scores can broadly be classified into environment-based and accessibility-based methods. The former emphasises the physical characteristics of the built environment, while the latter gives greater consideration to pedestrian behaviours and needs (Horak et al., 2022). Accessibility-based walkability indices generally follow a structured logic: based on the travel demands of the target population, relevant facility types are identified and assigned indicator weights. The distances from origin points to surrounding facilities are then computed and adjusted using a distance decay coefficient. The weighted values for each origin point are aggregated to generate a base walkability score, which is subsequently modified using a correction coefficient to produce a final index ranging from 0 to 100 (Horak et al., 2022). Given that older adults

are particularly reliant on local facilities and prioritise ease of access, this study adopts an accessibility-based approach to walkability assessment.

The principal framework for adjusting the walkability index in this study is presented in Figure 2.

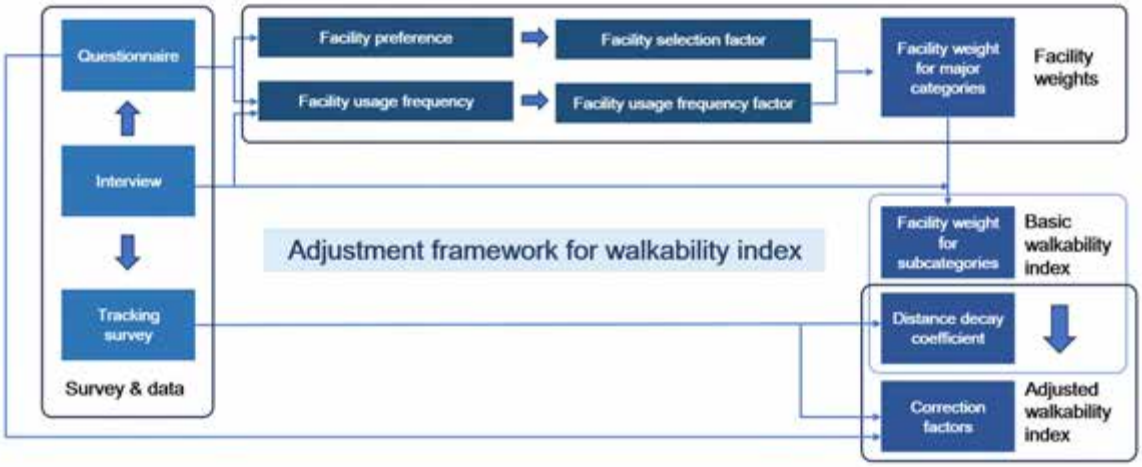

Figure 2 Adjustment framework for walkability index

At present, walkability indices are typically applied at a relatively coarse spatial scale, often using the community centroid as the point of origin. This method tends to neglect intra-community travel distances and spatial variation(Duncan et al., 2013; Hall and Ram, 2018)]. However, owing to the enclosed nature of community design and management in many urban areas, significant spatial heterogeneity may exist even within small-scale neighbourhoods (Li et al., 2024). For example, residents living closer to community entrances may demonstrate stronger travel intentions. Accordingly, this study adopts a fine-grained, grid-based analytical approach, calculating walkability scores at 50-metre intervals to capture localised variations more accurately.

The base walkability index is computed by identifying the types and quantities of facilities surrounding each origin point and aggregating these using the corresponding facility weights, as defined in Equation (1).

$$W_b = \sum_{j=1}^{N}\left[Q_j * \left(\sum_{i=1}^{n_j}(F_{ij} * Y_{ij})\right)\right] \Big/ \sum_{j=1}^{N} Q_j \qquad (1)$$

Where W_b is the basic walkability index, Q_j denotes the original weight value of facility j, n_j is the number of decay intervals of facility j, F_{ij} is the number of facility j in decay interval i, and Y_{ij} is the distance decay coefficient corresponding to the i-th facility of facility j.

The calculation method of adjusted walkability index is as follows Equation (2):

$$W_a = W_b * (1 - C_i) * (1 - S_i) * (1 - N_{1i}) * (1 - N_{2i}) \qquad (2)$$

Where, W_a is the adjusted walkability index, W_b is the basic walkability index, I_i is the intersection density correction coefficient, L_i is the block length correction coefficient, N_{1i} is the first new correction coefficient, N_{1i} is the second new correction coefficient.

2.3 Model

This study adopts the Gradient Boosting Decision Trees (GBDT) model—a machine learning approach that improves predictive accuracy by iteratively combining multiple weak learners into a single, robust learner. The model approximates true outcomes by minimising the loss function through gradient descent. Compared with conventional linear regression techniques, GBDT offers superior accuracy and is capable of accommodating a diverse range of explanatory variables simultaneously(Ding et al., 2018).

Moreover, GBDT inherently captures interactions between variables without requiring a priori assumptions regarding functional forms, thereby addressing one of the principal limitations of linear models(Wang and Wang, 2021). It is also notably resilient to multicollinearity among independent variables, rendering it especially suitable for models involving a large number of predictors. As a non-linear modelling technique, GBDT is well equipped to detect localised effects and threshold phenomena, demonstrates robustness against outliers, and more accurately reflects empirical patterns. These features collectively enhance its utility in informing planning practices.

Accordingly, this study employs the GBDT model to analyse the influence of various factors on respondents' travel behaviours across different neighbourhoods, thereby effectively mitigating the distorting effects of non-linear variable interactions on overall model performance.

3 Results

3.1 Survey results

3.1.1 Basic Information and Travel Characteristics

The survey findings concerning the respondents' demographic profiles and health conditions are illustrated in Figures 3 and 4.

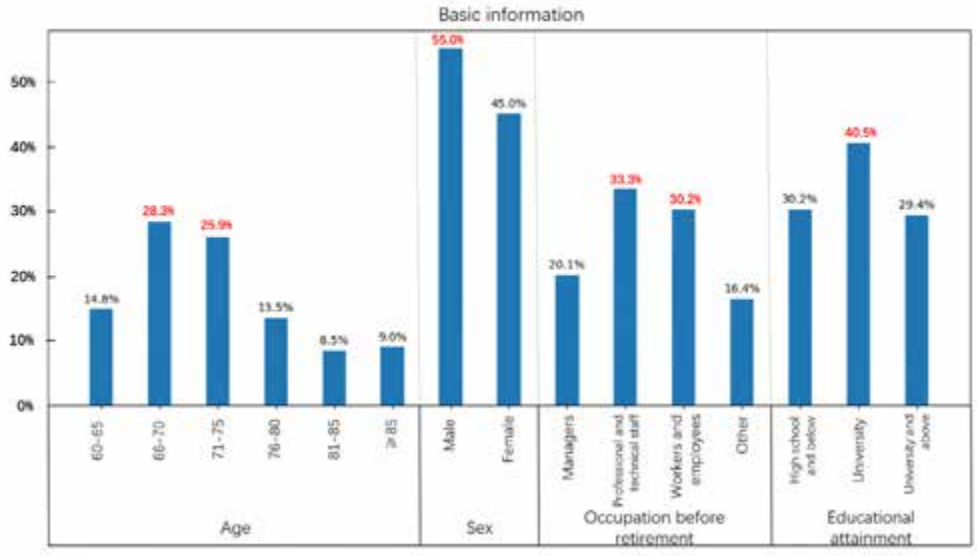

Figure 3 Basic information of the respondents

All respondents are retired residents aged 60 and above, the majority of whom reside either with their spouse or with both spouse and offspring. Approximately 70% are primarily responsible for household shopping. Fewer than 20% of respondents self-assess their health as "good" or "very good". Regarding chronic illnesses, 64.3% report not suffering from any long-term health conditions.

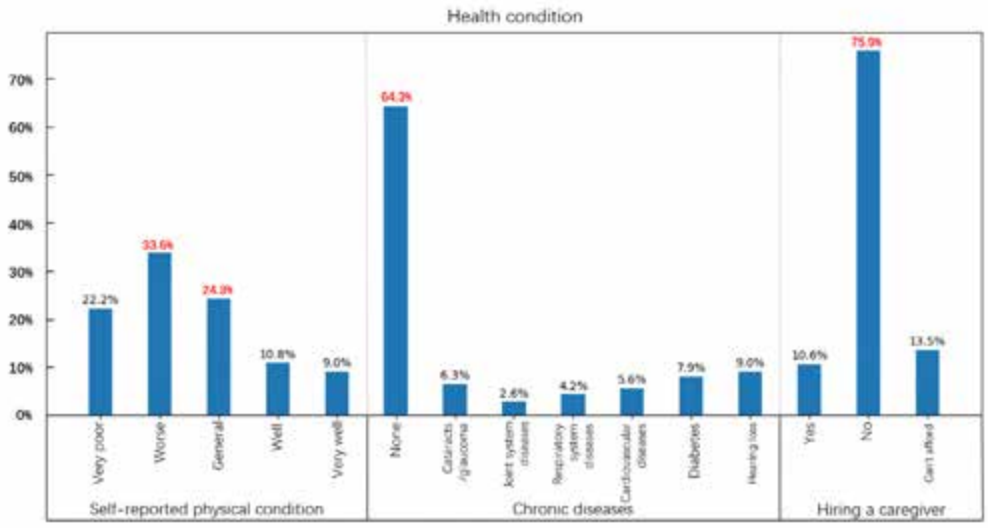

Figure 4 Health condition of the respondents

Respondents typically go out between once and four times per day, with nearly one-third reporting the need to leave their home twice daily. Fewer than 80 respondents are able to travel independently; the remainder rely on mobility aids such as walking sticks or wheelchairs. Furthermore, 42 respondents require the assistance of a companion when travelling, indicating that a significant proportion of the sample population faces mobility-related challenges (Figure 5).

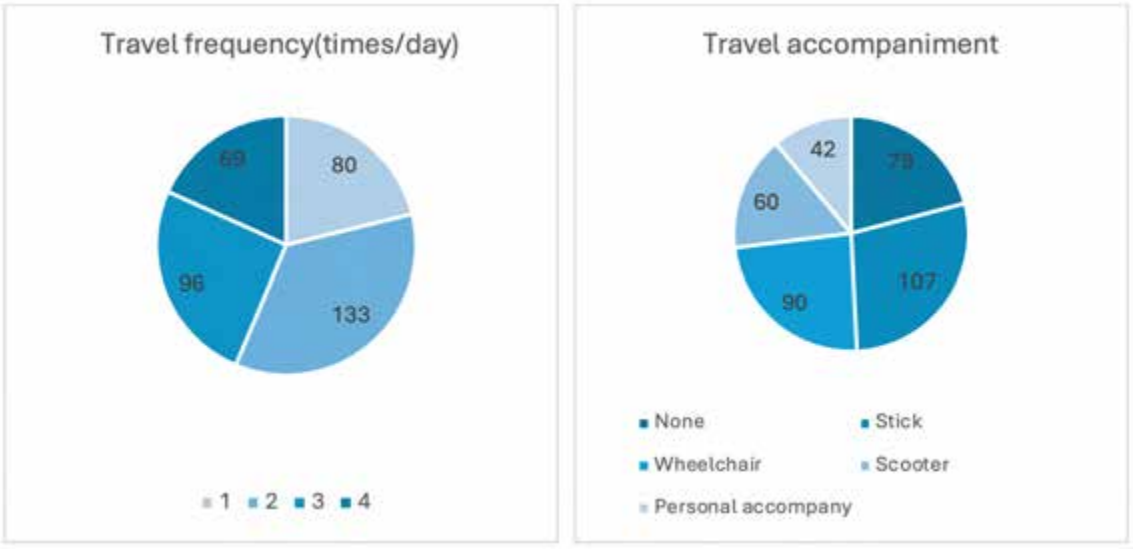

Figure 5 Travel frequency(left) and travel accompaniment(right)

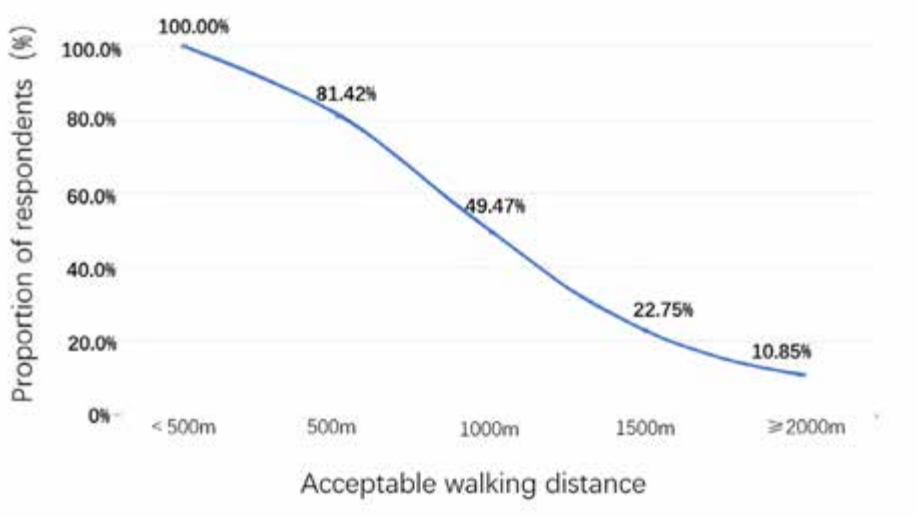

Figure 6 Distribution of acceptable walking distances

The majority of respondents are willing to walk distances of up to 500 metres, while only around 10% are capable of walking 2,000 metres or more (Figure 6). For longer journeys, respondents tend to favour public transport, although a subset uses non-motorised modes such as electric bicycles and mobility scooters designed for older adults. A small number of respondents report using private vehicles or taxis.

3.1.2 Travel problems

When asked about the difficulties encountered during travel, respondents' concerns were classified into four primary categories: inadequacies in facilities, issues related to urban management, challenges in pedestrian flow organisation, and safety risks (Figure 7).

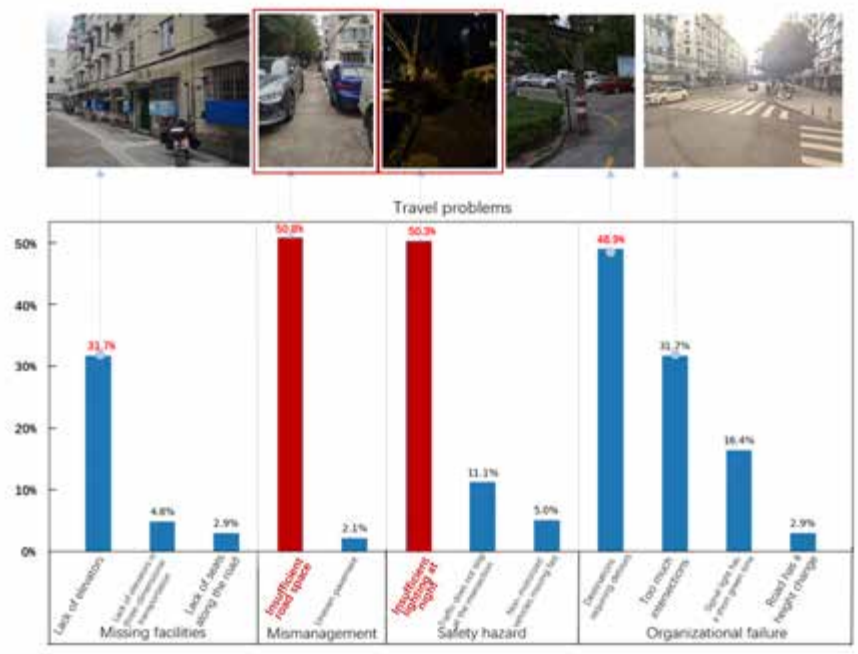

Figure 7 Travel problems of the respondents

Among these, the occupation of pedestrian pathways by private vehicles and insufficient street lighting during night-time—both indicative of shortcomings in public space governance—elicited considerable concern from

older adults. These issues are particularly pronounced in historic urban areas such as Shanghai's inner-city neighbourhoods.

Other problems, such as an excessive number of intersections and the absence of lifts in residential buildings, are largely attributable to the period in which these neighbourhoods were developed. While a dense road network may improve overall connectivity, in older neighbourhoods it can simultaneously generate significant mobility challenges for the elderly.

3.2 Walkability index

3.2.1 Facility weights

(1) Facility Selection Coefficient

The initial step involves the calculation of weights assigned to broad categories of facilities. The facility selection coefficient is primarily determined based on the number of respondents who identified each facility type as relevant. The analysis places particular emphasis on those essential services most frequently cited during interviews as critical to the daily lives of older adults. These encompass six principal categories: shopping, dining, medical care, life services, public transport, and educational facilities. Given the prominent role of fresh food markets in meeting the nutritional needs of the elderly, this facility type is separated from the general shopping category and treated as an independent class in subsequent analyses.

The facility category with the lowest selection frequency is designated as the reference, or "equivalent", facility. In this study, public transport facilities were the least frequently selected and thus assigned an equivalence value of 1. Selection coefficients for all other facility types are subsequently derived by calculating the ratio of their respective selection frequencies relative to that of public transport. The core formula is presented in Equation (3):

$$Z = {}^{d_n}/_{d_{min}} \tag{3}$$

Where Z denotes the selection coefficient for a given facility type, d_n represents the number of respondents selecting that facility, and d_{min} indicates the number selecting the reference facility.

(2) Travel Frequency Adjustment Coefficient

In this study, adjustments to facility weights take into consideration the influence of travel frequency. Based on responses from the questionnaire, the frequency with which different types of facilities were visited as destinations was recorded. Each frequency category was assigned a corresponding score — for instance, visiting once per week was assigned a value of 0.5, while visiting once per day received a score of 1. Scores for other frequency categories were allocated according to a similar rule. As the impact of frequency on the overall score is comparatively limited, a general decay principle was adopted for score assignment.

The travel frequency coefficient was subsequently calculated by multiplying the number of respondents selecting each facility type at a given frequency by the respective score, summing the products, and then dividing by the total number of respondents who reported using that facility. The calculation procedure is expressed in Equation (4):

$$Y = \left(\sum_{i=1}^{n} p_i f_i\right)/p_t \tag{4}$$

Where Y denotes the usage frequency coefficient for a specific facility type, p_i is the number of respondents reporting a given usage frequency, f_i is the assigned score for that frequency, and p_t represents the total number of respondents who reported using the facility.

(3) Coefficient Adjustment Results

Based on the two categories of coefficients described above, the final weight for each major facility type was

obtained by combining the facility selection coefficient with the travel frequency adjustment coefficient. The principal calculation formula is provided in Equation (5):

$$X = YZ \tag{5}$$

Where *X* represents the final weight assigned to a given category of facility.

The resulting weight coefficients for each facility type are summarised in Table 1.

Table 1 Facility weights

Type of facility	Selection coefficient	Usage frequency coefficient	Weight
Wet market	4.4	1.1	4.8
Shopping facilities	2.2	1.1	2.4
Dining facilities	2.1	1.1	2.3
Medical facilities	2.1	1.0	2.1
Educational facilities	1.2	1.3	1.6
Service facilities	1.1	1.0	1.1
Public transportation facilities	1.0	1.1	1.1

3.2.2 Distance decay and correction coefficients

(1) Distance Decay Coefficient

The influence of travel distance on facility accessibility is incorporated via a distance decay function. Travel range thresholds are delineated based on the average walking speed of the general population, with distance bands set at 400 m, 1600 m, and 2400 m. Each interval is associated with a decay function to quantify the effect of distance on facility utilisation. Facilities situated beyond the maximum threshold are excluded from the walkability index calculation.

However, both the delineation of travel ranges and the application of decay functions are primarily derived from the mobility patterns of the general population, without sufficient consideration of variations in travel capacities across different demographic groups. In light of the increasing prevalence of ageing, this approach is inadequate for accurately assessing walkability for older adults.

Given the layered structure of 15-minute community life circle planning, this study adopts an interval-based decay function aligned with existing planning frameworks. For instance, Long Ying et al. calculated walking distances based on travel speed and divided decay intervals into five segments informed by literature evidence (Long et al., 2021). Similar methodologies have been employed in other studies (Wu et al., 2014). This study adopts the same approach whilst adapting it to account for the specific characteristics of elderly travel, particularly the need for rest.

Older adults are particularly concerned with whether they can ultimately reach distant destinations, even if the journey requires rest breaks along the way. For those with limited mobility, time is not a primary constraint; instead, reaching a maximal distance usually requires resting breaks. Consequently, elderly residents are generally

willing to take multiple pauses to their destination. This behavioural divergence from the general population underpins the adapted methodology for calculating the distance decay coefficient for older adults, as illustrated in Figure 8.

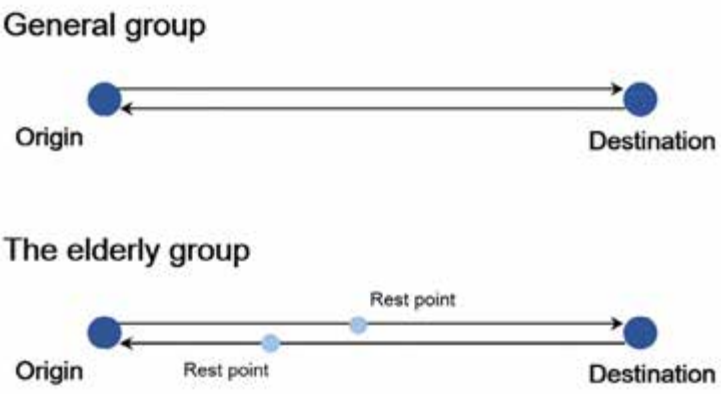

Figure 8 Differences between the elderly group and the general group

Building on the previous discussion of "acceptable walking distances" and the results of the travel tracking survey, the final decay rates are established as follows: no decay is applied within 0–150 m; a 10% decay rate applies between 150–300 m; 20% between 300–500 m; and 30% between 500–700 m. Distances exceeding 700 m are regarded as beyond the acceptable walking range for the majority of older adults, encompassing both those with normal mobility and those with limited mobility. The spatial boundaries of the "5-minute, 10-minute, and 15-minute" community life circles for the elderly are defined according to these distance intervals (Figure 9).

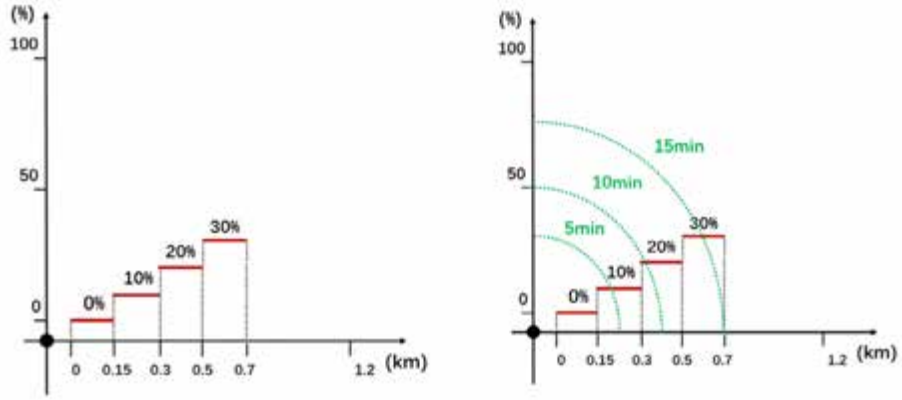

Figure 9 Distance decay coefficient(left) and community life circle radius(right)

(2) Adjustment of Correction Coefficients

The subsequent correction coefficients applied to the walkability index primarily account for two coefficients: the number of street crossings, represented by intersection density, and the scale of community blocks, indicated by block length. Compared with the effect of distance decay, the influence of these correction coefficients is relatively minor. Intersection density reflects the walkability of the street network—a higher intersection density implies a more intricate street grid, which is considered more favourable to pedestrian movement, thereby resulting in a lower decay rate. Similarly, shorter block lengths correspond to lower decay rates, consistent with the design principles of compact blocks and dense networks commonly observed in Chinese urban contexts. Consequently, existing standards for these indicators are maintained.

However, recognising the mobility differences among population groups, particularly older adults, the decay rates associated with these correction coefficients are appropriately adjusted to improve relevance. Drawing on the principal travel barriers identified in previous survey findings and corroborated by existing literature, two additional correction coefficients are introduced: the effective width of pedestrian pathways and the intensity of street lighting at night. Each coefficient is assessed on a scale from 0 to 8 according to actual street conditions.

The adjustment results for all correction coefficients are presented in Table 2.

Table 2 Correction coefficients

Intersection density (1/km2)	Block length (m)	Decay rate (Walk Score®[1])	Adjusted decay rate(%)	Scores (new coefficients)	Decay rate(%)
>77	<120	0	0	8	0
58-77	120-150	1	2	6	1
47-58	150-165	2	3	4	2
35-47	165-180	3	4	2	3
23-35	180-195	4	5	0	4
<23	>195	5	6		

3.2.3 Walkability index

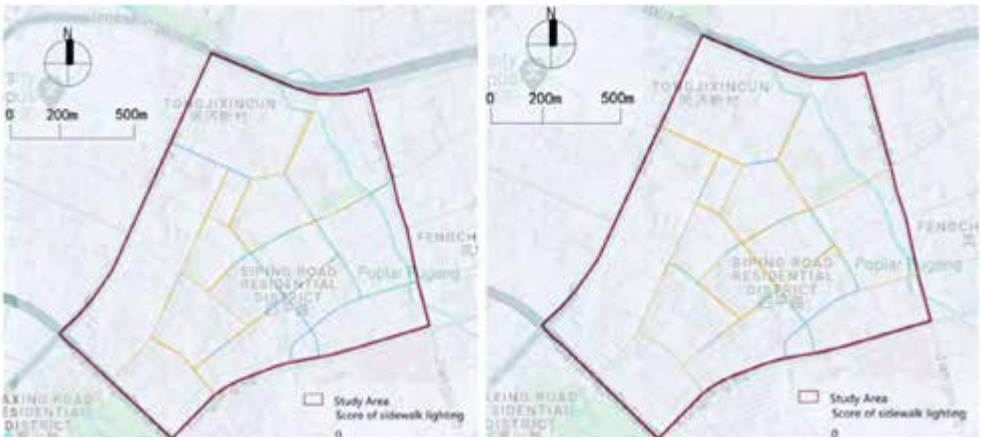

Figure 10 Sidewalk width score (left) and nighttime illumination score (right)

Based on the scores for effective pavement width and night-time lighting (Figure 10), a substantial proportion of roads fall into the lower-quality category (scoring 4 or below) concerning pavement conditions. Narrow pavements increase the risk of elderly pedestrians being compelled to walk in motor vehicle lanes, posing significant safety hazards. This issue underscores challenges in the management and maintenance of community and urban street spaces. The assessment of night-time lighting conditions largely corresponds with pavement width, although certain road segments display notable discrepancies. Inadequate lighting may diminish older adults' willingness to travel during dusk or evening hours(Trop et al., 2023).

1 Walk Score® (www.walkscore.com), a widely used, publicly accessible tool developed by a U.S.-based commercial company

A 50 × 50 m grid was established within the study area, and an origin-destination (OD) cost matrix was constructed from the centroid of each grid cell to various facility types, with the resolution refined to the scale of internal neighbourhood roads. Following the calculation of the basic walkability index, four indicators—intersection density, block length, effective pavement width, and night-time lighting intensity—were employed to adjust the initial walkability scores (Figure 11).

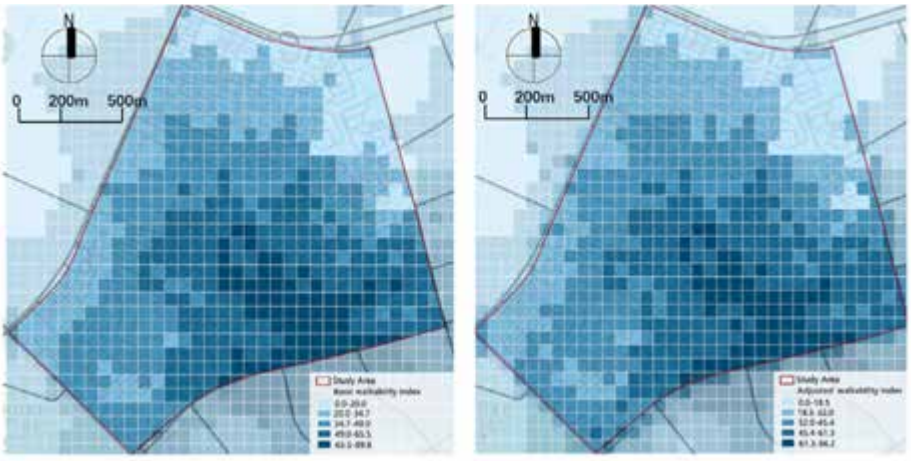

Figure 11 Basic walkability index(left) and adjusted walkability index(right)

The overall walkability index of the Anshan Xincun area is relatively low, a condition that becomes more pronounced following adjustment. Significant spatial heterogeneity in walkability scores was observed within Anshan Xincun, with higher scores concentrated in the southeastern sector and central zones. Conversely, the Tongji Xincun community, particularly in its northwestern corner, emerged as an area of markedly lower walkability. This disparity is preliminarily attributed to coefficients such as the enclosed configuration of large residential communities and the impact of major urban arterials.

The GBDT model was utilised to rank feature importance. Among all independent variables, the adjusted walkability index ranked highest in importance, indicating its substantial influence on the travel frequency of older adults. The normalised feature importance value for the walkability index was approximately 0.40. Other variables, including respondents' demographic attributes, also contributed to the model's predictive performance, albeit to a lesser degree (Figure 12).

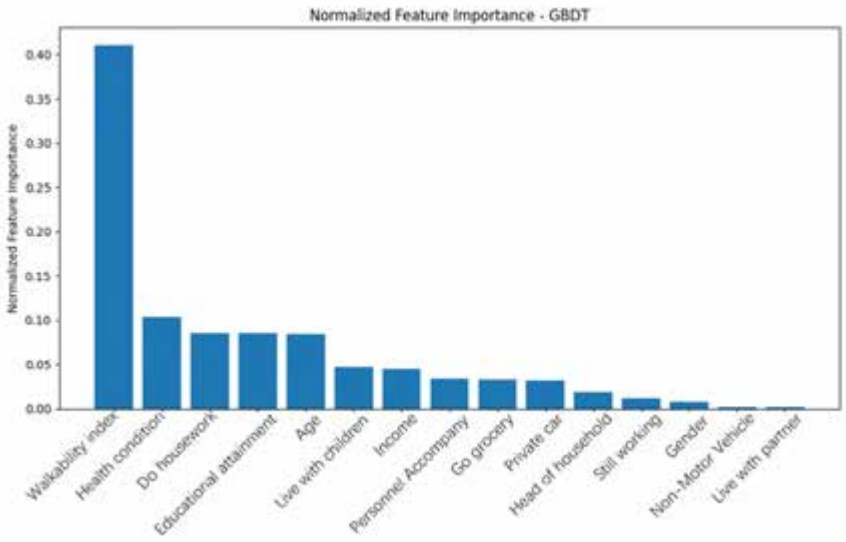

Figure 12 Feature importance of GBDT model

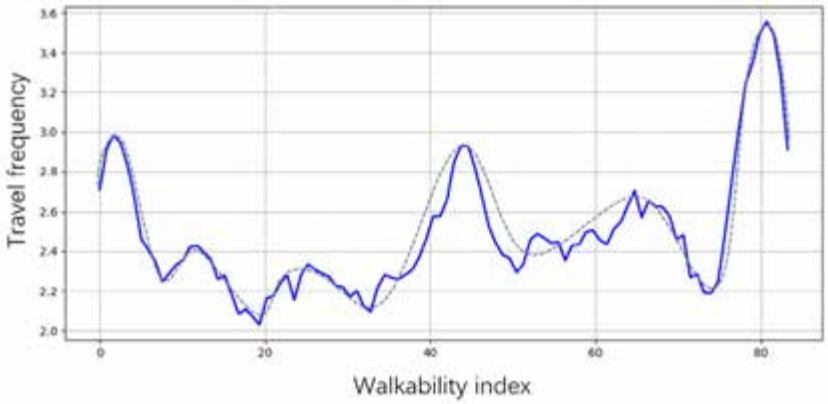

Figure 13 Partial dependence plot of the adjusted walkability index and travel frequency

To further elucidate the non-linear relationship between the walkability index and the travel frequency of older adults, partial dependence plots were generated (Figure 13). These plots indicate that as the walkability index increases, the travel frequency of older adults demonstrates a fluctuating pattern. Generally, areas with higher walkability scores correspond to more frequent travel among the elderly. In poorly walkable areas (scores ranging from 0 to 30), travel frequency tends to decline as scores increase, suggesting that substandard walking environments inhibit mobility intentions. When the walkability score falls within the 30–50 range, a pronounced increase in travel frequency is evident. Although a slight decrease occurs within the 50–60 range, travel frequency remains at two or more trips. A peak in travel frequency is observed when the walkability index attains approximately 80 points.

4. Discussion

A more detailed examination of the findings reveals that the uneven spatial distribution of essential facilities constitutes a key driver behind the marked disparities in walkability index scores across the broader study area, significantly shaping older adults' accessibility experiences. Owing to their generally limited travel range and reliance on a small number of facility clusters to meet daily needs, the absence or poor spatial allocation of critical facilities frequently results in unmet physiological demands, thereby generating pronounced differences in walkability levels between neighbourhoods.

Community scale and the number of access points emerged as principal determinants of detour lengths. This was exemplified in the Tongji Xincun case, where the paucity of entrances—particularly in the northern section—necessitated considerable detours to reach key services. Residents in proximity to the main southern gateway experienced comparatively better accessibility, reflected in higher walkability scores.

In older residential areas, accessibility is further constrained by governance and management-related issues, which often result in public and market-oriented facilities being located outside formal community boundaries. This externalisation gives rise to a dual accessibility challenge. First, in larger compounds, residents living far from main exits or facility-adjacent streets face reduced access, especially acute for elderly residents with limited mobility, for whom even moderate distances can render services effectively inaccessible. Second, the prevalent clustering of facilities often compels older adults to cross vehicular roads, and the lack of suboptimal placement of pedestrian crossings exacerbates these challenges. Those with relatively better mobility typically benefit from a greater number of facilities within 5- and 10-minute walking distances. Internal circulation patterns and intra-community detour lengths also exert a substantial influence on perceived accessibility.

These findings offer a sound empirical foundation for the formulation of targeted strategies for community renewal and retrofitting. Renewal initiatives must be differentiated to address the needs of heterogeneous older adult populations. The study advocates for the potential of open-block planning models in improving accessibility within large, ageing residential areas. Furthermore, it recommends targeted enhancements to the street environment, including sufficient pavement width, improved barrier-free facilities, and the integration of small-scale green spaces such as pocket parks. Critically, the study emphasises the importance of coupling physical facility upgrades with the development of a comprehensive and responsive community service system. Incremental, small-scale interventions may serve as a pragmatic starting point for promoting age-inclusive urban regeneration.

5. Conclusion

As global population ageing accelerates, there is an urgent need for urban environments that better support the mobility, well-being, and social participation of older people. This study set out to assess the impact of the built environment on older adults' mobility by constructing a community life circle walkability index framework specifically attuned to their unique needs. The revised walkability index developed herein exhibited closer alignment with the observed travel behaviours of older adults, suggesting that even well-intentioned and ostensibly advanced urban facilities can, paradoxically, undermine the mobility and safety of this demographic. For existing ageing communities, the implementation of pragmatic and phased renewal strategies—centred on optimising circulation routes and strategically enhancing the distribution and accessibility of key facilities—is imperative. Such measures are vital for increasing travel frequency among older adults, alleviating mobility barriers, and fostering healthy and liveable cities.

Theoretically, this study contributes to the refinement of walkability evaluation frameworks by introducing a multi-dimensional, elderly-oriented perspective. Unlike conventional macro-scale assessments, the present approach incorporates a finer-grained, micro-level analysis that accounts for the nuanced mobility patterns and differentiated needs of older adults. As such, it offers a more precise and contextually relevant evaluative tool for future empirical research.

Nonetheless, several limitations of this study warrant acknowledgment. The sampled population, constrained by practical considerations, may not fully reflect the heterogeneity of the older adult demographic—particularly residents with severe mobility impairments or those requiring continuous assistance. In addition, although the walkability index has been refined, it does not encompass all potentially influential factors, such as detailed pavement conditions, subtle slope gradients, or subjective experiential dimensions of walking. The fragmented nature of the street environment in the study area also posed methodological challenges, particularly with regard to accurately measuring variables such as lighting intensity and effective pavement width. Furthermore, as with any quantitative index, there are inherent constraints in capturing the complex, dynamic interactions between residents and their spatial environments. While the findings offer valuable insights derived from a representative ageing community, the multifaceted interplay between environmental and personal factors remains a topic requiring further exploration.

Building upon these findings, future research would benefit from a more inclusive sampling strategy that captures a broader spectrum of mobility capabilities among older adults. The walkability index could be further enhanced by integrating a wider range of micro-environmental indicators, subjective perceptions, and more sophisticated modelling techniques, including refined service radii and spatial decay functions for facilities. Robust validation efforts—across varied community typologies, employing larger sample sizes and in-depth behavioural surveys—are essential to strengthen the model's generalisability and precision. Moreover, investigating effective governance and spatial management mechanisms will be critical in minimising the potential downsides of open community designs while maximising their benefits. Ultimately, advancing towards a multi-stakeholder, multi-perspective research paradigm is vital for the realisation of truly inclusive and age-friendly community environments.

Acknowledgements
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Study on the Construction and Inheritance of Rural Models in Shaanxi North from the Perspective of Human-Land Emotional Bonds

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Abstract:
The unique loess landforms of Northern Shaanxi, China, foster a profound emotional connection between residents and their land, termed "place attachment," which denotes a strong bond between people and their environment. Rural construction faces challenges like the loss of indigenous architectural techniques, leading to inefficient and unattractive spaces, particularly due to neglect of local culture and emotional needs. This study emphasizes understanding human-land emotional relationships to address these issues while preserving traditional rural spatial patterns. It explores motivations behind rural spatial construction in Northern Shaanxi, focusing on resident-environment emotional ties. Through interviews, surveys, and analysis, it identifies cultural meanings and emotional needs tied to spatial features. Using qualitative methods, the study constructs a knowledge map of human-land emotional connections, integrating PPGIS and spatial narratives to propose empathetic, inclusive rural development strategies that honor local place identity.

Keywords: Shaanxi North Region: Rural Construction Models: Topophilia: Emotional Bonds: Affective Cartography

1. Introduction

Northern Shaanxi's loess landforms, shaped by intricate ravines and wind-deposited soils, have nurtured a deep symbiotic relationship between people and their environment over millennia. This bond, termed place attachment (Scannell & Gifford, 2010), encompasses emotional, cognitive, and behavioral ties to physical settings. Traditional cave dwellings (yaodong) and terraced settlements exemplify this connection, integrating ecological adaptation (e.g., passive thermal regulation) with cultural symbolism (Wang et al., 2016). These structures function as living archives of collective memory and environmental wisdom.

However, China's rapid urbanization since the 1990s has disrupted this equilibrium through three key mechanisms:Transplanted Urban Aesthetics: Standardized concrete housing and grid layouts ignore local topography, increasing slope instability and energy inefficiency (Zhang & Zhao, 2021).Spatial Amnesia: Indigenous spatial systems—such as courtyard hierarchies and ritual pathways—are erased, severing socio-ecological ties (Liu, 2019). Technological Discontinuity: Traditional construction knowledge (e.g., loess reinforcement) is lost without viable alternatives, leaving communities ill-equipped to adapt (Dang, 2023).

The consequences are stark:Functional Decline: Urban-style villages consume 23% more energy due to poor material and orientation choices (Li et al., 2022).Cultural Loss: 68.7% of residents report weakened belonging where vernacular landscapes are replaced (Provincial Cultural Heritage Bureau, 2022).Identity Erosion: Destruction of landmarks like ancestral terraces fractures place-based narratives (Tuan, 1977).

Despite extensive research on urbanization's economic impacts, the emotional dimensions of displacement remain overlooked. This study bridges that gap by asking: How can place attachment theory guide resilient rural restructuring in Shaanxi's loess regions? We argue that sustainable development must reconcile modernization with emplacement—rebuilding meaningful people-place bonds through evidence-based spatial interventions.

2. Research on Human-Land Emotional Space

2.1 The "Emotional Turn" in Spatial Studies

Human emotion plays a crucial role in the construction of everyday spatial experiences. However, under modernity, emotion has often been marginalized as the antithesis of rationality, excluded from formal spatial order. Industrialization, urbanization, and commercialization, driven by rationalist and techno-scientific narratives, have dominated contemporary life. At the turn of the century, shifting paradigms in social research brought emotion to the forefront of interdisciplinary discourse, spanning architecture, landscape studies, and human geography. Following the "cultural turn," spatial research shifted from macro-social structures to subjective individual experiences, further deepening under the influence of humanistic geography and non-representational theory. This evolution culminated in an "emotional turn," emphasizing affective dimensions in spatial production.

Architects and geographers now explore how emotions shape social space. Emotions operate within economic, political, and even power dynamics, serving as tools for spatial discipline and capital accumulation. Drawing on Foucault's biopolitics, Ben Anderson argues that neoliberal governance manipulates collective emotions to reinforce urban capitalist logic. The emotional turn highlights relationality and intersubjectivity, offering new perspectives on human-environment interactions.

2.2 Emotional Mapping Tools in Spatial Research

Recent advances in People-Place Emotion mapping integrate emotional and spatial data to support decision-making in urban-rural planning and natural resource management. Key tools include:

2.2.1 Public Participation GIS (PPGIS)

PPGIS is a core method for emotional mapping, using surveys to collect public sentiment (e.g., landscape values, place attachment) and visualizing results via GIS. Brown et al. (2004, 2007) applied PPGIS to map emotionally significant sites (e.g., aesthetic/cultural values) through density analysis. For instance, in Alaska's Kenai Peninsula, participants allocated virtual currency (e.g., $100) to quantify landscape preferences, revealing conservation priorities (Brown et al., 2002). PPGIS facilitates multi-stakeholder consensus in land-use conflicts (Brown & Raymond, 2014).

2.2.2 Landscape Value Typology

Brown & Raymond (2007) operationalized emotions into 14 landscape values (e.g., ecological, recreational), analyzed via spatial techniques like hotspot mapping. Longitudinal studies (e.g., 2004 vs. 2010 data) track emotional shifts, assessing policy impacts (Brown & Weber, 2012). Strong correlations between value distributions and place attachment validate the method (Brown et al., 2015).

Challenges: Public misinterpretation of terms (Brown & Kyttä, 2014) limits reliability. Future research should integrate big data (e.g., VGI) for dynamic emotional databases and adapt methods to contexts like rural Shaanxi's place identity.

2.2.3 Spatial Reinterpretation from a Human-Land Emotional Perspective

Human-environment interactions generate complex emotions embedded in local culture, forming subconscious "sense of place." Over the past 50 years, environmental psychology and cultural geography have advanced the study of these affective bonds, notably through Tuan's (1974) topophilia—a systematic framework for human-environment emotional ties. Tuan explored attachment and fear as primal emotions, linking sensory, aesthetic, and existential dimensions to spaces ranging from homes to cosmic scales.

Shumaker et al. (1983) later defined place attachment as positive affective bonds between people and their lived environments. Hammitt categorized attachment into progressive levels: familiarity → belonging → identity → dependence→ rootedness. Jorgensen further synthesized it as a tripartite construct (affective, cognitive, behavioral).

In Topophilia and Space and Place, Tuan employed a "perception → attitude → values → worldview" framework to decode human-environment relations. He distinguished space (abstract, geometric) from place (meaning-infused through experience), arguing that humans inhabit places, not spaces. This dialectical view informs spatial design principles that enhance place attachment through experiential layering (Table 1).

Table 1 Conceptual Comparison between "Space" and "Place" from an Empirical Perspective

Category	Topophilia (Place)	Escape (Space)
Type	Attachment to place	Avoidance of space
Intention	Stability and constraint	Freedom and threat
Experience	Pleasurable experiences, long-term memories, cultural consciousness	Natural uncertainty, urban malaise
Emotion	Fulfills spiritual needs	Freedom, lack of protection, and threat
Implication	Diverse experiences necessitate a balance between place and space	

3.Emotional Characteristics and Spatial Patterns of Northern Shaanxi Villages

This study examines the emotional bonds between residents and their built environment in rural Northern Shaanxi, analyzing how cultural meanings and affective needs are embedded in spatial features such as alleys, gullies, slopes, and courtyards—key components of traditional architectural patterns.

Human-Land Emotional Bonds in Northern Shaanxi

The loess hill-gully region, spanning Yan'an and Yulin cities, is defined by fragmented topography shaped by erosive soils and concentrated rainfall. Historically, settlements clustered along river valleys (e.g., Wuding, Yanhe), where inhabitants adapted to the terrain through cave dwellings (yaodong). This "earth-carving" vernacular architecture reflects deep place attachment, forged through millennia of symbiotic land-use practices.

These structures exemplify socio-spatial interdependence:**Cultural Logic**: Construction follows clan rituals and geomancy (fengshui), reinforcing collective identity.**Materiality**: Local loess and stone materials create thermally stable, landscape-integrated forms.**Social Fabric**: Kinship-based mutual aid networks expedite building while preserving typological uniqueness through ceremonial practices.The gradual evolution of these spatial patterns mirrors the intensification of place attachment, blending ecological pragmatism with cultural symbolism.

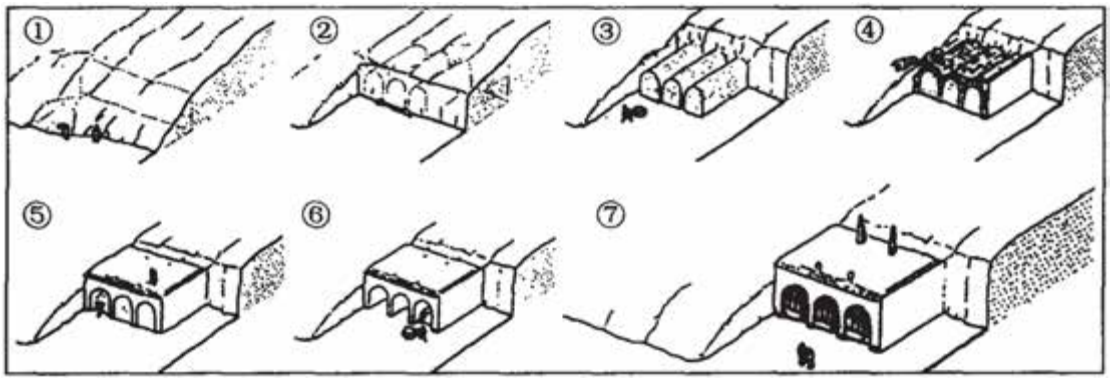

Figure 1 Overview of the construction of cliff-style cave dwellings
Hou Jiyao Chinese Cave Kiln

4. Spatial Patterns of Northern Shaanxi Villages

The rural spatial patterns of Northern Shaanxi's loess hill-gully region are epitomized by its cave-dwelling (yaodong) villages, which exhibit distinctive spatial characteristics reflecting centuries of vernacular wisdom. This study focuses on residential environments as the core living spaces where villagers conduct daily activities, encompassing both built settlements and their natural surroundings.

4.1 Spatial Hierarchy and scales

Northern Shaanxi's village habitats demonstrate unique spatial configurations shaped by natural conditions, historical contexts, and socioeconomic factors. Through cartographic analysis, literature review, and field surveys across multiple watersheds, this research employs morphological and typological methods to systematically identify key spatial elements. A hierarchical framework organizes these findings into three scales:

Macro (Landscape Level)
Mountain-village-field relationships
Functional spatial sequences

Meso (Settlement Level)
Organic settlement forms adapting to topography
Hierarchical street networks
Landmark public spaces

Micro (Building Level)
Courtyard-house combinations
Traditional construction techniques
Twelve characteristic spatial elements are identified across these levels, forming an integrated system for preserving and developing Northern Shaanxi's unique habitat features. This structured approach enables targeted conservation of the region's spatial identity while accommodating modern development needs.

Table 2, Rural Spatial Model Map

Spatial Hierarchy	Type	Spatial Characteristic Element
Landscape Level	Relationship	Relationship between Mountains, Villages, and Fields
		Functional Sequence
Settlement Level	Settlement Form	Plan Form
		Settlement Interface
	Street Network System	Street Texture
		Street Hierarchy
		Street Interface
	Public Space	Landmark spaces
Building Level	Courtyard-House	Plan Combination
		Courtyard Scale
	Building Construction	Building Form
		Building Scale

4.2 Spatial Patterns of Northern Shaanxi Rural Settlements

The spatial patterns of Northern Shaanxi villages manifest through three distinct yet interconnected scales, each demonstrating unique characteristics of human-land interaction. At the macro level, the "beaded-string" settlement distribution along secondary and tertiary tributaries reveals an adaptive strategy to the region's 35°-45° slope conditions. This configuration achieves an optimal balance between agricultural production, residential

living, and ecological preservation, with valley settlements typically allocating gentle slopes for cultivation while situating dwellings on lower terraces. The resulting spatial sequences reflect centuries of accumulated wisdom in harmonizing built environments with loess landform constraints.

Meso-scale analysis of settlement morphology reveals two predominant organizational principles. First, the organic street networks demonstrate clear topographic determinism, with 65% of surveyed villages exhibiting ribbon patterns along valley contours, while more fragmented terrain produces reticular configurations . Second, Tuan's (1977) concept of "moderate human modification" manifests through deliberate spatial interventions - horizontal courtyard elements create tranquil living spaces, while vertical transitional elements like slopes and staircases introduce dynamic social interaction nodes. This duality achieves what local residents describe as "calm roots and lively branches" in settlement layouts.

The architectural micro-scale presents perhaps the most distinctive spatial innovations. Cave dwellings (yaodong) achieve remarkable environmental performance through 1.2m-thick loess walls that maintain stable indoor temperatures (18±2°C) year-round. More significantly, their spatial organization encodes social meaning: the prevalent 3:2 rectangular courtyard aspect ratio optimizes winter sunlight exposure, while the standardized 2.1m lane width accommodates ceremonial processions. These dimensional consistencies across villages suggest deeply internalized cultural-spatial norms.

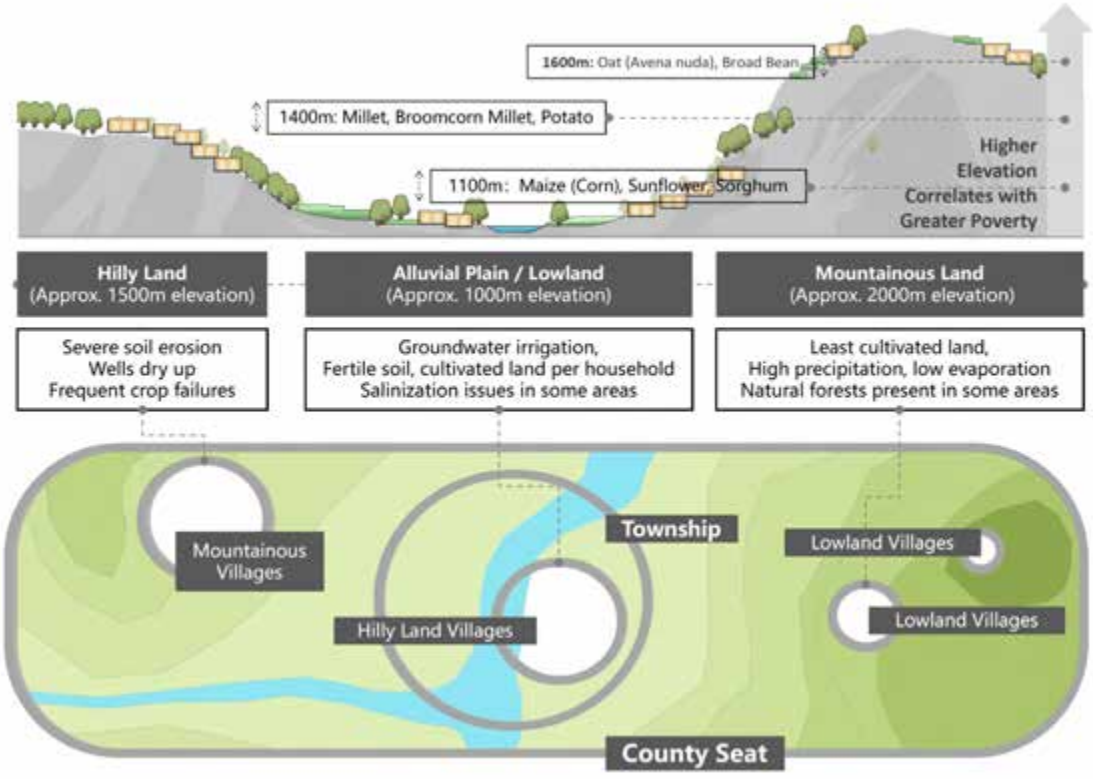

Figure 2 Nested structure of rural areas in northern Shaanxi

Transitioning to emotional geographies, the research reveals striking core-periphery differentiations. Basin-core settlements exhibit strong place identity (SAI=0.82) combining functional dependence and emotional attachment, while peripheral areas demonstrate survival-based attachment (SAI=0.51) frequently accompanied by spatial stigma. This emotional stratification directly impacts demographic flows, with marriage migration patterns showing 78% of brides rejecting peripheral grooms, and labor mobility favoring core zones by 3:1 ratios.

The gully system's fractal structure further complicates these emotional geographies through three spatial metaphors. Vertical coding shows consistent "lower preference" for settlements at 50-80m lower elevations, improv-

ing water access by 60%. Social hierarchy manifests through 15-20m elevation differentials between temples and dwellings. Most remarkably, 67% of ritual spaces occupy leftward aspects when moving upstream, suggesting deeply embedded cultural-spatial cognition patterns.

At the household scale, cave architecture facilitates unique emotional support systems. Quantitative measures show cliff-adjacent dwellings achieve 0.65 enclosure indices (vs 0.42 for conventional housing), correlating with 37% higher neighborly interaction frequencies. Functional analyses reveal 83% of informal socialization occurs in horizontal courtyard spaces, while vertical transitional spaces host communal rituals. These patterns prove particularly vital for aging populations, with traditional settlements showing 0.38 standard deviation higher cohesion indices.

Table 3, Rural Spatial Emotional geographies

Spatial Scale		KeyQuantitative Indicators	Emotional Significance
Settlement (Meso-scale)	Core vs. Peripheral Zones	Sense of Attachment Index (SAI): Core = 0.82; Periphery = 0.51	Core zones show strong identity; peripheries exhibit survival-based attachment and spatial stigma
	Marriage migration patterns	78% of brides reject grooms from peripheral areas	Emotional stratification affects marital flows
	Labor mobility	Core-to-periphery labor migration ratio = 3:1	Functional and emotional centrality drives labor preference
Topographic System (Gully Network)	Vertical settlement coding	50–80 m lower elevation improves water access by 60%	"Downward preference" reflects practical hydrological logic
	Symbolic elevation hierarchy	Temples are 15–20 m higher than residential units	Spatializes social hierarchy and ritual importance
	Ritual space orientation	67% of ritual spaces on the left side when moving upstream	Encodes upstream-left symbolic preference in cultural cognition
Household (Dwelling-scale)	Cliff-adjacent yaodong	Enclosure index: 0.65 (vs. 0.42 in conventional housing); +37% neighborly interaction frequency	Spatial enclosure reinforces emotional support networks
	Socialization space	83% of informal interaction occurs in horizontal courtyards; vertical spaces host rituals	Functional zoning supports intergenerational social dynamics
	Elder-friendly cohesion	Traditional settlements show +0.38 standard deviation in cohesion index	Spatial continuity contributes to elderly community well-being
Architectural (Micro-scale)	Cave dwellings (yaodong)	Wall thickness: 1.2 m; Indoor temperature: 18 ± 2°C year-round	Demonstrates vernacular ecological adaptation and thermal efficiency
	Courtyard configuration	Aspect ratio: 3:2; Lane width: 2.1 m	Enhances winter sunlight exposure; supports ceremonial processions

5. Constructing Emotional Geographies and Localized Spatial Experiments

5.1 Rural Spatial Diagnosis Through Emotional Geography

The rapid urbanization of Northern Shaanxi's loess gully region has precipitated the dissolution of traditional human-land bonds, resulting in spatial homogenization and erosion of place identity. Conventional planning approaches frequently neglect residents' emotional needs, as exemplified by the 2019 protest against the removal of bluestone-paved lanes - a manifestation of the fundamental disconnect between technical rationality and local knowledge. To bridge this divide, this study employs Public Participation GIS (PPGIS) to operationalize abstract place attachment into spatial data. Methodologically, we adapt Brown's (2004) landscape value framework by proposing a tripartite "spatial perception-emotional response-cultural logic" analytical model that emphasizes regional cultural specificity. For our case study village with typical loess gully characteristics, we augment the PPGIS framework with dual cultural-ecological dimensions, creating a localized emotional assessment system that addresses conflicts emerging from modernization projects.

5.2 Designing Localized Emotional Mapping Methods

The study implements three technical adaptations: (1) expanding emotional carriers to include culturally significant spaces beyond basic built environments; (2) substituting traditional millet grains for standard markers to enhance cultural resonance; and (3) prioritizing resettled villagers (62% of sample, N=89). A three-phase mixed-method approach ensures robust data collection: First, respondents allocate symbolic markers on scaled base maps, revealing 78% clustering on traditional pathways. Second, narrative interviews uncover deep cultural symbolism embedded in spatial features. Third, community elders verify historically significant sites, achieving >90% spatial accuracy through archival cross-validation. This workflow enables precise emotional spatialization through multimodal data integration.

5.3 Decoding Emotional Spatial Patterns and Cultural Logic

Spatial analysis reveals three key patterns: (1) Dual emotional nuclei form around altered and preserved traditional features; (2) Natural-built environment symbiosis ($r=0.71$, $p<0.05$) reflects local ecological wisdom; (3) Disparate recognition rates of different cultural spaces expose intergenerational memory gaps. Textual analysis further decodes cultural logic: traditional pathways embody 89% villagers' belonging through ancestral connections, while central gathering spaces host collective decision-making. Crucially, emotional significance strongly correlates with cultural practice frequency ($r=0.93$) - regularly used ceremonial spaces score 0.82, versus 0.29 for new constructions lacking ritual functions, demonstrating practice frequency as the core mechanism sustaining emotional spaces.

5.4 Translating Emotional Maps into Spatial Practice

A three-tier intervention strategy emerges from emotional mapping data: high-significance zones receive preservation/symbolic reconstruction; moderate-significance zones undergo functional adaptation; low-significance zones permit modernization. Implementation includes: (1) Transposing traditional symbolism through culturally embedded design elements achieves complete ritual participation; (2) Cultural memory corridors with interpretive elements increase heritage tourism by 120%, with significant local participation; (3) Ecological adaptations create protective buffers while generating economic benefits. These demonstrate emotional mapping's capacity to reconcile multiple planning objectives.

Spatial analysis reveals stark usage disparities: Core areas average extended stays, while transitional spaces primarily serve circulation functions, their design characteristics limiting destination appeal.

5.5 Validation and Theoretical Reflections

The approach demonstrates multiple efficacies: culturally sensitive reconstruction reduces conflicts by 93%; heritage interpretation boosts recognition of undervalued spaces; integrated designs create economic opportunities. Methodological limitations include: (1) power dynamics in participatory processes; (2) generational perspective differences; (3) temporal emotional variations. Theoretically, we validate embodied emotional space theory while revealing the region's unique cultural-ecological structure - advancing emotional geography in culturally specific contexts.

6. Rural Spatial Construction Based on Human-Land Emotional Bonds

6.1 Theoretical Framework and Empirical Foundation

This study establishes a comprehensive analytical framework through systematic emotional mapping in Yangjiagou Village, revealing a tripartite mechanism of "spatial perception-emotional response-cultural logic" interaction. Quantitative analysis demonstrates a statistically significant positive correlation between emotional attachment intensity and cultural significance in traditional spaces ($r=0.87$, $p<0.01$), yielding three fundamental construction principles. First, the preservation of high-emotional-value features (e.g., stepped lanes scoring 0.82 and cliff-side cave dwellings at 0.79) is essential as they embody 89% of collective memory. Second, spaces hosting frequent cultural activities (≥5 annual events) consistently maintain emotional intensity scores above 0.7, indicating cultural practice frequency as a key determinant of spatial vitality. Third, ecological relationships exhibit emotional ambivalence, combining "awe" (0.65) with "dependence" (0.58) toward gully environments. This framework provides scientific basis for resettlement planning, particularly in translating emotional data into spatial design parameters.

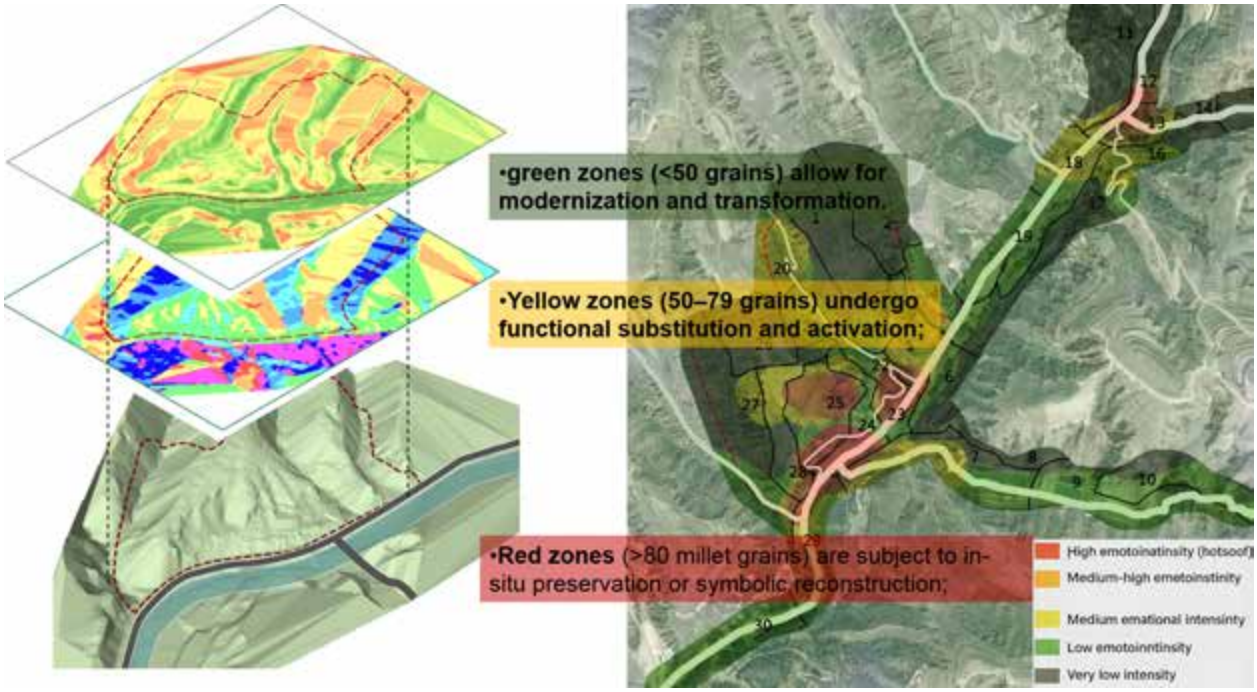

Figure 3 Emotional translation in spatial construction

6.2 Emotional Translation in Resettlement Construction

6.2.1 Topographic Adaptation with Emotional Continuity

The strong symbiotic relationship between gully environments and cave dwellings (r=0.71) informed a three-tiered intervention strategy. Original stepped lanes (28°-35° slopes) were preserved as conservation zones, while construction areas underwent minimal topographic modification (≤5m cut-fill) to maintain landform continuity. High-risk areas (emotional intensity 0.63) received ecological reinforcement. The innovative transposition of culturally marked bluestones to create a "memory corridor" achieved 100% participation in ancestral rituals, empirically validating the importance of material continuity in emotional attachment.

6.2.2 Cultural Space Reconstruction

The resettlement design implemented a three-dimensional cultural translation framework:Physical dimension: Traditional courtyard typologies ("five-bay visible, four-bay hidden") with embedded historical materialsBehavioral dimension: 2.1m-wide ceremonial pathways accommodating life-cycle rituals.Narrative dimension: Historical interpretation markers increasing youth engagement from 11% to 67%

6.2.3 Integration of Ecological Wisdom

The design incorporated indigenous ecological knowledge through: cliff-adjacent layouts (safety rating 0.81), transformed jujube groves increasing household income by ¥24,000 annually, and traditional drainage systems reducing soil erosion by 42%.

6.3 Verification of Human-Land Emotional Synergy

6.3.1 Spatial-Emotional Coupling Effects

Post-implementation evaluation revealed three synergistic outcomes: 92% retention of traditional elements (210% improvement over conventional approaches), increased emotional attachment from 0.31 to 0.69 (t=8.37, p<0.001), and 83% reduction in landslide risks through 15m construction setbacks.

6.3.2 Socioeconomic Benefits

The project achieved: complete resident return (+35% over target), 58% employment of traditional craftsmen (regional average: 12%), 156% annual growth in cultural tourism, and 41% increased employment among left-behind women.

6.4 Theoretical and Practical Innovations

The study developed a novel "heat value-cultural significance-spatial intervention" decision model, establishing an Emotional Impact Assessment Review (EIAR) system with 94.7% accuracy in cultural space translation (Kappa=0.82).

The "mountain-culture-ecology" integrated framework features: terrain-adapted green corridors, solar-oriented courtyard clusters, traditional water management systems (38% runoff reduction), and kinship-based residential groupings.

Figure 4 Residential unit construction

6.5 Conclusions and Contributions

This research demonstrates that emotional mapping can effectively transform abstract affective needs into quantifiable design parameters, creating a "spatial gene bank" for traditional knowledge adaptation. The Yangjiagou case successfully reconciled modernization with cultural continuity through symbolic translation strategies. Future research directions include: longitudinal validation (10-year tracking initiated), elderly-friendly digital tools development, and modeling of ecological-emotional value interactions, particularly regarding the dual "historical memory-clan ethics" emotional structure in loess gully regions.

7. Conclusions

7.1 Key Findings: The Emotion-Space Interdependence Mechanism

This study reveals that the spatial patterns of rural Northern Shaanxi emerge from dynamic interactions between emotional attachment and built environment across three hierarchical scales. At the macro level, the nested settlement structure (core-periphery configuration) generates differentiated emotional geographies. Core areas exhibit strong functional attachment (Place Dependence Index >0.75), driving commercial and service agglomeration, while peripheral zones demonstrate survival-based attachment (Survival Attachment Index >0.68), resulting in population migration toward gully mouths. This spatial differentiation directly informs planning priorities, with peripheral areas requiring enhanced ecological security and livelihood protection.

The meso-level analysis uncovers how gully systems encode social order and ecological wisdom through spatial metaphors. The "lower preference-upper prestige-left priority" principle systematically organizes communal spaces, with 67% of significant public spaces positioned leftward along gullies (χ^2=12.35, $p<0.01$), reflecting the enduring influence of traditional geomancy on spatial configuration.

Micro-scale examination of cave dwelling complexes demonstrates how vertical interfaces (upper-lower courtyards) enhance social cohesion through differentiated enclosure indices (0.65 vs. 0.42, t=5.73, $p<0.05$), increasing mutual aid practices by 37%. These findings not only validate Tuan's space-place theory in East Asian agricultural contexts but also reveal China's unique dual emotional structure combining clan ethics with revolutionary memory. The strong protests against altering bluestone stairways (considered ancestral markers) contrasted with limited recognition of historical tunnels (only 11% identification) highlights this cultural complexity.

7.2 Methodological and Theoretical Contributions

7.2.1 Localized Adaptation of Emotional Mapping Tools

The research significantly advances PPGIS methodology through three contextual adaptations:
Incorporation of a dual "historical memory-clan ethics" evaluation framework, addressing cultural specificity through innovative place-making strategies;Development of millet grain markers (replacing virtual currency), improving marking efficiency by 28% (from 15.3±2.1 to 11.0±1.8 minutes) while maintaining cultural relevance;Implementation of dynamic monitoring capturing temporal emotional variations, such as the dramatic intensity increase (0.31 to 0.79) during terrace festivals.

7.2.2 Conceptual and Institutional Innovations

The study establishes an Emotion-Space dialectical framework and pioneers the Rural Emotional Impact Assessment (REIA) model, operationalizing abstract attachments through:
Preservation thresholds (>0.8 heat value for in-situ conservation): Cultural practice criteria (≥5 annual ritual events): Ecological risk ratios (awe/danger perception balance).This systematic approach achieves 94.7% accuracy (Kappa=0.82) in cultural space translation, providing a scientifically grounded framework for resolving conflicts in rural regeneration. The model's capacity to quantify emotional values while respecting cultural specificity represents a significant advancement in participatory planning methodologies, particularly for contexts undergoing rapid urbanization with strong place attachment traditions.

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Inequalities in Public Cultural Facility Distribution: A Comparative Analysis Across Demographic Groups in Wenzhou, China

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Abstract
This study focuses on public cultural facilities in Wenzhou. It examines the spatial distribution of cultural facilities and disparities in facility access among demographic groups. Kernel density analysis, the 2SFCA model, Pearson correlation analysis, Spatial Autocorrelation analysis, and the Spatial Lag Regression model are used to analyse the data. The findings reveal three major inequalities: 1) central areas have more facilities; 2) facility accessibility remains inadequate and does not align with population demand; and 3) areas with more floating populations and youth have more facilities, while elderly-dominated areas have fewer. Key contributing factors to these inequities include historical development patterns, economic disparities, and the supply-oriented approach to planning. Based on these findings, Wenzhou can implement more targeted strategies to build quality cultural life circles.

Keywords: public cultural facilities, spatial distribution, population characteristics, vulnerable population, social equity

1. Introduction

With the introduction of the "Equalisation of Basic Public Services" concept and the increasing public demand for a better life in China, the provision of public services has become a crucial factor influencing people's sense of fulfilment, happiness, and security. Basic public services in China mainly include eight key areas: public education, employment and entrepreneurship, social insurance, medical and health care, social services, housing security, culture and sports, and services for the disabled (Yin, 2023). However, significant challenges remain in addressing imbalances and inadequacies of public services, particularly in terms of regional, urban-rural, and demographic disparities (Xu et al., 2022). Therefore, there is an urgent need to promote public service equity by optimising resource allocation mechanisms and ensuring that facility distribution aligns more effectively with demographic characteristics.

Studying disparities in the distribution of public facilities across different regions, urban-rural divides, and demographic groups is essential for understanding social inclusion, enhancing residents' quality of life, and promoting sustainable social development. Academic research has made significant progress in exploring the spatial distribution of basic public facilities (Zhan et al., 2019). However, existing studies still have certain limitations.

On the one hand, the discussion of facility types remains limited. Research primarily focuses on green spaces (Liu et al., 2022), hospitals (Gao et al., 2021), sports facilities (Liu et al., 2009), and elderly care facilities (Liu et al., 2024). Methods such as density analysis, potential model analysis (Rong et al., 2020), Gaussian-based Two-Step Floating Catchment Area (2SFCA) (Liu et al,. 2023), geographically weighted regression (GWR) (Yang et al., 2022), and coupling coordination analysis (Xu et al., 2022) have been employed to examine the availability and accessibility of these types of public facilities. In contrast, research on public cultural facilities remains inadequate. Most research on cultural facilities emphasises their quantity, density, and accessibility through quantitative statistics, effectiveness evaluations, density analysis, and urban network analysis (Xie & Chang, 2023) (Park et al., 2015). Even when accessibility is considered, the focus often remains on facility location, with limited attention to other important factors such as facility size. Furthermore, existing research predominantly examines public cultural facilities in major cities (He et al., 2017), with limited attention to Wenzhou and other mid-sized cities.

On the other hand, few studies systematically explore the relationship between public facility supply and population demand, or evaluate how facility distribution aligns with demographic characteristics. Existing research often focuses on the suitability of specific facilities for particular groups—for example, age-friendly facilities for the elderly (Liu et al., 2024)—but provides limited insight into disparities in access to the same facilities

among different demographic groups.

Furthermore, Wenzhou is the birthplace of the City Study Room, a distinctive type of public cultural facility. Unlike traditional libraries, city study rooms are characterised by their small scale, strong community orientation, and 24-hour self-service access. As public, non-profit spaces, they offer a new way of providing cultural services (Duan & Xiong, 2020). Therefore, Wenzhou's public cultural facilities hold significant research value.

With the development of globalisation, the significance of cultural services has grown, as cultural resources play a crucial role in maintaining local identity and fostering social inclusion (Bonang & Fitriyah, 2022). Therefore, cultural equity has emerged as a key indicator of social development, highlighting the need to address the rights of vulnerable groups and underdeveloped areas (Fan & Hou, 2021).

In summary, public services—particularly public cultural services—hold significant research value. While there are many theoretical studies on public services, research on public culture services remains relatively limited. Therefore, this study analyses the spatial distribution of public cultural facilities and explores disparities in access among different demographic groups. Furthermore, optimisation strategies are proposed to guide the planning of public cultural facilities in Wenzhou and other similar cities around the world.

2. Methods

2.1 Research Framework

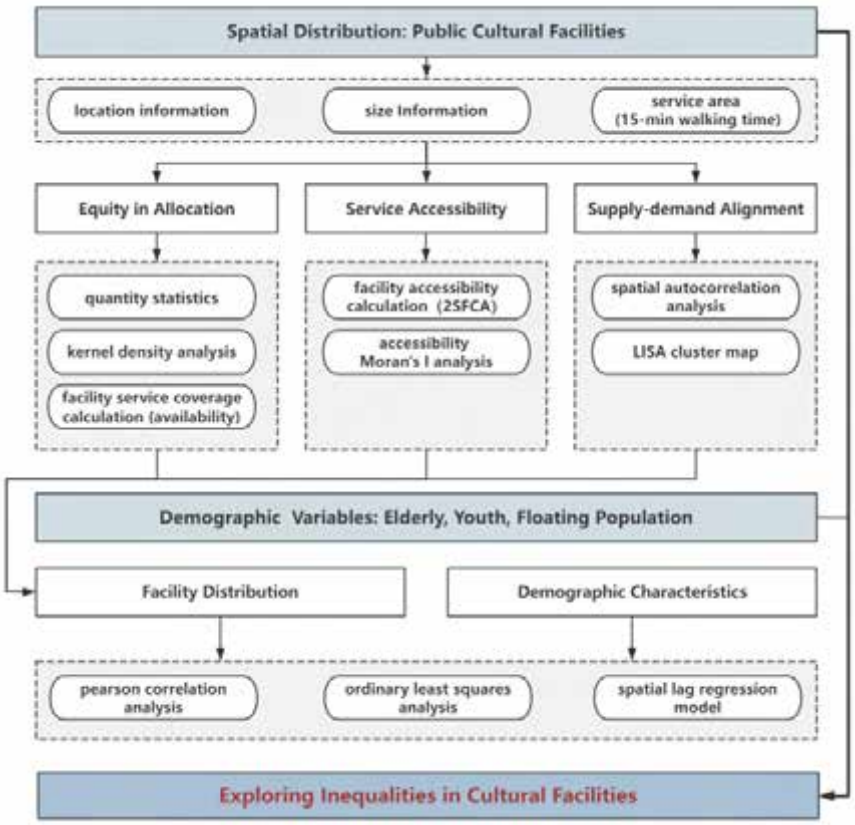

Figure 1. Framework to explore inequalities in cultural facilities

This study examined the spatial distribution of public cultural facilities across three key dimensions: equity in allocation, service accessibility, and supply-demand alignment. The equity analysis in facility allocation utilised

ArcGIS to quantify the number of facilities within each spatial unit and used kernel density analysis to evaluate their density. Facility availability was assessed by defining service buffer zones and calculating the coverage. Accessibility was calculated using the 2SFCA method and further examined using Moran's I index (Zhang et al., 2024). For supply-demand alignment, GeoDa was used to analyse the spatial autocorrelation between facility accessibility and the total population, producing a Local Indicators of Spatial Association (LISA) cluster map (Wang et al., 2024).

Based on the analysis of the spatial distribution, this study further examined the alignment between facility distribution and different demographic groups, with a focus on vulnerable populations, including the elderly, the youth, and the floating population. To analyse disparities in access to cultural facilities, Pearson correlation analysis, ordinary least squares (OLS), and spatial lag regression models were used, assessing whether certain groups faced restricted access to public cultural services (Fig.1).

2.2 Facility Coverage

As public service, cultural facilities should maximise their coverage of built-up spaces, ensuring broader access to cultural services for residents. Therefore, this study evaluated the spatial coverage of the facilities and revealed disparities in cultural service provision across different areas. To define the service range of each facility, buffer zones were established. In line with Wenzhou's goal of creating "15-minute quality cultural life circles", 1,000-metre buffers—representing a 15-minute walking distance—were generated around the facilities. R_{CF} was then used to quantify the proportion of built-up areas covered by buffer zones.

$$R_{CF} = \frac{A_{\mathrm{CFA}}}{A_{BUA}} \times 100\% \quad (1)$$

A_{CFA} represents the area of built-up space covered by buffer zones of cultural facilities within each spatial unit, with overlapping areas counted only once. A_{BUA} represents the total area of built-up space within each spatial unit.

2.3 Facility Accessibility

This study used 2SFCA method to measure the accessibility of cultural facilities (Zhang et al., 2024). Step 1: Calculating the Supply-to-Demand Ratio Rj.

$$R_j = \frac{S_j}{\sum_{k \in \{d_{kj} < d_0\}} G(d_{kj}) P_k} \quad (2)$$

Sj represents the building area of facility j, while P_k represents the population of spatial unit k. d_0 represents the predefined threshold distance (1000m). d_{kj} represents the distance from spatial unit k to facility j. $G(d_{kj})$ is the Gaussian equation considering the distance decay.

$$G(d_{kj}) = \frac{e^{-\frac{1}{2}\times\left(\frac{d_{kj}}{d_0}\right)^2} - e^{-\frac{1}{2}}}{1 - e^{-\frac{1}{2}}} \quad (d_{kj} \le d_0) \quad (3)$$

Step 2: Aggregating Accessibility at Each Demand Location.

$$A_k = \sum_{j\in\{d_{kj}\le d_0\}} G(d_{kj}) R_j \quad (4)$$

A higher A_k represents greater accessibility to cultural facilities.

3. Study Area and Data Sources

Wenzhou, located in south-eastern China, enjoys a strategically advantageous geographic position. Renowned for its dynamic economy characterised by "small commodities and large markets", the city also possesses a rich cultural heritage, including traditional handicrafts, OuYue culture, and a strong entrepreneurial spirit. Wenzhou consists of 12 districts. The core urban area includes Lucheng, Longwan, Ouhai, and Dongtou districts. Longgang and its surrounding areas serve as the secondary urban centre. Ruian and Yueqing are considered non-core areas, while Yongjia, Wencheng, Pingyang, Taishun, and Cangnan are considered rural areas (Fig.2).

Figure 2. Districts in Wenzhou

Population data in Wenzhou were collected from the 2020 China Population Census Data by Township, Town, and Sub-district. The youth population includes individuals aged 0 to 14, while the elderly population includes those aged 60 and older. The floating population is defined as the difference between the total population and the local population. The local population is defined as individuals whose registered household location matches their place of residence.

Wenzhou's population shows a clear trend of concentration. The total population is concentrated in the core urban area and the secondary urban centre. The floating population is also more densely located in economically developed central districts. In contrast, both youth and elderly residents are less concentrated in the core urban area (Fig.3 -6). Additionally, the population dynamics show a clear trend of inflow and growth. The floating people from outside Wenzhou account for 26.1% of the permanent population. Most of these floating people move from rural to urban areas and generally have lower educational backgrounds. Meanwhile, the implementation of fertility policies has led to an increase in the 0 to 14 age group. At the same time, population ageing has accelerated, with the proportion of residents aged 60 and older rising significantly. Given these demographic

characteristics and shifts, it is essential to explore disparities in access to cultural facilities among the youth, the elderly, and the floating population in Wenzhou.

Figure 3. Distribution of the total population

Figure 4. Distribution of the floating population

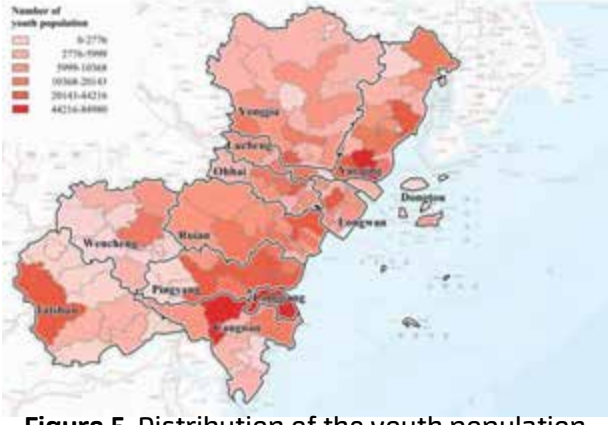

Figure 5. Distribution of the youth population

Figure 6. Distribution of the elderly population

This study defines public cultural facilities as government-led, socially supported institutions that provide cultural services. These facilities include reading spaces such as libraries, city study rooms, community reading rooms, and mobile libraries, as well as exhibition venues such as museums, cultural centres, memorial halls, art galleries, and science centres. The data on public cultural facilities in Wenzhou were obtained from publicly available records provided by the Wenzhou Government, updated as of January 2024. After data processing, 337 facilities were identified, with details including facility names, locations, and area sizes.

4. Results

4.1. Spatial Distribution of Cultural Facilities

4.1.1 Equity in Allocation

The spatial distribution of public cultural facilities in Wenzhou is uneven, with district disparities and concentrations in specific areas. Cultural facilities in Wenzhou are mainly concentrated in the core urban area of Lucheng, Longwan, and Ouhai districts. Although Dongtou District is also planned as an urban centre area, its island location limits connectivity with other districts, resulting in a lower concentration of public facilities. Statistical analysis indicates that all sub-districts with more than 10 facilities are located exclusively in Lucheng and Longwan. Kernel density analysis further highlights a particularly high concentration in Wuma, Nanhui, and Binjiang sub-districts of Lucheng District. In Ruian District, as a non-core area, moderate clustering is observed in Xincheng, Feiyun, Anyang, and Tingtian sub-districts. A slight degree of clustering is also found in the rural areas of Wencheng and Taishun districts. However, there is no obvious clustering in Yueqing, Longgang, or Cangnan districts. Although Longgang is the secondary urban centre of Wenzhou, it also lacks a concentration of facilities (Fig.7).

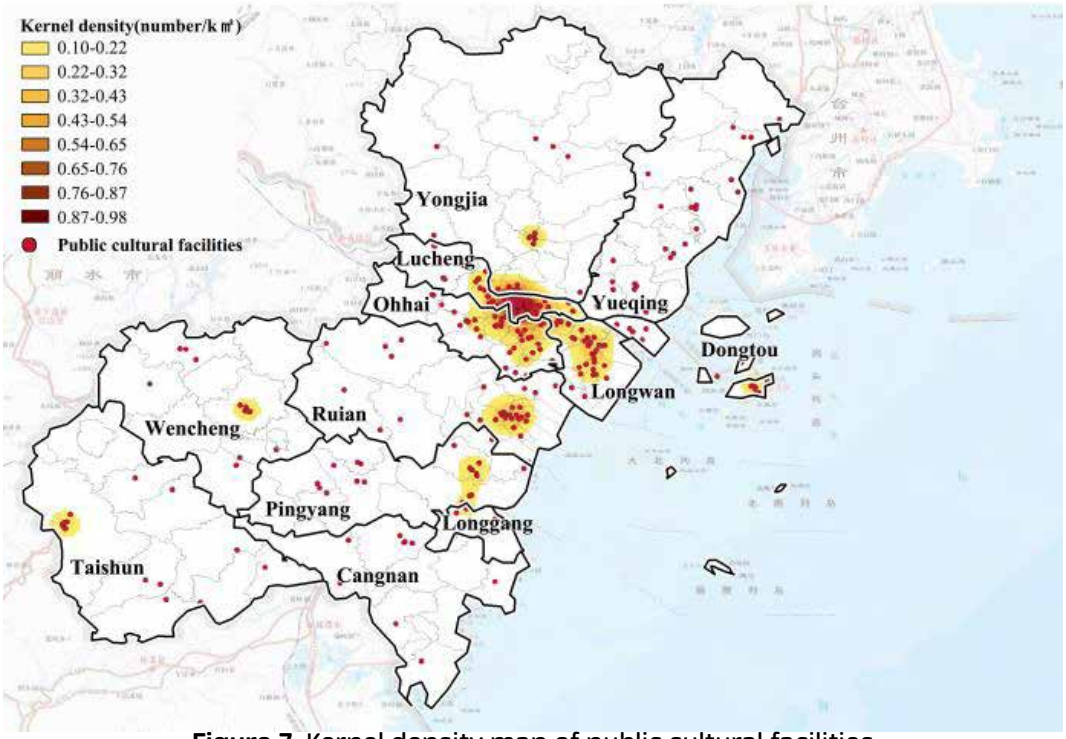

Figure 7. Kernel density map of public cultural facilities

The availability of cultural facilities in Wenzhou remains insufficient and requires significant improvement. For each spatial unit, the more built-up areas are covered by 1000m buffer zones, the higher the availability is. However, the average coverage rate (R_{CF}) is only 23.36%, with a median of 13.12%, highlighting the overall inadequacy of cultural facility availability in Wenzhou. Additionally, there are spatial disparities in facility availability, with higher coverage rates primarily concentrated in core urban areas. For instance, Wuma and Binjiang sub-districts in Lucheng District, along with Puzhou sub-district in Longwan District, have R_{CF} values exceeding 88%. In contrast, areas located farther from the city's geographic and planning center exhibit very low facility availability. For example, the western part of Ruian District and the northern part of Yueqing District have R_{CF} values close to zero. Many rural areas, including most of Wencheng and Taishun Districts, also show similarly low R_{CF} values (Fig.8).

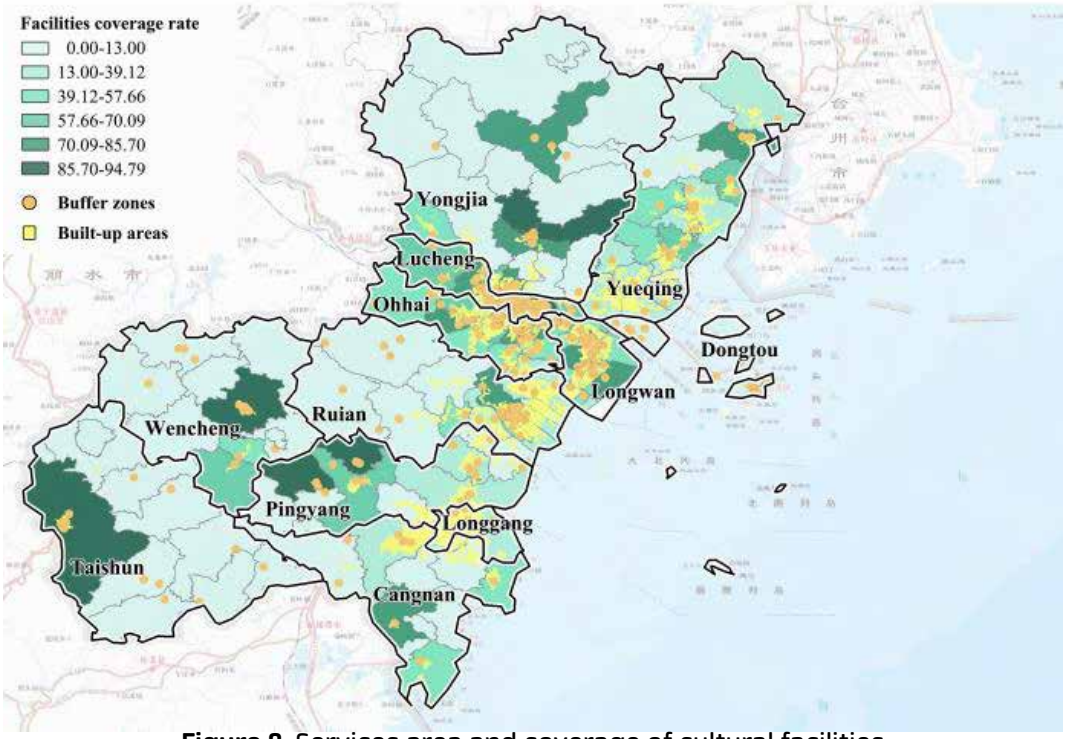

Figure 8. Services area and coverage of cultural facilities

4.1.2 Service Accessibility

The study use the 2SFCA method, evaluating facility accessibility by considering both population size and the area of public cultural facilities. The analysis reveals that only 29 sub-districts (21% of the total) have facility accessibility that exceeds the per capita area of public cultural facilities. Notably, sub-districts with high accessibility are not necessarily clustered around Wenzhou's core urban area or secondary centre. In fact, some sub-districts in rural areas demonstrate higher accessibility than those in the urban core. For instance, Fanshan sub-district in Cangnan District has the highest facility accessibility among all sub-districts, despite being situated in a rural area (Fig.9). To examine the spatial patterns of facility accessibility, the spatial autocorrelation analysis was used. The univariate Moran's I value was -0.023 (close to 0), with a p-value of 0.366 (>0.05), indicating that facility accessibility is spatially random, without significant clustering or dispersion.

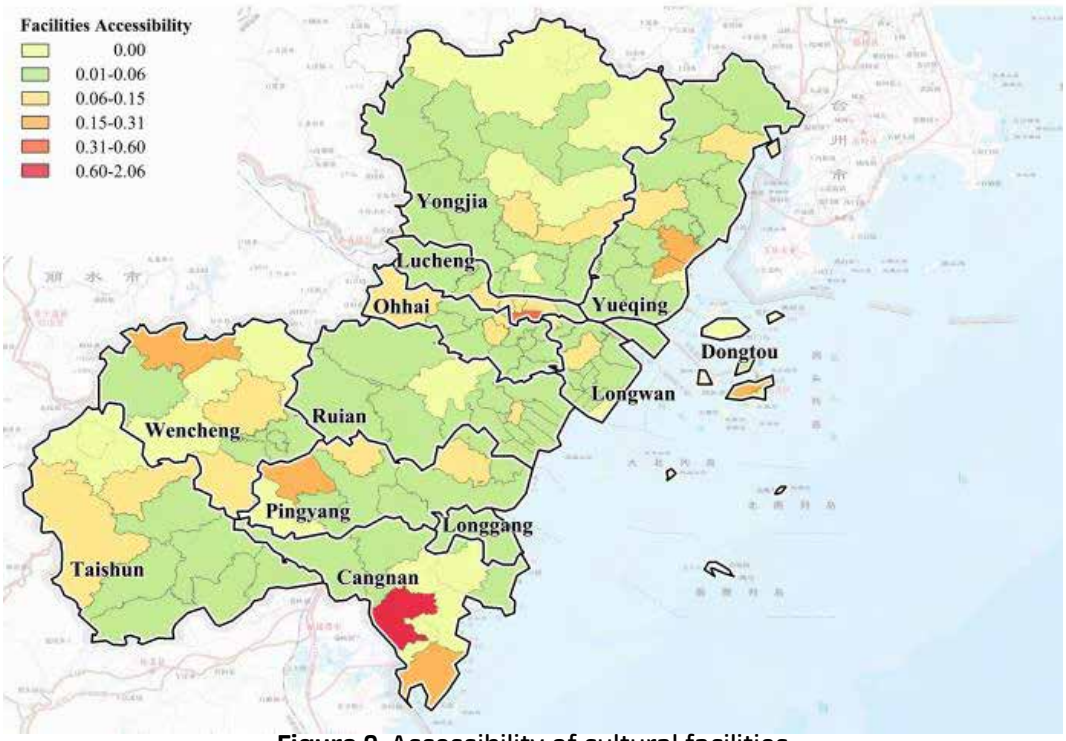

Figure 9. Accessibility of cultural facilities

4.1.3 Supply-demand Alignment

This study evaluates the alignment between facility accessibility and population demand by using a bivariate Moran's I analysis and generating a LISA cluster map. This map shows spatial units with significant mismatches between accessibility and population demand, along with their clustering locations. The LISA cluster map shows that only one sub-district—Songtai, located in the core urban area of Lucheng District—meets the "high accessibility–high demand" condition. Sub-districts classified as "low accessibility–high demand" are primarily clustered around the secondary urban centre in Longgang. Similar mismatches are also observed in the non-core areas, including Yanpen, Wengyang, and Baishi sub-districts in Yueqing District, as well as the Tingtian sub-district in Ruian District. In contrast, some sub-districts in rural areas, such as Nantian, Dajun, and Shanxi in Wencheng District, Mazhan in Cangnan District, and Luoyang in Taishun District belong to the "high accessibility–low demand" category due to their relatively small populations (Fig.10).

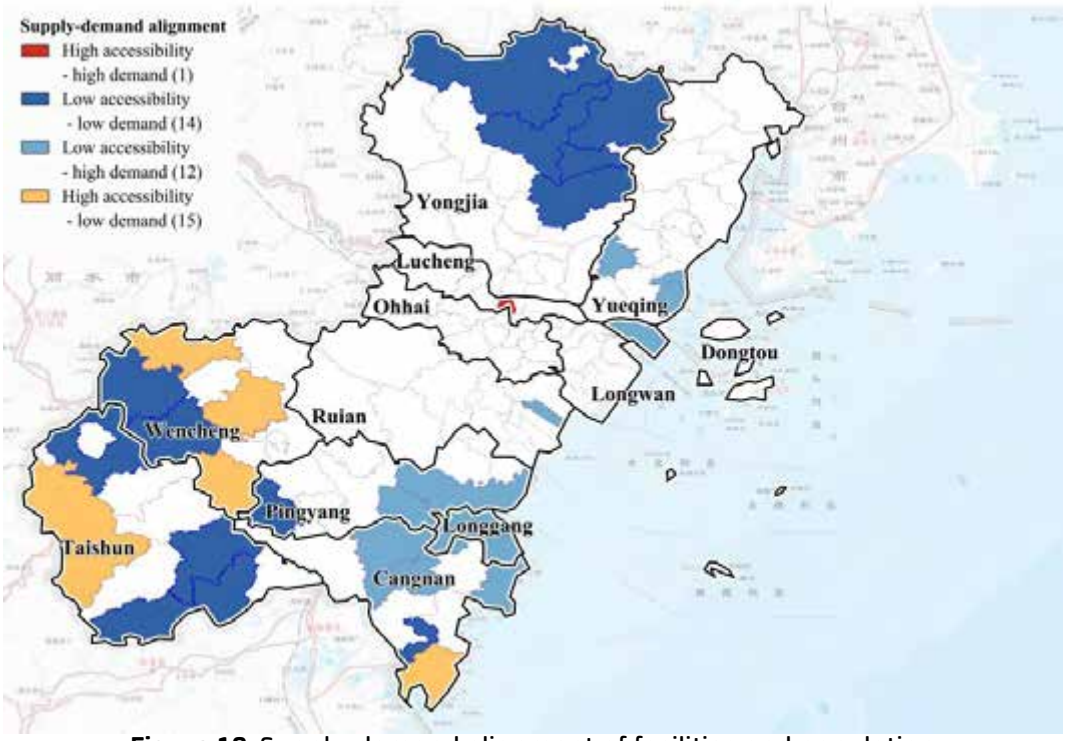

Figure 10. Supply-demand alignment of facilities and population

4.2. Facility Access Across Demographic Groups

4.2.1 Pearson Correlation Analysis

This study investigates the relationship between the public cultural facilities distribution and population variables. Pearson correlation are used to analyse the data. The findings show that the facility coverage rate (R_{CF}) is significantly positively correlated with both the total population and the floating population. In contrast, R_{CF} shows no evident correlation with the youth population and even exhibits a significant negative correlation with the elderly population. Additionally, facility accessibility (A_k) has no correlation with the youth, elderly, or the floating population. However, it is significantly positively correlated with facility coverage, quantity, and total building area (Table1).

Table 1. Results of correlation analysis

Variable	1	2	3	4	5	6	7	8
1 total population	1							
2 percentage of youth	0.15	1						
3 percentage of elderly	-.434**	.228**	1					
4 percentage of floating	.387**	-.411**	-.871**	1				
5 facility accessibility	-0.003	0.083	0.096	-0.082	1			
6 facility coverage	.199*	0.047	-.305**	.412**	.297**	1		.
7 quantity of facilities	.451**	0.069	-.273**	.336**	.174*	.597**	1	
8 total facility area	.235**	0.16	-0.093	0.081	.701**	.429**	.574**	1

** indicates at the 0.01 level, the correlation is significant.
* indicates at the 0.05 level, the correlation is significant.

4.2.2 OLS and Spatial Lag Regression Analysis

Since Pearson correlation analysis does not account for spatial effects, this study further explores the relationship between facility coverage rate (R_{CF}) and population variables using OLS regression and spatial lag regression. The univariate Moran's I analysis of R_{CF} shows a statistically significant p-value (<0.05), confirming

the presence of spatial autocorrelation and supporting the use of regression modelling. The results indicate that the total population does not have a significant direct impact on facility coverage. However, the youth and floating populations have a significant positive effect on facility coverage, while the elderly population has no significant influence (Table2).

Table2. Results of regression analysis

	spatial lag regression		OLS	
Variable	coef.	P	coef.	P
CONSTANT	-40.67*	0.01	-42.57*	0.01
total population	<-0.01	0.88	<-0.01	0.78
percentage of youth	1.89**	<0.01	1.93**	<0.01
percentage of elderly	0.34	0.42	0.51	0.27
percentage of floating	0.51**	<0.01	0.71**	<0.01
R-squared	0.324		0.230	
AIC	1236.34		1246.96	
Log likelihood	-612.17		-618.48	
R_{cf} Univariate Moran's I=0.2946< p-value= 0.001<z-value: 5.2172				

** P<0.01;* P<0.05

4.2.3 Supply-Demand Alignment Across Different Demographic Groups

The match between the demands of different population groups and facility accessibility is analysed. Using LISA cluster maps, it identifies areas where low accessibility coincides with high demand, revealing spatial mismatches among different demographic groups. For the floating population, these areas are concentrated in the districts of the core urban area. Among the youth, "low-accessibility, high-demand" areas are mainly located around the secondary urban centre and in non-core areas, including Longgang District along with its neighbouring Xiaojiang sub-district and Hongqiao sub-district in Yueqing District. Additionally, these areas are also found in rural regions, such as Shatou sub-district in Yongjia District. For the elderly, such areas are primarily located in the rural areas of Pingyang, Wencheng, Taishun, and Cangnan districts (Fig11).

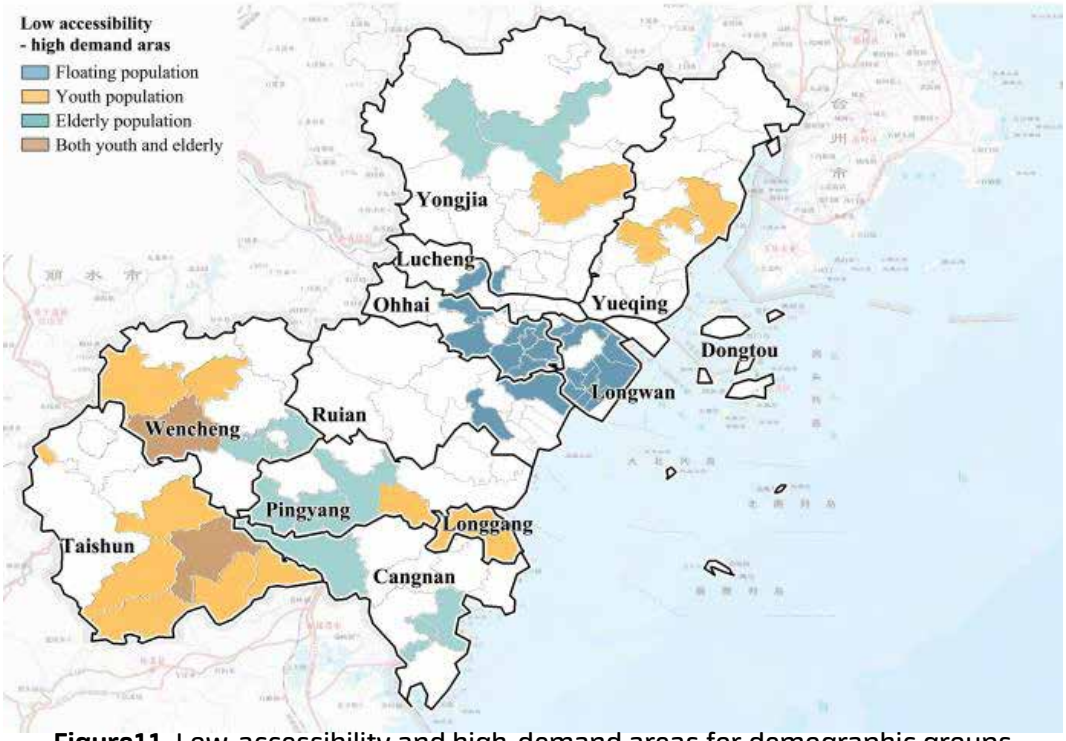

Figure11. Low-accessibility and high-demand areas for demographic groups

5. Discussion

5.1 Characteristics and Impact

The distribution of public cultural facilities in Wenzhou is highly uneven. Cultural facilities are concentrated in the core urban area, while the secondary urban centre faces a shortage. And rural areas have even fewer cultural facilities. This imbalance restricts cultural participation for lower-income residents and may exacerbate social stratification. Notably, individuals from lower social classes often have more active perceptions about the equalisation of basic public services (Chen et al., 2023). The lower their socio-economic classes, the higher their evaluation of and demand for public services (Liu & Qu, 2020). However, the current spatial distribution of cultural facilities fails to match these heightened demands, further exacerbating existing inequalities.

Cultural facilities in Wenzhou do not exhibit the typical pattern of declining accessibility from the urban core to the periphery (Zhao & Zhang, 2020). Instead, accessibility is unevenly distributed and lacks a clear hierarchical structure. Its random distribution may result in both over-concentration and under-provision, making it difficult to ensure spatial equity. Additionally, population distribution and facility accessibility are poorly matched, with only one sub-district achieving the high supply-demand balance. This misalignment highlights a significant shortcoming in the accessibility of cultural facilities in Wenzhou, making it difficult to meet people's cultural needs.

Different population groups have unequal access to facilities. The elderly are particularly highlighted as facing a shortage of public cultural resources. Areas with higher concentrations of youth and floating populations tend to have more facilities, while areas with larger elderly populations often have fewer. The youth, the elderly, and the floating population are vulnerable groups in accessing cultural facilities (Fan & Hou, 2021). They should have equal opportunities to utilise culture resources. Limited physical mobility restricts the elderly' s access to facilities, and the negative correlation between facility and the elderly population further restricts their cultural participation. Furthermore, while areas with a high floating population tend to have more facilities, limited accessibility still restricts cultural participation, revealing a gap between provision and effective access.

5.2 Reasons

The historical development of Wenzhou has established the foundation for the spatial patterns of its facilities. Public facility construction follows a core-to-periphery expansion pattern (Li&Feng, 2017). Planning documents from 2003 and 2021 indicate that Wenzhou's urban development. Lucheng, Longwan, and Ouhai were initially planned as the core districts. Later, Yueqing, Ruian, and Dongtou were added as auxiliary areas, with Longgang identified as a secondary urban centre. As a result, cultural facilities are mainly concentrated in the core urban area and gradually extend to the surrounding areas along the planned axis (Fig12), while there are few cultural facilities in rural areas. However, Longgang was designated as a secondary urban centre only about six years ago. Before that, it was just a sub-district within Cangnan District, which partly explains its clear shortage of cultural facilities.

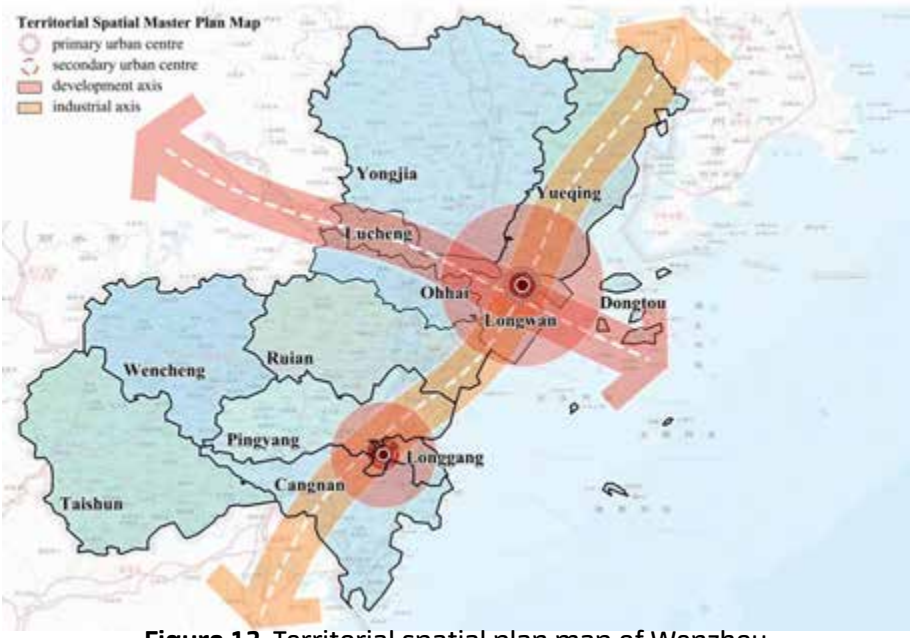

Figure 12. Territorial spatial plan map of Wenzhou

Wenzhou's public cultural facilities have relatively low accessibility, partly due to previous facility allocation policies. Wenzhou's cultural development policies set standards for facility quantity and service coverage but lack mandatory per capita area requirements. While the quantity of facilities has kept pace with urban and population growth, the quality often falls short of requirements, resulting in poor accessibility and mismatches between supply and demand. This issue has not only happened in Wenzhou. The early "supply-oriented" approaches to facility allocation ensured compliance with quantitative targets but often overlooked population needs and spatial accessibility. In recent years, however, China has gradually shifted toward a "demand-oriented" model in public facility planning (Chen et al., 2025).

Disparities in access to facilities among different population groups are influenced by policies and economic development. The floating population is primarily concentrated in economically developed areas, where cultural facilities are generally more abundant. For young people, spatial lag regression analysis indicates a positive relationship between their population distribution and the allocation of cultural facilities. This can be partly attributed to Wenzhou's cultural policies, which place a particular emphasis on youth services. The government has implemented measures to promote cultural exchange among youth and enhance the quality of their cultural life. In contrast, existing policies pay insufficient attention to the cultural needs of the elderly, often prioritizing pensions and healthcare. As a result, the elderly population is in a more vulnerable position in terms of access to cultural facilities.

5.3 Suggestions

Firstly, improving the socialisation of public cultural facilities. Public cultural facilities can be built together with other public facilities and social forces should also be encouraged to participate in their development. On the one hand, public cultural spaces can be combined with green parks, sports facilities, and stations to address shortages in facility distribution (Yang & Li, 2021). On the other hand, the development of public facilities also requires the joint participation of the government and social forces. For example, enterprises are a strong social force in the development of cultural facilities. Enterprises can provide funding and space, while cultural facilities enhance the area's attractiveness, creating mutual benefits. Wenzhou's non-core urban areas and the secondary centre have a high concentration of enterprises, which presents an opportunity to address the shortage of cultural facilities in these areas.

Secondly, promoting balanced facility development. Cultural resources should be allocated to rural areas to promote urban–rural integration. Constructing mobile cultural facilities and guaranteeing cultural spaces in both new and renovated residential areas are feasible actions. In addition, the cultural rights of the youth, the elderly, and the floating population should be protected. According to the distribution characteristics of various demographics, priority should be given to improving the "Low-accessibility and high-demand" areas. In areas with high demand for youth cultural services, facilities such as youth libraries and science museums can be established. Similarly, in areas with high demand for elderly cultural services, accessible and elderly-friendly cultural spaces can be developed. In areas with a large floating population, cultural exchange spaces can be provided.

Thirdly, promoting the integration of the floating population into local communities through cultural resources. It is worth emphasizing that cultural facilities play a crucial role in preserving and transmitting cultural memory. The adaptation of the floating population to the local culture promotes cultural integration and contributes to deeper social cohesion (Zhou et al., 2021). Therefore, it is an advantage that areas with high floating populations often have more cultural facilities. Wenzhou should expand the facility area to improve accessibility. At the same time, Wenzhou should take action to develop distinctive cultural facilities and hold activities that highlight OuYue traditional culture and the city's entrepreneurial spirit. This not only strengthens local residents' cultural identity but also helps the floating population integrate into the city.

6. Conclusion

The Equalisation of basic public services is essential for promoting social inclusion and harmony. To achieve a greater distribution of public services and better match supply with demand, vulnerable groups and underprivileged areas should be given attention.

This study examines 12 districts in Wenzhou, using sub-districts as the smallest spatial units. It examines the spatial distribution of public cultural facilities and their alignment with various demographic groups. The findings include: (1) Significant differences exist in the quantity and service coverage of cultural facilities. The core urban area is the most well-equipped, followed by secondary centre and non-core areas, while rural areas are the least equipped. (2) Facility accessibility remains inadequate and does not match population demand. (3) Access to facilities varies by demographic. Areas with a high elderly population tend to have fewer facilities. In contrast, areas with a large floating population have more facilities; however, low accessibility still restricts their effective utilisation.

Key contributing factors to these inequities include historical development patterns, economic disparities, and the supply-oriented approach to facility planning. Based on these findings, three improvement strategies are proposed: (1) Improving the socialisation of public cultural facilities. (2) Promoting balanced facility development by building facilities in rural areas as well as offering targeted cultural services for different demographic groups. (3) Promoting the integration of the floating population into local communities through cultural resources.

With the development of globalisation, the significance of cultural services has grown. As a key indicator of social

inclusion, cultural equity demands greater attention to the rights for vulnerable groups and underdeveloped areas. Based on the findings and underlying causes, Wenzhou can implement more targeted strategies to build quality cultural life circles and to establish a people-centred public cultural service system. Moreover, the insights gained from Wenzhou's example can guide other cities in advancing their cultural facility planning efforts.

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A Study on the Optimization of Public Service Facilities in the Inclusive '15-Minute Community Life Circle' Based on Equity: A Case Study of Wujiaochang Sub-district, Shanghai

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Abstract
The concept of the "15-Minute Community Life Circle" aims to enhance urban quality of life, but it faces challenges related to social inclusivity in practice. This article takes Wujiaochang Sub-district in Yangpu District, Shanghai, as an example. Through participatory action research, it is found that while the distribution of existing public service facilities meets various indicators, there is a significant mismatch between their layout and the needs of different groups, making it difficult for vulnerable populations to equally access public services. Additionally, the current utilization of space is insufficiently flexible to substantively meet residents' needs. This article proposes two strategies: optimizing facility configuration and enhancing the use of flexible spaces, to improve the social inclusivity of the "15-Minute Community Life Circle" .

Keywords: 15-Minute CLC, Inclusivity, Community Development, Participatory Action Research

1. Introduction

As the process of urbanization accelerates globally and people's living standards improve, residents' demands for daily services are becoming increasingly diverse, prompting a shift in urban development models from "scale expansion" to "quality enhancement." Against this backdrop, the concept of the "15-Minute City" was proposed by French scholar Carlos Moreno in 2016. This concept emphasizes the optimization of urban spatial structures to allow residents to meet their basic needs—such as housing, work, education, and healthcare—within a 15-minute walk or bike ride, thereby reducing commuting pressure and enhancing the convenience of life (Moreno et al., 2021). This idea has quickly resonated worldwide, with cities like Paris and Melbourne incorporating it into their planning practices, advancing urban planning from a "car-centric" approach to a "people-centric" one.

China introduced the concept of the "15-Minute Community Life Circle" for the first time at the inaugural World Cities Day Forum held by the Shanghai government in 2014 (Zhuang, 2014). This concept resonates with the global idea of the "15-Minute City" but places greater emphasis on service provision at the community level. In 2015, the United Nations formally adopted the 2030 Agenda for Sustainable Development, which includes Sustainable Development Goal 11 (SDG 11), emphasizing the need to "make cities and human settlements inclusive, safe, resilient, and sustainable," thereby providing an international framework for practices in China. In recent years, Shanghai has actively explored localized pathways that align with SDG 11, aiming to build a "People's City" that serves its residents.

In 2016, Shanghai released the "15-Minute Community Life Circle Planning Guidelines," which stipulate achieving the "Five Needs" goals of being "livable," "workable," "tourism-friendly," "educational," and "supportive of the elderly" within a 15-minute walking distance, thus creating safe, ecological, and comfortable communities(Shanghai Government, 2023). In 2018, the revised version of the "Standards for Planning and Designing Urban Residential Areas" published by the central government also incorporated the concept of time. The planning of residential areas considered the provision of facilities within different time dimensions, including 15-minute, 10-minute, and 5-minute living circles (Ministry of Housing and Urban-Rural Development, 2018). In 2023, Shanghai's "Three-Year Action Plan (2023-2025)" outlined detailed standards and indicators for the comprehensive promotion of the "15-Minute Community Life Cycle" (State Council of China, 2023). The document specifies that the population range for a 15-minute community life circle should be between 50,000 to 100,000, covering an area of approximately 3 to 5 square kilometres.

The Shanghai government defines the scope of street-level government (streets) as a community, with the street-level government responsible for providing infrastructure and convenience facilities for residents within

its jurisdiction. A 15-minute living circle is composed of multiple communities. Shanghai has been exploring the practice of the "15-Minute Community Life Circle" for nine years and has made significant progress, with the city-wide public service facility coverage exceeding 80% within a 15-minute reach (Ge et al., 2021).

Although the concept of the "15-Minute Community Life Circle" has achieved notable results in enhancing service convenience and supply, its focus primarily centres on physical space. In specific practical explorations, there remains a lack of an inclusive perspective, especially concerning vulnerable groups with limited mobility or scarce social resources—including the elderly, people with disabilities, children, and their caregivers—whose diverse needs are often not effectively addressed by existing facility layouts. This is specifically manifested in the following ways:

1. Barriers to Physical Accessibility: For instance, elderly individuals and people with disabilities are sensitive to walking environments (such as gradients and accessibility features) due to physical limitations. However, current planning often sets the "15-minute" threshold based on the mobility of healthy adults, and the inadequacy of road facilities results in a disconnection between nominal accessibility and actual usability.
2. Insufficient Functional Adaptability: The design of facilities tends to be overly simplistic. For example, community activity centres may lack areas for child care, making them unusable for dual-income families. Rehabilitation clinics may not be equipped with age-friendly signage, increasing the difficulty for individuals with cognitive impairments to navigate.
3. Lack of Temporal and Spatial Inclusivity: There can be mismatches between service hours and the schedules of different groups. For instance, community canteens may only operate during lunchtime on weekdays, thereby excluding families that require nighttime care. Additionally, canteens may only provide meals during designated eating times, making it inconvenient for elderly individuals who may want to rest after they finish eating.

Improving the quality of urban life has always been one of the goals pursued in urban planning. Under the context of the 15-Minute Community Life Circle, the provision of facilities has been significantly promoted and implemented. This study, conducted over a period of one year through planning work and interviews in the Wujiaochang Sub-district of Yangpu District, Shanghai, found that the service provision of facilities still requires inclusive optimization, mainly including: (a) enhancing the utilization of inefficient spaces, such as the misalignment between population and facility distribution leading to resource idleness or redundancy; (b) promoting flexible use of space, which mainly encompasses functional flexibility and temporal flexibility. Currently, some facilities have a singular function, making them difficult to meet the diverse needs of different groups. Time-wise, there is a need to guide different groups to use the same space at staggered times. The structure of the other sections of this article is as follows: the second section provides a literature review related to the current research for experience and basis; the third section explains the data and methodologies; the fourth section conducts a results analysis; and the fifth section offers relevant recommendations.

2. Literature Review

2.1 Overview of the "15-Minute Community Life Circle" at Home and Abroad

The concept of the "15-Minute City" can be traced back to E. Howard's "Garden City," proposed in 1890. Subsequently, Clarence Perry introduced the "Neighbourhood Unit" as a planning approach, using a 5-minute radius to define the neighbourhood's boundaries. This concept emphasizes the convenience between urban facilities and citizen usage, highlighting the importance of creating a safe walking environment for residents within neighbourhood units (Sharifi, 2016). In the concept of the "Neighbourhood Unit," the fundamental requirement of addressing transportation issues emerged, leading to a shift in planning models from attracting citizens to reducing the distance between citizens and their destinations. However, during the 1920s and 1930s, modernist planners, including Le Corbusier and Frank Lloyd Wright, began promoting modern urban planning, resulting in the separation of work and living environments (Pozoukidou and Chatziyiannaki, 2021). After World War II, the idea of "humanization" returned, with scholars advocating for mixed-use development, green spaces, walkable, and compact cities. In 2016, Carlos Moreno introduced the concept of the "15-Minute City," which shares similar ideas with "Chrono-urbanism," proposed by French urban planner and sociologist François Asher in 2001. Both

concepts aim to better serve urban residents through supporting nearby services. The method of "Chrono-urbanism" emphasizes the importance of urban rhythm in understanding urban life quality, particularly through the integration of spatial and temporal dimensions (Ye, 2006).China's exploration of the "X-Minute City" concept is primarily reflected in the proposal and practice of the "15-Minute Community Life Circle." In a 2015 article, Chai Yanwei used Beijing as an example, combining studies on living spaces in foreign cities with advancements in living circle planning practices. Based on temporal and spatial behaviours, he proposed constructing an urban living circle planning theoretical model centred around "basic living circles - commuting living circles - extended living circles - collaborative living circles" to address urban issues and optimize the structure of urban living spaces (Chai et al., 2015). In 2017, Li Meng proposed planning ideas and countermeasures for constructing the "15-Minute Community Life Circle" by examining the differences and issues between community supply and residents' future needs, focusing on five systems: residence, employment, services, transportation, and leisure (Li, 2017). In conjunction with current practical research, Yang Baojun believes that the domestic practice of the "15-Minute Community Life Circle" improves social governance in China and serves as a spatial carrier for addressing urban ailments and enhancing residents' quality of life(Planning Theory Editorial Board, 2020).

2.2 Mobility and Facility Equity

Research on community equity in foreign countries began relatively early, with attention drawn to issues of racial segregation around the year 2000. Sheller and Urry (2006) proposed the new mobilities paradigm to challenge the traditional social sciences' neglect of mobility, constructing an interdisciplinary theoretical framework to analyse contemporary social mobility phenomena(Sheller and Urry, 2006). The social inequalities brought about by mobility have also garnered attention and discussion across various fields. Urry introduced the concept of unequal mobility, arguing that mobility is an important resource that reflects and reinforces power, with significant disparities existing in the mobility of different populations. Law (1999) pointed out that women's mobility is constrained by social structures and emphasized the need to focus on the everyday mobility practices of different genders (Law, 1999). The mobility disadvantages faced by marginalized groups constrain individuals' spatiotemporal behaviours, while social capital and power relations further reinforce mobility inequities (Chang & Zhang, 2022). In the field of urban studies, mobility theory is similarly applied to the research of social-spatial imbalances (Lynam et al., 2023). In China, the focus on community equity arises from the spatial segregation issues caused by rapid urbanization, with the field of urban planning paying more attention to the protection of spatial rights, the spatial allocation of public resources, and the reconstruction of social spaces (Zhou and Zhong, 2016).

Many scholars have found that various factors such as gender, income level, age, and housing type can influence an individual's range of activity space (Wang et al., 2012). Currently, assessments based on residential space mainly rely on static measurements, neglecting the dynamic interactions between living environments and individual mobility. Different individuals display distinct behavioural patterns, and with advancements in technology, contemporary behavioural geography has developed various methods for measuring spatiotemporal accessibility based on "people." (Jiang et al., 2014)

These measurement methods are primarily used to assess the actual enjoyment of parks and green spaces, such as calculating the number of visits to green spaces using mobile signal data (Xiao et al., 2019).

The evaluation of the equity of public service facilities can be divided into two aspects: equality and fairness. Jiang Haiyan summarized Western studies on the equity of national public services into three stages (Jiang et al., 2011): "regional equality, spatial fairness, and social equity." Tang Zilai further differentiated between social equity and social justice (Tang and Gu, 2016), noting that the former assumes that the abilities and needs of various social groups are the same, whereas the latter recognizes the differences between groups and advocates for basic public services to be tilted towards specific socially disadvantaged groups.

2.3 Inclusive Sharing of Public Service Facilities

In recent years, the inclusive sharing of public service facilities has become a hot topic of research, encompassing aspects such as public spaces, public service facilities, and street designs. In the realm of community gov-

ernance, "inclusiveness" is increasingly regarded as one of the standards for assessing whether a community achieves good governance (Han and Ren, 2025). In terms of spatial inclusiveness, diverse spatial designs are essential components of resilient community planning, requiring consideration of the needs of various groups and the establishment of multifunctional activity areas (Du et al., 2025).

Research on the social attributes of community public spaces primarily focuses on the "humanistic" qualities of these spaces, paying attention to residents' individualized needs and embodying the community's humanistic care. Li Xinyang and others have proposed construction strategies for suitable public spaces from the perspective of combining the needs of the elderly and children(Li et al., 2015). From the angle of humanistic care, several scholars have noted the shared needs of different age groups within the community and have proposed design strategies for neighbourhood activity centres (Zhang et al., 2021), community centres (Ma & Zhang, 2022), and shared public facilities (Wu, 2023) based on the physical and mental needs and behavioural characteristics of the elderly and children.

Concerning shared streets, both domestic and international research has conducted extensive theoretical exploration and practical implementation. Current studies focus on functionality and integration, but there is a lack of flexible time-guiding strategies and concrete feedback on implementation.

2.4 Participatory Action Research

Sun Shiwen and Yin Yue (2004) trace public participation in urban planning back to the 1947 UK Town and Country Planning Act, which mandated that planning should grant the public the right to express their opinions (Sun and Yin, 2004). Zhang Fan, Li Xun, and other scholars (2022) note that participatory planning gained significant development abroad with the revival of liberal ideas and the emergence of civil rights movements in the 1960s. Taiwan began exploring "community building" early on, while mainland China initiated research on participatory community planning in the 1980s (Zhang and Li, 2022).

Participatory Action Research (PAR) is a community-centered research method that emphasizes democratic participation and co-creation of knowledge. Its core concept is "democratization of knowledge production," meaning that residents shift from being traditional research subjects to co-researchers, directly participating in diagnosing issues, designing solutions, and implementing plans, thus promoting social change and restructuring power relations. This research method not only focuses on knowledge acquisition but also emphasizes achieving social equity and justice through participation and action (Chen, 2023).

In terms of community participation, PAR stresses the active involvement of community members, especially in the stages of problem identification, solution formulation, and implementation (Astoriga-Lineros et al., 2023). Comparatively, community members tend to rely on experts' knowledge and participate less in the research process, which may affect the flexibility and effectiveness of the study (Graef and Sieber, 2018). To ensure effective communication in participatory research, researchers and participants should establish open and transparent communication channels to guarantee two-way information flow (Rosenthal and Khalil, 2010). Through continuous adjustments and adaptations during the research process, participants can play an active role in decision-making.Regarding the methods, processes, and models of participatory community planning, some studies have sought technical solutions to enhance public engagement. New technologies(Maffei et al., 2016; Saija L et al.,2017), such as image recognition and virtual reality, can lower participation barriers and invigorate public involvement. Additionally, creating different public participation scenarios, such as gardening or street experiences, can improve the public's participatory experience (Cilliers & Timmermans, 2014). Many scholars, based on planning practice experiences from various regions, analyse the participation process and summarize public participation pathways and participatory community planning models suitable for China's socio-economic development context (Liu et al., 2017; Liu et al., 2019).

Participatory community planning impacts the social space of communities. With the transformation and development of urban and rural areas in China and the awakening of public participation awareness, participatory

community planning is regarded as a process for addressing social issues in urban and rural regions and producing social space (Liu and Deng, 2016).

3.Research Methods and Case Studies

This study adopts a predominantly qualitative research approach through a mixed-methods framework, including local workshops and in-depth interviews. Stakeholders such as community residents and current students are treated as equal research partners. This approach is necessitated by the fact that the research area has a significant elderly population, and big data cannot objectively capture data on this demographic. Additionally, many existing studies on equity and inclusion rely heavily on quantitative data, which fails to uncover the genuine needs of residents in depth.

The theoretical foundation of Participatory Action Research (PAR) encompasses democracy, equality, liberation, and empowerment. It emphasizes an egalitarian relationship between researchers and participants, opposing the asymmetry found in traditional subject-object relationships. The methodology of PAR focuses on participation, collaboration, reflection, and action, employing various methods such as discussions, interviews, and observations to facilitate knowledge co-creation and action implementation. To ensure the scientific integrity of the research, this participatory planning includes four processes: identifying issues, understanding needs and strengths; proposing action plans and soliciting residents' opinions; reflecting on actions taken after multiple rounds of workshops to improve subsequent actions; and striving to ensure the interests of a broader range of groups.

3.1 Case Study

This case study focuses on the Wujiaochang Sub-district, located in the Yangpu District of Shanghai. It is situated in the core area of the Jiangwan-Wujiaochang urban sub-centre and covers an area of approximately 7.66 square kilometres, consisting of 32 subdistrict offices (with each subdistrict office managing a community). According to the data from the seventh national census conducted in 2020, the total resident population of the Wujiaochang Sub-district is 145,000, with a registered population of 119,200 and a permanent registered population of 98,500, resulting in a population density of nearly 20,000 people per square kilometre. The population aged 60 and above in Wujiaochang Sub-district is 36,080, accounting for 25% of the total population; the population aged 65 and above is 25,276, making up 17.5%. Considering that internationally a population proportion of 10% aged 60 and above or 7% aged 65 and above is often used as a criterion for a country or region to enter an aging society, the aging problem in Wujiaochang Sub-district is relatively pronounced.

In 2023, Shanghai initiated the construction of a 15-minute community living circle, planning for Wujiaochang Sub-district to be divided into four 15-minute living circles, with each circle serving a population of approximately 36,000 over an area of about 1.9 square kilometres. With the support of the "community planner" system, the research team can continuously follow up on community renewal efforts in Wujiaochang Sub-district, obtaining precise spatial data such as population data, facility POIs (points of interest), and road network data, which meet the analytical precision requirements. Furthermore, with the support of government street staff and community workers, the team conducted interviews and surveys via four participatory workshops to gather the genuine needs of the community, striving to fully incorporate the demands and opinions of diverse groups in response to the challenges of spatial equity and facility adaptability. During the research process, the workshops were divided into three stages: issue diagnosis, flexible co-creation, and consensus decision-making, focusing on in-depth discussions regarding the misalignment in facility supply and insufficient spatial flexibility.

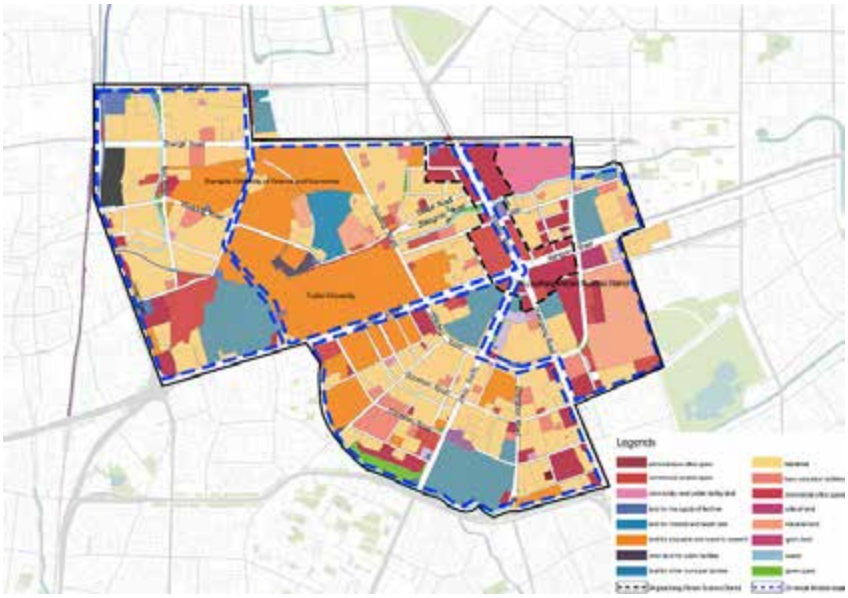

Figure 1. Existing Land-use and Planned four life-Circles in the area of Wujiaochang sub-district

3.2 Research Design

In the preliminary stage of the research, the research team organized survey groups, consisting of students with backgrounds in urban planning, who possess a certain level of professionalism and judgment. At the start of the study, four workshop locations were determined. The research group focused on identifying the fundamental issues related to facility usage in the area while promoting the construction of the "15-Minute Community Living Circle." Concurrently, geographic analysis of facility locations was conducted, later shifting focus to the issues of misalignment in facilities and their flexible use. With the assistance of the local government, we conducted random street interviews and surveys within the subdistrict, aiming to engage a diverse range of groups. This direct communication method facilitated timely feedback on needs from stakeholders and their participation in the planning and design process.

3.2.1 Preliminary Discussions and Collection of Resident Opinions

The research team held preliminary discussions and gathered opinions in a small meeting room on the second floor of the Jingshi Bookstore, involving representatives from various grassroots government departments, the Fudan Community, the Urban Investment Company, and resident representatives. Representatives from the Wujiaochang subdistrict briefly presented the development history, planning policies, and current status of the subdistrict. The Urban Investment Company shared some of the ongoing planning content, while the community committee leadership introduced the goals and vision expected to be achieved during this renewal period, along with key design points and areas that need to be updated and renovated. The research team provided a brief report to the subdistrict office leaders on the preliminary preparations, the nature of the bottom-up participatory planning design, work timelines, and workshop methodologies, achieving a general consensus among participants. After the initial discussions, under the guidance of the community committee leadership, the design team conducted a site survey to gain a preliminary understanding of the site's boundaries, the current situation of important update points, traffic conditions, population dynamics, and usage needs.

3.2.2 Preliminary Analysis of Facility Locations and Population Data

The research team obtained multiple pieces of information regarding the locations of public service facilities and the seventh national census data in Wujiaochang Subdistrict. A simple analysis and processing of the base map was performed, and road network data was collected and processed to generate a network dataset, forming the basis for network analysis. The handling of population data involved entering the population data into the attribute table according to the jurisdiction of the community committees. Then, the data was visually represent-

ed on the map using a point density symbol system, where red represents the population aged 0-19, blue represents the population aged 60 and above, and orange-red represents the population aged 75 and above. Each point in the data represents 10 individuals, resulting in a population data base map. Building on this, an analysis of facility coverage was conducted using analytical tools for network analysis and service area analysis, setting interruption values for service radii of 300, 500, and 800 meters.

3.2.3 Multi-Round Scheme Design and Communication

Based on the feedback and data collected from two rounds of workshops, design strategies for the corresponding facilities were proposed. Additional workshops were held within Wujiaochang Subdistrict to continue gathering feedback from residents.

3.3 Data Analysis and Research Findings

3.3.1 Phase One: Collaborative Problem Diagnosis—Identification of Facility Supply Misalignment and Equity Challenges

In the first community workshop, the research team organized residents to draw daily activity trajectory maps based on spatiotemporal behaviour analysis from time geography. This helped collect information on residents' activity areas and assess the coverage of existing facilities. The results indicated a misalignment between facility supply and actual demand.

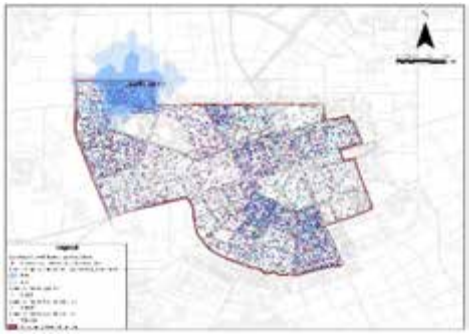

Figure 2: Coverage Map of Nursing Homes at the Township Level Within 500 and 800 Meters

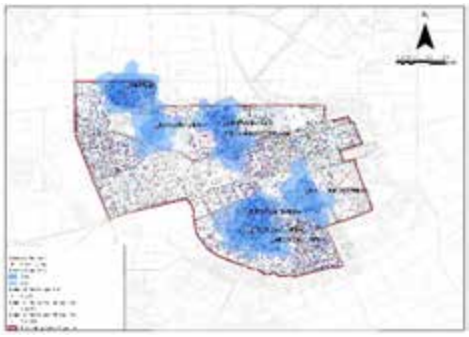

Figure 3: Service Radius of Community-Level Elderly Care Stations in Wujiaochang Subdistrict at 300 and 500 Meters

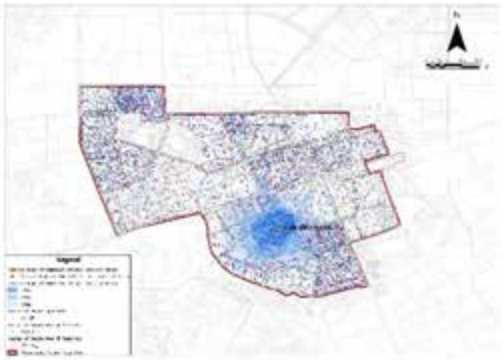

Figure 4: Community Cultural Activity Center in Wujiaochang Subdistrict.

There is a nursing home facility in the Wujiaochang Subdistrict (Figure 2). Considering the road network, a coverage analysis of 500 meters and 800 meters was conducted, revealing that its coverage is severely inadequate. Notably, the elderly population in the southeast direction of this subdistrict is significantly higher, yet there are no corresponding facilities available in that area.

In Wujiaochang Sub-district, there are eight community-level elderly care stations (Figure 3). After conducting a coverage analysis of each facility point within 300 meters and 500 meters, it was found that their coverage is also severely lacking. Furthermore, in the southeast and northwest directions of Wujiaochang Sub-district, the proportion of the elderly population is relatively high, but these areas lack community and elderly care stations. The subdistrict also has a community cultural activity centre (Figure 4), which, after analysis of its 300-meter, 500-meter, and 800-meter coverage, also showed severely insufficient coverage.

In addition to the inadequacies in elderly facility coverage and misalignment identified through geographical data analysis, the feedback from residents during street interviews mainly included the following points:

The elderly population faces limitations due to physical function, making it difficult for them to conveniently utilize the nominally "15-minute" green spaces and activity areas. Some public facilities, such as a nearby convenience restaurant, have high prices and do not cater to the taste preferences of older adults, causing elderly residents to seek alternative dining options that are farther away. Although the construction of the "15-Minute Community Living Circle" emphasizes walkability as an evaluation criterion, in practice, the age-friendly design and economic viability of facilities still require further optimization. Some elderly residents reported the complete absence of elevator services, a lack of accessibility features on the road, and difficulties in descending stairs due to the absence of elevators in residential buildings.

Figure 5: Photos from the Workshop and Feedback Collection

3.2.2 Stage Two: Co-creation Design - Adaptation and Expansion of Flexible Space Utilization

This stage clarified the equity shortcomings in the misalignment between facilities and population demands, highlighting the need for optimization in the refinement and adaptability of the "15-Minute Community Living Circle" concept in practice. The research methodology at this stage drew on the model of "co-creation workshops," utilizing public participation to identify local development needs and organizing community planning around these issues to facilitate connections and consensus among various social stakeholders.

In the participatory design workshop of the second stage, the planning team introduced blank base maps for residents to document their spatial and temporal trajectories throughout the day (Figures 6 and 7). Residents were guided to describe their ideal design proposals, which the designers then illustrated, received feedback on, revised, and presented again. During the co-creation process, residents and planners engaged in discussions around the flexible use of space concerning functional co-location and time-sharing. The core issues and explorations included:

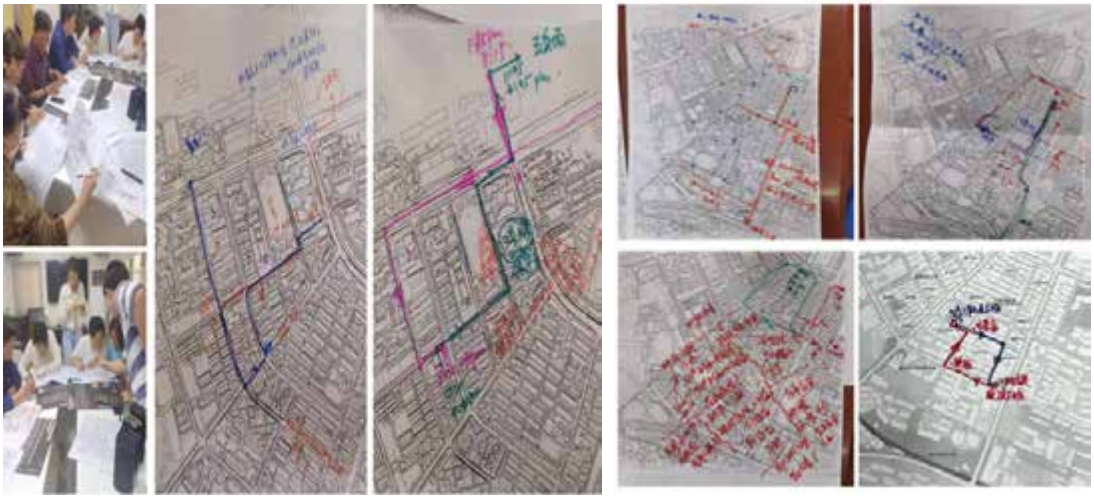

Figure 6: Residents record their travel times and locations for a day on a blank map.

Lack of Functional Complexity: Existing public spaces are mostly single-functional and cannot flexibly transform to meet the diverse needs of the elderly for daytime socialization, or the youth for nighttime cultural and creative activities or café gatherings. This indicates that the multifunctionality of community spaces is key to achieving "flexible utilization." Research shows that the multifunctionality of community spaces can not only enhance space usage efficiency but also strengthen residents' sense of belonging and participation.

Insufficient Time-sharing: Residents have proposed initiatives such as a trial nighttime pedestrian street in the Zhengsu Road area and the concept of shared streets. However, current facilities and management still lack mechanisms for flexible adjustment and guidance, failing to achieve efficient switching of crowds and time periods. This suggests that the time-sharing mechanism of community spaces is an important guarantee for achieving "flexible utilization." Research indicates that the establishment of a time-sharing mechanism relies on flexible management strategies and active participation from residents.

Space Adaptability for Vulnerable Groups: Insufficient flexible utilization results in high usage thresholds for elderly people, children, and individuals with disabilities, especially during peak traffic periods and in terms of social activity demands. This indicates that the adaptability of community spaces is a core element in achieving "flexible utilization." The adaptability of community spaces needs to consider not only the physical accessibility of the space but also the inclusivity of the social space.

During this stage, multiple rounds of simulations emphasized the necessity of multifunctional complexity and

staggered usage to enhance space equity and sharing. Additionally, it accumulated rich data on residents' preferences and usage scenarios. The research methods in this stage borrowed from the theoretical basis of "participatory design," emphasizing the integration of residents' subjective experiences and needs into the design process, thus achieving a "people-centred" community regeneration.

3.2.3 Phase Three: Consensus Decision-Making — Responding to Diverse Needs, Balancing Flexibility and Safety
In the consensus negotiation meeting of the third phase, the research team established a veto power for vulnerable groups based on the theory of deliberative democracy, along with a voting weight of 70% for residents and 30% for experts, to promote equal dialogue among multiple stakeholders. The meeting focused on the following key issues:

1. Facility Function Differentiation and Reconfiguration: How to promote the adaptation of old residential buildings for the elderly (such as installing elevators), enhance the flexibility of indoor activity spaces, and regenerate outdoor activity nodes within the existing building stock.

2. Equity Assurance: Representatives of vulnerable groups, such as the elderly and people with disabilities, explicitly expressed their core concerns about facility accessibility and economic feasibility, ensuring that the renewal plan is optimized for both physical and social equity. The equity of community spaces is a core element in achieving "flexible utilization," requiring consideration not only of the physical accessibility of spaces but also of the inclusivity of social spaces.

Through recordings and notes, the research team further explored the distribution of opinions and value trade-offs among residents during the negotiation process, enriching the diverse perspectives of spatial governance. The research methods in this phase drew from the theoretical foundation of "deliberative democracy," emphasizing the integration of residents' subjective experiences and needs into the decision-making process, thereby achieving a "people-centred" community renewal. Additionally, this phase reflects the application of the concept of "dual rationality," balancing between instrumental rationality (program design) and communicative rationality (consensus negotiation) (Li Qing and Lin, 2023).

4.Findings and Improvement Measures
In the third phase of the participatory planning work at Wujiaochang Sub-district, this article summarizes three core issues closely related to "misalignment of facilities" and "insufficient flexible use of space," based on residents' demands, current situation surveys, and on-site discussions. Additionally, corresponding improvement measures were developed based on the co-creation process.

4.1 Main Research Findings
1. Misalignment between Facility Supply and Diverse Needs
The research found that despite the nominally reasonable layout of public service facilities within the community according to the "15-minute living circle" standard, there are significant gaps in accessibility and economic adaptability for the elderly, children, and other vulnerable groups. For example, elderly residents generally report that community canteen prices are high and the food does not suit their tastes, making it difficult to meet their daily dining needs. In areas with a high proportion of elderly population, there is a lack of elderly care facilities. Although the community activity center has a certain level of coverage, the activities offered have some barriers to entry, which creates an invisible exclusion for many elderly individuals who do not possess special talents. Meanwhile, young people and working professionals report a lack of diverse commercial facilities and flexible social spaces.
2. Insufficient Flexibility in Space Function and Time Utilization
Regarding flexible usage, there are two aspects of flexibility needs: spatial flexibility and temporal flexibility. In the various workshop stages, residents generally expressed that the community space lacks flexibility and cannot meet the diverse needs of different groups at different times. For an idle space within the street, many elderly residents pointed out a desire for someone to organize and make use of it, as the street lacks multifunc-

tional spaces that can simultaneously accommodate daytime gatherings for the elderly and nighttime social activities for youth. The outdoor activity spaces primarily consist of single green areas or scattered seating, lacking diverse scene combinations.

Some community service facilities, such as canteens and activity centres, are only open during limited hours. Residents tend to leave quickly after eating and, on occasions when they want to gather with friends for tea, they struggle to find suitable indoor spaces, thus leading to the neglect of their off-peak usage needs in real life.

4.2 Improvement Measures

Based on the needs of community residents and feedback from participatory workshops, the research proposes targeted and actionable spatial improvement measures aimed at addressing the misalignment of facilities and the lack of flexible space utilization. The goal is to enhance the "15-minute community living circle" to better respond to the equitable needs of diverse populations. The specific measures include the following two main strategies:

1. Strategy 1: Activating Inefficient Spaces

In light of the current situation where some facilities are idle or underutilized, community renewal should start by "reactivating spatial potential." This can be achieved through various methods to enable flexible and efficient space reuse. For instance, after the renovation of Guoding Road, four small micro-spaces of around ten square meters each were created. These spaces incorporate functions such as elderly services, party and community activity rooms, and reading rooms, which not only meet the diverse needs of residents but also enhance the overall appearance of the space through function implantation.

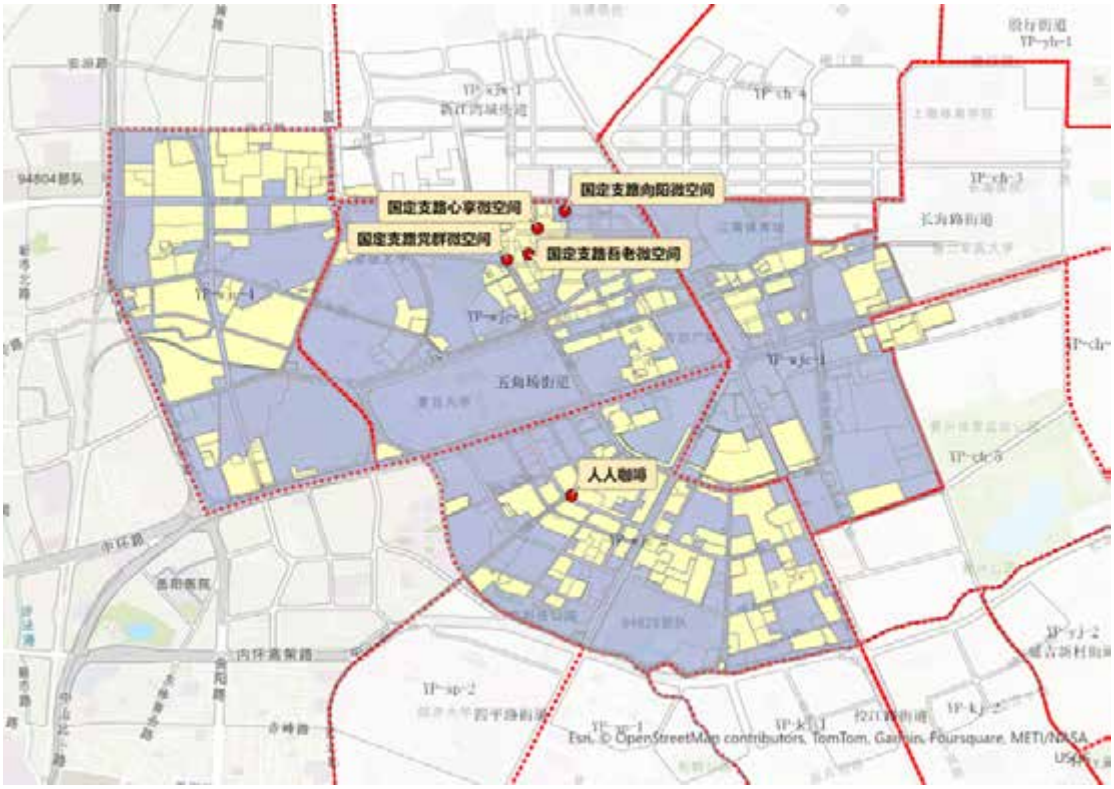

Figure 7. Distribution Map of "Six Arts Pavilion" in Wujiaochang Sub-district

Dynamic Demand Response System: A dynamic questionnaire link is established and distributed to residents through the neighbourhood committee to collect real-time usage preferences and feedback, enabling dynamic adjustments of space utilization.

"Parasitic Renewal" Model: New functional modules are "embedded" within existing redundant facilities to enrich the service levels and adaptability of the facilities. To address the current issue of high accessibility thresholds in community activity centres, children's reading corners or elderly leisure corners are added to the community library, enhancing the diversity and multifunctionality of public spaces.

2. Strategy 2: Designing Elastic Spaces
The elastic use of space is regarded as an important means to alleviate the contradictions between facility supply and demand, as well as to enhance equity. This study explores the following two levels of elasticity strategies in practice:

In terms of functional elasticity: 1) Modular facility configuration—drawing on cases such as Shanghai's "People's Square" and "Liuyi Pavilion," we promote the integration of multifunctional settings and the transformation and utilization of micro-spaces for diverse functional implantation; 2) Shared space agreements: Encourage enterprises, schools, and other institutions to sign facility-sharing contracts with the community, promoting practices such as opening school gymnasiums to residents at night, thereby enriching community activity scenarios.

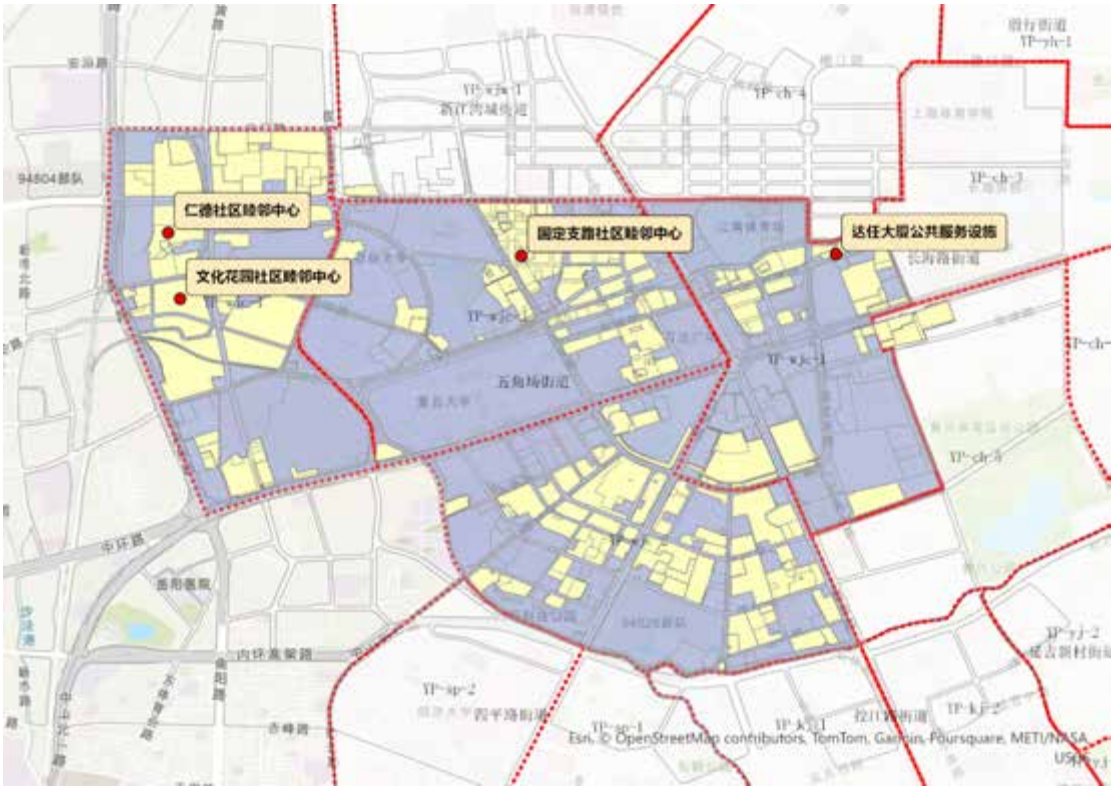

Figure 8: Distribution Map of "People's Square" in Wujiaochang Sub-district.

In terms of temporal elasticity: 1) Staggered usage system—based on the daily rhythms of residents, prioritize usage time slots according to different groups (e.g., elderly people prioritized from 7-9 AM, working individuals from 6-8 PM) to maximize space utilization efficiency. 2) Digital management platform: Establish a community digital reservation platform to display the real-time status of facility usage, support online reservations, and facilitate crowd management to achieve staggered facility usage and equitable distribution. 3) From the perspective of community governance, promote a "time-sharing" management model (such as timed pedestrian streets and nighttime community shared spaces) to maximize the efficiency and equity of limited space usage.

5. Discussion

This study deepens the academic understanding of how the "15-minute community life circle" transforms from physical supply to social inclusivity, highlighting the key roles of precise facility supply and flexible spatial sharing in achieving spatial equity.

5.1 From "Nominal Accessibility" to "Substantial Accessibility"

The "15-minute life circle," as a macro indicator, can only shift from "nominal accessibility" to "substantial accessibility" when it genuinely responds to the daily mobility capacities and temporal rhythms of different groups (such as the elderly, teenagers, and caregivers of children). The micro-renewal process within the community shows that disparities in accessibility due to factors like age, physical ability, and income directly limit fair distribution of services, necessitating more detailed data on population needs and adaptive modifications for contextual fit.

5.2 Flexible Utilization is Key to Bridging Service Gaps

The multi-round co-creation workshops in this study indicate that the functional complexity of spaces and staggered time sharing provide effective pathways to reconcile the shortage of spatial resources with the diverse needs of society. This aligns with international experiences such as Japan's "shared streets" and Singapore's community centers with time-sharing, where "flexibility" plays a role not only in the adjustment of physical spaces but also as a part of multi-stakeholder collaborative governance models.

5.3 Implications for Policy and Practice

This study suggests that to achieve the vision of a "15-minute community life circle," it is necessary to prioritize both physical renewal and social governance, concurrently advancing spatial flexible transformations and diverse resident consultations. Efforts should span multiple scales from micro (neighbourhood and building levels) to macro (street and regional levels), dynamically responding to resident needs. Additionally, establishing a regular participatory governance mechanism can encourage residents to maintain long-term attention and involvement, forming a sustainable model of community co-construction and sharing.

6. Conclusion

Globally, the "15-minute community life circle" has become an important pathway for high-quality urban development and a human-centred transformation. This paper takes Wujiaochang Sub-district in Yangpu District, Shanghai, as a case study, combining a year-long field research and participatory workshops to focus on issues such as misalignment in facility supply and insufficient flexible utilization of space. It systematically summarizes the multidimensional challenges and potential improvement pathways encountered in actual updates. The research highlights several key points worth noting:

1. The issues of facility misalignment and spatial flexibility are core challenges to community equity. Small sample sizes and detailed interviews are necessary supports for big data analysis. Although the concept of the "15-minute life circle" emphasizes balanced distribution of basic service supply, significant disparities exist at the micro practice level regarding residents' daily time arrangements, mobility abilities, and economic conditions, leading to a gap between nominal and actual accessibility.

2. Flexible spatial utilization and time-sharing are effective ways to resolve resource conflicts. Practical experience shows that flexible spatial conversion and time-sharing arrangements not only enhance the usage efficiency of existing facilities but also effectively alleviate usage conflicts among different groups.

3. Participatory governance and equity mechanisms are core guarantees for promoting community renewal. By introducing a three-phase workshop model of "co-creation, co-measurement, and co-decision-making," along with governance innovations such as granting veto power to marginalized groups, the practice enables deep participation of residents in spatial transformations and ensures equity. It also highlights the complex trade-offs in community governance between safety, vitality, and equity.

However, the study still has limitations. Due to the long construction period, the proposed solutions could not be promptly implemented, and management measures were not timely executed or feedback obtained. A long-term dynamic monitoring system still needs to be established. Additionally, this research only analysed a few communities in Wujiaochang Sub-district, and the survey work did not unfold comprehensively, necessitating more in-depth research in the future.

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Embodying Justice in the Built Environment: Transatlantic Reflections on Carbon Neutrality, Circularity, and Justice

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Abstract
Unjust practices have shaped the built environment, involving land dispossession, exclusionary planning and development, exploitative labor practices, and environmentally harmful material building cycles. These practices have (re)produced material and spatial inequities. Embodying Justice in the Built Environment is a framework to answer the question: How can planners, government agencies, and communities meaningfully centre justice and equity in working towards carbon neutrality and reducing embodied carbon? Developed through collaborative and case study methods, this research produced a series of guides and workbooks to support local governments and community organizations in addressing 1) Circularity and Waste and 2) Just and Equitable Land Use Transitions. Though rooted in North American cases, the framework offers insights for educators, policy-makers, and planners in other contexts.

Keywords: Embodied carbon, carbon neutrality, circularity, planning practice, justice, land use, waste

Introduction: Embodying Justice in Building Carbon-Neutral Futures

In recent years, national and local governments, along with nongovernmental organizations (NGOs), have increasingly focused on decarbonisation—particularly on reducing greenhouse gas (GHG) emissions from buildings and urban development. In Europe, and to a growing extent in North America, efforts have shifted toward addressing embodied carbon: the GHG emissions associated with a building's entire life cycle, including material extraction, manufacturing, transportation, construction, maintenance, and end-of-life processes. While policies targeting embodied carbon are gaining momentum as part of broader climate action, they often overlook the social, spatial, and material legacies that shape, enable, or constrain these transitions. The built environment is a system of emissions and infrastructures, and a reflection of deep-seated and layered injustices. Historical and ongoing practices—such as land dispossession, exclusionary zoning, the use of toxic materials, and demolition-driven redevelopment—continue to determine who has access to land, resources, and decision-making power (Corner, 1999; Escobar, 2018). In addition, injustices in land use have been compounded with historical and contemporary housing and transportation policies that have severely impacted racialized and minoritized communities in North America (Bullard, Johnson and Torres, 2004; Desmond and Bell, 2015; Caverly, 2022; Bronin, 2024; Millard-Ball et al., 2024). As the push for carbon neutrality accelerates, the question is not just how to reduce emissions, but how to do so justly.

This paper introduces the Embodying Justice framework—a collaborative initiative involving researchers, local authorities, and community partners that seeks to centre justice and equity in decarbonisation strategies. Developed through applied research, the framework sets out guiding principles, domains of justice, and reflective questions with corresponding actions to support planners, policymakers, and scholars working at the intersection of climate and equity. From the Embodying Justice framework two interconnected research projects have

been produced: one focused on circularity, waste, and building and building material reuse; the other on land use transitions. Despite their differing areas of emphasis, both raise a shared concern: that without deliberate attention to social context and historical harm, low-carbon transitions risk reinforcing patterns of exclusion and inequality. A key insight from this work is that embodying justice demands a move beyond technocratic metrics and calculative logics that solely tend to the reduction of carbon. This framework calls for approaches grounded in social and material systems of repair—anchored in inclusive, reparative, and community-led planning.

The two Embodying Justice in the Built Environment resources were developed within a North American context, in collaboration with the international NGO the Carbon Neutral Cities Alliance (CNCA) and local officials from cities in the United States and Canada. Grounded in participatory research with community leaders across New York State, this work was carried out in partnership with the Circularity, Reuse, and Zero Waste Development (CROWD) network. The resulting outputs comprise two guides, each accompanied by workbooks, designed to support communities in reflecting on and implementing justice-centred planning practices (see, for example, Minner et al., 2024).In the context of a climate emergency—and amid a political environment in the United States increasingly hostile to both climate action and diversity, equity, and inclusion—this work offers practical tools for local authorities pursuing just transitions towards circular economies and equitable land use.

This paper offers an overview of how these resources were developed, outlines key justice considerations embedded in the Embodying Justice framework, and shares insights from their development. The following section introduces foundational and emerging literature related to embodied carbon emissions and intersections with structural injustices. Next, we describe the research methods used. We then present the Embodying Justice framework, identifying its core areas of intervention and practical resources it offers for planners, scholars, and communities. We discuss the format of the guides and workbooks and how they are intended to be used. In the discussion, we note that although grounded in North American case studies, the framework is intended to be adaptable to other contexts. This paper concludes with We conclude with how these resources aimed to offering scaffolds for addressing injustices in the built environment. Through their use, it is hoped that government agencies can realize means of situated, collaborative, and accountable action that pairs the reduction of carbon emissions with the systematic dismantling of injustices.

Embodied Carbon Emissions and Structural Injustices

European cities have emerged as leaders in advancing circular and sustainable economies, implementing material reuse strategies and designing for disassembly (see, for example, Heisel et al., 2022; Vullings et al., 2024; Williams, 2021). Many have also adopted embodied carbon policies to reduce emissions embedded in building materials and processes. By contrast, progress in North America has been more fragmented. Only a few municipal and county governments in Canada and the United States have adopted regulations to address embodied carbon (CROWD, 2023; Winters, 2025).

Efforts to integrate justice and equity into urban policy are evident in both European and North American contexts. For example, the World Green Building Council (WGBC) has proposed a framework for addressing the social aspects of sustainability, noting: "The impacts of the built environment as an industry... go far beyond the users of individual assets—the sector impacts upon human rights at every stage of the building and construction life cycle" (World Green Building Council, 2023, p. 3). The WGBC proposes a broad framework in four scopes to "consider workers, occupants, users and entire communities" (ibid.) within the building industry, with building users and the site of construction, within surrounding communities, and throughout supply and value chains.

Recent efforts by professional organisations have also helped to clarify how planning and design practices are implicated in historical and ongoing harm. The American Planning Association Equity in Zoning Policy Guide underscores that zoning is a tool shaped by racialised exclusion, displacement, and uneven development. The guide identifies zoning as a contributor to land use and environmental injustice while calling for reparative approaches that centre procedural inclusion, redistribution of benefits and burdens, and address legacies of harm through policy reform and accountability (APA, 2024, pp. 10-12).

Parallel contributions from the American Institute of Architects (AIA) emphasise that justice must be embedded throughout the life cycle of the built environment, from the extraction of materials to labour conditions, construction decisions, and long-term stewardship. In its "Justice in the Built Environment" supplement, the AIA frames equity as a relational and process-oriented commitment. The guide asks questions such as: "Are we making a discernible difference in the particular population it's designed for? "What does it look like when we center justice?" and "Is it possible to envision a system without dominance, where there is space for everyone to thrive equally?" (AIA, 2021).

Together, these resources produced by professional organizations sit at the forefront of planning and architectural practice in the US, reinforcing shared recognition that equity and justice are an ethical imperative, and that the design professions must address the injustices both past and present. These resources acknowledge that a justice-oriented planning and design must address the material and spatial processes they guide, both in terms of their process and outcomes, working toward both practices of collaboration and structures redress.
These are important directions for planning, design, and allied professions. However, there remains a notable gap in the literature addressing embodied carbon reduction and structural injustice. As noted, embodied carbon refers to the greenhouse gas emissions associated with a building's entire lifecycle—from material extraction and processing through to construction, maintenance, and eventual demolition (NYCEDC Circular Construction Guidelines, 2024). Embodied carbon emissions are not incidental; they often represent a substantial proportion of a building's total climate impact (Huang, 2018; Liboiron, 2021). Nor are they produced by neutral systems. They are reflect "embedded injustices" —a built environment that is a produced from "[land] dispossession, denial of land rights, discriminatory land use, zoning, and urban renewal policies, as well as harmful material extraction and toxic production processes, wasteful construction and consumption practices" (Minner et al., 2024, pp. 2; Taylor, 2014). The same systems that generate embodied emissions also shape access to land, housing, health, and generational wealth into the future. Globally, material supply chains—spanning cement, timber, and increasingly, renewable energy components like solar panels and batteries—have relied on forced labour, toxic exposures, and unsustainable extraction practices (Grace Farms Foundation, 2022). Such burdens disproportionately affect communities of colour and low-income populations around the world. In the US and Canada, zoning ordinances and urban renewal programmes have contributed to racialised displacement, while redlining, land transfers, and highway construction have historically dismantled neighbourhoods of colour (Hirt, 2014; Poe et al., 2025; Silver 1997). These injustices are not confined to the past; they are reproduced today through cycles of demolition and development. Moreover, carbon reduction policies that ignore local context may intensify inequality, accelerating gentrification, displacing vulnerable populations, and favouring high-tech solutions over community-led ones (Liboiron, 2021, p. 115).

The cumulative nature of harm—across zoning, building, maintenance, and demolition—necessitates a systemic and situated response. Amid developments in embodied carbon policies and growing inequalities, justice should be understood as foundational and place-based, not an optional add-on to climate mitigation strategies. The Embodying Justice guides rest on this principle. Informed by community partners, local government leaders, and practitioners, they assert that climate action must begin with a clear understanding of the historical, material, and policy conditions that shape both emissions and equity. Embodied carbon is both a technical issue and a repository of priorities, exclusions, and decisions that accumulate across time and space. A just response demands an equally expansive framework. The Embodying Justice framework was produced as an aid for recognising, redressing, and transforming these embedded harms through climate action.

Methods: Developing the Embodying Justice Framework
The Embodying Justice framework was developed through a multi-phase, collaborative process involving university researchers, municipal staff, and community partners across the United States. Led by teams from Cornell University and the University of Washington, the project began with a systematic review of policy frameworks promoted by the Carbon Neutral Cities Alliance (CNCA), with a focus on reducing embodied carbon through circularity, waste management, and land use regulation (Carbon Neutral Cities Alliance and One Click LCA, 2020). The research analysed building life cycles and governance systems related to land, care, and transition, conducting

interviews with local governments and community organisations to build context-specific case studies.

The team first assessed documents, guidance, and case studies concerning embodied carbon, deconstruction, reuse, zoning, and climate planning—reviewing carbon accounting tools and local planning documents with an eye toward both policy design and implementation challenges. Subsequently, we focused on producing practice stories grounded in North American cities (USA and Canada) to understand how justice was or was not emerging in their climate work, and to identify areas for further development. Interviews for Phase I on Circularity and Waste were conducted with contacts at local governments and community organizations at the City of San Antonio Office of Historic Preservation (Texas, USA); The Esperanza Peace and Justice Center (a community-based organization, Texas, USA); Re:Purpose Savannah (Georgia, USA); Bureau of Development Services (Oregon, USA); Austin Office of Historic Preservation (Texas, USA); BLOCK Architects and Facing Homelessness (Washington, USA); Black Women Build-Baltimore (Maryland, USA); Better Futures Minnesota (Minnesota, USA); and Green Step Cities Program (Minnesota, USA).

In Phase II on Just Land Use Transitions, interviews are being conducted with contacts associated with the City of Vancouver, B.C., Rondo Community Land Trust, Beacon Hill Food Forest Non-Profit, and Detroit Planning and Development. The final list of interviews for the second phase will be available at a later date, when the Phase II guide and workbook have been finalised.

In addition, the research team has met with another research team in Barcelona, Spain, led by Isabelle Anguelovski. Additional informal interviews with researchers at Tampere, Finland, related to circularity in the built environment have also informed this paper.

Embodying Justice Framework Structure and Principles

Through this research, two final guides were produced: 1) circularity and waste management, and 2) land use policies and zoning regulations (Carbon Neutral Cities Alliance and One Click LCA, 2020). Each guide outlines key justice principles, a workbook for reflection and implementation, and locally grounded practice stories drawn from interviews, workshops, and city-specific policy review. Together, they were crafted to offer practical tools that reflect shared goals while allowing for contextual adaptation.

Each workbook is grounded in five interrelated justice principles:

Justice is reparative. It concerns itself with making right what has been wronged, reconnecting what has been broken, and balancing the imbalanced.

Justice is fair. It equitably distributes social, cultural, political, economic, and environmental benefits and burdens.

Justice is community-driven. It centres historically oppressed and marginalised communities in a collaborative and inclusive process to move toward just futures.

Justice is placed. It is grounded in the specific community context in which it is invoked, rather than an abstract concept.

Justice is not a singular endpoint. It is a continuing process of reflection, acknowledgment, and action.

The framework is organised around several interrelated dimensions: acknowledging and addressing historical harm, ensuring inclusive and fair decision-making, recognising local knowledge, culture, and spatial histories, and building capacity and accountability in implementation. These categories, referred to as the "J's," guided the selection of questions and structures for the workbooks and reflect an effort to move from principles into applied planning reflections and support. Throughout the process, the research team continually checked in to strike a balance between offering general guidance and reflecting insights specific to real places. Local govern-

ments expressed a need for flexible, adaptable resources rather than prescriptive checklists. This process also showed the importance of starting with shared language before introducing technical tools. This grew into the inclusion of worksheets, reflection prompts, and open-ended guiding questions rather than fixed policy recommendations.

The resulting guides are structured around a shared framework: five justice principles (reparative, fair, community-driven, placed, and ongoing), and justice domains or J's that are described as follows:

J1 Community Impacts
- Map a strategy's impact across communities (people, places, spaces, ecologies), ensuring equitable distribution of benefits, health, and well-being for priority communities.
- Examine how a strategy's design and implementation reflect priority communities' values, needs, and cultures.
- Consider a strategy's potential to redress past and ongoing harm.

J2 Economic Impacts
- Map a strategy's impact on uneven development and local economies, ensuring equitable distribution of benefits for priority communities.
- Examine a strategy's relationship with commercialization, cost, and affordability across communities, identifying opportunities to balance local economies.
- Consider a strategy's potential to develop community-driven approaches for economic growth that aim to redress the impact of extractive development.

J3 Labor and Workforce
- Examine a strategy's impact on workers' health and well-being, ensuring equitable distribution of benefits for priority laborers.
- Identify how a strategy can support balancing opportunities and access to the workforce for priority communities that have been unjustly excluded.
- Consider a strategy's potential to invest in worker agency in ways that lead to a more just workplace and field.

J4 Historical Context
- Examine how legacies of injustice and resistance can influence a strategy's design and implementation in ways that inform a more just approach in the present and future.
- Contextualize the strategy in local histories through an in-depth reflective process that centers priority communities to make right what has been wronged.
- Consider a strategy's potential to be situated in place by uplifting local stories of people, places, and sites historically abandoned or undervalued.

J5 Community Engagement and Involvement
- Examine a strategy's transparency and inclusiveness, ensuring priority communities have equitable access to knowledge, engagement, and opportunities.
- Promote processes that allow a strategy to be co-produced with priority communities through open dialogue.
- Consider a strategy's potential to invest in community-driven approaches that honor community knowledge and values and repair past and ongoing harms.

J6 Transportation Equity and Access
- Examine a strategy's impact on transportation access and mobility, ensuring equitable distribution of benefits and protection from harms.
- Promote in-depth reflective processes for determining how the strategy impacts priority communities'

well-being and access to opportunities.
- Consider a strategy's potential to repair past harms from the planning and provision of transportation facilities and infrastructure.

J7 Housing Security, Equity, and Access
- Examine a strategy's impact on housing security and access, ensuring equitable distribution of benefits and protection from displacement.
- Promote processes that welcome new residents while fostering priority communities' long-term connections to place.
- Consider a strategy's potential to repair past harms from the private and public provision of housing.

The project sought to illustrate the Justice Considerations (Js) through reflective questions and case studies tied to practical interventions. This structure is aimed at supporting cities and organisations in contextualizing justice. The reflective design of the workbooks was informed by an iterative process of dialogue, testing, and revision with municipal and community collaborators. The format is described in the next section.

Applying Justice to Practice: Format of the Workbooks
Both phases of the project have involved creating workbooks to make potentially abstract principles more concrete and actionable for local governments. These workbooks demonstrate how justice-oriented approaches can be applied in practice and are structured around two key components: question sets and practice stories. Question sets were designed to support dialogue—particularly cross-agency conversations and communication between local governments and community organisations—and encourage direct work toward justice with priority communities. The question sets are not intended to be prescriptive tools, but rather as prompts to spark reflection, analysis, and collaborative action. Figure 1 provides an example from Phase 1 of the project, which focused on circularity and waste (discussed in more detail in the following section).

These guiding prompts throughout the workbooks are aimed at helping unpack:

- How does a policy, practice, or program redress past and ongoing harms?
- Who benefits from them, and who is at risk of being excluded?
- How do they address local histories of injustices related to the built environment?

Practice stories offer brief case studies of local governments or community organisations implementing equity or justice-focused strategies that support lower embodied carbon or, more broadly, climate action. These stories, developed through interviews, highlight successful efforts to embed justice into practice. In Phase 2, this format was expanded to include a question-and-response structure. This evolution supports a deeper understanding of each case and encourages readers to reflect on how similar strategies might apply in their own contexts. In a sense, the workbook structure mimics the kind of problem sets that one might encounter in a textbook, but turns them on their head. Instead of practicing route mathematics, users gain practice applying the Js to their local context. Thus, the new format of practice stories in the second workbook, are aimed at creating "story problems," that again, require contextual reasoning.

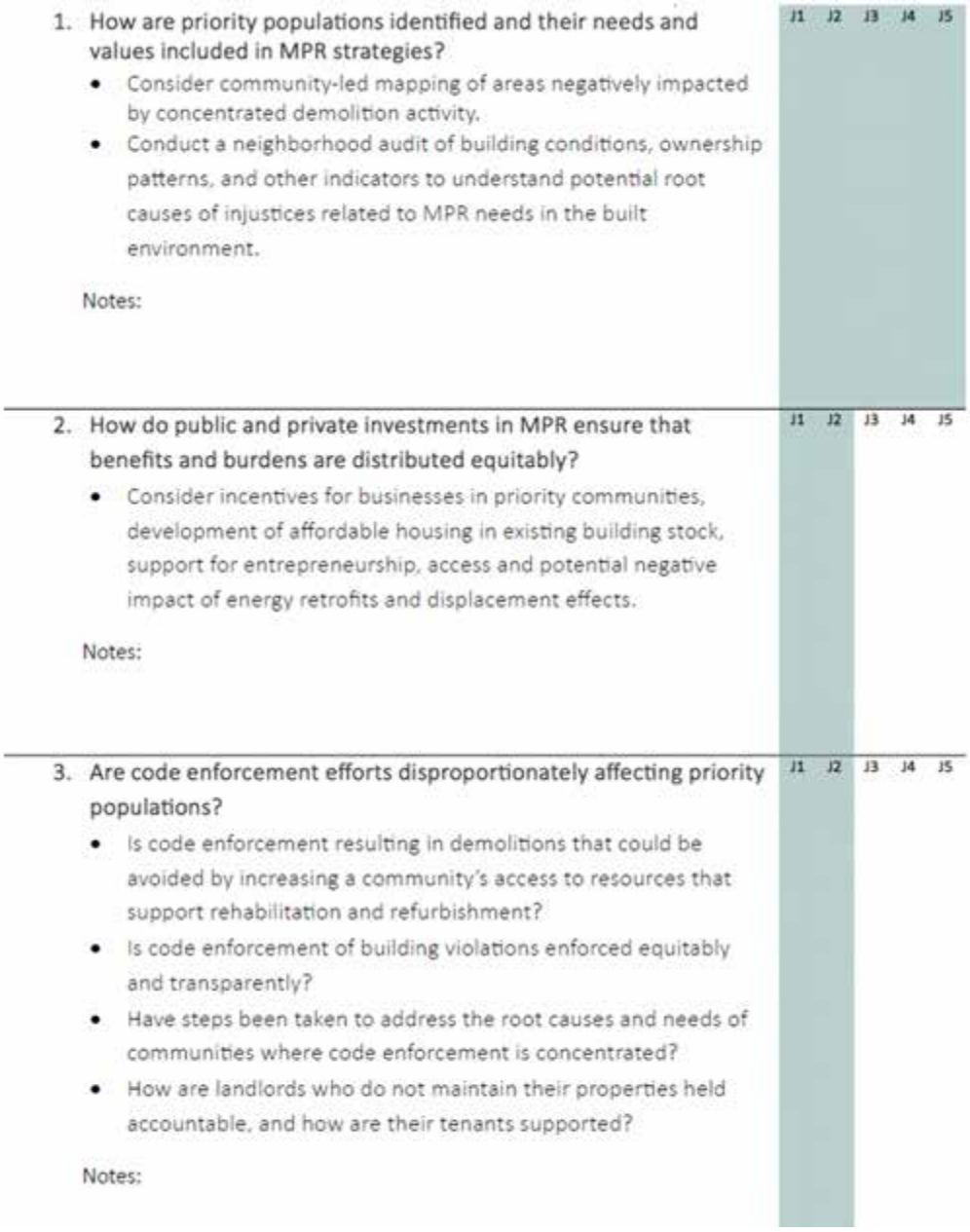

Figure 1 Example workbook page showing question sets for Maintenance, Preservation, and Refurbishment (MRP) strategies.

The development of this framework raised broader questions about the role of researchers in producing justice-oriented planning tools. Rather than positioning expertise as separate from practice, the workbook and practice stories emphasise co-production, long-term partnerships, and iterative feedback. The guides are not final, abstract products but living resources, designed to be adapted in local contexts.

Phase I Guide and Workbook: Circularity and Waste

The first guide and workbook: Embodying Justice in the Built Environment: Circularity in Practice, is structured around three critical phases in the building lifecycle: alternatives to demolition or the end life of built environment, resource management or the redistribution of materials from the end-of-life of buildings whether that is through distribution of reusable materials or status quo practices of landfilling these materials as waste; to

new construction (See figure 2.) (Minner et al., 2024, p. iv). Each phase presents an opportunity to repair harm and reimagine how materials, labour, and place are valued. The workbook offers justice-oriented questions intended to support practitioners in identifying interventions that can shift extractive, exclusionary systems toward more equitable and circular practices. While each city context is distinct, these strategies encourage planning professionals to examine embodied carbon and structural injustice in tandem.

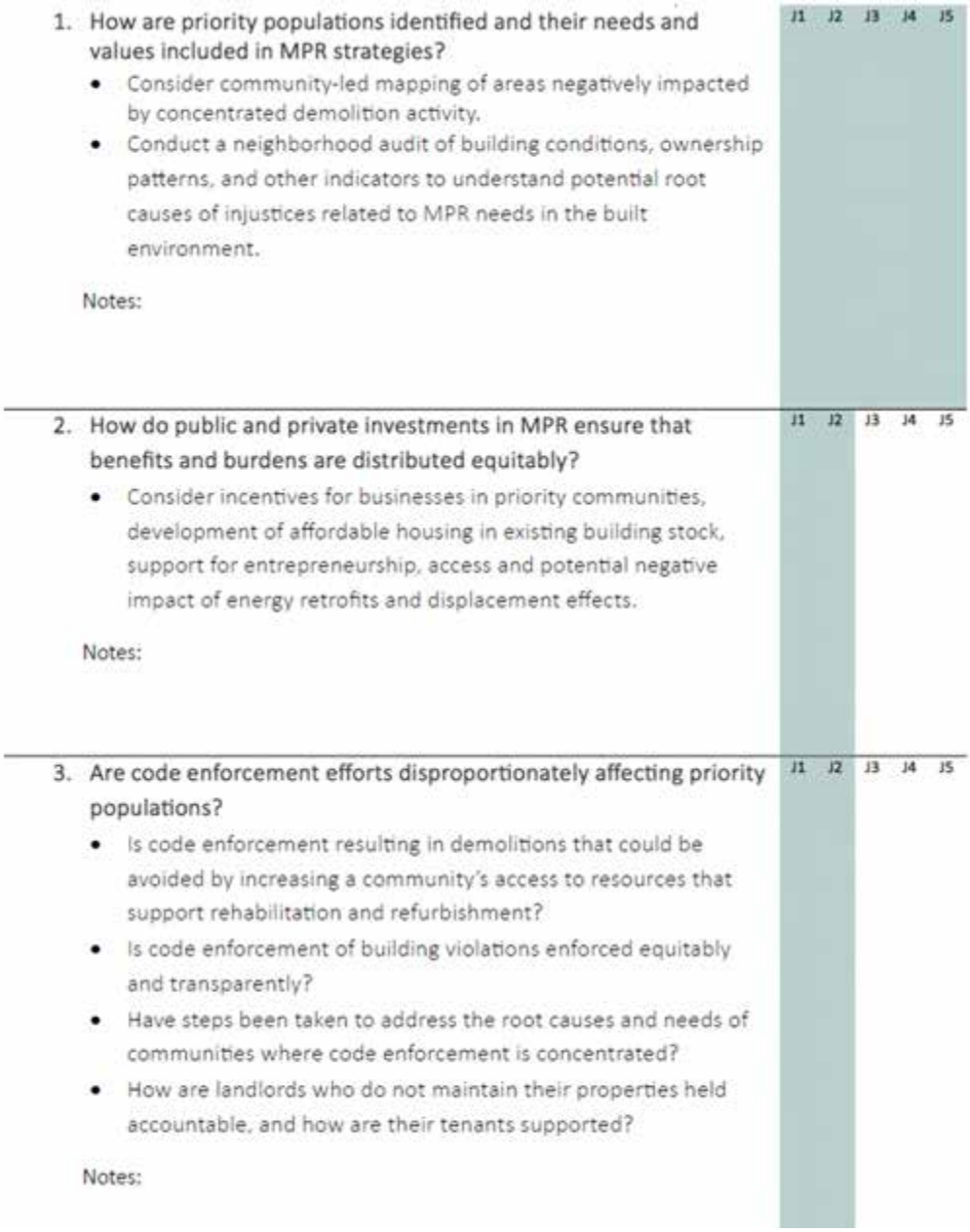

Figure 2 Three strategies addressing waste and circularity in the built environment. (Credit: Circular Construction Lab)

1. Alternatives to Demolition

Developing alternatives to demolition requires attention to past injustices while incorporating just practices along a spectrum of building reuse. As the guide notes, "Places where building demolition activities have been concentrated are often sites of injustice" (Minner et al., 2024, p. 10). Demolition can signify both historical neglect and speculative redevelopment that threatens community stability. The workbook encourages planners to con-

sider building maintenance, preservation, refurbishment, and adaptive reuse as justice-oriented alternatives that reduce waste and dislocation. Justice prompts ask:

Is this code enforcement resulting in demolitions that could be avoided by increasing a community's access to resources that support rehabilitation and refurbishment (Minner et al., 2024, p. 12)?

How can salvaging opportunities benefit communities that have lost a valued building or site? Are there practices that can extend the life of materials and thereby extend their cultural presence (Minner et al., 2024, p. 22)?

The guide includes a practice story about the City of Portland's Empowered Neighborhoods Program, which assists BIPOC community members and persons with disabilities who have been notified by the City of code violations on their residential or commercial properties. Residents submit a simple online form and receive a response within two days. A municipal staff member works directly with them, connecting them to a network of community organisations that can provide architectural drawings, construction services, and access to free or low-cost reclaimed building materials for necessary repairs. Assistance is available in multiple languages.

2. Resource Management
The just distribution and reuse of building materials demands transparency, safety, and equity. Resource management strategies that support deconstruction, salvage, and material redistribution are evaluated in the guide using justice domains that attend to labour protections, environmental burden, and economic access. As stated in the workbook, "Unjust displacement and disruption through manufacturing facilities, brownfield growth, and off-gassing of materials within the supply chain perpetuate injustice globally" (Minner et al., 2024, p. 3). Interventions in this domain must address the invisible harm caused by linear material flows.

The guide includes a practice story about Re:Purpose Savannah, a women-led nonprofit, that advances deconstruction and material reuse by salvaging and labeling building components with their histories. Each site is carefully researched and documented, forming part of an online archive—Re:Purpose Neighborhoods—that preserves place-based stories through maps, oral histories, and photographs, while inviting public contributions to collective memory (Minner et al., 2024).

3. New Construction
Justice and equity in new construction involve changes to permitting, procurement, and design development that acknowledge past injustices and actively build inclusive futures. The guide calls for attention to "design stages, material sourcing, construction process, labor and workforce hiring and training, and building disassembly– must be reimagined as an apparatus for centering justice and equity." and for practices that ensure community voices shape what is built and how (Minner et al., 2024, p. 39). Policies that centre justice in construction contracts, material specifications, and workforce development are essential.

The BLOCK Project, run by Facing Homelessness, builds backyard homes for unhoused residents as sustainable ADUs. The homes are designed for disassembly, use Red List-free materials, minimise construction waste, and meet Living Building Challenge standards—reducing both carbon emissions and environmental harm across the building lifecycle. Residents help shape each design through an iterative, community-informed process. (Minner et al., 2024).

These strategies go beyond standing alone; they are interlinked responses to interlocking crises. Circularity becomes a justice practice when embedded in the lived realities of land, labour, and livelihood. The Embodying Justice framework asks planners to use every stage of the building lifecycle as a site of accountability and transformation.

Phase II: Just and Equitable Land Use Transitions
The Just and Equitable Land Use Transitions guide was developed to address a critical gap in climate planning:

how land use systems and regulations influence access, exclusion, and the ability of communities to remain in place. Where the circularity guide focused on building lifecycles and circularity, this phase focused on the governance and spatial planning that regulates what can be built, where, and by whom. Planning tools, such as zoning codes, overlay districts, and housing incentives, are often viewed as neutral policy mechanisms within the US. However, they represented contemporary mechanisms of land use control that are layered atop histories of injustice associated with settler colonialism, racial covenants, redlining, and exclusionary development practices. Land use is not neutral. Histories of dispossession, redlining, and exclusion shape it. These legacies continue to shape who can access and participate in land, services, and environmental quality, as well as who remains vulnerable to disinvestment or displacement. Some jurisdictions are under the impression that historical unjust practices remain in the past. This is not the case, as this history is deeply embedded in present patterns of land use and urban development. By considering new justice orientations, cities have an opportunity to develop land use that repairs and heals generations now and to come, fostering a more resilient and equitable urban environment.

The guide structures its justice questions through seven domains (J1-J7), asking planners, municipalities, and community members to reflect on how proposed land use changes intersect with historical harm, labor, and housing precarity, economic access, community involvement, and cultural continuity. For example, zoning reforms may increase density or green infrastructure but may also exacerbate gentrification or obscure Indigenous land claims if not carefully designed with justice in mind.

For example, Detroit's Community Benefits Ordinance (CBO) was the first city-wide policy of its kind in the United States, requiring developers of major projects to engage with residents and negotiate tangible community benefits. The ordinance arose from grassroots efforts by the Equitable Detroit Coalition and was formalised through a legally binding process. It has since secured a range of outcomes, including affordable housing, green space, job training, and sustainability investments. The Michigan Central Station redevelopment project included $5 million for workforce education, $2.5 million for affordable housing, and green infrastructure standards as part of its Community Benefits Agreement (CBO) process (Poe et al., 2025). Detroit's approach demonstrates how land use policy can embed justice, climate goals, and community leadership at the core of urban development.

This example illustrates a broader shift in land use planning: from top-down decisions to collaborative governance, accountability, and co-created futures. It also shows how climate mitigation can be woven into justice-based frameworks, such as through adaptive reuse, embodied carbon reduction, and urban greening. The Detroit CBO also demonstrates how communities can leverage legal mechanisms to institutionalise participatory planning and ensure long-term monitoring and enforcement, a key aspect of just implementation. In parallel, the guide highlights the importance of Indigenous sovereignty in land transitions. It outlines strategies to support land rematriation, honor treaties, and integrate Indigenous ecological knowledge into planning processes (Poe et al., 2025). Moving beyond recognition, this approach affirms co-governance, resource-sharing, and repair.

Justice-oriented land use planning requires moving past abstract equity checklists toward relational, place-based strategies. It requires centring those most impacted by planning decisions, acknowledging historical legacies, and designing tools that empower rather than dilute complexities and generational experiences. The Embodying Justice framework provides a methodology to ground this work in history, partnership, and the potential for land use as a form of repair.

Reflections for Scholars and Practitioners

The Embodying Justice framework provides planners, scholars, and policymakers with a set of flexible tools for engaging with justice in their work toward lowering embodied carbon and climate action. These tools were created to be conceptual, practical, situated, and adaptable to a wide range of settings. For planning, architecture, and other allied researchers, the framework's emphasis on reflection, co-creation, and critical engagement could make it a research tool in the assessment of local government programs and community engagement of carbon neutrality. In classroom settings, the justice questions and workbook prompts can structure assignments, case

study evaluations, or design workshops and studios focused on the intersection of climate action and justice. As a pedagogical contribution, the framework supports justice-based planning education by explicitly naming histories of harm, centring community expertise, and fostering relational accountability. It offers an alternative to technical rationality by insisting that planning is not value-neutral and that students must grapple with questions of power, legacy, and repair.

In practice, the framework supports policy and project teams in assessing proposals through multiple justice lenses. The "J" domains create entry points for dialogue across departments, allowing planners, architects, landscape architects, sustainability offices, procurement staff, and community engagement specialists alike to identify where justice is being advanced or bypassed. Their non-prescriptive nature allows for local calibration while supporting both highly-focused and expansive definitions of equity and justice. While the framework is intentionally flexible, local adaptation is critical. Each city has unique histories, governance constraints, and community dynamics. One risk of this set of workbooks is the misapplication of justice language as a checkbox or branding exercise. Without adequate capacity, institutional support, and community trust, even the well-intentioned process could either ignore or reinforce harms. Planning educators and researchers play a key role in cultivating critical reflexivity.

Across both guides, the emphasis on process, not just outcome, provides a durable foundation for teaching and practice alike. The call to "make notes, draw lines, and connect ideas" invites ongoing co-learning, interdependence, and situated action (Poe et al., 2025, p. 6). The guide does not offer universal metrics, but rather reminds us that justice must be continually enacted through embedded, relational work. As cities and institutions around the world pursue carbon neutrality, there is a growing demand for justice frameworks that are rigorous, actionable, and rooted in place. Embodying Justice contributes to the emerging body of work by naming harms, offering practical tools, and illuminating pathways toward transformation. It invites planners and scholars not only to ask what can be done, but to imagine who it must be done with, and for.

In discussions with the Carbon Neutral Cities Alliance, one issue that emerged in conversations was the challenge of working with European cities and the need to avoid imposing North American concepts of justice onto the European context without deeper reflection. Our conversations with the CNCA and European research teams revealed perceptions that community organising to address justice and equity do not work in the same ways as in Canada and the US. Thus, more work is necessary to understand how a framework derived from an articulation of principles and discussion of histories and practices specific to a North American context translates across the Atlantic. In future phases, more insights will be gleaned from further conversations with research contacts in Europe. Additionally, more information will be gathered from the application of the Embodying Justice resources in a North American context, their reception, and impact.

Conclusion

Justice is not a supplement to climate action; it is the foundation upon which meaningful transitions must be built. As this research has shown, the impacts of land use and building material lifecycles are inextricably linked to the histories that shape them. Extractive planning, exclusionary zoning, and carbon-insensitive development are not merely technical failures, but the outcomes of unjust policies and unequal participation and power.

Embodying Justice invites practitioners and scholars to centre repair and relationship, not efficiency alone. This requires collaborating with communities, particularly those most affected by past and present planning decisions, to co-create alternatives rooted in care, memory, and justice. It means using climate goals not only to reduce emissions, but also to restructure who holds power, who benefits, and whose voices are heard and considered.

We argue that justice cannot simply be layered onto existing frameworks; it must shape them from the outset. The guides developed through this project offer a scaffold for doing just that—not by prescribing fixed solutions, but by opening up pathways for situated, collaborative, and accountable action.

Cities must reckon with the buildings and zones they have inherited, as well as with the futures they envision for themselves. To build carbon-neutral futures that are not only technically effective but also socially transformative, we must take seriously the entangled legacies of place, people, and power.

Justice is both a goal and a method. It demands reflection, imagination, and a shared vision for what lies ahead. This project extends an open invitation: to keep building tools and visions for the present and beyond—and to work toward a lower-carbon future steeped in deep and enduring justice.

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How Spatial Factors Affect Respiratory Health in Coal Resource-based Cities: a Case-control Study in Eastern Yunnan Province, China

Yuxing Zhao & Lan Wang

Abstract:
Urban planning can affect respiratory health. Due to industrial and mining pollution, unique urban and rural spatial structure, etc., the built environment factors of coal resource-based towns have special impact paths on respiratory health. Lung cancer is one of the cancers with the highest incidence and mortality rates worldwide. Qujing City, located in the eastern part of Yunnan Province, China, is dominated by the coal mining industry. Since the survey in the 1970s, it has been the area with the highest incidence of lung cancer in China. Compared with the national average, the standardized mortality rate is 3 times that of men and 5 times that of women. Existing studies are mostly centered on the field of epidemiology, among which there are few studies on spatial influencing factors and the research indicators are single. This study aims to explore the association between environmental factors and the risk of lung cancer in residents in coal resource-based urban and rural areas at different stages of the life course, and propose corresponding intervention measures.

The study adopted a case-control study based on life course theory. Lung cancer patients and healthy controls were interviewed in two local hospitals, and individual-level influencing factors that could not be obtained through external data were obtained through questionnaires. Among them, non-spatial factors such as smoking history were confounding factors and were controlled; spatial influencing factors such as migration history and living environment history were the core content of the study. On this basis, Landsat remote sensing images were identified through supervised classification methods in ENVI5.6, and pollution sources such as mining land and industrial land were extracted. Frequency matching was established according to gender and age (±2 years old), and 51 cases in each case group and control group were obtained. The exposure ratio in the case group and the control group was compared through spatial statistics and the use of non-conditional Logistic regression model.

The study found that the case group and the control group showed obvious urban-rural differences in space. Compared with the control group, the hotspots were mainly concentrated in rural areas, and the case clustering was strongest when the analysis radius was 2km. After controlling for factors such as fuel use and housing type, long-term residence within 2km of a coal mine was still a significant risk factor after adjustment (OR: 2.433; 95%CI: 0.951-6.222). The living environment has a heterogeneous effect on the incidence of lung cancer at different stages of the life course. After adjustment, living in earthen houses in early adulthood (25-44 years old) (OR: 2.891; 95%CI: 1.144-7.311), living in brick and wood houses in middle-aged and elderly (45 years old and above) is a risk factor in univariate analysis (OR: 2.759; 95%CI: 1.159-6.567), while living in concrete houses during the development period (0-24 years old) (OR: 0.108; 95%CI: 0.013-0.894) and early adulthood (OR: 0.292; 95%CI: 0.103-0.823) may have a protective effect. Although cooking in the kitchen and the main room, and the type of stove, were not included in the final model, the univariate analysis still indicated the health risks of poor ventilation and indoor pollution. The above research provides a basis for promoting the implementation of health equity planning at the micro and medium levels.

Keywords: Resource-based cities; Lung cancer; Case-control study; Residence history; Life Course; Health equity

1. Introduction

Urban and rural space is the main carrier of human activities, directly or indirectly affecting people's physical and mental health through complex paths. "Healthy city planning" is based on reducing health risks, optimizing health resources, and promoting healthy behaviors. It regulates and shapes space. It is an important policy tool for achieving health promotion and disease prevention and control, and plays an important role in "preventing disease" at the population level (Wang L, 2023). Respiratory health is an important research area in the field of healthy cities. A large number of scholars have explored the ways and mechanisms to promote respiratory health around four types of urban space elements: land use and facilities, development intensity and form, road traffic system, green space and open space. However, compared with other types of towns, the impact path of built environment factors on respiratory health in coal resource-based towns is special: for example, industrial and mining pollution has a stronger explanatory power for respiratory health results (Wei H, et al., 2022), and lower aggregation levels and more small and medium-sized settlements may also have some impact on the action path (Lu S, et al., 2020).

Qujing City, Yunnan Province, located in the eastern Yunnan region of China, is extremely rich in coal resources

and has formed a coal industry chain dominated by coal-fired power, coking, and chemical industry. Various pollutants generated by widely distributed coal mines, coal washing plants, coking plants, etc., bring long-term health risks to local residents. Eastern Yunnan is a high-incidence area of lung cancer in China. A retrospective survey of causes of death in the 1970s showed that the lung cancer mortality rate in Xuanwei was 4.1 times and 7.9 times that of the national male and female lung cancer mortality rates during the same period. At present, compared with the national average, the standardized mortality rate is 3 times that of men and 5 times that of women. Since the 1970s, a large number of studies from an epidemiological perspective have shown that factors such as coal type, frequency and amount of use (Barone-Adesi, et al., 2012), stove type (Hu W, et al., 2014), and years of work in coal mines (Hosgood III HD, et al., 2012) are related to the incidence of lung cancer. However, in existing studies, the number of studies on spatial influencing factors is small and the research indicators are single. This study aims to explore the spatial influencing factors of lung cancer in resource-based towns in eastern Yunnan and propose corresponding spatial intervention measures.

2. Materials and methods

2.1.Study Area

This study takes Fuyuan County and Xuanwei City under the jurisdiction of Qujing City, Yunnan Province as the research objects. Fuyuan County has a total area of 3,348 square kilometers and a total population of 840,000; Xuanwei City has a total area of 6,070 square kilometers and a total population of 1.19 million. The two places are located in the eastern part of Yunnan Province, which is a slope area where the Yunnan Plateau transitions to the Guizhou Plateau and belongs to the Wumeng Mountain System. Most areas have relatively straight peak lines and relatively gentle mountain tops, which are shallowly cut mountains with small terrain slopes and small relative height differences. The local plains between the mountains are called “Bazi”, which are usually economic centers with prosperous agriculture and dense population.

Fuyuan and Xuanwei both belong to the coal-bearing belt of the eastern Yunnan coalfield, which is distributed to the east of the Niu Shoushan uplift. The coal-bearing strata are consistent with the tectonic axis of the earth, and the coal types are distributed in strips from southwest to northeast. The coal in the two places is shallowly buried and easy to mine. Since the late Ming Dynasty and early Qing Dynasty, people have mined coal for cooking and heating in the two places.

Through field research, it was found that there are a large number of pollution sources such as coal mines and thermal power plants adjacent to towns, coal is easily available, local residents burn coal indoors, and pollution diffusion conditions are poor, which poses health risks.

2.2. Research Framework

This study adopts the research framework of epidemiology. First, the current situation study in descriptive epidemiology is used to describe the distribution of diseases or health and other factors affecting the incidence of lung cancer, which can reveal the phenomenon and provide clues for etiology research. In this study, the average nearest neighbor, nearest neighbor hierarchical cluster analysis, and multi-distance spatial cluster analysis were used. Subsequently, the case-control study in analytical epidemiology was used to test the above hypothesis and explore the impact of built environment exposure at different stages on the incidence of lung cancer from the perspective of life course. In this study, the logistic regression analysis method was used.

2.3. Data Collection

2.3.1.Health Outcomes

The cases were new lung cancer cases from two local hospitals in Qujing in the past five years, and the controls were patients from departments of the two hospitals that were not related to respiratory diseases (such as orthopedics, etc.). Through face-to-face interviews and filling out questionnaires, individual-level confounding

factors and spatial influencing factors that could not be obtained through external data were obtained. 162 questionnaires were obtained from April 7 to August 2024. After excluding samples that had lived outside the research scope for a long time, whose addresses were not accurately located, and whose some indicators were missing, a total of 138 samples were obtained, including 72 cases and 66 controls. A database was established in EpiData3.1, and frequency matching was performed according to gender and age (plus or minus 2 years old), and 51 cases and 51 controls were obtained. Oral informed consent was obtained from all study subjects.

2.3.2.Spatial Factors

Spatial influencing factors focus on the meso-micro scale. The meso-level includes spatial relationships (the distance between the residence and the pollution source), wind environment (wind direction), and topography (relatively flat areas, surface undulation). The micro-level includes residential history (house structure, ventilation conditions), stove type, and cooking location.

The address data of the samples came from the questionnaire. The urban samples were accurate to the road intersection, and the rural samples were accurate to the natural village. The spatial location was performed in ArcGIS Pro. The pollution sources include mining land and industrial land. Using the remote sensing images of the Landsat-8 satellite in December 2019, the results of the third land survey in Fuyuan County were used as samples, and the maximum likelihood method was used for supervised classification. Mining land and industrial land were identified in ENVI5.6. The wind direction is plus or minus 30 degrees from the local dominant wind direction.

Relatively flat areas (RFA) are areas with a relative height of no more than 30 meters within a range of 300m*300m around the grid according to GDEMV3 30M resolution digital elevation data. The relief degree of land surface (RDLS) represents the average altitude, the proportion of flat areas, and the elevation range of a specific area. The calculation formula is as follows:

$$RDLS=ALT/1000+Range(H)*[1-P(A)/A]/BM$$

Where ALT is the average altitude within 2 km of the sample, Range(H) is the difference between the highest and lowest altitudes within 2 km, P(A) is the area of relatively flat area (RFA) within 2 km, A is the total area of 2 km, and BM is the benchmark altitude of mainland China (500 m).

Micro-level data were obtained through questionnaires.

2.3.3. Non-spatial Factors

Non-spatial influencing factors include the respondent's smoking history (cumulative smoking duration, smoking amount, passive smoking), occupational exposure history (occupation type, employment duration, whether engaged in coal-related industries), life fuel use history (fuel use type, use duration, use amount), personal medical history and family genetic history. The above data were obtained through questionnaires.

2.4.Analytical Methods

2.4.1.Spatial Analysis

1-Average Nearest Neighbor

The average nearest neighbor is the ratio of the "average observed distance" to the "expected average distance". If the index is less than 1, it is a clustered mode, and if the index is greater than 1, it is a discrete mode.

2-Nearest Neighbor Hierarchical Cluster Analysis

The nearest neighbor hierarchical cluster analysis method is used to explore the hot spots of spatial distribution of point data (Zhan D, Meng B, 2013). This method defines a threshold distance (random nearest neighbor

distance) for clustering, and only points closer than the threshold distance will be selected for clustering. The first clustering forms the first-order clustering, followed by subsequent clustering to form second-order and third-order clustering until all clusters converge into a single cluster or clustering fails. This study used Crimestat 4.02 software to compare the hot spots of the current residence distribution of the case group and the control group to explore the differences in distribution and agglomeration between the two.

The study found significant differences in their distribution: the clusters of the case group were located in rural areas; the clusters of the control group were located in Fuyuan County, Housuo Town and Yingshang Town.

3-Multi-distance Spatial Cluster Analysis (Ripley's K function)
Ripley's K function is used to analyze the spatial distribution pattern of points at different distance scales (Zhan D, Meng B, 2013). Its principle is to calculate the number of other points within a certain distance r around the point (K observed value) and compare it with the theoretical value of completely random distribution (K expected value). If the K observed value at a specific distance is greater than the K expected value, the distribution is more clustered than the random distribution at that distance; if the K observed value is less than the K expected value, the dispersion is higher.

2.4.2. Case-control Study Based on Life Course Theory
Case-control study is the most commonly used analytical epidemiological research method, mainly used to explore the causes or risk factors of diseases and test etiological hypotheses. Its basic principle is to use a group of patients who have been diagnosed with a specific disease as the case group, and a group of individuals who do not have the disease but are comparable as the control group. Through inquiries and other methods, the subjects' previous exposure history to various possible risk factors is collected, and the differences in the exposure ratios of each factor between the case group and the control group are compared to see whether they are statistically significant.

Chronic diseases are affected by a variety of factors over a long period of time, and the occurrence of chronic diseases cannot be explained entirely by exposure in adulthood (Zheng Y, He D, 2015). Exposure at different ages may directly or indirectly affect health in adulthood (Bever A M, Song M, 2023). The life course theory holds that in the course of life, various factors independently, cumulatively, and interactively affect health and disease in adulthood (Kuh D, et al., 2003). Exposure to air pollution at a younger age may have more harmful effects because organ systems are still developing (Portengen L, et al., 2023). Lung development begins in early pregnancy and continues to grow until the age of 25, when lung function reaches a physiological stable period (Mahmoud O, et al., 2023). Since the age of 45, the incidence of lung cancer has increased rapidly. According to the life course, it is divided into three time periods, namely the development period (0-24 years old), early adulthood (25-44 years old), and middle-aged and elderly (45 years old and above). The association between risk exposure and lung cancer incidence in the three time periods was calculated separately.

SPSS29.0 was used for data analysis in this study. Cross-tabulation was used for univariate studies, and conditional logistic regression was used for multivariate studies to calculate the odds ratio (OR) and 95% confidence interval (95% CI) between risk factors and lung cancer incidence. Each continuous variable (each risk factor for cumulative exposure duration) was converted into a categorical variable using a dichotomy method, and the critical point was the average value of the control group.

3. Results
3.1.Spatial Statistics
The average nearest neighbor calculation was performed on the case group and the control group in Fuyuan and Xuanwei, and it was found that the degree of clustering of the case group in both places was higher than that of

the control group (table). Through the nearest neighbor hierarchical cluster analysis method, it was found that the clustering areas of the case group were mostly located in rural areas, while the clustering areas of the control group were located in urban areas, and there was a significant difference in the distribution of the two. Through multi-distance spatial cluster analysis, it was found that the case group was clustered within 21.5km, and the degree of clustering was the highest at 2km, while the control group was clustered within 21km, and the degree of clustering was the highest at 5km (Figure 1).

Table 1 Average nearest neighbor of the case group and the control group

Group		Nearest neighbor ratio	Z score	P value
Fuyuan	Case group	0.47	-7.38	0.00**
	Control group	0.82	-2.57	0.01**
Xuanwei	Case group	0.46	-4.53	0.00**
	Control group	1.01	0.09	0.93

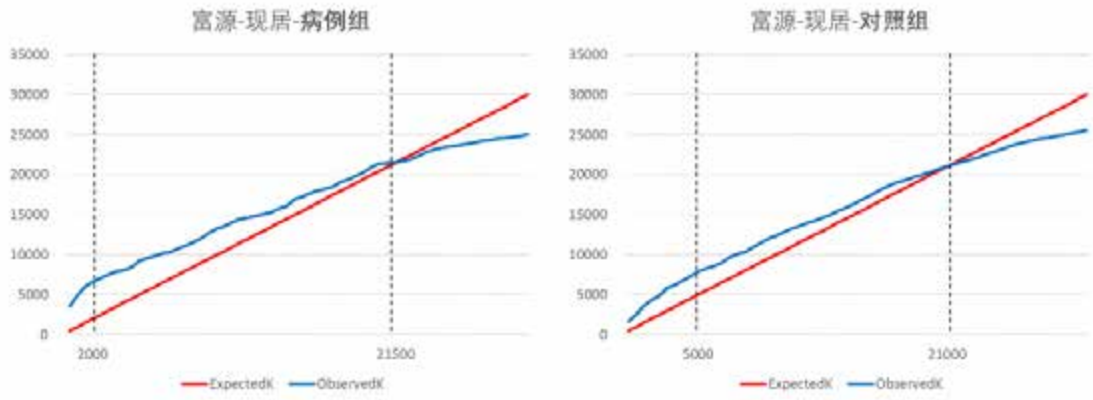

Fig.1 Multi-distance spatial clustering of case group and control group

In summary, the study found that the degree of clustering in the case group was higher than that in the control group, and the spatial distribution and scale of the clusters were significantly different, indicating that the local incidence of lung cancer was affected by spatial factors.

3.2.Case-control Study Results

3.2.1. Univariate Analysis

The odds ratios of spatial influencing factors are shown in Table 2.

In terms of the spatial relationship between residence and pollution sources, living within 2km of a coal mine for a cumulative period of 50 years is associated with a 4-fold risk of lung cancer (95%CI: 1.691-9.256). Living within 1km of a coal mine for a cumulative period of 30 years is also associated with an increased risk of lung cancer (OR: 2.220; 95%CI: 1.004-4.908). From the perspective of different life stages, long-term residence within 1km of a coal mine in middle-aged and elderly people is associated with a 2.4-fold risk of lung cancer (95%CI: 1.088-5.368); living within 1km of a coal mine during development and early adulthood is also a risk factor, but it is not significant in the study. Living within 1km of an industry for 26 years is less associated with lung cancer. However, in terms of stages, long-term residence within 1km of the surrounding industry during the developmental period was negatively correlated with the incidence of lung cancer (OR: 0.475; 95%CI: 0.212-1.066), while long-term residence within 1km of the surrounding industry during the middle-aged and elderly period was positively correlated with the incidence of lung cancer (OR: 2.218; 95%CI: 0.958-5.131), although the two were not statistically significant. The

area of mining land within 2km of the residence was weakly associated with the incidence of lung cancer, and it was not significant. Being born in the downwind area closest to the coal mine was positively correlated with the risk of lung cancer (OR: 1.680; 95%CI: 0.739-3.818), but it was not statistically significant. In terms of housing structure, from the perspective of the whole life course, living in a civil house for a total of 28 years was associated with a 2-fold risk of lung cancer, but it was not significant (95%CI: 0.928-4.499); living in civil houses and concrete houses for a long time was weakly associated with the incidence of lung cancer. In terms of life course, during the developmental period, living in concrete houses was negatively correlated with the risk of lung cancer (OR: 0.108; 95%CI: 0.013-0.894); living in earthen houses and brick-wood houses was not significantly associated with the risk of lung cancer. In early adulthood, living in earthen houses was positively correlated with the risk of lung cancer (OR: 3.391; 95%CI: 1.499-7.668), living in concrete houses was negatively correlated with the risk of lung cancer (OR: 0.292; 95%CI: 0.103-0.823), and living in brick-wood houses was weakly associated with the risk of lung cancer. In middle-aged and elderly age, living in brick-wood houses for 3 years was positively correlated with the risk of lung cancer (OR: 2.759; 95%CI: 1.159-6.567), living in concrete houses for 6 years was positively correlated with the risk of lung cancer (OR: 3.853; 95%CI: 1.665-8.915), and living in earthen houses was weakly associated with the risk of lung cancer.

In terms of cooking location, cooking in the main room for 9 years in early adulthood was positively correlated with the risk of lung cancer (OR: 2.220; 95%CI: 1.004-4.908), and cooking in the kitchen in middle-aged and elderly age was positively correlated with the risk of lung cancer (OR: 6.500; 95%CI: 2.722-15.521).

Table 2 Spatial influencing factors and lung cancer risk

Characteristic	Case (n=51)		Control (n=51)		OR(95%CI)
	No	Yes	No	Yes	
Living within 2km of a coal mine for 50 years	**12**	**39**	**28**	**23**	**3.957(1.691-9.256)**
Living within 1km of a coal mine for 30 years	**19**	**32**	**29**	**22**	**2.220 (1.004-4.908)**
0-24 years old for 13 years	17	34	23	28	1.643 (0.737-3.663)
25-44 years old for 9 years	17	34	24	27	1.778(0.798-3.960)
45 years old and above for 9 years	**22**	**29**	**33**	**18**	**2.417(1.088-5.368)**
The mining area within 2km of the residential area exceeds 90,000 m2 for 30 years	24	27	25	26	1.082(0.497-2.353)
Living within 1km of the industrial area for a total of 26 years	28	23	30	21	1.173(0.536-2.571)
0-24 years old for 12 years	35	16	26	25	0.475(0.212-1.066)
25-44 years old for 8 years	29	22	30	21	1.084 (0.494-2.379)
45 years old and above for 6 years	29	22	38	13	2.218(0.958-5.131)
The birthplace is located in the downwind area closest to the coal mine	30	21	36	15	1.680(0.739-3.818)
Living in a civil house for a total of 28 years	20	31	29	22	2.043(0.928-4.499)
0-24 years old for 17 years	9	42	14	37	1.7669(0.685-4.551)
25-44 years old for 6 years	**20**	**31**	**35**	**16**	**3.391(1.499-7.668)**
45 years old and above for 3 years	38	13	39	12	1.112 (0.451-2.743)
Living in a brick-and-wood house for a total of 16 years	25	26	31	20	1.612 (0.735-3.537)
0-24 years old for 5 years	45	6	39	12	0.433(0.149-1.263)
25-44 years old for 6 years	30	21	32	19	1.179(0.532-2.613)
45 years old and above for 3 years	**29**	**22**	**40**	**11**	**2.759 (1.159-6.567)**

Living in concrete house for a total of 12 years	33	18	31	20	0.845(0.379-1.888)
0-24 years old for 1 year	**50**	**1**	**43**	**8**	**0.108(0.013-0.894)**
25-44 years old for 6 years	**45**	**6**	**35**	**16**	**0.292(0.103-0.823)**
45 years old and above for 6 years	**22**	**29**	**38**	**13**	**3.853(1.665-8.915)**
Cooking in the main room for a total of 37 years	21	30	28	23	1.739(0.794-3.810)
0-24 years for 22 years	10	41	12	39	1.262(0.489-3.252)
25-44 years for 9 years	**19**	**32**	**29**	**22**	**2.220(1.004-4.908)**
45 years and above for 5 years	36	15	34	17	0.833(0.361-1.926)
Cooking in the kitchen for a total of 19 years	22	29	28	23	1.605(0.734-3.507)
0-24 years old for 2 years	44	7	42	9	0.742(0.254-2.174)
25-44 years old for 9 years	32	19	26	25	0.618(0.280-1.360)
45 years old and above for 8 years	**12**	**39**	**34**	**17**	**6.500 (2.722-15.521)**
Use fire pit for a total of 18 years	10	41	18	33	2.236(0.910-5.493)
0-24 years old for 16 years	9	42	16	35	2.133(0.840-5.416)
25-44 years old for 2 years	40	11	43	8	1.478(0.540-4.048)
45 years old and above for 1 year	46	5	48	3	1.739(0.393-7.697)
Use floor stove for a total of 21 years	22	29	27	24	1.483(0.679-3.237)
0-24 years old for 7 years	42	9	36	15	0.514(0.201-1.315)
25-44 years old for 10 years	19	32	24	27	1.497(0.679-3.300)
45 years old and above for 4 years	**29**	**22**	**40**	**11**	**2.759(1.159-6.567)**

The odds ratios of non-spatial factors are shown in Table 3.

Using bituminous coal for 11 years in early adulthood and 3 years in middle-aged and elderly age were positively correlated with the risk of lung cancer (OR: 2.401; 95%CI: 1.040-5.546, OR: 3.540; 95%CI: 1.472-8.782). Using a floor stove for 4 years in middle-aged and elderly age was positively correlated with the risk of lung cancer (OR: 2.759; 95%CI: 1.159-6.567).

Table 3 Non-spatial influencing factors and lung cancer risk

Characteristic	Case (n=51)		Control (n=51)		OR (95%CI)
	No	Yes	No	Yes	
Cooked for 19 years	24	27	29	22	1.483(0.679-3.237)
Used bituminous coal for 33 years	15	36	23	28	1.971(0.871-4.461)
0-24 years old for 18 years	12	39	13	38	1.112(0.451-2.743)
25-44 years old for 11 years	**13**	**38**	**23**	**28**	**2.401(1.040-5.546)**
45 years old and above for 3 years	**29**	**22**	**42**	**9**	**3.540(1.472-8.782)**
Using anthracite for a total of 7 years	37	14	36	15	0.908(0.384-2.148)
0-24 years old for 4 years	47	4	43	8	0.457(0.129-1.628)
25-44 years old for 2 years	45	6	43	8	0.717(0.230-2.236)
45 years and over for 2 years	39	12	45	6	2.308(0.792-6.726)
Total firewood usage for 25 years	34	17	30	21	0.714(0.319-1.600)
0-24 years old for 12 years	29	22	26	25	0.789(0.362-1.721)
25-44 years old for 8 years	33	18	29	22	0.719(0.324-1.597)

45 years and over for 5 years	35	16	38	13	1.336(0.563-3.170)
Have smoked before	23	28	25	26	1.171(0.538-2.549)
0-24 years old ever smoked	32	19	28	23	0.732(0.328-1.595)
25-44 years old ever smoked	28	23	26	25	0.854(0.392-1.860)
45 years and over ever smoked	31	20	29	22	0.850(0.386-1.873)
Worked in coal-related jobs	33	18	32	19	0.919(0.410-2.060)
Have a family medical history	32	19	37	14	1.569(0.680-3.624)
Have a personal medical history	46	5	47	4	1.277(0.323-5.057)

3.2.2. Conditional Logistic Regression

Due to the limited sample size of this study, the significant variables in the univariate study were included in the binary logistic regression model using the stepwise method. The input variables were living within 2km of the coal mine for a total of 50 years, living within 1km of the coal mine for a total of 30 years, living within 1km of the coal mine for a total of 9 years for people aged 45 and above, living in earthen houses for 6 years for people aged 25-44, living in brick and wood houses for 6 years for people aged 25-44, living in concrete houses for 1 year for people aged 0-24, living in concrete houses for 6 years for people aged 25-44, living in concrete houses for 6 years for people aged 45 and above, cooking in the main room for 9 years for people aged 25-44, cooking in the kitchen for 8 years for people aged 45 and above, using bituminous coal for 11 years for people aged 25-44, using bituminous coal for 3 years for people aged 45 and above, and using floor stoves for 4 years for people aged 45 and above.

The odds ratio of the independent effect of each influencing factor is shown in Table 4. The study found that long-term residence in earthen houses in early adulthood was positively correlated with the risk of lung cancer (OR: 2.891; 95%CI: 1.144-7.311); the use of bituminous coal for 3 years in middle-aged and elderly people was positively correlated with the risk of lung cancer (OR: 3.612; 95%CI: 1.431-9.731); and living within 2km of a coal mine for a cumulative period of 50 years was positively correlated with the risk of lung cancer (OR: 2.433; 95%CI: 0.951-6.222).

Table 4 Independent effects of various influencing factors on lung cancer risk

Characteristic	Case(n=51)		Control(n=51)		OR(95%CI)	P Value
	No	Yes	No	Yes		
25-44岁居住土木房达6年	20	31	35	16	2.891(1.144-7.311)	0.025
45岁后使用烟煤达3年	29	22	42	9	3.612(1.431-9.731)	0.011
居住在煤矿2km内达50年	12	39	28	23	2.433(0.951-6.222)	0.064

4. Discussion

4.1. Spatial statistical analysis

In spatial statistics, it was found that the degree of agglomeration of the case group was higher than that of the control group, indicating that in addition to the agglomeration of towns and villages, there are other spatially related factors that cause the cases to agglomerate. The study found that when the research range was 2km, the degree of agglomeration of the case group was the highest, and when the research range was 5km, the degree of agglomeration of the control group was the highest, indicating that with a range of 2km, the environmental factors around the study sample were a suitable distance for the impact of lung cancer. The analysis of the agglomeration hotspots of the case group and the control group found that the hotspots of the control group were in Fuyuan County, Housuo Town, and Yingshang Town, which were urbanized areas with concentrated populations; while the hotspots of the case group were mainly distributed in rural areas. There were significant urban-rural differences between the two, and the urban-rural differences are the content that needs to be paid

attention to in subsequent studies. In addition to geographical location, urban-rural differences also include different living environment quality, fuel use types, occupations, living habits, etc. The combined effect of multiple factors has created lung cancer hotspots in rural areas.

4.2. Univariate analysis

In the univariate analysis, long-term residence within 2km of a coal mine was positively correlated with the risk of lung cancer; living within 1km of a coal mine in middle-aged and elderly age was positively correlated with the risk of lung cancer, while similar trends were shown in the developmental period and early adulthood, but not significant. The middle-aged and elderly stage of the sample corresponds to the period from 2000 to the present. Some studies have shown that the local incidence of lung cancer has dropped significantly after the 1970s thanks to the improvement of stoves (Lan Q, et al., 2002). Although some studies have shown that early life exposure has a greater impact on lung cancer (Portengen L, et al., 2023), the exposure risk in middle-aged and elderly age should not be ignored.

Studies have shown that long-term residence within 1km of industry is not significantly associated with the risk of lung cancer, but in terms of life course, living around industry in the developmental period tends to be a protective factor, while living around industry in middle-aged and elderly age tends to be a risk factor. This may be because industrial areas have changed from “development centers” in the early years to “environmentally degraded areas” in recent years: in the developmental period of the research sample (corresponding to the 1960s-1990s), industrial areas are often the places where various resources are most concentrated, such as schools for children of workers and miners, employee hospitals, and unit housing, providing better education and health resources, thereby promoting early health; while in the middle-aged and elderly period of the research sample (corresponding to the 2000s to the present), non-industrial areas have generally achieved rapid development, while the aging of infrastructure around industrial areas, the accumulation of industrial pollution, and the deterioration of the ecological environment have increased the risk of exposure to coal dust, heavy metals, etc., which has become a health burden. In addition, people with higher socioeconomic abilities may choose to move out of the most polluted industrial areas and move into new urban areas far away from industry. In subsequent studies, analysis of urban-rural differences and socioeconomic levels should be included. (Subsequent analysis of socioeconomic level, whether living in urban/mining areas, and facilities poi)

In terms of the structure and materials of the house, living in earthen houses in early adulthood and brick-wood houses in middle-aged and elderly age are risk factors for lung cancer; long-term residence in concrete houses is not significantly associated with the risk of lung cancer, but in terms of life course, it is a protective factor in the developmental period and early adulthood, while it is a risk factor in the middle-aged and elderly age. The house structure may affect indoor ventilation, and thus affect the diffusion of pollutants. Tile houses with earthen structures and brick-wood structures are typical local residential forms, usually two-story, with the first floor for the main room (living, cooking) and bedrooms, and the second floor for bedrooms or for storing sundries; there are doors and windows on the front facade, no windows on the back wall, and poor ventilation conditions. Tile houses with earthen structures are usually older, while brick-wood structures are more recent. The form of concrete houses is no different from that of other regions, with complete rooms and through-the-hall wind conditions. Living in concrete houses during development and early adulthood is a protective factor, probably because concrete houses have better ventilation capacity and are easier to be equipped with smoke exhaust systems, and are also a sign of a higher socioeconomic level. Living in earthen houses in early adulthood and brick-wood houses in middle-aged and elderly age are risk factors, which may be due to the poor ventilation of earthen and brick-wood houses, and are also related to poor socioeconomic levels. The study found that living in concrete houses in middle-aged and elderly age is a risk factor, which is contrary to common perception. This may be because concrete houses are more common in urban areas and industrial and mining areas, thus exposing people to environmental pollution for a long time. In addition, due to the good airtightness of the house, if

the windows are not opened for ventilation, pollutants may accumulate. (Subsequently supplemented with floor plans, socioeconomic levels, and whether living in urban areas/mining areas)

In terms of cooking location, cooking in the living room in early adulthood is a risk factor; cooking in the kitchen in middle-aged and elderly age is a risk factor; cooking in the kitchen during development and early adulthood tends to be a protective factor, although not significant. This may be because there is a clear partition between the kitchen in development and early adulthood, which can effectively reduce indoor air pollution in the living area; in middle-aged and elderly age, due to the change of family roles, they need to mainly undertake cooking tasks, and pollution is easy to accumulate in the kitchen, resulting in higher pollution exposure. (Further analysis will be conducted based on whether or not the person is responsible for cooking at home)

In terms of stove use, the use of fire pits in each life course showed a tendency to be a risk factor, although it was not significant, which is consistent with the conclusion of existing studies that pollution generated by burning organic matter indoors cannot be discharged. Using a floor stove in middle-aged and elderly age is a risk factor, probably because it is still more polluting than gas stoves. (Gas stoves will be added later)

Among non-spatial influencing factors, the duration of coal use in early adulthood and middle-aged and elderly age is a risk factor, which is consistent with existing studies.

4.3. Multivariate Analysis

In the multivariate analysis, it was found that long-term living within 2km of a coal mine, living in earthen houses in early adulthood, and using bituminous coal in middle-aged and elderly age were risk factors for lung cancer.

Although some variables (such as cooking in the kitchen, using floor stoves, and living in concrete houses for many years) were shown as risk factors or protective factors in the univariate analysis, they were not included in the final model. This may be due to the following reasons: 1) There was collinearity between the variables, or the variables themselves were mediators or proxy indicators of other key exposure factors. For example, “cooking in the living room at the age of 25-44” and “living in earthen houses” both reflected fuel exposure and ventilation conditions under low living conditions. “Brick and wood houses” are the intermediate type of housing structure, and their ventilation and pollution isolation capabilities are between earthen houses and concrete houses. Their protective or risk effects may be masked; 2) The exposure time of some variables is relatively short, such as using floor stoves for 4 years for people over 45 years old, and the exposure period is relatively short; 3) The direction of action of some variables is inconsistent at different stages of life. For example, concrete houses are usually regarded as variables with protective effects, but there are also proxy variables such as other environmental factors such as proximity to industrial and mining areas that are eliminated.

Through multivariate logistic regression model, the study revealed the core influencing factors of meso-scale, micro-scale and confounding factors among many influencing factors.

5. Conclusions

5.1. Researching Conclusions

This study used a case-control study based on life course theory. Through spatial statistics, univariate and multivariate logistic regression analysis, it systematically explored the association between environmental factors and lung cancer risk in residents in coal resource-based urban and rural areas at different life course stages, and the following conclusions were drawn:

1) There are significant urban-rural differences in spatial distribution, and 2km is the sensitive radius of environmental exposure to lung cancer. The case group showed higher spatial agglomeration, and hotspots were

mainly distributed in rural areas; the hotspots of the control group were concentrated in densely populated urban areas. Spatial scale analysis found that when the analysis radius was 2km, the agglomeration of lung cancer cases was the strongest, indicating that environmental exposure within a 2km range had a strong impact on the incidence of lung cancer and should be used as a key spatial unit for future environmental health intervention.

2) Even if the use of fuel factors such as bituminous coal is taken into account, long-term residence around coal mines is still a significant risk factor for lung cancer. Both univariate and multivariate analyses showed that living within 2km of a coal mine for more than 50 years significantly increased the risk of lung cancer. The risk of living within 1km of a coal mine in the middle-aged and elderly (after 45 years old) is higher, indicating that the long-term accumulation of industrial pollution and the exposure effect at an advanced age cannot be ignored.

3) The characteristics of the living environment at different stages of the life course have heterogeneous effects. Living in earthen houses in early adulthood (25–44 years old) is a risk factor for lung cancer, which may be related to poor ventilation conditions and the use of highly polluting fuels; living in brick and wood houses in middle-aged and elderly (≥45 years old) is also a risk factor, suggesting that environmental aging may increase the health burden on the basis of unimproved quality of life. In contrast, living in concrete houses during development and early adulthood showed a certain protective effect, which may be related to better ventilation conditions and higher socioeconomic status; but living in concrete houses in middle-aged and elderly people showed a risk tendency, suggesting that concrete houses may be a proxy indicator of exposure to industrial areas or highly enclosed polluted environments.

4) Although the location of cooking in the kitchen and the main room and the type of stove were not included in the final model, they are still important risk factors. Cooking in the main room (early adulthood) and cooking in the kitchen (middle-aged and elderly) are both potential risk factors for lung cancer, reflecting the problem of no isolation between the living area and the cooking area and the diffusion of indoor pollutants. The use of floor stoves in middle-aged and elderly people is also a risk factor. Although these variables were not retained in the multivariate model, they still have certain public health significance as behavioral indicators of ventilation and combustion pollution.

5.2. Planning inspiration: meso- and micro-level interventions

In terms of spatial intervention, at the meso level, we should identify high-risk areas for lung cancer and make the 2km area around coal mines the key intervention area for public health; distinguish urban and rural differences and strengthen pollution detection around industrial and mining areas. At the micro level, we should promote the renovation of rural houses and the renewal of ventilation facilities, incorporate the concept of "through-hallway wind" into local architectural design, and improve the effect of natural ventilation; promote the supply of clean energy (such as electricity, gas, etc.) in rural areas.

In terms of policy recommendations, industrial and mining planning should conduct health impact assessment (HIA) and no longer be dominated by economic benefits alone; for residents who have lived in coal mines and highly polluted areas for a long time, lung screening should be vigorously promoted; and clean energy and healthy buildings should be promoted.

5.3. Research deficiencies and follow-up work

Socioeconomic attribute variables have not been included. The current model lacks variables such as the respondents' education level and occupation type, which may misestimate the actual effects of residential location and house structure. The changes in residential history at the urban and rural levels have not been sorted out. Urban and rural differences include multiple influencing factors such as environmental pollution, fuel type, ventilation conditions, and medical accessibility. For example, living in a concrete house for people over 45 years old is a risk

factor. It may not be a problem with the house itself, but "the house is located in an urban area or an industrial and mining area." Subsequent research needs to further analyze whether people have moved from rural areas to cities during their life course. The interactive effects of multiple variables have not been taken into account, ignoring the synergistic effects between variables.

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Who gets less urban greenness: A case study of Sydney

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Abstract
Inequalities in urban greenness have been investigated based on multi-source data. However, studies in Australia often overlook eye-level greenness - an important measure that captures human-perceived greenery. This study examines Sydney's eye-level greenness using Google Street View images and employs Geographically Weighted Regression (GWR) to analyse its association with neighbourhood socio-economic status. The findings reveal that older adults in central Sydney may experience inadequate greenness. Female, unmarried, non-English, indigenous, less-skilled, and unemployed individuals are more likely to face insufficient greenness outside the city centre. Additionally, foreign-born, low-income, carless, and less-educated individuals may experience greenery shortages in both central and suburban Sydney. This study explores Google-Street-View-derived urban greenness – a less employed data source in Australia, offering valuable insights for policymakers in mitigating green space inequalities.

Key words: Green inequality; Google Street View; Eye-level greenness; Australia

1. Introduction

Urban greenery provides substantial benefits to both urban environments and individuals, such as mitigating urban heat island effects and improving air quality (Luo, Zhang and Zhang, 2025), encouraging physical activity (Lu et al., 2019), and fostering social interactions (Enssle and Kabisch, 2020), thereby contributing to enhanced human well-being. However, urban greenery is often unevenly distributed in cities, particularly in the context of urban consolidation. In settings characterized by socio-spatial differentiation driven by market forces, socio-economically advantaged populations tend to enjoy greener urban environments, while disadvantaged groups are more likely to reside in areas with limited greenery. This disparity has led to concerns about green gentrification (Sharifi et al., 2021). Against this backdrop, green space inequality emerges as a critical issue within the discourse of environmental justice, highlighting the need to promote equity in the planning of urban greenness.

Like many other cities influenced by neoliberal urbanism, Australian cities are experiencing increasing socio-spatial differentiation under market forces, which channels populations of varying socio-economic status into distinct urban areas. This process has the potential to exacerbate inequalities in green space access, which requires further exploration. While several studies in the Australian context have examined green space inequalities using land use data (Mushangwe et al., 2021) or satellite imagery (Lin, Meyers and Barnett, 2015), these data sources predominantly capture urban greenness through aerial perspectives, failing to adequately represent the experiential quality of eye-level greenery that characterizes urban dwellers' daily visual environments. Recently, street-view imagery has gained traction in green space research for its ability to capture human-scale greenness. Nevertheless, studies employing this data source in Australia remain limited.

Drawing on data at Statistical Area Level 1 (SA1) from Sydney, this study addresses the following research questions:

(1)What is the spatial distribution of eye-level greenness in neighbourhoods across Sydney?

(2)How are neighbourhood socio-economic statuses associated with eye-level greenness?

To answer these questions, the study first employs machine learning techniques to extract eye-level greenness from Google Street View imagery and visualizes its spatial distribution. It then applies a Geographically Weighted Regression (GWR) model to examine the spatially varying relationship between neighbourhood socio-economic status and eye-level greenness.

The remainder of the paper is structured as follows: Section 2 reviews relevant literature on green space inequality and socio-economic status. Section 3 outlines the research methods. Section 4 presents the findings, followed by a discussion of implications and policy recommendations in Section 5. Section 6 concludes the paper.

2. Literature review: Green space inequality in relation to socio-economic status

Urban greenness provides significant environmental and health benefits, prompting growing scholarly interest in equitable green space planning. Existing green space studies have utilized green space data from various sources, with the most commonly used being parkland use data derived from online maps (Feltynowski et al., 2018)and urban green space management in particular, require proper data on urban green spaces. The potential of urban green spaces to provide benefits to urban inhabitants (ecosystem services or local statistical authorities (Zhang and Luo, 2024), as well as vegetation coverage extracted from satellite imagery such as Landsat (Zhang and Luo, 2025) and Sentinel (Aryal, Sitaula and Aryal, 2022). However, these data sources primarily offer a bird's-eye view of greenery and fail to adequately capture the green environments as perceived by individuals at the human scale, thereby motivating the exploration of alternative data sources.

In response, street view imagery has recently gained traction in green space research. This emerging data source captures eye-level greenness, offering a more human-centred perspective for assessing green space exposure (Zhang and Luo, 2025). Consequently, it has been increasingly adopted in the literature (Li, 2021; Liu et al., 2023; Zhang and Luo, 2025).

Existing literature has extensively examined inequalities in the exposure, availability, accessibility, and use of green spaces across different socio-economic groups. For example, scholars have argued that women have historically been overlooked in urban planning processes, leading them to bear a disproportionate burden of social injustice (Walker, Frediani and Trani, 2013). However, a study in Iran suggests that gender justice in the use of green spaces is achievable, with both male and female residents having their needs adequately met (Rahimi et al., 2023). In the Chinese context, a study conducted in Guangzhou reveals that neighbourhoods with higher proportions of older adults are at greater risk of green space inequality (Yang, Yang and Zhou, 2022). Furthermore, family structure and marital status have also been identified as potential indicators of social vulnerability, which may lead to unequal access to green spaces (Rahman and Zhang, 2018). Ethnicity is another important dimension of green space inequality. For instance, a study across Sydney, Newcastle, and Wollongong found that individuals who do not speak English at home are more likely to face inadequate access to parkland and open grass areas. Similarly, those born in Italy, Lebanon, Vietnam, or China were found to be disproportionately affected by insufficient parkland provision (Mushangwe et al., 2021). In the Australasian context, indigenous people represent a structurally disadvantaged group. A study in New Zealand showed that indigenous communities are more likely to experience lower levels of green space availability and accessibility (Zhang et al., 2024). Moreover, neighbourhoods with more affluent residents such as those with higher incomes or car ownership may enjoy greater access to green space (Dai, 2011; Astell-Burt et al., 2014), while less affluent communities may experience limited green space availability. Educational attainment also plays an important role: a study in Germany demonstrated that urban greenery is unevenly distributed based on education levels (Wüstemann, Kalisch and Kolbe, 2017). Additionally, unskilled workers may be spatially segregated into disadvantaged neighbourhoods, which often lack basic amenities and infrastructure such as urban green spaces (Csomós et al., 2021). In relation to labour force status, a study in Shanghai found that subdistricts with higher unemployment rates exhibit lower levels of green space access (Shen, Sun and Che, 2017). Overall, green space inequality is intricately linked to socio-economic status, warranting continued and in-depth scholarly inquiry into these associations.

3. Research method

3.1 Study area and research framework

This study focuses on Sydney (Figure 1), a neoliberal city in Australia marked by pronounced socio-spatial differentiation driven by market forces, where urban greenery is unevenly distributed across different urban neigh-

bourhoods. The analysis is conducted at the Statistical Area Level 1 (SA1), a geographic unit commonly used in neighbourhood-level research (Zhang and Luo, 2024, 2025). Each SA1 typically contains a population ranging from 200 to 800 individuals, with an average of approximately 400. To minimize potential bias in the calculation of proportional variables, we excluded SA1s with populations fewer than 20 and those without any street view sampling points. After this filtering process, 11,328 SA1s were retained for analysis.

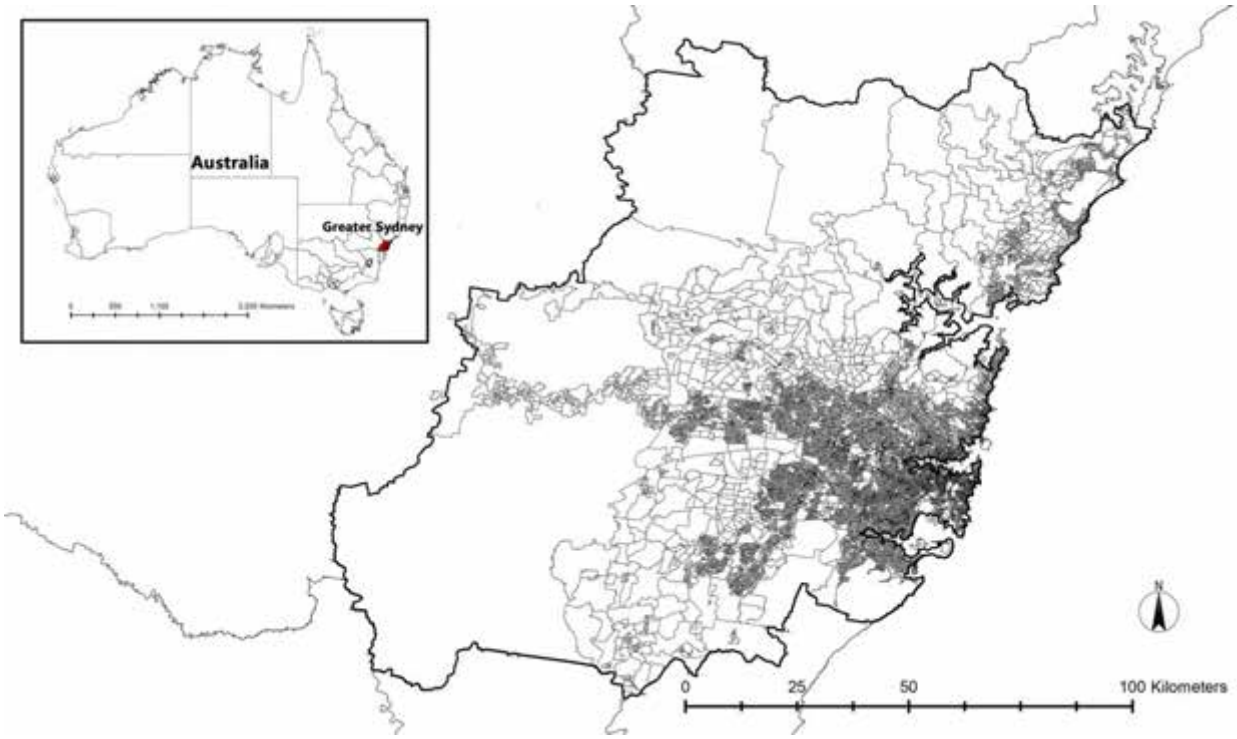

Figure 1. The location of Sydney.

As outlined in the research framework (Figure 2), this study first maps the eye-level greenness of neighbourhoods in Sydney and subsequently employs a Geographically Weighted Regression (GWR) model to examine its spatially varying association with neighbourhood socio-economic status.

Figure 2. Research framework.

3.2 Data

This study draws on two primary data sources. Eye-level greenness was calculated using Google Street View imagery, while socio-economic variables at the SA1 level were obtained from the 2021 Australian Census released by the Australian Bureau of Statistics (ABS). The variables used in the analysis were derived from these sources, with further explanations and descriptive statistics provided in Sections 3.2.1 and 3.2.2, as well as in Table 1.

3.2.1 Dependent variable: eye-level greenness

As shown in Fig. 2, the calculation of eye-level greenness includes the following steps: First, the road network data in Sydney was acquired from OpenStreetMap. Second, 199,090 image-generating points with 100 m intervals were created using ArcGIS. Third, the coordinates of these points were fed into a Python-based crawler to download four Google Street View (GSV) images per point, with headings of 0°, 90°, 180°, and 270°, each with a 90-degree field of view. After removing points with invalid or missing imagery, we retained 144,850 valid points, which includes a total of 579,400 street-view images. Fourth, we used the Deeplab_v3 image segmentation algorithm, trained on the Cityscapes dataset (https://www.cityscapes-dataset.com/), to extract the street view greenness from each image using Python. Fifth, the ratio of vegetation pixels to the total number of pixels across the four images for each point was calculated, yielding the Street View Greenness (SVG) indicator for that location.

$$SVG_singlepoint = \frac{Vegetation\ pixels\ of\ four\ images}{Total\ pixels\ of\ four\ images} \quad (1)$$

After that, the average SVG of sampling points within each SA1 was calculated as the eye-level greenness of that SA1.

3.2.2 Independent variables: socio-economic status

Eleven variables that capture neighbourhood socio-economic disadvantages at the SA1 scale were selected as dependent variables for their potential relevance to green space inequality (as shown in the literature review): the proportion of females, the proportion of individuals aged 65 and older, the proportion of individuals without partners, the proportion of individuals who speak English not well or not at all, the proportion of populations born abroad, the proportion of indigenous populations, the proportion of low-income (weekly income < AUD 800) households, the proportion of dwellings without cars, the proportion of populations whose educational levels are below bachelor, the proportion of populations whose occupations are not in the manager, administrator, and professional categories, and the proportion of unemployed individuals. The VIF values of all the selected independent variables are smaller than 5, indicating no multi-collinearity.

Table 1. Descriptive statistics of dependent and independent variables.

	Mean	S.D	Min.	Max.
Dependent				
Eye-level greenness	0.282	0.129	0.000	0.840
Independent				
female	0.506	0.035	0.000	0.986
age65+	0.156	0.097	0.000	1.000
noPartner	0.126	0.060	0.000	0.708
nonEnglish	0.061	0.067	0.000	0.642
bornAbroad	0.415	0.170	0.000	1.000
indigenous	0.018	0.028	0.000	0.745

lowIncome	0.068	0.051	0.000	0.388
noCar	0.078	0.082	0.000	1.333
belowBachelor	0.458	0.110	0.000	0.950
nonMAP	0.733	0.109	0.314	1.000
unemploy	0.052	0.039	0.000	0.500

3.3 Geographically Weighted Regression (GWR)

To explore the equity issue in urban greenness, we employed the Geographically Weighted Regression (GWR) model to examine the associations between neighbourhood socio-economic status and eye-level greenness. Compared to frequently used linear regression models such as the ordinary least squares (OLS) regression which yields constant coefficients across the whole sample, the GWR model allows the coefficients of explanatory variables to vary across geographic locations, thereby capturing the spatial heterogeneity of these relationships (Kang et al., 2021). The GWR model is specified as follows:

$$y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) X_{ik} + \varepsilon_i \qquad (2)$$

Where y_i is the eye-level greenness at SA1 *i*; $\beta_0(u_i, v_i)$ represents the intercept at SA1 *i*; $\beta_k(u_i, v_i)$ is the coefficient (weight) of the *k*th independent variable estimated for each SA1 *i*; ε_i is a random error.

4. Results

4.1 The spatial pattern of neighbourhood eye-level greenness in Sydney

Figure 3 illustrates the spatial pattern of neighbourhood eye-level greenness in Sydney. A general trend is observed whereby eye-level greenness increases from the central urban area toward the suburban regions. Specifically, neighbourhoods in the southern and western parts of the city exhibit relatively lower levels of eye-level greenness compared to those in the north. Notably, the southwestern region of Sydney is recognized for its concentration of socio-economic disadvantage. Accordingly, it is essential to further investigate the relationship between neighbourhood socio-economic status and eye-level greenness. Such analysis can deepen the understanding of green space inequality and offer valuable insights for advancing environmental justice through urban planning and design policies.

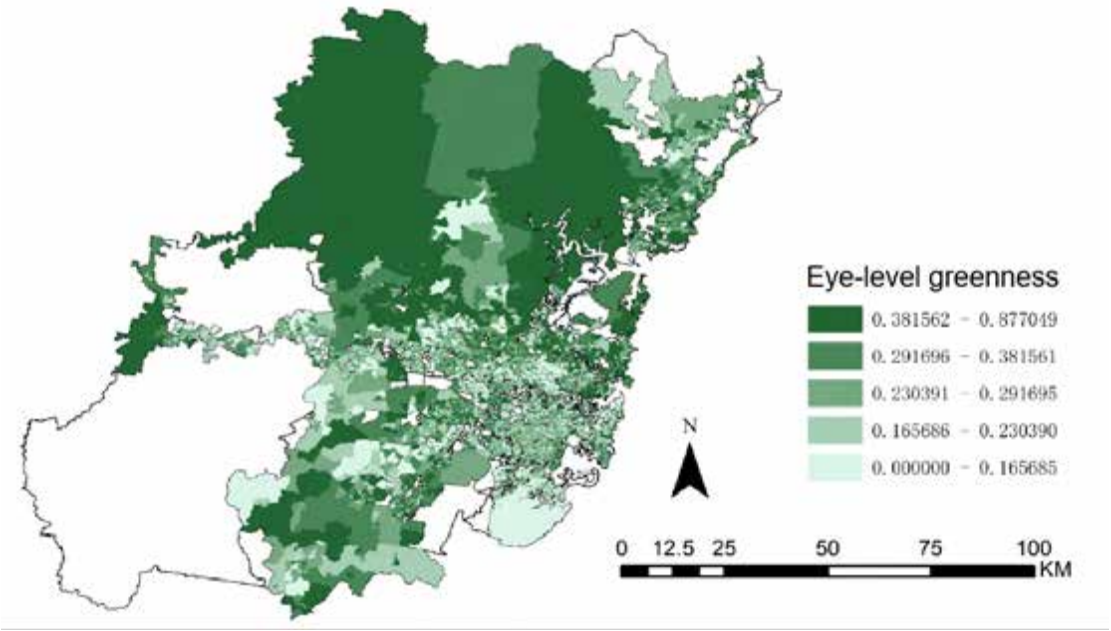

Figure 3. The spatial pattern of neighbourhood eye-level greenness in Sydney.

4.2 Association between neighbourhood socio-economic status and eye-level greenness

Table 2 shows the regression result summary of both the OLS model and the GWR model. The OLS model suggests that the higher proportions of females, individuals without partners, foreign-born, carless, less-educated, and less-skilled people are significantly associated with insufficient eye-level greenness. The adjusted R^2 values of the OLS and the GWR models are 0.206 and 0.465 respectively, indicating that the GWR has better performance than the OLS and spatial heterogeneity exists in the association between neighbourhood socio-economic status and eye-level greenness.

Table 2. Regression result summary of the OLS and the GWR models. (All coefficients are standardized.)

	OLS		GWR	
	Coef.	**Sig.**	**Coef.(median)**	**Coef.(mean)**
female	-0.068	0.000	-0.028	-0.038
age65+	0.304	0.000	0.148	0.150
noPartner	-0.053	0.000	-0.014	-0.013
nonEnglish	0.013	0.409	0.013	-0.055
bornAbroad	-0.312	0.000	-0.213	-0.230
indigenous	-0.011	0.313	0.025	0.017
lowIncome	-0.015	0.209	-0.016	-0.011
noCar	-0.095	0.000	-0.026	-0.038
belowBachelor	-0.195	0.000	-0.138	-0.112
nonMAP	-0.100	0.000	-0.070	-0.075
unemploy	0.068	0.000	0.056	0.062
R^2	0.207		0.473	
Adjusted R^2	0.206		0.465	

Since GWR has better performance compared to OLS, we further explain the associations between the selected socio-economic variables and eye-level greenness based on the results of the GWR model. Figure 4 presents the results of the GWR model, reflecting the spatially varying relationships between neighbourhood socio-economic status and eye-level greenness in Sydney. Neighbourhoods highlighted in red indicate a negative association between the examined socio-economic disadvantages and eye-level greenness, whereas those highlighted in blue indicate a positive association.

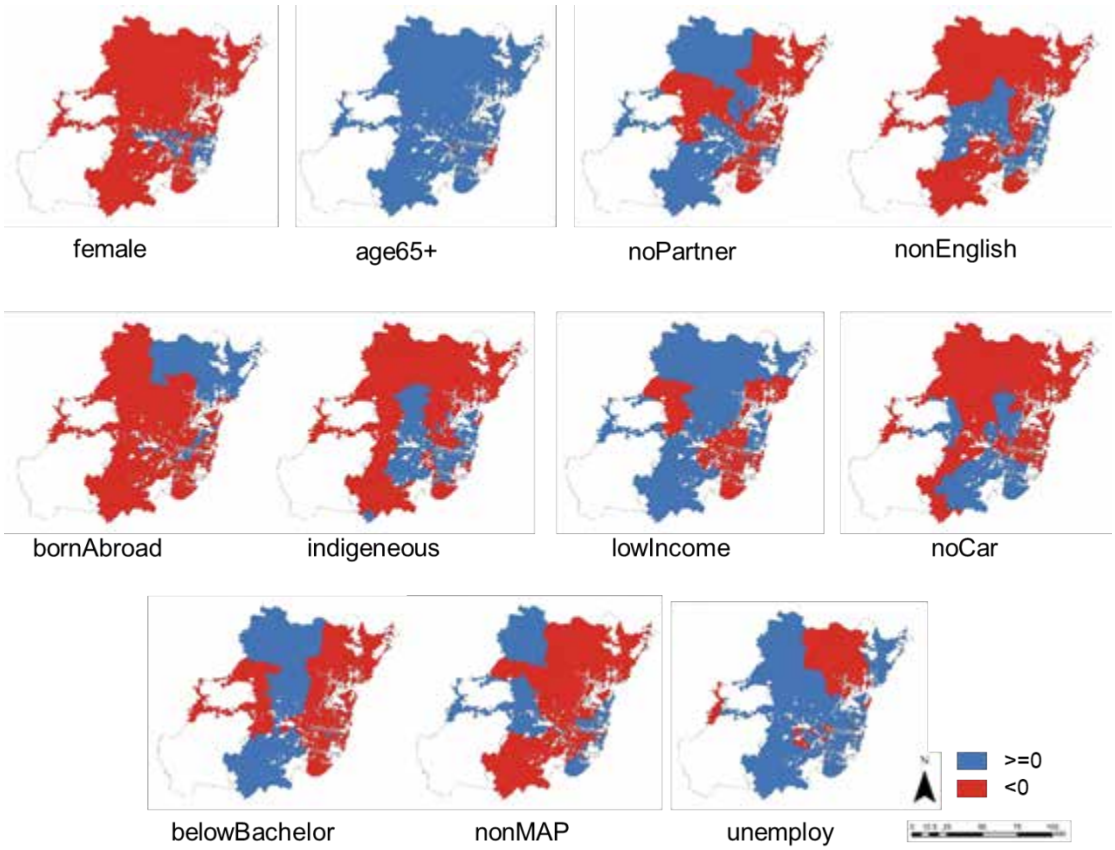

Figure 4. Associations between neighbourhood socio-economic status and eye-level greenness. (All coefficients are standardized.)

Female
In areas near the city centre and the western transport corridor, neighbourhoods with a higher proportion of female residents are associated with greater street-view greenness, whereas those outside these regions exhibit lower eye-level greenness.

Age65+
Neighbourhoods with higher proportions of older adults (65+) in the eastern city centre exhibit lower eye-level greenness, whereas this association is positive in most other regions of Sydney.

NoPartner
In many eastern and some western regions, neighbourhoods with higher proportions of individuals without partners tend to have lower eye-level greenness. Conversely, in the eastern city centre as well as some northwestern and southwestern areas, the association is positive.

NonEnglish
Most northern and southern neighbourhoods show a negative association between higher proportions of non-English speakers and eye-level greenness. In contrast, neighbourhoods in the eastern centre and some western suburban areas exhibit a positive association.

BornAbroad
Neighbourhoods with higher proportions of foreign-born residents generally have lower eye-level greenness, except for some suburban neighbourhoods in the north.

Indigenous
In suburban Sydney, neighbourhoods with higher proportions of indigenous residents tend to have lower eye-level greenness, whereas those in the eastern city centre or some western suburbs exhibit higher levels of human-perceived greenness.

LowIncome
Neighbourhoods with higher proportions of low-income households in eastern regions and some western fringes are associated with lower eye-level greenness. In contrast, such neighbourhoods in western suburbs and some northeastern areas show higher levels of greenness.

NoCar
In many suburban and eastern central areas, neighbourhoods with higher proportions of carless households have lower eye-level greenness. However, in some northwestern and southern areas, the association is positive.

BelowBachelor
Neighbourhoods with higher proportions of less-educated individuals in eastern and some western regions display lower eye-level greenness, while those in northwestern and southwestern suburbs show higher greenness.

NonMAP
Across suburban regions, neighbourhoods with higher proportions of low-skill workers tend to have lower eye-level greenness. However, in some areas near the city centre or peripheral zones, these neighbourhoods exhibit higher greenness.

Unemploy
In most regions of Sydney, neighbourhoods with higher unemployment rates are associated with higher eye-level greenness. However, some southwestern and northern neighbourhoods with higher employment rates are characterized by lower levels of greenness.

5. Discussion and policy implications

5.1 Discussion

The case of Sydney demonstrates a decline in eye-level greenness alongside urbanization, with central areas exhibiting higher eye-level greenness while suburban neighbourhoods are significantly greener. This spatial pattern aligns with observations in other global cities, such as Shanghai (Wu et al., 2019), New York (Li, 2021), and London (Pan, Bardhan and Jin, 2021), as urban centres are dominated by built-up areas, with limited space left for urban greenery.

Green space inequality is evident in less socio-economically advantaged neighbourhoods. In Sydney, older adults in the eastern central areas are more likely to experience lower eye-level greenness. This negative association can also be observed in other urban contexts, such as in Guangzhou, China (Yang, Yang and Zhou, 2022). A possible explanation is that those residing in the city centre are long-term residents, and they age alongside

the densification of urban cores over time. Females, unmarried individuals, non-English speakers, indigenous people, low-skilled workers, and unemployed individuals face greater insufficiency of greenness outside the city centre. These populations may concentrate within certain socio-economically disadvantaged suburban neighbourhoods, wherein green resources are limited. Furthermore, other less-advantaged populations, such as overseas-born individuals, those with lower incomes, those without car ownership, and those with lower educational attainment tend to experience lower human-perceived greenness in both central and suburban areas. These associations are supported by evidence in existing literature (Dai, 2011; Astell-Burt et al., 2014; Wüstemann, Kalisch and Kolbe, 2017; Mushangwe et al., 2021).

5.2 Policy implications

To mitigate green space inequalities across socio-economically stratified neighbourhoods, tailored urban greening interventions should be differentially implemented according to distinct spatial and demographic characteristics. In the city centre where urban consolidation limits available space for traditional greening, vertical greenery, such as green façades on buildings, could enhance eye-level greenness and should be implemented in dense urban environments. In suburban areas where socio-economically disadvantaged groups (including higher proportions of females, unmarried individuals, non-English speakers, indigenous people, low-skilled workers, and unemployed individuals) reside, maintaining sufficient tree coverage is crucial. This requires the local government to scientifically and systematically consider green space planning during suburban development. Furthermore, the institutional coupling of subsidized housing initiatives with green infrastructure development emerges as a demonstrably effective policy mechanism for advancing environmental justice, ensuring socioeconomically disadvantaged groups gain equitable access to green urban environments.

6. Conclusion

Guided by the environmental justice discourse, this study examines equity in urban greenery by investigating the associations between neighbourhood socio-economic status and eye-level greenness in Sydney, Australia. The findings reveal that older adults residing in the eastern central areas of Sydney are more likely to experience lower levels of eye-level greenness, while females, unmarried individuals, non-English speakers, indigenous people, less-skilled workers, and unemployed individuals tend to encounter insufficient greenness outside the city centre. Furthermore, foreign-born, low-income, carless, and less-educated individuals are generally exposed to less eye-level greenness greenery in both central and suburban areas.

Drawing upon these findings, the study proposes a differentiated urban greening framework that accounts for distinct spatial contexts. Specifically, implementing green façades in the city centre may help enhance eye-level greenness. In socio-economically disadvantaged suburban neighbourhoods characterized by higher proportions of the aforementioned vulnerable groups, it is crucial to maintain adequate tree canopy coverage and to integrate green space planning with the development of affordable housing projects.

A key limitation of this study is its reliance on cross-sectional data, which precludes the identification of causal relationships between socio-economic status and eye-level greenness. Future research should incorporate longitudinal data by regularly collecting street-view imagery to facilitate deeper insights into the causal dynamics of green space inequality.

Despite this limitation, by leveraging street-view imagery, a data source underutilized in Australian green space research, this study contributes novel insights into spatial inequality in urban greenery. It elucidates how socio-economic disadvantage correlates with eye-level greenness and extends the environmental justice discourse with an Australian case study, thereby supporting future international comparative research.

Declaration of generative AI in scientific writing

During the preparation of this work the authors used ChatGPT in order to proofread the sentences. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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Beyond the ideal: rethinking Aging in (urban) Place through the lens of vulnerability. Insights from Italian CASA Project

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Abstract
Aging in Place is increasingly central to debates on urban aging, especially in the context of demographic transitions and endless urbanization. While often framed as a desirable goal both for individuals and welfare systems, it can also expose older adults to hidden vulnerabilities. Remaining in the same setting over time may exacerbate forms of exclusion, isolation, or distress. Aging must therefore be seen as a situated and dynamic process, shaped by the evolving interaction between individuals and their environments. Reframing Aging in Place through this lens reveals the need to move beyond static, universal models. This is the premise of the CASA project, which explores how urban and housing contexts influence aging trajectories, offering tools to support more inclusive, context-sensitive policies for healthy longevity.

Keywords: Aging in place, age-friendly city, healthy longevity, empowerment, inclusion

Introduction

In the near future, cities will become the stage for a dual, epochal transformation. On one hand, the global population aged 60 and over is rapidly increasing, with projections suggesting it will double in the coming decades (WHO, 2023). On the other hand, for the first time in history, the majority of people are choosing to live in urban areas—a trend that, since 2008, has been profoundly reshaping human geography (UNFPA, 2007; UN, 2024) and, along with it, people's lifestyles.

Italy offers a clear illustration of this dual shift. The country is experiencing a dramatic decline in birth rates—reaching new historical lows—alongside a steady rise in life expectancy (ISTAT, 2024a). These trends are significantly altering the population structure, leading to an increasingly aging society, with a notable rise in the proportion of people aged 65 and over. In this context, medium-sized cities play a crucial role, acting as true pillars of Italian life and hosting a significant portion of the national population (OECD, 2014).

The Italian city of Bergamo is a perfect example of this reality: a complex and layered territory, where the historic urban fabric coexists with new expansions, and where residents over the age of 65 represent a significant proportion, higher than the national average (ISTAT, 2024b). Here, stories of urban growth, strategic connectivity, and the challenges of demographic change converge, prompting new reflections on the cities of the future.

In this scenario, it becomes essential to understand how health and the urban environment can mutually influence each other, and how population aging might transform the way we design and experience our cities. The World Health Organization (2017) calls for an integrated approach that places the well-being of older adults at the center, promoting a model of "active aging" in which health and quality of life are closely interwoven with the

urban environment.

Within this framework, the concept of Aging in Place (AIP)—growing older in one's own home and community—has emerged as a key focus in contemporary debates on aging, particularly in urban contexts. As populations age and cities evolve, scholars and policymakers increasingly promote AIP as a pathway to healthier, more independent, and economically sustainable aging (Pynoos, 2008). This model aligns closely with older adults' preferences to remain in familiar surroundings, maintaining their routines, identity, and social networks (Wiles et al., 2012). However, although the AIP paradigm holds great potential, it is not without complexities or criticisms. As noted by Golant (2015) and reaffirmed by other scholars, remaining in one's own home may, in some cases, exacerbate rather than alleviate vulnerability— effectively keeping individuals stuck in place (Cadmus et al., 2023), rather than supporting healthy longevity.

This article aims to present the reflections emerging from the analysis of these tensions within the Italian PNRR CASA Project. It begins by exploring the evolution and appeal of Aging in Place (AIP), then delves into the critiques that challenge its long-term sustainability. The discussion is framed through the multidimensional concept of vulnerability, which—rather than being viewed as a sign of failure—should be recognized as a crucial dimension to be actively addressed in AIP-related policies and practices

Toward a multidimensional understanding of aging

In today's demographic landscape, aging is no longer a marginal issue: it is one of the structural features of our time. The steady global increase in the older population marks a turning point that challenges traditional conceptions of age, productivity, and social roles. Older adults do not represent a homogeneous group, but rather a population that is increasingly diverse in social, economic, cultural, and functional terms. This complexity calls for a critical reconsideration of aging—not as a problem to be solved (Phillipson, 2013), but as a structural condition of modern societies to be addressed with foresight.

For many years, medical sciences have described aging as an "innate and immutable" process (Powell & Hendricks, 2009), contributing to the construction of a medicalized paradigm of old age. This paradigm still persists today as a deeply rooted cultural legacy, evident in everyday life through the ongoing prevalence of ageist stereotypes (Butler, 1975).

Morganti's theoretical perspective aligns with a much-needed shift in the study of aging. In her model of "Longevity as Responsibility", Morganti (2024) describes aging within a situated life course perspective—not merely as a biological process, but as a multidimensional experience influenced by personal, social, and environmental factors. As Morganti (2022) asserts, "To study aging is to accept the challenge of understanding the ultimate complexity of human beings". This vision resonates with the New Map of Life, launched by the Stanford Centre on Longevity (2022), which encourages a rethinking of life stages through a map in which the final phase remains to be drawn—not as a time of fragility and loss of self-determination, but as a space of potential.

These models help to overcome deficit-based views of aging, proposing theoretical frameworks rooted in agency, responsibility, and potential. They represent a true paradigm shift, inviting us to recognize older adults as active agents and valuable contributors, rather than passive recipients of care. At the same time, we must acknowledge the profound inequalities that shape the experience of aging. These intersect with factors such as class, gender, ethnicity, geography, and disability, producing vastly different conditions of later life. While some may experience aging as a time of freedom and fulfilment, others encounter isolation, poverty, and frailty. As Morganti (2022) reminds us, aging healthily is both a right and a responsibility. It requires personal commitment in taking responsibility for one's own aging trajectory, and at the same time, political engagement aimed at

addressing structural injustices, ensuring equitable access to resources, and safeguarding the right to age with dignity and autonomy.

The demographic transformation associated with aging is not a challenge to be feared, but an extraordinary opportunity to reconceptualize later life as a stage rich in potential (Morganti, 2022). Embracing this challenge means investing not only in healthcare and pensions, but also in social planning, policymaking, and urban design, through empowerment strategies and the promotion of active aging as a path toward healthy longevity.

Aging in Place: navigating longevity through autonomy, responsibility, and environment

The concept of Aging in Place (AIP) represents one of the most significant and concrete responses to the challenges posed by demographic aging. It is grounded in the idea that older adults should have the opportunity to continue living in their own environment—autonomously, safely, and with social integration—even in the presence of functional limitations or care needs. This perspective reflects not only a pragmatic orientation linked to the efficiency of welfare systems (Pynoos, 2008)—which tend to prioritize home-based solutions over institutionalization—but also embodies a dignified and relational vision of aging, one that values the connection to place and territory as crucial dimensions of well-being in old age.

Viewed through the theoretical lens of "Longevity as responsibility" (Morganti, 2024), AIP gains further conceptual depth. Longevity, in this framework, is not a neutral or purely biological condition, but a dynamic process that involves individuals, communities, and institutions—all of whom share responsibility for creating the conditions that support active and sustainable aging. In this sense, inhabiting one's old age means far more than simply remaining at home: it implies being embedded in a context that affirms one's right to continuity, identity, participation, and self-determination. AIP, in fact, encompasses a plurality of dimensions: physical (accessible housing, safe neighbourhoods), social (proximity networks, meaningful relationships), cultural (recognition of the role and skills of older people), and political (local services, inclusive urban planning).

Recent studies have highlighted how the desire of older adults to remain in their own homes reflects not only a practical need, but also a deep emotional and identity-based connection with the places they inhabit (Wiles et al., 2012; McGrath & Hand, 2021). The home, the neighbourhood, the community thus become spaces dense with meaning—capable of holding memories, routines, and relationships. The relational dimension of AIP is emphasized in the definition offered by the World Health Organization, which affirms that older adults should be able to "remain at home in their familiar environment and maintain relationships that are important to them" (WHO, 2020). The ability to sustain meaningful social ties—with family, friends, and neighbours—has been identified as a key protective factor against frailty, depression, and cognitive decline (Holt-Lunstad et al., 2015; Bourassa et al., 2017). At the same time, scholars have urged a more nuanced discussion of AIP—one that foregrounds place and its intersectional dimensions. Not all places are created equal: differences in accessibility, safety, and social cohesion produce uneven opportunities for quality aging in place (Greenfield, 2018; Yarker et al., 2024). This calls for a rethinking of domestic and urban space through the lens of spatial justice, with attention to disparities shaped by gender, class, ethnicity, and disability. In this light, dwelling is not a neutral act, but a negotiated and situated process that demands both political awareness and design innovation. Conceiving AIP as a "journey"—as suggested by Rogers et al. (2020)—also helps overcome a static view of both place and and the aging individual, and instead embrace a dynamic, process-oriented, and transformative view. Aging, then, becomes a trajectory marked by change, along which individuals can implement adaptive strategies to preserve their flow and well-being (Morganti, 2024).

Defining Aging in Place univocally remains a rather complex task, as many scholars observe and describe it from

different perspectives (Rogers et al., 2020). A more comprehensive understanding must reflect the heterogeneity and complexity of the concept. The theme of Aging in Place prompts significant reflection across multiple disciplines, raising important questions about the ambiguity of its definition and its implications in terms of spatial justice and inequality (Finlay et al., 2021).

Aging in place between ideals and limitations: critical perspectives and vulnerability

While the dominant discourse often tends to romanticize Aging in Place, a growing body of literature calls for a more critical perspective, raising doubts about its actual effectiveness for all individuals—particularly in the absence of adequate support systems. Golant (2008), for instance, highlights how the idealization of AIP may overlook the complexity of older adults' experiences, potentially concealing situations of isolation, neglect, and decline. Similarly, Wiles et al. (2012) question the assumption of the home as an inherently positive place, emphasizing that the experience of AIP is not universally empowering but is instead deeply contingent on context, resources, and relationships.

In this context, Aging in Place reveals its inherently ambivalent nature. On the one hand, it remains the preferred option for many older adults (Cutchin, 2003), who associate it with several benefits: environmental familiarity, a sense of control and autonomy, continuity with personal history (Golant, 1984), and the perception of home as a strategic economic asset—both as a safeguard for future health-related expenditures and as an inheritance to pass on to future generations (Di, 2003). Over the past two decades, public policies have largely reinforced these preferences, aligning with broader trends toward deinstitutionalization and home-based care. On the other hand, however, AIP can exacerbate everyday challenges such as mobility issues, limited access to healthcare services, and social isolation (Plouffe & Kalache, 2010; Thomas & Blanchard, 2009). From this perspective, AIP reveals its "dark side": while it can certainly represent an opportunity, it may also expose older individuals to forms of vulnerability that hinder the fit between person and environment (Lawton & Nahemow, 1973), negatively affecting their ability to cope with the challenges of aging.

Within this framework, vulnerability emerges as a key concept in evaluating the extent to which AIP can be considered a sustainable or problematic aging strategy. Vulnerability is a complex and multidimensional concept, often associated with terms such as "fragile," "exposed," "susceptible," or "powerless" (Schroeder & Gefenas, 2009). However, the New Oxford Dictionary defines it as "the state of being exposed to the possibility of being harmed or attacked, physically or emotionally" (Tong, 2014), suggesting a condition that can be situational and relational rather than intrinsic to the individual. Schröder-Butterfill and Marianti (2006) offer a particularly useful definition, describing vulnerability as "a high risk of negative outcomes resulting from a combination of exposure to risk, lack of resources, and an inability to cope." From this perspective, vulnerability is not an inherent characteristic of old age, but rather the result of interactions among personal, environmental, structural, and relational factors. The authors emphasize the importance of protection, attributing a central role to the concept of coping, understood as the set of personal resources used to deal with difficult or stressful situations—a crucial protective mechanism against vulnerability. Alongside individual capacities, social and support networks, as well as formal protections offered by health and social services, play a key role. Nevertheless, vulnerability is frequently conflated with frailty in much of the aging literature, where older adults are often depicted as physically, psychologically, or socially diminished (Sarvimaki & Stenbock-Hult, 2016). Schröder-Butterfill and Marianti (2006) challenge this reductive view, arguing that frailty is only one dimension among many. Exposure to external risks, the nature and severity of those risks, and an individual's adaptive capacity all contribute significantly to vulnerability in later life—regardless of physical condition.

As previously discussed, acknowledging the broad heterogeneity of aging is essential. This involves taking into

account the psychological dimensions that characterize this stage of life (Morganti, 2022) and resisting ageist assumptions that homogenize older adults into a single, vulnerable group. The World Health Organization has echoed this imperative through its 2016 global campaign to combat ageism (WHO, 2021), and more recently via the endorsement of an international "Charter on Ageism in Healthcare" signed by leading scholars worldwide (Ungar et al., 2024).

The study of vulnerability in older adults can be approached from multiple perspectives, as highlighted by Channer (2020), given the wide array of contributing factors. To fully capture its complexity, it is helpful to distinguish between various categories of vulnerability, even though they often overlap and interact. For example, psychological aspects can influence physical vulnerability: it has been demonstrated that negative self-perceptions of aging predict adverse outcomes in performing daily living activities (Moser et al., 2011). Similarly, economic vulnerability, particularly low income, has been consistently identified in cross-sectional studies as a key factor in older adults' exposure to disadvantage (Smeeding et al., 2008; Stewart et al., 2011; Allan et al., 2011; Clarke & Gallagher, 2013). According to Allan and colleagues (2011), economic conditions are central to any comprehensive assessment of vulnerability in old age. Some studies highlight the interplay between economic and social or relational vulnerabilities. For example, older adults experiencing financial hardship are more likely to face mobility restrictions (Ryser & Halseth, 2012), which can lead to increased social isolation. Scholars agree that this subgroup is particularly susceptible to negative outcomes (Clarke & Gallagher, 2013; Dong et al., 2012).

Since social vulnerability is contextually shaped rather than innate, it can also be exacerbated by medical conditions: physical impairments may restrict mobility, impede social interaction, and intensify feelings of isolation (Rapaport et al., 2015). Given its dynamic nature, social vulnerability is not limited to economic poverty, but includes events and conditions that undermine social, cultural, political, and economic relationships (Cruz et al., 2019).

Environmental vulnerability, by contrast, concerns the relationship between the older adults and the physical environment in which they live. It emerges from the interaction between population characteristics, access to services, and infrastructure. Due to its complexity, the study of vulnerability in urban life allows for a deeper understanding of the "causes of the causes"—that is, the social determinants that shape a vulnerable urban population (Marmot & Wilkinson, 2006). Understanding this form of vulnerability requires multi-level interventions that address not only the physical, social, and economic environment, but also the institutional and regulatory frameworks that shape everyday life.

Among individual vulnerabilities, we must consider not only potential declines in health, but also in mobility or cognitive functioning, as well as mood disorders—often exacerbated by social isolation. Individual vulnerabilities become critical when they interact with the environment—when people perceive physical or psychological barriers in their surroundings, leading them to feel restricted in their everyday lives. These factors can, in turn, undermine safety and independence, increasing exposure to the risk of aging trajectories marked by frailty (such as falls, illness, or isolation).

As previously discussed, economic vulnerability intersects with environmental factors in significant ways: when older adults lack the financial means to maintain or modify their homes, access home-based care, or meet basic living expenses, they are at heightened risk of housing insecurity, which can generate chronic instability and anxiety, thereby reducing quality of life and reinforcing pathways toward frailty. Social and relational vulnerability, resulting from the loss of meaningful relationships, withdrawal from community life, or absence of informal support networks, may require an Aging in Place approach supported by strong social infrastructures—such as

community centres, accessible transportation, and intergenerational initiatives—capable of promoting active aging and, above all, fostering a cultural shift toward the assumption of personal responsibility in the aging process. As outlined previously, the risks of isolation and loneliness can have significant negative consequences for mental health (Nicholson, 2009).

From a Bronfenbrennerian ecological perspective (Bronfenbrenner, 1979), environmental vulnerability can be located at the mesosystem level, where the individual interacts with settings immediately outside of their proximal networks. From there, it extends across further levels, up to the macrosystem, which includes cultural, institutional, and regulatory contexts. Institutional vulnerability, for instance, can stem from inadequate public policies: fragmented, expensive, or inaccessible services can expose older adults to trajectories of frailty. A lack of coordination among health care, housing, and local welfare systems represents a significant risk. This ecological framework enables a multidimensional interpretation of vulnerability—one shaped by dynamic interactions between the individual, the environment, and wider societal systems.

Recent research conceptualizes advantages and disadvantages in later life—including in health, social connectedness, and financial stability—as cumulative outcomes of life course processes. Over time, these processes lead to growing heterogeneity among older adults, with vulnerability unevenly distributed and associated with highly diverse outcomes (Cihlar et al., 2023). In line with this view, Shin et al. (2021) analysed vulnerability as a multidimensional concept, identifying six distinct profiles based on four dimensions: material, physical, mental, and social. Among these, the combination of health and social vulnerability had the most significant negative impact on subjective well-being, followed by profiles that also included material vulnerability. The results support the notion that vulnerability, in relation to perceived well-being, must be approached from a multidimensional perspective. Cihlar et al. (2023) further reinforce this perspective, showing that social support can significantly buffer the negative impact of vulnerability on quality of life. From this multidimensional and ecological standpoint, aging appears not as a fixed condition but as a process shaped by the accumulation of heterogeneous changes over time, across multiple life domains and environmental contexts (Cihlar et al., 2023). Given this complexity, Aging in Place cannot be regarded as a one-size-fits-all solution or as universally desirable. Rather, it is an option that requires a context-sensitive understanding of both individual and environmental characteristics in order to be sustainable. The balance between personal capabilities and environmental demands must be dynamically monitored, with a view to preventing vulnerability and promoting autonomy, in support of active and responsible aging, and ultimately of healthy longevity.

The thin space between people and places in "Aging in Place" studies:
In light of the reflections proposed thus far, we argue that Aging in Place can no longer be considered solely as a linear process or merely as the outcome of individual choices driven by the desire to remain in one's own home. Instead, it is necessary to place this phenomenon within a broader theoretical framework, capable of capturing the interplay between individual characteristics, environmental dimensions, and cultural factors that influence both its experience and feasibility. Aging, in this sense, emerges as a relational and situated process, unfolding within a system of affordances—opportunities for action—that both reflect and influence individuals' ability to act, dwell, and participate in social life. The home and the neighbourhood thus become much more than physical containers; they are transformed into lived and symbolic spaces, contributing to identity construction, biographical continuity, and a sense of belonging.

This approach calls for a paradigm shift. The question is no longer merely whether an environment is accessible or meets specific standards, but rather whether and how that environment supports, sustains, or inhibits the possibility of aging well. From this perspective, affordances—as defined in Gibson's (1977) ecological theory—are

neither objective properties of environments nor purely subjective perceptions but instead emerge in the thin space between individual and context (Butti & Morganti, under review), particularly within their dynamic interaction. Each space, therefore, is not neutral: it becomes meaningful to the extent that it can be used and interpreted by those who inhabit it. Urban spaces offer potential and limitations to older adults not through their architectural features alone, but through the embodied and situated interactions between those features and the individuals engaging with them. Consequently, the design of aging-related policies cannot ignore an integrated analysis of the characteristics of places and the people who live in them, of social networks, cultural norms, and everyday practices.

Moreover, acknowledging that affordances also include relational dimensions—such as the availability of support, social interactions, and mutual recognition—implies recognizing that well-being in old age is intimately tied to the quality of community life. Designing age-friendly spaces cannot be reduced to the removal of architectural barriers or the expansion of service provision. Rather, it requires the adoption of a systemic vision, one that considers the multiple layers of context—as proposed by Bronfenbrenner's ecological model of human development (1979)—as well as the diverse roles that older individuals occupy in daily life, beyond the passivizing lens often perpetuated by ageist stereotypes (Butler, 1975).

The adoption of a complexity epistemology proves, within this framework, not only desirable but indispensable. A reductionist approach, which isolates variables and produces generic models, cannot account for the heterogeneity of the aging experience nor adequately respond to its challenges. Instead, it is necessary to recognize that aging is always a singular experience, rooted in specific places and times, mediated by cultural representations, individual resources, and social constraints. Consequently, any intervention aimed at promoting Aging in Place must be calibrated on the basis of contextual and participatory analyses, capable of listening to the narratives of older people and reflecting their complexity.

In this scenario, it becomes essential to develop research and design practices that place the voices of older adults at the centre, actively involving them in the definition of the spaces in which they live. Autonomy, a sense of control, identity continuity, and the possibility of participating in community life cannot be guaranteed by top-down measures but must emerge from co-constructive processes that recognize older adults as active agents in the production of their living environment. This perspective also helps counter homogenizing logics that treat older adults as an undifferentiated category, instead fostering a personalized approach attentive to differences in gender, class, culture, health, and individual history.

Conclusions

Drawing from the considerations discussed, the need to overcome simplistic and universalizing views of aging and Aging in Place becomes evident. Studies on AIP should embrace a complex epistemological approach, capable of capturing the dynamic interaction between people and places, between evolving subjectivities and specific urban and cultural contexts. Aging is not a uniform process but a unique and situated journey, constructed through continuous interaction with the affordances offered by the environment and the meanings individuals attribute to the places of their daily life. For this reason, it is urgent to recognize older adults as active actors capable of influencing their own life trajectory. Promoting empowerment, awareness, and self-determination among older people also means combating ageist stereotypes and valuing the plurality of experiences. The integration of Bronfenbrenner's ecological model of development offers a useful tool to analyse AIP through multiple levels of interaction, from micro to macro, thereby restoring complexity and depth to the phenomenon of aging.

In Italy, the debate on AIP remains limited and often dominated by sectorial perspectives, with little attention

to the experiential and relational dimensions of aging. For this reason, we consider it fundamental to initiate multidisciplinary and contextually situated research paths, capable of enhancing local experiences, dialoguing with the culture of living and dwelling, and recognizing the subjectivity of older adults as a central element in the construction of inclusive urban environments.

It is within this theoretical horizon that the PNRR CASA project is situated, aiming to deepen the relationship between housing conditions, urban space, and aging trajectories in medium-sized Italian cities. The project adopts a multidimensional and multilevel approach to analyse how specific urban configurations can support or hinder healthy aging pathways, taking the city of Bergamo as a case study—a territorial reality paradigmatic for its spatial, social, and institutional characteristics. Through the integration of data from institutional and territorial sources at the neighbourhood level, it seeks to capture different forms of urban and housing vulnerability, as well as the potentials of contexts to promote autonomy, participation, and well-being among older adults. The ultimate goal is to develop a model, applicable to other medium-sized Italian cities, able to provide a vulnerability index of the over-65 population.

In line with the assumptions of Aging in Place and inspired by complexity epistemology, CASA aims to overcome reductive views of aging by promoting a situated and relational reading of interactions between individuals and environments. In this sense, the project aspires to provide knowledge tools useful for defining more inclusive and aware urban policies, capable of addressing the challenges posed by population aging in an equitable and sustainable manner.

We believe that only through this paradigm shift will it be possible to design cities and policies that support aging with full responsibility and promote healthy and active longevity.

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A Bibliometric Analysis on the Relationship Between Migration and Urban Design

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Abstract
This study examines how migration is addressed in the field of urbanism and, in particular, urban design. Migration, which significantly affects space and social life in today's cities, is often discussed in the literature through policy and regional/urban scale studies, while its relationship with urban design remains limited. Urban design decisions can influence migrants' lives, either reinforcing or overcoming social divisions. Using bibliometric analysis, this study explores how the migration-urban design relationship is shaped and identifies literature gaps. Data were collected from Scopus, ULAKBIM TR Dizin, and DergiPark databases. Findings show that migration is mainly associated with topics like housing, urbanization, gentrification, and segregation, while concepts like integration and cultural adaptation remain underexplored. The results aim to guide future research in this field.

Keywords: migration, urban design, city planning

1. Introduction

Migration, as a fundamental phenomenon that transforms social, economic and spatial dynamics throughout history, has been on the research agenda of different disciplines. However, academic studies on this multi-layered phenomenon have mostly been shaped from the perspectives of sociology, economics and political science, while spatial planning and design disciplines have been relatively limited. However, migration is not only the physical relocation of individuals, but also a complex process that has direct effects on the production, use and remodelling of urban space.

This study aims to analyse how the issue of migration is handled in the context of urbanism and especially urban design, both in the world in general and in Turkey in particular, on the basis of conceptual relations. In this context, it is aimed to reveal the prominent themes, trends and gaps in the production of knowledge on migration. Within the scope of the research, migration is analysed in relation to the concepts of urbanism and urban design, and how these relations are established in the existing literature is questioned.

Methodologically, bibliometric analysis method is used in the study in order to evaluate the relationship between migration and research topics in the field of urban design. Thus, both how migration is represented in literature and the conceptual links established with the discipline of urban design will be analysed systematically. This analysis aims to contribute to identifying the limits of spatially based academic production on migration and to shed light on the gaps in knowledge in this field.

2. Conceptual Framework

2.1.Migration

Migration refers to the movement of people across a state border or within a country. These movements are defined as population movements based on the displacement of people, regardless of their duration, nature or cause (Perruchoud & Cross). The migration process often causes social, environmental, economic and political transformations and has an impact on both the sending and receiving societies. In today's globalised world, it is seen that migration phenomenon emerges as a result of social and economic development. In this context, migration can contribute to the improvement of economic and social conditions, but it can also pave the way for the formation of various inequalities (Castles, De Haas, & Miller, 2014).

According to Tekeli (2006), migration is a social process that enables settlement systems to adapt to changing conditions. Factors such as transformations in the political and economic external relations of the society or economic inequalities at regional level require the settlement structure to adapt to new conditions. When this adaptation is not achieved, disadvantaged social groups emerge within the city and significant segregation is

experienced in the urban fabric. This incompatibility can be shaped depending on factors such as income level, class structure, ethnic and religious characteristics of the society (Tekeli, 2006). One of the main causes of socio-spatial segregation is large-scale migration movements and race-based discrimination. These large-scale urban migrations experienced in certain periods lead to polarisation in the labour market and increase in injustice in income distribution. With migration and the factors that trigger this process, the boundaries of spatial segregation become more apparent (Erder, 1997). With large-scale migration processes, the socio-spatial segregation of migrants is accompanied by social exclusion and racial discrimination. With the globalisation process, there has been a concentration at the upper and lower ends of occupational fields; the weakening of the middle class has increased occupational polarisation and deepened discrimination against migrants (Fahey & Fanning, 2010).

Migration management is considered as a process that is mostly under the jurisdiction of central governments around the world. The global increase in migration movements in recent years has been defined as a 'migration crisis' by many governments. Looking at this process from a perspective based on 'crisis management' and centralised decision-making structures, migration management poses various challenges for different social groups. According to the 2020 World Migration Report of the International Organisation for Migration (IOM), there are currently around 272 million international migrants, accounting for approximately 3.5% of the world population (IOM, 2020). Accordingly, migration management has become an increasingly critical issue in the context of a significant mass of people (Çevik, 2021). Migration, in its most general definition as human mobility, has the power to change and shape the destiny of cities as well as nations.

In line with this general framework, we will now proceed to examine how migration intersects with urban design and with which conceptual approaches this relationship is addressed in the literature.

2.2. Migration and Urban Design Relationship

While the structural characteristics of urban space shape society, society also produces new spatial organisations. In this process, inequalities emerging in social relations are reflected in space; similarly, inequalities produced at the spatial level have an impact on social relations (Lefebvre, 1974).

In this framework, the reflections of the phenomenon of migration on urban space in Turkey constitute an important area of investigation. Turkey has faced intense migration movements since the mid-20th century. Considering the urbanisation process in Turkey, Kıray states that the urban structure is shaped in line with both the socio-economic development process and the class structure. In particular, gecekondu areas, which were formed as a result of the inability of the population migrating from rural areas to the city to settle in the city, constituted a clear example of spatial segregation (Kıray, 1998).

The relationship between urban design and migration has a complex and multidimensional structure. Migration movements are effective in many areas from the physical structure of cities to social dynamics. In this process, the effects of migration on the urban structure bring about the formation of cultural diversity and new identities in the urban space, while bringing integration and social cohesion processes to the agenda. Housing and zoning policies need to respond to the changing needs arising from migration; at the same time, it necessitates the development of new approaches in line with environmental and sustainable urban development principles. An effective urban design approach can contribute to the formation of sustainable and livable cities by producing a balanced solution between the challenges and opportunities brought by migration (LeGates and Stout, 2020).

In line with this conceptual framework, examples that concretise the relationship between migration and urban design through the impact of spatial transformations on social structure are noteworthy. In this context, the 'Comuna 13' project in Medellín, Colombia offers a meaningful example of implementation. Within the scope of the project, the effective use of urban art in public spaces, increasing the level of accessibility and supporting social integration were aimed. These interventions aimed to improve the living conditions of socio-economically disadvantaged communities, strengthen social cohesion and reduce security problems. The Comuna 13 example

is important in terms of demonstrating the potential of urban design to transform social segregation shaped by migration and to promote social interaction and integration through space. (Comunaproject.org, n.d.) (Dorene, 2022)

Figure 1: Images of the Columbia 13 project (taken from Dorene, 2022)

As can be seen from the example cited, urban design has an important role in the spatial and social transformations that emerge with migration. Spatial arrangements shape not only the physical environment but also the forms of social interaction and the inclusiveness of urban life. In this context, it is clear that urban design decisions can directly affect the living conditions of migrants, reinforce spatial segregation and social divisions, or transform these processes to create a more inclusive urban environment. Therefore, the need to take into account the phenomenon of migration and the needs of migrants in urban design processes stands out as an important conceptual and practical requirement (Tuohy and Talen, 2017).

In this respect, it is clear that the phenomenon of migration should be addressed in a more holistic and inclusive manner in urban design processes. In the remainder of the study, the methodology and analysis process applied in order to analyse these relationships in more depth on the basis of the literature will be explained in detail.

3.Method

In this research, bibliometric analysis method was used to understand the reflections of migration on urbanism and especially urban design. This method enables the quantitative analysis of academic publications produced by individuals or institutions within a specific discipline, in a specific time period and in a specific geography, and the relationships between these publications (Arslan, 2022) (India, 2024). In this context, the analysis aims to reveal the dimensions of the concept of migration in the literature and the place it occupies in the context of urbanism and urban design.

Within the scope of the analysis, not only the concept of migration, but also the prominent themes, trends and conceptual frameworks in the literature related to this concept have been evaluated. In particular, the extent to which social and spatial issues directly related to migration, such as integration, have found a place in the urbanism and urban design literature has been examined; thus, priorities and gaps in the literature have been tried to be revealed.

3.1. Bibliometric Analysis Process

While creating the bibliometric data set within the scope of the research, leading academic databases such as Scopus, ULAKBIM TR Index and DergiPark were used. These databases were preferred in order to search the national and international literature published in the fields of migration, urbanism and urban design in a comprehensive manner. During the data collection process, academic publications published using the relevant keywords were selected and exported in a format suitable for analysis.

VOSviewer software was used to visualise the data obtained during the bibliometric analysis process and to reveal the relationships between the subject clusters. Through the programme, keyword matches, conceptual concentrations and thematic distributions were presented as word networks and maps. In addition, word clouds were created in line with the results obtained, and visual traceability of the prominent themes related to the subject of migration in the literature was provided.

Thanks to this method, it has been systematically revealed with which concepts the issue of migration has been handled in the context of urbanism and urban design both in Turkey and internationally, and which themes have come to the fore.

3.2. Bibliometric Analysis Findings

Scopus Database Findings

In the bibliometric search conducted using the Scopus database, a total of 377,216 publications were found as a result of a general search with the keyword 'migration'. These publications point to a very large body of literature dealing with migration in various aspects. However, when the search scope is narrowed down with the concept of 'urban studies', the number of relevant publications decreases to 24,898. This decrease shows that the treatment of migration in the context of urban studies is relatively limited. When the term 'urban design' is added to the search, the number of publications is only 1,627. This result reveals that the subject of migration has been the subject of very few studies in urbanism, especially within the framework of urban design.

When a geographical limitation centred on Turkey was added to the filtering process, only 25 publications were found in this conceptual intersection. This situation clearly shows that the number of academic publications addressing the relationship between migration, urbanism and urban design together in the Turkish context is extremely limited.

Table 1: scopus database data

Used filters	Number of publications
"migration"	377.216
+"urban studies"	24.898
+"urban design"	1.627

The network map shown in Figure 2 was created based on the publications obtained as a result of the search in the Scopus database with the keywords 'migration' and 'urban design' and visualised using VOSviewer software with bibliometric analysis method. The visualisation reveals which concepts are associated with migration and urban design in the literature, the density of the relations between them and the conceptual clusters. Each node in the visual represents a specific keyword, and the links between nodes represent the frequency of these concepts being used together in the same publication. The size of the nodes reflects the frequency of repetition of the keyword in the analysed publications, while clusters with the same colour indicate thematic groups that are located within close meaning areas.

The fact that concepts such as 'urban planning', 'urbanisation', 'housing', 'urban development' and 'urban design' are at the centre and with dense connections shows that the subject of migration is generally studied in the context of urban design by associating it with these titles. Concepts such as 'integration', 'segregation', 'gentrification', 'accessibility' and 'neighbourhood', on the other hand, highlight the effects of migration on social space with their social context. On the other hand, it is observed that concepts such as 'migrant', 'gated communities', 'exclusion' and 'place attachment' are positioned in relatively lower groups. This situation suggests that there are special areas where studies on the spatial experiences and belonging relations of migrant individuals are

concentrated thematically, although they are few in number. In the literature, it is seen that the issue of integration under the titles of 'migration' and 'urban design' is addressed in a limited number of studies through the concept of 'integration'. This situation reveals that the number of academic productions in which the relationship between migration and urban design is addressed from the perspective of social integration is insufficient.

As a result, this analysis provides an important basis for understanding which concept clusters the phenomenon of migration is associated with, in which areas it is concentrated and which thematic gaps exist when it is addressed within the framework of urban design.

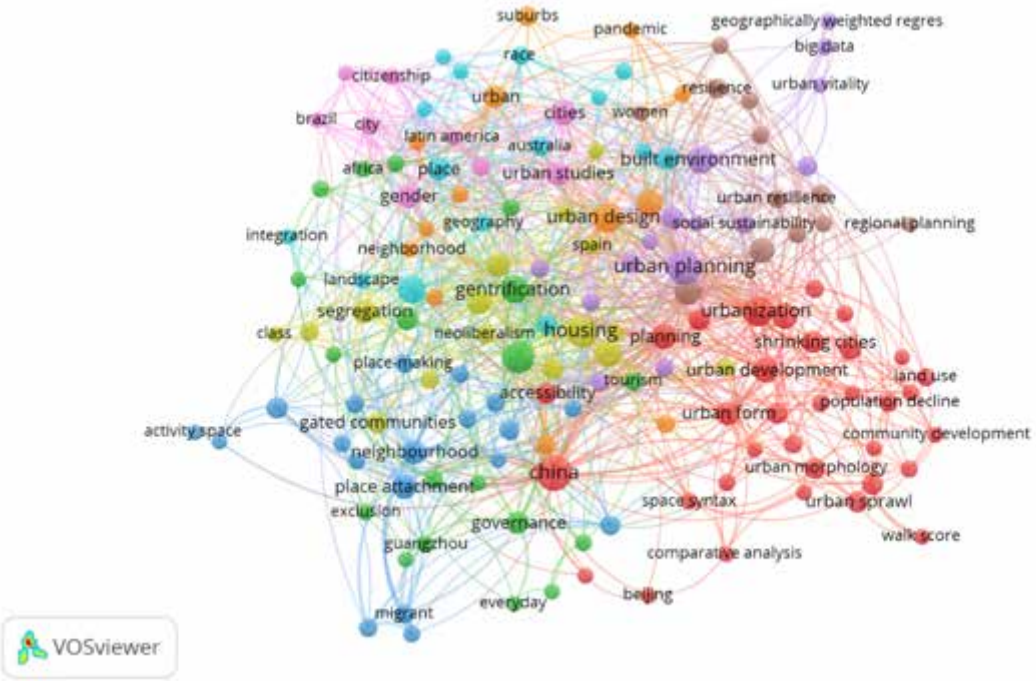

Figure 2: Keyword analysis using the Scopus database

The author network map in Figure 3 was created based on Scopus data searched with the keywords 'migration' and 'urban design' and visualised by bibliometric analysis method through VOSviewer program. The map reflects the collaboration structure created based on the citation relationships of researchers working in this field and academic clusters in the literature. Each node represents an author and the lines between nodes represent the citation or co-publication relationships between authors. Node size represents the author's visibility in the analysed literature, i.e. citation density, while clusters with the same colour represent a specific collaboration group or academic communities working on similar topics.

In the map, Li, Zhigang stands out as the largest and centrally located node. This shows that this author is one of the important reference points in the literature on the themes of 'migration' and 'urban design'. Names such as Wu, Fulong; Liu, Yuqi; Lin, Sainan; He, Shenjing have also gained an active place in the literature by being both cited and involved in various collaborations. The existence of distinct clusters among authors shows that researchers working on migration and urban design issues mostly collaborate within their own groups and that academic networks with regional or thematic axes are formed. The dense connections especially among China-based authors also reveal that the production in this field is significantly concentrated in certain geographies.

This analysis is important not only in terms of identifying the most cited authors under the titles of migration and urban design, who play a leading role in the literature, but also in terms of showing around which regional or thematic networks the existing literature is shaped.

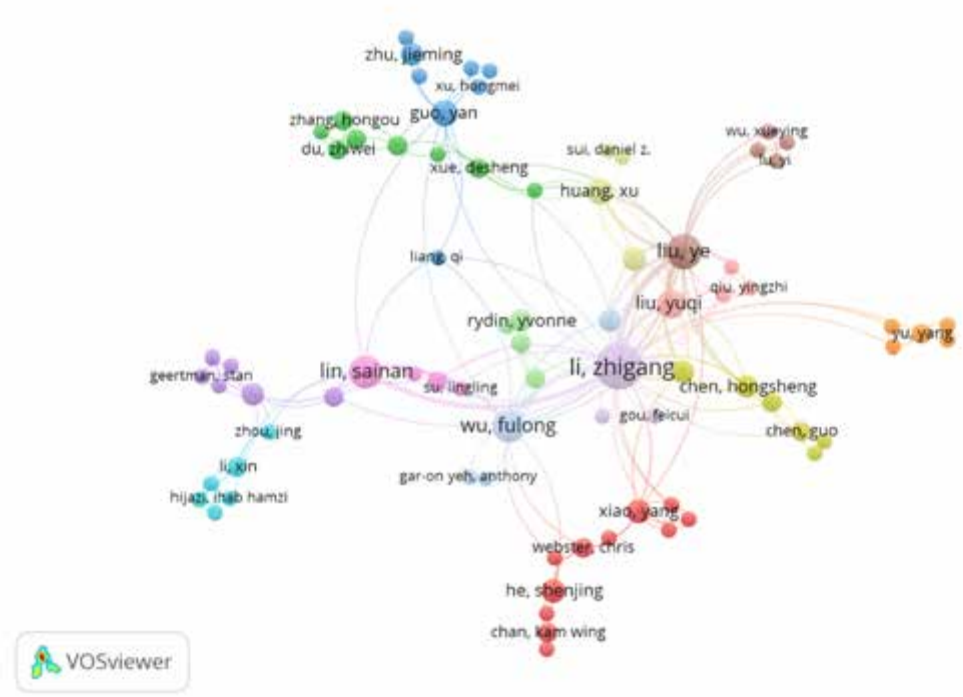

Figure 3: Author-citation analysis using the Scopus database

Figure 4 visualises the keyword network of publications produced in Turkey. This analysis is based on the results obtained by filtering the keywords 'migration' and 'urban design' in the Scopus database. The clusters that stand out in the visualisation provide important clues about the conceptual frameworks and themes around which the relationship between migration and urban design is shaped in the literature.

As a result of the analysis, it is seen that on the one hand, concepts such as 'urban regeneration', 'urban politics', 'Ankara', 'squatters' and 'Islamic neoliberalism' cluster together; on the other hand, concepts such as 'urban renewal projects', 'squatter rehousing projects', 'social space/abstract space', 'neoliberalism' and 'Islam' form a second cluster. This structure shows that migration is strongly associated with urban regeneration policies, slum areas, neoliberal urban policies and social spatial production processes in Turkey. The analysis also reveals that academic production on the relationship between migration and urban design is largely discussed through urban regeneration practices and the socio-spatial effects created by these practices.

These findings support that the interactions between migration, spatial change and social structure, emphasised in the previous sections, are intensified in the Turkish context, especially in urban regeneration and spatial policy debates.

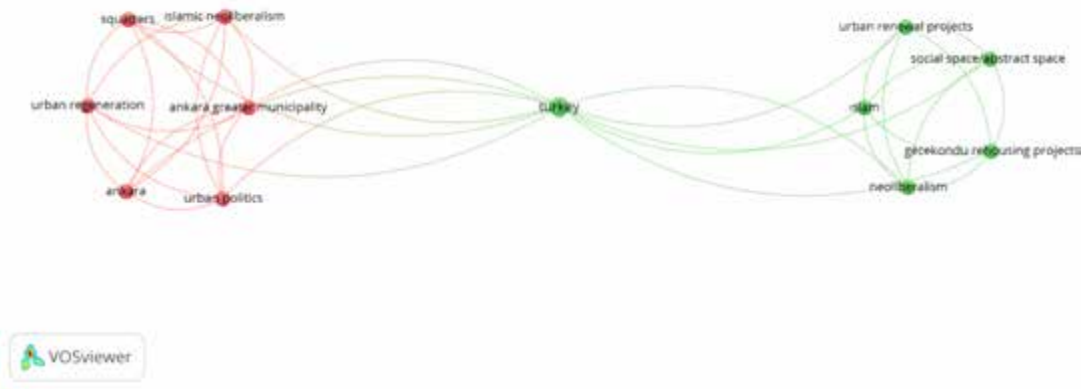

Figure 4: Keyword analysis of publications produced in Turkey using Scopus database

Figure 5 visualises the author-citation analysis of publications produced in Turkey. This analysis is based on the results obtained by using the keywords 'migration' and 'urban design' in the Scopus database. The visual represents the citation relationships and interaction networks of the authors producing in this field within the literature.

As a result of the analysis, it is seen that certain authors are cited more intensively and stand out in the field. Names such as 'Taşan-Kok, Tuna', 'Eraydın, Ayda', 'Batuman, Bülent', 'Paköz, Muhammed Ziya' and 'Baycan-Levent, Tüzin' are among the notable authors in the literature in this field. The relatively scattered distribution of the authors shows that academic studies on the intersection of migration and urban design have not yet formed a distinct and strong research network. This situation also reveals that this topic is an emerging research area in the literature and needs more interdisciplinary cooperation and deepening. This finding also supports the assessments highlighted in the previous sections that point to gaps in the literature and lack of conceptual coherence.

Figure 5: Author-citation analysis of publications produced in Turkey using Scopus database

The results of the analysis from the Scopus database show that the concept of migration is predominantly addressed within the framework of themes such as 'gated communities' and 'spatial segregation in settlements' in the international literature. However, it is also associated with the concept of 'integration', albeit at a more limited level. In the Turkish context, it is noteworthy that studies on the relationship between migration and urban design are limited to a narrower range of topics and that this relationship has not yet been sufficiently deepened in the literature.

ULAKBIM TR Index Database Findings

ULAKBIM TR Index is an important national database that compiles and makes available academic and scientific studies carried out in Turkey. In this study, the TR Index database was used to filter the abstracts of the publications through certain keywords. As a result of the analysis, it has been determined that studies on migration and urban context show an increasing trend over the years. While an increase in the number of publications has been observed especially since the 2000s, it is seen that this increase has accelerated significantly in the last five years. It was determined that the highest number of publications was reached in 2021 and a total of 411 publications were recorded in this year.

According to the filtering results, 3,624 publications were identified with the keyword 'migration'. If this number is used with the concept of 'city', the number of publications decreases to 236. When concepts that narrow the filtering are added, 5 publications were identified with 'urbanism', 1 with 'urban planning', 2 with 'urban planning' and only 1 with 'urban design' (see Table 2). This finding shows that academic studies produced at the intersection of migration and urban design are quite limited in the Turkish context.

Table 2: Ulakbim TR dizin database data

Used filters	Number of publications
"migration"	3.624
+"urban"	236
/ + "urbanism"	5
/ + "city planning"	1
/ + "urban planning"	2
/ + "urban design"	1

In the data set obtained, the scans were evaluated in a more qualified and detailed manner due to the lack of sufficient number of publications on the intersection of migration and urban design. In this framework, the results are visualised and presented through word clouds in order to reveal conceptual trends and thematic relationships more clearly. In Figure 6, the word cloud reflecting the main study topics obtained as a result of the analyses made in the ULAKBIM TR Index database is visualised. When the prominent key concepts in the image are examined, it is seen that the concept of 'migration' has a central position. In addition, concepts such as 'belonging', urban sociology', 'urbanisation process', 'cultural adaptation' and 'transformation processes', which emphasise social and spatial dimensions, also draw attention. In addition, elements that point to more specific contexts such as 'urban architecture', administrative structure' and 'Hatay' as a place name also come to the fore.

This structure shows that the migration phenomenon is mainly addressed in the literature in Turkey in relation to social belonging, cultural adaptation and urbanisation processes, and that it is still a limited but potentially developing research area in the spatial context.

Figure 6: Ulakbim TR index database word cloud

DergiPark Database Findings

DergiPark is a comprehensive database that brings together scientific studies published in Turkish academic journals and provides open access to them in a digital environment. In this study, a search was conducted using keywords identified in the abstract sections of publications in the DergiPark database.

The data obtained from the analysis are presented in Figure 7. According to this analysis, 6,507 publications were identified using the keyword 'migration'. When the keyword 'urbanism' was used alongside 'migration', this number dropped to 10 publications, while three publications were identified with 'urban planning' and five with 'urban design' (see Table 3).

Table 3: Dergipark database data

Used filters	Number of publications
"migration"	6.507
+"urbanism"	10
/ + "urban planning"	3
/ + "urban design"	5

These results suggest that migration is a significant topic in general literature, but research addressing it in the context of urban planning and design is limited. Consistent with previous database analyses, the findings once again highlight that the relationship between migration and urban design in Turkey is a topic that has not yet been sufficiently explored in academia.

Figure 7 shows a word cloud visualisation of the key concepts obtained from the DergiPark database analysis. Due to the limited amount of data available, the word cloud method was used to highlight conceptual trends and demonstrate which themes stand out in the literature more clearly. Key concepts that stand out in the visualisation include 'urban design', 'heritage area', 'urban open space', 'urban area adequacy', 'urban landscape', and 'Diyarbakır', which refer to spatial and local contexts. Themes such as 'socio-spatial approach', interdisciplinary approach', ecological design' and 'user preferences' also hold a significant place in the literature.

Figure 7: DergiPark database word cloud

This structure reveals that the DergiPark database addresses the topics of migration and urban design, particularly in terms of spatial quality, the protection of heritage areas and urban open spaces. However, studies focusing directly on the context of migration are limited in number.

The DergiPark database analysis shows that the topic of 'migration' generally reflects the current state and social dynamics of contemporary cities. It is also noteworthy that publications produced in Turkey within the scope of urban design largely address the themes of 'housing', 'urban transformation', and 'informal settlements'. Consistent with previous database analyses, these findings indicate that academic studies on the relationship between migration and urban design remain limited in scope, highlighting the need for further in-depth research in this area.

In this context, trends in the literature and research gaps have been identified based on the findings of the analysis. The conclusions drawn from these findings will be evaluated in detail in the final section.

4. Conclusion

The analyses conducted aimed to reveal how the relationship between migration and urban design is addressed in the literature at a conceptual level. Within the framework of the stated objectives, themes related to migration in urban planning and urban design were evaluated and gaps in the existing literature were identified.

The analysis results showed that academic publications related to migration increased in the 2000s, with this trend accelerating significantly in the last five years. This trend indicates the growing importance of the issue in the context of current urban dynamics and social changes. Findings show that migration is predominantly addressed in international literature in terms of spatial segregation themes such as "closed communities" and "segregation in settlements". However, it has also been observed that it is associated with the concept of "integration", albeit to a lesser extent. A similar pattern emerges in the context of publications produced in Turkey: migration is primarily addressed in relation to "urban transformation", "slum formation" and "housing", while studies addressing concepts such as "adaptation" and "cultural integration" are quite limited.

Overall, it can be concluded that the relationship between migration and urban design remains limited in the literature, highlighting the need for more comprehensive, interdisciplinary, and inclusive research in this field. In particular, considering urban design as a tool that supports 'integration' and 'adaptation' processes, and discussing these issues through public spaces, could be an important direction for future research.

These findings provide concrete evidence of the gap in the literature that motivated this study. Notably, the dearth of studies examining migration from an urban design perspective underscores the necessity for more comprehensive research on this subject.

The limitation of the study is that only the Scopus, TR Dizin and DergiPark databases were used in the bibliometric analysis. This has limited the scope of the analysed publication set. Nevertheless, the analyses provide valuable insights into trends and research gaps in the existing literature.

In conclusion, this study emphasises the need for more comprehensive and diverse research at the intersection of migration and urban design, particularly the importance of incorporating social cohesion, integration and public space perspectives into urban design processes.

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The Urban Factors in Highly Skilled Migration Motivation: The Case of Turkish Professionals in the Netherlands

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Abstract
This study investigates the role of the "urban factor" in the location choice motivations of highly skilled individuals migrating from Türkiye to the Netherlands. Using a mixed-method approach, the research compares spatial (transportation, infrastructure, public facilities, spatial quality, cost of living) and non-spatial (economic, political, social, personal) factors affecting migration decisions, based on data collected from participants via online survey. The findings indicate that for highly skilled participants, spatial elements hold equal importance to economic and social reasons in their migration decisions. While contributing to discussions on talent migration and urban competitiveness, the study highlights the necessity of inclusive, liveable, and holistic planning policies for cities to attract human capital and facilitate integration processes.

Key words: Highly Skilled Migration, Urban Competitiveness, Locational Preferences

1. Introduction

In recent decades, international migration has undergone a profound transformation, increasingly characterized by the mobility of highly skilled individuals. Unlike traditional migration patterns, this new wave is not primarily driven by survival or displacement but rather by aspirations for professional development, creative autonomy, and integration into global knowledge economies. Highly skilled migrants—often associated with the creative class—are not only economic actors but also contributors to the cultural, social, and technological dynamism of cities. As such, their locational choices hold significant implications for urban planning, regional development, and national competitiveness.

Cities and regions are no longer passive recipients of global talent; they actively compete to attract and retain it. This competition has intensified in recent years due to demographic shifts, labour shortages in specialized sectors, and the increasing relevance of innovation-based growth. In this context, urban environments have become key arenas for global talent flows. Notably, the Netherlands has emerged as a prominent destination for highly skilled migrants, including an increasing number of professionals from Türkiye. This trend raises critical questions regarding the spatial and non-spatial factors that influence mobility decisions and shape urban experiences for this group.

This study aims to investigate the locational preferences and decision-making processes of highly skilled Turkish migrants in the Netherlands. It seeks to understand how spatial factors—such as infrastructure, transportation, environmental quality—interact with non-spatial determinants like social cohesion, administrative efficiency, safety, and cultural inclusivity to inform migration trajectories. Grounded in a mixed-methods research design and informed by theoretical frameworks, the research provides both conceptual clarity and empirical insight into the drivers and lived experiences of this increasingly mobile population.

By focusing on the Turkish case within the Dutch context, the study not only contributes to the broader literature on highly skilled migration and urban attractiveness but also addresses a critical gap in understanding the interplay between individual agency and structural urban conditions in migration decisions. Ultimately, it offers guidance for policymakers, planners, and scholars seeking to navigate the complex dynamics of global talent mobility in an era where cities must simultaneously be engines of economic growth and spaces of social inclusion.

2. Highly Skilled Migration: City, Economy, and Global Competition

In the contemporary era, highly skilled migration has emerged as a distinct form of mobility, differing notably from other types of migration. As a result, its definition, underlying motivations, and impacts also take on unique characteristics.

The new economic order that emerged from modern life and urbanization driven by capitalism was initially shaped by Fordist production models, which emphasized mass production and regular working conditions (Murphy & Redmond, 2009). Over time, however, knowledge-based economic systems began to replace traditional modes of production. Scott (2006) defines this transformation as an innovative economy composed of high technology, financial services, and cultural-artistic sectors.

In this context, Markusen (2006) and Florida (2012) emphasize that the creative class—characterized by highly educated, innovative, and mobile individuals—contributes significantly to the economic growth of cities. According to Florida (2012), the creative class is a fundamental driver of both economic and cultural development due to its problem-solving and creative thinking capacities. Similarly, Cedefop (2010) defines highly skilled individuals as well-educated and competent people specialized in particular sectors.

From this perspective, human capital, referring to the stock of knowledge, skills, and experience possessed by individuals, is of critical importance for innovation and productivity (Becker, 1964). Glaeser et al. (1995) argue that cities with higher levels of human capital experience faster growth, while Florida (2012) suggests that the creative class fuels urban economic dynamism and attracts investment and labor, thus supporting urban development. Florida's (2012) framework reinterprets the traditional human capital model, expanding it to include technology, art, culture, education, and managerial professions (Darchen & Tremblay, 2010). Moreover, highly skilled individuals not only contribute economically but also enhance social and cultural dynamism through active participation in urban life (Florida, 2012). Glaeser and Saiz (2003) note that cities with an educated population tend to have a higher quality of life and become more attractive, while Rodrik et al. (2004) highlight that these regions foster strong institutions that promote economic growth.

Cities function not only as economic hubs but also as cultural, political, and social centers where knowledge production, innovation, and creativity converge (Brown & Męczyński, 2010). Therefore, urban development is closely linked to dynamic production systems and work-life relations (Scott, 2006). The geographic clustering of knowledge-based economies enhances global economic networks and increases the competitiveness of cities on an international scale (Murphy & Redmond, 2009).

Global competition to attract highly skilled migrants is expected to become even more intense soon. The need for skilled talent is increasing not only in developed nations but also in rising economies. Consequently, the Netherlands is competing for talent not just with countries like the United States and Germany, but also with emerging players such as Brazil and Türkiye. This increased competition is often described in popular discourse as the 'battle for the brightest,' the 'brain race,' or the 'war for talent' (Berkhout, Heyma, Volkerink, & Werff, 2016).

Creative class members—highly skilled individuals—drive both cultural development and economic growth by producing knowledge-based content (Scott, 2006; Glaeser, 2005). They shape urban identity, boost investment appeal, and stimulate economic dynamism. Cities attracting such talent benefit from enhanced innovation, collaboration, and productivity. Florida (2012) terms these professionals "creative human capital," emphasizing their central role in the "new economy" and in fostering both economic and cultural progress (Murphy & Redmond, 2009). A city's ability to retain this group is essential for local development and is intertwined with global skilled migration dynamics. For developing countries, this often manifests as brain drain, leading to economic losses from unrecouped educational investments and sectoral labor shortages (Beine, Docquier & Rapoport, 2008; Lowell & Findlay, 2001). The departure of skilled labor undermines innovation, service quality, and competitiveness. Retaining creative talent is thus vital for economic vitality and socio-cultural sustainability (Glaeser & Saiz, 2003; Rodrik et al., 2004).

3. Defining Highly Skilled People

The definition of highly skilled individuals varies significantly depending on the context and purpose of classification. In political and administrative settings, lawmakers and institutions may define highly skilled persons based on salary thresholds or national policy needs. For instance, certain migration policies, such as the EU Blue Card system, identify a highly skilled migrant as someone earning at least 1.5 times the average national salary. However, this approach can exclude professionals engaged in high-level scientific research if their earnings fall below this threshold. Danış (2023) highlights it and then illustrates this limitation by highlighting the case of a doctoral researcher at a European university who, despite working on an advanced research project, does not qualify as "highly skilled" due to income criteria.

In addition to income-based definitions, educational attainment serves as another fundamental criterion. According to the International Organization for Migration (IOM), a highly skilled person is generally defined as someone with at least two years of post-secondary education. Similarly, scholars such as Borjas (2005) and Cerna (2013) emphasize education and occupational status in their definitions. A common approach in the literature is to utilize occupational classifications. For example, Czaika and Parsons (2017) refer to the first three major groups of the International Standard Classification of Occupations (ISCO) to identify skilled professions. Likewise, visa regimes such as the U.S. H-1B and the EU Blue Card consider a combination of education, income, and occupation.

While education and income remain the most prevalent measures, some scholars have approached the concept from a broader socio-economic and cultural perspective. Mellander and Florida (2007), as cited in Dai, Zhou, Keane, and Huang (2012), categorize the concept of the "creative class" according to three criteria: educational level, income, and occupational sector. Florida (2012) defines this group as workers engaged in occupations rooted in creativity, innovation, and knowledge production. Their primary economic function is to generate new ideas, develop technology, and create content. This definition encompasses a wide spectrum of professions within both the creative and knowledge-based industries. The creative industries include fields such as advertising, architecture, fashion design, the arts, publishing, and media production, while the knowledge industries span ICT, finance, law, R&D, etc.

In parallel with Florida's (2012) approach, other scholars have adopted a similarly inclusive framework. Clark, Lloyd, Wong, and Jain (2003) offer a comparable perspective, identifying the creative class as individuals contributing to the knowledge economy and cultural production. Their classification includes medical professionals, academic staff, financial analysts, consultants, legal professionals, and other experts in intellectually and creatively demanding sectors. These professions are further grouped into science, technology, education, business, cultural industries, and service/recreation. While the former are valued for their problem-solving and knowledge advancement, the latter—such as artists, designers, and writers—contribute to cultural vibrancy and enhance cities' attractiveness through tourism and investment.

Howkins (2002) situates the creative class within the global creative economy, valuing original ideas, innovation, and design over physical goods. His definition spans advertising, architecture, media, R&D, education, and even law, where intellectual autonomy is central. Despite such frameworks, defining the highly skilled remains complex. Salt (1997) underscores conceptual and data-related challenges, proposing a typology that reflects group heterogeneity—covering professionals, managers, and technical experts. This model accounts for education levels, mobility patterns, and includes transferees, consultants, technicians, healthcare workers, etc.

4. Drivers of Highly Skilled Mobility

The creative class consists of individuals with innovative thinking, problem-solving abilities, and cultural production skills, characterized by high levels of education, a tendency toward independent work, and the capacity to integrate easily into diverse cultural environments and global labour markets (Florida, 2012). These individuals actively contribute to the economic and cultural development of cities by working in sectors that form the core dynamics of the knowledge economy, as mentioned. Therefore, the international mobility of highly skilled people holds strategic importance in today's global economy. They tend to prefer locations where they can expand their

opportunities, express their freedoms, and further develop their skills.

In this context, studies on the factors influencing the settlement decisions of highly skilled migrants have been addressed at various levels and scopes. This study will examine these influencing factors under two main categories: spatial and non-spatial. Non-spatial factors include Florida's (2012) 3T model as well as personal trajectories as discussed by Liu and Shen (2014) and Chen and Rosenthal (2008), and Florida's (2012) soft factors. Spatial factors, on the other hand, will be evaluated under the categories of Florida's (2012) Hard Factors and Quality of Place, and urban amenities.

4.1. Non-Spatial Drivers of the Highly Skilled Mobility

Highly skilled individuals, often referred to as the creative class, are central to the economic and cultural development of cities through their capacity for innovative thinking and cultural production. These individuals form the backbone of the knowledge economy and are positioned at the core of global competition. Florida (2012) offers a comprehensive framework for understanding the factors that attract and retain this talent through his well-known "3Ts" model.

However, it is essential to recognize that individuals' migration decisions are not shaped solely by structural or economic factors. Different life stages and personal circumstances also play a critical role in shaping their mobility preferences. While young professionals often prioritize career prospects and urban dynamism, families and retirees tend to prefer locations that offer high living standards and quality public services (Liu & Shen, 2014; Chen & Rosenthal, 2008).

Soft factors—like cultural amenities, environmental quality—shape a city's identity and liveability. Though intangible, they significantly influence highly skilled migrants' location choices by enhancing lifestyle quality and fostering inclusive, vibrant urban environments that appeal to creative and talented individuals.

4.1.1. 3T Model of Florida

Among the conceptual frameworks proposed to understand the location choices of talented individuals, Florida's (2012) 3T model stands out as a pioneering approach. According to this model, the three fundamental pillars that attract highly skilled individuals are: Technology, Talent, and Tolerance.

The first component, Technology, refers to the infrastructure and institutional environment fostering innovation and technological advancement, including universities, research centres, and high-tech firms central to knowledge-based economies. Talent encompasses not only formally educated individuals but also those with creativity, problem-solving skills, and entrepreneurial potential (Florida, 2005). The third component, Tolerance, reflects a region's openness and receptivity to diverse lifestyles, cultures, and ideas. As Asheim and Hansen (2009) emphasize, regions that embrace diversity and encourage open dialogue offer a supportive environment for creativity and collaboration, attracting a more dynamic and skilled workforce.

Together, these three dimensions form a synergistic environment that enhances a city's or region's ability to compete in the global knowledge economy by appealing to highly mobile, skilled individuals.

4.1.2. Personal Trajectories

In addition, personal life trajectories significantly influence individual migration decisions. Life course theory emphasizes that age, life stage, family status, and career progression intersect with mobility preferences and constraints. For instance, Liu and Shen (2014) demonstrate that the preferences of older adults and retirees are often shaped by their search for high-quality services, healthcare, and environmental amenities. These groups tend to relocate to areas offering comfort, safety, and access to recreational opportunities.

Conversely, younger individuals in the early stages of their professional lives tend to be more mobile and responsive to economic opportunities and urban vibrancy. Chen and Rosenthal (2008) emphasize that young, single, and

highly educated individuals are more likely to migrate toward dynamic urban centres that offer career advancement, cultural richness, and social networks. In contrast, married individuals or those with children prioritize stability, access to quality education, and secure neighbourhoods.

Moreover, Whisler et al. (2008) classify university graduates into six different life stages and find that the relative importance of quality-of-life indicators, such as cultural amenities, urban infrastructure, and work-life balance, varies significantly across these groups. These findings highlight the necessity of understanding migration decisions as evolving processes shaped by both personal and contextual factors over time.

4.1.3. Soft Factors

A third group of non-spatial drivers, often termed soft factors, refers to the intangible and experiential elements that shape individuals' perceptions of places. These include lifestyle quality, cultural and artistic opportunities, environmental aesthetics, social diversity, and community tolerance (Florida, Mellander & Stolarick, 2008). Unlike hard infrastructure, these elements are less quantifiable yet profoundly influence locational attractiveness, particularly for the creative and highly skilled population (Asheim & Hansen, 2009).

Soft infrastructure refers to the cultural, social, and physical qualities shaping a city's identity and perceived liveability (Helbrecht, 2004). According to Murphy and Redmond (2009), Brown and Męczyński (2010), and Trip (2007), soft factors fall into three categories: cultural and recreational amenities (e.g., festivals, museums, cinemas, shopping centers, sports facilities); urban environmental conditions (e.g., cleanliness, noise and air pollution, waste management); and tolerance and openness toward minorities, immigrants, and diverse socioeconomic or sexual backgrounds. These factors significantly affect a city's liveability and its ability to attract and retain highly skilled migrants.

4.2. Spatial Drivers of the Highly Skilled Mobility

In the literature, it is emphasized that the migration decisions of highly skilled individuals are shaped not only by economic opportunities but also by the spatial characteristics of the places they reside in. In this context, the spatial factors influencing high-skilled migration are examined in this section under three main headings: "hard factors," "quality of place," and "urban amenities."

4.2.1. Hard Factors

Hard factors refer to tangible and measurable elements such as economic structure, transportation infrastructure, and access to healthcare and education. According to Florida (2012), leading components among these include employment opportunities, competitive wages, and robust infrastructure. Musterd and Gritsai (2013) note that while employment is the primary determinant for location choices among creative individuals in Europe, hard and soft factors are evaluated together. In this regard, quality of life elements are described as "the icing on the cake." Similarly, Sezgin (2021) emphasizes that although employment forms the basis of migration motivation, cultural diversity, urban aesthetics, and quality of life also influence decision-making processes.

Studies by Murphy and Redmond (2009), Brown and Męczyński (2010), and Trip (2007) classify hard factors under the following categories: public services, transportation infrastructure, and cost of living. Public services include street safety, police and healthcare services, and social security systems. Transportation infrastructure refers to public transit, intra- and inter-city connectivity, and bicycle lanes. Cost of living encompasses housing prices, basic consumer goods, leisure activities, and transportation expenses. These elements directly impact individuals' everyday experiences and strongly influence location choices.

According to Mash (2022), hard factors also cover broader economic and physical conditions. These include land and housing availability, taxes and subsidies, proximity to suppliers and clients, transportation access, the presence of a skilled workforce, and proximity to research institutions. Administrative flexibility and efficiency in bureaucratic procedures also play critical roles in decision-making processes. Collectively, these factors are particularly important for investors and creative professionals.

4.2.2. Quality of Place

In several studies, quality of place is identified as a significant factor in attracting and retaining highly skilled individuals. Florida (2012) and Trip (2007) argue that certain urban characteristics—such as diverse social and cultural amenities, environmental quality, recreational opportunities, and community ties—play a decisive role in location decisions. Based on Trip's (2007) framework, Brown and Męczyński (2010) define quality of place through ten sub-categories.

The first is diversity, which relates to functional diversity, distinctive neighborhoods, and sufficient population density. Unique amenities include individual sports facilities, recreational spaces, retail and dining venues per capita, and public gathering areas. Vibrancy and culture refer to the variety of cultural and musical events, while aesthetics are assessed through architectural quality and urban heritage. Environment encompasses natural assets, environmental quality, brownfield redevelopment, and sustainability principles.

On the other hand, technology, talent, creativity, openness, and safety in quality of place headings are key to urban attractiveness and part of a holistic quality of place framework (Trip, 2007; Florida, 2012). Florida links these to the "creative class," echoing earlier theories. Darchen and Tremblay (2010) see this as an extension of Jacobs' ideas, while Glaeser (2005) highlights urban idea generation, reinforcing the relevance of creative environments.

4.2.3. Urban Amenities

Urban amenities constitute another important dimension that can influence location choices of highly skilled individuals. Landry (2000) argues that originality, spatial diversity, cultural and entertainment facilities, public spaces, and openness and tolerance are effective in attracting such individuals. However, there is no consensus in the literature regarding the impact of urban amenities. Some studies (Greenwood & Hunt, 1989; Arntz, 2010; Niedomysl & Hansen, 2010, as cited by Darchen and Tremblay, 2010) suggest that their influence on migration decisions is limited, while Storper and Scott (2009) challenge the rationale behind this assumption. Conversely, Liu and Shen (2014) report growing evidence in Western literature indicating that urban amenities have become increasingly influential in shaping migration trends and urban growth.

Glaeser et al. (2001), through the concept of the "consumer city," propose that modern urban growth is linked to the services and consumption opportunities cities offer, particularly in attracting highly skilled human capital. Arntz et al. (2023) also note that certain urban amenities—such as restaurants, nightlife, and cultural venues—can serve as attractions for highly skilled workers and influence their migration decisions. Drawing on Glaeser's (2005) perspective, Storper and Scott (2009) argue that attracting highly skilled individuals requires offering high-quality public schools, safe streets, and affordable housing.

5. Methodology, Case, Data

The Netherlands was selected as the case study for this research due to its increasing attractiveness to highly skilled migrants in recent years. An OECD report (2023) highlights that the country received approximately 171,000 new immigrants in 2021. According to Statistics Netherlands (CBS), the Turkish-Dutch community surpassed 170,000 between 1996 and 2022. In addition, the Global Competitiveness Report (Schwab, 2019) ranks the Netherlands fourth globally, with an overall competitiveness score of 82.4, and a notably high score of 84.6 in the highly skilled labour.

Projections by the Netherlands Interdisciplinary Demographic Institute (NIDI) and CBS estimate that by 2050, around 40% of the Dutch labour force will consist of immigrants (Moca-Grama, 2020; Pieters, 2020, as cited in Haşar, 2020). Furthermore, Türkiye is identified as one of the most significant countries of origin for graduate immigrants in the Netherlands, accounting for nearly 7% of all foreign knowledge workers (OECD, 2023). In the same year, migration from Türkiye to EU countries rose by 34%, reaching 71,000 individuals, with the Netherlands among the primary destinations.

5.1. Research Design and Approach

In that case, this study employs a mixed-methods design, combining quantitative and qualitative approaches for a deeper understanding of migration drivers (Creswell & Plano Clark, 2007). A semi-structured online survey—distributed via Google Forms using voluntary and snowball sampling—targeted highly skilled Turkish professionals in the Netherlands. It included Likert-scale, multiple-choice, and open-ended questions to capture both standardized data and personal insights. A pilot study improved clarity and alignment with the spatial and non-spatial migration factors. Ethical approval was granted by METU's (Middle East Technical University) Human Research Ethics Committee, and all responses were anonymous with informed consent obtained.

5.2. Analytical Framework: Spatial and Non-Spatial Factors

The conceptual framework of this study is grounded in the well-established distinction between spatial and non-spatial factors. Spatial factors are primarily linked to physical and infrastructural elements of urban planning and design, while non-spatial factors pertain to social, cultural, administrative, and economic drivers that are not directly tied to the built environment but nonetheless influence locational preferences.

Based on this classification, the study constructs its analytical model to evaluate how these categories of factors shape the international mobility decisions of highly skilled migrants. In this context, the research is guided by the following central question: **"**To what extent do spatial and non-spatial factors respectively influence the migration preferences of highly skilled people relocating from Türkiye to the Netherlands?"

These question serves as the analytical foundation for both the design of the survey instrument and the interpretation of empirical findings. It also aims to contribute to the broader scholarly discourse on international highly skilled migration by offering a structured comparison between tangible and intangible drivers of mobility.

Spatial-based variables are directly related to urban planning and physical infrastructure. Five primary categories were identified:

- Public Facilities: Encompassing healthcare, education, commercial and cultural services, recreational and shopping amenities, and urban scale.

- Transportation: Addressing urban transit systems, intercity connectivity, bicycle infrastructure, and parking accessibility.

- Infrastructure: Covering access and quality of essential services such as electricity, water, internet, as well as environmental factors like waste management and cleanliness.

- Urban Aesthetics: Evaluating the visual and spatial quality of the city, including preservation of natural and historical heritage.

- Cost of Living: Focusing on the affordability and accessibility of housing, land, and commercial spaces.

- Non-spatial factors, though indirectly shaped by spatial policies, are not directly tied to the built environment. These were categorized into six groups based on previous research (Murphy & Redmond, 2009; Brown & Męczyński, 2010; Musterd & Gritsai, 2013; Trip, 2007; Masch, 2022; Florida, 2012):

- Cultural and Recreational Activities: Availability and diversity of concerts, festivals, and theatres.

- Social Structure: Perceived community cohesion and social integration.

- Safety: Low crime rates, resilience to natural hazards, and general urban security.
- **Climate Conditions**: Comfort and sustainability of local weather patterns.

- **Public Administrative Services**: Efficiency and accessibility of administrative processes, residence and work permits.

- **Consumer Diversity**: Breadth of goods and services, particularly relevant to creative and financially independent individuals.

5.3. Data Analysis Methods

Quantitative data were analysed through descriptive frequency and numerical (percentage) analysis, enabling the identification of dominant patterns and trends. Open-ended qualitative responses were evaluated using thematic analysis by open, axial and selective coding methods (Moghaddam, 2006) to uncover deeper insights into participants' subjective experiences and motivations.

5.4. Participant Profile

A total of 198 highly skilled migrants participated in the survey, with 196 responses deemed valid and included in the final analysis. The majority of participants (90%) were between the ages of 25 and 44, with 46% in the 25–34 age group and 44% in the 35–44 age group. In terms of gender distribution, 73% identified as women, 25% as men, and 2% as LGBTI+. Regarding marital status, 71% of the participants were married, 18% were single, 7% were married with children, and 4% fell into other categories. The educational background of the sample was notably high, with 99% holding at least a bachelor's degree; specifically, 43% had completed a master's degree and 12% held a doctoral degree. Professionally, the sample was dominated by engineers, who constituted 38% of respondents. IT professionals followed this at 11% and researchers and academics at 8%. Other professional fields, including finance, marketing, healthcare, architecture, and design, were each represented by 4% to 7% of participants. The creative service sector had the lowest representation, with only 1.5% of respondents employed in that area.

Figure 1: Geographical Distribution of Highly Skilled Turkish Participants in the Netherlands

Geographically, participants were concentrated in major urban centers such as Amsterdam, Rotterdam, and Eindhoven. Smaller numbers were located in cities like Groningen, Enschede, and Nijmegen. Key factors in location choice included employment opportunities and perceived quality of life.

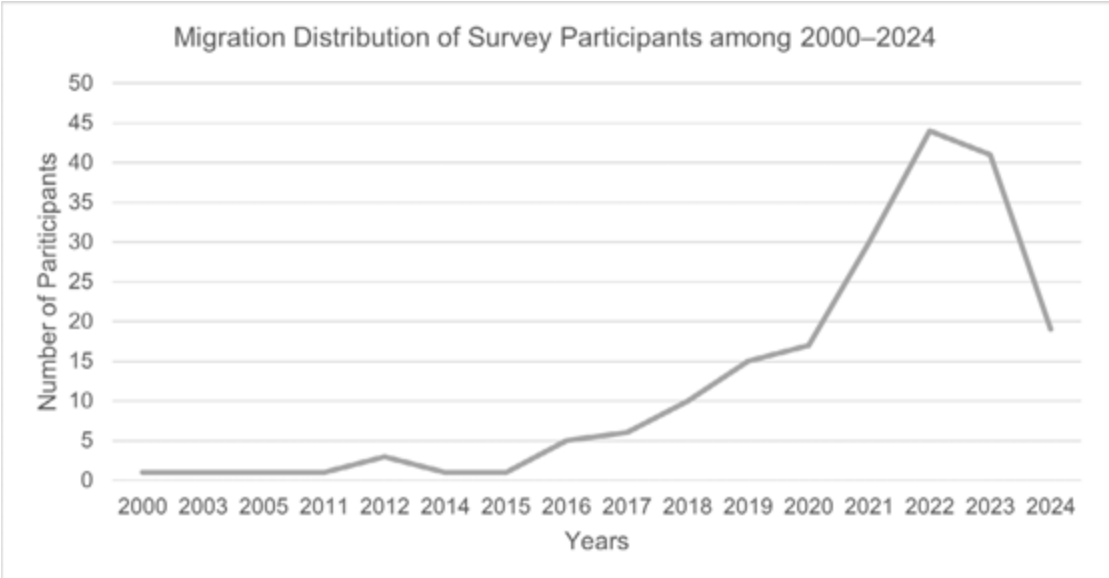


Figure 2: Annual Migration Distribution of Survey Participants among 2000–2024

Migration timing analysis showed an average length of stay of 40.3 months. A notable increase in migration occurred post-2016, attributed to domestic political instability, economic crises, and rising unemployment in Türkiye. Migration peaked between 2020 and 2022, spurred by the digitalization of work, remote employment opportunities, and increased living costs during the COVID-19 pandemic. A decline was noted in 2023–2024, likely due to stricter immigration and visa policies in European countries.

6. Findings

The survey results show that family ties are generally not a determining factor in decisions to migrate to the Netherlands; 93.4% of the participants find this factor unimportant, while the presence of friends and relatives is not a motivation for migration for the majority (67.3%, "not suitable"). However, family or personal reasons are important for some; 34.7% of the participants stated that they chose the Netherlands because of their spouse, partner or family's employment situation. While educational background is ineffective for most (89.3%,"not suitable"), education plays a role in the decision to stay in the Netherlands for a small number (9.7%). On the other hand, employment conditions are a very important factor in migration decisions, with 45.9% of the participants seeing this as a "priority factor". Living conditions are similarly influential, with 63.8% seeing this as a "priority factor". Participants indicated that urban and social factors make the Netherlands attractive. These results reveal that migration decisions are mostly based on individual, economic, occupational and urban conditions.

It is clear that participants consider working and living conditions a priority in their migration decisions. How they define these conditions is illustrated in Tables 3 and 4, supported by excerpts from their responses to open-ended questions.

Table 1: Categorization of Participant Responses Regarding Living Conditions

PART OF RESPONSES	CODING	F	P (%)
"Green cities, beautiful architecture, urban planning" *"Environmentally friendly, calm, harmony with nature"* *"Less dense cities"* *"Ability to use public transport and bicycles"* *"Having the 15-minute city concept"* *"Short distances"* *"Easy access to other European countries"* *"Environmental cleanliness"* *"Availability and cleanliness of parks/gardens, availability of day-care centers in residential areas, financial and regional availability of activities/courses for children"* *"Accessible urban services"* *"Access to free education for children"* *"The salary and opportunities offered by doctoral programs were attractive"* *"Quality of education"*	Urban and Environmental Factors	146	30,1
"Welfare level of society" *"High purchasing power"* *"Work life balance"* *"Low inflation"* *"Financial accessibility (house, car, vacation)"* *"International environment"* *"Liberal lifestyle, high rate of English speaking, relatively low racism"*	Economic and Finance	96	19,8
"Stress-free life" *"Protection of human rights"* *"Individuality of religious values"* *"Feeling safe on the street at all hours as a woman"* *"Security, safety, peace"* *"People speak English and are used to immigrants"*	Social and Cultural Environment	193	39,8
"Social state concept" *"Democracy"* *"Reliable legal system"* *"Fair progress of bureaucracy"* *"Living away from politics"* *"Secularism"*	Governance and Public Administration	35	7,2
"Quality of life"	QoL	15	3,1

Participants' responses, analysed through open, axial, and selective coding (Moghaddam, 2006), highlight the strong influence of distinct features on migration decisions. Key factors included access to green spaces, environmental cleanliness, efficient and reliable public transport, and high urban accessibility. Low population density and compact city layouts were also valued, especially in reference to the "15-minute city" concept, which supports time efficiency and quality of life. Proximity to other European countries further enhanced settlement preferences.

Education was another vital factor. Free, high-quality schooling and academic opportunities, especially at the doctoral level, shaped long-term professional goals. Economic motivations cantered not only on income but also on financial stability, purchasing power, job security, and access to basic needs.

The social and cultural environment including safety, low discrimination, personal freedoms, and multicultural integration played a key role. Widespread English use and respect for diversity were seen as essential. Lastly, strong governance—marked by democracy, legal reliability, and transparent institutions— legal-political stability reinforced security and supported long-term planning.

Table 2: Categorization of Participant Responses Regarding Living Conditions

PART OF RESPONSES	CODING	F	P (%)
"The weekly working hours are generally 36-40 hours, and flexible work opportunities are common" "Low hierarchy, open communication culture, and employee appreciation" "Humane working conditions, work-life balance" "Flexible work models" "Employees are entitled to 20-25 days of paid vacation per year" "Dismissal procedures are regulated, and job security is high" "Work-life balance, vacations"	Work-Life Balance and Working Conditions	124	43,1
"High salary" "Fair wage policies" "Purchasing power"	Salary and Economic Factors	87	30,2
"Job descriptions are clear" "PhD programs and job opportunities" "Education and career development opportunities" "Professional development opportunities"	Job Description and Career Development	29	10,1
"Variety of alternatives" "International job opportunities"	Sectoral and Professional Opportunities	40	13,9
"Taxes are high (37-49%), but social services are good" "Tax advantages may be available for foreigners"	Taxation and Being a Social State	8	2,8

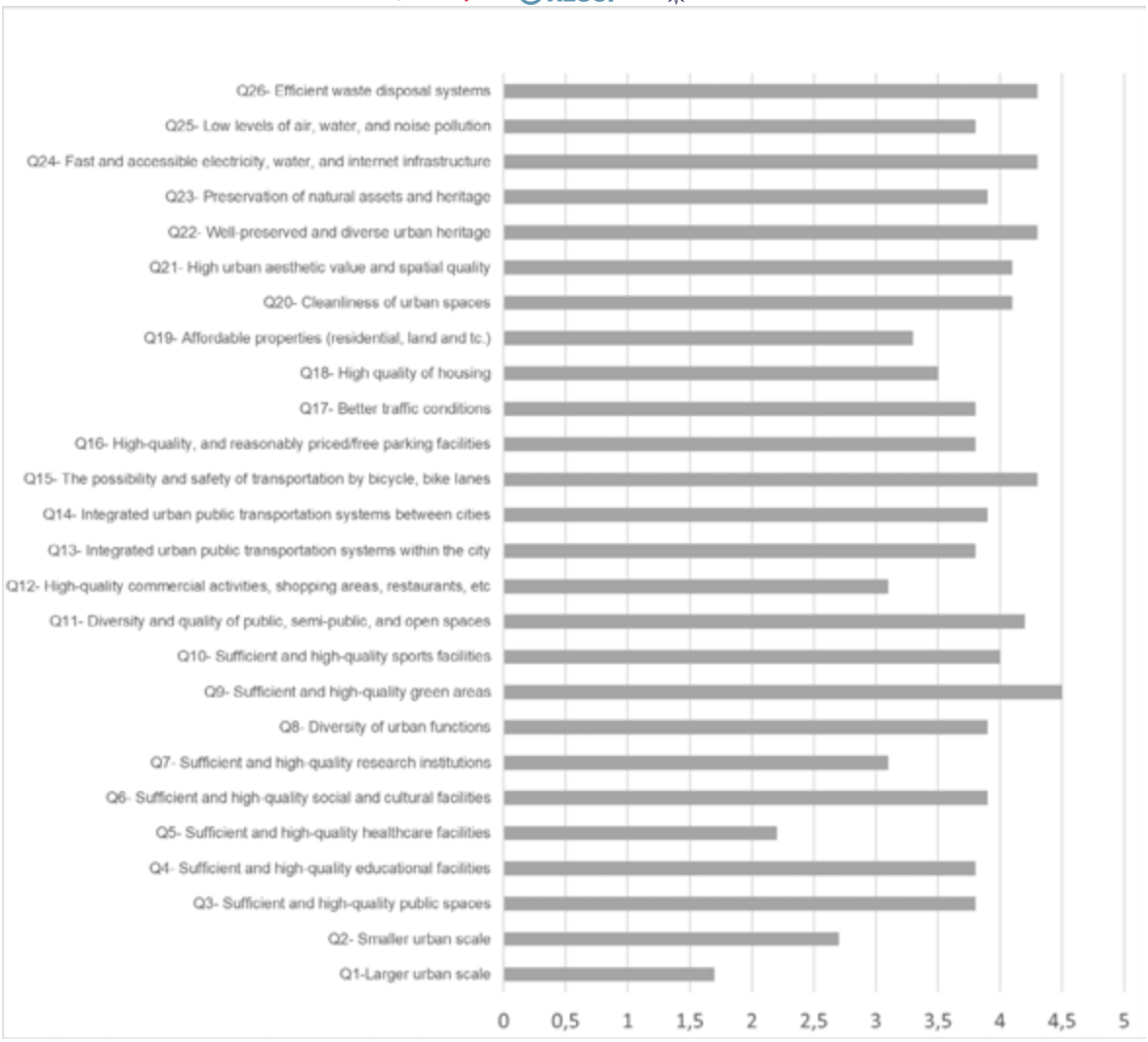
Participants' responses regarding work-life balance and working conditions come right after living conditions. It frequently emphasized flexible working arrangements, 36–40 hours of weekly work, horizontal organizational

structure and open communication environment. High job security, 20–25 days of paid leave per year and regular dismissal procedures were evaluated as important elements indicating the stability of the work environment. Responses regarding salaries and economic conditions reveal that strong purchasing power and fair wage policies are effective in attracting employees. In terms of job description and career development, respondents emphasized the clarity of job descriptions and the importance of various career opportunities regarding sectoral and professional diversity in the labor market and international job opportunities. In the views on the taxation system and the concept of the social state, it was stated that high tax rates are balanced with strong social services and that tax advantages and incentives offered to foreigners are an effective strategy in attracting international labor particularly highly skilled ones.

6.1. Assessing Spatial Factors

The analysis of spatial factors reveals that urban infrastructure, environmental quality, and mobility systems play a crucial role in the settlement choices of highly skilled Turkish migrants. Notably, a significant proportion of participants assigned high priority to access to high-quality green areas (Q9, 69.9%), the quality of public infrastructure such as electricity, water, and internet (Q24, 60.7%), safe and efficient bicycle infrastructure (Q15, 60.2%), and well-preserved urban heritage (Q22, 57.7%). Additionally, waste management systems (Q26, 55.6%) and urban aesthetics (Q21, 54.1%) were prioritized by more than half of the respondents. These findings collectively suggest that highly skilled migrants are particularly sensitive to the functionality, sustainability, and aesthetic value of their urban environments.

However, while spatial factors generally play a significant role in shaping mobility decisions, the level of importance attributed to individual features varies. For instance, elements such as city size (Q1, Q2; 68.2%, 32.7%), the availability of sufficient and high-quality healthcare services (Q5, 42.3%), and the provision of adequate, affordable parking facilities (Q16, 39.8%) were evaluated as less critical by a considerable segment of participants. This indicates that certain spatial dimensions hold a more limited role in the decision-making processes of highly skilled Turkish migrants, despite the broader relevance of spatial context.



Supporting this interpretation, the average score assigned to spatial factors on a five-point Likert scale was calculated as 3.7, underscoring the general importance attributed to urban infrastructure and environmental quality. Particularly prominent among the highly rated factors were access to sufficient and high-quality green spaces (4.5), cycling infrastructure and safety (4.3), well-preserved urban heritage (4.3), reliable and accessible infrastructure services (4.3), and efficient waste management systems (4.3). These findings highlight that participants place considerable value on the quality of infrastructure, landscape design, and historical fabric of the urban environments in which they reside (Florida, 2012).

In addition, other urban attributes such as access to sports facilities, diversity of public spaces, urban aesthetics, and cleanliness also received relatively high scores, further indicating that urban quality of life emerges as a central criterion in this case. Well-integrated public transportation systems, dedicated bike lanes, accessible highways, and international airports facilitate ease of movement and access to urban amenities (Glaeser et al., 2001). Similarly, cities become more attractive when traffic congestion is low and effective recycling services are available and consistently implemented (Lloyd & Clark, 2001). The cleanliness of streets, air quality, and overall visual character of the urban setting—as well as access to natural environments—have a demonstrably positive effect on individuals' physical and emotional well-being (Lloyd & Clark, 2001). Furthermore, the significance of monuments, architecture, and environmental quality in shaping urban appeal is also highlighted in the work of Brown and Męczyński (2010).

Conversely, certain factors such as city scale (1.7) and the perceived quality of healthcare services (2.2) were evaluated with relatively low scores, indicating their limited influence in pre-migration assessments. Interestingly, some of these less prioritized elements, such as healthcare and parking, emerged as sources of dissatisfaction

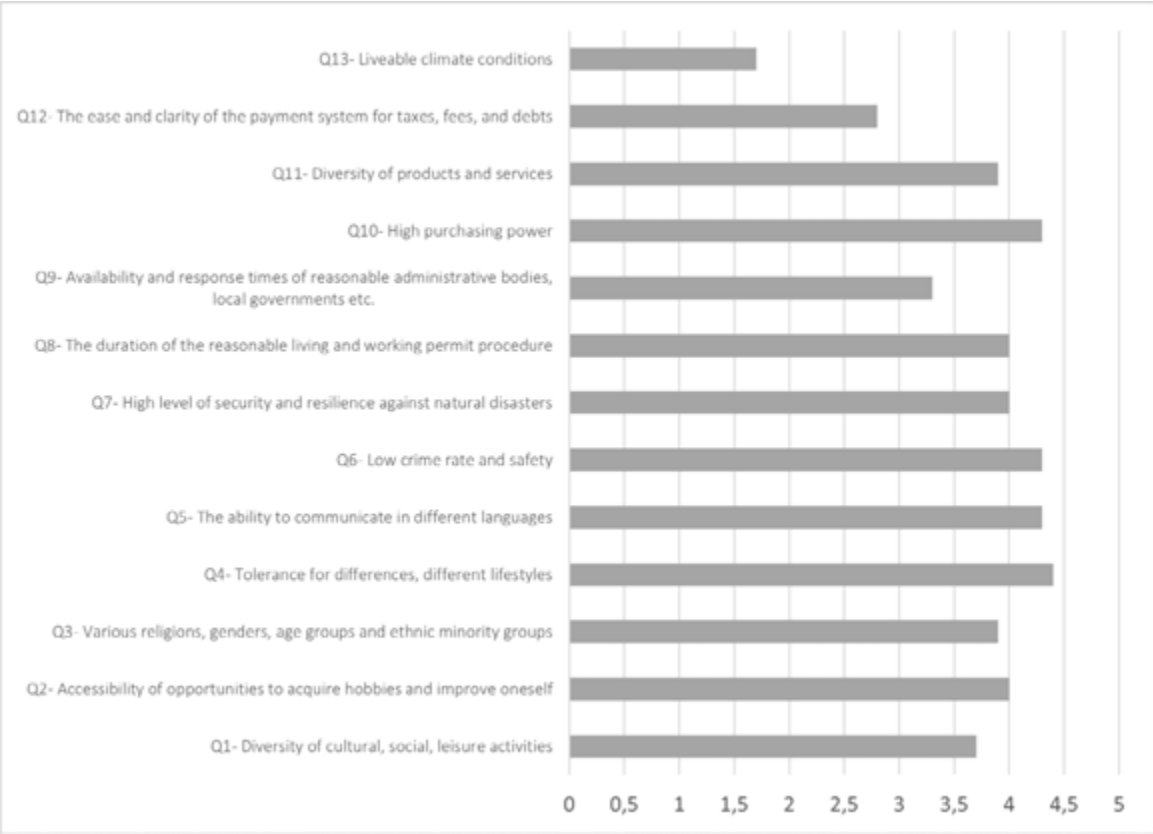
after migration. This suggests that pre-migration decision-making may benefit from a more comprehensive and forward-looking planning process that takes potential long-term needs into account.

In line with this, Landry (2000) emphasizes that a set of specific urban attributes such as authenticity, spatial diversity, cultural and entertainment amenities, the vibrancy of metropolitan life, access to public spaces, openness to diversity, and tolerance are particularly attractive to highly skilled individuals.

6.2. Assessing Non-Spatial Factors

On the other hand, non-spatial factors proved to be equally influential in shaping migration preferences. Public safety (Q6, 59.7%) emerged as particularly salient. Multilingual communication opportunities (Q5, 57.7%) and the level of cultural tolerance (Q4, 57.7%) were also marked as highly significant. Administrative efficiency in obtaining residence and work permits (Q8, 51.5%) and cultural inclusivity (Q3, 44.9%) followed. Protection from discrimination (Q7, 49.5%) and access to diverse consumer goods and services (Q11, 40.3%) were relatively less emphasized. These findings underscore that psychological comfort, social integration, and legal-economic stability are central to the formation of place attachment and the well-being of highly skilled migrants in this context.

One notable exception among non-spatial factors was climate. More than half of the participants (55.6%) indicated that "liveable climate conditions" (Q13) did not apply to their decision-making processes. This suggests that climate is a secondary concern of highly skilled participants compared to spatial, institutional, economic, and social variables.



Similarly, non-spatial factors were also attributed to high levels of importance, with an overall average score of 3.7 on the five-point Likert scale. The highest-rated dimensions included tolerance for different lifestyles (4.4), opportunities for multilingual communication (4.3), low crime rates and general safety (4.3), and high purchasing

power (4.3). These findings indicate that social cohesion, cultural diversity, and safe living environments play a decisive role in the urban preferences of highly skilled individuals. Moreover, factors such as administrative efficiency in obtaining residence and work permits (4.0), resilience to natural disasters (4.0), and access to a wide range of goods and services (3.9) were also evaluated positively, demonstrating their relevance in decision-making processes.

As Florida, Mellander, and Stolarick (2008) suggest, talented individuals from diverse backgrounds are more likely to feel at home in cities that foster an inclusive and tolerant culture. Complementing this view, Clark et al. (2003) emphasize that decisions regarding city selection extend beyond employment opportunities to encompass a broad array of life-quality factors. High earnings potential, professional growth opportunities, and a stable economic infrastructure further attract migrants (Storper & Scott, 2009). Additionally, crime rates are underscored by also Brown and Męczyński (2010) as a critical element shaping a city's appeal.

Conversely, certain variables such as the transparency of tax and fee systems (2.8) and liveable climate conditions (Q13, 1.7) received comparatively low scores. In particular, the low evaluation of climate-related factors suggests that this group of migrants tends to prioritize economic, social, and administrative criteria over environmental variables in their decision-making processes. Masch (2022) identifies such elements—including administrative flexibility, taxation, subsidies, and the availability of a skilled workforce—as "soft factors," which, along with climatic considerations, are shown to be less influential in this context (Murphy & Redmond, 2009; Brown & Męczyński, 2010; Musterd & Gritsai, 2013).

Taken together, the findings illustrate that both tangible urban infrastructure and intangible socio-cultural conditions jointly shape the decisions of highly skilled migrants. A particularly notable outcome is the fact that spatial and non-spatial factors received equal average scores (3.7), suggesting that both categories are perceived as equally significant in shaping migration preferences. This equilibrium indicates that physical urban elements are evaluated in conjunction with social attributes like inclusivity, safety, cultural diversity, and administrative functionality in that case.

In other words, for Turkish highly skilled individuals in the Netherlands, urban liveability is not solely determined by the social atmosphere and institutional arrangements offered within it, but also by the quality of the physical environment. This balance underscores the multidimensional nature of mobility decision-making in today's global labour market. Rather than being driven solely by economic or environmental considerations, location choices are increasingly grounded in holistic assessments. Consequently, for cities aiming to attract and retain highly skilled migrants, the development of integrated and sustainable urban policies—addressing both physical infrastructure and social cohesion—plays a critical role in ensuring long-term attractiveness.

7. Conclusion

This study set out to explore the locational preferences and migration drivers of highly skilled Turkish individuals who have relocated to the Netherlands, with a particular focus on the influence of spatial and non-spatial factors. Drawing on a comprehensive literature review, theoretical frameworks such as the 3T model and life-course perspectives, and empirical findings from a mixed-methods survey, the research reveals that highly skilled mobility is shaped by a complex interplay of tangible urban attributes and intangible socio-cultural, economic, and political conditions.

The results show that spatial factors—particularly urban infrastructure, environmental quality, green spaces, and cycling infrastructure—play a crucial role in shaping settlement preferences. Participants placed significant value on well-preserved urban heritage, waste management systems, and urban aesthetics. However, some physical attributes such as city scale and healthcare services were rated as less critical in pre-migration evaluations, though they later emerged as sources of dissatisfaction post-migration. This highlights a potential gap between expectations and lived experiences that cities must address through more comprehensive planning.

Equally important, non-spatial factors demonstrated a high degree of influence on migration decisions. Safety, cultural tolerance, multilingual communication, and administrative efficiency were among the most decisive variables. The prominence of these factors indicates that psychological comfort, legal clarity, and inclusive urban atmospheres are key components of urban attractiveness for highly skilled migrants. Notably, climate conditions—which are often assumed to influence migration—were rated among the least important factors in this context.

A particularly significant finding of the study is the nearly identical average scores assigned to spatial and non-spatial dimensions (3.7 out of 5), underscoring their equal importance in the migration decision-making process. However, when disaggregated, social and cultural factors appear to slightly outweigh physical attributes in overall impact. This suggests that cities aiming to attract and retain global talent must not only invest in infrastructure and services but also foster a tolerant, inclusive, and culturally rich environment.

In sum, the migration decisions of Turkish highly skilled individuals are not determined by a single dimension but shaped by the combined effects of quality of life, institutional efficiency, urban functionality, and socio-cultural climate. This underscores the need for integrated, holistic urban strategies that address both material and experiential dimensions of city life. As global competition for talent intensifies, cities that balance these attributes will be better positioned to sustain long-term economic vitality and social cohesion.

8. Limitations

The findings of this study should be evaluated within the framework of some methodological and practical limitations. Due to the dynamic and context-specific nature of the migration phenomenon, temporal and spatial variables are important. This situation limits the generalizability of the findings to different periods or geographical contexts.

Although the participants showed a certain diversity in terms of age, gender, marital status, education level and occupational fields, the sample was concentrated in knowledge-based fields such as engineering, informatics and academia.

In terms of time, most of the participants migrated after 2016. This migration movement accelerated even more after 2020 and reached its peak in 2022. The number of participants migrating in 2023 and 2024 was lower. The data only reflects a certain period. Therefore, the study has limited capacity to make inferences about long-term trends. Although there was diversity in terms of time, demographics and occupation, equal representation could not be achieved among the subgroups.

Data collection was conducted only through a survey, and qualitative methods were used only within the survey. This situation made it difficult to obtain in-depth information.

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Urban Form and Social Exclusion: A Spatial Perspective on Residential Segregation in Czech Cities

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Abstract
Urban residential segregation, shaped by historical, economic, political, and cultural factors, varies in its spatial form, which varies across regions (Dadashpoor, 2024). Recent approaches by architects and planners explore links between the built environment and the inhabitant's socioeconomic traits, highlighting specific spatial features that can reinforce segregation (Vaughan et al., 2005; Knaap & Rey, 2024; Legeby, 2013). This study builds on these approaches and proposes a framework focused on spatial connectivity and accessibility in relation to socioeconomic deprivation in the Czech Republic. The focus is on access to amenities, public transportation, and urban connectivity. The research methodology is grounded in identifying localities with high concentrations of socially excluded residents, using available data on recipients of the subsistence allowance (Sýkora, 2015).

Keywords: Residential Segregation; Urban Form; Spatial Inequality; Urban Design

Introduction

Despite significant advances in research on urban segregation, the phenomenon continues to shape the social and spatial fabric of cities worldwide. Defined as the physical separation of socioeconomic or ethnic groups within urban areas (Musterd, 2020; Musterd et al., 2016; Massey & Denton, 1988), segregation not only reinforces inequalities but also limits opportunities for social mobility and integration (Musterd, 2023).

Socioeconomic inequalities in urban settings have garnered growing scholarly attention; however, the complexity of residential segregation, rooted in a combination of historical, economic, and spatial factors, necessitates a multidisciplinary approach (Vaughan & Arbaci, 2011). The concentration of disadvantaged groups in specific neighbourhoods has been linked to stigmatisation, discrimination, and reduced access to essential services, with profound consequences for both individual well-being and community cohesion (Musterd, 2023; Van Kempen & Bolt, 2012). Moreover, the spatial configuration of urban environments plays a significant role in shaping patterns of social inclusion and exclusion, underscoring the importance of spatial justice as a critical dimension in addressing urban inequalities (Lehman-Frisch, 2011; Massey, 1993; Van Kempen and Bolt, 2012).

While the adverse impacts of segregation, including unequal access to education, employment, and healthcare, are well documented (Yue et al., 2024), less attention has been paid to how spatial structures and urban morphology contribute to these patterns, particularly in post-socialist contexts. Current policy efforts, such as those by the European Union or SDG policy goals by the United Nations (Eurocities, 2023; United Nations, 2024), aim to address social exclusion and inequality, yet effectively integrating these goals into urban policies remains a significant challenge.

This study seeks to contribute to addressing this challenge by examining the spatial features of residential segregation in the Czech context, where socioeconomic exclusion can be traced through the concentration of people reliant on state welfare systems (Agentura pro sociální začleňování, 2024; Sýkora, 2023). By developing a theoretical framework that links spatial connectivity, accessibility, and residential segregation, this study aims to contribute to practical policy interventions.

Literature review

Conceptual Approaches to Studying Segregation

The exploration of urban segregation varies depending on the analytical perspective adopted. Musterd (2023)

identifies four dimensions of segregation based on sociodemographic characteristics. The first concerns class or social status (Sassen, 2001; Atkinson, 2006; Musterd, 2020). The second encompasses race and ethnicity, sometimes considered alongside religion and migration (Phillips, 2010). The third pertains to demographic attributes, such as age and life-cycle stage, while the fourth involves cultural distinctions, which may be reflected in differing lifestyles and educational levels. Although approaches to studying segregation may differ, this paper focuses specifically on the spatial aspects of socioeconomic segregation, following the assumption that spatial distance corresponds to social distance and that poverty often concentrates in particular areas and disadvantaged neighbourhoods (Musterd, 2020; Duncan and Duncan, 1955; Park, Burgess and McKenzie, 1925).

Within the discourse on residential segregation, scholars frequently distinguish between voluntary and involuntary forms of segregation (Dadashpoor, 2024; Musterd, 2020). Voluntary separation typically involves the self-selected separation of affluent groups into exclusive residential enclaves, such as gated communities. In contrast, involuntary segregation refers to the marginalisation of low-income populations, often manifesting in concentrated areas of poverty, such as ghettos or slums. However, the boundary between voluntary and involuntary segregation is not always clear-cut. What may appear as voluntary separation can, in some instances, be shaped by shared cultural or social characteristics or driven by a collective desire for security and cohesion (Dadashpoor, 2024; Toušek, 2007).

The distinction between what is sometimes termed "chosen" enclaves and "enforced" ghettos (Peach, 2005) highlights the complex interplay between individual agency and structural constraints. While ethnic concentration in specific neighbourhoods may initially offer certain advantages, such as social support networks and access to culturally familiar services, it can also create barriers to long-term integration and broader societal inclusion (Musterd, 2023). This phenomenon is particularly evident within the broader context of macroeconomic and political processes (Vaughan and Arbaci, 2011; Peach, 2005).

Musterd (2020) warns against the simplistic categorisation of segregation into 'good' and 'bad' forms. Such binary distinctions risk overlooking the nuanced and context-dependent nature of segregation. Although the emergence of gated communities represents a significant dimension of socio-spatial stratification, this study focuses specifically on exclusionary forms of segregation that affect marginalised populations.

The Multidimensional Nature of Exclusion

Spatial exclusion is the most visible manifestation of the broader phenomenon of social exclusion. Residential segregation forms part of the process that confines certain groups of people to specific regions, settlements, localities or buildings (Toušek et al., 2018). When these groups are defined by ascribed characteristics such as ethnicity, religion, nationality or similar attributes, the process can be understood as discrimination (Sýkora and Temelová, 2005).

However, social exclusion in its entirety does not necessarily equate to poverty, although it is often a contributing cause (Madanipour, 2011; Musterd, 2020). Exclusion can be understood at multiple levels and may take different forms depending on cultural, political and economic contexts. Madanipour (2011) argues that various forms of exclusion underpin all social relations. The division of life and activities into private and public spheres creates boundaries that are both temporal and spatial in nature. The author also conceptualises exclusion as an issue of access to places, activities, resources, information and other vital components of everyday life.

The Physicality of Urban Space: Influence on Social Life

Since the concept of the "right to the city" was introduced in the 1960s by the French philosopher and sociologist Henri Lefebvre, urban studies have increasingly grappled with space not only as a physical structure but also as the product of social ties, relations and dynamics. Lefebvre, followed later also by David Harvey, called for the democratisation of urban planning, arguing that all inhabitants have a stake in shaping their urban environments (Lefebvre, 1968; Harvey, 1973). Edward W. Soja builds on Lefebvre's work by arguing that our geographies, or lived spaces, are socially produced and not merely physical forms. According to Soja, justice and injustice are

embedded in the multi-scalar geographies we inhabit, from households to the global economy (Soja, 2010). At the same time, Soja rejects spatial determinism, warning that it would narrow the scope of the discussion. Instead, he advocates for a comprehensive approach that recognises the mutual influence of space and society for the reason that it is evident that some form of inequality will always exist.

There is ongoing debate in the literature regarding the extent to which the physical characteristics of a settlement influence the social ties among its residents (Vaughan and Arabaci, 2011). While some scholars argue that neighbourhood environments play a significant role in shaping individual behaviour and health outcomes (Galster et al., 2010), this relationship is complex and not always straightforward.

Space can be perceived as an expression of social relationships and, simultaneously, as a factor that influences them. When individuals face restrictions in their social opportunities, their spatial mobility is similarly constrained, and therefore, their personal experience of exclusion deepens (Madanipour, 2011). In turn, spatial inequalities tend to reinforce existing social inequalities (Vaughan, 2007; Madanipour, 2011).

The Role of Housing Policies and Spatial Planning

Regarding the approach to housing policy, Madanipour (2011) identifies two processes. First, the real estate market treats space as a commodity, creating socio-spatial segregation through residents' differential access to this commodity. This represents a purely market perspective. On the other hand, spatial and urban planning seeks to regulate and rationalise urban development and impose a form of order in the public interest. These two processes often contradict each other and produce what Madanipour calls the collectivisation of difference, meaning sharper social differences within smaller spatial units.

Following this idea in the context of post-socialist countries, Kovács (2020) refers to this urban transformation as mosaic-type urban development, where through the lens of administrative units, the population may be diverse, i.e. that people of different socioeconomic status live in the same neighbourhood, but in reality, they are small sharply segregated structures.

Dadashpoor (2024) identifies a potential driver of segregation in what is described as a form of invisible segregation, indirectly conditioned by the decisions of governing bodies and influenced by housing and social policies. As Luděk Sýkora et al. (2010) note, residential segregation also encompasses a spatial planning dimension. At various scales, spatial planning documents contain tools that can potentially contribute to desegregation. Furthermore, social segregation is acknowledged as a concern within national policy frameworks.

However, Musterd and Ostendorf (2009) caution that focusing solely on residential segregation may be insufficient to understand the social dynamics at playfully.

Research relying heavily on census data often emphasises segregation at the city-wide or neighbourhood scale, which can vary in conceptualisation. Moreover, everyday experiences of ethnic segregation may be more accurately reflected in other spatial settings such as streets, community centres, workplaces, parks, and other public spaces, and these sites may hold particular significance for vulnerable communities. For these groups, the spatial boundaries of social interaction differ from those captured by residential data (Phillips, 2007).

Moreover, architectural or urban form alone cannot be directly blamed for social problems. Bill Hillier (1996) emphasises the importance of analysing the spatial configuration of environments and how these influence patterns of movement and interaction. This approach provides a more nuanced understanding of the relationship between architecture and social behaviour (Hillier, 1996).

Detour to Post-Socialist Transition and Urban Transformation

In the twenty-first century, metropolitan Europe has become increasingly unequal, with a persistent and widening gap between high- and low-income populations observed across the continent (Musterd, 2017). To under-

stand the roots of segregation in Central Europe, particularly in the Czech Republic, it is essential to take a brief detour and examine the economic and urban transformations that have taken place over the past few decades.

The political changes following the collapse of the Soviet Union and the subsequent economic transformation brought dramatic shifts for all countries of the former Soviet bloc. The roots of the current patterns of segregation lie in this historical context.

Under state socialism, housing was considered a universal right, which in practice led to the mass construction of prefabricated housing estates and the expansion of the housing stock through the subdivision of expropriated apartments into multiple housing units (Kovács, 2020). However, this right was not distributed evenly. Socialist cities were characterised by a particular form of segregation based on allocated privileges, reflecting a marked stratification of society (Häussermann, 2008). Housing thus became, to some extent, a tool for distributing these privileges (Lux and Sunega, 2014).

The trajectories followed by individual republics in Central Europe after the fall of socialism differed considerably. For example, Tsenkova (2006) describes how the transition to a market economy, technological change, and industrialisation also transformed the urban environment.

Massive housing construction, housing allowances, expropriation, and rent regulation created a substantial publicly owned housing stock, which partially substituted for social housing. At the same time, there was no significant support for people in social need from other entities such as charities or churches. This absence contributed to a deepening of socio-spatial inequalities following the fall of the regime and large-scale privatisation (Lux and Sunega, 2014).

The privatisation of housing stock and the restructuring of the economy led to greater income diversification and the emergence of new socio-spatial inequalities (Kovács, 2020).

Another common feature across the former Soviet bloc countries is the high level of private ownership within the housing stock. Due to large-scale privatisation in the 1990s and 2000s, almost 90 per cent of the housing stock in the Czech Republic is now privately owned (Lux, 2014). Lux (2014) further notes that in the 1990s, nearly all housing stock was transferred to cities and municipalities, which became the largest owners of real estate. However, government limitations on their rights, combined with often outdated housing lacking repair funding, created difficulties. At a time of stagnant economic growth and some disillusionment with the economic transformation, privatisation emerged as a convenient tool to relieve municipalities of unwanted burdens and secure voter support. This process was also accompanied by widespread distrust of social housing, which, despite being built under favourable conditions in the 1990s, frequently ended up in private hands (Lux, 2014).

The lack of a sufficient public sector housing stock, combined the absence of governmental legislation on social housing, has led to the current situation of socioeconomically segregated neighbourhoods so-called excluded localities (Toušek, 2018). As the author notes, this term is rather challenging to grasp and lacks a clear definition. The Analysis of Socially Excluded Localities in the Czech Republic[1] (Čada et al., 2015) defines a socially excluded locality as "a space (house, street, neighbourhood) where there is a concentration of people who can be identified as having characteristics associated with social exclusion," further noting that such areas are negatively and symbolically labelled by the surrounding population. The spatial forms of socially excluded localities can vary in both size and structure; however, there are no clear implications for urban form that would allow for their consistent spatial identification.

Knowledge Gap: Urban Structure and Residential Segregation

Despite over a century of research on urban segregation, the settlement patterns of segregated populations remain insufficiently understood (Vaughan and Arbaci, 2011). Much of the comparative study to date has primar-

1 Translated by the author of this text from: Analýza sociálně vyloučených lokalit v ČR.

ily focused on capital cities, limiting broader generalisations about segregation across different urban contexts (Musterd et al., 2017).

Comparing levels of segregation and the approaches used to analyse them presents a range of methodological challenges. As Musterd (2023) notes, units of analysis can vary considerably depending on the research objective. Additionally, the spatial dimension of segregation can be studied using a variety of analytical methods, each influenced by the availability, type, and granularity of data employed.

While the causes and consequences of social exclusion have been widely studied, the traditional segregation measures often rely on predefined administrative boundaries, which can obscure the fluid and continuous nature of social and demographic distributions (O'Sullivan and Wong, 2007). O'Sullivan and Wong (2007) highlight that traditional segregation measures often rely on administrative boundaries. Because these units are arbitrary, the results can vary significantly depending on the size and shape of the areas chosen. This issue, where the scale or zoning of spatial units affects the analysis outcome, is known as the Modifiable Area Unit Problem (MAUP). This problem arises when discrete units show mixed populations, making it challenging to detect actual segregation patterns.

A notable challenge is addressed in the literature regarding the relationship between urban structure and residential segregation, a topic that has garnered growing scholarly attention in recent years (Vaughan et al., 2005; Legeby, 2013; Maffini and Maraschin, 2018; Knaap and Rey, 2024). A more comprehensive understanding of residential segregation necessitates analysing the spatial configuration of cities. This involves understanding the complex interrelationships between discrete urban elements and the city as a whole (Vaughan and Arbaci, 2011).

The presented analytical framework aims to contribute to this evolving field by addressing the issue at a broader spatial scale, with a specific focus on the built environment, particularly in terms of connectivity and accessibility. The objective is to develop a conceptual framework capable of examining multiple levels of spatial segregation, thus enabling a more nuanced understanding of how physical urban form shapes patterns of social division.

The contribution of this study to spatial planning practice lies in identifying the specific characteristics of segregated areas and the spatial factors that contribute to social exclusion. A data-driven approach offers the potential to apply these insights to other urban areas, providing an objective and quantitative perspective. This approach can support the formulation of more effective planning policies by identifying potential spatial factors that drive residential segregation.

Developing a Framework to Address the Spatial Dimensions of Residential Segregation

This study proposes a framework that emphasises connectivity and accessibility as spatial factors associated with residential segregation. By focusing on measurable spatial parameters commonly used in urban planning, it investigates how these elements correlate with the concentration of socioeconomically excluded populations. To bridge spatial analysis with practical planning, the research is scaled down to individual buildings and plots, which are the fundamental units used in neighbourhood and city-level masterplans.

The central research question is whether objective spatial patterns can be consistently identified in areas where segregated populations reside. A data-driven, quantitative approach ensures both replicability and applicability across different urban contexts. It aims to offer a methodological toolkit for assessing segregation at finer structural scales, supporting integration into urban design and planning practices.

The framework builds on extensive research into residential segregation in the Czech Republic, providing a robust foundation for broader comparative studies (Agentura pro sociální začleňování, 2024; Sýkora, 2010; Sýkora, 2023; Čada et al., 2015).

The study examines spatial features of segregation through the lens of accessibility to opportunities and the

permeability of the built environment. Segregation is analysed across three dimensions:

- Urban morphology, understood as the structural fabric that enables or constrains movement and access.
- Transportation and mobility.
- Access to public amenities.

Figure 1 illustrates each step of the proposed framework. In the next stage of the research, this framework will be applied to three Czech cities, selected as case studies based on their status as regional centres located in structurally deprived regions.

While recognising the importance of other factors, such as the quality of public space and patterns of social interaction, this research limits its focus to quantifiable spatial features at the building and plot levels in alignment with the tools and scales available to urban planners.

The following section will discuss each component of the framework, along with its theoretical and methodological foundations.

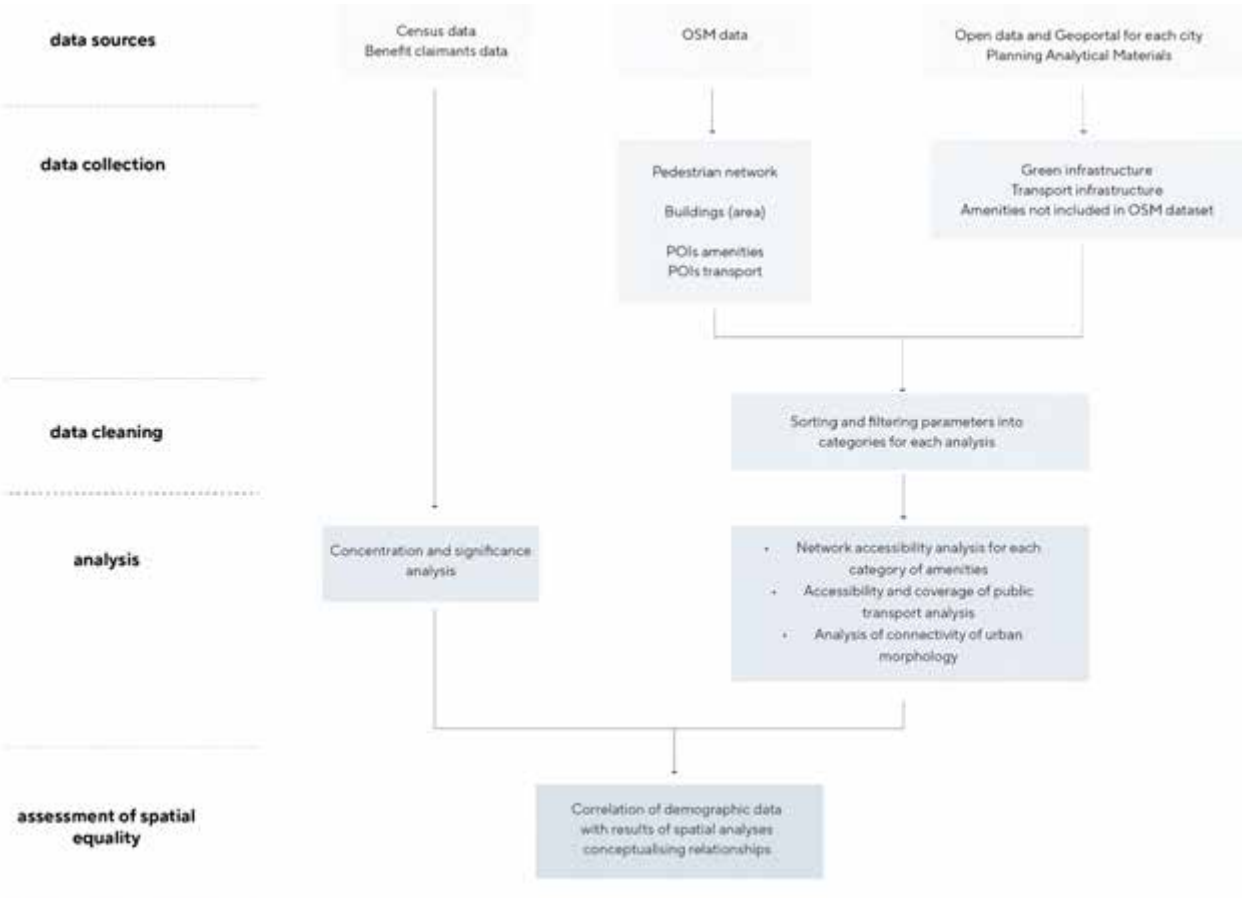

Figure 1: Proposed framework for assessing the spatial dimension of residential segregation.

Data

This study builds on existing analyses of residential segregation conducted within the Czech Republic. It draws on annually reported data based on the Methodology for the Identification of Localities of Residential Segrega-

tion[1](Sýkora, 2023). This data will be further refined to reflect specific residential structures by incorporating additional sources, including academic research and municipal reports on residential segregation in the surveyed cities.

The Methodology for the Identification and Evaluation of Segregation Sites identifies areas of segregation and assesses the suitability of social housing in preventing deeper exclusion. It assesses segregation at the level of primary settlement units (ZSJ) through three main steps: defining the target social group, identifying areas of concentration using statistical data, interviews, and discourse analysis, and evaluating findings with field verification to ensure that concentration reflects actual social exclusion (Sýkora, 2023).

The methodology utilises the abbreviation SPO PNZ, i.e. "co-assessed persons for the provision of a subsistence allowance". These are the populations at risk of poverty. The provision of the allowance is linked to the household and encompasses a wide range of individuals in varying social positions. Information on the location of public infrastructure will be sourced from open data platforms and mapping services provided by individual municipalities. Data on the street network and built environment will be obtained from OpenStreetMap (OSM), and these datasets will be further tailored and processed to meet the requirements of spatial analysis.

Urban Morphology and Spatial Configuration

Studies of urban morphology provide a framework for analysing the physical structure of cities. Configurational approaches focus on the spatial arrangement and interconnectivity of fundamental urban elements such as plots, buildings, and streets. These structural relationships shape how cities function, influencing movement patterns, social interactions, and access to resources (Hillier and Hanson, 1984; Hillier, 1996).

Research using configurational theory has explored the links between urban form and social deprivation, highlighting how spatial configurations may contribute to the concentration of disadvantaged populations (Vaughan et al., 2005; Legeby, 2013; Maffini and Maraschin, 2018; Knaap and Rey, 2024). Recent studies suggest that analysing and classifying distinct urban forms can help identify which spatial patterns are more susceptible to socioeconomic exclusion (Venerandi et al., 2024).

Evaluating Urban Morphology: Urban Morphometrics

Advancements in geographic data analysis and the growing availability of geospatial data have given rise to a data-driven branch of urban morphology known as 'urban morphometrics' (Araldi and Fusco, 2019; Fleischmann et al., 2021; Porta et al., 2022). This approach typically involves quantifying urban form across numerous metrics at the building level, using clustering techniques to define morphological regions or urban types, and profiling them for comparative analysis (Venerandi et al., 2024).

Drawing on digital mapping sources such as street networks, building footprints, and morphological tessellations, these methods enable the classification of homogeneous urban tissue types. This systematic approach supports comparative studies of urban form, facilitating a deeper exploration of how spatial patterns relate to broader issues, such as environmental quality, public health, and social inclusion. This study builds on established methods in urban morphology (Fleischmann et al., 2021), selecting a set of spatial characteristics to guide the analysis of urban form, as shown in Table 2. The chosen variables are aligned with the research objective of examining connectivity, accessibility, and permeability within the built environment.

This approach will generate a dataset that can be correlated with the distribution of socioeconomically excluded individuals to gain an understanding of the variables associated with segregation.

2 The title translated by the author of this text from: Metodika identifikace a hodnocení lokalit segregace.

Table 2 Primary morphometric characters from the Methodological foundation of a numerical taxonomy of urban form, sorted by "element" (Fleischmann et al., 2021).

Element	Set of parameters	Data Source
building	Area of building Height of a building Volume of the building Perimeter of a building Courtyard area of a building Circular compactness of a building Corners of a building Squareness of a building Equivalent rectangular index of a building Elongation of a building Centroid - corner distance deviation of a building Centroid - corner mean distance of a building Solar orientation of a building Street alignment of a building Cell alignment of a building	OSM data
tessellation cell	Longest axis length of a tessellation cell Area of a tessellation cell Circular compactness of a tessellation cell Equivalent rectangular index of a tessellation cell Solar orientation of a tessellation cell Street alignment of a building Coverage area ratio of a tessellation cell Floor area ratio of a tessellation cell	OSM data
street segment	Length of a street segment Width of a street profile Height of a street profile Height to width ratio of a street profile Openness of a street profile Width deviation of a street profile Height deviation of a street profile Linearity of a street segment Area covered by a street segment Buildings per meter of a street segment	OSM data
street node	Area covered by a street node	OSM data

adjacent buildings	Shared walls ratio of adjacent buildings Number of courtyards of adjacent buildings Perimeter wall length of adjacent buildings	OSM data
neighbouring buildings	Alignment of neighbouring buildings Mean distance to neighbouring buildings Mean inter-building distance between neighbouring buildings Building adjacency of neighbouring buildings	OSM data
neighbouring cell	Weighted neighbours of a tessellation cell Area covered by neighbouring cells Mean distance to neighbouring buildings	OSM data
neighbouring segments	Reached cells by neighbouring segments Reached area by neighbouring segments	OSM data
neighbouring nodes	Degree of a street node Mean distance to neighbouring nodes from a street node Reached cells by neighbouring nodes Reached area by neighbouring nodes	OSM data
neighbouring tessellation cell	Gross floor area ratio of neighbouring tessellation cells	OSM data
block	Weighted reached blocks of neighbouring tessellation cells Area of a block Perimeter of a block Circular compactness of a block Equivalent rectangular index of a block Compactness-weighted axis of a block Solar orientation of a block Weighted neighbours of a block Weighted cells of a block	OSM data
street network	Local meshedness of a street network Mean segment length of a street network Cul-de-sac length of a street network Reached cells by street network segments Node density of a street network Reached cells by street network nodes Reached area by street network nodes Proportion of cul-de-sacs within a street network Proportion of 3-way intersections within a street network Proportion of 4-way intersections within a street network Weighted node density of a street network Local closeness centrality of a street network Square clustering of a street network	OSM data

Mobility and Connectivity

Residential segregation can also be understood as a consequence of limited interactions and co-presence in public space (Legeby, 2013). As argued by Rokem and Vaughan (2018), segregation is shaped and potentially reshaped by patterns of mobility. Connectivity, defined as the opportunity for encounters between different population groups, is, therefore, a key consideration in addressing issues of social and spatial justice. A potential tool for assessing the intensity of flows and potential interactions in public space, as highlighted in the research mentioned above is the Space Syntax method. Developed in the 1970s by Bill Hillier, Julienne Hanson, and colleagues at The Bartlett, University College London, the Space Syntax method established a foundational link between spatial configuration and social phenomena in urban environments (Hillier and Hanson, 1984; Hillier, 1996). Their research demonstrated that the layout of spaces influences pedestrian movement, the distribution of safety, and the vibrancy of public life. Today, Space Syntax represents a broad interdisciplinary field encompassing diverse analytical tools and methodologies for quantitative spatial analysis across multiple scales.

Mobility patterns expressed not only through walkability but also via the coverage of public transportation systems, play a crucial role in urban planning, as transport infrastructure has the potential to either bridge or deepen social divides (Rokem and Vaughan, 2018). By shifting focus from where people live to where they travel in their daily lives, a more nuanced understanding of urban social dynamics can be achieved (Kolkowski et al., 2023). Focused interventions, such as the introduction of new public transport lines, have been shown to significantly improve access to essential services (Lee and Miller, 2018).

Evaluating mobility

This framework addresses both structural and service-related aspects of urban accessibility. The street network is analysed using the Space Syntax method, and public transport coverage is assessed using data from local municipalities, including connection frequencies; both analyses are linked to individual buildings. This approach aims to capture the actual daily mobility opportunities available to residents in different parts of the city.

Table 2 Accessibility standards for public Infrastructure, selected categories translated by the author of this text (Maier et al., 2020).

Type of Public Infrastructure	Description / Reference Point for Accessibility: Starting / Destination	Accessibility Standard	Data Source
Public Transport Stop	Building entrance / Platform centre	500 m (300 m) 600–700 m	OSM data / Open City Data

Accessibility in the Urban Environment

Accessibility in urban environments is commonly defined as the degree to which residents can efficiently reach essential services and destinations (Hansen, 1959; Nicoletti, Sirenko and Verma, 2023). Despite its importance, travel remains constrained by existing infrastructure and various physical or invisible barriers. Ensuring equitable access to urban services, institutions, and economic opportunities is widely recognised as a key component of sustainable development and improved quality of life (Weiss et al., 2018).

However, access to public infrastructure often reflects underlying socioeconomic disparities. Research shows that socioeconomically disadvantaged populations are frequently underserved by public amenities, experiencing limited access to services such as healthcare, education, and community infrastructure (Nicoletti, 2022; Ashik, Mim and Neema, 2020; Lee, Jeong and Go, 2024; Weiss et al., 2018; Hosseini et al., 2022). While some communities benefit from a diverse range of accessible facilities, marginalised and spatially segregated populations face

persistent obstacles in reaching these services (Van Wee and Geurs, 2011). In response, urban planners have increasingly advocated for a more equitable distribution of resources (Hosseini, 2021).

Evaluating Spatial Accessibility

There is an ongoing debate about the best approaches for evaluating spatial accessibility. Many scholars argue that analyses should extend beyond simple walking distance to incorporate travel time, demand, and service capacity (Ashik, Mim and Neema, 2020). Building on these insights, this study focuses on assessing the accessibility of key urban amenities, as defined by methodology issued by the Czech government: Accessibility standards for public amenities[2] (Maier et al., 2020). Walking distance is calculated from individual buildings to the nearest type of public amenity based on the categories shown in Table 1. These measures will later be correlated with the spatial concentration of socially excluded residents to better understand inequalities in urban service provision.

Table 1 Accessibility standards for public amenities, selected categories translated by the author of this text (Maier et al., 2020).

Type of public amenities	Description / Reference Point for Accessibility: Starting / Destination	Accessibility Standard	Data Source
Education			
Kindergarten	Residential building / Kindergarten	600 m (400 m)	OSM data / Local Geoportal of Planning Analytical Materials
Primary School	Residential building / Primary School	600 m	OSM data / Local Geoportal of Planning Analytical Materials
Social services:			
Day Service Center and Day Care Center	Residential building / Social Care Facility	600 m	OSM data / Local Geoportal of Planning Analytical Materials
Facility for children and youth, weekly care centre, intervention centre	Residential building / Social Care Facility	Location in the municipality	OSM data / Local Geoportal of Planning Analytical Materials
Healthcare			
General practitioner, paediatrician, dentist, gynaecology and obstetrics, pharmacy	Residential building / Doctor's office, Pharmacy	600 m	OSM data / Local Geoportal of Planning Analytical Materials
Culture:			
Library	Residential building / Library	15 min walk or travel	OSM data / Local Geoportal of Planning Analytical Materials
Community Centre	Residential building / Community Centre	600 m (depending on the position in the municipality)	OSM data / Local Geoportal of Planning Analytical Materials
Multipurpose Hall	Residential building / Multipurpose Hall	Location in the municipality	OSM data / Local Geoportal of Planning Analytical Materials
Public Administration			

3 The title translated by the author of this text from: Standardy dostupnosti veřejné infrastruktury

Post Office / Postal Counter	Residential building / Post Office	Location in the municipality	OSM data / Local Geoportal of Planning Analytical Materials
Civil Protection			
Volunteer Fire Station	Residential building / Fire Station	1 000 m	OSM data / Local Geoportal of Planning Analytical Materials
Fire Station	Fire Station / Any location	According to the legal definition	OSM data / Local Geoportal of Planning Analytical Materials
Permanent Shelter for Residents	Residential concentration areas / Permanent Shelter	500 m	OSM data / Local Geoportal of Planning Analytical Materials
Playgrounds:			
Playground for Preschool Children	Residential building / Playground	200 m	OSM data / Local Geoportal of Planning Analytical Materials
Playground for Younger School Children	Residential building / Playground	500 m	OSM data / Local Geoportal of Planning Analytical Materials
Playground for Youth and Adults	Residential building / Playground	500 m (1 000 m)	OSM data / Local Geoportal of Planning Analytical Materials

Discussion and conclusion

This study presents a framework for identifying potential spatial factors contributing to residential segregation by linking them with data on the location of segregated residents, as identified in previous comprehensive studies on segregation in the Czech Republic (e.g. Sýkora, 2023; Čada et al., 2015). The analysis is conducted at a scale relevant to urban planning practice.

By refining the spatial scale to the level of individual buildings and plots, the study aims to bridge academic research with practical urban planning, providing concrete insights that can inform planning decisions.

The analytical framework integrates multiple methodologies to investigate three dimensions of spatial segregation. First, it examines urban form as a structural barrier and a defining feature of settlement patterns. Second, it considers mobility, focusing on the walkable street network and the extent of public transport coverage. Third, it assesses accessibility to public amenities and services as a measure of spatial equity. Each dimension will be analysed for every building in the selected cities, and the results will be correlated with data on the concentration of socially segregated populations. Findings within the proposed research framework could provide deeper insights into the underlying patterns of spatial segregation and enhance existing research on segregation, particularly in the context of spatial planning and urban design.

This research project does not address a broader temporal scope or investigate the dynamic processes underlying social exclusion. Incorporating a longitudinal perspective and analysing patterns at the scale of individual buildings could yield a more comprehensive understanding of the migration trajectories of socially excluded populations, particularly when situated within broader regional trends. Such an approach would benefit from a qualitative analysis of spatial planning documents and policies, tracing the arguments and. A historical examination of planning paradigms would provide essential context for understanding how approaches to segregation have evolved in response to shifting political, economic, and social conditions.

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Counteracting digital divides through a place-based inclusion process. Insights from an ongoing research project

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Abstract
The inclusion paradigm raises a paradoxical question: how inclusive is inclusion in contexts marked by deep socio-economic vulnerability? Digitalization — especially through the "smart city" model — claims to promote inclusion but often reinforces inequality by placing responsibility on individuals and ignoring structural barriers. Drawing on the '(E)Welfare in the City' project in Rozzano, south of Milan — part of Italy's PNRR-funded M.U.S.A. program — this paper rethinks digital inclusion through ecological thinking. By combining insights from urban planning, sociology, and design, the project co-designs inclusive digital solutions with both youth and older residents, at the same time leveraging Rozzano's strong local networks that everyday address pressing challenges such as poverty, school dropout, and demographic complexity. The goal is to create place-based, equitable digital futures that respond to the lived realities of marginalized communities.

Keywords: digital divide; welfare; co-design

1. Introduction

In an increasingly digitized society, inclusion must be recognized not as a secondary objective, but as the very foundation of democratic digital transformation. The modernization of public services — particularly welfare — has often focused on efficiency and cost-effectiveness, overlooking how such transformations may deepen exclusion for those already on the margins. The term inclusion, frequently used in policy discourse, is too often limited to notions of access — providing broadband or devices — without questioning whether individuals and communities are genuinely empowered to participate in the digital public sphere.

This paper argues for a radical rethinking of digital inclusion: not as a technical issue to be solved through infrastructure investment alone, but as a social, spatial, and relational process grounded in local realities. Inclusion is about people — about dignity, agency, participation, and the right to shape the systems that shape their lives.

This text reflects on physical and digital spaces for social inclusion in the metropolitan area of Milan through the on-going E-Welfare in the City project. It is led by Politecnico di Milano, funded under the M.U.S.A. program within the framework of the National Recovery and Resilience Plan (PNRR), and offers a concrete application of this inclusive, ecological design approach in Rozzano, Italy.

A municipality on the outskirts of Milan, Rozzano is often labelled as a "marginal" territory: it has a large concentration of public housing, high unemployment, and low educational levels among the population. Yet it also possesses dense social networks and active civil society organizations. These characteristics — significant socio-economic fragility but also a rich network of local actors combating social exclusion — make it both a challenging and fertile ground for inclusion-based innovation. In this setting, digitalization is approached not as a purely technical endeavor but as a catalyst for rethinking and reconfiguring social, territorial and spatial relations.

Presently, the project is in the process of co-designing a hybrid welfare access point that would be responsive to the local community's needs through co-design and community participation. As the work is still on-going, this paper will reflect on the progress thus far, specifically how those of us involved in the E-Welfare in the City project have begun to understand the relationship between 'inclusion' and 'digitalization' and focusing on the supply of some welfare services and youth capacity building. The discussion draws on the project's process of research & action, unpacked through interviews and joint work with local actors, and on reflections on the project's participatory design workshops.

The paper is organized into two main sections. The first section focuses on how the concept of inclusion has been taken up in the digital turn. While much existing discourse centers around simply providing access or developing digital skills, this section shifts the focus towards the conditions by which 'smart citizenship' can emerge. Grounding this discussion in the case of Rozzano — specifically pulling from the PNRR-supported investment aimed at expanding Italy's digital facilitation network — it offers concrete examples of how the 'digital divide' is neither a monolithic category nor a challenge that can be overcome through a universal, 'one-size-fits-all' program. As the PNRR investment is exposing persisting social and digital vulnerabilities in Rozzano, there is the need to build from the outcomes of this 'digital inclusion' program, crafting a space and digital services that are actually responsive to the diverse needs of the communities it intends to serve.

Building from this, the second half of this paper aims to expand the concept of 'digital inclusion', framing it as a systematic, relational, and contextual practice. Drawing from the Rozzano case, this section introduces the E-welfare in the City's ongoing pilot program Spazio Verso and details how it is proposing a 'new kind of space' within this frame — one that is co-created with local actors to address the communities' varied social and digital vulnerabilities in Rozzano.

Ultimately, this paper argues that 'digital inclusion' is not an individual achievement but a collective one, and as such, it considers the ways 'exclusive inclusiveness' — a means to account for the diversity of experiences within these systems — may actually be a promising way forward.

2. Inclusion as a Cornerstone of Digital Transformation

2.1. Digitization and Urban Transformation

The digitization of urban spaces, propelled by technologies like artificial intelligence (AI), automation, and informatization, is profoundly transforming society and public spaces. This transformation began in the mid-2000s, in parallel to the advent of the "smart city", which was initially a North American industrial proposal reflecting the urban and the third industrial revolutions driven by digital technology.

Framed as a new economic space for the deployment of connected sensors and devices — aimed at optimizing urban management, governance, and, ultimately, commercial exploitation by a select few actors — the smart city has increasingly promoted a discourse of individual responsibility regarding the level of "smartness" (Kitchin, 2021; Vanolo, 2014) that each person is expected to demonstrate. This trend echoes the broader shift associated with the rise and consolidation of neoliberal political ideologies since the 1980s, characterized by a growing emphasis on personal accountability and a parallel disregard for structural and systemic determinants of social conditions. Within this logic, precarious employment is seen as the result of individual shortcomings — such as inadequate education, a poor CV, or insufficient effort in pursuing better opportunities — rather than as the out-

come of labor market deregulation and the broader deterioration of working conditions, ultimately leading to escalate social and economic exclusion. By obscuring the processes of legitimation and implementation — how deep and pervasive they are, how they are integrated into local contexts (Angelidou, 2017; Kitchin, 2014), and what choices are made regarding the promotion or neglect of social objectives such as justice (Datta & Odendaal, 2019; Papa & Ferreira, 2018; Papa & Lauwers, 2015) — the smart city reveals weak and underdeveloped visions of long-term sustainability and social inclusion.

Rather than being truly "smart," smart cities risk becoming dystopian: polarized, unlivable — in the literal sense of uncivil — not built for those who inhabit them, inhumane.

Unexpectedly, the COVID-19 pandemic was a stress test for these models (Languillon-Aussel, 2021), exposing the weaknesses of the smart city model. As the pandemic forced the widespread adoption of simplistic, analogue solutions (e.g., social distancing markers), it exposed the rigid, non-adaptive nature of many digital systems, which were confined to their original programming and couldn't evolve quickly in response to new challenges (ibidem). Contactless services, QR codes, and remote access systems were designed for users who had the right device, the necessary skills, and stable connectivity. Those without these prerequisites found themselves further excluded — not just from services, but from participation in public life. What happened, on the other hand, was that digital technology became essential for maintaining continuity during the pandemic — particularly for teleworking and social events — absorbing much of the functionality that had previously depended on physical spaces. It also facilitated a neoliberal stance that rejected public and collective spaces in favor of private ones, prompting a reconsideration of space itself. In this way, the decade that began with global social movements like Occupy Wall Street, the Arab Spring, and Spain's Indignados — movements that transformed public spaces into sites of protest — ended with a shrinking of (public) spaces (ibidem) and the evident deficiencies of the smart city model, highlighting the urgent need to rethink and reconfigure the relationship between physical urban spaces, city services, and the digital realm.

As we are increasingly called to reconceptualize space not merely as a physical, Euclidean construct, but as a dynamic sphere of transversal, intergenerational exchange — where services and access to citizenship rights unfold across both material and digital infrastructures — it becomes essential to critically examine the ways in which digital technologies are reshaping the access to and uses of physical space and transforming both individual and collective behaviors. For urban environments to maintain their relevance in the digital age, they must continue to serve as sites of civic engagement, anchored in territorially and socially shared forms of belonging.

In this context, the question is not simply how to build smart cities, but under what conditions smart citizenship can emerge — understood as the cultivation of a digitally literate, civically engaged, and socially responsible publics. This shift in focus necessitates a more nuanced exploration of the socio-spatial consequences of digital transformation, particularly within vulnerable communities, where such technologies often risk deepening, rather than bridging, existing digital and social divides.

Inclusion, therefore, cannot be reduced to technological provision alone; it must be understood as a design principle grounded in participation and attentiveness to those most at risk of marginalization. This, in turn, demands a profound cultural and political reorientation — from a top-down, efficiency-driven logic toward one rooted in care, equity, and responsiveness to diverse lived realities.

Reliable internet access is increasingly recognized as a critical component of digital inclusion, not only in terms of affordability but also availability. In many public housing contexts, for example, residents often contend with substandard or inconsistent connectivity. However, digital inequality extends well beyond mere access to the internet. It also encompasses the quality of that access, including the reliability of service and the accountability of providers, particularly in low-income neighborhoods and among individuals who rely primarily on smartphones as their point of connection.

Digital inclusion is shaped by a constellation of interrelated factors such as income level, educational attainment, and residential geography. These disparities in turn contribute to unequal access to essential opportunities, including education, employment, and civic participation. Indeed, the notion of the "digital divide" is not monolithic.

At least four distinct levels of digital inequality and exclusion (van Dijk, 2005) can be identified:

- First-level digital divide – Access Divide, which concerns the availability of digital infrastructure, including devices, software, connectivity, and power supply.

- Second-level digital divide – Usage Divide, which focuses on the differences in the ways and frequencies with which people use technologies, as well as the activities carried out online (such as information gathering, communication, education, etc.). People with more limited or superficial use of technologies are less able to fully take advantage of the benefits of the digital society.

- Third-level digital divide – Skills Divide, which refers to the ability to effectively use digital tools and platforms, encompassing not only technical competencies but also critical awareness, such as understanding personal data privacy.

- Fourth-level digital divide – Structural inequalities, that arise from broader socio-demographic factors such as gender, age, socio-economic status, and citizenship, reflecting how digital exclusion intersects with and amplifies pre-existing social inequalities.

Digital literacy, in fact, can either be a key factor in enabling upward mobility or an element deepening the digital divide, particularly among vulnerable groups.

Importantly, as digitalization advances, inequalities do not simply worsen linearly. Instead, they intersect with other factors such as generational gaps, the economic affordability of hardware, software, and information, as well as social and cultural capital. Moreover, digital divides manifest not only at the individual level but also across multiple layers: between individuals occupying different societal roles (e.g., citizens, welfare recipients, caregivers, workers, active volunteers, and more); across institutions, reflecting disparities in resources available at specific service locations (e.g., schools in education, hospitals and clinics in healthcare, social service centers); within networks of institutions, such as the coordinated social service offices within a municipality; and across geographic contexts, acknowledging that not all municipalities or regions are equally equipped.

This means that, within the ongoing process of digitalization, digital divides play a crucial role in enabling individuals to exercise their rights and responsibilities as citizens. Framing this within Amartya Sen's capabilities approach, it becomes clear that neither access nor skills alone are sufficient for digital inclusion. What truly matters is whether individuals are genuinely empowered to convert digital resources into meaningful outcomes — outcomes that enhance their well-being, development, and access to urban rights, while also expanding their agency within their families, communities, and the territories they inhabit.

2.2. Harnessing the National Recovery and Resilience Plan (PNRR) as a Catalyst for Digital Inclusion in Vulnerable Communities

The COVID-19 pandemic not only accelerated the adoption of digital technologies and services, but also starkly exposed the barriers that many face in accessing and benefiting from digital services. Given that these barriers were not new but rather intensified by the pandemic, the EU Commission designed the Recovery and Resilience Facility (RRF) to not simply act as a temporary recovery instrument but also as a systematic response, supporting investments and reforms to make EU Member State economies more sustainable and enabling them to address local challenges. The RRF stands out from other EU programs given its sheer size — i.e., €750 billion through the NextGenerationEU funds, the largest budgetary instrument in EU history — but also its funding model. The RRF is financed through international capital markets (instead of the EU budget), implemented via a multi-level man-

agement model, and distributed through results-based payments (tied to achieving certain targets rather than expenditure costs). While thematic requirements are minimal, the RRF outlines six key policy areas of relevance to the EU, two of which have been highlighted together as complementary priorities to address digital divides: digital transformation and social and territorial cohesion.

Given a recognition of the significant delay in the Italian context regarding digitalization, Italy's National Recovery and Resilience Plan (PNRR) — the plan drafted by Italy to access the funds of the RRF — allotted, in 2021, 27% of its fund[1] to digital initiatives, surpassing the required 20%, and demonstrated a particular interest in the development of digital skills (i.e., Investment 1.7. Basic Digital Skills), to help mitigate the social impacts of the pandemic. This investment aims to reduce the digital exclusion in Italy by improving digital skills among at-risk populations through creating a network of young volunteers to provide digital education and support and by expanding the network of digital facilitation centers to develop the digital skills of at-risk populations through both in-person and online training.

In the program to expand Italy's digital facilitation network, digital inclusion is not only the driving force but the main aim, as is evident in the programs' three main targets: (T1) increasing the digital skills and digital inclusion of 2 million citizens, (T2) offering 3 million digital training services, and (T3) increasing the number of facilitation centers from 600 to 3.000 throughout the country. While this is a temporary instrument, the digital facilitation network is intended to be a structural action, and as such, the implementing entities (i.e., the Region or a third party) were pushed to consider how the facilitation centers can continue operating after the end of the investment.

Given the multi-level management of the digital facilitation network, this effort towards digital and social inclusion has been able to play out differently across regional and local levels. As this program has been entrusted to the regions, its implementation regionally varies in aspects, such as, but not limited to, the method in which services are distributed and the requirements for digital facilitation centers and their facilitators. In Lombardy, the Region claims to have promoted a 'learning by doing' strategy in an effort for more practical and reflective skill acquisition and to create a stronger connection between citizen preferences/needs and the digital facilitation offerings. The service model adopted is based on a one-shot, voucher-based provision system[2]to deliver pre-packaged facilitation services (referred to as 'service baskets'). Lombardy Region has implemented this strategy through its territorial branches, such as the Metropolitan Agency for Training, Guidance and Employment (AFOL) — particularly active in the Milan metropolitan area — and the vocational training centers (CFPs), building from its pre-existing networks and programs.

As one of ten professional training centers in the network of Metropolitan AFOL, Rozzano's vocational training center (CFP) became an active facilitation center in the region in fall 2024. Primarily, it is a vocational training center in Rozzano that provides three-year courses in sectors such as beauty, electronics, and IT. Rozzano's CFP plays a critical role in combating school dropout rates and social exclusion by offering professionalized and personalized education and enrichment activities. While not all 10 CPFs in AFOL's network have joined the initiative, Rozzano's CFP's manager responded positively to the call.

Consulting the Region's guide for facilitators and interviewing two on-site facilitators in Rozzano's CFP, our research team has attempted to understand how this PNRR sub-investment is being managed across levels, the types of services that are offered, and if these services are responsive to the local needs in the context of Rozzano.

1 Italy is the largest beneficiary under the RRF, approved for a €194.4 billion recovery plan (€71,780 billion in grants; €122,602 billion in loans).

2 The so-called "dote" (endowment) system has become the main way to deliver social and employment services in the Lombardy Region in the last quarter of century, based on a political approach strongly inclined towards quasi-markets (Sabatinelli and Villa, 2015).

As depicted in Figure 1, Rozzano's CFP, like all other digital facilitation centers, is responsible for a four-step process to provide and register training services: (1) intake, (2) provision of services, (3) registration of services, and (4) validation of services. As many in the community still perceive the CFP only as a school, to raise awareness of the CFP's additional digital training services, they have focused on the 'old-but-gold' method of a flyer — in particular, because they did not perceive digital campaigns to be as effective to reach citizens in need of digital skills training — and meeting at-risk populations where they are — e.g., organizing with the president of the senior citizens' center.

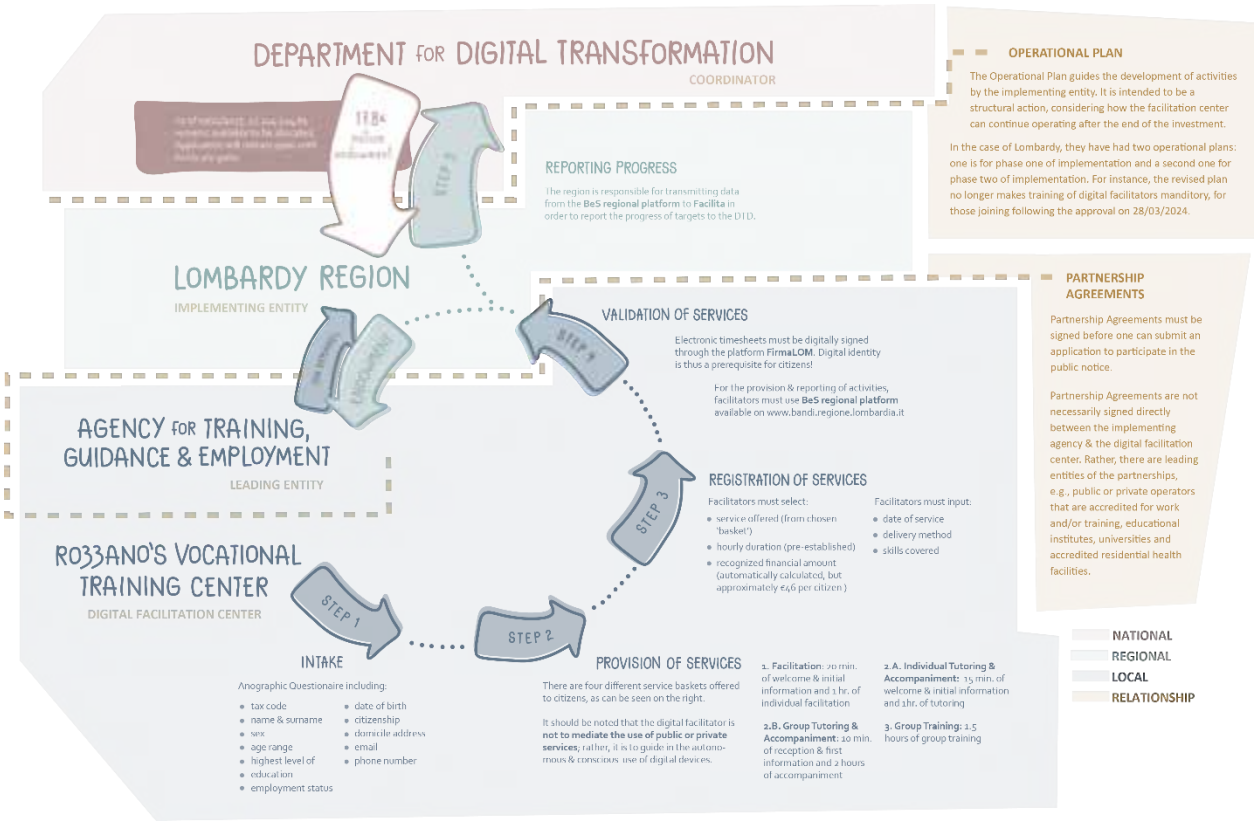


Figure 1. The registered digital facilitation process in Rozzano's CFP

Elaboration by Aubrey Toldi

According to the on-site facilitators, all citizens who have received a training service to date have reserved their voucher online, not via a 'walk-in'. This creates a paradox in which, to access the digital facilitation pathway, one must already possess basic digital competence. As elaborated on by one of the two on-site facilitators, P.T.: "Basically, to be recognized as someone in need of digital support, you already need to have some digital skills — which is kind of ironic. Meanwhile, we're thinking of people who are truly struggling with technology, who still use their smartphones mostly just for phone calls, if anything at all"[3]. Without minimal digital skills, the service is challenging (if not seemingly impossible) to access.

If citizens are able to register, they can choose one of the four offered service baskets. Within all four options, it should be noted that the facilitation services are not intended to mediate citizen's use of public or private welfare services, rather, the focus of this initiative is to guide the autonomous and conscious use of digital devices. Yet, mediation is the very assistance that many in Rozzano need. The principle on-site facilitator A.E. states: "Here's

3 Original quotation in Italian: "Cioè, in pratica, per essere riconosciuto da facilitare devi già avere delle competenze, in buona sostanza! Mentre noi ci immaginiamo le persone che hanno proprio difficoltà, che usano il telefono ancora come telefono o poco più."

a fairly significant issue right from the start, in my opinion: the people who receive—or are still receiving—digital support in the Lombardy region are required to already have a SPID[4] or an electronic ID card. And that's a first barrier that definitely acts as a filter, because while we can support them with a range of digital issues, we can't issue a SPID or an electronic ID card ourselves"[5]. The need for mediatory services in the community is echoed by the facilitator P.T.: "Unexpected needs emerged from the people who attended, such as small, practical issues related to using smartphones. Therefore, we dedicated the last session to an online grocery shopping app. But even that was somewhat limited by the fact that the topic had already been set: it was going to be about smartphone use. Sometimes we get our students' parents who come in because they need to send an email and don't know how. For example, they might need to request a document from their child's middle school, and they just hand us the phone saying, 'Can you write it for me?'"[6].

Without registration, the facilitators can still deliver training services, but these services cannot be registered within the monitoring system. A.E. notes that in practice this is a common occurrence, providing an example of one such instance: "We just completed a digital facilitation course with about twenty elderly participants, but we were only able to officially include four or five of them in the digital support program. The others couldn't be enrolled because they didn't have a SPID, or they couldn't remember the password for their electronic ID card, or they had the PIN and PUK but hadn't completed the full activation process for the card. So, unfortunately, we couldn't include them in the official project"[7]. Since the endowment is distributed by individual service registered, the leading entity (in this case, AFOL) will not receive compensation for these services provided. It should be noted, though, that even when compensation is received, the facilitators are not remunerated for their services, but rather, it has been given as an additional workload.

The service must be validated by the citizens who receive the training (i.e., digitally signing the electronic timesheet) through yet another platform — FirmaLom. A.E. details the challenges of this application: "We helped them download the app, which didn't work very well at first... It was the app for digital signatures. But again, there was the prerequisite of having either a SPID or an electronic ID card"[8]. While the operational plan details that exceptions can be made for certain populations lacking a digital ID, e.g., persons with disabilities or non-Italian citizens who cannot have a SPID, CIE or eIDAS identity, it appears that this alternative validation system may not have been well-communicated to those on-the-ground or perhaps is not applicable in the cases they mentioned.

While this program certainly opens up a space of (some) possibilities, the regional approach, in many ways, failed

4 The SPID (Public Digital Identity System) is Italy's official system for digital identity. It serves as a verified online identity, enabling both citizens and businesses to securely access a wide range of online services offered by public authorities and authorized private entities. These services include tax filings, health records, educational platforms, and more, all accessible through a single username and password. Without SPID, accessing these services would not be possible.

5 Original quotation in Italian: "Con una problematica secondo me abbastanza significativa alla partenza: che le persone che venivano, che vengono tuttora facilitate, per quanto riguarda la regione Lombardia, devono essere già in possesso di SPID o carta d'identità elettronica. E questa è una prima soglia che sicuramente fa da filtro, perché noi possiamo facilitarli su tutta una serie di problematiche digitali, ma non possiamo rilasciare lo SPID, così come non possiamo rilasciare la carta d'identità elettronica".

6 Original quotation in Italian: "Poi sì, ne sono venute fuori altre dalle persone che c'erano, altre piccole necessità legate all'utilizzo dello smartphone dalle persone che c'erano, quindi abbiamo fatto l'ultimo incontro su un'applicazione di spesa online… però anche qui un po' vincolato dal fatto che il tema si sapeva che fosse quello, che fosse l'utilizzo dello smartphone. A volte ci capita che ci arrivino dei genitori che devono mandare un'email e non sono in grado perché devono fare richiesta alla scuola media di qualche documento che hanno le medie e ti danno il telefono in mano dicendo 'me la scriva lei'".

7 Original quotation in Italian: "Tant'è che abbiamo appena fatto un percorso di facilitazione con una ventina di anziani di cui siamo riusciti a far rientrare nel progetto della facilitazione digitale solo 4-5 persone, perché non avevano lo SPID, perché non si ricordavano le password della carta d'identità elettronica, perché avevano il PIN e il PUK ma non avevano fatto tutto il processo di attivazione della carta d'identità, per cui non è stato possibile inserirli nel bando".

8 Original quotation in Italian: "Noi li abbiamo aiutati a scaricare l'app, che all'inizio non funzionava benissimo… Li abbiamo aiutati a scaricare l'app per poter firmare digitalmente, però c'era il prerequisito dello SPID o della carta di identità elettronica".

to provide the necessary conditions to meet the specific needs of the citizens of Rozzano. Additionally, despite being envisioned as a systematic response, this program does not structurally (or even economically) support the local actors in contact with the potential beneficiaries of the service; instead, facilitators often simply face an additional workload. And even more, in the PNRR frame it is not possible to account for all the training activities that were actually offered! As this program's funds come to an end later this year, this is a crucial time to reflect on more than simply "what" the technological outcomes of this project are and, instead, open the discussion towards "how" we can build from these outcomes to concretely counteract the social and digital vulnerabilities that came to the surface during its implementation. There is an opportunity to build from the invested resources, current momentum, and lessons learned to more intentionally ground the aim of 'digital inclusion' in the Rozzano context and allow for the construction of more coherent, continuous training paths for its residents.

3. Beyond Access: Redefining Inclusion as a Systemic, Relational, and Contextual Practice

The concept of inclusion must be redefined in relational and situated terms. Relational inclusion emphasizes that access is not only about infrastructure, but about the presence of supportive human relationships: mentors, teachers, educators, facilitators, neighbours, social and community workers. Situated inclusion recognizes that people's ability to engage with digital services is shaped by place: the neighbourhoods they live in, the institutions they encounter, the histories they carry. This approach challenges the prevailing assumption that digital transformation is a neutral, universally applicable process. Instead, it advocates for place-based inclusion, where local context becomes a resource rather than a barrier; participatory design, wherein services are co-created with communities rather than imposed upon them; and hybrid infrastructures, where both physical and digital spaces mutually support one another to foster belonging and agency.

True inclusion begins when users become co-authors of the systems they interact with.

To understand and implement this expansive vision of inclusion, especially applied to digitalization, an ecological framework (Caciagli et al., forthcoming) offers a particularly valuable perspective. This framework situates individuals within broader interconnected systems — social, environmental, institutional, and technological — emphasizing that inclusion must be understood not as an individual achievement but as a collective one (Capone, 2018). People are not isolated actors; their engagement with technology and their capacity to build interdependencies are shaped by diverse starting points, resources, and forms of engagement (Escobar, 2018). An ecological approach, therefore, recognizes the diversity of experiences within these systems.

In this context, digital inclusion is not a final goal but rather a means to a deeper form of participation — what we might refer to as inclusive, smart citizenship. This form of citizenship ensures that everyone, regardless of background or ability, can participate meaningfully in the social, political, and economic spheres of life.

3.1. The Rozzano Case Study: Building an Inclusive Ecosystem of Local Associations and Groups through Digital Services

The E-Welfare in the City project aims to explore how welfare access spaces could be designed in the context of digitalization to promote inclusion and active citizenship. In deciding where to ground the study and the pilot project, Rozzano was selected for several reasons.

Situated 9 km south of Milano and connected to the city center by tram line 15, Rozzano represents a space of profound contradictions. As an area in Milan's periphery, it shares proximity to the city's urban center, but its distinctive social, economic, and infrastructural characteristics set it apart. Rozzano's infrastructure reflects its history as an agricultural area first and later an industrial hub. Over time, the town's economy has transitioned from manufacturing to services, though this shift has been uneven. Socially, Rozzano reflects broader regional trends. The population is aging, with 22% of residents being over the age of 65, which aligns with metropolitan averages.

However, other indicators set the town apart in a more significant way. Rozzano is notably distinguished by its high concentration of public housing and socio-economic vulnerabilities. In the 1960s, Rozzano was chosen to

host a large public housing estate to serve a residential function that supported the attractiveness of industrialized Milan in comparison to less industrialized regions. As a result, approximately 30% of families now live in public housing, far surpassing Milan's 9% and making Rozzano unique within the Italian context (see Figure 2).

Figure 2. Map of the percentage of families residing in public housing (ERP)
Our Analysis and Visual Representation Based on the 2023 Istat Population Census Data. March 14, 2024
Elaboration by Carlotta Caciagli, Andrea Parma, and Paola Piscitelli

Additionally, the town ranks among the lowest in the Lombardy region in income, with an average annual income of €22,000, whereas the average annual income per household in Italy is approximately €30,000 - €32,000, according to the latest available data (2022-2023) from the Italian National Institute of Statistics (ISTAT) (see Figure 3). The town also has a disproportionately low percentage of university graduates, further reflecting its socio-economic challenges.

Unemployment is another pressing issue, with Rozzano having the highest unemployment rate in the southwest metropolitan area at 9.2%, compared to the regional average for Lombardy, including Milan and its metropolitan area, which typically ranges from 6-7% in recent years (ISTAT, 2022). Finally, Rozzano stands out for its younger demographic, with 19% of its population under the age of 19, a figure that exceeds the provincial average of around 15-16% (ISTAT, 2024).

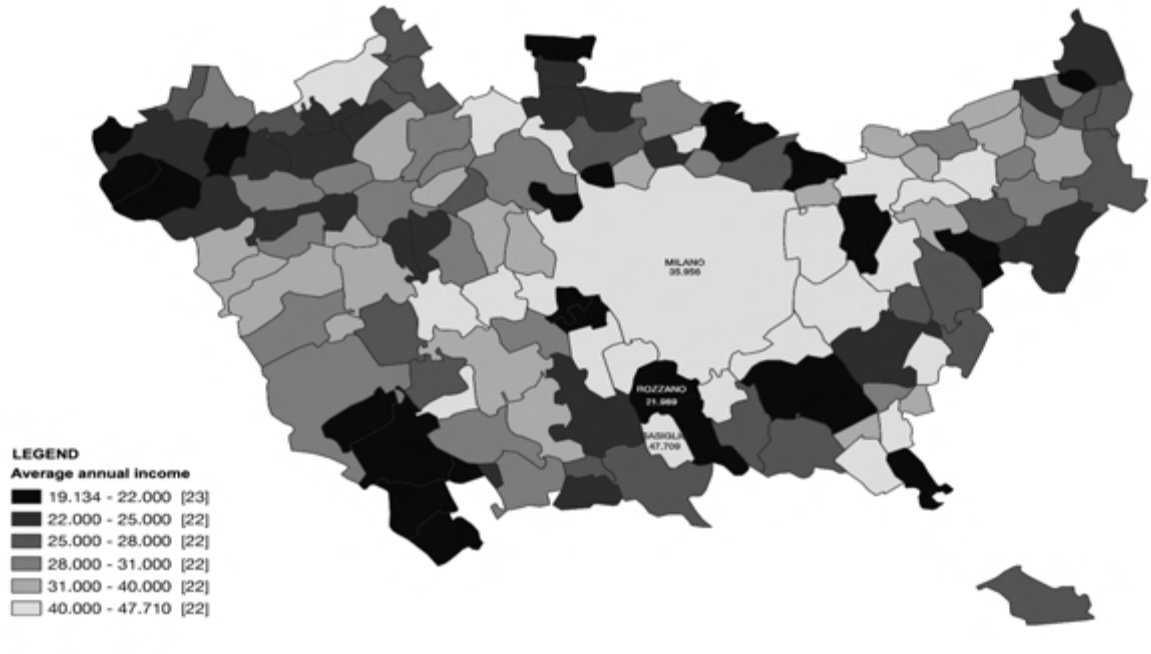
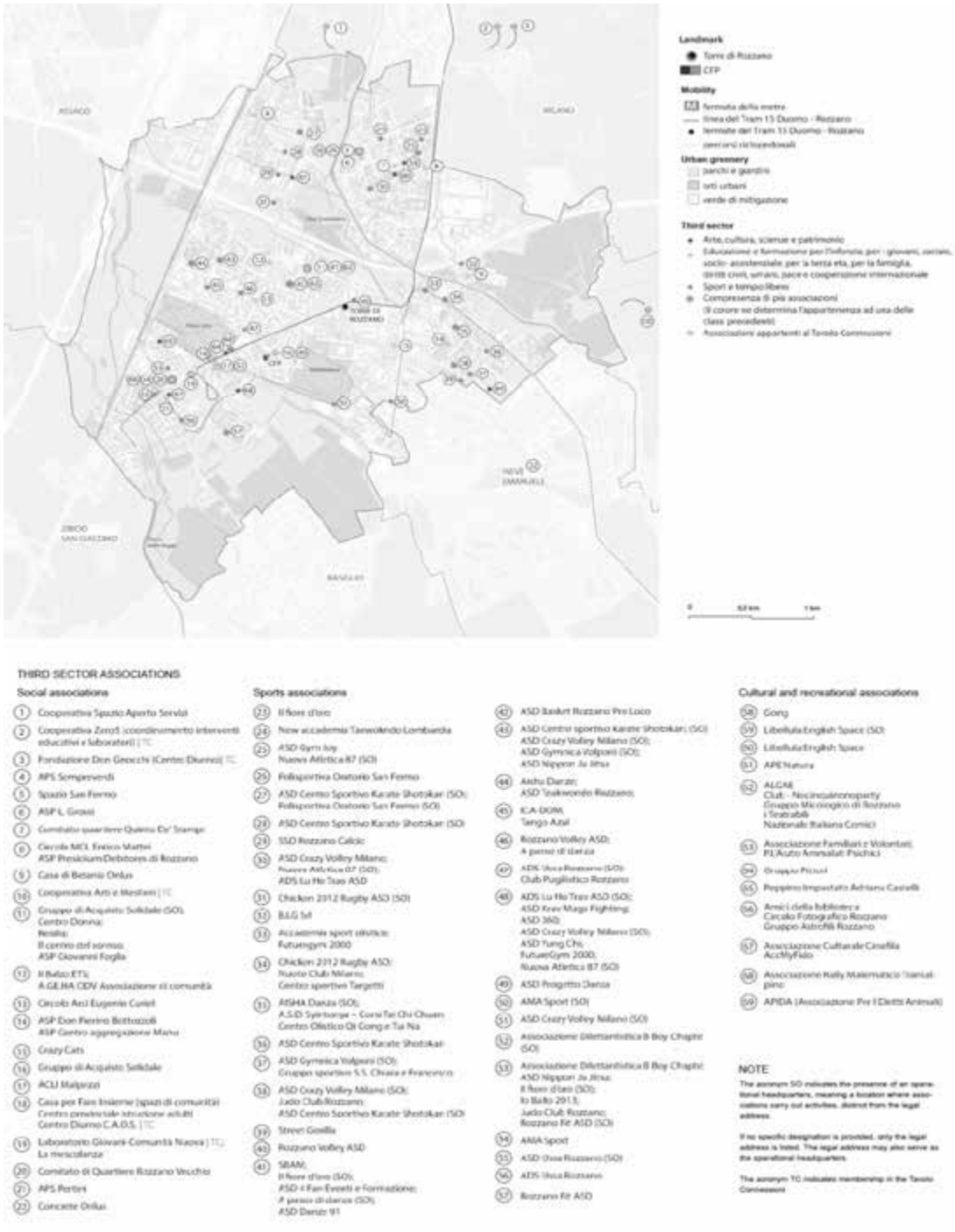


Figure 3. Map of the average income
Our Analysis and Visual Representation Based on the 2021 Istat Population Census Data. March 14, 2024
Elaboration by Carlotta Caciagli, Andrea Parma, and Paola Piscitelli

Indeed, Rozzano is often associated with issues of crime and social exclusion, common features in discussions of marginalized suburban areas. Recently, Rozzano has been included in a significant top-down national funding initiative called Decreto Caivano; it is the only municipality in the North of Italy included in the initiative which targets a few peripheral municipalities or neighborhoods that are considered — somewhat opaquely — to be highly problematic.

Yet, it holds potential as a site for innovation — particularly in the field of digital inclusion and welfare access — given the concentration of third sector organizations (see Figure 4). Rozzano's same socio-economic challenges, including a high proportion of youth who are neither in education nor employment (NEETs), make the town a critical area for social inclusion initiatives, particularly those focused on digital access to services. These initiatives aim to address vulnerabilities by fostering a more inclusive, digitally connected community.



THIRD SECTOR ASSOCIATIONS

Social associations

1. Cooperativa Spazio Aperto Servizi
2. Cooperativa Zero5 (coordinamento interventi educativi e lavoratori) [TC]
3. Fondazione Don Geocchi (Centro Diurno) [TC]
4. AFS Sempreverdi
5. Spazio San Fermo
6. ASP L. Grossi
7. Comitato quartiere Quinto Da' Stampi
8. Circolo MCL Enrico Mattei
ASP Presidium Debitores di Rozzano
9. Casa di Betania Onlus
10. Cooperativa Arti e Mestieri [TC]
11. Gruppo di Acquisto Solidale (GAS)
Centro Donna
Nesilia
Il centro del sorriso
ASP Giovanni Foglia
12. Il Bello ETS
A.GE.NA ODV Associazione di comunità
13. Circolo Arci Eugenio Curiel
14. ASP Don Pietro Bottazzoli
ASP Centro aggregazione Manu
15. Crazy Cats
16. Gruppo di Acquisto Solidale
17. ACLI Malpezzi
18. Casa per Fare Insieme (spazi di comunità)
Centro penitenziale istruzione adulti
Centro Diurno C.A.D.S. [TC]
19. Laboratorio Giovani Comunità Nuova [TC]
La mescolanza
20. Comitato di Quartiere Rozzano Vecchio
21. AFS Portes
22. Concrete Onlus

Sports associations

23. Il fiore d'oro
24. New accademia Taewokendo Lombardia
25. ASD Gym Joy
Nuova Atletica 87 (SO)
26. Polisportiva Oratorio San Fermo
27. ASD Centro Sportivo Karate Shotokan (SO);
Polisportiva Oratorio San Fermo (SO)
28. ASD Centro Sportivo Karate Shotokan (SO)
29. SSD Rozzano Calcio
30. ASD Crazy Volley Milano;
Nuova Atletica 87 (SO);
ADS Lu Ho Tzao ASD
31. Chicken 2312 Rugby ASD (SO)
32. B.E.G Srl
33. Accademia sport olistico;
Futuregym 2000
34. Chicken 2312 Rugby ASD;
Nuova Club Milano;
Centro sportivo Targetti
35. ATSHA Danza (SO);
A.S.D. Sylentorge – Corsi Tai Chi Chuan
Centro Olistico Qi Gong e Tui Na
36. ASD Centro Sportivo Karate Shotokan
37. ASD Gymnica Volpiani (SO);
Gruppo sportivo S.S. Chiara e Francesco
38. ASD Crazy Volley Milano (SO);
Judo Club Rozzano;
ASD Centro Sportivo Karate Shotokan (SO)
39. Street Gorilla
40. Rozzano Volley ASD
41. SBAM;
Il fiore d'oro (SO);
ASD 4 Fan Eventi e Formazione;
A' passo di danza (SO);
ASD Danze 91
42. ASD Basket Rozzano Pro Loco
43. ASD Centro sportivo Karate Shotokan; (SO)
ASD Crazy Volley Milano (SO);
ASD Gymnica Volpiani (SO);
ASD Nippon Ju Jitsu
44. Aichi Danze;
ASD Taekwondo Rozzano
45. K.A. DOM;
Tango Azul
46. Rozzano Volley ASD;
A passo di danza
47. ADK Unica Rozzano (SO);
Club Pugilistico Rozzano
48. ADS Lu Ho Tzao ASD (SO);
ASD Krav Maga Fighting;
ASD 360;
ASD Crazy Volley Milano (SO);
ASD Yung Chi;
FutureGym 2000;
Nuova Atletica 87 (SO)
49. ASD Progetto Danza
50. AMA Sport (SO)
51. ASD Crazy Volley Milano (SO)
52. Associazione Dilettantistica B Boy Chapter (SO)
53. Associazione Dilettantistica B Boy Chapter;
ASD Nippon Ju Jitsu;
Il fiore d'oro (SO);
Io Ballo 291.1;
Judo Club Rozzano;
Rozzano Fit ASD (SO)
54. AMA Sport
55. ASD Unica Rozzano (SO)
56. ADS Unica Rozzano
57. Rozzano Fit ASD

Cultural and recreational associations

58. Gong
59. Libellula English Space (SO)
60. Libellula English Space
61. APE Natura
62. ALGAE
Club - Noi(n)cuànnopoparty
Gruppo Micologico di Rozzano
i Tintirabili
Nazionale Italiana Comici
63. Associazione Familiari e Volontari;
P.I.Auto Amenalati Psichici
64. Gruppo Pittori
65. Peppino Impastato Adriano Castelli
66. Amici della Biblioteca
Circolo Fotografico Rozzano
Gruppo Astrofili Rozzano
67. Associazione Culturale Cinefilia
AcctlyFilo
68. Associazione Rally Matematico Transalpino
69. APIDA (Associazione Pro I Diritti Animali)

NOTE

The acronym SO indicates the presence of an operational headquarters, meaning a location where associations carry out activities, distinct from the legal address.

If no specific designation is provided, only the legal address is listed. The legal address may also serve as the operational headquarters.

The acronym TC indicates membership in the Tavolo Connessioni

Figure 4. Network of associations in Rozzano.
Elaboration by Carlotta Caciagli, Andrea Parma, and Paola Piscitelli

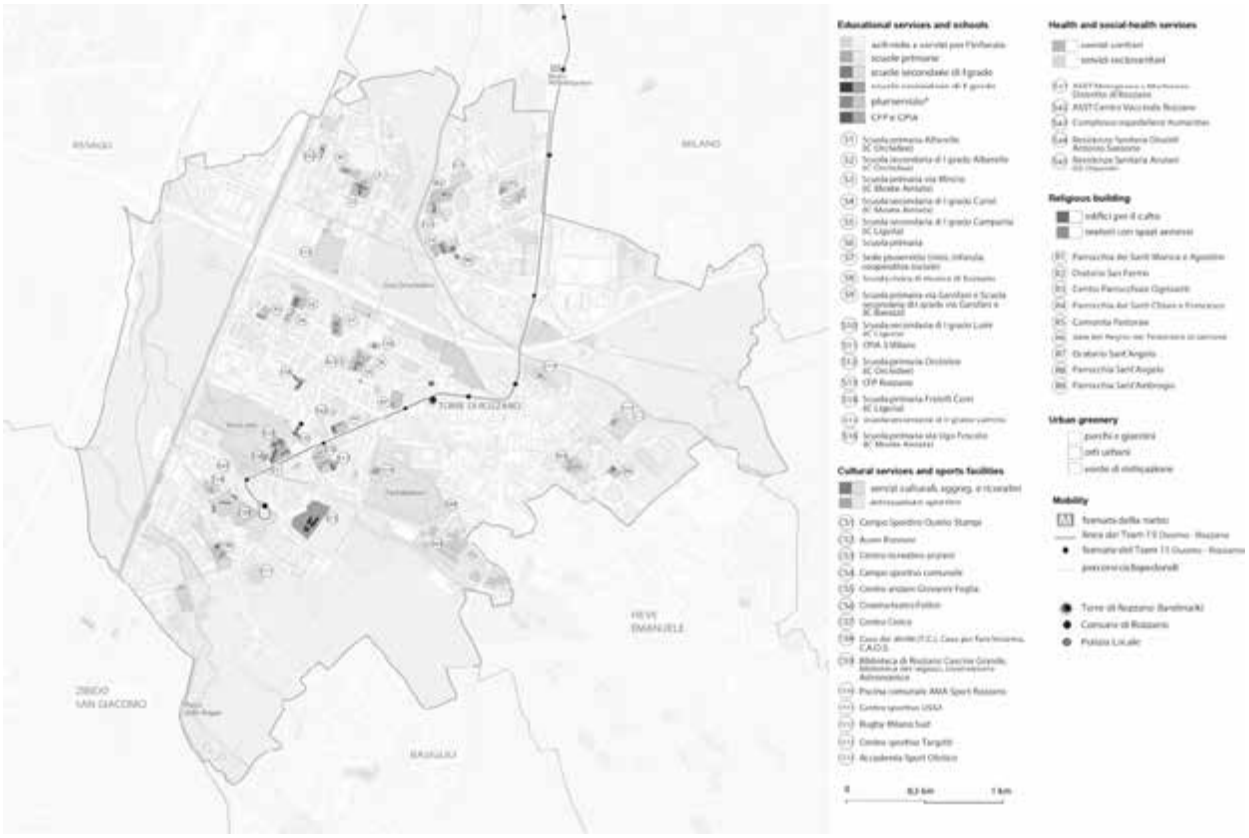


Figure 5. Maps of the context. System of service
Elaboration by Carla Baldissera, Federica Rotondo, and Paola Piscitelli

One of the most notable efforts in this regard is the Tavolo Connessioni, a network of local actors that focuses on preventing youth distress through collaboration and joint case management since 2016[9]. The Tavolo Connessioni network seeks to address the challenges faced by young people in Rozzano by developing continuous management models that integrate local authorities, schools, and social services. Regular meetings are held at the CFP, which plays a critical role in combating school dropout rates and social exclusion by offering personalized education and enrichment activities. Its integration into the Tavolo Connessioni network makes it a pivotal space for local youth.

For these reasons, the E-welfare in the City project began working closely with Rozzano's CFP, where a co-design process was initiated. The co-design approach aims at ensuring that the space and the service that will be created reflect the needs and aspirations of the local community, particularly in terms of their role in supporting vulnerable groups and promoting active digital citizenship. Selected as the approach by our diverse E-Welfare project team — which the project itself is a component of the PNRR — the co-design process brings together

9 The network was established through the Texère – Weaving Connections Together project, funded by Fondazione Cariplo and operating within the Visconteo District, a socio-economic and territorial area that encompasses eleven municipalities, including Rozzano. This district is an organizational and functional division of the broader territorial area (ASST), tasked with ensuring essential services such as foster care, child reception and inclusion, along with initiatives to address poverty. Since March 2019, the Visconteo Sud Milano District has been empowered to define and manage services and interventions specifically designed to combat poverty.

urban planners, sociologists, and designers from the Departments of Architecture and Urban Studies, as well as Design, at the Politecnico di Milano. For, this process is both multidisciplinary, reflecting the diverse composition of the team as well as the local institutions and community members reached out, and embedded, underscoring the importance of grounding design processes in the local context while leveraging existing resources and networks (Figure 5).

The goal of the co-design process is to ultimately realize a pilot project, Spazio Verso, envisioned as a hybrid environment dedicated to supporting access to digitized welfare services. Through the hybridization of physical and digital spaces — places where physical and digital services coexist to reduce the disintermediation brought about by the digitization process and to foster inclusion and participation — the project aims to enhance the community's resilience and foster a sense of belonging and empowerment.

3.2. The co-design of the *Spazio Verso* pilot project. A New Kind of Space Co-Created with Local Actors to Address Social and Digital Vulnerabilities

To effectively prepare for the co-design phase, a comprehensive preliminary analysis was conducted to map the territorial system, specifically visiting 6 key locations identified as important reference points for both young people and the elderly in the neighborhood. These locations included:

- the 'APS Pertini', a senior recreation center;
- the 'Cascina Grande' Library, the local library and a key cultural reference point in both the town and the surrounding area;
- the 'Casa dei Diritti', the headquarters of several local associations working on social cohesion;
- the 'Don Gnocchi-Vismara centre', a semi-residential facility hosting minors at risk of school dropout;
- the 'Laboratorio Giovani', a youth center in Rozzano, supported by Comunità Nuova[10] and operating in the area for 15 years; and
- the above-mentioned Rozzano's CFP (Centro di Formazione Professionale).

Linked to these spaces, we conducted 3 interviews with institutional actors from child and social services and facilitation programs, 3 interviews with local key actors, and 9 interviews with educators and coordinators of third sector bodies, mostly connected with the Tavolo Connessioni.

This preliminary phase highlighted the need to design a relational space that promotes digital citizenship — not just by providing access to digital tools and training, but through a broader, more inclusive approach that actively addresses the exclusionary dynamics amplified by digitalization. This requires a careful integration of service content, the role of digital tools, and the physical environment where these services are delivered.

The core idea solidified: to create a space where the approach to digital facilitation is both intergenerational and transgenerational, with young people involved as active agents, not just passive users, and where they can teach other residents, and in doing so, learn themselves. This was informed by the feedback of educators and social workers, who have stressed in different interviews the necessity of a more personalized and inclusive environment that addresses the specific needs of young people in the community.

Local stakeholders working with youth, in fact, have reported a significant shift in recent years. While an "open access" model once attracted large numbers of young people, post-COVID, it has become clear that more targeted and focused activities are now more effective. A peer-driven model has been identified as crucial in facilitating this change. As one educator from Laboratorio Giovani has noted, the goal should be more and more to create spaces where young people feel their individuality is acknowledged, and where they can choose to engage in workshops and activities aligned with their personal interests. This strategy helps establish spaces that pursue inclusion via being "exclusive", meaning that they aim at fostering a sense of belonging and ownership—critical factors for sustaining youth participation. Thus, the new service and space can be designed to respond to the

10 It was founded by a chaplain of the 'Cesare Beccaria' Juvenile Penal Institute and a group of volunteers.

latent needs of the (youth) community.

Many young people in Rozzano possess limited digital skills. While the majority own smartphones, they typically use them for entertainment or social media, with few using them for more productive purposes, such as searching for information or utilizing digital resources effectively. This highlights a clear need for educational programs that go beyond simple access to technology, and instead focus on enhancing digital literacy, fostering autonomy, and developing transversal skills. In this context, co-design can serve an essential tool for engaging young people in the creation of their own learning environments, transforming them from passive users into active co-creators of the new hybrid space imagined at the CFP, and digital facilitators for their families and the local residents, thus making the CFP a pilot hub for smart citizenship.

In efforts to achieve this, the following co-design program was structured around three primary stakeholder groups identified: Group 1, comprising professionals, educators, municipal representatives, and members of the Tavolo Connessioni network; Group 2, including students from the CFP and youth service participants; and Group 3, consisting of older residents and other potential users from the broader community. The aim was to engage these groups more deeply in understanding both the identified needs and the latent, often unrecognized ones, while exploring possible integrated solutions.

Each group participated in two thematic workshops (see Figure 6) — one focused on services and the other on the spatial environment — resulting in a total of six sessions.

Figure 6. Pictures from the 3 workshops with the TC, the youth and the elderly at the CFP.
Ph. by Matthew Spialtini and Claudia Mastrantoni

The workshops had three main objectives: 1) to define the goals of the co-design process in relation to both service provision and spatial design; 2) to develop and tailor co-design tools suited to the needs of the diverse participant groups; and 3) to structure the engagement strategy, ensuring effective dialogue between all stakeholders.

These objectives gave rise to two core thematic axes: the first, focusing on the service dimension, which encompasses the system of activities, functions, and interactions designed to address local needs and connect users with essential resources and tools; and the second, the spatial dimension, which concerns the physical environment where users engage with each other and with the digital and material components of the services.

However, from the outset, the co-design process emphasized the reciprocal relationship between these two dimensions, with the ultimate goal of creating a physical space that supports an integrated, community-driven e-welfare service. This led to a refined focus on integrating service and space, which helped define the key objectives more clearly:

- To pilot a hybrid space-service model that integrates physical infrastructure, digital tools, and support services to reduce digital exclusion, facilitate welfare access, and prevent early school leaving.
- To improve access to welfare services for the elderly through empowerment and tailored support, while also providing young people with opportunities to apply and develop their skills through hands-on involvement.
- To co-design a multigenerational hybrid hub where physical spaces, digital infrastructures, and capacity-building initiatives converge.
- To envision a model that could be replicated across Rozzano and potentially scaled regionally, anchored by the CFP (Centro di Formazione Professionale) and interconnected with other key communities.

Several critical insights emerged across all workshops, revealing both technological and social needs. Some participants expressed reluctance to assist others with digital tools due to a lack of self-confidence, while others highlighted the absence of a personal computer at home.

A common interest in digital repair, particularly among younger participants, emphasized the potential value of incorporating a hardware repair station into the proposed space.

In our efforts to understand what worked well in the recent municipal initiatives to provide digital facilitation desks for seniors — though unfortunately not on a continuous basis — we found that these desks were generally well-received in Rozzano. They were not only viewed as service points but also as spaces for digital empowerment. At the same time, some social concerns were raised, particularly the need for respectful treatment when seeking assistance, emphasizing the importance of relational dynamics in service design and of spaces enabling users to connect with others and learn to use digital tools in a supportive environment, thus highlighting the value of relational spaces in promoting digital inclusion.

These insights confirmed the validity of our previously discussed ecological approach to the digitalization of welfare, which prioritizes local knowledge, relationships, and resources and aims to design a responsive and adaptable space that addresses the specific needs of the Rozzano's community and evolves alongside their changes.

After the six workshops, a seventh session brought all three groups together for a plenary restitution event at the Cascina Grande Cultural Center, a prominent civic space in Rozzano, where the preliminary findings and the pilot project were presented to the wider local community (see Figure 7).

The Spazio Verso pilot project aims to be a flexible, inclusive, and relational space that responds to the challenges of digital transition in Rozzano. It is conceived as a model for integrating online and offline services, with the goal of promoting autonomy rather than simply addressing immediate needs. Therefore, it must be a flexible and accessible space. Various configurations produced through the workshops include dedicated areas for facilitation and training, spaces for both scheduled and drop-in support, secure storage (e.g., cabinets or lockers) for shared digital equipment, and accessible waiting areas and furniture to accommodate diverse user needs. These recommendations serve as the foundation for the development and co-creation of a physical and service infrastructure promoting inclusive access to e-welfare services in the coming phase of our research project.

Figure 7. Plenary session presenting the outcomes of the co-design process at Cascina Grande
Ph. by Paola Piscitelli

The ideal location for Spazio Verso naturally coincided with the CFP itself, as it played a central role in the process by hosting all the workshops. Additionally, it is a well-known and frequented space for young people and families, well integrated into the local network, and strategically located within the territory.

The CFP had already planned to relocate its main entrance, thus freeing up the current lateral entrance, which serves as a reception area near the administrative offices, just before the actual classrooms. This space, situated at the boundary between the interior and exterior, is particularly suited for alternative forms of access, beyond those of just teachers and students.

However, this shift raises important questions concerning the management of access, opening and closing procedures, and related logistical issues, emerged during the plenary final session, highlighting the need to collaboratively define key aspects of the project. Among the priorities identified were the establishment of a shared governance model for the newly envisioned space, guidelines for its access and use, a manifesto that reflects the project's core values and collective vision, and a shared activation calendar to coordinate the initial implementation of Spazio Verso. These objectives are essential for ensuring alignment among all involved stakeholders and facilitating a cohesive launch strategy.

The next phase of the project will focus on refining and addressing these elements, ensuring inclusive and participatory management. This will involve continuing to engage those who emerged as key stakeholders (such as educators from the CFP), the Municipality of Rozzano, local associations (e.g., Tavolo Connessioni), and residents, ensuring that all voices are considered in the development and operation of the space.

4. Conclusions

By involving individuals with limited digital skills in the design of their own learning content and environments, digital tools can play a multifaceted role: they become more than mere access points, acting as catalyst for fostering a sense of ownership and responsibility. Through this approach, youth are empowered to acquire skills and competencies they may not have previously envisioned, and such spaces can evolve into community hubs, that not only offer digital services but also provide opportunities for socialization, skill-building, and empowerment. In other words, they enable true inclusion.

This approach recognizes that the needs within a community are not uniform. Therefore, while the project proposal must consider how to structure services in complementary ways, it should also apply a model of "exclusive inclusiveness": targeting marginalized territories, populations, and groups by providing them with something exclusive and previously unimagined.

This paper challenges the idea that digital citizenship can be built only through programs that are (apparently) universal – or "one size fits all". Instead, by applying an ecological framework to inclusion, inclusion can be realized as a more multivalent notion, e.g., expanding to entail both relational and situated aspects. This situates inclusion in a network, rather than viewing it as something that can be accomplished through simply providing 'open access'. Co-designing a variety of spaces (or a network of spaces) geared towards addressing a specific community's interests and needs is collectively more inclusive than working towards broad notions of accessibility. In this sense, it can be argued that 'exclusivity' may actually be an unlikely ally to overcome the paradox of inclusion.

What we envision for Spazio Verso is a platform that complements and fills the gaps left by national and regional programs, such as the PNRR and the digital facilitation initiatives implemented locally. While these programs tend to be one-off interventions, Spazio Verso would allow people to come and go as needed, offering courses in multiple sessions that not only address specific issues but also promote empowerment. It may even tackle critical topics such as privacy awareness and other essential issues. While those programs may paradoxically require a digital identity for access, Spazio Verso offers a more accessible model, where individuals can simply walk in, ask questions, schedule appointments when necessary, explore ongoing activities, or even volunteer to contribute, not just seek help.

This is precisely because people and situations are diverse; the solution cannot be "one-size-fits-all". A one-time appointment is not enough for everyone. It can serve as a starting point, around which we can build in a complementary way, avoiding overlaps and gaps by beginning with a deep, specific understanding of the local context.

As progress continues to be made towards Spazio Verso, collaboration between researchers, local institutions, and the community remains on-going. The co-design process continues to focus on crafting ways to not only provide services co-designed by those who will use it, but also to create opportunities for social interaction and community building through developing digital competences.

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Track 8

EDUCATION AND SKILLS

Pedagogy for the future: Equipping students for complex and climate-relevant practice

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Abstract:
What do students need to know and be able to do to work effectively in the unfolding world of polarization, climate breakdown, and challenges to governance? This central question of core curricula has been at the heart of our work at the University of Northern British Columbia in our recent curriculum transformation. In this paper, we present the theories that guide the work, the learning context, barriers and opportunities in curriculum planning, and our reinvented planning studio curriculum. We will also present the outline of a specific climate action studio within the new structure that combines expected learning outcomes with community partnership and opportunities for relevant climate innovations.

Keywords: climate pedagogy; student learning outcomes; competency frameworks; planning studios

Introduction

What do students need to know and be able to do to work effectively in the unfolding world of polarization, climate breakdown, and challenges to governance? This central question of core curricula has been at the heart of our work at the University of Northern British Columbia in our recent curriculum transformation. In this paper, we present the theories that guide the work, the learning context, barriers and opportunities in curriculum planning, and our reinvented planning studio curriculum progression. We will also describe how we plan to combine 'required competencies' and learning innovation in the first iteration of a new course, the Local Climate Action Studio.

Our first curricular principle is that the future is not like the past. Climate breakdown is affecting communities worldwide, in a litany of fires, floods, droughts and plagues. We are also dealing with a new intensity of divisiveness fueled by profitability – where the information industry accumulates through fear, hatred and distrust. Students will need to be equipped to develop new approaches to a new future.

Our second curricular principle is that the knowledges of the past are vital. The identity of the profession, while contested, also roots us in a set of practices and knowledges that equip us to engage the future, and to avoid reproducing the wrongs of colonialization, scientism and dehumanization.

We introduce this future/past contrast to highlight the contrast between the predictable and programmatic part of planning knowledge, from the unpredictable and developmental. In this contrast, 'the past' is roughly defined as the areas of knowledge defined in standards. In planning education in Canada, we are responsible to our accrediting body, the Planning Standards Board, for the demonstration of specific 'competencies' across subject areas.[1] This is not a 'perfect' contrast, as methods of foresight, future and uncertainty are part of these knowledges. We have found it useful to balance the 'programmatic' with the opportunity for students to learn in ways we did not predict.

In the studio progression along with course work, we have attempted to 'program' such that students learn and are mentored in the planning knowledges 'of the past,' while co-creating the abilities that we expect will allow them to thrive in an uncertain future. We are guided by pedagogical theories that speak to both these cases. For those competencies that are rooted in known practices, we have tried to make better use of 'student learning outcomes' theory. We can articulate these skills, set standards, and attend to student work to measure learning. As we are certain that our students will need to have the capacity to critically and resourcefully develop new practices, we are guided by the theories that emphasise 'development capacity' – transformative learning, and experiential learning.

1 Planning Standards Board, University Accreditation, Competencies, are at this website:

As we report our experience with an ongoing process of curriculum change, we will also present our context, including our opportunities and challenges. Our ongoing effort to manage an institutional change process in a theory-relevant way is a story worth telling.

We have implemented a core progression in studio learning, emphasising experiential and community engaged learning. Our studios have responsibility for 'accreditation competencies,' but it is also important that these studios feature the elements of uncertainty, mentorship, and 'learning-to-learn' that are key to their development as future professionals.

Finally, we will offer some examples of student work and learning that offer examples of both programmatic and/or competency-based learning, as well as what we are seeing as examples of student development in uncertainty.

The learning context: Climate, hegemony through clickbait, and 'best practices'

It is important to work in relationship to the world in which we find ourselves. While the curriculum review and change process is relatively slow, the world changes quickly.

Situated where we are in northern Canada, the future is clearly not like the past. Climate breakdown is affecting communities worldwide. Around us, climate breakdown is taking place in fires, floods, droughts, heat events and diseases both human and ecological. Ecological change renders itself visible in the changes in the availability of country food, in the increases in some wildlife conflicts, and in the extent of recent burns. Many First Nations along the Fraser River have their annual salmon 'catch' brought in from another watershed. This year the forest mosses crunch underfoot in the spring, the sound of impending danger.

Seeking a policy solution to fit the wildfire moment, communities adopt "FireSafe" rules that seek to protect buildings from fire, but at the same time rule out having trees for shade or delight in urban centres. Air conditioners for cooling are now required in buildings that were not designed with a 'hot season' in mind.

Our community context also includes a new intensity of divisiveness, as we harness ourselves to divided digital universes. Divisiveness is not unusual in the world, but it is of recent origin in our small, rural communities. We were not, admittedly, skipping through fields of flowers, but we were fighting over things like land, water and minerals that we all agreed we wanted. Now, community members see each other through the stereotypical and minimizing kaleidoscopes of memes – most of which are not even produced with northerners in mind.

We can see that the new media of cultural hegemony are also profitable, and that the product of this twin motive of profit and control through division is creating a culture that is unready and opposed to the promise of 'public deliberation' and 'give and take' that practical governance needs.

This is the scene that new planners will enter and within which we expect them to pursue justified and deliberated public actions and encourage comprehension and compliance with policies and plans.

Students will need to be equipped to develop new approaches to a new future.

It all seems new, but the knowledges of the past are vital. The identity of the profession, while contested, also roots us in a set of practices and knowledges that equip us to engage the future, and to avoid reproducing the wrongs of colonialization, scientism and dehumanization.

There is a contrast between the predictable and programmatic part of planning knowledge and the new, less predictable and developmental. For the purpose of this contrast, 'the past' is roughly defined as the areas of knowledge defined in standards. In planning education in Canada, we are responsible to our accrediting body

(Planning Standards Board) for the demonstration of specific 'competencies' across subject areas. This is not a 'perfect' contrast, as methods of foresight, future and uncertainty are part of these knowledges. We have found it useful to balance the 'programmatic' with the opportunity for students to learn in ways we did not predict.

Theories and frameworks of curriculum assessment and design in Planning:
There are various representations of the consensus on the set of skills and abilities that professional planners require. These change slowly over time (Anacker 2024). At the present time, the Planning Standards Board accredits Canadian Schools of Planning in part (how) they relate to a set of Planning competencies. These competencies include both 'functional' and 'enabling' competencies. Functional competencies are planning-specific knowledges and practices, while enabling competencies are communicative and relational. The Association of European Schools of Planning stewards a Core Curriculum (AESOP 2024). It is organised to specifically distinguish between knowledge and 'competency,' as the ability to bring knowledge and skill to bear on a situation. In Canada, these distinctions are not currently part of the accreditation vocabulary.

Different schools, different faculty members, and different accreditation teams may view these competencies differently; the 'standards of achievement' are set in this process.

Roughly, the identification of competencies that students are required to learn over the course of an accreditation program is broadly compatible with student learning outcomes theory.

In 'student learning outcomes theory,' a student-orientation in curriculum design and implementation uses 'what students learn' as the measure that should inform the design of assignments, curricular progression, and the assessment of program success. In this theory, the evidence of learning is demonstrated in student work, in what students know and are able to do.

Table 1: Teacher-Centred and Learner Centred Paradigms

Teaching Centred Paradigm	Learner Centred Paradigm
Knowledge is transmitted from professor to students	Students construct knowledge through gathering and synthesising information and integrating it with general skills of inquiry, communication, critical thinking, problem solving and so on.
Students passively receive information	Students are actively involved.
Knowledge can be demonstrated by performance on tests	Knowledge cannot be demonstrated outside its context of application – students must know how to use information in real life contexts
Assessment is used to monitor learning	Assessment is used to promote and diagnose learning
Desired learning is assessed indirectly through performance on objectively scored tests.	Desired learning is assessed directly through papers, projects, presentations and other products like those that they will be expected to produce in the future.
Culture is competitive and individualistic	Culture is cooperative, collaborative and supportive.
Not everyone can pass the test; faculty role is to distinguish between those that can and those that cannot pass.	Everyone ought to be able to learn to use knowledge effectively in a context; some may take more time to do so.

(Huba and Freed 2000)

In the context of a single course, student learning outcomes assessment is the measurement and evaluation of student learning against clearly articulated goals. To assess student learning, faculty must engage in a process of making desired learning outcomes explicit, assessing coursework and student experiences for learning opportunities, feedback and performance, and establishing measurements and assessments of learning outcomes within the course.

The emphasis on the articulation and measurement of learning outcomes is intended to support both faculty and students in identifying and building the knowledge and skills in an explicit and measurable way. In its emphasis on identifying 'differences that make a difference,' the emphasis is on ensuring that students have internalised new concepts into a new constructed framework sufficient to apply them in action.

Ideally, student learning outcomes assessment is linked to the social construction of knowledge through the participation of the students in internalising, conceptualising, and synthesising their new knowledge in work. Bloom's taxonomy of knowledge provides a framework for the sequencing of cognitive knowledge within a class, and across a curriculum. It is a practical and sequential interpretation of how learners construct and adopt and gain competency in new knowledges and practices across cognitive, affective and 'motor' domains (Wellington 2006).

The risk of fully implementing the measurement of student learning outcome theory is the tendency to reduce student learning to the more easily observed elements. It is easier to assess the structure of a paragraph than to assess how well the learner was able to listen and charitably interpret different stakeholder interests.

An increasing demand for measurability and predictability in the classroom leads to a reduced agency for the learner, shifts the content towards the mechanistic or programmatic, and changes the content – reduces – the concept of learning to reproduction of a prescribed action.

On its own, a focus on student learning outcomes assessment can lead to mechanism in teaching and learning – an industrial model of skills learning without reflection. That is, the more clearly an 'action' or 'work product' is defined by the instructor, the less room there is for an individual learner to create new solutions, and the less personal and individualized the 'learning' can be.

More than that - While student learning outcomes theory is a practical pedagogy for novice practice learning, the world demands creativity, resourcefulness, and learners that are capable of things that have not yet been demonstrated. So, while the 'right method' or 'right answer' culture is widespread and many learners require this for a feeling of safety, planners of the future will require the ability to develop, test, critique, and implement new solutions.

If we lived in a world where the solutions and right actions were known, then clearly defining and expressing the right action that each learner should 'do' might be sufficient if mechanistic. While 'demonstrates creativity' could be a student learning outcome, the demand for 'clarity in expectation' is in tension with the need for discovery, novelty and new solutions.

At the program level, conceptually the learning outcomes to be measured are the learnings from a whole set of experiences, demonstrated in capstone or senior level assignments. In fact, student work itself at this level is complex – typically comprising sets of values, skills, knowledges and limitations into products – presentations, reports, recommendations. From a 'whole curriculum' perspective, there is the risk that learning outcomes theory could be implemented in such a way as to amplify the 'reductionism and depersonalisation' problem. On the other hand, the ambition of this project renders it a low risk for us.

In our work, we conceptualize our learners as unique. To the extent that we are trying to assess competencies and qualities that will be expressed uniquely. We are building a smaller set of 'program learning outcomes' that can be mapped against a smaller set of senior-level work products. This measurement will continue to be rough.

For our external audiences of accreditation and program quality, we are developing evidence of learning including examples of student work, employer reports of students' readiness and competence, and student reports of their improved competence and/or confidence in specific skills.

In planning in Canada, we have never gone very far down the path of fully implementing the shift from faculty-oriented curriculum design and assessment (what topics do faculty cover) to student learning oriented curriculum design and assessment (what skills, abilities, knowledges and values do students incorporate in their work?). In the United States, planning schools and the Planning Accreditation Board have been active in this area since 2011 (Clapp and Johnson 2011). Planning schools have shared their work on program learning outcomes and their assessment on the Planning Accreditation Board website (PlanningAccreditationBoardWebsite).

Accordingly, for the most part, the practices of programs, individual faculty and accreditation teams continue to practically emphasise 'what faculty do' over 'what students learn.' The identification and assessment of competencies in the process of program assessment is not necessarily or even typically undertaken in conformance with student learning outcomes theory. For the most part, there has not practically been a shift from 'content' to 'coverage' when it comes to program design and assessment. On the whole, the theoretical push to move from a teacher-centred perspective to a learner-centred perspective has been met by the inertia of institutional practice and measurement capacity. In both of the planning programs where I have been involved in this effort, we adopted a dialogic solution

Curriculum assessment and change: opportunities and challenges
At the University of Northern British Columbia, we undertook – are still in the process of undertaking – an assessment, restructuring and implementation of the core curriculum in the planning program. We had inherited a curriculum and culture where community engaged and experiential learning were valued by faculty but were not well resourced. While efforts to gain appropriate investments in capacity had not borne fruit, we were able to bring about an investment in a 'studio classroom.'

We are situated in the north of British Columbia and of Canada, and our program(s) respond to the context of the economic resource periphery, small cities, vast rural areas, and a complex geography of unceded First Nations, diverse indigenous cultural and language relationships and traditional territories. Our programs are uniquely suited to that context: community planning with a northern emphasis, First Nations Planning, and environmental planning with an emphasis on the policy, resource and ecological relationships of places.

Our curriculum must respond to a framework of competencies that comprise the requirements for an accredited program in planning. As well, our program is undergraduate, so the basic components of a university education must also be present for student development – including critical thinking, communication and literacy, numeracy and the breadth of experience that allows for the development of personal and social perspectives. At the same time, given our location, we have a relatively high proportion of non-traditional students, first generation students, and we find that our new generations of students require the relevance of application.

In a strategic planning exercise at the School level, we decided to invest in an experiential and community engaged studio curriculum, where students would have at least one full studio experience in their last two years(Botchwey and Umemoto 2020; Long 2012). This choice is consistent with the regional context of the School, consistent with the aspirations of the students to be doing real work with real people, and is allowing us to more fully develop the community engagement that faculty and students were doing with more appropriate resources of space and time.

Through our competency mapping undertaken in 2021, we had identified some accreditation competencies that were important in our context and focus where student learning needed to be improved. At that time, we used student focus groups, discussions with employers, and competency mapping by faculty to identify some areas for improvement. In particular, we wanted to augment students learning of the financial and economic context of spatial planning, improve their basic design skills such as iteration and critique, and the incorporation of system factors at diverse scales. Incorporating feedback from earlier accreditation teams as well as our own thinking as relatively new faculty, we wanted to strengthen the program in the areas of decolonization and indigenous rights and title. As relatively new faculty, we also wanted to build our own understanding of the progress

and pacing of student skill-building and assessments through the program.

Involvement in this higher-level curriculum development is reliant on the willingness to collaborate. We are fortunate that so many of our faculty are committed to building their own courses and assessments in relation to those of other faculty members.

Desk-ready planners and the temptations of critical dialogical practice

In the studio progression along with course work, we have attempted to 'program' such that students learn and are mentored in the planning knowledges 'of the past,' while co-creating the abilities that we expect will allow them to thrive in an uncertain future. We are guided by pedagogical theories that speak to both these cases. For those competencies that are rooted in known practices, we have tried to make better use of 'student learning outcomes' theory. We can articulate these skills, set standards, and attend to student work to measure learning. As we are certain that our students will need to have the capacity to critically and resourcefully develop new practices, we are guided by the theories that emphasise 'development capacity' – transformative learning, and experiential learning.

We have implemented a core progression in studio learning, emphasising experiential and community engaged learning. Our studios have responsibility for 'accreditation competencies,' but it is also important that these studios feature the elements of uncertainty, mentorship, and 'learning-to-learn' that are key to their development as future professionals.

In the initial development of the 'studio core progression,' and choices about how we would create titles and conceptual programs for the new progression, we were influenced by:

- The programmatic and conceptual needs of the different majors in our program;
- Input from regional governments about their capacity to engage with studios; and
- Faculty capacity.

Studios that are ideally taken in the third year include:

- Community engagement and inclusion studio – from listening, to facilitation, to process design and engagement messaging;
- Land use and development studio – at the site-to-neighourhood scale, analyzing need, supply, and policy, and developing feasible proposals (volume, density, floor area) within a neighbourhood context

Students may choose from three studios in their last year – depending on their interests, program area, and pace of study. One is a site scale studio in sustainable and inclusive design, one is a relational landscape studio in indigenous planning, and the other is a studio in local climate action.

Local Climate Action Studio 2026: An Example

The Local Climate Action Studio is intended to engage students in the application and synthesis of climate action planning competencies from across the curriculum as well as learning in the class. While others have developed 'climate competencies' intended to inform 'climate education,'[2] through the development of this studio, we will also explore and develop competencies for resilient communities taking climate action.

From an accreditation competencies perspective, we envision this studio as consistently including functional competencies in 'information gathering and analysis,' and 'planning regulatory tools such as the Official Community Plan,' with adaptation and resilience to climate change as a social and environmental issue. As in all of the studios, there are a range of 'enabling competencies' required; the focus in this studio is the development of

2 See Climate Action Competency Framework, for 'business and social purposes,' available at Royal Roads University. https://macal.royalroads.ca/introducing-the-climate-adaptation-competency-framework/

policy fluency, from analysis to recommendation.

Part of the vision and structure for this studio was developed out of an experimental version of the course delivered in Winter 2024. A very strong partnership with a local government including staff and a local elected official created an enriching policy learning opportunity. Students hosted virtual and in-person community engagements in the rural area, completed a policy analysis, and prepared draft policy statements. Students presented their policy work to the local government, and elements of their engagement results and recommendations influenced the Official Community Plan adopted for that area.

The present project is uniquely focused on identifying and mobilizing competencies for climate action(Infield, Seasons, and Lyles 2025), but we also expect the work to produce policy actions, specifically in the Official Community Plan.

Resilience thinking has evolved dramatically - permeating the field of planning. As the unfolding response to devastating wildfires demonstrates, it is no longer tenable for communities to 'bounce back' to a previous state following a climate shock. Planners and other professionals must be able to collaborate from local to national scales to help communities 'bounce forward'. This need to promote system transformability –is widely accepted in theory and increasingly in practice. Less clear is what professional competencies are required to succeed in this work.

Across local governments in northern BC, financial and human capacity is typically scarce. As a result, planners and local government professionals in the north must find creative ways to harness existing local government and/or community functions (e.g., policy tools) to promote resilience building (refs). Promising pathways for this work include the mainstreaming of climate policy and the construction of policy that promotes climate co-benefits (ref).

Most recently, in the Robson Valley the Village of Valemount lobbied senior governments for financial assistance to offset tourism revenues lost to the Jasper wildfire (Labbe, 2025). Set within this context, the UNBC School of Planning and Sustainability and the Regional District of Fraser Fort George (RDFFG) are partnering to advance local climate action through a project that will achieve two objectives:

The project team members listed above will meet for two half day working sessions to co-design the local climate action course.

Dr. Groulx will host virtual conversations with northern professionals leading climate action work in the fields of planning, public health, and natural resource management. These conversations will identify the competencies that future climate action professionals need to promote effective system transformation.

This project focuses on land use policy and community engagement as interrelated leverage areas for identifying and mobilizing competencies that will be required by effective future climate professionals. As the NRESi mission states, it is "together with the community and partners [that we] have the ability through expertise and experience to address and look for solutions" (NRESi 2020, p. 3). Consistent with this mission, as part of this project students will partner with Regional District staff and take part as active participants in the Official Community Plan update for the rural area. Students will prepare a regional climate trend and impacts report, design and implement community climate engagements, run a vulnerability assessment workshop, and take part in a two-day intensive climate resilience policy writing workshop.

Activities in 2026 include climate trend and impacts research, community engagements, a climate vulnerability workshop, and a climate resilience policy writing workshop (hosted in McBride and Valemount). Activities in 2025 prepare for this work.

In developing analytical competency, students will work with PCIC's Plan2Adapt tool and academic and grey literature to produce a report on regional climate trends and impacts.

Building on engagement competencies from an earlier studio, students will design and deliver a series of engagements and workshops that support climate resilience policy development. Students will also host and report on a series of virtual climate engagements designed to document how communities are experience climate impacts across the region.

Students will run a full day vulnerability assessment workshop with local experts. The workshop will be designed based on protocols from ICLEI Canada's Building Adaptive and Resilient Communities (BARC) framework. The BARC framework is designed for use with local government and its tools and processes can be scaled for use in communities of different sizes.

Students will take part in a two-day intensive policy writing workshop designed and ran with input and guidance from local government staff and climate policy experts. Policy development will draw on findings from the vulnerability assessment, as well as knowledge gathered through other course milestones.

Conclusions:
We do our best to equip our students with the adaptability, resilience and system-thinking skills that they will need to be planners in an uncertain world of climate breakdown and political tensions. One of these skills is innovation, another is the creativity of drawing new connections in a new circumstance.

As we work at the program level and at the course level with both the Planning Standards Board competency framework and our overall program learning outcomes, we continue to see the tension between the standardised imagination where all students acquire the same skill set, and the surprise and delight of intense individual and peer development that we see the students experience in studio learning.

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Research-Driven Pedagogy: Advancing Transformative Skills in Spatial Justice and Urban Sustainability through Educational Innovation. Insights from the REPLACE Project

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Abstract
This paper presents a transformative educational initiative developed within the REPLACE project, which integrates university research with civic engagement. Focusing on a pilot workshop conducted in a primary school, the study analyses the design and implementation of The REPLACE Game, a board game that introduces children to spatial justice, sustainability, and cohesion policy through experiential learning. Co-created with university students, the game fosters critical thinking, ethical awareness, and teamwork in young learners while promoting public engagement and pedagogical innovation. The paper outlines the design process, pedagogical goals, and learning outcomes, and discusses further developments in higher education as well. The experiece illustrates how schools can become laboratories of democracy, translating abstract policy concepts into accessible, action-based learning experiences.

Keywords: Spatial Justice, Transformative Learning, Research-Driven Pedagogy, Civic Engagement, Research extension

Introduction

In recent years, universities have increasingly embraced the so-called Third Mission or Research Extension expanding their role beyond teaching and research to include civic engagement, knowledge dissemination, and collaborative innovation. The REPLACE project[1] exemplifies this paradigm by integrating educational innovation with public-oriented research on spatial justice and sustainable development. Within its broader Dissemination and Communication strategy, REPLACE translates complex policy frameworks, such as territorial cohesion and spatial equity, into accessible and engaging formats. This paper focuses on one of its most compelling pilot initiatives: a pedagogical workshop co-developed with the International European School "Altiero Spinelli" in Turin at primary level, centered around a custom-designed board game titled The REPLACE Game.

The article is organized into six chapters. Chapter 1 situates the REPLACE project within the framework of the Third Mission and transformative pedagogy. Chapter 2 introduces the conceptual foundations and rule system of the game. Chapter 3 outlines the implementation strategy of the workshop. Chapter 4 analyzes the educational objectives and observed learning outcomes, while Chapter 5 reflects on the experiential and transformative dimensions of the initiative. Finally, Chapter 6 presents the future developments of the project, particularly its forthcoming expansion into secondary education through the VIBES initiative. By exploring this case study, the article proposes a replicable model of research-driven pedagogy that empowers young learners through experiential, civic-oriented education. It argues that such initiatives are not peripheral but central to the university's evolving public mission and to the cultivation of active, critical, and socially engaged citizenship.

1. From Research to Civic Impact: Educational Innovation in the REPLACE Project

In recent years, universities have increasingly embraced an expanded vision of their societal role, one that transcends the traditional binary of teaching and research. This broader mandate, often described as the Third Mission of the University, encompasses a set of activities that connect academic institutions to wider society through civic engagement, public dissemination of knowledge, and collaborative innovation (Zomer & Benneworth, 2011; Perkmann et al., 2013). Within this framework, new spaces of interaction between academia and civil society have emerged, particularly in domains where research has direct implications for pressing societal challenges such as inequality, urban development, and sustainability. One area where this convergence is espe-

1 The project has been developed within the Department of Architecture and Urban Studies (DAStU) of the Politecnico di Milano and funded by NextGenerationEU and the Italian Ministry of University and Research. It has been coordinated by Sarah Isabella Chiodi, assistant professor at DAStU, Polimi. The activities of extension of the research have been managed by a research group made up of the coordinator, Dr. Lorenzo Liguoro and three Polimi's students: Antonio Perrone, Jana Ondrejkovicova and Teresa Kucich.

cially evident is in the field of spatial and territorial justice, where universities are uniquely positioned to act as mediators between scientific knowledge and public understanding.

The REPLACE project embodies this approach, overcoming the traditional missions of research. While its core research objective is to promote integrated territorial development by bridging regional planning and EU structural funds, the project has consistently operated under the principle that knowledge production must be matched by knowledge dissemination. In other words, the research not only aims to influence policy and planning practices but also to foster awareness and dialogue among diverse segments of the population, including youth and local communities. To this end, the project has developed a Dissemination and Communication strategy, which has been embodied into a dedicated Work Package of the REPLACE project (WP.B): it places significant emphasis on educational outreach, targeting both academic and non-academic audiences. The WP.B has become a cornerstone of the project, encompassing a wide array of initiatives which range from academic publications and international seminars to innovative outreach tools aimed at younger audiences, such as interactive workshops, visual storytelling, seminars in Brazil, and participatory games. Through these activities, the project promotes critical thinking about the socio-spatial dynamics of urban environments, helping to instill foundational knowledge of planning principles and European policy frameworks among new generations.

Among the most innovative dimensions of WP.B is its collaboration with the school, which has served as a platform for translating abstract research themes, such as cohesion policy, spatial inequality, and participatory planning, into accessible and engaging formats for students at various educational levels. This collaboration is aligned with a growing body of literature emphasizing the importance of partnerships between universities and schools as a fundamental expression of the Third Mission (Benneworth et al., 2016; Facer & Enright, 2016). Such alliances are not only vehicles for civic engagement but also catalyze transformative learning experiences that benefit both students and researchers. Schools gain access to contemporary knowledge and new pedagogical tools, while universities are challenged to render their work intelligible and meaningful to broader publics.

The partnership between REPLACE and the Scuola Internazionale Europea Statale Altiero Spinelli in Turin, the only public institution in Italy offering a complete European curriculum from elementary to high school, represents a flagship initiative in this regard. The unique nature of this public European school, which is characterized by a multicultural and international environment[2], provided fertile ground for engaging students with themes of socio-spatial justice and sustainable urban development. This collaboration aims to represent a pilot porject in educational innovation and civic engagement, with specific emphasis on introducing concepts of spatial justice to younger generations.

The activities undertaken with the Spinelli School form the focal point of this article. It will concentrate specifically on the laboratory held in the primary school and the interactive board game created for that occasion. The forthcoming activities with the high school division, which are currently in the design phase and scheduled for implementation in 2025, will also be briefly discussed as part of the project's forward-looking trajectory.

The elementary school initiative was conceptualized as an immersive educational experience built around a workshop and an interactive game titled "the REPLACE Game", co-designed by the research team and a group of bachelor students from the Politecnico di Milano through a structured internal internship. The rationale for engaging such a young audience stemmed from the conviction that spatial justice, despite its complexity, could

2 Families are often multicultural and made by parents both from different countries and multilingual. The School "A. Spinelli" was born as an educational project aimed at Italian and foreign students, formulated in the main European languages: French, English, Spanish, German, in addition to Italian of course. The Istituzione Torinese per una Educazione Responsabile (ITER) has promoted and signed with the School "A. Spinelli", the European Nursery School and the Madr&lingua Association, the Educational Pact for the implementation of the "Language Project", to develop the multilingual competence of all students in a multilingual environment. The Project therefore aims to promote cultural integration through the daily exchange of experiences between students and teachers of different nationalities, in a relationship of dialogue and reciprocity, enhancing multicultural cognitive skills.

be meaningfully introduced through experiential learning. The workshop aimed to familiarize children aged 8 to 10 with ideas such as equity, spatial distribution, and urban form, using language, tools, and activities tailored to their developmental stage. The Game employed role-playing, strategic thinking, and creative problem-solving to simulate urban scenarios in which participants had to balance environmental constraints, social needs, and budgetary limitations: a miniature, age-appropriate metaphor for real-world planning challenges.

A key component of the initiative was the involvement of undergraduate students through an internship program activated within the Department of Architecture and Urban Studies. The **internship**, advertised through a departmental call, offered students the opportunity to contribute directly to the "Impact of Research" component of the project. Participants were tasked with co-designing and conducting educational laboratories in schools located in Italy. The activities spanned a variety of functions: from simplifying complex research findings into school-appropriate narratives, to coordinating hands-on learning experiences, and even participating in the drafting of dissemination materials and articles. Importantly, the internship was formally recognized with academic credits, contributing to the students' graduation requirements and underscoring the pedagogical value of their involvement.

Within the context of the Spinelli elementary school, the interns played a pivotal role. Not only did they assist in classroom activities and support the facilitation of the workshop, but they were also actively involved in the co-creation of the REPLACE Game. Working side by side with the research team, the students contributed to the conceptual design, created the visual content for the game cards (e.g., user profiles, urban functions, infrastructure types), and helped define the operational rules that govern the dynamics of gameplay. This collaborative design process not only enhanced the quality and accessibility of the game but also provided the interns with a real-world application of their academic knowledge, while fostering their skills in communication, team coordination, and design thinking.

As outlined in the internship description, the objectives of the program included educating and engaging younger audiences on EU cohesion policy and spatial inequalities, promoting socio-spatial justice, and developing the interns' own competencies in scientific communication and public engagement. The initiative served a dual purpose: it enriched the pedagogical content delivered to schoolchildren and, at the same time, empowered university students to act as agents of knowledge transfer. In doing so, it created a virtuous cycle in which research, teaching, and civic responsibility reinforce one another.

By focusing on the Spinelli collaboration, and particularly on the elementary school workshop and game, this article sheds light on a replicable model of **research-driven pedagogy**. It proposes that such models are not peripheral but essential to the university's evolving public role. Moreover, they offer an opportunity to reimagine education as a collaborative, multi-level process in which learning flows not only from academia to society but also, in reverse, where researchers, educators, and students co-create knowledge that is responsive to the needs and realities of local communities.

In the chapters that follow, we will provide a detailed account of the Game and its pedagogical framework, including its design process, learning objectives, and classroom outcomes. We will also contextualize these activities within broader educational theories and discuss the potential for scaling such initiatives across different age groups and institutional contexts. Through this exploration, the paper aims to contribute to the discourse on the Third Mission by offering a grounded, practice-based reflection on how universities can meaningfully engage with society to advance spatial justice and sustainable urban futures.

2. Designing the REPLACE Game: Concepts, Mechanics, and Educational Aims

The REPLACE Pedagogical Game was conceived as an educational bridge between the abstract policy framework of territorial cohesion and an engaging, child-centred learning experience. The design team began by distilling three abstract pillars—spatial inequality, sustainability, and social cohesion—into a set of tangible mechanics that players could manipulate, argue over, and re-configure. Central to this translation was the decision to create

a **full-fledged board game**, complete with high-resolution A1 boards, laminated card decks and professionally printed iconography, signalling to pupils that they were engaging with an authentic game world rather than a didactic exercise. At the same time, deliberately "unfinished" elements—pasta shapes for coins and environmental tokens, blank cards awaiting pupils' own structures—left visible the scaffolding of a work-in-progress construction site, inviting collective authorship. Its purpose was to translate complex concepts such as spatial inequality, sustainability, and social cohesion into tangible, interactive mechanics that primary school pupils could manipulate, explore, and reflect upon. The resulting board game combines rigorous design with elements of play, immersing children in urban planning scenarios that require them to navigate trade-offs, prioritise needs, and co-create inclusive, sustainable spaces.

The game was introduced through a multi-session workshop in which pupils, organised in teams, were tasked with reimagining the public space surrounding their school. Activities followed a coherent sequence—from problem identification and scenario building to spatial negotiation and collective reflection—culminating in a simulated redistributive intervention modelled on the logic of EU Cohesion Policy. The use of the school's actual site plan as the game board embedded the activity within a familiar spatial context, reinforcing Gruenewald's (2003) call to treat place as pedagogy and anchoring abstract ethical debates in real environments.

A key design feature was the co-creation process involving intern-researchers, who collaborated with the academic team to prototype and refine the game. Their contribution ensured both conceptual rigor and accessibility, modelling a learning pyramid in which university students, trainee educators, and primary pupils occupied successive rungs. This structure reflects the principles of **service learning**, an educational approach that integrates meaningful community service with academic instruction and reflection. Within this framework, students are not passive recipients of knowledge but active contributors to projects that address real social needs. They designed solutions, implemented activities collaboratively, and participated actively to the workshops. They provided a tailored design for the game and a logo[3] as well. In the context of REPLACE, the university interns engaged not only in the technical design of the educational game but also in its delivery, co-facilitating workshops that directly served younger learners and their schools. This experience embodied the core elements of service learning: community-oriented service, application of academic knowledge in real-world settings, active student involvement in all project phases, and the cultivation of civic awareness. Through this integration of research, design, and action, the REPLACE project nurtured transversal competences such as problem solving, teamwork, and ethical reflection, while fostering a stronger connection between higher education institutions and local communities.

Figure 1. The REPLACE project logo. Two stylised human figures—composed of circles and inverted triangles—symbolise inclusion and the complementarity of differences. The minimalist, symmetrical design visually conveys the project's core values: spatial justice, territorial cohesion, and participatory citizenship, reflecting its commitment to equity through education and dialogue.

This iterative process led to a well-calibrated rule set with clear thresholds and an integrated framework of **pedagogical constraints and ethical goals**. Each group of five to six pupils was assigned the task of **designing an inclusive, functional, and sustainable urban or green space** directly on the actual site plan of their school. To complete this mission, teams had to comply with five compulsory constraints and one ethical objective. First, each group was required to integrate at least three **functions**, in order to diversify the intended uses of the space.

3 The logo has been an original creation designed by the intern student Antonio Perrone.

Second, they had to satisfy the needs of at least three different kind of **users**, thus embedding inclusion into the core of the design process. Third, teams could place no more than fifteen **structures**, including both pre-printed and custom-designed cards, with each structure's physical form reproduced using 5 m² tiles and spatially arranged within the boundary of the map, requiring teams to manage land occupation like a spatial puzzle. Fourth, teams were assigned an asymmetric economic **budget** and were encouraged to spend their entire allocation strategically, as the funds represented earmarked resources intended for the school's improvement. Lastly, **land consumption** was constrained by the number of available tiles: when space ran out, students had to remove or reconfigure structures to make them fit, enhancing spatial reasoning under constraint. Beyond these formal rules, the game introduced an ethical challenge linked to **environmental impact**. Each structure carried an ecological cost, which symbolised emissions or biodiversity loss. While teams began with a generous allocation of tokens, they were encouraged to preserve as many as possible.

Therefore, at the core of the game are six component families. **Structure Cards** (red) include twenty pre-printed elements such as the Hopscotch Grid, Stargazing Telescope, Hammock, Pottery Shed, Pocket Theatre, and Vegetable Garden. Each card specifies its functions, compatible user categories, economic cost (1–5 coins), ecological impact (1–5 tokens), and spatial footprint (in 5 m² tiles). Blank Structure Cards allow pupils to invent their own facilities, encouraging creativity and numeracy.

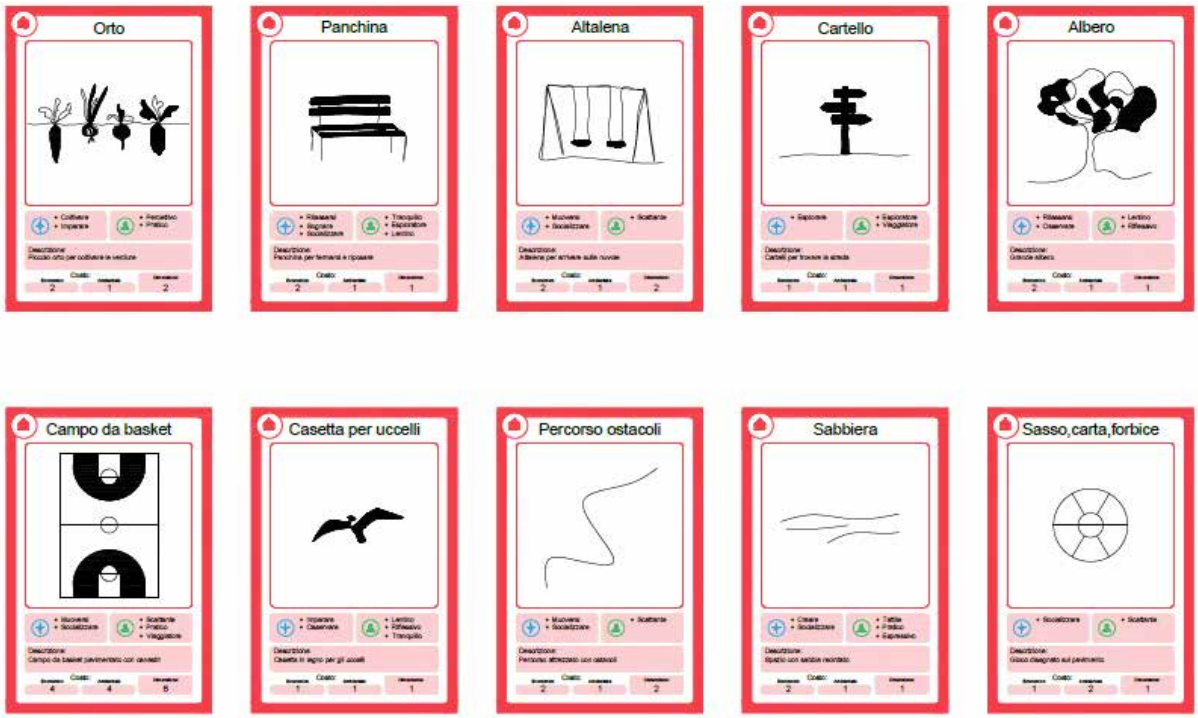

Figure 2. Examples of Structure Cards designed for use in the REPLACE board game. Each card represents a potential spatial intervention, with associated costs in surface area, budget, and environmental impact.

User Cards (green) represent ten accessibility profiles inspired by Italy's Special Educational Needs (SEN) framework: Slow Mover (requires obstacle-free routes and longer transition times), Calm Seeker (benefits from quiet, low-stimulus areas), Quick Mover (needs space for active movement and physical play), Hands-On Learner (prefers interactive and manipulable environments), Tactile Explorer (responds to textured and sensory-rich surfaces), Expressive Communicator (communicates through non-verbal or alternative languages and needs multimodal stimuli), Reflective Thinker (requires calm observation points and time for processing), Sensory Sensitive (sensitive to noise, light, and unpredictable layouts, needs controlled sensory environments), Cultural Traveller (requires inclusive symbols and multilingual access), and Explorer (thrives in open-ended paths and spaces that

reward curiosity and movement). These personas place inclusivity at the centre of spatial design, compelling teams to accommodate different learning styles and physical needs.

Figure 3. Examples of User Profile Cards. These cards draw inspiration from inclusive education frameworks and help players consider the diverse needs of school users when planning interventions.

Function Cards (blue) define the curricular and behavioural goals of each intervention, including Explore, Create, Socialise, Learn, Relax, Move, Observe, Cultivate, Experiment, and Dream. The selection of functions is designed to prompt students to reflect on the multiple functional properties of space and to recognise that certain functions may exclude others. This focus on the functionalisation of public and shared space enabled reflection on how to mediate between individual preferences and collective choices. Together, user and function cards define the brief for each team, determining which combinations of structures best fulfil their stated goals.

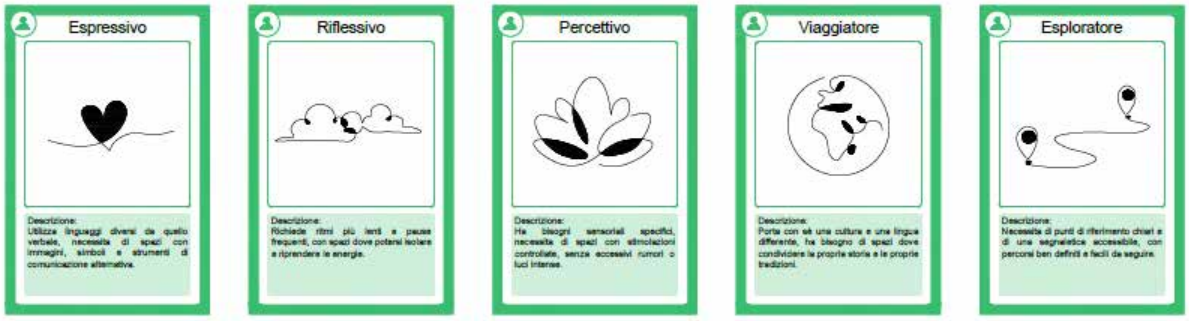

Figure 4. Examples of Function Cards. These cards represent key functions of inclusive public space—such as learning, moving, and socialising—and guide teams in ensuring functional diversity within their designs.

Each team is also assigned six **Role Cards** (teal), which mirror the division of labour in real planning processes: the Master of Ceremonies (MC) selects the functions to be pursued in the space and the users to whom the project should be addressed, chairs group discussions, sets priorities, and delivers presentations; the Supreme Shape Creator (SSC) sketches new structures and quantifies costs and impacts suitable for the selected users and functions; the Dream Architect (DA) curates the structure catalogue by identifying the most suitable structures—both new and standard—to meet user needs and to support the implementation of the selected functions; the Grand Treasury Accountant (GTA) manages finances, negotiates trade-offs, and purchases the structures to be included in the project; the Space Genius (SG) positions the structures within the available space, places tiles, and ensures accessibility and circulation; and the Harmony Guardian (HG) safeguards fairness and ecology, holding veto power and maintaining a public ledger of coins, butterfly tokens, and space used, administers environmental resources, and verifies that teammates' decisions have respected the initial commitments to provide specific functions for selected user profiles. This mutual interdependence enforces constant negotiation and fosters teamwork, as no action can proceed without coordination across roles.

Figure 5. Examples of Role Cards. Each card assigns specific responsibilities—such as managing resources, designing layouts, or facilitating group harmony—encouraging cooperation, accountability, and active participation within the team,

The material components of the game further support its educational goals. The game board—a high-resolution A1 printout of the school grounds—is accompanied by coins (penne-shaped pasta), environmental tokens (butterfly-shaped pasta), and space tiles (white 5 m2 cardboard squares). Pupils must tape together tiles to physically construct the shapes of proposed structures, confronting issues of adjacency, circulation, and land consumption in a kinaesthetic mode.

In sum, the REPLACE Game transforms policy discourse into a dynamic, material, and collaborative exercise. It engages children as designers, planners, and citizens, cultivating the cognitive, ethical, and practical competences needed to imagine more just and sustainable futures.

3. Implementing the REPLACE Workshop: Pedagogical Strategies and Facilitation

The implementation of the REPLACE game workshop followed a carefully designed pedagogical trajectory, combining elements of direct instruction with inquiry-based learning, and progressively guiding pupils through a structured yet flexible educational arc. The process began with a collectively framed discussion on the notions of socio-spatial justice, land scarcity, and sustainability. Rather than delivering a one-way lecture, facilitators employed a dialogic and visual approach, encouraging children to identify inequalities within their own neighbourhood and to reflect on the spatial and material deficiencies of their school environment. This opening activity reframed the map of the school grounds from a neutral diagram into a socially contested and emotionally resonant terrain, setting the stage for more complex spatial reasoning and ethical deliberation.

As pupils moved into the design phase, they began customising their own components of the game. Working in pairs, they created new Structure Cards using blank templates and were asked to estimate three key values—land footprint in tiles, economic cost in coins, and ecological impact in environmental tokens. These estimations were not arbitrary: each proposed structure had to be explicitly linked to a User Card and a Function Card, thereby rooting design imagination in the needs of specific user profiles and tangible programme goals. This creative act, guided by the role of the Supreme Shape Creator, enabled pupils to develop a sense of authorship over the game material while enhancing their numeracy and evaluative skills through peer dialogue and negotiation.

Resource allocation introduced asymmetry as a deliberate pedagogical tool. Facilitators distributed uneven starting budgets—45, 35, or 25 coins per team, along with an equal number of environmental tokens—thereby

making inequality immediately visible. The Grand Treasury Accountant recorded each team's balance on a public scoreboard, prompting early discussions on fairness, responsibility, and the relationship between resources and obligations. This staged disparity would later become the basis for a simulated redistributive intervention, allowing pupils to critically engage with concepts underpinning cohesion policy.

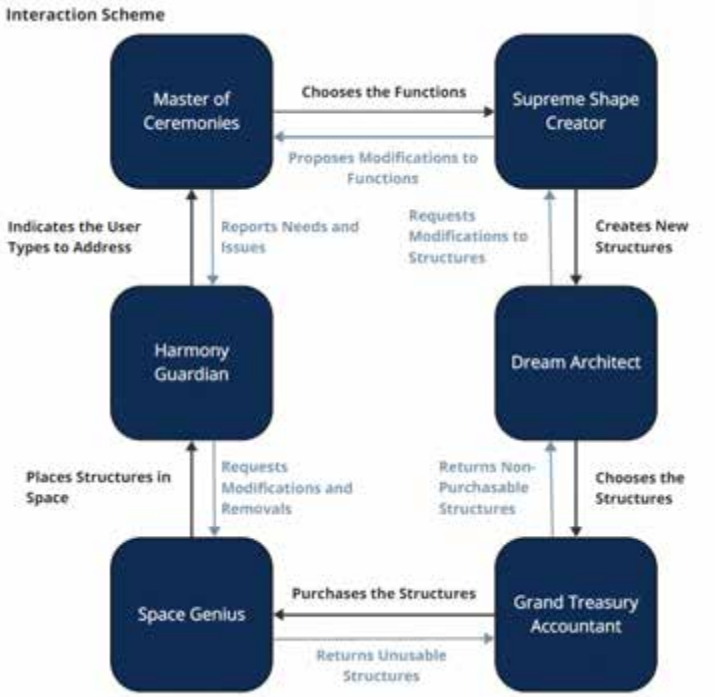

Figure 6. Group roles and interaction dynamics within the REPLACE workshop. The diagram illustrates how task-specific responsibilities (e.g., Space Genius, Dream Architect) structure collaboration and collective decision-making.

The **design phase**, occupying a substantial portion of the workshop, tasked teams with composing spatial layouts using a maximum of fifteen structures, while integrating at least three different user categories. The Space Genius orchestrated the physical placement of tiles on the map, and the Dream Architect curated the final configuration of selected structures. Throughout this process, facilitators maintained a reflective and non-directive presence, asking open-ended questions such as "Who might be excluded from this design?" rather than prescribing answers. This fostered an atmosphere of self-correction and ethical inquiry, as students revised their plans to increase inclusivity and accessibility.

Midway through the session, the workshop simulated **a redistributive shock** modelled on EU cohesion mechanisms. Additional funding was introduced: the team with the lowest initial endowment received the largest injection, followed by moderate support to the middle group and minimal increase for the most advantaged. This moment forced teams to reassess priorities under new conditions of equity, with the Master of Ceremonies in each group renegotiating goals in dialogue with teammates. In this way, abstract principles of distributive justice became embedded in the gameplay itself.

The final segment of the workshop was devoted to presentation and reflection. Teams publicly shared their spatial layouts, remaining coins and environmental tokens, and described the logic behind their decisions. The Harmony Guardian articulated how trade-offs were resolved and whether sustainability and inclusion had been achieved. A concluding plenary discussion, guided by facilitators, invited pupils to reflect on the most challenging dilemmas, the emotional impact of resource redistribution, and what they might do differently in a future

iteration. These conversations surfaced not only the design outcomes but also the values and social reasoning cultivated throughout the activity.

Throughout the workshop, facilitators adopted a deliberately Socratic posture—questioning, mirroring, and guiding rather than evaluating—to create a space of co-inquiry. The classroom thus became a rehearsal ground for collaborative planning and democratic participation, where children could practise critical citizenship through playful yet meaningful engagement with real-world challenges.

4. Learning in Action: Educational Goals and Outcomes

The game was purposefully designed to foster a comprehensive set of competencies that reflect the multidimensional profile of a future-oriented citizen-planner. Among the core learning goals were mathematical reasoning, spatial literacy, communication skills, civic awareness, empathy, and creative problem-solving. These were not addressed in isolation but emerged organically through the mechanics and social dynamics of the game-based experience.

Budget management, for instance, required pupils to engage in continuous arithmetic, calculating expenses, converting spatial units into square metres, and recalibrating available resources following a redistributive top-up. This process embedded mathematical operations such as addition, subtraction, and proportional reasoning within an authentic, time-sensitive scenario, thereby sharpening estimation skills and unit conversion abilities. Simultaneously, the manipulation of 5 m^2 tiles on a scaled map of the school site engaged pupils in spatial reasoning tasks. By repositioning playground equipment or designing new layouts, they developed an understanding of adjacency, circulation, and orientation, acquiring a practical grasp of spatial planning principles.

Communication and teamwork were equally central. The structured distribution of roles, each with distinct responsibilities, required participants to practise active listening, negotiate effectively, and coordinate actions with their peers. The division of powers (for instance, only the Treasury Accountant could release coins, and only the Space Genius could place tiles) reinforced interdependence and the need for clear, respectful dialogue. These dynamics offered a lived experience of relational and communicative competence under conditions of mild pressure and complexity.

The game also served as a rehearsal for democratic practice. Decisions regarding the allocation of resources, the selection of functions, or the response to new constraints were made collectively, with facilitators modelling procedural fairness and encouraging inclusive debate. The figure of the Harmony Guardian, with the authority to veto inequitable or ecologically harmful choices, ensured that deliberation was grounded in shared values of justice and sustainability. In this way, pupils were introduced to the principles of deliberative governance, simulating microcosms of participatory decision-making.

Empathy and social awareness were developed through the use of ten “User Cards”, each inspired by profiles drawn from the Italian framework for Special Educational Needs (BES). These profiles prompted participants to imagine the needs of different users—such as slow movers, sensory explorers, or multilingual learners—and to incorporate accessibility and inclusiveness into their spatial solutions. Children often expressed a sense of responsibility toward “their” users, and many reported adjusting their decisions to better accommodate these imagined perspectives. This affective engagement reflects the emergence of perspective-taking and ethical reasoning, key foundations of civic maturity.

In terms of creative capacity, the presence of blank Structure Cards empowered pupils to assume the role of novice designers. Estimating land take, costs, and ecological impacts became a process of iterative sketching, peer critique, and problem-solving that mirrored real-world design studios. The most inventive teams proposed hybrid installations—such as a combined “Reading-Garden Pergola” or a “Bike-Repair Kiosk”—capable of satisfying multiple user needs and functional goals at once. These examples demonstrated a capacity for divergent thinking and adaptive creativity under constraint.

At a deeper level, the workshop asked pupils to manage three parallel ledgers—**spatial, economic, and ecological**—each governed by different norms and logics. The spatial ledger, linked to physical tiles representing 5 m² units, introduced constraints of shape and fit: an L-shaped pergola or winding footpath might occupy the same area as a rectangle but proved more difficult to position effectively, prompting children to experiment with layout efficiency and spatial optimisation. The economic ledger, represented by penne-shaped pasta coins, captured financial trade-offs: while the objective was to spend the entire budget, groups had to evaluate utility over prestige, understanding that unspent funds held no advantage in the final assessment. The ecological ledger, expressed through farfalle-shaped environmental tokens, reflected the cost of carbon emissions, resource depletion, and habitat loss. Unlike coins, these tokens were best conserved. Though overspending was technically permitted, it carried social consequences, as seen when peers chided others with remarks like "You're wasting butterflies!", thus transforming planetary limits into a shared moral concern.

Balancing these ledgers required pupils to confront complex trade-offs and to understand that land, money, and ecological resources are interconnected but governed by conflicting imperatives. Through this balancing act, they encountered a form of moral arithmetic—"Can we afford it? Can we fit it? Should we do it?"—that encouraged systems thinking and early eco-ethical awareness. The result was a rich, multidimensional learning experience that went far beyond the accumulation of isolated skills, instead nurturing the kind of integrated reasoning necessary for navigating the socio-spatial dilemmas of contemporary urban life.

5. Transformative Learning in Practice: Reflections on Experience, Impact, and Educational Value

The REPLACE workshop demonstrated how play-based learning can integrate complex urban planning concepts with the cognitive, emotional, and social development of primary school pupils. Far from a mere educational diversion, the initiative yielded robust outcomes: students developed spatial awareness, demonstrated empathy toward diverse user profiles derived from inclusive education frameworks, and produced creative, context-sensitive design solutions under a range of constraints. Teachers reported enhanced attention, sustained enthusiasm, and strengthened cooperative behaviour among participants: evidence of the game's ability to merge analytical rigour with affective engagement.

A distinctive feature of the workshop was the pedagogical role of emotion, which acted not as a peripheral effect but as a primary vector of reflection and transformation. The asymmetrical distribution of initial budgets sparked humour, frustration, and pride; the subsequent redistributive intervention triggered surprise in some groups and resentment in others. Rather than downplaying these emotions, facilitators framed them as learning opportunities, inviting pupils to examine their reactions and articulate connections between personal feelings and principles such as fairness, responsibility, and solidarity. These affective dynamics reinforced the ethical foundations of the experience and mirrored the kind of value-based negotiation found in real-world planning processes.

As pupils advanced through the design and evaluation phases, this reflective capacity deepened. When comparing remaining budgets and environmental tokens, students collectively evaluated the outcomes of their decisions not in terms of competition, but mutual improvement. Each team succeeded in meeting the pedagogical requirements addressing at least three SEN profiles, staying within budget, and reducing ecological impact. The final presentations reinforced a culture of shared learning and peer recognition. The result was a shift in classroom dynamics: from individual achievement to collaborative responsibility.

Three pedagogical strengths emerged clearly. First, high levels of sustained engagement: even typically less vocal students remained deeply involved throughout the workshop, forming strong attachments to the needs of "their" users and the success of "their" proposals. Second, the emergence of justice-oriented thinking: pupils began to spontaneously reference equity-based principles such as "fair shares of shade" or "step-free access," revealing the internalisation of inclusive spatial reasoning. Third, inventive capacity under constraint: when challenged by tight budgets and spatial limitations, students produced innovative hybrids—like a pergola that doubled as a sensory retreat—regarded by teachers as exceeding the expected outcomes of standard de-

sign-and-technology curricula.

Alongside these achievements, the pilot also revealed areas for future refinement. A central limitation concerned the documentation of reasoning. Although the negotiation processes were often rich in dialogue and deliberation, much of this was only partially recorded through facilitator notes. Future versions could benefit from integrating tools such as video recordings or structured logbooks to capture the full depth of students' decision-making. Another challenge relates to the game's localisation: while the use of the actual school site enhanced engagement and realism, it also constrained replicability. Addressing this tension will require context-sensitive adaptations—such as replacing the site map with locally relevant public spaces, adjusting economic parameters to reflect regional conditions, and aligning user profiles with national SEN frameworks—to ensure that the pedagogical intent is preserved across diverse socio-cultural settings.

At a broader level, the Game offers a compelling model for translating academic research on cohesion policy, sustainability, and spatial justice into accessible, impactful educational experiences. By employing intergenerational co-design, role-based collaboration, and material proxies for territory, money, and ecology, the game renders abstract planning dilemmas concrete and emotionally resonant. In doing so, it fosters deliberative, imaginative, and ethical competences—skills that are foundational for civic agency and long-term democratic participation.

The decision to use a serious game format is not incidental, but central to the project's pedagogical strategy. Games situate learning in embodied, interactive, and emotionally charged environments, turning abstract concepts into negotiated realities. Within the REPLACE workshop, pupils did not passively absorb content but actively co-constructed meaning, experimenting with choices, negotiating trade-offs, and collaboratively building scenarios. The game thus functioned as a microcosm of territorial governance, where scarcity is felt, roles are distributed, and every spatial decision becomes simultaneously technical and ethical.

This design is grounded in multiple pedagogical traditions. Mezirow's theory of transformative learning is evident in how pupils confronted disorienting dilemmas that challenged their assumptions about justice and responsibility. Wals and Corcoran's vision of sustainability education as experiential, participatory, and action-oriented is embedded in the game's structure, which obliges players to balance environmental, social, and financial factors. Finally, Gruenewald's critical pedagogy of place is realised in the spatial immediacy of the game board—a real map of the school grounds—which reframes space not as a neutral backdrop but as a site of social negotiation.

Within the broader framework of the REPLACE project—which investigates governance and territorial cohesion at the European scale—the workshop stands as a concrete micro-level enactment of these themes. It enables children to "live" the concepts of spatial justice, rather than merely hear about them, and to explore how collective agency can shape public space. The result is not only a model for future replication, but a pedagogical prototype for engaging schools as active laboratories of democracy, where planning literacy becomes a tool for inclusive citizenship.

6. From Simulation to Action: Future Developments and Scaling Potential

The REPLACE project was conceived as a multi-level initiative that interweaves territorial governance, educational innovation, and civic engagement. At its core, the project aims to translate abstract policy constructs—such as spatial justice, sustainability, and territorial cohesion—into concrete, participatory experiences across diverse educational levels and socio-territorial contexts. Among its most impactful outputs, the game-based workshop for primary schools has proven particularly effective in disseminating these concepts through co-design, experiential learning, and inclusive urban literacy. This immersive approach not only fosters foundational planning competences among young learners, but also positions universities as agents of civic imagination and transformation.

In 2025, the project enters a new developmental phase through the launch **of VIBES – Visioni Innovative per un BEne comune nella Scuola**, a participatory initiative targeted at upper secondary students of the Spinelli School.

Building on the pedagogical groundwork laid in the primary-level pilot, VIBES shifts from simulated planning exercises to real-world spatial interventions. It adopts a project-based learning methodology that invites students to critically reinterpret and redesign their school courtyard, engaging directly with the social, environmental, and spatial dynamics of their everyday surroundings.

Structured in three progressive phases—Contextual Exploration and Data Collection, Collaborative Design and Scenario Building, and Project Presentation and Community Engagement—the initiative guides students from situated inquiry to actionable spatial strategies. Supported by researchers from the Politecnico di Milano, participants translate empirical data[4] into design proposals aligned with the principles of equity, sustainability, and cohesion. These proposals are then shared with the broader school community and local stakeholders, fostering intergenerational dialogue and civic visibility.

The VIBES initiative reinforces the longitudinal ambition of REPLACE by extending its core learning objectives (systems thinking, spatial literacy, and democratic participation) across developmental stages. It exemplifies how school environments can evolve from passive spaces of instruction into active sites of civic agency and collaborative design. In this way, education becomes not only a process of knowledge transmission but a platform for public action.

Taken together, the REPLACE project and its expansion through VIBES articulate a robust model for integrating research-driven pedagogy with societal relevance. By embedding abstract concepts within participatory, place-based frameworks, these initiatives demonstrate how schools can serve as laboratories of democracy and how academic research can animate civic life. As parallel efforts across Europe[5] are beginning to show, cultivating the capacity of younger generations to design more inclusive and sustainable spaces is not merely aspirational, it is essential for addressing the socio-environmental urgencies of our time.

Conclusions

This paper has presented the REPLACE project as an innovative model of research-driven pedagogy that bridges academic research, civic engagement, and educational transformation. Through its focus on spatial justice, territorial cohesion and sustainability, the project exemplifies how universities can extend their mission into the public sphere by developing participatory, place-based learning experiences.

The discussion began by situating the REPLACE research extension's activities within the broader framework of the University's Third Mission, underscoring its orientation toward knowledge dissemination and societal impact beyond traditional academic boundaries. It then examined the conceptual development of The REPLACE Game, a pedagogical board game designed to translate complex policy ideas into accessible, experiential learning for primary school pupils. The workshop's implementation and facilitation strategy was analysed in detail, highlighting how co-design, role-play, and structured simulation fostered civic imagination, ethical reasoning, and spatial literacy.

4 Empirical data refers to a digital questionnaire which has been submitted to school mates, school workers and inhabitants in order to investigate the issue of the school courtyard's renewal

5 See, for example: La Città dei Bambini by Francesco Tonucci, an international initiative active in over 200 cities worldwide, which establishes Children's Councils to involve young citizens in urban planning and governance, promoting child-friendly city designs; the Youth Engagement Programme in London, which collaborates with schools to engage students in real urban development projects through workshops with architects and planners, fostering early civic involvement; Helsinki's Nuortenbudjetti, an annual participatory budgeting process where youths aged 12–17 propose and vote on the allocation of approximately €150,000 for youth services, empowering them in municipal decision-making; and the Our Cities project, an Erasmus+ initiative led by the Hill School in Athens, engaging primary school students in exploring their urban environment, identifying infrastructural challenges, and collaboratively designing models of ideal cities, thereby cultivating active citizenship and spatial awareness from an early age.

Subsequent sections explored the workshop's **transformative learning** outcomes. Pupils demonstrated not only increased spatial awareness and mathematical reasoning, but also developed empathy, teamwork, and environmental consciousness. Emotional responses and ethical dilemmas were not incidental but central to the learning process, catalysing reflection and value-based decision-making.
The final part presented future developments, particularly the VIBES initiative, which expands the REPLACE methodology to the secondary school context. Through real-world design challenges and community engagement, this new phase furthers the project's commitment to building civic capacity across educational levels.

Taken together, the REPLACE game and VIBES initiatives align with the principles of critical pedagogy, as articulated by Paulo Freire (1970) and Ivan Illich (1971). Freire's emphasis on education as a practice of freedom, where learners critically engage with the world to transform it, is incorporated in the research extension's activities provided by REPLACE and its dialogic and participatory structure. Similarly, Illich's vision of deschooling society and reclaiming education as a cooperative, learner-driven act echoes in REPLACE's challenge to traditional instructional hierarchies and its relocation of learning into real, contested, spatial environments, as suggested by its transformative educational initiative.

In sum, the REPLACE project offers a replicable, scalable model for integrating research, teaching, and civic responsibility. By aligning academic knowledge with critical pedagogy, it demonstrates how schools can become laboratories of democracy and how educational institutions can cultivate the competences and critical awareness required to address today's most pressing socio-spatial and environmental challenges.

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UBT "SMART City": A Small-Scale City Ecosystem for Experimentation in Knowledge-Driven Urban Planning

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Abstract
«SMART Cities» and its applications represent a high level of complexity, including the skills required for urban solutions based on new models of education, research and policy framework design. This paper elaborates a specific model named UBT "SMART City" (Small Scale Smart Sustain System) which represents an Entrepreneurial Innovation Ecosystem, which could also be used as a Test-Bed for Future and Innovative Urban Planning with a particular focus in education, future-planning concepts and emerging technologies. Located in an Area of 30.000 m^2, the model is the state-of-art Development Program, designed and developed by at University for Business and Technology (UBT), with the aim to modernize and integrate the sustainable and SMART planning, community living standards, advanced technologies, education, innovation and economic and social impact.

Keywords: Smart Cities; Emerging Technologies; Transformative Urban Planning; Sustainable Development; Innovation Ecosystem

1. Introduction and Theoretical Background

• The evolving needs in urban planning education

Higher education institutions play a critical role in advancing urban sustainability. Universities and colleges not only educate the next generation of leaders, planners, and professionals but also serve as hubs for research, innovation, and policy development. They are in a unique position to lead by example, demonstrating sustainable practices through their operations and campus management. Many universities have begun integrating sustainability into their curriculum, offering specialized courses, degrees, and certifications focused on environmental science, sustainable development, and urban planning. These programs equip students with the knowledge and skills needed to address complex sustainability challenges. Additionally, interdisciplinary approaches that combine aspects of engineering, economics, sociology, and environmental studies provide a holistic understanding of sustainability issues.

Research conducted within these institutions is invaluable for the advancement of urban sustainability. By exploring new technologies, materials, and methods, academic research can drive significant progress in areas such as renewable energy, sustainable architecture, and waste management. Universities can also influence policy by providing evidence-based recommendations to government bodies and urban planners.

Moreover, colleges and universities often act as microcosms of larger urban systems, where sustainable initiatives can be tested and refined. From energy-efficient buildings and sustainable transportation options to waste reduction programs, the sustainable practices implemented on campuses can serve as models for broader urban applications.

• The role of education and innovation ecosystems in future cities

Education and innovation ecosystems are crucial in shaping the sustainable, inclusive, and resilient cities of the future. As urban areas increasingly face multifaceted challenges—ranging from climate change and resource scarcity to demographic shifts and governance complexity—the need for well-informed, interdisciplinary, and technologically adaptive urban professionals is greater than ever (OECD, 2020).

Urban Planning Education (UPE) has undergone significant reform since the 1990s, moving beyond technocratic models of environmental management to embrace a sustainability-driven and participatory paradigm. Inspired by global frameworks such as the **Brundtland Report** (WCED, 1987), the **New Urban Agenda** (UN-Habitat, 2016), and the **2030 Agenda for Sustainable Development** (UN, 2015), modern UPE integrates principles of ecological integrity, equity, collaborative governance, and innovation. Contemporary curricula emphasize competences such as strategic foresight, anticipatory thinking, stakeholder negotiation, ethical reasoning, and systems-based problem solving—skills essential for planning in rapidly changing and culturally diverse environments (Friedmann, 1996; Gunder, 2010; D'Alessandro & Zuluaga, 2022).

At the heart of these efforts lies the integration of education with innovation ecosystems. Universities function as living laboratories and microcosms of cities, offering real-world contexts for testing sustainable solutions—from energy-efficient buildings and zero-waste systems to smart mobility networks (Cavada et al., 2016). Innovation ecosystems surrounding HEIs—including research institutes, start-up incubators, policy labs, and civic tech platforms—facilitate cross-sector collaboration, enabling the development and scaling of technologies that advance urban sustainability (Etzkowitz & Leydesdorff, 2000; Carayannis & Campbell, 2009).

The rise of advanced technologies—such as **Artificial Intelligence (AI)**, **Extended Reality (XR)**, the **Internet of Things (IoT)**, and **digital twins**—is redefining the possibilities of urban design, governance, and engagement. AI is increasingly used in predictive modeling, urban analytics, and optimizing resource management (Batty, 2018), while XR technologies (augmented and virtual reality) are transforming the way urban plans are visualized, communicated, and co-created with communities (Portman, Natapov & Fisher-Gewirtzman, 2015). These tools enhance spatial awareness, participatory planning, and scenario simulation, making urban development more inclusive and data-informed (Alizadehsalehi et al., 2020).

Education plays a critical role in equipping future professionals with the technical literacy and ethical frameworks needed to responsibly harness these technologies. Pedagogical approaches are evolving toward **learner-centered, experiential, and transformative models**. **Education for Sustainable Development (ESD)** promotes critical thinking, self-awareness, and systemic understanding, empowering learners to become agents of change (Sterling, 2001; UNESCO, 2017). Incorporating digital tools and immersive technologies into teaching methodologies not only enhances engagement but also fosters interdisciplinary collaboration and creativity (Mulder, 2017).

The paper frames current human development within the convergence era and the Fourth Industrial Revolution (4IR), characterized by the blending of physical, digital, and biological technologies. This era demands interdisciplinary approaches and transformations across political, social, economic, and technological systems, emphasizing sustainability, innovation, and resilience. Cities are viewed as complex adaptive systems requiring integrated governance and policy frameworks. Smart Cities are presented as ecosystems that integrate advanced technologies like IoT, AI, and 5G with urban infrastructure to improve efficiency, quality of life, and sustainability. UBT's Smart City model exemplifies this trend by combining technology, education, and community engagement in an innovation ecosystem that serves as a living lab for sustainable urban solutions.

Despite these promising frameworks, several challenges persist. Small-scale ecosystems such as UBT's Smart City testbed encounter limitations related to resource constraints, scalability, and complexity management. The intricacies of urban systems—spanning infrastructure, governance, and socio-economic factors—require adaptive and multi-level governance approaches to effectively manage complexity and scale innovations beyond localized pilot projects (Batty et al., 2012; Kitchin, 2014).

However, these limitations also offer unique opportunities. Testbeds like UBT's Smart City can serve as models for policy transfer, regional replication, and cross-border learning, especially in contexts of emerging economies where scalable smart city solutions are urgently needed (Albino, Berardi & Dangelico, 2015).

In the context of planning education, UBT's integrated Smart City initiative underscores the critical role of higher education institutions as catalysts for sustainable urban development and social innovation. The initiative's experiential learning environment equips future planners with competencies essential for navigating the complexity of smart urbanism, including systems thinking, anticipatory governance, and multi-stakeholder negotiation skills (Wiek et al., 2011).

Looking ahead, the future outlook for smart city development at UBT involves expanding the testbed's technological infrastructure, scaling pilot innovations to regional urban environments, and deepening partnerships among academia, government, and industry. This evolution will support the broader diffusion of data-driven governance practices that enhance urban resilience and inclusivity, thereby positioning UBT as a regional leader in smart city research and policy influence (Neirotti et al., 2014; Nam & Pardo, 2011).

2. SMART Cities: Concept, Definitions, key dimensions

By 2050, it is estimated that roughly 70% of the world's population will live in cities. With more citizens to serve, and a climate that is rapidly degrading, public service efficiency and effective resource-usage are becoming pressing issues for cities. In this context, ensuring sustainable development and quality of life in complex social ecosystems of cities and urban areas are important concerns. Cities are increasingly aware of the concept of "smart city" and are actively developing strategies towards the goal of becoming "smart" and manage city resources more efficiently while addressing development and inclusion challenges. To understand the concept of smart city, we begin with understanding the conceptual relatives of the model. Although limited in scope, they set the theoretical framework for the holistic notion of the smart city currently understood by the urban planning sphere. The notion of smart city is established from the combination of the knowledge society and digital city. It is defined as a "multi-layer territorial system of innovation" made up of digital networks, individual intellectual capital, and the social capital of the city, which together constitute collective intelligence (Komninos, 2008). Economic competitiveness and innovation achieved through the knowledge-based economy marks a city as intelligent, allowing it to generate a "spatial competitive advantage" through industrial districts, regions, and learning clusters that produce sophisticated R&D and are supported by digital networks and artificial intelligence (Komninos 2008). Based on the exploration of a wide and extensive array of literature from various disciplinary areas, the identified factors– Social, Management, Economy, Environment, Technology, Sustainability, (SMEETS) forms the basis of an integrative framework. This comprehensiveness is the distinguishing factor of the smart city, which integrates a number of physical, institutional, and digital components to create a holistic definition of what smart planning would look like.

• Pillars of Smart City

The structure of smart city is widely comprised by six pillars, namely 1) Social; 2) Management, 3) Economy; 4) Environment; 5) Technology; and 6) Sustainability.

At its core, a smart city framework leverages from the existing legal, economic and technical environment and impacts the social and management aspects in a sustainable manner. Setting a smart city vision and effectively moving towards it with a systems-based approach is imperative to ensure optimum resource efficiency and security, along with preserving socially inclusive growth. Drawing on the literature and the factors considered above, we have conceptualized an integrative framework that explains the relationships between these factors in a more coherent fashion. We have named it as SMEETS framework (Social, Management, Economy, Environment, technology and Sustainability. Each of these factors enables both the public and private sectors to plan and implement Smart City initiatives more commendably. These elements provide a basis for matching how different cities are envisaging their smart initiatives, employing shared services, and the related challenges. This framework also analyses the actual impact of different factors on the success of smart city initiatives. The framework

indicates that each factor is both affecting and getting affected by each other factor. It also indicates that some factors may be more influential than the others depending on the context. The framework can be bifurcated in two levels. The inner level consists of the factors, which have greater impact on the smart city initiatives. This also consists of technology, which is the foundation of smart cities. The outer level factors are the ones, which might get influenced by the inner level before impacting the smart city initiatives. This includes governance and the socio balance of the community apart from sustainability, which should be the basis of any development.

Fig.1. Smart City Framework

A contextually adapted and citizen-centric approach [2], using both human and technological resources, can bring multiple benefits for municipalities, particularly those that are struggling with specific problems - such as inefficient waste management systems, lack of civic participation, or traffic and congestion.

• Definitions and Terminology

A **smart city** is an urban area that uses different types of electronic Internet of things (IoT) sensors to collect data and then use these data to manage assets and resources efficiently. This includes data collected from citizens, devices, and assets that is processed and analyzed to monitor and manage traffic and transportation systems, power plants, water supply networks, waste management, crime detection,[1]information systems, schools, libraries, hospitals, and other community services.[2][3][page needed]

The smart city concept integrates information and communication technology (ICT), and various physical devices connected to the IoT network to optimize the efficiency of city operations and services and connect to citizens.[4] [5] Smart city technology allows city officials to interact directly with both community and city infrastructure and to monitor what is happening in the city and how the city is evolving. ICT is used to enhance quality, performance and interactivity of urban services, to reduce costs and resource consumption and to increase contact between citizens and government.[6] Yet, the term itself remains unclear to its specifics and therefore, open to many interpretations.[10]

Terminology

Due to the breadth of technologies that have been implemented under the smart city label, it is difficult to distill a precise definition of a smart city.

Deakin defines the smart city as one that utilizes ICT to meet the demands of the market (the citizens of the city),

and that community involvement in the process is necessary for a smart city.[27] A smart city would thus be a city that not only possesses ICT technology in particular areas, but has also implemented this technology in a manner that positively impacts the local community.

• Characteristics
It has been suggested that a smart city (also community, business cluster, urban agglomeration or region) uses information technologies to:

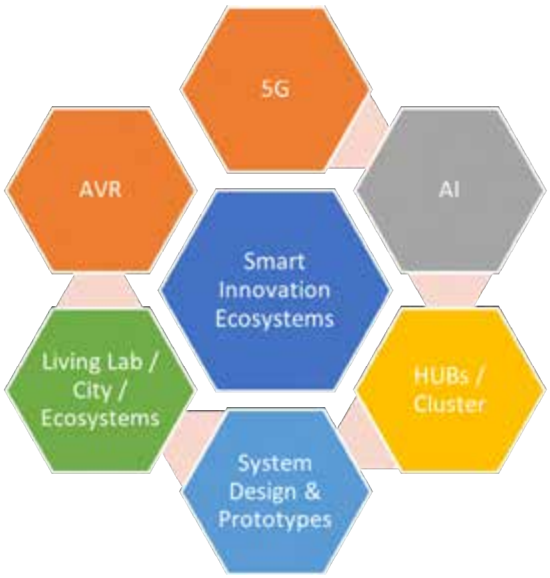
1. Make more efficient use of physical infrastructure (roads, built environment and other physical assets) through artificial intelligence and data analytics to support a strong and healthy economic, social, cultural development.[36]
2. Engage effectively with local people in local governance and decision by use of open innovation processes and e-participation, improving the collective intelligence of the city's institutions through e-governance,[7] with emphasis placed on citizen participation and co-design.[37][38][39]
3. Learn, adapt and innovate and thereby respond more effectively and promptly to changing circumstances by improving the intelligence of the city.[7][40]

According to David K. Owens, the former executive vice president of the Edison Electric Institute, two key elements that a smart city must have are an integrated communications platform and a "dynamic resilient grid." Both are large investments.[46]

3. The UBT "SMART City" Concept
In the context of smart city development, focusing on the functions of everyday urban life is essential to understanding how new technologies and integrated approaches transform living spaces. A unique example in this regard is the **"UBT Smart Self-Sustain System"**, developed by the University for Business and Technology (UBT) in Kosovo. This model represents an innovative and holistic approach aimed at creating a **"city of knowledge"**—an environment where education, technology, healthcare, employment, housing, and community life are intertwined in an integrated ecosystem.

Since its beginnings UBT has always followed the current technological and socio-economic trends and developments, while in certain situations it has taken the leading roal towards future oriented solutions and forward-looking initiatives. In these terms, UBT now bases its scientific, research, teaching and innovation activities on the UNIVERSITY 4.0 Concept, by integrating Fully Digitalized Research and Education Process, CLASSROOM 3.0, Augmented and Virtual Reality (AVR) and 5G Telecommunication Network in its main Innovative and Scientific Campus in Lipjan/Kosovo and its other campuses and premises around Kosovo. The campus has been designed and developed around the small-scale smart city concept by covering all fields of life occurring in an open campus.

UBT Model for Fylly Smart based University is fellow:



This model integrates Smart Systems, Resilience and Sustainability, also the concept of Society 5.0.

At the core of this concept lies the idea of transforming traditional urban functions through advanced technologies and practical learning. This **smart ecosystem** includes more than **150 fields of study**, **300 laboratories**, and a network of **80 functional companies** where students actively engage throughout their studies. **Practical experience and real-world learning** are embedded in every aspect of life, creating a new model for education and professional training.

Urban life functions—such as education, employment, technology, healthcare, public services, culture, and social infrastructure—are integrated into this system. For instance, in the field of healthcare, UBT has built a functional hospital and polyclinic, while in technology, it operates software companies and 5G networks. In the media field, the university has its own radio, television, and news portal, enabling students to directly participate in media content production and digital platform development. Another important aspect of this model is the use of advanced technologies such as **5G, artificial intelligence, virtual reality, robotics, cloud computing, and laser technologies**. These technologies are not only present in laboratories or classrooms but are part of the campus's daily life, offering an integrated learning and working experience. Students learn by solving real-world problems, participating in concrete projects, and collaborating with industry experts, transforming the campus into a **living urban ecosystem**. This system not only meets the demands of modern education but also generates **thousands of new jobs every year**, ensuring a seamless transition from education to employment. The integration of technology, professional practice, and core urban life functions makes this model valuable for study in the context of smart cities, where **innovation, social inclusion, and economic development** converge to create a **sustainable and livable environment**. This approach challenges traditional models of education and urban development, proposing a new paradigm that can inspire the cities of the future.

4. Physical and Technological Components

Campuses and Premises

UBT operates across multiple locations, with main campuses in Prishtina and Lipjan, and branches in Prizren, Gjilan, Ferizaj, and Peja. Its total campus area spans approximately 65,000 m², covering open spaces, green areas,

and parking, with major facilities including the Innovation Campus, City Center Campus, and University Hospital Campus. UBT is home to a community of 15,000 members, comprised by students, staff, and third part community.

To better address emerging needs of physical and operation transformation, UBT has developed its Institutional Strategy and Action Plan for a Green, Carbon-Neutral and Smart Campus. The project focuses on nine key Initiatives, namely: Clean Energy, Building green, Getting around, Sustainable water management, Good food, Zero plastics, Smart technologies, Sustainable landscape, and Print responsibly. The given Initiatives-directly linked with certain SDGs- and related actions & project are briefly summarized below:

Clean Energy / Switch to Renewables: From 252 kWp of electricity need for its campus and premises, UBT premises are generating 50 % of it (126 kWp) from already installed solar panels – and thus from renewable resources. Currently, the institution is looking forward install the rest of panels needed to generate 100 of its electricity by solar panels. This will make the campus and its premises a 100 % renewable energy-based campus.

Building Green/Green Building: The Initiative of "Building green" emphasizes the need for sustainable construction practices and ongoing maintenance to ensure that buildings remain environmentally friendly over time. By incorporating sustainable design, choosing eco-friendly materials, implementing energy-efficient systems, incorporating renewable energy sources, and establishing an ongoing maintenance plan, our campus can create buildings that have a positive impact on the environment and contribute to a green future.

Getting Around / Biking and Walking: Promoting non-motorized transportation options will reduce carbon emissions and foster a healthier lifestyle by developing a campus Master Plan, installing bike racks, implementing a bike share program, promoting biking and walking events, and integrating with public transport.

Never Waste a Drop / Sustainable Water Management: By conducting a water audit, implementing water-efficient fixtures and appliances, implementing rainwater harvesting and greywater recycling systems, improving landscape irrigation practices, and educating and engaging the campus community, UBT campuses are reducing water consumption, conserve resources, and minimize environmental impact.

Good Food, Healthy Planet / Zero Food Waste Campus: By implementing a sustainable sourcing policy, implementing portion control and food recovery programs, implementing a composting program, educating and engaging the campus community, and measuring and monitoring food waste, UBT campuses can contribute to a healthier environment and support a carbon-neutral future.

Zero Plastics, Zero Waste/Single-Use Plastic Free Campus and Minimization of Disposable Items: By implementing a ban on single-use plastics, promoting reusable items, establishing recycling and composting stations, organizing waste reduction and recycling programs, and educating and engaging the campus community, UBT campuses are going to significantly reduce their reliance on disposable plastic products and move towards a Zero Waste future.

When it comes to Principle 6.1- **Minimization of Disposable Items,** it particularly emphasizes reducing the reliance on single-use items in campus' everyday activities, with a particular focus on various faculties, including Medicine and its branches, Nursing, Agriculture and Environmental Engineering, and Food Processing and Biotechnology. This involves identifying alternatives, implementing recycling programs, and promoting responsible usage to minimize waste and promote sustainability. In conclusion, Minimization of Disposable Items underscores the importance of reducing reliance on single-use items in various faculties, including Medicine and its branches, Nursing, Agriculture and Environmental Engineering, and Food Processing and Biotechnology.

Adopting Smart Technologies/AVR: Integration of smart technologies will enhance efficiency, sustainability, and learning experiences by integrating smart building systems, incorporating AVR technologies, implementing IoT

solutions, promoting remote learning, and developing smart campus initiatives.
Sustainable Landscape / Open and Green Areas: The Initiative of "Sustainable Landscape / Open and Green Areas" focuses on creating and maintaining outdoor spaces that are ecologically sustainable and enhance the quality of life on campus. This approach emphasizes using native plants, conserving water, promoting biodiversity, and providing areas for relaxation and recreation.

Print Responsibly/Save the Planet: The Initiative of "Print Responsibly / Save the Planet" emphasizes the need to reduce paper consumption and minimize the environmental impact of printing activities on campus. By promoting responsible printing practices, campuses can conserve resources, reduce waste, and contribute to a more sustainable and Eco-Friendly environment.

The Institution is already implementing all mentioned initiatives, with most of them being fully implemented, and with the rest of initiatives being particularly addressed. Thus, this project proposal contains four important dimensions, namely as following:

a) Description of Green and Carbon Neutral Campus Initiative in context of Institution's long term and strategic orientation
b) Elaborating nine initiatives for making our campus Green, Carbon-Neutral and Smart, including concrete projects to be implemented and actions to be performed
c) Identifying concrete steps, actions and projects that are put in place already
d) Identifying ongoing actions and projects in order to fully implement Institution's initiatives and objective for making its campus Green, Carbon-Neutral and Smart.

Applying Crisis Management Principles in real life and university's everyday operations
The University for Business and Technology (UBT) has developed a robust framework for Institutional Crisis Management, encompassing resilience, economic and financial stability, and technological safeguards. This multi-dimensional strategy ensures UBT's preparedness for diverse challenges, aligning with its commitment to sustainability, operational continuity, and global excellence. Central to this approach are the following pillars: **a) the Sustainable Campus Resilience Program (SCRP); b) an Integrated Program for the Resource Diversification** and **c) Cyber Security Measures Package**- with the triplet integrating environmental sustainability, economic diversification, and technological innovation into a cohesive crisis management model.

UBT strengthens institutional adaptability through resilience-focused initiatives such as the Climate Crisis Response Team, renewable energy implementation, and comprehensive sustainable practices. These efforts align with the Sustainable Development Goals (SDGs), fostering environmental stewardship and institutional readiness for crises, including natural disasters and infrastructure disruptions. UBT continuously evolves its resilience strategies to address emerging risks, ensuring adaptability in a dynamic global landscape. To safeguard economic stability, UBT diversifies its income sources through over 100 Spin-Offs, international research projects, and sustainable procurement practices. These initiatives generate sustainable revenue while providing practical learning opportunities for students and bridging academia with industry. In the technological domain, UBT prioritizes cybersecurity by establishing a Computer Emergency Response Team (CERT), investing in secure IT infrastructure, and incorporating advanced technologies like artificial intelligence for threat detection. The institution's three-pronged strategy—readiness, response, and recovery—ensures robust defenses against evolving digital threats.

Resilience: Strengthening Institutional Adaptability through the Sustainable Campus Resilience Program (SCRP):
Resilience is the cornerstone of UBT's crisis management strategy, enabling the institution to adapt and thrive amidst adversities. UBT's SCRP drives this adaptability by addressing critical dimensions of environmental sustainability and climate crisis management through initiatives such as:

• **Climate Crisis Response Team:** A dedicated team of experts prepared to address environmental risks and enhance institutional readiness. Their task include producing strategic documents and follow-ups of the fulfillment of the strategic objectives of these documents by aligning those with university's everyday operations and practices.

• **Institutional Strategy on Implementing and Promoting SDG-s**: The University has developed an extensive university strategy for dealing with the 17 Sustainable Development Goals (SDGs)- a comprehensive and integrated approach that aims to ensure that the university plays an active role in promoting sustainability across its operations, research, curriculum, community engagement, and institutional culture.

• **Renewable Energy Solutions:** Implementation of solar panels and other renewable technologies to transition UBT's campuses towards carbon neutrality.

• **Sustainable Practices:** Comprehensive recycling programs, water conservation initiatives, and promotion of non-motorized transportation options to minimize environmental impact.

• **Smart Building Practices:** Adoption of advanced technologies for energy efficiency, resource management, and user comfort across all UBT campuses. This includes integrating smart lighting systems, energy monitoring tools, and automated climate control to optimize resource utilization and create sustainable learning environments.

• **Education and Awareness:** Integration of resilience-focused modules into academic curricula, fostering a culture of preparedness and environmental stewardship among students and staff.

Economic and Financial Stability: Diversification as a Shield
UBT recognizes the critical importance of financial resilience in navigating economic disruptions. To this end, the university has adopted a multi-faceted approach to diversify its income sources and mitigate financial risks. Key initiatives include:

• **Spin-Off Ecosystem:** UBT has established over 100 Spin-Offs that generate sustainable revenue while providing valuable services such as business incubation, strategic consulting, ICT solutions, and engineering projects. These Spin-Offs also offer students practical learning opportunities, bridging the gap between academia and industry.

• **International Projects Office:** By participating in and managing international research and development projects, UBT secures funding to support its strategic objectives and operational needs.

• **Sustainable Procurement Practices:** Integrating sustainability criteria into procurement and supply chain management ensures responsible business practices and enhances economic stability.

• **Financial Contingency Planning:** UBT has developed comprehensive financial strategies to address potential enrollment fluctuations due to demographic challenges like migration and low population growth.

UBT's financial resilience strategy is bolstered by its focus on long-term planning and resource optimization. The institution continuously identifies new opportunities for revenue generation, such as partnerships with industry leaders, regional economic collaborations, and consultancy services tailored to public and private sector needs.

Technological Stability and Cyber Security: Safeguarding the Digital Future
In an increasingly digital world, technological stability and cybersecurity are essential components of UBT's crisis management framework. The university's approach includes:

• **Computer Emergency Response Team (CERT):** A specialized team dedicated to monitoring, preventing, and responding to cyber threats.

• **Secure IT Infrastructure:** Investment in secure and resilient systems to support online education, administrative operations, and research activities.

• **Continuous Monitoring and Training:** Regular simulation exercises and training programs to prepare staff and students for potential cyber crises.

• **Promoting Cyber Hygiene:** Educating the UBT community on best practices for safeguarding digital assets and maintaining vigilance against cyber risks.

UBT's cyber strategy is structured around three pillars: readiness, response, and recovery. This ensures the institution remains secure, vigilant, and resilient against evolving technological threats.

UBT has also integrated advanced technologies such as artificial intelligence and machine learning into its cybersecurity measures, enhancing its ability to predict, detect, and neutralize threats in real time. Additionally, the university collaborates with global cybersecurity experts to stay ahead of emerging threats and adopt best practices.

Entrepreneurship

Entrepreneurship and Innovation are priorities within UBT and due to this fact, UBT has managed to create Innovations that have created a long-standing impact on society and that include large ecosystems of knowledge that bring the best and most popular practices of the world to Kosovo. A majority of these practices are the first in the Western Balkans and beyond. UBT's approach to entrepreneurship and innovation is completely different from traditional approaches. By providing many opportunities for students, staff, industry, third parts, and the wider community to develop their ideas and entrepreneurial skills and by enabling them to incubate, grow and get into the market. UBT has constantly invested in developing new education and business venturing concepts, focusing also on creating an environment conducive to entrepreneurial activity that also fosters and inspires the entrepreneurial spirit. Advising and mentoring students, staff, industry, third parts and wider community throughout projects that can be funded donors and industry is an effective method and we expect to further strengthen

So far, more than 30 impactful innovations have been generated, and more innovative projects are being developed and expected to make significant impact for our students, partners, relevant stakeholders and the wider community. These initiatives include developing a **Full-Scale Entrepreneurial Ecosystem** which cultivates a culture of innovation and entrepreneurship within emerging technologies like augmented reality (AR), AI etc. The given ecosystem encourages cross-disciplinary collaboration to turn ideas and research into real-world applications, and supporting startups that arise from the university's incubation programs. In this regard, beside establishing **more than 100 Spin-Offs**, UBT has also established the first innovative center in the region, named **"UBT Accelerator"**. Opened in the Innovative Science Park of UBT, this Accelerator has been in the service of students, staff, industry, and wider community for the development of creative, innovative ideas and the creation of technological advantages.

Furtherly; based on its strategic commitment to foster and support entrepreneurship, UBT has undertaken the following initiatives and has performed the following projects **UBT Start-Up School; 5G Technology Test-Bed; Center of Virtual and Augmented Reality; Artificial Intelligence Lab**, Internet of Things (IoT) Lab, Robotics and Industrial Automation; UBT Smart City Small-Scale Ecosystem; **National Cyber Security and Resilience Lab**; **UBT Research Hubs**; **UBT Junior Hub**; UBT Sport, E-Sport & Art Hub; **UBT Innovation and Technology Hubs**; UBT Knowledge Hub; Tailored Manufacturing and Services; Remote/Contactless Delivery Services; **Creativity Industry Hub;** Central Testing Hub; Smart, Green and Carbon-Neutral Campus; UBT EdTech; UBT Digital Innovation Hub; **National**

Public Policy Simulation Lab; UBT Integrated Media Center; **UBT GIS and Spatial Data Infrastructure Center; UBT High Schools**; **UBT Professional Schools**; Virtualization based Delivery Services; UBT Community Services; **UBT Integrated Health Care Services**; UBT University 4.0; **UBT Go International**; **UBT Science and Technology Park** etc.

When it comes to Spin-Off-s; the followings are only a few among over 100 Spin-Off-s of UBT: **IEME (**Institute for Enterprise Management and Engineering); **Quality Kosova (**Kosovo Association for Management – member of International Project Management Association and European Organisation for Quality) **CA–CASE (**Kosovo Association for Control, Automation and Systems Engineering – member of International Federation of Automation and Control); **KA-SIM (**Kosovo Association for Modelling and Simulation-Member of EUROSIM European Federation of Simulation Associations); **IES (**Intellectual Excellence Service); **IFC (**International Professional Certification and Evaluation); **UBC (**Budapest Joint Transformative Research Centre- jointly with University of Budapest for Technology and Economics and Szent Istvan University); **EON-UBT (**Joint Excellence Centre of Augmented and Virtual Reality – Immersive Technology); **UBT Institute for Urban Studies and Spatial Planning** etc.

"Hub Revolution Your Start Up" Center: In October 2024, UBT inaugurated this center in collaboration with Italian partners at its Smart City campus in Lipjan. The hub serves as an innovation and professional development center, fostering dialogue between academia and business to facilitate knowledge transfer and entrepreneurship.

Gold Venture Investments Western Balkan: Established in partnership with Israel's GVI Global, this company aims to support startups, public and private enterprises, and the civil society sector across the Western Balkans, contributing to sustainable economic development and international market expansion.

Thus; UBT has been playing a crucial role, both in developing the ethos and systems of a smarter society and giving people hope through supporting their journey to attain qualifications, engage in research, development work or entrepreneurial endeavor. UBT has contributed to enhancing employability prospects and personal fulfilment for various segments of the population availing of our services. The Institution has specifically made a mark in helping Kosovo become a member in international bodies, as such as IPMA, EOQ, IFAC, EUROSIM etc.

When it comes to written statements and public engagement toward entrepreneurship, it is important to refer the UBT Integrated Strategy 2027, which is constituted by the following objectives, among others:

- UBT will foster four challenges to regional and global needs: Caring for our environment: environmental science, design, engineering, architecture and social structure; Promoting wellness in our communities: access and equity in education and health outcomes, community-based participatory research, biomedical sciences and entrepreneurship; Food and fuel security: sustainable food systems, precision agriculture, energy production, transmission and storage; Securing the future: cybersecurity, governance and public policy.
- "UBT College will enhance education of undergraduates and graduate students through increased participation in **research, creative and entrepreneurial activities** by 10% by 2022";
- UBT Students will be encouraged to consider **entrepreneurship as a career option** through extracurricular awareness and taster programs, as well as embedded modules, assignments or dedicated degree programs within the UBT suite of curricula.

The university's establishment of over 100 spin-offs and its proactive role in creating more than 80 business functions reflect the broader economic revitalization efforts in Kosovo. UBT's initiatives, such as the UBT Science and Technology Park and the EON Virtual and Augmented Reality Center, illustrate its commitment to advancing technology and fostering a vibrant entrepreneurial ecosystem.

UBT's growth and impact have been profound. It has become a central player in Kosovo's economy, significantly contributing to the job market and individual sectors. For example, 65% of ICT sector employees hold UBT degrees and over 1,000 jobs are created annually through the UBT Ecosystem – including its Spin-Offs, UBT Alumni and newly-established independent businesses supported by the UBT Accelerator – highlighting UBT's direct and

fundamental contribution to Kosovo's growth. The university's international acclaim, including awards like the "European Young Entrepreneurial University of the Year" and high rankings in global university assessments, underscores its pivotal role in positioning Kosovo as a hub for innovation and skilled labor. This is also a reflection on Prof Hajrizi, who understood the needs of his region and created the right opportunities for its development in key sectors.

8. Impacts and Lessons Learned

The implementation and ongoing development of the UBT "SMART City" model—designed as a Small-Scale Smart Sustainable System—has generated multiple layered impacts, particularly within the fields of education, urban planning, and socio-economic-environmental transformation. These impacts can be summarized as follows:

Educational Impact

The UBT "SMART City" has demonstrated significant educational value by fostering future-ready competencies through the integration of theoretical knowledge and practical skills. The model serves as a vibrant community center for experiential learning and interdisciplinary education, enabling students, academicians, and others researchers to use and benefit from emerging technologies such as AI, IoT, AVR, and digital twins. This environment facilitates **skill development in systems thinking, urban innovation, and digital transformation**, while also promoting **knowledge integration across engineering, policy development, urban planning and design, ICT, and sustainability practices**. By incorporating methodologies such as life-cycle-based design and user-centered approaches, the model cultivates problem-solving capabilities aligned with the demands of the 4th Industrial Revolution.

Urban Planning Impact

From a spatial planning perspective, the UBT "SMART City" provides a **scalable and transferable framework** that models how smart infrastructure and urban services can co-exist in a compact, integrated ecosystem. This approach introduces **new planning tools**, including dynamic land-use systems, place-based innovation ecosystems, and real-time feedback. As such, it contributes to a **cultural shift in planning**, moving from static, top-down approaches to **adaptive urbanism**. The model aligns with global trends toward compact, walkable urban forms—similar to the "15-minute city" which could be replicated in bigger scale of urban environments.

Socio-Economic and Environmental Contributions

The UBT "SMART City" Model lies in its ability to support **entrepreneurship, innovation, and job creation** within a community-centric environment. The embedded innovation hubs, spin-offs, and research centers contribute to local development by supporting knowledge-based economies. Moreover, the integration of **sustainable energy systems, green spaces, water and waste management and recycling** reinforces the model's alignment with climate transition.

Finally, the UBT "SMART City" illustrates the necessity of **multidisciplinary collaboration**, **user involvement**, and **iterative design testing** in smart urban development. As such, the model stands as an innovative model of convergence between **pedagogy, urbanism, and technology**, by offering a replicable paradigm for next-generation urban transformation.

9. Challenges and Opportunities

Small-scale entrepreneurial ecosystems, such as those developed by UBT in Kosovo, face inherent limitations that constrain their growth and broader economic impact. These limitations often arise from constrained financial resources, limited local markets, and underdeveloped institutional infrastructure necessary for innovation scaling (Stam, 2015). Although UBT has generated over 30 impactful innovations and more than 100 spin-offs, the size and economic capacity of the local environment limit startups' potential for sustainable market expansion and scaling (Isenberg, 2011). Moreover, emerging ecosystems typically encounter challenges related to immature regulatory frameworks and insufficient access to venture capital, which restrict the transition of ideas from incubation to commercialization (Spigel, 2017).

Managing complexity within such ecosystems requires effective governance and multi-stakeholder collaboration involving academia, industry, government, and civil society (Cohen, 2006). UBT's model integrates education, research, incubation, and acceleration functions to foster cross-disciplinary cooperation, which is critical in innovation ecosystems (Autio, 2014). However, scaling these systems demands overcoming structural bottlenecks, such as fragmented markets and limited human capital specialized in emerging technologies like artificial intelligence and augmented reality (Mason & Brown, 2014). Furthermore, the presence of multiple innovation hubs necessitates coordinated resource allocation to avoid duplication and ensure ecosystem cohesion (Martin & Sunley, 2011). Investments in infrastructure and capacity building are pivotal to support the adoption and diffusion of new technologies (Feldman & Zoller, 2012).

The experience of UBT's entrepreneurial ecosystem reveals significant opportunities for policy transfer, regional replication, and cross-border learning. Given the socio-economic similarities within the Western Balkans, best practices developed in Kosovo can inform regional policy frameworks to promote entrepreneurship and innovation (Rogers, 2003). UBT's partnerships, such as the Gold Venture Investments Western Balkan collaboration and memberships in international bodies like IPMA and EUROSIM, facilitate knowledge exchange and the harmonization of innovation policies (Bercovitz & Feldman, 2008). Innovation hubs like "Hub Revolution Your Start Up" serve as platforms to foster dialogue between academia and business, enabling replication of ecosystem components in neighboring countries with contextual adjustments (Bathelt, Malmberg & Maskell, 2004). Cross-border learning accelerates ecosystem development by integrating diverse experiences and catalyzing regional innovation clusters (Asheim & Isaksen, 2002).

In conclusion, small-scale entrepreneurial ecosystems face limitations related to market size, funding, and institutional maturity, making complexity management and strategic scaling critical for sustainable growth. UBT's integrated ecosystem approach provides a valuable framework for addressing these challenges. Leveraging opportunities for policy transfer and cross-border collaboration can expand the ecosystem's impact, contributing to economic development and innovation capacity building across the Western Balkans region.

10.Conclusion and Future Outlook

UBT's "SMART City" initiative serves as a crucial testbed for future urban planning, enabling applied experimentation with emerging technologies such as the Internet of Things (IoT), artificial intelligence (AI), and augmented reality (AR) within an integrated urban environment. As Prof. Skender Kosumi emphasizes, this living laboratory approach allows researchers and practitioners to analyze complex urban systems in real time, facilitating the development of scalable, adaptive solutions to pressing challenges like energy efficiency, mobility, and environmental sustainability (Batty et al., 2012; Cocchia, 2014). The UBT SMART City campus in Lipjan exemplifies how testbeds can accelerate innovation diffusion and provide empirical data essential for evidence-based planning (Townsend, 2013).

From an educational perspective, the initiative significantly enriches planning curricula by fostering experiential learning and interdisciplinary collaboration. Engaging students directly with cutting-edge technologies cultivates competencies in systems thinking, data analytics, and participatory governance, skills identified as essential for contemporary urban planners (Wiek et al., 2011; Angelidou, 2015). Moreover, embedding the SMART City concept within an entrepreneurial ecosystem aligns with calls for integrating innovation and sustainability into planning education to prepare graduates for dynamic urban futures (Haughton & Hunter, 2004; Sisson & Stough, 2017).

Key lessons for educators, planners, and policymakers emerging from the UBT experience include the necessity of embedding adaptive, technology-driven frameworks within urban planning and education to respond flexibly to rapid technological advances and complex social dynamics (Caragliu et al., 2011; Dameri, 2013).

Looking forward, the vision for UBT's SMART City involves expanding technological infrastructure, deepening multi-stakeholder collaborations, and scaling pilot projects to influence broader urban areas, thereby enhancing

regional resilience and sustainability (Kitchin, 2014; Nam & Pardo, 2011). UBT's initiative positions the university as a regional leader in smart city research and innovation, fostering cross-border knowledge exchange and contributing to policy formulation beyond Kosovo's borders.

Thus, it is to conclude that UBT's SMART City initiative advances planning education and practice by integrating technology, sustainability, and entrepreneurship in a real-world setting, offering a replicable model for other emerging economies. Its ongoing development promises significant impacts on regional urban transformation, equipping future planners with the tools and mindset to design adaptive, inclusive, and resilient cities (Georges et al., 2020; Angelidou, 2014).

Conclusion: Building a Sustainable Future through Education

The role of education in promoting urban sustainability is multifaceted and far-reaching. From early childhood education to higher learning, from community engagement to leveraging technology and policies, education is the cornerstone of a sustainable urban future.

Investing in sustainability education is an investment in our collective future. It empowers individuals to make informed choices, inspires innovation in sustainable practices, and strengthens communities to work together towards common goals. As we strive to create sustainable cities, the knowledge and values imparted through education will be our guiding light, ensuring that urban development progresses in harmony with environmental stewardship and social well-being.

Contemporary UPE is essentially rooted in the sustainable development paradigm, and its principles are part of the curricula of planning schools throughout the developed world. In the 1990s, the growing significance of the environment exerted a major influence on changes to UPE. Following the Brundtland Report, rising global environmental concerns caused the purpose of planning to shift from the seemingly benign management of environmental change to the explicitly normative goal of achieving sustainable development (Davoudi and Pendlebury, 2010). At this time, it became commonplace to see planning as having to be basically oriented toward solving the needs of society within the framework of sustainable development (AESOP, 1995).

However, there are no common core curricula or even universally agreed guidelines for UPE, and even within Europe, planning schools do not agree on the competences professional planners should have (Frank et al., 2014; Mironowicz, 2015). Although some authors have suggested the development of a uniform Western planning doctrine (Kunzman, 2004), there is a considerable need to adapt planning to local circumstances and to recognise the specific features of the environment in which the planning education curriculum and educational approach are applied (Frank et al., 2014; Mironowicz, 2015). Political and socio-cultural realities and specific environmental and ecological challenges make the contextual grounding of UPE essential.

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Sismopoli, playing cities in risk

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Abstract
The limited attention given to risk management in public policy, combined with a lack of awareness among civil society, has led major international organizations to recommend innovative and effective communication strategies. These strategies aim to engage communities in the critical issues shaping our cities, foster interest in the spaces we inhabit daily, and promote a culture of prevention.

This contribution introduces Sismopoli, a serious game focused on seismic risk reduction from an urban planning perspective. The game serves as a tool to make complex issues more manageable and understandable. Its goal is to stimulate knowledge-building processes by encouraging players to view the territory as a common good, where risk reduction is a vital component and planning is the key tool for addressing priority issues in urban contexts.

Keywords: Urban planning, seismic risk awareness, serious games, board games

1. Introduction

Over the past fifty years, Italy has experienced seven major earthquakes—averaging one destructive event every seven years—compared to the national average of one seismic disaster every 4–5 years over the last 150 years (D'Agostino, 2024). This significant seismic hazard is compounded by the high vulnerability of buildings and the considerable exposure associated with Italy's dense population and long settlement history (Dolce et al., 2021; Guidoboni, 2018).

Nevertheless, few resources have been invested in proactive urban prevention policies or in awareness-raising and knowledge dissemination initiatives. As a result, risk management remains largely reactive, focusing on emergency response and reconstruction (Benigni et al., 2024; Balducci et al., 2021; Coviello et al., 2021; Fera, 2020).

The inherent uncertainty surrounding seismic phenomena and their management (Doyle et al., 2019), combined with low public risk perception and widespread gaps in relevant knowledge and skills, are key factors that hinder or delay the implementation of effective risk reduction and mitigation strategies (Crescimbene et al., 2014). Behavioral sciences highlight cognitive limitations among both public decision-makers and the general population, which obstruct political and administrative choices and divert attention from these pressing issues (Di Bucci et al., 2017; Speranza et al., 2019; UNDRR, 2022).

International organizations have strongly emphasized the importance of "understanding disasters," promoting the involvement of civil society and the adoption of both formal and non-formal educational approaches—accessible even to non-experts—to build a culture of safety and resilience at all levels, including professional training (ISDR, 2005). Seven years after the launch of the Sendai Framework (UNDRR, 2015), the 2022 Global Assessment Report on Disaster Risk Reduction further underscores the need to move away from top-down, solely scientific approaches in favor of more participatory, community-based Disaster Risk Reduction (DRR) strategies (UNDRR, 2022). Despite these global efforts, awareness of seismic risk remains limited, particularly at the community level.

In Italy, even with the two-decade experience of the Edurisk project and its significant efforts in seismic risk communication, this topic continues to struggle for attention within scientific education (Musacchio et al., 2023; Faravelli et al., 2024). Developing scientific expertise in risk management—especially in relation to urban areas and planning—is inherently complex, interdisciplinary, and multidimensional. Disasters are not merely the result of natural hazards but are also deeply rooted in human systems; studying their impacts requires examining exposure and vulnerability in urban and territorial contexts. Therefore, planning and urban policy must play a central role in defining how territories are used and transformed to reduce disaster risk.

Italy's higher education offerings in seismic risk reduction remain limited, especially outside of specialized technical fields. This gap in higher education mirrors shortcomings at the secondary school level, which in turn affects public awareness.

Engaging citizens in the core issues that shape our cities—both in everyday governance and in extraordinary contexts—can foster interest in the places we live and stimulate awareness around caring for and protecting seismically vulnerable urban areas. This process encourages a "return to the territory" in the territorialist sense, where the land is viewed as a common good (Magnaghi, 2012, 2020). Ensuring equitable access and safety becomes a fundamental right. In this light, seismic risk reduction should be seen as a collective responsibility tied to the public good, requiring integrated approaches and shared action (Di Bucci et al., 2017).

To shift societal approaches to risk, traditional training must be complemented by innovative educational and communication methodologies that allow people to imagine and reflect on potential urban futures (Hawthorn et al., 2023). Serious games—defined as games designed for purposes beyond entertainment (Abt, 1970)—can serve as effective tools to support learning about critical topics such as risk reduction (Schouten et al., 2017).

This article explores how game-based learning can support interdisciplinary education while enhancing community awareness of risk from an active citizenship perspective. We present Sismopoli, a serious game we have designed and begun testing, which focuses on seismic risk reduction in relation to urban planning. The complexity of this subject area—its scenario-based nature and the dynamics involved—makes it particularly suitable for interactive learning methods. Game mechanics allow participants to explore different scenarios, make decisions, and analyze their consequences.

To this end, the study was set up on three educational interpretative paths, both as a conceptual framework for the analysis of existing serious games, and as a guide for the development and objectives of Sismopoli: educating on i) the care of the territory, ii) the understanding of risk and iii) the promotion of community participation.

The contribution proposes a first review of the state of the educational offer related to risks in Italy and the use of serious games in the field of risk education in urban areas (Chapter 2); an analysis of existing games based on a taxonomy focused on the three key educational paths (Chapter 3); the illustration of the current version of Sismopoli declined in the proposed educational objectives (Chapter 4); the results of the initial experiments (Chapter 5); the conclusions and considerations for further developments (Chapter 6).

2. Serious game for urban seismic risk reduction

In Italy, the topic of risk reduction remains marginal in higher education courses related to urban and territorial planning. Similarly, an urban or territorial perspective is largely absent in the disciplinary fields—such as geology and engineering—where risk-related issues are typically addressed.

A lexical analysis of Italian university curricula, based on the Ministerial Decree of 16 March 2007, reveals that the terms territory and environment, when referring to spatial organization and transformation, appear in the educational objectives of degree programs in Earth Sciences, Environmental Studies, Human Geography, Engineering, Technology, and Planning. However, a closer look at the degree classes that include competencies in urban and regional planning reveals a notable absence of terms such as risk, prevention, soil defense, safety, and emergency. The term hazard is limited to programs in geological sciences, while vulnerability and exposure are not mentioned at all.

This suggests that risk reduction is still largely confined to scientific and technical domains such as geology, geotechnics, and engineering. Urban planning education, although occasionally intersecting with geological concerns, addresses them only superficially. The result is a foundational training that lacks a comprehensive understanding of the multiple dimensions of risk.

This gap extends to lower levels of education as well. A study of over 160 textbooks across 36 European countries found a general lack of content and activities aimed at raising awareness, building knowledge, or fostering sensitivity around disaster risk reduction (Komac, 2013).

To bridge this gap, it is essential to develop new tools for risk education—tools that connect disciplines, unify fragmented terminologies, and encourage interdisciplinary collaboration. In recent years, simulations, games, and interactive activities have gained traction in urban planning and governance as means of engaging communities on collective issues, stimulating reflection on the future of cities and territories, and imagining alternative scenarios.

The integration of playful elements into serious contexts—recognized by Abt (1970) as a powerful way to achieve educational goals—has significantly evolved in the past two decades, especially with the advent of new technologies (Ciziceno, 2023). The interactive nature, active engagement, and social dimension of serious games make them particularly well-suited to learning in complex domains such as socio-spatial planning (Kolb et al., 1984; McGonigal, 2011; Chow et al., 2011). Within urban and environmental disciplines, serious games have been employed to explore issues such as land use, transportation, ecological sustainability, and natural resource management (Coppard & Goodman, 1979; Ampatzidou, 2018).

Applying this approach to seismic risk reduction from an urban planning perspective reveals the potential of serious games to foster community awareness and make complex concepts more accessible.

In fact, it is possible to identify several shared characteristics between disaster risk reduction and serious games (see Fig. 1).

Fig. 1. Links between disaster risk reduction and serious game features.

1.The unpredictability of seismic events, inherent in the phenomenon's nature, and the resulting uncertainty of public decision makers in making decisions in complex urban contexts, is appropriately reflected in the typical randomness of games (e.g., random dice rolls or card draws).

2.The scenario-based approach of risk management, centered on managing and planning different options under uncertainty, can be effectively simplified through the simulation aspects of games. This experience encourages hypothetical reasoning, the evaluation of options and strategies, both in terms of potential moves and broader spatial configurations.

3.The roles of stakeholders involved in urban planning closely mirror those of the game. Public and private actors, operating at multiple levels of governance and representing civil society in discussions on complex and interdisciplinary issues, can be assimilated to players interacting in role-playing games, board games, live simulations, engaging in direct dialogue on different issues and testing their ability to collaborate.

4.The complexity of governance in urban risk reduction processes, defined by specific objectives, can be compared to game dynamics. These include abstract elements such as constraints, emotions, storylines and a sense of progression, as well as game mechanics, which include interactions between players, time and resource management and strategy development (Werbach and Hunter, 2020).

3. Three educational paths to raise community awareness

Based on research conducted by the CNR working group (Giuffrè et al. 2025), 39 serious games were analyzed that address issues related to natural risks and their management in complex environments, such as urban areas. The aim was to identify potential overlaps, shared approaches and open questions to develop new proposals that could frame urban risk reduction as a common good.

The analysis was structured around several general and specific parameters related to the three educational paths that the research aimed to explore: a) care of the territory, b) understanding of risk, c) community participation (see Fig. 2).

Fig. 2. Parameters considered to analyze the selected serious games

1) Care of the territory

The analysis investigated how games make us reflect on the concept of territory as a common good, that is, an urban space in which the community relates and recognizes itself. Educating to care for the territory means working with communities, in a material sense - protecting the resources of a specific place - and in an immaterial sense, promoting care for others and relationships that connect or facilitate communication between communities and social groups. The parameters used for the analysis of the games referred to (i) the spatial dimension, understood as the representation of buildings, functions, infrastructures and public spaces to interact with, through game boards, digital screens or abstract forms such as narratives and images, (ii) the community dimension, in which care actions of common spaces were proposed, promoting the sense of belonging to places through cooperation and decisions sharing for the protection of structures and public spaces, (iii) environmental sustainability as a collective objective, highlighting its impact on spatial quality and stimulating reflection on the challenges of management and exploitation of resources.

2) Understanding risk

The aim of this training path is to introduce the community to the concept of natural risk as an interaction between a physical phenomenon and society. This perspective frames earthquakes not only as natural events, but also as events that affect people and property, incorporating both the spatial and socio-cultural dimensions. The parameters used for the analysis took into account (i) the specific type of risk, with particular attention to seismic risk, (ii) the identification of the DRM cycle phase(s) referred to in the game, (iii) the role of the different risk factors and their interactions.

3) Community participation
The third training path is based on the idea that planning for prevention and risk reduction has a strong social and collective dimension, which cannot be separated from a process of sharing with communities (Wisner, 2006). The involvement between experts and citizens implements a process of mutual learning that not only improves knowledge, but also promotes a change in perspective and point of view (Musacchio et al., 2019). The parameters used for the analysis referred to (i) the methods of victory, whether they are linked to the achievement of common or individual objectives, (ii) the presence or absence of moments of discussion and cooperation on the choices to be made during the game, (iii) attention to social cohesion as an educational objective, promoting a culture of relationships, belonging and diversity.

The different games analysis focused on seismic risk or multi-risk, read in the light of the three training paths, shows the almost total absence of games that simultaneously satisfy all the parameters considered. In general, it can be noted that there are few cases in which explicit reference is made to the connection with urban planning and almost never all the phases of the disaster cycle are treated, giving priority only to the phases related to preparation and response; individual game modes are preferred to interactive ones, in which shared solutions are sought, and, from the point of view of the victory of the game, the individual victory prevails or, in the best of cases, mixed, to the detriment of collaborative approaches.

4. Sismopoli, the city that dares to play: scientific context, game description and goals
The topic of seismic risk reduction at the urban scale was introduced in Italy starting from the 80s, when some regional public administrations particularly attentive to these issues, started an intense technical-scientific experimentation on some smaller urban centers. On this occasion, the concept of "urban vulnerability" was introduced, overcoming the approach of mitigating the seismic risk of the single building, towards a systemic prevention perspective extended to the entire settlement; a multidimensional concept influenced by the characteristics of the building, the functional systems (Fiore et al., 2018; Anastassiadis et al., 2007; Kyprianou, et al., 2022) and socio-economic factors (Cutter et al., 2003; Pricope et al., 2019; Blackwood and Cutter, 2023) was thus proposed. This approach began to take shape more concretely in this direction after the seismic event that hit the Abruzzo Region on 6 April 2009. Following the extensive urban damage caused by that earthquake, the Italian government introduced a significant funding program of approximately 1.2 billion euros (Castenetto, 2024) to finance risk management interventions in seismically prone territories. Through the National Plan for the Prevention of Seismic Risk (PNPRS), the State launched an ambitious program of Seismic Microzonation (SM) investigations, Emergency Limit Conditions (ELC) analysis and structural interventions on buildings. Although the allocated funding represents only a small fraction of the average annual expected cost of earthquake damage (Dolce 2012), the PNPRS is the first seismic prevention plan in Italy that considers prevention also from an urban planning perspective on a national scale (Bramerini et al., 2013). These efforts have also favored the systematization of various types of knowledge and a more integrated vision of seismic prevention in urban contexts (Tomassoni et al., 2023).

The technical-scientific evolution of this approach subsequently led to the conceptualization of the limit conditions of settlements (Cavinato, 2013) which define a scale of performance levels for the urban center to be preserved in the event of an earthquake (Bramerini et al., 2013), as a reference for the planning of mitigation interventions. Considering emergency management as the minimum objective, in recent years several experiments have been launched that refer to more advanced levels of settlement performance for the recovery start-up phase (Fontana et al., 2024) and for post-earthquake recovery (Cattari et al., 2024). The logic that accompanies these approaches, and that we can find in the proposed research, refers to a gradual involvement of urban functions and systems in seismic risk reduction policies to ensure ever-increasing settlement performance: starting from the urban system responsible for emergency management, the subsequent recovery start-up objective also involves the school function and with the third, recovery, other urban functions are added, creating an increasingly complex system.

4.1 Sismopoli and the three educational paths

Sismopoli is a multiplayer board game, designed for 2-6 players and tested with students aged 16 and up, but also with a wider audience and with different scientific backgrounds. The aim of the game is to improve urban safety in a simulated settlement, divided into neighbourhoods with housing and urban functions, located in a region with variable local seismic effects due to the specific characteristics of the terrain.

In line with the risk management cycle, players must work together to retrofit buildings hosting public and private functions and ensure the safety of roads and public spaces in preparation for a potential earthquake. This will allow them to effectively manage the emergency phase, facilitate recovery and gradually rebuild more safely.

The performance requirements for the settlement are based on a scale of three safety levels to be achieved (see Fig. 3), gradually more complex: from the minimum safety level (the emergency management) to an intermediate level (the beginning of the recovery phase of the settlement), up to the complete level (the total reconstruction of the affected settlement).

Fig. 3. Different levels of settlement safety: a. emergency management; b. early recovery; c. long-term recovery.

The choice of the security level to be pursued, defined in agreement between the players, implies a different complexity of the gaming experience: each level corresponds to a different number of elements to protect, resources to invest and time to allocate. The main objective is to reduce the vulnerability (transform the buildings from red to green) of all the public use functions considered in the system, as well as of the "interfering" residential functions on strategic routes, whose collapse can interrupt the main communication routes and cause significant delays to emergency operations (Basaglia, 2018). The selected system is highlighted by a red line that connects the various elements and changes configuration depending on the objective, making the game board a dynamic tool (see Fig. 3).

The perimeter path of the board includes: "Interventions", to reduce the vulnerability of private and public buildings; "Knowledge", to deepen the understanding of seismic risk; "Bonus" and "Unexpected", where players encounter positive or unexpected critical situations; and finally, "Earthquake", which triggers the seismic event, affecting all players and elements on the board.

The game is designed to achieve two victories: a collective one, in which the entire urban system reaches the expected safety level, marking the end of the game, and an individual one. If the collective goal is not achieved at the time of the earthquake, the individual success is determined by the number of residential and public use functions still existing in each neighborhood, as well as their vulnerability class.

The general objective of Sismopoli is to contribute to a greater awareness of seismic risk and, as previously mentioned, to stimulate knowledge processes in terms of care of the territory as a common good, considering

risk reduction as a crucial component. The proposed educational paths, translated into various forms in the dynamics and rules of the game, – education on the territory, risk and participation – represent in our opinion the key aspects to address the issue of risk prevention.

The theme of "care of the territory" has been structured around the three parameters identified in Fig.2. The spatial dimension is represented in a game board explicitly inspired by a medium-sized urban system, divided into neighborhoods and streets, where urban and residential functions are positioned. There are ordinary urban functions that satisfy the essential needs of daily life and the residential function, with several homes located along the connecting roads and a central public square, which serves as an emergency area in the event of an earthquake. The key functions related to emergency management are also present. The collective dimension is in line with the specific goal of the game: to make the city safer by prioritizing public functions, streets and the main square, taking into account the available resources, time constraints and priorities of each group of players. Interventions on the urban system and its components lead to a reduction in the potential environmental sustainability caused by debris production and land consumption, which would otherwise occur to meet post-earthquake housing demand.

The theme of "risk understanding", structured around the management of the seismic event, is organized according to the phases of the disaster cycle: the prevention phase, in which the actors strengthen the elements of the chosen safety system and prepare to manage the emergency effectively; the response phase, in which the operational functionality of the three strategic buildings must be guaranteed and the capacity of the emergency area in the main square must be sufficient to accommodate all displaced residents; the recovery phase, in which the reconstruction of collapsed buildings begins, damaged structures are reinforced to reduce vulnerability, and new earthquake-resistant homes are built to better withstand future seismic events. In order to implement targeted interventions aimed at achieving specific levels of safety, actors must understand the role of individual risk factors and their interactions. The components of risk – geological hazard, building vulnerability, and exposure of people and property – form the basis of the game dynamics.

The theme of "community participation" is structured around the assignment of roles: each player is responsible for the safety of a strategic or ordinary function and of one of the six city districts, thus representing both individual interests and those of the entire community. The game includes both collaborative and individual victory conditions, but they are not equivalent. During the game, several moments of discussion and decision-making take place, from the definition of collective objectives to the determination of priority interventions.

Figura 4. Laboratorio Sismopoli

5. Sismopoli Laboratory: playability and first evaluations of the increase in awareness

After developing the prototype and conducting initial team tests, a preliminary assessment of the game's usability and playability was carried out in 2024 during three events: a dedicated workshop at the Institute of Environmental Geology and Geoengineering of the National Research Council (CNR-IGAG); the "I4SCIENCE – European Researchers' Night" event, part of the Horizon Europe - Marie Skłodowska-Curie Actions (MSCA) program for 2024–2025; and the "Malnisio Science Festival 2024." Participants, aged 10 to 49, came from diverse educational and professional backgrounds. Two game masters led the sessions, guiding gameplay and encouraging discussion and group reasoning with active engagement.

After playing, participants completed a 24-item questionnaire adapted from the "Game Experience Questionnaire" (Ijsselsteijn et al., 2013), tailored specifically to serious games and Sismopoli. Preliminary results provided valuable insights into the game's usability and engagement. The mechanics were found to be well-balanced and easy to follow; all participants successfully engaged with the instructions and gameplay on a board they found visually and structurally engaging. This is particularly notable given that a third of the participants were between 10 and 15 years old. Fewer than 10% struggled to understand the game's objectives initially, and 90% agreed that the number of tokens was appropriate for gameplay.

Emotionally, players appeared entertained and engaged. Nearly all expressed a desire to play again and maintained focus throughout, even while others took their turns—actively following decisions made by their peers. Only two participants reported moments of distraction. Most players aimed to make as many moves as possible, hoping their token would land in either the "intervention" or "bonus" spaces. The game's challenge, heightened by time constraints, was seen as satisfying. Around 70% feared landing in the "earthquake" space, which ends the game—indicating successful creation of tension and emotional involvement. Overall, results suggest strong performance in terms of rule clarity, enjoyment, and challenge, with minor adjustments needed to improve the engagement of the educational content.

However, the survey also revealed a notable inclination toward individual competition over collaboration. Despite the game allowing both individual and collective victory modes, approximately 60% of participants admitted to focusing their actions within their own areas of expertise to increase their chances of winning. Only 25%

engaged in discussion with other players, and just one-third reported appreciating or offering advice, indicating limited cooperation.

A second, more structured evaluation phase was carried out as part of the institutional project "Roma Scuola Aperta – Mappa della Città Educante 2024–2025," promoted by the Municipality of Rome to offer educational and training initiatives in schools. The Sismopoli Laboratory was introduced at the "Galileo Galilei" High School of Applied Sciences to assess the game's effectiveness in raising awareness about seismic risk, particularly regarding fostering a sense of responsibility toward the territory as a common good.

The lab was structured in two phases: an initial training session introducing the key concepts of urban seismic risk reduction, followed by a gameplay session to apply the knowledge in an experiential context. Topics addressed spanned multiple disciplines—earth sciences, engineering, urban and territorial planning, environmental and civic education.

To evaluate the laboratory's effectiveness, students completed a paper-based group test consisting of 30 multiple-choice questions, categorized into the three educational themes central to the research: the territory as a common good, risk, and community. The questionnaire included both cognitive and non-cognitive items and was administered twice: at the beginning (pre-test) and end (post-test) of the laboratory. In the first round, responses were based on prior knowledge and opinions; in the second, students answered after having experienced the game and associated discussions.

Evaluation was based on a scale from 1 to 4, reflecting the degree of alignment with the concept of risk awareness—understood here in line with Gambino (2005), as the recognition of territory as the outcome of complex and historically determined relationships between natural and human factors.

An initial set of non-evaluative questions gathered sociographic data (e.g., school distance from home and mode of transport) to provide context regarding students' community relationships and their use of public services.

Questions relating to territory prompted reflection on the idea of the city as the "home of society" (Salzano, 2008)—a place of interaction, functionality, and shared space, where care for the urban environment becomes a collective responsibility. These questions, which were directly addressed in gameplay, encouraged reflection on environmental stewardship and social responsibility.

The risk section assessed technical understanding of hazard factors, their interactions, seismic exposure in Italy, emotional responses, and capacity for reaction. It also addressed necessary skills, involved disciplines, and key stakeholders in risk management.

Finally, the participation section evaluated the extent to which individuals were willing to contribute, collaborate in group settings, and share life experiences in a civic context.

The lab was tested with a fifth-year class of 17 students. Results from the pre-test showed a relatively high baseline of knowledge: on a scale of 1 to 4, scores ranged from 2.8 to 3.6, with a class average of 3.2. The post-test showed a slight improvement, with a minimum score of 3.1, a maximum of 3.6, and an average of 3.3—indicating that, although the class was already well-prepared, the game contributed to a modest enhancement in awareness and understanding.

6. Conclusions

Disaster risk reduction at the urban scale represents a highly complex field of application. It involves multiple disciplinary areas, a variety of public and private stakeholders, and social issues that directly affect citizens and civil society at large. Despite the growing urgency of this issue—highlighted by the increasing frequency of extreme events in Italy and beyond—there remains a noticeable reluctance among public decision-makers and a general

lack of awareness within civil society. This disconnect is also evident in the education sector: disaster risk management is inadequately addressed in both higher education and in primary and secondary school curricula. As a result, the topic is often relegated exclusively to scientific disciplines, where it is approached in a highly sectoral and fragmented manner.

Leading international organizations are urging greater efforts to raise risk awareness in a comprehensive manner—one that encompasses all phases of the disaster cycle. They advocate for innovative and diverse modes of knowledge transmission, including peer-to-peer, formal, and non-formal learning methods.

In this context, the CNR research group has developed Sismopoli, a serious game designed to raise awareness about seismic risk in urban environments. Serious games are increasingly recognized as effective tools for conveying important messages in engaging and interactive formats. Sismopoli aims to foster awareness not only among school and university students, but also within broader civil society, by stimulating reflection on environmental and territorial issues that impact us all.

Sismopoli's primary objective is to promote greater risk awareness and to encourage a renewed sense of connection to the territory—framed as a catalyst for political and cultural change that recognizes the territory as a common good.

Inspired by existing practices in both technical planning and participatory engagement, Sismopoli uses a board game format to simulate the management of an urban area located in a seismic zone. The game draws upon theoretical and regulatory frameworks from the field of disaster prevention, reinterpreting them within the gameplay as models of territorial intervention. In particular, the game simulates an actual risk prevention initiative currently active in Italy, financed by the National Plan for the Prevention of Seismic Risk (Article 11, Law 77/2009). Since 2012, this initiative has involved over 3,500 Italian municipalities located in medium to high seismic risk zones—making the game an authentic reflection of real-world practice.

A review of 39 risk management games revealed a striking lack of tools that address risk reduction across the full disaster cycle. Very few incorporate urban planning perspectives. Sismopoli aims to fill this gap by offering a comprehensive, planning-based approach to seismic risk.

Initial playability testing across various events showed that the game mechanics are intuitive and the gameplay is enjoyable, while still engaging players in achieving risk-related objectives.

The current phase of the research focuses on evaluating the effectiveness of Sismopoli in increasing awareness of seismic risk. A structured educational laboratory was recently implemented at a secondary school in Rome as part of the institutional initiative Roma Scuola Aperta – Mappa della Città Educante 2024–2025, which promotes educational programs across schools. The evaluation was carried out through pre- and post-activity questionnaires, yielding promising results regarding student engagement and learning.

Simultaneously, the game is being disseminated more widely through public outreach efforts, including participation in scientific festivals and communication activities promoted by the National Research Council (CNR). These efforts aim to bring the game into classrooms, communities, and broader public settings.

The ultimate goal of Sismopoli is to initiate a broader path of public awareness, starting from simplified, engaging experiences that introduce the complex issue of seismic risk reduction in urban environments. The next phase will involve integrating the simulation into citizen science initiatives, allowing participants to apply the knowledge gained from the game in real-world contexts, directly within their own territories.

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Epistemological Uncertainties in Planning Education: The Transformative Role of Studio Pedagogy

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Abstract
Planning education faces a persistent challenge: equipping planners with the knowledge and skills to navigate an increasingly uncertain and complex world. As Ferreira, Sykes and Batey (2009) metaphorically describe it, planning theory resembles the mythical multi-headed creature, the Hydra, in that it lacks a single dominant paradigm and is made up of multiple paradigms that coexist.The evolving nature of planning theory raises critical questions: This paper argues that studio pedagogy is a critical tool in equipping students with the necessary skills to respond to contemporary urban challenges. By repositioning studio pedagogy as a transformative learning environment, this study contributes to the debate on how planning education can better respond to contemporary socio-spatial challenges. We believe that a pedagogical transformation that goes beyond theoretical teaching and actively prepares students for the uncertainties and ethical complexities of professional planning practice is essential.

Keywords: planning theory; planning education; studio pedagogy; transformative learning

1. INTRODUCTION

Planning theory has been shaped by the successive and intertwined coexistence of different paradigms. The rationalist and technocratic approaches of the modernist era have gradually been criticised and replaced by more pluralistic and interpretive perspectives. In the postmodern condition, planning theory no longer adheres to a single dominant framework; instead, it has developed into a multi-paradigmatic structure marked by ongoing transformation. As Ferreira, Sykes and Batey (2009) metaphorically describe it, planning theory resembles the mythical multi-headed creature, the Hydra, in that it lacks a single dominant paradigm and is made up of multiple paradigms that coexist.

Rather than resting on a singular body of knowledge or method, planning exhibits a contextual, relational, and layered epistemological structure. This inherent diversity gives rise to a fundamental question: what types of knowledge should planning prioritise? Davoudi & Pendlebury (2010, p. 638) identify three key areas: (1) space as the core object of inquiry; (2) the nature of integrative knowledge; and (3) the interface between knowledge and action. It is precisely through the infusion of disciplinary and experiential knowledge that planning has carved out a distinctive position within the family of social sciences. What distinguishes planners from, for instance, geographers, is not only their critical thinking about space and place, but their aspiration to transform them (Davoudi, 2009). Planning is thus a mode of doing—an epistemic field grounded in action and interaction, in which knowledge becomes operative in shaping spatial futures .

This dynamic, practice-oriented nature of planning inevitably finds reflection in its educational practices and pedagogical structures. Planning education is a site of reflexive engagement with the evolving paradigms of planning theory. Jane Rendell (2013) states that disciplinary uncertainties and boundaries create a productive transitional space. In this spirit, this text rethinks the uncertainties at the boundaries of the planning discipline not as deficits or dilemmas, but as spaces of strategic potential and intellectual creativity.

Yet it is precisely this multidimensional character of the discipline that perpetuates a sense of crisis in planning education. As Kunzmann (Kunzmann, 1985, p. 442) notes, planning education has been in crisis since its inception and will continue to be so, but this should not be seen as a weakness. The inherent complexity of planning demands a pedagogical approach that is reflective, adaptive, and dynamic. To better understand how these transformations have shaped planning education, one must revisit the changing role of the studio, which was foundational to the discipline's early formation.

In this context, understanding the transformation of planning education is critical for assessing today's spatial, political, and ecological crises and building an effective pedagogical framework for the future. This study explores the following research question: How can studio pedagogy be used as a transformative learning environment to equip planning students with the knowledge and skills necessary to navigate contemporary socio-spatial challenges and epistemological uncertainties in planning education? In line with this question, the research will employ reflexive and situated learning methods.

2. PARADIGMATIC SHIFTS IN PLANNING EDUCATION AND THE EVOLUTION OF STUDIO PEDAGOGY

The planning discipline, unlike empirical sciences, deals with wicked problems that require a specific type of (scientific) approach (Rittel and Webber, 1973, p. 160). Because of this complexity, planning necessitates a comprehensive and integrative educational model that operates independently from the disciplines it is traditionally associated with Rooij and Frank, 2016, p. 483).

One of the most significant shifts in planning education emerged during the "social turn," when the discipline began to embrace a social science orientation. The evolution of studio pedagogy has been shaped by broader paradigm shifts in planning education. In response to urban issues of the late 1960s and early 1970s, planning discipline adopted a social science orientation, which changed planning education in a broad way, and in particular the definition of 'studio' as a pedagogical approach (Wetmore and Heumann, 1988). As planning education reoriented itself, studio courses in planning curricula were gradually reduced in some curricula, and in some planning schools they are only offered in the last semester. This reorientation in planning education can be described as a hidden curriculum (Baum, 1997) that transforms practice-oriented teaching.

A similar transformation can be observed in the context of Turkey. With the first planning department established in 1961, planning education was initially carried out with a more physical design-oriented approach. However, over time, the influence of social sciences has increased and the direction of planning education has changed, especially after 1980 with the impact of neoliberal policies. Despite this, studios have continued to exist as an essential component of practice-based pedagogy.

Whether planning is primarily understood as a social science or a design discipline, both traditions remain integral to the field; however, there may still be differences in focus and priorities (Biggs and Büchler, 2011). By the late 1990s and early 2000s—what (Anacker, 2024) refers to as the fourth era of planning—the studio once again became a subject of planning education research, reflecting a renewed interest in practice-based education and studio-based learning.

To respond to the complexities of contemporary urban life, we argue that studio pedagogy must be repositioned as a critical and transformative site of learning. By repositioning studio pedagogy as a transformative learning environment, this study contributes to the debate on how planning education can better respond to contemporary socio-spatial challenges. We believe that a pedagogical transformation that goes beyond theoretical teaching and actively prepares students for the uncertainties and ethical complexities of professional planning practice is essential.

3. THE RETURN OF THE STUDIO: PEDAGOGICAL POTENTIALS IN TIMES OF CRISIS

We argue that two key dynamics triggered the return of the studio in planning schools: (1) The Rise of Neoliberalism and the Importance of Space and (2) Ecological Thresholds and Social Inequalities. The strength of studio pedagogy lies not only in its capacity as a medium in which theoretical knowledge is transmitted and practice is learnt, but also in its capacity to encourage students to question the way they think when making ethical and political decisions.

1. The Rise of Neoliberalism and the Importance of Space: Davoudi (2017) argues that the resurgence of spatial planning in the 2000s was a response to an awareness of the importance of space. She links this to two theoretical developments: (1) relational space and (2) communicative action.

2. Ecological Thresholds and Social Inequalities: Increasing income inequality, housing problems, social exclusion, and crises related to food and water rights directly affect the content of planning. It is crucial to acknowledge that neoliberal policies not only exacerbate spatial inequalities, ecological crises, and social vulnerabilities but also utilise planning tools in the process.

In this context, understanding the transformation of planning education is critical for assessing today's spatial, political, and ecological crises and building an effective pedagogical framework for the future. By examining how planning theory translates into pedagogy, this study offers a framework for integrating equity and sustainability into planning education, ensuring that studio pedagogy evolves in response to contemporary crises. To make this evolution meaningful, it is necessary to understand not only what issues studios address, but how they function as environments for learning and transformation. In this regard, the studio's pedagogical structure becomes as important as its thematic content.

Studio teaching methods typically follow a "learning by doing" pedagogy (Schon, 1985). Studios are environments where students actively engage in place-based problem solving (Neuman, 2016), negotiating semi-structured and open-ended real-world problems situated within a physical and social context (Alizadeh, Tomerini and Colbran, 2017). One of the most influential studies on design education, Nigel Cross's Designerly Ways of Knowing (Cross, 1982), argues that much of what designers know about their own problem-solving processes remains as "tacit knowledge," which they struggle to externalise—thus leading design education to rely heavily on an apprenticeship model. Therefore, it is essential to investigate this tacit knowledge within studio courses: how it is produced, and how students discover and engage with it. It is crucial to articulate the specific learning characteristics associated with studio pedagogy and to evaluate its potential and limitations in addressing contemporary challenges in urban and regional planning education.

4. THE CASE OF "BAŞKA TÜRLÜ STÜDYO" IN PLANNING EDUCATION

As discussed in previous sections, the contemporary return of the planning studio demands not only a reconsideration of pedagogical form, but also a reimagining of the kinds of knowledge and practices that planning education should cultivate. To explore this further, this section presents a pedagogical experiment conducted in the third-semester undergraduate planning studio at Istanbul Technical University (ITU) during the 2022–2023 fall term. Titled Başka Türlü Stüdyo (Another Kind of Studio), this studio engaged cinematic techniques as a tool for spatial inquiry, offering a concrete example of how epistemological uncertainty and multidimensional knowledge can be translated into pedagogical method.

The studio was designed as a method-oriented inquiry into housing site planning and design, focused on the city of Gömeç in Balıkesir, located in western Türkiye. Drawing from site visits and grounded in everyday life observations, the studio was structured around the use of cinematographic products and techniques as a method for tracing spatial knowledge. The pedagogical intention was to reverse the traditional shift from upper-scale planning to design and execution, instead shifting from life scale to upper scale, based on human experiences and the immediate environment. Although this may seem very challenging for second-year students at the beginning of their planning education, they were able to adapt to this shift in scale while also benefiting from their first-year interdisciplinary studio experience. This intentional disruption of scalar hierarchy functioned as part of the studio's hidden curriculum (Purpel, 1983), fostering a transition from top-down planning approaches to bottom-up, situated spatial exploration.

The Başka Türlü Stüdyo unfolded through a carefully sequenced structure designed to foster a shift in how students perceive and represent space. The studio's workflow was structured in three key phases: (1) Field-Based cognitive mapping:, (2) Cinematic representation and analysis, and (3) Site-specific planning and design proposals. Each phase was underpinned by a different mode of inquiry—experiential, visual, and design-based—integrated into a broader pedagogical narrative.

1. Field-Based cognitive mapping: In the first phase, students conducted fieldwork in Gömeç and collected qualitative data on urban, ecological, and social dynamics. Their observations were translated into cognitive mappings enriched by direct quotes, personal impressions, everyday life images, and informal material evidence. The goal was to generate layered and situated understandings of space through lived experiences and affective readings of the site.

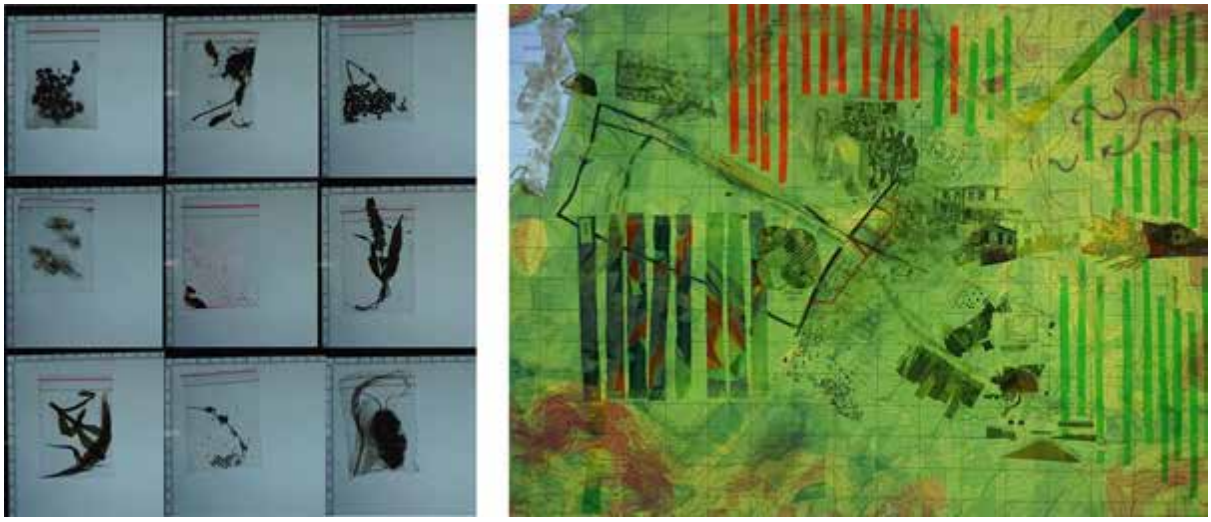

Figure1: Field-Based Cognitive Mapping

2. Cinematic representation and analysis: The second phase introduced cinema as a speculative research method. Students were asked to select a film of their choice—without genre or region constraints—provided that the film depicted domestic life and housing environments. They produced hand-drawn storyboards of key scenes, analysed the everyday rituals within domestic settings, and speculated on spatial organisation by drawing plans and sections. These interpretations were then transformed into scaled urban plan and physical models representing the film's spatial universe. This pedagogical strategy reversed the conventional scalar logic of planning education. Instead of beginning with macro-level planning frameworks, students started from the micro-scale of the dwelling unit and gradually expanded their focus to the neighborhood and settlement scale.

Figure2: Cinematic Representation and Analysis

Through this process, they were encouraged to develop a critical awareness of scale, perception, and material representation. By interpreting cinematic environments and transforming them into planning proposals, students navigated the relationship between imagination, representation, and spatial thinking.

Figure3: Models and Material Representation

3. Site-specific planning and design proposals: Drawing on insights from fieldwork and cinematic analysis, students developed comprehensive housing site plans for Gömeç. This phase involved a gradual scalar transition from interior to settlement level, enabling students to grasp the cognitive and practical challenges of spatial scaling. Students produced 1/1000 scale plans that responded to the ecological landscape and local social needs, proposing innovative, context-sensitive, and materially informed housing typologies. The use of experimental materials and model-making techniques encouraged tactile engagement with scale, form, and spatial organisation.

Figure4: Exhibition of The Başka Türlü Stüdyo

The use of cinematic tools in Başka Türlü Stüdyo served as a valuable medium for enriching the creative studio experience and facilitating students' perception of urban space across multiple scales. This approach enabled students to transition from an embodied, human-centered perspective to a more analytical, planning-oriented gaze. Through this pedagogical journey, cinema functioned not only as a representational technique but also as a cognitive device that guided students in navigating scalar complexities and engaging critically with spatial transformation.

5. CONCLUSION

This paper has explored how planning education can respond to the epistemological multiplicity of planning theory and the pressing crises of our time by rethinking the pedagogical potential of the studio. Beginning with the recognition that planning is a multi-paradigmatic and action-oriented field of knowledge, we examined how educational practices, particularly studio pedagogy, have evolved in tandem with shifts in the discipline's theoretical foundations.

Through a critical review of historical and contemporary developments, we argued that the studio must be repositioned—not merely as a site for practicing technical skills, but as a generative space for ethical reflection, creative speculation, and spatial imagination. Amidst ecological thresholds, deepening inequalities, and the instrumentalisation of planning under neoliberal regimes, the studio offers a unique pedagogical environment for confronting complex realities.

The Başka Türlü Stüdyo case study illustrated how reversing scalar hierarchies and integrating cinematic tools can enable students to navigate between lived experience and planning logic. By centering embodied perception, relational spatial thinking, and visual research, the studio functioned as a performative and reflexive learning environment, opening up new epistemic pathways for planning education.

More broadly, Başka Türlü Stüdyo exemplifies how visual culture and cinematic representation can be embedded into planning education as both an epistemic and creative practice. By positioning cinema as a planning tool, the studio facilitated students' transition from human-scale spatial perception to rational, studio-based thinking. This process enabled them to connect subjective experience with analytical inquiry. Through experimental techniques, the studio fostered critical engagement with issues such as ecological vulnerability, housing, and social inequality. This pedagogical experiment not only expanded the scope of studio-based learning but also cultivated a socially responsive and ecologically aware planning mindset. It reaffirmed the potential of studio pedagogy to operate as a dynamic interface between narrative imagination, empirical research, and spatial design.

Ultimately, reimagining the studio as a site of uncertainty, experimentation, and learning space the way for a more situated, inclusive, and resilient planning education that is capable of confronting the unknown and cultivating new imaginaries for spatial futures. In this context, understanding the transformation of planning education is critical for assessing today's spatial, political, and ecological crises and building an effective pedagogical framework for the future.

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AI + Geospatial Models for Engagement and Performance Measures in the Pedagogy of Sustainable Planning Studio

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Abstract
The emergence of the 15-minute city concept is linked to the climate crisis. Research on streamlining decisions in the planning practice to respond to this crisis shows that technology integration guides better decisions and strengthens citizen engagement. This paper focuses on two questions; will the use of AI tools help make public engagement truly meaningful? and how can technology platforms in urban planning curriculum enhance students' experience? I utilized an Artificial Intelligence tool to examine engagement and integrated mixed reality to develop neighbourhood scenario models in an undergraduate studio. Feedback from student assessment and peer's input yielded an effective engagement, appreciation for technology, geospatial platforms, and role play tools. Quantitative measures using campus standard surveys were utilized to measure the impact of the revised curriculum.

Key Words: AI, GIS, XR, Immersive Environment, Planning Studio

Cutting-edge Technologies & Urban Planning Practice

Research on the planning practice and automation shows that integration of cutting-edge technologies can inform decision making, enhance resource allocation, predict trends, and mobilize citizen engagement (Ghisleni, 2024). With the rapid economic growth and urbanization, cities are challenged with a myriad of problems (i.e. traffic congestion, noise, air and water pollution). City officials are rethinking their decision process through various scenario simulation and spatiotemporal analysis that examines socio-spatial inequalities and prepares for sustainable urban development (Wang et al., 2021). Both the planning education and practice have encountered an enormous transformation through integrating technology at various levels and scopes in the pedagogy and processing and implementation of projects. In recent years, researchers explored the attributes defining the ideal plans that correspond to the "15-minute city" concept by training an automated system using previous human-designed projects and factors that are predictive of positive outcomes (Ghisleni, 2024). Urban planning practice is also seeing revolutionary changes by relying on algorithms, automation, and artificial intelligence (AI) to predict scenarios and decisions (Sanchez, 2025). Curriculum revisions in planning schools now aim to integrate structured methodology for aligning academic goals, learning outcomes, and accreditation with the recent trends and technology to advance the planning profession.

In this paper, I review a case study for integrating multiple technology platforms including AI speech recognition tool and geospatial modelling for redevelopment of four neighbourhoods (Cherry Creek, Highland, Lincoln Park, and South Park Hill) in Denver Colorado. The case study is part of a core undergraduate planning studio in the University of Colorado Boulder.

AI is defined by the Council of Europe Framework Convention on AI and Human Rights, Democracy and the Rule of Law as:

"a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations or decisions that may influence physical or virtual environments. Different artificial intelligence systems vary in their levels of autonomy and adaptiveness after deployment." (European Center for Not-for-Profit Law, 2024)

With the rising concerns about cities growth, climate crises, and migration, a shift in urban planning is growing by adopting automation and AI in land use and transportation planning. According to a study by Zeng et al. (2023), this shift is driven by the unreliable and intuition of human capacity in optimizing multiple metrics in large datasets. For instance, to estimate the optimal distance between various services and residential areas in the 15-minute city concept, AI or geospatial tools for processing large datasets is utilized to create visuals to help in decision making. These visual and quantifiable metrics are processed by computational AI tools, which are

trained based on millions of previous trials (Zeng et al., 2023). Another example is developed by a team in Tsinghua University in China, where urban planners and scientists developed an AI tool that surpassed the performance of humans. The research team utilized attributes of the 15-minute city concept. In their automation approach, the team trained the system using variables described as positive characteristics of the city in formerly human-developed projects (i.e. parks, bike lanes, and entertainment spaces). The system, which was tested in a 3x3 grid, revealed that its project outputs have the same -or more- quality of those created by planning experts, while saving an ample time in processing (Ghisleni, 2024).

In an article on the popular planning platform, Planetizen, Sanchez (2025) discussed some of the fundamentals of planning practices that benefit from AI integration in their workflow. These include:

1) As planning relies on extensive data analysis, AI tools enhance planners' ability to process large datasets and help with output interpretation.
2) AI is not a substitute for human judgment. Since planners are taking a critical role in shaping AI's impact, the power of integrating AI workflows is to identify unseen patterns, and evaluate complex scenarios, and thus support planners' decisions.
3) Transformation of planning practice started when hand-drawn maps switched to Geographic Information Systems (GIS) generated maps, or when windshield surveys transitioned to computer vision. As such, AI is a continuation evolution of the practice, which offers a toolkit for planners to extend their capabilities as well as their possibilities.
4)Skillsets to run and customize AI tool are attainable for planners without prior knowledge in coding or a degree in computer science.

With its capabilities and versatility, AI can assist local governments in responding to the impact of climate change. Using predictive modelling, risk assessment, and early warning systems enable planners to address extreme weather events through resilient planning (Ghisleni, 2024). As an example, Google's Tree Canopy tool, powered by AI and shown in Figure 1 helps to mitigate the impact of extreme heat waves. As an integrative part of Google's Environmental Insights Explorer (EIE), the tool combines AI with aerial images of cities. AI literacy is soon becoming essential knowledge for practitioners and researchers alike. Thus, developing AI knowledge as a primary component of planning curriculum is now equal to understanding budgets, zoning, land use, and citizen engagement. AI Knowledge helps planners to be key players in decisions about how AI is used and regulated. If they did not participate in regulating such use, their voices and insights could be excluded (Sanches, 2025).

Figure 1: Google's EIE AI Tree Canopy Tool applied on the City of Los Angeles, California
Source: https://insights.sustainability.google/places/ChIJE9on3F3HwoAR9AhGJW_fL-I

Climate Crisis and the Emergence of the 15-Minute City

History of City Planning

The city planning vision that Le Corbusier's approach created was centred on rationalizing and organizing urban space to improve residents' quality of life. Stimmed from a functionalist and rationalist zoning approach, his vision prioritized the efficiency and separation of land use activities, while maintaining modern aesthetics and orderly building forms (Moreno, 2024).

In the 1960th, the construction industry in the United States underwent a boast in expansion and transformation. Accompanied by considerable economic growth and cities transformation, this decade resulted in a massive scale of new buildings construction and expressways that traversed the city's urban fabric. As a result, the decades that followed 1960s suffered from damaged urban landscape and fragmentation and segregation of the neighbourhoods that were encroached by the multilane expressways. Physical barriers between communities and increasing air and noise pollution were the utmost anticipated result of such damage. Movements to urbanize and reconnect neighbourhoods arose in the following decades including new urbanism, which responded to the need to address proximity, community cohesion, and the traditional activities of city life (i.e. local markets, walkability, and urban nature), (Moreno, 2024).

City's Urbanization and Climate Crisis

As a result of the fragmentation of the city structure in the 1960s and 1970s, movements to transform the city into a city of proximity, where basic goods and services are available at short distances within 15 minutes of one's residence, evolved. The new approach envisioned the city as an urban environment that would not only eliminate reliance on traffic, but also encourages a daily happy lifestyle (Moreno, 2024). In 2015, the Paris agreement recognized this vision and supported actions to invest in the built environment of cities to reduce greenhouse gas emissions and strengthen society's resilience. Using nationally determined contributions (NDCs), the agreement tailors its action plans to reduce greenhouse gas emissions and adapt to climate change for each member city. The 15-minute city concept developed by Moreno (2024), which aligns urban growth and city plans with the anticipated response to climate crisis, emphasized promoting more frequent and meaningful social interactions through prioritizing human interactions and social networks traffic jams. Municipalities that adopted the 15-minute city concept promote cleaner, more renewable energy sources. They support the 15-minute city's holistic approach through creating more sustainable, resilient, and liveable cities for present and future generations. This is attained through electrifying the building sector and infrastructure by relying on sustainable energy systems and the use of electric or hydrogen-powered public transportation. This concept also aspires to create a more balanced infrastructure, where uses are harmoniously integrated in areas where residents can live, work, play, and connect easily. Adopting a land use system -comprising mixed-use neighbourhoods- is essential for executing this concept and to ensure adequate living spaces that support community interaction, strengthen social cohesion, and promote a better quality of life (Moreno, 2024). Inspired by the matrix developed by Professor Muhammad Yunus as well as premises of sustainable development goals (SDGs); this concept in broad and open, while focusing on an array of detailed plans to improve the quality of life in towns and cities.

While addressing proximity, liveable spaces, and community cohesion, the 15-minute city, shown in Figure 2, is also centred on climate action. It supports the creation of a naturally linked system of ecological, economic, and social dimensions. The transition to this concept requires thoughtful changes and a commitment to transform one's lifestyle and the urban landscape of the cities and towns into a system of neighbourhoods that create living spaces that are attractive, welcoming, and conducive to interaction. This means designing neighbourhoods where the use of public spaces for cultural, economic, and social activities, as well as the relocation of local shops and services are intermingled. Moreno (2024) also re-envisioned a 30-minute territory concept for medium and sparsely populated areas (Moreno, 2024).

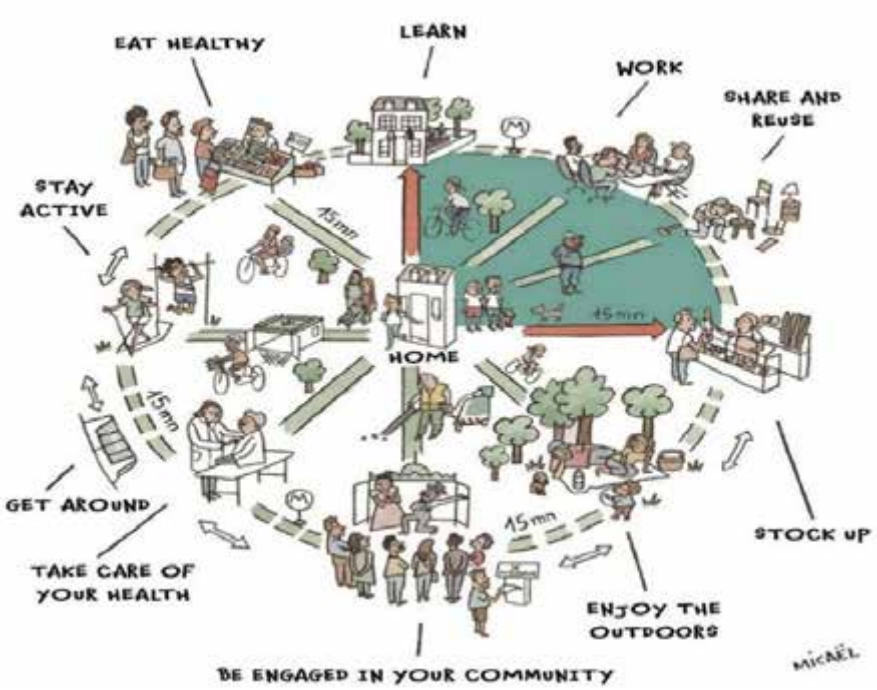

Figure 2: The 15-minute city Paris
Source: Moreno (2024)

Rethinking The Sustainable Planning Curriculum

Transformation of urban planning training for undergraduate students using advanced technology for planning scenarios and placemaking helps prepare students for the job market and be ready for the shift in planning practice discusses in Sanchez's (2025) article. A revised design for the planning curriculum helps to equip students with a mix of skills including technological know-how to tackle complex and technically challenging problems that require processing large datasets (i.e. climate adaptation, resilient planning, zoning reform). Continuous improvement of our pedagogical approaches in the 21st century is a necessity not a luxury. I see a value in dynamic instruction tools that regularly change and adapt to align with the needs of decisions and support changes in the planning practice. Designing innovative pedagogies helps to tailor technology platforms to student capability and align digital applications with the project and course needs. Instructional methods also need to be enhanced through integrating methods that best reach students of diverse backgrounds and ability, so we can prepare our students for the future. At the University of Colorado Boulder, Arts and Sciences Support of Education Through Technology (ASSETT) program provides support for integrating technology with pedagogy to promote impactful learning for all faculty. Through a two-semester workshops and reflection meetings, the program helps faculty to engage in a discourse with fellow faculty members from other disciplines and coaches to address the best practices and lessons learned from technology integration into instructional methods. It helps to emphasize the importance of continuous improvement of studio instructions, enhance active learning, and infuse technology where it could best align with the scope of work and the learning outcomes.

After completing this program, a proposal for instructional revision is proposed and tested in course instruction or a program of study.

Considerations and Risks of AI Adoption

Although AI tools might steer a fast pace of data processing and lead to radical efficiencies and deeper connections with the public, one must be aware that these tools need to be responsibly adopted. Concerns arose among practitioners on the use of AI and thus, the leading international corporation, Deloitte (2025), addressed the following considerations and risks, shown in Figure 3, related to the best practices in the adoption of AI-assisted outreach and engagement:

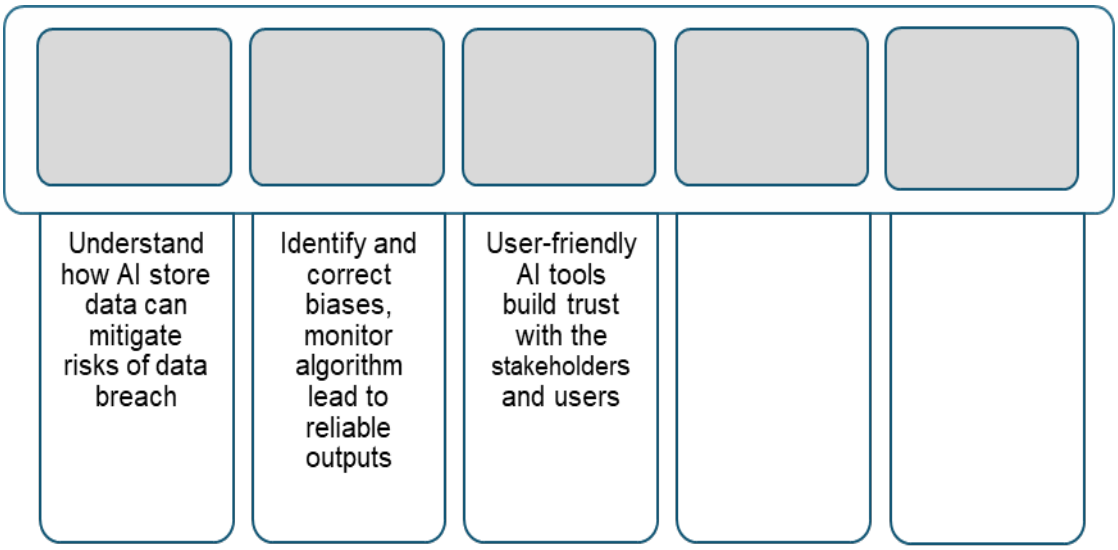

Figure 3: Deloitte's key considerations and risks for AI adoption in outreach and engagement.

Technology Integration in Sustainable Planning Studio

In the academic year 2024/2025, the program helped to support the revised course instructions for an undergraduate planning studio that I led at the Program in Environmental Design. Carefully revised modules, shown in Table 1 and Figure 4, in partnership with two campus institutions, helped to advance course and project content, enhance student engagement, and equip students with technical and communications skills through hands-on learning and experimenting.

The optimal goal was to equip students with technical skills included focusing on geospatial tools and mapping and using different Geographic Information Systems apps and online tools for 2D, 3D mapping and data visualization apps for interactive data visualization (Esri, 2024). In this paper, I discuss the pedagogical innovations that included collaboration with the Immersive Media Lab, where students utilized VR/AR devices and the Sketchup Software (Trimble, 2024) to develop intervention models of the pre-post retrofit scenarios of Denver neighbourhoods. I also analyse the results of quantifiable use of an AI tool to measure a week-long Role-Play workshop series, led by students to emulate the roles of stakeholders and their -often- conflicting interests. This Co-Design CoBI AI tool was a collaboration with the campus Institute of Cognitive Science, which has tested the tool in different secondary education classrooms.

Table 1: Revised planning studio curriculum using advanced technology and AI tools.

Module	Tool	Weeks	Modality
Research on Denver neighbourhoods and planning reports	Policy analysis	Three	Individuals
Case study research	Reports review	One	Individuals
City & neighbourhood resilience	Environmental and sociodemographic analysis	One	Individuals
Experiential learning through role play	CoBI AI	One	Randomly assigned groups

Retrofit planning proposal	GIS Pro + StoryMap	Three	Self-assigned groups
Immersive environment for scenario modelling	XR devices Trimble Connect	Four	
Final development proposal	All tools	Two	

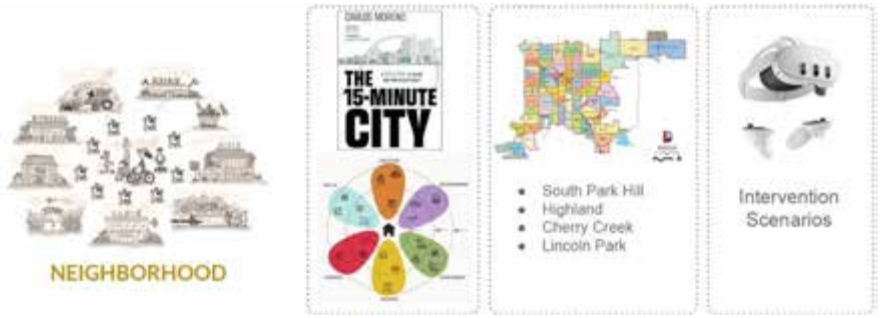

Figure 4: Revised planning studio; research and immersive environment integration

Denver as an Open Lab

Wang et al. (2021) examines research trends and the usefulness of urban scenario modelling. Their approach focused on global planning practices, urban planners, and politicians who should draw up suitable frameworks to implement sustainable urban development policies. Based on their systematic and quantitative review of 126 articles, they concluded that utilizing scenario modelling to help achieve sustainable development goals (SDGs).

In this undergraduate studio, the City of Denver, Colorado, US, was the open urban lab, where students were tasked with exploring, analysing, and redesigning four neighbourhoods (Cherry Creek, Highland, Lincoln Park, and South Park Hill) using the 15-minute city principles and local zoning and sustainability plans. In addition to site visits and visual analysis using site images for critical areas, students reviewed the existing zoning codes, newly adopted ordinances for minimizing parking requirement, and resiliency and climate action initiatives. In this studio 19 undergraduate students were introduced to sustainability and resilience measures, and contemporary urban design to examine urban growth as well as the development regulations on four prototype neighbourhoods. The neighbourhood characteristics entail different building typologies and density in order to propose a retrofit plan for each within the framework of the 15-minute neighbourhood concept. As an undergraduate studio, pedagogy challenges them to think through a multi-faceted and complex lens that intertwines environmental and equity measures.

After individual analysis of the City of Denver zoning, environmental and resiliency metrics, students were organized in four -randomly assigned- groups to undertake AI engagement workshops. The goal of the engagement module, shown in Table 1, was to engage students in a series of research activities, and to let them acquire research knowledge through engaging in small-group discussion and analysis. Students worked in groups of four to five students each to analyse each neighbourhood and its context.

AI for Community Engagement

The challenges of community engagement that the government sector faces are largely due to the need to establish trust with the populations they serve (Deloitte, 2025). Cities and public sector organizations don't have to re-invent the wheel — they can advance their existing outreach and engagement practices using AI platforms. According to Deloitte (2025) guidelines, AI offers new opportunities for public sector communicators at each step of the marketing and outreach process. AI-powered analytics can uncover behaviour patterns and preferences

with precision in real-time, Generative AI (GenAI) tools can produce hundreds of tailored content options, and Machine Learning (ML) technologies can now make real-time data-driven decisions to maximize every dollar (Deloitte, 2025).

Hurley's (2024) article questions the ability of urban planners to use AI to support their public engagement work. Centred on AI for public engagement, the article discussed ways that planners have proposed or adopted AI for public engagement. These ideas include the utilization of tools such as Chat GPT, Claude, or Microsoft Bing, and include the following possibilities:

Writing Support Uses

• Edit text to convert planner terminologies to everyday language at a 6th grade reading level: as Hurley explained, planners and related professionals such as engineers, architects, and landscape architects have higher levels of education than the population at large. The jargons of each of these professions could be very challenging to be understood by the general public. This shorthand makes it easier and more accurate to talk amongst peers, but it can be a barrier when communicating with the public. It is also a challenge to write for a reading level lower than one's own. Hurley assures that AI is great at adjusting a short piece of text to a particular reading level.

• Expand the options to consider: Planners are often asked to give an overview of policy options for a particular problem or analyse a possible solution for pros and cons. Due to the broad scope of planning expertise; not all planners are qualified to provide information in an area where they are not an expert. Even if the planner is familiar with the topic, it may require further research to ensure an accurate response. In situations like this, AI can help furnish some options for planners or provide a few examples to support their policy (Hurley, 2024).

• Convert one form of writing into another: Plans often have text to describe the graphic and analysis content to the public. In many occasions, AI could help create the first draft of the goals based on the vision or to support the intended goals (Hurley. 2024).

Meeting Support Uses

• Convert handwritten notes to text: It is very common for planning practitioners to use markers and flip charts for meeting notes. Visibility of the notes helps keep people focused, the messiness of the handwriting reinforces the idea that this is a work in progress and change is possible. I tis -however- time consuming to transcribe all those handwritten notes into a word document or presentation slides. AI could help with the transcribing task.

• Develop slides from text: despite lack of complete accuracy when putting together the text for a presentation and importing into an AI tool, this could be a first draft and save planners time to create the full presentation. With minor editing, the presentation could be enhanced in accuracy and visual content.

• Provide ideas for meeting activities or a draft agenda to meet meeting goals: AI tools could help planners and facilitators develop scenario of activities that could take place during the meeting to help achieve the goals for that meeting.

The Power of Role Play & AI

The terms "role play" and "simulation" are sometimes used interchangeably. yet, the two have some differences. While simulations can incorporate role play, leading to the term "role-playing simulation", they often involve instances where each participant may not have a prominent role. By contrast, in a role play exercise, the focus is more on the interaction between participants (or the characters students emulate), hence each participant role is a primary (UNSW, 2025). Role play is a form of experiential learning (Russell & Shepherd, 2010). In a role play scenario, students take on assigned roles and act out those roles through a scripted play. The role play can be carried out one-to-one (individual role play) or as a group role play with each member in the group taking on a role/character. In the script provided by instructors, roles and rules for the role play exercise are clearly defined

to help students prepare for effective engagement and enhance the quality of the output. Role plays can provide very powerful learning experiences for students by immersing them in simulated real-world situations, where they act out a particular role/character in a safe -and often fun- environment.

As today's global education policies address the benefits of problem-based, and active learning models, which further reflects curricula contents for achieving twenty-first century skills (Darling-Hammond, 2006; Vincent-Lancrin et al., 2014). Role play and simulation are becoming critical in enhancing student engagement and immersing them in an environment for real problem-solving scenarios. Role plays and simulations function as learning tools for groups or individuals in an online or in-person environment. They shift the power and autonomy in teaching and learning processes between students and educators, as students learn through their explorations and the viewpoints of the character or personality they are emulating in the environment (Aura et al., 2023). As a powerful student-centred space, role plays can enable learner-oriented assessment, where the design of the task is created for active student learning. Students are actively involved in both self- and peer-assessment, where they both give and receive feedback, and thus feel they contributed to the teaching pedagogy. In role-play exercise, students adopt different characters and work through a given scenario together, interacting in their assumed roles. Role-play is particularly effective for learning about complex social/human systems (Russell & Shepherd, 2010).

In this studio and in collaboration with the leadership team in the Institute of Cognitive Science at the University of Colorado Boulder, I was able to examine the NSF-funded tool Community Building [CoBI] tool that utilizes Artificial Intelligence [AI] Automated Speech Recognition [ASR]. The tool is designed to help researchers measure effective engagement through capturing and analysing the conversation during the engagement workshops. I conducted a role play in a well-structured one-week module that focused on enhancing student collaboration through emulating public participation in planning and design process. The activities encompassed in this week enabled students to fully represent a unique stakeholder's persona, where they can address the stakeholder's interests and concerns through addressing the SWOT analysis for each neighbourhood and the neighbourhoods' re-envisioning ideas. The activities throughout the week included workshops that took place during studio meeting time on Monday and Wednesday. The output of which were reconfigured and presented -using a visual and analytical collage of manually rendered maps and infographics and presented in class on Friday.

Utilizing an active learning jigsaw approach, students from each neighbourhood group I randomly assigned a different role, and students from all groups with similar roles formed a new group to represent matching stakeholders' interest. The Jigsaw active learning technique ensured that a person from each neighbourhood will be participating with three new students to envision the neighbourhood plan from a specific interest perspective that represents the stakeholder they were assigned:

- Environmental specialists (advocacy)
- Residents (Social + Cultural)
- Real estate (developers)
- City planners/public officials (Zoning/Land use)

The workshops were organized to engage the newly formed groups of stakeholder's mutual interests in a sequence of short exercises to conduct a Strengths, Weaknesses, Opportunities, and Threats [SWOT] Analysis and develop a visioning plan for the four assigned neighbourhoods. The short exercises were designed to empower students to take actions and address the -often-conflicting- stakeholder's interests. SWOT analysis workshops for each of the four neighbourhoods assigned to student groups. Figure 5 shows the workshop and its outputs including an engagement tree that measures effective use of languages associated with each attribute during the workshop, a comparison radar that uses pie-wedges to compare the three attributes of the engagement session (being committed to community, moving thinking forward, and being respectful) and measures and examples of thinking critically using specific algorithm-based wording from students speeches and the level of confidence in this analysis.

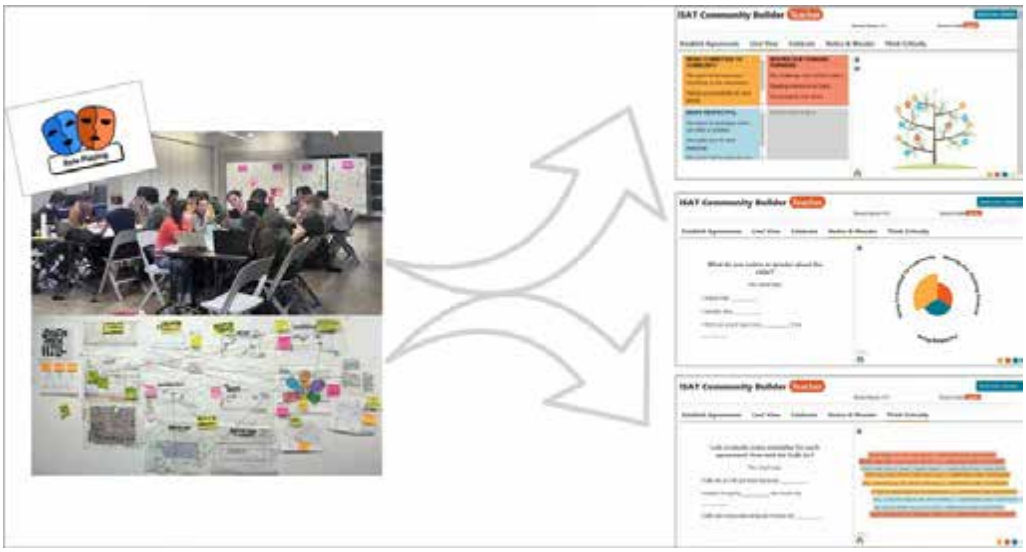

Figure 5: Role play workshops using CoBI AI tool and output [1. engagement tree (top), 2. a comparation radar (middle), and 3. examples of statistical confidence (bottom)].

Following the one-week workshops, students developed a preliminary and a final plan for sustainable neighbourhood's and analysed proximity of basic services using geospatial GIS models and the 15-minute city concept. Part of their analysis was proceeded with lab tutorial, where they attained hands-on instructions on using GIS for proximity analysis and data clipping and reporting (see Figure 6 for an example of students work). A final neighbourhood model was developed using Trimble Sketchup and a revised model was cast on Trimble Connect and navigated through an immersive environment using mixed-reality (XR) device.

Figure 6 shows the outputs of the geospatial scenario models created in GIS by Cherry Creek student team, which was later then integrated into Trimble Connect and visualized by the XR headset.

Discussion

There are multiple technological platforms that can be used to provide decision support to urban planners to obtain useful information and provide effective support (Anthony et. al., 2006, and Ning-rui and Yuan, 2005). Planning Support System (PSS) was proposed by the American scholar B. Harris in 1989. The system has been developed primarily to support planning processes (Geertman, 2002), based on the assumption that an increase in access to relevant information will lead to a greater number of alternative scenarios and, thus, a better-

informed public debate (Shiffer, 1995; Gerrit and Ligtenberg, 2007). Harris's proposed idea was to combine information technology with urban planning methods to provide decision-making assistance during every step of the planning process (Mao et al., 2008). PSS not only covers the ultimate act of decision making, but also the discovery, analysis, and evaluation stages of planning; it has been applied to urban-rural planning for the past 20 years. DSS also furnishes a process for analysing problems, establishing models, and simulating decision-making alternatives and results, all of which help improve decisions. The most significant area where spatial planning can be used in planning is to integrate it into decision making on various different scales. In the Netherlands the National Environmental Policy Plan (Ministry of VROM, 2001) emphasized the responsibility local authorities have for creating a sustainable environment, stressing that spatial planning at the local level has a direct impact on both urban and rural environments. This requires an area-specific planning approach at the local level.

The benefits of incorporating interactive forms of decision-making using GIS applications have developed beyond an operational support system and into a strategic decision-making support system (Grothe, 1994, and Cornelius and Medyckyj-Scott, 1991). AI-powered tools can facilitate communication between urban planners and the community. Applications of virtual reality (VR) or augmented reality (AR) can assist residents in visualizing proposed changes and provide feedback, promoting a more participatory planning process (Ghisleni, 2024). Comparing the results of engagement effectiveness will inform future pedagogies and assignment structure for next years. The results of student assessment, integration of AI and geospatial tools and other online environmental performance platforms utilized in this studio, serve as an opportunity to discuss and reimagine planning education as a critical change agent for enhancing student experience. Curriculum enhancement and partnerships with the Institute for Cognitive Science and the Immersive Media Lab helped to align faculty interests while advancing student experience and increasing their access to campus resources without adding any financial burden on their tuition and fees. Student evaluation is discussed in the conclusions section.

Conclusion and Recommendations

Planners are crucial contributors to the conversation on AI applications in urban planning practice and education. According to Sanchez (2025), planners have a long-term perspective, a commitment to public participation, and a thorough understanding of the intersection of policy, infrastructure, and daily life. These strengths are exactly what is needed to ensure that AI supports a sustainable and equitably built environment. Through a revised studio pedagogy using the capacities and support of University of Colorado's ASSETT program, I developed a curriculum for an undergraduate sophomore planning studio to respond to two primary questions. In the curriculum modules, I employed technology tools and geospatial platforms to support the learning objectives and to align student learning with the shift in the planning practice. Collaboration with two campus institutions yielded great success and supported student access to multiple technologies at no additional cost. The responses to these questions showed a positive and effective impact on students learning experience, measured through the campus administrative survey, peer-feedback, and unstructured observations of group performance.

Question 1: Will the use of AI tools help make public engagement truly meaningful? In the case study of this undergraduate -sophomore- studio, the students reported excitement and full autonomy of the engagement process including the decision making and their views of the SWOT elements of each neighbourhood. Role play exercise helped to maintain clarity of stakeholder's interest in each part of the exercise and students were able to immerse themselves in their assigned roles. One of the students' feedbacks is shown here:

"*I enjoyed the stakeholder workshop and the different formats of the class periods.*"

Question 2: How can technology platforms in urban planning curriculum enhance students' experience? Since the studio integrated multiple platforms including Esri and Trimble products and XR device developed by Metaverse, it was challenging to measure the effective use of each tool or platform separately. However, unstructured observations showed that students were more committed to learning Esri products (ArcGIS Pro and StoryMap) than applying what they learned in the analysis of their neighbourhood. Some students utilized ArcGIS Pro to analyse proximity of goods and services to the residential areas in their assigned neighbourhood,

while others utilized Adobe Illustrator to draw proximity buffers. Further tutorial sessions are needed to ensure that students will apply all tools. The most remarkable part of student interactions with technology was when they were introduced to AR/VR and XR as they started to navigate through their developed neighbourhood models. The following quote from students' feedback is related to technology use in this studio:

"The VR thing is so cool, I really do love it. Thanks for the great studio!"

Using in-class tutorials to train students on applying geospatial technology and AI tools in their projects is essential to ensure that students graduating can conduct neighbourhood proximity and flower of opportunity analyses. Students are also prepared to tackle real world problems related to mixed use and residential neighbourhoods. Future tools for assessing studio outcomes could be developed in the form of structured and systematic survey.

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Track 9

URBAN FUTURES

Local Appropriation Model for Circular Maker Spaces (CMS) in Istanbul

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Abstract
This study focuses on circular maker spaces as catalysts, integrating new technologies and creative industries within Circular Economy (CE) strategies at a local neighbourhood scale in cities within the embedded narratives of equity and just future. The research develops a Local Appropriation Model (LAM) to guide site selection and integration, combining (1) the Local Communities Comprehension Tool (LCCT) to assess local expectations and a GIS-based multi-criteria spatial analysis for site selection. By analysing local dynamics, the study developed the core structure of the Local Appropriation Model based on common findings from six pilot neighbourhoods. Ultimately, it offers an inclusive and holistic framework, serving as a vital roadmap for integrating Circular Economy (CE) strategies into urban environments through CMSs.

Keywords; Circular Economy, Circular Maker Spaces, Sustainable Development, Local Appropriation, Neighbourhood Scale, Just Future

01. Circular Economy & Circular Maker Spaces – Why is it necessary?

The rapid consumption of natural resources and ongoing urbanization have led to various socio-economic and environmental challenges around the World. In response, the concept of a circular economy (CE) emerging from debates on sustainability and sustainable development has gained increasing importance and is continuously evolving through academic and policy research.

Unlike the dominant linear economy model, which follows a make-use-dispose trajectory, the circular economy emphasizes reuse, durability, and recycling. Here, the Ellen MacArthur Foundation, which provided one of the first and most widely accepted definitions of the circular economy, describes it as follows:

> "A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims to eliminate waste through the superior design of materials, products, systems, and business models." (Ellen MacArthur Foundation, 2013, p. 7)

Over time, the circular economy has evolved beyond its initial focus on recycling to encompass a broader range of strategies to minimize resource use and environmental impact. In this context, many countries have developed different approaches and policies related to the circular economy. For instance, early frameworks such as Japan's 3R Initiative (reduce, reuse, recycle, 2004) and the EU Waste Framework Directive (2008) laid the foundation for this shift by introducing basic "R" strategies (Ekins et al., 2019).

By 2017, this framework was expanded into the 9R strategy, introducing a more comprehensive and hierarchical approach to circularity (Potting et al., 2017; Kirchherr et al., 2017; Ekins et al., 2019). This framework targets smarter product use and circularity by prioritizing sustainability. Among the approaches developed in this context, the most important and primary strategies are rejection, rethinking, and reduction (R0–R2). It focuses on reducing overconsumption through innovative technology, product design, and organizational change. The second most important strategies are reuse, repair, refurbishment, remanufacturing, and repurposing (R3–R7); It contributes to resource efficiency by extending product life. The last and third most important strategies include recycling and recovery (R8–R9), material processing and energy recovery processes, and are closer to traditional linear

economic applications. This expanded R-framework supports a more sustainable future by promoting the transition from end-of-life waste management to systemic design and socio-technical transformation (Potting et al., 2017; Kirchherr et al., 2017; Ekins et al., 2019).

Followingly, the circular economy is operationally examined under 3 main scales in this context. These are respectively: It is defined as the micro level (products, companies, consumers), meso level (eco-industrial parks), and macro level (city, region, nation, and beyond) (Ekins et al., 2019). This provides an important framework for understanding the scope of potential future circular economic activities at different levels.

Furthermore, many researchers highlight that the circular economy will likely drive major changes in the labour market, which will affect the operations in different levels. New employment opportunities are expected to emerge in sectors such as repair, maintenance, remanufacturing, and reuse, as well as in digital technologies and sustainable design. In line with this, the European Commission (2020) predicts that over 700,000 new jobs could be created across the EU by 2030 as a result of new circular economy policies in the EU. The Ellen MacArthur Foundation (2015) also emphasizes that circular models stimulate growth in labour-intensive sectors, thereby supporting local employment. Cities will play a pivotal role in this transformation, as they not only host a large share of the global population but also account for 60–80% of global energy consumption and 75% of carbon emissions (Chen & Chen, 2012; Environment, 2017; Coskun et al., 2022).

On the other hand, the circular economy serves as an alternative economic model that promotes social and environmental sustainability while seeking a balanced relationship among the three pillars of sustainable development: environmental protection, social equity, and economic growth (Coşkun et al., 2022). At this point, while cities face various socio-economic and environmental challenges, questions arise regarding how circular economy strategies can be scaled and implemented within urban environments.

In line with this, it is crucial to recognize that urban space is a collective value and that all city residents have equal rights to its production (Lefebvre, 1996). Harvey (2008) emphasizes that residents have a collective right to access existing urban resources and engage in urban transformation, which are essential principles for fostering an inclusive and just transition in the cities. Accordingly, implementing circular economy practices in cities must be diverse, democratic, and equitable (Fainstein, 2010). Ensuring both a just transition and justice in emerging urban structures is essential.

Here, CMSs, which have the potential to advance sustainable development goals (SDGs) through circular-making activities such as reusing, repairing, refurbishing, and recycling (Galleguillos et al., 2023), emerge as a key mechanism for accelerating the just transition to a circular economy in urban spaces. Makerspaces provide an opportunity for individuals from diverse backgrounds to connect, exchange knowledge, and collaborate on creative projects (Einarsson & Hertzum, 2021). At the same time, these maker spaces serve as key focal points for building a sense of community and engagement, facilitating the adoption and implementation of circular economy principles within society. (Galleguillos et al., 2023, Kohtala & Bosqué, 2014). Moreover, they will function as platforms for social empowerment and social justice in the city.

As a result, the circular economy, which has emerged as part of the concept of sustainability in the face of various socio-economic problems that arise in a rapidly depletion and urbanization of the world, is seen as an important model that will reverse or slow down this situation due to its scope and capacity. In this context, CMSs appear as an important tool to implement the principles of the circular economy in cities, both environmentally and socially, and to ensure a just transition.

In this context, the local-scale implementation of circular production spaces, as tools for applying circular economy (CE) principles at the urban scale, will play a significant role in accelerating the process and promoting its wider integration at the grassroots level. In this regard, the next phases of this study explore how CMSs can be integrated at a local neighbourhood scale in cities within the embedded narratives of equity and a just future.

02. Local Appropriation of Circular Maker Spaces (CMS) – How Can CMSs Be Integrated at the Local Scale?
The concept of appropriation, based on Lefebvre's discussions on the production and construction of space, has been used by architects, planners, and designers since the 1960s and 70s in line with various discourses and policies in urban planning and development. Due to the multi-layered and complex nature of urban space, appropriation is shaped and realised not only physically, but also through socio-political, cultural, and environmental processes. (Lefevbre, 1991). Therefore, appropriation refers to the sum of all the actions we take to transform our environment for a specific purpose, while the individual's motivation is essential to initiate this transformation (Noschis, 1978).

On the other hand, the urban space that surrounds us can encourage or restrict us from this transformation. In the process of appropriation of space, understanding local elements is also an important factor in terms of sustainability and ownership of the space. In this context, the research seeks to provide a framework for the appropriation of circular maker spaces in urban space in line with CE principles.

While makerspaces serve as platforms for sharing knowledge, ideas, skills, and equipment by prioritizing sharing and learning over commercial gain (Kuznetsov & Paulos, 2010; Peppler et al., 2016; Galleguillos et al., 2023), they also foster community building. Additionally, makerspaces act as structures that promote local economic development through the use of digital technologies and traditional methods. In this context, circular makerspaces have the potential to support and transform existing local networks within the city. As social and inclusive spaces, they enhance the well-being of city residents and contribute to sustainability (Taylor et al., 2016; Galleguillos et al., 2023). (Taylor et al., 2016; Galleguillos et al., 2023).

The adoption of CMSs in urban areas is important for implementing CE principles locally and accelerating the transition. This study aims to provide a framework for integrating CMSs at this level. In this context, the study focuses on 6 different neighbourhoods of Bayrampasa district in Istanbul, which include different groups and have various application bases for CE applications. The selected neighbourhoods within the district borders, respectively, are Yıldırım, Kartaltepe, Cevatpasa, Muratpasa, Kocatepe, and Altıntepsi. The studies conducted in these neighbourhoods have been supported by qualitative and quantitative research methods to understand how urban residents perceive CMSs and where they place them in future scenarios. In addition, analyses have been conducted to determine how these spaces will be physically integrated into the urban space, in order to select an appropriate location.

Subsequently, a Local Community Comprehension Tool was developed through a survey conducted with neighbourhood residents and an examination of studies that will serve as a foundation for the municipality's CE applications. The Local Communities Comprehension Tool (LCCT) aims to understand local communities and authorities' expectations, their perception of the CE and its implementation on the local scale.

To ensure sustainable implementation, criteria for site selection were subsequently developed and tested through pilot applications using a Multi-Criteria Decision Analysis method based on GIS (Geographic Information Systems) that supports spatial decision-making. The site selection criteria included several important factors, such as accessibility for local residents. Additionally, detailed descriptions of related facilities and networks were considered, enabling discussion on the physical integration of these spaces into neighbourhoods.

02.1. Local Community Comprehension Tool (LCCT)
The Local Community Comprehension Tool consists of 3 stages. These intertwining phases aim to understand how the circular economy and circular production spaces are perceived in the local context, and what applications they have.

These phases are as follows:
(1) Understanding how local residents perceive the circular economy and maker spaces.
(2) Reviewing the local government's approaches and implementations regarding the circular economy and circular production.

(3) Understanding how city residents perceive the local government's implementations regarding circular production and CMSs. (Figure 01).

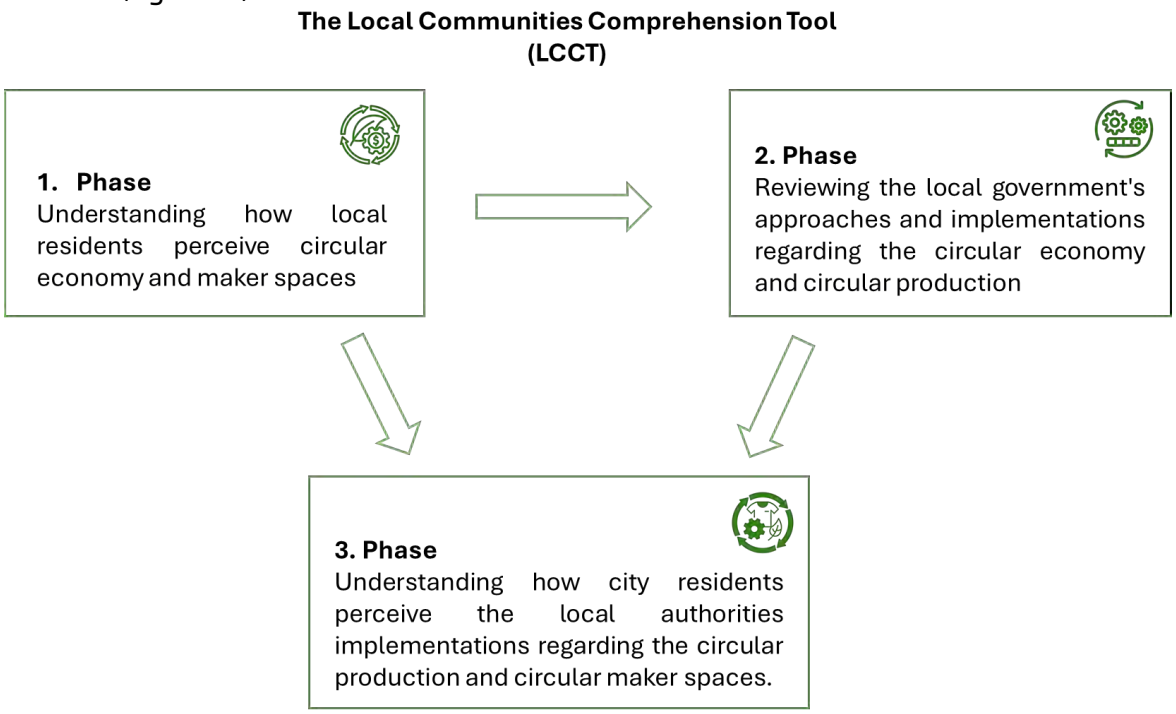

Figure 01. The Local Communities Comprehension Tool (LCCT)

Phase 1 contains survey data about the circular economy and maker spaces. Phase 2 contains a review of the implementations of the Bayrampasa Local Municipality related to the circular economy. Phase 3 contains survey data to understand the local authorities' perceptions of their implementations and their expectations of CMSs.

Phase 1: Understanding How Local Residents Perceive the Circular Economy and Maker Spaces

The survey on the circular economy and production spaces was conducted online. The survey questions were directed at city residents and were organised under five main headings. These were: 'Circular Economy', 'Circular Production Spaces', 'Circular Production Spaces and the Municipality', 'Circular Production Spaces and Participation', 'Circular Economy and the Future of the City', and 'Circular Production Spaces and Social Impacts'.

A total of 66 people participated in the survey. Of these, 30 were male and 36 were female. Therefore, men accounted for 45% of the total participants, while women accounted for 55%. (Table 01)

Table 01. Participants' Age Ratios

Age Range	Number of Participants	Participant Ratio (%)
18-25	15	23
26-35	25	38
36-45	11	17
46-55	6	9
55>	9	13
Total	66	100

The participants are divided into six age categories. These are the 18–25 age range, the 26–35 age range, the 36–45 age range, the 46–55 age range and the over-55s. The proportion of participants in the survey is as follows: 23% are in the 18–25 age range, 38% are in the 26–35 age range, 17% are in the 36–45 age range, 9% are in the 46–55

age range, and 14% are in the over-55 age range. These values show that the majority of participants are young. (Table 02).

The section measuring the participants' level of education is divided into five categories. These are: primary school (compulsory education); high school, vocational school, university; and graduate education.

Table 02. Participants' Educational Background

Educational Background	Number of Participants	Participant Ratio (%)
Primary School – Compulsory Education	6	9
High School	10	15
Vocational School	9	14
University	35	53
Master's Degree	9	9
Total	66	100

Nine per cent of the respondents have completed compulsory education (primary school). Their education levels are as follows: high school (15%), vocational school (14%), university (53%) and master's degree (9%). The survey data shows that the majority of participants have a higher level of education. (Table 02).

The proportion of survey participants from the sample neighbourhoods selected for the study in the Bayrampaşa district are as follows: Yıldırım District (26%), Kartaltepe District (20%), Cevatpaşa District (15%), Muratpaşa District (15%), Kocatepe District (13%) and Altıntepsi District (11%).

According to the survey data, 33% of participants said they had heard of the circular economy, while 67% said they had not. Of those who had heard of the concept, 26% associated the circular economy with the efficient use of resources, while 74% associated it with the reuse and recycling of waste.

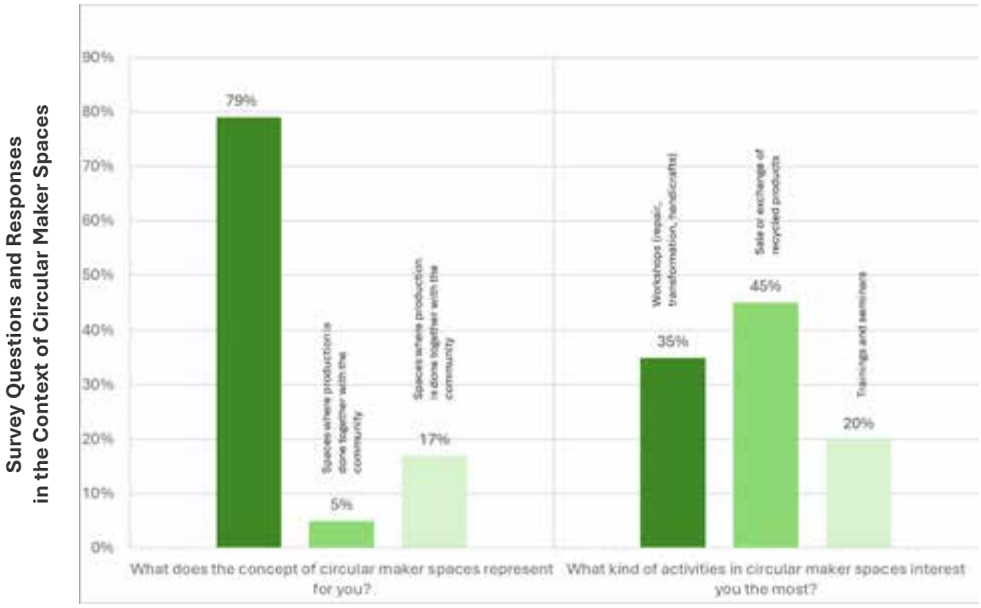

Figure 02. Survey Q&R in the context of Circular Maker Spaces

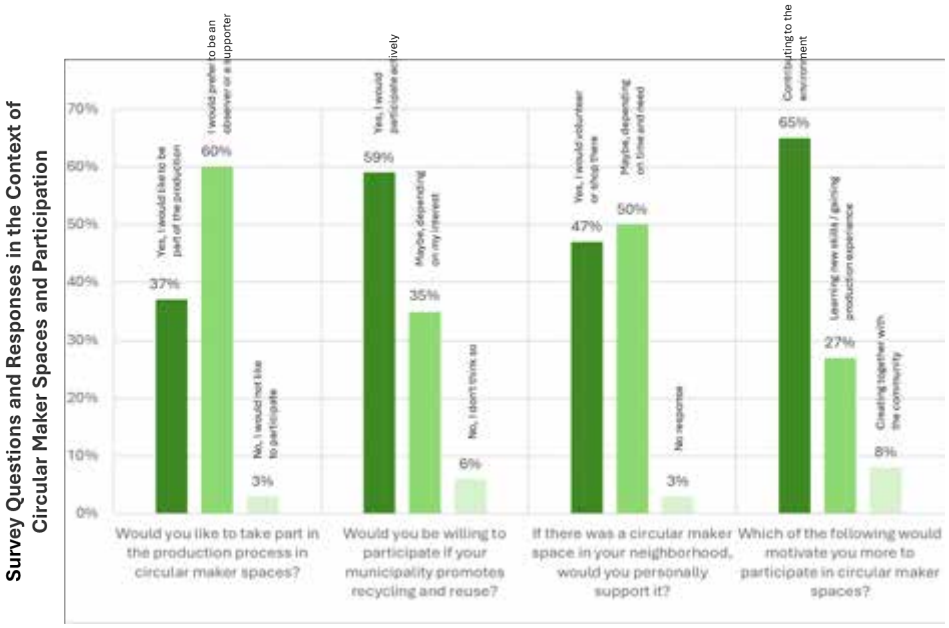

Figure 03. Survey Q&R in the context of CMS and Participation

Participants defined circular production spaces as places where new products are made from waste, with 79% defining them as such. Meanwhile, 17% defined them as places focused on repair, transformation, and sharing, and 5% as areas where production is carried out with society. On the other hand, when asked what activities they would like to take part in at circular production spaces, 35% replied workshops (e.g., repair, conversion, and handicrafts), 40% replied selling or exchanging recycled products, and 20% said training and seminars. As a result, it illustrates that the participants support activities that produce new added value from existing waste products. (Figure 2).

When asked about the municipalities' CMSs, 41% of participants stated that they were familiar with the municipalities' practices regarding CMSs, while 58% stated that they were not. One percent did not answer this question. Following this, when asked about participation, 37% of participants stated that they wanted to be involved in the production in circular maker spaces, while 60% stated that they just wanted to be observers or supporters. Three per cent of participants said they did not want to be involved in the production process.

This result shows that, although the participants have reservations about the production process, they still support it. This can be considered a positive development for the production of CMSs (Figure 03).

Another question about the participation process is whether municipalities promoting recycling and reuse should be allowed to participate. While 59% of participants said they would actively participate in recycling and reuse practices if encouraged by municipalities, 35% said they might participate depending on their interest, and 6% said they would not participate. This result shows that most participants support waste recycling and reuse and want to be involved in the process (Figure 03).

While 47% of participants said they would volunteer or shop individually if there were a circular production space in their neighbourhood, 50% said they might support it, depending on their schedule and needs. Consequently, it is assumed that participants will support the implementation of CMSs or applications at the neighbourhood scale at a high rate. In the following question, when asked what would motivate them the most to participate in CMSs, 65% of the participants said contributing to the environment, 27% said learning new skills or gaining production experience, and 8% said producing with the community. This reveals that environmental concerns are the most important factor encouraging participants to engage with CMSs. (Figure 03).

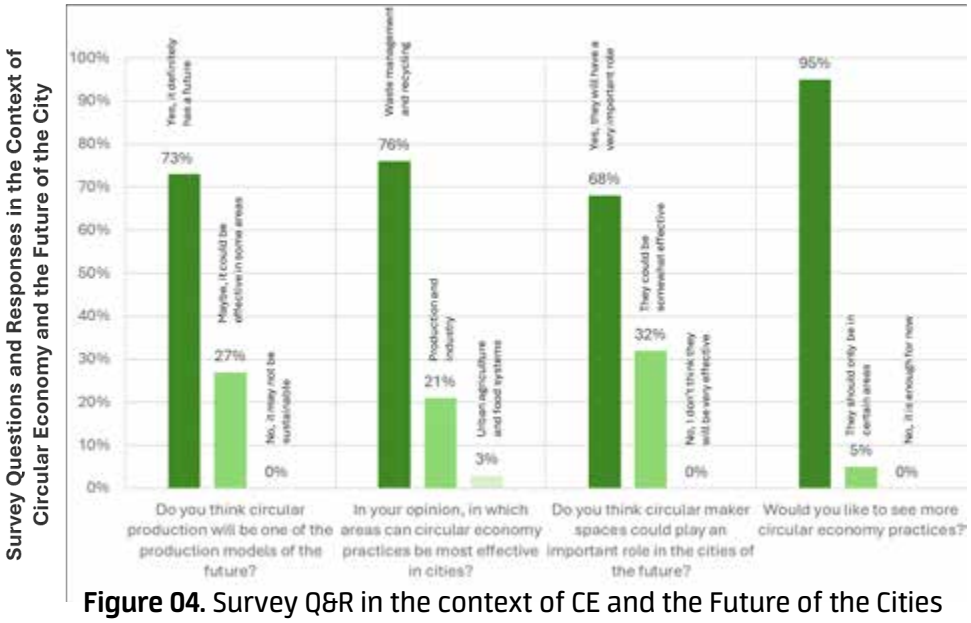

Figure 04. Survey Q&R in the context of CE and the Future of the Cities

While 73% of participants said that circular production would be one of the dominant production models in the future, 27% said that it might only be effective in certain areas. All of the participants agree that circular production will be one of the dominant production models of the future. Therefore, based on the survey data, we can conclude that the participants firmly believe that circular production will be one of the dominant production models in the future (Figure 04). When asked which areas of the city could benefit most from circular economy practices, 76% of participants answered waste management and recycling, 21% replied production and industry, and 3% responded urban agriculture and food systems. This question supports the above answers and reveals that participants are concerned about environmental and waste issues (Figure 04).

In answer to the question of whether CMSs will play an important role in the future of cities, 68% said that they would be very important, while 32% said that they might be partially effective. None of the participants said that they did not think it would be effective. This question's outcome reflects participants' belief that CMSs will play an important role in future scenarios. Additionally, 95% of participants supported the implementation of circular economy practices throughout the city, while 5% favoured a more targeted approach. None of the participants considered existing circular economy practices to be sufficient (Figure 04).

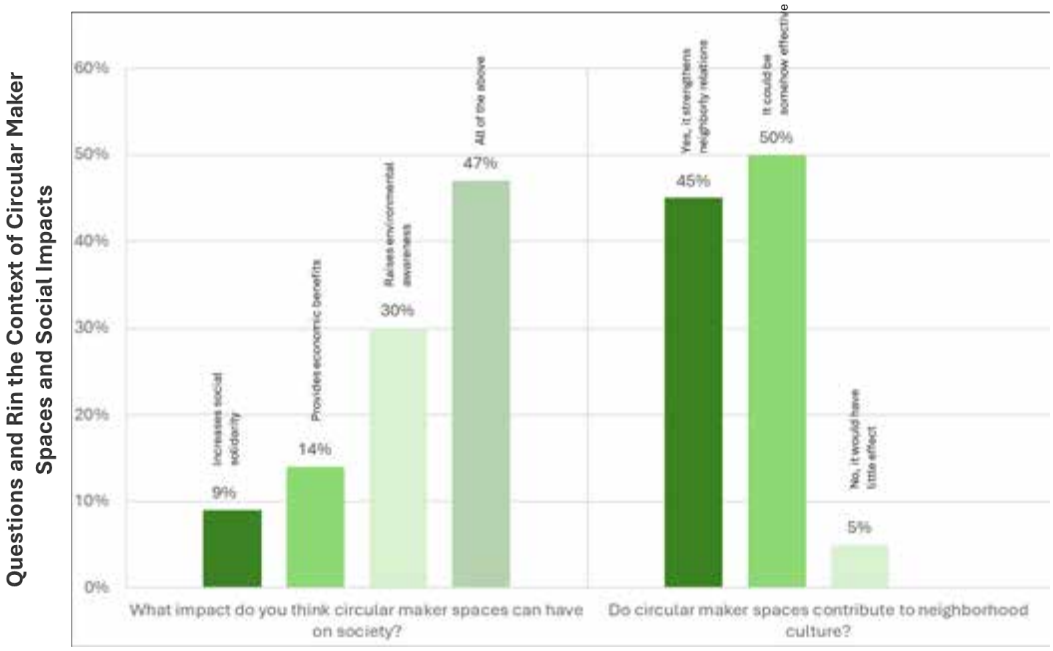

Figure 05. Survey Q&R in the context of CMS and Social Impact

Figure 05 shows the responses given by participants when asked what impact maker spaces can have on society in the context of CMSs and their social impacts. The responses were as follows: 9% increased social solidarity, 14% provided economic benefits, 30% increased environmental awareness, and 47% all ticked. Examining the survey data for this question reveals that participants believe circular maker spaces will have a positive social, economic, and environmental impact on society. This demonstrates that participants view CMSs as socially sustainable. In response to the question regarding the contribution of CMSs to neighbourhood culture, 45% of participants agreed that they strengthen neighbourhood relations, while 50% believed they could be partially effective. Five percent of participants believe that CMSs will not contribute to neighbourhood culture (Figure 05).

As a result of this phase, the survey revealed that participants were sensitive to environmental issues and found solutions and waste management practices to be insufficient. Furthermore, they believe that CE practices will be crucial in addressing these problems, particularly the promotion of CMSs. Although the survey data emphasizes that municipalities should support these practices, it also shows that participants are quite willing to support circular maker spaces on their own. Lastly, participants responded very positively to questions about the future social impact of circular production spaces, stressing that these spaces would be socially sustainable.

Phase 2: A review of Bayrampasa Local Municipality's Implementations related to CE

Although the Bayrampasa Municipality does not officially adopt the principles of the circular economy, it has implemented numerous projects of various sizes and scopes related to this concept. These projects aimed to encourage waste separation at source, promote recycling and energy efficiency, and foster sustainable environmental awareness. In addition, the Istanbul Provincial Zero Waste Management System Plan (2020), published by the Ministry of Environment, Urbanisation and Climate Change, states that the Zero Waste Management and Practices, which have been in active implementation since 2018, were started by the Bayrampasa Municipality in 2019 (URL 01).

Figure 08 shows the municipality's practices related to CE principles and supporting the transition to CE. These include the Bayrampasa Recycling Mobilisation, the Collection of Recyclable Waste, the Zero Waste Project Containers, the Recycling Education Programme, the Zero Waste Children's Play Area, the Pasakart and the Solar-Powered Lighting. (Table 03).

Table 03. Implementations of the Bayrampasa Municipality

Implementations that are related to Circular Economy	
Implementations	**Purpose**
Bayrampaşa Recycling Mobilization	Raising Public Awareness
Collection of Recyclable Waste – Distribution of Blue Waste Bags	Promoting Recycling
Zero Waste Project – Recycling Waste Collection Containers (glass, clothing, batteries, oil, etc.)	Promoting Recycling
Recycling Education in Schools	Raising Public Awareness & Education
Zero Waste Children's Play Performance	Raising Public Awareness & Education
Paşakart (point accumulation within the scope of the Zero Waste Project)	Raising Public Awareness & Economic Development
Solar-Energy Lighting in Parks and Squares	Promoting Energy Efficiency

These applications have various purposes, including raising public awareness, education, local economic development, and improving energy efficiency. In this context, some of them stand out. The Zero Waste Project, initiated and supported by the ministry, is particularly well known among city residents. Conversely, these practices are concrete examples of the environmentally friendly policies and approach of Bayrampasa Municipality, which will form the basis for a circular economy. Incorporating waste into the economy, raising environmental awareness, and taking steps towards a sustainable future demonstrate the municipality's engagement with this issue.

Another application, Pasakart, is a recycling initiative introduced by the municipality. Thanks to this project, citizens can take recyclable waste, such as paper, plastic, glass, and metal, accumulated in their homes to waste collection points in their neighborhood on certain days. 'Money Points' are loaded onto the Pasakart according to the weight of waste measured by digital scales. These points can be used by citizens at contracted markets and restaurants within the borders of Bayrampasa. According to data from 2023, over 1,300 people became Pasakart holders, and a total of 13,437 kg of recyclable waste and 350 litres of waste oil were collected. As a result of these recycling activities, citizens received a total of 22,638 TL worth of Money Points. Additionally, approximately 24,000 trees were saved from being cut down, and millions of litres of water were saved from pollution by collecting 50 tonnes of waste vegetable oil. In addition, approximately 24,000 trees were saved from being cut down, and millions of litres of water were saved from becoming polluted by collecting 50 tons of waste vegetable oil (URL 02). This project, which protects the environment while providing economic benefits to citizens, is an important step towards a sustainable future and CE practices.

As part of the Bayrampasa Recycling Mobilisation initiative, teams from the Municipality's Climate Change and Zero Waste Directorate visited 8,063 households in the Kocatepe district. They informed citizens about the importance of recycling and distributed brochures and household waste bags for recycling. This event is important in terms of both community empowerment and raising public awareness. It supports the transition to recycling, which is one of the principles of the CE. (URL 03).

Phase 3: Understanding the Perception of the Local authorities' Implementations and Expectations from CMSs
In this phase of the study, an online survey on circular maker spaces was conducted with city residents living in six selected neighbourhoods in the Bayrampasa district of Istanbul. The survey aimed to understand urban residents' perspectives on CMSs in different neighbourhoods. In this context, the survey includes a total of 14 questions, organised under the following headings: the municipality's zero waste management and practices;

the use and operation of circular production spaces; the settlement preference of CMSs at neighbourhood level; the individual impact of CMSs at neighbourhood level; and how city residents imagine the context of CMSs. Thirteen of these questions are multiple-choice and one is open-ended.

A total of 53 people took part in the study. Of these, 30 identified as female and 23 identified as male. This equates to 43% male and 57% female participants. The participants' ages were divided into five categories. These were 18–25 years old, 26–35 years old, 36–45 years old, 46–55 years old, and over 55 years old. The proportion of respondents in each age range who participated in the survey is as follows: 18-25 years old (13%), 26-35 years old (42%), 36-45 years old (21%), 46-55 years old (13%), and over 55 years old (11%). These values reveal that the majority of participants are young people (Table 04).

Table 04. Participants aga range

Age Range	Number of Participants	Participant Ratio (%)
18-25	7	13
26-35	22	42
36-45	11	21
46-55	7	13
55>	6	11
Total	53	100

The section measuring the participants' level of education is divided into six categories. These are: primary school (compulsory education), high school, vocational school, university, and graduate education. 9% of respondents have completed compulsory education (primary school). The respective education levels of the participants are as follows: high school (14%), vocational school (6%), university (51%), and master's degree (8%). The survey data shows that the majority of participants have a higher level of education. (Table 05).

Table 05. Participants educational background

Educational Background	Number of Participants	Participant Ratio (%)
Primary School – Compulsory Education	5	9
High School	14	26
Vocational School	3	6
University	27	51
Master's Degree	4	8
Total	53	100

The participant rates from the six selected sample neighbourhoods are as follows: Yıldırım Neighborhood (17%), Kartaltepe Neighbourhood (25%), Cevatpasa Neighbourhood (6%), Muratpasa Neighbourhood (11%), Kocatepe Neighbourhood (34%), and Altıntepsi Neighbourhood (8%).

The survey questions and answers are divided into four groups according to their context. The questions were designed to understand the municipality's participation in the zero-waste project since 2018, the communication between the municipality and city residents, and the effectiveness of the project's practices. The results revealed that 66% of participants were aware of the project, while 34% were not.

In response to the question about Bayrampasa Municipality's practices within the scope of the Zero Waste Project, based on information from the municipality's website, it emerged that participants were less familiar with the municipality's practices in neighbourhoods beyond routine activities such as the collection of recycling waste and the provision of recycling waste containers.

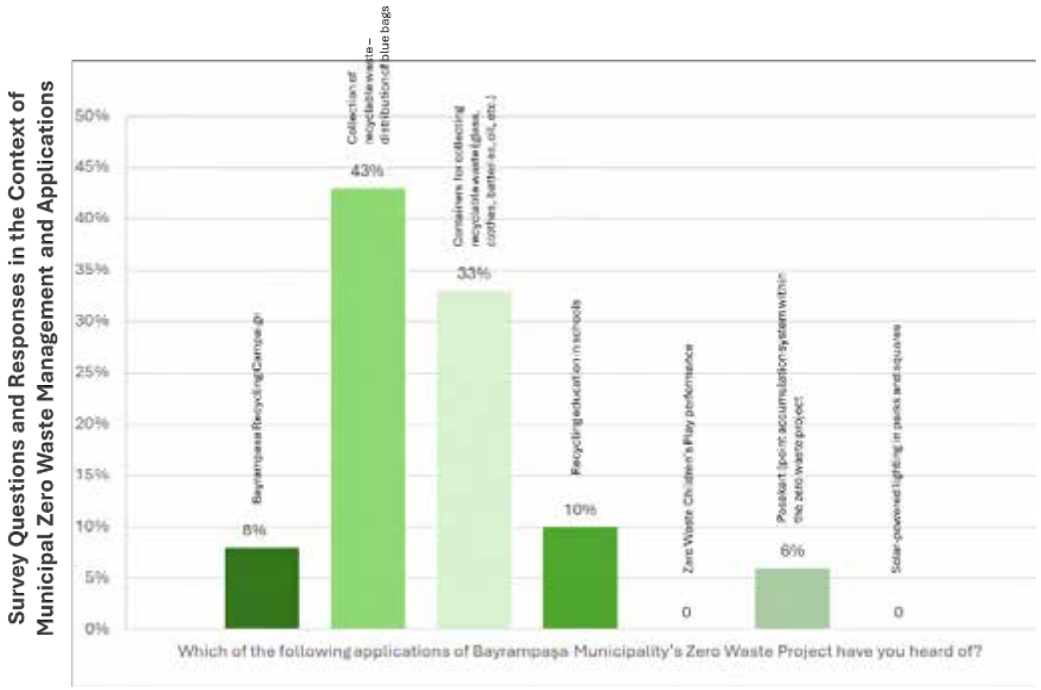

Figure 06. Survey Q&R in the context of Municipal Zero Waste Management and Applications

As an act and routine practice of the municipality in neighbourhoods, the collection of recycling waste (the distribution of blue bags) is recognised by 43%, as are recyclable waste collection containers (33%). The Bayrampasa recycling mobilisation is known by 8% of participants, the recycling education programme in schools by 10%, and the Pasakart scheme (which involves accumulating points within the scope of the zero-waste project) by 6% (Figure 06). The Zero Waste Children's Play Demonstration held at the municipal cultural centre and the solar-powered lighting projects in parks and squares are not known to the participants.

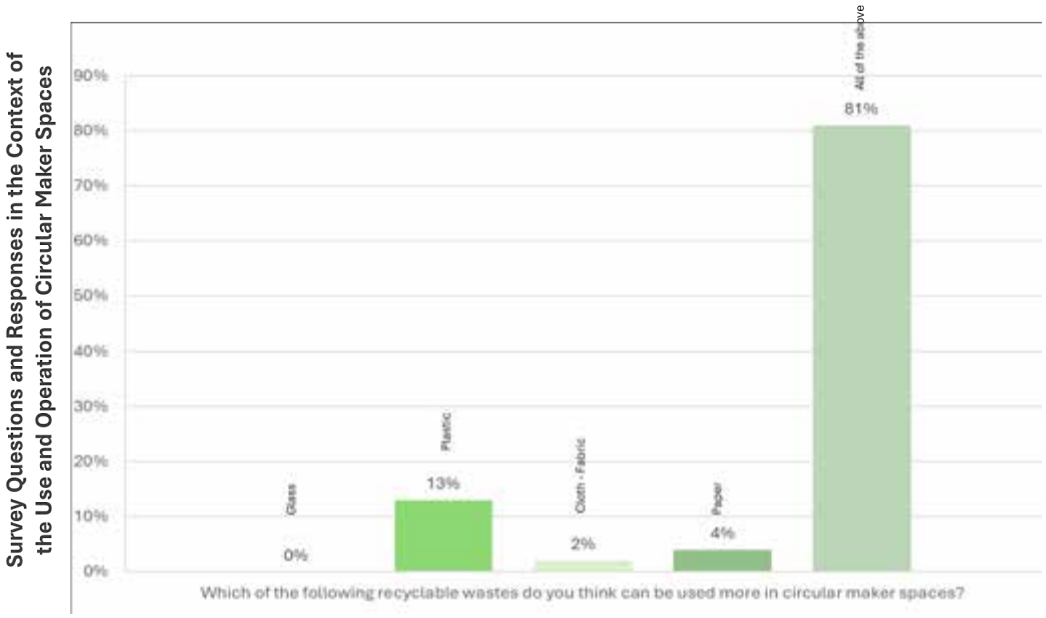

Figure 07. Survey Q&R in the context of the Use and Operations of CMS

Various questions were asked about the materials to be used in circular production spaces, as well as how these spaces would function and be governed. These questions aimed to measure participants' perceptions of circular production spaces. The aim of the questions prepared for those considering materials that can be used in CMSs as part of the zero-waste project is to provide participants with an insight into the production models that will exist in these spaces. The majority of participants (81%) stated that all products (glass, plastic, clothing, and paper) will be used together in these production areas. In addition, 13% of participants only selected plastic, 12% only selected clothes, and 4% only selected paper, saying that these items could be recycled in these places. Nobody marked the glass as recyclable. (Figure 07).

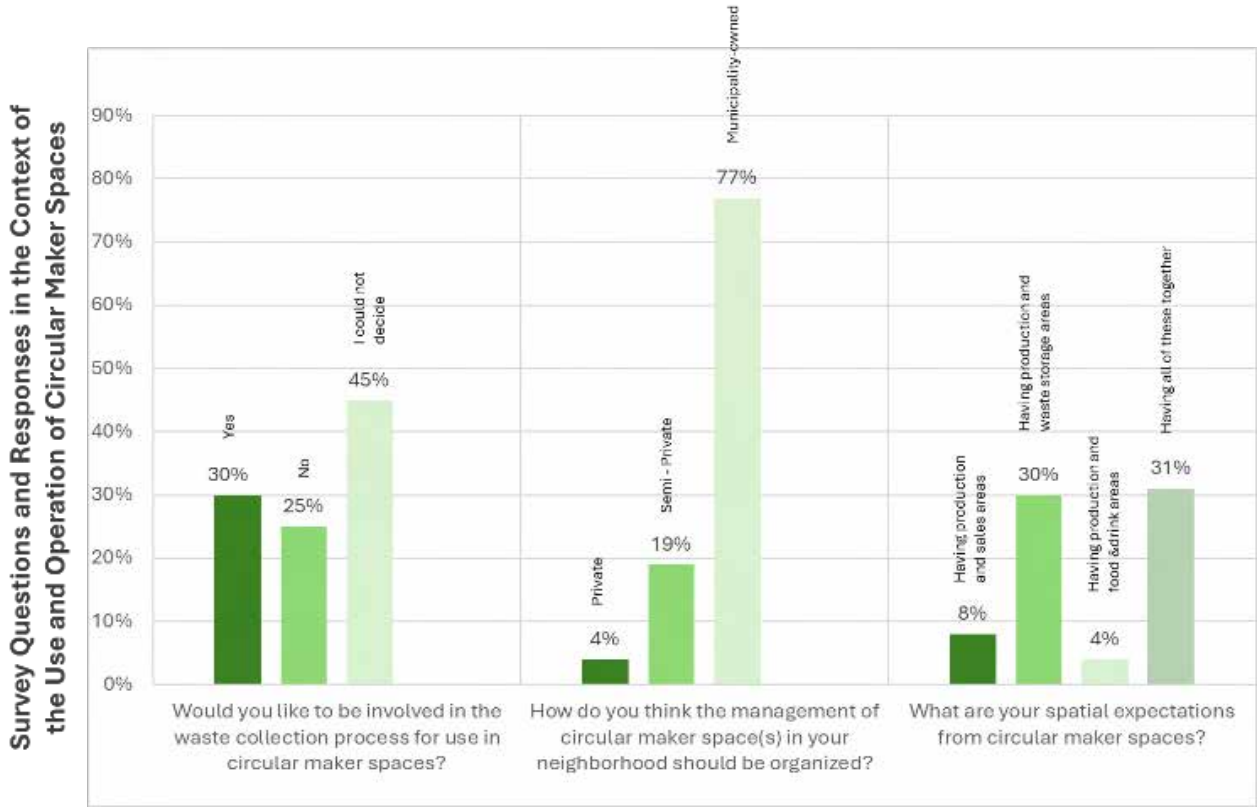

Figure 08. Survey Q&R in the context of the Use and Operations of CMS

In response to the question about participation in the waste collection process, 30% of respondents agreed, 25% disagreed, and 45% were undecided. This shows us that participants tend to act after seeing the process. (Graphic .07) Regarding the question about the management of CMSs, the majority (77%) indicated that the municipality should own them. Meanwhile, 19% of respondents thought that semi-private management would be good, while 4% supported private management. This result shows that urban residents want the municipality to initiate or carry out the expansion process of CMSs. (Figure 08)

In another question, participants were asked about their spatial expectations for CMSs. Eighty percent stated that there should be a production and sales area only, 30 percent stated that there should be a production and waste storage area only, and 4 percent stated that there should be a production and food and beverage area only. Thirty-one percent of the participants stated that all these areas should coexist. Regarding the preference for the spatial organization of circular maker spaces, the majority (31%) thought that different functions should be together. The other majority (30%) stated that these spaces should be used only for production and waste storage (Figure 08).

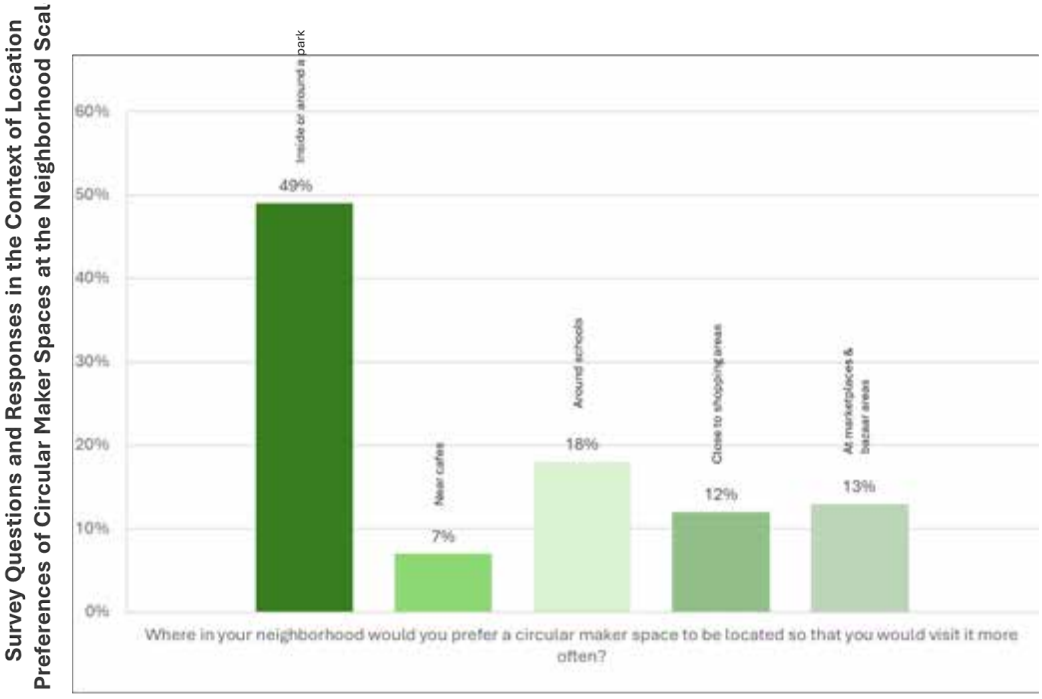

Figure 09. Survey Q&R in the context of Location Preferences of CMS at the Neighbourhood Scale

When asked about their preferred location for CMSs, 49% of participants said they should be in or around the park. The next highest responses were around schools (18%), in marketplaces (local bazaar areas) (13%), near shopping areas (12%), and near cafes (7%). These answers indicated that, while participants imagined circular production spaces alongside the green infrastructure of cities, they also believed these spaces should be combined with social activities (Figure 09).

When asked how neighbourhood-scale circular production spaces could affect their lives, most participants (60%) indicated positive effects, and 25% said they would have a very positive effect. This shows that the presence of CMSs in neighbourhood design is viewed positively. Additionally, 14% of respondents said it would have no impact, while only 1% said it would have a negative impact. Participants did not select the option that a circular maker space would have a "very negative impact" (Figure 10).

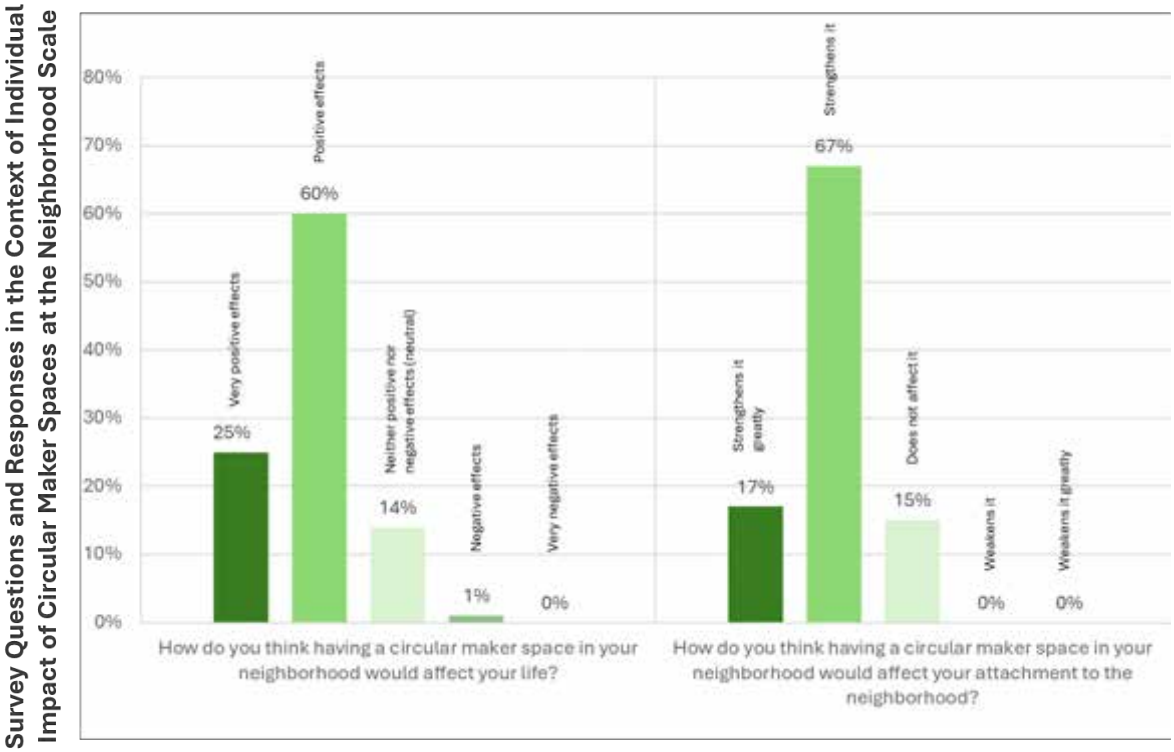

Figure 10. Survey Q&R in the context of Individual Impact of CMS at the Neighbourhood Scale

Additionally, participants stated that a circular maker space in their neighbourhood would have a mostly positive effect on the bond they have established with the neighbourhood. They stated that their bond with the neighbourhood would strengthen by 17%, and 67% said it would strengthen. Fifteen percent of participants think that CMSs will not affect the bond they establish with the place. None of the participants expressed a negative opinion on this issue. This demonstrates that CMSs can foster relationships and a sense of belonging in the neighbourhood (Figure 10).

As a result, the participants perceive circular production spaces as a tool that can strengthen existing socioeconomic and environmental factors in neighbourhoods. In this context, the local government is expected to play an active role in these areas. Lastly, it was revealed that the participants were not sufficiently informed about zero waste projects that could contribute to the municipality's circular economy practices and circular production spaces.

As part of the qualitative research, neighbourhood residents were asked to describe their vision for the circular maker space. A wide variety of responses were received. Analysis of the responses indicated that participants exhibited varying levels of awareness, interest, and imagination regarding the concept of circular production. The responses were associated with six different concepts. These concepts are safe and environmentally friendly, environmental sustainability, social interaction, location of the space, management and organization, uncertainty, and hesitation, respectively. (Figure 11)

Many participants emphasized that CMSs should adapt to their environment. They stressed the importance of avoiding environmental harm. This shows that a circular maker space is perceived as both a technical process and a social value that raises ecological awareness. However, participants had different opinions about the location and structure of CMSs. Some argued that this type of building should be located independently and safely.

Others imagined it as an aesthetically pleasing, well-maintained open space in public areas such as parks. While some participants described circular production spaces on a mesoscale, most envisioned them as part of the neighbourhood's urban space on a microscale.

Open-Ended Questions and Responses in the Context of How City Residents Envision Circular Maker Spaces

	Scope	Number of Responses	Short Definition
	Safe and Environmentally Friendly	1	The expectation for the space to be independent, safe, and isolated from environment
	Enviromental Sustainability	2	Zero-waste managment and environmentally sustainable facility concept
	Social Interaction	3	Spaces for co-production, solidarity, and social interaction
	Location of the Space	3	Located inside the park or in public spaces with an aesthetic design
	Managment and Organisation	2	Serious management attitude and awareness-raising information
	Uncertainty and Hesitation	2	Participants who have no idea or have a negative perception

Figure 11. Open Ended Survey Q&R in the context of How City Residents Envision Circular Maker Spaces

Furthermore, some participants described CMSs as places where not only waste is collected or recycled, but people also come together, work together, and produce social benefits. They also emphasized the importance of incorporating sales spaces into CMSs. This perspective demonstrates that society can develop and embrace a socio-economic perspective, along with circular economy practices and circular production spaces. Some participants emphasized the importance of promoting CMSs and highlighted their educational function and potential to raise public awareness. These responses reveal that communication strategies and physical design are integral to the process.

Some participants were unfamiliar with the concept of circular maker space, could not visualize the space, or thought it was not suitable for their neighbourhood. This shows that society has not yet embraced the concept. Various communication strategies are needed to improve this situation.

The results of the open-ended survey question illustrate that awareness of CMSs varies at the neighbourhood level. These spaces are considered not only physical structures but also spaces for social interaction and environmental awareness. In this context, it has become clear that a holistic strategic planning approach focused on design, education, social participation, and awareness is needed to implement circular production practices at the neighbourhood scale.

02.2. GIS-based Multi-Criteria Analysis (MCDA) for Site Selection

Multi-criteria decision analysis (MCDA) helps decision makers analyse possible actions or alternatives based on multiple, often incomparable, factors or criteria. Geographic information system (GIS)-based MCDA provides a powerful tool by enabling the evaluation of objective and subjective criteria together in decision-making processes. This type of analysis uses decision rules to combine criteria and rate or rank alternatives (Eastman, 2009; Figueira et al., 2005; Malczewski, 1999a; Greene et al., 2011). According to the literature, the main factors affecting the selection of multi-criteria decision analysis methods are the effects of elements such as the number of decision makers, stage of the decision process, number of targets and alternatives, level of uncertainty, risk toler-

ance, measurement scales, experience level, and technical resources on method selection (Greene et al., 2011).

The summary table provides an explanation of each factor in relation to the relevant literature and is structured to guide the selection of methods in decision-support processes. This method was developed to increase the contextual sensitivity of decision analysis, evaluate the suitability of techniques, and ensure transparency and repeatability in analytical processes. It also enables one to perceive the difficulties related to location selection from a broad perspective. (Figure 12).

This study developed a multi-criteria decision analysis (MCDA) evaluation framework of the Analytic Hierarchy Process Table (AHP) to help select locations for circular production spaces. The AHP Table comprises various factors grouped under three main headings.

1. Natural factors: This group evaluates topographic features and suitability for settlement, such as dominant areas and landslide risk areas, as well as distance to water resources and slope.
2. Social and Economic Factors: This group discusses distances to local economic activities, residences, public spaces, and buildings.
3. Access factors: This group includes distances to pedestrian paths, green spaces, public transportation networks, and main transportation axes.

Each factor and subfactor is graded by dividing it into distance-based suitability classes. During the analysis process, the weight of each factor on the total decision is expressed as a percentage. (Figure 14).

Factor	Explanation	Key References
Number of Decision Makers	MCDA techniques designed for individual decision-making can be modified for group settings, typically requiring consensus-building through negotiation or aggregation strategies.	Malczewski (1999b, 2006a); Hwang & Lin (1987); Balram & Dragicevic (2006); Joerin et al. (2009); Rinner (2001)
Decision Phase	Decision-making generally consists of two key phases: problem structuring and evaluation/recommendation, each demanding specialized tools and methodologies.	Anderson et al. (2003); Bouyssou et al. (2006); Turban & Aronson (2001)
Number of Objectives	Single-objective problems are addressed through methods like MCE or MADM, whereas multi-objective decision making (MODM) involves recognizing conflicts or synergies among objectives and organizing criteria accordingly.	Jankowski (1995); Malczewski (1999a, 2004); Eastman et al. (1995)
Number of Alternatives	When alternatives are few, the problem is discrete; when options are numerous or continuous, such as all possible land parcels, it falls within a screening or suitability analysis framework.	Chakhar & Mousseau (2007); Eastman (2009); Malczewski (1999a)

Existence of Constraints	Constraints can limit available options or impose minimum requirements, such as ensuring contiguity or connectivity in spatial analysis.	Eastman (2009); Chakhar & Mousseau (2008)
Risk Tolerance	Risk-tolerant decision makers might optimise for alternatives that satisfy fewer criteria, whereas risk-averse individuals tend to favor options that meet all specified conditions	Eastman (2005, 2009); Chen et al. (2001)
Uncertainty	Decision models can process criteria and weight assignments using a deterministic approach or incorporate uncertainty through probabilistic methods or fuzzy logic techniques.	Jiang & Eastman (2000); Malczewski (1999a); Shepard (2005)
Measurement Scales and Units	The feasibility of normalizing heterogeneous criteria such as monetary values and qualitative data onto a unified scale depends on methodological approaches and the comfort level of decision makers with numerical representation.	Chakhar & Mousseau (2008); Joerin et al. (2001)
Experience	The methodological choices in decision-making are shaped by the expertise and background of the decision maker and the analyst, particularly due to the varied assumptions embedded in MCDA approaches.	Belton & Stewart (2002)
Computational Resources	The choice of methodological approaches can be influenced or constrained by the availability of suitable software and hardware, and financial limitations.	Malczewski (1999a); Weistroffer et al. (2005)
Direction of Problem Solving	Most issues are examined with a forward-thinking mindset, but analyzing past choices through preference disaggregation provides insight into underlying value judgments.	Jacquet-Lagrèze & Siskos (2001); Siskos (2005)

Figure 12: Summary of Factors Influencing Multi-Criteria Decision Analysis (Greene et al. ,2011)

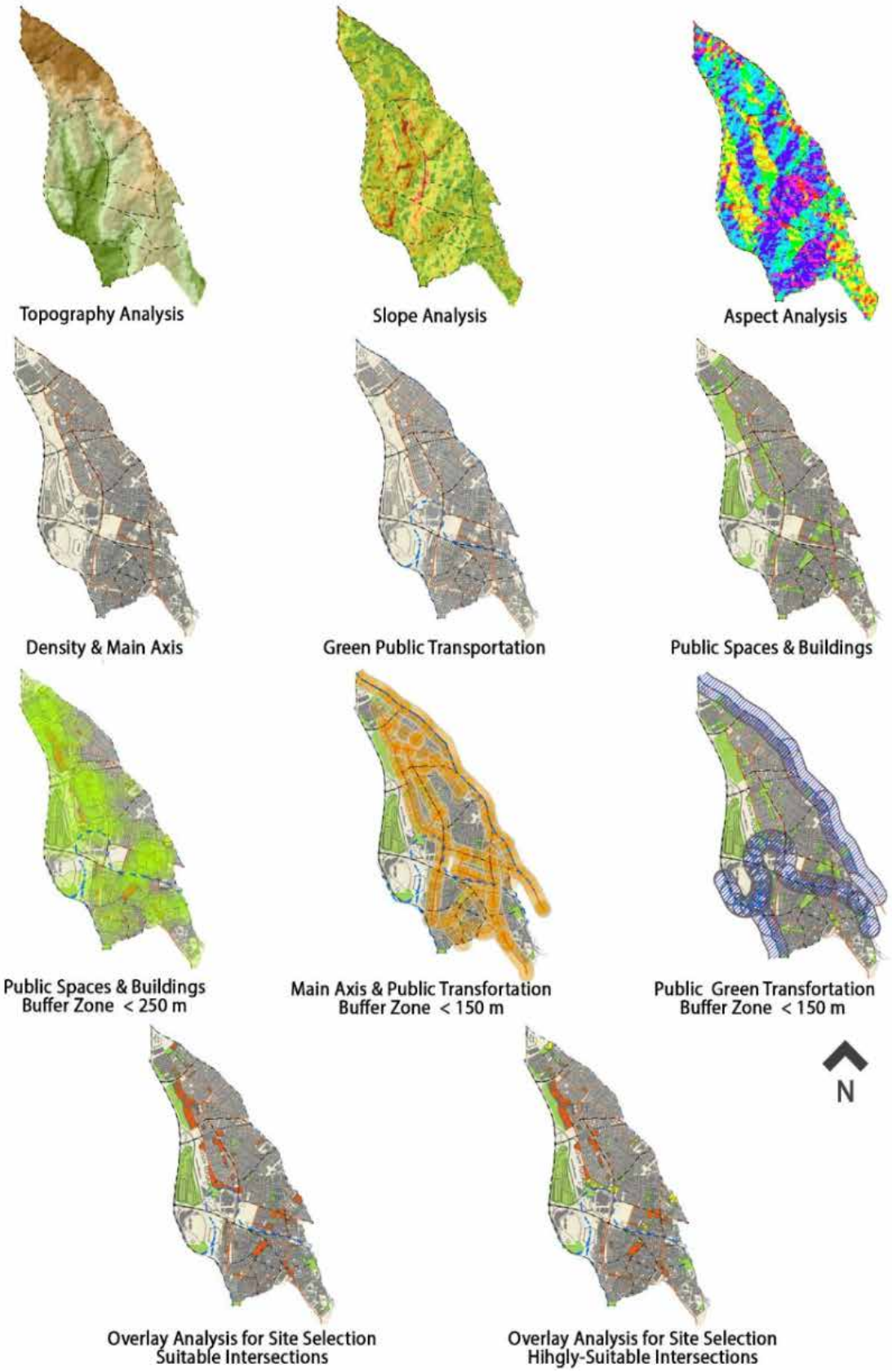

Figure 13. GIS Based Analysis of Bayrampasa / Istanbul

	Criteria / Factor	Subcriteria	Suitable Class	Rank	Weighting order
Natural Factors	Slope	0-1 %	High Suitable	5	13%
		1-5 %	Suitable	4	
		5-8 %	Moderately Suitable	3	
		8-10 %	Less Suitable	2	
		> 10 %	Not Suitable	1	
	Hydrology	> 1000	High Suitable	5	7%
		500-1000	Suitable	4	
		250-500	Moderately Suitable	3	
		100-250	Less Suitable	2	
		0-100	Not Suitable	1	
	Geology	Very Solid Foundation	High Suitable	5	10%
		Solid Foundation	Suitable	4	
		Average Solid Foundation	Moderately Suitable	3	
		Soft Foundation	Less Suitable	2	
		Very Soft/Weak Foundation	Not Suitable	1	
Social and Economic Factors	Proximity to Housings	0-100	High Suitable	5	10%
		100-250	Suitable	4	
		250-500	Moderately Suitable	3	
		500-1000	Less Suitable	2	
		> 1000	Not Suitable	1	
	Proximity to Public Spaces and Buildings	0-100	High Suitable	5	17%
		100-250	Suitable	4	
		250-500	Moderately Suitable	3	
		500-1000	Less Suitable	2	
		> 1000	Not Suitable	1	
	Proximity to Local Economic Activities	0-100	High Suitable	5	8%
		100-250	Suitable	4	
		250-500	Moderately Suitable	3	
		500-1000	Less Suitable	2	
		> 1000	Not Suitable	1	
Accessibility Factors	Proximity to Pedestrian Paths	0-100	High Suitable	5	15%
		100-250	Suitable	4	
		250-500	Moderately Suitable	3	
		500-1000	Less Suitable	2	
		> 1000	Not Suitable	1	
	Proximity to Public Transportation	0-100	High Suitable	5	10%
		100-250	Suitable	4	
		250-500	Moderately Suitable	3	
		500-1000	Less Suitable	2	
		> 1000	Not Suitable	1	
	Proximity to Main Axis	0-100	High Suitable	5	10%
		100-250	Suitable	4	
		250-500	Moderately Suitable	3	
		500-1000	Less Suitable	2	
		> 1000	Not Suitable	1	

Figure 14. AHP (Analytic Hierarchy Process) Table for GIS-Based Site Selection for CMS in Bayrampasa

Figure. 15 GIS Based MCDA Analysis - Overlay Analysis for Highly Suitable Areas for CMSs in Bayrampasa / Istanbul

These factors were determined using sustainable strategic planning principles. The goal is to make them accessible to different groups and support sustainable transportation methods. GIS allows MCDA to support complex land-use planning, site selection, and resource management decisions. (Malczewski, 1999, p. 1).

In addition, the analysis included the main axes in the district and their surroundings, taking into account the importance of adapting cyclical production spaces to economic activities and local elements in the neighbourhoods. Public spaces and buildings accessible to city residents were prioritized during the analysis process. Then, all these layers were overlapped according to the determined sub-factors, and suitable and highly suitable areas were identified for the site selection analysis. The analysis revealed that the yellow areas shown in Figure 13 are highly suitable. These areas are located 100 m away from green transportation networks, 150 m away from the main axes, and at the intersection of public spaces and buildings. (Figure 15)

As a result, the analyses consider the importance of taking a holistic approach to evaluating environmental, social, and economic factors when choosing the location of circular production spaces. Using the superimposed layers in line with the determined sub-factors, it was determined that the yellow zones, located 100 meters away from green transportation networks, 150 meters away from main roads, and at the intersections of public areas, are highly suitable for such production activities (Figure 15). These findings demonstrate the effectiveness of data-driven, multi-criteria decision support systems in sustainable urban planning.

03. Discussion – What are the possibilities for LAM?

The circular maker spaces discussed in the study are believed to be vital instruments in spreading the CE model during the transition process, helping to accelerate it. The results of the surveys conducted in this context sup-

port this hypothesis. Here, an important question arises: how can CMSs be appropriated into urban spaces on a local scale? This section discusses the potentials and constraints of the appropriation process.

The qualitative and quantitative data presented in this empirical study reveal many potentials for the development of local appropriation models for CMSs, but also constraints at different scales.

Firstly, the expectations of local residents regarding CMSs and the current practices of the municipality were examined as part of the empirical research conducted in the context of the Local Community Comprehensive Tool (LCCT). According to the survey data, CMSs are perceived as environmentally sensitive spaces that support green transformation. In parallel, the findings revealed that in future urban scenarios, CMSs are envisioned as spaces that merge with urban space, are easily accessible, are dominated by technology, and will create added value for neighborhoods and residents while implementing CE principles. These expectations demonstrate that CMSs are seen as potential spaces to support local economic development in neighborhoods.

On the other hand, the municipality's existing practices (Pasakart, etc.) promote waste recycling and support residents to gain added value from it, but are not well known by residents. This highlights various constraints that will occur in the process of transition to CE while highlighting various failures in the governance forms of local government. In general terms, these constraints point to a lack of cooperation and communication between local government and residents.

Furthermore, residents' expectations from the municipality regarding CE implementations and the management of CMSs reveal that local government is one of the most important actors in meeting expectations in this process. The presence of the local government as a mediator is an important element as the process of finding a place for CMSs in urban space will be a multi-actor process. Indeed, issues such as inequality, power relations, accountability, and adaptation to changing needs over time are important in the governance process. In this context, these concerns of local residents have also revealed the importance of the unity of management models and implementations in the integration of CMSs at the local scale. This highlights the importance of shaping these practices within a framework of just city understanding, equality, diversity, and democracy (Fainstein, 2010) in order to gain social acceptance.

Conversely, the fact that residents perceive CMSs as a means of strengthening their sense of belonging to the neighbourhood suggests that these spaces could be supported locally. It is important to consider the nature of space, which is defined by the idea that 'space is permeated with social relations; it is not only supported by social relations, but also produced by, and produces, social relations' (Lefebvre, 1991: 286, cited in Hayden, 1995: 31; Low, 1996). Apart from the physical production process of CMSs, integrating these spaces into the urban landscape through participatory processes is important for redefining the meaning of urban spaces for residents. Additionally, this process fosters place attachment and the perception of CMSs as places that transcend urban spaces.

This is because place attachment emphasises the emotional relationship that people develop with specific places. In this case, it significantly affects how urban residents experience, perceive and engage with these spaces, shaping their identities and well-being. Strong place attachment plays an important role in protecting and maintaining these places (Scannel & Gifford, 2010). At the same time, residents must see CMSs as social empowerment platforms that go beyond spaces focusing on CE principles. The process must also be transparent and diverse to support social well-being.The presence of CMSs in neighbourhoods is the most important factor in ensuring their sustainability in urban spaces.

As supported by the survey results, it is clear that these places will support social empowerment and contain possibilities for a diverse and just future. The location of CMSs, their easy accessibility, support from green city networks, and enabling activity for different socio-economic groups also support local implementation in this regard. The second part of the study is a GIS-based, multi-criteria analysis that considers the suitability of CMSs for urban spaces. Taking a holistic and analytical approach, this analysis provides important findings on these spaces within the framework of strategic, sustainable urban planning. Supported by qualitative data, this offers possibilities for achieving the ideal result in terms of site selection.

Developing existing applications in line with CE principles and integrating CMSs with local government will initially help these spaces flourish on a local scale. Understanding these principles, ensuring their adoption by society, and managing this process are important for the success of the applications. Additionally, the different functions of these spaces encourage residents to use them more frequently. These CMSs support local appropriation at the neighbourhood level. At the same time, this situation also demonstrates the different potential of CMSs.

04. Result

In a nutshell, the acceleration and dissemination of CMSs in cities regarding the implementation of CE principles process should be managed through bottom-up, transparent, and democratic methods by local authorities. This process should be able to create added value in neighbourhoods and enable various functions and spaces to be combined within the context of local appropriation. The study concluded that the local appropriation process of CMSs has the potential to support socio-economic empowerment and environmental improvement. As a result, the study revealed that the local appropriation process of CMSs has the potential to support socio-economic empowerment and environmental improvement. This result is a significant finding in terms of supporting the sustainable development of future cities.

In the context of the study, it provides an important roadmap for integrating circular economy (CE) strategies in cities, offering an inclusive and holistic perspective. Ultimately, it aims to address the lack of literature on the subject by offering insights into future scenarios for the sustainable development of cities in terms of the implementation of circular economy (CE) principles.

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AI tools were used to translate this paper from Turkish to English and to check its English grammar.

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Unveiling Hidden Potential. A Typological Approach for the Underground Landscape.

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Abstract
Urbanization and environmental challenges underscore the importance of utilizing underground spaces as strategic resources for future cities. However, a systematic framework for analysing the complexity of these spaces is missing. This research proposes a typological analysis of underground environments, categorizing them into four layers: surface, medium, deep, and ultra-deep—each with distinct functionalities. While the underground is recognized for its potential in stabilizing temperatures and reducing energy consumption, it remains fragmented mainly in analysis. The article proposes an underground taxonomy generating a hierarchy of configurations, divided into geometrical and topological, and networks, divided into vertical, nodal and horizontal, helping to understand better how underground layers influence above-ground development and emphasizing the need for a robust urban planning theory.

Keywords: Underground Urbanism, Typological approach, Subterranean Taxonomy, Three-dimensional city, Layered Urban Landscape.

Introduction

The city should be considered a unique entity defined by combining different objects and (Hillier, 1984) considering a three-dimensional perspective, the connection between the above and below-ground realm. However, even if these two spaces have a different structure and forms, their point of connection defines the relationship between them. The encounter between the superficial city and the ground is usually reduced to a simple line, while it is a thick object container of activities and transformations (Berlanda, 2014). This complex object is the catalyser of motion, transforming the horizontal movement to the vertical and again to the horizontal in a continuous circle. Already, this concept divides the city into three principal stratus: the city above the ground, the one below it, and what we find in the middle, the ground itself. This last term does not refer to a static plane but a negotiable, permeable membrane that can be traversed, penetrated, and reinterpreted. Therefore, today's subterranean realm cannot be considered only a tunnel network or utility corridor but a complex system answering to the urban metabolism.

The lack of understanding of how the underground landscape is structured prevents us from projecting its coherent and strategic management into the future. As a result, planning below the surface tends to be treated as a subordinate extension of what is planned above ground. The absence of a holistic vision capable of harmonising design between ground-level and underground areas limits the functional and ecological potential of these spaces and reflects a short-term vision. This article analyses the subterranean landscape as a component of urban morphology that has not been explored due to its difficulty in extending the above-ground analysis to the underground realm.

Methodology

The article is structured in two phases: one theoretical, where the underground realm is analysed in its urban development, and one practical, classified in its possible typological components.

Firstly, the theoretical background defines a historical excursus of how the underground realm has been considered from the birth of modern cities until now. From the chronological analysis, the subterranean results as a non-liu, unconnected to the superficial space and, therefore, not easy to analyse. That brings the author to the first classification of the below-ground layers, described by the depth, the location of the activities and the actual use of the underground realm in today's urban planning. Then, a typological approach is provided after describing Henry Beck's Diagram and understanding a new abstraction method for defining the subterranean which is analysed in terms of its taxonomy, spatial, and network configuration.

The outcome mirrors how the underground realm can be described and classified.

State of the Art

Ground Strata

Although the Earth's complex structure extends deep below the surface, human activities have primarily focused on the upper layers for urban development. This preference is mainly due to the temperature and material conditions in these shallow strata (Admiraal, 2018). As one descends closer to the Earth's core, temperatures increase significantly, complicating infrastructure construction and costs. The soil consists of several horizontal layers, and its structure and quality depend on the climate, temperature, geological, and hydrographic local conditions. The most superficial layer is the litter of undecomposed or partially decomposed organic plant and animal residues. Beneath this lies humus, rich in organic matter that is actively decomposing, where intense biological and chemical activity occurs to transform the soil. Further down, the layers become increasingly solid, consisting of silt, sand, and clay, with the deepest layer being inert rock, often referred to as the mother rock (Parisi, 2019).

Therefore, this article will concentrate on the top forty meters below ground level. As we explore underground layers, the characteristics of each stratum, the infrastructure and activities present within them, and the geological and structural factors that shape their development will be examined. This analysis aims to enhance our understanding of subterranean environments by proposing a classification system with five distinct strata, each typically linked to particular urban activities.

- The Surface and Shallow Layer, extend up to 10 meters deep, crucial for building construction and underground basements, as it maintains surface integrity. It supports underground parking, shopping malls, sewer systems, utility facilities, and service tunnels, which are affected by weather and urban activities.
- The Mid-depth Layer, 10 to 40 meters underground, contains more complex security and environmental protection infrastructure. It supports metropolitan transport networks, rail tunnels, underground warehouses, power distribution networks, and environmental control systems.
- The Deep Layer, from 40 to 100 meters deep, features denser and more stable soil with increased temperature and pressure. It supports specialized infrastructure, such as rail and road tunnels, geothermal plants, underground storage facilities, research laboratories, and water treatment systems.
- Finally, extending beyond 100 meters, the Ultra-deep Layer presents extreme geological and environmental challenges. At such depths, temperature and pressure are significant, complicating access. This layer is utilized for specialized activities, including mining, oil and gas storage, seismic monitoring, and communication networks.

It is essential to note that these divisions are not rigid; various processes can overlap within the same layer, leading to a mixture of different infrastructures existing together in a single space.

Surface-Subsurface Representation

Today, the architectural approach considered the division of what was happening above and below as a fixed object, simple to analyse due to its minimal dimension. The way of representing the vertical city led to three main methods. The section (Figure 1) is the most used solution[1], where the city is presented as an iceberg, and what we see above and below is divided by a simple linear object without form (Berlanda, 2014). The result emphasises the division between the two elements that define the city: what lies above and below. Then, the axonometry[2] (Figure 2) creates a more holistic overview of the city (Frampton et al., 2012). This solution creates a three-dimensional perspective of the metropolis but needs a fundamental comprehension of how the space is made. The result is a unique, indistinct object.

Finally, the scheme[3] (Figure 3) is a representation method that synthesises concepts and helps comprehension

1 Representations in the book: Berlanda, T., (2014). Architectural Topographies. A graphic lexicon of how buildings touch the ground, Routledge: New York.

2 Representations in the book: Frampton, A., Solomon, J. D., Wong C., (2012). Cities Without Ground. A Hong Kong Guidebook, ORO.

3 Representations in the book: Reynolds, E., (2020). Underground Urbanism, Routledge.

(Reynolds, 2019).

Figure 1 (left): Section of J. M. Tjibaou Cultural centre in Noumea (New Caledonia) by Renzo Piano 1991-1998 (Source: Berlanda, 2014)
Figure 2 (centre): Axonometry of the city of Hong Kong (Source: Framptonet al., 2012).
Figure 3 (right): Schematic representation of the underground (Source: Reynolds, 2019).

To understand correctly the transition between above and below urban landscapes, we have to start from its role in the urban composition. The shift from below ground to above ground connects two distinct urban flows: one that moves through a horizontal underground city layout and the other that aligns with a horizontal aboveground city layout, traversing a substantial element known as the groundline. Furthermore, this element defines the vertical relationship between different parts of the three-dimensional city and can be analysed by three variables:

- Altimetry, which considers the different heights it has to connect;
- Orography, which defines the natural conformation of the environment under study;
- and Topography, which represents the form and movement of the earth's surface.

This space's final design can create separation or promote inclusion among different city areas, enhancing accessibility, reducing barriers, or potentially leading to the opposite outcomes (Berlanda, 2014).

Another essential role of this transition is determined by its social effect in the city and can be classified as invisible (or passive) or visible (or active).

The passive purpose addresses the practical requirements for constructing the city: it is essential to consider the transition layers as key areas shaped by the foundation technology. The deeper the foundations are for the structures above ground, the stronger the connection between the surface and underground environments. These layers define how dependent different parts of the city are on one another. This solution is also described as invisible since we do not consider it in everyday life but instead create the structural basis for the city itself.

On the other hand, the visible transition emphasises vertical layering in the metropolis and determines how we move around it. This solution is well represented in the axonometric views of Hong Kong by Frampton et al. (2012), who creates an actual layering in the city according to the different activities. Taking these drawings as a reference, the metropolis can be organized into three distinct movement levels: a lower level for vehicles, a middle level for pedestrian pathways, and an upper level for high-speed public transport. In this design, the traditional concept of the ground takes on new significance as individuals primarily navigate one of these three layers, depending on their roles in transportation. With this in mind, the ground moves up or down with the user and its needs.

When we look at technology, the lines between physical infrastructure and digital interfaces are becoming less distinct, creating a seamless technological environment. Underground spaces are becoming vital technological hubs that significantly change how we experience urban areas. They are more than just physical structures; they function as dynamic systems facilitating communication, movement, and social interaction. As technology influences our understanding of urban spaces, underground infrastructure has shifted from a passive element to an active part of urban life. It engages with us, changes our experiences, and continually shapes our interactions with technology. In this new perspective, the underground is not just below the city. Again, what 'ground' means shifts depending on the user's experience (Kim, 2016).

The division between private and public spaces becomes essential in the active transitions. This separation clarifies the level of accessibility in space, defining what is reachable and what is not and to who (Admiral et al., 2018). The result is a different perception among inhabitants of the city's depth, and again, the ground level moves according to this perception.

Michel Foucault's idea of heterotopia is relevant here, as it helps explain the complex interactions within urban spaces (Foucault, 1967). These spaces are not fixed or stable. They are dynamic environments where social and technological factors continuously reshape our experiences. The ground transforms into a lively realm where various spatial principles coexist and interact. This perspective challenges our fundamental beliefs about city dimensions, influencing urban dynamics and morphology: architectural forms, infrastructure, and human experiences are blended into a complex, 3D system that defines the city. In this context, every urban layer influences the metropolitan dynamics.

Subsurface Conceptualization

In the early years of the nineteenth century, navigating the underground city was challenging due to its lack of design planning. The first underground maps, introduced in 1908 (Figure 4), were created for the London subways to aid travellers in finding their way to address this issue and make them orientate in a space without an apparent coherent form.

The English maps of the 20s were folded and sold in shops, railway stations, or companies as an orientation device. The standard dimensions were 14,7x22,1 cm, and the paper was folded twice to obtain a pocket size. All provided the 'Underground Map of London' title (Burwood et al., 1982).

Figure 4 - Underground Map of London, 1908 (Source: Garland, 1994)

Figure 5 - Underground Map of London, 1923 (Source: Garland, 1994).

While the first maps did not directly guide users, they were essential in connecting the above-ground and underground public transport networks. They helped create a sense of unity among the different layers of the city by

illustrating concurrent activities both on the surface and underground. Additionally, the maps aligned the transport routes with the city's geography, allowing users to quickly understand the relationship between the station locations and the city's overall layout. However, looking carefully, the geographical coordinates also needed to be more precise to guarantee the integration of the above-below network, resulting in the distortion of some lines: few maps were accurate to scale (Toor, 2013).

The first colours used distinguished only the surface network (red) from the subterranean one (blue) as visible in the map of 1923 (Figure 5): different palettes were used in the various editions. As visible in the image, the lettering needed to be more precise, overlapping, or directly omitted (Gerland, 1994).

As the city grew, the public transport network became more complicated, making it harder for people to read the map and find their way around. In an attempt to address this issue, symbols were added to the map in 1927, but more was needed to improve the situation significantly.

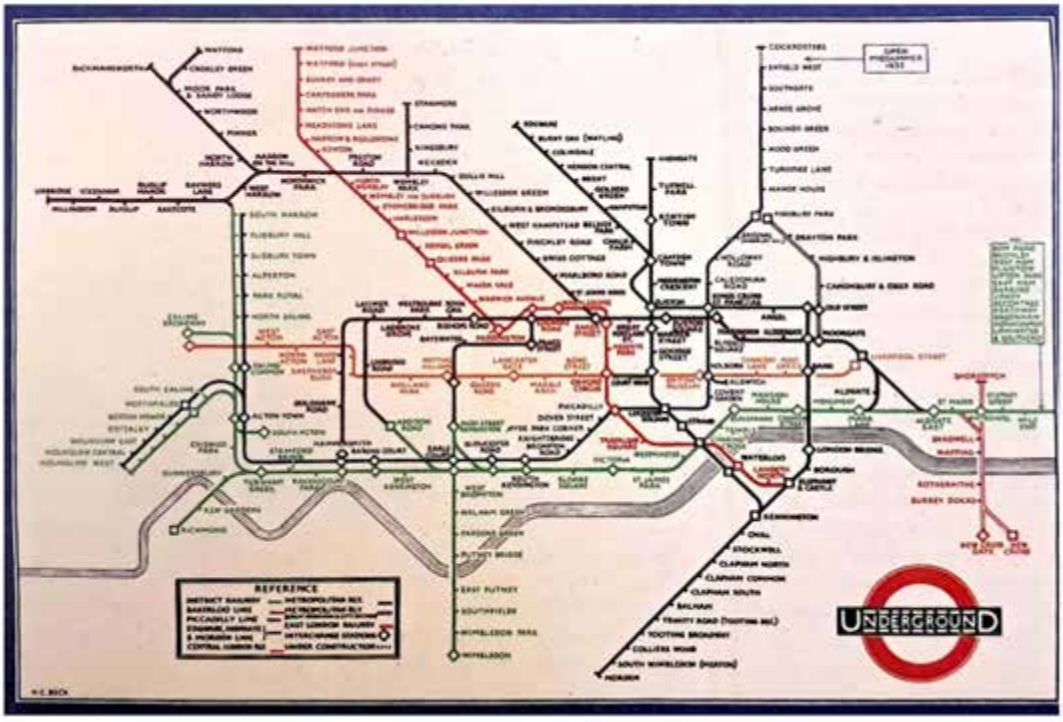

Figure 6 - Underground Map of London, January 1933 (Source: Garland, 1994).

The chaotic, incomprehensible reality of the modern underground city was simplified by the design of the Diagram (Figure 6), the new map of the London Underground network published in 1933. In the previous editions, the geographical approach created difficulty in comprehending the devices, which entailed concerns about orientation in the subterranean network. Therefore, it is no coincidence that Beck's Map was so highly appreciated in its foldable, pocket-sized form and practical use. The defined colours, orderly lines, rational rigor, and structural grid stayed within a reasonable conceptual distance from those of Mondrian, so beloved at the time. All these elements helped to define the Diagram, one of the great modernist aesthetics inventions of the London Subways (Ashford, 2013).

> "Looking at the old map of the Underground railways, it occurred to me that it might be possible to tidy it up by straightening the lines, experimenting with diagonals and evening out the distance between stations. The more I thought about it the more convinced I become that the idea was worth trying, so, selecting the Central London Railways as my horizontal base line I made a rough sketch. I tried to image that I was using a

> convex lens or mirror, so as to present the central area on a large scale. This, I thought, would give a needed clarity to interchange information." (Ashford, 2013)

From these assumptions, he decided to convert the old 'vermicelli' (what he used to call the previous geographic network setting) into a new solution.

When he designed the first proposal, Henry Beck was a 29-year-old engineer of the London Underground Railway who remained impressed by the complexity of the maps published before and wanted to get involved to create a more effective solution (Gerland, 1994).

Already in the first sketches and the first map from 1931, the background usually used in the previous editions disappeared, and only the River Themes remained as an orientation reference. The colours were the same as the Stingemore solution, while the map structure was defined by horizontal, vertical, and 45- or 90-degree diagonal lines (Garland, 1994).

A new non-lieu

What emerges is an underground realm analysed in its forms of abstraction and an undefined entity, which seems unconnected to the surroundings and the city as a whole. In fact, before Henry Beck's Diagram, the first underground experience in the nineteenth century was noisy, chaotic, and confusing. The fear of the first travellers in the underground was the perception of being compared to goods where passengers were left or picked up at the stations in what was instead shown by the government of all of Europe as the most revolutionary discovery of the century. In the environment, contact with the landscape was lost, and without a map, only those familiar with the lines and underground structure could orientate themselves below ground (Ashford, 2013).

Marc Augè (1992) defined a non-place as a space lacking connection to the surrounding landscape, where it is difficult to move without signals or indicators. Based on this definition, the subterranean realm can be considered a non-lieu. Its complex structure and distinct characteristics compared to the surface require guides—such as colours, lighting, and design elements—to help individuals orient themselves within this environment.

We analyse our space at three levels that, little by little, help us understand and experience it. The first level is perceived space, representing what is captured from the outside. This space is not conveyed by reason; our senses determine it, and it is innate. Once inserted into an environment, our body automatically perceives temperature, colours, and lights and transforms them into physical or mental sensations. Then there is the second layer, defined by society and the need to live in the same space governed and determined by rules and ways of behaving: the conceived space. It is abstract, presupposes knowledge of basic concepts of representation (symbols, signs, colours to which a meaning is associated), and is structured according to the logic of the dominant social power. The conceived space is built by specialists (engineers, architects, artists, etc.) who, with their representations of space, try to reduce the environment to rational and geometrical solutions, thinking technically and logically, creating a standardisation of the space. Finally, the lived space is chaotic and full of personal memories and conflicts. This space escapes social rules and constraints, preserving a more authentic and personal dimension of human experience. Here, the imagination plays a fundamental role in creating representational spaces, images of reality, then transformed by the human mind to appropriate and personify them (Lefebvre, 1974).

In the first forty years of the subway, the subterranean realm was not understood by travellers and was considered abstract and not comprehensible by the majority. They needed to wait at least two decades after the opening of the first line for the first station interiors and the first underground map in 1933 designed in the UK. Advertisements were not immediately all around, and the first solutions were provided in case of emergency (escape exits or personal support) (Ashford, 2013).

Results

How it has emerged, the city is usually analysed without connecting what lies below the ground layer with the su-

perficial realm, with consequent difficulty in understanding the city as a whole. Moreover, the approach is usually typographical since it is considered the point of departure and the one of arrival, not the space between them. Harry Charles Beck introduced this method in 1908 to help Londoners navigate the city's underground transit system more effectively. His approach made it easier for users to understand the network quickly and logically. It improved subway navigation and provided a clearer overall view of the city, allowing people to describe the urban morphology from perspectives beyond just the surface.

Although the underground is integrated into the urban environment through its four layers of stratification, which create a vital foundation for surface functioning, capturing it as a cohesive entity remains challenging. The concept of the underground revolves around human experiences related to what lies beneath our feet. This contrasts the idea of landscape, which evokes a sense of frontality and represents everything within our line of sight. The subterranean, however, is largely hidden; it can only be imagined or described metaphorically. As a result, a clear opposition exists between landscape and underground: the landscape encompasses the spaces we can immediately perceive and articulate, while the underground necessitates time and exploration to uncover. Therefore, it is essential to consider how underground spaces can be classified and described to ensure their connection to the city as a whole system.

Discussion

Typological Analysis of Underground Spaces

The following paragraph explores the typological characteristics of the space beneath us, trying to encompass the previous studies for the subterranean landscape: architectural planning often overlooks the complexity of the underground realm, focusing on engineering and geological assessments. This approach creates a disconnect between the subterranean and the surface, leading to a predominantly two-dimensional perspective on urban design. The following classification will categorise underground spaces to enhance our understanding.

Typological Taxonomy

The urban underground represents a complex and multifaceted spatial realm that goes far beyond the stereotypical image of dark, damp tunnels. Delving into this subterranean dimension reveals a diverse tapestry of spaces, each shaped by distinct functional, architectural, and experiential characteristics. Drawing from the taxonomic framework, the first categorization of the underground world that immediately results in our mind is the division between what can be considered a mere excavation in the underground and what needs a more structured architectural and engine eristic background. Starting from this point, we can examine three primary typologies that encapsulate the richness of the urban subsurface.

The first category will be the excavated spaces - subterranean environments carved out through deliberate human intervention or natural geological processes. These solutions range from ancient underground cities, such as the remarkable Uchisar complex in Cappadocia, Turkey, to more contemporary forms of spontaneous, adaptive reuse. Excavated spaces demonstrate the noteworthy adaptability of the urban underground, as well as its ability to accommodate alternative modes of inhabitation. The Cappadocia region is characterized by lava material solidified after an eruption, creating interesting plastic objects called "fairy chimney" that differ in depth, dimensions, and colour. Initially, these spaces were used for shelter, but then, thanks to the handwork of the area's inhabitants, it was transformed into an actual caved city where all the natural rocks called 'fairy chimney' were converted into churches, houses, or collective spaces simulating stone houses with decorations, columns, vaults, and arches. These spaces, which could not contain more than 15-20 people at a time, guaranteed isolation and protection for other civilizations surviving during the time. According to the architectural elements used for the construction, the fairy chimney was used for different purposes, as seen in the image below (Erdem, 2008).

Then, there are the infrastructure spaces that represent the critical technological arteries that sustain the functional operations of the city above. These spaces include extensive transportation networks, such as the renowned subway systems of global metropolises and intricate utility distribution systems for water, electricity, telecommunications, and other essential services. These infrastructure spaces facilitate the efficient flow of peo-

ple, resources, and information, incorporating advanced engineering solutions and cutting-edge technologies. They transcend their purely utilitarian role, becoming integral to the urban experience. Even if these spaces are used only for the flow of utilities (water pipes, gas pipes, electricity pipes, etc.) or people and can be defined as places of movement, they are characterized by designed features mostly in spaces where citizens can walk. The Moscow Metropolitan Line, for example, was designed not only to exhibit the city's technological development but also as a manifesto of traditional socialism aesthetics. The stations should be attractive for those who pass through them with long corridors with vaulting breakthroughs, recesses, coffers, false skylights, projecting cornices, dividing piers into orders, creating niches, and blind windows (Toson, 2024).

The third type of underground space includes architectural spaces designed for human use in subterranean environments. These solutions are intentionally created to support various activities, such as recreation, commerce, education, and cultural exchange. Unlike infrastructure spaces, which are characterized by a continuous flow of movement, these architectural spaces focus on specific activities within the underground environment. Infrastructure spaces serve as pathways to these architectural areas, aiming to enhance the environmental qualities of the surface and offering experiences that reflect traditional urban layouts. They also differ from excavated spaces because they need a more structured and planned to characterize today's cities.

As urban populations grow and land use becomes more intense, many cities are exploring innovative solutions to meet the basic needs of their residents. In Beijing, for instance, some individuals live underground to stay close to the city centre while keeping costs manageable[4] (Kim, 2016). The city contains over 10,000 bunkers initially built during the Cold War for protection against bombings: these bunkers have now been repurposed as homes. It is estimated that around 1 million residents in Beijing live underground. Typically, these apartments are small, averaging about 10 square meters, and often shared by multiple occupants. Residents have access to shared bathrooms, centralized heating, gas air conditioning, internet services, and some retail spaces below ground. To foster a sense of community, those living underground have formed groups like the "Rat Tube" and Digua Shequ ("Sweet Potato"). These communities provide shared amenities such as gyms, cinemas, theatres, and cafes, enhancing the living experience for their residents. The spaces are intentionally designed with colourful decor, specific lighting, and materials that aim to minimize a cave-like atmosphere (Reynolds, 2018).

In **Table 1**, the principal activities that can located underground are defined.

Table 1 – Underground principal activities

Commercial	***Civic & Public***	***Industrial***	***Specialised Environment***	***Technological Interfaces***
Shopping Complexes	Cultural Spaces	Data Centres	Military Installations	Communication Networks
Retail Arcades	Government Facilities	Manufacturing Spaces	Scientific Research Facilities	Sensor and Monitoring Systems
Commercial Galleries	Emergency Shelters	Research Laboratories	Archaeological Preservation Zones	Automation Infrastructure
Service Tunnels	Public Amenities	Utility Management Zones	Climate-Controlled Repositories	Energy Management
Storage Facilities	Educational Complexes	Technical Infrastructure Hubs	Secure Storage Facilities	Smart Control Systems

Spatial Configuration

The underground landscape has yet to be analysed from a morphological point of view, creating difficulty in defining, describing, and understanding it. Many solutions have been brought to the catalogue between objects

4 Distance to the centre is the principal element that creates the price of these spaces, and the data provided by the www.ganji.com website show that depth is not a factor influencing the value of the apartment.

and networks, otherwise defined as containers of activities and connections between receptacles. In addition, it is also possible to distinguish between private and public spaces according to the ownership of the space it is looked at (Admiral et al., 2018). Specifically, objects are all spaces that represent an area of being, while networks represent movement (what was divided between architectural spaces and infrastructure space before).

Even if it is easy to understand and describe, this definition still needs to tell the form of the underground and the possible configuration it can assume according to the city and the environment analysed. In the following chapter, the analysis will consider the possible morphological arrangements the underground can acquire. The metropolitan network will be used as an example to make the study more comprehensible and connected to reality. The same considerations can be repurposed to people, vehicle flows, networks, utilities, and fluid movement.

The analysis will start with a division between geometrical and topological configurations. The first ones refer to structures' physical form and spatial disposition, and their measurable characteristics define them. These solutions find linear, radial, or grid patterns following precise geometrical roles, explaining the physical organization of space and its proposition and dimension. The topological configurations refer to how spaces are connected and related: connection networks, hierarchy, functional relations, flow and way of movement through space, and logical and relational organization between different systems.

If we take the metropolitan line as an example, its geometrical configuration will explain the tunnels' physical layout, dimensions, and forms. At the same time, the topological characteristics will analyse how different lines are connecting, which are the principal nodes, and how people are moving inside.

This distinction is fundamental to understanding the underground landscape's physical form and how it functions as an interconnected system of spaces and relations.

The geometrical configuration can be divided into three subcategories.

The linear configuration represents the simplest type of metropolitan configuration, defined by main routes connecting to the nodal points of the city. This solution may represent the first stage in constructing an underground network, thus symbolizing a city in the development process or not too large to need a more articulated network. This simple solution guarantees rapid movement around the metropolis without the need for other intermediate connections.

The second configuration is the radial one. It develops from a centre outwards, creating a radial structure. This configuration is particularly effective in the historic centres of European cities, where a central core serves as a distribution hub and aims to keep the landmark centre as intact as possible. This solution also had a significant following during the post-war period because, through a well-known external connection for all lines, it was possible to keep the underground city well-connected and ensure a greater connection between the various lines.

Underground grids often reflect the surface urban structure, creating an ordered system of interconnections, the grid configuration. They are solutions that require careful and orderly planning at the base and, therefore, were not found in early metro solutions, where it was essential to combine planning with technologies and construction methods that had never been applied before. These solutions are seen again in often very extensive underground landscapes related to metropolises of considerable size. The underground grid facilitates orientation and navigation by creating a simple and intuitive movement logic.

Lastly, the interconnected configuration is the most complex solution, requiring different systems to overlap at various levels. This solution is mainly found in vastly expanded metropolises where the flow of people is so high that parallel paths connected at other levels are required. We are primarily talking about solutions that have developed over time, requiring a continuous adaptation of the underground space to the surface space and, in some cases, modifying the initial rigor with solutions capable of extending the underground route to the entire urban fabric.

There is then the topological configuration which can be divided into three subcategories.

The nested spatial arrangement describes how underground spaces fit into each other, creating layers of depth and connection. The hierarchy envisages central bodies as centres of activity and hubs from which pathways, in turn, branch off to other central cores. The result is a highly dynamic and quickly developed structure of nodes and axes that concentrate urban sprawl in the poles that become social, economic, housing, and resource catalysts for the entire city.

The ramified network system represents a diffuse net of connections where all the central stations have the principal role. The configuration has an inward-looking development; the historical centre is the most preserved and connected area. This solution results from a historical city that wants to maintain the city centre from extended metropolises and guarantee a strong identity in each neighbourhood.

The decentralised distributed system is the opposite solution before described. It represents a diffuse net of connections where all the stations assume the same hierarchy. The configuration has an outward-looking development and guarantees a quick reach of peripherical areas still well connected to the historical centre. This solution usually needs both a superficial and underground development and results from an extended metropolis that guarantees a strong identity in each neighbourhood.

Network Configuration
The network structure of underground environments can be analysed in various ways, starting with the concept of hierarchies, which is essential. When planning a network, it's crucial to establish a hierarchy to ensure an organized layout throughout the city. Typically, the lines are categorized into primary, secondary, tertiary, etc., which allows for quick connections between areas, while less critical lines intersect with these to reach different parts of the city.

This categorization serves multiple purposes. Firstly, it helps facilitate smoother navigation through the city, reducing congestion in high-traffic areas where a fast flow is necessary. Additionally, different levels of connectivity can highlight various characteristics of the network. Underground connections often link to surface networks, varying depths affecting how elements connect and what (or who) they transport.

Another important aspect of this hierarchy is accessibility. Not all underground areas are available to everyone due to their natural layout or urban needs. As a result, spaces are typically divided into public, semi-public, and private zones. Public zones like the metropolitan line are open for general use, allowing people to move freely across the city. Semi-public zones are accessible only to particular groups, like companies or institutions with limited access. Private zones are restricted to a select few who own or have permission to enter those areas.

Lastly, networks can also be divided based on security levels for military considerations. For example, in Moscow, the metropolitan line is categorized into first-grade and second-grade lines, indicating which can withstand bomb attacks and which cannot (Toson, 2024).

Another possible classification of the network can be done from a geometric point of view, considering the disposition of the spaces and how they are disposed of in the space. Considering this perspective, we can talk about horizontal systems that are the subject of the underground landscape and represent all the networks, lines, and pipes we can find underground. Then, vertical systems connect between the above-ground level and the underground realm. Lastly, the nodal connections represent the junction between different levels in the subterranean realm and help move from one horizontal system to another or reach the vertical exit/entrance.

The underground landscape "is defined by a world usually described as cylindric, cones, cube-piped, connected, or overlapped," as Christian Toson defines in his book Memorie del sottosuolo. La metropolitana di Mosca (2024).

From a horizontal perspective, tunnels play a crucial role in the city's management and operations by facilitating the underground movement of people, goods, and services. They can be categorized based on their purpose and construction, and each type serves a specific function contributing to the city's efficiency and safety. They include the following types. Firstly, there are the transportation Tunnels. These are essential for public mobility, such as subway lines connecting different city parts. Another type is the Service Tunnel, which houses utilities like electrical systems, sewage lines, and telecommunication networks. Finally, the escape tunnels are designed to allow rapid emergency evacuation.

The list should also include the Transit platform located in elevated areas within the station, facilitating passengers' movement along the line. Occasionally, service personnel utilize these spaces to maintain the lines. The English engineers who designed the first underground line in 1863 implemented a solution that involved placing trains in a central area, supported by platforms on both sides, to effectively manage passenger flow.

Additionally, different technologies were adopted by Moscow stations based on the expected passenger volume. Stations designed with shorter depths that featured columns, a floor slab, and a central platform, allowing trains to operate on either side, hosted a small flow of people. In contrast, deeper stations were designed to accommodate larger crowds, with three interconnected tunnels and various entry points (Toson, 2024).

The passage between the surface and the subsurface should not be perceived as a simple line but as a thick object, a receptacle of the transition between these two parts of the city and the vehicle for moving vertically (Berlanda, 2014; Frampton, Solomon & Wong, 2012): what is going to be called the transition strata. The descent into the underground realm represents a vertical travel between urban time and space (Graham, 2016). Access to the subterranean landscape can be categorised into four primary types: standard entrances typically marked by staircases, entrances enhancing accessibility for individuals or linking to additional stations, entries from public spaces, and entries from private properties.

- *Standard Transitions.* Stairs are the usual way to access the subway, while ladder stairs provide a straightforward way to access the unseen underground, symbolising an immediate shift from the surface to a mysterious, hidden world (Manaugh, 2012). Descending a ladder is viewed as a transformative action, shifting from the familiar and routine to the unexplored and concealed. This movement requires effort and can foster a sense of vulnerability and reflection. These accesses are usually used for maintenance and access to critical infrastructure such as sewer systems and underground power lines (Graham, 2016).
- *Transitions Enhancing Accessibility or Linking to Stations.* The issue of accessibility is crucial when it comes to vertical movement. In 2018, just 25% of New York's subway stations were accessible to people with disabilities who could not use stairs to move between levels. The situation has improved with enhancements such as elevators, access ramps, handrails, tactile indicators on ramps and stairs, and accessible service entry gates[5]. Similarly, in Hong Kong, the Island Line constructed in 2014 features high-speed elevators with high capacity, ensuring easy movement around the city and providing access for people with disabilities, guaranteeing benefits in the use of underground utilities (Chan, Lai-Chi, Mansoor & Chen, 2022). Furthermore, the introduction of the PATH signage program in the 1980s in Toronto by Paul Arthur facilitated orientation below ground level and, more generally, in public spaces in other metropolises (Bélanger, 2007).
- *Transitions from Public Spaces.* The entrance to the subway is designed to facilitate access from the local area to the underground realm. Therefore, the design of Hector Guimard's projected metropolitan accesses in Paris serves an aesthetic purpose and guarantees better orientation, facilitating pedestrian flow (Reynolds, 2020).

- *Transitions from Private Properties.* In Hong Kong, some skyscrapers offer direct access to subway stations, seamlessly integrating public transportation with commercial buildings and enhancing the efficiency of daily commutes. These private spaces are strictly regulated, prohibiting noisy activities, smoking, or animal walking (Frampton, Solomon & Wong, 2018). An opposite example is the structure of Toronto's underground landscape:

5 Inclusive City Makers (last access 30/07/2024)
Source from: https://www.inclusivecitymaker.com/innovation-accessibility-new-york-city-subway/

its logical axes-nodes structure ensures a direct connection to more than fifty buildings, six hotels, two department stores, and 20 underground parking lots. Those underground tunnels guarantee better climate conditions yearly (Bélanger, 2007) and such a straightforward structure facilitates the movement of pedestrians and their orientation below ground level.

Finally, the nodal connection represents an architectonical system complex where different space typologies converge in a unique fulcrum where all different characteristics must be combined. Two leading solutions can be considered, and one is the evolution of the other. The design plays a fundamental role in all these solutions, and all the possible issues need to be addressed to avoid segregation situations.

Firstly, there are the transfer zones, complex areas where different forms of movement intersect and interact. Designing these spaces requires careful consideration of their functionality and dimensions and how individuals perceive and experience them. These zones must accommodate various movement types, including pedestrians, vehicles, and public transit systems. The primary objective is to create a hub as a crossing point and a social and economic activity centre.

Transfer zones must seamlessly link different transportation systems, such as trains, metro lines, and other vehicles, to effectively manage the simultaneous and varying traffic flows. A clear and easy-to-navigate layout enhances efficiency, allowing these areas to handle different speeds and absorb peak traffic volumes effectively. Designing transfer zones necessitates a multidimensional approach. It's not enough to focus solely on functional connections; the movement through these spaces should also be engaging and inviting. Elements such as lighting, materials, spatial configurations, and wayfinding strategies are essential for guiding individuals and creating a sense of continuity as they navigate different levels and areas.

Additionally, these spaces must be adaptable to change, with designs that anticipate future developments. A flexible, implementable, and regenerative layout accommodates ongoing transformations over time.

The other typology is represented by the Central Hubs, zones of transfer that are big catalysers of people and are defined not only by the movement of people (infrastructural spaces) but also by place of being (architectural spaces). They developed and increased their connecting role until becoming a destination point where activities and social interactions happen. Here, movement and permanence coexist. Together with the characteristics of the transfer zones, they also need to offer complementary services, create a social environment, and dispose of the flows of movement directed to another point of the city (Admiraal et al., 2018).

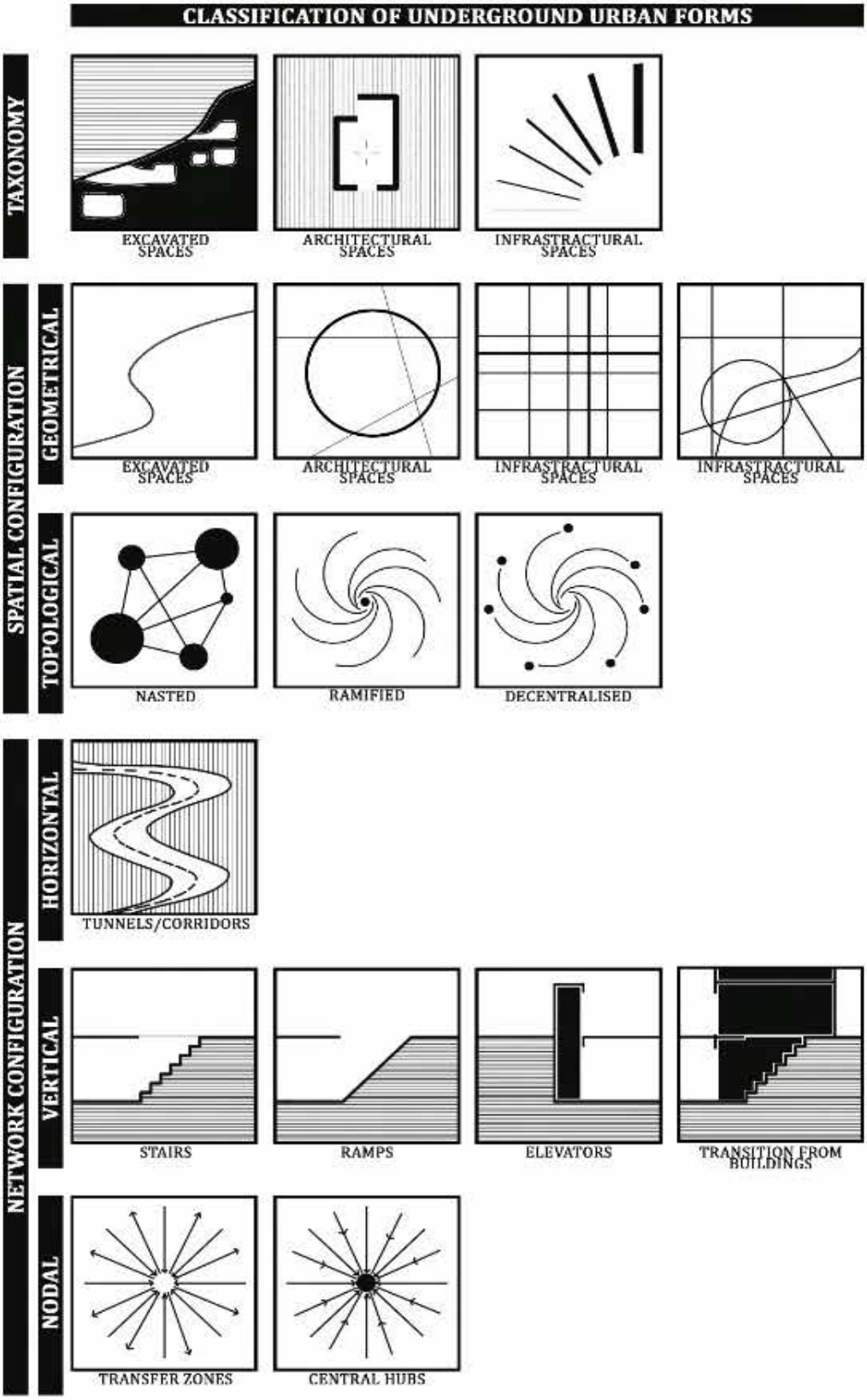

Figure 7 – Classification of underground urban taxonomy

Conclusion

This study has explored the urban underground landscape by proposing a typological and morphological framework capable of interpreting its complexity and overcoming the traditional separation between surface and subsurface realms. Through stratigraphic analysis, the classification of spatial configurations, and the examination of connective networks, a theoretical model has been outlined that recognizes the underground landscape as both an autonomous entity and a deeply interconnected component of urban metabolism. This research highlights the need to develop specific analytical and design tools for the subterranean environment, fostering a three-dimensional vision of the city. However, in order for the underground landscape to be fully integrated into contemporary urban practices, it will be essential to advance interdisciplinary studies that also address the social, technological, and ecological dimensions of subterranean spaces, consolidating their role as an active and strategic part of urban morphology.

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Reimagining the future of peri-urban spaces: planning narratives for the sustainability of these areas. The case study of "Stena tou Nestou" in Xanthi, Greece

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Abstract
Despite the appearance at international level of planning narratives regarding the equal growth of urban areas, whether they are economically strong or not, we note significant differences in the development of small and big urban areas. Considering the need for inclusive and resilient communities, the paper tries to envisage the future of peri-urban spaces, particularly the visions and models that lead to the economic, social and environmental sustainability of these areas. The choice of the case study the Thrace region in Northern Greece and the 'Stena tou Nestou' area was based on the necessity to reflect and change old narratives in the planning processes for poor urban and peri-urban areas and to propose a safe and equitable living environment for the inhabitants of these areas.

Key words: planning narratives, sustainability, peri-urban areas, social and economic injustice, Xanthi (Greece)

Introduction

In the last four decades and especially during the 21st century we observe a strong interest in discourses, strategies and norms regarding the form and functions of urban areas in a sustainable way (Michalina and al, 2021). Concepts like the compact city, the 15 minutes city or the smart city try to give responds to issues such as population increase, demanding human needs as well as environmental degradation related to human activities (Allam and al, 2022, Bibri and al, 2020, Shafiri and al, 2024). Sustainability is not only a solution to increasing environmental pollution and cities' environmental footprint, but also to questions related to the social and economic structure of cities like high unemployment rate, discriminations and closure of local enterprises and shops (Eizenberg and Jabareen, 2017). It is important to mention the role of sustainability in big agglomerations where there are issues related to the relationship between the city and its suburbs (connection, dependency of suburbs from the activities inside the city) (Riffat and al, 2016) as well as with its surrounding peri-urban area which is usually not built and there is always the risk for urban sprawl towards this area (Geneletti and al, 2017). Urban sustainability as a concept has two distinctive dimensions; internal and external sustainability (Wamsler and al, 2021). While the first one refers to an equitable and inclusive development of all cities' districts and activities (Bhatia and al, 2024), the second one refers to the relationship between the city and its surrounding environment particularly natural environment (Zucaro and Agostinho, 2025). The external sustainability is a critical issue in contemporary urban and strategic planning. The protection and equitable and inclusive development of peri-urban areas have positive effects on cities' internal organisation and functions as the two units (city and its peri-urban areas) do not depend on each other but rather collaborate on issues they cannot work alone such as environmental protection and economic development (Marmo and al, 2025).

Even though in documents of international organisations, such as the Agenda 2030, the notion of sustainability is linked to a strong commitment for the equal growth of urban areas despite their economic growth and their geographical position (UN, 2015), we note significant differences in the development of small and big urban areas, urban and rural areas as well as areas of the Global North and Global South (Nagendra and al, 2018). Cities of the Global South and their surrounding peri-urban areas are affected by population increase inside cities' limits and the consequent exploitation of natural resources that are found in peri-urban areas (Follmann, 2022). The main problem is the absence of urban planning regulations that allow cities to expand towards their periphery without taking into consideration issues such as the protection of the natural environment (Venter and al, 2021). Population increase in cities and urban sprawl are also observed in cities of the Global North as cities' functions

and organisation seem to attract people from small cities and rural areas. Despite this point in common, we should underline that in cities of the Global North we observe policies and tools for the protection of peri-urban areas such as land uses (for example agricultural activities) and green belts that fit to the more natural character of these areas (Klimczuk-Kochańska and Klimczuk, 2023). Small urban areas as well as rural areas suffer in many cases by economic difficulties and the loss of local population due to changes in production systems that shift industrial and agricultural activities outside big agglomerations or to other countries (Castellano-Álvarez and al, 2024). The result is that these areas progressively lose their urban identity and role at regional and national level (from active economic zones they are transformed to inactive spaces) and in cases of urban sprawl they become part of nearby big urban areas.

Considering the framework of the Sustainable Development Agenda and the need for equitable, inclusive and resilient communities, the main question of the paper is which narratives that is to say which tactics and models lead to the economic, social and environmental sustainability of peri-urban areas? Peri-urban areas are spaces outside the cities' limits which are not fully urbanised, there are houses and small-scale economic activities, but the most part of these areas are either agricultural lands or natural spaces (Sahana and al, 2023). These areas are considered as a supplement to the cities' activities and functions, and their relationship is based on dependency; cities' inhabitants need the products and the resources of peri-urban areas while the economic activity and prosperity of peri-urban areas depends on the exchange links between themselves and the cities (Ravetz and Sahana, 2024). This close relationship between cities and their surrounding areas has an impact on the development model of peri-urban areas as in many cases they lack the necessary infrastructure, equipment, facilities and services (schools, small health care centres, post offices) and they cannot function independently from the cities (Ravetz and al, 2012). In other cases, the geographical proximity of cities and their surrounding peri-urban areas lead to the progressive urbanisation of the latter as the cost of buying land is lower compared to the cities' urbanised districts and there are many vacant lands (Tione and Holden, 2020). It is clear that existing planning strategies for the development of these areas like urbanisation policies and economic dependency between the cities and their surrounding areas do not lead to the creation of sustainability conditions as peri-urban areas cannot be considered as equitable, inclusive and resilient communities. Furthermore, car dependency in peri-urban areas in order to have access to necessary facilities and services on a daily basis deteriorates the air quality and leads to environmental degradation and not to sustainability.

In this context, it is important to question the appearance of new planning policies for areas outside the cities' limits, which are not fully urbanised and maintain the traces of their past (physical and social). These new narratives seem to be closer to the main axes of sustainability (environmental protection, economic development, social cohesion) and to be different from the existing development strategies resulting from the capitalist economic development model. The basic idea is to take into consideration and to put forward the particular local characteristics and existing power dynamics in order to propose a development scenario for peri-urban areas that responds to inhabitants needs, reduces the dependence between peri-urban areas and cities while at the same time agricultural land and natural resources outside cities' limits are protected from exploitation (Fanfani and al, 2024). Even though the economic development of these areas is a critical point to be considered due to existing conditions of population decrease and economic recession, two equally important parameters for their development are the creation of social cohesion conditions and environmental sustainability. Social cohesion refers to the ties developed between the inhabitants of a certain area due to common goals and beliefs that progressively transform them into communities (Moustakas, 2023). This dimension of sustainability is particularly important to peri-urban areas facing socio-economic difficulties and have a population with different ethnic origins due to the need to create community ties in order to respond to the challenges posed by cities' functions and activities. Environmental sustainability refers to the capacity of existing natural resources to be able to exist in the future (Powe, 2020) in order to create an equitable and inclusive environment for all, for both cities and peri-urban areas population. Development models and strategies that equally manage these three main questions seem to create sustainability conditions in peri-urban areas that were considered for many years as cities satellites.

By taking into consideration the previous narratives regarding the sustainability of peri-urban areas, our research tries to investigate and critically think of the ways which potentially could lead to the economic, social, and environmental sustainability of peri-urban areas. A critical point is to recommend through our research planning methods and tools which could be used as narratives for the development of a specific category of peri-urban areas, the ones that face either economic or social difficulties as economic growth and social equity are, together with environmental protection, the three pillars of sustainable development. Under these unfavourable conditions, where the lack of financial means seems to deteriorate the future development of peri-urban areas, it is important to base the development of these areas according to their internal strengths and power dynamics as well as to search for external opportunities at regional and national level. Which are the strategies, policies and tools to develop these areas and which people should be involved in the procedures of their development? The development of peri-urban areas concerns not only the inhabitants of these areas but also the inhabitants and local authorities of neighbouring cities as their functions and activities in certain cases (for example a peri-urban area could be a Natura Zone and a National Park) affect the development of bigger administrative areas such as regions. In our methodology we identified planning policies for peri-urban areas based on the toolkits of international organisations such as the United Nations (UN, 2015), regional scientists (Spyra and al, 2021) and groups of academics working on the internal strengths and characteristics of urban areas (Kamalipour and al, 2023) in order to analyse the processes that lead to the sustainability of peri-urban areas facing economic and social difficulties.

Methodology

The research method used was the descriptive-analytic. The descriptive method was used in order to define planning narratives for the development of peri-urban areas. Our main hypothesis is that the development of peri-urban areas in a sustainable way, based on their particular characteristics should be the basis for the development of such areas and particularly of those facing socio-economic and environmental difficulties, as in several cases these areas have an ecological interest (national and regional parks, Natura zones) and gather activities of regional and national interest (for example tourism). At the same time, in contemporary city and regional planning policies (urban and peri-urban ecology, environmental urban and regional planning) peri-urban areas are designed as zones that protect natural resources due to the fact that they are protected by national and international legislation. This means that in these areas we can find a significant number of indigenous trees and plants, which in certain cases act as filters to the cities' high pollution levels (air and water pollution). The same areas try to reconcile cities with nature as many indigenous animals (birds and mammals) find shelter in these areas. Peri-urban areas, especially the ones that are part of big environmental zones that are divided between different countries (such is the case of several Natura zones), seem to solve environmental problems which cannot be handled by one country such as rivers and seas water pollution and forests protection as they foster international co-operation in the field of environmental sustainability. This means that these areas can act as places of experimentation of environmental policies and tools with the participation of researchers, practitioners and politicians from different countries.

Peri-urban areas near cities that face significant economic and social difficulties due to deindustrialisation, or the closure of local enterprises seem to bear the effects of this negative context as there are not sufficient funds for their environmental protection and economic development. Areas resulting from deindustrialisation such as former industrial lands, they are heavily polluted and struggle with economic recession. In certain cases, we observe informal settlements in these areas (small houses and warehouses) whose presence in these areas deteriorates the environmental degradation, while contractors, investors and local authorities show a particular interest to build them in order to boost the local economy of neighbouring cities facing social and economic difficulties. In this context the development of peri-urban areas in a sustainable way that takes into consideration the needs of the local population and proposes economic activities in accordance with the local characteristics offers a second life to places that were underdeveloped and neglected for several years due to socio-economic problems. Our hypothesis is that the development of neglected peri-urban areas in a sustainable way and their subsequent integration into the regional and national economic channels fabric is not only a measure towards environmental and economic sustainability and resilience, but it can also serve as a measure to solve social

conflicts as underdeveloped peri-urban areas are places for activities of regional and national interest such as research labs and tourism facilities.

Another point to underline in contemporary practices for the strategic development of peri-urban areas, related to cultural geography and to the protection of peri-urban and cultural landscapes, is the planning of a certain category of these areas, the ones that have a significant number of historical landmarks and natural landscapes, as a measure that protects small communities with particular ethnological characteristics. In areas where the cities' limits are expanded towards their surrounding peri-urban spaces historical landmarks and natural landscapes cannot be usually identified as they seem to be part of the urban fabric, while the bad connection of these spaces with the national road network and the absence of signage creates disconnection conditions. Peri-urban spaces like small villages and communities as well as regional and national environmental parks which have a significant historical and ethnological value (presence in the area of minorities and historical buildings and monuments) and which are not easily reachable by car, train and bus, seem to improve the inhabitants and visitors experience in understanding the different historical eras of cities and their surrounding spaces. Taking this into consideration, our third hypothesis is that the development of peri-urban spaces in areas characterised by their unique historical, cultural, ethnological and environmental identities could act as a measure for a new regional branding, when they are well connected with the national road network, and thus lead to the discovery of unknown areas that have a significant importance in the development of their regions.

The analytic method was used in order to identify first the reasons that lead to economic decline and social injustice in several small and medium-sized cities and make the necessary correlation between environmental sustainability, economic growth and social equity for the development of these areas. In second place we developed our strategy and model for the development of peri-urban areas near small and medium-sized cities facing socio-economic difficulties based on their transformation in a sustainable way which takes into consideration the local social, economic, environmental and cultural characteristics. The method proposes an experimental approach in the planning of peri-urban areas and their relationship with the surrounding cities based on the case study of "Stena tou Nestou", (which in English could be translated as narrow pathway near the Nestos River) a peri-urban area located near the city of Xanthi in Northern Greece. Our proposal was developed during an urban and landscape design studio named 'Landscape and Architecture' at the School of Architecture of Democritus University of Thrace. The studio emphasises on the development of peri-urban natural spaces, located near small and medium-sized cities with important social and ethnological characteristics, through small-scale economic activities such as tourism, culture and research activities that lead to sustainability and resilience conditions. At the same time semi-structured interviews were conducted with local elected officials and inhabitants in order to take into consideration their needs and expectations for the development of these peri-urban spaces. We suggested a development scenario for the peri-urban space 'Stena tou Nestou' located near the city of Xanthi, based on the principles of sustainable development (environmental protection, social cohesion, economic development) and the local cultural and ethnological landscape (presence of ethnic minorities and important historical elements from antiquity to present time). The development scenario focuses on measures such as: 1) the protection of the natural resources of peri-urban areas as a means to reduce the cities ecological footprint, 2) the revalorisation of significant cultural and natural landscapes such as regional parks and historical buildings and monuments as a means to protect and show the identity of these spaces, 3) the connection of peri-urban spaces with the national road network as a means to facilitate mobility and reduce disconnection as well as 4) the development of small-scale economic activities to boost tourism, recreation, sports practice and research as a means to reduce local unemployment rate and to lead to economic resilience and sustainability.

For the development of our scenario for the peri-urban area outside the city of Xanthi we took into consideration existing power dynamics of the city and its surrounding area as well as of the region of East Macedonia and Thrace in which administratively is part the city of Xanthi. It is important to mention that the region of East Macedonia and Thrace is among the less developed at national (Greek) level and is characterised by deindustrialisation and the closure of local enterprises. Despite the above weaknesses of the region, the presence of Democritus University of Thrace (DUTH) in six cities of the region (Drama, Kavala, Xanthi, Komotini, Alexandroupoli, Orestiada),

including Xanthi, is among the strong points of the area as it brings people from other cities in a region affected by deindustrialisation and population decline. The presence of small-scale enterprises of regional interest in the sectors of agriculture and food products create the conditions for a development based on the local characteristics. The ports in the city of Alexandroupoli and Keramoti, a small town in the outskirts of the city of Kavala, the airports in the city of Alexandroupoli and Xrisoupoli, a small town in the outskirts of the city of Kavala, as well as Egnatia Odos, a highway that connects the north part of Greece with neighbouring countries (Bulgaria, Turkey) create the conditions for the development of the cities of the region based on commercial and retail activities. At the same time, peri-urban areas of the region are used as spaces for tourism facilities and research labs due to the environmental characteristics of the area. We should also mention the presence of important natural parks inside the region, including three Natura Zones in Evros, Rodopi and Xanthi (Nestos river delta whose part is 'Stena tou Nestou') which consist of its internal dynamics, and the presence of the Greek Muslim Community in the cities of Xanthi and Komotini posing challenges regarding the support of ethnic minorities and the enhancement of social cohesion through the development of peri-urban areas.

The case study: the city of Xanthi in the region of East Macedonia and Thrace in Northern Greece and the 'Stena tou Nestou' area

The choice of the case study was based on the necessity to reflect and change old narratives and discourses in the planning processes for poor urban and peri-urban areas and to propose a safe and equitable living environment for the inhabitants of these areas.

The city of Xanthi is located in the north part of Greece, in the region of East Macedonia and Thrace, with an area of 495.01 square kilometres (Greek Statistical Institute, 2015). It is built on the foot of Rhodope Mountain chain, close to the Nestos River (Figure 1). Based on the 2021 population census, the Municipality of Xanthi has 58,760 inhabitants (Greek Statistical Institute, 2021).

Figure 1. Xanthi's location on the map of Greece. In detail the cities of the Xanthi regional unit, whose capital is the city of Xanthi, and the neighboring regional units. Source: Greece-map.net

As most of the cities of the region of East Macedonia and Thrace, Xanthi is characterised by the diversity of its urban fabric combining neighbourhoods with a historical significance and architectural cultural value such as the Old Town (Figure 2) with contemporary city's expansions built during the 19th and 20th century (Figure 3). At the same time, we should note the continuity between the city and its neighbouring peri-urban areas as they are neighbourhoods inside the city's limits that are not fully urbanised, which have significant natural elements such as a small river and forests. Xanthi is characterised by its dense urban fabric especially in the neighbourhoods that were built during the Ottoman era while the rest of the city follows contemporary urban planning policies (presence of public spaces, tall buildings and large streets with pavements).

Figure 2. Xanthi's old town. In the photo we can see the neoclassical mansions of Greek merchants from the 18th and 19th centuries that characterise the old town of Xanthi. In the same city neighbourhood, we can find elements from the presence of the Greek Muslim Community in the area such as Ottoman-Era mosques. Source: www.flickr.com

Figure 3. Xanthi's panoramic view. In this panoramic view of the city, we can distinguish in the front part of the photo the Old Town from the contemporary city that appears in the photo's background. At the right side of the photo, we can see the surrounding peri-urban spaces of Xanthi characterised by the presence of natural elements. Source: www.newsbreak.gr

After the Greek Turkish War of 1919–1922, the city of Xanthi entered a new era of prosperity and development due to the industrial, commercial and agricultural activities (Archaeology Newsroom, 2012). Xanthi became greatly involved and developed further in the processing and trading of tobacco mainly with European countries (Lantitsou, 2015). Many buildings related to the storage and processing of tobacco from that era are preserved in the city and act as landmarks of the city's past. During the last decades, tourism has also increased, especially during the period of the "Old Town Festival". As most of the Greek cities, especially small and medium-sized, Xanthi faces in the 21st century the consequences of deindustrialisation and the closure of local enterprises, despite the fact that the presence of university departments in the area increases the local inhabitants' incomes due to apartments' rentals.

"Stena tou Nestou" (in English it could be translated as narrow pathway alongside Nestos River) is a peri-urban area located near the city of Xanthi in the region of East Macedonia and Thrace in Northern Greece, an area that maintains its physical and social characteristics since the 20th century and which is nowadays used as a space for leisure and sports (natural regional park). It is important to underline the particular characteristics of the region of East Macedonia and Thrace as it is among the less developed at national (Greek) level, while at the same time the presence in the region of the Greek Muslim Community poses challenges regarding the just and peaceful transition towards a safe and equitable living environment for all despite their ethnic and cultural background. Our case study is located in a place with particular natural and historical characteristics and is part of the Nestos River delta, a Natura zone, while Nestos River is protected by International Water Law. The narrow pathway that crosses the peri-urban space 'Stena tou Nestou' was created in the 19th century to serve the workers who built the railway line connecting West European countries with the Ottoman Empire (Orient Express). The natural landscape is dominated by the river itself through the presence of water, the steep rock inclination, and the small sandy shores (Figure 4). The space has access by the small city of Toxotes while the hiking route inside this area connects the city of Toxotes with the city of Stavroupoli.

Figure 4. Natural and cultural characteristics of the 'Stena tou Nestou' peri-urban space. In the photo they are represented constructive elements of the particular landscape of 'Stena tou Nestou' such as the railway, which was part of the Orient Express, the pathway which is still used as part of a hiking route, Nestos River and the mountains of the region of East Macedonia and Thrace. Source: Varvara Toura

During our field research in the city of Xanthi and its surrounding areas and particularly in the 'Stena tou Nestou' peri-urban space we observed that the access to the 'Stena tou Nestou' area was only possible through the local road network that connects the city of Xanthi with small cities and villages of the Regional Unit of Xanthi. At the same time, vehicles are not allowed inside the 'Stena tou Nestou' area as it is a Natura Zone and there is a parking lot at the entrance of the park. Inside the park the only activities allowed are connected to recreation and sports practice while at the entrance of the park there is a small open-air café and restaurant (Figure 5).

Figure 5. The entrance to 'Stena tou Nestou' peri-urban space. The photo shows the first landscape unit of the park where recreation and sports facilities are found while at the left corner in the background is the area of the park where the café, the restaurant and the parking lot are located. Source: Varvara Toura

Outcomes-Results

The study of the region of East Macedonia and Thrace, of the city of Xanthi and its surrounding peri-urban spaces especially the 'Stena tou Nestou' area revealed areas with different characteristics. While the main cities of the region, the capitals of regional units, have a rather dense urban fabric and are well connected to the national road network, the peri-urban spaces are disconnected and have many unbuilt spaces. The main economic activities, such as commercial and retail activities as well as activities related to research and development, are located in the main cities of the region, leaving peri-urban spaces with activities related to agriculture and small-scale commerce. We can do the same remark regarding the revalorisation of the significant landscapes of the region, cultural and natural, as the ones located in the main cities of the region they are preserved and restored (for example the Old Town of Xanthi), while similar landscapes in peri-urban spaces are neglected (for example the train stations serving several of peri-urban areas) and not integrated in the development plans of these spaces. Despite this problem of abandonment and neglect of significant local cultural elements, we should highlight the fact that many peri-urban spaces of the region that have a significant environmental interest such as Nestos River delta and the 'Stena tou Nestou' peri-urban space are protected by International Environmental Law by being defined as Natura Zones. The expansion of the main cities of the region into the natural peri-urban spaces (we already described the urban development system of the city of Xanthi) due to the high demand for new housing poses problems in the protection of the natural resources of peri-urban areas and requires actions to reverse this phenomenon. The analysis of the interviews with local elected officials and inhabitants of peri-urban spaces of the region revealed the necessity to reconsider these spaces according to sustainability and resilience criteria as they are spaces with particular characteristics (there are still unbuilt spaces inside them and have significant natural and cultural elements) that could be developed through a model that takes into consideration the three parameters of sustainability (environmental protection, economic development, social cohesion) as well as the local cultural and ethnological identity (presence of ethnic minorities in the area).

Our proposal for the development of peri-urban areas located near small and medium-sized cities, focusing on the case study of the 'Stena tou Nestou' peri-urban space located near the city of Xanthi, was based on policies and tools to improve the main problems identified in the region. These policies focused on a development scenario of the Natura zone located inside the 'Stena tou nestou' peri-urban space which will be transformed into a research and recreation area, combing the existing facilities for sports practice and dining with new ones. These new facilities will host a small-scale research centre where researchers of the local Democritus University of Thrace and Athena research centre will work on issues related to biodiversity and environmental sustainability. The proposed facilities, which are located close to the pathway serving the visitors, will have spaces for the researchers (library and working spaces) as well as spaces for the visitors of the area such as a small café and living room, WC and a souvenir shop as a means to boost small-scale economic activities in an area facing socio-economic difficulties. The development plan for the 'Stena tou Nestou' peri-urban space as well as the activ-

ities and buildings inside its perimeter were decided together with the inhabitants of the area in order to foster the dialogue between professionals and citizens and to create the conditions for the public acceptance of our development plan for the peri-urban spaces near the city of Xanthi. The basic idea was to propose rather simple solutions, respecting the local identity and landscapes that could be easily adopted and implemented by the Region of East Macedonia and Thrace and the local Municipalities and to avoid complicated and expensive policies and tools. The economic activities proposed are linked to the local economic activities network and take into consideration the internal power dynamics of the region while the materials and the vegetation that were proposed in the new building inside the 'Stena tou Nestou' peri-urban space (wood, stone, ceramic tiles, pine trees) are all local in order to reduce the cost of the project in an area facing significant socio-economic difficulties.

Concerning measures for the connection of the 'Stena tou Nestou' peri-urban space with other areas of the region of East Macedonia and Thrace, we have already mentioned that the area is not connected to the national road network (Figure 6). In our development plan we considered important to facilitate the travels of the area's inhabitants and to make it accessible to visitors and people working on this area in order to facilitate mobility and reduce disconnection. Our proposal suggested the connection of the peri-urban space with the national road network (exit on Egnatia Odos towards the 'Stena tou Nestou' area) as well as signage boards on local and national road network especially for people who come to region for the first time.

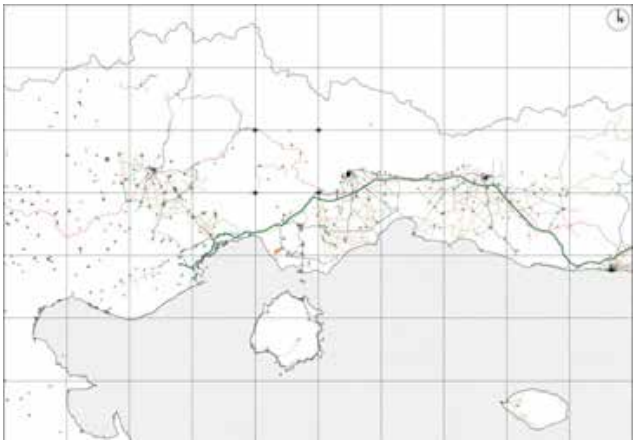

Figure 6. The main road network serving the region of East Macedonia and Thrace. The national road network serves mainly the cities of the region while peri-urban spaces are served by the local road network that connects cities with their surrounding spaces. Source: Alexandros Mpantogias

The 'Stena tou Nestou' peri-urban space is nowadays a space for recreation and sports practice (canoe kayak, hiking) in its area defined as Natura Zone, while the economic activities in villages and small cities in its perimeter such as Toxotes and Stavroupoli are primarily agricultural and commercial (Figure 7). As we have previously mentioned the region of East Macedonia and Thrace and particularly its peri-urban spaces struggle with the consequences of deindustrialisation and closure of local enterprises.

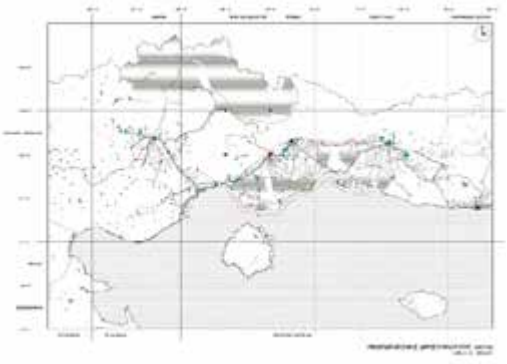

Figure 7. The main economic activities developed in the region of East Macedonia and Thrace. The areas marked in grey colour are protected areas such as Natura Zones while the industrial activities in blue colour are located near the national road network (Egnatia Odos). It is clear that the region struggles with the effects of deindustrialisation while in the interior of protected areas we can find a small number of houses. Source: Alexandros Mpantogias

In our development plan for the 'Stena tou Nestou' peri-urban space we emphasised on the development of small-scale economic activities to boost tourism, recreation, sports practice and research as a means to reduce local unemployment rate and to lead to economic resilience and sustainability. The small research and recreation centre located inside the Natura Zone of the peri-urban space (Figure 8) highlights the importance of proposing economic activities that fit to the local cultural, social and economic landscape and create sustainability conditions based on the existing power dynamics of the area (the presence of Democritus University of Thrace).

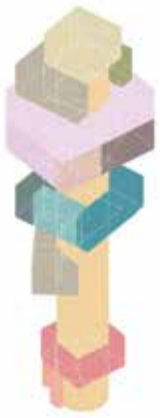

Figure 8. The functions of the new research and recreation centre proposed inside the perimeter of the Natura Zone of the 'Stena tou Nestou' peri-urban space. In purple and red colour are the spaces for recreation, in blue the small souvenir shop for the visitors and an exhibition space while in green colour are the spaces that will be used by the researchers. Source: Alexandros Mpantogias

As we have previously mentioned the region of East Macedonia and Thrace is characterised by the dense urban fabric of the main cities of the region while there are many natural landscapes and environmental protected areas located in peri-urban areas (Figure 9). The cities' organisation and the land uses in their peri-urban spaces resulted from the arrival in the region of East Macedonia and Thrace of refugees from Anatolia region after 1923 (end of Greek-Turkish war) which had as a result the increase of housing needs inside cities and the use of peri-urban spaces as agricultural lands. In the years following the Second World War (1950 and 1960) and especially in the late 1970s several industrial units were built inside the perimeter of peri-urban spaces thus affecting their natural characteristics. In our strategy for the development of the 'Stena tou Nestou' peri-urban space

we emphasised on the protection of the natural resources of peri-urban areas as a means to reduce the cities ecological footprint. For this reason, we proposed the increase of vegetation around new buildings and in deindustrialised areas where in previous years there were active industrial units in order to restore the relationship between the natural and the built environment (Figure 10).

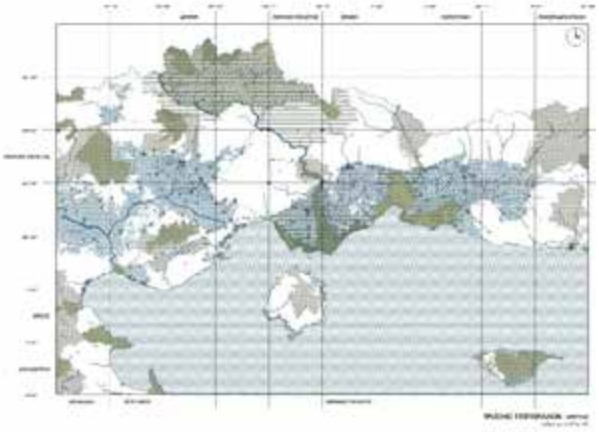

Figure 9. The natural landscapes in the region of East Macedonia and Thrace. The region is characterised by a significant number of natural landscapes including Natura Zones and zones protected by International Environmental Law. Source: Alexandros Mpantogias

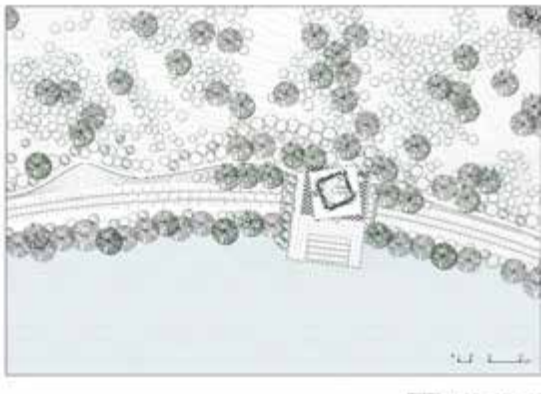

Figure 10. The proposed and existing vegetation (plants and trees) around the new research and recreation centre proposed inside the perimeter of the Natura Zone of the 'Stena tou Nestou' peri-urban space. Plants and trees around the new building are proposed as a means to restore the relationship between the natural and the built environment. Source: Alexandros Mpantogias

In our strategy for the development of peri-urban spaces we considered that the notions of sustainability and resilience are connected to peri-urban landscape where all phases of the region's cultural and natural history are present and repurposed alongside contemporary needs (small size economic activities) (Figure 11). The inscription of new buildings in these areas which host economic activities, is based on the understanding of the structural elements of the space and the protection of the natural and cultural landscapes. For this reason in our development scenario we proposed the co-existence on the same space of different elements (cultural, natural, contemporary architecture) which are connected through suitable vegetation (tall trees) and urban equipment (pergolas and benches) that highlight the unique historical characteristics of the above spaces and offer a different experience in the discovery of these peri-urban spaces (Figure 12).

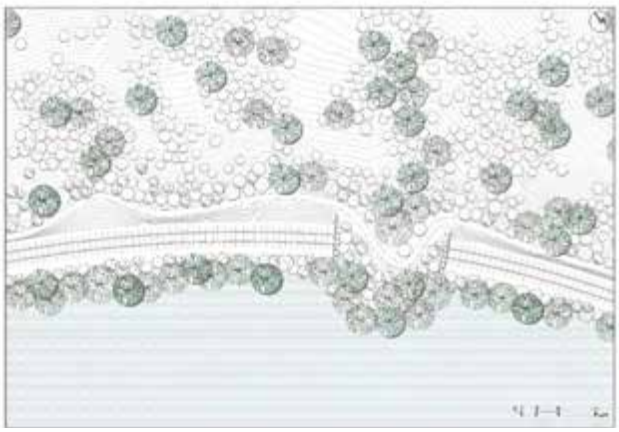

Figure 11. Significant cultural and natural landscapes inside the perimeter of the Natura Zone of the 'Stena tou Nestou' peri-urban space. The revalorisation of significant cultural and natural landscapes such as regional parks and historical buildings and monuments acts as a means to protect and show the identity of peri-urban spaces. Source: Alexandros Mpantogias

Figure 12. The inscription of the natural and cultural landscapes of the area in the planning of the new research and recreation centre proposed inside the perimeter of the Natura Zone of the 'Stena tou Nestou' peri-urban space. The new building is located close to the mountain and River Nestos offering a view of the Nestos River Delta while at the same time there is access to the train tunnels built in the 19th century.
Source: Alexandros Mpantogias

Discussion

The study of a real-world setting and its particular characteristics (socio-economic difficulties, environmental protected peri-urban space) revealed the necessity to consider planning in poor peri-urban areas as a transformative action which seeks to achieve sustainability goals through strategies and tools at different governance levels (national, regional, municipal) and in different sectors (economic, environmental, social, cultural). The development of peri-urban spaces in a sustainable way could act as a new narrative for inclusive urban and peri-urban transformations when local elected officials and inhabitants work together with researchers and practitioners in their planning processes and try to find solutions that fit not only to technical and legislative norms but also to the needs of communities. It is important to mention that this democratic procedure, which can sometimes take the form of co-decision and co-planning and not only inhabitants' consultation, in small-

scale development projects acts as a planning laboratory for the strategic design and testing of solutions that could later be implemented at regional level (the planning methodology and tools in a development project of a peri-urban space could also be used in development projects at regional level concerning housing policies, environmental policies and socio-economic policies). The cost of development projects in peri-urban spaces is an issue to consider when proposing development scenarios in small and medium-sized areas facing socio-economic difficulties. The discussions with local authorities and especially with the inhabitants allow to propose policies and measures that are closer to their expectations and needs, while the socio-economic analysis of the local regional, urban and peri-urban context allows to adjust these policies and measures to the economic dynamics of the area. Good strategies for the development of peri-urban spaces do not mean expensive and complicated technical solutions but rather proposals inscribed in the local social, economic, environmental and cultural peri-urban context.

Another issue to further consider through the planning of peri-urban spaces and their role in regions' development is the preservation of the local cultural and natural landscapes. We saw in the analysis of the case study and the subsequent development scenario for 'Stena tou Nestou' peri-urban space that the particular characteristics of the local landscapes are reflected in the planning of the peri-urban space. Landmarks from the previous land uses of the space (train stations), monuments and natural landscapes (mountains and rivers) that have shaped the region's history are not only living memorials of the different eras of the cities and peri-urban spaces but are also vital elements for contemporary strategic planning as they are often inscribed in national and regional development plans. Their integration on the development plans of peri-urban spaces, by giving an emphasis on the protection of the local cultural and natural landscapes, could lead to a new regional branding, especially when these spaces are well connected with the national road network (accessibility criteria), and to the discovery of unknown areas that had a significant importance in the development of their regions. Through these planning policies on peri-urban spaces, they could be identified significant landscapes, both cultural and natural, and define them as protection zones in order to protect them from mass-tourism and overscale construction projects that seem to not respond to the cultural and historical characteristics of these peri-urban areas. On the contrary small-scale economic activities such as recreation activities and research centres in accordance with the existing power dynamics of the areas could be found inside these spaces as they serve as measures for facing socio-economic difficulties (high unemployment rate).

To go further on the field of urban sustainability and resilience and the relationship between urban spaces and peri-urban spaces we should underline that measures and policies in favour of nature's protection in peri-urban spaces, such as the planning of national and regional parks and the definition of Natura zones in spaces with a particular ecological interest, should be proposed and implemented in peri-urban spaces close to dense urban areas based on the local characteristics of each area (cultural, environmental, social, economic). These measures and policies should put forward the relationship between the urban environment and its surrounding peri-urban spaces and try to find a balance between them in order to improve socio-economic and environmental conditions. At the same time urban planners and local authorities should carefully consider that the protection of the natural resources in the planning of peri-urban spaces could have positive effects on the cities functions as well as to water and air quality. Peri-urban spaces planning, organisation and functions based on environmental sustainability criteria could reshape urban and peripheral areas of the Mediterranean region that are exposed to extreme weather conditions (heat waves) during summer. For this reason, it is important to consider the planning of peri-urban spaces as a process inscribed in the fields of urban sustainability and resilience as peri-urban spaces like Natura zones and national and regional parks serve also as places for social encounters that boost citizens' health and well-being and solve social problems.

In many cases of neglected peri-urban spaces located near cities facing population shrinkage due to the swift in their economic model (former industrial cities), social problems appear after this swift related to the high unemployment rate. This local economic context combined with the loss of local population who moves in other areas in order to find work has as a result the recession of certain urban and peri-urban areas who are trying to find a new identity (social, economic, cultural) in order to increase their population and improve the living conditions

of the local population. Peri-urban spaces could play a key role in the development strategy of these areas, as we have previously seen in the case study of 'Stena tou nestou' peri-urban space located near the city of Xanthi a medium-sized city affected by deindustrialisation and the loss of local population. The creation of community conditions (people who have the same goals and needs), in urban and peri-urban spaces affected by economic recession, could be achieved through the planning of peri-urban spaces as these spaces act as places for social encounters where people with different social and ethnic backgrounds gather and spend time with other people. Research activities in these spaces focusing on the study of the local natural and cultural landscapes as well as activities related to sports practice and recreation bond the relationships between the inhabitants and their living environments and help them to act together as a group in issues related to social, economic and environmental policies of their municipalities and regions.

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Spatiotemporal Evolution Characteristics and Planning Strategies of Population and Construction Land in Shrinking Chinese Counties

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Abstract:
This study focuses on the contradiction between population loss and construction land expansion in China's shrinking counties. It explores the spatiotemporal change patterns of permanent population, urban population and construction land through three time sections: 2000, 2010 and 2020. On this basis, the decoupling model is used to further analyze the degree of coordinated development of population and construction land in shrinking counties, summarize its characteristics and causes, and compare them with international shrinking cities. Planning strategy recommendations are proposed to optimize the human-land relationship and promote coordinated and sustainable development.

Keywords
population and construction land relationship;urban shrinkage;spatial-temporal evolution;coordinated development; Planning strategy

1. Introduction

1.1 Research background

1.1.1 The universality and challenges of the shrinking county phenomenon in China

Against the backdrop of accelerating global urbanization and cities entering the post-growth era, China is experiencing extensive population mobility and reconstruction of spatial development. Due to factors such as unbalanced regional development, in sharp contrast to the continued expansion of large cities, the shrinking of China's counties is gradually becoming an undeniable reality in the process of new urbanization. According to the China County Statistical Yearbook, between 2010 and 2020, many of the country's counties (cities) experienced a continuous loss of permanent population, with the Northeast and central mountainous areas being particularly significant. This shrinking phenomenon not only reflects the objective law of population agglomeration in developed coastal areas and high-level cities, but also exposes the deep-seated contradiction between the county development pattern and spatial resource allocation(Wu and Sun,2017).

1.1.2 The particularity of China's county shrinkage phenomenon compared with international shrinking cities

The phenomenon of urban shrinkage is common in Western developed countries, but China's urban shrinkage phenomenon is significantly different from that of Western developed countries. On the one hand, unlike Western developed countries, urban shrinkage occurs in the mature stage of urbanization development. For example, in developed countries such as the United Kingdom and the United States, the shrinkage of population and idle housing land are developing in the process of urban deindustrialization and suburbanization.(Yang,Wu Wang etc,2021) China's urban shrinkage phenomenon occurs in the rapid urbanization development cycle. A large number of people flow out of county towns and move to large cities, resulting in widespread shrinkage of county towns. The slowdown in China's urbanization growth in recent years will further aggravate the phenomenon of urban shrinkage(Yang,Long,Yang etc 2015). On the other hand, the shrinkage phenomenon in Western developed countries is the "double shrinkage" of population and construction land, while China has a more widespread contradiction between population shrinkage and construction land growth(Sang,Pan,Zhang etc,2024). The transfer and flow of population and the corresponding changes in construction land continue to affect the allocation efficiency of urban construction resources. To achieve high-quality urbanization development, it is necessary to coordinate the evolution and coordination relationship between population and construction land, and promote the rational use of resources and sustainable development.

1.2 Research Questions

Many scholars have conducted research on the phenomenon of urban shrinkage in China, but most of them focus on the prefecture-level cities in some regions, with few nationwide studies and insufficient long-term analysis of county-level units. At the same time, most studies focus more on the phenomenon of population shrinkage

itself, ignoring the contradiction between population decline and increase in construction land, and insufficient analysis of the spatiotemporal heterogeneity of the response to human-land relations. Relevant planning strategies do not make targeted distinctions between shrinking cities in different regions and development types across the country. Therefore, based on the above contradictions and gaps, this study takes the spatiotemporal evolution pattern of population and construction land in shrinking county-level cities in China, the analysis of coordination degree, and the analysis of classified planning strategies as the main research issues.

1.3 Research framework and technical route

This study first clarifies the universality of the development of shrinking cities in China and its uniqueness from the Western country. Then, it takes county-level cities in China with shrinking population as the research object, selects three time sections of 2000, 2010 and 2020, uses spatial statistical tools to deeply analyze the spatial characteristics of the evolution of their population and construction land, and comprehensively analyzes their development coordination. It classifies and summarizes the coordination types and development trends of the relationship between people and land in shrinking counties in different regions, analyzes their influencing factors by category, and proposes planning optimization strategies based on international shrinking cities comparisons.

2. Research area and methods

2.1 Research area

More than 1,848 county-level units (excluding urban districts) with available data across China were selected as the research scope, and county-level cities that had a county-level permanent population and whose permanent population increased by no more than 20,000 people between 2000 and 2020 were defined as “county-level shrinking cities shrinking counties”. A total of 280 research objects were selected. They are distributed throughout the country.

2.2 Data Source

The county population data comes from the fifth, sixth and seventh national census data in 2000, 2010 and 2020, and the construction land data comes from the China Urban Land Cover Remote Sensing Monitoring Dataset (CNLUCC) produced and released by The Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (RESDC) (Xu,Liu,Zhang etc,2018)

2.3 Research Methods

2.3.1 Standard Deviation Ellipse

Standard deviation ellipse is a spatial statistical method widely used to describe the spatial distribution characteristics of geographical elements, and depicts the centrality, spread, directionality and other spatial morphological characteristics of geographical elements. This study constructs the standard deviation ellipse of urban construction land in shrinking cities in counties across the country from 2000 to 2010 and from 2010 to 2020 to analyze the spatiotemporal evolution pattern of construction land.

2.3.2 Change coupling mode measurement

This study constructs a decoupling model of shrinking cities in counties based on the elasticity coefficients of urban population and urban construction land area in counties from 2010 to 2020.

$$F=\triangle P/\triangle L$$

Where F is the elasticity coefficient, $\triangle P$ and $\triangle L$ are the ratios of the change rate of urban population to the change rate of urban construction land in a certain period, reflecting the coordinated relationship between urban population change and construction land change. According to the positive and negative change rates of urban population and construction land(Yi,Wang,Zhang etc,2023), as well as the value of the elasticity coefficient, the decoupling type of human-land relationship can be further established to judge the current status and trend of human-land relationship.

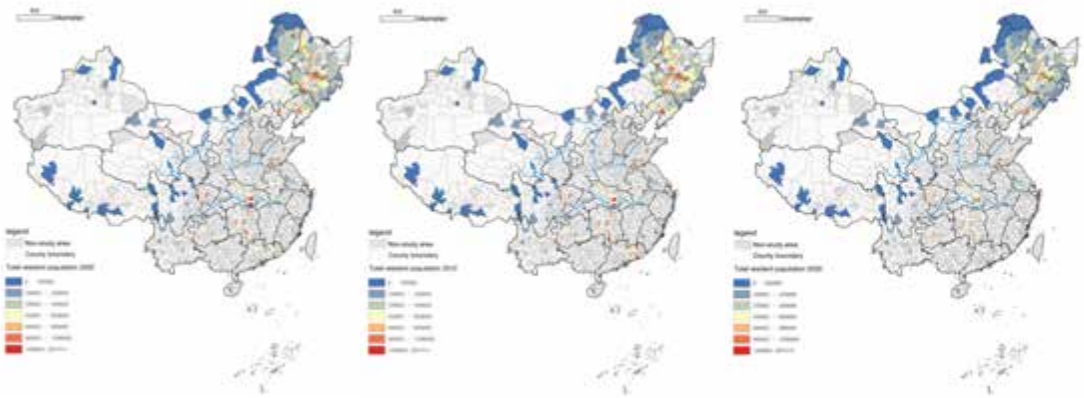
3. Characteristics of the spatiotemporal evolution of population and construction land in shrinking counties

3.1 Characteristics of population shrinkage

3.1.1 Spatial distribution pattern of total population in counties

As can be seen from the figure 1, the shrinking counties development in China are mainly concentrated in the Northeast, Sichuan Province, Hubei Province, Hunan Province in the upper and middle reaches of the Yangtze River, and Fujian Province and Guangdong Province in the southeast coast.

In terms of total volume, the total population of shrinking counties showed a straight-line downward trend in the two decades from 2000 to 2020, with the total population dropping from 110.665 million in 2000 to 86.232 million, which was significantly reduced in all regions of the country. Among them, the total population base of shrinking counties in the Northeast, Central and Western regions is large, and the reduction is the largest. The total population in the Northeast region has decreased by more than 10 million in 20 years. It is the region where the urban shrinkage phenomenon in my country has occurred most profoundly and extensively, and is experiencing a large-scale population outflow; the total population of shrinking counties in the eastern region is small. Due to the high level of economic development and small county gaps, the population mobility changes are relatively slow. Overall, the total population of shrinking counties in all regions of the country showed a more obvious decrease between 2010 and 2020, and the population shrinkage phenomenon further intensified.



(a)2000 (b)2010 (c)2020

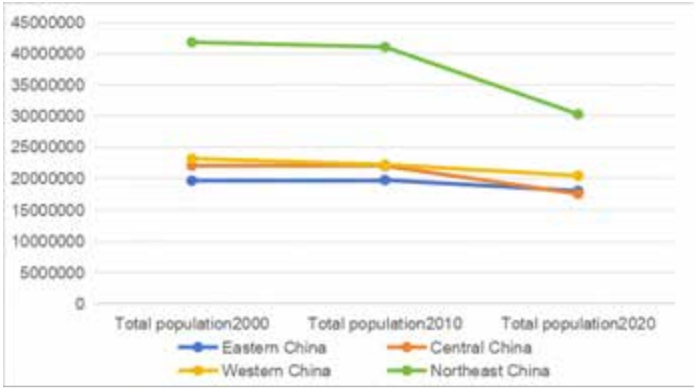
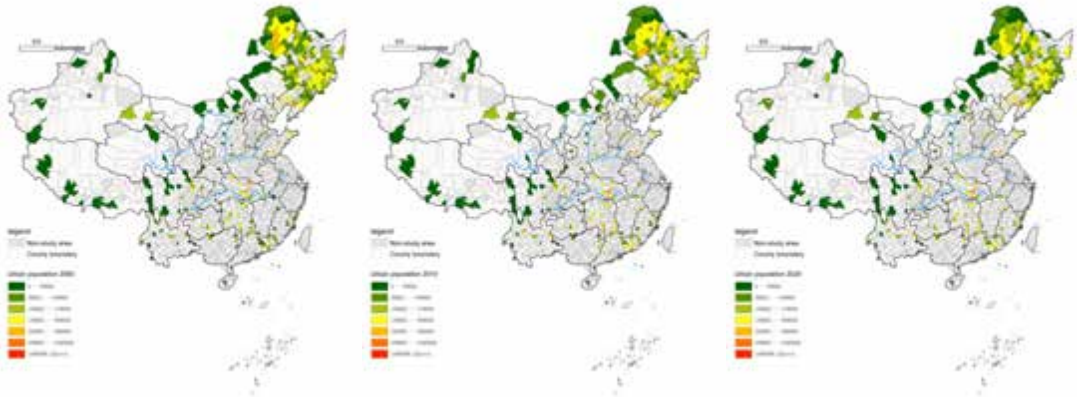


Figure 1 Spatial and Temporal Pattern of Total Population Changes in Shrinking Counties in China

3.1.2 Spatial distribution pattern of urban population

The figure 2 shows that from 2000 to 2020, the urban population of shrinking counties in China first increased and then decreased. The total urban population eventually increased from 33.806 million in 2000 to 40.231 million in 2020, and the changes in various regions across the country were different. Among them, the number of urban residents in the Northeast and Central regions first increased and then decreased, showing an overall downward trend. The urban population in shrinking counties decreased significantly, and the population loss was more serious. It is the most important shrinking development region in China. The urban population in the western and eastern regions continued to increase. The growth rate of the urban population in shrinking counties in the eastern region gradually slowed down after 2010. The urban population in the western region continued to increase. This is largely due to the fact that the economic and urbanization development in the western region lags behind other regions. It is still in the stage of converting rural population into urban population on the spot, which has led to a certain increase in the urban population.



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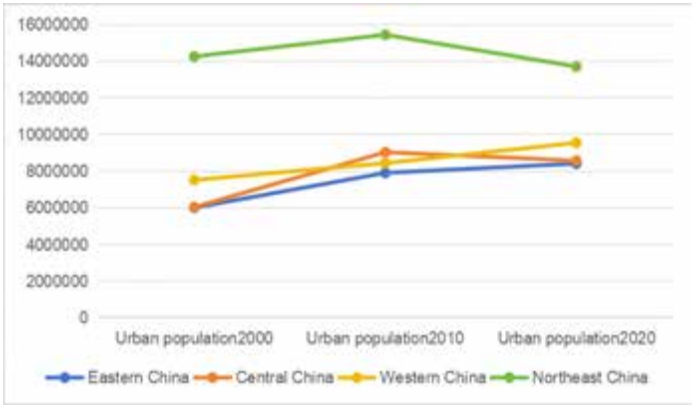


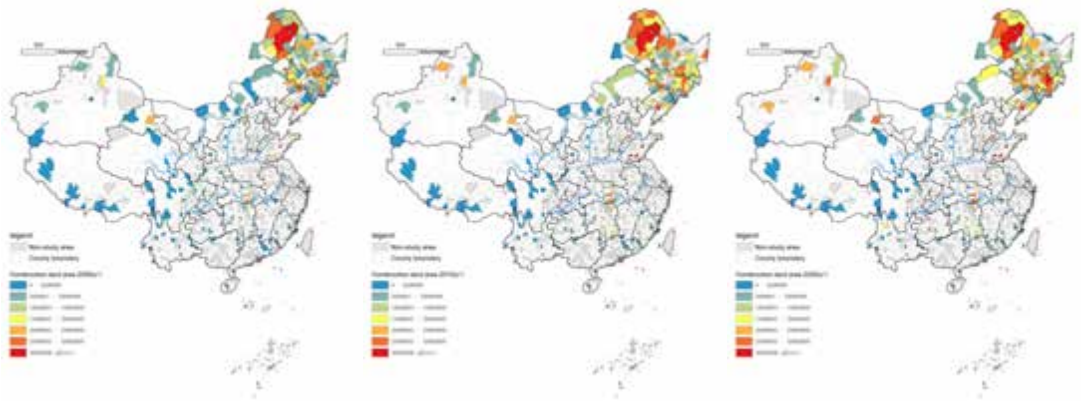
Figure 2 Spatial and Temporal Pattern of Urban Population Changes in Shrinking Counties in China

3.2 Changes in construction land

3.2.1 Dynamic changes in the total amount of urban construction land

In terms of total amount, the area of urban construction land in shrinking counties across the country increased from 2584.21 square kilometers in 2000 to 3949.86 square kilometers in 2020, with a growth rate of 52.8%. The changes in the area of construction land in shrinking counties in different regions of the country vary greatly (Figure 3). Except for the western region, the growth rate of construction land in other regions has slowed down after 2010. The slowdown in the growth rate of construction land in the northeast region may be related to the transformation and development of industry, the slowdown of urban economic growth, and the large-scale population loss; the counties in the more developed eastern and central regions may gradually enter the stock development period, and the speed of urban land construction and development will slow down. The western

region is still in the process of accelerated development, and the area of urban construction land is accelerating. The large-scale growth of urban construction land has formed a paradox with the shrinking population, and it presents an unbalanced and contradictory development state in different regions.



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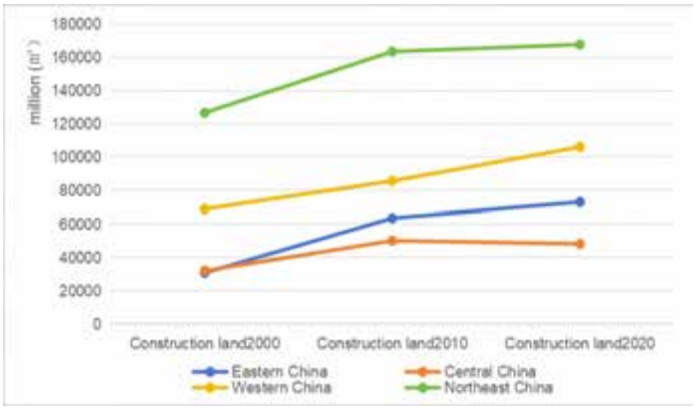
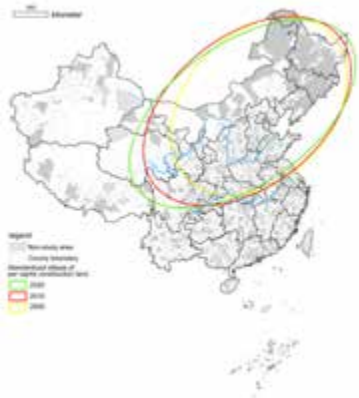


Figure 3 Spatial and Temporal Pattern of Urban Construction Land Changes in Shrinking Counties in China

3.1.2 Dynamic changes in the average amount of urban construction land

As can be seen from the figure 4, the per capita construction land in shrinking counties across the country has been growing over the past 20 years, with the average value increasing from 76.4 square meters per person in 2000 to 98.2 square meters per person in 2020. This is related to the continued growth of construction land while the population in shrinking counties is declining. It can be seen that the uncoordinated development of the relationship between people and land in shrinking counties is likely to cause resource waste and unsustainable development problems. During this period, the centre of gravity of urban per capita construction land area continued to move toward the central and western regions. The northeast region with vast land and sparse population is the main area of population loss. The per capita construction land area is large, and there is obvious waste of resources. The change direction of construction land and urban population in the central region is relatively consistent, but the growth rate of construction land is still faster than the growth rate of population, resulting in an increase in per capita construction land area. The western region is still in a rapid urbanization development stage, and the construction land area is increasing rapidly. In addition, the local towns have limited attraction to the population, and the population growth lags behind the growth of county construction land. The per capita construction land area continues to expand. The eastern region is densely populated, construction land is tight, and the per capita construction land area is growing slowly. There is a spatial mismatch between the per capita construction land area in county towns and the economically developed and more densely populated regions in China. The problem of uncoordinated development of population and construction land needs to be optimized and solved urgently.

a(2000) b(2010) c(2020)



(d)standard deviation ellipse of per captia construction land area

Figure 4 The Spatiotemporal Evolution of Per Capita Construction Land Area

4 Analysis of the coordinated relationship between shrinking county population and construction land

4.1 Construction of a decoupling model for human-land relationship

Based on the analysis of the spatiotemporal evolution of shrinking urban population and construction land in the previous study, the changes in population and construction land during 2010-2020 are more diverse, which can better reflect the dislocation and disharmony of human-land relationship. In order to further measure the mismatch relationship between shrinking urban population and construction land, this time period is selected to analyze the decoupling relationship between shrinking county population and construction land changes. According to the provisions of China's "Urban Land Classification and Planning Construction Land Standards" on per capita construction land indicators and related research by other scholars, the types and trend standards of the decoupling relationship between urban population and construction land are formulated as follows.

Figure 5. Types of the Decoupling Relationship Between Urban Population and Construction Land

decoupling type		△P	△L	F	human land relationship status
decoupling	strong decoupling	△P<0	△L>0	F<0	Population decreases, land use increases
	weak decoupling	△P>0	△L>0	0<F<0.8	increase at the same time, the growth rate of land use is greater than the growth rate of population
	weakening decoupling	△P<0	△L<0	F>1.2	decrease at the same time, the land use slowdown is smaller than the population slowdown
negative decoupling	strong negative decoupling	△P>0	△L<0	F<0	Population increases, land reduction decreases
	expansion negative decoupling	△P>0	△L>0	F>1.2	increase at the same time, the land use growth rate is lower than the population growth rate
	weak negative decoupling	△P<0	△L<0	0<F<0.8	decrease at the same time, land use slowdown is greater than population slowdown
connection	expansion Connection	△P>0	△L>0	0.8<F<1.2	Relatively synchronous increase
	declining Connection	△P<0	△L<0	0.8<F<1.2	Relatively synchronous decrease

A corresponding analysis of shrinking counties across the country found that there is a clear correlation between the shrinkage of counties and the decoupling development of the relationship between people and land, resulting in three types of decoupling of the relationship between people and land: negative decoupling type, connection type and decoupling type (Figure 6). The negative decoupling type includes a strong negative decoupling mode with population growth and reduction in construction land, an expansion negative decoupling mode with both urban population and construction land increasing, and the growth rate of construction land being lower than the growth rate of urban population, and a weak negative decoupling mode with both urban population and construction land decreasing, and the deceleration of construction land being higher than the deceleration of population. From 2010 to 2020, county units of this type of decoupling accounted for about 31.7% of the total, and nearly half of the counties' urban construction land area exceeded the national standard. Under the trend of population shrinkage, these areas should continue to maintain slow growth and negative growth in construction land to further optimize and coordinate the relationship between people and land.The connection type includes a pattern of relatively synchronous growth and decrease of urban population and construction land, which is a type of relatively harmonious human-land relationship. From 2010 to 2020, such county units accounted for about 5.2% of the total. Only very few counties were in such a good state of human-land relationship. More than half of the shrinking counties were in the third decoupling type of unharmonious human-land relationship, indicating that the human-land relationship in shrinking county units is more likely to be out of balance.

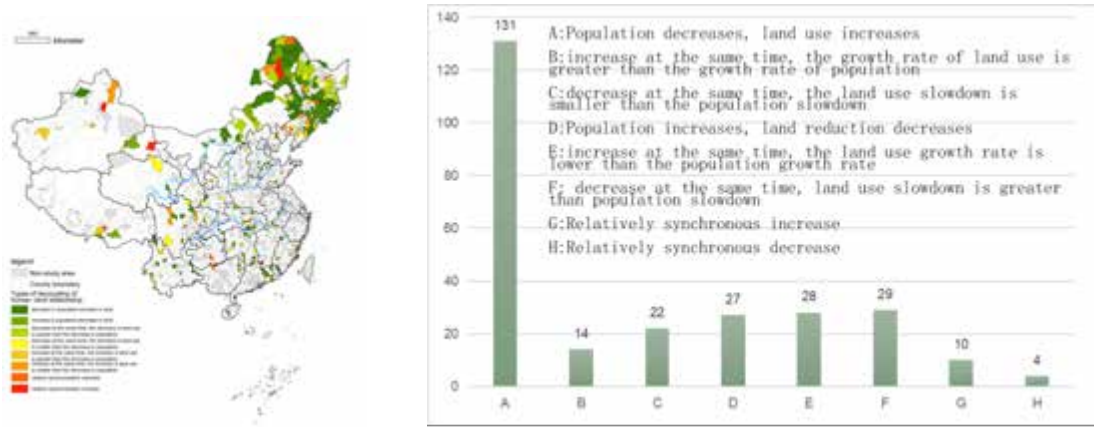


Figure 6. Space distribution of the decoupling relationship between urban population and construction land

4.2 Analysis of the uncoordinated human-land relationship of "decreasing population and increasing construction land" in shrinking counties

In the decoupling type of human-land relationship presented by most shrinking counties, three different development models have been formed according to the different rates of change of urban population and construction land: the first is the strong decoupling model with decreasing population and increasing construction land area. From 2010 to 2020, this type of shrinking county units has the largest number, accounting for 49.3% of the total, and is widely distributed. It is more concentrated in the three northeastern provinces, Hebei Province, Hunan Province, Sichuan Province, Yunnan Province and Guangdong Province. These areas are the main areas facing population shrinkage problems. Among them, the development gap between counties in Hebei Province, Hunan Province and Sichuan Province is large. The counties with strong decoupling of human-land relationship in these areas are mostly in the "depression area around the provincial capital". The urban population in shrinking counties is continuously transferred to large cities in the province or larger cities around them due to the siphon effect, resulting in the continuous loss of urban population in counties. At the same time, compared with the developed eastern coastal areas, these regions are still in the process of accelerated urbanization and have a strong driving force for construction and development. Some government-oriented investments have led to the continued expansion of construction land, resulting in a resource contradiction of reduced population and increased land. The three northeastern provinces are the areas with the most concentrated shrinking counties in China. They are facing the pain of transformation and development of traditional resource-based industries. Many counties still retain a large amount of inefficient industrial land, which has formed a driving force for population outflow. The lag in industrial transformation has caused a mismatch in land space. At the same time, the phenomenon of "reduced population and increased land" is common in counties with shrinking populations, and is also affected to a certain extent by land finance and local administrative management factors. With the loss of county population and the continuous reduction of tax revenue, many governments tend to expand land transfer to maintain finances, and then ignore the current population situation and continue to accelerate infrastructure investment, which has led to the continuous expansion of land use, becoming an institutional cause of the contradiction between people and land in shrinking counties.

This type of county should correctly deal with the current situation of its own population outflow, accelerate the transformation of development mode, reduce population outflow and attract population return by improving competitiveness; make full use of existing construction land and stock land, reduce large-scale development of construction land, and avoid waste of resources(Figure 7).

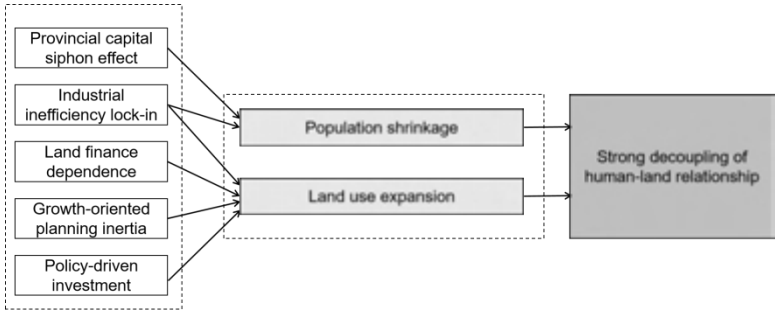


Figure 7. Space Distribution of the Decoupling Relationship Between Urban Population and Construction Land .

The second is the weak decoupling mode in which both urban population and construction land grow, and the growth rate of construction land is greater than the growth rate of urban population. From 2010 to 2020, the number of shrinking county units of this type accounted for about 5.28% of the total, mainly distributed in the eastern part of Liaoning Province, Yunnan Province, Xinjiang and Tibet Autonomous Region. These counties are mostly located in frontier border areas and ecologically fragile areas, and are prone to passive urbanization. Ecological immigration and poverty alleviation relocation have brought a certain increase in population and construction land, and the failure of related supporting facilities and industries to follow up simultaneously can easily lead to vacant new homes. Counties in these areas should strictly abide by the ecological red line, reduce the ecological damage caused by construction and development, and reasonably determine and implement construction indicators in immigration and relocation to avoid waste of resources.

The third is the weakening decoupling model in which both the urban population and construction land are reduced, and the deceleration of construction land is less than the deceleration of population. From 2010 to 2020, the number of shrinking county units of this type accounted for about 8.3% of the total, mainly distributed in Heilongjiang Province, Sichuan Province and Shaanxi Province. These regions are relatively backward in economy, lack of self-development, and show a clear shrinking trend. It is necessary to further optimize the use of construction land and reduce resource waste. The above three development models are all facing the spatial mismatch problem of "more land and fewer people". It is urgent to change their own economic development mode, reduce extensive construction and development, vacate some inefficient land according to the current population situation, and promote the efficient and intensive use of construction land.

5. International Experience and Planning Strategies

5.1 Differences in Shrinking Characteristics

Based on the development characteristics and causes of shrinking cities in county levels in China, there are significant differences compared with other shrinking cities in the world, mainly reflected in the three aspects of economic structure, policy orientation and spatial characteristics.

(1) Differences in Economic Structure

Shrinking cities in European and American countries are mostly due to the process of "deindustrialization". For example, the relocation of manufacturing industries in the "Rust Belt" cities in the United States has led to a sharp decline in jobs and a continuous loss of population; after the reunification of the two Germanys, the East German region of Germany suffered a structural recession due to insufficient industrial competitiveness. In contrast, the shrinking of Chinese counties is more manifested as a "gradient shrinkage" under the background of "semi-urbanization" - the siphon effect of large cities has led to the outflow of population from counties, but the counties as the outflow of population are still making up for the shortcomings in infrastructure construction, expanding the investment in construction land, and forming a decoupling phenomenon of "reducing population and increasing land".

(2) Differences in Policy Orientation
European and American countries generally adopt a market-oriented regulation model. For example, the United States acquires abandoned properties for redevelopment through the "Land Bank", and Germany promotes the spatial reorganization of East Germany through federal fiscal transfer payments. The shrinking of Chinese counties is more subject to administrative intervention. The inertia of past growth-oriented planning is likely to lead to continued infrastructure investment. Some local governments still rely on land finance to maintain development.

(3) Differences in spatial characteristics
In terms of macro-spatial distribution, foreign shrinking cities are mainly distributed in industrial urban areas where local resources are exhausted or industries are undergoing transformation. Shrinking counties in China are more widely distributed, including resource-based counties in the northeast, agricultural counties in the central region, and border counties in the west. In terms of micro-spatial shrinkage characteristics, international shrinking cities generally show "hollowing out of central urban areas"; while Chinese urban shrinkage has the characteristics of "decentralized shrinkage": large cities and regional central cities are plump, surrounding counties are shrinking, and the population is moving to provincial capitals and regional central cities. Regional development differences may further aggravate the shrinkage of counties around large cities.

5.2 Planning strategies discussion
By summarizing the international experience in shrinking city governance and the national conditions of China, we can summarize the following planning strategies to deal with the uncoordinated development of the relationship between people and land in shrinking counties.

(1) Change in planning approach
The planning approach should shift from incremental expansion to stock optimization, establish a dynamic linkage mechanism of "population-land use", adjust the construction land indicators according to the elasticity of permanent population changes, optimize the economic construction and development assessment mechanism, and avoid the influence of the inertia of past growth-oriented planning. At the same time, it is necessary to shift from rigid planning control to flexible governance, promote the mixed use of industrial land, and improve the efficiency of construction land use.

(2) Differentiated governance
Based on the different types of county-level shrinkage, differentiated governance should be carried out, and smart shrinkage should be implemented by drawing on international experience. In the face of resource-declining counties in Northeast China, inefficient industrial areas should be "closed, stopped, merged and transferred", and space and construction land resources should be integrated and utilized. Follow-up industries, such as industrial heritage tourism, should be fully developed to inject new momentum into regional development and avoid continued decline. In the face of the population loss in the central provinces, we should shift from the homogeneous layout of construction land and public service facilities to precise allocation, learn from Japan's bus-oriented development to reasonably compress the radius of public services and reduce duplication and excessive construction.

(3) Regional coordinated development
To deal with the problem of county shrinkage through regional coordination and build a "core-contraction" matching mechanism for urban agglomerations, we can achieve complementary development through land quota transactions and regional function decentralization. At the same time, we should also improve the regional infrastructure sharing belt. Ultimately, through smart contraction and transformation, regional coordinated optimization, and the comprehensive construction of a full-chain governance system of "institutional constraints-market regulation-spatial optimization", we can further coordinate the matching of population and construction land and achieve high-efficiency and high-quality sustainable development.

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Planning for Play-Friendly City: Global Narratives and Local Interpretations in the Context of Istanbul

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Abstract
The concept of a "play-friendly city" has gained prominence in urban planning, highlighting the essential role of play in children's development and well-being. This paper investigates global frameworks promoting children's right to play and examines how cities interpret and implement these principles in diverse local contexts. It first reviews the theoretical foundations of play-focused urban planning, underscoring its importance in creating inclusive environments that support children's physical, cognitive, and social growth. It then analyzes international policy narratives and city-level strategies, identifying shared objectives and local adaptations. Finally, Istanbul is examined as a case study, with a particular focus on the Istanbul Play initiative, which seeks to embed play into the city's planning processes through holistic, participatory, and community-driven approaches. The study forms part of ongoing doctoral research aimed at developing decision-making tools to guide local authorities in planning for play-friendly urban environments.

Keywords: play-friendly city; urban development; local adaptation; strategic planning; decision-making

1. Theoretical and Practical Dimensions of Planning for Children and Play

Play is widely recognized as a fundamental aspect of children's physical, emotional, social, and cognitive development. Through play, children develop creativity, problem-solving abilities, social skills, and resilience, all of which contribute to their overall well-being and healthy growth (Ginsburg, 2007; Lester & Russell, 2010). Urban environments have a profound influence on the quality and quantity of opportunities children have to engage in play. Thoughtfully designed cities can offer safe, stimulating, and accessible spaces that encourage children to explore, interact with peers, and connect with nature, which supports not only individual development but also community cohesion (Hart, 1997; Fjørtoft, 2004). In contrast, poorly planned urban areas often restrict such opportunities, limiting children's physical activity and social interactions, which may negatively affect their health and well-being (Veitch, Bagley, Ball, & Salmon, 2006).

Designing child-friendly cities involves integrating specific principles into urban planning and development to prioritize children's diverse needs and rights. Among the most essential principles is ensuring mobility and accessibility, which means providing safe pedestrian pathways, dedicated cycling lanes, and proximity to essential services such as schools, parks, and healthcare facilities (Llewellyn & Wheeler, 2013). Safety and security are also crucial components; implementing traffic-calming measures, ensuring adequate lighting, and creating well-supervised, welcoming play areas are necessary to allow children to play independently with minimal risk (Hillman, Adams, & Whitelegg, 1990; Moore, 1986). Furthermore, urban environments should support play and learning by offering ample green spaces, interactive installations, and flexible public areas that stimulate children's cognitive, emotional, and social development. These spaces function as informal "third places," facilitating learning, creativity, and community engagement outside of home and school contexts (Worpole, 2000; Malone & Tranter, 2003). Equally important is community engagement in the design and planning processes. Involving children, parents, educators, and other local stakeholders helps ensure that play spaces meet the actual needs and desires of users, promoting ownership, inclusivity, and sustainability (Hart, 1992; Burke & Grosvenor, 2008).

Increasingly, urban planners and policymakers recognize children as active agents in shaping their environments rather than passive recipients of adult decisions. Participatory planning approaches that involve children directly in decision-making processes empower them to express their experiences, preferences, and ideas regarding urban spaces (Chawla, 2002; Skelton, 2007). Techniques such as guided neighborhood tours, creative workshops, drawing exercises, and storytelling have proven effective in eliciting children's perspectives, often

highlighting needs and opportunities that adults might overlook (Filler, 2007). This participatory approach aligns with the United Nations Convention on the Rights of the Child, which emphasizes children's rights to be heard in matters affecting their lives (UNCRC, 1989). Embedding participatory methods within urban governance not only enhances democratic decision-making but also leads to more responsive, inclusive urban environments that better support children's rights and well-being (Tremblay, 2014).

2. Global Narratives and Planning Frameworks for Child-Friendly Urban Environments

Urban planning increasingly acknowledges the essential role of play and recreation in shaping inclusive, healthy, and vibrant cities. Across the globe, municipal strategies and international policies converge in emphasizing children's rights to safe and accessible play as fundamental to sustainable urban development. This chapter synthesizes the guiding global frameworks alongside pioneering city plans from Barcelona, London, Dublin, Nottingham, Berlin, and Australia, illustrating a shared commitment to embedding play within urban design.

2.1 International Policy Foundations

The cornerstone of the global movement toward child-friendly cities is the United Nations Convention on the Rights of the Child (UNCRC), Article 31, which guarantees every child the right to rest, leisure, play, recreational activities, and participation in cultural life. Building on this, the UN Committee on the Rights of the Child General Comment No. 17 (2013) elaborates on the significance of play in children's development and urban environments. The Sustainable Development Goals (SDGs), particularly Goal 11 (Sustainable Cities and Communities), emphasize inclusive, safe, and accessible green and public spaces that promote well-being and social cohesion. These global mandates set the normative framework urging cities worldwide to prioritize play infrastructure and policies.

2.2 City Plans as Expressions of Global Commitments

The examined city plans operationalize international principles within localized contexts, offering concrete frameworks, strategies, and actions that reflect and advance global aspirations. City authorities increasingly integrate play into urban planning approaches as a means to enhance the quality of life, promote social cohesion, and foster healthier, more inclusive environments for all residents.

Barcelona's Public Space Play Plan Horizon 2030 integrates play within a broader sustainability agenda aligned with the Sustainable Development Goals (SDGs), emphasizing well-being, inclusion, and environmental quality. The plan positions outdoor play and physical activity as core policy priorities for a healthier urban life. It reflects UNCRC principles by aiming for universal access to diverse, accessible play spaces and promoting inclusive environments for all ages, genders, and abilities. The interdisciplinary drafting process and comprehensive implementation strategy illustrate how global norms can be translated into actionable urban policies. (Barcelona City, 2019)

Through its Good Growth Plan and Supplementary Planning Guidance (2011), London aligns with the UNCRC and SDG frameworks by embedding children's rights into urban design, prioritizing independent mobility and safe access to play. The London Play Plan advances the concept of a "child-friendly city" by shifting focus from isolated playgrounds to integrated neighborhood play ecosystems. Its emphasis on safe routes and pollution reduction through initiatives like Ultra Low Emission Zones demonstrates the intersection of environmental health and play, consistent with international sustainability goals (London City, 2012).

Dublin's City Play Strategy 2022–2027 explicitly references international legal instruments such as the UNCRC and General Comment No. 17, grounding its vision in children's rights. The strategy promotes a coordinated, cross-departmental approach to ensuring equitable access to quality play opportunities, reflecting the global narrative of inclusive urban environments. The city's commitment to participation and inclusive design further embodies the principles of meaningful child involvement advocated in international frameworks. (Dublin City, 2022)

Nottingham's Play Strategy 2008–2020 aligns with international policies by defining play as a right and emphasizing inclusion, safety, and community engagement. It promotes accessible, well-maintained play spaces

throughout the city, supporting social inclusion and well-being—key themes within the SDGs and the UNCRC. The strategy's emphasis on sustainable, inter-agency collaboration reflects global calls for integrated governance in child-friendly urban planning. (Nottingham City, 2008)

Berlin's Urban Development Concept Berlin 2030 offers a holistic vision that integrates play and recreation within broader goals of sustainable and inclusive development. Its focus on public participation, including engagement with future generations, mirrors international calls for child participation and community inclusion. The city's approach to balancing urban density with green spaces fosters livability, social cohesion, and environmental sustainability—central pillars of global urban development agendas. (Berlin City, 2015)

Australia's Play Strategic Plan 2020–2025 embeds play within national frameworks of public health and urban design, recognizing it as a fundamental human right. The plan's alignment with UNCRC Article 31 and SDG goals reinforces the global priority of accessible play for all children. Through legislative and urban design reforms, and grassroots initiatives such as the 1000 Play Streets Movement, Australia demonstrates a multi-level approach to implementing international play frameworks. (Australia Play, 2020)

2.3 Synthesis of Global and Local Frameworks

Together, these city plans and international policies articulate a shared vision: urban environments must be designed and managed to facilitate daily, meaningful play opportunities for children. The global policy frameworks provide normative guidance, emphasizing children's rights, equity, and sustainability, while city plans translate these ideals into concrete commitments and strategies tailored to local contexts. A key convergence across these documents is the recognition of play as a fundamental right, grounded in Article 31 of the United Nations Convention on the Rights of the Child (UNCRC), which frames play as essential not only to children's development but also to their active citizenship. Additionally, inclusivity and accessibility are central concerns; universal design principles and cross-sector collaboration ensure that play opportunities are available to children of all abilities, genders, and socioeconomic backgrounds. Furthermore, play is increasingly understood as an integrated element within broader urban systems, embedded not only in designated playgrounds but throughout transport networks, green spaces, and community facilities—promoting independent mobility, environmental health, and seamless access. This vision is complemented by a strong emphasis on participation and co-design, with children and communities actively engaged throughout planning and implementation processes, thereby reflecting the principle of meaningful involvement and agency. Finally, the role of play is linked to wider urban objectives such as environmental sustainability, public health, and social cohesion, recognizing that fostering playful, inclusive environments contributes to the well-being of the entire city. Despite these advances, challenges persist in scaling up the integration of play within diverse urban contexts and ensuring equitable access for all children. Emerging innovative approaches, such as London's "Slow Build" model and Australia's digital Playground Finder, illustrate the potential for responsive, adaptive play planning that can better meet the needs of rapidly changing cities. Looking forward, continued alignment with evolving international frameworks and the strengthening of inclusive governance mechanisms will be crucial to advancing child-friendly urban futures that fully embed play as a vital element of city life.

3. Istanbul's Journey Towards Becoming a Playable City

Istanbul's vast and complex urban fabric presents both significant challenges and unique opportunities for embedding play within the city's evolving landscape. As a city that straddles continents and cultures, with sprawling metropolitan dimensions and diverse socio-economic realities, Istanbul's pursuit of becoming a "playable city" illustrates how global narratives on child-friendly urbanism adapt to local specificities.

3.1 Overview of the Istanbul Play Initiative

Istanbul's journey toward becoming a "playable city" reflects an ambitious and contextually nuanced effort to embed play within a highly complex and diverse urban environment. As a sprawling metropolis bridging two continents, Istanbul's urban fabric is characterized by vast dimensions, diverse socio-economic realities, and multifaceted spatial patterns. These factors distinguish Istanbul from many other cities undertaking similar

child-friendly urban initiatives, making its approach to play deeply rooted in local interpretations while still engaging with global narratives. (IMM, 2022)

The Istanbul Play initiative, anchored by the Istanbul Play Master Plan, represents a comprehensive framework aiming to integrate play into the very fabric of the city beyond conventional playgrounds. It embraces a holistic planning vision that seeks to incorporate play opportunities throughout the urban environment—whether in streetscapes, parks, community centers, or informal spaces—ensuring play becomes a seamless part of everyday urban life. This shift towards a "playable city" is guided by the recognition that children's right to play is not limited to designated areas but must be interwoven into the broader urban experience. (IMM, 2022)

A fundamental aspect of this initiative is its strong emphasis on community engagement. Given Istanbul's cultural diversity and complex social dynamics, the planning process prioritizes collaboration with local residents, families, and children to create public and play spaces that resonate with their specific needs and cultural contexts. This participatory approach fosters local ownership and encourages sustainable use of public areas. Moreover, the initiative seeks to align urban planning policies with international frameworks such as the United Nations Convention on the Rights of the Child (UNCRC) and the Sustainable Development Goals (SDGs), ensuring that play is integrated into wider municipal policies that promote children's well-being and rights. Efforts to strengthen institutional coordination and embed play considerations into broader urban development policies are critical elements of this policy integration. (IMM, 2022)

3.2 Comparative Analysis with Other Cities

While Istanbul's play initiative shares many foundational principles with global examples of child-friendly cities—such as London, Barcelona, and Dublin—the city's unique characteristics present distinct challenges and opportunities (Meier and Thiel, 2014; IPA, 2017). Unlike these relatively compact European cities, Istanbul's enormous size and sprawling urbanization extend far beyond the boundaries of formally controlled urban patterns (Yardımcı and Şenol, 2020). The city's rapid expansion includes large informal settlements and irregular development that complicate efforts to provide equitable access to safe, inclusive play environments across all neighborhoods (Akkaya, 2015; UNICEF, 2018). This complexity stands in contrast to cities with more uniform urban governance where play infrastructure can be coordinated more systematically (Karaman, 2018).

Furthermore, Istanbul's urban fabric is extraordinarily heterogeneous, ranging from dense historic districts and tightly knit neighborhoods to sprawling suburban zones and informal settlements (Çelik, 2019). Such diversity demands adaptable and context-specific play solutions that accommodate varying spatial conditions—from intimate courtyard spaces in compact areas to expansive green parks in suburban localities. This variety differs significantly from cities where the urban form is more homogeneous, requiring less tailored interventions (Dover and Daly, 2021).

The socio-cultural dimensions of Istanbul also shape its approach to play. Traditional attitudes, family structures, and concerns about safety influence how public spaces and play are perceived and used (Dover and Daly, 2021). Unlike cities with long-standing traditions of public child-friendly design, Istanbul's initiative places particular emphasis on cultural sensitivity and community engagement to foster acceptance and participation in public play (Hart, 1992). This cultural dimension adds a layer of complexity to the planning process, necessitating thoughtful dialogue and inclusive design.

Institutionally, Istanbul continues to develop its governance mechanisms to better facilitate children's participation and cross-sector collaboration in urban planning (Karaman, 2018). While some cities have established mature interdepartmental frameworks dedicated to child-friendly urbanism, Istanbul is still evolving these structures to enhance accountability and effectiveness (UNICEF, 2018).

3.3 Outcomes and Future Directions

Istanbul's play initiative aligns closely with global aspirations to recognize play as a fundamental right and essential component of children's health, well-being, and social inclusion. The city adopts a rights-based framework that draws from international commitments while tailoring implementation to local realities. (IMM, 2022)

Since its inception, the Istanbul Play initiative has achieved promising outcomes. Innovative play environments have been introduced, showcasing a range of approaches such as natural playgrounds, interactive installations, and the creative reuse of public spaces that reflect Istanbul's unique cultural and environmental context. The initiative has also succeeded in raising awareness among policymakers, urban planners, and the general public about the importance of play as a core urban function. (IMM, 2022)

Looking forward, Istanbul's efforts focus on strengthening mechanisms for monitoring and evaluating the impact of play spaces on children's well-being and community life. There is a clear commitment to continuously refine policies, incorporating new insights and feedback from stakeholders to improve the quality and inclusivity of play provision. Scaling up successful pilot projects to reach Istanbul's diverse neighborhoods, including informal areas, remains a central priority. Embedding play within broader urban strategies—such as transportation planning, housing development, and green infrastructure—will be essential for sustaining progress. (IMM, 2022)

Crucially, the city aims to deepen participatory frameworks, ensuring children and communities have a meaningful voice throughout planning, implementation, and evaluation processes. Istanbul's experience demonstrates how global principles of child-friendly urbanism can be interpreted and adapted to address the specific challenges of a sprawling, diverse metropolis. This adaptive process offers valuable lessons for other large, rapidly growing cities seeking to make play an integral part of urban life.

4. Conclusion

This study, situated within the broader framework of doctoral research, has explored the complex interplay between global narratives of child-friendly urbanism and their localized interpretations in the context of Istanbul's ambitious journey toward becoming a play-friendly city. By examining international policy frameworks alongside the specific urban, social, and cultural realities of Istanbul, this research highlights both the universal principles and the distinctive challenges that shape how play is integrated into city planning.

Play is increasingly recognized not only as a fundamental right of children but also as a critical component of healthy, inclusive, and vibrant urban environments. Integrating play into urban planning contributes significantly to the physical, social, emotional, and cognitive development of children, while fostering community cohesion and enhancing the overall quality of public spaces for people of all ages. Embedding play in urban design challenges planners to move beyond isolated playgrounds and instead create interconnected, accessible, and diverse play opportunities that respond to the varied needs of children and families within complex cityscapes.

The comparative analysis of international city plans reveals several prominent principles that underpin successful play-friendly urban strategies. These include ensuring accessibility and inclusivity for all children regardless of age, gender, ability, or background; promoting independent mobility and safe routes within neighborhoods; embedding play within broader sustainability and public health agendas; and fostering meaningful participation of children and communities in planning processes. Plans from cities like Barcelona, London, Dublin, and Berlin consistently emphasize the importance of cross-sectoral collaboration, adaptive design approaches, and ongoing monitoring and evaluation to sustain play infrastructure that evolves with changing community needs.

The comparative analysis with other global cities underscores Istanbul's unique position as a vast, diverse metropolis with sprawling urbanization patterns that extend beyond conventional regulatory boundaries. This complexity necessitates adaptive, context-sensitive approaches that go beyond replicating international models, emphasizing community engagement, cultural inclusivity, and flexible planning strategies. The Istanbul Play initiative and Master Plan exemplify this localized interpretation by embedding play into a wide range of urban

spaces and fostering collaboration between policymakers, communities, and children.

Importantly, this research contributes to a deeper understanding of how play can be systematically incorporated into public services and urban planning processes, moving beyond ad hoc interventions to more holistic, sustainable frameworks. As part of an ongoing doctoral study, the insights gained here aim to inform the development of a decision-making tool for local authorities. This tool is intended to support strategic planning for play, ensuring that children's rights and needs are at the core of urban development policies and practices.

Ultimately, the study reinforces that fostering play-friendly cities requires both a commitment to global child rights frameworks and a nuanced appreciation of local urban realities. Istanbul's experience serves as a valuable case study, demonstrating how cities with complex, rapidly evolving urban fabrics can successfully integrate play into their public spaces and policies. The findings offer practical guidance for policymakers and urban planners seeking to create inclusive, vibrant, and equitable environments where children can thrive.

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Research on the Distribution and Typological Characteristics of Urban Office Centres from a Fine-Grained Perspective: A Case Study of Yangpu District in Shanghai, China

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Abstract
IT maturity has transformed business operations and the preferences for office space, altering urban office distribution. This study uses geospatial data to map fine-scale office space patterns in Yangpu District, Shanghai, identifying office centres, exploring their typologies and relationships with nearby facilities. Key findings: (1) Offices are dispersing from central CBDs and re-aggregating spatially forming new centres. (2) These centres feature high-density, mixed-use surroundings, good subway access, and proximity to residences/universities. Five spatial types emerge: TOD Developments in Peripheral Location, University-linked Mini Industrial Clusters, Small-scale Creative Parks in urban renewal, We-work space based on Multiple-Functional Community Complexes, and CBD Zones. This study enhances understanding of internet-era office spaces and provide theoretical support for the refined organisation and optimisation of urban employment spaces.

Key words: urban office centres; facilities in the environment; clustering analysis; decentralisation

1. Introduction

Residence and work are considered two fundamental urban functions by Le Corbusier, and the jobs-housing relationship – the spatial layout relationship between employment and residential areas – has long been a classic and critical topic in urban planning. Since the late 19th century, shifts in policy thinking and advancements in transportation and communication technologies have continuously presented new opportunities and challenges for this relationship, giving rise to numerous urban theoretical models addressing it. In China, abundant job opportunities and higher wages continue to attract populations towards cities, with urban population size projected to grow further. By the end of 2023, China's permanent urbanisation rate reached 66.16%, and it is expected that the urban population will surpass one billion for the first time by 2030. Where to live and where to work are two core questions urban residents inevitably face. Over the past decade, rapid regional and urban economic development has driven continuous global industrial upgrading. Modern service industries, particularly producer services, have gradually become pillar industries in major cities. Office spaces, primarily comprised of commercial office buildings, provide urban residents with substantial employment opportunities and high-quality work environments, exerting a significant influence on the urban jobs-housing relationship. Optimizing the spatial organisation of office space is thus a major research focus in global geography and urban planning disciplines.

The maturity of information technology (IT) has seen information connectivity gradually replace traditional transportation connectivity, revolutionizing office models in the internet era. During the Third Industrial Revolution, the proliferation of digital infrastructure and remote collaboration tools enabled cross-spatiotemporal communication. Online office forms like video conferencing, web-based training, and mobile working became widely adopted, even partially replacing face-to-face interaction. By the end of 2021, the number of online office users in China reached 469 million (Sun Bindong, 2021). Devices like mobile workstations became new carriers for resources and information, diminishing the external gravitational pull and spatial effects of industrial clusters, thereby reducing the physical scale of industrial spatial agglomeration (Castells, 1989, 1996). Advances in communication technology and online interaction tools liberated people from geographical and physical office constraints, enabling work from virtually anywhere. Concurrently, digitisation and knowledge-intensive activities transformed the nature of work itself, making flexible employment models like remote work and freelancing increasingly important, leading to the virtualisation and decentralisation of workspaces (Long Ying, 2022). Many companies are transitioning towards networked, distributed management models. Progress in office organisation methods has greatly enhanced flexibility. Driven by factors such as rent, resource availability, and environmental quality, office functions are gradually detaching from traditional industrial cluster areas and dispersing spatially (Yang Dejin, 2012). Against this backdrop, office space is developing in a decentralised manner within cities, with significant

emergence outside traditional urban cores, showcasing diverse urban office scenarios and vibrant economic activity.

Theoretically, academia widely agrees that breaking the "agglomerated yet separate" polarised development pattern of employment centres and residential centres, and enhancing urban functional mix, is one pathway to optimizing the jobs-housing relationship. Urban planning concepts like Smart Growth and New Urbanism also endorse this view. Building on the "Neighbourhood Unit" concept, China has further developed the "Community Life Circle" concept based on "15-Minute City" theory. This serves as a spatial carrier for residential life, aiming to meet residents' diverse activity needs. Localizing employment opportunities is a key aspect of building 15-Minute Cities. Shanghai's community renewal practices explicitly include "Suitable for Employment" as one of its "Five Amenity Goals" (Wu Yi), advocating for ample job opportunities within or near communities to reduce commute times and pressure. Current research on urban office spaces often focuses on the agglomeration patterns of high-level employment centres at a macro scale (e.g., CBDs, sub-centres, polycentric structures). Studies investigating finer-scale, decentralised yet re-agglomerating office centres are relatively scarce, and the pathways to achieve localised employment opportunities within the "15-Minute City" framework remain unclear. Therefore, addressing this gap, this paper focuses on fine-scale office centres. We propose the hypothesis: "Office space is dispersing from the urban CBD and re-agglomerating spatially on a smaller scale to form new office centres." After validating this hypothesis, we explore the characteristics of these office centres to decipher the mechanisms behind employment decentralisation and localisation. This analysis may offer insights for optimizing urban spatial layouts under constrained land development conditions. The structure of this paper is as follows: Section 2 presents a literature review on office space research, establishing the necessity and innovation of this study. Section 3 details the methodology for hypothesis validation and subsequent analysis. Sections 4 and 5 present systematic empirical research. Conclusions are summarised in Section 6.

2. Literature Review

Reviewing research themes on office space structure both domestically and internationally, collecting relevant literature through searches in Science Direct and the CNKI helps establish a relatively comprehensive literature database system on office space research. Searches were conducted based on keywords such as "producer services," "office space," "office centres," "urban spatial structure," "influencing factors," "evolutionary trends," and "dispersed distribution." encompassing research themes including CBDs, business offices, business districts, office buildings, urban design, layout characteristics, spatial structure, and evolutionary features.

Early research on office spaces in Western countries was not an independent topic but appeared within economic studies. Based on classical economic methods, core theories such as Thünen's Agricultural Location Theory, Weber's Industrial Location Theory, and the Market Location Theories of Scheffler, Christaller, and Lösch were formed, primarily focusing on economic activities in urban centres and their spatial carriers. In the 1920s, alongside the transition from secondary to tertiary industries, the Central Business District (CBD) emerged as a typical spatial carrier, prompting specialised research on office spaces in western planning academia. From the 1920s to 1940s, research focused on the characteristics and causes of the centripetal agglomeration of office activities. The classic urban spatial structure theories proposed by the Chicago School—Burgess's Concentric Zone (1923), Hoyt's Sector (1939), and Harris and Ullman's Multiple Nuclei (1939)—all indicated that office space should be highly concentrated in urban centres. After the 1950s, the office industry became a pillar industry in major Western cities, and related research became increasingly systematic. Guided by Location Theory, Urban Spatial Structure Theory, Central Place Theory, theories of office decentralisation, and stage development models, academia conducted extensive theoretical and empirical research on office activities, the office industry, and office spaces, leading to a maturing theoretical system. Research subjects were concentrated in three main fields: urban economics, financial economics, and urban geography. Content covered office space location, spatial structure, types of agglomeration distribution, morphological structure, formation mechanisms, and increasingly, research on layout evolution under suburbanisation and informatisation.

Research on office spaces in China began in the 1990s, approximately 70 years later than in the West. Relying

on theories such as Office Space Location Theory, Agglomeration-Diffusion Structure Theory, and Enterprise Behavioral Decision Theory, research mainly focused on the concept of the office industry, office location theory, headquarters economy space, urban CBDs, and the interaction between office space and urban development. In recent years, improved research capabilities and data informatisation have significantly expanded data coverage and reduced acquisition difficulty. Using GIS technology to analyse the agglomeration characteristics of urban functional spaces has become a trend. Concurrently, transformations in office models have spawned various new forms of office spaces such as co-working spaces, SOHO, and renovated industrial buildings, enriching the typology of office architecture.

2.1 Research on Factors Influencing Office Space Distribution

Western office location theory takes corporate autonomous site selection as its basic premise, viewing it as the intrinsic driver shaping office spatial patterns. Since the mature development of Central Business Districts (CBDs) in the 1980s, academia has gradually revealed the formation mechanisms and influencing factors of office space agglomeration structures through empirical case studies. As an emerging industrial space characterised by low land occupancy and low transportation costs, its site selection is primarily dominated by non-production cost factors, encompassing multidimensional influences such as agglomeration economies, face-to-face communication needs, information technology advancements, changes in corporate organisational structures, urban cultural environments, and market environments. These factors can be categorised into three levels: economic-market, technological-social, and organisational-institutional.

The spatial agglomeration distribution of office spaces at the urban scale can essentially be seen as a product of the co-evolution of the city's multifunctional systems, shaped by both the active force system (office districts, residential areas, commercial districts, transportation hubs, etc.) and the environmental constraint system (natural ecology, green spaces, built environment, etc.). Agglomeration scale reflects the level of development of urban functional spaces, agglomeration characteristics reveal endogenous development laws, and the uneven distribution of spatial elements leads to heterogeneous effects of the same influencing factor in different regions, exhibiting significant non-stationary characteristics. For instance, a specific factor might strengthen agglomeration in the centre while potentially triggering dispersion in the suburbs. This is the particularity of this complex mechanism within the Chinese context. The three-dimensional driving framework proposed by XUE Dongqian et al. (2011) for Xi'an's producer services confirms this: market orientation creates demand pull, locational factors trigger spatial competition, and government guidance implements policy intervention. Together, these three aspects explain the evolutionary logic of office spaces during the transition period.

2.2 Research on Trends of Concentration and Dispersion in Office Spaces

The agglomeration and dispersion, equilibrium and disequilibrium of office spaces within cities are core topics in geographical research. Agglomeration is considered a fundamental characteristic of office space. Studies show that regardless of changes in urban structure, the Central Business District (CBD), centreed on office functions, typically maintains its core position, with office buildings generally tending to locate in relatively central urban areas. This pattern has been confirmed in the urbanisation processes of Western countries (Kee Boim Nahm, 1999). However, although the agglomeration trend has not fundamentally changed, office space layouts in developed metropolitan areas in recent years have shown a tendency towards dispersion, gradually spreading to sub-regional urban centres. Large companies, in particular, are increasingly likely to relocate some operations to lower-cost peripheral areas, forming localised office functions. This dispersion pattern first appeared at the national urban system level, accompanying the shift from centralised to dispersed regional development models. Simultaneously, dispersion also occurs within cities. For example, research in Toronto shows that non-central urban areas can also become new office centres to reduce communication costs.

Accompanying the maturation of CBDs and the localisation of office space, academia has gradually identified typical layout patterns such as "Cluster" and "Net of mixed beads." Integrating the research of Erickson and Hart, Masu proposed a universal four-stage localisation evolution framework: 1) Spillover and Specialisation; 2) Dispersion and Diversification; 3) Polycentricity (Filling Nuclei / Diffusing Nuclei); 4) Three forms of suburban office space

(Loop Centres, Radial Road Centres, Unstructured Expansion). Castells argued that concentration and dispersion often coexist rather than being absolute, both at the regional and urban levels, categorizing office space distribution states into four types: Agglomeration, Dispersion, Concentrated Agglomeration, and Concentrated Dispersion. Similarly, ZHANG Jingqiu et al. (2011) quantitatively analysed Beijing's office building distribution, extracting three industry-specific agglomeration types: "Large Dispersion - Small Agglomeration," "Large Dispersion - Large Agglomeration," and "Small Dispersion - Large Agglomeration," noting their spatial coupling with major transportation arteries. Scholars such as WANG Yang (2016), WANG Junrong (2017), ZHANG Zhibin (2019), and YE Qiang (2022) subsequently conducted empirical studies in cities like Guangzhou, Zhengzhou, Lanzhou, and Changsha, further enriching regional case support. This stage saw the extensive application of mathematical statistical analysis methods.

The existing literature review indicates that international research has recognised the trend of office space decentralisation, theoretically explained the process, and dialectically analysed the two spatial organisation modes—agglomeration and dispersion—from macro perspectives of regions or cities. However, relevant research still exhibits relative gaps: First, the research objects mostly focus on traditional commercial office buildings, with less identification and differentiation of new office space types from spatial or industrial perspectives. Second, there is a scarcity of in-depth studies targeting dispersed office centre entities at the meso-micro scale and a lack of systematic exploration into the characteristic typologies of new office spaces.

3. Research Design

This study is divided into two main parts. The first part describes the evolving characteristics of office space distribution within the study area and verifies the hypothesis. The second part identifies office centres within the study area at a fine scale and conducts an exploratory analysis of their characteristic typologies. This research utilises Point of Interest (POI) data and Location-Based Service (LBS) data as the basis for identifying office spaces and office centres. Open geographic information data from OSM, Baidu Maps, and AMap are employed for spatial calculations to describe the fundamental characteristics of the office centres. The study adopts spatial analysis methods such as Standard Deviational Ellipse Analysis and Spatial Autocorrelation Analysis, alongside quantitative analytical methods like Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA) for induction and interpretation.

3.1 Research Approach

To address the hypothesis proposed in this paper – "Office space is dispersing from the urban CBD and re-agglomerating spatially on a smaller scale to form new office centres" – this study primarily utilises multi-temporal POI data for the study area obtained from online sources. First, data pre-processing is performed in ArcGIS to filter business office POI point data exhibiting characteristics of producer services. Facilities within the jurisdiction capable of providing employment are treated as individual discrete points. The Standard Deviational Ellipse (SDE) method is used to determine the overall distribution characteristics of office space within the study area. Based on planning documents, the study area is divided into central urban areas and non-central areas. Spatial grid statistics are employed to count office spaces. Data visualisation and spatial analysis methods, including spatial autocorrelation analysis, are then used to intuitively present the spatial clustering distribution characteristics of office spaces in different years within the study area, describe their evolutionary trends, and thereby verify the hypothesis.

For the exploration of the spatial patterns and typological characteristics of office centres, the process is as follows: First, POI data and LBS data are used to identify office centres within the study area. Basic geographic data, including POI data, AOI data, and road network data, are utilised in spatial calculations to obtain proxy descriptive parametres representing the locational, morphological, and functional environmental attributes of the identified office centres. Subsequently, the PCA method is applied to reduce the dimensionality of these parametres to extract the most critical feature elements. Finally, the HCA method is employed to classify the identified office centres and analyse their groupings.

3.2 Research Method

(1) Standard Deviational Ellipse Analysis

This study uses standard deviational ellipse to summarise the spatial characteristics of geographic features, including central tendency, dispersion, and directional tendency. The ellipse represents the spatial distribution direction and range of employment position data.

(2) Spatial Autocorrelation Analysis

Spatial autocorrelation analysis can examine whether the attribute values of elements with spatial locations are correlated with the attribute values at neighbouring spatial points, including global spatial autocorrelation and local spatial autocorrelation. The global Moran's I index is used to analyse the overall spatial correlation and spatial differentiation of the region, and then the Getis-Ord Gi* statistics are used to create hotspot and cold spot maps with statistical significance.

(3) Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a commonly used dimensionality reduction method that transforms a large number of complex linearly correlated variables into a smaller number of linearly independent principal components through orthogonal transformation, while preserving the main characteristics of the data and reducing its dimensionality. It effectively eliminates redundant information and extracts key features, thereby simplifying complex datasets. PCA projects high-dimensional data into a low-dimensional space by maximizing variance retention, and these principal components can be used for data visualisation, classification, clustering, and other applications.

(4) Hierarchical Cluster Analysis (HCA)

Hierarchical Cluster Analysis (HCA) is a method for grouping samples based on the similarity of their characteristic data. This method constructs a hierarchical clustering dendrogram by iteratively merging or splitting the most similar samples or clusters. The clustering process is conducted according to specific linkage criteria (such as nearest neighbour, farthest neighbour, and average linkage between groups). Ultimately, by analysing the hierarchical structure of the dendrogram, the optimal number of clusters and grouping schemes are determined based on research needs, revealing the inherent natural grouping patterns within the sample data.

3.3 Research Case

The case, Yangpu District (Figure 1), is located in the northeast part of Shanghai's central urban area, on the northwest bank of the lower reaches of the Huangpu River, covering an area of 60.61 square kilometres. It has jurisdiction over 12 sub-districts (the smallest administrative division in China). As of December 2024, Yangpu District has a population of 1.1997 million, with a density approaching 20,000 people per square kilometre. In the 2023 "15-minute community life circle" initiative in Shanghai, Yangpu District has delineated 33 15-minute community living circles, each with a population of approximately 36,000 and covering an area of about 1.8 square kilometres.

Yangpu District is located on the outskirts of the traditional work centre and has undergone industrialisation, rapid urbanisation, and urban renewal since its establishment as a district in 1960. Some areas of WJC Sub-district were planned as a sub-centre of Shanghai in 1991, while some areas of JPL Sub-district were planned as a regional centre in 2004. Additionally, the district is rich in educational and scientific resources, with 14 various types of higher education institutions, which accounts for more than one-third of the total number of higher education institutions in Shanghai. Therefore, there are various types of urban spaces present, including urban centres, new and old residential areas, remnants of industrial factories, and knowledge-intensive areas around universities. In terms of industry and economy, by 2024, the added value of the tertiary sector will account for 90.0% of the district's GDP, with traditional and emerging office industries such as new media, the internet, technological innovation, and finance being the key development targets for Yangpu District. In summary, Yangpu District is an excellent case study for researching office spaces and office centres.

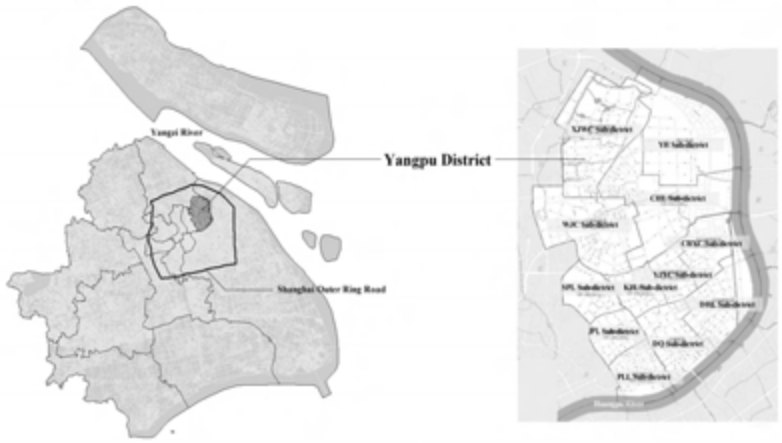

Figure 1. The location of Yangpu District

3.4 Data Description

In the hypothesis verification section, this study adopts a grid with a side length of 300 metres to describe the evolution trend phenomenon of the macroscopic office space distribution in Yangpu District, in order to lay the research foundation. By analysing the aggregation characteristics, characterisation accuracy and computational efficiency of employment facilities using spatial units of 100 metres, 300 metres, 500 metres and 1000 metres, it is found that the 300-metre grid can better represent the spatial distribution within Yangpu District.

Considering that this study mainly focuses on the distribution of office space and the identification of office centre locations at a more refined scale, although using the regular grid cutting base map as the analysis unit can effectively unify the research scale, this method has the following significant drawbacks: (1) Spatial fragmentation: The regular grid ignores the natural boundaries of the urban texture and may cut the complete functional areas into different grids; (2) Scale untruthfulness: Fixed grids are difficult to reflect the spatial heterogeneity between the dense road network in the central urban area and the sparse road network in the suburbs. Therefore, in the feature research section, an attempt is made to adopt the logic of "natural demarcation - functional integration" to divide the research units. The office centre land units are specifically delineated mainly through road and land use functions. The plots (different land use function sections) within the blocks (units enclosed and demarcated by urban public roads) are taken as the basic research units. The specific methods are as follows: By adopting the OSM open map to obtain the vector data of the entire road network in Shanghai, the four-level road network (expressways, main roads, secondary roads, and important branch roads) within Shanghai was extracted, and extract the centre line of the road network to simplify the road network into a single line. Reconstruct the topological network model again to eliminate redundant nodes and hanging points (node spacing) 50m automatic merge. The generated network model is used to cut the blocks to obtain the initial block units, and then the plot within the block are divided by referring to the land resource survey and unit planning of Yangpu District. Finally, inspect the plots and eliminate the area. For 200m^2 of fragmented patches, reduce the number of cracked plots and inspect the hard boundaries with expressways and major water systems. Cross-plot consolidation is prohibited. Finally, the area of Yangpu District was divided into 2,002 research units (Figure 2).

The point of interest (POI) data used in this study comes from Amap and is updated to 2024. Integrating the research of other scholars and the 20 major industry categories in the "National Economic Industry Classification Standard (GB/T 4754-2017)," this study selects the following data as categories related to the business office industry (Table 1), covering five major categories: life services, finance and insurance, automotive services, science and education culture, and corporate enterprises from the POI data accessed through Amap. To ensure the consistency between industry classification standards and POI data, this study cleaned the POI data for Yangpu District from 2014, 2019, and 2024, filtering to include key information such as company name, address, type, and geographical coordinates. The dataset contained 2,425 points in 2014, 3,975 in 2019, and 2,982 in 2024, leading to

the establishment of a GIS spatial database for subsequent research.

In addition, the LBS data used to identify office centres comes from the Baidu Huiyan data platform, covering the period from November 11 to 17, 2024, with data selected from weekdays at 10, 11, 14, 15, 16 and 17 o'clock. The rest of the spatial data is sourced from the Amap, Baidu Map, and OSM. Considered that some indicators involve descriptions of the surrounding environment of plots, this study uses a 300-metre buffer zone around each plot as the calculation range. Specific data descriptions detailed in Table 2.

Figure 2. Research unit on Plot Accuracy in Yangpu District

Table 1. Office POI Types

Industry Type	POI Data Content
E - Construction industry	Construction companies, architectural firms
K - Real Estate Industry	Real estate companies, sales centres, real estate agencies, property management companies
P - Education Industry	Cultural and educational companies, training institutions
R - Culture, Sports, and Entertainment Industry	Cultural media companies, animation design companies
I - Information Transmission, Software, and Information Technology Service Industry	Telecommunication business halls, graphic and text advertising companies, postal services, information technology service companies
M - Scientific Research and Technical Service Industry	Technology companies, high-tech companies, research institutes

J - Financial Industry	Banks, securities companies, trading companies, insurance companies, futures companies
L - Leasing and Business Service Industry	Car rental companies, machinery rental companies, daily necessities rental companies, advertising companies, management consulting companies, law firms, accounting firms, assessment firms, certification firms, patent firms, talent markets

Table 2. Spatial data sources

Data Name	Data Description	Data Source	Data update time
Office function - Point Data	Data points that describe the distribution of office functions. Obtained based on the classification and screening of Amap POI.	Amap API https://lbs.amap.com/api	2014 -2019-2024
Behavioural activity heat - Point Data	Vitality statistics of urban at different times based on "mobile device location services".	Baidu Huiyan https://huiyan.baidu.com	2024. Sep.11-17
Urban road network – Polyline Data	Urban road network information, including road classification	Open Street Map https://openstreetmap.org	2024
Urban architecture - Polygon Data	Urban completed building data, including location, area, and height, number of floor.	Baidu Map	2024
Urban functional area - Polygon Data	Urban functional zone data, including functional classification, location and area.	Amap API https://lbs.amap.com/api	2024
Urban public/commercial service - Point Data	Data points that describe the distribution of public/commercial service. Obtained based on the classification and screening of Amap POI.	Amap API https://lbs.amap.com/api	2024

4 Distribution Characteristics of Office Spaces in Yangpu District

4.1 Overall Distribution Exhibits a Trend of Decentralisation

Using the standard deviation ellipse analysis method, we visually compare the spatial distribution of POI data for business office enterprises in Yangpu District for the years 2014, 2019, and 2024. In this analysis, the first-order standard deviation ellipse covered 63% of the point elements within the study area. Specifically, the standard deviation ellipse for 2014 had a long axis of 2710.14 metres and a short axis of 1902.63 metres(Figure 3a); in 2019, the long axis was 3041.61 metres and the short axis was 2055.78 metres(Figure 3b); and in 2024, the long axis measured 3306.87 metres and the short axis was 2013.33 metres(Figure 3c). The standard deviation ellipses from 2014

to 2019 show significant expansion in both the long axis and short axis, with the area also increasing, indicating a trend from concentration to decentralisation in the distribution of business office enterprises in Yangpu District over these five years. From 2019 to 2024, the changes in the standard deviation ellipse are minimal, suggesting that on a macro scale, the decentralised characteristics relative to 2014 have been maintained, while potential adjustments in the distribution structure at the micro level are occurring, which is a topic for further research.

Figure 3a, 3b, 3c. The standard deviation ellipse of office space distribution in 2014, 2019 and 2024

4.2. Evolutionary Pattern of "First Dispersal, Then Re-aggregation" Forms Hierarchical Office Centres

Quantitative visualisations of the POI data of business offices in Yangpu District for the years 2014, 2019, and 2024 were conducted, utilizing the local spatial autocorrelation Getis-Ord G* statistic to identify hotspots and describe the aggregation characteristics of business office functions over different periods. According to the illustrations, in 2014(Figure 4a, 5a), the business office functions in Yangpu District were primarily aggregated around important urban functional areas, including the WJC urban sub-centre and the JPL regional centre. By 2019(Figure 4b, 5b), the area of business office function hotspots significantly increased in the WJC sub-centre and JPL regional centre, with a few point-like and linear business office hotspots emerging in the central hinterland outside the urban core. In 2024(Figure 4c, 5c), the planned urban sub-centres and regional centre business office functions continued to enhance; additionally, more business office functions concentrated in the central hinterland and certain areas in the northern suburbs, forming point-like decentralised office centres.

Figure 4a, 4b, 4c. Statistical description of office POI distribution (Jenks) in 2014, 2019 and 2024

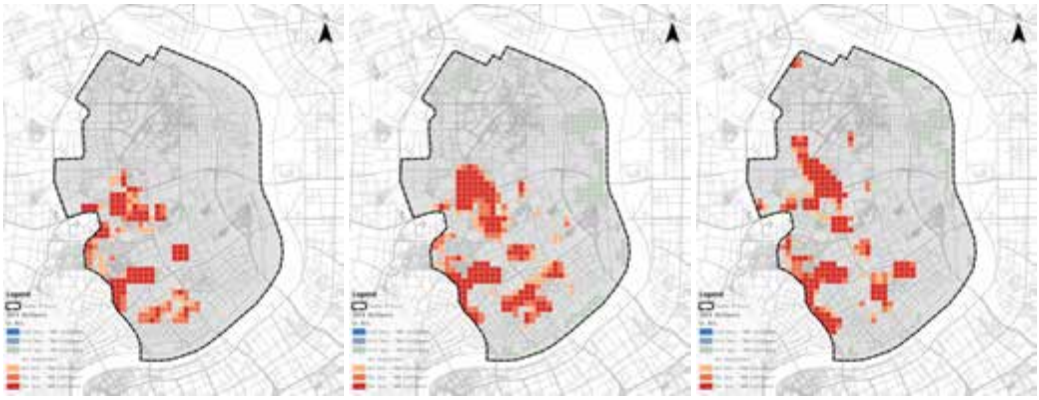

Figure 5a, 5b, 5c. Identification of Office Hotspots in 2014, 2019, and 2024

Quantitative visualisation of the changes in the number of business office POIs within the grid from 2014 to 2019 and from 2019 to 2024 was conducted to explore the evolutionary pattern of the distribution of business office functions in Yangpu District. The chart reveals that between 2014 and 2019(Figure 6a), most areas in Yangpu District, including some hinterland regions primarily characterised by residential functions, showed an increasing trend in the number of office enterprises. The area with the largest increase was the rapidly developing WJC urban sub-centre. During this period, the number of office POIs in the central urban area of Shanghai, including traditional business office centres like People's Square and Lujiazui, was sharply declining. From 2019 to 2024(Figure 6b), there was a decrease in the number of business office enterprises in most residentially dominated areas in Yangpu District, while a few grids within the reduction area showed significant increases. Specific sectors that saw growth included the WJC urban sub-centre, KIC Space, the National University Science Park of SUFE, Changyang Innovation Valley, and Yangpu Riverside.

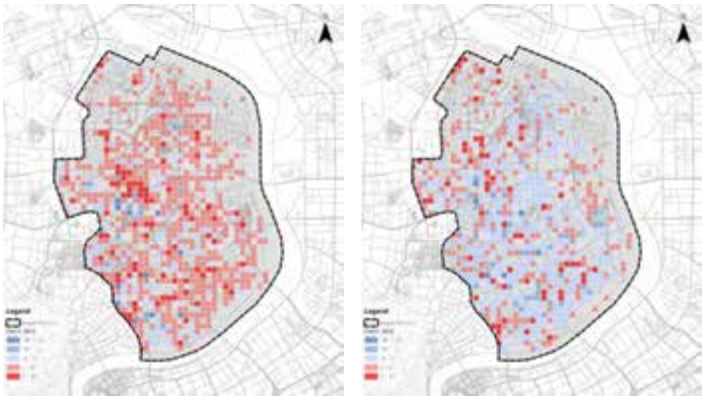

Figure 6a, 6b. Changes from 2014 to 2019 and from 2019 to 2024

Overall, the preliminary description of the evolutionary pattern during the 2014-2019 phase is that office functions dispersed significantly from the urban office centres of Shanghai to the emerging urban sub-centres and residential blocks outside the urban core in Yangpu District. In the 2019-2024 phase, the business office functions that surged in Yangpu District during the previous five years began to re-aggregate at a microscopic scale in localised areas. While the urban sub-centres and regional centres continue to develop, the functionality of secondary point-like office centres outside the urban core is also steadily enhancing.

5. Exploration of the Spatial Patterns and Typological Characteristics of Office Centres in Yangpu District

5.1 Identification of Office Centres

The identification of office centres in Yangpu District employs a "function-heat" dual-verification method. The data used consists of cleaned 2024 office POIs in Yangpu District and 2024 LBS data. Utilizing ArcGIS software, spatial overlay statistics were conducted on the density of office POI points within plots (research units), and

natural breaks were applied for visualisation (Figure 7a). Additionally, kernel density calculations were performed on 100-metre precision point LBS data to conduct overlay statistics of crowd activity heat during office hours for each research unit from November 11 to 17, 2024, with natural breaks again used for visualisation (Figure 7b). Ultimately, research units exhibiting significantly high values in both office function and activity density were selected, resulting in the identification of 197 office centres in Yangpu District.

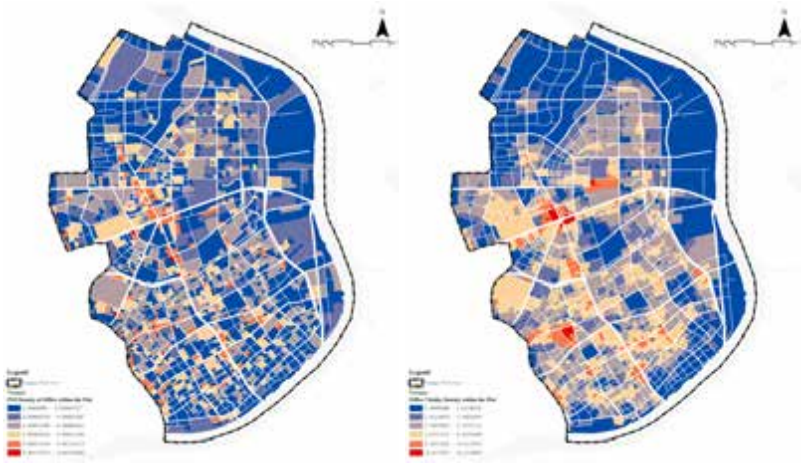

Figure 7a. Office centre identified based on functional data
Figure 7b. Office centre identified based on behavioural activity data

5.2 Spatial Pattern Analysis Framework and Key Factor Extraction

The formation and evolution of office centres are the results of the synergistic effects of multiple factors. To systematically deconstruct the spatial organisational logic of office centres in Yangpu District, this section extracts spatial pattern characteristic analysis factors from multiple dimensions, aiming to transcend the limitations of traditional one-dimensional research by incorporating the locational potential, material carriers, and functional environments of office centres into a unified analytical system. In the end, 17 key influencing factors were summarised and extracted for research, forming a dynamic and multidimensional spatial analysis system. The extraction logic for core factors across various dimensions is described in Table 3.

Table 3: Key Characteristic Factors and Descriptions of the Spatial Patterns of Office Centres

Dimension	Indicator		Description
Location	Loop Location	virtual variable	The location relationship of office centres in the city (within the inner ring, from the inner ring to the Middle ring, from the Middle ring to the Outer Ring)
	Transportation Location	km	The distance from the office centre to the main and secondary roads of the city
	Public Transportation Location	km	The distance from the office centre to the subway station
Form	Spatial Density	m^2/km^2	The ratio of the total base area of buildings to the total area of the plot
	Floor Area Ratio	Score	The ratio of the total floor area of all buildings within the plot to the total area of the plot
	Maximum Building Height	m	The maximum building height within the plot
	Road Network Density	km/km^2	The ratio of the total length of the road network around the office centre to the total area of the buffer zone
Function and environment	Educational Density	pcs/km^2	The POI density of schools, training institutions, etc. around the office centre
	Traffic Density	pcs/km^2	The POI density of subway stations and bus stops around the office centre
	Medical Density	pcs/km^2	The POI density of hospitals, clinics, etc. around the office centre
	Catering Density	pcs/km^2	The POI density of restaurants, cafes and other facilities around the office centre
	Culture, Sports And Entertainment Density	pcs/km^2	The POI density of museums, theaters, gyms, etc. around the office centre
	Poi Shannon Index	Score	Measure the diversity and degree of mixture of different types of POIs around the office centre
	Proportion Of Residential Land	km^2/km^2	The proportion of residential land area around the office centre
	Resource Distance	km	The distance from the office centre to universities and research institutions
	Central Distance	km	The distance from the office centre to the city centre
	Green Space Distance	km	The distance from the office centre to the public park

5.3 Principal Component Analysis

After collecting all the indicators, a preliminary data quality check was conducted to eliminate indicators with severe missing data or insufficient variability. Then, Z-Score standardisation was applied to different dimensions and data types to create a standardised data matrix, eliminating weight shifts caused by numerical differences. During this process, dummy variable elements were also standardised through methods such as feature multiplication, resulting in a matrix with only 0 and 1. The variable "ring location" was split into three variables: "within the inner ring," "between the inner and middle rings," and "between the middle and outer rings."

The final summary results are shown in Appendix Figure x1-x17. Subsequently, the SPSS tool was utilised to perform PCA on the 17 indicators based on the correlation coefficient matrix for dimensionality reduction analysis, yielding a total of 12 principal components (PC1-PC12). According to the Total Variance Explained in Table 4 and the scree plot shown in Figure 8, the cumulative explanation rate of the first 5 principal components is approximately 80.2%, with a notable gap compared to the subsequent eigenvalues. Therefore, considering spatial complexity and interpretability, this study comprehensively uses the first five principal components to characterise the spatial patterns of office centres.

Table 4. Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.348	28.900	28.900	3.348	28.900	28.900
2	1.748	15.567	44.466	1.748	15.567	44.466
3	1.547	13.888	58.355	1.547	13.888	58.355
4	1.230	11.250	69.605	1.230	11.250	69.605
5	1.152	10.599	80.203	1.152	10.599	80.203
6	0.773	5.442	85.646			
7	0.632	4.270	89.915			
8	0.577	3.810	93.726			
9	0.374	2.119	95.844			
10	0.243	1.529	97.373			
11	0.195	1.327	98.701			
12	0.180	1.299	100.000			
Extraction Method: Principal Component Analysis.						

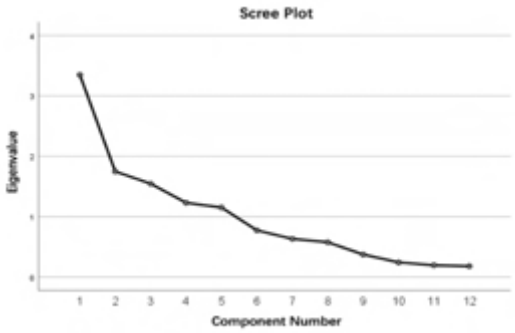

Figure 8. Scree Plot

Based on the component loading matrix (Table 5) to better explain the correlation between each principal component and each element. The specific analysis is as follows:

Table 5. Component Matrix

	Component				
	1	2	3	4	5
Zscore(Floor Area Ratio)	0.247	0.650	-0.511	0.396	0.035
Zscore(Maximum Building Height)	0.297	0.574	-0.670	-0.104	-0.065
Zscore(Building Density)	-0.095	0.014	0.099	0.369	0.145
Zscore(Road Density)	0.436	0.374	0.600	0.053	-0.032
Zscore(Distance to the Metro	-0.530	-0.257	-0.033	0.416	-0.102
Zscore(Distance to the City Center)	-0.676	-0.117	-0.078	0.090	0.347
Zscore(Distance to the Main Road)	-0.292	0.516	0.242	-0.270	0.452
Zscore(Distance to Universities/Research Institutions)	0.166	0.534	0.608	-0.457	0.055
Zscore(Proportion of Residential Area within the Buffer Zone)	-0.415	-0.028	-0.127	-0.067	0.732
Zscore(Education POI Density within the Buffer Zone)	0.799	-0.211	-0.119	-0.016	0.421
Zscore(Culture and Sports POI Density within the Buffer Zone)	0.820	-0.289	0.036	0.042	0.193
Zscore(Catering POI Density within the Buffer Zone)	0.816	-0.311	-0.019	0.148	0.186

Extraction Method: Principal Component Analysis.
a 5 components extracted.

(1) PC1 (explanation rate 28.9%): Urban centrality, comprehensive support intensity, and transportation accessibility. From the loading matrix, we can see that the indicators with a large positive loading in PC1 include: density of dining POIs (0.816), density of cultural, sports, and entertainment POIs (0.820), and density of educational POIs (0.799), as well as the density of public services and commercial facilities. Additionally, road density (0.436), maximum building height (0.297), and floor area ratio (0.247) also contribute positively. The corresponding indicators with significant negative loadings include: distance to the central area (-0.676), distance to the subway station (-0.530), and proportion of residential land nearby (-0.415). Overall, combining the two significant negative loadings of "distance to the central area" and "distance to the subway station" (-0.530), along with the high density of various public services/commercial facilities (dining, cultural entertainment, education, etc.), PC1 represents a gradient from high-support, high-function mixed-use in the city centre to low-support, low-mix in the outer ring and suburbs. It reflects the characteristics of the urban core area, manifested as high-density public service facilities, central location advantages, and high-rise, high-intensity building layouts. Higher scores indicate proximity to the core urban area, with convenient public transportation and comprehensive facilities, as well as a high degree of spatial mixing in functional layouts.

(2) PC2 (explanation rate 15.6%): Emerging areas outside the centre and high-intensity TOD development. In PC2, the indicators with a significant positive loading include: floor area ratio (0.650), building height (0.574), and road density (0.374) related to public services and commercial facilities. Moreover, road density (0.436), maximum building height (0.297), and floor area ratio (0.247) contribute positively as well. The corresponding indicators with significant negative loadings include: densities of various public services/commercial facilities, distance to the subway station (-0.257), and distance to the central area (-0.117). PC2 reflects development characteristics of high-intensity urban expansion areas around subway stations from the city centre. Higher scores indicate areas near the city centre that are well-serviced by public transportation, primarily focusing on business office functions, with high road network density, small plot sizes, and high building development intensity, embodying the features of emerging urban functional areas.

(3) PC3 (explanation rate 13.95%): Old city renewal. In PC3, the primary positively loaded variables include: road density (0.600) and distance to universities/research institutions (0.608), while the main negatively loaded variables are floor area ratio (-0.511) and maximum building height (-0.670). Overall, combined with the high road density reflecting a mature road network foundation and significantly lower-than-average development intensity (with floor area ratio and building height as strong negative loadings) and density of public/commercial services, PC3 characterises areas of old city renewal where spatial forms are constrained by historical textures, following a gradual renewal model. It is characterised by a high-density road network post-renewal, dominated by low-rise, high-density large-scale buildings, markedly lower development intensity than emerging business districts, and spatial separation from core higher education and residential areas.

(4) PC4 (explanation rate 11.3%): Island effect of scientific and educational resource concentration. In PC4, the main positively loaded variable is distance to the subway station (0.416), while the significant negatively loaded variable is distance to universities/research institutions (-0.457). This loading combination indicates that areas with higher PC4 scores are closer to universities/research institutions but have significantly poorer accessibility to the subway. Overall, PC4 reveals the spatial mismatch between areas of high concentration of scientific and educational resources and public transportation infrastructure (especially rail transportation), reflecting typical characteristics of traditional cultural and educational districts or emerging scientific and educational parks (such as university towns without subway access) — despite the high concentration of educational functions and substantial knowledge spill over, they form relatively isolated "office enclaves" due to insufficient rail coverage.

(5) PC5 (explanation rate 10.6%): Centrality of residential communities. In PC5, the main positively loaded variables include: proportion of surrounding residential land (0.732), density of educational POIs (0.421), distance to the central area (0.347), and distance to main roads (0.452). This combination points to urban peripheral residential communities dominated by residential function and educational service: a high proportion of residential land and dense educational facilities drive community functionalities, while the positive loading for distance from the city centre (0.347) further reinforces its spatial location characteristics. Therefore, PC5 represents community service centres in the urban fringe or suburbs, centred on residential functions, supported by education-related facilities. Higher scores indicate greater distance from the city centre and main roads, reflecting the characteristics of peripheral residential community service centres.

5.4 Hierarchical Cluster Analysis

This study primarily references the HCA methods and parametre designs used by Dibble et al. in urban morphology research. Euclidean distance is employed as the measure of similarity between observation points (office centres). The linkage method selected is Ward's linkage, which tends to generate clusters with minimised variance and higher homogeneity within groups, making it widely used in urban morphology studies. In terms of selecting the number of clusters, this research tested various group numbers (k=3, 4, 5, etc.) and found that the clustering effect is optimal when k=5. The HCA clustering operations were completed using SPSS.

Based on the results of HCA, this study categorises office centres into 5 different spatial patterns (Figure 9) each exhibiting unique location characteristics, spatial forms, and functional environments. The arithmetic averages of PC1 to PC6 by cluster were calculated to characterise the results and features of each specific cluster (Table 6).

Table 6. HCA clustering results and Characteristic Interpretation of Office Centres in Yangpu District

	PC1	PC2	PC3	PC4	PC5
Cluster1	0.1779	1.0025	-2.3231	0.5437	-0.5773
Cluster2	-1.5839	-0.8558	-0.0114	0.4277	-0.5464
Cluster3	0.5596	1.5005	1.6086	-0.9275	-0.4962
Cluster4	-1.7495	0.1151	-0.1886	-0.3148	1.5482
Cluster5	6.6383	-1.6928	0.149	0.3588	0.5753

Among them, Cluster 1 (East Shanghai Lehoo Square, Sanhaowan Plaza, Yangpu Technology Building, China (Shanghai) Entrepreneur Public Training Base, Baodi Square, etc.) exhibits typical characteristics of newly built Transit-Oriented Development (TOD) commercial buildings that overflow from the central area, with a core focus on high-rise office buildings located near the urban centre and subway stations. Cluster 2 (Huantongji Industrial Circle, East Shanghai Technology Park, Fudan University South Campus, Shanghai University of Finance and Economics Science and Technology Park, etc.) is characterised by knowledge spillover around universities and the re-use of existing land to form industrial clusters. It leverages university resources and research institutions, possessing strong capabilities for technology promotion and application. Some areas are developed or updated based on existing plots around the universities, creating diverse spatial forms that support the development of knowledge-intensive industries. Cluster 3 (Interlink Baodi, Changyang Innovation Valley, Dongfanggu Creative Park): This cluster includes a combination of industrial relics from the old city and newly built commercial buildings forming comprehensive industrial parks, showcasing the integration of traditional urban renewal and creative industries. These areas, despite having a high historical background and urban hinterland advantages, utilise industrial buildings to concentrate technology promotion, professional technical services, and creative cultural industries, resulting in a more diversified industrial structure and significant urban renewal demands. Cluster 4 (Xuhui Plaza, Core Area of Xinfengcheng Residential District, Guohe 1000 Community Commercial Centre, etc.): This cluster features small-scale decentralised community service centres and office We-work spaces, located within areas primarily designated for residential functions, mixing with newly built large public buildings such as apartment buildings, community commercial centres, and community clubhouses. These spaces are typically smaller in scale, possess a certain degree of transportation convenience, and generally serve as office spaces preferred by small and micro-enterprises and start-ups. Cluster 5 (WJC Urban Sub-Centre): This cluster demonstrates characteristics typical of a high-energy urban CBD core area.

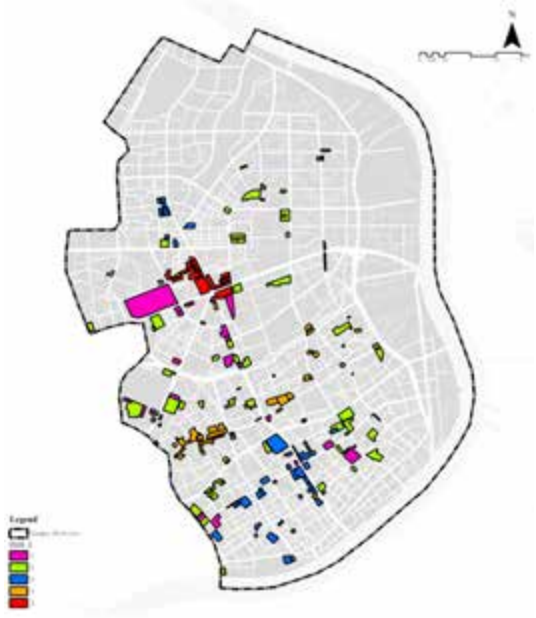

Figure 9. HCA clustering results

6 Conclusions

The main purpose of this study is to explore the distribution patterns and typological characteristics of urban office spaces and office centres in Yangpu District, Shanghai, at a fine scale. Through the integration of geographic information big data and field research, a series of important conclusions have been drawn.

Firstly, the study found a significant phenomenon of dispersion and re-aggregation in office spaces. This indicates that, with the rapid development of information technology, office spaces have gradually expanded from traditional Central Business Districts (CBDs) to peripheral areas, forming several small-scale office centres between specific locations. This trend reflects the ongoing evolution of the work-residence relationship in cities, as the advancement of communication technology and changes in office patterns have led to a demand for flexibility and diversity in the working environment, particularly among the younger generation.

Secondly, the analysis shows that office centres are typically located in areas with a mixture of urban functions, urban centrality, convenient public transportation, and close proximity to residential communities and universities. This finding emphasises the importance of integrating office spaces with urban functions.

Furthermore, through hierarchical cluster analysis, the study identified five types of office centres in Yangpu District: newly constructed TOD commercial buildings that overflow from the central area, mini industrial clusters formed by knowledge spillover and re-use of existing land around universities, comprehensive industrial parks that result from the renewal of industrial relics in the old city and newly built commercial buildings, decentralised small-scale office We-work spaces in community service centres by function multiply used, and high-energy urban CBD core areas.

This research contributes to a deeper understanding of urban office spaces in the internet era and provides theoretical support and practical guidance for the development and refined organisation of business office functions and employment spaces in Shanghai and other megacities in China.

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Appendix: Description of the characteristics of the Office Centre in Yangpu District

Figure x1. office centre feature - Loop Location
Figure x2. office centre feature - Public Transportation Location
Figure x3. office centre feature - Transportation Location

Figure x4. office centre feature - Spatial Density
Figure x5. office centre feature - Maximum Building Height
Figure x6. office centre feature - Floor Area Ratio

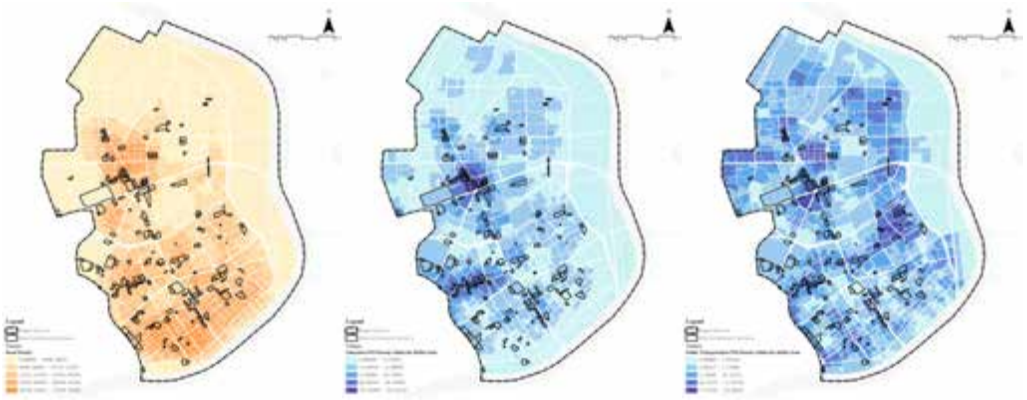

Figure x7. office centre feature - Road Network Density
Figure x8. office centre feature - Educational Density
Figure x9. office centre feature - Traffic Density

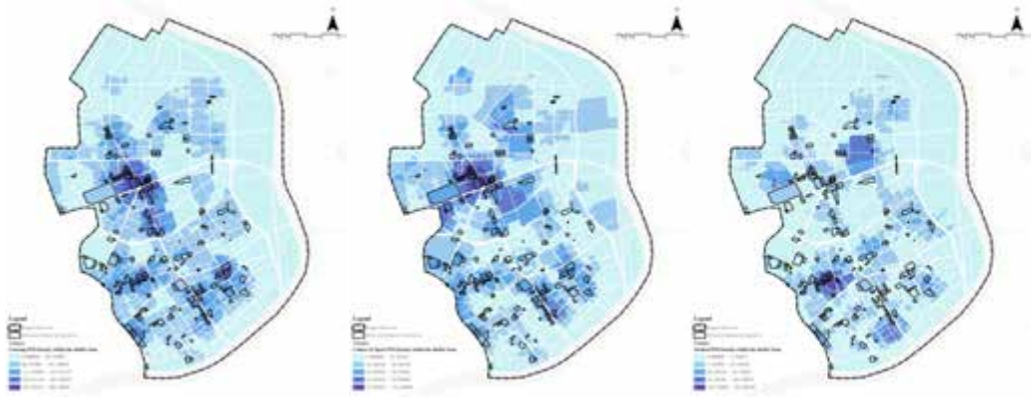

Figure x10. office centre feature - Catering Density
Figure x11. office centre feature - Culture, Sports And Entertainment Density
Figure x12. office centre feature - Medical Density

Figure x13. office centre feature - Poi Shannon Index
Figure x14. office centre feature - Proportion Of Residential Land
Figure x15. office centre feature - Central Distance

Figure x16. office centre feature - Resource Distance
Figure x17. office centre feature - Green Space Distance

Research on the Potential for Future Development of Labin and Raša in Istria

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Abstract
Small and medium-sized towns and cities represent the very important elements of the polycentric urban structure and have a crucial role in regional economic development and social well-being. The aim of this work is to emphasize the importance of the scenario method in planning the future development of small and medium-sized towns and cities that is used in the education of future spatial planners. Within the Spatial Planning Workshop, the integral vision for the development of Labin and Raša were propose as the result of the elaboration of five different possible scenario - Karbona, Kulturizam, Koza Nostra, Dystopia and Dispersion, and their valorisation. For vision realisation, necessary activities in the form of different development projects for a period of 25 years were proposed.

Keywords: development vision; former industrial towns; scenarios; tourism

1. Introduction

Spatial planning involves different professionals and actors in complex processes. Primary it focuses on the interests of society, the settlement or the region as an entity, and the longer-term future.

In the "Torremolinos Charter" (1983) it is pointed out that "Regional/spatial planning gives geographical expression to the economic, social, cultural and ecological policies of society. It is at the same time scientific discipline, an administrative technique and a policy developed as an interdisciplinary and comprehensive approach directed towards balanced regional development and the physical organization of space according to an overall strategy." (CEMAT, 1983: 3)

Spatial planners are serving and protecting the general interest and local democracy. Their key role is to be leaders of change in society towards a more sustainable future. According to the ECTP-CEU (2013) the planner's role responds to developments in society, planning laws and policies. Depending on different political and social frameworks, the planners are engaged as visionaries, technocrats, managers, advisors, mentors or instructors. So spatial planners deal with different scales and specific challenges that characterise different entities in space and their interconnection. Those entities are interlinked and linked with their surrounding environment. A systemic approach is needed to understand their specificities, interconnections, and above all processes that happen.

Small and medium-sized towns and cities represent the very important elements of the polycentric urban structure of the European Union. They have a crucial role in regional economic development and social well-being while providing jobs and sustaining local and regional services. Those entities have the possibility to offer good living and working conditions, helping the local community to attain a good quality of life. They demonstrate in-

trinsic value for European environmental and cultural heritage. Research on small and medium-sized towns provides insight into unexplored potential for shaping sustainable urban-rural relations. Based on comprehensive spatial planning different integrated and place-based policy measures should be suggested to make the most of their development assets. (ESPON, 2024)

In order to choose the most suitable development direction for small and medium-sized towns, it is necessary to consider, besides regional development plans, the possibilities and potential of the area at the local level considering the long-term needs of the inhabitants.

The aim of this work is to emphasize the importance of the scenario method in planning the future development of small and medium-sized towns and cities that is used in the education of future spatial planners in order to be able to choose the best possible scenario for long-term development of the selected area.

2. Planning of small and medium sized towns based on the scenario method

2.1 Small and medium sized towns and cities in the EU context

At the European level, the ESPON project TOWN (ESPON, 2014) has set a framework for considering the topic of small and medium-sized towns (SMSTC) by providing their definition based on the work of the OECD and DG Regio on the degree of urbanization. Small and medium-sized towns are defined as urban settlements of 5,000 to 50,000 inhabitants with a population density of 300–1,500 inhabitants/km2. For studying small and medium-sized towns three approaches have been identified: morphological, administrative and functional. Since they represent an unexplored potential for achieving sustainable urban-rural relations, this requires policy intervention in the form of integrated and place-based territorial support measures. The strategic potential of small and medium-sized towns for achieving further development is the role of their cooperation with the environment, their regional position and their ability to mobilize civil society and establish PPPs.

Territorial agenda 2030 points out that SMSTC have different development potential and challenges, as well as demographic and societal imbalances, which particularly applies to remote areas but also inner peripheries lacking access to public services, and adequate economic and social opportunities.
Over the years, the processes of metropolitanisation led to different directions of development of small and medium-sized cities, which largely depended on the proximity of large cities. Some gained importance when they were integrated into functional urban areas profiting from common transport systems, some thanks to their location on a high-speed transport corridor benefited from providing travel opportunities, and some due to their peripherality failed because they could not provide resources to maintain services for the surrounding areas or to be poles of growth.

In rural and peripheral regions, SMSTCs are often assigned the role of territorial anchor centres, thanks to their service and labour market functions, but they face various constraints such as limited capacities, smaller public budgets and more difficult access to private financing. Therefore, strengthening such SMSTCs becomes a key policy objective at all levels of planning, from local to European.

The processes of depopulation of small towns and the aging of their populations are widespread in most European countries. The negative ecological consequences of urbanisation and the gradual changes in rural-urban relations over time have led to an increase in awareness of the importance of small towns (Nesticò et al., 2019), as indicated by the research of numerous authors dealing with the topic of small towns, emphasizing their importance in the urban system. As early as Christaller's central place theory (1933), great emphasis was placed on small towns as centres of goods and services for the rural hinterland. Although there have been significant socio-economic changes in the area (Courtney et al., 2007), small towns continue to provide the surrounding area with various services such as education, healthcare, trade, banking, etc. (Vaishar and Zapletalová, 2009).

De Rossi (2018) points out that small towns are recently seen as an opportunity, rather than a spatial problem, and that their reactivation opens an opportunity for sustainable territorial development, the renewal of local

and regional identity, and the reduction of further land occupation. Zawadzka (2017; 2021) points out that despite the lower accessibility and service provision of small towns, it is precisely their "smallness", their human scale of development, and their unique urban-architectural structure that represent their particular value. In addition, unlike large cities, residents in small towns have valuable social capital characterized by a deep sense of belonging to the place of residence with strong social ties and the ability to cooperate. This results in a synergistic effect, influencing and strengthening the mutual relations of residents and contributing to the improvement of the quality of life of communities in small towns.

The negative consequences of socio-economic processes in the space of small towns, especially in peripheral areas, have led to the need to consider their recovery and possible further development. D'Andria et al. (2021) address the issue of recovery and valorisation of small towns through multi-criteria analysis schemes that encompass the relationships of small municipalities with the territory and with neighbouring medium/large cities or other surrounding small towns, forming a city-village network or a network of small municipalities. The results of their research represent an important tool for determining the priorities for the implementation of interventions based on public and private investments according to the principles of sustainable development with an emphasis on economic policy.

In their work, Somoza Medina and Relea Fernández (2024) deal with the evolution of five cases of small towns in the interior of Spain that a few decades ago invested in culture as a strategy to maintain the population and increase the quality of life of their residents. The results of the conducted research indicate the possibilities of developing cultural policies for small towns in Europe and the world.

Rural peripheral development strategies can be based on traditional activities (Saxena, 2007). In such strategies, tourism has a dual role as a means of strengthening local development processes (Lopez and Ivona, 2018) and as a means of diversifying and regenerating traditional lifestyles (Jackson and Murphy, 2006). In their work, García-Delgado et al. (2020) explore the possibilities of revitalising areas based on tourism and promoting heritage as an opportunity for local development. The research resulted in an analysis of the process of heritage and increasing its tourist value and its impact on local development in rural areas of Portugal, indicating a significant correlation between heritage, rural tourism and local development.

2.2 Importance of small and medium sized towns and cities in Croatia

The Report on the Spatial Situation in the Republic of Croatia for the Period 2013 – 2019 (2021) highlights that the Republic of Croatia is characterized by numerous small settlements. Although four largest cities in the Republic of Croatia (Zagreb, Split, Rijeka and Osijek) are relatively evenly distributed spatially and represent a good foundation for the country's polycentric development, the rest of the settlement system in Croatia has asymmetrical hierarchical and spatial characteristics. According to data from the Register of Spatial Units from 2019, there were 6,755 settlements in the Republic of Croatia. There were 150 settlements without inhabitants, and small settlements stand out in number: as many as 80.2% of them had fewer than 500 inhabitants, and 14.3% had 501 to 2,000 inhabitants, or 38.9% of the population lived in settlements of up to 2,000 inhabitants. Furthermore, 2.7% of settlements had between 2,001 and 10,000 inhabitants, and only 0.5% had between 10,001 and 35,000 inhabitants. There were 10 settlements with more than 35,000 inhabitants. Almost half of the population (48.9%) live in settlements with less than 5,000 inhabitants.

Marinović Uzelac (1999) points out that a small town is an urban agglomeration that meets the minimum population requirements (in the Republic of Croatia in 2000), with the absence of a primary sector of activity within the urban corpus, and which has at least a minimal gravitational influence on its immediate rural surroundings in terms of commercial and financial services, entertainment and culture, and local government and health care.

The polycentric concept of development of the Republic of Croatia, set out in the *Physical Planning Strategy of the Republic of Croatia* from 1997, was based on the then existing structure and system of settlements. In the polycentric concept of development, the focus is on advocating for a careful distribution of residents, activities,

central and other functions and infrastructure systems. Although the planned polycentric concept of development did not fully succeed, due to the too short time foreseen for its implementation, partly due to the sectoral inconsistency of development plans, and partly due to the lack of a system for monitoring implementation, in the Spatial Development Strategy of the Republic of Croatia it still has the leading role.

The spatial distribution of central settlements of all degrees of centrality in the Republic of Croatia shows unevenness, and is the rarest in areas with numerous development constraints and poor availability of higher-level services (hilly-mountainous and border parts of the Republic of Croatia and on some islands), while it is the most developed in the northern and northwestern parts of central Croatia and in the far eastern part of Croatia.

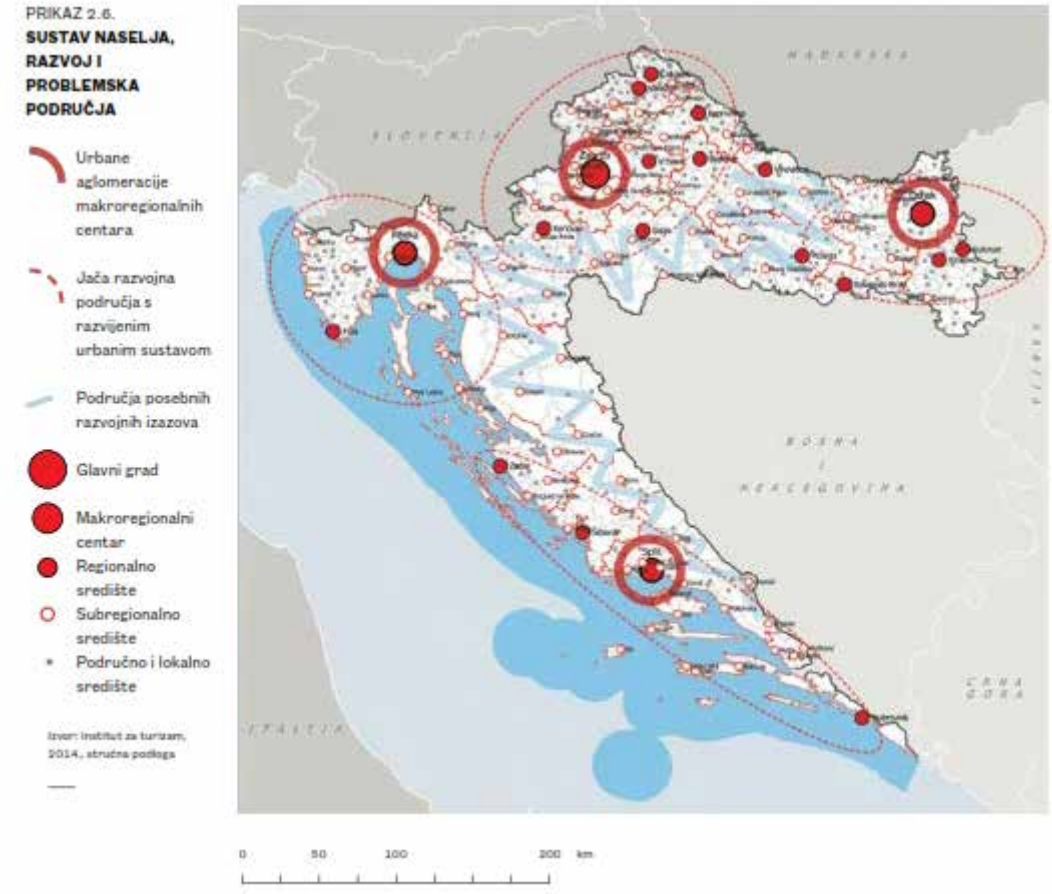

Fig.1: Settlement system, development and problem areas of the Republic of Croatia. Source: Ministry of the Construction and Physical Planning, 2017.

The distant planning of the network of central settlements complicates the trend of reducing (the number of) public facilities. Municipalities and cities located near macro-regional and regional centres are becoming new trade and business zones, while less densely populated areas do not attract investments.

The Spatial Development Strategy of the Republic of Croatia (2017) states that the sustainability of spatial organization should continue to be based on the polycentric model of development, since it has been accepted as the optimal model of spatial development in the EU and has been determined as a key element for achieving territorial cohesion.

By promoting such territorial development, polarisation between the capital, metropolitan areas and medium-sized cities at the national level is avoided. The document emphasizes that medium-sized and small cities should play a key role at the regional level, and represent a link between larger urban areas and rural areas.

The following elements are listed as possible approaches to revitalising the economic role of medium-sized and small towns:

• business based on the use of information technologies
• processing industry related to locally grown agricultural products
• tourism based on the attractiveness of cultural heritage (including industrial heritage), on landscape features, traditional religious sanctuaries, health and spa tradition (untapped or underutilized geothermal water potential), regionally designed tourist routes, traditional local festivals and innovative cultural products, and on gastronomy.

Furthermore, the preservation of historical fabric and the restoration of identity elements are important for increasing tourist attractiveness, economic development and investment, as well as preserving the number of the existing population and attracting new ones.

2.3. Scenario method and education of future spatial planners

Spatial planning is a profession that has its own areas of expertise in territorial development processes. According to the Charter of European Planning (ECTP-CEU, 2013) the planners' key commitments include research and analysis, advocacy and mediation, the ability to envision, evaluate and promote potential future options for urban, spatial, and territorial development. Therefore, future spatial planners should learn how to combine scientific and creative conceptual thinking with practical approaches to be able to define future vision of the city or region.

During the education process and in practical application, students as future spatial planners are directed to think strategically and to use the scenario method as a par excellence tool to articulate future development vision of study area. Scenario methods are research subjects of many authors, especially related to the field of spatial planning that encourages strategic thinking and comprehensive planning. In the education process besides the application of theoretical knowledge, the intention is to encourage the students' creativity. The scenario planning, based on the Intuitive logics school (Stanford Research Institute International) stimulates students' creativity and intuition. As Huss and Honton (1987) pointed out, the advantage of the SRI approach is the development of flexible, internally consistent scenarios from an intuition and logical perspective. In defining the preferred model and creating a common development vision it is important to be able to have an open discussion regarding different actors' interests, so Vogelij (2010) pointed out that there is a need to conceive at least four development scenarios for the study area.

During the spatial planners' education at the Faculty of Architecture of the University of Zagreb students have the possibility to gather theoretical and practical knowledge about the scenario method in spatial planning. On the third semester of the Master Study in Architecture and Urbanism students choose between fourteen workshops led by professors from the Faculty of Architecture. The Workshop 3 - Spatial planning is one of three workshops led by professors of the Department of Urban Planning, Spatial Planning and Landscape Architecture. The main goal of the course is to propose a vision for the spatial development of the chosen area (region or city) based on the principles of sustainability using the scenario method. The work on the course is adapted to the student and takes place in three main stages. The first stage of students' work includes a consideration of theoretical starting points and a detailed analysis of the existing situation and spatial planning documentation, which ends with a SWOT analysis. Students are guided to perceive spatial strengths, weaknesses, opportunities, and threats from different perspectives, that is, to immerse themselves in the different roles played by various actors in space. In addition, they are encouraged to use questionnaires to determine the key issues and needs of residents and users of the study area. In the second phase, based on the previous conclusions, students conceive different development scenarios for the chosen area, considering complex systems and numerous processes in space. In this phase they conceive their assessment tool based on the set criteria in order to choose the most appropriate development scenario and propose a development vision and conceptual solution. In the third phase, a more detailed elaboration of the program for the selected location and the proposal for strategic and development projects are made. Finally, for their designed strategic projects to be realised, they review and propose, if neces-

sary, changes to the actual spatial planning documentation on the local level.

3. Case studies: City of Labin and Municipality of Raša in Istria

Cities Labin and Raša in Istrian Peninsula were chosen as case studies for this research because of their historical significance in the economy of the region and rich potential for future development. The project was made within the Workshop 3 – Spatial Planning in the Academic year 2024 / 2025 (student: Teodora Jelić, mentor: Associate Professor Lea Petrović Krajnik, PhD). The goal of the project was to set up an optimal shared vision for two administrative entities, that once were treated as one unit due to their regional economic role and their spatial characteristics.

3.1 Spatial specificities and urban development

The city of Labin and the municipality of Raša are located in the eastern part of Istria between Plomin and Raša bays covering the area of 152,7 km2 with a population of 13 233 inhabitants (2021). The administrative area of the city of Labin (72,3 km2 with a population of 10 424 inhabitants) today includes the central settlement of Labin and 16 other settlements, and the municipality of Raša (80,4 km2 with a population of 2 809 inhabitants), along with the central settlement of Raša includes another 22 settlements. The settlements are characterised by a variety of spatial, cultural and socio-economic specificities.

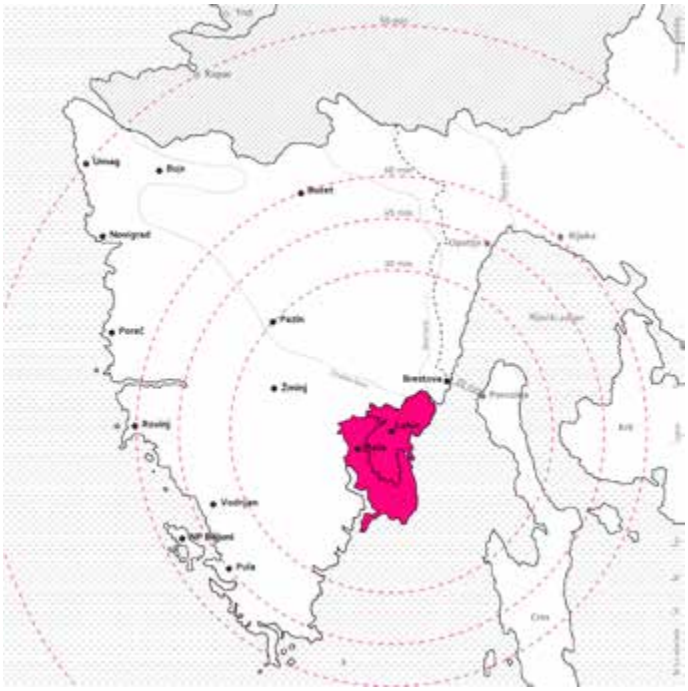

Fig.2: Position of City of Labin and Municipality of Raša in Istria. Source: Jelić, 2025.

In the 19th and 20th century the area was known for its mining activities as a basis for its economy. In the 1930s the greatest economic and infrastructural development of the Labin mining basin took place. As part of the then policy of the Italian government of the time to establish the so-called »città di fondazione« on new premises of urbanism and architecture in the area, planned mining settlements were built: Arsia - Liburnia (today Raša) in 1936/1937, designed by the Trieste architect Gustavo Pulitzer Finali, and Pozzo Littorio (today Podlabin) as a suburb of the historic core of Labin, built in 1940-1942, designed by the Roman architect Eugenio Montuori. (Karač 2010)

Thanks to the melioration works on the former marshland and the undeveloped mouth of the Raša River and its tributary the Krapan Creek, favourable conditions for the development of the settlement along the Rijeka-Pula road and the undeveloped green hills have been ensured.

In order to ensure optimal living conditions for the mine workers, the Italian architect Gustavo Pulitzer Finali prepared the basis for the urban unit of Raša (Arsia, designed under the name Liburnia) in 1935 and the architectural projects (1935-1937). The settlement, designed according to the principles of a garden city, was planned for 3,000 inhabitants. The longitudinal settlement is characterized by a clear functional and social division. Two-thirds of the settlement consists of workers' houses, which are separated from the apartments of the managers and the villas of the managers by an urban centre. South of the creek is an industrial zone with the mine administration building, power plant and other buildings.

Particular attention was paid to the design of the central area around which buildings with public facilities were placed (the church of St. Barbara - the patron saint of miners, the municipal headquarters, a hotel with a café on the ground floor, a complex multi-purpose building with shops, leisure halls and rooms for various associations, a post office, etc.). The central area was designed as a connection between the large *Piazza dell Impero* and the small *Piazzetta del Mercato*, which are connected by "triumphal" doors from the building set to the very edge and open porticos with deep shadows. (Radović Mahečić, 2000)

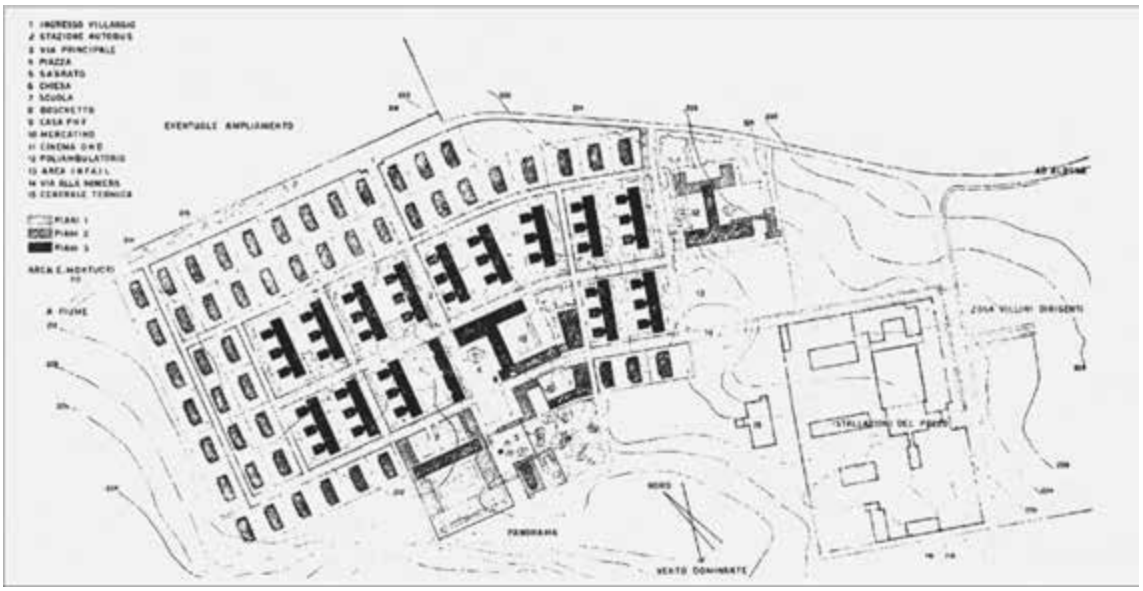

Fig.3: Regulatory basis Pozzo Albona, Eugenio Montuori, 1938. Source: Braun at al., 2019.

The mining and industrial complex of Pozzo Littorio, located north of the old town of Labin, was the reason for the construction of the urban unit of Podlabin *(Pozzo Littorio, Pozzo Littorio d'Arsia or Pozzo Albona)*. In 1938, the Italian architect Eugenio Montuori designed the regulatory basis for a new settlement with 3,000 inhabitants, as well as the projects of all residential and public buildings. The construction of the settlement took place in the period from 1939 to 1942. The main town square of the settlement was designed on a Roman forum model and was divided into a sacral and profane part (with the administration, cinema, sports hall, post office and other buildings of social standard). The spatial accents of the square are the bell tower of the church of St. Francis of Assisi in the axis of the central street and the massive *Torre Littorio* on the Ceva house. The residential part of the settlement is divided into parts intended for the residence of workers, civil servants, engineers and managers, the division of which can be read both by the different typology of construction and the size of the plots. (Braun et al., 2019)

When planning Podlabin, a holistic approach was applied, taking into account the climate, sunlight, dominant winds, views, pedestrian paths, and the author incorporated the existing greenery into the urban design of the settlement. (Laginja, 2024)

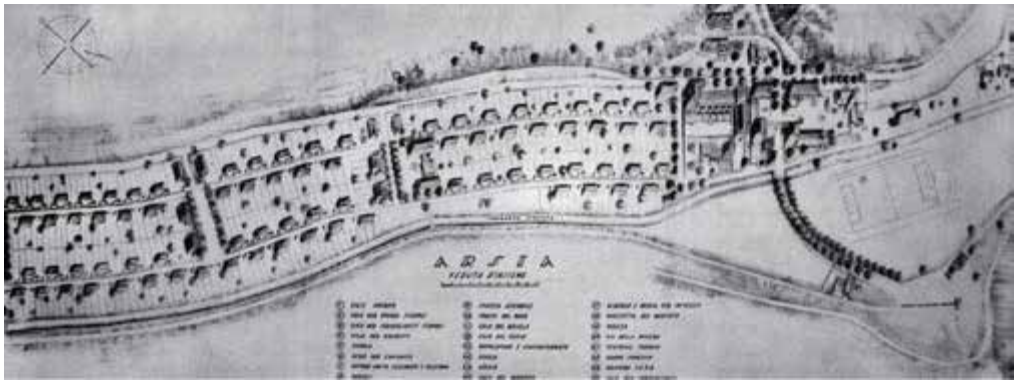

Fig.4: Axonometry of Arsia, 1937. Source: Arsia, il villagio per il minatori della S.A. Carbonifera Arsa, Trieste: Editrice Libraria, 1937.

At the end of the 20th century, all coal mines were closed, which led to the need for economic orientation shift. The city of Labin has focused on small and medium-sized enterprises, the opening of economic zones and tourism, while the municipality of Raša sees its potential, besides the cement factory in Koromačno, in agriculture especially in the Raša valley, in fishing, and in tourism thanks to two camps and large number of private accommodations.

3.2 Strategic and Spatial planning documentation

In 2017, the Government of the Republic of Croatia initiated a reform of strategic planning and development management in order to implement improved public policies and projects at all levels for achieving synergistic links between Croatian and European development policies. Strategic planning and development management on the national level and the adoption of legislative and institutional framework for its optimal arrangement have the aim to ensure social progress, enhanced and more focused territorial development. The strategic planning system is regulated by the *Law on the System of Strategic Planning and Development Management of the Republic of Croatia* (Official Gazette, 123/17, 151/22). The strategic framework of strategic planning system and development management of the Republic of Croatia is based on defined principles and includes acts of strategic planning of national significance, acts of strategic planning on local and regional level, strategic planning acts related to the EU economic management framework.

The spatial planning system, which ensures the conditions for the use, protection and management of space in the Republic of Croatia as a particularly valuable national asset, is the result of long-standing practice and tradition of spatial planning. It is based on the Constitution and the territorial organization of the state determined by a special law, the authority and jurisdiction of the Croatian Parliament, regional units and other public law bodies. The spatial planning system is regulated by the Physical Planning Act (Official Gazette 153/13, 65/17, 114/18, 39/19, 98/19, 67/23) and the basic principles are harmonized with EU regulations.

Below is a brief overview of the valid Spatial Planning documentation, i.e. the spatial planning plan of the city and municipality, the basic spatial planning documents of the local self-government unit, and the implementation programs of the local self-government units as short-term strategic planning acts.

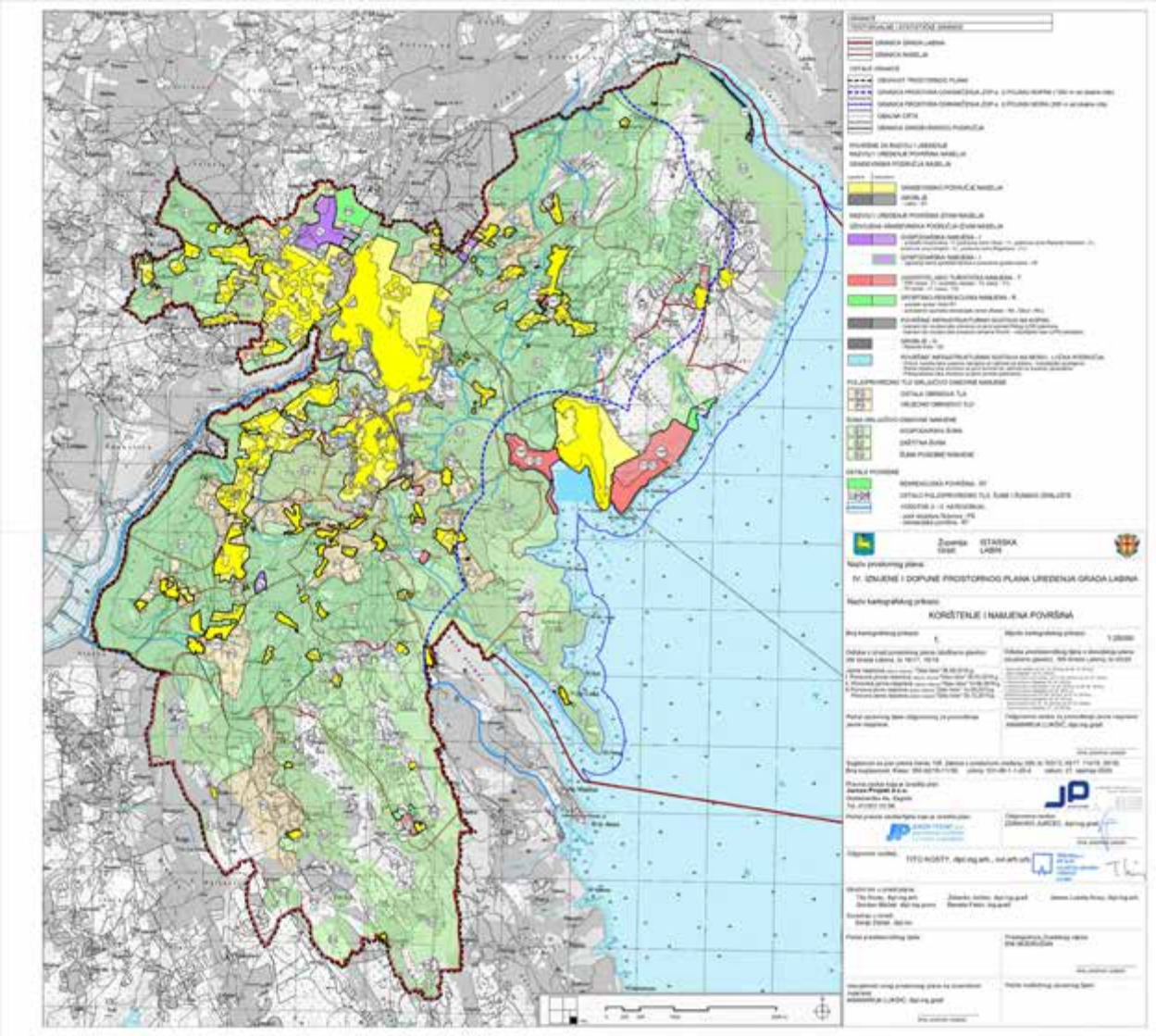

Fig.5: Spatial Development Plan of the City of Labin. Source: City of Labin, 2025.

The Spatial Plan of the City of *Labin* stipulates that the City's space will be developed and renovated in parallel and in interdependence with the balanced and even development of both the Istrian County and the Republic of Croatia.

The law envisages the rational use and preservation of spatial resources along with the development of the City of Labin as a recognizable smaller regional centre and the development of the Istrian County's space, creating prerequisites for the renewal of the economy and strengthening tertiary and quaternary functions. The development of urban and rural settlements is planned through the spatial development structure and space use, while preserving the traditional and ambient values. The infrastructure network is planned in accordance with the transport connections of the Istrian County, and settlements are connected within the City, establishing a rational transport structure. The distribution of economic activities in the existing partially built economic zone and the planned economic zone is planned, as well as the arrangement of tourist development areas and tourist areas in accordance with the Spatial Plan of the Istrian County.

A specific goal set by this development plan is the functional addition of central, public and social facilities, as well as the expansion and development of sports and recreational zones. (City of Labin, 2025)

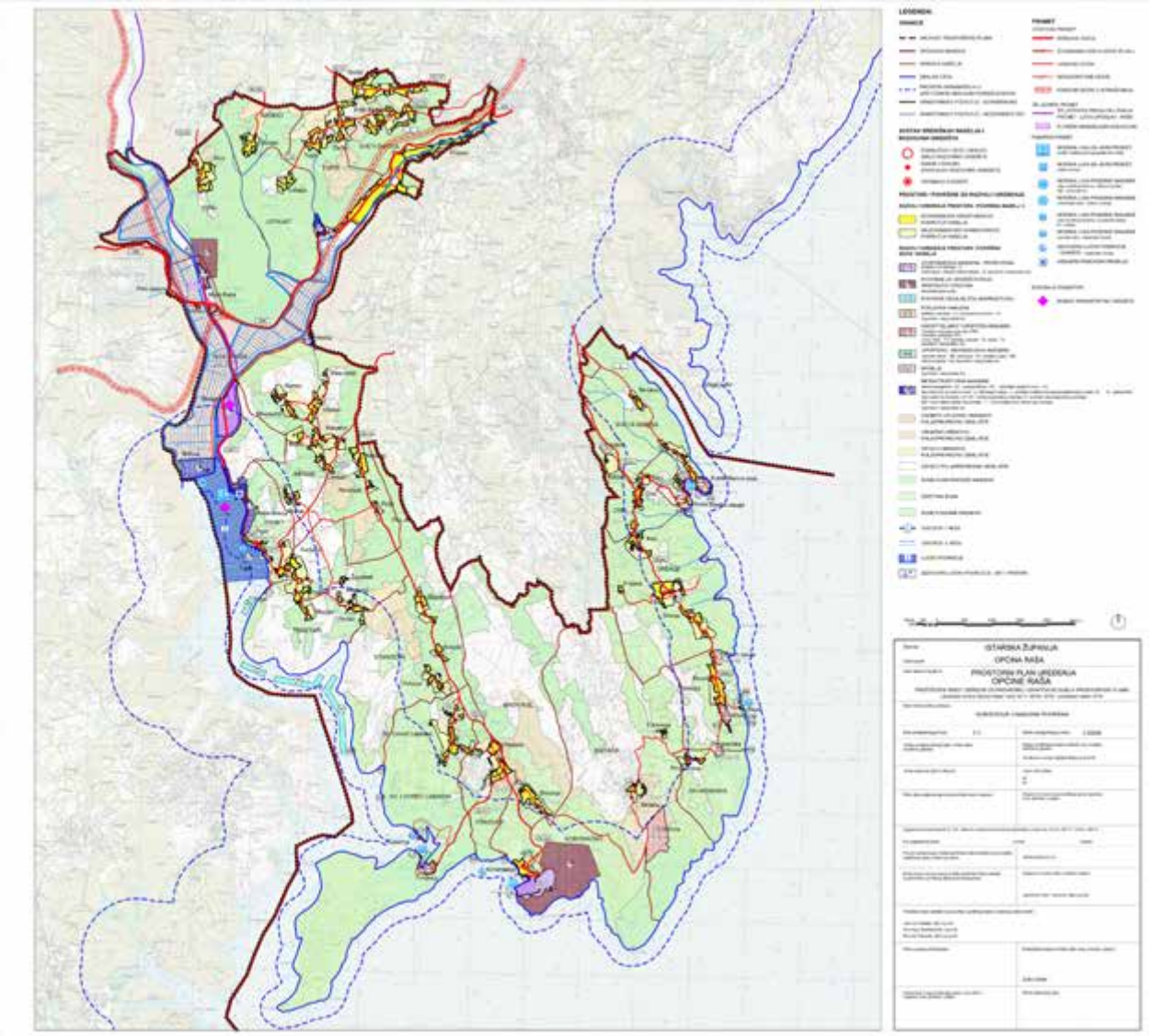

Fig.6: Spatial Development Plan of the Municipality of Raša. Source: Municipality of Raša, 2025.

The Spatial Development Plan of the Municipality of Raša, as a long-term and coordinating planning document, establishes the conditions for development, determines the purposeful use, design, renovation and rehabilitation of building stock, environmental protection and protection of cultural monuments and particularly valuable parts of nature.

The plan provides measures to direct development with the aim of better use of natural and anthropogenic values (especially coastline and cultural heritage) of individual spatial units, determining the size, structure, quality and capacity of the tourist offer in accordance with the permissible load limit of the coast, and in accordance with the provisions of the Act relating to the development and protection of the protected coastal sea area (ZOP), rationalization of the construction area, determination of the water protection regime, forests, other particularly valuable parts of nature, agricultural soils, architectural heritage, and all natural and cultural values.

One of the basic starting points is to subordinate development to improve the quality of life. In further economic development and use of space, natural and other fundamentals of life must not be compromised, nor must the already partially achieved standard and quality of life be compromised.

The plan determines the system of central settlements related to the planned central functions and expected development of residential and economic activities. (Municipality of Raša, 2025)

In accordance with the development directions of the *National Development Strategy of the Republic of Croatia* until 2030, the *Implementation Program*[1] of the City of Labin for the period 2021-2025 has set the following priorities:
1. "Digital transformation and transparency" which is based on the digitalization of processes at the city administration level
2. "Development and diversification of the economy" through which measures are defined with the ultimate goal of economic progress (in line with national development direction 1 - "Sustainable economy and society")
3. "Progress in the quality of life of citizens" which refers to increasing the quality of life in the City through several aspects (in line with national development directions 1 "Sustainable economy and society" and 2 "Strengthening resilience to crises")
4. "Strengthening infrastructure and environmental protection" - which focuses on green and sustainability (in line with national development directions 3 "Green and digital transition" and 4 "Balanced regional development").

The Implementation Program of the Municipality of Raša for the period 2021-2025 sets the direction for economic and social development of settlements in the municipality, taking into account all development needs and potentials, as well as limitations.

Thus, the Program establishes priorities for future development contained in the following priority areas:
1. "Development of a competitive and sustainable economy",
2. "Improvement of infrastructure, environmental protection and improvement of the quality of life of citizens", and
3. "Protection and sustainable valorisation of mining, industrial, cultural and natural heritage". (Municipality of Raša, 2025)

3.3 Considering future development of Labin and Raša: Beneath - Beyond Labin & Raša

Project made within the Spatial Planning Workshop at the master's Study of Architecture and Urbanism proposed the vision for the future development of Labin and Raša. The development vision is the result of the elaboration of five different possible scenarios - *Koza Nostra, Karbona, Kulturizam, Dispersion and Dystopia* and their valorisation according to the set development goals and related criteria. For the purposes of vision realisation, necessary activities in the form of different development project for a period of 25 years were proposed.

Based on the analysis of the existing situation, spatial planning documentation, strategic documents, and SWOT analysis, general goals for the further development of Labin and Raša were set, covering four specific topics: society and community, nature and environment, economy and tourism, and transport.

Using the scenario method, five possible scenarios for the further development of the Labina and Raša area with reference to the 4 main themes were proposed.

The first scenario, *Koza* nostra, is aimed at creating a community that cherishes the tradition, history and cultural identity of Labin and Raša. The development of agritourism is encouraged as a sustainable alternative to mass tourism, which allows the preservation of local customs, gastronomy and authentic lifestyles. The scenario plans to establish a college for education in agriculture, livestock farming and renewable energy sources, as well as

1 The implementation program is a short-term act of strategic planning. The implementation program of a local government describes and ensures the implementation of specific objectives set out in the local government development plan (if one has been drawn up), or the implementation of specific objectives set out in the development plan of a public utility, as well as the link between measures and the corresponding items in the local government budget (activities and projects) for which funds for implementation need to be planned.

an innovation incubator, providing opportunities for young entrepreneurs. The planned collection of rainwater for irrigation and the use of renewable energy sources contributes to the preservation of the natural environment. In order to protect the landscape and natural resources, the expansion of construction area is limited. The scenario plans to revitalize the primary sector through the cultivation of indigenous crops, sustainable fisheries and local processing of products. The construction of modern markets and the development of agritourism creates a sustainable local economy, while educational programs and innovation centres enable the application of modern techniques and employment. The scenario envisages the reactivation of the railway for the transport of local products, reducing pressure on road infrastructure. The construction of new ports in Rabac and Trget settlements enable wider distribution of products and development of fisheries.

The second scenario, called *Karbona*, proposes revitalisation of Labin and Raša industrial heritage by converting mining buildings into sport, education and cultural facilities. The plan is to rebuild Raša according to the original concept, restoring facilities of cinema and the city pool, while industrial buildings are transformed into museums and educational institutions. Industrial heritage becomes a driver of development through new tourist and educational facilities. The scenario's focus on cultural and historical tourism reduces pressure on coastal areas, which contributes to nature conservation. This focus encourages the influx of visitors throughout the year. Revitalization encourages the creation of new jobs, which also strengthens the local economy. The renovated mining tunnels serve as a high-speed railway connecting Raša, Labin and Rabac, while the mining shaft is reactivated as an elevator.

The third scenario, *Kulturizam*, emphasizes cultural sites connected by cable cars, tunnels, and bike paths, allowing locals and visitors to experience the area in a unique and comprehensive way. The preservation of natural resources is achieved through a sustainable approach to tourism, using cable cars and bike paths that allow visitors to explore natural beauty without harming the environment. The preservation of cultural heritage creates new economic opportunities through ecotourism and cultural tourism. Developed infrastructure of cable cars, public transport and bike paths will attract visitors throughout the year, extending the season creating new jobs in tourism, and as sustainable transport solutions relieve road traffic.

The fourth scenario, called *Disperzija*, focuses on the decentralization of the city and the strengthening of smaller, rural settlements. The focus is on creating a network of settlements that interconnect social, cultural and educational facilities, thereby enabling more balanced development and a better quality of life in rural areas. Strengthening rural settlements reduces the need for further urban expansion while protecting natural areas. Rural areas become key for food production, reducing the need for imports. The scenario enables more balanced economic development by strengthening rural settlements that become centres of agricultural production, thereby contributing to self-sufficiency and sustainability. Decentralization contributes to the creation of new jobs and entrepreneurial opportunities. The main element of the scenario is the improvement of transport infrastructure, including roads, railways and sea connections, and the establishment of efficient public transport. These links enable better connectivity of smaller settlements with urban areas, facilitating the distribution of resources.

The fifth scenario, titled *Distopija*, is based on organizing shelters in underground tunnels under Labin and Raša, so that the local population, in the event of natural disasters or other crisis situations, could find haven. These shelters would include sleeping areas, medical stations, survival and training education centres. It is planned to establish environmentally friendly systems for food production and water filtration. The area would be self-sufficient. Underground laboratories and food production systems would provide a basic food supply for the population. The underground tunnels would also house transport infrastructure, such as underground trains or transportation systems which would enable the rapid and safe movement of people and resources within the "survival system".

In order to choose the optimal scenario for the further development of the Labin and Raša area, the valorisation of the scenario was carried out based on the set criteria. 4 main themes and 20 sub-themes were selected for the valorisation and subsequent comparison of the scenarios. The evaluation of the elements is graded as a strong

positive effect, as a positive effect, and elements that have neither a positive nor a negative effect. All scenarios are designed to have a positive impact on the subject area, with some scenarios being rated better than others. By comparing the evaluations of the elements of the scenario, it follows that the scenarios complement each other, and for the vision of further development, it is proposed to combine the three scenarios Cosa Nostra, Carbon and Culture into a single scenario called 3K_Beneath & Beyond.

Fig.7: Valorisation of five scenarios and merging three scenarios into a development vision 3K_Beneath & Beyond. Source: Jelić, 2025.

The selected scenario, or vision for the further development of *3K_Beneath & Beyond*, achieves a positive rating in all topics and subtopics, which means that it has fulfilled the condition in each of the listed fields, or has a significant impact on the development of the selected area. The vision is planned for a period of 25 years with 22 development projects.

In order to reduce the demographic challenges of depopulation, the vision is focused on creating conditions that would encourage young people to stay in their hometowns and thus stimulate population growth. In the centre of the city of Labin, the construction of new cohousing communities and residential buildings according to the POS model is planned, which would ensure affordable and sustainable forms of housing, as well as transformation of industrial heritage buildings into social facilities. The large bathroom on the Piazzale is being revitalized and converted into a cinema. In Raša, the renovation of the former city swimming pool is proposed. The building of the former Mine Directorate becomes part of the Open University and Innovation Centre.

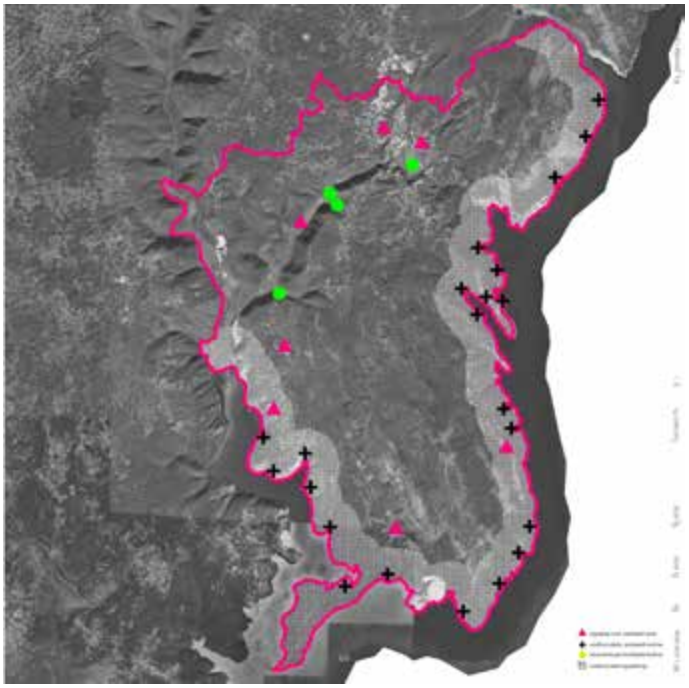

Fig.8: K1_ nature and society in the development vision 3K_Beneath & Beyond. Source: Jelić, 2025.

Particular attention is paid to the coastal area. Development of new public beaches in the Raša Bay (Škvaranska, Crna Punta, Koromačno, Šebešnica and Prtlog), through minimal interventions, ensuring accessibility, is planned to relieve overcrowded coastal area.

The construction of bicycle paths and lanes through the centre of the city of Labin as well as setting up points for electric bicycles and scooters rental is planned to encourage the use of sustainable means of transport and reduce traffic congestion during the tourist season. The introduction of new public transport lines would improve the mobility of residents and visitors, which would also result in reduction of private car traffic the need for parking spaces. The vision proposes the activation of former underground mining tunnels that would serve for occasional traffic and as a part of tourist tours and attractions. Panoramic cable cars on the stretch between Raša, Labin and Rabac, and Skitača and Škvaranska are planned for public transport and as a tourist attraction. In order to increase traffic flow and reduce congestion, the construction of a city bypass from the settlement of Vozilići to the tourist settlement of Rabac is planned, while the reactivation of the railway infrastructure will have a dual role - supporting the industrial sector and the function of public transport. In order to strengthen maritime transport, interventions that enable the distribution of locally produced food by sea and increase the tourist connections of the region with the islands of Kvarner, Dalmatia and the eastern coast of neighbouring Italy are planned.

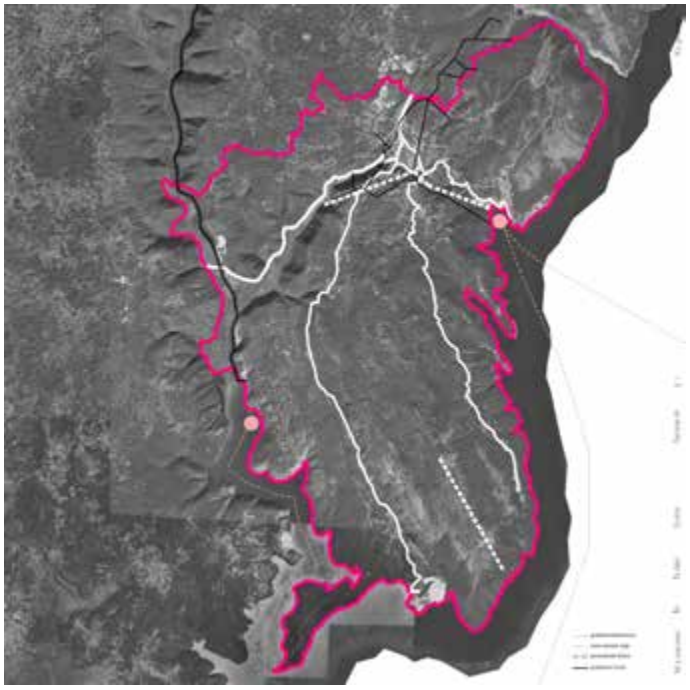

Fig.9: K2_ traffic in the vision development 3K_Beneath & Beyond. Source: Jelić, 2025.

The planned interventions should encourage the creation of new jobs, the development of primary and service activities, with a controlled expansion of tourist settlements to preserve the natural and cultural heritage. One of the goals of the vision is the preservation of industrial heritage and the expansion of the tourist offer. The opening of new public facilities (museums, social and cultural centres) would contribute to the quality of life of the local population and the overall attractiveness of the area. Agriculture production encouragement with a focus on growing crops characteristic of eastern Istria (olives, vines, root vegetables, fruits and lavender). Fishing, shellfish farming and livestock farming - breeding of indigenous animals (goats, sheep, Boškarini, donkeys and horses) is also planned. One of the main goals is to encourage the development of agritourism and marine tourism in order to valorise natural resources and enrich the tourist offer. In order to strengthen local production and sustainable development, the establishment of family farms, markets with locally produced food, new incubators and educational centres that will serve as areas for retraining and professional training of the population for work in sectors such as agriculture, livestock, fishing and tourism are planned.

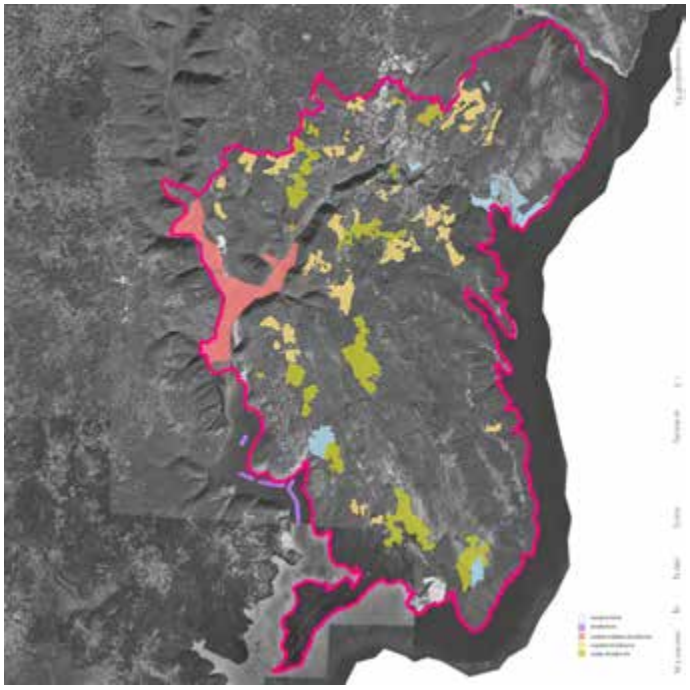

Fig.10: K3_ economy and tourism in the development vision 3K_ Beneath & Beyond. Source: Jelić, 2025.

4. Discussion

European organizations conduct various research and develop projects related to the development of urban systems. One of the current topics is the development of small and medium-sized cities, which represent a still insufficiently explored potential, especially in the context of European urban systems and the achievement of sustainable urban-rural relations.

European documents emphasize that such entities of the urban system are characterized by various demographic and social inequalities, especially those located in remote areas or inner peripheries, since they lack access to public facilities and appropriate economic and social opportunities.

Over the years, the processes of metropolitanisation have led to different directions of growth and development of small and medium-sized cities depending on their position in relation to large cities, profiting from integration into functional urban areas or development along fast transport corridors, while some have stagnated or even declined due to their peripherality and insufficient services.

At the national level, *the Spatial Development Strategy of the Republic of Croatia* from 2017, modelled on European documents on spatial development, states that the sustainability of the spatial organization of the state should be based on a polycentric model of development, which is a key element for achieving territorial cohesion. The document states that medium-sized and small cities should play a key role at the regional level and represent a link between larger urban areas and rural areas. The revitalization of the economic role of medium-sized and small cities should be based on business, processing industry and various forms of tourism.

Conceiving the further development of cities and regions is a very important process that Architecture and Urbanism students have the opportunity to learn at Workshop 3 - Spatial planning. The education of future planners is based on a combination of the collection of additional theoretical knowledge, such as the method of scenario planning and the process of valorisation, and the practical application of knowledge related to research, analysis, design, valorisation, and the selection and elaboration of a development vision. The practical application of the scenario planning method in the education process is particularly important for encouraging the use of planning intuition and strategic thinking.

The analysis of the existing situation, spatial planning documentation and strategic plans for further development at the local level enables the collection of information about the area and its possibilities and represents the basis for designing development goals and applying the scenario planning method. Determining the criteria and implementing the valorisation of the proposed scenarios gives future planners the opportunity to practice making decisions as objectively as possible. In addition to graphic representations that follow the planning steps, models are also created in the planning process so that future planners can better present and communicate their ideas with the public.

Fig.11: Model of the development vision of Labin and Raša - 3K_ Beneath & Beyond. Source: Jelić, 2025.

In this case study, five possible scenarios for future development of Labin and Raša were proposed. In this project, two local self-government units, the city of Labin and the municipality of Raša, were considered together as a whole due to their spatial, economic and social specificities and historical economic significance.

The realization of 22 designed development projects (8 related to the topic of nature and society, 8 related to the topic of transport and 6 related to the topic of economy and tourism) in accordance with the proposed vision of *3K_Beneath & Beyond* in a period of 25 years would lead to the revitalization and improvement of the quality of life at the local level, the revitalization of economic activities in the region, contributing at the same time to the objectives of the Spatial Development Strategy of the Republic of Croatia, i.e. strengthening the polycentric model of development and territorial cohesion.

Conceiving development scenarios and development projects based on the sustainability goals indicates an awareness of the importance of global trends, which by planning at the local level contribute to the achievement of global goals.

5. Conclusion

Research on the possibilities of further development of an area and the prediction of possible development scenarios is a very important topic in professional circles. In addition to the theoretical knowledge in the field of spatial planning and urbanism, which is collected during the studies, the practical application of the collected knowledge and skills on different scales is possible towards the end of the master's study within the framework of Workshop 3 - Spatial planning.

On different scales, future planners can practice research, analysis, synthesis, strategic and critical thinking, forecasting, modelling evaluation tools and decision-making process while planning the future development of selected area. The ability to choose the area further encourages future planners to go through the comprehensive process themselves in just 15 weeks with joy and a special interest in the space.

During the education process, considering the space in a broader context and considering its significance at the regional level can provide additional impetus for planning in a broader context, i.e. crossing the administrative boundaries of local self-government, which was agreed upon by the city of Labin and the municipality of Raša in this case. We can say that this work has set a new model of approach, i.e. that a new entity has been formed, formally composed of two local self-government units, and through comprehensive consideration, a proposal for a vision of future joint development has been given based on historical elements, recognized potentials and possibilities of space in the context of sustainable development, while maintaining the specificities of individual elements in the space.

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Towards transformative actions through perceptions research: Q-methodology as a tool for identifying ideological dimensions of planning problems

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Abstract
Addressing complex planning problems requires being able to respond to a diverse spectrum of perceptions and ideas. However, capturing nuanced perspectives to develop transformative actions remains difficult in research and planning processes. This paper explores Q-methodology as a tool to analyse ideological dimensions in planning problems. By combining qualitative and quantitative analytical techniques, Q-methodology is a useful tool for studying subjectivity, revealing consensus and divergence among perspectives. Here, I reflect on five diverse applications of Q-methodology—to inform or analyse stormwater and flood risk policy, ease water conflict tensions, and assess co-creation's role in shifting perceptions of transdisciplinarity in climate change adaptation. While acknowledging that there are limitations, these studies illustrate the method's capacity to uncover narratives, foster dialogue, and study transformative processes.

Keywords: Q-methodology, subjectivities research, narratives analysis, communicative planning

1. Introduction

Urban planning presents various "wicked" problems that are complex, multifaceted, and pervasive throughout social systems (Rittel and Webber, 1973). These problems are challenging to manage because they involve several interrelated and co-evolving processes, each with its own counterbalancing forces, making a single best solution impossible. Collaborative planning emerged as a postmodern framework for addressing wicked problems by engaging with diverse viewpoints and fostering inclusive decision-making (Innes and Booher, 2016). Despite planning being largely government-led, postmodern theories advocate for bottom-up approaches that centre inhabitant and user perspectives, recognising that scientific analyses offer only a partial understanding, often overlooking the social, cultural, and ideological forces shaping decisions (Allmendinger, 2002; Innes and Booher, 2010; Irving, 1993). Since its emergence as a dominant postmodern theory, collaborative planning has evolved to address the complexities of power, communication, and governance, challenging modernist assumptions of order and predictability in planning processes (Healey, 2003, 1997). As a result, communicative planning scholarship promotes leveraging communication and collaboration not just as mechanisms for problem-solving, but as essential tools for identifying challenges, negotiating competing interests, and fostering collective capacity to navigate the uncertainties of urban design in dynamic socio-political contexts.

Capturing nuanced viewpoints in planning is a significant challenge due to the inherent complexity of subjective experiences and power dynamics that shape decision-making processes. Similarly, studying wicked problems has multiple modes of entry and requires drawing wieldy boundaries around an inherently complex system (Holling, 2001; Hou et al., 2022). Studying wicked urban planning problems and deciding necessary research priorities is, by definition, reductive even when attempting to cast the widest possible net. Because of the complex nature of wicked problems, mixed-methods approaches offer a means to look at multiple aspects of a problem (Mertens, 2015). One mixed-method technique increasingly used to study wicked problems subjectively is Q-methodology (QM). It uses data reduction techniques to condense multi-dimensional subjectivities into a practical set of perspectives regarding a particular subject. William Stephenson is credited with founding this research method within psychology (Stephenson, 1936, 1935), and it has since been incorporated as a valuable tool in many human research disciplines (Ramlo, 2016a).

In this paper, I reflect on the use of QM as a tool in collaborative urban design. The methodology offers a means to identify multi-dimensional subjective views of various planning problems. This paper is structured as follows. In section 2, I give an overview of QM and how the studies are designed, implemented, and analysed. In section 3, I give a summary of the five QM studies from which this reflection is based. In section 4, I provide insights in the positive aspects of using the QM in planning applications and some of the limitations. Finally, I close the paper with brief concluding remarks.

2. Understanding Q-Methodology

The Q-method (QM) recognises that an individual's subjectivity is better understood in a sociocultural context with respect to the perspective of others. William Stephen developed the methodology out of the idea of an inverted factor analysis (Stephenson, 1953, 1935). Indeed, QM inverts the traditional factor analysis by having m subjects react to n tests rather than performing m tests on n subjects. In other words, QM enables individuals to define themselves through the relative ranking of a set of ideas, and is thus a useful tool for studying subjectivity on a topic of interest (Brown, 1980; Robbins and Krueger, 2000; Stephenson, 1953). The method distinguishes itself from pure quantitative methods as a technique to make discoveries rather than test theories (Stephenson, 1953; Watts and Stenner, 2005). QM is also distinct from purely qualitative methods in that it uses quantitative techniques to articulate these discoveries. Although the method developed in the field of psychology, it has expanded into many different academic and professional fields over the decades (Ramlo, 2016a), for example, human geography (Eden et al., 2005; Robbins and Krueger, 2000), environmental sustainability and conservation (Sneegas et al., 2021; Webler et al., 2009; Zabala et al., 2018), healthcare research and education (Churruca et al., 2021; Hensel et al., 2022)the methodological variations, and the major implications to inform best practices. Design: Scoping review design using the Preferred Reporting Items for Systematic Reviews Extension for Scoping Reviews. Data sources: Academic Search Complete, CINAHL Complete, Education Research Complete, Embase, ERIC, Proquest Nursing and Allied Health, PubMed, PsycInfo, SocINDEX, and the Web of Science Core Collection. Review methods: A comprehensive search of English language journal articles was conducted for Q methodology studies published between 2015 and 2020 that used undergraduate nursing students or nursing faculty as participants. Data were extracted using a modified version of the Assessment Review Instrument for Q Methodology. Results: Eighteen studies from five countries met inclusion criteria. The majority were single-site studies and used nursing students as participants. The number of stimuli for sorting in the Q sample ranged from 21 to 60. Study aims fell into three broad domains: attitudes about patient populations or settings (N = 7, and educational research (Lundberg et al., 2020).

Generally, a QM study proceeds in four major phases: developing a concourse, Q-sampling and Q-set finalisation, collecting Q-sorts and interviewing participants, and data analysis and interpretation. In addition to systematic literature reviews (Dieteren et al., 2023; Sneegas et al., 2021), several primers offer detailed theory and instructions for carrying out a QM study (Brown, 1993; McKeown and Thomas, 2013; Watts and Stenner, 2005). For reference, Table 1 provides a guide to terminology used in QM studies and their meanings.

Table 1. Terminology specific to a QM study.

Term	Meaning
Concourse	A collection of stimuli, usually statements, often numbering in the hundreds, that pertain to a specific topic of interest. The concept of a concourse is that it is the collection of all ideas possible, and therefore can never truly be complete.
Q-sampling	The process of selecting the stimuli that will comprise the Q-set.
Q-set or Q-sample	The final set of stimuli (e.g., statements that are not provable) used for the QM study.
P-set	The set of participants participating in the QM study.
Q-sort	The sorted set of stimuli ranked by each participant according to the pre-defined semi-normal grid.

Phase 1: Building the Concourse. A concourse is created to represent the body of thoughts on the subject of inquiry. While QM studies typically use statements, other stimuli like images, poems, and words can also be used. The concourse, drawn from sources such as interviews, forums, literature or media, provides subjective stimuli for an eventual Q-set selection. Though in theory never exhaustive (Stephenson, 1986), ideas are added to the concourse until the 'point of saturation' when no new ideas are emerging.

Phase 2: Q-Sampling and Q-Set Selection. Once saturated, Q-sampling selects a subset of statements, the Q-set, from the concourse often guided by a structured framework (Brown et al., 2019). To enhance clarity, pilot tests help refine the Q-set, reducing and refining the statements as needed. Statements should be ideas that cannot be readily tested. In environmental sustainability research studies, Sneegas et al. (2021) found the number of statements in the Q-set range from 9 to 69, with a mode of 36. Across other disciplines, the average number may be higher (Dieteren et al., 2023). The appropriate number depends on the ability to capture the breadth of the concourse while considering interview time constraints and participant fatigue.

Phase 3: Participant Selection and Q-Sorts. Study participants are then asked to rank the Q-set based on a pre-defined grid. QM studies focus on identifying the perspectives present among a group rather the central tendencies of a population. Therefore, there are no hard and fast rules on sample sizes, which vary in most studies between 20 and 50 participants (Dieteren et al., 2023). Principally, the number of participants should reflect the amount needed to address the research question at hand (McKeown and Thomas, 2013). Each participant creates a Q-sort—participant-ranked statements based on the pre-defined grid—which are collectively analysed and often complemented by semi-structured interviews for deeper interpretation. While traditionally in-person, use of online Q-sort platforms have expanded in the wake of the COVID-19 pandemic.

Phase 4: Data Analysis and Interpretation. Collected Q-sorts undergo factor analysis. There is an active debate among QM researchers regarding the most appropriate analytical tools and choices at this step (Akhtar-Danesh, 2017, 2016). For instance, QM traditionally used centroid factor analysis and manual rotation, which were largely necessitated by computational constraints in its early development; however, modern studies favour Principal Component Analysis (PCA) and varimax rotation as the prevalent techniques for analysis (Dieteren et al., 2023; Zabala et al., 2018). Nevertheless, since these analytical tools are generally designed for large datasets and QM studies use smaller datasets, careful interpretation is crucial to choosing an analytical path that reflects viewpoints collected. The process reduces the full collection of Q-sorts down to a handful of key perspectives, reconstructed Q-sorts based on the weight of participant correlations to factors. After analysis and interpretation, many researchers suggest this as the starting point of a deeper conversation with the participants, informed by the findings.

3. Example Studies Illustrating the Application of Q-Methodology in Planning

This reflection paper pulls from 5 diverse QM studies employed to different ends related to contemporary planning issues. A summary of the studies is provided in Table 2. Among all studies, a forced grid was used for data collection with ranking statements on a scale from most disagree (-) to most agree (+), and analysed using PCA and varimax rotation to identify the factors. Online interviews were conducted using Q-Tip without a pre-sort step (https://qtip.geography.wisc.edu/) or EQ Web Sort (Banasick, 2023) with a pre-sort step. Data were analysed using Ken-Q Analysis (https://shawnbanasick.github.io/ken-q-analysis/).

Table 2. Summary of various applications of the Q-method

Study: Context and research objective	Study design	Study application	Q-sort design
Study 1 (Honolulu study): Honolulu, Hawaii. A study on stormwater management priorities amid community-government tensions over a US Army Corps flood project	Concourse built from comments taken from media, public forums, and semi-structured interviews. Participants included stakeholders and experts from the community, academia, and government	Online only (Q-Tip) Q-set: 25 P-set: 18 Factors: 4 (3 with one bipolar split into two)	±4: 1 ±3: 2 ±2: 3 ±1: 4 0: 5

Study 2 (Maui study): Lahaina, Maui fire (Hawaii). A study exploring agreement and disagreement on water management strategies after the Lahaina Fire	Concourse built from post-fire press articles. Participants were part of a closed advisory group that guides water management strategies for Hawaii	Online only (Q-Tip) Q-set: 22 P-set: 12 Factors: 3	±4: 1 ±3: 2 ±2: 3 ±1: 3 0: 4
Study 3 (GAM study): Grenoble-Alpes Métropole (GAM), France. A study to understand tensions in flood risk management	Concourse built from semi-structured interviews. Participants were part of a public advisory committee on flood risk management, including managers, experts, and elected officials	Majority in-person (online: EQ Web Sort) Q-set: 32 P-set: 55 Factors: 3	±5: 2 ±4: 2 ±3: 3 ±2: 3 ±1: 4 0: 4
Study 4 (TAA study): Trentino-Alto Adige (TAA), Italy. A comparison study with Study 3 to understand how the EU's principle of subsidiarity plays out in flood risk management	Same study design as Study 3. Participants were flood risk managers or experts. Comparative stats analysed ranking differences among 26 similar GAM and TAA participants	Majority in-person (online: EQ Web Sort) Q-set: 32 P-set: 31 Factors: N/A	Same as study 3
Study 5 (TD-assess study): International. A study to assess the changes in ideas about transdisciplinarity in climate services for climate action	Concourse drawn from semi-structured interviews with international climate service experts. Young professionals from various countries attended a two-week transdisciplinarity school in Arusha, Tanzania, completing a Q-sort before and after the program	Online only (EQ Web Sort) Q-set: 23 P-set: 25 (16 before, 9 after, 7 repeats) Factors: 4 (3 including one bipolar split into two)	±3: 2 ±2: 3 ±1: 4 0: 5

The first application, the Honolulu study conducted in 2020, explored the expectations of stormwater management prompted by a flood risk management project framed in the press as a community-versus-government issue. The QM revealed tensions existed over the role of the government in planning and financing stormwater management, whereas everyone was in agreement to move towards green infrastructure and away from grey solutions. Further details can be found in Arik (2022).

The Maui study was conducted among a non-public stakeholder group in the wake of the Lahaina fire in 2023 which decimated the entire town. Decisions about water releases made during the unfolding disaster prompted a battle that played out over national newspaper outlets—a unusual occurrence for Hawaii-related issues. The conflict stemmed from a decades-long struggle to secure in-stream water rights for indigenous Hawaiian practices, against a deep-rooted legacy of colonial-era water diversion. The purpose of using the QM was to start a conversation between some of the parties at the heart of this conflict—as a means to acknowledge with data the differences of opinion and move quickly to productive conversation.

The GAM study and TAA study are twin studies conducted in 2022 and 2023, in two similar urban settings in France and Italy to understand how flood risk management decisions are made. They both used the same study de-

sign with statements and interviews conducted in French and Italian respectively. Further details about the GAM study can be found in Arik et al. (2023). For the GAM study, an additional judgmental rotation was employed based on one participant who had a leading role in flood risk management. The study was conducted among affiliates of a democratically structured flood risk management steering committee. However, QM revealed that this structure tended to suppress marginal issues—those significantly affecting local communities but not severe enough to become watershed-level priorities. The TAA revealed somewhat of an opposite problem that voices of change were often externalised from flood risk management decision, and that flood risk management decisions remained insular. To compare the GAM and TAA data, comparative statistics were used on the raw Q-sort ranking data. In this case, the PCA was not applied for the comparison.

The TD-assess study explored how participants in a two-week climate services school that took place in 2024 shifted their views on transdisciplinarity in climate action (Vigna et al., forthcoming). To measure this change, they were asked to complete a Q-sort before and after the program. Participants were young professionals from diverse disciplines, working or studying worldwide, but primarily based in Europe or Africa. Unlike the other studies described, which included one-on-one interviews, the TD-assess study gathered perspectives through commentaries in a post-sort survey. The QM revealed a growing recognition of the value of transdisciplinary collaboration.

4. Reflections on the Use of the Q-method in Planning

The QM is a valuable tool for analysing discourse, systematically categorising subjectivities to reveal patterns of agreement and divergence. By bringing clarity to complex planning issues, it helps uncover underlying perspectives that shape decisions and guide deeper discussions. While its effectiveness depends on thoughtful design and interpretation, QM offers a structured approach to fostering more inclusive and informed decision-making in planning. Here, I elaborate on some of its strengths and limitations based on the applications described in the previous section.

4.1. Strengths and Impacts

Understanding the Roots of Conflict. The QM offers a structured approach to analysing discourse, helping to uncover the underlying factors driving disagreements in planning and policy decisions. By identifying viewpoints present among participants, it highlights sources of friction—whether stemming from miscommunication, competing priorities, or deeply held values. This ability to clarify tensions provides a useful lens for understanding how conflicts emerge and where opportunities for dialogue exist. Mapping diverse perspectives can help planners recognise not only points of consensus but also areas of divergence that require negotiation. The Honolulu study illustrates this dynamic, showing that even though stakeholders broadly supported green infrastructure, disagreements about governmental roles in planning and funding fragmented overall alignment. This suggests that consensus on solutions sets alone does not guarantee cooperation—governance structures and expectations around responsibility play a critical role in shaping stakeholder engagement.

The Maui study further demonstrates how structured discourse analysis can facilitate dialogue in deeply rooted conflicts. The Lahaina fire brought long-standing tensions over water rights into national focus, underscoring the historical struggle between indigenous Hawaiian practices and colonial-era water diversion policies. By framing perspectives in a structured way, QM served as a tool to initiate conversations among a critical stakeholder group, offering data-driven recognition of differing viewpoints to move discussions toward more productive outcomes. These studies highlight that understanding stakeholder perspectives is not just about identifying agreement and disagreement, but about recognising the governance, historical context, and discourse structures that shape how conflicts evolve, where QM can help define how they may be navigated.

Amplifying Underrepresented Voices. Dominant narratives in planning often shape decision-making processes in ways that overshadow minority perspectives, limiting the inclusion of diverse viewpoints. Unlike survey instruments that aim to measure consensus or central tendencies, QM provides a structured approach to identifying distinct perspectives among participants, making it particularly useful in highlighting overlooked priorities. The

GAM and TAA studies demonstrate how flood risk management decisions are shaped not only by technical assessments but also by institutional structures. In the GAM study, conducted within a democratically structured steering committee, QM revealed that while decisions reflected majority preferences, they tended to suppress marginal concerns—issues significant at the community level but too localised to influence watershed-scale priorities. Conversely, the TAA study exposed a different issue: voices advocating for change were largely externalised from decision-making, reinforcing an insular approach to flood risk governance. These findings illustrate that participatory structures do not always guarantee inclusivity, emphasising the need for tools that can expose both dominant and marginalised viewpoints.

By systematically categorising viewpoints, QM helps uncover underlying patterns that might otherwise be concealed within governance processes. The comparative analysis between the GAM and TAA studies highlights how flood risk decisions are shaped not just by technical assessments but also by institutional dynamics that determine whose voices are amplified and whose are excluded. In GAM, a structured democratic process inadvertently side-lined concerns that did not meet broader strategic priorities, while in TAA, exclusionary decision-making reinforced internal confidence at the cost of external perspectives. Together, these studies reveal that different governance structures produce distinct challenges in integrating diverse viewpoints into planning processes. QM's ability to illuminate such discursive patterns makes it a useful tool for analysing how decision-making frameworks operate, and how they may be adapted to foster more inclusive engagement.

Facilitating Collaborative Solutions. In complex policy and planning contexts, productive dialogue is often hindered by competing interests, conflicting priorities, and the sheer diversity of perspectives involved. QM helps structure these discussions by reducing the dimensionality of viewpoints, revealing nuanced patterns in stakeholder perceptions rather than treating opinions as isolated and competing. By clustering perspectives, identifying consensus, and highlighting points of divergence, QM enables planners to navigate discourse with greater clarity, offering a structured framework for untangling dense debates and facilitating more effective negotiation. This was evident in the Maui study, where QM findings were used to initiate dialogue, allowing acknowledgement of differences without dwelling on them in a discussion. Similarly, the TD-assess study demonstrated QM's ability to track shifts in participants' perceptions of transdisciplinarity, illustrating how structured discourse analysis can reveal changing attitudes within collaborative settings. These examples highlight QM's potential to bring coherence to complex discussions, ensuring that planning processes account for both areas of alignment and persistent tensions.

4.2. Challenges and Considerations

Dependence on a Well-Designed Q-Set. The effectiveness of QM relies heavily on a carefully constructed Q-set that accurately captures the breadth of perspectives relevant to the study. A poorly designed Q-set can limit the insights derived from the method, restricting the ability to identify meaningful clusters of viewpoints. For example, in the GAM and TAA studies, the statement set attempted to incorporate ideas that were not necessarily central to all participants, leading to many consensus statements around neutral positions that were not very insightful because they reflected a non-positionality. Moreover, since the study was initially designed for GAM and later deployed in TAA, certain statements did not align as well with the TAA context, illustrating the challenges of adapting a Q-set across different governance structures. This underscores the importance of tailoring statement selection to the specific decision-making environment to ensure meaningful insights, which can limit its usefulness to the context. Finding the right balance between participation and the validity of the Q-set can also be tricky. In the case of the TD-assess study, we faced challenges related to participation rates, prompting us to reduce in the number of statements in an effort to increase engagement in the study for future iterations of the program, but preventing us from using the first dataset to compare to future studies. These examples highlight the need for careful Q-set construction, keeping in mind the participants, and ensuring that statements will be effective in capturing the nuances of the participant perspectives while remaining relevant to the study's context.

Complexity in Explanation and Lack of Visualisation Tools. The method itself and its findings can be challenging to communicate effectively due to its complexity and lack of conventional numerical summaries, making

interpretation less intuitive for broader audiences. To date, visualisation tools to communicate QM finding are underdeveloped as well. In the Honolulu and GAM studies, findings were shared openly through reports with opportunity for reactions, with no feedback given. Similarly, a presentation was given to the stakeholder group in the GAM study with no substantive follow-up. This highlights the importance of carefully considering how its results are presented to enhance engagement in planning processes. In contrast, the Maui study demonstrated a more effective approach—using QM as a tool to initiate dialogue among key stakeholders, helping structure conversations around conflicting perspectives because it was conceived as a tool to enhance the discussion. These examples suggest that QM's effectiveness depends not only on its methodological rigor and the ability to communicate the method and findings effectively, but also on its integration in planning processes to foster meaningful discussion.

Context-Specific Nature and Limited Generalisability. The QM is highly context-dependent, meaning its findings often cannot be directly transferred across different studies or planning environments. This is evident in the Honolulu and GAM/TAA studies, which both focus on flood risk management yet show minimal overlap due to their distinct governance structures and local dynamics. While Honolulu study of identifying priorities in stormwater management which revealed underlying tensions, the GAM/TAA studies deployed a Q-set to test potential tensions as hypotheses and revealed governance dynamics. Similarly, the TAA study particularly underscored the importance of designing the Q-set to fit its specific context, as transferring statements from GAM resulted in misalignment of certain statements in the Q-set with local context. Meanwhile, the TD-assess study took a different approach by designing its Q-set with broader applicability in mind—allowing its framework to be potentially redeployed to measure shifts in transdisciplinary collaboration in climate services and adaptation planning. These examples emphasise the need for careful Q-set construction tailored to the study's objectives while considering ahead of time whether the potential for adaptability across similar research domains is a goal or not.

5. Concluding Remarks

Addressing complex planning problems requires approaches that can engage with a diverse spectrum of perceptions and ideas. However, translating subjective viewpoints into actionable strategies remains a fundamental challenge in research and policy-making. Q-methodology can be a valuable tool for analysing ideological dimensions in planning, offering a structured way to assess areas of consensus and divergence. By combining qualitative and quantitative techniques, QM facilitates the study of subjectivity in decision-making contexts, uncovering narratives that influence planning outcomes. This paper examined five distinct applications of QM—from informing stormwater and flood risk policy to navigating water conflicts and assessing co-creation's role in shifting perspectives on transdisciplinarity in climate adaptation. While QM is not a universal solution, its use in these cases demonstrates its ability to highlight discursive patterns, foster dialogue, and provide a structured approach to understanding differing viewpoints.

At the same time, employing QM in planning comes with important considerations. The method's effectiveness relies on a well-designed Q-set and thoughtful implementation, requiring careful framing to ensure meaningful insights. Additionally, its context-specific nature means that findings from one study may not be broadly generalisable, limiting direct application across different cases. Furthermore, QM's complexity can make it challenging to communicate results to diverse audiences, especially given the lack of visualisation tools. Despite these limitations, QM remains a useful mixed-method approach to studying subjective perspectives in planning. When used appropriately, it can offer decision-makers a clearer view of ideological tensions, highlight voices that might otherwise go unheard, and contribute to more informed and inclusive planning processes.

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From Masdar City, Abu Dhabi to Florya, Istanbul: What Can We Learn from Smart Cities?

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Abstract
Masdar City is one of the first smart city models that emerged as an ambitious project, aiming to become the world's first zero-carbon, zero-waste city, weaving technology into its urban fabric. Today, the project remains unfinished and is largely a ghost town, neglecting the most crucial component of a city: people. Learning from Masdar City, how can we design more people-centric smart cities? This paper proposes a future city model for a site in Florya, Istanbul. We explore how urban planning can benefit from "smart" initiatives that promote social connection through volunteering, supporting local production, and prioritising pedestrian-friendly mobility. Future cities do not have to be technological utopias but offer a reasonable interpretation of community needs to build a just and equitable future.

Keywords: Masdar City; Florya, Istanbul; Urbanisation; Future Cities; Community Development

1. Introduction

In light of the world's rapid technological development and increased environmental consciousness, future cities, often called smart cities or eco-cities, emerge as an initiative to leverage technology for sustainable development. Sustainable development, composed of the social, economic, and environmental pillars (United Nations, 2002), has become a pressing global concern, and balancing these pillars is a significant challenge in our capitalist-driven world. This dilemma has been particularly evident in future cities as the vision drifts away from a people-centric approach to a revenue-driven, profit-oriented urban model.

Masdar City is no stranger to the aforementioned urban challenge. Located in Abu Dhabi, United Arab Emirates (UAE), Masdar City came to life as the world's first city with a zero-carbon, zero-waste goal. Considering the UAE's oil-based economy and future resource scarcity, it became essential for the UAE to explore potential urban solutions and alternative economic models. Launched in 2006 as a subsidiary of the Mubadala Investment Company, the 640-hectare city is a testing ground for innovative renewable energy solutions and diverse sustainability-oriented technologies within the UAE's challenging context (Foster + Partners, n.d.), particularly its harsh climate and the Emirati society's lavish lifestyle (Fattah, 2007). Thus, one of Masdar City's main goals is to show that achieving a high quality of life with minimal environmental impact is possible (D'Eramo, 2021).

Masdar supports Abu Dhabi's transition to a knowledge-based economy as part of the Abu Dhabi Economic Vision 2030 (Masdar, 2020), and its goal as a zero-carbon, zero-waste city further creates a positive incentive towards technological and economic development. Foster and Partners, the design firm that dealt with Masdar City's master plan, introduced design solutions and strategies that aim to reduce energy consumption while fostering Masdar's desire for technological innovation, including narrow shaded streets inspired by traditional Emirati architecture (Ibrahim, 2016), "wind and photovoltaic farms, research fields, plantations" (Foster + Partners, n.d.), and an electric personal rapid transport system (Cugurullo, 2013). The city also attracted major companies, including Siemens and General Electric, reflecting its power as a business hub. These companies play an integral role in Masdar's economic model as their innovations are promoted and displayed in Masdar City as a living portfolio (Cugurullo, 2013; Cugurullo, 2016).

While the master plan of Masdar City is still not fully implemented, the analysis in this paper discusses how the city has a business-oriented model focusing on the economic pillar of sustainability, rendering the social component of the city neglected. Furthermore, it highlights how the integrated technologies resulted in more shortcomings than advantages. Thus, this study envisions what prioritising social sustainability while benefiting from technology could look like. To explore this concept, this paper proposes an experimental approach entitled "The Social City" in Florya, Istanbul. "The Social City" aspires to integrate urban planning and design decisions along with technology to create a lively city that fosters community bonds and encourages people to socialise and interact with each other.

2. To What Extent Is Masdar City What It Claims to Be?

The current reality of Masdar City has not aligned with its initial vision. After the 2008 financial crisis, the UAE's economy was highly affected, and ever since, the plans and reality of Masdar City have changed significantly (Griffiths and Sovacool, 2019). The original goal was to become a zero-carbon, zero-waste city with 40,000 residents by 2016 (Premalatha et al., 2013). Masdar City's reports indicate that the current sustainability efforts have been modified to decarbonisation initiatives, and the original net-zero goal is to be reached by 2050 (ESG 2023, 2023). However, the multiple delays and changes in defining the goal (Figure 1) and the budget cut from 22 billion dollars to 18 billion dollars may reflect some scepticism about the vision's attainability and feasibility.

Figure 1: The Construction Progress of Masdar City since 2009

While integrating technology into future cities can be beneficial, multiple technologies adopted in Masdar City failed in terms of efficiency, application, and utilisation. For example, the photovoltaic plants, which were expected to generate approximately 17,500 megawatt-hours of clean energy (masdar.ae, n.d.), face the issue of excessive dust accumulation, which significantly decreases their efficiency, and cleaning them is a resource-intensive solution (Omar, 2018). Another example is the idea of the Ergos energy-based currency that replaces traditional money with kilowatt-hours to monitor household consumption (Günel, 2014). Each citizen is given an energy budget, helping Masdar reach its energy and zero-carbon goals. However, while the solution appeared to be a promising tech-based innovation, the idea was disregarded due to the cost and financial considerations of installing the necessary monitoring systems, the solution's heavy reliance on educating the human actors in the system, and the fear of data exploitation (Günel, 2014; D'Eramo, 2021). Such examples reflect how some of the tech and innovation-based solutions adopted in the city were rendered inefficient due to the cost needed to maintain them or their requirement of a significant paradigm shift in citizen lifestyles and governance. This highlights the paradox that excessive dependence on technology in a smart city may, in practice, be "unsmart."

Another primary concern is Masdar City's reliance on the UAE's conventional oil-based economy for sustenance since the renewable energy solutions adopted were insufficient to power the city (Cugurullo, 2016). As Masdar City was supposed to be the world's first zero-carbon city, such an approach defeats the entire raison d'être of Masdar City. Furthermore, its reliance on oil raises an important question: If the existing infrastructure is inadequate to sustain a partially built city, how can we be sure that Masdar City will truly achieve its net-zero goals

once fully developed? While this reality may change once the master plan is complete, it still highlights the drawbacks of an overly ambitious vision, often fuelled by the smart city concept.

While Masdar City claims to aim for a well-rounded sustainable approach, the city, which operates as a living portfolio for companies that produce green technologies, is, in reality, a research and development-based business model that aims to attract developers, investors, and potential buyers (Cugurullo, 2013; Cugurullo, 2016). These companies play an integral role in Masdar's economic model as their innovations are promoted and displayed in Masdar City as a marketing and business strategy for both parties. While this is not necessarily a negative approach, it prioritises economic sustainability over the other pillars. Furthermore, environmental sustainability in Masdar City is primarily attained by supporting green technology companies and working towards sustainability certifications. While a good start, it still reflects a limited interpretation of the pillar and its complexity. Social sustainability, however, remains largely neglected. A city's main living component is its people; however, Masdar City is deemed a "ghost town" (Goldenberg, 2016). Even though the project was designed for around 50,000 people, the almost-empty city's main users are those associated with Masdar City's research university or company employees. The reasons go back to multiple factors, mainly the high living costs. Masdar City's design focused more on titles, numbers, catchy marketing ideas, and futuristic innovations rather than the actual needs of the users. Furthermore, considering its approach as a business city, it innately appeals to social elites rather than people of diverse backgrounds and social classes (Cugurullo, 2016).

Upon examining the initial vision of Masdar City, it was primarily meant to be an investment company that aims to create a new model of economy motivated by climate change and resource scarcity in the form of a techno-city (masdar.ae, 2019; Cugurullo, 2016). This goal boasts a commercial incentive instead of truly targeting sustainability and all its pillars. Thus, sustainability is approached more as a business strategy than a holistic urban practice, and social sustainability remains fundamentally unaddressed.

3. Background

As smart cities like Masdar City emerge, analysing their implications is necessary for a more conscious, well-informed approach to urban planning. Some leading voices in the study of smart cities include Carlo Ratti, Anthony Townsend, Adam Greenfield, and Ben Green, who present their varying ideas, thoughts, and concerns about integrating smart solutions into our urban fabric.

Ratti affirms the potential of technology in creating more efficient and adaptive urban systems through the power of data and citizen interaction (Ratti and Claudel, 2016). In his book "The City of Tomorrow: Sensors, Networks, Hackers, and the Future of Urban Life" with Matthew Claudel, he discusses how more mobile phones with active service exist than people, showing the potential of sharing services in a way that has never been done before. With this potential unlocked, Ratti envisions the transformation of urban dynamics with the Internet of Things to improve quality of life and make our lives more efficient and practical. For example, he discusses a scenario where self-driving cars and other modes of transportation could be shared and moved where needed based on a model that predicts demand (Ratti and Claudel, 2016). His views are relatively optimistic about the potential of technological integration in our cities; however, his thoughts are more exploratory, lacking solid grounds for how people would interact and come together considering this new movement. In addition, the potential he discusses is only relevant in the developed world or places where sufficient funding is available for this technological leap (Evans-Cowley, 2016).

On the other hand, Townsend highlights how our transition to smart cities is inevitable; however, he finds that our response to technology is a critical challenge (Townsend, 2013). In his book "Smart Cities Big Data, Civic Hackers, and the Quest for a New Utopia", Townsend (2013) discusses how "smart cities need to be efficient but also preserve opportunities for spontaneity, serendipity, and sociability." He believes that our current cities are the "smartest cities" and that envisioning utopian smart cities does not necessarily mean addressing the problems we currently face. He also acknowledges that each city and society is unique, meaning no tech-based solutions will be the same everywhere (Townsend, 2013). Thus, involving citizens in the planning and implementation pro-

cess of smart cities is crucial to ensure that technology serves the public.

Greenfield, in his book "Against the Smart City", criticises the conception of a top-down smart city approach that reduces people, their complexities, and interactions with the built environments to mere algorithms, warning against the dangers of treating technological systems as a universal solution (Greenfield, 2013). Greenfield (2013) also depicts how efficiency cannot be the only "metric by which urban processes ought to be judged," emphasising how this approach resembles the views of modernist planning approaches, which ultimately failed. His views also shed light on people as the smart component of the city, reflecting how urban technology should aim to support human activity instead of overpowering them and treating humans as mere sources of data. This is crucial since he regards technology as non-neutral, with each technology "encoding a hypothesis about human behaviour" (Greenfield, 2013).

Finally, Green, the author of "The Smart Enough City: Putting Technology in Its Place to Reclaim Our Urban Future," advocates for the concept of the smart enough city, reflecting how too much technology can have significant drawbacks on the city and public life. Green (2019) introduces the term "tech goggles", which "warp behaviours, priorities, and policies according to the logic of technology." Like Greenfield, he describes the risk of oversimplifying people and the city's concerns, which often results in inadequate tech solutions that do not address root causes. One serious risk of utilising technology in governance is that it may reproduce social, institutional, and racial biases in its outcomes, as the data used to train algorithms often reflects these existing biases (Green, 2019). Therefore, technology must not be the driving force in a city's political and social reforms but rather a supporting tool. This indicates that participatory design is essential in shaping a future city's tech innovations. Furthermore, Green (2019) emphasises the importance of understanding the limitations of technology to protect our cities from its potentially detrimental effects.

4. Research Question and Methodology

While the discussion highlights some of Masdar City's shortcomings, it is important to note that the city is a work in progress. The analysis does not attempt to undermine the city's accomplishments but instead aspires to learn from the city's development process as an essential part of this project's methodology. Thus, upon examining Masdar City, several lessons can be derived. Primarily, experimenting on a large-scale means spending larger budgets to prove a concept that may not work in the first place. This reflects that working on smaller-scale research and development projects, perhaps on the neighbourhood scale, could be more efficient. Secondly, while technological development is inevitable, balancing technological interventions in the urban fabric is crucial, as Townsend, Greenfield, and Green highlight. Therefore, selecting and implementing reasonable tech solutions can be more sustainable and cost-efficient than developing full-scale innovations. Furthermore, Masdar City's business-oriented approach shows that focusing on economic sustainability is insufficient for a city to succeed; a more people-centric approach ensures a well-rounded interpretation of sustainability and its varying pillars.

Considering these lessons, we pose a significant question: How can we design a city that integrates technology into its urban fabric to promote and foster community values and connectivity?

To answer this question, a framework was developed as part of "MBL 537E: Architectural Design Futures", a graduate course at Istanbul Technical University. It consisted of analysing a case study of a future city, which in this paper is Masdar City, understanding its implications and features, and then implementing a design strategy on the grounds of a site in Florya, Istanbul. As Istanbul is no stranger to the effects of urbanisation, experimenting on its grounds could provide valuable insights. The comparison of Masdar City and Florya, Istanbul, allows us to envision and implement strategies to create a more inclusive city. The design framework for Florya is entitled "The Social City" and comprises four main approaches focused on public spaces, walkability, supporting local production and initiatives, and volunteering. Each approach consists of detailed, actionable goals that are comprehensively outlined.

5. "The Social City" for Florya, Istanbul

The project site, located in proximity to Florya's residential area and public transportation facilities—namely the Marmaray train, the Metrobus line, and bus routes—is approximately 0.6 km² in size, which is ten times smaller than Masdar City (Figure 2). The site's manageable scale and strategic location make it a reasonable experimentation spot, reducing the need for building entirely from scratch (Figure 3).

Figure 2: Florya and Masdar City's Scale Difference

Figure 3: The Selected Site in Florya, Istanbul

The Social City is a response to urbanisation and its negative consequences on community life to promote community and citizen well-being. The Social City aspires to strengthen community bonds and revitalise the sense of community and civic responsibility that has faded due to rapid urbanisation. It proposes a shift in urban thinking by transforming cities into smaller "smart villages," promoting a model that fosters community engagement, social connection, healthier lifestyles, innovation, and community identity. Investing in a stronger, well-connected community helps support social sustainability, one of the often-neglected dimensions of sustainability, and positions it as a foundation for environmental and economic development. The Social City model aspires to put

people at the heart of urban planning while developing platforms and regulatory frameworks that ensure long-term sustainable living. Through people-centric, scalable technological interventions, The Social City provides an opportunity to explore how technology and urban design can work towards social sustainability in a city like Istanbul.

In metropolitan cities like Istanbul, scale and distance often form significant mobility and infrastructural challenges, which are reflected in the social dimensions of urban life and citizen well-being. This research proposes a smaller-scale urban model to address these challenges and create a more liveable and inclusive environment. The project aspires to develop a well-connected, walkable city by making all essential services and destinations accessible within walking distance. This way, the proposed model encourages walking and cycling, promoting healthy lifestyles.

This structure also strengthens the role of public squares and spaces as accessible community zones where different civic and cultural activities can be planned and organised through a digital citizen event-planning platform. Furthermore, the city is envisioned to be connected to the broader Istanbul metropolitan area via an integrated transportation system complemented by a digital mobility application that informs citizens of public transportation schedules and bus locations.

In addition, supporting local and small businesses is a primary goal in The Social City, where residents are provided with a platform that helps connect these community-based initiatives. This structure enables small businesses to flourish and provides revenue opportunities for underrepresented or economically disadvantaged groups through increased access to work and business potential.

To foster community engagement and promote civic responsibility, the model includes a volunteer-based platform where youth and residents can offer their time to support local needs. In return, participants are awarded social points to recognise their contribution. This system not only supports participants' educational and financial needs but also strengthens intergenerational ties and reinforces community identity.

The Social City is structured around four main approaches and strategies: **i. Dynamic Community-Centric Public Spaces, ii. The Walkable Grid for Green Mobility, iii. Local Business Empowerment Through Community, iv. Volunteering as a Bridge to Stronger Communities.**

5.1 Dynamic Community-Centric Public Spaces

Public spaces are paramount in connecting people; without such spaces, people cannot meet and socialise. As part of fostering community ties, providing well-located, well-designed public spaces that promote citizen interactions is essential to encourage people to socialise and interact with one another. Furthermore, by allowing citizens to play an active role in choosing and developing events of their interest, The Social City model can ensure that its public spaces are used effectively and inclusively. The key goals are designing central public spaces and city squares that are user-attractive and user-friendly and developing an app that provides citizens with the chance to be part of city events to promote citizen activity and interaction.

5.1.1 Designing central public spaces and city squares that are user-attractive and user-friendly

The city square serves as the city's main event and gathering space (Figure 4). As a well-serviced, accessible space with a central location within the heart of the city, everyone can participate in local events and enjoy the city spirit. Public spaces like walkways and courtyard spaces are meant to be green, walkable spaces where people can meet and socialise while hosting smaller-scale events at the neighbourhood scale (Figure 5).

Figure 4: The Social City's Main Public Square

Figure 5: The Social City's Open Spaces

5.1.2 Creating *The Social City* Platform, an app that provides citizens the chance to be part of city events, to promote citizen activity and interaction

Through The Social City Platform, citizens can suggest, organise, and vote for events of their interest (Figure 6). For large-scale events in the city square, citizens can share their ideas, which are later organised by the municipality. For small-scale events in local neighbourhoods, such as having a picnic, citizens can send a public invitation to a specific category. For example, an old lady wants to meet other women her age in her block. She can send an invitation to this category asking them to meet for tea in a specific public location. Furthermore, health-oriented events that promote socialising and connection, such as marathons, walking events, and sports activities, are to be highly promoted and encouraged. Citizens are encouraged to participate in these events and engage with one another through digital awards.

Figure 6: The Social City's Event App

5.2 The Walkable Grid for Green Mobility

This approach aims to provide a safe, green environment that promotes walking and cycling activities. Through a grid organisation and well-served central city artery, users are almost 5-15 minutes away from everything they could need. In addition, to promote the safe, social, and well-connected city model, the city is organised in a car-free grid with the peripheries and a main artery designed to serve as service and transportation zones. The key goals include creating a walkable city through a grid organisation, providing car-free lanes that encourage walking and cycling, and creating a mobility application for the city.

5.2.1 The walkable city through a grid organisation

The city is designed in a grid at a reasonable scale to enable users to navigate their surroundings easily while having different locations and target destinations within less than 15 minutes (Figure 7).

Figure 7: The Social City's Organisation & Dimensions

5.2.2 Providing car-free lanes and promoting cycling and walking activities while managing the peripheries and the city's main artery for a functional city model

The grid organisation and the scale of the city facilitate moving around and allow the grid's intersections to be car-free (Figure 8). The peripheries of the city, represented by the perimeter of the rectangular grid and its main central curved artery, allow vehicular access as part of the transportation strategy. While the city's policies do not promote private car ownership, users with cars or taxis can move around the grid's perimeter and central axis with one main parking space to the northern part of the master plan (Figure 9). The interior roads are designed to be utilised as service roads when necessary.

Figure 8: The Social City's Lanes

Figure 9: The Social City's Access Points

5.2.3 A mobility application to organise vehicular movement and public transportation with a regular schedule for demand-based supply

A mobility application will track people's movement patterns, their varying transportation activities, and the city's rush hours to tailor and provide transportation services accordingly. The app also allows users to track nearby buses' locations and The Social City's minibuses to plan their movement accordingly (Figure 10). The mini-buses within The Social City provide access points to the surrounding neighbourhoods and Istanbul's public transportation, like Marmaray.

Figure 10: The Social City's Mobility App

5.3 Local Business Empowerment Through Community

The Social City aspires to empower citizens with small businesses or services. The "Thrive Local" platform is a local business platform that allows those with small businesses to operate via an e-store where they can sell their services. Users looking for a specific product or service may search for it and find locals who can provide it. This model encourages local production and strengthens social bonds by fostering the values of supporting small business owners and community empowerment. The key goals include creating the "Thrive Local" app and marketing the platform to support its usage.

5.3.1 The "Thrive Local" App

The "Thrive Local" app is a platform that aims to connect local business owners with local consumers to encourage local production and consumption. Thus, the app acts as a digital marketplace where users can browse different online businesses, search for various products or services, and talk to business owners for special requests and orders. Quality control is maintained through community rating and with the value of trust that the city aims to foster (Figure 11).

Figure 11: The Thrive Local App Model

5.3.2 Marketing the platform to encourage users to support local

To encourage users to support this socially empowering business model, citizens can receive coupons, discounts, and gifts based on how frequently they use the app and engage with online businesses (Figure 12).

Figure 12: The Thrive Local App's Marketing and Economic Sustainability Strategy
(This diagram was created with the help of Napkin AI)

5.4 Volunteering as a Bridge to Stronger Communities

Different social and age groups may need help from others. Whether you need help carrying some heavy groceries or moving around your furniture, The Responsible City Platform connects those who need help with available volunteers who are rewarded with social points and develop a good citizen score, which provides them with education and financial benefits. This promotes volunteering as an essential social value while rewarding citizens dedicated to social good. The key goals include creating "The Responsible City" volunteering platform, establishing the citizen score system, and ensuring safety measures for the volunteering system.

5.4.1 *The Responsible City Volunteering Platform*: Connecting those who need help with volunteers

Through The Responsible City Volunteering Platform, people in need of help can request the aid of a volunteer through the platform, which connects them to an available volunteer (Figure 13). This ensures that people who need help will have support from people who want to be active community members.

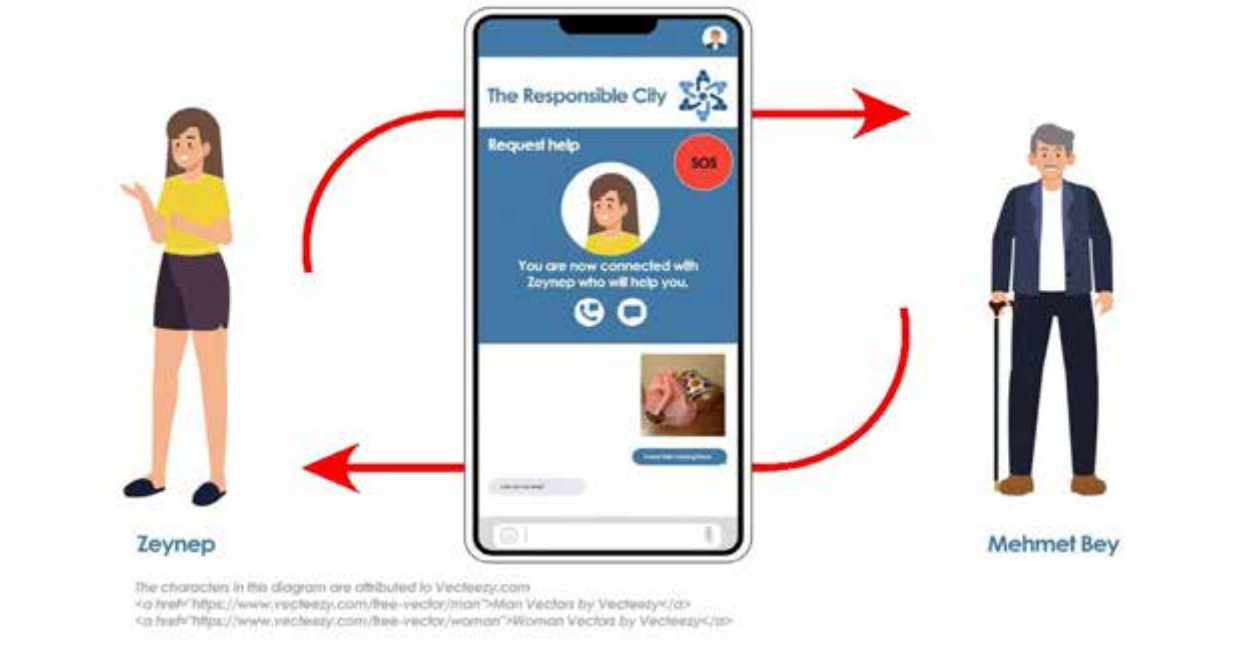

Figure 13: The Responsible City Volunteering Platform Model

5.4.2 The Good Citizen Score as a measure of volunteering activity

Citizens who actively engage as volunteers are rewarded with a good citizen score. The higher the score, the more benefits a citizen can acquire, ranging from financial support to educational fee support, discounts, and volunteering certificates (Figure 14). Furthermore, those who obtain high citizen scores can receive further training to "climb up" the social work and volunteering ladder and have a more effective social role and impact, potentially as a profession or with increased benefits. This fosters a volunteering environment that promotes civic responsibility, which enhances social bonds and connects people.

Figure 14: The Responsible City App Citizen Score and Benefits

5.4.3 Implement safety measures through volunteer training, user feedback, a point system, and tracking

To ensure the model's safety, interested individuals must attend training sessions to learn how to deal with different social and age groups before starting as volunteers. Furthermore, the Responsible City Volunteering app allows both volunteers and help recipients to offer feedback and explain their experiences. Users, whether volunteers or help recipients, acquire a score that reflects their honesty and integrity, and any users with questionable activity can be blocked from the app as a safety measure. Users are also tracked, and the app provides an emergency button if they feel unsafe and want to request help from a third party. Lastly, users may specify certain traits they seek in a volunteer, including gender and age (Figure 15).

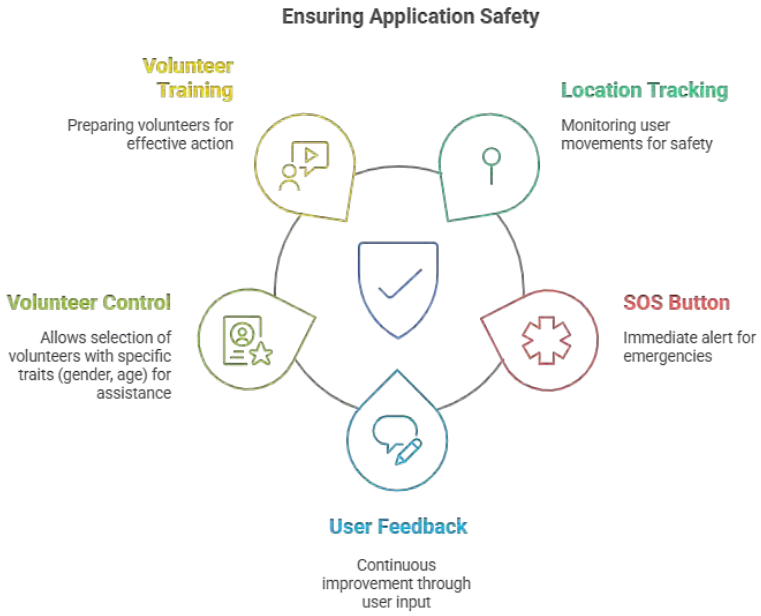

Figure 15: The Responsible City App Safety Precautions and Measures (This diagram was created with the help of Napkin AI)

6. Conclusion

Through an experimental approach, this paper aims to propose a potential smart city model for the selected site in Florya, Istanbul, based on a thorough examination of one of the most prominent examples of a smart city: Masdar City. Taking into consideration the views of influential scholars like Green and Greenfield, the proposed model aims to focus on people and their varying needs while utilising technology to foster community bonds. At the same time, it seeks to adopt simple urban planning and design decisions to render the city more liveable and functional. The Social City helps envision a smart city without heavy technological infrastructure, with a focus on using mobile phones, which are highly available (Figure 16).

Figure 16: A Summary of The Social City's Approach (This diagram was created with Napkin AI)

As this project's approach was more exploratory and experimental, more attention was given to the ideation and innovation process. Thus, a more thorough investigation of the social construct in Florya is required to modify and tailor the proposed solutions accordingly. Further studies should revolve around understanding the community of Florya and their needs and concerns in the form of a participatory process to better understand how the proposed ideas could be integrated with the existing neighbourhood and society.

Initiatives like the "Thrive Local" app and "The Responsible City" volunteering platform advocate for a shift towards participatory and inclusive urbanism; however, potential obstacles, including safety and trust-related concerns, could hinder their progress or render them inefficient. Predicting how people would engage with new ideas is challenging; thus, testing such solutions before their full implementation is essential, and developing efficient and accurate testing methodologies for the proposed ideas could take "The Social City" a step further. Ultimately, The Social City in Florya, Istanbul sets the foundation for an approach that focuses on serving people and meeting community needs with technology.

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Co-Producing the Future: Imaginaries at Work in Spatial Planning Practice

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Abstract
Two emblematic products of imagination reflect contrasting attitudes toward the future. The film Back to the Future evokes a nostalgic longing for a 'good world', while Paul Klee's Angelus Novus embodies the inevitable trail of destruction left by progress. Such tensions are inherent in collaborative spatial planning, where stakeholders are often guided – consciously or not – by divergent imaginaries. Co-producing a shared future requires the alignment of these imaginaries. Generative metaphors can serve as catalysts for convergence. This paper presents a case study that explores how such metaphors can be used to strengthen coherence among fragmented projects and different stakeholder perspectives. While this experimental attempt yielded mixed results, the concept of 'correspondence' – supported by evocative 'thought-images' – emerges as a promising avenue for enhancing collective spatial imagination.

Keywords: imaginary; co-production; metaphor; correspondence; thought-image

Introduction: Imagining Imaginaries

Planning is fuelled by imaginaries. In his comprehensive critical introduction The Urban Planning Imagination, Nicholas Phelps defines this imagination as: '[...] the faculty of forming ideas, images or concepts relevant to the task of city building where these need not be entirely new but instead are the products of an historical stream and geographical diversity of ideas, images and concepts.' (Phelps, 2021:1) Considering that imagination is defined as a faculty or capacity, and images are but one of the results of this faculty at work, we are tempted to define imaginary as the mental construction of a more or less coherent set of ideas, images, concepts, narratives, fantasies, symbols, ... This realm of imaginative representation can vary according to the socio-geographical context and can change over time.

Imaginaries can be individual and collective. Using the terms 'image of the world' and 'universe of discourse', Kenneth Boulding describes a vivid picture of the rich and complex content of individual and shared or public imaginaries. Their multiple dimensions are coined as a complex of 'images': spatial, temporal, relational, personal, value-related, affectional or emotional. These images are modulated by scalar meta-dimensional images: certainty-uncertainty, reality-unreality, public-private, conscious-unconscious-subconscious. His 'organic theory of knowledge' (Boulding, 1977:16) opens ways to 'develop a really adequate theory of behavior' (Boulding, 1977:18). Those imaginaries are necessary for people to understand themselves and their position and role in a context. It means that imaginaries play a crucial role in human behaviour. This proposition is central to our argument: changing imaginaries implies influencing behaviours. And vice versa.

Persistent crises can be the result of ingrained behaviour. Daily, we experience the results from massively spoiling water, sealing the ground, dumping garbage, thoughtless car-driving, ... Stimulating alternative attitudes, knowledge, and practices can be influenced by changing existing imaginaries. Consciously or not, that is what planning processes realise when they are designed to install new conceptual frames, e.g. sustainable development, robustness, degrowth, soft mobility, ...

In this paper, not a world crisis is calling for alternative imaginaries, but a more modest upheaval in a former mining town. A clash about the way industrial heritage is being developed, urged the Municipal Government to appoint a project director and install a quality platform (Schreurs, 2024). From firsthand experience, as project director, I describe the context and condition of this case before embarking on a metaphorical imaginary, which was created to help change the mindsets of the principal actors and stakeholders. Next an assessment analyses the positive results, as well as some setbacks of the initiated process. Thinking ahead towards improving this situation, the concluding reflections concerning correspondence, refer back to the first part, which problematises

co-production from the perspective of imagining futures, and the power of though-images.

1 Co-Production And The Future

1.1 The Future Caught In Imaginaries

1.1.1 A Lot Of Small Actions (Can) Make The Future

The number of challenges calling up spatial planning for transformative actions is dazzling and increasing: climate, water, biodiversity, neocolonialism, (anti)globalisation, degrowth, social injustice, migration, ... In planning literature 'crises' fight for focus. What would be the 'best' way to tackle this planetary crisis? What kind of spatial planning might help to resolve those big issues?

A picture in a street - a sentence on the wall of the UGent rectorial building - hit my imagination: 'The next big thing will be a lot of small things.' For many years, I have cultivated a sensibility to bottom-linked and bottom-up initiatives (e.g. Kuhk, et al., 2019). This explicit formulation on the façade of the university of Ghent's academic seat fueled my imagination ànd my hope for a potentially successful distributed and collaborative planning approach. Could 'many small things' mean: ideas and actions from many people (inhabitants, organisations, ...)? Could the sentence thus mean: ideas and actions from a large number of acting subjects can make a big difference? Then the message 'the next big thing is a lot of small things' means intrinsically the same as: our future is the result of a lot of small actions. But, how can it lead us to a better future? How to organise those many small actions as contributions to shared ambitions and aims? How to reach an immense transformative result, even without a predefined, integral plan in the 'major key' (Stengers, 2005)?

1.1.2 Expecting The Unexpected?

The future is a central issue in planning. On a regular basis, planning literature is harking back to future's uncertainty (e.g. Hillier and Healey, 2010). The character 'future' is indeed ambivalent. How drastically diverging the imaginaries about the future can be is illustrated by Jacques Derrida's witty reflection on the difference between two common French words for 'future': 'There's a future that is predictable, programmed, scheduled, foreseeable. But there is a future, l'avenir (to come), which refers to someone who comes, whose arrival is totally unexpected. For me, that is the real future.' (White, 2007:407) Such differences often stay unnoticed, while tacitly playing an immense role both while making plans and while discussing or implementing those plans.

1.1.3 'Back To The Future' As Imaginary

How important it is to be aware of the differences between contextual imaginaries can be illustrated by two emblematic narratives: a movie and a painting. Both implicitly value 'what comes' and the relevance of change, while they stage two different attitudes towards the future. Robert Zemeckis' movie Back to the future cultivates the longing for flying back from the past world of 1955 to the 'good world' of 1985. Paul Klee's Angelus Novus captures the catastrophe of progress, inevitably driving him forward into the future. Adolescent and Angel both stand with their back to the future, however, with diametrically opposite attitudes. Marty knows the future and wants to go back, but cannot because his car needs the power of plutonium, not yet available in 1955. The Angel does not know the future but is frightened to go there because it only sees the devastation of 'progress'. For one, 'future' is a brilliant destination; for the other, 'future' is leading away from paradise.

A similar ambivalence concerning the future is looming into spatial planning. With their back to the future, planners cannot 'see' the future, but have to deal with the present, using assembled knowledge and experiences from the past. Past and present are fueling imagination. Now, imagine planning initiatives for a 'better future' when some actors around the table believe in gradual improvement (e.g. thanks to technology), while others only see further degradation (e.g. also due to technology)! How to bring them into the same imaginary? How to change their attitude?

This insight about tacit imaginaries, which are potentially contradictory, results from Walter Benjamin's interpretation of the Angelus Novus. This critical analysis of history's presumed linearity of progress, offers a clear example of his famous 'Denkbilder' (Richter, 2007). Interpreted as 'thought-image', Gerhard Richter not only uses

this concept as a critical lens, but also acknowledges its 'formal site for singular and unpredictable – but not arbitrary or facile – acts of conceptual creation' (Richter, 2007:18) It illustrates both the richness and the power of (tacit) imaginaries. Imaginaries help think complex issues in coherent ways, and are instruments for innovation. This touches upon the focus of this paper: how to influence or create imaginaries for the sake of a better common future?

1.2 Co-Producing A Future

1.2.1 Challenging Co-Production

During the complex quest for concepts, strategies and instruments, collaboration is a crucial factor in spatial planning. Rightfully, it is promoted by many scholars and professionals. The circulation of a multitude of terms collaboration is dealt with in literature (e.g. co-creation, co-production, collaborative, coalition, collective...) is an indication of some confusion concerning meaning, relevance, and applicability of this concept. These span from normative (e.g. Albrechts, 2012) to functional (e.g. Medina-Garcia, 2024). Multi-actor collaboration is a major condition within planning situations, not limited to analysis, research and design, but extending into operational aspects such as action programs, communication, and implementation. In this paper, such situations will be labelled as co-production.

The practice of collaboration is not obvious. 'Co-creation and co-production [...] relate to the broader challenge of combining different types of knowledge and experiences in collective learning trajectories' (Medina-Garcia, 2024:14). Actors then have to work in processes of joint problematisation and building shared meanings (De Blust, Devisch and Schreurs, 2019). Many stakeholders need to be informed, motivated and mobilised while they are preparing to invest their creativity, time, and money in realising a project. The always present diversity in values, knowledge, experience, and means does not help to bring and keep stakeholders easily on the same track. Moreover, the actual turbulences urge planners to include and integrate knowledge and goals from an increasing number of specialist fields of research and practice: climate, biodiversity, water, energy, health, food, justice... . In addition, within participatory processes, stakeholders arrive with diverging models and imaginaries of what it means 'to collaborate': some 'take part' while others 'take a share'; some work in a complementary way while others invest (care) in a common project. Different attitudes, aims, interests and means only reinforce tensions between those images. It means that collaboration is co-laborious. How to deal with those frictions? How to create coherence?

1.2.3 Metaphors As A Medium For Changing Interaction

Metaphors are an intrinsic part of our language, shape our thoughts, and influence actions (Lakoff and Johnson, 1980). Evidence from research learns e.g. that people who think about crime as a beast or as a virus defend different remedies: more police and severe penalties versus better education and more jobs (Dekeyser, 2018). Within a context where collaboration between diverse actors with divergent backgrounds is essential, metaphors can play an important role. As creative device, metaphors produce similarity. They can make actors see sameness notwithstanding difference (e.g. 'argument is war', 'ideas are objects'). Thus, metaphors integrate by making connections between unlikely ideas, aspects or objects, often in a novel and unexpected way, creating new understanding. As framing device, metaphors can serve to reframe thoughts and practices (e.g. learn to see 'argument as dance' and not 'as war'), thus offering a similar perspective to different actors in a co-ordinated way. As epistemological device, metaphors can work integrative because of the unifying meaning of their 'vehicle' or referent that conveys the comparison (e.g. 'love is a collaborative work of art'). Metaphors' emotive character (Schön, 1979) helps to engage persons into such shifts. Thus, by introducing a well-tuned mix of metaphors, the ideas of different actors can be stimulated to shift from their evident meanings towards referents with a collective or/and integrative character.

For the case analysed in the paper, three referents played a role as generative metaphors (Schön, 1979). Ship, beacon and wayfaring were metaphorically mobilised to help look in a systematic way at the 'planning ecology' at stake (Schreurs, 2024). They were introduced to respectively frame the intended change of the character of the planning process, to guide diverse projects towards coherence, and to offer a medium for the co-ordination of ideas and activities.

1.2.4 An Experimental Co-Productive Setting

This paper analyses a specific planning practice where collaboration is a structural condition. In Beringen-Mijn, a public-private-partnership (PPP) is responsible for the urban renewal of an extensive former industrial coal mining site. As project director and chair of a multi-disciplinary quality platform, I am expected to help pilot the planning process towards a high level of spatial qualities and coherence. It is my privilege to observe and assess what is happening in a real-life instance of intense collaboration among a multitude of actors.

Within each project, steps can be intentionally induced due to my responsibilities. Whenever appropriate, transformational imaginaries (e.g. 'mine-landscape'[i]) or co-creative actions (e.g. research by design) could be introduced to generate changes in ideas or practices. The resulting dynamics are at least partially motivated by such steps in the projects. Linking those effects to infused imaginaries and actions allows to learn for next (steps in) planning processes. Although this local situation is not comparable to the more global crises often referred to, I see this case and the lessons learned as a modest experimental action research concerning the power of imaginaries in strategic spatial planning.

2. How To Co-Produce In Beringen-Mijn?

2.1 A Case Of Structural Co-Production

2.1.1 A Partnership With A Vocation

One possible way of grasping the accuracy of imaginaries in a critical way, is to learn from cases. The case is 'Beringen-Mijn', a district in a mid-sized Belgian city, developed out of a huge coal mining plant. From motor of prosperity, this miner's district became a monumental burden when the mine closed down. On October 28th, 1989, status, conditions and perspectives of the historical mine site gradually tilted in terms of physical problems (large derelict land, empty impressive industrial buildings, abandoned heritage, a worn-out garden city, ...), social tensions (spatially isolated and socially divided communities of migrants and newcomers, ...), and mental disruption (loss of work and collective ethos, traumatic history, emptied signifiers, ...).

Its enormous heritage became a heavy financial burden for the central government, which had to take care of the social passive, as well as of buildings and infrastructures. Dwellings in the 'cité', the miners' garden district, were sold rather cheaply, preferentially to renting inhabitants. The empty industrial buildings and warehouses deteriorated while being 'mined' by copper thieves and urban explorers.
Typically, such burdens also have a huge potential for new developments.

2.1.2 Heritage As A Field For Development

From dynamic productive machine, the mine turned into a complex of massive heritage, which was listed in 1993 and 1994. Considerable amounts of subsidies became available for these protected buildings, but this came with an ambitious vocation. Being listed implied conserving a coherent image of a complete mining plant, enabling to demonstrate, to explain, and to experience its former role and functioning. This huge expectation was motivated by the production unit's representativity and grandeur, its age, completeness of buildings and installations, architectural and technical value, state of preservation, compactness, clarity, present complementary activities, the presence and location of two slag heaps (Team Vlaams Bouwmeester, [2019]). The immense coal washing plant was the main reason for this entrusted vocation. With its four parts, it was formally and functionally the heart of the industrial complex (Figure 1, 2), and Beringen was the only place of preservation of such plant in the mining region of Limburg.

To implement this vocation, a public-private-partnership (PPP) was founded in 2009. This was formalised as a public limited company, named NV be-MINE, with the goal to restore, renovate, and repurpose the former mining site. A reconversion plan was made in which the destination of the mine site was seen as a touristic-recreational project. It had to comply with a new local legally binding plan (Bongaerts, 2000) that defined the location as a

i In this paper, I introduce the term 'mine-landscape' to denote a dual perspective: it refers to the physical landscape shaped by extractive coal mining; it also evokes a personal, subjective relationship to that space. The hyphenated form intentionally plays on the possessive pronoun 'mine', suggesting both territorial belonging and emotional or mnemonic attachment.

zone for urban development. The restoration and re-use of the plant was gradually implemented.

When the NV be-MINE asked the responsible minister to drop the heritage label for two of the four parts of the coal washing plant, the project took a dramatic turn in December 2018. The entailed compulsory public investigation provoked a gulf of national and international protest and pressure, and resulted in 1.311 notices of objections. Instead of coming to a head using legal procedures, the minister preferred to find common sense amongst the development consortium and heritage associations.

Figure 1. Painting (1957) of mine site with huge coal washing plants in the centre
Figure 2. Condition (2021) of coal washing plant

2.1.3 Problematising The Case

Looking for a way out of the conflict, the Flemish Government Architect was asked to mediate between the stakeholders. Reporting optimistic principles for a constructive consensus, he ventilated severe criticism as well of the way the PPP was managed. His report identifies a lack of coherence and co-ordination between stakeholders and their initiatives as one of the major objectionable aspects of the ongoing development on the mine site (Team Vlaams Bouwmeester, [2019]). Precisely this argument convinced the Municipal Executive (board of mayor and aldermen, in Dutch: College van Burgemeester en Schepenen or CBS) of the city of Beringen to take bold measures in 2020. Enlarging and re-qualifying drastically the former 'quality chamber' (kwaliteitskamer) and installing a project director (projectregisseur) explicitly aimed at fully integrated development in co-production (CB&S, 2020a). In line with the advice of the Government Architect, success was expected from two goals. Synergy and added value had to be found within an overall long-term vision on a larger scale; coherence between projects should be steered systematically and supported by all relevant actors. It would be the project director's responsibility to guard sufficient coherence and co-ordination among all current and future projects, both content- and time-wise, while pursuing cross-pollination and societal added value (CB&S, 2020b). This decision of the Municipal Executive launched a trajectory of redirection, and the direction was clear. A vision would focus on a much broader work field than the coal washing plants and was even extended towards the complete mining site. At the same time the Executive enumerated a list of at least 15 projects that waited for co-ordination, in co-production with the many partners involved: private developers and their architects, city government and administration, provincial government and administration, Flemish Government Architect, Flemish Heritage Agency, local and regional heritage associations, organized local stakeholders, and individual inhabitants.

2.1.4 Development By Bits And Pieces

The Government Architect's evaluation quite precisely assessed the situation on the field. The ex-mining territory had been compartmentalised into lots, and the fragments were declutched under separate ownerships. About 11 ha. were split off to realise 'Houtpark', a new housing district. On newly created plots between the listed historic buildings, a private swimming pool, a restaurant, and a shopping boulevard had been constructed. Besides the existing tourist reception and small mine museum, parts of the old mine buildings had been reused for nursery classes, a climbing hall, a banquet hall, a bike shop, and offices. The former thickener of the coal-washing process had been transformed into a diving centre. The largest part of the listed buildings was still empty. However, plans

were already on the table. The main spaces would be used for an experiential museum, focusing on the 'path of the miner', to be run by the province of Limburg. The technically worst part would be partly opened up to invite trees, light and rain, and partly be transformed into a casco, to be sold piecemeal.
Ownership of the partial project on the site was already given to separate stakeholders: NV be-MINE, province of Limburg, city of Beringen, region of Flanders, social housing company, school community, private families, and investors. Only NV be-MINE had a clear development model: restore listed buildings supported by subsidies, find a new, fitting program, transmit (part of) the building to third parties, by selling or establishing a long-term right in rem (e.g. long lease). Without intervention, the demonstration of a complete and coherent coal-mining history, as the minister was expecting when listing the building, would obviously not be the result of the ongoing development.

2.2 Creating An Imaginary By Images And Metaphors

2.2.1 A Working Program Fitted For Change

From the previous section we learn that levers for easily steering the coherence between projects were already gone when the project director could start to remedy. Because of the distributed 'ownership', the situation was an amalgam of collective and individual actors, each with their 'own' goals, means and trajectories. To cope with this situation, the Municipal Executive of Beringen approved my proposal for a twofold approach: conceptual and process-oriented (CB&S, 2020b). It combined Maarten Hajer's conviction that socio-spatial transitions need a shared 'imaginary' ('denkbeeld') (Hajer, 2016), with George Brugmans' three-step approach for a 'sabbatical detour' (Brugmans, 2016). In my proposal for the working program (Schreurs, 2020), the suggestion of the Government Architect to instrumentalise the 'power of designerly research' (Team Vlaams Bouwmeester, [2019]) would find a productive 'locus' in three successive workshops with the crucial stakeholders. Each workshop would deal with one of three cohesive questions. First: What do we aim at? How do we collectively look at the city-district Beringen-Mijn (including the ex-mining site)? Second: What can we aim at? How can we together articulate and discuss the desired qualities for Beringen-Mijn? Third: What will we do? How will we work conjointly while developing Beringen-Mijn?

Content-wise, the essence of each question was illuminated by supporting images. Making or choosing inspiring paintings or pictures was suggested as a guiding beacon for stakeholders' later designs. Collectively developing a 'language for quality' could eventually function as a metaphor for both understanding each other's aims and for agreeing on appropriate manners. Collectively planting and caring for a tree was foregrounded as a conceptual image for 'growing' a collaboration.

2.2.2 Becoming A Fleet

The overarching metaphor of the text was 'becoming a fleet'. The collective search for a common perspective on both the socio-physical context and the collaboration was explicitly framed within the metaphor of 'projects as ships'. Inspired by the actual, fragmented situation, I conceptualised the ongoing diverging projects as individual 'ships' with autonomous commanding officers, following a singular route towards their predefined destinations. However, to attend to coherence between these projects, captains should start thinking and acting as a collective, as a 'fleet' heading for a common destination: to realise, each for her or his part, the vocation of the ex-mine site. To reach out for that destination would demand a decisive tack, a specific twist in each ship's course. Ships' noses needed to be redirected, sometimes drastically. Imagining how wind or weight can influence the course of a ship makes us aware of the careful manoeuvre needed, but also of the energy, time and risks involved.

Since no predefined goals in terms of form and program were available, a 'beacon' for the new directions had yet to be defined collectively. And since that beacon would become defined en cour de route, a co-creative process of collective learning seemed an appropriate image to frame the future trajectories of the captains, to be defined and redefined continuously and collectively.

2.3 From A Nautical Imaginary To A Territorial Practice

2.3.1 Mine-Landscape As Common Beacon

The working program proposed to the CB&S conceptualised the quality platform as 'locus of co-production'. This platform was not only meant to be the 'place' where actors would meet to find out why and how to co-produce the different projects, but also as 'moments' of effectively co-producing a collective.
During the first meeting of the quality platform, developing shared imaginaries as 'beacons' to co-orient the 'noses' of 'ships' was presented and discussed as a success factor for co-production. As guide for qualitative development of Beringen-Mijn, the quality platform formulated a mission-and-vision statement concerning the expedient rectification of ongoing courses of the projects (Kwaliteitskamer Beringen-Mijn, 2021). In line with the Government Architect's suggestions, this text expresses enduring concerns about a mutual attuning of projects, in space and time. That mission is taken up by a vision which promotes working within interdisciplinary, integrating frameworks. The basis of their articulation is the explicit ambition to work towards sustainable development and socio-spatial qualities, but first and foremost towards a coherent mijnlandschap (mining landscape, or mine-landscape), articulated at different levels of scale. Within this perspective, open spaces, heritage and community are foregrounded as its most important facets. The focus of the vision is on links amongst, and within these facets, both on the short term (masterplan, project) and on the long term (strategy, management).

The choice for 'mine-landscape' as beacon may seem obvious, but has a fourfold motivation. First mijnlandschap is a common name in Beringen-Mijn, known and used by most stakeholders. This term does not sound far-fetched or strange, and mentally covers the territory in need of coherence. Second, 'landscape' is a concept most people can attach to easily. Everyone has an image of landscape and sees making a landscape most of the time as a positive action. Third, because of its common and positive connotations, inhabitants feel attached to the process because the term landscape – and even more: mine-landscape – makes them feel it is about 'their' habitat. Finally, because the concept is understood by most participants, but is also sufficiently plastic, landscape can work as a bridge between different individual or social imaginaries. It can be interpreted differently across social worlds, but with enough immutable content to maintain integrity. Therefore, mijnlandschap can function as a 'boundary object' (Star & Griesemer, 1989), a means of translation to help sustain coherence within the imaginaries in progress.

Figure 3. Collectively generating design ideas for Beringen-Mijn
Figure 4. Design presentation and dialogue during design week

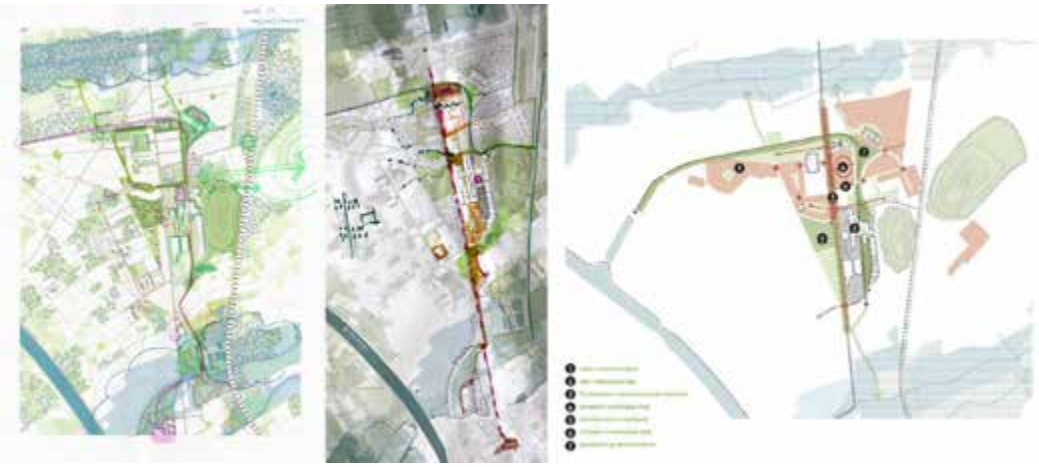

Figure 5. Strategic project interpreted by the quality platform
Figure 6. Designerly researching with the Flemish Government Architect
Figure 7. Structure sketch for Beringen-Mijn (© BUUR PoS)

2.3.2 Wayfaring Through Design-Based Workshops

An always compromising practice of priorities and agendas was responsible for a less strict working scheme than the setup of the 'sabbatical detour'. The trajectory of the projected 'tacks' involved more than three steps. Rather than rolling out a clear-cut route ahead, the pioneering search for a common definition of 'mine-landscape' turned into adventurous wayfaring. Although aims did not change, partners did fluctuate, depending on evolving dossiers, progressing insights, and personal affinities. In practice, the three thematic questions – concerning exploring aims, articulations, and actions – intertwined iteratively. This was not completely unexpected: both gradually articulating qualities more clearly and reshuffling coalitions of practice can lead to shifting ways of seeing the territory and its vocation, as well as each other's ambitions and attitudes. Nevertheless, two factors were kept constant: the middle of the table was always occupied by maps, plans, pencils and pens, and the idea of 'landscape' was never obliterated (Figures 3 and 4).

During the first 'internal workshop' of the quality platform, external experts and civil servants of the city administration prepared a new vision framework. Inspiration was found in a situation scan published by the team of the Flemish Government Architect (BUUR, 2021). This tool is offering a socio-spatial diagnosis to local governing bodies, highlighting spatial and executive strongholds and weaknesses concerning the communal territory. Stimulating a local agenda-setting of projects and policies, the scan articulates potential strategic projects. One of these projects – 'Augmenting living quality and improving the spatial structure of Beringen-Mijn' – was assessed and evaluated by the participants. Collective brainstorming produced alternative design ideas suggesting new green connectors at the scale of Beringen-Mijn. These would also strengthen cohesion between green and blue open space structures to the East and West of the central nucleus (Figure 5).

As a next step, a 'week of design and dialogue' was organised. Developers, associated designers, inhabitants, external experts, administrations, and aldermen collectively contributed by offering ideas for and comments upon the strategic project (Figure 6). Simultaneously, designerly imaginations produced a first version of what would be elaborated later into a spatial structure sketch for Beringen-Mijn. The central figure is a landscape structure of two parallel north-south axes: a functional city boulevard lined with urban services, and a recreational green connector for soft mobility. This idea was complemented by a set of seven possible actions to interconnect these axes and the surrounding cité (Figure 7).

Next, an extensive series of 'advisory design workshops' was organised, bringing together NV be-MINE, city ad-

ministrators and representatives of the quality platform. Spread over several months, this group discussed and designed innovative but feasible proposals for the use and layout of coal washing plants 1 and 3. Breaking away the worst parts of the structure should enable incorporating nature and enjoying it while growing. Although spatially invasive, this intervention was going to serve as a flag and symbol for a 're-nature' strategy, ambitiously framed as philosophy and essence of the whole redeveloped ex-mining site, and gradually applied as landscaping strategy.

In parallel, intensive 'research by design' played a decisive role in an extensive trajectory of meetings and workshops, aiming to complete the necessary plans for receiving a building permit for the new living quarter, 'Houtpark'. Starting with a declaration of intent, signed by NV be-MINE and the city of Beringen, these partners launched a steering committee, also incorporating members of the quality platform. After ten months of co-production, the result was 'Houtparkboek', an abundantly illustrated quality guideline, stimulating future designs beyond building regulations (SWECO, 2023). With its qualifying descriptions and visual references, this book gives designers and administrators tools to grasp the desired qualities of buildings and generous landscape connectors between the existing cité and the new quarter.

2.3.3 A Meshwork Of Interactions As Armature Of Co-Production

In line with favouring effective co-production, the mission-and-vision text expresses a clear intention: 'The quality platform's way of working should lead to incorporating this vision as an evident dimension of ideas and practices of crucial stakeholders and actors' (Kwaliteitskamer Beringen-Mijn, 2021; my translation). This ambition to structurally enrich the stakeholders' imaginaries was intended to be realised within a process of co-productive trajectories: during numerous conversations and dialogues, while constructing narratives about interaction, coherence and co-ordination, and during designerly research, while drawing and representing imaginative mine-landscapes.

The series of workshops already described is a good example of such trajectories. Those ran simultaneously with numerous meetings of the quality platform (hosting external experts with different backgrounds, major and aldermen, civil servants; inviting developers and designers related to the project discussed) and project-related or thematic mixed working groups. Depending on the project at stake, its character, importance, and timing, either the quality platform or ad hoc working groups (including some representatives of the quality platform) discussed intermediate proposals or engaged in more intensive dialogues with partners and stakeholders.

Gradually, the frame set during the 'week of design and dialogue' was enriched. Spatially, the structure scheme served as reference for a following series of projects on the agenda: a lightning plan for the public space on the mine site, renovation of the park surrounding the former mine director's villa, new building regulations for the garden-district mine cité, urban role of the listed former football-stadium, defining principles for the destination and development of the former water-tower, extension of the logistic park at the former coal-harbour, new policy for development and access of the southern hinge of Beringen-Mijn, destination of the restored coal-washing plant, landscape plan for Houtpark and design of the first phase of the housing-development, trajectory for a regional cycling-path, building plans for a kindergarten, renewing the school playground, ...

Analogous to the idea of 'landscape', throughout the whole process, elements were systematically situated within their context, and not given meaning without that larger picture. E.g. inspired by their original way of functioning, each coal washing plant was systematically valued in terms of complement to the three others. E.g. the relevance of building new dwellings was explained in terms of what the housing quarter will receive from, and what it will offer to the larger environment. E.g. the water tower was evaluated in terms of potential local facility, generous entrance to the park, historic demarcation, and visual signal.

All these wayfaring trajectories entangle, because – often – the same actors were meeting about many projects, in different constellations, on several occasions. Even without intersecting in conclusions or clashes, their ideas, arguments and suggestions nevertheless were influencing each other, similar to how the lines walked by pedes-

trians on a footpath develop along and with each other. Together, the bundles of narrative and designerly lines weaved a co-productive meshwork of actors, intentions and actions, into a potential armature for continuing development.

3. Evaluation And Reflections

3.1 Flourishing Development

Although turbulent at times, everyone structurally involved agrees about the positive results of four years of work. Two projects, formerly heavily criticised, were given formal permission to start implementing: the reconversion of two listed coal-washing plants and the development of a new housing quarter. Meanwhile, aspects of social and spatial sustainability improved throughout the site: re-nature became the main principle for the landscape design; stocks and infiltration of water are reinforced by new WADI's; substantial open space on the mining site is safeguarded; relationships between inhabitants and developers relaxed; collective heating is discussed and calculated for feasibility; experiments with timber frame construction are on the way to implementation; cycling and car sharing are systematically put at the agenda.

An evaluation of the process is promising. The design-and-dialogue week was emblematic of the planned approach. A co-created structure sketch shows opportunities for strengthening spatial and functional coherence between the new projects, the urban facilities and the housing district of Beringen-Mijn. Actions needed to operationalise those opportunities were identified. Moreover, designing the structure sketch staged formerly 'tacit' elements of the new 'mine-landscape': infrastructure, suburbanisation, centrality, mixed use ... and the open heath landscape where this all settled. Innovative ways of interaction between developers, the city, external experts, and inhabitants established intensive exchanges, especially during the design week, participatory dialogues, collective biking, co-visiting coal washing plants and relevant external projects. As a result, mutual understanding grew between planners, developers and inhabitants.

3.2 Flagging Imaginary

However, ambition and trust amongst the quadruple helix involved (PPP-developer, city government, social actors, external experts) gradually lost track. Looking back, several contextual reasons influenced this loss. Two key actors of the 'first hour' – the strategic manager 'environment and city development', and the director of NV be-MINE – left the scene and were replaced by less experienced and poorly networked newcomers, lacking precious contextual knowledge. As time went by, the developer gradually became more nervous about the increasing imbalance between cost and gain. Consequently economy of means burdened discussions about spatial qualities of the public space. Expenses for designers were cut, and design workshops were no longer organised.

Moreover, the option to collectively shape the beacon mijnlandschap (mine-landscape) during the wayfaring process, together with its metaphorical expression, probably led to an unthought-of flou artistique. Indeed, this option implied instrumentalising only a short description of the nautical imaginary, conveyed to the quality platform when starting, with no showing off to the public. While its facets and principles functioned as a source of inspiration during dialogues, the mission-and-vision text of the platform was never published. Probably more important was the absence of a figuration of the proclaimed beacon. The 'content' of the pursued mine-landscape was not addressed in a tangible way, other than stories. As a result, the beacon loomed up as a rather foggy silhouette. Moreover, the short narrative of ships tacking to a collective beacon might have generated a rather one-dimensional imaginary of projects with one final destination, to be reached within a limited time frame, one project at a time. The continuous and collective care, which will be needed to keep the mine-landscape in good shape, leached from the image. The time necessary for creative wayfaring, as well.

3.3 Strengthening The Landscape Of Correspondence

Regarding this situation, the motivation to hark 'back to the future' is growing. Implied questions are: How to construct a performative shared perspective on the world, that spurs a commonly supported goal-orientation and enables enduring practices? What kind of imaginary (as imagined representation of the future) can help to make the beacon 'mine-landscape' stand out of the fog?

3.3.1 Correspondence Needs A Language For Quality

Co-production is primarily social interaction, as demonstrated in the case description. Interestingly, Tim Ingold spells out two modalities of relationship among acting subjects: 'between' and 'in-between' (Ingold, 2015). For instance, communicating by letters, people bridge the distance in space and time between them by informing each other about matters of interest. These letters are written with an intention. But in sending, waiting for an answer, reading, answering, expecting, ... respondents also generate a flow of in-betweenness. 'Thus while letters may go back and forth, the correspondence has no starting point or end point. It simply carries on.' (Ingold, 2013:105) And, importantly, this 'midstream' of correspondence, this movement is sentient. 'To read a letter is not just to read about one's respondent, but to read with him or her.' (ibidem) Writing and answering embody a flow of attention.

Ingold frames continually answering to one another as a 'correspondence of lines'. According to him, this concept is relevant for many areas of human relationships, such as kinship, economy, religion and politics (Ingold, 2015). I see no reason to exclude spatial planning. To get an implementation-oriented design made, authors with diverse disciplinary backgrounds need to create occasions to communicate, with the intention to exchange ideas, test them designerly, critically discuss proposals, and translate them into decisions. In Beringen-Mijn, many such connecting moments were established between actors during every project. Those interactions served the articulation of matters of interest: functional intentions such as making timelines or setting agendas; or qualitative intentions such as goal-setting, discussing referential projects or enriching successive sketches.

The importance of an attentional 'ecology of correspondence' (Ingold, 2015:155) is, however, highly undervalued, though crucial for long-term success. City development is more than delivering enrolled projects. Upcoming projects to anchor and strengthen still vulnerable societal aims, need to be welcomed. Management and enduring care are necessary to keep results in good shape. Actions of inhabitants and builders should capture the guiding imaginary, and carry this on. To ensure this ongoing correspondence continuity, a language to articulate matters of concern becomes a crucial condition. Let's call it a 'language for quality'. Mastering and continually enriching such an in-betweening language will be necessary to capture and convey crucial interpersonal aspects of affect, such as building trust.

3.3.2 Correspondence Needs Translation

Considering some hindrances of the co-production in Beringen-Mijn (different actors depending on projects, personal changes, more projects to go, ...), it seems important to strengthen the long-term dynamic of correspondence.

Co-producing a beacon was expected from wayfaring through a collective mental landscape. During the numerous meetings, words and images of many participants were reassembled by dialogue and design along imaginative lines of thought. Often, those were open ideas and reflections, not necessarily meeting in a final design. Usually, they developed along and with each other, as entwining lines, sometimes interweaving, sometimes knotting. Together, they form a meshwork of mental paths, as memory of collective learning. This imaginative memory was, however, never grounded in a synthetic representation, e.g. an inspiring landscape design.

Within the quality platform, the idea is looming that this memory for the future might be backed up by a contextual thought-image. To make developing lines of thought of engaged actors enduringly tally with the overall vocation of a coherent mine-landscape, a 'transducer' (Ingold, 2013) will be useful. Such representation could help to translate the flow of ideas about 'mine-landscape' from the register of actors' ideas (concepts, values, engagements, interests, ...) to the register of actions (designing, qualifying, calculating, constructing, ...). Gradually, the concept for such a thought-image is being developed already by synthesising and enriching existing maps, projects and images of the mine-landscape. As a start-up, a first attempt was included in the evaluation report (Schreurs, 2024b). A collage of projects-in-the-making on the map of actual Beringen-Mijn hints at a future-to-be-made of the evolving mine-landscape: a 'landscape of landscapes' (Figure 8).

Figure 8. Future Beringen-Mijn: a landscape of landscapes (collage of 3 plans)
Figure 9. Eidetic thought-image 'seeing-being-caring' (© Jan Schreurs)

Prospect
Co-producing an open, more artistic visual representation could probably be a well-functioning and richer planning method (Phelps, 2021) to seduce or persuade actors into an engaging correspondence. Inspired by two examples from Richter (2007) – Benjamin's staging of the Angelus Novus, and the structure of Baroque emblems – the format of a three-fold thought-image seems promising.

First, the name mijnlandschap (mine-landscape) can be transformed into a conceptual 'motto' by 'estranging' the word into mijn|land|schap. In Dutch, this decomposition evokes both mine-land-scape and my-land-scape. Each component carries layered meanings: mijn (mine) refers to personal perception and appropriation, land (land) to the geological and biophysical characteristics of a place, and schap (scape) to the collective ownership and care of a shared environment. This linguistic and conceptual shift opens up the notion of landscape: from primarily optical to haptic, from individual to collective, and from static to dynamic.

Second, a triadic lens may help to articulate this broadened perspective in three dimensions: zien & zijn & zorgen (seeing & being & caring). An interpretive commentary or 'epigram' can highlight the interplay of engaging personal experiencing, social living and timely caring. These dimensions capture the mine-landscape as 'the sum total of actions that people and groups undertake to build and shape their environment' (Oles, 2014:22).
Finally, a layered 'icon' can function as an 'eidetic' image (Corner, 2014), expressing those dimensions in terms of place, meaning and use (Figure 9). As an open collage, with changeable pictures, this is an artistic/poetic invitation to 'a way of thinking that is neither instrumental nor representational but simultaneously both' (Corner, 2014:250).

This emblem or thought-image for the mine-landscape, is a potential canvas for a 'language for quality'. The combination of a vocation (motto), a grammar (epigram) and a vocabulary (icon) allows stakeholders to explore the landscape of common concerns. By collaboratively layering (representations of) place, meaning and use, they can discuss how the mine-landscape will not only be materially transformed but also personally and culturally inhabited.

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Sensemaking In Urban Experiments: The Case of Barcelona's Superblocks

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Abstract
This research analyses the Superblocks initiative in Barcelona within the broader context of urban experimentation. It assesses whether the participatory process adopted aligns with the constructs formulated within Weick's (1988) concept of enacted sensemaking. The research uses a thematic analysis of the minutes from 11 participatory meetings that took place before, during and after the project. The results emphasise the importance of considering the overlooked identity dimension when planning future projects, as this can promote social learning. This study addresses the current lack of literature bridging the gap between urban experimentation and organisational change theories.

1. Introduction

Recently, a substantial body of literature on urban experimentation has emerged, offering a relevant, inclusive and practical approach to system innovation and structural change in contexts of urban uncertainty and ambiguity (Raven et al., 2019; Sengers et al., 2018, 2019). By promoting piecemeal interventions and gradual changes to the urban landscape, urban experimentation enables deep-rooted transitions and adaptations to urban reforms, encouraging support and legitimization of these measures (Evans et al., 2021). Consequently, urban experimentation has become a central concept in sustainability transition literature, with urban and transition studies scholars exploring these processes and how urban experimentation can influence broader transformational processes (Raven et al., 2019).

Urban experimentation has also been situated in the context of complex systems (Sengers et al., 2018) and thus in the context of complexity theories. Rittel & Webber (1973) first developed the concept of 'wicked' or complex problems in planning, conceptualised as issues shared by multiple stakeholders with competing perspectives, conflicting interests, different types of uncertainty and significant intangibles. Urban structures tend to evolve through cooperation rather than being dictated by a central planner (Rittel & Webber, 1973). Portugali, one of the most relevant authors on complexity in urban contexts, has elaborated on the concept of urban self-organisation (Portugali, 1997), derived from Haken's (1980, 1985) synergetics, to describe urban structures. The call for a trial-and-error, as found in complexity theories of cities (CTC), makes planners participants in a 'huge self-organising process' (Portugali, 1997). This approach helps to connect complexity theory with the exploratory nature of urban experimentation.

The concept of learning is central to both urban experimentation and complexity (Sengers et al., 2019). Approaches to urban experimentation that are relevant to this focus on the learning processes initiated by these experiments, such as transition-oriented experimentation (van den Bosch & Rotmans, 2008) or strategic niche management (Seyfang & Haxeltine, 2012). Meanwhile, concepts such as double-loop learning (Sterman, 1994) and adaptive and generative learning (Senge, 2003) frame learning in terms of complexity, locating it at the level of assumptions, behaviours, norms, and interpretative frameworks.

Yet, despite the clear link between urban experimentation and complexity, there has been no systematic interaction between the former concept and relevant complexity-related organisational theories. These theories encompass a broad range of research, including Lewin's action research (Lewin, 1946, 1947), systems approaches (Checkland, 2000; Ulrich & Reynolds, 2010) and enacted sensemaking (Weick, 1988, 1995).

This research aims to demonstrate the undeniable utility of organisational theory, particularly Weick's (1988,

1995) seminal work on enacted sensemaking, in the context of the uncertainty and ambiguity of urban experimentation (Sengers et al., 2019). Sensemaking is the process of interpreting cues about reality to create knowledge about a given situation (Weick, 1988). In short, sensemaking involves placing an input within a framework (Weick, 1995). Understanding these concepts enables better control of appropriate enactment strategies, which can facilitate new approaches to urban experimentation.

This paper uses a framework drawn from Weick's work (Maitlis & Sonenshein, 2010; Weick, 1988, 1995) to investigate perhaps the most iconic case of urban experimentation: Barcelona's Superblocks. The aim is to determine whether the Superblock project addressed the principles of enacted sensemaking, and to explore the potential benefits of doing so.

The paper is structured as follows. The 'Context' section provides an overview of the Superblock project with a focus on Sant Antoni and offers a brief summary of the concept of sensemaking. The 'Research Framework' section adapts the three meanings of sensemaking to the research framework used. The 'Research Methodology' section details the principles of the thematic analysis performed and outlines the documents used. The 'Results' section explains the objective outputs of the analysis and presents categorisation examples for each analysis topic. The 'Discussion' section presents the research's key arguments, linking the discussion of sensemaking to urban experimentation and learning. Finally, the 'Conclusion' section summarises the key findings and suggests avenues for future research.

2. Context

2.1 The Experimentation of the Superblocks

The Superblocks Project is a flagship initiative launched by Barcelona's city council in 2015. The project involved creating clusters of traditional grid-shaped city blocks with car-free public spaces within them. Implementing these superblocks required severely restricting car access to pedestrianised areas and changing traffic flow, with main car traffic being diverted to neighbouring streets. The project aimed to create urban spaces that are more pedestrian-friendly and suitable for children and other vulnerable groups, while promoting more sustainable mobility.

The first superblock was introduced in the Poblenou neighbourhood in 2016, with further projects implemented in other districts until 2023. The implementation of the superblocks was associated with the government of Ada Colau, who achieved an unexpected victory in the 2015 municipal elections. Although a preliminary policy had been approved and included in the Urban Mobility Plan by the previous centre-right mayor (Estruch-Garcia et al., 2024), it was under Colau's leadership that the city adopted the superblocks as a signature project, linking them to other initiatives aimed at reducing car use through pedestrianisation and expanding cycle lanes. From the outset, the city has used the 'superblock' label for various operations across the territory, even reframing earlier, unrelated interventions under the same heading, such as those in Gràcia or Passeig Sant Joan (Boeck, 2021).

The first Superblock Project implementation in Poblenou was met with criticism. A group of citizens organised a non-legally binding referendum, which resulted in the project being discontinued. However, the referendum had a low turnout, raising doubts about its representativeness. The city council proceeded with the Superblock project without adequately informing the public, prompting opposition (Versigghel et al., 2023). According to the same authors, although some opposition to the project persisted, the municipality was able to increase acceptance of the project by undergoing more participatory processes and intensifying consultation rounds after the initial implementation. The Sant Antoni Superblock followed, and the Municipality's strategy was reportedly more cautious, slowing down the intervention stages and actively consulting local residents and workers.

The Sant Antoni Superblock was the first to feature a participatory process from the start. The first meeting with the Steering Group took place in February 2017, and a further ten were held until April 2022 (Supermanzana de Sant Antoni, 2017).

Despite its international success, the project was controversial in the city and polarised political parties during Colau's government (Boeck, 2021; Estruch-Garcia et al., 2024). In the 2023 elections, Ada Colau lost votes and went into opposition. During the campaign, differing positions on the Superblock were set the stage for a reward-punishment dynamic in voter behaviour, and residents directly impacted by the project were likely to either reward or punish the incumbent party (Estruch-Garcia et al., 2024) Although different studies have shown an increase in the tendency to vote for Ada Colau in the Superblock districts (Estruch-Garcia et al., 2024; Marquet et al., 2024), these studies have some limitations. Firstly, they do not guarantee the same population measurements and may overlook events such as the gentrification of districts, which is one of the concerns associated with the measure. Secondly, they only test the localised effects of the superblocks in their immediate vicinity and do not consider how the wider public perceives the actions (Marquet et al., 2024).

Conversely, the media's opposition to the measure often focused on issues such as Barcelona's alleged disorder and decadence, the 'war on cars', and strangulation of the city (Nello-Deakin, 2022). Although the Municipality repeatedly expressed its intention to implement the measure systematically across the whole city rather than in certain neighbourhoods only (Versigghel et al., 2023), by 2023, the affected districts were mainly in central locations (e.g. Poblenou, Sant Antoni and Eixample), raising concerns about gentrification and the promotion of tourism.

The potential challenges of the Superblocks concept are consistent with recent studies that have focused on the limitations of urban experiments, particularly with regard to their ability to promote learning, legitimacy, and the alignment of social goals (Eneqvist et al., 2022; Scholl & Kraker, 2021). Additionally, Colantone et al. (2024) have demonstrated how the implementation of comparable green initiatives has resulted in mounting public dissatisfaction and electoral repercussions. Their study found that residents affected by a car ban in Milan were significantly more likely to vote for the far-right Lega party, which opposed the ban, in subsequent elections. These findings highlight the need for a more in-depth discussion and understanding of the real impact of urban experimentation on urban transitions.

2.2 Enacted Sensemaking

Enacted sensemaking involves a process of forming a coherent worldview by interpreting cues, as well as contributing to the worldviews of others through a sense-giving process (Maitlis & Christianson, 2014a). Therefore, sensemaking involves actively creating environments through one's actions and interpretations (Weick, 1988). This "two-pronged" process of learning and acting relates to Lewin's (1946) action-evaluation interactive process and to Checkland's (2000) conception of an ever-changing problematic situation. This means that action not only proceeds cognition – meaning that one cannot understand a system without trying to change it (Schein, 1996) –, but also that any action upon a problematic situation is immediately followed by a change in the problem itself, requiring constant adaptation to the situation. These core concepts help to explain how urban experimentation shapes broader processes of transformation (Raven et al., 2019).

These authors' emphasis on process-oriented strategies, human-centred approaches, and the tentative nature of change renders their work relevant to the literature on urban experimentation. It should also be noted that all of the literature highlights the risks associated with failure in collective learning processes. Failure to enact sensemaking can negatively impact the life of an organisation. Lewin's three-step model — unfreeze, move and refreeze — can be used to illustrate the importance of ensuring that the sensemaking process freezes in the final stage, rather than returning to the previous status quo and becoming just a 'shot in the arm' for the problem (Lewin, 1947). Failure to refreeze the organisation leads to a process of disconfirmation, resulting in a counter-productive contribution to change (Schein, 1996). Better control over appropriate enactment strategies could empower urban experimentation.

This research builds on Weick's three basic constructs of enactment, namely commitment, capacity and expectations (Weick, 1988). It also builds on the update made by Maitlis & Sonenshein (2010) , relating it to turbulent organisational contexts and renaming the concept of capacity 'identity'. This concept of identity is consistent with

other relevant literature (see Weick, 1995). These three concepts enable us to understand the activities involved in creating a shared worldview, which is present in both crisis and change management literature. These concepts serve as building blocks for analysing the enactment process in urban experiments, acting as both enablers and barriers to the sensemaking process (Weick, 1988, Maitlis & Sonenshein, 2010).

Commitment reflects the extent to which we recognise the need for change, and is foundational to sensemaking (Maitlis & Sonenshein, 2010). However, it can be both productive and unproductive to associate commitment with a previous state of affairs, as individuals tend to generate retrospective explanations to justify a position they have already committed to (Weick, 1995).

Capacity, which Maitlis & Sonenshein (2010) also refer to as 'identity' (a term adopted for the purposes of this study), is the way in which we understand our role and agency within a given context. People tend to pay attention to what they believe they are capable of acting upon (Weick, 1988). Identity is usually most evident when it is threatened; therefore, it is necessary to create an environment in which our identity is adequately challenged. Our perception of identity is never free of preconceptions and can easily be influenced by salience. During organisational change, identities are often completely replaced (Corley & Gioia, 2004).

Expectations, combined with contextual cues, create meanings which are then used to filter subsequent cues, building confidence in a definition of the situation (Maitlis & Sonenshein, 2010, p. 564). Undermining or exaggerating the impact of urban change can have significant implications for its implementation and acceptance by the population. Table 1 displays different examples of the conditions of enacted sensemaking.

Table 1 – Applied constructs of enacted sensemaking

	Context	**Commitment**	**Identity**	**Expectation**
Mann Gulch Fire	Weick's (2009) analysis of a fire incident in which several smoke jumpers were killed after choosing not to leave their tools behind	Firefighters are committed to a set of meticulously rehearsed procedures for extinguishing fires	Firefighters told 'drop your tools' immediately feel as losing their identity to one of people fleeing the fire	Hopeful expectations were created by labelling the fire as routine and relatively easy to manage
Alps' Lost Soldiers	Weick's (1979, in Maitlis & Sonenshein, 2010) tale of a group of soldiers who safely find their way through the Alps using a map that later turns out to be of the Pyrenees	Tenacious commitment to a plan to escape from the mountains helped keeping the group moving	Soldiers believing that escaping was within their capabilities helped keeping the plan	Setting hopeful expectations on the plan helped keeping panic at bay and keep moving
Bhopal Disaster	Weick's (1988) analysis of a disaster in a plant whose symptoms were overlooked by everyone (e.g. alarms were shut off and refrigeration equipment was disconnected).	Lack of commitment to safety and commitment to other opposing values – commitment to secrecy and cost cutting	Employees readily grant the supervisor's claim to authority and the implied capacity to act, taking any responsibility away from them	Low regard for the tasks at hand led to sloppy procedures and inattention to details from every worker and manager in the factory

3. Research Framework

This research adapts Weick's (1988) framework to the context of urban experimentation. Each construct – commitment, identity and expectations – has specific implications for the population and different ways of addressing. This section briefly adapts these three dimensions to an urban setting, providing clear definitions and outlining the framework used in this analysis. The intention is to create a roadmap for analysing the minutes, providing possible examples found within them. The role of each dimension is extensively explored in the discus-

sion section, as well as the concrete cases found and the links to other relevant discussions.

In an urban experimentation setting, the commitment shared by all people should be to the idea of sustainable transition. Common problems arise when faced with divergent opposing commitments, for example a shopkeeper who sees pedestrianisation as a barrier to their business, which can lead to resistance to the transition and retrospective justifications. Therefore, the person presenting the policy should seek to present the case and emphasise the need for deep commitment to the experimentation. At the identity level, the focus is on understanding the scope of action as broadly as possible in order to encompass actions that will meet the need for experimentation. In an urban context, the problem often lies in abandoning an old identity rather than finding a new one – for example, adopting a new way of commuting. An individual's choice of commute (e.g. using a car) may become part of their identity. Expectations relate to a person's understanding of how a given transformation will impact their life at any given moment. In an urban setting, clearly stating the consequences of interventions, providing good descriptions of them and promoting population engagement from an early stage can help to ensure that expectations are formed correctly. Table 2 shows how the meanings have been adapted to fit this research framework.

Table 2 – The research framework

	Commitment	**Identity**	**Expectations**
Relevant objectives in an urban experimentation, related to each construct	Emphasise the importance of the project for society and future generations. Align the commitment to sustainable transitions with other commitments in one's life. Create a sense of urgency around achieving sustainable transitions.	Demonstrate one's ability to adapt to urban transitions. Facilitate a process of questioning preferences, identifying implicit biases, minimising distractions, reducing certainty and overcoming paradigm blindness. Build a new shared identity around sustainable mobility that is compatible with people's lives and culture.	Address people's anxiety about disruption to their lives by describing the impact of the process and providing a clear picture of how it will play out. Demonstrate one's control over the process.

4. Research Methodology

After an initial enforcement period of the superblocks, the city of Barcelona launched intensive rounds of consultation with citizens and stakeholders (Versigghel et al., 2023). The city council hosted participatory meetings that brought together traders, residents, and other local district entities to propose and co-create the analysis and design of the interventions. The Sant Antoni district was the first to hold these meetings since the beginning of the project.

Considering these meetings as triggers of the sensemaking process, characterised by a confrontation of the status quo and interruption of an ongoing activities (Maitlis & Christianson, 2014b), this research uses the minutes from Santo Antoni district meetings to analyse the three constructs of enacted sensemaking during the participatory process. Thematic and critical analyses of the minutes were carried out. The different documents and meeting minutes were accessed via the Ajuntament de Barcelona website (Supermanzana de Sant Antoni, 2017) (Table 3).

Table 3 – Minutes consulted

Document	Date	Coded Remarks
Minutes of the Session with the Sant Antoni Driver Group	27 Feb 2017	36
Minutes of the Session with the Sant Antoni Driver Group	15 Mar 2017	19
Minutes of the Session with the Sant Antoni Driver Group	13 Jun 2017	43
Minutes of the Session with the Sant Antoni Driver Group	14 Jun 2017	15
Minutes of the Session with the Sant Antoni Driver Group	02 Nov 2017	2
Minutes of the Session with the Sant Antoni Driver Group	12 Dec 2017	80
Minutes of the session of the Driving Group and traders of the Sant Antoni Superblock	09 May 2018	40
Minutes of the session of the Driving Group and traders of the Sant Antoni Superblock	26 Feb 2019	23
Minutes of the meeting with merchants and the AVV of St. Antoni in relation to the Superilla de Sant Antoni	28 Jun 2019	38
Minutes of the expanded Driving Group of the Sant Antoni Superblock	28 Oct 2019	46
Monitoring Session of the Sant Antoni Superblock	26 Apr 2022	52

Files retrieved from: https://ajuntament.barcelona.cat/superilles/es/content/sant-antoni (accessed 16/09/2024)

Braun & Clarke (2006) define thematic analysis as a foundational qualitative research method involving the identification, analysis and reporting of patterns within data. According to the authors, it offers a flexible and accessible approach and allows the organisation and description of qualitative data sets in rich detail, deriving meaningful insights from it. This has made thematic analysis a valuable tool in psychological research and beyond.

The analysis does not aim to cover the content of the initial project presentation or the project's specific details. Rather, it aims to understand the nature and content of the discussion held during the meeting segment dedicated to the participatory exchange of ideas with the public (i.e. the question-and-answer session). The analysis of the minutes was conducted at a participation level, meaning that each entry point in the dataset was a remark made by an individual, which was divided into different parts when covering different ideas. This approach was adopted both to achieve a reasonable level of segmentation and because the way the minutes were typed changed throughout the project, resulting in inconsistent data structure and necessitating adaptation of the thematic analysis.

Each entry point was coded according to three main themes: 'Remarks type', whether the remark was voiced by a project proponent or participant and whether it was a positive, negative or neutral comment, request or question; 'Remarks subject', depending on the main subject covered in the remark, which was coded as public space, automobiles, public transport, bicycles, motorcycles or logistics; and 'Remarks nature', that varies according to the construct, i.e. commitment, identity, expectation or the group 'others'. Each remark was coded according to the most salient category concerning its 'type' and 'nature', while the 'subject' was coded according to specific keywords that featured in the text.

5. Results

This section presents the results of the thematic analysis of the minutes. The website of the Ajuntament de Barcelona states that the work carried out in Sant Antoni is the result of a debate process involving neighbours, business owners and other local associations, who constituted the steering group (Supermanzana de Sant Antoni, 2017).

The first meeting was held on February 17th 2017 and the last one on April 26th 2022, with a total of 11 meetings listed on the Ajuntament de Barcelona website (Supermanzana de Sant Antoni, 2017). Work on implementing the

Superblock began in September 2017 and was divided into three phases, extending until October 2019 (Ajuntament de Barcelona, 2019c).

The meetings always followed a similar format. First, there was an opening session with an introduction to the agenda and an overview of the superblock framework, along with some remarks about previous sessions. Then, there was a question-and-answer session about the project or specific issues regarding the intervention. For example, the meeting held in February 2019 focused specifically on loading and unloading logistics, while the meeting held in June 2019 focused specifically on the construction process and timings.

5.1 Remarks Type

The type of remark was coded into two main groups: proponents and participants. These two groups represent a clear distinction between the people participating in these sessions: the Ajuntament representatives, who were on the side of those proposing the superblocks, and the civic society entities participating in the process. This clear differentiation is evident throughout all the analysed minutes.

The remarks from civic society entities and individuals were categorised according to the type of participation they represented: questions, neutral comments, negative comments, or positive comments. This categorisation provides a brief insight into the views of these entities (Table 3).

Table 4 – Type of remarks

Row Labels	Remarks
Participant	178
Neg Comment	41
Neutral Comment	42
Pos Comment	9
Question	86
Proponent	205
Proposal	205
Grand Total	383

The balance of remarks from participants (178) and proponents (205) indicates a participatory process. Within the group of participants' remarks, a prevalence of questions (86) is visible, followed by a nearly equivalent number of neutral comments/requests (42), negative comments (41), and lastly, positive comments (9).

Questions were mainly asked for two reasons. The first was related to the project's operational characteristics, e.g. requests for information on unloading and street parking, or specific points such as the Ferran Sunyer School exit (Ajuntament de Barcelona, 2017b) , the location of motorcycle parking spaces (Ajuntament de Barcelona, 2017a), the location of logistics unloading bays or cycle lanes (Ajuntament de Barcelona, 2018), or issues related to the construction site (Ajuntament de Barcelona, 2019a). The second category of questions was related to the outcome of the project. It was asked whether the project was the same as that implemented in Poble Nou (Ajuntament de Barcelona, 2017b), . Other questions related to forecasts for an increase in traffic looking for parking, specifically on Viladomat Street (Ajuntament de Barcelona, 2017a), whether there would be a gentrifying effect on the neighbourhood (Ajuntament de Barcelona, 2017e), and whether there were studies proving that the project would reduce pollution, given that it would cause vehicles to slow down and turn more (Ajuntament de Barcelona, 2017d).

Neutral comments/requests are usually remarks that describe the participants' needs without making any direct positive or negative judgements about the project. Examples include requests for traffic management, such as

improving neighbourhood access (Ajuntament de Barcelona, 2017b) or reducing traffic speed with the help of speed cameras (Ajuntament de Barcelona, 2017e), managing parking by creating new parking areas or changing from blue to green parking zones (Ajuntament de Barcelona, 2017e), and deciding on furniture locations, such as placing benches outside a school (Ajuntament de Barcelona, 2017a), and expressing opinions on newly created or grown bar terraces (Ajuntament de Barcelona, 2019b).

Negative comments encompass negative opinions on various topics, such as the outcome of the project – e.g. the idea that the neighbourhood would become a maze (Ajuntament de Barcelona, 2017b) –, the fainess of the project – e.g. illustrating that some streets will be improved but others will worsen their current situation (Ajuntament de Barcelona, 2017c) –, or general complains – e.g. complains from Shopkeepers on Calabria Street and Viladomat expressing being "left out" of the action (Ajuntament de Barcelona, 2019a), or the idea that Sant Antoni is tired of being a testing area for Barcelona (Ajuntament de Barcelona, 2022) –; and even complains about specific operational characteristics – e.g. complaints about the loss of parking spaces (Ajuntament de Barcelona, 2018), complaints about two-way cycle lanes (Ajuntament de Barcelona, 2017d), and specific traffic management in certain areas, such as next to the Cotxeres Civic Centre (Ajuntament de Barcelona, 2017c), as well as the lack of cleaning and maintenance of the new spaces created (Ajuntament de Barcelona, 2019b).

Positive comments are usually expressed in support of the project. For example, AMPA Ferran Sunyer School appreciates the work done (Ajuntament de Barcelona, 2017b), Vicenç Gasca values input, consensus and support for the measure (Ajuntament de Barcelona, 2017e), requests for the expansion of the measure (Ajuntament de Barcelona, 2017a), or the great satisfaction with the project demonstrated by the Ferran Sunyer Primary School (Ajuntament de Barcelona, 2019b).

5.2 Remarks Subject

The subject of the remark is divided into the six most common topics: public space, automobiles, public transport, bicycles, motorcycles and logistics. Each remark was attributed to one of these categories when a keyword related to the concept was found. This means that each remark may cover different subjects (Table 3).

Table 5 – Remarks subject

Public Space	Automobile	Public Transport	Bicycle	Motorcycle	Logistics
92	76	12	21	6	54

The subject of 'public space' was the most frequently addressed topic (92), relating to street furniture, greenery and shop terraces. This was followed by 'automobiles' (76) and logistics (54). Further down the ranking were 'bicycle' (21), 'public transport' (12) and 'motorcycle' (6). Different topics arose in different meetings. Different topics arose in different meetings. Figure 1 shows the proportion of topics covered in each meeting.

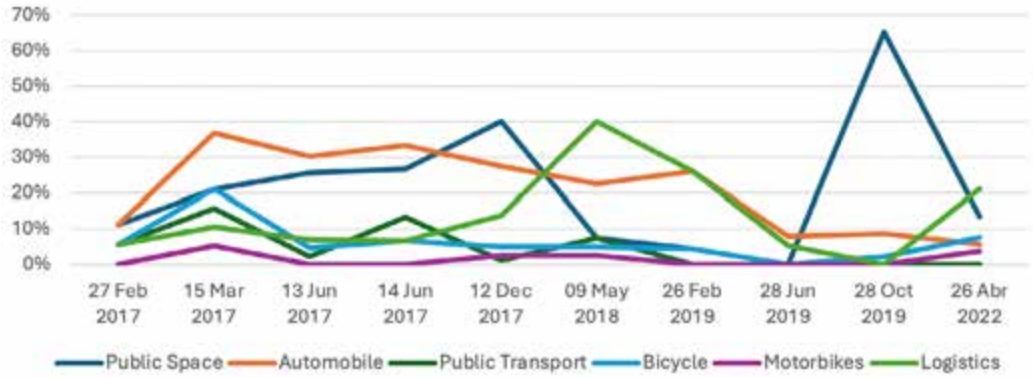

Figure 1 – Proportion of remarks attributed to each subject per minute[1]

1 The minute of the meeting held on November 2017 was excluded from the graph due to lack of substantial content

5.3 Remarks Nature

The nature of the remarks was coded according to the main themes addressed in the research framework, which draws on Weick's (1988) and Maitlis & Sonenshein's (2010) three constructs of enacted sensemaking: commitment, identity and expectations. A fourth group, 'Others', was included, encompassing remarks dedicated to overall project details and operational information on how the participatory process will proceed. Similarly to what happened with the type of remark, the nature theme is coded based on the most salient category for each one. The results are shown in Table 3.

Table 6 – Remarks nature

Remarks nature	Nr of remarks
Commitment	29
Expectation	228
Identity	7
Others	111
Grand Total	375

The results clearly show a higher propensity for remarks to fall within the realm of 'expectations' (228), with a significant difference from the other two categories: 'commitment' (29) and 'identity' (7).

Distinguishing between remarks that express the idea of expectation and general enquiries about the project is a complex task, as the line between the two is thin. The general rule applied was as follows: continuation of a given activity versus interest in general details of the plan. For example, asking 'What material is this wall made of?' is different from asking 'Will I be able to hang a frame on this wall?'. The former seems to be a general enquiry about the project (although there may be a hidden intention), while the latter is a direct concern about expectations regarding the outcome of an activity. The categorisation criteria and examples are shown in Table 7.

Table 7 – Categorisation criteria and examples

Nature of remark	Criteria	Examples
Commitment	Questioning or referring to general goals and consequences of the measures	"Will we get safe streets for children to play on?"; "(...) the measures to be taken should generate spaces to avoid sedimentation (...)"; "If bicycles ride next to cars, are they very exposed to pollution?" (Ajuntament de Barcelona, 2017b)
Identity	Questioning or referring to ways of being or one's agency	"(...) citizens have the right to have a car" (Ajuntament de Barcelona, 2017a); "(...) they are used to doing things in a certain way and that they are concerned about change" (Ajuntament de Barcelona, 2018)
Expectations	Questioning or referring to specific tasks or tasks already taking place	"Situation regarding the Ferran Sunyer School exit"; "What about the buses?"; What will Ronda Sant Antoni look like? (Ajuntament de Barcelona, 2017b); "How will you access the Sant Antoni Market?"; "Will there be a reduction in parking for residents?" (Ajuntament de Barcelona, 2017a);
Others	Questioning or referring to general dynamics of the project, the participatory process or specific operational assumptions	"Question: Is this the same idea that has already been implemented in Poble Nou?", "what type of actions will be carried out?" (Ajuntament de Barcelona, 2017b); "Is there a forecast for an increase in traffic on Viladomat Street?" and "Why is Parliament Street considered a civic axis?" (Ajuntament de Barcelona, 2017a)

6. Discussion

6.1 General Conclusions

The initial conclusion to be drawn from the analysis is that the three pillars are not consistently addressed during the Sant Antoni Superblock participatory meetings. The minutes show that the expectation dimension is given more emphasis than commitment and identity (Figure 1). Further elaboration of this preliminary analysis is outlined below.

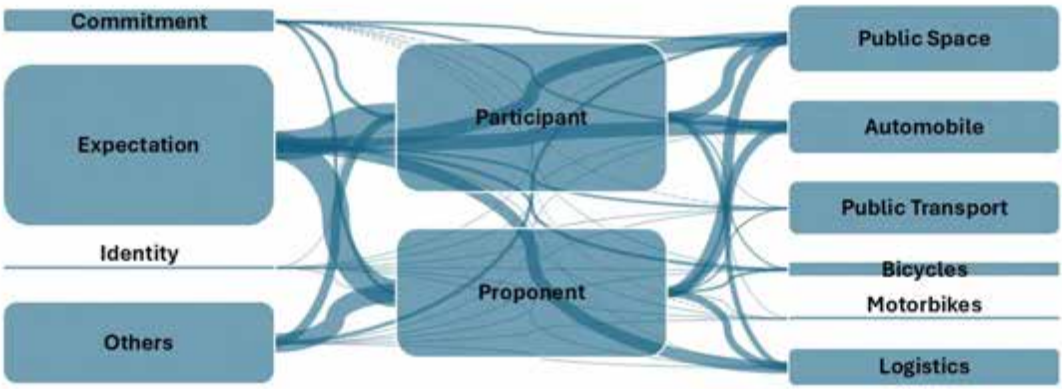

Figure 2 – Cognitive mapping of the type, subject and nature of remarks

Commitment

Commitment is associated with adherence to a specific set of actions. It is a necessary element in providing a sense of value to one's actions and is a vital foundation for keeping individuals moving forward and keeping panic at bay (Maitlis & Sonenshein, 2010). However, the concept of commitment can also be counterproductive when an individual is committed to an opposing worldview. In order to achieve commitment during a process of change, it is necessary to create a clear and compelling vision of successful change; storytelling is generally considered to be an essential part of this process (Weick, 2012).

Although this construct was not explicitly addressed in the minutes, examination of other documents suggests that the Ajuntament de Barcelona endeavoured to emphasise the importance of the project in the introduction to each meeting (Supermanzana de Sant Antoni, 2017). The initial segment of the participatory meetings consisted of a presentation by a municipal representative outlining the Superblocks project's overarching objectives. This presentation addressed the need to reduce greenhouse gas and carbon emissions, as well as the city's gradual pedestrianisation. Furthermore, the documentation reveals the integration of the commitment to sustainable transitions with other commitments, such as promoting healthier lifestyles and enhancing commerce. This integration fosters a sense of urgency for the realisation of sustainable transitions.

Therefore, although commitment was not a common theme in the content analysis of this research, it is a construct that has been considered when implementing Superblocks.

Expectations

Expectations are related to the anticipation of the outcome of certain actions on a problem. Consequently, they are associated with the ability to interpret cues, form a mental image of the problem and decide how to address it (Weick, 1988). Excessively optimistic or pessimistic expectations can influence the outcomes of a given situation. For expectations to align, people must possess a coherent conceptual understanding of the progression of activities.

A thematic analysis of the minutes revealed that remarks concerning expectations were the topic that was addressed most frequently. In most of these meetings, the tangible impact of the transformations on each street is discussed, along with the alternatives and participants' opinions. A key issue in the presented documentation

is the creation of a clear mental image of the planned interventions, which involves presenting visual aids and providing detailed explanations of specific street segments.

In the context of the Superblocks initiative, the municipal authorities placed significant emphasis on establishing consistent communication channels and disseminating information about the project's progress and subsequent implementation phases. Despite potential critiques regarding the extent to which the project was a bottom-up initiative (Boeck, 2021), proximity to the population promoted effective management of expectations.

Identity
Identity refers to how we understand our role and agency within a given context (Maitlis & Sonenshein, 2010; Weick, 1988). As our actions are limited by what we perceive as possible, the larger this scope, the wider the variety of actions we consider. Remarks such as 'citizens have the right to have a car' (Ajuntament de Barcelona, 2017a) and 'they are used to doing things in a certain way and are concerned about change' (Ajuntament de Barcelona, 2018) suggest that some participants were unable to broaden their perception of possible actions beyond the current paradigm.

According to Weick (1988), someone who believes they can adapt to a wide range of situations is open to a variety of inputs because they will always find a way to cope with them. Conversely, a person whose identity is closely linked to the way they currently do things - for instance, driving home - will not be able to consider alternative ways of being.

The Superblocks project challenged the dominant identity of car users. However, the analysed minutes barely addressed the question of identity or attachment to previous ways of doing things before the Superblocks intervention. Had the project encouraged people to broaden their perceptions of what they can do, they might have been more open to accepting changes. The following sections will explore the lack of consideration given to this issue, and its potential impact on urban experimentation.

6.2 Identity Problems and Implications
Due to their promotion of the pacification of streets, the Superblocks were often portrayed by the media as a 'war on cars' (Nello-Deakin, 2022). However, despite a scientific consensus on the need to promote more sustainable modal choices, the reasons behind our natural inclination towards cars is explained by transport behaviour science (Dyson & Sutherland, 2021). Dyson & Sutherland (2021) explain that the preference for the automobile over public transport, for example, can be attributed to convenience, reliability and status, deeply ingrained processes that have a tremendous impact on our subconscious decision-making processes. 90–95% of our daily tasks are performed automatically, and drivers only consider which mode of transport to use for 14% of trips (Dyson & Sutherland, 2021).

The problem stems from the fact that we see the car as an extension of our identity. In his famous analysis of the 1949 Mann Gulch fire in Montana, Weick (1995) reports that the smokejumpers resisted instructions to leave their tools behind in order to sprint to safety more quickly. Those who left their tools behind were reportedly able to run to safety, while those who did not were overtaken by the flames. Some men did not consider leaving their tools behind because they were part of their identity – the idea did not even cross their minds. Identity therefore acts as a filter for potential actions, which become more rigid in a crisis situation when most of us act almost on autopilot. Cars may be seen as tools for fighting fires. Despite the fact that they prevent us from running away from a figurative fire – the climate crisis – we tend to cling onto them.

Our identity shapes our worldview and influences the way we perceive problems. This can result in tenacious justification, blind spots, selective attention, confident action, and self-confirmation (Weick, 1988). Even when the other dimensions of sensemaking — commitment and expectations — are aligned with the change process, these mental processes affect how we interpret information. This can lead to retrospective justifications for certain events, causing commitment to change to fade.

The analysis of the minutes reveals a preoccupation with project parameters that were repeatedly proven to be irrelevant by municipal research and presentations, yet which were still addressed by the population. This may be due to selective attention, such as the preoccupation with increased traffic due to fewer available parking spaces and lower speed limits (e.g. 'Question: Pacifying traffic slows down vehicles and makes them turn more. Has it been well studied whether this reduces pollution?" (Ajuntament de Barcelona, 2017d), "Will there be an increase in traffic looking for parking?" (Ajuntament de Barcelona, 2017a)). Furthermore, during the implementation of the project, there was an increase in problems that were only indirectly related to superblock implementation and derived from deeper roots. These included an increase in robberies in the area during construction (Ajuntament de Barcelona, 2019c), rats appearing in flowerbeds (Ajuntament de Barcelona, 2019c), increased noise on the streets due to more people using them, and groups of skaters using the new pedestrian area (Ajuntament de Barcelona, 2022). The attention dedicated to these issues may be seen as a selective attention bias towards the outcomes of the project.

6.3 Experimentation and Social Learning

The Superblocks project was developed based on the principle of urban experimentation. These experiments are socially inclusive, practice-based and challenge-led projects and initiatives that aim to develop system innovation through social learning, addressing ambiguity and uncertainty (Sengers et al., 2016). The implementation of urban living labs and urban experiments has increased due to municipalities' growing confidence in "government by experiment" (Bulkeley and Castan Bróto, 2013, in Raven et al., 2019, p. 258). The Superblocks project aimed to facilitate urban transitions through small, tactical interventions showcasing the positive impact of street pacification and a gradual rollout across the city (Rueda, 2019).

The primary intention behind urban experimentation is to introduce solutions into limited urban environments to generate objective or empirical evidence of their advantages (Caniglia et al., 2017, in Evans et al., 2021). However, as we have seen, a lack of identity in a project can lead to tenacious justifications and blind spots. Since these justifications influence both perception and action, they often become self-confirming (Weick, 1988). In other words, people will perceive the 'objective evidence' and act unconsciously according to their preconceptions. Physical changes alone will not promote a transition.

The concept of social learning has also been addressed in literature on experimentation (Evans et al., 2021; Raven et al., 2019; Sengers et al., 2019). Experimentation is considered to be characterised by social actors aiming to facilitate social learning in relation to a new socio-technical configuration (Sengers et al., 2019). This type of experimentation requires facilitation to enable systemic learning by doing. This necessitates an inclusive, broad-based and iterative approach to learning with goals that are monitored and evaluated across a series of steps and phases (Sengers et al., 2016).

Identity can then hinder the learning process. According to Weick (1988) , as people only understand their actions after they have taken them, it is inevitable that they and their actions will become part of a crisis. Learning therefore often requires one to admit to being part of the problem and accept that, had people acted differently all along, they would face a 'different set of problems, opportunities and constraints' (Weick, 1988, p. 309). During organisational change, identities are often completely replaced (Corley & Gioia, 2004). We can therefore conclude that learning depends on updating one's identity, making it an essential concept for successful urban experimentation.

6.4 Path Forward

According to Weick, the process of sensemaking is initiated by a trigger event, which he defines as 'a specific event that is identifiable in time and place, and traceable to specific man-made causes' (Shrivastava, 1987, in Weick, 1988, p. 308). In the case of the Bhopal plant, the triggering event was the leakage of toxic gas (Weick, 1988, p. 309). For the purposes of this research, the triggering event is considered to be the meetings that preceded the implementation of the Superblock. These meetings introduced a change in the outside world, altering the way people perceived it and how they thought it behaved. Weick (1995) describes this moment as 'sensebreaking'.

Sensebreaking increases sensemaking activity, since people have to reinterpret external cues in light of new events. According to Maitlis & Sonenshein (2010), two actions associated with wisdom are required to promote an adaptive rather than destructive role for shared meanings: the capacity to update and the capacity to doubt. Updating involves awareness and enables individuals to revise their interpretations based on new information. Doubting involves considering different possibilities, trying them out, and modifying, transforming, or abandoning them as necessary. Various processes can be employed to encourage a sensebreaking and sensemaking dynamic.

This approach aligns with the concepts of double-loop learning (Sterman, 1994) and adaptive and generative learning (Senge, 2003). These are forms of learning that operate at the level of assumptions, behaviours, norms, and interpretative frameworks. Senge has developed group techniques that provide feedback on accepted assumptions and behaviours. These techniques may include visioning processes, scenario building, backcasting exercises and small-scale social-technical experiments/bounded socio-technical experiments (Vergragt & Brown, 2007).

Updating our identity may also involve reassessing the boundaries of our possible actions and expanding our perception of problems. Ulrich & Reynolds (2010) develop the idea of boundary experiences as joint activities that foster a sense of community and lead to boundary judgements through a participatory process.

According to Senge (2003), the role of a leader in a learning organisation should be to: build shared visions by encouraging personal views, communicating and asking for support, consider visioning as an ongoing process, engage in extrinsic and intrinsic visioning and differentiate between positive and negative visioning; bring mental models to the surface and challenge them, help spot leaps of abstraction, balance advocacy and inquiry, differentiate between espoused theory and theory in use; recognise and defuse defensive routines; and, lastly, to engage in systems thinking, seeing interrelationships and processes (not things and snapshots) and understanding dynamic (not detailed) complexity. Methodologies such as soft systems methodologies (Checkland, 2000) and critical systems heuristics (Ulrich & Reynolds, 2010) can be employed to this end.

The goal of the learning process should be to reduce saliency and promote a safe environment in which to question and doubt present preconceptions. This makes it possible to update shared meanings, particularly those relating to identity.

7. Conclusion

Urban experimentation can facilitate meaningful, sustainable transitions in today's cities. However, to promote the necessary learning and deployment of urban solutions, enacted sensemaking must be addressed. The sensemaking process may be hindered by a lack of commitment, conflicting identities or unrealistic expectations. Moreover, given that all sensemaking is provisional and incentivised by the fast pace of the world in which we live, the capacity to update meanings must be permanent.

The results of the thematic analysis of the minutes make it clear that the identity dimension was not adequately addressed during the participatory meetings. The codification used showed a low prevalence of remarks related to this shared meaning. When these were addressed, they tended to demonstrate a limited perception of people's agency. The paper has also explored the problems arising from the lack of proper shared meanings in an urban experimentation. By analysing complexity-related organisational literature, we can understand how a lack of shared identity around a change can affect an organisation.

Although the research was limited to analysing the meeting minutes, considerable findings emerged that will inform future agendas. Future research could extend these findings and test their validity among those affected by the Superblock implementation. Questionnaires and semi-structured interviews with participants and Ajuntament members could shed light on the challenges of not incorporating sensemaking into participatory meetings. Additionally, new research could focus on strategies that encourage doubt and the updating of shared

meanings, particularly with regard to commitment, expectations, and identity. This could involve exploring new participatory processes that promote complex systems thinking.

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The fictional municipality of "Zwirgberg" as a model for spatial planning in rural Rhineland-Palatinate

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Abstract
Rural regions in Germany face significant structural transformations due to climate change, demographic shifts, digitalization, and mobility transitions. The research project "Kommune 2050" addresses the challenge of limited strategic planning capacities in rural municipalities by developing a transferable model framework. Using the fictional collective municipality "Zwirgberg," based on existing municipalities in Rhineland-Palatinate, the project integrates GIS analyses, modular synthesis, and participatory scenario development. Zwirgberg functions as a digital experimental space that combines real data with creative projections. The result is a planning tool that allows municipalities to explore future development paths and translate abstract challenges into spatial strategies. This methodological approach offers an innovative and replicable model for strategic spatial planning in rural areas.

Keywords: Data-Driven, Model Municipality, Scenario Modeling, Rural Development

1. Introduction and theoretical background

The ramifications of the substantial challenges confronting contemporary society, encompassing the climate crisis, demographic shifts, social transformations, the digitalization of numerous domains, and the mobility transition are already exerting an influence on nearly all aspects of municipal endeavors. These repercussions are poised to persist, engendering increasingly disparate (spatial) repercussions on our lives in the forthcoming years. This phenomenon is not merely an abstract concept; it is one that is particularly pertinent to the German state of Rhineland-Palatinate. It presents challenges, opens up new perspectives, offers opportunities for control and highlights areas where action is required. But what will future change look like? Where and how strongly will changes be felt? How can we identify, formulate, visualize, and communicate changes? What conclusions must be drawn and what innovative solutions are available?

The "Kommune 2050 - Die nächste Generation" (English: "Municipality 2050 - The next Generation") research project was concerned with these issues and is developing new planning approaches. The objective of the project was to develop a set of tools with which municipalities - exemplified by the fictional model municipality of "Zwirgberg" – can concisely identify, design, test, and spatially concretize their own futures and development paths, but in particular, possible solutions. In order to develop practical and transferable solutions, it was essential to consider both general future trends and local characteristics. In consideration of the model nature of the fictional "Collective Municipality" (German: "Verbandsgemeinde") it is possible to derive and transfer corresponding conclusions to analogous structures and the entire federal state. These conclusions can then be classified in the context of future (spatial) developments and their control.

In the German administrative system, a Verbandsgemeinde (roughly translated as "collective municipality") is a specific form of local government structure, predominantly found in the federal state of Rhineland-Palatinate. It consists of a group of smaller, municipalities (Ortsgemeinden) that collaborate under a shared administrative body. While each local municipality retains its political autonomy and elected council, key public services - such as urban land-use planning, school administration, infrastructure management, and fire protection - are managed collectively by the Verbandsgemeinde. This structure is designed to improve administrative efficiency and ensure the provision of essential services in sparsely populated areas. Due to the lack of terminology for precisely this form of municipality, the German word Verbandsgemeinde is used in this paper, also the term Hauptort refers to the largest and functionally most central town within the Verbandsgemeinde and the word Nebenort denotes the smaller surrounding villages or localities.

Also used in German are the words Grundzentrum, Mittelzentrum and Oberzentrum. Germany's spatial planning system categorizes settlements into a three-tiered hierarchy of central places to structure public service provision and regional development, where a Grundzentrum (basic center) serves everyday local needs (e.g. primary schools, groceries, basic healthcare), a Mittelzentrum (intermediate center) offers a broader range of services such as secondary education, hospitals, and specialized retail, and an Oberzentrum (major center) provides high-level services and infrastructure, such as universities, major hospitals, and cultural institutions, typically serving large regions (ARL, 2010).

During a preparatory phase, the essential foundations for this were laid: future topics were identified, necessary data sets were analyzed, and methodological approaches were formulated. The development of a realistic yet abstract model that provides a framework for iterative planning processes was a primary focus. The emphasis was placed on interdisciplinary collaboration between students and teachers, who cooperated as part of a 'Masterprojekt' (English: 'master's project' - a final project at the very end of the Master's programme) or as student assistants. The objective of the research project was to employ creative and data-driven methodologies to conceptualize a fictional municipality derived from authentic structural components.

The methodological structure of the project was based on a three-phase process; however, the practical work revealed the necessity for increased iteration. In the initial phase, entitled 'Understanding the Territory' the emphasis was placed on the analysis, categorization, and design of the model community. In the subsequent phase, entitled 'Construction of the Model' the elements of the model community were specified, reconstructed, and digitized. In the third phase, entitled 'Developing Future Visions', scenarios were formulated to illustrate potential future trajectories for the developed Verbandsgemeinde.

The methodological value of fiction is the central aspect under consideration here. Zwirgberg's - the fictional Verbandsgemeinde - model does not represent an arbitrary real community; rather, it is composed of real fragments. This phenomenon gives rise to a reflexive space wherein authentic communities can discern their own identity without the sense of being addressed in a direct manner. In this context, Zwirgberg functions as a projection-open planning tool - as a digital experimental space for exploring realistic yet innovative development paths. The structural modularity enables the flexible composition of fictional community types and targeted transfer of individual components to real contexts.

The project thus demonstrates an innovative approach to planning processes in rural areas based on geodata, creativity, and strategic planning. Working with "Zwirgberg" allows concrete actions and the exploration of potential spatial configurations prior to their implementation in actual planning instruments. This lays the foundation for subsequent development of digital, modular, and participatory tools in municipal planning.

2. Methodical approach

The objective of the project was to develop a fictitious municipality based on existing Verbandsgemeinden in Rhineland-Palatinate. Subsequent to this, the future development visions of several Verbandsgemeinden were to be formulated and presented. During the initial six-month period, a collaborative effort was undertaken with a team of four students enrolled in master's programs specializing in 'Urban and Regional Development' and 'Urban Planning'. As a culminating element of their master's program, students were tasked with the development of the fundamental structures of the fictional municipality and its future vision. These were subsequently elaborated upon by a group of three students, two of whom were in the initial stages of their bachelor's degree program. It was anticipated that they would offer a novel and impartial perspective on the future of the municipalities in Rhineland-Palatinate.

The initial plan was to divide the project into three phases; however, as work progressed, it became evident that this approach was not feasible. Conversely, alternating between task areas (analysis, construction, replication, detailing of previously developed content) and levels of consideration (Verbandsgemeinde and municipalities within the Verbandsgemeinde) has been demonstrated to be a more fruitful approach. Nevertheless, the three

phases remained as a rough framework for the order of processing:

• Phase 1 - "Understanding the Territory"
Reading, analyzing, and understanding: Getting to know and developing the framework of the fictional Verbandsgemeinde
• Phase 2 - "Construction of the Model"
Recreating, assembling, and defining the model municipality; Describing its characteristics or "genetic code"
• Phase 3 - "Developing Future Visions"
Examination of developments and trends at the Verbandsgemeinde level and their manifestation in the individual municipalities

Database and selection of existing Verbandsgemeinden
The research project was commissioned by "Entwicklungsagentur Rheinland-Pfalz e.V." which had already formulated specifications the fictitious Verbandsgemeinde to be developed was to embody. These were as follows:

The Verbandsgemeinde is comparable to a modern-day municipality in Rhineland-Palatinate: The Verbandsgemeinde has approximately 20,000 inhabitants. It consists of a Hauptort (5,000 inhabitants, Grundzentrum with schools) and 15 Nebenorten (150 to 800 inhabitants). All 16 individual towns (Hauptort and Nebenorte) are run on a voluntary basis. The Verbandsgemeinde has a full-time administrative head who is responsible for all 16 municipalities. It has its own independent administration. The Verbandsgemeinde is situated in the rural area of Rhineland-Palatinate. The property is located approximately 30 kilometers from the nearest Oberzentrum.

According to these criteria, all Verbandsgemeinden in Rhineland-Palatinate with 18,000 to 22,000 inhabitants that are also more than about 30 km from the nearest Oberzentrum were selected for inclusion in the study: Aar-Einrich, Bad Marienberg (Westerwald), Birkenfeld, Brohltahl, Cochem, Kirchberg (Hunsrück), Kirchheimbolanden, Linz am Rhein, Prüm, Südeifel (northern half), and Wirges.

The Verbandsgemeinden of Annweiler am Trifels, Edenkoben, and Wonnegau are located approximately 30 kilometers from the nearest Oberzentrum (red circles). However, they are situated within the 20-kilometer catchment areas of a Mittelzentrum with partial functions of a Oberzentrum (Mittelzentren mit Teilfunktionen eines Oberzentrums) (yellow circles). It should be noted that this selection does not yet take into account the number of sub-locations, i.e., "one Hauptort and 15 Nebenorte"

The initial spatial structural studies are summarized in the map below:

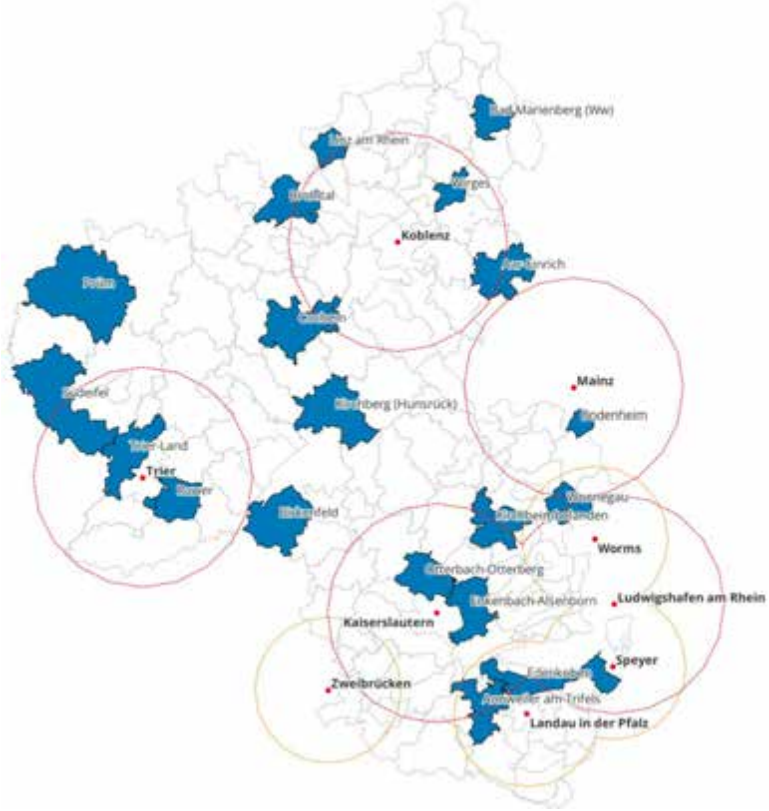


Fig. 1: The map shows the first spatial structure studies. All municipalities with a population of 18,000 to 22,000 are coloured blue, the red circles show the 30-kilometre radius around the Oberzentren, the yellow circles around the Mittelzentren with partial functions of a Oberzentrum. Source: Authors 2024.

Role of students and didactic format

A central feature of the methodological design is the involvement of students in various stages of their education: Master's students provided initial drafts and structural concepts as part of project-based work and developed the fictional Verbandsgemeinde in its entirety. Bachelor's students then took over the further elaboration, reflection, and critical development—their impartiality proved to be particularly productive. This interdisciplinary and multi-stage process enabled a deep understanding of both systemic relationships and the challenges of concrete municipal development.

3. Phase 1: Understanding the Territory

Following the methodological foundation of the project, an empirical analysis of existing Verbandsgemeinden in Rhineland-Palatinate was conducted. This analysis forms the backbone for the subsequent construction of the model Verbandsgemeinde "Zwirgberg." The analysis can be divided into three sections.

In the initial phase, profiles were created for the eleven selected Verbandsgemeinden. The objective of this stage was to acquire a comprehensive understanding of them. In the subsequent phase, the land distribution of the Verbandsgemeinden was examined and classified into categories so that comparable or similar structures could be grouped together. The third and final step of the analysis entailed the creation of a modular system that would serve as the foundation for establishing the fictional association of municipalities.

The objective was to identify the typical structural characteristics, development potential, and spatial functional patterns of the Verbandsgemeinden in Rhineland-Palatinate. These characteristics were then used as the basis for building the fictional association of municipalities.

Profiles and comparison criteria
The initial phase of the study centered on eleven selected Verbandsgemeinden of comparable size (18,000–22,000 inhabitants) and remote location (more than 30 km from the regional center). For each of these Verbandsgemeinden, structured profiles were created, reflecting the following criteria:
- Demographic structure: age distribution, population development,
- Household sizes
- Settlement structure: density, types of centers, types of urban development
- Land use: proportions of settlement, vegetation, traffic areas
- Accessibility: distance to medium-sized and larger centers, public transport connections
- Infrastructure: education, health, and administrative services

Comparability was ensured by a standardized profile template that combines both quantitative data and qualitative assessments.

Spatial analyses of similar existing Verbandsgemeinden in Rhineland-Palatinate
In order to gain a more nuanced understanding of the selected Verbandsgemeinden's spatial characteristics, a range of structural elements were subjected to analysis, including boundaries, settlement patterns, primary access routes, the location of the primary urban center, agriculture, topographical features, water bodies, green spaces and points of interest.

To this end, cartographic representations were developed through the utilization of a geographic information system (GIS) and hand sketches, which were made based on such maps. Infrastructure aspects such as interregional connections, public transportation, and bicycle paths were also considered. During this phase, statistical data was also processed and subsequently compared with the data from the other Verbandsgemeinden.

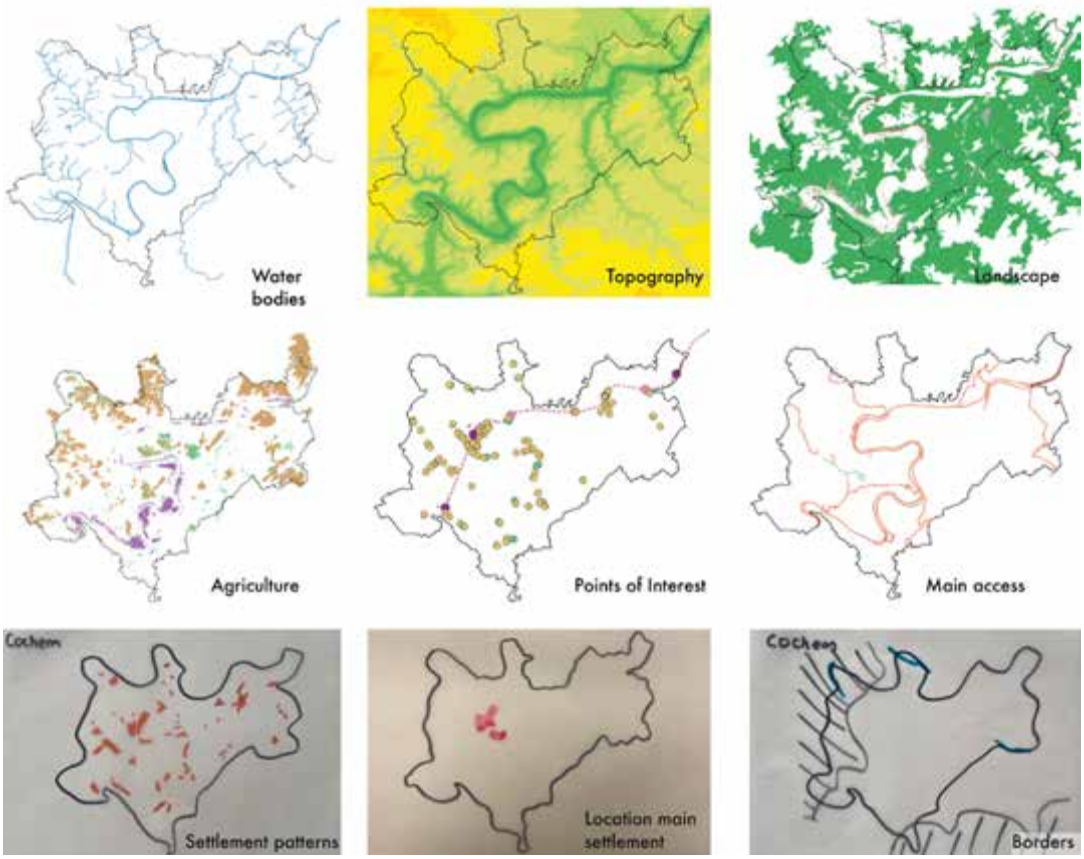


Fig. 2: The structures of the municipalities examined using the example of Cochem. Source: Authors 2024.

Following the examination of the Verbandsgemeinden individually, the results were compared with the analysis results of all the other considered Verbandsgemeinden. Based on these comparisons, categories were developed for each analysis topic into which the eleven municipalities could be classified (even though transitions can be fluid).

The following example illustrates the investigation of all subject areas, as evidenced by the presentation of the various settlement patterns. A distinction was made between:

• Cow spots:
Large-scale settlement structures are dispersed in a seemingly random manner.
• Drops:
The settlement structures under consideration are of a smaller nature, with some larger drops situated between them.
• Sprinkles:
The settlement structures are diminutive in size and dispersed in a seemingly random manner.

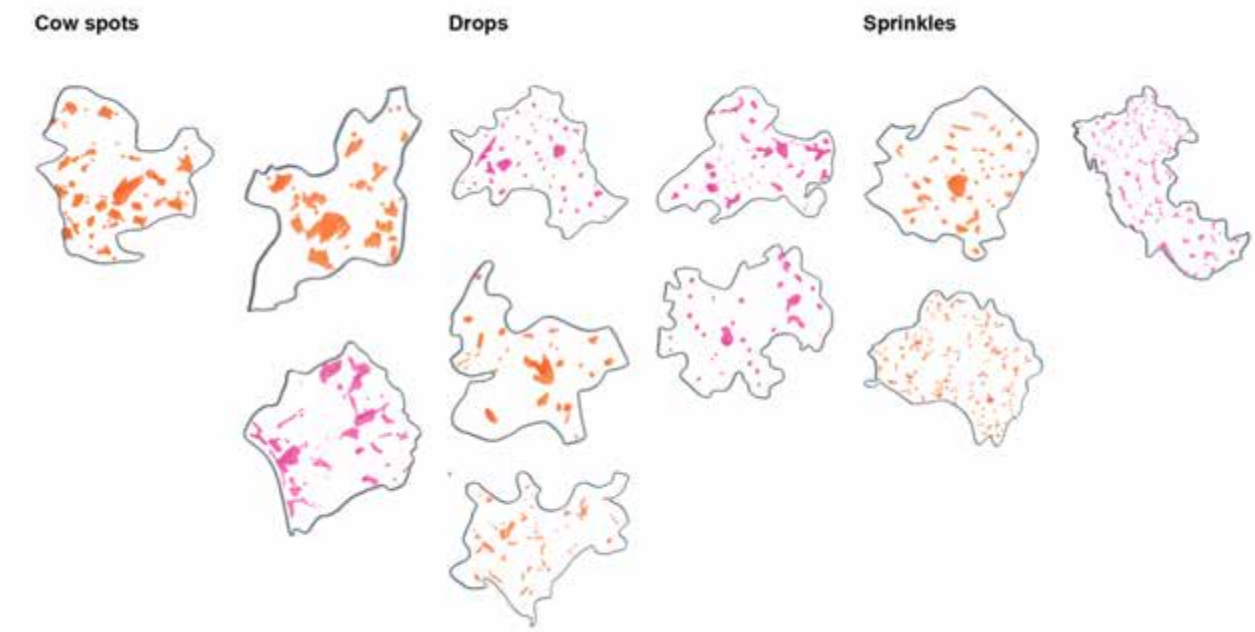


Fig. 3: The settlement structures of the eleven municipalities divided into the categories of cow spots, drops and sprinkles. Source: Authors 2024.

Derivation of a modular system of similar existing municipalities
A modular system was created by analysing and categorizing the structures. Based on this, the fictitious Verbandsgemeinde was to be designed and built in the next phase. A distinction was made between two categories:

• Fundamentals: The foundational elements of the municipal framework such as topography and settlement structure
• Infrastructure: Encompasses elements such as public transportation and bicycle pathways.

The following presents an overview of the components of the modular system. These modules can be flexibly combined in further planning to develop structurally similar municipalities in a differentiated manner. This approach facilitates the synthesis of empirical evidence and planning creativity.

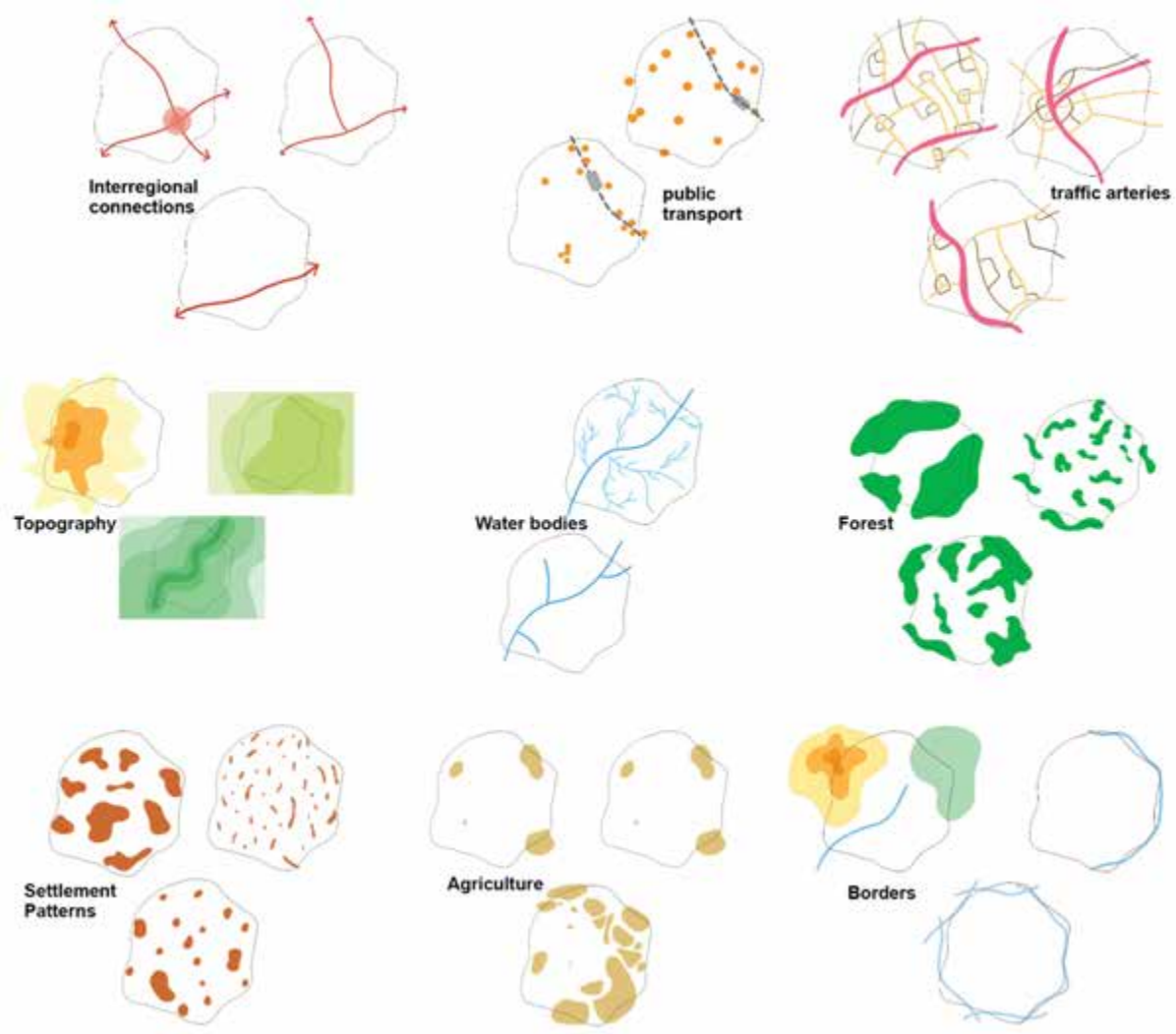
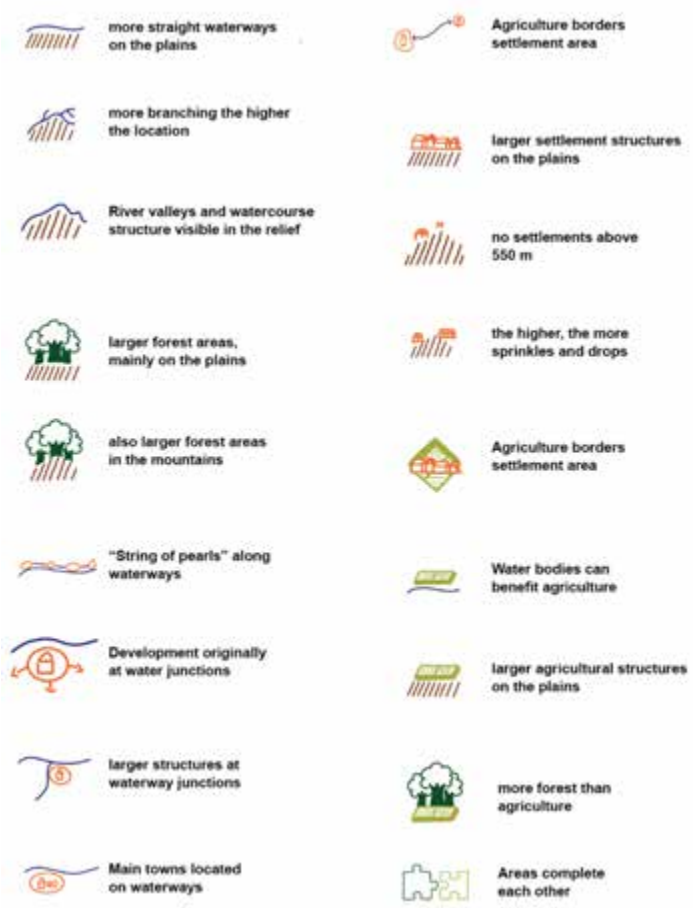


Fig. 4: Characteristics of the municipalities within the Verbandsgemeinde in accordance to the modular system. Source: Authors 2024.

Identification of correlations between the categories considered in the analysis

In order to be able to derive initial design guidelines for the fictitious Verbandsgemeinde from the results of the analysis, it was investigated whether the categories analysed were somehow mutually dependent.

Depending on the constellation, there are varying numbers of connections and mutual conditions. For example, four relationships could be identified between settlement structure and water bodies, but only one between water bodies and agriculture. No conclusions about mutual conditions could be drawn from other constellations, such as forests and settlements.



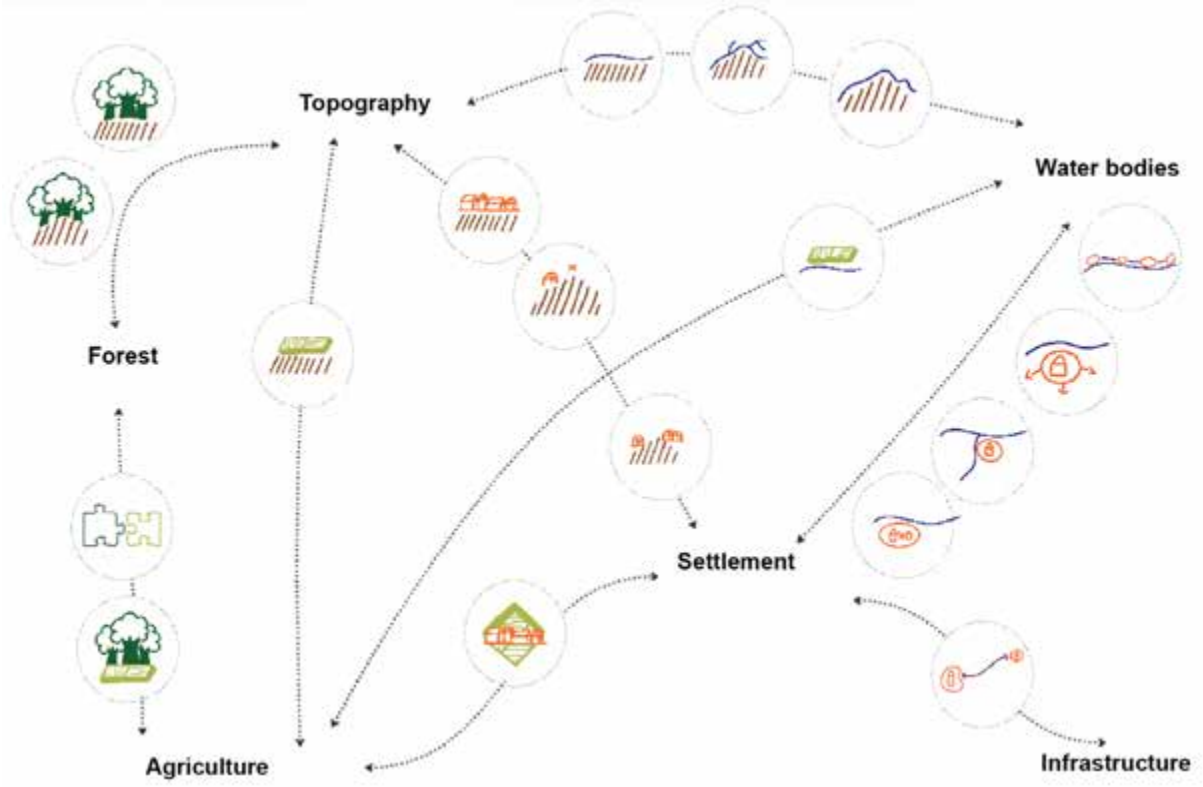


Fig. 5: The diagram shown illustrates the relationships between the categories, the legend above provides explanations of the symbols within the diagram. Source: Authors 2024.

4. Phase 2 - Construction of the Model

During the preceding analysis phase, the modular system was developed and the overarching relationships were examined. In the subsequent design phase, the current status of a fictitious Verbandsgemeinde was determined.

The fictitious Verbandsgemeinde of Zwirgberg was designed by first developing two types of Verbandsgemeinden from four basic designs. These were then combined into one type. Using hand drawn sketches, the individual layers were digitized with the help of a geographic information system (GIS), so that the basic structure of the Verbandsgemeinde became visible.

In further steps, the relationships within the settlements were analyzed. In the present study, sprinkles in higher topographical levels, pearl chains along waterways, cow spots, and even drops in the landscape were analyzed. The results were used to reconstruct fictional municipalities from fragments of real local communities before these were digitally reconstructed in the GIS using the corresponding census data.

Impromptu design

The construction of the fictitious Verbandsgemeinde began based on the analysis. As part of the project, each participating student carried out an individual “basic impromptu design”. The aim was to develop their own design for the municipality based on the knowledge gained.

Fig. 6: Basic impromptu designs for the fictional municipality. Source: Authors 2024.

On closer inspection of the drafts produced, two types of draft could be identified.
• Many smaller villages at higher altitudes and branched water structures
• Larger villages in lower, flatter locations and straighter watercourse structures
Therefore two new drafts were produced, each resembling one of the distinct types.

Fig. 7: The two types of designs for the fictional municipality. Source: Authors 2024.

The fictitious Verbandsgemeinde of Zwirgberg was ultimately developed from these variants. The derivation of the individual layers and the entire Verbandsgemeinde was based on the previously developed modular system and the identified correlations between the categories of the superordinate structures. The aim was to integrate as many special features of the previously considered existing Verbandsgemeinden in Zwirgberg as possible. This duality also allows the exemplary treatment of central areas of tension - such as between the formation of centers and peripheralization - in the model. Furthermore the choice of these types reflects the demographic, infrastructural and functional heterogeneity of many real Verbandsgemeinden.

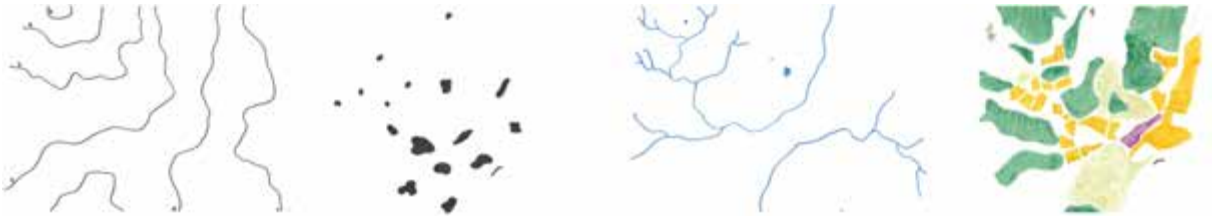


Fig. 8: The municipality of Zwirgberg and its layers: topography, settlement structure, water bodies, and land use. Source: Authors 2024.

Several points were relevant in the development process. The boundaries were to be defined as the final element of the process in order to avoid a limited and therefore incorrect alignment of the subsequent steps from the outset. In addition, it should be noted that the category of open spaces is not limited exclusively to forest and agricultural areas but also includes green spaces to which no specific function is ascribed. In view of these findings,

the corresponding work steps in the previous phases were modified and carried out again until a satisfactory result was achieved.

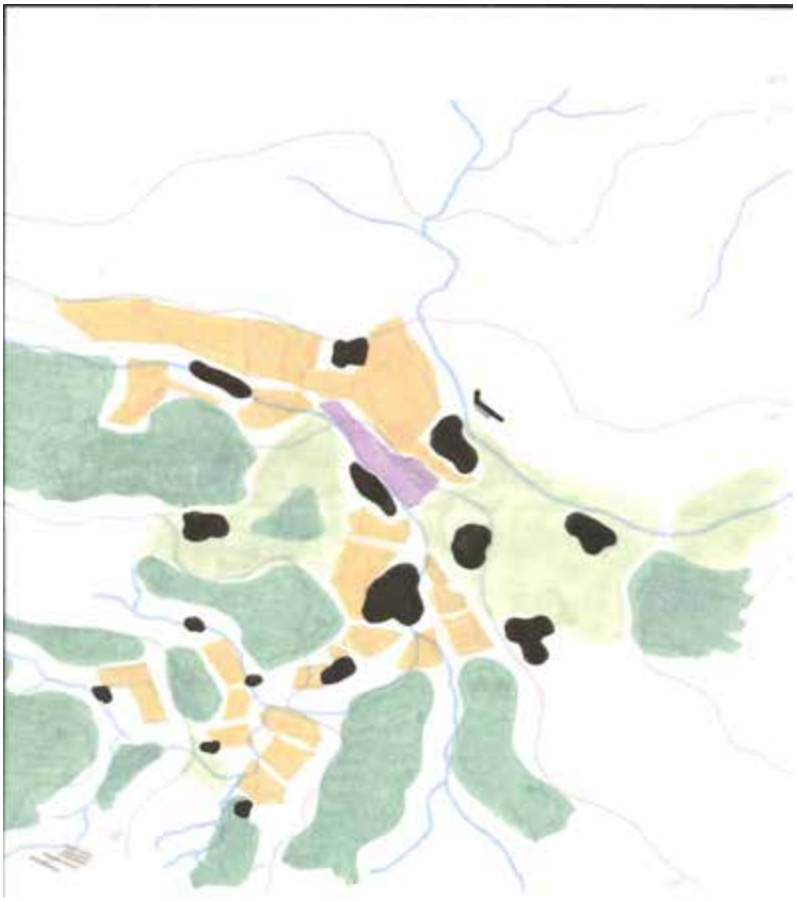


Fig. 9: Overlay of the hand drawn layers of the Verbandsgemeinde of Zwirgberg. Source: Authors 2024.

Transfer and reproduction of the fictitious municipality in a Geographic Information System (GIS)

After developing a joint design for the fictitious Verbandsgemeinde, it was transferred to a GIS. As part of the topographical incorporation, a structural simplification was carried out in which the topographical levels were numbered from one to five and assigned specific properties without a detailed GIS representation. Level 1 represents the lowest level, while level 5 indicates the highest elevation. Subsequently, the other levels of the municipality are successively transferred to the GIS. These are settlements, forest, agriculture, waterways, meadows, vineyards and a quarry.

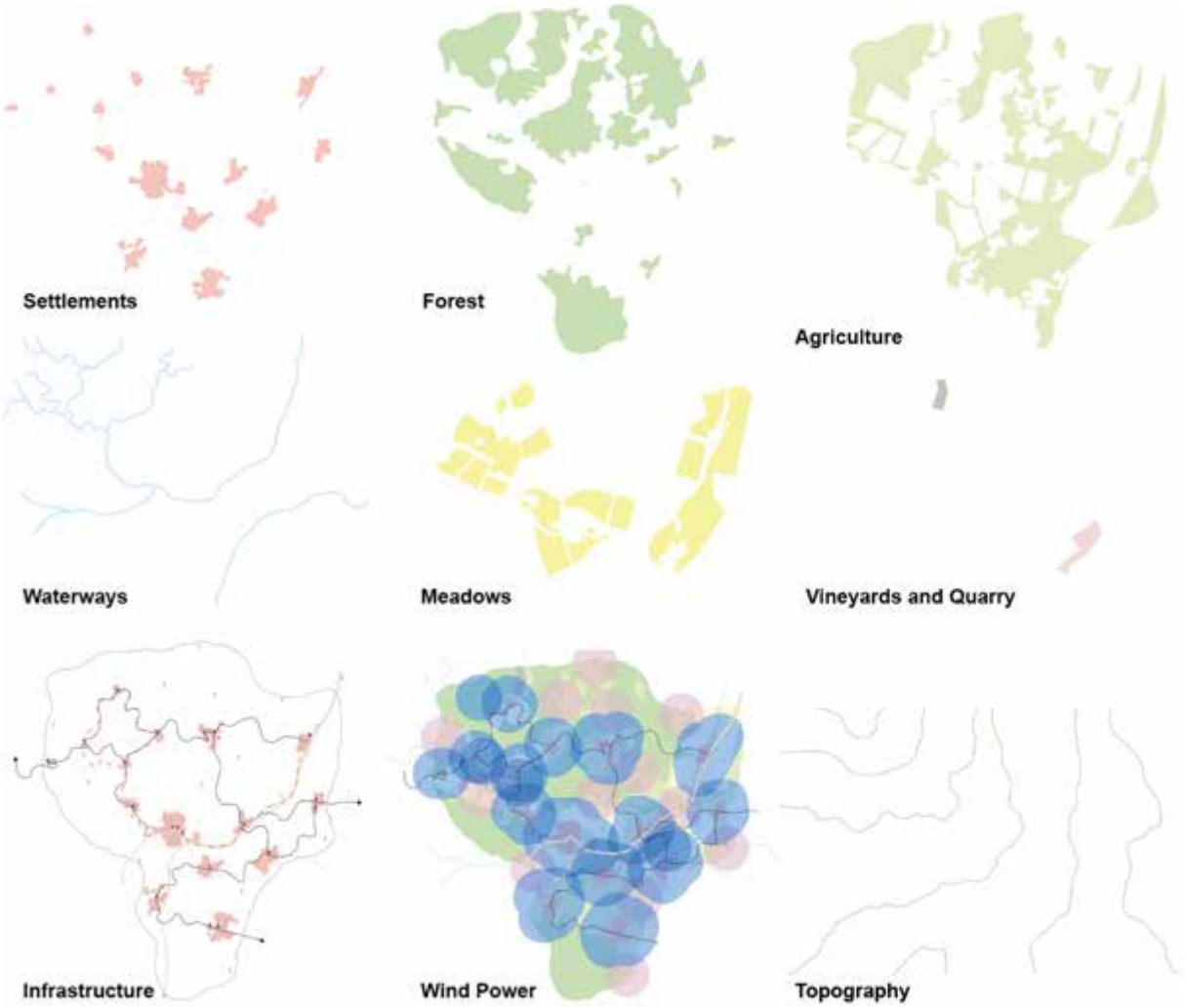


Fig. 10: The digital layers of the Verbandsgemeinde of Zwirgberg. Source: Authors 2024.

Once the relevant layers had been recorded, the infrastructure could be added. In the present context, a hierarchy with main roads, connecting roads and residential roads was selected for traffic, which was supplemented by active and disused railroad tracks and bus stops. Due to the fact that an average of eleven wind turbines are installed in the previously considered municipalities, this number of wind turbines should also be placed in Zwirgberg.

According to the applicable guidelines, wind turbines must be installed at a distance of at least 900 meters from residential areas. In addition, a minimum distance of around 1,000 meters between individual turbines must be ensured. Furthermore, positioning in bird or nature conservation areas is not permitted and they must not impair the appearance of the landscape (Vhw - Bundesverband für Wohnen und Stadtent-wicklung e.V. 2023). Following corresponding analyses, the areas marked in blue were excluded as locations so that the turbines could be positioned in the remaining areas.

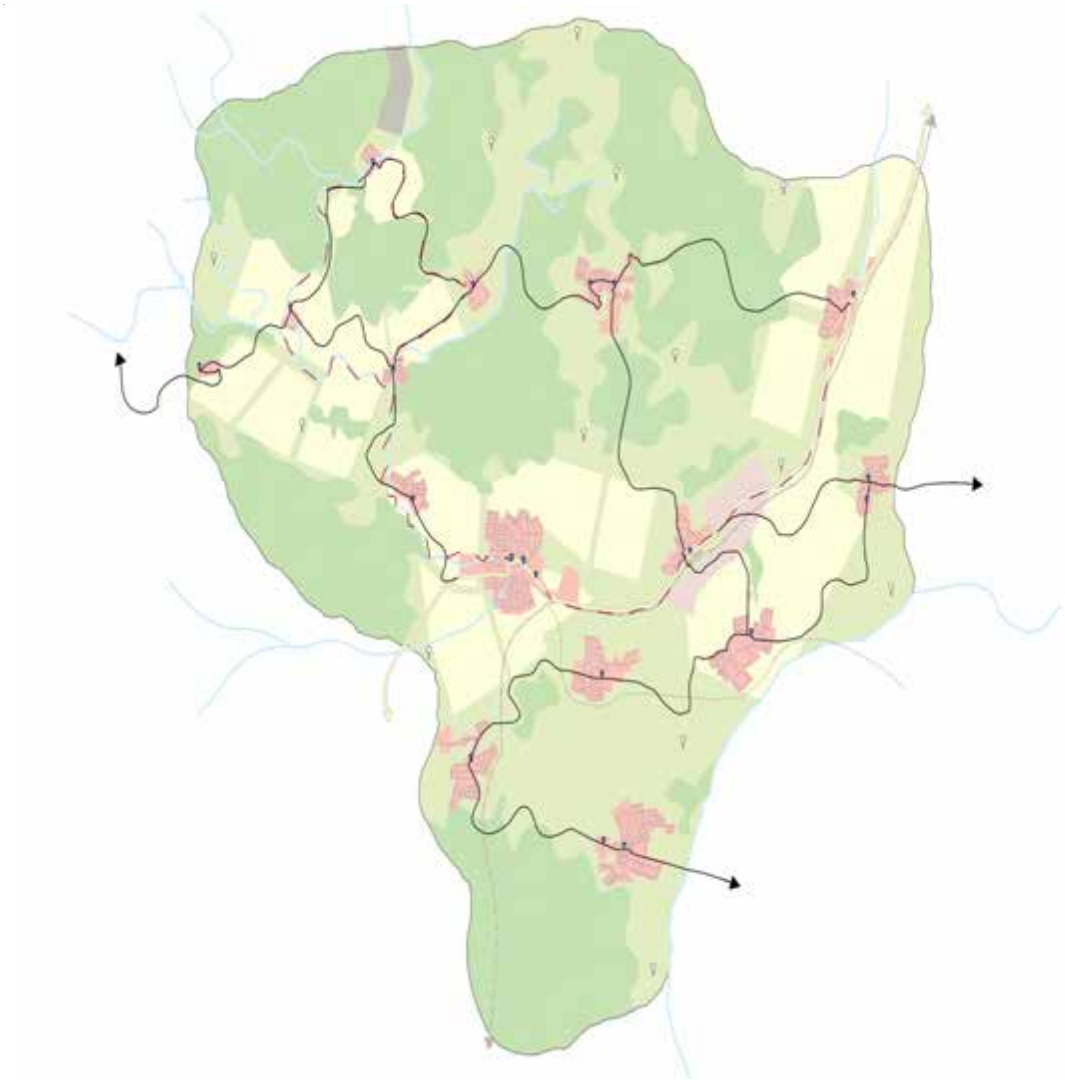


Fig. 11: Digital model of the Verbandsgemeinde of Zwirgberg without detailed settlement structures. Source: Authors 2024.

Settlement structures and their characteristics - Territory categories
In order to create realistic local structures based on settlement areas, it is first important to identify connections between settlement structures within the localities. To this end, the 15 localities are first divided into three "Territory categories":

• Territory category 1
Sprinkles to Drops in topographically higher locations
• Territory category 2
Cow spots as a string of pearls
• Territory category 3
Cow spots surrounded by agriculture or meadows

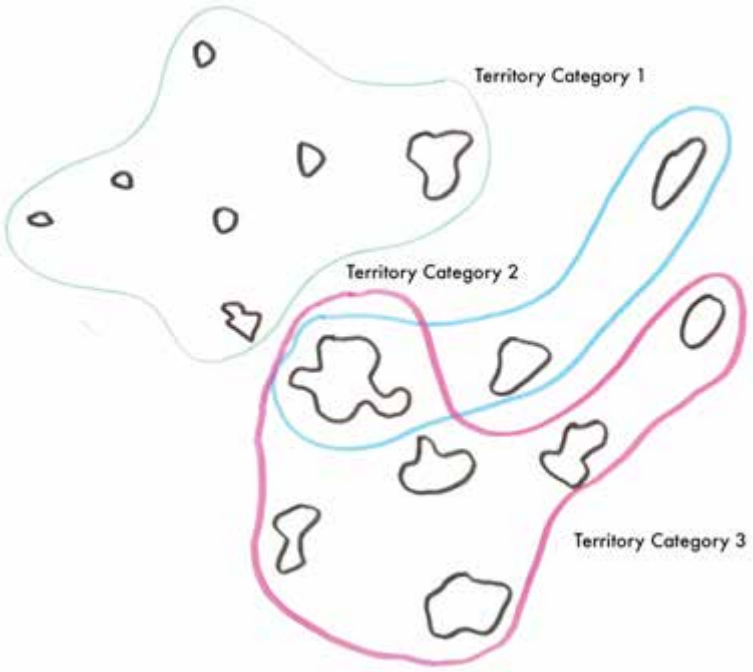
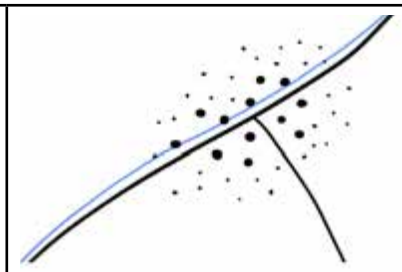
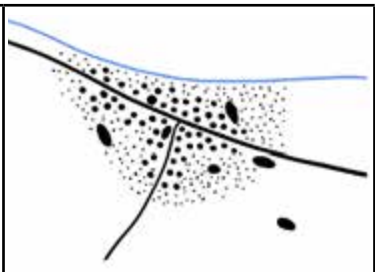
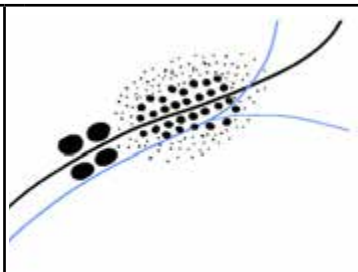


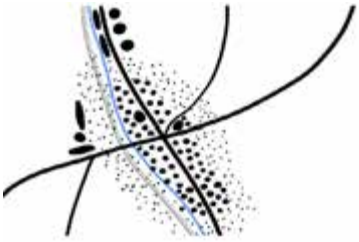
Fig. 12: Division of Territory Categories in the municipality of Zwirgberg. Source: Authors 2024.

Based on these categories, the eleven existing Verbandsgemeinden were analysed and examined for their local characteristics. Particular attention is paid to the town centre, the boundaries to the surrounding area, how the town has grown, how the single-family home areas are arranged, where waterways run, what typologies are present, how the transportation infrastructure runs and what uses are located where and how.

Furthermore, the analysis examines how local structures have grown along waterways, surrounded by vineyards or surrounded by agriculture and to what extent they differ from one another. The analysis also distinguishes between main towns and secondary towns. Since the scattered settlements in the higher-lying areas of the analysed existing Verbandsgemeinden do not contain any Hauptorte, only Nebenorte can be analysed for Territory category 1.

Tab. 1: Settlement structures and their characteristics divided into the three Territory Categories and their respective characteristics in the areas town center, typology, traffic, infrastructure and waterways. Source: Authors 2024.

			
	Territory Category 1	**Territory Category 2**	
	Nebenorte	**Hauptorte**	**Nebenorte**
Town Center	Type 1: denser town center with a street village character, directly on the main road Type 2: looser town center, characterized by several groups of farms	Town center along the intersection of a state road Retail and supply along the town center	Compare with Hauptort
Typology	Single-family houses on both sides of the main road, which runs through the center of town. Mostly, there are no large single-family house areas in the smaller drops, but several (usually two) smaller ones	Single-family home areas border directly on the town center, without transition If commercial or industrial areas are present, they are located along major roads, railway lines, or bodies of water	Commercial enterprises are often located on the outskirts. Denser local structures can be seen along the main roads. Agricultural farms are often found on the outskirts. Type 1: The town develops elongated along the water. Type 2: The town developed as a cluster across the water.
Traffic	Mostly arranged in T-junctions Main road runs through the town center or directly past it	T-junctions Roads often run parallel to the watercourse	A country road or federal highway runs through the town. District roads connect the neighboring towns. The towns are partially divided and split in two by major roads.
Infra-structure	Sports fields are mainly located on the outskirts of town	Sports fields mainly on the outskirts of town School facilities available Market square near church and water, surrounded by main road	Compare with Hauptort

Waterways	Often run parallel to the roads	Type 1: Flows through the main town Type 2: Borders one side of the development Type 3: Recognizable branch of the water in the main town	Compare with Hauptort
			
	Territory Category 3		
	Hauptorte	**Nebenorte**	
Town Center	The town center stretches along the main roads. It is partially surrounded by waterways.	Along the main road in some cases, no clearly recognizable town center, but denser structures along the larger roads and less dense structures away from the main roads	
Typology	Commercial enterprises are located along the main roads or important transport links and mostly on the outskirts. Single-family residential areas adjacent to the town center are mostly laid out in a grid pattern.	Commercial enterprises on the outskirts along transport routes Agricultural farms are located slightly outside or adjacent to the outskirts of the town	
Traffic	Star-shaped traffic axes: State, federal, or district roads often converge at a roundabout.	Compare with Hauptort	
Infra-structure	Some isolated green spaces in the town. Educational institutions are often grouped together in one location in connection with a sports field and clubhouse. Most main towns have a hospital adjacent to the single-family home areas, which is often located on the outskirts of the town.	Volunteer fire department in the town center or on the outskirts	

Development of fictional municipalities

An analysis of settlement structure interdependencies was conducted and suitable structures were first sought from the eleven existing Verbandsgemeinden with the help of a GIS. The structures were color-coded according to their use: town centers, single-family home areas, multi-family homes, educational institutions, healthcare facilities, industry, commerce and agricultural farms.

In the subsequent phase, the GIS snippets were extracted and integrated to generate new settlements. This was done by printing them out, cutting them into smaller sections and "puzzling" them into new settlements. The composition of the locations was based on the identified connections and findings from the analysis phase. Following the integration of the snippets, they were transferred back to the GIS, along with the raster-based census data (as of 2011, the newest data available to this date) corresponding to the building structures. The existing street layouts were adopted and adjusted or expanded as needed.

Fig. 13: Students during the development process of individual settlements in Zwirgberg, cutting and puzzling the snippets of the selected segments. Source: Authors 2024.

Fig. 14: Exemplary representation of three municipalities of the Verbandsgemeinde of Zwirgberg, once in their raw form consisting of snippets of different thematic categories and once integrated into the GIS. Source: Authors 2024.

Zwirgberg's Profiles

Following the completion of the digitization process for all 16 municipalities (15 Nebenorte and the Hauptort Zwirgberg), the subsequent phase involved the consolidation of the individual localities' identities. Since the local communities that had been developed only existed in their current state in the present, the first concern was to underpin them with a historic background to be able to better shape the future of the localities on this basis.

Based on the structure of the municipalities, open questions were formulated that could find their answers in the history of the places: Questions have been raised regarding the rationale behind the location of Strempelfeld, which is situated in a forested area, and the relative size of the town Zwirgberg in relation to the broader municipality.

In order to address these inquiries, a comparative analysis was conducted on the historical functions and origins of the eleven existing Verbandsgemeinden, which revealed a variety of patterns. The majority of the local communities were characterized by agricultural use, although there were also some forest clearing and craft settlements, mining and wine-growing villages, as well as industrial sites, mayoralties, trading centers, and monasteries or castles. In accordance with the categories delineated above, the fictional local communities are allocated to one of these categories, contingent on their geographical location and settlement structure.

Fig. 15: Characteristics. Source: Authors 2024.

In addition to the historical background of the fictional municipalities, further information was assigned to them (based, among other things, on the census data on file). This additional information included the following:
- Size of the settlement area and
- Population
- Local and regional connections
- Individual distribution of land use
- Distribution of open space and
- Leisure activities

This information can be found in respective profiles, such as the one shown below for the Verbandsgemeinde and the Hauptort Zwirgberg. The location of the municipality in the Verbandsgemeinde can also be seen in the illustration next to the name of the town. The illustrations appended to the profiles offer insight into the specific spatial configuration of the municipality.

Fig. 16: Profile for the entire municipality of Zwirgberg and, representing the profiles of all 16 local communities, an exemplary profile for the town of Zwirgberg. Source: Authors 2024.

5. Phase 3 - Developing Future Visions 2050

The development of scenarios is a central aspect of strategic future planning. As part of the "Kommune 2050" project, they were used to design different plausible development paths up to the year 2050 based on the fictional model community of Zwirgberg. The objective was not to provide exact forecasts, but rather to present a range of possibilities that existing Verbangsgemeinden in Rhineland-Palatinate can use as a guide. The scenarios are based on trends such as climate change, demographic change, digitalization, and the mobility transition. These developments have a profound impact on rural areas. The fictional Verbandsgemeinde of Zwirgberg is the result of a synthesis of the existing Verbandsgemeinden that were reviewed during the analysis. As a result, many of the ideas and visions realized in this fictional Verbandsgemeinde can also be transferred to the existing ones. This approach enables these Verbandsgemeinde to gather ideas or find inspiration without being subjected to specific criticism of their shortcomings.

Methodological approach to the scenario development

The scenarios were developed in close coordination with the previous phases of analysis, construction, and vision. Based on Zwirgberg's structures, three consistent futures were developed using narrative elements, trend syntheses, and graphic sketches. Using the GIS model, which contained real demographic and morphological data, iterative feedback enabled the scenarios to be precisely anchored in space. Participatory elements and critical reflections - such as those concerning the plausibility or scope of visionary proposals - complemented the methodological process.

To ease the transition into developing visions of the future, three phases were completed as part of a "Future Workshop" (Zukunftswerkstatt). During the 15-minute criticism phase, the municipality's weaknesses and risks were identified and noted. Next came a 20-minute utopia phase, during which future developments were designed without restrictions due to practical constraints to capture all wishes, dreams, and utopias. The concluding 25-minute implementation phase reviewed the utopian designs for feasibility and translated them into concrete, realizable projects.

Fig. 17: Characteristics. Source: Authors 2024.

Three Scenarios for Zwirgberg in 2050

Based on current trends, the results of the 'Future Workshop', and Zwirgberg's existing potential, three visions of Zwirgberg's future were developed.

These visions are interconnected and mutually dependent. The visions 'Net Zero Tourism', 'Climate-Positive Zwirgberg', and 'Interconnected Community' contain core building blocks that can be implemented with the help of the developed tools. The cross-cutting themes of digitalization and mobility are reflected in all three.

A conceptual image was created for all three future visons, and corresponding areas of action and associated measures were developed for each. The conceptual image is provided for all visions; the detailed version, which includes the fields of action and measures, is only shown as an exemplary model in the case of vision a, but was also developed for the other visions.

The scenarios were not only designed as thought models, but systematically translated into concrete action paths. These include: the reactivation of vacant properties, the transformation of mobility infrastructure, the promotion of civic energy projects and digital inclusion. Thanks to the modular structure of Zwirgberg, these building blocks can be transferred directly to existing Verbandsgemeinden. Each Verbandsgemeinde can select the components from the Zwirgberg toolbox that suit its starting point and objectives.

A. Net-Zero Tourism

The future vision is predicated on the trends of mobility and climate change. The region's potential for hiking and cycling trails, the distinctive characteristics of the surrounding villages, and viticulture will be fully utilized. The Verbandsgemeindes distinctive selling point is its commitment to net-zero tourism. It is hypothesized that Zwirgberg will become an oasis for climate tourism. Measures such as the renaturation of the Meerbach stream, the introduction of new forms of mobility (autonomous shuttle buses, mobility stations, mobility on demand), and the expansion of the cycle path network will improve accessibility. The implementation of additional measures is expected to enhance the appeal of the towns and the broader municipality.

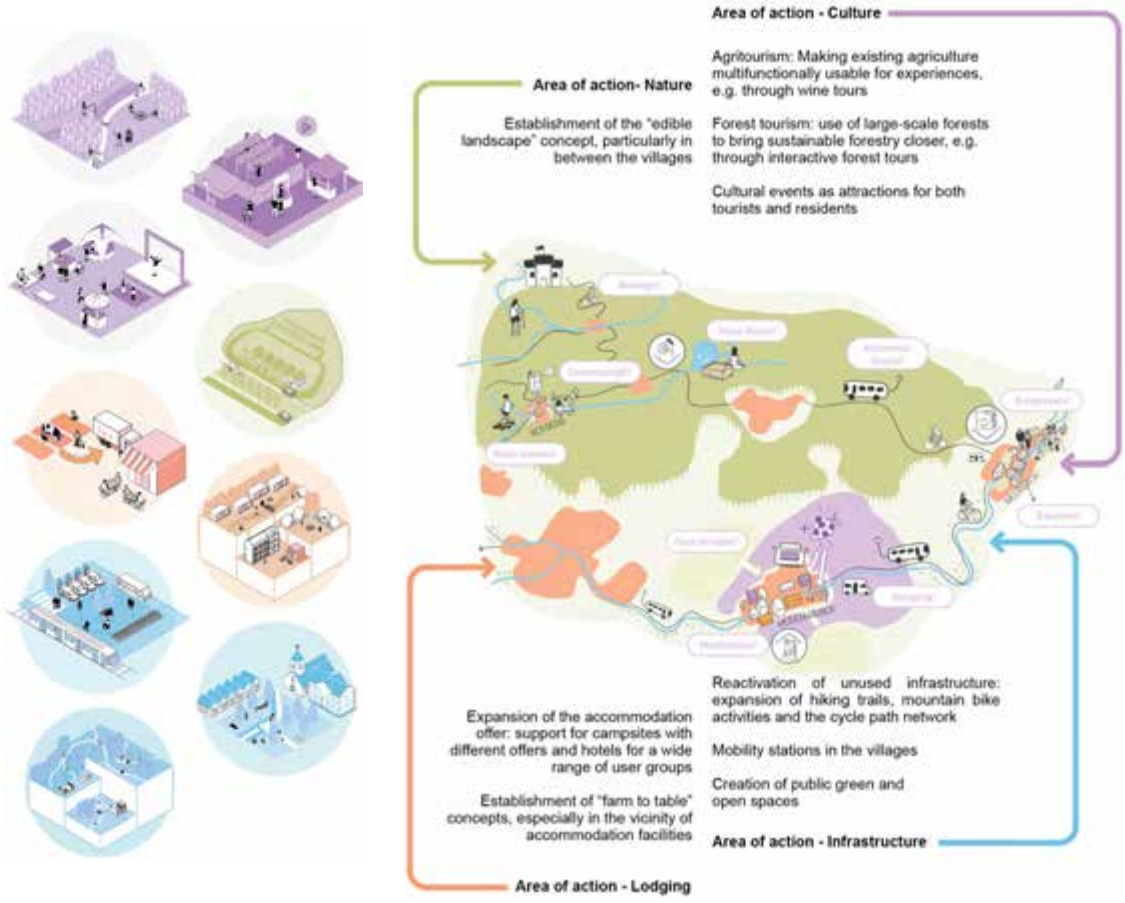


Fig. 18: Areas of action and the according catalogue of measures of the future vision 'Net-Zero Tourism'. Source: Authors 2024.

B. Climate-Positive Zwirgberg

This vision focuses on climate change, particularly extreme weather events, changes in biodiversity, the energy supply, and sustainable mobility. Forest structures, agriculture, wind turbines, and places such as Niederkalm are characterized by climate-adapted development. Zwirgberg aims to become climate-positive by 2050, surpassing the goal of merely achieving climate neutrality. This proactive approach to climate change is included in the vision for the future. The measures cover construction and housing, forestry, and agriculture.

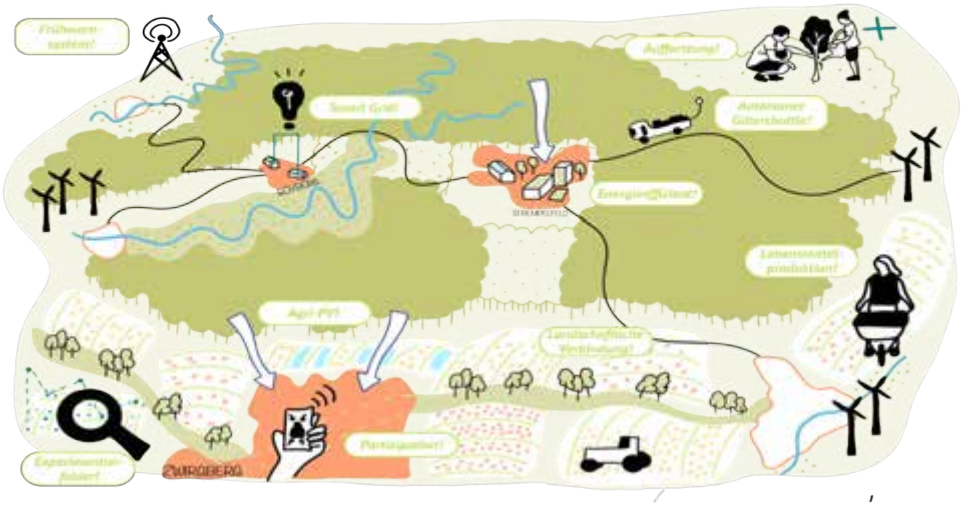


Fig. 19: The conceptual image of the future vision 'Climate-Positive Zwirgberg'. Source: Authors 2024.

C. Interconnected Community

Central to this vision is the reorganization of the administrative and supply structure. Zwirgberg becomes a federally cooperating community in which administration, social services, mobility, and education are networked via a digital platform. Shared infrastructure, shared resources, and hybrid co-working spaces form the basis of a new municipal governance model. Smaller local units retain their autonomy but benefit from the network character of the overall community.

Fig. 20: The conceptual image of the future vision 'Interconnected Community'. Source: Authors 2024.

6. Discussion and conclusion

The 'Municipality 2050 - The next Generation' research project demonstrates the potential of an experimental approach using digital, creative and analytical methods. The chosen approach of using a fictitious but realistic model municipality as a projection surface for future issues has proven to be a viable basis for reflecting on real development challenges.

The combined methods proved to be particularly effective: the combination of GIS-based analysis, modular settlement structuring, participatory scenarios and narrative elements enabled a high degree of reflection and connectivity. The creative and analytical work with real settlement fragments strengthened the transferability to real contexts. At the same time, the fictional nature of the model allowed for a certain degree of non-bindingness, which opened up scope for the municipal actors to selectively explore possible future options without political pitfalls.

Nevertheless, it is important to acknowledge the limitations of this approach: Transferability depends largely on the willingness of local authorities to embrace new ways of thinking. Methodologically, the approach also requires a certain degree of planning and data expertise in order to be able to interpret and use models, scenarios and spatial analyses. Collaboration with students proved to be a strength in this context, as their perspectives provided creative impetus, but also required a substantial degree of guidance and structuring.

The central realisation is that it is less about a 'right model' and more about a comprehensible and well-structured process of self-assurance and perspective building. Zwirgberg as a fictional but realistic model space offers a versatile framework for this. The further development now lies in transferring the reflection into real practice - with the Verbandsgemeinden, for which Zwirgberg can also be a mirror.

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Next Generation EU The Case of Rome, two strategic actions within a list of projects

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Abstract
This paper examines the implementation of the Italian National Recovery and Resilience Plan (PNRR) in Rome, with a particular focus on its urban dimension. It analyses how city governance, through the creation of a dedicated department and a Special Council Commission, has responded to structural deficiencies by strategically integrating extraordinary resources with long-term urban planning goals. Special attention is given to the Integrated Urban Programs (PUI) of Corviale, Tor Bella Monaca, and Santa Maria della Pietà, highlighting their transformative potential as nodes of innovation and inclusion. The case of Rome exemplifies a shift from top-down emergency planning to territorially grounded governance strategies.

Keywords: Urban regeneration; PNRR; Rome; Integrated Urban Programs (PUI); Living Labs; Urban governance

1. Introduction

In recent years, cities have emerged as crucial actors in responding to major global transitions — from climate adaptation to social resilience and digital innovation. However, this urban protagonism has often clashed with the rigidity of national frameworks and the inertia of institutional systems. The COVID-19 pandemic accelerated this tension, exposing not only the fragilities of public infrastructure and governance but also the untapped capacity of cities to act as laboratories of policy innovation.

In this context, the European Union launched Next Generation EU, a historic recovery instrument endowed with €750 billion to support Member States in addressing the post-pandemic crisis. The Italian National Recovery and Resilience Plan (PNRR), the most extensive national plan in the EU with over €190 billion allocated, represents a once-in-a-generation opportunity to reshape public investment, institutional capacity, and territorial development.

Despite its transformative potential, the Italian PNRR has been repeatedly criticised for lacking an overall vision — a "plan without a plan" — with limited coordination, a top-down allocation of resources, and little attention to territorial specificities. Especially in urban areas, this disconnect has often resulted in a mismatch between funding opportunities and actual urban needs.

The city of Rome, Italy's capital and largest metropolis exemplified this contradiction (De Leo, 2022). Initially receiving only two projects within the national strategy — Caput Mundi (focused on tourism) and Cinecittà (media infrastructure) — Rome found itself relegated to a marginal role despite its scale, complexity, and governance challenges.

However, Rome did not remain passive. The change in municipal leadership in late 2021, with the election of Mayor Roberto Gualtieri, marked a decisive turning point. The new administration implemented an ambitious institutional framework to realign the city's strategic vision with the fragmented architecture of the PNRR. It established a dedicated Department for Strategic Planning and PNRR (DPSP) and created a Special City Council Commission (CS PNRR), facilitating interdepartmental coordination and participatory oversight.

This paper examines how Rome utilised the PNRR not only as a financial opportunity but also as a catalyst for strategic urban governance. Through a detailed analysis of the Integrated Urban Programs (PUI), particularly those of Corviale, Tor Bella Monaca, and Santa Maria della Pietà, this study aims to understand how cities can transform emergency funding into long-term urban development.

The aim is twofold: first, to identify the institutional, spatial, and participatory mechanisms that have enabled

Rome to reclaim agency within a nationally constrained framework; second, to reflect on how this experience aligns with the principles of the evolving Urban Agenda for the EU, proposing a path toward institutionalising such practices beyond 2026.

2. The PNRR in Rome: Context, Governance, and Actors

Rome's relationship with national investment programs has historically been complex and ambivalent. As the capital city, Rome is burdened with both symbolic and administrative functions, but it lacks the financial and institutional autonomy typical of European metropolises. The PNRR has made this contradiction even more evident.

Rome's National Recovery and Resilience Plan (PNRR) was developed in two distinct phases. The first phase, conducted in parallel with national planning, was led by the municipal administration under Mayor Virginia Raggi (Five Star Movement), in office until the end of October 2021. The second phase commenced with the inauguration of the new administration, headed by Mayor Roberto Gualtieri (centre-left), on 3 November 2021, marking the start of the PNRR's operational implementation in the city.

During the initial phase, the City Council focused on drafting a "Resilient and Sustainable Development Plan" (Autumn 2020), incorporating 159 projects proposed by various departments of Roma Capitale. The total value of this plan amounted to €25 billion, intended to be financed through the Recovery Fund. The proposals addressed strategic domains for the city's recovery and growth: social inclusion and urban regeneration, sustainable and integrated mobility, safe and efficient infrastructure, ecological transition, and digital innovation. However, this strategic vision and the projects it comprised were not included in the national PNRR approved by the European Commission in July 2021. In that version, Rome was represented only through two national projects of relevance: Caput Mundi and Cinecittà. Nevertheless, parts of Raggi's proposal, especially those related to the tram lines and the enhancement of the city's archaeological and historical heritage, were later reabsorbed into national programs.

With the arrival of the Gualtieri administration, the launch of the first national funding calls marked a turning point. To successfully participate and secure funding, Roma Capitale signed cooperation agreements with universities in the Lazio region, ensuring a high level of scientific and technical support in the preparation of project proposals. Simultaneously, based on a national agreement between the government and **Invitalia**, the city coordinated its departments to prepare tenders for the design and/or implementation of works (Caudo G., Baioni M., Celata F., De Leo D., Fava, F., Piselli E., Tomasello P. (2024).

A pivotal agreement was also signed with the **Metropolitan City of Rome (CM)** to jointly participate in the call for **Integrated Urban Programs (PUI)**, which allocated €300 million to the CM. This agreement established a collaborative framework between Roma Capitale, the CM, and its municipalities, reserving approximately €200 million for Rome and the remaining funds for other municipalities within the metropolitan area.

In 2022, the majority of the PNRR-related calls were issued, and the city engaged in negotiation procedures with the respective ministries. In June 2022, Mayor Gualtieri, acting as Government Commissioner for the Jubilee, signed an agreement with the Ministry of Tourism (the lead authority for Caput Mundi) to transfer its governance to Roma Capitale. Following this agreement, some of the projects were integrated into the Jubilee framework, while others remained under the direct responsibility of Roma Capitale or were managed by the Ministry of Culture through its Special Superintendency for Rome.

Roma Capitale and the CM participated in nearly all available calls for which they were eligible. In addition, they engaged in "negotiated procedures" with central government entities for strategic, non-competitive projects, such as Caput Mundi, the bicycle lane network, tram and electric bus infrastructure. Some initiatives already financed through other programs (e.g. **PINQuA** — the National Innovative Program for Urban Quality of Living) were also integrated into the implementation framework.

Rome's participation rate in national calls approached 100%, and the city succeeded in securing approximately **90% of the total resources requested**, resulting in an allocation of **€1.15 billion** (excluding additional co-funding from the Ministry for tramways and municipal contributions for PINQuA and cinema/theatre projects). However, one principal exclusion concerned funding for **waste treatment infrastructure** under Mission 2, Component 1, Investment 1.1 (lines A and B), totalling €191.4 million. This rejection was due to selection criteria established by the Ministry for the environment, which prioritised projects in small- and medium-sized cities based on expected impact, thus penalising large metropolitan areas such as Rome.

At the end of the funding acquisition phase, the scope of PNRR investments in Rome had expanded significantly, covering a wide range of strategic sectors (e.g. mobility, digitalisation, culture, and inclusion). From an initial allocation of just under €230 million for Caput Mundi, the city's direct management of resources grew to nearly **€1.2 billion**. Despite several critical issues, the formation phase of Rome's PNRR can, therefore, be regarded as a **successful institutional response** to a challenging national framework.

This paper adopts the perspective of those who view the PNRR not simply as a disbursement mechanism but as an **opportunity to be amplified through the introduction of new tools, methods, and institutional arrangements**. These mechanisms — although shaped by exceptional and complex circumstances — can serve as catalysts for long-term transformation.

While maintaining a critical eye on the structural weaknesses of the PNRR — such as the excessive emphasis on the **quantitative volume of resources** as the dominant evaluative criterion — this contribution argues for a broader and more qualitative understanding of its governance implications. The prevailing narrative has obscured the **absence of strategic planning** and reinforced the impression of a "plan without a plan" (Pizzo, 2022). Furthermore, the national government's interpretation of Rome's role has appeared **anachronistic**, limiting the capital's potential to two symbolic areas — **Cinema and Ancient Rome** — as though the city still belonged to the era of La Dolce Vita. Such a reductive vision fails to grasp the complexity of contemporary Rome and its need for integrated, future-oriented planning.

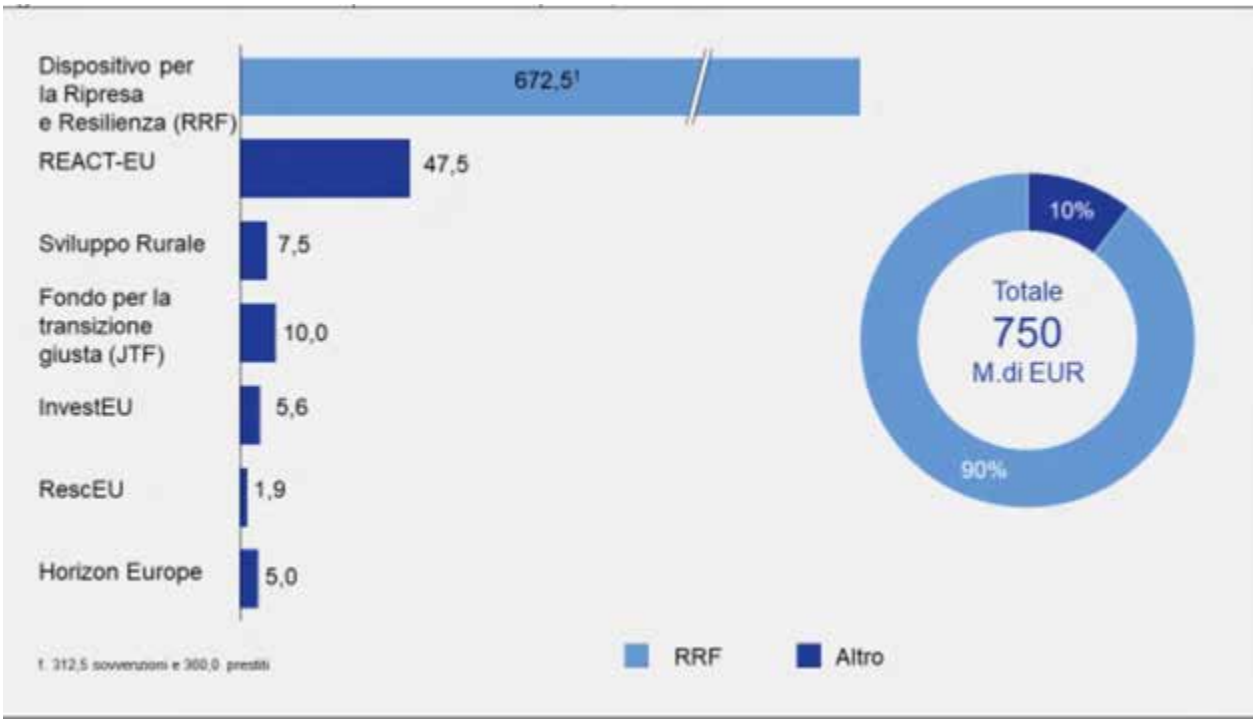


Fig. 1: Next Generation EU – European Commission

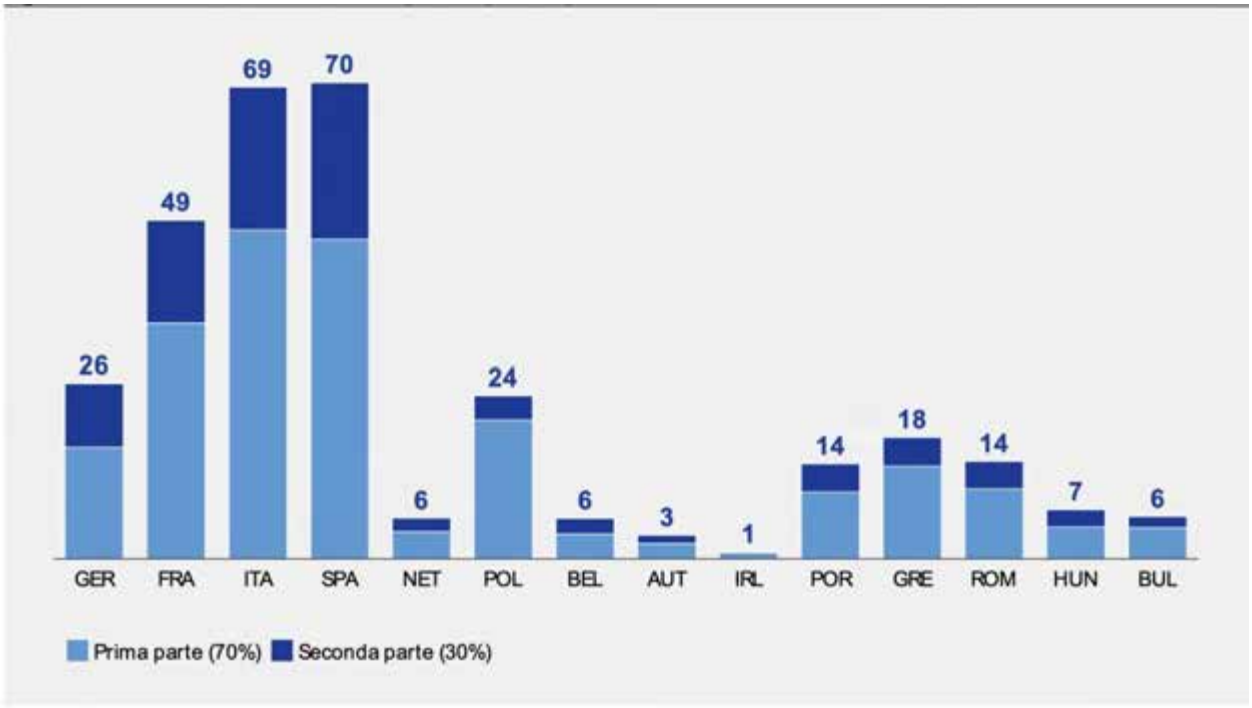


Fig. 2: Next Generation EU – Resource for countries, grants - European Commission

Fig. 3: Rome's NRRP, investments by individual measures and localisation

3. Urban Regeneration Strategies: The Integrated Urban Programs (PUI)

The PUIs, funded under **Mission 5** of the PNRR (Cohesion and Inclusion), represent the most territorially grounded and socially complex component of the plan. In Rome, three priority areas were selected: **Corviale**, **Tor Bella Monaca**, and **Santa Maria della Pietà** — each a symbol of spatial marginality and socio-economic fragmentation. The regeneration model adopted goes beyond physical upgrading. It involves:

- Multi-level coordination (City, Region, ATER, third sector)
- Activation of **30 Civic and Cultural Hubs**
- Integration of **immaterial actions**, such as job activation, education, and care services
- Strong emphasis on **participation and proximity governance**

This integrated approach aims to shift the paradigm from housing-centric redevelopment to **neighbourhood-based regeneration**, embedding welfare, culture, and active citizenship into the very structure of public space.

3.1 Corviale and Tor Bella Monaca, two peripheral icons

Corviale and Tor Bella Monaca are among the most emblematic cases of public housing estates in Rome and, more broadly, in Italy. Both represent the architectural and social outcomes of large-scale, modernist planning in the post-war period. Over time, however, these projects became spatial containers of structural inequality — synonymous with marginalisation, physical decay, and institutional neglect.

However, these same spaces have also become laboratories for resilience, experimentation, and urban innovation. The PNRR's Integrated Urban Programs (PUI) did not impose regeneration from above but built upon years of local action, community work, and territorial knowledge.

3.1.1 Corviale: From Architectural Symbol to Regenerative Ecosystem

Corviale is one of the most iconic urban structures in Italy — a monolithic, one-kilometre-long residential block built between the late 1970s and early 1980s in the southwestern quadrant of Rome. Originally conceived as a "linear city" capable of self-sufficiency, with housing, services, commerce, and leisure integrated within a single continuous structure, Corviale soon fell short of its utopian vision.

Only 80% of the complex was completed, and the entire fourth floor, designed for public and commercial use, remained empty. Over time, this space was informally occupied by families in need of housing, reinforcing the area's stigma. Corviale became a symbol of both architectural excess and public policy failure.

However, since 2014, a new phase began with the launch of the Laboratorio di Città Corviale, coordinated by Roma Capitale, the Lazio Region, ATER (the public housing agency), and multiple academic and social actors. The Laboratorio operates as a place-based institutional infrastructure, combining participatory design, public deliberation, and technical planning.

Thanks to this groundwork, when the PNRR was launched, Corviale was already equipped with a governance platform capable of channelling new investments. The €43 million allocated through the PUI was not a starting point but an accelerator of an ongoing process.

The core objective of the PUI in Corviale is the **completion and functional reactivation of the fourth floor** — the so-called piano libero. This space, once a void and a site of informal appropriation, will be transformed into a **linear public infrastructure** housing:

- Social and cultural services
- Spaces for education and training
- Job creation hubs and co-working areas
- Healthcare and psychological support facilities

The project explicitly adopts the principles of **proximity urbanism**, aiming to restore access to rights and services within walking distance. It is not only a physical intervention but an **institutional reconfiguration** of space — converting a zone of abandonment into a civic backbone.

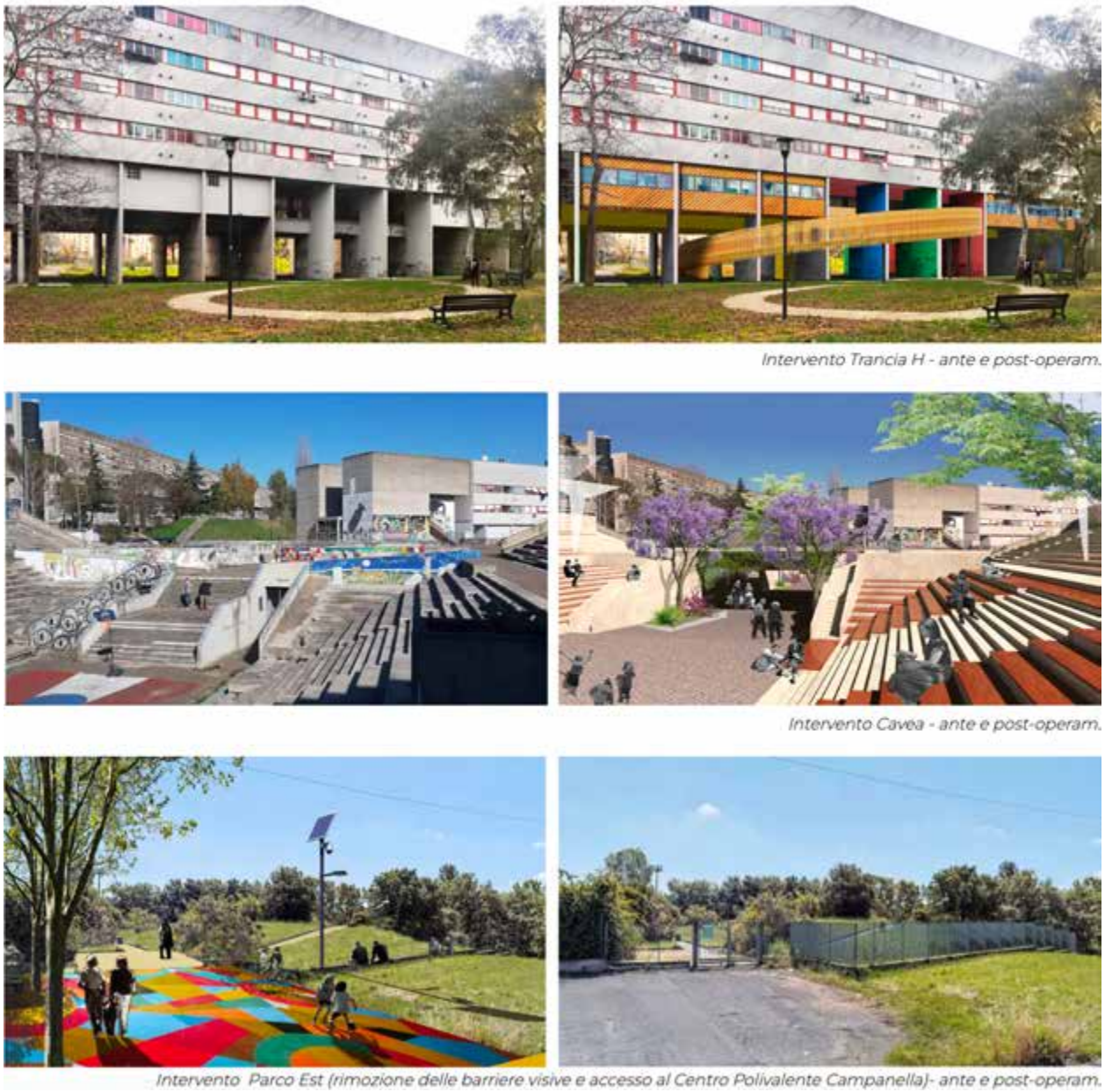
Parallel to the physical works, a package of **"immaterial" actions** has been activated, encompassing educational support, health services, and employment pathways tailored to the residents' skills and needs. These programs are implemented in cooperation with third-sector organisations selected through public calls.

3.1.2 The Role of the Laboratory

The **Laboratorio di Città Corviale** plays a central role in ensuring the continuity and coherence of the regenera-

tion process. It serves as:
- A **platform for co-design** involving residents, schools, cultural associations, and local businesses
- A **mechanism of coordination** among city departments, ATER, the Lazio Region, and technical offices
- A **monitoring and learning space** where policies are assessed, adapted, and scaled

This multi-actor configuration ensures that regeneration is not only planned "for" Corviale but "with" Corviale. Moreover, the Laboratory maintains a **public presence within the building itself**, operating from offices located inside the complex — a deliberate choice to **reduce institutional distance** and promote trust.



Intervento Trancia H - ante e post-operam.

Intervento Cavea - ante e post-operam.

Intervento Parco Est (rimozione delle barriere visive e accesso al Centro Polivalente Campanella)- ante e post-operam.

Fig. 4 – Corviale's pojects

What emerges in Corviale is more than a redevelopment project. It is a **shift in urban policy** from isolated, short-term interventions to **systemic, cross-sectoral governance** rooted in place. The integration of PNRR resources into a pre-existing strategic trajectory demonstrates how **extraordinary funding can reinforce, rather than distort, local priorities**.

This model challenges traditional notions of urban renewal, which often treat physical upgrading as sufficient. In Corviale, **social infrastructure and public institutions are considered integral components of the regeneration strategy**, not add-ons.

In that sense, Corviale is not only a case study but a **prototype** — offering insights into how European cities can manage complexity through adaptive, participatory, and spatially grounded urban governance (Nevens, F., Frantzeskaki, N., Gorissen, L., & Loorbach, D. (2013).

3.1.3 The Laboratory as a Living Lab: Participatory Urbanism in Practice
The Laboratorio di Città Corviale can be interpreted through the conceptual lens of the **Urban Living Lab** (ULL) — a model of urban experimentation that combines **multi-stakeholder engagement, place-based co-creation, and iterative learning cycles** to address complex challenges in real-life settings (Schliwa & McCormick, 2016; Steen & van Bueren, 2017).

Living Labs are increasingly recognised in urban studies and innovation policy as **arenas for collaborative experimentation**, where public institutions, residents, researchers, and civil society actors engage in the co-production of knowledge, policies, and services. They aim not only to test solutions but to transform institutional relationships and build new capacities for governance.

In this light, the Laboratorio di Città Corviale functions as a **territorially embedded Living Lab** with distinctive characteristics (Nevens et al., 2013; Marvin et al., 2018):
• **Spatial anchoring**: The Laboratory is physically located within the Corviale complex, reducing the symbolic and operational distance between the administration and residents.
• **Actor plurality**: It engages a broad coalition of stakeholders — including Roma Capitale, the Lazio Region, ATER, universities (e.g., Sapienza, Roma Tre), local associations, and informal groups — operating under a shared, negotiated framework.
• **Iterative co-design**: Project development unfolds through **cycles of consultation, feedback, and redesign**, echoing the iterative logic of Living Labs. This is particularly evident in the reprogramming of the "piano libero" and the tailoring of social services to residents' expressed needs.
• **Learning infrastructure**: The Laboratory not only implements but also **documents and reflects on processes**, producing governance knowledge that can be transferred or scaled to other contexts (e.g., the Lab is now in dialogue with similar initiatives in Tor Bella Monaca and Santa Maria della Pietà).

In contrast to traditional participatory mechanisms, which are often limited to public hearings or consultative boards, the Laboratory adopts a **model of embedded co-governance**. This means that citizens are not merely external observers but **co-producers of planning decisions**, contributing both their lived experiences and social knowledge.

This approach aligns with recent scholarship that frames Urban Living Labs as **transitional governance spaces** (Bulkeley et al., 2016) capable of mediating between formal institutions and grassroots innovation. The Laboratory acts as an **intermediary arena** where diverse rationalities — bureaucratic, political, civic — are negotiated and recomposed into shared actions.

Moreover, the Laboratory has become a **site of institutional learning**, allowing Roma Capitale to experiment with regulatory flexibility, cross-sectoral coordination, and capacity-building in a low-risk, high-feedback environment — precisely the conditions recommended in the literature for successful ULL implementation (Nevens et al., 2013; Marvin et al., 2018).

Perhaps the most important legacy of the Laboratory is cultural: it fosters an alternative narrative about Corviale, moving beyond stigma toward a **collective re-imagining of the city**. Demonstrating that collaborative processes can be compelling, legitimate, and inclusive contributes to a shift in the institutional mindset of public administration.

As Rome looks to scale similar approaches to other neighbourhoods — including Tor Bella Monaca and Santa Maria della Pietà — the Corviale experience offers a **blueprint for cultivating a city-wide Living Lab ecosystem**, where regeneration is understood not as an intervention **in** the territory but **with** and **through** it.

4. **Toward a Strategic Description of the Plan: PUI and the Monumental Archaeological Center**
Currently, two coordinated efforts can be identified in Rome as attempts to develop a more strategic reading of the National Recovery and Resilience Plan (PNRR): the **Integrated Urban Programs (PUI)** and the **Fori Project**, specifically, the projects related to the **Monumental Archaeological Centre of Rome** (CArMe).

The three PUI initiatives are described as **innovation hubs** that combine interventions on the built environment and the creation of public spaces with the ambition of integrating **immaterial (social and relational) projects** aimed at supporting physical redevelopment through responses to the **real needs of the local communities**.

This aspect has been strongly emphasised by the work of the **Special Commission on the PNRR (CS PNRR)**, which has held a series of hearings on the implementation of the PUIs. These meetings have involved actors from the **third sector**, **trade unions**, and **neighbourhood associations**, all engaged in building paths toward meaningful integration. One concrete result of these participatory processes has been the **issuance of calls for expressions of interest** by the Department of Social Affairs for the **co-design of interventions** within the PUIs, which will also benefit from additional resources — approximately **€10 million** from the PON Metro fund (currently being finalised).

Among the **immaterial projects** included in the PUIs is the **experimental adoption of active labour policies**, inspired by the French model of Territoires zéro chômeur de longue durée ("Territories with Zero Unemployment"). The PUIs are further reinforced by the development of **30 Civic Hubs (Poli Civici)**, which together create a **strategic framework for the urban periphery** of Rome, structured around three principal axes (Corviale, Tor Bella Monaca, and Santa Maria della Pietà) and thirty civic nodes distributed across the city.

What is meant by "Civic Hub" is, in fact, a central question being addressed through these projects. For example, the transformation of a local library into a **Civic Hub** provides an opportunity to design a **context-sensitive offering of proximity services** tailored to the specific characteristics and needs of each neighbourhood. The Civic Hub thus becomes a flexible infrastructure, adaptable to local differences and a vehicle for redefining the scale and nature of urban welfare.

The **Monumental Archaeological Centre of Rome (CArMe)** is a project currently under development by **Walter Tocci**, whom the Mayor has appointed to coordinate interventions in the areas of the **Imperial Fora, the Colosseum Park, the Circus Maximus, the Celio Hill**, and the **Archaeological Promenade** (Passeggiata Archeologica).

This initiative builds upon the vast set of investments launched under the Caput Mundi programme — not only those developed by Roma Capitale but also those promoted by the Ministry of Culture — with the objective of delineating a **comprehensive and unified strategy** for the archaeological heart of the city.

Naturally, the project is also being developed in alignment with the **Jubilee 2025**. It revives the conceptual thread of long-term reflection, dating back to Leonardo Benevolo's **Progetto Fori** (1985), reactivating the ambition to make the monumental core of ancient Rome **more accessible, integrated, and coherent**, both in terms of urban form and cultural function.

5. Conclusion – Beyond the PNRR: Strategic Futures and the Urban Agenda for the EU
The implementation of the PNRR in Rome offers not just a case study in urban resilience under extraordinary conditions but a window into the possible futures of urban governance in Europe. While the PNRR was born as a crisis-driven funding mechanism, its unintended consequence has been to expose both the latent capacities and systemic shortcomings of local administrations. In Rome, this stress test has produced a response that is

not only reactive but, in many respects, structurally transformative (Viesti, 2023).

The introduction of dedicated institutional frameworks (DPSP PNRR and CS PNRR), the successful engagement of civil society, and the embedding of participatory practices in the design of public investment all point to a more mature, place-based model of urban policymaking. These developments contrast sharply with Italy's traditional model of urban governance, which has long been characterised by fragmentation and limited strategic capacity at the local level.

As the 2026 deadline approaches, the sustainability of this transformation is far from guaranteed. The risk is that institutional innovations may be dismantled once the extraordinary funding cycle ends — a step backwards when cities must act as frontline actors in addressing climate, social, and digital challenges.

In this context, the Urban Agenda for the EU is crucial. Since its launch in 2016, it has evolved to give cities a role in shaping EU policies. The New Leipzig Charter and Ljubljana Agreement promote integrated, place-based, multi-level governance — principles Rome has already put into practice.

Italy now faces the task of institutionalising these practices. The PNRR has been a stress test; now, it must become a foundation. The Urban Agenda should guide ordinary planning, supported by:
- Long-term funding for cities;
- Stronger inter-municipal governance;
- Enhanced capacity building and civic participation.

Rome can become a living laboratory for the Urban Agenda — not just reacting to emergencies but planning its future. The real goal is not merely to administer funds but to institutionalise the capacity for continuous, democratic, and inclusive urban change.

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Track 10

THEORIES

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Should planning and policy gather around the concept of "community of disagreement"?

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Should planning and policy gather around the concept of "community of disagreement"?

Abstract
The planning field tends to have consensus building as a guiding inspiration. Politics, on the other hand, is an activity characterised by disagreement and competition over ideology, values, knowledge, and planning solutions.

Since, or if, we in the planning field today are concerned with giving politicians a leading position, we must recognise the need for politicians to highlight disagreement. Only then will planning become a tool for political governance and for strengthen democracy.

We will in this paper present some main positions in the field of planning theory regarding handling professional and political disagreements, and then introduce the concept «communities of disagreement», as it is defined and discussed in the book Communities of disagreement: perspectives on democratic interaction[1] (Iversen, 2014).

Key words: Community of disagreement, politics in planning, disagreement in planning

Introduction

This text is more of a reflection than a conclusive answer. to the question "Should planning and policy gather around the concept of 'community of disagreement?" I will argue that this concept, with its theoretical foundation and practice, will be fruitful to use in the debate on how societal planning has dealt with and should deal with disagreement. The field of planning, both in theory and practice, often has consensus as its guiding star for normative theory and practice development. Politics, on the other hand, is an activity characterised by disagreement and competition over ideology, values and what constitutes legitimate knowledge. In politics the goal may be to cultivate disagreement, rather than to reach an agreement. If, or when, we in the planning field are concerned about that politicians should take the leadership position that planning legislation[2] emphasises they should do, the planning field must both recognise and make room for politicians' need to highlight disagreement, also in planning processes. Only then will societal planning become a tool for both political leadership and for strengthening democracy.

I stumbled upon the concept a couple of years ago at the Nansen Center for Peace and Dialogue in Lillehammer (https://peace.no/), which uses the concept in its dialogue work, e.g. in the New handbook: A practical approach to public dialogue NEW HANDBOOK: A practical approach to public dialogue https://peace.no/en/new-handbook-a-practical-approach-to-public-dialogue/

For a number of years, I have followed and admired this dialogue work that takes place primarily in other countries other countries i.a. the Balkan countries, Ukraine, Chile, Afghanistan, Poland, but also in Norway. The core of their work is to build trust and communities in societies with strong opposing interests and high levels of conflict. The ambition is to increase the understanding and respect for disagreement, to be able to better live with, rather than resolve, such disagreements.

Disagreement is normal within organisations and societies. It is important in a democracy to accept disagreement, to consider it as something inevitable. Disagreements can be both problematic, action-paralysing, and destructive, while also engaging, and have the potential for new thoughts and actions, for innovations.

In this paper, I primarily focus on how the field of planning over the years has given attention to disagreement with emphasis on the place of politics and politicians in the planning field. I delve into some Norwegian and

1 Own translation from Norwegian
2 At least in Norway

international planning theory texts, Norwegian planning research, government planning guidelines, and apply experiences from my own planning research, teaching, student guidance and lecturing activities. I will also draw on experiences from 40 years as a political activist, 25 years as an elected official at local, regional, and national levels, and as an active member of a political party, various organisations, and trade union movements. Politics, however, is not my academic field, just my field of practice, cf. the book Planners in Politics: Do they make å difference (Albrechts ed., 2020) where I have written the chapter 'Forty years as a politician with a background in planning. How did this affect me as politician and as a planner?' (Hagen, 2020).

Concluding opinion

My concluding opinion is that (i) politics and politicians are given too little attention in the field of planning. When attention is given, it is more that politics and politicians are part of the problem rather than part of the solution. The dominant narrative is that politicians come late into the process and often politically tear up thoroughly prepared comprehensive planning proposals. (ii) The field of planning, with its focus on striving for agreement and consensus, finds it difficult to incorporate politics' inherent need to highlight disagreement with other politicians and political parties, and to compete for perception of reality, goals and means of action. I believe that this normative pressure to achieve consensus weakens both planning's and politics' place in societies and organisations by making the activities less interesting and relevant for people - citizens and voters. This is unfortunate and pity, especially because part of the purpose of planning should be to sustain and refine an engaged and vibrant democracy.

Politics as a theme in the field of planning – ideals and realities.

Planning is an inevitable activity. "We are constantly thinking about the future and how to control it. Man is therefore a planning animal. ... Planning is as old as man." says José L. Ramírez (Ramírez, 1995:24). The public sector is planning like never before, at least in Norway - the Nordic countries. One of the many reasons is that politicians increasingly see planning as a tool for putting their own political issues on the agenda.

Planning theorists and practitioners who aim to make planning as comprehensive as possible often describe planning as a stepwise activity with four main phases: 1) Basis for decision-making: Interpretations of current situation, likely and desirable futures and means to get there. 2) Decisions: Determination of what we want to achieve in the future, in what way. 3)Implementation: From 'words to action'. 4) Evaluations: Output and outcome, what happened, with which results and why.

Traditionally, planning theorists and practitioners have limited planning to be only phase 1. For others phase 2, is defined as part of the planning process, making planning contain two main elements (Kleven ed. 1998:12): Element no 1 - using some form of scientific, knowledge-based analysis method. Element no 2 - making decisions about future actions based on this methodological analysis foundation. Politicians have traditionally been relegated to phases no 2 and element no 2. Politicians are decision makers, not planners.

This brings us to a core question within planning: To what extent can organisations and societies be scientifically, or shall we say professionally, observed, cf. phase no 1? Traditional planning processes are often characterised by professionals, primarily planners and consultants, producing and informing about facts of the present and forecasting both possible and professionally recommended futures. Then, elected politicians, 'lay people,' signal which of these futures with associated means they desire.

Tha planning field have both theoretically and practically developed away from this position in recent decades. However, the growth of participatory and co-creation theories and methods in recent decades has not decisively changed this basic culture and practice of division of labor between disciplines/administration/planners and politics/politicians. For example, it is preferably professionals, and professionals alone without participation and political involvement, who prepare the "knowledge base" in municipal and regional planning documents.
An alternative approach involves a rejection of the fact that facts about the present and expected future unambiguously exist, and a rejection of the fact that correct action comes as an automatic consequence of

being aware of specific, selected facts. Organisations and societies must be "read", understood, interpreted like text in a book, more than unambiguously registered, investigated and researched using statistical methods. It is also impossible to make certain forecasts for the future development of open systems such as municipal organisation and municipal/county society. My experience as a politician over many years is that there are often greater disagreements about what the current situation is in a society or a thematic area such as climate change or inequality, than about what are good future situations and good planning solutions.

This gives us a situation where neither politicians (lay people), planners (the scholars) nor researchers (the super-scholars) can objectively or adequately capture the past or present, i.e., describe the situation unambiguously as it was and as it is. The cognitive basis is that facts and truth, right and wrong, good, and bad can be fleeting, situational, deeply individual, i.e., something that fundamentally belongs to politics. Then it is problematic when/if the planning field has agreement as a guiding star, when politics undeniably has competing disagreements as an inherent feature.

Planning theory – A glimpse into historical main positions

Most of the leading planning theorists from the 1960s have focused primarily on developing the normative aspects of planning. This one-sided focus on improving and refining the normative approach has tended to go beyond understanding the planning activity that takes place. This has led much theoretical development away from practice rather than attempts to understand and respect practice. The theoretical contributions have become of little practical use; even misleading with all their heavily normative expectations for both the planning process and the planning product.

Here follows a brief introduction to a few theoretical contributions that, for me, stand out as most relevant in the discussion of the place of politics in societal planning. Such brief glimpses do not do justice to the planning theory debate - most contributors and perspectives are not mentioned.

It seems that Edvard C. Banfield in the 1950s gave us the recipe for a normative ideal for planning: First, present a normative model ideal and then analyse various means to achieve the goal, choosing the means that professionally ensure the best goal achievement (Banfield, 1959:149).

The rationalist planning theory and method are born. The normative guiding star becomes consensus because of unequivocal knowledge produced by experts. One must then expect that politicians will loyally listen to the experts when they are invited to make the formal planning decisions.

However, Charles Lindblom immediately responded with the following criticism (Lindblom, 1959, 1973, 1979): It is both useless and unproductive to operate with an ideal that is completely impossible to achieve, which lies in "The range of impossibilities."

In a reality characterised by uncertainty and disagreement about what constitutes valid knowledge, by conflict of interests and political disagreement, we should choose what is possible, what can be politically implemented given the prevailing power relations. Incremental planning therefore prescribes a step-by-step approach where you try, occasionally fail, and learn during the processes, and where you do not waste time identifying all workable solutions and consequences.

Incremental planning provides a greater room and need for politics than Banfield's rationalist planning ideal. Lindblom argues that consensus about goals and means in societal planning is often unrealistic, not achievable, and not politically rational. Lindblom warns against unrealistic ideals:

"What kind of aspiration, norm, or ideal gives direction and other specific guidance to a body builder - his hope to have the strength of a gorilla or his attention to exceed Arnold Schwarzenegger? For a soprano, the impossible aspiration to hit a note six octaves above the highest note ever sung, or the resolve to reach A above high-C?"

(Lindblom, 1979: 518)

Practice must seek to achieve what is possible, what can be achieved, a consensus on minor ("incremental") changes that occur without the resistance becoming too noisy and paralysing. This gives a greater degree of both room for and need for politics than in Banfield's rationalist planning ideal. Politicians must develop solutions that at least a majority of elected officials in, for example, a municipal or county council can support.

Later, throughout the 70s and 80s, and up to the present day, other theories became more visible, especially the communicative approach. Where Banfield's normative ideal has professional analysis as a key concept, and Lindblom relies on incremental changes, reestablishes the communicative position the idea of consensus. Achieving agreement should be possible thanks to the 'force of the best argument' (Pløger, 1998). Pløger writes in the research report «Communicative Planning: Between Communication and Rhetoric" (Pløger, 1998) that there are two research perspectives dominating the 80s and 90s; the communicative planning theory inspired by Jürgen Habermas and "the perhaps less known research that views planning as a 'rhetorical activity' and exercise of power (Pløger, 1998:3), inspired by, among others, Michel Foucault. Consensus is neither possible nor desirable as a planning ideal.

Inspired by the communicative turn, much planning practice in the seventies, also in Norway, was genuinely concerned with active participation, and that this could result in unified planning solutions (e.g., "Arbeidsbokmetoden"[3] Orhaug, 1988). What is new in this communicative turn lies in the fact that influential planning theorists to a particular extent focused on the dialogue itself, the dialog in practice: How to get dialogue to promote understanding, how to get it to be as "dominant-free" as possible, so that it ensures that always "the best argument" wins.

The process becomes central. It becomes important to involve, in the planning dialogue, as many as possible of those affected by the planning work. Direct participation is more appropriate and better for so-called weak groups than being represented by spokespersons and "radical" planners, respectively "Advocacy Planning" and Radical Planning (Pløger, 1998:11). While incrementalism heavily relies on the assumption of a functioning representative democracy, the communicative position focuses on more people engaging in dialogical processes where it becomes paramount to promote mutual understanding of each other's positions in dialogue and develop new, agreed-upon positions.

Patsy Healey writes in her article "Planning through debate. The communicative turn in planning theory" (Healey, 1992) that planning is a child of modernity. By using scientific knowledge and reason, people/organisations/societies are liberated from the "tyranny of thought" that can follow from religious regimes and political/military dictatorships. One of the main challenges to this planning paradigm is related to the criticism of the idea of the scientifically based reason's superior position, in relation to local, tacit, or experience-based knowledge. The salvation for the planning project lies in developing the communicative aspects of planning. By moving from individual reason to reason that emerges because of intersubjective communication, one avoids "destructive relativism." The good and right is what we can develop together through communication and simultaneously agree upon. The dialogue should be informed by knowledge; the communicative position does not reject scientific knowledge, cf. Banfield's normative planning ideal – it is just not seen as superior. For all the planning theorists who lean heavily on Habermas, the dialog-based consensus often becomes a requirement that we can and should make for planning. The pursuit of consensus becomes a central content in the very understanding of normativity.

Bent Flyvbjerg argues in his doctoral dissertation Rationality and Power (Flyvbjerg, 1991) that Habermas's discourse ethics are based on the following thinking: If the rules in this discourse ethics are followed, the result will be rational and acceptable actions. But for Flyvbjerg, it makes little sense to separate power and communication as much as he believes Habermas does by composing such process ideals. He aligns himself

3 The Workbook Method – my translation

with Richard Rorty, who claims that communicative rationality almost has a religious status in Habermas's thinking (Rorty,1985). Habermas's optimism about reason is problematic in relation to what happens in actual communication processes. Communication will be characterised by interest preservation, not by domination-free and consensus-seeking (Ramírez, 1995). Flyvbjerg argues that Habermas's work for more democracy diverts attention away from fundamental power relations. This is unfortunate because attention to power relations is precisely a first prerequisite for more democracy.

In this sense, Flyvbjerg's criticism of Habermas and all the planning theorists inspired by him has much in common with Lindblom's criticism of Banfield's normativity. Both Flyvbjerg and Lindblom ask us not to overlook, or develop theories away from, power games and politics.

Månson gives us an additional argument about politics that is relevant for societal planning when he points out that a dialogue will always contain a "... flow of power relations that envelop and condition the discourse[4]" (Månson, 1989:326). It is unreasonable, "irrational," to be communicatively rational if one wants to gain support for their viewpoints. This was emphasised by Davidoff, the father of advocacy planning, already in the mid-60s: "... it may be simpler for professionals, politicians, or lobbyists to make deals if they have not laid their cards on the table" (Davidoff, 1965:287).

Research, development work, guidance booklets

What attention is given to politics and politicians in research, development work, and guides in planning from national ministries and KS - The Norwegian Association of Local and Regional Authorities? The main picture, up until 2018, is that politics and politicians have been given little attention. Where politics is given attention, it is usually under the theme of participation and involvement: Inhabitants, landowners, users of public services, civil society representatives, businesses should be involved early in all planning processes. Politicians are hardly mentioned in connection with participation in, and/or management of planning processes.

'Program Plan 2017-2024 Democratic and Effective Governance, Planning and Administration'[5] (DEMOS) (Forskningsrådet, 2018) is a typical example where politicians are mentioned, but mostly as one of several groups that planning must include - "... residents and users, local politicians ..." (page 17). Another clear feature is that research is to be conducted on and about politicians and then communicated to politicians. It is not conducted together with politicians. There are no co-research ambitions in this research program.

The research project 'Evaluation of the Planning and Building Act' (EVAPLAN) (NIBR, 2014) aimed, among other things, to find out to what extent broad participation and political governance are the basis for planning. When we search for the words 'politics' and 'politicians' in the two books presenting findings from the research project (Hanssen & Aarsæther a and b ed., 2018), we find that only one of the 47 chapters has the word politics in the title, namely the chapter on Planning Strategy (Kvalvik 2018). There is some writing about political leadership (pages 34 and 192), politician training (page 48), and politicised problems (page 229). The researchers have interviewed mayors but have hardly talked to part-time politicians about, for example, how to help/support/encourage part-time politicians to take the lead in planning work or to use plans/planning as a political tool.

The guidance booklet 'Municipal planning process' (Miljøverndepartementet, 2012) hardly mentions politicians. The same applies to the guidance booklet 'Participation in the planning process' (Kommunal- og distriktsdepartementet, 2014) and '10 pieces of advice for a well-functioning and effective planning system'[6](KS, 2016). None of the three addresses politicians about leading planning processes, even though we have a planning law that precisely assumes that societal local and regional planning is a fundamentally political activity.

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However, 'Let's do it together! Handbook in local co-creative social innovation'[7] (KS, 2018) addresses the role of politicians in the co-creative municipality. It emphasises that politicians must use time for policy development together with inhabitants in various workshops, working groups, and open thematic meetings, and not spend all their time preparing for and attending meetings - with piles of ready-made documents with proposals for decisions.

Community of disagreement – introduction and theoretical foundation

The concept of "community of disagreement" is used in various areas in Norway, especially related to democracy, education, and culture. In the book "Uenighetsfellesskap: blikk på demokratisk samhandling,", "Community of Disagreement: A Look at Democratic Interaction"[8] Lars Laird Iversen writes that the term can refer to a group of people who come together around a common theme, problem, or goal but have different or conflicting views on how this theme, problem, or goal should be handled (Iversen, 2014).

In my search for the use of this concept, I have come across a bunch of texts, none of them planning texts. I therefore in this paper rely heavily on this book (Iversen 2014) and Trond Solhaug's review in the Journal of Social Research (Solhaug, 2015).

The first sentence in the first chapter titled 'Community of Disagreement' sets the tone: "Norge er et uenighetsfellesskap, og har alltid vært det" (Norway is a community of disagreements and always has been[9].) (Iversen, 2014:11). Norwegians share problems and arenas for discussion, but we share values to a much lesser extent. Our democratic communities are communities of disagreement, which he which he defines as follows:

"Et uenighetsfellesskap er en gruppe mennesker med ulike meninger, som er i en felles prosess for å løse et problem eller en utfordring" (A community of disagreement is a group of people with different opinions, who are engaged in a common process to solve a problem or challenge[10]) (Iversen, 2014:12).

For me, this goes directly to the core of what community planning is, namely solving problems and challenges together in a democracy. With this book, Iversen aims to create greater insight and debate about managing disagreement, creating consensus on critical issues, and, importantly, living with diversity (Solhaug, 2015:251). Iversen mentions school classes, religious communities, and institutions as examples of community, and in what he refers to as 'public sphere of democratic nations'[11] (Iversen, 2014:18). That must mean, in my view, that we can also include local and regional communities, as well as communities such as municipal planning committees, city councils, neighborhood associations, county councils, and civil society organisations.

Iversen is concerned with several ways to normalise and demystify disagreement, including value disagreement, so that individually and collectively, we become better at living with all this disagreement. Iversen claims that behind much perceived agreement, there is much disagreement, from the internal disagreement within the individual to disagreement in several types of communities. We must be aware that agreeing as well as disagreeing is about relationships, strategies, politics, and conventions. (Solhaug 2015:251). This reminds me of the discussion we have within planning regarding wicked problems (Rittel and Webber, 1973). The point is that 'living with' is often a wiser strategy for practice than seeking to solve these types of problems, which is precisely why they are labeled 'wicked.'

Iversen is focused on revitalising and expanding democratic processes. Influence must be genuine. We need to take more decisions back to real democratic bodies "– and away from experts, bureaucrats, markets, and

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regional enterprises"[12] (Iversen, 2014:135). He argues that disagreement stimulates creativity (Iversen, 2014:52–58). Freedom of expression, free debates, and a positive approach to disagreement stimulate new thinking.

Iversen discusses Habermas' argument for a power-free conversation, where only the rational value of arguments is emphasised, where everyone has a real opportunity to participate. Iversen disagrees with Habermas on the view of rationality:

"Habermas argues for freedom from power in public discourse because the best arguments will then prevail. This is not necessarily the case in a community of disagreement"[13] (Iversen, 2014:138). Within the community of disagreement, the arguments for open, free, real discussions are that multiple voices provide a greater diversity of ideas, more innovation.

In the end of the book, Iversen points out that the community of disagreement closely resembles Chantal Mouffe's theory of political leadership and agonistic politics (Mouffe, 2000 and 2005, in Iversen 2014:145-156). What Iversen presents here are the same arguments found in definitions and discussions of agonistic planning theory. This is an approach to planning that has recently emerged as a critique of and alternative to communicative planning theory. The agonistic perspective recognises that conflict is an inevitable part of democracy. Therefore, the idea that the goal of democracy is to achieve consensus among society members is rejected. On the contrary, disagreement is somewhat of an inherent necessity in a lively, engaging democracy. In an agonistic model, both for politics and planning, the conflicting parties acknowledge each other as legitimate, even though they disagree. They accept common premises and procedures for political struggle and planning discussions, enabling a more constructive form of conflict, and increasing the likelihood of innovation.

Community of disagreement – implications for planning practice

Planning literature is dominated by arguments that agreement is preferable, a prerequisite for successful planning. It is about, among other things, creating legitimacy for a plan, preventing frequent rematches, and showing outwardly that one stands united. Overall societal plans, such as municipal plans and regional plans, should preferably give a positive picture, that it is attractive to live and work in this local/regional society. It is therefore important to show optimistic agreement, not to expose disagreement and conflict.

However, such a consensus ambition also has negative consequences. Firstly, it can weaken party politics and thus engagement among party members and voters. The consensus ambition can suppress political debate, as it encourages compromise and agreement rather than highlighting and addressing political divides and ideological differences. Furthermore, it risks overlooking or smoothing over fundamental differences and conflicts in society. This can make it harder for voters to see clear differences between parties, thereby weakening parties' ability to profile themselves and mobilise voters based on clear political alternatives. Without clear conflict and debate, voters may also feel that democracy is not functioning properly because the planning documents do not contain disagreements and conflicts.

Secondly, consensus gives increased attention to planners, administrative staff, and experts. Consensus-oriented planning is often characterised by a heavy emphasis on inputs from planners, administrative staff, consultants, and researchers. This marginalises the political dimension, where different values and interests compete. It reduces the space for political discussion and influence from political parties. Voters might get the impression that politicians do not have real power over the most important decisions. Likewise, it can marginalise participation from civil society and inhabitants. Processes become more ritualistic and characterised by information dissemination and feedback rather than real discussions where participants can draw on their own experiences and values.

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Thirdly, consensus can suppress political innovation. Consensus-driven planning processes can also hinder political innovation, as compromises often lead to radical or new ideas being toned down to achieve broad agreement. This can reduce the dynamics of party politics and lead political parties to be more cautious in their political programs. When consensus is the goal, it can be tempting for parties to avoid promoting new or controversial ideas that might disrupt the established agreement. This can lead to stagnation in political development and prevent parties from challenging the status quo, which in turn weakens parties' ability to represent the interests of different voter groups and ability to promote real political change.

Flyvbjerg argued (Flyvbjerg, 1991) that heavily normative planning theories, both the classic rationalist approach (Banfield, 1959) and the classic communicative ones (e.g. Healey, 1992,1997, Harper and Stein, 2012, Innes, 2004, Sager, 1994) would soon appear as a historical phenomenon because they will not survive all the attacks that will eventually come against them. They will fail the practice criterion (Flyvbjerg, 1991). I believe, mostly hope, that this is now about to happen. The rational planning model and the communicative planning models are not two extreme positions. They represent a common mindset that only the normative ideal, the maximum, is good enough as an ideal. In this sense, they are both located in "The range of impossibilities" (Lindblom, 1959, 1973, 1979). They overlook realities on the ground such as power imbalances, the inherent communicative limitations of language, ideological and value-based conflicts of interest, disagreements, and uncertainties in knowledge, and therefore, fundamentally, politics as well.

Three planning Theories – relevant for community of disagreement

I will briefly point out three theoretical positions that support the argument for community of disagreement as a concept and ambition for planning in organisations and society. These three are not independent planning methods but rather approaches that can appear in collaboration or be integrated into other planning methods and processes. What all three have in common is that they have internalised that planning is fundamentally political, and therefore must provide understanding for, respect for and relevant room for action for politicians, for the exercise of their political rationality.

Planning as rhetorical exercise of power - as previously mentioned, Pløger argues that two research perspectives dominate planning in the 80s and 90s; communicative planning theory and the perspective that views planning as a "rhetorical activity" and exercise of power (Pløger, 1998:3). A key point in this latter perspective is that planning is about communicating successfully (Hellspong, 1995: 2), not about finding or jointly developing objectively correct answers. Rhetoric is a practical logic, not a descriptive model, not a normative model, but a prescriptive model. It gives advice, it points out approaches in planning processes. (Hellspong, 1995).

James A. Throgmorton is one of the most visible planning theorists in the USA working with rhetoric. He argues like Hellspong when he claims that planners should work in the following way:

"Planners should strive, not to be good and be right and get things done, but to create, sustain and participate in a public, democratic discourse that enables them (and others) to argue persuasively and coherently about contestable views of what is good, right, and feasible" (Throgmorton, 1996:54).

Throgmorton sees planning as a form of storytelling about the future in which one seeks to convince and constitute the perception of the situation (Throgmorton, 1996:250,251). He compares society to a weave that lacks objective structure or meaning (Throgmorton, 1996:253). What we see depends on where we are placed in the weave. The same applies to what we plan, how we plan, and how we participate in the planning process. Sometimes this leads to agreed positions/consensus, other times to clarified disagreement. In this perspective, the planning text (text – images – maps and figures – design) and speech/conversation become important. Not least, politicians would like to activate their political project, their political ambitions, in such planning processes. It is then important for all those participating in such processes to be good at "storytelling." This is a well-known acknowledgment for politicians.

Innovative planning - increasingly, planning theorists argued throughout the nineties that creativity and innovation are restricted, even hindered, by planning theories and methods that rely heavily on either the analysis perspective (Hillier, 2008) or the communicative perspective (Mäntysalo, 2002). Mäntysalo (2002) argues that Habermas's concept for dialogue is too narrow, too static, and not creative enough. Others claim that planning theory with communicative ideals does not allow and can even stifle creativity and innovation (Stein & Harper, 2012).

Regardless of this specific planning theoretical discussion, we know that planning practice has already benefited from being inspired by innovation theory and practice for many years. No matter what planning theorists may think about the power of various theoretical positions, planners and politicians have increasingly appreciated theoretical and practical contributions from the field of innovation. Arguments that frequently appear in texts about innovative planning is that planning must encourage the development of innovative and liberating planning practices, stimulate innovation, and value and refine disagreement (Hagen and Higdem, 2023). Politicians who want change can therefore be inspired by innovative thinking and practice. The fact that this perspective also celebrates disagreement inspires many politicians to engage in planning processes. Planning that accepts and values disagreement is far more politically relevant than traditional consensus-seeking planning (Hagen and Higdem, 2023).

Agonistic planning - recognises and embraces conflict as an inevitable and productive part of democratic politics. This comes from the political theory of agonism, already mentioned (Mouffe, 2000, 2005, 2013), which emphasises the importance of political competition and disagreement within a democratic society. Instead of resolving or minimising conflicts, agonistic community planning views conflicts as an opportunity to promote democratic participation and innovation. Agonistic community planning acknowledges that groups in society have different interests and values and that these differences can be both legitimate and productive. This is precisely what politics is all about.

Agonistic theories aim to open and provide a new approach to democracy, where the rules of democracy are always open to questioning, competition, disagreement, discussion, negotiation, and changes over time. The same ambitions must also be used as a basis in planning processes. It is important that planning reflects the diversity of today's society in terms of opinions and interests. A central element then becomes how to develop methods and cultures for planning practice characterised by such contradictions, which can still result in accepted decisions (Pløger, 2004, 2012, 2018). The agonistic approach is less focused on achieving consensus as in communicative planning theory. It is more concerned with how to make decisions in planning processes (Pløger, 2018: 265), which can later be accepted and implemented in the community, even though there is disagreement.

Conclusion

It is fundamentally important to both take care of and seek to refine disagreement in planning processes and planning documents. Both planning theorists and practitioners must realise that disagreement is an inherent reality that one cannot theorise away from – neither within the field of planning theory nor within the field of practice. If planning theory should be able to follow up on its ambitions to both describe and prescribe practice, disagreement must at least be accepted, preferably treated as something potentially positive. It represents a potential for change.

Further, acceptance of disagreement by planning professionals is necessary to make planning interesting, relevant, and effective for organisations and society. Acceptance of disagreement by planning professionals is also necessary if planning want to contribute to preserving and building democracy.

Of course, we will continue to seek to reduce disagreement in planning processes, when the participants involved in the planning process, including politicians, see this as possible and appropriate. In other situations, however, it may be wise to do the opposite, to make visible, communicate and explain disagreements that often do not come up in analyses, debates, and the public. Accepting, exploring, and refining disagreements can also be positive in

stimulating innovative thinking, and in recruiting new people and environments into planning processes.

Developing good processes and procedures for voting, and how to work further afterwards in situations with winners and losers, also needs more and better attention in research and practice development.

Good, safe, trusting communities of disagreement are likely to promote individual and collective well-being, innovation, and democracy (Iversen, 2014). We must realise that we cannot plan our way out of many disagreements, only hide them by, for example by forcing a minority to remain silent. This is ethically and democratically reprehensible, and overall, simply counterproductive, or simply stupid.

The question in the title of the paper is: "Should planning and politics gather around the concept of 'community of disagreement'?" My answer is 'yes' and a call to both the planning field and the politic field, theoreticians as well as practitioners, to cultivate and refine theories – models – methods based on 'communities of disagreement.

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Progressive Urbanism

Chandrima Mukhopadhyay

Abstract
It is time to better understand how despite numerous constrains innovative, equitable practices that lead to progress have emerged in cities in the global south and east, especially acknowledging new development pathways which are different than how cities in the developed countries had evolved. This essay proposes a new understanding of "progress" and "urbanism" building on recent research on development- and urbanism-literature. The term 'progressive' is meant to signify an advancement of and a convergence towards a new form of economic development which leads to climate-friendly urbanism, in line with the global urban agenda, which calls for an inclusive built environment for the majority. Cities and regions in the Global South are the best places to understand about progressive urbanism right now.

1. Introduction: Progressive Urbanism

The term "progressive" in the development literature has been used in multiple ways. I take two main works into consideration here, to criticize and build on a "progressive urbanism" that emerged from the Global South and East: first, Walt Rostow's stages of growth (Rostow, 1960) and the Stiglitz Commission's report (2008) on Measurement of Economic Performance and Social Progress. I argue that based on a broader understanding of progress and human well-being, including environmental concerns, the global urban agenda like the Paris Agreement, UN's Sustainable Development Goals, and New Urban Agenda were formulated. And the essay conceptualizes the "Progressive urbanism" term grounded in a context where such global urban agenda are being localized and implemented. In doing so, it accumulates new meaning as well, such as, incremental development.

India, being rapidly urbanizing now, and being known for large share of informality (e.g. around 90% jobs are in informal sector), it would be important to understand how these components could be captured in the "progressive urbanism" concept. Census of India defines "urban" by population, density and share of non-agricultural jobs. This is quite unique way of defining. A World Bank Report published in 2015 called India's urbanization as messy and hidden, along with other South Asian countries. It is called "hidden" as based on a different methodology like Agglomeration Index, India's urbanization rate was found to be around 55%, when by the census it was found to be 33%. It's called "messy" as a major part of urbanization is informal and unplanned. In India, 65 million people live in unplanned settlements. 40% of South Asia's urbanization lives in slum. The essay aims to understand what sort of changes could define "urban" in Indian context as progressive, in the contemporary times, including a combination of economic growth and social progress. There is need to critically look into whether Indian cities are truly urban, as Mukhopadhyay (2021)[1] does based on social emancipation, political agency, and economic progress or engines of growth. "Unplanned urbanisation" has become a buzz word. Planning may not be a single step intervention, it could be a step by step process. One recommendation could be at least defining a sub-level of "progressive urban" category.

There is a large share of jobs, housing and other infrastructure sectors in informal sector. In Indian context, informality and/or unorganized sector is defined quite broadly. It is important to focus on informal sector due to its large contribution towards the nation's GDP (around 45%), its relevance with social equity, and hence, social progress for all. In South Asia, informal sectors contribute towards 40%-60% of GDP. As prescribed by multiple civil organizations that directly work with the vulnerable population on the ground, and as recommended by academics, a progressive and differentiated formalization is the way out. We would like to cite some examples showing how such "progressive and differentiated" formalization are already taking place on the ground, including the acknowledgement of "informal spaces" needed in the formal spatial plans.

•The link between progressive urbanism and the Informal Sector could be:
o **Initial Growth:** During the early stages of urbanization, the informal sector often experiences rapid growth, fuelled by migration from rural areas and the need for basic services.
o **Challenges of Informality:** Rapid urbanization can also lead to challenges for informal workers, including low

wages, lack of social security, limited access to finance, and precarious working conditions.
o **Potential for Formalization:** Some argue that progressive urbanization should focus on supporting the formalization of the informal sector, providing more stable employment and better working conditions for workers.

One of the predominant understandings of "progress" in development literature has been measuring the economic development, and meeting the western standard, not only in terms of economy, but also in the development sector. In the essay, this popular meaning of "progress" is contested. As explained in the essay, the term can potentially capture the need to measure qualitative (social) growth including fulfilling the aspiration of the majoritarian or pluriverse, in addition to an inclusive economic growth, and yet drastic reduction of wasteful resource uses in cities of the Global South and East. The essay proposes multiple usage of "progress". Although the contested meaning is provoked by the development predominantly taking place in India, many Southern and Eastern countries are going through a similar transition. In many cases, such as India, such transitions come about because of national-level policies (e.g. Make in India), which can remain path dependent to some extent, and influenced by the international agenda (e.g. Paris Agreement, Sustainable Development Goals etc.). "Progressive" here is not used as a drastic transition, rather a step-by-step transition or advancement, an incremental process. I would like to explicitly point out the difference here between Global South and East. Global South and East is specific geographical and cultural context. 'International' as a term involves more than two countries. I use certain concepts and terms below that originated from international organizations. However, I consider them relevant here as these international organizations are operative in large numbers of emerging countries or Global South and East countries as well. The essay brings a critical understanding of "progressive" (based on two works as mentioned above), the changing meaning of "urbanism" including behavioral changes, supporting the majoritarian ideology, and based on innovative practices emerging mainly from the Global South and East context together.

Urbanism is defined as a way of life. "Progressive urbanism" is a form of urbanism that converges or synergizes every interest groups' (mainstream, marginalised and subaltern groups') interests or the interests of the pluriversal actors (e.g. heterogenous onto-epistemological positions), including meeting the need of both built environment and ecology/environment (referring to ecological priorities); it is progressive for all groups that allows socio-economic mobility, along with achieving economic development, while respecting the environment/ ecology. The way Wirth (1938) mentions that the urban mode of life is not confined to cities, similarly, the urban mode of life is not confined to the concrete jungle/built environment either in "progressive urbanism". Nature is brought into the city/built environment in the form of nature-based solutions, nature-based infrastructures, green infrastructure as an integral component of "urban" to take climate action and to be sustainable in the long run. Urban farming, green and blue infrastructures, roof gardens, vertical gardens are increasingly becoming part of urban life. Climate-friendly urbanism also promotes the lifestyle change for all, which is essential to deliver climate actions. Low-carbon urbanism (Bulkeley et al., 2012); Climate urbanism (Long and Rice, 2019). In addition, circular economy/ circular urbanism (ICLEI, no date) adds new dimension to the "way of life" through behavioural changes. The idea aligns with the majoritarian view, which is a political philosophy or ideology with an agenda asserting that a majority, whether based on a religion, language, social class, or other category of the population, is entitled to a certain degree of primacy in society, and has the right to make decisions that affect the society. "Majoritarian urbanism" is a term that has been used in explaining the neoliberalism, informality, resistance and well-being in Mumbai (Patel et al., 2022).

The term "progressive urbanism", in a nutshell, means the way of life that is progressive, in terms of delivering socio-economic mobility over generations, economic development, prioritising ecology, progressive for the "pluriversal" (Moreno-Tabarez et al., 2023), including mainstreamed, marginalised, subaltern, and externalised groups, progressive for "where many worlds fit in", for multiple elsewhere (Gandy, 2022), and has an emerging meaning of "urbanism" which is not confined to the concrete jungle/built environment, encourages behavioural changes for circularity, and explains the neoliberalism, informality, and resistance for the sake of the majoritarianism. The essay argues that such "progressive urbanism" has emerged being inspired from the

complexities and dynamics in the southern and eastern contexts, and originated by the Global South and East.

2. Progressive in what sense? : A new definition

For unplanned and hidden urbanization, progressive in the sense of combined impact of economic growth or engine and social progress. Progress in terms of improving the quality of urbanisation.

For informality and messy urbanization, progressive formalization in terms of slowly or step-by-step formalization.

I take two major works on "progress" in the development literature, to criticize and build the new meaning. Following Rostow (1960), there are five stages in Walt Rostow's stages of growth (Rostow, 1960): Traditional society, Preconditions for take-off, Take-off, Drive to maturity, and Age of High mass consumption. Rostow's (1960) view on development in the South has been closely linked to the World Bank and International Monetary Fund's politics of progress, where 'progress' means becoming like the West. Based on this understanding, the term "progressive" is highly critiqued within the Global South and East in the essay. The essay develops the concept of "progressive urbanism", which is considered "progression" by the Global South and East.

The second work I focus on is the Stiglitz Commission-published report on "Measurement of Economic performance and Social Progress" in 2008, authored by Stiglitz, Sen and Fitoussi, which was a French initiative. Their report provided an opportunity to redefine the meaning of human progress. Instead of relying on a one-dimensional measure of success, i.e., the gross domestic product (GDP), the Stiglitz Commission argued that societies should insist on a broader understanding of their achievements and predicaments. Besides social progress, the component of environmental and/or ecological crisis was added as an urgent issue. The central message of the report was that human wellbeing is far more than the sum of the economic resources. Wellbeing also depends upon health, education, environment, housing, access to information, the ability to communicate, and the overall quality of life experience. Sen's capability approach explains how provision of basic services and infrastructure improves the communities' capability for socio-economic mobility (Sen, 1993). Instead of measuring the performance of national economies, the activities and experiences of households should also be considered to understand progress. Rather than absolute levels of wealth, the distribution of income and the extent of inequality should be deciding factors. Kanbur et al (2016) including Joseph Stiglitz as one of the authors draws a link between the Sustainable Development Goals (SDGs) introduced by the UN with a number of goals and targets going beyond GDP, with a focus on developing countries, and the logic behind defining "progress" in the Stiglitz Commission Report (2008). The essay builds on its definition of "progress" depending on this idea.

The term Global North and South are basically defined based on economic well-being, and the term East-West is defined based on cultural identity (Yiftachel, 2006). In the essay, in order to define "progressive" for Global South-East, the proposed use of the term is NOT limited to economic progress, however, it includes economic growth as well (explained below in relation to degrowth literature). It indicates technological, financial, institutional innovative pathways and practices taking place in the cities in Global South and East, with converging positive outcomes including economic progress, synergic relationship between (economic) development, climate action and poverty alleviation, towards a better, liveable, and healthy urban life. For instance, the Deep Decarbonisation Pathway Program[1] that aims to deliver GreenHouse Gas (GHG) emission mitigation and economic development while promoting socio-economic mobility of all interest groups. The essay defines this approach as progressive, in the sense of progressing towards both socio-economic and ecologic progression for all or the pluriversal[2]. On the ground, planners are working towards delivering both the Paris agreement and United Nation's (UN's) Sustainable Development Goals in synergy. The essay argues that in the southern theory literature, it is timely to start theorizing about the innovative approaches, and re-define the term "progressive" for the South and

1 Accessed at https://www.iddri.org/en/initiative/deep-decarbonization-pathways.

2 Pluriversal indicates the existence of many worlds somehow inter-connected, including the human world is connected to the natural world and to the spiritual world.

East. Synergic[3] urbanism or converging[4] urbanism could be alternative terms. Converging cities, as already used, indicate to decreasing gap between the rich and poor, however, in Europe. Similarly, progressive urbanism will finally lead to decreasing inequality.

Figure on Dashboard for Monitoring Economic Performance, Quality of Life and Sustainability
Source: Kroll (2011)

Global Urban Agenda: Paris Agreement, UN's SDGs, New Urban Agenda (~2015)

Conceptualising Progressive Urbanism

Figure 1. A conceptual diagram on conceptualising Progressive urbanism
Source: Kroll (2011) and Author

Unlike the traditional use of the word "progressive" in development sector, in the essay, "progress" or "progressive" has multiple meanings as follows:

• Example 1: Deep Decarbonisation Pathway as progressive:

The Deep Decarbonization Pathways[5] initiative helps global and national decision-makers take actions towards a deeply decarbonized world with drastically reduced inequalities. The program aims at keeping the global warming well below +2°C, which requires immediate changes, through choices that will lead economies towards a carbon-neutral world by the second half of the century. The program aims to deliver both economic development and GHG emission mitigation in synergy. They ground their national and international engagement on the principles of being country-driven, country-led, country-owned. DDPP's partners are both from the developed and emerging economies. The emerging economies or Global South and East countries are South Africa, Indonesia, Argentina, Nigeria, Senegal, Mexico, India, China, Brazil etc. Comparing the pathways adopted by the developed economies and emerging economies, and specially considering the pathway developed by India, the essay argues that

3 Accessed at https://www.degruyter.com/document/doi/10.1515/9783035606867-028/html.

4 Accessed at https://www.conted.ox.ac.uk/news/converging-cities.

5 Initiative on Deep Decarbonisation Pathway Program (2017): https://www.iddri.org/en/initiative/deep-decarbonization-pathways.

India is following a complicated pathway in order to deliver both economic development and global urban agenda including the Paris Agreement through innovation in a context with complexities that the developed economies did not have to do while becoming a developed economy. With economic development and socio-economic mobility, one's lifestyle would improve along with their economic activity, therefore there are chances of increased GHG emission. The program takes a progressive approach in terms of innovative pathway through which socio-economic mobility over generations is achieved while delivering climate action in synergy.

There are some recent studies that have already attempted to develop a link between the Stiglitz report and climate action based on IPCC report. For instance, Tokimatsu et al.'s (2019) "Tackling the Stiglitz Report: Measuring Social Progress and Economic Performance under **Various Climate Policy Scenarios"**, connects the measurement of social progress from the Stiglitz report and climate change mitigation (CCM) by the Intergovernmental Panel on Climate Change (IPCC) assessment reports. They operationalize this in terms of various climate policy scenarios ranging from business as usual to economically efficient, CO_2 double stabilization, and targeting two degrees Celsius (DC).

Another example to be considered through the lens of deep decarbonisation pathway program in India would be to understand the planning and implementation of the economic and industrial corridors, where business induced scenarios increase or improve manufacturing sector production, output and export, while still achieving deep decarbonization. The national government's vision is to achieve economic development through rapid urbanization using these corridors as tools; hence, it is imperative to understand what "progressive" pathway would be taken to implement these corridors, achieve economic development, and yet deliver deep decarbonisation.

• Example 2: Localising and implementing multiple Global urban agenda as "progressive":

Cities across the globe aim to implement multiple global urban agenda such as the Paris Agreement, Sustainable Development Goals, and New Urban Agenda. In this regard, Global South could be used in an analytical way to address how these agenda are localised and implemented in an inclusive way to address the need of the vulnerable groups. It is progressive in terms of delivering multiple global urban agenda through minimal interventions.

Here are some examples from the various sectors of infrastructure. For instance, in urban transport sector, accessible and affordable electric public transports are sourced by renewable energy. Low-carbon public transport modes are both climate-friendly and healthy. For instance, the use of electric three-wheelers or e-rickshaws both achieve GHG emission mitigation and deliver multiple SDGs such as SDG1 on reducing poverty, SDG3 on health and well-being, SDG5 on gender equality, SDG11 on inclusive cities. Planners and designer make decisions as providers, and industry and individuals as consumers.

Within water supply and the sanitation sector, which is a nature-built environment interface, nature-based infrastructures deliver both mitigation and adaptation strategies in climate action, and implement relevant SDGs as well at a lower cost. For the Solid Waste Management (SWM) sector, segregation of waste at source imparts public awareness about what is waste, how it is related to one's consumption pattern, what waste that can be recycled. A sense of responsibility amongst the public that the pre-capitalism era had is reviving. This also delivers economic development, climate action, and UN's SDGs in synergy.

• Example 3: Post-growth or de-growth in the South

Post growth or degrowth is a northern concept that aims to create a sustainable and equitable society by reducing economic output and throughput. While the southern scholars aim to apply this in a southern context, the use has been limited so far. Economic development remains a priority for the Southern countries unlike the northern context. Hence, even though the concept is originated from a northern context, its application in

the south shows that 'growth' in the south (and eastern) part of the world, will still incur economic growth as a priority. [Why would this be progressive?]

• Example 4: Using new vocabularies in Planning as "progressive":

Bhan's (2019) list of new vocabularies for planning in southern cities is progressive. Acknowledging informality, accepting activism for planners is progressive. Progressive in terms of developing new vocabulary in planning practice that fits into a context, repairing, squatting, organising etc. [This is South specific.]

• Example 5: Decentralisation and hybridisation of infrastructure as problem-solving and progressive

With rapid unplanned urbanisation process, it is a challenge to provide basic services such as water supply and sanitation, and solid waste management towards the periphery of the cities and regions specially in the low-income areas. Decentralised and hybridised infrastructures are the solution with incremental investment in a step-by-step manner depending on resources and in an inclusive manner, and to upgrade the infrastructure or development in the future. Such infrastructures are mainly provided in the global South context. For instance, city-wide inclusive sanitation is a great example.

- Two synonymous terms with added meaning:

a. Synergetic urbanism: A combination of top-down and bottom-up planning.[6] Progressive in terms of democratic decision making within built environment. Participatory democracy.
b. Converging urbanism/cities: Reducing inequality.[7] Progressive in terms of reducing inequality. Stiglitz's "progress" includes reducing inequality.

3. Urbanism: What is new about the way of life?
Wirth (1938) defines urbanism as a way of life. "Progressive urbanism" introduces the new meanings of way of life within an urban area:

a. Definition of urbanism/urbanisation:
Over-defined: Need to modify the definition

Messy: informal settlements. With economic growth, social progress, also concern about public health.

Hidden: urbanisation rate is actually higher than calculated.

b. Shift to non-western & traditional behaviour to deliver climate action:
In order to effectively implement climate actions, both behavioural change and change of life style are integral to the process. For instance, such urban way of life is about:

-Growing own food in on your roof or within a plot in cities: urban farming, roof garden.
-Creating lesser waste- consumption pattern change, and recycling your own waste.

c. Way of life as urbanism is not confined to the concrete jungle/ built environment:
Nature is brought into urban life. Green and blue infrastructure is brought in within the city fabric at different scale: Urban farming, roof garden, bioswales, lakes, Vertical green. (IUCN)

d. Circularity as a urban way of life (traditionally non-western):
Circular urbanism is becoming a way of life, such as, using biogas produced from municipal waste and wastewater

6 Accessed at https://www.archdaily.com/1005567/top-down-and-bottom-up-urban-planning-a-synergetic-approach.
7 Accessed at https://www.conted.ox.ac.uk/news/converging-cities.

in running buses. Many of such projects are delivered at the community level, and require public awareness and public acceptance.

e. Synergetic urbanism:
The term synergetic urbanism is already in use, which indicates a combination of top-down and bottom-up approach. Improved public participation and democratic decision making in planning- Way of urban life is about participating in democratic decision-making in urban decisions with trust.

f. Converging urbanism:
Converging urbanism is also a term already in use, which indicates reduced inequality. Increasing equality for all- way of life is in not discriminating between various income groups, which is also reflected in built environment and in actions.

4. Representative Spatial imaginaries for Progressive Urbanism
Spatial imaginaries are deeply grounded, widely circulated collective understanding of socio-spatial relations that are performed by, give sense to, make possible and change collective socio-spatial practices (Davoudi et al., 2018). They are produced through political struggles over the conceptions, perceptions and lived experiences of a place. They are circulated and propagated through images, stories, texts, data, algorithms, and performances. This section attempts to offer spatial imaginaries on what "Progressive urbanism" could be. Although it is not usual to use actual pictures to represent spatial imaginaries, and more focus is on the narratives, I attempt to use both images and narratives below to establish how spatial imaginaries could represent "progressive urbanism". For each example, there is one component of "progressive", in a way moving towards sustainability, and an associated component on "way of life" or lifestyle.

Spatial imagery 1. Is there an urban form for inequality? Reduced inequality can be represented through urban form in terms of individual land holding.

Figure 1. Aerial view of Dharavi housing in Mumbai showing inequality
Source: https://qz.com/india/1396785/drone-photos-capture-the-staggering-inequality-in-mumbai

Spatial imagery 2. Sponge cities as spatial imaginaries of bringing nature into the urban way of life, which is progressive in terms of climate action. Climate urbanism. Stated in China in 2014. China is considered to be the Global East.

Figure 2. Representing Sponge City in China
Source: https://earth.org/sponge-cities-could-be-the-answer-to-impending-water-crisis-in-china/

Spatial imagery 3. Decentralisation and hybridisation of infrastructure as form of circular urbanism.

In developing countries or emerging economies, as an innovation to serve the informal sector with low income at the periphery.

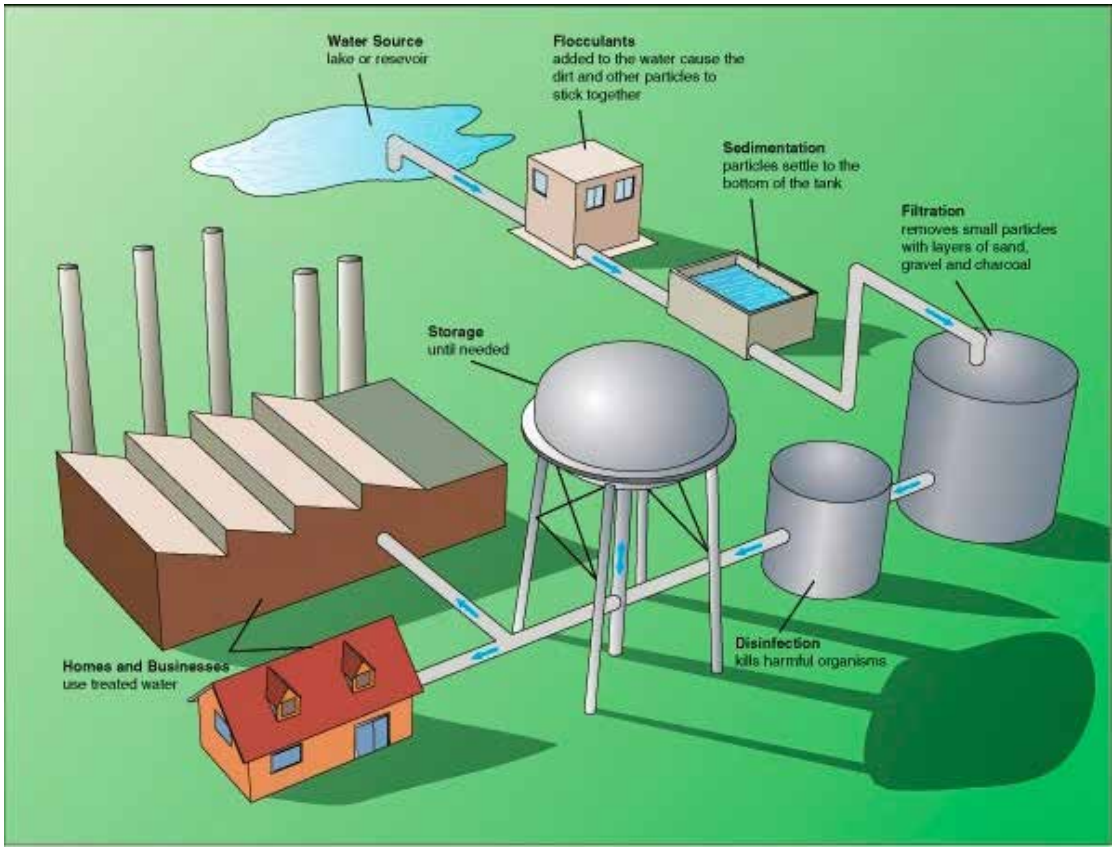

Figure 3. Decentralised wastewater system

Spatial imagery 4. Participatory budgeting

Participatory budgeting could provide a narrative for "progressive urbanism", where "progress" is about participatory decision-making within built environment, and a new way of life where it is usual to participate in decision-making about the urban. Originated in Brazil in 1989.

Figure 4. Women-led participatory budgeting in Penang, Malaysia
Source: https://www.socdemasia.com/latest/news/gender-responsive-and-participatory-budgeting-programme-penang

5. Conclusion: Towards an emerging form of "progressive urbanism"

Progressive urbanism is not a large drastic transition; it is the summation of many little transitions in day-to-day activities. It is about the incremental day-to-day decisions made by all socio-economic groups, not only by the marginalised, subordinates, and externalised ones today, but even those who are in power, physically, wealth-wise, politically, as a society, towards a more equal, economically well-off, healthy future for tomorrow, for the next generation. This equal society, economically progressed than what it was before, healthier and climate-friendly urban for all, indicates the "progress" here, decided by those who are working as academics, scholars, practitioners, policy makers, based in the South-East. This generation is optimistic of delivering a better and competitive future.

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Localization and Application of Scene Theory in the Context of Historic Town Preservation in China: A Case Study of Shannxi Mizhi Ancient Town

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Abstract
Under the discourse of value inheritance in Chinese historic towns, the dual challenge of preserving cultural heritage and revitalizing urban vitality has emerged as a pivotal issue in contemporary urban studies. Clark's scene theory, with its innovative theoretical framework and quantitative analytical methodology for assessing cultural values, has stimulated extensive interdisciplinary research and academic discussions. This study employs Mizhi County as a representative case to establish a localized interpretation and analytical framework of scene theory within the Chinese context. The findings reveal that creative scenescapes serve as crucial catalysts for heritage conservation and vitality regeneration. Furthermore, scene measurement proves effective in quantifying value orientation transmission and public perception patterns, providing empirical evidence that cultural spaces function as dynamic mediators between historical continuity and contemporary urban development.

Key words: Value Transmission; Historic Town Conservation; Scene Theory Contextual Adaptation;

1 introduction

Cultural destiny intertwines with national fortune, and cultural lineage connects with national vitality (Xu Zhong, 2023). As Lewis Mumford noted, "Complex civilizations require stable historical urban containers." President Xi Jinping has repeatedly emphasized strengthening cultural confidence and enhancing the protection of historical heritage. The 19th CPC National Congress highlighted that preserving cultural relics and inheriting cultural heritage are crucial components in building cultural confidence and promoting socialist cultural prosperity, requiring continuous advancement in the "creative transformation and innovative development" of traditional Chinese culture. Sun Jing's (2024) analysis of Operational Guidelines revisions reveals an epistemological breakthrough: historic towns are now recognized as dynamic human ecosystems, transcending traditional monument-centric conservation frameworks. ICCROM defines living heritage sites as "places continuously shaped by historical actors, maintaining both physical structures and socio-cultural practices, with core communities inhabiting or adjacent to these sites" (Zhao Xiaomei, 2016). As inhabited heritage, they differ fundamentally from conventional monuments by preserving not only material artifacts but also unique socio-cultural ecosystems formed through centuries of evolution. However, current conservation practices often prioritize physical preservation over humanistic dimensions while lacking methodologies to measure communities' spiritual perception of heritage values. This study therefore investigates scene theory's applicability in addressing value transmission and vitality regeneration in Chinese historic towns.

2 Literature review: The Evolution of Historic Town Conservation and Theoretical Research in China

2.1 Review of the Development and Research on Historic Town Conservation in China

Historic town conservation in China began later than in Western countries. By integrating Western conservation philosophies with local practices, China has gradually developed a context-specific heritage protection system. The enactment of the Cultural Relics Protection Law in 1982 marked a significant milestone by initiating state-level rescue protection for heritage sites and introducing the concept of "historical and cultural cities." In 1986, the idea of "historical and cultural protection zones" was officially proposed. The 2002 revision of the same law integrated "historical and cultural blocks" and "villages and towns" into urban master planning. The 2008 "Regulations on the Protection of Famous Historical and Cultural Cities, Towns and Villages" established a tiered national conservation framework, comprising three levels: cities, blocks, and cultural relics. In 2010, the Ministry of Housing and Urban-Rural Development introduced management guidelines that emphasized not only authenticity and integrity but also the continuity of social life.

Since the 18th CPC National Congress, cultural heritage "revitalization" has gained prominence, with strategic policies accelerating the construction of integrated urban-rural heritage protection and transmission systems. A value-oriented approach to cultural conservation has gradually taken shape.

Recent research has shifted from the authenticity of heritage objects to system integrity and sustainable cultural transmission. Some scholars have revisited traditional Chinese urban philosophies. Wang Shusheng (2019) conceptualized the "landscape-cultural spatial pattern," proposing that landscape serves as a natural axis and culture as a spiritual axis. Based on this, Gao Yuan (2023) and others constructed a regional network in the Guanzhong region; Liu Shuhu (2024) analyzed visual connectivity in ancient Quanzhou; and Yan Pei (2024) examined the spatial logic of towns along the upper Han River by interpreting their geomorphic settings.

Additionally, scholars are increasingly focused on the spiritual heritage and activation of historic towns. At the macro level, Chen Shuangchen (2022) proposed a heritage value system rooted in the evolution of Chinese civilization. Zhang Huan (2022) developed a collaborative protection framework emphasizing full-element and full-spatial coordination. Wang Kai (2022) explored systemic models for urban-rural heritage transmission. At the meso level, Zhang Guanghan (2023) designed a cultural transmission path for the Grand Canal, and Li Heping (2022) employed scene theory to address the holistic, dynamic, and multi-dimensional characteristics of historic towns.

At the micro level, models have been developed to assess residents' cultural sustainability through dimensions such as cognition, emotion, and practice (Li Lu et al.,2022); and to decode landscape and cultural "genes" to capture spatial vitality (Xiao Jing et al.,2021). Quantitative frameworks have also been proposed to evaluate cultural inheritance (Yang Liguo et al.,2017), liveliness (Zou Jun et al.,2020), and rurality (Liu Peilin et al.,2012), identifying areas of weakness in the preservation process.

In conclusion, China's historic town conservation has transitioned from static protection under a relic-oriented paradigm to dynamic strategies emphasizing social and cultural continuity. The current core of conservation practice lies in addressing how to effectively transmit heritage values and achieve cultural revitalization.

2.2 Literature Review of Scene Theory

Scene theory, pioneered by Terry N. Clark of the New Chicago School, emphasizes cultural consumption as the foundation for urban revitalization. It views urban space not merely as a functional environment but as a cultural amalgam of consumption symbols, with convenience and comfort as essential preconditions (Wu Jun, 2014). Clark's theory argues for fostering urban regeneration through the integration of creative scenes, and subsequent studies have highlighted the role of "amenities" as drivers of population concentration and urban economic growth (Wu Jun et al., 2022; Wang & Wu, 2011). At its core, scene theory evaluates space from the perspectives of aesthetics and lifestyle, focusing on its embedded values, cultural meanings, and aesthetic qualities (Wu Jun, 2022).

Unlike "place," which emphasizes rooted identity through kinship and geography, the concept of "scene" stresses constructed identity within diverse social groups. Bian Lanchun et al. (2024) argue that creative districts function as a synthesis of site, place, and scene, integrating spatial forms, cultural narratives, and social activities.

In applied research, the theory has been extended in various ways. Zhang Ye et al. (2024) proposed a cultural framework for national cultural parks based on the triad of "cultural genes–cultural elements–cultural scenes." Chen Mingkun et al. (2024) introduced micro-renewal strategies for park cities based on holistic assessment and feature recognition. He Xiaorong et al. (2023) explored how nostalgic consumer spaces, such as the Super Wenheyou project in Changsha, are constructed and perceived under scene theory.

Further local adaptations have emerged to align the theory with Chinese contexts. Xia Shu (2019) emphasized reconstructing scenes' spatial-temporal dimensions and emotional content in the digital era. Guo Chen et al. (2022) proposed six elements and four levels for scene planning in metropolitan coordination. Xu Wanting et al. (2024) retranslated the concepts of authenticity, theatricality, and legitimacy into "cultural authenticity," "cultural consumability," and "cultural balance" to guide heritage renewal. Tang Juan et al. (2023) applied scene theory to develop a cultural value assessment system for Suzhou's historic streets.

Overall, scene theory offers a holistic, pluralistic, and systematic analytical framework, combining culture-driven development strategies with methods that integrate subjective perceptions and objective evaluations. Beyond serving as an effective tool for assessing cultural value transmission, it also provides a strategic pathway for revitalizing urban vitality and restoring the livability of human settlements. Meanwhile, scholars across disciplines have made contextualized adaptations of scene theory to suit their respective domains. In the context of historic town value transmission in China, its emphasis on culture as the core driver, the value–carrier logic of cultural inheritance, and an integrated perspective that spans all regions, elements, and time periods aligns closely with the foundational principles of scene theory. As such, it is both necessary and timely to explore its applicability in this context and to develop a localized theoretical framework tailored to the cultural preservation of historic towns.

3 Theoretical Framework: A Scene-Based Analytical Model for Value Transmission in Historic Towns

3.1 Compatibility between the Context of Value Transmission in Historic Towns and Scene Theory

3.1.1 Applicability Analysis

(1) Scene theory provides a quantitative analytical framework integrating subjective and objective dimensions for the preservation and renewal of historic towns.

Scene theory constructs a dual-dimensional analytical system encompassing both subjective perceptions and objective environmental elements. Through three core dimensions—legitimacy, authenticity, and theatricality—and their corresponding 15 sub-dimensions, it offers a robust theoretical tool for identifying and quantifying scene characteristics in urban spaces. By analyzing combinations of these coded sub-dimensions, researchers can systematically evaluate what types of scenes attract which groups, trigger specific activities, and generate varying socio-economic and cultural impacts. This process ultimately informs strategic decisions regarding scene configuration for specific development goals.

The integration of subjective and objective dimensions enables a comprehensive pathway for linking tangible heritage environments with intangible value perceptions. It offers a theoretical foundation for unifying the "form" of heritage preservation with the "spirit" of cultural transmission, thereby providing a quantifiable and operational approach for guiding value renewal in the context of historic town conservation.

(2) The cultural-driven model in scene theory offers theoretical guidance for the cultural revitalization of historic towns.

Scene theory advocates for a shift from the traditional post-industrial economy-driven paradigm toward a culture-led model of urban development. By strategically supplying and configuring "comfort amenities," it aims to cultivate a livable and culturally vibrant environment that attracts and retains members of the creative class, thereby stimulating urban regeneration.

In the context of historic town conservation, protection strategies that solely emphasize heritage elements—akin to "museum-style" preservation—often overlook the everyday production and living needs of local residents, ultimately weakening the town's livability and vitality.

The culture-driven model thus provides a new developmental logic for revitalizing historic towns: placing traditional culture at the core while integrating emerging contemporary cultural expressions to forge new forms of creative culture. This approach fosters the aggregation of social groups sharing common interests and values, enabling a proliferation of participatory cultural activities. Such a framework not only facilitates the dynamic inheritance of cultural values but also offers a viable theoretical foundation for promoting the integrated economic, social, and cultural revitalization of historic towns.

(3) The amenity system of historic towns contributes to the formation of distinctive scene characteristics

"Amenities" refer to elements that provide comfort and pleasurable experiences for residents, encompassing facilities, activities, and services aimed at improving urban quality of life (McNulty et al., 1985). Early definitions of amenities emphasized their nature as non-market, non-productive public goods (Ullman, 1954; Clark, 2003). Later, Clark expanded the concept to include the spillover effects of private goods, thereby developing a more comprehensive and flexible theoretical framework (Silver & Clark, 2016). Overall, amenities are generally categorized into three types: natural, social, and cultural (Wu Jun et al., 2024).

In the spatial construction of historic towns in China, traditional planning philosophies—particularly the interaction between settlements and natural landscapes—have resulted in the creation of natural amenities. Meanwhile, the integration of rich tangible and intangible heritage resources has fostered a robust cultural amenity system. This, combined with deeply rooted, localized social-cultural amenities, helps form distinctive cultural scenes within historic towns. An emerging academic consensus suggests that the construction of cultural scenes and the conservation of historical heritage are not isolated undertakings but rather interdependent and mutually reinforcing processes (Li Heping et al., 2022).

3.1.2 Inapplicability Analysis

(1) Divergence in Value Orientations under Consumption-Driven Logic

Scene theory is grounded in a logic of cultural consumption. It emphasizes the cultivation of specific urban scenes to attract and retain the creative class, thereby revitalizing urban economies in the post-industrial era. Within this framework, the primary function of scenes lies in stimulating economic growth through consumer-oriented spatial experiences.

In contrast, the contemporary context of historic town conservation in China assigns these spaces a broader set of responsibilities. Beyond supporting the everyday production and living needs of local residents, historic towns are increasingly regarded as key spatial carriers of China's national cultural revitalization strategy. They serve as integral components of the urban-rural cultural heritage system and play a crucial role in reinforcing national and ethnic identity.

Accordingly, the value orientation of historic towns in China extends far beyond that of consumer-driven scenes. These towns must simultaneously support autonomous, daily-life activities of indigenous populations and facilitate the transmission of cultural heritage and collective memory. This dual function—rooted in cultural identity and historical continuity—stands in marked contrast to the economic utility-driven logic embedded in Western scene theory.

(2) Semantic Divergence of Key Elements in the Context of Migration Societies

Scene theory emerged within the sociocultural context of Western immigrant societies, where urban life is shaped by ethnically diverse communities, heterogeneous value systems, and pluralistic cultural practices. Its conceptual foundation assumes a social structure characterized by individual mobility, multicultural coexistence, and high degrees of personal autonomy in spatial and lifestyle choices. Key elements such as "neighborhood," "amenities," and "activities" are thus defined within this framework of diversity and voluntary association.

In contrast, the value transmission of historic towns in China is grounded in a context of cultural continuity, rooted in localized traditions and collective memory. These towns emphasize the dialectical relationship between the national and the local, privileging emotional attachment to place and shared cultural identity. Rather than being shaped by fluid migration patterns or market-driven consumption behaviors, the social relations embedded in Chinese historic towns prioritize authenticity, temporal continuity, and spatial rootedness.

Consequently, the conceptual underpinnings of scene theory—developed in a Western immigrant context—require contextual reinterpretation when applied to Chinese historic towns. A localized reconceptualization of core elements is necessary to address the specific cultural, social, and functional demands of heritage preservation and value transmission in the Chinese context.

In summary, while scene theory offers a systematic analytical framework and valuable methodological tools for understanding the value transmission of historic towns, its foundational concepts—such as the integration of subjective and objective dimensions, the culture-driven development model, and the interaction between amenities and values—resonate well with China's heritage logic that emphasizes both tangible forms and intangible meanings, as well as the mutual construction of carriers and values.

However, the sociocultural context underlying scene theory—rooted in Western post-industrial and immigrant societies—differs significantly from the cultural missions and social structures faced by Chinese historic towns. These divergences are particularly salient in the value orientations and spatial-social logics that inform scene construction.

Therefore, when applying scene theory to the context of China's historic towns, it is essential to adapt and reinterpret its key concepts, structural elements, and value systems. By constructing a localized analytical framework, scholars and planners can more effectively identify cultural scene characteristics and design more contextually appropriate pathways for value transmission and urban revitalization.

3.2 Scene-Based Analytical Framework for Value Transmission in Chinese Historic Towns

3.2.1 Contextual Adaptation of Scene Elements in Chinese Historic Towns

Silver et al. (2010) argue that the essence of urban scenes lies not in isolated elements such as neighborhoods, facilities, or population, but in the combination of these factors and the resulting activities they engender. Grounded in the theory of social dramaturgy, scene theory conceptualizes the city as a symbolic "stage," where amenities form the "set," diverse populations act as "performers," neighborhood relations provide the "social context," and activities function as "scripts" that convey meaning and identity. Within this integrative framework, scene theory underscores the interaction between spatial components and cultural values.

Given the unique cultural lineage and spatial characteristics of Chinese historic towns, this study proposes a localized interpretation of the four core components of scene theory—amenities, population, neighborhood, and activities—as follows:

Amenities: Defined as both tangible and intangible resources that bring pleasure or comfort, amenities in historic towns encompass not only physical heritage, natural landscapes, and public infrastructure, but also symbolic environments and cultural atmospheres shaped by intangible heritage and traditional lifestyles.

Population: The population structure of historic towns typically consists of: (1) indigenous residents deeply embedded in local cultural traditions; (2) tourists attracted by the historic and cultural milieu; and (3) new residents who migrate due to shared cultural values or employment needs. These groups interact and co-shape the dynamics of cultural inheritance.

Neighborhood/Social Networks: In the context of historic towns, neighborhoods refer not just to physical proximity, but also to the embedded social relationships, including kinship- and place-based networks, occupational mobility-based communities, and emerging value-based cultural collectives.

Activities: As the dynamic core of scenes, activities embody the interactions among amenities, populations, and social networks. In historic towns, activities range from traditional cultural expressions such as festivals and rituals, to modern cultural-creative practices and participatory events, as well as the daily practices of life and work that continually animate the space.

This contextualized understanding of scene elements provides a more grounded theoretical and practical basis for identifying cultural values, constructing meaningful scenes, and guiding the conservation and regeneration of historic towns in China.

3.2.2 The Scene Hierarchy of Historical Towns

Historic towns possess dual attributes of historical-cultural significance and contemporary living functions. They are required not only to convey profound cultural values but also to meet the diverse production and living needs of residents, thereby revitalizing the town's vibrancy. As a crucial node within the urban-rural cultural heritage system, historic towns must effectively integrate with territorial spatial planning and cultural inheritance systems to ensure comprehensive spatial coverage and dynamic integration. Due to constructive recognition of diverse lifestyles by multiple stakeholders, the boundaries of scenes in historic towns are often ambiguous and dynamic.

Based on related research (Guo Chen et al., 2022), and centered on cultural inheritance, the scene hierarchy in historic towns can be delineated along both horizontal and vertical dimensions:

Horizontal Dimension: Scenes are categorized into three concentric layers—cultural scenes, creative scenes, and living scenes.

Cultural scenes are spaces of cultural significance formed around key historical nodes, serving as the foundation and source of cultural transmission.

Living scenes focus on facilities and services essential for daily production and life, underpinning residents' everyday existence.

Creative scenes lie between cultural and living scenes, representing the integration of traditional and contemporary cultures, embodying cultural innovation and quality of life enhancement, and acting as the core driver of cultural vitality revival.

Vertical Dimension: Scenes are structured from micro to macro levels, including scene units, scene clusters, scene cluster groups, and scene aggregations. These correspond respectively to specific components of cultural scenes, entire categories of cultural scenes, the historic town's complete scene system, and its position within the broader urban-rural cultural heritage framework.

This hierarchical framework clarifies the internal composition logic of scenes in historic towns and provides a theoretical and practical basis for the organic integration of cultural inheritance and spatial planning.

3.2.3 Value Dimensions of Historic Town Scenes

While scene theory offers robust tools for measuring scene dynamics, the value dimensions it proposes—rooted in Western consumer culture—are not universally applicable, especially in contexts like Chinese historic towns where cultural inheritance plays a central role. Scholars have thus proposed localized reinterpretations of scene value structures. For example, Hou Xueyan (2025), through analysis of 43 rural public cultural spaces, distilled three perception dimensions: locality, consumer orientation, and cultural depth. Similarly, Chen Bo (2025), drawing on the triadic dialectic of spatial production and historical town value systems, identified local expressiveness, symbolic perception, and social integration as key dimensions.

In contrast, Clark's formulation, developed within the framework of Western cultural consumption, identifies three primary value layers: Dramaturgy – the emotional expressiveness of a scene; Legitimacy – the behavioral norms and regulations embedded within the scene; Authenticity – the degree to which individuals can derive identity and belonging.

These three dimensions effectively address how scenes evoke emotions, structure behavior, and foster identification. They also reflect the capacity of space to guide cultural meaning and social conduct.

For this study, these are consolidated into three analytical layers: Emotional Layer (linked to dramaturgy); Behavioral Layer (linked to legitimacy); Identity Layer (linked to authenticity).

This framework is applied to a representative historic town case, and thus the observed value orientations reflect specific characteristics of that locality.

3.2.4 Analytical Framework for Historic Town Scene Typologies
This framework unfolds in four key steps:

Step 1: Constructing a Database of Comfort Amenities. Identify and catalog both cultural and daily-life elements within historic towns. Cultural elements are derived from field surveys and planning documents, including various levels of heritage sites, historic buildings, traditional-style architecture, time-honored commercial entities, and landscape-oriented urban design features. Daily-life elements are extracted primarily through POI (Point of Interest) data mining, including public services and cultural industry facilities.

Step 2: Scene Typology and Hierarchical Structuring. Based on the dual nature of historic towns—cultural heritage and everyday life—this step identifies cultural scenes and living scenes. The creative scene serves as a dynamic link between the two, offering pathways for cultural innovation and revitalization. From the perspective of integrated heritage systems, scene typologies are structured hierarchically as follows: Scene Units: constituent elements of cultural scenes; Scene Clusters: typological groupings of cultural scenes; Scene Cluster Groups: aggregations of scenes across a town; Scene Aggregations: macro-level systems aligning with the national cultural heritage framework.

Step 3: Scene-Based Diagnosis through Measurement. This involves two diagnostic approaches: Scene Cluster Value Assessment—quantifying the cultural value supply by comparing actual scene characteristics with expected symbolic representations. Scene Cluster Group Value Diagnosis—evaluating the integrity of the value system at the emotional, behavioral, and identity levels.

Step 4: Integrated Scene Analysis and Strategic Response. Using a holistic approach, this step synthesizes comfort amenities, user groups, social network structures, activities, and value orientations to analyze cultural transmission bottlenecks and formulate adaptive planning strategies for historic towns.

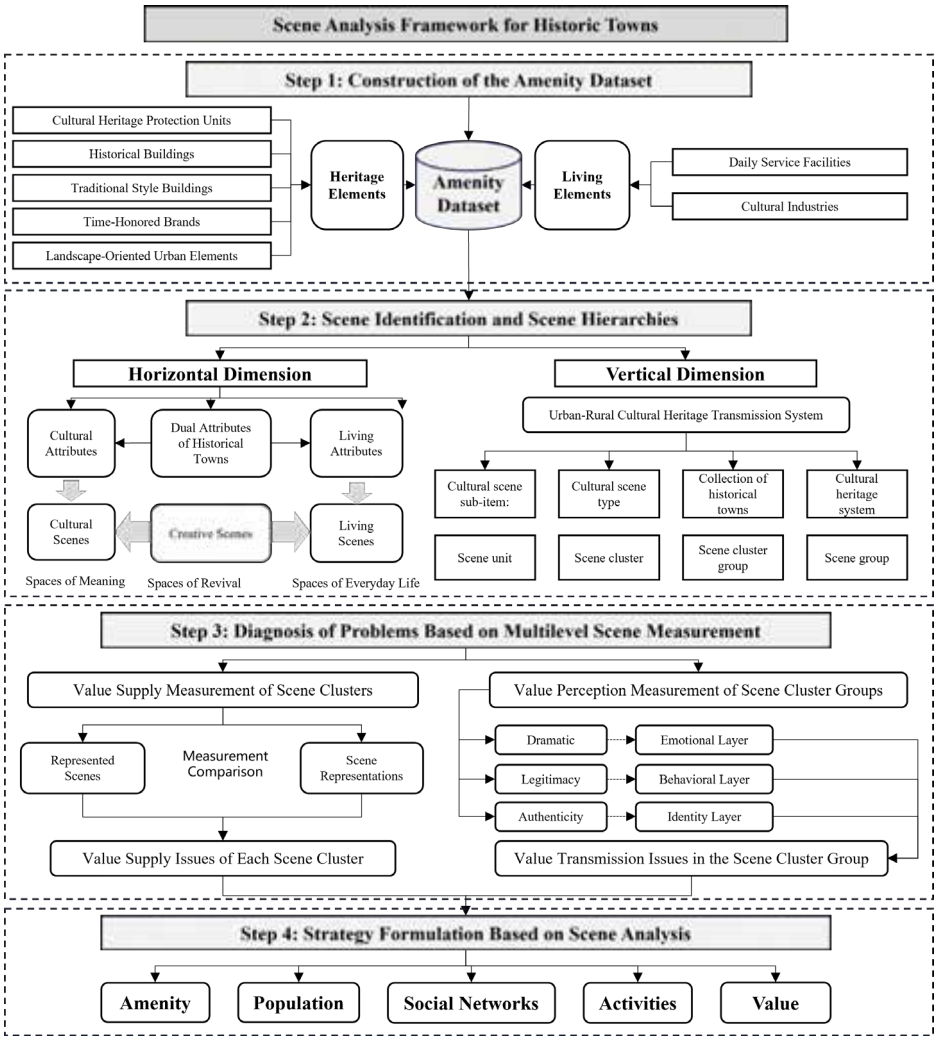

Fig1 Analysis framework of historical town scenes

4. Empirical Study: Scene Analysis of Mizhi Historic Town

4.1 Overview of Mizhi Historic Town

Mizhi, historically known as "Yinzhou," derives its name from the saying, "the land yields golden streams and fertile soil; its rice juice is as smooth as fat." In 2023, it was designated as the sixth batch of provincial-level historic and cultural cities by the Shaanxi Provincial Government. Located in the Wuding River Basin in eastern Yulin City, Shaanxi Province, Mizhi lies in the transitional zone between agriculture and pastoralism in the middle reaches of the Yellow River. It has long served as a cultural intersection between farming and nomadic civilizations, fostering a rich and diverse heritage that remains vibrant today through numerous forms of intangible cultural heritage.

On one hand, Mizhi boasts abundant historical and cultural resources, including 50 officially protected heritage sites, 59 historic buildings, and 64 items of intangible cultural heritage at or above the county level. On the other hand, situated in the heart of the Loess Plateau, the town faces significant challenges due to its fragile ecological environment, the demographic siphon effect of the Xi'an metropolitan area, and a resource-dependent industrial structure. These factors have led to a reconfiguration of the local social structure and hindered the transformation of rich historical resources into drivers of urban revitalization. As such, Mizhi represents a typical case among China's historical towns, highlighting the developmental constraints faced by many similar locales.

Fig2 satellite image of Mizhi historic town

Fig3 The landscape layout map in the county annals

(Source: Mizhi County Annals)

4.2 Research Setting and Data Source

This article takes "Mizhi" as the keyword, and searches on websites such as Weibo, Douyin, and Ctrip. Through Python programming, 785 pieces of online text data were crawled. After data cleaning, 512 online review data related to Mizhi were obtained.

Then, through a Python program connected to an AI large model, multimodal analysis was conducted on the online text data. It obtained keyword strength and keyword information based on the comprehensive number of likes, reposts, and comments, as well as the emotional tendency attached to the online texts.

4.3 Cultural Scene Identification

Based on fieldwork and questionnaire surveys, a "comfort objects" database was constructed for Mizhi Historic Town. Four distinct types of cultural scenes were identified through thematic categorization:

4.3.1 Scholarly Culture Scene

Mizhi is renowned as a cradle of education and literature in northern Shaanxi. It was once said, "Every three steps there's a scholar's courtyard; every five steps, a residence of a successful candidate." During the Ming and Qing dynasties, Mizhi produced 24 military and civil jinshi, a successful candidate in the highest imperial examinations, 105 juren, a successful candidate in the imperial examinations at the provincial level, and 345 tribute students, earning it the name "Cultural District of Shaanxi." Notable figures include Li Jiqian, Li Dingming, Du Bincheng, Du Yuming, Li Jianhou, and Ma Jianling. Comfort objects in this scene include academies, ancestral halls, historic residences, and literary landmarks.

4.3.2 Landscape Culture Scene

The county's majestic topography, marked by hills and gullies, exemplifies classical Chinese geomantic principles. The town is strategically situated "facing mountains and overlooking water," with northern elevation provided by Phoenix Ridge and southern proximity to three rivers: Yinma, Liu Jin, and Wuding. It is surrounded by Panlong, Wenping, and Xiangfeng Mountains, forming a natural defense. Key comfort objects include mountain and river systems, scenic nodes, and culturally resonant landscape features.

4.3.3 Revolutionary Culture Scene

As part of the revolutionary heartland of Shaanxi-Gansu-Ningxia, Mizhi played a pivotal role during the Anti-Japanese War and the Chinese Civil War. It hosted early communist institutions like the Mizhi Party Branch and the County Committee, nurturing significant revolutionary developments. Associated comfort objects include martyrs' memorials, revolutionary heritage sites, and historical signage.

4.3.4 Loess Culture Scene

Situated at the intersection of agrarian and pastoral civilizations, Mizhi developed a unique regional identity blending both traditions. Its rich folk customs and tangible heritage reflect the essence of the Loess Plateau. This category includes intangible cultural heritage like paper cutting, suona music, and folk tales, with comfort objects encompassing cave dwellings, traditional hamlets, and folk performance spaces.

4.4 Measuring Cultural Scenes in Historic Towns

4.4.1 Scene Clusters Based on Representation of Scene

In the context of historic towns, scene representation refers to the projected scenes constructed by governmental bodies and planners under specific ideological and planning frameworks. These representations reflect the top-down expectations for cultural expression and spatial organization.

Scene cluster measurement under this logic relies on policy-based weighting, where cultural assets are scored according to their protection status: National-level protected heritage sites: 50 points; Provincial-level sites: 40 points; Municipal/county-level sites: 30 points; Registered historic buildings: 20 points; Other minor cultural elements: 10 points; Non-contributive points: 5 points. Using this scoring system, comfort objects associated with six previously identified scene types (Scholarly, Landscape, Revolutionary, Loess, Everyday, and Creative) were analyzed. The results were visualized via GIS (see Figure 4).

The analysis reveals several patterns: Scholarly scenes are highly concentrated along West Street, East Street, and around the Palace of Li Zicheng, mainly located in the Ming–Qing Lower Town zone. Landscape scenes align with natural topography, clustering along the town's periphery and in the Song–Yuan Upper Town, while the river-converging Ming–Qing Lower Town shows a notable deficiency. Revolutionary scenes are scattered due to fragmented comfort object distribution, but mainly appear in the Republican New Town and Song–Yuan Upper Town. Loess cultural scenes are shaped by traditional cave dwellings and intangible heritage, concentrated between the Yinma River and Galaxy River, across the upper and lower historical zones. Everyday scenes show a striking vacuum in both major historic zones, indicating insufficient integration of contemporary residential life. Creative scenes, defined by integration of tradition and industry, are sparse and predominantly composed of low-tier education-related facilities, lacking cultural-industrial synergy.

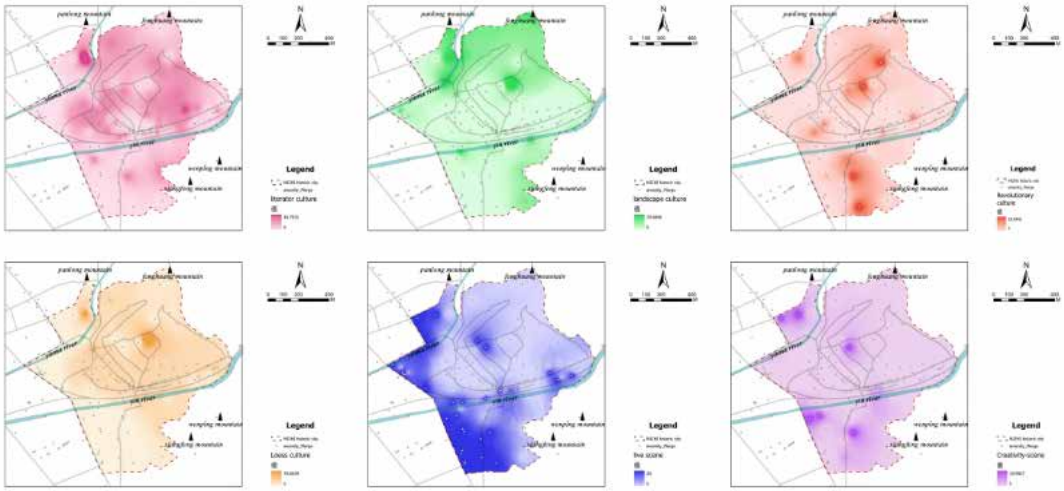

Fig.4 The measure of scene clusters in the representation of scene

4.4.2 Scene Clusters Based on Representational Scene

Representational scenes refer to the meanings assigned to spaces by users such as residents and tourists through symbols, memory, and cultural practices. To evaluate this subjective perception, surveys were conducted with 20 residents and 20 tourists, asking them to rate the contribution of each comfort object to six identified

scene types. A five-point Likert scale was used, and the resulting data were standardized to generate a "Comfort Object–Perceived Intensity Matrix." These data were then integrated into GIS for spatial visualization (Figure 5).

Overall, the distribution of representational perception values shows greater dispersion than the values from the scene representation perspective. There are no clear high-value clusters, suggesting a lack of strong perceptual hotspots. This implies that the current interpretive and display mechanisms in Mizhi Historic Town are underdeveloped, and public cultural perception is fragmented and ambiguous.

However, substantial spatial overlap between perceived scenes and designed scene representations indicates that comfort objects possess strong inherent cultural attributes that are widely recognized across different user groups.

Key spatial patterns include: Scholarly cultural scenes cluster in the northern areas (Song–Yuan Upper Town and Ming–Qing Lower Town); Everyday life scenes concentrate in the southern Republican New Town; Revolutionary scenes are perceived more strongly than their institutional weightings suggest but lack focal centers; Loess and literati cultures are generally perceived north of the Galaxy River; Landscape culture perception focuses on major mountains (Panlong, Fenghuang, Wenping, Xiangfeng), but riverine landscapes are less perceptible; Creative culture has not formed significant or perceptible clusters.

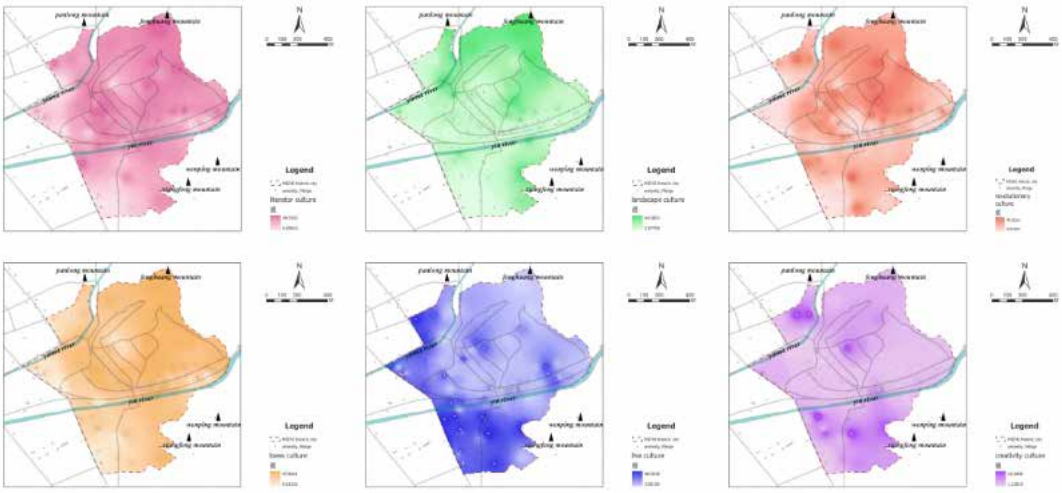

Fig.5 The measure of scene clusters in representational scene

4.4.3 Scene Cluster Value Perception

Based on the web-text data crawled via Python and cleaned accordingly, NVivo 20 was used for word segmentation. The top 60 keywords were selected for coding within the behavioral and identity dimensions. Since emotional inclinations are often implicit in text, Python interfaced with DeepSeek to perform sentiment analysis on individual texts, extracting the top 20 high-frequency emotional words for coding the emotional dimension.

Following grounded theory, a total of 80 keywords and their related texts underwent open coding, axial coding, and selective coding, progressively refining the emotional, behavioral, and identity layers of scene values. This process culminated in the establishment of a value perception framework for the scene clusters of Mizhi Historic Town.

As shown in Table 1 and Figure 6, the emotional layer clusters into five categories: joy, pride, comfort, sadness, and negativity. Positive emotions (joy, pride, comfort) accounted for 67%, indicating that the scene clusters generally evoke significant positive affect. Joy and pride primarily stem from awe and grandeur related to heritage sites, while comfort arises from the town's atmosphere. Sadness accounts for 7.62%, largely reflecting reflections

on historical events; negative emotions comprise 25%, partly due to resentment towards certain negative historical figures and partly due to ecological challenges faced in Northern Shaanxi.

Behaviorally, clusters are categorized as nostalgic, innovative, integrative, and philanthropic. Nostalgic behavior dominates at 45%, demonstrating strong public reminiscence and respect for heritage. Integrative behavior follows at 32.5%, showing a sense of affinity and participatory intention toward the town. Innovative behavior stands at 19.3%, reflecting a strong public interest in new developments. Philanthropic behavior is the least prevalent, mainly driven by official initiatives and lacking spontaneous societal engagement.

The identity layer divides into local, national, ethnic, historical, and fashionable identities. Historical and local identities predominate, reflecting the profound historical and regional cultural significance of Mizhi. National identity ranks next, based more on general patriotism without strong resonance to the town's red heritage. Ethnic and fashionable identities extend from regional ties and contemporary trends.

From score distribution and item concentration analysis (Figure 7), high cohesion in pride and comfort (emotional), philanthropy (behavioral), and fashionable and ethnic identity dimensions are pivotal for optimizing cultural heritage transmission in Mizhi. Attention must also be paid to mitigating concentrated negative sentiments regarding environmental facilities.

Table 1 Value Perception Metrics of Scene Clusters in Mizhi Historic Town

Selective coding	Axial coding	Open coding	Example
Emotion	Delighted	Liked (68), Affirmed (60), Praised (54), Amazed (10), Anticipated (13)	"Visited Li Zicheng's Palace on Panlong Mountain. The architecture towers majestically, exuding imperial grandeur."
	Proud	Shocked (17), Excited (16), Proud (15), Admired (4), Recalled (2)	"The palace appears solemn and majestic, narrating the glory of past dynasties."
	Comfortable	Suitable (20), Romantic (20), Leisurely (12), Refreshing (12), Satisfying (6), Pleasant (7)	"Had lamb offal with Chinese hamburger in Mizhi—absolutely delicious!"
	Sentimental	Regretful (23), Campaigns (10), Sorrowful (4), Disappointed (2)	"Though the rebellion failed, the grandeur of the palace remains a poignant memory."
	Negative	Indifferent (86), Resentful (24), Angry (13), Disgusted (4)	"Dusty winds in Mizhi—feels like eating sand outdoors."
Behavior	Nostalgic	Historical past (83), Transitions (64), Deeds (45), Remembrance (42), Exclamation (30);Nostalgia (6)	"Though Li Zicheng failed, his deeds inspire generations."
	Novelty	North of shaanxi Ballads (52), Cultural Festivals (43), Folk Songs (20)	"A north of shaanxi folk song is now trending in local tourism promos."
	Integrative	Participate (48), Recommend (46), Together (45), Follow (32), Charm (23)	"Joined local folks, danced Mizhi's sky and waters into memory."
	Public	Caring (10), Friendly (5), Warm (2)	"Story-sharing event featuring Mizhi's local role models."

Identity	Regional	Place (413), Mizhi Millet (275), Cave dwellings (97), Mizhi Aunts (91), Hometown (89), Loess (82), Taste (30), Down-to-earth (12), Paper-cutting Art (24), Intangible Cultural Heritage (37), Li Dingming Clinic (6), Iron Flower (20)	With a quick stroke of the knife, cut it into thin shreds and pour it over the simmered minced meat. That's the taste of home.
	Historical	Li Zicheng (314), History (167), Western Xia (145), Ming Dynasty (123), Period (107), Emperor (24), Ancient Times (28), Emperor Xiaowen of Northern Wei (12), Tongwan City (4)	In Chinese history, Li Zicheng is an inescapable figure. This "pioneer" from Mizhi County, Shaanxi Province, led the peasant army to launch a nationwide uprising, eventually overthrowing the Ming Dynasty and establishing the Great Shun.
	National	China (170), the State (138), "Dawn" (24), the Yan 'an Spirit (20), the Eighth Route Army (11), the War of Liberation (6)	Mizhi County held a research and study activity for the "Red Millet" cultivation project. This event closely combined red education, cultural inheritance and knowledge learning, allowing students to receive spiritual cleansing in a variety of rich and colorful activities.
	Fashionable	National Trend (25), Pop-up (20), style (12)	The rice fat in Hayao Miyazaki's paintings is undoubtedly a romantic collision of Oriental rural and fantasy aesthetics
	Ethnic	Ethnicity (74), Military (51), Ancestor (19), Thousand-year-old County (17), Genealogy (10), Descendants (7), Continuation (5), Branch (3)	"The Du clan of Mizhi traces its lineage over 800 years through detailed records."

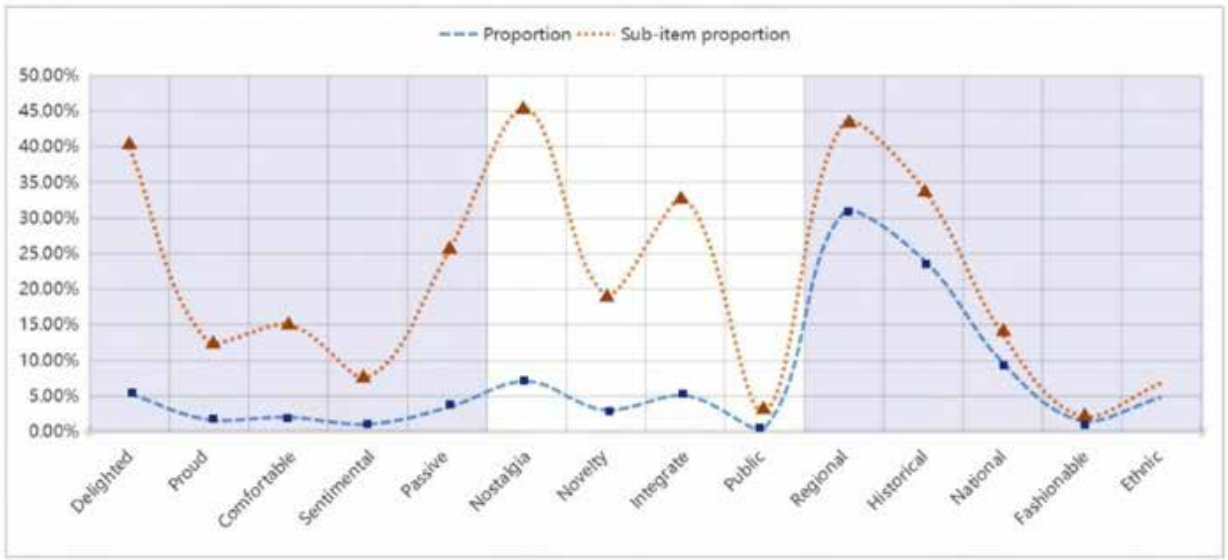

Fig6 The scores and the number of items of the scene cluster values

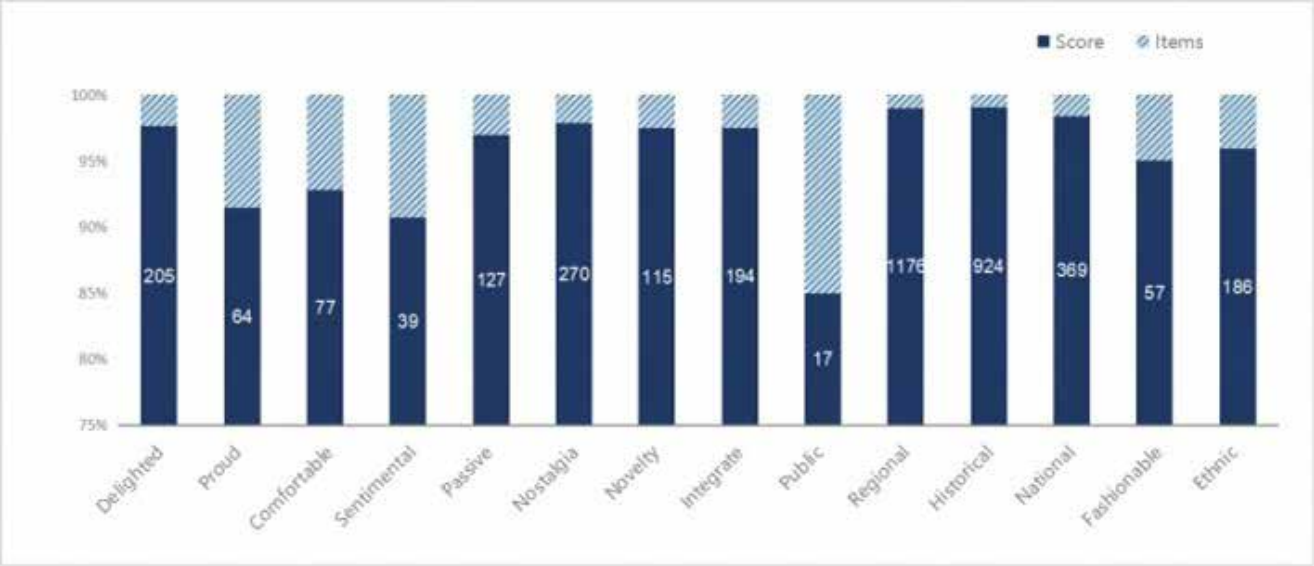

Fig7 The scores and the number of items of the scene cluster values

To conclude, the scene-based evaluation of value transmission in Mizhi Ancient Town reveals three key challenges: First, there is a clear rupture in everyday life scenarios, as local cultural elements have not been effectively transformed into creative or experientially meaningful scenes, leading to a disconnect between daily practices and cultural representation. Second, a structural mismatch exists between the supply of and demand for landscape-oriented and red culture scenes. This has resulted in an unclear, even chaotic, perception of cultural clusters, undermining the coherence of scene-based cultural value. Third, the value perceptions within the scene clusters tend to focus on grand historical and national narratives, or on aesthetic enjoyment derived from historical atmospheres, rather than cultivating targeted cultural transmission or sustaining distinct cultural types embedded in each scene. Notably, there is an emerging enthusiasm for integrating traditional culture with contemporary, trendy expressions. Effectively channeling this momentum to enhance emotional resonance, behavioral engagement, and identity expression will be crucial to realizing the creative transformation and innovative development of traditional Chinese culture.

5 Conclusion

Space in itself holds no inherent meaning. It is through the diverse needs of individuals—manifested in comfort objects, neighborhood interactions, and human activities—that space materializes into scenes and acquires meaning. Responding to the practical challenges of value transmission in China's historical towns, this study constructs a localized scene analysis framework rooted in Clark's scene theory and informed by Lefebvre's theory of spatial production. By incorporating the dual perspectives of "scene representation" and "represented scenes," the framework enables measurement of scene clusters to reveal mismatches in value supply within the spatial production process.

Building on this, the paper evaluates the value transmission of historical town scenes from the perspective of collective value perceptions across scene clusters. It further examines whether the transmission process effectively achieves both spiritual inheritance—from heritage to human consciousness—and living cultural revitalization—from preservation to regeneration.

Creative scenes, as intermediaries between cultural and everyday life scenes, play a critical role in mediating traditional and modern cultural expressions. Using the value dynamics of scene clusters as indicators, this approach provides a viable method to assess the direction and effectiveness of value transmission in historical towns. Moreover, scene connections at varying scales offer a practical pathway for linking different levels and missions

of urban-rural cultural heritage.

Finally, while the scene analysis framework offers a holistic tool for evaluating outcomes and influencing factors of value transmission in historical towns, it remains limited in diagnosing specific combinations of comfort objects, user groups, and activities. Thus, it is imperative to integrate process-based assessments of cultural transmission effectiveness, in order to identify actionable elements and links, and ultimately enhance the overall effectiveness of cultural inheritance in historical towns.

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The Role and Value of Theory in Urban Design: Can They Truly Shape the City?

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Abstract
This paper critically examines the role and value of planning theory in urban design, using the evolution of the Neighbourhood Unit and its reinterpretation within the 15-minute city model as an analytical lens. It first situates theory within two key debates: urban design as a temporal process of spatial-social change and as a form of activism. The study then explores how the Neighbourhood Unit operates within interdisciplinary frameworks, assessing its theoretical contributions and limitations in the face of socio-spatial complexity and postmodern fragmentation. Ultimately, the paper argues that theory both constructs and contests the order of urban design, marking a shift from static, prescriptive models toward dynamic, adaptive frameworks that reshape how cities are imagined, negotiated, and transformed.

Keywords: urban design, planning theory, neighbourhood unit, proximity-based models, 15-minute city

1 Introduction

The urban fabric and the forms of urban life are being profoundly reshaped by global crises and transformative events. These shifts have triggered new policies and strategies that address social, cultural, and other aspects across multiple dimensions (Longo et al., 2022). In particular, the challenges posed by accelerating urban sprawl and climate change as global issues, together with regulatory failures that have been exacerbated by neoliberal planning environments, have prompted renewed attention to alternative urban models. In response, urban planners, scholars, and policymakers are engaging in renewed discussions on alternative approaches aimed at delivering more sustainable, liveable, and healthy cities (Logan et al., 2022; Walters, 2021). As a result, the way in which urbanisation is conceived has shifted rapidly and significantly over the past few decades, reshuffling the imagination of urban space and transforming the way everyday urban life is experienced. For example, superblocks, low-traffic neighbourhood plans, doughnut models, and hybrids of these have emerged. Among these, the x-minute city model (15-minute city, with its variations) has gained increasing momentum (Di Marino et al., 2023; Moreno et al., 2021; Nieuwenhuijsen, 2021).

This paper adopts Alberti and Radicchi's (2023) study, From the Neighbourhood Unit to the 15-Minute City: Past and Recent Urban Models for Post-COVID Cities, as its primary analytical lens. It examines how the theoretical lineage of the Neighbourhood Unit (NU) continues to inform proximity-based urban models, situating the x-minute city within a broader historical and conceptual continuity. Through this case, the paper critically investigates the role and value of theory in shaping contemporary urban design discourse and practice.

1.1 The Re-emergence of the Neighbourhood Unit

Although the x-minute city is often regarded as a new paradigm, its conceptual foundation rests on well-established precedents (Pozoukidou and Angelidou, 2022). Central to this lineage is the NU, a planning concept introduced by Clarence Perry in 1923, which defined the neighbourhood as the fundamental unit of urban organisation (Mumford, 1954). Despite ongoing critiques and debates surrounding its socio-spatial implications, the NU continues to exert influence in urban planning practice, often in implicit or adapted forms.

In recent decades, the New Urbanism movement has reinterpreted the NU through a contemporary lens, incorporating its core principles of walkability, accessibility, and spatial decentralisation into modern proximity-based planning frameworks, such as the x-minute city (Duany, 2021; Kissfazekas, 2022; Moreno et al., 2021). Consequently, both the NU and the broader notion of the proximity city have re-emerged as focal points in planning theory and urban design practice.

1.2 Case Selection and Analytical Approach

While the 15-minute city and related proximity-based models have been extensively examined in recent academic literature and urban policy discourse, relatively limited attention has been devoted to re-examining the theoretical foundations from which these models originate, particularly the NU. This gap presents a timely opportunity to assess how enduring urban theories are being recontextualised within contemporary planning frameworks.

Within this context, the NU, as the conceptual foundation of the x-minute city, is employed as a lens through which to interpret the underlying principles and intentions of urban design. To address this, the paper draws on Alberti and Radicchi's (2023) study as a case for critical analysis. Their research traces the historical and conceptual evolution of the NU, demonstrating how its spatial logic continues to inform proximity-oriented and decentralised urban models. Furthermore, the study explores how interdisciplinary interpretations of the 15-minute city may provide a framework for addressing the socio-ecological challenges of urban transformation in the post-COVID era. Through this case, the paper interrogates how urban design theory is mobilised, reinterpreted, and contested in shaping future-oriented planning imaginaries.

2 Theoretical Debates in Urban Design

2.1 First Tier: Urban Design as a Temporal Process of Spatial-Social Change

The notion of urban design as a temporal process of spatial-social change responds to the so-called 'spatial turn' (Evans, 2010) and incorporates a temporal dimension into the spatial-social processes that unfold through dynamic interactions (Lefebvre, 2010; Madanipour, 2006). This perspective positions urban design as an ongoing, never-complete process shaped by two interrelated forces: top-down strategies and everyday spontaneous practices (Gańko, 2019). More specifically, it emphasises the role of time in urban design by framing it within the temporalities of "the pace of life and space" and "the historical processes of place" (Carmona, 2014).

Building on this theoretical framework, Alberti and Radicchi (2023) propose that the NU functions as a socio-spatial model and employ it as a historical anchor to illustrate how the concept of urban proximity has evolved across various theoretical paradigms. Their analysis demonstrates an ongoing dialogue in neighbourhood-scale urban design, reflecting a shift from physical spatial forms (isolated units) to social dynamics (interconnected spaces). That is to say, the role of the NU has shifted over time, profoundly influencing the gradual transformation of the concept of neighbourhood in urban design, from a physical space to a carrier of social meaning and identity. This transformation reflects theory as a framework for structuring and organising urban design, sustained through the continuity and repetition of theory within urban processes. Accordingly, theory provides a set of principles that enable urban design to adapt, transform, and reconfigure itself in response to socio-spatial-temporal evolution, thereby contributing to the pursuit of ideal urban visions and supporting the generation of diverse discursive dimensions within urban design.

2.2 Second Tier: Urban Design as a Form of Activism

Urban design as a temporal process of spatial-social change offers a broad conceptual framework that enables challenges to existing urban fabric and social relations. Building on this foundation, urban design as a form of activism reimagines urban space as a site of debate, positioning activism as a key driver in urban transformation (Usubillaga, 2022).

In the recent wave of activism, often undertaken at the neighbourhood or community level, urban activism is increasingly recognised as the seed of transformative change within neoliberal urban contexts (Monno, 2016). Alberti and Radicchi (2023) offer a critical perspective on how the NU theory implicitly contests conventional planning paradigms by re-evaluating urban proximity as a foundational dimension of sustainable cities. Beyond its theoretical role, the NU has contributed to substantial shifts in community lifestyles. By promoting social cohesion, inclusivity, environmental sustainability, and public health, the NU supports a broader transition toward the eco-social urban model.

Most importantly, NU theory has stimulated what has been described as a shift from conventional urban planning to a more integrated form of urban life planning (Allam et al., 2023a; Staricco, 2022). This transition foregrounds the notion of the "right to the city" as a foundational component in the production of spatial, neighbourhood, and social life. In this context, theory functions as a mechanism for structuring urban design by shaping the built environment and envisioning new modes of urban living. It is not only intrinsic, intangible, and embedded in practice, but also operates as a connective framework that aligns physical space, social interaction, and environmental experience. Through this integrative role, theory contributes to the realisation of high-quality urban life.

2.3 Revisiting the Neighbourhood Unit

The evolution of the NU has long been a subject of scholarly debate. Inspired by Ebenezer Howard's (1898) Garden City approach, Perry (1923) introduced the NU as a unit-based spatial method of urban planning (Lawhon, 2014). Notably, this approach was also intended to intervene in existing communities, and is therefore recognised as a tool for urban regeneration (Marchigiani and Bonfantini, 2022). However, the NU has faced severe criticism, particularly for its failure to account for the organic spatial and functional structures embedded within established neighbourhoods (Bauer, 1945; Isaacs, 1948; Pozoukidou and Chatziyiannaki, 2021). Jane Jacobs (1961) critiqued its approach for disregarding the complexity of urban environments and the social fabric embedded within them (Allam et al., 2023b). Similarly, Kevin Lynch (1960) emphasised the need for urban elements to be arranged in a lively and integrated manner that enables people to connect with their localities, rather than be separated by space.

Despite these critiques, modernist planning paradigms have frequently led to spatial fragmentation, reinforcing the need to reconsider neighbourhood planning. In response, Alexander (1962) sought to restore the meaning of the NU as a composition of multiple physical and social units coexisting within the broader urban context. Since then, the neighbourhood principle has continued to be reinterpreted, culminating in the emergence of the x-minute city, which is regarded as the most recent evolution of the NU.

Nevertheless, the NU theory is more than a purely rhetorical statement. A review of its critical reception reveals that the initial controversies stemmed from its perceived role in promoting spatial and social segregation and hindering organic urban regeneration. In response to these criticisms, the x-minute city model seeks to rebuild the connection between spatial form and social function by returning to the fundamental principles of the NU and reaffirming the concept of proximity (Marchigiani and Bonfantini, 2022). This return has resulted in urban design being compressed into a singular and highly localised spatial framework.

In this context, proximity is understood as both a physical and socially relational manifestation of urban space that supports the adaptation and reinforcement of NU theory in contemporary applications. In this way, while the relationship between proximity and neighbourhood planning is ambiguous, the NU theory has become a partial disguise for the complex grammatical characteristics of urban space (D'Onofrio and Trusiani, 2022; Gil Solá and Vilhelmson, 2019; Marchigiani and Bonfantini, 2022). It is tacitly accepted as a representation of urban design's potential to activate new forms of social practice and everyday life (Sennett, 2018). At the same time, an expanding vocabulary of buzzwords related to proximity and community has produced a set of ambiguous terms that are often mechanically repeated in urban discourse. As a result, the NU increasingly appears as a branded concept, detached from its original theoretical foundations.

3 Reinterpreting the Neighbourhood Unit in Postmodern Urban Paradigms

In the late twentieth century, urban planners increasingly shifted their attention to the neighbourhood scale and localised communities, largely in response to the functional-spatial separation and widening socio-spatial divide resulting from modernist planning. Within the context of postmodernism, the NU concept has informed several contemporary urban planning movements (Pozoukidou and Chatziyiannaki, 2021), including Transit-Oriented Development (TOD), New Urbanism, and Smart Growth (Furuseth, 1997). It has also contributed to a range of compact city models aimed at facilitating sustainable urban transformation, such as the compact city, the urban village or transit village, and the x-minute city (Lobner et al., 2021). Postmodern urbanists continue to adopt key principles of NU, including mixed-use, housing and work proximity, human scale, adequate green space, walkability, and

compactness (Wheeler, 2013), and expect this to lead to high-density, walkable, mixed-use, and diverse neighbourhoods, which in turn will promote social interaction and sustainable development (Talen, 2005).

However, physical interventions based on these principles are insufficient to address complex urban challenges such as socio-spatial segregation (Kafkalas et al., 2015). Urban models inspired by the NU often lack the replicability to be adapted to operate effectively across diverse urban environments (Khavarian-Garmsir et al., 2023), particularly in the postmodern era of increased social mobility and pluralistic lifestyles (Al-Khanbashi, 2020). Furthermore, while postmodern models critique and partially move beyond the NU framework, they are frequently criticised for lacking genuine innovation. For instance, New Urbanism is often viewed as an extension of earlier paradigms rather than a truly novel theoretical contribution; it is considered a practice rooted in methodological repetition rather than conceptual advancement (Cuthbert, 2007). Consequently, the persistent ambiguity surrounding the conceptualisation, interpretation, and evolution of the NU theory has contributed to confusion in its application, rendering urban design increasingly contested and theoretically ambiguous.

4 Theoretical Frameworks of the 15-Minute City: A Critical Evaluation

4.1 Framework Composition

Alberti and Radicchi (2023) conceptualise the 15-minute city as a proximity-based framework integrating multiple theoretical strands (see Figure 1). At its core is the NU, complemented by Central Place Theory (service hierarchy and accessibility), Proxemics (human-scale spatial relations), TOD (connectivity through transit), and compact city principles (density and sustainability). This synthesis allows for a multidimensional understanding of urban proximity, bridging spatial, social, and environmental considerations. In the theory of urban planning and design, the NU emphasises the concepts of community-centred facilities and their walkability, which form the basis of urban proximity. The proximity extends its related theories in urban design through interdisciplinary approaches to the Central Place Theory (CPT) and the Proxemics Theory (PT) from geography and anthropology. The CPT develops a hierarchy and mobility of services and facilities to provide the NU with accessibility of facilities in a broader spatial scope. On the other hand, the PT promotes the philosophy of human-scale relationships with distance and space to enhance the interaction between humans and urban spaces for the NU. The TOD, which follows the principles of New Urbanism, further develops proximity by extending the walkability range of the NU to public transport. Additionally, urban proximity is given the concepts of sustainable cities in the Compact City and the Ecocity models. The concepts incorporate the consideration of urban density, mixed-use urban networking, and green areas contributing to the accessibility of urban sustainability to the NU prototype.

The integration of these theories and concepts as a theoretical framework for this research provides the concept of urban proximity and the evolution of the NU's theories to be more comprehensive and adaptable to a wider context. Although the research does not present new theories or unique arguments of its own, through a holistic and critical review and discussion of these existing theories, it makes recommendations for the 15-Minute City within this theoretical framework under urban design and planning research and practice.

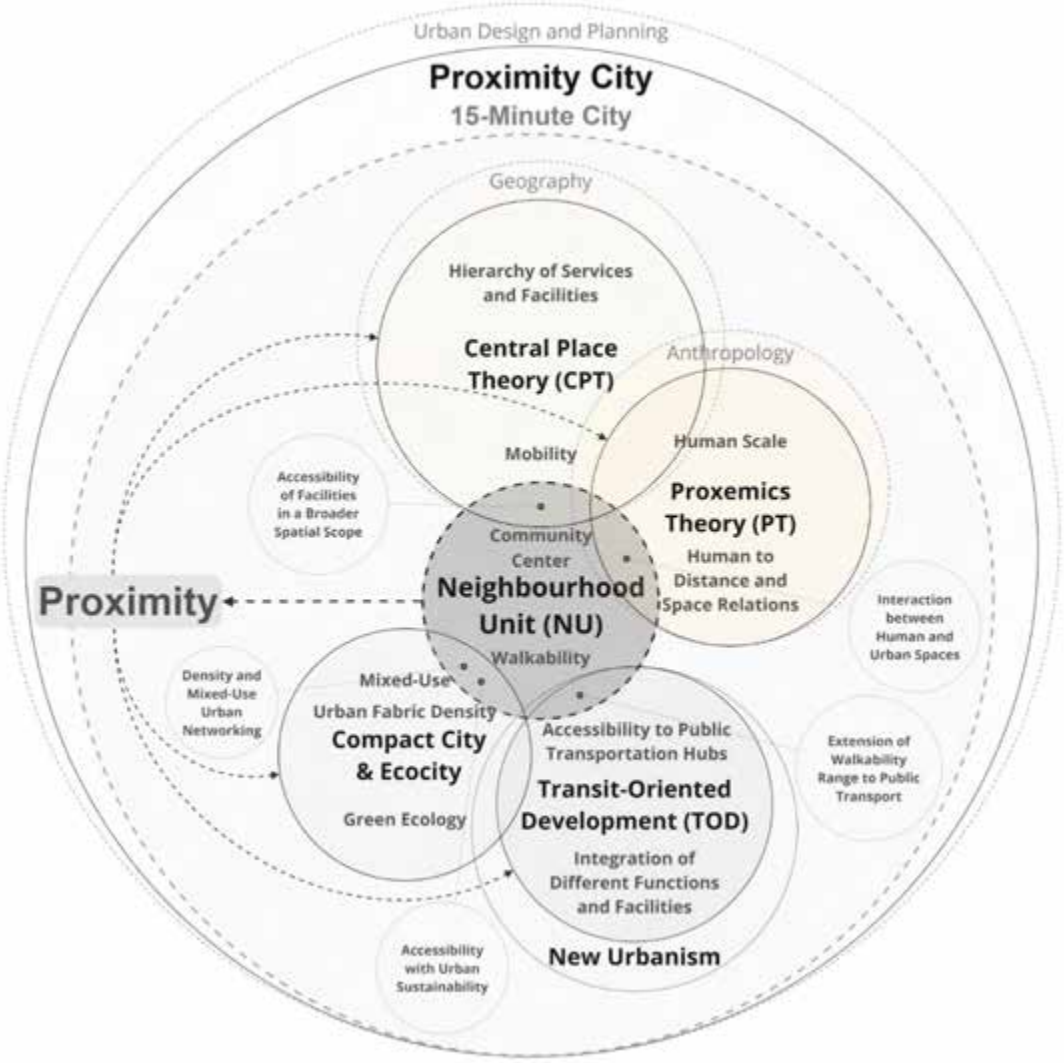

Figure 1: Theories and concepts in the 15-Minute City theoretical framework (made by author)

4.2 Benefits and Limitations

The theoretical framework facilitates the evolution and continuity of urban design in the concept of spatial social change and allows cities to respond to the unpredictability of global challenges, which also significantly addresses the aims of the research project. These benefits derive from the humane accessibility of urban spaces and distances through the comprehensive perspective of proximity across time, as well as the promotion of spontaneous social cohesion and inclusiveness from the neighbourhood order, and the combination of sustainable relevance.

The NU and proximity-centred framework also tend to bring limitations, mainly due to a lack of consideration of social diversity and the challenges of operationalising it in reality. Specifically, the theoretical framework does not adequately consider the social segregation and urban inequalities that may result from the heterogeneity between different socio-economic groups. In addition, its practical implementation in situations where the urban fabric is already relatively fixed will encounter considerable problems in community participation and policy support.

4.3 Integrating and Comparing Alternative Theoretical Frameworks

Among existing theoretical frameworks, the Social-Ecological Model for Physical Activity offers a valuable multilevel structure that emphasises how individual behaviours are shaped by interactions across multiple contextual layers. This model holds considerable potential for integration into the theoretical underpinnings of the 15-minute city.

As illustrated in Figure 2, a comparative analysis of the hierarchical structure of the 15-minute city and the Social-Ecological Model enables the construction of a layered theoretical hierarchy. This hierarchy ranges from the human scale, through neighbourhoods and urban networks, to mixed-use sustainable communities and ultimately the proximity city. Such a structure supports a systematic organisation of urban proximity, beginning with walkability and accessibility at the individual and neighbourhood levels, extending to social interaction and cohesion at the community level, and culminating in spatial deployment and service provision at the urban policy level.

This multilevel approach provides a useful framework for designing urban strategies that simultaneously address the needs of individuals, communities, and governance structures. It facilitates the development of interventions that are both context-specific and scalable. However, the incorporation of multiple layers may introduce analytical complexity and operational challenges in the planning process. Further research is required to understand the interdependencies and dynamics across these levels to ensure effective implementation.

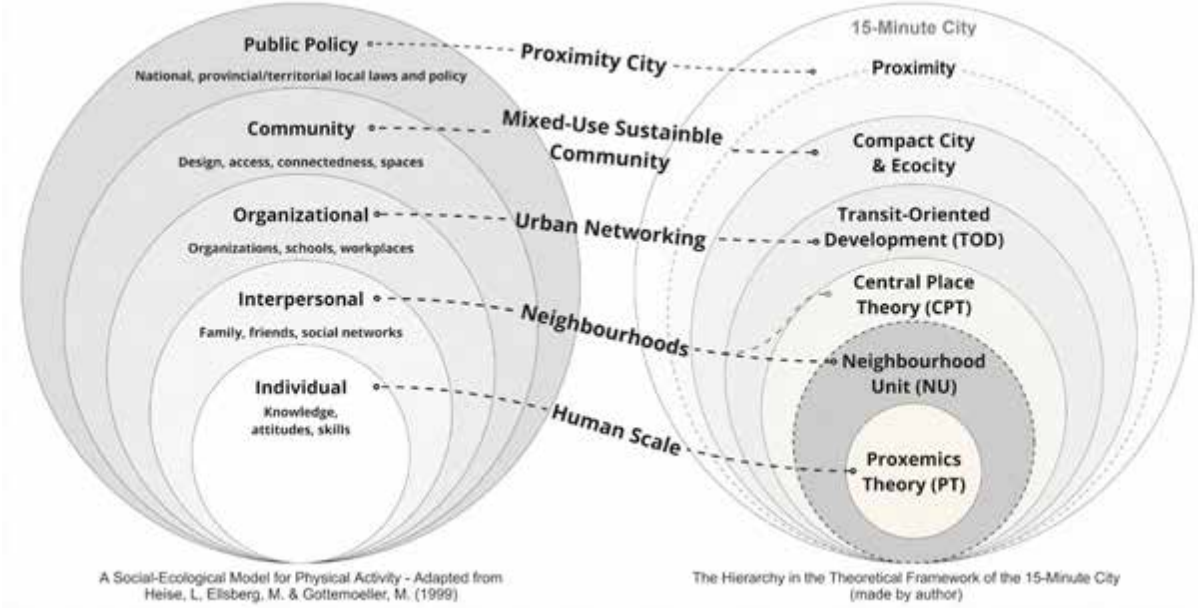

Figure 2: Comparison and adaptation from a Social-Ecological Model theoretical framework to the 15-Minute City theoretical framework (made by author)

5 Conclusion

This study adopted the NU as a dynamic analytical lens to investigate whether theory can truly shape the city. By exploring the evolutionary nature of NU Theory and its progression toward the 15-Minute City, the research reveals the two-fold role and value of theory in urban design. First, theory serves as the order of urban design. Theory, as both a tangible and intangible construct, shapes and reforms the inner principles of urban design, enabling it to adapt to ongoing urban transformation and to stimulate innovation. Second, theory creates an order for urban design that connects the space of place and everyday life. This order is metaphorical and progressive, encouraging urban design to take action in order to reconfigure urban space and enhance the overall quality of urban life.

Although the validity of major urban planning and design theories has been questioned in recent years, largely due to their tendency to oversimplify the complexity of urban design while repeatedly reiterating concepts that have emerged in the past but remain unresolved, this ambiguity has nonetheless stimulated wider critical thinking and urban imagination. Thus, rather than merely serving as a rhetorical gesture, theory acts as and creates the order of urban design. It views the urban as a process and asserts that urban design precipitates and embeds its distinctive historical and practical dimensions into urban space and everyday life.

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Rethinking Promethean planning: An epistemological enquiry of technoscientific-centrism in planning theories

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Abstract
The paper provides a critical exploration of technoscientific-centrism in planning theory through the lens of the Promethean myth. Considering the prevailing trends of hyper-specialisation, resurgent scientism and the associated risks of depoliticisation, there is a need to unpack the overreliance on techno-scientific rationality within planning disciplinary practices. This can be achieved by drawing upon concepts and analytical categories from outside the discipline. Accordingly, the Promethean myth offers a valuable opportunity to reinterpret the history of planning as 'science of prediction', that is, a field which has been marked since its origins by a conception of 'absolute' space introduced by modern scientific thought. The present paper delineates the paradigm of Promethean Planning, while concomitantly establishing the foundations for a post-Promethean conception of planning.

Key words: Promethean planning, positivist spatiality, scientism, specialisation, technology.

1. Planners, technology, and the never-ending quest for prediction and control

This paper presents an alternative perspective on the evolution of technoscientific-centrism in planning by exploring the myth of Prometheus. Given the apparent distance, in disciplinary terms, of the Promethean myth with respect to urban planning culture and history, a preliminary clarification is necessary. In the subsequent section, the tale of Prometheus, son of Iapetus, will be illustrated and analysed in relation to that of Atlas. A particular focus of this study lies in the relationship between humans and technology, with great emphasis placed on the consequences of this relationship for the domain of urban planning. The primary feature of the Promethean myth that will be examined subsequently is the aspiration for omniscience as the ultimate objective of a techno-centric conception of planning. As will be argued in the fourth section, Promethean planning consists primarily of the combination of prediction and control – in the terms described by John Friedmann (1987) –, the result of which tends precisely to omniscience, ensured by the progressive enhancement of the predictive and modelling apparatus at the disposal of planners starting, at least, from the quantitative revolution.

This vision is deeply rooted in the positivist culture of planning and could be summed up effectively in the expression of George B. Ford (1913), according to which "In the science of city planning the whole city is our laboratory" (p. 551). The concept of an artificial space in which total control is ensured, as will be argued below, is predicated on the notion of 'absolute space' introduced by modern scientific thought (Voegelin, 1948). In such a space, actions and behaviours can be programmed, and therefore, everything can be predicted. The underlying thesis suggests that contemporary planning is characterized by the return of scientism, which insidiously combines the advancement of predictive technologies, based on the extraction of data on an increasingly large scale, and hyper-specialisation. In this regard, it's worth considering that such a trend is particularly striking within planning academe (Signoroni, 2022). As the Promethean myth becomes a way to deconstruct the role of planners as specialists, a key to unpack the origins of the relationship between the planner-specialist and technology might be traced back to early 20th century planning[1]. Notwithstanding the critiques to rationalist planning, and to its

1 Since its inception as both a discipline and a professional practice in the aftermath of the Second Industrial Revolution, urban planning has established what may be considered an enduring overreliance on techno-scientific rationality (Sandercock, 1998). Indeed, the integration of technoscientific rationality into planning theory and practice has profoundly shaped the process of professionalisation and institutionalisation since the early steps of the discipline. For instance, the social reform movement – which was imbued with positivist philosophy – significantly shaped the epistemological foundations of planning (Beauregard, 1990; Fairfield, 1994). The emergence of planning as a distinct field of practice has been extensively documented in scholarly literature (Birch,1980; 2001; Birch and Silver, 2009; Peterson, 2009; Davoudi and Pendlebury, 2009). Notably, the evolution from

overreliance on technoscientific rationality, an in-depth inquiry into technoscientific-centrism in the domain of urban planning has never been undertaken. For this reason, an incursion into the language of myth may prove more beneficial.

Specifically, this study focuses on the Promethean myth. A substantial body of literature exists that examines the myth of Prometheus and its implications for science and technology (see: Kahn, 1970; Calame, 2005). Given the emphasis on the spatial dimension of technoscientific-centrism as the primary focus of this study, a thorough investigation of the Myth's spatial ramifications is envisaged. While drawing upon classical sources, particularly Hesiod (Arrighetti, 1984), the present study primarily draws upon three contributions. Robert Graves' well-known book, The Greek Myths (1960), serves as main reference to introduce the figure of Atlas. Carlo Sini's (1981) appraisal of the myth of Atlas and Prometheus – along with Simona Chiodo's (2020) analysis of the evolution of the relationship between humans and technology – serves to unpack the Promethean legacy, that is, the concept of scientific specialisation that underpins the 'destinal' movement of technology and, accordingly, the quest for prediction and control.

In the domain of planning, a prevailing technoscientific-centrism characterised by the pervasiveness of specialisation as the underlying rationale of the Western faith in technology (see section 3) has evolved into the prime component of what Gabriele Pasqui (2022a) delineates as 'the atmosphere'. Such curtain represents "the set of discourses, traditions, memories within which the practice of urban planning takes form (urban cultures, repertoires, transmission of knowledge, valorisation mechanisms)" (p. 45, translated in English by the author). Accordingly, Pasqui argues, "It is necessary [...] to recognize, together with the transformations of the [disciplinary] field, the concomitant shifts in the atmosphere" (ibidem). The extensive utilization of planning technologies – in the broadest possible sense, yet with specific emphasis on the comprehensive predictive modelling apparatus – has contributed, as Pasqui would assert, to the 'thickening' of the prevailing atmosphere by directing "the operational guidelines, the techniques, the tools" (ibidem). In the absence of "a fertile relationship between the development of tools and techniques for analysing territorial phenomena, also connected to the extraordinary availability of georeferenced data at our disposal [...]" the risk would be that "of supporting a (perhaps presumed) scientisation of urban planning analysis" (ibidem, p. 47). In this sense, examining the past through the lens of myth can offer insights into the present state of the art of the discipline, and potentially inform future theory-building scenarios.

2. Prometheus and Atlas: Symbols of 'technical mediation'

The figure of Prometheus unveils a peculiar reflection on the Western conceptualisation of technology, as it has been extensively discussed in the academic literature (see Kerenyi, 1997). Apart from Prometheus, a compelling parallel can be drawn between the myth of Atlas and the rise of faith in technology. Indeed, the two myths are deeply interrelated. Prometheus' older brother, Atlas "with a violent heart" (Hesiod: 509), is remembered as an inhabitant and lord of the far west, the Land of Atlas: "This land of Atlantis lay beyond the Pillars of Heracles, and a chain of fruit-bearing islands separated it from a farther continent, unconnected with ours. Atlas's people canalized and cultivated an enormous central plain, fed by water from the hills which ringed it completely, except for a seaward gap. They also built palaces, baths, race-courses, great harbour works, and temples; and carried war not only westwards as far as the other continent, but eastward as far as Egypt and Italy" (Graves, 1960: p. 143).

The myth of Atlantis is significant for two reasons. Firstly, it conveys the tale of a potent and technologically sophisticated population whose calamitous destiny is analogous to that of Prometheus. This is because when technological enhancement becomes hubris – that is, when it is employed to challenge the limits imposed by the gods or by fate – it must be stopped. In this regard, the case of Atlantis serves as a paradigmatic example: "The Egyptians say that [...] [Atlas and his brothers] at first [...] were extremely virtuous, bearing with fortitude the burden of their great wealth in gold and silver. But one day greed and cruelty overcame them and, with Zeus's permission, the Athenians defeated them single-handed and destroyed their power. At the same time, the gods

an engineering focus to a planning emphasis within the field resulted in a substantial shift in terms of urban expertise. Traditionally, engineers addressed the ailments of industrial cities (Schultz and McShane, 1978); in contrast, urban planners adopted a more comprehensive and scientific approach in addressing the broader needs of the city as a whole (Karvonen et al., 2021).

sent a deluge which, in one day and one night, overwhelmed all Atlantis, so that the harbour works and temples were buried beneath a waste of mud and the sea became unnavigable" (ibidem).

In contrast to the prominent recognition of Prometheus as the 'ancestor of human beings', Atlas has received comparatively less attention in this regard. The reasons for this discrepancy in treatment, so to speak, are not limited solely to a genealogical question. In the ancient Greek mythos, Prometheus is recognized as the progenitor of Deucalion, who, in collaboration with Pyrrha, is tasked with the responsibility of reestablishing humans in the aftermath of a deluge unleashed by Zeus. However, according to the myth, he is also the deity who oversaw the creation of humankind, shaping it from mud and infusing it with fire. Herein a critical distinction emerges between Prometheus and Atlas. Following the destruction of his kingdom, Atlas aligned himself with Kronos, taking a stance against the Olympic gods (an action that would result in a punishment from Zeus). In contrast, Prometheus chose to support the offspring of the Titans. This decision was met with respect and trust from Zeus. In contrast, Atlas' punishment is regarded as exemplary in that "he is placed on the western edge of the Greek cosmos with the task of holding the sky with his shoulders. Atlas is therefore the one who operates the separation between heaven and earth. The alternation of day and night, or rather the birth of time, is the result of his work" (Sini, 1981: p. 255, translated in English by the author).

Accordingly, Atlas directly operates "the separation between human and divine, being the one who started the relentless flow of time that devours the creatures of a day" (ibidem). This would position him, along with Prometheus, as an alter ego of human beings, thereby serving as a symbol of technical mediation. This reflection is further enriched when considering the subsequent myths associated with the figure of Atlas. According to the 1930 edition of the Treccani Encyclopaedia, "with the diffusion of the euhemeristic interpretation [...] it even goes so far as to make him an astronomer and a mathematician, inventor of the sphere" (translated in English by the author). Accordingly, as a second-generation Titan, Atlas is the brother of Prometheus, the lord of Atlantis, and the rebel ally of Kronos in the Titanomachy. Much more importantly, because of his treason and the consequent punishment, he becomes a mediator between the celestial and terrestrial realms; the originator of time and, in a broader sense, the progenitor of astronomy, to whom we owe the conceptualisation and development of the sphere[2].

What most deserves to be considered here with respect to the myth of Prometheus and Atlas is precisely their being 'mediators'. Atlas creates space by holding up the celestial vault with his own body. It is no longer the Euclidean space – an abstract notion of space (Friedmann, 1993; Graham and Healey, 1999) – but, rather, the space of human life, the space where bodies can breathe, walk, meet, and collide[3]. Moreover, he presides over the alternation of day and night, the natural pace of time. Symbolically placed in the extreme West, to hold up the sky, Atlas is therefore complementary to Prometheus, chained on the Caucasus, in the extreme East – where an eagle sent by Zeus every day devours his liver, destined to grow again in the night, thus perpetuating the torture for eternity (Chiodo, 2020). The two titans are therefore considered ancestors of mankind because they preside over the very first 'technical acts': the invention of time (its scanning, its control) and of fire. Prometheus's actions, in this case the act of stealing fire from the gods, are driven by a desire to assist humanity, whom he had previously endowed with intelligence and memory. However, it is through the agency of fire that men achieve emancipation. It serves as a symbol of technology, that is, techne: "the study and use of techniques, procedures, and advanced technical and scientific knowledge for the solution of practical problems" (Wikipedia). Accordingly, technology

2 It is noteworthy that from the 16th century onwards, the term 'atlas' has traditionally been employed to denote a compendium of graphic works – that is, cartography – which have constituted, and continue to constitute, a primary instrument of graphic communication for planners as well as for geographers and, albeit to a lesser extent, for architects and engineers.

3 In a recent essay, Cristina Bianchetti (2020) examined the relationship between bodies, space, and design. Filled with 'extra disciplinary' references, the contribution enables critical and original readings of the relationship between the body (in its many variations of state and movement) and the space (of the project). Affirming the presence of the body is a political act in itself; however, 'scientific planning' is such in the extent to which it replaces the body (of the subject, of the expert in the field) with pervasive technological mediation – georeferenced data, for example. For further insights into this topic, I refer the reader to Signoroni (2023b).

does not represent an external force; rather, the myth of Prometheus suggests that humans are innately 'technological beings'.

The human being, created with a deficiency due to the fault of Epimetheus (the foolish brother of Prometheus), becomes such when it can handle fire intelligently: "through the fire, jointly with the other Prometheus' gift to the Humans, namely, the intelligence, they can survive animals and atmospheric agents, live under the sun, and even rule the earth. [...] the fire intelligently used is divine in that it is so powerful that humans can rule the earth. Moreover, the fire intelligently used is divine in that it is precisely what makes the humans analogous to the gods" (Chiodo, 2020: p. 212).

3. The Promethean legacy: Specialisation and the civilisation of technology

It is therefore not by chance that human beings are the dominant species on Earth. They are destined for domination precisely because they are technological beings, that is, beings whose actions draw upon (and are informed by) specialisation. In this regard, the concept of specialisation must be understood in its profound meaning, intimately linked to the nature of man and the advent of the 'age of technology':

specialisation means to look at the species. The original Latin meaning of species is 'image', 'appearance', 'spectacle', 'form'. The related verb specere means 'to observe', 'to watch', 'to look at' [...] The species is what lets itself be seen. And in turn, 'it is by virtue of its visibility that the species can be observed, analysed, controlled, measured, desired, feared, refused, shunned [...]. We interpret things as species and enact specialisation, and scientific specialisation is 'the certainty of the difference between things' put into practice in the most coherent and powerful manner: science 'isolates a part (species) of reality; it separates it from the other part in order to be able to observe its configuration and behaviour' (Pitari, 2019: pp. 368-369).

When interpreted in this manner, specialisation can be regarded as anticipating the utilisation of technology by humankind: "Humans can exist as the beings who organise means, realise ends, make decisions and transform the 'world' only in virtue of the prior ontological isolation of all things [...] This is how we define human beings as technological beings" (ibidem: pp. 369-370). Scientific specialisation, therefore, responds to a very specific criterium (isolation of the predetermined field of observation, for purposes of control and manipulation), progressively accentuating it in parallel with technological enhancement. The emergence of the scientist-expert is also a consequence of scientific specialisation. Over the course of a few decades, the modern scientific method was established and with it the figure of the scientist-expert under the influence of astrologists as Johannes Kepler and Galileo Galilei and of philosophers such as Francis Bacon and René Descartes.

All in all, specialisation emerges as "the factual realisation of humankind" (ibidem). Through it, the Western civilisation accomplishes its own destine, becoming a true civilisation of technology. On the 'destinal' character of the event of technology, Carlo Sini (1981) dedicated an insightful reflection which is worth mentioning in this context:

The word 'essence' [...] means 'destiny', both in the sense of the occurrence of a destinal event, and in the sense in which Peirce, in the 'pragmatic maxim', speaks of consequences that are destined. In these two cases a movement (kinesis) is implicit which [...] involves a distinction between 'sense' and 'significance': the interpretant revealing of the present involves a reinterpretation of the sense of the past; it is that which awaits the passage into the future. With the help of an image we can [therefore] depict the destinal movement [...] as a wave which, in its progress, draws away a mobile and expanding circumference. However, the circumference swings in two directions: in the direction of expansion and, also, in the direction of continuous decentralisation. [...] Now, as involved in the movement of this spatially precipitating wave [...] we miss the perception of the propelling center of the circumference that is unfolding, of the movement itself of that center. Similarly, the event of technology, by destining us, drags us along; and thus, also and in a certain way, it directs us towards the driving force of the unfolding movement in which we ourselves are but together it dis-orients us from it (pp. 251-252, translated in English by the author).

Such unfolding movement of technology, therefore, while it destines us, it also compels us to acknowledge that "the present technological configuration of our civilisation may be a recent historical circumstance, but its Weltanschauung is as ancient as humankind" (Pitari, 2019: p. 371). Scientific specialisation, which lies at the heart of the destinal movement of technology, plays a critical role in shaping the direction of technological development and establishes the foundations for subsequent technological progress.

In correspondence with the rise of modern science, the concept of specialisation began to represent the structure of modern thought and accordingly imbued the culture of the 16th and 17th centuries, including the arts. In this regard, a compelling and particularly effective representation of specialisation is that provided by John Marlowe in his Doctor Faustus (1587). As acknowledged in the literature (Watt, 2007), the Faust is a potent 'contemporary' myth. It sheds light on specialisation as the implicit, though well-established, framework of modern thought. In order to exercise dominion over the capricious and uncontrollable forces of nature, it is necessary to acquire profound knowledge, which can be obtained through an 'isolation' process. This is to say, by acknowledging each entity as isolated from the rest. In this sense, the words spoken by Marlowe's Faustus can be interpreted as prophetic.

In the opening scene, as the character of Doctor Faustus is presented to the audience, he goes through all the disciplines in which his studies excel, including logic, medicine, law and theology. While appreciating logic and the law, he harbours a strong aversion to medicine, perceiving it as a discipline that offers no promise of immortality to humankind[4]. Moreover, he expresses disdain for theology, deeming it futile given the inherent propensity of humanity to commit sins[5]. In the domain of magic, a realm that Faustus has not investigated yet, he discerns the potential for greatness and potency[6]. The whole discourse is characterised by a sense of Promethean fashion. This is due to the fact that the "metaphysics of magicians" would bestow upon Faustus omniscience, thereby conferring the ability to foresee the future (hence the meaning of Prometheus: the 'foreseeing'). Though, it is the specialised conception of knowledge that is most striking. The words used by Faustus are indicative of the advent of modern science, as they already embody its fundamental premise, which is to be found in the scientist's essentially manipulative eye.

A second relevant consideration pertains to necromancy. As posited by several works in the field of anthropology (see, for instance: Gell, 1988; Stahl, 1995), magic may be regarded as a rudimentary form of technology. In this regard, Arnold Gehlen's contribution is worthy of mention. In his essay Die Seele im technischen Zeitalter (1957), which was subsequently translated and published in English under the title Man in the Age of Technology (1980), Gehlen discusses the extent to which both primitive and advanced civilisations, such as the Egyptian and the Greco-Roman, relied on magic as a form of proto-technology to bring order in, and equilibrise, the world. Accordingly, magic was performed to ensure predictability, regularity, and order in the face of a chaotic and unpredictable natural environment. In a world perceived as inhospitable to life, the cyclical repetition was assumed to provide a sense of security and stability. Therefore, magic was comprehended as a means to ensure and preserve the automatic, self-regulating, and repetitive character of the natural course. This compelling observation regarding

4 "Be a physician, Faustus, heap up gold, / And be eterniz'd for some wondrous cure. / Summum bonum medicinae sanitas, / The end of physic is our body's health. / Why, Faustus, hast thou not attain'd that end? / Is not thy common talk sound aphorisms?/ Are not thy bills hung up as monuments, / Whereby whole cities have escap'd the plague / And thousand desperate maladies been cur'd? / Yet art thou still but Faustus, and a man. / Couldst thou make men to live eternally/ Or being dead raise them to life again, / Then this profession were to be esteem'd. / Physic, farewell!" (Marlowe, 1616, retrieved from the John D. Jump's 1965 edition).

5 "When all is done, divinity is best. / Jerome's Bible, Faustus, view it well. / Stipendium peccati mars est. Ha! Stipendium, etc. The/ reward of sin is death: that's hard. Si peccasse negamus, / fallimur, et nulla est in nobis veritas. If we say that we / have no sin, we deceive ourselves, and there's no truth in/ us. Why, then, belike we must sin, and so consequently / die. / Ay, we must die an everlasting death. / What doctrine call you this? Che sarà, sarà: / What will be, shall be! Divinity, adieu!" (ibidem).

6 "These metaphysics of magicians / And necromantic books are heavenly; / Lines, circles, letters, and characters: / Ay, these are those that Faustus most desires. / O, what a world of profit and delight, / Of power, of honour, of omnipotence, / Is promis'd to the studious artisan!" (ibidem).

magic as a supernatural technology may become a useful key to understanding the meaning of contemporary technology. If the abovementioned assertion that the ultimate aspiration is to exercise control over the surrounding environment is accurate, then technology – like magic before it – is nothing more than a faith or, at least, a theory – certainly not the absolute truth[7].

The following section will explore the influence of these factors on the Promethean conception of planning, with particular emphasis on the role of planners during the early decades of the 20th century, marking the inception of the planning academe. Particular emphasis shall be placed on the following areas:

- The formation of the concept of expertise in the field of urban planning, as shaped in the light of positivist rationality. That is to say, the combination of prediction and control as a means to achieve a virtual omniscience
- The related conceptualisation of space
- The consolidation of the planners' professional epistemology in the face of older and newer scientistic postures.

4. Theorizing Promethean planning

The distinctive feature of the Promethean conception of planning is the unique combination of predictive capabilities and the exercise of control as a means to achieve virtual omniscience. It is precisely with reference to such characteristics that the definition of Promethean planning is going to be used here, in order to depict the dawn of planning as a professional practice and an institutional activity which was, and still is, imbued with Promethean fashion. However, a comprehensive understanding of Promethean planning necessitates a preliminary clarification regarding the conceptualisation of space, which will constitute the primary focus of this section. As a discipline dealing with socio-spatial dynamics – in terms of theorisation, regulation, and design – planning is inherently concerned with the concepts of 'space' and 'place'. In the context of Promethean planning, it is essential to note that the inclination towards control, which is both facilitated and reinforced by the integration of predictive technologies within planning practices, is underpinned by a distinct conceptualisation of space. The concept of omniscience, which constitutes the unconfessed ambition of planners could not have been achieved in the absence of the idea of space as theorised by Euclid and subsequently by modern scientists, an idea of space which ensures full control.

The interpretation of the myth of Prometheus (and Atlas) suggests a pertinent reflection: the abstract conceptualisation and representation of space paves the way for human domination of the Earth. According to the myth, the rebel titan provided human beings with technology and, in so doing, he set them on the path for domination. The latter is realised primarily and necessarily through the possibility of controlling space and time. It has previously been posited that the creation of space for human life was initiated by the actions of Atlas (Sini,1981). By granting to human beings the measurability of time through the alternation of day and night, Atlas enabled a 'technological' conception of time which complements the representation of space in relation to its manipulability. This combination ensures an unparalleled dominion over nature which has been introjected in planning epistemology. Thus, in the domain of urban planning space has historically been regarded as a 'given'; an a priori condition that has influenced and indeed been instrumental in the development of the discipline during the 19th and 20th centuries. In order to comprehend the genesis of planning as an "art and science" (Birch, 1980), it is necessary to analyse the conditions that determined its professional, institutional and academic structure (as well as its current and future development).

As previously indicated, the positivist paradigm, of Comtean descent, has played a pivotal role in the develop-

7 In this regard, as argued by Paolo Pitari, Emanuele Severino's theoretical endeavour is paramount in that it "invites us to consider that there may be good reason to doubt what we take for granted" (Pitari, 2019: p. 384). In appraising Severino's work on specialisation and technological thinking, Pitari asserts that "We are the Occidens, the West" and that "We pray at the altar of individual freedom, elevating our belief in our power to be technological beings to the ultimate truth" (ibidem). If technology is nothing more than a faith, only "through an interpretation of reality entirely other could one question the ethos of technology (the ethos of power). Only if the technological interpretation of reality is wrong, the ethos of power could and should be questioned" (Pitari, 2019: pp. 384-385).

ment of planning. Of particular interest here is the positivist conception of space, which depends as much on the Euclidean tradition (Friedmann, 1993; Davoudi, 2012) as on what, according to Harari (2017), we could define as the 'myth of Newton'. When considering the genesis of the concept of positivist spatiality, Davoudi (2012) emphasises that "Positivism portrays an absolute view of space which is rooted in Euclidean geometry. Euclid's three-dimensional geometry enjoyed uninterrupted sovereignty until it was challenged in the late 19th century. His ideas were accepted for a long time because 'it had been covertly built into Newtonian physics'" (p. 5). Accordingly, Isaac Newton's contribution as both a scientist and philosopher is paramount in that it established the conceptualisation of space as an "infinite container" (ibidem), characterised by objectivity and measurability, which are also assumed to inform the conceptualisation of place (ibidem). Indeed, according to Davoudi: "Place is considered as objective, bounded, self-contained and measurable [...] [so that positivism] considers space and place as either synonymous or binaries" (Davoudi, 2012: p. 5, italic added).

This conception, firmly anchored in the Euclidean tradition and subsequently confirmed by the scientific revolution, established the foundations for the impulse to control space that is characteristic of Promethean planning. A closer examination reveals that such vision is deeply rooted in the Enlightenment tradition (ibidem), wherein science establishes the epistemic underpinnings of the theory of space. In such a milieu, the role of the scientist-expert attained an unparalleled status, which was established on the basis of a novel 'myth' according to which only by mastering sufficient knowledge heaven on Earth could be achieved (Harari, 2017). The scientific method, therefore, endows humanity (in the role of the scientist-expert) with the will and power to exert control over nature, unravel its mysteries, and establish dominion over creation. This authentic project of conquest is made possible by reducing space to an object, and as such: knowable, measurable, and manipulable. The above-mentioned Euclidean spatiality, which centuries later would become the domain of action for planners (Friedmann, 1993), was hence reinvented and strengthened by modern science – which complemented the Euclidean geometry with Newtonian laws of physics.

Albeit only more recently with respect to the major professions, planning too has joined the ranks of the scientific-technological apparatus devoted to achieving the "technological paradise" (Severino, 2006). Two seminal figures in the field can be regarded as the initiators of the scientific approach to planning: Patrick Geddes and Ebenezer Howard. The contributions of Lewis Mumford, Raymond Unwin and Patrick Abercrombie, even though to a lesser extent, are also worthy of mention. At the turn of century, when planning was not yet institutionalised, the contributions of extraordinary figures such as Geddes and Howard helped shape the core of a disciplinary field strongly focused on social utopianism. The principles of urban planning were already firmly rooted in the positivist model. The notion of the survey (Geddes) and, subsequently, that of the garden city (Howard, Unwin, Abercrombie) were predicated on the ideology of social reformism, which emerged as a response to the squalor of the industrial city (Benevolo,1963).

Indeed, the utopian projects of the first decades of the 20th century played a decisive role in defining planning as an institutional activity. In this regard, Howard's model is exemplificative, as Luigi Mazza contends: "Howard's proposal can be taken as the anticipation of a technocratic planning approach which assumes that it possesses an optimal and progressive model of urban growth and applies it in an almost undifferentiated way throughout the territory. The assumption that the model is excellent and scientifically based is one of the reasons for justifying that it is the state that imposes it. [...] Howard's proposal [...] ends up providing the technical basis for general state intervention in planning and land uses" (Mazza, 2002: p. 27, translated in English by the author). According to this perspective, the first attempts to plan urban growth according to decentralisation models effectively contributed to the subsequent utilisation of planning as an institutional technology, that is, a form of social control pursued through the imposition of specific spatial models (Mazza, 2007, 2009).

However, in that initial phase, the planning techniques and tools that would have facilitated the success of those models were rudimentary, if not yet developed. Moreover, an adequate regulatory framework and the expertise capable of overseeing the complex implementation processes were lacking too. Accordingly, during the 19th and 20th centuries, practitioners engaged in urban planning were, de facto, 'non-experts'. Geddes was a sociologist,

Howard a parliamentary stenographer, and Mumford a historian (just to mention the three most influential). The combination of these two shortcomings – the utilisation of obsolete techniques and a paucity of expertise – profoundly conditioned the origins of the disciplinary field. This condition of precariousness, due to the absence of a shared disciplinary epistemology, decreased significantly in the following decades in conjunction with the institutionalisation process that took place, above all, in the United Kingdom and the United States.

It was in the 1950s that a significant transformation occurred, with planning being recognised as an autonomous discipline and academic field, thus marking the beginning of a period of consolidation (Davoudi and Pendlebury, 2009). Consequently, the role of the planners as 'experts' was considerably strengthened[8]. During this period, specialisation dominated the disciplinary debate, with the assumption that without specialisation, there is no disciplinary epistemology capable of guiding education and professional practices. Harvey Perloff's renowned formula, "A generalist with a specialty" (Perloff, 1956: p. 203), effectively summarise the paradigm that emerged in the mid-century. Such a model fosters the planner as a specialist who also possesses knowledge in a broader range of subjects. Founded upon the rational conception of planning, in continuity with the Enlightenment tradition (Friedmann, 1987; Sandercock, 1998; Allmendinger, 2002; Beauregard, 2020), that disciplinary paradigm also marks a shift with respect to the technocratic, positivistic planning culture of the early 20th century. Indeed, as remarked by Davoudi (2012) the latter is founded upon empiricism: "Positivism refers to an empiricist approach to scientific knowledge which starts from the senses and particulars and gradually rises up to the most general axioms. [...] For empiricists, knowledge is a matter of bottom-up experience (a posteriori)" (p. 3). The rational-comprehensive model, by contrast, is predicated on the conceptual and epistemological foundations of rationalist philosophy. The substantial difference between the two approaches lies in the fact that for the rationalists "knowledge is a matter of top-down underlying theories and laws (a priori)" (ibidem), while for the positivists "it rests on observation as the moment of the truth when hypotheses are tested against the facts of the world" (ibidem).

The transition from the positivist model to the rational-comprehensive one is of crucial significance: it constitutes an unprecedented reversal of perspective on the epistemological level. Prior to the advent of the rational-comprehensive model, technocratic planning was essentially conceived as a form of craft, with a strong association to architecture and engineering. This conception underwent a shift with the introduction of the abovementioned model. Consequently, planners are regarded as comprehensive experts whose actions draw upon a scientific theory of the discipline: "systems analysis and other rational-comprehensive approaches [...] imagine a specific type of planner: a technical expert who draws conclusions and develops advice based on the analysis of scientific evidence [...] Expert knowledge and scientific theories are thus central to how rational planning is to be done" (Beauregard, 2020: p. 23). In the context of the "Systems Revolution", a term coined by Peter Hall (1996), the culmination of Promethean planning is ultimately reached. This development, characterized by the utilisation of computational tools and modelling, enabled unprecedented capabilities, including the previously unattainable control over the development trajectories of urban growth:

The subject changed from a kind of craft, based on personal knowledge of a rudimentary collection of concepts about the city, into an apparently scientific activity, in which vast amounts of precise information were garnered and processed in such a way that the planner could devise very sensitive systems of guidance and control, the effects of which could be monitored and if necessary modified. More precisely, cities and regions were viewed as complex systems [...] while planning was seen as a continuous process of control and monitoring of these systems, derived from the then new science of cybernetics developed by Norbert Wiener (Hall, 1996: p. 327).

Back then, the increase in the predictive capabilities – of a true Promethean fashion – assumed a position of paramount significance. Indeed, the evolution of the scientific-technological apparatus, which began in the early

8 In this regard, Peter Hall observes that "the job of the planners was to make plans, to develop codes to enforce these plans, and then to enforce those codes; relevant planning knowledge was what was needed for that job; planning education existed to convey that knowledge together with the necessary design skills. […] planning was now institutionalized into comprehensive land-use planning" (Hall, 1996: p. 322).

1960s, has been accompanied by a progressive strengthening and extension of urban planners forecasting capabilities. Despite the initial enthusiasm expressed by some planning theorists, the practical application of the systems approach proved to be largely unsuccessful and was criticised accordingly (Goodman, 1972; Rittel and Webber, 1973; Wildavsky, 1973). Among the criticisms that have been raised, some originated from within the community of rational planners themselves, as observed by Beauregard (2020). Accordingly, notwithstanding their technological apparatus and scientific methods, "Planners are poor predictors of the future, never fully cognizant of the consequences that their plans will engender, and are often inattentive to unintended outcomes" (pp. 25-26).

5. Is a post-Promethean conception of planning possible?

The Promethean planning paradigm has endured and thrived to the present day. In the contemporary urban digital era, tools and applications which were formerly unimaginable now appear to have no limits when it comes to their ability to explain, predict, and eventually control urban phenomena. Such boost of scientisation is already re-setting urban planning research agenda globally. A whole new field of study has emerged under the name of 'urban science', which seeks to harness new technologies and enhanced computational power to deliver reliable, accurate scientific knowledge about cities (Karvonen et al., 2021). Differently from the previous attempts to establish a scientific basis for the discipline (Signoroni, 2024), urban science introduces a significant shift. Instead of being incorporated into planning disciplinary practices, it lays the foundations for a competing field aimed to eventually complement planning. Accordingly, the Promethean paradigm would extend its scope far beyond the boundaries of academic and professional planning. Indeed, a number of urban science promoters posit that they can inform scientifically planning decision-making. In contrast to conventional experts such as planners and architects, they claim to address urban challenges in a scientific manner. As specialists in the hard sciences, they provide public decision-makers with something that planners have attempted to provide, albeit unsuccessfully, namely 'bulletproof' scientific evidence.

Returning to the concept of 'atmosphere' (Pasqui, 2022a), as previously introduced, it can be observed that the scientisation of the discipline not only thickens this atmosphere but also dilates it. The applications of digital technology in the urban realm are expanding exponentially. Evidence of this phenomenon can be found in the growing availability of georeferenced datasets and the employment of advanced modelling software and sophisticated sensing technologies for the purpose of harvesting fine-grained data. While this atmosphere thickens and expands rapidly, it is critical for planners to introspect regarding the efficacy of their actions (Balducci, 1991) and the challenges posed by situations of radical uncertainty (Pasqui, 2022b). This introspection must encompass the acknowledgment of two fundamental human uncertainties: the cognitive and the historical (Morin, 2000).

In the current era, characterised by the proliferation of technology, there has been an inevitable rise in complexity (Ceruti, 2015). This phenomenon manifests not only in the magnitude of the prevailing challenges and issues but also in the constraints (and inherent dangers) of hyper-specialisation, which is the true legacy of the Promethean conception. If, as has been suggested, specialisation has underpinned the development of both the hard and social sciences, hyper-specialisation can be considered pernicious. According to Morin, "the disciplinary institution involves [...] a risk of hyper-specialisation of the researcher and a risk of 'cosification' of the studied object, of which we risk forgetting that it is extracted from the context or constructed. The object of the discipline will then be perceived as a self-sufficient thing: the bonds and solidarities of this object with other objects, treated by other disciplines, will be neglected, as will the bonds and solidarities with the universe of which the object is part" (Morin, 2000: p. 112, translated in English by the author). In this context, post-Promethean planning entails acknowledging the intricacies inherent in complex systems, while concurrently eschewing the pitfalls of hyper-specialisation. This represents a considerable challenge that planners are called to take up in that the initial step towards a post-Promethean conception necessarily involves a distancing from hyper-specialisation, intended as the key to virtual omniscience and hence the nucleus of Promethean planning. If it's true that without specialisation there is no technology, then without technology there is no omniscience. Nowadays, planners are confronted with constraints imposed by pervasive disciplinary rhetoric (Palermo, 2022; Signoroni, 2023a),

which is combined with the resurgence of a positivist epistemology of an empiricist nature – as advocated by proponents of urban science. Furthermore, contemporary planners are faced with the dilemma of whether to place their trust in technology – that they hardly acknowledge as an ideology (Habermas, 1972) – or to refuse it.

While it expresses an unwavering confidence in the efficacy of technoscientific rationality in steering the scientific-technological apparatus, thereby governing the transformation processes of the territory, the faith in technology frequently manifests as a scientistic disposition. Akin to a kind of "Mumbo Jumbo" (Scruton, 2011) which serves to address all inquiries and circumvents forms of dissent or conflict, this scientistic attitude fosters a pernicious depoliticisation of planning processes, which are removed from the logic of accountability and public scrutiny. Novel forms of data-driven planning appear to substantiate such hypothesis, notwithstanding prior failures – particularly about effectiveness, but also in terms of participation and inclusion. This drift appears to coincide with, and potentially exacerbate, the tangible risk of the academic expert becoming 'isolated' (Wachs, 2016; Signoroni, 2022, 2023b).

Conversely, it would be imprudent to rely on the opposing faith: the repudiation of any assertion of scientific belief, thus resulting in the pursuit of planning reduced to a mere discursive practice. To overcome the Promethean conception and avoid falling into its opposite, it is necessary to overcome faiths and acknowledge technology as a vision of the world that can be challenged. Because a post-Promethean conception of planning transcends both faith and rhetoric, a first attempt towards alternative theory-building scenarios should be to 'perforate the atmosphere' and thereby pave the way for a meta-disciplinary project that is open to practices of trespassing (Morin, 2000).

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What planning needs from theorizing on place in times of global challenges

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Abstract
The paper argues for stronger integration of the theoretical notion of place in planning against multiple current challenges. It revisits some established and novel conceptual readings of place and outlines its implications for urban planning, arguing for the theoretically informed use of the place notion as instrumental in planning better cities for people. With its practical focus on shaping physical spaces in cities, urban planning delivers applied results and contributes empiricallydriven insights on the physical setting of cities. Notion of place, on the other hand, allows formalizing diverse social, subjective and intersubjective relations that shape our spatial experience in cities in no less impactful ways than its physical setting. The paper argues that conceptual potential of the term place for urban planning lies in bridging the physical realities of urban spaces with the human dimension of spatial experience at the level of middle range theories connecting empirical application with conceptual premises.

Key words: Urban planning, urban space, place, place-making, human-centered design

Introduction

Cities have undergone dramatic transformations since 'the world's first' city of C¸atalh¨oy¨uk in Konya, T¨urkiye, marked the transition from rural to a new urban type of settlement. Planning strives to respond to constant urban transformations. As any other institutionalized domain, for decades planning faces challenges of institutional inertia, path dependency, and rigidness of established paradigms (Blotevogel et al. 2014; Albrechts 2010) among others, that hinder the responsive potential of planning. At the same time, planning itself acts as a major agent of urban transformation, bringing novel challenges of growth and development that uproot established ways of living. In the age of planetary crisis and accelerating global changes, the responsibility of planning is not only in providing adequate response by leading transformations but in ensuring continuity and upholding a human-centric approach in tackling the above (Good et al. 2017).

Place-based measures are an often-evoked response to the above conditions across many facets of planning. Yet, place is far from being an established conceptual term across planning landscape. While receiving some dedicated theoretical attention on its own (), the most common way for place to feature in planning remains at applied level in an ad hoc or common sense manner without underlying conceptual substantiation (Ellery et al. 2021; Strydom et al. 2018).

Meanwhile the term 'place' is a theoretically loaded notion, albeit no overarching theory of place exists (Cresswell 2015). Place is theorized across a heterogeneous landscape of spatial and social disciplines, spanning from geography, environmental psychology, urban and social studies, humanities, among others. Early systematic theorizing on place in spatial disciplines is attributed to humanistic geography as a critique of the overtly abstract notion of space that dominated the spatial disciplines in the 1960s (Tuan 1979; Relph 1976). Since then, a broad notion of place as space imbued with meaning enters common use. Along with it, the notion of place is being interpreted in many other ways within phenomenological, non-representational, feminist, critical and socio-constructivist veins, relational, post-human philosophies, psychological, cognitive and behavioral models, among many others.

The common conceptual feature to all of the above is a premise underlying a humanistic geographical approach: place changes the mode of our engagement with space. Depending on an adopted theoretical approach, sources, agents, impact and effects of such change can be conceptualized and grasped, entailing different practical

implications and methods to tackle it. Relational readings of place suggest that cities cannot be adequately governed without considering dynamic flows of people, resources and information that all play out on a local scale (Massey 2005). Feminist perspectives on place demonstrate how spatial experience differs along gender lines (Dyck 2005). Phenomenological approach brings forward an embodied and perceived spatialities which are closer to human experience of cities than abstract plans (Seamon 2013).Emergent novel approaches to place building on advances in GIS, data science, and other areas (Wagner et al. 2020; Rossetti et al. 2019; Mocnik 2023) conceptualize the mediating impact of digitalization and pervasive impact of geospatial technologies on human spatial experience.

Being so conceptually versatile, place can equip planners with a fertile framework to understand better a human perspective on space in the city in a multifaceted way. Planning better cities for people contains an underlying but rarely articulated question as to how do we engage with space shaped by and intervened to with planning means:

'The translation of social purposes into space then presupposes that something is known about how patterns of living and working can be affected, for good or ill, by the physical and spatial forms imposed on them. In fact, beyond common-sense and accumulated experience, little is known. p.217 Hillier (Hillier 2008).

Articulating this questioning is pivotal in theorizing on place. Spatial and urban planning as 'knowledge-centered epistemic practices' (Alexander 2016) which link knowledge to organized action towards spatial organization of social relations (Lake 2017), are concerned with theoretically grounded knowledge in no lesser extent than with an empirical realm of action. The present paper argues that theorizing on place falls under both these concerns.

Theoretical body of planning is heterogeneous and subject to long-standing academic debate (Allmendinger 2017; Alexander 2016). Difficulties to determining clear boundaries between theoretical, empirical and applied domains, as well as extensive borrowing from many other disciplines and subjects are recognized as characteristic to planning discourse (Allmendinger 2017). In such state there is a recognition and call for theoretical efforts across different levels, from fundamental theorizing on linking spatial forms to societal processes (L¨ow 2018), to stronger conceptual support for planning actions, and empirical evidence-based planning. While fundamental theories comparable in ambition and grasp to social theory of space (Hillier 2002) might seem as far reaching and distant prospects requiring solid theoretical advancements, the place theory can fulfill the need for middle-range (design-level) theories (Marshall 2012; Hillier and Netto 2002; Cuthbert 2007), bridging conceptual underpinnings with empirical and applied implications at the level of specialized planning domains (such as spatial and urban planning referred to in the present paper).

In what follows, the paper will outline arguments towards more systematic purposeful theorizing on place as a socio-spatial notion from the perspective of spatial and urban planning in its concern of spatial organization of urban space and its physical settings in pursuit of social goals. (In this light, all references to planning in the present paper refer to spatial planning and urban planning insofar as they are preoccupied with urban space and planning cities). First, the paper will sketch out instances of how place features in planning discourse and practice. Then, the paper will proceed with outlining implications for three broad approaches to place in its humanistic, relational, and phenomenological readings, arguing for the latter as instrumental in linking theoretically grounded human perspective on urban settings for planning.

Place of place in planning

While advocating for stronger integration of theoretically grounded notion of place in planning, one faces challenge of theoretical ambiguity of the very notion of place. The elusive nature of place evading a clear definition is a commonplace statement in much of place literature: "Place is a human relation. There is no set of immanent ontological features adhering to a given site that would allow us to define it as a place" (Prieto 2012, p.13). However, complexity of place definition does not have to imply that it is an indeterminate concept bound to ad hoc readings. Rather, it attests that place lends itself to be conceptualized through various approaches leading

towards sometimes remarkably different directions.

In spatial disciplines the starting point for theorizing on place often becomes space. This does not add certainty to understanding of place. Instead, it creates a conceptual state prone for terminological ambiguity, where the terms space and place go hand in hand, as one is being defined through the other, or what the other is not. Widely quoted metaphorical phrase of Yi-Fu Tuan "if we think of space as that which allows movement, then place is pause" (Tuan 1979) illustrates such characteristic vagueness and interlinked thinking about the two notions. Already heterogeneous discourse around geographical space draws the notion of place into self-referential circle: space as fundamental stuff of geography is rarely explicitly talked about in spatial disciplines (Thrift 2003), while place is being commonly defined as 'space imbued with meaning' (Cresswell 2015).

Similar situation appears with usage of the terms 'space' and 'place' in planning (Davoudi and Strange 2009). Fundamental theorizing on the nature of space is not absent, but often carried on higher theoretical levels across other disciplines and discourses (Kühne and Berr 2022), rarely featuring as an explicit issue that requires own planning disciplinary reflection, or a proper conceptual explication from planning practitioners in planning handbooks. It is not uncommon that a table of content from a handbook on urban planning does not feature a chapter or a section on what is urban space that we ought to plan. Instead, the focus could be given to 'making plans', not ordering space, as a main concern of urban planners, as for example (Crane and Weber 2015). Such focus is illustrative of the conceptual position of the two notions in literature which supports planning practice: space as object of intervention remains obscured or hidden within other agendas.

In the context of urban planning and design, both terms acquire adjectives and attached to them wider connotations and definitions. It is common to refer to 'urban space' as space with particular geometrical and aesthetic properties that could only be discerned against the built form (Krier and Rowe 1979). In addition, other terms, such as 'open space', 'public space', 'place', 'public place' and more, are also used, sometimes interchangeably, and sometimes to denote different notions (Abusaada and Elshater 2021). Accepting such varied use, the term 'place' still resonates broadly with the humanistic geographical understanding of place through such distinguishing factors as knowledge, value and quality, lifestyles, experiences and meanings, identity and character, and atmospheres and sense of place (ibid).

In such a state, use of both terms 'place' and 'space' in planning becomes a separate subject of investigation (Davoudi and Strange 2009; Madanipour and Hull 2017; Strydom et al. 2018). Keeping in mind the wider debate on space as important overarching context, the remainder of the paper will refer to uses of the term 'place' in spatial and urban planning discourse on three levels - one of overarching theory, one of middle range theories and conceptual frameworks, and one of applied interventions and empirically driven planning practice. For each level, the paper will suggest concrete contributions that place theory can bring to planning.

On humanistic reading of place in planning

On a higher theoretical level scholars both from within geography (Relph 2015; Good et al. 2017; Bull 2008) and planning itself (Good et al. 2017; Bull 2008) evoke the notion of place towards a humanistic approach to planning. The notion of place serves there a similar critical role as in its humanistic geographical origins against the prevalent current of a positivist turn in geography and spatial disciplines, planning including. A humanistic approach re-orients planning towards a situated perspective onto the lived world as it appears to us in our experience (Lake 2017). Place denotes such turn from abstract objectified space to experiential dimension of spatiality.

Major hindrances appear on the way of such re-orientation. Arguing for fundamental uprooting of primacy of space in favor of place requires ample theoretical efforts to re-work the very way of thinking about the focus and subject of planning, from fundamental underlying premises all the way down to empirical approaches. Along these lines, the above efforts meet limitations and critiques inherent to any attempt at integrating a qualitative paradigm to human-environment relations. These include focus on individual and subjective accounts over patterns and generalizable knowledge in a natural science fashion (Pocock 1983), and incompatibility with quantita-

tive methods and rapidly advancing GIScience (Leszczynski 2009), where planning tend to lean.

Turning to theoretically grounded notion on place, however, is not meant to bring over-individualization of diverse lived experiences, nor to channel planners' attention exclusively onto subjective perceptions of urban milieu by means of qualitative inquiry. On the contrary, place can be a fruitful notion to formalize experiential perspective on space by quantitative means in a way highly relevant and instrumental for planning. Elements of human perception (as in pioneering visibility analysis (Benedikt 1979)), cognition (Penn 2003), and even aesthetic preferences (D'Acci 2019) are already being incorporated in quantitative models of space. Correspondences are drawn between such measures and traditionally qualitative inquiries as in for ex. in phenomenological tradition of place and environmental psychology (Marcus 2018; Seamon 2007, 2013).

Theorizing on place from platial perspective advanced by place-based GIS can contribute to the above direction (the term `platial' is used as the place-based counterpart to the space-based adjective `spatial' (Westerholt et al. 2018)). Place-based GIS works towards operational modeling and representation of places aimed at grasping qualitative characteristics of meaningful spatial units converted into quantifiable variables and accessed through amply available georeferenced data (Tang and Painho 2021).

Among other concerns, the above efforts deal with division of space in the city, which is one of ever-present planning concerns, too. This question underlies not only methodological issues of modifiable areal unit problem, but in many instances can severely affect planning decisions and actions. Administrative census, postal codes, urban structural units, clusters of urban form typologies derived from geometrical plans all have their efficient application for varied planning purposes. However, oftentimes such approaches do not grasp how people organize and divide their space. It is recognized that we differentiate and discriminate urban space: to us it appears in the form of islands of places along undifferentiated space (Zeiher 2003). Conceptual and methodological efforts on spatial footprints of places (Westerholt 2019, 2025), linking geometrical composition of places with functions (Papadakis et al. 2020), grasping fuzzy place boundaries (Gao et al. 2013; Davies 2020) to formalize it for spatial analysis can offer more efficient ways than costly participatory mapping neighborhoods techniques and similar qualitative inquiries into perceived division of space in the city.

On relational reading of place in planning

Place appears in many instances at the level of conceptual frameworks applicable to concrete domains, relation, and areas of planning actions to address manifold crises, from climate change, economic depression, to social fragmentation and migration. Place-based policies to promote local solutions (Barca et al. 2012), place attachment in public participation (Manzo and Perkins 2006), sense of place to foster stewardship of locales (Chapin III and Knapp 2015), place-making initiatives to improve public spaces (Palermo and Ponzini 2014) are among such instances. Place receives dedicated theoretical attention and being reflected upon in such role (Castello 2016; Madanipour and Hull 2017).

Prominent in the above instances are relational interpretations of place. Relational take on space calls for shifting focus from a static view onto dynamic relations among agents, seeing place as a site of complex emergent interrelations across scales in the context of globalization (Massey 2005). Such perspective allows incorporating multi-network actors, complex sets of relations, and non-linear dynamics playing out in spatial dimension, among many others (Graham and Healey 1999; Madanipour and Hull 2017). In this, relational conceptions of space and place support planning practice in setting up frameworks of actions and relations for multiple agents and actors on access to and distribution of material resources (Robertson 2018).

Relational approaches to place speak to a widely theorized tradition of seeing space as socially produced (Lefebvre 2017). This tradition approaches space and place via social praxis at different scales. Critical socio-constructivist school (Lefebvre 2017; Harvey 2012) argues against the objectified and reified totalizing order of space, calling for seeing space as a product of socio-economic relations (i.e. global dynamics of capital (Harvey 2012)). Non-representational approach (Thrift 2008; Anderson 2016) propounds a performative reading of space and

place as being constituted and reconstituted by human actions, or individual tactics of moving through and ordering space in everyday life (De Certeau 1985).

Reading space and place as products of individual human and collective social relations equips us with conceptual lenses to investigate cities as socially produced dynamic entities at higher theoretical and conceptual levels. As such, the above theorizing on place is often not directly applicable to planning and design actions which shape and intervene into cities as built physical entities. High level of abstraction in much of such theorizing, and at times almost exclusive focus on the social risk neglecting "everyday physicality of the spaces in which human beings live". (Hillier 2008, p. 218). Instead of 'humanizing space', place risks abstracting its social meaning from its physical settings.

Meanwhile, a holistic notion of place can allow us to argue that 'meanings of place are not simply attached to places; they are already part of it.' (Muminovic 2015). Place locales, that is, physical settings where everyday-life activities take place, including visible and tangible aspects of a place such as buildings, streets, parks, etc., comprise a constituent element to place, not its mere passive background. Interpretations of place as assemblages ((Latour 2005)) works towards the shift from immaterial relations to material settings (Muminovic 2015; Dovey 2020). The latter are attributed with agency over not only receiving and hosting, but producing place meanings.

Even closer attention to the agency of physical settings on shaping place experience and its meaning is brought by the actor-network theory for architecture and design domains (relevant for the present inquiry on the level of 'urban architecture' in how it shapes our spatial experience on urban scale) (Yaneva 2009, 2022). This approach brings us one step closer to the applied domain of planning where it delivers actual planning solutions and design choices that form place settings in the most immediate and straightforward way of physical shape of locales.

Actor-network approach not only introduces non-human actors to the set of proactive agents shaping and co-creating our lived experiences (Dincer 2020). The approach re-configures the very way of seeing nonhuman material actors, from static material objects to materialized but constantly re-negotiated and re-constituted materialities that themselves are evolving products of socio-material dynamics (Yaneva 2009). Theorizing on place along this direction can not only bring a human perspective on space, but on the entirety of is material settings:

It is not only the architects, his or her clients, de Certeau's pedestrians, Benjamin's flaneurs that do not live in Euclidian space: it is also the buildings themselves! If there is an injustice in "materializing" human embodied experience, there is an even greater injustice in reducing matter to what can be drawn. (Latour and Yaneva 2017) p. 105

Alongside the argument for bringing place for humanizing space from the hold of geometric abstraction place can also 'humanize' built form of the city as shaped by planning and lived by us. Of course, urban space can only be discerned against urban form, as the latter configures the former. In this way, distinction between material settings and urban space could only be drawn to certain extent by formal or conceptual means. Yet, oftentimes this distinction pervasively underlines much of inquiry and theorizing on space and place. Engaging with deeper theorizing on place in a holistic way allows us addressing place meaning, spatial experience and place settings under one conceptual term.

Rounding up the presented argument, in the last part the paper will outline such holistic take on place from a phenomenological perspective as instrumental in humanizing the city for planners from the perspective of place-making as engaged with the city in the most direct empirical way.

On phenomenological reading of place in planning

One of the most noticeable use of the term 'place' in planning appears in place-making. Place-making is a very broad umbrella term that can refer to bottom-up initiatives targeting small improvements at local scale, to top-

down city policies and actions aimed at redevelopment of entire parts of the city. Common for such efforts, regardless of their scale or origins, is their aim at improving quality of life in cities through converting urban space to lively and well-functioning urban places (Ellery et al. 2021).

Place-making engages with the city primarily at the empirical level of practical interventions, policies, projects, and case studies. In-depth theorizing on underlying conceptual understanding of the very notion of place is not common in the above (Strydom et al. 2018). Underlying understandings of place are diverse. Place-making approach draws upon humanistic geographical origins of place in conceiving meaningful engagement with space as premises for creation of places, recognizing place as first and foremost a social and human phenomenon (Strydom et al.2018). Community-bound participatory place-making appears to lean towards relational understanding of place, as it considers relations among actors, stakeholders and social ties as constituents of places (Cilliers and Timmermans 2014). In promoting social events and emphasizing participation as a constant process of community building it taps into performative take on place. Finally, much of place-making efforts are realized via design and direct interventions and changes to physical appearance of urban spaces (Palermo and Ponzini 2014).

At times, place-making debates can appear to refer to a false dichotomy: what is primary, promoting community or delivering good design for places? In practice, however, the question addressed by place-making concerns how the two come together to create places. This demands a holistic concept of place to guide the practice.

Phenomenological reading of place offers a framework towards such holistic reading, as it attempts at discarding a dichotomous understanding of human-environment relations, conceptualizing the two in interconnected instead of juxtaposed way (Locke and McCann 2016; Seamon 2010). The phenomenological school approaches place as a specific category of direct human experience, intrinsic and even formative for human subjectivity. For this reason, it is often viewed as focused on human, subjective domains of place. Place appears deterritorialized and delocalized from its particular site, because the locus of phenomenological inquiry is centered on an inner subjective standpoint.

However, an approach to place grounded in the phenomenological account of human experience in fact opens up a way to integrate material settings of place into a holistic view of body-subjects of perceptual experience (Merleau-Ponty 2012). Physical settings of place in such a view are not abstracted from the perceiving subject into a neutral backdrop, but instead, all merge into a 'perceptual field' (Merleau-Ponty 2012), where subjective perception and objective external world are integral to each other.

Such premises bring important implications for place-making approach. It allows us interpreting an authentic place-making process as "an operation of synthesis' where goods and people are amalgamated to spaces by way of processes of perception, imagination, and memory" (Löw 2016, p.135) from a phenomenological perspective. Such process of synthesis constitutes no less important part of place-making along with actual arrangements of physical objects in space (Löw 2016). We endow a certain arrangement of things and settings in space with unity and meaning attributed to it, conceiving it as a place. Phenomenological inquiry into processes of perception, imagination and memory that synthesize place out of available to us physical settings grasps the lived city in its spatial and physical configuration as experienced by us in a holistic way. In it, the approach is doing justice for physical, material and tangible aspects of places as it brings them from the realm of abstract objective physical city to the actual lived city in the same way as place is meant to bring lived spatiality from the abstract geometrical plane.

Place is conceptualized prominently within the phenomenological approach (Buttimer and Seamon 2015; Relph 2014; Dovey 2009). The phenomenological tradition of place finds a close affinity with a humanistic geographical stance, as it draws into the focus human, subjective, affective, and perceptual dimensions of place. The phenomenological approach also contributes to capturing the embodied aspect of place as expressed in our bodily actions, which create and recreate places in constant flux (as in David Seamon (2015) notion of place-ballet). This

connects the phenomenological reading of place with the non-representational and performative interpretations.

The phenomenological approach has been criticized for its essentialist take on place, while its methods of radical empiricism and interpretative analysis have been associated with compromised objectivity and non-retrievability of results (Murray and Holmes 2014). These, however, do not discard the value of phenomenological approach as argued above, but call for theoretical and methodological efforts towards rigorous and instrumental apparatus. The phenomenological tradition evolves and finds novel interpretations ((Talebian and Uraz 2018)), and not so obvious affinities (such as the above-mentioned parallels with space syntax methods (Seamon 2007, 1994)). In this sense, the phenomenological account of place bears rich potential which translates and feeds into novel platial approaches, reaffirming its potential usefulness on urban grounds (Aravot 2002).

Conclusions

Theoretical, methodological and practical advancements of planning compete against ever increasing complexity of challenges which planning faces. Accelerated crisis dynamics at global and local scales acquire such recurring character that state of multiple crises becomes a new normal of planning as argued by some (Martin et al. 2022). In such a state, calls for more theorizing in planning should not divert planning efforts from pressing agenda, but amplify and support it. Present call for theorizing on place is made towards the above goal.

The paper outlined how the notion of place in humanistic geographical, relational, and phenomenological interpretations appears in planning at higher theoretical, conceptual and empirical levels, amplifying each use by suggesting potential contributions and synergies that are coming from theorizing on place.

The value of place in its humanistic geographical reading is recognized in calls for humanistic planning and planning for people. The paper argued that in addition to that, a humanistic geographical notion of place can offer a robust theoretical framework for operational and instrumental inquiries into human perspective on the city built on advances of quantitative, geo-referenced data and GIS-driven research.

Relational notions of place support planning in organizing and navigating complex relations and actions of multiple agents towards spatial organization of socio-economic relations. In addition to dynamic interactive understanding of planning outcomes as socially produced, the relational approach to space and place opens up a way to introduce novel agents which contribute to production of spatial relation in different ways. In particular, material aspects of our spatial experience become recognized, conceptualized and grasped by planning. Place locales which denote physical settings of places are active contributors, not passive holders of meaning in our engagement with spaces in urban context.

Phenomenological readings of place match empirical place-making efforts concerned with perceived aspects of physical urban features (as in perceived qualities of urban design for ex.). In addition to supporting the above inquiries, further theorizing along phenomenological lines allows integrating all material settings of places as perceived into the construct of spatial experience of the city under the notion of place grounded in a holistic view of human perception and environment. Novel methodological affinities allow phenomenological framework to support models accounting for spatial cognition, perception, psychological and emotional response to urban settings.

Adding the term place to planning vocabulary is not meant to inundate it with yet another vague label of indeterminate use. On the contrary, place as a key word can bring under its conceptual umbrella a wide range of theoretical issues, empirical studies and applied interventions since long carried out by planners towards balanced socio-ecological planning for sustainable cities for people.

Theoretical body of planning is heterogeneous and subject to long-standing academic debate (Allmendinger 2017; Alexander 2016). Difficulties to determining clear boundaries between theoretical, empirical and applied

domains, as well as extensive borrowing from many other disciplines and subjects are recognized as characteristic to planning discourse (Allmendinger 2017). In such state there is a recognition and call for theoretical efforts across different levels, from fundamental theorizing on linking spatial forms to societal processes (Löw 2018), to stronger conceptual support for planning actions, and empirical evidence-based planning. While fundamental theories comparable in ambition and grasp to social theory of space (Hillier 2002) might seem as far reaching and distant prospects requiring solid theoretical advancements, the place theory can fulfil the need for middle-range (design-level) theories (Marshall 2012; Hillier and Netto 2002; Cuthbert 2007), bridging conceptual underpinnings with empirical and applied implications at the level of specialized planning domains (such as spatial and urban planning referred to in the present paper).

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Different rental housing policies models and the ongoing difficulty of overcoming the housing crisis

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Abstract
This paper argues that rental housing is globally growing as a means to access housing in the face of multiple crises and as a financialized real estate frontier of capital accumulation. In Latin America and Brazil, where the homeownership model historically prevailed, households are increasingly renting, the real estate market is incorporating new formats (build-to-rent, multifamily), and professional rental management is spreading in formal and informal markets.

Through a panorama of global and Brazilian cases gathered from a Rental Housing Policies Seminar (2024), we identified different modalities in a wide scope of rental policies worldwide. The paper presents the Brazilian cases analytically organized in three State modulations, understood as incremental processes in which contradictions and variations can coexist: Emergency, Provider and Conceding State.

Key words: Rental housing; housing policy; affordable housing; Latin America; Brazil

Different rental housing policies models and the ongoing difficulty of overcoming the housing crisis

1. The prevailing and increasing importance of rental housing

1.1. Housing as an asset class and rental housing in the global context of financialisation 2.0

Rental housing is on the rise worldwide as multiple crises enhance the role of houses as financial assets, traded not only in formal markets, but also in the informal markets of popular territories.

The financialisation of housing has been widely discussed in its european and north american variations (Fernandez and Aalbers, 2016). In the context of a "rentier capitalism" (Christophers, 2020), houses are properties that as such allow for rent extraction: assets, with projected inflows and expectations of increasing its market value.

More recent literature points out that rental housing is occupying a central role in the expansion of the financial geography of the real estate market (Fields and Ufer, 2016; Fields, 2018). Wijburg et al. (2018) state that there has been a shift from what was deemed financialisation 1.0 - which involved reforms that introduced state subsidised rental housing as assets for "pure speculation" in global investment markets (Idem, p. 1) - to financialisation 2.0, characterised by "long-term investment strategies [...]used by REITs and listed funds in order to release housing into the privatised mainstream of capital accumulation" (Ibidem). The short-term rationale of "buying low and selling high" is not overridden, but relocated to the stock market where the shares of the funds are negotiated (Ibidem).

In the same direction, Aalbers (2019) argues that
"The financialization of real estate is not limited to the rise in household debt, mortgage securitization and international investment in office markets, but increasingly also affects rental housing: private equity, hedge funds and REITs buy up large portfolios of social and private rented housing, while housing associations use derivatives and other financial instruments" (idem, p. 1).

1.2. Rental housing growth in Latin America and Brazil as perceived by its agents

All these research highlights the importance of rental housing in the global landscape of the financialised real estate market. In Latin America, though, this process evolves in a diverse context and assumes new forms. In this region and particularly in Brazil, rental housing is currently on the rise, contradicting its history of social housing policies heavily anchored in the model of home ownership - that fomented the ideal of the casa própria[1] and reinforced the rule of private property (Bonduki, 1998; Cardoso, 2013; Maricato, 2015; Rolnik, 2019). Nowadays, rental housing represents a new frontier for capital accumulation in Latin America (Guerreiro et al., 2022; Marín-Toro, 2024).

The homeownership model has been showing signs of exhaustion over the last years, bringing to question its reign as the exclusive solution for social housing in the region. Centered on the production of new houses destined to subsidised sales, this model is insufficient in the response of a wider set of housing needs, such as that for well located housing - where the land prices are higher - and the inability to validate a steady income, as a great proportion of the brazilian workforce is informally occupied[2]. Even for families that manage to access housing loans, to keep up with the payments is a considerable challenge, along with that of paying the bills and fees that come with the formalization of housing (i.e. water, electricity, taxes - costs that don't necessarily exist in informal living). This picture results in widespread indebtedness and, consequently, in threats and evictions. The recent experience of mass production of social housing prioritised areas of urban expansion, resulting in poorly located dwellings, with no access to any urban facilities and services such as public transport, jobs, education and health care institutions and leisure. In the homeownership paradigm, well located housing becomes inaccessible for the higher land cost must be met by the buyer.

Alternatively to the casa própria model, rental housing is on the rise based on the growing understanding of houses both as dwellings and investment opportunities. This is a variegated process that involves diverse agents and strategies.

Households

In 2022, 20,9% of the Brazilian population, equivalent to 42,2 million people, lived in rental houses, the largest rate since 1980. In 2000, the rate was that of 12,3%, and in 2010, 16,4% (Censos IBGE). Along with this evolution, the num-

1 Casa própria literally means 'owned house', or 'house of my own', but is also commonly used as a metonymy to refer to the ideology of homeownership. The largest housing provision program of Brazil's history, launched in 2009, is named in regards to such ideology: Minha Casa, Minha Vida (My House, My Life).

2 According to the PNAD Contínua research, conducted by the Instituto Brasileiro de Geografia e Estatística (IBGE), the informality rate (proportion of informal workers in the total occupied workforce) is of 37,9% in may 2025. Available at: <https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/43503-no-trimestre-encerrado-em-abril-taxa-de-desocupacao-fica-estavel-e-emprego-com-carteira-bate-recorde> (Accessed: 29 May 2025).

ber of rental houses in Latin America grew 15% between 2000 and 2022 (Cepal Stat - Nações Unidas, 2023 apud Marín Toro, 2024)[3].

The increase in the supply of rental houses does not coincide with a trend of increased accessibility. The excessive burden on urban rent is currently the largest and fastest growing component of the Brazilian housing deficit. In 2022, it represented 52,2% of the total deficit of 6,2 million dwellings (Fundação João Pinheiro, 2024). It is worth noting that households headed by women account for 62% of the Brazilian deficit (3,89 million domiciles) and that non-white headed households are the majority in four of the five regions of the country (the exception is the south, the only region with a white majority[4]).

Possible explanations for this trajectory pose that rent is a flexible tool suited to the instabilities of income and employment. Tenants can more easily move to different neighbourhoods and cities according to work opportunities, which is enhanced by the possibility of short stays or monthly contracts. The purchase of a home, on the other hand, is subject to the fluctuations of inflation and interest rates that determine the cost of housing loans. In that regard, some social groups have structural difficulties in accessing credit for home ownership, such as youths, elders and vulnerable populations.

Real estate market

Rental housing has always been a part of the Brazilian real estate market, even a predominant one, as shown in data from big cities such as São Paulo in the beginning of the 20th century. In this particular case, both entrepreneurs and families explored urban rent as a business and as income supplement or retirement income.

Currently, in the financialised phase of the real estate market, new rental housing models are structuring a new frontier for capital accumulation (Guerreiro et al., 2022; Rolnik et al., 2024) based on the securitisation of inflows captured through rent in certain periods of time. Rental housing ascends as a lucrative investment field motivating new housing products that stem from its financial asset status. Some of the main trends are:

(i) production of new rental housing units financed by international funds and combined with the assetization of rent (debentures and securitization); also with support from government actors through urban and fiscal incentives (as in the case of retrofit incentives in São Paulo) for build-to-rent (Vannuchi, 2020) or multifamily projects found in Santiago do Chile, São Paulo and Mexico City (Marín-Toro, 2024).

(ii) professional management of rent and platformization (depersonified management with increased efficiency in collecting and evicting);

(iii) growth in the temporary rent market, characterised by relatively more expensive rent prices, drawing properties that used to be available for traditional rental contracts (competition between short/medium stay and long stay markets);

(iv) articulation of home ownership and rental policies in the form of leasing, shared ownership and buy to let (Aalbers et al., 2021) models, resulting in individual investors taking public funding to buy property as investment. Moreover, in low liquidity markets, rent is an advantageous destination for the stock of new housing units that haven't found solvable demand at first.

3 The percentual variation of rented houses in selected Latin American countries was: 70% in Chile, 42% in the Dominican Republic, 41% in Colombia, 36% in Brazil and Argentina, 34% in Costa Rica, 21% in Peru and Uruguai, 17% in Mexico, 15% in El Salvador, 9% in Guatemala, 6% in Paraguay, 5% in Panama, 3% in Honduras. Degrowth was only identified in Bolivia and Ecuador (Cepal Stat - Nações Unidas, 2023 apud Marín Toro, 2024).

4 According to the 2022 IBGE census, available at <https://www.ibge.gov.br/estatisticas/sociais/saude/22827-censo-demografico-2022.html>

(v) funding structures involving housing impact bonds[5] based on rent securitization. Such structures are still incipient and supplementary to the public and semi-public fundings (FGTS[6] and SBPE[7]), that are, nonetheless, showing signs of exhaustion. This trend is articulated to the ESG (Environmental, Social and Governance) agenda and retrofit incentive policies in city-centres in Rio de Janeiro, São Paulo, Mexico City (Ciudad de México, 2021) and Buenos Aires (Buenos Aires, 2021).

This "new frontier for capital accumulation" is also set upon markets regardless of its legal formality (Guerreiro et al., 2022; Rolnik et al., 2024) as we watch its expansion through the production of small rental buildings (predinhos) in popular territories (Guerreiro et al., 2022).

Government

The public dimension of housing can be perceived in the State's leading role in different fronts: the building of a financial system for housing production and consumption, the conception of housing both as a public interest theme and an asset class, and the construction of ideological narratives - that are currently shifting from the casa própria paradigm towards more contemporary ways of living compatible with rental housing models.

Governments have recently been studying and testing housing policies centered around rent and, in doing so, are mobilizing different 'State modulations'. Rental policies have never been central in Latin America and Brazil, where housing production policies (for homeownership) had a primary role in economic development plans. Social rent was never really integrated into any kind of housing policy system, constituting at best isolated policies or private market initiatives. Using social politics terms (Geels and Kemp, 2012), home ownership is the historically "dominant regime", and rent is a "niche" undergoing an evolution towards a "subaltern regime" status within the dominant regime that structures the housing policy system[8].

2. Different modalities and arrangements of rental housing policies

In the context of growing importance of rental housing worldwide, it has been possible to put forth a synthetical outlook at modalities and arrangements of rental housing policies based on the review of the international literature and the organisation of an International Seminar on the theme (D'Almeida and Santoro, 2024), as follows:

Rent control

Rent control refers to the regulation of rental relations including rental increase and pricing caps attached or not to the access of public subsidies. Rental control programmes were mainly found in European countries during the post-Second World War period. They responded to a high demand and low supply housing market that demanded State action in order to make houses accessible both by habilitating construction and controlling prices (Harloe, 1995; Kenpen et al., 2005; Ronald, 2013).

In Brazil, there was an unsuccessful experience of rent control implementation with the Lei do Inquilinato (Tenants Law) in 1942. This pioneer measure, not repeated since, consisted of a rent freeze and, although short-lived,

5 Based on the concept of social impact investment and Social Impact Bonds (SIBs), Chiavone (2022) identified those specifically directed to housing issues, deemed "housing impact investment".

6 Fundo de Garantia por Tempo de Serviço (FGTS) is the compulsory savings fund for the brazilian formally employed workers, managed by the public bank Caixa Econômica Federal (CEF). The aforementioned Minha Casa, Minha Vida federal housing program is heavily reliant of this fund, for example.

7 Sistema Brasileiro de Poupança e Empréstimo (SBPE) is the banking system that nationally gathers funds from savings accounts specifically for funding the real estate credit market for the middle classes.

8 The notion of "subaltern/dominant regimes" is borrowed from Gemp and Keels' (2012) approach to mobility transitions. They argue that "there is not just one regime (auto-mobility) but also other regimes (e.g., train, tram, bus, cycling)" and that "It makes no sense to call these transport modes 'niches' in the sense of being radically new and precarious innovations. But these transport modes capture only a small percentage of total mobility (in terms of passenger kilometers) and in that sense occupy small market niches. We propose to call these transport modes subaltern regimes in contrast to the dominant auto-mobility regime" (Gemp and Keels, 2012, p. 56).

had as a main outcome - according to some authors - an stimulus to the growth of favelas and the expansion of the casa própria model by taking down the (no longer lucrative) supply of rental houses (Bonduki, 1998).

Rental assistance[9]
Rental assistance is a financial monthly aid transferred unconditionally to the beneficiaries. Although its intended use, as per its name, is meant for accessing housing, this kind of programme does not attach or supervise the destination of the allowance, resulting that it can be used freely for other purposes. When used for rent, though, it comprises available dispersed housing units, unchecked by the housing authorities and not listed in any housing programme. For that, it can be interpreted as an income-transfer policy, rather than a proper housing policy. Rental assistance is granted to people and households in many contexts, but mostly in emergency scenarios: victims of housing evictions driven by public works or assumption of risk, victims of disasters, women victims of domestic violence, people experiencing homelessness, amongst others.

This is the most disseminated modality of rental policy in Brazil, approximately 55,2% of all the cities offered a similar programme in 2020 (Munic IBGE). From different regions of the country, they are: Florianópolis, Goiânia, Natal, Niterói, Petrópolis, Rio de Janeiro, Sobral, Brumadinho, Belo Horizonte, Campinas, Juiz de Fora, Diadema, Mauá, Ribeirão Pires, Rio Grande da Serra, Santo André, São Bernardo do Campo, São Caetano do Sul and São Paulo (D'Almeida et al., 2024).

Voucher
A voucher is a financial aid attached to the rental of a private house. The properties available are usually registered as part of a private rental housing stock selected by the housing authorities according to some criteria - therefore committed to a housing programme - and with some form of involvement of state actors in the formalization of the rental contracts.

This type of rental policy is often combined with programmes of social rent in privately owned housing stocks and was first implemented in Europe and the United States in the second half of the 20th century, simultaneously to the dismantling of the public housing stocks (Harloe, 1995; Kenpen et al., 2005; Ronald, 2013). The Section 8 programme is one of the most famous cases, funded by the US Federal Government and managed by local governments, it supplements people's capacity of meeting rent prices in private houses.

In Brazil, we identified ongoing formulations of voucher programmes in the municipalities of Recife (Pernambuco State) and Campo Grande (Mato Grosso do Sul State). In Belo Horizonte (centre-east state of Minas Gerais), a programme of social rent in privately owned housing stock combined with a tenant subsidy is already implemented after been regulated by Municipal Decree nº 17.150/2019 (Paolinelli et al., 2025) This experience is inspiring that of the neighbouring municipality of Contagem, which is also been formulated based on the supply of privately owned houses.

Social rental housing
We define social rent as the State operated destination of a publicly or privately owned housing stock to the low income population, through the regular payment of rent, subsidized or not, and without transferring the property to its beneficiary. The management of a social rent programme and stock can be performed by public, private or public-private actors and arrangements.

In the case of a publicly owned and managed stock, rent can be totally or partially met by the beneficiaries, usually with a subsidy calculated according to the household income so as to not burden it with rent. Public management can be temporary or permanent and also articulated with other public services e policies.

In Europe and the United States, welfare state collaborated with the conception of social rent policies in the postwar period. From the 1970's onward, and more intensely in the last couple of decades, processes of dismantling

9 The consecrated term in Brazilian policy is auxílio aluguel, although the names of rental assistance policies vary a lot.

and privatization of public housing stocks took place (Kirchner, 2007; Aalbers and Holm, 2008; Ronald, 2013; Wijburg et al., 2018).

In Brazil, pioneer experiences with social rent are found in the social housing complexes developed by the Popular Housing Department of Rio de Janeiro, that were initially meant to be accessed by rent deducted directly from the worker's salaries (Nascimento, 2004, p. 156). More recently, the São Paulo Social Rent Programme was implemented in 2002 and currently has a housing stock of 937 units divided in seven complexes (Rodrigues et al., 2025).

Another arrangement combines social rent in privately owned stock managed by public authorities, consisting in private units verified and availed by the municipality. This could be deemed as assisted rent.

In Brazil, the aforementioned pilot experience of Belo Horizonte is an example (Paolinelli and Gimenez, 2023), along with the ongoing formulations in Contagem (Paolinelli, 2024), Recife and Campo Grande.

Publicly owned social housing can also be produced and managed in Public-Private Partnerships (PPPs), with the State conceding the building, rental and management rights to a private consortium for a set period of time. This kind of contract is based on a public bidding process where bidders take interest in assessing the project's profitability.

Athought Brazil has experiences with social housing PPPs, none of the implemented cases involve social rent. Two projects of this kind are in the making, though, in Recife and Campo Grande. The first and more advanced one, named Morar no Centro (Live in the Centre) is set to be the country's first social rent PPP. It delegates to a private consortium the construction of six housing complexes and its management throughout 25 years. Out of the 1.128 housing units to be built, 631 (56%) will integrate a social rent programme, and the other 497 (44%) units will be sold to beneficiaries of the Minha Casa, Minha Vida programme. All the urban land involved in the project is publicly owned, by the municipality or the federal government, and will be conceded free of cost for the exploitation by the consortium (Ursini and Santoro, 2025).

Associative management

The management of the housing stock and rental contracts can also be executed by civil society entities, such as hired CSOs and NGOs or even social movements, associations or cooperatives. This arrangement can be combined with subsidised rent and operate in a stock owned by the State or by the managing association. The Housing Associations in the United Kingdom and the Community Land Trusts in New York (Angotti and Jaggu, 2007) are known examples.

The Brazilian examples of associative management are of different types. A first refers to the many experiences of rent management in occupations lead by housing social movements - a theme that receives little attention in the housing literature -, which can be associated with housing and urban policies and the processes of squatts renewal and access to land (Santoro, 2024). Another type comprises recent pilot initiatives that articulate philanthropy with social impact investments, in some cases acting as incubators. A well known example is the FICA Fund, a NGO created in 2015 that rents housing units in São Paulo through a "Social Housing Service" focused on vulnerable households. The fund currently manages 12 properties with a total of 53 housing units acquired through donations or conceded by supporting proprietors. More recently, the NGO created an investment fund, separated from the donations fund, offering an yearly interest rate of 4%[10]. Similarly, the SOMA (Organized System of Accessible Housing) initiative also combines a non-profit entity with social impact investment to offer rental housing for low-income families. The project, headed by the responsible construction and real estate company in association with a securitization company and a law firm, issued a social impact bond (in the form of Certificates of Real Estate Receivables) to fund the construction of a building with 110 units, including the plot acquisition in a central area of São Paulo. An NGO was created specifically to manage the building and the rental contracts that back the certificates.

10 See <https://fundofica.org/>.

Leasing
It refers to contracts of rent or financing that allow for the use of the property during its extension and offers an option to buy at the end of the tenure.

A derived model is that of the shared ownership in England, object of a fomenting state programme in the aftermath of the subprime crisis, that allows the purchase of a quota of a property, requiring the payment of rent corresponding to the remaining property value for the right of living in it.

In Brazil, the Programa de Arrendamento Residencial (PAR) of the federal bank Caixa Econômica Federal, implemented in 1999 by the federal government, consisted in renting houses to families with a maximum total income of six minimum wages for fifteen years with an option to buy at the end of the period. The programme was fairly disseminated in many Brazilian cities and included the creation of an exclusive fund, the Fundo de Arrendamento Residencial (FAR).

3. Housing as service and State modulations in Brazil
Various modalities found use the idea of habitation as a service as justification and as a structural change so that something can be developed as a service. Overlooking the identified set of types and arrangements of rental policies, we initially highlight the dissemination of the understanding of housing as service in Brazilian housing policy. This concept, however, assumes different and often contradictory meanings according to the State modulation to which they associate with.

Recent research on social rental policies in Brazil have used the term 'housing service' or 'housing as service'. Some authors (Balbim, 2015; Cymbalista and Moreira, 2006; Cymbalista, 2024; Costa, 2023) have sought to define it - especially in the realm of public policy conception - demonstrating that the term is key to a narrative dispute involving actors with different interests. Generally, the term is associated with a rental policy conceived by public or private agents or to a set of policies that propose alternatives to homeownership.

The term is also used in urban planning and housing material, such as reports and norms, possibly signaling a dispute for the meanings of housing itself. It is also approached by the critical urban literature interested in the processes of financialisation of housing, that frame 'housing as a service' to the rent concentration dynamics of the real estate financial market - one supported by public policy and urban regulation (Santoro and Chiavone, 2020). Thus, the term appears to be simultaneously defined by different actors guided by different concepts of the role of the State.

4. State Modulations
In that sense, it is crucial to identify the determined State modulations that influence its action and agenda. In the analysed experiences, we identified three modulations preliminarily named as: Emergency State, Provider State, and Conceding State. The first, widespread in Brazil, responds to crises with precarious and temporary solutions, and is widely used throughout the country; the second enforces public governance frameworks, mostly restricted to small scale and pilot initiatives; the third integrates market logics into the production and management of housing and housing services through the advancement of Public-Private Partnerships (PPPs), and to do so they incorporate logics from the financialization of the real estate market.

The use of the term modulation - instead of model - is meant to highlight the understanding of the State as a process in motion, incrementally shifting. Distinct processes of State modulation can coexist, even within the frame of a given location's housing policy. For instance, in São Paulo's municipal housing policy we could identify emergency policies of rental assistance, a (resisting) social rent programme with a publicly owned housing stock - typical of the Provider State - and a housing PPP, aligned with the Conceding modulation. These experiences are not equally institutionalized and implemented; some are more extensively applied while others are embryonary. They reveal, nonetheless, tendencies and enunciate a dispute in the current scenario of social rental policies in Brazil.

3.1. Emergency State

In essence, the Emergency State is one that responds to emergencies and crises with precarious and temporary solutions. This set of experiences comprises different forms of emergency rental assistance; temporary and much disseminated, although lacking a public policy structure of its own. The Emergency State, therefore, is the one that strays most from the idea of a modulation, for it is characterised by the constancy of precarious answers to a permanent crisis of recurrent emergencies.

Rental assistance, the direct transfer of a monthly allowance, is one the most implemented emergency policies on account of its efficacy in supporting evictions in public interest or disaster prone areas. It is limited in terms of a housing response (Guerreiro, 2021; Ximenes, 2023); temporary, with a frequent need for renewal; a palliative for the chronic ineptitude of the State in offering permanent and adequate housing solutions that secure tenure for those in need. It is structural in reproducing the condition of "permanent transitoriness" (Miranda et al., 2019) and keeping "instability, irresolution and temporariness" (Rolnik, 2019). Rental assistance has been granted to households waiting in line for social housing homeownership or home renovation programmes and is commonly introduced in the negotiations around displacement processes. It is the typical (temporary) solution for those that won't accept the State's offers of relocation in distant housing complexes (Fernandes, 2024).

In most cases, the beneficiary households are unassisted by public authorities in the pursuit of a home, which is selected without inspection or technical evaluation. On top of that, rental assistance has a price setting effect over formal or informal housing markets, with the public allowance tending to set the floor for rents in the most seeked after areas. Therefore the granted value often is (or soon becomes) insufficient for accessing rental housing even in popular territories. In that sense, the assistance can be more accurately defined as a supplement of income rather than a means to access housing.

Rental assistance is mostly a fragmented policy, implemented by local governments in an unprogrammed manner, unattached to any encompassing plan in the municipal, state or national level. It needs little management capacity and can be set without integration with other public policies and programmes. As a municipal policy, it can be supplemented with federal resources, as in the recent case of a flood disaster in Porto Alegre (in the southern state of Rio Grande do Sul), in April 2024. In these instances, the resources are contingent to a public calamity situation, and can be taken from different budget rubrics.

A few recent experiences show some degree of policy articulation in the use of rental assistance. In the case of Belo Horizonte, a kind of rental assistance supplements or even overlaps with the municipal social rent programme (Paolinelli, 2023; 2024), as the process of selection of a private housing stock lacks sufficient technical personnel for evaluations. In Sobral (in the northeastern state of Ceará), a rental policy is articulated with income generation programmes (Lessa et al., 2024), and in Brumadinho (in the southwest state of Minas Gerais), it is mobilised as part of the reparative measures pack after the collapse of a dam in the Feijão river (Biasotto, 2024). In the state of São Paulo, rental assistance is granted to women victims of domestic violence and in the city of São Paulo, people experiencing homelessness can also apply for a similar grant.

In that regard, the debate over Housing First policies - pointed as a strategy for dealing with homelessness and drug abuse - is integrated into that of social rent. Pilot experiences that claim the Housing First label were implemented in São Paulo's Reencontro (Reunion) programme. This case has been criticised on the limitations of available housing units and the lack of coordination with care services required by the beneficiaries, demanding an intersectoral integration in the public administration. Calil (2024) gathered research that supports the effectiveness of Housing First programmes and poses that, ideally, rental housing would be seen as a temporary measure, but with no preset time limit: the beneficiary should remain as such until they reach a structured condition of income, social and work reintegration and access to a permanent dwelling (Pinho and Martines, 2024).

Despite being recognised as "emergency responses", these policies are widespread in Brazilian cities and, in some big cities, they occur in more than one type of assistance and exceed all other housing programmes in

number of active beneficiaries. Approximately 55,2% of the Brazilian municipalities had implemented a rental assistance programme in 2020. Among the larger municipalities, with over 500 thousand inhabitants, the percentage goes up to 80% (Munic IBGE 2020; Ximenes, 2024, p. 201). Although temporary, this kind of programme is broader than many other housing policies and responses. In the cities of Rio de Janeiro and São Paulo, for instance, rental assistance reached, respectively, 33 thousand (Ximenes, 2024) and 30 thousand (Guerreiro, 2020) households simultaneously. It is suggested that the emergency state is a permanent one. The increasing challenges of climate change tend to enhance this scenario.

Ximenes (2024) states that this type of policy is actually a resource for managing the housing waiting list (or the "line", as said in the public management lingo), reinforcing instability of tenure specially for those in risk of forced displacement. The city of Rio de Janeiro issued its first decree on "housing assistance" in 1998, updating the term to "temporary housing assistance" in 2013. In the context of Rio's major sports events (specially the 2014 World Cup and the 2016 Olympics) - with its major displacement wave connected to a surge of construction works - the number of households recipient of rental assistance went from 10 thousand in 2009 to 22 thousand in 2016 (Idem, p. 201).

Guerreiro (2020), analysing the experience of São Paulo, goes even further and deems the rental assistance policy as a device for "managing housing insecurity": instead of assuring the right to adequate housing, the policy acts on the regulation of the lack of housing solutions. This response doubles down on the transitoriness of a surplus population and directs resources to the popular housing market. In the form of rent, such resources can be concentrated as financial assets, possibly turning rental allowances into instruments of connection between popular ways of dwelling and the real estate financial capital.

The aforementioned authors highlight a strong correlation between rental assistance and policies of eviction or forced displacements in urbanization and land titling processes in informal settlements. In that sense, rental assistance should not be recognised as a housing policy, but rather its very opposite, as it enables displacement without guaranteeing resettlement. It can even be questioned as a proper policy, as it mostly lacks institutional structuring for its management, funding and articulation to (publicly disclosed) planning, directives and goals. In some cases, though, rental assistance is conceived as a subsidy in the context of a social rental policy.

The expansion of assistencialist policies in Brazil, such as income transfer or minimum income programmes, consolidated on account of its electoral efficacy, has reached the state and municipal levels of politics. Housing policies are incorporating this agenda through policies such as the Aluguel Social provided by the center-west state of Goiás and its capital city of Goiânia. The registration for these programmes is via mobile application. One can quickly download the app and register for an eighteen months allowance of R$350, even with some proof, such as receipts of rent payment every three months.

3.2. Provider State

A Provider State is characterised by mobilizing social rental policies on essentially public arrangements or governance models; a State that claims the responsibility for the production and provision of rental housing. Different from the welfare state model implemented in the central countries after 1945, the Provider State's context is that of peripheral fordism and its limited experiences that have never gone beyond the scale of pilot programmes, with few housing units. These experiences currently resist dismantling efforts relying on a body of engaged civil servants that are willing to face the many challenges of keeping the rental policy accessible to those most in need and guaranteeing their tenure over time. In the peripheral fordism, the paradigm of welfare is experienced as an ideological construct and greatly as frustration.

In general, this State modulation mobilizes municipal social rent policies with public management of a public or private housing stock destined to the low income population through subsidised rent, without possibility of transference of property. These policies are essentially structured in frameworks and governance models centered around the agency of the public sector.

The Provider State seeks to amplify the pilot experiences of State managed social rent by resisting dismantling efforts while also working on improvements in the existing programmes. A sort of militant – although institutional – activity of a mid-level bureaucracy carries out this resistance in the defense of a Provider State. Small scale programmes, managing small housing stocks, are developed in the interstices of the dominant homeownership framework by governments concerned with the public responsibility over housing implied in social rent programmes – capable of reaching specific population groups that are unable to access housing (and maintain tenure) through the formal real estate market. However, the interstices are small, and social rent still hasn't reached a significant scale in the Brazilian housing policy.

Gradually, the Provider State modulation has given way or even reshaped into the Conceding State. The global trend towards managerialism (Harvey, 1989) lands in Brazil initially in its metropolises in, for instance, the outsourcing of services such as housing and social assistance and also of the conception, management and regulation of public policies (Pulhez, 2016). Consultancy agencies, at first hired for specialised services, came to be responsible for public services, replacing and dismantling the established public management structures, resulting in the downsizing of the public servants workforce, in an "unequivocal example of transference of state functions to private agendas" (idem, p. 101). The conception of recent rental housing policies is in tandem with this process. Once hired by the public agent, they become a sort of administrative intermediary, which puts them in a position that is traditionally recognized as State responsibility, controlling the activity of other outsourced parts, conducting execution schedules, setting deadlines, evaluating deliverables etc." (ibidem, p. 100).

3.3. Conceding State[11]

A Conceding State originated in the outsourcing of isolated aspects of housing policies now combined in Public-Private Partnerships that comprise the production of housing and the management of 'housing services' over decades. There are a few initiatives of this sort, formulated in cooperation with international entities such as the Inter American Development Bank (IDB) and in tandem with an agenda for the advancement of the private rental housing market. This State modulation gradually integrates the logics of financialisation into housing policies by: diminishing the State's role in executing policies, relegating it to a regulatory function and to the support of market-oriented projects; destinating public assets (real estate and financial) and tax and urban incentives to stimulate market activity; elaborating and perfecting contract models for PPPs; advancing the concept of social mix in housing developments as a tool for broadening the "social" character associated with public housing.

Romero and Waeywnberge (2020) observed this managing and financing movement as a "private turn" in development finance. They argue that PPP has been a buzzword, with no universally agreed definition, and part of a framework of different typologies and arrangements for engagements between public and private actors for the deliverance of specific infrastructure assets and services (Romero, 2015). According to the authors:

"PPPs, in essence, are one manifestation of State support for the transformation of infrastructure or public services into private assets[12] that often generate revenue streams for asset-holders – with the exception of partnerships with non-for-profit organisations" (Romero and Waeywnberge, 2020, p. 40).

Here, the Conceding State modulation is based on the Housing Public-Private Partnership framework advanced by pilot initiatives on the concession to private entities of the rights of construction and management of housing units over decades, mainly in home ownership arrangements that alienate public land (Bleich, 2025). It is opposed

11 We opted for the most direct translation of Estado Concedente. In portuguese, concedente characterises the part or the power that gives, lends or grants something. For 'Conceding', in english, the same meaning applies, but with an underlying connotation of 'defeating', 'desisting', 'yielding', 'surrendering'. Although involuntary at first, we did not find the double-meaning to be inadequate for our proposition.

12 In this definition they combine the notion of "infrastructure-as-asset" as asset understood as the increasing involvement of the state to engage financialised capital in expanding provision of economic and social infrastructure, but this can take different forms, that they try to exemplify by the existing PPP typologies analysed.

to the original (and residual) framework of the Provider State, that sets to amplify and perfect pilot experiences of social rent in a publicly owned stock managed by public actors.

Some of the experiences in course originated from the federal government's policy of fomenting PPPs. The national structuring of social rental housing policies is conceived inside the federal programme of private partnerships and concessions[13]. The instrument, therefore, appears to be at the root of the housing policies, instead of any analyses of the specific housing needs of the territories. The municipal availability to take the opportunity presented by the federal government seems to have been the main criteria for the selection of Recife and Campo Grande for the implementation of pilot programmes: Brazilian law restricts municipal expenditure with PPPs to 5% of the net current revenue. The housing PPPs are not formulated as responses to housing needs diagnoses, but as investment opportunities to market agents interested in supplying a product - public interest housing - in the framework of "inclusionary housing policies" (Calavita and Malach, 2009; Santoro, 2019). These private partners demand contractual financial models that include the mobilisation of many public assets (Bleich, 2025; Santoro et al., 2018a) and in return, offer a relatively small production of housing units (Santoro et al., 2018b; Romero, 2015).

Critical analysis of the PPP model and its increasing implementation have shown that it "only provides about 15–20 per cent of total infrastructure investment. The lion's share is still provided by the public sector, and this situation is likely to continue", bringing to question why so much focus is placed on the private sector rather than improving public sector capacities (Romero, 2015; Romero, Waeyenberge, 2020). In most cases, it represents the most expensive method of financing, significantly increasing the cost to the public purse, and typically involves complex negotiations and implementation. Additionally, PPPs are high-risk financing operations for public entities, with limited and weak impact, challenging when it comes to reducing poverty, have low transparency and are subject to limited public scrutiny which undermines democratic accountability (Romero, 2015, p. 6-8).

We recently found different formulations in progress: two projects in advanced structuring in Recife[14] and Campo Grande[15], and three in the contracting phase: São José dos Campos/São Paulo State, Santo André/São Paulo State, Maceió/Alagoas[16].
The current formulations of rental policies in Recife and Campo Grande, articulate the modulation of the Conceding State, are pilot programmes, now in final formulation or initial implementation stages, are divided into two types: PPPs for production and management of a public stock of rental housing and voucher policies for subsidised access to private rental housing. They were designed in cooperation with consultancy agencies hired by the federal government as a first result of a broader cooperation with the Inter American Development Bank (BID) that established recommendations for Brazilian housing policies, including guidelines and strategies for a national rental housing policy.

Recife and Campo Grande PPPs actually combine the production of rental housing and market social housing for controlled sale, in the homeownership model. All of the plots for construction (including some existing buildings that will be renovated, in the case of Recife) are public property, municipal or federal. The rental stock will be managed by the private partner for the contractual period of 25 years - after which the property remains public - and the for sale stock will be alienated with no costs related to the concession of the public land. Analysing the financial models of the PPPs, it becomes clear that the cost-free donation of public real estate assets is a crucial element for the composition of attractive return rates for the potential investors. In the same way, the social rent model, one that contemplates a more vulnerable low income public, seems to be subsidised by the traditional homeownership model, that reaches a relatively higher income population (although still classified

13 We are referring to the Partnerships Investments Programme (PPI), created in 2016.

14 See <https://parcerias.recife.pe.gov.br/projetos/ppp-de-habitacao-social/>. Acess 05 June 2025.

15 See <https://www.pppmorarmelhor.com.br/>. Acess 05 June 2025.

16 See Social Rental Housing PPP Webinar anouncement at PPI platform: <https://ppi.gov.br/participe-do-webinar-ppp-de-habitacao-para-locacao-social/?TSPD_101_R0=086567d05fab2000b29d2affcae589ff1b1854d739cc592e0962d25e088b39dfca77c8a6930ff1af0841a292c91430002717d6259650c730501feac0780d865909420a952bbbddffcccf7ccbbd2c7a20ea828ac1009cf7aadc986ef965fa99e7>. Acess 05 June 2025.

as low-income). The poor subsidise the even poorest, and the implementation of social rent is a burden for the investors relative to the profitability of the for sale production. It is worth noting that the expected return rates for investments in Brazil are typically measured against the basic interest rate set by the Central Bank, one that is always among the highest rates in the world and frequently the highest. The opportunity costs considered in the financial modeling of PPPs is therefore chronically high.

Alongside the PPPs, both municipalities are either formulating (Recife) or already implementing (Campo Grande) a voucher programme that subsidises the access to private rental housing. This model is different from the rental assistance in two key aspects: the policy includes processes of housing stock selection and inspection and the vouchers are paid directly to the proprietors, not the tenants. In Campo Grande, the programme is structured around the outsourcing to local real estate agencies of the management of the housing stock and rental contracts. The coordinating public actor is the municipal housing agency, a public company that manages the municipal real estate assets. In Recife, the implementation of the different rental policies involved different municipal offices, such as housing, social assistance, and one specifically responsible for concession projects.

In this scenario, the challenge of conceiving decommodified alternatives for housing is discarded from the start, as the design of a business opportunity is the primary feature of the framework. There is no consideration for the potential of mobilizing subsidised rent as a means of isolating the use value of housing while taming its exchange value in the public interest. On the contrary, differential and maximised profits captured through rent set a new frontier for the financialisation of housing. One possibility for restructuring the PPP paradigm would be the introduction of non-state and non-profit actors as the partners in the production and management of the rental housing stock, such as cooperatives, Civil Society Organizations (CSOs) and social movements.

5. Final remarks

This paper argues that rental housing is globally growing as a means to access housing in the face of multiple crises and as a financialized real estate frontier of capital accumulation. In Latin America and Brazil, where the homeownership model historically prevailed, households are increasingly renting, the real estate market is incorporating new formats (build-to-rent, multifamily), and professional rental management is spreading in formal and informal markets.

It presents Brazilian cases, analytically organized by three State modulations, understood as the agenda and practices of a State "in progress." An Emergency State, that responds to crises with precarious, temporary solutions. A Provider State, that implements public governance models with pilot programmes. A Conceding State, that incorporates market logics by advancing Public-Private Partnerships in the production and management of housing services.

Through this proposed analytical framework, we observed the evolution of emergency policies, which constitute by far the most disseminated type of rental policy in Brazil. One that seems intended to urgently respond to crises and disasters, but is mostly implemented as an income transfer policy and lacking institutional or programmatic filiations. Through the rental assistance policy, rent is not actually assisted; what is enforced - recycled, recreated and managed - is the precariousness and transitoriness of (the lack of adequate) housing solutions; an anti-policy as such (Guerreiro, 2020).

We also identified a "private turn" in development finance that imposes a PPP agenda, as pointed out by Romero and Waeywnberge (2020), but with regional characteristics. Latin America did not have a welfare state along the lines of the central countries' experience. Here, the Provider State presented pilot-scale projects, and rental policies were never a part of the dominant regime. Recent formulations of rental housing PPPs are aligned to the agenda of international entities and advance the paradigm of inclusive housing policies, where housing is seen as a service and public assets are mobilized to advance investment opportunities.

Furthermore, the three modulations of the State, interacting in processes in progress, enunciate the current dis-

putes surrounding rental policies in Brazil.

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Pathways to Urban Resilience: Tactical Urbanism vs. Transdisciplinary Approaches

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Abstract
This article explores how tactical urbanism and transdisciplinary approaches intersect in fostering urban resilience within Türkiye's evolving planning context. Tactical urbanism, characterised by small-scale, low-cost, and community-led interventions, promotes rapid adaptation and public engagement. In contrast, transdisciplinary approaches integrate diverse disciplines and stakeholder perspectives to address systemic urban challenges through long-term, collaborative strategies. Drawing on international frameworks and Turkish case studies—including Istanbul's parklet projects and İzmir's public space renewals—the study reveals that combining these two methods can bridge the gap between experimentation and institutional transformation. It argues that fostering synergy between grassroots initiatives and structured collaboration enables adaptive, inclusive, and context-sensitive urban resilience. Ultimately, integrating both approaches supports sustainable, participatory, inclusive and regenerative urban futures.

Keywords: Tactical urbanism, transdisciplinary approach, urban resilience, participatory planning, Türkiye

1. Introduction

The term resilience originates from the Latin word resilientia, referring to the capacity of a substance to return to its original shape after deformation. In the 19th century, Thomas Young and Thomas Tredgold defined resilience as a material's ability to absorb energy and withstand sudden forces, introducing concepts such as the "modulus of resilience" (Rogers, 2017, p. 14). In broader systems theory, resilience is understood as "a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973, p. 17). It has also been defined as "the capacity of a system to absorb disturbance and reorganise while undergoing change" (Walker et al., 2004). Resilience can refer to engineering resilience, which is the time required for a system to return to equilibrium after a disturbance. It also encompasses dynamics far from equilibrium, describing the magnitude of disturbance a system can endure before shifting to a different stable regime with distinct governing variables and structures. In ecological contexts, the terms ecological resilience and ecosystem resilience are often used interchangeably (Brand and Jax, 2007).

Urban resilience refers to the capacity of cities to adapt to both predictable changes and novel conditions, such as population growth, resource scarcity, and climate change. Effective urban resilience planning is essential for cities to anticipate and respond to unexpected shifts (Yaman Galantini, 2020, p. 349). Two key considerations are central to this process. First, a city's ability to cope with change while maintaining stability must be strengthened. Second, resilience strategies need to be context-specific, tailored to the unique characteristics of each city, as the impacts of global challenges vary across local contexts. Given the dynamic nature of urban resilience, cities must periodically reassess their goals and capacities. An effective resilience plan should address three fundamental questions: 1) What are the immediate vulnerabilities? 2) What are the spatial scales for intervention? 3) What are the key components of the planning framework? These components include stakeholders, spatial scale, interdependencies, resilience indicators, planning tools, and policies—all of which together form the foundation for developing context-sensitive, adaptive, and sustainable urban resilience strategies (Yaman Galantini, 2020, pp. 348-349).

"The Urban Resilience Hub," managed by UN-Habitat, is a global platform designed to enhance urban resilience and promote its practical implementation. The hub provides access to research, news, case studies, and best practices, fostering collaboration among local governments, practitioners, researchers, and international organisations. It offers toolkits, guidance documents, and other resources to help cities assess risks and implement resilience strategies, advocating for the integration of resilience thinking into urban planning and policy at local, national, and global levels. Additionally, the hub supports city alignment with global frameworks such as the Sendai Framework for Disaster Risk Reduction, the Paris Agreement, and the Sustainable Development

Goals (Urban Resilience Hub, n.d.). Similarly, "Making Cities Resilient 2030" (MCR2030) is a global initiative led by the United Nations Office for Disaster Risk Reduction (UNDRR). It aims to help cities become safer, more inclusive, and resilient to disasters and climate-related risks, with a target of achieving enhanced urban resilience at the local level by 2030. The initiative contributes to Sustainable Development Goal 11 (SDG11) and other global frameworks, including the Sendai Framework, the Paris Agreement, and the New Urban Agenda, by promoting advocacy, knowledge sharing, learning networks, technical support, coordination among government levels, and the establishment of partnerships (Making Cities Resilient, MCR2030).

Another notable urban resilience initiative is the "New European Bauhaus", launched by the European Commission in 2020, promotes sustainable, inclusive, and human-centered urban living. Bridging the European Green Deal with everyday life, it emphasizes sustainability, aesthetics, and participation, fostering community-driven urban transformation through both commission-led and grassroots projects that support climate goals and social inclusion (New European Bauhaus, n.d.).

A complementary strategy for enhancing urban resilience involves the adoption of tactical urbanism. Recent initiatives that integrate participatory models and tactical urbanism have highlighted both notable progress and persistent systemic challenges. While these approaches aim to democratise decision-making and strengthen resilience, their effectiveness is often limited by fragmented implementation and insufficient transdisciplinary integration.

In the context of Türkiye, the adaptive use of urban open spaces plays a crucial role in enhancing resilience and supporting adaptation to emerging climate conditions. Historically, top-down strategies have dominated urban planning, however, there has been a gradual shift toward participatory practices and project-based policies designed to engage citizens in decision-making processes. Despite these efforts, participatory models have often proven insufficient in effectively addressing urban resilience challenges. Key issues include the sustainability of urban governance, the early-stage implementation of participatory processes, and the tensions between top-down policies and grassroots initiatives.

Conversely, transdisciplinary collaboration and research offer significant potential to manage uncertainties, support adaptation, and drive development in response to emerging challenges, thereby enhancing urban resilience. To address issues of urban sustainability and resilience, architects, planners, and researchers require training and experience in knowledge transfer, with design research recognised as a legitimate method of knowledge generation (Després et al., 2011). In this context, planners can play a pivotal role by raising awareness among local governments and citizens, influencing the outcomes of resilience-building initiatives. Accordingly, this research focuses on strategies for implementing transdisciplinary approaches to strengthen urban resilience. It examines the role of participatory processes in fostering resilience and explores ways to enhance transdisciplinary urban participation within Turkish urban contexts through a theoretical framework.

In light of the theoretical foundations of resilience and its diverse interpretations, this study situates the concept within the specific context of urban resilience and its application to contemporary planning challenges. While global frameworks and initiatives offer valuable guidance, there remains a gap in understanding how tactical urbanism and transdisciplinary approaches can jointly enhance urban resilience, particularly within Türkiye's evolving planning landscape. Accordingly, this research examines how these two approaches—one grounded in grassroots experimentation and the other in integrative, long-term collaboration—can complement one another in addressing systemic urban vulnerabilities. The study argues that bridging the immediacy of tactical interventions with the structural depth of transdisciplinary processes can foster adaptive, inclusive, and context-sensitive models of urban resilience. It seeks to answer the following questions: 1) How can tactical urbanism contribute to strengthening urban resilience through participatory, short-term interventions? 2) In what ways can transdisciplinary collaboration expand these efforts into sustainable, long-term frameworks for urban transformation? By addressing these questions, the study aims to contribute to a more coherent and operational understanding of resilience in urban planning—linking theory, practice, and policy through both bottom-up and

cross-sectoral strategies.

2. Tactical urbanism: A catalyst for active participation

Historically, citizens have modified streets and public spaces—sometimes without formal approval—to address unmet needs, such as improving street safety or creating more open areas. These initiatives are community-led, emerging from the efforts of residents and activists who implement swift, incremental improvements in response to gaps or delays in official action, particularly in areas where municipal authorities are perceived as ineffective or unresponsive. The concept of tactical urbanism draws inspiration from earlier urban experiments, including Paris's pop-up book stalls (les bouquinistes) in the 16th century, Ciclovía in Bogotá, and pedestrian plazas in New York City (Lydon and Garcia, 2015, p. 51). Tactical urbanism arose as a response to the limitations of conventional urban planning methodologies. Its intellectual roots can be traced to the seminal work of Michel de Certeau, The Practice of Everyday Life (1984). De Certeau contrasted the tactical actions of ordinary individuals with the strategic actions of institutions, offering a perspective on social dynamics and the role of individuals in shaping urban environments. He introduced the concept of "making do," a tactical approach employed by urban residents that he described as "invisible." This strategy embodies what he termed an "art of the weak," a means of temporarily subverting hegemonic authority that structures both tangible and intangible urban spaces. Tactics, as de Certeau demonstrated, are structurally shaped by social orders, yet they remain contingent and timeless, adaptable across different contexts (Copeland and Feldman, 2016).

Tactical urbanism has been defined as a "decentralised, bottom-up, extraordinarily agile, networked" and "citizen-led, quick, and affordable" approach to urban planning, characterised by low-cost and low-tech interventions (Mohankumar, 2020, p. 15; Lydon and Garcia, 2015, p. xii). It emphasises the use of short-term, low-cost, and scalable interventions to catalyse long-term change in neighbourhoods and public spaces (Mohankumar, 2020, p. 15). The concept emerged as a grassroots response to the slow, bureaucratic pace of conventional urban planning. Early initiatives included pop-up bike lanes, parklets, and temporary plazas, designed to demonstrate the potential for long-term improvements (Lydon, 2011; Tactical Urbanist's Guide, n.d.; Urban Design Lab, 2023). The approach gained widespread attention during the 2008 financial crisis, when budget constraints prompted cities to adopt cost-effective, community-driven strategies for urban revitalisation.

Tactical urbanism formally coalesced in 2010, at a meeting of the Next Generation of New Urbanist (CNU NextGen) group in New Orleans, convened by Mike Lydon with Anthony Garcia, Lydon authored the influential book Tactical Urbanism: Short-term Action for Long-term Change (2015), which catalyzed collaborative open-source projects and the broader adoption of the approach (Planetizen, n.d.). Their reports documented the experiences of urbanists and activists across the U.S., highlighting practices such as "guerrilla urbanism," "DIY urbanism," "planning-by-doing," "urban acupuncture," and "urban prototyping." These case studies underscored the popularity and potential of tactical urbanism as a method for rapid, community-led change.

By the late 2010s, tactical urbanism gained traction among city governments and grassroots organisations, who implemented pop-up parks, pedestrian plazas, street murals, and other temporary interventions. This period also fostered experimentation with novel public space concepts, alternative street uses, and community-led initiatives such as street art and urban farming. The approach is characterised by its informal, hands-on, and experimental nature, allowing cities to test and evaluate ideas before committing to permanent urban modifications (Tactical Urbanist's Guide, n.d.; Anderson, 2023). The Street Plans Collaborative (2012) defines tactical urbanism as a phased, low-risk approach to urban change that emphasizes local, short-term, and community-driven interventions. It promotes incremental experimentation, context-specific solutions, and the building of social capital through collaboration among citizens, institutions, and organizations (Lydon et al. 2012, pp. 12).

2.1. The role of tactical urbanism in urban resilience

Lydon and Garcia (2015) draw a clear connection between tactical urbanism and broader urban planning movements, particularly emphasising citizen participation and the critical role of residents in shaping their communities. They also promote open-source urbanism, which enables the sharing of ideas and designs,

fostering collaborative problem-solving across communities. Tactical urbanism projects are distinguished by their experimental and adaptive nature, allowing for rapid testing and immediate community feedback. The global pandemic has further increased the appeal of this approach, as it offers flexible, low-cost interventions that can respond to urgent urban needs (Lowe et al., 2024). These initiatives are typically modest and cost-effective, yet they hold the potential to generate significant impacts in creative placemaking, empowering communities to test new concepts and develop a sense of ownership over their surroundings, often led by local residents (CoUrbanize, 2020). The application of tactical urbanism has been shown to enhance adaptability, social cohesion, and environmental sustainability through community-driven interventions such as pop-up parks and street murals (Mohankumar, 2020). As illustrated in Figure 1, tactical urbanism embodies a diverse set of characteristics and practices that collectively support responsive, community-centered urban transformation.

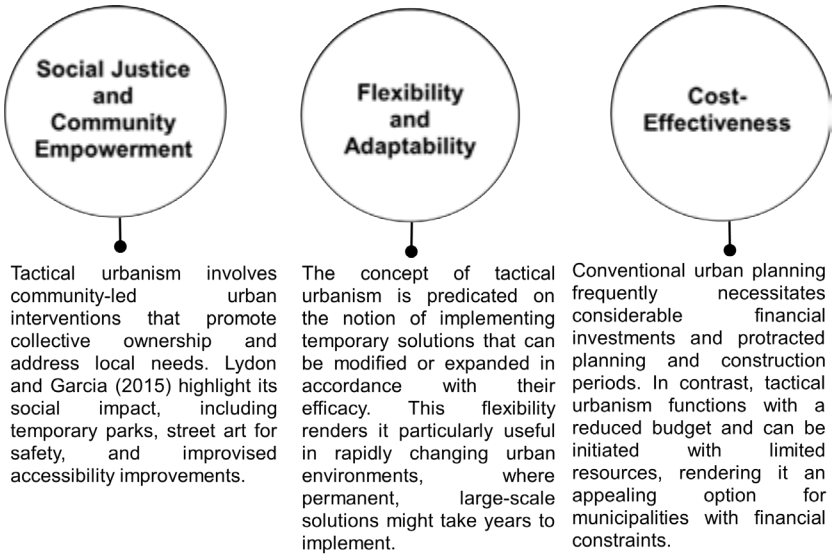

Figure 1. Benefits of tactical urbanism (Derived from Lydon and Garcia (2015)

Table 1 showcases global examples of tactical urbanism, illustrating how temporary, community-led interventions—such as street closures, pop-up parks, and pedestrian zones—can improve public spaces, mobility, and social engagement across diverse urban contexts.

Table 1. Notable Examples of Tactical Urbanism

Project	Year	Location	Description	Impact	Reference
Times Square Pedestrian Plaza	2009	New York City, USA	Pedestrianisation of Times Square using temporary materials; later made permanent.	Improved safety, increased foot traffic, and economic benefits.	Snøhetta (n.d.)
Paris Plages	2002-…	Paris, France	Seasonal transformation of Seine banks into urban beaches since 2002.	Enhanced public access to riverfronts and recreation.	Paris (2022)
Superblocks	2016-…	Barcelona, Spain	Car-free superblocks promoting pedestrian and cyclist priority since 2016.	Reduced traffic, pollution; increased green spaces.	(Iturralde, 2021)

Ciclovía	1970-…	Bogotá, Colombia	Weekly car-free events encouraging cycling and pedestrian use since the 1970s.	Boosted public health and global influence on similar events.	(Lydon et al, 2012)
Park(ing) Day	2005-..	Global (orig. San Francisco (USA)	Temporary conversion of parking spaces into public spaces; annual event since 2005.	Raised awareness on public space use; inspired parklets.	(Bela, 2023)
Better Block Project	2010-…	Dallas, USA	Temporary revitalisation of blighted blocks for urban improvement potential.	Catalysed global community-led urban projects.	Better Block (n.d.)
Play Streets	2019-…	London, UK	Temporary street closures for children's play and community interaction.	Encouraged child-friendly design and community cohesion.	(Sustrans, 2019; Playing Out, 2020)

Despite its successes, tactical urbanism faces several challenges and criticisms, including governance limitations, concerns about inclusivity, and the constraints of temporary interventions in addressing systemic urban vulnerabilities (Mohankumar, 2020). In contrast, participatory approaches to urban planning have demonstrated considerable benefits by fostering collaboration, integrating diverse perspectives, and supporting long-term sustainability and resilience. Such initiatives have been shown to enhance community resilience, strengthen local ownership, and leverage local knowledge to develop context-specific and effective solutions (Özdamar and Önay, 2024). However, challenges persist in contemporary urban transformation practices, particularly in Istanbul. Large-scale projects, such as the planned redevelopment of 600,000 earthquake-prone housing units, often emphasise physical reconstruction over community participation. This prioritisation can lead to community discord and limit opportunities for meaningful engagement in shaping urban outcomes (Gün, Pak, and Demir, 2020).

2.2. Tactical urbanism in Türkiye

The concept of tactical urbanism has gained global recognition, including in Türkiye, where cities have employed temporary, low-cost interventions to address diverse urban challenges and respond to immediate needs. Measures such as street closures, parklets, and pop-up green spaces offer valuable opportunities to enhance public spaces, promote sustainability, and actively engage citizens in urban transformation. Research on tactical urbanism in Türkiye emphasises original processes, participatory engagement, and exemplary case studies (Türkoğlu and Terzi, 2021; Vardı Topal, 2023). These projects primarily focus on improving public spaces, enhancing mobility, and fostering community participation. Notable examples include the Roman Orchard Project in Istanbul and the Transformation of Zümrütevler Square (2019), both of which implemented low-cost, temporary interventions to redesign urban areas. The Zümrütevler Square initiative, led by Maltepe Municipality with support from the Bernard van Leer Foundation, NACTO, and Superpool, aimed to improve pedestrian safety for children and families in the neighbourhood. Interventions included road painting, traffic calming measures, and seating areas, resulting in a 72% increase in square usage (Günç, 2021; Superpool, 2021). Despite these successes, such projects often face limitations in scalability and integration within broader urban planning frameworks, which can constrain their long-term impact on urban resilience. These challenges highlight the importance of linking tactical urbanism initiatives to strategic planning and stakeholder collaboration to ensure lasting benefits for cities.

The "Parklet" Projects in Istanbul (2020), initiated by WRI Türkiye Sustainable Cities as part of the WRI Ross Center for Sustainable Cities' Urban Mobility initiatives, in collaboration with the Istanbul Metropolitan Municipality Transportation Department, transform on-street parking spaces into small, temporary public parks known as parklets. The initiative was supported by the Fund of the "Partnership for Healthy Cities" (PHC), and implemented

in partnership with the World Health Organization. These parklets, deployed across multiple neighbourhoods—particularly in Beyoğlu—feature amenities such as benches, greenery, and public art. The objectives of parklets are threefold: to create pedestrian-friendly spaces, promote social interaction, and enhance public areas. By converting automotive space into pedestrian zones, parklets aim to reduce traffic congestion and increase foot traffic for local businesses. Additionally, these temporary interventions allow communities to assess the potential impacts of long-term urban design changes (Yaman and Yaraç, 2023; IBB, n.d.).

Similarly, the Sokak Bizim Derneği (Street Belongs to Us, 2010), an Istanbul-based NGO, seeks to improve pedestrian infrastructure by temporarily closing streets to cars and reopening them for pedestrians and cyclists (Sokak Bizim Derneği, n.d.) (Table 2). This initiative promotes walking, cycling, and social interaction, raising awareness of sustainable urban mobility and aligning with David Harvey's concept of "the right to the city." While such interventions have the potential to foster more equitable and inclusive urban politics and encourage authentic participatory urbanism, they also carry the risk of failing to generate sustained or comprehensive urban opposition, limiting their long-term transformative impact (Öcal and Erkut, 2019, p. 116).

Table 2. Examples of Tactical Urbanism in Istanbul

Name	Year	Location	Initiated by	Strategy and Description
Squat house	2013-2015	Kadıköy, Istanbul	Don Quixote Squat Collective (2013-2015, currently Squatters İstanbul (SQI))	Social sustainability and governance
Roma Orchard	2013	Beyoğlu, Istanbul	Roma Orchard Volunteers (2013)	Sustainability of natural resources
Kuzguncuk Orchard	2014	Üsküdar, Istanbul	Kuzguncuk Association	
Historical Yedikule Orchards	2017	Fatih, Istanbul	Historical Yedikule Orchards Protection Initiative (2013)	
The Transformation of Zümrütevler Square	2019	Maltepe, Istanbul	Bernard van Leer Foundation, NACTO and Superpool	Social sustainability and governance (Türkoğlu and Terzi, 2021)
***Mahalleni Onar* (Fix Your Neigbourhood)**	2019	Kadıköy, Istanbul	*Onaranlar Kulübü,* Kadıköy Municipality	Local identity and urban aesthetics
Boğada Project	2017	Kadıköy, Istanbul	*Herkes için Mimarlık, Onaranlar Kulübü*, TAK Kadıköy (Municipality)	Local identity and urban aesthetics
Istanbul's "Parklet" Projects	2020-2022	Beyoğlu, Istanbul	WRI Türkiye Sustainable cities, part of urban mobility within WRI Ross Center for Sustainable Cities.	Local identity and urban aesthetics, urban mobility
Ayda Bir Gün Sokak Bizim	2010-2019	Şişli, Kadıköy, Beyoğlu, Beşiktaş, Sarıyer	*Sokak Bizim Derneği* (Street Belongs to Us, 2010)	Urban mobility

Several projects in Türkiye illustrate how tactical urbanism can successfully transform public spaces through rapid, low-cost, and participatory interventions. The Tersane Neighbourhood Public Space Renewal Project in İzmir, implemented in collaboration with the United Nations Development Program (UNDP) and Karşıyaka Municipality, aimed to enhance two public spaces through innovative tactical urbanism measures. Engaging neighbourhood residents, the project included improvements such as shelter and health solutions for stray cats and the revitalisation of green areas (UNDP Türkiye, 2022).

In Kadıköy, tactical urbanism initiatives have focused on temporarily converting streets into car-free zones for pedestrians and cyclists, fostering human-centered environments that encourage social interaction and public activity. These interventions also promote alternative transportation modes, such as walking and cycling, reducing reliance on private vehicles. The Boğada Project, a collaborative effort with Herkes için Mimarlık (Architecture for All), Onaranlar Kulübü (Fixer's Club), TAK Kadıköy, and other partners, transformed the area around the Bull statue in Kadıköy. Over ten days, participants conducted field research, generated design ideas, and installed urban furniture, demonstrating the participatory and experimental nature of tactical urbanism (Boğada n.d.; Trak n.d.).

Despite these successes, tactical urbanism faces several challenges. The temporary nature of interventions may limit long-term impact, particularly when projects lack institutional support for permanence. Without a robust planning framework, tactical urbanism initiatives can become fragmented or disconnected, potentially resulting in ineffective outcomes. The approach's emphasis on simplicity and short-term solutions can conflict with broader urban development plans that demand larger-scale investment and long-term vision. Additionally, implementing tactical urbanism in densely populated areas often introduces greater logistical and organisational complexity (Ramos, 2022). These limitations underscore the need to integrate tactical urbanism with strategic planning and stakeholder collaboration to ensure that experimental interventions contribute meaningfully to long-term urban resilience and development.

3. Transdisciplinary methods in urban resilience planning and action

Transdisciplinary approaches originated in the social sciences during the 1970s and were subsequently extended to the physical sciences, including mathematics and quantum physics. They are conceptualised as Mode II knowledge production, referring to knowledge that is socially distributed and accessible to individuals and groups across society. This process-oriented framework facilitates communication beyond traditional institutional boundaries, creating a global network of interconnected nodes (Gibbons et al., 1994). Transdisciplinarity is characterised by its focus on real-world problems, the integration of diverse disciplinary perspectives, and active engagement with stakeholders outside the academic sphere. Through interdisciplinary collaboration and multi-sectoral participation, transdisciplinary approaches are particularly well-suited to addressing the complex, interconnected challenges of urban resilience.

The primary goal of transdisciplinary approaches is to achieve a "unity of knowledge" that transcends disciplinary silos, fostering improvements in the issue under study, the generation of new knowledge, and mutual transformative learning between researchers and participants. This methodology has proven especially effective in tackling sustainability-related challenges, including climate change, poverty, and resource security. The concept of "unity of knowledge" can be traced to early formulations by Jean Piaget (Klein, 2008) and has been further elaborated by scholars such as Hirsch Hadorn (2008), who emphasises the integration of scientific, ethical, and pragmatic knowledge from diverse scientific disciplines and non-academic stakeholders to address complex societal problems. Its primary aim is to co-produce knowledge that enhances understanding (system knowledge), informs decision-making (target knowledge), and guides practical action (transformation knowledge) toward sustainable solutions (Hirsh Hadorn, 2008; OECD, 2020). Similarly, Julie Thompson Klein (2008) highlights the necessity of cross-sectoral cooperation to resolve complex issues and embrace integrative practices that reflect the multidimensional nature of reality. These principles have been institutionalised in frameworks such as those developed by CIRET (Nicolescu, 2002), all of which underscore the importance of combining diverse forms of knowledge to confront complex societal challenges effectively.

Research on transdisciplinary planning demonstrates a paradigm shift in knowledge production and application, moving away from isolated disciplinary approaches toward collaborative, problem-oriented, and socially embedded research practices (OECD, 2020). A growing body of literature highlights the critical role of transdisciplinary approaches in urban planning and urban resilience, showing their effectiveness in addressing multifaceted challenges, including public health, climate change, social vulnerability, and sustainable development. The transdisciplinary approach is a problem-solving methodology specifically designed to address the complex and interconnected societal challenges of the contemporary world. It involves engaging with complexity, acknowledging multiple scientific and societal perspectives, generating actionable knowledge, and bridging the gap between academic understanding and practical application to produce outcomes that are both scholarly and socially relevant (Hirsh Hadorn, 2008). This approach relies on the collaboration of community organisations, private enterprises, and policymakers to co-create knowledge and solutions that are contextually meaningful and implementable. By transcending traditional disciplinary boundaries, transdisciplinarity produces insights that are simultaneously scientifically rigorous and socially applicable.

The transdisciplinary process is iterative and non-linear, requiring the formation of diverse teams that combine disciplinary expertise with practical experience. Engaging relevant stakeholders throughout every stage of research—from the formulation of questions to the integration and evaluation of results—is essential. The process often necessitates negotiation and dialogue among participants with different knowledge bases, assumptions, and interests (OECD, 2020).

Research on transdisciplinary planning has explored a wide range of applications, including urban planning, sustainability, healthier urban environments, and the interaction between Global North and Global South contexts (Després et al., 2011; Pärli, Fischer, and Lieberherr, 2022; Lawrence, 2022). As summarised in Table 3, these studies illustrate key aspects of transdisciplinary planning research, highlighting its capacity to integrate diverse academic disciplines with non-academic stakeholders to collaboratively address complex societal challenges (Table 3).

Table 3. Transdisciplinary Planning Research Focus Areas

- Integrative knowledge production combining academic and non-academic insights
- Collaborative stakeholder engagement as co-producers of knowledge
- Iterative, flexible research processes tailored to complex societal problems
- Development of actionable knowledge that informs policy and practice
- Emphasis on sustainability and societal relevance in research outcomes
- Addressing challenges in research system structures and cultural contexts

3.1. Transdisciplinary approaches in urban resilience

Urban resilience research underscores the critical role of participatory and transdisciplinary approaches in enhancing cities' capacity to respond to social and environmental shocks, such as floods, climate change, and other urban stresses. Central to this is the integration of diverse perspectives and knowledge domains, the promotion of social innovation, and the strengthening of multi-stakeholder collaboration—core components of co-creation and participatory urban planning. These processes enhance both the adaptive capacity and the legitimacy of urban governance. International frameworks, including the United Nations 2030 Sustainable Development Goals, stress the importance of fostering trust, transparent communication, and meaningful participation, particularly among marginalised communities (United Nations Framework Convention on Climate Change, 2015; United Nations, 2015).

However, implementing transdisciplinary research faces several challenges. Disciplinary silos, institutional constraints, and the complexity of integrating heterogeneous knowledge systems can impede progress. Moreover,

methodologies developed in Western contexts are often not directly transferable to developing countries, highlighting the need for context-sensitive approaches (OECD, 2020). Despite these obstacles, transdisciplinary planning is widely regarded as a transformative strategy, capable of overcoming the limitations of fragmented disciplinary work and top-down planning. By integrating diverse stakeholders and knowledge systems, it provides a framework for addressing the complexity and uncertainty inherent in urban environments, including climate-related risks and social inequalities, thereby facilitating more sustainable and equitable urban futures (Karaman, 2022).

Research on transdisciplinary planning in the context of urban planning and resilience highlights its effectiveness in generating inclusive, proactive, and integrated solutions to complex urban challenges. By engaging multiple stakeholders and knowledge domains in collaborative processes, transdisciplinary approaches enhance cities' capacity to promote health, sustainability, and resilience amidst growing urban complexities (Lawrence, 2022; Karaman, 2022). These methods have also been applied in spatial planning education (Van der Knaap, 2022) and in managing collaborations between universities and municipalities (Brink et al., 2018).

The concept of urban resilience requires attention to interrelated dimensions such as social equity, environmental sustainability, and economic stability. Transdisciplinary approaches allow cities to address these dimensions holistically—considering environmental, social, cultural, and economic factors within a unified framework. Incorporating diverse perspectives has been shown to produce more robust and durable solutions. Unlike tactical urbanism, which often focuses on short-term, immediate interventions, transdisciplinary strategies aim for long-term structural change, addressing systemic issues through coordinated planning and sustained action. This enables the creation of comprehensive resilience strategies capable of withstanding future shocks. A key feature of transdisciplinary methods is the emphasis on inclusive stakeholder engagement, ensuring that marginalised communities and non-expert voices are actively involved in decision-making. Such inclusivity is essential for developing equitable solutions that garner broad support, which is critical for the success and legitimacy of urban resilience initiatives (Figure 2).

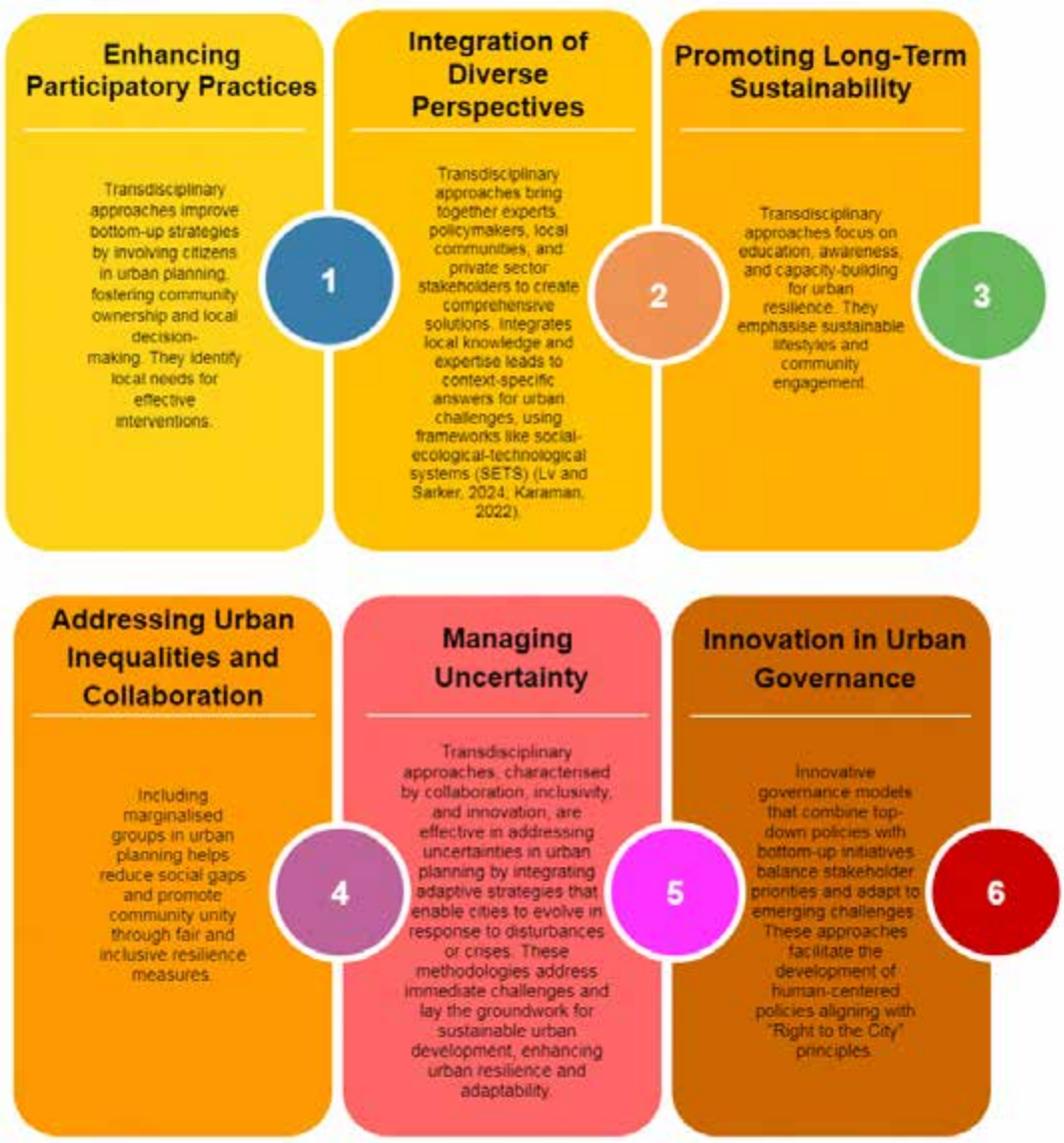

Figure 2. Transdisciplinary approaches promote different dimensions of urban resilience

This figure illustrates how transdisciplinary approaches enhance multiple, interconnected dimensions of urban resilience, including ecological, social, economic, and institutional aspects. By fostering collaboration among diverse stakeholders and integrating knowledge across disciplines, transdisciplinary practices enable cities to:

- Strengthen ecological resilience through sustainable resource management and environmental regeneration;
- Enhance social resilience by empowering communities and encouraging inclusive participation;
- Support economic resilience via innovation, adaptability, and equitable growth; and,
- Bolster institutional resilience through adaptive governance and cross-sectoral cooperation.

Transdisciplinary approaches also encounter several significant challenges. Integrating knowledge across diverse disciplines often proves complex, requiring not only methodological flexibility but also a shared conceptual framework among collaborators. Coordinating multiple stakeholders—each with distinct priorities, institutional constraints, and professional languages—can further complicate the process. Additionally, the substantial time, financial investment, and institutional commitment required for transdisciplinary initiatives may pose considerable barriers, particularly for cities operating with limited budgets or insufficient political support.

3.2. Transdisciplinary practices in Türkiye

Turkish cities have increasingly implemented human-centered policies, participatory practices, and urban rehabilitation initiatives aimed at strengthening both social inclusion and urban competitiveness. These efforts have enabled cities to enhance their global standing while safeguarding citizens' rights and promoting sustainable development. According to the 2014-2023 Istanbul Regional Plan (2016), improving urban resilience requires the integration of interdisciplinary collaboration with bottom-up participation. This plan marked a shift toward a more tailored, inclusive, and locally driven model of regional development. It was developed through the joint efforts of the Ministry of Development, academic institutions, local governments, and non-governmental organisations (NGOs). The plan adopted an interdisciplinary framework, emphasising stakeholder engagement and the co-production of knowledge to generate innovative solutions for sustainability and resilience in Istanbul.

Similarly, the Urban Renewal Project sought to merge bottom-up urban concepts with participatory mechanisms for urban rehabilitation and development. Although the project fell short in meeting the essential needs of local communities, it nonetheless incorporated participatory and community-based strategies into urban transformation processes—addressing challenges such as illegal construction, disaster risk, and uncontrolled urban expansion (Yılmaz Bakır, 2020). However, while interdisciplinary and multidisciplinary frameworks have been widely utilised in Türkiye's planning and development initiatives, transdisciplinary approaches—which move beyond disciplinary boundaries to foster genuine co-creation between experts and communities—have yet to be systematically integrated into these processes (Özdamar and Önay, 2024).

According to Arslan and Kaya Erol (2023), the Turkish planning system lacks a legal framework for participation because it is necessary to create flexible and legal frameworks that incorporate participation arrangements in planning and design to build a knowledge and experience base for participatory-oriented design. The development of comprehensive solutions for complicated problems like disaster preparedness and fair resource allocation is made possible by transdisciplinary approaches, which encourage cooperation between technical specialists, local communities, and legislators. However, the development of cooperative platforms that bring together sociologists, architects, and inhabitants in co-design processes is essential to the success of this approach (Özdamar and Önay, 2024). It has been shown that implementing a transdisciplinary approach is a successful tactic for breaking down silos. A key component of the process is the integration of knowledge. In order to build a resilient neighbourhood, for example, engineering, sociology, ecology, and economics must be integrated (Breaking Down Silos: Collaboration Across Disciplines).

While not specific to a particular city, these examples demonstrate efforts to incorporate transdisciplinary and bottom-up approaches in urban planning and development. The overarching objective of these initiatives is to enhance urban resilience, strengthen local communities, and reduce urban inequalities by promoting collaboration, incorporating multiple perspectives, and involving local communities in decision-making processes (Özdamar and Önay 2024).

While the participatory experiments conducted in Türkiye represent a departure from rigid top-down models, the efficacy of these experiments in building resilience is contingent upon the systemic integration of transdisciplinary collaboration and ICT-enabled inclusivity. It is argued that, by anchoring design-thinking processes in empathy and shared expertise, Istanbul's urban transformation could evolve into a model of adaptive, citizen-centred planning that is globally replicable. Transdisciplinary approaches have the potential to significantly enhance urban resilience in Türkiye by addressing complex urban challenges through integrative, participatory, and innovative strategies.

4. Tactical Urbanism vs. Transdisciplinary Approach

While both tactical urbanism and transdisciplinary approaches play vital roles in advancing urban resilience, they differ markedly in their focus, scale, and methodology. Tactical urbanism is characterised by its immediacy, flexibility, and low-cost implementation—emphasising short-term, community-driven actions that can quickly address local needs and test new ideas. In contrast, transdisciplinary approaches operate at a broader and

more complex level, integrating multiple fields of knowledge and stakeholder perspectives to develop long-term, systemic strategies for sustainable urban transformation (Table 4).

Table 4. Differences Between Tactical Urbanism and Transdisciplinary Urban Approaches

		Tactical urbanism	Transdisciplinary Approaches
1	**Temporary vs. Long-Term Solutions**	Short-term interventions (Karaman, 2022)	Systemic, long-term resilience (Karaman, 2022)
2	**Scalability and Impact**	Hard to scale up Tactical urbanism, like parklets, can be scalable but must be mindful of their limitations in addressing systemic issues in urban areas.	Bigger impact Transdisciplinary initiatives are conceived with the objective of achieving a more substantial impact.
3	**Community Engagement Models Ownership**	Grassroots-driven (Karaman, 2022; Mohankumar, 2020) Value community input. Starts with the community Tactical urbanism, a cost-effective strategy, emphasises community engagement as a fundamental element in its implementation.	Institutional collaboration (Karaman, 2022; Mohankumar, 2020) Value community input. Need to involve community members Although transdisciplinary projects require significant resources, their long-term benefits and transformative potential make such investments highly worthwhile.
4	**Cost-Effectiveness and Resource Allocation**	Cost-effective	Require more resources
5	**Scale and Scope**	Focuses on small, localised Interventions that are swift and cost-effective, often focusing on specific issues in specific neighbourhoods.	Operates on a larger scale, addressing systemic urban challenges and requiring coordination across various sectors and levels of government.
6	**Flexibility vs. Structure**	Thrives on flexibility, experimentation, and immediate action, allowing for rapid adaptation based on real-time feedback, a critical aspect of urban planning and management in dynamic environments.	Prioritises structured collaboration and long-term planning, often requiring more time and resources to develop comprehensive solutions.
7	**Community vs. Expert-Centric**	Primarily driven by community involvement, often with little reliance on experts or formal planning processes.	Integrates expert knowledge across multiple fields, while still emphasising the importance of community participation and inclusivity.
8	**Who Can Use?**	Urban planners can use tactical urbanism to test ideas.	Policymakers can support transdisciplinary projects.
9	**Adaptability to Climate Challenges**	They both address climate change-induced risks like rising water levels and extreme weather events (Lv and Sarker, 2024) (Karaman, 2022).	

Despite the apparent distinction between tactical urbanism and transdisciplinary approaches, these frameworks are not mutually exclusive. When applied together, they can reinforce one another, strengthening urban systems and enhancing their resilience. Both approaches demonstrate their effectiveness through the empowerment of communities: tactical urbanism serves as an experimental platform for testing localised ideas, while transdisciplinary approaches integrate these experiments into broader, long-term strategies for urban sustainability and resilience. Likewise, insights gained from transdisciplinary collaboration can inform and scale tactical interventions, ensuring their coherence with wider resilience objectives.

4.1. Challenges in Türkiye

Despite the increasing emphasis on bottom-up strategies and tactical urbanism in Türkiye, notable shortcomings persist in how these approaches are conceptualised and implemented. A transdisciplinary framework is proposed as a means to enhance their effectiveness by fostering deeper collaboration across sectors and knowledge domains. One of the primary obstacles to active participation in Türkiye is the highly centralised administrative system, which necessitates the development of alternative models to facilitate genuine and continuous collaboration (İzci and Geylani, 2021). Within this context, the participatory democracy model envisions citizens as proactive agents in governance processes (Tekeli, 2012). Although numerous reforms have introduced new mechanisms aimed at promoting openness, transparency, citizen participation, and decentralisation, these efforts often remain procedural rather than transformative. To advance participatory governance, policymakers and public authorities should prioritise establishing platforms that enable sustained, interactive engagement—supported by regulatory frameworks and strategic policy proposals. However, given the limited success of such initiatives to date, it is essential to strengthen citizens' involvement in parliamentary committees and to encourage voluntary collaboration with city councils and civil society organisations. Ultimately, this approach seeks to cultivate sustainable and resilient communities by nurturing open systems of governance grounded in shared responsibility, inclusivity, and collective learning.

4.2. Implementation strategies for synergy between tactical urbanism and transdisciplinary approaches

By adopting these strategies and emphasising participatory processes, Türkiye can cultivate more resilient cities capable of confronting complex urban challenges while advancing long-term sustainability. Empowering local communities, fostering collaboration, and engaging diverse perspectives have proven effective in addressing multifaceted problems and generating more inclusive, context-sensitive solutions. This vision is achieved through strengthening stakeholder cooperation, integrating local knowledge and expertise, and promoting sustainable living practices via community education initiatives. As illustrated in Table 5, the following dimensions are crucial for establishing a productive synergy between tactical urbanism and transdisciplinary approaches.

Table 5. Building synergy between tactical urbanism and transdisciplinary approaches

Balancing Priorities	When implementing both bottom-up and transdisciplinary approaches, it is critical to strike a balance between competing priorities and interests among stakeholders. This requires; • Empowering local communities • Encouraging collaboration • Engaging diverse perspectives
Stakeholder Collaboration	Fostering stakeholder collaboration is essential for addressing complex urban challenges and promoting long-term urban resilience and sustainability. This can be achieved through; • Engaging local knowledge and expertise • Promoting sustainable lifestyles through community education initiatives • Creating awareness among local governments and citizens
Training and Knowledge Transfer	Architects, planners, and researchers need to receive training and experience in knowledge transfer. Design research should be recognised as a legitimate method of knowledge generation to address emerging issues of urban sustainability and resilience (Eker, 2022).

Implementing both bottom-up and transdisciplinary approaches simultaneously requires careful negotiation among diverse stakeholders to balance competing priorities and interests. Empowering local communities, fostering collaboration, and integrating multiple perspectives have consistently proven effective in tackling complex urban challenges and generating inclusive, sustainable solutions. Achieving this necessitates cultivating cross-sectoral cooperation, mobilising local knowledge and expertise, and promoting sustainable lifestyles through community education initiatives. Such an integrated approach enables the formulation of adaptive strategies that respond to immediate needs while fostering long-term urban resilience and sustainability.

A promising pathway for combining these methodologies lies in participatory planning, which actively engages communities, experts, and institutions in shaping urban interventions. Tactical urbanism can act as a catalyst for community engagement—creating opportunities for experimentation and collective learning—while transdisciplinary approaches provide the overarching framework that aligns these small-scale actions within a coherent, strategic vision for the city's future.

The synergy between tactical urbanism and transdisciplinary approaches merits further study. For instance, in a flood-prone city, temporary rain gardens could serve as tactical interventions demonstrating quick adaptation, while transdisciplinary collaboration among experts and residents could develop long-term water management strategies. Insights from these short-term actions would refine broader plans, illustrating how iterative, integrated practices can foster resilient, adaptive, and community-driven urban environments.

6. Conclusion

In the context of Türkiye, it is essential to draw on the insights gained from both tactical urbanism practices and inter/transdisciplinary approaches to counterbalance the impacts and limitations of top-down planning initiatives. Urban planners can play a transformative role in this process by raising awareness among local authorities and citizens, thereby shaping the trajectory and outcomes of urban interventions. Building urban resilience requires diverse, multifaceted pathways that embrace innovation and collaboration. Tactical urbanism represents a flexible, grassroots-driven strategy that facilitates rapid and localised responses to urban challenges, while transdisciplinary approaches provide a more systematic, long-term framework for addressing the complex and interrelated problems cities face. By recognising the respective strengths and constraints of these two approaches, cities can integrate them to cultivate urban environments that are both resilient to

present challenges and adaptable to future uncertainties.

Democratic participation extends beyond the simple involvement of citizens or local authorities; it requires the establishment of an integrated and coherent system capable of realizing a city's collective aspirations. The "right to the city" is grounded in egalitarian principles, rejecting hierarchical structures that privilege certain groups over others. Instead, it evolves through a dynamic redistribution of power and shared responsibility. Crucially, both transdisciplinary approaches and tactical urbanism must orient themselves toward the creation of regenerative cities—urban systems that merge long-term ecological renewal with short-term resilience. Such cities cultivate ecosystems that sustain themselves, foster circularity, and support the well-being of all forms of life, not only humans. Achieving this vision requires equitable and inclusive planning and design processes grounded in community-centered prosperity. However, a critical debate arises regarding the extent to which tactical urbanism and transdisciplinary approaches can effectively operate in tandem. In some contexts, these strategies may be appropriated by local governments as symbolic gestures that only partially fulfil the "right to the city." In this regard, the transdisciplinary approach may hold deeper transformative potential—emerging as an inherently grounded and long-term pathway toward realizing a genuine and enduring "right to the city."

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The Insufficient Role of Urban Form and Its Uses in Baseline Assessments of Urban Plans in France

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Abstract
When broadly defined, urban form is a key dimension of planning, directly tied to the challenges of 21st-century urbanization. In France, municipalities and metropolitan areas use the Local Urban Plan (PLU) as a powerful tool to move beyond outdated functionalist approaches. For these plans to engage meaningfully with urban form, however, their baseline assessments must identify the strengths and weaknesses of built forms and their multiple connections to related issues. Yet the French Urban Planning Code remains vague on both the content and methodology of such assessments, resulting in varied and often inconsistent practices. A comparative textual analysis, supported by an analytical grid applied to diagnostics from Lille, Bordeaux, and Lyon, shows that urban form is generally reduced to physical features of the built environment. However, it belongs to a broader systemic perspective, which is unevenly recognized across the documents. The absence of standardized protocols, spatial analyses, and detailed cartography reflects the lack of a shared framework—ultimately limiting these cities' ability to produce robust, spatially informed strategies.

Keywords: Urban form in planning; Baseline Assessments; Human practice in public space; Urban morphology theories; France

1.Urban Form, Public Space, and the Limits of Baseline Knowledge in French Planning

In a changing global context, 21st-century cities face both new and enduring challenges — in France, as elsewhere in the world. The impacts of climate change and socioeconomic tensions at all scales demand more resource-conscious urban development models centered on human needs. At the same time, the complexity of urban systems challenges planning practices, pointing to inevitable interconnections between geographic scales and policy domains. The United Nations' New Urban Agenda (UN-Habitat, 2017) calls for a fundamental reorientation of planning goals and approaches. After decades of functionalist urbanism, urban form is increasingly recognized as a key driver of cost efficiency, ecological performance, and social sustainability. Its spatial dimensions — from the human scale to the integration of metropolitan infrastructures — are now seen as essential to achieving inclusive, integrated, and environmentally responsible urbanisation. Together with buildings and building codes, the New Urban Agenda identifies urban public space as a key element of the form of the human-centred sustainable city. It is explicitly recognized in the new urban paradigm and is the focus of eight specific planning commitments.

How can the solemn commitments of the New Urban Agenda be translated into operational practice? National planning cultures, along with differing priorities across urban contexts, inevitably shape how this question is answered in practice. A central issue lies in the specific forms of knowledge that are mobilized in the conception of plans and policies.

Since the foundational work of Patrick Geddes (1915), planning has relied on preliminary assessments (civic surveys, in his terms) to build a shared understanding of the urban condition. In France, since 2000, the core document of local planning has been the Local Urban Plan (Plan Local d'Urbanisme – PLU)[1], which articulates a municipality's overall spatial development strategy. It must be grounded in a baseline assessment (diagnostic territorial), often informed by the expertise of public urban planning agencies. Unlike the highly functionalist Land Use Plan (Plan d'Occupation des Sols – POS)[2] it replaced, the PLU is intended to address a broader set of local

1 Due to resource constraints, Local Urban Plans (PLU) were initially implemented in cities within major urban areas. It was only later that Intercommunal Local Urban Plans (PLUi) were extended to rural territories. By 2019, 49% of French municipalities were covered by a PLU, representing 89% of the national population (CEREMA, 2020).

2 Adopted under the Land Use Planning Act (Loi d'Orientation Foncière, LOF) in 1967, the Land Use Plans (Plans d'Occupation des Sols, POS) remained in effect until 2000, when the Solidarity and Urban Renewal Act (Loi Solidarité et Renouvellement

challenges: limiting the consumption of natural and agricultural land, ensuring access to quality housing, fostering economic activity, improving mobility, adapting to climate change, enhancing public space, and more. The integration of Development and Planning Guidelines (Orientations d'Aménagement et de Programmation – OAP)[3] within PLUs reflects the ambition of local authorities to adopt more qualitative, spatially sensitive planning tools, often engaging with urban design.

In France, as in many other countries, the baseline assessments that informed functionalist plans like the POS were primarily focused on managing the demands of urban growth. Their main goal was to evaluate population trends, future needs for public services, land for housing and employment, and infrastructure development. Quantitative standards were introduced for the provision of green space, public facilities, parking, and of course Floor Area Ratio (FAR), typically without regard for the spatial configuration of the urban fabric. These assessments rarely engaged with issues of urban form — except in designated heritage districts. The Malraux Law (1962) introduced Conservation and Enhancement Plans (Plans de Sauvegarde et de Mise en Valeur – PSMV) for historic centers, where assessments necessarily addressed urban form to justify preservation (Merlin and Choay, 2015). This contributed to a lasting association between urban form and heritage, often focused on visible stylistic and architectural features.

Since the 1960s, an extensive body of academic literature has explored how urban form shapes spatial structure, human behavior, and the social and symbolic dimensions of urban life. The early work of urban morphologists such as Muratori (1960) and Conzen (1960) focused on historical cities, but later scholars extended the scope to contemporary urban contexts (Lynch, 1960; Jacobs, 1961; Alexander, 1965; Rossi, 1966; Newman, 1972; Hillier and Hanson, 1984; Hillier, 1996; Salingaros, 2005). Over time, this literature has come to advocate for human-centered urban environments (Alexander 1979; Lynch, 1981; Gehl, 2011). Recent meta-analyses (Carmona 2018) synthesize empirical findings to highlight how urban form directly influences the usage value of space and the nature of everyday urban practices. Nevertheless, urban form remains marginal in many baseline assessments of French urban plans. To understand why, it is necessary to trace the intellectual and institutional trajectory of form-based thinking within the French planning context.

The emergence of urban morphology as an interdisciplinary field in France was explicitly intended to raise awareness of urban form among planners and designers (Vernez-Moudon, 1997). Despite the academic importance of the French school, best known as "école de Versailles" (Panerai et al., 1997; Panerai et al., 2004), urban morphology was the subject of strong critique from leading voices in the planning establishment (Merlin, 1984). These critiques shaped both academic legitimacy and practical influence, particularly during the 1980s and 1990s (Fusco, 2023). It was only at the end of the 1990s and beginning of the 2000s, within the new agenda of sustainable urban development, that urban form re-emerged in official discourse. The French Ministry of Ecology — also responsible for planning — and various research bodies began to reframe urban form through related themes: densification (Wiel, 1999), walkability and public space use (CEREMA, 2021), and landscape or townscape quality (MEDDE, 2015).

However, the French Urban Code remains relatively ambiguous regarding the integration of urban form in baseline assessments. While the assessment must anchor the plan in demographic and economic trends, it is also required to address landscape — including its forms and perceptions — as well as infrastructure and mobility systems. Densification potential must be assessed "while taking into account urban forms." In contrast, public space, although now central to the objectives of many PLUs, is not explicitly listed as a required theme in the baseline assessment. PLUs must include by law objectives related to the improvement of public space, the promotion of social cohesion, and the spatial coherence of streets, squares, sidewalks, vegetation, and other elements — indicating a growing association between public space and urban form. Yet, at the diagnostic stage, these concerns remain optional or inferred rather than obligatory.

Urbain, SRU) replaced them by PLU, also establishing a minimum quota of social housing in each municipality (Merlin and Choay, 2015).

3 Flexible components of Local Urban Plans (PLU), Orientation and Planning Guidelines (OAP) translate planning objectives into operational and qualitative terms. They may focus on a specific area, a particular theme, or both (CEREMA, 2023).

Within this contradictory framework, a few pioneering local authorities began to address urban form — most often through the lens of public space strategies or densification policies. Lyon took an early lead in both areas: since the 1990s, it has combined urban renewal with the requalification of public space as a structuring tool (Cosnier, 2001). It was followed by ambitious regeneration in Lille and the transformation of Bordeaux into a walkable, design-oriented metropolis, where the quality of public space became a central component of urban marketing. In each case, planning agencies produced studies, charters, and frameworks — often non-regulatory, and not always integrated into PLUs — that nonetheless helped shape local debate.

It is therefore legitimate to ask: to what extent have these form-conscious strategies influenced the baseline assessments of the PLUs in these three cities? This is the central question of the present paper, which also examines how different dimensions of urban form thinking are represented and interrelated within official planning documents.

The remainder of this paper is structured as follows. Section 2 defines the concept of urban form as it will be used in this study, identifying the key components that will guide our analysis of baseline assessments. Section 3 presents our methodology for analyzing planning documents from Lyon, Lille, and Bordeaux. Section 4 reports the results of this analysis. Section 5 offers a comparative synthesis and critical discussion of the findings. Finally, Section 6 concludes the paper and outlines directions for future research and policy development.

2. Framing Urban Form for Planning Analysis

Urban form has long been a subject of debate in urban planning. Several studies have offered critical insights and proposed alternative approaches. Four main perspectives have proven particularly fruitful: the need to go beyond reducing urban form to the urban fabric alone; the view of street networks as dynamic systems, not just mobility infrastructures; the concept of landscape as a way to connect natural and built environments; and the focus on uses—especially public space uses—as key to understanding and designing cities.

In France, Lévy (2005) was among those who most clearly challenged the narrow definition of form in urban morphology. Here, it is often limited to the relations between buildings, parcels, and street grids at fine scales, or to major urban layouts. According to Lévy, these represent only two dimensions—fabrics and structural layouts—whereas urban form is inherently multifaceted and polysemic. Earlier (Lévy 1999), he also criticized the tendency to focus on historic city centers, overlooking vast areas shaped by more recent urbanization.

Configurational approaches to street networks (Space Syntax, Hillier 1996) allow for computational analysis of entire metropolitan areas. But their value goes beyond digital modeling. They offer a new analytical lens—focused on the topological properties of networks in relation to mobility, social interaction, and spatial control. Contrary to Lévy (2005), Fusco (2018) considers the configuration of street networks as an additional dimension of urban form. Space Syntax reverses the usual perspective: it prioritizes the spatial void of public space over the built environment. Yet this focus is not new. Camillo Sitte (1889), an early figure in urban morphology, already placed public space at the heart of his thinking. The novelty of configurational methods is the multi-scale analysis of the complex network of public space in the city.

The landscape approach also deserves attention. Spatial analysis lends itself well to reading both urban (cityscape) and natural/rural (townscape) forms through the lens of landscape. Early urban morphologists drew inspiration from rural geography and its analysis of landscape units—highlighting the intellectual overlap between fields. This overlap is even more evident today, as diffuse urbanization, green and blue networks, and urban agriculture form complex continuums between urban, peri-urban, and rural forms. Capturing this complexity is essential.

A final shift has come from the humanistic turn mentioned earlier. Since the work of Jacobs (1961), Alexander (1977), and Gehl (1971), urban form can no longer be reduced to geometry. What matters is spatial affordance

(Gibson 1979)—how form enables or constrains action, whether in motion or at rest. This refocuses attention on public spaces that are accessible and usable by many, and on the affordances of different mobilities—walking, cycling, or driving. More broadly, it raises the issue of human scale and conviviality, in Illich's sense (1973): urban forms that support autonomous, creative use of space without heavy reliance on technology.

Indeed, Lévy has also outlined other dimensions of urban form: visual and material landscapes (corresponding to the already mentioned landscape approach), the spatial distribution of populations and functions (social morphology), and bioclimatic form—how the physical arrangement shapes environmental phenomena.

All these dimensions of urban form intersect with key planning concerns: housing, socio-spatial inequalities, health, economic development, tourism, retail, energy, risk management, pollution, and more. But this expanded view also brings a risk: turning urban form into a catch-all category, compensating for its earlier reduction to fabric alone. How, then, should urban form be understood?

A good starting point is to examine how urban form is addressed in the baseline assessments of French local urban plans (PLU). Given the diversity of existing approaches, looking at the operational practices of local governments can help reveal both limitations and opportunities, and suggest ways forward.

In this light, and building on the perspectives above, we propose four entry points to analyze how PLU assessments frame urban form:

- **Urban fabrics**, including building typologies—whether analyzed through their historical layers, heritage value, or functional aspects (housing, densification, etc.);
- **Public spaces**, with attention to their qualities, usages and degrees of conviviality;
- **Natural spaces**, as components not only of natural landscapes, but also of urban ones, structured by the ecological connections that link them together;
- **Mobility networks**, including transport infrastructure such as stations, terminals, and parking, which strongly influence both urban fabric and landscape.

Because of their clear intent to develop a more complex understanding of the city—its forms, functions, and uses—the metropolitan areas of Bordeaux, Lille, and Lyon have been chosen for focused analysis. In France, these cities are seen as pioneers in efforts to observe and reshape the city through the lens of public space. The baseline assessments in their local urban plans (PLU) are examined in the following sections, first individually, then comparatively, to identify shared insights and common directions.

3.Analyzing How Urban Form Is Framed in the Baseline Assessments of Local Urban Plans

Our analysis of the baseline assessments (diagnostics) from the local urban plans (PLU) of Bordeaux (2016), Lille (2024), and Lyon (2019) followed a two-phase approach. The first phase consists of a textual analysis of the occurrences of the keywords "urban form(s)" and "morphology(ies)," to understand how these terms are used in the documents (3.1). The second phase involves a deeper reading of the texts to examine how urban form is addressed, even when it is not explicitly named (3.2). For this second phase, we used a conceptual graph as a heuristic tool, structured according to a predefined evaluation grid. This method was chosen for its ability to represent complex interrelations between concepts and their uses (3.3).

3.1.Phase 1: Keyword Occurrence Analysis

The terms "urban form(s)" and "morphology(ies)"—whether singular or plural—appear in all three baseline assessments. For "morphology(ies)," we only considered occurrences related to urban morphology, excluding unrelated uses (e.g. river morphology or household composition).

The table below shows the number and frequency of keyword occurrences in the three documents. Overall, while the absolute number of "urban form(s)" references varies—partly due to differences in document length—the

frequency is similar for Lille and Lyon, but nearly cut in half for Bordeaux. As for "morphology(ies)," it is almost absent from the Lille and Bordeaux assessments, while present in Lyon's.

Table 1 : Occurrences and frequencies of selected keywords in PLU baseline assessments.

	Lille	Bordeaux	Lyon	Total
Page Count	**214**	**190**	**660**	**1 064**
Occurrences				
Urban Form: Forme(s) urbaine(s)	14	7	48	69
Urban Morphology: Morphologie(s)	1	0	20	21
Frequencies (= occurrences / page count * 100)				
Urban Form: Forme(s) urbaine(s)	6,5	3,7	7,3	6,5
Urban Morphology: Morphologie(s)	0,5	0	3,6	2,3

For each occurrence, we identified how the term was defined and what issue or policy domain it was connected to. For example: is "urban form" mentioned in support of densification strategies to limit sprawl and soil sealing? Or is urban morphology discussed in relation to urban greening and climate adaptation? These recurring themes are explored further in section 3.2.

The low frequency—or near absence—of terms directly linked to urban form in some cases confirmed the need for a second phase of analysis.

3.2.Phase 2: Item Analysis Using a Conceptual Grid

To deepen our understanding of how urban form is handled in the three assessments, we developed an analytical grid to extract, describe, and interpret elements referring to urban form and morphology—even when the terms themselves are not used.

The grid is structured around three guiding questions that helped extract and interpret concepts:

1. Content: what is being addressed? What does each assessment actually say about urban form? Are the elements presented in isolation, or are links made between them? While not all assessments address urban form directly, the analysis of fabrics, public spaces, natural areas, and mobility networks contributes to capturing urban morphology in its physical and qualitative dimensions, as previously stated.

Following this logic, Alexander et al. (1977) approached urban form as a set of interrelated elements, giving rise to a "pattern language." Inspired by this, we extracted items related to the core components of urban form—typically discussed as fabrics, public spaces, natural areas, and mobility networks. The goal was to detect the "language" each city might have developed.

We thus followed the anthropological distinction (De Sardan, 1998), between emic and etic perspectives: terms and logical categories used by the surveyed human group vs those used by the researcher. We treated all extracted elements as equally important, preserving the terminology used in the original texts (emic perspective). The researcher's only role was to assign each item to one of the four pre-identified domains.

To go beyond a simple list, we mapped the items and their connections—causal links, composition, association, reciprocal implication, etc.—into concept graphs. Each document produced four such graphs, one per domain. By analyzing the links within and across graphs, we could reconstruct how each assessment implicitly or explicitly

addresses urban form. Items appearing in multiple graphs were duplicated and linked to show identity.

2. Evaluation: are the elements assessed? Does the baseline assessment lead to an explicit evaluation of the various elements it describes? And how does it characterize them? An assessment cannot be limited to a neutral description, a snapshot of existing conditions, or an inventory of features. Beyond mere observation, an evaluation is expected—at a minimum through plain-language judgments, and ideally through a reproducible protocol that can guide public decision-making as part of the PLU development process.

This kind of protocol-based evaluation typically involves either a qualitative or quantitative scale. It may establish a threshold to distinguish what is considered "good" versus "less good," or define minimum or maximum standards that help assess how far the current state of the space deviates from an ideal or target condition. Evaluation, in this sense, depends on the reference framework adopted, which is itself chosen to focus and structure the diagnostic process.

For each element extracted from the baseline assessments, we therefore recorded whether it was subject to an explicit evaluation and whether this evaluation was framed in positive or negative terms. In doing so, we aimed to understand not just what is observed, but also how it is valued—what is considered desirable or problematic within the documents.

3. Spatialisation: are the elements mapped? Are the elements spatially located, and if so, how are they represented cartographically? Spatialization—especially through maps—is a powerful tool in planning, particularly during diagnostic phases (Debarbieux and Lardon, 2003; Lascoumes, 2007). It enables a transition from isolated evaluations to a spatial overview that reveals patterns, which can be recognized as strengths of weaknesses.

Urban form is inherently spatial and scale-dependent. Smaller-scale forms combine to create larger ones. For instance, mapping the walkability of public space at a fine scale can show whether pedestrian-friendly corridors create a coherent network across the city (Mezoued, 2020).

To assess spatialization, we noted whether items were mapped, whether the spatial granularity was coarse or fine, and whether maps used full choropleth coverage or focused on specific zones.

These three criteria—content, evaluation, and spatialization—form the analytical grid through which we read and interpreted the three baseline assessments. To make the results of this analysis more legible and comparable, we translated the grid into a visual format, using a standardized legend (Figure 1) to guide the construction of the graphs. This graphical coding system allowed us to represent, in a consistent way, how each element was addressed in the documents across the different dimensions of analysis.

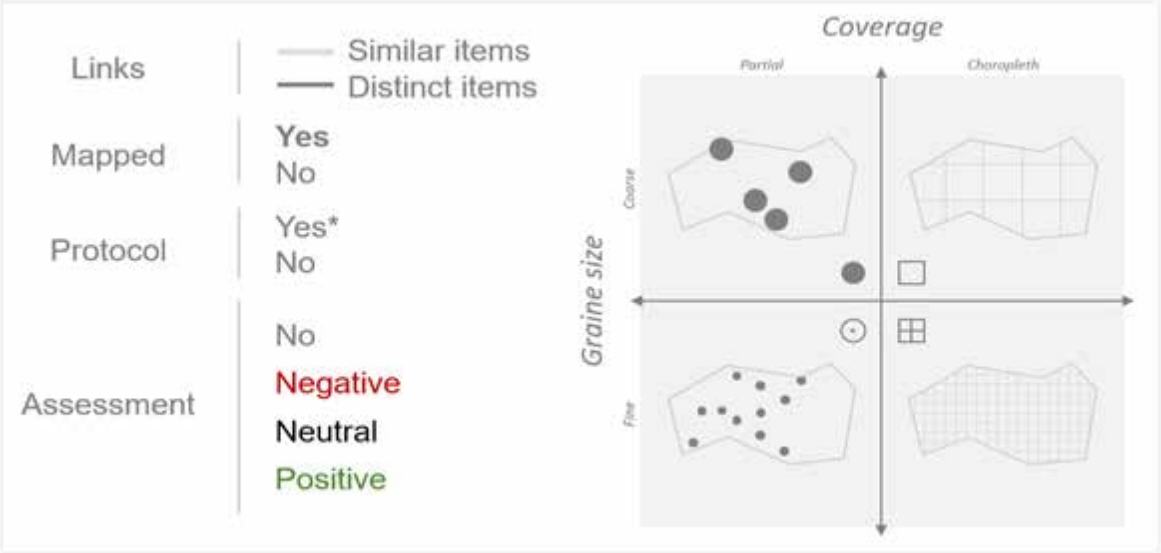

Figure 1 : Constitutive elements in the legend of graphs

This graphical language was used to produce the concept graphs presented and discussed in Section 4. The graphic representation is a heuristic visual method: graphs serve both as visual summaries of dense textual material and as tools for analysis. In short, drawing the concepts helped us understand them. These graphs aim to make visible—however imperfectly—how urban form is perceived and addressed in each document.

3.3.Concept Graphs: Strengths and Limits

It's important to clarify what the graphs represent. They do not depict the actual urban systems of the cities, nor do they reflect the full knowledge of local authorities. Instead, they show how the assessments express their understanding of urban form—filtered through our own reading.

For example, while there is a clear link between parking and public space usage, if that link isn't made explicit in the document, it's not shown in the graph. That doesn't mean authors are unaware of it—only that it wasn't articulated.

These results reflect only what is in the texts. A richer understanding would require complementary methods such as interview-based discourse analysis—a promising direction for future research. Very recently, (semi-)automated methods have been developed in this direction, such as those by Salazar-Miranda and Talen (2025) or Arlati and Nagel (2025). However, these methods do not offer a nuanced analysis of grammatical relationships between words or of evaluative and mapping modalities as we do here

Another limitation lies in the nature of the graph itself. It's built incrementally, item by item, and the overall picture may not match how the authors see the subject. In reality, different sections of the assessments are often written by separate teams (in-house or outsourced), coordinated by project managers and steering committees. The graph is thus a reconstructed vision of fragmented statements. It may not reflect a shared consensus among all contributors. It is a partial and situated representation of how a city presents and positions itself on the topic at a given moment.

A final challenge arises from the distinction between items and labels—that is, between the underlying concept (which is general and abstract) and the specific terms used to refer to it. For instance, labels such as "motorway system," "highways," or "major automobile corridors" all refer to the same broader concept: large-scale mo-

bility corridors. Beyond the practical issue of choosing which label to use when adding an item to the concept graph—should it be the most frequent, the most intuitive, or the most precise?—this raises the deeper problem of conceptual ambiguity. That is, how clearly defined is each concept being represented? And how do we deal with the grey areas between similar terms? This is a common difficulty in terminological or ontological approaches (Roche and Papadopoulou, 2020): how do we strike the right balance between grouping together different expressions that refer to the same thing, and avoiding the mistake of merging two distinct concepts just because they sound similar or are used interchangeably?

To manage these issues, we applied a few guiding principles. First, we started from a list of concepts drawn from the academic literature, but remained open to including more specific terms found in the actual planning documents. Second, we kept the original labels (in French) used in the documents, as noted earlier. Third, in constructing the graphs, we prioritized the most commonly used label in each document, to remain consistent with an emic approach—one that reflects the internal logic and language of each local case. This also allowed us to highlight semantic differences between the ways different cities refer to similar concepts, and to make these variations visible in the resulting graphs.

We deliberately chose not to build a full formal ontology, despite the many advantages such a method offers (Keita et al., 2008). In our case, that approach would have flattened the diversity and complexity of the documents we analyzed. Like a palimpsest, these texts carry meaning not only through what they say clearly, but also through their ambiguities, contradictions, and contextual nuances. A formal ontology would risk stripping away those layers and undermining the richness of the source material.

4.Understanding Urban Form in the Metropolitan Areas of Lille, Bordeaux, and Lyon

Following the corpus analysis protocol described above, this section aims to examine the content of the Local Urban Plan (PLU) for each of the selected metropolitan areas, before outlining comparative insights in the next section. Initial observations based on the analysis of textual occurrences are followed by broader and more in-depth reflections drawn from the infographic representation approach using graphs.

4.1.The Lille Case: A Systemic Vision Structured around Core Items, with human uses as the Guideline

In the baseline assessments section of Lille's Local Urban Plan , the term "urban form(s)" (forme(s) urbaines) is primarily mentioned within the typology of urban fabrics developed by Lille's urban planning agency (ADULM, 2017a). This work was carried out in preparation for evaluating the optimization potential of these same fabrics (ADULM, 2017b), in compliance with legislation requiring PLUs to analyze the potential for densification and transformation of all built-up areas, taking into account both urban and architectural forms[4]. A connection is also made with the 2021 Climate and Resilience Act, which sets the Zero Net Artificialization aim (ZAN) by 2050[5]. In this context, the typology proposed by the Metropolitan Authority of Lille (MEL) has the merit of presenting a wide range of urban fabrics at a fine level of granularity—namely the parcel—across the entire administrative territory of the metropolis. However, some aspects are debatable: only a functional approach is used to define fabric types (primarily based on building use), and the classification does not take into account the relationship between buildings and public or open spaces, nor with their broader environment. The concept graph allows to go beyond the limited view of urban form conveyed by these textual occurrences.

Overall, the graph extracted from the text is structured around a few main "core items"—that is, words that hold the most connections with other items—such as metropolis (métropole), major roadways (axes routiers majeurs), parking (stationnement), waterways (voies d'eau), public space (espace public), hemicycle (hémicycle), and fabrics (tissus). The four domains we identified as essential for understanding urban form in a PLU baseline assessments are all represented, though disparities in treatment are evident. There is a lower density of items in the domain of public spaces, and conversely, a higher density in the domain of urban fabrics. These core items are most often

4 Article L151-4 (2022) of the French Urban Code (2025), which frames the content of a Local Urban Plan (PLU).

5 This law prohibits the artificialisation of new agricultural, natural, or forested areas by 2050, requiring municipalities to turn to other urbanisation processes such as densification, renovation, or rehabilitation (Vie publique, 2023).

evaluated and more rarely mapped. They link to a wide range of peripheral items, mostly shown in grey—meaning they are neither evaluated nor mapped.

Moreover, the numerous cross-domain references and relationships reflect a systemic vision of the Lille metropolis. For instance, the hydrographic network (réseau hydrographique), located at the bottom right of the graph, highlights the relationship between built and natural elements through the development of riverside walkways (promenades). Another example is suburban expansion, in the top left of the green cluster dedicated to landscape, which connects with the domains of public spaces and urban fabrics.

In terms of evaluation, lengthy descriptions often accompany the items, sometimes leading to textual assessments. These evaluations are relatively evenly split between positive and negative observations, with some intermediate cases as well. Few evaluations follow a standardized protocol; they typically consist of simple ratios to the population size, followed by comparisons with other French metropolitan areas as part of a benchmarking approach. For example, the total length of the cycling network is compared with that of other major cities. Similarly, parking provision is ranked in comparison with other large French urban areas. This reflects the broader strategy of metropolitan competitiveness observed in France, where each metropolitan authority seeks to highlight its strengths and uniqueness to support its attractiveness.

Finally, some key elements are treated in a particular way.The document provides an in-depth analysis of two main elements. First, the typology of urban fabrics, which accounts for most of the fine-grain maps in the diagnostic, even though these do not undergo a systematic or protocol-based evaluation. Despite the density of items and relationships in this domain, the star-shaped structure of the graph shows few links between the different types. This suggests an image of the city as a juxtaposition of fabric types, rather than an integrated assembly of subtypes forming a complete urban fabric. Second, the notion of centralities (centralités) is also subject to in-depth analysis, again conducted by the Lille urban planning agency. Entirely addressed in a dedicated chapter of the diagnostic, this approach is functionalist: various levels of concentration of functions are identified as centralities based on the availability of amenities and services within a 500-meter grid. The centralities item, located in section of the graph dedicated to public spaces, also demonstrates Lille's ability to conduct inter-domain analyses: it links the domain of public spaces with those of mobility and landscape.

To conclude, two final points should be highlighted, as they cut across the four domains and, more broadly, the entire diagnostic.

The issue of human uses appears throughout the document, across the sections—particularly in relation to public spaces, centralities, and networks. Although not fully developed, this approach has the potential to recognize usage as an essential element of any urban baseline assessments, whether focused on urban form or not.

Lastly, and it's an important point for us, at the neighborhood or city scale, the Lille diagnostic acknowledges the importance of the street as a key component of urban form. Seen as a building block of public space and a support for human uses, particularly "mobility, commerce and dining, socialization and exchanges between neighbors..." (p. 201, PLU). The street acts as a link between the domains of urban fabric, public space, transport, and amenities, though it is worth noting the strong emphasis placed on mobility and transport.

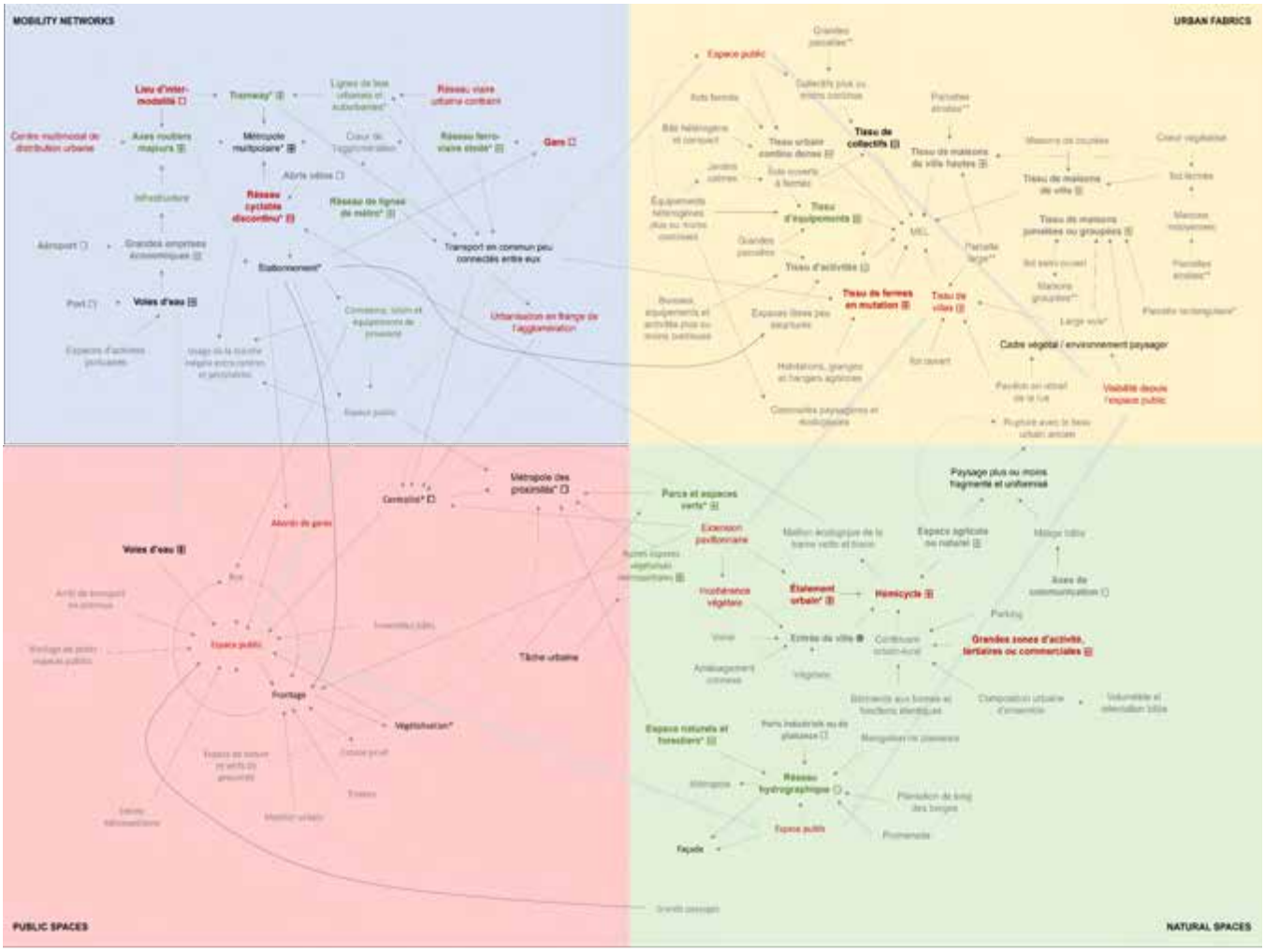

Figure 2: graph of Lille

4.2.The Bordeaux Case: A Diagnostic Rich in Challenges, but Lacking Spatialization and Systematization

In the diagnostic of the PLU for the Bordeaux metropolitan area, analysis of the occurrences of the term "urban form(s)" (forme urbaine) reveals that, as in Lille, the concept is primarily linked to the domain of urban fabric. However, when considering the broader context of its use, some nuances emerge, as these occurrences are associated with a variety of challenges (enjeux). Indeed, these fabric types are mainly discussed in relation to their density, organization, or broader environment: "fairly dense urban form" (p. 61), "urban form with scattered buildings" (p. 77), "low-compactness urban forms" (p. 35), or "surrounding urban forms" (p. 91). Urban fabrics are not viewed in isolation, but rather in relation to their surroundings—particularly for reasons of landscape and heritage coherence. There is also the question of densifying these fabrics in the context of "urban recycling and renewal," to use the terms of the diagnostic. Finally, unbuilt, impermeable, and green spaces—whether public or private—are included in the analysis of the urban fabric as supports for various uses, contributing to a high-quality living environment and human health. They are recognized for their potential to support "soft mobility, sports, relaxation, education, social interaction..." (p. 35).

However, no systematic analysis of the urban fabric or public spaces appears in the PLU of the Bordeaux metropolitan area, despite two notable studies produced by its urban planning agency.

The first is a document from 2008, related to the former PLU, which presents a zonal typology of the metropolitan space. This is a morpho-functional typology broken down into four main categories (heritage fabrics, collective

housing fabrics, suburban fabrics, and economic activity and facility zones) and 21 types. It identifies potential metropolitan centralities and assesses the quality of the living environment, in which public spaces link built forms with major landscapes. Combined with other variables, this typology was later used to create a mapped evaluation of urban heat island risk levels (a'urba and Alec, 2019).

The second is a collection of maps of public spaces in the Bordeaux metropolitan area, produced by the urban planning agency in 2015. Urban forms are analyzed through various lenses (bioclimatic, social, urban fabric), with public spaces as the keyline: alignment of building fronts with the street, relationship between facilities/functions and public spaces, form of transportation networks, integration of waterways and urban parks into the green and blue infrastructure, etc. With a 500-meter grid, this abundance of maps covers the entire metropolitan territory, is the result of a structured methodology, and occasionally includes cross-evaluations.

Although these notable works are nowhere to be found in the current PLU Baseline assessments of the Bordeaux metropolitan area, the concept map produced nonetheless reveals a relatively systemic vision of the metropolis in its understanding of the territory, with a high density of connections between items across different domains—mainly between those related to transport, urban fabric, and urban landscapes. However, there are significant disparities between the domains. While mobility and natural spaces are the focus of entire chapters, the domain of public spaces seems largely neglected. The domain of urban fabric suffers from the absence of a typo-morphological analysis comparable to Lille or Lyon. Unlike Lille, the core items are less obvious; although some, like rail and road infrastructure (infrastructures ferroviaires et routières), street mesh (maillage viaire), public space (espace public), and hydrographic network (réseau hydrographique), do stand out. Another possible interpretation is that this reflects a broader and more systemic approach that assigns equal value to all the components of urban spaces.

Evaluations are generally scarce. The few existing protocols are similar to those found in Lille—simple and comparative. The limited evaluations that are provided are expressed in textual form, but they are relatively balanced between negative, intermediate, and positive assessments. Maps are also less frequent, and most are either produced at a coarse granularity or cover only part of the metropolitan area.

To conclude, three more targeted reflections emerge from the analysis of the Bordeaux diagnostic.

Despite the interesting approach mentioned earlier regarding the connection between urban fabrics and planning challenges, the observations remain fundamentally focused on the city of Bordeaux itself, omitting the rest of the metropolitan area. Moreover, the document provides figures with limited spatial context, indicating only a specific municipality or vaguely referring to the west or east of the river, which hinders a more rigorous analysis of urban fabrics and a systematic reflection on their potential for densification.

Secondly, the PLU acknowledges both the environmental and social qualities of the green and blue infrastructure. On the one hand, it presents a wealth of descriptive information on biodiversity and the state of ecosystems within the administrative perimeter of the metropolis with items such as wetlands (zones humides), landscape entities (entités paysagères), ecosystems (écosystèmes), and ecological heritage (patrimoine écologique). On the other hand, it recognizes the human uses of this green and blue meshes (trame verte et bleue), such as green and local loops (boucles vertes et locales).

Finally, a specific reflection is dedicated to public facilities (educational, healthcare, sports, cultural, tourism, and leisure). The authors recognize their role in metropolitan attractiveness, but once again the spatial dimension is underdeveloped. The evaluation is carried out solely through comparisons with other metropolitan areas, and by calculating the equipment ratio.

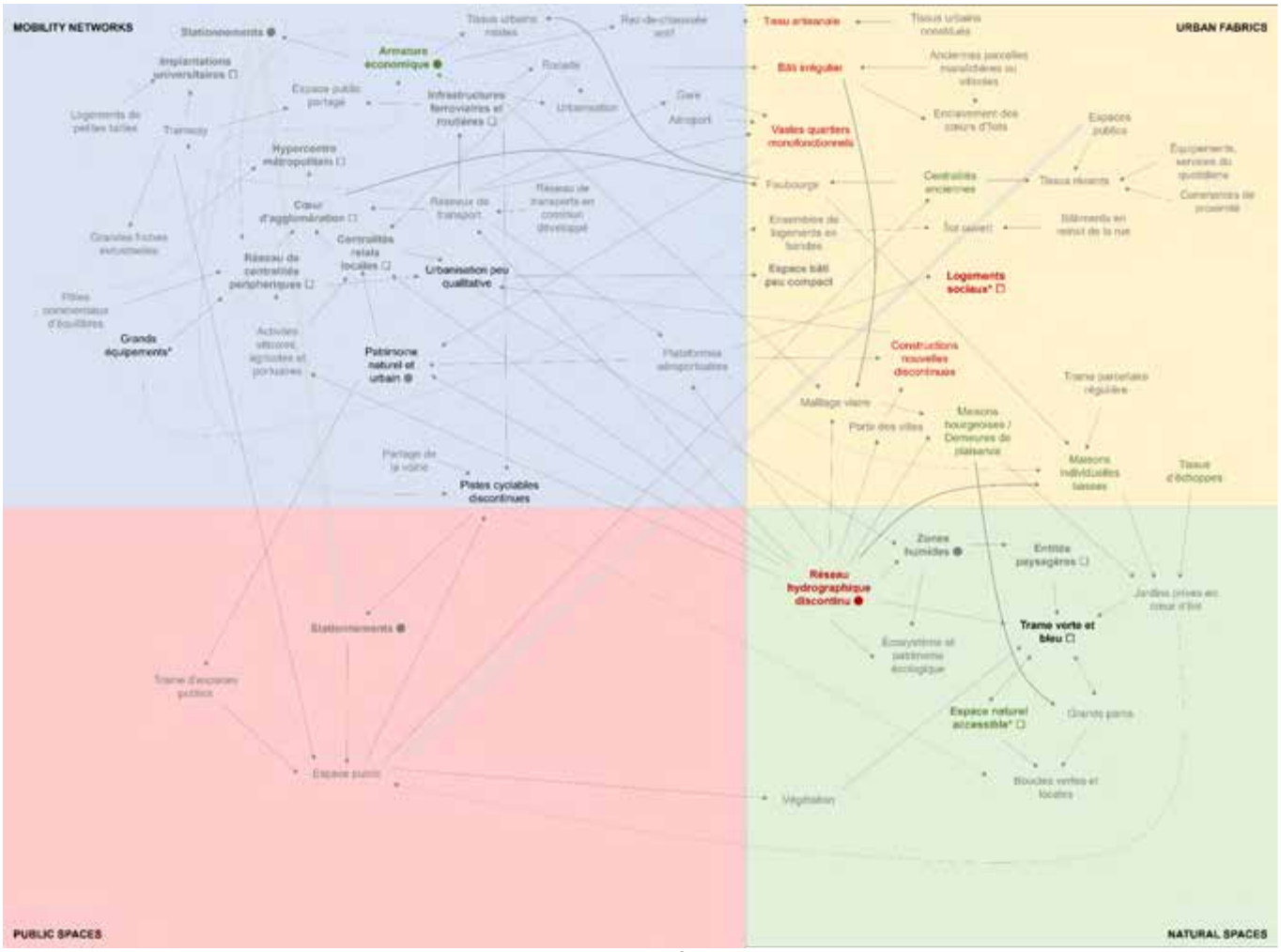

Figure 3: graph of Bordeaux

4.3.The Lyon Case: An Apparent Siloed Vision saved by the Underlying Role of Public Spaces

In the diagnostic of the Lyon metropolitan area's PLU, the terms "urban form(s)" and "morphology(ies)" refer once again primarily to the typology of urban fabrics (27 mentions)[6], or to the architectural characteristics of buildings (23), and to a lesser extent, to the spatial organization at the neighborhood scale (7). Produced by the Lyon urban planning agency, this typology of urban fabrics—first introduced in the 2005 PLU—covers the entire administrative territory of the metropolitan area with a granularity between the block and the neighborhood. Its morpho-functional approach provides a relatively comprehensive reading of urban fabrics, including highly vegetated, natural, or agricultural areas. Moreover, the proposed typology takes into account the relationship between built and unbuilt spaces, as well as a criterion of spatial homogeneity. However, no detailed information is provided on the methodology used to combine all variables and produce the resulting typology.

The treatment of urban fabrics is primarily based on the architectural characteristics of the buildings that compose them (17 mentions). Occasionally, their analysis is linked to issues of heritage (8), landscape (4), and densification (5) or housing typologies (collective, individual, and suburban) (4). Quality of life (3), centralities (2), and urban functions (2) are also addressed. Other topics are mentioned only once, such as the consistency and integration of buildings with their environment, greening, the fight against urban sprawl, and the articulation between built forms and public spaces.

6 It's the document that contains the highest number of occurrences of the targeted expressions (Table 1). Consequently, in the case of Lyon, it becomes relevant to report the number of occurrences—something that was not done for the cases of Lille and Bordeaux.

The Lyon metropolitan area presents a segmented image of the diagnostic, which is reinforced by the structure of the document itself: it first addresses natural spaces, then transport, and finally urban fabrics and landscapes—these forming the first three chapters of the document. Public space does not have a dedicated chapter, yet it plays an important role, as the concept map demonstrates.

Although the map is dense in items and relationships, interrelations between domains are rare and of highly uneven nature and density. Only a few cross-domain relationships are observed—for instance, the item shared public space (espace public partagé), which links the transport domain with public spaces, or urban nature network to be developed (réseau de nature en ville à constituer) , which connects the landscape domain to many items from the urban fabric domain –although these latter are not subsequently linked to other items. However, this relative independence among the different domains is mitigated by the role of public space, which subtly links them in the background.

Finally, beyond inter-domain relations, other core items structure the overall concept map—similar to the case of Lille: infrastructure mesh (maillage d'infrastructures), polycentric metropolitan areas (métropole polycentrique), public space (espace public), different types of urban fabrics, and the green and blue meshes (trame verte et bleue). These items are frequently evaluated and mapped, generally forming clusters of related items around them.

In the case of Lyon, no formal protocol is followed by evaluation of the different items. With a majority of intermediate cases, these evaluations are sometimes positive, more rarely negative. The authors aim less to deliver evaluations and more to identify challenges, which results in a more neutral stance throughout the baseline assessments. These issues are revealed through lengthy descriptions, with varying degrees of quantification and quality—particularly concerning urban forms.

As for mapping treatment, urban fabrics and natural areas are mainly represented through choropleth maps at a fine grain size. The domain of public spaces lacks any map, and the items related to it are systematically interrelated with items from other domains. In the case of transportation, maps vary in both coverage and grain size. Among the specific considerations regarding the approach employed by the Lyon metropolitan area, the treatment of urban fabrics, public spaces, and uses deserves particular attention.

The domain of urban fabrics is structured as a constellation, similar to the case of Lille. Numerous connections exist between the various components of the fabric types, such as historical axes (axes historiques), plots (parcelle), vegetation (végétation), or public spaces (espaces publics), leading to this in-between state. Presented as a morpho-landscape typology, it places significant emphasis on the role of vegetation in defining urban fabrics, and—albeit to a lesser extent—on public space, notably through the item of the street (rue). As shown in the graph, the street is recognized as an organizer of the building on the plot, creating visual links with the built and natural heritage.

The domain of public spaces is a triple-star constellation. Its numerous links to other domains reveal this concept as the backdrop of the entire baseline assessments. Public space is considered both as a component of urban fabrics linked to items such as: plots (parcelles), blocks (îlots), streets (rues), inner-block gardens (jardin en coeur d'îlot), frontages, etc., as a primarily shared space (illustrated through items such as sidewalks (trottoirs), pedestrian crossings (traversées piétonnes), parking (stationnement), public transport (transports en commun), car (voiture), soft mobility (mobilité douce), etc., and also as a space encompassing natural areas (as demonstrated by connections to items like green and blue meshes (trame verte et bleue), vegetation potential (potentiel de végétation), and built and natural landscape heritage (patrimoine bâti et naturel), for instances.

Finally, the topic of uses takes a much more prominent role than in Lille's baseline assessments, and even more so when compared to Bordeaux's. However, their treatment remains relatively vague and indirect in relation to

urban forms, becoming apparent primarily when parks and natural spaces are discussed.

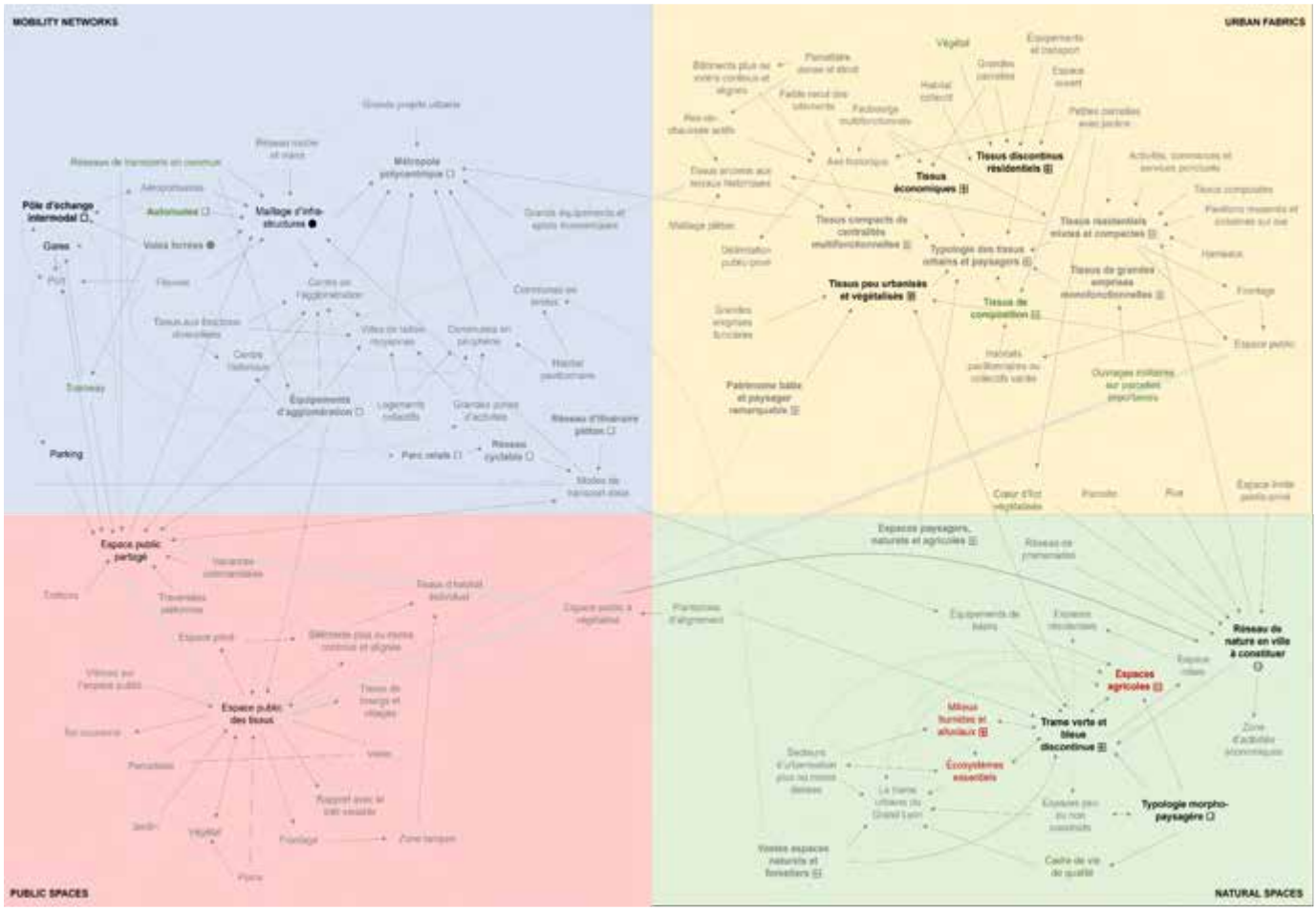

Figure 4: graph of Lyon

5.Urban Form in PLU Baseline assessments: A Relatively Systemic Vision, with Limited Protocols and Mapping under a Constraining Context

The analysis of PLU baseline assessments from the three selected metropolitan areas highlights specific observations for each case. Lille shows an approach to urban form through a few key concepts. Bordeaux demonstrates a wide reflection on urban space and its issues, but this momentum is hindered by insufficient methods for evaluation and spatialization. Finally, Lyon reveals a more siloed approach to diagnostics, but one that has the merit of recognizing public space as a foundational element of urban form, linking the various components. Beyond the specificities of each metropolitan area, broader reflections can be drawn about how urban forms are understood in France in PLU baseline assessments—insights that can also inform approaches developed in other French cities.

In general, when PLU authors refer to urban forms and morphologies, it is mainly to describe types of the urban fabric, buildings, or housing types. This reflects a broader trend in France to reduce urban form to the materiality of the built environment—an approach that overlooks key contributions already established by Italian typomorphology since the 1970s, which emphasized the broader context of urban form, including urban history and everyday uses. It also ignores the more recent developments brought by configurational approaches such as Space Syntax.

However, the creation of graphs—extending beyond what is conventionally referred to as "urban form"—broadens the definition to include a wider set of spatial registers, which are present in the baseline assessments and are variously linked to the narrowly defined issues of built-up forms. It is thus interesting to note that the analyzed metropolitan areas demonstrate both the intent and the capacity to grasp urban spatiality through a variety of elements beyond the built form. Yet this promising openness is not consistently supported by a rigorous and systematic methodology.

A transversal reading of the three graphs also reveals a similar treatment of the four domains selected for analysis. Three of the four—mobility networks, urban fabric, and natural spaces—proved to be well aligned with the contents of the diagnostics. Public spaces, however, suffer from the absence of a dedicated analytical section, even though they are consistently addressed across the other three domains, even linking them. Public space can serve as the guiding thread, as in the case of Lille, or as a background theme connected to the issue of uses and feeding into the characterization of urban form, as seen in Lyon.

Among the background elements present in the baseline assessments, human uses also emerge, though they are treated in a more superficial way. They are more often associated with transport and natural spaces, while their connection to the urban fabric—and more broadly to urban form—is only vaguely addressed. No diagnostic attempts to spatialize these uses, unlike many anthropological or sociological studies that examine how frequently and in what ways residents use public space (Gehl and Svarre, 2013). Even urban planning agencies have started addressing such issues: studies on children's presence in public space (a'urba, 2021), or on gendered and socio-economically differentiated mobility (urbalyon, 2021), have recently appeared.

Finally, the three graphs follow more or less general structures—star, constellation, lattice. They also rely on a variety of "core items" that are surrounded by numerous peripheral items, reflecting how the diagnostics are conducted. The texts unfold linearly, presenting the elements considered important by the authors: urban fabric, green and blue networks, transport systems, and so on. However, each diagnostic also features rich cross-domain connections, revealing a degree of systemic vision that these metropolitan areas nonetheless have of their territories.

Evaluation is generally rare and lacks standardized protocols. Scientific methodology traditionally involves building a reproducible protocol, applying it with appropriate adjustments to produce results, interpreting those results, and then offering an assessment. Here, however, the diagnostics bypass this effort, providing a series of qualitative evaluations in natural language without formal procedures. There are a few exceptions: the rare existing protocols rely on counts, quantified inventories, or simple calculations (e.g., equipment ratios, volume), enabling comparisons with other metropolitan areas.

One would also expect these protocols to be followed by proper evaluations, but there seems to be a disconnect between the two stages. Instead of evaluation, the notion of challenges (enjeux) is often preferred—intellectually richer but less demanding in terms of method and vague in spatial terms. Without being qualified and spatialized, challenges remain vague in terms of assessment,and spatial delimitations, strengths, or areas for improvement are neither clearly recognized nor encouraged.

As for cartography, it remains rare, thematically and compositionally variable in style. Three domains favor mapping: transport, urban fabric, and natural spaces—especially green and blue networks. These maps are usually choropleth. When not, they tend to highlight only major instances of a given item or focus on a limited area within the broader metropolitan perimeter. As mentioned previously, these maps are almost always descriptive or indicative, rather than evaluative. The distinction lies in the fact that it is possible to map existing elements (e.g., road layouts or hydrographic networks) without illustrating the quality of those spaces.
In the French professional literature, a few examples of such evaluative cartography do exist: maps of wide sidewalks with or without vegetation in the Lille metropolitan area (ADULM, 2017c), or maps showing areas with

sufficient or insufficient public space density in Bordeaux (a'urba, 2015). These maps are valuable because they help precisely locate and assess areas requiring intervention, or conversely, areas to preserve or enhance. However, these cartographic outputs produced by urban planning agencies are not found in the PLU baseline assessments, raising broader questions about the relationship between metropolitan authorities and their planning agencies in the development of Local Urban Plans.

In conclusion, one final point is essential to situate the considerations we present here regarding the quality of PLU baseline assessments. Our analysis is based on an initial assumption: we argue that a diagnostic should mobilize multidimensional content with a systemic vision, follow structured protocol evaluations, and spatialize analysis results using fine-grained choropleth mapping. However, questions arise concerning the predefined objectives set by the authors of these baseline assessments at the time of their drafting. The criteria and objectives we propose here are not necessarily those of the authors: while PLU baseline assessments are a regulatory requirement in urban planning, the methodology used in their preparation and the outcomes they are expected to achieve remain unclear. Moreover, it is important to recall that PLUs are short-term planning documents, subject to electoral calendars and political pressures. They are heavy documents, produced in institutional and political contexts that can be unstable or conflictual. In addition, the skills, time, and resources available for their development can vary widely, which may partly explain the scarcity of evaluation protocols and maps. Therefore, our considerations should be understood more as suggestions—an invitation for planning authorities to broaden their perspective on urban form, beyond the built environment—and as reflections that could, at a later stage[7], lead to an alternative method for approaching urban form in a more systematic way.

6.Conclusions

In general, the analysis of baseline assessments documents reveals that French metropolitan areas share a common vision: cities of high quality, accessible to pedestrians and public transport users, with efficient and safe mobility, pleasant public and natural spaces, and a good diversity and density of services, amenities, and local functions. However, this shared ideal does not lead to a unified reference model applicable to all cities. While similarities exist, each territory develops its own approach to conducting territorial diagnostics. This allows for an appreciation of local specificities, but also makes it difficult to establish a collectively recognized framework and methodology for understanding and analyzing urban spaces.

In this context, the understanding of urban form in France remains largely confined to a typo-morphological approach, based on the architectural and functional qualities of the built environment. While this perspective is valuable for identifying and distinguishing the urban fabrics that make up different territories—and for ensuring protective attention to built heritage—it overlooks a more complex vision and a rigorous methodology capable of integrating the various elements that constitute and animate urban form.

The ambition of the research project underlying this article is precisely to propose urban form—as long as it is approached in a systemic and protocol-based way—as a coherent and rich method for producing meaningful and comparable territorial baseline assessments at the national scale. The development of a reference urban model goes beyond existing legislative objectives, such as the Zero Net Artificialisation (ZNA) target (Climate and Resilience Act, 2021), or mandatory quotas of social housing (SRU Law, 2000). While we acknowledge that these objectives are closely related to urban form and have implications for other contemporary urban planning issues, these are often addressed independently within diagnostics.

Our hypothesis is that urban form, if properly conceptualized, constitutes a strategic dimension through which the material, social, and politico-economic dynamics of urban spaces can be more effectively understood, spatialized, evaluated, and finally acted on. Moreover, developing an urban model that integrates a vision of the desired forms of the city—and their connection with the various objectives of urban planning—should also enable

7 This contribution forms part of the early stage of Grégoire Picard's doctoral research, the article's first author, whose ultimate objective is to propose a new method for understanding urban form within the beeline assessments sections of Local Urban Plans (PLU) in France.

the production of more evaluative baseline assessments. Not merely descriptive overviews, but differentiated spatial assessments across the metropolitan area, identifying what aligns most or least with the intended goals.

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Track 11

EMERGING TECHNOLOGIES

"Love the Specific Scene of Life": A Visual Analysis of User-Generated Narratives on Walkable City Spaces

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Abstract
The increasing convergence of technology and media interactivity continues to shape novel urban landscapes and social connections, catalysing the emergence of place in media and the phenomenon of "Wang Hong urbanism". This research investigates urban aesthetic appeal in the digital era through analysis of photographs posted on the social media platform Douban under #CityWalk, utilising a deep learning scene recognition model with Class Activation Mapping. The visual content analysis established three primary categories: natural landscapes, built structures, and human presence. This classification framework illuminates how distinct aesthetic elements are emphasised in user-generated urban representations. The findings demonstrate how pedestrians reconstruct their perceptions of walkable urban spaces through social media engagement, whilst providing insights into contemporary urban tourism within the context of Wang Hong's urbanism.

Keywords: Citywalk, wanghong urbanism, social media, urban design

1. Introduction

In recent decades, urban China has witnessed a significant shift in leisure patterns, marked by increased free time and disposable income among city dwellers. Despite these changes, the range of daily leisure activities has remained relatively constant (Newman et al., 2014). Within this context, walking has emerged as a universally appealing leisure pursuit, transcending age barriers and offering an accessible, cost-effective, and flexible form of physical activity. This rise in urban walking not only reflects changing lifestyle preferences but also represents a unique form of engagement with the city itself. As previous research notes, walking serves as a powerful medium through which individuals interact with and interpret urban heritage, embodying qualities that are at once grounded in place, performative in nature, and potentially transformative in impact (Middleton, 2018).

Jan Gehl (1987) highlighted that optional and social activities, particularly non-purposive recreational pursuits, are more sensitive to the built environment than necessary activities, offering rich opportunities for shaping urban spaces. This insight has gained renewed relevance in the post-pandemic era. Since the World Health Organization declared the end of the pandemic in May 2023, there has been a noticeable shift in people's preferences towards "high-quality" travel and leisure experiences, often beyond conventional tourist destinations (Lehtinen and Vihanninjoki, 2020). In the wake of this global tourism resurgence, localities worldwide are striving to position themselves as objects of the tourist gaze (Zheng et al., 2024). This trend marks a significant shift in urban identity: cities are no longer content to be merely centres of production or symbols of power, but increasingly seek to reinvent themselves as sites of entertainment and leisure (Zhang et al., 2023). Consequently, urban environments now serve a dual purpose - as aesthetic objects and as crucial venues for recreational activities (Li et al., 2024)there is currently limited attention given to related research. Based on this, the study focuses on Jinshan Park in Fuzhou City, Fujian Province, China, to investigate the relationship between landscape features and the coexistence of landscape aesthetics and recreation values of urban parks. The research employed field observations and questionnaire surveys to assess the landscape aesthetic and recreational values of urban parks and explore their coexistence. Additionally, semantic segmentation and other methods were introduced to quantify landscape features. Linear regression analysis was then applied to further examine the impact of landscape features on the landscape aesthetic and recreational values in urban parks, as well as their coexistence. The results revealed: (1. This dual role of urban spaces underscores the importance of balancing aesthetics and functionality. A space that prioritizes only utilitarian functions while neglecting aesthetic considerations would likely be perceived as uninteresting (Li et al., 2024)there is currently limited attention given to related research. Based

on this, the study focuses on Jinshan Park in Fuzhou City, Fujian Province, China, to investigate the relationship between landscape features and the coexistence of landscape aesthetics and recreation values of urban parks. The research employed field observations and questionnaire surveys to assess the landscape aesthetic and recreational values of urban parks and explore their coexistence. Additionally, semantic segmentation and other methods were introduced to quantify landscape features. Linear regression analysis was then applied to further examine the impact of landscape features on the landscape aesthetic and recreational values in urban parks, as well as their coexistence. The results revealed: (1. Therefore, maximizing the synergistic interplay between the aesthetic and recreational values of urban spaces has emerged as a critical focus for urban research and design. This approach not only enhances the appeal of cities for tourists but also improves the quality of life for residents, creating environments that are both visually pleasing and functionally enriching.

On the other hand, there has been a growing emphasis on the quality of leisure activities among the public (Wu, 2023). "City Walk," an emerging travel mode, has gained particular popularity among younger generations due to its focus on "nearbyness"(Xiang, 2021) and authentic experiences. In the digital age dominated by social media, the advent of geomedia has transformed the traditional urban walking experience, creating a dynamic interplay between physical cityscapes and digital representations that allows individuals to engage with urban spaces in unprecedented ways, blending personal narratives with collective urban exploration (McQuire, 2017).

Previous research has identified several factors influencing leisure walking, including built environment features, leisure facility provision, walkability, and land use diversity (Bayar and Yılmaz, 2023; Jian et al., 2020; Wang and Yang, 2019). Walkability encompasses environmental features, outcomes fostered by walkable environments, and serves as a proxy for better urban design (Forsyth, 2015). While extensive research exists on walking tours in tourism and urban morphology from a top-down perspective (Giddy and Hoogendoorn, 2018; Wan, 2023)this exploratory study examined the stimuli that triggered tourists to take a casual walk in an urban tourism setting, whether and how these stimuli interacted, and how the stimuli evoked the tourists' emotions, experiences, and responses. Macao (China, there's a lack of understanding of city walkers' preferences in everyday urban settings. The interaction between urban landscapes, particularly socio-cultural landscapes and built environment elements, and this emerging leisure activity of city walking remains unknown.

In light of this, this study aims to capture and collage the multidimensional experiences of walkers from the landscape of visual accumulation (spectacle), revealing how they encounter, interpret, and present the urban environment. We seek to understand the relationship between landscape elements and aesthetic values during their recreational city walk behaviours in urban settings. This study will provide new perspectives for urban planners, policymakers, and marketers to better understand and promote vibrant interactions with urban daily life.

2. Literature Review

2.1 Wang-hong Urbanism: A Geomedia Perspective

In 18th century Europe, painting was the primary medium for landscape dissemination, giving rise to the picturesque aesthetic. Subsequently, the advent of photography, development of mass media, and widespread transportation contributed to the flourishing of mass tourism and popularization of photo-op spots in scenic areas (Adams, 2009). Since the early 21st century, advancements in geographic information technology have strengthened the connection between media and physical space, promoting research and development in media geography. The widespread adoption of digital technologies, particularly social media platforms that facilitate the sharing of text and images, has transformed how individuals document and share their daily experiences, creating a vast collection of digital data that serves as a powerful medium for communication. Against this background of geomedia (McQuire, 2017), the contemporary urban experience is characterized by a simultaneous engagement with both physical environments and digital media, offering new perspectives on the multifaceted nature of everyday life (Zook and Graham, 2007). Contrary to initial concerns, research suggests that the advent of digital communication technologies has not replaced local community connections but rather enhanced them, fostering a stronger sense of belonging among users (Boy and Uitermark, 2017). The urban landscape is now shaped by a complex interplay between tangible and virtual social dynamics, with physical attributes influenc-

ing digital behaviours, while digital trends reciprocally impact the material world in a continuous cycle of mutual influence (Zook and Graham, 2007).

This study conceptualises "Wang-hong Urbanism" as an urbanization phenomenon rooted in the intricate interrelationships between physical, digital, and social spaces (Jian et al., 2022, Figure 1). The rise of social media has created a pervasive communication infrastructure that enables instant local and global connections (Adams, 2009). Within this framework, users actively participate in shaping urban narratives by creating and sharing diverse representations of specific places across multiple platforms. This process of digital place-making blends the virtual and physical aspects of urban life, leading to a reimagining of city spaces. The digital footprints left by users through shared photos, stories, and interpretations collectively influence how places are perceived and experienced (Bronsvoort and Uitermark, 2021). This interplay between media and urban spaces creates what can be described as "media in place" and "place in media". "Media in place" refers to how digital platforms intersect with physical urban environments, while "place in media" encompasses the digital representations and narratives that shape perceptions of urban spaces. This digital layer of urban experience has begun to shape physical development, with new spaces being designed to cater to social media aesthetics and "Instagrammable" (Boy and Uitermark, 2017). The constant flow of digital content about urban spaces feeds back into the physical realm, influencing urban planning and design decisions. Wang-hong Urbanism thus represents a cyclical process where digital representations inspire physical changes, which in turn generate new digital content. This phenomenon is reshaping urban landscapes, potentially altering the way cities are developed, experienced, and understood. As this trend continues, it raises important questions about authenticity, inclusivity, and the future direction of urban development in an increasingly digitally-mediated world.

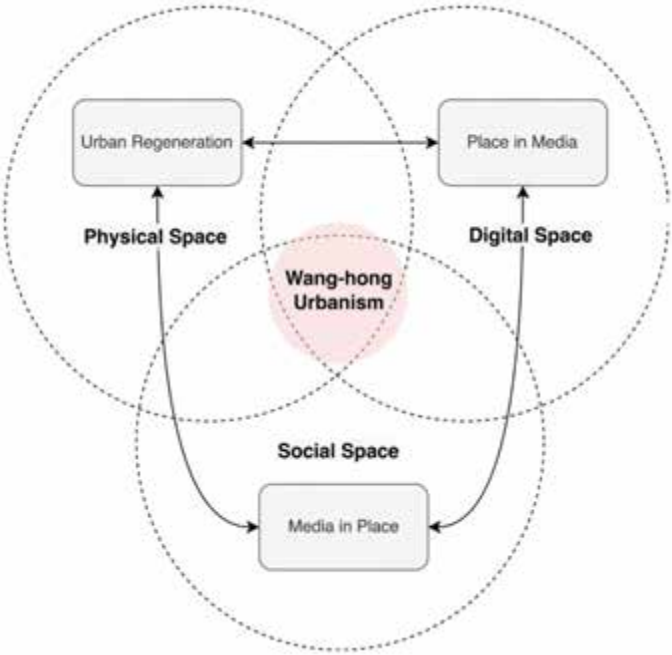

Figure 1. Conceptual framework to understand Wang-hong Urbanism
Source: (Jian et al., 2022)

2.2 City Walk in China: Explore the Nearby

In the context of Chinese urban life, city walking has emerged as a significant cultural phenomenon, embodying the concept of exploring the nearby as a scope of seeing the world (Xiang, 2021). In Chinese social media, City Walk is associated with spontaneity, leisure, and exploring non-mainstream attractions (Wu, 2023). This trend is closely linked to the "micro-vacation" model popularised during the pandemic. The 2023 Tourism Research Report lists city walking as a highly favoured emerging travel mode, with 82% of respondents willing to try it. Social media platforms have seen hundreds of thousands of "#citywalk" tagged posts. This practice, popularised through social media platforms and amplified by pandemic-induced travel restrictions, represents a shift in how urban residents engage with their immediate environments.

This study views City Walk as a daily leisure activity rather than solely a tourism practice. Unlike "commando-style travel," walking is the goal itself, not just a means to reach a destination. This approach to urban exploration encourages people to discover beauty and meaning in the quotidian aspects of urban landscapes. It serves multiple functions: it re-enchants ordinary cityscapes, prompts the re-discovery of familiar neighbourhoods, and deepens the perception and appreciation of local culture (Borucka, 2019).

The rise of city walking in China reflects a growing desire among urban dwellers to authentically interact with their surroundings in the context of attention economy and digital era (Giddy and Hoogendoorn, 2018), countering the homogenising effects of wang-hong urbanism (Jian et al., 2022). By engaging in this embodied leisure activity, participants not only alleviate stress and anxiety but also develop a more nuanced understanding of urban spaces and issues. This practice transforms urban landscapes into sites of everyday aesthetic discovery, where the physical act of walking intersects with digital documentation and sharing. Consequently, city walk in China has become a powerful tool for (re)connecting with urban spatial landscapes, fostering local identity, and cultivating a sense of belonging. It represents a microcosm of global exploration within the confines of one's local environment, offering a rich, multifaceted experience that challenges standardised representations of urban life while promoting a more sustainable and mindful approach to urban living and tourism (Wan, 2023)

City Walk has transformed urban landscapes into sites of everyday aesthetic practice, with participants documenting and sharing their experiences through photos (Cao, 2023). This intersection of physical exploration and digital documentation offers a unique window into urban residents' aesthetic preferences. Despite the proliferation of City Walk imagery, there remains a critical gap in our understanding of what specific urban elements attract walkers' attention and how they choose to frame and present their city, particularly in the context of China's diverse and rapidly changing urban landscapes. By analysing these shared images, researchers can gain valuable insights into how individuals perceive, interact with, and value different elements of their urban environment. This visual data provides a nuanced understanding of the evolving relationship between urban residents and their landscapes, revealing both overlooked beauty in everyday scenes and changing patterns of urban appreciation. Such analysis contributes to our understanding of urban aesthetics and holds potential implications for urban planning and design.

3. Methodology

In the realm of urban studies and tourism research, social media data analysis has emerged as a pivotal method for uncovering socio-cultural characteristics and collective digital imaginaries or urban spaces (Kelley, 2013). This approach harnesses the pervasive nature of geographic media and real-time feedback, thereby transcending the constraints of traditional data collection methods in terms of scale and timeliness (reference). Our study employs web scraping techniques to extract user-generated content from the "CityWalk|Urban Street Wandering Project" topic on the Douban website (www.douban.com), a popular Chinese social networking platform focused on user reviews and discussions of various media. This methodological choice aligns with our objective to explore the "place in media" constructed by users, offering insights into contemporary urban experiences (Figure 1). The data collection process, concluded in February 2024, yielded 10,185 valid images. To ensure the integrity and accuracy of our analysis, we implemented rigorous data preprocessing procedures, including data cleaning and error correction. Notably, the absence of geographic tags in Douban posts precluded the inclusion of spe-

cific location information. Moreover, to maintain ethical standards and protect user privacy, we systematically removed all user IDs and identifiable personal information during data processing. We then employed Class Activation Mapping (CAM), an advanced technique for interpreting Convolutional Neural Network (CNN) predictions, to analyse this visual dataset. CAM enables the identification of discriminative image regions crucial for prediction outcomes (Deena Divya Nayomi et al., 2023). In our study, this method allows us to pinpoint the primary elements within urban landscape photos that capture user attention and inform their descriptions of cities on social media platforms.

3.1 Method – Class Activation Mapping

Our study employs the PlacesCNN model, introduced by Zhou et al. in 2017, which offers a multifaceted approach to image analysis by simultaneously predicting scene categories, attributes, and generating Class Activation Maps (CAMs) (Zhou et al., 2018). This model's architecture is based on a ResNet-18 backbone, augmented with two separate fully-connected layers for scene category and attribute prediction, respectively. The core idea behind generating CAMs is to leverage the final convolutional feature maps and the classification layer weights to compute an importance score for each feature map with respect to a particular class. These important scores are then summed and upsampled to obtain the CAM for the input image. The mathematical formulation is as follows:

$$C_c(x,y) = \sum_k w_c^k f_k(x,y)$$

Where C_c *(x, y)* denotes the CAM for class *c*, w_c^k is the weight corresponding to the *k*-th feature map in the classifier for class *c*, and f_k *(x, y)* is the value of the k-th feature map at location *(x, y)*.

3.1.1 Scene Classification Framework

This study uses a scene classification model trained with the Places365 dataset to perform scene recognition on self-collected image samples. To facilitate a more systematic analysis of the model's outputs, we propose a hierarchical classification framework that consolidates the 365 fine-grained scene categories identified by the model into 10 high-level semantic categories. This approach provides a more structured and interpretable analysis framework, enabling us to elucidate the relationship between image content and scene types from a macro perspective. Our proposed high-level categories are as follows:

- Natural environment

This category includes scenes that are identified as natural landscapes that have not been modified by humans. It covers a variety of landforms such as mountains, beaches, forests, deserts, glaciers, etc. These environments usually represent areas with less human activity and reflect the original state of the earth.

- Artificial outdoor environment

This category covers scenes that are identified as outdoor spaces that have been artificially designed and built. Including urban streets, parks, squares, courtyards, etc. These environments reflect how humans shape and organise external spaces to meet social needs.

- Indoor public spaces

This category includes scenes that are identified as indoor places for public use. For example, airport terminals, train stations, shopping malls, libraries, etc. These spaces usually have social, transportation or commercial functions and are an important part of the operation of modern society.

- Private/residential spaces

This category covers scenes identified as private spaces for personal or family life. Including various residential interior spaces, such as bedrooms, living rooms, kitchens, etc. These environments reflect personal lifestyles and home culture.

- Transportation-related places

This category includes scenes identified as places related to various modes of transportation. Such as parking lots, gas stations, airport runways, train platforms, etc. These places support and promote the mobility of mod-

ern society.
- Commercial/service places
This category covers scenes identified as various commercial and service facilities. Including shops, restaurants, bars, beauty salons, etc. These places reflect the characteristics of consumer culture and service economy.
- Cultural/educational places
This category includes scenes identified as places related to cultural dissemination and education. Such as schools, museums, art galleries, libraries, theatres, etc. These places play an important role in knowledge dissemination and cultural protection.
- Sports/entertainment places
This category covers scenes identified as various sports and entertainment facilities. Including stadiums, gyms, amusement parks, cinemas, etc. These places reflect the leisure and entertainment needs of modern society.
- Industrial/production places
This category includes scenes that are identified as places related to industrial production and resource development. Such as factories, mines, farms, construction sites, etc. These environments reflect economic activities and production processes.
- Special/other places
This category covers scenes that are identified as special places that are not easily classified into other categories. Including religious places, medical facilities, military bases, etc. These places often have unique functions or social significance.

The framework demonstrates the complexity of urban environments, breaking down each main category into numerous specific locations (e.g., alley, skyscraper, subway station). This granular approach enables us to explore the distribution of different environmental types within our collected image samples and investigate potential correlations between image content and scene categories.

3.1.2 Implementation Details

Based on the proposed framework, the implementation of the PlacesCNN model and CAM generation in our study follows a systematic approach using PyTorch:

i) Model initialization: Load the model weights pre-trained on the Places365 dataset (Deena Divya Nayomi et al., 2023).
ii) Feature extraction: Define a hook function to obtain the final convolutional feature maps from the model.
iii) Image processing: Perform a forward pass on the input urban landscape image.
iv) CAM computation: Compute the CAM using the feature maps and classifier weights from the fully-connected layer corresponding to the scene category prediction.
v) Visualisation: Visualise and save the CAM as an image overlay on the original input.

4. Results and Discussions

The results show a clear predominance of outdoor scenes, accounting for 7,638 images (75.0% of the dataset), while indoor environments are represented in 2,547 images (25.0%). Examples of the analysis results can be found in Figures 2, 3, and 4. This distribution suggests that urban wanderers on the platform have a strong preference for documenting external urban spaces, which aligns with the nature of city walks and urban exploration. To provide a more nuanced understanding of the urban landscapes captured, we further analysed the subcategories within these broad classifications.

Figure 2. Example of analysis results: alley
Figure Source: "CityWalk/Urban Street Wandering Project" topic on the Douban website (www.douban.com)

Figure 3. Example of analysis results: promenade
Figure Source: "CityWalk/Urban Street Wandering Project" topic on the Douban website (www.douban.com)

Figure 4. Example of analysis results: sky
Figure Source: "CityWalk / Urban Street Wandering Project" topic on the Douban website (www.douban.com)

4.1 Predominant Photographed Categories

Table 1 presents a comprehensive overview of the categories of urban elements captured in city walk photography. The data reveals that urban explorers sharing photos on social media during city walks demonstrate a clear preference for human-made structures and unique urban locations.

Table 1. Top 10 Photographed Urban Categories

Category	3 Example elements and counts	Count	Percentage	Rank
Artificial Outdoor Environment	Street (265) Parking garage/outdoor (218) Crosswalk (214)	2014	19.77%	1
Special/Other Places	Cell (167) Medina (116) Loading dock (114)	1441	14.15%	2
Transportation-related Places	Historic transportation hub (285) Highway (138) Canal/urban (120)	1253	12.30%	3
Cultural/Educational Places	Pagoda (174) Temple/asia (104) Synagogue/outdoor (91)	1145	11.24%	4
Commercial/Service Places	Beauty salon (182) Gas station (212) Fastfood restaurant (90)	1140	11.19%	5
Natural Environment	Sky (310) Forest/broadleaf (81) Lagoon (76)	1001	9.83%	6

Industrial/Production Places	Industrial area (135) Skyscraper (129) Hangar/outdoor (68)	891	8.75%	7
Indoor Public Spaces	Booth/indoor (110) Elevator shaft (67) Subway station/platform (54)	525	5.15%	8
Sports/Entertainment Places	Water park (82) Ice skating rink/outdoor (46) Amusement park (39)	491	4.82%	9
Private/Residential Spaces	Residential neighborhood (154) Beach house (64) Tree house (61)	284	2.79%	10

To elaborate, Artificial Outdoor Environment dominates the photographs, accounting for 19.77% of all images. This category includes common urban features such as streets, parking garages, and crosswalks. Special/Other Places rank second (14.15%), followed closely by Transportation-related Places (12.30%). This suggests that city walkers are particularly drawn to unique or unusual urban spaces, as well as the infrastructure that facilitates movement within the city. It's noteworthy that functional areas like Transportation-related Places and Industrial/Production Places feature more prominently than purely recreational areas such as Sports/Entertainment Places. This suggests that city walkers are particularly drawn to the infrastructure and daily operations of the city, rather than its leisure facilities. Cultural/Educational Places and Commercial/Service Places occupy the middle ranks, each accounting for about 11% of the photographs. This near-equal representation indicates a balanced interest in both the cultural aspects of a city and its commercial offerings, reflecting the diverse attractions of urban environments.

Interestingly, there's a marked inclination towards capturing built environments over natural ones. While Artificial Outdoor Environments top the list, Natural Environments rank sixth, comprising only 9.83% of the photos. This suggests that city walkers are more captivated by urban architecture and infrastructure than by parks or green spaces within the city. The data also highlights a significant preference for public spaces over private ones. Categories representing various public areas dominate the top of the list, while Private/Residential Spaces rank last at just 2.79%. This trend underscores the public nature of city walks and the focus on shared urban experiences.

4.2 Top 10 Recurring Visual Elements

Table 2 provides a more granular look at the specific urban elements most frequently captured in city walk photography. From natural environments to cultural spaces and encompassing both large-scale elements (like sky and streets) and localised features (such as alleys and beauty salons), the top 10 list demonstrates that urban explorers are drawn to a wide spectrum of urban characteristics. This diversity suggests an appreciation for both macro and micro aspects of city landscapes, extending beyond traditional tourist attractions. The list covers various urban functions including transportation, commerce, culture, and public spaces, providing a holistic representation of the urban fabric. Such a comprehensive engagement with different facets of the built environment offers valuable insights into how people perceive and interact with cities, highlighting the complex nature of urban appeal and the importance of considering diverse elements in urban planning and design.

Table 2. Top 10 Recurring Urban Elements

Class name	Category	count	Percentage	Rank
sky	Natural Environment	310	3.04%	1
historic transportation hub	Transportation-related Places	285	2.80%	2
street	Artificial Outdoor Environment	265	2.60%	3
parking garage/outdoor	Artificial Outdoor Environment	218	2.14%	4
crosswalk	Artificial Outdoor Environment	214	2.10%	5
gas station	Industrial/Production Places	212	2.08%	6
promenade	Artificial Outdoor Environment	200	1.96%	7
alley	Artificial Outdoor Environment	199	1.95%	8
beauty salon	Commercial/Service Places	182	1.79%	9
pagoda	Cultural/Educational Places	174	1.71%	10

Six out of the top ten elements (sky, street, parking garage/outdoor, crosswalk, promenade, and alley) are associated with outdoor environments, underscoring the importance of open-air spaces in the urban exploration experience. Interestingly, while Artificial Outdoor Environment dominates in the broader category analysis, the single most photographed element is the sky, a Natural Environment feature, with 310 occurrences, ranks as the most photographed element. Even in the heart of cities, people are drawn to open spaces and the visual relief provided by the expanse above the urban landscape. It's important to note that even the highest-ranked element (sky) only accounts for 3.04% of the total, indicating a high degree of variety in the dataset beyond these top elements.

On the other hand, the prominence of everyday urban elements in the dataset reveals the fundamental role of urban network infrastructure in shaping a city's character and the urban exploration experience. "Street," ranking third with 265 occurrences, alongside "crosswalk" (ranked 5th, 214 occurrences), "promenade" (ranked 6th), and "alley" (ranked 8th), each with approximately 200 occurrences, emphasises that city walkers find significant interest in the everyday urban spaces. These elements, serving as the arteries of urban life, capture the essence of city movement and design beyond monumental or extraordinary sites. For instance, promenades, normally designed for leisurely walks and social interaction, represent the more aesthetic and planned aspects of urban design. In contrast, alleys often embody the more intimate, less curated sides of urban environments. The near-equal representation of these contrasting elements in the dataset suggests a balanced interest among urban explorers in both the polished and grittier facets of city life.

The appearance of "parking garages/ outdoor" (ranked 4th), "gas station" (ranked 6th) and "beauty salon" (ranked 9th) in the list indicates that functional and service-oriented spaces also capture the attention of urban explorers, possibly due to their role in daily urban life or their aesthetic qualities. These functional spaces often feature distinctive architectural styles, signage, and lighting that contribute to the visual landscape of a city. Gas stations, for instance, may attract attention due to their often bold, modernist designs or retro aesthetics, while beauty salons might showcase vibrant storefronts or unique interior designs visible from the street. Parking garages, especially multi-story structures, offer unique vantage points of the city. They may attract urban explorers for their potential to provide elevated views of the urban landscape, adding a vertical dimension to the exploration experience. On the flip side, Parking garages and gas stations serve as transition points between modes of transportation, representing liminal spaces in the urban fabric. The frequent appearance of these spaces in the dataset may also simply reflect their ubiquity in urban environments, making them common subjects for urban photographers.

The inclusion of "pagoda" in the top 10, as a representative of Cultural/Educational Places, highlights urban explorers' interest in historical and cultural landmarks. These structures serve as both functional elements and

symbolic representations of a city's heritage and global connections. Their popularity among photographers reflects an appreciation for the blend of architectural grandeur and historical significance in urban landscapes. This focus also suggests a broader fascination with how cities evolve, inviting observers to contemplate the intersection of ancient traditions and modern urban life within the cityscape.

5. Conclusions

The analysis of City Walk imagery provides valuable insights into the everyday aesthetic preferences of urban residents, revealing a nuanced appreciation for urban landscapes that often diverges from mainstream or "wang-hong" representations. This analysis reveals that city walkers engage with a diverse range of urban elements, from grand vistas to intimate street-level details, and from historical landmarks to everyday functional spaces. Our study indicates that city walkers are particularly drawn to elements that embody the authentic character of their urban environment. These include historical architecture juxtaposed with modern structures, vibrant street life scenes, hidden alleyways, and pockets of urban nature. Notably, there is a marked preference for scenes that capture the interplay of light and shadow on urban surfaces, as well as moments of serendipity in daily urban life. Moreover, there is a clear appreciation for spaces that facilitate community engagement, such as public squares, parks, and street corners that serve as informal gathering spots. These insights underscore the importance of preserving and enhancing the diverse tapestry of urban environments, rather than pursuing homogenised urban aesthetics.

From an urban design perspective, these findings have significant implications. They suggest a need for urban planning strategies that prioritise the preservation of local character, the integration of historical elements with contemporary design, and the creation of spaces that encourage spontaneous social interactions, so as to facilitate walkability. Urban designers should consider incorporating elements that enhance the sensory experience of walking, such as varied textures, engaging streetscapes, and green corridors. Furthermore, the popularity of images capturing transitional spaces and thresholds between different urban zones highlights the importance of thoughtful design in areas of urban connectivity. By aligning urban design with the aesthetic preferences revealed through City Walk practices, cities can create more engaging, livable environments that resonate with residents' everyday experiences and foster a stronger sense of place and community.

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Spatiotemporal perception of disasters based on social media data in the context of climate change: A case study of Shanghai

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Abstract
Extreme weather events are frequent in the context of climate change, which brings severe challenges to cities. Therefore, it is urgent to explore more adaptive planning methods to achieve climate resilience. Correspondingly, this paper conducts spatiotemporal perception research on typhoon disasters in Shanghai based on social media data. The results show that there are 3 types of disaster themes. Meanwhile, there presents different spatiotemporal characteristics among public concern index, negative sentiment intensity and positive sentiment intensity. Based on above situation, this paper proposes corresponding planning response strategies, and the purpose of this paper is to explore social media data in responding to climate change challenges and provide reference for resilient urban planning.

Keywords: climate change, resilient city, social media, spatiotemporal perception, typhoon disasters

1. Introduction

Due to the intensification of global climate change, various extreme climate disasters have occurred frequently, which poses a huge threat to urban safety. Typhoon is one of the most frequent and widespread natural disasters in the world, and the harm of hurricane and typhoon is becoming more prominent with the intensification of climate change. From the perspective of global cities, many cities in the world (such as New York, New Orleans, Tokyo, and Singapore) have experienced the impact of hurricane and typhoon disasters which caused a large number of casualties and property losses. China is one of the countries affected by typhoon disasters, and most of Chinese cities affected by typhoon disasters are located in the southeastern coastal area with highly concentrated industries and high-density population. Meanwhile, cities in the China's eastern coastal areas have accommodated more and more people with the advancement of urbanization, which means the impact of typhoon disasters will become increasingly serious. Therefore, it is urgent to enhance the climate resilience through urban spatial planning to cope with typhoon disasters.

In 2016, United Nations Conference on Housing and Sustainable Urban Development (Habitat III) advocated the construction of inclusive, safe, sustainable and resilient cities to meet the challenge of climate change. In recent years, city resilience improvement and resilient city development have received increasing attention and recognition with the advancement of Chinese new urbanization strategy and high-quality urban development strategy. For example, Shanghai has proposed the urban development goal of "responding to global climate change, enhancing the city's ability to resist natural disasters, and building a more sustainable and resilient ecological city". However, typhoons can bring secondary disasters such as strong winds and rainstorms which are characterized by high disaster intensity, rapid changes, and high uncertainty. Traditional urban disaster prevention planning methods (such as improving defense standards and formulating prevention planning) cannot respond to rapidly changing disaster situations in a timely manner. It is urgent for city planners to explore more adaptive planning methods to cope with the challenges brought about by climate change. In this context, urban planning should use dynamic models to improve the spatiotemporal governance paradigm and technical system except traditional static spatial strategies (Cai et al., 2018).

With the promotion and popularization of mobile Internet technology, disaster-stricken people can post real time disaster information on social media platforms at first time, such as disaster time, rescue request messages, and disaster locations. Social media data has become an emerging source of disaster situation information. Compared with traditional media reports, social media data has the advantages of large data volume, strong timeliness and wide spatial coverage (Allaire, 2016, Li et al., 2024). Based on identifying, extracting and analyzing

relevant disaster information from social media data, urban planners and policymakers can better perceive disasters and dynamically optimize spatial elements according to changes in disaster characteristics to ensure the governance effectiveness of urban planning and achieve climate resilience.

This paper selects Shanghai as the research area and analyzes the spatiotemporal perception characteristics of typhoon disasters by the real time disaster information published on social media during the disaster. It explores the application path of big data technology and social media data in responding to climate change challenges in order to provide reference for exploring new technical methods for resilient urban planning.

2. Literature review

Disaster perception is the process of hazardous environment cognition and risk avoidance (Kieu and Senanayake, 2023). Due to global climate change, extreme weather intensifies the uncertainty and complexity of disaster risk, which leads to the weakened significance of accurate prediction, control and prevention for disaster reduction (Linkov et al., 2013). Correspondingly, it is more important for disaster response to obtain disaster information and conduct disaster perception. However, it is not enough to cope with complex and changeable disaster disturbances based on traditional methods of data acquisition and analysis. Firstly, comprehensive spatiotemporal data on disasters cannot be obtained through disaster information of traditional news media. Secondly, although statistical survey can provide direct disaster information, this method is costly and often accompanied by safety risks (Guo et al., 2025). Thirdly, it is also technically difficult for real-time emergency response to analyze remote sensing images (Shastry et al., 2023), because remote sensing cannot take into account both time and spatial resolution (Hou et al., 2024). In recent years, social media has increasingly become the main medium for information dissemination natural disasters (Chu et al., 2024). The widespread use of social media has promoted the rapid dissemination of real-time information during disasters (Liang and Ramirez-Marquez, 2024), which can integrate a large amount of spatiotemporal disaster information in a short time, and Therefore social media can make up for the method defects of traditional disaster information acquisition such as high cost and poor timeliness (Hou et al., 2024).

Social media can enhance situational perception during the disaster (Li et al., 2023a). Many scholars have paid attention to the role of urban public in disaster response, and try to conduct perception analysis through disaster information published on social media. At present, the application dimensions of social media in disaster mainly include temporal dimension, spatial dimension, text dimension and network dimension (Li et al., 2023a), and the analysis methods include sentiment analysis, text themes analysis, spatial correlation analysis and social network analysis. In the time dimension, social media data can be applied to analyze the changing characteristics of public sentiment and disaster themes. For example, Zhang et al. analyzed the public sentiment changes during typhoon disasters based on social media data, and find that typhoon disasters lead to a corresponding increase of negative sentiment (Zhang et al., 2024). Han and Wang identified 6 types of flood-related themes and 9 types of public sentiment reactions with text analysis on Sina microblog, and found that different types of themes and sentiment reactions closely corresponded to different development stages of flood disaster (Han and Wang, 2019). In the spatial dimension, social media data can be applied to analyze the distribution pattern of disaster vulnerability. For example, Forati and Ghose analyzed the spatial distribution characteristics of social media data during Hurricane Irma based on Twitter data and found the uneven characteristics of community vulnerability (Forati and Ghose, 2022). Zou et al. analyzed the geographical location of rescue requests on Twitter during Hurricane Harvey and found that communities with more rescue requests had more vulnerable environments and socioeconomic conditions (Zou et al., 2023). In the text dimension, social media data can be applied for sentiment recognition and disaster theme classification. For example, Karimiziarani et al. conducted sentiment recognition and topic classification of Twitter text with natural language processing (NLP) methods, and reveal the characteristics of social media responding to hurricanes (Karimiziarani et al., 2023). In the network dimension, social media data can be applied to analyze the relationship among Individual actors in social networks in order to identify important disaster information. For example, Lu and Brelsford applied Twitter data and the Infomap method to analyze the dynamic evolution of social networks during Japanese earthquake and tsunami in 2011, which reveals the change pattern of social interaction mechanisms under extreme events (Lu and Brelsford, 2014).

From an objective point of view, there are also certain challenges in applying social media data to disaster perception. In terms of data sources, disadvantaged groups may lack access to social media, resulting in "digital divide" problem (Xiao et al., 2015). Meanwhile, there may be low engagement in social media use in these area which suffer from severe disasters (Crawford and Finn, 2015). In terms of data processing, social media data may also present problems with the spread of misinformation (Erokhin and Komendantova, 2024). Therefore, it is still a major challenge to extract disaster information from massive social media messages (Hou et al., 2024). Fortunately, the analysis accuracy of social media can be improved through the improvement of analysis methods and the combination of multi-source data and it means that social media data can cope with the application challenges. At the same time, residents in different environments may suffer from differentiated disaster risks (Kaźmierczak and Cavan, 2011, Carvalho et al., 2022, Smiley et al., 2022, Nielsen et al., 2023). Therefore, as a type of real-time big data, social media data is essential for the efficiency improvement of disaster response in the case of disaster uncertainty challenge.

In general, the application of social media has profoundly changed the way of social communication and interaction. Correspondingly, social media has become an important element of "social perception", and it has become a research focus to conduct disaster perception based on social media data (Liu et al., 2015, Fang et al., 2019). In China, because of frequent and diverse disasters, social media is equally significant for the level improvement of urban disaster perception and the capability enhancement of disaster response. However, due to the complexity of Chinese semantics and the differences in social media type, it is under development to apply social media data to disaster perception in China (Jin et al., 2021). Therefore, there is still great application potential in the research on social media data such as city cases, disaster types, and research methods (Xie and Shao, 2024).

3. Research method

3.1. Study area

As the center of Chinese economic and technological innovation, Shanghai is a well-known megacity with a high population density and frequent economic activities. However, Shanghai is extremely vulnerable to typhoon disasters because of subtropical monsoon climate. According to statistics, Shanghai has suffered from typhoon disasters almost every year, which have had an impact on infrastructure damage, urban transportation, and social economy (Table 1). It means that typhoon disasters have become a challenge of resilient city development in Shanghai. Therefore, this paper selected Shanghai as the research object, the spatial scope covers the entire administrative region of Shanghai.

Table 1. Typhoon disasters statistics in Shanghai from 2010 to 2024

Year	Number of typhoon	Typhoon name and typhoon number
2010	0	/
2011	1	Typhoon Muifa (1109)
2012	1	Typhoon Haikui (1211)
2013	1	Typhoon Fitow (1323)
2014	2	Typhoon Fung-wong (1416), Typhoon Vongfong (1419)
2015	3	Typhoon Chan-hom (1509), Typhoon Goni (1515), Typhoon Dujuan (1521)
2016	1	Typhoon Meranti (1614)
2017	1	Typhoon Talim (1718)

2018	6	Typhoon Ampil (1810), Typhoon Jongdari (1812), Typhoon Yagi (1814), Typhoon Rumbia (1818), Typhoon Maria (1808), Typhoon Kong-rey (1825)
2019	4	Typhoon Lekima (1909), Typhoon Mitag (1918), Typhoon Lingling (1913), Typhoon Tapah (1917)
2020	3	Typhoon Hagupit (2004), Typhoon Bavi (2008), Typhoon Maysak (2009)
2021	2	Typhoon In-Fa (2106), Typhoon Chanthu (2114)
2022	1	Typhoon Muifa (2212)
2023	0	/
2024	2	Typhoon Bebinca (2413), Typhoon Pulasan (2414)

Data sources: The data is collected from China Meteorological Disaster Yearbook, and China Climate Bulletin.

3.2. Analysis scenarios and data sources

3.2.1. Analysis scenarios

From September 14, 2024 to September 22, 2024, Typhoon Bebejia and Typhoon Prasang landed in Pudong New Area and Fengxian District of Shanghai respectively, and passed directly through the urban area. Typhoon Bebejia and Typhoon Prasang caused serious disasters in Shanghai such as rainstorm and waterlogging. Specifically, the central wind speed of Typhoon Bebiga reached level 14 (the range of wind speed is 41.5m/s - 46.1m/s) when it landed, making it the strongest typhoon to land in Shanghai since 1949. Typhoon Plasang brought a 500-year rainstorm to Shanghai especially Fengxian district and Pudong New Area. Furthermore, it was the first time that Shanghai was hit by two typhoon disasters in a week. Therefore, this paper selects Typhoon Bebejia and Typhoon Prasang as research scenarios, and conducts the spatiotemporal perception of typhoon disasters with the real time disaster information published on Sina microblog during the disaster (Figure 1).

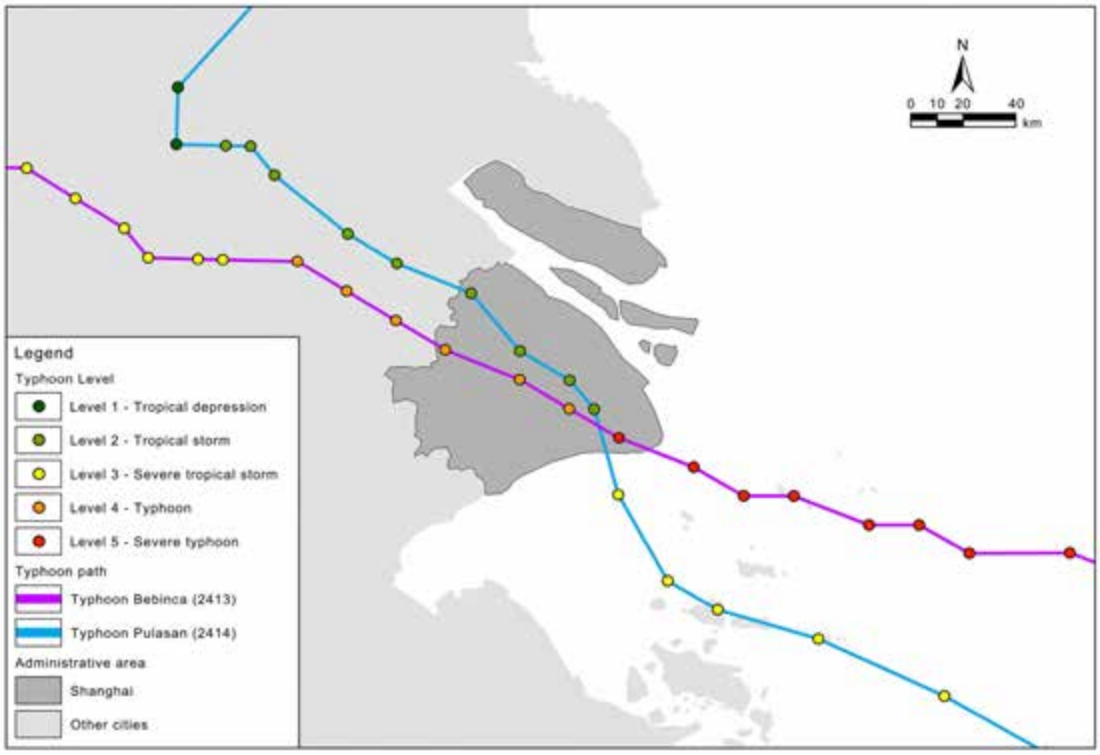

Figure 1. The paths of Typhoon Bebejia and Typhoon Prasang

3.2.2. Data sources

Sina microblog is a very popular social media in China which is equivalent to Twitter (Li et al., 2023b). Therefore, this paper collects typhoon disasters information from Sina microblog messages. Firstly, this paper collects Sina microblog messages in Shanghai area with a time range from September 14, 2024 to September 22, 2024. According to statistics, 27521 pieces of Sina microblog message are collected, which includes comment text, time and spatial location. Secondly, these Sina microblog messages are filtered based on keywords related to typhoon disasters (such as typhoon, Bebejia, Prasang, rainstorm, strong wind, waterlogging, water outage, and power outage). Thirdly, 2734 pieces of relevant messages are sorted out.

3.3. Research design

3.3.1. Text features analysis

Text features analysis includes disaster themes determination and text sentiment evaluation according to the disaster information published on the Sina microblog.

In terms of disaster themes determination, this paper classifies the disaster themes that the public is concerned about based on the LDA (Latent Dirichlet Allocation) topic model. LDA is a commonly used topic model in natural language processing, which can identify different themes from a text collection. At the same time, this study determines the optimal number of disaster theme through the perplexity test and pyLDAvis (python library for Latent Dirichlet Allocation visualization). The perplexity test formula is:

$$\text{perplexity}(D)=\exp\left\{-\frac{\sum_{m=1}^{M}\log P(W_m)}{\sum_{m=1}^{M}N_m}\right\} \qquad (a1)$$

In the formula a1, D represents the text dataset, M represents the number of text items in the text dataset, N_m represents the number of words in the text item m, W_m represents the word sequence of the text item m, P(W_m) represents the appearance probability of each word in the text set.

In terms of text sentiment evaluation, this paper firstly applies the HowNet sentiment dictionary to identify and score the sentiment of Sina microblog text. Next this paper calculates the scores of positive or negative microblog texts respectively, and the range of sentiment score is limited to [0, 5] to avoid extreme values.

3.3.2. Analysis of disaster perception in the time Dimension

This research step mainly analyzes the change characteristics of Public Concern Index of Time Dimension (PCITD), Negative Sentiment Intensity of Time Dimension (NSITD) and Positive Sentiment Intensity of Time Dimension (PSITD) during the typhoon disasters. PCITD indicates the public attention to the event. Meanwhile, NSITD and PSITD reflect the overall change of the public sentiment towards the event.

(1) The formula of PCITD is:

$$PCITD=\frac{NT_{related}}{NT_{total}} \quad (b1)$$

In the formula b1, $\mathrm{NT}_{\mathrm{related}}$ represents the number of Sina microblog messages related to typhoon disasters within the t time interval, $\mathrm{NT}_{\mathrm{total}}$ represents the total amount of Sina microblog messages within the t time interval, which can also be called background information.

(2) The formula of NSITD is:

$$NSITD=\frac{\sum_1^t(ntmes_i)}{nn_t} \quad (b2)$$

In the formula b2, represents the sentiment score of each negative Sina microblog message within the t time interval, nn_{t} represents the total number of negative Sina microblog messages within the t time interval.

(3) The formula of PSITD is:

$$PSITD=\frac{\sum_1^t(ptmes_i)}{np_t} \quad (b3)$$

In the formula b3, represents the sentiment score of each positive Sina microblog message within the t time interval, np_{t} represents the total number of positive Sina microblog messages within the t time interval.

3.3.3. Analysis of disaster perception in the spatial Dimension

Firstly, this research step mainly analyzes the characteristics of Public Concern Index of Spatial Dimension (PCISD), Negative Sentiment Intensity of Spatial Dimensions (NSISD), and Positive Sentiment Intensity of Spatial Dimensions (PSISD) based on ArcGIS in order to quantify the public perception level of typhoon disasters and the spatial distribution characteristics of the typhoon disasters impact on the public. Secondly, this paper performs spatial autocorrelation analysis and hotspot analysis on PCISD, NSISD, and PSISD.

Importantly, there will be few data in many grids due to the division of the 1km*1km grid which will result in small sample problems (Wang et al., 2020). Therefore, this paper applies a 2km*2km grid for spatial statistics.

(1) The formula of PCISD is:

$$PCISD=\frac{NS_{related}}{NS_{total}} \quad (c1)$$

In the formula c1, $\mathrm{NS}_{\mathrm{related}}$ represents the number of Sina microblog messages related to typhoon disasters in the grid, $\mathrm{NS}_{\mathrm{total}}$ represents the total amount of Sina microblog messages in the grid.

(2) The formula of NSISD is:

$$NSISD=\frac{\sum(nsmes_i)}{nn_s} \quad (c2)$$

In the formula c2, represents the sentiment score of each negative Sina microblog message in the grid, nn_{s} represents the total number of negative Sina microblog messages in the grid.

(3) The formula of PSISD is:

$$PSISD=\frac{\sum(psmes_i)}{np_s} \quad (c3)$$

In the formula c3, represents the sentiment score of each positive Sina microblog message in the grid, np_{s} represents the total number of positive Sina microblog messages in the grid.

4. Results

4.1. Text features

4.1.1. Disaster themes determination

This paper applies the perplexity test and pyLDAvis to determines the optimal number of disaster themes. In terms of the perplexity test, the optimal number of themes corresponds to the low perplexity. In terms of the overlap analysis among themes, each circle represents a theme, and the area of the circle is positively correlated with the frequency of the topic. The distance between different circles represents the independence between different topics, and the distance between circles is positively correlated with the independence between subjects. When the circle does not overlap, it means that the optimal number of disaster themes is determined. Combining the perplexity test and the overlap analysis among themes, this paper finally determined three disaster themes (Figure 2).

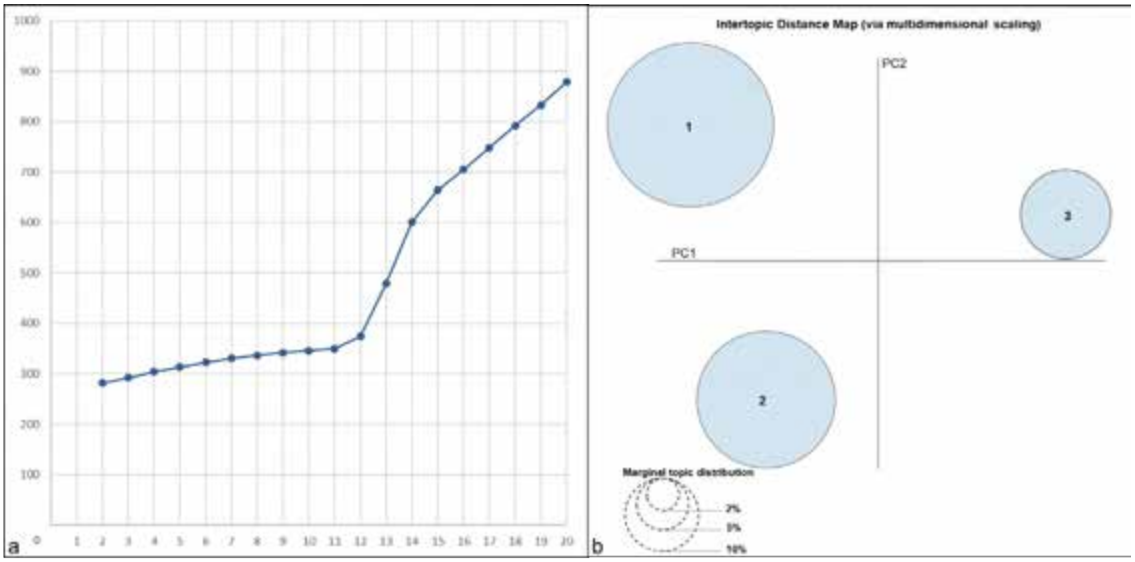

Figure 2. The perplexity test (a) and pyLDAvis (b)

At the same time, this paper screens the keywords within each disaster theme and filters out a total of 30 keywords by eliminating duplicates, unclear meanings and other invalid words. This paper finds that the keywords of each theme have different focuses. Among them, the keywords of theme 1 focus on the interference of typhoons in daily activities, especially the daily travel activities of urban residents. The keywords of theme 2 focus on the disaster-stricken places and people, especially Fudan University, ports and urban streets. The keywords of theme 3 focus on the status of public places after the disaster, such as campuses, hotels, squares, Shanghai Bund, subway stations and other public places (Table 2).

Table 2. Statistics of disaster themes determination

Number	Keywords	Disaster theme focus
Theme 1	Typhoon landfall (24.10%), garden (12.17%), impact (10.98%), life (10.04%), strong typhoon (9.35%), terminal building (8.55%), flight (7.10%), Pudong New Area (6.47%), outings (5.91%), community (5.33%)	Interference on daily activities
Theme 2	Fudan University (14.90%), rainstorm (13.84%), ferry (10.60%), Shanghai Port (10.43%), building (8.58%), wind and rain (8.58%), river bay (8.54%), road (8.35%), Suzhou River (8.32%), students (7.85%)	Affected locations and populations
Theme 3	After the disaster (16.15%), campus (14.61%), hotel (11.33%), square (10.89%), Bund (10.56%), notes (8.31%), power outage (8.24%), weather (7.67%), Baoshan district(6.39%), subway station (5.85%)	Post-disaster public places

Note: The value behind the keyword represents the discussion proportion of keyword in the disaster theme.

Combined with the actual situation of Shanghai, the characteristics of typhoon disasters can be summarized according to the disaster theme. Firstly, the typhoon disasters caused secondary disasters such as strong wind, rainstorm and waterlogging. These secondary disasters led to flight delays, subway suspension and public traffic interruption which had a great impact on travel activity of residents. Secondly, typhoon caused damage to houses and public service facilities. Therefore, affected places and people have become one of the focuses in the disaster. Finally, Typhoon Bebinca and Typhoon Pulasan landed in Shanghai consecutively within a week, which had a certain impact on the progress of post-disaster recovery, especially the restoration of the public places.

4.1.2. Text sentiment evaluation

According to the sentiment identification and sentiment score, there are 559 texts of negative sentiment (accounting for 20.45%), 1016 texts of positive sentiment (accounting for 37.16%), and 1159 texts of neutral sentiment (accounting for 42.39%). From the perspective of sentiment intensity, the average score of negative sentiment is -1.53, and the average score of positive sentiment is 1.71 (Table 3). From the perspective of the frequency distribution of the sentiment scores, there shows the characteristics of normal distribution among negative sentiment, positive sentiment and neutral sentiment (Figure 3). These statistics show that the sentiment intensity of positive sentiment is slightly higher than that of negative sentiment, which means the overall mood of urban residents was relatively optimistic during this typhoon.

Table 3. Statistics of text sentiment evaluation

Type	Quantity	Percentage	Average score
Sina microblog messages expressing negative sentiment	559	20.45%	-1.53
Sina microblog messages expressing positive sentiment	1016	37.16%	1.71
Sina microblog messages expressing neutral sentiment	1159	42.39%	0
Total	2734	100%	/

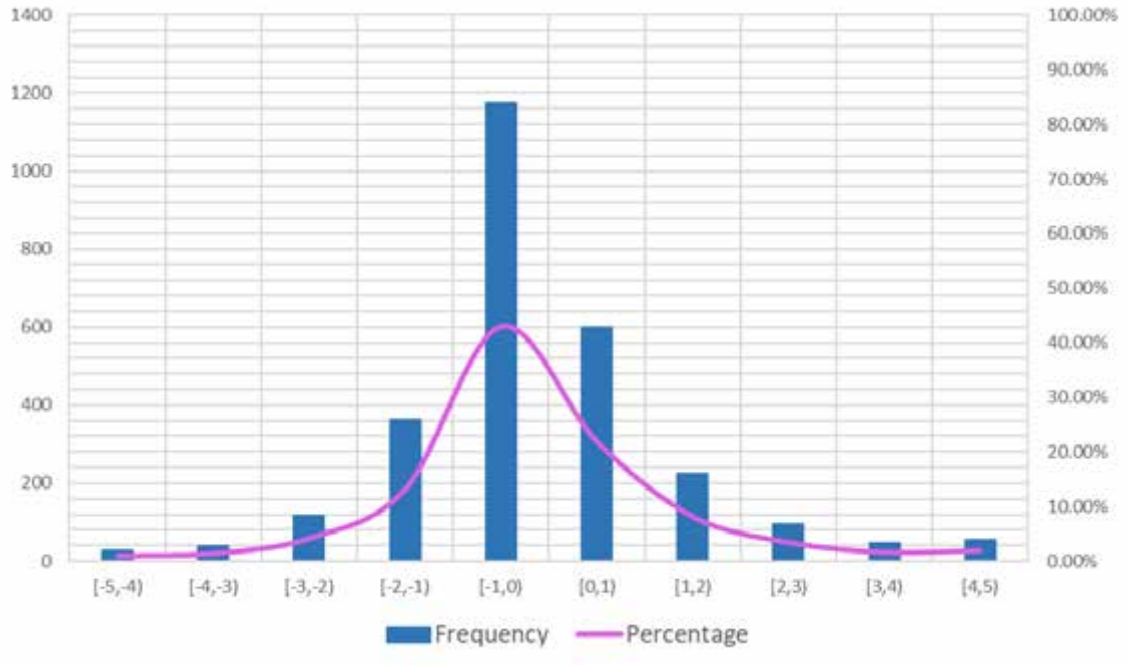

Figure 3. Frequency distribution of sentiment scores

4.2. Disaster perception in the time dimension

The entire period of typhoon disasters is from September 14, 2024 to September 22, 2024 which includes pre-disaster prevention stage, emergency response stage and post-disaster recovery stage (Table 4). The public perception and sentiment intensity also show obvious fluctuations and changes due to the impact of the typhoons.

Table 4. The impact of Typhoon Bebinca and Typhoon Pulasan on Shanghai

Time	Event	Disaster stage
September 14, 2024	Shanghai Central Meteorological Observatory issues typhoon warning for Typhoon Bebinca.	Pre-disaster preparation stage for Typhoon Bebinca
September 15, 2024	Shanghai Meteorological Bureau launches highest level typhoon emergency response.	
September 16, 2024	Typhoon Bebinca landed in Shanghai Pudong New Area.	Emergency response stage for Typhoon Bebinca
September 17, 2024	Typhoon Bebinca moved away from Shanghai, and Shanghai entered the post-disaster recovery stage.	Post-disaster recovery stage for Typhoon Bebinca
September 18, 2024	Shanghai Central Meteorological Observatory issues typhoon warning for Typhoon Pulasan.	Pre-disaster preparation stage for Typhoon Pulasan
September 19, 2024	Typhoon Bebinca landed in Fengxian District, Shanghai.	Emergency response stage for Typhoon Pulasan
September 20, 2024	Rainstorm occurs in Shanghai	

September 21, 2024	Typhoon Pulasan moved away from Shanghai, and Shanghai entered the post-disaster recovery stage again.	Post-disaster recovery stage for Typhoon Pulasan
September 21, 2024 - September 22, 2024	Post-disaster recovery work is basically completed.	

Source: The information is collected from news reports related to Typhoon Bebinca and Typhoon Pulasan

4.2.1. Change characteristics of PCITD

PCITD presents obvious double peak characteristics. The first peak occurs from 0:00 to 12:00 on September 16, 2024 (Emergency response stage for Typhoon Bebinca) and the second peak occurred from 0:00 to 12:00 on September 20, 2024 (Post-disaster recovery stage for Typhoon Pulasan). It shows that PCITD always reaches the peak when the typhoon landed in Shanghai, and the peak level of PCITD during the occurrence of Typhoon Bebinca was higher than that during the occurrence of Typhoon Pulasan (Figure 4).

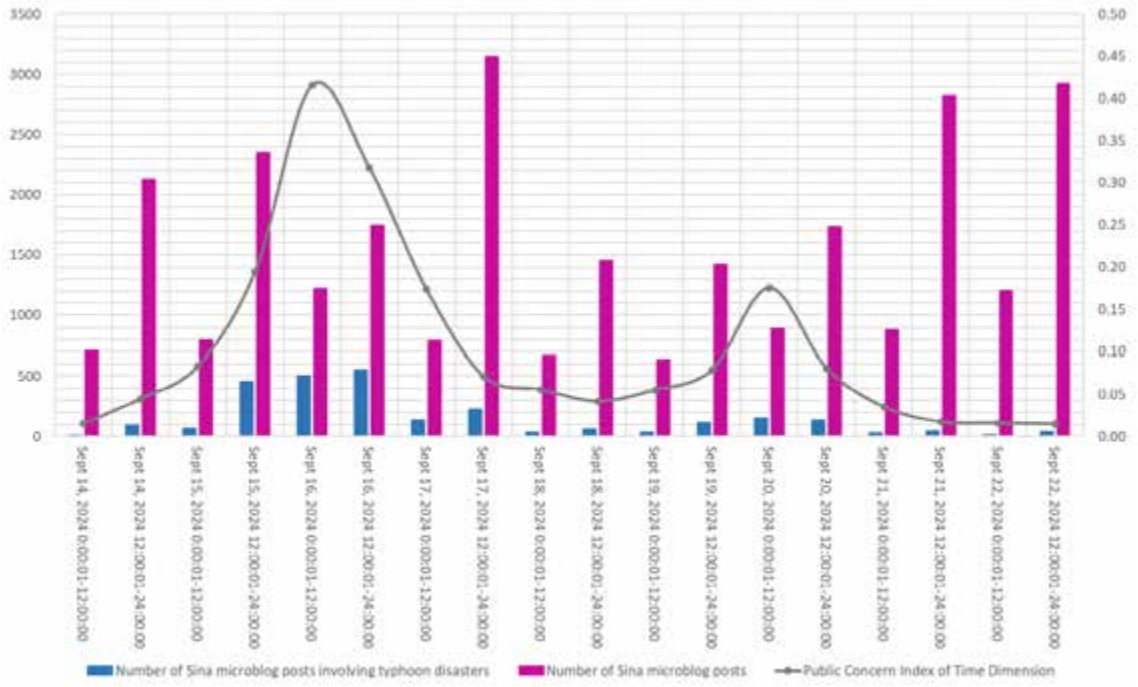

Figure 4. Change of PCITD

4.2.2. Change characteristics of NSITD and PSITD

NSITD and PSITD also presents double peak characteristics. The first peak occurred from 0:00 to 12:00 on September 18, 2024 (Post-disaster recovery stage for Typhoon Bebinca) and the peak of NSITD is higher than the peak of PSITD. The second peak occurred from 0:00 to 12:00 on September 22, 2024 (Post-disaster recovery stage for Typhoon Pulasan) and the peak of PSITD in this stage is higher than the peak of NSITD. At the same time, there is a significant difference between the NSITD and PSITD. The two peak levels of NSITD are basically the same, while the two peak levels of PSITD are quite different. The second peak level of PSITD is higher than the first peak level of PSITD (Figure 5).

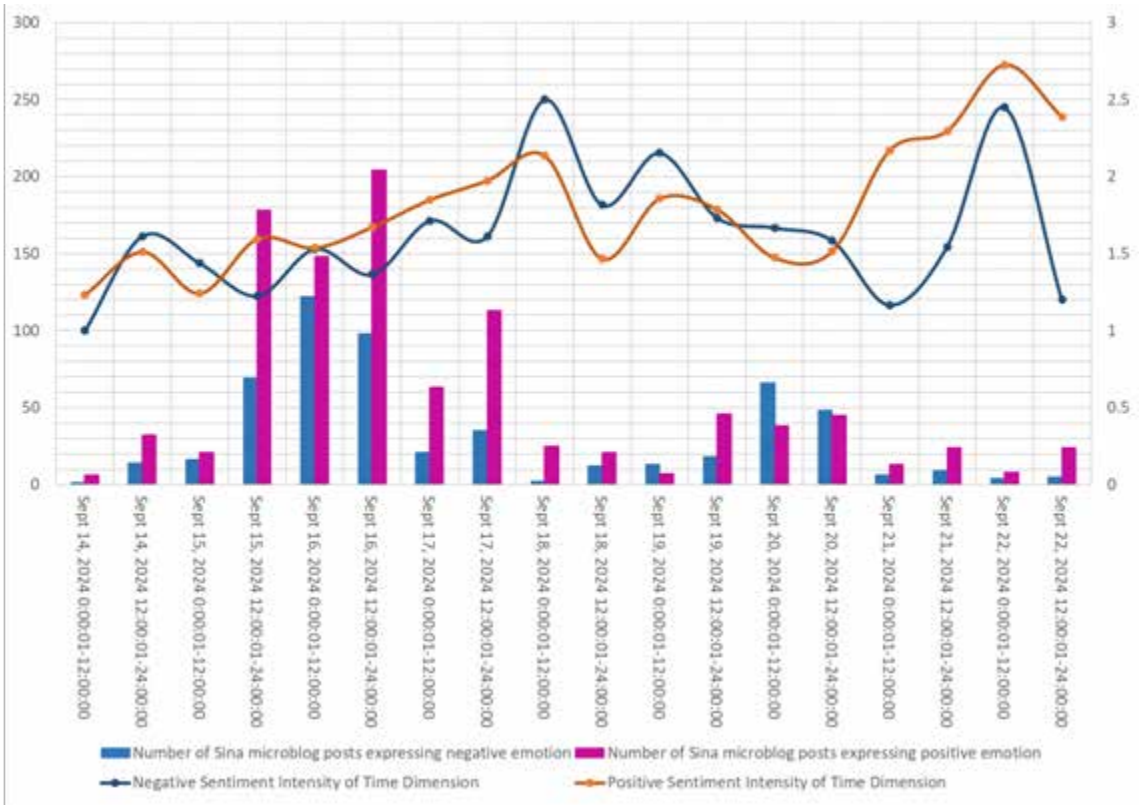

Figure 5. Change of NSITD and PSITD

4.2.3. Comparative analysis of PCITD, NSITD and PSITD

Although PCITD, NSITD and PSITD have two peaks, they have different characteristics. Firstly, the peak of NSITD and PSITD lags behind the peak of PCITD. The peak of PCITD occurs in the emergency response stage, while the peak of NSITD and PSITD occurs in the post-disaster recovery stage. Secondly, the time curve of PCITD is relatively smooth with obvious upward and downward trends, while the time curves of NSITD and PSITD show the fluctuating characteristics. In view of this disaster period, Typhoon Bebinca is stronger than Typhoon Pulasan, and Typhoon Bebinca causes greater damage to the city than Typhoon Pulasan. Therefore, PCITD during the Typhoon Bebinca is higher than that during the Typhoon Pulasan, which also causes the NSITD to be significantly higher than PSITD during the Typhoon Bebinca. At the same time, the continuous disaster impact also caused NSITD to reach two peaks. Fortunately, PSITD rises faster during the Typhoon Pulasan, which also shows the high efficiency of post-disaster recovery work in Shanghai.

4.3. Disaster perception in the spatial dimension

4.3.1. Distribution characteristics of PCISD

The areas with high value of PCISD are mainly distributed around the Shanghai Suburban Ring Road, especially in the southern coastal areas. While, the value of PCISD is relatively low in the areas within the Outer Ring Road (Figure 6).

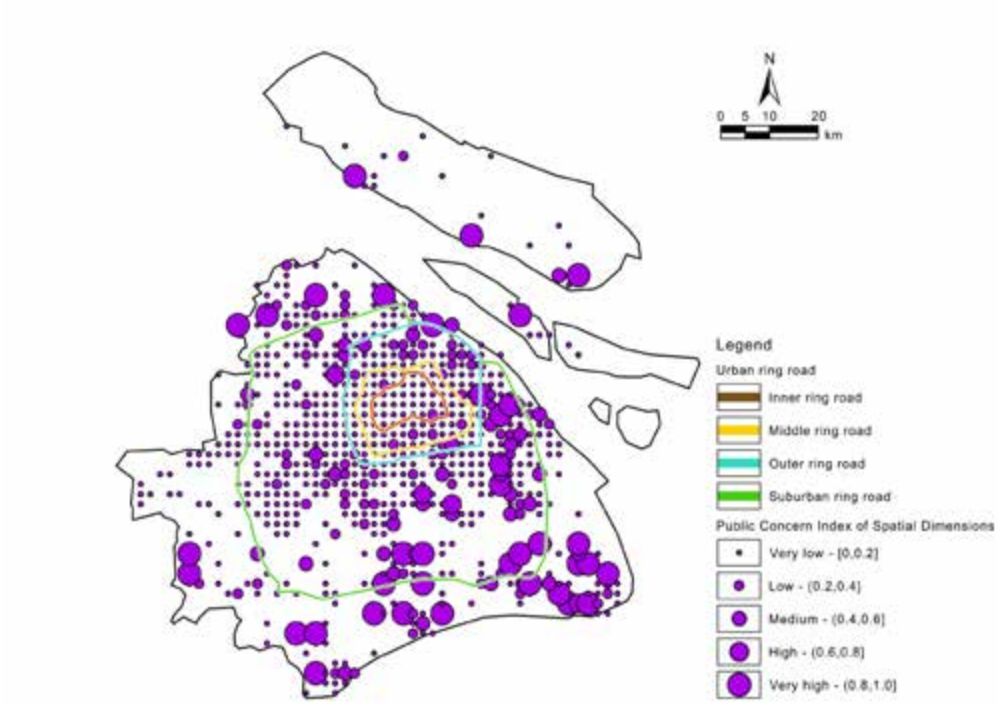

Figure 6. Spatial distribution of PCISD

According to spatial autocorrelation analysis, it shows that the spatial distribution of PCISD has obvious spatial clustering characteristics. For example, the hotspots are distributed in the coastal areas near the south of suburban ring road which are close to the typhoon landing sites and subject to typhoon disasters. While, the cold spots are distributed in the inland areas which are relatively less affected by typhoon disasters (Figure 7).

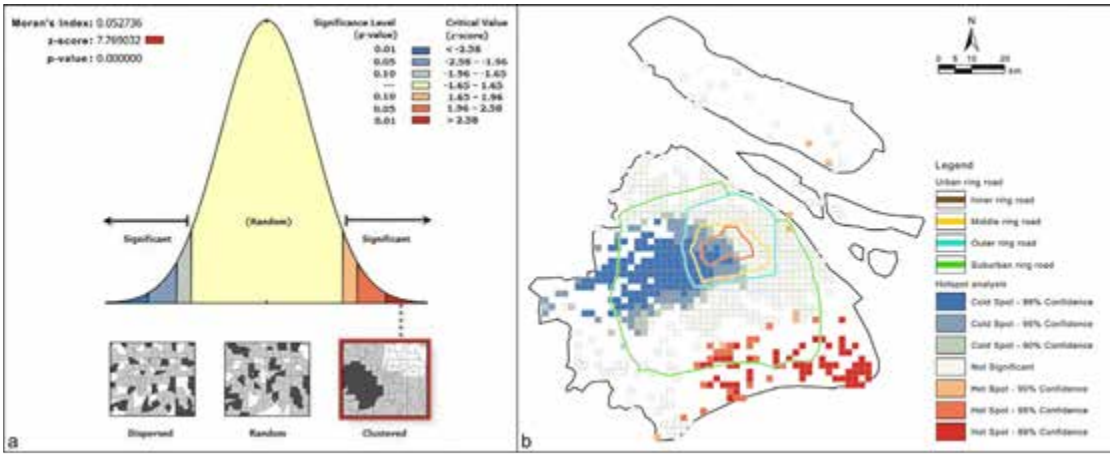

Figure 7. Spatial autocorrelation analysis of PCISD (a) and hot spot analysis of PCISD (b)

4.3.2. Distribution characteristics of NSISD and PSISD

In terms of NSISD, the areas with high value of NSISD are generally located within the outer ring road, while the areas outside the outer ring road present low high value of NSISD, with a small number of high value points of NSISD (Figure 8). In terms of PSISD, the spatial distribution of high value of PSISD is dispersed, the areas with high

value of PSISD includes the area within the outer ring road, the area between the outer ring road and suburban ring road, the area near the southern coast (Figure 9).

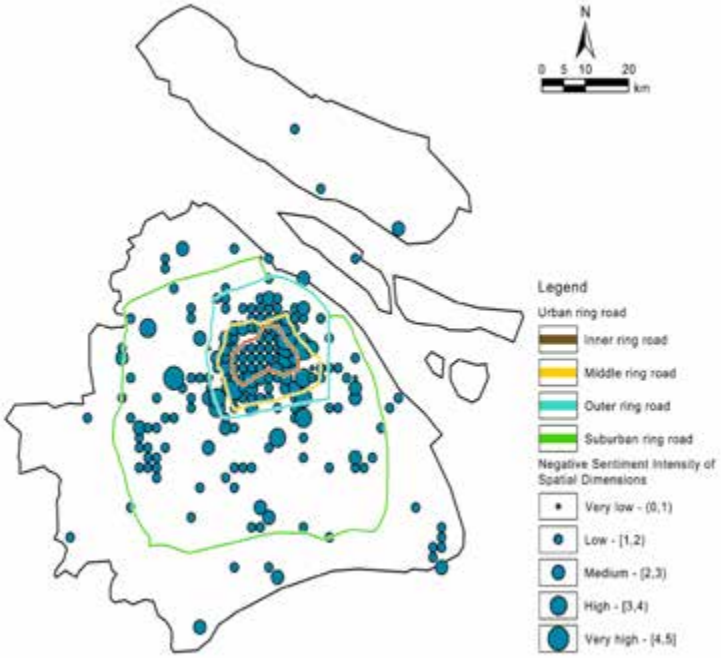

Figure 8. Spatial distribution of NSISD

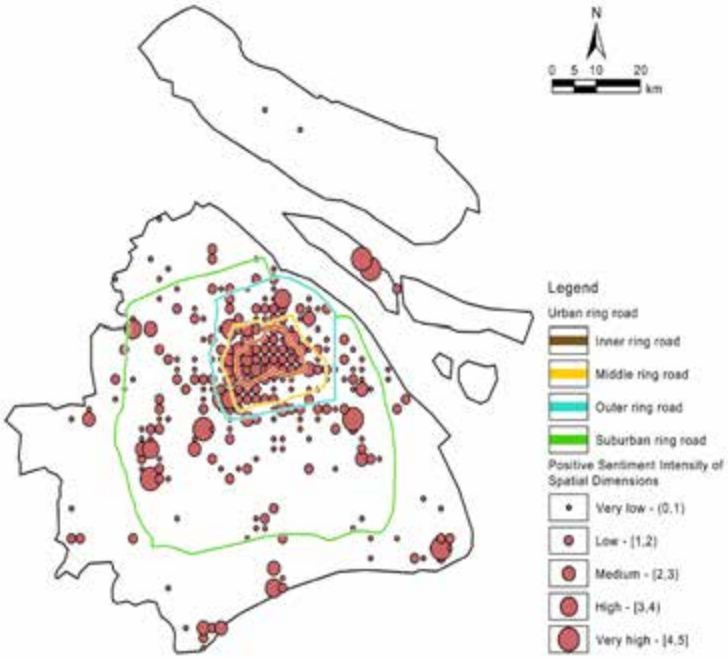

Figure 9. Spatial distribution of PSISD

According to spatial autocorrelation analysis, NSISD and PSISD present different spatial clustering characteristics. In terms of NSISD, NSISD exhibits obvious spatial clustering characteristics. Meanwhile, hotspots of NSISD concentrated within the middle ring road and cold spots of NSISD located in the western area of the suburban ring road (Figure 10). In terms of PSISD, PSISD exhibits random distribution characteristics (Figure 11). Furthermore, there are densely populated population and public service facilities within the middle ring road, which are highly vulnerable to typhoon disasters. Therefore, negative sentiment easily gathers in these areas and becomes hotspots.

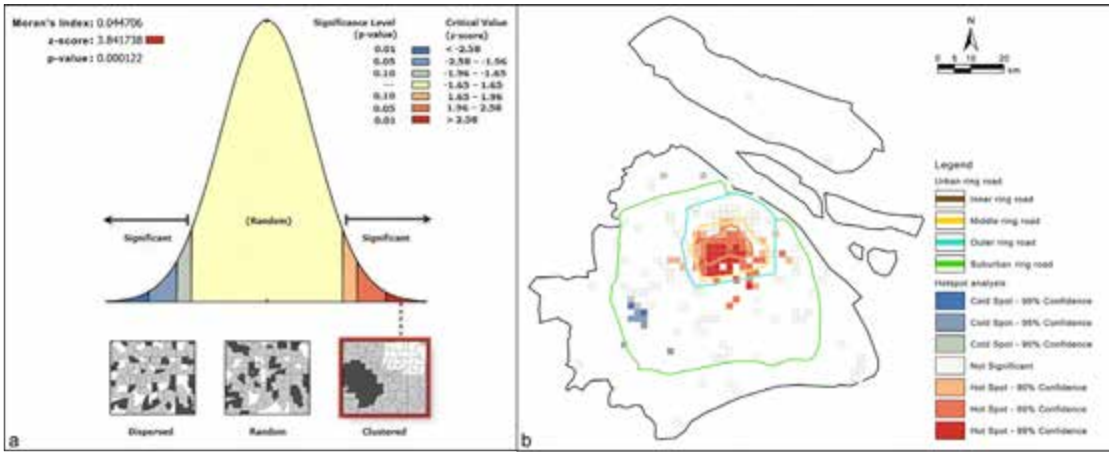

Figure 10. Spatial autocorrelation analysis of NSISD (a) and hot spot analysis of NSISD (b)

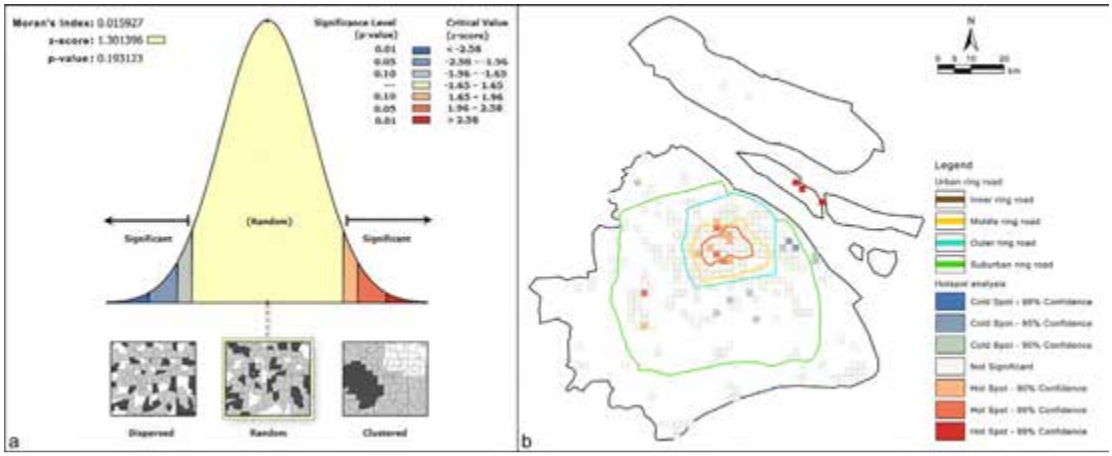

Figure 11. Spatial autocorrelation analysis of PSISD (a) and hot spot analysis of PSISD (b)

4.3.3. Comparative analysis of PCISD and NSISD

By comparing the hotspots of PCISD and NSISD, there is spatial differentiation between PCISD and NSISD. The area with high attention (high value of PCISD) distributes in the southern coast where the negative sentiment is not obvious (low value of NSISD). However, the area with low attention (low value of PCISD) distributes within the middle ring road where negative sentiment concentrated (high value of NSISD). Because low density of population and facility distributes in the southern coast with the greatest typhoon disasters impact, negative sentiment are not concentrated. Meanwhile, high density of population and facility distribute in the area within the middle ring road, but typhoon disasters have different impacts on people in different neighborhoods, which may cause public attention to be dispersed. This phenomenon shows that extreme weather events have greater uncertainty and cause different impacts on different parts of the city.

5. Discussion and conclusion

5.1. Discussion

Based on social media data, this paper conducts spatiotemporal perception analysis on typhoon disasters in Shanghai. Firstly, during the typhoon disasters, residents mainly focused on three themes, including daily travel activities, disaster-stricken locations and people, and post-disaster public places. It means that the focus of typhoon disasters prevention should include urban transportation, highly vulnerable neighborhoods and people, and public spaces. Secondly, the peak of PCITD occurs during the emergency response stage, while the peak of PSITD and NSITD occurs during post-disaster recovery stage. It means that PCITD can reflect the changing trend of the disaster impact, and disaster recovery effects can be evaluated based on NSITD and PSITD. Thirdly, PCISD can reflect the spatial distribution of disasters impact, and NSISD can reflect the spatial distribution of disaster-stricken conditions.

Typhoon disaster is the main type of natural disasters that affect the resilience level of cities in the China's eastern coastal areas. With the intensification of climate change, it is urgent to strengthen the ability of typhoon disaster prevention and improve the effectiveness of planning response. According to the above analysis, this paper proposes the following planning strategies.

(1) Construction of disaster intelligent perception platform for planning support system
Social media data provides a data source matching the dynamic change of disaster events, which can establish the disaster intelligent perception platform to achieve intelligent monitoring of typhoons. On the one hand, social media data can be applied to determine the impact and changing trend of the typhoon disasters based on the analysis of the disaster themes, the change of public perception, and the evolution of sentiment intensity. On the other hand, the disaster intelligent perception platform should integrate multiple data resources such as social media data, mobile signaling data and remote sensing data in order to identify disaster hotspots, delineate risk zones, and determine the location of disaster-stricken people.

(2) Layout optimization of emergency facilities based on disaster perception
In the pre-disaster preparation stage, urban planners can timely strengthen the refunction of emergency facilities and plan emergency evacuation routes based on hotspots of public concern on the social media. In the emergency response stage, urban planners can identify the location of disaster-stricken areas and provide decision-making support for the allocation of emergency relief resources through the text features analysis of social media. In the post-disaster recovery stage, urban planners can determine the spatial distribution characteristics of disaster damage, allocate relief supplies and set up emergency rescue sites and emergency hospitals based on the analysis of disaster themes and public sentiment intensity.

(3) Integration social media analysis tools into resilient urban planning
In order to cope with the uncertain challenges of disasters, resilient urban planning needs to incorporate dynamic analysis models to enhance adaptability. In terms of spatial dimension, social media data can be applied to conduct spatial distribution analysis of disaster hotspots and sentiment intensity. Meanwhile, these analysis results can be incorporated into disaster risk maps to support shelters selection and evacuation routes organization. In terms of temporal dimension, social media data can be applied to conduct the analysis of disaster themes and sentiment intensity, which can help determine the risk level of typhoon disasters and the key disaster response tasks at different stages.

5.2. Conclusion

As one of the most significant stakeholders in urban governance system, citizens are important force in resilient city construction. In the process of disaster response, it is crucial to analyze the disaster impact on citizens for the formulation of disaster response strategies and the improvement of urban emergency response capabilities. This paper shows that disaster perception through social media data can help reveal the characteristics of typhoon disasters impact on urban residents, which can provide reference for disaster management departments and explore new technical methods for resilient city planning.

With the development of social media and the advancement of messages dissemination, social media data contains multiple data formats such as sound, pictures, and videos in addition to text data, which contain a large amount of disaster information. This paper focuses on text data. In the future, we will further explore the potential of social media data in disaster perception, and conduct comprehensive analysis in combination with multiple data formats to improve the accuracy of disaster perception.

Acknowledgements
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Statements and declarations
All figures in this paper are created by the authors. Meanwhile, this paper adopts the 2024 version of China's administrative divisions map published by the National Geographic Information Public Service Platform (https://www.tianditu.gov.cn/), and the approval number of China's administrative division maps used in this paper is GS(2024)0650.

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Intelligent Urban Design: Self-organized Block Form Generation Using Reinforcement Learning - An Empirical Study from Nanjing, China

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Abstract
With the rapid rise of AI technologies, intelligent design has enhanced urban planning through algorithm-driven diversity, flexibility, and efficiency. This study proposes a reinforcement learning-based method for the self-organized generation of block forms, enabling adaptive spatial layout optimisation. Using Nanjing, China, as a case study, geometric calculations extract topological relationships to build a prototype database. A reinforcement learning model is then applied, incorporating design constraints like development intensity, building density, height, and green space ratio. Generative design experiments on three Nanjing blocks demonstrate how feedback allows dynamic adjustments, achieving economic, ecological, and social benefits. Unlike traditional rule-based approaches, this model learns through autonomous interaction with the environment and can better adapt to environmental characteristics, offering a novel framework and practical support for intelligent urban design.

Keywords: Block form; self-organized generation; reinforcement learning; intelligent optimisation; urban design

1. Introduction

With the acceleration of global urbanisation, urban design systems are facing the continuous impact of multiple dynamic constraints, such as population mobility and demand for mixed land use [1]. Traditional static planning methods (e.g., zoning planning or morphological guidelines) gradually reveal fundamental flaws in dealing with these real-time changes: First, the construction of the rule base is highly dependent on the experience of experts, and it is difficult to cover the special requirements of different cultural backgrounds and geographic conditions; Second, when faced with the multi-objective optimisation problem, the fixed weight allocation mechanism will easily lead to the solution falling into the local optimum, and often produces a single morphologically homogeneous solutions. This dilemma has given rise to the urgent demand for adaptive generative design methods, to dynamically adjust the spatial form through a real-time feedback mechanism instead of fixed rules [2,3].

Current intelligent design methods are mainly presented as two types of technological paths: multi-objective optimisation based on evolutionary algorithms and generative adversarial networks based on deep learning [4,5]. The former can generate Pareto frontier solution sets, but in practice, it is found that a single iteration is too time-consuming and the morphological diversity is limited; the latter can quickly generate visually reasonable solutions, but there are response delays and the decision-making process lacks transparency [6]. In essence, the existing methods have not yet broken through two key technical bottlenecks: (1) How to maintain the coherence of spatial topological relationships (e.g., the connectivity of the street network); (2) How to achieve real-time integration of dynamic constraints (e.g., dynamic adjustments of construction indicators). These shortcomings seriously restrict the practical application value of self-organised generation of neighbourhood morphology [7].

Reinforcement Learning (RL) provides new possibilities to solve the above problems. Its 'trial-and-error-feedback-optimisation' mechanism is intrinsically compatible with the process of self-organization of urban space: by simulating environmental interactions (e.g., crowd activity scenarios), intelligences can autonomously explore morphological evolution paths that satisfy multiple constraints [8]. The breakthrough research of Zheng et al. (2023) [9] indicates that RL can significantly enhance the working efficiency of human planners in architectural layout optimisation and efficiently generate design schemes of different styles. This lays a theoretical foundation for constructing an adaptive design system at the plot scale. Based on this, this study proposes a reinforcement learning framework that integrates spatial topological relations and dynamic constraints. Its technical implementation includes three core links: Firstly, the spatial topological characteristics of typical blocks in Nanjing are extracted through geometric operations to construct a design prototype database; Secondly, the constraint conditions such as development intensity and building density are quantified as reward functions; Ultimately, generative design was implemented in three districts in Nanjing, and the dynamic optimisation of form was

achieved through the real-time feedback of the revenue function.

Compared with the traditional rule-driven methods, the innovation of this study is reflected in: (1) Mapping the theory of spatial self-organization systematically into the state-action space of reinforcement learning for the first time, which makes the morphogenesis process both environmentally adaptive and topologically stable; (2) Developing an interpretable reward mechanism, which achieves the comprehensive optimisation of economic, ecological and social benefits in the Nanjing case; (3) Constructing a design assistance link to support planner interaction, and the response time of the system was controlled within 30 minutes. The empirical results show that the method can not only meet the current design constraints, but also respond to future demand changes through continuous learning, providing a new technical paradigm for intelligent urban design.

2. Methods

2.1 Technical framework

The Dynamic Coupled Reinforcement Learning (DCRL) framework proposed in this study realizes the intelligent generation and optimisation of building layout schemes through the collaborative operation of four core modules (Fig. 1).

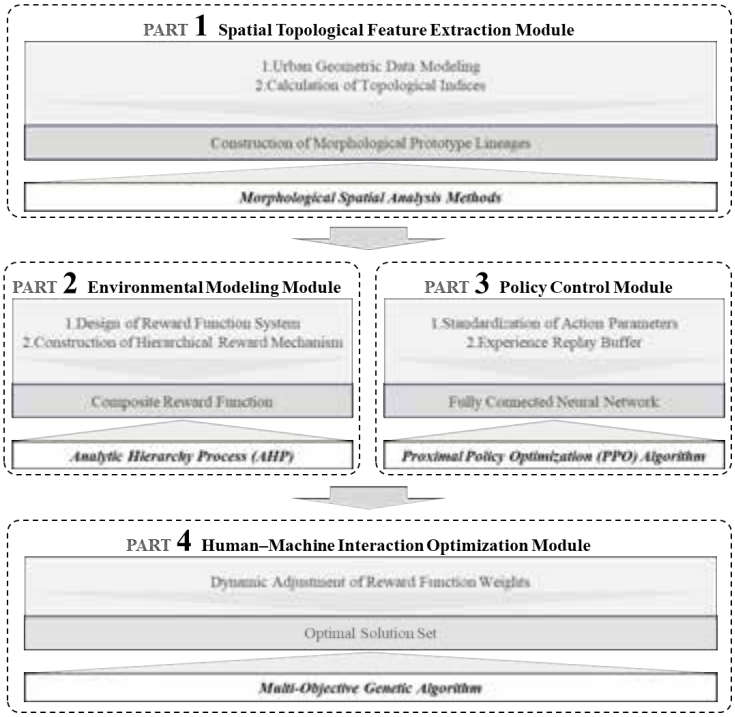

Fig.1. Technical framework

Firstly, the spatial topological feature extraction module conducts three-dimensional modeling of the geometric data of urban blocks, integrates spatial elements such as plot boundaries, street and lane networks, and the contours of existing buildings, and extracts topological indicators such as the curvature of streets and lanes, the fractal dimension of plots, and the proportion of building base area through computational geometric algorithms. Then, the Morphological Spatial Analysis (MSA) method is used for clustering to form a benchmark library containing multiple basic morphological prototypes [10], covering typical patterns such as “grid-type blocks - low-density development” and “radial road networks - mixed functions”, providing multi-dimensional morphological evolution benchmarks for reinforcement learning.

Secondly, the environmental modeling module converts the control elements of urban design into a calculable

reward function system, builds a hierarchical reward mechanism for legal indicators such as floor area ratio and green space ratio, penalizes the indicators deviating from the target interval through the exponential attenuation function, and finally forms a comprehensive reward function through hierarchical weighting, where the weight coefficients are determined by the initial values of the AHP analytic hierarchy process.

Thirdly, the strategy control module adopts the improved Proximal Policy Optimisation (PPO) algorithm [11] to construct the state input layer containing multi-dimensional spatial features and multi-dimensional constraint indicators. Feature fusion is achieved through the fully connected neural network, and the output layer generates standardized action parameters using the Tanh function. Design a double-loop training mechanism: The inner loop synchronously updates the policy network and the value network, and reduces the variance through dominance estimation; For external environmental storage, the strategy transfer is carried out with the optimal 5% scheme of each generation to avoid local optima. In the specific implementation, a 10,000-capacity experience replay buffer is set up, the mini-batch update model is adopted, and the learning rate decays according to the cosine annealing strategy.

Finally, the human-computer interaction optimisation module builds a two-way interaction system. Designers can dynamically adjust the weight of the reward function (such as increasing the green space ratio weight to 0.4). The scheme optimisation module uses the multi-objective genetic algorithm for Pareto frontier optimisation. The iteration termination mechanism is set so that the comprehensive score change rate of the optimal scheme for 10 consecutive generations is less than 1.5% or triggered by manual intervention. Finally, output the solution set of the preferred scheme.

2.2 Case selection and feature extraction

The study selected three typical blocks in Nanjing as the experimental objects: The Gulou Historical Block (1.2 km²) retains the "fishbone-shaped" street and alley layout of the Republic of China era, contains three cultural relics protection units, and has a floor area ratio of 1.2-1.8, representing the protective development of the historical urban area; The CBD of Hexi Area (1.5 km²) features a modern grid-type road network with a plot ratio of 2.5 to 3.5, reflecting high-intensity business development. The Zhujianglu Area (0.8 km²) integrates multiple functions through a radial road network, with a plot ratio of 1.8 to 2.8, reflecting the mixed functional scenarios in urban renewal (Fig. 2).

Fig.2. Three experimental areas

The feature extraction process is divided into two stages: Firstly, the ArcGIS platform is used to conduct geometric analysis of the basic spatial data of the study area, quantitatively extracting topological parameters such as street and alley connectivity, plot division patterns, and plot construction intensity. Secondly, K-means clustering analysis was conducted on the topological characteristics of buildings and plots in the main urban area of Nanjing, and they were classified into different prototype categories to construct a design prototype database. This database not only provides the initial state set for reinforcement learning, but also can generate composite topological structures through parameter combinations, effectively enhancing the diversity basis of form generation.

2.3 Reinforcement learning model construction

The state space design integrates three layers of feature vectors: static features, dynamic constraints, and spatial performance. The static layer includes the One-hot coding of the plot prototype and location features (standardized coordinate values, unique hot coding of road grades, and land use mixing degree index). The dynamic layer covers deviations of legal indicators, simulated values of environmental performance, and social indicators (such as walkability; The performance evaluation layer determines the weights of secondary indicators through the entropy weight method and linearly weights to generate the comprehensive score as the measurement of state value.

The action space defines four types of explainable form adjustment operations: ① Building volume reorganization (base area ±20%, height ±50%, step lengths 5% and 10% respectively), which needs to meet the requirements of fire fighting surfaces and aviation height limits; ② Interface offset (street-back line ±4m, step length 1m, continuous interface ±15%), it is necessary to ensure the width of the sidewalk and the continuity of the interface. ③ Public space replacement (minimum 100 square meters unit, conversion between green space and hard ground) must comply with the lower limit of the green space ratio and the proportion limit of public space in the plot. ④ Development intensity adjustment (FAR±0.2 for adjacent plots, not exceeding 20% of the original index), it is necessary to ensure that the indicators of each plot are compliant and the total construction volume change is ≤5%. Before each action is executed, a multi-constraint verification module that includes 3D spatial conflict detection, planning regulation inspection, and engineering feasibility assessment is adopted to ensure the implemtability of the plan.

3. Results

3.1 Spatial Topological Relationship Graph

The 180 plots of the three typical blocks in Nanjing were geometrically analyzed through the ArcGIS platform, and four types of spatial parameters including Road network, Land function, Development intensity and Building density were extracted. Through K-means clustering, a total of 54 spatial combination prototypes were formed (Fig. 3).

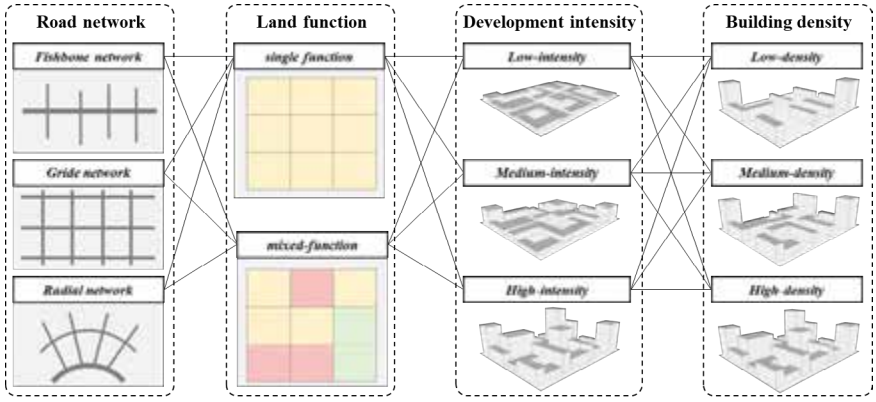

Fig.3. Space prototype combination mode

Among them, the Gulou Area is mainly based on the prototype of "fishbone-shaped streets and alleys + small-scale plots (average 3,000 square meters) + high building density (35%-45%)", and the integration degree of the streets and alleys (spatial syntax α=0.5) reaches 0.82, reflecting the high accessibility of the historical space. The Hexi Area is mainly based on the prototype of "grid-type road network + medium and high-intensity development (FAR=2.5±0.3) + low building density (20%-30%)", and the plot compactness index (0.75±0.05) reflects the regularized form of the modern business district. The Zhujianglu Area presents the characteristics of "radial streets and alleys + mixed functional layout + medium development intensity (FAR=2.2±0.3)", and the variation coefficient of the plot shape coefficient reaches 0.38, reflecting the morphological diversity brought by functional mixing. The prototype database contains various types of geometric parameter thresholds (such as the building aspect ratio 1:1.2-1:1.5) and planning constraints (such as the building height of the plot ≤150m), providing a multi-input space for the initial state vector for reinforcement learning.

3.2 Generation of the design plan for the Gulou Area

In response to the protection and renewal requirements of the Drum Tower Historical Block, the agent generated 32 effective solutions through 150 generations of iterations, and the Pareto optimal solution scheme was obtained through NSGA-II screening (Fig. 4). The optimal plan, while maintaining the integrity of the historical street and alley framework (92%), increases the green space ratio from 18% to 25%, and at the same time reduces the number of households with substandard sunlight exposure in cultural relics protection units from 12 in the initial plan to 0. The specific optimisation strategies include: ① Through the "building volume reorganization" action, reduce the base area of the three plots by 10%-15% to release the space for the construction of pocket parks at street corners; ② Utilize the "interface offset" operation to adjust the receded lines of the buildings along the street (with an average retracement of 2.5 meters), and widen the pedestrian passage to 4.5 meters without disrupting the continuity of the historical interface (maintaining a line alignment rate of 85%). ③ By adjusting the development intensity across plots (reducing the FAR from 1.8 to 1.6), the saved construction volume is transferred to non-protected plots to balance the protection requirements and development benefits. Compared with the traditional rule-driven method, the sunshine compliance rate of the DCRL scheme is increased by 23%, and it avoids the conflict between the green space ratio and building density caused by manually setting weights (the traditional scheme sacrifices an average of 5% of the green space ratio to meet the density requirements).

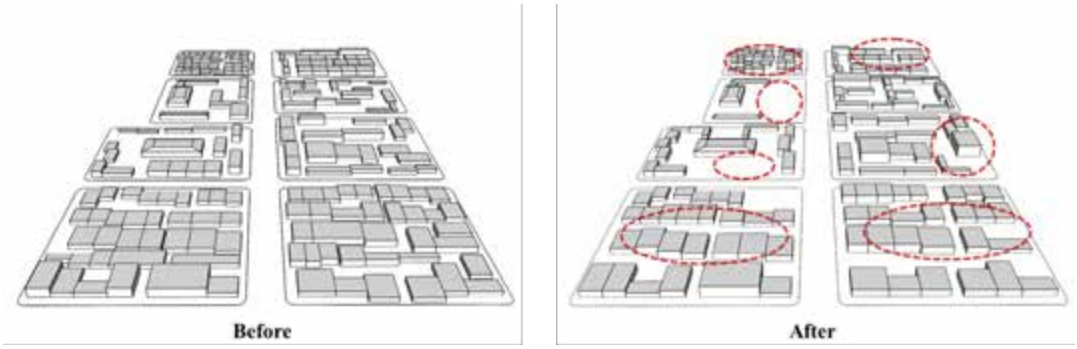

Fig.4. The design optimization plan of the Gulou Area

3.3 Generation of the design plan for the Hexi Area

In the high-intensity development scenario of the Hexi Area, the agent generated 56 compliant schemes after 200 generations of training. The optimal scheme achieved a comprehensive balance of a plot ratio of 3.0 and a building density of 25% (Fig. 5). The key optimisation paths include: ① Converting idle and inefficient land into green space in the center of the plot through "public space replacement", increasing the green space ratio of the block from 18% to 22%; ② Increase the floor area ratio to meet the demands of high-intensity development by raising the FAR of commercial plots from 1.5 to 4.0-7.0; ③ Add landmark buildings. Add landmark high-rise buildings to the plots close to the main roads to enhance the visual experience of the economic core area and economic corridors.

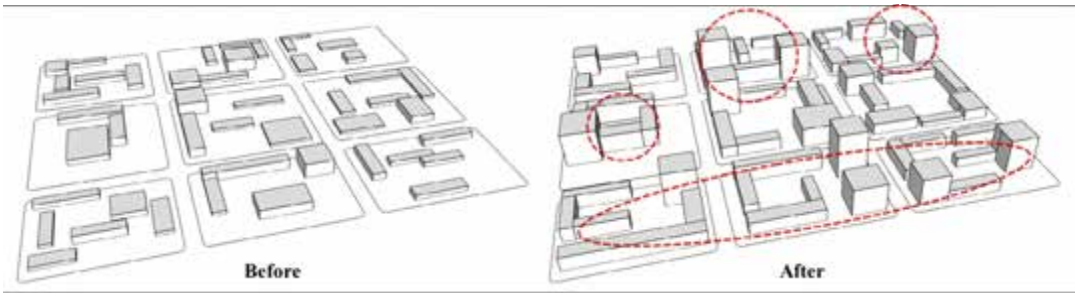

Fig.5. The design optimization plan of the Hexi Area

3.4 Generation of the design plan for the Zhujianglu Area

In response to the complex constraints of the Zhujianglu Area, the agent generated 45 effective schemes. The optimal scheme achieved a functional ratio of commercial building area accounting for 35%, residential building area accounting for 50%, and office building area accounting for 15% (Fig. 6). At the same time, the coverage rate of bus stops within a 500-meter walk reaches 100% (Figure 5). The core optimisation methods include: ① Through the "interface offset" operation, continuous arcade interfaces (200m in length) are set up in commercial plots to enhance the commercial atmosphere of the street, while meeting the requirement that the width of the sidewalk is ≥3m; ② Utilize "building volume reorganization" to adjust the building height of the residential plot (increase by 15%), expand the residential area without exceeding the height limit (50m), and maintain the uniformity of the street interface simultaneously through the control of the line connection rate (75%). ③ Through cross-plot development intensity adjustment (FAR±0.2), the excess 0.3 FAR of residential plots was transferred to commercial plots to achieve functional optimisation without changing the total construction volume. Compared with the traditional scheme, the scheme generated by DCRL has significant improvements in social indicators such as the functional mixing degree (the mixing degree index calculated by the entropy method is 0.89) and the efficiency of the walking network (the average shortest path is reduced by 120m).

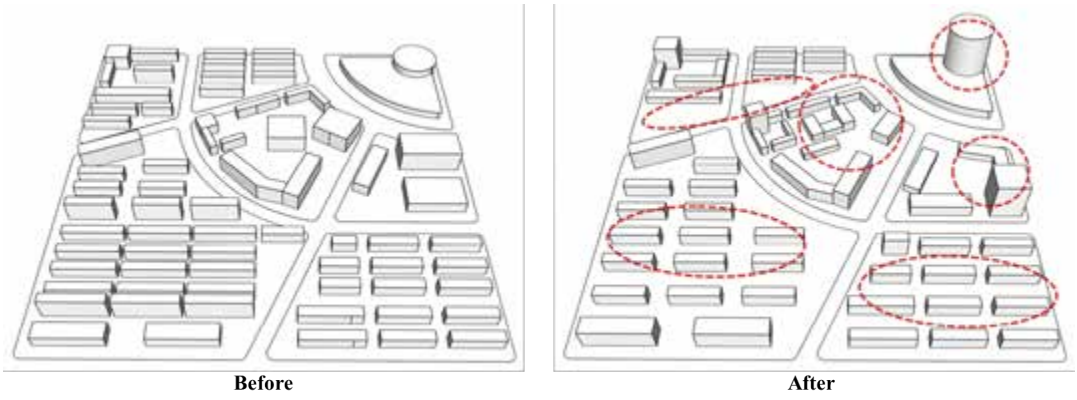

Fig.6. The design optimization plan of the Zhujianglu Area

Experimental data show that the optimal schemes of the three types of blocks all meet all the legal constraints (floor area ratio deviation ≤±0.1, green space ratio ≥ the legal lower limit), and on average increase by 18%-25% in environmental and social indicators compared with the initial schemes. The average training time was shortened by 15% compared with expectations, verifying the improvement effect of the elite solution set transfer strategy on computational efficiency. Visual analysis shows that the retention degrees of the morphological prototypes of each block generation scheme all exceed 70%, proving that DCRL has achieved innovative optimisation while maintaining the stability of spatial topology.

4. Discussion

4.1 Method Innovation

The core difference between the DCRL proposed in this study and the traditional generative design method lies in the construction of an intelligent decision-making mechanism of "dynamic feedback - continuous optimisation", breaking through the limitation of the traditional method that relies on "static rule base + heuristic search". Traditional generative design mostly generates schemes based on preset form rules (such as building regression lines, floor area ratio zoning, etc.), and its optimisation process is essentially parameter traversal under fixed constraints, making it difficult to respond in real time to complex environmental changes and multi-objective conflicts (such as the dynamic balance between economic benefits and ecological benefits). The DCRL converts urban design constraints into quantifiable dynamic reward signals through the environmental modeling module. Combined with the PPO algorithm of the policy optimisation module, it enables the agent to independently learn the optimal layout strategy in the interaction with the virtual environment, achieving a paradigm shift from "rule-driven" to "data-rule dual-driven". For example, when dealing with the contradiction between floor area ratio and green space ratio, traditional methods require manual setting of priority weights. However, DCRL, through the adaptive adjustment of the reward function, can dynamically search for the optimal solution that takes both into account in the Pareto front solution space, avoiding the local optimal problem caused by static rules.

The design of the reward mechanism plays a key coordinating role in multi-objective optimisation. The comprehensive reward function constructed in the research integrates the legal control indicators, environmental performance and social effects. Through hierarchical weighting (determining the initial weight by AHP) and dynamic adjustment (the human-computer interaction module supports real-time weight modification), the systematic quantification of multiple design goals is achieved. Compared with the linear weighting method commonly used in traditional multi-objective optimisation (with fixed weights and difficulty in reflecting the nonlinear relationship between objectives), the reward mechanism of DCRL has stronger dynamic adaptability: On the one hand, the implicit design requirements are transformed into calculable optimisation objectives through continuous reward signals (such as real-time simulation values of sunlight accessibility and pedestrian network convenience); On the other hand, combined with the generation and visualization of Pareto frontier solutions (the NSGA-II algorithm supports multi-scheme trade-offs), it provides designers with clear solutions to target conflicts, enabling the balance process of "economic benefits - ecological benefits - social benefits" to shift from empirical judgment to data-driven. This method of encoding urban design knowledge into computable reward signals provides a universal framework for the intelligent generation of complex built environments.

4.2 Practical Significance

The DCRL framework has shown significant application potential in the scenario of urban stock renewal. Stock renewal faces challenges such as complex spatial ownership, numerous constraints of existing facilities, and diverse demands of stakeholders. Traditional design methods are difficult to efficiently handle the dynamic coupling problem of multi-dimensional constraints. Take the Nanjing Gulou Historical Block as an example. Its spatial prototype of "fishbone-shaped streets and alleys + high-density plots" has strict protection requirements for building volume and interface continuity, and at the same time needs to meet the demands of modern traffic organization and public service improvement. The prototype database constructed by the spatial topological feature extraction module of DCRL can accurately identify existing morphological genes (such as small-scale plot boundaries and historical interface alignment rates), and combine the reward mechanism to quantitatively balance the protection elements (sunlight spacing of cultural relics protection units) and the renewal demands (new green space ratio). Generate a layout plan that not only meets the requirements of historical style protection but also enhances spatial performance. This workflow of "prototype recognition - constraint translation - intelligent optimisation" is particularly suitable for the refined design of complex existing Spaces such as old urban areas and industrial heritage areas, providing technical support for urban renewal to shift from "incremental expansion" to "existing quality improvement".

In terms of interface compatibility with the urban planning management system, DCRL has achieved seamless

integration of intelligent design achievements with the existing planning control system through standardized data interaction mechanisms and constraint translation methods. Firstly, the spatial topological feature extraction module adopts the CityGML standard to construct a three-dimensional spatial information model, and forms data intercommunication with the ArcGIS platform commonly used in the planning management system to ensure the consistency of basic parameters such as plot division and construction intensity. Secondly, the environmental modeling module directly converts legal indicators such as floor area ratio and building density into the core variables of the reward function, enabling the schemes generated by the agent to naturally comply with the planning control requirements (such as the development intensity deviation controlled within ± 0.2FAR), reducing the frequent compliance verification costs in the generation of traditional schemes. Finally, the human-computer interaction module enables designers to adjust the constraint weights in real time (such as adjusting the priority of the green space ratio according to the control plan), enabling the optimisation process to respond synchronously to changes in planning management policies and forming a closed-loop workflow of "intelligent generation - manual guidance - policy adaptation". This compatibility lays the foundation for the deep integration of the planning approval system and intelligent design tools, promoting the transformation of urban design from "experience-based decision-making" to "data-driven intelligent decision-making".

4.3 Limitations and Future Prospects

Although the DCRL framework shows advantages in method innovation and practical application, its performance is still limited by the quality of training data and computational efficiency. Firstly, the construction of the spatial prototype library relies on the typical morphological features obtained by K-means clustering. When facing small sample scenarios (such as special functional blocks and extreme terrain conditions), the limited training data may lead to insufficient prototype coverage, thereby affecting the diversity and adaptability of the generation schemes. For example, if a certain block has a unique form of "valley landform + irregular road network", and there is a lack of similar samples in the prototype library, the agent may not be able to effectively identify the key constraints, resulting in spatial performance deficiencies in the scheme. Future research can introduce transfer learning techniques. By using the pre-trained basic prototype model combined with a small amount of data in the target area for fine-tuning, the generalization ability of the model in small sample scenarios can be enhanced. Meanwhile, explore self-supervised learning methods to automatically discover potential morphological patterns and dynamically expand the coverage of the prototype library.

Secondly, the balance between the real-time computing efficiency and the design cycle of the reinforcement learning model urgently needs to be optimized. The PPO algorithm adopted in the current strategy optimisation module takes a long time in a single iteration when dealing with the high-dimensional state space and the continuous action space (a single case requires approximately 4 to 6 hours to complete 200 generations of training), and it is difficult to meet the requirements of rapid scheme comparison and selection in actual projects. Although the research has improved the training efficiency through the experience replay buffer and the elite solution set transfer mechanism, in the design of large-scale urban districts, the consumption of computing resources still increases exponentially. In the future, breakthroughs can be made in two aspects: algorithm optimisation and hardware acceleration. On the one hand, develop lightweight neural network architectures (such as the combination of deep reinforcement learning and graph neural networks) to reduce the computational complexity of state processing. On the other hand, the distributed computing platform is utilized to process the optimisation tasks of multiple plots in parallel. Combined with GPU acceleration technology, the time of a single iteration is shortened, promoting the framework to be implemented from the experimental environment to engineering application scenarios. Furthermore, exploring the two-tier architecture of "offline training - online rapid generation", pre-training the universal layout strategy model, and conducting rapid fine-tuning only for site-specific constraints in specific projects can further balance computational efficiency and design flexibility.

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Unravelling the Complexity of Urban Functional Organization Based on Explainable GeoAI

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Abstract:
Urban expansion and population diversity have created increasingly complex functional organizations, challenging traditional land use strategies and highlighting the need for advanced analytical approaches. This study leverages explainable GeoAI, specifically a Multi-level Receptive Field Graph Convolutional Network, to decipher underlying patterns in urban functional organization across different spatial scales. The explainable AI framework enables interpretable analysis of spatial-functional interactions among urban functions across varying distance thresholds. Comparing five metropolitan five representative cities, the model achieves 92% accuracy while providing transparent insights into scale-specific spatial interactions. Results reveal distinctive distance-dependent patterns: Chinese cities exhibit stronger long-range dependencies, Western cities show balanced multi-scale interactions, while Paris demonstrates short-range relationships. This explainable GeoAI approach advances both methodological transparency and cross-cultural understanding of urban functional complexity.

Keywords: Explainable AI, Graph Neural Networks, Urban Functional Organization, Multi-scale Spatial Analysis, Cross-cultural Urban Planning

1. Introduction

Urban land use planning represents one of the most critical components of sustainable urban development in contemporary cities. The strategic allocation of spatial resources not only shapes the physical landscape of urban environments but also profoundly influences socioeconomic dynamics, environmental sustainability, and residents' quality of life. As cities continue to expand both horizontally and vertically, the importance of efficient and adaptive land use strategies has never been more pronounced.

The complexity of urban land use systems has escalated dramatically in recent decades. This increasing complexity is characterized by intricate interdependencies between diverse urban functions, multi-scale spatial interactions, and emergent behavioural patterns that often defy traditional analytical approaches. Urban areas no longer adhere to simplistic mono-functional zoning paradigms but instead exhibit polycentric, mixed-use configurations driven by changing social preferences, technological advancements, and economic imperatives. Understanding these multi-level spatial interactions requires analytical approaches that can simultaneously capture local neighbourhood dynamics, intermediate district-level relationships, and metropolitan-scale structural patterns, a challenge that traditional analytical methods struggle to address comprehensively.

Under this complexity, incompatible land use allocations can lead to inefficient transportation networks, socioeconomic segregation, environmental degradation, and diminished urban resilience. Conversely, thoughtfully designed urban functional arrangements can foster social cohesion, economic productivity, environmental sustainability, and human wellbeing. The far-reaching impacts of these decisions necessitate sophisticated analytical approaches that can capture the multidimensional complexity of urban functional organizations across different spatial scales while remaining interpretable for planning practitioners who must translate analytical insights into actionable policy recommendations.

Modern urban systems are characterised by hierarchical spatial organization patterns that operate across multiple scales simultaneously. Drawing from central place theory (Christaller, 1933) and more recent polycentricity frameworks (Kloosterman and Musterd, 2001), urban functions naturally organise themselves into nested hierarchies where different activities serve catchment areas of varying sizes. Daily convenience services typically operate within pedestrian catchments (300-500m), while specialised services and employment centres serve larger regional catchments (5-10km). However, the spatial configuration of these hierarchical patterns varies significantly across different cultural and institutional contexts. Theoretical frameworks from geographic economics suggest that spatial interaction patterns reflect underlying preferences for mobility, social organization, and service delivery models deeply embedded in cultural practices (Fujita et al., 1999). European cities, shaped by

millennia of pedestrian-oriented development, tend to emphasize short-range spatial interactions and neighbourhood self-sufficiency. In contrast, cities developed during the automobile era, or those with different transportation philosophies, may exhibit fundamentally different spatial organization principles where longer-range interactions dominate functional relationships. Thus, under the complex multi-scale urban structure, it is the key step to make the proper urban decision of land use from understanding the relationship between inner emerging pattern within multi-level functional layers.

This research posits that the interactions among diverse urban functions, particularly their spatial arrangements along network-constrained pathways at multiple distance thresholds, hold the key to understanding emergent urban phenomena and cultural variations in urban organization. By examining how functional relationships operate differently at pedestrian (0-500m), cycling (500m-1km), and transit/automotive (1-2km) scales, we can decode the underlying organizational principles that distinguish different urban planning paradigms. By leveraging recent advances in explainable graph neural networks and multi-level spatial analysis, we develop a framework that not only predicts urban functional patterns but also illuminates the scale-specific causal mechanisms underlying these patterns across different global cities, providing both scientific rigor and practical relevance for cross-cultural urban planning applications.

2. Related Work

The application of neural networks in urban studies has gained significant momentum in recent years, offering powerful tools to model complex urban systems. Convolutional Neural Networks (CNNs) have been widely employed to extract spatial features from urban imagery and remotely sensed data, enabling automated land use classification (Zhang et al., 2019) and urban growth prediction (Boeing., 2017). Recurrent Neural Networks (RNNs) have proven effective in capturing temporal dynamics of urban phenomena, including traffic flow prediction (Veličković et al., 2018) and human mobility patterns (Yuan et al., 2012). While these approaches have demonstrated impressive predictive performance, they often function as "black boxes," providing limited insights into the underlying mechanisms driving urban spatial patterns.

The urban planning discipline emphasizes evidence-based decision-making, where understanding causal relationships is as important as predictive accuracy. This requirement has spurred interest in explainable AI techniques within urban research. Doshi-Velez and Kim (2017) emphasized that explainability in AI systems is crucial for domains where decisions have significant societal impacts. In urban studies, Arrieta et al. (2020) employed attention mechanisms to highlight influential features in transportation mode choice models. Despite these advances, explainable AI in urban planning remains nascent, with significant challenges in translating model insights into actionable planning recommendations. The planning profession's need for transparent and interpretable models stems from several factors, due to its career nature of public service and decision. First, it should provide reliable as well as legal and ethical requirements for justifying planning decisions. Second, the multidisciplinary nature of planning has to necessitate communication across different expert domains. Finally, its result is highly relate to daily life, which requires to build public trust in each process. As noted by Batty (2018), while AI may enhance the efficiency of planning analyses, the discipline's emphasis on participatory processes and value-based judgments requires models that can effectively communicate their reasoning processes to diverse stakeholders.

Spatially explicit neural networks have emerged as a promising approach for incorporating geographical context into predictive models. Yao et al. (2017) developed a spatial autoencoder for neighborhood-level land use classification that preserved spatial relationships between urban features. Similarly, Gao et al. (2017) employed spatial attention mechanisms to capture location-specific influences in housing price prediction models. These approaches recognise that urban phenomena are inherently spatial, with observations exhibiting dependencies based on proximity and connectivity.

However, most spatially explicit models rely on Euclidean distance metrics that fail to capture the network-constrained nature of urban interactions. Urban activities typically follow street networks rather than straight-line paths, making topological distance more relevant than Euclidean distance for many analyses. This limitation has

been partially addressed by recent graph-based approaches that model cities as networks, as seen in Zhong et al. (2014)'s application of Graph Convolutional Networks (GCNs) to analyze urban functional mix patterns. Nevertheless, these graph-based models often lack interpretability, limiting their utility for planning practice despite their strong predictive performance.

The integration of explainability into graph-based models for land use analysis represents an emerging frontier. Early work by Ying et al. (2019) utilised GNN Explainer techniques to identify influential nodes in urban mobility networks. Ying et al. (2019) proposed a self-attention GCN for land use classification that provided attention weights as a measure of feature importance. Despite these advances, existing approaches typically offer post-hoc explanations rather than incorporating explainability directly into model architecture.

A particularly critical gap in current research is the lack of methods that align neural network operations with established urban planning theories. The AI applications in planning should not merely provide statistical predictions but should be designed to complement and extend existing theoretical frameworks. This study addresses this gap by developing a GNN architecture that explicitly incorporates urban behavioral theories through spatially constrained receptive fields and multi-level aggregation mechanisms that correspond to different scales of urban interaction.

3. Methodology

We represent the urban environment as a graph G = (V, E), where vertices V correspond to street intersections or points of interest, and edges E represent street segments connecting these locations. Each vertex is associated with a feature vector xi that encodes local urban characteristics, including land use types, building attributes, and socioeconomic indicators. This graph-based representation captures the network-constrained nature of urban interactions, recognizing that urban activities and flows primarily follow street networks rather than Euclidean paths.

Traditional GCN approaches often suffer from over-smoothing when propagating information across multiple hops, potentially obscuring the distinctive characteristics of local neighborhoods. Additionally, they typically employ fixed-distance aggregation that fails to account for varying scales of urban interactions. Different urban functions operate at different spatial scales—daily convenience services typically serve smaller catchment areas compared to specialised commercial or recreational facilities.

To address these limitations, we propose a Multi-level Receptive Field Graph Convolutional Network (MRF-GCN) that controls information propagation based on urban behavior theories. Specifically, we define multiple receptive fields for each node, corresponding to different travel distance thresholds that align with common urban mobility patterns (e.g., 5-minute walking distance, 15-minute cycling distance, 30-minute driving distance). Formally, for each vertex vi, we define a set of receptive fields {Ri1, Ri2, ..., Rik}, where each Rik represents the subgraph containing vertices reachable from vi within the travel time threshold from k-1th to kth. The graph convolution operation at level k is then defined as:

$$H_i^k = \sigma\left(D^{k^{-\frac{1}{2}}} A^k D^{k^{-\frac{1}{2}}} X^k W^k\right)$$

Where H_i^k represents the hidden representation at receptive field level k, A^k is the adjacency matrix restricted to connections within the k-th travel time threshold, D^k is the degree matrix corresponding to A^k, X^k is the feature matrix restricted to nodes within the k-th travel time threshold subgraph, W^k is a learnable weight matrix, and σ is a non-linear activation function.

These level-specific representations are then combined through an attention mechanism that learns the relative importance of different spatial scales for predicting urban functional patterns:

$$H_i = \sum_{k=1}^{K} \alpha_{ik} H_i^k$$

Where α_{ik} are attention coefficients determined by:

$$\alpha_{ik} = \frac{\exp(q^T \tanh(W_a H_i^k + b_a))}{\sum_{k'=1}^{K} \exp(q^T \tanh(W_a H_i^{k'} + b_a))}$$

Here, q, W_a, and b_a are learnable parameters. This formulation allows the model to adaptively weight the importance of different spatial scales based on the specific prediction task.

Our MRF-GCN architecture offers three levels of explainability that directly align with urban planning theory and practice:

• Behavioral-Technical Unification: The graph convolution operation mathematically formalises the urban planning concept that neighborhood characteristics emerge from the aggregation of nearby functions and activities. By structuring the aggregation process along the street network, our model captures how urban functions interact through actual travel paths rather than direct Euclidean distance, providing a more realistic representation of urban behavior.
• Scale-Specific Functional Interactions: The multi-level receptive fields allow us to identify which urban functions interact strongly at different spatial scales. For instance, the model might reveal that residential satisfaction is more strongly influenced by proximity to daily necessities at the 5-minute walking scale, while employment opportunities at the 30-minute driving scale have greater impact on housing prices. These insights directly inform planning decisions about functional mix and distribution.
• Attention-Based Importance Attribution: The attention mechanism provides quantitative measures of which spatial scales and functional combinations most strongly influence particular urban outcomes. By analysing attention weights , planners can identify the critical spatial thresholds for different urban phenomena, potentially revealing threshold effects in urban service provision.

This explainability framework transcends mere technical transparency, offering insights that are directly interpretable within established urban planning paradigms. Rather than providing post-hoc explanations of model predictions, our approach integrates explainability into the model architecture itself, ensuring that the model's internal representations align with meaningful urban concepts.

4. Results

1.1 Data Collection and Preprocessing

Our study utilises comprehensive urban data collected from five major metropolitan areas with varying urban morphologies, development histories, and cultural contexts: Shanghai, Beijing, New York, London, and Paris. These cities were strategically selected to represent diverse urban development paradigms and cultural backgrounds. Shanghai and Beijing, both Chinese megacities, share similar political and economic systems but exhibit distinct functional organizational characteristics, providing a test case for detecting subtle intra-cultural variations. New York and London represent Western global cities with comparable international connectivity and economic structures. Paris serves as a distinctive European model, smaller in scale compared to the other four cities and with unique historical urban development patterns.

For each city, we extracted the complete road network from OpenStreetMap and integrated Points of Interest

(POI) data encompassing 12 primary functional categories (residential, commercial, educational, healthcare, recreational, transportation, industrial, governmental, religious, cultural, financial, and mixed-use) and their subcategories. We also incorporated socioeconomic indicators from census data and human mobility patterns from anonymised smartphone trajectories. The final dataset comprises over 1.5 million POIs across the five cities, geocoded and associated with their nearest network nodes to construct a graph representation where nodes represent urban intersections and edges represent road segments.

Unlike conventional land use classification tasks, we designed our experiments to test whether our model can identify distinctive urban functional patterns that characterize different cities based solely on their spatial-functional organization. Specifically, we extracted subgraph samples representing local urban areas of approximately 4km × 4km each, ensuring sufficient spatial coverage to capture meaningful functional interactions while maintaining computational feasibility. The prediction task requires the model to identify which of the five cities each subgraph originated from, based solely on its functional arrangement patterns and network structure.

The inherent similarities and differences among these sample cities are crucial for validating our model's explanatory capabilities. The functional organizational similarities between Shanghai and Beijing increase identification difficulty, testing the model's ability to detect subtle variations within similar cultural contexts. Conversely, Paris's relative difference in scale and global connectivity compared to the other four cities provides a contrasting sample that helps validate the model's sensitivity to distinctive urban organizational patterns.

1.2 Model Performance

Our MRF-GCN demonstrates robust performance in distinguishing urban functional organization patterns across the five metropolitan areas. The model achieved an overall accuracy of 92%, with F1 scores ranging from 0.75 to 1.0 across different cities, as shown in table 1:

Table 1: Model Performance

City	Accuracy	F1 Score
Beijing	0.60	0.75
London	1.00	0.91
New York	1.00	1.00
Paris	1.00	0.91
Shanghai	1.00	1.00
Overall	**0.92**	**0.91**

The performance variations across cities reveal important insights into urban functional organization complexity. Beijing exhibits the lowest individual accuracy (60%), reflecting the challenge of distinguishing it from Shanghai due to their shared cultural and institutional context. However, the model's ability to achieve 92% overall accuracy while successfully differentiating between culturally similar cities demonstrates the effectiveness of our multi-scale spatial analysis approach. The perfect accuracy achieved for New York, Paris, and Shanghai indicates that these cities possess distinctive spatial-functional signatures that are readily identifiable through our multi-level receptive field approach. London's high accuracy (100%) but slightly lower F1 score (0.91) suggests some classification uncertainty, likely reflecting London's complex hybrid characteristics that blend elements of both European and global city patterns. The overall F1 score of 0.91 indicates balanced precision and recall across all cities, confirming that our model avoids overfitting to specific urban patterns while maintaining sensitivity to cross-cultural variations in functional organization.

The performance variations across cities reveal important insights into urban functional organization complexity that extend beyond simple classification accuracy. Beijing's comparatively lower individual accuracy (60%)

is particularly revealing when examined alongside Shanghai's perfect classification rate (100%). This performance differential suggests that while both cities share broad cultural and institutional frameworks, Beijing exhibits more heterogeneous spatial organization patterns that occasionally overlap with characteristics found in other global cities.

The perfect accuracy achieved for New York, Paris, and Shanghai indicates that these cities possess highly distinctive spatial-functional signatures that create clear decision boundaries in our model's feature space. For New York, this distinctiveness manifests in consistent grid-based organization combined with high functional density across all scales. Shanghai's distinctiveness emerges from systematic long-range functional relationships combined with planned community structures that create recognizable spatial signatures. Paris demonstrates uniquely consistent short-range functional clustering that differentiates it clearly from all other urban contexts. London's classification performance (100% accuracy, 0.91 F1 score) reveals an interesting pattern where the model exhibits high confidence in positive classifications but shows some uncertainty in boundary cases. Further analysis indicates that London's complexity lies in its hybrid characteristics—combining European pedestrian-scale organization in historic areas with global city-scale commercial districts, creating spatial patterns that occasionally approach other cities' signatures without fully overlapping.

1.3 Multi-Scale Spatial Interaction Analysis

The most significant contribution of our research lies in the interpretable analysis of spatial-functional interactions across different distance thresholds. We extracted attention weights from our model to reveal how different cities prioritize spatial interactions at varying scales: short-range (0-500m), medium-range (500m-1km), and long-range (1-2km) spatial dependencies, as shown in figure 1. The attention weight analysis reveals three statistically distinct patterns of urban functional organization, each representing fundamentally different approaches to spatial resource allocation and accessibility:

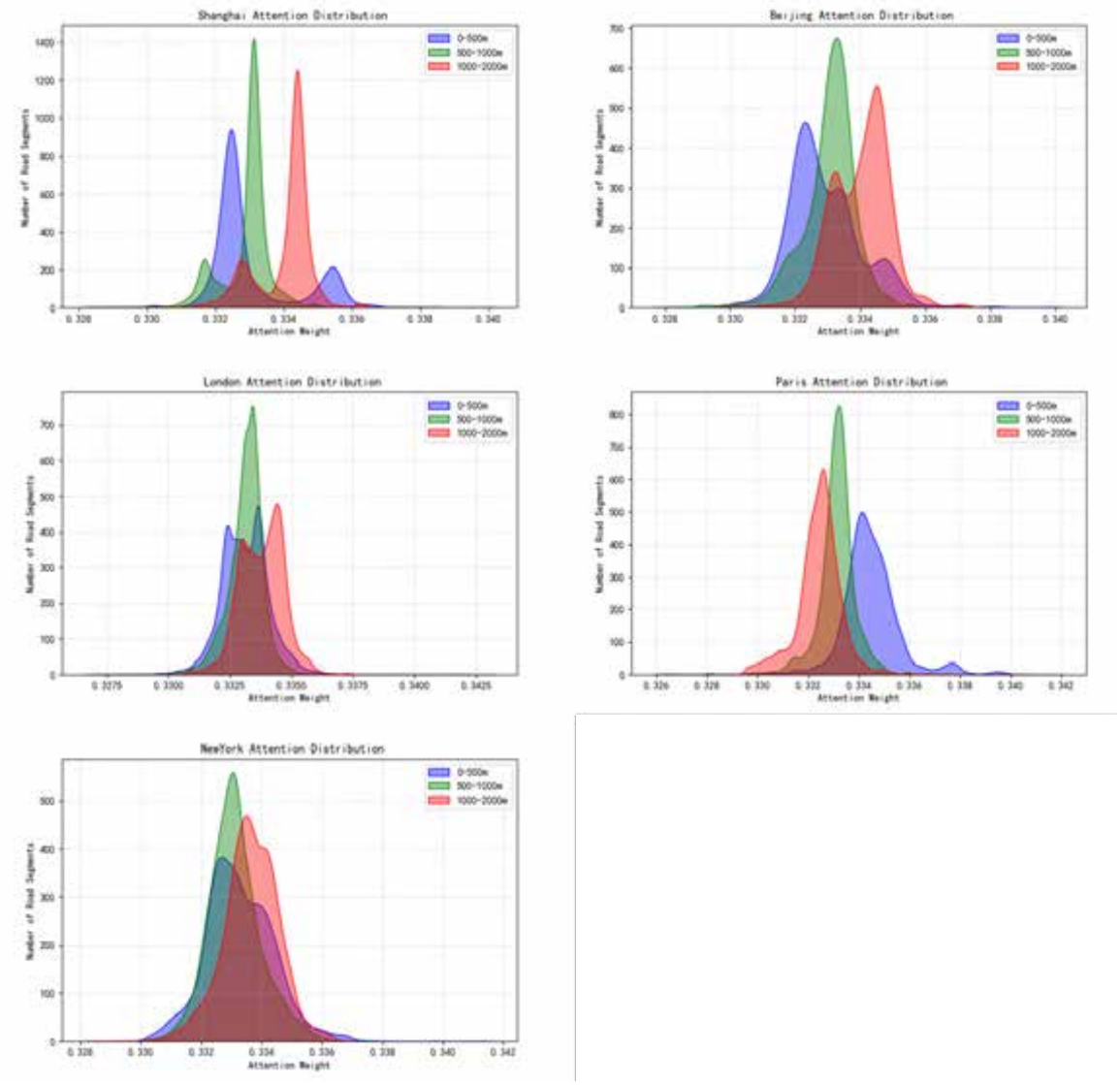

Figure 1: Attention Weight Distributions Across Multi-Scale Spatial Interaction Thresholds in Five Metropolitan Areas. This figure presents the attention weight distributions extracted from the Multi-level Receptive Field Graph Convolutional Network (MRF-GCN) across five representative metropolitan areas: Shanghai, Beijing, London, Paris, and New York. The distributions reveal distinct patterns of urban functional organization at three spatial interaction scales, represented by different colours: Blue (0-500m): Short-range pedestrian catchment areas, Green (500m-1km): Medium-range cycling accessibility zones, Red (1km-2km): Long-range transit/automotive accessibility areas

The attention weight analysis reveals three distinct patterns of urban functional organization:

Chinese Cities Pattern (Beijing and Shanghai): Both cities exhibit pronounced peaks in long-range spatial dependencies (1-2km). This pattern indicates that functional organization in Chinese cities relies heavily on long-distance spatial relationships, likely reflecting the impact of large-scale residential compounds, centralised service provision, and relatively low-cost transportation systems that enable residents to access services across larger geographical areas.

Western Global Cities Pattern (London and New York): These cities demonstrate relatively balanced attention across all three spatial scales. This balanced pattern suggests that Western global cities maintain functional organization coherence at multiple scales simultaneously, reflecting mixed-use development patterns, diverse transportation options, and polycentric urban structures.

European Regional Pattern (Paris): Paris exhibits a distinctive emphasis on short-range spatial interactions, with maximum attention weight for the 0-500m range, second for medium-range, and minimal for long-range dependencies. This pattern reflects Paris's compact urban form, pedestrian-oriented neighborhoods, and strong emphasis on local amenity provision within walking distance.

1.4 Cultural and Planning Implications

The spatial interaction patterns revealed by our model have significant implications for understanding cultural differences in urban functional organization:

Chinese Urban Planning Philosophy: The emphasis on long-range spatial dependencies in Beijing and Shanghai reflects China's planning approach of creating large-scale residential compounds with centralised service provision, but this pattern also reveals cultural acceptance of mobility-based urban living strategies. Detailed mobility analysis shows that Chinese urban residents demonstrate higher tolerance for travel distances and greater reliance on public transportation for daily activities. The lower importance assigned to short-range interactions indicates higher functional homogeneity within immediate neighbourhoods, reflecting planned community development that prioritizes large-scale efficiency over neighbourhood-scale diversity.

Western Polycentricity: The balanced attention patterns in London and New York reflect the polycentric nature of Western global cities, where urban functions are organised to serve residents at multiple spatial scales. This pattern aligns with market-driven development principles that create redundancy across scales—neighbourhood services provide convenience, district services offer choice and specialization, and regional services deliver metropolitan-scale amenities. Economic analysis suggests this multi-scale redundancy increases urban resilience but also reflects higher land values that support multiple service layers.

European Pedestrian Culture: Paris's short-range spatial emphasis aligns with European urban design principles, emphasizing walkability and neighbourhood self-sufficiency. The 500m walking radius emerges as the critical scale for understanding Paris's urban functional organization, supporting the concept of the "15-minute city" that has gained prominence in European urban planning discourse. However, this pattern also reflects historical urban development patterns where neighbourhood-scale infrastructure developed before automotive transportation, creating a path-dependent spatial organization that persists despite technological change.

5. Discussion

Our research demonstrates that explainable GeoAI can successfully unravel the complexity of urban functional organization while revealing systematic cultural differences that have important implications for both urban theory and planning practice. The methodological contributions of our Multi-level Receptive Field Graph Convolutional Network extend beyond technical innovation to address fundamental challenges in making urban AI interpretable for planning practitioners.

The development of our explainability framework represents a crucial advancement in bridging the gap between computational urban analysis and planning theory. Unlike previous approaches that provide technical explanations primarily meaningful to data scientists, our distance-threshold explainability framework translates complex neural network operations into concepts directly relevant to urban planning. This achievement is particularly significant given the planning profession's emphasis on evidence-based decision-making and the growing regulatory requirements for AI transparency in public decision-making contexts.

The cross-cultural insights revealed through our comparative analysis challenge conventional assumptions

about optimal urban organization. The identification of three distinct spatial interaction patterns—Chinese long-range dependency, Western balanced multi-scale organization, and European pedestrian-oriented emphasis—provides empirical evidence that successful urban organization takes multiple forms rather than converging on universal optimal patterns. This finding has profound implications for international planning practice and development cooperation, suggesting that planning strategies cannot be directly transferred between different cultural contexts without careful adaptation to local spatial organization principles.

The finding that Chinese cities rely more heavily on long-range spatial dependencies particularly challenges Western planning orthodoxies that prioritize neighborhood-scale self-sufficiency. Rather than indicating planning deficiencies, this pattern reflects successful adaptation to different cultural preferences, transportation systems, and institutional contexts. The superior performance of Chinese cities in our classification task indicates that their spatial organization patterns are highly systematic and coherent, suggesting effective planning coordination at metropolitan scales.

Similarly, Paris's emphasis on short-range interactions validates European urban design principles while demonstrating the continued relevance of pedestrian-scale planning in contemporary urban contexts. The statistical significance of these differences across functional categories indicates that these are not superficial variations but reflect deep structural differences in how different cultures organise urban space and daily life.

These insights have immediate practical applications for planning education and professional development. Planning professionals working in international contexts can use these insights to better understand local spatial organization patterns and adapt their approaches accordingly. The quantitative identification of critical spatial thresholds can inform service provision planning, helping planners understand which amenities need to be provided at neighborhood scales versus regional scales in different cultural contexts.

6. Conclusions

This study successfully demonstrates that explainable GeoAI can decode the complexity of urban functional organization while providing interpretable insights that bridge computational analysis and planning practice. Our Multi-level Receptive Field Graph Convolutional Network achieves high accuracy in distinguishing urban functional patterns across diverse global cities while revealing systematic differences in spatial organization that reflect fundamental cultural, institutional, and developmental variations.

The identification of three distinct spatial interaction patterns provides empirical validation for cultural theories of urban development while challenging universal approaches to urban planning. Chinese cities' emphasis on long-range spatial dependencies, Western global cities' balanced multi-scale organization, and European cities' pedestrian-oriented short-range focus represent coherent and successful alternative approaches to urban organization rather than stages in a linear development progression.

Our explainable framework addresses growing regulatory requirements for AI transparency while providing practical value for planning decision-making. By integrating explainability directly into model architecture rather than relying on post-hoc analysis, we ensure that computational insights remain interpretable within established planning frameworks. This approach positions explainable GeoAI as an essential tool for contemporary urban planning practice that enhances rather than replaces professional judgment.

Looking forward, our framework provides a foundation for expanding comparative urban research to include cities from different developmental stages, sizes, and cultural contexts. The successful integration of graph neural networks with urban planning theory demonstrates the potential for AI to extend human understanding of urban systems while maintaining interpretability for practical application. As cities worldwide continue to grow and evolve in response to technological change, climate challenges, and shifting social preferences, understanding the complexity of urban functional organization becomes increasingly critical for sustainable urban development.

Importantly, our model focuses exclusively on identifying characteristic distance-dependent interaction patterns rather than making normative evaluations of urban quality. This analytical neutrality preserves the framework's utility for diverse planning contexts while maintaining objective comparative analysis capabilities. For applications requiring evaluative assessments of urban performance, the framework could be integrated with appropriate outcome indicators, maintaining its flexibility for diverse analytical purposes.

Future research should explore the temporal dimensions of these spatial organization patterns, investigating how cultural differences in spatial organization respond to technological change, policy interventions, and evolving social preferences. The framework developed here provides both the methodological foundation and empirical baseline for understanding how different urban systems adapt to contemporary challenges while maintaining their distinctive organizational characteristics.

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Monitoring the Impact of Urban Regeneration on Green Infrastructure: Istanbul Case

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Abstract
This study examines the impact of urban regeneration projects carried out in Istanbul within the scope of Law No. 6306 on green infrastructure. The change in green infrastructure between 2014 and 2024 in three distinct regeneration sites was analysed using remote sensing, spatial texture analysis and machine learning techniques. NDVI, NDBI, and first-order statistical metrics derived from Landsat 8 satellite imagery are integrated into the change detection analysis using random forest classification. The findings show significant losses in green infrastructure, especially in areas where vertical densification is at the forefront. The results support that the level of integration of disaster-focused urban regeneration policies with climate adaptation and sustainability goals in the Istanbul case is limited, pointing to the need for more holistic planning approaches.

Keywords: urban regeneration; green infrastructure; NDVI; random forest; change detection

1. Introduction

Urban regeneration projects as transformative operations that strengthen and restructure the built environment under the risk of natural disasters have become one of the prior urban policies. These disaster-responsive projects aim to support resilience, contribute to sustainability, and increase the quality of life by optimizing the green infrastructure (Tzoulas et al., 2007; Wolch, Byrne and Newell, 2014). Green infrastructure is identified as a network of natural and semi-natural areas, including both green and blue spaces and it is part of the strategic planning approach for land conservation and optimized land use (Benedict and McMahon, 2006). It encompasses not only conserved natural areas, ecological corridors, urban drainages, and wetlands but also semi-natural, functional open spaces such as parks, farmlands, recreational sites, and greenways (Schilling and Logan, 2008; Fletcher et al., 2015). Also, as one of the main components of the urban ecosystem, green infrastructure supports adaptation to climate change (Oke, 1989; Spronken-Smith and Oke, 1999; Norton et al., 2015; Ramyar, Ackerman and Johnston, 2021). It helps mitigate the urban heat island effect, improve water and air quality, and manage stormwater, which are crucial for reducing the impacts of climate change and enhancing urban resilience (Nowak, Crane and Stevens, 2006; Meerow and Newell, 2017; Matasov et al., 2020; Senosiain, 2020; Halecki, Stachura and Fudała, 2025). Also, designing green infrastructure enhances city biodiversity by providing habitats for various species, contributing to ecological stability (Mathey et al., 2015; Pitman, Daniels and Ely, 2015). Apart from its advantages for the environment, green infrastructure is supposed to support public health, social cohesion, equity, and accessibility (Pauleit et al., 2019; Lu et al., 2023; Ogwu et al., 2025). Thus, green-driven urban renewal initiatives have evolved into useful instruments for resilience-oriented climate change adaptation policy (Gill et al., 2007; Semeraro, Aretano and Pomes, 2017). Supported by policy frameworks encouraging the use of green infrastructure, successful urban regeneration projects need the integration of resilience and sustainability ideas into urban agendas (Ignatieva and Mofrad, 2023; Zhang et al., 2025).

In Turkey, urban regeneration implementations are based on state law 6306 on the Regeneration of Areas at Disaster Risk. The main objective of the law is to constitute healthy and safe urban settlements (T. C. Resmi Gazete, 2012). Hence, the regeneration projects are recognised as opportunities for increasing sustainability in urban areas and developing climate-adaptive cities (Köylüoğlu, 2015; Yalazi et al., 2017; Korkmaz and Balaban, 2020; Yenidünya and Limoncu, 2024). By simulating possible risks such as flooding, the integration of the blue-green infrastructure systems in urban regeneration projects is highlighted as a strategy to adapt to climate change effect and improve urban resilience (Gündel and Kalaycı Önaç, 2025).

As a metropolitan city with vulnerable building stocks, Istanbul faces great seismic risk. Therefore, within the aim of law 6306, urban regeneration projects are operated as comprehensive planning tools in the city. According to the Istanbul Planning Agency's report (2023), after the law entered into effect, 70 urban areas have been declared

as risky in Istanbul. Those risky areas correspond to about 2000-hectare urban settlements and 84,000 buildings at least. Policies for climate change mitigation and disaster mitigation-led urban regeneration have the potential to be conducted together. However, the actions for developing green infrastructure through regeneration projects are lower than expected (Kocabas, Gibson and Diren, 2015). Despite efforts to incorporate sustainability, the regeneration projects in Istanbul imply many speculative implementations, such as green gentrification, where green spaces become exclusive and inaccessible to the public (Yazar et al., 2020).

Contrary to the expectation of contributing to the quality of life by increasing the amount of green space in the city, preliminary findings show that urban regeneration projects implemented in areas declared risky have a diminishing effect on green spaces (Cengiz, Atmiş and Görmüş, 2019; Yağçı, 2025). Mostly, those projects result in higher density, and green spaces per cap remain inadequate. Limited empirical research focuses on how urban regeneration projects have influenced the green infrastructure in Istanbul over a long time. Addressing this issue, the study aims to investigate how urban regeneration projects based on law numbered 6306 impact the changes in urban green infrastructure. Under the green infrastructure umbrella, the study particularly focuses on urban green fabric as a projection of green infrastructure into the urban settlements, including all vegetation that can be observed in two dimensions by remote sensing, such as parks, urban forests, woodlands, grasslands, narrow green strips, street trees, green roofs, and green unfunctional spaces between buildings.

2. Material and Methods

In this study, a holistic method based on remote sensing and machine learning was designed to analyse the temporal change of urban green fabric in risky areas subjected to regeneration under law no 6306. Within the scope of the research, urban regeneration areas with sufficient data (n=21) were clustered, and three representatives from each cluster were selected as study areas. NDVI, NDBI, and first-order texture statistics were derived using Landsat 8 satellite multispectral images from 2014 and 2024 and clipped into those selected areas. These layers were composites into a multispectral raster mosaic for each year and random forest algorithm was used for the classification. As a final step, spatial transformations in green fabric were revealed through categorical change analysis over two years (Figure 1).

This methodological approach provides to evaluate the effects of urban regeneration practices on green fabric with objective data. It seeks to obtain accurate results through advanced spatial analysis that can direct policies for sustainable urban regeneration. In contrast to traditional planning methods, the use of machine learning techniques in this study enabled more optimised spatiotemporal analysis to address the complexity of urban space (Hoang and Tran, 2021; Jia, Cui and Liu, 2022; Rahaman et al., 2025).

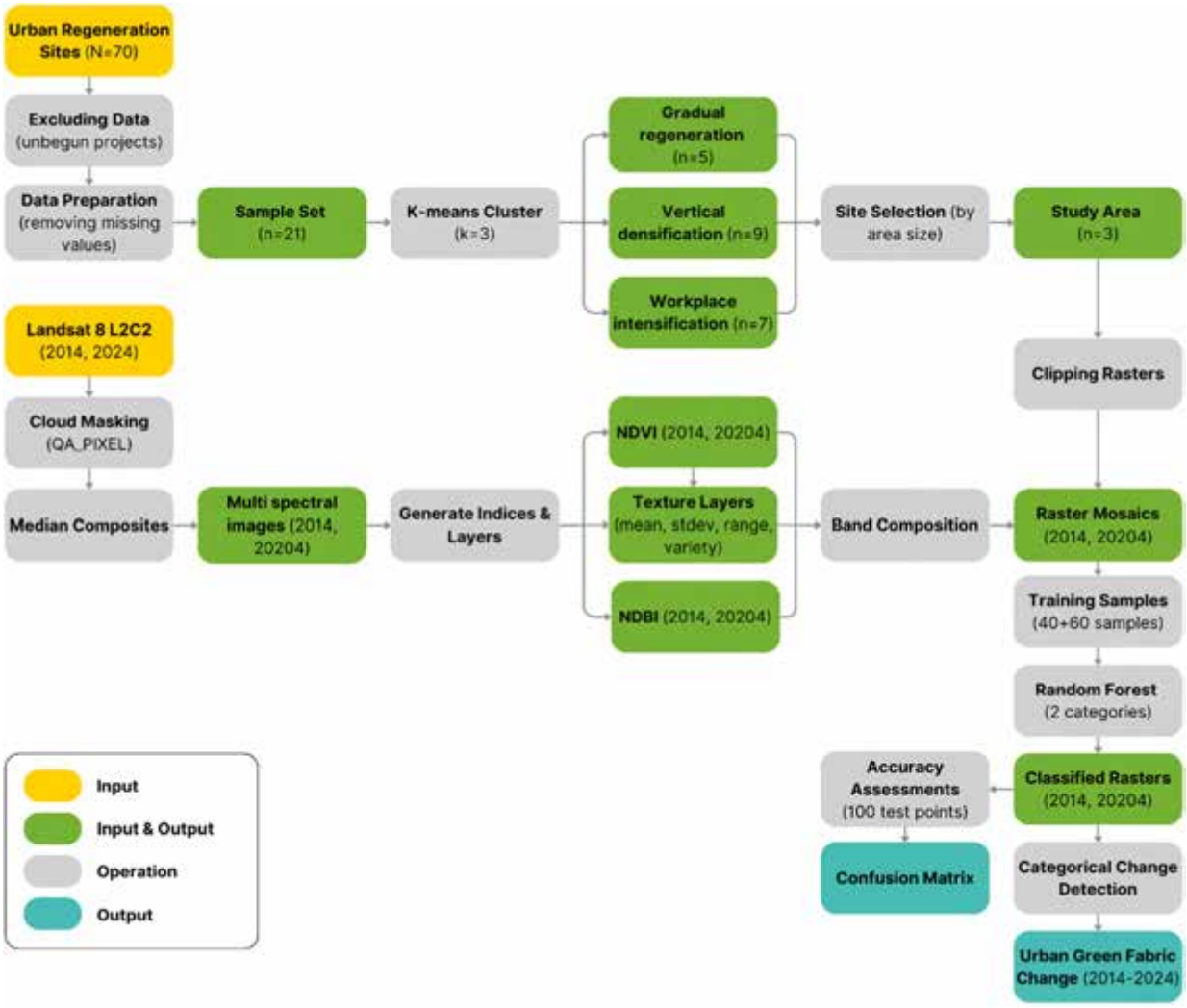

Figure 1. Workflow of the study.

2.1. Sample Selection and Study Area

Istanbul, one of the most highly populated and valued cities in Turkey, is in great seismic risk. By law 6306, 70 urban risk areas have been declared as urban regeneration sites in the city by the government (T. C. Resmi Gazete, 2012; Istanbul Planning Agency - IPA, 2023). This study focused on 25 projects which implementation has already begun of 70 declared urban regeneration sites, and 4 regeneration projects with missing data were excluded from the evaluation. Thus, 21 urban regeneration sites with sufficient data were accepted as the sample set (Table A. 1). To analyse the change in urban green fabric between 2014 - 2024 in different type of urban regeneration sites, k-means cluster analysis was applied with the logarithmic change rate of the following criteria below.

- Population capacity: the change in population capacity in the project area calculated before and after implementation
- Number of buildings: change in the number of buildings in the project area before and after implementation
- Number of workplace units: the change in the number of workplace units in the project area before and after implementation
- Gross construction area: the change of the total construction area in the project area before and after implementation

• Building renewals: the number of new buildings built for every building demolished during the implementation phase

Based on the Elbow score, regeneration sites have been clustered into three groups: (1) Gradual regeneration, (2) Vertical densification, and (2) Workplace intensification (Table 1).

Gradual regeneration represents areas with relatively low intervention levels, with values below the average in log-ratio-based indicators. Negative ratios in the number of buildings (-0.64) and gross construction area (-0.28) indicate that regeneration has been conducted gradually. The decrease in the number of workplaces (-0.37) indicates that the regeneration process in these areas is progressing with a priority on housing and away from functional diversity. In addition, the building renewal rate is also quite low (-1.96), which may indicate that the regeneration is more in the "processing" stage (Yazar et al., 2020).

On the other hand, vertical densification stands out with radical reconstruction and urban fabric densification practices. The construction area change rate (+2.47) indicates that parcels are combined to produce larger buildings. While the number of buildings is decreasing (-1.56), the increase in population capacity (+0.64) and the number of workplaces (+0.21) is a distinct indicator of vertical growth and mixed-use developments. The low rate of building renewal (-2.41) shows that the regeneration model in these areas is not "renewal" but entirely redevelopment-based. This cluster covers areas mostly high-investment, densely populated, and open to speculative development, which are symbolic examples of urban regeneration discussions in Istanbul (Turk, Tarakci and Gürsoy, 2020).

Workplace intensification defines the areas where the regeneration process is shaped towards gaining trade and services function. The workplace unit change rate is quite high (+4.03). This situation shows that existing housing or empty buildings are transformed into new function or mixed structures are built with commercial layers. Population growth (+0.98) and an increase in construction areas (+1.22) support this regeneration. Although the building renewal rate is relatively low (-1.36), it points to a scenario where functional transformation is preferred instead of dense construction.

Following cluster analysis, the urban regeneration site with the largest area size from each cluster was selected as a representative so that the classification analysis (random forest) could be applied in the study and yield reliable results (Figure 2). Features of designated study areas, cluster centre distances, and area sizes are given in Table 2 and Table 3.

• Site – 1: Karabekir, Fevziçakmak project site is located on the east side of Gaziosmanpaşa district (41°5′7″ N - 41°5′46″ N, 31°54′17″ E - 31°54′58″ E). The regeneration has started in 2017; it is still in the early stages of demolition and reconstruction (Figure A. 1). Based on the capacity population before the regeneration project, the total construction area per capita was 41 m2, and it is expected that the construction area per capita will decrease by 12% and become 36.21 m2 after the project. This regeneration site is one of the highly representative samples of the gradual regeneration cluster.

• Site – 2: Fikirtepe project site is located at centre of Kadıköy district near to D100 highway (41°0′17″ N - 41°0′18″ N, 32°2′36″ E - 32°4′15″ E). The project's start date was 2012 (Figure A. 1). While the total construction area per capita based on the capacity population was 22.33 m² before the regeneration project, this value is expected to increase by 473% and reach 128 m² after the project based on the planned capacity population. This situation indicates a remarkable increase in the building density. The project strongly represents a vertical densification cluster.

• Site – 3: Çınar, İnönü, Sancaktepe, Yavuzselim, Merkez project site is located in the south-east of Bağcılar district (41°2′56″ N - 41°3′11″ N, 31°51′7″ E - 31°51′33″ E). The beginning date of the implementations was 2013 (Figure A. 1). While the total construction area based on the capacity population before the project was 65.09 m2, the

construction area per capita is expected to decrease by 32% and become 44.21 m2 based on the planned capacity population after the project. The regeneration site is a moderate-represented member of the commercial intensification cluster; however, it is the only project site with a considerable area size for the classification.

Table 1: Attributes of urban regeneration zones.

Average Change Rates					
Clusters	Population capacity	Buildings	Workplace units	Construction area	Renewals
Gradual regeneration	0.14	-0.64	-0.37	-0.28	-1.96
Vertical densification	0.64	-1.56	0.21	2.47	-2.27
Workplace intensification	0.98	-0.93	4.03	1.22	-1.36

Figure 2. Study Areas in 2024: (a) Site – 1; (b) Site – 2; (c) Site – 3.

Table 2. Features of the selected study areas.

Indicators	Rates of Change Between Periods		
	Site - 1	Site - 2	Site - 3
Population capacity	0.295	0.556	0.685
Number of buildings	-0.082	-1.568	-0.185
Number of workplace units	-0.256	-0.063	6.895
Gross construction area	0.170	2.302	0.298
Building renewals	-1.686	-3.112	-2.114

Table 3. Cluster representation of the selected study areas.

Regeneration Site	Cluster No	Cluster Centre Distance	Area Size (Ha)
Karabekir, Fevziçakmak - Gaziosmanpaşa	1	0.788	59.03
Fikirtepe - Kadıköy	2	0.901	98.73
Çınar, İnönü, Sancaktepe, Yavuzselim, Merkez - Bağcılar	3	3.204	22.07

2.2. Satellite Images and Data Processing

Landsat 8 surface reflectance images (Collection 2, Level-2) were used for 2014 and 2024 to classify urban green fabric in regeneration sites. Based on the project start date of selected regeneration sites, the oldest year, one year after Landsat 8 was launched, has been selected as the reference year. The image data was obtained from the Google Earth Engine platform. Cloud-free composite images were generated by applying a pixel-based median compositing technique after cloud masking with the QA_PIXEL band. After filtering out low-quality pixels, annual median composites were generated by taking the median reflectance values from all valid images within each two years. All images were clipped to the Istanbul metropolitan area and exported at 30-meter resolution in EPSG:4326 projection (41.0082° N, 28.9784° E).

NDVI was used as the basis to analyse urban green fabric in Istanbul regeneration sites. For more accurate classification, NDVI was supported with NDBI and texture layers. The pre-classification process (clipping, band composition, etc.) and advanced analysis were conducted in ArcGIS Pro 3.1.

NDVI Calculation

NDVI is a well-accepted index to quantify vegetation in urban areas by comparing reflectance values in the red and near-infrared (NIR) spectral bands (Weng, Lu and Schubring, 2004; Yuan and Bauer, 2007; Feyisa, Dons and Meilby, 2014). It helps to identify vegetation density, vegetation health, and developed areas. The NDVI value ranges from -1 to 1; an upper value than 0.2 refers to vegetation cover. The index is also useful in spatiotemporal analysis and monitoring the vegetation change over time (Jeevalakshmi, Reddy and Manikiam, 2016; Luo et al., 2021). Here, NDVI was generated from Landsat 8 multispectral image data for 2014 and 2024. The calculation is as follows:

$$NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}} \quad (1)$$

Where p_{nir} and p_{red} represent the red reflected radiant flux (Band 4, 0.64 - 0.67 µm) and near-infrared radiant flux (Band 5, 0.85 - 0.88 µm) respectively. However, granular surfaces in urban areas with high heterogeneity may have similar NDVI values. NDBI and texture layers were also used to avoid this misleading and to facilitate the discrimination of low vegetation areas such as parks, gardens, and grasslands from built-up areas (Haralick, Dinstein and Shanmugam, 1973; He et al., 2010).

NDBI Calculation

The primary use of NDBI is to map and monitor urban built-up areas. It also combines with NDVI to distinguish vegetation from built-up areas. It ranges from -1 to 1, and similarly to NDVI, positive values indicate built-up areas (Zha, Gao and Ni, 2003; Bhatti and Tripathi, 2014). NDBI addresses the challenge of distinguishing urban areas from bare ground and providing more accuracy in identifying urban green fabric. Hence, its combination with NDVI especially assists in separating barren land from urban areas (He et al., 2010). NDBI is computed as below:

$$NDBI = \frac{\rho_{swir} - \rho_{nir}}{\rho_{swir} + \rho_{nir}} \quad (2)$$

Where p_{swir} and p_{nir} represent the short-wave infrared - 1 reflected radiant flux (Band 6, 1.57 - 1.65 µm) and near-infrared radiant flux (Band 5, 0.85 - 0.88 µm) respectively.

Texture Analysis

Texture analysis in image processing is effectively used to classify vegetation in urban areas. As one of the texture extraction methods, the grey-level co-occurrence matrix (GLCM) captures the spatial relationship between pixel pairs in an image, reflecting the texture by considering the direction, distance, and magnitude of changes in grayscale values (Haralick, Dinstein and Shanmugam, 1973; Gao et al., 2015; Yan, Shaker and El-Ashmawy, 2015). The method has been used to extract texture features from high-resolution satellite images to classify various types of urban vegetation, such as parks, street trees, grasslands, and scrub vegetation (Liu and Yang, 2013). Combining GLCM with spectral indices significantly improves the classification accuracy of green fabric in urban areas (Wu et al., 2019). Alternative to GLCM, some research measures texture using histograms based on the sum and difference of pairs of pixels (Unser, 1995; Sarker and Nichol, 2011). Other researches argue that geostatistical texture metrics provide more accuracy in classification (Rodriguez-Galiano, Chica-Olmo, et al., 2012).

Although texture measures such as GLCM and geostatistical-based metrics can improve classification accuracy, they require increased computational demands and higher data dimensionality (Pacifici, Chini and Emery, 2009; Ghimire, Rogan and Miller, 2010; Sarker and Nichol, 2011). In this study, first-order statistical descriptors (mean, standard deviation, range, and variety) were used instead. They offer an efficient alternative with adequate discriminatory power for medium-resolution imagery.

Here, first-order statistical metrics were derived from the NDVI raster using the Focal Statistics tool in ArcGIS Pro. These metrics included mean, standard deviation, variance, and range – each calculated over a 7×7 moving window (Franklin et al., 2000; Kayitakire, Hamel and Defourny, 2006): (i) Mean represents the local green density where x_i is for each pixel value and N for total number of pixels; (ii) Standard deviation reflects surface heterogeneity and variation where µ is for mean, x_i for each pixel value and N for total number of pixels; (iii) Range was used to identify environmental transition areas, indicating structural contrast where x_i stands for each pixel value; and (iv) Variety counts how many different pixel values are in the neighbourhood window. It measures diversity like "entropy" in GLCM but in terms of class diversity, not randomness (Table 4).

Table 4. Texture layers calculation.

Texture ayers of NDVI	Raster Calculation	GLCM Calculation
Meanv	$\frac{1}{N}\sum_{i=1}^{N} x_i$	-
Standard deviation	$\sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i-\mu)^2}$	-
Range (contrast)	$max(x_i) - min(x_i)$	$\sum_{i,j}(i-j)^2 . P(i,j)$
Variety (entropy)	$UniqueClasses(x_i)$	$-\sum P(i,j).\log_2 P(i,j)$

2.3. Green Fabric Classification and Accuracy Assessments

This study performed a random forest classifier to distinguish between urban green fabric and built-up areas in urban regeneration sites. This technique offers high accuracy rates in different image data (Rodriguez-Galiano, Ghimire, et al., 2012; Talukdar et al., 2020) and gives balanced performance in both homogeneous and heterogeneous land cover classes (Shi and Yang, 2017). Studies have shown that random forest-based classification is suited for reducing the data dimensionality of complex urban land cover types while reserving discrimination of different classes (Gan et al., 2016; Isaac, Easwarakumar and Isaac, 2017). It is also robust to reductions in training data size and noise (Rodriguez-Galiano, Ghimire, et al., 2012) and the risk of overfitting by averaging the predictions of multiple decision trees (Gislason, Benediktsson and Sveinsson, 2006).

As detailed in Section 2.2, NDVI, NDBI, and texture layers generated from NDVI were computed separately and composed into a multispectral image for each year. Due to the radiometric inconsistencies observed in parts of the 2014 Landsat 8 image, particularly in non-urban northern-east regions, the classification process was restricted to the regeneration project boundaries. This spatial constraint minimizes the uncertainty introduced by low observation density and ensures that the classification model is trained and applied to radiometrically stable regions.

Two main classes were determined to run random forest classifications: urban green fabric and built-up area. The training data were manually selected from the composited multispectral images. For both classes, sample polygons were determined by considering clearly separated areas, and pixel samples were taken from these regions for two images. The samples were collected individually for both years. The class distribution of the training samples was determined in parallel with the existing spatial ratios in the study area; 40% of samples were used for the urban green fabric class, and 60% of them were used for the built-up area class.

Classification results for 2014 and 2024 show that the model is adequately accurate (Table 5 and Table 6). In 2014, the overall accuracy was 84%, and the kappa statistic was 0.68; in 2024, these values were 85% and 0.70%, respectively. For both years, the built-up area class performed very strongly regarding user accuracy (94% and 98%), demonstrating the model's ability to correctly identify built-up areas. The urban green fabric class performed relatively low in user accuracy (74% and 72%) despite high producer accuracy values (92.5% and 97%). The relatively low user accuracy in the urban green fabric class indicates that some class assignments may be inaccurate when classifying small and fragmented urban areas using satellite imagery with a spatial resolution of 30 meters. This is related to the lack of clear spectral separation of green areas that have been transformed or are simply intersected with buildings, making them hard to identify. However, given the overall accuracy of the model (84-85%) and the kappa statistics (0.68-0.70), this limitation does not undermine the overall reliability of the classification results. It reveals that the outputs obtained are acceptable (Figure 3).

Table 5. Accuracy assessment of green fabric classification for 2014.

	Built-up Area	Green Fabric	Total Count	User's Accuracy
Built-up Area	47	3	50	0.94
Green Fabric	13	37	50	0.74
Total Count	60	40	100	0
Producer's Accuracy	0.78	0.925	0	0.84
Kappa Statistics: 0.68				

Table 6. Accuracy assessment of green fabric classification for 2024.

	Built-up Area	Green Fabric	Total Count	User's Accuracy
Built-up Area	49	1	50	0.98
Green Fabric	14	36	50	0.72
Total Count	63	37	100	0
Producer's Accuracy	0.77	0.97	0	0.85
Kappa Statistics: 0.70				

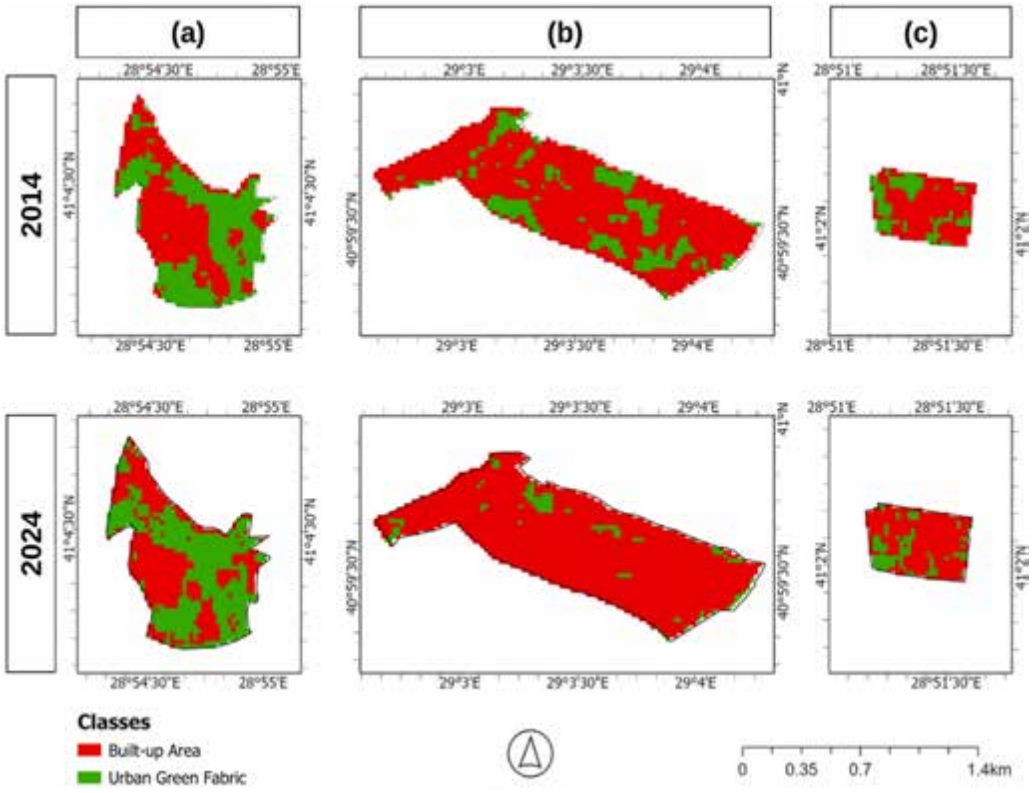

Figure 3. Urban green fabric classification in 2014 and 2024: (a) Site – 1; (b) Site – 2; (c) Site – 3.

3. Urban Green Fabric Change in Regeneration Sites

To analyse the change of green fabric in selected regeneration sites between 2014 and 2024, categorical change detection was processed with defined classes of urban green fabric and built-up areas. In order to suppress pixel-level random noise in the classification results and to ensure spatial consistency in the change map, a 3×3

smoothing neighbourhood window was used, and the median was preferred as the statistical filling method. This configuration reduces the effect of random pixel fluctuations in fragmented and small-scale urban green areas, allowing for more reliable and coherent change detection (Chen, Stow and Gong, 2004; Ghimire, Rogan and Miller, 2010).

The findings show that remarkable spatial changes were observed in the three representative urban regeneration sites between 2014 and 2024 (Figure 4). In Site – 1, which represents a gradual regeneration cluster, there is a 9.18% increase in green fabric, accompanied by a 9.43% loss of building development (Table 7). Since regeneration interventions are still in process and reconstruction not being completed substantially, the increase in green fabric cannot be interpreted as final result unlike in the other two regeneration sites (Figure A. 1). The green fabric per capita decreased from 21.47 m2 to 17.45 m2 by the planned population capacity (Table 7 and Table 8). Based on the current population in 2023, the amount of green fabric per capita is 58.56 m2. This current high ratio supports the inference about ongoing reconstruction process.

Site – 2, as a strong member of the vertical densification cluster, reveals an intensified urban regeneration process, exhibiting an increase of 18.42% in buildings with a very high green fabric loss of 74.15% (Table 7). During the regeneration process, this area has come under intense building pressure and exhibited a negative picture regarding environmental sustainability and life quality. According to planned population capacity, green fabric per cap has dramatically decreased from 4.61 m2 to 0.68 m2. Also, the current green fabric per cap is 3.07 m2 (Table 7 and Table 8). These rates are significantly below the World Health Organization's (WHO) minimum rate – 9 m2 (World Health Organization - WHO, 2012).

As a member of the workplace intensification cluster, in Site – 3, the building rate increased by 11.7%. In comparison, the green fabric decreased by 28.79%, indicating that the green fabric was largely transformed into built-up areas (Table 7). Here, it should be considered that Site – 3, which has been selected due to its optimal area size, has relatively low cluster representation; so, similar rates may not be seen in other areas where functional transformation has occurred. During the regeneration, green fabric per capita has decreased from 18.85 m2 to 6.76 m2. As seen in Table 7 and Table 8, the current rate is more negative than the planned one; green fabric per capita is 4.94 m2 by the population in 2023. Considering the functional transformation of the project, it is expected that some of the current population will be replaced. However, according to WHO's minimum limit, planned green fabric per capita is still lower than the rate before the regeneration (World Health Organization - WHO, 2012; Russo and Cirella, 2018).

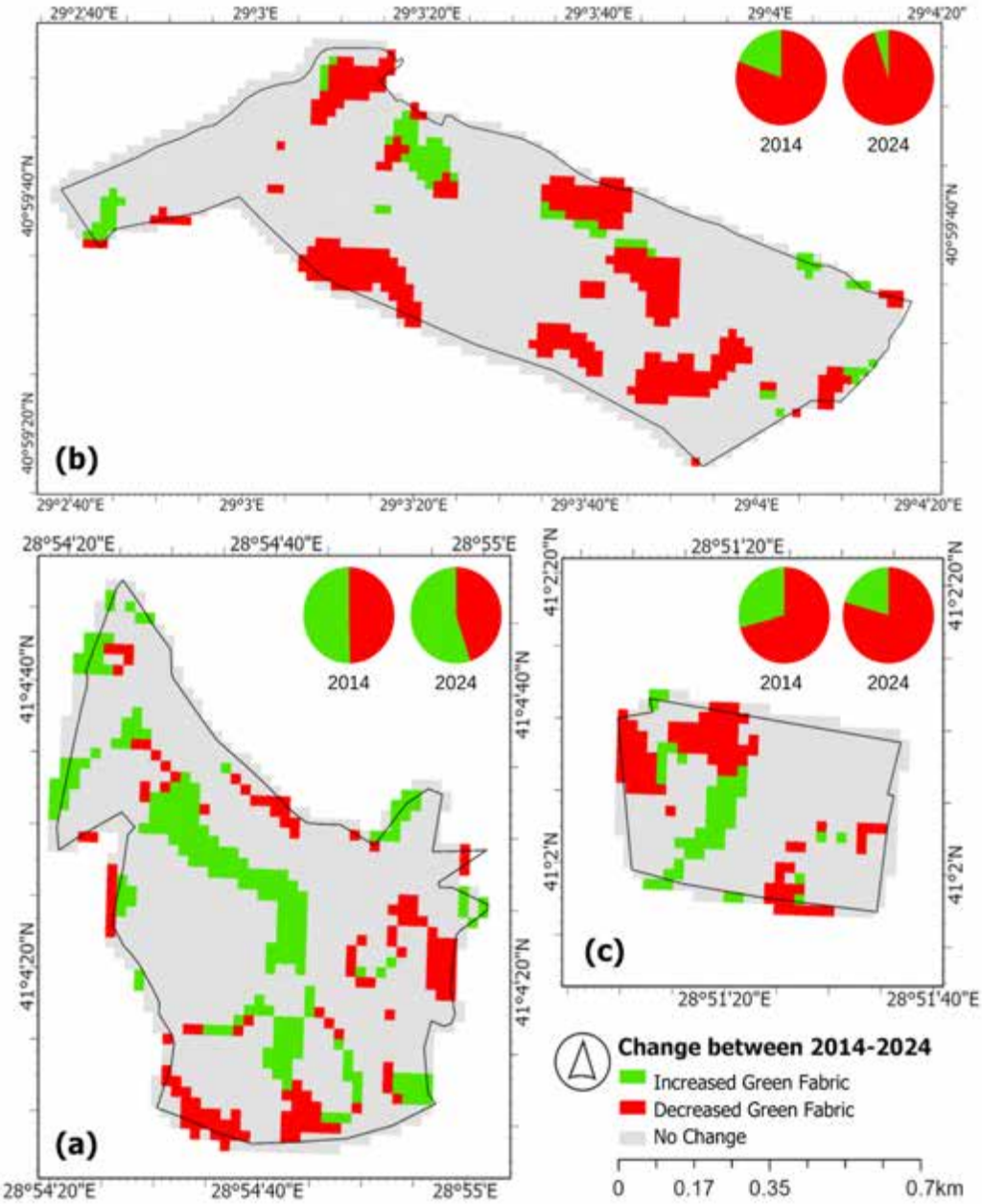

Figure 4. Urban green fabric changes in selected regeneration sites between 2014- 2024: (a) Site – 1; (b) Site – 2; (c) Site – 3.

Table 7. Change in urban green fabric between 2014-2024.

	Area Size						Change Rate (%)		
Project Site	2014			2024					
	Built-up (ha)	Green Fabric (ha)	Green Fabric per cap (m2)	Built-up (ha)	Green Fabric (ha)	Green Fabric per cap (m2)	Built-up	Green Fabric	Green Fabric per cap
Site - 1	28.73	29.23	21.47	26.02	31.92	17.45	-9.43	9.18	-18.58
Site - 2	77.17	18.66	4.61	91.38	4.82	0.68	18.42	-74.15	-85.24
Site - 3	15.50	6.34	18.85	17.31	4.51	6.76	11.70	-28.79	-64,13

Table 8. Changed population in regeneration sites.

Project Site	2014		
	Population Capacity		Current Population
	Pre-regeneration	Post-regeneration	
Site - 1	13615	18291	5451
Site - 2	40439	70563	15681
Site - 3	3363	6674	9129

4. Conclusion

This paper investigates the spatial change in urban green fabric between 2014 and 2024 using three representative areas in Istanbul subjected to urban regeneration policies under law no. 6306. Combining NDVI, NDBI, and texture-based statistics with random forest classification reveals the different effects of various regeneration strategies on green areas in the analysis. Notably, the vertical densification cluster experienced a drastic decline of 74.15% in green fabric, highlighting the conflict between intensive redevelopment and environmental sustainability. The workplace intensification site also experienced a significant transition from green to built-up zones (28.79%). In contrast, the gradual regeneration cluster showed a moderate increase in green areas. However, this increase in green fabric detected based on NDVI should not be interpreted as a final conclusion comparable to the other two regeneration sites since construction activities are largely incomplete in Site-1 (in Gaziosmanpaşa). The decrease in planned green fabric per capita in post-regeneration of Site -1, as shown in Table 7, supports this caution. In all areas, the amount of green fabric per capita (based on the planned capacity population) after regeneration remained below the pre-regeneration era. Additionally, current rates in Site – 2 (in Kadıköy) and Site – 3 (in Bağcılar) are lower than the minimum value recommended by the WHO.

Although law no. 6306 aims for healthy and safe urban settlements, the findings show that it remains insufficient in terms of protecting or increasing green fabric during the implementation phase. The spatial decrease in urban green fabric in different regeneration clusters emphasize the decisive role of planning strategies on ecological and climate-adaptive outcomes. However, it should be noted that the negative change in the urban green fabric detected through remote sensing and advanced spatial analysis cannot be evaluated only in two-dimensional spatial criteria that are reduced to urban settlement. Urban green fabric functions as a part of a regional green infrastructure that includes urban elements (parks, street trees, gardens, etc.) as well as forests, agricultural areas, riparian zones, and wide-open spaces outside the city. Although these urban periphery natural elements are located outside urban settlement areas, they directly affect the quality of urban life by providing critical ecosystem services such as improving air quality, providing biodiversity corridors, climate regulation, and groundwater recharge. Therefore, changes in the urban green fabric should also be evaluated in the context of the continuity and integrity of the holistic green infrastructure network, not limited to urban borders. Accordingly, there is a need for multi-dimensional planning approaches that integrate disaster-focused response objectives with cli-

mate adaptation and urban ecology. Green infrastructure should be considered a holistic planning component in regeneration areas and a fundamental precondition for building sustainable and resilient cities.

Although this study proposes a powerful method based on remote sensing and machine learning, it has some limitations. First, to improve classification accuracy, the regeneration project with the largest area from each cluster was selected as a representative. However, this choice may have weakened how well some clusters are represented. Second, the 30-meter spatial resolution of Landsat 8 imagery may be insufficient to detect small-scale green areas like narrow strips, street trees, or green roofs. Although NDVI, NDBI, and texture statistics were used to improve classification accuracy, spectral similarities between low-density vegetation and built-up areas may still cause confusion. Additionally, first-order statistics (mean, std, range, variance) were used instead of second-order metrics like GLCM to describe spatial texture, which reduced computational cost but also limited detailed discrimination. Third and finally, the analysis only covers the years 2014 to 2024, so it cannot fully reflect all temporal changes, regeneration stages, or land use transitions during the ongoing projects. This may lead to temporary vacant areas or unbuilt parcels between new buildings being misleadingly perceived as green fabric on NDVI. Future studies can address these limitations by using higher-resolution data, time series analysis, and field observations.

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Appendix

Table A. 1. Sample set of the study (n=21).

No.	**Project Site**	**District**	**Area Size (ha)**
1	Demirkapı	Bağcılar	4.73
2	Evren	Bağcılar	1.74
3	Çınar, İnönü, Sancaktepe, Yavuzselim, Merkez	Bağcılar	22.07
4	İstiklal	Beyoğlu	8.8
5	Örnektepe, Sütlüce	Beyoğlu	2.5
6	Havaalanı	Esenler	7.18
7	Oruçreis 2	Esenler	4.65
8	Alibeyköy	Eyüpsultan	2.36
9	Çırçır 2	Eyüpsultan	1.52
10	Sarıgöl	Gaziosmanpaşa	5.83
11	Karabekir, Fevziçakmak	Gaziosmanpaşa	59.03
12	Sarıgöl, Yenidoğan	Gaziosmanpaşa	33.17
13	Bağlarbaşı	Gaziosmanpaşa	16.6
14	Yıldız Tabya 1. Kısım	Gaziosmanpaşa	14.16
15	Fikirtepe 1	Kadıköy	98.73
16	Fikirtepe 2	Kadıköy	35.61
17	Yahya Kemal	Kağıthane	3.39
18	Kaynarca	Pendik	5.24
19	İçmeler	Tuzla	6.78
20	Sümer	Zeytinburnu	3.8
21	Beştelsiz	Zeytinburnu	0.5

Table A. 2. Selected regeneration sites.

	Site-1	Site-2	Site3
	Karabekir, Fevziçakmak	Fikirtepe	Çınar, İnönü, Sancaktepe, Yavuzselim, Merkez
Pre-regeneration			
Population Capacity	13,615	40,439	3,363
Num. of Buildings	917	4,035	277
Num. of Wokplace Untis	388	2,384	0
Construction Area (M2)	558,508.31	903,056.10	218,912.00
Post-regeneration			
Population Capacity	18291	70,563	6,674
Num. of Buildings	844	840	230
Num. of Wokplace Untis	300	2,238	987
Construction Area (M2)	662,296.14	9,032,574.66	295,026.00
Current Population (2023)	15,681	9,129	5,451
Area Size (Ha)	59.03	98.73	22.07
Num. of Demolished Building	134	3,236	57
Num. of New Buildings	24	143	6

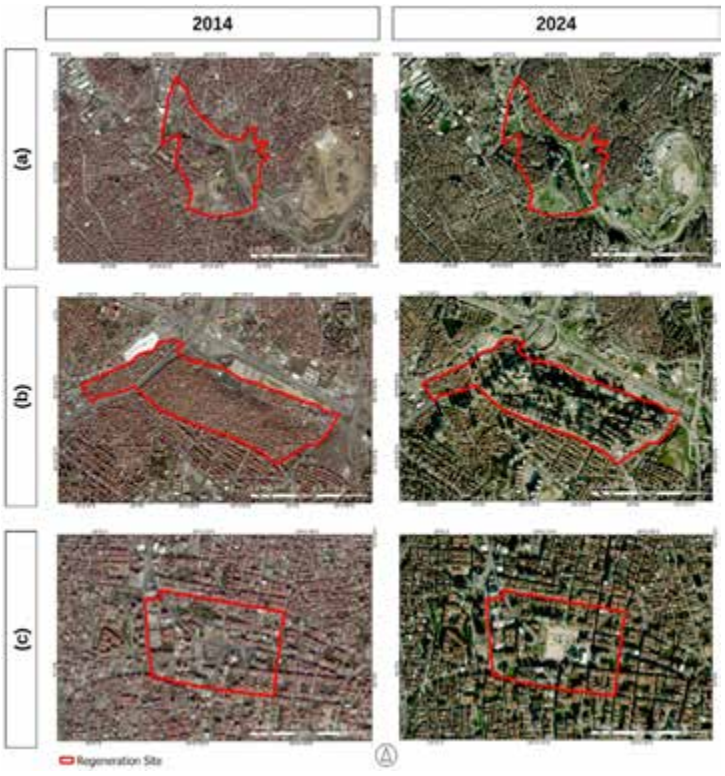

Figure A. 1. Study areas in 2014 and 2024: (a) Site – 1, Karabekir, Fevziçakmak – Gaziosmanpaşa; (b) Site – 2, Fikirtepe – Kadıköy; (c) Site – 3, Çınar, İnönü, Sancaktepe, Yavuzselim, Merkez – Bağcılar.

Exploring the Emotional Spatial Patterns and Functional Perceptions of Internet-Famous Streets Based on Large Language Models: A Case Study of Nanjing Old City

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Abstract
This study analyzes over one million geo-tagged Sina Weibo posts (2019–2024) to evaluate emotional patterns and influencing factors on internet-famous streets in Nanjing Old City. First, high-traffic streets and their functional zones are identified using ArcGIS-based spatial analysis. Second, advanced large language models (LLMs) are used to detect residents' and tourists' emotions through a four-dimensional structure: primary and secondary emotions, intensity, and polarity. These emotional labels are mapped to street-level sentiment profiles. Spatial clustering and semantic analysis reveal distinct emotional dynamics driven by spzeatial semantics and functional typologies.

Keywords: large language model; internet-famous streets; social media sentiment; urban emotion map; Nanjing old city

1 Introduction

With the rapid development of information and communication technologies, society has quietly entered the era of big data. The widespread use of GPS, mobile devices, and the internet has brought new opportunities for urban spatial perception research. Since 2012, disciplines such as urban geography, planning, and sociology have increasingly embraced big data, with location-based social media becoming a prominent data source. Check-ins are considered conscious behaviors—users tend to post only when they spend significant time in a location worth recording, reflecting their emotional and psychological states (Yadollahi, A., 2017).

Against this backdrop, geo-tagged data from social media enables researchers to capture spatial emotional interactions and geographic tendencies. It has been widely applied in urban zoning, spatial evaluation, vitality analysis, and spatiotemporal behavior studies. Sina Weibo, as one of China's most popular social media platforms, offers broad national coverage and robust user-generated data for such analyses.

Meanwhile, networked communication has reshaped social and spatial experiences. The rise of online interaction has increasingly influenced physical urban space—cloud experiences often replace physical ones, and media representation tends to precede actual function. As a result, media-oriented "internet-famous streets" have proliferated (Niu, X. and Lin, S., 2022). Streets, as key urban spaces for communication and culture, now serve as dynamic platforms for emotional expression and interaction among users.

However, traditional sentiment analysis methods based on rule-based or shallow classifiers struggle with unstructured, ambiguous, or sarcastic content common in social media texts (Nandwani, P. and Verma, R., 2021). With the advent of large language models (LLMs), such as ChatGPT, sentiment analysis has entered a new phase. Trained on vast corpora, LLMs can understand context, capture nuanced emotions, and infer user attitudes and motivations (Lü J., 2022.), significantly enhancing the accuracy and interpretability of emotional computing.

In the field of emotion research, scholars have developed relatively mature theoretical frameworks across various dimensions. Emotion dimension theories propose that emotions can be understood through multiple attributes,

with two- and three-dimensional models being the most widely used. Russell introduced the two-dimensional model, suggesting that emotions can be interpreted along two axes: valence (positive to negative) and arousal (high to low intensity) (Russell, J.A., 1980.). Valence reflects pleasantness, while arousal captures emotional intensity or excitement. Later, Mehrabian and Russell (1994) proposed the PAD model (Mehrabian, A., 1980.), a three-dimensional theory consisting of Pleasure, Arousal, and Dominance. In this model: Pleasure (P) represents the positive or negative quality of the emotion; Arousal (A) indicates the level of emotional activation or excitement; Dominance (D) reflects the degree of control or influence the individual feels within a given environment. In terms of classification, psychological theories typically distinguish between basic and complex emotions. However, definitions of basic emotions vary significantly among researchers due to differing perspectives from linguistics, behavioral science, and other fields. Figure 1 below outlines several mainstream classification systems and their respective emotional categories.

Researcher	Categories	Specific Emotions
Darwin	6 types	Joy, Sadness, Anger, Fear, Disgust, Surprise
Arnold	11 types	Sadness, Anger, Terror, Disgust, Anticipation, Hope, Frustration, Disappointment, Expectation, Resentment, Love
Izard	10 types	Joy, Sadness, Anger, Fear, Disgust, Surprise, Interest, Shame, Guilt, Contempt
Ekman	6 types	Joy, Sadness, Anger, Fear, Disgust, Surprise
Johnson	5 types	Joy, Sadness, Anger, Fear, Disgust
Lazarus	10 types	Joy, Sadness, Anger, Fear, Disgust, Jealousy, Pride, Shame, Love, Comfort

Figure 1: Basic Emotion Classifications (Image source: redrawn based on Reference 6)

In the domain of spatial emotion research, scholars began exploring the relationship between space and emotion as early as the mid-20th century, proposing concepts such as “place perception” and “place attachment” to examine how spatial environments influence human emotions. Initial studies emerged in philosophy, sociology, and psychology before expanding into specific investigations on how spatial elements trigger emotional responses and the types of emotions involved. These studies often adopt macro, meso, or micro-scale perspectives to depict the spatiotemporal distribution of emotions and explore their associations with physical spatial elements.

At the macro scale, research focuses on citywide emotional distributions and their correlations with urban form and built environment. This stream typically employs big data analysis, especially from geo-tagged social media. Bertrand mapped emotional tendencies across New York City using Twitter data, finding that parks concentrated positive emotions, whereas facilities like transport hubs, cemeteries, hospitals, and prisons correlated with negative sentiment (Bertrand, K., Bialik, M. and Virdee, K., 2015.). Shanshan Chen et al. analyzed Twitter data from 26 parks in Berlin to examine how cultural demands and green space supply interact to affect public emotions (Chen, S., Liu, L., Chen, C. and Haase, D., 2022.). Sakshi Khare et al used Bhopal, a rapidly growing Indian metropolis, as a case study to explore the link between urban built environment and subjective well-being (Khare, S. and Chatterjee, A., 2023.).

At the meso and micro scales, studies often focus on streets, parks, squares, and neighborhoods, using data sources such as surveys, interviews, or physiological signals. Li et al. examined the emotional coupling between people and urban spaces to evaluate spatial environments and provide recommendations for improving urban design (Li, X., Hijazi, I., Koenig, R., et al., 2016.). Hijazi et al. combined Twitter sentiment data with spatial features to analyze how certain spaces or spatial sequences trigger emotional arousal (Hijazi, I.H., Koenig, R., Schneider, S., et al., 2016.). Similarly, Koenig et al. used one week of Twitter data from Osaka to show how pedestrian emotions shift with spatial sequences (Koenig, R., Schneider, S., Hamzi, I., et al., 2014.).

In the context of large language models (LLMs) and sentiment analysis, scholars have argued that "emotions have never been aliened in AI." LLMs have demonstrated promising potential in understanding social emotions. Traditional sentiment analysis methods—including dictionary-based approaches, machine learning, and deep learning—have been widely used. While dictionary-based methods match words with emotion tags, and machine/deep learning models can identify emotional types within specific contexts, they often struggle with complex emotional structures, mixed emotions, sarcasm, and contextual nuances. As a result, they risk misclassifying emotions in nuanced or ambiguous content (Maynard, D.G. and Greenwood, M.A., 2014.).

Recent advances in large language models (LLMs) have demonstrated exceptional performance in understanding human language. Fu highlighted the effectiveness of LLMs in analyzing public sentiment, emphasizing their ability to significantly reduce the time and cost associated with processing emotional corpora. Unlike traditional methods ((Fu, X., Sanchez, T.W., Li, C. and Reu Junqueira, J., 2024.), LLMs approximate human-like comprehension of complex emotional expressions. Li Yin applied ChatGPT to analyze multi-category and multi-level sentiments in COVID-19-related tweets across New York State, identifying nuanced emotional patterns such as relief, hope, and anxiety. The study achieved refined sentiment classification and thematic associations, revealing regional differences in emotional attitudes (Yin, L., Han, M. and Nie, X., 2024.). Gao M conducted sentiment analysis on geo-tagged social media data from 32 urban blue spaces in London using LLMs, introducing three indices—the Happiness Probability Index (HPI), Happiness Intensity Index (HII), and Happiness Equilibrium Index (HEI)—to quantify the impact of blue spaces on public well-being (Gao, M. and Fang, C., 2025.).

Building on existing sentiment analysis frameworks, this study utilises LLMs to analyze the spatiotemporal patterns of public emotion on internet-famous streets in Nanjing's old city. First, using preprocessed social media data and ArcGIS-based spatial analysis, high-traffic and high-engagement internet-famous streets are identified. Second, the functional tags of Weibo check-in locations are manually sorted, and classified into standardised categories: education, public services, parks and squares, transportation, commerce, residential, cultural and sports services, and others. Based on this, the dominant functional type of each street is determined. Finally, by applying a GPT-based LLM, the study extracts complex emotional structures from the dataset and conducts a street-level spatiotemporal analysis of emotion patterns in relation to spatial features and function types.

This research focuses on the following core questions:
(1) How can internet-famous streets be identified through virtual media, and how can their online popularity boundaries and physical boundaries be accurately delineated?
(2) How can the functional types of internet-famous streets be classified based on social media perspectives?
(3) How can LLMs be used to mine multi-level sentiment structures from Weibo texts, and what are the relationships between emotional spatial patterns and functional types on these streets?

2 Data and Methods

2.1 Data Source

Using "Nanjing" as the keyword, original Weibo posts containing check-in information for Nanjing from July 31, 2019 to July 31, 2024 were collected via a Python-based web scraping framework. After removing invalid entries—such as abnormal check-in records, advertisements, and blank posts—and cropping the dataset to the boundaries of Nanjing's central urban area, a total of 1,004,755 valid records were obtained.
Each valid entry contains the following fields: user nickname, province, check-in location name, check-in location

type, geographic coordinates (latitude and longitude), post time, and Weibo text. The check-in location type is a label provided by the Weibo API, which tends to be fragmented and thus required manual cleaning and classification.

This study focuses on internet-famous streets rather than the entire city or old town of Nanjing. Therefore, the text dataset is constructed at the street scale. Buffer zones were generated using a length of 150 meters—corresponding to pedestrian-scale street segments—around identified street linear features. All Weibo posts falling within these buffers were included in the final dataset of internet-famous streets, resulting in a total of 68,215 valid records.

nickname	province	Location name	Location type	latitude	longitude	post time	Weibo text
A roadside little flower kid	Other	Taiyanggong Square	Square	118.8089	32.06694	2024/7/31	To the one I may be separated from—salute giving up. ps: my crying voice is too ugly.
I want you to become a persimmon cake	Jiangsu	Baolong Times Plaza	Shopping mall	118.6333	32.05627	2024/7/31	The most relaxing moment after work every day. July comes to an end.
Big Bastard Pig	Jiangsu	Nanjing University of Aeronautics and Astronautics	University	118.8152	32.03713	2024/7/31	After the plum rain season comes the dog days—seamlessly connected.

Figure 2: Weibo Dataset Structure (Figure source: self-compiled)

2.2 Kernel Density Spatial Analysis

The principle of kernel density analysis is that each analyzed point is covered by a smooth surface, where the surface value is highest at the point's location and gradually decreases with distance until it reaches zero at the defined search radius. A larger search radius yields a smoother and more generalised raster surface, while a smaller radius results in steeper, more detailed raster outputs.

In this study, kernel density analysis is employed to identify the spatial clustering boundaries of point-based datasets, thereby delineating the virtual heat boundaries of hotspot check-in streets.

2.3 Multi-Level Sentiment Analysis Framework Based on Large Language Models

This study utilises OpenAI's pretrained generative transformer model (GPT) as the primary tool for multi-category and multi-level sentiment analysis. The model excels in text comprehension and generation, offering human-like interpretation of social media content and outperforming traditional natural language processing methods in semantic depth and accuracy. OpenAI's model has demonstrated excellent performance in multiple benchmark evaluations and is particularly effective for processing unstructured, noisy, and linguistically diverse data such as tweets. Compared to open-source large language models that often require complex GPU deployment, OpenAI's API offers greater accessibility and ease of use, enhancing both the efficiency and stability of this research.

Prior to emotion classification, we used the LLM to objectively extract the emotional tone of each tweet without preset category labels or emotional constraints. By analyzing the natural emotional expressions in a large corpus of raw texts, and based on commonly recognised emotion types in Chinese contexts, we identified frequent emotional categories within social media discourse. The model ultimately classified the following sentiment types:

- Positive emotions: anticipation, happiness, affection
- Negative emotions: sadness, disgust, anger
- Neutral emotions: neutrality

The model was instructed to identify both a primary sentiment and a secondary sentiment for each post. If a secondary sentiment could not be detected, it was left blank, but a primary sentiment was always required. Through prior prompt tuning, we also enabled the model to output both the sentiment intensity and polarity for each sentence.

2.4 Research Framework

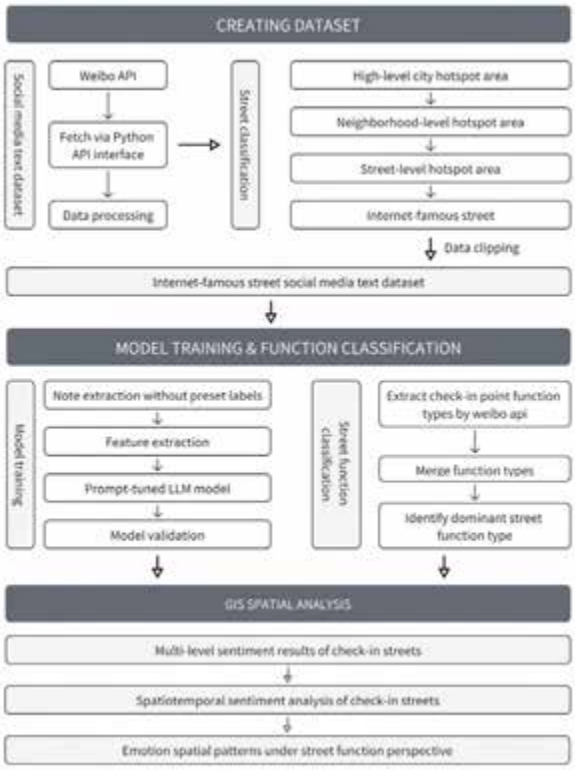

Figure 3: Research Framework (Figure source: self-compiled)

From Figure 3, this study establishes a Weibo text-based framework for identifying and classifying the functions of "internet-famous streets," encompassing three main stages: data collection, model training, and GIS spatial analysis. Data are collected via the Weibo API, functional types are determined using a large language model, and spatiotemporal patterns of internet-famous streets are ultimately visualised from a functional perspective through spatial analysis.

3 Case Study

3.1 Introduction to Nanjing

Nanjing is the capital of Jiangsu Province, a major central city in eastern China, and a megacity within the Yangtze River Delta region. As a historically and culturally renowned city, Nanjing boasts a profound cultural heritage and is historically known as the "Ancient Capital of Six Dynasties" and the "Metropolitan Capital of Ten Dynasties." In addition, the city is celebrated for its natural and urban landscape— "embracing the river and lakes, coiled like a dragon and crouching like a tiger"—and for its spatial structure characterised by "mountains and water interwoven, nested and layered." Immersed in such rich cultural and natural surroundings, Nanjing was named "China's Most Livable City" for the fourteenth time by 2023. This reflects the high level of happiness and satisfaction reported by its residents. The city's cultural and tourism vitality is also notable: during the 2025 May Day holiday alone, Nanjing received more than 12 million tourists. The shared access to high-quality urban space and cultural experiences among residents and visitors further reinforces a sense of belonging and emotional connection to the city.

The Old City of Nanjing, as shown in Figure 4 located in the heart of the urban core, serves as both the origin and continuation of the city's historical and cultural legacy. Its spatial form is framed by the Ming Dynasty's city wall, forming a structure of "outer city enclosure with an inner-city core." The Old City is not only a concentrated area of historic architecture but also a quintessential representation of traditional urban life. With a dense street network and human-scale dimensions, it offers strong walkability and a localised experience. This area integrates multiple functions including cultural tourism, commercial activity, and community life—preserving traditional atmospheres while blending with modern urban elements. Driven by the dynamics of social media, distinctive streets in the Old City—such as Laomendong, Gongyuan Street, and the Qinhuai River waterfront—have gradually evolved into popular "internet-famous" check-in spots, becoming key nodes for emotional expression, cultural identity construction, and urban image dissemination.

Figure 4: The old city of Nanjing (Figure source: self-compiled)

3.2 Hotspot Check-in Streets

3.2.1 Identification of Internet-Famous Check-in Streets

In studies focusing on the identification of internet-famous streets or blocks based on social media data, Zhang Wenquan proposed a method to delineate internet-famous districts. He identified high-popularity roads and blocks and then integrated real traffic networks with social media heat data, outlining check-in districts using a "connect-line-to-polygon" approach (Zhang, W., 2023.). Meanwhile, Yu Yidong et al. divided internet-famous spaces at the city, regional, and block levels into polygonal areas, and further identified the most representative check-in spaces at the block level. Both approaches provide valuable references: Zhang's framework effectively captures road-level connectivity but lacks a broader macro perspective, while Yu's model covers macro to meso-levels but does not extend down to the street scale(Yu, Y., Wang, J., Jiang, X., et al., 2024.).

This study builds on both methodologies and establishes a multi-level identification framework that progresses from city-level hotspot delineation,
district-level hotspots, block-level hotspots, final identification of internet-famous check-in streets, as is shown by Figure 5.

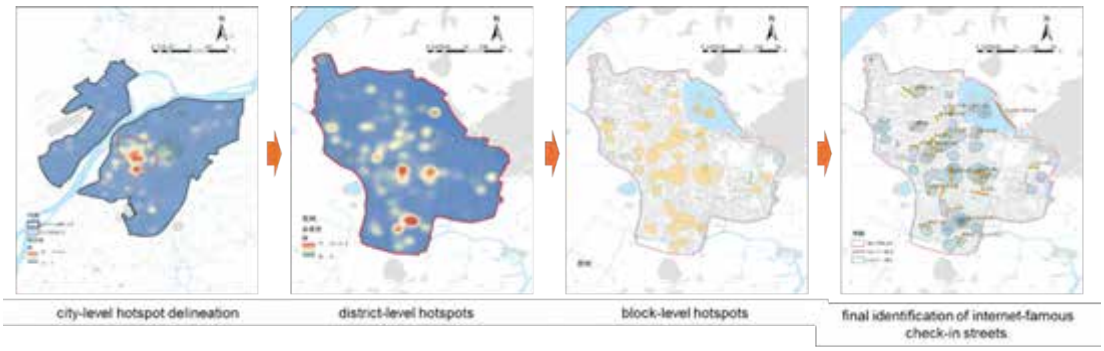

Figure 5: Multi-Level Identification Framework for Internet-Famous Streets (Figure source: self-compiled)

The scope of this study is defined through four hierarchical steps: (1) delineation of city-level hotspot zones, (2) district-level hotspots, (3) block-level hotspots, and (4) the final identification of internet-famous check-in streets.

First, the full dataset of 464,494 check-in Weibo posts with location information from Nanjing's main urban area is filtered by levels. Kernel density analysis of the main urban area reveals that internet-famous check-in zones are highly concentrated in the old city, with smaller clusters in Jiangning and Qixia districts. Due to their lower intensity and scale, the second-level scope is refined to focus on the old city, which contains 285,966 check-in posts.

Kernel density and raster binarization analyses are conducted within the old city to delineate block-level hotspots. Among the many hotspot areas, Xinjiekou, Daxinggong, and the Fuzimiao area show the most intense clustering.

Finally, based on block-level hotspot zones, check-in streets are identified. The top 20 streets and blocks in the old city are selected based on term frequency, along with the top 200 most popular check-in locations. The study integrates these block-level hotspot boundaries with the physical street boundaries to define the spatial extent of check-in streets, excluding overly long streets like Beijing East Road and Zhujiang Road that fall entirely outside hotspot areas. For blocks labeled as area-based check-in types, streets that connect the highest number of check-in points are selected as proxies—e.g., "Zhongshan South Road (Xinjiekou section)" is used to represent the Xinjiekou area.

Moreover, if a road clearly connects multiple check-in spots within a hotspot zone and displays a linear relationship, it is considered a check-in street—for example, Ke Xiang (Kexiang) and Taogu Xincun Road (Taogu New Village Road), which link numerous check-in points. Based on this classification approach, the final set of

internet-famous streets within the study area is determined, as is shown in Figure 6 and Figure 7.

Street Name (English)	Check-in Frequency
Zhongshan South Road (Xinjiekou Section)	13,592
Yangtze River Road	6,293
Fuzimiao Pedestrian Street	5,622
Zhujiang Road	5,513
Zhongshan North Road	4,120
Zhongyang Road (Xinjiekou Section)	3,399
Jimingsi Road	3,089
Kexiang Street	3,029
Shanghai Road	2,801
Shiziqiao Pedestrian Street	2,638
East Ring Road of Xuanwu Lake	2,443
Gutong Alley (Laomendong Area)	2,281
Sanshan Street	2,215
Mochou Road	1,958
Yihe Road	1,486
Changfu Street	1,347
Sanpailou Street	1,228
Jiqingmen Road	1,208
Houzaimen Street	1,011
Shanyin Road	1,005
Taogu Xincun Road	932
Fengfu Road	620
Jinyin Street	442

Figure 6: The list of the famous check-in streets (Figure source: self-compiled)

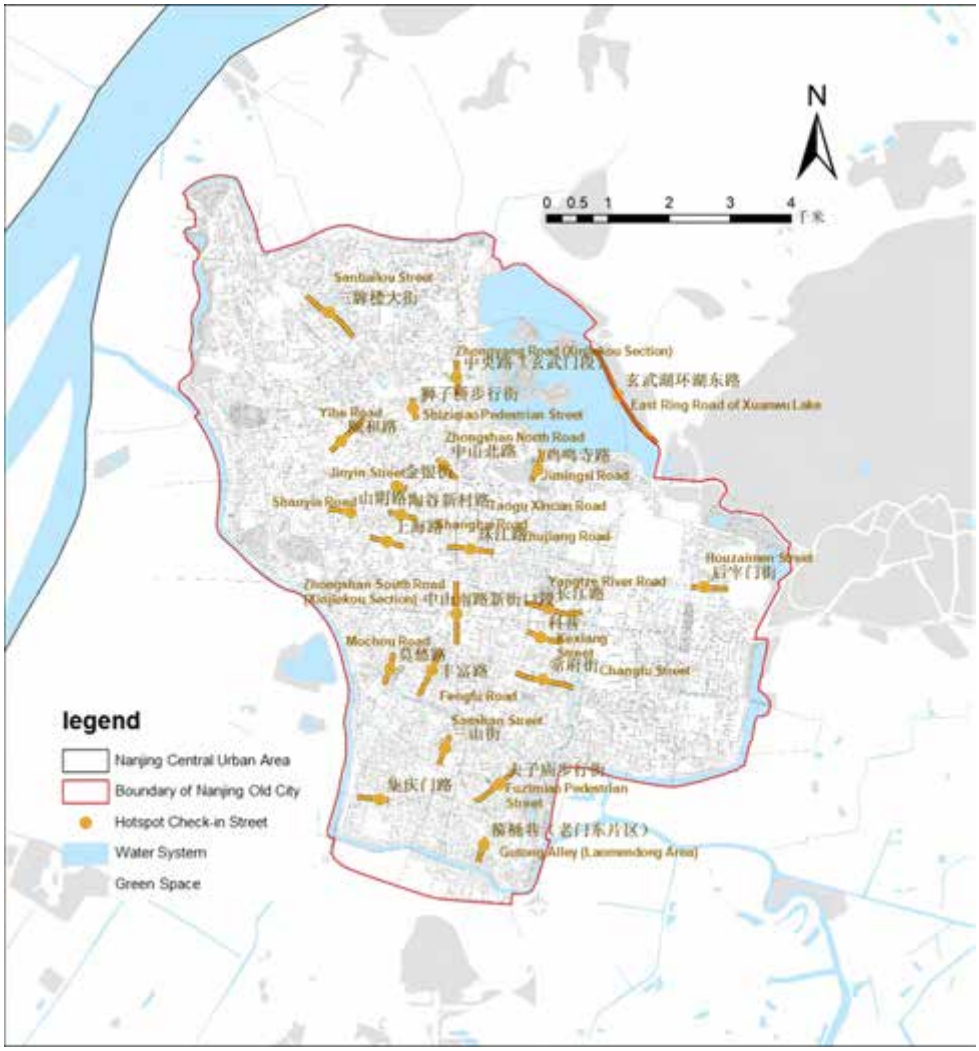

Figure 6: The list of the famous check-in streets (Figure source: self-compiled)

3.2.2 Identification of Check-in Location Functions

The Weibo API provides functional labels for check-in locations; however, these classifications are relatively broad, covering 154 categories such as five-star hotels, dining facilities, road infrastructure, metro station shops, cafés, bars, and more. To streamline the analysis, all location types were manually reclassified into eight major functional categories: education, public services, parks and squares, transportation, commerce, residential, cultural and sports services, and others, as is shown in Figure 7 and 8.

Category	Classification Criteria
Education	Includes educational institutions providing various levels of education, such as universities, secondary schools, and kindergartens.
Public Services	Covers facilities related to government, healthcare, and administration, focusing on public service and welfare functions.
Parks and Squares	Refers to open urban spaces with ecological, landscape, leisure, and social functions, including urban parks, pocket parks, and green plazas.
Transportation	Includes transportation infrastructure such as bus stops, metro stations, and railway stations.
Commerce	Encompasses spaces with commercial functions such as retail, dining, business offices, and entertainment or leisure venues.
Residential	Consists of residential-dominant units including commercial housing complexes, affordable housing, and dormitory areas.
Cultural and sports services	Facilities aimed at culture, education, leisure, or physical activities, such as libraries, stadiums, exhibition halls, and cultural centers.
Others	Special or mixed-use spaces that cannot be classified under the categories above.

Figure 7: Functional Types of Check-in Locations (Summarised Based on Weibo API Check-in Labels)

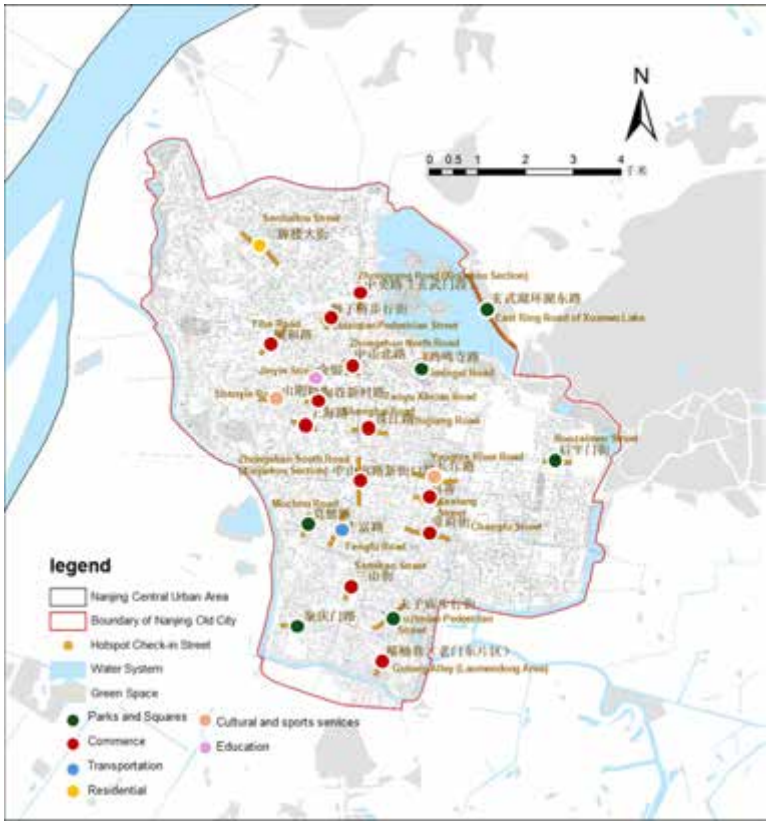

Figure 8: Dominant Functional Type of Internet-Famous Check-in Streets (Figure source: self-compiled)

3.3 Spatiotemporal Analysis of Emotional Patterns in Hotspot Check-in Streets

3.3.1 Overall Emotional Pattern Recognition of Internet-Famous Check-in Streets

Figure 9 illustrates the multi-category and multi-level emotional structure of the internet-famous check-in streets in Nanjing's Old City. Overall, public emotions are predominantly positive, with "happiness" and "affection" forming a strong co-occurrence relationship. Together, they constitute the core positive emotional backbone of the street spaces in the Old City. This emotional structure reflects not only a high level of public approval of the spatial environment but also highlights the streets' appeal as high-quality public spaces that integrate leisure, consumption, and culture, resonating strongly with positive emotions.

Within the positive emotion spectrum, "happiness" tends to convey immediate sensory experiences—such as pleasant scenes or a comfortable atmosphere—while "affection" emphasises long-term spatial preference and emotional attachment. This dual nature suggests that the Old City's streets provide both immediate experiential value and deeper emotional significance.

In contrast, "anticipation," as a secondary positive emotion, flows between several primary emotional nodes, playing a transitional and bridging role. It is positively linked with both "joy" and "affection," but also connects with "neutral" and even "sad" emotions, indicating that when expressing anticipation, users may reveal hopes for future spatial experiences, intertwined with dissatisfaction or desires for improvement in the present environment.

Negative emotions appear more fragmented and complex. Although the overall proportion of negative sources such as "sadness," "disgust," and "anger" is relatively low, their emotional pathways are highly scattered. For example, "sadness" connects not only to "disgust" and "anger" but also to positive emotions like "affection" and "anticipation." This suggests that negative emotions are not merely rejections of space but often represent critical feedback embedded within active urban experiences—such as perceptions of street congestion, over-commercialization, or disorder—interwoven with aspirations for improvement and positive transformation.

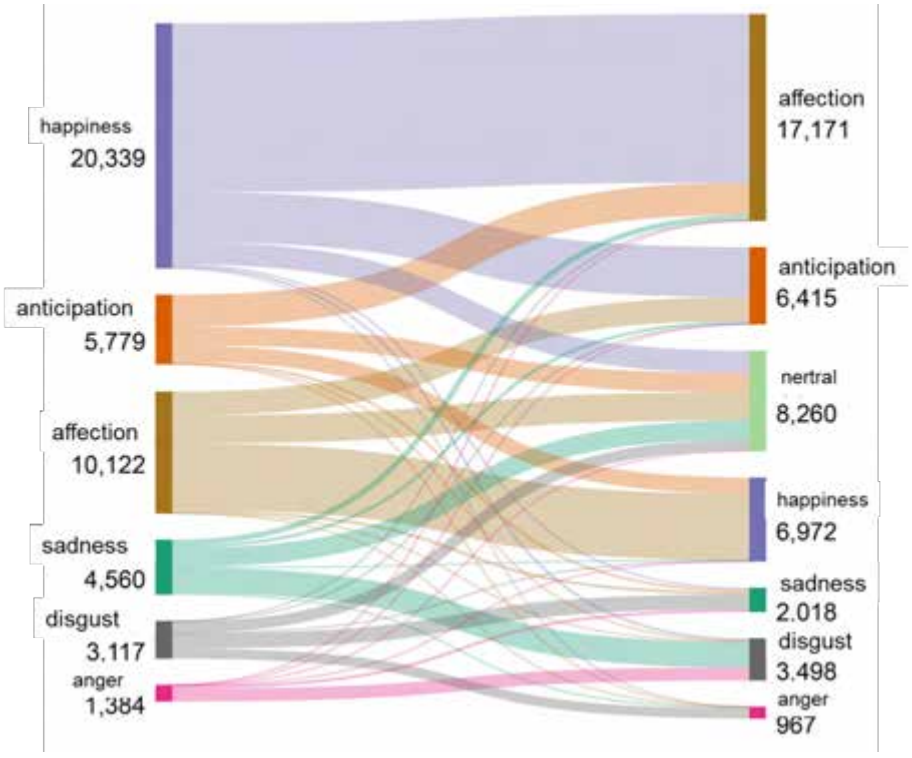

Figure 9: Dominant Functional Type of Internet-Famous Check-in Streets (Figure source: self-compiled)

3.3.2 Overview of Emotional Patterns in Internet-Famous Check-in Streets

Overall, the internet-famous check-in streets in Nanjing's Old City exhibit a predominantly positive emotional pattern, with a generally uplifting spatial atmosphere. Figure 10 illustrates that in most streets, positive emotions account for over 70%, with "happiness" and "affection" consistently serving as dominant sentiments. This pattern indicates a strong foundation of emotional perception among the public—these streets not only fulfill functional needs but also create environments imbued with a sense of pleasure and belonging.

From a finer spatial perspective, the emotion of "affection" highlights spatial identity and cultural attachment. Streets such as Mochou Road, Taogu Xincun Road, and Gutong Alley (Laomendong Area) show a significantly higher proportion of "affection" than other streets. This suggests that these locations carry strong cultural symbolism in the public consciousness and enjoy greater emotional recognition in terms of spatial image, historical memory, and sense of belonging.

A few streets, such as Shanyin Road, Houzaimen Street, and Kexiang Street, show relatively higher proportions of negative emotions like "sadness" and "disgust," potentially reflecting localised issues in functional facilities, environmental ambiance, or congestion experiences.

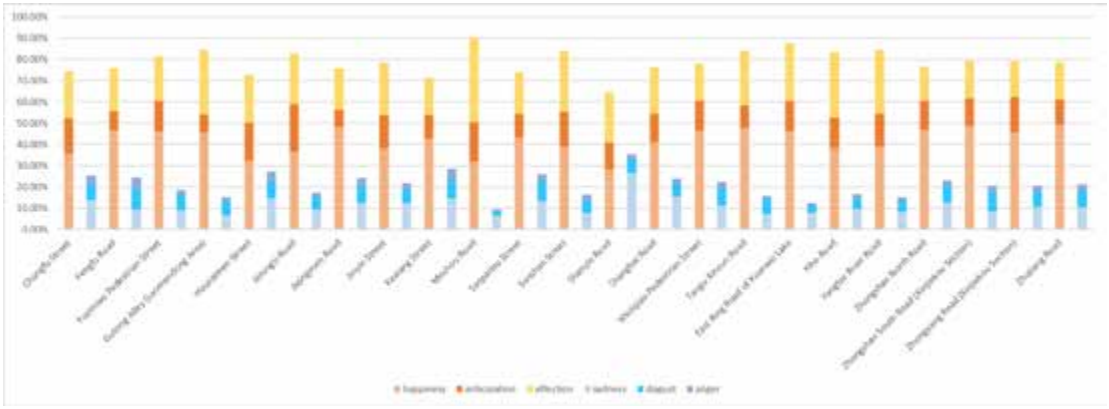

Figure 10: Primary Emotion Categories of Different Check-in Streets (Figure source: self-compiled)

As is shown by Figure 11, streets with different functional types exhibit significant structural differences in emotional expression. Streets characterised by commercial, park and square, transportation, and cultural-sports service functions show a highly consistent pattern of dominant positive emotions. Among these, the emotion "joy" holds an overwhelmingly dominant position across all functional types—particularly in transportation and park/square streets, where it accounts for over 40%, reflecting the public's immediate sense of pleasure and positive experience in such spaces.

In contrast, streets serving educational and public service functions show more pronounced expressions of negative emotions. Specifically, "sadness," "disgust," and "anger" are relatively more prevalent on streets surrounding university areas. This may be linked to issues such as traffic congestion, commercial sprawl, inadequate infrastructure, or restrictive management policies in these zones. Public service streets also display a strong emotional polarization. Although residential streets are similarly dominated by "happiness", they also show relatively high proportions of "disgust" and "sadness," which may be closely related to challenges in old urban residential areas, such as high housing density, lack of supporting public amenities, and spatial aging.

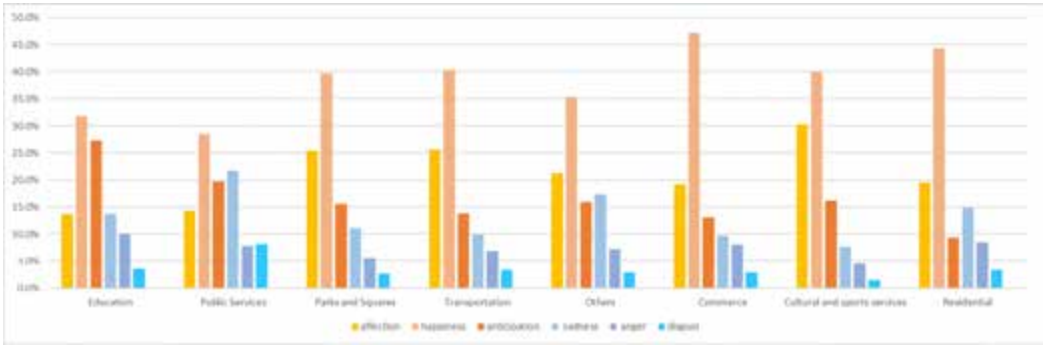

Figure 11: Emotional Patterns from the Perspective of Check-in Location Functions (Figure source: self-compiled)

3.3.3 Spatiotemporal Analysis of Emotional Patterns in Internet-Famous Check-in Streets

(1) Temporal Patterns of Emotions in Internet-Famous Check-in Streets

Figure 12 illustrates the monthly emotional trends of internet-famous check-in streets in Nanjing's Old City from 2019 to 2024. In terms of check-in volume, the overall frequency remained relatively stable between 2019 and 2022, fluctuating between 500 and 1,000 per month, with seasonal peaks typically occurring during summer holidays and national festivals. Since 2023, the check-in volume has seen a steady rise, with significant growth from early 2024 onward. Monthly check-ins have exceeded 3,000, marking a 3–4 fold increase compared to earlier years.

Emotional intensity (blue line) has remained between 0.65 and 0.7, with minimal fluctuation, indicating a strong and consistent level of emotional expression. The absolute value of emotional polarity (green line) has stabilised between 0.55 and 0.6, suggesting that emotional responses are steady and sustained. Emotional polarity (red line) consistently remains positive, fluctuating between 0.3 and 0.4, reflecting a persistently favorable emotional evaluation of the area by the public.

During the COVID-19 outbreak in early 2020, check-in volumes temporarily declined, but emotional indicators remained stable. From 2023 onward, check-in activity rebounded rapidly, with a noticeable surge in early 2024. Overall, despite the sharp increase in activity, emotional indicators remained positive, indicating that the internet-famous streets in Nanjing's Old City have achieved a robust post-pandemic recovery while maintaining a high-quality public space experience amid growing traffic.

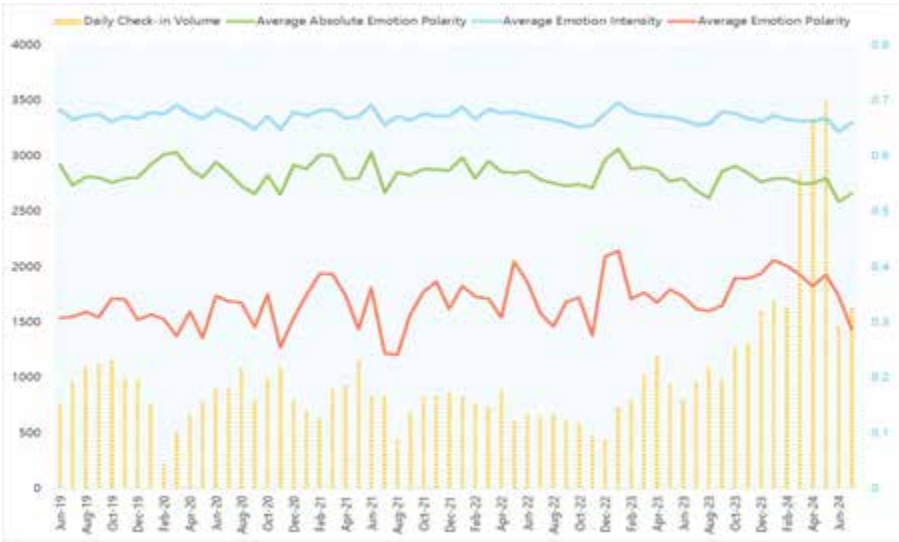

Figure 12: Monthly Analysis of Check-in Frequency, Emotion Polarity, and Emotion Intensity in Internet-Famous Streets (Figure source: self-compiled)

According to Figure 13, based on weekly-scale statistics, the emotional and check-in behaviors on Nanjing Old Town's internet-famous streets exhibit clear cyclical patterns. Firstly, check-in volumes show a typical "weekend effect," with significantly higher activity on Saturdays and Sundays compared to weekdays, reflecting the streets' primary roles in leisure, entertainment, and socializing. Interestingly, check-in volumes on Mondays are slightly higher than other weekdays, possibly due to the "Monday syndrome," as people tend to share their weekend outings and social experiences. During the workweek (Monday to Friday), check-in volumes remain relatively stable, suggesting that these areas attract consistent foot traffic even on weekdays.

In terms of emotional indicators—emotion intensity, polarity, and absolute polarity—there is little variation across the week, with all metrics maintaining a steady level. Even during peak weekend traffic, emotional values do not show notable fluctuations, indicating that these streets possess strong capacity and resilience in spatial management. They consistently deliver a satisfying urban experience across different time periods. Overall, Nanjing Old Town's internet-famous streets demonstrate a high degree of temporal stability in both spatial appeal and emotional perception.

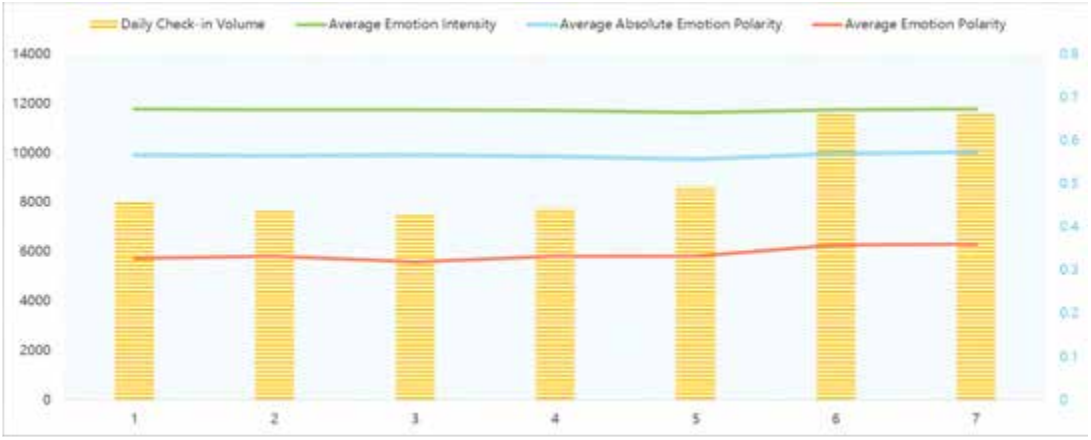

Figure 13: Emotional Patterns from the Perspective of Check-in Location Functions (Figure source: self-compiled)

Based on statistics by the dominant function of streets and on a monthly scale, two key insights emerge:

From the temporal perspective, emotional indicators fluctuated significantly and check-in volumes remained low during 2019–2020, reflecting the impact of the pandemic on urban vitality across all functional areas. In 2021–2022, emotional metrics began to stabilise and check-in volumes gradually recovered, indicating a transitional recovery phase. By 2023–2024, check-ins rose markedly, and emotional indicators remained steady, signaling a positive development trend.

From the functional perspective, commercial streets exhibited the highest level of activity and check-ins, showing sensitivity to holidays and seasonal changes. Due to the large data volume, the emotional indicators were relatively smooth. Parks and squares followed with high activity levels and strong seasonality, performing well particularly in spring and autumn, with stable emotional indicators. Streets with cultural and sports services had moderate activity and generally positive user experiences. In contrast, streets with traffic, residential, or university functions saw relatively low check-in volumes and more noticeable emotional fluctuations, especially under extreme values. Notably, university streets showed negative emotional polarity in the first half of 2020.

Figure 14: Emotional Analysis of Streets with Different Functions from a Monthly Perspective (Figure source: self-compiled)

(2) Spatial Emotional Patterns of Internet-Famous Streets
As shown in Figure 15, the emotional spatial pattern of internet-famous streets in Nanjing's Old Town demonstrates a dual characteristic of "highly clustered positive emotions + locally scattered negative emotions."

Areas dominated by positive emotions are highly concentrated. Red and orange grids representing high emotional polarity are widely distributed in commercial and park/square-type streets. Notable examples include Xinjiekou, Zhongshan South Road, Jiqingmen Road, and Gutong Alley (Laomendong area), where positive emotional polarity is particularly strong and grid coverage density is high. This indicates that such streets not only possess strong commercial appeal but also consistently evoke positive emotional experiences among users. Although streets like Fuzimiao Pedestrian Street and Houzaimen Street show some fragmented expressions of negative emotions, their overall sentiment remains predominantly positive.

Negative emotions are more scattered and localised. University-related streets (e.g., Jinyin Street) exhibit relatively higher proportions of negative sentiment. Transportation-oriented streets (e.g., Fengfu Road) also show high levels of negative emotions, potentially due to factors such as noise pollution, traffic congestion, and accessibility stress. Residential streets (e.g., Sanpailou Street) maintain a certain level of positive emotion but are also interspersed with negative sentiment. Cultural and sports service streets (e.g., Shanyin Road and Changjiang Road) reveal similarly elevated levels of negative emotions, which may be linked to inadequate public facilities, aging infrastructure, or limited capacity for hosting activities—suggesting these spaces may lack adaptability for high-frequency public use.

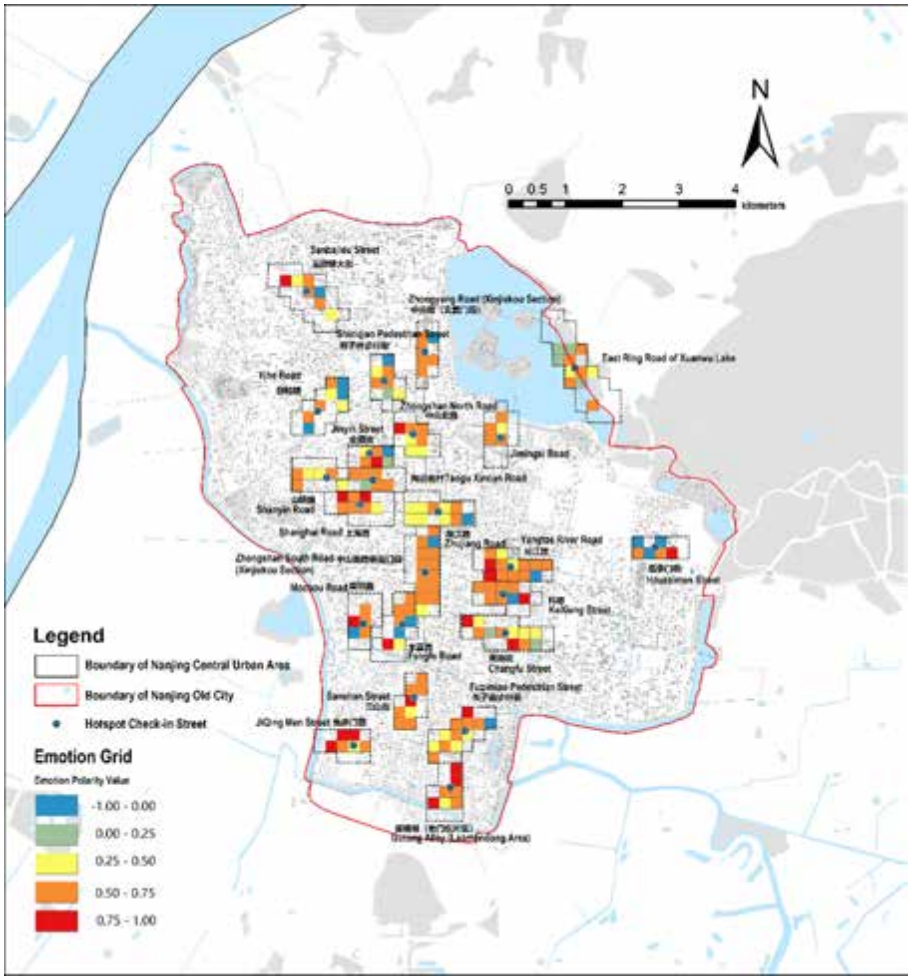

Figure 15: Spatial Visualization Analysis of Emotion Polarity in Internet-Famous Streets (Figure source: self-compiled)

3.4 Emotional Pattern Analysis of Hotspot Check-in Streets from a Functional Perspective

As is shown from Figure 16, from the commercial function perspective, commercial check-in points are the most prominent among Nanjing's hotspot streets. Streets such as Zhongshan South Road (Xinjiekou section), Gutong Alley, Kexiang, and Changfu Street display multiple red and orange grids, representing areas with the strongest positive emotional polarity. Overall, the high proportion of orange grids reflects a well-developed commercial environment and a strong consumer atmosphere in these areas.

From the public service function perspective, the emotional distribution of internet-famous streets in Nanjing's Old City shows a more prominent tendency toward negative sentiment. A higher proportion of blue grids is observed, indicating a pattern of low-value clustering with mixed positive and negative emotions. Negative emotions are dominant, and spatial consistency is relatively weak. Low emotional polarity zones are mainly concentrated along streets such as Shanyin Road, Changjiang Road, Zhongshan North Road, and Huanhu East Road of Xuanwu Lake, suggesting certain negative perceptions regarding the spatial environment, functional amenities, or user experience of public service facilities.

From the perspective of cultural and sports services, the emotional spatial distribution of hotspot check-in streets shows a more dispersed pattern of positive sentiment. Overall, red and orange grids are spread across

multiple streets, forming a generally positive emotional landscape. High-value zones are mainly concentrated along Gutong Alley, Taogu Xincun Road, and Kexiang. In contrast, grids representing negative emotions (blue or green) are relatively few and scattered, primarily appearing in limited areas such as Zhongshan North Road and the Xuanwumen section of Zhongyang Road. Although the distribution of positive emotions in cultural and sports service spaces lacks strong spatial continuity, most check-in locations maintain a high level of positive emotional expression, indicating strong positive spatial perception.

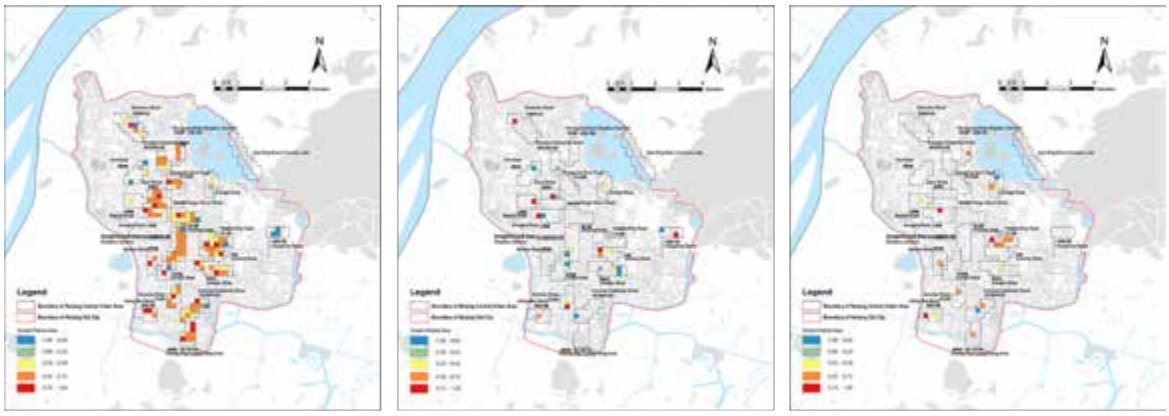

Figure 16: Spatial Visualization Analysis of Emotion Polarity in Internet-Famous Streets from Commercial, Public Service, Cultural and Sports Service Function (Figure source: self-compiled)

From the perspective of university-related functions, the emotional spatial distribution of internet-famous check-in streets in Nanjing's Old City is relatively limited. Overall, check-in points associated with universities are few and sparsely distributed. The primary low-emotion grids (blue and light blue) are concentrated in areas surrounding Jinyin Street and the Xuanwumen section of Zhongyang Road, indicating more prominent expressions of negative emotions.

From the perspective of parks and squares, both tourists and residents in Nanjing show high levels of satisfaction with such spaces. Red and orange grids are densely concentrated in areas such as the surroundings of Xuanwu Lake, Laomendong, and Mochou Lake, suggesting that these park and square spaces receive strong positive emotional feedback in public check-ins. In contrast, more negative comments are found around Yihe Road and Kexiang, which may be linked to crowd congestion, insufficient maintenance, lack of facilities, or conflicts with nearby developments.

From the perspective of transportation functions, the emotional spatial distribution of internet-famous streets in Nanjing's Old City is generally dominated by positive sentiment, with fewer negative expressions. Most transportation-related check-in points fall within orange and yellow grids, indicating a reasonably planned transportation layout and a relatively pleasant travel experience. However, localised high negative emotion zones are concentrated around Yihe Road and Kexiang, reflecting potential inconveniences or congestion issues in traffic conditions or accessibility in these areas, as is shown in Figure 17.

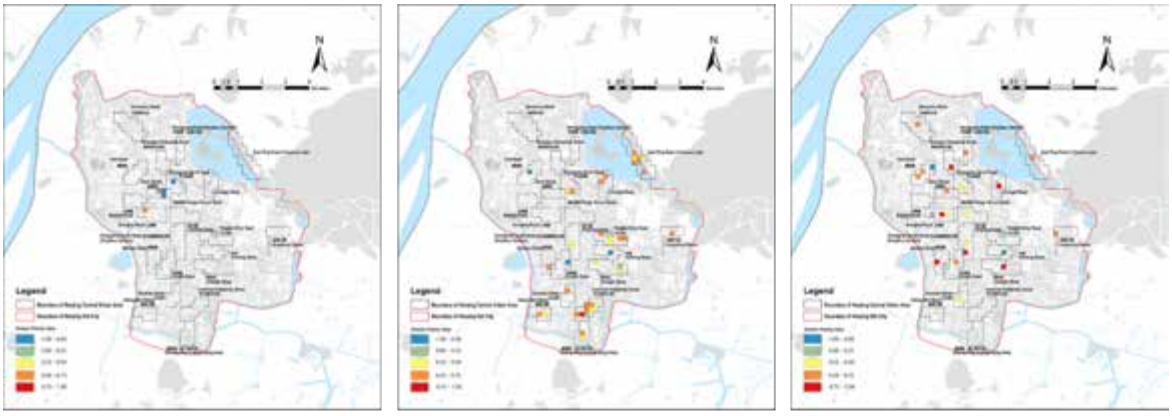

Figure 17: Spatial Visualization Analysis of Emotion Polarity in Internet-Famous Streets from Education, Parks and Squares and Transportation Function (Figure source: self-compiled)

4 Discussion and Conclusion

4.1 Discussion

This study provides an in-depth analysis of the emotional spatial patterns of internet-famous check-in streets in Nanjing's Old City. The findings show that public sentiment is predominantly positive, with "joy" and "affection" being particularly prominent. This emotional structure reflects a high level of public approval toward the street environment and indicates that these spaces offer both immediate experiential value and long-term emotional attachment. For example, Xinjiekou, as a core commercial area, shows exceptionally high levels of positive emotion, highlighting strong public resonance with its vibrant commercial atmosphere.

A detailed analysis of emotional patterns further reveals that while negative emotions account for a smaller portion overall, they exhibit fragmentation and complexity. Emotions such as "sadness" often interact with positive ones like "anticipation" and "affection," indicating that critical feedback from the public is often accompanied by expectations for spatial improvement. For instance, although Kexiang Street demonstrates generally positive emotions, there are noticeable localised expressions of negativity, likely due to crowding and inadequate facilities.

From a spatiotemporal perspective, the emotional activity on internet-famous streets in the Old City shows clear cyclical characteristics, with higher emotional engagement during weekends and holidays, suggesting that these areas serve primarily recreational, social, and cultural functions. Monthly and yearly trends further demonstrate the streets' emotional resilience and recovery—especially after the impacts of the COVID-19 pandemic—with a notable revival in vitality from 2023 onward, and stable sentiment levels, reflecting the rapid recovery capacity of urban public spaces after disruptive events.

This study offers two key methodological innovations: First, it incorporates large language models (LLMs) for emotion analysis, significantly enhancing the accuracy and efficiency of detecting emotional patterns in complex social media texts. Second, while most previous research has focused on citywide emotional mapping, this study adopts a street-level perspective, uncovering fine-grained interactions between public sentiment and spatial function types at the micro-scale. This shift in scale not only enriches the field of emotional geography but also offers precise decision-making support for urban planning and spatial optimization.

Future research could further extend the application of emotion analysis technologies, exploring the interaction between emotional patterns and spatial optimization strategies, thereby advancing urban governance toward greater refinement and human-centered development.

4.2 Conclusion

From a functional perspective, the internet-famous check-in streets in Nanjing's Old City exhibit clear spatial emotional distribution characteristics. Commercial streets—such as Xinjiekou, Zhongshan South Road (Xinjiekou section), Shiziqiao Pedestrian Street, Gutong Alley, Taogu Xincun Road, and Mochou Road—are dominated by positive emotional clustering, forming the core zones of highest emotional polarity. Streets associated with parks and squares—such as Fuzimiao Pedestrian Street, Houzaimen Street, and the East Ring Road of Xuanwu Lake—also feature mainly positive emotions, though some areas display scattered negative sentiment.

Cultural and sports service streets—such as Shanyin Road and Changjiang Road—exhibit a bipolar pattern, with both positive and negative emotions relatively balanced. University-oriented streets—such as Jinyin Street and the Xuanwumen section of Zhongyang Road—show a more pronounced distribution of negative emotions. Transportation-oriented streets—such as Fengfu Road—present a stronger concentration of negative emotions. Residential streets—such as Sanpailou Street—display a mix of both positive and negative emotions.

Overall, commercial and park/square streets emerge as primary hubs of positive sentiment, whereas streets associated with universities, transportation, and some residential or cultural service functions exhibit relatively more negative sentiment. The emotional spatial pattern shows a clear functional differentiation driven by street type.

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Gamifying Participatory Design: A Digital Platform for Urban Renewal in Gangxia Urban Village, Shenzhen

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Abstract
China's urbanization has spurred the growth of urban villages, with Shenzhen's Gangxia exemplifying intersections of social complexity, policy shifts, and digital innovation. This study designs a gamified digital platform engaging migrant workers, landlords, and officials in participatory urban planning. Quantitative coding of structured interviews revealed core interaction patterns and preference clusters, informing platform architecture integrating real-time feedback loops and tiered rewards. Key findings: 1) Adaptive UI/UX layers address technological literacy gaps; 2) Dynamic scoring algorithms reconcile power asymmetries; 3) Behavioral data granularity determines platform efficacy. This data-driven approach demonstrates context-sensitive digital tools for informal settlements, proposing a replicable framework for technology-mediated planning that bridges socioeconomic divides while enhancing governance. The research advances practical applications of gamification and AI analytics in sustainable urban renewal.

Keywords: Urban Villages, Gamification, Digital Participatory Design, Digital Platform - Urban Renewal

1. Introduction

Since the economic reforms of 1978, China has experienced transformative socio-economic growth, with substantial increases in investment, consumption, and overall living standards that have reshaped the urban landscape and driven significant rural-to-urban migration (Hao et al., 2011). In this context, urban villages—known as "villages in the city" (Chengzhongcun)—have emerged as distinctive informal settlements within Chinese urban centers. Originally traditional rural villages, they have become gradually surrounded by expanding urban zones, evolving into unique communities that coexist within the larger urban fabric (Wang et al., 2009). In first-tier cities such as Shenzhen, the status quo of urban villages has created a series of challenges, including poor housing conditions, low land utilization and poor infrastructure. Meanwhile, Different social groups within urban villages have varying resources, including capital, skills, land rights, and social rights, leading to conflicts of interest (He et al., 2010). These villages play a critical role in providing affordable housing and fostering informal economies, yet they face significant challenges such as poor infrastructure, weak governance, and limited public participation in urban renewal processes (Lin et al., 2014). Traditional top-down urban planning approaches often exclude local residents from decision-making, resulting in conflicts and inefficiencies in redevelopment projects (Wu, 2016).

Digital participatory design (DPD) has emerged as a promising solution to address these challenges by integrating digital tools into participatory urban planning (Foth et al., 2009). Community digital interaction platforms, such as mini-programs, offer accessible interfaces that enable residents to express their preferences, provide feedback, and engage with urban renewal initiatives. However, the willingness and ability of urban village residents to adopt such tools remain uncertain, particularly given their unique socio-economic conditions and varying levels of digital literacy.

While digital participation has been extensively studied in urban governance (Stern et al., 2020), its application in informal urban areas like urban villages requires further exploration. Residents of urban villages often face barriers such as limited digital skills, low trust in government initiatives, and distinct socio-economic constraints, all of which may influence their acceptance of digital participation platforms. Therefore, understanding their technology acceptance and developing a tailored digital participation framework is essential for enhancing their involvement in urban planning. This research proposes a gamified digital platform tailored to the unique context of Gangxia Village to address the challenges of participatory urban renewal. Grounded in quantitative coding of structured interviews with key stakeholder groups—including migrant workers, landlords, and municipal officials—the study systematically identifies interaction patterns, participation barriers, and preference clusters.

These insights directly inform the platform's architecture, including adaptive user interfaces, real-time feedback mechanisms, and a tiered reward system designed to incentivize engagement and mitigate power asymmetries.

The findings underscore two core insights: first, localized, data-driven interface design is essential to accommodate varying levels of technological literacy and cultural diversity; second, gamification fosters not only participation but also cross-group empathy, reframing urban planning as a collaborative rather than transactional process. By demonstrating how context-sensitive digital tools can support inclusive planning in informal settlements, this research offers a replicable framework for developing technology-mediated participation platforms, contributing practical strategies for more equitable and sustainable urban governance.

2. Literature Review

2.1 Spatial Marginality in Urban Villages

The establishment of the Shenzhen Special Economic Zone initiated a fragmented land acquisition process, wherein the nascent government selectively appropriated agricultural land for critical public infrastructure—including the civic center—while largely excluding existing village settlements from urban road networks and municipal services (Wang et al., 2009). This piecemeal spatial governance, compounded by fiscal constraints that hindered comprehensive employment provision, accelerated the dissolution of agrarian landscapes. As urbanization intensified post-1990s, residual rural enclaves evolved into "urban villages," their transformation propelled by market-driven responses to rural migrants' demand for affordable housing (Zhang, 2005). These urban villages now epitomize a paradoxical spatiality: While functioning as self-contained nodes through dense commercial ecosystems (Laclau & Mouffe, 1985; Abrahamson, 2005), they simultaneously exhibit infrastructural collapse—manifested in chronic sewage overflow and waste accumulation (Liu et al., 2010). This duality reflects deeper contradictions in urban rights allocation. Traditional communal spaces like ancestral halls coexist uneasily with gated sports facilities and pay-to-access venues (Chung, 2010; Hsing, 2010), materializing the erosion of spatial justice into a structural impediment to sustainable community development. Spatial segregation further crystallizes identity politics. The hukou system institutionalizes rural migrants as "floating populations" (Fan, 2002; Wu, 2004), a bureaucratic label that persists despite their demonstrated aspirations for permanent settlement and civic engagement (Wu, 2012). Excluded from participatory planning processes, migrants inhabit a liminal state of "physical presence but political absence" (Kochan, 2009), a condition amplified by local residents' monopolization of social capital. Consequently, urban villages become both symbolic markers of failed integration in mainstream discourse (Siu, 2007) and concrete arenas for class antagonism.

By 2021, Shenzhen hosted over 1,000 urban villages exhibiting divergent evolutionary trajectories. Some retain low-rise vernacular architectures encircled by remnant farmland, while others metamorphose into high-density mid-rise clusters embedded within modern urban grids. This morphological diversity encapsulates the contested interplay between institutional elasticity and capitalist spatial logic.

2.2 Evolution and Digitalization of Public Participation

Citizen participation refers to the process by which citizens actively engage in political and economic processes through the redistribution of power, enabling previously marginalized poor citizens to be intentionally included in shaping the future. Public participation is crucial in urban planning and decision-making, allowing community members to take part in policy formulation, spatial planning, and project development. With the rapid pace of urbanization and the increasing complexity of social demands, the significance of public participation has grown substantially. However, Arnstein's (1969) "Ladder of Citizen Participation" model highlights the issue of tokenistic participation in traditional civic engagement, where actual power devolution remains limited.

In the context of urban renewal, low-income community residents often lack long-term planning capabilities, are unfamiliar with abstract matters, distrust urban institutions, and experience a low sense of efficacy in organized actions, making them less likely to engage proactively in urban governance. The concept of "planning with residents" assumes that communities have the willingness and capacity to collaborate in pursuing the common good. However, when urban renewal entails large-scale demolition, mandatory housing standard upgrades, or

requires residents to bear renovation costs themselves, this willingness is often absent. Additionally, due to differences in organizational capacity across social classes, middle-class groups are more likely to be included in "collaborative planning," while low-income groups tend to be excluded, becoming passive recipients of urban renewal processes (Wilson, 1963). These issues are particularly pronounced in informal urban areas such as urban villages, where many residents are migrants with limited access to information and resources. The urban-rural divide further exacerbates their exclusion, highlighting the need to explore new mechanisms to enhance participation and inclusivity.

To address these challenges, Digital Participatory Design (DPD) has emerged as a potential solution, leveraging information technology and digital platforms to facilitate community engagement in urban planning and governance (Smith, 2009). Digital platforms offer an accessible and interactive means for residents to participate in decision-making, providing real-time feedback and opportunities for involvement (Lee & Kim, 2019). This is particularly important in urban villages, where the lack of physical public spaces for participation limits engagement. However, the implementation of DPD also raises concerns, including the digital divide, technological adaptability, and platform usability (Muller, 2017). Many urban village residents, especially older generations and those with limited digital literacy, may struggle to use these technologies effectively. Furthermore, debates persist over whether digital platforms genuinely enhance democratic decision-making or merely serve as symbolic participation tools (Carver et al., 2008). To maximize the effectiveness of DPD, platform design must align with community needs, minimize accessibility barriers, and foster meaningful interactions among residents.

By integrating discussions on public participation challenges, digital participatory design, and technology adoption theories, this analysis underscores the importance of bridging both digital and social divides in urban village governance. Ensuring that digital participation platforms are both accessible and effective can play a transformative role in enhancing civic engagement, promoting social inclusion, and improving urban planning outcomes in informal settlements.

3. Research Methodology

3.1 Case study Area Background information - Gangxia, Shenzhen

China's open-door policy, initiated in 1979, led to the establishment of Shenzhen as an innovative and experimental metropolis. Situated in the Pearl River Delta of South China, Shenzhen has since evolved into one of the country's most dynamic cities, characterized by extraordinary economic growth and rapid population expansion, largely driven by its market-oriented economy (Ng, 2003). Originally a small border town with a population of approximately 310,000, Shenzhen's strategic proximity to Hong Kong made it an ideal candidate for developing an export-driven economy. In 1980, Shenzhen was designated as China's first Special Economic Zone (SEZ), marking a pivotal shift towards a market economy aimed at attracting foreign investment, advanced technology, and modern management expertise. Over the decades, Shenzhen has transformed into a sprawling metropolis with a population of 14 million (Zacharias & Tang, 2010), significantly surpassing the official count of 8.8 million recorded in 2008 (Yearbook, 2020). The Shenzhen SEZ encompasses 410 square kilometers across the districts of Luohu, Futian, Yantian, and Nanshan, while the adjacent districts of Baoan and Longgang, covering 714 km^2 and 845 km^2 respectively, extend to its north.

When the Shenzhen Special Economic Zone was established, the government acquired land for development from nearby villages in a gradual and piecemeal manner. While ancient villages were preserved, new agricultural land was repurposed for planning the civic center and other significant public structures. Village dwellings were often excluded from road and infrastructure projects, creating a unique urban-rural dichotomy. The nascent administration faced challenges in providing employment opportunities for all local village residents due to its limited size and financial constraints. As urbanization accelerated and more agricultural land was converted for urban use, these ancient villages gradually evolved into "urban villages" (Wang et al., 2009). These urban villages emerged as a direct consequence of urban expansion, but their transformation into migrant enclaves was a commercial response to the growing demand for affordable housing among rural migrants (Zhang, 2005). Under China's hukou system (Fan, 2002; Wu, 2004), rural migrants, often referred to as the "floating population" (Good-

kind & West, 2002), are considered transient residents in urban areas. Consequently, the influx of these migrants has fueled the growth of urban villages. By 2021, Shenzhen was home to over 1,000 urban villages, evenly distributed across the city (Du, 2020). Over the past four decades of rapid urbanization, these urban villages have undergone significant transformations, albeit at varying speeds and times depending on their locations. They have transitioned from "low-rise traditional building forms surrounded by large tracts of farmland" to "high-density mid-rise building forms surrounded by modern urban blocks."

This study focuses on the urban villages in Shenzhen: Gangxia Village(Table 1).

Table 1. The information of Gangxia

Category	Content
Village Name	Gangxia Village
Location	Located in central Futian, Shenzhen
Area	Approximately 151,600 m²
Population	Around 100,000 people
Initial Redevelopment Proposal	Proposed by the municipal government in 1998 (Hin & Xin, 2011)
Project Launch	Initiated by the Futian Urban Renewal Office (FURO) in 2002 (Hin & Xin, 2011)
Start of Demolition	April 2009, after redevelopment agreements were reached (Hin & Xin, 2011)
Impact of 1992 Urbanization Reforms	- Transition from rural to urban governance - Villagers granted urban household registration - Village committees converted into neighborhood committees - Production teams restructured as joint-stock companies - Legalized leasing led to dense rental housing and commercial construction (O'Donnell, 2021)
Designation as Urban Renewal Unit (URU)	Officially designated in 2009 as part of early urban renewal efforts (Hin & Xin, 2011)
Shift in Renewal Strategy	In response to resident concerns, a more integrated rehabilitation approach was adopted in 2016, focusing on infrastructure upgrades while preserving community identity (Hin & Xin, 2011)
Community Function	Provided affordable housing and diverse commercial services such as family-run shops, restaurants, and small businesses (O'Donnell, 2021)
Economic and Geographic Role	Due to its proximity to high-end urban infrastructure, Gangxia served as an accessible space for workers and businesses priced out of other parts of Shenzhen (O'Donnell, 2021)
Social Structure	- Original residents: property owners relying on rental income - Migrant workers: attracted by low rents, working in low-income sectors- Shop owners: operating small-scale businesses - Renters: short- or long-term tenants (He et al., 2010)
Social Relations and Power Dynamics	- Economically interdependent groups - Original residents hold the most decision-making power, especially in redevelopment matters - Migrants and shop owners are vulnerable to displacement and lack formal representation (He et al., 2010)
Challenges in Redevelopment	- Issues of safety, sanitation, and unregulated development - Tensions due to unequal influence in redevelopment decisions - Balancing renewal with community preservation (Hin & Xin, 2011; He et al., 2010)

3.2 Interview Design

The study provides insights into the willingness, needs and barriers of different stakeholders to use digital participation platforms in urban regeneration, and therefore semi-structured interviews were conducted in Gangxia Village, Shenzhen, with three key groups: migrant tenants (n=15), local landlords (n=15), and government officials (n=10), for a total of 40 interviewees. In order to guarantee representativeness while accounting for the viability of research resources, the sample size was determined using Creswell's (2013) guidelines for qualitative research in case studies. Purposive and snowball sampling techniques were used to recruit participants in order to guarantee diversity in terms of age, gender, occupation, and degree of digital literacy. Interviews were conducted mainly face-to-face, with some interviewees being interviewed by telephone or video, and each interview lasted approximately 30 minutes, and was recorded with the written or verbal informed consent of the interviewees and with strict protection of their privacy.

A number of central themes guided the interview outline, such as respondents' perceptions of the usefulness and usability of digital platforms, their experiences participating in communities at the moment, potential obstacles (such as the digital divide, a lack of trust, and power asymmetry), and their expectations for future digital participation tools. The questions were customised according to the respondents' identities to better reflect their specific roles and concerns: migrant tenants' questions focused on the living environment, the use of digital devices, and motivation to participate; landlords focused on policy attitudes and acceptability of the platform; and government officials focused on the difficulties of policy implementation, cross-sectoral collaboration, and the role of technological tools in governance. The design of the questions follows a logical sequence from individual experience to attitude expression, and from problem recognition to policy recommendations.

The interview data were transcribed and processed using thematic analysis, with open coding to extract core information units, and then axial coding to summarise key themes such as 'digital trust', 'data accessibility', 'motivation to participate', 'perception of fairness', and so on. The main themes such as 'digital trust', 'accessibility', 'participation fatigue' and 'perception of fairness' were then summarised through axial coding. The qualitative interview findings from the study were not only used to understand user perspectives, but also directly guided the design of the subsequent digital platform system. For example, the multi-role interface, gamified feedback mechanism, and low-threshold interactive features in the platform were all tailored based on the interview findings. Thus, the interview design not only serves as an information-gathering tool, but also lays the empirical foundation for the socio-technical system architecture of this study.

4. System design

4.1 Functional & Non-Functional Requirements Analysis

To ensure the effectiveness and inclusivity of the gamified digital platform proposed for participatory urban renewal in Gangxia Village, a detailed requirement analysis was conducted. This analysis distinguishes between functional and non-functional requirements to structure the system architecture in a way that responds to the socio-technical complexities identified in prior sections.

Drawing upon the structured interviews with migrant workers, landlords, and local officials, as well as a contextual understanding of the digital divide, power asymmetries, and participatory inertia in informal settlements, the platform must not only provide basic participation functionalities but also address user diversity, trust-building, feedback responsiveness, and long-term behavioral engagement. Therefore, the requirements are rooted in both empirical insights and participatory design principles, ensuring the platform serves as a meaningful vehicle for deliberative engagement and not a mere symbolic interface.

Functionally, the platform must support multi-role user interaction, reward-based engagement, and real-time feedback loops, as these features have been identified as central to enhancing motivation, mitigating decision-making asymmetries, and reinforcing transparency. Non-functional requirements such as accessibility, scalability, adaptability, and usability are equally critical, particularly in contexts characterized by low digital literacy, infrastructural limitations, and cultural heterogeneity.

The following table summarizes the identified requirements:

Table 2. Functional & Non-Functional Requirements

Requirement Type	ID	Description	Justification
Functional Requirements	F1	Multi-role account system: Supports differentiated user roles (migrants, landlords, officials)	Reflects socio-political heterogeneity and supports role-specific interaction paths.
	F2	Gamified feedback mechanism: Real-time scoring, reward tiers, and progress tracking	Enhances user motivation, reduces participation fatigue, and addresses power asymmetry by creating transparent recognition mechanisms.
	F3	Issue reporting and suggestion module: Allows submission of community concerns and renovation suggestions	Enables bottom-up expression of needs, aligned with participatory design objectives.
	F4	Real-time feedback from authorities: Government can respond to suggestions and report renovation progress	Builds trust and accountability through bidirectional communication.
	F5	Community voting and prioritization feature	Facilitates deliberative democracy and helps identify consensus-driven priorities.
	F6	Mobile-friendly interface with intuitive navigation	Addresses digital literacy gaps prevalent in urban village populations.
Non-Functional Requirements	N1	Accessibility across devices and OS platforms	Maximizes reach and ensures usability for users with different technical resources.
	N2	Scalability to other urban villages	Ensures long-term replicability and cross-context adaptation.
	N3	Data privacy and consent safeguards	Addresses concerns over surveillance and fosters digital trust among vulnerable populations.
	N4	High usability and low learning curve	Critical for older residents and digitally marginalized groups; reduces entry barriers.
	N5	Cultural localization: Multilingual options and culturally resonant visual design	Enhances inclusivity and emotional engagement by tailoring the interface to diverse user demographics.
	N6	Offline data caching and low-bandwidth compatibility	Enables reliable use in low-connectivity environments, which is essential in underdeveloped or congested urban infrastructures.

4.2 System Working Flow

The designed system workflow captures the full process of participatory engagement facilitated by a gamified digital platform in the context of Gangxia Urban Village. The system is intentionally structured to accommodate a diverse user base—including migrant workers, landlords, and residents—and to promote their sustained involvement in urban renewal processes through meaningful feedback loops and incentive mechanisms.

The workflow begins when users identify a potential urban issue within their local environment. Utilizing a mobile device or terminal, they request location information via integrated GPS services or mapping APIs (e.g., Google Maps or open-source platforms). Once the digital map of the target area is retrieved, users are prompted to pinpoint the location of the problem.

If the issue can be effectively geolocated, the system activates a problem description interface, where users may provide textual input, visual evidence, and perceived urgency levels. This input is then analyzed by the backend system using a hybrid model combining rule-based filters and AI-driven semantic clustering to determine the problem's significance and validity.

A novel feature of this platform is its gamified reward system. When the system confirms that the submitted issue is valid and relevant to ongoing urban renewal efforts, the social group responsible for reporting it (e.g., a specific user or user type) receives quantifiable rewards—typically in the form of digital points or merits. These rewards not only contribute to a leaderboard system but are also symbolically visualized in the digital twin environment, where the user's virtual avatar and contribution record are permanently stored. This mechanism fosters long-term engagement, enhances user identity within the community, and transforms digital participation into an emotionally and socially rewarding experience.

In parallel, the issue is routed to government stakeholders through a secure firewall-protected channel, where it is reviewed and incorporated into the digital twin simulation of the target area. IoT sensor data, where available, is utilized to validate and cross-reference the reported issue, further enhancing system accuracy.

Finally, feedback is delivered back to the original user through the platform, including status, timeline for resolution, or requests for additional information. The feedback loop reinforces accountability and provides a clear indication that citizen input translates into visible action. The entire process is visualized in Figure 1, highlighting multi-directional information flows and the integration of reward-driven participation within a socio-technical system for equitable urban governance.

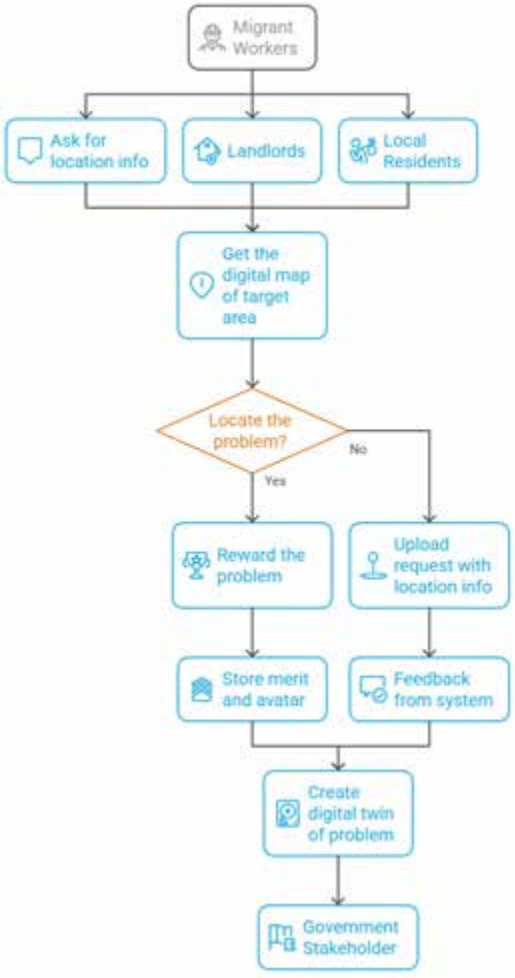

Figure 1. Working Flow of Gamified Urban Issue Reporting System

5. Discussion

This study explores the feasibility of implementing a gamified digital participation platform and its impacts in the urban village of Gangxia, Shenzhen by combining insights from three stakeholder interviews with system design requirements. The findings reveal the complex interplay between digital inclusiveness, power asymmetry, and willingness to participate in informal area renewal contexts.

5.1 Acceptance and expectations vary between stakeholder groups

Semi-structured interviews revealed different expectations and concerns between the three stakeholder groups. Mobile tenants, while expressing dissatisfaction with living conditions, showed cautious optimism about digital platforms, especially when defining them as simple, reward-based systems. Their main concerns include technological unfamiliarity, privacy protection, and scepticism about government responsiveness - issues echoed in the wider literature on digital marginality (Muller, 2017; Stern et al., 2020). In contrast, landlords emphasise property rights protection and are concerned that digital engagement may be detrimental to their financial interests. However, some landlords expressed interest in digital tools for tracking policy updates and accessing curated landlord-only content. Government officials recognise the potential of digital platforms to streamline feedback collection and increase transparency, but also express concerns about disinformation, opinion overload, and the administrative capacity of digital engagement.

These different perspectives reinforce the need for differentiated design logic and adaptive interfaces, and validate the platform's multi-actor architecture and customisable user experience features. The use of gamification - particularly point-based rewards and visual presentation of contributions - was found to be a cross-group motivator, especially when designed to recognise opinions without undermining authority or triggering economic anxiety.

5.2 Digital divide and power asymmetry

The interviews demonstrated that digital participation in urban villages is not just a matter of tool availability, but is deeply affected by structural inequalities, the digital divide and asymmetries of institutional power. Mobile tenants often lack digital literacy and political voice, resulting in 'physical presence and political absence' (Kochan 2009). At the same time, landlords and officials have easier access to digital and institutional capital. These dynamics are in line with Arnstein's (1969) critique of symbolic participation, which tends to be more symbolic than substantive. The platform is designed with a low-threshold interface, localised language support, offline data caching, and tiered participation features that identify different user capabilities. In addition, gamification mechanisms not only act as incentives, but also provide partial balance to otherwise excluded voices by providing visibility and recognition. However, gamification alone cannot address deeper systemic inequalities, suggesting the need for parallel offline empowerment and institutional reform.

6. Conclusion

This study explores the potential of a gamified digital engagement platform to enhance stakeholder participation in the urban regeneration process of urban villages in Gangxia, Shenzhen. By incorporating semi-structured interviews with stakeholder groups (migrant workers, local landlords, and government officials) into the platform design process, the study designed a contextual system to address technical, social, and institutional barriers common to informal regional settings.

The findings emphasise the capacities, motivations and concerns of different stakeholders. Migrant workers expressed a willingness to participate when the platform was easy to access, trustworthy and practically achievable. For landlords seeking mechanisms that both protect property rights and keep them informed, government officials also acknowledged that such platforms can help improve governance efficiency, despite concerns about inaccurate information and the complexity of data processing. These diverse needs have directly shaped the functionality of the platforms, including multi-role account architectures, gamified feedback systems and adaptive user interfaces.

The research confirms that digital participation is not just a technological intervention, but a socio-political process. The digital divide, unequal access to institutional power and participation fatigue remain structural challenges that cannot be solved by interface design alone e.g. UI, UX. Thus by embedding transparency, recognition and feedback mechanisms, digital platforms can create inclusive digital opportunities while potentially reforming traditional pathways of community governance.

The contribution of this study lies in its empirical foundation, participatory methodology and the application of digital design thinking to complex urban governance issues. This study advances the discussion on digital participatory design (DPD) by demonstrating how gamification can be a strategic tool under the construction of fine contexts that not only enhances participation, but also balances different stakeholders in urban spaces.

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Appendix A

Stakeholders	English Question
Migrant Workers	How long have you lived in Gangxia? Are you satisfied with your current living environment? What aspects would you like to improve?
	Have you ever participated in community affairs? If not, why?
	Do you use mobile phones or apps like WeChat? Do you find them easy to use?
	If a platform allowed you to share suggestions on community improvement, would you use it? Why or why not?
	Would you be concerned about privacy or your opinions being ignored on a digital platform?
	Would earning points or rewards motivate you to participate more actively?
	How do you think the government should listen to the voices of people like you?

Stakeholders	English Question
Local Landlords	What's your view on the current urban renewal policy? Have you participated in related discussions?
	Would you use a digital platform to track progress or express your opinions?
	Do you worry that information on the platform might affect your rental income or property rights?
	Do you think different groups are treated fairly during urban renewal?
	What are the most important issues that need coordination between landlords and tenants?
Government Officials	How does the government currently collect public opinions? Are there challenges in the feedback process?
	Are you concerned about public backlash or irrational comments on the platform? How can these be managed?
	In what ways do you think digital platforms can enhance policy transparency?
	What key features should an ideal digital participation platform include?

Using Social Media Big Data and ChatGPT for Identifying Counter-urbanisation Hot Spots in China

Jian Chen, Guy Garrod & Menelaos Gkartzios

Abstract
While urban areas remain home to most of the global population, the countryside is increasingly becoming a preferred place of residence, even in some developing nations such as China. Potential benefits and challenges for rural development posed by this counter-urbanisation trend make it essential to monitor its extend and progression. However, in China, statistical data on this phenomenon remains scarce due to the restrictions on rural property ownership by outsiders, who mostly rent properties from individual rural residents, leaving no formal record. This research uses the data from the Chinese social media platform, XiaoHongShu (or RedNote, a platform similar to Instagram), where specific users share their experience renting houses in rural areas or moving back to home villages. A web crawler was developed to collect all these 'big data', which was subsequently cleaned and processed by ChatGPT AI model. To ensure credibility, partial human validation was also applied to AI-generated results. Despite certain limitations, the findings provide original insights into the counterurbanisation trend in China, highlighting its widespread occurrence and identifying several hot spot areas. This study demonstrates that combining social media big data with AI processing offers an effective and timely way to identify human migration flows between urban and rural areas, enabling valuable reference for policymakers and the real estate sector.

Keywords: Big data; ChatGPT; Counterurbanisation; Rural; China

1 Introduction

The countryside has become the preferred place of residence for an increasing number of people, although the majority of the world's population still generally dwell in urban areas. Whereas this phenomenon of rural inflows, termed as counterurbanisation (Berry, 1976), was initially perceived as a form of 'population redistribution' or rural 'population renaissance' (Fielding, 1982) in the early stages during the 1970s and 1980s, emerging research has presented that counterurbanisation carries diverse economic, social and environmental potentials to support local development in both developed and developing countries.

However, in developing countries like China, the lack of relevant statistical migration dataset makes it difficult to monitor and access the extend and progress of counterurbanisation trend, although a growing number of case studies with a focus of rural tourism and rural entrepreneurship has add up nuanced knowledge to enlarge the global counterurbanisation story. This research explored the possibility to use massive social media data source and efficient AI-based data processing methods to generate an overview of the counterurbanisation progress in China.

This paper begins by introducing relevant concept and theories of counterurbanisation, followed by a synthesis of Chinese scholars' perspectives, including dominant understanding, ongoing debate, and methodological approaches. It then examined the challenges associated with using social media data source and AI-based methods in existing literature. Subsequently, this paper outlines the ethic considerations, data source and its limitation, and technical aspects of research methodology, covering data acquisition, data cleaning, AI-based data processing, case mapping, and thematical analysis. The results are presented in two parts: geographic distribution maps of identified counterurbanisation cases and narrative insights into general counterurbanisation patterns and specific cases. Finally, the discussion addresses new findings and their alignment with existing literature, as well as the advantages and limitations of the methodology applied in this study.

2 Literature review

2.1 Counterurbanisation

2.1.1 What is counter-urbanisation?

In the 1970s, attention was drawn to anomalous – at least for the then data – population growth in non-metropolitan America as a result of downward migration by Beale (1975) and this phenomenon was subsequently studied and popularised by Berry (1976) who coined it as 'counterurbanisation'. Robert and Randolph (1983) indicate that counterurbanisation has a clear division between extended suburbanisation and is comprised of both population growth in the hinterland of 'a metropolitan area's "daily urban system"' and movement beyond that system.

The literature has created various taxonomies of different counterurbanisation types based on the location of counterurbanisation and the different motives associated with it. For example, Mitchell (2004) proposed three sub-forms of counterurbanisation: ex-urbanisation (the commuter); anti-urbanisation (those who want to escape from cities); and displaced-urbanisation (households forced to move due to 'new employment, lower costs of living and/or available housing'). Today counterurbanisation is also commonly discussed in the global south and emerging economy contexts (Gkartzios and Halfacree, 2023). The breadth and richness of counterurbanisation research have extended to involve a diverse group of rural newcomers and returnees, to cover various rural areas, and to generate different context-specific experiences of migration worldwide (ibid., 2023).

2.1.2 Rural Incomers

The inflow of rural populations resulting from internal or international movement is commonly observed to follow two directions: primarily downward within urban hierarchies (from urban to rural areas) and, to a lesser extent, lateral migration between different rural areas (Stockdale, 2016).

However, there is no very clear distinction in the types or characteristics of newcomers between accessible and remote rural areas based on the literature review in Table 1, although this may vary geographically and in terms of quantity.

Table 1 Types and characteristics of newcomers in both accessible and remote rural areas

Factors	Accessible rural areas	Remote rural areas
Employment	well-educated (Herslund, 2012) /professional (Burchardt, 2012) /creative class (Herslund, 2012) /artists (Yang and Xu, 2022) /remote working (LiuBai and Ravenscroft, 2023) /entrepreneur (Bosworth, 2010) /retired people (Gallent, 2014)	well-educated (Löffler and Steinicke, 2006) / ~~professional/ creative class/ artists/remote working~~ /entrepreneur/seasonal proprietors (Shannon and Mitchell, 2020) /retired people (Winkler, 2013)
Income	Wealthy/affluent (Burchardt, 2012) / high-and-middle income (YuWang and Li, 2024)	Wealthy/affluent (Löffler and Steinicke, 2006) /~~high-and-middle income~~
Age	young families with children (Herslund, 2012) /retired people (Gallent, 2014)	young families with children (Zollet and Qu, 2024) /retired people (Winkler, 2013)
Motives	returnees (ChenZhang and Wang, 2022) /second-home owner (Gallent, 2014) /tourist (ChenZhang and Wang, 2022)	Returnees (Ji, 2024) /second-home owner (Winkler, 2013) /tourist (Winkler, 2013)/

2.1.3 Factors and Motivations

Generally, rural inflows are driven by two causes of interactions: individuals' will to move to rural areas (personal factors), and the facilitation or permission to do so (macro factors). Despite a little dated, these two causes can also be interpreted as 'desirable' and 'feasible' factors by Beale (1975), or 'motivational' and 'environmental' aspects by Champion (1998). Migration behaviours is typically a combination of macro factors and personal motivations, though the balance between these varies from case to case. The distinction is intended for descriptive purpose only, as these factors often overlap and cannot be clearly separated.

Gkartzios (2013) concluded that 'early research centred around a dualism between economic (or job-led) and quality of life (or people-led) considerations of the migrants involved'. But currently, counterurbanisation has globally become a much more story-based narrative of different experiences and representatives (ibid., 2013).

2.1.3.1 Macro factors

In terms of liveability, the advantages of urban life have been diminished by massing populations (Beale, 1975) and recent or ongoing challenges including covid-19 pandemic and climate crisis (ScottGkartzios and Halfacree, 2024), Whilst the countryside has undergone modernisation and can offer access to more natural and green spaces, safer neighbourhood. And the enhanced mobility and its enabling development, in other words, 'easy transportation and communication' (Beale, 1975) or 'freedom to move' (Berry, 1976), 'wider spread of services and the changing distribution of employment' (Champion, 1998) or 'ruralisation of employment' (Frost and Spence, 1984), further facilitate rural in-migration. Besides, general societal changes, such as increased overall affluence and aging populations (Beale, 1975), have led to the accumulation of individual rural inflows as a demographic trend later accepted as counterurbanisation.

2.1.3.2 Personal motivations

Rural newcomers can have very diverse and personal motives for moving in, which are usually grouped under headings such as employment, housing, neighbourhood, proximity to families/partners/friends or services, preference for living pace or the environment (Halfacree, 1994, Champion, 1998). Each category encompasses considerable variability among individuals and locations.

2.1.4 Implications

In the early stages during the 1970s and 1980s, counterurbanisation was initially only perceived as a form of 'population redistribution' (Robert and Randolph, 1983) or rural 'population renaissance' (Fielding, 1982).

Emerging research has presented that counterurbanisation carries diverse economic, social and environmental potentials to support rural development and local communities. Rural incomers may bring or bridge new investments, create jobs, demonstrate business running and disseminate new commercial concepts. They help maintain the village as a human settlement and 'provide new hope' for locals (LiuBai and Ravenscroft, 2023), '"bridge" social capital' – exchange of skills, knowledge and resources – to the 'closed' or 'more limited' rural network 'to solve collective problems and improve or maintain the wellbeing of that community' (Gallent, 2014). Besides, newcomers tend to introduce organic agriculture or businesses, engage in green volunteer work, and advocate for environmentally friendly construction practices (LiuBai and Ravenscroft, 2023).

However, positive contributions associated with counterurbanisation can remain limited and many issues also have arisen in the literature. Economically, it varies in specific business types and places whether these in-migrant proprietors will create extra or attractive jobs for rural locals and contribute to the 'local' market rather than outside market (Pristed Nielsen, 2022, LiuBai and Ravenscroft, 2023). Incomers may even take away the job opportunities (Yan et al., 2023) or business customers (LiuBai and Ravenscroft, 2023) from locals because of the inequality of marketing knowledge and networks. Socially, the countryside can be reconfigured as alternative settlements, taking into account the fact that amenity and lifestyle inflows are the mainstream of counterurbanisation, which has reportedly led to the loss of some residential services (Clout, 1986, Stabler, 1987, Herslund, 2012), housing affordability and social exclusion issues, and gentrification and displacement problems (Phillips et al., 2021).

2.2 Counterurbanisation in China

2.2.1 The progress of counterurbanisation in China and related debate

Two decades after the introduction of counterurbanisation in the English literature, Chinese researchers like Zhang (1987) started to introduce relevant theory and international cases from developed economies into China concerning the US, the UK, some western European countries and Japan. Drawing on aggregate demographic data Kong and Liu (2011) reported that counterurbanisation happens after the urbanisation rate reaching 70%, while in China it was 51% in 2011 and increased to 70% by 2021.

However, there has been debate about what kinds of rural incomers can be identified as counterurbanisers, or whether China has been experiencing a counterurbanisation process. Some Chinese scholars such as Cai and Zhou (2014) regarded working-class rural returnees who constituted the dominant rural inflows during periods of economic crisis as counterurbanisers. But, Liu and Li (2017) argued that these crisis rural returnees in China

cannot be treated as counterurbaniser but stakeholders who are just 'unable' to urbanise rather than those who are 'unwilling' to migrate to cities (Xue and Zhang, 2017). Similarly, Wu (2020) also found that Chinese governments historically promoted young people moving to rural areas during periods of economic depression and high urban unemployment rate. And this promotion always failed to meet government expectations, as evident by the subsequent return of these rural incomers to urban areas.

Duan (2015) highlights that urban out-migration was closer to sub-urbanisation rather than counter-urbanisation. These rural inflows and outflows in China were just a dynamic process of migration distinct from the counterurbanisation in western countries, which occurs in the premise of relative balance between urban and rural infrastructure and public service provision (ibid., 2015). But most Chinese rural areas were significantly underdeveloped then.

Beyond western counterurbanisation paradigms, Chen (2020) emphasises the profound cultural foundation in China that historically motivated Chinese educated gentry moving to rural areas whether for retirement or pastoral seclusion. This Chinese traditional cultural foundation can be associated with the new term, 'imagined rurality', that Yang and Xu (2022) employ to frame Chinese gentrification phenomena or British 'rural idyll'. Also, it parallels the western notion of anti-urbanisation involving those who want to escape from cities (Mitchell, 2004).

Besides, Li (2017) offers a nuanced interpretation, acknowledging that while the migration patterns in China have not yet to exhibit full-scale counterurbanisation, related phenomena are emerging in diverse forms—including an increasing number of rural amenity consumers and diverse rural returnees, such as rural tourists, outside retirees, tenants from cities, and returning entrepreneurs—across multiple regions.

The challenge in measuring counterurbanisation in China lies not in mapping western models directly but in exploring its unique and emerging forms through a bottom-up approach. This involves examining everyday practices, imaginations and representations in relation to rural in-migration.

2.2.2 General methods to investigate counterurbanisation in China

Regardless of the debate around the understanding of counterurbanisation by Chinese scholars, the methods they adopted mainly include case studies and qualitative interviews, or statistical analysis, quantitative questionnaire sampling, and Roxy model indexing.

Specifically, case studies and qualitative interview methods tend to focus on analysing individual motivations for rural incomers, their local life and social network development, and implications of counterurbanisation. Typical cases in literature include middle-class inflows in Dali, Yunnan Province, China (Zhang, 2018), entrepreneur in-migrations (tourism entrepreneurs in Yiwu (Wang, 2022) and Hangzhou (Zhou, 2024), Zhejiang Province, China, agricultural entrepreneurs in Yaoan, Yunnan Province, China (Wei, 2022)), seasonal second-home flows traveling more than 600 kms between Lichuan and Wuhan, Hubei Province, China (Xu and Xu, 2023).

Quantitative methods based on secondary data generally are applied to monitor the extend of counterurbanisation trend in certain geographical regions with discussions around its causes. For example, Wang (2024) sampled 312 villages in Guangdong Province, China, and sent questionnaires to local village councils or town governments investigating whether there were rural incomers. Fan (2022) used agricultural census data to analyse the population changes in 3, 772 villages in Beijing, China. Several researchers applied statistical data to structure Roxy index model which is close to the deconcentration of population in cities (Tang and Xiao, 2017) to identify the 'counterurbanisation situation' in Beijing, Tianjin, Shanghai cities (Tang and Xiao, 2017), urban agglomerations alongside Yangtze River Basin (Zhang and Mei, 2020), or Yangtze River Delta (Chen, 2023).

2.3 Quantitative and qualitative research using AI-based methods

Researchers often face challenges when analysing collected data—whether quantitative or qualitative—via specialised software R, Stata, SPSS, Python or NVivo. These tools frequently demand expertise that extend beyond

'an individual's established skillsets and technical knowledge' (PrandnerWetzelhütter and Hese, 2025). Particularly, qualitative content analysis is 'notoriously time and labor intensive because of the work to detect, assess, and code a large amount of data' (Bijker et al., 2024), compared to usually well-structured quantitative data.

Scholars have been exploring how to use machine assisted methods, or more precisely Artificial Intelligence (AI), to reduce data analysis burden and accelerate the process. These methods evolve from machine learning, pre-trained/fine-tuned models, to large language models. However, it can raise two main questions (Morgan, 2023): a) whether AI methods can produce similar results without the demanding process by human; and b) whether the simplicity of using AI methods and time savings worth the effort. Generally, AI methods are more adapted in qualitative research and more deeply involved in qualitative data analysis. According to the search results in Scopus database with keywords 'AI + qualitative/quantitative research' on 28 April 2025, qualitative group outweigh quantitative set by 4292 versus 3432. And AI methods often are only applied to help with scripts, get help for visualisation in quantitative research (PrandnerWetzelhütter and Hese, 2025).

Large language models developed in the past few years, such as ChatGPT, are proved to be acceptably effective, efficient, and simple to apply in a variety of settings. It is argued that ChatGPT can 'create code, category and theme, cite directly from within the text, interpret data sets, and analyse the meaning at the core of the data sets' (ŞenŞen and Şahin, 2023), and 'performed better in developing an inductive coding scheme that emerged from the data than adapting an existing framework into an unconstrained coding scheme or coding directly into a structured matrix' (Bijker et al., 2024). Specifically, many social science researchers use ChatGPT chatbots to interactively code interviews, focus groups, social media posts and the like, either big or small data, which is 'quite easy to use and required very little effort' (Morgan, 2023). For example, Bijker et al. (2024) used the ChatGPT chatbots in ten different dialogues to analyse the same 537 forum posts data, and generate ten versions of responses. When comparing with the results from three human, the precision of ChatGPT results were evident to range from 66% to 88%, which is 'fairly reliable' (ibid., 2024).

However, using AI methods does not mean there is no need for any human work. Bijker et al. (2024) stated that AI generated results also require various postprocessing steps to clean the data and check whether responses are in line with the instructions. Regardless of how many argue for the reliability of AI methods, human validation remains essential—not only to build trust for the researchers themselves but also to ensure credibility for readers and broader audiences.

3 Methodology

3.1 Ethical considerations

The ethic concerns for using social media data and AI methods were considered (London School of Economics and Political Science, 2025) during the whole process of data collection, processing and reporting.

The data collected from the social media platform, XiaoHongShu (, includes posters' user name (all pseudonyms), profile URL, postdate and post IP (provinces – the first-level administrative division in China, if available), posts' title, content and hashtags, comments replied by the poster. The general location of their house (such as village name or city district), tenancy conditions, personal emotions, marriage status, employment status may be involved. This information may be considered as sensitive or private but technically, it is open data which originally is published to all the users on XiaoHongShu platform, and the original intention of these posters is to share this information to present a whole story to all the other users.

Following the anti-crawler restriction of XiaoHongShu platform, a two steps web crawler was developed based on python using Google Chrome to automatically explore the XiaoHongShu platform and save targeted data properly simulating human behaviours.

Subsequently, these data were cleaned and processed in Python using OpenAI API[1], which accesses the ChatGPT AI model. According to the OpenAI Data Usage Policy (OpenAI, 2023), data submitted through the API will not be used for training purposes but retained for 30 days to monitor potential abuse and misuse. Regarding concerns about bias, inaccuracy and misinformation, in the research, ChatGPT AI model was applied solely to extract targeted information, primarily through direct quotations in the original language (Chinese). And the accuracy of any directly quoted information in this paper were double checked.

Data reported in this paper will not be identifiable for original posters and the quotations either direct or indirect are also all anonymised or paraphrased to avoid this issue. Additionally, we took care to translate the quoted text from Chinese to English but we accept that some details and nuances may have been lost (LiuBai and Ravenscroft, 2023). Besides, location data-without any other identifiable information about the poster-will be converted into geographic coordinates using Gaode Map (a Chinese navigation service provider) API and visualised on national base map of China using ArcGIS Pro only to show the rough distribution of these rural incomers.

3.2 Data collection

3.2.1 Data source and limitations

The data for this present paper comes from one of the main Chinese social media platforms, XiaoHongShu (http://xiaohongshu.com) that translates to 'the small red notes'. Its function is similar to Instagram where 320 million[2] of the 1.4 billion Chinese share their daily lives. Many rural second home tenants and rural returnees make posts sharing their rural relocation experiences. Although the number of these posters is relatively small compared to the Chinese population and can only represent certain groups especially young generation, this data source still supplements the absence of official statistical data related to counterurbanisation in China and provide an insightful lens to explore the spread of this migration phenomenon. These bottom-up representations are intrinsically connected with Chinese culture and as such provide a fascinating dimension towards understanding China's counterurbanisation. As Halfacree (2008) argues, the 'more culturally imaginative dimensions of counterurbanisation also come through in the way the phenomenon is represented in popular telling of the counterurbanisation story' (p489-490).

In addition to being limited to specific user group, each social media post collected from XiaoHongShu platform may not contain all the targeted information. Consequently, the total number of valid cases varies across different thematic analysis.

3.2.2 Raw data collection: a web crawler

Following the anti-crawler restriction of XiaoHongShu website, a two steps web crawling strategy was developed based on python using Google Chrome to automatically explore the website properly simulating human behaviours and on 24 December 2024, recorded 668 counterurbanisation related posts covering 644 different posters. At step one, the web crawler searches by two sets of keywords in Chinese, which can be translated into 'rent in countryside/rural areas/villages' and 'return to countryside/rural areas/villages from cities'. Given the complexity of the term rural outside anglophone uses (GkartziosToishi and Woods, 2020), we have used five original Chinese keywords in total trying to include all related data considering the multi expressions of 'countryside' in Chinese. The four keywords, in group 'Rent in countryside/rural areas/villages', were searched in the order as shown in Table 2 and duplicated posts were excluded during web crawling. Post URL, title, poster username and poster profile URL were recorded. At step two, the web crawler browses recorded poster profile to open the targeted post recording its contents, hash tagged topics, comments replied by the author, postdate and post IP (if available), which is saved in spreadsheets like Table 3.

1 An API (Application Programming Interface) allows applications or code to send request to another service and receive data or results in return. In the case of web APIs, URL addresses typically serve as endpoints that specify where the requests should be directed. In this research, API services were used to automate batches of data processing tasks.

2 Data from https://www.sohu.com/a/842803232_121846117

Table 2 Relevant posts in XiaoHongShu website

Keywords (Translated)	Keywords (Original Chinese)	Posts with contents	Covering people	Posts with IP
Rent in countryside/rural areas/villages	农村租房住	203	188	129
	乡村租房住	111	109	74
	乡下租房住	85	83	59
	村里租房住	81	80	45
	*Sub total	480	460	307
Return from Cities	城里回村住	188	184	55
In Total		668	644	362

Table 3 examples of data obtained from XiaoHongShu website (incomplete, anonymised and rephrased)

				Author		Note			
Post ID	IP	Post date	Author	profile	Title	URL	Content	Comments_replied	Search keyword	Search_date
1	江苏	2024-11-28	*	*	去乡下租院子*	*	我们与乡村	[{'comments: 转租吗', 'a	农村租房住	2024-12-04 15:33:05.960802
2	北京	2024-10-26	*	*	别来村里租房	*	如果你在考	[{'comments: 今年搬进	农村租房住	2024-12-04 15:33:28.250602
3	上海	2024-12-04	*	*	*几百/月我找到了人	*	在*农村租里	[]	农村租房住	2024-12-04 15:33:39.380422
4	上海	2024-11-04	*	*	请问*房子 能满足这	*	#远离城市的	[{'comments: 这个房子	乡下租房住	2024-12-04 15:33:55.570771
5		2024-06-04	*	*	一个人住看月租100$	*	十八线城市	[{'comments: 生活太美	农村租房住	2024-12-04 15:34:18.481639
6		2024-06-10	*	*	签了10年的农村租房	*	大概4年前，	[{'comments: 那么好的	农村租房住	2024-12-04 15:38:57.035989
7		2024-08-16	*	*	想在农村租房子，没	*	*因为第一次	[{'comments: 租房装修	农村租房住	2024-12-04 15:39:22.496740
English Traslation										
1	Jiang	2024-11-28	*	*	rent in the countrysid	*	we and the v	[{'comments: subretting	rent in the countryside	2024-12-04 15:33:05.960802
2	Beijin	2024-10-26	*	*	Do not rent in the vill	*	if you're con	[{'comments: move in th	rent in the countryside	2024-12-04 15:33:28.250602
3	Shang	2024-12-04	*	*	several hundreds pcn	*	Rent in a villa	[]	rent in the countryside	2024-12-04 15:33:39.380422
4	Shang	2024-11-04	*	*	which kindd of house	*	keep away fr	[{'comments: still rent t	rent in the countryside	2024-12-04 15:33:55.570771
5		2024-06-04	*	*	live alone in an ¥100	*	a remote vill	[{'comments: wonderful	rent in the countryside	2024-12-04 15:34:18.481639
6		2024-06-10	*	*	10 years tenancy cont	*	4 years ago,	[{'comments: such as go	rent in the countryside	2024-12-04 15:38:57.035989
7		2024-08-16	*	*	want to rent in the co	*	first time ren	[{'comments: the protec	rent in the countryside	2024-12-04 15:39:22.496740

3.3 Data Process

3.3.1 Data clean and key information extraction: ChatGPT

3.3.1.1 Information extraction piloting

Five sets of information are established to be coded into 'Post Information', 'Poster Information', 'House Information (include house location)', 'Tenant or Returnee-Specific Information', 'Letting or Renting-Specific Information'.

10 posts covering various posts were picked to pilot the information extraction results by human and batch ChatGPT 40-mini-2024-07-18 model, showing an 87% average accuracy with no key information missing only some small mistakes (e.g. identify a 'landlord' as 'returnee') and different information grouping (e.g. save 'village description' in 'complaints').

3.3.1.2 ChatGPT prompts and batch

A clear prompt is expected to go with these posts to tell ChatGPT what task it is, steps to follow, and which information to extract and extraction requirements.

First it is suggested to ask ChatGPT to adopt a persona, such as

'You are an information extraction assistant. Follow the steps below to extract targeted information with delimiters '*' from social media posts provided. And structure the output as JSON[3] format.'

3 JSON (JavaScript Object Notation) is a lightweight, text-based format for storing and exchanging data. Results in JSON format are saved as Excel spreadsheets later through Python.

Second, considering the original language of the social media data is Chinese, it is better to require ChatGPT to use original language:

'Requirements for extraction: if there is targeted info, use original text from the post as detailed as possible and do not translate it into English.'

Third, after checking the relevance to counterurbanisation topic, ask ChatGPT to extract targeted info one by one using human language, such as:

House Information:
- House Location: Where is the house located?
- Refurbishment: (Options: refurbished, needed refurbishment, no need)
- .....

Once the prompt is established, it is very easy to use the codes provided on OpenAI platform to submit batch information extraction requests. Calling ChatGPT-4o-mini to batch the tasks in non-peak hours costs around one day for all returns and less than $0.01 for one request covering approximately at most 100 thousand words inputs and 25 thousand words outputs.

Table 4 ChatGPT batch input examples (anonymised, rephrased and translated by ChatGPT)

Post content go with the prompt	Post comments go with the prompt
Chinese Original ID: 26 title:*，租到600元山上的房子 post by* on 2024-09-10 in 广东 with content: 今年四月，我因公司裁员而离职，带着赔偿金开始了一段随心所欲的旅行，走访了多个城市。随着时间推移，我对大城市的喧嚣愈发感到厌倦。九月，我来到了这个被绿色环绕的小县城，租下了一间每月仅600元的山景房。每天清晨，拉开窗帘便能看到青翠的山峦，阳光洒满整个房间。房子前面是热闹的街道，后面则是宁静的乡村，真正实现了"出门在市井，归家入山林"的生活。日出日落之间，山色光影不断变化，我沉浸在风声、雨景、朝霞与晚霞之中。散步成了我最享受的日常。在这里，我的思绪慢了下来，曾在大城市中积累的焦虑逐渐被抚平。连续熬夜五个月的我，终于开始按时入睡。皮肤也肉眼可见地变得细腻白皙，痘痘消失了。从小我就有一个隐居的梦想。还记得高中时第一次读到"离群索居"这个词，内心便怦然心动。那时我特别喜欢李白的山水诗、王维的田园诗，常常在笔记本上抄写和背诵。我原以为要等到四五十岁退休后，才能实现山水田园的生活。没想到在30岁这一年，我就提前实现了这个梦想。真的感到非常幸福，也非常幸运。 #隐居 #山居生活 #躺平 #低成本 #失业 #裸辞 #租房 **Translation** ID: 26 title:30-year-old girl unemployed, moved into a 600 yuan mountain view room post by * on 2024-09-10 in Guangdong with content: After being dismissed by the company in April this year, took the compensation to open the roaming, to play a few cities. More and more tired of the big city, September came to this small county full of green, living in the 600 yuan mountain view room. Every morning when I woke up and pulled open the curtains is the green mountains, sunshine sprinkled all over the house. In front of the house is a lively street, behind the house is the countryside, really out of the downtown, home hermitage. Every day, you can see the green mountains from sunrise to sunset, in different light and shadow of each moment. Listening to the wind, watching the rain, watching the sunrise and chasing the sunset. Walking has become the most enjoyable thing in my daily life. Thinking just slowed down, and some of the anxious nerves from the big city were soothed. After 5 months of staying up late, I finally went to bed on time. My skin went from pore size to fine, yellowish black to fair, and acne disappeared as far as the eye could see. My childhood dream of seclusion was realized. I remember reading the word "seclusion" in high school, and my heart thumped like a deer in the headlights. At that time, I loved Li Bai's landscape poems and Wang Wei's idyllic poems, and I copied one after another in my notebook, and I memorized one after another. I thought I would have to retire in my forties or fifties before I could realize my idyllic landscape. I didn't expect to suddenly realize my dream of seclusion just in the year I turned 30. Really happy and lucky~ #seclusion #mountain life #lying flat #low cost #unemployment #naked resignation #rental housing	Chinese Original (incomplete) [('others: 对于隐居来说房租太贵，你这是短暂疗伤可以'， 'author: *农村等地更便宜，但我更看重交通便利和山景，这里最合适'), ('others: 白天睡觉会吵吗作息颠倒的夜猫子的疑问'， 'author: 有时外面施工，会有点吵'), ('others: 这是多大平米的房子？单人套房吗？有独立厨房卫浴吗？'， 'author: 三室三卫一厅，客厅有厨房区'), ('others: 这是*进入一点'， 'author: 是的，你很熟悉啊'), ('others: 感觉还不错，生活方便吗，购物买菜呢？这种山里要注意蚊虫吧'， 'author: 骑电瓶车十分钟买菜，外卖能送，附近也有饭店'), ('others: 大*风景就是美丽'， 'author: 如画中游'), ('others: 600一个月？'， 'author: 是的，是和朋友合租的一间房'), ('others: 这个价格是合租吗？','author: 是的')] **Translation** [('others: rent is too expensive for a hermitage, you're a short-term healing can', 'author: rent is cheaper in many places, such as the silver beach in *, 2,000 yuan can be rented for a year, or two or three thousand a year inside the countryside, but for me to be easily accessible, and to go out to the nature, and also need a mountain view, the house would be more than suitable'), (' others: daytime sleep will be noisy? work and rest reversal of the night owl's questions', 'author: sometimes there is construction outside, will be noisy'), ('others: this is how big square meters of the house? Is it a single room? Does it have a separate kitchen and bath?' , 'author: three rooms, three bathrooms and one living room, with a kitchen area in the living room'), ('others: This is the entrance to the * a little bit', 'author: Yes, you're familiar with it'), ('others: It feels pretty good, is it easy to live in, and do you shop for groceries? This kind of mountain should pay attention to mosquitoes, right?', 'author: Riding a battery car, ten or so minutes, shopping for groceries. The takeout can be there. There are also restaurants nearby.') , ('others: The scenery of Great Guangxi is just beautiful', 'author: Like swimming in a painting'), ('others: 600 a month?' , 'author: Yes, but it's a room, shared with a good friend') ('others: Is this price shared?') , 'author: Yes') , 'author: yes') ...]

Table 5 ChatGPT outputs example (anonymised)

Targeted info	Outputs (original)	Outputs (translated)
Post Info		
Post ID	26	26
created_time	2025-01-14 01:52:49	2025-01-14 01:52:49
model_used	gpt-4o-mini-2024-07-18	gpt-4o-mini-2024-07-18
Relevance	Yes	Yes
Post Location	广东	Guangdong

Targeted info	Outputs (original)	Outputs (translated)
Date of Post	2024-09-10	2024-09-10
Poster info		
Poster Type	Returnee	Returnee
Employment Status	Unemployed	Unemployed
Work	线上工作	work online
Commute	工作在线	work online
Marriage Status	single	single
Gender	Female	Female
House Info		
House Location	*	*
Village Description	这个满是绿色的小县城，房子前面是热闹的街道，房子后面就是乡村。	This small county full of green has lively streets in front of the houses and countryside behind them.
House Rental	600元	600 yuan
Contract Duration	/	/
House Size	/	/
Floors	1	1
Bedrooms	3	3
Bathrooms	3	3
Kitchen	有厨房区域	has kitchen
Living Rooms	1	1
Refurbishment and how	不需要	no need
Refurbishment Cost Facilities and accessibility	/ 附近有吃饭的店，骑电瓶车十几分钟可以买菜，外卖也可以送到。	/ There are eating establishments nearby, and you can buy groceries in ten minutes by electric bike, and take-out can be delivered.
Tenant or Returnee-Specific Information		
Date of Move-in	2024-09-01	2024-09-01
Length of Stay	1 month	1 month
Rental Contract Duration	/	/
People in the House	和好朋友合租	rent with friends
move in rural areas	越来越厌倦大城市，想实现隐居梦想。	Growing tired of the big city and wanting to realize the dream of seclusion.
move in this village and this house	因为环境优美，出门就是热闹和自然。	Because of the beautiful surroundings, the buzz and nature are right outside your door.
Satisfaction Level	Very good	Very good
Descriptions related to satisfaction	真的很幸福，很幸运。	really happy and lucky
Difficulties/Complaints	有时候外面有施工，会吵。	Sometimes there is construction outside and it can be noisy.
Letting or Renting-Specific Information		
Advertised/Expected Advantages	环境美丽，适合隐居，同时交通便利，出门方便。	The setting is beautiful for seclusion, while the transportation is convenient for getting out and about.

3.3.2 Data clean and selection

After processed by ChatGPT-4o-mini-2024-07-18 model, the 668 outputs still required cleaning for further analysis (Table 6), leaving 426 posts from 394 unique posters. The cleaning work based on the ChatGPT-generated outputs and manual filtering. Specific cleaning includes excluding posts not in China, posts not relevant to counterurbanisation, and updating other miscellaneous information such as location and poster types. The effort of updating unspecified or unclear house location aims to safeguard the credibility of further cases mapping in ArcGIS pro. Besides, 222 entries of rural incomers were extracted out, including 66 cases of rural returnees and 142 rural tenants. Posts from one same poster are merged using an Excel formula[4].

Table 6 Data cleaning and selection

Criteria	Method	Processed /posts	Remain /posts (668)
Not in China	Human (post IP) ChatGPT (content)	16 (excluded)	652
Not relevant	ChatGPT Human (occassionaly)	189 (excluded) 35 (excluded)	463 428
House location	Unspecified house location (e.g. '村子(a village)', '县城 (a county)', '老家 (hometown)' Unclear house location (e.g. only has town or village name)	175 (update)	428
Occasional corrections	Human (after ChatGPT): Blank poster type update (14) Poster type (8) Employment status (5)	27 (updated)	428
Rural incomers: tenants, tenants (subletting), returnees	Human (after ChatGPT): filtered by poster types merged posts by the same poster	66 (returnees) 142 (tenants) 28 (merged into 14)	208 (posters) 222 (posts)
Mapping rural incomers: tenants, tenants (subletting), returnees	Human (after ChatGPT): excluded posts without location information, categorised the precision of house location into three levels	58 (excluded) 26 (Province level) 74 (City level) 50 (Village level)	150 (posters)

3.4 Data Analysis

3.4.1 Mapping

To identify the counterurbanisation hot spots in China, Geocoding and ArcGIS Pro are applied to map the location of recorded rural incomers. Geocoding is the process of converting addresses or place names into geographic coordinates. Locations of rural incomers—such as accurate village names, or rough city/county/province names and nearby tourism attractions—were processed in Python[5] using GaoDe Map (or Amap, one of the main Chinese

4 Formula example: =TEXTJOIN(", ", TRUE, IF(A2:A100=A2, B2:B100, ""))

5 The script was published in https://gitee.com/sidchen0122/coordinates-convertor

navigation service providers) API. For imprecise locations, GaoDe Map will use the geographical coordinates of their administrative governments-usually located in the city centre-as replacement. For example, if the rough location is Shanghai, returned geographical coordinates will be the Shanghai City Government. Subsequently, all these coordinates were loaded into ArcGIS Pro to create XY points on the base map of the whole China. Since there were too many points overlapped in one same location, Kernel Density analysis[6] was conducted to provide a clearer view of the concentration of rural incomers (exclude very rough province level house locations).

3.4.2 Thematic analysis

Thematic analysis aims to construct a general narrative of counterurbanisation in China, focusing on the associated population groups, their characteristics, motivations and levels of post-move satisfaction. For each theme, Excel's filtering and statistic tools like PivotChart were used to extract and summarise relevant information. However, due to occasional inaccuracies in ChatGPT-generated outputs, researchers were required to manually correct certain text coding and revisit original social media posts.

4 Analysis results

4.1 Overview of counterurbanisation hot spots and general distribution

As shown in Figure 1, Figure 2, and Table 7, identified counterurbanisation migration in China has presented to be relatively widespread covering general South and East China, with a high concentration in the Yangtze River Delta region (Shanghai, Zhejiang, Jiangsu), Beijing, Chengdu (Sichuan) and Dali (Yunnan), and less concentrated around Guangzhou (Guangdong), Chongqing, and Changsha (Hunan). Apart from these metropolitan areas, there were also many counterurbanisation cases in Shandong Province and Guangxi Province (Table 1).

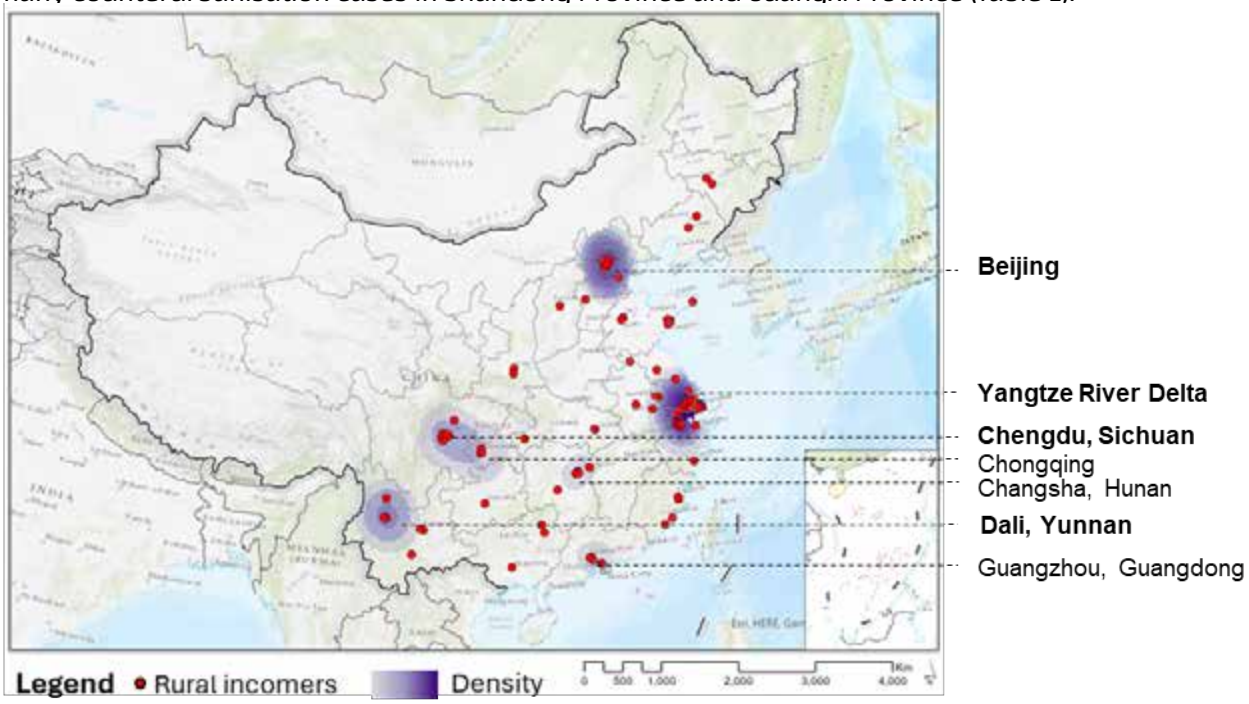


Figure 1 Distribution and Density of Rural Incomers
(Topographic basemap provided by ArcGIS Pro; boundary data obtained from China standard map service: http://bzdt.ch.mnr.gov.cn/)

6 '*Calculates a magnitude-per-unit area from point or polyline features using a kernel function to fit a smoothly tapered surface to each point or polyline.*' (https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/kernel-density.htm)

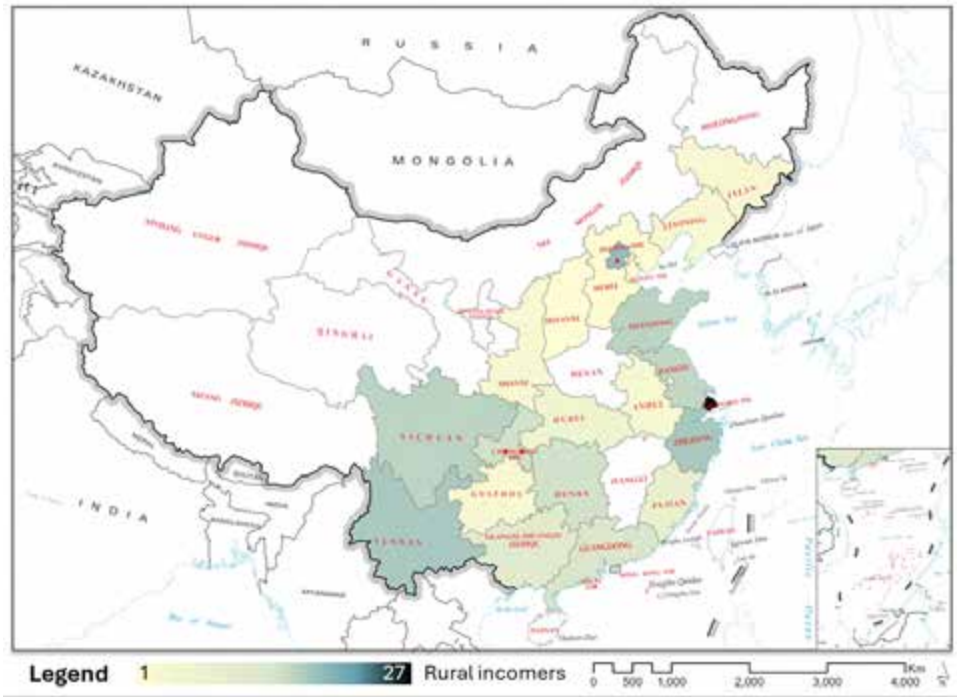


Figure 2 Distribution and Density of Rural Incomers by Province
(Basemap obtained from China standard map service: http://bzdt.ch.mnr.gov.cn/)

Table 7 Distribution of Rural Incomers by Province

Province & Region		Incomers	Province & Region	Incomers
Yangtze River Delta	Shanghai City	27	Fujian	4
	Zhejiang	14	Hubei	3
	Jiangsu	9	Anhui	2
Beijing City		22	Shaanxi	2
Yunnan		14	Liaoning	2
Shandong		10	Jilin	2
Sichuan		10	Guizhou	1
Chongqing City		7	Hebei	1
Hunan		7	Shanxi	1
Guangdong		6	Tianjin City	1
Guangxi		5	**Grand Total**	**150**

4.1.1 Identified counterurbanisation hot spots

Zooming in onto these hot spots, it is found that most counterurbanisation cases are in metropolitan areas (examples in Figure 3) with good transportation connections and natural resources enabling both urban and rural amenity consumption. This is a typical scenario for counterurbanisation—living within a 'daily urban system' (Robert and Randolph, 1983).

Figure 3 Counterurbanisation cases in selected hot spot areas
(Topographic basemap provided by ArcGIS Pro)

To be more precise (Figure 4), the distance from the village populated by rural incomers to nearby city centre usually are within 50 km requiring 1-1.5 hrs driving or bus, calculated through GaoDe Map navigation API based on 54 valid cases with precise village level location.

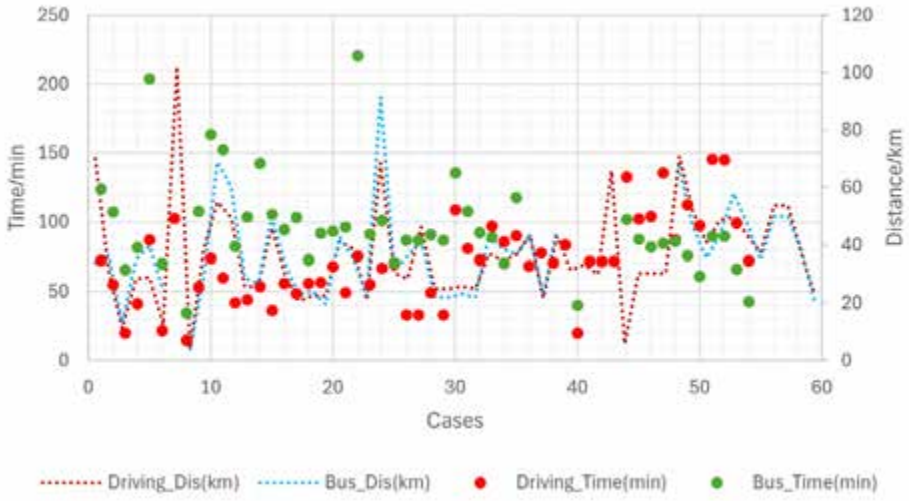


Figure 4 Navigation distance and time from recorded villages to city centre by car and bus
(Calculated using Gaode Map navigation API)

Most of these hot spots (Figure 1) have been documented in the literature (see, for example, section 2.3) with comparative fewer mentions of cases in Changsha City, Chongqing City, Shandong Province and Guangxi Province. Besides, existing literature mostly focuses on tourism-oriented villages, tourism or agriculture entrepreneurship incomers, gentrification phenomenon, or population deconcentration in metropolitan areas.

However, beyond these counterurbanisation narratives, there remain a number of cases within identified hot spots where stakeholders have relocated to the general countryside primarily for residential purpose. To provide a concrete illustration of identified residential counterurbanisation, three cases were selected from top hot spot areas (Table 8).

For Shanghai case (case ID:[7]: 41), the tenant rented a two-floor rural house living with children. There is a metro station in 10 minutes away by car and the tenant need around another 1.5 hrs commuting to work on metro. It was considered convenient to live in the village due to the accessibility of essential facilities and the availability of home delivery services. This individual expressed that 'the aspiration to live in Shanghai—as an outsider—is fulfilled by moving to the beautiful "socialist new countryside", where I have a yard, vegetable fields, and a small forest nearby'.

For Beijing case (case ID: 538), the tenant had lived in a small rural house with two bedrooms for two years and commuted to work by a 40-minute drive. This individual was very satisfied with the comfortable and convenient life there. One wonderful moment was 'enjoying sunshine at the yard, getting a cup of coffee, feeling the bleeze, listening to the birdcall or music, and petting the dog'.

For Chengdu case (case ID: 190), the tenant rented a whole rural house (about 1,000 m^2) in west Chengdu for 20 years when this individual will be 50 years old. The individual spent ¥280,000 on all refurbishment work. Adding up the average refurbishment expense to original rental, the monthly rent was ¥2500, which was five times cheaper than ¥1,2000 for a similar size property in the nearest cheapest urban district[8]. And the house was just rented for private living rather than commercial purposes.

The selected Shandong case (case ID: 216) is in the provincial capital city of Shandong, Jinan City. It is a little bit similar to Shanghai case in terms of location, although Jinan is far less developed, with a per capita GDP of around ¥55,000 in 2024—four times lower than Shanghai's ¥217,000. The tenant rented a rural house in the northeast of Jinan. There is a railway station and metro station (connecting to the airport) nearby. The rent was cheap, and the house included a yard and a vegetable field with clean and green neighbourhood and welcoming villagers. This individual said, 'I deeply regret not renting (a similar rural house) earlier'.

7 Case IDs are anonymised reference to individual social media posts in the dataset.

8 It is ¥12 per square metre per month in Shou'an County, Wenjiang District, Chengdu. Data from website: https://cd.bendibao.com/fangchan/2025418/196937.shtm

Table 8 Selected counterurbanisation cases in hot spot areas (Imagery basemap provided by ArcGIS Pro)

Case	Location	Village
Qingpu, Shanghai case		
Haidian, Beijing Case		
Wenjiang, Chengdu case		imprecise location
Jinan, Shandong case 216		

4.1.2 Widespread occurrence in East and South China

This research highlight the widespread occurrence of counterurbanisation in general East and South China. Both existing literature and identified hot spot areas in the previous section predominantly concerned with the most developed (Shanghai and Beijing) or well-known regions (Dali) in China. However, even based on the limited data source (Figure 1, Figure 2), evidence suggests that counterubanisation cases also occur in less developed areas in general South and East China (1-2 cases for each province as shown in Table 7). These cases, however, are also located near the provincial capital cities—typically most developed district in their respective regions—reflecting both the general improvement of societal wealth and emerging signs of the counterurbanisation tendance.

Once again, several residential counteruabnisation cases are illustrated below (Table 9) to enrich existing counter-

urbanisation story in China with newly observed scenarios.
For Changsha case (case ID: 225) in south-central China, the tenant decided to rent a rural mountain house for 20 years after coming across it when driving by. It is located 20 km away from the centre of Changsha city, approximately half an hour driving away. The refurbishment work was estimated at ¥200, 000 and monthly rental was ¥300. This individual said, 'at my youth, I felt exhausted and anxious about building a life. my dream was simple: have a house with a garden. Now, in middle age, I gathered courage to reconnect to the nature and to rest peacefully in that garden'.

For Liaoning case (case ID: 116) in the northeast of China, the tenant paid only ¥50 for a rural house with two bedrooms and vegetable fields in both the front and back yard. This individual spent summer there with families and moved back to urban home during winter because of the coldness. The biggest motivation for having a rural second home was to 'growing vegetables' and experience rural life.

For Xi'an Case (case ID: 199) in central China, the tenant rented a huge rural house in the south to Xi'an City, with 4 bedrooms and a large garden. It is 40min driving distance away from nearby city centre and 10min on motorcycle to nearest county centre. The commuting time to the city is similar—or even shorter—due to lighter traffic. This individual lived with families and parents, and was motivated by the concern about virus in cities, aiming to prevent the child from falling ill too often. This individual's one-and-a-half-year-old child and parents were very happy to live in a home with bigger space for daily activities. Besides, the house is very close to many nearby orchards and mountain valleys. The tenant felt very satisfied to live there, 'I find myself liking this place more with every passing day'.

Table 9 Selected residential counterurbanisation cases in South and East China (Imagery basemap provided by ArcGIS Pro)

Case	Location	Village
South-central China: Lianhua County, Changsha case		
Northeast China: Fushun, Liaoning case		imprecise location

Central China: Xi'an case		imprecise location

4.2 General counterurbanisation stories in China

Based on recorded social media posts, two main groups of rural incomers were identified: rural returnees (66 records), who moved back to home villages, and rural tenants (142 records), who rented houses in rural areas—although most rural tenants also originally came from the countryside. This distinction was made in consideration of differing challenges each group faces when integrating into village life, particularly in terms of land ownership and social bonding. However, these two groups were found to share many similarities regarding personal characteristics, migration motivations, post-move satisfactions—an unsurprising outcome, given that both involves transition from urban life to rural life. Nevertheless, quantitative comparisons were constrained due to the limited data source.

4.2.1 Personal characteristics

Recorded rural incomers consist of a variety of groups, including the employed, unemployed and retired (Table 10). Individuals who commute to work outside the village typically travel by electric motorcycles for 10 to 30 minutes, while a few drive cars for journey over 40 minutes. Self-employed tenants usually work from home or within the village, for example running business such as homestay or engaging in artistic work.

Table 10 Employment status of rural incomers

Poster type	Employed	Work Online	Self-employed	Unemployed	Retired	blank	Grand Total
Tenant	40	1	7	4	2	88	142
Returnee	10	0	5	2	2	47	66
Grand total	50	1	12	6	4	135	208

4.2.2 Migration motivations

There is no significant difference in migration motivations between rural returnees and rural tenants. Although it is generally easier for returnees moving back—since they already own a rural house and farmlands and are members of local communities—relocating to rural areas fundamentally reflects the shift of preferences from urban to rural life. Specifically, for example, the difference can be that rural returnees may have rural parents to visit or live with, whereas rural tenant may choose to rent a rural house because their parent who originally come from countryside struggle to adapt to urban life. Generally, their key motivations—often individually mixed—can be grouped under eight headings, acknowledging potential overlapping among them.

'Escaping' from cities and shift to (imagined) 'rural life'. Many rural incomers indicated that they were seeking refuge from the noisy, congestion and health risks of urban environment. Their relocation patterns varied; some moved temporarily, such as for a weekend, to get recovered from tiring work or life in cities; others relocate seasonally to enjoy more milder climate; and some opted for almost permanent settlement, exemplified by long-term tenancy agreements up to 20 years. From their perspectives, rural life is quiet, slow-paced, relaxing, simple, free ('ultimate freedom' for certain individuals), natural, and environmentally healthy with clean and well-oxygenated air. Incomers could more focus on their own life, even do pastoral seclusion, or start a 'new life after retirement'. A lot of incomers found it easier to have high quality sleep and fostered better work and rest routine

after moving to the countryside.

Farming and organic food. Engaging in Farming activities themselves was a major driven for some rural incomers. They enjoyed planting vegetables and flowers, raising livestock and pets. One returnee (case ID: 222) shared, 'I come to enjoy the feeling of the softening change in soil and the sweating process from physical work on fields'.

Cheaper living expense and bigger space. For some rural incomers, purchasing or renting spacious and nice house in a megacity is financially unfeasible, whereas similar properties are more affordable in accessible rural areas. Due to the lack of high-end commercial facilities in the rural hinterland, overall living expense can be significantly reduced.

Enjoying the process of refurbishment and making their own home. Many incomers took pleasure in refurbishing old rural houses and creating gardens, activities that provided them with 'a sense of achievement' (case ID: 157) or helped them 'fulfil their garden dreams' (case ID: 510). Some professional social media posters can even generate economic benefits by sharing their refurbishment experience.

Caring for household members, including children, parents, or pets. Some rural incomers relocated mainly because they want to take good care of their household members, for example, living with their elderly parents—a more specific situation in China culture, providing happy, free and safe grow-up environment for kids and pets. One tenant expressed that she rented a rural mountain house after retirement mainly for the safety for her 13 dogs (case ID: 161).

Proximity to workplace or entrepreneurship opportunities. With the diffusion of employment such as factories moving to more suburb areas, some workers chose to rent house in nearby villages. Besides, young civil servants were encouraged by China government to stay in a village for several years. Additionally, some people who prefer rural life move to scenic villages to find ways to support themselves financially and fulfil their personal needs. Nostalgic attachment. For some people who were born and grown in the countryside they may have one kind of nostalgic feeling about rural life, such as the garden of their childhood house. Even when renting a house in a different rural area closer to their workplace, these individuals may create similar garden spaces to evoke familiarity and a sense of security. As one tenant reflected, 'when I was a child born and grown in the countryside, living in my own rural house with fields, I dreamed of tall buildings. But after growing up, working in a high-rise and on busy street, I came to realise that what I truly long for is the garden from my childhood' (case ID: 238). In Chinese culture, there is a traditional term, ye luo gui gen, which translates to 'falling leaves settle on their roots'. One tenant interpreted this as, 'as long as you know where you are from, you will not be afraid of how far you go' (case ID: 632). In this case, many individuals invest in refurbishing and prepare their rural home for retirement life.

4.2.3 Moving in

The village populated by rural incomers often has good transportation linkages and natural resources, as noted in section 4.1.1, although the availability of specific amenities varies depending on their proximity to cities. Metropolitan rural areas generally can benefit from enhanced infrastructures, such as direct bus service or metro connection to city centre, accessible kindergartens and primary schools, and convenient links to major transportation hub like railway stations and airports. The village size can even reach 1,000 households (case ID: 18). While rural incomers in remoter countryside also find it convenient to use the facilities in nearby towns. However, there are some rural tenants relocate to extremely remote mountain villages—consisting of a few households and lacking basic public infrastructure—in pursuit of pastoral seclusion (case ID: 231). But what in common is that most local long-term residents in the villages are elder population.

Rural incomers include both families and singles (Table 11). And rural tenants either rented a whole house or just a flat with one bedroom, one kitchen and one toilet. The tenancy contract varied from several months or years to 10 or 20 years. Both tenants—typically holding leases of over ten years and renting entire houses—and most

returnees undertook significant refurbishment work before or after moving in. The most expensive refurbishment case among returnees is ¥880,000 (case ID: 614) covering all renovation work, furniture and appliance. In comparison, expenditure among tenant is ¥600,000 (case ID: 159) associated with a 15-year tenancy.

Table 11 Household members of rural incomers

	Families	Families with children	Alone	Blank	Grand total
Tenant	8	5	28	101	142
Returnee	3	1	7	54	66
Grand total	11	6	35	155	208

Regarding move-in dates, recorded instances of counterurbanisation migration (Figure 5) began in 2020 for both returnees (12 complete cases) and tenants (22 complete cases) with an increase in entries during 2023 and 2024.

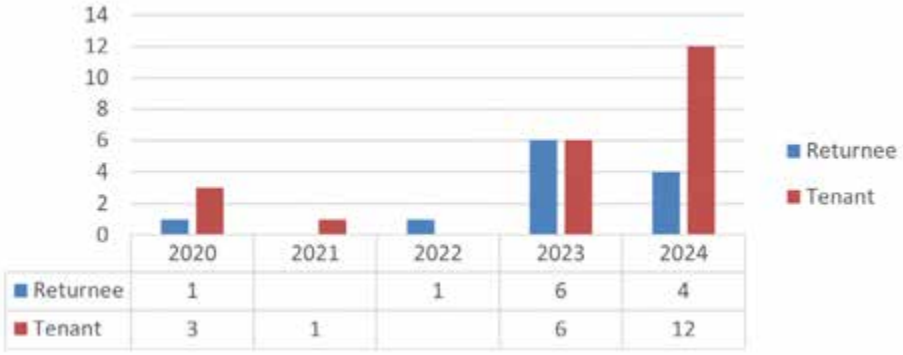


Figure 5 Recorded move-in dates of rural incomers

4.2.4 Post-move satisfaction

Generally, it shows a high level of satisfaction for rural incomers moving to or back to rural areas (Table 12), as identified by ChatGPT through the content analysis of social media posts.

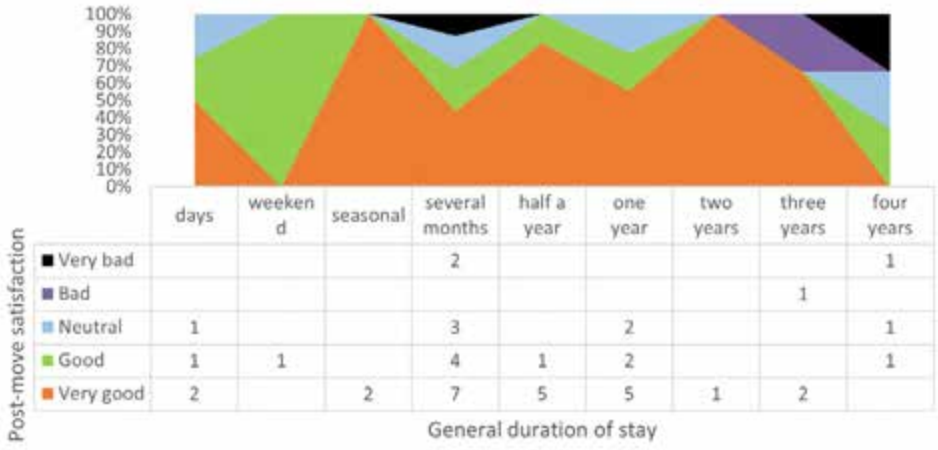
For example, one tenant (Case ID: 463) shared a rural house with others in Shanghai metropolitan area and had lived there for half a year. This individual enjoyed exploring nearby nature areas, such as foraging for edible wild herbs in spring. At times, they found it hardly to believe they were still within the boundary of Shanghai—despite the presence of a metro station near the village. This person even expressed, 'I truly feel like a human being in the countryside, rather than merely a tool used for work in the city centre'.

Table 12 Post-move satisfaction levels of rural incomers

	Very Good	Good	Neutral	Bad	Very Bad	blank	Grand total
Tenant	29	20	10	3	76	4	142
Returnee	16	5	5	1	/	39	66
Grand total	45	25	15	4	76	43	208

Based on 45 valid cases, the cross-analysis results (Figure 6) generally reveal a consistently high level of satisfaction, regardless of the duration of stay in countryside. But rural incomers with longer duration of stay often have a more discreet attitude towards relocating to the countryside, recognising the effort required to adapt and maintain rural life.

For example, one returnee (case ID: 575) worked online and had moved back for 4 years mainly for the children to have a happy childhood. This person did not feel regret but warned that 'no matter where you live, it requires efforts for better living environment'. This returnee spent two years refurbishing the property, primarily working alongside family members. The renovation work was relatively costly due to larger size of a rural house. Moreover, cultivating seasonal vegetables is not an easy work, as it requires both physical efforts and self-directed learning about planting techniques and storage methods.



	days	weekend	seasonal	several months	half a year	one year	two years	three years	four years
Very bad				2					1
Bad								1	
Neutral	1			3		2			1
Good	1	1		4	1	2			1
Very good	2		2	7	5	5	1	2	

Figure 6 Cross analysis of Post-move Satisfaction and General duration of stay

However, some incomers had expressed concerns that contrast with their 'imagined rurality'. These includes the safety concern for living alone in a village, displacement when the demolishment required by the government happens, bad landlord or uncomfortable feeling to live with the landlord, bad living and hygienic conditions, poor employment opportunity, bad public transportation, unfair service fee required by village council and the like.

For example, one tenant (case ID: 6) rented a rural house for 10 years to escape from the noisy in city centre when she was trying to have a baby. She became regret soon and realised that she did not enjoy the 'imagined' rural lifestyle—activities such as planting vegetables and flowers, picking fruits and playing in the river. And she found herself uncomfortable with the insects and frogs there. After her baby was born, she had less time to use the garden of the house and were more concern about the hygiene condition for her baby. She had lived there occasionally for four years and found herself in a dilemma: she no longer wished to return yet could not bear to leave the house behind that she had so carefully built.

5 Discussion

5.1 Findings compared with existing literature

Recorded counterurbanisation migration in China presented to be in its early stage. Different from patterns observed in some western countries, currently most rural incomers in China were concentrated in 'a metropolitan area's "daily urban system"' (Robert and Randolph, 1983)—typically refers to areas located around 50km away from city centre requiring 1-1.5 hrs of travel by car or bus based on this research—and very few cases were recorded in remote countryside. Although identified counterurbanisation cases were found in the most developed areas in China, this research highlights the broader presence of counterurbanisation across general south and east of China—revealing many instances that have not yet been reported in existing literature. Additionally, apart from typical family rural incomers, single tenants or rural house shares were also observed in various areas.

Current research on migration motivations of counterurbanisation in China emphasizes tourism related activities, potentially influenced by China's Rural Revitalization Scheme initiated in 2017. However, this study identifies

a significant number of cases involving rural returnees and tenants moving to the countryside for long-term residential purpose. Besides, individuals of rural origin are particularly inclined to invest in refurbishing their home rural houses preparing for retirement life. This tendency is shaped by the unique context of permanent yet unpurchasable rural land rights—covering both residential plots and farmland—as well as by culture norms of returning to one's hometown in old age. And the opportunity to cultivate vegetables on the land attached to the rural house has emerged as a major motivation for rural incomers. Similarly, rooted in anti-urbanisation sentiments, the concept of 'imagined rurality' is also the key factor motivating individuals moving to the rural hinterland. Although most incomers reported a high level of post-move satisfaction regardless of their duration of stay, some expressed regret or adopt a more cautious stance towards rural relocation.

5.2 Social media data source

Monitoring migration trends between urban and rural areas in China has been challenging due to the lack of formal migration records. The social media platform, XiaoHongShu, has proved to be a valuable data source supporting both geographic overview of counterurbanisation and specific rural relocation cases, despite its limitations—particularly data being restricted to certain groups of population and inconsistent sample size across thematic analysis, which complicate comparisons. As with other incomplete data sources such as case study, the primary guidance for using social media data in research is to acknowledge the presence of certain phenomenon—such as various counterurbanisation movement examined in this study—rather than making quantitative comparison between different groups or regions. For instance, while it is valid to conclude that residential counterurbanisation has emerged in certain parts of China, it would be inaccurate to claim that most reverse movement in China is driven by residential motives. In addition, most recorded cases are isolated and lack of interconnection, making it difficult to identify the broader implication of counterurbanisation in specific rural contexts. Detailed case studies and fieldwork are therefore essential for a more comprehensive understanding.

5.3 AI-based processing methods

As noted in section 2.3, the primary concerns for AI-based processing methods include result accuracy, ease of use, and time efficiency compared to manual processing.

Although ChatGPT-generated results demonstrated almost 90% accuracy during pilot testing, the remaining 10% inaccuracy posed challenges for researchers, creating an uncertainty about which part of the output is reliable and which are not. While this sense of uncertainty must be acknowledged, researchers had come to recognise that ChatGPT-generated outputs should not be treated as a settled final result, but rather provisional data that requires a little further validation and interpretation. For example, there are several occasions when the researcher had to revisit the original data to correct errors made by ChatGPT. Corrections often had implications for earlier stage of analysis. Nevertheless, this iterative process was ultimately deemed acceptable. Besides, since the original data in this research is in Chinese, ChatGPT's limited proficiency with Chinese language posed more challenges for accurate processing. AI models such as DeepSeek, which are primarily trained on Chinese data, are expected to yield higher accuracy over generated results. But technical issues with DeepSeek's batch API service in early 2025—when the model gained widespread popularity—prevent this hypothesis from being tested.

As for ease of use, AI tools like ChatGPT currently are evolving to offer more user-friendly experience and interfaces. Batch scripts usually will be provided and hardly require any prior knowledge for coding. Alternatively, these tools can function as a professional data processor, enabling users to input their requirements and receive interactive, tailored, outputs—potentially improve the accuracy of results.

The primary advantage of AI tool is its time efficiency. For example, in this study, coding each social media post required an average of 10 min. With around 650 original posts, this amounts to 6,500 min—or more than 100 hrs—of labour-intensive and tedious work, equivalent to nearly half a month of full-time effort base on an 8-hour workday. Errors are still likely to occur, although potentially at a lower frequency. By contrast, when using AI models, a single click can process entire dataset in under 10min. Despite the risk of inaccuracy, rough results can be considered acceptable within a certain fault tolerance threshold. Achieving higher accuracy just need several

days of data cleaning and refinement.

5.4 Counterurbanisation in China

Despite the limitation of available data, counterurbanisation in China is beginning to take shape, with a growing number of urban residents opting for rural lifestyle. Given the general underdeveloped and population decline in China's rural hinterland, this tendency of reverse migration presents a significant opportunity for future rural revitalisation. However, some levels of Chinese government still exhibit a bias against the countryside, preferring to concentrate the rural residents to facilitate more convenient infrastructure provision. For instance, one tenant (case ID: 33) expressed high satisfaction with the five months of rural life but was compelled to leave due to the government's planned demolition of the village. In addition, rural tenants often face the challenge of independently locating a suitable house and negotiating rental terns with landlords. Rural housing has the potential to be a new growth driver of the real estate industry. Even though China government may uphold current rural land rights system—which prohibits land purchases—in order to maintain the societal stability, there remains room for the formalisation of rural tenancy. Such reforms could help safeguard the rights of both tenants and landlords, thereby encouraging more people moving to depopulated villages and fostering mutual beneficial outcomes. Future research could focus on potential inequity issues—such as housing affordability, gentrification and displacement—that may arise as the counterurbanisation trend progresses in China. It is also important to develop an appropriate framework that both encourage rural in-migration and mitigates associate challenges.

6 Conclusion

Counterurbanisation is an inclusive and useful concept for understanding the reverse migration from cities to the countryside. When comparing the Chinese context with western patterns, Chinese scholars have debate on how to classify migration flows—whether as counterurbanisation or failed urbanisation. There is also discussion about how these flows relate to similar concepts such as suburbanisation, deconcentration.

Despite ongoing debates, this research identified a significant number of rural incomers using social media data from XiaoHongShu platform. These include both returnees moving back to their home village and tenants renting rural houses, mostly in metropolitan rural areas within 50km or 1-1.5 hrs of travel from a city centre. Overall, counterurbanisation in China exhibits a widespread occurrence in general South and East China with several hot spots in Yangtze River Delta region (Shanghai, Zhejiang, Jiangsu), Beijing, Chengdu (Sichuan), Dali (Yunan).

Many of the observed cases represent long-term in-migration particularly for residential purpose, rather than short-term stay associated with rural tourism. Recorded rural incomers display a high degree of diversity, in terms of employment status, household composition and migration motivations. Given that counterurbanisation often involves very individualised decision, these incomers typically are driven by a range of motives: 'escaping' from cities and shifting to (imagined) 'rural life', farming and organic food, cheaper living expense and bigger space. enjoying the process of refurbishment and making their own home, caring for household members including children, parents and pets, proximity to workplace or entrepreneurship opportunities, and nostalgic attachment. Some of these factors are particularly rooted in Chinese context regarding rural land rights and traditional culture, such as returning to live with elderly parents, preparing a rural house for retirement, seeking pastoral seclusion in extreme remote villages. Most of these individuals reported a high level of post-move satisfaction regardless of the duration of their stay—some dating back to 2020.

Social media data source and AI-based processing methods like ChatGPT AI model were proven to be a reliable and efficient way for monitoring and accessing counterurbanisation trend in China.

Counterurbanisation in China appears to be in its early stage. Rural incomers face several challenges, including the risk of government-planned demolition of their living village, and, for rural tenants, the difficulty of locating a suitable rural house and dealing with landlords. Further research is needed to better understand the implications of counterurbanisation in China and developed an appropriate framework that both encourages more in-migration and prevents potential issues.

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Declaration of generative AI in scientific writing
Generative AI and AI-assisted technologies including ChatGPT and Copilot were used in the writing process to improve the readability and language of the manuscript.

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Unraveling the relationship between the digital platforms and gentrification: Evidence from Nanjing, China

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Abstract
Information-driven digital platforms are reshaping urban and social space, often intensifying gentrification. Using Nanjing (2019-2024) as a case, we combine Beike second-hand housing transactions with Weibo check-ins to map community gentrification stages, applying spatial autocorrelation, cluster and regression analyses. Gentrification correlates strongly with check-in density: commercial cores, tourist spots and university districts form "high-high" clusters, while peripheral zones remain "low-low". Check-ins by non-locals, KOLs and KOCs exert greater influence than those by residents. Algorithmic "discursive investing" turns informational capital into place branding, attracting investors and accelerating change. These findings highlight digital platforms as new engines—and amplifiers—of urban inequality, calling for governance that regulates platform algorithms and protects spatial justice.

Keyword: gentrification-digital platforms-Social Media Check-ins; SHAP

Introduction

Gentrification was initially used to describe the socio-spatial transformation in inner-city London, where the middle class moved into declining working-class neighborhoods, revitalised the physical environment, and established residential enclaves(Glass, 1964). Over the past half-century, research on gentrification has expanded from its early focus on class displacement in urban neighborhoods of Western Europe and North America to encompass narratives of socio-spatial change across the Global South and broader urban-rural contexts. The "planetary gentrification" (Shen et al., 2018) theory posits that gentrification has become an inevitable experienced phase in global urban development, emphasizing the need to examine its processes across diverse geographical, economic, political, and cultural settings worldwide. In the context of the informatised city, many scholars have begun exploring the relationship between geo-media(Hartmann and Jansson, 2024), urban mediatisation(Törnberg and Uitermark, 2022), digital platforms(Shan et al., 2023), and planetary gentrification. Against the backdrop of accelerating global digital transformation, platform capitalism is reshaping the logic of urban spatial production through location-based services (LBS). Traditional gentrification studies emphasize the linear relationship between physical space renovation and class displacement but overlook the hidden power of digital platforms in shaping spatial perception through information flows.

China, as the world's largest social media application market, sees platforms like Weibo and Douyin generating over 500 million daily location tags. Social-consumption platforms such as Weibo, Dianping, and Xiaohongshu are reshaping the visibility and appeal of urban spaces through algorithmic recommendations and user-generated content. These platforms not only alter consumption patterns but also invisibly accelerate the demographic and landscape reconfiguration of specific neighborhoods, creating a new transmission chain of "digital footprints-spatial value-capital flow." Against this backdrop, this study takes Nanjing as a typical case to reveal the relationship between platform activities, user behavior, and gentrification, offering a new perspective for urban research in the Global South context.

Digital Platforms and Gentrification

Currently, Western scholars have begun exploring the relationship between gentrification and digital platforms, including social media platforms, lifestyle service platforms, and the sharing economy. Concepts such as platform capitalism and mediated narratives of gentrification have emerged as key theoretical tools for understand-

ing gentrification in the new era. On one hand, cities and capital have always been deeply intertwined. Digital platforms have shifted capital's exploitation of urban space from explicit domination to implicit discipline. Through algorithmic "black box" operations and discursive construction, urban spaces are commodified as "idle" resources to facilitate capital accumulation. On the other hand, digital platforms reshape the terrain of identity formation. The middle class utilises these platforms as stages to showcase their aesthetic preferences, attracting like-minded groups and fostering spatial clustering. This leads to a more subtle form of cultural isolation and social segregation, where exclusion occurs under the guise of digital connectivity.

2.1 Digital Platform "Discourse" and Spatial Representation

Digital platforms possess the capacity to frame urban spaces as consumable commodities or investment opportunities, constructing specific discourses that shape spatial representation and attract capital to facilitate spatial valorisation. Törnberg et al. examined the portrayal of Vidigal across diverse media platforms-such as YouTube, Airbnb, and Flickr-demonstrating how these platforms strategically reimagined the neighborhood from a stigmatised, impoverished, and hazardous area into a dynamic space brimming with opportunity. By accentuating its "heterogeneity" and "authenticity," these platforms effectively drew in tourists, new residents, and investors. Consequently, new residential and commercial developments gradually eroded local cultural heritage and transformed community structures, accelerating the area's gentrification(Törnberg and Uitermark, 2022). Similarly, Erika Polson's case study of Denver's RiNo Art District analyzed the interplay between graffiti, Instagram, and gentrification. The study argues that social media platforms are reconfiguring the production, aesthetics, and consumption of graffiti and street art. The viral dissemination of Instagram imagery has repurposed street art as a tool for enhancing neighborhood cultural capital, making its commercial potential visible to upper-middle-class residents and investors. This process ultimately attracts capital inflows, further accelerating gentrification (Polson, 2024).

In a critical examination of Instagram and Facebook posts related to Brisbane's West End, Walters highlights the hegemonic influence of social media in constructing immaterial yet highly symbolic spatial narratives. The study contends that digitally mediated placemaking tends to obscure the complex, lived realities of communities, effectively erasing the socio-spatial diversity that originally constituted the neighborhood. This erasure indirectly facilitates gentrification by promoting a sanitised, marketable version of urban space. Real estate developers and marketers leverage social media platforms to rebrand and promote urban districts, selectively curating images and content that align with an idealised urban lifestyle-trendy cafes, boutique stores, fitness studios, and other aspirational commercial activities. These representations reinforce the upscale aesthetics of gentrifying neighborhoods, further aligning them with the tastes of affluent newcomers (Walters and Smith, 2024).

2.2 Platform User Identity and Gentrification

Digital platforms have fostered new modes of "consumption" and "leisure" that emphasize personalised experiences, cultural tastes, and identity formation. Within this framework, the middle class leverages social media to express their identity and social status, attracting like-minded groups to specific locations. This process influences neighborhood reputation, rent, and housing prices, ultimately driving gentrification. For instance, Zukin conceptualise user reviews on Yelp as a form of "discursive investing," where reviewers deploy their cultural capital through critiques, showcasing their tastes and preferences. These digital expressions attract consumer groups with similar socioeconomic backgrounds, shaping the developmental trajectory of entire neighborhoods and accelerating their restructuring and gentrification (Zukin et al., 2017). Platforms such as Yelp, TimeOut, and Eater further reshape consumers' geographical imaginations through user-generated content (reviews, descriptions, and ratings), influencing culinary and spatial aesthetics. By promoting certain local food cultures, these platforms attract new residents and investors-often at the expense of long-term residents and indigenous community culture, thereby hastening displacement and gentrification. Irene Bronsvoor's case study of Amsterdam's Javastraat district illustrates how social media platforms serve as stages for affluent groups to construct lifestyles and assert status. Through their online activities, these actors reinforce their social prestige and cultural capital, actively shaping the street's developmental direction. In doing so, they not only reflect but also amplify and reconfigure the dynamics of middle-classification, further entrenching gentrification processes (Bronsvoort

and Uitermark, 2022).

2.3 Digital Platforms and the Marginalisation of Vulnerable Groups

The technological barriers inherent in digital platforms, combined with profit-driven algorithmic content distribution mechanisms, may inadvertently contribute to the marginalisation of vulnerable populations and exacerbate social segregation. This phenomenon manifests in two primary dimensions. Firstly, digital technologies can function as exclusionary mechanisms that restrict access to specific urban spaces. For instance, coworking spaces (CWS), while ostensibly designed as shared work environments, effectively operate as exclusive domains for the "mobile elite." Through financial barriers, technological requirements, and access control systems (e.g., keycard entry), these spaces systematically exclude individuals "deemed unworthy," transforming ostensibly public platforms into high-end venues catering specifically to global network elites. These spaces thus serve triple functions: as consumption sites for elites, mobility hubs for privileged professionals, and networking nodes for exclusive social circles (Fast, 2024). Secondly, the profit-oriented nature of platform capitalism leads to algorithmic mechanisms that disproportionately prioritise young, affluent demographic groups with significant consumption potential. Berglund et al.'s study of digital platforms in Detroit's downtown gentrification process reveals how platform algorithms contribute to the social isolation of elderly populations. Their research demonstrates that promotional materials on digital and social media platforms predominantly target young professionals - exemplified by initiatives like the "live downtown" campaign designed to attract this demographic to urban centers. These platform-mediated place-marketing strategies typically present sanitised, aesthetically enhanced urban imagery tailored to younger sensibilities, which may unintentionally intensify the marginalisation of vulnerable groups (particularly elderly residents) while accelerating downtown gentrification processes. This dual dynamic of technological exclusion and algorithmic bias creates a self-reinforcing cycle where platform-mediated urban development increasingly caters to privileged groups while rendering vulnerable populations increasingly invisible in both digital and physical urban spaces (Berglund et al., 2022).

In conclusion, a growing body of evidence demonstrates that user-generated content on lifestyle service platforms and social media, coupled with platform capitalism-driven discourse construction and algorithmic operations, significantly impacts neighborhood reputation, investment patterns, and demographic shifts, ultimately influencing community restructuring and gentrification processes. However, substantial research gaps remain in this field. Current discussions on digital-era gentrification predominantly remain at the level of theoretical speculation or fragmented case studies of individual communities. Existing research has primarily relied on field investigations and small-sample data from specific neighborhood cases to examine digital platforms' influence on gentrification, while neglecting macro-level analysis of how platform-generated check-in popularity and content differentially affect communities at various stages of gentrification, with a notable lack of large-scale, longitudinal data support and systematic analysis. To address these research gaps, this study selects Nanjing's main urban area as a case study. By integrating multi-source platform data from 2019 to 2024, we aim to establish a multidimensional gentrification impact factor system. Incorporating machine learning and other quantitative methods, we will investigate how check-in popularity on digital platforms influences gentrification processes, thereby providing a more comprehensive understanding of platform-mediated urban transformation mechanisms.

3.Methods

3. 1 Study Area and Data Sources

This study focuses on the main urban area of Nanjing City, Jiangsu Province, China, which comprises 600 neighborhoods (as shown in Figure 1). As a major provincial capital undergoing rapid urbanisation and digital transformation, Nanjing represents an ideal case for investigating the impact of digital platforms on gentrification processes. The research utilises two primary data sources: Beike (China's largest real estate transaction platform) and Weibo (one of China's most influential social media platforms). Specifically, we collected 37,974 property transaction records from Beike covering the period 2019-2024 within Nanjing's main urban area. These records contain detailed transaction information including neighborhood location, transaction date, average price, and floor area, as well as property characteristics such as building age, floor area ratio, and green space ratio. Con-

currently, we obtained 693,638 geotagged check-in records from Weibo during the same period, each containing precise longitude and latitude coordinates, venue categories, user-generated content, engagement metrics (including reposts, comments, and likes), and user profile information (including followings, followers, gender, and IP addresses). This comprehensive, multi-source dataset provides a robust foundation for examining the mechanisms through which digital platforms influence urban gentrification.

Figure 1. The area of central Nanjing

3.2 Gentrification Measurement Methodology

In China's socioeconomic context, where residential property values serve as the primary indicator of household economic status (with real estate constituting approximately 70% of average household assets), the transaction volume of secondary housing markets provides an empirically valid measure of actual residential mobility patterns within urban neighborhoods (Shan et al., 2023). Based on this conceptual framework, our study employs property transaction data from the Beike platform to construct a multidimensional gentrification assessment system through three specifically designed indices: (1) the Average Social Stratification Index (ASSI), which quantifies neighborhood-level socioeconomic composition through property value distributions; (2) the Fixed Property Index (FPI), measuring physical asset appreciation while controlling for structural characteristics; and (3) the Value Change Index (VCI).

(1) Average Social Stratification Index (ASSI)

Based on the average transaction prices and floor areas of housing transactions in Nanjing in 2019, we first categorised the average transaction prices of properties in the main urban area of Nanjing into five tiers using the quintile method (Table 1). Through weighted summation, we obtained the community social stratification index. Given that housing constitutes the most significant household asset in China, this index can reflect the average economic-social stratification within each community. The formula is:

$$ASSI_i = \sum_{k=1}^{5} k \cdot P_{ki}$$

where k represents the weighting coefficient for each tier, with assigned values of 1 (less than 2 million CNY), 2 (2-4 million CNY), 3 (4-6 million CNY), 4 (6-8 million CNY), and 5 (greater than or equal to 8 million CNY). Pki denotes the percentage of properties in each tier within a given community.

Table 1. Property classification

Level1	Below 2 million CNY
Level 2	2-4 million CNY
Level 3	4-6 million CNY
Level 4	6-8 million CNY
Level 5	Above 8 million CNY

(2) Fixed Property Index (FPI)
The Fixed Property Index (FPI) is designed to measure whether the average household asset composition within a community exceeds Nanjing's 2019 average level. Using the mean TASSI (Total Average Social Stratification Index) of Nanjing's main urban area in 2019 as the benchmark, this index evaluates the relative asset level of communities within the city's central districts.The calculation formula is:

$$FPI_i^{2019} = \frac{ASSI_i^{2019}}{TASSI^{2019}}$$

Where:ASSI_i2019 represents the ASSI value of individual communities in 2019;TASSI_2019 denotes the aggregate ASSI value of all communities in Nanjing during 2019

(3) Value Change Index (VCI)
The Value Change Index (VCI) measures the transformation in household asset composition across communities between 2019 and 2024. By comparing the relative change in community-level ASSI to the citywide TASSI during this period, this index isolates gentrification-driven social replacement from general market fluctuations. The formula is expressed as:

$$VCI_i = (ASSI_{i2024}/ASI_{i2019})/(TASSI_{2024}/TASSI_{2019})$$

Where:
ASSI_i2019 and ASSI_i2024 represent the ASSI values for individual communities in 2019 and 2024 respectively.
TASSI_2019 and TASSI_2024 denote the aggregate ASSI values for all Nanjing communities in the corresponding years.

Finally, the gentrification stages of communities in Nanjing's main urban area were determined based on their FPI and VCI values, with specific classification criteria as shown in Table 2.

Table 2. Gentrification Stage Classification Criteria

Ungentrified	FPI2019< 1 and VCI < 1, set Gentri-type = 0;
Gentrifying	FPI2019< 1 and VCI > 1, set Gentri-type = 1;
Gentrified	FPI2019>1 and VCI < 1, set Gentri-type = 2;
Re-gentrifying	FPI2019> 1 and VCI > 1, set Gentri-type = 3;

3.3 Selection of Influencing Factors
Digital footprints have been empirically demonstrated to provide early-warning signals for urban gentrification processes. The "check-in" popularity on social media platforms, visitor demographics, and spatial distribution patterns exhibit strong coupling with neighborhood value reassessment and consumption upgrading (Chapple et al., 2022). In the Chinese context, Weibo's advantages - including its massive user base, real-time information flow, and geotagging features - have made it widely adopted for studies on urban vitality and public space utilisation. This study systematically constructs Weibo check-in independent variables across three dimensions:

check-in popularity, user demographics, and location characteristics.

Table 3. Independent Variables

Dimension	Variable ID	Variable Name	Mean
Neighborhood Check-in Popularity	X1	Total number of Check-ins	1170.15
	X2	Total interactions of Check-ins	14861.55
	X3	Total reposts of Check-ins	1592.56
	X4	Total comments of Check-ins	3157.81
	X5	Total likes of Check-ins	10111.19
Neighborhood Check-in User Demographics	X6	Normal user check-ins	927.50
	X7	KOC check-ins	203.47
	X8	KOL check-ins	39.18
	X9	Female check-ins	711.21
	X10	Male check-ins	458.94
	X11	Nanjing resident check-ins	398.74
	X12	Non-Nanjing resident check-ins	771.41
Neighborhood Check-in Locations	X13	Check-ins at residential locations	266.11
	X14	Check-ins at commercial locations	341.02
	X15	Check-ins at workplace locations	93.27
	X16	Check-ins at university locations	77.71
	X17	Check-ins at public service locations	62.67
	X18	Check-ins at parks	59.08
	X19	Check-ins at tourist attractions	95.21
	X20	Check-ins at cultural & sports venues	58.80
	X21	Check-ins at public transportation facilities	45.99
	X22	Check-ins at other locations	41.145

3.4 Local Bivariate Moran's I

To characterise the spatial coupling between Weibo check-in activity and different gentrification stages at micro-scale levels, this study employs the local bivariate Moran's index to detect spatial associations between these variables. The computational formula is:

$$I_i^{XY} = z_{x_i} \sum_{j=1}^{n} w_{ij} z_{y_j},$$

Where:

$z_{xi} = (x_i - x-)/s_x$ and $z_{yj} = (y_j - Y)/s_y$ represent standardised residuals of gentrification stage values and Weibo check-in counts respectively;w_{ij} denotes row-standardised spatial weight elements.

3.5 Random Forest Model

Given the multiclass categorical nature of the dependent variable, this study employs a Random Forest classification model (Breiman, 2001) as the primary analytical framework. As an ensemble tree-based learning algorithm, the Random Forest classifier comprises multiple decision trees, each constructed through bootstrap sampling of observations and random feature selection from the dataset. This non-parametric model demonstrates particular strengths in handling high-dimensional, multiclass data with complex nonlinear relationships,

while exhibiting superior generalisation capacity and robustness against overfitting - characteristics that have led to its increasing adoption in urban studies(Deb and Smith, 2021; Kim, 2022). The model was implemented using Python's scikit-learn library, with the dataset partitioned into training and testing subsets at an 80:20 ratio. Model performance was evaluated using standard classification metrics including accuracy and F1-score on the test set. To ensure model stability and reproducibility, hyperparameter tuning and validation were conducted through 5-fold cross-validation.

3.6 Shapley Additive Explanations (SHAP)

To elucidate the operational mechanisms and relative importance of predictive factors in gentrification classification, this study incorporates SHAP (SHapley Additive exPlanations) for both global and local interpretation of the trained Random Forest model (Lundberg and Lee, 2017). Grounded in cooperative game theory and Shapley value principles, SHAP provides a theoretically-grounded framework for quantifying the marginal contribution of each feature to model predictions. This approach not only yields feature importance rankings but also reveals the directional effects (positive/negative) of specific feature value ranges on classification outcomes, thereby effectively demystifying the "black box" nature of Random Forest models and enhancing overall interpretability. All modeling and visualisation procedures were implemented in Python 3.7, utilizing established open-source libraries including scikit-learn for machine learning, pandas for data manipulation, matplotlib for visualisation, and the specialised shap package for model interpretation.

4.Results

4.1 Spatial Distribution of Gentrified Communities in Nanjing

The main urban area of Nanjing comprises 600 communities, which were classified into four categories based on our indicator calculations: 107 non-gentrified communities, 246 communities undergoing gentrification, 155 gentrified communities, and 92 re-gentrified communities. The results demonstrate that most regenerated communities in Nanjing exhibit varying degrees of gentrification. The gentrified and re-gentrified communities are predominantly concentrated in several key areas: Jianye District, the old urban areas of Gulou and Qinhuai Districts, the riverside areas of Pukou District, the Southern New City of Jiangning District, and the eastern Zijin Mountain area of Qixia District. These areas correspond precisely with recent government-led urban redevelopment projects, including the urban renewal initiatives in Gulou District and Qinhuai old town, as well as new urban developments such as the Hexi New City in Jianye District, the core area of Jiangbei New District, Southern New City, and Zidong New District.

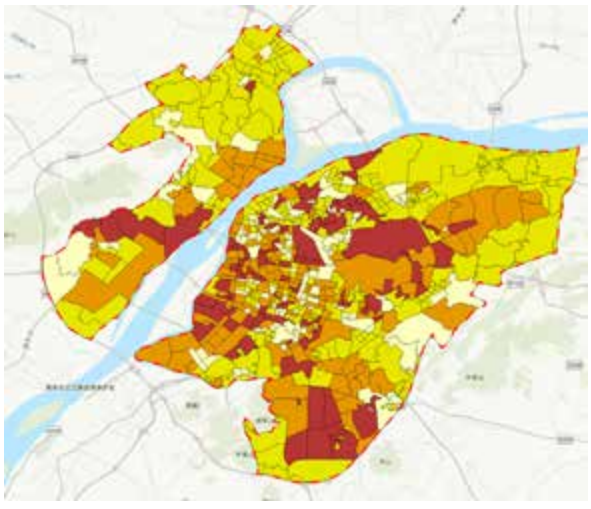

Figure 2: Gentrification Stages in Central Nanjing

4.2 Local Bivariate Moran's Index Analysis

The research findings reveal a significant spatial correlation between the gentrification index of communities in Nanjing's main urban area and the popularity of check-in activities on social platforms. Distinct spatial clustering patterns emerge: "high-high" agglomeration is observed in communities surrounding commercial centers, central business districts, tourist attractions, and university towns, while "low-low" agglomeration characterises peripheral urban areas. This spatial association demonstrates the close relationship between digital platform activities and urban gentrification processes, particularly in areas undergoing rapid urban transformation and redevelopment.

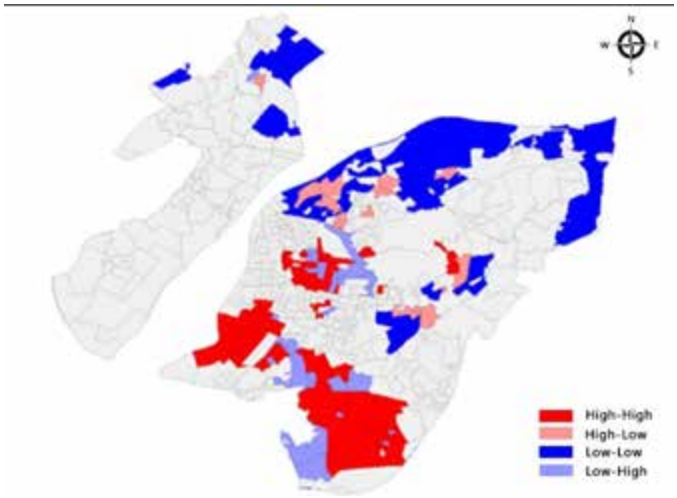

Figure 3: Gentrification Stages in Central Nanjing

4.3 Regression Results

To comprehensively evaluate the model's discriminative capability for identifying community gentrification stages, this study employed a dual analytical approach. First, we constructed Receiver Operating Characteristic (ROC) curves (Figure 4) and calculated the Area Under Curve (AUC) values for each classification category. The results demonstrate an average AUC≈0.68, indicating that the model exhibits reasonable feasibility in distinguishing communities at different gentrification stages.

For deeper insight into the key variables influencing gentrification stage evolution, we computed SHAP values from the trained multiclass Random Forest model and generated both global (Figure 5) and class-specific feature importance Pareto charts (Figures 6a-d). These visualisations present the hierarchical ranking and cumulative contribution of variables across all samples and for each of the four gentrification types, with detailed cumulative contribution rates provided in Table 4.

The analysis reveals three key findings regarding variable contributions: (1) Overall community check-in popularity metrics (X1-X5) demonstrate the highest explanatory power, accounting for 39.58% of cumulative contribution; (2) Neighborhood check-in user demographics (X6-X12) show moderate influence at 35.8%; while (3) Neighborhood check-in location characteristics (X13-X22) exhibit relatively minimal impact at 24.62%. This pattern underscores the predominant role of community check-in popularity in gentrification processes, particularly for communities in the ongoing and completed gentrification stages. Conversely, the specific types of check-in locations appear to exert comparatively weaker effects on gentrification dynamics.

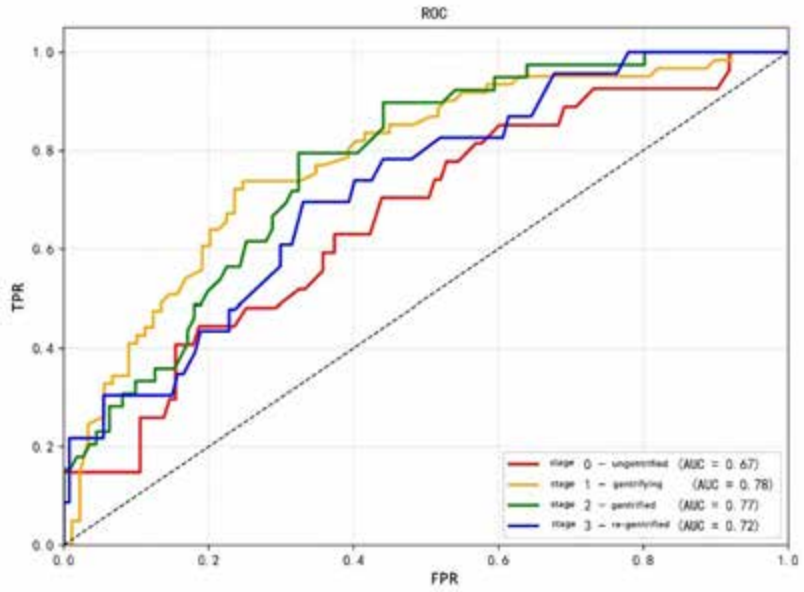

Figure 4. Multiclass ROC Curve

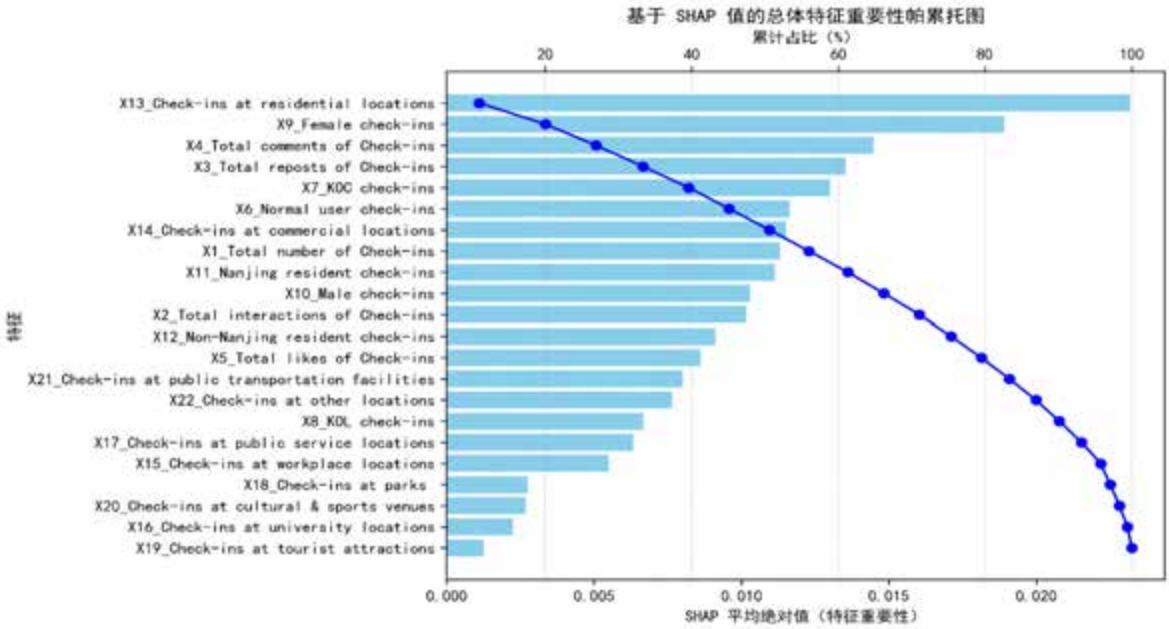

Figure 5. Pareto chart of feature importance

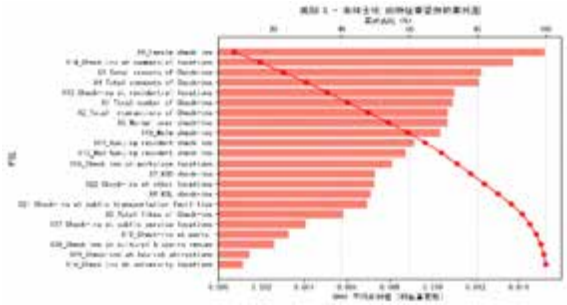

Figure 6-a. Pareto chart of feature importance for ungentrified stage

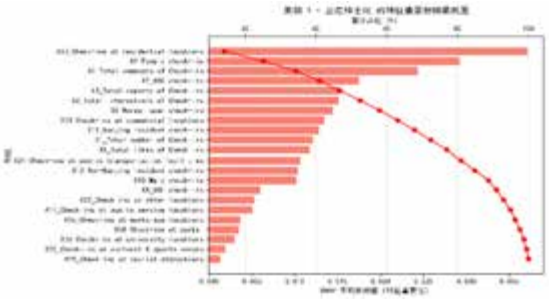

Figure 6-b. Pareto chart of feature importance for gentrifying stage

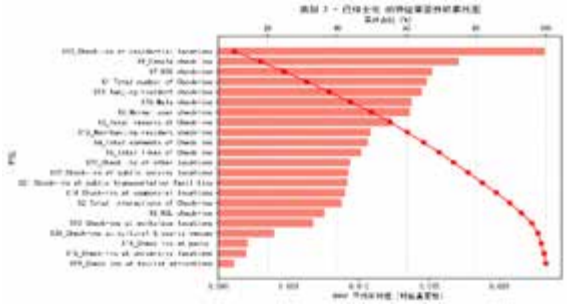

Figure 6-c. Pareto chart of feature importance for gentrified stage

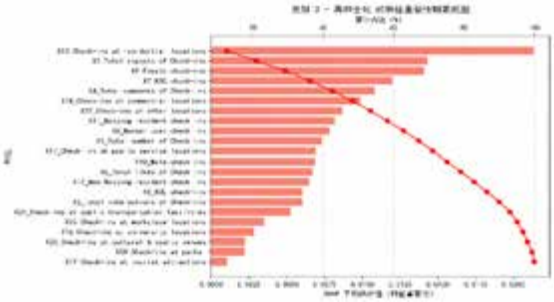

Figure 6-c. Pareto chart of feature importance for re-gentrifying stage

Table 4. Precision and Recall Values of the Random Forest Model

Stage of Gentrification	Neighborhood Check-in Popularity (X1–X5)	Neighborhood Check-in User Demographics (X6–X12)	Neighborhood Check-in Locations (X13–X22)
Average	39.58%	35.80%	24.62%
Ungentrified	35.79%	38.13%	26.08%
Gentrifying	46.72%	34.22%	19.06%
Gentrified	37.68%	35.82%	26.50%
Re-gentrifying	42.54%	32.65%	24.81%

To elucidate the specific mechanisms through which different variables influence model outputs, this study conducted interpretability analysis using SHAP value distribution plots (Beeswarm Plots) for the classification models of four gentrification stages, with results presented in Figures 6a-d. Each plot displays the SHAP value distribution of variables for the respective category, where the horizontal axis represents the marginal effect of each variable on model output, and the color gradient indicates the magnitude of variable values. Comparative analysis reveals significant differences in variable effect mechanisms across distinct gentrification stages.

The analysis reveals distinct patterns in the marginal effects of Weibo check-ins across different gentrification stages. Notably, check-in activities demonstrate predominantly negative marginal effects in non-gentrified and ongoing gentrification areas, while exhibiting significantly positive effects in gentrified and re-gentrified communities.

In ungentrified and gentrifying neighborhoods, model predictions primarily rely on variables including female user check-ins (X9), commercial location check-ins (X14), interaction metrics (e.g., X3 reposts and X4 comments),

and residential area check-ins (X13). The SHAP values for these variables predominantly cluster near zero, indicating relatively moderate influences on model outputs. Nevertheless, these patterns suggest that lower female activity and weaker commercial engagement represent key characteristics of non-gentrified areas. Overall, these communities exhibit distinctive features of limited platform engagement, low social interactivity, and predominantly residential space utilisation.

For gentrified areas, the discriminative factors concentrate on residential area check-ins (X13), female user check-ins (X9), Key Opinion Consumer (KOC) check-ins (X7), and total check-in volume (X1). These variables reflect high-frequency, targeted social activity patterns, indicating these areas have developed mature "internet-famous" attributes. Additionally, check-ins by Nanjing local residents (X11), male users (X10), and content dissemination metrics like reposts and comments demonstrate significant influences, suggesting synergistic effects between online reputation and local participation in reinforcing community stability.

Re-gentrified areas display complex, multi-source participation characteristics. Decision-making incorporates not only traditional factors like residential check-ins (X13), reposts (X3), and female check-ins (X9), but also variables such as KOC check-ins (X7), comments (X4), and commercial location check-ins (X14). This broad participation spectrum indicates that after one or multiple rounds of redevelopment, these areas have evolved into urban spaces characterised by diverse user coexistence and complex dissemination mechanisms. The more dispersed SHAP values and varied effect directions reveal higher dynamism and diversity in re-gentrified areas, potentially featuring composite social nodes that combine both consumption power and community cohesion.

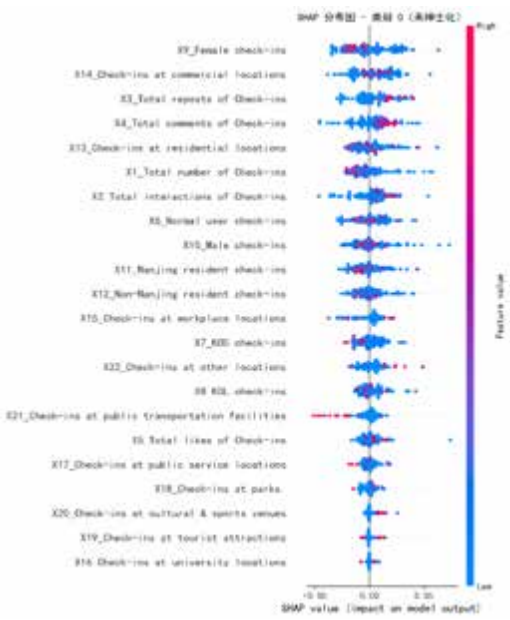

Figure 7-a. beeswarm chart for ungentrified stage

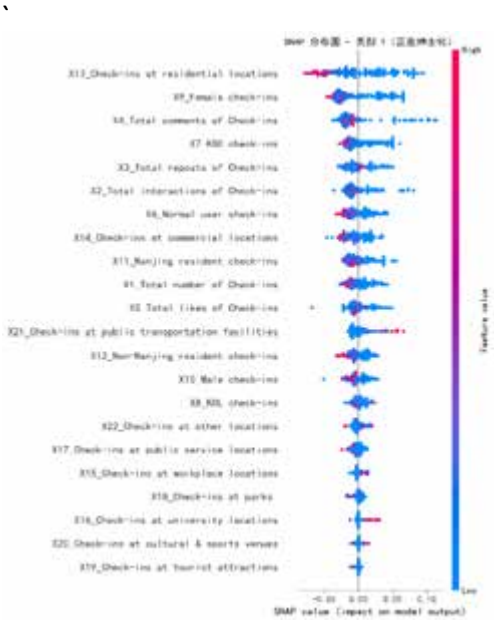

Figure 7-b. beeswarm chart for gentrifying stage

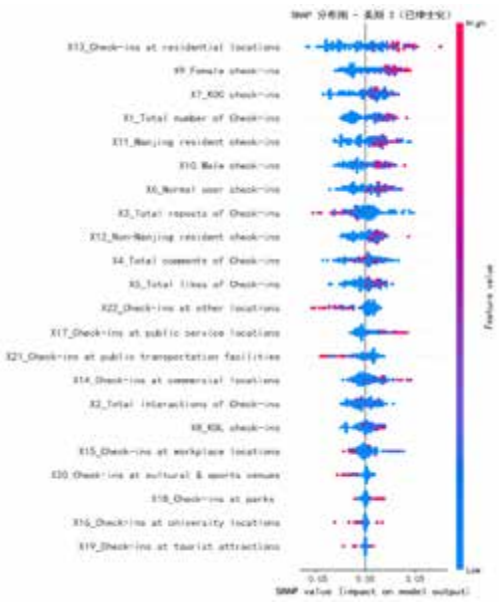

Figure 7-c. beeswarm chart for gentrified stage

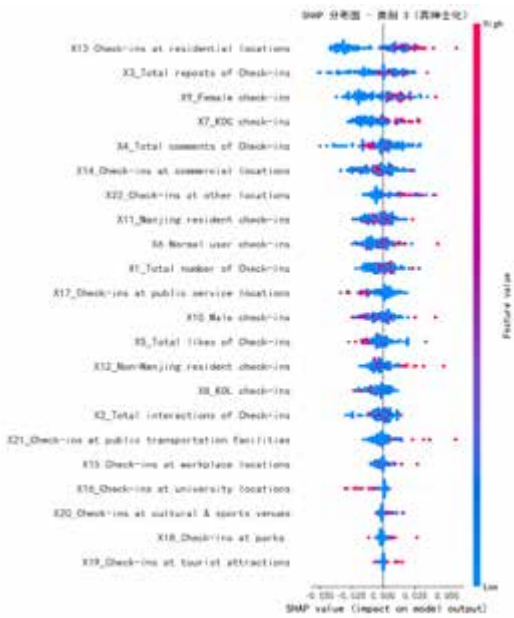

Figure 7-d. beeswarm chart for re-gentrified stage

5.Conclusion

This study pioneers an analytical approach that integrates multi-platform data from Beike and Weibo with interpretable machine learning models, establishing a behavioral-oriented research paradigm for understanding urban gentrification in the digital era. The findings yield significant theoretical contributions by demonstrating that social media engagement patterns - particularly check-in frequency and interaction levels - exhibit strong correlations with neighborhood gentrification processes. Notably, the activities of female users, Key Opinion Consumers (KOCs), and local residents exert disproportionately greater influence on gentrification dynamics compared to other demographic groups. The analysis further reveals that gentrification stages show the strongest association with check-in intensity in residential compounds and commercial districts.

The study elucidates how digital capital transcends spatial-temporal constraints to commodify urban space through platform-mediated mechanisms. Algorithmic governance structures guide social media users to anchor textual and visual content to specific physical locations through geotagging practices. This process of 'discursive investing' systematically attracts socioeconomically homogeneous groups and investors to targeted neighborhoods, thereby accelerating gentrification through subtle, digitally-mediated pathways. These insights necessitate critical policy considerations: urban governance frameworks must incorporate the impacts of high-engagement digital activities on community transformation, particularly regarding demographic restructuring and emerging gentrification landscapes. Concurrently, regulatory interventions should address platform algorithms and content curation to mitigate inter-neighborhood disparities and advance spatial justice in platform urbanism.

While this research provides macro-level evidence through the analysis of Weibo check-in data in Nanjing, the complex mechanisms of platform-driven gentrification warrant further investigation. Future studies should incorporate multi-dimensional data streams (including textual comments, visual imagery, and mobility traces) from representative urban contexts to more comprehensively capture the logic of digitally-mediated spatial reproduction. Particularly crucial is examining the symbiotic relationship between algorithmic recommendation systems and commercial capital accumulation in shaping gentrification outcomes. Such inquiries would strengthen the theoretical foundations for platform governance and equitable urban policy frameworks in the digital age.

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Towards Drone-Based 3D City Information Modeling for Urban Analysis and Planning

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Abstract
City Information Modeling (CIM) has emerged as a digital extension of Building Information Modeling (BIM), enabling integrated representations of urban systems through 3D spatial data, semantic modeling, and temporal dynamics. While its potential aligns with the digital transformation of cities, CIM research remains fragmented by conceptual ambiguities and limited practical implementations. This paper addresses these gaps through a dual-method approach: (1) a PRISMA-BSMS-based systematic literature review of 159 CIM-related publications indexed in Scopus, and (2) an empirical case study applying UAV-based photogrammetry to generate a neighborhood-scale 3D model for Emniyettepe, Istanbul. By integrating bibliometric analysis with a UAV-to-CIM workflow, the study aims to bridge theory and application, offering insights into scalable, cost-effective, and replicable city modeling strategies for planning and research.

Keywords: City Information Model; City Information Modeling; bibliometric analysis; systematic review; PRISMA; Drone.

Introduction

By providing a digital paradigm that expands the capabilities of Building Information Modeling (BIM) beyond individual buildings to the city scale, City Information Modeling (CIM) has become a game-changing strategy for managing urban complexity. CIM, which has its roots in the combination of 3D geometry, semantic information, and temporal data, makes it easier to visualize, simulate, and coordinate urban elements in a single digital environment. Unlike traditional GIS platforms that primarily represent spatial data in static layers, CIM enables dynamic, object-based modeling that can support real-time analysis, stakeholder interaction, and lifecycle planning.

This shift toward integrated urban informatics positions CIM at the intersection of architecture, planning, computer science, and geospatial technologies. It incorporates data from Geographic Information Systems (GIS), remote sensing, BIM, and urban sensors while embedding social, economic, and environmental dimensions into city models. Accordingly, CIM is increasingly linked to discourses on smart cities, resilience, and data-driven urbanism, promising to enhance urban governance, infrastructure management, and participatory planning.

Yet, despite growing scholarly interest, CIM remains underdeveloped in both conceptual clarity and practical deployment. Existing literature is often fragmented—ranging from semantic data models and technical ontologies to simulation tools and design case studies—without convergence toward a standardized methodology. Furthermore, real-world implementations, especially at the neighborhood or district scale in developing contexts, remain scarce. This is largely due to high entry costs, challenges in integrating heterogeneous datasets, and the absence of open-access, scalable tools tailored to CIM.

By providing a digital paradigm that expands the capabilities of Building Information Modeling (BIM) beyond individual buildings to the city scale, City Information Modeling (CIM) has become a game-changing strategy for managing urban complexity. CIM, which has its roots in the combination of 3D geometry, semantic information, and temporal data, makes it easier to visualize, simulate, and coordinate urban elements in a single digital environment.

Building on this potential, the study follows a dual methodology. First, it conducts a systematic literature review using the BSMS (Bibliometric Analysis, Systematic Review, Meta-Analysis, and Storytelling) process, urban research–specific adaptation of the PRISMA framework. This step maps the evolution, themes, and gaps in CIM-related research. Second, it presents a field-based case study in Emniyettepe Neighborhood, Istanbul, where UAV

photogrammetry is deployed to generate a localized CIM dataset and propose an adaptable workflow for future urban applications.

By bridging theory and practice, the study aims to inform both academic discourse and practical planning, contributing to the operationalization of CIM as a planning and design tool in diverse urban contexts.

Background and Theoretical Context

In order to facilitate the integrated modeling of urban systems, the interdisciplinary invention known as City Information Modeling (CIM) combines the fields of architecture, urban planning, geospatial science, and digital technology (Kolbe, 2009; Batty, 2007). CIM is a city-scale framework that uses semantically enhanced 3D models to visualize and manage urban form, infrastructure, and socio-environmental dynamics. It is theoretically and technically derived from Building Information Modeling (BIM). The capacity of BIM to manage the lifetime of buildings has led to its widespread adoption in the architectural and construction sectors; however, CIM extends this power by using layered spatial, temporal, and relational data to depict complex urban settings.

Buildings, roads, vegetation, and utilities are modeled as interactive entities with defined behaviors and attributes in CIM, in contrast to traditional Geographic Information Systems (GIS), which usually handle spatial datasets in a layered and frequently static manner. This method enables CIM to serve as a simulation and decision-support environment in addition to a geographic database. It may facilitate planning interventions, resilience strategies, infrastructure management, and public involvement through scenario modeling and digital twins.

In academic literature, CIM has been increasingly positioned within the larger framework of smart cities and urban digital transformation. Scholars have investigated the use of CIM in energy modeling, flood risk analysis, mobility optimization, heritage conservation, and sustainability evaluations. Gil et al. (2019), Biljecki et al. (2020), and Xue et al. (2022) are among the studies that emphasize the integration of CIM with cutting-edge technologies like blockchain, artificial intelligence (AI), the Internet of Things (IoT), and extended reality (XR) (Kitchin and Thrift, 2009). As a modeling tool, CIM may now be used as an operational platform for real-time urban management thanks to these interfaces.

Nevertheless, several critical challenges continue to limit the operationalization of CIM. These include:

1. The absence of widely accepted standards and workflows for CIM implementation;
2. The technical and conceptual difficulty of integrating multi-source and multi-scale datasets;
3. A lack of CIM-specific software ecosystems relative to the maturity of BIM platforms;
4. Expensive and technically difficult data collection techniques, such as satellite imaging and airborne LiDAR.

Despite the growing capabilities of UAVs and open-source modeling tools, existing literature lacks well-documented and replicable workflows that demonstrate how such data can be integrated into CIM frameworks at fine-grain scales. Most published examples focus either on theoretical frameworks or large-scale city-level models, often overlooking neighborhood- or district-scale implementations that are essential for detailed planning analysis.

This gap underscores the need for studies that not only evaluate the conceptual landscape of CIM but also present grounded methodologies for urban planners and designers. Addressing this need, the current study integrates a systematic literature review with an empirical UAV-based case study to offer a structured and replicable CIM workflow suitable for localized applications.

Methodology

This study applies a dual-method research design that combines a systematic literature review based on the BSMS process and a field-based UAV photogrammetry case study in Istanbul.

• Systematic Review Method (PRISMA-BSMS)

To investigate the current state of research on City Information Modeling (CIM), this study employed the BSMS review process—an urban-planning-specific adaptation of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Page et al., 2021; Abusaada and Elshater, 2022; Elshater and Abusaada, 2022). The BSMS process enhances traditional review methodologies by incorporating:

1. Bibliometric analysis to quantify research output and trends;
2. Systematic review to identify themes and conceptual models;
3. Meta-analysis to detect methodological patterns;
4. Storytelling to frame the insights within urban and planning discourse.

The search was conducted in May 2024 using the Scopus database, chosen for its wide coverage of peer-reviewed literature and its compatibility with bibliometric tools. The query focused on terms such as "City Information Model," "City Information Modeling," and their plural and alternate spellings. The search string used was:

TITLE-ABS-KEY("city information model") OR TITLE-ABS-KEY("city information modeling") OR TITLE-ABS-KEY("city information models")

The inclusion criteria were articles, conference papers, books, and chapters; publications in English; and relevance to CIM as a modeling, planning, or design approach. A total of 159 documents published between 2009 and 2024 were identified. The full dataset was exported for analysis and cleaned to eliminate duplicates and irrelevant entries.

• Bibliometric and Thematic Analysis

To analyze the structure and evolution of City Information Modeling (CIM) literature, bibliometric and network visualization tools were employed to extract quantitative patterns and semantic associations from the selected corpus. Two primary software tools were utilized: VOSviewer (version 1.6.18) for keyword co-occurrence and author co-citation analysis, and CiteSpace (version 6.3.R4) for temporal and structural mapping of citation networks, keyword centrality, and cluster evolution.

The bibliographic data retrieved from Scopus—including titles, abstracts, author keywords, and indexed keywords—served as the foundation for this analysis. A thesaurus file was developed by the authors to standardize terminologies and merge synonymous terms (e.g., "CIM," "City Information Model," and "City Information Modelling" were unified under "City Information Modeling"). This step was essential to minimize fragmentation in keyword frequency and ensure consistency across the dataset.

For VOSviewer, a minimum occurrence threshold of five keywords was applied to filter the dataset and focus on terms with sufficient network weight. This threshold yielded 42 valid keywords. The software then generated a network visualization based on co-occurrence link strength, allowing identification of clusters that reflect thematic groupings in the literature. A similar threshold was applied for author co-citation analysis, using a citation count of 30 as the minimum threshold for inclusion.

CiteSpace was employed to assess the structural significance of keywords using centrality and degree metrics. The analysis was based on a g-index with a scaling factor of k=25 to balance citation volume and influence. This tool enabled the detection of pivotal keywords that serve as conceptual connectors between research themes, as well as the identification of burst terms and citation turning points that suggest emerging directions in the field.

Results and Discussion

• Publication Trends and Growth

The Scopus database had 159 papers about City Information Modeling (CIM) from 2009 until the middle of 2024,

according to the bibliometric study. Peer-reviewed journal articles, conference proceedings, book chapters, and review papers are all included in this corpus, which shows how academic interest in CIM has grown over the last ten years. Figure 1 shows the number document count for the 159 documents by year, see figure (1).

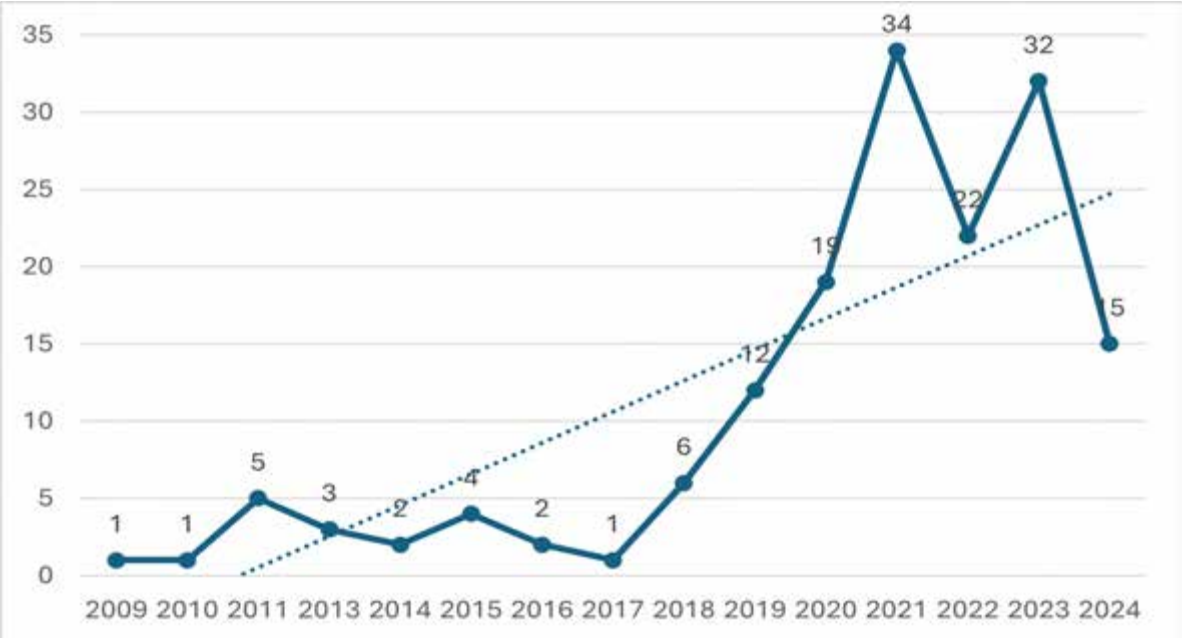

Figure (1): The document count for the 159 documents.

2009 was the first publication that was known to exist, and there was no rise in 2010. The number of publications increased 400%, or a high pace, from one to five in 2011. Following that, the trend experienced cyclical swings. 2013 had a 40% decrease, 2014 saw a little rebound, and 2015 saw a 33% fall. Interestingly, after a huge jump in 2018 (500% growth), the publications doubled in 2019 at a 100% growth rate. In 2021, 34 publications were released, a 79% increase over the year before. In 2022, there was a 35% decrease after this.

The number of publications as of mid-2024 indicates a preliminary 53% decrease from 2023. As more documents are indexed, this number is anticipated to alter by the end of the year. The average yearly growth rate for the examined time is almost 83%, if 2024 is excluded as an incomplete year. This indicates a persistent and growing interest in CIM, fueled by developments in digital twins, smart cities, and urban informatics.

• Geographical and Disciplinary Distribution

The geographic distribution of the 159 publications reveals a broad international interest in City Information Modeling (CIM). China leads the research output with 42 documents, followed by the United Kingdom and Portugal. These figures highlight the active engagement of both Eastern and Western academic institutions in advancing CIM scholarship. The prominence of China may be attributed to its parallel leadership in urban digitization, smart cities, and geospatial technology, while European contributions reflect strong ties between academic research and spatial planning practices.

In terms of disciplinary focus, the analysis reveals that Engineering and Computer Science dominate the subject areas. This suggests that CIM is still strongly rooted in technical and computational research, particularly in areas such as data modeling, digital infrastructures, and software development. However, substantial contributions from the Social Sciences and Environmental Science also point to an evolving interdisciplinary trajectory. These include topics like stakeholder engagement, participatory planning, and sustainable urban development—indicating a gradual integration of CIM into planning and policy-making discourses.

CIM's twin function as a technology platform for data integration and an urban planning decision-support system is reflected in this interdisciplinary collaboration. Because of this, scholars from a wide range of disciplines are coming together more and more around CIM to address issues of governance, resilience, and spatial justice in modern cities in addition to enhancing modeling accuracy.

• Citation Performance and Impact Indicators

The 159 documents retrieved from Scopus generated a total of 1,160 citations, underscoring the growing academic interest in CIM. When self-citations are excluded, the total citation count stands at 974, indicating substantial external engagement and cross-disciplinary relevance, see figure (2).

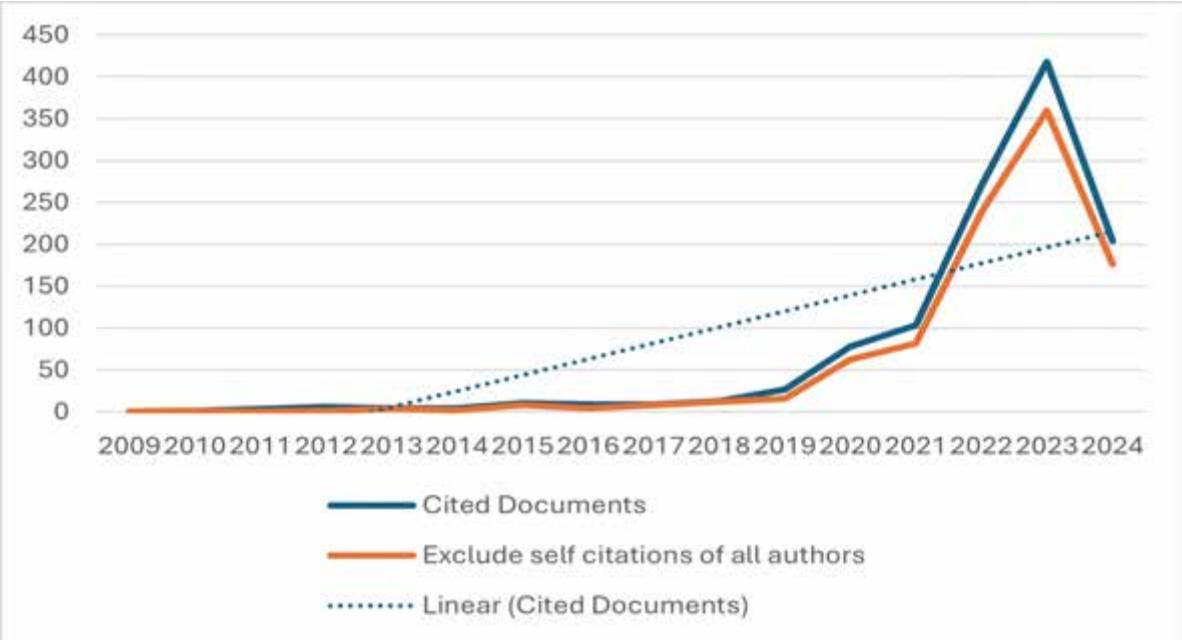

Figure (2): The citation count for the 159 documents, Self-citations included and excluded.

The annual citation trends reveal fluctuations typical of emerging research domains. After a slow start in 2009 and 2010, citations significantly increased in 2011 (200% rise). 2015 showed a 150% increase, regaining momentum after a 33% dip in 2013. Citations nearly doubled in 2019—a especially good year—and then increased by 163% in 2022. These peaks suggest that certain publications or themes triggered heightened academic attention at specific points in time.

The average annual attention rate, excluding the incomplete data for 2024, stands at approximately 77%, indicating consistent scholarly engagement with CIM topics. While 2024 data currently reflect a 53% decline, this is expected to adjust upward as new citations accrue throughout the year.

• Keyword Co-Occurrence and Clustering (VOSviewer Analysis)

To reveal underlying thematic patterns in the CIM literature, a keyword co-occurrence analysis was conducted using VOSviewer on the 159 Scopus-indexed documents. A custom thesaurus file was applied to harmonize keyword variants (e.g., "CIM," "City Information Model," and "City Information Modelling" were unified under "City Information Modeling") to avoid redundancy and improve consistency.

A threshold of five occurrences was set, resulting in 42 qualified keywords for inclusion. The resulting network visualization displays four major thematic clusters, each color-coded and indicating distinct lines of inquiry within CIM research:

• Cluster 1 (Red): Urban Modeling and GIS Integration
This largest and most densely connected cluster (14 keywords) includes terms like “three-dimensional modeling,” “urban design,” “urban planning,” and “geographic information system.” It represents the methodological backbone of CIM, highlighting the fusion of 3D spatial modeling with GIS technologies to support urban planning, simulation, and visualization.

• Cluster 2 (Green): Remote sensing and data systems
This cluster, which consists of 11 terms including “information systems,” “data acquisition,” and “remote sensing,” highlights CIM’s technological backbone. It shows interest in the collection, organization, and integration of urban data, especially via sensors and remote sensing technology.

• Cluster 3 (Blue): BIM-Driven Decision Support
With 10 keywords including “building information modeling,” “decision making,” and “urban growth,” this cluster illustrates how BIM methodologies are leveraged to inform policy and design decisions in urban contexts, extending BIM from architectural to city-scale applications.

• Cluster 4 (Yellow): Emerging Technologies and Sustainability
Terms such as “blockchain,” “sustainable development,” and “quality of life” are included in the smallest cluster (7 keywords). It covers themes that gaze ahead, examining how cutting-edge technologies and moral issues will shape urban futures.

While the thickness and number of connecting lines show the overall connection strength, or how frequently keywords appear in the same publications, node size in the network represents the frequency of keyword occurrence. The network’s node sizes reveal the frequency of keywords, with conceptual anchors such as “city information modeling” (74 occurrences), “information models” (68), and “building information modeling” (43) acting as prominent phrases. The overall link strength statistic emphasizes the importance of important phrases in the changing conversation by further quantifying the degree to which one keyword is related to others. The network map displayed in Figure 3 illustrates these interactions, with cluster colors, node sizes, and links reflecting co-occurrence strength, keyword frequency, and theme structure, see figure (3).

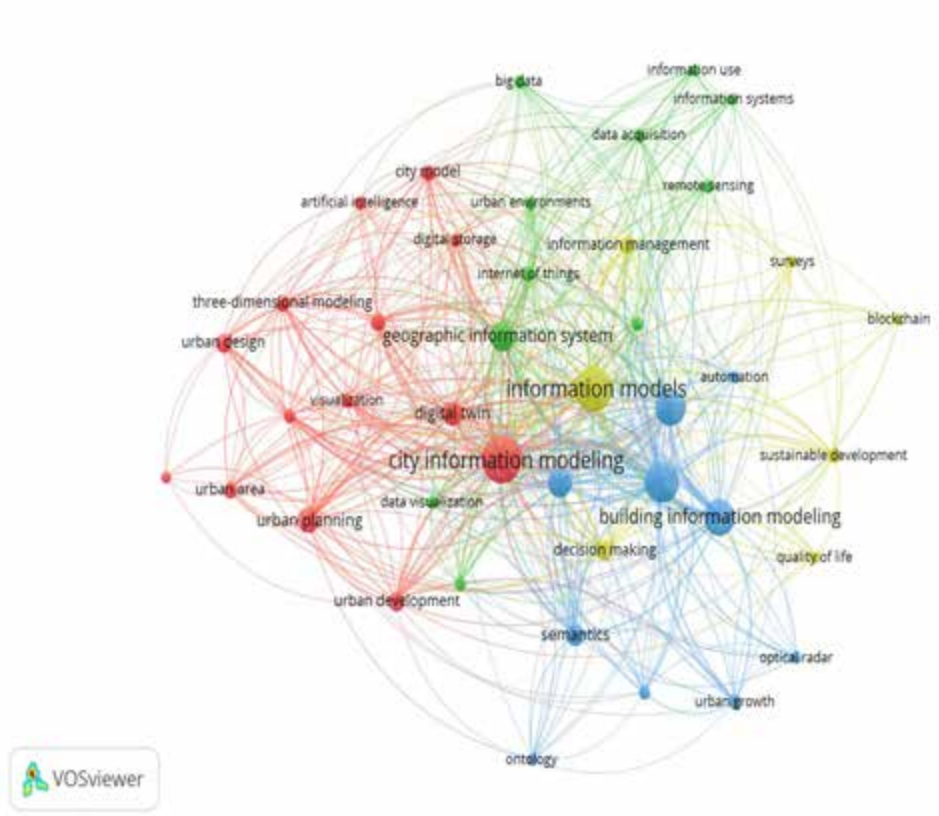

Figure (3): Analysis of the 159 documents retrieved from Scopus focusing on their keywords using VOSviewer (by authors).

• Author Co-Citation Network

To assess the intellectual structure of City Information Modeling (CIM) research, a co-citation analysis of authors was conducted using VOSviewer, with a citation threshold set at 30 citations. This approach identifies how frequently pairs of authors are cited together, highlighting core contributors and collaborative networks that shape the field.

The analysis resulted in a network visualization consisting of three author clusters, each representing a distinct epistemological orientation within the CIM discourse:

• Cluster 1 (Red): Multidisciplinary Pioneers

This largest cluster includes 13 authors with diverse disciplinary affiliations. Notable people include Biljecki, F. (56 citations; 1147 link strength) and Gil, J. (67 citations; 1171 total link strength), who are both acknowledged for their groundbreaking work at the nexus of spatial analysis, 3D modeling, and GIS. The cluster represents a wide range of study that combines planning techniques, data science, and urban informatics.

• Cluster 2 (Green): BIM-Oriented Scholars

Comprising 6 authors, this group is more tightly linked and focuses on extending Building Information Modeling principles to the city scale. Lu, W. (70 citations; 1110 link strength) and Xue, F. (65 citations; 1104 link strength) lead this cluster, contributing extensively to the development of semantic modeling, data structures, and BIM-to-CIM transition frameworks.

• Cluster 3 (Blue): Urban Design and Simulation Experts
With 5 authors, including Stoter, J. (59 citations; 1202 link strength) and Beirão, J. (43 citations; 733 link strength), this cluster specializes in spatial simulation, generative urban design, and visualization techniques. Their work bridges technical modeling and design-oriented inquiry, reflecting a synthesis between qualitative urbanism and quantitative modeling.

Across all clusters, the link strength metric reveals the intensity of co-citation relationships, underscoring the interconnectedness of leading scholars. The presence of well-known theorists such as Batty, M. (44 citations; 811 link strength) further reinforces the theoretical backbone of the field, see figure (4).

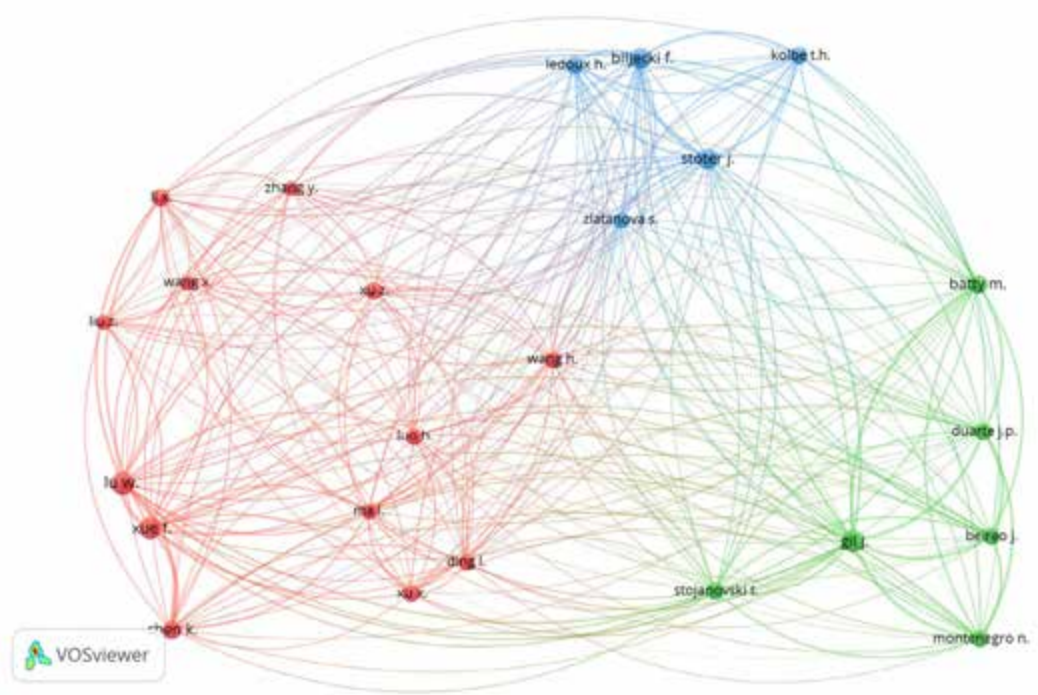

Figure (4): Network analysis based on co-citations of authors using VOSviewer (by authors).

• CiteSpace Keyword Network Analysis
To complement the bibliometric mapping of author contributions, a keyword co-occurrence analysis was conducted using CiteSpace software. This method enables a deeper understanding of thematic concentrations and emerging topics within the CIM literature by identifying central and highly connected keywords across the dataset. The analysis was based on keywords extracted from titles, abstracts, author keywords, and Keywords Plus. A g-index (k=25) was applied to define node inclusion thresholds, ensuring focus on the most influential terms.

The most frequently cited keywords reflect the foundational themes in CIM research:

Table (1): Keywords citation counts and node names by CiteSpace software (by authors).

Citation Counts	Node Name
67	information modeling
51	information theory
42	architectural design
29	cim
28	smart city
25	bim
20	digital twin
20	urban planning
15	gis
13	decision making

The importance of "Architectural Design" and "Information Modeling" attests to their function as conceptual pillars of the CIM discipline. The growing technical integration of CIM with urban digitalization and spatial analytics is indicated by keywords such as "Smart City," "Digital Twin," and "GIS."

Further insight is provided through degree and betweenness centrality metrics, which indicate the structural importance of each keyword within the network:

• Top keywords by degree (number of direct connections):
o BIM (55)
o Architectural Design (48)
o 3D Modeling (35)
o Big Data (33)
o GIS (29)

• Top keywords by centrality (influence as bridges between topics):
o BIM (0.33)
o Architectural Design (0.21)
o Information Modeling (0.19)
o Urban Development (0.19)
o 3D Modeling (0.17)

These metrics reveal that BIM functions as a pivotal bridge in the CIM discourse, connecting a wide range of subtopics from semantics and 3D environments to decision-making and sustainability. Similarly, architectural design serves as a core term linking design methodologies with information systems.

The keyword clusters derived from CiteSpace demonstrate that CIM research is shaped by three intersecting agendas:

• Technological Foundations: Emphasizing BIM, information modeling, GIS, and smart city tools.
• Design Integration: Highlighting architectural and urban design processes within digital frameworks.
• Analytical Expansion: Including big data, AI, and decision-support systems for adaptive urban planning.

UAV-Based Case Study and Workflow Development
This paper includes a field-based case study employing Unmanned Aerial Vehicles (UAVs) for 3D spatial data collecting in order to close the gap between theoretical investigation and real-world application in City Information Modeling (CIM). The objective is to assess the viability and efficiency of a UAV-to-CIM process that aids in neighborhood-scale urban planning. The Emniyettepe Neighborhood in Istanbul, Turkey's Eyüp District—an area experiencing significant urban change—has been chosen as the testbed for its execution.

• Study Area and Rationale
Emniyettepe was selected because of its diversified urban morphology, which comprises residential blocks, business corridors, green spaces, and underused areas, as well as its advantageous location close to Istanbul's central urban infrastructure. It is a typical model for testing UAV-based urban analytic technologies because of its diversity in land use and physical shape. The neighborhood's blend of public, commercial, and residential areas creates a diverse urban landscape, showcasing how flexible 3D modeling is for examining various urban typologies.

The region's usefulness as a case study is increased by its geographical and structural variety, which makes it possible to examine elements like building heights, terrain differences, and green areas. Additionally, the model could support future urban planning efforts, particularly if Emniyettepe is part of redevelopment projects or faces seismic risks, as seen across Istanbul. The practical benefits of choosing Emniyettepe include fewer regulatory hurdles for drone operations due to its moderate population density and lack of high-rise obstructions. By focusing on a moderately dense, underrepresented neighborhood like Emniyettepe, this project can showcase the scalability of drone-based modeling.

• Data Acquisition Using UAV and Photogrammetry
Data acquisition was conducted using a commercial-grade quadcopter UAV equipped with a high-resolution RGB camera. The choice of the drone depended on several aspects, firstly is its ability to capture high resolution 4k images, the images' size produced by the drone is 4000*3000 pixels, with 72 dpi resolution, all photos produced has geo-referencing according to the built-in GPS, with latitude, longitude and altitude measurements, the camera has gimbal that stabilize the image for less blurriness during the drone's motion and has the ability to capture different camera angle (oblique, aerial). Secondly, the DJI platform is compatible with different data processing tools like PIX4D mapper, Reality Capture, and Drone Deploy, Map Pilot Pro, along with its compatibility with the flight planning tools of the same platforms. Thirdly, the weight of the DJI Mavic air 2 is 570 grams, making the pilot license falls in the least license category according to the Turkish Civil Aviation Law. Lastly, the battery of the drone lasts for about 30 minutes, including the take-off and landing, giving about 18 minutes single flight maximum duration.

Flights were planned and executed under suitable weather conditions, adhering to Turkish civil aviation regulations. The photogrammetric mission covered approximately 1.2 square kilometers of urban fabric, capturing oblique images at an altitude of 80 meters. Flight paths were generated using Pix4Dcapture, ensuring 80% frontal and 70% side overlaps for accurate model generation. A total of 520 images were collected and processed in Pix4Dmapper, which generated a dense point cloud, digital surface model (DSM), orthomosaic, and 3D textured mesh. Ground control points (GCPs) were manually identified using local cadastral data to enhance the geospatial accuracy of the outputs. The final outputs serve as high-fidelity spatial datasets suitable for integration into CIM environments.

• Workflow Development: From UAV to CIM
The study proposes a replicable workflow that integrates UAV-derived data into CIM-compatible platforms. The workflow comprises the following key steps:

1. Flight Planning and Data Capture: Mission design with pre-defined overlaps and GCP targeting.

2. Image Processing: Use of Pix4Dmapper to generate georeferenced outputs, including point clouds and orthophotos.
3. Data Cleaning and Classification: Removal of noise points and classification into ground, vegetation, and structures.
4. Model Export and Conversion: Export of point clouds (.las/.xyz) and mesh models into interoperable formats (.obj, .fbx).
5. CIM Integration: Import into BIM/CIM platforms such as Autodesk Revit and InfraWorks. Point clouds are referenced using Dynamo scripts to support semi-automated model reconstruction.

This UAV-to-CIM pipeline not only enables spatially accurate modeling of existing urban conditions but also facilitates data-rich visualizations and planning simulations.

• Limitations and Technical Challenges
Several challenges were encountered during the field application. These include:

• Regulatory constraints: Flight restrictions in certain sub-areas limited full coverage.
• Data occlusion: Vegetation and narrow alleys reduced image clarity in specific zones.
• Model accuracy: While GCPs improved alignment, some distortions persisted at building edges.
• Software interoperability: Manual adjustments were required to align datasets across platforms.

Despite these constraints, the workflow proved robust in generating CIM-ready datasets with reasonable accuracy and scalability.

• Implications for Urban Planning Practice
The proposed UAV-to-CIM workflow offers a cost-effective and scalable alternative to traditional 3D city modeling methods. It enables planners, municipalities, and researchers to:

• Rapidly capture and model existing urban fabric.
• Conduct scenario testing for redevelopment or infrastructure projects.
• Integrate UAV-generated spatial data with semantic CIM databases.

This approach democratizes access to urban modeling tools, particularly for small and medium-sized cities or research institutions lacking access to high-end LiDAR or proprietary datasets.

Case Study: UAV-Based CIM in Emniyettepe, Istanbul
• Site Description and Rationale
The selected case study site for this research is the Emniyettepe Neighborhood, located within the Eyüpsultan District of Istanbul, Turkey. Emniyettepe lies at the intersection of historical legacy and contemporary urban transformation, making it a compelling environment for testing emerging City Information Modeling (CIM) techniques. The neighborhood features a mix of dense residential fabric, mid-rise housing blocks, narrow streets, and a variety of public infrastructure, characteristic of many transitional urban zones across Istanbul.

The rationale for selecting Emniyettepe is threefold. First, the neighborhood represents typical spatial conditions found in many post-industrial, middle-income areas of Istanbul, thus offering valuable insights for broader urban modeling applications. Second, it lacks recent comprehensive digital spatial documentation, presenting an opportunity to demonstrate the added value of UAV-based data acquisition in underrepresented urban zones. Third, its manageable geographic scale (approximately 0.3 km²) allows for detailed photogrammetric data collection and processing within the constraints of low-cost UAV technology and limited flight windows.

The area is also experiencing increasing planning interest due to infrastructural upgrades and population pressures. These dynamics further justify the implementation of CIM as a tool for scenario testing, urban analysis, and participatory planning processes. The study shows how UAV-enabled processes may facilitate granular, scalable, and reproducible CIM creation in congested urban environments by concentrating on a neighborhood-level site, especially in situations where the available spatial data may be out-of-date, insufficient, or unavailable.

• UAV Data Collection Methodology

A consumer-grade UAV with an RGB camera was used to collect photogrammetric data in order to create a high-resolution spatial dataset for the Emniyettepe area. Early summer 2024 provided ideal illumination and little wind interference for the airborne survey, which was carried out in pleasant weather. Pix4Dcapture software, which allowed for automatic path construction based on terrain elevation, flying height, and necessary ground sampling distance (GSD), was used to pre-plan the flight mission.

As mentioned, several flights were performed in a duration of two days. Details of these flights are as following, (1) Flight Day One: Dates 2nd of January 2025, the images were taken between 4:53 pm and 5:44 pm, the total number of the images taken were 120 images. The flight aim was mainly for the testing of the Map Pilot Pro platform after the failure in connecting the mobile app with the drone using other platforms in a free trial version. Also the timing of the flight was not accurate, which caused the images to be losing brigtness. (2) Flight Day Two: Dates 3rd of January 2025, the images were taken between 4:47 pm and 5:27 pm, the total number of images taken were 160 images, since there isn't distortion in the orthomosaic map, only oblique photos were taken, whereas all georeferenced images can be combined in the processing, see figure (5).

A total number of two oblique flights were performed, drone altitude was set to be 60 meters, in order to capture all buildings' elevations, front and side overlaps were increased to be 80% and 80% respectively, the camera angle was set to be 30 degrees not looking at grid centre (camera face along the grid lines). No ground control points (GCPs) were used in this preliminary workflow due to logistical constraints and to test the capabilities of a GCP-free approach. However, image georeferencing was performed using the UAV's onboard GPS and IMU data. While this introduces a margin of spatial error compared to GCP-aided methods, it demonstrates the feasibility of lightweight data acquisition in constrained or resource-limited urban environments.

Following data acquisition, the image set was imported into Pix4Dmapper for processing. The software executed key photogrammetric steps including image alignment (structure-from-motion), dense point cloud generation, mesh reconstruction, and orthophoto production. The outputs included a classified point cloud, a 3D textured mesh model, a digital surface model (DSM), and a high-resolution orthomosaic map.

UAVs have been widely applied in surveying, archaeology, and environmental monitoring (Fahlstrom and Gleason, 1993; Sauerbier and Eisenbeiss, 2010). The UAV-based data collection workflow adopted in this study highlights the potential of cost-effective photogrammetry for producing CIM-compatible datasets at the neighborhood scale. It also underscores the accessibility of drone-based urban modeling for researchers and planning practitioners working with limited technical infrastructure.

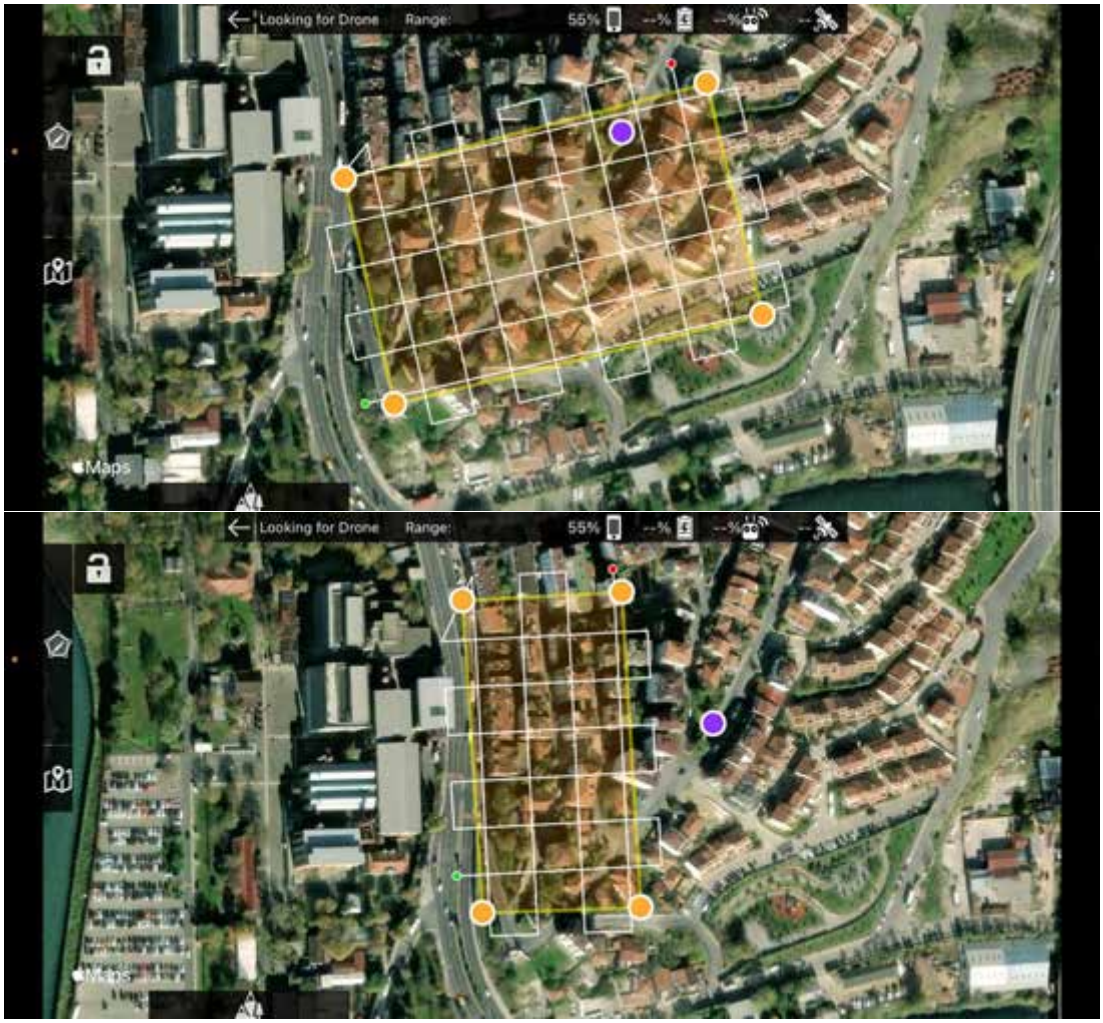

Figure (5): Map Pilot Pro platform.

• Point Cloud Processing and Model Preparation
Following UAV-based data acquisition, the image set was processed in Pix4Dmapper to generate a dense point cloud representing the Emniyettepe neighborhood's built and natural environment. This raw point cloud contained millions of georeferenced spatial data points, encoding x, y, z coordinates and RGB values for each sampled surface.

To prepare the dataset for integration into a City Information Modeling (CIM) workflow, several processing steps were undertaken:

o Noise Reduction and Point Cloud Cleaning
Initial filtering was performed to eliminate erroneous or floating points often resulting from poor lighting or reflective surfaces (e.g., glass facades, water puddles). The point cloud was then decimated to reduce density in less relevant areas while preserving critical architectural and morphological features. This process was conducted using CloudCompare, an open-source 3D point cloud processing software.

o Classification and Segmentation
Points were semi-automatically classified into ground, building, and vegetation categories using colorimetric and elevation-based rules. Manual adjustments were applied in areas where automated classification proved

insufficient, such as shadowed alleys or high-density tree canopies. Segmenting the point cloud into thematic layers allowed for greater control and selectivity during subsequent modeling operations.

o Mesh Reconstruction and Texturing
From the cleaned and classified point cloud, a 3D mesh was reconstructed using the Delaunay triangulation method in Pix4Dmapper. Textures extracted from original UAV images were overlaid on the mesh to enhance visual realism and enable context-aware urban analysis. The resulting textured mesh model provides an intuitive and scalable representation of neighborhood morphology.

o Format Conversion and BIM/CIM Compatibility
To enable downstream use in urban planning environments, the outputs were exported in open formats such as. LAS, .OBJ, and .FBX. Additionally, for future integration with Building Information Modeling (BIM) or CIM environments (e.g., Autodesk Revit, InfraWorks, or openCIM platforms), the processed point cloud was prepared for import into Dynamo scripts and Rhino-Grasshopper pipelines, facilitating procedural modeling and semantic enrichment. Through this multi-step approach, a photorealistic and spatially accurate 3D urban model was derived, serving as the foundation for neighborhood-scale CIM applications. The methodology underscores the adaptability of low-cost UAV workflows in producing structured urban datasets suitable for further analysis, simulation, and planning.

Drone-based imaging was conducted to capture high-resolution data for urban analysis, utilizing a DJI FC3170 camera. A total of 160 geolocated images were captured and processed using the Pix4D cloud platform, achieving 100% calibration success. The project was conducted using the WGS 84 / UTM zone 35N + EGM2008 height coordinate system, ensuring a consistent spatial reference for accurate mapping and analysis. The average Ground Sampling Distance (GSD) was 0.03617 meters, indicating the dataset's high spatial resolution and suitability for detailed 3D modeling and analysis.

The Pix4D platform's processing workflow highlighted exceptional quality checks throughout the project. The median number of keypoints per camera was 35,611, with an impressive 12,176 median matches per camera, demonstrating the robustness of image matching and calibration. Additionally, all 160 images were successfully geolocated, providing a solid foundation for generating accurate 3D models. The relative difference between initial and optimized camera parameters was 8.67%, further emphasizing the calibration process's precision. The dataset generated a 3D Ray Cloud comprising 774,731 points, which is critical for detailed reconstruction and urban feature analysis, see figure (6).

The quality checks also assessed absolute geolocation and orientation variances, with errors minimized across X, Y, and Z axes to ensure accurate spatial representation. Orientation errors for omega, phi, and kappa were similarly controlled, enabling precise 3D positioning and alignment of the images. The high density of observed keypoints and the low rate of weak matches validate the dataset's integrity and its potential for generating reliable outputs, such as Digital Surface Models (DSMs), Digital Terrain Models (DTMs), and orthomosaics.

Processing via the Pix4D cloud platform proved efficient and effective, particularly for a neighborhood-scale project. The integration of drone-based imaging with Pix4D facilitated the creation of detailed outputs for urban analysis. These include potential applications in infrastructure planning, land-use mapping, and environmental assessments (Shi et al., 2015). The ability to process a compact but detailed dataset underscores the feasibility of using drones for urban studies, with Pix4D providing a streamlined workflow for high-quality results.

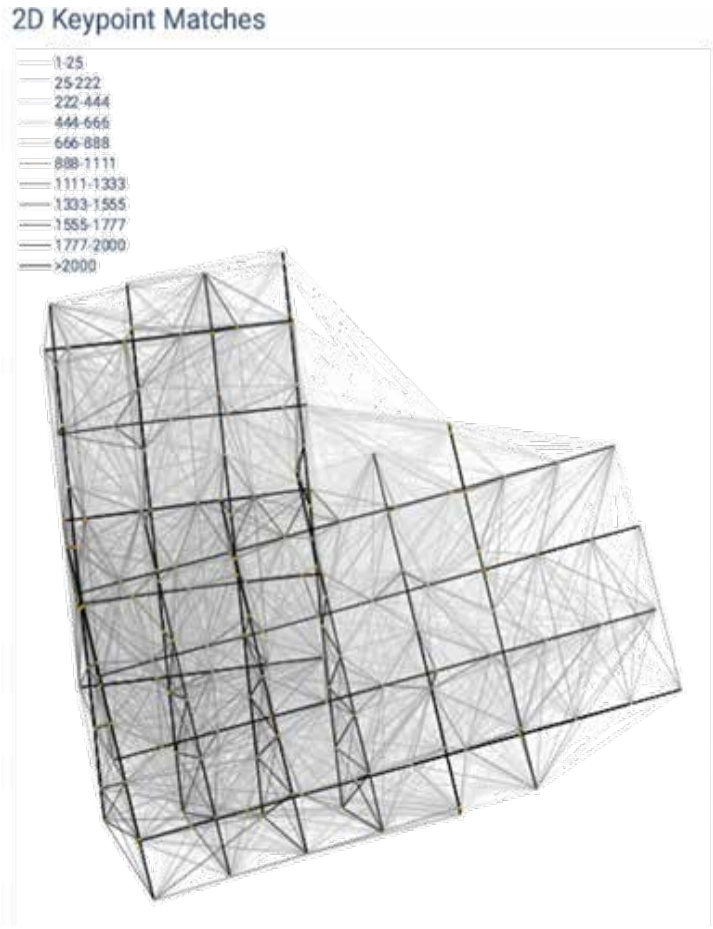

Figure (6): 2D key point matches of drone imageries.

• UAV-to-CIM Workflow and Integration

The processed point cloud and reconstructed 3D mesh were subsequently integrated into a City Information Modeling (CIM) workflow designed to support neighborhood-scale urban analysis and planning. This workflow aims to demonstrate how low-cost UAV photogrammetry can be translated into structured, analysis-ready models that are both visually rich and semantically informative.

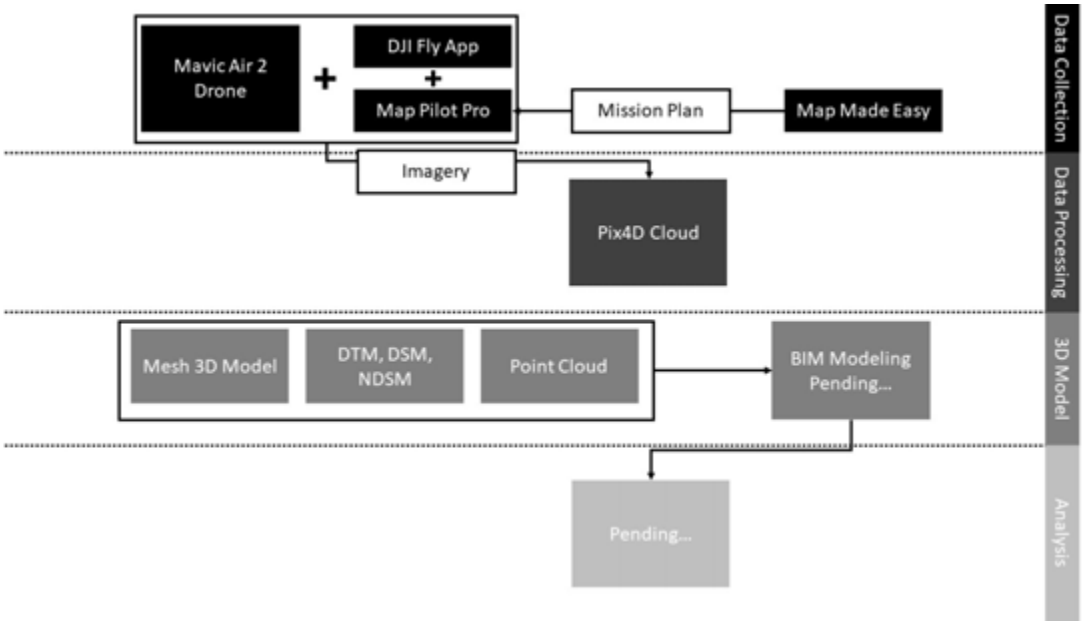

Figure (7): Workflow overview.

o Workflow Overview, see figure (7):
The UAV-to-CIM workflow developed in this study consists of five primary stages:

1. Aerial Data Acquisition (via UAV photogrammetry)
2. Image Processing and Point Cloud Generation (Pix4Dmapper)
3. Point Cloud Cleaning, Segmentation, and Mesh Reconstruction (CloudCompare & Pix4D)
4. Semantic Enrichment and Model Structuring (Rhino + Grasshopper)
5. CIM Visualization and Analysis (QGIS, Unity, or BIM tools)

This modular structure enables iterative refinement and potential expansion to include additional datasets such as cadastral layers, mobility networks, or environmental indicators.

o Semantic Modeling and Attribute Assignment
In order to transition from a visual 3D model to an information-rich CIM dataset, the mesh and point cloud were imported into Rhino and processed through Grasshopper scripts. Basic semantic attributes were assigned to key elements—such as building footprints, roof types, terrain surfaces, and vegetation clusters—allowing for basic querying and spatial categorization.

Where available, public GIS data (e.g., land use, parcel boundaries) were overlaid to spatially align real-world urban attributes with the drone-derived model. This integration facilitates early-stage urban assessments such as shadow analysis, density estimation, and accessibility studies.

o Use Case Scenarios and Planning Potential
The finalized CIM prototype enables a variety of planning-related applications, including:

- Neighborhood diagnostics: Visualizing built-environment morphology and open space distribution.
- Scenario testing: Modeling development options or simulating interventions at a detailed level.
- Stakeholder engagement: Enhancing communication with policymakers or community members through immersive and spatially accurate 3D models.

• Heritage documentation and resilience planning: Archiving current conditions of historically significant structures or assessing exposure to environmental risks (e.g., landslides, flooding).

The system remains scalable and open-ended, with potential for future automation via AI-based classification and integration with Internet of Things (IoT) urban sensing platforms.

• Workflow Limitations
Despite its strengths, the UAV-to-CIM workflow faces several challenges:

1. Data size and processing time: High-resolution point clouds and meshes require significant storage and computing resources.
2. Semantic limitation: Manual or semi-automated classification still relies on domain expertise and lacks standardized ontologies for CIM.
3. Scalability: While effective at the neighborhood scale, scaling to entire city districts requires adjustments in flight planning, data fusion, and computing infrastructure.

• Process Output
Below is a detailed overview of the generated outputs and their quality, as described in the quality report:

Point Cloud: The 3D point cloud generated during the processing included a total of 774,731 points, derived from the dense matching of 2D keypoints. The high number of observed 3D points reflects excellent feature extraction and matching. The distribution of 3D points indicates good coverage across the area, with keypoints observed in multiple overlapping images, increasing the accuracy and robustness of the reconstruction. The report indicates that most points were observed in 3-6 images, which enhances the reliability of their 3D coordinates. However, a small percentage of points were observed in more than 10 images, leading to high precision for specific features. The average ground sampling distance (GSD) of 0.03617 meters further underscores the high resolution and suitability of the point cloud for detailed urban analysis, see figure (8).

Figure (8): 3D point cloud.

Digital Terrain Model (DTM): The DTM created provides a clear representation of the terrain, excluding structures and vegetation. The processing used dense sampling and geoid-based height data (EGM2008) to ensure accurate elevation values. Given the GSD and the precise geolocation of input images, the DTM exhibits minimal vertical errors, as highlighted by the geolocation error checks.

The elevation of every element in the region, including plants, buildings, and other structures, is reflected in the Digital Surface Model (DSM). The DSM benefits from the high-resolution input images and accurate image matching, ensuring detailed height data for urban structures. Errors in height estimation were minimal, with the RMS error for geolocation at 0.826 meters, which is within acceptable limits for urban analysis, see figure (9).

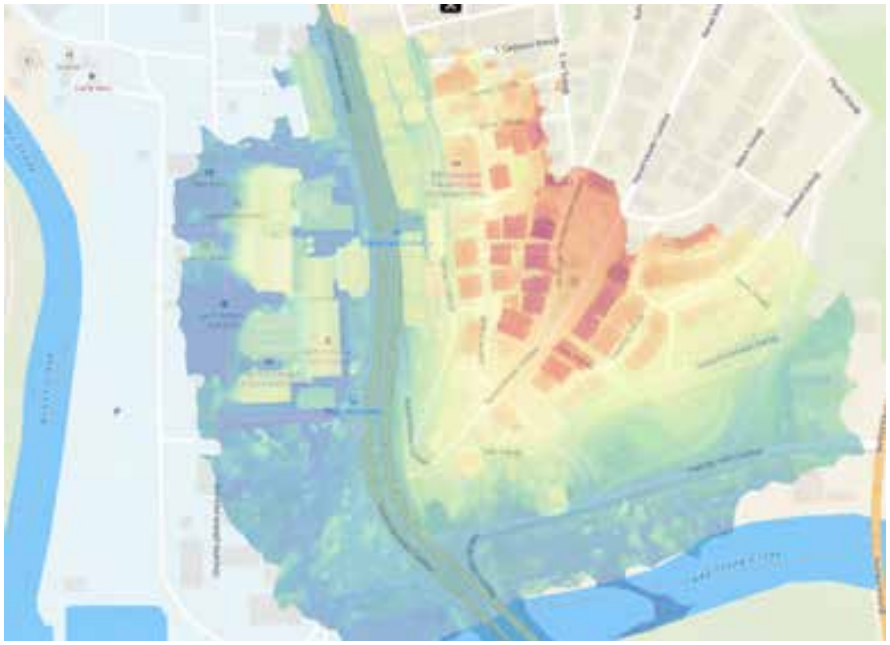

Figure (9): Digital Surface Model (DSM).

Orthomosaic: An orthomosaic was generated using the captured images, providing a georeferenced 2D representation of the area. The orthomosaic benefits from the high GSD, ensuring exceptional clarity and detail, with no major distortions noted in the quality checks, see figure (10).

Figure (10): orthomosaic was generated using the captured images.

3D Mesh Model: A 3D mesh model was created from the dense point cloud, integrating texture data from the input images. The mesh model captures the geometric and visual properties of the area, providing a detailed and realistic representation of the neighborhood (Nan and Wonka, 2017; Lafarge and Mallet, 2012; Oesau et al., 2016). The relative difference between initial and optimized camera parameters (8.67%) indicates successful alignment and calibration, ensuring the quality and accuracy of the mesh, see figure (11).

Figure (11): 3D Mesh Model.

The outputs generated from the drone data include high-quality DSM, DTM, point cloud, orthomosaic, and 3D mesh model, each with minimal errors and high precision. These deliverables provide a comprehensive basis for urban studies, including land use mapping, infrastructure assessment, and planning. The processing quality ensured by Pix4D highlights the effectiveness of the workflow for creating reliable and accurate models from drone imagery.

Findings and Discussion

This section synthesizes the insights derived from both the bibliometric literature review and the UAV-based field implementation. The dual-method approach provides a nuanced understanding of City Information Modeling (CIM), highlighting not only its theoretical evolution but also its practical feasibility in real-world urban contexts.

• Key Insights from the Literature Review

The systematic review conducted using the BSMS-PRISMA framework revealed several thematic and methodological patterns across the 159 CIM-related documents retrieved from Scopus:

1. Discipline Focus: While planning theory, social equality, and public engagement in digital modeling are covered in comparatively few publications, the bulk of CIM research are focused on the domains of engineering, computer science, and architecture.
2. Trends in Keywords: Words like “information modeling,” “BIM,” “smart city,” and “urban planning” showed up a lot, indicating a good desire to combine digital technology with urban administration. Emerging keywords like “digital twin” and “blockchain” signal the increasing diversification of CIM applications.
3. Author Networks and Citation Patterns: Co-citation and keyword network analyses identified a handful of pro-

lific authors (e.g., Gil J., Stoter J., Biljecki F.) who form intellectual clusters. These networks point to evolving research communities and schools of thought within CIM.
4. Gaps Identified: The review also exposed gaps, particularly in the standardization of CIM workflows, limited integration of environmental datasets, and lack of attention to citizen-centered or participatory modeling approaches.

• Key Insights from the UAV-Based Workflow
The practical application of UAV photogrammetry in the Emniyettepe Neighborhood demonstrated several capabilities and limitations of drone-based CIM integration:

o Feasibility and Accessibility: The UAV-based workflow proved effective in generating high-resolution, georeferenced 3D models using commercially available drones and software. This confirms the viability of cost-efficient data collection methods, particularly in under-resourced urban settings.
o Accuracy and Detail: The derived models captured detailed architectural and topographical features, suitable for various urban analyses such as land-use visualization, elevation profiling, and density assessment.
o Semantic Potential: While the point cloud and mesh were successfully processed into visually accurate models, the transition into fully semantically enriched CIM datasets remains partially manual. This presents a challenge for automation and scaling.
o Replicability: The proposed five-step UAV-to-CIM workflow is modular and adaptable, suggesting potential for deployment in other urban contexts with minimal reconfiguration.

• Theoretical and Practical Convergence
By pairing literature insights with real-world implementation, this study highlights the converging trajectories of theoretical research and applied urban modeling:

o From BIM to CIM: The strong conceptual link between BIM and CIM found in literature is mirrored in the UAV workflow, where BIM tools and logic were repurposed for urban-scale applications.
o Bridging Gaps: The empirical case study addresses gaps identified in the literature, particularly the need for standardized, low-cost, and scalable workflows for city modeling.
o Urban Planning Implications: For urban planners and policymakers, the findings suggest that CIM can be effectively initiated at the neighborhood scale, serving as a decision-support tool for both long-term planning and rapid diagnostics.

• Limitations and Considerations
Several constraints emerged during the study:

o Temporal Staticity: UAV-based models represent a static snapshot in time, limiting their ability to reflect dynamic urban processes without continuous data updates.
o Data Fusion Complexity: Integrating UAV data with other municipal datasets (e.g., cadastral, infrastructure, sensor data) remains technically and administratively challenging.
o Governance and Ethics: As CIM platforms increasingly incorporate detailed urban and citizen data, ethical concerns around surveillance, privacy, and data ownership must be addressed in future studies.
o Despite their benefits, UAV operations face evolving regulatory frameworks (Stöcker et al., 2017).

Conclusion and Future Work

This study investigated the evolving landscape of City Information Modeling (CIM) through a dual-method approach that combined a systematic literature review using the BSMS-PRISMA framework with a practical UAV-based case study in the Emniyettepe neighborhood of Istanbul. By identifying dominant patterns in the scholarly literature and assessing the viability of an approachable, reproducible workflow for urban-scale data modeling, the study sought to close the conceptual and practical gaps in CIM.

Although CIM has attracted increasing interest from a variety of fields, including engineering, computer science, and architecture, the literature analysis found that it currently lacks standardized tools, thorough frameworks, and extensive application in actual urban settings. In situations where traditional data sources could be out-of-date or unavailable, the UAV-based pilot research showed how drone photogrammetry might assist CIM operations in a technically possible and cost-effective way.

The study adds to the continuing discussion on the relevance, scalability, and integration of CIM within urban planning practice by contrasting bibliometric findings with actual application. The findings confirm that CIM is not merely a conceptual extension of BIM but a distinct paradigm requiring its own methodologies, toolchains, and interdisciplinary governance structures.

Future research should focus on several key directions:

1. Developing automated workflows for semantic enrichment of 3D models to reduce reliance on manual post-processing;
2. Using artificial intelligent powered platforms to generate 3D models using descriptive text and integrating them into CIM. (Liu et al., 2023)
3. Scaling the UAV-to-CIM framework to other urban environments to test generalizability and adaptability.

Final Remarks and Acknowledgements

It is important to note that the final conversion of the textured mesh model into a fully operational 3D City Information Model (CIM)—including semantic enrichment, object classification, and integration into BIM/CIM platforms like Revit—is still a pending task and constitutes a subsequent phase of this research. This work forms part of an ongoing thesis project, and further technical development and validation will be addressed in the upcoming stages. The author gratefully acknowledges Istanbul Technical University and Türkiye Scholarships (Türkiye Bursları) for academic support.

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Advanced Quantification of Urban Complexity and Adaptive Capacity: Sub-Fractal Analysis and Spatial Statistics in Izmir

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Abstract
This study evaluates the adaptive capacity of İzmir, Turkey, by applying sub-fractal and difference analysis to assess urban complexity from the 1950s to 2020s. Using principles of fractal geometry (Batty & Longley, 1994), it quantifies the morphological evolution of the city's road network to determine resilience to socio-environmental change. The findings identify a consistent Adaptive Capacity Range (ACR) of 0–0.25, indicating moderate adaptability constrained by structural thresholds (Özdemir, 2021; Erdoğan, 2021). Drawing on statistical mechanics and theoretical physics, the study introduces computational tools for modelling urban expansion (Salingaros, 2010) and offers a transferable framework for resilience assessment (Triantakonstantis, 2012; Jiang & Yin, 2014). This interdisciplinary approach advances understanding of urban complexity and provides a replicable model for analysing adaptive capacity in dynamic city systems.

Keywords: Adaptive Capacity, Sub-Fractal Analysis, Urban Complexity, Urban Planning, Fractal Geometry, Urban Growth

1. Introduction

The dynamics of urban complexity and adaptive capacity occupy a central position in contemporary urban planning theory. These constructs embody the multifaceted interactions between spatial configurations, infrastructural systems, and the socio-economic mechanisms that sustain urban life (Salingaros, 2005). Adaptive capacity, originally conceptualized within ecological and environmental sciences, refers to a system's potential—whether biological, ecological, or social—to adjust to disturbances and changes while preserving its fundamental functions (Salingaros, 2010). Closely tied to the notion of resilience, it denotes a system's ability to reorganize amidst disruptions without forfeiting its core identity and operational integrity.

This concept aligns conceptually with the principles of fractal geometry, which have proven instrumental in interpreting urban form and complexity (Batty & Longley, 1994). Fractal geometry elucidates urban spatial organization and developmental trajectories by revealing scale-invariant and self-similar patterns—allowing complexity to be both measured and visualized (Triantakonstantis, 2012). Situated within this analytical framework, the present study employs fractal methodologies to explore the morphological development of İzmir, Turkey, tracing the evolution of its urban spatiality across decades shaped by both deliberate planning and spontaneous transformation (Özdemir, 2021; Erdoğan, 2021).

As Turkey's third-largest metropolitan area, İzmir offers a compelling case for examining urban adaptability through the lens of sub-fractal analysis (Erdoğan, 2021). This technique dissects the granularity of urban forms across varying scales, thereby illuminating how spatial structure influences responsiveness to socio-econom-

ic and environmental perturbations (Jiang & Liu, 2009). In tandem, difference analysis tracks temporal shifts in fractal configurations, providing empirical evidence of the impacts of historical planning initiatives and unforeseen urban developments. Anchored in interdisciplinary theory spanning urban morphology and computational physics, the study utilizes quantitative methods to interrogate the nexus between form and adaptive functionality (Jiang & Claramunt, 2004; Jiang & Yin, 2014).

By integrating these analytical tools, the research articulates actionable insights for urban policy and planning, advocating for data-informed strategies that bolster urban resilience and adaptability (Salingaros, 2005; Özdemir, 2021). Ultimately, the study advances the formulation of standardized methodologies capable of evaluating adaptive capacity across diverse urban settings, contributing to a globally relevant framework for resilience assessment (Batty & Longley, 1994; Triantakonstantis, 2012).

2. Measurement Techniques and Data

Urban complexity constitutes a foundational dimension in evaluating cities' capacity to adapt to evolving socio-spatial and environmental dynamics. Among the most salient methodological tools for investigating this complexity is fractal analysis, which offers a quantitative framework for identifying recursive, self-similar patterns inherent in urban form—patterns that elucidate dynamics of sprawl, density, and morphological transformation (Batty & Longley, 1994; Frankhauser, 1998). Extending this approach, sub-fractal analysis interrogates the internal complexity of specific urban elements, thereby revealing fine-grained heterogeneities that are often obscured at broader scales (Allain & Cloitre, 1991). In the context of İzmir, such an analysis facilitates the exploration of inter-district variability in spatial complexity, closely tied to differential capacities for urban adaptation.

Difference analysis complements this by capturing temporal shifts in urban complexity through comparative evaluations of fractal dimensions across multiple historical junctures. This technique effectively foregrounds the impact of strategic planning decisions and unanticipated perturbations on the urban fabric, rendering visible structural discontinuities in density and sprawl patterns (Batty & Longley, 1994). Applied to İzmir, it enables a retrospective assessment of how specific interventions have altered resilience trajectories. To operationalize an assessment of İzmir's adaptive capacity, sub-fractal analysis is employed to measure the evolution of the city's road network across temporally distinct phases, as indicated by fluctuations in fractal dimensionality (Salingaros, 2010; Jiang & Yin, 2014). This methodological lens serves to index the structural plasticity of the urban grid by mapping its complexity dynamics over time. The empirical basis for this analysis comprises a series of high-resolution cartographic datasets from the General Directorate of Maps, each rendered at a 1:25,000 scale and covering İzmir's metropolitan territory during four historical intervals: 1958–1964, 1974–1980, 1996–2000, and 2012–2020. These maps, standardized in cartographic design and digitally harmonized via NetCAD software, provide a coherent temporal sequence for evaluating the morphogenetic evolution of the urban road network. Subsequent image processing and complexity quantification are conducted using Frac_Lac software, with parameters set at a 1%-pixel ratio and an R^2 coefficient consistently exceeding 0.999, ensuring statistical reliability. The spatial scope of the study is carefully delineated to coincide with İzmir's official metropolitan jurisdiction during each examined period, particularly aligning with the master planning boundaries that underpin the respective base maps of the urban transportation network. Within these demarcated regions, a corpus of sixteen geospatially referenced maps is analyzed to estimate the city's adaptive resilience. The master plans informing this analysis include:

- The 1952 competition proposal by Aru, **Özdeş**, and Canpolat, revised in 1955.
- The 1972 Metropolitan Planning Office's Plan, authorized in 1973 and revised in 1978.
- The 1989 1/50,000 scale plan by the Metropolitan Municipality.
- The 2012 1/25,000 scale plan by the Metropolitan Municipality of İzmir.

3. Methodology

3.1. Sub-fractal and Sub-fractal Difference Analysis

Sub-fractal analysis constitutes a refined methodological approach for interrogating the spatial intricacies of urban form by isolating and quantifying the geometric complexity of discrete urban components—such as transportation infrastructures or neighbourhood morphologies. Rooted in the theoretical underpinnings of fractal geometry, this technique elucidates scale-invariant, self-replicating patterns that typify urban spatial organization (Frankhauser, 1998; Chen, 2021).

Operationalized through a mesh-grid framework, sub-fractal analysis determines the minimal count of non-overlapping square boxes, denoted as $N_{(S)}$, necessary to comprehensively enclose a given urban structure at a specified box size S. The fractal dimension D, an index of spatial complexity, is derived from the linear relationship between the natural logarithms of $N_{(S)}$ and S, where the slope of the resulting log-log regression line yields:

$$D = \lim_{\Delta_S \to 0} \left(- \frac{ln\, N_S}{ln\, S} \right)$$

The regression model is typically expressed as:

$$ln\, N_S = A + D\, ln \left(\frac{1}{S} \right) + E_S$$

In this regression-based approach, A signifies the intercept, D denotes the estimated fractal dimension, and E_S represents the standard error term associated with the model. The robustness of this method is affirmed by its requirement for a coefficient of determination typically exceeding $R^2 > 0.999$, as demonstrated in the work of Thomas and Frankhauser (2013). For the application in İzmir, the sub-fractal analysis was conducted on the map encompassing the most extensive geographical coverage within the delineated urban planning boundaries. A minimum analytical window of 800 m × 800 m was employed, corresponding to a 1%-pixel resolution, which enabled a high-resolution assessment of spatial complexity across multiple temporal epochs (see Figure 2 for visualization). Building upon this foundation, sub-fractal difference analysis examines temporal shifts in spatial complexity. This technique involves computing the variation in sub-fractal dimension values for each individual grid cell across two temporal snapshots. The change is expressed as:

$$\Delta Sf = Sf_{post} - Sf_{pre}$$

Where Sf_{pre} denotes the sub-fractal value in the pre-plan period and Sf_{post} indicates the corresponding value in the post-plan period, the resulting ΔSf expresses the net change in spatial complexity. This differential value serves as a quantitative indicator of morphological transformation, signalling either an increase or a decrease in urban complexity (Chen, 2021; Thomas & Frankhauser, 2013). The computed ΔSf values are systematically grouped into fixed intervals, typically segmented using a threshold of 0.25, to establish what is referred to as the Adaptive Capacity Range (ACR). The ACR represents the standard interval within which complexity changes are considered typical across the urban landscape. Subsequently, a visual map is generated to spatially represent the variation in ΔSf values, employing a color-coded gradient to differentiate the magnitude and direction of change:

- Cool colors (indicating negative ΔSf values) reflect a reduction in complexity.
- Warm colors (indicating positive ΔSf values) signify an increase in complexity.

This cartographic output (see Figure 3) captures the spatiotemporal dynamics of urban transformation, illuminating how different zones within İzmir react to urban planning interventions. By analysing these fluctuations, the study provides a nuanced assessment of the city's adaptive responses over time, revealing patterns of resilience and structural evolution shaped by specific policy decisions (Sutton et al., 1997; Thomas & Frankhauser, 2013).

3.2. Statistical Analysis of *Adaptive Capacity Range*

Within the framework of urban systems theory, the capacity to adapt to environmental, socio-economic, or institutional perturbations is a foundational determinant of long-term sustainability and functional integrity. The Adaptive Capacity Range (ACR) serves as a diagnostic metric for assessing this resilience. A positive ACR value signifies that the urban system is endowed with sufficient structural and organizational flexibility to withstand and absorb external shocks, thereby maintaining continuity and performance under changing conditions. In contrast, an ACR value that approaches zero or becomes negative would imply an absence of adaptive mechanisms, effectively indicating systemic rigidity and heightened vulnerability to disruption—conditions that could precipitate breakdown or systemic collapse. Such a scenario is antithetical to the principles of urban resilience, which posit that adaptive capacity is an indispensable element in sustaining viable urban environments (Ahern, 2011).

Consequently, by theoretical and practical definition, ***ACR must invariably assume a positive value to meaningfully reflect the presence of adaptability.*** A zero or negative ACR would conceptually denote total incapacity for adjustment—an implausible condition for any operational urban system. Positive ACR values thus ensure the existence of a minimal threshold of resilience embedded within the spatial and functional structure of the city.

The Adaptive Capacity Range (ACR) is formally defined as:

$$ACR = [\mu - k\sigma, \mu + k\sigma] \ \ where \ \mu - k\sigma > 0$$

In this formulation, μ represents the arithmetic mean, σ denotes the standard deviation, and k is a coefficient corresponding to a selected confidence interval.

To ensure that the Adaptive Capacity Range (ACR) robustly captures the central tendencies of adaptive behaviour, both the mean and median values from each analysed time period are incorporated. The inclusion of these statistical descriptors is essential: the mean reflects the average tendency across all grid cells, while the median highlights the central point of the data distribution, mitigating the influence of outliers or skewed patterns. This dual-statistic approach allows for a more comprehensive representation of urban adaptability over time (Hu & He, 2018).

Without accounting for both the mean and the median across all measurement intervals, key variations in adaptive capacity may remain undetected, thereby compromising the reliability and interpretive depth of the analysis. ***Therefore, for the ACR to effectively capture the dynamics of urban resilience, it must systematically include the mean and median values derived from each temporal stage of analysis.***

Formally, for each time period ti, the ACR is defined as a function of both:

$$ACR(t_i) = [\mu(t_i) - k\sigma(t_i), \mu(t_i) + k\sigma(t_i)] \ \ where \ \mu(t_i) - k\sigma(t_i) > 0$$

In this framework, μ(ti) and i(ti) denote the mean and standard deviation of adaptive capacity at a given time point ti, respectively.

Sub-fractal analysis, by its design, enables the detection of fine-grained spatial variations embedded within the urban morphological structure. To preserve the analytical coherence of the Adaptive Capacity Range (ACR) as a holistic indicator of variability, it is imperative that differences in sub-fractal mean values across time intervals remain bounded within the limits defined by the ACR. This constraint ensures that abrupt anomalies or exaggerated deviations do not compromise the validity of the model, thereby sustaining the consistency and robustness of longitudinal interpretations.

Accordingly, the deviation between sub-fractal means at any two measurement points must not surpass the ACR. This stipulation guarantees that the variability in adaptive behaviour, as indexed by mean sub-fractal values, is effectively encapsulated within the expected bounds of system adaptability. It mitigates the risk of statistical distortion and upholds the integrity of the model's predictive and descriptive capacities. More precisely, to avoid overstating variability, the absolute difference in sub-fractal means must never exceed twice the amplitude (2A) of the ACR. Here, the amplitude A denotes the maximum permissible deviation from the central value (typically the mean) within the ACR. Constraining sub-fractal variability to within ±A ensures symmetrical balance, while enforcing the 2A threshold prevents the emergence of outlier patterns that could misrepresent adaptive trends.

This condition is formally expressed as:

$$2A \geq \left|\mu(t_i) - \mu(t_j)\right|$$

In this context, **A** denotes the amplitude, which defines the extent of variability within the Adaptive Capacity Range (ACR). A narrower amplitude reflects a more tightly bounded range of adaptive capacity, offering enhanced interpretive precision.

High data density within a confined interval signifies that a substantial proportion of the sub-fractal values are concentrated near the central tendency, thereby suggesting a stable and consistent characterization of the system's adaptability. This characteristic is fundamental for calibrating the ACR in a manner that ensures both statistical rigor and predictive reliability. A well-optimized ACR, grounded in high-density intervals, provides a resilient basis for assessing long-term urban adaptability under varying conditions (Weisstein, n.d.; Montgomery & Runger, 2014).

By focusing on regions of maximal data concentration, the methodology effectively filters out outliers and anomalous values, ensuring that the resulting metric reflects a dependable and coherent measure of adaptive behaviour. ***Thus, the ACR is defined as the narrowest range that encompasses the highest data density while satisfying all required statistical constraints. This ensures that the ACR functions not only as a bounded interval of change but as a robust and analytically sound index of urban system resilience.***

To further refine this characterization, a Gaussian (normal) distribution is applied to model the data, allowing for the identification of the central cluster and enhancing the accuracy of range determination.

The probability density function (PDF) of a normal distribution is expressed as:

$$P(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where x is the variable of interest, μ denotes the mean, and is the standard deviation. The interval exhibiting the highest data density is selected to define the Adaptive Capacity Range (ACR), as it contains the most concentrated portion of the distribution. High data density within this range indicates that the majority of observations are tightly clustered around the mean, signifying a consistent and representative measure of adaptive capacity. This central clustering provides the statistical foundation for the ACR.

Mathematically, this density concentration can be represented by integrating the PDF over the interval surrounding the mean:

$$\int_{\mu-k\sigma}^{\mu+k\sigma} f(x)d(x)$$

This integral quantifies the total probability (or cumulative density) of data points lying within the range, where k is a coefficient determining the breadth of the interval. The selected interval is the one that yields the highest probability mass while maintaining analytical precision, ensuring that the ACR reflects the most stable and recurrent patterns in adaptive behaviour.

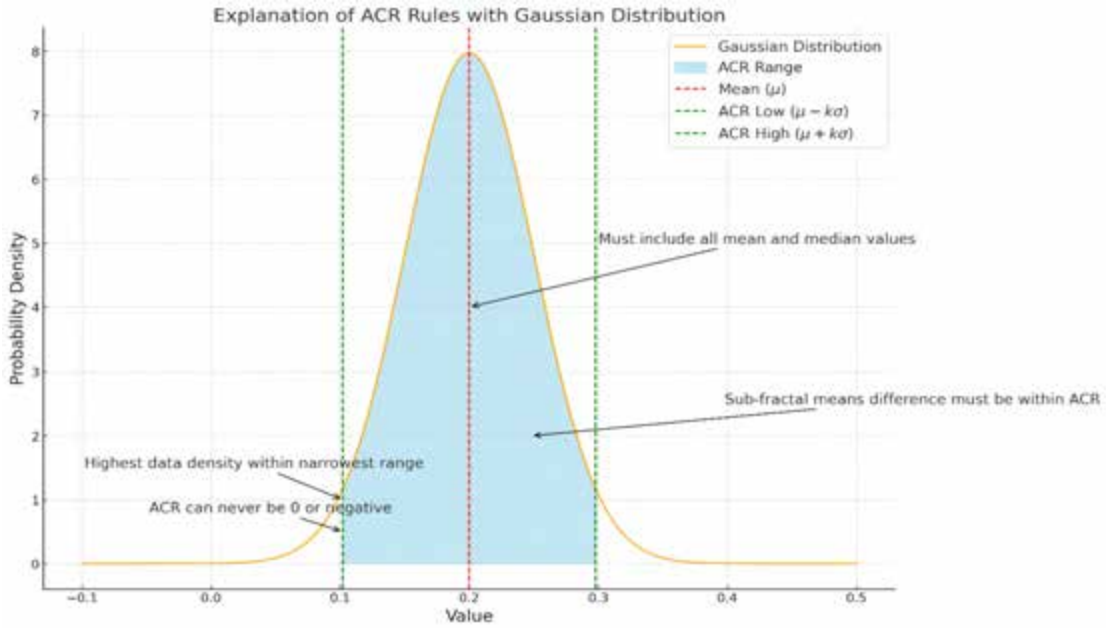

Figure 1. Conceptual Representation of Adaptive Capacity Range (ACR) Conditions Modelled with a Gaussian Distribution.

The graph presented in Figure 1 visualizes four fundamental criteria governing the definition of the Adaptive Capacity Range (ACR) within a Gaussian distribution framework:

• The ACR must remain strictly positive to signify the presence of adaptive potential, as indicated by the distribu-

tion's non-zero probability density.
• It must encompass both the mean and median values across time periods, visually marked by the red dashed line denoting the mean.
• Differences in sub-fractal mean values must fall entirely within the ACR bounds, illustrated by the extent of the blue-shaded region.
• The optimal ACR corresponds to the interval exhibiting the highest data density within the narrowest feasible range, also represented by the blue-shaded area, ensuring both statistical robustness and adaptive relevance.

4. *Sub-Fractal Analysis* of the Izmir City System by Related Plan Boundaries

The study operationalized sub-fractal analysis by structuring network data into spatial maps delineated by historical master plan boundaries. A total of sixteen sub-fractal analysis maps were produced, each corresponding to distinct phases in İzmir's urban planning history. For each planning interval, both the initial (pre-plan) and post-plan states were precisely defined, allowing for the accurate subtraction of sub-fractal box values to generate differential maps. These maps were constructed by calculating the change in sub-fractal dimension values between the two time points, denoted as t_1-t_0.

• Kemal Ahmet Aru's İzmir Plan (1955):

The initial state corresponds to 1950 (Period I), and the post-plan state to 1970 (Period II). The comparative analysis of urban network characteristics under the influence of the 1955 Kemal Aru Plan reveals significant transformations in İzmir's spatial structure over this 20-year span. Using a consistent analytical framework based on 81 sub-fractal boxes per network map (Figure S4), the fractal dimension increased from 1.49 in 1950 to 1.55 in 1970. This upward shift signifies an intensification in spatial complexity, likely driven by increased urban development and diversification. In parallel, the average sub-fractal box value—a finer metric for spatial distribution—rose from 1.188 to 1.341, yielding a net change of 0.152. This trend underscores the densification and increasing emergence of self-similar patterns in the city's infrastructural layout.

• İzmir Metropolitan Municipality (IMM) Plan (1973–1978):

The initial condition is set in 1970 (Period II), with the post-plan state established in 2000 (Period III). The comparative analysis across these three decades under the IMM Plan framework demonstrates continued evolution in urban spatial complexity. The sub-fractal assessment, employing 309 boxes per network map (Figure S5), identified an increase in fractal dimension from 1.43 in 1970 to 1.47 in 2000. Although the growth appears modest, it indicates a steady progression toward greater morphological intricacy. Concurrently, the average box values rose from 1.189 to 1.361, with a differential of 0.172. This increase reflects ongoing densification and the reinforcement of fractal-like, self-similar urban forms, likely shaped by both strategic planning interventions and organic spatial expansion.

• Metropolitan Municipality İzmir Plan (1989):

The initial state for this analysis is defined as 1970 (Period II), while the post-plan condition corresponds to 2000 (Period II). The investigation into urban network transformations under the 1989 İzmir Metropolitan Municipality (IMM) Plan reveals pronounced developments in spatial complexity and structural organization over the 30-year span. Utilizing a detailed grid of 413 sub-fractal boxes per network map (Figure S6), the analysis documented an increase in fractal dimension from 1.51 in 1970 to 1.57 in 2000. This growth reflects an ongoing intensification in the intricacy of the city's spatial configuration, indicating that the urban fabric has evolved in alignment with the transformative objectives embedded in the IMM 1989 planning framework.

In addition to fractal dimension changes, average sub-fractal box values—serving as a granular indicator of spatial distribution and internal variation—also exhibited a marked rise. The average value increased from 1.141 in

1970 to 1.383 in 2000, amounting to a differential of 0.242. This substantial increment underscores the processes of densification and the consolidation of self-similar spatial patterns within İzmir's urban infrastructure. The results highlight the effectiveness of the planning period in fostering more complex and resilient urban morphology.

• ***Metropolitan Municipality İzmir Plan (2012):***
The initial state for this phase of analysis is defined as the year 2000 (Period III), with the post-plan state corresponding to 2020 (Period IV). The evaluation of spatial complexity under the İzmir Metropolitan Municipality (IMM) 2012 Plan reveals continued yet moderated transformation in the city's urban morphology. Employing a high-resolution grid composed of 1,252 sub-fractal boxes per network map (Figure S7), this analysis facilitated a fine-grained assessment of structural evolution over the two-decade span. In 2000, the fractal dimension of the urban network was recorded at 1.39, representing the baseline complexity of the city's spatial structure at the beginning of the planning period. By 2020, this value had modestly increased to 1.41, suggesting a gradual enhancement in urban intricacy. Compared to earlier planning periods, this shift reflects a more restrained trajectory of spatial development—potentially indicative of more regulated urban growth or maturing morphological patterns. Further evidence of densification and internal complexity is provided by the average sub-fractal box values. These values rose from 1.150 in 2000 to 1.316 in 2020, yielding a net difference of 0.166. This increase highlights the persistence of self-similar patterning and the consolidation of spatial structure, albeit progressing at a more tempered rate than in previous decades. Overall, the findings suggest a phase of steady, controlled urban evolution under the guidance of the IMM 2012 Plan.

5. *Sub-Fractal Difference Analysis* of the İzmir Urban System by Planning Periods
The sub-fractal difference analysis delineates the temporal evolution of urban complexity in İzmir across four major planning intervals: the 1955 Kemal Aru Plan, the 1973–78 İzmir Metropolitan Municipality (IMM) Plan, the 1989 IMM Plan, and the 2012 IMM Plan. This assessment is based on variations in both the mean and median values of sub-fractal differences, which are visualized in Figure S8.

The mean values of sub-fractal differences, indicated by the solid blue line, exhibit the following sequence: 0.15 for the 1955 plan, 0.17 for the 1973–78 plan, 0.24 for the 1989 plan, and 0.17 for the 2012 plan. Correspondingly, the median values—depicted by the red dashed line—are recorded as 0.15 (1955), 0.09 (1973–78), 0.11 (1989), and 0.13 (2012). All measured values for both mean and median fall within the designated Adaptive Capacity Range (ACR) of 0 to 0.25. This alignment underscores a consistent pattern of manageable complexity shifts, indicating that despite varying degrees of planning intervention and urban growth, the city's adaptive transformation has remained within statistically and structurally interpretable bounds.

• ***Kemal Aru İzmir Plan (1955):***
Sub-fractal difference analysis conducted within the planning boundary of the Kemal Aru 1955 Plan, comparing network configurations from 1950 and 1970, revealed that 37 out of 81 analysed grid boxes fell within the Adaptive Capacity Range (ACR) of 0 to 0.25. This finding suggests substantial adaptive potential embedded within the urban system during this period (Figure S9). The frequency distribution of sub-fractal differences was assessed using a bin width of 0.05. The proportion of values within the ACR range accounted for 52.44% of the total dataset, reflecting a high degree of adaptability. A Gaussian curve was fitted to the data, yielding a mean (μ) of 0.15 and a standard deviation of 0.45. The distribution's peak corresponded precisely with the mean value, confirming central clustering. Both mean and median values were well-contained within the defined ACR, affirming its statistical robustness. The regression model exhibited an exceptionally high degree of fit, with an R^2 value of 0.9998, indicating an almost perfect linear relationship between the bin means and the fitted curve. Additionally, the

Q-Q plot for this period demonstrated close alignment between empirical quantiles and the theoretical normal distribution, further validating the Gaussian fit (Figure S10).

• ***İzmir Metropolitan Municipality Plan (1973–1978):***
An analogous sub-fractal difference analysis was performed within the boundaries of the IMM 1973–78 Plan, comparing urban network data from 1970 and 2000. Of the 309 sub-fractal box values examined, 127 were found to fall within the ACR (0–0.25), indicating that a considerable segment of the urban landscape demonstrated adaptive spatial characteristics (Figure S11). The distribution analysis revealed that 44.52% of all values resided within the ACR, slightly lower than the 1955 period but still reflective of a resilient urban system. The Gaussian distribution fitted to the data produced a mean (μ) of 0.17 and a standard deviation (σ) of 0.44, with the distribution peaking at 0.20. This central tendency illustrates a notable concentration of difference values within the adaptive threshold. The regression fit demonstrated strong linearity, with an R^2 value of 0.9998, validating the model's precision. Additionally, the Q-Q plot confirmed that empirical and theoretical quantiles were closely aligned, supporting the statistical consistency of the Gaussian approximation (Figure S12).

• ***İzmir Metropolitan Municipality Plan (1989):***
Sub-fractal difference analysis conducted within the spatial scope of the IMM 1989 Plan aimed to assess the impact of planning decisions on the city's spatial complexity. A total of 413 sub-fractal box values were analysed, of which 166 fell within the Adaptive Capacity Range (ACR) of 0 to 0.25—marking a substantial expression of the city's capacity to absorb change and maintain structural functionality in the face of planned interventions or emerging urban pressures (Figure S13). The proportion of values within the ACR constituted 42.03% of the dataset, indicating moderate but meaningful adaptability. A Gaussian distribution was fitted to the difference data, yielding a mean (μ) of 0.24 and a standard deviation of 0.44, with the distribution's peak occurring at 0.26. These statistical parameters suggest that the bulk of sub-fractal variation remained concentrated around the ACR's upper threshold, highlighting the persistence of adaptability within an increasingly complex urban form. The model fit was highly reliable, confirmed by an R^2 value of 0.9998. Moreover, the Q-Q plot demonstrated a strong correspondence between empirical and theoretical quantiles, reinforcing the validity of the normal distribution fit (Figure S14).

• ***İzmir Metropolitan Municipality Plan (2012):***
The city-wide sub-fractal analysis for the IMM 2012 Plan evaluated spatial complexity changes using 1,252 box values, providing a comprehensive account of adaptive patterns over time. Of these, 603 boxes displayed sub-fractal differences within the defined ACR (0–0.25), signifying a widespread capacity for structural adaptation and resilience across İzmir's urban landscape (Figure S15). The results indicated that 52.07% of the observed values were contained within the ACR, reflecting a high degree of adaptability during this planning phase. The application of a Gaussian fit produced a mean (μ) of 0.17 and a standard deviation of 0.45, with the peak of the distribution observed at 0.15. These outcomes suggest a well-centred and consistent distribution of difference values within the ACR, reinforcing the notion of sustained adaptability in the city's urban morphology. As with previous periods, the model demonstrated exceptional precision, with an R^2 value of 0.9998, and the Q-Q plot confirmed the close alignment between observed and theoretical quantiles, validating the Gaussian approximation (Figure S16).

- **Regional Sub-Fractal Analysis within the 2012 IMM Planning Boundary**
The 2012 İzmir Metropolitan Municipality Plan was subjected to a detailed regional analysis to evaluate spatial adaptability using sub-fractal difference values. This assessment involved calculating the mean, median, and standard deviation for each region and determining the proportion of data falling within the defined Adaptive Capacity Range (ACR) of 0 to 0.25 (Figure S17).

o ***Northern İzmir:*** Of the 228 grid boxes analysed, 73 (37.99%) fell within the ACR. The sub-fractal difference values exhibited a mean of 0.17, a median of 0.10, and a standard deviation of 0.62. The Gaussian model fit was confirmed with a robust R^2 value of 0.9998, indicating a strong correlation (Figure S18).

o ***Southern İzmir:*** In this region, 48 out of 131 boxes (40.15%) were within the ACR. The mean difference was 0.20, the median was 0.16, and the standard deviation measured at 0.46. The model's accuracy was validated by an R^2 value of 0.9998 (Figure S19).

o ***Western İzmir:*** Here, 82 of 191 boxes (46.88%) were within the ACR. The statistical outputs showed a mean of 0.19, a median of 0.15, and a standard deviation of 0.39. The Gaussian model demonstrated a strong fit with an R^2 of 0.9998 (Figure S20).

o ***Eastern İzmir:*** Of the 148 boxes assessed, 66 (51.01%) fell within the ACR. The region recorded a mean of 0.20, a median of 0.17, and a standard deviation of 0.42. The fit quality was high, supported by an R^2 value of 0.9998 (Figure S21).

o ***Tourism Region (Gümüldür Area):*** In this area, 17 out of 48 boxes (42.86%) were within the ACR. The mean sub-fractal difference was 0.14, with a median of 0.12 and a standard deviation of 0.46. The Gaussian fit held with an R^2 of 0.9998, confirming model validity (Figure S22).

o ***Central İzmir:*** Central İzmir demonstrated the strongest adaptive capacity among all regions, with 313 of 506 boxes (64.69%) falling within the ACR. The mean difference was 0.14, the median was 0.13, and the standard deviation was 0.37. The correlation between observed and theoretical values remained strong, with an R^2 of 0.9998 (Figure S23).

Collectively, the regional analysis confirmed the effectiveness of the 0–0.25 Adaptive Capacity Range in capturing the city's multifaceted ability to accommodate urban transformation. The consistent Gaussian distributions, relatively moderate standard deviations, and uniformly high R^2 values across all sub-regions reinforce the reliability of the model in representing İzmir's systemic resilience to planning and environmental pressures.

6. Discussion on the *Adaptive Capacity Range* of İzmir as a *Complex Physical System*

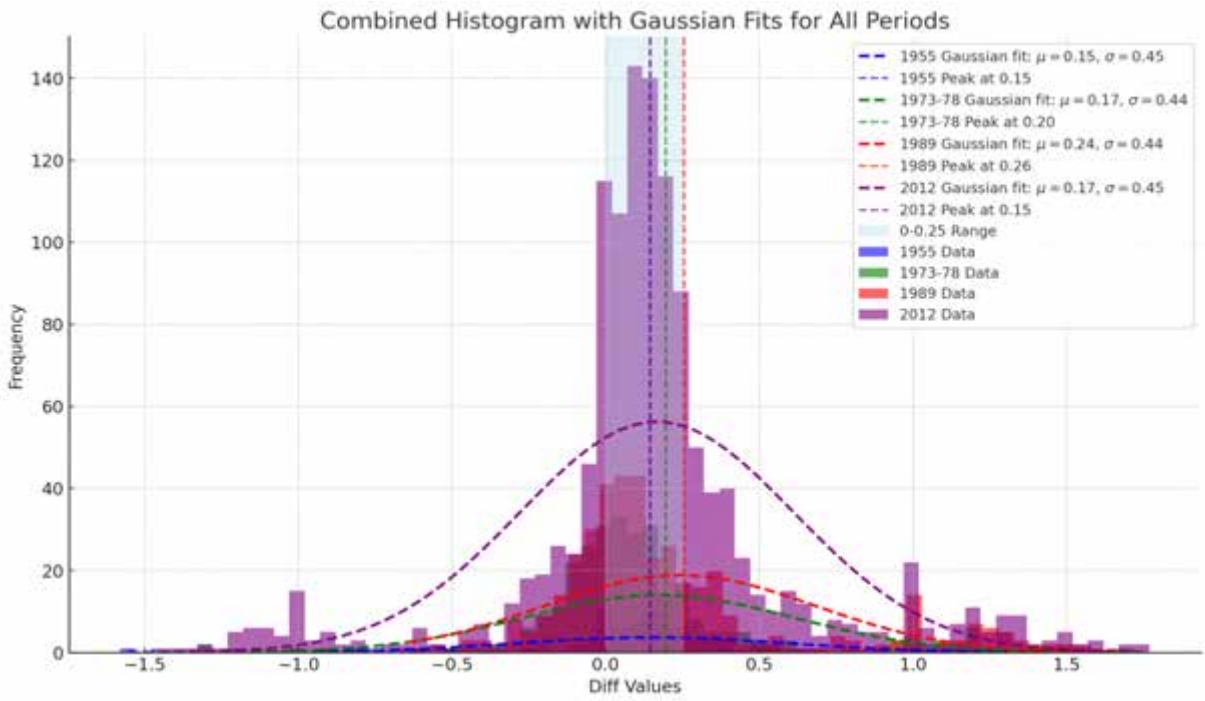

Figure 2. Combined Histogram with Gaussian Fits for periods (Distribution of Metric Differences across All Time Periods and Regions)

The longitudinal analysis of İzmir's urban development, employing sub-fractal and difference analysis methodologies applied to its road network, offers a nuanced understanding of the city's Adaptive Capacity Range (ACR) and its implications for resilient urban planning. This investigation spans network configurations from 1950 to 2020, with fractal dimension values extracted to trace the evolving complexity of İzmir's spatial structure in response to successive planning initiatives. Across all periods, the ACR was consistently situated within the interval of 0 to 0.25, suggesting a moderate but structurally meaningful degree of adaptability. This bounded range underscores the city's ability to reorganize and sustain infrastructural functionality amid socio-spatial transformations (see Figure 1).

Methodologically, the study synthesizes sub-fractal computation with difference analysis, grounded in the mathematical logic of fractal geometry and the dynamic principles of complex systems theory. Originally formulated by Mandelbrot (1982), fractal analysis offers a theoretical lens for interpreting the self-similar and scale-invariant patterns that characterize urban morphology. This paradigm is reinforced by Batty (2005), who posits that urban spatial forms inherently manifest fractal behavior, enabling their internal structural dynamics to be captured through rigorous quantitative measures.

The conceptualization of adaptive capacity is enriched by interdisciplinary analogies, particularly from statistical mechanics and quantum theory. In statistical mechanics, the notion of phase transitions and critical thresholds demonstrates how marginal perturbations can catalyze disproportionate systemic reconfigurations—a dynamic mirrored in urban environments, where minor policy adjustments or spatial interventions can induce marked transformations in form and function (Batty, 2005). Similarly, the probabilistic ontology of quantum systems provides an apt metaphor for urban complexity, wherein outcomes are shaped not by deterministic rules but by fluctuating probabilities and interdependent interactions (Mandelbrot, 1982).

Through this interdisciplinary integration, the research frames cities as complex adaptive systems and positions

the ACR as a predictive metric that operationalizes resilience. Functioning as a quantitative analogue to critical thresholds in physical systems, the ACR encapsulates the city's adaptive behavior by incorporating both mean and median sub-fractal difference values. This dual inclusion ensures that the analysis reflects central tendencies while preserving sensitivity to distributional asymmetries, thereby offering a comprehensive representation of urban adaptability. Such a framework aligns with broader ecological and socio-technical theories of resilience, notably those advanced by Folke et al. (2002), which emphasize the importance of systemic flexibility and transformative potential in the face of uncertainty.

The regional sub-fractal analysis further illuminates the spatial heterogeneity of İzmir's adaptive capacity, revealing distinct variability in resilience across different urban zones. Northern and Southern İzmir exhibit moderate adaptability, with 37.99% and 40.15% of data points respectively falling within the Adaptive Capacity Range (ACR). The Western and Eastern districts display comparatively higher resilience, with ACR coverage rates of 46.88% and 51.01%. Notably, Central İzmir demonstrates the most robust adaptive performance, with 64.69% of its data residing within the ACR. This pattern of variation substantiates the concept of spatial heterogeneity in urban resilience, as articulated by Folke et al. (2002), which posits that adaptive capacity is unevenly distributed across the urban fabric, shaped by historical, socio-economic, and infrastructural asymmetries.

The practical implications of these findings extend beyond theoretical analysis, offering actionable tools for urban planners and policy designers. By systematically quantifying urban complexity and delineating adaptive thresholds, this methodology enables planners to anticipate structural vulnerabilities and design targeted interventions. Such an approach aligns with broader urban resilience discourses, emphasizing the pivotal role of adaptive planning in guiding sustainable urban transformation (Batty, 2005). Moreover, the methodological integration of sub-fractal analysis with principles derived from theoretical physics highlights a novel and interdisciplinary pathway for urban systems modeling—bridging statistical mechanics, complexity theory, and spatial analytics to forecast urban evolution.

In conclusion, this study reinforces the necessity of embedding complex systems theory into the praxis of urban planning to effectively contend with the nonlinear and unpredictable nature of urban growth. The results suggest that urban environments characterized by higher degrees of spatial complexity, as measured through detailed fractal metrics, exhibit enhanced adaptive capacities—positioning them to more effectively absorb and respond to future socio-environmental challenges. Looking forward, the extension of this analytical framework to other metropolitan contexts, coupled with the integration of real-time geospatial and socio-economic data, holds significant potential for advancing our understanding of urban adaptability and fostering the development of more resilient and sustainable urban systems.

7. Conclusion

The analytical approach employed in this study—integrating sub-fractal and difference analysis—draws theoretical grounding from Mandelbrot's (1982) seminal contributions to fractal geometry and Goldenfeld's (1992) investigation of phase transitions within statistical mechanics. By transposing the conceptual apparatus of statistical physics to the domain of urban studies, this research establishes a robust analytical framework for interpreting and managing the nonlinear dynamics of urban expansion and adaptive transformation. The methodologies illustrate how micro-scale fluctuations—such as minor infrastructural or morphological alterations—can precipitate pronounced changes at the macro-urban scale, reflecting the emergent behavior described by Yeomans (1992) in relation to the aggregation of microscopic interactions into large-scale phenomena.

The quantification of Adaptive Capacity Range (ACR) within this context exemplifies a productive intersection between theoretical physics and spatial urban analytics. This convergence equips urban planners with advanced tools for anticipating and steering urban morphological evolution. Consistent with the principles of complex systems theory—which conceptualizes cities as adaptive, self-organizing entities (Bar-Yam, 1997)—this research applies fractal diagnostics to capture the intrinsic irregularities and hierarchies of urban form. In doing so, it contributes empirical support to Batty's (2005) assertion that cities inherently exhibit fractal structures, and that

these patterns can be rigorously interrogated to illuminate underlying processes of spatial complexity and systemic adaptability.

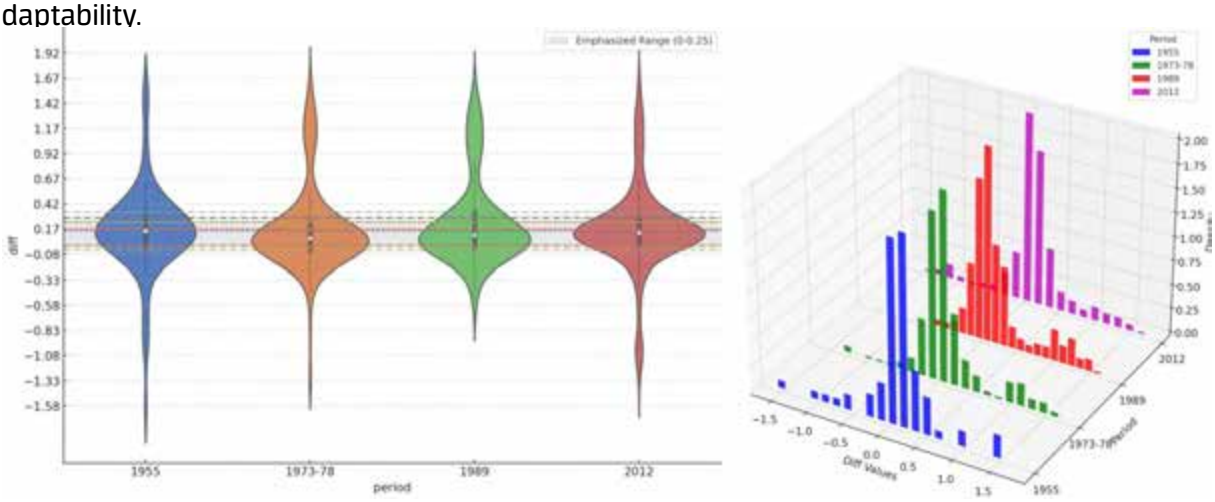

Figure 3. Density Distributions of Sub-Fractal Difference Values Across All Periods and Regions

This figure depicts the distributional characteristics of sub-fractal difference values across all examined temporal and spatial domains in İzmir. Utilizing both violin plots and 3D histograms, the visualization reveals the variability, skewness, and concentration of data points. Central to this representation is the highlighted 0–0.25 range, corresponding to the Adaptive Capacity Range (ACR), which encompasses the majority of observed values. This reinforces the notion that urban systems exhibit measurable, intrinsic adaptability, which can be captured through sub-fractal metrics. Beyond visual analysis, the findings underscore the methodological significance of ACR as a robust and transferable metric for urban adaptability. The empirical demonstration that ACR is not only computable but also meaningful within the urban planning context lays the groundwork for methodological standardization. Such a framework could be extrapolated to diverse urban contexts, enabling comparative resilience assessments and fostering evidence-based planning strategies. This aligns with Portugali's (2012) call for integrating complexity science into urban design and policy, advancing a data-driven, systemic approach to fostering urban resilience.

Future Directions

Future research should extend the application of sub-fractal and difference analysis to a wider range of urban contexts to evaluate the universality of the Adaptive Capacity Range (ACR). Comparative studies across cities with differing scales, complexities, and socio-economic profiles will help determine whether İzmir's patterns are generalizable or context-specific (Bettencourt, 2013; Arcaute et al., 2015; Ribeiro et al., 2019). Incorporating real-time data—such as traffic, mobility, economic activity, and environmental conditions—can enhance model accuracy and responsiveness (Calabrese et al., 2013; Hasan et al., 2013). Such integration would enable more dynamic assessments of adaptability, particularly during disruptions (Lu et al., 2016). The rise of smart cities offers further opportunities to leverage IoT technologies and big data analytics for tracking and modeling urban complexity (Batty, 2018). Combined with AI and machine learning, these tools can identify patterns, predict growth, and simulate policy outcomes (Harris, 1991).

Interdisciplinary collaboration is essential for advancing holistic models that incorporate social, economic, and environmental dimensions of resilience (Ahern, 2011; Folke et al., 2010). Engagement with planners, policymakers, and communities will also be key in translating academic findings into practical tools (Portugali, 2012; Adger et al., 2005). In sum, expanding geographic scope, integrating dynamic data, leveraging AI, and fostering cross-sector collaboration will deepen our understanding of urban adaptive capacity and support more resilient and sustainable urban development.

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Appendices

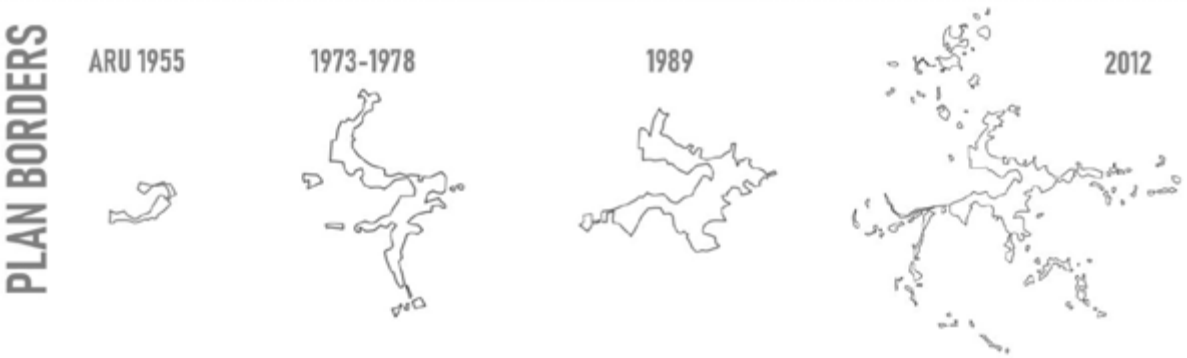


Figure S1. Plan borders for sub-fractal analysis process by periods.

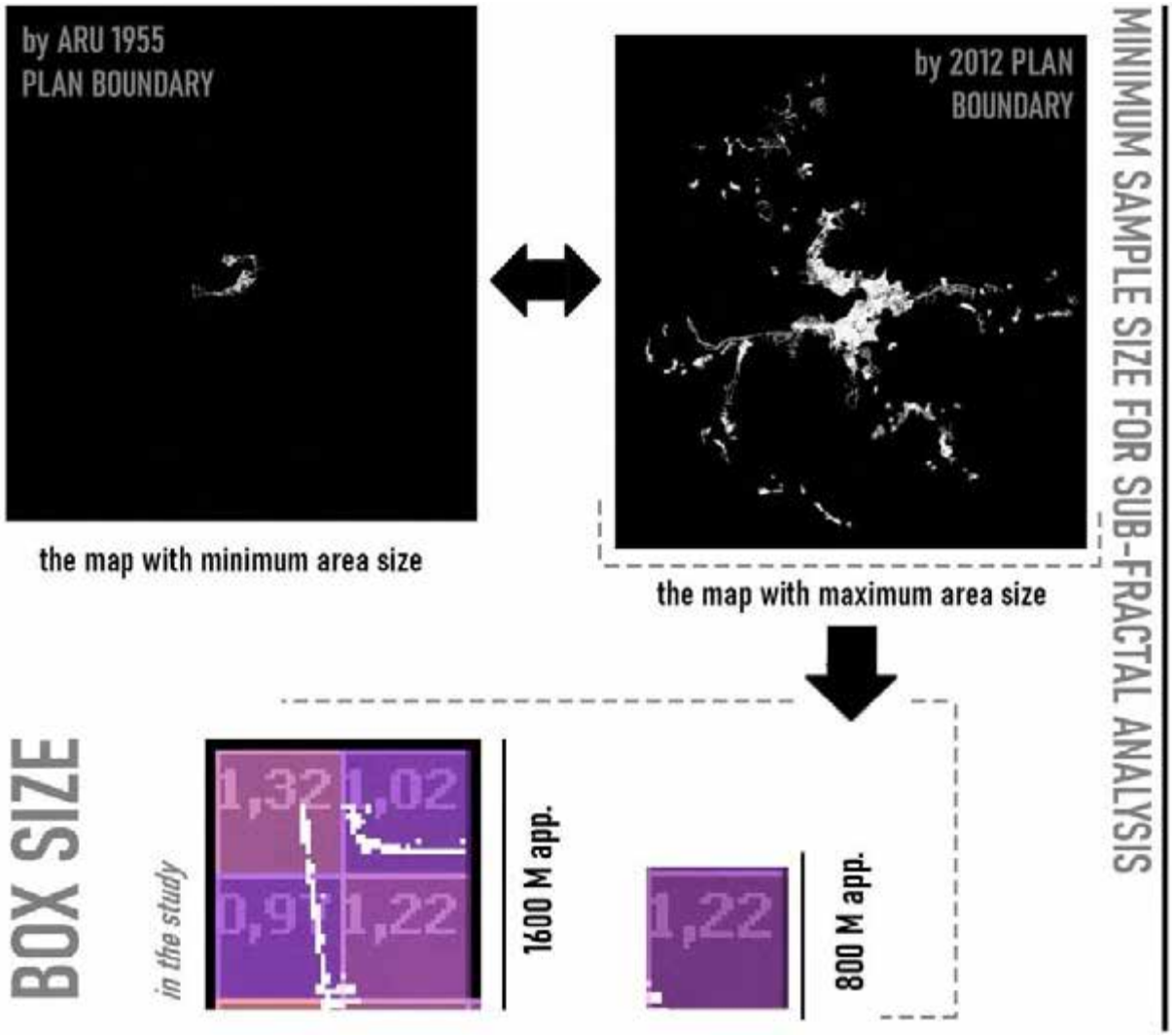
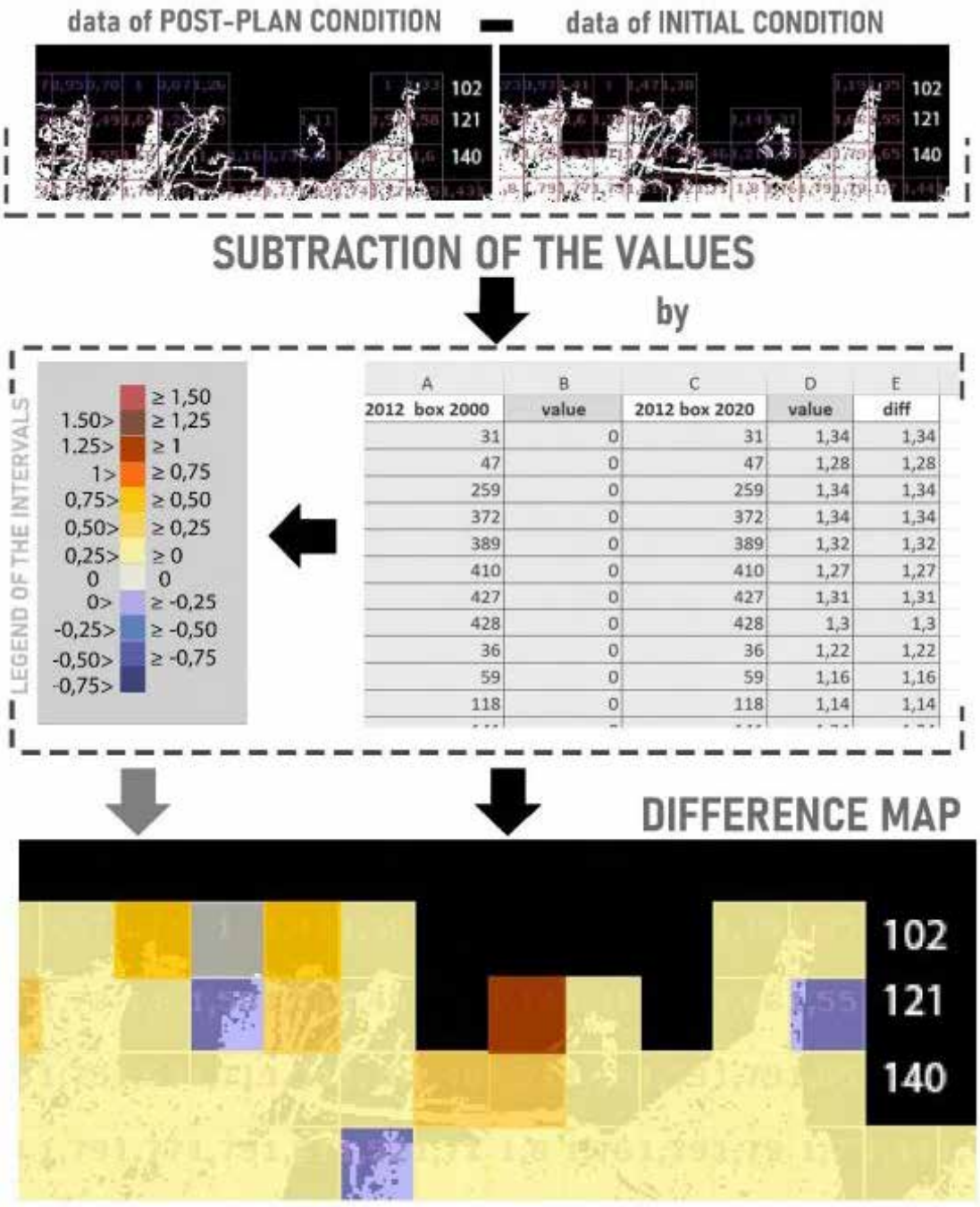


Figure S2. Minimum sample size algorithm for sub-fractal analysis



A	B	C	D	E
2012 box 2000	value	2012 box 2020	value	diff
31	0	31	1,34	1,34
47	0	47	1,28	1,28
259	0	259	1,34	1,34
372	0	372	1,34	1,34
389	0	389	1,32	1,32
410	0	410	1,27	1,27
427	0	427	1,31	1,31
428	0	428	1,3	1,3
36	0	36	1,22	1,22
59	0	59	1,16	1,16
118	0	118	1,14	1,14

Figure S3. Flow chart showing difference map production.

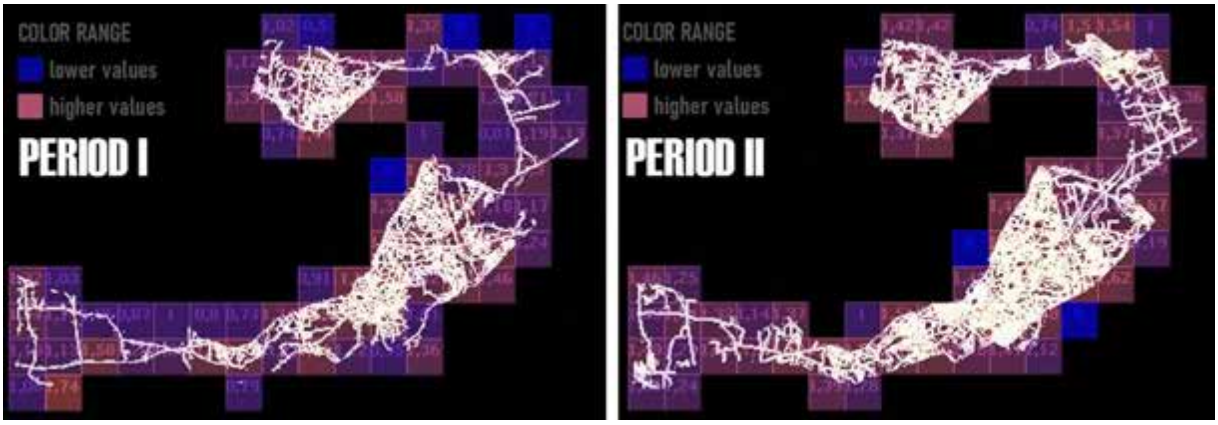


Figure S4. Sub-Fractal analysis of pre-plan state and post plan state of the İzmir plan of Kemal Ahmet

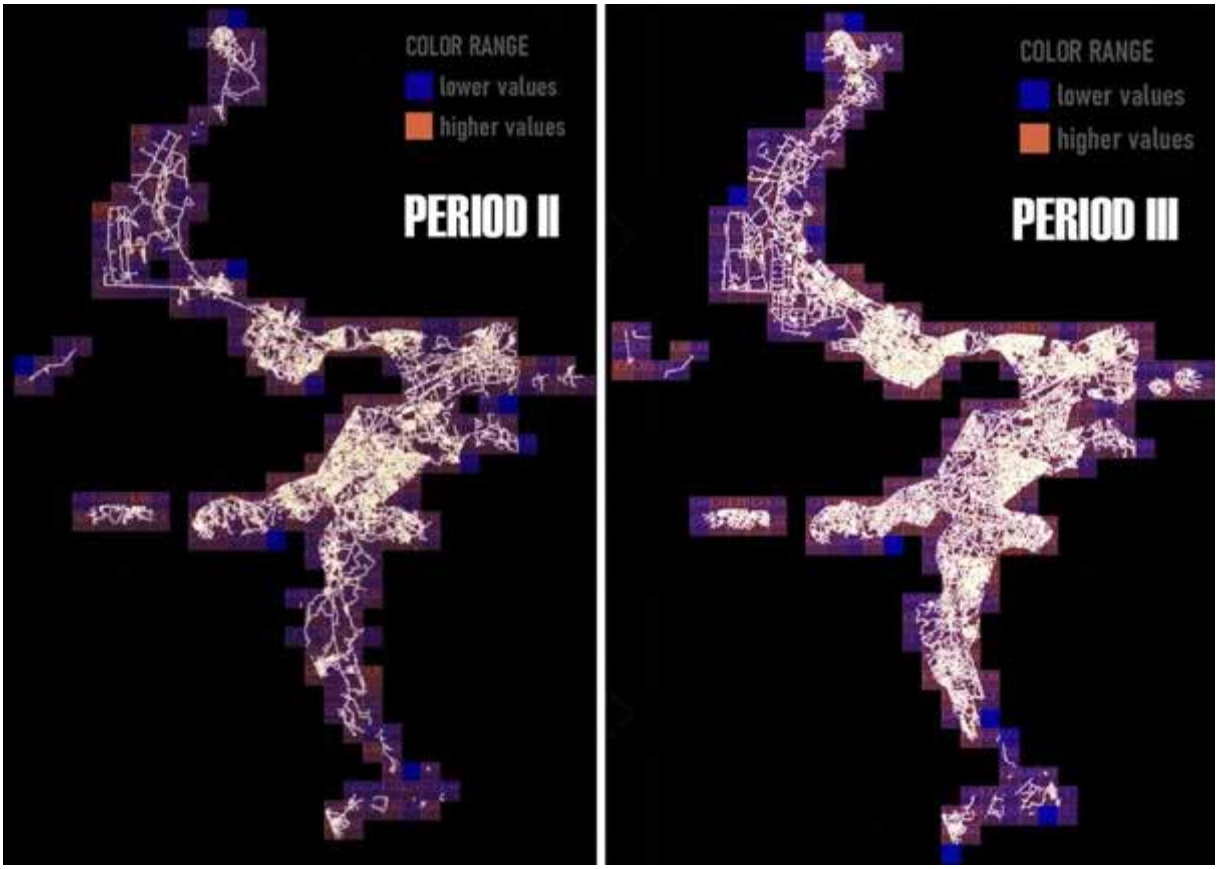
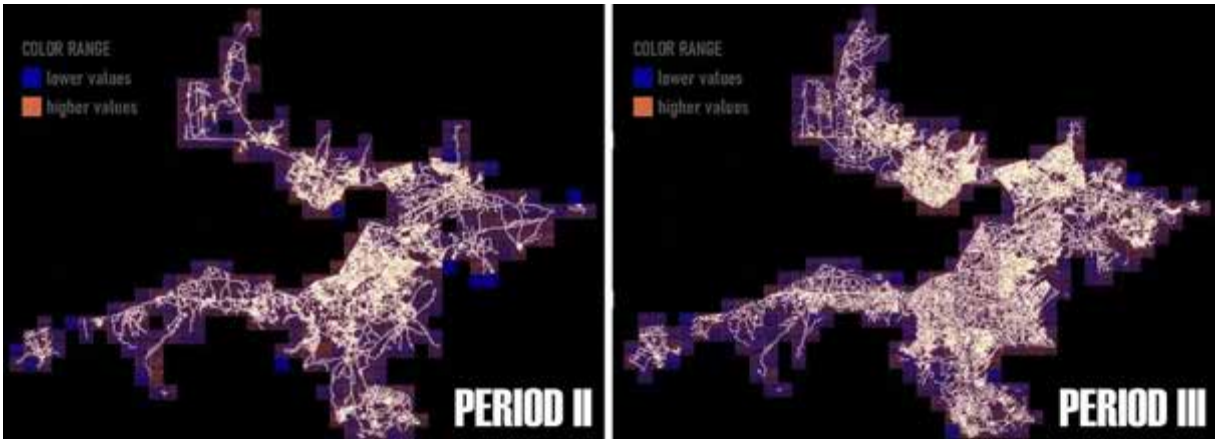


Figure S5. Sub-Fractal analysis of pre-plan state of the İzmir plan of metropolitan municipality, 1973-78



FigureS6. Sub-Fractal analysis of pre-plan state of the İzmir plan of metropolitan municipality, 1989.

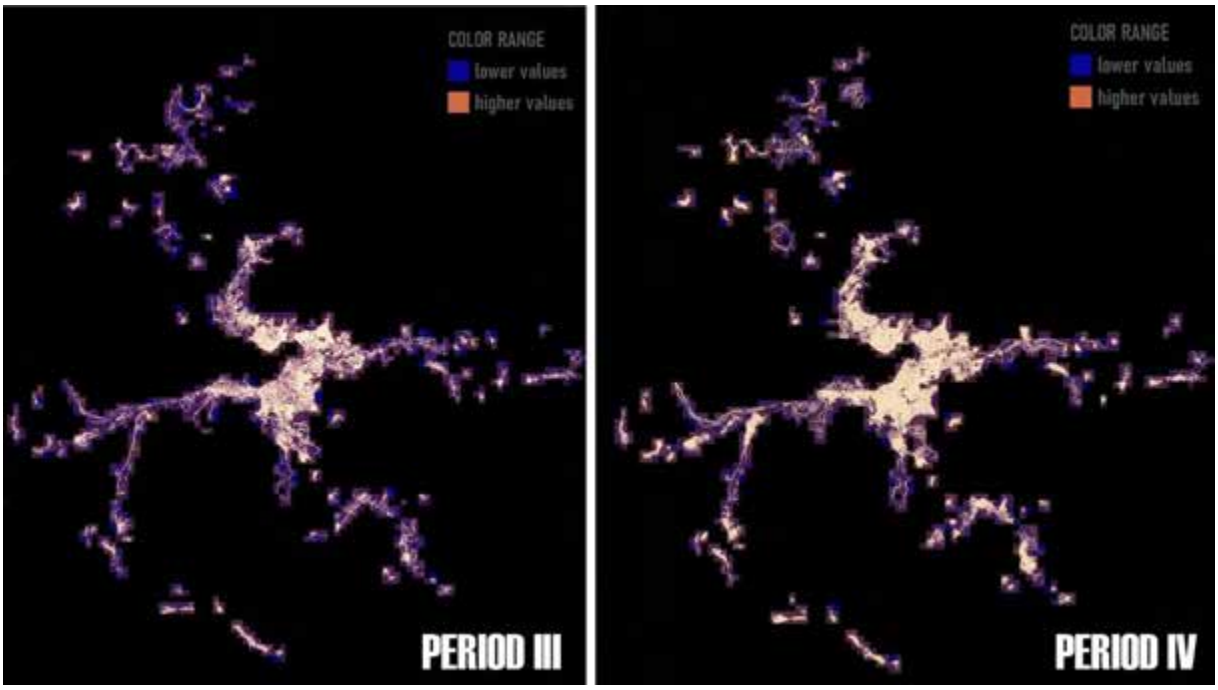


Figure S7. Sub-Fractal analysis of pre-plan state of the İzmir plan of metropolitan municipality, 2012.

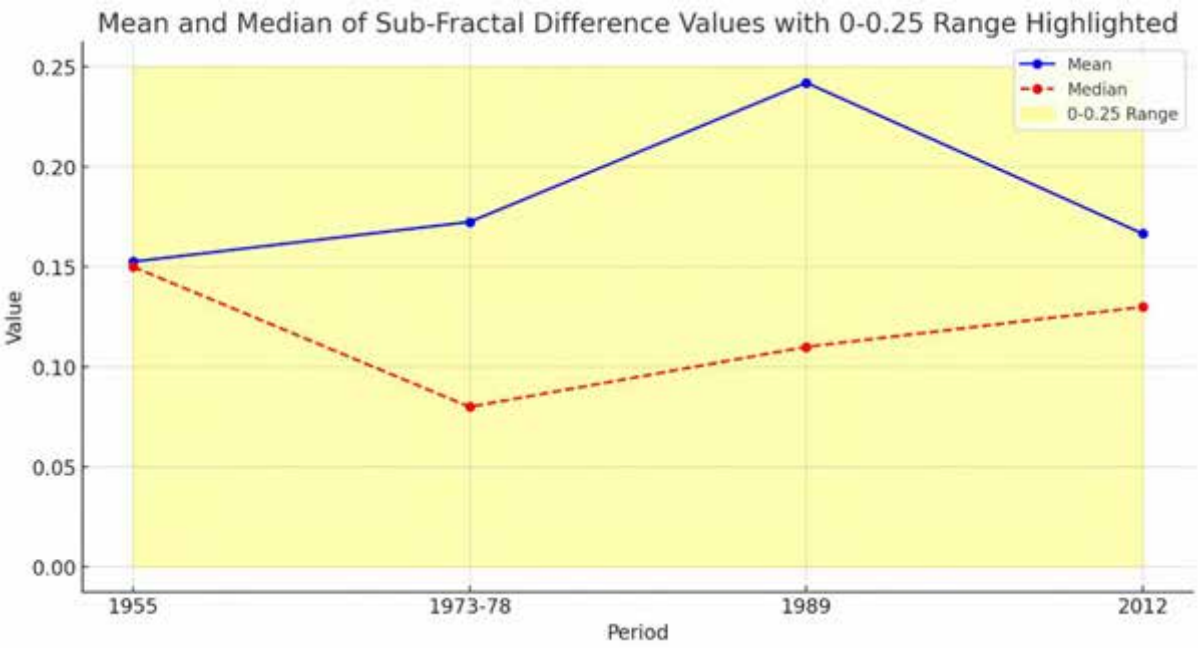


Figure S8. Mean and Median of Sub-Fractal Difference Values with Adaptive Capacity Range

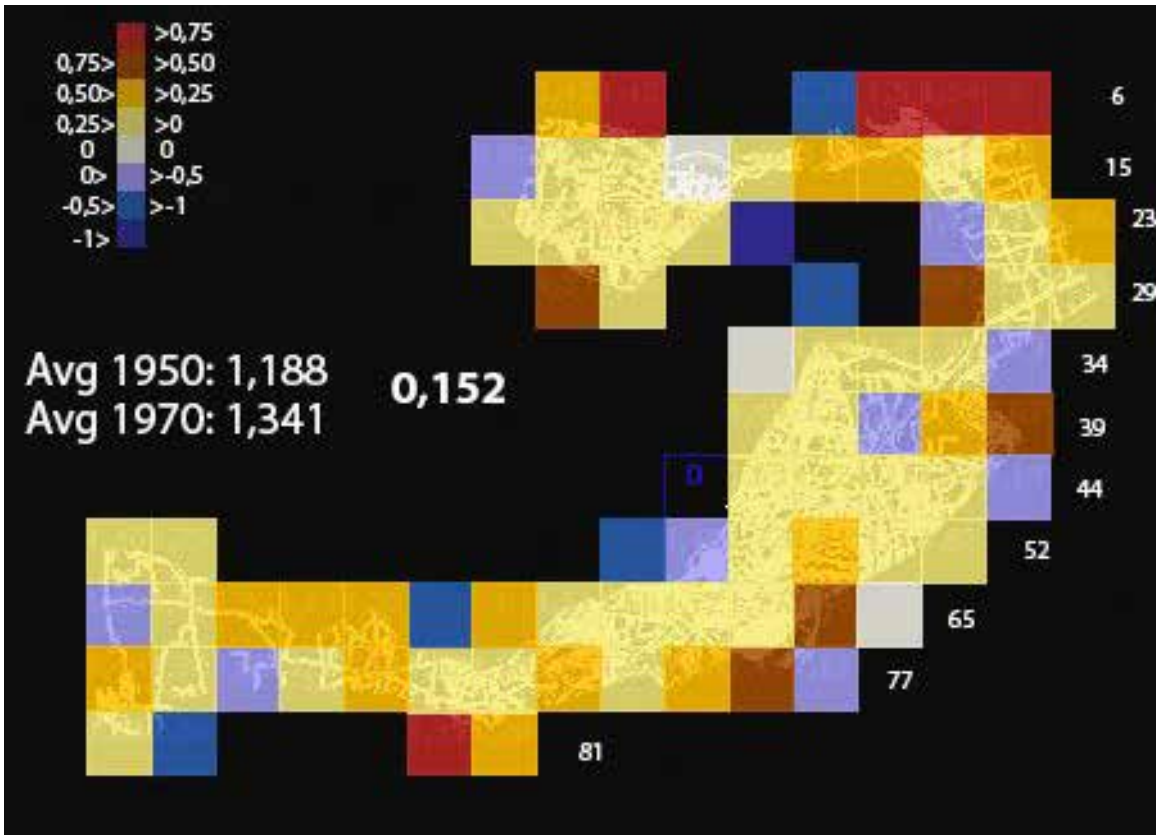


Figure S9. Difference Analysis of Periods I and II by Kemal Ahmet Aru Plan, 1955.

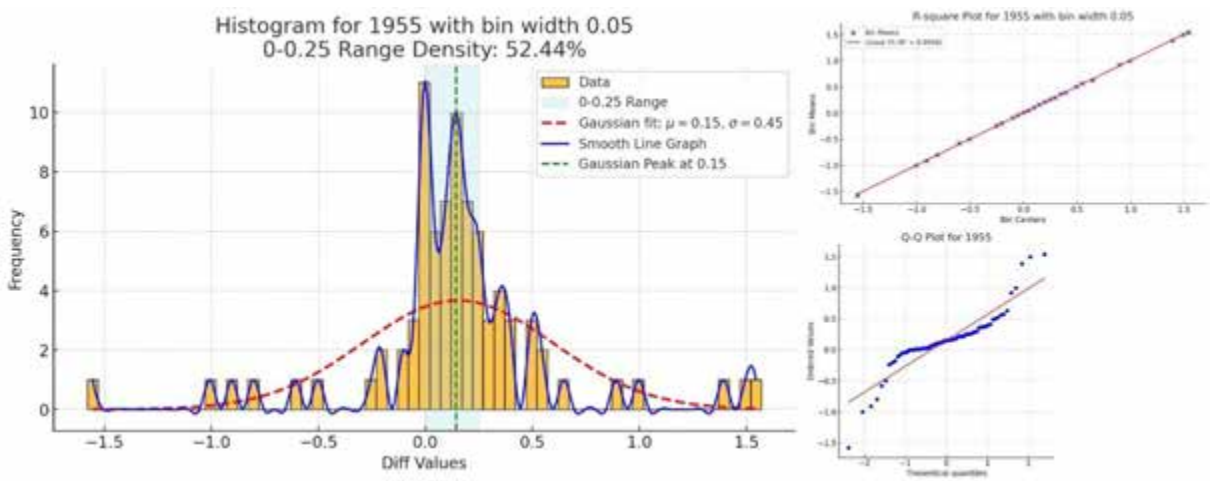


Figure S10. Statistical Analysis of Sub-Fractal Difference Values for the İzmir Plan of Kemal Aru 1955: Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

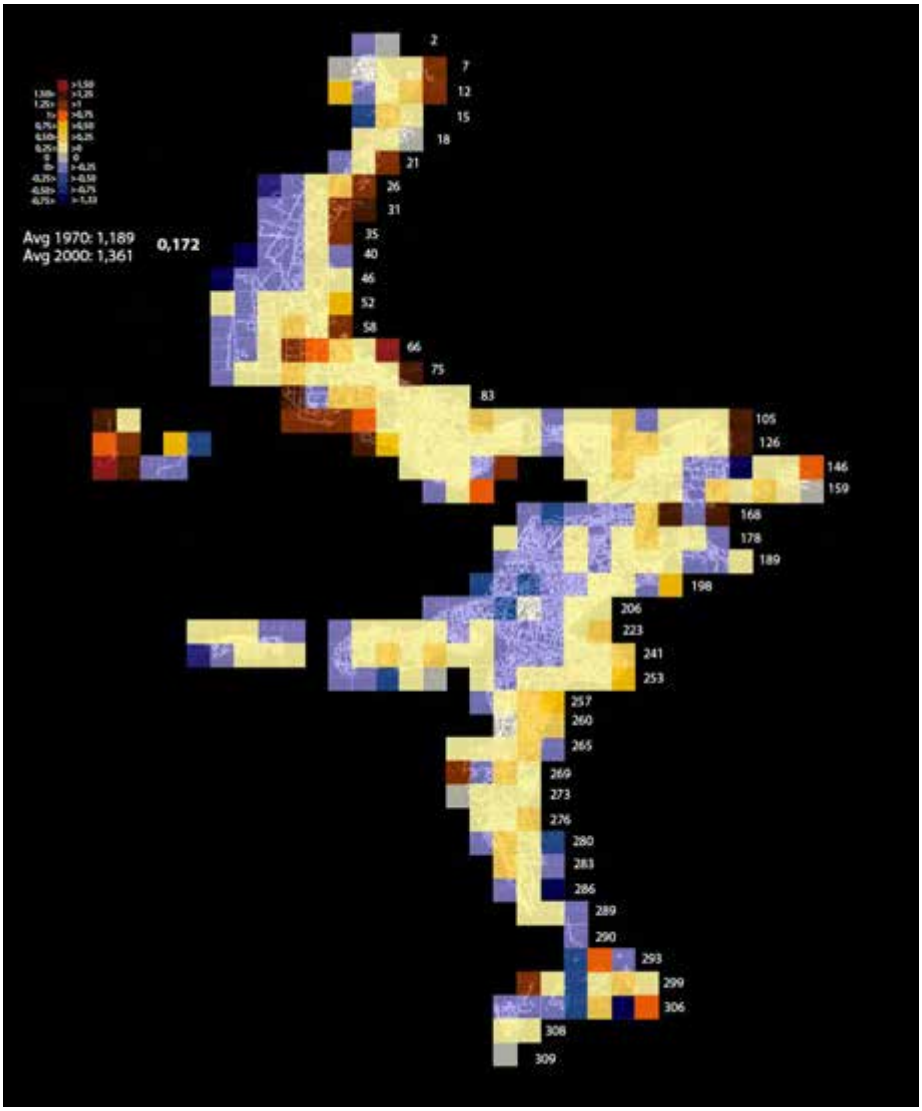


Figure S11. Difference Analysis of Periods II and III by the İzmir plan of metropolitan municipality,1973-78.

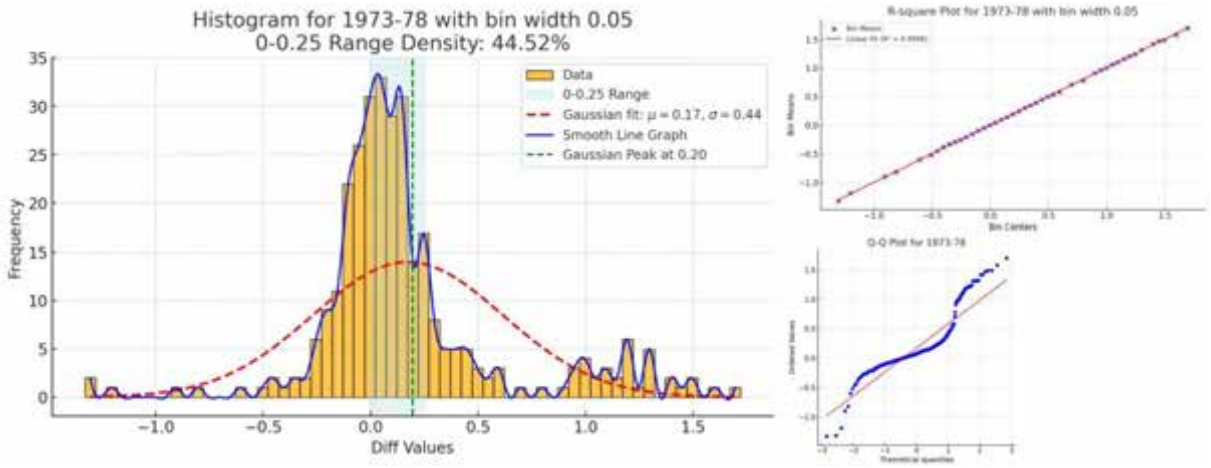


Figure S12. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 1973-78: Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

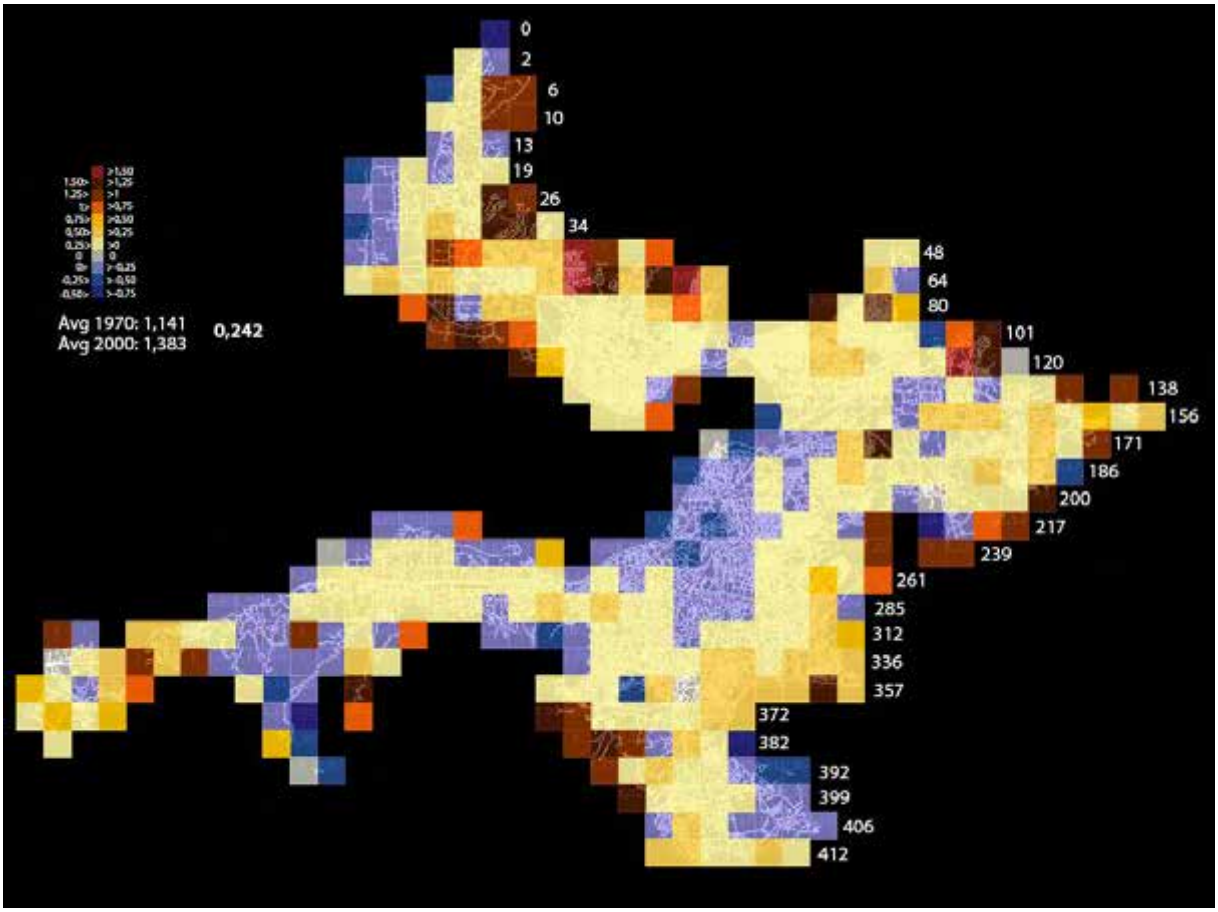


Figure S13. Difference Analysis of Periods II and III by the İzmir plan of metropolitan municipality, 1989.

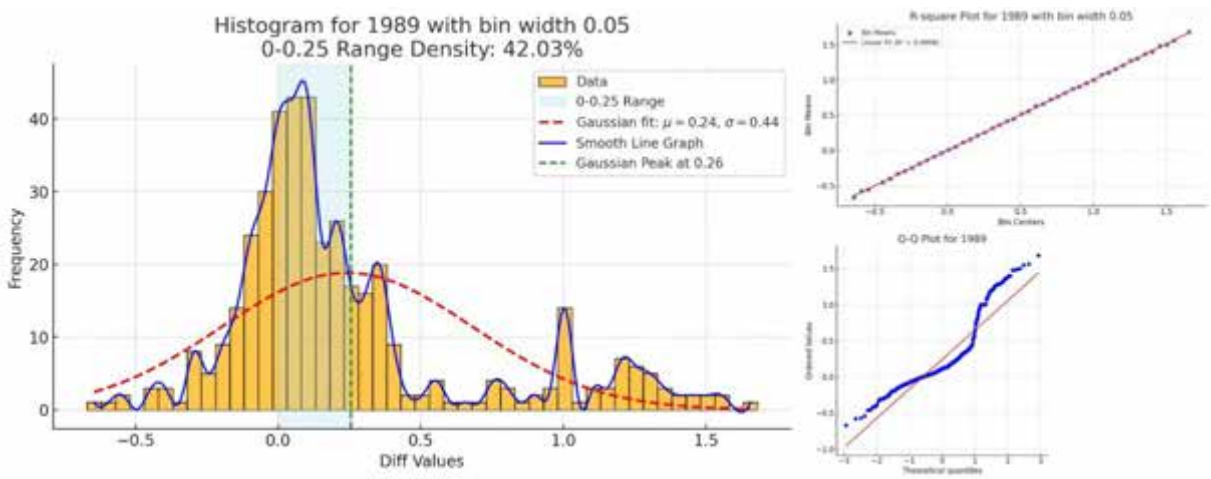


Figure S14. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 1989: Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

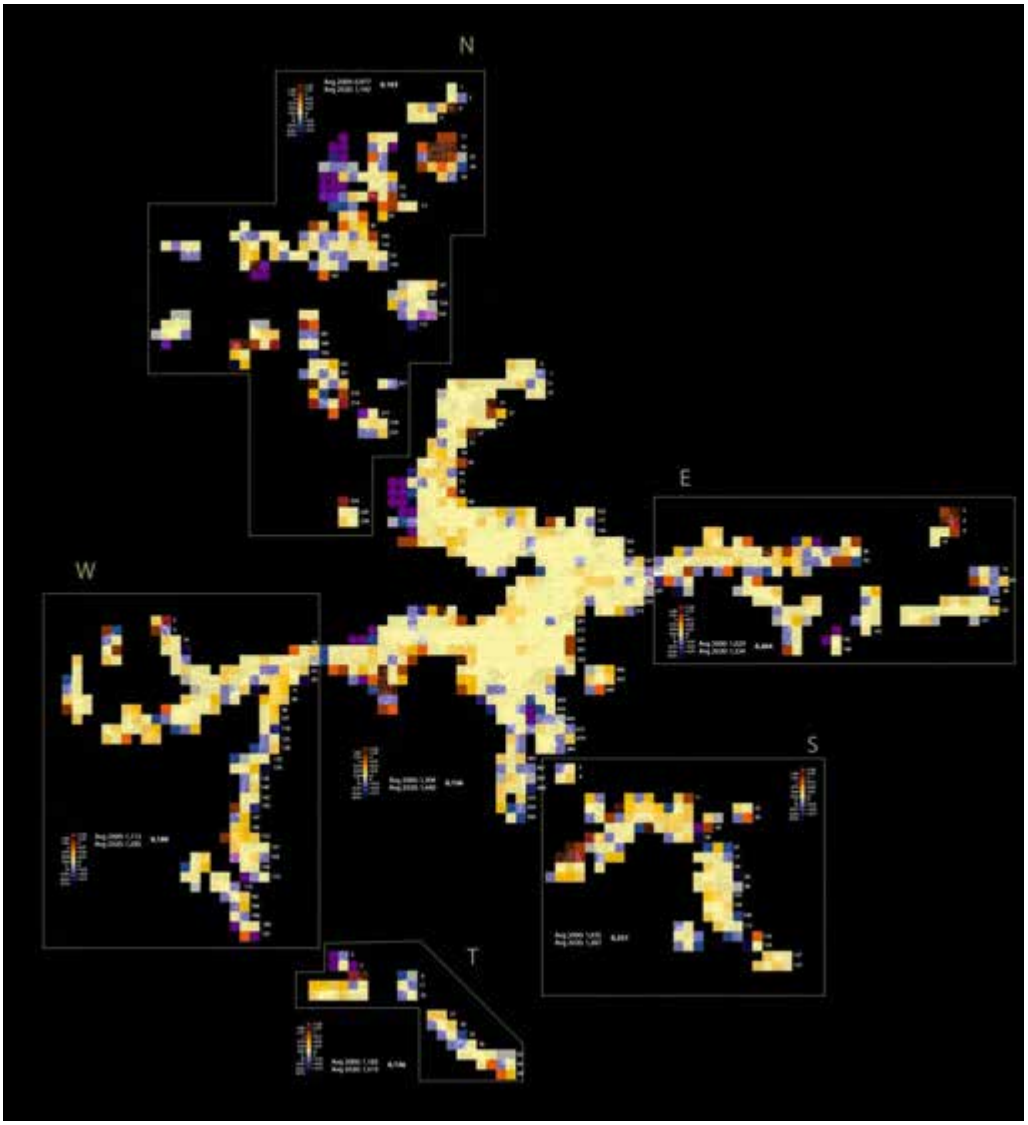


Figure S15. Difference Analysis of Periods III and IV by the İzmir plan of metropolitan municipality,2012.

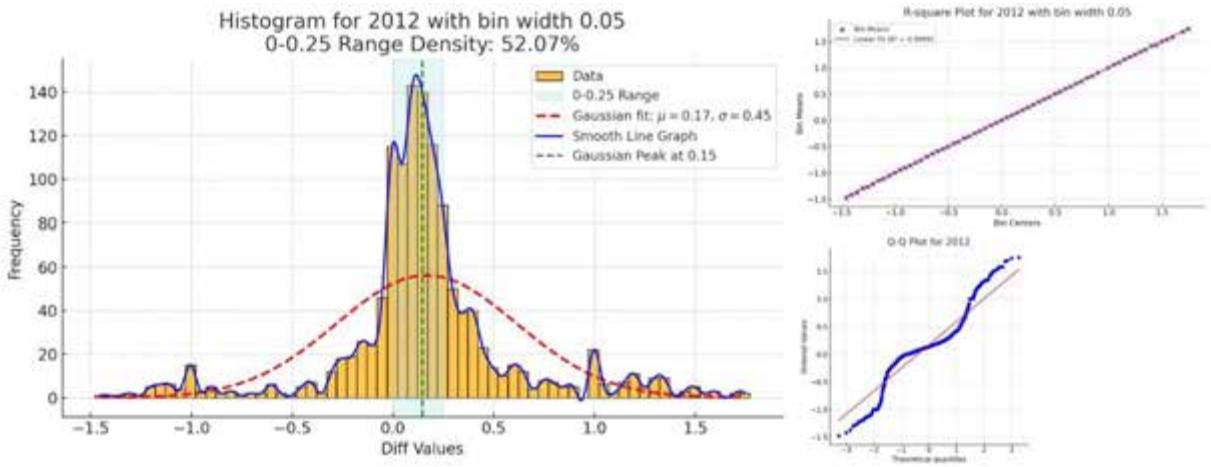


Figure S16. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 2012: Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

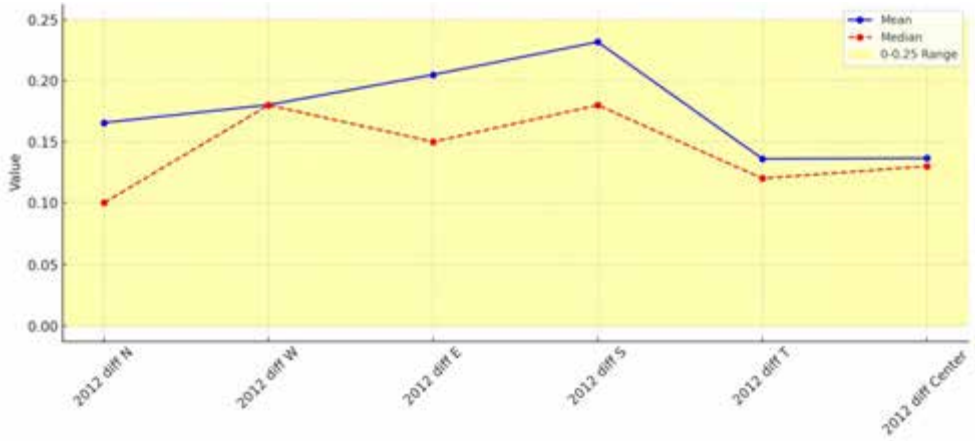


Figure S17. Means and Medians of Sub-Fractal Difference Values of 2012 Plan Period's Regions with Adaptive Capacity Range Highlighted.

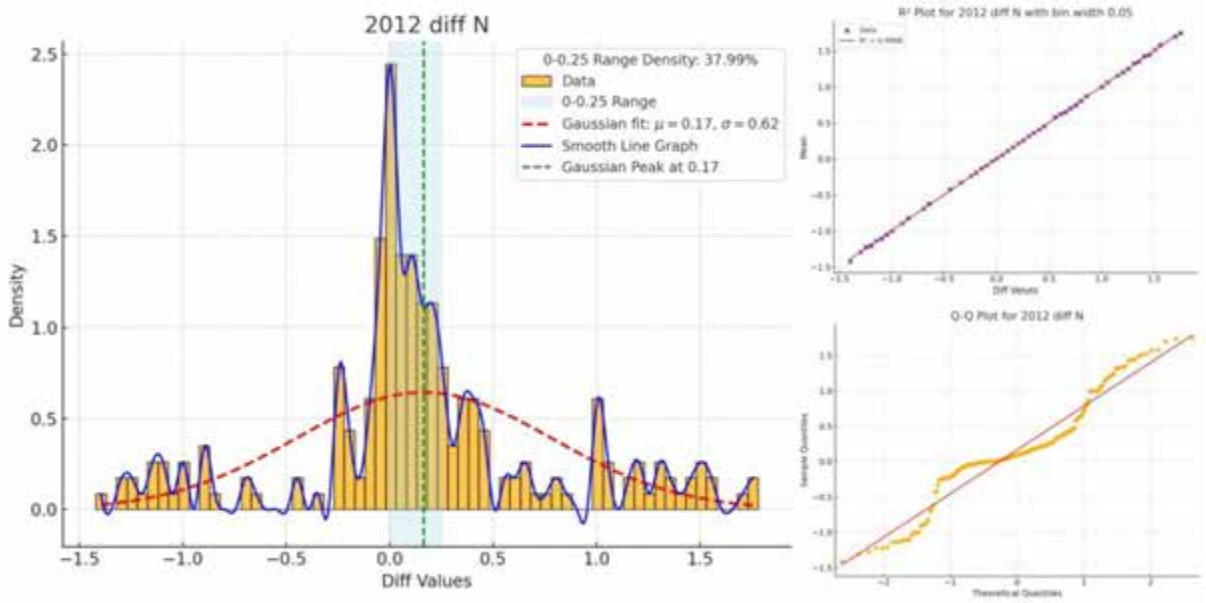


Figure S18. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 2012 (Northern Region): Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

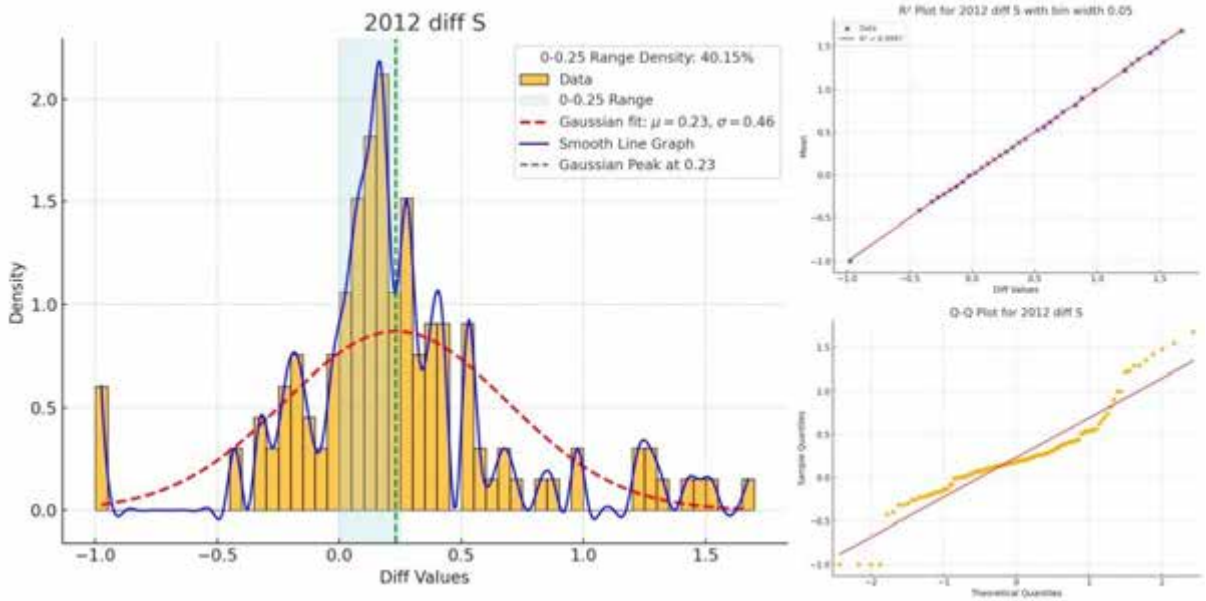


Figure S19. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 2012 (Southern Region): Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

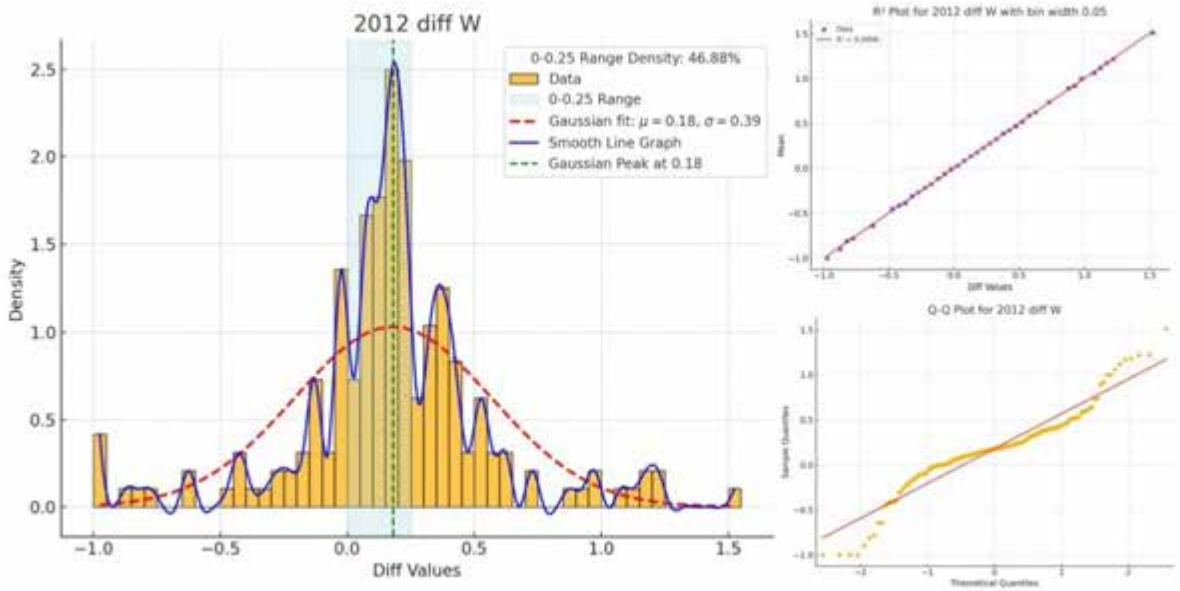


Figure S20. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 2012 (Western Region): Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

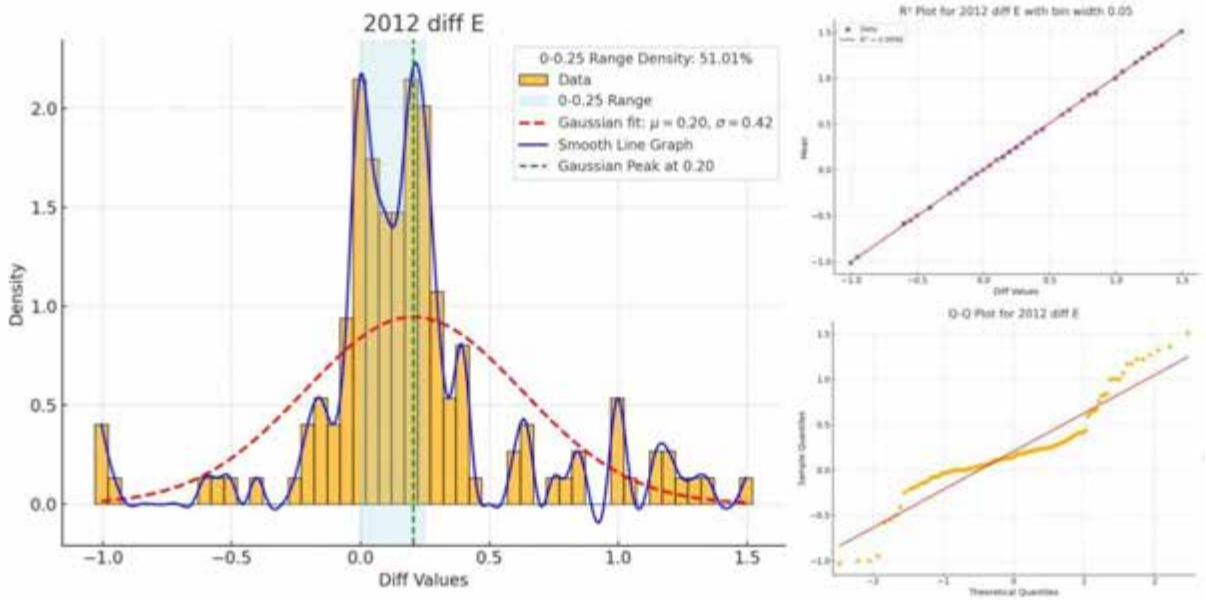


Figure S21. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 2012 (Eastern Region): Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

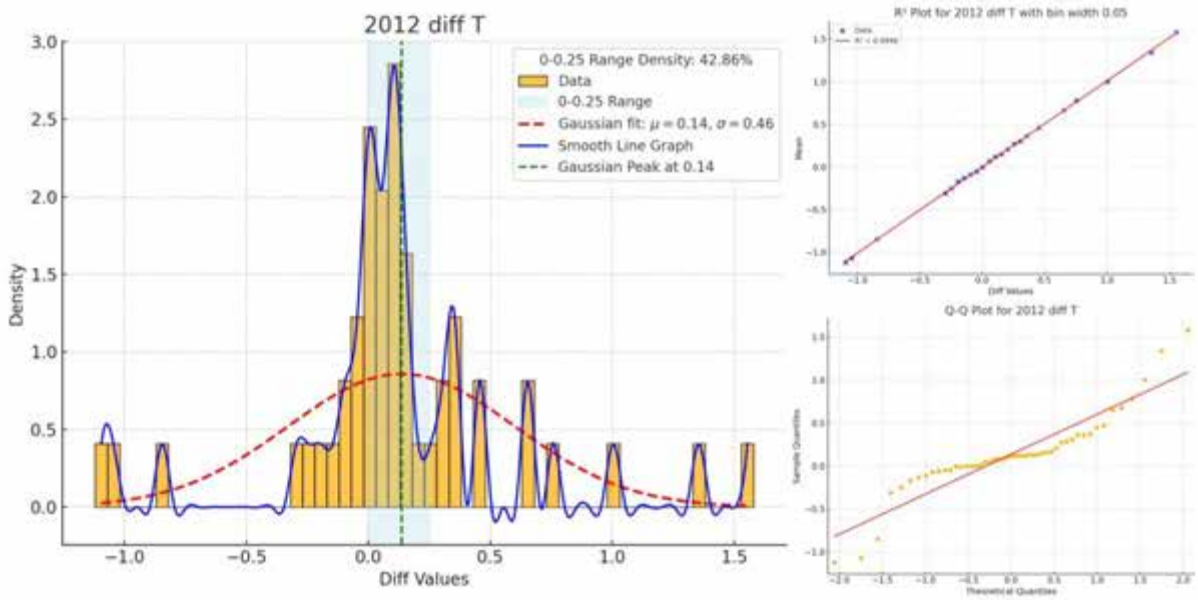


Figure S23. Statistical Analysis of Sub-Fractal Difference Values for the Izmir Plan of Metropolitan Municipality, 2012 (Central İzmir): Histogram with the Range Density, Gaussian Fit, QQ Plot and R^2 value.

Geographically weighted machine learning for modeling spatial heterogeneity in off-campus student housing rents

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Abstract

This study employs Geographically Weighted Machine Learning (GW-ML) to analyze spatial patterns and influencing factors of off-campus rental prices near colleges in Taiwan. Using Moran's I, LISA, and K-means clustering, the research identifies rent clusters and segments the market. OLS, GWR, and GW-ML models were compared in terms of their performance, with Geographically Weighted LightGBM showing the best predictive accuracy. Key factors affecting rents include proximity to colleges, housing age, and access to public transportation. The GW-ML framework captures spatial heterogeneity and nonlinear relationships more effectively than traditional models. The results reveal that rental properties in city centres place more importance on rental area, while those in suburban areas focus more on building age for improving housing affordability and guiding policy in college neighborhoods.

Keywords: geographically weighted machine learning; machine learning; housing rents

1. introduction

In recent years, rising housing costs in Taiwan have highlighted challenges in property transactions, rental housing, and housing justice. For students living away from home, rising rents create financial burdens, compounded by information asymmetry and lack of market transparency, making the rental process stressful and complex. School districts, characterized by high rental demand, experience price fluctuations influenced by economic, spatial, and resource factors. Despite their importance, limited research addresses the spatial characteristics and factors influencing rental prices. This study investigates rental price spatial correlations and influencing factors near universities, thereby offering insights into rental market management.

2. Research Methodology and data sources

2.1. Study Area

This study investigates the spatial distribution characteristics of rental prices in areas surrounding school districts. To comprehensively analyse the factors influencing the rental market, the study encompasses eight administrative districts in Tainan City: West Central District, North District, East District, South District, Anping District, Annan District, Yongkang District, and Rende District. They are shown in Fig. 1.

Fig. 1. Location of study area.

2.2. Methods of Analysis

2.2.1. Global Spatial Autocorrelation

Moran's index method was adopted to evaluate the overall level of spatial autocorrelation of a specific attribute across a geographical area. It describes the spatial distribution characteristics of an observed variable, indicating whether it exhibits clustering, dispersion, or randomness within the study area. The calculation formula is as follows:

$$I = \frac{n}{\sum_i \sum_j W_{ij}} \frac{\sum_i \sum_j W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2} \quad (1)$$

Where *n* represents the number of samples; x_i and x_j denote the attribute values at locations *i* and *j*; $\bar{x}$ represents the mean attribute value across all samples; W_{ij} is the spatial weight matrix between locations *i* and *j*.

The value of Moran's I ranges from -1 to 1. Moran 's I > 0 indicates a positive spatial autocorrelation, meaning the attribute demonstrates clustering. Conversely, Moran 's I < 0 suggests negative spatial autocorrelation, which is indicative of a dispersed pattern. When Moran's I = 0, it implies no spatial autocorrelation, signifying that the spatial distribution of the attribute is random.

2.2.2. Local Spatial Autocorrelation

Local Indicators of Spatial Association (LISA) is a measure of local spatial autocorrelation used to infer the extent of clustering within specific areas. It serves as a set of local indicators to identify the boundaries of clustered regions. The significance test primarily evaluates whether the clustering of spatial elements within a given study area is statistically significant. Higher levels of significance indicate more pronounced spatial clustering. Compared to the global indicator Moran's I, LISA focuses on detecting the variation of a specific area or unit and its association with neighbouring units. Proposed by Anselin (1995), the LISA indicator extends the concept of Global Moran's I by incorporating spatial weight considerations and calculating the Moran index for each spatial unit. The formula for calculating LISA can be expressed as follows:

$$I_i = Z_i^T \sum_j W_{ij} Z_j^T \quad (2)$$

Where Z_i^T and Z_j^T represent the standardized observed values (mean-centered) in vector form. W_{ij} is the spatial weight matrix indicating the adjacency relationship between spatial units *i* and *j*, W_{ij}=1: *i* and *j* are adjacent; =0: and are not adjacent.

Anselin (1995) categorized LISA into four quadrants based on the degree of spatial clustering, as shown in Fig. 2.: high-high (HH), low-high (LH), low-low (LL), and high-low (HL). This classification facilitates the analysis of spatial clustering intensity. HH and LL are also referred to as hot spots and cold spots, respectively. The quadrant diagram aids in analyzing the relationship between high or low observed values in a specific area and those in surrounding areas. It identifies spatial association patterns across the study area, highlighting local spatial anomalies and instabilities. Typically, the LH and HL categories reflect anomalies that are inconsistent or contradictory to their surrounding areas (Gray, 2011). These values indicate significant deviations and provide insight into local spatial heterogeneity.

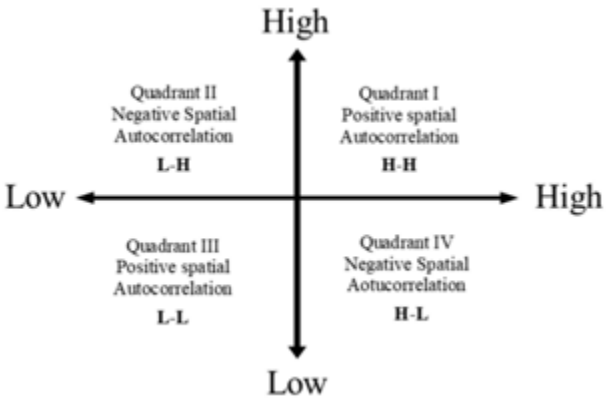


Fig. 2. LISA Local Spatial Autocorrelation Quadrant Map.
Source: Wang et al., 2019

2.2.3. OLS and HPM

The housing characteristic price model (HPM) often uses OLS for estimation, using OLS as the basic estimation technique to study how different characteristics of housing affect market prices. Its basic assumption is that housing prices can be predicted through the attributes of the unit's structure and location as independent variables, and it discusses housing prices as a heterogeneous product from a macro perspective (Ucal & Kaplan, 2020)using a hedonic price model with a large dataset and a single variable for locational attributes. Research Design & Methods: The analysis of consequent housing prices in İstanbul's counties with hedonic price modelling and the extrapolation of results by comparing the prices to the human development level of counties. We use multiple regression and Ordinary Least Squares (OLS. Many studies have proposed that various characteristics do indeed affect rent, and a regression model framework has been established to create a system for housing prices, further analyzing the effective analytical structure and characteristics of regional real estate prices. According to the research by Sirmans et al. (1989) , the impact of various local amenities and building characteristics on housing prices was studied, Davis et al. (2023) assessed the impact of green infrastructure on housing prices through a characteristic price model, including analysis of artificial wastewater wetlands, crystal gardens, ponds, etc., to further understand the property value of the ecosystem services they provide. The OLS calculation formula is as follow:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \qquad (3)$$

The HPM calculation formula is as:

$$lnP = \alpha_0 + \sum_{i=1}^{n} \alpha_i z_i + \epsilon \quad (4)$$

Where *P* represent the asset price, *lnP* is the natural logarithm of *P*, Z_i is the price characteristic, α_0 is the intercept, α_i denotes the coefficient of the price characteristic, and ϵ is the error term.

OLS serves as a method for estimating and calculating global regression coefficients, testing whether there is a relationship between variables and the dependent variable, and checking the independence of residuals. It has been widely used in real estate price research, but it cannot explain the interactions of spatial data with heterogeneous characteristics. Therefore, most studies use GWR to compensate for the shortcomings of OLS (Koohpayma & Argany, 2021; Liu & Strobl, 2023).

2.2.4. Geographically Weighted Regression

Geographically Weighted Regression (GWR) is a local analysis technique for spatial heterogeneity that is non-stationary and conforms to the first law of geography, primarily used to understand the relationships of spatial changes, calculating each local regression through data estimated by distance decay, using the function of spatial location as coefficients in the GWR model, and allowing them to vary spatially within the study area (Fotheringham et al., 2002), thereby identifying differences in the impact and intensity of features across the overall space. For example, Gutiérrez-Posada et al. (2017) use GWR to understand whether the determining factors of local population growth in Spain have uniform or non-uniform effects over time and space, analysing the local effects of spatial differences to plan appropriate local policies.

GWR has the core concept that regression coefficients are not fixed constants but vary according to different geographical spaces. Thus, it can capture the relationship between dependent and independent variables in space and the non-stationarity of housing prices, achieving higher accuracy and fitting effects than classical regression models(Cellmer et al., 2020; Iliopoulou & Feloni, 2022)as well as of real estate prices and values. The main aim of the study was to analyse an effect of these socio-demographic and environmental factors on average housing property prices and on the number of transactions in a spatial approach. In previous research conducted on a national scale, usually all variables were treated in a similar way, i.e., as global or local variables. During the research, an attempt was also made to answer the question of which of the variables adopted for analysis have a local impact on prices and market activity, and which are global. The study was conducted in Poland and used data from the year 2018 on 380 counties (Local Administrative Units. The impact range of spatial heterogeneity and observation points has now been widely applied in various fields, such as economics, environmental science, public health, and the housing prices. The key point to note is the need to choose appropriate distance weighting functions and bandwidth (Brunsdon et al., 1996), and it can only describe continuous heterogeneity, still requiring other methods to assist in describing complete spatial heterogeneity, such as spatial autocorrelation analysis. The GWR calculation formula is as follows:

$$y_i = B_0(u_i, v_i) + \sum_{k=1}^{p} B_k(u_i, v_i) x_{ik} + \varepsilon_i \quad (5)$$

Where y_i is the rental price at the *i*-th observation point; $B_0(u_i, v_i)$ is the intercept term at the *i*-th observation point, varying with spatial location (u_i, v_i); $B_k(u_i, v_i)$ represents the regression coefficient of the *k*-th independent variable at the *i*-th observation point; x_{ik} is the value of the -th independent variable at the *k*-th observation point; ε_i is the error term at the *i*-th observation point.

To estimate the location-specific coefficients in equation (5), GWR constructs a diagonal weight matrix W_i centred on each observation *i*. The most widely adopted choice is the Gaussian kernel, which assigns weights according to

$$W_{ij} = \exp\left(-\frac{d_{ij}^2}{2h^2}\right) \quad (6)$$

where d_{ij} denotes the Euclidean distance between observations *i* and *j*, and *h* is the bandwidth that produces smoother spatial surfaces, whereas a smaller value allows stronger local variation. The optimal bandwidth is typically selected by leave-one-out cross-validation or the corrected Akaike information criterion (AICc) (Brunsdon et al., 1996). The Gaussian kernel provides continuous, strictly positive weights, which stabilise local estimations and avoid singular design matrices (Fotheringham et al., 2002).

2.2.5. Applications of Machine Learning in Rental Market Analysis

The geographical distribution and influencing factors of rental market prices have been focal research areas. Traditional regression models, such as linear regression and geographically weighted regression (GWR), face limitations in handling high-dimensional features and non-linear relationships. Machine learning models, including Random Forest, Support Vector Regression (SVR), KNN, and gradient boosting frameworks (XGBoost, LightGBM), are increasingly replacing traditional methods, offering improved prediction accuracy and efficiency.

XGBoost and LightGBM stand out in particular. Research indicates that XGBoost effectively avoids overfitting and enhances computational efficiency through regularization and parallel computation, while LightGBM further accelerates large-scale data processing with improved accuracy (Chen & Guestrin, 2016; Ke et al., 2017). For instance, Takahiro Yoshida et al. (2021) demonstrated that XGBoost outperforms traditional regression models in accuracy and efficiency on large datasets. Similarly, Yue Ming (2020) verified XGBoost's precise prediction of Chengdu's housing prices, with a mean squared error (MSE) of just 0.04. These studies highlight the significant advantages of XGBoost and LightGBM in handling non-linear and spatially heterogeneous rental market data.

Taking advantage of its ability to evaluate spatial impacts and analyze nonlinear relationships, geographically weighted machine learning methods have been applied in research recently. Wang et al. (2024) used geographically weighted random forest (GW-RF) model to explore the local associations between crash frequency and various influencing factors in the US. Yang et al. (2023) introduced geographically weighted support vector regression (GWSVR) for analysing soil metal chromium (Cr) and PM2.5 concentrations. Assigning sample weights according to Gaussian kernel values—paralleling Geographically Weighted Regression—enhances model performance. Hence, the present study employs a geographically weighted LightGBM to describe spatial heterogeneity in the rental housing market. The geographically weighted approach is expected to outperform a LightGBM model that does not incorporate geographic weighting.

2.3. The factor selection and data sources

This study aims to explore the spatial distribution patterns of rental prices within school districts and examine the impact of various influencing factors on these rental prices, as shown in Table 1. Taking rental price as the research subject, the study adopts price per ping as the measurement standard for rental prices. The data are sourced from the Real Estate Transaction Price Inquiry System of the Ministry of the Interior, encompassing rental housing transaction records within the study area. The research period spans from January to September 2024, covering a complete three-season interval. The dependent variable for the GWR analysis is defined as rental price (NTD/ping).

In selecting potential influencing factors, this study considers the rental demands of student populations, which are typically constrained by commuting distance to schools and daily convenience. Starting from this perspec-

tive, the research identifies and analyzes nine potential factors that may affect rental prices, based on the residential convenience and accessibility needs of students, as well as the functional and structural characteristics of rental housing. These factors include: (1) distance to the nearest university, (2) distance to nearest convenience store, (3) distance to nearest supermarket, (4) distance to the nearest bus stop, (5) distance to the nearest bike stop, (6) house age, (7) rental area, (8) elevators, and (9) furniture. Table 1 shows the details of each factor. These factors serve as independent variables in the GWR analysis, which is employed to calculate the relative impact and spatial heterogeneity of these factors on rental prices within school districts.

Table 1. Potential impact factors on rental prices and valuation methods

Categories	Variables	Measurements	Data sources	Reference
Educational characteristics	Distance to nearest university	Straight line distance (meters)	Ministry of Education	Wen et al.,2015 Wen et al.,2018
Location characteristics	Distance to nearest convenience store	Straight line distance (meters)	Administration of Commerce	Ti-Ching Peng, 2021
	Distance to nearest supermarket	Straight line distance (meters)	Administration of Commerce	Wang et al., 2022
	Distance to nearest bus stop	Straight line distance (meters)	Gist Transport data	Villada-Medina, 2022
	Distance to nearest bike stop	Straight line distance (meters)	Gist Transport data	Jiang et al., 2017
Buildings characteristics	House age	year	Dept of Land Administration	Cao et al., 2017 Wen et al.,2015
	Rental area	Number of square meters	Dept of Land Administration	Cao et al., 2017 Wen et al.,2015
	Elevator	yes=1 no=0	Dept of Land Administration	Ti-Ching Peng, 2021
	Furniture	yes=1 no=0	Dept of Land Administration	Zhao et al., 2024

3. Result

3.1. Spatial Autocorrelation analysis

3.1.1. Global Moran's I

Moran's I is used to determine whether the distribution characteristics of rent unit price in the overall space are agglomeration, dispersion, or random distribution. The value is between -1 and 1. A positive value indicates that the rental unit price is clustered in space, and near points have similar prices; a negative value indicates that the unit price of adjacent points has a large difference, which indicates a scattered data distribution; approaching 0 means that the space is randomly distributed.

The results of global Moran's I are presented in Fig. 3. It shows that the Moran's I value of the rental unit price in the school district is 0.3402, the Z value is 45.9976, and the P value is 0.000, passing the significance test. It shows that there is indeed spatial autocorrelation of the rental unit price. To have a more straightforward picture pre-

sentation for the following LISA analysis, we conduct Moran's I at the neighborhood scale to confirm whether the phenomenon of spatial autocorrelation still exists if the rental unit price is presented using polygon data. Calculate the average unit rental price in the neighborhood using the representative data here. The results are shown in Fig. 4. Moran's I value is 0.101, Z value is 3.684, and P value is 0.000, passing the significance test, the space shows a positive correlation. Although the value is closer to a random distribution, the significance test still shows a non-random spatial distribution of rental unit prices, and the polygon data can help present a clearer picture.

Both point data and polygon data illustrate that rents are spatially autocorrelated. The factors affecting unit rents may vary significantly across different regions. When modeling unit rents, the bandwidth and intensity of the impact of each variable on the local scale should be considered.

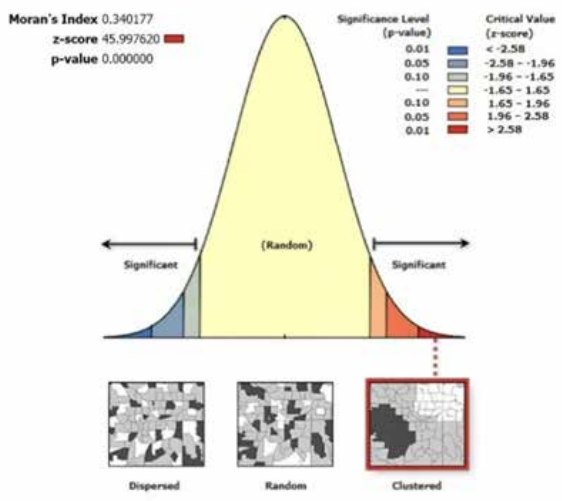


Fig. 3. Rental price data in point format; Results of spatial autocorrelation analysis by ARCGIS software.

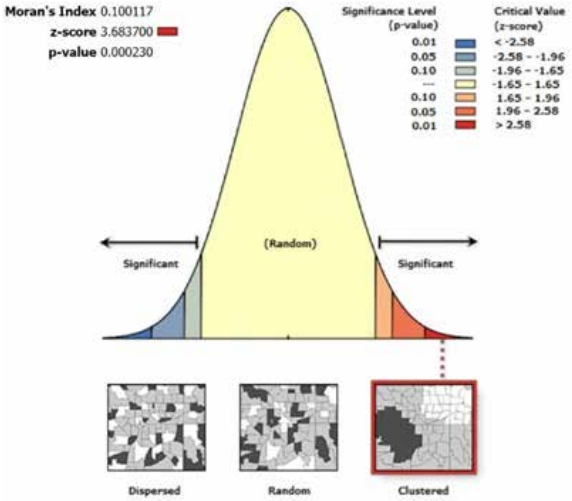


Fig. 4. Rental price data in polygon format; Results of spatial autocorrelation analysis by ARCGIS software.

3.1.2. Local autocorrelation analysis (LISA)

After confirming the spatial autocorrelation of rental unit prices, the neighbourhood scale was used to calculate the facet data of average rental unit prices. The LISA values were calculated to observe the clustering phenomenon of high and low values in each area, and the results are shown in Fig. 5.

High rent unit price clusters (H-H) are in the East, West Central, and North Districts, which are the city centre of Tainan. With complete living functions, and several colleges are clustered here, including National Cheng Kung University, Tainan Nursing College, and the University of Tainan, etc., leading to high rental demand, the rental price thereby increase; The low-rent unit price agglomeration area (L-L) is located near the sea in South District and Yongkang District adjacent to Xinhua District. It is a suburban area far away from the core development areas and schools of Tainan City. The convenience of life is low, resulting in the phenomenon of low-rent unit price clusters. In addition, the areas with a mix of high and low rent prices, H-L points, are located at the junction of the Yongkang District. It is speculated that the proximity to the Tainan Industrial Park and the Yongkang Interchange of National Highway No. 1 has resulted in higher rents in this area than in other areas. However, there is less rental data in this area, so bias due to insufficient sample size cannot be ruled out; L-H points are located in the West Central District and Annan District, which is the transition zone between the city centre and the suburbs. It results in a spatial distribution phenomenon where high-rent and low-rent properties coexist.

Then, we analysed the spatial cluster phenomenon on the main variables that affect housing prices. There are two variables in total, namely house age and floor area. The results are shown in Fig. 6. and Fig. 7. Aged housing areas are in the city centre and overlap with high-rent areas. Although the results of subsequent model construction show that the overall impact of house age on unit rent is negative, the unit rental price in areas with older houses is still higher in the city centre due to the location value and the impact of the specific rental market structure. Smaller floor area clusters also overlap with high-rent areas. Land resources in the city centre are scarce, and the unit area design tends to be smaller to improve space utilization efficiency. Furthermore, in response to the special target groups around the city centre, such as students, young tenants, etc., the rental price of the units is relatively high.

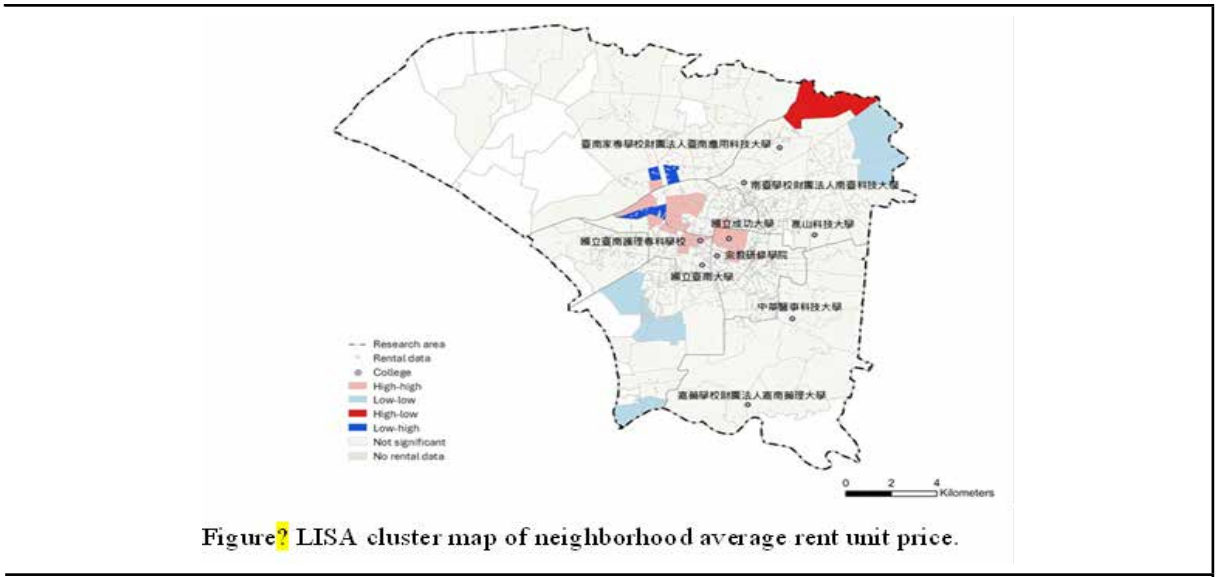


Fig. 5. LISA cluster map of neighbourhood average rent unit price.

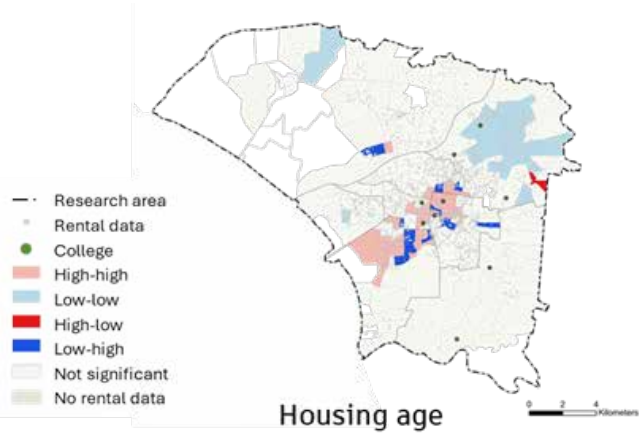


Fig. 6. LISA cluster map of average housing age.

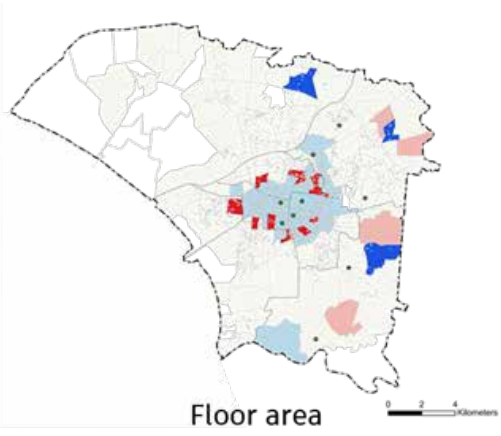


Fig. 7. LISA cluster map of average floor area.

3.2. Ordinary Least Squares (OLS)

Ordinary Least Squares (OLS) is a statistical method used to determine the relationship between two or more variables by minimizing the sum of the squared differences between predicted values and actual observed values. This method identifies the best linear relationship. The OLS estimation results are shown in Tables 2 and 3.

From the regression statistics, the model is based on an analysis of 4,942 samples, which is a sufficient sample size. The multiple R value is 0.289, indicating the correlation between variables ranging from 0 to 1. This suggests a relatively low correlation, meaning the model has limited explanatory power for the dependent variable. The R-squared value explains the proportion of variance in the dependent variable accounted for by the model, which is only 8.35%. This indicates that the explanatory variables in the model have limited ability to explain housing prices, and other important variables may not have been included. The adjusted R-squared is slightly lower than the original R^2 because it accounts for the number of variables, providing a more conservative measure of the model's explanatory power. The standard error, which represents the range of prediction errors, is 104.209. A smaller value is preferable, but the relatively high standard error indicates that the model's accuracy is suboptimal.

In the regression coefficient analysis, the coefficients show the direction of the impact of each variable on the dependent variable. When all independent variable values are zero, the predicted value of the dependent variable is 298.431. Among the independent variables analyzed, most were statistically significant, except for the distance to elevators and supermarkets, which were not significant.

Overall, the findings indicate that as housing age, distance to schools, convenience stores, bus stops, and bicycle lanes increase, housing prices decrease. Although the model is statistically significant, the R^2 value is only 0.084. It suggests that the model may be missing important variables, such as location, school district quality, and transportation. This causes limitations for the research.

Table 2. Result of OLS regression statistics

regression statistics	result
Multiples of R	0.289
R-squared	0.084
Adjustable R Square	0.082
Standard Errors	104.209
Number of observed values	4942

Table 3. Result of OLS regression model

	coefficient	Standard Errors	t Stats	P-value	Lower Limit 95%	Up to 95%
intercept	298.431	5.942	50.227	0.000	286.782	310.079
Age	-0.346	0.040	-8.588	0.000	-0.426	-0.267
Area	-0.067	0.006	-10.719	0.000	-0.079	-0.055
Furniture	-10.589	3.621	-2.925	0.003	-17.687	-3.491
Manage	-46.400	5.299	-8.756	0.000	-56.789	-36.011
Elevator	6.696	5.761	1.162	0.245	-4.598	17.990
Coll_Dist	-0.009	0.001	-6.920	0.000	-0.012	-0.006
PX_Dist	0.002	0.004	0.428	0.668	-0.006	0.010
Conv_Dist	-0.052	0.016	-3.323	0.001	-0.082	-0.021
Bus_Dist	-0.036	0.015	-2.358	0.018	-0.065	-0.006
Bike_Dist	-0.034	0.008	-4.171	0.000	-0.050	-0.018

3.3. Geographically Weighted Regression (GWR)

As shown in Table 4. The overall model's R^2 reaches 0.22, significantly improving the performance compared to the linear model. Based on the t-values, The primary influencing variables are Age, Area, Coll_Dist, Manage, Conv_Dist, and Bike_Dist. The secondary influencing variables are Furniture and Bus_Dist. Elevator and PX_Dist are identified as non-significant variables.

Table 4. Calculation results of the GWR model

Variable	Standard Deviation	Mean (Coefficient)	Maximum	Minimum	t value
Intercept	5.9416	298.4305	377.5660	265.3773	2.00E-16
Age	0.0403	-0.3465	-0.1252	-0.6986	2.00E-16
Area	0.0062	-0.0668	-0.0220	-0.8823	2.00E-16
Coll_Dist	0.0013	-0.0090	0.0010	-0.0278	5.08E-12
Furniture	3.6207	-10.5890	5.5771	-44.9303	0.003465
Manage	5.2994	-46.4001	1.2113	-75.2109	2.00E-16
Elevator	5.7609	6.6956	33.3501	-48.9803	0.245192
PX_Dist	0.0041	0.0018	0.0735	-0.0323	0.668474
Conv_Dist	0.0155	-0.0516	0.0601	-0.2283	0.000897
Bus_Dist	0.0151	-0.0356	0.0730	-0.1372	0.018406
Bike_Dist	0.0082	-0.0342	0.0228	-0.1068	3.08E-05

1.1.1. The impact of educational characteristics on rental housing prices

By comparing the distance map of each point to the nearest university (Fig. 8) with the results of the Geographically Weighted Regression (GWR) analysis (Fig. 9), it is evident that the closer the distance to a university, the higher the housing prices.

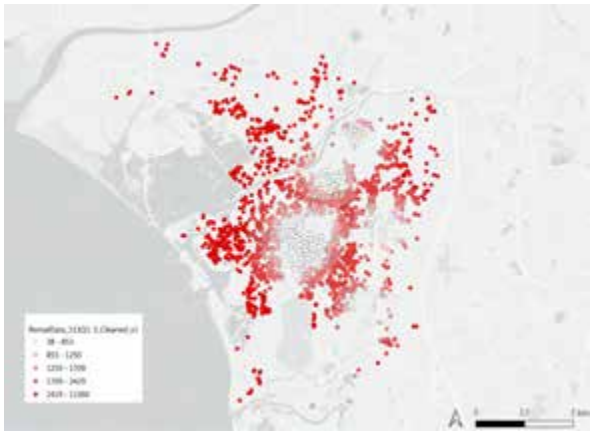


Fig. 8. The distance map of each point to the nearest university.

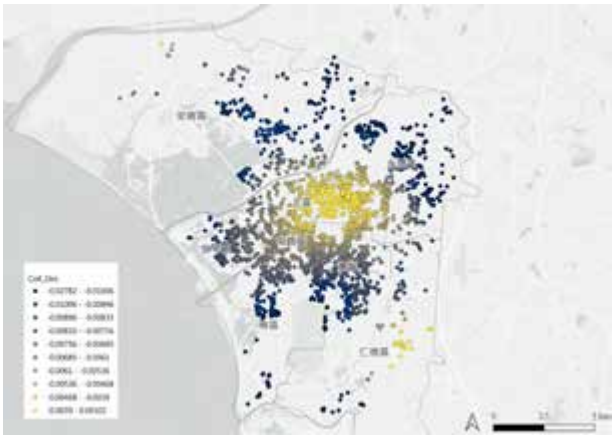
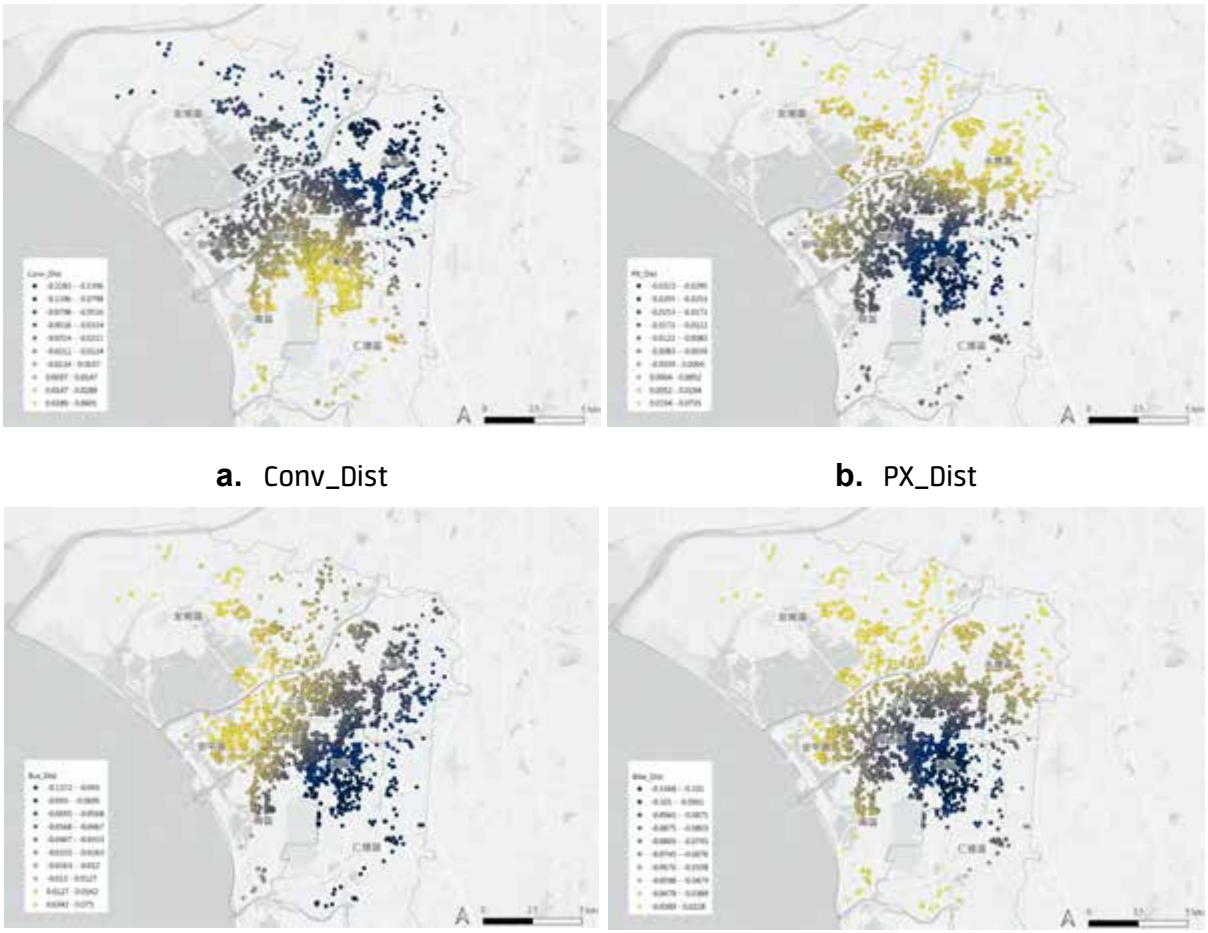


Fig. 9. The impact of educational characteristics on rental housing prices.

1.1.2. The impact of location characteristics on rental housing prices

As shown in Fig. 10(a-d), the distances to the five major convenience stores and shared bicycle stations are the primary variables affecting housing prices, while the distance to the nearest bus stop is a secondary variable. The negative impact of the distance to convenience stores on housing prices is more pronounced in Yongkang District and Annan District, which can be attributed to the density of convenience stores in these areas. The neg-

ative impact of the distance to shared bicycle stations on housing prices is more significant in the East District, likely due to the demand for bicycles and the number of station installations in this area.



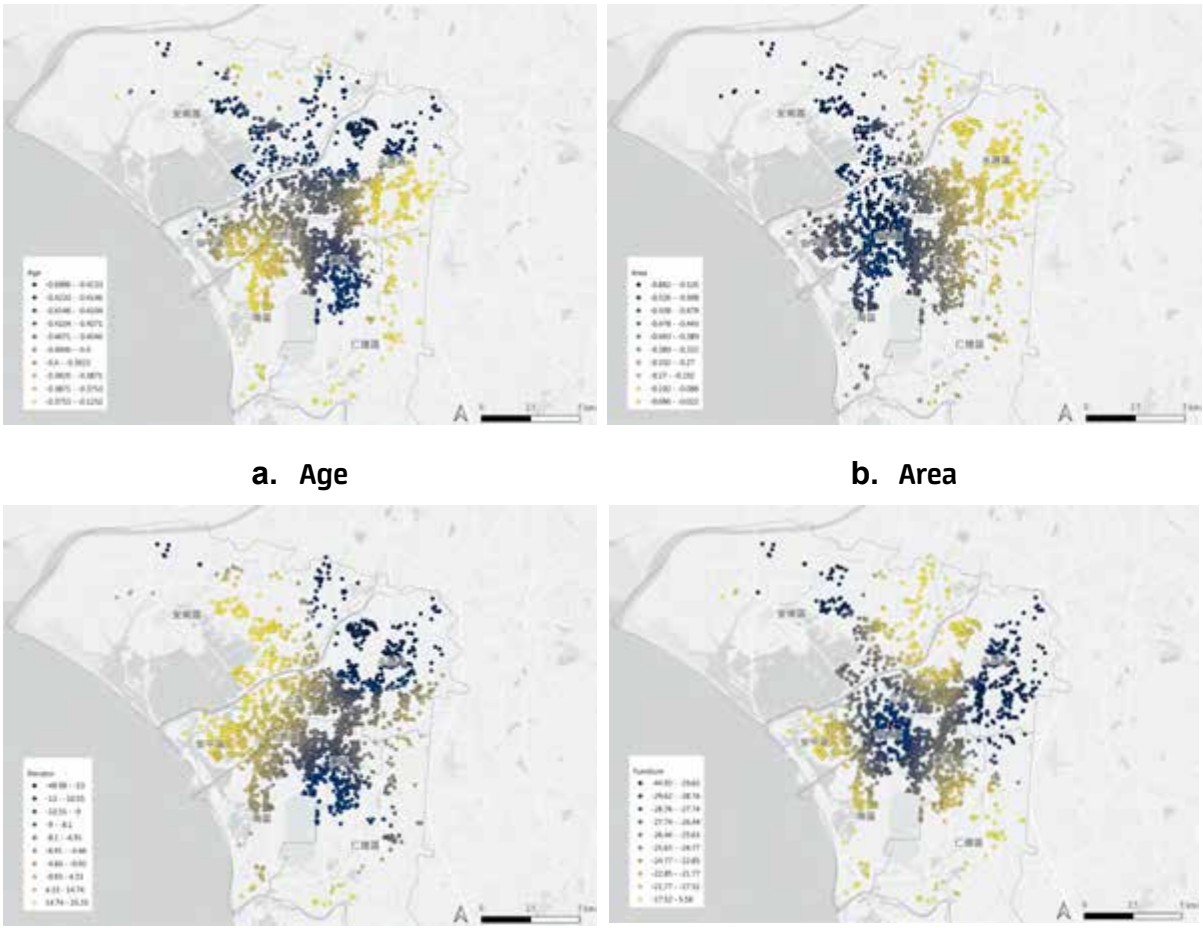
a. Conv_Dist **b.** PX_Dist

c. Bus_Dist **d.** Bike_Dist

Fig. 10. The impact of location characteristics on rental housing prices.

1.1.3. The impact of building characteristics on rental housing prices.

As shown in Fig. 11 (a-d), building age and floor area are the primary variables influencing housing prices, with the presence of furniture being a secondary factor. The negative impact of building age on housing prices is more pronounced in the East District and Yongkang District. Additionally, there is a significant north-south disparity in Yongkang District, with Provincial Highway 20 serving as a dividing line; this is likely because the southern area consists of older neighbourhoods, while the northern area features more newly constructed houses, resulting in a greater influence. The impact of floor area on the negative effects of building age is more significant in Annan District and the West Central District. Cross-referencing the analysis of building age, it can be inferred that Annan District contains newly constructed houses, leading to noticeable differences in floor area.



a. Age b. Area

c. Elevator d. Furniture

Fig. 11. The impact of building characteristics on rental housing prices.

3.4. Geographically Weighted Machine Learning

The study employed geographically weighted LightGBM (GW-LGBM) to capture spatial heterogeneity and nonlinear relationships more effectively than traditional models. The bandwidth selection and Gaussian kernel weighting scheme were used in the same way as geographically weighted regression (bandwidth = 0.023), so that each observation receives a distance-decay weight relative to the prediction location—the farther an observation lies from the test point, the smaller its weight becomes, as illustrated in Fig. 12.

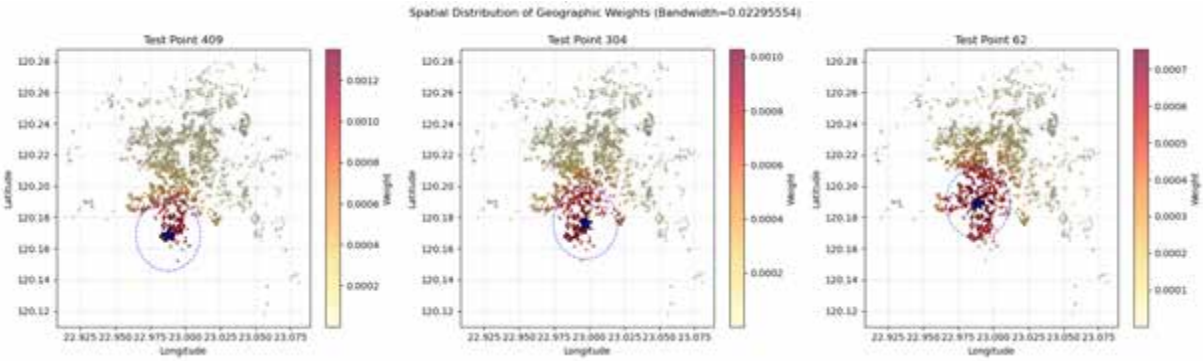


Fig. 12. Spatial Distribution of Geographic Weights.

The geographically weighted LightGBM (GW-LGBM) model attains a root-mean-square error (RMSE) 68.53 in predicting unit rental prices. Feature-importance analysis identifies floor area, building age, and furnishing status as the three most influential predictors, with floor area exerting a markedly greater effect than the others. SHAP analysis shows that its contribution to explaining unit rent diminishes as floor area increases. This attenuation is likely due to a neighbourhood-level rent ceiling. Once that threshold is approached, additional square metres generate progressively smaller rent increases, making unit-rent estimation more challenging for the model. Consequently, lower building age shows a positive association. Newer properties improve the model performance for the unit rental price. Furnishing status displays a highly polarised pattern: because most Taiwanese rental units are furnished, an unfurnished listing becomes a distinctive indicator that enhances predictive accuracy.

Spatial mapping of SHAP values demonstrates that predictor importance varies across the research area. In the city centre, the floor area contributes most strongly to the model's discrimination of unit rents, whereas in suburban areas, building age becomes the dominant explanatory factor. Furnishing status shows far less spatial variation. These results indicate that the GW-LGBM framework yields superior predictive performance and captures the rental market's inherent spatial heterogeneity when combined with SHAP diagnostics.

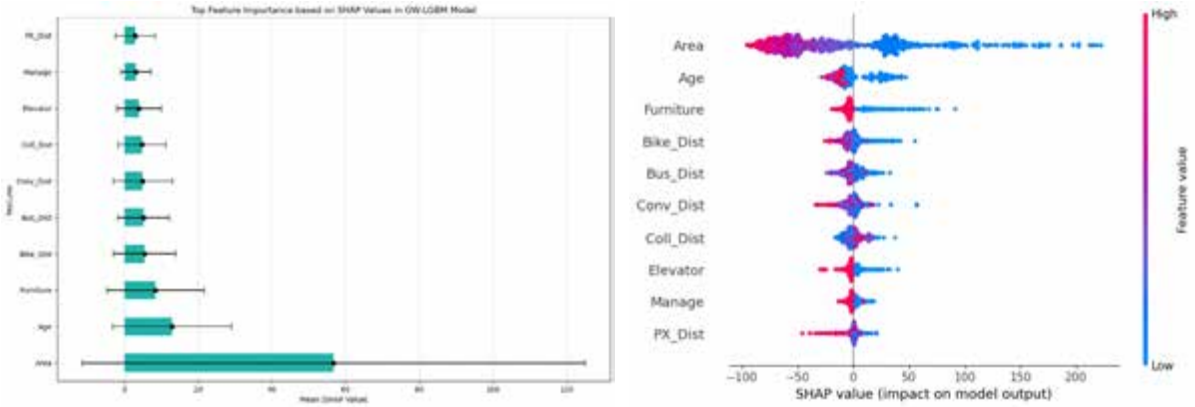


Fig. 13. Feature Importance on SHAP Value

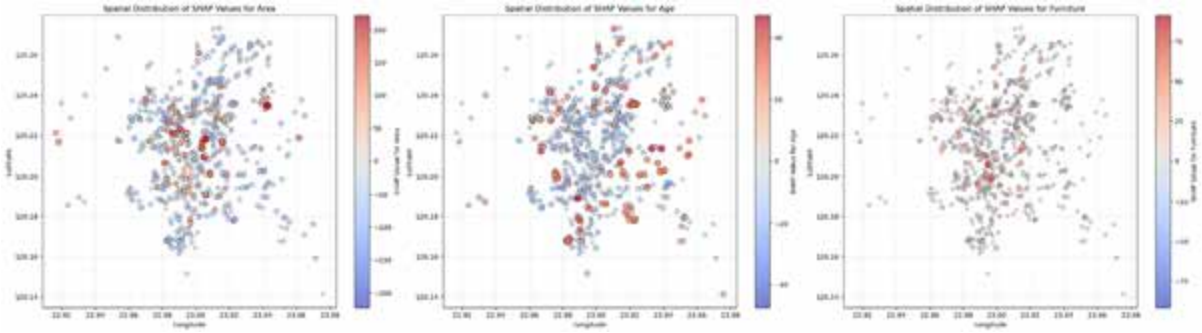


Fig. 14. Spatial distribution of SHAP Value for Area, Age, and Furniture

3.5. Model Comparison

In this study, geographically weighted models show better performance than original models. This study employed OLS, GWR, and GW-ML models to compare their performance. In order to evaluate the effectiveness of these models, a comparison was also made with general machine learning methods that do not incorporate geographical weighting. The comparison results were shown in Fig. 15. Previous studies have primarily compared linear regression models with GWR, demonstrating that GWR is a superior analytical method. This phenomenon is also confirmed in the present experiment, where the RMSE of the linear regression model is 112.36,

while that of GWR is 96.23, indicating a significant improvement in model performance. However, upon including machine learning models in the comparison, it was observed that the RMSE values of all machine learning models outperformed those of GWR. This suggests that machine learning provides a more effective approach to analysing unit rental prices.

The superior performance of machine learning models may be attributed to the inherent characteristics of GWR, which is a spatial statistical method specifically designed to capture spatial heterogeneity. Factors that influence unit rental prices exhibit limited spatial characteristics, rendering GWR effective in enhancing linear regression but insufficient for addressing the details of rental data. Consequently, machine learning models demonstrate better performance than GWR in this context.

The results showed that the geographically weighted machine learning model (GW-LGBM) achieved the lowest RMSE of 68.53, outperforming all other models. It significantly surpassed both the linear regression model and state-of-the-art machine learning models. This indicates that when data exhibits spatial heterogeneity, applying geographical weighting to the model can notably improve its performance.

Table 5. RMSE for all models

Model Type	Model Name	RMSE
	Linear Regression	112.36
	OLS	
	Bayesian Ridge	112.38
	Lasso	112.36
Machine Learning	Support Vector Regression (SVR)	108.84
	Random Forest (RF)	75.64
	Gradient Boosted Decision Tree (GBDT)	76.88
	eXtreme Gradient Boosting (XGBoost)	78.70
	Light Gradient Boosting Machine (LightGBM)	75.08
	K-Nearest Neighbor (KNN)	94.35
GWR	Geographically Weighted Regression	96.23
GW-ML	**Geographically Weighted LightGBM (GW-LGBM)**	**68.53**
	Geographically Weighted Random Forest (GW-RF)	70.81

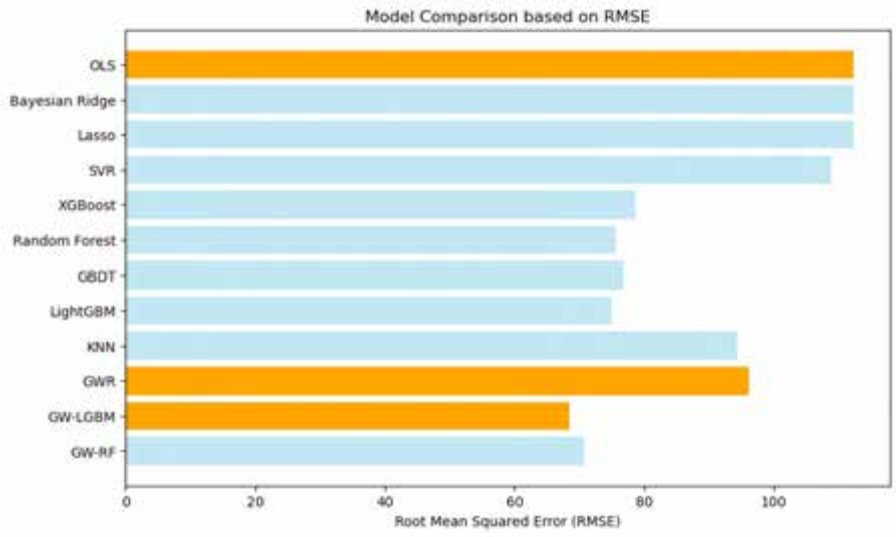


Fig. 15. Model Comparison

The aim of this study is to analyse the spatial characteristics of rental housing using various analytical methods, including Geographically Weighted Regression (GWR) and Geographically Weighted Machine Learning (GW-ML). The GW-ML model outperforms linear regression, machine learning, and GWR models due to its ability to simultaneously accommodate spatial sample weight adjustments and non-linear relationships that describe interactions with rental prices. The results reveal that, within the GWR model, factors such as rental area, building age, distance to universities, and the availability of management staff are the most significant determinants of rental prices. Meanwhile, in the GW-LGBM model, rental area, building age, and furniture availability are the most important factors influencing model performance. Both methods highlight rental area and building age as key factors impacting rental prices. From the GW-LGBM model, it was found that rental properties in city centres place more importance on rental area, while those in suburban areas focus more on building age. These findings can assist urban planners in understanding the preferences and spatial heterogeneity of rental populations, enabling the development of policies that provide appropriate subsidies or other measures to enhance overall social welfare.

However, the R-squared value for the GWR model in this study is only 0.22, indicating that it cannot fully explain the variations in unit rental prices. Although the GW-LGBM model performs better, some errors remain. Future research could leverage Graph Neural Networks (GNNs) or other models to further investigate the underlying causes of rental behaviour and price fluctuations.

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Exploring Regionalazation and Centralization in İzmir: A Dual-Phase Analysis of Urban Morphology Using Sub-Fractal and Space Syntax Methods

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Abstract
This study explores İzmir's spatial evolution from the 1950s to the present through an integrated dual-phase methodology combining sub-fractal and space syntax analyses. Grounded in complexity science, the city is conceptualized as a self-organizing system influenced by nonlinear urban dynamics. The exogenous phase applies sub-fractal analysis to assess macro-scale morphological changes across four time periods, identifying a progression from fragmented rural complexity to consolidated urban form, especially along a north–south axis. The endogenous phase analyzes changes in centrality through space syntax, revealing a decrease in spatial embeddedness until the 1990s, followed by renewed centralization. This multi-scalar approach contributes to planning strategies for managing regional complexity and urban growth.

Keywords: Urban Morphology, Regionalization, Centralization, Sub-Fractal Analysis, Space Syntax

1. Introduction

The transformation of urban systems in the 21st century is increasingly characterized by the recognition of cities as self-organizing, open systems shaped by dynamic, nonlinear, and adaptive processes. The complexity of an urban region emerges from micro-level changes that generate macro-level transformations. In other words, regional complexity arises intrinsically. Within this framework, fractal and syntactic methods have increasingly been used to explore the hierarchical and self-similar characteristics of urban form, aligning with the core tenets of complexity theory in urban studies.

This study adopts such a complexity-informed perspective to examine the evolution of regionalization and centralization tendencies in İzmir from the 1950s to the present. A dual-phase methodological approach is employed, integrating both exogenous and endogenous analyses by combining sub-fractal and space syntax methods at the regional scale. This integrated approach addresses the methodology of complexity studies by bridging analyses of macro-regional patterns and local spatial centrality.

The exogenous analysis focuses on İzmir's 30 districts, each exhibiting distinct development patterns shaped by tourism, industry, agriculture, services, and logistics. This phase investigates regionalization dynamics through macro-scale morphological changes, using district boundaries as analytical frames and applying sub-fractal analysis to road networks and administrative divisions. By disaggregating the urban system into smaller spatial units, sub-fractal analysis reveals variations in spatial complexity that diverge from the system's overall fractal dimension, highlighting the heterogeneous and often non-self-similar nature of urban growth. Four temporal intervals are considered: 1950s–1960s, 1970s–1980s, 1990s–2000s, and post-2010.

The endogenous phase explores centralization tendencies through space syntax analysis, focusing on the configurational properties of the urban road network. Drawing on patchwork theory, the study evaluates inter-segment relationships across radii ranging from 500 meters to 50,000 meters, capturing scales of both pedestrian mobility and vehicular commuting. Correlations between syntactic measures at different radii were used to determine the most representative scales of local complexity, which then informed the box sizes for sub-fractal analysis. The results indicate a contraction in centralization radii until the 1990s–2000s, followed by a subsequent expansion, reflecting a more dispersed urban structure and shifts in spatial centrality.

By combining these two analytical perspectives, the study demonstrates main findings of how regionalization and centralization processes interact over time to shape İzmir's urban morphology. The exogenous component reveals system-wide patterns of spatial integration, while the endogenous analysis captures internal structural dynamics. This multi-scalar approach contributes to a deeper understanding of urban and regional complexity and offers a foundation for more adaptive and responsive planning strategies in the face of spatial transformation.

2. Fractal and Syntactic Approaches to Urban Complexity

The term "fractal" was introduced by Mandelbrot in 1967 to describe shapes characterized by intrinsic asymmetry, scale invariance, and self-similarity. Fractal geometry serves as a spatial representation of chaos theory, reflecting interactions between chaotic and orderly elements across multiple scales in complex systems. Baranger (2000) emphasizes that fractals maintain their complexity at every scale, resisting simplification upon closer examination. Richardson's (1961), work on measuring the length of coastlines and national boundaries prompted Mandelbrot to expand the concept through his paper "How Long Is the Coast of Britain?" (1967). Fractals typically have a Euclidean parameter between 1 and 2—shorter than a plane but longer than a straight line. As with other natural fractals, such as mountain ranges, these features may have fractal dimensions ranging between 2 and 3, indicating greater complexity than a surface but less than a volume.

Unlike the classical Euclidean framework, which uses whole-number dimensions—0 (point), 1 (line), 2 (plane), and 3 (cube)—fractal analysis introduces fractional dimensions (Fd). Figure 1 illustrates how geometric complexity evolves with increasing dimensionality: from isolated points (0D), to a branching fractal (~1.2D), to nested cubes (~2.3D). This progression highlights how higher dimensions contribute to greater structural complexity in fractal and spatial systems.

Since the publication of Batty & Longley's seminal work Fractal Cities in 1994, numerous studies have adopted the complex systems approach to analyse urban morphology. These studies aim to calculate the fractal dimensions of cities and urban fragments, producing a range of insights into the structural complexity of urban form. One core theoretical contribution is the observed alignment between fractal dimensions, power-law distributions, and central place theory (Batty & Longley, 1994; Frankhauser, 1998; Lu & Tang, 2004; Chen, 2008; Myint & Liam, 2005; Thomas & Frankhauser, 2013).

Fractal dimensions of urban components can be measured using a mesh that identifies the minimum number of non-overlapping boxes (Ns) needed for a given box size (S). The optimal mesh size is achieved by adjusting the coverage-to-resolution ratio. As emphasized by complexity theory, urban systems are dynamic, involving scaling behaviors, power laws, and spatial centrality. Therefore, appropriate grid sizes may vary depending on centrality. To better understand the spatial complexity—or "metabolism"—of parts within an urban region, the most suitable mesh size can be identified through space syntax methods that assess spatial centrality in large urban systems. While fractal analysis emphasizes morphological characteristics, space syntax complements this perspective by

focusing on the relational configuration of space. Space syntax analysis is a morphological method developed to identify spatial characteristics of urban environments using axial maps and convex spaces. This set of theories and techniques, collectively referred to as space syntax provides tools to analyze spatial configurations(Hillier & Hanson, 1984; Volchenkov & Blanchard, 2008). Although space syntax is often applied to urban neighborhoods, several studies have extended its use to larger urban or regional contexts to investigate spatial hierarchy and boundary definition. On a regional scale, space syntax has been employed to understand spatial hierarchies, with centrality commonly represented by accessibility measures (Serra, 2013; Yamu et al., 2017; Yamu & van Nes, 2020).

As urban systems involve scaling, power law behaviour, and centrality, grid sizes used in fractal analyses must be adapted accordingly. The appropriate grid size—whether for measuring fractal dimension or evaluating connectivity—can be determined using space syntax by examining centrality across various spatial scales. Given these shared conceptual foundations, fractal analysis and space syntax have been jointly applied in several studies. Axial line maps, central to space syntax, exhibit fractal characteristics because urban street networks typically include a small number of long lines and a large number of short lines (Vaughan, 2007; van Nes & Yamu, 2018), noting that this results in a statistically nonlinear, long-tailed curve akin to power laws. This property aligns with fractal logic, where self-similarity across scales is expressed through hierarchical spatial organization (Yamu, 2014). Urban structures are therefore self-similar and partially scale-free. In line with this, studies have found that the distribution of integration values, choice values, and open space configurations in cities such as Rothenburg, Bielefeld, Amsterdam, Venice, and Manhattan conform to power-law behaviour (Volchenkov et al., 2008). Hillier et al. (2010) and Molinero & Thurner (2021) further argues that when power laws are observed, the scaling dimension remains relatively stable across all node pairs, consistent with fractal dimensionality. Since transportation networks themselves are fractal in nature, axial maps inherently reflect these properties (Hillier et al., 2010).

Although both fractal analysis and space syntax offer valuable tools for investigating urban complexity—particularly through the analysis of transportation networks—studies that integrate the two remain relatively limited.

Kaya & Bölen (2017) examined the morphogenetic structure of Istanbul using both approaches, likening settlement patterns to the DNA of living organisms. They classified spatial parameters into four categories: (i) geometrical, (ii) topological, (iii) visibility-perception, and (iv) complexity. The second and third categories were based on syntactic values, while fractal dimension analysis was incorporated as a complementary measure of complexity. Similarly, Yamu and van Nes (2017, 2020) and Frankhauser et al. (2018) proposed integrated models that combine space syntax and fractal analysis. These models, applied to metropolitan regions in Southern France, Vienna, and Bratislava, use space syntax to support the identification of multifractal strategic development patterns.

3. Methodology

Fractal analysis studies conducted at the scale of the entire city or region can focus on the macroform, road network, and built environment. In this study, the fractal dimensions of the road network were examined, taking into account both the preservation of comparability of historical data sources and the blurriness between the distinction of urban and rural areas. Urban road networks are commonly recognized as fractal systems and are considered effective for assessing complexity (Batty & Longley, 1994; Shen, 1997; Chen & Luo, 1998; Shen, 2002; Lu & Tang, 2004; Avineri, 2010; Thomas et al., 2011; Thomas & Frankhauser, 2013; Wang et al., 2016; Sreelekha et al., 2015; Lu et al., 2016; Lan et al., 2019; Wen et al., 2023; Yang & Fu, 2023; Abid, 2024).

Road network data for İzmir were obtained from 1:25,000-scale maps produced by the General Directorate of Mapping of the Republic of Turkey. These maps cover four historical periods—1958–1964, 1974–1980, 1996–2000, and 2012–2020—and include comprehensive depictions of roads, terrain, and infrastructure. A total of 123 sheets were digitized and georeferenced using NetCAD software to support comparative analysis across periods.

Fractal analysis was conducted using the box-counting method, which determines spatial complexity by counting the number of non-overlapping boxes of a given size required to cover the road network. The relationship is expressed as:

$$K=A.\ \varepsilon^{-Df}$$

Where "K" denotes the number of boxes, "ε" represents the grid size, "A" is a constant coefficient, and "Df" is the fractal dimension.

A consistent legend across all periods ensures uniform representation of road thickness, which is essential for understanding infrastructure hierarchy and changes. The analysis also integrates satellite imagery and open-source road maps to align historical data with current urban configurations. The road maps were analysed using Fractalysis software with non-linear estimation ($R^2 > 0.999$).

For endogenous analyses, space syntax tools are integrated with fractal analysis to evaluate centrality. As an important aspect of complex relational networks, centrality is one of the key elements sought by the analysis. The growth of settlements involves a reorganization of spatial systems, including the hierarchy of centres and sub-centres—referred to as 'centrality' and 'periphery.' Space syntax measures two primary relationships: (1) the to-movement potential of each street segment with respect to all others, and (2) the through-movement potential of each street segment with respect to all pairs of others. The integration measure indicates how well a street is connected to other lines, based on the shortest path from one node or line to the others. As a result, shorter paths correspond to higher integration values. The other measure, also based on shortest distance, is the "choice" measure, which evaluates the extent to which a given street lies along the shortest path between pairs of streets. In other words, choice shows how frequently a street would be used if pedestrians always selected the shortest path. The two primary centrality measures used in this study are choice and integration, along with total node count. Integration represents "to-centrality," while choice represents "in-between centrality" (Van Nes & Yamu, 2018).

Three main distance-based measures for system analysis can be defined as:

- **Metric:** Measures the network as a system of shortest paths
- **Topologic:** Measures the network as a system of fewest-turn paths
- **Geometric:** Measures the network as a system of least angle-change paths

Serra (2017) analyzed the road network of inside of Oporto's municipal metropolitan borders from local scale (400 meters) to the regional scale (30.000 meters) by closeness centrality analysis which is a measure of the average distance of each node to the entire network. The main outcomes of this study can be summarized as; at local scales like 400 meters, small centers can be visualized including small ancient towns, inner cores of larger settlements and emergent centers. By increasing the spatial scale, small centers disappear while the metropolitan core began to appear. This observation is reported to be maximized at 3800 meters while centrality disappears at larger scale while a very large central zone dominates the entire metropolitan region (from 14700 to 30000 radii). With respect to correlations depending on principal component analysis, three centrality scales are determined as; neighbourhood (400-1200 meters), city (1200 to 8200) and region (8200 to 30000).

A wider study is conducted for the complete road network of United Kingdom that the results of the study are compared by spatial socio-economic variables and movement flows by correlation analysis (Serra, et al., 2015). Three graphs for centrality algorithms are used by metric radius as; node count, angular integration and angu-

lar choice. The metric radiuses attained from 10 kilometres to 50 kilometres. For vehicular movement it is found that all measures are capable of measuring centrality in terms of movement flow for medium radii (from 10.000 meters to 20000 meters as the best fit).

The other study based on the differentiated radii effect is the study of Hillier et al. (2010). It is aimed to explore the nature of boundaries including internal structure of urban space and how this relates to external structure by exploring properties of the context rather than simply focusing on internal morphology. The suggested representation is called as fuzzy boundaries. Each axial line or segment in the whole map is taken as the root of the graph then by increasing radius, the rate of change of the numbers and axial lines are calculated. The rate of change value is assigned to original axial line and neighbouring trends can be observed for the central areas of London and Beijing. The other sole explanation of the study of Hillier et al. (2010) is to find which syntatic variable can be used to illustrate the process of embeddedness of urban space. One of the sole approaches identifying the radius in a larger urban system is "patchwork theory". It is based on spatial differentiation of the background urban network into a patchwork of local areas. The patchwork structure represents metric and local effects. The effect of radius on centrality is explained as;

"μ(v,r), of node v for radius r as local metric mean depth as;

$$\mu(v,r) = \frac{1}{N(v,r)} \int_0^r x \frac{\partial N(v,x)}{\partial x}\, dx$$

where $x = x(v, u)$ is metric depth of node from the reference node v and $N(v, r)$ is the number of nodes with $x(v, u) \leq r$ and

$$N(v,r) = \int_0^r \frac{N(v,x)}{\partial x}\, dx$$

$$\Theta(v,x) = \frac{\partial \log N(v,x)}{\partial \log x} = \frac{x}{N(v,x)} \cdot \frac{\partial N(v,x)}{\partial x}$$

Where the rate of change of node count Θ(v,x) of metric mean depth so;

$$\frac{\partial N(v,x)}{\partial x} = \frac{N(v,x)\Theta(v,x)}{x}$$

By substuting (22) into (20);

$$\mu(v,r)\, N(v,r) = \int_0^r N(v,x)\, \Theta(v,x)\, dx$$

where μ(v,r) N(v,r) is total metric mean depth; differentiating both sides of equation (5) with respect to r;

$$\frac{\partial \mu(v,r)}{\partial r} N(v,r) + \mu(v,r) \frac{\partial \mu(v,r)}{\partial r} = N(v,r)\, \Theta(v,r)$$

$$\frac{\partial \mu(v,r)}{\partial r} N(v,r) + \mu(v,r) \frac{N(v,r)\Theta(v,r)}{r} = N(v,r)\, \Theta(v,r)$$

$$\frac{\partial \mu(v,r)}{\partial r} + \frac{\Theta(v,r)}{r} \mu(v,r) = \Theta(v,r)$$

Since metric mean depth and radius have the same linear dimension, the first derivative term in equation (26) must be independent of r as; $\partial\mu(v,r) / \partial r < 1$. Sı equation (26) can be expressed as;

$$\mu(v,r) = r\left(1 - \frac{c(v)}{\theta(v,r}\right)"$$

By those equations it is expected that there is a positive correlation between node count change and metric mean depth. If radius increases, Hillier et al. (2010) explains three possible routes of development can be observed as;

(i) μ(v,r)can increase while decreases,
(ii) μ(v,r)can increase while remains stationary,
(iii) μ(v,r)can increase while increases

It is noted that these different development routes induce an inversion of centrality, whereby more central nodes at smaller radii tend to become decentralized at larger radii. This relationship depends on the scaling between the radius and its node count (Hillier et al., 2010). Another key explanation in the study was to identify which syntactic variable can be used to illustrate the process of embeddedness of urban space. As Hillier et al. (2010) state, Yang's measure of node count change—(NCr+r/2) / (NCr-r/2)—produces a result very similar to MMDr (Metric Mean Depth at the given radius), meaning that one measure explains the other. In addition, Dalton (2005) explains that for restricted radii, simple segment count is the strongest component of the integration measure, whereas the local urban correlations between total depth and integration break down for larger radii.

The centrality measures of this study are determined as choice, integration, and total nodes, based on a region-focused literature survey in the field of space syntax. The validity of the mapped representations is evaluated with respect to real-world data observed from the 1:25,000 scale maps, as well as from the narrated regional history. The reliability of the centrality measures for restricted radii is examined through principal component and correlation analysis (Serra & Pinho, 2013; Serra et al., 2015).

Three centrality measures are defined: integration, choice, and total nodes, including their segment length–weighted versions. For each of the four periods, different radii from 250 meters to 50,000 meters are analysed—including 250 m, 500 m, 1,000 m, 2,000 m, 5,000 m, 10,000 m, 20,000 m, and 50,000 m—to identify patterns ranging from the neighbourhood pedestrian scale to the entire regional system. The 50,000-meter radius is determined based on the system size, where the widest elliptical approximation of the network is around 100 kilometres, and the narrowest is 25 kilometres. To identify the global system, an analysis with radius "n" is also calculated.

The axial model corresponds to a total network length of 7,469, 11,206, 25,660, and 32,671 kilometres for each of the four periods, respectively. First, the axial maps are produced via the digitized road network for each period. Then, these maps are converted into segment maps. As identified by Serra & Pinho (2013), segment analysis allows for a finer-grained assessment. The historical space syntax terms of "integration" and "choice" are equivalent to the more general terms of "closeness" and "betweenness centralities" (Hillier & Iida, 2005; Serra et al., 2015; Vaughan et al., 2025). Therefore, three centrality measures are investigated: angular integration, angular choice, and metric node count, for different radii ranging from 500 meters to 50,000 meters.

For each period, correlation analyses are run to identify the radius at which the correlation level is highest before decentralization effects are observed. The results of the process of embeddedness of urban space—analysed through varying radii—are observed and compared with the centrality measures and with real-world data ac-

quired from maps and a literature review on regional history. For each period, a "breaking point" is identified as the centrality-embeddedness scale—in other words, a radius at which local centrality becomes most evident. Subsequently, sub-fractal analysis is conducted using the Frac_Lac software and the box-counting method, with the mesh size set equal to the radius obtained from the syntactic measure.

4. Main Findings

The major findings discussed here encompass the results of both the exogenous and endogenous phases. In the exogenous analyses, which were conducted for 30 districts within the entire city-region of İzmir, the findings reveal that during the initial period (1959–1964), rural areas exhibited higher spatial complexity than urban cores, suggesting a fragmented pattern of urbanization. In the second period (1976–1980), regionalization trends intensified, and the system's overall complexity surpassed that of its individual components. Notably high fractal values were recorded in central İzmir, including Karşıyaka and Bayraklı. By the third period (1996–2000), a pronounced north–south axis had emerged, reflecting spatial consolidation. In the most recent interval (2012–2017), a general decline in fractal dimensions was observed across the region, including coastal districts, indicating a plateau in growth and a redistribution of spatial complexity. Changes in the fractal dimensions of the districts from the first to the fourth period are presented in Figure 1.

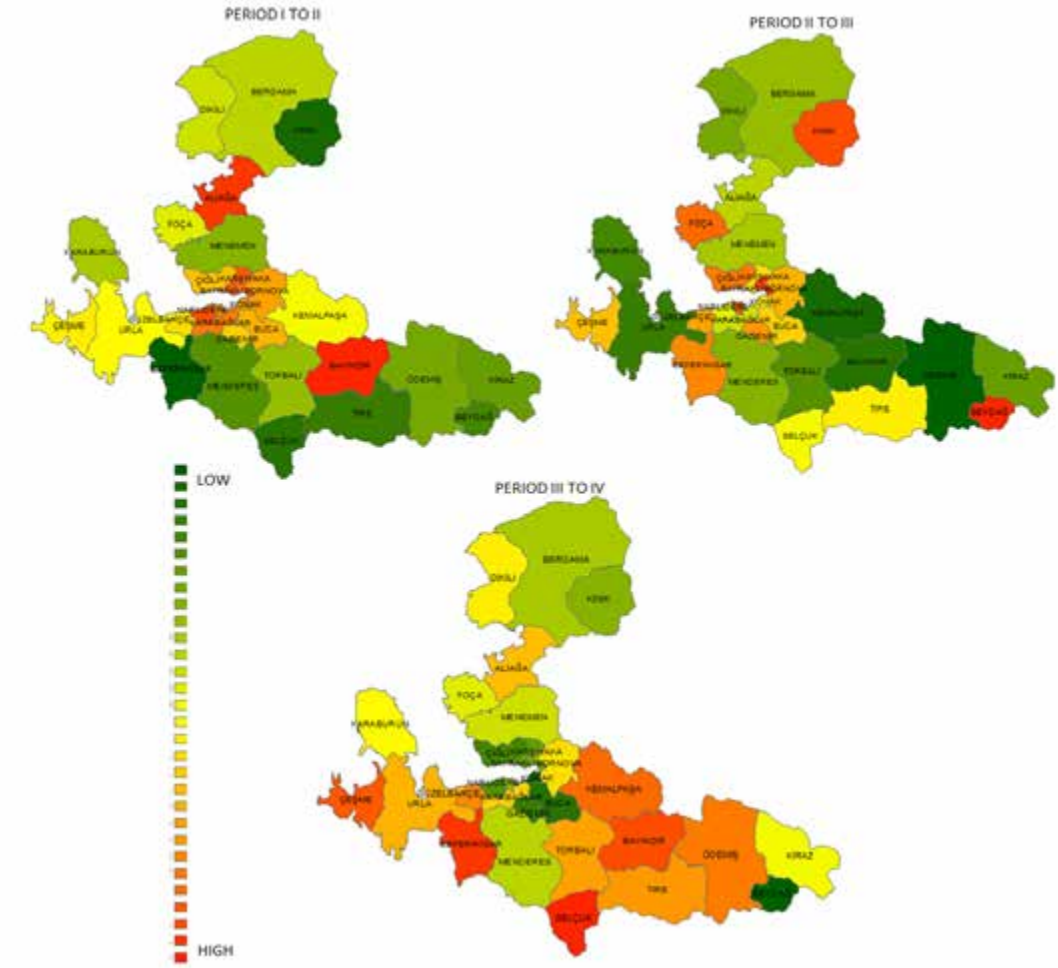

Figure 1: District-level changes in fractal dimension in İzmir across the first to fourth periods

For endogenous analyses proposing main arguments about centrality and regionalization, space syntax analyses and sub-fractal analyses are run for the third period. This period is selected since the highest fractal dimen-

sion values are observed during this time interval from 1996 to 2000 both in terms of parts (districts) and the whole system.

In space syntax analyses it is observed that the local betweenness centrality are observed for small radii by segment length weighted measure. In addition, the local centres can be observed for the radiuses of 500 meters to 1000 meters while could be best observed for the radius 500 meters. The medium scale is observed between the radii 2000 to 20.000 meters that until the radius of 10.000 meters, only the paths connecting the central core could be visualized (Figure 2).

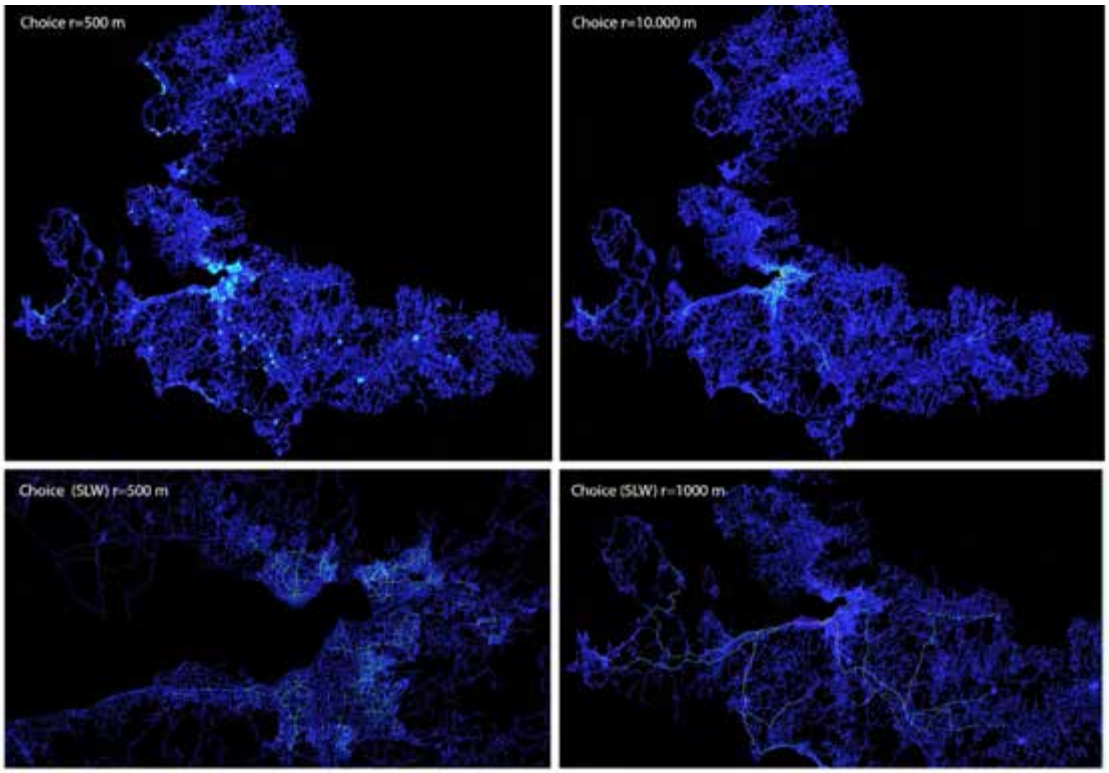

Figure 2. Angular choice analysis for small and medium radii during the third period (1996-2000)

For small radii, the main differences in centrality are not clearly visible for the declining core of Konak. However, the central paths of Alsancak and Eşrefpaşa Road can still be visually identified. Aside from the informal housing stock identified through the analysis—particularly around Tepecik and Kadifekale—local central paths have shifted toward Bayraklı. The highest choice value is calculated for Girne Avenue, the main artery of Karşıyaka. Karabağlar has gained betweenness centrality, while İnönü and Mithatpaşa Roads are identified as central paths near the Poligon area. These altered centrality measures closely correspond with the core's development trends in the late 1990s.

When the regional system is analyzed for small radii, the dominance of central İzmir persists. Although all district centers can still be distinguished, the rural pattern is no longer clearly identifiable. On the other hand, coastal developments become increasingly visible in Çeşme, Dikili, Seferihisar, and Urla. This finding aligns with the expansion of coastal towns, particularly those focused on tourism and seasonal housing during the mid- to late-1990s. Although the regional rural network has declined, decentralization of the central paths can be observed around the core—toward Çiğli-Menemen in the north, Gaziemir in the south, and Kemalpaşa in the northwest. The prima-

ry central paths are concentrated in the southern part of the Bay. The highest centrality is observed along the İzmir–Çeşme Highway. Connections from the highway to Seferihisar, and from the core to Torbalı, are also identified as central paths. Additional central paths can be differentiated along the coastal route toward Karşıyaka, and in the connections to Buca, Kemalpaşa, Çeşme, and Karaburun. The larger radii range—defined as 20,000 to 50,000 meters—applies to the third period based on the information from the choice measure maps. The highest choice value within the central core is observed along the coastal road connecting Kültürpark to Bayraklı. The connections between Karşıyaka and Bayraklı, as well as between Kültürpark and the Gaziemir junction, represent secondary central paths. Links to peripheral districts such as Çiğli, Gaziemir, Bornova, and Kemalpaşa constitute the third-level differentiated central paths for the restricted 20,000-meter radius. For the 50,000-meter radius, a similar pattern emerges, with areas like Çiğli and Torbalı gaining centrality due to the expanded metric radius (Figure 3).

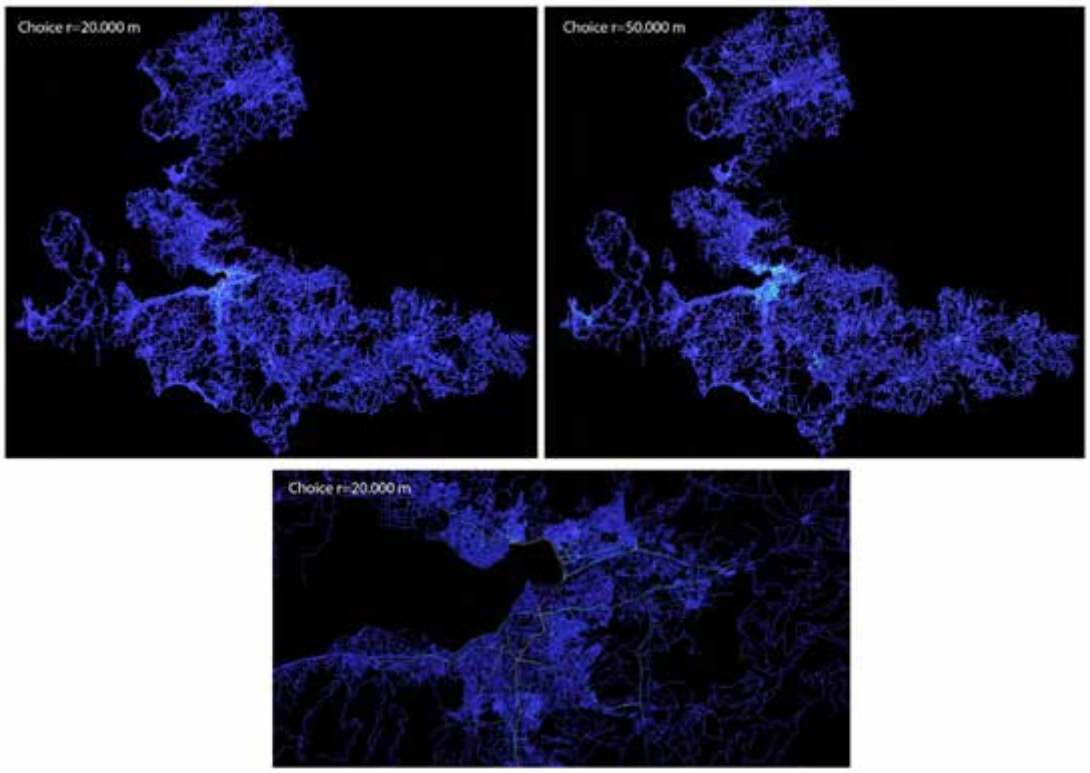

Figure 3. Angular choice analysis for large radii during the third period (1996-2000)

Angular integration analysis is also employed as a centrality measure. For small radii, similar to previous periods, irregular housing quarters are identified as distinct features exhibiting higher integration values within the central core. The main difference compared to earlier periods is the decline in integration values in the Konak vicinity. This result aligns with the findings from the choice measure and real-world data. The most integrated quarters are observed in Bayraklı, followed by Karşıyaka. As with the choice measure, differentiated integration patterns are seen around the metropolitan core. Additionally, coastal developments such as Çeşme, Dikili, and Seferihisar display higher integration values. For medium radii, a more regionalized pattern emerges. Within the central core, the highest integration values are observed along the coastal road from Kültürpark to Bayraklı, Gaziler Road, and the connection to Gaziemir. The regional medium-radius analysis, conducted at 20,000 meters, provides insight into the broader network. The strongest regional connection is observed between the central core and Torbalı. Linear development patterns radiate from the center toward the south and north, accompanied by coastal development along the Çeşme Highway (Figure 4).

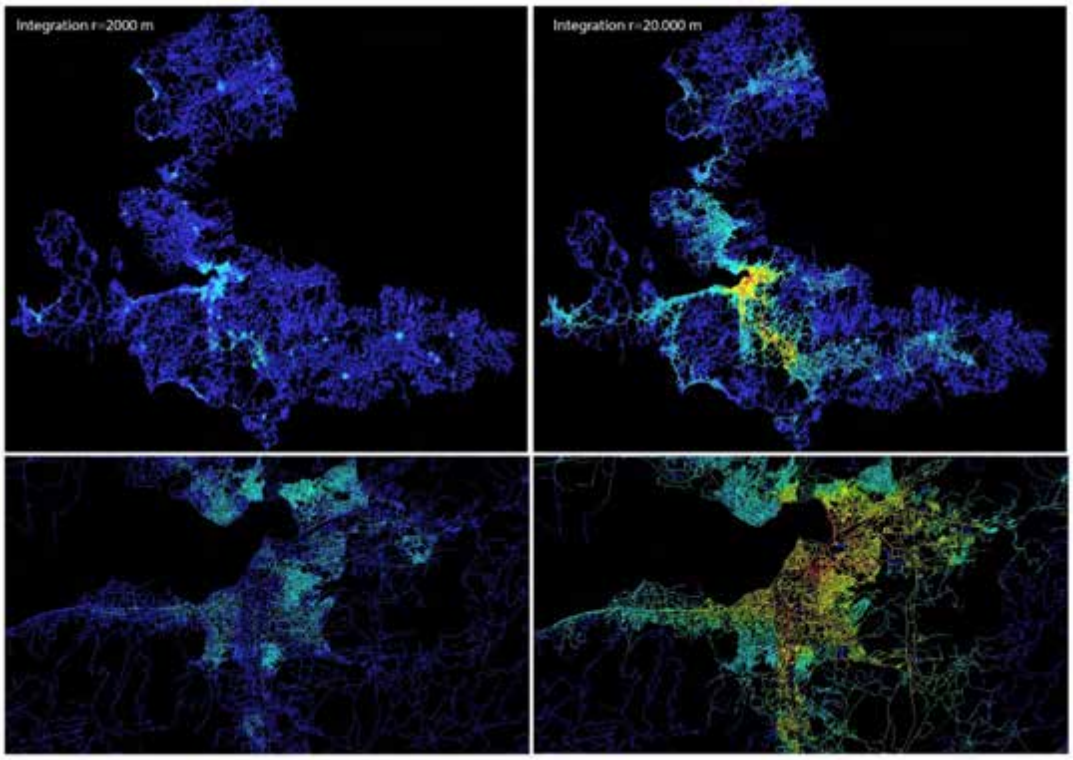

Figure 4. Angular integration analysis for small and medium radii during the third period (1996-2000)

During the initial period, sub-fractal analyses reveal higher fractal values in rural areas located in the northern, southern, and eastern parts of the region. These elevated fractal values are associated not only with urban activity but also with fertile agricultural land reserves. Despite exhibiting higher levels of spatial complexity, these areas did not display notable centrality. In the second period, the complexity of agricultural patterns decreased, while centrality increased alongside spatial expansion. Both complexity and centrality became more visibly aligned with urbanized areas, although some agriculturally dominant central districts still retained elements of centrality.

A significant transformation of the network system is observed during the third period. The complexity of former ex-urban areas rose once more. The key difference is the emergence of centrality nodes throughout the region, indicating a shift from purely rural characteristics to a more transitional spatial pattern. Moreover, the metropolitan core began to disperse along major corridors, blurring the distinction between rural and urban structures. In this context, peripheral and coastal towns gained both centrality and complexity, functioning increasingly like urban cores.

When sub-fractal analyses are integrated into the endogenous analysis, the results are found to closely align with those of the exogenous phase, indicating that centrality continues to manifest in the metropolitan core and in select districts that function as rural centers. An integrated representation of the sub-fractal analysis with a 1% pixel ratio and the connectivity map is presented in Figure 5. The sub-fractal analysis for this period reveals higher fractal values compared to previous decades. The lowest calculated value is 1.02, while the highest reaches 1.903. The most elevated values are observed in the central core, particularly in Karşıyaka–Bayraklı, Buca, Karabağlar, and Gaziemir. Although the urban core exhibits high sub-fractal values, regional complexity becomes more spatially varied compared to the second period. High sub-fractal values also appear in peripheral

urban centers such as Urla, Çeşme, Aliağa, and Menderes. Additionally, scattered high fractal values are found around Kemalpaşa, Torbalı, and Seferihisar. The transition from agricultural divisions to peripheral development has resulted in increased complexity along key corridors. The eastern part of the region shows generally lower fractal values, punctuated by isolated complex nodes. Although Bergama retains its sub-regional pattern, the dominance of its integrated network has diminished relative to the first and second periods. A significant macro-form transformation is observed for the İzmir metropolitan area: formerly peripheral districts have become functionally integrated into the core. A continuous and cohesive urban structure now includes Buca, Bornova, Karabağlar, Çiğli, Menemen, Menderes, and Gaziemir, with coastal development extending southward along the Bay toward Urla.

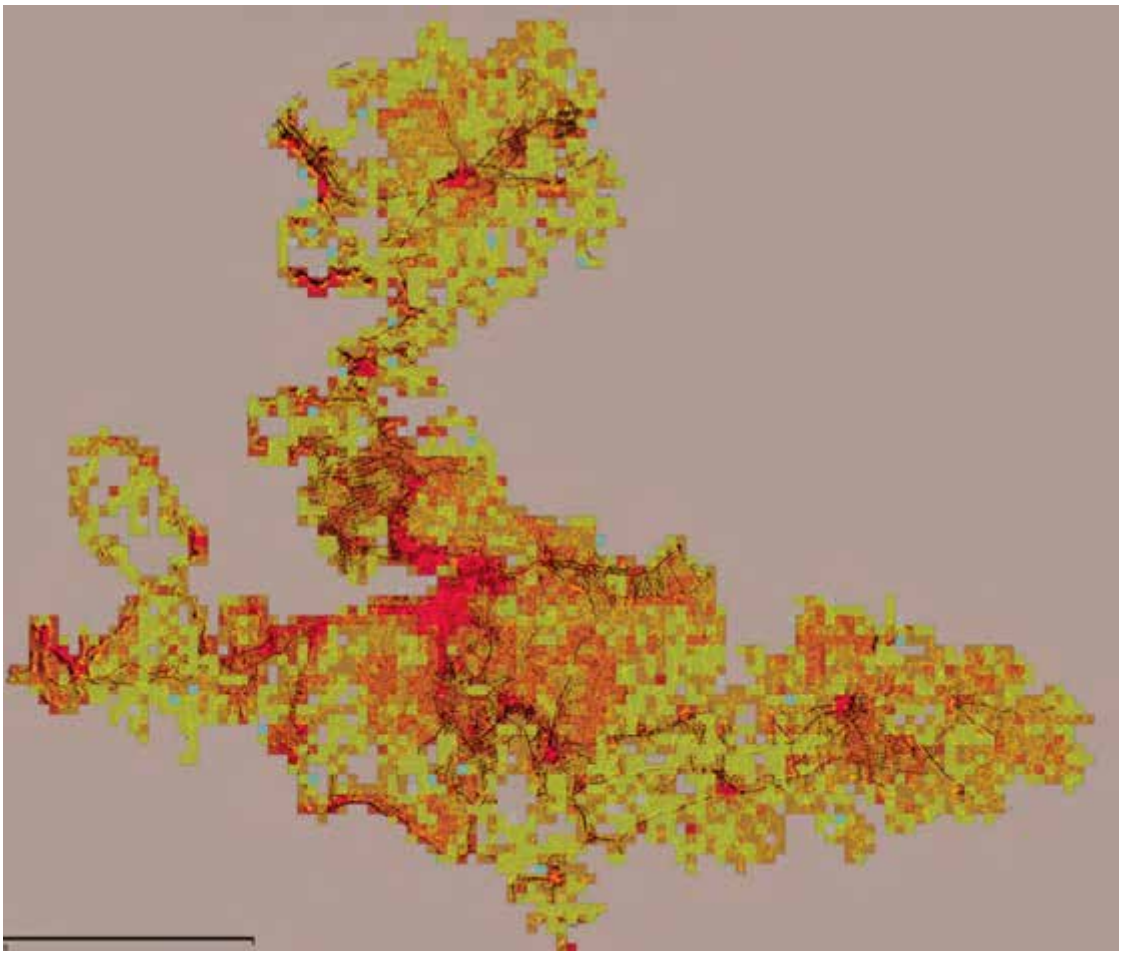

Figure 5. Integrated representation of the road network of İzmir in the third period using sub-fractal and space syntax analyses (1996-2000)

When centrality is assessed in conjunction with the revised patchwork theory, the radius exhibiting the highest correlation before decentralization begins is found to be the smallest during the third period (1996–2000). This suggests that spatial embeddedness declined up to the third period but increased again in the fourth period. Notably, the fractal dimensions of both the overall system and its constituent parts reached their highest levels during this final period. The results of the centrality and fractal dimension measures are presented in Table 1.

Table 1. Change of embeddedness and complexity

	r (m)	FD of the whole system	Mean FD of the parts
Period I (1959-1964)	5000	1,502	1,313
Period II (1976-1980)	1000	1,581	1,343
Period III (1996-2000)	500	1,819	1,521
Period IV (2012-2017)	5000	1,724	1,492

5. Conclusion

This study presents an integrated method for exploring the regional complexity of İzmir, a multi-layered and multi-sectoral city-region. By combining sub-fractal and space syntax analyses, the research advances a dual-phase approach to investigate the interplay between regionalization and centralization across different historical periods. Unlike conventional studies that narrowly focus on urban macroforms or the internal structure of road networks, this analysis extends to the broader regional fabric—capturing complexity within both urban and non-urban contexts, including agricultural, touristic, and industrial landscapes.

Fractal analysis serves as a quantitative measure of spatial complexity, spatial coherence, and urban sprawl. In parallel, space syntax analysis captures the relational properties of urban form, such as connectivity, integration, and centrality. The integration of these two methodologies enables a multi-scalar assessment of urban morphology, revealing how systemic shifts in complexity and centrality shape urban evolution over time. This approach uncovers critical transitions—from fragmented rural complexity in early decades to concentrated centrality and integrated regional structures in later periods.

The analysis identifies several key findings: In the initial period (1959–1964), rural areas displayed higher spatial complexity than urban cores, indicating fragmented urbanization. The second period (1976–1980) showed increasing regionalization, with complexity and centrality rising in core areas like Karşıyaka and Bayraklı. By the third period (1996–2000), a north–south urban development axis emerged, while peripheral districts such as Çiğli and Kemalpaşa began integrating into the urban network. In the final period (2012–2017), a decline in overall fractal dimensions was accompanied by a rise in complexity and centrality in coastal towns, revealing the influence of touristic and seasonal dynamics. Centrality shifted from traditional hubs like Konak to emerging centers such as Bayraklı, Karabağlar, and Karşıyaka, while roads like the İzmir–Çeşme Highway and Girne Avenue gained strategic importance. These changes reflect a blurring of rural–urban boundaries, as transition zones expanded and spatial embeddedness fluctuated. Correlation analyses identified threshold radii at which centrality peaked before decentralization, reinforcing the relevance of patchwork theory and multiscale syntactic measures. Sub-fractal values were highest in central and peri-central areas and validated through their spatial alignment with syntactic centrality, demonstrating the coherence between complexity and movement networks. Ultimately, İzmir has evolved into a polycentric metropolitan region, where formerly peripheral districts now function as secondary centers in a distributed urban system. From a planning perspective, the study highlights the utility of complexity-informed tools in guiding spatial development strategies. Two key applications are proposed: (1) employing fractal and syntactic measures as diagnostic indicators to inform regional planning frameworks, and (2) using complexity analyses as evaluative tools to assess compactness, sprawl, green space distribution, and development potential. As the conceptualization of cities as complex adaptive systems continues to gain traction, the integration of these methods offers valuable insights for planning resilient and adaptable urban futures.

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Planning and Design Methods for Robot Work spaces in Smart Elderly Care Communities

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Abstract
The global aging problem is becoming increasingly severe, and the innovative application of robotics technology has emerged as a key driver for upgrading the elderly care industry. In the face of the dual challenges of accelerating global population aging and the surging demand for elderly care services, how to rapidly and effectively integrate robotics into elder care has become an urgent issue. This study innovatively proposes transforming complex robotic operational requirements into three-dimensional architectural spatial models by analyzing the dimensional and motion space needs of eldercare robots in community environments. Through in-depth analysis of the functions, dimensions, movement angles, and ranges of eldercare robots, combined with spatial layout principles from architecture and urban planning, the study constructs a tangible model of the workspace requirements for robots. And starting from the six tasks of caring for the elderly, the key points of design and planning for bedrooms, living rooms and bathrooms based on the needs of care robots in architectural space are proposed.This approach not only ensures sufficient mobility for robots to perform various tasks but also enhances their operational efficiency and safety within elderly care communities. It opens new pathways for the precise renovation and optimisation of smart elderly care communities, driving deeper integration between technology and daily living.

Keywords: Smart elderly care community, robots, spatial planning, spatial design, elderly care space

Introduction

Amid the rise of smart eldercare, the innovative application of robotic technology has become a key driving force in upgrading the eldercare industry. Confronted with the dual challenges of a rapidly aging population and the surging demand for eldercare services in China, how to enable robotic technology to effectively support and care for the elderly has emerged as an urgent issue. In January 2024, the Opinions of the General Office of the State Council on Developing the Silver Economy to Enhance the Well-being of the Elderly explicitly stated the need to foster new models of smart healthcare and eldercare, and to promote the integrated application of intelligent nursing robots, household service robots, and other devices across home-based, community-based, and institutional eldercare settings [1]. Subsequently, in June 2024, the Shanghai Action Plan for the Innovative Development of Eldercare Technology (2024–2027) further emphasised the importance of accelerating the development of smart eldercare technology communities and advancing age-friendly home modifications. In particular, the plan highlights the application of advanced health equipment such as rehabilitation devices, exoskeletons, and nursing robots, and underscores the crucial role of technology in improving the quality of life for older adults [2]. As a vanguard in the smart eldercare domain, robots are increasingly becoming a critical force in enhancing the living standards of the elderly and advancing the development of smart eldercare communities.

Currently, eldercare robots primarily fall into three categories: rehabilitation robots, domestic service robots, and social companion robots [3]. Existing research mainly focuses on technological dimensions, such as human–robot interaction and social engagement, perception and navigation systems, as well as rehabilitation and health monitoring [4]. While each type of eldercare robot features unique design characteristics, studies examining their practical deployment within smart eldercare environments remain limited. Moreover, their physical dimensions are often constrained by a combination of technical feasibility, functional requirements, and safety considerations, making it difficult for them to achieve the same level of flexibility and spatial adaptability as human caregivers. As shown in Figure 1, the extended reach of BUSBOY's remote manipulation arms, the robust support structure of ROBEAR, the wheeled chassis of Stardust Intelligence, and the bipedal humanoid design by Unitree Robotics all demonstrate impressive technological advancements. However, they also underscore the diversity and challenges in robot size and movement range. In various eldercare settings—including home, community,

and institutional environments—different robot morphologies (e.g., bipedal humanoid, wheeled, tracked) may face limitations in terms of spatial compatibility, which can hinder service efficiency and negatively affect user experience. Therefore, it is imperative to adopt architectural approaches to assess and optimise care environments, ensuring the seamless integration of eldercare robots with diverse dimensions and forms into homes, communities, and eldercare institutions.

The age-friendly transformation of smart communities is, in essence, a bidirectional process of empowerment between technology and spatial design. The integration of these two dimensions enables the creation of intelligent eldercare scenarios, thereby enhancing the well-being and sense of fulfillment of older adults in the digital age [5]. At present, research on age-friendly residential design is relatively extensive, encompassing psychological and physiological needs of the elderly [6], barrier-free design principles [7], and smart home systems [8], among other topics. However, current community retrofitting efforts remain largely centered on the needs of older adults, with insufficient attention paid to the operational characteristics and spatial requirements of service robots. Existing studies related to the application of eldercare technologies are mainly focused on regulating the physical environment of residential buildings and monitoring the safety of older individuals [9], while research on the spatial integration of eldercare robots into residential settings is still in its infancy. To ensure that robots become effective assistants in the daily lives of older adults—rather than spatial obstacles—it is necessary to undertake a comprehensive restructuring and functional upgrading of home environments. The key research challenges are twofold: first, how to incorporate the operational characteristics and spatial demands of robots into the core of a human-centered design framework; and second, how to overcome the inefficiencies of in-situ adaptation testing by leveraging spatial modeling technologies to conduct multi-scenario simulation analyses. Such an approach can support and guide the precise transformation and optimisation of smart communities and residential spaces.

In the field of robotic modeling and simulation, advanced platforms such as Gazebo and V-REP provide researchers with powerful virtual testing environments, enabling preliminary validation of robotic system performance and adaptability without direct interaction with physical hardware. However, when applied to the specific context of eldercare communities, the widespread adoption of such tools faces notable limitations. While these platforms excel at simulating robotic dynamics, sensor integration, and complex interactions, they present significant challenges in accurately reconstructing the architectural nuances of real-world living environments—particularly with respect to furniture arrangements, soft furnishings, and the personalised characteristics of residential spaces. Given the complexity and variability of eldercare community environments, relying solely on robotics-focused simulation tools often fails to capture the fine-grained spatial distinctions that directly affect robotic navigation, task performance efficiency, and operational safety. Therefore, from an architectural perspective, it is essential to translate the functional requirements of eldercare robots into a design-oriented vocabulary and conduct in-depth spatial modeling and simulation tailored to residential care scenarios. This architectural reframing represents a critical bottleneck to be addressed in order to facilitate the effective deployment and integration of robotic technologies within eldercare communities.

The research objective of this paper is to optimize the layout of the home environment through scientific and reasonable spatial planning, enabling robots to operate freely under different spatial dimensions and activity angles, and meeting the diversified needs of the elderly. By analyzing the motion characteristics, working range and spatial requirements of robots, combined with the spatial layout principles of architecture, it is possible to create elderly care communities that not only conform to the operation norms of robots but also take into account the quality of life of the elderly. On this basis, by using advanced modeling and simulation technology, the potential obstacle areas are accurately marked, the working paths and activity Spaces of the robots are

optimized, and the design key points of the three areas of the bedroom, bathroom and living room based on six nursing tasks are proposed. Ensure that the robot can seamlessly integrate into the environment of the elderly care community during actual deployment to achieve efficient, safe and humanized services.

2. Methodology

2.1 Research Subjects

Eldercare Robots:This study focuses on general-purpose eldercare robots that are either currently available in the market or under active development in research laboratories. These robots typically possess functions such as care-giving, companionship, and health monitoring, and are designed to assist older adults with daily living tasks in residential environments. The research will examine the spatial requirements, behavioral patterns, and environmental interactions of these robots during actual operations, with an emphasis on how their physical and functional characteristics influence their performance within domestic settings.

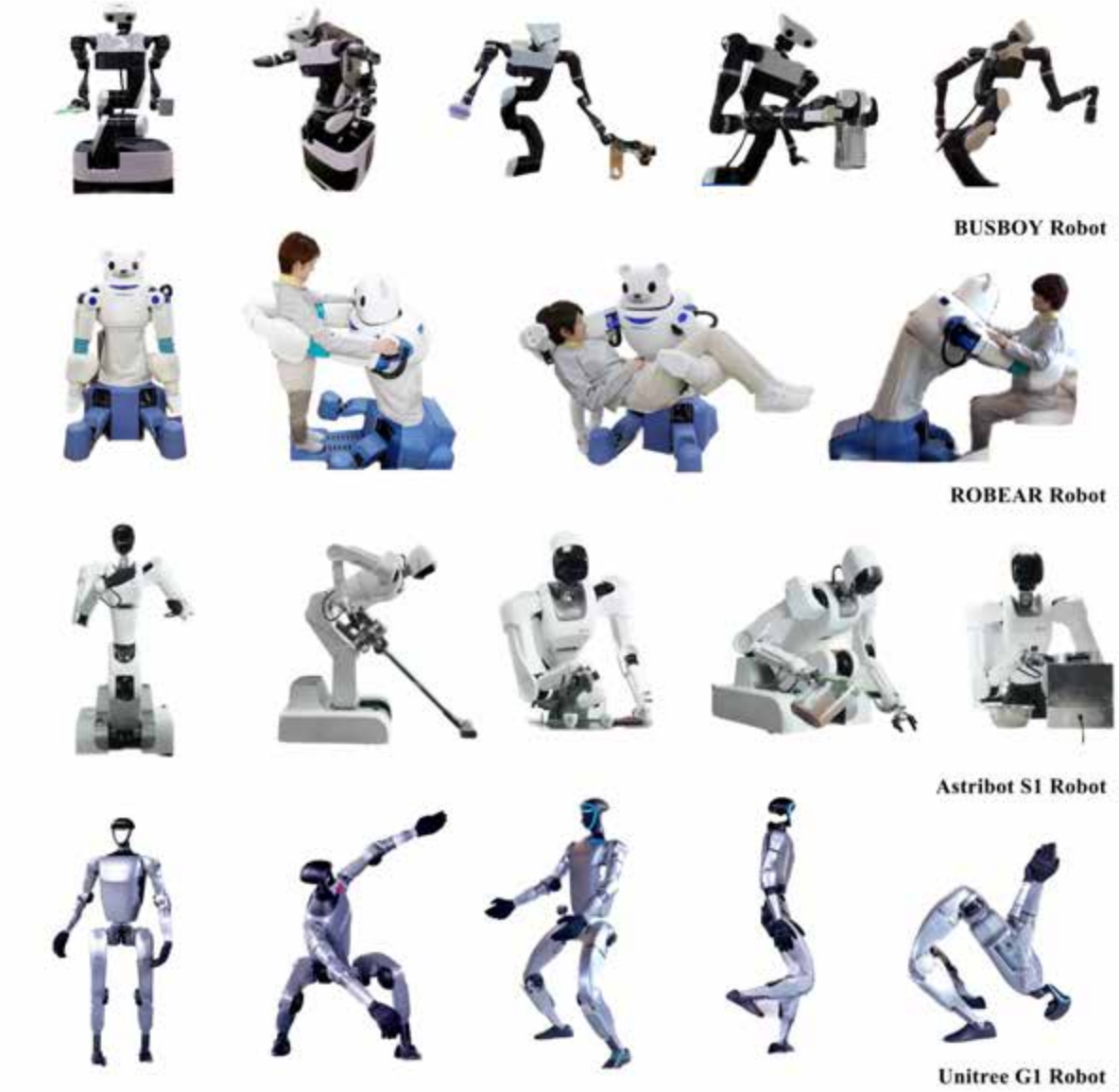
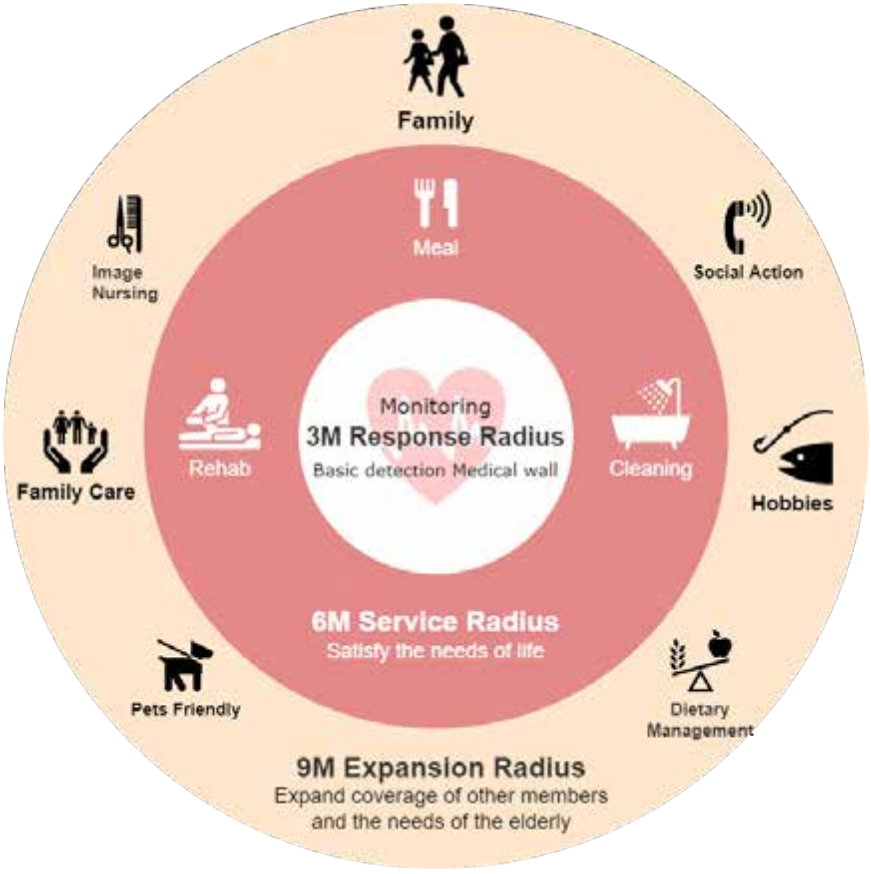


Figure 1. Display of various forms and motion ranges of the nursing robot

Residential Spaces in Smart Eldercare Communities:The study also targets the spatial layout and functional configuration of residential units within smart eldercare communities. Particular attention is given to analyzing how existing residential configurations—such as room layouts, furniture arrangements, and corridor designs—can be adapted or optimised to accommodate the integration of eldercare robots.In the elderly care scenario, nursing robots mainly undertake six key auxiliary tasks, namely: feeding, pushing wheelchairs, assisting with getting in and out of bed, helping with dressing, assisting with bathing and using the toilet. Ensuring that robots can operate efficiently and unobstructedly within these environments, while also supporting the daily needs of elderly residents, is critical for achieving seamless human–robot coexistence. In the design of smart eldercare communities, spatial planning must prioritise adequate mobility space for robots and prevent furniture from becoming obstacles to their movement. The introduction of robots imposes new spatial demands, including the allocation of walking paths, the establishment of interaction zones, and the assurance of universal accessibility. These spatial modifications must simultaneously address the physical and psychological needs of older adults and align with the dimensional and operational requirements of robotic systems.



2.2 Research Methodology

To accurately simulate and optimise the deployment and operational scenarios of eldercare robots with varying dimensions in smart eldercare communities, this study proposes a systematic methodology consisting of three core stages:

(1) Spatial Requirements Analysis and Robot Model Reconstruction:The study begins with an in-depth analysis of the functions, dimensions, and operational ranges of eldercare robots. Utilising robotic kinematics, key actions such as arm lifting, body rotation, and object manipulation are examined to determine the spatial footprint associated with daily tasks. By precisely measuring and simulating the trajectories of these movements, a three-dimensional entity model of the robot is constructed, effectively translating its operational space requirements into physical forms. Through virtual simulations, these models are used to replicate the robot's motion within residential environments, allowing early identification and resolution of potential spatial conflicts.

(2) Path Verification and Charging Zone Selection:In conjunction with SLAM (Simultaneous Localisation and Mapping) technology, the study investigates robot navigation paths within residential spaces to ensure unobstructed mobility—particularly in narrow corridors, doorways, and densely furnished areas. SLAM enables the real-time generation of environmental maps and supports path planning and obstacle avoidance algorithms, thereby ensuring that robots can complete tasks safely and efficiently in complex settings. Additionally, path optimisation algorithms are applied to analyze and select suitable locations for charging stations, ensuring robots can reliably return for charging without disrupting the daily routines of elderly residents. This technical framework provides scientific support for spatial layout and path planning tailored to robotic operations.

(3) Space, Furniture, and Soft Furnishing Validation Based on Task Simulation:A combined application of Sketch Up and Unity is used to conduct three-dimensional reconstructions of eldercare environments and to simulate robot adaptability. Sketch Up is utilised to build precise residential space models, into which dynamic robot models are embedded to assess spatial adaptability and predict potential obstacles. Unity is employed to simulate robot–furniture interactions, optimise path planning, and enhance task efficiency and operational safety. Furthermore, personalised validation of soft furnishing elements is conducted to ensure they align with the preferences of elderly users while avoiding interference with robotic operation. This process integrates principles from environmental behavior studies to identify suitable soft furnishing configurations that support harmonious human–robot coexistence. Ultimately, simulation results inform spatial optimisation strategies that facilitate the seamless integration of robots into eldercare environments, while simultaneously meeting the everyday needs of older adults—achieving a deep fusion of technology and daily life.

3.Case Study

3.1 Multi-Scenario Spatial Demand Analysis and Dynamic Model Construction for Eldercare Robots

An in-depth analysis was conducted on the functions, dimensions, and movement angles and ranges of eldercare robots to determine the spatial requirements for performing various tasks within elderly residential environments. Employing robotic kinematic analysis methods, this study examined key operational actions—such as assisting elderly individuals in standing or walking, performing household chores, and pushing wheelchairs—across a range of common care-giving scenarios. By precisely measuring and simulating the motion trajectories of these actions, the required spatial envelope and joint movement angles for each task were accurately derived.

The research focused on mapping the task-specific operational needs of eldercare robots across different residential settings. For each scenario, the robot's primary tasks were defined based on the functional zones of the living space. Corresponding motion postures and spatial operation strategies were then carefully designed to accommodate these tasks. Given the high spatial precision required for robotic flexibility, stability, and accuracy in residential settings, three-dimensional entity models of the robots were constructed based on measured data to convert operational requirements into physical spatial representations (Figure 2). By translating task motions into spatial forms, these models enable realistic simulation of robotic trajectories and workspace coverage in virtual environments.

The construction of robot entity models not only facilitates precise residential space planning but also allows for the early detection and resolution of potential spatial conflicts through virtual simulation. This modeling process lays the foundation for creating living environments that accommodate robotic assistance effectively and harmoniously.

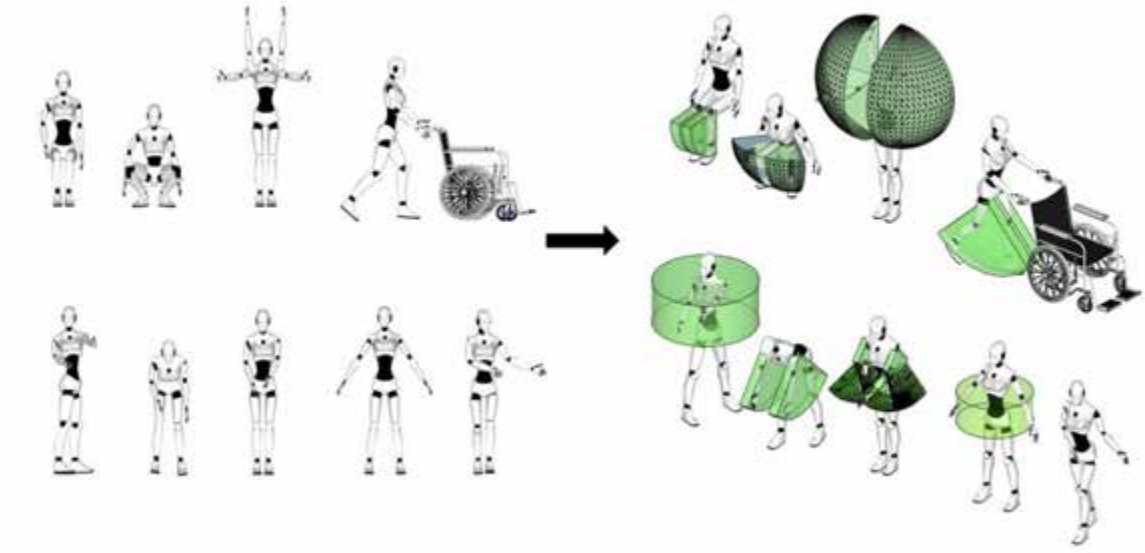


Figure 2 Construction of Dynamic Models of Spatial Requirements for Robots in Different Scenarios of Smart Elderly Care Communities - Taking bipedal humanoid robots as an example

3.2 Accessibility Analysis and Barrier-Free Optimisation Design for Care Robots

From a refined two-dimensional spatial perspective, this study systematically verifies the navigational accessibility of care robots within home environments and evaluates the rationality of charging and storage area layouts. A key innovation lies in the integration of SLAM (Simultaneous Localisation and Mapping) technology into the analytical framework. Based on dynamic models representing the spatial requirements of robots during actual operations, the robot's physical dimensions are defined as the unit scale for grid-based spatial processing. Functional zones within elderly residential spaces are then transformed into planar grid maps accordingly.

This process not only accounts for the geometric configuration of rooms but also carefully distinguishes critical factors such as furniture placement and corridor widths to ensure the accuracy and practical applicability of the model. The grid-mapped spatial layout is further subjected to scientific verification of movement flow lines, with detailed annotations of obstacle locations and the corresponding obstructed areas. This enables the construction of a comprehensive robot navigation map, providing a precise spatial reference for assessing movement feasibility and guiding subsequent optimisation strategies (Figure 3).

Figure 3 Spatial streamline verification of elderly care robots based on the SLAM principle

3.3 Simulation of Spatial Interaction and Environmental Perception for Care Robots

This part of the study focuses on simulating and verifying care robot interactions within eldercare residential spaces. High-precision three-dimensional reconstructions of the living environment are created using architectural modeling software. Through meticulous measurement and accurate modeling, the structural layout of rooms, furniture arrangements, and spatial dimensions are faithfully reproduced to ensure a high level of model fidelity. A dynamic model of the robot, constructed based on its actual dimensions and motion characteristics, is then embedded into the 3D residential space (Figure 4). Using this integrated model, the robot's movement trajectories and posture variations across different scenarios are simulated to assess its spatial adaptability and to identify or predict potential mobility barriers and spatial conflicts.

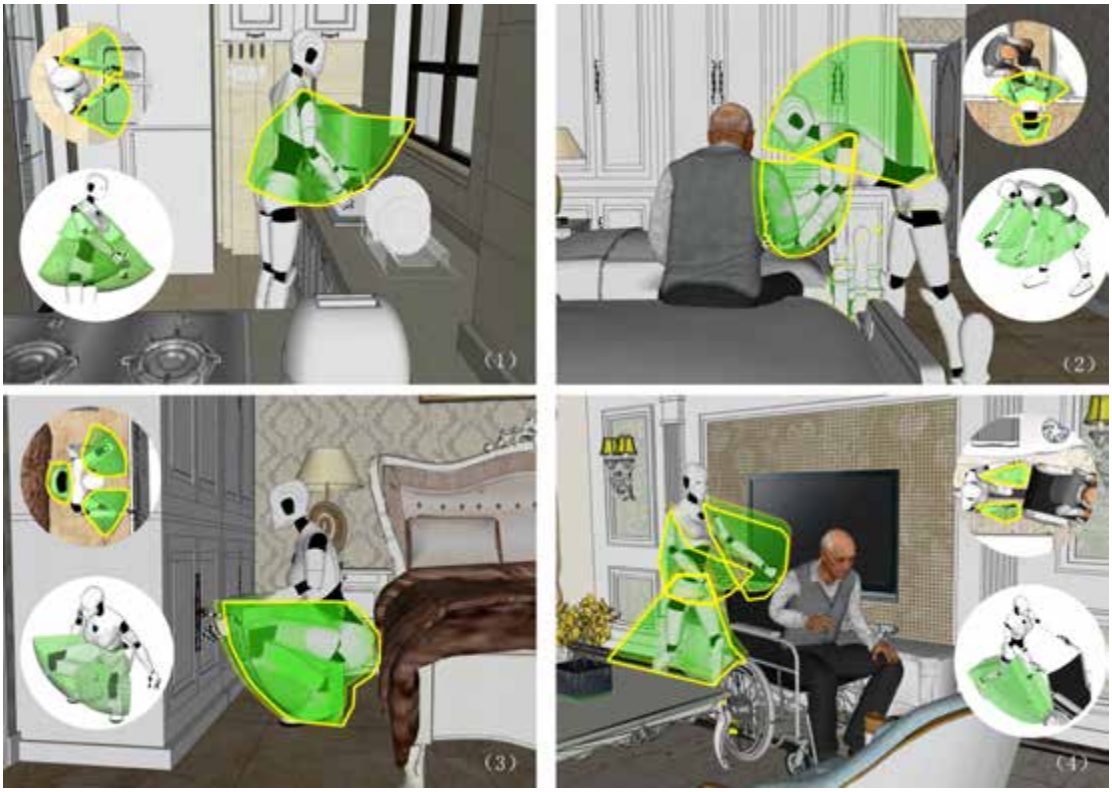
The Unity platform is employed to simulate the complete process of robot task execution within eldercare environments. Unity provides a realistic representation of interactions between the robot and household furniture. Simulations include daily tasks such as cleaning, transporting objects, and assisting with mobility. Throughout these scenarios, the robot's motion smoothness, operational stability, and physical interactions with furniture are observed and recorded. Based on the simulation outcomes, targeted spatial adjustment strategies are proposed.

Furthermore, the study incorporates the preferences of elderly users and the functional requirements of robotic sensors to evaluate and optimise soft furnishings within the residential space. It examines whether elements such as curtains, carpets, and decorative items interfere with robotic operations—particularly during movement or task execution—and whether they impact sensor performance. Methods from environmental behavior studies are utilised to understand how soft furnishings influence spatial use and robotic functionality, ensuring that such elements do not hinder sensor performance or cause disruptions in path planning. Additionally, the effects of soft furnishings on task efficiency and robot stability are assessed through simulation testing, allowing for the identification of soft furnishing configurations that meet both the preferences of older adults and the oper-

ational needs of robotic systems.

To enhance the environmental perception and human–robot interaction capabilities of care robots within residential spaces, this study proposes the deployment of an environmental sensing system to optimise the robot's ability to interpret its surroundings and respond to the needs of elderly users. For example, depth cameras, Li-DAR sensors, and smart detectors can be strategically installed in key areas such as bedside zones and bathrooms to assist robots in accurately recognising spatial structures and dynamic obstacles. This setup improves the efficiency of path planning and task execution. In addition, integrating voice recognition technologies enables multi modal interaction—such as voice commands and gesture recognition—allowing elderly users to communicate with robots more intuitively and conveniently.

Following simulation-based validation and analysis, the study integrates elderly users' physiological and psychological needs, behavioral habits, and the operational requirements of robots to propose an optimised spatial layout and functional configuration. This optimised scheme is designed to meet the dual demands of eldercare and robotic functionality. It includes the generation of annotated maps illustrating the robot's activity ranges and proposes a series of spatial optimisation strategies. These include: public space and circulation design, dedicated charging and storage zones, barrier-free accessibility features, privacy-preserving spatial segments, smart home integration systems, and environmental perception and interaction interfaces. Together, these recommendations provide both theoretical support and practical guidance for the development of intelligent aging-in-place environments within smart eldercare communities.



Washing dishes, (2) Helping an elderly person get up, (3) Doing housework and picking up items, (4) Pushing a wheelchair

Figure 4. Take the bipedal humanoid robot as an example - schematic diagram for verifying the spatial dimensions of the working scene simulation

3.4 Key points of spatial design for nursing robots

-1-Bedroom : Intelligent Spatial Reconfiguration for Dressing and Bed Transfers

As the most frequently occupied and private area for elderly residents, the bedroom must be proactively adapted to accommodate robotic assistance in two critical tasks: dressing and getting in and out of bed. Although dressing appears simple, it involves frequent posture changes (sitting, standing, arm-raising), garment delivery, and fine manipulation. During these operations, the robot must maintain a stable working distance from the bed and frequently transition among the bed, wardrobe, and dressing chair. Therefore, the spatial layout around the bed should allow 360-degree accessibility, and storage elements such as drawers and hanging rails must be adjusted to robot-reachable heights, potentially integrated with smart lift systems. This multi-point coordination not only improves task efficiency but also lays the spatial foundation for transforming the bedroom into a wearable-assistance unit in future designs (Figure 5).

Bed transfers, on the other hand, rely more heavily on the robot's ability to support body weight and stabilize the user's posture. The conventional layout—where beds are placed against walls on both sides—prevents parallel robotic access and must be reconsidered. A lateral clearance of at least 80 cm should be maintained along at least one side of the bed. Additionally, the bed frame itself should comply with robot-compatible structural standards, including appropriate height, unobstructed bed edges, and built-in sensor interfaces. Such a forward-looking design approach transforms the bedroom from a purely human-centered spatial model into a human–robot collaborative environment, enabling a new paradigm for intelligent caregiving at home.

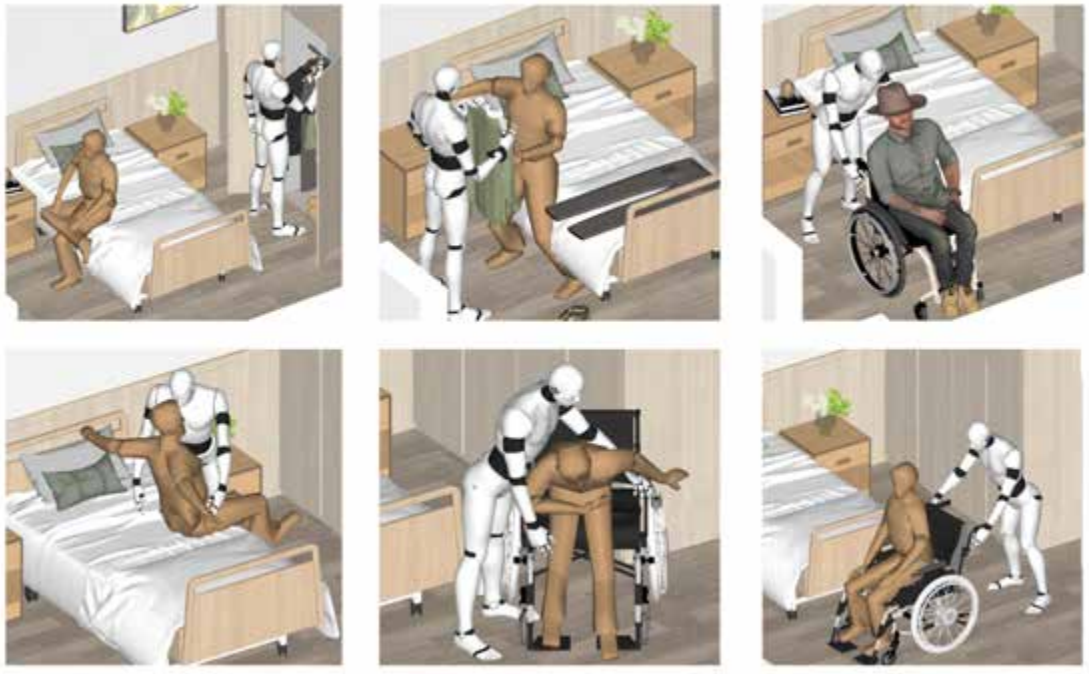


Figure 5. A schematic diagram of a care robot assisting the elderly in the bedroom space

-2-Living Room : Adaptive Upgrades in Public Zones Triggered by Feeding and Wheelchair-Assistance Behaviors
In the living room, where robots assist with tasks such as feeding and wheelchair propulsion, the space functions not only as a site for leisure and social interaction, but also as a dynamic caregiving operations platform. Feeding tasks require the robot to maintain a stable front-facing position relative to the elderly person, perform lifting actions, and deliver food with precision. This necessitates a layout that ensures accessibility and interaction compatibility—particularly in terms of adequate clearance between furniture, movable chairs, and slip-resistant flooring with guided navigation features. Future intelligent living rooms should adopt behavior-driven layouts, enabling real-time responsiveness to action chains such as "feeding – turning – obstacle avoidance – repositioning," while reserving zones for information interfaces and power docking points to support seamless human-robot-environment integration (Figure 6).

Wheelchair-pushing tasks demand precise spatial adaptations in terms of continuous circulation paths, doorway widths, and turning radii. The robot must detect and navigate through spaces at a height below 1 meter, avoid obstacles, and stably maneuver a weighted object, all while monitoring the elderly user's posture in real time. Common mixed-function household furniture layouts may hinder such mobility, introducing unpredictable obstructions. Therefore, design measures such as pathfinding cues, clearance control, and furniture-aided turning zones are necessary to optimize routes. The future senior-friendly living room will incorporate service flow logic, planning both primary and fallback robotic circulation paths, and will evolve into a truly intelligent and inclusive residential environment—where pets, home appliances, humans, and robots coexist in harmony.

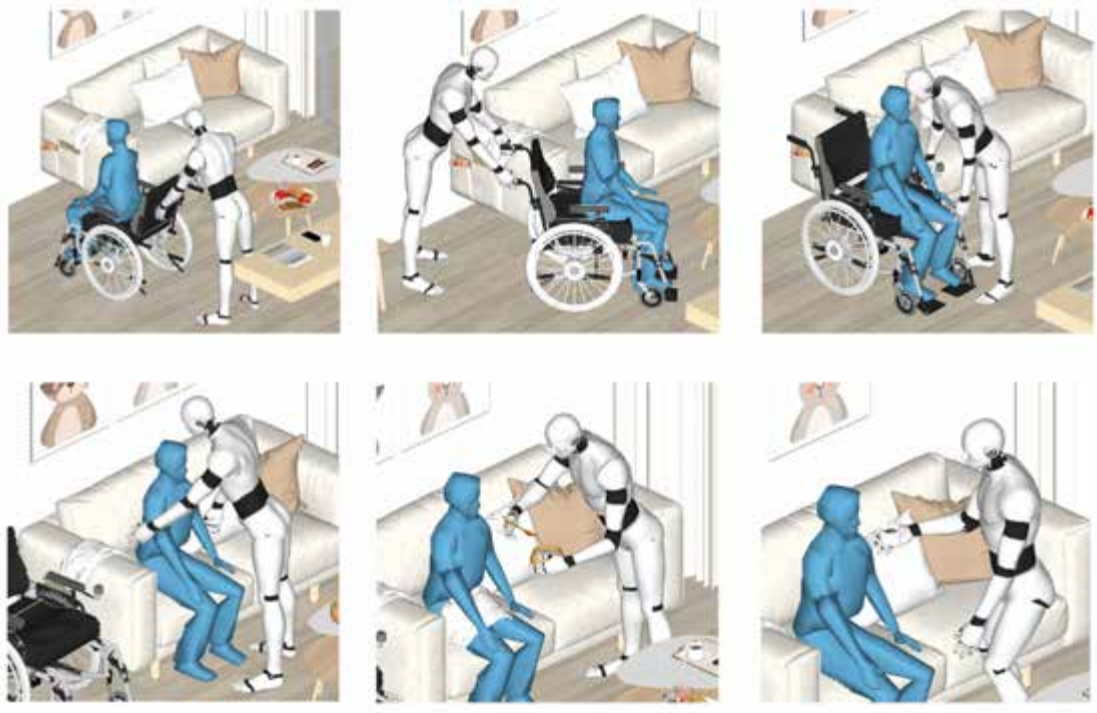


Figure 6. A schematic diagram of a care robot assisting the elderly in the living room space

-3-Bathroom : Fine-Tuned Spatial Responses for Bathing and Toileting Assistance

As the functional capabilities of caregiving robots continue to advance, assisting elderly users with toileting and bathing within the bathroom has become a crucial component of intelligent eldercare systems. Compared to traditional human-assisted care, robotic operation demands a higher degree of spatial precision and accessibility. For example, during bathing, the robot must perform a sequence of actions—supporting, washing, and transferring—typically from a lateral or rear position relative to the user. This necessitates not only sufficient rotational and extension space for dynamic movements, but also the integration of wet-zone electrical safety separation, non-slip waterproof materials, and proper drainage slope. Thus, bathrooms can no longer be designed solely based on minimal usable area standards; they must be redefined through a three-dimensional coordination model that aligns robotic motion, operating space, and embedded safety infrastructure (Figure 7).

Toileting tasks, on the other hand, require the robot to assist with sit-to-stand transfers, provide posture stabilization, and manage clothing adjustments—all within constrained spatial envelopes. This introduces new layout standards for the bathroom, including minimum clearances in the toilet zone, unobstructed side access around the toilet, and handrail configurations that accommodate the robot's arm reach and movement trajectories. Future intelligent bathroom design must go beyond conventional aging-in-place principles and evolve toward dual compatibility with humans and robots. By anticipating robotic workflow and movement patterns, such designs can embed both physical and digital interfaces, laying the groundwork for fully automated care environments in residential and institutional eldercare settings.

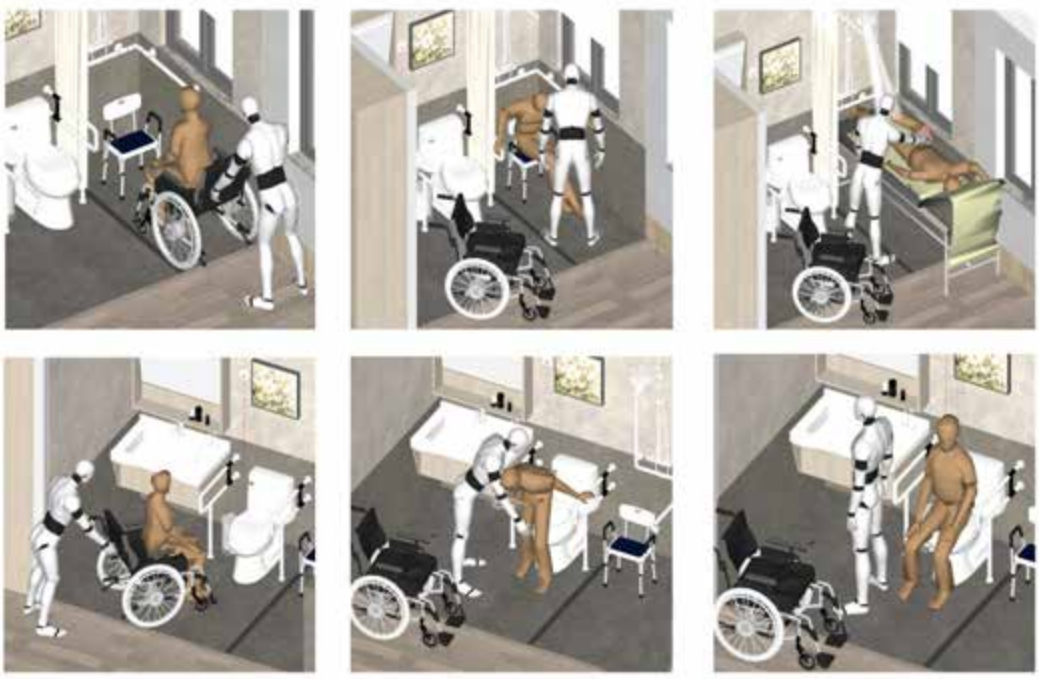


Figure 7. A schematic diagram of a care robot assisting the elderly in the bathroom space

4 Conclusion

As elderly care services continue to evolve toward greater intelligence and diversification, the integration of robots represents not only a technological innovation but also a fundamental shift in the organization and spatial logic of architectural environments. The spatial demand modeling method for care robots proposed in this study serves as a bridge between intelligent devices and architectural design, offering high scalability and practical applicability. By analyzing the motion characteristics of care robots in various caregiving tasks and applying principles of robotic kinematics, this research constructs an environmental requirement model to quantify the spatial needs associated with different tasks. It further assesses the mobility and accessibility of robots within typical eldercare spaces such as bedrooms and living rooms, and proposes environmental layout optimizations to enhance compatibility with robotic movement and operational zones. Additionally, the study explores the interactive relationship between robots and furniture, soft furnishings, and barrier-free facilities, and incorporates smart perception systems to improve robotic adaptability to complex residential environments.

Starting from six core caregiving tasks in real-world eldercare scenarios, this study provides an in-depth analysis of spatial adaptation principles and design requirements for robotic assistance in three representative spaces: bathroom, bedroom, and living room. A three-dimensional translational framework of "task–motion–spatial demand" is proposed to uncover spatial compatibility bottlenecks inherent in traditional human-centered residential layouts when confronted with robotic operation. Looking forward, this framework may be further enhanced by integrating machine learning, behavioral simulation, and multi-scenario dynamic optimization techniques, leading to the development of multi-scale design models that support human–robot–space co-evolution in intelligent eldercare communities offering both theoretical grounding and practical pathways for healthy aging in the urban context.

Acknowledgement

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Towards Ethical Implementation of Urban Digital Twins: Addressing Key Challenges & Recommending Best Practices

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Abstract
Urban Digital Twins (UDT) are transforming the way cities are designed and managed while also fostering trust, collaboration and transparency for all, including citizens. UDTs are a virtual built-up environment model, primarily adopted to digitally deliver data insights and evidence-based decision-making capabilities to policymakers, city managers and planners. The essential nature of data in UDT requires that its implementation and adoption follow an ethical, robust and secure data governance practice. This paper stems from a research collaboration between the ADAPT Research Ireland Centre and Dublin City Council, via the Smart Dublin unit. The authors distil their situated experiences and knowledge into 12 key principles, organised under the pillars of Data, People, and Platform, and conclude with actionable recommendations for facilitating ethical and inclusive UDTs.

Keywords: Urban Digital Twins, Ethical Principles, Smart Cities, Data Governance, Responsible Innovation

1. Introduction

Europe's digital decade policy programme has developed a comprehensive network of digital transformation projects, setting clear objectives and targets to advance concepts of Data Spaces, Local Digital Twins, Interoperability, etc. Smart city projects aim to utilise technology to address urban issues, enhance public service delivery, city infrastructure management and create long-term business competitiveness through extensive data collection and constant urban surveillance through sensing devices (Angelidou, 2015, Kitchin, 2014). This tendency to oversimplify complex, unpredictable social systems into controllable, measurable units and a technocentric approach raises several ethical concerns (Cureton and Dunn, 2020). Technical advancements now are able to support big data analytics, artificial intelligence and edge computing for near real-time response and autonomous systems as envisaged by smart cities (Batty, 2018; Yigitcanlar et al., 2020). This has resulted in a rising global trend to utilise digital twins as one of the emerging technologies by smart cities, promising urban intelligence, policy testing, future scenario visualisation, and outcome prediction before infrastructure is even constructed (Jeddoub et al., 2024; Ketzler et al., 2020).

Urban Digital Twin (UDT) is a virtual model of the physical built-up environment that digitally overlays geographical location-based processes, socio-economic information, historical datasets and real-time sensor inputs on a single platform (Raes and Ruston McAleer, 2025). The main advantages of UDTs entail enhanced urban decision making, novel ways to engage with stakeholders and citizens, immersive visual experiences, high-performing resilient infrastructure seeking to support the entire construction value chain (investors, owners, asset managers, contractors, consultants, suppliers, etc), better risk management, financial savings and improved resource efficiency (Bolton et al., 2018). Overall, data is at the heart of a UDT aiming to enable better outcomes and superior results for higher public value. However, managing this digital-urban fabric requires complex, multifaceted approaches because its formal and de facto processes can create structural and epistemic tensions within socioeconomic, cultural and environmental conditions.

The combination of big urban data obtained through passive and non-consent from sensors, further processed and analysed using unexplained large language models, can potentially lead to data biases and discrimination, creating uncertainty and fear among urban communities and planners, as well as policymakers (Sanchez et al., 2024; Sherman, 2023). Moreover, this process of urban-digital replication, if coupled with automated decision-making, can threaten human autonomy and lead to mechanistic decision systems for existing cities and their

societal frameworks (Zwitter and Helbing, 2024). A human-centred approach, thus, becomes even more challenging and necessary in modern technological urban development, the emerging regulatory policy landscape and multilateral governance structures (Pellegrin et al., 2021).

This paper investigates ethical problems that may occur when UDT technology is deployed for urban decision-making through a case analysis of Smart Dublin. It draws from an extensive literature review, along with direct and sustained engagement with Irish Local Authority staff through the collaboration between ADAPT Research Ireland Centre for AI-driven Digital Content Technology and the Smart City Unit at Dublin City Council (DCC). The outcome of this paper further outlines fundamental principles that public authorities should be mindful of when implementing UDTs into their operational procedures and institutional structures. The authors conclude by emphasising that ethics integration at the outset increases the chances of responsible innovation and value sensitivity in UDT experimentation through methods that preserve citizen autonomy and build strong governance structures for smart cities and societies.

2. Literature Review

The digital twin concept is not new and dates back several decades to when NASA first applied a mirrored system for their Apollo Missions during the 1960s (Glaessgen and Stargel, 2012). The term itself, however, later appeared in 2002 in the context of a product lifecycle management project and later spread to multiple sectors, including manufacturing, healthcare and urban planning during the 2010s (Grieves, 2014; Tao et al., 2018). Smart cities globally began focusing more intensely on digital twin applications for city design and management, evidenced by an exponential increase in Scopus-indexed research articles on UDTs and their widespread adoption by public bodies. According to a European Commission's report, there are nearly 135 UDT platforms across Europe, primarily at the city-level, primarily focusing on urban planning, environmental and mobility use cases (Correia et al., 2022). This section discusses some of the envisaged risks of a UDT project by city authorities and highlights a few frameworks which have been developed for their ethical and trustworthy implementation.

2.1. UDTs' Envisaged Risks and Challenges

Digital twin platforms can cause risks of stakeholders ignoring crucial sociological, political, historical and environmental factors that affect urban environments. The success of a UDT project relies on data quality since the system will produce results that match the quality of its input data. An attempt at total representation of people, their behavioural patterns, and dynamics of social and spatial systems through quantitative models and digital twins presents notable challenges (Cureton and Dunn, 2020). On the one hand, cybernetic governance embodies an optimism towards enhanced operational efficiency and financial savings, while on the other hand, without enough human agency, it is challenging to develop value-sensitive solutions which protect human rights and respect cultural and social aspects.

A surveillance-based society which relies heavily on data-driven AI control and indicator-based approaches might lead to poor problem identification of complex issues (Breuer and Pierson, 2020; Kerr and Pierson, 2025; Zwitter and Helbing, 2024). Some projects, such as the 'Replica' and 'Cord' by Sidewalk Labs, are examples which exemplify dataveillance practices through a massive collection of urban data for public decision-making, leading to systematic personal data collection, people's behavioural monitoring, raising multiple ethical and privacy-related issues (Helbing and Sánchez-Vaquerizo, 2023). Wang and Burdon (2021) documented that nine million New York City residents became part of algorithmic decision-making systems that determined policing actions and transportation routes. However, the entire system failed to provide New Yorkers with an understanding of these decision-making processes, resulting in opaque 'black box' cities.

Barcik et al. (2023) posit using Rotterdam as a case study that since UDTs rely heavily on interconnected data systems, they are more susceptible to cybersecurity threats, leakage of sensitive personal and location-based asset information, and unauthorised access. The incorporation of intellectual property provisions in contractual agreements can address some of the foreseen copyright and ownership issues by specifying permitted use and access rights to UDT and underlying datasets (Simpson, 2020). This is critical since the loss of access to a

data source during project execution may create negative impacts on the model's performance, validity and accuracy. These formidable challenges require the non-negotiable implementation of responsible innovation principles and maintaining sufficient reliability of a UDT system to build trust and minimise social risks (Helbing and Sánchez-Vaquerizo, 2023).

2.2. Existing UDT Frameworks

UN-Habitat (2022a) emphasises that governments must take responsibility for their actions, together with the effects of technological adoption in cities. Few frameworks already exist for ethical processes in a UDT design and adoption. The UK government's Gemini Principles (Figure 1) are the most common, with nine values suggested, serving as a guidance system for their National Digital Twin (NDT) programme (Bolton et al., 2018). The National Infrastructure Commission's report 'Data for the Public Good' resulted in the development of their NDT programme to enhance government services and asset management. The Gemini Principles consist of three core themes which encompass Purpose, Trust and Function. Each element of the UDT needs a defined purpose that matches organisational goals while creating sustainable value distribution between all parties for enhanced productivity and risk management, according to Gemini Principles. They posit that UDTs should be designed with ethical and secure features to build public trust and avoid any possible data breaches.

Figure 1. Gemini Principles (Source: Bolton et al., 2018: pg. 7)

The emerging digital twin technology can benefit from early foundational frameworks like the Gemini Principles to ensure trustworthy UDT development. It must enhance city system functions through transparent, accountable operations with an aim to serve the needs of the city residents. The trust model proposed by Wang and Burdon (2021), shown in Figure 2, suggests that perceived trustworthiness of a UDT exists in opposition to perceived risk, which relies on the trustor's tendency to trust. According to this model, perceived trustworthiness is a result of three aspects of a UDT – their ability, integrity and benevolence. The ability of UDT immensely depends on system robustness for handling data with care and using high-quality information to make decisions and offering authentic city insights to citizens. An automated decision-making process of UDT systems can diminish city organisations' capability to display benevolence toward citizens (Wang and Burdon, 2021). The platform architecture of UDTs needs to be completely examined for their ability to verify both the validity of assumptions and the competence of algorithms. The second point of Integrity requires UDTs to match the socio-political goals of the territory in addition to the technical aspects, i.e. digital twin's common data environment needs to have a design framework that incorporates legal, social and political considerations.

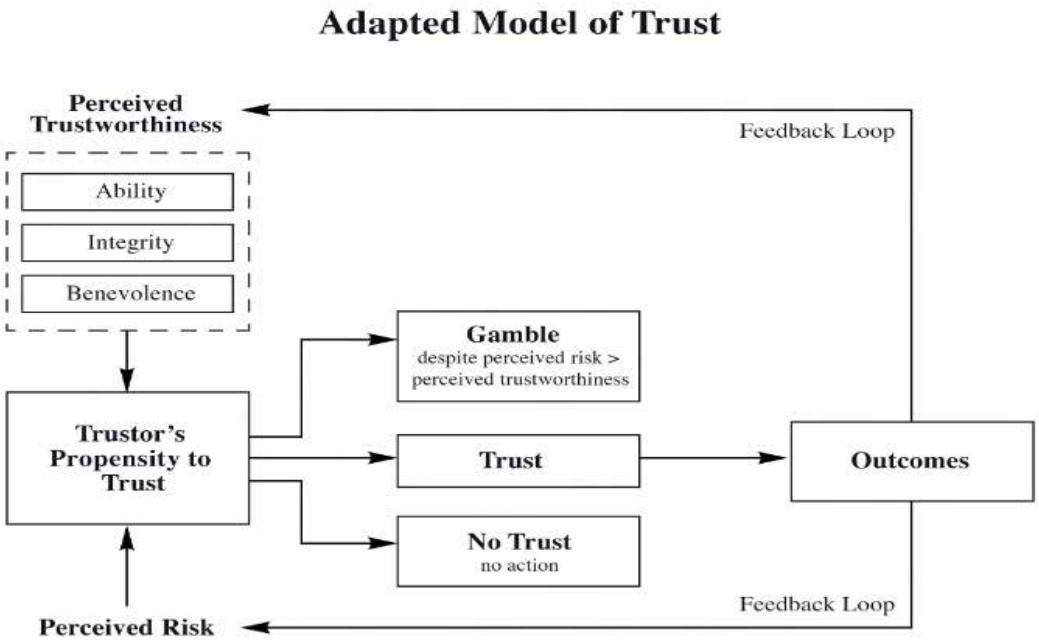

Figure 2. Adapted Trust Model for UDTs proposed by Wang and Burdon (2021: pg. 11)

Benevolence enables citizens to exercise their freedom to participate in social and cultural activities, as well as protect their fundamental human and digital rights. Citizens maintain the right to choose and maintain autonomy through their decision to participate and share their data. The acceptance of UDT can be increased if all stakeholders, including citizens, are able to understand how underlying datasets and algorithms in a UDT system align with democratic rules and city-making processes, also if they possess the ability to contest automated decisions at any time (Sadowski and Leurs, 2024). Human oversight mechanisms should therefore be established through human-in-the-loop, human-on-the-loop and human-in-command approaches for proper oversight (High-Level Expert Group on Artificial Intelligence, 2019).

The High-Level Expert Group on AI published Ethics Guidelines and a self-assessment list for Trustworthy Artificial Intelligence (High-Level Expert Group on AI, 2020; High-Level Expert Group on Artificial Intelligence, 2019), including AI principles from the Organisation for Economic Co-operation and Development (2019) and the Flemish AI Strategy (Digitaal Vlaanderen, 2024). UDT projects must comply with these trustworthy AI principles by following the three key principles of AI systems being a) lawful regarding all applicable laws and regulations, b) ethical regarding most of the moral values and c) robust regarding both technical aspects and social environment (High-Level Expert Group on Artificial Intelligence, 2019). It lays down seven requirements of equal importance, as shown in Figure 3, which must be deployed and monitored throughout the AI system's life cycle. Data protection alongside privacy needs to be respected while implementing adequate data governance systems, which prioritise data quality, integrity and validated data access. Moreover, the implementation of traceability systems can enable organisations to achieve transparency by providing decision explanations that match the level of understanding of their concerned stakeholders (City of Brussels, 2022).

Figure 3. Seven requirements for Trustworthy AI proposed by High-Level Expert Group on Artificial Intelligence (2019: pg. 15)

The three frameworks covered in this section aim to ensure trustworthiness and public value for the implementation of a UDT project. They serve three questions in general (Figure 4) – a) why a digital twin technology was chosen and whom does it serves, b) what steps can be taken towards improving trustworthiness, accountability, and transparency of a UDT system, and c) how technically competent is the UDT to support human decision-making processes. UDT should deliver public benefits, societal and environmental well-being, while ensuring diversity is respected throughout its project lifecycle.

Existing Frameworks relevant for UDTs

	Gemini Principles	Trust Model	Trustworthy AI
Why are we building a UDT and who are the beneficiaries?	**Clear Purpose** i. must be used to deliver genuine public benefits in perpetuity ii. must enable value creation and performance improvement iii. must provide determinable insight into the built environment	**Benevolence** *Is the system oriented toward public good and citizen wellbeing?* • active protection of privacy and dignity • allows user control and engagement • Support participatory city-making • Produce inclusive social outcomes	**Societal and environmental wellbeing** **Diversity, non-discrimination and fairness**
What makes UDTs trustworthy & transparent?	**Trustworthy** i. must enable security and be secure itself ii. must be as open as possible iii. must be built on data of an appropriate quality	**Integrity** *Does the digital twin act consistently with shared values and legal standards?* • transparent and accountable • ensure compliance with regulations and ability for users to consent and correct data about them	**Accountability** **Privacy and data governance** **Transparency**
How will UDTs enable data driven decision-making?	**Function effectively** i. must be based on a standard connected environment ii. must have clear ownership, governance and regulation iii. must be able to adapt as technology and society evolve	**Ability** *Can the digital twin perform effectively?* • Interoperable, secured, and ensure data portability • technically competent and functional	**Technical robustness and safety** **Human agency and oversight**

Figure 4. Existing Frameworks relevant to UDT implementation (Source: Authors)

3. Methodology

This study emerges from embedded research conducted through a collaboration between the ADAPT Research Ireland Centre, a national government-funded multi-institutional and interdisciplinary research centre, and Dublin City Council's Smart City Unit under the Smart Dublin umbrella (Dhingra and Kerr, 2024). The project between ADAPT and DCC began in December 2022 as a partnership aimed at trialling and testing ethical practices in the design and development of UDTs for public sector planning. It moves away from a technology push and prioritises an ethical, realistically achievable, and inclusive approach for UDT adoption (Dhingra and Kerr, 2024; Fernandez et al., 2024). Like drones and GenAI, digital twin is an emerging technology which is identified as one of the key priorities under the recently launched DCC's Digital Transformation Strategy 2025-2030 (Dublin City Council, 2025). This is seen as an opportunity for DCC to redefine its strategic roadmap for working towards embracing organisation-wide digital transformation management.

Figure 5 shows the project timeline, with the first phase focused on desk research to understand the concept of UDTs, its widely accepted definition, applications in urban planning, and the challenges raised by other scholars. Also, existing digital twin initiatives and bespoke pilots across Smart Dublin were mapped, enabling the understanding of key implementation barriers faced by stakeholders in Ireland. Phases 2 and 3 of the project streamlined the development of new use cases through a collaborative approach among the public sector, academia, and the research sector in Ireland. This includes a partnership with the Irish Centre for High-End Computing as part of the Digital Innovation Flagship call 2023, resulting in an engaging UDT platform architecture using the open data ecosystem, Google photorealistic 3D tiles, open-source gaming platforms like Unreal Engine and real-time APIs (Irish Centre for High End Computing, 2023).

Figure 5. Project Timeline (Source: Authors)

Parallelly, an INTERREG Northwest Europe (NWE) co-funded Twin4Resilience (T4R) project running from November 2023 to June 2027, led to the co-creation of an ethical framework for UDTs. T4R acknowledges the different levels of UDT maturity currently existing within EU member states and promotes transnational cooperation to enhance the adoption of UDTs by public sector bodies for data-driven resilient territorial planning. It is based on four co-developed frameworks – technical design, governance, ethics-inclusion-democratisation and training. DCC led the co-design of the ethics-inclusion-democratisation framework through an in-depth literature review and desk study, capturing the experiences of T4R project partners, their local stakeholders and the transnational community of practice. A detailed methodology is shown in Figure 6, highlighting how local, European and international experiences led to a participatory, iterative and structured approach for this study. Currently, the project is moving to align with other digital initiatives, such as strategy development of building information modelling for all public sector capital projects, a centralised common data environment, geospatial database management, etc, thus contributing to DCC's Digital Twin Programme.

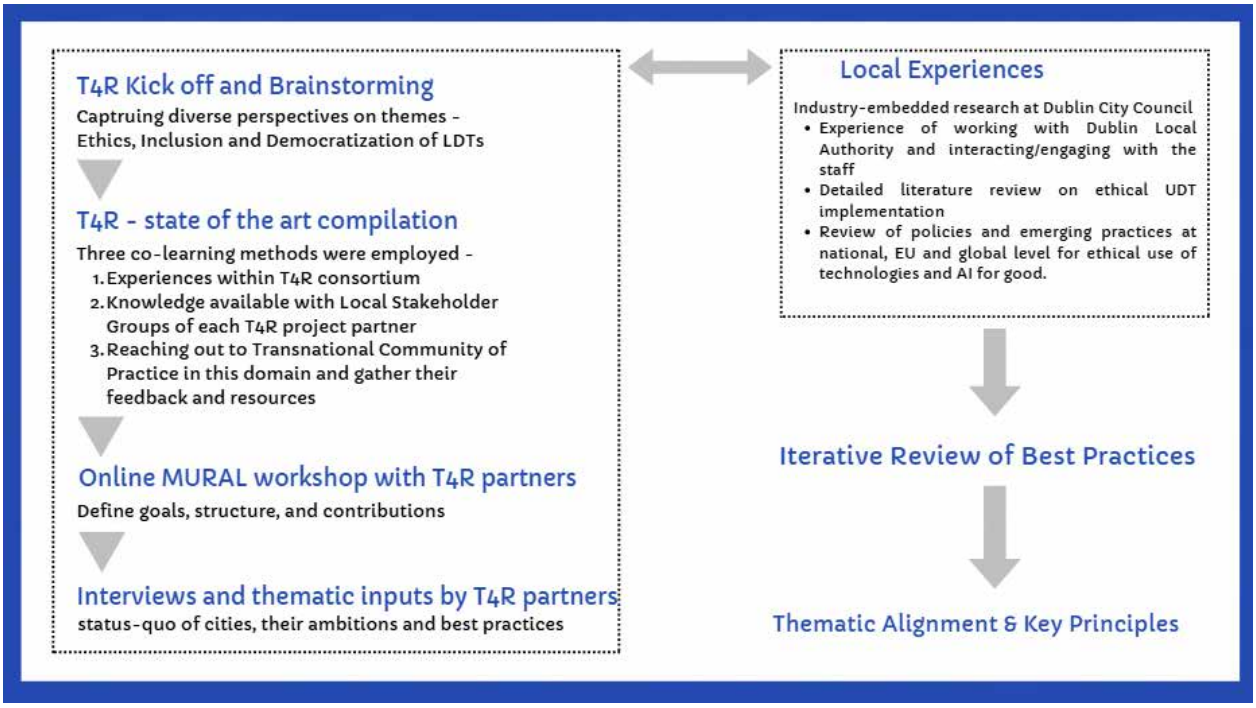

Figure 6. Methodological approach (Source: Authors)

The outcome of this study is also building on the UDT conceptual framework proposed by Dhingra et al. (2024), which placed People, Data and Platform at the core of UDT implementation while aligning with the ethical practices, robust governance mechanisms, high-impact use cases and continuous stakeholder engagement (Figure 7). The project simultaneously focusses on identifying high quality datasets for potential use cases, their management, storage and metadata requirements, exploring various enterprise and open software solutions available to DCC, evaluating best practices available locally and globally, building a dedicated stakeholder network across Ireland representing the quadruple helix model with academia, private, public and community partners, bridging current knowledge gaps with inspiring case studies and suggesting ways to mitigate potential ethical and social concerns.

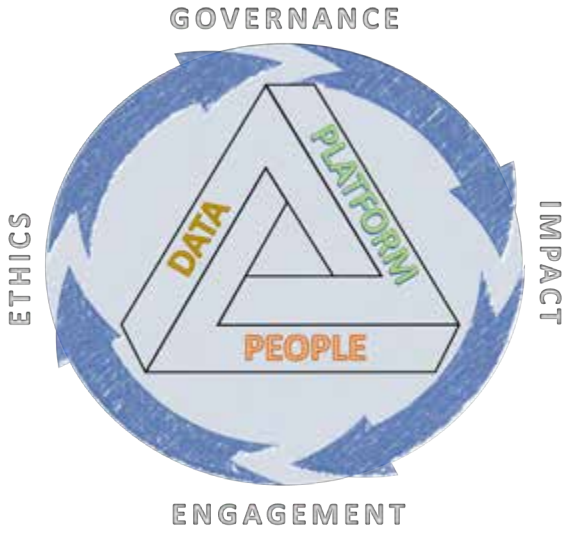

Figure 6. Proposed UDT conceptual approach (Source: Authors)

4. Findings, Discussion, and Recommendations

This section discusses findings of the study in terms of the issues that can arise during UDT implementation, understanding the current policy landscape in the EU, recommending contractual safeguards, best practices and some exemplars. This resulted in 12 key principles of UDT implementation, explained in the next section.

Figure 8 illustrates key implementation challenges identified as part of the ADAPT-DCC project. The most critical being a lack of high-quality datasets in standard data formats, and a realistic-looking 3D model of the whole city. The non-existence of interoperable solutions led to instances of vendor lock-in and an inflexible working environment. Data privacy, the possibility of surveillance of public spaces, potential biases, risk of techno-solutionism and black box AI systems also raise significant ethical and social concerns. Besides technical barriers, non-technical challenges such as lack of finances, under-skilled local authority staff, insufficient leadership buy-in, etc, are found to be of paramount importance.

Figure 7. UDT adoption barriers (Source: Authors)

4.1. Regulatory Compliance

Clarity of purpose, together with trust, openness, security, quality and effective UDT operation, are emphasised by the Centre for Digital Built Britain's Digital Framework Task Group (Bolton et al., 2018). An efficient information management system can enable better decisions, financial savings, improved performance of the built environment and urban services. This makes it imperative for an organisation seeking to implement a UDT to build a data-driven culture through open, transparent and inclusive processes combined with accessibility and accountability (European Commission, 2020; OECD Public Governance and Directorate, 2014). A UDT project must follow any applicable local, regional, federal, European and international laws. Some examples are listed in Table 1.

Table 1. Regulations relevant for a UDT project in the EU (Source: Authors)

Data Governance Act (DGA) (European Parliament, 2022)	A cross-sectoral framework to enhance trust in voluntary data sharing for the benefit of businesses and citizens and regulate the reuse of publicly held/protected data through proper data sharing intermediaries. This covers both personal and non-personal data.
General Data Protection Regulation (GDPR) (GDPR.EU, n.d.)	Europe's data security and privacy law has been effective since 2018, and sets clear guidelines to collect, store and process any personal data of citizens. It has seven principles: lawfulness, fairness and transparency; purpose limitation; data minimisation; accuracy; storage limitation; integrity and confidentiality; and accountability. Wherever personal data is concerned, GDPR legislation is applicable, implying it is critical to consider inbuilt safeguards to increase trust in data sharing and reuse.

Cybersecurity Frameworks	GDPR reflects some cybersecurity frameworks to comply to. Other security frameworks include the IoT Security Foundation (IoTSF), offering guidance and best practices for securing IoT deployments: iotsecurityfoundation.org, and NIST Cybersecurity Framework, providing a risk-based approach to managing IoT security.nist.gov.
Data Protection Impact Assessment (DPIA) (GDPR.EU, n.d.)	Required when using any new technologies tracking people's behaviour/location and monitoring publicly accessible spaces on a large scale, etc. It maps out the privacy risks of data processing in advance and helps to identify measures to reduce these risks.
Freedom of Information (FOI) Act	Requires organisations to maintain transparency with citizens. Subject to this Act, every person has the right to request and access any public record held by an FOI body.
EU AI Act	World's first comprehensive AI law (European Parliament, 2023) requires incorporating model contractual clauses to guide procurement of trustworthy AI services and systems (Naves et al., 2023)
Open Data Directive (European Parliament, 2019)	Regulates the reuse of publicly available information by the public sector, which is not of a protected nature, ensuring transparency for all stakeholders, including underserved communities and implements governance mechanisms that monitor fairness, accountability, and bias in AI-driven twin systems

Among these, GDPR's Privacy by Design principle is one of the most critical when it comes to any UDT project. It refers to data protection and privacy embedded into the design of data processing operations and information systems (European Parliament and Council, 2016). EU-based organisations are required to conduct an information audit to determine what information they store, process and who has access to it. Organisations can consult their Data Protection Officer (DPO) for each new data-collection service or technology and process implementation to pursue for their UDT use case. This will ensure that there is a legal justification for planned data processing activities and collected data is useful and necessary. Privacy Impact Assessments (PIAs) can be carried out to safeguard sensitive information within the organisation and align with legal requirements.

Besides ensuring compliance with legal requirements and secured cyber systems, the EU Digital Rights Principle of Sustainability requires digital products and services to experience their entire life cycle from creation through use, disposal and recycling while minimising economic, social and environmental impacts (European Commission, 2022a). AI-enabled applications in the minimal risk category include UDTs, which are subject to the EU AI Act requirements for transparency and non-binding codes of conduct. UDTs as government applications need to follow the EU's (High-Level Expert Group on Artificial Intelligence, 2019) ethics guidelines and code of conduct.

4.2. Contractual Safeguards

Trust-building relies on transparency in contracts and compliance with open data licenses. The legal definition of data ownership helps protect individual rights as well as shared copyright materials and resolves ownership disputes for the entire model, especially for UDTs when data is shared for public benefit use cases (Simpson, 2020). The licenses for data access need to have an extended duration which spans the entire twin lifecycle. The twin model benefits from various access permissions which protect against security breaches and information sensitivities among multiple users. Regular security assessments can be conducted, such as vulnerability assessments of devices and networks, penetration testing to evaluate the resilience of IoT devices and infrastructure and third-party inspections to engage independent auditors and verify compliance with security standards. Some extra-legal and contractual safeguards regarding data management for UDT projects are summarised in Table 2.

Table 2. Contractual safeguards for UDT projects (Source: Authors)

1. Data Protection Agreements	• Anonymise sensitive data to protect individual privacy and comply with regulations like GDPR, CCPA, or other relevant frameworks, which often prioritise the rights of the individuals whose data is collected. • Draft robust agreements, such as Data Processing Agreements (DPAs) or Service Level Agreements (SLAs), that define roles, responsibilities, and data handling requirements. • Incorporate model (standard) contractual clauses developed by the EU to guide the procurement of trustworthy AI services. These clauses align with the EU AI Act framework and assist public buyers in acquiring AI solutions that are ethical, fair, and secure.
2. Liability and Remedies	• Specify liabilities for breaches or misuse of data and include remedies such as penalties or termination of contracts.
3. Jurisdiction Compliance	• Address potential conflicts arising from cross-border data transfers and jurisdiction-specific ownership rules.
4. Data Ownership Clauses	• In principle, the ownership of the data remains with the government. This is undoubtedly the case when it concerns personal data. • Specify ownership of data generated, collected, or processed through external software or services in contracts. • In contracts with the private sector, the rule is that the ownership remains with the contracting authority. However, when purchasing private sector data, the use and ownership are part of negotiations. • Clearly distinguish between raw data collected from sources like sensors or user inputs and processed data as insights, reports, or models derived from the raw data.
4. Intellectual Property (IP) Rights	• Clarify who owns derivative works or outputs generated using proprietary software. For example, a public entity might retain ownership of raw traffic data collected by IoT sensors, but the company providing analytical services might claim ownership of proprietary algorithms used for processing.
5. Evaluate Data Licensing Terms	• Exclusive vs. Non-Exclusive Rights: Ensure the agreement specifies whether ownership is exclusive to one party or if data can be shared or resold. • Usage Restrictions: Define the permissible uses of data (e.g., no resale or use outside the project without explicit consent). • Licensing Models: Choose licensing agreements that favour public interest, such as open data models, while safeguarding sensitive information.
6. Secure Ownership Through Technical Measures	• Data Segmentation: Use separate environments for raw data storage to maintain control. • Encryption: Encrypt sensitive data to limit unauthorised access, even by the service provider. • Metadata Tags: Use metadata to tag data with ownership identifiers.
7. Conduct Due Diligence	• Vendor Assessment: Evaluate the vendor's data handling policies, IP claims, and track record regarding data ownership disputes. • Audit Rights: Include provisions for auditing the vendor's adherence to data agreements.

8. Address Ownership in Software Agreements	• Ensure Service-Level Agreements (SLAs) specify who owns data stored or processed by software solutions. • Include provisions for retrieving data in accessible formats if the contract ends or the software changes.

Highest standards of data governance, quality management and ownership clauses can also be ensured through adopting international standards on data quality, such as ISO 8000-150 "Data quality and ownership standards" (ISO - International Organization for Standardization, 2022). FAIR data principles can ensure that the used data is easy to find, use and access, has clear added value for your UDT, is interoperable and compatible with most of the platforms (Wilkinson et al., 2016). The European Commission (2023) also laid down a list of high-value datasets illustrated in Figure 9, which can provide important benefits for society, the environment and the economy, but are also open by design, free of charge, are populated with extensive metadata, and published in machine-readable formats.

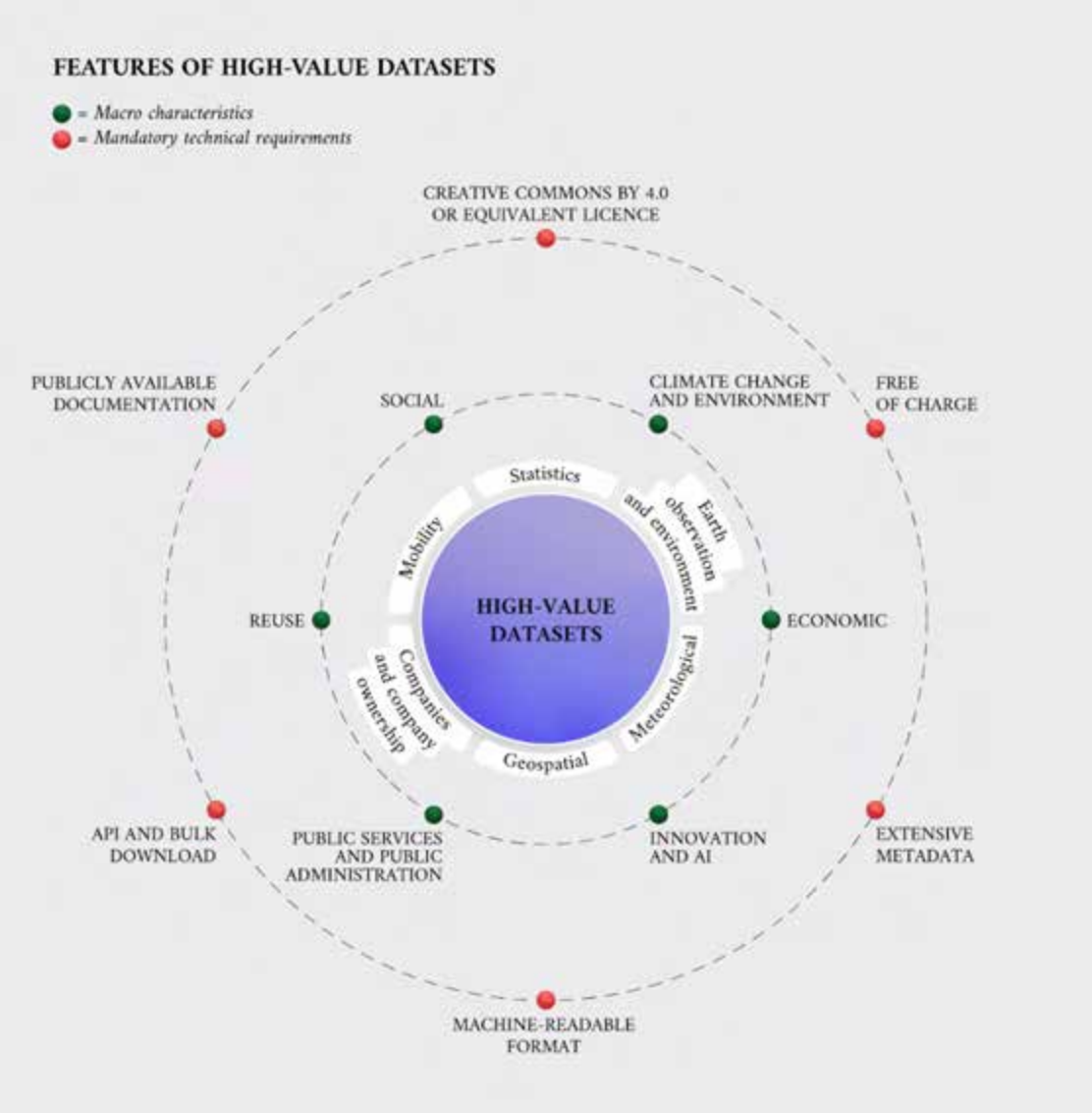

Figure 8. Features of high-value datasets. (Source: European Commission (2023))

4.3. Fundamental Rights-Based Approach

The democratic function of UDTs requires public social outcomes as their basis (Wang and Burdon, 2021). According to the European Declaration on Digital Rights and Principles for the Digital Decade, people stand as the primary focus of digital transformation in the European Union. A UDT must function for everyone who resides in the EU to provide secure empowerment that respects their fundamental human rights (European Commission, 2022b). It also emphasises that digital transformation should exclude nobody, i.e. it must benefit every person while delivering equality and protecting the vulnerable population.

The global design of UDT requires organisations to maintain cultural and social relevance by including people and local communities throughout the whole process. Any technological implementation must avoid uniform solutions because such approaches fail to respect the ingenious and diverse knowledge systems. The combination of social values along with soft data such as human behaviour, emotions and opinions within a UDT project can enhance the model's reliability to simulate complex real-world systems that contain human participation. Public or shared ownership models of technology products can potentially support communities to exercise control over technology management and deployment practices.

The principle of accessibility-by-design means products and services should be usable by most people without requiring special adaptation, and respect user diversity (Engineering Design Centre, n.d.). The curb cut effect described by Blackwell (2017) is an interesting example because accessibility features intended for marginalised groups often help a wider population. Some functionalities started as minority-specific tools but evolved into widespread standard elements, such as television and video content industry implementing closed captions initially designed for hearing-impaired viewers but now serve viewers in noisy settings, language learners and content creators, etc.

The public can also exhibit fear about UDT because of the unclear nature of privacy concerns and data control. Raising awareness can eliminate uncertainty by revealing the essential components of the UDT platform, including its purpose and method of operation, alongside its advantages and potential risks to those directly or indirectly affected by it. Breaking this fear requires good internal and external communication strategies, together with active citizen participation. Therefore, it would be fair to say that the governance structure of the digital offering relies on transparency as its main principle. Herrenberg in Germany (Dembski et al., 2020) and Malvalaan in the Netherlands (Najafi et al., 2023), are some examples of UDTs which use virtual reality technology for public participation (Figure 10).

Figure 90. Examples of public participation using UDTs (left - Herrenberg in Germany (Dembski et al., 2020: pg. 10), right - Malvalaan in the Netherlands (Najafi et al., 2023: pg. 13))

5. Key Principles for Ethical Implementation

Dhingra et al. (2024) proposed a conceptual approach advocating constant prioritising of ethics, governance, engagement and impact assessment. This section presents recommendations and best practices as 12 key principles under the pillars of People, Data, and Platform to implement an ethical approach for UDTs (Figure 11).

Figure 10. Key Principles for Ethical Implementation of UDTs (Source: Authors)

5.1. People

Any UDT project should start with the aim instead of technology, i.e. clarity of purpose is must, as suggested by Gemini Principles (Helbing and Sánchez-Vaquerizo, 2023; Wang and Burdon, 2021). It is critical to identify the urban issue which UDT should address, its scale and data requirements. Validation and verification of outputs of the model can ensure that it responds to the problem statement, and if underlying data, assumptions and uncertainties are considered (Herzog and Probst, 2024). A UDT must also align with the values, goals and mission of the organisation. For instance, in Amsterdam, the Municipal Executive has included the principles of the TADA Manifesto in the Coalition Agreement (Amsterdam Municipality, n.d.). It sets out important values such as inclusivity, a

say for residents, human scale, legitimate and verified data, openness and transparency for a responsible digital city. A rigorous check on the Tada values is now mandatory for every digitisation and data project at the municipality. Also, in 2023, the City of Brussels launched a Digital Rights Charter, which includes both the commitments on digitalisation and a list of actions to reflect these commitments.

To ensure a people-centric approach, stakeholders and beneficiaries must be identified at the inception of the UDT project. Some techniques, such as the Inclusive Segment Cards, can serve as a tool to understand target groups while ensuring everyone's viewpoint is considered in the design process (Friesinger, 2024). Also, impact assessment of UDT before the deployment can mitigate potential risks and harms often associated with it. A few best practices emerge from the Municipality of Amsterdam, which organises workshops and training for making moral decisions in technological projects, resulting in "ethical leaflets" (Schmidt, 2019). The Municipality of Utrecht has created a "Uthics method for ethical assessment" of digital projects based on the Data Ethical Decision Aid (DEDA model), shown in Figure 12 (Utrecht Data School, 2022). DEDA allows mapping of ethical dilemmas surrounding every digitisation process in the city that affects the residents in a Uthiek (Utrecht ethics) assessment. Rennes Métropoles works with a non-profit organisation, Ekitia, for an ethics assessment on their LDT Coopterr platform, as well as on other building blocks of their data ecosystem (Ekitia, 2022) .

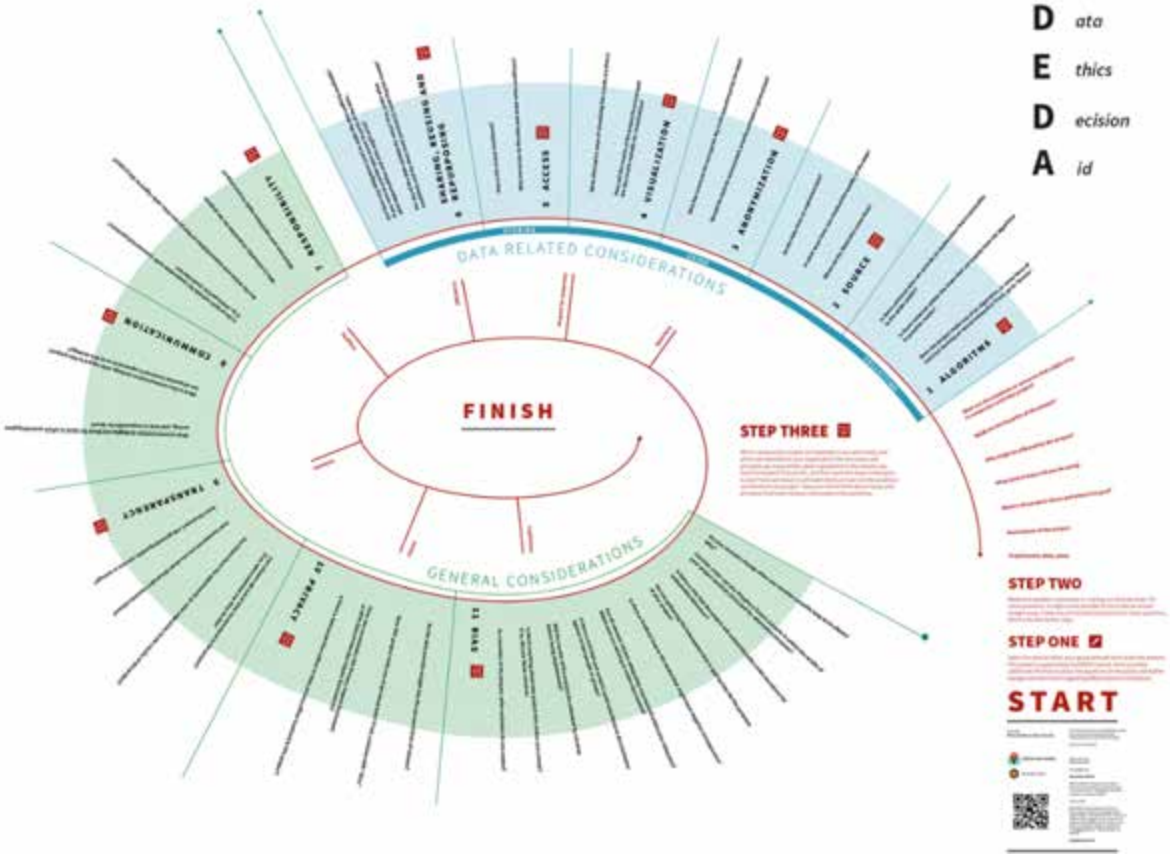

Figure 11. Data Ethics Decision Aid (DEDA) model proposed by Utrecht Data School (2022)

5.2. Data

Ensuring safe data handling practices and soft data integration which respect local socio-cultural settings can build trust in UDT decision making. Consider gender and age-sensitive design while developing a UDT (Nunes Inês et al., 2023, United Nations Human Settlements Programme (UN-Habitat), 2022) to avoid the emergence of new forms of digital exclusion (i.e. not being able to take advantage of digital services and opportunities) (OECD Public

Governance and Territorial Development Directorate, 2014).

The TEA-DT (Trustworthy and Ethical Assurance for Digital Twins) platform is an open-source tool for teams (and their host organisations) to show how specific goals or objectives have been realised within the context of their UDT project, and to communicate this clearly with relevant stakeholders and users (Burr et al., 2024). Figure 13 illustrates a word cloud of the definition of assurance for digital twinning, with the size of each term representing its frequency.

Figure 12. Definition of Assurance for Digital Twinning. Source: Burr et al. (2024)

Some cities already have specific GDPR processes in place to facilitate data ethics, such as Amsterdam Municipality using Quality Assurance Acceptance (QAA) Criteria procedure and Ethical leaflet, while Rennes Metropolis follows Ethical Charter for Data Usage (Ekitia, 2019). Many European cities, such as Dublin and Utrecht, conduct Data Protection Impact Assessment (Data Protection Commission Ireland, n.d.) for any new technology and data-related intervention/deployment under the EU GDPR Regulations. Both Utrecht and Amsterdam also maintain a publicly accessible camera and sensor register to inform citizens about the data that's collected via these tools and to reassure them that their privacy is respected.

5.3. Platform

To ensure sustainability, procurement clauses that foster open-source solutions and the reuse of open code are suggested. PIANOo, the Dutch Public Procurement Expertise Centre, provides comprehensive information on sustainable public procurement (SPP), also referred to as responsible and sustainable procurement (RSP). The information has been prepared specifically for public purchasers, focusing on the environmental and social impact of procurement and the price of the products or services in question (PIANOo: the Dutch Public Procurement Expertise Centre, n.d.). Tools such as the AI Ethics Card (Ideo, 2019) in Figure 14, Impact Assessment Human Rights and Algorithms (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (The Netherlands), n.d.), and Algorithmic Equity Toolkit (AEKit) empower non-technical stakeholders to engage with algorithmic systems (ACLU Washington, 2019).

Figure 13. AI ethical compass cards (Source: Ideo (2019))

The user interface (UI) and user experience (UX) design must reflect the cognitive and cultural preferences of the target audience. This could mean adjusting interaction modes (e.g., voice interfaces, gesture controls), making communication multi-lingual and culturally appropriate to suit users' preferences. Accessibility criteria as suggested by Digital Inclusion by Design Index/toolbox (DigitAll, n.d.), as illustrated in Figure 15, can assess the final UDT product. User tests with a group of people with diverse abilities, languages, and demographic profiles can open their resistance to new technologies by allowing them to work, play and interact with the UDT prototype. Digital means of communication (social media, website, online press articles, videos, etc.) should complement and not replace non-digital methods (paper magazines, presentations, workshops, trainings, panels, etc.) to be as inclusive as possible.

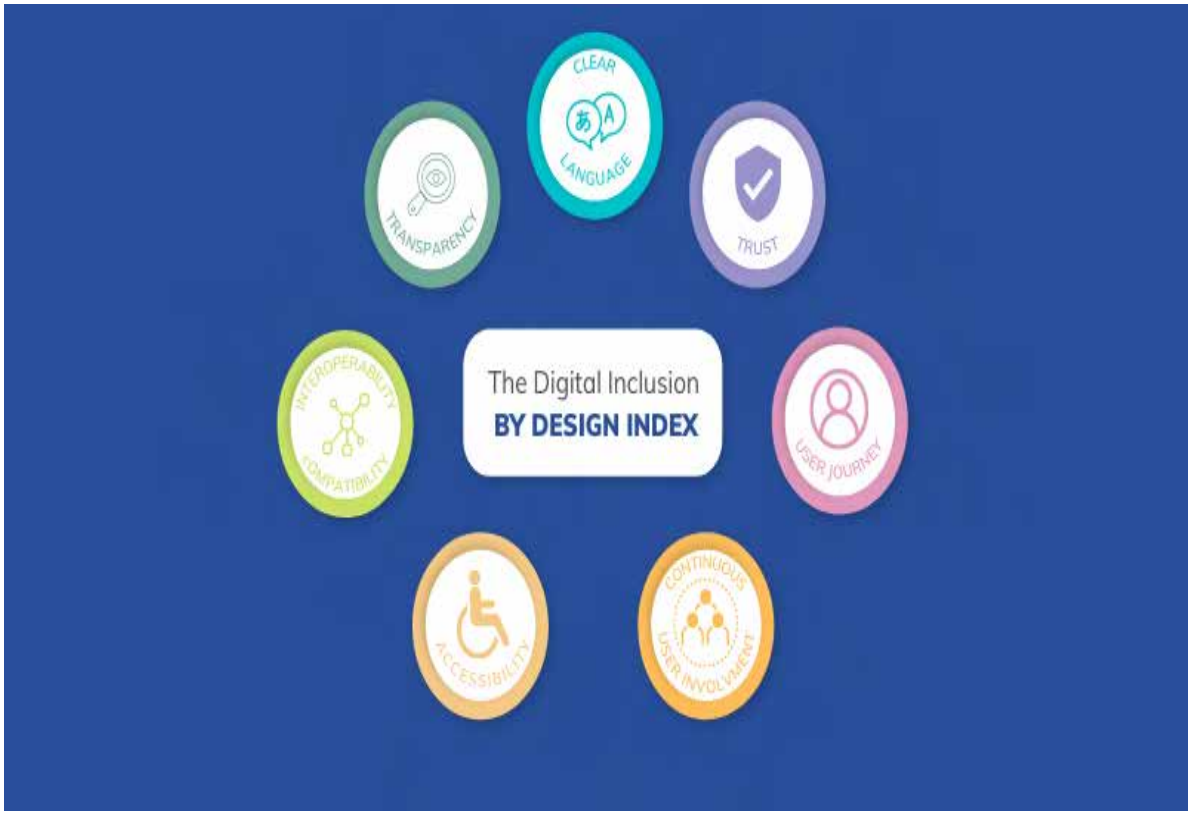

Figure 14. Accessibility criteria (Source: DigitAll (n.d.))

6. Conclusion

Smart cities encompass a range of complex socio-economic, cultural and environmental factors (e.g. Meijer and Bolívar, 2015; Kitchin, 2013). The cross-cutting nature of digital twins as an emerging technology increasingly engages multiple organisational, legislative and governance contexts. While the role of digital twins is increasingly referred to as crucial for contemporary spatial planning, they may raise many ethical, social and legal concerns (Helbing and Argota Sánchez-Vaquerizo, 2022; Wang et al., 2024). Technical barriers, such as achieving interoperable, open-data standards, are further compounded by non-technical hurdles, including capacity building and upskilling of local authority staff, privacy risks, cybersecurity threats, dataveillance, technological lock-ins, and potential social discrimination and democratic backsliding (Weil et al., 2023; Mazzetto, 2024). Sufficient evaluation of the performance and efficacy of twin products in smart cities is therefore contingent on a comprehensive approach to stakeholder input beyond extant technocratic remit — an input greatly enhanced by active and sustained citizen engagement.

A balanced framework for ethical, sustainable digital technology implementation in urban areas requires integration of the vision and objectives of organisations for their people and citizens, and high-quality datasets into a single digital twin software system. All UDT products must demonstrate digital inclusion and compliance. The triadic approach proposed by the authors combines public institution capacity-building with wellbeing and public value metrics to ensure smart city technologies create democratic and ethical and resilient futures. Starting with the people pillar is seen as an opportunity to establish digital equity and participatory governance as its core priorities. Cities can establish co-creation processes through living labs, active public engagement and cross-sector collaboration, combining experimental approaches with local knowledge.

To address privacy and cybersecurity concerns, trust in safe data handling is paramount. The foundation starts with two essential principles: data minimisation and contextual integrity. The system achieves its goals through transparent data processing methods, which enable users to understand consent and ownership mechanisms.

Open standards, ethical data governance frameworks and secure architectures with data stewardship integration form the basis of these on-the-ground implementations. The platform layer supports these values through interoperability for system flexibility, openness and algorithmic accountability for bias reduction, fairness maintenance and lifespan thinking of digital infrastructure. The operationalisation of these ideals happens through ethics-by-design approaches and auditable governance mechanisms to support vendor-neutral procurement policies and promote public value.

Sufficient human agency, integration of explainable procedures and frequent checkpoints to assess the performance of UDT in alignment with established values for the project can ensure trust in UDT decision-making. The pursuit of more inclusive and participatory models in the public sector has contributed towards more effective urban development strategies and their extended technological deployment. In a departure from singular or one-off consultation practices, ongoing feedback loops can help foster a dynamic environment of continuous and iterative improvement in urban planning delivery. Such engagement can be facilitated in a diversity of ways, such as via surveys, public forums, and digital platforms, enabling citizens to voice their experiences and suggestions to enhance and refine public service provision.

Nevertheless, the propensity of smart cities to prioritise market-led solutions can often overshadow the inclusivity required (e.g. Cardullo and Kitchin, 2018; Kitchin, 2013), meaning that many aspired frameworks run the risk of becoming a tick-box exercise, particularly when submersed into governmental and other organisational policies. This necessitates explicit efforts for aforementioned active and sustained engagement beyond 'business as usual' mentalities, whereby regular audits of twin products' integration and implementation are required to ensure quality assurance processes. Future research should embrace and advance these principles for their UDTs but also contribute to practical ways of implementing democratic UDT systems which ensure that no one is left behind.

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The Impact of Environmental Design Elements on Corporate Site Selection of Information Industry Companies in the Metaverse

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Abstract
As the metaverse grows into a new kind of shared and personal space, companies in Türkiye's information industry are turning to virtual offices to better support employees working in hybrid setups. This study looks at what drives these companies to choose certain locations in the metaverse, with a special focus on how environmental and urban design can make these digital workspaces more appealing and effective. Using an online survey and correlation analysis, the research identifies key design features that impact corporate preferences. It aims to bridge theory and practice in metaverse platform design and contributes to the literature by revealing environmental design elements unique to virtual environments, which may align with or diverge from those in the physical world.

Keywords: Metaverse, Environmental Design, Site Selection, Information Industry

Introduction

In recent years, the rapid advancement of technology and digitalization has led to radical changes in the business world. Information industry companies are experiencing a significant transformation from the physical world to digital environments. An important reflection of this transformation has emerged with the development of virtual universes such as the metaverse. The metaverse is a concept that offers a digital environment independent of the physical world, shaped by the combination of virtual reality (VR), augmented reality (AR), blockchain and other digital technologies. This new environment has the potential to reshape both working methods and corporate location strategies for companies.

Virtual offices and workspaces in the metaverse are drawing attention as an alternative that can replace or complement physical offices. Information industry companies, especially those operating in the technology and service sectors, have begun to adopt hybrid strategies that combine physical and virtual forms of doing business in digital spaces such as the metaverse. This situation brings about a transformation that affects not only business processes but also corporate layout planning, design approaches and environmental factors.

Many companies take environmental design elements into consideration when designing virtual offices and workspaces, aiming to increase employee productivity, strengthen interaction, and contribute to sustainability goals in workplaces in the metaverse. In this context, moving environmental design beyond the physical world is becoming an important factor guiding corporate location choices in the metaverse.

The purpose of this study is to examine the environmental design elements that information industry companies take into consideration when choosing locations in metaverse environments and the effects of these elements on the companies' corporate strategies. Environmental design aims to provide a sustainable and interaction-oriented environment that meets not only the aesthetic or functional needs of virtual workplaces in the metaverse, but also the psychological and social needs of employees. In this process, the impact of environmental design elements is of great importance in understanding the shaping power of the metaverse on the future business practices of companies.

Urban design implementation tools are divided into three levels. At the first level, there are physical tools that create designs and are developed in the form of design controls, including design programs, design principles,

design plans and design guidelines. The second level addresses the entrepreneurial process and financing, while the third level addresses management tools. Design guidelines, which are part of project implementation tools in urban design, provide a conceptual framework that urban designers, urban planners, municipalities and other urban management bodies should use to organize physical spatial changes caused by urban development and to guide new urban renewal projects and activities. The purpose of design guidelines can also be defined as the systematization of social and physical programs and design expressions related to problematic urban areas (Karaman, 1992).

Founded by Ronald L. Mace in 1989 and named The Centre for Universal Design at North Carolina State University in 1996, the centre published seven principles in 1997, consisting of "egalitarian use," "flexibility in use," "simple and intuitive use," "perceivable information," "tolerance for error," "low physical strength requirement," and "appropriate size and space for approach and use," in order to make the concept of "universal design" understandable and to make recommendations (Story, Mueller, & Mace, 1998).

In their study on urban design quality frameworks, Nase et al. (2015) examined and compared the design frameworks of Kevin Lynch (1981), Bentley et al. (1985), Jacobs and Appleyard (1987), Tibbalds (1992), Congress for the New Urbanism (1996), CABE and DETR (2000), Llewellyn-Davies (2000), Barnett (2003), and Savills (2007) and conducted a frequency analysis based on a score of 1-9 for the concepts under the titles of character visual scope, spatial relationship, building design quality, adaptation and flexibility, mixed use, movement and accessibility, density, design for society/public benefit, social mix, user participation, sustainability, and management in the context of design frameworks.

• According to Lynch, the conceptual infrastructure components of urban design are control, suitability, feeling, liveliness, access,
• According to Bentley, personalization, durability, richness, noticeability, variety, permeability, visual suitability,
• According to Jacobs and Appleyard, identity, control society and public life, urban self-confidence, imagination and pleasure, liveability, originality and meaning, access to opportunities, an environment that appeals to everyone,
• According to Tibbalds, addressing and consulting all segments of society, being long-term and adapting, human scale, incomprehensibility, pleasure and visual pleasure, avoiding very large-scale changes, spaces before structures, visually noticeable environments, combining uses, freedom to roam, learning from the past and respecting the context,
• According to the New Urbanism Congress, cities and districts shaped by community organizations, pedestrian and transit-oriented design, physically defined public spaces, diversity in use and population, universal accessibility, commemorating local history, climate, ecology and building practices,
• According to CABE and DETR, it has been implemented through the eight characteristics of urban form: compatibility, character, continuity and preservation, public space quality, visibility, diversity, ease of movement,
• According to Llewellyn and Davies, it has been managed investment-design for change, work with the landscape, mixed forms, places suitable for people, mixed uses, establish connections, enrich the existing.

Character visual scope, **spatial relationship**, **mixed use** and **design for community/public benefit** ranked first with 9 points each, **building design quality** and **movement and accessibility** ranked second with 8 points each, and **sustainability** ranked third with 7 points.

As a result of the literature review, it is revealed that the studies conducted mostly address urban design parameters in terms of urban quality. As a result, urban planning and urban design are disciplines that complement each other. While urban planning shapes the city with large-scale strategic decisions, urban design implements these decisions in a human-centred, aesthetic and functional manner. This interaction between the two fields ensures that cities are more liveable, sustainable and aesthetically pleasing.

Developments in the real estate market are directly affected by various elements of urban planning. The balanced planning of different usage areas in the city – such as mixed-use projects, commercial areas and residential areas – positively affects real estate values by increasing economic activities in the region (Ferm and Jones, 2016). Mixed-use projects increase economic vitality by providing not only residential areas but also commercial, office and social areas in the city, and this creates more attractive opportunities for investors (Duany, 2000). The urban planning process requires the development of appropriate strategies to establish a balance between supply and demand. Overbuilding or lack of infrastructure in cities can lead to a decrease in real estate values and a decrease in the quality of life.

A comprehensive classification of the value created in the built environment is provided by Macmillan (2006), who identifies six different types of value. **Exchange value** views the built environment product as a commodity to be traded, whose commercial value is measured by the price the market is prepared to pay. **Use value** considers the contribution to organisational outcomes such as productivity, profitability, competitiveness and repeat business. **Image value** arises from the built environment's contribution to corporate identity, prestige, vision and reputation; it demonstrates commitment to design excellence or innovation, openness or being part of the brand image. **Social value** arises when the built environment creates or enhances opportunities for positive social interaction, strengthens social identity and civic pride, increases safety and reduces vandalism and crime. **Environmental value** is created through the application of the principles of adaptability and/or flexibility, durability and low maintenance, and a whole-life cost approach. **Cultural value** relates to the concepts of context and sense of place and may involve consideration of rather abstract issues such as symbolism, inspiration and aesthetics.

Metaverse, Urban Design, Real Estate Relationship

Planning, design and real estate have undergone a major transformation with technological advances. Digital technologies, big data analytics, artificial intelligence and automation have made urban planning and design processes more efficient and harmonious. The information industry is a sector that includes the processes of information production, processing, storage, distribution and consumption and plays a central role in economic structures. This industry can be defined as a rapidly growing and transforming area with the increasing integration of digital technologies and information processing tools (Drucker, 2012).

With the developments in information and communication technologies, the virtual world is becoming a broader expression of our personal and collective space, and a two-way shaping is emerging. This situation reveals the uncertain area between a person's physical existence, their actions in the physical environment, and their virtual identity (and actions) in digital networks (Ulubaş Hamurcu & Terzi, 2022). Until the twenty-first century, the transformations experienced in technology have greatly affected both the city and urban life. Growing and developing cities are turning to smart applications to offer quality life opportunities to the public, increase the level of efficiency, expand the level of sustainability, facilitate urban life, and find innovative solutions to problems. In this process, the use of technology instead of traditional methods is very important (Terzi & Ocakçı, 2017).

The concept of the metaverse has emerged as a reflection of the historical and technological developments explained above and as a response to this area of uncertainty in the transformation of spatial areas from physical to digital. In general, the Metaverse is considered a fully immersive, hyper spatiotemporal, and self-sustaining shared virtual space that blends the physical, human, and digital worlds. The Metaverse is a virtual platform where one can immerse themselves in a three-dimensional digital space through avatars and NFTs, a type of cryptocurrency derived from blockchain-based smart contracts, by bringing real and virtual environments into interaction (Mystakidis, 2022).

The Metaverse platform today offers users opportunities in various areas such as attending concerts, watching

movies, communicating, visiting museums, playing games, and attending meetings and trainings in three-dimensional environments using virtual reality, augmented reality or mixed reality tools (Arvas, 2022). Today's important metaverse platforms and their basic features are shown in Figure 1.

Decentraland		Blockchain-based virtual world. Users can buy, build, and trade digital land. All assets are tokenized on the Ethereum blockchain.
The Sandbox		A platform focused on digital games and virtual property. Users can create, sell, and trade in-game assets. Blockchain-based.
Roblox		A platform for creating and playing games, popular among young users. Users can design their own games and hold social events.
Meta Horizon Worlds		Metaverse platform of Meta (formerly Facebook). Provides social interaction, games and participation in virtual events. Provides three-dimensional interaction and virtual life experience.
Somnium Space		Virtual reality focused metaverse platform. Users can buy virtual real estate, host events, and trade.
Cryptovoxels		Blockchain-based, low-resolution virtual world. Users can create digital art galleries and trade.

Figure 1: Important Metaverse Platforms and Their Basic Features

In the coming years, as service provision becomes more widespread in the Metaverse, social interactions and knowledge increase, and opportunities are unlimited, people will help increase liveability by using their resources for purposes such as personal development, health, and social development (Allam et al., 2022). As examples of developments in the private sector, Nike has created its own digital universe for virtual products that can be purchased in the Metaverse, Disney has begun work on creating a theme park, and Gucci has begun selling its own NFTs (Wise, 2023). In addition, Samsung has brought its Samsung 837 concept from New York City to the metaverse, and fashion chain Forever 21 has opened a branch in the virtual universe (Tekin, 2022).

The metaverse provides a synchronous platform for urban governance as it allows for the digital delivery of urban services and assets. Augmented reality, virtual reality, mixed reality, the internet of things (IoT), digital twins, and blockchain are the key technologies that are vital to the meta database, and cities are benefiting from these technologies in many areas of use (Aksu & Ercoşkun, 2022). For example, cities such as Orlando, Las Vegas, and Boston already have virtual replicas that allow local governments to envision and consider various scenarios, such as the impacts of planned land uses and new roads. Such efforts can be positively complemented by the meta database, where urban planners, developers, managers, and other stakeholders have equal opportunities to interact and collaborate in the digital realm while creating plans and finding solutions to various urban problems (Allam et al., 2022).

The basis of the urban metaverse is the merging of the consumer metaverse and industrial metaverse visions. From a general perspective, it can be said that the urban metaverse has the following main characteristics (Dienhart et al., 2025):

• Digital twins: virtual copies of physical objects, processes and systems in the city. These digital twins are constantly updated and interact with each other in a virtual environment.
• Real time and progression over time: an important aspect of the urban metaverse is that time in the virtual world progresses in parallel with the physical world (continuity). This can happen in real time or at regular intervals, depending on the usage scenario.
• Immersion: virtual reality (VR) and augmented reality (AR) technologies provide an immersive experience by allowing users to be fully immersed in the virtual environment.
• Interactivity: citizens, local governments and companies can interact in the virtual environment, perform simulations with objects and systems and make data-driven decisions.

The processes of creating virtual cities in the Metaverse have taken the concept of digital twins one step further, and in June 2022, DEIP Metaverse City opened a space in the metaverse for architects, urban planners and artists from all over the world to develop a creative virtual city industry. DEIP Metaverse City consists of a three-story exhibition area, a labyrinth of dozens of intersecting streets, tunnels and a square with an amphitheatre (Kashiripoor, 2023) as shown in Figure 2.

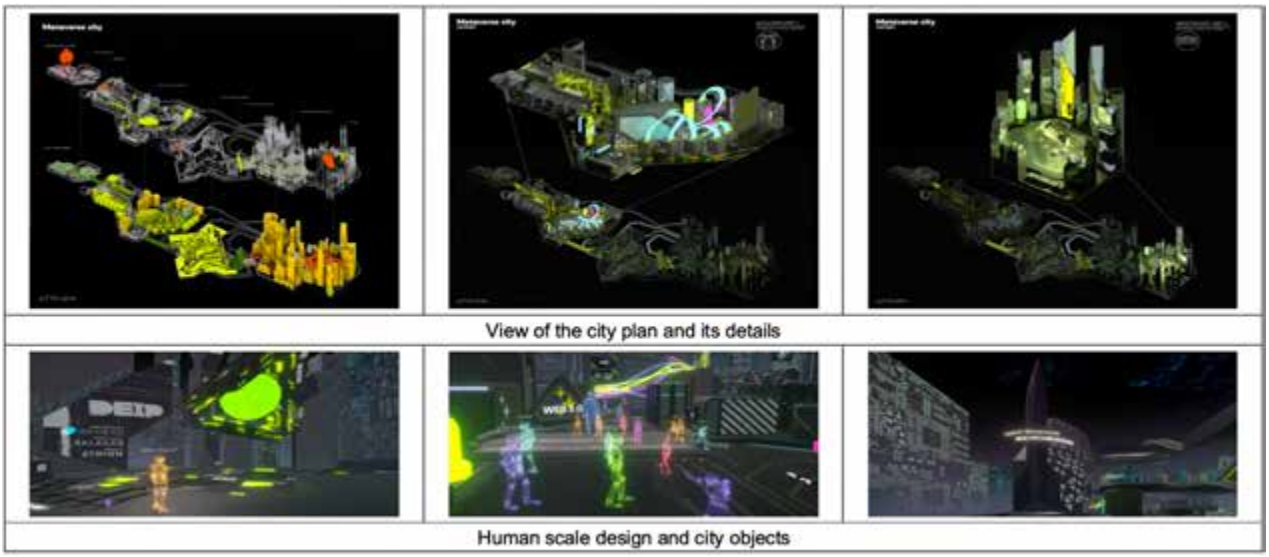

Figure 2: DEIP Metaverse City (Kashiripoor, 2023)

Liberland Metaverse, a major urban scale metaverse application, is a joint venture between four organisations: Liberland (client), Zaha Hadid Architects (design), Mytaverse (technology) and ArchAgenda (management). Liberland is a political initiative that aims to create a free micro-nation on a small, arid and disputed seven square kilometre area on the Danube River between Croatia and Serbia. Liberland, a city construction project by transferring a real-life space to the metaverse environment, has a decentralized financial structure-based approach and aims to reflect Web3 details representatively on space in the context of urban design. Figure 3 shows the urban design of Liberland located on the banks of the Danube River, while Figure 4 shows the effects of Web3 reflections on urban design as representations of the structures located in the city centre of Liberland.

Figure 3: Liberland Metaverse – Zaha Hadid Architects – 2022

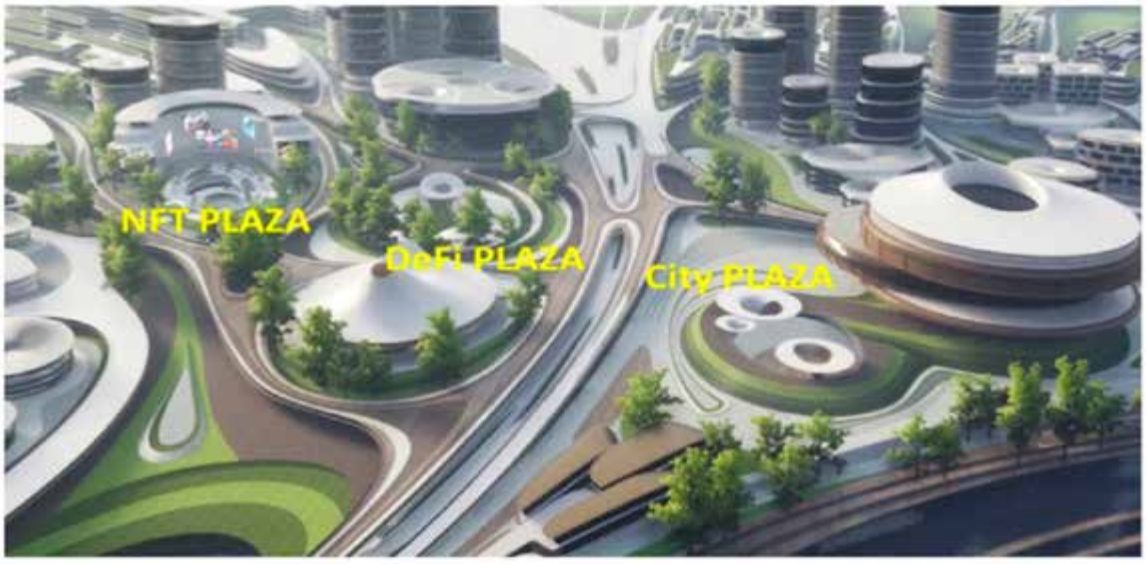

Figure 4: Naming Structures with Web3 Terms in the Liberland Metaverse Environment

Real estate activities in the metaverse provide people with a place and opportunity to connect with people in remote locations around the world. Developers can monetize their virtual properties to advertise services, host events, and provide unique visitor experiences. Like physical land, real estate can also be rented. Therefore, investing in metaverse real estate can be profitable for key players in the architecture-engineering-construction (AEC) industry. The expected market size data for the real estate sector in the entire metaverse between 2022-2030 is shared in Figure 5.

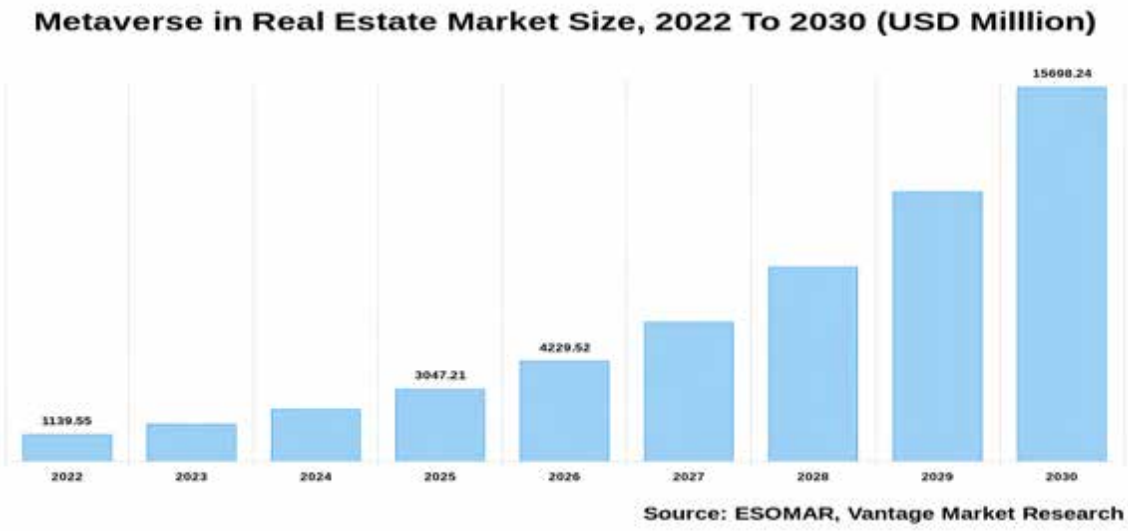

Figure 5: Expected Market Size of the Real Estate Sector in the Metaverse Between 2022-2030 (values are in millions of dollars)

The most important benefit of metaverse real estate is that it compensates for the lack of space in the physical world. For example, if an office lacks physical meeting spaces, employers can create conference rooms and event rooms in the metaverse. The metaverse also provides a seamless collaboration experience that allows people living in different parts of the world to communicate with each other. The value of location in the metaverse depends on the environmental conditions around the property rather than the travel distance (Güven & Ercan, 2022).

As a result of the literature review, it is revealed that the studies conducted mostly address urban design elements in terms of urban quality. After the process of associating these elements in the literature with strategies for increasing real estate value in urban space, urban design, regional identity, mixed uses, open spaces, building heights and appearances, spatial relationship, sustainability, visual and morphological concepts have become the most associated keywords as environmental design elements. The correlation of the keywords encountered regarding urban design/environmental design elements in the urban design literature review and the parameters suggested by Tiesdall and Adams for increasing real estate value in urban space strategies has been objectively interpreted because of the readings. Accordingly, **urban design, regional identity, mixed uses, open spaces, building heights and appearances, spatial relationship, sustainability, visual** and **morphological** concepts have become the most associated keywords as environmental design elements.

This study, which is addressed with theoretical and practical frameworks, aims to reveal which elements can determine the institutional location selection decisions of information industry companies in Türkiye on the metaverse platform and how added value can be created with urban/environmental design tools. Another aspect that makes this study unique is that it aims to reveal how environmental design elements that overlap with environmental design elements in the real (physical) world or completely different and new environmental design elements find a counterpart in the metaverse world. The research questions for this study are listed below.

Research Questions:
1- How do urban and environmental design elements affect the location selection decisions of companies and institutions operating in the Information Industry for their offices to be established in the metaverse?

2- Which urban and environmental design elements are most important for companies for the offices or facilities they will establish in the metaverse?
3- Are there other design elements that do not appear in the physical world or are not important but may affect the location selection decisions of information industry companies in the metaverse?

Methodology

The study aims to identify the factors influencing corporate site selection decisions of information industry companies in Türkiye within metaverse platforms and to explore how urban/environmental design tools can create added value. The structure of the study is concentrated on the relationship between the "metaverse and urban design" with also "real estate and urban design" through remarkable subtopics which have emerged as the key terms most frequently associated with environmental design elements such as regional identity, mixed uses, open spaces, building heights and appearances, spatial relationships, sustainability, visual and morphological concepts.

The method of this study involves an online survey application based on key elements encountered in literature review and other environmental design elements predicted in light of urban planning/urban design formation, to determine which environmental design factors influence corporate site selection decisions of information industry companies in the Metaverse.

This survey study aims to determine the general thoughts of the owners or authorized managers of companies and institutions operating in the information industry in Türkiye on institutional location selection in the metaverse environment and which environmental design elements they give importance to in location selection.

In total 26 respondents from information industry in Türkiye who represent their companies/institutions at executive level responded the online survey between December 2024 – May 2025 period. Based on the survey results, the relationships and importance evaluation of environmental design elements were conducted using correlation analysis in the SPSS software.

In the survey study, a scale application was made by selecting elements corresponding to the metaverse world from the table of corporate location selection determinants in the physical world (Figure 6) compiled from previous literature studies in Ramantswana's doctoral thesis (2019) titled "Determinants of headquarters location and site selection for companies listed on the Johannesburg Stock Exchange".

Table 2.2: Determinants/factors of location

Country	Author	Human resource (skilled labour force)	Labour costs (wage/salary/benefits)	Access to markets, customers, clients, services, and suppliers and information	Favourable sector-specific regulation	Government policies, tax and regulatory environment	Quality infrastructure (telecommunication and transport)	Political risk	Business environment	Economic incentives/favourable financial environment	Availability and cost of support services for employees housing	Same industry specialisation/ agglomeration of same sector	Location of Management/Executive
Klein et al., 2013	South Africa			x		x	x						
Davis & Henderson, 2004	US			x								x	
Lovely et al., 2005	US	x											
Lunnan et al., 2011	Norway			x				x	x				
Klier & Testa, 2002	US	x	x						x				
Wang et al., 2011	China			x	x				x				
Laamanen et al., 2012	Europe	x				x							x
Bel & Fageda, 2008	Europe	x	x	x		x				x			
Strauss-Kahn & Vives , 2009	US		x	x		x	x		x	x		x	
Luiz & Radebe (2016)	South Africa	x		x		x	x	x	x	x			
Coeurderoy & Verbeke, 2016	Multinational								x				
Meyer & Benito, 2016	Multinational	x		x		x		x	x			x	x
Baaij et al., 2004	Multinational								x				
Benito et al., 2002	Finland							x					
Birkinshaw et al., 2006	Sweden			x									
Egger et al., 2013	Multinational					x	x						
Laamanen et al., 2012;	Europe					x							
Holt et al., 2008	Europe & Asian Pacific	x	x	x	x	x	x		x	x	x		
Turok, 2013		x					x				x		

Figure 6: Determinants Affecting Location Selection Literature Review (Ramantswana, 2019)

Findings

Based on the initial findings of the pilot survey (with 26 respondents), environmental elements within the accessibility cluster have a more significant impact on the corporate site selection decisions of companies or institutions operating in the information industry compared to the urban space design elements cluster and building design cluster. It can be said that the dominance of this result is largely because the survey was conducted in Türkiye, particularly reflecting the responses of company representatives based in Istanbul. This is because Istanbul is a metropolitan city where traffic and accessibility issues are particularly pronounced. Therefore, environmental design elements within the accessibility cluster have become the most prominent criterion even when making site selection decisions in the Metaverse.

The average rating of level of knowledge about virtual/crypto investment instruments on a scale of 1: very little to 5: very much is **3.35** among the respondents whereas the level of knowledge about the concept of the Metaverse is rated **3.00** on average. Respondents are slightly more knowledgeable about crypto investment instruments compared to the Metaverse. However, the knowledge levels for both topics are around the mid-range, indicating that while there is a growing awareness, a deep understanding has not yet been achieved.

Demographic distribution of the respondents are 20 male (77%) and 6 female (23%). Among the survey participants, 14 are university graduates (55%), 8 hold a master's degree (30%), and 4 have a doctoral degree (15%). Of the institutions represented by the participants, 11 were established before the year 2000 (42%), 2 between 2000 and 2010 (8%), 7 between 2011 and 2020 (27%), and 6 after 2020 (23%). Out of these institutions 24 have a physical office as their headquarters. Additionally, half of these institutions have branch offices, while the other half are managed solely from their headquarters. Among the institutions where the survey participants work, 6 have between 1 and 10 employees (23%), 8 have between 11 and 100 (31%), 7 have between 101 and 1,000 (27%), and 5 have more than 1,000 employees (19%). The institutions with more than 1,000 employees have an extensive branch network across Türkiye. According to the 23 respondents, the average age of employees across all institutions is approximately **36.65 years**. The distribution of employees per age groups is detailed in Figure 7. Baby Boomers mostly

fall into the Lowest category (73%) with none in the Highest. Millennials (Generation Y) stand out with the highest percentages in Highest (35%) and High (38%), and no one in the Lowest category. Generation Z is more divided, with significant portions in both High (38%) and Lowest (38%) categories. This suggests a strong upward trend for Millennials compared to older generations, while Generation Z shows more polarization.

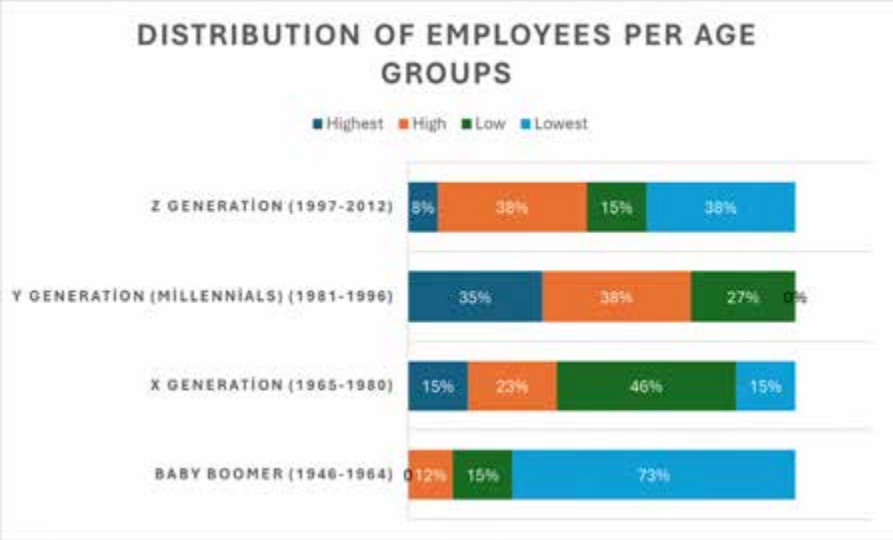

Figure 7: Distribution of Employees Per Age Groups

Institutions are nearly evenly divided between classic, independent buildings and large-scale, corporate-style plazas, with a noticeable move toward smaller or virtual spaces. This diversity reflects varying operational styles, from traditional roots to agile, modern models. Figure 8 depicts the distribution of central offices location types. Two most common office types are detached building with garden and plaza (higher than 10 floors), each with 27% - showing a split between traditional standalone buildings and modern high-rises. About 19% operate from small business centres (1–5 floors), reflecting a preference for mid-sized, cost-efficient office spaces. Virtual offices (8%) and apartments (8%) remain in the minority but still represent a shift toward flexible or unconventional setups. Only 12% are in 6–10 floor business centres, suggesting these are less favoured, possibly due to cost or practicality.

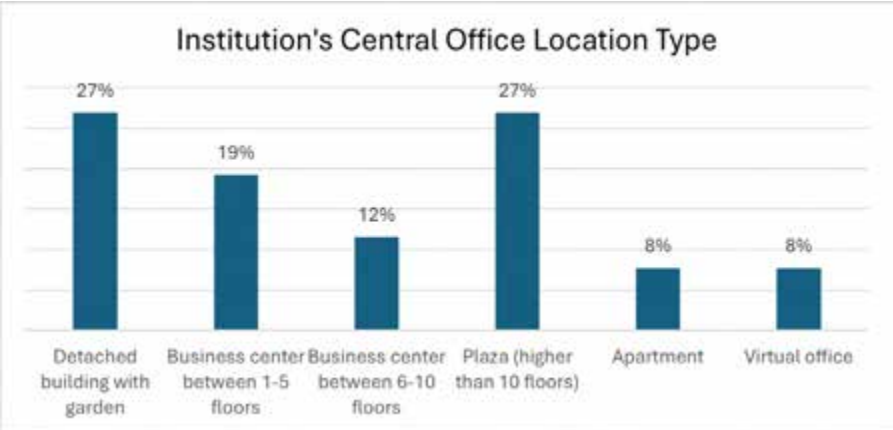

Figure 8: Distribution of Institution's Central Office Location Type

The respondents were asked to rate the importance of various environmental elements that affect the location selection of their current institution's physical head office under three main categories: accessibility factors, elements of urban space design, and elements of building design. Figure 9 provides the rating of each factor with a heat-map analysis.

Group Name	Environmental Element	Rating				
		1	2	3	4	5
Accessibility	Ease of access by public transportation	8%	0%	23%	31%	38%
	Ease of access by private vehicle	4%	4%	15%	31%	46%
	Access to parking	4%	4%	8%	15%	69%
	Access to recreational areas (urban green areas, parks, etc.)	8%	15%	31%	19%	27%
	Access to food and beverage facilities	4%	4%	31%	38%	23%
	Proximity to customer offices/locations	12%	8%	23%	46%	12%
	Access to public areas (squares, streets, etc.)	15%	12%	38%	23%	12%
	Affordability of rental costs	4%	4%	23%	42%	27%
	Located in a prestigious area of the city	8%	8%	12%	42%	31%
Elements of Urban Space Design	Livability and liveliness	4%	8%	23%	38%	27%
	Safe spaces	0%	12%	4%	35%	50%
	Diversity and flexibility	4%	8%	19%	50%	19%
	Density (people, vehicles, structural density)	8%	8%	19%	38%	27%
	Urban furniture (benches, street lighting, stops, waste collection units, flower pots, etc.)	23%	4%	27%	27%	19%
	Urban art (sculptures, murals, performing arts, etc.)	31%	0%	38%	15%	15%
	Necessary-sufficient office space size	4%	4%	4%	58%	31%
Elements of Building Design	Building - environment - street relationship	8%	4%	23%	42%	23%
	Urban form and building type	8%	8%	12%	38%	35%
	Space scale	4%	4%	15%	38%	38%
	Natural light and ventilation	4%	4%	19%	23%	50%
	Architectural identity and details	19%	0%	15%	31%	35%
	Material (types of materials used in the building)	12%	0%	12%	38%	38%

Figure 9: Current Office Location Selection Environmental Factors Heat Map

Figure 10 shows the distribution of ratings for each element affecting respondents' current office location selection. Institutions prioritize **functionality, safety, and accessibility**, especially for accessibility. While aesthetics and design quality are appreciated, decorative urban elements like public art rank lower. The findings reflect a preference for **practical, secure, and well-designed spaces** that support comfort and efficiency. **Access to parking** (69%) and **ease of access by private vehicle** (46%) are highly valued, showing the strong importance of car-friendly environments. **Safe spaces** (50%) and **natural light & ventilation** (50%) are also top priorities, emphasizing **safety and healthy work environments**. **Sufficient office space** (31% rated 5, 58% rated 4) stands out as a critical functional need. Architectural identity and building materials both receive 35%–38% 5-star ratings, suggesting **aesthetic and construction quality matter**. On the other hand, **urban art** (31% rated it only 1) and **urban furniture** scored lower, indicating these elements are **less critical** in office location or building evaluations. **Proximity to customer offices** and **access to public areas** are considered **less decisive**, possibly due to remote work trends.

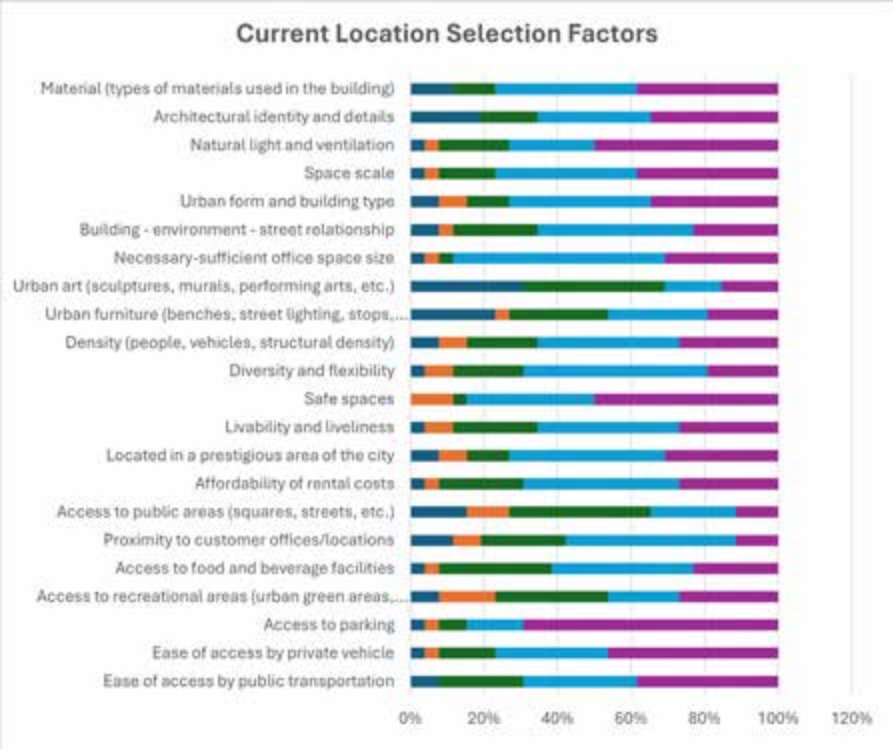

Figure 10: Distribution of Ratings for Each Element Affecting Respondents' Current Office Location Selection

Correlation analysis of ratings for each element affecting respondents' current office location selection is depicted in Figure 11. There is an **exceptionally strong correlation (0.99)** indicating that respondents ranking areas with better **access to public transportation** often also rank better **natural light and ventilation**. There is a very high correlation **(0.97)** between **access by private vehicle** and **natural light and ventilation**. The high correlation between **access by private vehicle** and **access by public transportation (0.95)** shows that areas with good access to one type of transportation often have similar importance to the other. This might point to areas that are centrally located or well-connected, where urban planners ensure that both private and public transportation options are available to accommodate various needs. A very high correlation between **building-environment relationship** and **natural light and ventilation (0.94)** suggests that buildings designed to complement their surroundings tend to also benefit from optimal natural light and airflow. This likely indicates that spaces with a strong connection between the building and its environment are intentionally designed to maximize comfort, taking advantage of environmental factors like sunlight and breeze. The strong correlation between **access to parking** and **ease of access by private vehicle (0.89)** suggests that locations with better access to private vehicles tend to have more parking available. The positive correlation between **urban art** and **architectural identity (0.85)** indicates that places with a stronger architectural identity often include significant artistic elements, such as sculptures or murals. This is because both urban art and architectural details contribute to the overall aesthetic and cultural richness of an area, and they are often planned together as part of a cohesive urban design strategy. **Urban art** contributes positively to **liveability** and **liveliness (0.72)**, suggesting that spaces with more urban art tend to be considered more vibrant and liveable.

These observations illustrate the strong interconnections between various design elements and their impact on accessibility, environmental quality, and the overall urban experience. For instance, **transportation access** (both public and private) is strongly linked to **natural light** and **ventilation**, while the **relationship between buildings and their environment** has a notable influence on both aesthetic and functional qualities. Similarly, the presence

of **urban art** often enhances **liveability**, suggesting a clear link between creative urban design and the vibrancy of a space.

Under virtual working experience section of the survey, majority of the respondents (81%, n: 20) confirmed that their organization have a remote (virtual/hybrid) working principle in place. Naturally, the year 2020 shows a spike of remote work implementation year due to COVID-19 restrictions experienced (Figure 12).

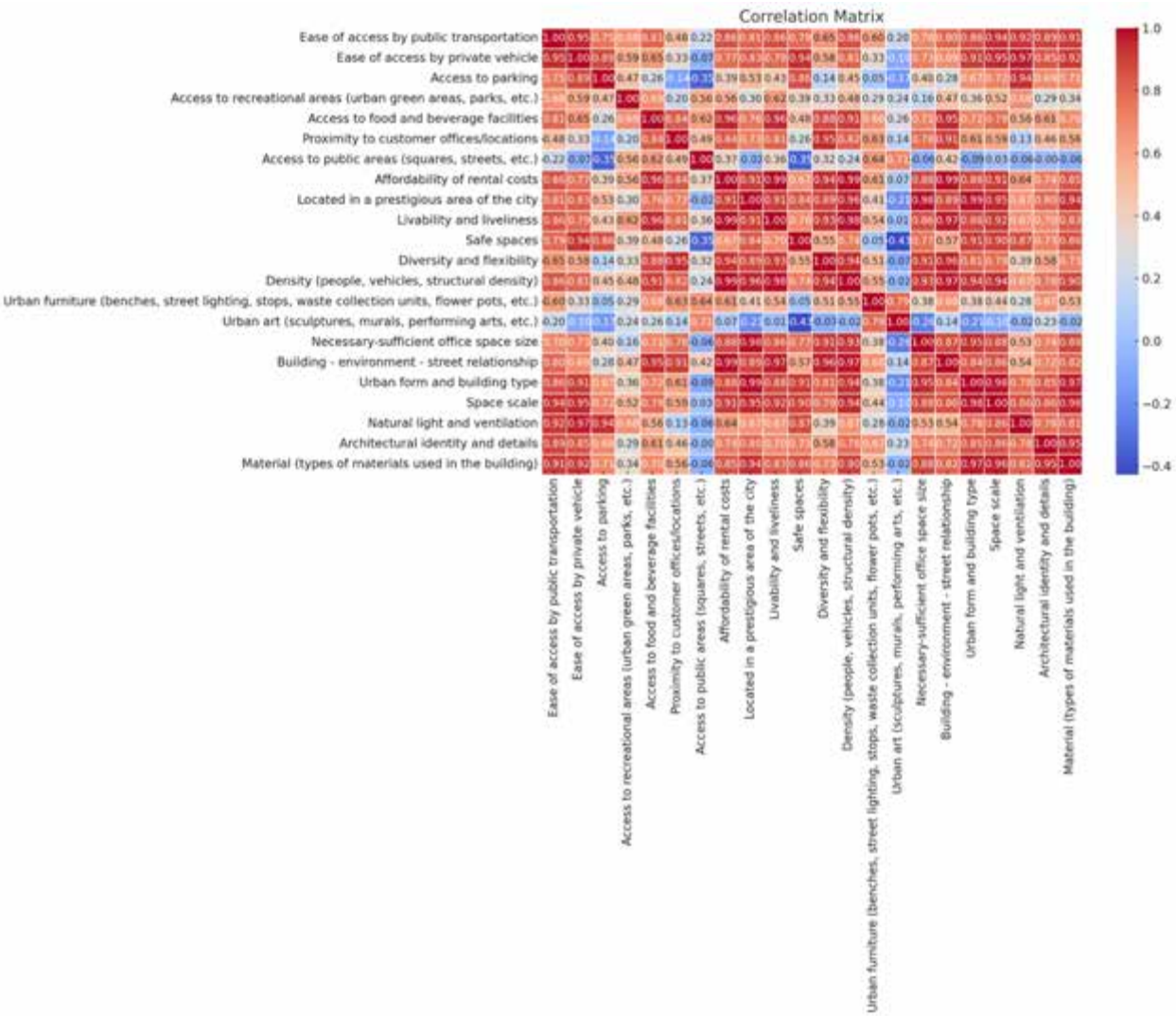

Figure 11: Correlation Analysis of Ratings for Each Element affecting Respondents' Current Office Location Selection

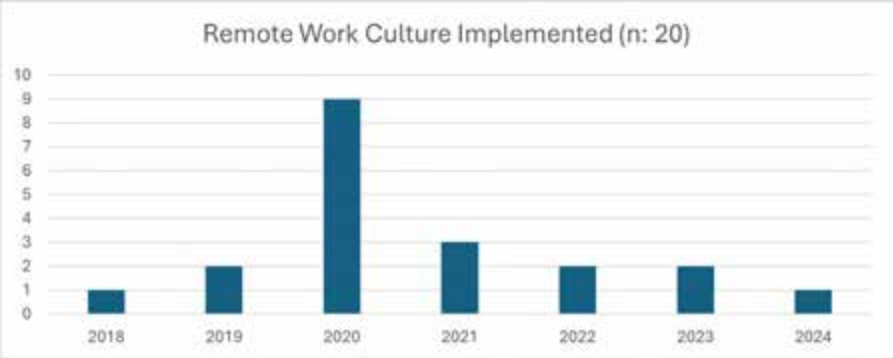

Figure 12: Remote/Hybrid Work Culture Implementation Year

Continuously, hybrid/remote work has been widely accepted among the information industry institutions. The dominant hybrid working trend is **2–3 days in the office**, often combined with **employee autonomy**. Organizations are clearly leaning toward **flexible**, **balanced setups** that maintain both collaboration and remote work benefits. Most common model preferred is 2 days a week (8 responses) suggesting a balanced hybrid approach (Figure 13).

Figure 13: Employee Office Days

There is general awareness and growing concern about the future of work, but not yet a fully mature or widespread focus. The **average rating of 3.65** indicates a moderately high level of interest and awareness regarding **future working conditions**. While it is not at the maximum, the score suggests that most respondents recognize the importance of evolving work models as this is strongly supported by 96% of the respondents that they plan to integrate new technologies into their working conditions in the future but there may still be room for deeper engagement or knowledge development. Rating of adapting technologies is shown in Figure 14 as a heat map and in Figure 15 with distribution.

	Rating				
	1	2	3	4	5
Virtual office work and meeting platforms (Microsoft Teams, Zoom, etc.)	4%	0%	12%	31%	54%
Virtual reality / augmented reality glasses	23%	8%	35%	23%	12%
Digital twin office (digital twin of your current office)	12%	15%	42%	19%	12%
Metaverse office	15%	15%	42%	12%	15%

Figure 14: Rating Heat Map of Adapting Technologies

The data indicate that traditional virtual meeting platforms like Microsoft Teams and Zoom are highly favoured, with most respondents giving top ratings. Emerging technologies such as virtual reality (VR)/augmented reality (AR) glasses, digital twin offices, and metaverse offices receive more mixed and moderate ratings, reflecting uncertainty and varying acceptance levels. This suggests that while virtual meeting tools are well-established and widely accepted, newer immersive technologies are still in the early stages of adoption and evaluation.

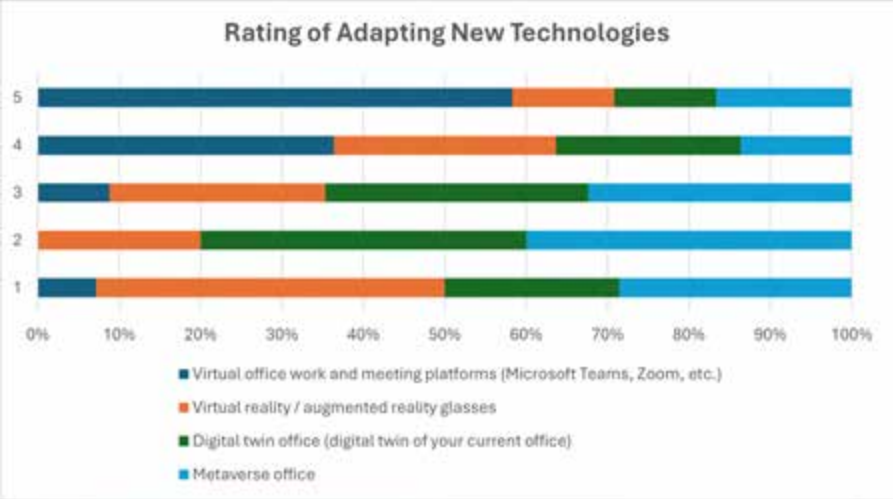

Figure 15: Rating Distribution of Adapting Technologies

Correlation matrix for adapting various technologies is shown in Figure 16. There is a slightly negative correlation between **virtual office work platforms** (such as Microsoft Teams and Zoom) and **virtual reality/augmented reality glasses (-0.19)**. This suggests that these two technologies are somewhat independent in usage, with some users favouring traditional virtual meeting platforms, while others may prefer immersive technologies like AR/VR. Also, there is a slightly negative correlation between **virtual office platforms** and **digital twin offices (-0.22)**. This could suggest that people who prefer traditional virtual office platforms may not be as interested in digital twin technology, which is a more advanced and immersive concept. As with the previous observation, the negative value is small, showing only a weak association. Similarly, there is a slightly negative correlation with **virtual office platforms** and **metaverse offices (-0.24)**. The metaverse office is a more futuristic concept, so it might appeal to different user segments compared to more established platforms like Microsoft Teams and Zoom. A strong positive correlation exists between **virtual reality/augmented reality glasses** and **digital twin offices (0.78)**. This suggests that users who engage with AR/VR technologies are likely to also be interested in digital twin offices. Both technologies share immersive, 3D modelling characteristics, and this correlation indicates that users interested in one may also gravitate toward the other. There is a strong positive correlation between **AR/VR glasses** and **metaverse offices (0.71)**. This makes sense because both involve immersive virtual environments. Users who engage with AR/VR technology are more likely to be interested in virtual worlds like the metaverse, which are designed to provide rich, interactive, and 3D virtual experiences. The very strong positive correlation between **digital twin offices** and **metaverse offices (0.93)** suggests that these two concepts are closely linked. Both are cutting-edge virtual environments, and users interested in digital twin technology (which replicates real-world offices in a digital format) are also highly likely to be interested in metaverse offices (virtual workspaces that provide immersive experiences). This indicates a shared interest in next-generation virtual environments. The correlation matrix shows that the virtual office work and meeting platforms have weak negative correlations with the more advanced technologies (AR/VR glasses, digital twin offices, and metaverse offices). These technologies, while related to the digital workplace, represent different levels of immersion and technological advancement. In contrast, **virtual reality/augmented reality glasses**, **digital twin offices**, and **metaverse offices** show strong positive correlations with each other, signalling a shared trend toward more immersive and futuristic work environments.

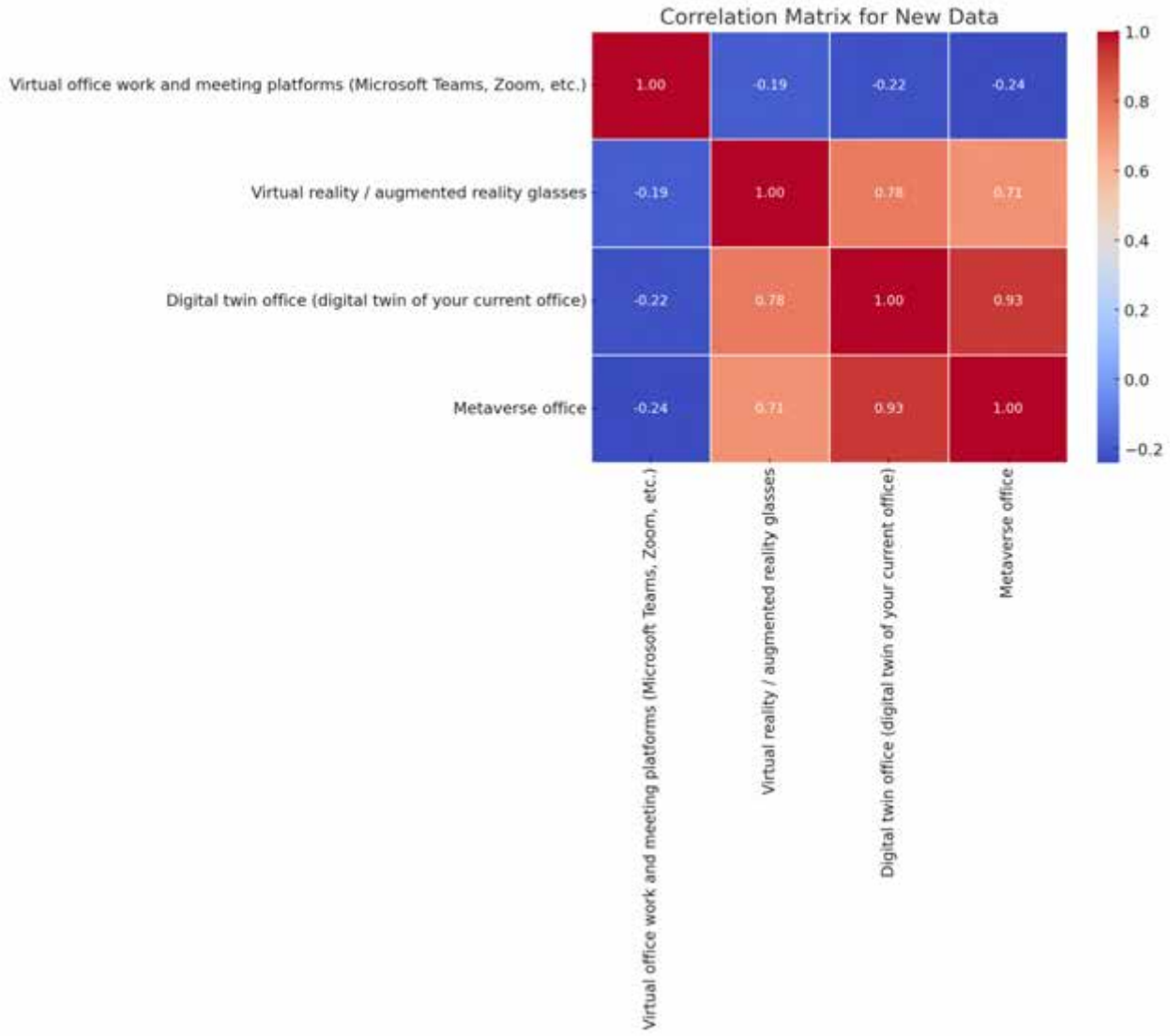

Figure 16: Correlation Matrix for Adapting Various Technologies

While understanding the virtual real estate investment details of the respondents, great majority (88%) responded that they have not invested in this area yet. The rest (12%) have invested in that area individually. No response is received regarding investment on virtual real estate on institutional level. On the other hand, 19% indicated that they plan to create an office in the metaverse environment for their institution. This highlights that there is a slight room for institutional metaverse office development opportunity with the existing trend. When analysing further to better understand the room size, respondents were asked in how many years they were planning to create an office in the metaverse (Figure 17). While majority just like their virtual real estate investment trend are not planning to create an office in the metaverse yet, about 16% aims to create metaverse office in the long term (8 years and beyond). In contrary, 20% of the respondents are supporting creation of metaverse office for their institution with the next 5 years. This situation sheds light on the fact that there will be a tendency to adapt to the metaverse concept over time.

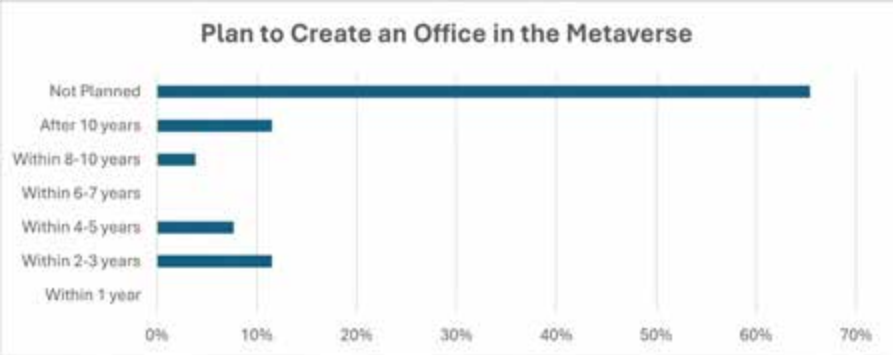

Figure 17: Respondents Tendency to Create an Office in the Metaverse

When asked how much they would invest to create a metaverse office, 21 out of 26 respondents who participated in the survey were reluctant to invest, while 60% of the respondents who found it appropriate to invest in metaverse office levelled the value at 20,000 USD.

Considering an office that can be created in the metaverse environment, the building where the office is located and the immediate surroundings of this building, respondents were requested to rate all of the elements shown in Figure 18.

	Rating				
	1	2	3	4	5
Ages and requirements of current employees	0%	12%	8%	50%	31%
Ages and requirements of new employees joining your organization	0%	12%	0%	54%	35%
Increasing employee experience	0%	4%	8%	54%	35%
Access to a talented workforce	0%	8%	4%	54%	35%
Inter-organizational competition	4%	8%	15%	42%	31%
Access to new markets	4%	12%	4%	35%	46%
Political risks	8%	8%	23%	35%	27%
Creating in-house events	8%	4%	12%	46%	31%
Locating in a prestigious area of the city	15%	8%	8%	38%	31%
Location costs	4%	8%	12%	35%	42%
Necessary-sufficient space size	4%	8%	15%	46%	27%
Time savings due to elimination of transportation (traffic-free)	4%	4%	0%	42%	0.5
Changeable/adaptable interior (architectural) design experience	4%	0%	15%	54%	27%
Changeable/adaptable exterior (urban) design experience	4%	0%	15%	54%	27%
Savings in operational (OPEX) and capital (CAPEX) investments	0%	4%	8%	27%	62%

Figure 18: Rating Heat Map of Elements Affecting Metaverse Office Creation

62% of respondents rated **savings in OPEX & CAPEX** as a top priority (5) - the highest among all factors. **Location costs** also received strong importance with **42%** scoring it 5. For both **current and new employees**, over **85%** rated **ages and requirements** at **level 4 or 5**, indicating a high focus on aligning workplace dynamics with workforce demographics. **Access to talented workforce** and **employee experience** both saw **89%** rating them as important to very important. **Changeable/adaptable architectural and urban designs** are valued, with **over 80%** rating these elements as 4 or 5, highlighting a demand for **agility and adaptability in workspace design**. Surprisingly, **time savings due to elimination of transportation** had very low importance (only 0.5% rated it 5). This suggests organizations may **undervalue the benefits of commute-free options**, possibly due to hybrid or on-site work preferences. 46% rated **access to new markets** as top priority, making it one of the most decisive external factors influencing organizational decisions. Cost and Efficiency are top priorities, workforce and talent are central concerns, flexible design matters, timesaving through reduced commute is overlooked, and market expansion is a key strategic driver. Figure 19 shows the rating distribution of elements in an office created in the metaverse.

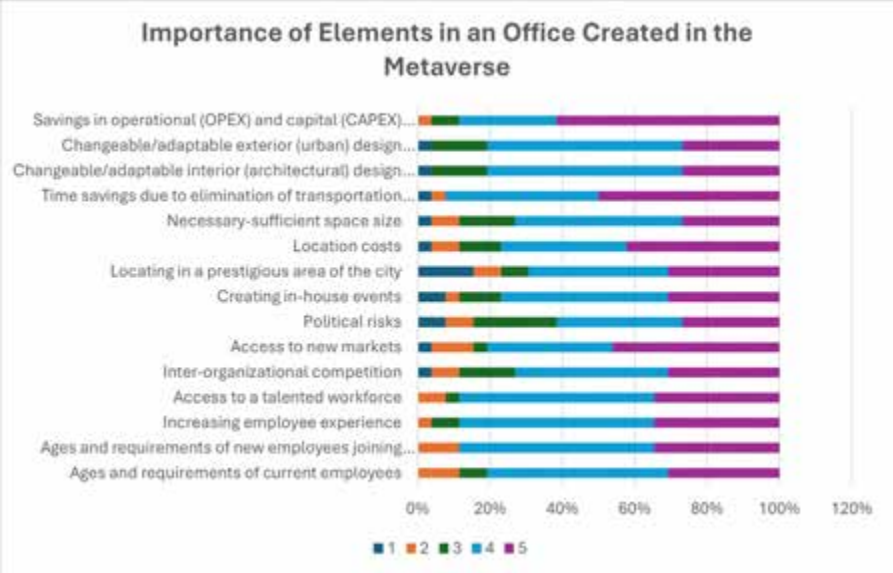

Figure 19: Rating Distribution of Elements in an Office Created in the Metaverse

Figure 20 details the correlation analysis of elements in an office created in the metaverse. There is an extremely strong positive correlation between **the ages and requirements of current employees and new employees joining the organization (0.99)**. This suggests that the age profiles and needs of new employees are very similar to those of current employees, indicating that the organization might be attracting employees with similar needs and characteristics. Similarly, **age and requirements of employees** are strongly linked to efforts in **increasing employee experience (0.99)**. This implies that understanding the demographic and professional needs of employees can play a critical role in improving their overall experience in the organization. There is also a very strong correlation between **ages and requirements of current employees and access to a talented workforce (0.99)**. The strong correlation here suggests that as the **age and requirements of employees** This could indicate that organizations are able to attract talent that aligns well with their current employee base and requirements. A very strong correlation exists between **increasing employee experience** and **access to a talented workforce (0.99)**, indicating that efforts to improve the employee experience are often associated with a higher ability to access top talent. A high correlation suggests that organizations focused on **improving employee experience** are also likely to be actively engaging in **inter-organizational competition (0.99)**. The drive to enhance the employee experience may be a strategic effort to stay competitive in a crowded market for talent. **Political risks** show a moderate correlation with **inter-organizational competition (0.85)**, indicating that the external political environment can have an impact on how organizations position themselves competitively. The moderate positive correlation **(0.72)** suggests that organizations engaged in **inter-organizational competition** may also be more likely to focus on **savings in operational (OPEX) and capital (CAPEX) investments**. This implies that staying competitive may drive organizations to optimize their costs and make more efficient investments.

Figure 21 evaluates how respondents value various urban space and architectural factors on a 1 to 5 importance scale. The most highly rated factor is **necessary-sufficient office space size** with **65%** marking it as level 4 and **19%** as level 5 — showing a clear priority on **having the right amount of space**. **Location costs** also remain a top concern (81% rating it 4 or 5), confirming **cost-efficiency** as a major driver, as seen in the previous table. **Safe spaces** scored very high, with **73%** of responses at levels 4 and 5. Safety continues to be a **non-negotiable baseline for workplace liveability**. **Liveability and liveliness** received mixed responses, with only 23% rating it as top importance, suggesting that **vibrancy** is seen as nice-to-have, not essential. Factors like **urban form, architectural identity,** and **building–environment–street relationship** scored fairly strong (50–65% at levels 4 or 5), indicating an appreciation for cohesive urban and architectural design, though not as pressing as cost or safety. Overall, there is a consistent emphasis on functional and contextual elements of office location and design, especially those tied to comfort, cost, and prestige.

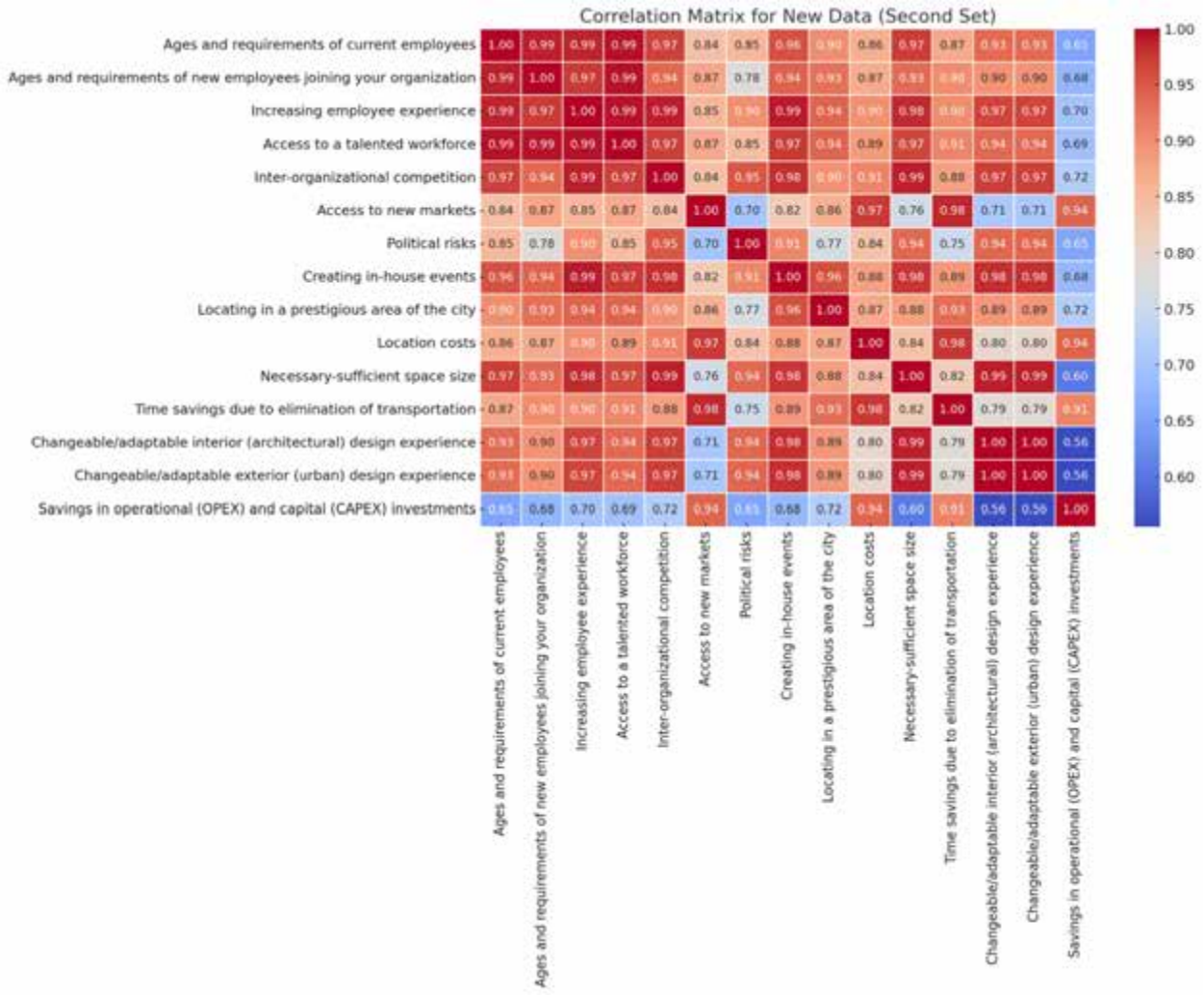

Figure 20: Correlation Matrix of Elements in an Office Created in the Metaverse

		Rating				
		1	2	3	4	5
Elements of Urban Space Design	Livability and liveliness	15%	4%	12%	46%	23%
	Safe spaces	12%	4%	12%	38%	35%
	Diversity and flexibility	12%	4%	19%	46%	19%
	Located in a prestigious area of the city	12%	0%	15%	31%	42%
	Necessary-sufficient office space size	4%	4%	8%	65%	19%
	Location costs	4%	4%	12%	46%	35%
	Density (people, vehicles, structural density)	8%	0%	19%	58%	15%
	Urban furniture (benches, street lighting, bus stops, waste collection units, flower pots, etc.)	12%	8%	23%	50%	8%
	Urban art (sculptures, murals, performing arts, etc.)	23%	4%	19%	42%	12%
Elements of Building Design	Building - environment - street relationship	12%	8%	19%	35%	27%
	Urban form and building type	12%	8%	15%	46%	19%
	Space scale	8%	4%	15%	54%	19%
	Natural light and ventilation	15%	12%	12%	46%	15%
	Architectural identity and details	8%	19%	8%	38%	27%
	Material (types of materials used in the building)	12%	8%	15%	50%	15%

Figure 21: Rating Heat Map of Urban Space and Building Design Elements

Figure 22 shows the distribution of urban space and building design elements influencing motivation of office selection in the metaverse ratings. Companies/institutions are prioritizing space efficiency, safety, and cost-ef-

fectiveness over aesthetic or cultural features of urban environments. While design cohesion and architectural quality are appreciated, factors like public art and urban furniture are seen as luxuries rather than necessities. The high importance given to prestigious location reveals a continued reliance on brand signalling and status value in workplace positioning.

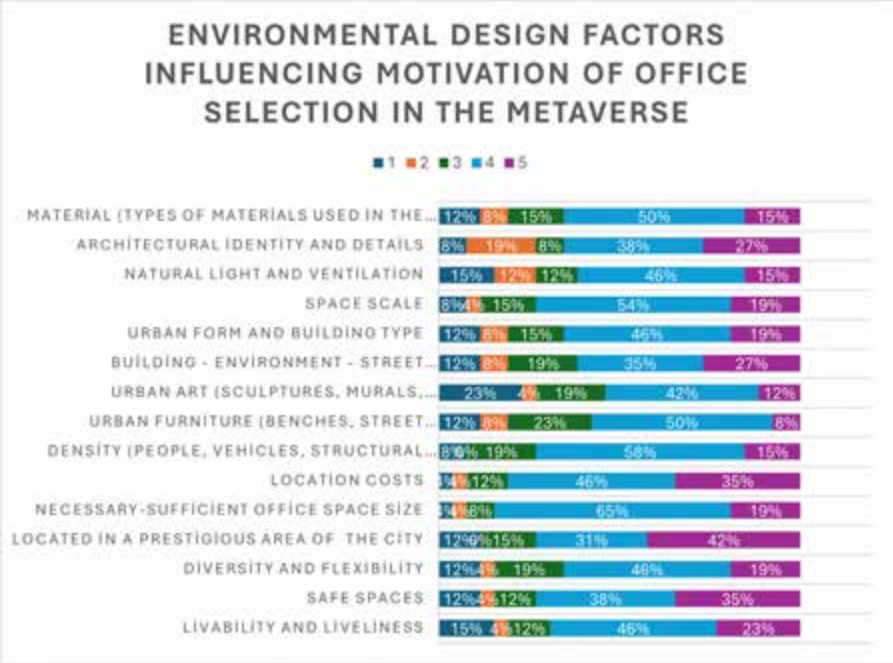

Figure 22: Environmental Design Factors Influencing Motivation of Office Selection in the Metaverse

Figure 23 depicts the correlation matrix regarding environmental design factors influencing motivation of office selection in the metaverse. The almost perfect correlation between **space scale** and **office space size (0.99)** highlights that larger office spaces tend to have a more expansive layout, offering employees more room to move, work, and collaborate. There is a very strong correlation between **natural light and ventilation** and **office space size (0.98)**. Larger office spaces tend to be designed with better natural lighting and airflow, contributing to a healthier and more comfortable work environment. The strong correlation between **urban furniture** and **density (0.97)** suggests that in densely populated areas, there is a greater need for urban furniture such as benches, street lighting, and bus stops. The high correlation between **liveability and liveliness** and **diversity and flexibility (0.96)** indicates that areas with a more diverse and flexible environment are perceived as more liveable and lively. There is a very high correlation between **diversity and flexibility** and **office space size (0.96)**. This is likely because flexible spaces require more room to accommodate different types of work styles and activities, offering employees the freedom to choose their work environment. **Urban art** contributes significantly to the **liveability and liveliness** of an area **(0.94)**. The correlation suggests that areas with more art installations (e.g. murals, sculptures) are perceived as more vibrant and engaging, enhancing the overall quality of life in urban environments. The strong correlation between **safe spaces** and **location in a prestigious area** (0.93) suggests that people tend to feel safer in prestigious areas. This could be due to better infrastructure, more surveillance, and generally lower crime rates in such locations. This relationship highlights how security and location prestige are interconnected in urban planning.

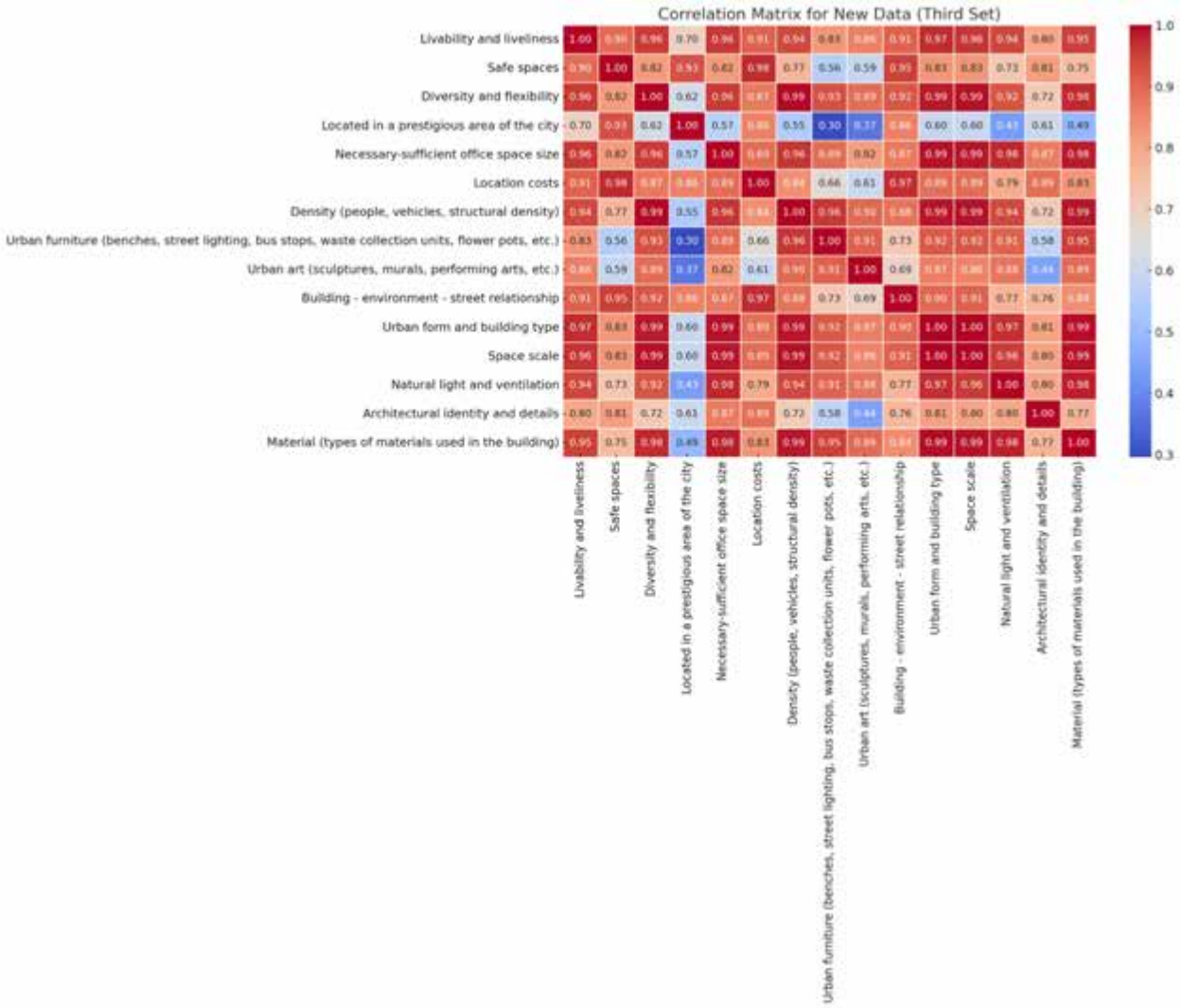

Figure 23: Correlation Matrix Regarding Environmental Design Factors Influencing Motivation of Office Selection in the Metaverse

Discussion and Conclusion

This study aimed to connect established theoretical frameworks of environmental and urban design with the evolving practice of corporate site selection within metaverse environments, with a particular focus on Türkiye's information industry. By aligning empirical findings with insights from existing literature, this research provides a valuable foundation for identifying and understanding the environmental design elements most likely to influence the creation of effective and engaging future metaverse workspaces.

The literature review highlighted key environmental and urban design elements traditionally associated with high-quality urban environments and value creation in real estate. When comparing these well-established concepts to the findings of this study, several noteworthy parallels and divergences emerge:

• **Accessibility** remains a fundamental concern in both the physical and virtual domains. In the survey, access to talented workforce, location costs, and flexibility in architectural/urban design were among the most influential factors shaping metaverse office selection. Similarly, in physical environments, accessibility and location quality are core drivers of real estate value and user satisfaction.

• **Safety** and **comfort-related elements** such as safe spaces and natural light & ventilation scored highly in both current office and metaverse-oriented responses. This suggests that even in virtual environments, companies value perceptions of security and comfort, mirroring psychological needs that underpin design principles in the physical world.

• **Architectural identity**, **building-environment-street relationship**, and **spatial relationships**—elements frequently emphasized in physical urban design frameworks—also emerged as relevant in metaverse considerations. Respondents valued cohesive, adaptable, and visually engaging virtual environments, signalling a continued importance of spatial and aesthetic coherence even when freed from physical constraints.

• **Diversity and flexibility**, a recurring theme in physical urban design literature (mixed-use spaces, flexible environments), was highly correlated with perceptions of liveability and employee experience in metaverse environments. This underscores the necessity of creating adaptable virtual spaces that cater to varied organizational needs and dynamic user preferences.

Conversely, several differences between the two domains were apparent:

• While **public art** and **urban furniture** are traditionally seen as important contributors to public life and identity in physical spaces, they were deprioritized in metaverse site selection. Respondents generally rated these elements lower in importance for virtual offices, possibly reflecting the current lack of mature design standards for virtual public realms and a stronger focus on functional and operational drivers at this stage of metaverse evolution.

• **Time savings from eliminating transportation**, a frequently cited benefit of remote and virtual work, was surprisingly undervalued by respondents. This indicates that while the metaverse reduces physical commute needs, organizations may still prioritize in-office experiences or hybrid models, diminishing the perceived importance of this particular advantage.

• The metaverse introduced new, distinct drivers of site selection not directly paralleled in traditional urban design literature. These include **OPEX & CAPEX savings** and **access to new markets**, both of which scored highly in respondent ratings. The virtual realm enables cost efficiencies and global market reach that are difficult to achieve in purely physical settings, marking a strategic shift in corporate priorities.

The **correlation analyses** further revealed critical interdependencies:

• Strong correlations between **employee experience**, **workforce access**, and **spatial/architectural flexibility** suggest that organizations view virtual office design as a key lever for talent attraction and retention—an emerging theme that aligns with evolving workforce expectations for hybrid and flexible work environments.

• The nearly perfect correlation between **space scale** and **necessary-sufficient office space size** highlights a persistent emphasis on spatial adequacy and comfort, even in virtual settings where physical limitations are less constraining.

• The close relationship between **urban form**, **architectural identity**, and **prestigious location** in metaverse decisions mirrors the symbolic and branding roles of corporate real estate in physical cities, demonstrating that virtual offices must similarly contribute to organizational image and culture.

This study has several limitations that must be acknowledged. First, it was conducted with a relatively small sample of 26 executive-level respondents, all from the information industry in Türkiye. The results, while indicative, cannot yet be generalized across different industries or geographies. Additionally, participants' varying levels of familiarity with the metaverse may have influenced their responses, particularly in relation to more advanced

technologies and design elements. Future studies should aim to expand the respondent pool to include a broader and more diverse set of industries and international contexts.

In conclusion, this research provides early evidence that **environmental design elements remain highly relevant in corporate site selection for metaverse offices**, but with important adaptations:

• **Accessibility**, **safety**, **architectural identity**, **spatial coherence**, and **employee experience** emerge as key priorities, paralleling traditional urban design concerns.

• **Cost efficiency** and **market access** are elevated drivers in metaverse contexts, reflecting new strategic opportunities offered by virtual environments.

• Elements tied to traditional public space design (urban art, furniture) currently play a lesser role but may gain relevance as virtual public realms evolve.

An important outcome of this study is the identification of a core set of environmental design elements that companies value when considering future metaverse office investments. Specifically, **flexible architectural/urban designs, natural light & ventilation, safe spaces, space adequacy, location costs, and workforce-related factors** are poised to be the most influential in shaping corporate location strategies in the metaverse.

Looking ahead, the next stage of this research will involve developing a **metaverse-based test environment** that simulates these identified environmental design elements. Companies will be invited to experience and interact with this environment, followed by a **post-survey study** to capture new insights and validate the practical relevance of these design factors. This iterative process aims to refine both academic understanding and practical design guidelines for building effective and engaging corporate spaces in the evolving metaverse landscape.

Appendices

Appendix 1: Online Survey Study Flow-chart

Acknowledgements
This study was prepared within the scope of the doctoral thesis titled "The Impact of Environmental Design Elements on Corporate Site Selection of Information Industry Companies in the Metaverse" by the first author and supervised by the second author at the Department of Urban and Regional Planning at Istanbul Technical University.

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Mapping Positive Energy: A Geographic Information System Approach to Defining Positive Energy Districts

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Abstract
Positive Energy Districts (PEDs) are urban areas strategically designed to reduce climate impact and promote sustainability by maximizing renewable energy use and optimizing energy consumption. Aligned with the European Strategic Energy Technology (SET) Plan, the aim is to establish 100 PEDs by 2025. This study utilized the Best-Worst Method (BWM) from Multi-Criteria Decision-Making (MCDM) techniques to assess criteria influencing PED boundaries. It also evaluated the effects of two-dimensional (2D) and three-dimensional (3D) data analyses on these boundaries. The findings suggest that combining 2D and 3D data yields more comprehensive results, with 3D data enhancing assessments of solar and wind energy. Regions with access to clean energy and favorable climate are ideal for PEDs, particularly where socio-economic status and education levels are high.

1. Introduction

Positive Energy Districts (PEDs) are urban areas designed to minimize climate impact and promote sustainability by maximizing the use of renewable energy sources and optimizing energy consumption (RISE, 2025). The concept of PEDs emerged to facilitate the energy transition and contribute to climate neutrality through enhanced energy efficiency and achieving a net-zero energy balance (Derkenbaeva et al., 2021). After extensive discussions with stakeholders, including cities and urban actors, the PED Programme developed a Reference Framework. According to this framework," Positive Energy Districts are energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy, mobility and ICT systems, while securing the energy supply and a good life for all in line with social, economic and environmental sustainability." (JPI Urban Europe, 2025).

The action plan titled "Smart Cities and Communities" developed as part of the European Strategic Energy Technology (SET) Plan, aims to facilitate the planning, establishment, and replication of 100 PEDs for sustainable urbanization by 2025 (SET Plan Action 3.2). In this context, several European Union-supported projects, such as MAKING-CITY, CitxChange, POCITYF, and PED4ALL, have played a significant role in achieving this goal. This study is also conducted under the PROPEL project, which is one of the initiatives supported by the European Union (MAKING-CITY, 2025; CityxChange,2025; POCITYF,2025; PED4ALL, 2025; PROPEL, 2025).

Significant distinctions exist among regions concerning their renewable energy landscapes, encompassing factors such as the availability of renewable energy sources, energy storage potential, population demographics, energy consumption patterns, costs, and regulatory frameworks. These elements collectively influence the design and operation of PEDs, resulting in unique characteristics for each district (Lindholm et al., 2021). In the process of identifying suitable areas for PEDs, a comprehensive analysis is conducted that considers various critical factors. These factors include the potential for solar energy, the options for district heating and cooling, the availability of wind and geothermal energy, and the density of the population in the region. Additionally, the local context regarding renewable energy source potential and the geographic location, along with related mobility considerations, are essential. Future environmental projections, particularly regarding carbon-free energy demand and supply, are also evaluated. Furthermore, financial assessments, renewal strategies, dynamics within energy communities, welfare and security implications, and marketing considerations play crucial roles in this planning process (Civiero et al., 2021; Zhang et al., 2021; Schneider et al., 2023). Research aimed at determining optimal PED locations often employs a flexible, Geographic Information Systems (GIS) - based Multi-Criteria Decision Analysis (MCDA) approach. This methodology is effective in identifying the most suitable areas for achieving an annual positive non-renewable energy balance. MCDA is instrumental in emphasizing the critical criteria influenc-

ing potential locations for positive energy outcomes, while GIS enhances the accuracy and comprehensiveness of the results obtained (Alpagut et al., 2021).

This study aimed to identify the criteria that influence the boundaries of the PED and to establish their respective weights and importance rankings utilizing the Best-Worst Method (BWM), a Multi-Criteria Decision Making (MCDM) approach. The contributions of both two-dimensional (2D) and three-dimensional (3D) data and analyses to the mapping of the PED boundaries were examined through comprehensive analyses. The novelty of this study is derived from a comparative assessment of results obtained through both 2D and 3D analyses. Additionally, it includes a comprehensive 3D evaluation of the potential of renewable energy sources about PED. The findings were assessed from both environmental and social perspectives, resulting in the successful conclusion of the study.

2. Data and Methodology

2.1 Study area

This study focuses on the Kadıköy district of İstanbul, Türkiye, as illustrated in Figure 1. Kadıköy is recognized as one of the most developed districts situated on the Anatolian side of Istanbul, alongside the coast of the Marmara Sea. It encompasses a land area of 25.20 km² and, according to TURKSTAT data for 2024, has a population of approximately 462,189 with estimates suggesting it is nearing half a million residents (Kadıköy Municipality, 2025; TURKSTAT, 2025). The district is known for its high socio-economic status and is primarily composed of residential and commercial areas. It features numerous older buildings that are currently being transformed through urban development. With its cosmopolitan atmosphere and strategically central location, Kadıköy provides a vibrant environment that blends historical and contemporary architecture, appealing to both local and international residents. Kadıköy offers a wide variety of urban activities, including social, cultural, and sporting events, as well as facilities for entertainment, recreation, and shopping. Additionally, it serves as a key transportation hub, featuring seven Marmaray train stations, five metro stations, tram and bus stops, and a ferry terminal. Together, these attributes contribute to a significant daily influx of visitors to the district.

Figure 1. Kadıköy District.

2.2 System Architecture

The system architecture of the study is presented in Figure 2. This methodology encompasses four stages: determining criteria for ped boundaries and calculating weights of criteria, 2D data for mapping PED, 3D data for mapping PED, and evaluating results.

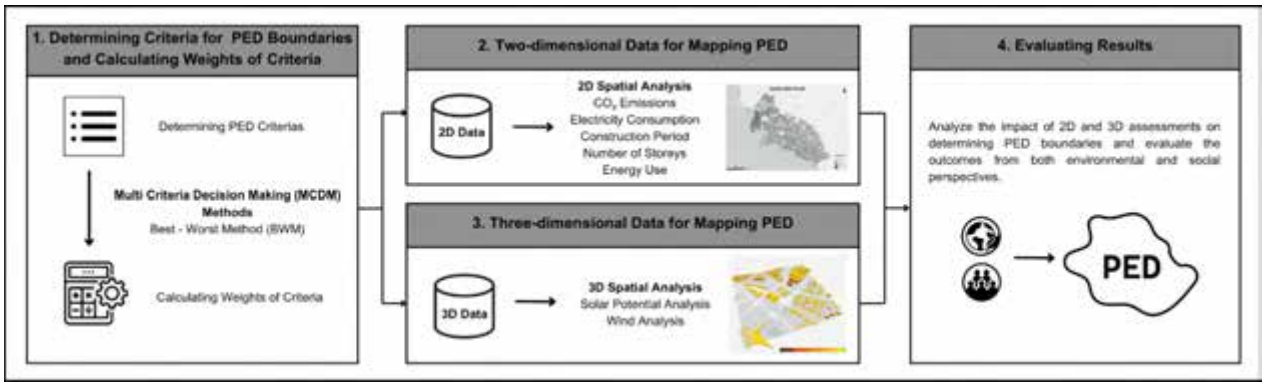


Figure 2. The proposed framework.

This study initially identified the criteria that are essential for establishing the boundaries of PEDs. A thorough review of the literature was conducted to ascertain these criteria, focusing on sources related to PED, sources associated with Zero Emission Districts (ZED) that contributed to the evolution of the PED concept, and relevant projects such as MAKING-CITY and CityxChange (MAKING-CITY, 2025; CityxChange,2025). Subsequent to the identification of the criteria, BWM, the well-known MCDM technique, were applied to evaluate the influence of the criteria and to calculate weights accordingly. After calculating the weights, analyses utilizing both 2D and 3D data were performed to determine the appropriate boundaries for PEDs. These analyses facilitated an evaluation of the advantages provided by both types of data. Open-source data, along with information from the European Union-funded MAKING-CITY and PROPEL projects, were employed in this investigation (MAKING-CITY, 2025; PROPEL, 2025). Data encompassing electricity consumption, greenhouse gas (GHG) emissions, energy types of buildings, and the structural characteristics of these buildings were sourced from these projects. Additionally, socioeconomic data and educational attainment information were obtained from the National Smart City Open Data Platform (Ulusal Akıllı Şehir Açık Veri Platformu -ULASAV) (ULASAV,2025). For the 3D analysis component, a building model was generated based on 2D data of buildings in Kadıköy. Ultimately, the study evaluated potential PED areas in the Kadıköy district, integrating various criteria alongside environmental and social factors.

2.2.1 Determining Criteria for PED Boundaries Calculating Weights of Criteria

As part of this study, a comprehensive literature review was conducted to identify the factors influencing the boundaries of PEDs. This review encompassed an analysis of existing research on the PED concept, as well as the foundational ZED concept. Furthermore, it included an examination of notable projects such as MAKING-CITY and CitxChange (MAKING-CITY, 2025; CityxChange,2025). The findings related to the criteria that affect the boundaries of the PED are presented in Table 1.

Table 1. Criteria about PED boundaries.

Main Criteria	Sub-Criteria
Energy	Biomass
	Natural gas
	Electricity consumption
	Solar energy
	Wind energy
	Greenhouse gas emissions (GHG)
Environment and construction profile	Building density
	Construction period
	Number of storeys
Social	Education level
	Socioeconomic status
	Population

After establishing the decision criteria, the weights for the sub-criteria outlined in Table 1 were computed using the BWM within the context of MCDM. Developed by Jafar Rezaei in 2015, the BWM is a systematic approach that employs two vectors of pairwise comparisons to determine the weights of the criteria (Rezaei, 2015). This method involves identifying the decision criteria, as well as the best and worst criteria. It requires the evaluation of the preference of the best criterion over all other criteria using a numerical scale ranging from 1 to 9, followed by an assessment of how each criterion is preferred over the worst criterion, utilizing the same scale. Finally, the optimal weights are calculated based on these evaluations (Rezaei, 2014).

2.2.2 Two-Dimensional Data for Mapping PED

A multitude of criteria significantly influences the establishment of PED boundaries. MCDM methods are employed to ascertain the relative importance of these criteria. Through the application of MCDM approaches, the impact of each criterion on the decision-making process can be quantitatively assessed and appropriately weighted. Subsequent to these analyses, GIS are employed to spatially evaluate the identified criteria, thereby facilitating the determination of PED boundaries. In addition to providing geographical data pertinent to urban environments, GIS provides essential spatial analysis functions critical to urban design processes (Xia et al., 2022). Moreover, GIS enables the integration of geographical and attribute data with spatial analysis tools and modeling methods, allowing for comprehensive analyses and visualizations of geographical, environmental, and natural resources, thereby supporting quantitative assessments of urban structures (Xia et al., 2022; Wu et al., 2017). Information about the data used in 2D analyses, including data types and sources, is presented in Table 2.

Table 2. Data used for 2D analysis.

Data	Type	Source
Biomass	Vector	PROPEL Project
Natural gas	Vector	PROPEL Project
Electricity consumption	Vector	PROPEL Project
Greenhouse gas (GHG) emissions	Vector	PROPEL Project
Building density	Vector	Derived from PROPEL Project
Construction period	Vector	PROPEL Project
Number of storeys	Vector	PROPEL Project
Education level	Raster	ULASAV

Socioeconomic status	Tabular Data	ULASAV
Population	Vector	TURKSTAT

2.2.3 Three-Dimensional Data for Mapping PED

Another important factors in determining the boundaries of a PED is the potential for solar and wind energy. Solar energy is beneficial for residential areas due to its practicality and cost-effectiveness. 3D spatial analyses can be performed to evaluate these factors in the context of a PED. For this purpose, a 3D building model of the study area was created using existing 2D spatial data. After this model was created, solar energy potential and wind energy analyses were performed using Autodesk Forma with a student license, and solar energy analysis was performed using the open-source Ladybug Tools.

2.2.4 Evaluating Results

In this study, the BWM was employed to identify suitable areas for PEDs. The evaluation criteria were established through a literature review and were organized to encompass environmental, structural, and social dimensions. Criterion weights were calculated using the BWM method to assess the importance of each criterion. Moreover, data related to renewable energy sources, including sun hour, solar energy potential, and wind potential, were analyzed as part of the environmental suitability assessments. Indicators related to biomass and natural gas usage were also examined to identify regions with the capacity to utilize clean energy sources. Social indicators, such as socioeconomic status and educational levels, were incorporated into the analysis due to their connection with technological adaptation and sustainability awareness. All criteria were spatially integrated using GIS-based datasets to create a comprehensive evaluation framework for the applicability of PEDs.

3. Results and Discussion

3.2.1 Determining Criteria for PED Boundaries Calculating Weights of Criteria

In the context of this study, the weights assigned to the criteria were computed utilizing the BWM, an approach within the realm of MCDM methodologies. This process was undertaken to ascertain the significance levels of the criteria presented in Table 1, which were established through an extensive review of the existing literature. The weights of the criteria derived from the application of the BWM are presented in Table 3.

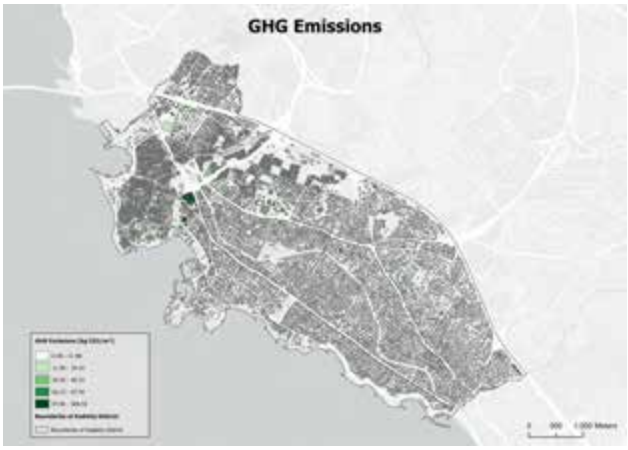
Table 3. Weights of criteria calculating using BWM.

Main Criteria	Sub-Criteria	Weight
Energy	Biomass	0.086
	Natural gas	0.072
	Electricity consumption	0.335
	Solar energy	0.108
	Wind energy	0.034
	Greenhouse gas (GHG) emissions	0.174
Environment and construction profile	Building density	0.041
	Construction period	0.034
	Number of storeys	0.024
Social	Education level	0.011
	Socioeconomic status	0.032
	Population	0.048

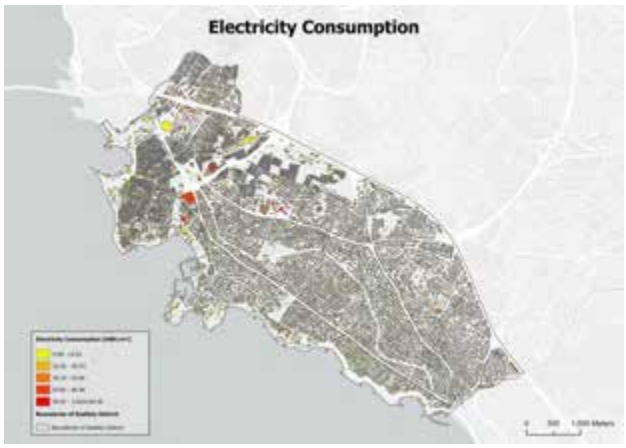
3.2.2 Two-Dimensional Data for Mapping PED

As part of the study, both 2D and 3D spatial analyses were conducted to assess the criteria detailed in Table 1. The 2D spatial analyses examined several factors within the Kadıköy district, including GHG emissions (a), electricity consumption in buildings (b), the utilization of biomass and natural gas as energy sources (c and d), the socio-

economic score (e), education levels (f), the year of construction of buildings (g), the number of floors in buildings (h), building density throughout the district (i), and population (j). The maps generated as a result of these spatial analyses are indicated in Figure 3.



(a)



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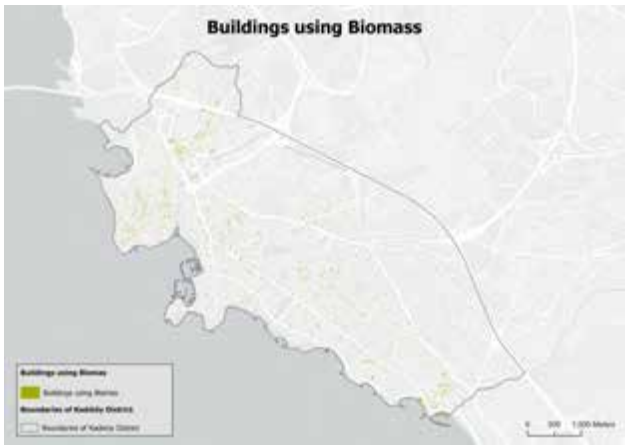
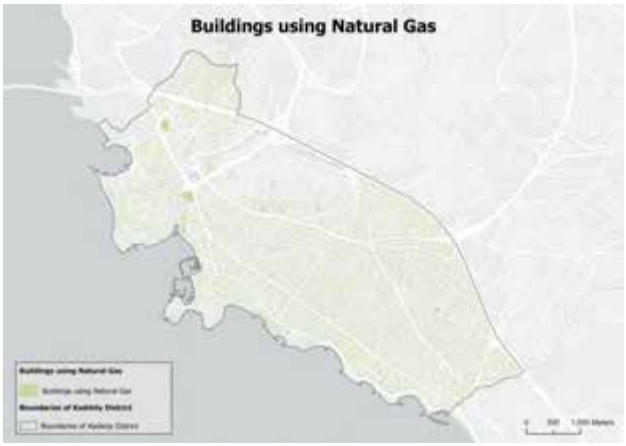
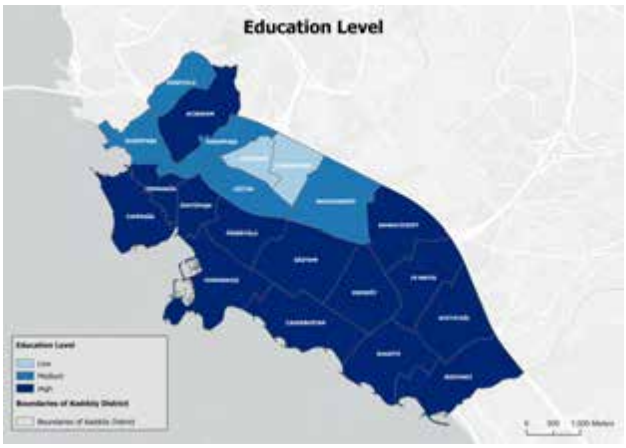


(c)



(d)

(e)



(f)

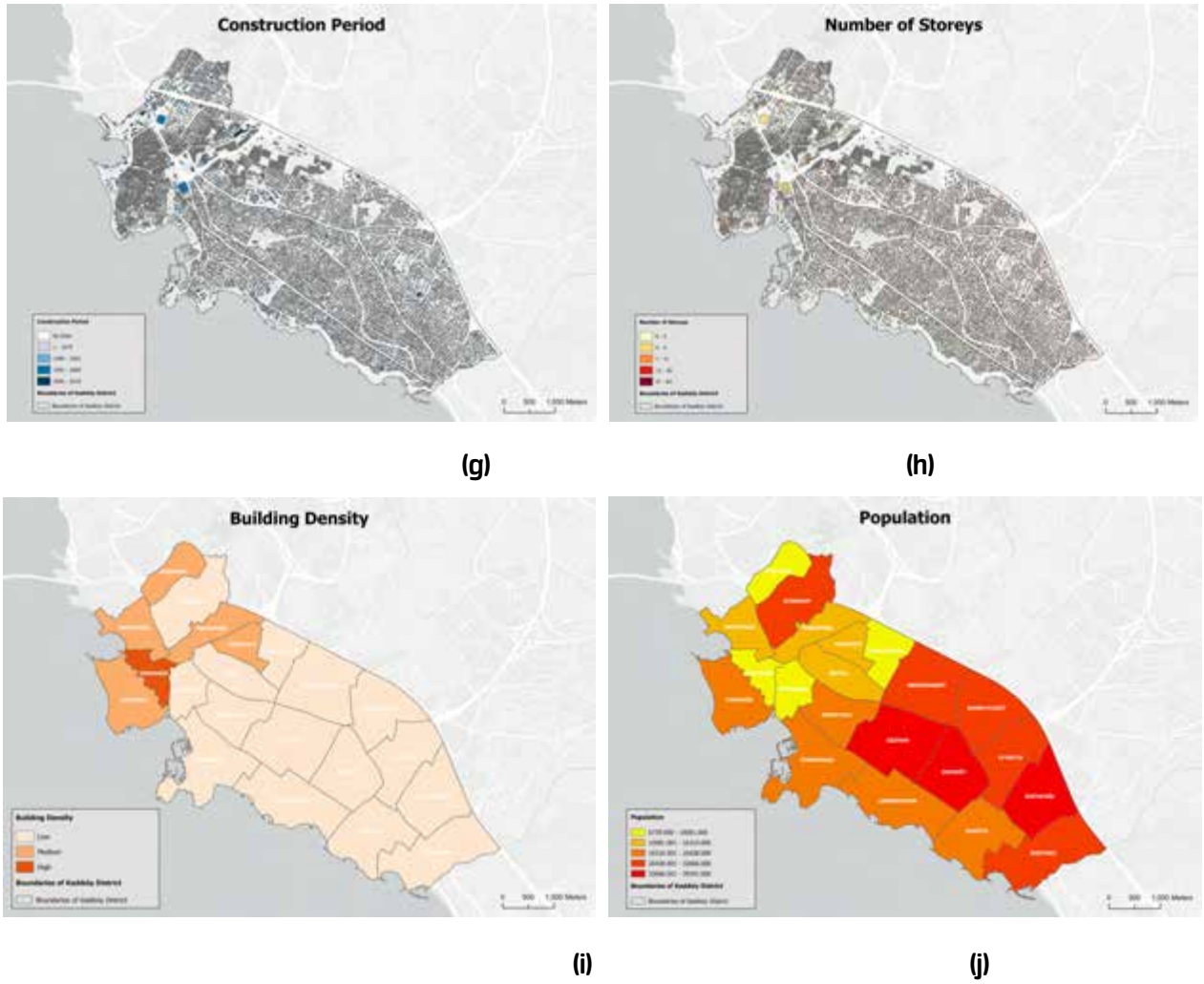


Figure 3. Results of 2D spatial analyses.

Following the creation of criterion maps through 2D spatial analyses, an examination was conducted on the effects of these criteria. The evaluation of the criteria weights presented in Table 3 indicates that the most significant criteria are electricity consumption and GHG emissions. The PED concept aligns with smart city initiatives that aim to reduce energy use and GHG emissions (JPI Urban Europe, 2025). Therefore, an analysis of the 2D spatial results depicted in Figure 3 reveals that regions characterized by low electricity consumption and GHG emissions are conducive to the designation of PEDs.

However, it is essential to recognize that the determination of PED boundaries should not be limited to these two criteria; a comprehensive assessment of additional factors is necessary. While PEDs derive benefits from energy-efficient buildings, smart grids, and advanced renewable energy technologies, they concurrently enhance urban resilience and make substantial contributions to achieving net-zero carbon targets (Bruckner et al., 2025). In this context, factors such as the age of construction and the number of floors in buildings significantly influence PED boundaries. Moreover, the type of energy utilized plays a pivotal role in this determination. To meet net-zero carbon targets within PEDs, the deployment of clean energy sources is imperative, making the use of biomass and natural gas appropriate for these areas. Although high-density construction is often perceived as a threat to open spaces, it can yield ecological advantages, such as optimized land, material, and energy utilization. Additionally, it provides socio-cultural benefits, including functional diversity at the ground level and improved urban organization (PED–ID, 2025). Consequently, areas characterized by high building density may be suitable for PED

development. The identification of viable locations for energy infrastructure installations presents a considerable challenge, particularly in densely populated urban regions that experience spatial constraints (Derkenbaeva et al., 2021). As a result, population density must be factored into the determination of PED boundaries. Finally, it is crucial to consider social factors, as a higher socio-economic status and level of education among residents will facilitate awareness and adaptation to the PED concept.

3.2.3 Three-Dimensional Data for Mapping PED

The study analyzed solar energy using Ladybug Tools and both solar and wind energy through Autodesk Forma. Direct sun hours were assessed using Ladybug Tools, while solar potential and wind analysis were conducted with Autodesk Forma to evaluate Kadıköy in terms of its solar energy potential and wind energy. The results of these analyses for a designated segment of the study area are presented in Figure 4, Figure 5, and Figure 6.

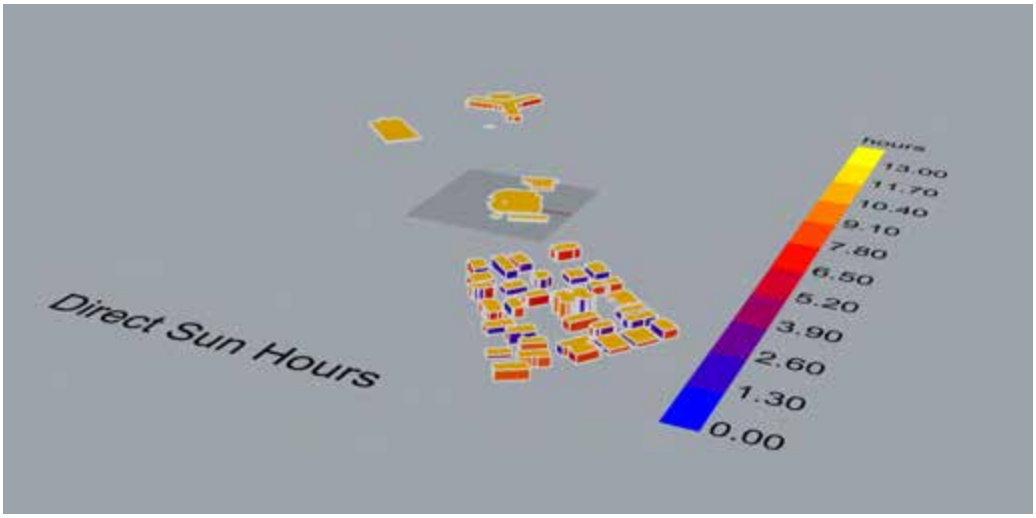


Figure 4. Results of direct sun hours analysis.

The Direct Sun Hours analysis, presented in Figure 4 and utilizing Ladybug Tools, enables a thorough evaluation of the historical sunlight exposure experienced by the roofs and facades of various buildings. In this analysis, the duration of sun exposure for the region depicted in the figure during August was examined. The study revealed that the maximum duration of sun exposure was 13 hours. This analysis is instrumental in identifying the most suitable locations for the installation of solar panels, thereby facilitating the generation of solar energy from renewable sources. Such insights are critical for the development of PEDs and allow for a comprehensive assessment of the solar potential of buildings across different seasons.

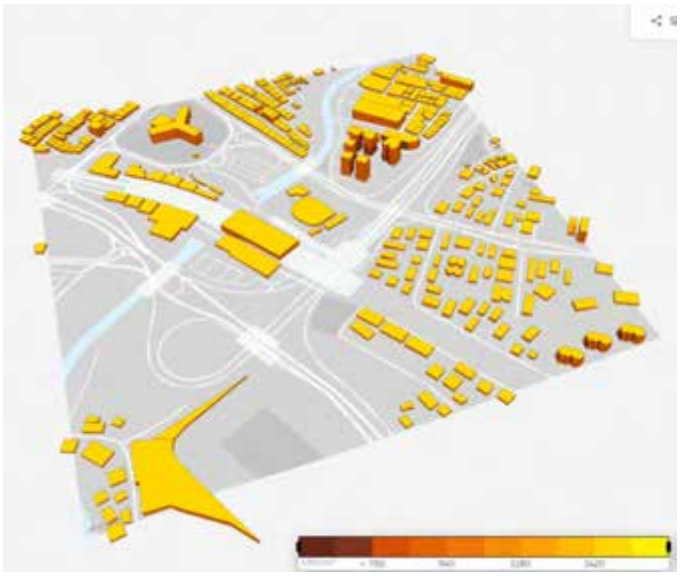


Figure 5. Results of solar potential analysis.

The solar potential analysis carried out utilizing the Autodesk Forma platform, as illustrated in Figure 5, facilitates the assessment of solar potential across various buildings, including their roofs and facades. This comprehensive analysis enables the calculation of the overall solar potential for the region, as shown in the figure. The results indicate that the annual solar energy generation for the area represented in the figure amounts to 221,000,000 kWh, with an average solar energy yield of 1,080 kWh/m².

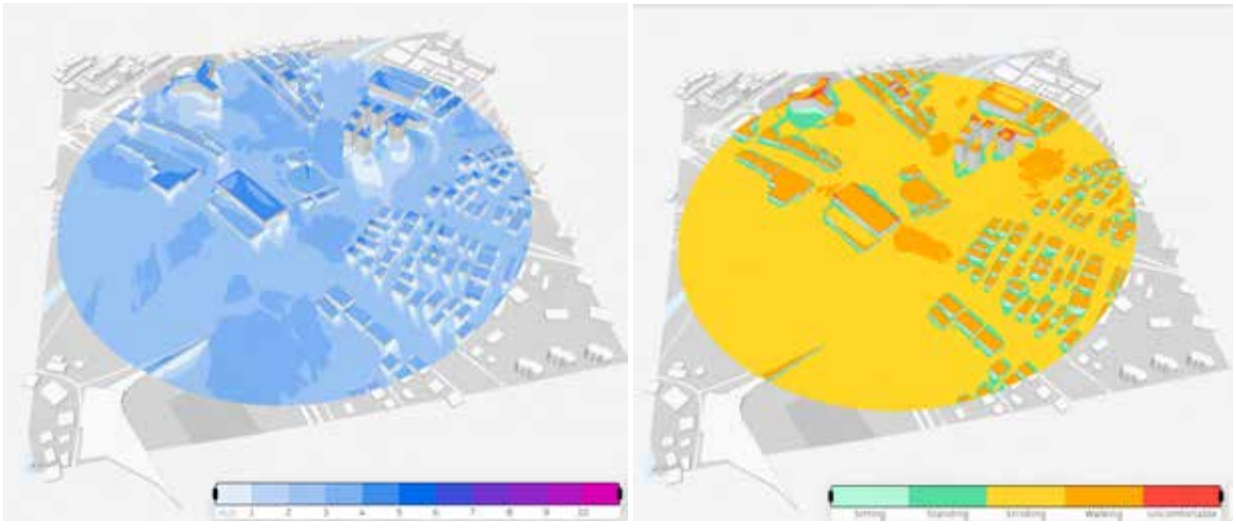


Figure 6. Results of wind analysis.

The wind analysis illustrated in Figure 6 facilitates the examination of how winds originating from various directions affect wind potential and variations in wind speed within the region. Furthermore, this analysis permits an assessment of the wind potential for both buildings and the surrounding terrain. By conducting this evaluation, stakeholders can gain insights into the wind energy potential in urban areas and identify regions with significant capacity for renewable energy production.

3.2.4 Evaluating Results

This study identifies that electricity consumption and GHG emissions are the most critical criteria for assessing suitable areas for the development of PEDs, as determined by the BWM used in MCDM. Regions with low levels of these two criteria are considered more favorable for PED development. However, it is essential to consider additional factors, such as building age, number of floors, type of energy source, building density, population density, socioeconomic status, and education level, which also significantly influence the suitability of development areas.

From an environmental standpoint, regions capable of utilizing clean and renewable energy sources, such as biomass and natural gas, are deemed appropriate for PED development due to their potential for producing clean energy. Furthermore, an analysis of solar and wind energy potential demonstrated that areas with extended sunshine durations and favorable wind patterns are advantageous for renewable energy production.

From a social perspective, the findings indicate that the PED concept can be effectively implemented in regions with high socioeconomic scores and elevated education levels. Residents in these areas typically exhibit greater awareness and sensitivity towards sustainability. Additionally, as education levels rise, individuals' understanding of innovative energy technologies and their ability to adapt to these advancements also improve. This adaptability facilitates the integration of technological infrastructures, such as smart grids, energy monitoring systems, and energy production and sharing applications, all of which are essential for the successful implementation of the PED concept.

Neighborhoods with higher socioeconomic levels often feature more organized and planned urban areas. Consequently, projects developed in collaboration with local governments can be executed more efficiently, leading to increased effectiveness. These characteristics enhance urban resilience and improve adaptive capacity in the face of climate change, contributing to the successful and sustainable implementation of PEDs.

4. Conclusion

In this study, the integration of both 2D and 3D spatial analyses together with a holistic approach to determining the boundaries of PEDs significantly increased the accuracy and applicability of the findings. The use of 2D data was effective in assessing the spatial distribution of PED criteria. Variables such as electricity consumption, GHG emissions, population density, building density, education level, and socio-economic indicators were mapped, and more favorable areas for PEDs were evaluated. Regions characterized by low GHG emissions and energy consumption, in particular, emerged as significant criteria. Additionally, building stock characteristics, such as building age and number of floors, were analyzed in terms of energy efficiency and the integration of renewable energy sources.

The use of 3D data, combined with 3D analyses, facilitated a comprehensive and detailed assessment of solar and wind energy potential. Studies of sunlight duration and annual solar energy production potential conducted using 3D building models allowed the determination of optimum roof and façade surfaces for solar panel installation. These assessments also allowed the assessment of energy potential in various temporal dimensions. Similarly, wind energy potential was analyzed at a micro-scale, taking into account prevailing wind directions. These analyses directly contributed to the shaping of energy production strategies for PEDs by enabling the assessment of local renewable energy resources. By synthesizing both 2D and 3D data, the study presents a comprehensive assessment that addresses horizontal dimensions, such as urban sprawl and density, as well as vertical factors, including sunlight, building height, and wind effects.

To conclude, the findings emphasize the need for a multi-criteria approach to PED planning that transcends energy-centric considerations by integrating social, structural, and environmental dimensions. This comprehensive approach provides a vital foundation for the development of PED models consistent with sustainable urbanism principles.

Acknowledgment
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Leveraging Social Media Big Data and Large Language Models to Quantify the Temporal Dynamics of Cross-Border Spatial Identity: Evidence from Shenzhen-Hong Kong Region

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Abstract
Cross-border spatial identity refers to the multifaceted, individually constructed perceptions that residents form through cross-border interactions and daily behaviors. It has emerged as a critical metric for evaluating the integration of cross-border regions, playing a pivotal role in fostering regional community cohesion and advancing integration initiatives. In the context of the Guangdong-Hong Kong-Macau Greater Bay Area, the Shenzhen-Hong Kong corridor exemplifies as a significant yet complex cross-border zone, where divergent political systems, administrative practices, and cultural norms impede seamless integration despite a shared national affiliation. Consequently, examining residents' subjective identity perceptions within cross-border spaces, as reflected in their daily activities, becomes imperative. However, the social, cultural, and linguistic heterogeneity in cross-border spaces complicates the clear definition of measurement dimensions, hampers the collection of long-term, high-quality data, and limits the ability to discern complex, multi-dimensional emotions. As a result, existing research has not adequately captured the temporal dynamics and addressed the multi-dimensional heterogeneity of cross-border spatial identity. To address these challenges, this study introduces an innovative measurement framework that integrates extensive long-term social media data with the semantic analysis capabilities of large language models. Focusing on the Shenzhen-Hong Kong cross-border space as a case study, we analyzed a comprehensive dataset of social media text from platforms such as Weibo and Xiaohongshu, covering the period from 2018 to 2023. By employing the chain of thinking prompt engineering of large language models (LLMs), we quantitatively assess the identity perceptions of Shenzhen and Hong Kong residents across three dimensions: spatial imagery, spatial satisfaction, and spatial sense of belonging. Our findings reveal that the spatial identity of Hong Kong residents experienced marked temporal fluctuations during critical events and policy shifts, such as the COVID-19 pandemic and the implementation of the Greater Bay Area development plan. Moreover, distinct variations in identity perception were observed across different types of cross-border spaces, with shopping and consumption areas displaying a notably positive spatial identity. This research provides a robust, efficient and scalable framework for the long-term tracking of cross-border spatial identity, offering valuable theoretical insights and quantitative evidence to better understand the temporal and spatial evolution of identity perceptions in cross-border populations. It offers important theoretical support and quantitative evidence for the evaluation of the cross-border region integration process.

Keyword: Cross-border spatial identity; Large language models; Social media data; Shenzhen-Hong Kong region.

1. Introduction

Globalization has blurred national borders, increasing resource sharing and economic-cultural interactions among border cities. Cross-border integration is a key to achieving spatial cohesion and regional equilibrium. Therefore, cross-border spatial identity is defined as the emotional attachment, psychological identification, and sense of place that residents develop through their cross-border activities. This identity, in turn, shapes the intensity of cross-border mobility, residents' willingness to participate in regional policies, social environment, and economic activities. Furthermore, it plays a pivotal role in the implementation of cross-border cooperation and cohesion policies, providing intrinsic motivation for resource sharing, social stability, and policy coordination within border regions. As such, cross-border spatial identity offers valuable insights into the mechanisms underpinning regional integration and serves as a crucial lens for evaluating the processes of cross-border spatial cohesion.

The Shenzhen–Hong Kong corridor exemplifies the highly complex dynamics of integration within the Guangdong–Hong Kong–Macau Greater Bay Area (GBA) Strategy framework, primarily shaped by deep-rooted structural differences and political disparities between the two systems. . Specifically, new cross-border transportation infrastructures, such as high-speed rail, metro, and maritime routes, have significantly boosted cross-border interactions, and strengthened cross-border spatial identity. However, complex social tensions in Hong Kong, exemplified in social movements such as the "Occupy Central" movement and the "Extradition Bill Protests", deep-seated cultural differences, mobility restrictions, and disparities in urban space complicate both regional

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integration policy implementation and the assessment of residents' psychological connections to the integration.

The conceptualization of spatial identity is inherently multidimensional, encompassing cognitive, affective, and behavioral dimensions. Cognitively, it is shaped by individuals' mental representations of space, influenced by spatial perception, historical narratives, and collective memory (R Hay, 1998)such as aesthetics and a feeling of dwelling. Insider status and local ancestry are important toward the development of a more rooted sense of place. Three contexts are used to examine the development of sense of place: residential status in the place (superficial, partial, personal, ancestral, and cultural senses of place. Affectively, it is built through emotional attachment and place-based belonging from lived experiences and spatial interactions (Hernández et al., 2007). Behaviorally, it manifests in mobility patterns, spatial preferences, and engagement in place-based social practices (Dorfman et al., 2021)place, and partners, with emphasis on the impact of the social environment on spatial behavior and on how individual spatial representations converge to form collective spatial behavior - i.e., common places and routes. Recent studies suggest that in addition to their mental representation (cognitive map. Given this multidimensional nature, any attempt to measure spatial identity must account for these interrelated components, making its quantification particularly complex.

In cross-border regions, factors like intricate socio-political and cultural landscape further complicate the measurement of spatial identity. These regions are often characterized by linguistic diversity, institutional fragmentation, and historical legacies that shape distinct spatial perceptions among different groups (Laven and Baycroft, 2008). Socio-cultural tensions, policy discrepancies, and asymmetries in economic development add further complexity, shaping individuals' sense of belonging and attachment to space (Gardner and Richards, 2017)an indigenous people divided by the Guatemala-Mexico border, identify collectively. We further existing sociological literature on collective identity "boundary work" by demonstrating how it is shaped by spatial, and not just symbolic, boundaries. Mam individuals and organizations define symbolic boundaries that sustain political-administrative borders (such as municipal divisions within Guatemala and Guatemala's border with Mexico. Moreover, the dynamic nature of cross-border interactions further underscore the fluidity and heterogeneity of cross-border spatial identity. As a result, traditional approaches of measuring spatial identity (e.g., surveys and questionnaires) are challenged in fully capturing the nuanced and evolving aspects of spatial belonging in cross-border contexts.

Existing studies on spatial identity primarily rely on qualitative data, such as surveys and interviews. However, these approaches are often limited by small sample sizes, high costs, and low temporal efficiency. Moreover, as they are typically based on cross-sectional data, they fail to capture the temporal dynamics of spatial identity. Additionally, such studies are geographically constrained, which limit their ability to address the complexities of cross-border contexts. Recently, the use of large-scale social media text data to capture residents' emotional perceptions has emerged as a promising method. Social media text data with geolocation information, provides a novel source of linguistic emotional feedback for measuring spatial identity (Gao et al., 2022). This approach offers significant advantages, including large scale data availability, low collection costs, extensive geographic coverage, and the ability to track long-term temporal dynamics.

However, collecting high-quality labeled social media data for measuring cross-border spatial identity remains challenging. First, divergent social media platform preferences on each side of the border lead to fragmented data access and varied data. Second, linguistic and expressive difference (e.g. Mandarin, Cantonese, English,...) further complicate data processing. Moreover, cultural diversity in cross-border regions creates a range of expression styles that can also introduce biases in emotion interpretation, making it harder to accurately capture spatial identity using computational models.

Based on social media data, machine learning algorithms have proven effective in extracting textual emotions. These algorithms automatically identify nuanced user opinions and detect emotional fluctuations by training models to classify sentiment polarity(positive/negative) (Mutanov, Karyukin and Mamykova, 2021) and quantify

intensity levels using features like lexical patterns, contextual embeddings, and temporal dynamics in posts (Mandhasiya et al., 2022). However, these methods face several challenges when applied to cross-border spatial identity measurement. They struggle to capture perceptions of abstract concepts accurately, rely heavily on large amounts of labeled data, interpret the prediction process, and their performance is limited by the quality of training data. The multi-source and heterogeneous nature of social media data in cross-border regions increases the costs of data labeling, reducing the efficiency and transferability of model training. Additionally, linguistic diversity in cross-border settings presents further challenges, as a single machine learning model typically struggles to conduct cross-lingual analysis. Furthermore, the black-box nature of machine learning models undermines the interpretability and credibility of prediction outcomes. Therefore, a critical research challenge lies in developing a spatial identity measurement framework tailored to cross-border contexts—one that effectively leverages large-scale social media data, addresses the complexities of multilingual and multicultural environments, and enhances the interpretability and reliability of analytical processes.

LLMs have shown potential in large-scale text analysis, semantic understanding, and complex emotion recognition tasks. Compared to traditional sentiment analysis models based on lexicons or supervised learning, LLMs offers clear advantages in capturing complex and implicit semantics(Xing, 2024), performing zero-shot or few-shot learning without heavy reliance on labeled data(Gandhi et al., 2024), and improving interpretability through self-explanation capabilities (Randl et al., 2024). These features open new avenues for conducting complex sentiment analysis based on social media data and for quantifying cross-border spatial identity perceptions.

Therefore, this study proposes an innovative framework for measuring cross-border spatial identity by integrating social media data with LLMs. We utilize a three-dimensional theoretical model that conceptualize cross-border spatial identity through spatial imagery, spatial satisfaction, and spatial sense of belonging. The framework involves several key steps: collecting and processing social media data, recognizing regional identity, developing chain-of-thought (COT) prompt engineering, and applying LLMs to quantify spatial identity scores. This approach enables precise and scalable measurement of cross-border spatial identity. [Specifically, incorporating LLMs introduces a novel semantic reasoning layer. By leveraging COT prompting, the framework decomposes complex spatial narratives into structured elements (location, activity, sentiment). Consequently, this approach supports dynamic, cross-lingual, and context-aware spatial identity scoring that surpasses traditional keyword-based methods, while also facilitating an analysis of the drivers behind spatial identity beyond conventional interpretability limits.] Using the Shenzhen-Hong Kong cross-border region as a case study, we employed mobile phone signaling data to identify the primary cross- border activity spaces for Hong Kong residents in Shenzhen and collected corresponding social media text data. We then examined the temporal fluctuations of spatial identity in Shenzhen's cross-border areas, the heterogeneity of identity perceptions across different functional spaces, and the differences in cross-border spatial identity between Guangdong and Hong Kong residents.

By systematically exploring the dynamic spatiotemporal patterns and underlying mechanisms, the framework contributes to a deeper understanding of spatial identity dynamics in complex cross-border environments. Compared to traditional methods, this research not only tackles the challenges such as multilingual and multicultural complexities and the heavy reliance on labeled data, but also significantly enhances semantic understanding and emotional analysis capabilities in large, heterogeneous datasets through LLMs. The findings from Shenzhen-Hong Kong cross-border region provide robust empirical evidence for understanding the cross-border integration dynamics and offer valuable theoretical foundations and practical insights for optimizing cross-border spaces and informing regional integration policies.

The remainder of this paper is structured as follows: Section 2 reviews the existing literature; Section 3 introduces the construction of the cross-border social media dataset; Section 4 presents the cross-border spatial identity analysis method based on large models; Section 5 discusses the experimental and analytical results using the research method; Finally, Sections 6 and 7 discuss the significance and limitations of this study and summarize the research conclusions.

2. Literature Review

2.1 Cross-Border Spatial Identity Measurement

Spatial identity refers to the emotional attachment, psychological affiliation, and cognitive bond that an individual or group has with a specific place. When a space's social and material resources meet residents' needs and preferences, they form a positive identity and attachment, which in turn encourages behaviors that support positive interactions with their environment.

Spatial identity develops through sustained interaction and comprehensive perception of both the physical environment and socio-cultural context (Robert Hay, 1998). Its abstract nature makes it challenging to represent concretely or intuitively. Researchers have constructed theoretical frameworks to measure spatial elements across multiple dimensions. For instance, Proshansky and other environmental psychologists proposed a three-dimensional model of spatial identity, which includes cognitive understanding, emotional experience, and behavioral intention (Proshansky, Fabian and Kaminoff, 1983). Breakwell, focusing on individual psychological needs, categorized spatial identity into distinctiveness, continuity, self-esteem, and self-efficacy (Breakwell, 1993). Knez further refined the concept of continuity into place-oriented coherence and place-consistent continuity, proposing a five-dimensional model of place identity (Knez, 2005)climate, place attachment and place identity using Breakwell's four processes model of place identity (e.g. Twigger-Ross, Bonaiuto, and Breakwell. (2003. In contrast to purely theoretical approaches, Lalli introduced the urban identity scale, dividing place identity into five dimensions: external evaluation, general attachment, commitment, continuity with personal past, and familiarity perception (Lalli, 1992)the following problems are seen to characterize the psychological research on 'place identity': heterogeneity of terms and their spatial extension, differing theoretical foundations and fragmented formulations, lack of adequate measuring instruments, and a scarcity of empirical work. This paper aims firstly, to present a systematic analysis of the theoretical traditions of the work on 'place identity'. Secondly, it uses constructs of medium range in order to systematize theory and research. An example of the latter is presented with respect to urban-related identity. A framework for conceptualizing urban-related identity and identification is developed on the basis of social psychological work on self-concept. The second part introduces a measuring instrument (the 'Urban Identity Scale'. This work marked the first quantification of spatial identity, providing an operational tool for theoretical inquiry.

Cross-border spatial identity emerges when residents traverse geographic, cultural, and institutional boundaries through ongoing engagement with cross-border activity spaces, developing emotional attachment and cultural affinity toward the border region (Newman and Paasi, 1998). Distinct from spatial identity confined within a single country, cross-border spatial identity is shaped by three fundamental asymmetries: political system disparities, uneven economic development, and cultural and linguistic divides (Pedersen, 2018), resulting in inherently multi-dimensional complexity. It demonstrates dynamic temporal evolution: individual level development occurs through cultural adaption, social integration, and life course progression (Rishbeth and Powell, 2013), whereas regional level transformations respond to historical trajectories and socio-political dynamics(Laven and Baycroft, 2008). Furthermore, exogenous shocks (e.g. pandemics) and planned interventions (e.g. economic zone development) affect both the intensity and structure of spatial identity. These factors make cross-border spatial identity a complex, dynamic phenomenon and position it as a critical interdisciplinary research focus, bridging geographical inquiry with political studies, psychological analysis, and urban planning (Robert Hay, 1998).

Existing research delineates cross-border spatial identity along several dimensions, reflecting its formation and connotations. For example, thereby building on Scannell and Giddord's three-dimensional model, Rishbeth et al. incorporated memory triggers, comparisons, and symbolic markers of local culture. (Rishbeth and Powell, 2013). Similarly, Pedersen et al. introduced the social interaction networks to examine changes in cross-border spatial identity (Pedersen, 2018), while Kajić et al. emphasized the significance of residents' perceptions of regional boundaries, emotional attachment, and socio-cultural and political systems in the construction (Kajić, Bogdanić and Fuerst-Bjeliš, 2022).

However, quantifying cross-border spatial identity presents considerable challenges. These difficulties stem

from the interplay of emotional, behavioral, and cognitive factors, including subjective conceptual boundaries (Peng, Strijker and Wu, 2020), intricate cognitive mechanisms (Arbab, Azizi and Zebardast, 2018), multi-dimensional interactions(Raymond, Brown and Weber, 2010) and diverse socio-cultural conflicts (Fikfak, 2009). While current theoretical frameworks offer valuable insights, they often neglect the key spatial elements, fail to capture dynamic evolution of spatial identity, and lack verified its cross-border applicability. Consequently, measuring cross-border spatial identity remains problematic, hindering further research.

Traditional methods for measuring spatial identity primarily rely on surveys, in-depth interviews, and participatory observation. For example, researchers have used random sampling with the place identity scale to quantify spatial identity in specific areas (Williams and Vaske, 2003), employed Likert scales to explore characteristics during its formation(Lalli, 1992)the following problems are seen to characterize the psychological research on 'place identity': heterogeneity of terms and their spatial extension, differing theoretical foundations and fragmented formulations, lack of adequate measuring instruments, and a scarcity of empirical work. This paper aims firstly, to present a systematic analysis of the theoretical traditions of the work on 'place identity'. Secondly, it uses constructs of medium range in order to systematize theory and research. An example of the latter is presented with respect to urban-related identity. A framework for conceptualizing urban-related identity and identification is developed on the basis of social psychological work on self-concept. The second part introduces a measuring instrument (the 'Urban Identity Scale', and conducted in-depth interviews to examine shifts in individuals' identity perceptions (Chow and Healey, 2008). However, these methods are often limited by small sample sizes, restricted coverage, high costs, lack of timeliness, and potential biases from self-reporting and researcher interpretation. They struggle to capture the intricate features of cross-border spatial identity. As surveys and interviews typically yield cross-sectional data, they inadequately reflect the temporal dynamics essential for deeper research.

With the advent of the "humans as sensors" concept (Resch et al., 2016), social media data, as a sensor for residents' emotions, offering new perspectives for urban emotional perception research (Kong et al., 2022) and serving as a critical tool for measuring urban sentiment. As an essential component of urban emotional perception, social media data holds significant potential for measuring spatial identity due to its unique advantages. Specifically, it provides extensive geotagged, long-term time series information that transcends geographical and cultural boundaries, captures cognitive patterns across spatial scales, and offering long-term, continuous, large-scale data coverage. Public emotional responses and cognitive characteristics toward spaces can be effectively captured, enabling more refined spatial identity measurement. For instance, Kong et al. quantified the positive emotions of park visitors using long-term Sina Weibo check-in data(Kong et al., 2022); Felasari et al. analyzed Twitter text related to tourism sites to explore the emotional connections between visitors and attractions across dimensions like understanding, psychological involvement, and self-identity fusion (Felasari et al., 2017); Jang & Kim employed Instagram image hashtags and geotags for text semantic analysis to reveal the public's collective cognitive and emotional connections to specific urban spaces (Jang and Kim, 2019).

To efficiently analyze large volumes of social media data, machine learning and deep learning methods have been increasingly introduced. Machine learning models, such as support vector machines, random forests, and logistic regression, have been applied to identify spatial emotions, place attachment, and spatial identity perceptions within social media data. For instance, Zhou et al. used Biterm topic modeling and other NLP algorithms to analyze residents' emotions expressed in social media texts about urban green spaces (Zhou et al., 2023); Jang & Kim used self-organizing map (SOM) algorithms to cluster social media text keywords, revealing latent patterns in spatial identity, and providing graphical representations of semantic relationships that enhance both analysis efficiency and interpretability (Jang and Kim, 2019), offering a comprehensive understanding of place attachment when integrated with text-based analysis.

Despite their capacity to parse complex semantics in large-scale data, current machine learning models remain facing limitations in the context of cross-border spatial identity research. Cross-border spatial identity is complicated by socio-economic disparities, diverse historical cultures, varying political systems, and cross-border

political dynamics. Its conceptual definition and measurement are inherently dynamic and multi-dimensional (Peng, Strijker and Wu, 2020). Moreover, these models typically require abundant high-quality labeled data for training, yet data collection in cross-border contexts is hindered by dispersed sources and heterogeneous data structures. They often exhibits poor generalization across different scenarios, performing optimally only within specific contexts. The complex socio-cultural environment of cross-border regions-characterized by multilingual and multicultural challenges, further complicates semantic understanding and emotional perception; a single machine learning model struggle to adapt effectively to cross-language text analysis. Finally, the “black-box” nature of machine learning models precludes transparent explanations for their outputs, thereby hindering insights into the underlying sources and mechanisms shaping cross-border spatial identity.

2.2 Utilizing LLMs for Measuring Spatial Identity

LLMs demonstrate advanced capabilities in reasoning, analysis, and generation, excelling particularly in tasks involving noisy data, complex contextual scenarios, and implicit semantic analysis. Their capability to capture bi-directional contextual dependencies facilitates the efficient analysis of large text corpora (Wan et al., 2024). Their extensive model parameters enable few-shot and zero-shot learning, reducing the dependence on labeled data and supporting transfer across diverse downstream tasks. LLMs trained on multilingual datasets can process and generate text in various languages, enhancing performance in cross-lingual tasks and enabling effective scenario transfer(Lai et al., 2023)large language models (LLMs. Furthermore, emerging approaches leveraging LLMs aim to provide more transparent reasoning process, potentially enhancing the interpretability of text-based quantification. Consequently, LLMs represent a promising tool for measuring spatial identity, particularly for capturing and quantifying it within cross-border regions characterized by cross-lingual and multicultural contexts.

The robust semantic understanding capabilities of LLMs provide a distinct advantage in interpreting implicit emotions like sarcasm, irony, and subjectivity, leading to strong performance in sentiment analysis tasks. Specifically, LLMs provide effective analysis pathways for tasks involving subjective and abstract emotional concepts, such as accurately distinguishing between moral foundations like care and fairness (Rathje et al., 2024). These capabilities allow LLMs to effectively address complex and ambiguous concepts to spatial identity, including place attachment (Zhou et al., 2024), social ideology (Liu and Shi, 2024), and personal values (Brigola, 2024), providing effective tools for its analysis.

LLMs inherently possess zero-shot and few-shot learning capabilities, which are among their most essential features. They can perform downstream tasks with little or no annotated data, bypassing the traditional reliance on large labeled datasets. This advantage reduces annotation costs and increases efficiency. For example, Kojima et al. introduced the zero-shot reasoning framework (Zero-shot-COT), demonstrating the effectiveness of zero-shot conditions in complex tasks (Kojima et al., 2022). Under zero-shot conditions, LLMs exhibit strong generalization and transfer capabilities across diverse tasks and scenarios. These zero-shot and few-shot capabilities are widely applied in sentiment analysis tasks. Studies indicate that LLMs effectively address sentiment reasoning tasks, including emotional inference, outcome reasoning and target identification, even with zero-shot prompts (Gandhi et al., 2024).

Training on multilingual data endows LLMs with robust cross-linguistic analytical capabilities, leading to superior performance in multilingual tasks. Lai et al. evaluated ChatGPT on 37 tasks, observing strong performance in high-resource languages like English, Chinese, and Spanish (Lai et al., 2023)large language models (LLMs, while also demonstrating consistent performance in cross-linguistic sentiment analysis. Consequently, the cross-linguistic capabilities of LLMs offer effective solutions for addressing the cross-cultural and cross-linguistic challenges inherent in measuring cross-border spatial identity.

LLMs can generate self-explanations based on instructions, thereby enhancing transparency and interpretability. For instance, Randl et al. distinguished between extractive explanations (e.g., identifying "the most important phrases") and counterfactual explanations (e.g., "modifying input text to change the prediction outcome"), verify-

ing the effectiveness and consistency (Randl et al., 2024). Similarly, Fragkathoulas & Chlapanis (2024) demonstrated that instructing LLMs to generate self-reasoning chains improves contextual understanding and accuracy (Fragkathoulas and Chlapanis, 2024). In addition, incorporating self-explanation prompts reduces information loss and contextual misunderstanding, thereby enhancing comprehension. Research has explored the deep interpretability of LLMs, particularly their attribution capabilities. In attribution analysis, LLMs support their response by generating attribution paragraphs or identifying source texts, thus verifying authenticity and reliability. For instance, Bohnet et al. validated attribution-enabled question answering (Bohnet et al., 2023), while Hu et al. combined knowledge graphs to automatically generate attribution categories, underscoring the advantages of LLMs in complex attribution tasks(Hu et al., 2024). Therefore, integrating the self-explanation and attribution capabilities of LLMs into the measurement of cross-border spatial identity can reveal more reliable emotional associations and attribution mechanisms. This provides urban planners and policymakers with precise sentiment feedback tools and critical insights for optimizing regional integration policies.

In summary, LLMs offer a groundbreaking approach for measuring cross-border spatial identity, leveraging their efficient text parsing, advanced semantic understanding, zero-shot and few-shot learning, cross-linguistic proficiency, and self-explanatory features.

3. Data

This study investigates cross-border activities between Shenzhen and Hong Kong, focus on the primary locations in Shenzhen frequently visited by Hong Kong residents . As a highly mobile groups within the Guangdong-Hong Kong-Macau Greater Bay Area, Hong Kong residents predominantly use Shenzhen as their main entry point to the mainland China. Their activities usually encompass shopping, dining, cultural engagement, leisure, and transit through border checkpoint (Wang, 2004). Furthermore, the diversity and density of these activity spaces provide rich contexts for the expression of spatial identity.

In order to...., this study constructs two key datasets to measure Shenzhen-Hong Kong cross-border spatial identity: (1) A spatial dataset derived from China Unicom's mobile signaling data for Shenzhen, utilized to identify hotspots of cross-border activities, and (2) A social media text dataset comprising posts from Weibo and Xiaohongshu related to cross-border spaces, employed to assess spatial identity scores.

3.1 Shenzhen-Hong Kong Cross-Border Spatial Data

The study focuses on the Shenzhen region (Figure. 1), specifically targeting areas characterized by frequent and representative visits by Hong Kong residents. To identify hotspots of activities for Hong Kong residents, we utilized mobile signaling data sourced from China Unicom's Smart Footprint platform, covering the month of May in each year from 2018 to 2023.It contains user identifiers, card registration locations, dates, and activity locations with geographic coordinates, comprising approximately 3.27 million Hong Kong-registered users and about 32 million mobile signaling records representative of Hong Kong cross-border population.

The process for defining the cross-border activity space is illustrated in Figure.2. First, based on the primary cross-border activities of Hong Kong residents, five types of cross-border spaces were identified: shopping and consumption, leisure, socio-cultural, border checkpoint, and policy spaces. Specifically, shopping and consumption spaces encompass retail, dining, and service areas in major Shenzhen commercial districts, catering to the consumption needs of Hong Kong residents. Leisure spaces include outdoor areas such as parks and tourist attractions, offering relaxation and social opportunities. Socio-cultural spaces comprise venues like museums and cultural centers, fostering cultural exchange and social interaction. Border checkpoint spaces refer to key transit points-including train stations, ports, and land crossings-serving as primary conduits between the Hong Kong and Shenzhen. Finally, policy spaces are delineated by regional cooperation policies, exemplified by the Shenzhen-Hong Kong Cooperation Zone in the Qianhai and Lok Ma Chau Loop.

Spatial boundaries for shopping and consumption, leisure, socio-cultural, and border checkpoint spaces in Shenzhen were extracted using the 2023 Area of Interest (AOI) data from Baidu Maps, whilst policy spaces were de-

lineated based on planning documents pertaining to the Qianhai and Lok Ma Chau Loop innovation cooperation zones. These boundaries were subsequently mapped onto a 250m×250m grid covering Shenzhen, allowing for the possibility of multiple space types co-occurring within a single grid cell.

Mobile signaling data was then used to calculate the number of Hong Kong cross-border residents in each grid cell for May of each year. For shopping and consumption, leisure, and socio-cultural, grids cell were ranked by resident count, with the top 20% designated as hotspots. All grid cells corresponding to border checkpoint spaces identified via AOI data were classified as activity hotspots. Policy space hotspots were defined by the geographical extent of the Qianhai and Lok Ma Chau Loop cooperation zones.

Finally, an expert panel refined the hotspots selection through discussion, considering criteria such as representativeness, geographic proximity, and uniqueness. Specifically, for shopping and consumption, leisure, and socio-cultural spaces, three representative areas were selected from the top-ranked grids. Core locations within these areas were subsequently identified using AOI and Points of Interest (POI) data. For policy and border checkpoint spaces, the expert panel confirmed all previously identified hotspot grids. Overall, 15 key areas and 100 core locations were identified (locations shown in Figure. 1b.)

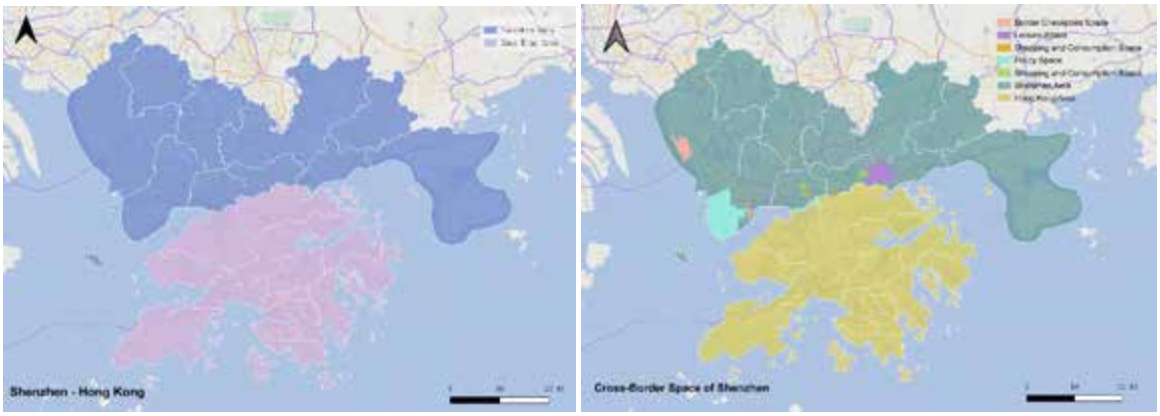


Figure. 1 a. Shenzhen-Hong Kong Map; b. Different types of cross-border space.

3.2 Cross-Border Spatial Social Media Text Data

Building upon the cross-border spatial areas defined above, we collected social media text data that either mentioned or was geo-located in those regions to construct a dataset for semantic analysis of cross-border spatial identity. Data was sourced from Weibo (www.weibo.com) and Xiaohongshu (www.xiaohongshu.com), selected based on platform activity level and data accessibility. As China's largest social media platform, Weibo reported 500 million daily active users in May 2020 (Kong et al., 2022). Xiaohongshu, an emerging platform integrating social networking, lifestyle sharing, and e-commerce, reached 200 million monthly active users in 2020, including a significant proportion of overseas users (He, 2024). Notably, with increasing engagement from Hong Kong users on mainland platforms, Xiaohongshu serves as a primary medium for accessing and sharing information related to mainland China (Digital Report, 2020). The dataset construction involved three steps: expansion of core location keywords, data collection, and filtering to isolate the Hong Kong cross-border population, as illustrated in Figure. 2.

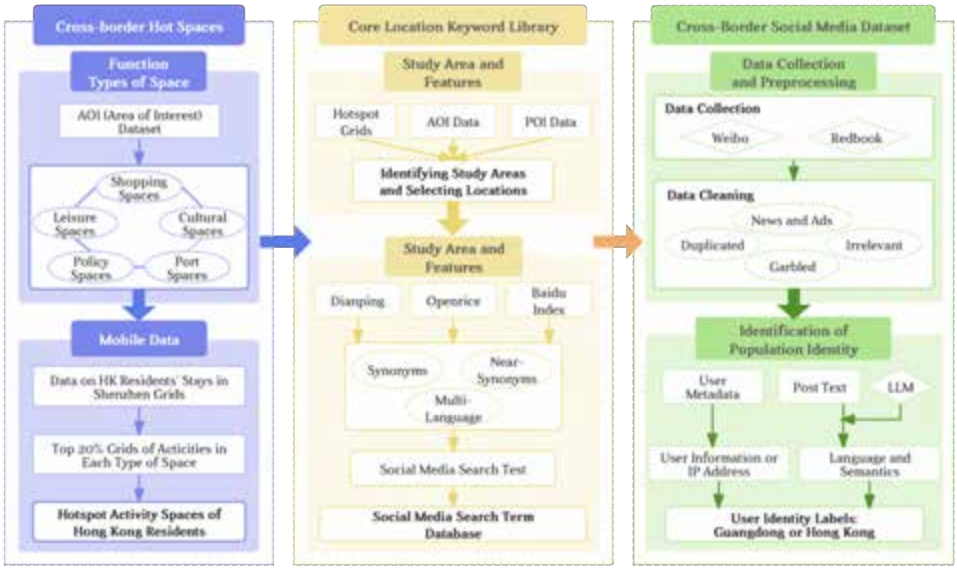


Figure. 2 Construction Process of the Cross-border Spatial Social Media Text Dataset

To ensure comprehensive data retrieval, the initially extracted core location keywords were expanded. Specifically, synonyms and related terms for each core location were generated by translating names into Simplified Chinese, Traditional Chinese, and English, accommodating Hong Kong residents' linguistic habits. Subsequently, the search functions of Weibo and Xiaohongshu were utilized to test and refine these keywords, identifying high-frequency terms and discarding low-quality ones. Tools such as Dianping, OpenRice, and Baidu Index were used to identify further high-frequency synonyms and phrases. Following an expert review to eliminate ineffective terms, a cross-border spatial location keyword bank comprising 405 search terms for the 100 core locations was established.

Using the keyword bank, we screened social media posts and location tags that mentioned relevant locations and collected 2.28 million original posts from January 1, 2018, to December 31, 2023. These posts include content, publication date, user ID, user type, follower count, IP location (since April-May 2022?), and location keywords. Since Weibo and Xiaohongshu began publicly sharing IP data in April-May 2022, we retained only content with IP addresses located in Guangdong and Hong Kong, while posts without IP data were reserved for later processing.

To enhance data quality, a systematic data cleaning process combining rule-based filtering and semantic analysis via LLMs was implemented. First, duplicate posts were removed by retaining only the earliest submission from each user in case of similar or identical post content. Second, special characters, irrelevant data fragments, and hyperlinks were removed to standardized text formatting. Third, a text length filter was applied, retaining posts containing between 20 and 1000 characters to ensure sufficient content relevance. Posts originating from official media or high-influence accounts were excluded to minimize promotional content bias. Finally, posts identified as advertising or news reports were removed using the ChatGLM, preserving only those reflecting genuine user opinions. This process resulted in 1.01 million valid posts, forming the analytical basis for the subsequent spatial identity assessments.

Based on this dataset, posts originating from the Hong Kong cross-border population were identified and extracted, considering metadata and semantic content, including Hong Kong-specific dialects, topics, and cultural factors. While existing research often relies on metadata (e.g., IP address, time zone, user profile data, social network data) and text analysis for population identification, this study employed a multi-level method combining post metadata, user profile data, and LLM-assisted content analysis to accurately capture posts from the target demographic.

Initially, posts were preliminarily identified based on metadata. Posts were classified as originating from the Hong Kong cross-border population if their associated IP address or user profile explicitly indicated a Hong Kong location. For posts lacking such definitive metadata, LLM was employed to analyze language style, writing patterns, and semantic content to infer the users' origin (see Figure. 3).

Step 1: Identifying Cantonese versus Mandarin Usage: This step focused on distinguishing between Cantonese and Mandarin text in the posts. First, an LLM prompt was developed, leveraging the distinct vocabulary and grammatical characteristics of Cantonese. The prompt design explicitly outlined the key differences between Cantonese and Mandarin and highlighted specific features indicative of Cantonese. Subsequently, few-shot learning examples representing both languages were provided. The LLM was then tasked with assigning a probability score indicating the likelihood that each post was written in either language (the probabilities sum to 1). Posts assigned a Cantonese probability exceeding 50% proceeded to Step2 for further refinement, while the remaining posts (classified as primarily Mandarin) were analyzed in Step3.

Step 2: Distinguishing Cantonese Variants (Guangdong and Hong Kong): Given that Cantonese spoken and written in Hong Kong exhibits differences from that used in Guangdong, particularly regarding character usage, vocabulary choices, frequency of English loanwords/transliterations, code-switching patterns, and grammatical structures. Posts identified as Cantonese in Step 1 underwent further examination. Recognition rules specific to Hong Kong Cantonese were established, focusing on the mentioned features. Manually identified social media examples illustrating these distinctions, along with discriminative criteria were provided to the LLM. Posts assessed as having a Hong Kong Cantonese probability exceeding 50% were classified as originating from Hong Kong users; otherwise, they are classified as originating from Guangdong users.

Step 3: Identifying Hong Kong Cross-border Semantics in Mandarin Posts: For posts identified as primarily Mandarin, semantic prompts were used to detect content indicative of a Hong Kong perspective. Indicators included phrases suggesting movement patterns typical of cross-border residents, such as "going to Shenzhen" (implying departure from Hong Kong) or "returning to Hong Kong" / "back to Kowloon" (implying residence in Hong Kong). Accordingly, the prompt design first introduced key features characterizing a Hong Kong perspective—including references to departure location, habitual residence, return destination, and expressions of belonging—along with culturally specific Hong Kong terms (e.g., "high tea," "OT," "taking the lift"). Next, manually curated examples demonstrating these features were provided. Explicit judgment rules were defined, instructing the LLM to assign a binary value (1 for Hong Kong perspective present, 0 otherwise). Consequently, posts assigned a value of 1 were classified as originating from Hong Kong residents, while the remainder were classified as likely originating from Guangdong residents.

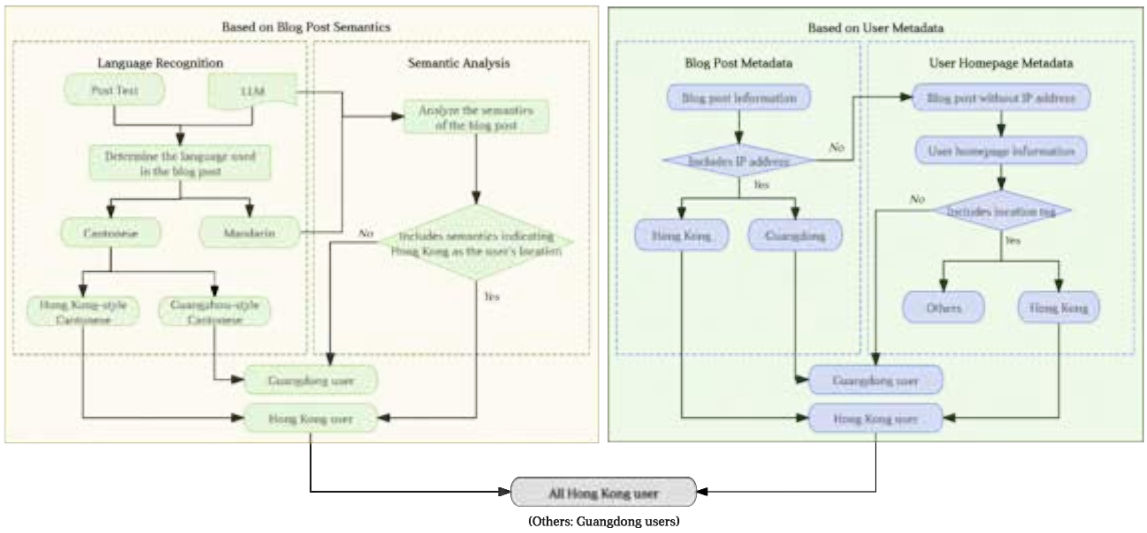


Figure 3: Crowd Identity Recognition Framework

To evaluate the performance of the developed LLM-based framework in differentiating user origins, we assessed its accuracy on distinct tasks. First, for differentiating Cantonese varieties (Steps 1 and 2), we compiled a test set comprising 100 samples each from the "Guangzhou Spoken Corpus" (representing Guangdong Cantonese) and the "Hong Kong MapTask Corpus" (representing Hong Kong Cantonese), supplemented by 200 Mandarin samples. The model (ChatGLM3) achieved 88% accuracy in distinguishing Cantonese from Mandarin, 100% accuracy in identifying Hong Kong Cantonese, and 74% accuracy for Guangdong Cantonese. Second, to evaluate the model's ability to identify a Hong Kong perspective in Mandarin text (Step 3), we addressed the absence of a suitable labeled corpus by generating synthetic data. Specifically, ChatGPT 4.0 was prompted to create 300 text samples exhibiting distinct Hong Kong-related semantic features; these samples were subsequently manually reviewed for quality and relevance. Evaluating the ChatGLM3 model against this curated, labeled dataset yielded a recognition accuracy of 81% for identifying the Hong Kong perspective. Overall, these results indicate that the proposed population identity recognition framework possesses robust discriminative capabilities. Following this validation, the framework was applied to classify the social media posts that initially lacked identifying metadata, assigning either a Hong Kong or Guangdong origin label to each. Finally, these newly classified posts were merged with the posts previously identified via metadata (IP address or user profile) to construct the final cross-border spatial social media text dataset. This comprehensive dataset serves as the foundation for the subsequent measurement of cross-border spatial identity.

4. Method

This study employed LLMs to assess cross-border spatial identity along three dimensions: spatial satisfaction, spatial imagery, and spatial sense of belonging. The methodology involved defining and labeling these dimensions, designing corresponding prompts for the LLM, computing identity scores for text data, and conducting attribution analysis (Figure. 4). After comparing models based on Chinese text analysis capabilities, response speed, and cost effectiveness, ChatGLM-3 was selected for implementation.

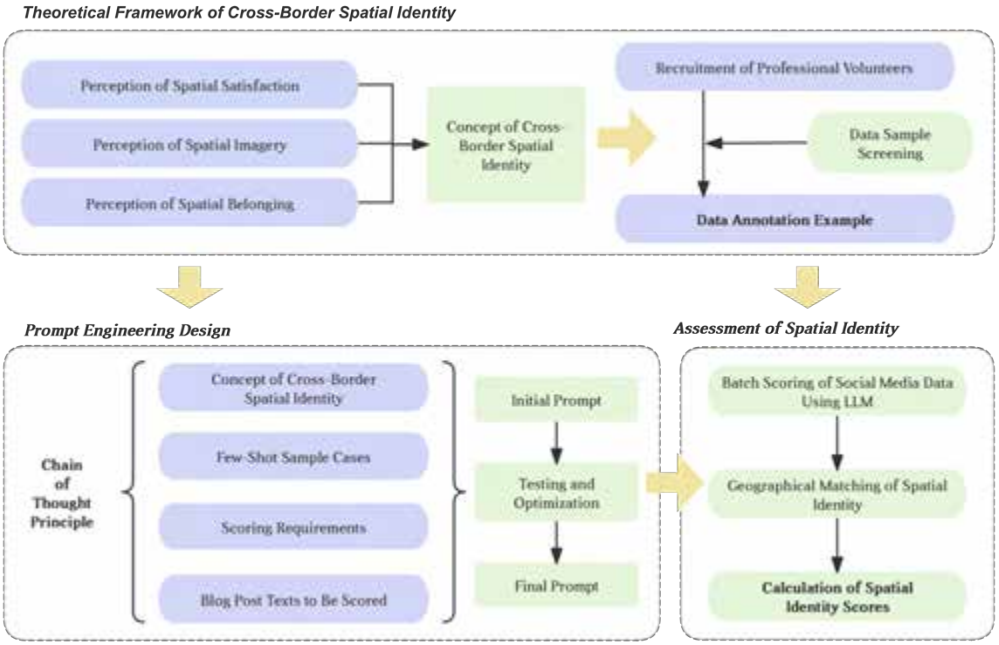


Figure. 4: Cross-Border Spatial Identity Recognition Framework

4.1 Definition and Labeling of Cross-Border Spatial Identity

Drawing on dynamic and hierarchical perspectives, this study proposes a framework comprising three dimensions to measure the cross-border spatial identity of Hong Kong residents concerning their activity spaces in Shenzhen (Casakin, Hernández and Ruiz, 2015).

1. Spatial Satisfaction: This dimension captures residents' evaluations of the quality and adequacy of the environment and facilities within the cross-border space, reflecting perceived convenience and suitability (Li et al., 2022). It assesses whether spatial functions meet individual needs, highlighting aspects significant for regional planning, such as public service provision, living convenience, and accessibility.

2. Spatial Imagery: This dimension relates to the residents' direct perceptual experiences of the cross-border space. It involves awareness of position and orientation, familiarity with spatial components and distinctive feature and the recalled events or memories associated with the space (Blajenkova, Kozhevnikov and Motes, 2006). Spatial imagery thus reflects the subjective impressions that shape the perceived character and image of a place.

3. Spatial Sense of Belonging: This dimension signifies the deep emotional attachment and loyalty residents develop towards the cross-border space. It manifests in behaviors such as willingness to engage in cross-border activities, protect the local environment, contribute to development, or make personal sacrifices for the place (Casakin, Hernández and Ruiz, 2015). This dimension underscores the planning objective of fostering inclusive and shared spatial environments.

Collectively, these dimensions represent a potential developmental trajectory where a strong sense of belonging emerges from cumulative positive spatial imagery and satisfaction. To quantify the perceived intensity for each dimension, this study employed an integer scale ranging from -3 (strong negative perception) to +3 (strong positive perception), with 0 indicating no discernible association. This approach frames the assessment of cross-border spatial identity as a three-dimensional multi-classification task, where each social media post is classified

according to the connotations expressed for each of the three dimensions.

To establish a benchmark for evaluating the LLM's performance, 10 volunteers with backgrounds in urban studies were recruited to manually annotate a sample of the social media data. These volunteers were provided with the definitions of the three cross-border spatial identity dimensions and asked to rate 500 randomly selected posts on the -3 to +3 scale for each dimension based on the text content. The resulting annotations were reviewed and refined by experts, establishing a reference standard for the abstract concept of cross-border spatial identity. This standard subsequently informed the design of few-shot learning prompts for the LLM and served as the basis for evaluating its measurement accuracy.

4.2 Prompt Engineering Design

Following the COT principle, the study designed a prompt engineering framework for scoring spatial identity using LLMs. The method guides the model's reasoning process step-by-step, thereby enhancing its ability to interpret complex semantic meanings in texts. Specifically, the framework comprises three steps: defining cross-border spatial identity, providing scoring examples, and iteratively refining the prompts.

Step 1: Definition. Cross-border spatial identity is defined in three dimensions: spatial satisfaction, spatial imagery, and spatial sense of belonging. This step clarifies the evaluation criteria and establishes a scoring range from -3 to 3, where negative values indicate negative identity, positive values indicate positive identity, and 0 denotes irrelevance.

Step 2: Scoring Examples. To instruct the model on the required logic and output format, the study present a small set of sample posts with corresponding scores and detailed reasoning for each emotional dimension. This step aids the model in accurately scoring spatial identity.

Step 3: Iterative Refinement. The effectiveness of the prompt design is evaluated through multiple rounds of testing, with continuous optimization based on model performance. Retry and backtracking principles are applied, requiring the model to review and correct its output (Yang et al., 2024). A self-consistency evaluation mechanism is also integrated to ensure the logical coherence and enhance result reliability (Wang et al., 2023). Additionally, the model is required to output its reasoning process and score explanations, thereby enhancing transparency. This approach has been shown to significantly enhance the reasoning capabilities of LLMs (Kojima et al., 2022).

Subsequently, the study employs the ChatGLM API, configured with the ChatGLM-3-turbo model, to assess the cross-border spatial identity of social media posts. Each post is individually embedded into the prompt and process to mitigate contextual interference. Posts are sequentially input into the model, which returns structured data. After sorting and cleaning, scores are assigned values of -3, -2, -1, 0, 1, 2, and 3, corresponding respectively to "Extremely Dissatisfied", "Dissatisfied", "Slightly Dissatisfied", "Unrelated to Spatial Identity", "Slightly Satisfied", "Satisfied", and "Extremely Satisfied". Posts scoring 0 were excluded (indicating irrelevance). Consequently, the final dataset comprises nearly 20,000 posts from Hong Kong and 687,000 posts from Guangdong, covering 15 spatial regions within Shenzhen. Each post is scored across the three defined dimensions.

4.3 Cross-Border Spatial Identity Scoring Model Evaluation

After computing the cross-border spatial identity scores, the study evaluates the LLM's performance. Precision and F1 score are adopted as evaluation metrics, as they are widely used in machine learning and have proven effective in sentiment analysis tasks. Precision is defined as the proportion of true positive instances (according to human annotations) correctly classified by the model. For example, in a post with a spatial sentiment score of 2, precision is the ratio of posts with a human-assigned score of 2 within the model's predicted category. The F1 score, calculated as the harmonic mean of precision and recall, provides a balanced evaluation of overall performance. The formulas are as follows:

$$Precision = \frac{|Correctly\ recognized|}{|All\ recognized|} \quad (1)$$

$$F_score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \quad (2)$$

In this study, 500 posts were randomly selected from the cross-border social media dataset. Sentiment analysis tools (e.g., SnowNLP) and mainstream machine learning models (e.g., Support Vector Machines and Random Forests) were employed to score the spatial identity of these posts. These supervised models were trained using manually annotated spatial identity scores from Section 4.1, with the data partitioned into training, testing, and validation sets at ratios of 0.4, 0.4, and 0.3, respectively. Furthermore, since SnowNLP outputs continuous values between 0 and 1, the three-dimensional scores (spatial imagery, spatial satisfaction, and spatial belonging) from both the LLM and machine learning models were averaged and standardized to a range between 0 and 1 for comparison. Finally, using manual spatial identity scores from volunteers as benchmark labels, the models' performance was evaluated by calculating precision and F1 scores, thereby assessing the LLM's applicability in measuring cross-border spatial identity.

4.4 Cross-Border Spatial Scoring Indicators

Based on the cleaned scoring data, regional multidimensional spatial identity indicators were calculated for each region using the following formulas to quantify spatial imagery, satisfaction, and sense of belonging:

$$M_i = \frac{\sum_{j=1}^{N_i} p_{ij}}{N_i} \quad (3)$$

$$S_i = \frac{\sum_{j=1}^{N_i} q_{ij}}{N_i} \quad (4)$$

$$O_i = \frac{\sum_{j=1}^{N_i} t_{ij}}{N_i} \quad (5)$$

Where:

p_{ij} is the spatial imagery score of the j-th post related to region i;
q_{ij} is the spatial satisfaction score of the j-th post related to region i;
t_{ij} is the spatial sense of belonging score of the j-th post related to region I;
N_i is the total number of posts related to region i;
M_i is the average spatial imagery score for region i;
S_i is the average spatial satisfaction score for region i;
O_i is the average spatial sense of belonging score for region i;

4.5 Attribution Analysis of Spatial Identity

LLMs can perform multi-dimensional evaluations of spatial identity on large-scale social media data and are capable of analyzing long texts and conducting inductive topic analysis (De Paoli, 2024). They can identify underlying meanings from sample annotations and qualitative data, thereby summarizing and generalizing vast amounts of qualitative text. In this study, the LLM analyzes social media data to uncover the driving factors behind spatial identity, akin to conducting semi-structured interviews (Dengel et al., 2023). The interview material comprises posts from platforms such as Xiaohongshu and Weibo, and the model's long-text analysis capabilities reveal core emotional features, enhancing the interpretability and credibility of the analysis. The process

involves the following steps:

1. Interview Guide Design: A semi-structured interview guide was developed for the LLM based on temporal and spatial influencing factors, spatial functions, changes in emotional identity.

2. Data Organization and Input: After obtaining the spatial identity scores for each region, social media posts were categorized into 90 groups based on five spatial types, three emotional dimensions, and six scoring outcomes. Each group was then summarized to form a database serving as the LLM's prior knowledge during the interview.

3. Model Inference and Interview: A semi-structured interview method was employed, using prompt engineering to guide the LLM in analyzing social media data and identifying spatial identity drivers. The prompts, designed in a role-playing format, instruct the LLM to act as a senior urban planning analyst to enhance its performance. Iterative questioning was applied to further probe underlying attributions when ambiguous or unexpected response emerged (Dengel et al., 2023).

4. Emotional Cause Induction: The LLM conducted an in-depth analysis of each text group, extracting underlying causes related to spatial identity and identifying potential influencing factors from the perspective of spatial function, along with providing targeted optimization suggestions.

Due to the ChatGLM's limitations in processing long texts, the Kimi Chat model was selected for further exploration. Through conversational prompts, attribution results for both positive and negative spatial identity across different spatial types were obtained. This approach combines quantitative and qualitative analyses, leveraging LLMs' strengths to offer a more comprehensive understanding of cross-border spatial identity.

5. Results

5.1 Measurement Results

This study evaluated the model's performance in scoring multi-dimensional cross-border spatial identity, comparing it against sentiment analysis tools (e.g., SnowNLP) and machine learning models (e.g., SVM) (Table 1). The LLM demonstrated superior performance, achieving 99% precision and an F1 score of 0.86, significantly exceeding the other models while closely aligning with human ratings.

Table 1. Comparison of cross-border spatial identity model assessments

	Precision	F1
LLM	0.99	0.86
SnowNLP	0.92	0.85
Random Forest	0.71	0.77
SVM	0.71	0.77
Logistic Regression	0.71	0.77
LightGBM	0.71	0.77

Table 2 presents the spatial identity perceptions of Shenzhen and Hong Kong residents. Guangdong residents consistently reported higher spatial identity than Hong Kong residents, consistent with literature indicating that local familiarity foster stronger place attachment (Hernández et al., 2007). Specifically, among the three dimensions, Hong Kong residents scored highest in spatial satisfaction (mean = 0.51) and lowest in spatial sense of belonging (mean = 0.34), with spatial imagery in between, indicating a more functional than emotional spatial identity toward Shenzhen. Similarly, Guangdong residents showed the lowest spatial sense of belonging, suggesting that robust emotional attachment and regional identity are more challenging to establish through short-term

cross-border interactions (Qian and Zhu, 2014).

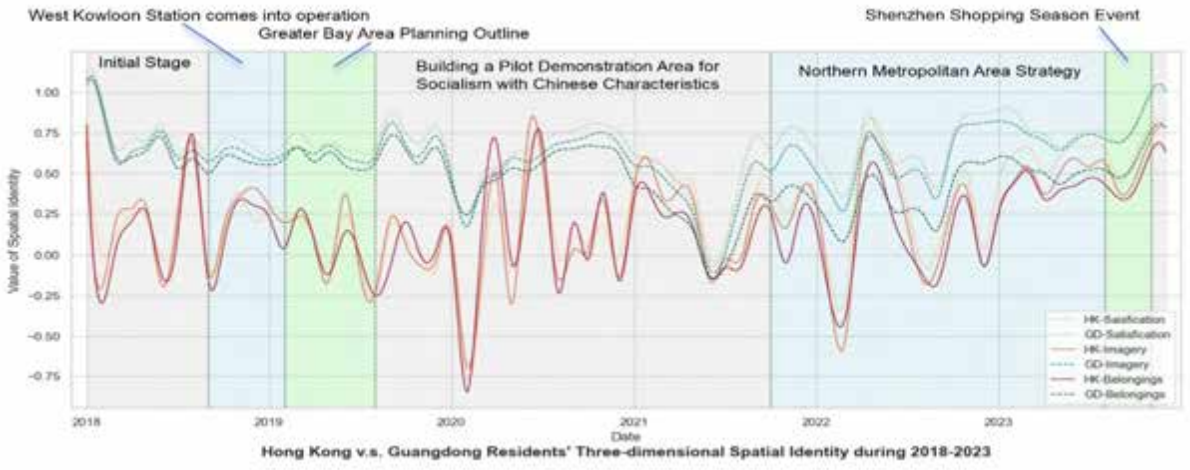
Despite a smaller sample size, Hong Kong residents exhibited greater variability in spatial identity perception than Guangdong residents. In contrast, Guangdong residents demonstrated more consistent spatial identity, likely reflecting more uniform spatial promotion and local culture in mainland China (Xie et al., 2020).

Table 2: Descriptive Statistics of Spatial Identity of Hong Kong and Guangdong Residents

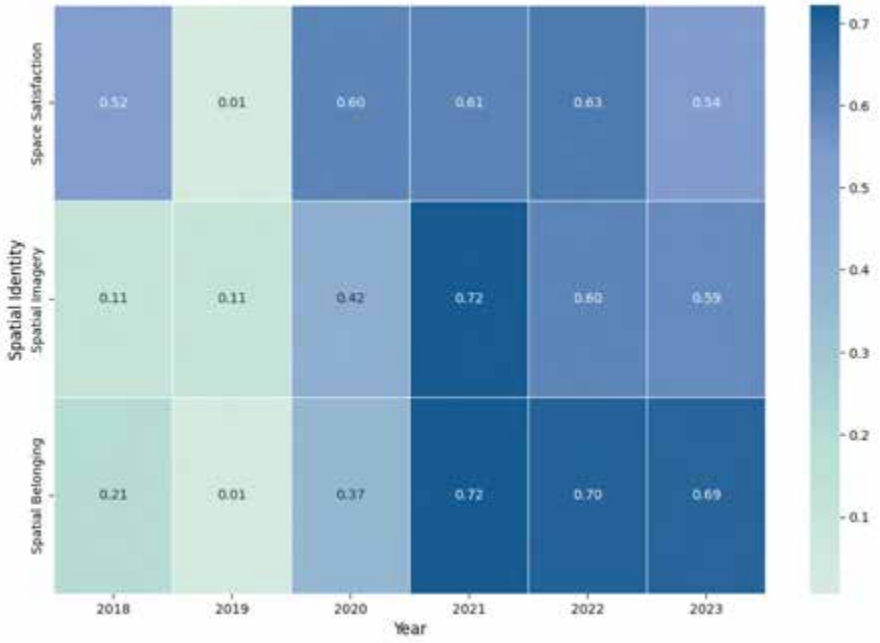
		Spatial Satisfaction	Spatial Imagery	Spatial sense of Belonging
Hong Kong	Mean	0.51	0.44	0.34
	SD	1.59	1.60	1.53
	observations	18374	17397	18421
Guangdong	Mean	0.71	0.70	0.47
	SD	1.55	1.57	1.44
	observations	664025	620594	669932

5.2 Temporal Heterogeneity

Figure. 5a illustrated the temporal evolution of cross-border spatial identity perceptions among Hong Kong and Guangdong residents, according to the timings of post publication. Cross-border spatial identity measured across three dimensions, fluctuated over time with alternating positive and negative values and consistent trends. For instance, in February 2020, Hong Kong residents' reached their lowest scores (satisfaction: -0.76; imagery: -0.69; belonging: -0.85), then experienced a brief peak in June-July 2020 (satisfaction: 0.68; imagery: 0.72; belongings: 0.70), followed by a rapid decline and recovery. Fluctuations intensified from 2021 to 2022, with the lowest scores in March 2022 (satisfaction: -0.24; imagery: -0.50; belongings: -0.37), and the highest in May 2022 (satisfaction: 0.76; imagery: 0.70; belongings: 0.55). After 2023, all dimensions gradually increased and stabilized. In contrast, Guangdong residents showed a more stable and consistently positive trend, with only minor fluctuations before 2020 and a slight decline in 2021 that recovered rapidly. Although the emotional disparity between the regions narrowed after 2021, the convergence reflects distinct regional dynamics in cross-border spatial identity.



a. Hong Kong v.s. Guangdong Residents' Three-dimensional Spatial Identity during 2018-2023



b. Correlation Matrix of Multidimensional Spatial Identity between Hong Kong and Guangdong Residents

Figure. 5a. Monthly Fluctuation Chart (Smoothed) b. Correlation Matrix of Multidimensional Spatial Identity between Hong Kong and Guangdong Residents

Fluctuations in Hong Kong residents' spatial identity were closely associated with key events in Hong Kong and Shenzhen, as well as regional integration policies. Significant shifts occurred during critical periods, such as the COVID-19 pandemic outbreak, the social unrest surrounding the extradition bill, the opening of West Kowloon Station, and the launch of the Greater Bay Area development plan. Specifically, between 2020 and 2023, the COVID-19 pandemic triggered marked declines in cross-border spatial identity, consistent with previous findings (Luo and Lam, 2020). Before the pandemic, gradual policy implementation maintained emotional connections; however, 2020's cross-border restrictions disrupted mobility and altered perceptions of Shenzhen. By 2023, as cross-border travel resumed, Hong Kong residents' spatial identity rebounded, with emotional intensity even surpassing pre-pandemic levels.

Similarly, sudden events such as the extradition bill protests might also affect Hong Kong residents' cross-border emotions. The protests in June 2019 led to a marked decline in cross-border spatial identity due to increased social tension and reduced mobility, while the 2020 National Security Law helped stabilize these fluctuations by boosting confidence in regional integration. (He et al., 2023). Although regional integration policies influence spatial identity, their net impact is moderated by key events and the pandemic, warranting further evaluation using econometric models.

Figure. 5a reveals significant differences in the trends and intensity of spatial identity dimensions between Hong Kong and Shenzhen residents. As shown in Figure. 5b, early in the study, the correlation between the regions' spatial identities was weak and divergent, with 2019 marking a clear trough when differences peaked. However, in 2020 and 2021, the correlation increased markedly, indicating reduced heterogeneity in spatial identity between the regions. This convergence likely reflects the progressive implementation of the Guangdong-Hong Kong-Macau Greater Bay Area development. The spatial satisfaction dimension consistently showed higher correlation, suggesting minimal heterogeneity, while spatial imagery and spatial sense of belonging initially showed more pronounced differences that diminished over time, particularly during 2020-2021. Overall, although some differences remain, the spatial identities of Hong Kong and Shenzhen residents are gradually converging under the

influence of policy initiatives and evolving cross-border dynamics.

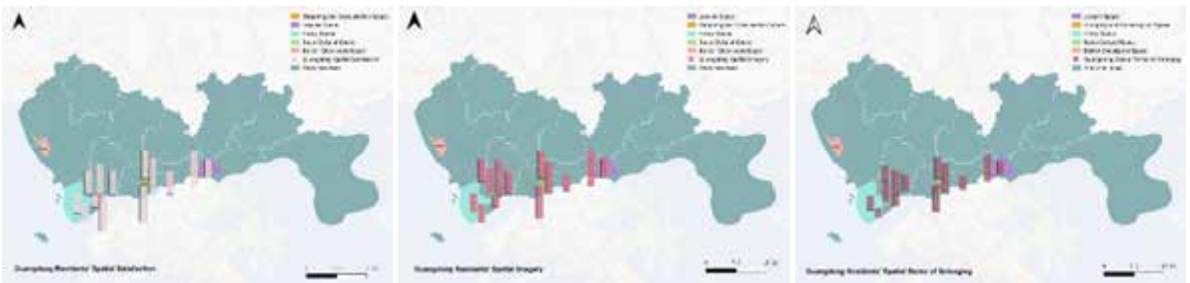
5.3 Spatial Heterogeneity

The study categorized cross-border activity spaces into five types based on spatial functions: shopping and consumption, socio-cultural, leisure, border checkpoint, and policy spaces. Figure. 6a illustrates the geographical distribution of Hong Kong residents' cross-border spatial identity perceptions in Shenzhen, with colors denoting spatial types and bar heights representing identity strength. Evidently, Hong Kong residents' spatial identity varies with location types.

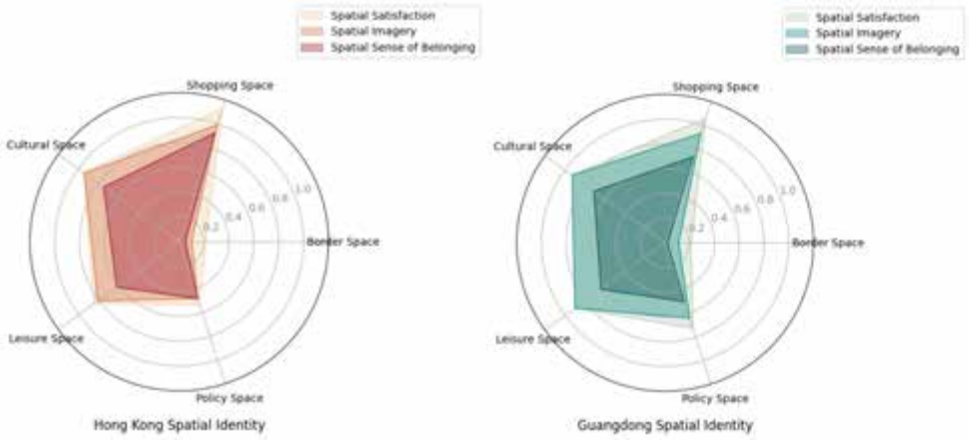
The study summarizes the spatial identity of Guangdong and Hong Kong residents across different spatial types. Hong Kong residents display distinct identity characteristics by function. In border checkpoint spaces, their spatial identity scores were low across all dimensions (0.1, 0.21, 0.05), significantly lower than in other spaces. This suggests that, although border checkpoint spaces are essential for cross-border movement, their limited facilities and services fail to fully meet cross-border needs. However, Hong Kong residents' spatial sense of belonging in these spaces was slightly higher than that of Guangdong residents, reflecting a stronger functional dependence. In contrast, shopping and consumption as well as socio-cultural spaces elicited the highest spatial identity scores among Hong Kong residents. In shopping and consumption spaces, scores peaked for spatial imagery (0.99), spatial satisfaction (1.33), and spatial sense of belonging (0.92), suggesting that these spaces best meet Hong Kong residents' needs for convenience and diverse facilities (Wang, 2004; Sharma, Chen and Luk, 2018). Shenzhen's advanced shopping services foster positive spatial imagery and, through routine activities, enhance emotional attachment and spatial belonging. Conversely, policy spaces received relatively lower identity scores, likely because their services primarily cater to mainland China.

Overall, Hong Kong residents demonstrate the strongest emotional attachment to shopping and cultural spaces, while their attachment to border and policy spaces is weaker. Guangdong residents demonstrate a similar trend. These findings marked significant spatial heterogeneity in cross-border spatial identity, suggesting service and facility imbalances that offer a comprehensive geographic perspective for policy development.

a. Geographic distribution of Hong Kong spatial identities in various types of cross-border spaces



b. Geographic distribution of Guangdong spatial identities in various types of cross-border spaces



c. Hong Kong v.s. Guangdong Residents' Three-dimensional Spatial Identity during 2018-2023

Figure. 6 a. Geographic distribution of spatial identities in various types of cross-border spaces; b. Radar map of three-dimensional spatial identity perceptions of Hong Kong and Guangdong residents.

5.4 Qualitative Attribution Analysis

The study employed LLM's long-text mining and summarization capabilities to conduct an attribution analysis on blog posts with varying identity scores among Hong Kong residents. A semi-structured prompt process was established to investigate the drivers of spatial identity. The results indicate that although there some common factors significant differences emerge concerning spatial functions.

Negative spatial identity among Hong Kong residents was chiefly driven by functional deficiencies and inadequate management services. Specifically, issues such as traffic congestion, overcrowding, and poor spatial layouts were prevalent in border checkpoint, shopping and consumption, and leisure spaces (e.g., "Futian checkpoint is too crowded," "Shenzhen Bay Park... the long queues and traffic jams are exhausting," "The mall's layout is poor, I always get lost," "During National Day, I couldn't even get on the subway"). These factors diminished spatial identity perceptions. Moreover, each space type presented specific problems. For example, negative reviews of border checkpoint spaces cited problematic customs policies and poor transportation hub management, whereas critiques of shopping and leisure spaces focused on product quality and service attitudes (e.g., "The crabs bought in Shenzhen are half the price of those in Hong Kong").

In contrast, positive spatial identity was more consistent, driven by modern infrastructure, comprehensive services, diverse consumer experiences, and rich cultural activities. Improved facilities at some border checkpoint spaces enhanced spatial satisfaction ("Luo Hu station's free dedicated passage always has enthusiastic and polite staff"), and shopping and consumption spaces were praised for competitive pricing and products variety (e.g., "Prices are half of what they are in Hong Kong"). Similarly, leisure spaces were appreciated for natural scenery and outdoor activities, boosting both spatial imagery and satisfaction (e.g., "The beautiful view at Wutong Mountain helped me relax"). Socio-cultural spaces fostered a sense of participation and belonging (e.g., "The cultural atmosphere here makes me feel at home"), and policy spaces reinforced confidence in regional integration (e.g., "The future of the Lok Ma Chau Loop area will be prosperous!").

Additionally, the spatial drivers of three emotional evaluations reflect not only functional attributes but also subjective perceptual differences in cross-border activities. For example, the impact of border-crossing efficiency on spatial identity varies with time and crowd density, while evaluations of shopping spaces involved interactions among price, layout, and service quality. Cultural activities and natural landscapes uniquely contributed to positive identity formation.

Based on these findings, the study further validates the accuracy of the LLM's attribution extraction by analyzing original negative posts for the presence of identified factors. Frequency data in Table 3 supports the reliability of the text analysis; common factors such as traffic congestion, overcrowding, and disordered spatial layouts were frequently noted. Notably, in border checkpoint spaces, complex customs procedures (32.26%) and poor transportation hubs service (4.74%), were prominent. Similarly, issues of poor product quality and inadequate service in shopping and leisure spaces were substantiated. Overall, these results confirm the effectiveness of the LLM in long-text analysis and support the credibility of the spatial attribution analysis.

Table 3. Frequency of occurrence of spatial identity-driven elements in the original blog post

Space Type	Posts No.	Traffic congestion	Pedestrian congestion	Confused spatial layout	Poor quality of goods	Poor services
Political	1359	0.37%	2.87%	0.66%	1.25%	0.59%
Cultural	2061	0.92%	8.05%	1.36%	0.87%	0.63%
Leisure	2110	0.95%	6.59%	0.57%	1.09%	0.90%
Consumption	2191	0.27%	10.45%	1.14%	2.83%	1.51%
	No. Posts	Traffic congestion	Pedestrian congestion	Confused spatial layout	Cumbersome clearance policies	Poor services at transport hubs
Border	10078	4.20%	15.24%	1.88%	32.26%	4.74%

In conclusion, LLM-based long-text mining revealed the key spatial drivers of diverse perceptions of Shenzhen's cross-border spaces. Specifically, functional factors (border-crossing efficiency, transportation convenience, and facility layout) and experiential factors (cultural activities, consumer experiences, and natural landscapes) emerged as critical. Negative emotions were primarily linked to functional deficiencies, while positive emotions were correlated with high-quality spatial attributes and experiential benefits. Analyzing original blog posts further improved the interpretability and reliability of cross-border spatial identity, offering valuable insights for spatial planning and management.

6. Conclusion & Discussion

As a critical psychological mechanism underlying cross-border activities, cross-border spatial identity not only shapes residents' cross-border behaviors but also exerts a profound impact on the planning and construction of cross-border spaces and the process of regional integration. However, measuring it is challenging due to conceptual ambiguity, contextual complexity, data scarcity, and methodological limitations. The study develops a systematic, scalable, and data-driven approach to quantifying cross-border spatial identity, integrating social media data to capture the perspectives and emotions of cross-border residents while leveraging large language models (LLMs) to interpret spatial identity perceptions. We utilize the framework to examine its temporal evolution, spatial and demographic heterogeneity in Shenzhen-Hong Kong cross-border areas. The findings contribute to a deeper understanding of intra-regional connectivity and residents' sense of belonging, providing a theoretical foundation for cross-border spatial planning and development.

This study introduces a precise, efficient, and scalable framework for the long-term tracking and recognition of cross-border spatial identity, validating the effectiveness of LLMs in integrating quantitative and qualitative approaches for measuring the perception. Traditional methods like surveys are limited by small samples, high costs, low temporal resolution, and inability to capture dynamic evolution. Traditional machine learning models also struggle with the abstract nature of spatial identity, hindering precise identification and quantification. Moreover, they often neglect socio-cultural nuances, require language-specific retraining, and demand extensive labeled data, limiting scalability. In contrast, our LLM-based approach leverages zero-shot learning and advanced text comprehension to analyze complex semantics. First, by embedding a detailed definition of cross-border

spatial identity via prompt engineering, and using a multilingual LLM supporting both Chinese and English, we achieve unified text recognition across different languages. Subsequently, validation against expert annotations confirmed the LLM's effectiveness in analyzing complex spatial identity-related text and performing fine-grained sentiment classification. The findings underscore the substantial advantages of LLMs in analyzing complex emotions and multidimensional perceptual constructs, capturing nuanced emotional fluctuations and variations in identity. Particularly in cross-cultural and cross-regional sentiment analysis, LLMs have demonstrated unique potential, significantly enhancing the depth and breadth of cross-border spatial identity measurement.

Also, the study uses long-time-series social media data to reveal the dynamic evolution of cross-border spatial identity in the Shenzhen-Hong Kong cross-border areas. By analyzing residents' perceptions over the period from 2018 to 2023, the study captures shifts in cross-border social relations and regional integration. This longitudinal perspective enables identification of key regional events (e.g. the COVID-19 pandemic, the extradition bill protests, and major policy changes) influencing cross-border spatial identity, aligning closely with prior research (Guinjoan and Rodon, 2014; Borz, Brandenburg and Mendez, 2022). Unlike static cross-sectional studies, our longitudinal approach identifies cyclical patterns, sudden disruptions, and gradual transformations in cross-border spatial identity over time. By capturing the interplay between structural factors (e.g., policy shifts, infrastructure development) and individual experiences, this approach facilitates a deeper exploration of the causal mechanisms underlying changes in cross-border spatial identity.

Additionally, the study explores the differing cross-border spatial identity between Guangdong and Hong Kong residents. The findings indicate that Guangdong residents exhibit significantly higher spatial identity than Hong Kong counterparts. This dual-perspective analysis reveals distinct identity preferences and underscores the need to accommodate diverse demands in cross-border spatial planning. Addressing these variations requires a nuanced understanding of the unique socio-cultural characteristics of border regions for targeted and equitable policy interventions.

Furthermore, the study identifies significant heterogeneity in cross-border spatial identity across different functional spaces. For Hong Kong residents, border checkpoint areas exhibit the lowest levels, whereas shopping and consumption spaces generate the highest. These variations across spatial dimensions provide a deeper understanding of identity differentiation in Shenzhen's cross-border spaces and support empirically grounded optimization of spatial design and policy formulation. For example, areas with low spatial identity, such as border checkpoint spaces may require transportation infrastructure and efficiency improvements. At the same time, for specific groups (such as people with disabilities and business commuters), fast-track channels and convenient services should be added to improve travel experience. While areas with high spatial identity like socio-cultural and leisure spaces could benefit from optimizing spatial design and environmental quality, introducing more cultural integration elements, and diversifying activity forms. For shopping and consumption spaces, where spatial identity is stronger, it is important to maintain advantages in pricing, product quality, and services, while further exploring the diversity of spatial functions. For example, integrating dining, entertainment, and other functions to expand the consumption experience can enhance the overall attractiveness and impact of cross-border spaces. By tailoring interventions to specific functional space characteristics, overall spatial identity can be enhanced, promoting the integrated development of Shenzhen-Hong Kong cross-border spaces.

This study also has certain limitations that warrant further investigation. First, the proposed framework for cross-border spatial identity recognition may be affected by LLM hallucinations in text reasoning and generation, stemming from inherent stochastic processes in the LLM architecture. This variability could lead to inconsistencies in sentiment evaluation, so future studies should conduct comprehensive validation and performance assessments of LLMs to ensure their reliability, applicability, and robustness in spatial identity measurement. Secondly, the reliance on social media data, which predominantly represents younger demographics, may introduce bias due to limited participation from children and older adults (Marchi et al., 2022). To mitigate this, future studies should incorporate complementary data sources—such as surveys, interviews, and other additional textual datasets—to achieve a more comprehensive understanding of..... Finally, the linguistic similarities

between Cantonese and Mandarin mean that language distinctions have not been fully explored in this study. Consequently, the extent to which LLMs can effectively handle complex cross-linguistic variations remains insufficiently tested. Future research should expand the geographical scope to include multilingual and multicultural border regions, enabling a more rigorous evaluation of the applicability and robustness of LLM-based spatial identity measurement across diverse linguistic contexts.

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Leveraging Digital Platforms for Circular Economy Implementation in the AECO Industry: Insights from Public-Private Partnerships

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Abstract
Digital platforms are increasingly adopted in the built environment to advance circular economy goals, yet their capacity to align policy and technology remains unclear. This paper examines how platforms enable or obstruct alignment in Public-Private Partnership (PPP) projects. A mechanism-oriented systematic literature review (SLR) of 24 studies identifies three alignment failures: lifecycle misalignment, platform–governance decoupling, and mobility-driven flow disruption. A three-tier coding framework—covering lifecycle stages, governance roles, and data flows—supports the analysis. Rather than calling for more platforms, the paper argues that circular transformation requires viewing platforms as institutional infrastructures that coordinate actors, data, and policy. It concludes with a conceptual alignment model, inviting empirical validation and adaptation, especially in regions with limited capacity and fragmented governance.

Keywords: Digital Platforms, Circular Economy, Public-Private Partnerships (PPPs), Policy–Technology Alignment, Governance

1.Introduction

The building sector, as a major contributor to global carbon emissions and resource depletion, is facing mounting pressure to transition toward circular economy practices (D'Amico et al., 2022). While digital tools such as Building Information Modeling (BIM), the Internet of Things (IoT), and Digital Twins have proliferated across the Architecture, Engineering, Construction, and Operations (AECO) industry, their deployment remains fragmented—mostly concentrated in early lifecycle stages and lacking systemic integration across the full project timeline (Dervishaj and Gudmundsson, 2024). More recently, generative AI and parametric design systems have emerged to support scenario-based optimisation and lifecycle-informed circular strategies in the design phase, yet their integration into platform-level governance remains limited.

Public-Private Partnerships (PPPs), increasingly adopted for large-scale infrastructure delivery, offer institutional leverage and cross-sector governance potential (Hueskes, Verhoest and Block, 2017). However, much of the current literature treats digital tools and policy frameworks in isolation, overlooking how digital platforms—within which these tools operate—can function as integrative infrastructures. In this study, digital platforms are conceptualised as socio-technical systems that coordinate policies, actors, and data flows throughout the building lifecycle. Digital tools (e.g. BIM, IoT, parametric design software) are understood as operational components embedded within these platforms, enabling specific functions such as simulation, traceability, or design optimisation. Governance refers to the institutional arrangements (e.g. PPP contracts, procurement mandates) that shape how platforms distribute roles, authority, and accountability. Alignment denotes the functional coherence between policy intentions and technological execution. Rather than focusing on tool adoption alone, this study foregrounds the platform as the central mechanism through which policy–technology coordination is structured (Figure 1).

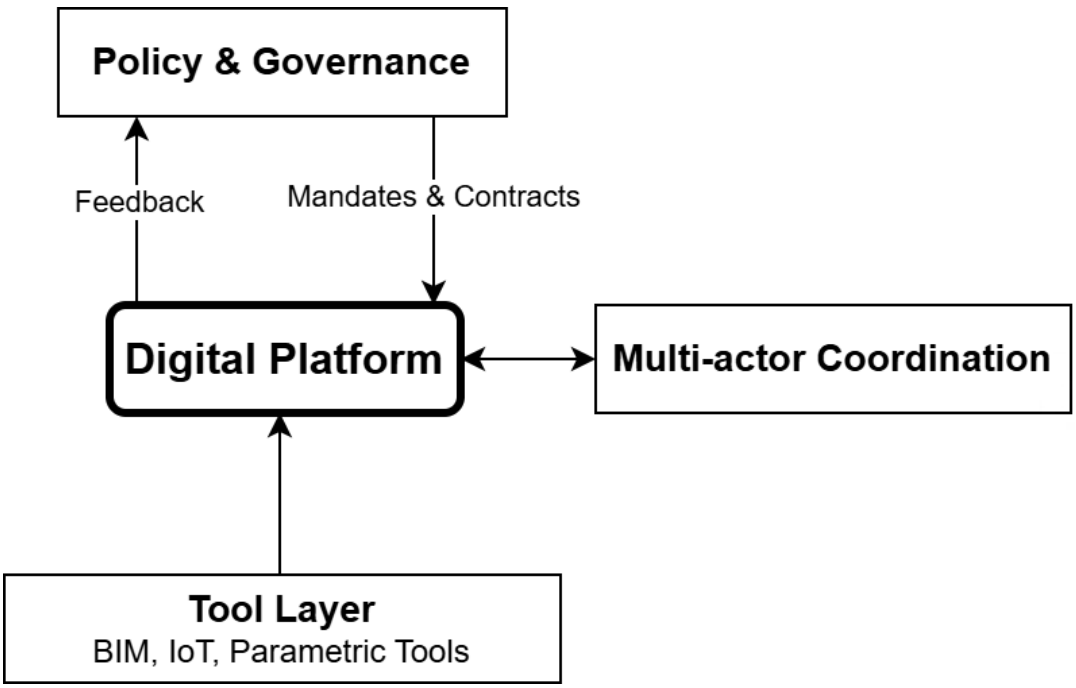

Figure 1. Platform–Tool–Policy Alignment Pathway

This paper introduces the concept of a Platform-enabled Policy–Technology Alignment Mechanism—a structural lens to examine how digital platforms mediate the interface between policy goals and technological interventions. It posits that structural misalignments between policy intentions, platform capabilities, and digital tool deployments are a key barrier to circular economy implementation in PPP-driven construction projects.

Drawing on a mechanism-oriented systematic literature review (SLR) (Pati and Lorusso, 2018), this study addresses the following questions: (1) how platform-embedded tools are distributed across different lifecycle stages in PPP contexts? (2) To what extent do platforms enable or constrain the alignment between policies and technologies? (3) What coordination bottlenecks and governance asymmetries emerge among stakeholders?

The findings provide a structured synthesis of alignment failures and coordination patterns, offering both a conceptual framework and actionable insights to support circular transformation in PPP-led AECO systems. This paper develops a policy–platform–technology alignment model to map structural mismatches and propose mechanisms for coordination in circular infrastructure governance.

2. Methodology: A Mechanism-Oriented Systematic Literature Review

This study adopts a mechanism-oriented systematic literature review (SLR) to explore how digital platforms mediate alignment between policy objectives and technological deployments in Public-Private Partnership (PPP) projects pursuing circularity in the AECO sector. Unlike traditional reviews that catalogue tools or trends, this approach focuses on identifying structural patterns of misalignment and coordination, with the aim of building a conceptual model of policy–platform–technology alignment.

2.1 Search Strategy and Screening Process

This study adopted a structured search strategy targeting the intersection of circularity practices, digital tools, lifecycle stages, and PPP governance frameworks. Four search strings were constructed (see Appendix A) to identify publications addressing either technological integration or collaborative mechanisms in the context of the built environment. The search was conducted across Web of Science, Scopus, and ScienceDirect, covering the

period 2014–2024. Only peer-reviewed journal articles and review papers in English were retained.

An initial pool of 184 articles was retrieved. After deduplication, title and abstract screening was conducted based on the following criteria: focus on the AECO sector, clear emphasis on circular economy practices (e.g., reuse, efficiency), mention of digital technologies (e.g., BIM, IoT, digital platforms), Reference to PPPs or multi-stakeholder coordination.

This stage resulted in 106 articles, which were further subjected to full-text screening. The final inclusion criteria required the study to: analyse digital tool deployment across lifecycle stages, discuss platform functions or governance roles, provide sufficient methodological and empirical detail to enable coding. After full-text assessment, 24 studies were retained for in-depth analysis and mechanism construction (see Figure 2).

2.2 Literature Screening Process

The review process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) four-step model: identification, screening, eligibility, and inclusion (D'Amico et al., 2022). Full-text evaluation was conducted on 78 articles, leading to the selection of 24 core studies for detailed coding and mechanism abstraction.

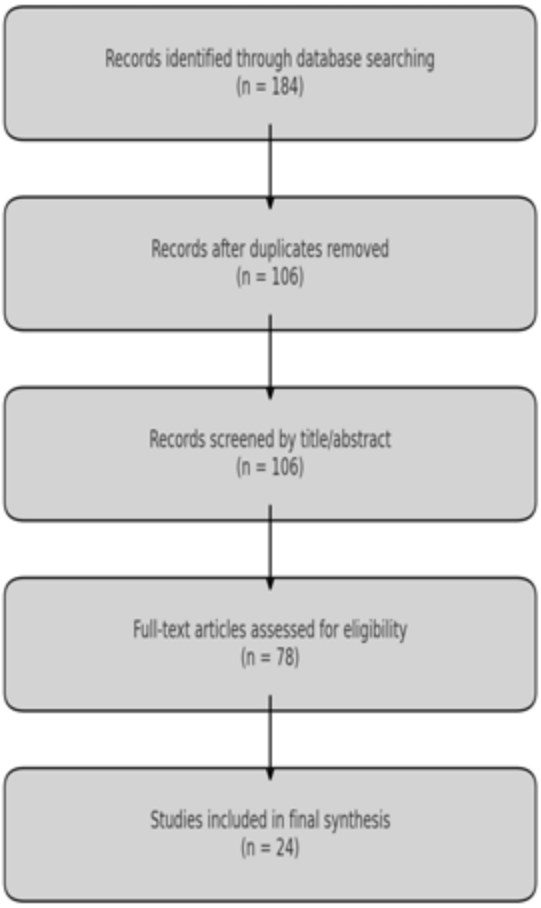

Figure 2. The PRISMA Flowchart

2.3 Data Extraction and Coding Framework

To go beyond static descriptions of digital tool usage, this study draws on Mobility Theory (Urry, 2007) as a conceptual lens to identify dynamic coordination mechanisms in PPP-based circular construction. Urry conceptualises modern systems as constituted by various forms of "flows"—including people, policies, materials, and information—which shape how institutions interact and evolve. In this context, platforms are not merely technical infrastructures but dynamic orchestrators of flow-based alignment across lifecycle stages and stakeholders.

Guided by this theoretical perspective, the coding framework integrates both structural and dynamic variables to capture how policy–platform–technology alignment is realised or constrained in practice. To capture both static structures and dynamic interactions underlying alignment processes, a three-tier coding framework was developed. Each retained study was analysed across the following dimensions (Table 1):

(1) System Structure Dimension — capturing technological deployment across the lifecycle;
(2) Platform Governance Dimension — capturing institutional design and platform functions;
(3) Mobility Flows Dimension — capturing dynamic flows of data, policy, and human coordination.

Table 1. Coding framework for analysing digital-platform-enabled alignment mechanisms

Dimension	Sub-Dimension	Examples
STRUCTURE	Lifecycle Stage	Design / Construction / Operation / Renovation / Demolition
	Digital Tool Type	BIM / IoT / Digital Twin / GIS / Blockchain
PLATFORM GOVERNANCE	Circular Economy Goal	Reuse / Efficiency / Emission Control
	PPP Model	Housing / Infrastructure / Public Works
	Platform Function	Monitoring / Coordination / Data Sharing
MOBILITY FLOWS	Policy Flows	Green Procurement / Policy Feedback / Regulatory Embedding
	Data Flows	Transparency / Traceability / Real-time Sensing via IoT
	Human Flows	Multi-stakeholder Collaboration / Cross-sector Teams / Role Integration

This coding framework enabled the abstraction of empirical patterns into a three-layer mechanism model: policy intentions, platform functions, tool deployments, which serves as the analytical structure for Section 3.

3. Results: Mechanism Construction from Literature Synthesis

This section presents the three core mechanisms derived from the systematic coding of 24 selected studies. Moving beyond thematic summaries, these mechanisms reflect structured patterns of alignment and misalignment between policy intentions, platform functions, and digital tool deployments in circular Public-Private Partnership (PPP) projects.

Based on the three-tier framework (Figure 3), the mechanisms are constructed through variable convergence across structural layers (e.g., tool type, lifecycle stage), governance design (e.g., PPP role, platform coordination), and flow dynamics (e.g., policy, data, and stakeholder mobility).

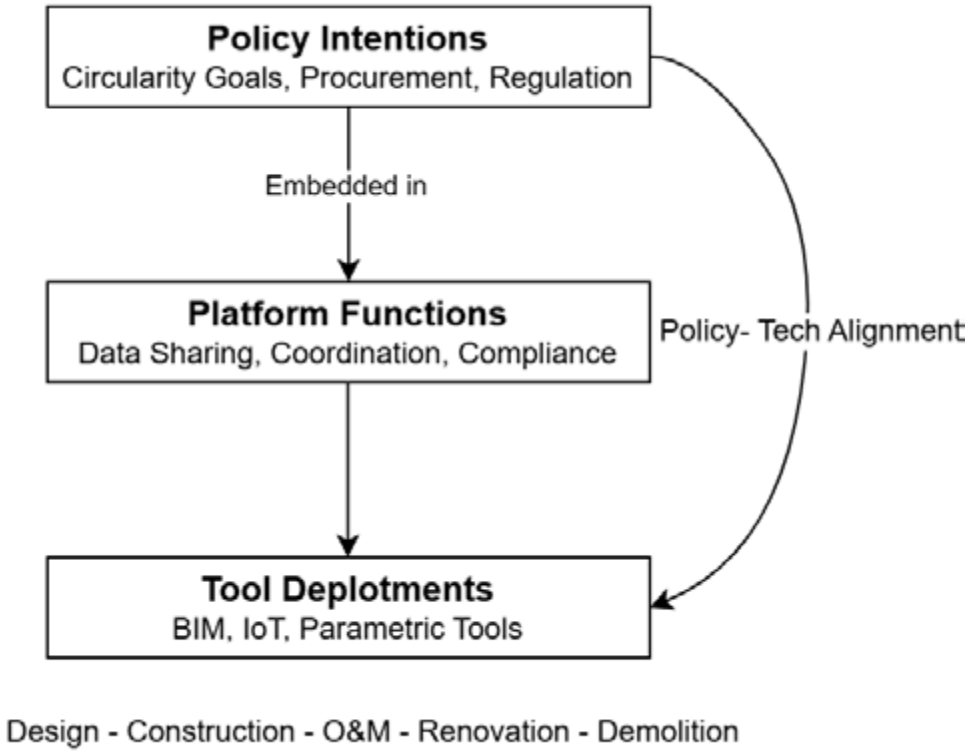

Figure 3. Platform-Enabled Alignment Model. This conceptual framework illustrates how digital platforms mediate structural alignment across policy intentions, technological tools, and governance mechanisms

Table 2. Mapping of extracted mechanisms to coding dimensions and empirical patterns in the literature

Mechanism	Key Misalignment / Enabler	Relevant Coding Dimensions	Empirical Support (n/24)
Lifecycle Misalignment	Tools heavily concentrated in early stages; renovation/demolition under-digitised	Lifecycle Stage, Digital Tool Type	20+ mention early-stage tools; <5 mention demolition/renovation
Platform–Governance Coupling	PPP structure and governance roles often unclear or missing	PPP Project, Governance Role, Policy-Tech Alignment	Only 4 explicitly focus on PPPs; 11 specify governance
Mobility-Driven Synchronisation	Policy, data, and human flows poorly integrated across lifecycle	Mobility: Policy Flows, Data Flows, Human Flows	Mobility flows rarely co-occur; dynamic feedback poorly explored

The mechanisms are summarised in Table 2. Together, these mechanisms illustrate that digital platforms are not merely technical infrastructures, but dynamic governance intermediaries that shape the success or failure of circular transformation in PPP settings. The details are elaborated in the following subsections.

3.1 Lifecycle Misalignment Mechanism

This mechanism captures the structural misalignment between digital tool deployment and the full building lifecycle in circular construction projects. While circularity principles advocate a closed-loop system across all lifecycle stages, from design to demolition, the analysis reveals a strong front-end concentration of technological interventions.

Based on the coding of 24 studies, over 80% mention tool applications in design, construction, or operation stages, while fewer than 5 papers explicitly reference refurbishment or demolition phases. Table 1 shows that tools such as BIM, IoT, and GIS dominate the early lifecycle, while end-of-life stages are largely under-digitised. This lifecycle asymmetry results in "digital blind spots", particularly where traceability and material recovery are critical to achieving circularity goals (Dervishaj and Gudmundsson, 2024).

For instance, although BIM is extensively used for planning and coordination during design and construction, very few studies explore its integration into disassembly modelling or deconstruction logistics. Similarly, Digital Twins—while theoretically suited for long-term lifecycle tracking—are rarely applied beyond building operation phases (Azcarate-Aguerre et al., 2022; Benedetti et al., 2022).

This misalignment is reinforced by two structural gaps: (1) a lack of regulatory mandates linking demolition data to material reuse policies, and (2) the absence of platform-level integration strategies that span the full lifecycle. As a result, even advanced digital platforms struggle to support closed-loop feedback, since critical end-of-life data never enters the system.

The Lifecycle Misalignment Mechanism thus reflects a fundamental weakness in circular PPPs: unless digital tools are embedded across the entire lifecycle—including post-use and reuse phases—policy objectives related to material recovery and traceability will remain aspirational and structurally unsupported.

3.2 Platform–Governance Coupling Mechanism

This mechanism highlights how the absence of robust governance structures within PPP projects weakens the ability of digital platforms to function as alignment mechanisms between policy objectives and tool deployments. While digital platforms are widely recognised for their technical capabilities, their actual performance in circular construction depends on how well they are embedded in the institutional and contractual fabric of PPP governance.

Among the 24 studies analysed, only 4 explicitly focus on PPP projects, and merely 11 provide any detail on the governance configuration (e.g., public-led, private-led, or joint arrangements). In many cases, the role of digital platforms is reduced to data repositories or coordination layers, with little attention to how they enforce contractual compliance, stakeholder incentives, or data sovereignty. As a result, platforms often fail to translate policy ambitions into enforceable lifecycle practices (Yu et al., 2023; Chartier and Pot, 2024)integrated information systems that are capable to identify, coordinate, and evaluate CE collaborations across heterogeneous projects are in demand. A digital collaborative hub, Circularity Information Platform (CIP. This is illustrated in Figure 4.

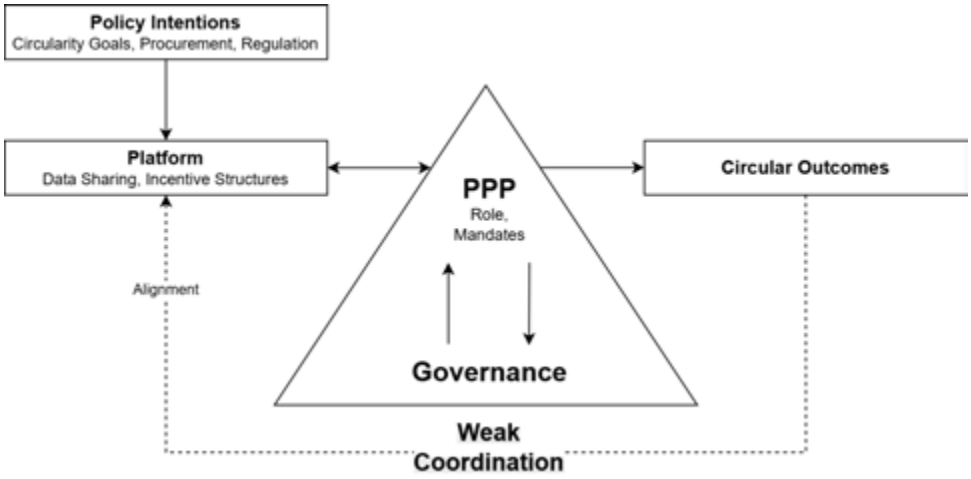

Figure 4. Platform–Governance Coupling Mechanism: illustrating weak contractual and institutional integration between platform, public authority, and private sector

For instance, Serrano (2022) show that platform efficacy in circular PPPs depends on contractual clauses that define responsibilities, access rights, and data transparency rules among actors. Without such governance scaffolding, platforms remain technically functional but politically inert. Similarly, Teigiserova and Schraven demonstrate that circularity outcomes in Dutch PPP housing projects were only achieved when platforms were backed by formal procurement mandates and institutional incentives (Teigiserova and Schraven, 2024).

The mechanism is further complicated by fragmentation between policy design and platform development. Many digital systems are developed by technology vendors or municipalities in silos, while policy makers and regulators are not involved in platform logic. This leads to implementation gaps—platforms that track data but lack authority, or policies that demand outcomes with no tool-based enforcement mechanism.

The Platform–Governance Coupling Mechanism thus reveals that alignment failure is not a technological problem, but a governance one. Without embedded authority, platforms cannot coordinate actors, distribute accountability, or translate circular goals into operational mandates.

3.3 Mobility-Driven Synchronisation Mechanism

3.3 Mobility-Driven Synchronisation Mechanism

This mechanism builds on Mobility Theory (Urry, 2007), which views modern systems as constituted through flows—of people, policies, information, and goods. In the context of circular PPPs, platform efficacy depends not only on structural deployment and institutional design, but also on the ability to synchronise multiple flows across the lifecycle and actor network.

However, the analysis reveals significant flow decoupling in the literature. Although 18 studies mention policy–technology alignment in some form, very few articulate how policy updates are operationalised through platforms, or how real-time data is used for feedback into regulatory processes. Furthermore, only a minority of studies (Yu et al., 2023; Teigiserova and Schraven, 2024) discuss cross-organisational collaboration as an embedded feature of platform logic.

For instance, in the Dutch "Circular Information Platform" case, Yu et al (2023) describe how material databases, LCA tools, and design software were interconnected, while the system relied on external incentives rather than integrated flow coordination. Similarly, Chartier & Pot observed that while policy dashboards existed in Nijme-

gen's PPP platform, there was little integration of citizen feedback or inter-departmental data exchange (Chartier and Pot, 2024).

Urry's framework helps explain why platforms often fail despite high technical capacity: these coordination breakdowns are illustrated in Figure 5, where policy, data, and human flows are depicted as interdependent but weakly synchronised. Solid arrows indicate desired coordination pathways (e.g., data flows enabling policy feedback), while dashed lines represent fragmentation. For instance, data from BIM/IoT platforms is often not fed back into procurement criteria (policy flow), and human collaboration across design, regulatory, and contracting units lacks institutional support (human flow). This weak synchronisation undermines the platform's potential to enable adaptive and circular outcomes.

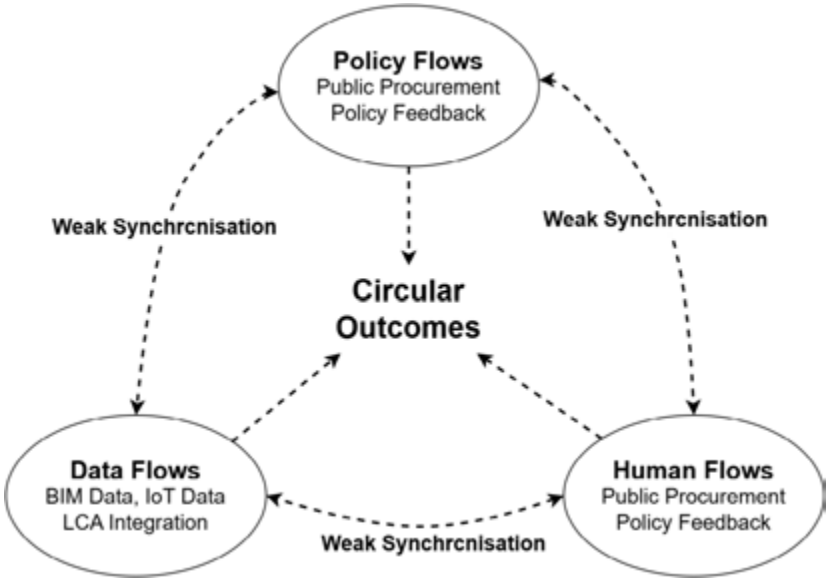

Figure 5. Mobility-Driven Synchronisation Mechanism. The diagram illustrates how circular outcomes depend on the effective synchronisation of policy flows, data flows, and human collaboration via digital platforms

The Mobility-Driven Synchronisation Mechanism therefore captures a dynamic misalignment: unless platforms are designed as multi-flow synchronisation infrastructures—connecting policy intentions, real-time data, and actor actions—they will fail to deliver system-wide circularity, regardless of governance or tool sophistication.

These three mechanisms collectively reveal that platform-based circularity in PPPs cannot be achieved through technical deployment alone. Structural coverage, institutional anchoring, and dynamic flow synchronisation are all necessary conditions for meaningful alignment between policy ambitions and material outcomes.

4. Discussion: Toward Mechanism-Informed Circular Governance

4.1 Translating Alignment Mechanisms into Design Challenges

This study identifies three systemic misalignments—lifecycle concentration, governance fragmentation, and flow decoupling—that collectively limit the capacity of digital platforms to support circular outcomes in PPP contexts. Each mechanism signals a distinct but interdependent research challenge:

(1) Lifecycle misalignment: The concentration of digital interventions in early building phases leaves end-of-life

stages under-digitised. Research should explore platform functionalities that support downstream activities, such as design-for-disassembly, demolition-data feedback, and reuse tracking.

(2) Platform–governance decoupling: Platforms often lack formal authority, operating as passive repositories rather than active coordinators. Future work should investigate how PPP contracts, institutional mandates, and platform governance roles can be re-designed to embed platform authority.

(3) Mobility-driven flow disruption: Digital platforms rarely synchronise the dynamic flows of policy, data, and people across lifecycle stages. Platform design must evolve to support cross-department data exchange, real-time feedback mechanisms, and contractual incentives for collaboration.

Together, these challenges call for a shift from platform deployment to platform architecture design—not just what platforms do, but how they govern, integrate, and learn across time and scale. Moreover, the three mechanisms do not operate in isolation—lifecycle gaps amplify governance ambiguities, while both undermine the potential for flow synchronisation. Understanding these interdependencies is key to platform redesign.

4.2 Regional and Conceptual Research Gaps

Despite the growing attention to circular platforms, the literature remains skewed toward Western European case studies, often situated in digitally mature, policy-rich contexts. These insights require adaptation to regions where PPPs face limited digital infrastructure, fragmented governance, or weaker enforcement environments.

Conceptually, terms like “integration” or “participation” are used rhetorically without institutional detail, and “digital tools” are often assumed to support circularity without tracing their role in material recovery or end-of-life planning. Future research should clarify the conceptual boundaries between sustainability and circularity, and explicitly link platform functionality to measurable circular outcomes. Moreover, most existing studies lack methodological frameworks capable of linking platform design choices to traceable circular performance outcomes. Addressing this gap should be a key priority for future empirical research.

4.3 From Diagnosis to Research Design: A Mechanism-Oriented Agenda

Based on the misalignments identified, this study proposes three strategic research directions. First, there is a need for cross-contextual validation to understand the conditions under which alignment mechanisms succeed or fail. Comparative research across different policy environments, contractual models, and lifecycle stages can reveal how asymmetries and disconnections in material and information flows manifest across various PPP regimes. Second, digital platforms should be prototyped not merely as coordination tools, but as flow-oriented infrastructures that synchronize policy feedback, enable traceable data exchanges, and distribute responsibilities across actors. Such prototypes can help bridge gaps between high-level circular ambitions and operational realities. Third, the integration of AI into platform governance presents both opportunities and risks. While AI can enhance predictive capabilities and dynamic alignment, it should be embedded within accountable and inclusive frameworks. Governance sandboxes or contractually bounded testbeds may offer controlled environments to evaluate AI’s performance not only in terms of efficiency but also in terms of equity and transparency. Ultimately, achieving alignment in circular PPPs is not solely a technical challenge—it is a matter of thoughtful design and responsible governance.

4.4 Visualising Alignment Architecture

To synthesise these findings, this paper proposes an Alignment Mechanism Model (Figure 6), mapping how misalignments across lifecycle, governance, and flows intersect to obstruct circular goals in PPPs. Rather than

treating platforms as neutral infrastructures, the model reframes them as governance-intensive systems whose performance depends on their institutional embedding, temporal continuity, and functional coherence. As such, the model offers both a diagnostic lens and a design heuristic—guiding empirical validation and informing future platform architectures tailored to circular goals.

Figure 6 synthesises these dimensions into a unified model, illustrating how circular governance failures emerge from the intersection of lifecycle asymmetry, governance fragmentation, and unsynchronised flows. At the core of the model is platform-based circular governance, which acts as a mediating mechanism between structural lifecycle phases and the need for flow-based coordination. Lifecycle misalignment is associated with coordination failures across different project stages, while mobility-driven synchronisation highlights the importance of aligning material and data flows across actors and timeframes. The figure underscores the importance of embedding authority within platforms to mitigate fragmentation and enable synchronised, circular outcomes.

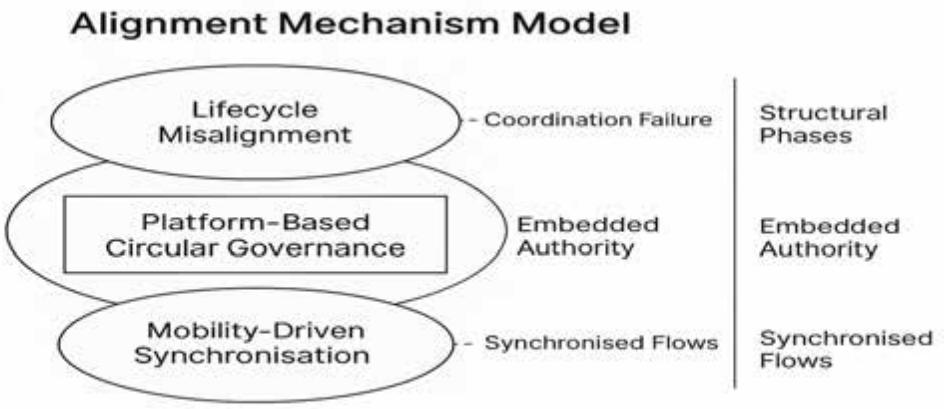

Figure 6. Alignment Mechanism Model

5. Conclusion and Policy Implications

This study set out to investigate how digital platforms mediate the alignment between policy goals and technological interventions in circular Public-Private Partnership (PPP) projects. Through a mechanism-oriented systematic literature review (SLR) of 24 core studies, it identified three interdependent misalignments, which are lifecycle asymmetry, governance fragmentation, and flow disruption, that collectively constrain the systemic capacity of platforms to enable circular outcomes. These findings suggest that digital circularity is not merely a matter of tool adoption, but a governance challenge that demands institutional integration, lifecycle coherence, and flow-based coordination.

Looking forward, platform-enabled circularity requires a shift from tool cataloguing to mechanism construction. Future research should validate the three mechanisms across diverse PPP contexts by examining how alignment breakdowns manifest under varying governance maturity, policy enforcement capacity, and infrastructural conditions. Experimental prototypes of digital platforms should be developed not just for integration, but also for synchronisation by embedding features such as real-time policy feedback, traceable data architectures, and incentive-compatible actor coordination. Equally important is the investigation of platform performance across scales: how effectively can platforms translate national circularity mandates into localised, lifecycle-informed interventions?

Ultimately, alignment is not a technical state. It is a design and governance achievement. As AI-enhanced platforms gain prominence, future studies must critically examine how algorithmic coordination tools can be embedded in transparent, inclusive, and adaptable institutional frameworks. Only through such systems-oriented experimentation can platform-based circularity advance from conceptual promise to operational transformation.

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Appendices

Appendix A. Search Strings Used in the Systematic Review

Search Focus	Search String
Part 1: Identifying Digital Technology	(circularity) AND (public spaces OR community spaces OR urban infrastructure OR built environment) AND (digital tools OR smart technology OR digital twin OR BIM OR IoT OR decision support tool*)
Part 2: Governance and Participation in PPPs	(circularity) AND (public spaces OR community spaces OR urban infrastructure OR built environment) AND (public-private partnership OR PPP)
Part 3: Resource and Material Management	(circularity) AND (material reuse OR waste management OR resource efficiency) AND (built environment) AND (digital tools OR BIM OR IoT OR digital twin)
Part 4: Intersectional Integration	(circularity) AND (built environment) AND (digital tools OR smart technology OR BIM OR IoT) AND (material reuse OR waste management OR resource efficiency) AND (PPP)

Databases: Web of Science, Scopus, ScienceDirect

Time span: 2014–2024
Language: English
Document Type: Peer-reviewed articles and review papers

Appendix B. Inclusion and Exclusion Criteria

B1. Abstract Screening Criteria

Inclusion	Exclusion
Mentions the **AECO sector** (architecture, engineering, construction, operations)	Focuses on unrelated domains (e.g., agriculture, generic urban policy)
Refers to **circular economy practices** (e.g., reuse, efficiency, low-carbon)	Only discusses sustainability in broad or undefined terms
Includes **digital tools or platforms** (e.g., BIM, IoT, Digital Twin, DSS)	Lacks any mention of digitalisation or technological intervention

B2. Full-Text Evaluation Criteria

Inclusion	Exclusion
Provides **empirical or analytical detail** enabling coding of mechanisms	Theoretical papers without clear empirical basis or methodological transparency
Discusses **digital tool deployment** across one or more lifecycle stages	Describes tools in abstract without lifecycle integration
Addresses **platform functions** (e.g., coordination, traceability, monitoring)	Mentions tools but omits platform-level architecture or governance discussion

Inclusion	Exclusion
Contains reference to **PPPs or multi-actor collaboration or governance mechanisms**	No indication of stakeholder interaction, public-private dynamics, or PPPs or governance dimension or stakeholder role specification

Appendix C. Coding Framework Variables

Dimension	Sub-Dimension	Examples
STRUCTURE	Lifecycle Stage	Design, Construction, Operation, Renovation, Demolition
	Digital Tool Type	BIM, IoT, Digital Twin, GIS, Blockchain
	Circular Goal	Reuse, Efficiency, Emission Control
PLATFORM & GOVERNANCE	PPP Model	Housing, Infrastructure, Public Works
	Platform Function	Monitoring, Coordination, Data Sharing
MOBILITY FLOWS	Policy Flows	Green Procurement, Policy Feedback, Regulatory Embedding
	Data Flows	Transparency, Traceability, IoT-based Monitoring
	Human Flows	Multi-Stakeholder Collaboration, Cross-Sector Teams

(Refer to Table 1 in the main text for operationalisation.)

Appendix D. List of Included Studies (n=24)

(Sorted by year of publication)

Author(s)	Year	Title	Source
Mangialardo, Alessia & Micelli, Ezio	2018	Rethinking the Construction Industry Under the Circular Economy: Principles and Case Studies	European
Maye, Damian	2019	'Smart food city': Conceptual relations between smart city planning, urban food systems and innovation theory	Europe
Antoniol, Emilio & Ferrari, Margherita	2021	From Crisis to a Sustainable Future: Processes of Technology Transfer from Europe to the MENA Region	MENA Region, Italy
Hirvensalo, Antero et al.	2021	Agency in Circular City Ecosystems—A Rationalities Perspective	Finland
D'Amico, Gaspare et al.	2021	Digital Technologies for Urban Metabolism Efficiency: Lessons from Urban Agenda Partnership on Circular Economy	European Union
Abadi, Mohamed & Moore, David	2022	Selection of Circular Proposals in Building Projects: An MCDM Model for Lifecycle Circularity Assessments Using AHP	United Kingdom
Casini, Marco	2022	Chapter 1 - Toward a new building era	Not Specified
Shukla, Saurabh & Hait, Subrata	2022	25 - Smart waste management practices in smart cities: Current trends and future perspectives	India
Azcarate-Aguerre, Juan F. et al.	2022	Facades-as-a-Service: The Role of Technology in the Circular Servitisation of the Building Envelope	Netherlands

Serrano, Will	2022	Verification and Validation for data marketplaces via a blockchain and smart contracts	United Kingdom (Newcastle Urban Observatory, UCL PEARL Project)
Benedetti, Anna Chiara et al.	2022	The Process of Digitalization of the Urban Environment for the Development of Sustainable and Circular Cities: A Case Study of Bologna, Italy	Bologna, Italy
Liu, Qinglan et al.	2022	A Framework of Digital Technologies for the Circular Economy: Digital Functions and Mechanisms	Not specified
Chen, Xiangru	2022	Machine Learning Approach for a Circular Economy with Waste Recycling in Smart Cities	Not specified
Beck, Donizete et al.	2023	Achieving the sustainable development goals through stakeholder value creation: Building up smart sustainable cities and communities	Not specified
Yu, Yifei et al.	2023	Circularity Information Platform for the Built Environment	Netherlands
Fahfouhi, Karim; Craveiro, Flavio; Bartolo, Helena	2023	The Role of Construction 3D Printing in Advancing Sustainability and Digitalization in Africa	Africa
Al-Raqeb, Hanan et al.	2023	Overcoming Barriers to Implementing Building Information Modelling in Kuwait's Ministry of Public Works: A Framework for Sustainable Construction	Kuwait
Ullah, Fahim; Olatunji, Oluwole; Qayyum, Siddra	2023	A scoping review of green Internet of Things in construction and smart cities: current applications and future directions	Not Specified
Wang, Liang et al.	2023	The controlled environment agriculture: a sustainable agrifood production paradigm empowered by systems engineering	Not specified
Banihashemi, Saeed et al.	2024	Circular economy in construction: The digital transformation perspective	Not specified
Chartier, Angeline; Pot, Wieke	2024	How to decide upon circular cities: The role of digital tools in participatory decision-making	Nijmegen, Netherlands
Teigiserova, Dominika A.; Schraven, Daan F. J.	2024	A comprehensive framework for circular product-service systems in infrastructure: Enhancing customer-contractor collaboration	Netherlands
Toprakli, Abdurrahman Yagmur	2024	Enabling circularity in Turkish construction: a case of BIM-based material management utilizing material passports	Turkey
Saradara, Shadeedha Mohamed et al.	2024	Advancing building construction: A novel conceptual framework integrating circularity with modified lean project delivery systems	Not specified

Intersection of Digital and Physical: Phygital Urban Public Spaces

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Abstract
Public space is in a constant state of evolution, continuously reshaped by its sociocultural context, technological advancements, and the shifting needs of urban life. This research aims to investigate the role of phygital spaces in transforming public space by transcending physical limitations. It intends to help rethink public space and phygital public spaces' potential to revitalise underutilised urban spaces. Using expert interviews and thematic and framework analysis, the research identifies key themes such as social interaction, space activation, governance and design. The research argues for a reconceptualisation of public space that embraces digital integration, offering an alternative framework relevant to urban planners, designers, and policymakers addressing contemporary spatial challenges.

Keywords: Phygital Space, Public Space, Underutilised Spaces, Spatial Digitalisation

Introduction

Space is a dynamic product of social relations (Lefebvre, 1991). These social relations are especially prominent in public space since it is the stage of communal life (Carr et al., 1992). With digital technologies improving and being incorporated into our daily lives every day, there is also a transition in social life in the context of urban public space with this change in contemporary society's needs, demands and perception towards space (Castells, 2004). People use public space relatively less than they did in the past for various reasons (Cybriwsky 1999; de Freitas, 2010; Bazzanella et al., 2014; Akkar Ercan, 2016; Lee, 2020; Badel & López Baeza, 2021; Del Vecchio et al., 2023).

Reconceptualising public space in this sense can be an alternative design approach towards new placemaking to encourage people to use public space more. Phygital spaces can be exemplified as an alternative due to their emphasis on user experience and flexibility in terms of physical limitations. This approach can be used in underutilised urban spaces to activate these spaces, and this way reintegrate them into the urban fabric.
To further investigate the potential of phygital spaces especially as a way to transform underutilised urban spaces, the following research questions are posed:

- What is the potential for phygital space to transform public space socially and spatially?
- How can they be used to enhance the value and functionality of underutilised public areas?
- How do individuals perceive public spaces that integrate physical and digital elements?

Phygital Space

Phygital spaces represent the intersection and interweave of digital and physical realms where the boundaries of these two realms are blurred (Mele et al., 2022). The term "phygital" was first introduced by a marketing company that created it as a conceptual idea of branding that contained "immersive real-world experience" (Nofal et al., 2017, p. 220). In terms of urban planning, digital tools are used to enhance the physical space and thus user's experience enriching the way they interact with their environment and sometimes with each other (Bazzanella et al., 2014; Brusaporic&Maiezza, 2021).

The idea is simply capturing each realms' best features and eliminating bad ones, strengthening both (Nofal et al., 2017; Mele, 2022; Sui & Shaw, 2022). They are immersive and mostly interactive. They have a promising potential for both storytelling since they are a great and mostly fun way to transfer information, and for engagement

and co-design with the potential of gathering opinions from citizens and actually analyse and evaluate their behaviour in these spaces. Through both of these potentials the crucial part is they can be conversation starters, social interaction points, collaborative and collective experiences because they can be attractive and interesting for many people (Bazzanella et al. 2014; Andrade & Dias, 2020; Cevallos Andrade & Del Blanco García, 2025). As Del Vecchio et al. (2023) underlines, people are both passive users and creators of the meaning of new public places in urban phygital environments, which serve as a foundation for new intentional or unintentional community sharing.

Additionally, they are placeless and adaptive, meaning they can be inside/outside, a façade/ big open space/ small room, in the urban periphery/centre. They are independent of many laws because they are not fixed, changeable, removable, flexible.

Space Activation through a Phygital Approach for Reclaiming Underutilised Spaces

Space activation can be achieved through daily use or attachment to the place, so feeling a sense of belonging, identity. To be able to attach a place -and since it is a public space in the first place-, it needs to be accessible and inclusive. All these elements are tied to people's perceptions of space and that is in the hands of urban planners and designers that "make place". The concept of placemaking is creating shared memories through different social groups and improving quality of life (Chen et al., 2022; Pavlaki, 2021). Digital placemaking is augmenting physical places with digital services to improve the quality of these spaces thus attracting people and enhancing social, cultural, environmental and economic value of places (Morrison, 2018). Therefore, if these spaces can be made places through digital interventions (phygital approach), they can be used as a technique to revitalise and reclaim underutilised spaces by activating them the same way as well.

Underutilised urban spaces are a byproduct of growth in every city mostly as a cause of losing or reducing value (i.e. the meaning and use) due to lack of planning or one that didn't anticipate some certain consequences leading to areas that are unwanted (Lynch, 1960; Trancik, 1986; Di Giovanni, 2018; Hwang& Lee, 2019). They create disconnectivity and discontinuities in urban fabric and become something in between with no clear purpose especially in heavily populated cities (Trancik, 1986; Sameeh et al., 2019; Azhar et al., 2020). Beyond only being empty or vacant, there are other types of underutilised spaces such as mono functional spaces which are limited to a part of the day or only some events. Reusing and revitalising these spaces are a great way to create cohesive and interconnected urban fabric spatially and socially (Di Giovanni, 2018; Sameeh et al., 2019).

There are many possibilities and potentials on how to achieve this activation such as creating safer environments, more greenery, better accessibility. Along with these approaches, the research proposes another opportunity that is focused on digital interventions. By taking advantage of digital tools and technologies, these spaces that are often neglected and/or overlooked can be integrated into the broader urban and functional system in a novel way.

Case Studies

A wide spectrum of case studies from around the world are explained for a more concrete and better understanding of phygital spaces varying in temporality (temporary vs. permanent), interactivity (interactive vs. non-interactive), thematic orientation (heritage and culture-focused vs. entertainment- or infrastructure-driven) and public accessibility (open public spaces vs. controlled environments) (Table 1).

Table 1: Comparison of case studies.

Case Study	Urban Context	Technological Approach	Cultural Dimension	Financial Accessibility	Location
Basel Cathedral	Enhancing cultural heritage	Projection mapping	Cultural heritage preservation and narrative	Free	Indoor exhibition in public space
Rel:attiva Presenza	Narrating local neighbourhood history	Projection mapping	Explanation of the identity of a neighbourhood	Free	Indoor exhibition in public space
Luminous Pathway	Promoting social interaction	Interactive Lighting	Everyday urbanism with artistic approaches	Free	Square
Hagia-Sophia H&E Museum	Enhancing cultural heritage	3D animations immersive environment	Cultural heritage preservation and narrative	Paid entrance	Indoor museum
The Sphere	Transforming the silhouette	High-res LED immersive environment	Futuristic entertainment	Paid entrance	Indoors venue

Krypta unter der Vierung in Basel Cathedral is a permanent and immersive installation in the basement of Basel Switzerland's main cathedral. The cathedral is crucial to the city and its image since it is over 1000 years old and has had many different phases. There is a narrative explaining the history of Basel through these phases with animations, lights and projections over the oldest Roman ruins in the cathedral (Figure 1). It exemplifies how digital technological interfaces can mediate between the past and present, enabling cities to reinterpret underused or hidden spatial layers through cultural heritage (Bernasconi et al., 2019).

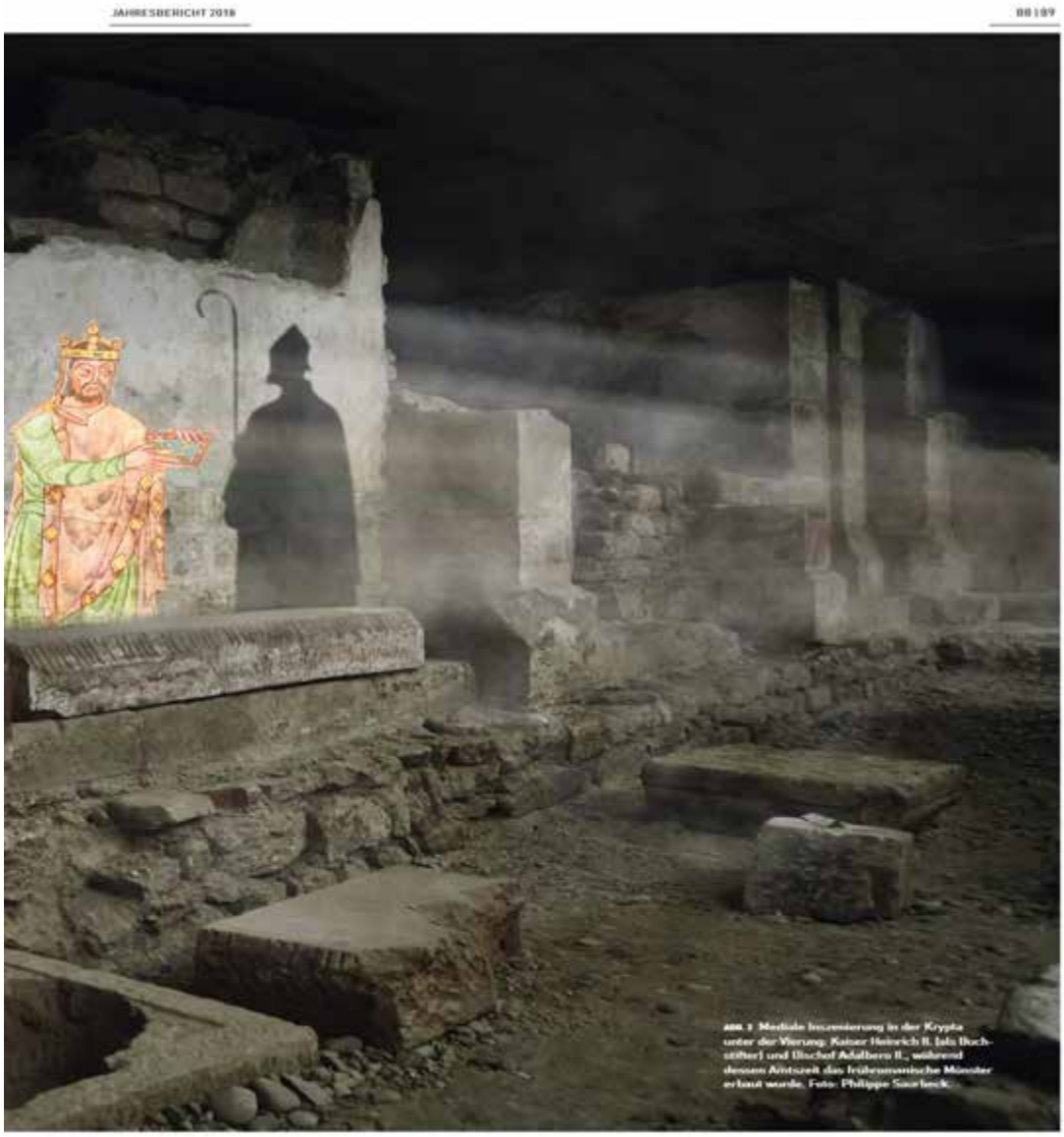

Figure 1: A part of the exhibition (Bernasconi et al., 2019, p88-89).

Rel:attiva Presenza was a temporary and immersive installation made in 2008 with projection mapping and sound environment in Mexico. The purpose was to describe the mutation of Coyoacán neighbourhood through time to create a narrative of the culture which is a historical and very important neighbourhood in Mexico City (Figure 2). The designated users were also the residents that had lived through these different forms of the neighbourhood, and this acted as the archive of perceptions, experiences and narrative of those people enabling them to reinterpret their environment with heritage (Iaconesi & Persico, 2013).

Figure 2: A part of the exhibition (AOS, 2008).

Luminous Pathway is a visionary media architecture and urban design project in Montréal, Canada in Quartier des Spectacles (QDS) which is the city's vibrant cultural district. The whole space covers 8 public spaces and 80 venues that change content and context (Figure 3). It is permanent as urban projection sites and temporary as luminous installations. The aim of the design is to attract people's interest, motivate them to engage, amaze, entertain, and provoke thought. It serves as a benchmark for experimental urbanism and media architecture where light acts as a spatial setting to change the perception and use of public space creating a sense of belonging. (Quartier des Spectacles, 2015; Quartier des Spectacles, n.d.)

Figure 3: Quartier des spectacles in 2023 (Quartier des spectacles, n.d.).

Hagia Sophia History and Experience Museum in İstanbul, Türkiye is an immersive and interactive museum with a historical narrative that blends digital technologies and cultural heritage again through a very crucial and iconic

building. Visitors are guided through a chronological journey from a pagan temple to a Byzantine cathedral and to an Ottoman Mosque including the stories of all 3 versions of rebuilding Hagia Sophia and with it İstanbul in different time spans (Figure 4). It has an urban memory and an urban perception in it that comes with such an important structure that shapes people's perception of the area after the visit of this phygital space adding another layer of importance and emotion on the visitor's eyes (Çelik &Kahraman, 2024).

Figure 4: The collapse of the dome of Hagia Sophia in past remodeled (Dem Museums, 2024, 7:19)

The Sphere is an immersive entertainment venue in Las Vegas, USA that is quite unique in terms of immersive architecture and experimental design (Figure 5). Very high technological equipment is used to achieve that level of immersive experience for many people which also brings high costs and sustainability issues (Nisa, 2023).

Figure 5: The inner design of The Sphere (Florian, 2023).

Methodology & Data Collection

The research used a qualitative method mixing thematic and framework analysis based on **in-depth interviews** with experts selected through purposive sampling. 10 experts participated in the research and experts were chosen based on their experience on intersecting themes of public space and digital transformation. There were urban planners, architects, interior and landscape architects and digital technology experts that have contributed to the research. While the sample size may appear limited from a quantitative standpoint, the aim was not statistical generalization but rather the extraction of rich, contextual insights.

The data of expert opinions was collected via semi-structured interviews based on 10 questions prepared with the light of research questions, objectives, literature review and case studies. There were 4 main themes in the questionnaire; general definitions and conceptual framework of phygital spaces, transformation of public spaces and digitalisation, transforming unused spaces and reconceptualising public space, future trends and recommendations (please see Appendices for the full interview form). The reason for the semi-structured design was to allow flexibility to the experts to engage in further conversation related to their expertise or newer topics that might be related to the topic.

Questionnaire for the interviews are presented below:
1. How do you evaluate the impact of merging physical and digital environments on public spaces?
2. What are the main advantages and disadvantages of phygital public spaces compared to traditional public spaces? Tip: Consider aspects such as accessibility, user engagement, privacy, economic opportunities, and over-reliance on technology.
3. Which urban challenges can be addressed through digitalization in public spaces? Tip: Some key challenges include overcrowding, rigid spatial configurations, lack of engagement in planning, inefficient land use, and public safety concerns.
4. What are the key drivers accelerating digitalization in cities? Tips: Factors may include urbanization, technological advancements, smart service demands, digital governance, sustainability goals, and citizen engagement.
5. What aspects of digitalization contribute most to user experience and satisfaction in public spaces? Tip: Think about factors like education, entertainment, personalization, and engagement.
6. Do you think phygital public spaces are effective in enhancing social interaction? Under what conditions are they more effective? Tip: Social engagement could be influenced by factors like design, ease of use, or cultural acceptance of technology.
7. What are your thoughts on transforming unused or underutilized urban spaces through phygital approaches considering limitations of size, capacity, and location? Tip: Examples include turning abandoned lots into interactive parks or using projection mapping to revitalize historical sites.
8. In your opinion, can the integration of digital technologies provide a sustainable solution for revitalizing underutilized spaces? Tip: Consider environmental, economic, and social sustainability in your response.
9. Do you think phygital public spaces can help create more attractive, functional, and sustainable urban environments? If so, how? What are the biggest barriers to implementation, and how can they be addressed?
10. Do you have any additional insights or perspectives on phygital public spaces?

The answers of the expert's insights were analysed through a combination of thematic analysis; identifying and analysing themes within qualitative data and framework analysis; systematically organising and interpreting this data through a structured matrix of themes and subthemes to identify patterns, relationships, and meaning. (Braun & Clarke, 2006; Ritchie & Spencer, 1994). Themes were created from the interviews based on the frequency and relevancy of the answers and later matrixes were created from summarised answers of interviews to have a holistic understanding of all experts' contributions for the topic.

Results

From the combination of literature, case studies and experts' answers and insights, a thematic and framework analysis has been conducted (Figure 6). Firstly, all interviews were transcribed and familiarised. Then, 6 themes have been created from codes in consideration with literature and case studies. Then the interviews were in-

dexed with the determined themes and matrixes were created with the summarised data from the indexing to be able to compare experts' opinions on the themes and interpret.

Figure 6: Word cloud from expert answers for each question.

The first theme is Blending of Digital and Physical Experiences in Public Spaces with 2 sub-themes: their evaluation of phygital spaces and the comparison to traditional public space (Table 2). Generally positive comments predominate in terms of the basics of phygital spaces.

Table 2: Blending of Digital and Physical Experiences in Public Spaces

Experts	Their evaluation	Comparison to traditional space	Keyword
A	Integration of these is quite seamless nowadays but digital is an augmentation that always reflects the precise moment where it is used in physical space.	Traditional public space is the inevitable goal and digital is an addition to it.	Integrated, Layer
B	It is more of a digital infrastructure, sensors and service in public space	People don't see traditional and enhanced space the same so they don't try to act like it but to immerse themselves in the digital parts more individually.	Amenity

C	There are many aspects to it like sensors, the environment and an interface level with people.	Digital enhancements create an alternative to a permanent physical infrastructure, maybe creating simpler solutions.	Diverse, Alternative
D	-	Users of merged digital and physical spaces can only compare the two with answering what value it brings	Layer
E	They could be both a bad experience that disconnects people from space with personal devices and also good one with a design that utilises digital tools well.	As the experience enriches the space, it might be a way of getting people's attention more.	Potential
F	There is a new type of physicality created through digitality which is a new cross-section.	It changes the perception of public space maybe by creating awareness for the existing space.	Enhanced
G	The integration depends on the users and their interest and background.	-	Dependent
H	As of now, such a discourse of integration or blending of digital and physical spaces is too bold.	-	Unrealistic
I	The boundaries of such a distinction of digital and physical space no longer exist.	-	Integrated
J	The integration of these spaces is positive because of an information layer that doesn't need effort.	With new layers like visuals, narratives and information, our experience in space changes than the traditional space (which is a different and still valuable experience as is)	Innovative

The second theme is Social Dynamics with 3 sub-themes: interaction, participation and engagement/co-design (Table 3). While some experts argue that social issues should be dealt with mostly basic design principles and several think that digital additions have a positive effect.

Table 3: Social Dynamics

Experts	Interaction	Participation	Engagement/ Co-design	Keyword
A	Digital enhancements don't necessarily improve social interaction.	Allows to have more ideas of the residents	-	Irrelevant
B	It generates different types of interactions but that might not be the result of digital technology.	Might create better outcomes because it is used to get data	-	Diverse interaction
C	Pointing at things together is the core of interaction and digital enhancements could create many things to point at with people.	Adding a digital layer makes it possible for a lot of people to participate in the imagination of what a public space can be.	They can be used to show a preview of space while being designed to make decisions on it with the people.	Convenient
D	A digital layer must be designed in a way that would enhance interaction than diminishing it.	Personal devices must not be the approach to create a suitable environment for participation.	-	Dependent on design
E	They help the creation of an arbitrary collective formed by users	The interactive nature makes participation and engagement to space easier and more effective maybe.		Easier
F	People are attracted to space through digital tools and meet in physical spaces enhancing interaction that makes them spend more time there than usual.		Adding digital layers to design processes is much more meaningful than seeing it as a billboard.	Communication
G	Social interaction is crucial in phygital spaces which is what is aimed.	Working with different types of people is beneficial for participation such as age	-	Goal
H	Interaction is encounters of people and aesthetic experience is individual not social.	Community engagement and participation cannot be discussed through these digital enhancements because there is very little material to talk about.		Irrelevant
I	It can increase interaction.	It could be used to get data about the demand.	There is not yet a bottom-up approach on these spaces.	Method for design

J	It is an effective way to increase interaction.	-	Gamification of spaces can be a great way to co-design and engage people.	Effective

The third theme is Governance, Ethics and Regulation of Phygital Spaces with 3 sub-themes: ownership, accessibility and inclusivity (Table 4). All experts gave great importance to the issue and highlighted the importance of these to create an equitable public space for all.

Table 4: Governance, Ethics and Regulation of Phygital Spaces

Experts	Ownership	Accessibility	Inclusivity	Keyword
A	Digital enhancement of any kind requires a budget, even through a public entity it will have a profit-driven or controlling approach that needs a digital conduct to be developed.	-	People who are disadvantaged such as homeless people might not be welcomed in these spaces.	Controlling
B	They create a controlled space either by a private or government. There should be implications and more research on the effects.	-	Might create inclusivity issues	Controlling
C	Ethical barriers like privacy or publicness of space are difficult problems.	It must be made sure that public space is still truly public and available and free for everyone. Digital additions might only serve privileged groups if not community oriented.		Inclusivity
D	A digital layer means controlled and regulated which can be both good and bad so there must be a balance of openness and security.	Space can be more accessible through a digital layer in terms of time of the use.	-	Reachable
E	-	Accessibility and inclusivity are about the basic design principles so the physical part not the digital one.		Irrelevant
F	The borders and level of digitality must be determined to decide on what should be regulated and controlled.	-	-	Prepared
G	-	Public space must be accessible and inclusive in any case, here the difference can be to determine who demands the digital additions.		Irrelevant

H	The digital space is controlled and limits the publicness of space.	Digitalisation is a tool of inequality now, there is a serious difference between societies that can access digital technology and those that cannot.	Because of the high possibility that these spaces are private and for a fee, it is semi-public so not entirely inclusive.	Controlling
I	-	The accessibility of digital technology might be limited because of infrastructure but will be overcomed with time.	-	Promising
J	-	-	-	-

The fourth theme is Revitalisation and Sustainability of Underutilised Spaces (Table 5). Some experts thought that phygital spaces would be an excellent match for the goal whereas others state that for a full transformation there must be something permanent that can fit into a daily routine, and they don't see digital interventions as such. Almost all experts underlined that physical basic design principles must be a part of the transformation and most thought that it is spatially, socially and economically sustainable as it is refunctioning a space.

Table 5: Revitalisation and Sustainability of Underutilised Spaces

Experts		Keyword
A	The biggest advantage of digital advancements is an opportunity to gain attention for certain underused and unrecognised spaces. It is sustainable socially and spatially.	Intriguing
B	Integration of digital technologies can provide a sustainable solution for revitalising underutilised spaces under circumstances, they can support the process, but they aren't transforming space by themselves.	Secondary
C	Digital could be few steps ahead of physical but ultimately physical investment must happen to really revitalise the space, it could be used as a drive to engagement and investment that would result with the aimed physical redevelopment.	Temporal
D	It is a good way to activate space in a flexible and temporary way without physical investment needed. But, there needs to be supporting reasons to use a particular underutilised space, digital things aren't enough by itself. The reason behind why this space isn't used must be investigated and connected to a supply demand approach.	Temporal
E	A well-designed physical space is needed for revitalisation, digital technology or digital tools are an addition of support.	Secondary

F	It is a great opportunity to revitalise the underutilised spaces from big parks to facades which would be very sustainable spatially.	Potential
G	There is a potential of revitalisation that would direct people into these areas providing economic, social and spatial sustainability but it is important to decide the reasoning behind it. If it is profit-driven, it might as well stay as it is.	Potential
H	There is a temporary possibility of transformation of underutilised spaces but just because there aren't many examples yet, it is not likely that a low-quality space is transformed with increased user experience. And sustainability shouldn't be searched with digitalisation.	Temporal
I	It has a great potential for especially monofunctional spaces with an existing infrastructure to integrate them into the urban fabric.	Potential
J	Underutilised spaces must be transformed without digitalisation first and be in a routine, after that it can be an addition.	Secondary

The fifth theme is Space Activation with Digital Tools with sub-themes; Enhancement of Sensation/Perception, Emotion, Memory, Experience and Urban narrative (Table 6). Many experts agreed that sensation, perception and experience would be enhanced through digital additions and several experts thought that this would add to the memory and emotions felt in this space creating room for sense of belonging and identity. Additionally, some experts pointed out that urban narrative would change in a way that people are more aware of their surroundings and open to information. However, some experts thought that this would be an unnatural way of experiencing space thus wouldn't be successful enough to activate space.

Table 6: Space Activation with Digital Tools

	Enhancement of...HN					
Experts	**Sensation/ Perception**	**Emotion**	**Memory**	**Experience**	**Urban Narrative**	**Keyword**
A	Digitalisation has a chance to synchronise the perceived space with inhabitants in public space.	-	-	It might bring a collective experience for people in an existing physical public space	-	Collective
B	They affect how we perceive space	-	-	-	They affect how we navigate space.	Minor difference
C	-	Telling the story of a space that includes curiosity, and playfulness adds emotion and memory to everyday spaces		-	Digital storytelling tools enhance attachment to places through layered historical or cultural narratives.	Identity

D	The triggers of space are the basics like senses to make a place.	-	-	Adds an experience to traditional space which makes it multifunctional and interactive.	Sensations could be integrated with the digital and physical application that is projected onto urban space	Novel experience
E	They stimulate the senses and load information triggering perception and thus emotion and changing the meaning of space.		Has an impact on collective memory, its construction and the creation of a culture.	Creates a new type of reality within physical space, changing the experience of the space and activate sensory ones.	Gives the possibility of space design even on a blank canvas that can be changed constantly	Adaptable, Identity
F	It changes the whole perception of public space.	-	-	Additions of experiences and playful interactivity can boost a sense of belonging.	People can participate more in the physical public space with digital additions, which makes it used more actively, effectively, for longer, activating the physical space.	Activating
G	-	-	-	The experience should be mild enough to blend in with the physical environment.	When the identity of cities and their physical reality don't create a need for interaction, digital technology may not be necessary.	Irrelevant
H	This can give a different form to the processes of sensing, feeling and mutual learning.		It wouldn't create memory because it is not organic.	It has the potential to transform the organic experience, into another form that is created with predefined content. We cannot anticipate the outcomes yet.	-	Cautious

I	It gives a new perspective and perception of the space at the same location and time especially when supported with senses.	-	-	It multiplies the experience by inverting the relationship of the user and space with being impressive and immersive.	It provides new ways of urban historical narrative that could be very informative.	Impressive
J	The spatial perception can be enhanced with digital tools.	-	The aim should be to create a memorable environment	It would create a new type of learning experience.	It can increase the awareness of an urban space with seamless information	Expansion of understanding

The sixth and final theme is Context Specific Design and Local Adaptation (Table 7). All experts highlighted the importance of context by content, culture, scale, location, existing situation of the physical environment, users and many more. They all agreed that without a context of specific space the evaluation of the phygital space is impossible since the context might vary vastly especially in different cultures but also in the same city or even the same neighbourhood. They stated that it depends on the people's existing perception of that space to be able to assess the change.

Table 7: Context Specific Design and Local Adaptation

Experts		Keyword
A	A context-oriented design approach is needed to have a certain observation and outcome with an emphasis on where the digital enhancement is done, by whom and how it could impact the public space.	Consequence
B	Technologies aren't the fast and easy solution; purposeful implementation is needed depending on the context. Social innovation, political will and change in public administration processes are needed.	Dependent on policy
C	Digital technologies are tools, not solutions. A sustainable integration must be adapted to local social, cultural and political contexts and must match people's needs rather than just being aesthetic or entertainment functions.	Need-driven
D	The design can never be disconnected from the context and the people.	Dependent on design
E	It depends on the place, scale, need and context. It might not be possible in every culture or urban environment.	Conditional

F	Design has an important role here. Digital additions can be integrated according to its scale, context, need, demand, user profile and usage patterns.	Dependent on design
G	The concept of phygital depends on the design, location and situation such as ease of use or cultural acceptance.	Acceptance
H	It is necessary to create a discourse of meta-digitalisation formed by associating the typologies of different types and contexts with how the experts evaluate them through a feedback mechanism.	Open to correction
I	The most important aspect is to integrate culture and locality into these spaces that would spark the interaction and participation.	Integration
J	The local adaptation and harmony of the space is very important for people to accept it.	Acceptance

Overall, it can be said that majority of the experts see phygital spaces as an opportunity for promising space activation and enhancement but without forgetting the essentials for proper design and planning structures and principles. They see it is an added value to a space, and that public space should already be of high-quality, accessible for all, inviting and welcoming both physically and by digital content including as an approach for revitalising an underutilised space. But most experts state that space can be activated through digital tools, and it is most of the time more effective or easier than physical investments.

There is a tie in terms of if social interaction could be achieved in phygital spaces mostly because of digital technologies' way of personalisation and individualism depending on who initiates this space which is why there should be regulations to make this space more accessible and simply available.

Finally, all the experts stated that phygital spaces depend on the context and can be successful only if it matches the physical, cultural, social and political sphere of the designated space.

Findings & Discussion

The general results of the expert interviews revealed that there is a consensus on change of user's perception and experience of space with the integration of digital technologies into public spaces. All experts investigated WH- questions for almost every question and have expended the questions and their insights mostly depending on their own expertise.

Integration of physical and digital spaces: Majority of experts agreed that the blending of digital and physical spaces is already underway. They emphasized that that digital layers should complement rather than replace physical space. According to them improvements in spatial conditions must first adhere to effective and well-established physical design principles, which should then be enhanced through thoughtful digital augmentation.

Sensory experience and memory: Most of the experts viewed phygital spaces as a challenge to traditional public space. They stressed the importance of existing public environments and the sensory experiences they offer in daily life—such as sounds of people and animals, or the smell of coffee. After establishing this, about half of the experts acknowledged that in certain contexts, phygital enhancements could enrich these experiences by making them more interactive and immersive, potentially encouraging the creation of new memories. Many

emphasized that the information that phygital interfaces provide is much more memorable and integrated than traditional space resulting in more awareness of surroundings. Because of this they can be a great way to create a collective memory and reinforce participation and local identity with urban narratives, digital storytelling, gamification through spaces that have historical and cultural value.

Practical benefits and data utilization: Majority of experts agreed that digitalisation can create innovative solutions for practical issues like communication between users and stakeholders especially due to the responsiveness potential of it. Several experts added that these spaces can be as platforms for collecting data from users—such as through speech input, surveys, co-design activities, or urban analytics—which can inform future design processes.

Temporality, flexibility and revitalization: Almost half of the experts thought that digital approaches are a great way to overcome rigid spatial configurations or investment hardships in congested urban areas due to phygital space's temporality opportunity and flexibility in terms of space and context. Especially in this sense, it was seen as a good opportunity for revitalising underutilised spaces without physical limits like size, capacity and location. Yet almost all experts emphasized that for this revitalisation to last basic design principles must be prioritised.

Critical perspective, ethics and governance: Nevertheless, several experts also pointed out that they are mostly controlled environments and thus there is an immense importance of content and context. All experts have underlined the importance and need of thoughtful design, ethical frameworks and governance models that pay attention to equity and long-term spatial justice.

With the light of these insights and previous literature and case studies, it can be said that phygital spaces are an alternative of space activation, and they can be used to reintegrate underutilised spaces to the broader city scape.

Expert opinions were a great match to the fragmented insights from different researchs in the literature review, even though the term phygital was new to many experts which is why there aren't many relevant comparisons to its definition in their eyes and the literature. Key themes from literature such as digital placemaking and space activation through digital interventions, adaptability, interactivity, immersivity were mentioned by almost all experts in a positive way complying with each other. Especially the cultural values and leisure time activities in public spaces that were very visible in many of the case studies were mentioned by the experts as enhanced experience, perception, sensation, emotion, and thus identity.

As also the patterns and inconsistencies of consensuses and conflicts show the nature of the topic to be polarising, and that individual experiences or perspectives might play a bigger part. This is why while experts' backgrounds were influential in terms of the results, all occupation groups' ideas were quite sharply divided in all questions. For each of the ten questions, responses were typically split, with around five experts expressing a positive view on phygital approaches and five a critical one, though the individuals in each group varied across questions. Nevertheless, there were many aspects that experts brought themselves up and agreed upon due to the general approach and favour of basic design principles. These aspects were a result of the cautiousness on the potential power that the designer institution holds in these spaces to the context and content.

In general, phygital spaces seem to bring more awareness and knowledge with them that could create an individual or collective identity. Nonetheless, this doesn't mean that urban challenges can be fixed entirely with digital additions. For permanent and just solutions to them, basic design principles that care about human centred, high-quality spaces that prioritise citizens' well-being are critical. Phygital space that centre users experience as their nature are a notable alternative when issues such as governance, ethics, context and content are secured.

Conclusion

The research explored the evolving nature of public spaces in the digital era through phygital spaces and their potential of revitalising underutilised spaces through space activation and engagement. It tried to explain the remarks for these spaces as a way to reconceptualise public space overcoming conventional limitations.

The findings and inferences from literature review, case studies and analyses showed that phygital space can be an alternative design approach for future public spaces. This is because it adds value to the existing space in a unique way that allows for freer applications than traditional implications. This freedom brings flexibility and adaptation possibilities to space which makes it applicable to many scopes taking the local context into consideration while doing so as exemplified with the case studies. Lifting the burden of conventional limitations like size, capacity and location physically and rigid construction codes legally enables this freedom which creates new opportunities for underutilised spaces that range from abandoned and neglected to monofunctional spaces.

Additionally, the change of perception and experience of space triggers a series of events that would make people see space differently, as a place. Cultural, locational and content specific examples can be great ways to revitalise any urban space, adding new experiences especially for leisure time in public spaces. This should be supported by basic design principles to create a holistic design approach for the space to be attractive and inviting and to be able to reintegrate into the urban fabric successfully and permanently. Through this process, regulations are vital to ensure an equal and ethical public space that fosters a responsive, adaptive and interesting nature.

Limitations of this research were reliance on limited sources and case studies due to the novelty of the topic, limited sample size of experts, no direct user comments or public data and subjective judgements about the topic due to the researchers' urban planning background.

Future research can further fill the gaps through large scale surveys, sensor-based research that really examines behavioural shifts of users; context-based research that focuses on the differences of culture and content in phygital spaces; focus on different types of digital technologies and their effect; political aspect of phygital spaces in terms of content and inclusivity.

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Appendices

EXPERT INTERVIEW FORM

Research Title: Digitalization and Phygital Public Spaces: Transforming Unused Urban Spaces

Researchers: Berna Gürkan & Prof. Dr. Fatih Terzi

Research Subject: This research explores the concept of Phygital Public Spaces, examining how the perception and function of public space evolve when integrating a spatial perspective of digitalization. The study aims to understand the implications of phygital environments on urban spaces and their potential benefits, particularly in activating underutilized areas.

Individual Consent for Participation: Your participation in this study is entirely voluntary. You have the right to withdraw at any stage without providing a reason. By agreeing to participate, you confirm that you have been informed about the study and consent to your responses being used for research purposes.

Estimated Duration of Participation: The interview is expected to last approximately one hour.

Publication of Information: The information you provide with the personal information you've given below will be included in the research findings and published as part of the master's thesis. The study adheres to academic and ethical guidelines, ensuring responsible use of all collected data.

Data Recording Consent: Audio and video recording will be conducted during the interview process.

Researcher:
Interview Date:
Expert's Name:
Profession/Field of Expertise:
Institution:
Years of Experience in the Field:

SECTION 1: GENERAL DEFINITIONS AND CONCEPTUAL FRAMEWORK
Guidance: The term phygital public spaces refer to the blending of physical and digital elements in urban environments. This integration can take various forms, such as smart infrastructure, augmented reality, or interactive digital features in public spaces. In this section, we aim to understand how experts define this concept and their perspectives on its role in urban transformation.
1. How do you evaluate the impact of merging physical and digital environments on public spaces?
2. What are the main advantages and disadvantages of phygital public spaces compared to traditional public spaces?
Tip: Consider aspects such as accessibility, user engagement, privacy, economic opportunities, and overreliance on technology.

SECTION 2: TRANSFORMATION OF PUBLIC SPACES AND DIGITALIZATION
Guidance: Digitalization is changing the way people interact with public spaces and each other. Smart cities, interactive installations, and digital governance tools are reshaping how these spaces function. This section explores the evolving role of public spaces in the digital era and benefits, and challenges of integrating digital technologies into public spaces.

3. Which urban challenges can be addressed through digitalization in public spaces?
Tip: Some key challenges include overcrowding, rigid spatial configurations, lack of engagement in planning, inefficient land use, and public safety concerns.
4. What are the key drivers accelerating digitalization in cities?
Tips: Factors may include urbanization, technological advancements, smart service demands, digital governance, sustainability goals, and citizen engagement.
5. What aspects of digitalization contribute most to user experience and satisfaction in public spaces?
Tip: Think about factors like education, entertainment, personalization, and engagement.
6. Do you think phygital public spaces are effective in enhancing social interaction? Under what conditions are they more effective?
Tip: Social engagement could be influenced by factors like design, ease of use, or cultural acceptance of technology.

SECTION 3: TRANSFORMING UNUSED SPACES

Guidance: Many urban areas contain underutilized or abandoned spaces that could be revitalized through digital technologies. Phygital approaches may provide opportunities to reimagine these spaces for cultural, social, or economic purposes.

7. What are your thoughts on transforming unused or underutilized urban spaces through phygital approaches considering limitations of size, capacity, and location?

Tip: Examples include turning abandoned lots into interactive parks or using projection mapping to revitalize historical sites.

8. In your opinion, can the integration of digital technologies provide a sustainable solution for revitalizing underutilized spaces?

Tip: Consider environmental, economic, and social sustainability in your response.

SECTION 4: RECONCEPTUALIZING PUBLIC SPACE & FUTURE TRENDS AND RECOMMENDATIONS

Guidance: As technology evolves, so do our expectations of public spaces. This section explores future trends and emerging technologies that may shape public spaces in the coming decades and aims to collect additional expert insights, potential research gaps, and practical challenges for future implementation.

9. Do you think phygital public spaces can help create more attractive, functional, and sustainable urban environments? If so, how? What are the biggest barriers to implementation, and how can they be addressed?

10. Do you have any additional insights or perspectives on phygital public spaces?

Acknowledgements

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Ethical approval for conducting expert interviews was obtained from Istanbul Technical University Ethics Board. All participants were informed about the aims of the study and their rights, and informed consent was obtained prior to participation.

Digitalization, Culture and Urban Space Interaction : A Design Fiction Approach

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Abstract
The relationship between urban spaces, cultural structures and social interactions are being thoroughly transformed by the digital age. Social processes and new forms of interaction are restructuring urban space within the framework of different developments and paving the way for the emergence of a new society that produces cultural practices outside the conventional realities. These changes have transcended the traditional physical use of urban space, shifting our activities to digital environments and reshaping urban life through digital platforms. Therefore, this study aims to analyse the impact of digital technologies on the reconfiguration of urban and public spaces as well as cultural practices. It examines the hybridization of physical and digital environments in shaping urban dynamics and evaluates their potential to address future urban challenges. The research uses a "design fiction scenario-based survey" technique to model the potential impacts of digitalization on urban spaces.

Keywords: Digitalization, Urban Space, Culture, Virtual/Hybrid Space, Scenario-Based Research

1. Introduction

The dichotomy between 'reality' and 'virtual reality' dates back to ancient times in human history. The distinction between reality and virtuality has affected social norms in different historical periods. For example, in medieval society, where religion and art were at the forefront, the 'virtual' was at the forefront, while in the industrial age, the 'material' and 'tangible' came to the fore (Floridi, 2014; Levin & Mamlok, 2021). With the introduction of digital environments into our lives, the perception of the duality of real and virtual began to change, the relationship between humans and the artificial products provided by digital integration blurred and a process of transition from information scarcity to information abundance began (Batty, 1997; Floridi, 2015).

Digitalization has had a transformative impact on individuals and their relationships with their environment, adding a new dimension to the dialectical relationship between space, time and social structure. In this context, it has become increasingly important to understand the potential of social processes to shape space, as well as the potential of space and time to transform social habits. The transformations caused by digitalization in many areas of life have radically affected urban living practices and the ways of using urban space (Matsuda, 2010). The relationship established with space has transcended the physical dimension and has become reconstructed in the virtual dimension.

In this process, traditional forms of urban use are being transcended; many activities that take place in the physical environment are being transferred to digital platforms, creating new forms of urban life. Thanks to the rapid development of technology, the increasing prevalence of telecommunication systems affects the relationships between people's work, socialization, entertainment and all other activities and changes the character of their activities (Moss & Townsend, 2000). The fact that new technologies give us access to a new "place" raises the issue of how humans relate to space and place in relation to territorial life (Graham, 1998). It is thought that especially developed capitalist societies will be liberated from spatial, temporal and distance constraints and that these elements will cease to be a constraint on social, economic and cultural life (Graham, 1998; Graham & Marvin, 2002).

Urban space use culture is a dynamic structure that includes behavioural patterns, social norms and cultural practices related to how individuals use public and semi-public spaces in the city. This structure is transforming with the impact of digitalization; individuals' preferences for physical, virtual and hybrid spaces are being re-shaped. How this change is shaped according to socio-demographic characteristics remains important. In this context, examining the effects of virtual spaces and digital forms of interaction on the future culture of urban space use is critical for the transformation of today's cities and the re-functionalization of urban spaces.

Therefore, with a scenario-based approach, this study provides a comprehensive framework on how urban life will be reshaped in the process of digitalization by examining space preferences in future fictions together with socio-demographic characteristics and seeks answers to the following research questions:

1- With the development of digital technologies, how will individuals' preferences between physical, virtual and hybrid spaces change in the next 20 years in the context of their different needs?

2- How do demographic factors influence individuals' preferences for physical, virtual, and hybrid environments?

2. Interaction of Digitalization, Social Structure and Urban Space

Although the development of digital technologies was initially considered only as a tool for scientific advances and innovative approaches, it has led to radical transformations in social, cultural and economic structures over time (Batty, 1997). The foundations of digitalization were laid with the binary coding system developed by Leibniz in 1689, followed by Shannon's work on digital logic in 1938, and digital technologies became a concrete part of life with the production of the first computer in 1946 (Shannon, 1938; Castells, 2000; Jandrić, 2019). The establishment of computer-to-computer networks marked an important stage in the evolution of digital communication; today, this process has been intensively integrated into all aspects of life in areas such as big data, social media and artificial intelligence (Ilie et al., 2017).

One of the most critical turning points in the digitalization process was the creation of the World Wide Web (WWW) infrastructure. This technological development, combined with the widespread use of portable devices, paved the way for the elimination of spatial and temporal limitations; internet access became possible at any time and under any circumstances. This digital transformation, with its increasingly globalized structure, has led to the blurring of the boundaries between the real and the virtual and to radical changes in the perceptions of individuals. In this process, the concept of distance, which forms the basis of the idea of "community", has lost its importance and the forms of interaction between city dwellers have been redefined (Webber, 2013; Kellerman, 2014; Mahajan et al., 2024).

The new social structure conceptualized as information society, network society or post-industrial society, regardless of its name, is characterized by a new era in cultural structure (Bell, 1976; Castells, 2000; Webster, 1995; Uzelac, 2008). Digital technologies, which permeate almost every aspect of our lives, have led to changes not only in the use of new tools but also in our daily life practices, ways of thinking, social relations, production and consumption patterns. Therefore, digitalization should be considered not only as the development of technology but also as transformations in social and cultural structures (Hand, 2016).

Webber (2013) believes that society will eventually break away from physical proximity and integrate into social communities. In opposition to this view, Nie and Erbrig (2002) argue that online networks further strengthen communication between individuals who are part of a community, while Tayebi (2013) argues that communities still exist based on physical space, but with the advances in information and communication technologies, this has become more widespread. Floridi (2015) argues that the development and widespread use of digital tools has

had a significant impact on people and society and even argues that technology should not only be considered as digital tools but also as environmental forces that have become part of our lives.

The nature of digital technologies is changing people's habits with a disruptive effect while providing opportunities (Levin and Mamlok, 2021). Innovations in the way people experience their environment and daily activities are part of the cultural changes in the digital age. The new "networked" consciousness of society creates a new reality that we can call digital culture and all these changes deeply affect the value system and life practices of society. This change has led to a significant dissolution of the traditional social structure, which was more closely tied to physical space; the connection between place and people has weakened, while virtual communities have become more visible (Goodspeed, 2017). However, this is not only a rupture, but also the construction of a new form of spatial consciousness (Goodspeed, 2017). While digitalization weakens the relationship between place and community, it actually creates a new form of individual belonging to many places. While commuting to work, school, or home, people can check traffic updates on their phones, socialize through apps like Facebook and Instagram, order food or shop online. These services provided by digital tools are transforming urban life by disconnecting our daily life activities from physical space (Goodspeed, 2017).

The new social norms created by digital technologies have profoundly affected the way individuals use space and the effects of information and communication technologies on urban space have long been a topic of debate. The subject has paved the way for the emergence of different views. Webber (1968) argues that even when technological developments are not yet very active, physical space can be substituted and the city centre will lose its importance, Marvin (1988) argues that space will lose its value as time constraints are overcome and Pawley (1995), with his "cities without space" approach, states that developing technologies will create a need for high-capacity digital tools instead of a place for people to spend time.

Hall (1998) states that during the transition from the industrial age to the information age, skyscrapers rising in urban centres caused the urban fabric to change. Moss (1987), on the other hand, sees telecommunications itself, rather than a part of society such as white-collar workers, as influencing the growth or decline of future cities. Although Castells (2000) thinks that the telecommuting culture, which has entered our lives with the development of digital technologies, may lead to the spread of urban centres to the suburbs and consequently to decentralization and urban decentralization, Nilles (1998) and Huws et al. (1990) argue the opposite and think that the impact of the telecommuting model on urban space cannot reach advanced levels. Gottmann (1983) argues that the economic, social and cultural integration of digitalization in cities does not substitute the function of urban space but rather enables new ways of doing things in urban space that were done before digitalization. Abler (1995) supports Gottmann's (1983) view and argues that virtual spaces, which emerged as an alternative to physical space with digitalization, cannot be a substitute for real space. Virtuality would only enrich the reality of physical space and make it more layered. At this point, the idea emerges that physical spaces will be supported by digital tools and transformed into hybrid spaces.

In general, these studies address the effects of digitalization on urban space and social structure from different points of view and reveal its importance in shaping both spatial and social relations of the future. Social processes and new forms of interaction restructure urban space within the framework of different developments.

3. Case Study: The Effects of Digitalization on Urban Use Culture

In this study, an online survey method was used to understand the interaction between digitalization, urban use culture and urban space. The questionnaire was designed to test the relationship between socio-demographic characteristics and space preference and was statistically tested with the Multiple Correspondence Analysis (MCA) method.

3.1. Scenario Based Approach

In rapidly changing and transforming cities, the inadequacy of traditional planning methods to produce solutions to urban problems has encouraged researchers to use different tools. Scenario-based practices are one of them. Scenarios, which consist of stories about the future, encourage new ways of thinking among planners and participants, questioning the future effects of current policies and revealing alternative future visions and expectations for urban spaces (Chakraborty and McMillan, 2015).

According to Schwartz (1997), the concept of scenario is a way of thinking about what tomorrow might be like, discovering the changing aspects of our current lives and creating stories about the future so that we can adapt to this change. In this context, "scenario" can be defined as "A tool for organizing one's perceptions of alternative future environments" (Schwartz, 1997, p. 4). Godet (2000) mentions 5 benefits of these strategic forward-looking approaches that we can characterize as scenarios. These are: Reducing inconsistencies, stimulating imagination, creating a common language, creating a collective way of thinking and ensuring its adoption by decision makers (Godet, 2000:8). Scenarios are a way of thinking and can help people make better decisions (Schwartz, 1997). The future thinking endeavour, also defined as "la prospective", aims to create a hypothetical idea of the future by basing decisions as far into the future as possible and to find the important trends of society (Godet and Roubelat, 1996, p. 2).

Scenario-based studies can be divided into qualitative and quantitative. However, the approach coming from recent international scenario studies is that we do not need to choose between qualitative and quantitative scenarios. On the contrary, the combination of qualitative and quantitative studies gives more reliable results in analysing scenario outputs (Alcamo, 2008). The scenarios created within the scope of this study were also prepared with a qualitative approach using a storyline and presented to the participants. However, the analysis of the scenario outputs allowed the future expectations that emerged as a result of the participants' directing the scenario to be analysed with analytical methods. The prominent feature of this method is that it obtains more realistic results by blending normative information with analytical information (Goodspeed, 2017).

The scenario was created with a design fiction approach. Design fiction generates data that is used to assess the impact on lifestyles of services that do not yet exist but have the potential to exist or that exist but are not widespread (Harwood et al., 2020). The functionality of possible future technologies is explored when creating new and alternative future scenarios (Tanenbaum, 2014). By presenting possibilities that can affect society while shaping the future, the approach enables the participant to activate their imagination, suspend negative attitudes and imagine the future by blurring the boundary between fiction and reality (Bleecker, 2022).

The transformation of cities at an uncontrollable pace and the emergence of new types of spaces with the development of technology have paved the way for the use of the scenario technique as a tool in developing assumptions about the future of urban and public space (Blythe, 2014). This process helps us generate ideas that will shape the future and analyse the social impacts of current technologies. This study presents virtual and hybrid spaces that exist today, that do not yet exist, or that exist but have not yet become widespread, to the participants' preference, taking into account the developments in information and communication technologies with a scenario-based design fiction approach. In order to analyse the participants' approaches to their future physical, virtual and hybrid space preferences, 3 different scenarios were created for their lifestyles after 20 years. The scenarios were structured in three different categories for the spatial preferences of working individuals, students and non-working/retired individuals. Participants participated in the evaluation by choosing the most appropriate scenario for themselves. The scenario includes a set of activities related to daily life within the context of a story and the participants indicate the spaces (physical-virtual-hybrid) through which they would like to perform each of the activities they are asked in between the stories. These activities are grocery shopping, sports activities, travel organization, language course, museum visit, dinner and socializing.

3.2. Sample Selection

Purposive (monographic) sampling method and snowball sampling method, which are among the qualitative research sampling methods, were used to determine the participants to represent the research population.

The population of the research consists of individuals across Turkey. However, due to the practical limitations of the application such as time, resources and accessibility, a subset that is considered to have sufficient representation in terms of technology and urban space use was selected. Therefore, in order to ensure the validity and reliability of the study, the top 5 cities with the highest population in Turkey (Istanbul, Ankara, Izmir, Bursa and Antalya) were selected as the sample group in line with a structure that has high demographic and socio-economic diversity, has sufficient representation in terms of digital access and technology use, and includes sectoral differences.

The survey started with one person from each city accessing the survey link and being asked to forward it to individuals aged 18 and over in their city of residence. It was emphasized that the survey should be delivered to individuals with different demographics. In addition, the survey was also shared on social media platforms. In this respect, it can be said that convenience sampling method was also used in sample selection.

3.3. Sample Size

The confidence level in sample determination can be 99% or 95%, and the acceptable margin of error can vary between 1% and 5%. In this study, 95% confidence level and 5% margin of error assumptions are accepted. On March 15-2025, the population of Istanbul, Ankara, Izmir, Bursa and Antalya for the year 2024, which is the most recent data, was accessed through TurkStat (Turkish Statistical Institute) and only the group aged 18 and over was included in the population. The population of the 5 cities for the year 2024 aged 18 years and over is Istanbul 11.986.847, Ankara 4.531.181, Izmir 3.562.064, Bursa 2.453.932 and Antalya 2.078.804, totalling 24.612.828 people selected according to the criteria (URL-1). In order to calculate the sample size, the sampling equation in which the number of individuals in the population is known and the frequencies of discontinuous data can be measured was applied:

$$n = \frac{N.Z^2.p(1-p)}{(N-1).e^2 + Z^2.p(1-p)}$$

n: Number of samples required
N: Population size
Z: Z value corresponding to the confidence level (95%)
p: Variance ratio (0.5)
e: Margin of error (5% / 0.05)

When the required data are added to the formula, a sample size of approximately 384 people is determined with a 95% confidence level and a 5% margin of error. In the study, a sample size of 391 people was reached.

3.4. Socio-Demographic Structure of Participants

The data on the demographic characteristics of the participants obtained through the survey applied within the scope of this research play a critical role in analysing the preferences of different demographic characteristics regarding digitalization and the use of urban space. In the study, demographic data were collected and evaluated in 4 groups: gender, age, education level and employment status.

When gender distribution was analysed, 69.1% of the participants were female and 30.9% were male. The distribution according to age groups was grouped into 5 categories and 44.25% were between the ages of 18-27, 29.41% between 28-37, 15.09% between 38-47, 7.42% between 48-57 and 3.84% between 58-65. When the educational status of the participants is examined, there are no illiterate and only literate participants; 1% have primary education, 1% have secondary education, 12% have high school, 7.2% have associate's degree, 60.9% have bachelor's degree and 17.9% have graduate or doctorate level education. The majority of the participants are employed with a rate of 62.66%, 19.18% are students, 13.8% are not working and 4.35% are retired (Table 1).

Table 1: Socio-demographic structure of participants.

Demographic Characteristics		Category	Number of Participants	Distribution (%)
Gender		Female	270	69.1
		Male	121	30.9
		Total	**391**	**100**
Age		18-27	173	44.25
		28-37	115	29.41
		38-47	59	15.09
		48-57	29	7.42
		58-65	15	3.84
		Total	**391**	**100**
Educational Status		Illiterate	0	0
		Literate	0	0
		Primary Education	4	1
		Secondary Education	4	1
		High School	47	12
		Associate degree	28	7.2
		Bachelor's Degree	238	60.9
		Graduate/Doctoral Degree	70	17.9
		Total	**391**	**100**
Employment Status		Unemployed	54	13.8
		Student	75	19.18
		Retired	17	4.35
		Employed	245	62.66
		Total	**391**	**100**

3.5. Multiple Correspondence Analysis (MCA)

Multiple Correspondence Analysis (MCA) was conducted to determine the demographic characteristics of the participants. As a first step in determining demographic characteristics, the responses obtained from 391 participants were evaluated as raw data. Data on "gender", "age", "education level" and "employment status" were used to identify prominent socio-demographic groups (Table 2).

According to the results obtained, 4 basic socio-demographic profiles emerge. Student, female, respondents aged 18-27 with a bachelor's degree (Group A); working, male, respondents aged 28-37 or 38-47 with a graduate/doctoral degree (Group B); respondents with primary and secondary education (Group C); and non-working respondents aged 48-57 with a high school or associate's degree (Group D). Most of the retired participants are aged 58 and over (Figure 1.)

Table 2: Multiple correspondence analysis model summary.

		Variance Accounted For		
Dimension	**Cronbach's Alpha**	**Total (Eigenvalue)**	**Inertia**	**% of Variance**
1	.625	1.881	.470	47.026
2	.490	1.581	.395	39.525
Total		3.462	.866	
Mean	**.563**[a]	1.731	.433	43.275

a. Mean Cronbach's Alpha is based on the mean Eigenvalue

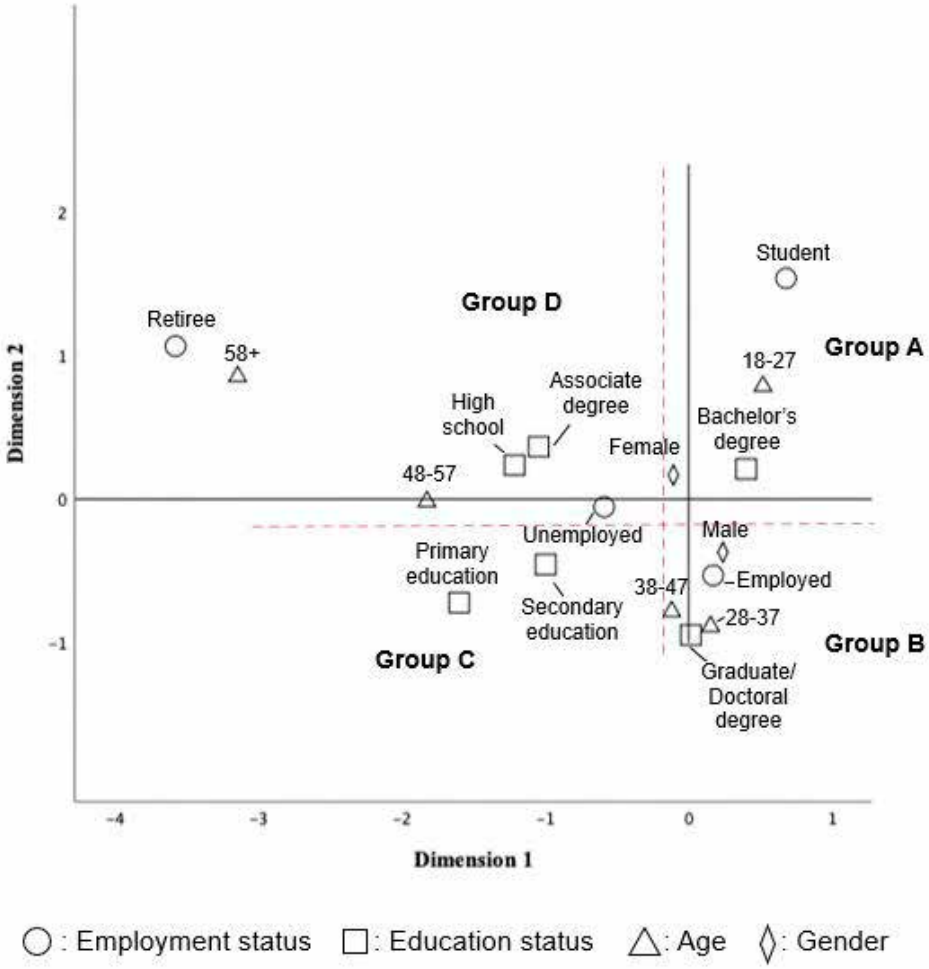

Figure 1: Socio-demographic profiles of participants.

After defining 4 socio-demographic profiles, the groups' preferences for virtual space, hybrid space and physical space in different activities related to daily life were investigated in the scenario-based survey section based on the design fiction. At this stage, "gender", "age", "educational status" and "employment status" were considered as independent variables, while the preference for virtual, hybrid or physical space according to different activity types was determined as the dependent variable.

In Figure 2, survey participants' preferences for virtual, hybrid or physical locations for grocery shopping are analysed together with socio-demographic groups. Respondents belonging to group A are highly represented by the option "Using a mobile application without leaving home". It is seen that hybrid space preference is predominant in this group. Participants belonging to group B are represented by the options "Connecting to the virtual market with VR glasses without leaving home" and "Physically going to the market but using augmented reality technology". In this group, it is seen that the preference for virtual space and hybrid space is predominant. This situation reveals that working male participants with a high level of education, between the ages of 28-47, want to experience digital technologies as well as experiencing the space and shows that they are individuals who are open to innovation and interested in digital systems. For the participants belonging to group C, there was no specific clustering feature on the choice of place for grocery shopping. Participants belonging to group D prefer the option of "physically going to the market". It is seen that participants aged 48-57, with high school or associ-

ate degree education level and not working are distant from virtual and hybrid spaces in shopping activities and prefer to shop physically.

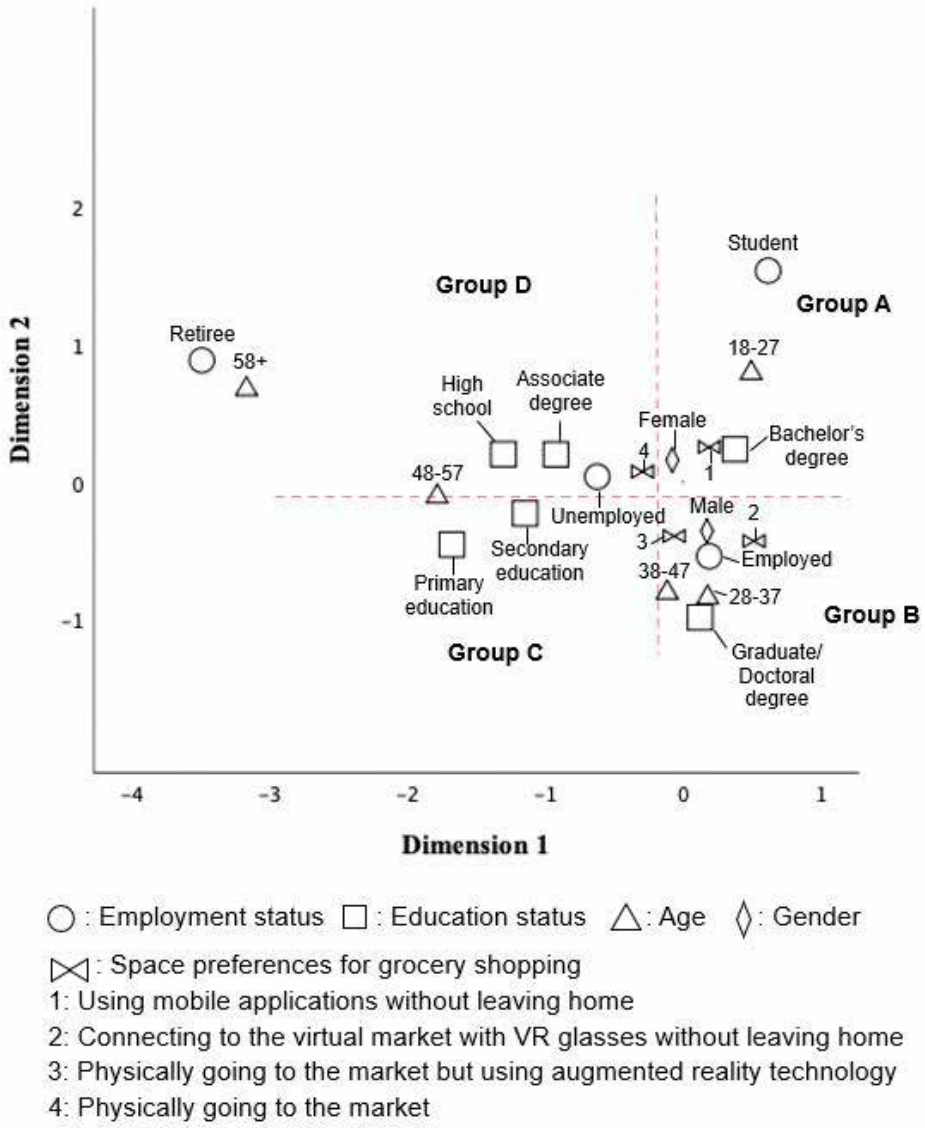

Figure 2: Socio-demographic characteristics of survey participants based on space preferences (Grocery shopping).

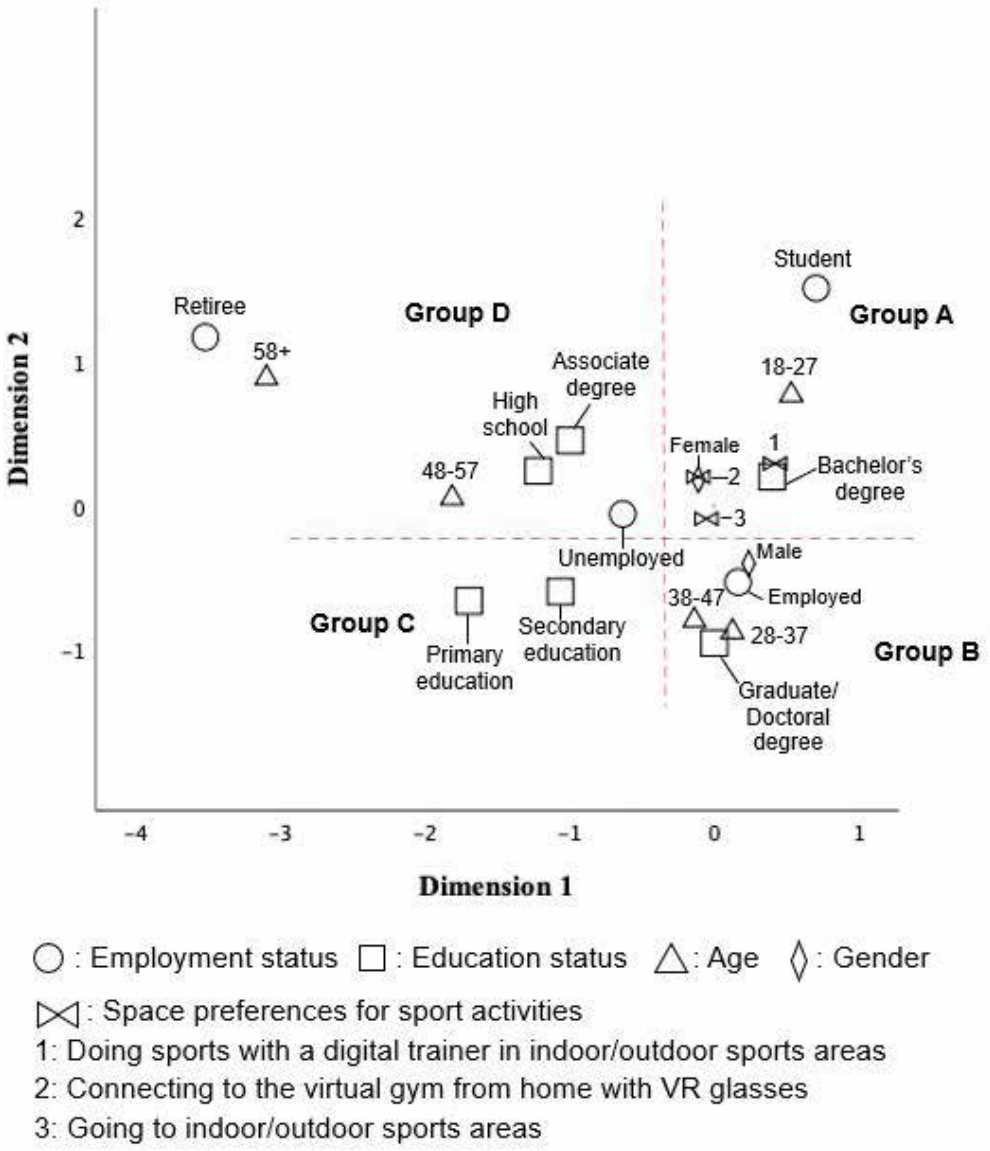

Figure 3: Socio-demographic characteristics of survey participants based on space preferences (Sports activities).

In Figure 3, survey participants' preferences for virtual, hybrid and physical spaces for sports activities are analysed together with socio-demographic groups. Participants belonging to groups B, C and D did not show any clustering in the choice of spaces for sports activities. Participants in group A are represented by all 3 space preferences: virtual, hybrid and physical. However, there is intense clustering between certain demographic characteristics and space preferences. For example, while individuals with a bachelor's degree are mostly represented by the option of "doing sports with a digital trainer in indoor/outdoor sports areas", almost all of the female participants prefer the option of "connecting to the virtual gym from home with VR glasses". This situation reveals that the participants at the undergraduate education level want to explore this space through digital tools as well as physically experiencing the space in sports activities. While female participants do not prefer outdoor spaces for sports activities, they want to experience digital tools at home and realize their activities through virtual spaces.

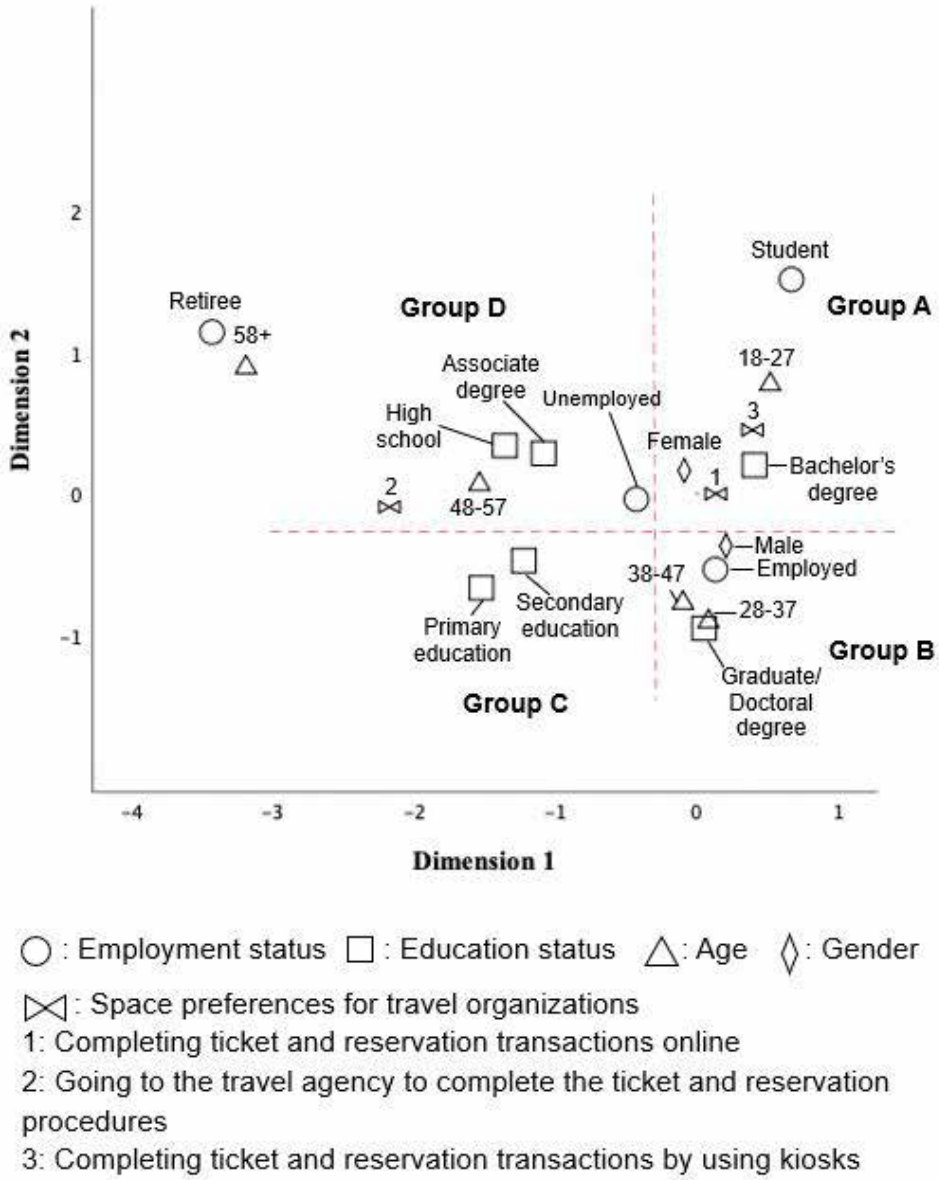

Figure 4: Socio-demographic characteristics of survey participants based on space preferences (Travel organization).

In Figure 4, survey participants' preferences for virtual space, hybrid space and physical space for travel organization are examined together with demographic groups. The answers "Completing ticket and reservation transactions online" and "Completing ticket and reservation transactions by using kiosks" stand out among the respondents belonging to group A. While it is seen that student participants at the young age group tend to prefer virtual and hybrid spaces for travel organizations, it also reveals the predisposition of this group to digital technologies. Although the answer "completing ticket and reservation transactions online" was prominent among the participants in group B, no clustering was found to characterize this group. No clustering feature was observed in the location preferences of the participants belonging to group C for travel organizations. The prominence of the answer "Going to the travel agency to complete the ticket and reservation procedures" among the participants belonging to group D reveals that the participants exhibit a tendency towards physical space preference. It is seen that the participants who belong to the middle-upper age group, have high school or associate's degree education and are not employed are distant from virtual and hybrid spaces for travel organizations

and want to complete their transactions physically.

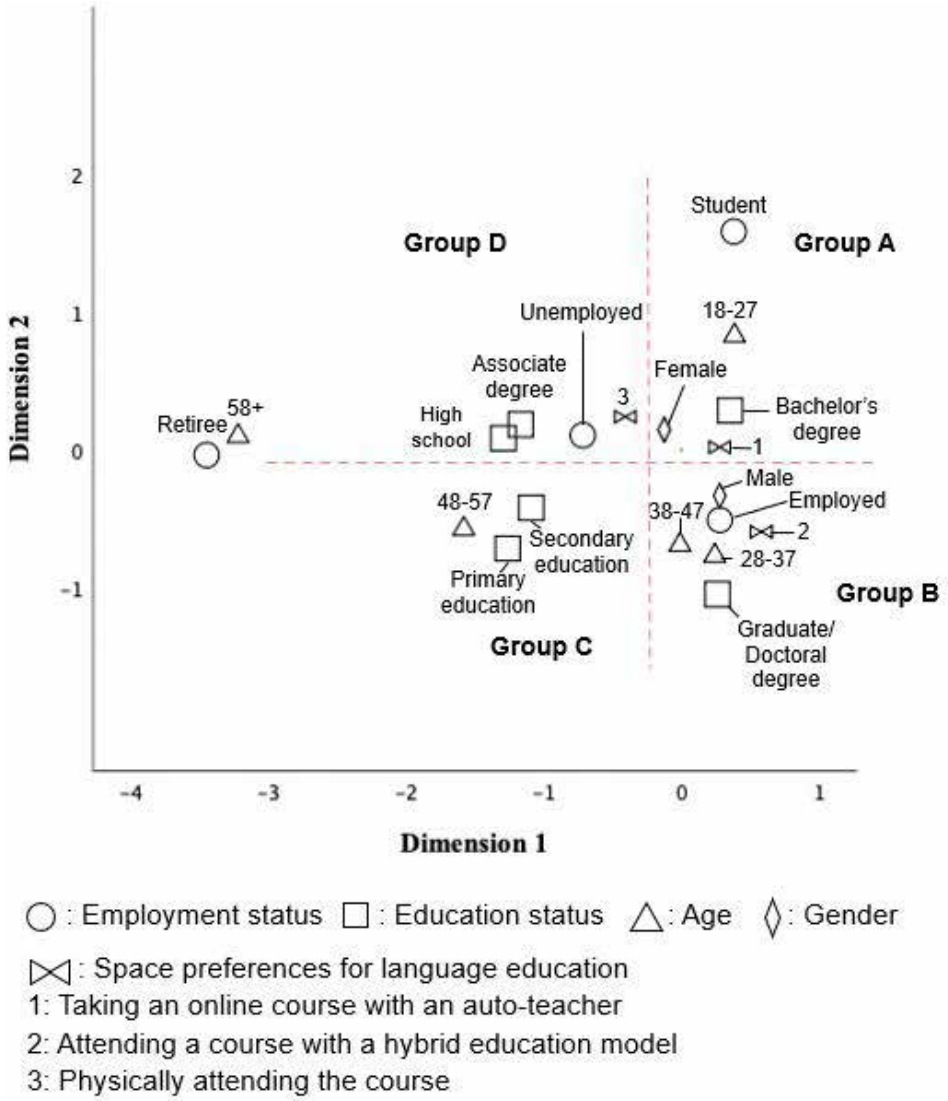

Figure 5: Socio-demographic characteristics of survey participants based on space preferences (Language education).

In Figure 5, survey participants' preferences for virtual, hybrid and physical spaces for language education are analysed together with socio-demographic groups. The answer "Taking an online course with an auto-teacher" stands out among the respondents belonging to group A. The fact that educated and student women prefer virtual spaces in the field of education is open to be associated with the fact that they have online education experiences with the effect of the Covid-19 pandemic due to their age group. Not being dependent on a place offered by online courses instead of physically going to a course for education provides a preferable environment for this group. Participants in group B show a clustering feature with the answer "Attending a course with a hybrid education model". Participants between the ages of 28-47, consisting of educated and working men, prefer an educational environment where they can both participate virtually and physically go whenever they want. When this situation is interpreted from the perspective of the working age group of these participants, it shows that a flexible understanding of space is important. Group A participants showed a tendency towards virtual space

preference and Group B participants showed a tendency towards hybrid space preference. Participants belonging to group C did not exhibit any clustering feature for the preference of location in language education. For the participants belonging to group D, the answer "physically attending the course" stands out. As a similar result with the previous questions on location preference, it is revealed that participants with high school and associate's degree education and who are not working prefer physical locations for education and want to experience the location directly without interacting with digital tools.

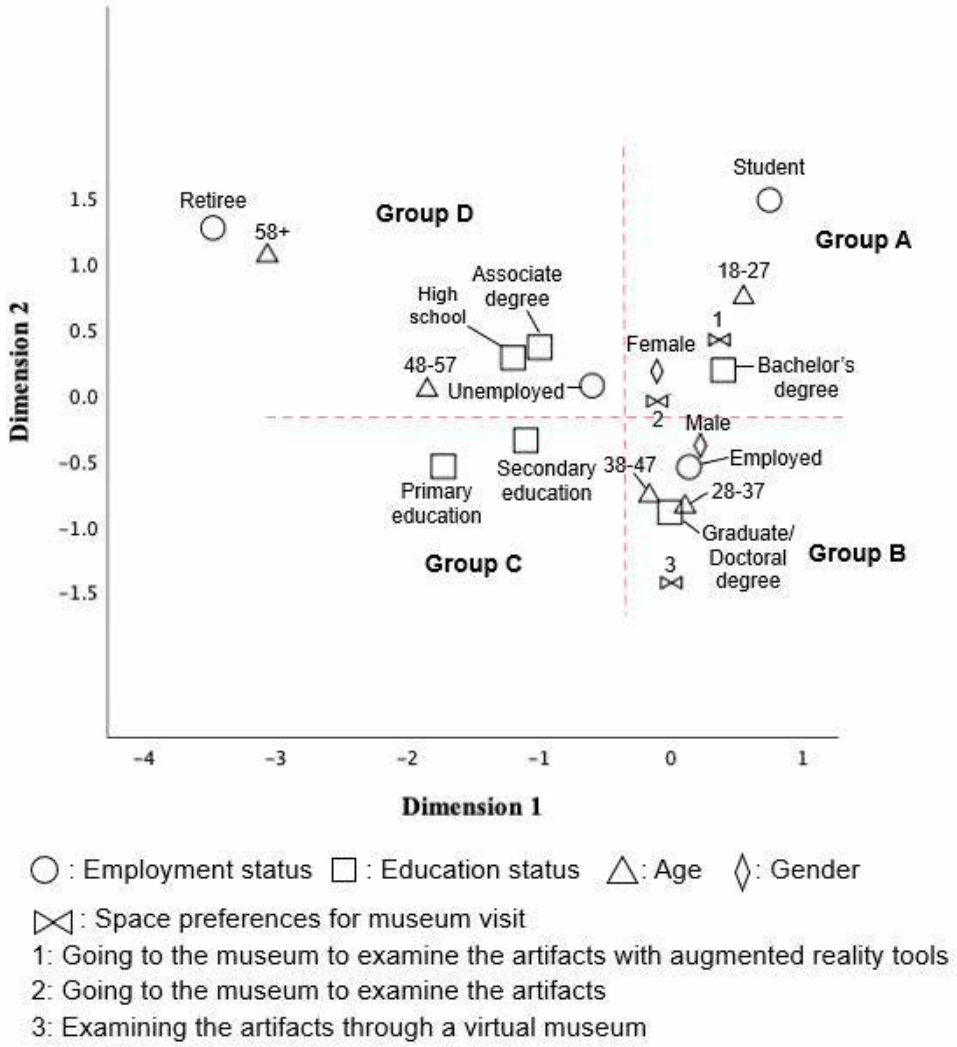

Figure 6: Socio-demographic characteristics of survey participants based on space preferences (Museum visit).

In Figure 6, the virtual space, hybrid space and physical space preferences of the survey participants for museum visits are analysed together with socio-demographic groups. The responses "Going to the museum to examine the artifacts with augmented reality tools" and "Going to the museum to examine the artifacts" show a clustering feature, especially among the participants of group A. It is noteworthy that participants between the ages of 18-27, with undergraduate education level and students attach importance to being physically present in the place in question for museum visits. However, while some of this group of participants would like to experience the artifacts in the physical space with digital tools, some of them do not prefer this. Participants in group B are represented by the response "Examining the artifacts through a virtual museum.". This reveals that 28-47 years old, educated and working men are a group of participants who are open to experiencing digital systems and innovations, as in the previous questions, and they want to realize their museum visits through virtual museum visits without the need for a physical space.

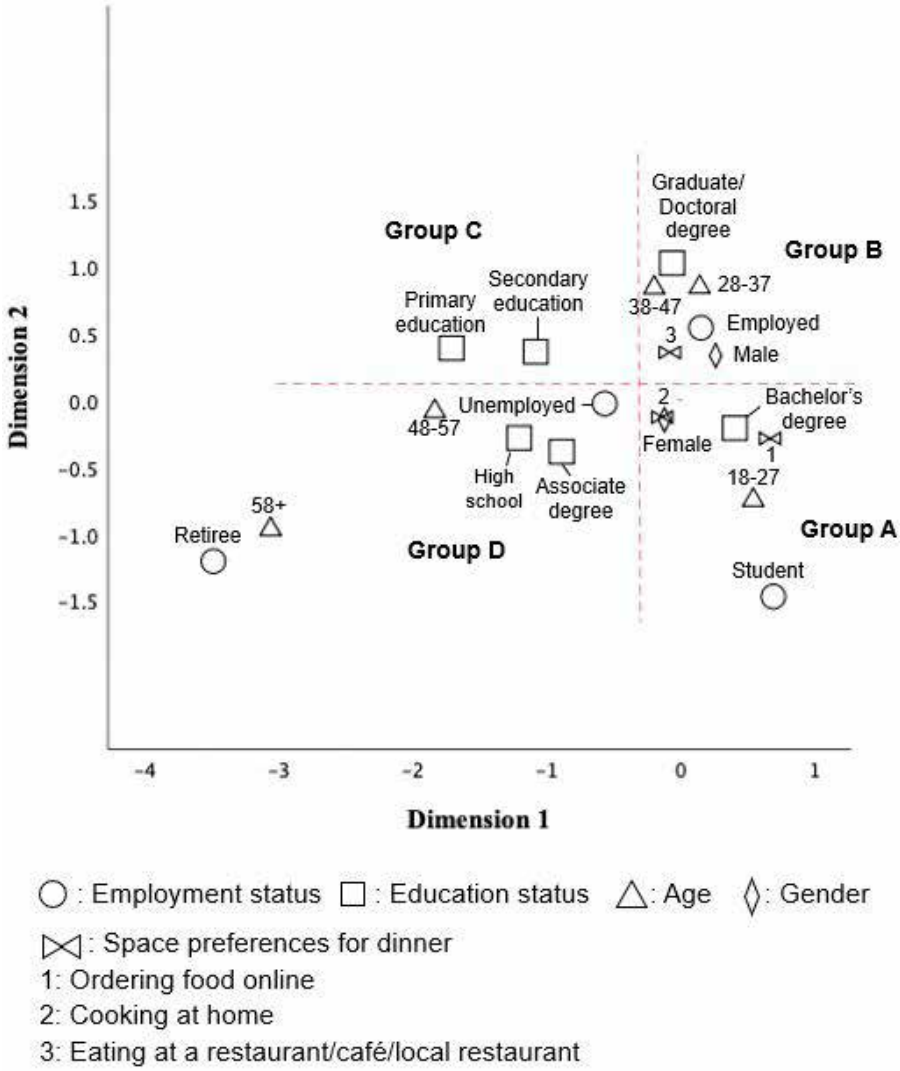

Figure 7: Socio-demographic characteristics of survey participants based on space preferences (Dinner).

In Figure 7, survey participants' preferences for virtual and physical spaces for dinner are analysed together with socio-demographic groups. The options "Ordering food online" and "Cooking at home" tend to cluster for respondents in group A. However, there is a strong correlation between certain demographic characteristics and space preferences. However, there is an intense relationship between certain demographic characteristics and space preferences. For example, almost all of the female respondents in group A prefer to cook at home, while the majority of respondents with a bachelor's degree prefer to order food online. Participants in group B, on the other hand, tend to cluster with the option of "Eating at a restaurant/café/local restaurant" for dinner. In this case, it can be said that 28-47 years old, educated and working male participants prefer out-of-home space for dinner. Participants with socio-demographic characteristics representing groups C and D did not show any clustering in their dinner preferences.

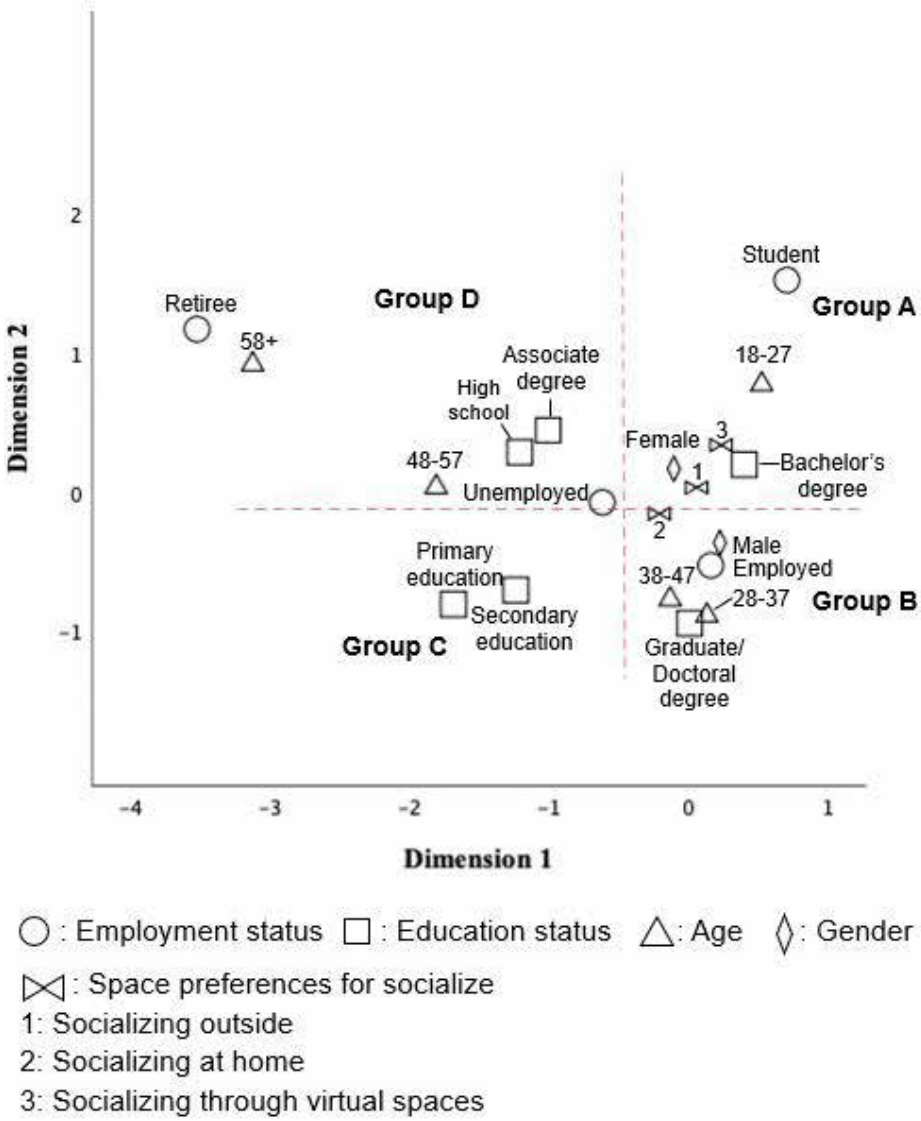

Figure 8: Socio-demographic characteristics of survey participants based on space preferences (To socialize).

In Figure 8, survey participants' preferences for virtual and physical spaces for socializing are examined together with socio-demographic groups. While the answers "Socializing through virtual spaces" and "Socializing outside" stand out among the participants in group A, the answer "Socializing at home" stands out among the participants in group B. Participants in group A preferred virtual spaces and physical spaces outside the home for socializing, while female participants generally preferred socializing outside and participants with a bachelor's degree preferred socializing through virtual spaces. Participants in groups C and D did not show any tendency characteristics in the options offered for socializing.

4. **Conclusion and Discussion**

This study aims to explore trends in the intersection of physical and virtual space in the future through a speculative approach while examining the impact of digital technologies on cultural dynamics and their potential to reconfigure urban space.

The scenario created with a design fiction approach was analysed in the context of its relationship with the future spatial preferences of the participants in line with their socio-demographic characteristics. The participants

were asked about their spatial preferences for several activities in daily life such as grocery shopping, sports activities, travel organization, language education, museum visits, dinner and socializing preferences. Multiple Correspondence Analysis was used to discover whether the socio-demographic characteristics of the participants showed a clustering feature. As a result of the test, 4 main groups emerged. These are: Female participants between the ages of 18-27, with a bachelor's degree, who are students; male participants between the ages of 28-47, with a graduate/doctorate degree, who are working; participants with primary or secondary education; and finally, participants between the ages of 48-57, with a high school or associate's degree, who are not working. Different socio-demographic groups showed certain variations in their preferences for spaces for different activities.

Student participants between the ages of 18-27, with a bachelor's degree, prefer virtual or hybrid spaces in almost all activities. This socio-demographic group prefers mobile applications for grocery shopping, digital coaches and virtual gym for sports activities, online booking or kiosks for travel organizations, auto-teachers for language education, augmented reality technologies and physical participation for museum visits, online ordering or home cooking for dinner and virtual spaces or out-of-home environments for socializing. Considering the space preference tendencies of this socio-demographic group in general, they can be called "digital natives" as defined by Marc Prensky (Prensky, 2001). As Souza e Silva (2006) points out, this group, due to the age range it represents, was born into the digital age or has been interacting with digital tools for a very long period of its life. For this reason, they prefer to perform many of their daily activities through virtual or hybrid spaces rather than interactively experiencing physical space.

Another socio-demographic group that shows clustering characteristics is the 28-47 years old, working, male participants with a graduate/doctoral degree. This group prefers to do grocery shopping through VR glasses or by using augmented reality technologies in the market, to visit artifacts through virtual museums and to use hybrid space for language education, while they prefer to go to outdoor environments such as cafes or restaurants for dinner and to be at home for socializing. When the virtual space preferences of this participant group are analysed, it is seen that they are interested in technologies that are not yet widely used but are expected to become widespread in the future and they want to experience the space together with technology. These characteristics, which Lengsfeld defines as "digital enthusiast", are represented by an intense interest in new digital technologies and an active participation in digital transformation (URL-2).

Another socio-demographic group that shows a prominent tendency in terms of location preference in the context of different activities is the participants between the ages of 48-57, with a high school or associate's degree and not working. This group prefers to go to the market for shopping, organize their travels through agencies and physically attend a course for education. Participants who prefer to experience the urban space firsthand in their daily life activities attach importance to face-to-face interaction even in the types of activities where technological applications are widely used today. It is seen that the behavioural norms brought by the digital age, which can be considered among the basic elements of cultural values, do not cause dramatic changes in the participants with the socio-demographic characteristics in question. This behaviour pattern, which tends to preserve the habits of the past, uses the Internet as a second option to access information, and which Marc Prensky calls "digital immigrants", would be an accurate approach to define the participant group in question (Prensky, 2001).

As the last noteworthy finding of the study, the expectations of different socio-demographic groups regarding their preferences for the use of urban space in the context of urban life in 20 years show different characteristics. Basically, 3 different approaches emerge: those who embrace the adopted urban use values, those who continue this tradition by being born into an already existing digital world and those who are open to the idea of experiencing urban space with digital tools. The results show that digitalization brings along various approaches in

the culture of urban space use in the context of different socio-demographic groups, thus creating the need to rethink the future of urban space.

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From Semantic to Thematic analysis: Extracting Research trends and topics from Text Data

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Abstract
Topic modelling and extraction is not a new field in synthesis-research, but with the current advancements in LLMs and Transformer-based models, such processes can as well be advanced with better accuracy and efficiency. In this paper, we explore the application of Transformer based methods, firstly to validate the domain experts based manual identification of topics and secondly, to create a benchmark method for machine-based extraction of Topics and Themes related to sustainable urban development. The research uses a corpus of documents, including Project proposals and Project profiles, from ten projects in the field of Sustainable Development. The process builds upon established methodology whereby the tokenized text is used to create embeddings with BERT (Bidirectional Encoder Representations from Transformers) to create a vector space. As part of the new proposed architecture, the embeddings are then clustered and labelled according to their cosine similarity with domain expert themes, which allows a comprehensive view of themes/topics and sub-topics.

Keywords: Topic modelling, BERT based transformers, Sustainable development, Semantic clustering, Thematic clustering

1. Introduction

1.1. Background

Sustainable urban development policies are essential to address global challenges such as climate change, rapid urbanization, and population growth. Cities, housing over half of the world's population, contribute approximately 70% of global carbon emissions and 60% of resource consumption (United nations, 2019). With urban populations projected to increase by 2.5 billion by 2050, primarily in Asia and Africa (UN-Habitat, 2020), the strain on resources and ecosystems will intensify, necessitating effective sustainable policies. Sustainable urban policies aim to mitigate environmental impacts while enhancing quality of life, resilience, and inclusivity. Climate change exacerbates extreme weather events in urban areas, posing risks to infrastructure and populations (IPCC, 2021). Effective policies must incorporate adaptation and mitigation strategies, such as green infrastructure and renewable energy, to reduce risks and vulnerability.

Furthermore, sustainable development addresses socio-economic disparities by promoting equitable access to resources and green spaces in densely populated areas (OECD, 2020). Policies encouraging resource efficiency and pollution control are pivotal for urban resilience and long-term viability. Trend analysis is critical for monitoring policy changes and literature themes in sustainable urban development. It detects patterns to identify significant shifts and emerging priorities, providing insights into policy evolution in response to societal needs and environmental pressures (Olawumi and Chan, 2018). Advancements in Artificial Intelligence (AI), particularly Natural Language Processing (NLP) and Large Language Models (LLMs), have enhanced trend analysis by automating data extraction from vast textual datasets. These tools enable real-time analyses, improving the relevance of policy insights (Levitt, 2018; Kashi and Shah, 2023). Thus, trend analysis is invaluable in navigating the complexities of sustainable urban development and ensuring that policies remain responsive and adaptive.

1.2. Rationale

Qualitative trend analysis offers significant advantages by enabling policymakers to detect shifts in priorities, assess policy impacts, and anticipate future needs. It captures nuanced changes that quantitative methods may overlook, such as emerging themes in resilience, social equity, and environmental sustainability within urban policies. As cities adopt sustainability-focused frameworks, qualitative trend analysis reveals the evolution of policy goals in response to societal and environmental demands, supporting more adaptive policymaking (Olawumi

and Chan, 2018). It also provides insights into the long-term efficacy of sustainable development policies. However, sustainable urban development involves complex interactions between social, environmental, and economic systems. Rapid urbanization and climate change present challenges not easily captured by numerical data. Moreover, the growing volume of grey and academic literature—such as sustainability reports, policy frameworks, and research papers—creates information overload, hindering decision-making. Addressing these challenges, this paper reports on the experiment undertaken to explore the application of Trend analysis in Sustainable Urban Development. The experiment aims to bring for the methodology and adaptation employed for extracting Topics from texts and converting them to themes for trend monitoring.

The paper begins with a comprehensive literature review of the scope of Topic modelling, followed by the experiment conducted with a modified version of the Transformer based models. The research is conducted within the context of the SURE Facilitation and Synthesis Research project, focusing on sustainable urban development in Southeast Asia and China.

2. Literature review

2.1. Evolution of Topic modelling

Topic modelling is a popular technique used for text analysis that provides an automatic approach for coding a collection of documents into a set of meaningful categories, known as topics (Thompson and Mimno, 2020; Lore, Harten and Boeing, 2024; El-Gayar et al., 2024). It is considered an unsupervised machine learning technique primarily used to uncover hidden patterns and structures from large sets of unstructured data (El-Gayar et al., 2024). The goal of topic modelling is to organize, search, and summarize unstructured data, making it a valuable tool in various fields (El-Gayar et al., 2024). Topic models aim to identify hidden topical patterns within a collection of texts (Egger and Yu, 2022).

Different techniques and approaches have been used to extract topics using topic modelling (El-Gayar et al., 2024). Among the most established and frequently adopted techniques is Latent Dirichlet Allocation (LDA) (Egger and Yu, 2022; El-Gayar et al., 2024). Introduced by Blei et al., LDA is a probabilistic generative model (Churchill and Singh, 2022; Egger and Yu, 2022; El-Gayar et al., 2024) that aims to discover the topics in a document based on the words it contains. It views each document as a mixture of topics, and each topic as a distribution over words (Churchill and Singh, 2022; Lore, Harten and Boeing, 2024; Kapoor et al., 2024). LDA became a widely used algorithm for extracting meaningful topics from various types of text data (Churchill and Singh, 2022; Egger and Yu, 2022; El-Gayar et al., 2024). It is often considered a classic or traditional approach to topic modelling (Mu et al., 2024; Kapoor et al., 2024).

2.2. The promise of Transformer based models

Transformer based Large Language Models (LLMs) offer a significant promise for the field of topic modelling, presenting a compelling alternative to traditional methods like Latent Dirichlet Allocation (LDA) (Mu et al., 2024). The promise of these models for topic modelling stems from their advanced language understanding capabilities and flexible application (Mu et al., 2024). Classic topic modelling approaches, such as LDA, may lack semantic understanding and struggle to capture nuanced semantics and contextual understanding (Mu et al., 2024; Kapoor et al., 2024). LLMs, on the other hand, leverage deep neural networks to learn rich, contextual representations (Kapoor et al., 2024) and can capture subtle semantic, pragmatic features, nuances, and subtle thematic undertones in language (Mu et al., 2024; Kapoor et al., 2024). This enables a richer and more detailed categorization of topics (Egger and Yu, 2022; Mu et al., 2024).

LLM-based models can generate more cohesive and interpretable topics compared to LDA (El-Gayar et al., 2024).

BERTopic and RoBERTa, representing Transformer-based models, generated more cohesive topics in a case study, where associated words were closely related thematically (El-Gayar et al., 2024). This increased cohesiveness makes the topic labelling process easier and faster compared to topics generated by LDA, which often contain a large number of focused words. While LDA may achieve a higher labelling rate, the process is more challenging due to the word count and potential overlapping labels (El-Gayar et al., 2024). As opposed to the traditional approach, LLMs or Transformer based models can produce topics with superior clustering and improved semantic coherence.

Unlike traditional methods that often require text preprocessing (like stemming and lemmatization) and post-processing like manual topic labelling and interpretation, LLMs can also aid in reducing the need for human involvement (Mu et al., 2024). They can automatically extract (or generate) topics and provide human-understandable explanations. LLMs can also be used off the shelf to automatically assess the coherence of topic word collections and their ratings have shown to highly correlate with human annotations (Mu et al., 2024). Studies have shown that using LLM-extracted key phrases for clustering can reduce noise, avoid manual data cleaning, and result in semantically concentrated clusters (Kapoor et al., 2024).

2.3. Semantic clustering

Transformer based models, such as BERT (Bidirectional Encoder Representations from Transformers) and RoBERTa (Robustly Optimized BERT Pre-training Approach), utilize contextualized word representations (Thompson and Mimno, 2020; Churchill and Singh, 2022). Unlike earlier models that assigned a single vector to each word regardless of its usage, BERT generates embeddings that capture the dynamic meaning of words in their specific context (Thompson and Mimno, 2020; Churchill and Singh, 2022; Lore, Harten and Boeing, 2024; El-Gayar et al., 2024). This capability allows BERT to understand nuanced phrases and word relationships by considering the surrounding sentence (Thompson and Mimno, 2020; Lore, Harten and Boeing, 2024). These contextual embeddings provide a better representation and performance compared to traditional word embedding techniques, especially when working with large sparse matrices in NLP (El-Gayar et al., 2024).

One significant application of these contextual embeddings is in semantic clustering. This involves grouping textual data (like words, tokens, or documents) based on their meaning or semantic similarity, as captured by the embeddings (Thompson and Mimno, 2020). Clustering token-level contextualized word representations can produce output that shares many similarities with traditional topic models (Thompson and Mimno, 2020; Churchill and Singh, 2022). Since each word type is modelled as a single vector in vocabulary-level embeddings, those methods cannot easily account for polysemy (words with multiple meanings) or leverage local context for disambiguation (Thompson and Mimno, 2020). In contrast, token-level clustering, grounded in specific documents, supports a wide range of analysis techniques (Thompson and Mimno, 2020).

A key example of a BERT-based model implementing semantic clustering for topic extraction is BERTopic (Egger and Yu, 2022; Sy et al., 2024; El-Gayar et al., 2024). BERTopic uses BERT embeddings and a technique called class-based TF-IDF (c-TF-IDF) to generate dense clusters of documents and extract topic representations (Egger and Yu, 2022; Sy et al., 2024; El-Gayar et al., 2024). The process begins by representing each document as a set of numerical values using BERT embeddings and these embeddings capture contextual information about words (Sy et al., 2024). After obtaining the high-dimensional embeddings, dimensionality reduction techniques like UMAP can be applied to transform them into a lower-dimensional space, which helps in data visualization and clustering (Egger and Yu, 2022; Sy et al., 2024). Clustering algorithms, such as HDBSCAN, are then applied to the lower-dimensional space to identify dense clusters of data points, effectively grouping documents into topics (Egger and Yu, 2022; Sy et al., 2024).

Other approaches also leverage BERT embeddings for clustering. For instance, clustering tokens based on their contextual vectors drawn from BERT using k-means clustering has been proposed as a method to produce topics (Thompson and Mimno, 2020; Churchill and Singh, 2022). Clustering vocabulary-level embeddings has been shown to produce semantically related word clusters (Thompson and Mimno, 2020). Furthermore, hybrid techniques combine manual labelling with BERT-based models, using manually created labels as training data to fine-tune a pre-trained BERT model for sequence classification tasks to identify topics (Lore, Harten and Boeing, 2024). LLMs, including BERT-based ones, combined with clustering techniques can provide a scalable approach to identifying themes and patterns in unstructured text data by leveraging LLMs' semantic understanding and clustering algorithms' ability to group similar responses (Kapoor et al., 2024). BERT-based models provide rich, contextual embeddings of text, enabling semantic clustering approaches that group words, tokens, or documents based on their context-aware meaning (Thompson and Mimno, 2020; Sy et al., 2024).

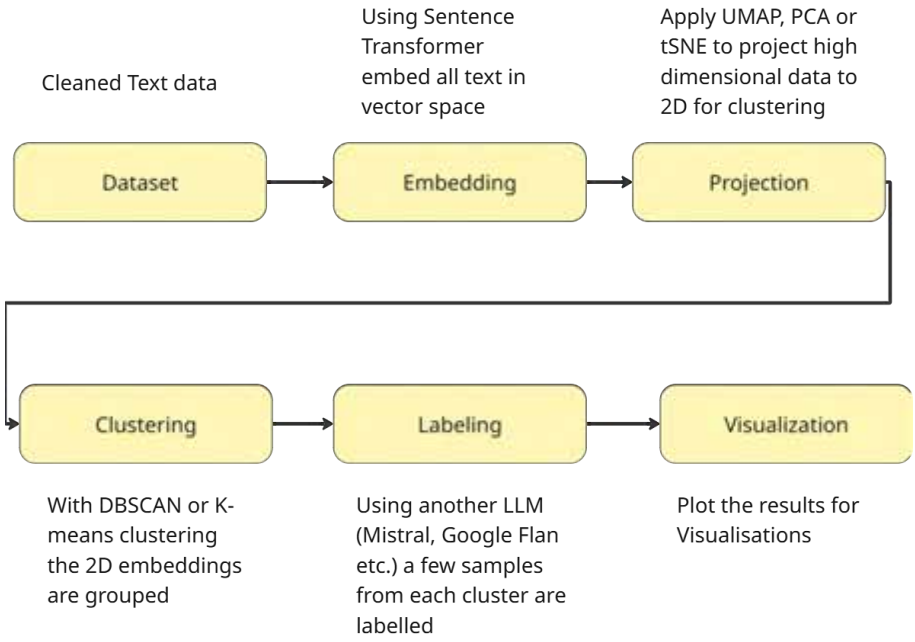

Figure 1 Typical BERT based topic modelling architecture, source: Author

2.4. Thematic Analysis

The rise of machine-based Topic modelling and analysis of text documents has provided immense help in understanding the semantic dimensions of text. This, however, is limited in some respects especially when compared with a more abstract level organization or classification of the said text. Such higher-level abstraction is where the Domain Expertise of humans becomes more valuable. Added to this, are the questions of traceability, reproducibility of knowledge and recognition of patterns over time that have been some of the obvious limitations of Machine based topic – modelling.

At the same time, Qualitative researchers have always focused upon the Thematic Analysis of texts as a qualitative analytic method (Clarke and Braun, 2017). Thematic analysis is defined as a method for identifying, analysing and interpreting patterns of meaning ('themes') within large text data (Clarke and Braun, 2017). According to Boyatzis (Boyatzis, 1998), such thematic analysis minimally organises and describes the text data in detail, but frequently goes further to interpret various aspects of the topic. Although it is one of the foundational method for qualitative analysis, there is no clear agreement about what thematic analysis is and how you go about conducting it (Braun and Clarke, 2006). Different fields of study, have approached the process of qualitative the-

matic analysis differently, but for the purposes of this research, we lean heavily on the fundamental work done by Braun & Clarke since the early 2000's (Braun and Clarke, 2006; Clarke and Braun, 2017; Braun and Clarke, 2021).

A simplistic structure proposed by (Clarke and Braun, 2017) for conducting a Thematic Analysis, involves Six main phases: Familiarising with data, generating/ extracting initial codes, searching for themes, reviewing themes, defining and labelling themes and lastly, reporting on the themes. In such a process, the researcher is not a passive participant but rather actively directs the identification of what's relevant in the text and what's not. As Braun and Clarke also argue that the notion that Themes are "Emerging" or "discovered", as a passive account of the process of analysis, denies such a role of the researcher. If anything, they conclude, Themes reside in our heads from our thinking about our data and creating links as we understand them (Braun and Clarke, 2006). There are usually two approaches to identifying themes as discussed below

2.4.1. Inductive versus Theoretical approach to Thematic analysis

In an Inductive approach, the themes are identified in a bottom-up way and are strongly linked to the text data under study. They do not necessarily need to reflect the researcher's theoretical interest in the subject (Braun and Clarke, 2006). Such an analysis involves coding or extracting key phrases from the text without any preconceptions of the researcher nor a pre-existing coding framework. As one can imagine, the Theoretical approach is driven by a researcher's analytical interest in the subject matter. The approach aligns with coding for a specific research question which is decided prior to the analysis (Braun and Clarke, 2006). In the context of Urban Development, this would be, for example, extracting phrases or coding the text on themes related to Ecosystem Services which deals with nature-based solutions.

Thematic analysis has however remained a rarely acknowledged method owing to its lack of transparency and lengthy ritual of execution. The flexibility of Thematic Analyses also allows for its drawbacks when compared to other qualitative approaches like Grounded Theory and Discourse analyses which could be considered 'Off- the -Shelf' methodologies.

2.5. Research Design

In qualitative research, a "trend" refers to a recurring pattern or tendency within data that reveals shifts over time, particularly in themes, priorities, or policy directions. A "trend signal" represents specific indicators or events that mark the emergence of these trends, such as policy revisions, increased funding in certain areas, or shifts in public discourse (Olawumi and Chan, 2018). These signals are vital as they enable researchers to identify the early stages of a trend, offering foresight into possible future developments. Key elements of trend analysis include "trend extrapolation" where researchers project current trends into the future to hypothesize potential directions (Sneegas et al., 2021). "Trend impact analysis" involves assessing the likely effects of these trends on a field, such as the impact of urban sustainability policies on climate resilience (Zhang et al., 2019). These components make trend analysis a comprehensive tool for understanding complex, qualitative data, facilitating a forward-looking perspective essential for adaptive and informed policy development.

For the purposes of our experiment, we derive the methodology for the first step of extracting "trend signals" and ascribe it the terminology of "topic extraction" which is often used in the topic modelling literature. We shall, use a modified BERT based methodology to extract semantic topics from the texts from ten projects under the SURE (Sustainable Urban Regions) funding. As we shall see, and is also advocated by (Braun and Clarke, 2006), themes do not just emerge from text but requires a certain view. Hence, we supplement the usual BERT based topic modelling architecture with a Theme mapping architecture as shown in Figure 2. Thereby, we propose a methodology for converting Semantic topics into Thematic topics.

3. Methodology

3.1. Project Data

The methodology outlines the approach used to review and analyse documents of ten research projects conducted under the Sustainable Urban Regions (SURE) initiative. The documents collected cover various phases of the projects, including the initial project proposals, the research and development phases, and the final reports. Each of these sources provides a comprehensive view of the projects, offering detailed insights into the participating institutions and collaborators, project funding structures, research objectives, identified problems, and the policy impacts. They also elaborate on the work packages, including the internal structure of the project and the distribution of tasks among partners. In addition, they contain project timelines, planning documents, academic profiles of team members, relevant references, and the academic literature that supports the research design and implementation.

Exclusion Criteria:

In order to ensure data confidentiality and maintain a focus on information directly relevant to the analysis, several categories of data were deliberately excluded from the review. First, the academic and professional curricula vitae of project partners were omitted, as they primarily contain personal backgrounds and qualifications that are not central to the scope of this analysis. Second, any personal contact information—such as email addresses, telephone numbers, or mailing addresses—was excluded in order to protect the privacy of the participants. Third, all financial documentation was removed from the analysis. This includes detailed funding information, cost breakdowns, and budgets.

Included Information:

The analysis focuses specifically on information that contributes directly to understanding the structure, aims, and scholarly contributions of each project. This includes general overviews and summaries that contextualize the research within broader goals, as well as detailed descriptions of the objectives, methodological frameworks, and policy relevance. In addition, the documents' descriptions of how work is divided through structured work packages, the scheduling and sequencing of tasks across timelines, and the incorporation of key academic references were all central to the analytical process. By narrowing the scope of the review to these components, this methodological approach ensures that sensitive personal and financial data are excluded, while allowing a comprehensive understanding of how the SURE projects contribute to sustainable urban regions´ development.

3.2. Focus Topics / Research Themes

In the initial stages of the project SURE, the team of qualitative researchers from the Synthesis team, had conceptualised 6 areas of Focus called Focus Topics. These are the research themes that each of the projects would fall under depending on their project proposal and expertise of research. The application of this methodology at the early stages of the project mandated that a limited number of documents were used for the manual thematic analysis. The documents used in this instance were the ones that we also use for the current experiment i.e, the project proposals and the shorter project profiles.

A systematic review was conducted to extract and identify the central themes from these documents. This process was complemented by open coding, a qualitative data analysis technique, to ensure an exhaustive identification of key topics. Following the coding process, thematic analysis was employed to group related topics, enabling the identification of overarching themes and priority areas. Table 1 shows the results of the initial experiment to derive the Research themes / Focus topics and their lower-order representations driven by domain expertise of the researchers involved.

Table 1 Overarching Themes or Focus Topics devised by domain expertise

Themes / Focus Topics	Lower-order Abstraction	Extracted from Documents
Integrated planning and development	Land use and urban development; Infrastructure and services	Strategic planning and governance tools; Build back better strategies; Integrated urban development; Integrated urban neighbourhood development; Co-development and decision support planning tools; Participatory urban development; Efficient municipal services of general interest; Reliable drinking water and sanitation supply; Integrated urban development
Urban Rural Nexus	Integrated territorial development	Urban-regional cooperation; Sustainable urban-rural development
Resource Efficiency and Mitigation	Strengthening circular development; Sustainable supply and waste infrastructure; Increase of indoor comfort; Energy and resource-efficient building	Urban -rural material flows
Risk management and Risk reduction	Concepts of multiple risk prevention; Strategic risk reduction; Risk transfer; Securing of critical infrastructure	Culturally adapted risk prevention; Informal settlements; Flood risk reduction; Improving (reduction) socio-economic vulnerability
Sustainable Behaviour and Practices	Migration; Environmentally friendly behaviour and sustainable living; Social and environmentally sustainable technologies; Sustainable utilization concepts for historic wooden houses; Environmentally friendly behaviour and sustainable lifestyles;	
Ecosystem Services and nature-based solutions	Blue and green infrastructures; Adaptation to flood risk	Sustainable water management; Strategic planning of green infrastructure; Modelling of nature-based solutions and blue-green infrastructure; Heat adaptation through green infrastructure and air quality improvement; Promotion of Urban Greening and Urban Climate; Improve of Air Quality

3.3. Proposed Architecture

Our proposed architecture for the experiment involves leveraging the original BERT workflow and integrating an additional flow that allows us to map the Semantic clusters on to a Thematic Analysis. Figure 2 shows the structure of the Integrated workflow, where the top part synthesizes all the Project documents like proposals and profiles, while the lower part synthesizes the Focus topic or Theme texts employing the same algorithms. We discuss each of these sections and the steps in the next section.

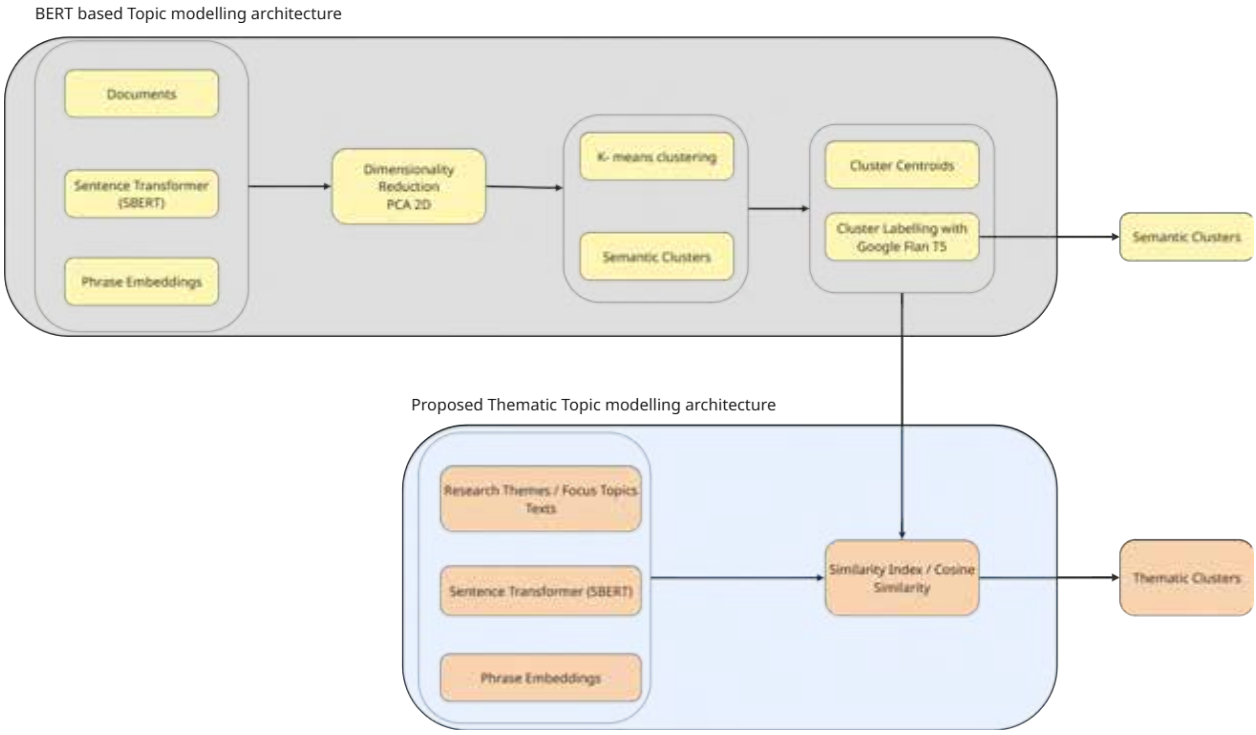

Figure 2 Proposed Architecture for Thematic clustering

4. Analysis

4.1. Phrase extraction

SBERT or Sentence BERT is a modification of the original BERT architecture, specifically designed to produce semantically meaningful phrase embeddings in a computationally efficient way. SBERT employs a Siamese Network structure map, which we shall not go into the details of in this paper, to map sentences into a vector space where semantically similar phrases lie close together and dissimilar ones far apart. As is evident form the study of (Cheng et al., 2023), SBERT's embeddings have been shown to align much better with human judgements of similarity and work effectively in downstream unsupervised tasks like clustering and topic modelling (Cheng et al., 2023).

We use the all-MiniLM-L6-v2 which is part of the SBERT family and used for its efficiency and small relative size. A total of 96,232 tokens were processed from the Project documents and these embeddings were saved with their metadata onto a ChromaDB vector database.

4.2. Dimensionality Reduction and Clustering

We use the PCA (Principal Component analysis) for transforming higher dimensional vector embeddings to 2D vectors to capture the highest variance. Here, as shown in Figure 3, the X-axis represents the highest variance and is the most important feature direction. The Y-axis represents the second highest variance in the data and together they aim to represent the highest possible variance in the data. This allows us to cluster the data in a more efficient way by using the standard k-means approach.

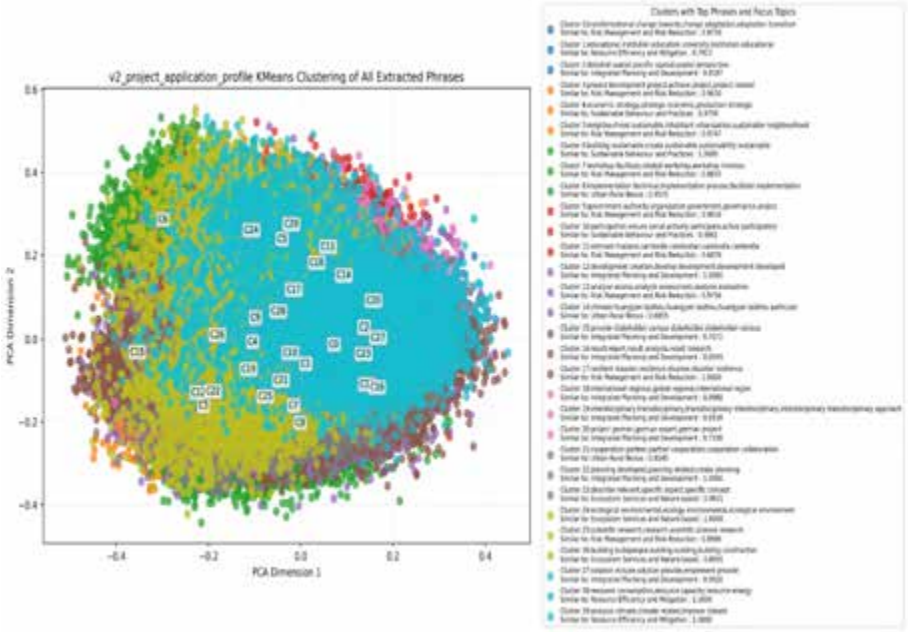

Figure 3 K-means Clustering of embeddings after PCA

Using K-means for clustering, our goal is simply to partition n data points into k clusters so that points within each cluster are as semantically similar as possible, and the clusters themselves are as distinct as possible. The challenge, however, is finding the optimal k for such large number of embeddings. We employ a heuristic approach of, what is commonly referred to as the 'Elbow Curve', where we plot for a loss function against every value (integer) of k iteratively until the change in the loss function is

minimal or stagnant. We use the function Inertia which is the total Within-Cluster Sum of Squared distances between each data point and iterate it over k.

$$Inertia = \sum_{i=1}^{k} \sum_{x \in C_i} \|x - \mu_i\|^2$$

To understand intuitively, a lower Inertia represents tighter clusters which means that the data points are closer to the cluster centroids. The eventual aim of the curve is to find the highest k for which the Inertia is the smallest and further reduction is not significant. Figure 5 shows the curve as applied in our experiment resulting in an optimal value of k = 30.

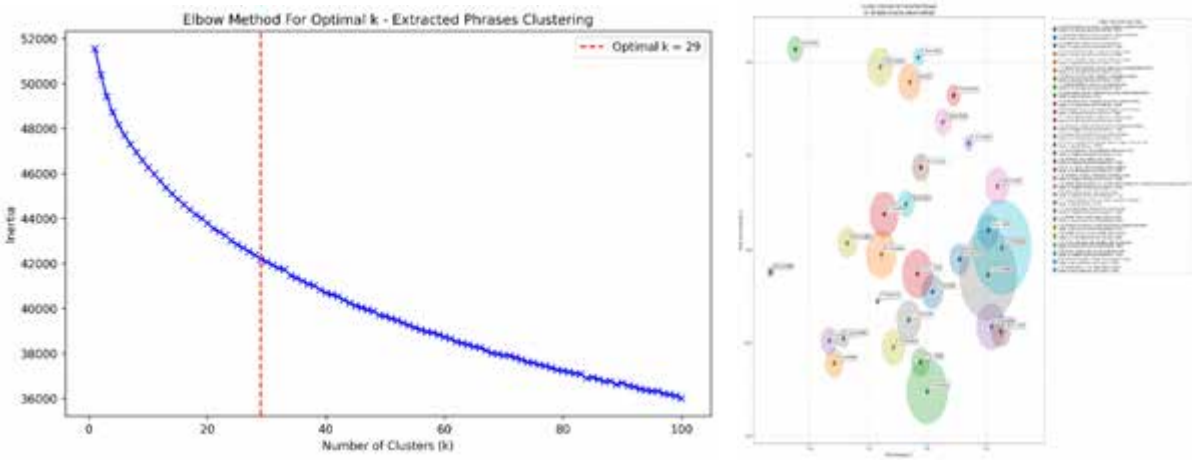

Figure 4 Deriving optimal K clusters
Figure 5 Clusters represented with their Centroids

A simpler visualisation of the resulting clusters is offered in Figure 5 which highlights the clusters, their sizes by the amount of data points they contain and their centroids. Table 2 shows some of the clusters and the data points or phrases extracted from the text.

In order to make these clusters human readable, we apply an open source LLM Google flan-t5-large, on the top 50 phrases in every clusters. This results in a stricter semantic topic creation, especially for larger clusters. Table 2 shows some sample clusters, the embedded phrases it contains and the LLM labelling of the semantic topic.

Table 2 Sample Cluster data points and their LLM labels

Cluster	Top 10 Phrases	Google flan-t5-large labelling
Cluster 0	transformational change towards; change adaptation; adaptation transition; transformational change; transformative change; transformation process towards; transformation process toward; change transformation process; adaptation transformation; transformative change towards	Transformational change and towards adaptation
Cluster 2	detailed spatial; specific spatial; spatial perspective; spatial structure; spatial mapping; spatial typology; spatial aspect; spatial perception; realistic spatial; investigates spatial	Spatial representations of a realism
Cluster 10	participation ensure social; actively participate; active participatory; analysis participatory; establishes participatory; realize participatory; involves participatory; effective participatory; community participation; approach participatory	Participatory analysis and the role of participation in social change

4.3. Converting Semantic Clusters into Thematic clusters

As is clearly seen from Table 2, the clusters have a significant semantic similarity whereby phrases with similar meaning or structure have been clustered efficiently. Yet, this erodes the thematic understanding of a 'topic' from the text while focusing only on parts of language as topics. To circumvent this issue, we propose the addition of the second part of our proposed architecture as shown in Figure 2 where we map our BERT based seman-

tic clusters onto the Thematic clusters derived by domain experts.

We follow the same methodology as used for the project documents, now with the Focus Topics/Themes that were devised by domain expertise as shown in Table 1. Each of the Focus topic has a short text that conveys the theoretical background and the current research directions in that theme. These texts are processed with all-MiniLM-L6-v2 and the embeddings for each theme are stored separately in a ChromaDB vector database. The number of key-phrases identified under each focus topic is shown in Table 3.

Table 3 number of Phrase embeddings in Focus Topics

Focus Topic / Theme	Number of key-phrases extracted
Integrated planning and development	146
Urban Rural Nexus	98
Resource Efficiency and Mitigation	167
Risk management and Risk reduction	147
Sustainable Behaviour and Practices	149
Ecosystem Services and nature-based solutions	168

We then undertook a cosine similarity to check the similarity of all the clusters obtained from the project documents with each of the six themes separately. Thus, we map each cluster from Figure 5 onto the theme embeddings and assign a cosine similarity score between 0 and 1, where 0 is no similarity to 1 is complete similarity with embeddings within the themes.

We noticed, that many a cluster would be less relevant to a certain theme and hence needed human intervention to design a threshold of similarity for inclusion. This was done manually based on the domain expertise and fixed at 0.75 which means that the clusters under the 0.75 score threshold were not considered relevant for the theme. Figures 6 – 11 show the different clusters belonging to each theme or Focus topic.

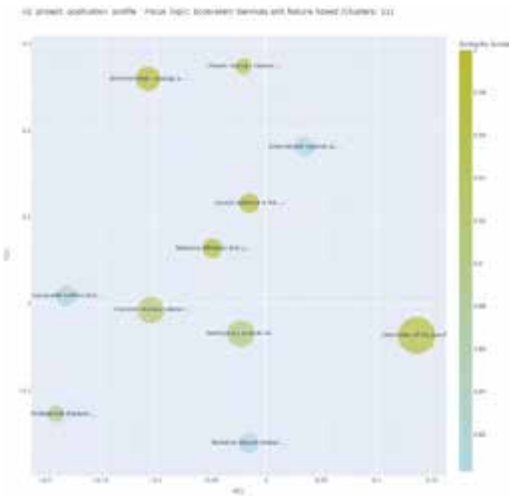

Figure 6 Ecosystem Services

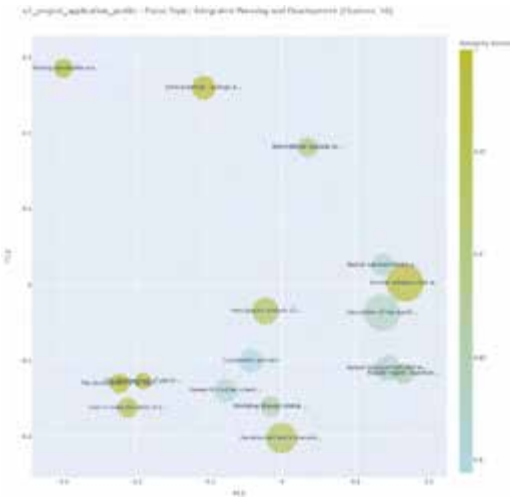

Figure 7 Integrated Planning and Development

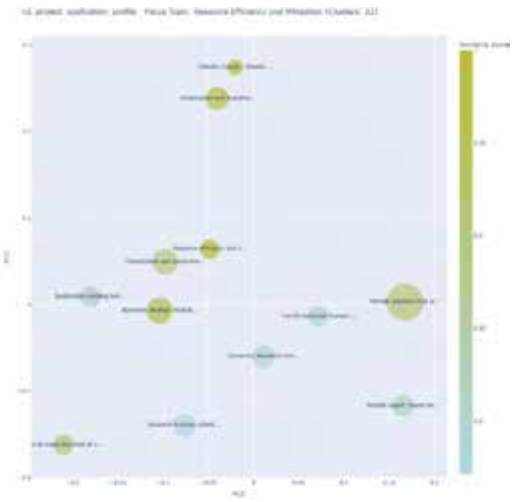

Figure 8 Resource Efficiency and Mitigation

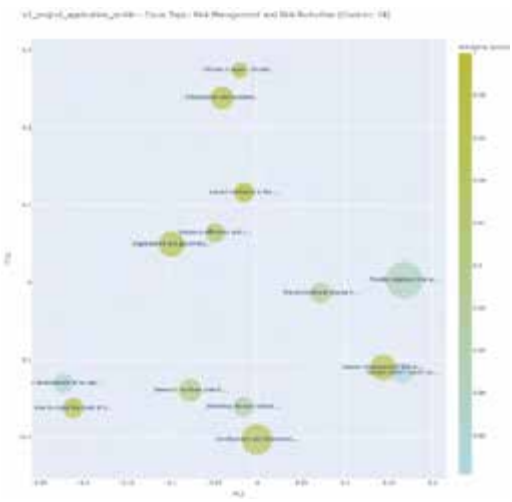

Figure 9 Risk management and Risk reduction

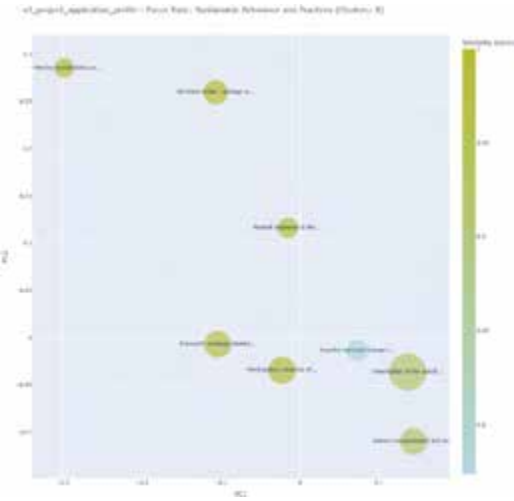

Figure 10 Sustainable Behaviour and Practices

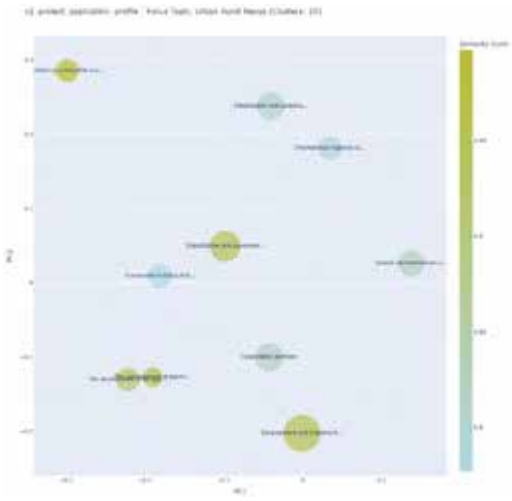

Figure 11 Urban Rural Nexus

5. Conclusion

5.1. Results

Our experiment focussed on generating thematic clusters from semantic clusters with the help of transformer-based models. The figures 6 – 11 show the details of thematic belonging of semantic clusters of our text data. To simplify our understanding, Figure 12 shows a Sankey chart referring to the relationship between semantic topics and their thematic focus.

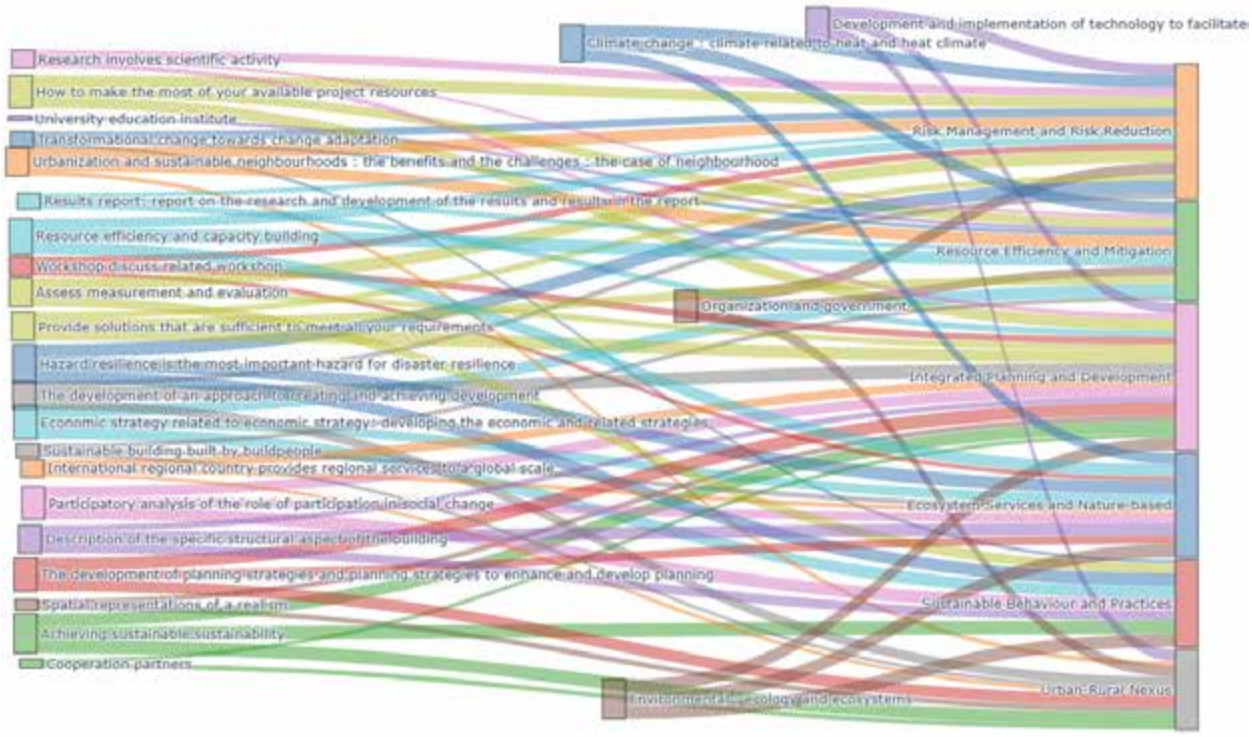

Figure 12 Sankey chart for understanding the links between Thematic and Semantic clusters

Some of the topics generated from the clusters, for example, 'Climate change related to heat stress mitigation' belongs to three different thematic groups viz. Risk Management and Risk Reduction, Resource Efficiency and Mitigation and Ecosystem Services and Nature-based solutions in varying proportions indicating its importance under these themes. In a similar vein, the topic 'Environmental: ecology and ecosystems' belongs in almost equal proportions to Integrated Planning and Development, Ecosystem Services and Nature based solutions and Sustainable behaviour and Practices. Yet, the accuracy overall can be argued to be a bit nuanced as it may not be entirely clear why a certain cluster should belong to a certain theme without the domain expertise present at our disposal.

5.2. Future pathways

This experiment was conducted as part of the Synthesis research project which aims to establish a sustainable contribution to the emerging field of knowledge management in the field of Sustainable Urban Development. It deals with a part of the larger question of monitoring trends in Urban Development research. As is our position, a topic is a subset of a Theme which mapped over time becomes a Trend, we aim to further this experiment with a larger corpus of structured Thematic texts onto which to map more documents and research and to monitor the consistent themes as trends.

5.3. Limitations

The experiment here is limited by the nature and sensitivity of the documents involved in within the larger SURE project. Thus far we have not used publicly available datasets like research papers, for our analysis and hence the architecture remains a proof of concept. Additionally, the text for the Focus topics or Themes devised by domain expertise is nimble and should be expanded to include more depth and breadth around a certain theme for better analysis.

5.4. Acknowledgements
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AI-Empowered Research on Healthy Streets: An Iterative Path of Streetscape Perception, Evaluation, and Optimization

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Abstract
This study presents a closed-loop AI framework for assessing and enhancing "healthy streets," applied to downtown Haining City, China. First, semantic segmentation of street-view images yields eight quantitative indicators (e.g., greenery, enclosure, openness). Second, an Elo-based pairwise survey combined with Random Forest and CNN models reveals how these indicators predict perceived street healthiness. Third, we use a Low-Rank Adaptation model(Lora) in Stable Diffusion generator to optimise low-scoring scenes by adding health-supportive elements. Results indicate that (1) the eight indicators capture key environmental qualities; (2) Elo-scoring aligns with machine-learning feature importances—especially greenery, human-scale enclosure, and visual diversity; and (3) the generative model improves predicted health scores by enhancing greenery and openness. This iterative approach offers planners a rapid tool for healthy-street design.

Keywords: Healthy streets; Street view imagery; Semantic segmentation; Machine learning; Generative AI

1 Introduction

The idea of the Healthy City has put citizens' physical and mental well-being at the centre of urban planning since the late twentieth century. Among all public spaces, streets—the city's "capillaries"—shape daily activity, social contact, and psychological comfort more than any other setting. When they are walkable, human-scale, green, and orderly, streets foster exercise, lower stress, and lift overall happiness. Empirical evidence underscores this link. Ulrich's controlled experiments showed that simply viewing greenery or water restores positive mood, whereas scenes dominated by bare concrete increase sadness and anger (Ulrich, 1979). In urban design and public-health scholarship, such environments are now labelled healthy streets: places that invite walking and conversation, provide safety and comfort, and deliver a pleasing sensory experience (Chen et al., 2020; Xu & Hu, 2020). Creating and promoting healthy streets has therefore become a core objective of livable-city strategies.

Rapid urbanisation and motorisation have left many streets marred by poor pedestrian conditions, sparse greenery, excessive enclosure, visual clutter, and traffic hazards—factors that undermine public health and well-being(Chen, Zhang & Long, 2020). To address these deficits, researchers increasingly rely on quantitative evaluations that can steer evidence-based upgrades. The explosion of street-view imagery and advances in computer vision now make city-wide, objective assessments possible (Long & Tang, 2019; Ye et al., 2019). A seminal example is MIT Media Lab's Place Pulse, which crowdsourced judgements by asking online participants which of two street scenes appeared safer, livelier, and so forth. The resulting perception dataset underpinned StreetScore, a model that predicts perceived safety and vibrancy directly from images, enabling block-by-block comparisons across entire cities(Quintana, Gu & Biljecki, 2024). Subsequent deep-learning work has generalised these mappings worldwide, showing that AI can "read" visual cues—building massing, tree cover, human presence—and infer how people are likely to feel in those spaces. Such image-based analytics now offer planners a scalable lens on the everyday quality of urban life.

However, most current research is confined to measurement and prediction, with limited attention to how AI could improve street design. A notable exception is Wijnands et al. (2019), who trained a generative adversarial network (GAN) to rewrite street-view images and then estimated the health-related perception shifts caused by those edits. Their experiments showed that GAN-based style transfer can faithfully render "greener" versus "grey" streetscapes, yielding a virtual test bed for design interventions. This pivot from assessment to interven-

tion points to a new frontier: harnessing generative AI to prototype and appraise street-design options before a single curb is moved.

Recently, researchers have made significant progress in two key areas. First, researchers have refined the measurement of objective streetscape features. Long & Tang (2019) showed that computer vision now enables city-wide appraisals with unprecedented scope and precision. Based on this, Ye et al. (2019) extracted fine-grained indicators—greenery cover, spatial openness, façade articulation—from street-view imagery to produce block-level quality maps. Second, studies have demonstrated how these features are translated into health-related outcomes. From a public-health stance, Chen, Zhang & Long (2020) argued that elevating a street's "spatial order"—reducing clutter, improving pedestrian continuity—directly enhances its health performance by removing discomfort factors such as noise, pollution, or disorganised furniture. Complementing this point, Xu & Hu (2020) proposed a "healing streets" model grounded in therapeutic-landscape theory, calling for generous greenery, water features, public art, and accessible open space to help residents relax and recover from stress.

Although existing work supplies robust theories and metrics for healthy-street assessment, three gaps remain. First, the link between objective spatial indicators and subjective well-being is only weakly understood; we still lack models that clarify how quantified image features translate into lived health benefits. Second, most intervention studies are theoretical—design prescriptions are seldom tested on real streetscapes. Third, this field lacks a closed loop that cycles from diagnosis to intervention and back to evaluation. We address these gaps by building an AI-enabled workflow that (i) diagnoses street health, (ii) generates targeted design alternatives, and (iii) iteratively verifies their predicted influence. By fusing multi-sourced imagery with complementary AI models, our approach shifts the agenda from data-driven perception to AI-assisted design, giving planners a scalable toolkit for healthy-street regeneration.

2 Study Area, Data and Methods

2.1 Study area

Haining, a county-level city in Zhejiang Province's Yangtze River Delta, serves as our case study. Nestled between Hangzhou and Shanghai, it hosts about 800 000 residents and an economically active urban core. We focus on four central sub-districts—Xiashi, Haizhou, Haichang, and Maqiao—which together span the historic downtown and its surrounding neighbourhoods. Within this zone, narrow heritage alleys, protected preservation blocks, modern commercial corridors, residential streets, and major arterials coexist. The resulting spectrum—from centuries-old lanes to newly built boulevards—mirrors the diversity found in many medium-sized Chinese cities, making Haining a fitting proxy for comparable contexts.

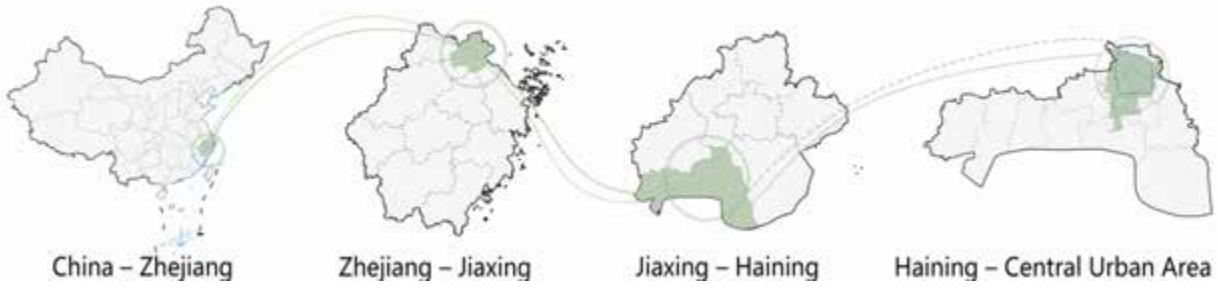


Figure 1. Study area: location and urban layout of Haining City

2.2 Data sources

Our analysis draws on four complementary datasets: geospatial vectors, street-view imagery, human-perception scores, and open-source generative-AI models.

·Geospatial vectors. Street-centreline geometries for the four sub-districts were downloaded from OpenStreetMap and cross-checked against Haining planning documents and statistical yearbooks to ensure coverage of all major land-use zones.

·Street-view imagery. Using the Baidu Street View API, we placed sampling points every 200 m along the network. At each of the 1077 points we captured the panorama and clipped two opposing perspectives aligned with the road axis, yielding 2154 images (1024 × 768 pixels). Shots were taken at pedestrian eye-level in fair daytime conditions during 2021–2022, spanning commercial cores, residential streets, park edges, and a few peril-urban roads (locations without imagery were excluded).

·Perception survey. To obtain subjective "street-health" scores, 50 participants (planners, public-health experts, and volunteers) performed Elo-style pairwise comparisons of randomly drawn image pairs (see section 5.1). The resulting crowd-sourced ratings provided training labels for our predictive models.

·Generative-AI toolkit. For the optimisation stage we employed Stable Diffusion 1.5 enhanced with Low-Rank Adaptation (LoRA) and ControlNet guidance. Pre-trained weights, open-source scripts, and a curated prompt library supplied the basis for domain-specific fine-tuning.

Figure 2 Road network and streetscape observation points in the study area

2.3 Methodological framework

Our study follows a three-stage, closed-loop workflow—Perception, Evaluation, and Optimisation.First perception, we run semantic segmentation on every street-view image to delineate key urban elements and compute objective visual indicators.Second evaluation, an Elo-style pairwise survey first yields subjective "street-health"

scores. These labels feed two predictive models: a Random Forest regressor trained on the indicator set and a convolutional neural network (CNN) trained on raw pixels. Together they explain how specific features shape perceived health and allow city-wide scoring. Finally optimisation, low-scoring scenes are redrawn with Stable Diffusion 1.5, fine-tuned via Low-Rank Adaptation (LoRA) and guided by ControlNet. The generator injects health-supportive cues—extra greenery, broader sky views, livelier façades—and the edited images are re-scored by the RF/CNN models (and inspected by eye). If gains fall short, the edit-evaluate cycle repeats until the target threshold is met.

By chaining computer vision, predictive modelling, and generative design, the framework moves seamlessly from diagnosis to intervention and back, offering planners a virtual test bench for healthy-street retrofits. The next sections unpack each stage in detail.

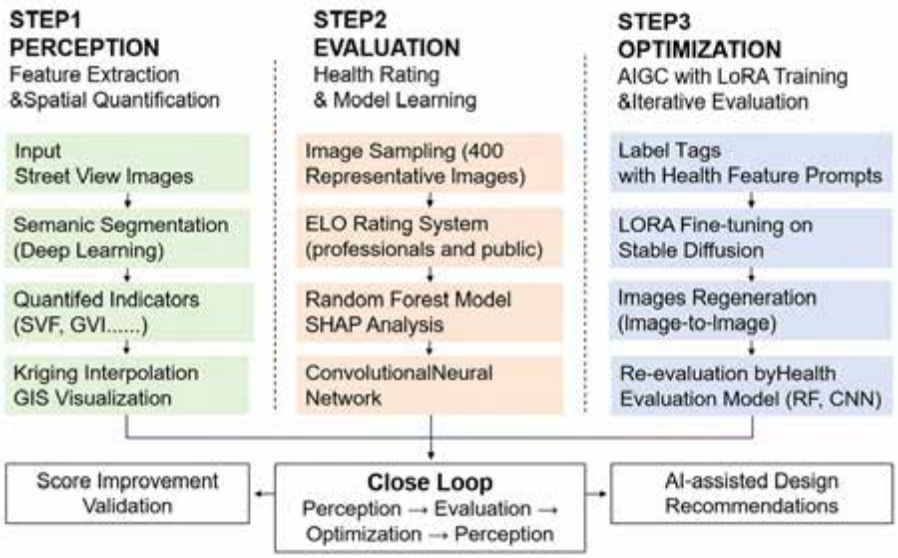


Figure 3 Flow chart of the overall methodological framework of the study

3 Perception: Visual-Indicator Extraction and Analysis

3.1 Semantic segmentation of street-view imagery

We applied semantic segmentation to all 2154 street-view photographs to convert raw pixels into meaningful urban elements. Using DeepLab-v3+ with a ResNet backbone—pre-trained on the Cityscapes corpus and lightly fine-tuned on 200 hand-labelled Haining scenes. Class masks were then aggregated into eight quantitative indicators aligned with four perceptual dimensions:

The eight visual indicators fall into four perceptual dimensions: Vibrancy, represented by Facade Diversity (FD) and Colour Richness (CR), captures the heterogeneity and chromatic variety of street façades; Comfort, measured by Building Enclosure (BE) and Height–Width Ratio (H/W), reflects spatial enclosure and human-scale proportion; Naturalness, via Sky View Factor (SVF) and Green View Index (GVI), assesses visual access to open sky and vegetation; and Safety, defined by Relative Walking Width (RWW) and Traffic-Facility Proportion (TFP), quantifies pedestrian space and the presence of traffic-management elements

To sum up, these metrics furnish a compact, interpretable synopsis of each streetscape's physical affordances for health. Table 1 details indicator formulas and class mappings, while Figure 4 illustrates a typical segmentation output.

Table 1 Definitions and calculation methods for the eight spatial indicators

Category	Indicator Name	Calculation Formula
Vitality	Facade Diversity	H = -∑(p_i * ln p_i),
Vitality	Color Richness	Entropy of HSV hue channel / $\log_2 36$, normalized to [0,1]
Comfort	Building Enclosure	Proportion of building elements
Comfort	Height-Width Ratio	(Building + Wall) / Road Elements
Nature	Sky View Factor	Proportion of sky pixels
Nature	Green View Index	Proportion of vegetation pixels
Safety	Relative Walking Width	Sidewalk / (Driveway + Trail)
Safety	Traffic Facilities	Proportion of traffic-related elements

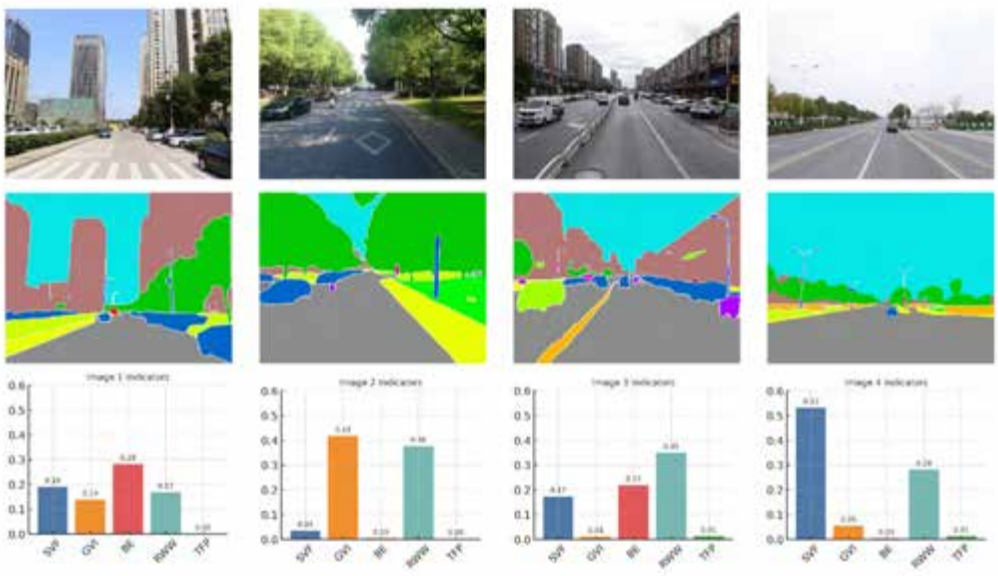


Figure 4 Street view image with semantic segmentation results

3.2 Indicator distribution and inter-relationships

After computing the eight indicators for all 2154 images, we examined their statistical profiles and pairwise links. Figure 5 plots the histograms, and Figure 6 shows the correlation heat-map.

The eight semantic indicators exhibit considerable variation across the dataset, capturing differences in vegetation, enclosure, openness, visual diversity, and pedestrian space. Some indicators, such as green view index and sky view factor, span a wide numerical range, while others, like traffic facility proportion, remain low but meaningful. These metrics provide a comprehensive quantitative basis for analyzing spatial patterns of perceived street healthiness.

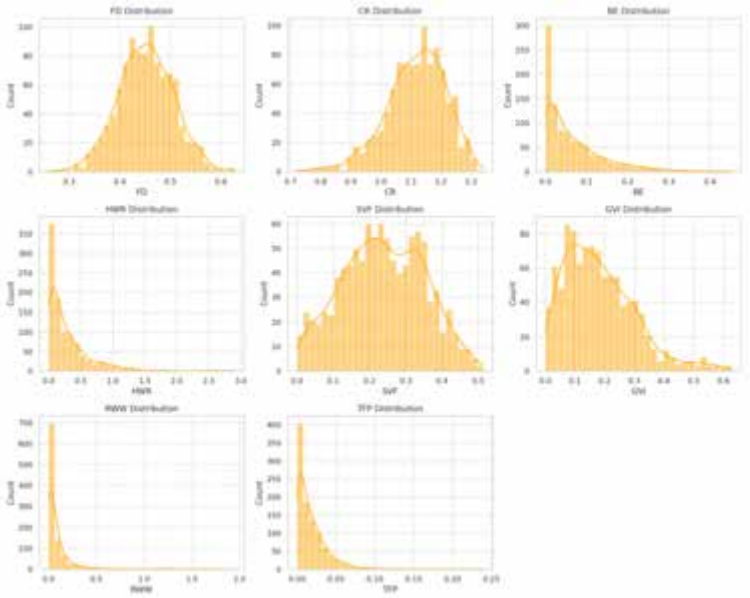


Figure 5 Histogram data distribution by indicator

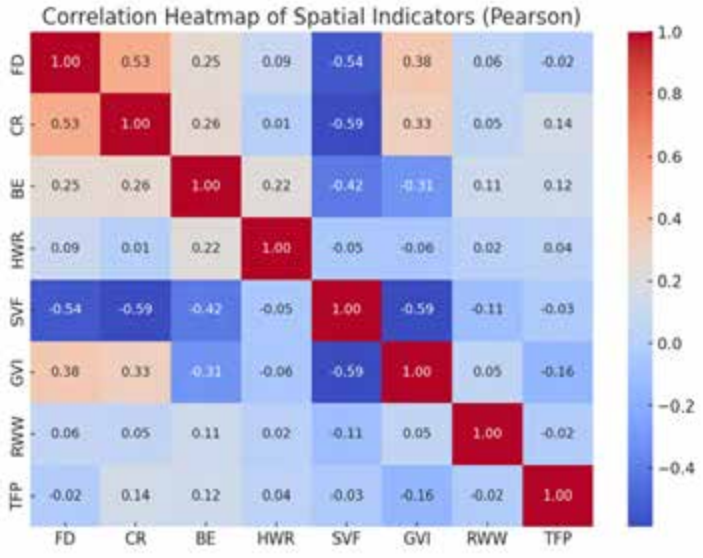


Figure 6 Heatmap of indicator correlations($p < 0.05$)

To read the eight indicators as coherent street profiles, we ran k-means clustering with k = 4. The feature set comprised the five most salient indicators—selected by variance and preliminary importance tests—which retained > 92 % of total information. Table 2 lists the centroid scores, Table 3 sketches the corresponding spatial traits, and Figure 7 plots the four centroids on a radar graph. The clusters form a clear typology. This four-way classification distils Haining's diverse streetscape morphologies into interpretable groups that anchor the subsequent evaluation stage.

Table 2 Clustering means

Cluster	Sky Openness	Green View Index	Building Enclosure	Road Width	Traffic Facilities
0	0.1343	0.1026	0.238	0.3027	0.0166
1	0.1394	0.3405	0.0385	0.2718	0.011
2	0.2283	0.1564	0.0726	0.2676	0.0766
3	0.3275	0.1187	0.0353	0.3296	0.0116

Table 3 Introduction to clustering types

Cluster	Street Type	Feature Keywords	Spatial Interpretation
0	Medium Road, High Enclosure	High enclosure (0.238), Medium road width (0.30)	Dense buildings on both sides, limited view, low greenery and sky, typical urban main road.
1	Open Green Type	Highest GVI (0.3405), Low enclosure & traffic facility	Rich vegetation, open and comfortable, few buildings, suitable for residential or park-side streets.
2	Infrastructure Enhanced	Most facilities (0.0766), Moderate enclosure, Mid-level openness	Strong infrastructure presence, visually active, functional streets or commercial corridors.
3	Wide Open Arterial Road	Highest openness (0.3275), Widest road (0.33), Few buildings	Extremely open, low architectural presence, likely highways or suburban roads.

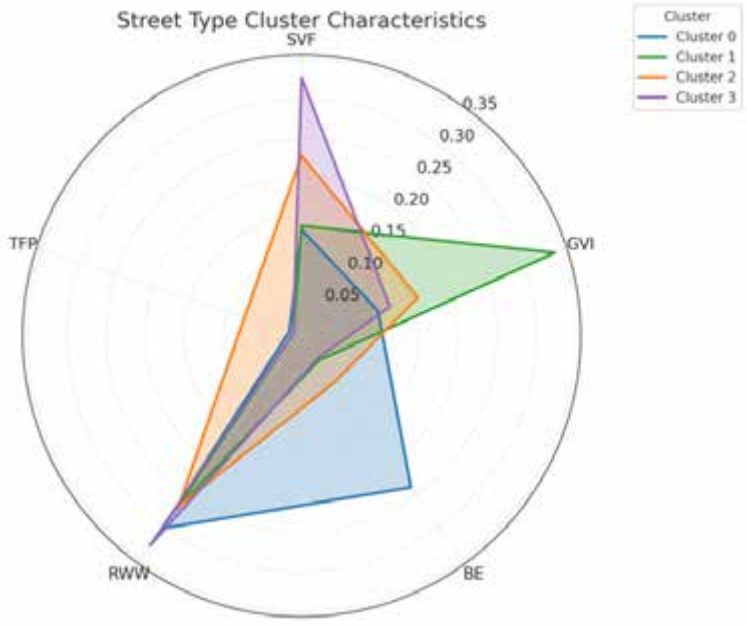


Figure 7 Radar diagram of clustering features

3 .3 Spatial distribution of street indicators

To locate where healthy-street attributes wax and wane across Haining, we interpolated each indicator from the 1 077 sampling points onto a continuous surface and rendered heatmaps (Figure 8).

·GVI ranges from less than 5% to over 60%, with a mean around 25%. Vegetation is heavily concentrated along the northern and northeastern river corridors, where greenways and linear parks flank the water. In contrast, the

dense downtown and the industrial southwest show severe vegetation deficits, making them visually "grey" and in need of greening.

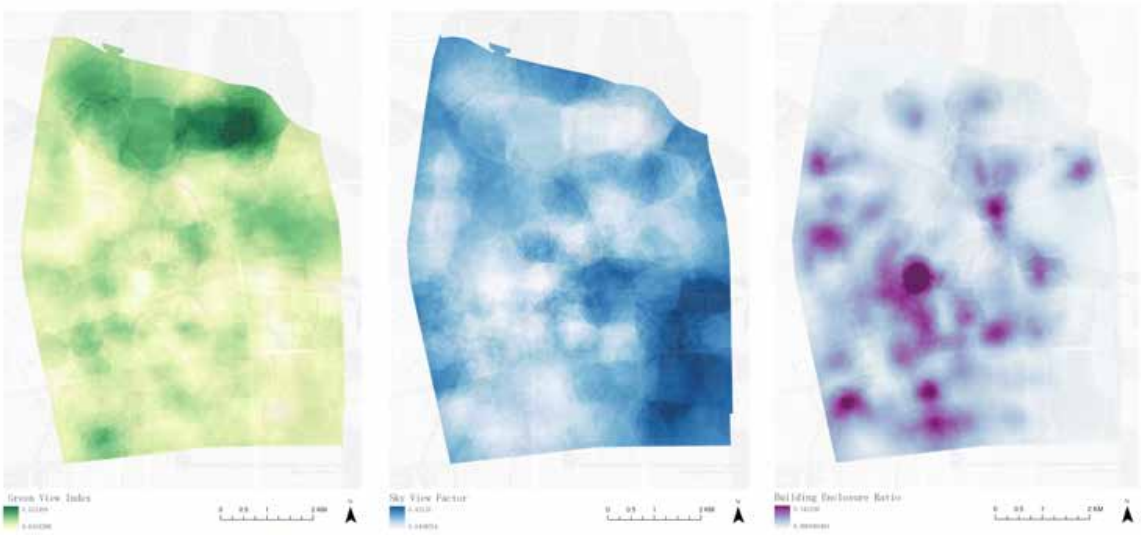
·SVF averages approximately 30%, but varies widely. High SVF values are found in southeast and fringe areas with fewer vertical obstructions, while low values occur in historic quarters where mid-rise blocks obstruct sky views and create enclosed street canyons.

·BE inverts the GVI trend. Traditional urban cores such as Haizhou and Haichang have high enclosure due to tightly built, narrow street networks. Newer districts like Maqiao, with wider setbacks and open cross-sections, register low enclosure values, contributing to a more open spatial feel.

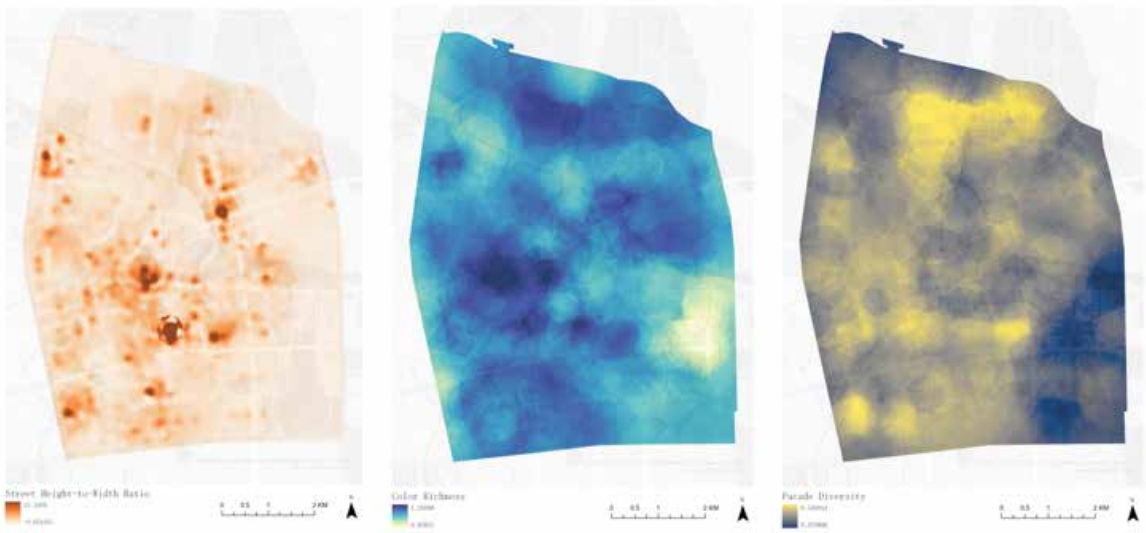
·H/W is strongly correlated with BE. Peaks occur along older corridors like Renmin and Yucai Roads, forming deep urban canyons with narrow view corridors. These areas may feel intimate, but risk reduced comfort under extreme conditions.

·CR and FD rise in commercial and mixed-use zones featuring varied signage, shopfronts, and building types. Uniform residential blocks and industrial areas score lower. These two indicators show a moderate positive correlation, as both are enhanced by land-use diversity and design articulation.

Taken together, the heatmaps reveal a stark spatial contrast in street environments—green, pedestrian-friendly corridors stand in sharp contrast to vegetation-poor, car-oriented zones in the historic core and industrial fringe. These disparities highlight priority areas for intervention, such as adding greenery, widening sidewalks, or improving traffic safety, and set the stage for the perceptual evaluation presented in the next section.



Top row (left to right): Green View Index, Sky View Factor, Building Enclosure



Bottom row (left to right): Height–Width Ratio, Colour Richness, Facade Diversity
Figure 8 Results of spatial interpolation of indicators

4 Evaluation: Street-Health Evaluation via Machine Learning

4.1 Elo-based collection of perceived-health scores

Because "healthy streets" are ultimately judged by people, we first needed a robust measure of perceived healthiness for each scene. We therefore adopted an Elo-style pairwise comparison, a method popular in online gaming and mirrored in the Place Pulse project, to translate thousands of binary choices into a continuous rating scale. A stratified sample of 400 images—drawn evenly from the four clusters described in § 3.3—served as the test set. An online survey then showed planners, public-health scholars, and lay volunteers random image pairs and asked, Which street looks healthier? Respondents judged greenery, openness, comfort, safety, and overall aesthetics; after each "match" the Elo algorithm updated both images' scores. Ratings stabilised after 10000 comparisons, yielding a scale from about 800 to 1 300. Inter-rater agreement was high (Kendall's W > 0.80), confirming that the scores capture a shared perception of street health. These Elo values can be used as basic truth labels for the predictive models to be presented below.

Figure 9 ELO evaluation system interface

4.2 Random-Forest regression and feature importance

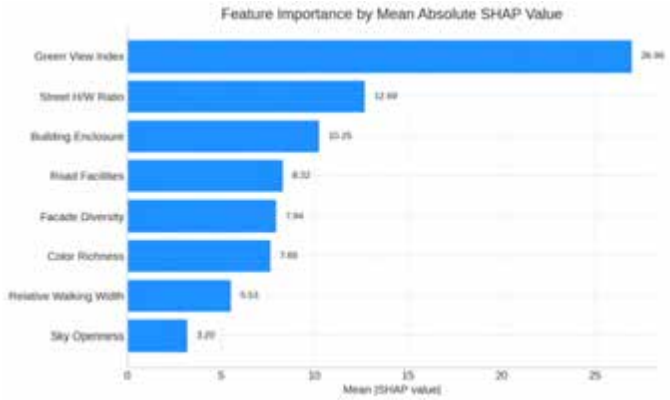
With Elo scores established for 400 street-view scenes, we next linked those subjective ratings to the eight objective indicators. A Random Forest (RF) regressor—well suited to modest sample sizes and non-linear feature interactions—served as the workhorse.

Model set-up. The images were split 80 / 20 into training (n = 320) and test (n = 80) folds. Input features were the eight indicators introduced in § 3.1; the target was the Elo score. A grid search with five-fold cross-validation tuned hyper-parameters. The best configuration—300 trees, maximum depth = 6, minimum samples per leaf = 2, delivered an out-of-sample $R^2 \approx 0.38$. Given the inherently subjective target, this indicates that the indicator set explains a substantial share of perceived street health, while leaving room for latent factors such as noise, smell, or social cues.

To unpack the model's decisions we applied Shapley Additive Explanations (SHAP). Figure 10 ranks features by their mean absolute SHAP value, and Figure 11 plots the full SHAP summary. Three findings stand out:

·GVI dominates the ranking, confirming greenery as the strongest visual cue of street health.
·BE and H/W follow, showing that human-scale enclosure matters, but only up to a point—very high values depress scores.
·CR and FD contribute positively, whereas TFP exerts only a minor influence, perhaps because safety cues are subtle in static imagery.

The RF model quantifies key design principles—more greenery, balanced enclosure, pedestrian-friendly features, and lively façades all contribute to higher perceived street health. These insights validate the indicator set and guide the optimisation stage by highlighting which attributes most efficiently lift perceived health.



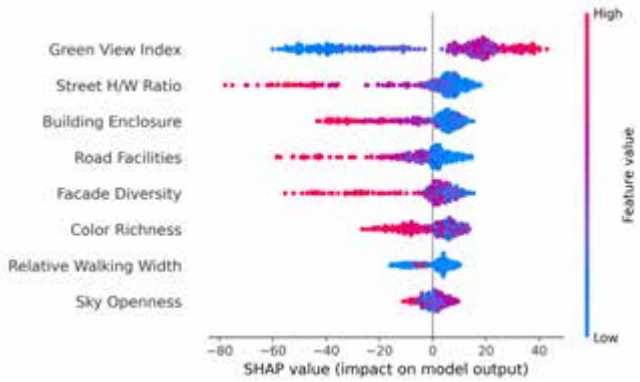


Figure 10 SHAP Importance Score (left)
Figure 11 SHAP Scatter Plot Analysis(right)

4.3 Convolutional Neural Network Prediction

To assess whether a deep model can learn health-related cues without predefined indicators, we trained a ResNet-50 convolutional neural network (with ImageNet weights) to directly regress Elo scores from street-view imagery, using the same 400 labelled images as in the Random Forest model.

The dataset was stratified 80/20 into training (n = 320) and validation (n = 80) sets. Each image was resized to 256 × 256 pixels, with any empty space padded with black pixels to preserve full scene content. The model was trained to minimise mean squared error, with early stopping applied once validation loss plateaued.er the small sample size.The model achieved an R^2 of approximately 0.48 and a mean absolute error of 72 Elo points, slightly outperforming the Random Forest, despite receiving no structured input features. High-scoring predictions consistently aligned with green, bright, and tidy scenes, while grey, empty, or car-dominated streets scored lower—paralleling SHAP findings from § 4.2. This confirms the CNN's capacity to autonomously extract relevant perceptual cues.

Table 4 Demonstration of RF model parameters

Parameter / Metric	Value
Model Type	Random Forest Regressor
Best n_estimators	300
Best max_depth	15
Best min_samples_leaf	2
Best max_features	sqrt
R^2 on Test Set	0.381
MSE on Test Set	≈ 1350

Table 5 Demonstration of CNN model parameters

Model	EfficientNet-B0
Input Size	224x224
Batch Size	32
Epochs	25
Learning Rate	1e-4
Optimizer	Adam

Loss Function	MSE (weighted)
Train Loss (final)	0.0023
Val Loss (final)	0.0172
MSE	7336.57
MAE	71.81
R^2	0.4792

Across the full 1,754-image dataset, the CNN's predictions correlated moderately with RF results (r ≈ 0.64), with both models identifying consistent high and low performers. Divergences likely reflect finer-grained visual textures perceived by the CNN but not captured by the indicator set, such as ground paving and street tidiness. Together, the two models offer complementary insights: strong agreement reinforces key design priorities (like greenery and human-scale proportion), while their differences point to additional visual nuances—some of which will be explored through generative enhancement in section 5.

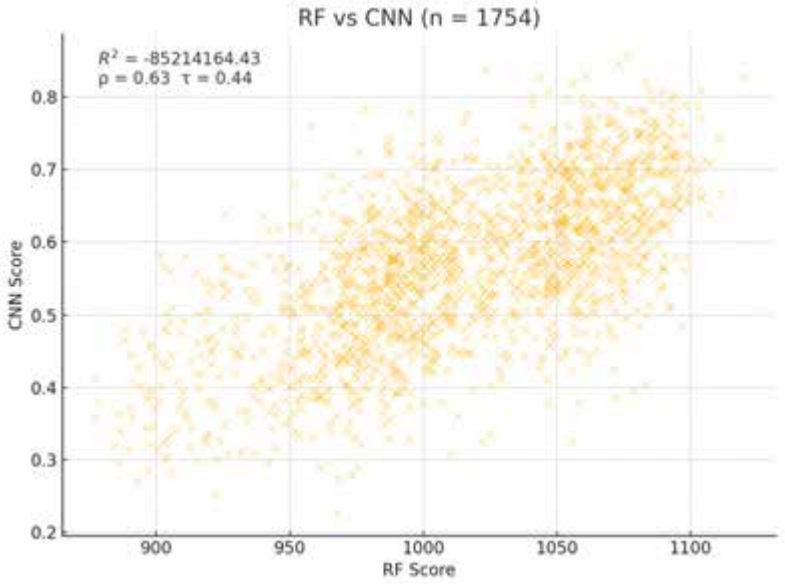


Figure 12 RF and CNN model prediction score correlation

5 Optimization: AI-Based Streetscape Optimisation and Iterative Validation

5.1 LoRA-fine-tuned image generation for healthy streets

With the key health features defined, we shifted from evaluation to visual intervention. To simulate healthier versions of low-scoring streets, we adopted an image-to-image generation approach using Stable Diffusion, and fine-tuned it via LoRA. This allowed the model to learn and apply health-promoting visual styles—while preserving the core structure of the original image.

(1)From Indicator Scores to Labels

The fine-tuning pipeline began with the 400 Elo-scored scenes. Each image was placed into one of three perceptual tiers—high, medium, or low health—defined by the upper, middle, and lower quartiles of the score distribution. Rather than feed the model cryptic numerical features, we distilled the eight indicators into short, human-readable phrases that echoed how survey participants had talked about the scenes. A frame with GVI ≈ 0.05 became "no trees"; GVI ≈ 0.25, "some street trees"; GVI > 0.40, "lush trees on both sides." Streets with BE and H/W at historic-core levels were tagged "narrow, tall buildings," whereas wide suburban corridors read "broad and open." Colour palettes and façade variety were rendered as "dull grey" or "bright and colourful." These textual

summaries were paired with the source images so that the generator learned not only which elements depressed a scene's health rating, but also how a healthier variant should look.Table 6 documents how to route from metric scores to specific labels, and Figure 13 illustrates the labels for a typical street map.

Table 6 Metrics and Labeling Transformation Logic

Indicator	Value Range	Level	Tags
facade diversity	≤ 0.3301	Low	plain building walls
facade diversity	0.3301 – 0.4905	Medium	simple facades with some variation
facade diversity	> 0.4905	High	street-level shops and balconies
color richness	≤ 0.9007	Low	gray and monotonous facades
color richness	0.9007 – 1.1294	Medium	some colored elements
color richness	> 1.1294	High	colorful signs and painted walls
building enclosure	≤ 0.2336	Low	buildings far apart
building enclosure	0.2336 – 0.4673	Medium	moderate space between buildings
building enclosure	> 0.4673	High	buildings tightly packed
street height width ratio	≤ 0.0198	Low	wide street with low-rise buildings
street height width ratio	0.0198 – 0.4810	Medium	balanced street scale
street height width ratio	> 0.4810	High	narrow road with tall buildings
sky openness	≤ 0.1904	Low	sky mostly blocked by buildings
sky openness	0.1904 – 0.3808	Medium	partial sky between buildings
sky openness	> 0.3808	High	open sky over wide street
green view index	≤ 0.2357	Low	no visible trees
green view index	0.2357 – 0.4714	Medium	scattered trees
green view index	> 0.4714	High	trees along both sides
relative walking width	≤ 0.0140	Low	narrow pedestrian strip
relative walking width	0.0140 – 0.0670	Medium	standard pedestrian space
relative walking width	> 0.0670	High	wide sidewalk with benches
road facilities	≤ 0.1395	Low	no visible traffic equipment
road facilities	0.1395 – 0.2791	Medium	some road markings
road facilities	> 0.2791	High	traffic lights and street signs
street health	≤ 850	Low	unhealthy street
street health	850 – 1075	Medium	average street
street health	> 1075	High	healthy street

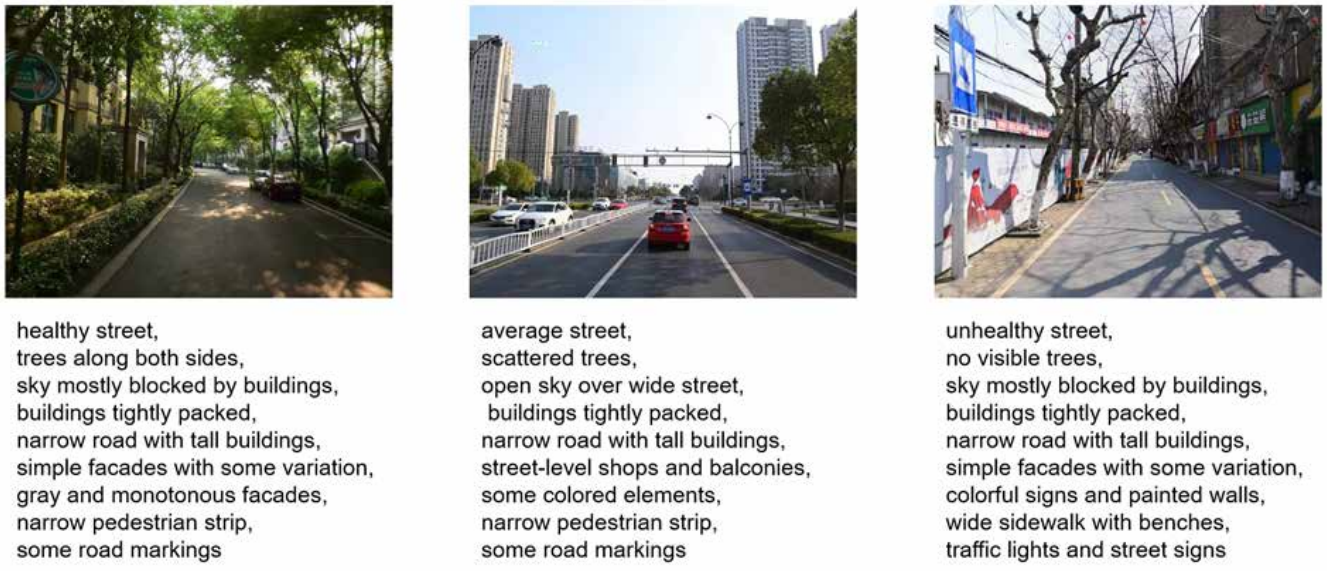


Figure 13 Representing the labeling results for Street View

(2)Lora Model Training
To enable health-aware generation, we fine-tuned the latent diffusion model AWPortrait_v1.4 using Low-Rank Adaptation. This lightweight approach inserts a small set of trainable matrices into the frozen UNet backbone, allowing the model to adapt to the new task—enhancing streetscapes for visual health—without updating the full network.

We used the same 400 Elo-scored images as in earlier models, resizing each to 512 × 512 pixels. Each image was paired with a prompt from the previously constructed label dataset, which provided explicit guidance on how healthy street features are visually expressed.

Training ran for approximately 16000 steps, with a learning rate of 1×10^{-4} and batch size of 4. We adopted an L1 loss function to guide the model towards stylistic enhancement without distorting structural geometry. As shown in Figure 14, the average training loss decreased from 0.30 to below 0.14, with key inflection points around steps 5000, 11000, and 14500. This indicates that the model successfully internalized the stylistic cues of healthier streets—such as greener vegetation, warmer colors, and cleaner appearances.

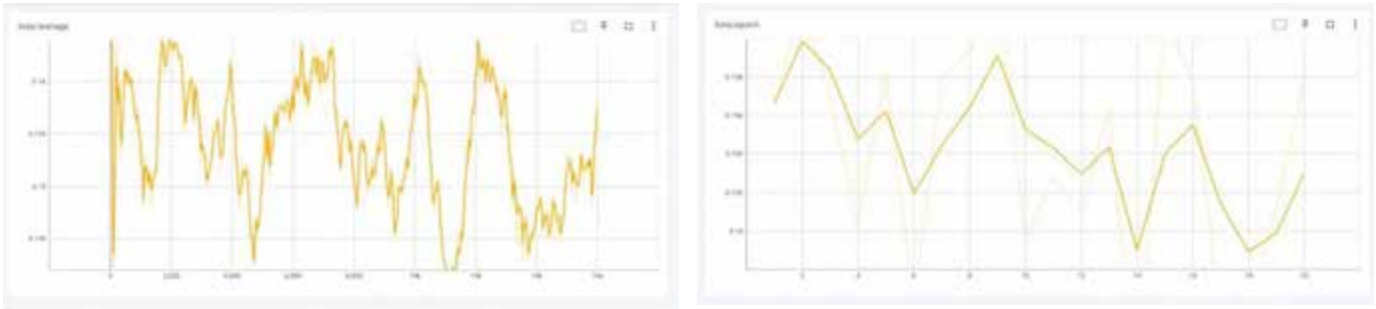


Figure 14 Variation of loss values for Lora model training

(3)Image-to-Image Regeneration
After fine-tuning, the LoRA-enhanced model was used to upgrade low-health street views via an image-to-image approach. Each original image was paired with a descriptive prompt that conveyed its intended transformation (e.g., “add lush trees,” “widen sidewalks,” “brighten facades”), and mild Gaussian noise was introduced to trigger generative variation.

To preserve spatial consistency, we incorporated ControlNet during inference. The model was switched to a large-scale base model (“Urban Streetview”), and semantic segmentation masks—obtained from previous analysis—were used as ControlNet input. This anchored the spatial structure of key elements such as roads, buildings, sky, and trees, ensuring layout fidelity while allowing stylistic transformation through the LoRA weights.

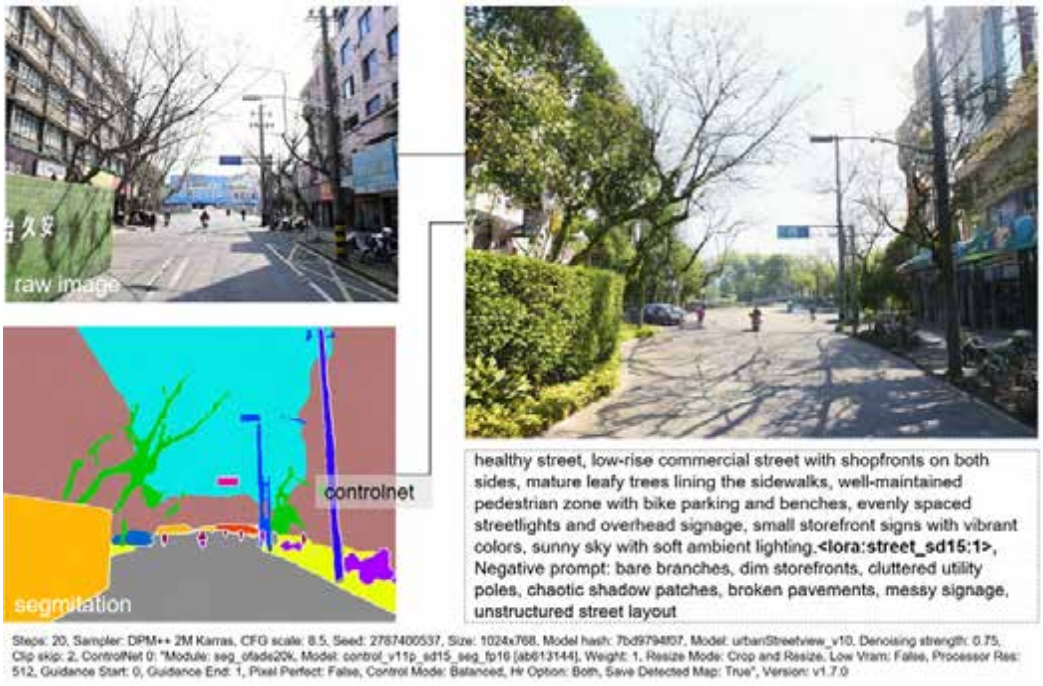


Figure 15 Typical street streetscape optimization process, sample 1

Figure 15 (Commercial Block Transformation) illustrates a typical result. The original scene shows a dull commercial street with gray façades and sparse vegetation. The generated version retains the layout but adds mature street trees, warm color tones, and new signage—creating a livelier and more inviting atmosphere.

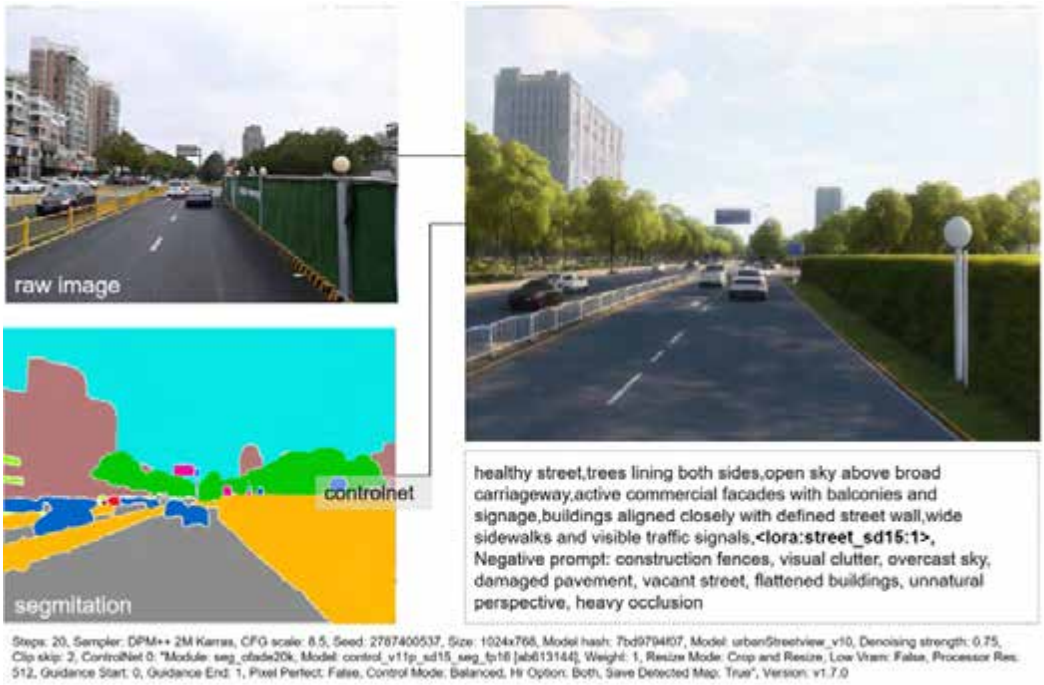


Figure 16 Typical street streetscape optimization process, sample 2

Figure 16 (Arterial Road Renewal) presents a congested urban road flanked by mid-rise buildings. The optimized output introduces planting strips, a brighter sky, and softened tones, improving the spatial feel while keeping the building envelope intact.

These examples confirm that the model has learned a coherent "visual grammar" of healthy streets. With only a semantic layout and a prompt, it can inject greenery, vibrancy, and visual order—offering a rapid, automated method for visual upgrading of urban streetscapes.

5 .2 Batch enhancement: results and evaluation

Encouraged by the single-scene trials, we ran the LoRA-adapted Stable Diffusion model on the remaining 1754 street views—every image outside the Elo survey. Using an NVIDIA RTX 4060, the image-to-image pipeline rendered the entire set in roughly one hour, underscoring the practicality of city-scale, AI-assisted retrofitting.

Figure 17 Batch optimization of Street View images

Figure 17 samples the outcomes. Across commercial corridors, residential lanes, and arterial roads, the AI generator consistently inserted or intensified health-supportive cues—canopy trees, brighter façades, tidier shopfronts, clearer skies—while retaining each street's geometry and landmarks. The resulting portfolio reads as recognisably Haining, yet palpably more verdant, colourful, and inviting.

To judge whether these cosmetic upgrades translate into a higher perception of street health, we re-scored every "before" and "after" image with RF and CNN models introduced in valuation section.

·RF Model: Predicted Elo scores rose by an average of +18.7 points, with a median gain of +26.5. Three-quarters of the images improved by more than +20 points. Only a handful of streets near the original ceiling showed little change, indicating that the model's headroom, not a failure of the generator, limited further gains.

·CNN Model: On the CNN's 0–1 scale, scores increased by ≈ 0.18 on average and ≈ 0.20 at the median. Many streets jumped by 0.4–0.5—an improvement large enough to shift them from the lower to the upper half of the distribution. A few scenes remained flat, typically where the generator's edits fell short of adding sufficient greenery or light.

Table 7 Score improvement under RF and CNN model scoring

Metric	RF Prediction Gain	CNN Prediction Gain
Sample Size	1754	1754
Mean Score Gain	41.89	0.065
Standard Deviation	40.3	0.086
Median Gain	37.59	0.059
Minimum Gain	-104.31	-0.205
Maximum Gain	202.88	0.43
Interquartile Range (25%–75%)	14.07 – 66.12	0.007 – 0.119

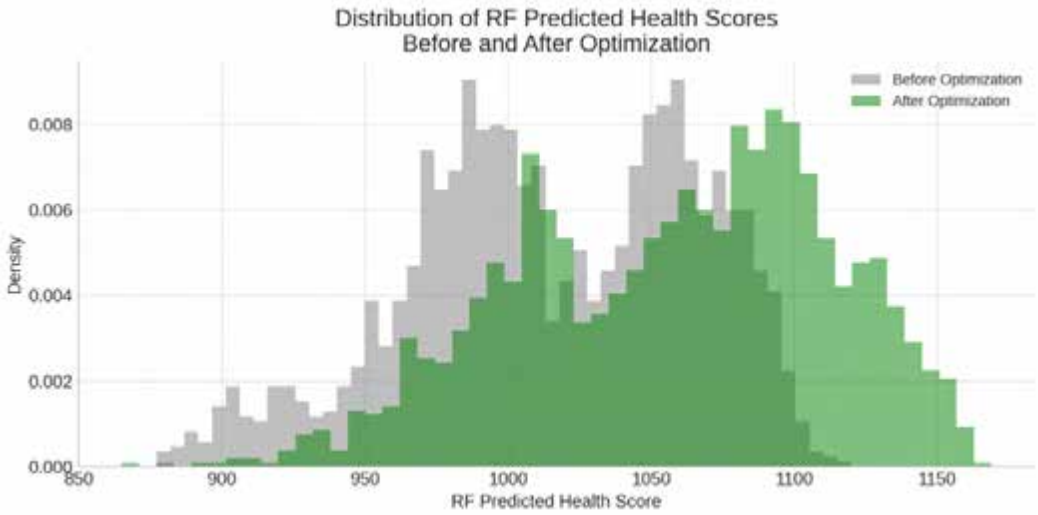


Figure 18 Histogram of RF and CNN model score changes

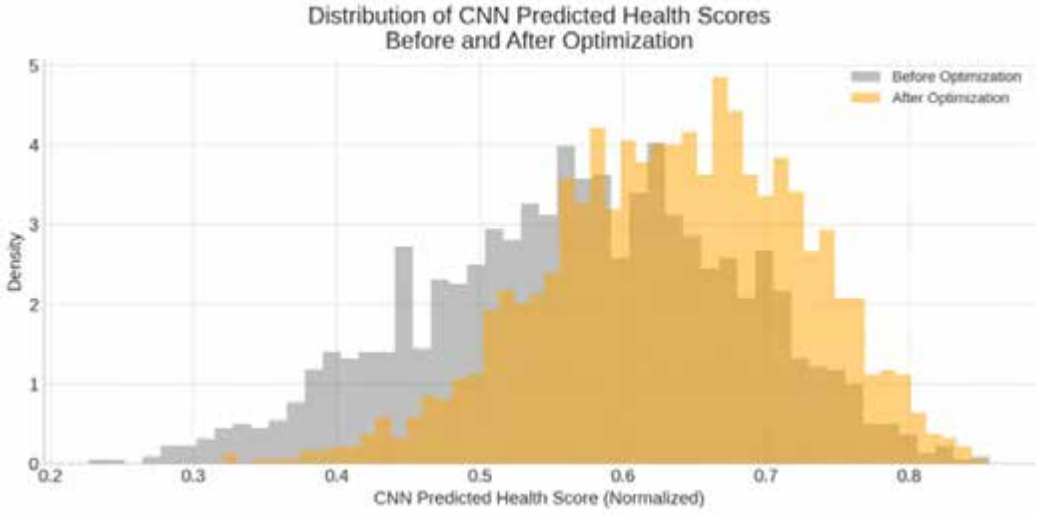


Figure 19 Histogram of RF and CNN model score changes

Taken together, the dual-model evaluation confirms that the AI intervention not only beautifies images but also measurably lifts the predicted healthiness of streets at scale. This quantitative uplift, combined with the rapid run-time, positions the workflow as a practical tool for planners seeking quick, evidence-based previews of healthy-street retrofits.

6 Conclusion

This study introduces an AI-driven workflow that links perception, evaluation and optimisation in a single, self-updating loop, and tests it on the streets of Haining. Deep-learning segmentation translated raw street-view imagery into eight visual indicators—greenness, enclosure, sky exposure, façade colour diversity and so on—whose city-wide maps expose where healthy-street qualities thrive and where they are scarce. Machine-learning models, trained on crowd-sourced Elo judgements, then bridged those objective metrics with subjective well-being: the Random Forest revealed that canopy trees, human-scale proportions, pedestrian infrastructure and visual vibrancy are the strongest predictors of health, while a convolutional network, working directly from pixels, echoed the same hierarchy. Finally, a Stable Diffusion generator, fine-tuned with Lora and anchored by ControlNet

masks, recast low-scoring scenes as greener, brighter and tidier streetscapes; re-scoring with the predictive models showed a clear, quantitative uplift. In short, the pipeline moves seamlessly from diagnosis to design suggestion and back to diagnosis, delivering a rapid, evidence-based aid for street retrofits.

This study introduces two major innovations that set it apart from prior work on street environment evaluation and design:
(1)A closed-loop methodology bridging perception, valuation, and intervention.Where many previous studies focus only on visual diagnosis or abstract design ideas, our research establishes a full-cycle framework that integrates objective spatial analysis, subjective well-being evaluation, and AI-based visual enhancement. By building a consistent pipeline—from semantic indicators to perception models to targeted visual regeneration—we enable not just problem identification, but also evidence-based solution generation and feedback verification.

(2) Deep integration of AI across the workflow, including pioneering use of generative models.We leverage state-of-the-art AI technologies throughout the process: deep-learning segmentation for semantic features, machine learning and CNNs for health score prediction, and—most notably—a fine-tuned generative diffusion model (via LoRA) for street-level transformation. Unlike typical AIGC applications focused on artistic or entertainment content, we demonstrate its use for purposeful, rule-informed urban design. By teaching the model to understand and apply the visual logic of healthy streets, we show that AI can not only see and evaluate cities but also reshape them—offering planners a novel and scalable tool for visual experimentation and public engagement.

But this study remains an initial probe. Haining is a medium-sized city with a mid-rise fabric; megacity canyons or small-town main streets may challenge the models in unforeseen ways, so cross-city replication is essential. Our indicator set is intentionally visual, yet everyday street health also hinges on sound, air quality and micro-climate; coupling image analysis with sensor feeds would yield a fuller diagnosis. In addition, the perceptual ground truth comes from a one-off survey. Embedding the system in an online platform where residents can iteratively rate—or even tweak—virtual street views would create a living feedback loop that refines both the evaluators and the generator while deepening civic participation.

Artificial-intelligence tools now let us see, evaluate and redesign the public realm in a single, accelerated workflow. By uniting quantitative perception analysis with generative design, the framework sketched here moves urban practice towards an interactive, evidence-based craft—a step, we hope, toward streets and cities that are not only smarter, but tangibly healthier and more delightful for those who use them.

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The Study on the Measurement and Enhancement Strategies of Urban Street Space Quality Based on Street View Images: A Case Study of Streets in the Central Urban Area of Xi'an

Tianxin Zhang & Mengde Zheng

Abstract
Identifying the spatial quality characteristics of urban streets is crucial for achieving scientific planning and effective management. This provides a basis for optimizing urban spatial layouts and promotes the intelligent and sustainable development of cities. However, most previous studies have been limited to specific neighborhoods, lacking a systematic analysis of street quality across large urban areas. Therefore, this study integrates spatial pattern data and street landscape image data from the main urban area of Xi 'an, constructing a quantitative database for street spatial quality. It establishes a measurement system from both objective physical space and subjective perception. The system covers four primary dimensions: safety, comfort, richness, and convenience, with fourteen evaluation indicators. The system uses the entropy value method to assign weights and completes a large-scale quantitative assessment of street spatial quality. The study results indicate: (1) The spatial quality of streets in the main urban area of Xi' an generally shows a 'high in the center, low in the periphery' layered distribution pattern. The central urban area has significant advantages in street interfaces, visual environments, and traffic organization, while the peripheral new districts face issues such as insufficient greenery, enclosed spaces, and single-function configurations. (2) Through K-means clustering, this study identifies four types of street spatial qualities: safety-oriented, ecological comfort, interface vitality, and pedestrian convenience. It further analyzes the causes and mechanisms of these types from four aspects: location conditions, land use, planning policies, and historical evolution. (3) The study also used the Cohen's s Kappa coefficient to test the consistency between model outputs and subjective perception levels. The results showed that the integrated model outperformed the single objective index model in terms of recognition accuracy, confirming the necessity of incorporating perception dimensions. (4) Enhancing the spatial quality of streets requires a multi-dimensional collaborative strategy, including enriching street interfaces, enhancing road surveillance and lighting design, and improving green spaces and pedestrian facilities. The framework for measuring street spatial quality proposed in this paper is highly scalable and adaptable, both methodologically and practically. It not only provides a basis for targeted measures to improve the quality of streets in Xi' an's main urban area but also offers a feasible path and technical support for other cities to advance the refined governance and human-centric optimization of public spaces.

Key words: street space quality; street scene image; subjective and objective fusion; cluster analysis

1. Introduction

As urbanization accelerates and urban governance concepts evolve, enhancing the quality of urban public spaces has become a critical support for achieving livable, resilient, and sustainable cities. Streets, being the most human-centric urban units, not only serve as basic traffic corridors but also play a vital role in connecting diverse urban activities, fostering social interactions, and shaping the city's image. The quality of street spaces directly impacts residents' daily experiences, travel preferences, and the overall vitality of the city, making it a core issue in urban planning and governance (Xuan & Zhao, 2022).

Traditionally, the assessment of street space quality has primarily focused on the physical environment, emphasizing 'visible structure' indicators such as road section design, greenery layout, and the continuity of street interfaces (Wan, Lu, & Sun, 2022). However, this method, which emphasizes structural objectivity, often overlooks the subjective feelings and emotional responses of space users, making it difficult to fully capture the comprehensive impact of street spaces on residents 'psychological and behavioral aspects. In the current trend of urban governance that increasingly emphasizes' people-oriented 'and' perception-focused 'approaches, there is an urgent need to develop a multi-dimensional evaluation system that integrates subjective experience with objective measurement, breaking through the limitations of existing theories and methods (L. Zhang, Ye, Zeng, & Chiaradia, 2019). Meanwhile, with the rapid advancement of street image technology and computer vision algorithms, the recognition of urban street space characteristics is becoming more automated and refined (Ye, Zeng, Shen, Zhang, & Lu, 2019). Street images, as spatial data that approximate the human eye's perspective, offer the advantage of high-frequency, low-cost acquisition of street visual landscape features. By integrating deep learning and perception modeling technologies, these images can achieve quantitative analysis of street spaces in terms of safety, livability, and aesthetics, significantly expanding the depth and breadth of evaluation metrics (Tang & Long, 2019; Yu, Zhang, & Zeng, 2019). Therefore, the data-driven measurement framework based on street view images has become a key development direction in the current research on urban spatial quality.

However, existing research still has several shortcomings: Firstly, most studies focus on typical street segments

with small sample sizes, lacking systematic coverage of large-scale urban areas, which makes it difficult to reveal the overall distribution and spatial heterogeneity of street space quality. Secondly, discussions on the integration of subjective and objective factors are mostly theoretical, without a mature and stable empirical approach. Thirdly, there is currently a lack of a comprehensive research chain that effectively links measurement results to the identification of street space types, the analysis of formation mechanisms, and the formulation of subsequent optimization strategies, which affects its practical application in urban governance.

This paper selects the main urban area of Xi'an City, China, as the research area and proposes a framework for evaluating street spatial quality that integrates street scene image recognition, subjective perception modeling, and the measurement of street physical characteristics. The framework systematically analyzes the distribution pattern, type characteristics, and formation mechanisms of street space. The main innovations of this study include: first, integrating street scene images with GIS spatial data to construct a multi-level indicator system that encompasses both subjective and objective dimensions, thereby enhancing the accuracy of street spatial quality assessment; second, using the K-means clustering method to identify different types of street space, revealing the combined differences in safety, comfort, interface vitality, and functional accessibility among these types; third, based on multiple factors such as location characteristics, land use, policy orientation, and historical culture, the study deeply analyzes the formation mechanism of street spatial quality and proposes practical optimization paths and spatial zoning suggestions.

2. Literature review

In recent years, with the advancement of big data and automated analysis technologies, the measurement of urban street space quality has shifted from traditional subjective surveys and manual observations to a quantitative evaluation method based on multi-source data integration. As a vital part of urban public spaces, streets not only influence travel behavior but also directly impact urban vitality and residents 'quality of life. Early theories, proposed by Lynch, Jacobs, and others, focused on the linear continuity, human scale, and visual appearance of streets. Today's research leverages deep learning, street view imagery, and GIS technology to automate the measurement of various elements of streets, including greenery, building facades, skylines, and pedestrian activities (Harvey & Aultman-Hall, 2016).

Traditional evaluation methods primarily rely on questionnaires and on-site observations to capture the perceived environment and visual effects of streets. While these methods can directly reflect user experiences, their limited sample sizes and subjective assessments make them unsuitable for large-scale application. To address this issue, researchers have developed automated evaluation methods based on street view images and geospatial data in recent years. These methods use deep learning and computer vision to segment street view images semantically, automatically extracting indicators such as green visibility, road width, building proportions, and sky perspective factors, forming a quantitative physical measurement system (Biljecki & Ito, 2021; Tang & Long, 2019). In contrast, other studies focus on integrating physical indicators with pedestrian perceptions, validating the accuracy of automatic measurements through expert ratings, questionnaires, or social media sentiment analysis (Du & Huang, 2022). Additionally, research based on indicator systems often draws from the 5D framework, which includes density (Density), diversity (Diversity), design (Design), destination accessibility (Destination Accessibility), and transportation distance (Distance to transit), and has been expanded to include dimensions such as social, safety, and cultural aspects, such as the 5D+3S model (Wan et al., 2022; L. Zhang et al., 2019).

Despite progress in quantifying street space quality, current research often focuses on measuring physical space in a single dimension, particularly on extracting and analyzing structural features such as green coverage, building density, and street interfaces. However, incorporating residents' subjective perceptions has lagged behind, facing issues such as insufficiently systematic indicator construction, inadequate coupling between dimensions, and limited validation methods (Han, Wang, Seo, He, & Jung, 2022). Even studies that attempt to integrate subjective and objective elements are often confined to specific street segments or small experimental areas, lacking systematic and standardized analysis for larger-scale urban spaces. Moreover, the current methods

for collecting subjective perception data still heavily rely on costly manual surveys or limited sampling, which cannot meet the demands for high-frequency, dynamic, and extensive street assessments (Ogawa, Oki, Zhao, Sekimoto, & Shimizu, 2024). Therefore, there is an urgent need to develop a street space quality measurement system that balances physical characteristics with subjective experiences, is scalable, and practical. This would not only enhance the precision of urban governance but also provide robust data support and decision-making for smart city development and public space optimization. Based on this background, this paper intends to carry out a systematic study integrating intelligent analysis and perception verification mechanism of street view images, focusing on filling the deficiencies of existing research in the construction of multi-dimensional index system, spatial heterogeneity identification and strategy optimization path, which has important theoretical significance and practical value.

3. Study areas and data sets

3.1 Research area

This study selects Xi 'an City in China as the subject of empirical analysis. Located in the middle of the Guanzhong Plain, Xi' an is situated between 107°24'00"E and 109°29'24"E, and 33°25'12"N and 34°27'00"N. It borders the Wei River to the north and the Qinling Mountains to the south, forming the heart of the 800-li Qin Plain. Known as the 'ancient capital of thirteen dynasties,' Xi 'an has a city-building history of over 3,100 years and a capital-building history of over 1,100 years. Thirteen dynasties, including the Western Zhou, Qin, Han, Sui, and Tang, have established their capitals here. This study focuses on the main urban area of Xi' an, which includes six administrative districts: Xincheng, Beilin, Baqiao, Yanta, Lianhu, and Weiyang (Figure 2). The district comprises 55 sub-districts and covers a total area of 836.02 square kilometers (Lin, Xiping, Junyi, Yongyong, & Zhiyuan, 2025).

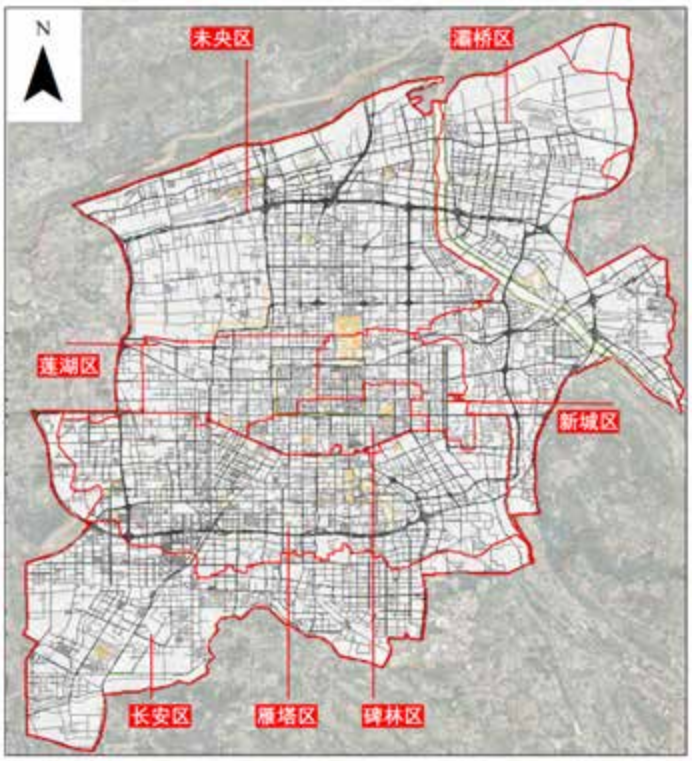

Figure 1. Scope of the study

3.2. Data sets and variables

The institute's data encompasses a variety of sources, including basic road information, spatial quality assessments, and administrative divisions. The basic road information is sourced from the 2021 updated OSM

platform (https://openstreetmap.org/). POI data are collected via Python 3.8 from Baidu and AutoNavi Maps, and have been corrected. Street view images are primarily sourced from Baidu Panorama Map, with 360 Maps providing supplementary data for missing areas. Sampling points are set at intervals of 100 m, capturing human-viewed images from 90°,180°,270°, and 360° angles (1024×512 resolution). Image semantic segmentation tools are used to extract the proportions of building interfaces, sky, and greenery. Administrative division base maps are sourced from the National Basic Geographic Information Public Service Platform and are uniformly projected into a consistent coordinate system using ArcGIS 10.7.

Table 1 Multi-source, multi-scale data types, sources and processing

data name	data sources	acquisition time	data handling
Road network data	Open Street Map	December 2024	After the road centerline is simplified and extracted by manual, the topology is checked and verified with reference to the Gaode satellite image
Street View data	Baidu Open Street View Map platform	December 2024	The Baidu Street View API was called to collect 289,664 static panoramic images with a spacing of 50 m, and the image size was 1024x512 pixels. Then the Mask2Former semantic segmentation model was used to segment the street view images.
Interest point (Point of Interest, POI) data	Baidu Map	December 2024	The geographic information interest point (POI) data was obtained from Baidu Map API. According to the research needs, 18 kinds of POI data such as food, hotel and shopping were obtained within the research scope and its surrounding area. The data contained industry categories, names, addresses, administrative areas and other information.
MIT Place Pulse Data set	MIT Media Lab Developed Place Pulse projects	December 2024	The Microsoft Trueskill algorithm was used to calculate the corresponding perception scores of six dimensions, and the model was trained to predict the scores of six perception dimensions on the streets in the central urban area of Xi 'an.

4. Research methods

4.1 Subjective perception score acquisition

In this study, to more accurately capture residents' subjective perceptions of the street space environment, the Place Pulse 2.0 dataset and its accompanying subjective perception model, developed by MIT Media Lab, were introduced as the core tool for generating perception scores. Place Pulse constructed a street scene perception evaluation system covering six dimensions—safety, security, livability, vitality, wealth, and sociality—by conducting paired comparisons and scoring global street scenes. The scoring results were then quantified and ranked using the Microsoft Trueskill algorithm (L. Wang, Han, He, & Jung, 2022).

In the implementation of this study, street view images from the main urban area of Xi 'an were selected as input data. Using a pre-trained Place Pulse perception model, scores were assigned to each image across multiple perceptual dimensions. To enhance the model's performance in localized applications, the model was fine-tuned and refined based on a small amount of manual scoring results. For each sampling point, four street view images were collected from four directions (90°,180°,270°,360°). Scores were assigned to each image and a weighted average was calculated to obtain the overall subjective perception score for that sampling point.

Subsequently, the study utilized GIS tools to map the scoring results onto street grid units, achieving a spatial visualization of scene perception. Ultimately, by calculating the weighted average of the scores from multiple

sampling points on each street, the study derived the representative subjective evaluation of that street. This scoring system not only provides a clear reflection of residents' overall impressions of the street environment but also offers crucial data and theoretical support for future analyses that integrate with objective physical indicators.

4.2 Objective perception score acquisition

The objective perception scoring system proposed by this institute primarily relies on semantic segmentation analysis of street view images and geospatial data processing. It aims to achieve automated and standardized quantitative evaluation of the physical characteristics of urban street spaces. The research team first used the Baidu Street View Open Platform API to set up sampling points at intervals of 50 meters in the main urban area of Xi'an City. They collected static street view images from four directions (90°,180°,270°,360°), with a uniform image size of 1024×512 pixels, to ensure data consistency and improve subsequent processing efficiency.

Subsequently, using the deep learning model Mask2Former, pixel-level semantic segmentation was performed on the images to automatically identify the proportions of greenery, sky, buildings, roads, and motor vehicles (Cheng et al., 2021). Based on this proportion information, a quantitative index system reflecting the spatial characteristics of streets was constructed, including dimensions such as road accessibility, motor vehicle interference intensity, visibility of greenery and sky, and street interface morphology (W. Zhang, Chen, & Tian, 2025). The image analysis results were matched with the road space network, and using GIS analysis tools, the measurement values were mapped to each street segment. An objective perception score at the street scale was formed based on the weighted average of the sampling points in each street segment.

To enhance the robustness and representativeness of the index system, the study integrates POI data to supplement the identification of street safety facilities (such as surveillance cameras) and functional interfaces (such as ground-floor openness). It also considers factors such as building openness, material diversity, and pedestrian accessibility, thereby constructing a more comprehensive framework for evaluating street physical characteristics (Miaoyi, Zhonghao, & Feng, 2021). The final scoring results not only reflect both structural and functional aspects but also lay a solid foundation for the integration of subjective perception results in subsequent analyses. This further supports the multi-dimensional modeling of street spatial quality and the identification of regional differences.

4.3 Construction of street quality index system

In constructing an evaluation system for assessing the quality of street spaces, this paper adheres to the urban design philosophy of 'people-oriented,' balancing practicality and interpretability. It integrates the objective attributes of physical space with residents' subjective perceptions, forming a diverse and systematic evaluation framework. This system primarily relies on street scene images, spatial data, and perception models as core information sources, aiming to comprehensively reflect the overall performance of street spaces from multiple perspectives, including function, environment, and experience.

On the objective level, the evaluation system focuses on the structural characteristics and functional environment of streets, covering key indicators such as spatial openness, traffic interference, green space ratio, street interface complexity, and pedestrian accessibility. It emphasizes the physical safety, comfort, and connectivity of streets (R. Wang, Huang, & Ye, 2024). On the subjective level, the system incorporates Place Pulse's perception scores, focusing on psychological dimensions like security, livability, vitality, and social interaction. This approach addresses the individual experience differences that traditional physical measurements often overlook, reflecting the environmental impact on residents' emotions and behaviors.

To achieve the organic integration of two dimensions, this paper uses a unified street segment spatial unit as the foundation and standardizes both subjective and objective indicators through Z-score normalization, enabling the comparison and analysis of indicators with different scales within the same system. By integrating the results of principal component analysis and correlation tests, the eight core indicators are categorized into three

primary dimensions: spatial efficiency, visual environment, and user experience, forming a hierarchical model for measuring street quality. This model not only highlights the multi-level characteristics of street space but also lays the theoretical groundwork for subsequent cluster analysis and spatial difference studies.

By integrating multi-source data and constructing a dual-dimensional framework, this paper transforms the spatial structure from 'visible' to 'felt' life experiences, advancing street quality research from a single physical measurement to a more comprehensive evaluation method. This approach provides practical pathways and assessment tools for creating urban spaces with a focus on humanistic care and refined governance (Wei, Tingting, & Jie, 2024). To validate the effectiveness of integrating subjective and objective dimensions in measuring street spatial quality, the paper further calculated the consistency between the fusion model and the single objective model in terms of street classification levels and subjective perception levels. The results showed that, based on Cohen's Kappa coefficient, the consistency between the single objective index model and subjective perception was -0.092, while the consistency between the subjective perception and the fusion model was -0.074 (Blackman & Koval, 2000; Warrens, 2015). Although neither model achieved a high level of consistency, the fusion model demonstrated better matching, confirming the importance of incorporating the subjective perception dimension in enhancing model accuracy and aligning with residents' experiences.

Table 2 Construction environment indicators and calculation methods

dimension	metric	computational method	weight	direction
safety	Vehicle interference	The degree of influence of motor vehicle traffic on pedestrian activity is measured by the number of vehicles in the unit.	0.0015	-
	Road surveillance	Assess the safety of a street, known as the "eyes on the street," by counting the number of surveillance facilities or pedestrians and shops on either side of the street.	0.1814	+
	sense of security	Based on the Place Pulse model, the "safety" dimension of street view images is scored, and the weighted average of multi-angle image scores is obtained to obtain the perceived safety score of street segments.	0.0138	+
degree of comfort	Visibility in the sky	The proportion of the visible part of the sky in the street space is calculated to reflect the degree of visual openness. The proportion of the sky in the total pixels is calculated through the analysis of street view images.	0.1663	+
	High ratings	The proportion of green vegetation in the street view is calculated to reflect the greening degree of the street. The proportion of green pixels in the total pixels is calculated through street view image analysis.	0.0792	+
	Sense of oppression	Based on the negative score results of "livability" and "safety" dimensions of Place Pulse model, the weighted calculation was carried out, and the lower the value, the stronger the sense of depression.	0.0162	-
	aesthetic feeling	The perception score of "aesthetics" dimension of Place Pulse model reflects residents' subjective evaluation on the visual image of the street, and the higher the score is, the stronger the aesthetic sense is.	0.0082	+

	Interface transparency	Measures the transparency of the facade of buildings on both sides of the street, i.e. the proportion of transparent or translucent parts (such as Windows, porches). Through street view image analysis, the proportion of transparent area to total facade area is calculated.	0.2699	+
rich	Interface richness	Evaluate the detail and diversity of the facade of buildings on both sides of the street. This can be measured by calculating the types and numbers of facade elements, such as decoration, material changes, etc.	0.0881	+
	Liveliness	The "activity" dimension of Place Pulse model is used to score the perception, which reflects residents' subjective evaluation on the visual image of the street. The higher the score, the higher the activity.	0.0264	+
	Boredom	The perception score of the "boredom" dimension of Place Pulse model reflects residents' subjective evaluation on the visual image of the street. The higher the score is, the higher the boredom degree is, which is a negative factor.	0.0096	-
convenience	Walkable accessibility	Measures how easily pedestrians can get from the street to various facilities (such as stores, public transport stops). It is usually calculated by calculating the number and distance of various facilities within a certain range around the street, combined with the street connectivity index.	0.1320	+
	Function mixing	The diversity of land use around the street is evaluated. The information entropy formula is usually used to calculate the proportion and distribution of different functions (such as residential, commercial, office, etc.) of land use around the street.	0.0013	+
	A sense of affluence	Based on the "sense of wealth" dimension score of Place Pulse model, the building material, facade decoration complexity and high-end commercial POI density are taken as auxiliary factors for comprehensive calculation.	0.0060	+

5.Results and analysis

5.1 Street quality identification results

To more deeply uncover the regional differences in the spatial quality of different streets within Xi 'an's main urban area, this study uses administrative districts as the basic analysis units. It employs the entropy value method to calculate comprehensive evaluation scores, conducting a systematic quantitative statistical analysis of the street quality in the five core urban districts: Xincheng District, Lianhu District, Beilin District, Weiyang District, and Yanta District. The study reveals that there are significant differences in street spatial quality among these five districts, reflecting a typical 'layer differentiation' spatial structure where the central urban area outperforms the peripheral new districts.

In terms of overall performance, the street space quality scores of Xincheng District and Lianhu District rank at the top, with average comprehensive scores of 10.39 and 10.38, respectively. Both districts have scores that are

close to each other and significantly outperform other administrative regions. This indicates that the central urban area has a clear advantage in street space interface design, environmental openness, greening levels, and pedestrian infrastructure construction, reflecting the long-term efforts of historical urban areas in refined urban management and planning. Additionally, the score standard deviations for the two districts are 2.69 and 2.96, respectively, indicating a high degree of balance in street space quality within the region, without significant polarization. The overall quality is maintaining a stable and balanced development trend.

The Beilin District, an old district with a rich historical and cultural heritage, also excels in street space quality, scoring an average of 10.00, ranking it among the top districts. The standard deviation of its score is 2.53, lower than that of Lianhu District, indicating relatively minor internal differences in street quality. However, the district's highest score of 26.58 significantly surpasses other districts, highlighting the outstanding performance of some historically significant and culturally rich streets in terms of visual appeal, environmental comfort, and interface diversity, showcasing the unique advantages of cultural streets. However, the lowest score in the district is only 5.77, significantly below the average of other districts, suggesting an uneven distribution of street quality within the district. The disparity in spatial quality between historical protection areas and ordinary streets warrants close attention during urban renewal efforts.

As key areas of urban expansion in Xi'an City in recent years, Weiyang District and Yanta District have an average street space quality score of 9.57 and 9.23, respectively, which is significantly lower than that of traditional central urban areas. While some streets in these districts have high scores, with the highest score exceeding 22 points, indicating a relatively good level of construction in certain areas, the overall standard deviation of street scores in these two new districts is relatively low, at 2.49 and 2.21, respectively, suggesting a noticeable trend towards homogenization in the design and construction style of street spaces. Notably, the lowest scores in Weiyang District and Yanta District are 4.60 and 4.69, respectively, far below the lowest scores in other administrative regions. These low scores are primarily concentrated in the urban fringe areas, highlighting issues such as strong motor vehicle interference, insufficiently transparent street interfaces, and inadequate green coverage, which require targeted improvements in future urban renewal efforts.

Further analysis of the distribution of street quality scores across different administrative districts reveals that high-quality streets are widely distributed in Xincheng District and Lianhu District, with generally superior spatial environments. In contrast, Weiyang District and Yanta District exhibit a dense concentration of medium to low-quality streets. This significant differentiation in spatial quality is closely linked to differences in urban development history, functional positioning, and policy resources, reflecting distinct development strategies in street spatial structure, land use methods, and functional layout across districts.

In summary, this study uses a comprehensive evaluation method to conduct a quantitative comparative analysis of the spatial quality of streets in various administrative districts of Xi 'an's main urban area. It highlights significant differences in spatial quality between traditional urban areas and emerging new districts. When formulating policies for future street quality improvements, it is essential to fully respect and integrate the specific development characteristics of each district. The central urban area should continue to enhance the optimization of interface details and the diversity of landscapes. For the peripheral new districts, the focus should be on increasing environmental openness, reducing traffic disturbances, and improving overall spatial comfort. This approach aims to promote the gradual coordinated development of street spatial quality across different regions, achieving balanced optimization and sustainable progress in the urban spatial environment.

Figure 2 Street quality identification results

Table 3 Street quality by district

canton	average value	standard deviation	maximum value	low
new city zone	10.39	2.69	24.83	5.22
Lianhu District	10.38	2.96	25.76	5.20
Beilin District	10.00	2.53	26.58	5.77
Weiyang District	9.57	2.49	22.45	4.60
Yanta District	9.23	2.21	23.12	4.69
Baqiao District	9.22	2.33	23.84	4.65
Chang'an District	8.83	1.77	24.38	4.46

5.2 Identification and characteristic analysis of street quality space types

In exploring the internal structural characteristics of street space quality in Xi 'an's main urban area, this paper uses the four core dimensions —— safety, comfort, richness, and convenience, established in the street space quality evaluation system, to classify the street spaces within the study area using the K-means clustering analysis method. Based on the performance differences of various streets across these dimensions, they are categorized into four types: 'safety-oriented streets,' 'ecological comfort streets,' 'interface vitality streets,' and 'pedestrian convenience streets.' The specific features of each type of street are as follows:

(1) Safety-oriented streets

These streets excel in safety, typically equipped with comprehensive road surveillance systems, offering a strong sense of security and relatively low motor vehicle interference. They are commonly found in densely populated or commercially active areas, providing robust public security. However, they fall short in terms of visual transparency (such as sky views) and green coverage, with room for improvement in the transparency and diversity of street interfaces. Therefore, future planning for these streets should focus on enhancing safety facilities while also improving ecological landscapes and visual quality.

(2) Ecological comfortable streets
These streets excel in green ecological indicators and visual environmental quality, featuring high green plant coverage, wide-open views, and a pleasant overall spatial experience. They are generally well-received by residents and are commonly found around green corridors, parks, and ecological scenic boulevards. However, they fall short in terms of pedestrian accessibility and mixed-use functionality, with insufficient interaction at street interfaces. Future urban renewal efforts should focus on enhancing functional complementarity and improving the pedestrian system to boost spatial vitality and usage efficiency.

(3) Interface dynamic street
Interface dynamic streets are renowned for their transparency, richness, and spatial vibrancy. They feature diverse building facades and strong visual appeal, creating a highly interactive and vibrant street environment. These streets are typically found in core commercial districts, historical and cultural areas, or tourist hotspots, making them ideal venues for cultural, commercial, and entertainment activities. However, high traffic volumes and a certain level of environmental pressure can also negatively impact the quality of experience. Therefore, while maintaining the vitality of the interface, enhancing traffic order and spatial transparency will be key areas for future optimization.

(4) Pedestrian-friendly streets
This type of street excels in pedestrian accessibility, mixed land use, and facility configuration. It features a well-planned spatial layout that is highly pedestrian-friendly, making it an essential part of daily commuting and living activities. Such streets are commonly found around urban commercial centers, transportation hubs, and comprehensive service areas. However, they generally lack visual appeal and greenery, with the street interface's attractiveness and visual comfort needing improvement. Future improvements should focus on enhancing visual experiences and ecological environments to comprehensively improve the quality and appeal of street spaces.

5.3 Analysis of the formation mechanism of street space quality types
The quality of street space is a key indicator for assessing the overall quality of urban public spaces, and its development is influenced by multiple factors. Based on the classification of street space types in Xi 'an's main urban area, this paper further explores the underlying mechanisms behind the differences in street quality from four perspectives: spatial location, land use, planning policies, and historical context.

(1) Differences in spatial location and endowment
The quality of street spaces is often closely tied to their location. Traditional central urban areas, such as Xincheng District, Lianhu District, and Beilin District, boast well-developed street systems and comprehensive commercial services and public facilities, offering superior location advantages. These factors naturally enhance the street vitality and pedestrian-friendliness of these areas. Moreover, early investment in public safety infrastructure has led to a dense distribution of 'safety-oriented streets' in central urban areas. In contrast, peripheral areas like Yanta District and Weiyang District, due to their later urban expansion, have less developed infrastructure, and the development of street safety and vitality is still in its early stages.

(2) Characteristics of land use mode and functional layout
The formation of different types of street spaces is closely linked to the intensity of land use and functional configurations. Pedestrian-friendly streets are typically found in commercial nodes, transportation hubs, and public service areas, where the land use is highly mixed, facilities are densely packed, and the focus is on enhancing pedestrian experience. Ecological comfort streets are mainly located around parks, green spaces, ecological axes, and new residential areas, characterized by low land density, high green coverage, and an open visual environment. Interface vitality streets, which rely on cultural and commercial land, feature interactive and visually diverse building facades, making the spatial interfaces highly attractive.

(3) Urban planning policy and governance orientation
In recent years, Xi 'an's planning policies have increasingly emphasized the quality of public spaces and the

refinement of urban governance. This has led to the updating of street safety facilities, the enhancement of interface images, and the optimization of pedestrian systems in the central urban area, resulting in a significant and stable improvement in overall spatial quality. Although the new urban areas initially focused on ecological space construction and created some ecologically comfortable streets, the lack of effective supporting policies has led to lagging development in other areas, resulting in a noticeable quality gap. In the future, it is necessary to enhance the vitality of the new district interfaces and pedestrian convenience through policy measures, promoting the coordinated development of the city's overall spatial layout.

(4) Historical development background and spatial heritage inheritance
The quality of street space is significantly influenced by the city's historical development and cultural heritage. Traditional urban areas, such as Beilin District and Lianhu District, are rich in cultural resources and humanistic landscapes. The streets in these areas have evolved over time, with highly dynamic spatial interfaces, making them an essential part of the urban landscape. In contrast, new urban areas lack historical and cultural support, and their street space design relies more on modern planning concepts, resulting in relatively weak visual and interface performance. Therefore, the renewal of street spaces should aim to protect historical and cultural heritage while integrating modern functional optimization, achieving an organic blend of tradition and modernity.

The formation of the spatial quality types of main urban streets in Xi'an City is essentially the result of the combined effects of various factors, including spatial location, land use, policy guidance, and historical and cultural elements. The location characteristics provide a foundation for development, land use enhances spatial functions, planning policies drive quality improvements, and historical heritage enriches the cultural significance of the spaces. Future urban street governance should, based on an understanding of these mechanisms, develop a multi-dimensional and balanced optimization strategy to promote the continuous improvement and coordinated development of urban public space quality.

6.Conclusion
This study, using the main urban area of Xi'an as a case, developed a framework for measuring urban street spatial quality that integrates intelligent recognition and perception scoring mechanisms of street scenes. It systematically integrates physical environmental elements with subjective perception factors, conducting a comprehensive and systematic analysis from the construction of evaluation indicators, data processing, spatial type identification to the analysis of formation mechanisms. Based on this framework, the study has reached the following key conclusions:

The subjective and objective integration evaluation system proposed in this paper has achieved significant breakthroughs in both theory and methodology for measuring the quality of street space. In terms of indicators, it expands the traditional measurement centered on physical structure to a multi-dimensional system that includes residents' perceptions. Technically, it leverages street view images and machine learning models to construct a large-scale, automated evaluation process, significantly enhancing the accuracy and applicability of street space quality analysis. By using Z-score standardization and entropy value weighting, a scientific, systematic, and hierarchical comprehensive index of street quality has been developed, providing a stable and reusable technical framework for spatial quality research.

(2) The spatial quality of the main urban area's streets generally follows a' high in the center, low on the periphery 'pattern. Traditional central areas, such as the new district and Lianhu District, excel in safety, interface diversity, green coverage, and pedestrian accessibility, with significantly higher average scores compared to peripheral new districts like Weiyang District and Yanta District. These structural differences are closely linked to the city's development stage, resource allocation, and policy priorities, highlighting the uneven distribution of urban spatial quality.

Through cluster analysis, four typical street types were identified: 'safety-oriented streets,' 'ecological comfort streets,' 'interface vitality streets,' and 'pedestrian convenience streets.' Each type of street excels in different

aspects, such as the completeness of safety facilities, the openness of visual landscapes, the vibrancy of interface interactions, and the integration and accessibility of functions. This classification highlights the diverse development paths of urban street spaces in terms of composite functions, structural forms, and service performance. The results provide a clear direction for future district governance and differentiated improvements.

(4) The classification and distribution of street spatial quality are influenced by multiple mechanisms, including location conditions, land use patterns, urban planning policies, and historical and cultural heritage. The spatial location determines the level of street infrastructure and the layout of supporting facilities. The structure of land use enhances the expression of spatial attributes, policy support accelerates the pace of quality improvement, and historical heritage profoundly influences the formation of street interfaces and forms. Urban street space optimization should be based on these factors, adopting comprehensive measures to achieve dynamic integration between planning logic and spatial practice.

(5) To evaluate the model's effectiveness, the study used Cohen's s Kappa coefficient to compare the consistency between different models and subjective perception levels. The results showed that the consistency between the single objective index model and subjective perception was -0.092, while the consistency between the integrated subjective-objective model and subjective perception improved to -0.074. Although the overall consistency level still needs improvement, the integrated model performed better, further confirming the positive impact of incorporating subjective perception factors in enhancing the explanatory power and accuracy of measurement models. This finding underscores the importance of a 'people-oriented' and 'perception-led' approach in future urban spatial quality assessments.

7.Discussion

This study introduces a street space quality measurement system that integrates subjective and objective perspectives. It overcomes the limitations of traditional urban space evaluation models in both theory and methodology, significantly enhancing the ability to identify the interaction between human perception and the spatial environment. By integrating street view images, subjective perception models, and multi-dimensional evaluation indicators, the study not only achieves a broad and high-precision assessment of urban street space quality but also demonstrates the positive impact of incorporating subjective factors on improving evaluation accuracy. Compared to a single objective model, the Kappa coefficient between the subjective level and the subjective-objective integration model is superior, although overall consistency has not yet reached a significant level, it shows potential for improving recognition accuracy. Additionally, the results of street type identification reveal the diverse patterns of urban street space functions and environmental characteristics, providing practical guidance for urban zoning governance and detailed updates.

Despite achieving some success, the research still has several shortcomings. Firstly, the quality of street view images is affected by shooting time, occlusion factors, and update frequency, leading to unclear or incomplete images in some areas. Secondly, subjective perception data primarily relies on the Place Pulse model, which has strong cultural biases in its training samples, making it difficult to fully reflect the actual perceptions of urban residents in China. Thirdly, the current method of integrating subjective and objective scores uses a simple averaging approach, lacking more robust weight optimization or structural modeling strategies. Lastly, while the classification of street spatial types has some application value in policy-making, it has not yet been effectively linked with land use, socio-economic characteristics, and governance units, resulting in a certain degree of disconnection between measurement and governance. Therefore, future research should enhance the model's adaptability to local conditions, expand the sources of diverse data, introduce mechanisms for behavioral responses and logic for matching governance scenarios, and promote the evolution of street spatial quality research from technical tools to governance mechanisms.

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A Digitalised Tourism Sector: Impact on Occupations and Geographies

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Abstract
Tourism plays an important role in the German economy, especially in hotspots in the northern coastal areas and the Alpine regions in the south, where up to 10% of the workforce is employed in tourism-related occupations. Like the broader labour market, these jobs are also affected by digitalisation trends and, as the analysis shows, they may be even more susceptible to certain aspects of it. This article maps digitalisation indicators to occupations and labour market statistics and defines digitalisation profiles that explain how digitalisation shapes employment in the tourism sector and where regional differences in susceptibility may occur.

Keywords: labour market, tourism, artificial intelligence, digitalisation, computerisation

1. Introduction

According to the United Nations World Tourism Organization (UNWTO, 2025), Germany ranked 8th among the world's top 10 most visited countries in 2024, recording 37.5 million international arrivals, an increase of 7.8% compared to 2023. The tourism industry is considered an important pillar of Germany's economy, significantly contributing to both the economy and employment. The World Travel and Tourism Council (WTTC) is forecasting that the sector could grow its annual GDP contribution to nearly € 554 billion by 2034, representing just over 12% of the German economy, and could potentially employ almost 6.5 million people across the country (WTTC, 2024).

Tourism data is sourced from the INKAR database (INKAR, 2024), maintained by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR). While cities such as Berlin, Munich and Hamburg attract the most tourists on absolute terms, the relative size of this economic sector is much larger in smaller, less-densely populated regions. Analysis on the level of districts and district-free cities ("Kreise" & "Kreisfreie Städte") shows large disparities in the importance of tourism, illustrated by the three maps on accommodation capacity, demand intensity, and tourism-related employment (Figure 1).

Focusing on the number of tourist beds per 1,000 inhabitants the analysis reveals high concentrations in the northern coastal areas (Baltic Sea and North Sea), the southern Alpine regions, and selected major cities such as Berlin, Munich, and Hamburg.

Tourism-related jobs are concentrated similarly, however some regions with high tourist accommodation capacities exhibit a relatively low share of tourism employment, for example some districts in Rhineland-Palatinate in the southwest of the country. This can result from factors such as reliance on external seasonal labour or a concentration of jobs in other sectors. The analysis of tourism demand, measured by overnight stays per inhabitant, shows some inconsistencies: regions with high accommodation capacity do not always exhibit equally high tourism demand, suggesting an under-utilization of facilities or stronger seasonality.

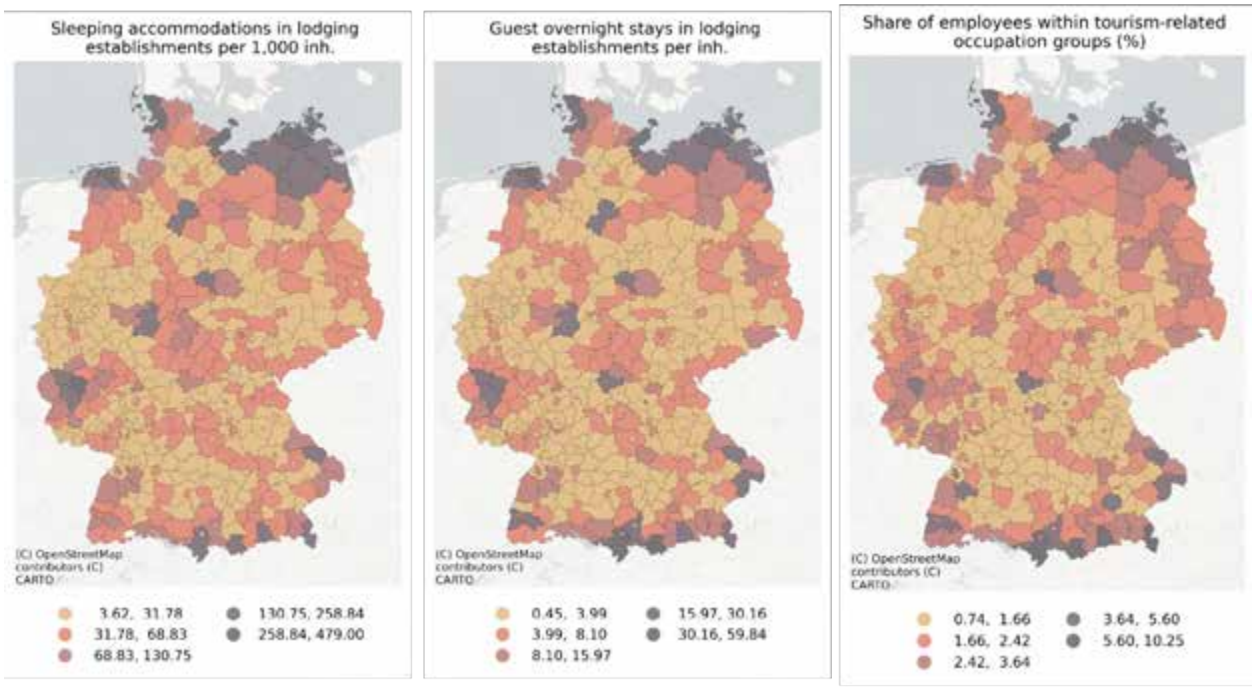

Figure 1. Regional variation in tourism intensity across Germany.

Tourism areas in Germany are not only leisure destinations but also important economic hubs, where tourism contributes to employment, income generation, and regional development. As a cross-sectional industry, tourism intersects with multiple sectors, ranging from transport and accommodation to gastronomy, culture, and business services, making it challenging to assess ongoing trends both statistically and spatially.

In a country where tourism plays a vital economic and cultural role, spanning urban, rural, and natural destinations, there is a growing need for a more integrated and comprehensive understanding of the sector. This article explores the structure, spatial distribution, workforce employments, and technological transformations shaping employment in the tourism sector in Germany.

2. Methods

2.1 Labour Market Information

To quantify and analyse the impact of digitalisation on the tourism sector, labour market data is queried from the employment statistics database (Bundesagentur für Arbeit, 2022) of the German Federal Employment Agency (Bundesagentur für Arbeit). This database consists of a structured list of occupations, occupation groups and sectors, as well as employment numbers per group and geographic entity.

Occupations are organised in a hierarchical system, which is described in the KldB 2010 structure. This occupational taxonomy distinguishes between 36 main occupational groups identified by 2-digit codes (e.g. 63 - Occupations in tourism, hotels and restaurants), which is split up into 140 occupational groups at the 3-digit level (e.g. 631 - Occupations in tourism and the sports (and fitness) industry), and 698 occupational subgroups at the 4-digit level (e.g. 6311 - Management assistants in tourism). On the lowest level in the hierarchy there are 1300 occupations with a 5-digit code (e.g. 63112 - Management assistants in tourism-skilled tasks). The Federal Employment Agency also provides with a list of job titles (with 18,838 entries) that can be linked to these occupations (e.g. jobs linked to occupation 63112 can have titles such as “travel agency assistant”, “economic assistant for tourism and foreign languages” or “tourism assistant”).

The data used within this research correspond to the reference date of 31 December 2022. Employment numbers

are available down to the occupational subgroup (4-digit) level on the federal scale and are differentiated by characteristics such as gender, nationality, age groups, and employment type (full-time, part-time, or marginal employment). At the regional level, data are only available at the level of occupational groups (3-digit), with a differentiation by employment type. This analysis builds up on data of full-time workers who are subject to social security contributions.

The regional breakdown follows the German system of districts and district-free cities (Kreise und kreisfreie Städte), corresponding to the NUTS-3 classification. There are a total of 400 districts and district-free cities, with a median population of 157,406 (INKAR, 2024). Due to data protection rules, occupational groups with fewer than 40 employees are masked in the regional statistics. There are 109 districts with masked data for more than 50 of occupational groups. For these groups, random numbers between 0 and 39 were assigned.

2.2 Data Constraints

A major challenge within this analysis results from the lack of availability of high-quality and disaggregated data, especially in labour market statistics. For instance, the occupational group 631, classified as "Tourism and Sport", includes up to 90 different job titles, ranging from tour guides and alpine guides to managers of travel agencies and graduates with an MBA in tourism economics. These job titles often differ in their qualification requirements, work environments, and digitalisation exposure. This complicates interpreting the impact of digitalisation on the level of occupational groups.

Furthermore, the regional units used in the analysis to obtain the number of workers in a given occupation group are relatively large and often internally diverse. This means that variation in the structure and relevance of the tourism sector may exist within a single district (Sarrión-Gavilán et al., 2015), which cannot necessarily be captured at the available level of resolution. In addition, tourism activities can be expected to produce spillover effects that extend beyond administrative boundaries. These spatial interactions are not reflected in the available data and should be kept in mind when interpreting the results.

2.3 Defining tourism jobs

Tourism is not a closed economic sector and involves a wide range of interactions with other industries. However, the structured and hierarchical nature of available labour market data cannot fully reflect these interdependencies (Liu and Wall, 2006). As a result, certain forms of economic activity are often underrepresented or misclassified, which can lead to a narrower depiction of the tourism sector, as it has been shown in an example in agrotourism (Guizzardi & Costa, 2023).

The classification of workers involved in the tourism sector in Germany by the broader framework of Tourism Satellite Accounts (TSA) is based on tourism-characteristic products and services. These classifications help determine which economic activities are directly or indirectly linked to tourism and, by extension, which types of employment are considered part of the tourism sector. Key tourism characteristic sectors in Germany include accommodation and food and beverage services as primary employers, along with various modes of passenger transport, travel agencies, and cultural, recreational, and sports services, while country-specific products such as health services, food, and fuel reflect additional tourist spending, and other products capture goods and services indirectly linked to tourism consumption (DeStatis, 2024).

Another way to delineate the sector is through activity-based definitions. For example, Melián-González (2025) suggests "accommodation activities; food and beverage service activities; travel agency, tour operator, and related activities" being representative of the tourism sector. Following a more pragmatic distinction, the scope of tourism employment can be interpreted using two complementary concepts: employment in tourism industries and tourism employment (Meis, 2014). The former includes all workers employed in industries that serve both tourists and non-tourists, while the latter focuses on jobs that would not exist, or would exist to a much lesser extent without tourism.

The KldB classification features three occupational categories that match the narrower definition of tourism:

- 631: Tourism and Sport
- 632: Hotel Business (Hotellerie)
- 633: Gastronomy

In order to test whether these three groups can reliably depict occupations in tourism in the narrower sense, the occupational classification was tested with two different methods.

2.3.1. Method 1: Keyword Search in Job Titles
Using the list of 18,838 official job titles, a keyword search was conducted to identify tourism-related occupations. Following keywords were used:

- tour
- hotel
- gast (guest)
- restaurant
- freizeit (recreation)
- camping
- unterkunft (accomodation)
- reise (travel)

Every job title that had one of these (sub-)strings was selected for being related to the tourism industry and was manually checked to exclude misleading results (e.g. "gastroenterology" containing "gast").

This approach identified 197 job titles, with the following distribution across occupational groups:

- 632 (Occupations in hotels): 62 job titles
- 631 (Occupations in tourism and the sports (and fitness) industry): 47 job titles
- 633 (Gastronomy occupations): 40 job titles
- 293 (Cooking occupations): 7 job titles
- 845 (Driving, flying and sports instructors at educational institutions other than schools): 5 job titles

This analysis shows that a vast majority of tourism employment is adequately captured within the three main occupational groups. Other occupational groups might contain individual occupations, though they are grouped along a large number of other jobs that do not belong to the sector. For example, group 845 includes both recreational sports teachers, but also occupations such as driving instructors. Due to the lack of data granularity, the inclusion of such occupations might lead to skewed results.

2.3.2. Method 2: Correlation Analysis with Core Tourism Groups
In a second method, a statistical correlation analysis was performed to identify occupational groups that consistently co-occur with the three tourism-related occupation groups across districts. The aim was to detect shared patterns that might indicate a functional relationship to tourism.

Occupational groups with correlation coefficients higher than 0.7 were considered relevant. The results are shown in the correlation in Table 1.

Table 1: correlation matrix of tourism-related occupational groups

Occupation group code (Kldb – level 3)	293	631	632	633
293 - Cooking occupations	1.00	0.28	0.53	0.89
631 - Occupations in tourism and the sports (and fitness) industry	0.28	1.00	0.57	0.47
632 - Occupations in hotels	0.53	0.57	1.00	0.70
633 - Gastronomy occupations	0.89	0.47	0.70	1.00

While group 293 (Cooking occupations) shows a relatively strong correlation with group 633, its weaker correlation with the other two groups suggests that it is not consistently aligned with core tourism employment patterns. Therefore, the final definition used in this study includes only occupations from groups 631, 632 and 633.

Although this excludes the broader landscape of tourism employment, it offers a focused and consistent basis for analysing tourism-related labour market structures using the available data.

2.4 Definition of digitalisation scores

The evolution of the labour market has been closely linked with technological advancements for centuries. Since the advent of the internet in the 1990s, digitalisation has played an important role in shaping labour market dynamics. Especially in the late nineties and early 2000s, technologies were expected to reduce the importance of physical space, which was signified through concepts such as "death of distance" (Cairncross, 1997). However, the internet and emerging technologies led more to a hybridisation of space (Frith, 2012) instead of a complete relocation of our activities to the virtual world.

The tourism sector is a good example for these hybrid places, with a high importance of physical interaction and real experience at its core, but with an integration of digital tools into related activities. The adoption of modern information and communication technologies (ICT) has significantly enhanced competitiveness and accessibility within the sector, enabling more efficient trip planning and booking, particularly for international travel and among younger age groups (Banescu et al., 2021), but has also been a contributing factor for challenges resulting from the adoption of short-term rental platforms (Bei and Celata, 2023). Immersive technologies such as Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) can be used as marketing tools (Bogicevic et al., 2019; Tussyadiah et al., 2018) or enhance tourist experience. However, tourism is a sector where the importance of the human context and authentic experiences remain an important factor during the adoption of new technologies (Pencarelli, 2020).

Digitalisation in the workforce within the tourism and hospitality industry can affect the whole guest cycle and has already been adapted by the industry, most for example in the form of social hubs, chatbots, travel assistants or robots (Lukanova and Ilieva, 2019), Currently, technologies are mostly used as a complementary to human labour (Melián-González and and Bulchand-Gidumal, 2025), as automation can also lead to negative reaction from customers, for example in the gastronomy sector (Pancer et al., 2025).

Quantifying the impact of these digitalisation trends and predicting potential future outcomes is currently an unattainable task, even when just focusing a clearly defined set of occupations within a given industry. Public discourse often centres on automation and the anticipated displacement of workers, but these processes are more complex than a simple narrative of job loss. Labour market outcomes are shaped by institutional, organisational, legal, and political contexts (Degryse, 2016; Gordon and Gunkel, 2024). Digitalisation has many different facets and goes beyond a replacement of workers through computers (Acemoglu and Restrepo, 2018; Arntz et al.,

2019), which is also true for the tourism sector (Ivanov, 2020).

We can imagine job losses (e.g. through automatic check-in counters in hotels instead of human agents), but potentially alongside with a reorganisation of the content or importance of tasks (e.g. management of bookings on third-party booking platforms before the quests even arrive), the creation of new tasks (e.g. content creation for social media) or even the creation of new jobs (e.g. through an increased need of data analysts in the sector). However, research also finds evidence for a polarisation through automation in the hospitality industry (Yuan and Liu, 2025).

For this reason, measuring the impact of a broad trend such as digitalisation on the labour market is challenging, especially if the aim is to create quantifiable or spatial results. A widely used approach in approximating the effects of this trend is to compare skills or tasks linked to occupation groups towards certain aspects of digitalisation and then depicted as a numeric score. Such scores can be consequently aggregated on the occupational level and linked to labour market statistics. Such methods have been used to assess the effect of digitalisation based on routinisation (Autor et al., 2003), machine learning abilities (Brynjolfsson et al., 2018), teleworkablitiy (Dingel and Neiman, 2020) and (especially more recently) Artificial Intelligence (Colombo et al., 2024; Eloundou et al., 2023; Georgieff and Hyee, 2022).

This paper draws on three such indicators:

- "Artificial Intelligence Occupational Exposure" (AIOE) (Felten et al., 2021)
- "Potential Risk of Computerisation" (PRoC) (Frey and Osborne, 2017), and
- "Digital Competencies Indicator" (DCI) (Lennon et al., 2023),

These indices are described in more detail below.

2.4.1. Artificial Intelligence Occupational Exposure (AIOE)
Artificial Intelligence (AI) is a currently actively discussed topic within the context of labour market transformation. Tools for text and image generation, which were introduced in recent years, have already altered how certain tasks are carried out within occupations. While it remains difficult to quantify the labour market effects of AI or to determine what role AI might play in the future (replacement or reinstatement effects), its significance can be approximated through the AI Occupational Exposure score (Felten et al., 2021). This measure compares the skills associated with occupations in the SOC/O*NET framework to areas of recent AI progress, as tracked by the Electronic Frontier Foundation (EFF).

The EFF dataset identifies advances in specific AI capabilities (e.g. "image recognition", "language translation"), which are then linked to occupations based on the overlap between these AI capabilities and the human skills required for the job. The AIOE score indicates how exposed an occupation is to AI, based on the similarity between AI capabilities and occupational skill requirements. It is constructed as a relative metric, normalised using the standard deviation of AI-related skill importance and prevalence across occupations. Scores range from -2.67 for dancers to +1.53 for genetic counsellors.

2.4.2. Potential Risk of Computerisation (PRoC)
Another widely debated aspect of labour market digitalisation is the potential replacement of human workers through automation. The probably most well-known attempt to quantify this risk was made in "The Future of Employment" report (Frey and Osborne, 2013, 2017) which assigns a probability of computerisation to specific occupations based on expert assessments on computational bottlenecks. These inputs were used as training data for a machine learning model that estimated scores on an occupational level.
The resulting scores range from 0 to 1, with higher values indicating a greater susceptibility to computerisation. At the low end of the spectrum are occupations such as recreational therapists (score: 0.0028), which consist of

tasks that are hardly automatable. Conversely, 11 occupations, such as telemarketers, data entry keyers, and cargo and freight agents, receive scores of 0.99, indicating a high potential susceptibility to automation. It is however important to note that these numbers can best be interpreted as the highest level of computerisation that is technically possible (Coelli and Borland, 2019; Frey, 2021), without taking the organisational, legal or societal context into account.

2.4.3. Digital Competencies Indicator (DCI)

A third aspect of digitalisation can be identified through the requirements for digital skills for workers within their occupations. Lennon et al. (2023) developed a digital skills indicator using the ESCO database, which links skills to occupations. The indicator builds on an adapted version of the Revealed Comparative Advantage (RCA) statistic, measuring the relative concentration of digital skills within an occupation compared to all others. The analysis distinguishes between essential and optional skills, as well as between narrower and broader definitions of digital skills. Whether a skill is defined to be digital is based on the original ESCO classification (narrower definition), or also through a text analysis of their descriptions (broader definition).

For this study, we use the Digital Competencies Indicator (DCI) based on essential digital skills as defined in the broader sense (Option 3 in the original paper). This avoids overestimating the relevance of digital skills through optional attributes and allows the inclusion of skills not explicitly labelled as digital in the original ESCO taxonomy.

Indicators obtained through this method define 1,269 (42.20%) of the 3,007 occupations requiring no digital skills. The highest scores are defined for database integrators (11.98), digital forensics experts (11.46) and data quality specialists (11.35).

2.5 Indicator matching

While the indicators presented previously provide structured information about certain aspects of digitalisation, they were developed based on a specific occupational statistic and taxonomy with unique definitions of occupation groups and their hierarchical organisation. Germany uses the Klassifikation der Berufe (KldB) system, while the PRoC and AIOE scores are based on the SOC/O*NET taxonomy of the US Department of Labour. The DCI score is linked to the ESCO classification of the European Union.

Although the general structure and logic of these taxonomies are comparable, they define occupation groups differently and also differ in how occupations are grouped hierarchically. During mapping these indicators to geographic statistics, the lack of high-quality regional data is a second issue in the case of this research. Figures are available only on the level of occupational groups (KldB 3-digit level), while the digitalisation indicators are associated with more detailed categories, especially in the case of DCI (3,007 scores need to be mapped to only 140 occupations). As a result, multiple matches are possible between the taxonomies, and direct one-to-one translation is in general not feasible.

To harmonise these systems, crosswalk tables are provided by the maintainers of these taxonomies. In the case case of this study, two conversion tables had to be used, one for matching between the SOC/O*NET and the ESCO taxonomy (Bundesagentur für Arbeit, 2021) and a second one to link the ESCO and the KldB taxonomies (European Commission, Directorate General for Employment, Social Affairs and Inclusion, 2022). This means, the assignment of digitalisation scores is based on a multistep mapping, with in many cases multiple possible linkages.

The classification problem has been discussed in depth in a study of transferring PRoC scores to the German labour market (Bonin et al., 2015), which describes the “equal distribution” approach. Aggregating potential digitalisation scores to a simple number (e.g. taking the average of all potential scores) can result in a gravitation towards the average and masking potentially extreme (but relevant) values. The equal distribution takes all possible scores across a certain occupation group and then divides the number of workers based on the number of potential matches, which enables a better estimation of digitalisation scores, even if data is available only on an aggregated level (Cserpes, 2024).

As the selected indicators use different scales of measurement, the weighted median of these scores were defined to help orientation and relative comparability, following the approach in Fossen and Sorgner (2019). The weighted median across all employees within the employment database (Bundesagentur für Arbeit, 2022) was calculated to be at 0.09 for the AIOE, at 0.66 for the PROoC and at 0.54 for the DCI indicator. Jobs with scores below these thresholds were defined as having low digitalisation scores, and those above as high.

3. Results

3.1. AIOE Scores

Figure 2 displays the AIOE (AI Occupational Exposure) scores for the tourism-related occupational groups. Within the "tourism and sport" group (631), scores tend to be located around the median or above, indicating an overlap between the skills required in these occupations and areas in which AI has made significant progress. An exception in this group is fitness trainers and aerobics instructors, whose low exposure is likely due to the physical and interpersonal nature of their work. This group is included here due to the classification under sport. In contrast, managerial and supervisory roles in tourism show high exposure, suggesting that while customer-facing tasks may remain stable, AI may increasingly support or transform planning, coordination, and back-office functions. Occupations such as tour guides and escorts or event planners fall into a moderate exposure range, indicating partial transformation rather than replacement.

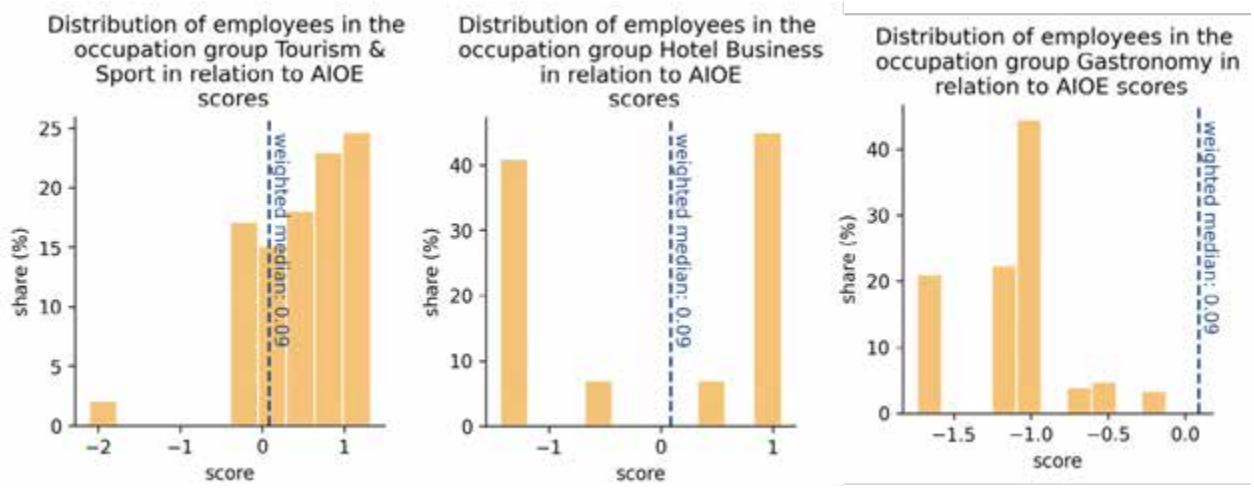

Figure 2. AIOE scores for tourism-related occupations

The hotel business occupational group presents a distribution of AIOE scores on both ends of the spectrum. On the lower end are jobs such as first-line supervisors and janitors, which involve significant managerial oversight or physical labour in areas where application of AI tools is unlikely. Conversely, a substantial portion of workers in this group are in high-exposure roles such as receptionists, administrative clerks, and secretaries who support managerial functions. This suggests that while the core structure of hotels may remain unchanged, the way administrative and support tasks are performed are likely to change due to AI adoption.

In the gastronomy sector, AIOE scores are clearly low, with only a few exceptions (such as food service managers) showing moderate exposure. This implies that, at present, AI is not expected to play a major role in reshaping most gastronomy jobs, which remain heavily reliant on physical presence and interpersonal service.

In summary, the level of AI exposure varies across tourism-related occupations. While workers in the general tourism sector exhibit higher AIOE scores (especially in managerial and planning roles) the hotel business shows a clear divide between supervisory and support roles. Meanwhile, the gastronomy sector appears largely unaffected by AI, at least in the near term.

3.2. PRoC Scores

Figure 3 presents histograms of the Potential for Replacement by Computerisation (PRoC) scores on the national level in Germany. The results indicate a heterogeneous distribution of susceptibility towards computerisation within the occupational group tourism and sport (group 631). Around two-third of the workers in this category can be assigned low susceptibility scores. These include managerial and supervisory positions, as well as occupations such as teachers, instructors, travel agents, and event planners. At the same time, around one-third of employees within this group show higher scores, such as hosts, tour guides and escorts or sales representatives.

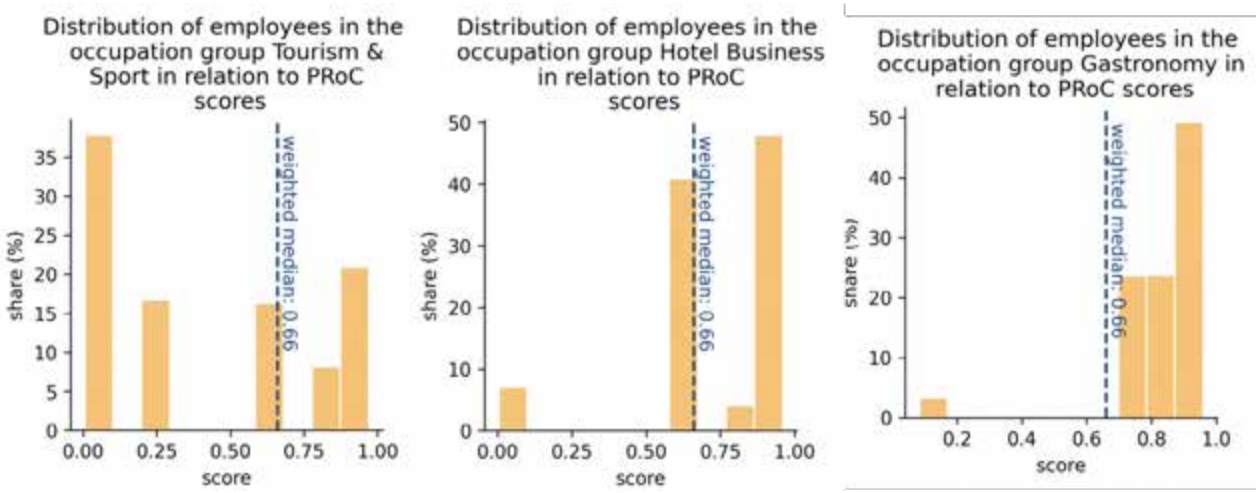

Figure 3. PRoC scores for tourism-related occupations

These findings highlight a central characteristic of task-based indicators such as the PRoC score: they are based on the technical feasibility of automating specific tasks. As such, they reflect the upper bound of automation potential but do not account for factors such as human oversight, social interaction, or customer expectations, which may limit the practical implementation of automation.

In the hotel business occupational group (632), the distribution of scores is more clearly skewed toward a susceptibility level at the median or above. Most jobs in this category, such as receptionists and administrative assistants, conduct tasks that are relatively straightforward to automate. An exception within this group are lodging managers, whose tasks tend to be less automatable due to their complexity and decision-making requirements. This pattern mirrors broader trends, such as the shift from traditional hotels to platforms like Airbnb, where check-in and service functions are largely automated, leaving only maintenance and cleaning staff physically required.

A similar picture emerges in the gastronomy occupational group. Here too, most occupations (such as food preparation workers, waiters, waitresses, and food servers) exhibit high computerisation potentials. Food service managers remain an exception with lower scores. However, despite the technical feasibility, the sector has not fully implemented automation.

In summary, occupations within the tourism sector tend to show different theoretical automation potentials, with higher tendencies within the hotel-business and gastronomy-related roles. However, this potential is not yet fully realised in practice, especially in the gastronomy sector, where human labour continues to play a central role despite the availability of automating technologies.

3.3. DCI Scores

In contrast to the PRoC and AIOE scores, the DCI data is originally available at a more granular occupational level (scores are assigned to 3,007 occupations), allowing for a more precise allocation of scores across occupation

groups (Figure 4). Despite this increased level of detail, distinct patterns in the distribution of digital skill intensity still emerge clearly.

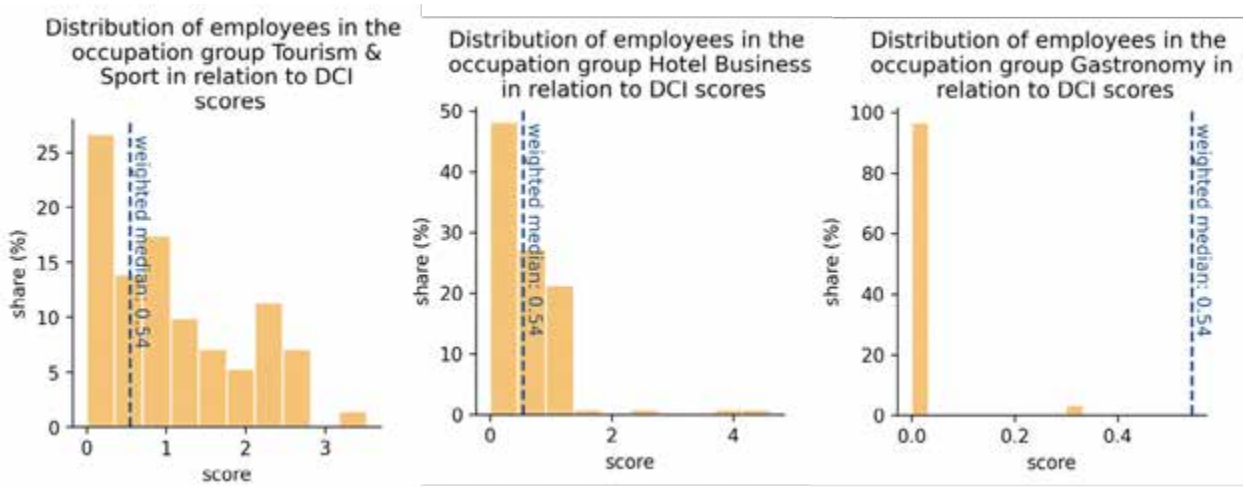

Figure 4: DCI scores for tourism-related occupations

The "tourism and sport" occupational group tends to showcase the largest proportion of workers above the median DCI score. These digital scores are primarily associated with jobs more closely tied to the business and organisational aspects of tourism (such as pricing specialists or customer experience managers). In contrast, roles like travel consultants, tour guides and (somewhat unexpectedly) clerks demonstrate low digital skill levels.

In the hotel business group, the concentration of low DCI scores is even more clear. Exceptions are limited to positions such as administrative assistants and executive assistants, likely due to their involvement in managerial and organisational responsibilities. As expected, occupations such as cleaners and helpers reflect minimal digital skill demands.

Interestingly, even accommodation managers register a DCI score of zero. This can be attributed to the methodology of the DCI, which focuses on essential core skills: in this case, the digital components are outweighed by other core, non-digital skills, suggesting that while digital skills may be present, they are not characteristic to the occupation's core requirements.

The gastronomy sector shows the clearest trend: aside from restaurant managers, nearly all occupations in this group exhibit practically no digital skills according to the DCI.

In conclusion, the findings confirm that the tourism sector is characterised by a contrast in digital skills requirements. There is a clear divide between customer-facing or operational roles and managerial positions, with the latter more likely to involve digital competencies.

3.4. Tourism Digitalisation Susceptibility Score

The selected three digitalisation scores highlight three distinct aspects of this trend, but to provide an overall estimation these indicators need to be analysed in combination. Such combinatory analysis has been applied to analyse AIOE scores per occupation and AI's potential complementarity (Pizzinelli et al., 2023), or through the mapping of occupations based on their PRoC and AIOE scores (Fossen and Sorgner, 2019) and relating them with spatial statistics (Cserpes, 2024). The methodology of this latter study is applied and enhanced in our analysis through the DCI-score as an additional dimension. Every occupation is matched with all possible scores for each of these three digitalisation indicators, then for each occupation the score of high or low is assigned, based on weighted medians of the scores as thresholds.

As an example, the occupation of barkeepers (KldB 6332) can be assigned the AIOE score of -0.62 (below the weighted median), the PRoC score of 0.77 (above) and the DCI score of 0 (below). This leads to the occupational digitalisation profile of low-high-low.

Three digitalisation profiles are particularly relevant for interpretation:

• High across all scores: Occupations with significant digital skill demands, high AI exposure, and high automation potential, likely to transform through digitalisation rather than be replaced (e.g. management assistants in tourism).
• Low AIOE, high PRoC, low DCI: Occupations that are technically automatable but neither heavily exposed to AI nor dependent on digital skills. These represent jobs that could, in theory, be automated but are not currently subject to strong digital transformation pressures (e.g. occupations in system catering).
• Low across all scores: Jobs with minimal digitalisation exposure, usually manual or service-oriented roles. These show limited susceptibility to technological change (e.g. occupations in hotel service).

Table 2 displays the distribution of German workforce across the digitalisation profiles in the whole labour market and within tourism-related occupations. Approximately 20% of all employees within the German labour market work in the low-high-low category, 11% in the high-all group, and another 11% in the low-all group.

Table 2. Overview of digitalisation metrics in tourism vs. the general labour market

AIOE	PRoC	DCI	Share in DE Employment (%)	Share in 631 (Tourism & Sport) (%)	Share in 632 (Hotel business) (%)	Share in 633 (Gastronomy) (%)	Share in all Tourism Occupations (%)
high	high	high	10.59	5.72	24.54	-	6.58
high	high	low	4.51	8.74	-	-	0.79
high	low	low	15.40	29.67	8.44	-	4.76
low	high	low	20.42	2.62	5.63	98.02	66.57
high	low	high	17.31	41.56	-	-	3.75
low	low	high	9.54	0.96	-	-	0.09
low	high	high	11.43	7.86	-	-	0.71
low	low	low	10.81	2.88	61.39	1.98	16.75

When looking at the tourism sector, this distribution is more skewed:

• Around 66% of workers in the tourism sector (especially in gastronomy) are working in an occupation with a low-high-low-profile, indicating technical automatability without current AI relevance or digital competence needs.
• 17% of tourism roles fall into the low-low-low category, including many in hotel maintenance and cleaning, where digitalisation plays a negligible role.

• A small segment (approximately 4%) scores high on all three indicators, mostly administrative or managerial roles in the hotel business, which are not easily replaced but are expected to change through digital processes.

3.5 Geographic distribution

Besides comparing these scores between occupational groups on the national level, understanding their geographic distribution can be a relevant question.

The low-low-low-group (displayed in Figure 5) shows a higher share within the tourism sector than in the general labour market, especially in the districts with high tourism activity in the southern part of the country at the Baltic and Northern Sea coast. This suggests that tourism-intensive regions are currently less strongly affected by digitalisation trends and a large share of their tourism workforce will experience little differences in how they conduct their jobs in future.

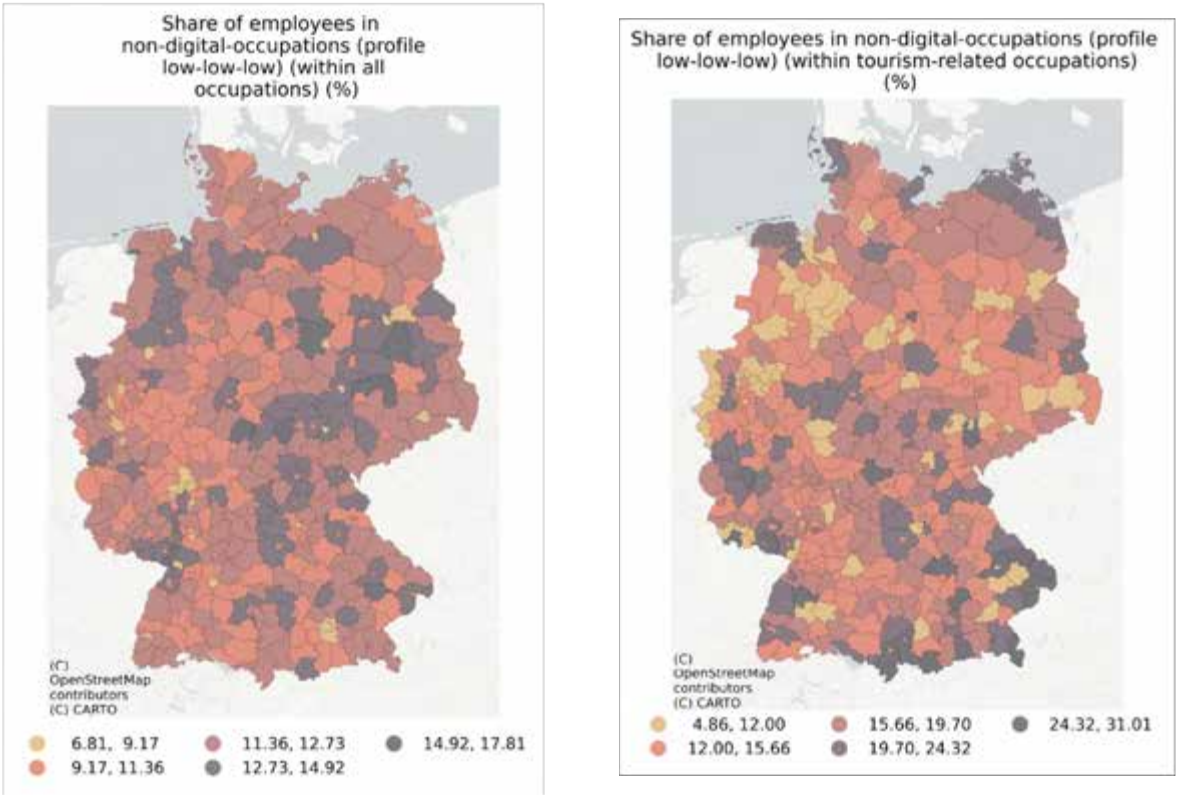

Figure 5. Spatial distribution of the low-low-low group across districts.

At the national level, the high-low-high-group (Figure 6) is the most prevalent, though the overall distribution of categories remains relatively balanced across districts, with some tendencies of urban areas showing lower shares of employees in this category. Within the tourism sector, this category becomes even more dominant. Besides a few exceptions, more than half of the tourism-related workforce has a share of more than 50% within this category, with some regions featuring shares of well above 70%, especially in regions that feature less tourism activity. However, no clear spatial pattern emerges for this category across the country, which suggests that these concentrations reflect local labour market and economic structures rather than broader regional trends or spatial typologies.

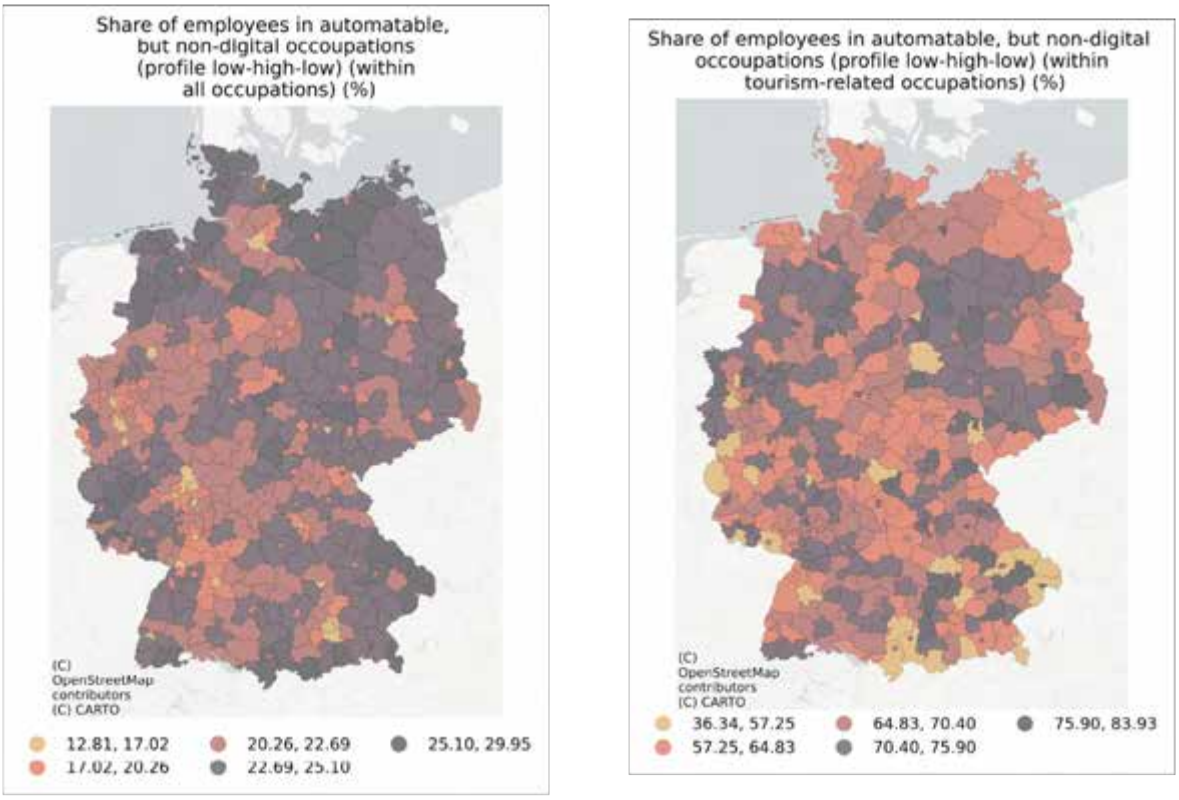

Figure 6. Spatial distribution of the high-low-high group across districts.

Meanwhile, the high-high-high-category (Figure 7) is more concentrated in urban areas, where both general employment and tourism sectors show a stronger presence of digital roles. Although this category is less prominent within tourism occupations compared to the general labour market, the difference is not as clear as with the other two categories. This indicates that digital transformation is affecting some tourism-related roles in a way comparable to broader national trends, particularly in cities.

Overall, the analysis shows that while large parts of the tourism sector remain less digitalised, certain urban areas are seeing a convergence with national trends in digitalisation, particularly in managerial and administrative roles.

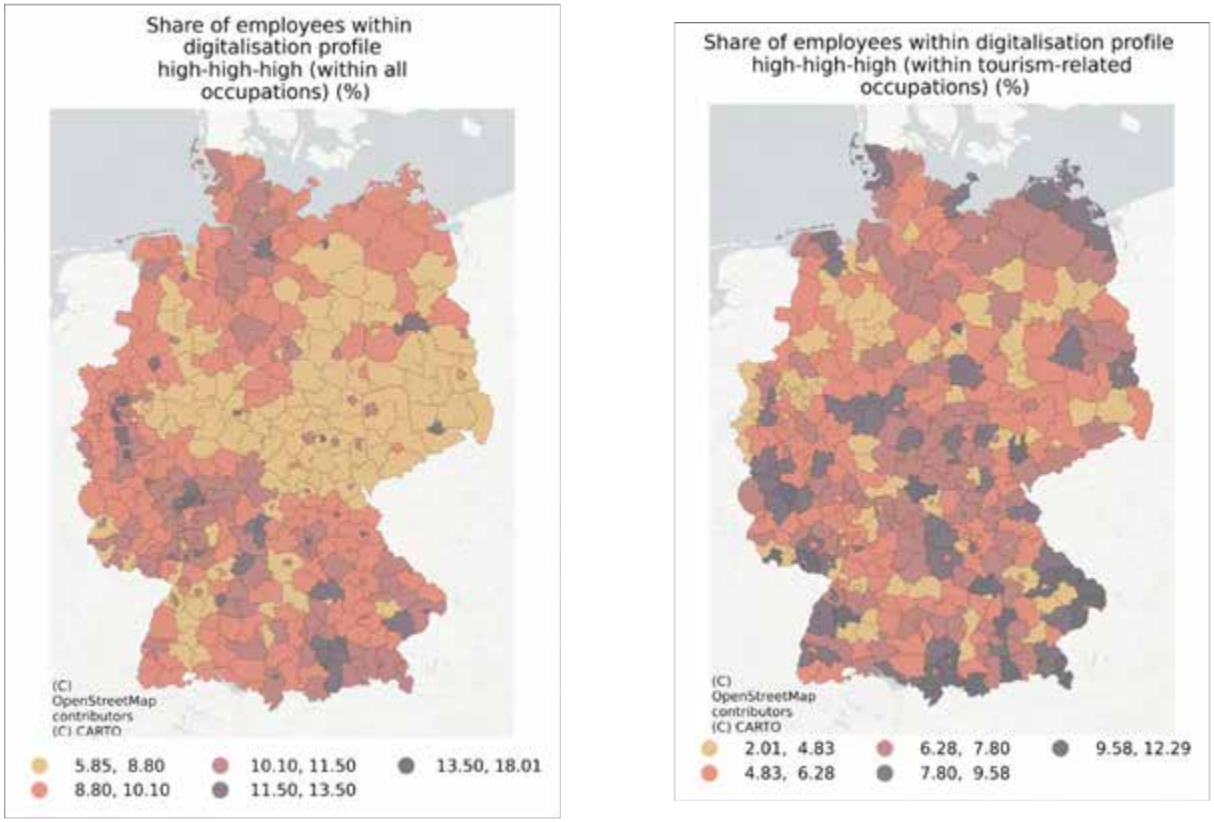

Figure 7. Spatial distribution of the high-high-high group across districts.

3.6. Discussion and outlook

Results of this research show that linking digitalisation indicators to labour market statistics offers a practical way to assess spatial exposure to technological trends. This approach enables a broad, comprehensible overview on both a sectoral (in this case tourism) and spatial level. However, the simplifications involved within this approach come with important limitations that need to be addressed.

The PRoC score, derived from the widely cited "Future of Employment" report, exemplifies both the potential and pitfalls of using quantitative digitalisation indicators. Although this score is useful for identifying technical automation potential, its reliance on expert judgments has been criticised for overestimating susceptibility to automation (Coelli and Borland, 2019; Frey, 2021). The sector of tourism serves as a good example, the occupational group of waiters was assigned a score of 0.94 (meaning high computerisation potential), despite the importance of human interaction in the everyday context (Pancer et al., 2025), which still characterised this occupation. Therefore, the scores presented here should be interpreted with caution, as the highest possible digitalisation potentials technically feasible, without taking the organisational, societal, political or legal context into account.

By incorporating the indicators AIOE and DCI, the composite approach helps to balance some of these overestimations. Nonetheless, each indicator is shaped by the assumptions of its original methodology, and thus still reflects inherent biases. Alternatives such as survey-based data, like PIAAC, can better reflect real-world work contexts, including actual tasks and skills (Georgieff and Hyee, 2021; Nedelkoska and Quintini, 2018). Such survey-based approaches however also come with trade-offs, especially when scaled to broader labour market estimates. Nevertheless, these indicators are only snapshots depicting the current situation and work context and cannot simply be used for future predictions.

For this study, two limitations need to be specifically addressed: the translation across occupational taxonomies and the quality and granularity of available labour market data. Two of the indicators (PRoC and AIOE) originate

from a U.S. classification system, which introduces potential mismatches when mapped to the German context. Though crosswalks and weighted distributions help mitigate this, a one-to-one mapping of occupations is hardly possible. More accurate results could potentially be achieved by either reconstructing the indicators using German-specific task or survey data (Bonin et al., 2015; Coelli and Borland, 2019; Georgieff and Hyee, 2021), or by applying the U.S.-based indicators within their original context. However, the occupational-level linkage of indicators remains robust when comparing the relative scores of occupational groups within a single national context (Bonin et al., 2015; Cserpes, 2024).

Second, Germany's regional labour market data is only available at an aggregated level, especially when conducting analysis related to geography. As a result, regional analyses in this paper offer general trends rather than precise local patterns, and should be interpreted accordingly. Finer-grained insights into regional impacts of digitalisation would require alternative data sources, such as targeted surveys or more qualitative elaboration.

From a territorial perspective, a limitation of this study is linked to the spatial resolution of the analysis in terms of referring to functional spatial realities of tourism areas generally overcoming statistical administrative boundaries and addressing analysis to especially in contexts commuting patterns, inter-municipal networks of tourism supply, or mixed economies (Batista e Silva et al., 2018; Li et al., 2018).

Future research should follow a more integrated spatial approach to tourism labour markets. It should focus on the relationship between local economic structures and digital vulnerability. Incorporating variables such as digital infrastructure, smart tourism investments, and public service quality in touristic areas could help to map a geography of tourism resilience, which would be useful for regional planning and targeted policy-making.

Additionally, the perspective to base the analysis on functional tourism networks that transcend administrative boundaries may un-disclose connections between local tourism supply chains and regional patterns of seasonal workers in tourism sector. This approach would enhance the overall understanding of the spatial logic of tourism employment beyond static territorial units.

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UBT "SMART City" Model as a Testbed for Emerging Digital Technologies and Transformative Urban Planning

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Abstract
Humankind is currently living in a hyper-dynamic and constant transforming environment- in the so-called convergence era and 4th industrial revolution. This level of development requires a complexity-led approach and transformations of our political, societal, economic and technological framework: the way we are living and being educated, creating new jobs and generating sustainable growth, providing security, managing hyper mobility, as well as other development aspects related with our living quality and human values. This paper elaborates a specific model named UBT "SMART City" (Small Scale Smart Sustain System) which represents a concept of Entrepreneurial Innovation Ecosystem which could also be used as a Test-Bed for Future and Innovative Urban Planning with a particular focus in education, future planning concepts and emerging technologies.

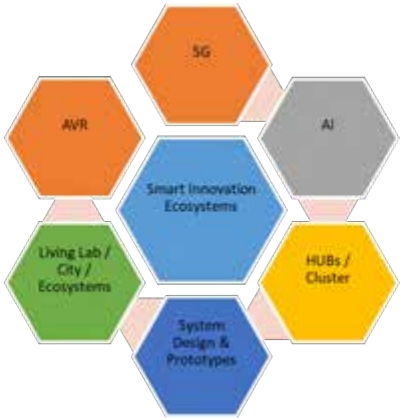
Keywords: *Smart Cities; Emerging Technologies; Transformative Urban Planning; Sustainable Development; Innovation Ecosystem*

Introduction and Background

The fourth industrial revolution is characterized by numerous emerging and disruptive technologies while technology is reshaping business practices, leading to improved market opportunities that also demand education and skills for innovation. AI, for instance, is currently used to fill a growing number of professional positions, and thus, the gig economy is booming. Ajah et al (2019) emphasizes that exponentially growing fourth revolution is characterized by the convergence of technologies that eradicate traditional boundaries across the physical, digital, and biological realms. Despite the fact that there are numerous opinions regarding the actual dates of beginning of the Fourth Industrial Revolution ((Ciulli, 2019) it is widely accepted that the term "Industrie 4.0" was firstly introduced at the Hannover Fair in Germany in 2011, and from this, the term "Industry 4.0" was derived, and it represents the Fourth Industrial Revolution. While the fourth industrial revolution (4IR) is gradually gaining momentum in a wide range- and as it gathers pace, innovations are becoming faster- many believe that the technologies that have been developed recently will allow organizations to enter a new computerized era to manufacture and manage large systems that were too complex to be integrated, monitored, and controlled before the advent of Industry 4.0 (Krajewski et al, 2022)....". On the other hand; since its beginnings UBT has always followed the current technological and socio-economic trends and developments, while in certain situations it has taken the leading roal towards future oriented solutions and forward-looking initiatives. In these terms, UBT now bases its scientific, research, teaching and innovation activities on the UNIVERSITY 4.0 Concept, by integrating Fully Digitalized Research and Education Process, CLASSROOM 3.0, Augmented and Virtual Reality (AVR) and 5G Telecommunication Network in its main Innovative and Scientific Campus in Lipjan/Kosovo and its other campuses and premises around Kosovo. The campus has been designed and developed around the small-scale smart city concept by covering all fields of life occurring in an open campus.

Driven by current technological development, innovative initiatives and its forward-looking vision, UBT has achieved a fully digitalized education and research process, mainly based on Augmented and Virtual Reality (AVR) technology offered by EON REALITY platform. In this regard, our institution has been recently implementing 2 important projects in Virtual and Augmented Reality technology. This platform allows all faculties (both students and staff) to contribute to the simplifying and enriching everyday life in terms of research and study.

UBT Model for Smart Ecosystem University can be illustrated as below:



This model fully integrates the Smart Systems, Resilience and Sustainability also the Society 5.0. Thus, we consider it one of the first small scales Systems Design globally.

In addition to previous initiatives, projects and innovations, UBT has recently established two institutes and laboratories in the fields of Artificial Intelligence and Cyber Security (CERT). This is in line with our strategic orientation and commitment to create and maintain a creative and innovative ecosystem which is based on integrative and transdisciplinary approaches in line with Convergence Revolution. This ecosystem should deliver all required resources to help others to fully realize one's potential- based on belief that human potential is unlimited. An important part on the digital transformation is as well the cyber security issues in the technological infrastructure. Thus, UBT has established the necessary tools, techniques and standards through which we ensure that all the assets including logical and physical are well protected and in compliance with industry standards. In these terms, UBT will focus their cyber crisis management on two main parts, namely Readiness and Response and these are detailly described below.

As per Augmented and Virtual Reality Platform; UBT has been recently implementing 2 milestone projects in Virtual and Augmented Reality technology (Prishtina, XK - EON Reality). This platform allows all faculties (both students and staff) to contribute to the simplifying and enriching everyday life in terms of research and study. Currently, the platform has over 1.8 million 3D, 2D and 360 Degree assets, while up to 40 thausands new assets are being created and added to the platform in each semester. Consequently, the implementation strategy for AVR and the connection of education with the industry occurs as following:

Each faculty contributes to the advancement of ICT in the industry using VR and AR industrial projects. *The Faculty of Management, Business and Economy (MBE), for instance, uses* the assets of this platform to change and transform the Marketing sector in the industry, creating assets for companies to promote their values using virtual interactivity. *The Faculty of Architecture and Spatial Planning* deals with the promotion of Tourism and historical values by turning this industry into VR and AR by digitizing the whole process of tourism promotion and virtual visits in historical sites and monuments. *The Faculty of Mechatronics* helps the manufacturing industry and all robotics industries to animate the work process for employees and management staff so that they can animate any process before starting the investment and as such it ensures time and cost efficiency in each company. *The Faculty of Design* uses VR and AR to help fields like Medicine, Manufacturing Industry, Marketing, Transport etc. on designing different tools and assets for their needs and purposes. *The Faculty of Computer Sciences* uses the VR and AR platform for enabling the creation of interactive games for education as well as enabling the heath

education in the field of medicine.

As per 5G Technology, 5G Hub and Test-bed; among many innovative and future based projects UBT has launched its 5G Hub which will be used for domestic needs (research, testing, experimentation) and also will help the industry to test their products and test them in a technology of the future as there is still no such network in Kosovo.

As per fully digitalization; driven by current technological development, innovative innitiatives and its forward-looking vision, UBT has achieved a fully digitalized education and research process, mainly based on Augmented and Virtual Reality (AVR) technology offered by EON REALITY platform and other supportive tools. The new digital forms enable students to access lectures 24/7 giving them the opportunity to study according to the schedule that was adjusted. Also through digital platforms students will have the opportunity to access new technologies through which they will receive faster information about national and global scientific developments in various scientific fields. The use of digital transformation will have a singular impact in improved accessibility and access, personalized learning approaches, access to Augmented Reality & Virtual Reality, Cloud-based learning opportunities, Incorporating the Internet of Things into the school environment, Security across digital devices, Big Data etc. Additionally to other initiatives and innovations that are presented previously, UBT has established two institutes and laboratories in the fields of Artificial Intelligence and Cyber Security System, which lays on Institution's CERT (Computer Emergency Response Team). Furtherly, UBT has recently established UBT VR/AVR Hub, UBT Knowledge Hub, as well as Sports, E-Sport & Art Hub. All of these developments and concrete actions are in line with Institution's strategic orientation and commitment to create and maintain a creative and innovative ecosystem which is based on integrative and transdisciplinary approaches in line with Convergence Revolution. This ecosystem should deliver all required resources to help others to fully realize one's potential- based on belief that human potential is unlimited, and thus is also in line with Institution's commitment to implement the 4th Industrialization advancements continually and with consistency.

Artificial Intelligence (AI) and Cyber Security System (CERT)
Both the institute and center aim to contribute to society as well as help the government, the army, the police and many other stakeholders. The institute that carries with it the laboratory of artificial intelligence with a data center with a supercomputer will be able to help many fields and faculties abroad, as described below:

The Faculty of Management, Business and Economy (MBE) will use the possibility of supercomputers for Business to enable banks and institutions to increase the quality of services by making predictions for the future thanks to artificial intelligence and supercomputers with their data. Also, the institute for security will enable all government institutions to increase the cyber security capacities of this institute and also to do the necessary tests in the CERT laboratory. *The Faculty of Architecture and Spatial Planning* will be supported through artificial intelligence to create the possibility for drones to take 3D images in real time and process those images for various purposes in the industry of virtual reality design, animations, etc. *The Faculty of Mechatronics* will use artificial intelligence in many fields and the testing of production machines in our laboratories, also supercomputers are used for testing algorithms for the image process in intelligent drones, and many new industries that use AI etc. *The Faculty of Computer Sciences* may use supercomputers for testing algorithms in various fields in medicine, the automotive industry, and all fields related to artificial intelligence. *The Faculty of Agriculture will* use supercomputers and artificial intelligence to calculate changes in drone scanning of the fertile area and the possibility for scientific research in the field of agriculture.

When it is combined with previously promoted initiatives and innovations, as such as UNIVERSITY 4.0 Concept, Fully Digitalized Research and Education Process, CLASSROOM 3.0, Augmented and Virtual Reality (AVR) and 5G Telecommunication Network, it will let our institution to further develop its research infrastructure in order to get research and its outputs more easy, fast, effective and more visible.

UBT VR/AVR Hub

Even though VR and AR are still largely in the developmental stage, these concepts are no longer science fiction. Considering the pace of the technological development, as well as consumer and industry demands, researchers have put an emphasis on producing technology through which we solve problems and interact with our world. From UBT's point of view, hosting the EON-XR Cluster Center and bringing EON-XR to campus comes with the opportunity to distinguish even further. By utilizing the interconnected self-service platform and the **Classroom 3.0 Model**, the world-class school is able to improve the interactivity and retention in lessons while also preparing students for the future by teaching them the technology that many leading industries and businesses are already using.

UBT Sports, E-Sport & Art Hub

UBT Sports, E-Sport & Art Hub is the newest center for the development of young talents in the field of sports and movement sciences. Through this center, young people have the opportunity to gain new knowledge in the field of sports and movement sciences, from the expertise of professional staff and to further develop their sports skills and talents. Among others, it integrates digital tools, software, and advanced technologies and application to help smart sport health managements, performance measurement and tracking, as well as managing the healthy nutrition processes.

Readiness and Response

UBT has established the necessary tools, techniques and standards through which we ensure that all the assets including logical and physical are well protected and in compliance with industry standards. In these terms, UBT will focus their cyber crisis management on two main parts, namely Readiness and Response, Readiness equates not only to vigilance, for example in the form of 24/7 Monitoring, but also to readiness of resources. A well prepared, multifunctional team will be poised to deal with all aspects of an incident or crisis. In addition, crisis simulation and war gaming enable management to understand what can happen, which steps to take, and whether the organization is truly prepared. On the other hand; Management's response can either contain or escalate an incident; indeed, a poor response can even create a crisis. Vigorous, coordinated responses to incidents limit lost time, money, and customers, as well as damage to reputation and the costs of recovery. Management must be prepared to communicate, as needed, across all media, including social media, in ways that assure stakeholders that the organization's response is equal to the situation.

Human Capital and Financial Resources

All given projects, initiatives and platforms require well prepared and professional staff/human and professional capital to maintain them and to assure that all services are being provided to people using them. UBT is able to cover, and is covering, all human requirements needed. These professionals are in charge to lead initiatives, projects, institutes, labs, centers and platforms, as well as to deliver tasks properly and to put other human resources in place whenever and wherever is needed. Furtherly, establishing and maintaining these structures, as well as assuring a proper service delivery of them require certain financial investments and maintain costs. However, based on its commitment to fully and effectively fulfill its 3rd mission towards society, UBT is also committed to, and is currently covering the all costs related to given structures. In parallel, AVR Platform is established and thus financed in partnership with EON Reality. When it comes to technological aspects of advanced smart applications, all Software, Online Platforms, Test Beds, Web-pages, PC Labs, Virtual Reality System tools and equipment, co-working areas, conference rooms, visualization and marketing means needed for the given structures are operating and being managed by UBT. The institution is covering all costs as an expression of commitment to fulfill its 3rd Mission in a fully and effective way.

1. Theoretical and Conceptual Framework of Smart Cities and Smart Development

By 2050, it is estimated that roughly 70% of the world's population will live in cities. With more citizens to serve, and a climate that is rapidly degrading, public service efficiency and effective resource-usage are becoming pressing issues for cities. In this context, ensuring sustainable development and quality of life in complex social ecosystems of cities and urban areas are important concerns. Cities are increasingly aware of the concept of "smart city" and are actively developing strategies towards the goal of becoming "smart" and manage city resources more efficiently while addressing development and inclusion challenges. To understand the concept of smart city, we begin with understanding the conceptual relatives of the model. Although limited in scope, they set the theoretical framework for the holistic notion of the smart city currently understood by the urban planning sphere. The notion of smart city is established from the combination of the knowledge society and digital city. It is defined as a "multi-layer territorial system of innovation" made up of digital networks, individual intellectual capital, and the social capital of the city, which together constitute collective intelligence (Komninos, 2008). Economic competitiveness and innovation achieved through the knowledge-based economy marks a city as intelligent, allowing it to generate a "spatial competitive advantage" through industrial districts, regions, and learning clusters that produce sophisticated R&D and are supported by digital networks and artificial intelligence (Komninos 2008). Based on the exploration of a wide and extensive array of literature from various disciplinary areas, the identified factors– Social, Management, Economy, Environment, Technology, Sustainability, (SMEETS) forms the basis of an integrative framework. This comprehensiveness is the distinguishing factor of the smart city, which integrates a number of physical, institutional, and digital components to create a holistic definition of what smart planning would look like.

1.1. Pillars of Smart City

At its core, a smart city framework leverages from the existing legal, economic and technical environment and impacts the social and management aspects in a sustainable manner[1]. Setting a smart municipality vision and effectively moving towards it with a systems-based approach is imperative to ensure optimum resource efficiency and security, along with preserving socially inclusive growth. Thus, the 5 pillars or factors of Smart Municipality are: (1) Smart Governance (Management), (2) Smart Public Infrastructure Services (3) Smart Transportation (4) Smart Economy, (5) Smart Environment, (6) Smart People & Smart Living.

Smart Governance[2]: "Smart Government" is about strengthening the connections and interactions between the government and all stakeholders - citizens, businesses and other organizations of the civil society - within a municipality. A municipal government following a smart city strategy is uniquely positioned to reconsider the quality, scale, and scope of services for citizens and businesses that it offers. Following a "city as a service" model can help to increase efficiency and effectiveness as well as transparency and trust. In this regard, smart public services, also known as digital public services or eGovernment, refer to the use of technology to provide services to citizens at local, regional and national levels. They bring many opportunities to both citizens and businesses: students can apply to study abroad, citizens can open bank accounts online, and workers can file taxes with the click of a button.

Smart Water Management: In simplest of words, a **smart water management system** is a concept that utilizes electronic and computerized engineering to increase information collection and analytics. Bigdata acquired from the system is used to maintain practical choices and upsurge the competence of water reserves[3]. As same as other smart infrastructure systems, Smart Water Management (SWM) uses Information and Communication

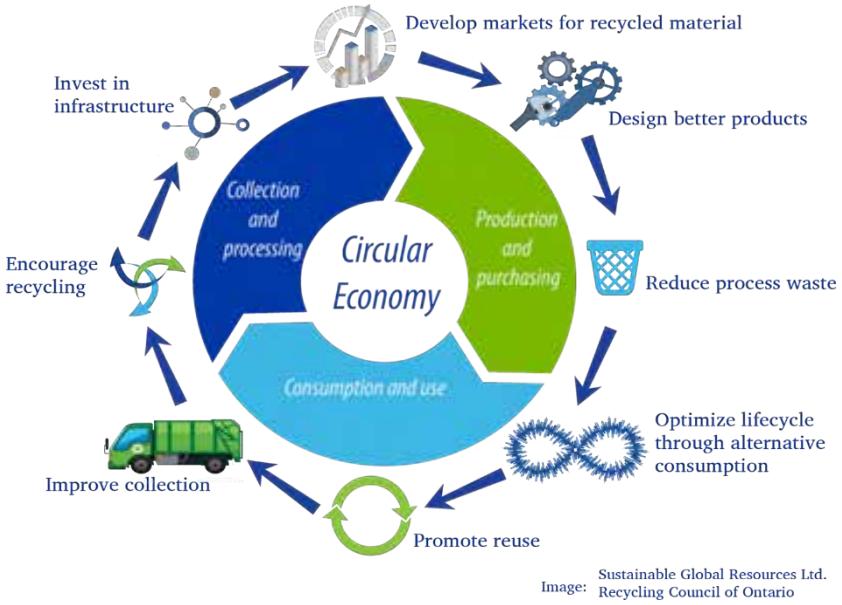
1 Moosavi, M.S., 2018. The Smart City; Challenges and Opportunities in Developing Countries. Iranian Online Journal of Urban Research, 3(1), pp.1-5.

2 The text used in this chapter is mainly based on two following sources: Smart City Indicators: Six Fields of Action for Success (beesmart.city) and Digital public services | Shaping Europe's digital future (europa.eu).

3 Smart Water Management: What You Need To Know | RPMANetworks

Technology (ICT) and real-time data and responses as an integral part of the solution for water management challenges. The potential application of smart systems in water management is wide and includes solutions for water quality, water quantity, efficient irrigation, leaks, pressure and flow, floods, droughts and much more. By applying SWM infrastructure such as sensors, smart meters, monitors, GIS and satellite mapping, and other data sharing tools to water management, real-time solutions can be implemented and broader networks can work together to reduce current water management challenges.

Smart Waste Management System[4] and Circual Economy[5]: Smart Waste Management (SWM) discusses the waste management process for different types of waste while introducing an intelligent approach to controlling the amount of waste. Thus; A smart waste management system, as a component of a broader "Smart Environment" initiative, should effectively integrate technology, data collection, and sustainable practices to optimize waste handling and enhance urban livability. This system is based on the following pillars: Advanced Data Collection; Automated and Optimized Routing; Recycling and Waste Segregation; Public Engagement and Education; Energy Recovery and Waste-to-Energy Solutions; Regulatory Compliance and Reporting. By implementing these features, municipalities can create a smart waste management system that not only efficiently manages urban waste but also contributes to the overall sustainability and resilience of the community, reducing environmental impact and improving the quality of life for all citizens. On the other hand; the **Circular Economy[6][7]** is a sustainable development strategy that aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources, and designing waste out of the system. Unlike a traditional linear economy, which has a 'take, make, dispose' model of production, a circular economy is based on three core principles: design out waste and pollution, keep products and materials in use, and regenerate natural systems. In a circular economy, the lifecycle of materials is maximized, meaning that products are designed and optimized for a cycle of disassembly and reuse. This systemic shift keeps resources in use for as long as possible, extracts the maximum value from them whilst in use, and then recovers and regenerates products and materials at the end of each service life.



The role of Industry 4.0 (I4.0) on 3Rs (Reduce, Reuse and Recycle)

4 https://www.sciencedirect.com/science/article/pii/S0956053X23005573
5 https://climatepromise.undp.org/news-and-stories/what-is-circular-economy-and-how-it-helps-fight-climate-change
6 https://www.researchgate.net/publication/306924920_Smart_Economy_in_Smart_Cities
7 https://www.oecd.org/cfe/regionaldevelopment/Ekins-2019-Circular-Economy-What-Why-How-Where.pdf

The role of Industry 4.0 (I4.0) technologies, particularly the Internet of Things (IoT), in waste management emphasizes enhancing the Reduce, Reuse, and Recycle (3Rs) approaches through advanced digital solutions.

Reduce: IoT technologies are instrumental in reducing waste by enhancing resource efficiency in various sectors. For instance, IoT-enabled smart fridge architectures help minimize food waste by monitoring expiry dates and consumption patterns, thus prompting more mindful consumption and purchase decisions.

Reuse and Repurpose: IoT also facilitates the reuse and repurposing of materials. Innovative uses of IoT include transforming agricultural waste into valuable products like compost or liquid fertilizer through smart processing technologies. Digital platforms can connect local retailers to promote the reuse of food products that might otherwise go to waste, exemplifying how IoT aids in creating circular economies at local scales.

Recycle: In terms of recycling, IoT enhances the efficiency and effectiveness of waste management systems. Smart bins equipped with sensors can classify waste more accurately, which improves recycling rates. Technologies like blockchain and AI integrated with IoT further refine the recycling process by automating sorting and enhancing the traceability of waste materials. This technological integration ensures that waste is handled more efficiently, reducing contamination and improving recycling outcomes.

Smart Energy Management[8]*: With the growth in world's population and the increasing global demand for energy, one of the greatest challenges of humanity is to ensure the balance between the environment and energy. As a result, using fossil fuels is no longer an alternative neither in terms of environmental protection nor in the construction of smart cities, so a handy solution to meet the energy demand is to use renewable resources such as solar, wind, hydropower and biofuels. Furtherly; all 6 of the main variables of Smart Municipalities need energy in different forms and modes, making it the key to sustainable development. Smart Energy involves more professional approaches that focus on adopting solutions based on an integrated approach to energy issues as crucial aspects in the sustainable development. Thus; Smart Energy Management (SEM) systems are crucial in optimizing energy use, enhancing sustainability, and reducing costs. These systems utilize Internet of Things (IoT) technologies to monitor and control the energy consumption of buildings and homes in real-time. For example, the Honeywell Building Management Systems offer solutions that integrate energy measurement tools with automated controls to enhance energy efficiency across various facilities*[9]*.*

Smart Mobility: Smart Mobility focuses on increasing the efficiency and service quality of urban transportation to enhance the use and adoption of new mobility solutions as well as to increase people mobility through efficient mobility management and targeted infrastructure investments. It also means achieving cheaper, faster, and environmentally friendly mobility as well as integrated multi-modal transportation.[10] Smart Mobility leverages the available technologies to gather and provide information to users, planners and transport managers, allowing the reshaping of urban mobility patterns, of planning mechanisms and the enhancement of multimodality by improving the coordination and integration of different transportation modes. **Intelligent Transportation System (ITS)** is often related to smart transportation. An intelligent transportation system is a technology, application or platform, that improves the quality of transportation or achieves other outcomes based on applications that monitor, manage or enhance transportation systems. Intelligent Transportation System relies heavily on data collection and its analysis.[11] Once the system is built to collect data and analyze it, the results are then used

8 https://www.researchgate.net/publication/372934843_A_Study_on_Smart_Energy_Management_Framework_Using_Cloud_Computing

9 https://buildings.honeywell.com/us/en/brands/our-brands/multisite/services/energy-management

10 Maldonado Silveira Alonso Munhoz PA, da Costa Dias F, Kowal Chinelli C, Azevedo Guedes AL, Neves dos Santos JA, da Silveira e Silva W, Pereira Soares CA. Smart Mobility: The Main Drivers for Increasing the Intelligence of Urban Mobility. Sustainability. 2020; 12(24):10675. https://doi.org/10.3390/su122410675

11 https://www.aindralabs.com/what-is-intelligent-transportation-system-its-applications-and-examples/

control, manage and plan transportation. Sensors play an important role in data collection. Since there is an inseparable conceptual bond between Sustainable Transportation Systems and Smart Transportation, below are mentioned various components of Sustainable Transportation Systems that work together to reduce environmental impacts, enhance mobility, and improve the quality of life: **Accessibility**; **Park and Ride Integrated Multi-Modal Transport Systems; Green Vehicles**; **EcoMobility; Organic Transportation etc.**

Smart Cultural Heritage Management

Vattano (2014) asserts that the integration of a city's historical elements into its modern reality is a significant factor towards the advancement of its urban intelligence. The specific benefits of including cultural heritage in smart initiatives derive from big data management and augmented reality (AR). Big data management allow to store and administer great amounts of data, beneficial for the preservation of cultural heritage, and the sustainable monitoring of its life cycle conservation[12]. Meanwhile, optimizing technological use in cultural heritage management leads to cost reduction in terms of maintenance. Further, Municipalities through smart initiatives could advance cultural heritage ontologies with AR characteristics allowing both citizens and visitors to readily access their historical value. **There are two main tools municipalities can use for Smart Cultural Heritage Management**, namely a) **Digital Interactive Map of Cultural Heritage and b) Virtual Museums.**

Digital Interactive Map of Cultural Heritage is another important tool of smart management of cultural heritage. It is a web application that combines online maps, digital archives and multimedia. This map focuses on research, digital preservation and visualization of cultural heritage, both tangible and intangible. It aims at allowing users to explore and better understand cultural heritage. Provides an opportunity for citizens to interact with cultural heritage in an easily accessible and stimulating format, while also enabling spatial analysis related to cultural heritage. This map also enables data collection and analysis of the spatial distribution of cultural heritage- both tangible and intangible in the territory of municipality.

On the other hand; **Virtual Museum** is among the main tools that Municipalities can use in their way of adopting smart management system approaches towards their heritage. It is a digital entity that draws on the characteristics of a museum, in order to complement, enhance, or augment the museum experience through personalization, interactivity and richness of content[13]. It's a collection of digitally recorded images, sound files, text documents, and other data of historical, scientific, or cultural interest that are accessed through electronic media[14]. The goal of the virtual museum is not to compete with or replace traditional museum visits, but to enhance, complement, and augment the museum experience by offering a level of personalization, interactivity, and richness of content that is impossible to bring in the real world. Thus, they need to be seen as a coequal to traditional museums[15].

Smart Economy

Smart economy is an economy that is based on technological innovation, resource efficiency, sustainability and high social welfare as engines for success. It adopts innovation, new entrepreneurial initiatives, increases productivity and competitiveness with the overall goal of improving the quality of life of all citizens[16]. Smart economy is expected to generate more products and services with less energy and pollution, and create social benefits. Smart economy should result from improvement of education and promotion of innovation[17]. **Smart**

12 Angelidou, M., Karachaliou, E., Angelidou, T. and Stylianidis, E., 2017. Cultural Heritage In Smart City Environments. International Archives of the Photogrammetry, Remote Sensing & Spatial Information Sciences, 42.

13 What is a Virtual Museum? | v-must

14 Museums (ubt-uni.net)

15 Museums (ubt-uni.net)

16 Information and communication technologies developing smart economies | The Sunday News

17 Digital Social Innovation for Better Connected Government: The Case of Republic of Macedonia: Government & Law Book Chapter | IGI Global (igi-global.com)

Economy describes all actions aimed at transforming and strengthening a city's economy, including improving the overall business climate, a city's attractiveness for start-ups, investors, businesses, and new (highly qualified) talent as well as growing the economy in an innovative and sustainable way to increase competitiveness. To achieve the desired objectives of Smart Economy, cities should focus on the following areas[18]:

AREA 1: Entrepreneurship | Productivity | Competitiveness: urban organization that fosters new entrepreneurial initiatives, an increase of competitiveness and high productivity in communities with the aim of improving the quality of life. In these terms, a smart municipality highly values creativity and welcomes new ideas, as well as enlightens entrepreneurial leadership.

AREA 2: R & D | Urban Labs: offer a solution which can be adopted by other universities or cities, and thus obtain a return on investment (ROI are its acronym in English) through the creation of innovative services and urban laboratories. In these terms, municipalities should be driven by innovation and supported by universities that focus on cutting-edge research, not only for science, industry, and business but also for cultural heritage, architecture, planning, development, and the like.

AREA 3: Tourist attraction and internationalization: Brandings which will provide a national and international perspective for the tourist promotion both social and economic. In these terms, a smart city is a destination that people want to visit (tourism).

AREA 4: Trainings and Life Long Learning | Smart Labor Force involves multiple components aimed at enhancing community engagement, personal development, and career progression through innovative educational technologies and customized training programs. These include actively assessing community training needs, integrating advanced educational tools such as AI and VR, and creating age-appropriate, inclusive learning modules for all demographics. Additionally, developing partnerships with industry ensures the relevance of training programs and provides practical experience, while strategies for attracting and developing local talent contribute to the region's attractiveness as a business location.

AREA 5: Smart Industry | Industry 4.0 or commonly known as the industrial internet of things (IIoT), describes the application of internet of things technologies in industrial processes and manufacturing. By implementing solutions/ concepts related to big data, machine learning, digital twin, artificial intelligence, predictive analytics etc., manufacturers aim to achieve the optimal level of responsiveness, adaptiveness and fully connected processes of a smart factory.

AREA 6: Smart Work Management | as per private sector, Smart Working means a new flexible working method. It is a new way of approaching work that gets rid of inflexibility and predetermined patterns in favor of focusing on what is relevant: ideas, projects and people.

Smart Environment

Smart Environment uses data collection from utility networks, users, and air, water, and other city resources in order to establish main areas of action in urban planning and city infrastructure planning as well as to inform urban services managers to achieve a more efficient and sustainable urban environment while improving the citizens' quality of life. The sustainable and smart territory leads reflections on the use and production of green and renewable energies, on more sustainable methods of food production or on the use of new technologies in order to optimize the management of resources (energy, air, water, waste, etc.). Urban agriculture, for example, is at the crossroads of these major issues. Thus, water management, waste management, emission reduction and smart air pollution monitoring are among topics to be considered in this context.

18 Smart Economy: Economía Inteligente. UA Smart University

Smart Air Pollution Monitoring
Smart Air Pollution Monitoring is a very important component of Smart Environment. Smarter Technologies' smart air quality monitoring solution is able to detect carbon dioxide levels, noxious gases and pollutants, sending real-time data to a central management dashboard. It provides enhanced visibility, improved situational awareness and earlier indications of pollution hotspots. The prime objective is to provide cost-effective access to air quality data to every citizen of the city, integrated with an accountable solution-mapping ability. Power and communication will lay the foundation of the monitoring network. The citizens of a smart city shall remain informed and engaged about the air quality via a dense network of monitors lodged with high-efficiency micro-sensors. A centralized dashboard will make this data extremely accessible.

3. UBT "SMART City" Overview / Transformative Planning Principles and Spatial Systems adopted by UBT Campuses

We are living in the times of convergence revolution which represents a very highly dynamic and complex environment. This dramatic transformation including using AI and other advanced technologies creates opportunities, but also new requirements for new competencies and skills. Traditional education is not enough today to provide the required future skills including skills adaptability, problem-solving, and collaboration. This requires a new solution for education, with highly complex and very dynamic-oriented models and systems. To support this causa, UBT – University for Business and Technology has created its model called UBT 5S – Small Scale Smart Selfsustained System or short UBT Smart City.UBT Smart City represents now an Entrepreneurial Smart and Sustainable Innovation Ecosystem. This model represents a dynamic complex system and is created to be used as a test bad system for smart and self-sustained solutions for education, innovation, and development. Made from different components for life and different technologies UBT Smart City creates a great opportunity to use Advanced and Innovation Technologies for Education, Training, Research and Development. Cases of using AI and XR Technologies in Education and their Impacts are presented to see the opportunities which is provided by UBT Smart City Ecosystem (Classroom 4.0). Classroom 4.0 provides many benefits, including an AI-powered immersive learning platform, the ability to quickly create courses for new types of job skills, cost-effectiveness, flexibility, real-time updates, accessibility, and inclusive retraining opportunities.

To support its mission of advancing and fully implementing smart systems in its everyday activities and processes, UBT has developed its Institutional Strategy and Action Plan for Green, Carbon-Neutral and Smart Campus. The Strategy and Action Plan focuses on nine key Initiatives, namely: Clean Energy, Building green, Getting around, Sustainable water management, Good food, Zero plastics, Smart technologies, Sustainable landscape, and Print responsibly. The given Initiatives-directly linked with certain SDGs- and related actions & project are briefly summarized below:

Clean Energy / Switch to Renewables: We'll transition to clean energy sources, reduce the campus's carbon footprint, and support sustainability by conducting an energy audit, installing solar panels, encouraging energy conservation, and exploring other renewable options.

Building Green/Green Building: Sustainable construction and ongoing green practices will reduce environmental impact and ensure long-term eco-friendliness through sustainable design, eco-friendly materials, energy-efficient systems, renewable energy integration, and ongoing maintenance.

Getting Around / Biking and Walking: Promoting non-motorized transportation options will reduce carbon emissions and foster a healthier lifestyle by developing a campus Master Plan, installing bike racks, implementing a bike share program, promoting biking and walking events, and integrating with public transport.

Never Waste a Drop / Sustainable Water Management: Efficient use, conservation, and recycling of water resources will conserve water, reduce costs, and minimize environmental impact through water audits, water-efficient fixtures, rainwater harvesting, improved irrigation practices, and community engagement.

Good Food, Healthy Planet / Zero Food Waste Campus: Sustainable food practices and reducing food waste will contribute to a healthier environment and carbon neutrality by implementing a sustainable sourcing policy, portion control, food recovery programs, composting, community education, and monitoring food waste.

Zero Plastics, Zero Waste/Single-Use Plastic Free Campus and Minimization of Disposable Items: Eliminating single-use plastics and minimizing waste generation will promote sustainability and environmental friendliness through a ban on single-use plastics, reusable items promotion, recycling and composting stations, waste reduction programs, and community education.

Adopting Smart Technologies/AVR: Integration of smart technologies will enhance efficiency, sustainability, and learning experiences by integrating smart building systems, incorporating AVR technologies, implementing IoT solutions, promoting remote learning, and developing smart campus initiatives.

Sustainable Landscape / Open and Green Areas: Creating and maintaining sustainable outdoor spaces will enhance the quality of life and promote biodiversity by using native plants, implementing water-efficient irrigation systems, creating multi-functional spaces, and engaging the community.

Print Responsibly/Save the Planet: Reducing paper consumption and minimizing the environmental impact of printing will conserve resources and promote sustainability through a print management system, digital document management, recycled paper and eco-friendly inks, a paperless initiative, and community education.

3.1. Embedded Emerging Technologies

UBT has embraced the **UNIVERSITY 4.0 Concept** as the foundation for its scientific, research, teaching, and innovation endeavors. This concept is actively implemented through a **Fully Digitalized Research and Education Process**, **CLASSROOM 3.0**, **Augmented and Virtual Reality (AVR)**, and the integration of a **5G Telecommunication Network**. These technologies are embedded within UBT's **Innovative and Scientific Campus in Lipjan/Kosovo**, as well as across its other campuses and facilities throughout the country. The campus itself is designed around the **small-scale smart city** concept, encompassing all spheres of life in an open and interactive environment. Fueled by technological advancements, innovative vision, and ongoing strategic initiatives, UBT has successfully transitioned to a **fully digitalized educational and research model**, prominently utilizing AVR technologies powered by the **EON Reality platform**. In this context, UBT is currently implementing **two major projects** centered on Virtual and Augmented Reality. The platform empowers both faculty and students across all disciplines to contribute toward simplifying and enriching everyday academic and research experiences.

The **UBT Smart Ecosystem University Model** integrates core principles of **Smart Systems, Resilience, Sustainability**, and **Society 5.0**, making it a globally relevant example of small-scale systems design. In alignment with its strategic direction and past achievements, UBT has recently established two pioneering institutes and laboratories in the fields of **Artificial Intelligence (AI)** and **Cybersecurity (CERT)**. These institutions reflect UBT's mission to foster an **integrative, creative, and transdisciplinary innovation ecosystem**, consistent with the **Convergence Revolution**. This environment is designed to unlock human potential—anchored in the belief that such potential is limitless. Moreover, cybersecurity plays a critical role in UBT's digital transformation agenda. The institution has established comprehensive **cybersecurity standards, tools, and protocols** to protect both digital and physical assets, in full compliance with international norms. UBT's **Cyber Crisis Management** approach is structured around two key components: **Readiness** and **Response**, both of which are outlined in detail.

Augmented and Virtual Reality (AVR) Platform: UBT is currently implementing two strategic projects focused on Virtual and Augmented Reality technologies in cooperation with **EON Reality (Prishtina, XK)**. This platform allows every faculty—students and staff alike—to actively develop, share, and apply educational and research-based content. Currently, the platform hosts over **1.8 million digital assets (2D, 3D, and 360°)**, with **approximately 40,000 new assets** added each semester.

5G Technology: UBT 5G Hub and Test-bed: UBT has launched a cutting-edge **5G Hub**, serving both internal (academic/research) and external (industrial) needs. As Kosovo currently lacks a 5G infrastructure, this hub is critical for future-oriented experimentation. Key capabilities include:

- Testing integration from **4G to 5G** networks for Internet Service Providers.
- Exploring **real-time communication** for **autonomous vehicles**.
- Facilitating **telemedicine** and **remote surgical simulations**.
- Testing **smart city solutions** for municipalities before full-scale implementation.
- Enhancing public/private transport systems through digital communication tools.
- Supporting **crisis communication networks** for national emergencies (medical, military, law enforcement, government, and media).
- Boosting service delivery by **centralizing servers** (Google, Facebook, Microsoft, etc.) and improving access speed by up to **300%**.

Fully Digitalized Education and Research: UBT's digitalization efforts, led by innovations such as AVR and supported by other smart technologies, have created a seamless 24/7 learning environment. Students benefit from real-time access to global scientific content, flexible study schedules, and personalized learning paths. This digital transformation enhances Accessibility and inclusion, Custom-tailored education**,** Access to AVR content**,** Cloud-based learning platforms**,** Internet of Things integration**,** Secure digital infrastructure, Big data analytics.

Strategic Institutes and Labs: In addition to previously outlined innovations, UBT has established the following hubs and institutes **Artificial Intelligence Institute and Laboratory; Cyber Security CERT Lab; UBT VR/AVR Hub; UBT Knowledge Hub; UBT Sports, E-Sports & Arts Hub.**

These are designed to reinforce UBT's commitment to the **4th Industrial Revolution** and the broader **Convergence Revolution**—enabling cross-sectoral, creative, and knowledge-based ecosystems for innovation.

Artificial Intelligence (AI) and Cybersecurity (CERT): These centers support both public and private stakeholders, including government bodies, military, and academia. Notable applications include:

- **Faculty of MBE**: Utilizes supercomputing for forecasting and service enhancement in the banking and finance sector; supports national cybersecurity efforts via the CERT lab.
- **Faculty of Architecture and Spatial Planning**: Leverages AI and drones for real-time 3D mapping and VR animation design.
- **Faculty of Mechatronics**: Applies AI to robotics, machine learning, and intelligent drone algorithm testing.
- **Faculty of Computer Science**: Develops AI applications for medicine, automotive, and technology sectors.
- **Faculty of Agriculture**: Uses AI and drones for soil fertility mapping and agricultural research.
- **UBT Stats Office**: Employs AI to refine and interpret large datasets for informed decision-making.

UBT VR/AVR Hub: Although still an emerging technology, VR and AR are no longer futuristic concepts. They are being actively used at UBT to solve practical problems and enhance interaction with the real world. As one of

EON Reality's top international centers, UBT has produced over **20,000 AVR lessons** across **20 different academic programs**, many of which are now part of featured global curricula.

This comprehensive approach underscores UBT's leadership in higher education digitalization and innovation—not only in the Western Balkans but also across Europe—further solidifying its role as a model for the Smart Ecosystem University of the future.

4. Challenges, Opportunities, and Transferability

Despite the integrative strengths of the UBT campus model, several challenges must be addressed to ensure long-term success and replicability. First; the **management of systemic complexity** poses difficulties in coordinating cross-domain data streams, infrastructure components, and stakeholder engagement. As Batty (2013) notes, cities—and by extension, campuses—are complex adaptive systems requiring non-linear and iterative governance models. Second; the governance of data, including issues of privacy, security, and interoperability, remains a significant barrier to fully operationalizing smart infrastructure (Kitchin, 2014). The challenge of **scaling** pilot innovations and interventions to whole campus area or regional implementation (always considering community's needs and expectations) requires institutional readiness, funding continuity, and administrative integration (Evans et al., 2019). Third; **digital inclusion** emerges as a critical issue, as emphasized by van Dijk (2020), since the benefits of smart systems must be equitably distributed among all campus users to avoid reinforcing socio-digital divides. Conversely, the UBT model presents valuable **opportunities** for innovation and policy learning. University campuses serve as ideal sites for **experimentation in urban resilience**, where modular, adaptive, and data-informed planning can be deployed and transferred (Karvonen, Evans & van Heur, 2014). The cross-sectoral nature of UBT's projects—engaging public institutions, tech providers, businesses, civil society, and local communities—supports collaborative innovation ecosystems, as core component of the process. Furthermore, the campus functions as a real-world interface for **policy prototyping**, facilitating agile testing of regulatory and planning frameworks in energy, mobility, and land-use systems.

Regarding **transferability**, the UBT framework offers a model adaptable to both local and global contexts. Its emphasis on tactical urbanism, integrated land-use, and community participation (although limited only to university community) aligns with principles of New Urban Agenda (UN-Habitat, 2016) and the EU's mission on Climate-Neutral and Smart Cities (European Commission, 2020). Thus, it is to emphasize that such university-based innovation ecosystems can be instrumental in supporting **institutional policy making in smart concepts and innovation strategies**, providing a scalable pathway for transitioning toward sustainable and inclusive urban futures.

5. Conclusion and Future Outlook

The UBT "SMART City" model represents a pioneering approach in integrating adaptive urbanism, circular economy principles, and smart infrastructure systems into a cohesive spatial and institutional ecosystem. As a transformative model, it redefines the role of university campuses from static educational environments to regenerative urban microcosms capable of responding dynamically to environmental, technological, and social shifts. Through its adoption of dynamic land-use modeling (Batty, 2009; Waddell, 2002), UBT has created a campus framework that enables continuous spatial adaptability and responsiveness to emerging demands, aligning with long-term sustainability goals. One of the key contributions of the UBT model lies in its operationalization of circular economy principles across campus infrastructures, drawing on theories of closed-loop systems to reduce waste and enhance resource efficiency (Ellen MacArthur Foundation, 2015). This has been translated into concrete actions in energy, water, food, waste, and material management, fostering synergies between environmental sustainability and everyday campus operations. Moreover, smart infrastructure deployments—including IoT-based environmental monitoring, smart building management, and integrated mobility systems—illustrate how technology can enhance campus resilience, optimize resource flows, and improve quality of life for all users (Batty et al., 2012; Neirotti et al., 2014). For planners, the UBT model offers a practical demonstration of multi-

functionality and scalability in spatial systems. By designing hybrid-use environments that support education, housing, innovation, and public interaction, the campus becomes a living lab for spatial experimentation and an ideal ground for testing forward-looking planning strategies (Gehl, 2010; Sharifi, 2016). Technologists can leverage the model's integration of smart systems to explore new configurations of energy management, sensor networks, and data-driven service delivery, while simultaneously addressing challenges of interoperability, data governance, and inclusion (Kitchin, 2014; van Dijk, 2020). For educators, UBT offers a context where pedagogy is embedded within the physical and operational fabric of the campus itself—an experiential learning environment where sustainability, technology, and design converge. Policymakers are presented with a platform for policy prototyping and institutional experimentation. The UBT campus has demonstrated how regulatory frameworks in sustainability, transport, and land use can be tested at a micro-scale before being scaled regionally or nationally (Karvonen, Evans & van Heur, 2014). Its alignment with broader agendas such as the EU's Climate-Neutral and Smart Cities mission and the UN-Habitat's New Urban Agenda positions UBT as both a local innovator and a globally relevant actor (European Commission, 2020; UN-Habitat, 2016). Looking ahead, UBT's future development plan, encapsulated in its Strategic and Action Plan "Towards a Smart, Green and Carbon-Neutral Campus," provides a structured roadmap for deepening these innovations. Priorities include further integration of clean energy solutions, digitization of learning environments, expansion of green infrastructure, and institutionalization of sustainability governance mechanisms. Importantly, UBT envisions broader global engagement through knowledge transfer, cross-border collaboration, and participation in international research and innovation networks. As such, the UBT "SMART City" model is not only a physical manifestation of adaptive and intelligent planning but also a replicable and scalable framework that can inform future city-making processes. It illustrates how academic institutions can be reimagined as leading agents of spatial transformation, social innovation, and environmental stewardship in the era of climate change and digital transition.

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Harnessing Smart Technologies in Real Estate: A New Paradigm for Spatial Planning and Urban Development

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Abstract
This paper presents a dual-tool system to support the assessment and development of smart cities and smart real estate. The first tool is a comprehensive evaluation framework that independently and jointly measures the smartness of urban systems and real estate projects across seven strategic categories. The second is a smart technology utilization map that identifies the added value of specific technologies across different phases of the real estate lifecycle—from land acquisition to post-operation. Together, these tools enable stakeholders—such as city authorities, developers, and investors—to identify performance gaps, prioritize improvements, and plan smarter, more integrated developments. The study also outlines the role of public and private actors in enabling smart infrastructure and encourages coordinated, data-driven decision-making to advance urban sustainability, efficiency, and resilience.

Keywords smart city, smart real estate, smart technologies, urban planning

1. Introduction

Urbanization is accelerating faster than ever before, with the United Nations estimating that 68% of the global population will be living in cities by 2050 (UN-Habitat, 2022). This trend puts significant pressure on urban infrastructure, urban governance, and real estate markets.

Simultaneously, smart technologies (for example, the Internet of Things (IoT), artificial intelligence (AI), and geographic information systems (GIS)) are altering urban systems, and cities are beginning to adopt these technologies to respond to these pressures (Batty *et al.*, 2012; Ahmed *et al.*, 2017).

Real estate development, as a fundamental urban development component, provides a major opportunity for technological convergence. However, at present existing models do not provide a reliable framework to identify smart technology interventions through the real estate development space. Most smart city (SC) models also do not appropriately integrate real estate or treat it as a small part of the overall model (Albino, Berardi and Dangelico, 2015; Allam and Newman, 2018) Therefore, there is a need for a hierarchy system that assesses the smartness of developments, identifies the smartness gap, and matches the better innovation and technology intervention to the necessary development stages.

This paper will help fill that gap by offering a practical roadmap for stakeholders (i.e. municipalities, real estate developers, investors, and decision-makers) to determine and improve the assessment of SC systems and smart real estate (SRE) development. The paper proposes two primary tool components that stakeholders can utilize or adjust to their urban and project contexts:

1. An Evaluation Framework: This assessment instrument compares and evaluates the level of 'smartness' of both city and real estate levels, provides a diagnosis for current inadequacies, and identifies objectives for governance, infrastructure, people, environment, building, and technology, and identifies the gaps in each level (Al-Rimawi and Nadler, 2023).
2. A Smart Technology Utilization Map: This component identifies the added value of smart technologies along the real estate life cycle and identifies when and where to use technologies. Utilizing recent integrative reviews (Al-Rimawi and Nadler, 2025)It identifies which technologies, such as GIS, BIM, AI, IoT, VR/AR, and digital twins, are most impactful during specific phases of the real estate life cycle, from land development, development, operation, and redevelopment.

These tools provide strategic purpose and meaningful insights both across and up and down the hierarchy. The

framework supplies coordinated planning and a policy context, while the technology map indicates investments that can be made in smart systems that drive more operational efficiency, sustainability, and value over time. The study addresses this need for collaborative integration rather than fragmentation and contributes to a stream of research recognizing the importance of collaboration across sectors and interoperable planning processes. While no case studies are present, illustrative examples are provided to demonstrate how these tools can be applied in practice.

2.Theoretical Foundations and Literature Review

2.1 Defining Smart Cities and Smart Real Estate

The concept of the SC has been developing since the early 1990s, starting the knowledge-based city, which emphasized the importance of knowledge-based urban development (Šiurytė, 2015). Among the key hindrances to both the development and actualization of the SC concept is the lack of a shared definition. This lack results in definitional ambiguity, which weakens conceptual clarity for smart cities and could jeopardize their practical value. The variation in definitions is due to the fact that the SC is an interdisciplinary concept with several fields such as urban planning, information technology, environmental sustainability, and real estate being involved. Scholars and practitioners thus define SC based on their respective areas of specialization.

In response to this challenge, Al-Rimawi and Nadler (2025) propose a comprehensive and inclusive definition that that captures the key dimensions of smart cities and brings together the key elements of SC. Where it is the city that utilizes smart technologies to render its interlinked sectors and essential elements, including city administration, citizens, energy, infrastructure, property, technologies, information, and nature more intelligent, sustainable, integrated, and efficient. This perspective positions smartness as a two-pronged change—technological and strategic—with profound consequences for governance, infrastructure, and the quality of urban life. To avoid what could be termed smart washing—the superficial or misleading application of the term—the SC must move beyond definitions. It must become a tangible and measurable reality, grounded in practical implementations, data-driven evaluation, and meaningful impact across its various systems and stakeholders.

SRE is a similar but distinct concept. It refers to the integration of smart technologies into the property development, operation, and management sectors in order to achieve operational efficiency, user-centered functionality, and sustainable performance throughout the real estate life cycle. In contrast to smart buildings, which focus primarily on building automation and system efficiency (e.g., HVAC, lighting, security) smart real estate permeates the whole property life cycle. These include the land development stage, project development, operational stage, and post-operation activities (Ullah, Sepasgozar and Wang, 2018; Al-Rimawi and Nadler, 2025). In each phase, decision-making, design optimization, predictive maintenance, and user engagement are facilitated by technologies such as IoT, GIS, AI, and big data analytics (Yigitcanlar, 2021; Al-Rimawi and Nadler, 2025).

SRE cannot be an isolated category; rather, it is inherently integrated into the framework of the SC. The interaction between the built environment and urban infrastructure—such as energy networks, transportation systems, and information platforms—allows a synergistic interaction. SRE initiatives are part of essential elements producing and reacting to information at the city level, assuming their position in reinforcing urban efficiency and sustainability goals (Albino, Berardi and Dangelico, 2015; Apanaviciene and Shahrabani, 2023). This integration underscores the need for comprehensive frameworks that evaluate smartness across both scales—urban and real estate—ensuring coordinated innovation, data interoperability, and systemic impact.

2.2 Smart Cities and Smart Real Estate Integration

Integrating SRE within smart cities is critical to the success of efficient, resilient, and sustainable urban systems. SRE, especially smart buildings, constitutes a fundamental element of the overall urban infrastructure, facilitating contributions toward energy management, automation, and adaptive technologies (Al-rimawi and Nadler, 2023). Successful integration, however, requires an integrated approach at three levels: physical (e.g., accessibility to urban infrastructure and utilities), data (interoperable platforms for real-time exchange), and functional (integration with urban goals like energy efficiency and well-being of the citizens) (Apanaviciene and Shahrabani, 2023).

Strategies for SRE integration differ according to technological capability and developer goals. Al-Rimawi and Nadler (2023) discern three principal strategies: leading, in which RE establishes the standard for nearby smart developments; following, in which RE conforms to existing smart standards; and waiting, whereby selective and piecemeal introduction of isolated smart features is undertaken without strategic planning. Every strategy demonstrates disparities in smartness levels and likely influence, underlining the necessity for diligent coordination between real estate developments and city-wide systems. Ultimately, proper integration allows for mutual gains—maximized utilization of resources, improved urban development, and augmented environmental and social returns cementing the position of renewable energy as a core facilitator in SC frameworks.

2.3 Smart Technologies

Smart technologies are the enabling infrastructure, or foundation, for both smart cities and SRE, enabling a digitally transformed built environment and urban space. These technologies facilitate functionality, efficiency, and sustainability across the entire life cycle of city and real estate development and delivery processes. These are the core technologies that enable intelligent decision-making and enable automation and integration within urban contexts and built environmental systems. Figure 1 represents the different smart technologies groups based on their main function and utilization.

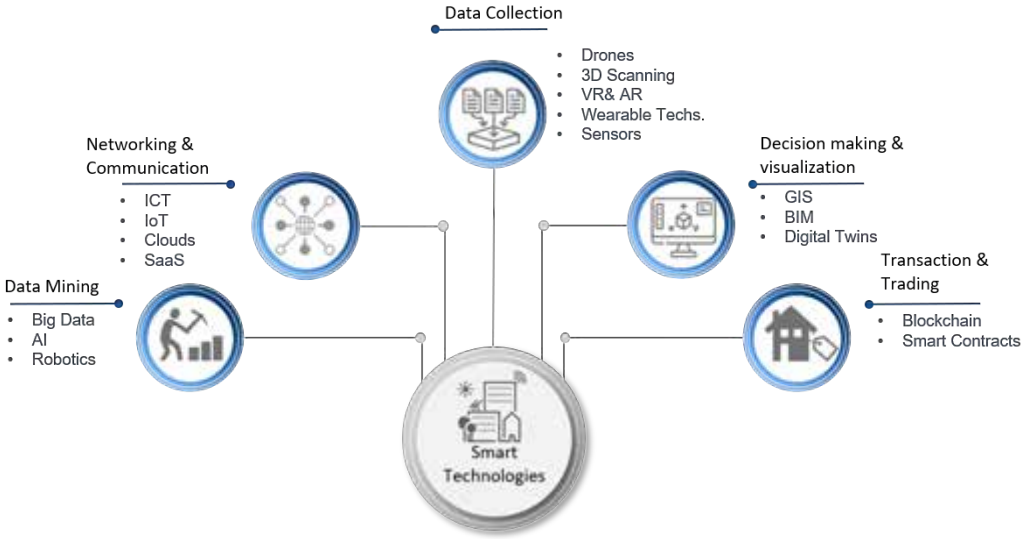

Figure 1 Smart city technologies that impact smart real estate (Al-Rimawi and Nadler, 2025, p. 04)

Data Mining & Intelligence Tools: Technologies such as big data analytics and AI serve a central role in the analysis of complex data sets, to help inform predictive analytics in models of traffic, energy, and operations of building management systems (Kitchin *et al.*, 2015). In assisting in a variety of project marketing processes, as well as maintenance projections and user behavior, AI will improve operational efficiencies and with enhanced service personalization (Ullah, Sepasgozar and Wang, 2018; Al-Rimawi and Nadler, 2025). Networking and Communication Tools: Information and communication technologies (ICT), the Internet of Things (IoT), cloud computing, and software as a service (SaaS) are part of the digital nervous system of smart cities and are the fundamental tools used to facilitate interoperability and communication between all buildings, infrastructure, and user devices (Boulos and Al-shorbaji, 2014).

Data Collection Technologies: Tools such as drones, 3D scanning, wearable devices, virtual reality (VR), and augmented reality (AR) facilitate real-time monitoring, visualization, and augmented experience for users, and are particularly influential in project marketing, design and refurbishment aspects of real estate (Naeem, Rana and Nasir, 2023; Al-Rimawi and Nadler, 2025) Decision-Making & Visualization Platforms: Geographic Information Systems (GIS), Building Information Modeling (BIM), and Digital Twins (DT) can facilitate, support, and contribute

towards the urban planning, real estate design, simulating, and lifecycle management processes. GIS has had a strong impact in land development and land selection, while BIM and DT can support integrated design and operations (Bronckers, 2024); (Malik *et al.*, 2021); (Karan, Irizarry and Haymaker, 2016; Arcuri *et al.*, 2020).

Transaction and Governance Tools: Blockchain and smart contracts provide transparent and tamper-resistant systems for land registration services, lease agreements, and real estate trading, which can improve trust and increase efficiency in ownership transfer processes (Ullah and Al-Turjman, 2023).

A recent integrative review (Al-Rimawi and Nadler, 2025) conducted an analysis of how these technologies are contributing to the real estate life cycle. The study discovered that the greatest added value through these technologies was experienced during project acquisition, conception, and operation, with GIS contributing the greatest value during site selection and land development processes. GIS and BIM also dominated during the conception stage, while BIM was the most visible during the realization and construction stage. For promoting marketing a product, either AI, Virtual Reality or Augmented Reality tools assist in portraying the property with simulation and visualizations that attract end-users and experience more traction during this stage of the real estate life cycle.

Emerging technologies like AI, the IoT, wearables, DT, and BIM were key technologies during the operation and maintenance phases, facilitating performance, user interface, and energy consumption improvements. BIM and 3D scanning facilitated refurbishment, however, a transition from vacancy and demolition proved more challenging with limited outcomes. Operational enhancements were generally noted with enhancements in emergent technologies manifested as better decision-making, reduced errors, better resource management, and reductions in operational tasks. Integrating the emergent technologies improves value propositions as they create synergies that lead to new uses and efficiencies. Although the emergent technologies offer transformative potential, there will be challenges to implementation including financial capacity, institutional inertia, and the issue of interoperability with data. However, with some strategic planning, these emerging technologies can be a more useful tool and can cater to urban and real estate development (Ullah, Sepasgozar and Wang, 2018; Al-Rimawi and Nadler, 2025).

3. Materials and Methods

3.1 Research Design

The study takes a conceptual and systems-design approach to create an integrated assessment and enhancement system for SCs and SRE. The research is based on the author's two previous frameworks ((Al-Rimawi and Nadler, 2023, 2025)) that outlined:

1. A comprehensive evaluation framework for determining and measuring the smartness of cities and real estate.
2. A structured model for identifying the added value of SC technologies throughout

This paper presents a framework that is open for use generally and practically, based on academic references and supplemented with examples that demonstrate the inaugural use of the original system in practice. Prioritize smart upgrades in terms of strategic impact and feasibility.

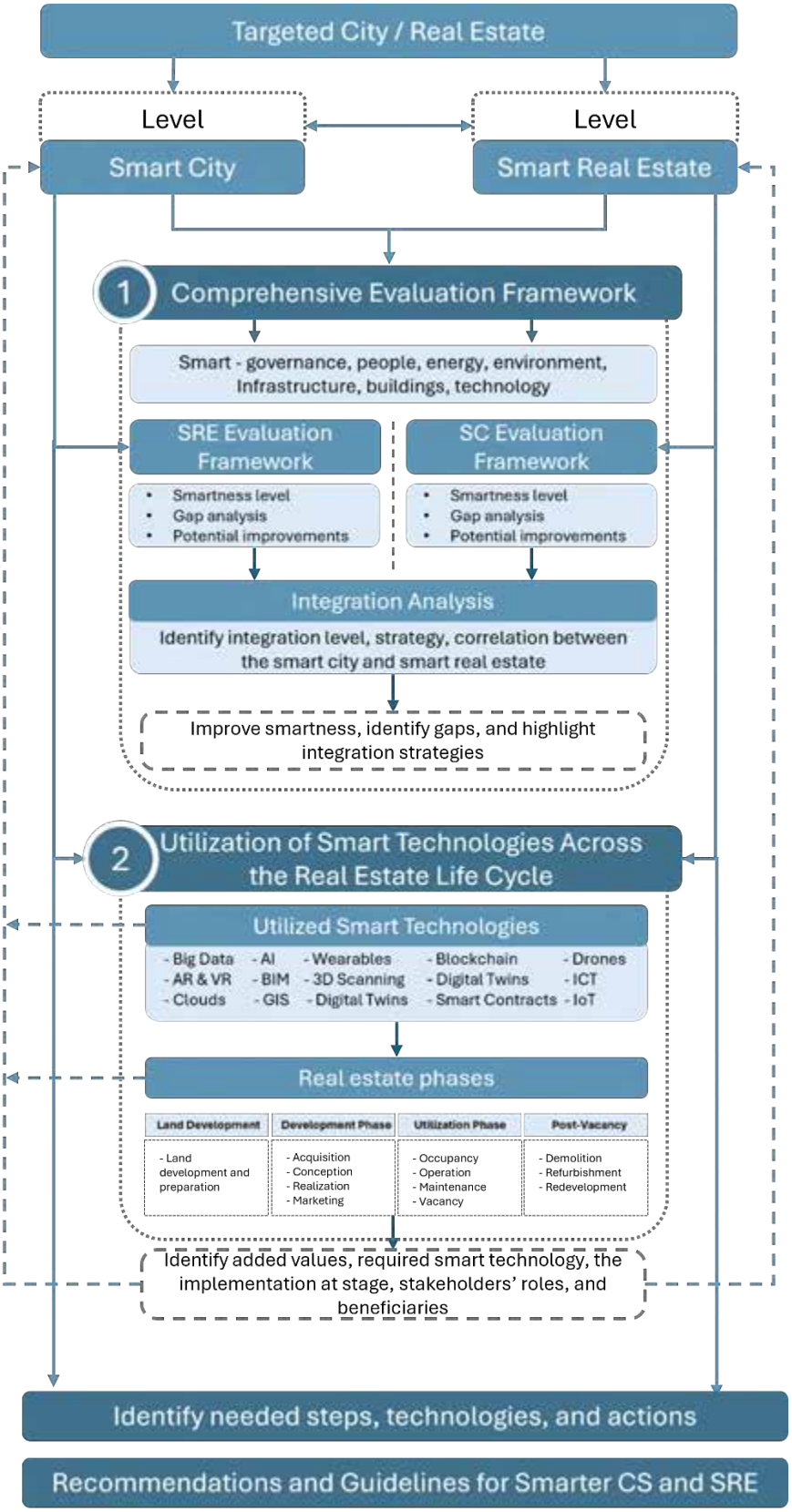

Figure 2 . *Research methodology. Source: Author, 2025.*

4. Roadmap and Tools for Smartness Improvement

The road map proceeds in the following steps:

4.1 Step 1 - Comprehensive Evaluation Framework

Smartness Determination and Assessment

The smartness of both the city and the real estate sector are assessed separately following the evaluative frameworks developed by (Al-Rimawi and Nadler, 2023). This assessment includes:

- Verifying whether the city or real estate qualifies as "smart" based on indicator thresholds.
- Evaluating performance across seven smart dimensions: governance, environment, economy, people, mobility, living, and real estate.
- Assigning scores to each dimension for comparative and developmental analysis.

The comprehensive Evaluation Framework is designed to assess and guide the development of SCs and SRE. It identifies current performance, highlights gaps, and suggests improvements, with a focus on interoperability and future adaptability. The flexible structure allows for the integration of emerging technologies and indicators. This tool supports municipalities, developers, contractors, and investors in planning, evaluating, and enhancing smart initiatives. It is applicable for both assessing existing developments and providing a roadmap for future ones.

The framework is structured around seven shared categories: smart governance, people, infrastructure, energy, environment, technology, and real estate development (RED) status. Each category includes sub-categories and indicators derived from academic research, established indexes, and regulatory frameworks.

For SCs, key references include the Smart City Index (2021), City in Motion Index (2020), EU Taxonomy (2020), and studies by (Kaluarachchi, 2022) and (Shari, 2020). For SRE, indicators were informed by SBISC (Apanaviciene, Vanagas and Fokaides, 2020), Jain's evaluation system (Jain, 2019), and Ullah et al.'s Big 9 study (Ullah, Sepasgozar and Wang, 2018), alongside certification schemes like LEED, BREEAM, and the EU Smart Readiness Indicator (SRI).

Each indicator is scored based on relevance and importance, using three methods:

- Published indexes: Weighted according to indicator significance.
- Quantitative data: Based on figures or percentages within defined ranges.
- Multi-source elements: Scores are compiled from several components, each contributing to the overall value.

4.1.1 Step 1.1- Evaluation Framework City level

The SC evaluation framework includes 28 sub-categories and 85 indicators. Each indicator is assigned a weighted score of 4, 6, 8, or 10 points, based on its relevance and importance. The total possible score is 560 points, evenly distributed across the seven main categories (80 points each). Figure 3 provides a simplified overview of the SC-level framework, as developed by (Al-Rimawi and Nadler, 2023). It outlines the primary categories, their sub-categories, the number of indicators, and the scoring structure—offering a quick snapshot of the framework's scope and focus areas.

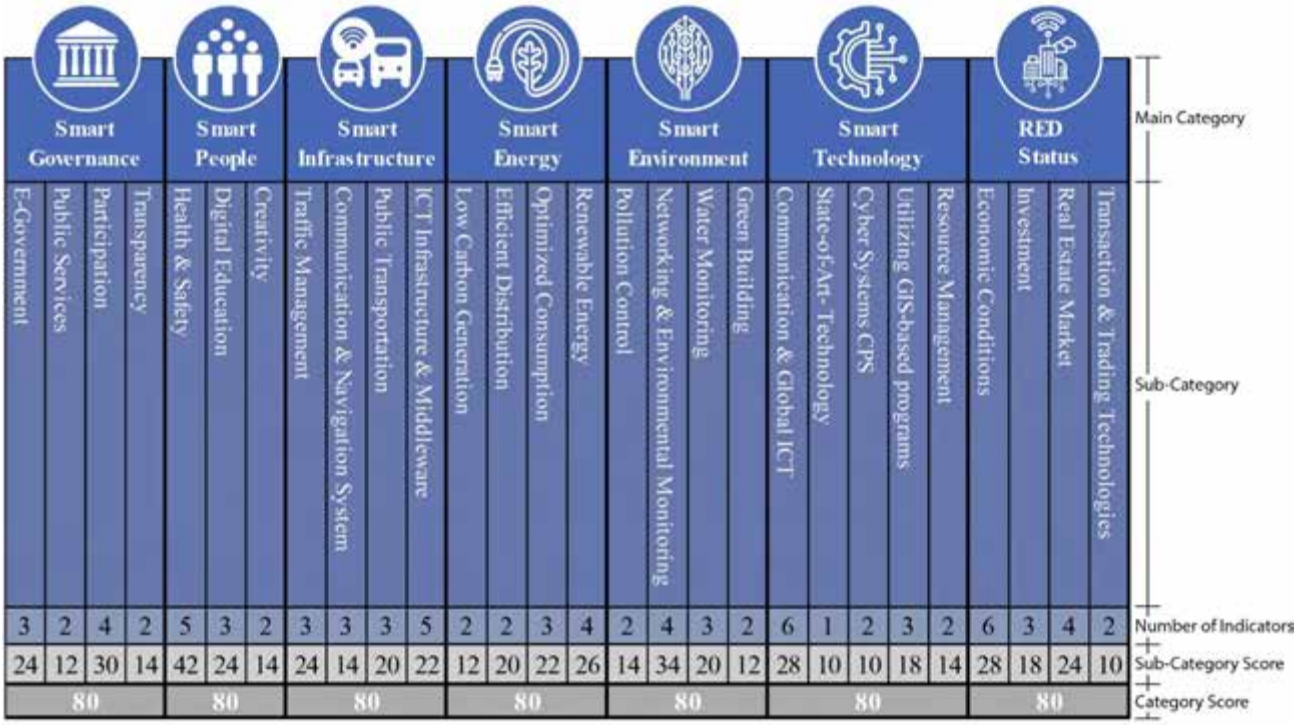

Figure 3 *Smart City Level Simplified Evaluation Framework, Author, 2025.Based on (Al-Rimawi & Nadler, 2023)*

4.1.2 Step 1.2- Real Estate (Project) Level Evaluation

The SRE project evaluation includes 90 indicators grouped into 28 sub-categories, with a total possible score of 255 points. Scores are allocated based on each category's relevance to SRE. Smart technologies, being the core of SRE, received the highest share (60 points), followed by smart energy and environment (40 points each). Smart infrastructure and real estate development (RED) status were allocated 35 points each, while smart people and governance—less directly linked—received 30 and 15 points, respectively.

Each indicator was scored on a 1–5 point scale, weighted according to its importance. Unlike the city-level framework, which uses higher point ranges, the project-level framework focuses on finer evaluation granularity. Although the maximum score per indicator is lower, results are calculated as percentages to maintain comparability and simplify evaluation across different cases. The framework follows the same process and steps as the SC, with different subcategories and indicators.

4.1.3 Step 1.3- Gap Analysis

Following the smartness assessment, the framework provides a gap detection mechanism to:

- Identify underperforming indicators and dimensions;
- Reveal areas with potential for enhancement in smart technologies, policies, or strategies;

To validate the developed evaluation frameworks, in the publication (Al-Rimawi and Nadler, 2023) the evaluation frameworks were applied to seven selected benchmarks, at both levels of SC and SRE. This practical application enabled a comparative analysis across various indicators, revealing performance gaps and opportunities for improvement. These gaps highlight where interventions or strategic enhancements are needed at both the city and project levels.

Figure 4 presents the average performance scores of the selected benchmarks, visualizing the relative impact, utilization, and importance of each indicator. Some indicators demonstrated consistently strong performance across all cities, suggesting they are already well-integrated and can be considered critical success factors for SC development. Conversely, underperforming indicators indicate areas where cities and developers can prioritize future improvements to enhance smartness, efficiency, and integration.

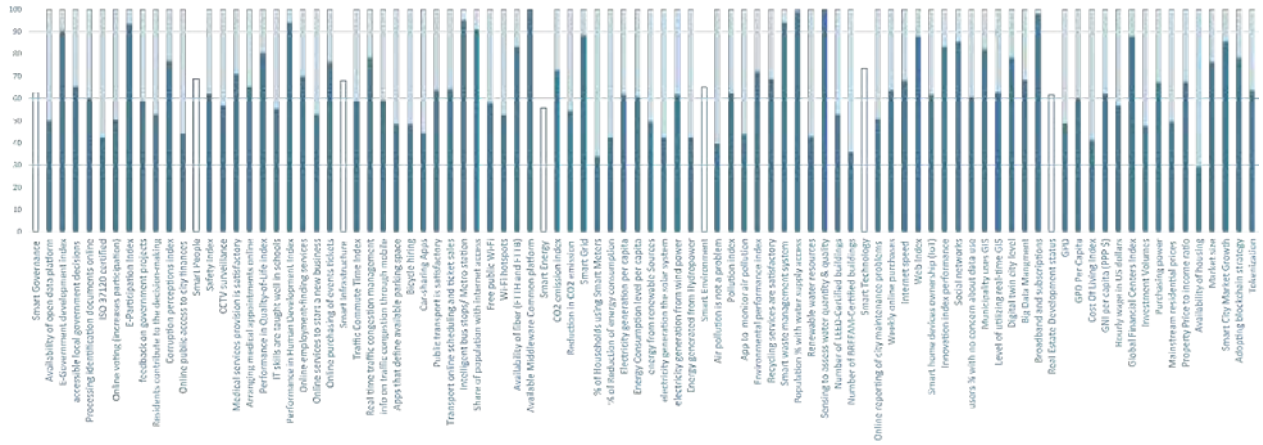

Figure 4 *Average performance and gap analysis example. Based on the case* (Al-Rimawi and Nadler, 2023)

4.1.4 Step 1.3- Integration Level Analysis

Integration between the city and real estate is analyzed using a dual-scope structure:

- Intra-scale integration: Assessing alignment and interconnectivity within the city or the real estate sector at three levels—indicator-to-indicator, sub-category-to-sub-category, and main category-to-main category.
- Cross-scale integration: Assessing the relationship and interdependence between city systems and real estate systems at the same three levels.
- This multi-level analysis will support the identification of ways in which the real estate sector supports or integrates with broader city-level smart strategies.

Several elements represent the integration analysis, Figure 5 represents a cross-sectional analysis, that represents SC and SRE performance.

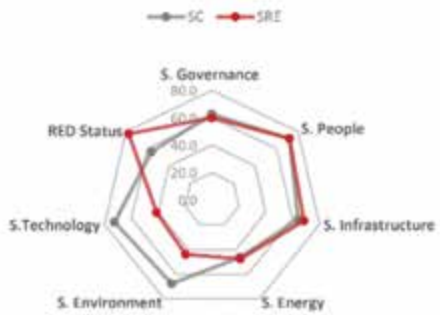

Figure 5 *Example of Sectional analysis, Smart Real Estate integration into Smart Cities and the performance. Author, 2025*

In order to capture the level of impact and correlation at all the levels SPSS (Statistical Product and Service Solutions) software is used on both SC and SRE levels and their integration. The analysis tests the three classifications: main categories, subcategories, and indicators.

4.2 Step 2- Added Value Analysis of Smart Technologies

After evaluating the smartness level, identifying gaps, and integration level, the next step would be implementing technologies to fill these gaps and improve the smartness level of the city or the real estate. The Publication (Al-Rimawi and Nadler, 2025) provides a tool that represents 16 technologies (represented in Figure 1) utilized at both levels, that have been investigated. The research followed an integrative review methodology; the review is based on 168 publications. The compiled results based on metadata analysis displayed the state of each technology's added values and usage in both scales. A total of 131 added values were identified.

4.2.1 Step 2.1 - Identification of Real Estate Life Cycle Phases

It determines how SC technologies provide value throughout a real estate lifecycle as represented in Figure 6. Real estate phases, sub-phases, and processes. (Al-Rimawi and Nadler, 2025) Across the four main phases, and their subphases:

1. Land Development
2. Project Development (Acquisition, Conception, Realization, Marketing)
3. Operation (Occupancy, Operation, Maintenance, Vacancy)
4. Post-Operation (Project Demolition, Refurbishment, Redevelopment)

Figure 6. *Real estate phases, sub-phases, and processes.* (Al-Rimawi and Nadler, 2025)

4.2.2 Step 2.2 - Identification of Added Values and Critical Elements

Each technology is evaluated in terms of:

- Functional benefits (e.g., efficiency, automation, environmental performance);
- Strategic contributions to SC goals;
- Relevance and feasibility across the lifecycle phases.
- Provider and beneficiaries

Main Phase	Sub Phase	Process/Task	Added Value *	Technologies	Provider **	User
Land Development		Land Surveying	Enhance boundary and detailed topographic mapping with integrated spatial analysis	GIS, Drones	Municipal authorities (urban planners, surveyors)	Real estate developers, municipal authorities
		Zoning and Planning	Enhance analysis of zoning and land-use data and simulate various scenarios	GIS, BIM	Municipal authorities (urban planners)	Real estate developers, municipal authorities, investors
			Improve communication with zoning and permitting authorities	ICT	Municipal authorities, technology providers	Real estate developers, municipal authorities
		Site Preparation	Improve site conditions and constraints analysis	Big Data, GIS	Municipal authorities (urban planners, architects, surveyors)	Real estate developers, municipal authorities
			Coordinate and manage site preparation activities	ICT, GIS, BIM	Municipal authorities, construction managers	Real estate developers, municipal authorities
			Facilitate and enhance site clearing and grading	Drones, 3D Scanning, GIS	Construction managers, surveyors	Real estate developers, municipal authorities
		Infrastructure Development	Improve Infrastructure network management and planning	ICT, IoT, VR and AR, GIS	Municipal authorities (urban planners), technology providers	Real estate developers, municipal authorities, investors
			Coordinate infrastructure development activities	GIS, BIM	Municipal authorities, construction managers, technology providers	Real estate developers, municipal authorities
			Develop and create e-government infrastructure	ICT, Blockchain and Smart Contracts	Municipal authorities, technology providers	Real estate developers, investors, citizens
			Optimize municipal systems and provide geodata	ICT, GIS	Municipal authorities, technology providers	Real estate developers
			Improve essential data access and transparency	Big Data, ICT, Clouds, and SaaS	Municipal authorities, technology providers	Real estate developers, investors
		Environmental Impact Assessment	Provide a simulation of environmental impacts and help mitigate hazards	VR and AR, GIS, BIM, DT	Municipal authorities (environmental scientists, urban planners)	Real estate developers, municipal authorities, investors
		Community Impact Assessment	Increase participation	ICT, IoT	Municipal authorities	Real estate developers, investors, citizens
			Facilitate communication with the stakeholders	ICT	Municipal authorities (urban planners)	Real estate developers, municipal authorities, investors,

* These results are based on metadata analysis, highlighting the technologies that significantly achieve that added value. These technologies can contribute to other added values and have different abilities. The responsibility is not only for the highlighted stakeholders, but those are the key ones, and their significant role is in the scope of smart cities and smart real estate. This applies to Tables 3–6. ** The provider, the stakeholder responsible for activating these added values, can delegate the responsibility to an external expert to activate these added values highlighted between brackets. This applies to Tables 3–6.

Figure 7 *Screenshot of the technology utilization analysis*, (Al-Rimawi and Nadler, 2025)

4.2.3 Step 2.3 - Stakeholder Roles and Technology Utilization

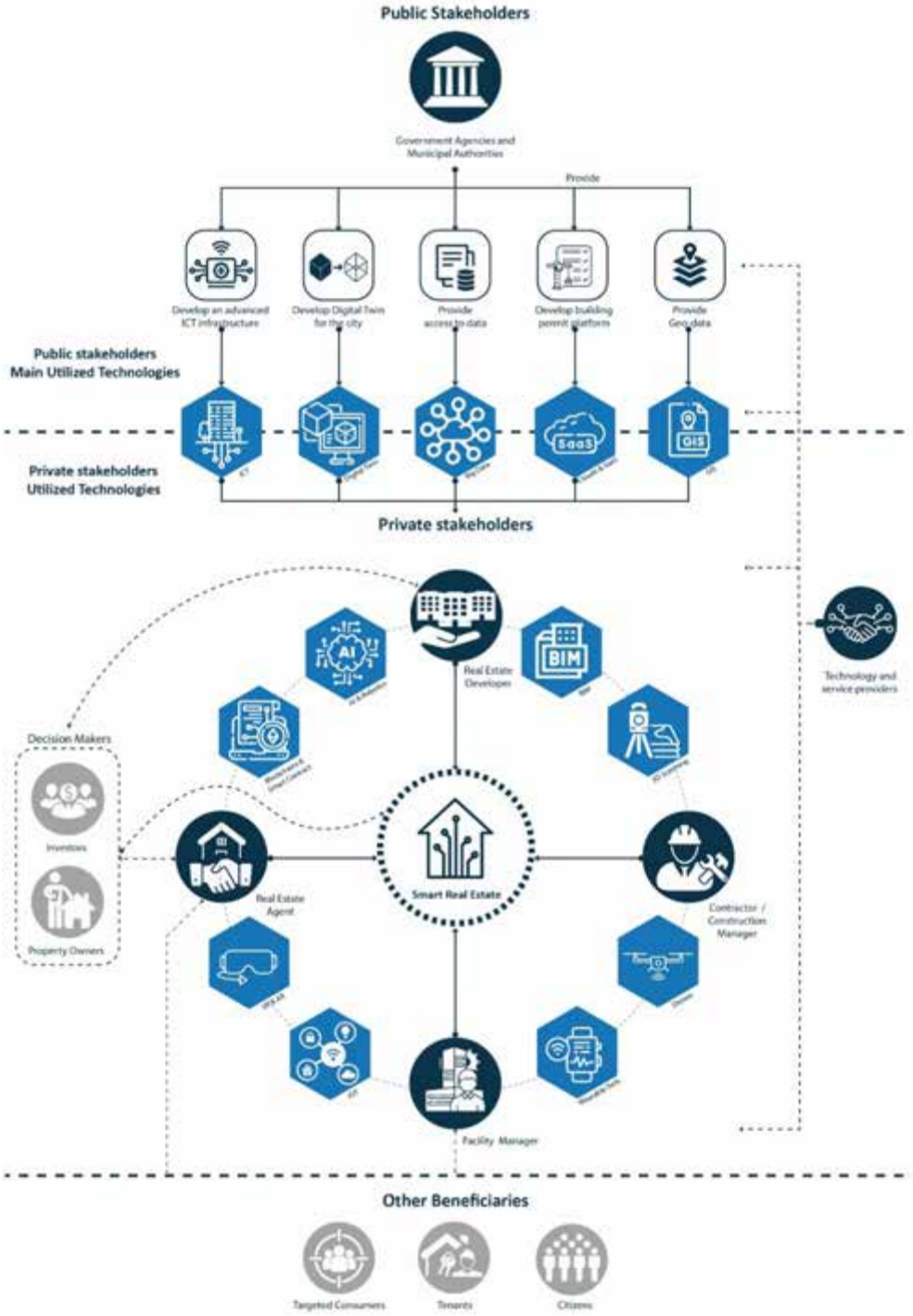

Figure 8 *Public and private stakeholders' relationships and their utilized technologies.* (Al-Rimawi and Nadler, 2025)

SC and SRE development relies on coordinated efforts between public and private stakeholders, each utilizing different technologies at various stages of the development cycle represented in Figure 8 (Al-Rimawi and Nadler, 2025).

Public stakeholders such as municipalities and government agencies—lay the foundation by upgrading digital infrastructure, deploying IoT networks, and creating centralized platforms for data integration. They invest in open geospatial and big data systems, enabling advanced analytics through AI. Technologies like GIS, ICT, and Big Data are commonly used, with a growing influence on AI adoption. Additionally, they support automation in permitting and planning through cloud-based tools and help build digital twins to support urban management. These actions directly enhance land development and early real estate phases, encouraging smarter private sector involvement.

Private stakeholders, including developers, contractors, agents, and facility managers, adopt a broader range of smart technologies. Developers use GIS, BIM, Big Data, and AI for acquisition, design, and planning. Contractors rely on BIM, AI, and wearable tech for safety, coordination, and resource optimization during construction. Agents leverage VR, AR, drones, and blockchain for immersive marketing and secure transactions. Facility managers use BIM, digital twins, AI, and IoT for real-time operations and predictive maintenance during occupancy and operation phases.

Together, both sectors drive smarter, more connected urban and real estate ecosystems by leveraging the right technologies at the right development stages.

4.3 Step 3 - Strategic Implementation and Action Planning

Now that gaps, strengths, and opportunities are identified through the evaluation and technology mapping, the attention should shift to implementing a strategic plan. This step involves:

4.3.1 Step 3.1 - Prioritizing Improvements

- Rank areas with the largest performance gaps or with indicators of high impact.
- Identify quick wins (e.g., tech already available but underutilized) vs. long-term investments.

4.3.2 Step 3.2 - Developing a Roadmap

- Outline short-, medium-, and long-term actions in consideration of stakeholder capacity and goals of the city/ real estate.
- Assign responsibilities among public and private actors.
- Define timelines, budgets, and measurable targets.

4.3.3 Step 3.3 - Integration and Collaboration Mechanisms

- Propose ways to **align public and private efforts**, such as:
  - Data-sharing protocols
  - Public-private partnerships (PPPs)
  - Joint investment strategies

4.3.4 Step 3.4 - Monitoring and Feedback Loops

- Establish mechanisms to **track progress** and update the framework as technologies evolve.
- Identify KPIs associated with each indicator to measure ongoing performance.

5. Discussion

The evaluation framework and technology utilization analysis presented in this study offer a structured approach to understanding the smartness of cities and real estate developments. This dual-tool methodology revealed significant insights into the performance status, technological gaps, and opportunities for enhancement across

both city-wide and project-level developments.

5.1 Smart Cities and Smart Real Estate Dependence
The evidence presented provides further support for the idea that smart cities and SRE are dependent on one another, one cannot advance fully without the other. Smart cities ultimately provide the foundation of policies and infrastructure whereas SRE projects can offer innovation and scale at the project level. The evaluation framework revealed that categories such as smart governance or smart people tend to lag in privately led projects whereas smart technologies and smart infrastructure are more developed for commercially driven real estate projects. This can mean that a greater emphasis on collaboration between public and private actors is ideally required to ensure appropriate development across all smartness pillars.

5.2 Technological Readiness and Strategic Timing
Differences in technology adoption were evident in the utilization analysis of the lifecycle. Technologies, such as GIS, BIM, IoT, and AI, are performing strongly in the cradle phases of conception, construction, and operation, respectively, and underperforming in transition sub-phases (e.g., vacancy, and demolition). These differences in readiness speak to the importance of strategic timing this includes not only knowing what technology you are going to use but also when and where you are going to utilize that technology relative to its value.

5.3 Stakeholder Roles and Gaps
The review found that public and private stakeholders both had instrumental roles to play. Public entities likely have the foundational enablers - high-speed communication, open data platforms, digital governance tools- while private stakeholders tend to more easily adopt new private innovation technologies (e.g., AR/VR, wearable tech, blockchain), especially around marketing and customer engagement.

However, these efforts remain fragmented without coordinated strategies/research. This reinforces the need for coordinated approaches, including integrated plans, joint data-sharing frameworks, and clear incentives for coordination between public and private stakeholders.

5.4 From Assessment to Action
The gap assessment in the evaluation framework is, diagnostic and directional in orientation. It shows where cities and projects exist today and where to act next (the next step). The next step should focus on:

- Customized action plans to develop high-impact indicators/outcomes.
- Cross-sector partnerships to leverage shared data and infrastructure.
- Capacity-building and awareness programs to ready stakeholders, specifically municipalities and smaller developers.

5.5 Limitations and Future Work
Although comprehensive, the framework is not a complete evaluation process. It has been reflective of the state of the literature and technologies available today, and updates will need to be conducted as urban challenges evolve and technologies emerge. Additionally, this study does not contain primary case studies and, therefore lacks empirical verification. Future work can utilize this methodology in specific urbanities to validate and improve the overall practical value of the evaluation framework.

It was also observed that certain technologies – e.g., Digital Twins, predictive tools with AI – yielded the most value during the utilization and maintenance phases, suggesting that investment priorities are shifting beyond construction whereby optimizing lifecycle use is the highest value proposition for these technologies.

6. Conclusion and Future Directions
This paper presented a dual-tool approach to support the assessment and development of smart cities (SC)

and smart real estate (SRE). The first tool a comprehensive evaluation framework was designed to measure the "smartness" of urban areas and real estate projects based on seven key categories and a set of weighted indicators. The second tool analyzed the added value of smart technologies across the real estate lifecycle, identifying when and where each technology could contribute to the real estate development cycle, as well as when and how each technology should fit in the real estate development life cycle (which stage, when, and where in the development cycle) order to maximize value-added performance.

Together, these tools provide a practical roadmap for municipalities, developers, investors, and policymakers. They enable informed decision-making by identifying performance gaps, prioritizing technology integration, and aligning stakeholder efforts. The results emphasize the interconnectedness of SC and SRE, showing that both public infrastructure and private development must advance in tandem to achieve holistic urban innovation.

While the paper does not conduct empirical case studies, it offers a structured methodology and insights that can guide future implementations and research. As technologies evolve and cities continue to grow, the framework is flexible and adaptive, capable of incorporating new indicators and innovations to remain relevant.

In conclusion, advancing smart cities and smart real estate requires strategic planning, coordinated efforts, and the intelligent use of technology. The tools developed in this study offer a foundation for such advancement—helping cities and developments transition from traditional models to smarter, more resilient, and more sustainable futures.

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LLM-enabled Ontology Alignment to Support Complex Decision-Making in the Built Environment

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Abstract
Cross-domain knowledge integration is crucial for complex urban and architectural decision-making, with ontology engineering playing a foundational role. To address limited automation and low interpretability in ontology alignment, this study proposes an LLM-powered agent framework to support ontology reuse across built environment domains. The performance of four LLMs and three prompt strategies is explored in alignment tasks. Three specialised agents, for context generation, expert validation, and explanation synthesis, are proposed and integrated with retrieval and mapping agents. Together they form a closed-loop framework linking automatic alignment, expert review, and explanatory feedback. This agent-enhanced architecture improves the traceability and interpretability of alignment results and facilitates expert involvement and iterative refinement, offering a solid foundation for managing and reusing ontologies in complex urban-scale contexts.

Keywords: Large Language Modelling (LLM), ontology alignment, knowledge integration, semantic interoperability

1 Introduction

Complex decision-making in the built environment increasingly relies on multi-source and heterogeneous data across domains (Li et al., 2022; Fadhel et al., 2024). Semantic data modelling has emerged as a key strategy to explicitly represent domain knowledge in a machine-interpretable and human-comprehensible format (Gruber, 1993; Alexopoulos, 2020). Among various representation techniques, ontologies—formalized schemas of domain entities and their relationships—serve as the backbone of semantic integration. Powered by Semantic Web technologies (Berners-Lee, Hendler and Lassila, 2001), ontologies enable structured knowledge from different systems to be unified, queried, and reasoned over, bridging disciplinary boundaries.

Extensive efforts have been made to develop ontologies that capture different layers of spatial, physical, and operational semantics across the built environment. These efforts span diverse areas including infrastructure systems (Nandini and Shahi, 2019; Du et al., 2023), smart city development (Qamar et al., 2019), healthy city planning (Pietra, De Lotto and Bahshwan, 2021), urban disaster response (Dutta and Sinha, 2023), building performance optimization (Utkucu and Sacks, 2025), facility operation and maintenance (F.H et al., 2025).

While numerous ontologies have emerged across domains, their independent and purpose-specific development has led to persistent semantic heterogeneity and limited interoperability. Ontology alignment remains a critical role in enabling scalable knowledge integration and system-level semantic reasoning, especially in large-scale built environment systems like integrated digital twins and urban energy platforms. Ontology alignment, or matching, is the first step toward resolving semantic heterogeneity by generating correspondences between entities such as concepts, properties, or instances (Shvaiko and Euzenat, 2013; Algeria et al., 2015). By comparison, ontology mapping denotes the structured expression of alignment results, often stored as external documents or internal annotations.

Ontology alignment in practice remains heavily dependent on manual efforts (Elshani et al., 2025). It often requires significant cross-domain expertise to interpret conceptual differences, resolve ambiguities, and validate alignment decisions—making the process both time-consuming and difficult to scale. Moreover, the lack of

systematic validation and explanation mechanisms undermines the reliability and reuse of alignment results. Despite its critical role, alignment is rarely treated as a first-class concern in ontology engineering workflows. Mappings are often missing, informal, or undocumented, especially in domain-specific ontologies developed for isolated use (Ma et al., 2024).

These issues severely restrict semantic interoperability across domains and impede the evolution of shared knowledge infrastructures in the built environment. Recent advances in LLMs have opened new possibilities for automation in various phases of ontology engineering (Li, Garijo and Poveda-Villalón, 2025). With their powerful capabilities in semantic understanding, contextual reasoning, and cross-domain generalization, LLMs have shown promising results in a range of ontology-related tasks, including ontology learning (Babaei Giglou, D'Souza and Auer, 2023) ontology generation (Doumanas et al., 2025), terminology annotation and entity completion (Norouzi et al., 2025), ontology evaluation (Tsaneva, Vasic and Sabou, 2024) , among others. However, their potential for application in ontology engineering of the built environment remains largely unexplored and unvalidated.

To address the persistent challenges of low automation, missing alignment modules and mappings and limited interpretability in ontology alignment, this study aims to explore the potential of LLMs to enhance ontology alignment processes in the built environment domain. Specifically, it explores how different LLM types and prompting strategies perform in alignment tasks. Furthermore, this study proposes a dedicated LLM-powered agent framework to improve the interpretability, traceability, and reusability of alignment process and results.

This study presents the first empirical exploration of using LLMs to support cross-domain ontology alignment in the built environment. It fills key gaps in existing frameworks by introducing verification and documentation capabilities, and pioneers a paradigm shift in ontology alignment—from mere result generation to semantic asset construction. Furthermore, it provides an agent-based toolchain that enables ontology experts to generate interpretable alignment comments and reusable documentation.

This paper is structured as follows. Section 2 reviews key challenges in built environment ontologies, the evolution of ontology alignment methods, the integration of LLMs for semantic modelling and alignment, and recent advances in LLM-enhanced documentation generation and interpretability. Section 3 presents a systematic evaluation of four representative LLMs and five prompting strategies across six ontology alignment datasets, highlighting their strengths and limitations under varying semantic complexities. Section 4 analyses the experimental results. Section 5 introduces an enhanced agent-based framework that integrates semantic context construction, human-in-the-loop validation and explanation generation. Section 6 summarizes key findings and outlines future directions for extending ontology alignment as a traceable and interpretable semantic infrastructure.

2. Related Work

2.1 Ontological Engineering Challenges and FAIR Bottlenecks in the Built Environment

Although a large number of urban and architectural ontologies have been proposed, their overall performance across the four dimensions of the FAIR principles, Findability, Accessibility, Interoperability, Reusability, which remains suboptimal. For instance, Mazimwe et al. (2021) evaluated 69 disaster management ontologies and identified significant deficiencies, particularly in interoperability and reusability. Specifically, the average FAIR score was only 19.54%, with 'findability' (or discoverability) scoring as low as 1.8%. Even urban ontologies constructed in recent years, such as city infrastructure ontologies (Du et al., 2023)the ground, roads, and buried pipes, Urban District Sustainability Assessment Ontology (Kuster, Hippolyte and Rezgui, 2020)factoring in environmental, social and economic requirements. However, the current assessment schemes are (a, and Smart City Services Ontology (Qamar et al., 2019)interconnected and intelligent. However, absence of a centralized system produces many

troubles for its stakeholders i.e. citizens and administration in order to perform their day-to-day actions. Semantic web technologies, and in particular linked open data is a tool which allows sharing and merging of data of different systems. Consequently, this paper aims to propose a Smart City Services Ontology (SCSO, generally lack standardized alignment documents and readable annotation structures. While it is widely acknowledged that publishing an ontology should be accompanied by detailed documentation of its concepts and relationships, to reduce the prevalent tendency of researchers to create new ontologies rather than reuse existing ones (Farghaly, Soman and Zhou, 2023), this best practice is rarely implemented in practice. In addition, the resulting mappings are often difficult to interpret, making it challenging for non-ontology experts to understand their semantic intent and the boundaries of their applicability (Mazimwe, Hammouda and Gidudu, 2021).

In recent years, several studies have explored automated and even semi-automated ontology alignment in the built environment (Schneider, 2019; Schlenger et al., 2025). However, no research to date has investigated the use of large language models (LLMs) for ontology alignment within the built environment.

2.2 Extending the Semantic Capabilities of LLMs in Built Environments

With the breakthrough of LLMs in natural language understanding and generation, increasing researchers are trying to introduce them into semantic modelling tasks in built environments. Feng et al. proposed the CityGPT framework, which significantly improves the LLM performance in spatial cognition, path planning, and instruction comprehension by constructing an urban task dataset and an evaluation benchmark (Feng et al., 2024). Li et al. (2025)operation and maintenance (O&M further mapped the mapping relationship between urban tasks and language modelling capabilities, pointing out that it has a high potential for interfacing with urban perception, prediction, and interactive reasoning.

In the context of building systems, Zhang et al (2025) constructed a chain of LLM-based energy simulation agents capable of directly transforming natural language descriptions into EnergyPlus model files. In addition, a control interpretation module incorporating the Shapley mechanism has been preliminarily validated to enhance the transparency of LLM in the field of semantic control of buildings (Zhang, Chen and Ford, 2024). The Shapley mechanism, originally developed in cooperative game theory, assigns credit to input features by quantifying their marginal contribution to a model's output—thus making the decision logic of black-box models more interpretable (Lundberg and Lee, 2017).

However, most of the above studies focus on mid-level tasks, such as information extraction, semantic questions and answers, or operation execution, and there is still a lack of in-depth exploration of semantic alignment at the structural level.

2.3 Evolution of Ontology Alignment Techniques and Trends in LLM Integration

Ontology alignment, as a key link to support ontology reuse, heterogeneous system integration and cross-domain semantic interoperability, has undergone three major stages in recent years. The first stage is represented by rule-based systems such as AML (Faria et al., 2013) and LogMap (Jiménez-Ruiz and Cuenca Grau, 2011), which mainly rely on manually set structural mapping rules with strong logical consistency but lack self-adaptation, which makes it difficult to apply to scenarios with variable contexts. The second stage introduces deep semantic embedding, such as BERTMap (He et al., 2022), which improves the alignment accuracy by word vector training, but requires large training sets and the generalisation ability is limited, which makes it difficult to cover the semantic migration between multiple domains. The third phase is the current key trend: generative alignment methods centred on LLMs. Such approaches achieve zero/few-shot alignment through prompt engineering, with low sample dependency, high generality, and strong semantic generalisation (Hertling and Paulheim, 2023).

Early studies on LLM-based ontology alignment primarily relied on prompt engineering to explore zero-shot and few-shot capabilities, often evaluated on benchmark datasets like Ontology Alignment Evaluation Initiative (OAEI) (Hertling and Paulheim, 2023; Norouzi, Mahdavinejad and Hitzler, 2023). These methods showed promise in terms of recall and generative flexibility, enabling the discovery of novel candidate alignments. However, they also revealed persistent limitations: low precision, unstable outputs, and poor structural consistency. Consequently, LLMs were often positioned as semi-automated tools requiring manual filtering by experts, rather than end-to-end alignment systems.

In addition, LLMs research has gradually shifted focus from early-stage prompt engineering to the development of more autonomous and modular LLM agents. As illustrated in Figure 1, the core of an LLM agent lies in its planning module, which enables the decomposition of complex tasks and iterative improvement through self-reflection. It leverages modular tools (e.g., domain-specific software) to perform both internal reasoning and external actions, and employs short-term and long-term memory to retain contextual knowledge and enhance decision-making (L. Zhang et al., 2025). In contrast to traditional prompt-based LLM usage, which is often inefficient, stateless, and hard to control when handling complex tasks such as ontology matching, Agent-OM exemplifies a paradigm shift: transforming LLMs from reactive generators into proactive decision-makers equipped with planning, memory, and tool-use capabilities. Qiang, Wang and Taylor (2025) introduced the Agent-OM framework, where LLM-based agents are equipped with planning, memory, and tool-use capabilities to modularly execute retrieval and matching workflows. The framework demonstrated competitive performance with state-of-the-art systems in simple tasks and outperformed most baselines in complex and few-shot ontology alignment scenarios, showing particular strengths in handling domain-specific and cross-domain alignment tasks. It slightly underperformed only against a few deep learning systems such as Matcha.

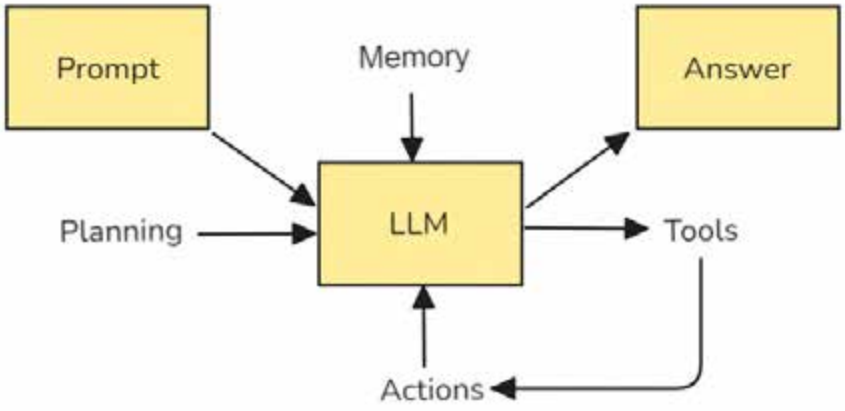

Figure 1. Architecture of an LLM-powered Agent with Prompt, Memory, and Tool Modules

Meanwhile, integration attempts between LLMs and traditional algorithms are also emerging. Taboada et al. (2025)but it remains challenging due to the need for large training datasets and limited vocabulary processing in machine learning approaches. Recently, methods based on Large Language Model (LLMs proposed the MILA framework, which incorporates a Prioritized Depth-First Search (PDFS) strategy to optimize LLM-driven ontology matching. This method significantly reduced the number of LLM queries required for complex alignment tasks. In multiple OAEI tracks, MILA outperformed existing unsupervised and some supervised systems without requiring fine-tuning. Sampels, Efeoglu, and Schimmler (2024) presented a hybrid approach that combines graph-based search algorithms (random walk and tree traversal) with prompt engineering. Their method extracts local

contextual information of candidate entities and verbalizes it into natural language prompts. This approach achieved an F1-score of 0.7147, outperforming zero-shot methods such as GPT and OLaLa, and highlighted the effectiveness of contextualization and verbalization in improving both precision and recall.

2.4 Documentation Generation and LLM-enhanced Interpretability

Recent advances in ontology engineering highlight a growing emphasis on human-readability and interpretability, particularly through documentation generation. While LLMs have demonstrated initial potential in generating ontology-related texts, this area remains underexplored. Only a few studies have addressed ontology publication via documentation generation (Li, Garijo and Poveda-Villalón, 2025). Existing work primarily focuses on generating Competency Questions (CQs) (Rebboud et al., 2024, 2025) and transforming ontology structures into user-facing documentation. In biomedical domains—often more mature than the built environment, researchers have developed specialized tools to enhance accessibility. For example, Giri et al. (2024)Gene Ontology (GO proposed GO2Sum, a model that converts complex lists of Gene Ontology (GO) terms into human-readable functional summaries, improving both usability and interpretability. Complementing this, Norouzi et al. (2023) introduced alignment explanation generation as a novel use of LLMs, enabling experts to provide feedback that informs model refinement through prompt tuning or few-shot updates. These approaches collectively point toward the future of ontology systems that are not only machine-readable but also meaningfully explainable to human users.

3. Performance Comparison of LLMs and Prompting Strategies in Ontology Matching

To explore the adaptability of existing LLM-powered ontology alignment in the context of architectural and urban ontologies, we designed two complementary experiments. Experiment 1 isolates the effect of model version by keeping the prompt fixed, examining whether newer or instruction-tuned models improve semantic alignment. Experiment 2 fixes the model and varies the prompt strategy, evaluating the influence of prompt design on alignment performance. The experimental protocol is presented in Table 1.

Table 1. Overview of Experimental Design

	Objective	Variable Tested
Experiment 1	Explore impact of different LLMs on ontology alignment tasks	Type of LLMs
Experiment 2	Explore impact of different prompt strategies on complex alignment tasks	Type of prompt strategies

Most existing experiments utilize large-sample OAEI datasets and primarily focus on exploring equivalence relationships between ontology entities. However, in real-world engineering applications, subclass and superclass relationships are more prevalent. Therefore, this experiment centres on non-equivalent inclusion relationships, covering the types summarized in Table 2. These relationship types are used to classify semantic mappings in ontology alignment tasks, especially when identifying non-equivalent inclusion relationships.

Table 2 Semantic Relationship Types Between Ontology Entities

Symbolic Form	Description
a ≡ b	a is equivalent to b
a ⊑ b	a is a subclass or subproperty of b

Symbolic Form	Description
a ⊒ b	b is a subclass or subproperty of a
a ⊥ b	a and b are unrelated or disjoint

Note: a refers to entity1, and b refers to entity2

3.1 The Selection of LLMs and Prompting Strategies

To systematically compare LLMs for ontology alignment, we selected four models based on two criteria: (1) demonstrated performance in recent studies on semantic alignment and reasoning, and (2) diversity across commercial and open-source paradigms. Prior work has evaluated models including GPT-3.5/4, LLaMA, BLOOMZ, FLAN-T5, and Falcon-7B (Hertling and Paulheim, 2023; Li, Garijo and Poveda-Villalón, 2025). Among these, the latest high-performing models from the GPT series have achieved state-of-the-art results in zero- and few-shot alignment tasks involving complex semantics (Macilenti, Stellato and Fiorelli, 2024; Qiang et al., 2025)Stellato and Fiorelli, 2024; Qiang {\\i{}et al.}, 2025. GPT-4.1—the most capable publicly available model in the GPT series during the study period—was selected for its semantic reasoning strength and reliable performance. Claude Sonnet 4, a commercial model from the Claude family, was selected for its balanced trade-off between semantic performance and response latency. LLaMA3.1–8B served as a widely adopted open-source baseline, while DeepSeek-R1 was chosen for its emerging benchmark strength and reasoning-oriented design. Table 3 summarizes all model configurations. The four models were evaluated under a unified prompt and task setup in Experiment 1.

Table 3. Test model version and base information

Model Name	Version	Type	Source / API Access
GPT-4.1	gpt-4.1-2025-04-14	Commercial	OpenAI
Claude Sonnet 4	claude-sonnet-4-20250514	Commercial	Anthropic
Deepseek	deepseek-ai/DeepSeek-R1	Open source	Siliconflow
llama3.1	llama3.1:8b	Open source	Local Deployment

In Experiment 2, we designed five prompt types with progressively increasing levels of contextual and semantic richness, as summarized in Table 4. This categorization was developed with reference to recent classification schemes in prompt engineering research (Macilenti, Stellato and Fiorelli, 2024; Amini et al., 2025; Dang et al., 2025), aiming to evaluate model behaviour under varying degrees of input complexity. Prompt 1 served as a minimal baseline, using only basic instructions to assess the model's default generalization ability. Prompt 2 introduced ontology-level background information, such as the ontology's name, domain, and intended purpose. Prompt 3 incorporated few-shot examples to provide more explicit behavioural guidance. Prompt 4 added syntactic and semantic attributes—including domain and range—to test the model's ability to leverage structured information. Finally, Prompt 5 further enriched the input by integrating lexical features extracted from the ontology's entity structure, namely the comment, definition, and example fields, to support fine-grained semantic reasoning and enhance robustness under potentially adversarial conditions.

Table 4. Overview of Prompt Types Used in Experiment 2

Prompt Type	Description
Prompt 1	Minimal instructions to test default generalization
Prompt 2	Adds ontology background (name, domain, purpose)
Prompt 3	Includes few-shot examples to guide model behaviour
Prompt 4	Combines syntactic cues (e.g., labels) with semantic attributes (e.g., domain, range)
Prompt 5	Further enriches input with lexical features (comment, definition, example) for fine-grained semantic understanding

3.2 Experiment Data

This study employs two types of cross-domain ontology alignment datasets: a series of author-curated alignment modules cantered on the Occupant Feedback Ontology (OFO) (Donkers, de Vries and Yang, 2024); and a set of alignment cases derived from Building Topology Ontology (BOT). The former refers to the alignments between the Occupant Feedback Ontology (OFO) and several external ontologies, including the Building Performance Ontology (BOP), Friend of a Friend Ontology (FOAF), Smart Appliances REFerence ontology for Wearables (SAREF4WEAR), Ontology for Property Management (OPM), and the Semantic Sensor Network Ontology (SOSA/SSN) (Donkers et al., 2021). The latter refers to the alignments between the Building Topology Ontology (BOT) and both the Industry Foundation Classes (IFC) and the Brick ontology.

To introduce varied levels of alignment difficulty, we selected entity pairs from the database where the source and target names are non-equivalent and grouped them into distinct subsets according to their semantic complexity.

Table 5 provides a comparative overview of all alignment datasets used in this study. Among them, OFO-BPO represents the most challenging set, especially due to its inclusion of abstract and dynamic concepts related to communication and sensing. Similar levels of complexity are observed in the OFO-SAREF4WEAR and OFO-SOSA/SSN subsets, which also involve cross-domain and behaviour-oriented semantics. BOT-BRICK and OFO-OPM are categorized as medium-difficulty datasets. These alignments remain largely within the architectural domain and do not exhibit substantial conceptual shifts across domains, though they still involve structural and functional abstraction. Finally, the BOT-IFC dataset is considered the easiest. In this set, many target entity names contain the source entity name as a substring (e.g., IfcBuildingStorey vs. Storey), without being strictly equal. These name-based cues make the alignment more straightforward compared to the others.

Table 5. Ontology Alignment Datasets Overview

Dataset	Classes	Properties	Example Pair
OFO-BOP	0	4	monitors Feedback ↔ performs Execution
OFO-SOSA/SSN	1	2	Wearable ↔ System
OFO-SAREF-4WEAR	2	2	Result ↔ Measurement
OFO-OPM	1	0	Result ↔ Property State

BOT-IFC	5	0	Space ↔ IfcSpace
BOT-BRICK	2	3	contains Zone ↔ has Part

Note: The numbers of Classes and Properties refer to aligned pairs

3.3 Experiment Procedure

The experiment consists of three main stages: (1) environment setup and configuration, (2) data preparation and gold-standard alignment generation, and (3) ontology matching execution. All experiments were conducted in an Anaconda virtual environment. Model variants and prompt strategies were specified via the configuration file, and necessary API keys (e.g., OpenAI) were securely initialized.

This study partially adopts the retrieval module and configuration setup from Agent-OM by Qiang et al. (2025), particularly for extracting syntactic, lexical, and semantic features. To address the high semantic heterogeneity across ontologies and the limited number of reference alignments, we implemented a full-retrieval strategy that exhaustively generates all possible candidate pairs and evaluates them individually to ensure comprehensive coverage. On top of this, we customized the prompt templates and extended the explanation module to support more interpretable and task-specific alignment outputs.

Each experiment run relied on three input files: the source ontology, the target ontology, and a reference alignment file. The ontologies were retrieved from publicly accessible repositories and provided in RDF/XML format. Reference alignments, originally authored by ontology developers, were standardized into Alignment API-compliant XML files and subsequently parsed to generate gold-standard alignment pairs, from which subclass and superproperty mappings were explicitly extracted. We began by applying a baseline prompt (Prompt 1) to evaluate the ontology alignment performance of four representative LLMs. Based on the results, GPT-4.1 demonstrated the most favourable trade-off among accuracy, efficiency, and cost, and was therefore selected for downstream experiments. Subsequently, we conducted a systematic evaluation of five distinct prompt types across six benchmark datasets, allowing for a fine-grained analysis of how prompt design impacts ontology matching performance.

4. Results

This section presents the results of two ontology alignment experiments and discusses the comparative performance of different LLMs and prompting strategies.

4.1 Performance Comparison of Different Models

Across all alignment tasks, GPT-4.1 consistently outperformed other models in terms of F1 score, demonstrating superior robustness in both semantic generalization and relation directionality detection. Claude exhibited comparable precision to GPT yet suffered from reduced recall in structurally divergent pairs such as OFO-OPM and OFO-SOSA. DeepSeek-R1, while capable of identifying general subclass relations, frequently hallucinated symmetric alignments, especially in BOT-IFC and OFO-SAREF4WEAR, where it confused $\sqsubseteq$ with $\equiv$. LLaMA, though lightweight, showed competitive recall in BOT-BRICK, but struggled in abstract property mappings across OFO-centric scenarios.

Notably, precision-recall trade-offs were observed across all models. For instance, Claude exhibited high precision on BOT-BRICK but missed multiple legitimate subclass mappings, leading to low recall. Conversely, DeepSeek's aggressive recall yielded inflated false positives, lowering precision. The OFO-BOP and OFO-OPM tasks proved most challenging, as they required semantic bridging across distinct conceptual layers, such as subjective feedback and operational control, which many models failed to capture reliably. These findings indicate that

current LLMs remain sensitive to ontology lexical divergence and relation asymmetry, and highlight the need for context-augmented, agent-based refinement to achieve consistent alignment performance in multi-domain ontology ecosystems.

4.2 Comparison of Prompting Strategies

To investigate how prompting strategies affect the performance of large language models in ontology alignment tasks, we compared GPT's outputs across six ontology pairs using three prompt types: Prompt 1, Prompt 2, and Prompt 3. Figure 2 illustrates that prompt formulation significantly influences alignment quality, especially in scenarios with structural complexity or abstract semantics. For relatively straightforward alignment tasks, Prompt 1 often led to high recall, retrieving a large number of candidate alignments. However, this came at the cost of reduced precision, particularly due to overgeneration of subsumption and equivalence relations. This trend is evident in ontology pairs such as BOT-IFC, where many predicted matches reflected broad semantic overlaps but lacked precise correspondence.

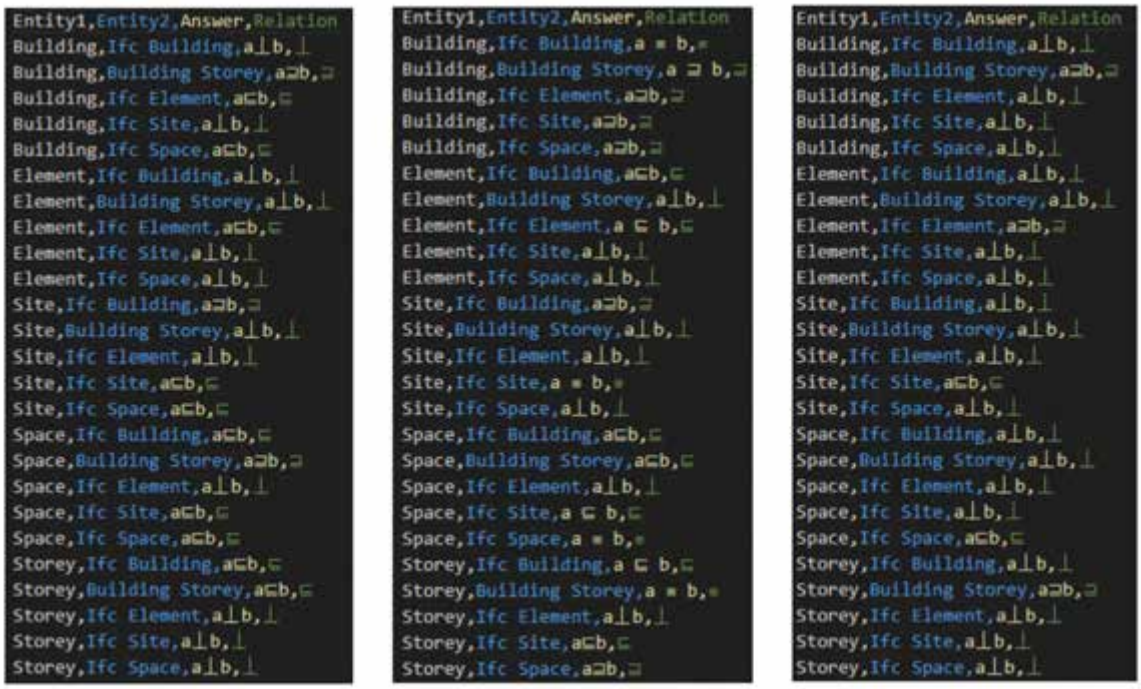

Figure 2. Alignment Outputs under Three Prompting Strategies (Prompt 1 → Prompt 2 → Prompt 3, from left to right)

In contrast, Few-shot prompting improved precision, especially for subclass and part-of relationships. This indicates that GPT was able to effectively learn from curated examples, producing more selective and accurate matches. Nonetheless, minor directional errors were observed in some subsumption cases, suggesting sensitivity to example framing. When Context-enhanced prompts were used, the output pattern resembled that of the Simple prompts: high recall with a large number of inferred equivalence and subsumption relationships. This suggests that while additional ontology context enriches the semantic field, it may also amplify GPT's tendency to generate broader relational assertions, potentially at the expense of specificity.

Overall, Few-shot prompting yielded better balance in precision-recall trade-off for structurally simple align-

ments, while Context-enhanced prompts were more effective in hierarchical or nested ontologies, such as BOT-BRICK and OFO-OPM, where semantic context is essential for interpreting complex relations. These findings highlight the nuanced effects of prompt design and support the inclusion of tailored prompting strategies in ontology alignment systems.

Prompt 1, Prompt 4, and Prompt 5 were compared to evaluate the impact of different types of semantic information on ontology alignment performance. Among them, Prompt 4, which integrates structural and contextual information (e.g., domain, range, hierarchical roles), consistently achieved the highest balanced F1-score, demonstrating its necessity for reliable prediction. In terms of prompt design, Prompt 4 significantly outperformed Prompt 5, particularly in alignment tasks of moderate difficulty within the built environment domain. While Prompt 5 introduces additional annotations and ontology-specific details (e.g., comments, URIs), this extra information occasionally misleads the model, causing it to infer inclusion or equivalence relationships even when entities are only loosely or indirectly related.

As illustrated in Figure 3, entity pairs such as contains Element and is Location Of were correctly judged as unrelated under Prompt 4. However, under Prompt 5, GPT tended to generate false positive relations, interpreting such pairs as semantically connected due to the presence of shared terms in the textual context. Moreover, in moderate alignment tasks, entity pairs often exhibit partial or ambiguous overlap, making it easy for the model to avoid predicting "unrelated." This behaviour inflates recall but comes at the cost of reduced precision, particularly when weak semantic signals are amplified by prompt structure.

Figure 3. Alignment Outputs under Three Prompting Strategies (Prompt 1 → Prompt 4 → Prompt 5, from left to right)

5. Discussions and extended framework for enhanced ontology alignment

5.1 Discussions

The adoption of agent-based design in ontology alignment is not merely beneficial but increasingly necessary. As the complexity of alignment tasks and the scale of ontological data continue to grow, agent architectures offer critical advantages—most notably in modularity, scalability, integration with external reasoning tools, contextual management, and expert-in-the-loop support.

The Agent-OM framework proposed by Qiang, Wang, and Taylor (2025) provides an important starting point by introducing LLM agents for retrieval and matching. However, it lacks a dedicated mechanism for generating alignment context, which limits its ability to capture precise domain semantics and background knowledge. In addition, the capabilities of large language models remain constrained, particularly when addressing abstract or structurally complex concepts. Despite ongoing efforts to enhance automation, human-in-the-loop verification remains indispensable, especially in cross-domain ontology alignment tasks within the built environment. Current approaches still lack robust mechanisms for error correction, result validation, and for ensuring interpretability and traceability throughout the alignment process. As Doumanas et al. (2024) emphasize, while LLMs can significantly accelerate ontology development, expert oversight remains essential to guarantee alignment quality, transparency, and reliability. Bridging this gap calls for standardized benchmarks and hybrid workflows that combine automated alignment with structured expert feedback (Li, Garijo and Poveda-Villalón, 2025).

Finally, although the original Agent-OM architecture supports multi-layer parsing and semantic-syntactic feature extraction, the direct feedback from LLMs tends to be verbose and lacks clarity. It does not generate concise, high-quality explanatory documentation necessary for human interpretation and downstream reuse. Our preliminary experiments using JSON-formatted outputs confirmed the difficulty of interpreting LLM errors in the absence of structured rationale. These findings highlight the need for enhanced tool integration for structured reasoning, tighter expert–LLM interaction loops, and more interpretable output formats.

5.2 An LLM-powered agent framework for enhanced ontology alignment

To address the above, we propose an LLM-powered agent framework for enhanced ontology alignment. The overall architecture and workflow are presented in Figure 4. Building on the architecture of Agent-OM, our extended framework integrates Retrieval and Matching Agents into a centralized planning loop and introduces three additional agents: the Context Agent, which constructs structured semantic context; the Expert Review Agent, which enables multi-level human validation for complex relations such as containment and subclassing; and the Explanation Agent, which generates interpretable alignment rationales and enhanced OWL/XML annotations.

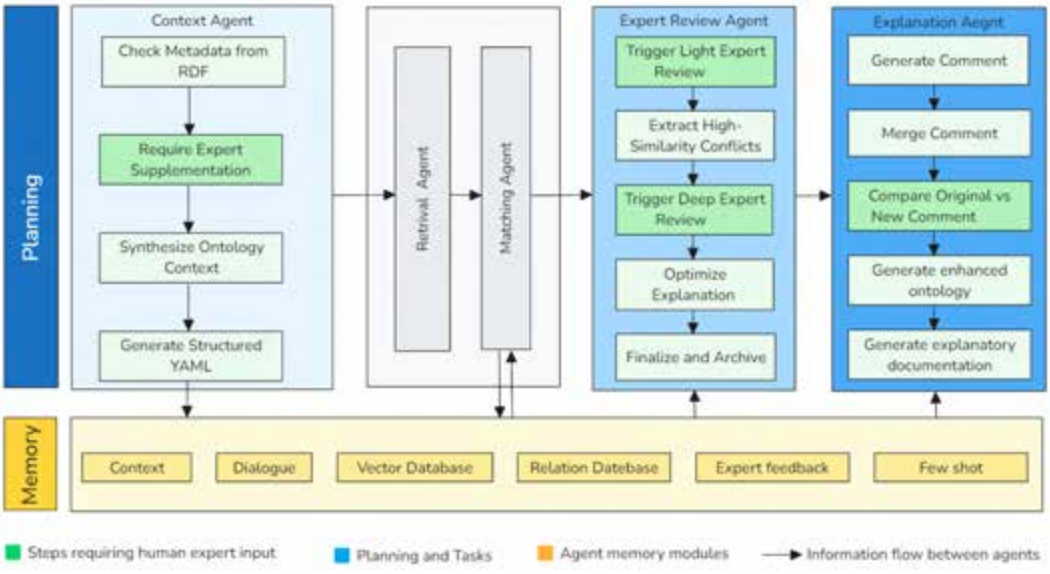

Figure 4. Explainable ontology alignment agent architecture

Note: The system consists of four agent modules: a Context Agent that synthesizes ontology background knowledge, a Retrieval Agent and Matching Agent for candidate generation, an Expert Review Agent for human-in-the-loop validation, and an Explanation Agent that produces revised comments and final documentation.

The Context Agent constructs a complete semantic context to support ontology alignment. It begins by extracting RDF metadata from the source ontology and, if necessary, performing supplementary web searches to enrich missing descriptions. When critical context fields are absent, expert-driven supplementation is triggered. Experts provide additional inputs, including the expected application domain of the target ontology, representative use cases for both ontologies, and the rationale for alignment—that is, why specific components of the source ontology should be aligned to parts of the target ontology. The resulting metadata is stored both in the central database and in the Context Agent's internal memory module, enabling reuse across future alignment sessions and improving contextual continuity.

The Expert Review Agent supports interactive human-in-the-loop validation, including not only equivalence but also complex structures such as containment and subclassing. It conducts both light and deep review stages: the light review focuses on quickly confirming high confidence matches and identifying potential misclassifications, while the deep review targets ambiguous or structurally complex entity pairs. Experts annotate each decision with structured justifications. These justifications are further refined by the LLM to ensure clarity, consistency, and future reusability. Finally, all verified results are archived for use by the Explanation Agent to generate comprehensive alignment rationales. Expert feedback is also stored as potential few-shot exemplars to guide future alignment tasks.

The Explanation Agent transforms validated alignment rationales into structured, human-readable documentation. It first processes the verified results from the Expert Review Agent to generate semantic alignment justifications, which are then merged with existing ontology comments. Experts may review and confirm whether the new comments should overwrite the originals. Finalized annotations are written back into the ontology, resulting in an enhanced OWL/XML version with improved interpretability and traceability. In parallel, the agent compiles an external explanation document, serving as both a human-readable rationale archive and a resource for ontology reuse and future alignment transparency.

5.3. Limitations and future work

Several limitations in the current study warrant further investigation. First, although multiple LLMs were evaluated, the analysis did not encompass some of the most recent models—such as Claude 4 and LLama 4—whose advanced architectures may offer advantages in particular alignment scenarios. Second, the evaluation datasets used in this study primarily basic containment relations. However, ontologies in the built environment often embody more complex semantic structures, including hierarchical constraints, compositional dependencies, and semantic overlaps. Expanding benchmark coverage to include such relation types is necessary to fully validate the utility of the experimental results. Third, additional algorithmic and empirical efforts are needed to determine optimal few-shot configurations and prompt engineering strategies that can improve LLM-based ontological reasoning. The interaction between prompt design, context granularity, and relation types remains insufficiently explored, yet is likely to significantly impact the robustness and generalizability of alignment performance across domains. Furthermore, based on the present framework, we are developing an LLM-powered agent system that operationalizes enhanced ontology alignment through modular planning, expert feedback integration, and explainable output generation.

6. Conclusion

This study investigates the potential of LLMs to support ontology alignment across built environment domains and proposes an agent-based enhancement to address observed limitations. We first conducted systematic experiments comparing four LLMs and five prompting strategies across ontology alignment tasks. The results show that GPT-4.1 achieves a favorable balance between performance and cost, and that prompting strategies significantly influence alignment quality depending on the semantic complexity and structural characteristics of ontology pairs. However, the experiments also reveal that relying solely on prompt engineering is insufficient—particularly for handling complex, ambiguous, or hierarchical relations. In response, we propose an enhanced LLM-powered agent framework that builds on the initial pipeline and introduces three additional agents: a Context Agent for semantic grounding, an Expert Review Agent for human-in-the-loop validation, and an Explanation Agent for generating interpretable alignment rationales. These enhancements improve the interpretability, traceability, and reusability of the alignment process and outputs. Rather than treating alignment as a static, one-time task, the proposed framework supports iterative expert involvement and positions ontology alignment as an evolving semantic asset in complex, multi-domain settings. Rather than treating alignment as a static, one-time task, the proposed framework supports iterative expert involvement and positions ontology alignment as an evolving semantic asset in complex, multi-domain settings.

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Track 12

DISASTER-RESILIENT PLANNING

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Floods and Livelihoods: A Multi-dimensional Comparative Study of Territorial Space Planning Policies for Flood Detention Areas in China

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Abstract
Spatial planning integrates policies to enhance people's well-being globally, yet its effectiveness is constrained in China's flood detention areas (FDAs) balancing flood control and development. Vertically, policy priorities, synergies, and coherence deviate across planning levels. Horizontally, jurisdictional overlaps exist with other management systems. This study employs a comparative approach in China's Huaihe River Basin, analyzing territorial spatial plans across provincial, municipal, and county levels covering nine key FDAs, alongside multi-tiered construction management policies. In-depth fieldwork including resident interviews was conducted in one area. We scrutinize interactions between flood management and spatial planning systems, revealing policy framework characteristics and goal orientation similarities/differences. The research provides insights for optimizing spatial planning and improving well-being in these critical zones.

Keywords: Flood detention areas; Territorial spatial planning; Policy comparison; livelihood

1 Background

1.1 Flood detention areas in China

China's Flood Detention Areas (FDAs) are specialized low-lying zones within river basins designed to mitigate flood losses and redistribute floodwater temporospatial patterns (Yu et al., 2022). They serve dual roles in flood storage and residential livelihood. China's seven major river basins host 98 FDAs (National Revised Directory, 2010). Pre-2000, FDA management was fragmented, with inadequate flood-control infrastructure, emergency response, and post-disaster compensation. Since 2000, integrated policies on flood engineering, population control, and economic compensation have been implemented.

Nevertheless, FDA development faces persistent challenges, notably in the **Huaihe River Basin**. Constrained by frequent flooding and environmental limits, it is a "double-depression" in geographic and socioeconomic terms (Wang, 2018), exhibiting the highest economic/population density yet the lowest urbanization level among China's major basins (Song, 2023). Human-flood land competition is acute. Rural hollowing intensifies yearly, exacerbated by weak transport, substandard infrastructure, and low resource efficiency. These issues accelerate village hollowing, degrade public space resilience, and amplify social vulnerability through population loss. Targeted research and interventions for livelihood security in Huaihe's FDAs are urgently needed.

Spatial planning is a technical and policy instrument for coordinating spatial development and integrating objectives (Xu et al., 2017), functioning as a political governance process (Qian & Luo, 2011) and a mediator of human-environment relations (Zhao et al., 2024). China's spatial planning system, reformed through integrating multiple plans (e.g., land use, urban-rural), now adopts a "five-tier vertical structure (national to township) and three-category horizontal framework (master/specialized/detailed plans)" for territorial spatial planning (Li et al., 2025). This system coordinates socio-economic activities, ecological supervision, and cross-regional infrastructure.

Nevertheless, implementation challenges persist in vertical policy transmission and horizontal coordination, including fragmented departmental oversight, disconnected regulatory tools, and unaligned land-use control procedures (Li et al., 2025). FDAs in the Huaihe River Basin epitomize these issues. As critical flood regulation zones subject to dual planning systems (flood control and spatial planning) (Dong et al., 2016), FDAs bear dual mandates of disaster prevention and regional development, necessitating focused assessment of their planning objectives and outcomes.

1.3 Research focus

Existing studies on China's FDAs predominantly adopt engineering perspectives—covering hydraulic infrastructure, disaster compensation, resident relocation (Bi & Pan, 2024; Wang et al., 2020), land use patterns, social networks, and resilience assessments (Zhang, 2021; Du, 2023)—yet lack systematic analysis of territorial spatial planning. This study fills this gap through a comparative approach: vertically examining FDA management systems, and horizontally comparing multi-level spatial plans across 9 key FDAs in the Huaihe River Basin. The research analyzes similarities and differences in planning priorities, spatial structures, and policy instruments, integrating qualitative policy assessment with quantitative metrics. An in-depth case study of Mengwa FDA—the basin's primary flood buffer—evaluates policy implementation outcomes and resident interactions. Findings inform spatial planning optimizations for people's well-being in FDAs.

The study comprises four sections:

1) Vertical Analysis of the FDAs management system;
2) Horizontal Comparative Analysis of provincial, municipal, and county-level spatial plans for key FDAs;
3) In-depth Case Study of the Mengwa FDA integrating fieldwork findings;
4) Synthesis of Challenges in current management frameworks and proposed optimization strategies.

2.Research Methods

Data were sourced from official portals at multiple governmental levels, including policy documents, technical standards, spatial planning reports, and implementation records. Supplementary data came from interviews with water-resource officials and FDAs residents, focusing on policy implementation dynamics.

The policy analysis employed a comparative framework:

1)Vertically: Examining policy transmission characteristics across administrative tiers;
2)Horizontally: Contrasting goal alignment, priority focus, and content coherence among peer-level policies.

A two-day field campaign in the Mengwa FDA involved structured workshops and semi-structured interviews with local officials and 30 residents. Interview protocols and questionnaires were designed a priori, with follow-up interviews conducted for data triangulation and depth validation.

3. Institutional Framework for FDAs in China

China's FDAs cluster in low-lying plains of seven major river basins. Their management follows a three-tier vertical hierarchy: national - basin/provincial - municipal/county levels, operating through government-led, ministry-coordinated, multi-agency collaboration. Flood control infrastructure is planned, constructed, and managed via categorized, zoned, and tiered approaches under legal statutes and specialized planning instruments (Figure 1).

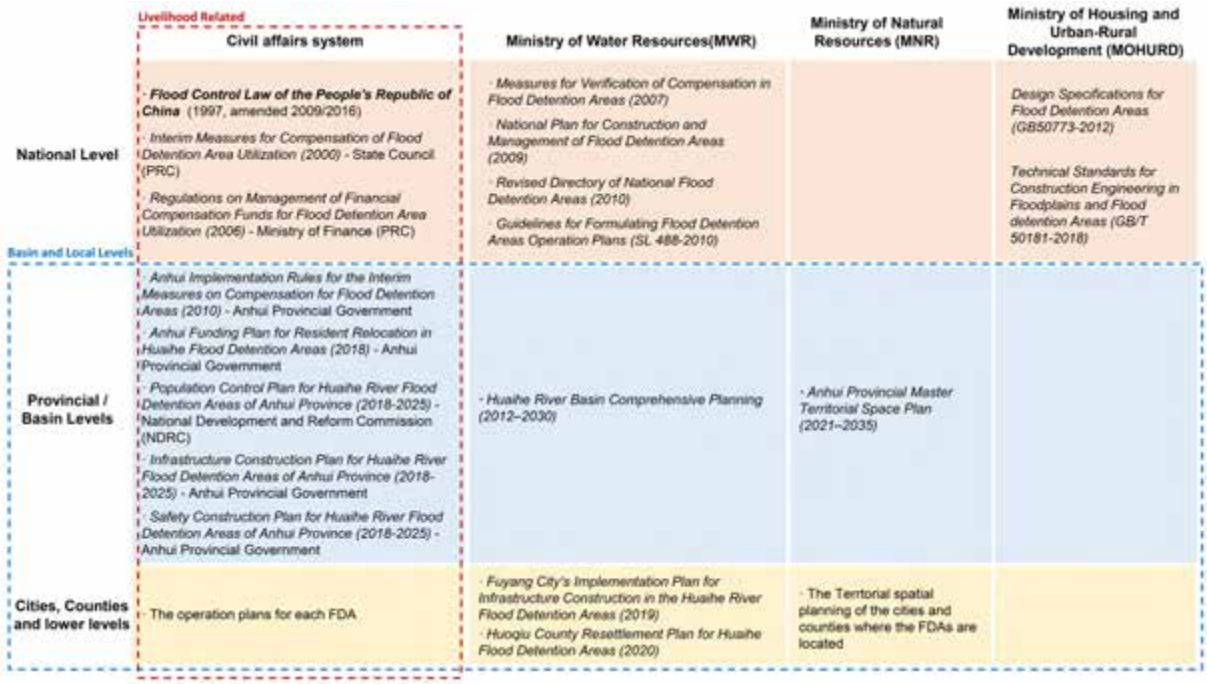

Fig.1 Institutional framework for FDAs in China (Anhui section of the Huaihe River Basin)

3.1 National Policy Framework by Agencies

3.1.1 Supreme Legislation

The Flood Control Law of the People's Republic of China (1997, amended 2009/2016) establishes a three-tier flood planning system (major river basins/other basins or regions/urban flood control), mandating safety infrastructure planning, population growth control, and organized resettlement in FDAs.

3.1.2 Ministry of Water Resources (MWR)

1) National Plan for Construction and Management of Flood Detention Areas (2009): Synthesizes basin-level and provincial plans, with thematic studies on safety construction models, economic development frameworks, and management systems; systematically evaluates flood risk objectives.
2) Guidelines for Formulating Flood Detention Area Operation Plans (SL 488-2010): Specifies requirements for organizational safeguards, early-warning systems, evacuation protocols, and engineering operations.
3) Measures for Verification of Compensation in Flood Detention Areas (2007): Audits compensation procedure compliance, loss data authenticity, and compensation standard rationality.
4) Revised Directory of National Flood Detention Areas (2010): Designates 98 FDAs based on flood risk assessment.

3.1.3 State Council & Ministry of Finance (MOF)

1) State Council: Interim Measures for Compensation of Flood Detention Area Utilization (2000): Defines compensation recipients, scope, and criteria; announces first 97 national Flood Detention Areas.
2) MOF: Regulations on Management of Financial Compensation Funds for Flood Detention Area Utilization (2006): Standardizes fund usage targets, coverage, criteria, and application/approval procedures.

3.1.4 Ministry of Housing and Urban-Rural Development (MOHURD)

1) Design Code for Flood Detention Areas (GB 50773-2012): Requires flood-control works to comply with integrated basin planning and flood control plans, with designs categorized by FDA types and risk levels.

2) Technical Standard for Buildings in Floodplains and Flood Detention Areas (GB/T 50181-2018): Regulates technical requirements for foundations, masonry structures, and reinforced concrete frame buildings.

3.2 Provincial Policy Framework (Anhui Section of the Huaihe River Basin)

3.2.1 Ministry of Water Resources

Huaihe River Basin Comprehensive Planning (2012–2030): Coordinates flood regulation, development governance, and environmental protection to guide construction and management of basin-scale flood control projects.

3.2.2 Civil affairs system

1) Anhui Implementation Rules for the Interim Measures on Compensation for Flood Detention Areas (2010): Issued by Anhui Provincial Government, refines compliance audits, loss verification, and fund supervision procedures for compensation disbursement.
2) Anhui Funding Plan for Resident Relocation in Huaihe Flood Detention Areas (2018): Issued by Anhui Provincial Government, establishes diversified funding mechanisms and implementation pathways for resettlement initiatives.
3) Population Control Plan for Huaihe River Flood Detention Areas of Anhui Province (2018-2025): Issued by National Development and Reform Commission (NDRC), implements population management, resettlement programs, diversified relocation, and supporting infrastructure in 16 designated FDAs along the Huaihe River.
4) Infrastructure Construction Plan for Huaihe River Flood Detention Areas of Anhui Province (2018-2025): Issued by Anhui Provincial Government, standardizes construction tasks, technical criteria, funding allocation, and implementation responsibilities for transportation, power grids, potable water, and telecommunications systems.
5) Safety Construction Plan for Huaihe River Flood Detention Areas of Anhui Province (2018-2025): Issued by Anhui Provincial Government, specifies technical requirements for resident relocation, flood-resistant shelter construction, relocation subsidies, and operational modifications of detention basins.

3.2.3 Provincial Department of Natural Resources

Anhui Provincial Territorial Space Master Plan (2021–2035): Mandates spatial control measures for FDAs within urban-rural coordination frameworks, emphasizing disaster resilience and ecological conservation.

3.3 Local Implementation

Operational plans for FDAs are developed by city/county water resources departments with multi-level government input. Natural resources bureaus formulate territorial spatial plans for localized land-use control. Selected governments enact resettlement plans, e.g.: Fuyang City's Implementation Plan for Infrastructure Construction in the Huaihe River Flood Detention Areas (2019), Huoqiu County Resettlement Plan for Huaihe FDAs (2020), specifying relocation principles, scope, and compensation.

3.4 Systemic Challenges in Flood Detention Governance

China's flood management centers on the Flood Control Law of the People's Republic of China, with national policies coordinating standards and compensation. Local implementations exhibit critical gaps:

1) Regulatory Hierarchy Deficits
The Flood Control Law establishes statutory principles for area operation and safety.
Supplementary regulations (e.g., Interim Measures) lack binding force (Wang et al., 2022).
Poor articulation between basin and spatial plans persists.
2) Fragmented Management Conflicts
Divergent departmental objectives lead to Interest conflicts; Cross-sectoral/regional complexities lead to Coordination failures; Disparate low relocation standards across basins (Table 1).

Table 1 Management Responsibilities and Departments

Management Responsibility	Responsible Authority
Engineering Planning	Basin Agencies + Water Administrators
Flood Operation & Safety Plans	Flood Control Headquarters + Governments
Socioeconomic Management	Local Governments
Spatial Planning	Natural Resources Bureaus + Local Governments

4. Comparative Study of Territorial Spatial Planning

The Huaihe River Basin's 9 critical FDAs are all located in Anhui Province (selected from its 16 total basins), spanning 5 cities and 9 counties (Figure 2 and Figure 3). Divergent planning objectives and priorities emerge from geographical, resource, and disaster exposure variations. This study conducts a comparative analysis of municipal/county plans (Table 2), examining key aspects including livelihood security, disaster resilience, "Three Zones and Three Lines," and agricultural/ecological layouts to identify systemic challenges in spatial planning frameworks and propose targeted optimization strategies.

Fig.2 The 9 key FDAs in the Huaihe River Basin within Anhui Province

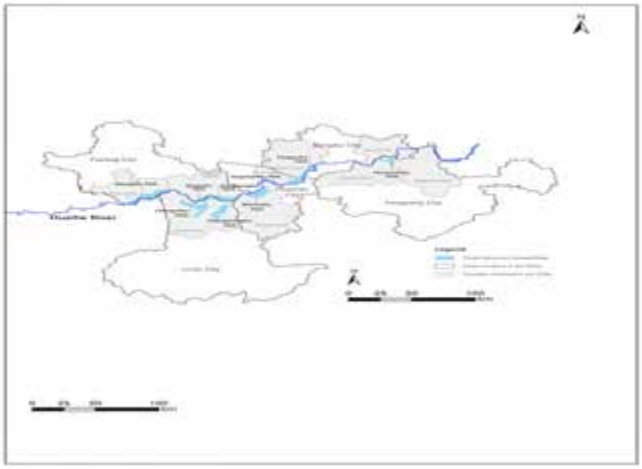

Fig.3 The 5 cities and 9 counties covered by 9 key FDAs

Table 2 Cities and Counties with FDAs and Their Spatial Planning

Crucial Flood Detention Areas	Related City-County	Municipal Spatial Planning	County-level Spatial Planning
Mengwa FDA	Fuyang-Funan	Fuyang Master Territorial Space Plan (2021-2035)	Funan Master Territorial Space Plan (2021-2035)
Qiujiahu FDA & Jiangtanghu FDA	Fuyang-Yingshang		Yingshang Master Territorial Space Plan (2021-2035)
Lu'an-Huoqiu	Lu'an Master Territorial Space Plan (2021-2035)	Huoqiu Master Territorial Space Plan (2021-2035)	
Chengxihu FDA	Lu'an-Huoqiu		
Chengdonghu FDA			
Shouxiihu FDA	Huainan-Shouxian	Huainan Master Territorial Space Plan (2021-2035)	Huaiyuan Master Territorial Space Plan (2021-2035)
Tangyuhu FDA	Huainan-Panji		Panji Master Territorial Space Plan (2021-2035)
Bengbu-Huaiyuan	Bengbu Master Territorial Space Plan (2021-2035)	Huaiyuan Master Territorial Space Plan (2021-2035)	
Jingshanhu FDA	Bengbu-Huaiyuan		
Huayuanhu FDA	Bengbu-Wuhe		Wuhe Master Territorial Space Plan (2021-2035)
Chuzhou-Fengyang	Chuzhou Master Territorial Space Plan (2021-2035)	Fengyang Master Territorial Space Plan (2021-2035)	
Chuzhou-Mingguang		Mingguang Master Territorial Space Plan (2021-2035)	

4.1 Provincial Spatial Planning

1) Three Zones and Three Lines: "Three Zones" refer to Agricultural Space, Ecological Space and Urban Space; "Three Lines" refer to Permanent Basic Farmland Protection Line, Ecological Conservation Red Lines and Urban Development Boundaries. Delineate flood risk control zones incorporating FDAs and riparian lands;

2) Ecological Restoration: Designate Huaihe River ecological recovery zones (Fuyang, Huainan, Bengbu, Chuzhou, Lu'an), enforce riparian flood-control standards, phase out development threatening flood safety, and enhance flood regulation;
3) Settlement Relocation: Relocate high-risk villages;
4) Infrastructure: Expand water storage capacity through basin adjustments, resident relocation, and channel dredging;
5) Regional Coordination: Implement integrated governance aligned with rural revitalization;
6) Heritage Conservation: Strictly protect hydraulic engineering heritage sites.

4.2 Comparative Analysis of Municipal Planning

Municipal planning, as the operational implementation of provincial-level strategies, serves as the foundational basis for county and township-level spatial planning and development activities. The comparative analysis reveals systematic deployment across five dimensions: "Three Zones and Three Lines" spatial patterns, ecological function optimization, agricultural development, infrastructure improvement, and regional coordination.

4.2.1 Three Zones and Three Lines Spatial Layout

Uniform designation of flood risk control lines with strict restrictions on non-flood control construction. Fuyang

and Chuzhou adopt zonal control mechanisms to prohibit irrelevant development, implementing a dual-track approach (dike reinforcement + wetland restoration).

Fuyang and Lu'an emphasize integrated population resettlement and spatial layout optimization, while Huainan innovatively proposes proactive avoidance of high-risk zones in urban development boundaries, reflecting resilience-oriented spatial governance.

4.2.2 Ecological Restoration and Governance
Watershed-based ecological restoration focuses on rehabilitating Huai River wetland systems. Bengbu establishes an "Ecological and Healthy Water Network System," enabling integrated governance of flood storage areas with river-lake-wetland complexes.

Huainan innovates by converting coal mining subsidence areas into flood regulation reservoirs, creating a "subsidence remediation-space expansion" composite model; Fuyang develops watershed-partitioned restoration units to refine systematic governance frameworks.

4.2.3 Disaster Prevention and Infrastructure Support
Standardized flood control and drainage systems are implemented, with Fuyang and Lu'an prioritizing urban-rural resilience through Baizhuangwei construction. Huainan explores integration of mining subsidence remediation with disaster prevention systems.

Bengbu establishes specialized heritage site protection mechanisms, balancing cultural conservation with flood control demands.

4.2.4 Regional Coordination
Optimization of upstream-downstream flood control systems in the Huai River Basin is universally adopted. Fuyang and Huainan construct cross-regional disaster prevention networks to enhance emergency response capabilities; Bengbu and Chuzhou integrate with the Yangtze River Delta urban agglomeration, advancing transportation and economic synergy.

Lu'an innovates inter-regional population resettlement and ecological land ratio optimization mechanisms, offering institutional innovation for regional coordinated development.

4.2.5 Short Summary of Municipal Planning
Municipalities align on flood risk management and ecological restoration objectives, adopting a watershed-based governance framework with rigorous risk zoning to reinforce dual "flood regulation + ecology" functions and promote regional coordination. However, divergent resource endowments and spatial strategies lead to differentiated approaches:

1) Functional Orientation:
Fuyang: Prioritizes flood storage integrity and emergency coordination.
Huainan/Lu'an: Integrates mining remediation with basin-scale ecological coordination.
Bengbu: Balances flood protection with heritage conservation.
Chuzhou: Aligns with Yangtze River Delta eco-economic integration.
2) Utilization Models:
Bengbu/Chuzhou: Focus on wetland restoration and biodiversity enhancement.
Fuyang/Huainan: Expand depression management and multifunctional flood regulation space.
Lu'an: Optimize population resettlement through territorial spatial planning.
3) Regional Coordination:
High-risk dense areas (Fuyang/Lu'an/Huainan): Establish cross-regional flood control networks.

Yangtze River Delta-linked areas (Bengbu/Chuzhou): Promote Huaihe River ecological corridor integration with regional development.

4.3 County-level Spatial Planning

County-level planning refines provincial/municipal territorial spatial strategies, focusing on "Three Zones and Three Lines" patterns, ecological protection, agriculture, infrastructure, and regional coordination in flood storage zones, with most plans emphasizing safety resilience. Panji District, integrated into Huainan City after administrative reorganization, follows municipal planning; Fengyang and Mingguang jointly cover the Huayuanhu FDA, where draft plans remain incomplete and strategies are consolidated at the municipal level.

4.3.1 Three Zones and Three Lines Spatial Layout

Counties integrate along-Huaihe FDAs, rivers, and lowlands into flood control lines under the "Three Zones and Three Lines" framework, enforcing strict regulations and optimizing flood prevention. Upper-middle reaches (Funan, Yingshang, Huoqiu) apply rigid constraints due to high pressure; middle-lower reaches (Shouxian County, Huaiyuan, Wuhu) prioritize ecological restoration with flood engineering.

4.3.2 Ecological Restoration and Governance

Ecological restoration focuses on key areas: Funan's Wangjiaba Wetland, Huoqiu's Chengdonghu / Chengxihu, and Wuhu's Huayuan Lake. Yingshang targets dynamic water balance ("inflow, flow, outflow"); Shou County divides ecosystems into "flood regulation and biodiversity zones"; Huoqiu balances ecology with tourism.

4.3.3 Agriculture Development

Agriculture emphasizes farmland protection: Funan values ecological functions, Huoqiu (grain base) addresses disaster risks, and Wuhu consolidates rural settlements for urban resource concentration.

4.3.4 Disaster Prevention and Infrastructure Support

Disaster resilience includes Funan's Mengwa drainage and irrigation, Yingshang's emergency command centers, Shou County's "sponge city," and Wuhu's integrated water transport-flood engineering.

4.3.5 Regional Coordination

Regional coordination involves Funan/Yingshang in spatial collaboration and Wuhu in Huaihe River eco-economic integration and rural revitalization.

4.3.6 Short Summary of County-level Planning

Counties adopt watershed-based flood-ecology integration, delineate flood risk control lines, and emphasize synergy between flood regulation and ecological restoration. Divergences arise from geographical positions and resource endowments:

1) Functional Priorities:
High-pressure areas (Funan, Yingshang, Huoqiu) focus on infrastructure and disaster resilience, supporting flood storage zone restoration and regional coordination; low-risk areas (Shou County, Huaiyuan, Wuhu) leverage resources for development.
Specific strategies: Funan enhances safety resilience, Huoqiu balances flood control and grain security, Shou County integrates flood prevention with tourism, Wuhu adjusts population/resource layouts.
2) Utilization Models:
Ecology-led (Yingshang, Shou County, Wuhu): Link FDAs with ecological functions via natural/historical resources;
Agriculture-composite (Funan, Huoqiu, Huaiyuan): Balance farmland protection with agricultural expansion.
3) Industrial Integration:
Huoqiu and Yingshang propose "mine remediation + flood regulation + ecological restoration" synergies.

4) Driving Factors:
Topography, resources, and spatial contexts shape strategies, reflecting "pressure-driven" and "resource-oriented" dual logics.

5. Critical Issues in Spatial Planning Systems

5.1 Deficiencies in Vertical Coordination

Provincial plans macroscopically coordinate regional positioning, standards, and resource allocation; municipal plans mesoscopically decompose watershed and FDA functions; county plans microscopically implement engineering solutions. However, three-tier planning faces coordination failures:

1) Insufficient vertical linkage: Cross-regional FDAs lack management division/compensation mechanisms with unstandardized emergency support;
2) Weak horizontal synergy: Provincial ecological restoration zones misalign with local endowments (e.g., no specialized plans for coal mining area restoration in Huainan City and Lu'an City);
3) Functional conflicts: Mengwa FDA simultaneously pursues flood storage and agricultural expansion, while Huoqiu County's grain production base contradicts flood control functions;
4) Priority ambiguity: Unclear hierarchy among ecological restoration, cultural preservation, and flood control.

5.2 Failure of Horizontal Coordination

1) Jurisdictional overlaps: Water authorities lead personnel transfers, but multi-agency responsibility boundaries remain blurred;
2) Data standard conflicts: Temporal gaps between spatial planning (2021–2035) and watershed plans (2018–2025) cause classification inconsistencies;
3) Implementation deviations: Potential policy conflicts during overlapping plan periods (2021–2025).

5.3 Conflicts in Development Goals and Functional Positioning

1) Goal-Implementation Gap:
While current municipal/county plans promote watershed eco-economic integration and safety resilience (e.g., coordinating Huaihe Ecological Economic Belt development, cross-basin water quality protection), critical deviations exist:
FDAs are still treated as monolithic risk sources (e.g., strict construction restrictions within "Three Zones and Three Lines"); Absence of livelihood-oriented policies for public service facilities and agricultural development;Inadequate support mechanisms for underdeveloped areas (e.g., homogenized facility standards in FDAs).
2) Hierarchical Misalignment:
Identical requirements are categorized differently across plans:
Fuyang City, Funan County, Yingshang County, Wuhe County classify flood risk control lines under "Three Zones and Three Lines"; Lu'an City, Huainan City, Huoqiu County, Shou County, Huaiyuan County categorize them as "basic support systems"; Wuhe County integrates rural settlement consolidation into agricultural planning.
3) Divergent Regional Coordination Priorities:
High-disaster areas (e.g., Funan County) emphasize inter-city disaster emergency coordination; Ecologically sensitive zones (e.g., Shou County, Yingshang County) prioritize ecological governance and flood regulation along the Huaihe, reflecting diverse governance needs.

6. Empirical Study of Mengwa FDAs, Huaihe River Basin

As the primary FDAs in the Huaihe Basin (180.4 km²), Mengwa exhibits chronic flood exposure due to topographical depression and high population density. Its operational protocol consists of three phases: 1) Gate opening for flood storage, 2) Months-long water retention, 3) Controlled discharge upon downstream water level reces-

sion. The registered population (2022: 184,900) is concentrated within 131 Zhuangtai (earthen platforms) and 6 Baozhuangwei (embanked settlements), with agricultural predominance. There 2 key questions:

1) Flood impacts: Complete inundation of low-lying farmlands/roads restricts transportation to dam-bridge networks.
2) Livelihood challenges: Structured interviews with 30 residents and governmental stakeholders identified critical gaps in resettlement compensation, employment, and public service delivery.

6.1 Demographic Structural Imbalance

Stringent migration policies promote out-migration while restricting return, with compensation via land exchange and housing support. Spatial planning data reveal:
1) Resident-to-registered population ratio <70% in Funan County (2020),
2) 12 townships exhibiting >40% hollowing rate,
3) 47% of surveyed residents aged ≥60 years, indicating accelerated aging.

6.2 Compensation Mechanism Failure

1) Housing disparity persists:
1960s/1980s resettlement housing remains overcrowded and structurally deficient. New housing projects, co-funded by residents and government based on registered/resident population quotas, achieve merely 28% occupancy (<30% adoption rate despite 62.3% relocation intent). And compensation standards fall significantly below Yellow River floodplain benchmarks.
2) Post-flood recovery deficit:
34.5% of households require structural reinforcement and 27.6% need interior rehabilitation, yet compensation prioritizes agricultural losses.

6.3 Employment-Agriculture Dilemma

1) Limited industrial absorption:
Labor-intensive factories (e.g., Hongliang Bag Factory in Wangjiaba Township: 160 jobs) provide marginal employment.
As for agricultural suppression, prohibition of large machinery (planters/harvesters) to prevent flood damage necessitates manual farming, reducing productivity by 35–40% (estimated).
2) Migration paradox:
While 80% of working-age youth engage in temporary migration, permanent relocation rates remain below 50% due to compensation insufficient to cover actual resettlement costs, and disincentives from forfeiting land revenue streams.

6.3 Public Service Delivery Gaps

1) Allocation inefficiency:
All townships in floodwater detention zones have established health facilities, elderly care centers, and schools per Territorial Space Planning mandates (allocated by administrative divisions or population proportion). However, Funan County's status as Fuyang's lowest public-budget jurisdiction results in: accessibility barriers, quantity-over-quality service provision, and significant service discontinuity between normal and flood periods (Table 2).

Table 3 Flood-Nonflood Service Disparity

Period	Education Access	15-min Medical Coverage
Non-flood	Off-village access required for 55%	56.2%
Flood	Partial school closures	49.2% (Δ=-7.0%)

2) Service accessibility degradation:
Infrastructure underutilization: 50% of nursing homes (3/6) operate on state subsidies. "Three Connections and One Leveling" infrastructure (sanitation/waste/water systems) experiences <40% utilization amid persistent depopulation.

7. Discussion

This study reveals that while China's spatial planning in Huaihe River Basin FDAs exhibits institutional resilience, its effectiveness is constrained by fragmented cross-level coordination, policy fragmentation, and disconnection from livelihood needs.

7.1 Planning Resilience Deficits

1) Vertical implementation gaps: Provincial macro-goals disconnect from municipal/county implementation. For instance, integrated flood regulation-coal mining subsidence restoration-water heritage conservation initiatives lack specialized planning, causing uneven resilience resource allocation.
2) Horizontal coordination failures: Overlapping responsibilities among water resources, planning, and civil affairs agencies reduce efficiency. Absence of standardized cross-city emergency mechanisms undermines disaster response resilience.

7.2 Multidimensional Livelihood Resilience Imbalance

1) Spatial-social resilience disjunction: Overreliance on rigid flood risk control lines neglects dynamic adaptation of public services to population outflow. As Mengwa demonstrates, high housing vacancy and degraded medical/educational services exacerbate social vulnerability.
2) Economic resilience deficiency: Ambiguous industrial positioning and uncoordinated agricultural-ecological functions (e.g., harvesters ban) suppress income growth.

7.3 Pathways for Planning Optimization

1) Strategic innovations:
Multi-scale resilience synergy: Establish a "watershed-administrative region" dual framework to integrate flood control, ecological, and industrial planning, ensuring vertical coherence and horizontal accountability (e.g., aligning spatial and population control planning timeframes).
Dynamic adaptation: Adopt resilience stress-testing tools for iterative planning evaluation.
Livelihood-oriented transition: Embed public service quality (e.g., 15-min medical coverage) and resettlement compensation equity into core assessment metrics.
2) Methodological advancements:
Integrated planning governance: Emulate the Dutch water resilience model (Lu et al., 2020) by coupling water management with spatial planning through multi-stakeholder collaboration.
Specialized livelihood planning: Develop zone-specific strategies for agricultural modernization and emerging industries.

8. Conclusions

Addressing the paucity of systematic research on spatial planning policies for FDAs, this study employed a comparative approach within the Huaihe River Basin. It systematically identified key characteristics and challenges

pertaining to vertical policy transmission and horizontal coordination across provincial, municipal, and county-level territorial spatial plans, contrasting these with the FDA construction and management system. Key findings indicate:

1) Institutional fragmentation, manifesting as vertical transmission gaps and weak horizontal coordination, characterizes China's spatial planning system for FDAs;
2) A predominant focus on disaster risk reduction within both frameworks contributes to multidimensional livelihood resilience deficits;
3) Inadequate integration between spatial planning and construction management systems constrains effective governance, necessitating enhanced institutional coordination with water resources management and flood risk management to advance multi-plan synergy.
From a resilience perspective, future territorial spatial planning must prioritize systematicity, dynamism, and equity. Integrated institutional reforms and technological innovation are essential to catalyze a paradigm shift from «passive flood control» to «proactive adaptation,» strengthening cross-system collaborative governance to achieve the tripartite resilience imperatives of flood safety, ecological restoration, and sustainable livelihoods.

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Industry 5.0 as a Tool for Strenghtening Urban Resilience Against Disaster Risks

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Abstract
Each Industrial Revolution throughout history has brought about significant economic, social, and spatial transformations, with cities serving as the primary arenas of these changes. This paper investigates how production paradigms shaped by Industry 5.0 in the 21st century may transform urban metabolic systems and contribute to enhancing urban resilience. Introduced by the European Commission in 2021, Industry 5.0 differs from previous industrial models by prioritizing human-centric, sustainable, and resilient production approaches. In this context, urban forms and metabolic structures aligned with Industry 5.0 are expected to offer new frameworks for developing resilient urban environments, particularly in response to crises such as climate change and natural disasters. Through a comprehensive review of the literature on Industry 5.0, urban resilience, and urban metabolism, this study outlines the fundamental characteristics of an Industry 5.0-oriented urban environment and proposes a conceptual model to guide planning and design practices.

Keywords: Industry 5.0, Urban Resilience, Urban Crises, City Planning

1. Introduction

Natural disasters such as floods and earthquakes, which have disrupted economies, ecosystems, and cities worldwide, have been significantly intensified by human-induced environmental degradation. In particular, the growing number of warnings about anthropogenic climate change suggest that humanity may be approaching the sixth mass extinction of life on Earth. In this context, the transition from the "Age of Progress" to the "Age of Resilience" marks a profound philosophical and psychological restructuring in how humanity perceives nature and its place within it (Rifkin, 2022).

The Age of Resilience is characterized by a shift from efficiency to adaptability, from productivity to renewability, from seller-buyer markets to provider-user networks, from centralized supply chains to distributed ones, from corporate conglomerates to high-tech SMEs, from globalization to localization, and from negative externalities to circular systems. In this transformative process, the fact that more than half of the global population now resides in urban areas positions cities as critical actors in shaping this new paradigm.

Industry 5.0 is increasingly considered a key driver in this transformation. This thesis assumes that integrating Industry 5.0—a new phase in industrial development—into urban metabolic processes can enhance urban resilience against disasters.

2. Problem Definition

"Cities are spaces that enable the coexistence, interaction, and integrated functioning of individuals, networks, organizations, and various infrastructure components." (Eraydın, 2022, p.50). With the Industrial Revolution, cities underwent radical changes in scale, and these transformations brought by industrialization became the main driving force of change in the 19th century. As a result, they created the most degenerated urban environments the world had ever seen; cities became overcrowded and unhealthy spaces (Mumford, 1961/2007).

Since then, cities have become both amplifiers of disasters and the places most affected by them. One-third of the world's topsoil has been degraded since the 19th century, and studies suggest that only 60 years of arable soil remain to feed the global population. Moreover, the planet's oxygen levels are depleting at a rate not seen in two billion years. One of the most critical reasons for this is that emissions resulting from global climate change have increased ocean temperatures, leading to the destruction of phytoplankton — one of the planet's primary oxygen sources (Rifkin, 2022).

As emissions driven by climate change continue to raise the Earth's temperature, the frequency of disasters such as floods, hurricanes, and droughts is also increasing. These disasters — whether climate-induced or natural events like earthquakes — affect the sustainability of urban systems and bring the issue of urban resilience to the forefront. The planning approach that Jane Jacobs referred to as "orthodox city planning," which remains in effect today — one that divides cities into distinct functional zones — is considered inadequate in addressing such challenges. Instead, the transformation emerging around Industry 5.0 within urban metabolism is seen as a potential tool to strengthen urban resilience.

3. Disaster Risks

Disasters are defined as serious disruptions in the functioning of a community or society that result in widespread human, material, economic, or environmental losses. These disruptions often exceed the affected community's or society's ability to cope using its own resources. Disaster risk, on the other hand, refers to the potential for such losses to occur in the future, within a given time period and among a specific population. It is shaped by the interplay between natural or human-induced hazards and the vulnerability of the exposed elements (Şenol Balaban, 2017).

In the contemporary era, the majority of the world's population resides in urban areas—a trend that is projected to accelerate in the coming decades. This urban concentration amplifies exposure to hazards, making cities critical arenas for both disaster risk and resilience. Urban areas are increasingly affected not only by acute, high-impact events such as earthquakes or floods but also by slow-onset and cumulative stresses, including heatwaves, water scarcity, and land degradation, which are exacerbated by climate change (Rifkin, 2022).

Moreover, anthropogenic pressures—such as uncontrolled urban sprawl, excessive resource consumption, pollution, and ecological degradation—further erode the resilience of urban systems. These pressures often stem from unsustainable development practices and inadequate planning frameworks. Consequently, cities become more vulnerable to cascading risks, where one disruption (e.g., a heatwave) may trigger or exacerbate others (e.g., energy shortages, health crises) (Gencer et al., 2018).

In this context, enhancing urban resilience requires a shift toward integrative and anticipatory planning approaches that not only mitigate risks but also address the underlying causes of vulnerability. This includes investing in adaptive infrastructure, promoting inclusive governance, strengthening social safety nets, and preserving and restoring urban ecosystems.

An Industry 5.0-oriented urbanization model and production relations—innovative, sustainable, human-centric, and resilient—can serve as a strategic tool in strengthening cities' capacity to cope with crises.

4. Urban Resilience

With the ongoing and intensifying effects of urban crises such as global climate change, it is expected that the world will undergo radical transformations, and that existing ecosystems and settlements will be exposed to these changes. To cope with various shocks that cities may experience—particularly those caused by climate change—the concept of urban resilience has been introduced. To better understand urban resilience, it is helpful to first discuss the broader concept of resilience. The term "resilience" originates from the Latin word resilio, which means "to bounce back" (Klein, Nichols, Thomalla, 2003; as cited in Meerow, Newell, Stults, 2016). In line with this definition, resilient systems are described as structures that maintain functionality in the face of shocks and can rapidly restore systems after disruptions or breakdowns (Bruneau et al., 2003; O'Rourke, 2007; McBain, Wilkes, Ritter, 2010; as cited in Tyler, Moench, 2012). Resilience increases the capacity to cope with encountered challenges and is therefore often considered the opposite of vulnerability (Adger, 2000). The concept of resilience has been adopted by various disciplines. Originally rooted in physics, it was defined as the ability of materials to withstand external forces and maintain elasticity under pressure (Gordon, 1978; as cited in Galderisi, 2014). Later, the term gained prominence in fields such as psychology and ecology. The modern understanding of resilience is often traced back to Holling's work in 1973 (Meerow, Newell, Stults, 2016). Holling's perspective emerged as a critique

of the traditional ecological paradigm put forth by Clements (1936), which claimed that ecosystems possessed a static structure. A review of the resilience literature reveals that different types of resilience have been identified, generally distinguished based on the concept of equilibrium. These include engineering resilience, which is based on a single equilibrium state; ecological resilience, which allows for multiple equilibrium states; and approaches focused on dynamic non-equilibrium (Holling, 1996; Folke, 2006; Davoudi, 2012; as cited in Meerow, Newell, Stults, 2016).

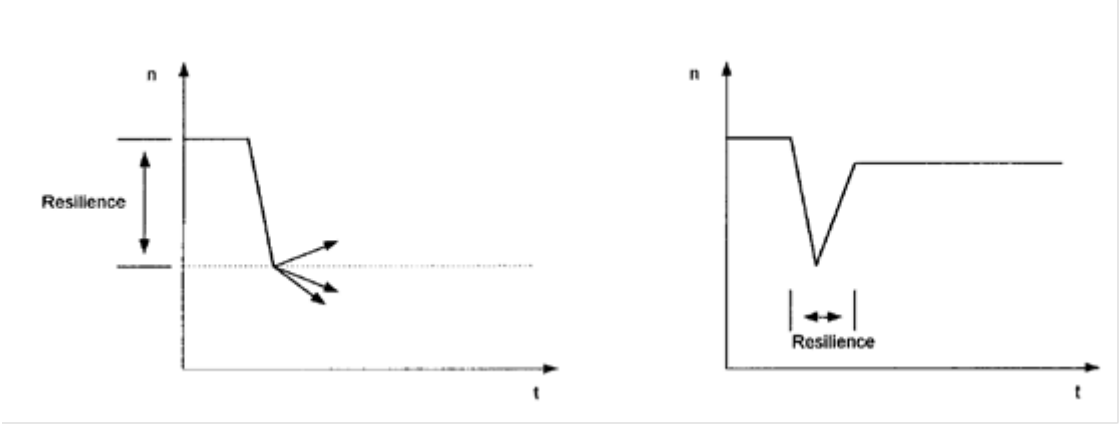

Figure 1 "Resilience Types Based on Different Equilibrium Conditions: Ecological (Left) vs. Engineering (Right) (Adger, 2000)"

As shown in Figure 1, engineering resilience depicted on the right side of the diagram refers to a single-state equilibrium. This understanding of resilience defines the capacity of a system to return to its original or near-original state after a shock or disruption (Holling, 1996; as cited in Meerow, Newell, Stults, 2016). The engineering resilience approach is commonly used in fields such as disaster management, psychology, and economics (Pendall et al., 2010; as cited in Meerow, Newell, Stults, 2016). In this context, resilience is defined as the rate at which a system recovers from disruption (Adger, 2000).

In contrast, the ecological resilience approach argues that systems can have more than one stable equilibrium. According to this view, systems may shift from one stability state to another in response to disturbances (Holling, 1996; as cited in Meerow, Newell, Stults, 2016). Rather than emphasizing the ability to return to a previous state, ecological resilience focuses on understanding how complex, nonlinear, and self-organizing systems respond to change (Berkes et al., 1998; Holling, 2001; Walker et al., 2004; Bankoff et al., 2004; as cited in Galderisi, 2014). Holling (1996) emphasized that while the traditional understanding of resilience in engineering disciplines is based on stability, efficiency, and predictability, ecological resilience refers to a system's capacity to absorb change and continue functioning (Holling, 1973, 1996; Galderisi, 2014; as cited in Meerow, Newell, Stults, 2016).

Beyond these two approaches, the more recent dynamic non-equilibrium perspective suggests that systems do not have a fixed balance and are in a constant state of change (Pickett, Cadenasso, Grove, 2004; as cited in Meerow, Newell, Stults, 2016). In this framework, the concept of resilience moves away from simply "bouncing back" and instead focuses on the capacity of a system to manage change (Matyas, Pelling, 2014; as cited in Meerow, Newell, Stults, 2016).

Based on these dynamic approaches, Holling (1973) developed the concept of resilience to explain the sustainability of ecosystems in the face of events such as fires, droughts, and floods (Marcus, Colding, 2014). In socio-ecological systems, resilience is defined by three core attributes:

- The ability of a system to maintain control over its structure and function despite disturbances,
- The capacity for self-organization,
- The ability to learn and adapt.

• Additionally, other attributes associated with resilience include:
• Maintaining core functions or developing new methods to fulfill them,
• Having backup capacities to meet demands under extreme stress,
• The ability to absorb shocks and disruptive changes (Tyler, Moench, 2012; Marcus, Colding, 2014).

Within this framework, resilience has increasingly been viewed as a strategic response to the impacts of global climate change on both natural and human systems. Resilient systems maintain functionality not through the strength of individual components, but through strengthening and diversifying the functional relationships between them (Tyler, Moench, 2012).

The increasing impact of climate change and other shocks on cities in recent years has affected millions of people and necessitated the development of risk reduction and adaptation policies. As a result, the concept of resilience has entered the urban planning discourse, giving rise to the broader concept of urban resilience, which encompasses issues from infrastructure to basic services (UN-HABITAT, DIMSUR, 2020). Urban resilience is defined as the capacity of especially low-income, marginalized, and excluded populations to survive and thrive amid urban risks (ARUP & Rockefeller Foundation City Resilience Index, 2014). This approach does not solely focus on minimizing losses due to disasters but seeks to enhance system performance against multiple threats. Approaches developed to assess urban resilience can be grouped into four categories (ARUP & Rockefeller Foundation, 2014):

Asset-based approaches: Focus on physical assets (infrastructure, buildings, etc.), but may overlook abstract values (social networks, culture, knowledge, etc.).

System-based approaches: Consider the city as a meta-system composed of social, economic, and physical subsystems, emphasizing inter-systemic and holistic thinking.

Sector-based approaches: Focus on the resilience of sub-systems such as transportation, health, or energy, rather than overall urban resilience.

Performance-based approaches: Emphasize the city's capacity to maintain core functions. This approach evaluates performance as a combination of systems, actors, and practices, while addressing interdependencies across different scales.

According to ARUP (2014), resilient urban systems should possess the following attributes:

Reflectiveness: The capacity to accept uncertainty and change by learning from the past and integrating it into decision-making processes.

Robustness: Well-designed and well-managed structures that can withstand hazardous events without severe damage or loss of function.

Redundancy: The presence of alternative options and backup capacities to ensure functional continuity.

Flexibility: The ability to adapt to changing conditions. This attribute is especially associated with decentralized and modular infrastructure approaches.

5. Industrial Revolutions and Cities

The relationship between the city and production has been inextricably intertwined. The extensive history of the city from the Industrial Revolution to the present can be traced through the changing role of industry within it—from being a driver of growth to becoming a source of political and social upheaval (Lane & Rappaport, 2020). Throughout history, production has constituted a fundamental function of cities and, as such, has consistently

been attributed a privileged position within the urban context. This centrality is also reflected in mythological narratives. For instance, in Greek mythology, the story of Prometheus giving fire to humanity after stealing it from the gods is interpreted not merely as the transfer of a physical element, but as the symbolic transmission of knowledge, technology, and civilization. The gifting of fire represents a significant turning point in human history, enabling people to protect themselves from the cold, cook food, and develop more complex tools and production techniques. In a similar vein, the Industrial Revolutions marked critical historical junctures that radically transformed modes of production and, consequently, had profound effects on urban structures, societal organization, and everyday life. This section examines how the five historical Industrial Revolutions have reshaped production processes and, in turn, reconfigured urban systems.

5.1 Cities Before Industrial Revolutions

Before the emergence of the First Industrial Revolution in the 19th century, cities were essentially small-scale settlements based on a trade economy and a rigid social order inherited from the tradition of feudalism. Sjoberg (1960) presented an idealized model of the social geography of the pre-industrial city. At its core, this model reflects the spatial expression of the division of the pre-industrial city into a small elite and much larger lower classes and marginalized groups (Knox & Pinch, 2010).

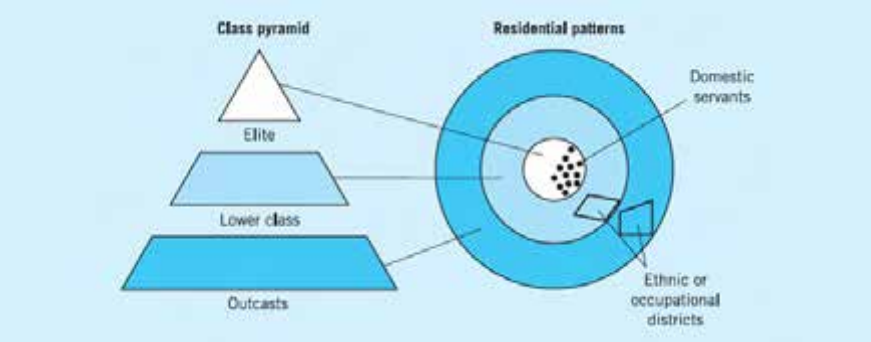

Figure 2 Sjoberg's idealized model of the social and geographical structure of the preindustrial city. (Radford, 1979; akt. Knox ve Pinch, 2010)

As shown in Figure 2, in the pre-industrial city, the elite generally lived around a pleasant and calm central area, while the lower classes and marginalized groups resided in poorly built and waste-filled surroundings. According to Sjoberg, the elite consisted of groups that managed and controlled the city's religious, political, administrative, and social functions (Sjoberg, 1960; cited in Knox & Pinch, 2010).

Although there was no highly diversified population beyond the core area inhabited by the upper classes, lower-class populations did exist. Distinct socio-economic clusters emerged as a result of the spatial coexistence of different types of artisans, and these were reinforced by social organizations such as guilds, which encouraged the spatial clustering of guild members. Poorer, less organized groups within the city — such as ethnic and religious minorities — found themselves in the outer neighborhoods, in expansive yet densely populated areas characterized by substandard and unhealthy housing areas (Knox & Pinch, 2010).

In each occupational district, housing, workshops, and storage spaces were arranged not horizontally, but vertically. Workshops were located on the ground floor, the living quarters of the master's family occupied the floor above, and the uppermost levels housed workers and storage rooms. This model of the city, in which spatial differentiation was dominated by a mosaic of occupational areas, contributed to a second dimension of class and status stratification that was more vertical than horizontal. The pre-industrial city has often been portrayed as a pedestrian city in which everything was physical and the distance between home and workplace was tightly constrained by the patriarchal and familial organization of labor (Knox and Pinch, 2010). In general, pre-industrial cities based on mercantilist production were characterized by a close relationship between workshops

and housing areas. However, with the advent of the Industrial Revolution in the 19th century, urban form began to shift: production areas were organized on the inner periphery of the rapidly expanding city, strategically connected to steam-powered railways and maritime transport systems (Çalışkan & Çağlar, 2023).

5.2 First Industrial Revolution (Industry 1.0)

Revolutions can be defined as major milestones in history. A revolution is a turbulent and transformative event—and a series of actions—that seeks to change a nation, a region, or a society, including its production processes and, more recently, its business world (Groumpos, 2021). The First Industrial Revolution (Industry 1.0) took place in the second half of the 18th century and the early 19th century. It caused profound transformations in production processes, initially in England and then worldwide, significantly affecting economic and social systems (Mohajan, 2019). In England, James Watt invented the first steam engine in 1776, and in the years that followed, the steam engine became a transformative phenomenon across Europe and America (Rifkin, 2022). This transformation is considered the starting point of the Industrial Revolution. With Watt's steam engine being used as the primary source of power, the revolution included the shift from manual to machine-based production, the development of new chemicals, the use of steam and water as main energy sources, the emergence of machinery, and the rise of mechanized factory systems (Groumpos, 2021). Economic historians argue that the onset of Industry 1.0 was one of the most significant developments in human history since the domestication of animals and plants and the beginning of agriculture (Weightman, 2010; as cited in Groumpos, 2021). The innovations brought by Industry 1.0 affected almost every aspect of people's daily lives. For example, by the end of the 18th century, with the dissolution of feudalism in Europe, waves of peasants without land ownership began migrating to cities where industrial production took place. This long-term migration movement gave birth to the urban working class (Koca, 2020). Along with these migrations, agricultural production was pushed into the background, while industrial production came to the fore. The importance of capital and labor in wealth creation was emphasized, and the resulting changes marked a transition from an agricultural and feudal society to an industrial and capitalist one (Rifkin, 2022; Prisceru, 2016; as cited in Kılıç, 2023).

The development of industry and the accompanying migration waves led to profound qualitative and quantitative changes in urban systems, especially in Europe (Benevolo, 1993/2006). For instance, London's population, which was around 1 million at the end of the 18th century, rose to 2.5 million by 1851; Manchester's population, which was around 12,000 in the 1760s, reached approximately 450,000 by the mid-19th century (Benevolo, 1993/2006). However, this rapid urbanization and population growth negatively impacted quality of life; low-income groups and workers were condemned to live in unhealthy and inadequate conditions, while everyday life became dominated by issues such as social inequality, poverty, and social instability (Kılıç, 2023).

When examining the spatial effects of Industry 1.0 on urban areas, it becomes clear that industrialization—the dominant force of the 19th century—created the most degraded urban environment ever seen up to that point (Mumford, 2007). The political foundation of this new type of urban clustering was built on three pillars: the abolition of guilds and thus the dismantling of traditional labor organization, the establishment of an open competitive market for labor and goods, and the acquisition of overseas colonies to supply raw materials and serve as markets ready to absorb the surplus products of mechanized industry (Mumford, 2007). The economic foundations of the new industry in cities were based on the exploitation of coal mines, iron, and the introduction of steam power (Mumford, 2007). Industrial facilities were established in cities close to ports and railway stations, which facilitated access to markets and raw materials, turning them into major destinations for intense rural migration. With innovations in transportation, the movement of people and goods became easier (Sharma and Singhi, 2020). Factories were typically built along rivers or near rail lines leading to rivers, and there was no planning principle aimed at keeping noisy or health-damaging industrial activities away from residential areas (Mumford, 2007).

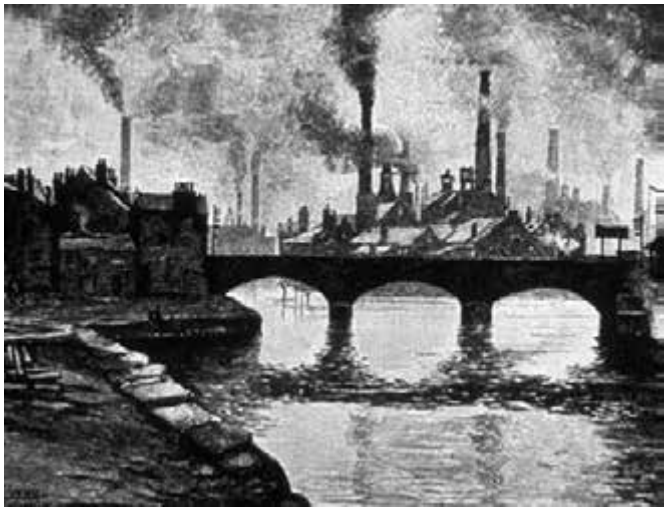

Figure 3 Industrial towns contained many polluting factories [URL 1]

As illustrated in the figüre 3, the placement of production zones in city centers led to inefficient land use, contributing to urban sprawl and traffic congestion. Basic municipal services were often absent in these new industrial towns. A general lack of hygiene prevailed. Deficiencies in access to sunlight, clean water, fresh air, and food were so widespread that they caused significant health and sanitation problems for large segments of the population (Mumford, 2007).

5.3 Second Industrial Revolution (Industry 2.0)

Due to the slow adoption of the original innovations of Industry 1.0—such as mechanized spinning and weaving—and the saturation of markets, an economic stagnation was experienced from the late 1830s to the mid-1840s (Donovan, 1997; cited in Groumpos, 2021). The Second Industrial Revolution (Industry 2.0) began in the 19th century with the discovery of electricity and the development of the assembly line through the use of new technologies (Groumpos, 2021). The United Kingdom, which played the leading role during Industry 1.0, began to give way to countries such as Germany and the United States (Koca, 2020).

Industry 2.0 marks a period during which industrial products developed significantly in terms of both quantity and diversity. The technological innovations of this period include electricity, electronics, mechanical devices, and automobiles (Kılıç, 2023). During this era, the steam engine was replaced by petroleum-based electric vehicles, a defining feature of Industry 2.0 (Koca, 2020). One of the major intellectual architects of this revolution was Frederick W. Taylor. In his book The Principles of Scientific Management, Taylor aimed to place efficiency in production at the center of modern civilization. His ideas, later systematized under the name Taylorism, were based on separating management and planning from the execution of tasks in the production department and subdividing the general production process into simpler parts to increase productivity. This method emphasized the coordination of each subtask and the separation of intellectual and manual labor.

To achieve this, Taylor advocated for the standardization of all worker actions within a work environment in which laborers were not distinguished from the machines they operated, essentially treating workers as an extension of the production apparatus (Koca, 2020; Rifkin, 2022). As a result, a vertically rigid division of labor and hierarchy emerged, leading to a high degree of differentiation in tasks and positions. This allowed for the execution of work by unskilled or semi-skilled labor, reducing businesses' dependency on skilled workers (Koca, 2020).

Two innovators, Henry Ford and Taiichi Ohno, adopted and expanded upon Taylor's theory. Ford pioneered the use of moving assembly lines to meet rising demand, while Ohno, the architect of the Toyota Production System, emphasized product variety by focusing on customer needs (Yin et al., 2018; cited in Çelik, 2023). In the Fordist

system, based on Ford's production technique, a fixed relationship was established between unskilled labor and machinery. The moving assembly line standardized production, increased the number of products per worker, and created economies of scale, ultimately aiming to enhance productivity and profit (Tokol, 2000).

By the 1870s, the use of electricity had become widespread. Technological advancements in production also affected other industrial fields such as iron-steel, chemical, transportation, and other manufacturing sectors (Kılıç, 2023). The significance of electricity grew steadily, beginning with the invention of the electric motor in 1821 and the dynamo in 1831, followed by the telegraph, arc lamp, and ring dynamo. Later innovations such as electric railways, electric blankets and stoves, electric trams, the modern lightbulb, multiphase electric motors, and transformers solidified electricity's critical role (Çelik, 2023).

In the realm of transportation, railways became faster, safer, and more comfortable during the Second Industrial Revolution. After 1870, ships began to be constructed increasingly from steel, enabling the building of larger, stronger, and faster vessels. The invention of the steam turbine in 1884 and subsequent advancements triggered a major revolution in maritime transport. The emergence of interchangeable parts and mass production at the end of the 19th century spurred the development of the automobile industry. By 1914, Henry Ford was selling nearly a quarter-million Model T cars annually. The development of the airplane further expanded the scale of transportation (Çelik, 2023).

With Industry 2.0, advancements in production technology facilitated the widespread adoption of various technological systems, including telegraph and railway networks that had previously been concentrated in a few industrial cities, as well as infrastructure for gas and water supply and sewage systems (Groumpos, 2021). Along with increasing urbanization, devices such as electric lighting, radio, and the telephone transformed how people lived and communicated. These innovations have led to the perception that the modern world was realized through Industry 2.0 (Groumpos, 2021).

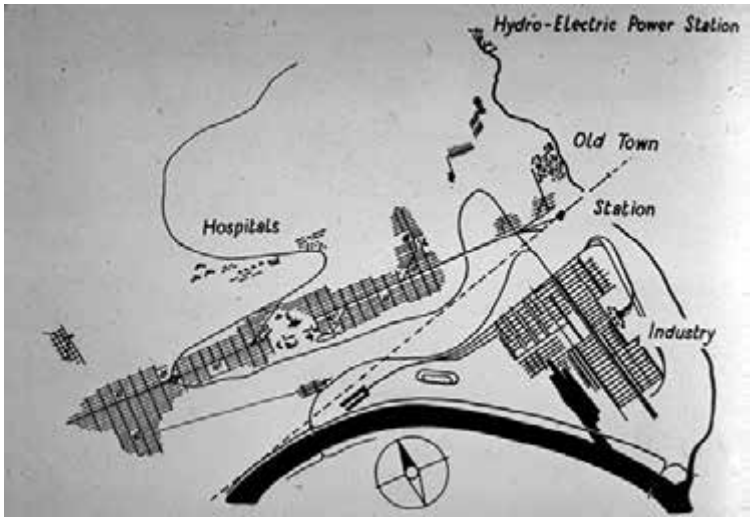

Figure 4 Tony Garnier's La Cite Industrielle Model [URL 2]

The urban planning approach that emerged during this period primarily aimed to respond to the urban problems caused by the First Industrial Revolution and to enhance production efficiency (Eraydın, 2022). As illustrated in the model developed by Tony Garnier—La Cité Industrielle—a city designed between 1899 and 1904 envisioned a settlement for 35,000 inhabitants. In this city, four essential functions were designated: living, working, recreation, and health, which were reflected in designated residential areas, industrial buildings, train stations, and other necessary public facilities. The model emphasized the physical integration of these functions through pedestrian pathways and transport systems, while ensuring industrial facilities were located close to energy sources and transportation infrastructure as a core principle (Eraydın, 2022).

Following the 1929 economic crisis, serial/Fordist production necessitated a redefinition of the urban-industry relationship. During this period, the Keynesian theories introduced by John Maynard Keynes also influenced the approach to the city. Contrary to the classical economists like Adam Smith—who dominated the previous era and emphasized the primacy of individual interests over societal ones—Keynes advocated for a greater role and function of the state in the national economy. He argued that the state should play an active role in ensuring efficient resource allocation, promoting economic development, maintaining price stability, achieving full employment, and establishing a more equitable income distribution (Yılmaz, 2009; Rifkin, 2022). These ideas also transformed perspectives on urbanism and planning.

Another urban approach related to the Second Industrial Revolution emerged through the CIAM (Congrès Internationaux d'Architecture Moderne) meetings held in the 20th century. The urban model discussed in CIAM was a response to the rapid urbanization, unhealthy housing environments, pollution, and congestion brought about by industrial society (Günay, 1988; cited in Eraydın, 2022). CIAM's most significant proposal was to define the city through four primary functions—dwelling, working, recreation, and transportation—and to spatially separate these functions into a distinct urban land use pattern. This approach claimed that by isolating industrial facilities from other urban functions, the environmental, transportation, and complexity-related problems could be mitigated (Eraydın, 2022).

5.4 Third Industrial Revolution (Industry 3.0)

It is acknowledged that the Third Industrial Revolution (Industry 3.0) emerged after the end of World War II, with the development of memory, programmable controls, and computer technology, leading to partial automation (Groumpos, 2021). Unlike Industry 1.0 and Industry 2.0 in terms of quality, the core components of Industry 3.0 include the internet, information and communication technologies, digital communication, and microelectronics, among others (Koca, 2020). Following the advancement of these technologies, the entire production process began to be automated without human assistance. For this reason, Industry 3.0 is also referred to as the automation and digital revolution (Groumpos, 2021; Kılıç, 2023).

The economic crisis of the 1970s marked a shift away from Fordist and Keynesian policies that had dominated the previous period, ushering in an era of neoliberal policies (Eraydın, 2023). Industry 3.0 represents the transition from an industrial society to an information society. During this period, flexible manufacturing systems were introduced to enable shorter production times, more personalized products, and quicker responses to consumer demands (Sharma, Singh, 2020). This process can also be described as a transition from economies of scale to economies of scope.

After the economic crisis of the 1970s, the new production order defining the global economy began to spatially fragment. Less developed countries became integrated into new production chains as subcontracted manufacturers, while deindustrialization processes started to occur in developed countries (Eraydın, 2023). During this time, many labor-intensive manufacturing units with outdated technologies shut down, and vast urban areas—especially those on the urban peripheries that hosted these industries—were abandoned (Eraydın, 2023). In the Industry 3.0 process, supply chains gradually acquired a global character, and no product was produced entirely in one single location anymore (Koca, 2020).

When examining the effects of Industry 3.0 on cities, a duality becomes apparent. In the Global North, considered developed, many large industrial units were shut down, and the number of people living in cities and working in industry significantly declined. To prevent deindustrialization, these cities attempted to create a production order based on knowledge and new technologies. During this period—characterized by the globalization of services and the growing dominance of new service sectors—reduced state intervention in the economy and a return to free market conditions defined a new accumulation regime. These processes led to problems such as rising income inequality, unemployment, and social fragmentation in cities (Eraydın, 2023).

Since the capacities of developing Global South countries were insufficient to fully implement new forms of

production, a dual structure emerged in both production and labor markets. In these countries, while there were mass-production factories and an organized workforce, there also emerged small-scale production enterprises and an informal labor market (Eraydın, 2023). Global South cities, which sought to become subcontracted production hubs in global markets, did not undergo a deindustrialization process; however, they became new playgrounds for capital focused on the real estate sector. During this period, the cities of Global South countries experienced major transformation and destruction due to a construction-led growth model. It is also observed that low-tech industries employing relatively cheap labor compared to developed countries were again located on the urban peripheries (Eraydın, 2023).

5.5 Fourth Industrial Revolution

The Fourth Industrial Revolution (Industry 4.0) was introduced at the 2011 Hannover Fair in Germany as a series of actions by the German government aimed at implementing its high-tech strategies (Xu et al., 2021; Kılıç, 2023). The primary objective of Industry 4.0 is to compete with manufacturing-centered countries such as India and China, and to prevent the outflow of wealth from developed countries like those in the European Union and the United States (Kılıç, 2023). To achieve this, Industry 4.0 is considered a stage that promotes and supports collaboration in production, transitions, and the integration of learning and knowledge flows among different types of manufacturers (Hatuka, Ben-Joseph, 2023).

There are two main reasons behind the emergence of Industry 4.0:

• First, it is the return of factories to their home countries. Following the 2008 economic crisis, many Western countries had shifted production to various countries—especially in the Far East—due to low labor and resource costs. Industry 4.0 represents the process of bringing this production back home.

• Second, the primary impact of globalization on the economy is the liberalization and mobilization of capital. With the liberalization of capital flows, capital tends to move toward countries where it can yield the highest profit (Koca, 2020).

The technological scope of Industry 4.0 is extensive and includes technologies such as cloud computing, the Internet of Things (IoT), artificial intelligence, autonomous robots, and blockchain, all aimed at creating smart factories (Barata, Kayser, 2023). Industry 4.0 has led to the development of cyber-physical production systems that integrate information technology and operational technology within enterprises and supply chains (Grabowska et al., 2022). The trends and impacts of this revolution can be observed across all macro and micro scales of the market.

The core principles of Industry 4.0 can be summarized as follows:

• Service-oriented reference architecture,
• Smart, self-organizing cyber-physical systems,
• Adaptability and flexibility to changing requirements,
• Optimization for overall equipment effectiveness,
• Data integration across disciplines and throughout the entire life cycle,
• Reliable and secure communication between enterprises (Xu et al., 2021).

The rapid increase in the application of Industry 4.0 technologies today and the tendency of businesses to remove human labor from production systems have raised concerns for workers, society, and governments. In Industry 4.0, the working environment is defined by integrated, advanced, and resilient production techniques equipped with sensors monitoring machines and advanced communication systems—rarely mentioning the role of existing workers (Grabowska et al., 2022). The main focus of Industry 4.0 policies is to withdraw human resources from production processes and replace them with autonomous and optimized industrial tools (Koca, 2020). The technologies of Industry 4.0 typically require more knowledge than what is available to engineers,

skilled manufacturers, or the traditionally low-skilled workforce (Rappaport, 2023).

When examining the relationship between Industry 4.0 and cities, it is based on the understanding of cities as innovation ecosystems. The speed and breadth with which cities adopt and distribute technology—supported by flexible policy frameworks—will determine their ability to compete in attracting talent. It is argued that having ultra-fast broadband, using digital technologies for transportation energy consumption and waste recycling, will make cities more livable and increase their competitiveness (Schwab, 2016). Cities can actively invest to create opportunities for digital transformation in order to attract entrepreneurs and investors to innovative ventures, and to encourage established businesses to align themselves with Industry 4.0 opportunities. According to the innovation organization NESTA, the five cities identified as having the most effective policy environments for promoting innovation are New York, London, Helsinki, Barcelona, and Amsterdam (Schwab, 2016).

In Industry 4.0-focused production, a dual structure can be observed in the relationship between cities and industry. The first of these structures refers to the attraction of small producers to urban areas. While large, vertically integrated companies dominated national production in previous industrial revolutions, today's production landscape consists of decentralized networks of small, specialized firms, largely operating in the United States (Rappaport, Lane, 2020). The other structure is characterized by large-scale areas containing standardized industrial buildings and surrounded by various boundaries. Autonomous industrial zones, usually located near infrastructure such as railways or airports, contribute to regional development, but may also compete with and weaken the economies of traditional industrial zones in nearby cities (Hatuka, Ben-Joseph, 2023).

Critics argue that Industry 4.0 aligns with long-term neoliberal capitalist models that emphasize profitability and prioritize shareholders, while intensifying several prevalent social and environmental concerns such as regional inequality, environmental degradation, and the fragility of the global economy (Javaid et al., 2020; cited in Ghobakloo et al., 2022). Automation may particularly have adverse effects on rapidly growing markets and developing countries, as these nations risk losing their comparative advantage in the production of labor-intensive goods and services (Schwab, 2016).

6. Emergence and Development of Indusry 5.0

The COVID-19 crisis that emerged in 2019 clearly demonstrated the need to reassess existing working methods and approaches. This crisis further deepened the vulnerabilities of industrial systems—such as fragile strategic value chains—and increased the necessity for both flexible and robust innovations to address these weaknesses (Breque et al., 2021).

6.1 The Emergence and Definition of Industry 5.0

In this context, the European Commission published a report in 2021 titled "Industry 5.0: Towards a Sustainable, Human-centric and Resilient European Industry" (Xu et al., 2021). Still in its early stages of development, Industry 5.0 has taken shape as a response to the challenges brought about by Industry 4.0, including unemployment, social inequality, and resistance to technological integration (Güdek, 2023). While Industry 4.0 primarily focused on production efficiency and digitalization, Industry 5.0 aims to establish production systems that are human-centric, sustainable, and resilient (Breque et al., 2021).

6.2 Human-Machine Collaboration and Value Proposition

One of the most distinctive features of Industry 5.0 is its emphasis on deeper collaboration between humans and advanced artificial intelligence systems (Nikolov, 2025). This collaboration aims to transform production processes into systems that are not only efficient, but also creative, fair, and capable of promoting long-term well-being (Huang et al., 2022). This vision involves the redesign of operations and supply chains based on principles of resilience, sustainability, and human-centricity (Grabowska et al., 2022; Ivanov, 2022).

6.3 Literature Analysis

As part of this study, a literature analysis was conducted on academic research related to Industry 5.0. A review of the annual distribution of studies reveals a notable increase in publications, particularly after 2020 (Figure 5).

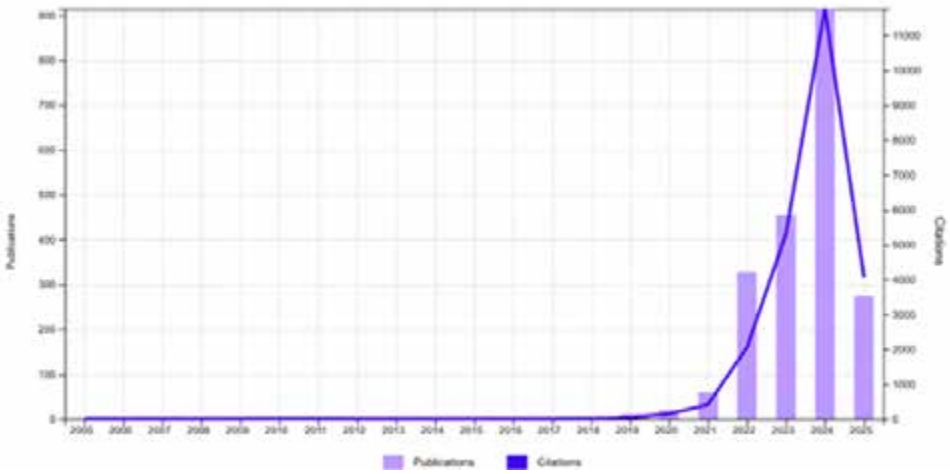

Figure 5 Distribution of Academic Studies on Industry 5.0 by Year (Obtained from Web of Science Data)

Keyword analysis highlights recurring themes such as smart manufacturing, sustainable development, digital transformation, Industry 4.0, and human-centricity (Figure 6).

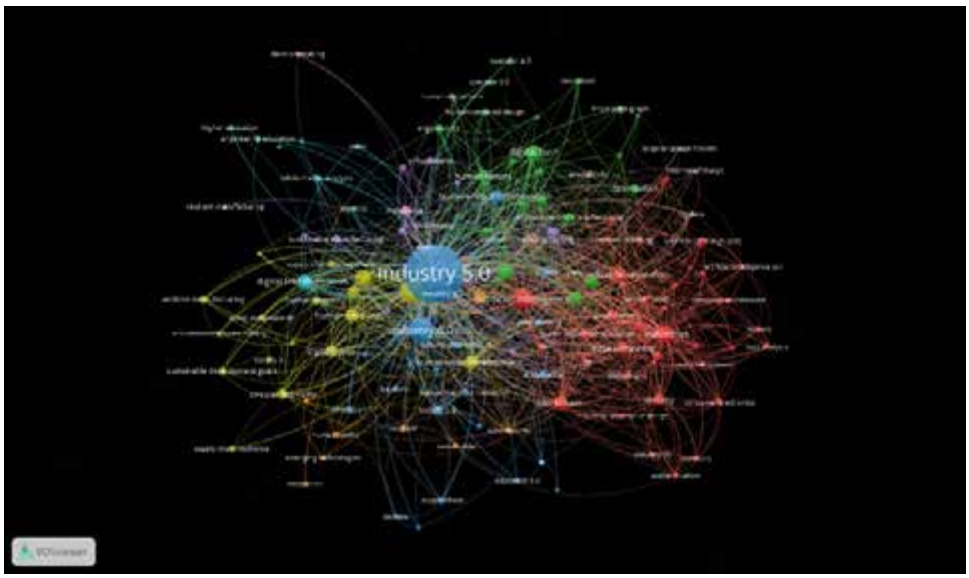

Figure 6 Distribution of Key Concepts Used in Studies on Industry 5.0 (Obtained from Web of Science)

When examining the relationship between these studies and the Sustainable Development Goals (SDGs), it is observed that the most commonly addressed goals are:
Goal 9: Industry, Innovation and Infrastructure
Goal 12: Responsible Consumption and Production
Goal 11: Sustainable Cities and Communities (Figure 7)

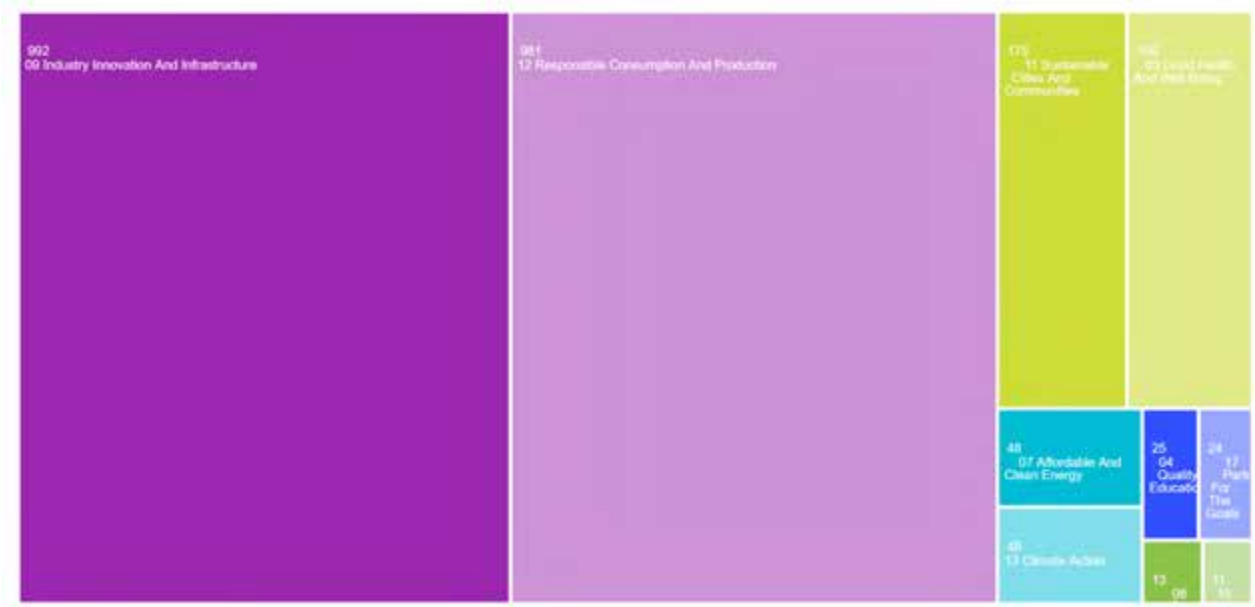

Figure 7 Sustainable Development Goals on Which Industry 5.0 Studies Concentrate (Obtained from Web of Science)

6.4 Relationship Between Industry 5.0 and Cities

The literature review revealed a lack of direct studies addressing the intersection of Industry 5.0 with urban planning and urban design. Therefore, the present study draws insights from existing research focusing on the core principles of Industry 5.0—human-centricity, resilience, and sustainability. Based on these principles, it can be argued that an Industry 5.0-oriented urban development model represents a paradigm shift from earlier urbanism approaches, emphasizing a form of urban circular symbiosis where industrial and urban systems are integrated.

This symbiotic approach particularly refers to the use of urban by-products (e.g., waste) as alternative raw materials or energy sources in industrial activities (Van Berkel et al., 2009). Through such an Industry 5.0-driven urban metabolism, the integration of residential, work, and industrial spaces is encouraged. This integrated model aims to regulate the transition between land uses, promote circularity and supply chain diversification enabled by new technologies, facilitate worker well-being in alignment with the principle of human-centricity, and foster spaces for social interaction (Eraydın, 2022).

In this context, the re-emergence of production activities within cities is gaining traction in novel forms such as maker spaces, innovation districts, vertical urban factories, and fab labs—highlighting emerging patterns of contemporary and future urban production (Lane & Rappaport, 2020). Historically, zoning regulations confined industrial activities to designated areas. However, Industry 5.0-compatible production activities—like 3D printing, laser cutting, small-scale prototyping, and media or film production—are not always compatible with traditional land-use regulations (Lane & Rappaport, 2020).

Therefore, the development of new planning and design strategies is required for spaces where Industry 5.0-based production can occur. These spaces should support fine-grained, mixed-use activities, maximize face-to-face interaction, and creatively resolve challenges related to material flow and building functionality (Lane & Rappaport, 2020). The identified urban design principles for such areas include:

• Street designs should support both the movement of goods and diverse modes of interaction between producers and non-producers.

• Open spaces should be flexible, vibrant, and active throughout the day.

• Edges of the zones should be well-defined yet permeable.

• Spatial configurations should accommodate new living-working relationships, ensuring gradual transitions between factories and adjacent neighborhoods in terms of scale and land use (Lane & Rappaport, 2020).

Elements of urban form—such as street and block networks, public spaces, edges, and adjacency of uses—play a crucial role in shaping the complex and flexible ecology of production (Lane & Rappaport, 2020). The design of Industry 5.0 production areas should ensure access to public transport, dining, and gathering facilities, thereby enhancing the quality of life for workers and realizing the human-centric vision (Lane, 2020).

In terms of resilience, such spaces should be conceptualized as ecosystems with diverse and interconnected supply chains. In times of crisis, flexible and adaptable production capacities can enhance systemic resilience (Ivanov, 2020; Kılıç, 2023). Furthermore, the transformation of production relations and urban systems through Industry 5.0—particularly aligned with the concept of urban symbiosis—points toward the development of circular systems that reuse, repurpose, and maximize resource efficiency, thus contributing directly to the principle of sustainability (Xu et al., 2021).

7. Conclusion

"The world has changed.
I see it in the water.
I feel it in the Earth.
I smell it in the air.

This passage from the beginning of Tolkien's The Lord of the Rings symbolically reflects the paradigm shift we are currently experiencing. Today, one of the most significant driving forces behind this transformation is the increasing frequency and severity of crises and disasters. Cities have become the primary sites where the most devastating impacts of these crises are felt. The fact that more than half of the world's population now lives in urban areas further complicates the issue. This study explores the potential of Industry 5.0 as a tool to enhance the resilience of cities against such crises, and examines the transformations it may bring to urban space. Within the framework of Industry 5.0's three core principles—human-centricity, sustainability, and resilience—it is anticipated that the resulting urban landscape will be more compact, mixed-use, and cyclical in nature.

Industry 5.0 seeks to merge technologies such as artificial intelligence and robotics with human creativity. Unlike previous industrial revolutions, it represents a shift toward placing not only economic growth but also social goals and a non-extractive view of nature at the center of production.Accordingly, in cities shaped by Industry 5.0, the reorganization of living, working, and production spaces is expected to integrate circularity and diversity into everyday life—thereby increasing urban resilience in the face of future crises.

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Exploring the Feasibility of Sponge City Solutions for Flood Resilience in Gangnam, Seoul

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Abstract:
Gangnam District in Seoul faces increasing flood risks due to rapid urbanisation, aging drainage infrastructure, and intensified rainfall linked to climate change. This study assesses the feasibility of implementing Sponge City strategies—such as permeable pavements, bioswales, and rain gardens—alongside the Deep Tunnel Sewer System (DTSS) to build long-term urban resilience. Employing a mixed-methods approach, the research combines GIS-based spatial analysis, flood simulation modelling, SHAP-informed risk prediction, and stakeholder engagement through public surveys. Findings identify spatial hotspots for intervention, highlight strong public support for green infrastructure, and underscore institutional and regulatory barriers to implementation. The study proposes a hybrid green-grey infrastructure pathway tailored to Gangnam's urban fabric and contributes to broader debates on integrating nature-based solutions in high-density cities facing complex climate and development pressures.

Keywords: Sponge City; Urban Flooding; Green Infrastructure; GIS Analysis; Gangnam Seoul

1. Introduction

Cities globally face escalating risks from climate change, with urban flooding emerging as a critical threat to infrastructure, public safety, and socio-economic stability (IPCC, 2014). Gangnam District in Seoul, South Korea, exemplifies this challenge. As a dense, economically vital urban area, Gangnam is increasingly exposed to pluvial flooding driven by extreme rainfall events, low-lying topography, and impermeable urban surfaces. The severe inundation of 2022 revealed the district's vulnerability and exposed the limitations of its aging drainage infrastructure and insufficient green space.

While municipal authorities have implemented temporary or reactive responses, these have proven inadequate for long-term risk reduction. There is a growing need to adopt comprehensive, forward-looking approaches grounded in nature-based, adaptive urban planning. This paper explores the feasibility of implementing Sponge City principles—originally developed in China by Yu Kongjian—as an integrated solution for enhancing flood resilience in Gangnam. Specifically, the study investigates how green infrastructure (e.g., bioswales, rain gardens, permeable pavements) can complement grey systems like the Deep Tunnel Sewer System (DTSS), currently under construction and scheduled for completion in 2028.

By combining spatial analysis, simulation modelling, and stakeholder engagement, this research aims to generate actionable insights for sustainable flood mitigation in Gangnam and offer a replicable planning framework for other high-density cities navigating similar climate and development pressures.

2. Conceptual Framework:

This study is guided by a multi-dimensional conceptual framework that connects physical infrastructure with governance, equity, and long-term resilience planning. Drawing from urban environmental planning theory and contemporary practices in climate adaptation, five key pillars form the basis for evaluating Sponge City feasibility in Gangnam:

2.1. Sponge City and Nature-Based Solutions (NbS)

Originally developed in China by Yu Kongjian, the Sponge City concept reimagines urban areas as permeable, living systems that absorb, retain, and filter stormwater much like natural ecosystems (Yu, 2016). As a form of NbS, it incorporates green infrastructure elements—such as bioswales, rain gardens, permeable pavements, and constructed wetlands—to manage water close to its source. These strategies reduce runoff, improve water quality, and deliver co-benefits like biodiversity enhancement, heat mitigation, and improved urban aesthetics (Li et al., 2017). This paper treats Sponge City design not only as a technical solution, but as a new paradigm for ecologically embedded urbanism.

2.2. Hybrid Infrastructure Approaches

While nature-based solutions provide essential ecological functions, they may not suffice alone in compact and heavily built environments. In such contexts, a hybrid approach—combining green and blue systems with traditional grey infrastructure—is needed to provide a multi-layered defence against extreme weather events (Park et al., 2024). The Deep Tunnel Sewer System (DTSS), for example, addresses large-scale runoff and deep storage needs, while decentralised GI interventions help mitigate frequent, less intense rainfall. This dual strategy improves system redundancy and allows for both surface-level adaptation and sub-surface drainage enhancement.

2.3. Urban Resilience and Adaptive Planning

Urban resilience refers to a city's capacity to withstand, adapt to, and recover from climate-related shocks. It is grounded in long-term, systemic thinking and spatial planning that anticipates change rather than reacting to crises (IPCC, 2014). Resilient flood management includes zoning for permeable land uses, regulating impervious surface expansion, and integrating hydrological data into urban planning tools. In this study, resilience is operationalised through spatial flood vulnerability mapping, scenario-based simulations, and identification of adaptive pathways for Gangnam under various future rainfall regimes.

2.4. Stakeholder Engagement and Participatory Governance

Infrastructure interventions are rarely successful without community support and institutional coordination. Meaningful stakeholder engagement—including residents, municipal agencies, planners, and the private sector—can foster local ownership, improve design outcomes, and resolve land-use conflicts (Reed, 2008). Participatory planning helps address socio-political dimensions of urban adaptation and surfaces place-based knowledge that may not be captured by technical analysis alone. In Seoul, where governance complexity and jurisdictional fragmentation are challenges, participatory mechanisms are essential for coordinated Sponge City implementation.

2.5. Planning for Equity and Feasibility

Finally, for any resilience strategy to succeed, it must be socially equitable and practically implementable. Equity involves ensuring that green infrastructure is not disproportionately concentrated in affluent areas, but distributed to benefit vulnerable populations and historically underserved zones. Feasibility includes legal, financial, and administrative capacities to support intervention deployment at scale. In Gangnam, where land is highly contested and built-up, planning for Sponge City implementation requires careful negotiation of regulatory frameworks, financing models, and land-use incentives (Choi and Kim, 2022; Ro and Garfin, 2024).

3. Methodology

To assess the feasibility of Sponge City implementation in Gangnam, this study employed a mixed-methods approach integrating quantitative spatial analysis, flood simulation modeling, and qualitative stakeholder engagement. This approach enabled both predictive modeling of flood risk and an evaluation of institutional and public readiness for green infrastructure adoption.

3.1. Study Area: Gangnam and Seocho 2-dong District, Seoul

Gangnam is a dense and economically significant district in Seoul, characterised by high-rise development, extensive impervious surfaces, and a legacy of inadequate drainage. Its low-lying topography and rapid urbanisation have contributed to repeated pluvial flooding, most notably during the extreme rainfall event of August 2022. As a representative case of high-density Asian urbanism, Gangnam offers both logistical challenges and strategic opportunities for Sponge City interventions.

3.2. GIS-Based Spatial Analysis and Flood Vulnerability Mapping

A Geographic Information System (GIS) database was developed to identify spatial patterns of flood risk and to prioritise zones for intervention. The analysis incorporated the following spatial layers:

• Topography: Digital Elevation Models (DEM) were used to calculate slope, curvature, and flow accumulation.
• Land Use/Land Cover (LULC): Classified surfaces by imperviousness and vegetation cover (e.g., urban, forested, water).
• Hydrology: Existing drainage infrastructure and natural flow paths were mapped to identify hydrological bottlenecks.
• Urban Fabric: Road networks, building footprints, and population density were used to assess urban exposure.
• Flood Records: Spatial extents of the 2022 flood event were digitised and validated with field reports and media documentation.

The Seoul metropolitan area was tessellated using H3 hexagonal grid cells (resolution: ~100 meters per edge) to spatially aggregate and compare variables. Zonal statistics (mean, sum, distance to) were applied to extract attributes for each cell, allowing for flood risk mapping across the district.

3.3. Machine Learning and SHAP Analysis

To quantify the influence of spatial variables on flood vulnerability, a binary classification model was trained using PyCaret, an AutoML framework in Python. The target variable distinguished between cells intersecting 2022 flood extents and those that did not.

After model comparison, a Random Forest classifier was selected for its performance and interpretability. To improve transparency and inform planning decisions, SHAP (SHapley Additive exPlanations) was applied to rank the most influential predictors. Key features identified included:
• **Distance to road:** Higher risk near roads with poor drainage.
• **Building count:** Proxy for impervious surface concentration.
• **LULC_Urban:** Direct correlation with runoff volume.
• **Downstream topography:** Low elevation and slope predict pooling zones.

These results were later cross-referenced with flood simulation outcomes and community priorities to recommend site-specific interventions.

3.4. Flood Simulation Modeling

To evaluate the hydrological performance of proposed interventions, a two-stage simulation was conducted:
1. **Baseline Scenario:** Simulated surface runoff and inundation extent under current land use and infrastructure, using design storm events calibrated from Seoul's rainfall history.
2. **Intervention Scenarios:** Modeled the impact of:
   A. Increased permeable surfaces (via bioswales and pavements)
   B. Rain gardens and vegetated detention zones
   C. The planned Deep Tunnel Sewer System (DTSS)
   D. A hybrid scenario combining green infrastructure with DTSS

Simulations estimated reductions in peak flow, runoff volume, and flooded area for each intervention. These outputs informed feasibility rankings and spatial targeting.

3.5. Stakeholder Engagement and Policy Analysis

To assess institutional readiness and public acceptance, two qualitative methods were employed:
• Stakeholder Consultations: Semi-structured interviews with representatives from the Seoul Metropolitan Government, Gangnam District Office, and environmental NGOs explored regulatory, financial, and implementation constraints. Key themes included jurisdictional overlap, land-use policy gaps, and funding needs.
• Community Survey: A structured survey (n = 35) was administered to Gangnam residents and frequent visitors to assess:
   • Awareness of flood risk
   • Trust in current governance

- Support for Sponge City interventions
- Willingness to contribute financially (via taxes or fees)

Survey data were analysed descriptively and visualised using bar charts and heatmaps, identifying key areas of public support and skepticism.

3.6. Integration of Methods

The mixed-methods design allowed for iterative triangulation between technical and social data:

- GIS and SHAP outputs identified risk hotspots and their physical characteristics.
- Simulation models quantified the expected benefits of nature-based and engineered interventions.
- Survey and consultation findings contextualised the feasibility of implementing these interventions within current governance structures and public sentiment.

Together, these methods produced a robust, evidence-based assessment of where and how Sponge City strategies could be implemented most effectively in Gangnam.

4. Key Findings and Analysis

Empirical Insights on Urban Flood Risk, Mitigation Efficacy, and Public Perception in Gangnam

This section presents the outcomes of spatial flood risk mapping, machine learning interpretation, simulation modeling, and stakeholder engagement conducted in Gangnam District. The analysis highlights key predictors of flood vulnerability, evaluates the relative performance of grey and nature-based interventions, and assesses public support and institutional readiness for Sponge City implementation.

4.1. Spatial Patterns of Flood Vulnerability

Spatial analysis using GIS and H3 hexagonal grids revealed concentrated zones of flood risk in Gangnam, notably around Gangnam Station, Seocho 2-dong, and Yeoksam-dong. These areas are characterised by a combination of high-rise commercial development, minimal green space, and low-lying topography. The spatial overlay of building footprints, elevation data, and known flood extents from the 2022 event confirmed these sites as high-priority targets for intervention.

The vulnerability assessment was further supported by SHAP analysis, applied to a Random Forest classification model trained on spatial features. Among the most influential predictors of flood-prone areas were proximity to roads, building count, urban land cover, and downstream elevation. Areas with high building density and impervious surface coverage were consistently associated with elevated flood risk. Low elevation values in the flow direction also increased the likelihood of water accumulation, confirming field observations. These insights provide a robust empirical basis for targeting green infrastructure interventions and align with broader literature on urban impermeability and runoff generation.

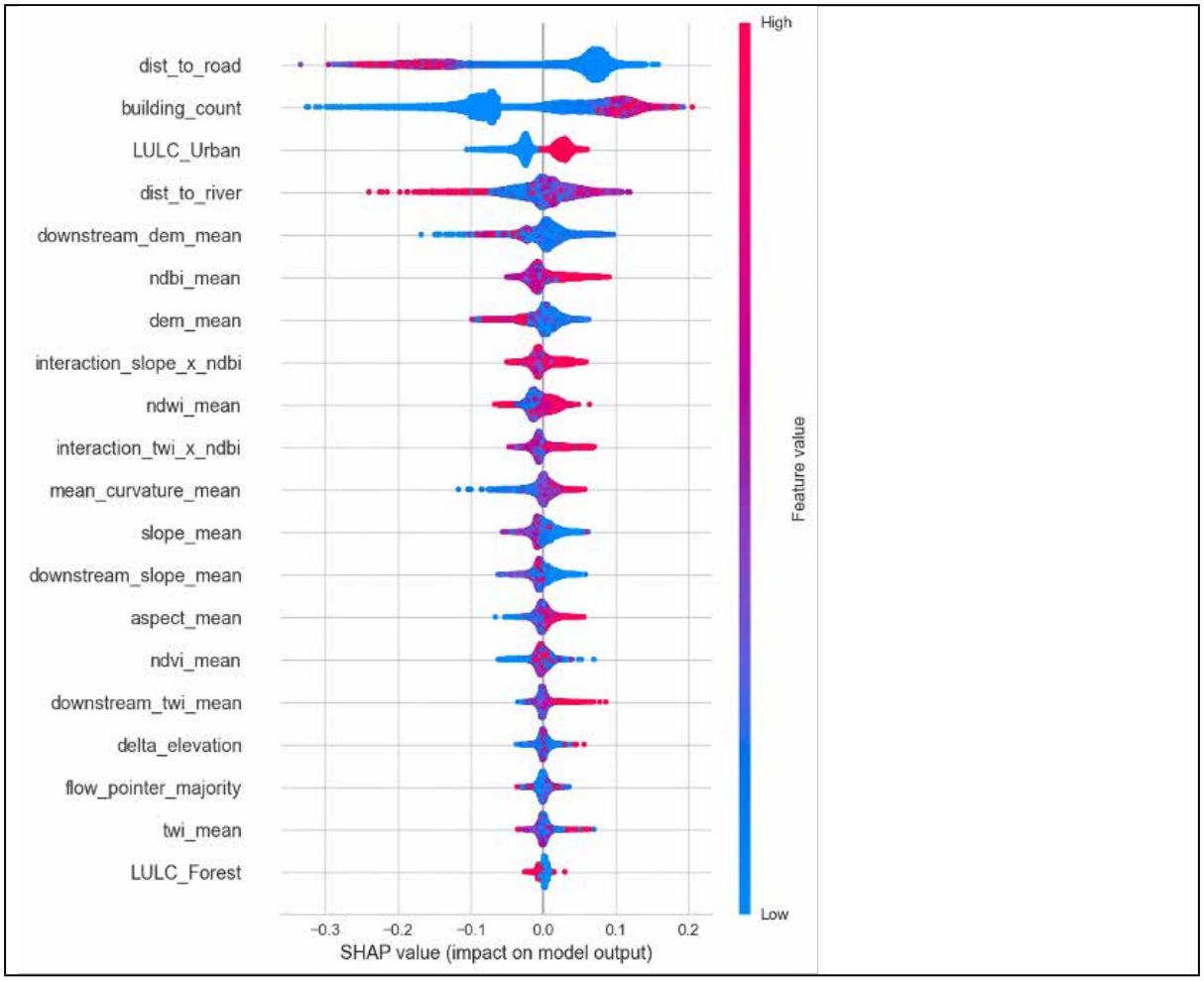

Figure X. SHAP feature importance plot

4.2. Hydrological Performance of Green and Grey Infrastructure

Flood simulation modeling was used to evaluate the projected effectiveness of various intervention strategies under both moderate and extreme rainfall scenarios. In the baseline model, current infrastructure conditions failed to prevent widespread pooling and surface runoff, particularly in low-lying commercial corridors.

Green infrastructure measures, including bioswales, permeable pavements, and rain gardens, were introduced into high-risk zones identified through GIS and SHAP analysis. These decentralized interventions reduced surface runoff volumes by approximately 18 to 25 percent and delayed peak discharge rates, especially during mid-intensity storms. However, their impact was limited in scenarios simulating high-intensity rainfall events.

By contrast, the Deep Tunnel Sewer System (DTSS)—a large-scale grey infrastructure project currently under construction—demonstrated substantial capacity to reduce overall flood extent during extreme events. While the DTSS did not significantly reduce nuisance-level flooding from frequent minor storms, its performance was critical in managing peak loads and preventing basin-scale inundation.

The most promising outcomes emerged from a hybrid scenario integrating Sponge City measures with the DTSS. In this configuration, green infrastructure absorbed and detained runoff at the surface level, reducing inflow pressure on sub-surface systems. This synergy led to a 30 to 35 percent reduction in total flooded area across storm categories. The results support recent scholarship advocating for polycentric, multi-layered flood defense systems in complex urban environments.

4.3. Public Perception and Support for Sponge City Implementation

To complement the technical analysis, a structured survey was conducted with 35 respondents, including both Gangnam residents and frequent visitors. Although only a minority had prior knowledge of the Sponge City concept, a substantial majority supported the general idea of using green infrastructure for flood mitigation once it was explained. Most respondents were aware of Gangnam's flood history, and over half expressed concern about increased flooding in the coming decade.

When asked to evaluate the current flood management system in Seoul, fewer than one in five respondents considered it effective. The most commonly cited shortcomings were insufficient drainage capacity, a lack of urban green space, and inadequate urban planning. In terms of proposed solutions, respondents prioritised expanding the drainage network, increasing green space provision, and adopting climate adaptation policies. Public education and preparedness training also ranked highly.

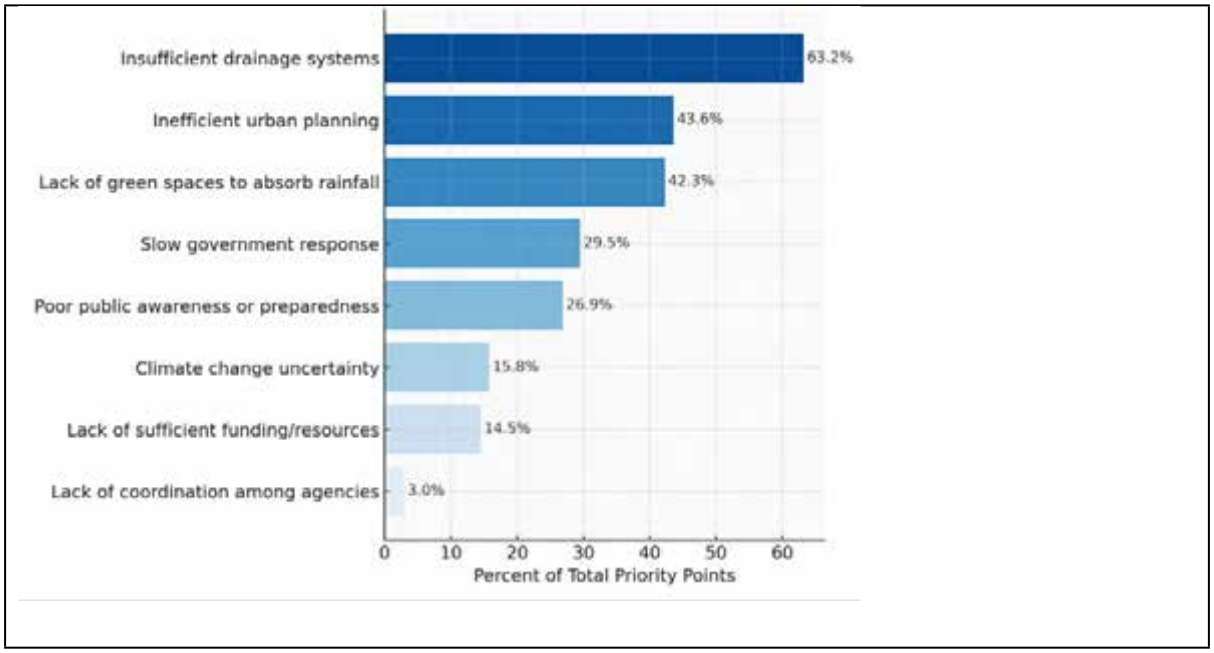

Figure X. Public ranking of top perceived flood management challenges

Crucially, the survey revealed a moderate willingness among residents to contribute financially to flood mitigation initiatives. Around 26 percent of respondents were willing to pay additional monthly taxes to support Sponge City measures, especially when the anticipated benefits were made transparent. However, many remained undecided, citing concerns about cost distribution and governmental accountability. These findings underscore the importance of transparent financing frameworks and communication strategies in securing long-term public support. Among all respondents, willing to pay or not, there was a strong agreeance for permeable payments, which while a strong sponge city intervention, does go against the researchers thinking that respondents would prefer green infrastructure developments. However, that said, as seen in Figure X below, the agreement does remain strong across all levels.

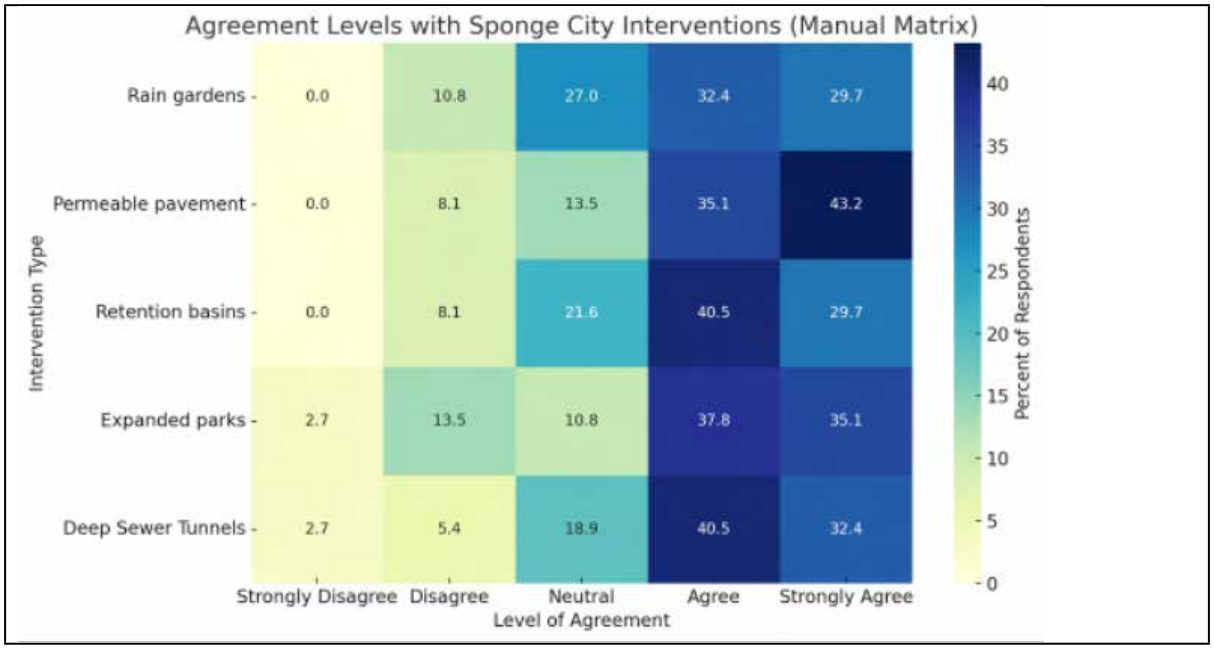

Figure X. Heatmap showing public support for specific Sponge City interventions

4.4. Institutional Readiness and Governance Barriers

Semi-structured consultations with municipal officials and planning practitioners highlighted both awareness of Gangnam's flood vulnerabilities and recognition of the limitations of existing governance structures. Participants cited fragmented responsibilities among departments, difficulties in retrofitting existing developments, and a lack of financial incentives for private developers as major constraints to Sponge City implementation.

While there is growing interest in adopting green infrastructure, current regulatory frameworks do not adequately incentivise or mandate its integration. Additionally, competition over limited urban space and jurisdictional overlaps between environmental and planning authorities present obstacles to coordinated action. Officials noted that without clearer national guidelines or earmarked funding, large-scale implementation of Sponge City strategies would be difficult to operationalise.

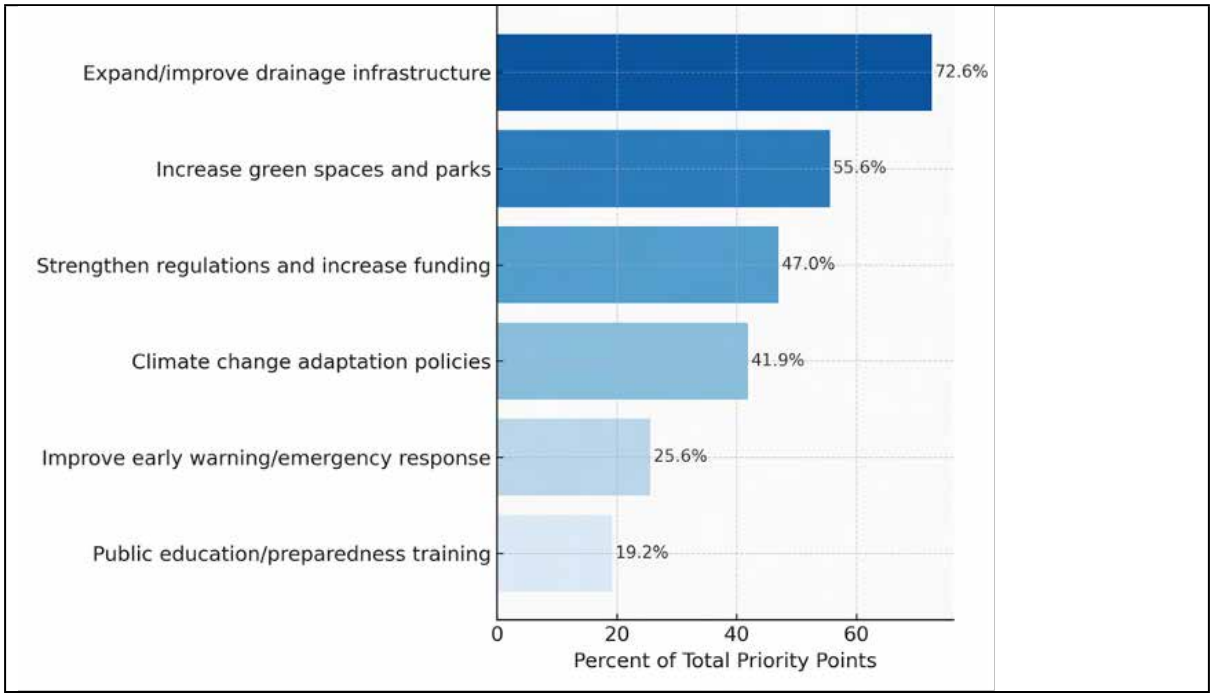

Figure X. Public preferences for improved flood resilience strategies

5. Discussion: Towards a Flood-Resilient and Sustainable Gangnam

The findings from this study provide compelling evidence that a hybrid flood mitigation strategy—integrating Sponge City principles with engineered drainage systems—can offer significant resilience benefits for Gangnam. Yet the success of such a transition is not solely dependent on technical efficacy. It requires coordinated planning, adaptive governance, and deliberate efforts to align infrastructure investment with public values and spatial equity.

5.1. Integrating Green and Grey Infrastructure in Urban Planning

The modeling results clearly demonstrate that neither green nor grey infrastructure alone is sufficient to address Gangnam's diverse flooding risks. While the DTSS is critical for managing large-volume storm events, it cannot address the more frequent, localised floods caused by everyday rainfall. Conversely, Sponge City interventions such as bioswales, permeable pavements, and detention areas are highly effective for mitigating surface runoff, but offer limited benefit during extreme events.

Urban planners should therefore prioritise a dual strategy: allocating large-scale investments toward the DTSS while simultaneously incorporating decentralised green infrastructure across the urban surface. This approach allows for tiered flood defense—absorbing, storing, and diverting water through multiple systems operating at different scales. Priority should be given to retrofitting high-risk corridors near transit hubs and commercial zones, using geospatial analysis to target interventions precisely, rather than implementing social and financing aspects of Sponge City concept uniformly due to Seoul's limited available area. In doing so, urban flood management should transition from a reactive drainage model to a proactive, spatially embedded strategy, to optimize resource allocation and maximize site-specific benefits.

5.2. Addressing Governance and Implementation Barriers

Despite technical feasibility, institutional inertia remains a key barrier to Sponge City adoption. The current division of responsibilities across Seoul's municipal agencies creates fragmentation in planning, budgeting, and execution. This is exacerbated by weak enforcement mechanisms, especially regarding the integration of green infrastructure into private developments.

Policy reform is essential. Urban planning regulations and building codes should be updated to mandate green infrastructure in both new developments and significant renovations. This can be facilitated through density bonuses, development incentives, or mandatory "greensurface ratios" that ensure minimum levels of permeability on each parcel. In dense districts like Gangnam, policies must also account for spatial constraints by allowing green infrastructure to be implemented creatively—e.g., through green alleys, parklets, rooftop gardens, and bioswales integrated into streetscapes.

In parallel, a coordinating body or task force should be established to unify efforts across planning, environment, and transportation departments. Such an entity would be responsible for standard-setting, monitoring, and managing cross-sector funding for hybrid infrastructure. Drawing lessons from European SuDS implementation and China's national Sponge City program, it is evident that without an institutional backbone, green infrastructure efforts tend to remain fragmented and underfunded.

5.3. Financing and Public Engagement as Cornerstones of Resilience

While a portion of Gangnam residents surveyed expressed the willingness to pay for Sponge City implementation, sustained financial support will depend on transparent, equitable, and accountable financing mechanisms. Public trust in local government was moderate at best, suggesting that confidence-building must precede any tax-based funding initiative. Urban planners and city governments must therefore adopt participatory budgeting strategies that involve residents in decision-making and clearly communicate how funds will be used and maintained over time.

Specifically, the external and internal incentives can be implemented by promoting nature-based infrastructure adoption among developers because the Gangnam and Seocho 2-dong district is composed of highly developed buildings. External incentives are divided into financial and non-financial incentives. Crispi and Abubakar (2022) claims that "Economic incentives that can facilitate uptake of adaptation activities include tax waivers, direct grants, municipal property tax rate reduction, tax abatements for infill development". Similarly, the non-financial incentives can be indicated that developers can receive it such as on their construction permission for higher buildings and increased density per land area in exchange for providing something beneficial to the public (Crispi and Abubakar 2022). On the other hand, internal incentives are motivated internally such as human well-being, market demand, and gratification related, which focus on internal motivations, not derived from external factors (Olubunmi et al., 2016).

Beyond financing, citizen engagement is crucial for long-term legitimacy. Planning processes should include mechanisms for co-designing interventions with communities, especially in areas where space is contested or perceived benefits are unclear. Equally, planners must recognise that green infrastructure provides not only environmental and hydraulic benefits but also contributes to public space quality, mental health, and environmental justice—co-benefits that should be integrated into cost-benefit analyses and planning narratives.

5.4. Spatial Equity and the Politics of Implementation

Finally, it is critical to address the unequal spatial distribution of both flood risk and mitigation resources. Green infrastructure should not be concentrated in affluent commercial zones or high-visibility flagship projects, but must be equitably distributed across residential areas, including vulnerable and under-resourced communities. This requires planners to develop spatial equity criteria that prioritise areas with limited existing green space, high exposure, and socio-economic vulnerability.

A resilience strategy that fails to address spatial justice risks reinforcing existing inequalities.The Sponge City framework, if implemented thoughtfully, offers an opportunity to reshape Gangnam's urban form toward a more just, inclusive, and ecologically resilient future.

Furthermore, inconsistency of politics in changing GI infrastructure policies lead to weak GI application. Enforcement policy is needed to enhance and emphasize the GI implementation in the highly urbanized city, Gangnam, offering more rapid and fast putting in GI.

6. Conclusion:

This study has demonstrated that the escalating risks of urban flooding in Gangnam, Seoul, cannot be addressed through conventional grey infrastructure alone. As the 2022 flood event illustrated, Gangnam's dense urban fabric, low-lying geography, and legacy drainage systems render it particularly vulnerable to climate-induced rainfall extremes. To mitigate these risks and build long-term resilience, an integrated approach is needed—one that blends engineered systems like the Deep Tunnel Sewer System (DTSS) with decentralised, nature-based interventions rooted in Sponge City principles.

Through a mixed-methods analysis combining spatial modeling, SHAP-informed feature interpretation, flood simulations, and stakeholder engagement, this research identified both the physical and institutional conditions necessary for effective implementation. Spatial analysis revealed that flood vulnerability clusters around areas of high building density, impervious land cover, and inadequate drainage. Simulation modeling showed that hybrid strategies significantly outperform single-mode interventions, reducing runoff and inundation under both frequent and extreme rainfall scenarios. Survey results and interviews further confirmed public interest in green infrastructure, though tempered by concerns over cost, trust in governance, and policy clarity.

These findings point to three key pathways forward. First, planning policy must mandate and incentivise green infrastructure, not as an aesthetic supplement, but as core urban infrastructure. Second, governance structures must be reformed to ensure inter-agency coordination, regulatory clarity, and implementation capacity. Third, meaningful public engagement and participatory planning processes must be embedded within infrastructure development to ensure legitimacy, equity, and long-term stewardship.

However, the high cost of real estate in Gangnam presents a significant barrier to Sponge City implementation, particularly in securing space for green infrastructure. Therefore, realistic budget analysis and land use strategies are encouraged to be combined. Future studies may include a scenario-based economic analysis that incorporates actual budget items for Gangnam-gu, public-private cost-sharing ratios, and average costs per LID unit installed.

The Gangnam case underscores a broader lesson applicable to many high-density cities across Asia and beyond: resilience is not merely a technical challenge, but a socio-spatial and governance imperative. Sponge City principles offer a powerful framework for rethinking the relationship between water, infrastructure, and urban space—but their success depends on more than design. It demands a planning paradigm shift toward preventative, adaptive, and community-supported systems.

Future research should continue to refine scenario-based planning tools that incorporate both quantitative and qualitative data, evaluate long-term maintenance and life-cycle costs of green infrastructure, and test co-production models that integrate citizens into the design and monitoring of urban resilience interventions. By advancing such interdisciplinary planning approaches, cities like Seoul can move beyond flood response toward transformation—designing not only to survive climate uncertainty, but to thrive within it.

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Flood Risk Perception Under the Levee Effect: Adaptive Management Strategies for Heterogeneous Individuals

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Abstract
As climate change leads to increasingly frequent extreme rainfall events, the risk of urban flooding disasters is rising. Urban areas commonly adopt structural flood control measures to mitigate flood risks. However, this may create a "levee effect," giving residents a false sense of security and promoting development in high-risk areas, ultimately increasing long-term risks. This study takes Tainan City as an example, using a literature review and spatial analysis to identify potential areas affected by the levee effect. A stratified random sampling method is employed for a questionnaire survey, followed by cross-analysis to explore the differences in risk perception among different groups. The research aims to enhance risk awareness, promote practical response actions, and provide references for adaptation strategies and policy planning.

Keywords: Levee Effect, Risk Perception, Adaptive Strategies, Flood Risk Management, Cross-tabulation Analysis

1. Introduction

As climate change increases the frequency of extreme rainfall events, which are becoming increasingly normalized, urban flooding disasters are becoming more severe, directly threatening the safety of residents' lives and property. In response to the rising risk of flooding, urban areas tend to adopt structural flood control engineering facilities, aiming to effectively mitigate the impact during flood events and ensure that cities do not experience flooding.

However, research indicates that these flood-prone areas often create a false sense of security among people, as urban managers rely on structural measures that can show significant improvements in the short term. This leads to the misconception that flood control projects can provide absolute protection while failing to recognize that, in the context of long-term changes due to climate change, the protective standards of flood control projects and facilities have technical and cost limitations. The reliance on structural measures can shift people's perception of flood risk, potentially accelerating development in high-risk areas and ultimately increasing long-term risk. This contradictory phenomenon is referred to as the "levee effect" (Burby,2006; Collenteur et al., 2015).

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report emphasizes that future adaptation efforts must shift from short-term disaster response and incremental adjustments to the current system to long-term transformative adaptation that can change the fundamental characteristics of social-ecological systems. This also signifies the importance of transitioning flood risk management from structural to non-structural measures. Risk perception, as a subjective assessment of the likelihood of threats and potential damages(Grothmann & Reusswig, 2006)and reduce the need for public risk management. But, research on the determinants of private households' prevention of damage by natural hazards is rare, especially in Germany. To answer the question of why some people take precautionary action while others do not, a socio-psychological model based on Protection Motivation Theory (PMT , is considered a core element in formulating effective flood management strategies (Kellens et al., 2011). Human dynamic behaviour plays a crucial role in flood risk management, and the dynamic changes in risk perception, attitudes, and adaptive behaviour are areas that current research urgently needs to deepen (Bubeck et al., 2012).

Although the concept of the levee effect has been widely discussed, the universality of its impact on changes in risk perception and whether it creates a similar "illusion" for everyone still requires further exploration. Individual differences in conditions, such as education level, age, socioeconomic background, and past disaster experienc-

es, have been shown to significantly influence personal risk assessment(Babcicky & Seebauer, 2017; Grothmann & Reusswig, 2006). In past discussions of the levee effect, it has often been directly concluded that flood control and disaster reduction measures lead to a decrease in risk perception, with less consideration given to how individual differences may play a moderating role in risk perception. As a result, the varying degrees to which flood control measures affect risk perception across different groups may have been overlooked, or it may not be the primary factor influencing their risk perception.

This study aims to re-examine the relationship between the levee effect and risk perception, considering individual differences in areas potentially affected by the levee effect. It explores the cognitive differences among various groups when facing flood risks to develop appropriate adaptive strategies for different groups. The empirical research will be conducted in Tainan, Taiwan. First, a systematic literature review will be carried out to organize relevant risk perceptions and risk measurement indicators from past flood management, which will inform the design of the questionnaire. Second, spatial analysis will be used to identify potential levee effect areas, and a stratified random sampling survey will be conducted in those areas. The survey results will be analysed through cross-analysis to compare the differences in risk perception and influencing factors among different groups. The goal is to promote more precise risk management and flood prevention behaviours in the future, enabling effective responses to flood risks. This can serve as a reference for adaptive management and planning policies, enhancing residents' awareness of flood risks.

2. Discussion on the levee effect and flood risk

2.1 Basic Concepts of Disaster Risk Management

This study takes "disaster risk and risk management" as the core perspective for exploring flood disasters. First, it follows the definitions provided by the United Nations Office for Disaster Risk Reduction (UNISDR, 2016) to define the core concepts.

Table 1: Definition of related terms

Disaster Risk	The potential loss of life, injury, or destroyed or damaged assets that could occur to a system, society, or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability, and capacity. 1. Hazard: A dangerous phenomenon, substance, human activity, or condition that may cause loss of life, injury, or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. 2. Vulnerability: The conditions determined by physical, social, economic, and environmental factors or processes that increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards. 3. Exposure: The situation of people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area. 4. Capacity: The combination of all the strengths, attributes, and resources available within an organisation, community, or society to manage and reduce disaster risks and strengthen resilience. Capacity may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management.

Hazard	A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. The mere occurrence of a flood event (hazard) does not constitute a flood disaster; only when the flood causes actual damage to social or environmental systems, such as loss of life or property, can it be called a disaster.
Residual Risk	The disaster risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.
Disaster Risk Management	The application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk, and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.
Disaster Risk Reduction, DRR	Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development. Disaster risk reduction can be divided into structural, which includes the application of engineering techniques such as dams and levees, and non-structural, which includes building codes, land-use planning laws and their enforcement, research and assessment, information resources, and public awareness programmes.

2.2 The Levee Effect in Flood-Prone Areas

The "Levee Effect" is a phenomenon of concern in the field of flood management, originating from White's (1958) study on land use in the floodplains of the United States. White pointed out that while flood control projects reduce the frequency of flood disasters, they also create a false sense of security, which encourages urban development and the concentration of population and assets in floodplain areas, thereby forming new potential sources of risk (White, 1958). In the context of industrialization , the sense of security provided by flood control projects has led to the gradual neglect of the fact that "engineering measures have their limits, and residual risks always exist". Therefore, the continuous increase in flood damage is primarily not due to an increase in the frequency or intensity of floods, but rather because flood control projects enhance the value of floodplain locations, leading to urban expansion and increasing the exposure of assets and populations, which in turn raises long-term flood disaster risks(Deeming et al., 2012) .

The "false sense of security" created by flood control projects often stems from an overreliance on these engineering solutions, leading to accelerated land development and urbanization. Under this perception, originally protected areas gradually transformed into "safe" areas, resulting in increased population migration and more prosperous commercial activities (Burby, 2006). Parker and Tapsell (2009) describe this phenomenon as the "Escalator Effect," which means that while flood control measures can effectively manage high-frequency, low-intensity flood events, they may significantly increase disaster losses when low-frequency, high-intensity events occur. Burby (2006) uses Hurricane Katrina's devastating impact on New Orleans as an example, emphasizing that the government's structural disaster reduction strategies and insurance systems have facilitated the expansion of high-risk areas, creating the "Safe Development Paradox," which ultimately exacerbates the severity of disasters.

The levee effect is not limited to the levees themselves; any measures taken through flood control projects to reduce disaster risks may produce similar effects. This phenomenon is commonly observed in floodplains with a "lack of effective land use regulation" (Parker, 1995). Research by Kuo et al. (2015) shows that residents of Benhe Village in Kaohsiung, due to the effective flood reduction provided by a retention pond during Typhoon Morakot,

became complacent about subsequent disaster preparedness. As a result, they faced greater losses during Typhoon Fanapi, confirming that other types of structural flood control measures can also lead to similar outcomes.

In the context of extreme rainfall events caused by climate change, areas with high exposure may face catastrophic losses that exceed expectations when encountering extreme flood events that surpass the design standards of flood control. These areas may experience more severe socio-economic impacts and long-term population effects than unprotected regions.

Therefore, the core issue of the levee effect, in addition to the lack of appropriate and continuous land use management and spatial planning constraints, also highlights the complex dynamic relationship between human society and natural hydrological systems, referred to as "coupled human-water systems." However, existing flood risk assessments often overlook the interactions between human behaviour and hydrological systems, failing to capture the long-term impacts of policies on behaviour and risk dynamics (Kuhlicke et al., 2020)we argue that these changes represent a wider behavioral turn in flood risk management (FRM. Consequently, flood prevention strategies cannot solely rely on single structural measures. From a long-term perspective, contemporary flood risk management must go beyond engineering thinking and shift towards a more comprehensive understanding of risk and adaptive strategies.

2.3 Characteristics of Flood Risk Due to Levee Effects

2.3.1 Harm Reduction

Structural flood control measures primarily target the "harm" aspect of risk, directly reducing potential casualties, property losses, and socio-economic activities by decreasing flood events. As illustrated in Fig. 1, the Farmer's curve is used in disaster risk reduction research to illustrate the relationship between the frequency and intensity of disaster events, which follows a power law distribution and exhibits an inverse relationship. After the construction of flood control projects, the actual disasters that occur will be low-frequency but high-intensity, harmful events. Since such events occur less frequently, there will be a phenomenon of reduced flooding and improvement in the short term (Renaud et al., 2013).

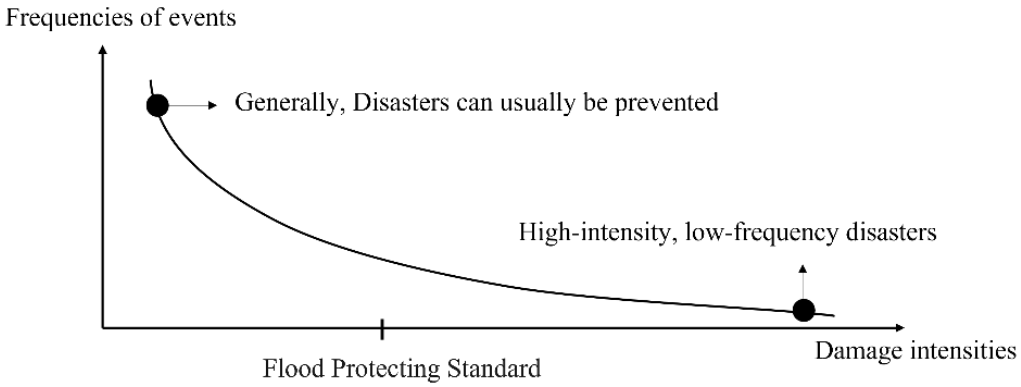

Fig. 1. The Relationship Between Farmer's Curve and Disaster Events

2.3.2 Spatial Concentration and Increased Residual Risk

As flood control infrastructure becomes more complete, floodplain areas may attract more population and development activities, leading to a concentration of risks and the emergence of residual risks. In disaster risk management, residual risk is defined as "the disaster risk that cannot be managed even after effective measures to reduce disaster risk have been taken" (UNISDR, 2016).

The causes of residual risk, based on its operational definition, can be divided into two perspectives: one is that "perfect engineering design and maintenance can eliminate the risks of flood control projects," and the other

is that "there are limits to engineering design standards, and residual risks will inevitably exist in flood control projects" (Chang & Hsu, 2021; Domeneghetti et al., 2015; Pinter et al., 2016)

There is still a lack of understanding and management research on addressing residual flood fronts in studies related to levee effects. However, in flood risk management, residual risks are still challenging to identify independently, which slows down the transfer of knowledge between cases(Wang et al., 2024).

2.3.3 Conceptual Framework and Influencing Factors of Flood Risk Perception
In the integrated flood risk management framework, public risk perception is a key factor in promoting effective disaster preparedness behaviours and enhancing community resilience. Risk perception is not merely a passive reception of objective disaster data; rather, it is a complex and subjective psychological construction process that involves individuals' interpretation and evaluation of the likelihood of a disaster occurring and its potential consequences (Kellens et al., 2011).

Individual flood risk perception is a dynamic and multifaceted process. Traditional approaches often fail to account for the interactions between physical and human systems (Fig. 2, top). They thus cannot fully capture the evolving human responses to and interactions with levee effects. Changes in flood risk should be understood as the result of coupled dynamics between hydrological and social systems, involving continuous interactions and feedback loops between society and the physical environment. The formation and evolution of this perception are influenced by a wide range of internal and external factors (Fig. 2, bottom)(Di Baldassarre et al., 2015), and the heterogeneity of these factors forms the basis of individual differences in flood risk perception(Bubeck et al., 2012; Lechowska, 2018).

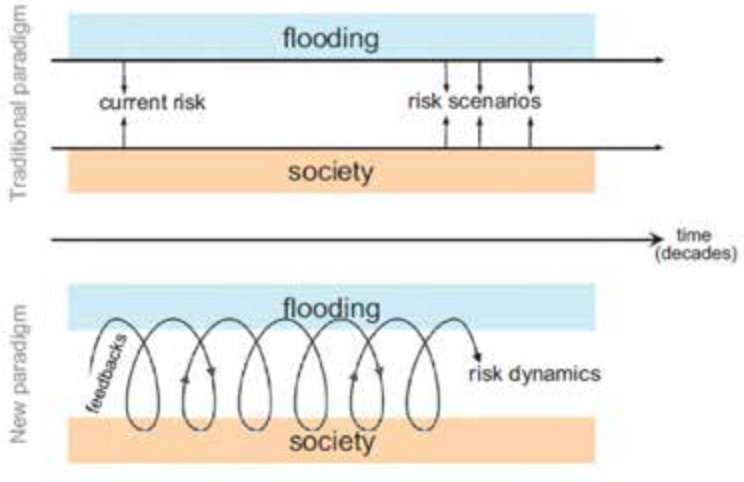

Fig. 2: Changes in Flood Risk
(Di Baldassarre et al., 2015)

Flood Risk Perception Influencing Factors :
a. Experiential Factors
An individual's direct or indirect experience with flooding is one of the most significant influences on risk perception. People who have experienced floods tend to perceive a higher level of threat, exhibit a stronger motivation to take adaptive actions, and consider themselves more vulnerable(Grothmann & Reusswig, 2006)and reduce the need for public risk management. But, research on the determinants of private households' prevention of damage by natural hazards is rare, especially in Germany. To answer the question of why some people take precautionary action while others do not, a socio-psychological model based on Protection Motivation Theory (PMT.

However, empirical studies also show that experience-based risk perception is not fixed—it tends to diminish over time, mainly when no subsequent disasters occur. Individuals may forget past impacts and underestimate future risks (Bubeck et al., 2012; Wachinger et al., 2013).

b. Socio-demographic Characteristics
Variables such as age, gender, education level, socioeconomic status (e.g., household income, occupation, property value), duration of residence, and place of household registration have all been widely shown to significantly influence personal risk assessments (Babcicky & Seebauer, 2017; Lechowska, 2022). For example, individuals with higher education levels are generally better at understanding complex risk information and the scientific basis of flood control infrastructure. Additionally, individuals from different socioeconomic backgrounds vary in vulnerability, resource access, and coping capacity.

c. Geographic and Environmental Exposure
The physical proximity of individuals to potential flood hazards, such as rivers or coastlines, the elevation of their location, and whether they live in officially designated floodplains or hazard-prone areas directly affect how exposed they perceive themselves to be (Ludy & Kondolf, 2012). These objective geographic features are transformed into subjective perceptions through everyday lived experience.

d. Knowledge and Information Access
An individual's knowledge of floods, understanding of the function and limitations of local flood control infrastructure, and awareness of official warnings and disaster preparedness information play a critical role in shaping risk perception. Effective risk communication must translate complex technical knowledge into accessible language for the public to reduce gaps in understanding (Kellens et al., 2011; Merz et al., 2009). Additionally, the credibility of information sources and the mode of dissemination (e.g., government, media, family and friends, or social media) significantly influence information acceptance and perception formation.

e. Social Influence and Social Capital
Social networks, community norms, trust in neighbors, and mutual assistance (i.e., social capital) indirectly influence individual risk perception by shaping how information is exchanged, how experiences are shared, and how collective behaviours form (Babcicky & Seebauer, 2017; De Dominicis et al., 2015). The perceptions of risk held by community members can reinforce each other and lead to collective interpretations.

f. Trust in Disaster Management Institutions
People tend to trust government agencies and experts perceived to possess disaster-related knowledge and to bear responsibility for reducing risk. However, the public often lacks a clear understanding of flood magnitudes and may not recognize the possibility of events exceeding infrastructure protection levels (Bradford et al., 2012). When land within protected areas is no longer officially recognized as flood-prone due to the presence of flood defenses, residents may continue living or working in such areas under the assumption that they are entirely safe. Governments, in turn, use tax revenue to protect these residents(Deeming et al., 2012). This mutually reinforcing relationship can increase public dependency on the government and reduce individual risk awareness.

These diverse and complex factors shape individuals' heterogeneous perceptions of flood risk. This subjectivity explains why the public's perception of risk often differs from the objective risk assessments made by experts based on scientific data(Glaus et al., 2020) . Research on the "risk perception paradox" indicates that people's judgments about risk are often influenced by intuition, emotions, and cognitive biases rather than being entirely rational; disaster risk perception is often composed of complex causal relationships and multiple intervening factors. For example, it is commonly believed that a higher perception of risk leads individuals to take protective actions. However, this is not necessarily true and still depends on various contextual factors, particularly personal memories of past losses or imaginations of disasters, which can influence individuals' actions.

At the same time, people's trust in managers also affects their risk perception (Wachinger et al., 2013). The study

by (Ludy & Kondolf, 2012) pointed out that even when most residents are well-educated professionals, new development projects in flood-prone areas can lead them to be unaware of the real flood risks they face, believing instead that a once-in-a-hundred-years levee can protect them from all floods. Therefore, the perception of flood risk is a complex process that requires a deep understanding of the interactions among these influencing factors.

3. Methodology

3.1 Research design-case study strategy

This study adopts a case study approach that integrates qualitative and quantitative methods, with Tainan City in Taiwan as the empirical study area. As one of the core metropolitan cities in southern Taiwan, Tainan has experienced rapid urbanization and has invested significantly in flood mitigation infrastructure, conditions that make it a likely context for the emergence of the levee effect. Given that the levels of urban development and flood vulnerability vary across districts in Tainan, the study focuses on areas that have experienced severe flood events and exhibit high degrees of urbanization and centrality.

The quantitative analysis aims to assess changes in residual flood risk over time. Spatial analysis techniques are employed to identify the clustering of flood-prone points and examine changes in their spatial distribution. Specifically, global Moran's I is first applied to determine whether spatial clustering of flood events exists within specific periods. This is followed by using Local Indicators of Spatial Association (LISA) to explore local variations in spatial patterns, identifying the spatial relationships between each unit and its neighboring areas. These analyses define the potential spatial scope of the levee effect, within which qualitative questionnaire surveys are subsequently conducted.

3.2 Background of the study area

After the major infrastructure works under Tainan City's 2006 "Flood-Prone Area Mitigation Project" were completed, significant changes in land use and urban development patterns were observed in certain areas, such as Yusheng Village in the East District and Sanjia Village in Rende District. These areas have since been identified as potential zones exhibiting the levee effect (Chang & Hsu, 2021).

In recent years, due to the increasing influence of extreme climate events, statistics from the Water Resources Bureau show that rainfall in 37 districts of Tainan has exceeded the design standards of local drainage systems, resulting in flooding. Moreover, compared to previous typhoon events, the cumulative rainfall over 1-hour, 3-hour, and 24-hour periods in flatland areas has surpassed the levels recorded during Typhoon Morakot—the most recent major flood disaster in Taiwan (see Table 1). This indicates that areas potentially affected by the levee effect also face residual flood risk issues.

Table 2. Accumulated Rainfall from Major Precipitation Events in Tainan (mm)

Maximum Accumulated Rainfall	2009 Typhoon Morakot		2018/08/23 Heavy Rain		2024 Typhoon Koinu	
	plain	Mountain area	plain	Mountain area	plain	Mountain area
1 hour	86.0	107.5	77	92.0	120.0	105.5
3 hour	159.0	286.0	173	195.0	205.0	191.0
6 hour	245.0	417.5	294	316.5	276.0	294.0
12 hour	391.5	692.5	438	458.0	370.5	535.0
24 hour	594.0	1089.5	735	843.5	567.5	919.0
Total Accumulated Rainfall	799.5	2316.0	827	923.5	881.0	1340.5

Source: Tainan City Government

3.3 Data collection and analysis

3.3.1 Questionnaire Design

This study draws upon existing literature on flood risk perception to design a comprehensive questionnaire that integrates various dimensions of how the levee effect influences risk perception. The questionnaire is structured into five main sections (Table 3).

In addition, given that flood control infrastructure and flood-related adaptive measures significantly impact both the development and risk profiles of flood-prone urban areas, a mismatch between the expected outcomes of these measures and the adaptive behaviours of individuals may lead to what is referred to as the "adaptation gap" (Aerts et al., 2024). Therefore, this study incorporates the concept of adaptation constraints into the questionnaire to further explore the extent to which residents are willing to accept flood risks and how much effort they are prepared to invest in mitigating them. This approach allows for an in-depth examination of the potential factors that contribute to the emergence of adaptation gaps.

3.3.2 Sampling Method

The questionnaire survey will be conducted in areas identified through spatial analysis as potentially affected by the levee effect. This study adopts a stratified random sampling approach to ensure the representativeness of the responses and the generalizability of the findings. The sampling design aims to adequately include geographically distinct strata related to the levee effect, specifically, (1) areas where flooding has been alleviated but residual risk has increased, and (2) areas where both residual risk and flood severity remain high. At least 400 residents will be surveyed, with 200 respondents selected from each stratum, to ensure sufficient data coverage and diversity.

3.3.3 Data Analysis Method

This study employs cross-tabulation analysis as an initial exploratory tool to examine the distributional differences of key categorical variables across different spatial strata related to the levee effect. This analysis provides critical preliminary insights , enabling a more comprehensive understanding of how the levee effect influences residents' risk perceptions and adaptive behaviours.

Table 3. Questions and their justification

Category	Question	Purpose
Flood Experience	During your time living in this village, have you ever experienced flooding caused by typhoons or heavy rainfall?	To understand whether respondents have experienced flood disasters in the past, and how these experiences have influenced their daily life and perception of flood severity.
	Have these flood events caused inconvenience in your daily life (e.g., health or property damage, commuting disruptions)?	
	How long has it been since you last experienced a flood disaster?	
	In recent years, Tainan City has implemented several flood mitigation projects. How has the severity of flooding near your home changed?	
	To what extent has flooding impacted your quality of daily life?	

Perceived Impact of Flooding	To what extent do you think flooding affects your personal safety?	To assess the respondent's subjective perception of the potential impacts of flooding, especially its effects on personal safety, property, and quality of daily life.
	To what extent do you think flooding affects your personal property?	
	To what extent do you think flooding affects your quality of daily life?	
Flood Risk Perception	I am aware that I live in a flood-prone area.	To explore respondents' subjective assessment of flood risk, including awareness of flood-prone conditions, perceived future risk, the impact of flood defenses, and confidence in individual and public preparedness.
	I believe there is a high possibility of flooding in my residential area in the future.	
	I feel less worried about floods because of the presence of flood control measures (e.g., levees).	
	Since the construction of flood control measures (e.g., levees), I believe the likelihood of flooding in my area has decreased.	
	I understand the flood prevention actions I can take in advance.	
	I believe that preventive actions taken before a flood can reduce flood-related losses.	
	I believe the government has the capacity to effectively manage flood disasters.	
	I believe the government provides sufficient information about the flood risks in my residential area.	
	I believe the government will take all necessary measures to protect me from flooding.	
	I believe the government fully considers flood risks when approving new developments or planning land use.	

Flood Risk Acceptability	What level of flood risk do you personally find acceptable?	To assess the respondent's willingness to accept various levels of flood risk, how much they are willing to invest to reduce risk, and their sense of responsibility in managing flood risk.
	If your home is located in a flood-prone area, how much would you be willing to spend to reduce flood risk?	
	Do you believe individuals have a personal responsibility to take action to reduce flood risk?	
	Under what circumstances would you consider relocating from your current residence?	
Socio-demographic Characteristics	What is your age?	To collect basic demographic information for analyzing how individual heterogeneity influences flood risk perception and behaviour.
	What is your gender?	
	How long have you lived in this area?	
	What is your highest level of education?	
	What is your approximate monthly household income?	

Expected Results

4.1 Risk Perception Heterogeneity under the Levee Effect

This study anticipates that individual flood experience, socio-demographic characteristics, and the level of trust in government-led flood management measures will significantly influence perceived flood risk. Through stratified random sampling, the study distinguishes between two types of areas: those where flooding has been alleviated but residual risk has increased and those where both flood severity and residual risk remain high. By comparing different groups, the study seeks to identify variations in flood experience perception, trust in government, and overall risk perception levels. This serves as a preliminary response to the hypothesis that the impact of levee effects on risk perception is not uniformly consistent across all populations.

4.2 Preliminary Insights on "Adaptation Gap"

This study incorporates the concept of adaptation limits in the questionnaire design, aiming to explore the public's acceptable level of flood risk and their willingness to make efforts to mitigate that risk. It is anticipated that potential cognitive factors leading to the "adaptation gap" will be identified from the collected data. These factors may include, but are not limited to, overestimating the effectiveness of structural flood control measures, underestimating personal responsibility, or overly relying on government.

5. Conclusion

This study addresses the long-standing oversight of individual heterogeneity in flood risk management by re-examining the complex interplay between the levee effect and flood risk perception. The potential distinctions of the levee effect are categorized into two types: "flooding situations are mitigated, but residual risk increases, and "flooding situations remain severe while residual risk continues to rise. This categorization reflects the diverse impacts of levee construction on actual flood scenarios under varying circumstances and explores the heterogeneity in flood risk perception among residents living in these environments.

Through empirical investigation, this study aims to uncover how residents' flood experiences, socio-demographic characteristics, and levels of trust in government disaster prevention measures collectively influence their perception and assessment of flood risk across various risk environments shaped by structural flood control interventions. However, merely enhancing risk awareness may be inadequate; if residents have a high tolerance for risk, they may still hesitate to take action despite acknowledging the threat. Therefore, it is crucial to examine variations in risk tolerance to gain a deeper understanding of the formation of adaptation gaps.This research aims to identify the social, psychological, and cognitive mechanisms underlying these heterogeneities, moving beyond the limitations of traditional "one-size-fits-all" flood control strategies. The goal is to develop differentiated policy designs tailored to groups with varying characteristics in the future. This approach will facilitate more precise risk management and flood prevention behaviours, serving as a reference for adaptation management and planning strategies.

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What Are the Obstacles in the Recovery Process Considering the Role of Actors? The Case of the Kahramanmaraş Earthquake in Turkey

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Abstract
The earthquakes centred in Kahramanmaraş on 6 February 2023 revealed profound structural and institutional vulnerabilities in Turkey's disaster management system. This study explores the post-disaster recovery efforts in Hatay and Adıyaman, focusing on the difficulties encountered by central and local governments, NGOs, international organisations, and community-based actors. Employing qualitative content analysis, the research demonstrates that the highly centralised governance structure restricts local adaptability and participation, resulting in spatial injustices and widespread institutional distrust. The findings underscore that recovery must extend beyond technical reconstruction and be guided by inclusive, multi-actor, and transparent governance approaches. Strengthening local institutional capacity and ensuring the meaningful integration of civil society and diverse actors into the recovery process are essential for building long-term resilience.

Keywords: Recovery; earthquake; actors; institutional hierarchy; Turkey

Introduction

Earthquakes are disasters that not only cause physical destruction but also disrupt social, economic, and institutional systems. Due to its location on active fault lines, Turkey frequently experiences earthquakes, which continuously challenge its disaster management capacity and reconstruction processes. The two major earthquakes that struck on 6 February 2023, centred in Kahramanmaraş and directly affecting 11 provinces, brought about severe difficulties not only on a physical level but also at institutional and societal levels. This disaster affected approximately 13.5 million people, resulted in the displacement of around 3.3 million individuals, and caused an economic loss exceeding 87 billion USD (Turkish Enterprise and Business Confederation [TÜRKONFED], 2023).

The post-disaster recovery process entails not only the reconstruction of destroyed infrastructure but also the restoration of the social fabric, the revitalisation of economic activities, and the rebuilding of governance capacity (UNDRR, 2015). In this process, coordinated action among actors at different levels—central and local governments, civil society organisations, international aid agencies, and community-based structures—is essential for effective recovery. However, Turkey's disaster management system largely operates through centralised structures, often limiting the roles of local actors.

The primary aim of this study is to examine the roles of actors involved in the recovery process following the Kahramanmaraş earthquakes and to identify the main obstacles encountered during this process. In this context, the research focuses on the following question: What challenges did the actors involved in the post-earthquake recovery process face, and how did these challenges affect the effectiveness of the process?

The study adopts qualitative content analysis as its research method. Within this framework, academic publications, official reports, documents produced by local administrations and NGOs, and media content related to the aftermath of the earthquakes were examined. Through the analysis of discursive and thematic patterns, findings were obtained regarding the roles of various actors, the institutional and structural challenges they encountered, their positions in decision-making processes, and the forms of interaction between them.

The article consists of five main sections. First, the literature review will discuss post-disaster recovery processes and actor-based governance approaches. The second section will explain the research methodology based on

content analysis. The third section will address the heterogeneity of the regions affected by the Kahramanmaraş-centred earthquakes. The fourth section will present the contextual framework of the study by describing the socio-economic and spatial characteristics of the two most affected provinces. The fifth section will focus on the findings obtained through thematic analysis, highlighting the challenges faced and the roles of different actors. In the final section, an evaluation of the findings will be provided, along with policy recommendations for an actor-based and inclusive recovery process.

1. Theoretical Framework and Literature Review

Post-disaster recovery processes are generally addressed in the literature in two main phases: short-term and long-term recovery. While short-term recovery refers to response-oriented processes such as search and rescue, emergency aid, and temporary shelter, long-term recovery involves not only physical reconstruction but also the restoration or more resilient rebuilding of social and economic systems (UNDRR, 2015). The success of these processes depends not only on the optimal use of financial resources but also on the ability of institutions and communities to develop strategies that enhance post-disaster resilience.

At this point, the concepts of resilience and adaptation come to the forefront in evaluating post-disaster recovery processes. Resilience refers to the capacity of societies or systems to withstand crises and recover rapidly (Cutter et al., 2008), whereas adaptation highlights the ability of these systems to adjust to changing conditions following such crises (Adger et al., 2005). Considering the diversity and complexity of disaster impacts across different spatial contexts, it becomes essential to examine these two concepts together.

Recovery processes are shaped not only by theoretical principles but also by the roles of the actors involved. Disaster management is considered a multi-actor domain; the relationships among central governments, local administrations, civil society organisations (CSOs), international agencies, and local communities directly influence the success of recovery. In this regard, the literature emphasises the multi-actor governance model, which prioritises the participation and collaboration of diverse stakeholders in decision-making processes, based on the principles of transparency, inclusiveness, and accountability (Ansell & Gash, 2008). The effective implementation of this governance model is directly dependent on institutional capacity. Kapucu (2008) stresses that the capacities of institutions involved in disaster management are shaped by factors such as access to information, resource mobilisation, coordination ability, and decision-making skills during crises.

In the Turkish context, disaster management has long been structured through centralised mechanisms. This centralisation has limited the participation of local authorities in decision-making processes and exacerbated coordination problems in post-disaster interventions. The formation and operation of such centralised institutions and their structural limitations have been observed in Turkey's past disaster experiences. For instance, the 1999 Marmara Earthquake triggered a major transformation in Turkey's disaster management system; in its aftermath, new institutional structures such as AFAD were established, and response coordination was consolidated under a single central authority (Ergünay, 2001). However, similar coordination problems, as well as imbalances in temporary shelter and resource distribution, were also noted in the 2011 Van and 2020 Elazığ earthquakes. These examples indicate that although institutional transformation in Turkey's disaster management system has begun, the capacity for multi-actor governance remains underdeveloped.

While the disaster management literature broadly discusses governance models, institutional capacities, and inter-actor collaboration, it often fails to address in sufficient depth the spatially differentiated roles of actors and how these roles manifest on the ground—especially in disasters affecting extensive and diverse geographies. Existing studies tend to focus on institutional actors at the macro level, with limited attention to local implementation patterns, variations shaped by local needs, and disparities in the capacities of local actors. In large-scale disasters such as the 6 February 2023 Kahramanmaraş earthquakes, which occurred in a socio-economically and spatially heterogeneous region, such comparative analyses are particularly significant. Given Turkey's multi-centred structure, regional disparities, and administrative differences, it is evident that the recovery process unfolds differently across provinces and actors.

This study aims to contribute to the existing literature by analysing the coordination deficiencies, institutional and structural obstacles, and functioning of multi-actor governance mechanisms in recovery processes across different provinces following the Kahramanmaraş earthquakes. In doing so, it not only proposes an actor-focused framework but also offers a comparative assessment of recovery practices shaped by different regional contexts, providing a critical contribution to the understanding of post-disaster governance in Turkey.

2. Method

This study aims to analyse the division of responsibilities, institutional visibility, and levels of collaboration among actors involved in the recovery processes across various provinces affected by the Kahramanmaraş earthquakes of 6 February 2023. In this context, content analysis was chosen as the primary method for data interpretation.

Content analysis is a qualitative data analysis technique that enables the systematic and objective examination of written or verbal materials. Through this method, hidden structures, patterns, and themes within texts relating to social phenomena can be revealed (Sheydayi and Dadashpoor, 2023). The approach adopted in this study was preferred for its ability to reconstruct statements from diverse sources within a coherent thematic framework. Content analysis includes both the explicit meanings of texts and the latent meanings embedded between the lines.

During data collection, various types of textual documents related to the Kahramanmaraş earthquakes were utilised. These included official disaster reports from public institutions, statements by local administrations, evaluation reports from civil society organisations, and academic articles published in the aftermath. These sources reflect not only the interventions of central authorities but also those of local actors, volunteer groups, and international institutions.

Although all provinces affected by the Kahramanmaraş-centred earthquakes were considered within the analytical universe, Hatay and Adıyaman were selected as case studies for in-depth analysis. The selection was based on the severity of physical destruction and the challenges encountered during the recovery process. Hatay was among the most severely affected in terms of absolute destruction and population loss, while Adıyaman stood out due to its high rate of building collapse per unit and the impact on rural areas. Additionally, the administrative, spatial, and socio-economic differences between these two provinces enabled a comparative analysis. Thus, the study aims to evaluate the recovery process with sensitivity to regional contexts.

The data analysis was structured according to the four fundamental stages of content analysis: identification of meaning units, coding, categorisation, and thematic interpretation. Each document was first read in detail, and relevant passages were marked as “meaning units.” These units were then translated into explicit codes based on their conveyed messages. Codes were grouped by similarity to form subcategories and themes, allowing for a systematic identification of recurring structures and governance-related patterns in the recovery process.

To ensure the reliability of the study, the principle of transparency was observed during the analysis process. The coding process was carried out systematically by the researcher, and the resulting themes were compared with the existing literature to strengthen internal consistency. This approach aimed to reduce the potential subjectivity inherent in qualitative analysis, while maintaining a transparent and traceable research process.

Ethical use of data was also a key consideration throughout the research process. All textual sources were compiled from publicly available documents, and no personal data or confidential information was used. Additionally, all sources referenced in the study were properly cited.

In conclusion, this methodological approach offers a suitable analytical framework for understanding the multi-actor structures and regional differences in post-disaster recovery processes. In doing so, it enables a comprehensive evaluation of both social and institutional dynamics, and considers post-earthquake governance not

only from a technical but also from a socio-political perspective.

3. The Impact Area and Regional Heterogeneity of the Earthquake

The earthquakes centred in Kahramanmaraş on 6 February 2023 are regarded as among the most devastating disasters in the history of the Republic of Türkiye. The two major earthquakes, measuring 7.7 and 7.6 Mw, occurred in the districts of Pazarcık and Elbistan in Kahramanmaraş and directly affected 11 provinces, causing severe physical, social, and economic destruction across a vast area of 110,000 km² (Disaster and Emergency Management Authority [AFAD], 2023; EERI, 2023). As a result of the earthquakes, a total of 51,158 people lost their lives in these 11 provinces (Turkish Statistical Institute [TÜİK], 2023).

Hatay recorded the highest number of fatalities, with 19,795 deaths. It was followed by the epicentral province of Kahramanmaraş, where 11,828 individuals lost their lives. Among the 11 provinces, the lowest number of fatalities was recorded in Kilis, with 107 deaths. Although Hatay reported the highest absolute death toll, Adıyaman had the highest relative fatality rate, with deaths amounting to 1.34% of its 2022 population. Across all affected provinces, the average fatality rate was recorded at 0.35% (Turkish Statistical Institute [TÜİK], 2023).

Table 1 Number of Fatalities and Their Percentage to the 2022 Population in the 11 Earthquake-Affected Provinces (Turkish Statistical Institute [TÜİK], 2023)

Province	2022 Population	Number of Fatalities	Fatalities as a Percentage of the 2022 Population
Hatay	1 686 043	19795	%1,17
Kahramanmaraş	1 177 436	11828	%1,00
Adıyaman	635 169	8523	%1,34
Gaziantep	2 154 051	4309	%0,20
Adana	2 274 106	1756	%0,08
Malatya	812 580	1626	%0,20
Osmaniye	559 405	1080	%0,19
Diyarbakır	1 804 880	968	%0,05
Şanlıurfa	2 170 110	829	%0,04
Elazığ	591 497	337	%0,06
Kilis	559 405	107	%0,02
Total	**14424682**	**51158**	%0,35

In addition to the human losses, 518,809 residential buildings were either destroyed or severely damaged, while a further 131,577 suffered moderate damage (Ministry of Environment, Urbanisation and Climate Change [ÇŞİDB], 2023). The extent of the damage varied significantly between provinces. Hatay was the province with the highest number of damaged or destroyed residences, followed by Kahramanmaraş. When the number of damaged and destroyed residences is evaluated as a proportion of the total housing stock in each province, Hatay ranks first with 60.22%, followed by Adıyaman with 52.45%.

Among the 11 affected provinces, Kilis reported the lowest number of damaged residences. However, the provinces with the lowest ratio of damaged or destroyed residences to the total housing stock were Adana and Şanlıurfa (Strategy and Budget Office of the Presidency [SBB], 2023; Ministry of Environment, Urbanisation and Climate Change [ÇŞİDB], 2023)

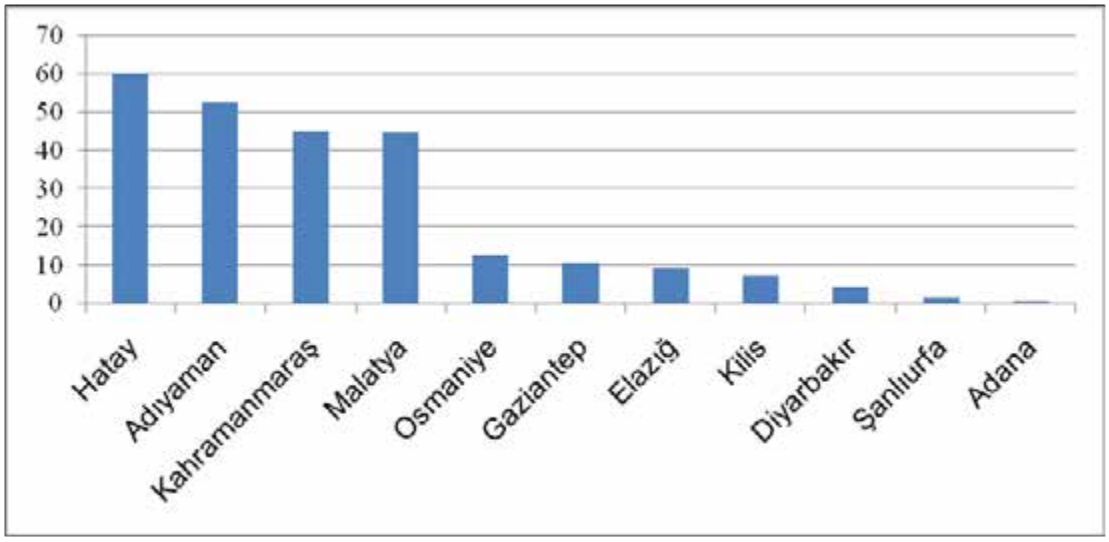

Figure 1 Percentage of Destroyed and Damaged Residential Buildings to the Total Housing Stock in the 11 Earthquake-Affected Provinces (Strategy and Budget Office of the Presidency [SBB], 2023; Ministry of Environment, Urbanisation and Climate Change [ÇŞİDB], 2023)

When examining the overall impact of the earthquake, it becomes evident that the extent of destruction across the affected provinces was not homogeneous. Significant differences emerged between provinces in terms of physical damage, loss of life, aid delivery processes, and reconstruction needs. This variation was shaped by a range of factors, including proximity to the earthquake's epicentre, soil conditions, the quality of the building stock, and the capacity for emergency response.

In this context, in order to enhance the analytical depth of the study and enable a comparative analysis, the research focuses on the two provinces that experienced the most severe disaster-related losses: Hatay and Adıyaman. Hatay was the most affected province in terms of total fatalities and infrastructure destruction, while Adıyaman recorded the highest relative fatality rate in proportion to its population. A comparative examination of these two provinces allows for a more concrete and multidimensional analysis of the structural and institutional challenges encountered during the post-disaster recovery process.

4. Regional Background and Socio-Spatial Characteristics

The pre-disaster structural, socio-economic, and spatial characteristics of Hatay and Adıyaman—the two provinces most severely affected by the Kahramanmaraş-centred earthquakes of 6 February 2023—largely explain the complexity of the subsequent recovery processes. These provinces, where societal, administrative, and spatial vulnerabilities intersect, proved more susceptible to external interventions during the crisis period, ultimately delaying the recovery process.

In terms of demography and social structure, Hatay had a population of approximately 1.7 million as of 2022, making it the 13th most populous province in Türkiye (Turkish Statistical Institute [TÜİK], 2023). With a population density of 258 people per km², Hatay comprises both densely populated urban centres such as Antakya, Defne, and İskenderun, and extensive rural areas. It is also characterised by a multicultural and multilingual social structure. The coexistence of diverse religious and ethnic groups has occasionally contributed to governance challenges and inequalities in resource distribution.

Adıyaman, by contrast, had a smaller population of around 635,000 in 2022 and a population density of 89 people per km². Despite its size, the province has a population growth rate above the national average and a significant-

ly high rural population; approximately 46% of its inhabitants reside in rural areas. The proportion of youth is high, while the elderly population remains below the national average (Turkish Statistical Institute [TÜİK], 2022). These demographic characteristics contributed to difficulties in accessing shelter, transportation, and emergency services during the earthquake. Furthermore, levels of education and income in Adıyaman are below the national average, increasing the province's overall vulnerability.

Prior to the earthquake, both provinces experienced both in- and out-migration. Hatay, due to its proximity to the Syrian border, hosted over 400,000 Syrians under temporary protection. In Adıyaman, mobility was mostly seasonal and based on agricultural labour, with temporary workers arriving from other regions during harvest periods.

The two provinces also differ significantly in their economic structures. Hatay was one of Türkiye's prominent industrial and port cities prior to the earthquake. It played a major role in iron and steel production, logistics, and agriculture. The Port of İskenderun was not only crucial for Hatay but also for foreign trade in Türkiye's eastern and southern regions (Eastern Mediterranean Development Agency, 2014). However, this economic potential turned into a major risk factor due to a lack of structural safeguards. The extensive damage to industrial infrastructure created a significant void in economic as well as physical recovery (Turkish Enterprise and Business Confederation [TÜRKONFED], 2023).

In contrast, Adıyaman's economy relies heavily on agriculture and small-scale industrial activities. The province is known for the production of tobacco, pistachios, and cotton, yet its industrial infrastructure remains weak (İpekyolu Development Agency, 2020). According to 2022 data from the Turkish Statistical Institute (TÜİK), Adıyaman ranks among the lowest provinces in terms of per capita income. This weak industrial base has constrained the ability of local economic dynamics to contribute to recovery. The province has low export capacity, a fragile production chain, and limited private sector investment.

In terms of the built environment, Hatay is marked by high urban density. The narrow street layouts and multi-storey buildings in districts such as Antakya and Defne were key factors that amplified the destructiveness of the earthquake. Much of the housing stock in these districts consists of old, structurally vulnerable buildings (World Bank, 2023). In Adıyaman, spatial vulnerabilities were more prominent in rural areas.

Due to their pre-disaster socio-spatial configurations, both Hatay and Adıyaman were among the provinces that faced the most severe challenges in the post-disaster recovery process. In both cases, physical vulnerabilities, limited economic capacity, and social inequalities exacerbated the impact of the earthquake.

5. Recovery Process: Actions, Challenges, and Governance

The previous section detailed the pre-disaster spatial, socio-economic, and administrative vulnerabilities of Hatay and Adıyaman, highlighting how these fragile structures intensified the impacts of the 6 February earthquakes. This background is critical not only for understanding the scale of destruction but also for explaining why the recovery process in these two provinces was particularly complex and delayed. This section focuses on the concrete actions taken during the post-disaster recovery process, the key challenges encountered, and the governance-based interactions among the actors involved.

In the literature, the recovery process is defined not merely as the reconstruction of physical infrastructure, but as a multi-layered endeavour shaped by the reorganisation of the social fabric, the establishment of institutional coordination, and the inclusion of local communities in decision-making (Smith & Wenger, 2007; Tierney, 2014). In analysing this multi-layered process, Hatay and Adıyaman are examined under two main subheadings. The first subheading presents post-disaster physical and administrative interventions and the problems encountered, based on thematic content analysis. The second subheading evaluates the governance relations among public institutions, local authorities, civil society organisations, and international actors, with a focus on the distribution of authority and contradictions in decision-making processes. Through this structure, the recovery process is revealed to be less a technical issue and more a matter of governance.

5.1. Recovery Actions and Challenges

The post-disaster recovery process initiated after the Kahramanmaraş-centred earthquakes of 6 February 2023 has raised numerous questions regarding its design and prioritisation. Analysis of the process reveals key challenges such as damaged infrastructure systems, reconstruction policies, centralised interventions, and inequalities in resource distribution.

Both Hatay and Adıyaman faced significant logistical infrastructure problems. These issues stem not only from earthquake-induced destruction but also from long-standing structural deficiencies. In Hatay, the collapse of urban transportation routes, the absence of alternative roads, and the disruption of port connections severely hindered search-and-rescue and aid delivery operations. Additionally, the fire and destruction at the Port of İskenderun interrupted the logistics chain (Şipal, 2023). In Adıyaman, the limited capacity and narrowness of the arterial roads connecting to the main highways caused significant delays in the delivery of aid to the region. Access problems in rural areas further exacerbated the situation. In Adıyaman's rural neighbourhoods, collapsed roads and landslide risks left many villages isolated for weeks. This not only restricted access to essential needs for the rural population but also delayed the provision of health, food, and temporary shelter services (Şipal, 2023). In Hatay, the dispersed settlement pattern in rural areas and the collapse of bridges also hindered emergency response teams from accessing certain zones.

Infrastructure deficiencies in temporary shelter areas also posed a major challenge to the recovery process. In both provinces, container and tent settlements were established without prior infrastructural preparation, and basic services such as water, sanitation, and electricity were either unavailable or provided at very low capacity in the initial days. In some tent areas in Hatay, safe drinking water, toilets, and showers could not be provided for several weeks (Erdoğan, 2023). These shortcomings not only increased public health risks but also contributed to social unrest and a growing sense of distrust. The lack of infrastructure reflects not only the limitations of local capacity but also the broader deficiencies of disaster management in preparedness and scenario planning.

A second and widely debated dimension of the recovery process concerns the centralised nature of reconstruction policies. The mass housing projects managed directly by the Housing Development Administration (TOKİ) under central authority bypassed local planning processes. In both Hatay and Adıyaman, these centrally implemented initiatives ignored local urban plans and zoning strategies, drawing serious criticism regarding their spatial integration, respect for historical context, and alignment with community needs (Bozkurt & Keleş, 2023).

Exclusion of local planning is not merely an administrative preference but also a governance issue. Decisions regarding the location, design, and social amenities of post-disaster housing were made by central actors, neglecting the needs and priorities of local residents. In Hatay, for instance, some TOKİ housing units were built in geologically controversial areas, which both violated scientific principles and undermined public trust.

Moreover, the implementation of standardised housing projects across different regions created issues in both spatial and social cohesion. Observations suggest that most TOKİ projects in Hatay and Adıyaman were constructed with similar scales, materials, and architectural styles, failing to adapt to the diverse cultural, climatic, and social contexts of the regions. While the needs of disaster victims varied greatly, the uniform solutions offered created a "one-size-fits-all" approach that contradicted the principle of equity.

This situation not only affects the physical environment but also undermines the sense of social belonging. Shelter is not merely the provision of a roof, but the reconstruction of a space where social relations are reorganised. Therefore, the rigid, standardised interventions of central institutions transform the recovery process from a purely technical effort into a matter of social cohesion. However, housing problems for earthquake survivors persist, and significant deficiencies remain in temporary accommodation areas. While the construction of new housing is being carried out predominantly by public authorities, the costs of repair and reinforcement have been left to homeowners, thereby exacerbating existing inequalities (Özüdoğru, 2023).

One of the most pressing difficulties encountered during post-disaster interventions and reconstruction was the inequitable distribution of resources at both spatial and institutional levels. In both Hatay and Adıyaman, serious disparities were reported in the allocation of in-kind aid and housing investments. In Hatay, for example, the concentration of aid in certain districts led to a sense of "invisibility" in others. In Adıyaman's northern rural villages, it was reported that aid had not reached some communities for several weeks (Özer, 2023). Furthermore, the involvement of political actors in the distribution of aid undermined the legitimacy of the entitlement system for disaster survivors.

Spatial injustice was not only about the volume of aid but also about the prioritisation of certain areas over others. In Hatay, despite the extreme devastation in central districts such as Antakya and Defne, some rural neighbourhoods did not see the initiation of housing projects for months. In Adıyaman, permanent housing construction began in specific zones, while other equally affected areas experienced no progress. This inequality was reflected not only in the physical landscape but also in demographic changes: 148,872 people reportedly migrated from Hatay due to the earthquake, while in Adıyaman, over 6% of the population relocated to other cities (Turkish Statistical Institute [TÜİK], 2023) (Table 2). These trends indicate that local-level assessments of both physical and social conditions were insufficiently incorporated into the recovery planning process.

Table 2 Migration Flows to and from the 11 Earthquake-Affected Provinces (Turkish Statistical Institute [TÜİK], 2023)

Disaster-Induced Migration Dynamics in Earthquake-Affected Provinces in 2023		
Province	**Out-Migration (Number of People)**	**InMigration (Number of People)**
Hatay	148 872	6 743
Malatya	93 895	8 382
Kahramanmaraş	71 709	8 565
Adıyaman	42 100	7 089
Gaziantep	30 987	22 172
Adana	28 546	17 028
Şanlıurfa	23 697	15 606
Diyarbakır	21 801	6 059
Osmaniye	12 643	9 690
Elazığ	6 399	14 470
Kilis	2 556	4 579
Total	**483 205**	**120 383**

The fact that permanent housing in some regions has yet to be completed illustrates the extent to which the recovery process has been shaped by regional inequalities. According to the most recent data published by the Disaster and Emergency Management Authority (AFAD) and the Housing Development Administration (TOKİ), the number of planned permanent housing units in Hatay exceeds 40,000; however, less than 15% of these units were completed within the first year. Similarly, in Adıyaman, only 17% of the approximately 25,000 planned housing units have been delivered (Table 3). Furthermore, when delivery performance is assessed as a percentage of documented urban housing needs, the disparities become even more pronounced. In Kilis, the number of delivered urban units (1,097) exceeds the identified need (733), reflecting a delivery rate of approximately 150%. In stark contrast, only 5% of the urban housing need has been met in Adıyaman (2,158 out of 41,171), and merely 3% in Hatay (6,572 out of 220,006). This contrast highlights significant inconsistencies in how provinces are prioritised within the recovery process.

The underlying causes of these delays are not purely technical; rather, they reflect political, bureaucratic, and capacity-based decisions embedded within the prioritisation mechanisms (Altay & Labonte, 2014). Thus, the recovery process must be analysed not only in terms of what has been implemented, but also in terms of what has not—or could not—be realised.

Table 3 Urban Housing Needs and Reported Number of Housing Units Ready for Delivery (Disaster and Emergency Management Authority [AFAD] and Housing Development Administration [TOKİ], 2024)

	Housing Development Administration [TOKİ], 2024			Disaster and Emergency Management Authority [AFAD], 2024	
Province	Urban Housing Need	Rural Housing Need	Commercial Space Need	Reported Number of Urban Units Ready for Delivery	Reported Number of Rural Units Ready for Delivery
Adıyaman	41171	23640	17392	2158	640
Hatay	220006	34129	55777	6572	703
Kahramanmaraş	82104	30310	34504	8122	716
Malatya	77717	25302	20744	5140	141
Adana	18583	2438	1744	1589	124
Osmaniye	13646	6856	8862	1242	156
Gaziantep	29315	12607	17650	10090	608
Şanlıurfa	13782	3000	1641	1208	106
Diyarbakır	13167	3614	1367	1374	139
Kilis	733	2628	697	967	136
Elazığ	20261	-	4528	2255	-
Total	**53672**	**165271**	**169000**	**39327**	**4574**

5.2. Actors and Governance in the Recovery Process

Following the earthquakes centred in Kahramanmaraş, the recovery process was shaped not only by technical and physical interventions but also by questions regarding who implemented these interventions, how, and at what level—questions which have become central to the discussion. Post-disaster governance entailed the involvement of multiple actors at various levels and with differing capacities; however, coordination among these actors was often fragile. The following thematic evaluations address this process through institutional structures, local administrations, civil society, international actors, and community-based organisations (Göver, 2023).

Neighbourhood volunteers played a prominent role in meeting fundamental needs such as aid distribution, the establishment of temporary shelter sites, and the support of vulnerable groups, particularly during the initial days. In certain neighbourhoods of Hatay and Adıyaman, where public institutions could not reach within the first 72 hours, neighbourhood volunteers took organised action to supply food and water and actively contributed to the physical setup of temporary accommodation areas.

Nevertheless, many of these structures were fragile due to a lack of both formal institutional recognition and financial resources. While they provided short-term solutions during the recovery phase, their inability to operate sustainably underscores the need for systematic recognition and support of these practices. Integrating local volunteer groups into formal frameworks would enhance capacity utilisation and reinforce a sense of belonging.

The research conducted in Hatay and Adıyaman indicates that, despite the theoretical presence of a multi-actor

structure in the recovery process, in practice, central government institutions were overwhelmingly dominant. Local authorities, civil society organisations (CSOs), and community-based structures were either marginalised or excluded from the process entirely. This governance model resulted in decision-making occurring behind closed doors, the exclusion of local knowledge and experience, and a deepening institutional distrust. The success of the recovery process is thus not solely dependent on technical capacity but is directly linked to how this capacity is mobilised through democratic, inclusive, and multi-actor mechanisms. Despite its strong central structure, Türkiye's current disaster management system suffers from severe limitations in terms of local adaptability and flexibility, hindering not only the pace but also the equity of post-disaster recovery.

One of the most striking issues during the recovery process in Hatay and Adıyaman was the multiplicity of institutional authorities and ambiguity in the distribution of responsibilities. The Disaster and Emergency Management Authority (AFAD), the Ministry of Environment, Urbanisation and Climate Change (ÇŞİDB), the Ministry of Interior, and the Housing Development Administration (TOKİ) operated independently of one another. At the provincial level, roles and responsibilities between the governor's office, metropolitan municipalities, and district municipalities were poorly defined (Göver, 2023). This fragmentation led to delays in decision-making and reduced the responsiveness of interventions to local needs.

The marginalisation of local governments posed a further serious issue. While local authorities in Türkiye possess limited disaster management capacity, they are known to be among the fastest-responding units with direct contact with the public during crises (Altay & Labonte, 2014). Nonetheless, in both Hatay and Adıyaman, municipalities were largely excluded from planning processes, resource allocation, and decision-making mechanisms. Instead, interventions were carried out directly through governorates, district governorships, and central government institutions. Municipalities were compelled to act on their own initiative due to a lack of official authorisation, which not only prevented the effective use of local knowledge and capacity but also weakened channels of communication with the public.

The centralised structure of The Disaster and Emergency Management Authority (AFAD) constituted the most critical aspect shaping the institutional framework of the process. Particularly in the early stages, The Disaster and Emergency Management Authority (AFAD) had full control over emergency response and shelter planning. In some cases, municipal settlement plans were disregarded and annulled by The Disaster and Emergency Management Authority (AFAD), pushing local actors into a subordinate role as mere implementers. This approach resulted in standardised intervention models being applied without consideration for the region's spatial, social, and economic diversity. In decisions ranging from the siting of container settlements in Hatay to the construction of permanent housing in Adıyaman, the exclusion of local dynamics was clearly evident.

This dominance of central government extended beyond decision-making to resource allocation and prioritisation of interventions. The distribution of aid, allocation of housing, and infrastructure investments often ignored local demands, damaging relationships between actors and leading to a lack of trust and cooperation on the ground. Such issues reflect not only governance shortcomings but also directly impact the effectiveness of the recovery process.

Civil society organisations (CSOs) played a crucial role in post-disaster recovery not only through service provision but also by contributing to social solidarity and the development of inclusive governance mechanisms. However, in the context of the earthquakes centred in Kahramanmaraş, CSOs were largely marginalised or rendered ineffective in Hatay and Adıyaman.

In the initial days following the earthquakes, CSOs were among the first actors to reach the affected areas, delivering critical assistance in areas such as shelter, food distribution, and psychosocial support. In Hatay, organisations such as Ahbap, along with local volunteer initiatives, provided essential services in regions where the state was unable to respond promptly. For instance, the Ahbap Association and its partner civil initiatives reportedly distributed over 4,000 containers across Hatay. In Defne, female volunteers established community kitchens with

their own resources, serving hot meals to thousands (Ahbap, 2023). In Adıyaman, small civil initiatives from neighbouring provinces organised tent distributions and similar relief efforts. However, many of these actions lacked a systematic coordination mechanism, and CSO representatives were frequently excluded from crisis coordination centres established under The Disaster and Emergency Management Authority (AFAD).

Moreover, central institutions predominantly portrayed relief operations in the media and public discourse as being driven solely by The Disaster and Emergency Management Authority (AFAD) and ministerial efforts. Yet, in many areas, it was in fact the work of CSOs that sustained living spaces, food supply chains, and emergency first aid points. This exclusionary approach not only created symbolic invisibility but also led to material constraints. Many CSOs faced difficulties obtaining permits to collect donations or were compelled to channel funds through AFAD, thereby limiting their operational autonomy.

Despite these challenges, some CSOs managed to maintain continuity in specific regions owing to their strong community ties and flexible organisational structures. Small-scale support efforts led by women's associations, youth initiatives, and neighbourhood forums effectively addressed the gaps left by central government agencies, particularly in rural areas. However, unless these contributions are integrated into a systematic governance structure, their scalability will remain limited.

The role of international actors in post-disaster recovery is particularly significant in terms of funding, technical assistance, and normative guidance. Following the 6 February 2023 earthquakes, Türkiye received financial and logistical aid from numerous international institutions. Nevertheless, how this support was translated on the ground and the extent of collaboration with local actors sparked considerable debate, especially in Hatay and Adıyaman.

Following the disaster, more than USD 1.6 billion in aid and credit was pledged by the World Bank, the European Union, the United Nations Development Programme (UNDP), and various international NGOs. Of this, USD 1 billion was allocated to Türkiye by the World Bank as an emergency credit package, channelled through central projects managed by The Disaster and Emergency Management Authority (AFAD) and the Ministry of Interior, and the Housing Development Administration (TOKİ). However, no information was shared regarding the provincial-level allocation of these resources. The European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO) provided EUR 25 million in direct funding for humanitarian aid efforts in Hatay and Adıyaman (World Bank, 2023; UNDP, 2023). Yet, these funds were distributed without the involvement of local authorities; in some neighbourhoods, interventions were unnecessary, while rural areas were entirely neglected. Most of these funds were allocated through the Disaster and Emergency Management Authority (AFAD) and relevant ministries. Public disclosure regarding the transparency of this aid, its distribution process, and provincial allocations remains significantly lacking. For instance, while some permanent housing projects in Hatay were reportedly financed through international aid, their visibility on the ground has been limited.

Transparency in the use of funds is not merely a technical administrative issue but also a key determinant of public trust in the process. In both Hatay and Adıyaman, there has been no publicly accessible reporting on the allocation of international aid, the criteria used to define regional priorities, or how decisions were made. This has fuelled perceptions that aid may have been guided by political or institutional preferences, eliciting backlash particularly from neglected rural communities.

Meanwhile, there have been limited efforts by institutions such as UNDP and the EU to promote local capacity-building through long-term technical support programmes. However, for these initiatives to expand and become sustainable at the local level, there is a need for clearer governance protocols and stronger partnerships with local actors.

In conclusion, the contribution of international actors to the recovery process has been largely mediated through central authorities, resulting in weak collaboration at the local scale. Yet, for recovery to be both effective and

equitable, it is not sufficient to ensure the flow of funds—these resources must be utilised in ways that are sensitive to the local context and involve active participation of local stakeholders.

Finally, it is essential to recognise that post-disaster recovery processes are not solely driven by institutional actors. On the contrary, informal community-led initiatives also played a critical role. Content analysis and field observations in Hatay and Adıyaman reveal that neighbourhood volunteers, local networks, and community-based organisations filled vital gaps in rebuilding life after the disaster.

6. Conclusion and Policy Recommendations

The earthquakes centred in Kahramanmaraş on 6 February 2023 marked a turning point in Turkey's disaster management history, leaving deep traces both physically and institutionally. The content analysis conducted within the scope of this study demonstrates that the post-disaster recovery process is not merely a technical reconstruction effort, but also a multi-actor and multi-level governance process. In-depth analyses of the provinces of Hatay and Adıyaman reveal that, due to their socio-spatial vulnerabilities, these two provinces faced more complex challenges in the recovery phase. The findings show that post-disaster interventions were spatially unequal and heavily centralised in terms of governance, with the roles of local governments, civil society organisations (CSOs), and international actors remaining limited.

In this context, regionally scaled policy recommendations are critically important for reducing the impact of disasters and accelerating recovery processes. First, the institutional capacity of local governments in high-risk areas must be strengthened. As evidenced in the cases of Hatay and Adıyaman, municipalities lacked both financial resources and planning authority, which hampered effective coordination on the ground. In order for local administrations to play an active role in disaster planning, their disaster management budgets should be increased, personnel training supported, and they should be structurally integrated into decision-making processes.

Second, institutional coordination mechanisms at both local and national levels must be restructured. One of the main issues encountered during the recovery process was the lack of clearly defined responsibilities and task allocations (Ergünay, 2001). Overlaps in authority between the Disaster and Emergency Management Authority (AFAD), the Ministry of Environment, Urbanisation and Climate Change (ÇŞİDB), the Housing Development Administration of Turkey (TOKİ), and local actors led to delays in the field and unjust distribution of resources. Therefore, task definitions for post-disaster interventions should be predetermined, and a clear coordination protocol ready for activation in times of crisis must be established.

Third, the integration of civil society organisations and volunteer structures into the process has become a necessity. The critical role played by the Ahbap Association and similar organisations in the initial days of the disaster ensured the continuity of essential services in areas unreachable by central institutions (Ahbap, 2023). However, the lack of visibility of these structures in the official process led not only to symbolic exclusion but also to material inequalities. CSOs should be subject to a pre-disaster certification and authorisation system; support-capable structures should be identified in advance and integrated accordingly. Furthermore, their operations should not be subordinated to the Disaster and Emergency Management Authority (AFAD)'s coordination, but rather conducted through horizontal collaborations and information-sharing platforms.

Fourth, international funding and technical assistance must be managed transparently. The provincial distribution of funds from institutions such as the World Bank, the European Union, and the United Nations Development Programme (UNDP) should be made public, and regular reports must be published detailing which projects these resources were allocated to, when, and according to which criteria. In Hatay and Adıyaman, the visibility of these funds remained particularly low in some areas, reinforcing perceptions that assistance was directed based on political or technical preferences. To counter this, transparent and accountable monitoring mechanisms that involve local actors in the allocation of international funds must be developed.

Finally, the long-term social impacts of the recovery process must be considered. Post-disaster migration, we-

akening of social belonging, and the erosion of trust have lasting effects not only on physical space but also on the social structure (Tierney, 2014). Given that more than 148,000 people migrated from Hatay and over 6% of Adıyaman's population relocated to other provinces (Turkish Statistical Institute [TÜİK], 2023), the recovery process must be supported not only through housing policies but also with community rebuilding programmes.

In conclusion, this study shows that Turkey's post-disaster recovery process has a highly complex and multi-actor nature; however, the current governance structure remains inadequate in addressing this complexity. For recovery efforts to be conducted effectively and equitably, central institutions must collaborate with local actors, strategies must be developed with sensitivity to social needs, and institutional capacity must be strengthened at every level. Implementing these recommendations is vital for building a more resilient society and governance structure in the face of future disasters in Turkey.

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How the coastal cities are transforming? The disaster as catalysts of change

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Abstract:
In the current climate crisis, coastal cities face growing risks related to both water scarcity and flooding. Climate change, uncontrolled urbanization, and the inherent vulnerability of coastal areas call for a rethinking of planning strategies. This contribution presents part of the PRIN COSTA|Med research project, which collects international case studies where environmental crises have triggered innovative adaptation strategies. Focusing on two examples—the Dutch Delta Programme and the PATIVEL in Valencia—we explore how planning and design can respond jointly to complex challenges. The goal is to identify shared trajectories and outline integrated guidelines for resilient coastal management, with a focus on the Mediterranean, one of the regions most exposed to sea-level rise.

1. Introduction. Designing with Disasters — Rethinking Coastal Urbanism in the Age of Climate Crisis.

In the 21st century, climate change has ceased to be a distant scenario and has become a structuring force transforming how we live, plan, and imagine our cities. Coastal territories—liminal spaces between land and sea—are among the most affected. The combination of rapid demographic growth, increasing anthropization, and the expansion of urban settlements into ecologically fragile zones has significantly heightened the exposure of coastal cities to natural disasters. These are not merely episodes of exceptional violence, but manifestations of a systemic imbalance in the relationship between human development and natural systems.

Among the various elements at play, water emerges as the central agent of crisis. Its dual character—both scarcity and excess—makes it pivotal to many of the most disruptive phenomena of our time. Prolonged droughts, wildfires, and water shortages reveal the fragility of inland ecosystems, while excessive precipitation and storm surges destabilize cities and coastlines. In parallel, slow-onset phenomena such as sea level rise, salinization, and coastal erosion threaten the long-term viability of urban development along the coasts.

These dynamics compel us to critically reconsider the human-nature relationship. As Neil Smith (2006) famously stated, "there's no such thing as a natural disaster"—what we perceive as disasters are often consequences of political, social, and spatial decisions, such as the occupation of flood-prone areas, the sealing of soil, or the removal of natural buffers like wetlands and dunes. In this sense, disasters are not nature's intrusion into the urban realm, but the return of suppressed ecological processes in territories overbuilt and overregulated.

The relationship between city and nature has never been static—it has evolved through centuries of shifting paradigms, from domination and separation to a more integrated and dynamic vision. Historically, urbanization in coastal territories has exemplified the impulse to control nature: land was reclaimed, estuaries filled, shorelines fixed, and rivers canalized to serve industrial, logistical, and speculative purposes. This anthropocentric model, rooted in the Enlightenment ideal of nature as inert matter to be shaped by human will, has generated a brittle urban ecology incapable of responding to contemporary environmental challenges. As climate change accelerates, sea-level rise, storm surges, and saltwater intrusion are reclaiming spaces once artificially stabilized, exposing the fallacy of this dichotomy. Contemporary scholarship—from Haeckel's early ecology (1866) to Latour's political ecology (2018) and the systemic readings of urban metabolism (D'Arienzo & Younés, 2018)—has argued for a more relational approach, one that recognizes humans as part of, not separate from, ecological processes.

This shift reframes the role of design: cities, and particularly coastal cities, must be understood not as closed systems protected from nature, but as open, adaptive infrastructures embedded within it. The goal is no longer to resist natural dynamics through static barriers, but to accommodate, absorb, and even learn from them—by

shaping urban forms that respond to hydrological rhythms, sediment flows, and climatic variability. In this regard, aesthetics and engineering must converge to support both functional resilience and cultural imagination. As Diana Balmori succinctly states, "We must put the twenty-first-century city in nature rather than put nature in the city; to put a city in nature will mean using engineered systems that function as those in nature and deriving form from them" (Balmori, 2010). This reorientation calls for a fundamental transformation in how we conceive urban life at the edge of water—shifting from opposition to coexistence, from containment to collaboration.

Jeremy Rifkin (2019) highlights the deep incompatibility between carbon-intensive urban models and the planetary limits we now face, calling for a "Green New Deal" of infrastructure capable of decentralizing and decarbonizing urban life. Similarly, landscape architect Kate Orff (2016) argues for a new ecological imagination in urban design—one that moves beyond cosmetic greening toward "living infrastructure" systems that mimic, restore, or collaborate with natural processes. For Orff, resilience is not about resistance, but about dynamic adaptation, cohabitation, and repair.

Such perspectives mark a fundamental shift in how disasters can be understood. Rather than treating them as interruptions, this research proposes to interpret disasters as revelatory episodes—moments that expose systemic weaknesses but also generate possibilities for innovation. This approach advocates for a move away from superficial "greenwashing" toward engineering-informed strategies inspired by natural systems, including sediment cycles, wetland restoration, oyster reef cultivation, and dynamic floodplain design.

Cities such as New York—through the Rebuild by Design initiative (2012)—Mumbai, and Rotterdam have pioneered these ideas, implementing forward-looking strategies that embed risk management into the DNA of urban and coastal planning. Northern European countries have institutionalized long-term resilience policies, but in contrast, the Mediterranean remains one of the world's most vulnerable and underprepared regions. Despite early efforts such as the Barcelona Convention (UNEP/MAP, 1976), many Mediterranean countries still suffer from fragmented governance, lack of integrated planning tools, and reactive emergency management. The flooding event that struck the Valencian coast in October 2024 is a stark reminder of this fragility.

According to recent projections (EEA, 2024), sea levels in the Mediterranean under low-emissions scenarios could lead to extreme flooding events becoming ten times more frequent by 2050—transforming what were once centennial phenomena into regular occurrences. In this context, a crucial question emerges: how can we plan and design coastal territories in a way that is proactive, integrated, and resilient?

This essay responds by developing a multidisciplinary framework that brings together urban design, spatial planning, and environmental systems thinking. At its core lies a curated archive of global case studies documenting how cities have reacted to, learned from, and reimagined themselves through coastal crises. These experiences are not seen merely as emergencies but as generative events—catalysts for transforming the built environment, governance models, and the relationship between land and water.

By drawing lessons from diverse geographies while grounding the analysis in the unique socio-environmental conditions of the Mediterranean, the research aims to define a set of spatial and strategic guidelines. These will serve not only to mitigate risk but also to inspire new design cultures capable of co-evolving with the rhythms of nature. In reframing disasters as design tools, this study advocates for a paradigm of coastal planning rooted in resilience, reciprocity, and long-term thinking.

2. **International References**

In the United States, a series of major climate-related disasters over the past two decades have spurred significant innovation in the fields of urban planning, infrastructure design, and resilience thinking. Among these, Hurricane Katrina in 2005 stands out not only as the costliest natural disaster in the nation's history, but also as a turning point in how vulnerability, inequality, and risk are understood and addressed in urban contexts.

Hurricane Katrina, which struck the Gulf Coast in August 2005, brought winds reaching 175 mph and a storm surge that overwhelmed the levee system, causing catastrophic flooding in New Orleans (Fig.1). The disaster resulted in over 1,800 deaths and displaced more than a million people. The damages exceeded $160 billion, making it the most expensive natural disaster in U.S. history (Graumann et al., 2005). Yet beyond the sheer scale of destruction, Katrina exposed long-standing systemic failures: racial and economic inequalities, aging infrastructure, and institutional fragmentation. Entire neighborhoods—particularly the predominantly Black and low-income Lower Ninth Ward—were submerged for weeks, showing how climate events magnify social vulnerability.

Fig. 1: Aerial view showing a flooded neighborhood adjacent to the 12th Street levee in New Orleans. Source: Vincent Laforet/The New York Times/Redux

The failure of the levee system—long believed to offer adequate protection—was not just a technical collapse but a manifestation of decades of underinvestment, poor planning, and environmental mismanagement (Colten, 2006). The Army Corps of Engineers, which oversaw much of the levee construction, later acknowledged critical design and construction flaws. The emergency response, primarily led by FEMA, was widely criticized for being disorganized and inequitable. In this sense, Katrina was not merely a natural disaster, but a human and political one.

Recovery efforts were uneven. While various plans such as the Unified New Orleans Plan (2007) attempted to guide reconstruction, many were top-down and failed to involve the communities most affected. Some areas of New Orleans have rebounded, but others remain marked by vacancy, slow repopulation, and continued risk. As historian Andy Horowitz has argued (Horowitz, 2020), Katrina should not be seen as an isolated crisis but as part of a "century-long disaster" rooted in the complex intersection of geography, policy, and inequality.

Despite its failures, the Katrina experience catalyzed a national rethinking of resilience and urban design. It helped lay the conceptual and institutional foundations for subsequent initiatives—like Rebuild by Design—that seek to merge ecological insight with participatory governance and long-term planning.

Nevertheless, Katrina sparked national and international conversations on urban resilience, environmental justice, and the ethics of reconstruction. It laid the groundwork for later initiatives, such as Rebuild by Design, that attempt to address climate risks through collaborative, inclusive, and ecologically informed planning. The lessons from New Orleans underscore the importance of designing not just for physical protection, but for social resilience, institutional accountability, and historical memory

The Rebuild by Design program, initiated in response to Hurricane Sandy in 2012, introduced a new design methodology based on interdisciplinary competition, co-design with local communities, and resilient infrastructural strategies (Rebuild by Design, 2014; Gould & Lewis, 2016). One of the most emblematic cases is the intervention in the Hudson Bay area, where the project "The BIG U," proposed by the Bjarke Ingels Group team, envisioned a continuous coastal protection system for Manhattan. This multifunctional belt not only serves as a physical barrier against flooding but also incorporates public spaces, parks, bike paths, and ecological devices that enhance urban quality (BIG Team, 2014; Lang & Rothenberg, 2017). The project stands as a prototype of resilient planning that integrates infrastructural scale with the quality of urban space.

However, Rebuild by Design is not limited to a single intervention. The competition launched in 2013 led to the selection of ten finalist proposals, each addressing specific vulnerabilities along the New Jersey and New York State coasts. Among these, "Living with the Bay" for Long Island, "Hunts Point Lifelines" for the Bronx, and "New Meadowlands" in New Jersey reinterpret riverine and coastal territories with integrated approaches that combine ecology, green infrastructure, and community engagement (Rebuild by Design, 2014; Oppla, 2020; Sanderson et al., 2016). These proposals share a core principle: the goal is not to resist nature but to learn to live with its dynamics.

Rebuild by Design has highlighted the importance of understanding natural systems — watersheds, marine currents, coastal ecosystems — as the foundation for urban management. This awareness has enabled the development of design strategies that not only respond to emergencies but also rebuild the relationship between human settlements and landscapes, promoting a vision of resilience based on adaptability, equity, and co-design (de la Peña et al., 2014; Lang & Rothenberg, 2017).

Another significant methodological contribution comes from the Atlas of Disaster, published in 2021 by Rebuild by Design in collaboration with New Jersey Future (Rebuild by Design & NJ Future, 2021). This document gathers data and narratives on climate disasters that have affected the State of New Jersey, highlighting socioeconomic inequalities, systemic vulnerabilities, and the need for cooperative governance. The atlas serves as a knowledge base to strengthen integrated planning, promoting the use of visual and collaborative tools to engage citizens, administrations, and professionals in the creation of fairer and safer scenarios.

In India, the SOAK project, proposed by Anuradha Mathur and Dilip da Cunha for the metropolis of Mumbai, radically rethinks the relationship between the city and water by proposing a dispersed and capillary model of coexistence with moisture rather than containment. SOAK's approach is based on cartographic and phenomenological observation of the monsoon landscape, where water does not follow a clear line but forms an extended, changeable, and distributed zone. Mumbai is interpreted as an estuary rather than land to be defended: the central idea is not to build barriers against water, but to design spatial conditions to absorb, distribute, and celebrate it. Water is not seen as an enemy but as a generative urban substance (Mathur & da Cunha, 2009).

SOAK's design methodology is distinguished by its exploratory, situated, and phenomenological character, emphasizing graphic and cartographic representations (Fig.2) that merge environmental data, material culture, and design imagination. This is not an abstract theoretical exercise, but a systemic and design-oriented response to a context marked by recurrent disasters such as the monsoon floods that cyclically affect Mumbai. SOAK does not stem from a single catastrophic event but from a critical understanding of the hydrographic landscape and its urban dysfunctions, which are attributable to modern hydraulic management based on containment and channelization. Here, resilience strategies are framed as narrative and spatial scenarios capable of inspiring a

new urban mindset oriented toward coexistence with climate variability and the valorization of water as a generative element of space.

Fig. 2: Drawing from the exhibition SOAK, opened at the NGMA (National Gallery of Modern Art) in Mumbai on June 23, 2009. Source: https://www.mathurdacunha.com/soak

In contrast with Rebuild by Design, which operates in a concrete field made of public competitions, inter-institutional partnerships, and infrastructural implementations, SOAK proposes an exploratory and conceptual design approach. Both projects share the centrality of water as a subject of urban design but differ in methods and language: Rebuild uses masterplans and implementation budgets; SOAK works with mappings, visions, and new territorial grammars.

Far from being a contradiction, this dichotomy offers fertile ground for a theory of urban hydraulic design that combines technical competence, geographical understanding, and symbolic imagination.

3. Europe at Risk

In the global context, the United States and India represent two distinct yet extreme environmental and climatic scenarios. In both contexts, differing socio-economic models—each driving specific patterns of urban growth—have resulted in heightened exposure to climate-related risks, ultimately culminating in large-scale natural disasters.

In Europe, by contrast, despite operating within a smaller geographical and demographic framework, there is a wide range of environmental conditions that have led to varied historical approaches to the relationship between land and sea. Northern European countries—such as the Netherlands, Belgium, Denmark, and the UK—have long faced the challenges of flooding and the delicate balance between human activity and natural systems. In response, these countries have implemented both governance and design strategies aimed at enhancing urban resilience.

Conversely, although Mediterranean countries have a long-standing cultural heritage of living with water, they have been comparatively slower in developing effective climate adaptation strategies, despite some noteworthy examples of adaptation in specific cities and regions. Yet, the Mediterranean remains highly exposed to climate-related risks, particularly in deltaic areas across Italy, France, Spain, Greece, and Egypt (De Lucia et al. 2022). As highlighted by the European Environment Agency (2024), the Mediterranean basin is among the regions most vulnerable to sea-level rise—making it especially at risk of experiencing extreme high water levels up to ten times more frequently across much of Europe by 2050. Coastal areas in this region are increasingly affected by erosion, soil salinization, infrastructure degradation, and declining habitability.

In Europe, flooding events—triggered by a variety of factors—have long been frequent and widespread across the continent (Bevacqua et al., 2019; van de Wal et.al., 2024). The HANZE (Historical Analysis of Natural Hazards in Europe) database (Paprotny et al., 2018) provides an overview of extreme weather events and their impact on European territories between 1870 and 2020. As illustrated in the map (Fig. 3), the number of recorded flood events during this period is surprisingly higher along Mediterranean coastal regions—reaching peaks of up to 45 episodes in the Venetian Lagoon, 39 along the Catalan coast, and 23 in the Comunitat Valenciana—than in other flood-prone northern countries such as Belgium, the Netherlands, or Denmark, where the relationship with water has long shaped spatial planning and territorial governance.

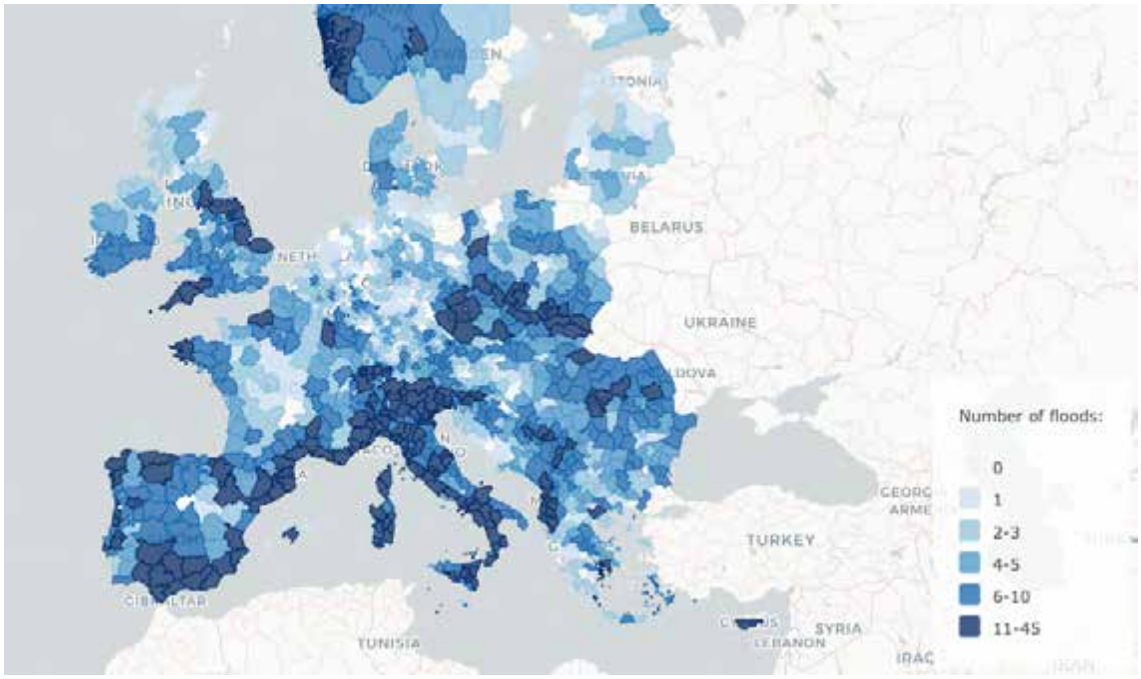

Fig. 3: number of recorded flood events in Europe between 1870-2020. Source: HANZE

However, it is important to note that both the frequency and the intensity of such events determine the actual level of risk for coastal territories. For example, areas like the Po Delta—despite recording a lower number of flood events—are among those most severely affected, with catastrophic impacts in terms of both human lives

and economic losses. This underlines the fact that, albeit with different patterns, the vast majority of European coastlines remain highly exposed to risk.

In territories that have experienced the most severe impacts, large-scale flood defense infrastructures have been implemented since the 20th century. In countries such as the Netherlands and the UK, extensive systems of movable barriers and beach nourishment programs have been deployed. These combined strategies have proven effective, particularly in semi-enclosed geographic contexts—such as bays and lagoons—where engineering solutions tend to have greater impact and efficiency. However, these systems come with high costs—not only for implementation but also for long-term maintenance (van de Wal et al., 2024). Moreover, as natural dynamics evolve—such as further sea-level rise or changes in tidal behavior—these infrastructures may become obsolete or inadequate. It is therefore increasingly evident that the paradigm must shift: rather than continuing to contain seas and rivers, it is human presence, with its settlement pressures and economic activities, that must adapt to natural processes.

Indeed, while climate change is clearly exacerbating existing vulnerabilities, flood events have always occurred across Europe. What has changed in recent decades is the growing urbanization of coastal areas—thereby increasing the exposure and risk to human populations—and the enhanced ability to record and analyze catastrophic events, which has led to a heightened awareness of the issue, including in the Mediterranean basin.

Europe presents a variety of approaches to coastal management and risk adaptation, with differences between northern and Mediterranean countries. While national strategies are more established in some northern contexts, southern regions are beginning to develop their own frameworks, often in response to specific environmental and social challenges. In many cases, it is only in the aftermath of a disaster that political and institutional momentum drives the development of long-term planning and strategic action. In this light, the two case studies presented in this paper—the Netherlands and the region of Valencia in Spain—illustrate parallel trajectories, where major flood events have triggered projects that later informed broader regional strategies.

3.1 Northern Europe: the Netherlands

Among the European countries most advanced in coastal zone management, the Netherlands stands out. The country's physical geography—characterized by the interweaving of the Rhine, Meuse, Scheldt, and Ems River deltas—exposes much of its territory to a constant risk of flooding, exacerbated by the ongoing rise in sea levels. These phenomena pose not only a threat to the resident population but also to the Dutch economy as a whole. As the world's eighteenth-largest economy (International Monetary Fund, 2018), any disruption in the Netherlands would have significant repercussions for the broader European and global economic balance.

This particular territorial condition led the Dutch government to develop flood risk protection strategies much earlier than many other European countries. Of particular interest is the Delta Programme—a modern evolution of the original Delta Plan, launched in response to the catastrophic North Sea flood of 1953, which devastated coastal areas of the Netherlands, the UK, Belgium, and Scotland.

In its initial phases, the Delta Plan focused on the construction of large-scale engineering works aimed at increasing the safety of the country's most low-lying and vulnerable areas. Specifically, the plan entailed the reinforcement of coastal dunes and the construction of a series of massive dams, including the renowned Oosterscheldekering (Eastern Scheldt storm surge barrier, Fig.4). These interventions were carried out between 1958 and 1997 and resulted in 14 major infrastructural works, including dams, sluices, and storm surge barriers. This first phase of the programme is emblematic of the engineering-driven approach typical of the second half of the twentieth century.

Fig. 4: Aerial photo of Oosterscheldekering flood barrier by Frans Lemmens

Today, however, with the increasing risks linked to climate change—coastal erosion, sea level rise, and the growing frequency of extreme weather events—there has been a marked shift toward a more adaptive and resilience-oriented strategy in the Netherlands' coastal management framework.

In 2007, the Dutch government established the Second Delta Commission (the first having been created in the 1950s), chaired by former Prime Minister Cees Veerman. The commission was tasked with assessing the potential impacts of climate change on the Netherlands and providing strategic recommendations for flood risk management. Its findings, compiled in an influential report, have guided national climate adaptation policy ever since.

The report contains twelve key recommendations, addressing a wide range of issues including:
- The structural integrity of dikes and flood defenses in the Netherlands;
- Urban development in areas with high flood risk;
- The administrative, organizational, and financial aspects of implementing flood prevention measures.

Following the adoption of these recommendations, the current Delta Programme was established through the Delta Act, which came into force on January 1, 2012. The Delta Act formally defines the roles of the Delta Commissioner (who manages the programme) and the Delta Fund (which provides its financing). The entire programme operates under the direct responsibility of the Ministry of Infrastructure and Water Management. The Act also mandates that the programme be updated annually, and it is financed through a dedicated annual budget of €1 billion from the Delta Fund.

The Delta Programme represents a long-term adaptation and resilience strategy for the Netherlands (Fig.5), operating across both national and regional levels. Its central goal is to align climate change management with socio-economic development needs. Operationally, this strategy is articulated through several key components: (i) Delta Decisions, which define the overarching national regulatory framework[1]; Delta Plans, which translate these

1 Between 2010 and 2014, five Delta Decisions were developed, forming the foundation for policy and planning over the next 35 years: 1. Delta Decision on Flood Risk Management; 2. Delta Decision on Freshwater Supply; 3. Delta Decision on Spatial

decisions into concrete implementation measures at both national and regional levels.[2]

Adaptive Delta Management
Since its establishment in 2009, the Delta Program has progressively evolved by adopting the so-called Adaptive Delta Management (ADM) approach—an adaptive strategy, capable of evolving in response to climate or socio-economic changes, and an integrated one, designed to address the various dimensions of water management in densely urbanized contexts (Bloemen, 2019).

Given its long-term perspective, the program's goals are intentionally broad to allow for adjustments and updates over time as priorities become clearer. The Delta Committee has proposed three distinct time horizons (scenarios) for achieving the program's objectives:
1. Concrete interventions through 2050;
2. A clear vision through 2100;
3. Long-term recommendations for beyond 2100.

The ADM methodology is critical to the success of the Delta Program:
«we look far ahead to the challenges facing us and, with this knowledge, we take the measures on time that are necessary and affordable at that point. In doing so, we ensure that we can always respond flexibly to new opportunities and new insights. For example by giving rivers more room step by step[3]. Or by strengthening the coast with sand nourishment operations that we can adjust easily when required: more or less nourishment, or in a different location»[4]

In pursuit of an efficient and adaptive model, the Delta Program relies on the Monitoring, Knowledge, Action cycle, which involves continuously assessing whether: (i) the program is on track with its implementation timeline; (ii) new developments or events necessitate updates to the roadmap; (iii) an integrated approach is being maintained; (iv) authorities, institutions, and stakeholders are being sufficiently engaged.

Based on this methodology, an annual assessment of the program is conducted, along with a comprehensive systemic review of the Delta Decisions and Preferred Strategies every six years.

Adaptation; 4. Delta Decision on the Rhine–Meuse Delta; 5. Delta Decision on the IJsselmeer Region

2 1. Delta Plan for Flood Risk Management; 2. Delta Plan for Freshwater Supply; 3. Delta Plan for Spatial Adaptation

3 The *Room for the River* project (lounched in 2007 and largely implemented by 2015) was a key precursor and pilot for the Delta Programme.

4 Deltaprogram.nl

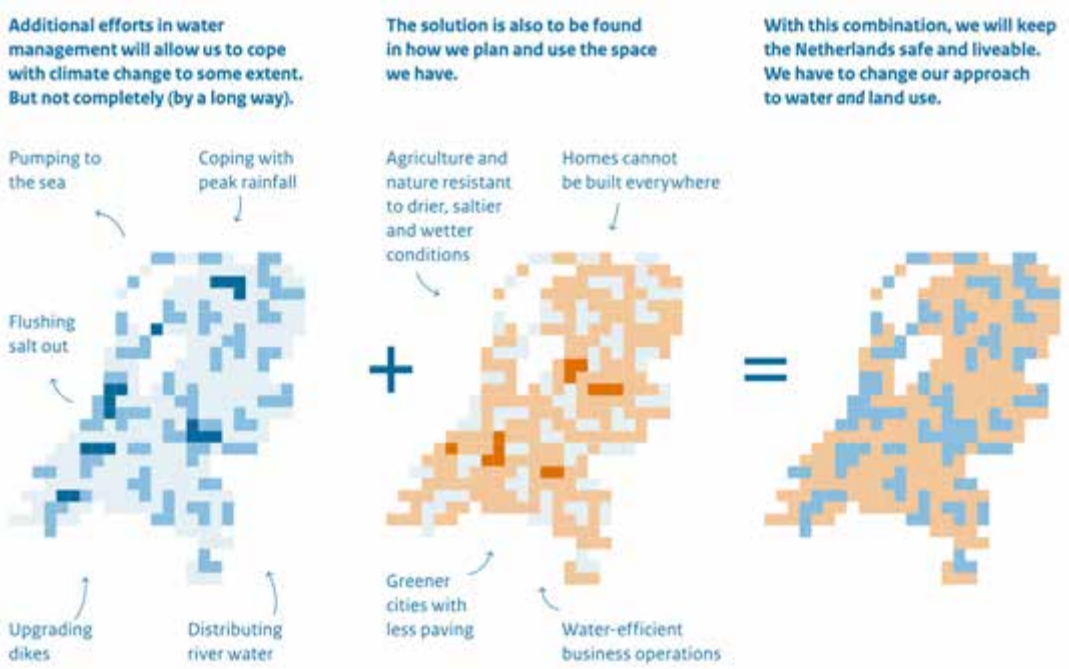

Fig. 5: Delta Program implementing both water management and spatial measures. Source: National Delta Program 2025 outline

Decision Making

The experience of the Delta Program is particularly relevant when it comes to the decision-making process, that is, the sequence of events that led the Netherlands to formally adopt this national strategy. In the early 2000s, although political interest in climate adaptation was steadily growing, no concrete decision had yet been made regarding when and how to move forward with a new, forward-looking approach to climate-related risks.

Once again, it was an emotional and political response to a natural disaster—specifically, the devastation caused by Hurricane Katrina in the United States (see section 2. International References)—that provided the necessary momentum for change in the Netherlands.

The key milestones that led to the institutionalization of the Delta Program can be summarized as follows:

- March 2005: Senator Lemstra introduces a motion urging the government to invest in a proactive strategy to anticipate climate change and rising sea levels.
- May 2005: In response to this motion, the Ministry of Housing, Spatial Planning and the Environment launches the national program Climate Adaptation and Spatial Planning (ARK).
- August 2005: Hurricane Katrina strikes the U.S. Gulf Coast. The catastrophic impact of the storm serves as a wake-up call for the Dutch government, reinforcing the urgency of the ARK program.
- 2006: The Royal Netherlands Meteorological Institute conducts a study to assess the potential impact of sea level rise on Dutch territory.
- 2007: ARK publishes the first National Adaptation Strategy (NAS), identifying flood safety as one of the most pressing issues to address.
- June 2007: The Ministry of Transport, Public Works and Water Management releases the Water Vision report. Among its most important proposals is the establishment of a high-level, independent advisory committee dedicated to long-term planning and climate adaptation.
- September 2007: In line with the Water Vision, the Second Delta Commission is established.
- 2008: The Delta Commission publishes its final report.

• 2009: Climate adaptation policies are consolidated through the creation of the Delta Fund, providing dedicated financial resources.
• 2012: The Delta Act comes into effect, giving full legal authority to the Delta Program.

In the analysis of coastal governance models, the Dutch case is particularly significant as it exemplifies a comprehensive institutional commitment to adaptive and integrated territorial management. This demonstrates that coastal governance in the Netherlands is not confined to sector-specific planning nor delegated solely to local authorities; rather, it is embedded within a national strategy prioritized as essential for the governance of the entire country. From this overarching strategy, regional-level plans and programs subsequently cascade. Specifically, the financial resources allocated annually to the program by the Delta Fund—with a medium-term horizon of seven years, periodically extended—enable operational capacity that goes beyond planning, supporting projects and initiatives at multiple scales.

3.2 Mediterranean Basin: Valencia Region

The urban transformation of Valencia in response to water-related disasters exemplifies a critical shift toward ecological awareness and urban resilience. The pivotal moment came in 1957, when a catastrophic flood of the Turia River inundated the city, causing widespread destruction and significant loss of life. The disaster exposed the inadequacy of existing flood control measures and forced the city to confront its vulnerability to extreme weather events. In response, authorities implemented a monumental hydraulic intervention: the diversion of the river's course to the south of the city. Known as the Plan Sur, this redirection removed the watercourse from the densely populated urban core, significantly reducing the risk of future flooding. Although it followed the technocratic logic of mid-20th-century modernist planning — emphasizing infrastructure and control — it inadvertently created an unprecedented urban opportunity: the potential reuse of the abandoned riverbed within the heart of Valencia (Fig.6).

Fig. 6: Green Infrastructure in the metropolitan area of Valencia. Source: Muñoz Criado, A., 2009

In the aftermath of the diversion, the former riverbed lay dormant, a linear void threading through the city's fabric. Initial proposals envisioned the space as a transport corridor, complete with highways and rail links, aligned with the era's emphasis on motorization and urban expansion. However, these plans soon met with increasing public resistance. During the 1970s, a groundswell of civic activism emerged, mobilized around the idea that this central space should be reserved for public use rather than further sealed by asphalt. Environmental groups, cultural organizations, and ordinary citizens coalesced around the slogan "El río es nuestro y lo queremos verde" ("The river is ours and we want it green"), successfully halting the infrastructure project.

The outcome of this mobilization was the creation of the Turia River Park (Jardín del Turia), a linear urban park that redefined Valencia's relationship with its hydrographic and ecological heritage. Formalized in the local planning framework of the late 1970s, the project reclassified the old riverbed as public green space, with an emphasis on natural character and multifunctionality. From that point forward, the park evolved as a symbol of the city's capacity for adaptive reuse and democratic planning (Galán, 2011a).

Constructed in 18 sectors and stretching more than 8 kilometers from west to east, the Turia Park integrates a wide range of uses and functions. It acts as a major piece of urban green infrastructure, combining recreational spaces, ecological corridors, cultural institutions, sports facilities, and pedestrian and cycling routes (Galán, 2011b; Medina Piles et al., 2010). Its physical configuration is one of its most distinctive features: sunken approximately four meters below street level, it provides an uninterrupted, traffic-free environment that contrasts sharply with the surrounding cityscape.

This recessed design has a dual character. On one hand, it has contributed to some fragmentation, weakening transversal connections and making parts of the park feel visually and physically isolated from the adjacent neighborhoods. On the other hand, it has proven to be a vital asset during extreme meteorological events. The DANA (Depresión Aislada en Niveles Altos) storm of 2024 demonstrated the park's strategic hydrological role. Acting as a massive floodplain, the park absorbed significant volumes of stormwater runoff, mitigating the impact of the torrential rains that overwhelmed other urban and peri-urban drainage systems (Generalitat Valenciana, 2025). In this way, the Turia Park provided an emergency buffer zone and reaffirmed its value as a piece of resilient infrastructure in the face of climate uncertainty.

Beyond its flood mitigation capacity, the Turia Park stands as a landmark example of urban ecological retrofit. It exemplifies how cities can repurpose obsolete or hazardous infrastructures into multifunctional public spaces that promote environmental sustainability, public health, and social equity. The park's genesis and growth reveal the importance of civic participation, flexible planning instruments, and the willingness of institutions to revise earlier technocratic visions in light of evolving ecological and cultural values.

Nevertheless, the park's full potential has yet to be realized. Its integration into broader territorial systems remains an open project. Linkages with the Albufera Natural Park to the south, the Huerta de Valencia agricultural landscape, and the upstream Turia Natural Park are still fragmented or underdeveloped (Muñoz Criado, 2009). These connections are essential for establishing a coherent regional green infrastructure that promotes ecological continuity, habitat connectivity, and integrated mobility.

Ultimately, the Jardín del Turia illustrates how cities can turn crises into opportunities — how a site once defined by risk and destruction can be transformed into a symbol of resilience, community, and sustainable urbanism.

Building on the lessons learned from inland adaptive strategies such as the Turia River Park, the Valencian region has progressively extended its environmental planning efforts toward the coastline — a territory equally vulnerable to both anthropogenic pressure and climate-induced hazards. The Mediterranean littoral of the Comunitat Valenciana is characterized by a sharp juxtaposition between ecological richness and urban expansion, where natural systems such as wetlands, dune fields, and fertile agricultural lands coexist uneasily with tourism-driven development and infrastructural sprawl. Recognizing the critical role of the coast in territorial resilience, the Generalitat Valenciana approved in 2015 the Territorial Action Plan for the Green Infrastructure of the Litoral, commonly known as PATIVEL (Plan de Acción Territorial de la Infraestructura Verde del Litoral) (Jódar-Abellán & Molina Giménez, 2019).

PATIVEL (Fig.7) represents a paradigm shift in Spanish coastal governance. Unlike earlier regulatory tools focused on isolated protected areas, this plan introduces an integrated and supramunicipal perspective aimed at ensuring the continuity and functionality of the coastal green infrastructure system. It does so by defining a coastal protection strip extending 500 meters inland from the shoreline — a distance that can be expanded up to 2,000 meters where necessary to guarantee ecological connectivity with inland natural systems (Jódar-Abellán & Molina Giménez, 2019, pp. 715–716).

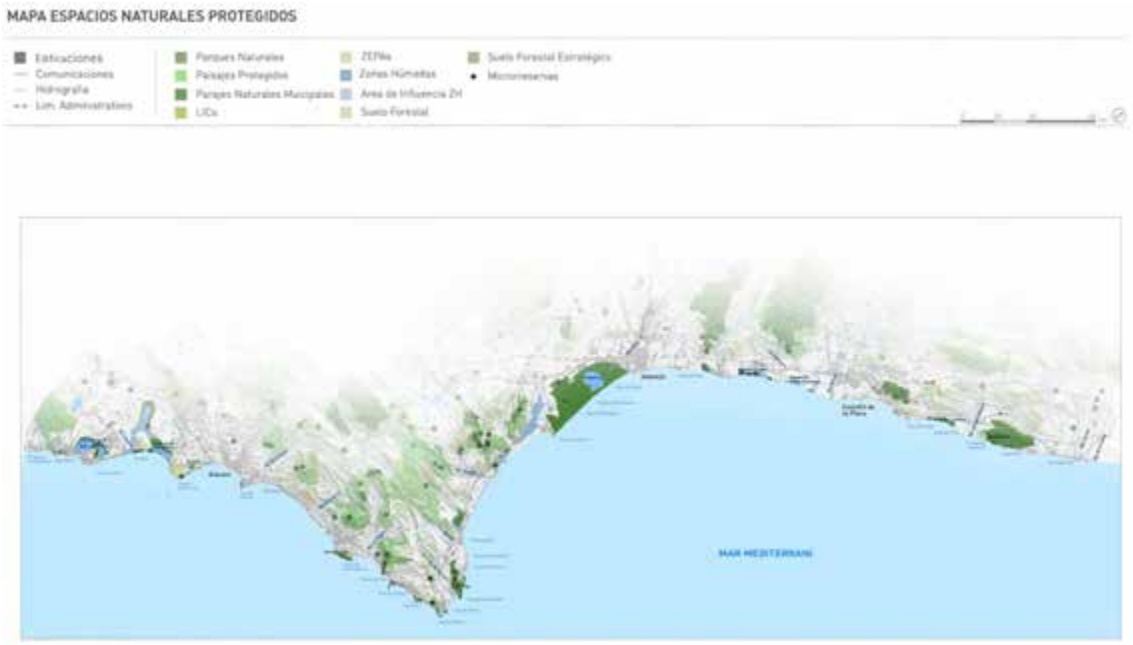

Fig. 7: Map of protected natural areas. Source: Pativel, 2018

This regulatory perimeter includes a wide range of environmental assets: wetlands of international importance (e.g., Albufera and El Hondo), coastal aquifers vital for water security, productive agricultural landscapes such as the Huerta de Valencia, and natural habitats listed under the EU Natura 2000 network. PATIVEL's guiding principle is that these assets should be preserved not only for their intrinsic ecological value but also for their contribution to public well-being, territorial permeability, and disaster risk reduction.

To operationalize this vision, PATIVEL defines five zoning categories based on environmental sensitivity and land-use constraints. These include non-developable coastal areas (ZRP-NA), ecological connectors (ZRC-AG1), regulatory buffers (ZRC-AG2), and areas of common agrarian interest (ZRC-AG3). Through this typological framework, the plan restricts new developments in high-risk or ecologically strategic areas and provides municipalities with a reference model for incorporating green infrastructure into their local planning instruments (Jódar-Abellán & Molina Giménez, 2019, pp. 717–719).

However, as with the Turia Park, the effectiveness of such territorial tools depends on institutional coordination, political commitment, and technical enforcement. One of PATIVEL's most innovative contributions is the creation of the Visor Cartográfico, a digital mapping platform that enables stakeholders — including public officials, professionals, and citizens — to interact with updated geospatial information regarding land classification, zoning restrictions, and environmental constraints. This platform enhances transparency and fosters a culture of participatory governance, echoing the role that civic engagement played in the creation of the Turia River Park (Galán, 2011a).

Despite these advances, the implementation of PATIVEL has faced substantial challenges. In the province of Alicante, for example, political pressures from landowners and local administrations led to a significant reduction — over 50% — of the initially proposed protected areas, raising concerns over potential rollbacks in environmental safeguards and exposing the administration to future claims of patrimonial responsibility for desclassified land (Jódar-Abellán & Molina Giménez, 2019, p. 721).

More importantly, recent events have demonstrated the urgency of PATIVEL's objectives. The DANA storm of October 2024, which caused the overflow of secondary watercourses such as the Poyo stream (Fig. 8) and devastated several peri-urban areas (Torrent, Paiporta, Picanya), illustrated the region's vulnerability not only along major river basins but also across minor drainage networks and urban margins. These territories, often excluded from

major hydrological plans, are precisely the types of zones PATIVEL seeks to regulate through ecological buffer zones and undeveloped corridors. In this sense, the plan functions not only as a regulatory document but as an adaptive framework — one that anticipates the multifunctional role of open spaces in risk mitigation, biodiversity conservation, and climate adaptation (Generalitat Valenciana, 2025).

Fig. 8: The Albufera area of Valencia, before and after the DANA. Source: ESA, Landsat-8 satellite, published by El Independiente

The coastal zone thus mirrors, on a regional scale, many of the tensions and possibilities observed in the case of the Turia Park: the friction between development pressure and landscape preservation; the necessity of cross-scalar governance; and the potential of green infrastructure to serve as both ecological and civic infrastructure. Just as the sunken corridor of the Turia River offered an unexpected but critical role during extreme rainfall events, the preservation of open coastal land — often undervalued — may prove essential in the face of sea-level rise, salinization, and hydrometeorological volatility.

In conclusion, PATIVEL represents a robust, if imperfect, attempt to shift coastal planning paradigms from reactive protection toward proactive resilience. Its integration with wider territorial plans — including the Plan de Acción Territorial del Paisaje, the regional wetland strategy, and local urban development plans — is crucial for its success. Like the Jardín del Turia, it reflects a broader redefinition of landscape not only as an aesthetic or natural element but as a strategic infrastructure for the future of Mediterranean cities.

4. Discussion: comparing pathways

Both the Dutch Delta Programme and the Valencian PATIVEL reflect how environmental disasters can act as pivotal catalysts in transforming spatial planning paradigms. The 1953 North Sea flood and the 1957 Turia River flood exposed systemic vulnerabilities and triggered immediate technical responses. Yet, rather than leading directly to comprehensive strategies, these events initiated a progressive trajectory—from emergency response to pilot projects, and eventually to the formulation of enduring territorial strategies.

The two case studies are particularly interesting to compare due to the temporal proximity of their trajectories, which both began in the 1950s. To facilitate comparison—both in terms of timing and in relation to governance structures and spatial scales—the main points are summarized in Table 1.

Table 1

Dimension	Delta Programme (Netherlands)	PATIVEL (Comunitat Valenciana, Spain)
Triggering Event	(i) **1953** North Sea flood disaster; (ii) renewed focus post **2005** with Hurricane Katrina	**1957** Turia River flood in Valencia; increasing coastal degradation
Precursor Projects	(i) 14 major infrastructural works including *Oosterscheldekering* (between 1958-1997), (ii) *Room for the River* (launched 2007) — spatial adaptation to flood risk	*Jardín del Túria* (post 1957) — river diversion and public park
Programme Launch	**2010** (official Delta Programme)	**2018** (official adoption of PATIVEL)
Key Objectives	Flood protection, freshwater security, climate change adaptation	Protect coastal green infrastructure, regulate urban expansion
Planning Philosophy	Adaptive Delta Management; "living with water"	Territorial ecological planning; limiting development
Geographic Scale	National (entire delta region); subdivided into regional sub-programmes	Regional: entire Valencian coastal strip (~500 km)
Governance Structure	Led by Delta Commissioner; multi-level collaboration (state, local, water boards)	Led by Generalitat Valenciana; coordination with municipalities
Public Participation	Strong participatory approach, co-creation, expert input	Formal consultations; more top-down approach
Legal and Planning Tools	Delta Act, Water Act, Environment and Planning Act; climate stress tests	PATIVEL as a binding Territorial Action Plan; land-use moratoria
Integration with Broader Policies	Linked with housing, agriculture, transport, and energy policies	Integrated with tourism, landscape, and sustainability frameworks
Focus Areas	River basins, coastal areas, urban settlements, agricultural zones	Ecological corridors, tourism zones, vulnerable coastal lands
Implementation Style	Long-term planning cycles (6 years); yearly updates	One-time plan with implementation oversight and revisions

In both contexts, it was the project—not the plan—that first redefined spatial and ecological possibilities. In the Netherlands, the Room for the River initiative (2007) marked a shift from purely technocratic flood defense to spatially integrated adaptation. Similarly, in Valencia, the creation of the Jardín del Túria transformed a flood-prone riverbed into a central green corridor, setting the stage for broader ecological thinking that would eventually underpin PATIVEL.

This trajectory underscores the value of concrete interventions—pilot projects capable of reshaping collective imaginaries and institutional approaches—as necessary precursors to robust, long-term strategies. In the Dutch case, this process was institutionalized through dedicated funding mechanisms like the Delta Fund and a multi-level governance framework. In contrast, PATIVEL's implementation faced fragmented authority and local resistance, particularly in areas like Alicante where political pressures halved the extent of proposed protections.

While the Netherlands and the Comunitat Valenciana differ in geographic, economic, and cultural contexts, they both illustrate a common pattern of adaptive transformation. This shared experience highlights the necessity of proactive planning, informed by past disasters but not dependent on future crises to spur action. As discussed in this paper, flooding has always been part of Europe's coastal and deltaic histories. The real challenge lies in moving from reactive responses to anticipatory governance, recognizing that all such territories remain inherently vulnerable under changing climatic conditions.

5. Conclusions

This contribution presents a section of the PRIN COSTA|Med research project, funded by the Next Generation EU initiative. The broader project focuses on collecting and analyzing international case studies (Fig.9) where climate

change adaptation and sea-level rise strategies have emerged in response to catastrophic events or situations of acute environmental, urban, and social vulnerability. The aim is to identify shared trajectories that can inform the development of guidelines for coastal zone management and adaptation across the Mediterranean—adopting an integrated perspective in which planning and design work together. Strategic visions must guide action, but strategies themselves are also shaped through concrete interventions.

Fig. 9: Location of the different global case studies considered in the PRIN COSTA|Med research project. In red, innovative territorial design initiatives; in blue, completed case studies.Source: Marta Rabazo Martin

The two case studies discussed—the Dutch Delta Programme and the PATIVEL in the Comunitat Valenciana—demonstrate this reciprocal relationship between strategy and project. These experiences are particularly relevant for other coastal territories, even those not yet severely affected by extreme events. As highlighted throughout this paper, the entire Mediterranean basin is exposed to a wide range of risks, with potential impacts on population, economic systems, agriculture, and cultural heritage.

Our intention here was to illustrate the methodological approach of our study and some of the key dimensions used to compare and analyze different experiences. In fact, our comparative research spans over [insert number] global case studies. COSTA|Med promotes a research by design approach—a methodology still relatively underdeveloped in Italy but clearly effective in many of the international contexts we have explored.

Furthermore, the project aims to broaden the focus of impact assessments: from analyzing consequences on populations and infrastructure to considering the vulnerability of cultural heritage and cultural ecosystem services. Raising awareness of these often-overlooked dimensions is essential to grasp the full scope of sea-level rise implications.

Finally, we may need to revise our understanding of what constitutes a "disaster." Rather than framing it solely as a sudden and disruptive event, we should also recognize the slower, progressive transformations of territorial practices and heritage uses—changes already underway in many places. Only by acknowledging these evolving dynamics can we begin to see this new form of "disaster" as a potential driver for change, adaptation, and forward-looking planning strategies.

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Post-Disaster Population Mobility: Considerations for the February 2023 Earthquakes in Türkiye

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Abstract
The February 6, 2023 earthquakes in Türkiye caused immense destruction, displacing millions and highlighting the importance of understanding post-disaster mobility. This study examines the socio-economic and environmental drivers of population flows after the disaster, using Geographically Weighted Regression (GWR) to analyse data from receiving cities. Key variables include GDP per capita, unemployment, education, population density, and climate conditions. Findings show that displaced populations mostly relocated to nearby, less-affected cities rather than distant western regions. This shift reveals the critical need for targeted policies addressing infrastructure, employment, and social integration. Unplanned relocation can worsen inequality and deepen socio-economic divides. The study underscores the importance of integrating mobility data into disaster recovery planning, emphasising equitable, long-term strategies that enhance resilience and reduce vulnerability in both affected and receiving areas.

Keywords: Post-disaster mobility, earthquakes, unplanned relocations, urban resilience, Türkiye

Introduction

The increase in the frequency, intensity and impact of natural disasters worldwide in recent years has made disaster management and recovery processes even more critical. Among natural disasters, earthquakes, with their devastating and unpredictable effects, cause great loss of life and property on a global scale. An analysis of nearly 100 major earthquakes that have occurred worldwide since 1900 shows that 93% of global deaths are caused by earthquakes (Daniell et. al., 2017). If urgent, fair and permanent solutions to the economic, ecological, psychological and social problems that occur after earthquakes are not produced, much more serious problems, including security, will come to the agenda (İrdem and Mert, 2023). Foremost among these problems is the earthquake-related phenomenon of forced migration. This makes post-disaster population mobility an important focus in understanding not only the physical but also the social and economic consequences of disasters.

This post-disaster population mobility is considered as a critical variable for the success of response and recovery plans. Wu et. al. (2021) state that understanding and predicting the direction and pattern of post-disaster migration is important for assessing the vulnerability levels and resilience capacities of communities. Similarly, it is stated that migration directly affects the demographic structure, labour market, social service provision and infrastructure, and therefore, post-disaster flows are not only temporary but may cause permanent social transformations. This situation forces city administrators to think about laws and practices that will make cities resilient especially in times of crisis.

Türkiye is one of the countries with a high earthquake risk, and the occurrence of two major earthquakes of magnitude 7.8 and 7.5 on 6 February 2023, nine hours apart, centred in Kahramanmaraş, was recorded as a first in history. More than 50 thousand people lost their lives as a result of the earthquake. Approximately 13.5 million people in 11 provinces including Kahramanmaraş, Hatay, Adana, Gaziantep, Kilis, Osmaniye, Adıyaman, Şanlıurfa, Malatya, Diyarbakır and Elazığ were affected and thousands of people had to leave their homes and migrate to other regions. This mass population mobility is not only a coping strategy, but also brings new problems at social, economic and spatial level for the receiving and giving cities. The critical role of population dynamics after the occurrence of disasters requires an in-depth study of this issue in order to draw useful conclusions for

post-disaster response and recovery plans. Understanding the direction, triggering factors and consequences of post-disaster population flows is of great importance in terms of both increasing the effectiveness of response processes and producing long-term resilience policies. At this point, earthquake, which is one of the natural disasters and has a significant impact especially considering the damage and loss of life it causes, also stands out in the legal framework in Türkiye and in making significant decisions on prevention and post-disaster response. In this context, the study aims to contribute to better management of the post-disaster process by addressing the spatial and socio-economic determinants of post-earthquake migration movements.

This article progresses in four sections after the introduction. In the second section, it examines the conceptual framework of post-disaster population mobility, the triggering factors behind post-disaster migration patterns, and the human movements that followed past earthquakes in Türkiye. In the third section, material and method used are explained. In the conclusion section, an evaluation of the results of the study conducted and understanding the direction, triggering factors, and consequences of post-disaster population movements are presented.

Literature Review

Disasters are multidimensional crises that create not only physical destruction but also social instability and vulnerability. Disasters have serious destabilising effects on individuals and societies. Management of these impacts is only possible through planned and multi-actor co-operation. In the literature, this process is generally handled within the framework of the concept of 'disaster management'. Disaster management deals with the pre-planning of natural or man-made disasters, minimisation of damages, effective response at the time of disaster and organisation of post-disaster recovery process (Duruel, 2023).

Population movements following disasters are expected occurrences (Myers, 2002). Especially the loss of life caused by earthquake, which is one of the types of natural disasters, the psychological effects that people experience as a result of the loss of their acquaintances, the destruction or damage of their houses, or the fear of earthquake again in the region where they live lead individuals to different coping strategies. Post-disaster human mobility is one of the main coping strategies adopted by individuals and households to respond to adverse conditions and recover their pre-disaster lifestyles (Dickinson, 2013). Following the devastating effects of earthquakes, individuals who have experienced the earthquake leave the place where they live and migrate to different cities where they feel safer after the disaster in order to meet the basic needs of the affected population such as shelter and safety. These movements may include temporary and permanent relocation, resettlement and return. Human mobility may cause long-term population changes that affect the economy and social structure of the country (Ting-Hsiang et. al., 2024). However, this situation has caused and is thought to continue to cause many problems both in the abandoned earthquake zone and in the settled provinces. While migrating individuals struggle with the effects of being cut off from social networks, adaptation difficulties and psychological traumas, migrating regions lose resources and resilience, and their economic and social structures are weakened (Ting-Hsiang et. al., 2024). Understanding the interaction between the recovery of infrastructure systems and population movement (displacement and return) after such large-scale disasters is essential for developing policies that can enable population return in communities and promote sustainable development in hazard-prone areas (Aerts et al., 2018). Therefore, it is vital to take preventive measures to reduce the possible destructive effects after an earthquake and eliminate risks as much as possible.

The direction and intensity of post-disaster population mobility may vary according to the socio-economic characteristics of the migrating individuals. After the earthquake, individuals show three different tendencies: migration to villages/rural areas where those affected by the earthquake think that they are relatively safer; migration to provinces not affected by the earthquake; and migration to large cities. Groen and Polivka's (2010) study on the aftermath of Hurricane Katrina revealed that households that suffered housing damage and were economically disadvantaged were less likely to return. On the other hand, it was observed that some households returned to their damaged houses in a short time due to financial inadequacies and difficulties in finding accommodation elsewhere (OCHA, 2023). There are similar dynamics in the case of Türkiye. After the 1999 Marmara Earthquake, the rate of migration from the region doubled compared to the previous year, while the rate of migration recei-

ved decreased (Peker and Şanlı, 2022). After the 2011 Van Earthquake, approximately 250,000 people temporarily migrated to metropolises such as Istanbul, Mersin, Antalya, Ankara, Bursa and Izmir (Tiryaki Yenilmez, 2023). On 6 February 2023, a similar picture emerged in the Kahramanmaraş earthquake. It was determined that 800,000 people took shelter in villages in the first month of the earthquake and 3.3 million people left the earthquake zone and migrated to other provinces (Sağıroğlu et. al., 2023).

Earthquakes not only displace individuals, but also lead to long-term demographic and economic changes at the country level. In Türkiye, the impact of disasters becomes more evident in the context of regional inequalities. The regional plans and urban plans prepared in Türkiye since the 1960s in order to reduce regional development disparities have not achieved the expected success. While regional plans were inadequate in practice, cities developed in an unplanned and risk-insensitive manner (Özgen, 2007). The post-1980 liberal economic policies led to the concentration of population and investments in the western metropolises and coastal regions located in the most risky seismic belts of Türkiye (Yoloğlu and Zorlu, 2024). This situation has led to the spatial concentration of disaster risks in certain regions and revealed the inadequacies of the planning system in managing these risks. At this point, it is possible to say that the spatial planning system implemented in Türkiye has failed both in reducing disaster risks and in the balanced distribution of population.

The phenomenon of migration has been at the centre of academic research for many years, and many theoretical approaches have been developed to explain the causes, scope and dynamics behind migration movements. One of these approaches, the neoclassical theory, explains migration by economic factors, especially interregional labour demand and wage differences (Rodríguez-Pose and Ketterer, 2012; Scott, 2010). According to this model, individuals tend to move from regions where job opportunities are limited and wages are low to regions where employment is more easily available and wages are high (Whisler et al., 2008). On the other hand, there are also approaches that argue that migration decisions are not limited to economic factors; environmental and social opportunities that affect the quality of life can also be determinant in individuals' relocation decisions. Individuals may prefer to move to regions where wages are lower but more attractive in terms of lifestyle, social environment or natural environment (Nelson and Ehrenfeucht, 2020). Discussions on such opportunities were first raised in the 1970s when Graves (1979) showed the influence of climate factors in migration patterns in the US (Li et. al., 2023). Over time, the concept of amenities has expanded to a wider range of factors that affect quality of life, such as social relations, cultural richness, recreational opportunities, and social tolerance (Scott, 2010; Whisler et al., 2008). However, there is no clear consensus in the literature on the relative weight of economic factors and such life opportunities in migration decisions (Buch et al., 2014; Nelson and Ehrenfeucht, 2020). These differences are thought to stem from the diversity in the social and economic structures of countries (Lee and Kim, 2019). In this context, it is thought that understanding the spatial and socio-economic triggers of post-disaster migration movements in Türkiye will form an important basis for urban managers, planners and stakeholders involved in the process in terms of disaster management.

Material and Method

In this study, a Geographically Weighted Regression (GWR) model was employed to analyze the factors influencing post-disaster migration flows, with a specific focus on spatial heterogeneity. Unlike conventional global regression models, GWR assumes that the relationships between dependent and independent variables may vary across geographic space. As highlighted in the literature (Fotheringham and Sachdeva, 2022; Fotheringham et al., 2009), the underlying mechanisms driving migration flows can differ spatially, and the factors that attract individuals to particular regions are often shaped by local contexts. Therefore, the socio-economic and environmental determinants of migration are expected to exhibit spatially non-stationary relationships (Rijnks et al., 2018; Wang et al., 2019; Szymanowski and Latocha, 2021). To account for these regional disparities, GWR was selected for this study, as it assigns spatially varying weights to each observation based on geographic proximity. The migration data utilised in this research are based on the 2023 records of the Turkish Statistical Institute (TURKSTAT). The dependent variable comprises the number of out-migrants from provinces directly affected by the earthquakes that occurred in February 2023. The independent variables were selected based on an extensive review of the literature and were grouped into three main categories: economic conditions, socio-demographic

structure, and environmental characteristics (Table 1). These variables were derived from 2022 data in order to reflect the pre-disaster context, thus capturing the underlying conditions that may have influenced subsequent migration decisions.

Table 1. Description of variables

Categories	Variable	Source
Economic conditions	Gross domestic product ($) per capita	TurkStat, 2022
	Rental value of a residential property (Unit Prices per m²)	Endeksa, 2022
	Sales value of a residential property (Unit Prices per m²)	Endeksa, 2022
	Unemployment rate (%)	TurkStat, 2022
	Number of enterprises in the agriculture, forestry, and fishing sector	TurkStat, 2022
	Number of enterprises in the manufacturing sector	TurkStat, 2022
	Number of enterprises in the construction sector	TurkStat, 2022
Socio-demographic status	Not finishing a school rate (%)	TurkStat, 2022
	Primary and secondary education rate (%)	TurkStat, 2022
	High school rate (%)	TurkStat, 2022
	Bachelor's degree rate (%)	TurkStat, 2022
	Postgraduate rate (%)	TurkStat, 2022
	Population ratio in the 0-14 age group	TurkStat, 2022
	Population ratio in the 15-64 age group	TurkStat, 2022
	Population ratio in the 65+ age group	TurkStat, 2022
	Population density (per square kilometer)	TurkStat, 2022
Environmental characteristics	Earthquake risk level	Disaster and Emergency Management Authority, 2022
	Distance from the earthquake zone	ArcGIS Pro Living Atlas of the World
	Erinç rainfall activity index	Meteorology General Directorate, 2022
	DeMartonne aridity index	Meteorology General Directorate, 2022
	Average air temperature	Meteorology General Directorate, 2022
	Total annual precipitation (mm)	Meteorology General Directorate, 2022

Economic, social, and environmental factors are considered as major pull determinants that shape individuals' decisions to relocate in the aftermath of a disaster (Görür and Yüzbaşı, 2024). These determinants contribute to differences in perceived utility, which in turn influence the direction and volume of migration. In the category of economic factors, key labour market indicators such as gross domestic product (GDP), unemployment rate, and entrepreneurial activity were considered (Buch et al., 2017; Lee and Kim, 2019; Li et al., 2023). Additionally, housing prices in the destination provinces were included in the model as an economic variable associated with local living conditions (Li et al., 2023). Recent research has shown that non-economic factors have become increasingly influential in shaping migration preferences, complementing traditional economic determinants (Buch et al., 2017; Wu et al., 2019). Accordingly, this study also incorporated socio-demographic indicators such as age distribution, educational attainment, and population density to evaluate the attractiveness of potential destinations. Given the proven relevance of climatic and geographical factors in migration behavior (Görür and Yüzbaşı, 2024), environmental variables such as seismic risk level, average temperature, and precipitation were also included in the analysis.

During the data analysis phase, all variables were first normalised using the min–max scaling method. To address potential multicollinearity, factor analysis was conducted to identify and exclude variables that could compromise the reliability of the model. Subsequently, variables free from multicollinearity were included in various model configurations, and model performance was evaluated using the Akaike Information Criterion (AIC), R^2, and Adjusted R^2 metrics. The spatially varying effects derived from the GWR model were then visualised through maps, enabling the interpretation of statistically significant spatial patterns in migration dynamics.

Empirical Results

Figure 1 illustrates the migration patterns originating from the earthquake-affected region. According to the results, the provinces with the highest out-migration are Hatay, Malatya, and Kahramanmaraş, while Elazığ and Osmaniye recorded the lowest migration figures.

Post-disaster migration flows predominantly occurred either within the vicinity of the affected region or toward western parts of Türkiye. Provinces that experienced substantial out-migration—such as Hatay, Adıyaman, Diyarbakır, Malatya, Adana, and Kahramanmaraş—sent large numbers of migrants to Türkiye's three major metropolitan areas: Istanbul, Ankara, and Izmir. In addition to neighboring provinces, Antalya and Mersin emerged as key destination cities. Notably, Hatay, one of the provinces most severely impacted by the earthquake and the highest source of migration, witnessed large-scale population movements to a wide range of provinces, particularly in western Türkiye. By contrast, provinces that suffered less severe damage primarily experienced migration to adjacent provinces or select major urban centres.

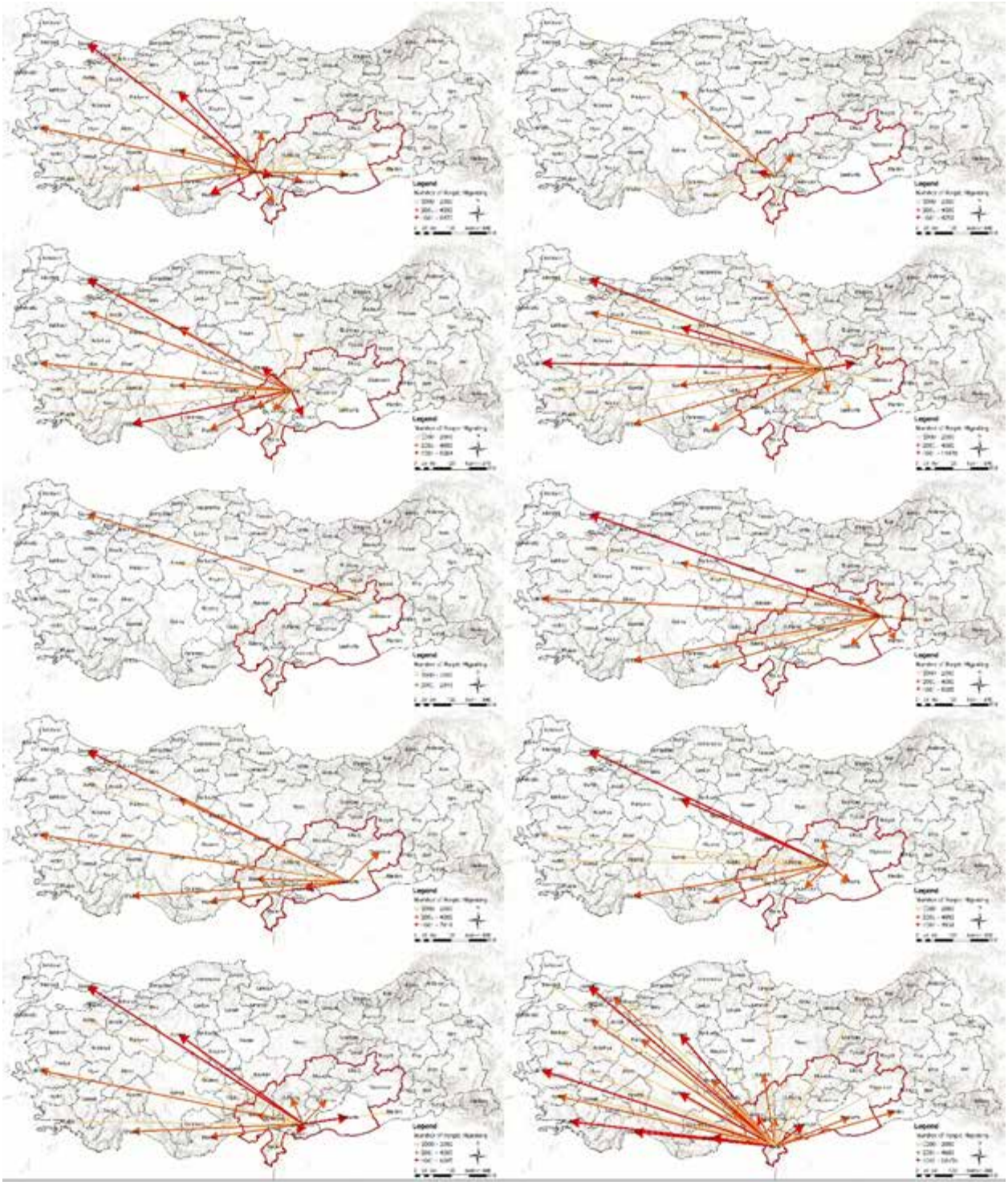

Figure 1. Spatial distribution of interprovincial migration density following the earthquake in Türkiye.

The results of the GWR analysis reveal how the effects of independent variables on the dependent variable vary across provinces, and these relationships are visualised through thematic maps. The figures include both the coefficient maps—which display the magnitude and direction of influence—and the statistical significance maps, which illustrate the spatial variability of effect strength.

Figure 2 presents the spatial relationship and significance levels between the number of migrants from the

earthquake-affected region (independent variable) and gross domestic product (GDP) per capita (dependent variable) across Turkish provinces. The coefficient distribution map indicates a strong negative relationship between GDP per capita and post-disaster in-migration in the coastal provinces of the Mediterranean region. In these areas, lower levels of GDP are associated with higher migration inflows following the earthquake. Conversely, in eastern Türkiye. a positive association was observed between GDP and migration inflows, although this relationship is not statistically significant. These findings reflect the spatial heterogeneity in economic attractiveness and the differentiated role of GDP in shaping post-disaster migration decisions across regions.

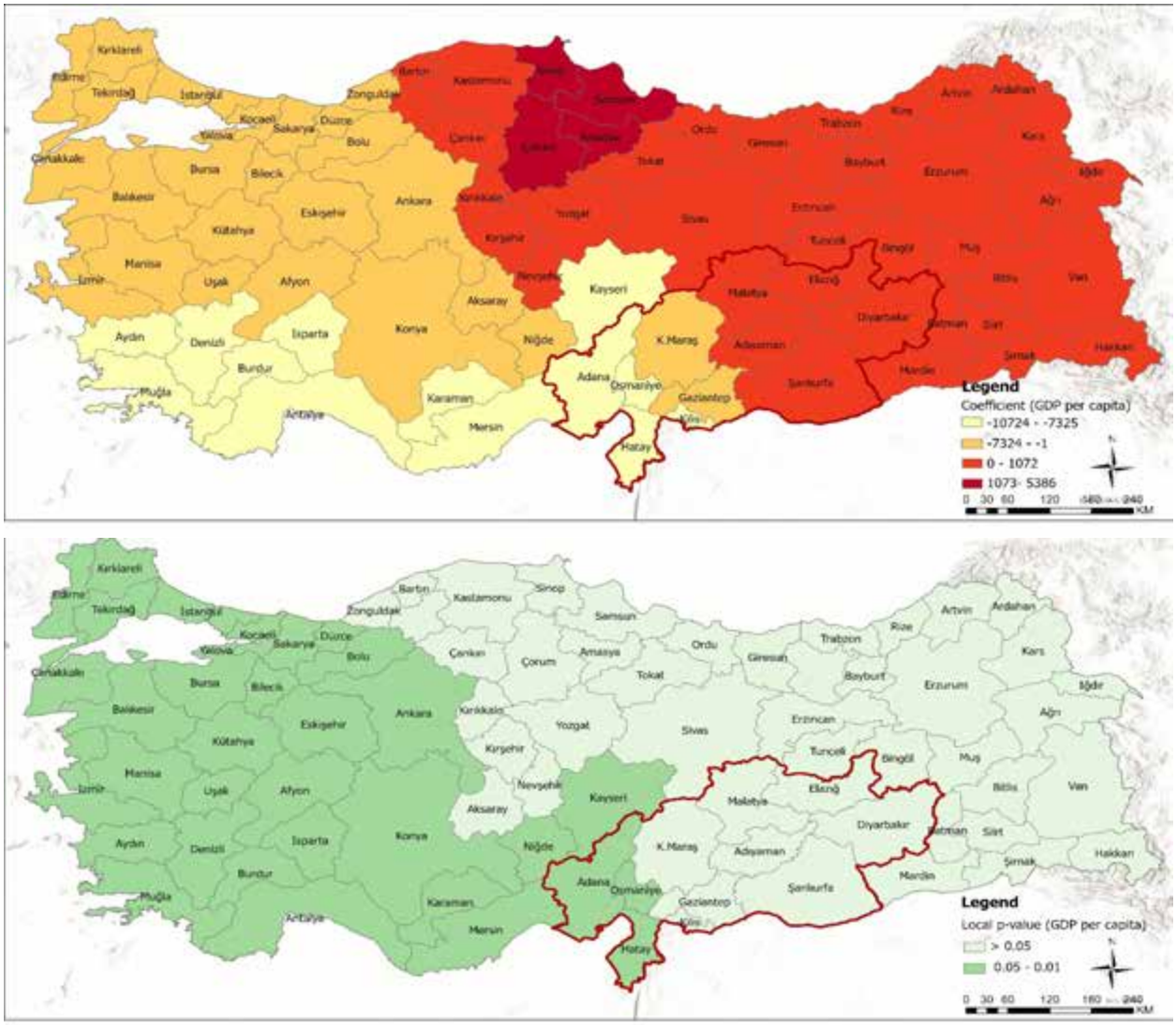

Figure 2. Distribution and significance of the relationship between GDP and post-disaster migration by province

Figure 3 demonstrates that the spatial effects of rental price levels on migration vary significantly across regions. In the northeastern provinces, increases in rental prices exert a negative impact on migration inflows, suggesting that rising housing costs act as a deterrent. In contrast, a positive association is observed in provinces located in Central Anatolia and western Türkiye, where higher rental levels are linked to increased migration inflows. This spatial divergence indicates that the influence of housing costs on migration decisions is not uniform across space. Notably, in western Türkiye, rental price increases do not appear to function as a deterrent, suggesting that post-disaster migration toward these regions is driven by factors other than affordability, and that housing costs are not a decisive factor in migration preferences in the western provinces.

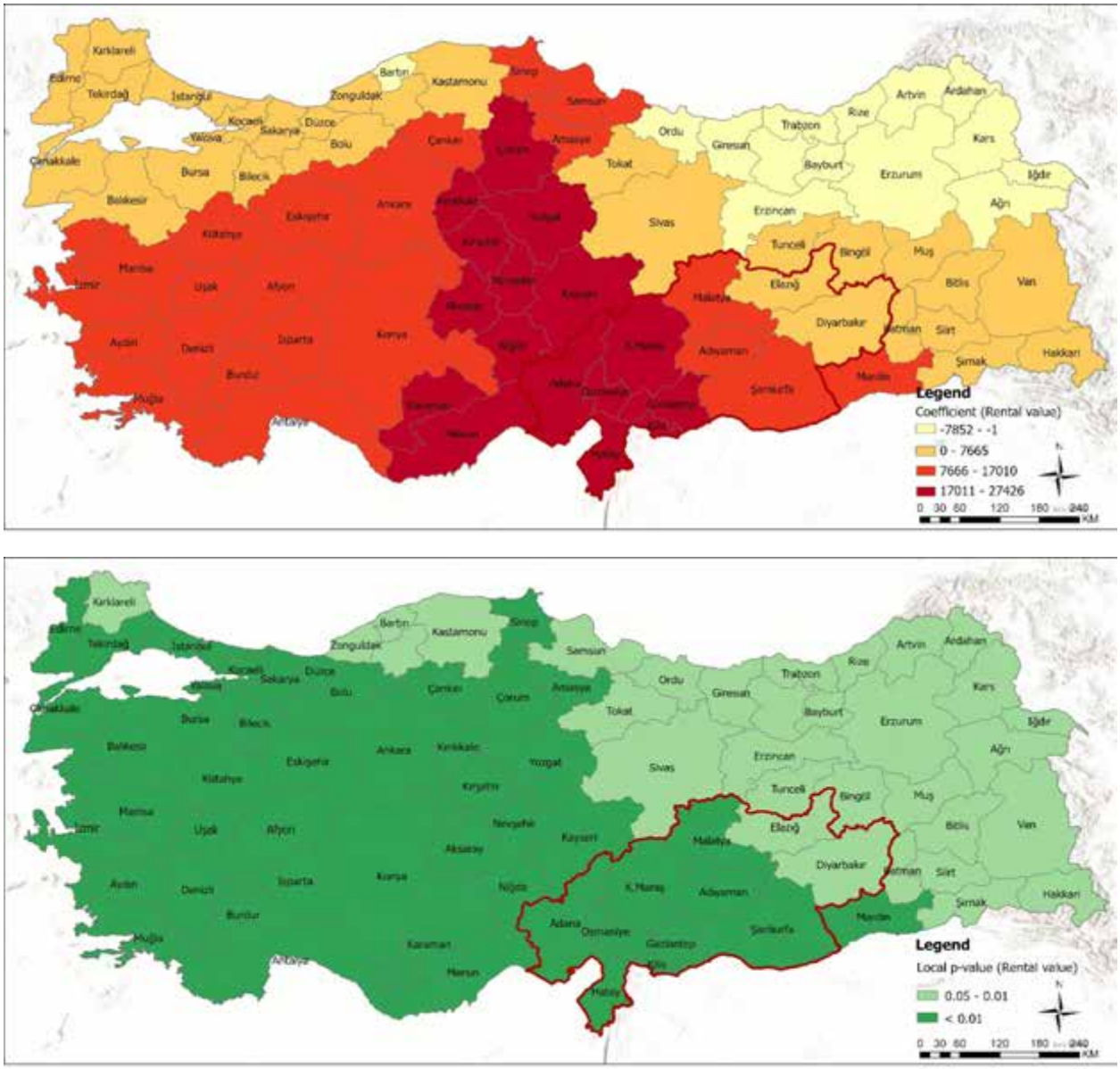

Figure 3. Distribution and significance of the relationship between rental value and post-disaster migration by province

Figure 4 reveals a positive relationship between the number of enterprises in the manufacturing sector and post-disaster migration across all provinces. This suggests that increases in the number of manufacturing enterprises are consistently associated with higher levels of in-migration from the earthquake-affected areas. The effect is particularly pronounced in the eastern regions of Türkiye, where industrial development remains in progress. These findings highlight that investment in the manufacturing sector exerts a significant positive influence on the migration attractiveness of less-developed provinces. In this context, the presence of industrial opportunities appears to act as a key pull factor, especially for populations relocating in the aftermath of the disaster.

Figure 4. Distribution and significance of the relationship between number of enterprises the manufacturing sector and post-disaster migration by province

Figure 5 illustrates the relationship between the proportion of the population holding a bachelor's degree and post-disaster migration. The results indicate a strong positive association between higher education attainment and in-migration in western Türkiye, suggesting that provinces with a higher share of university-educated residents attract more migrants from the earthquake-affected areas. In contrast, in eastern Türkiye, the relationship between the bachelor's degree rate and migration appears to be negative, meaning that increases in the proportion of educated residents are associated with lower levels of in-migration. However, this relationship is not statistically significant in the eastern region. These findings suggest that the higher concentration of educated populations in western Türkiye enhances the migration attractiveness of these provinces. This pattern can be linked to the more developed labour markets, diverse employment opportunities, and higher perceived quality of life in western regions, which collectively act as strong pull factors for disaster-induced migration.

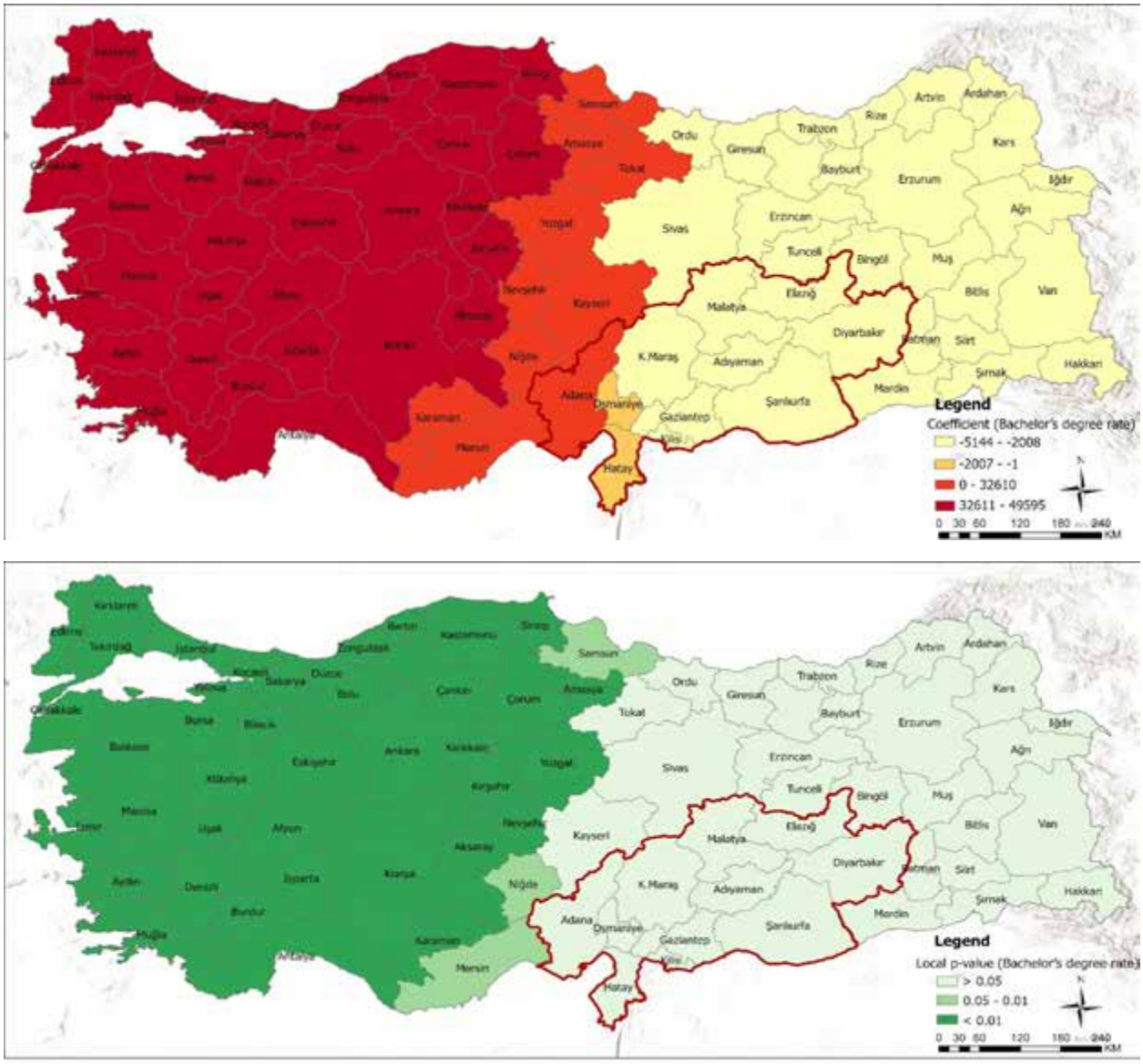

Figure 5. Distribution and significance of the relationship between Bachelor's degree rate and post-disaster migration by province

Figure 6 demonstrates the spatial variability in how provincial earthquake risk levels shape post-disaster migration patterns. In eastern Türkiye, higher seismic risk is significantly associated with reduced in-migration from the affected areas, suggesting that individuals are more likely to avoid relocating to high-risk zones in the aftermath of the disaster. In contrast, in western Türkiye elevated earthquake risk does not appear to discourage migration, indicating that risk perception exerts a less influential role in destination choices in these regions.

These findings highlight the geographically differentiated nature of risk perception in migration behavior. In particular, major western cities such as Istanbul and Izmir continue to attract significant post-disaster migration despite their high seismic vulnerability. This implies that the economic and social advantages offered by these urban centres, such as robust labour markets, higher quality of life, and strong institutional infrastructure, override concerns about earthquake risk, maintaining their appeal even in the face of elevated hazard exposure.

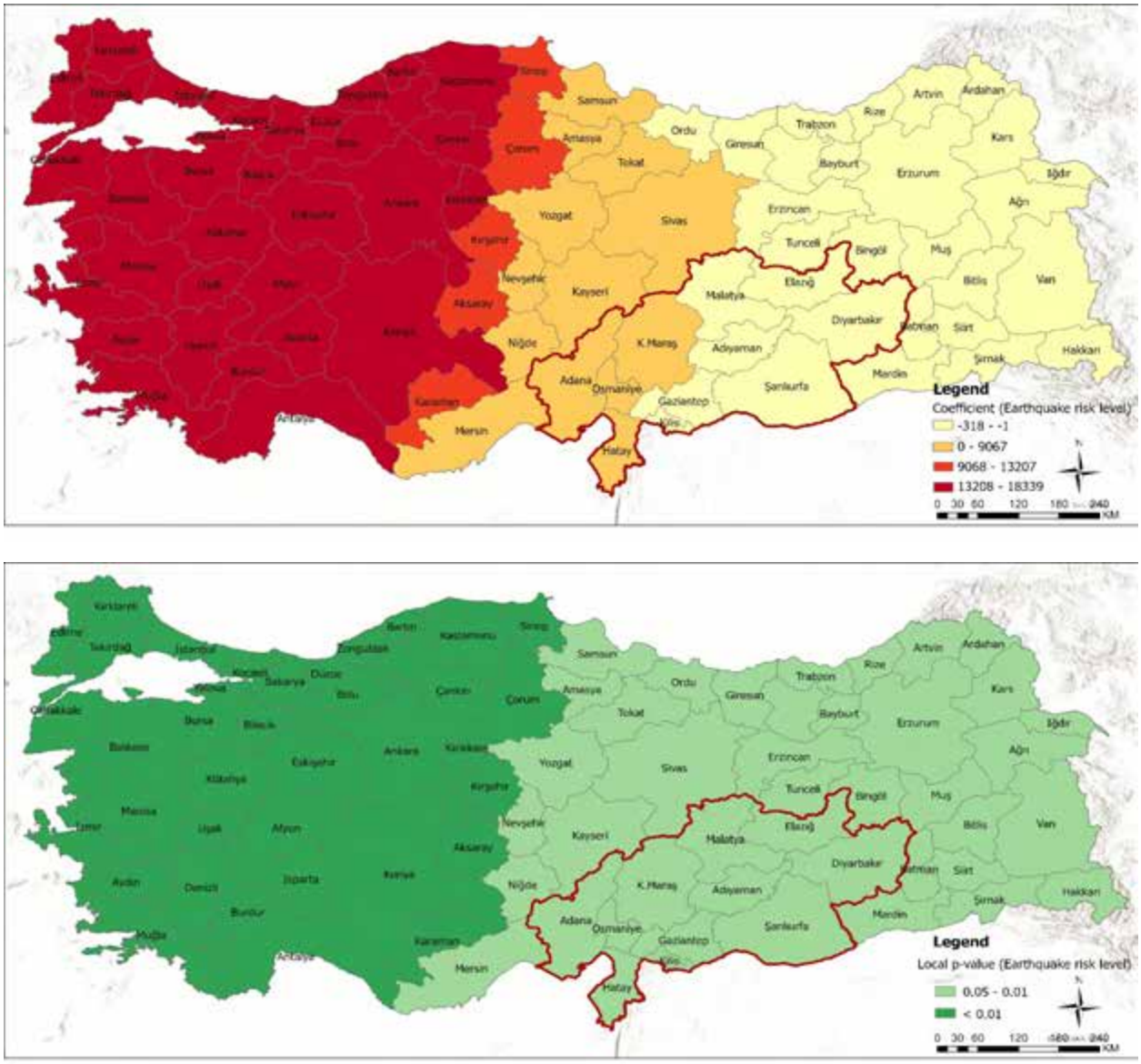

Figure 6. Distribution and significance of the relationship between Earthquake risk level and post-disaster migration by province

Figure 7 reveals the spatial relationship between the Erinç Rainfall Activity Index and post-disaster migration. The findings indicate that in eastern Türkiye, higher levels of rainfall activity are significantly associated with a decline in migration, suggesting that more intense and challenging climatic conditions may discourage displaced populations from relocating to these areas. This relationship was found to be statistically significant. In contrast, in western provinces, although an increase in the Erinç index shows a positive tendency to attract migration, this association does not reach statistical significance. This suggests that while greater climatic comfort may enhance migration appeal in the west, economic and social factors play a more decisive role in shaping post-disaster relocation preferences in those regions.

These results underscore the regionally differentiated impact of climate conditions on migration decisions. In the east, unfavorable weather patterns—despite potentially supporting agriculture-based livelihoods—may act

as a deterrent for disaster-affected individuals seeking resettlement. Conversely, in the west, the limited role of rainfall-related comfort highlights a greater dependence on structural and socio-economic advantages. Overall, the varying influence of the Erinç Rainfall Activity Index points to the non-uniform role of environmental factors in shaping post-disaster migration. Particularly in eastern provinces, climate-related constraints appear to exert a more pronounced effect, emphasising that disaster-induced mobility is not solely determined by economic considerations, but also by environmental conditions within the spatial context.

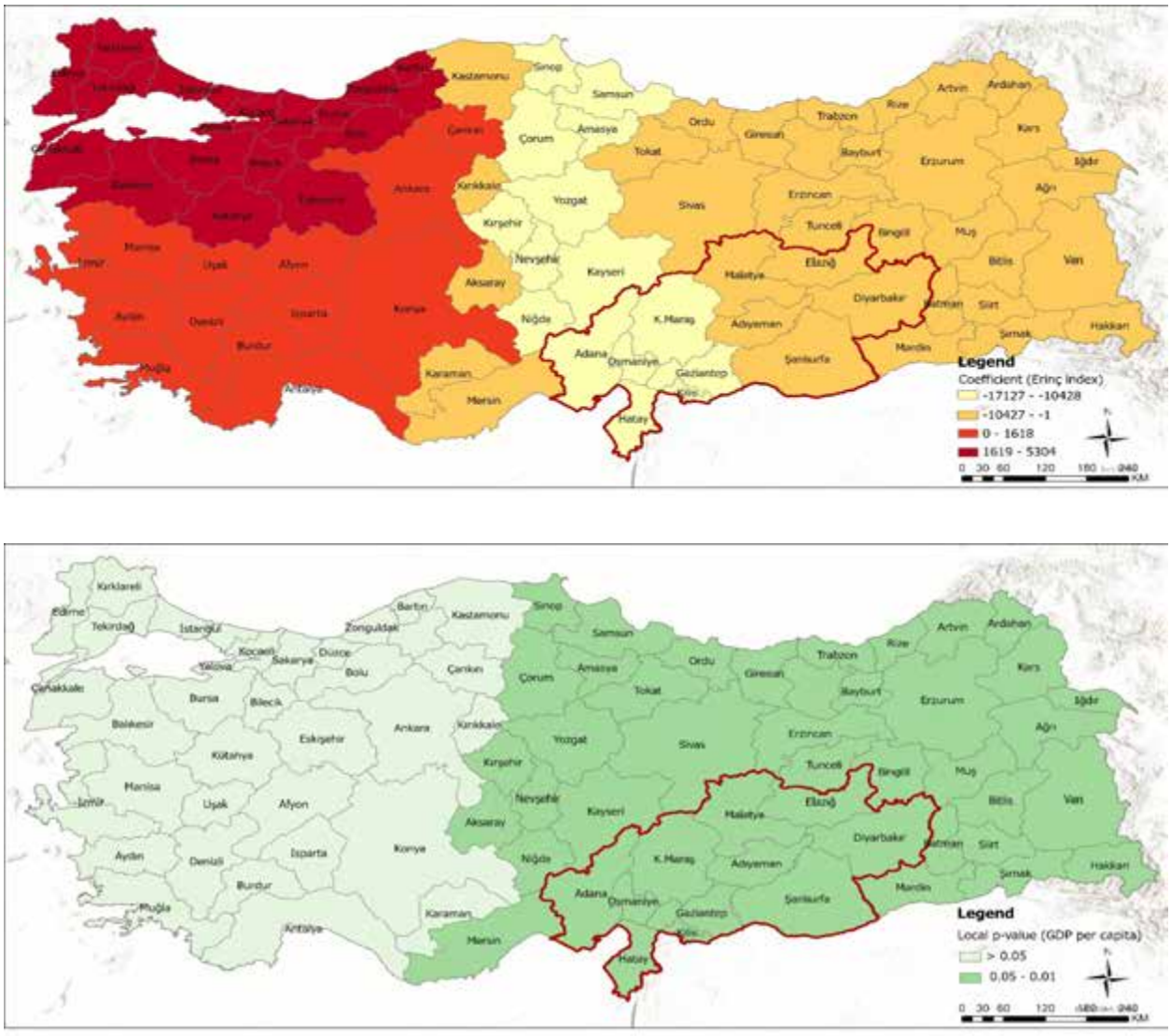

Figure 7. Distribution and significance of the relationship between Erinç rainfall activity index and post-disaster migration by province

Conclusion

This study demonstrates that post-disaster migration flows were disproportionately concentrated in the western regions of Türkiye—particularly in major metropolitan areas such as Ankara and Istanbul—compared to the eastern provinces. In the western regions, economic prosperity (as measured by GDP per capita) and higher education attainment emerged as primary pull factors driving migration. Conversely, in the eastern provinces, the expansion capacity of the manufacturing sector was identified as the most influential determinant shaping increased migration inflows.

On the other hand, factors such as seismic risk, rising housing costs, and adverse climatic conditions were found to suppress migration in eastern regions. Notably, these deterrent factors did not exhibit a significant impact on migration decisions in the west, where their influence appeared negligible.

These findings highlight that the spatial structure of post-disaster migration is shaped not only by economic opportunities but also by a complex interplay of environmental and socio-demographic factors. The fact that migration flows to the eastern regions are more sensitive to a broader range of variables suggests that these areas may be more vulnerable and volatile in terms of their migration dynamics. In this regard, the manufacturing sector's potential to attract migrants in the east holds strategic importance for the formulation of post-disaster population redistribution policies aimed at spatial balance.

Importantly, the study also reveals that post-disaster migration dynamics cannot be fully explained by economic indicators alone. In the eastern provinces, the increasing influence of environmental factors—particularly those linked to climate change—on migration decisions underscores the urgency of developing climate-adaptive settlement and development strategies. Therefore, effective governance of post-disaster migration requires the implementation of integrated policy frameworks that prioritise not only economic development but also environmental sustainability and regional resilience.

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Why should we bother about risk reduction at the urban scale? The Early Recovery System (ERS) framework to assess the impact of prevention instruments on post-quake urban functionality

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Abstract
Italian seismic risk management has traditionally prioritized post-disaster recovery instead of effective urban prevention strategies. This approach carries significant costs, and the speed of recovery plays a critical role in determining whether communities choose to rebuild or relocate permanently. To accelerate post-earthquake recovery and enhance urban resilience, effective disaster risk reduction policies centered on urban prevention strategies to safeguard territorial safety effectively, are needed.

In this work, we introduced the Early Recovery System (ERS) framework that identifies essential urban elements with potential for seismic retrofitting. Through the calculation of 18 indicators over different time intervals and across three hypothetical scenarios in the case study of L'Aquila post 2009 earthquake, we generated recovery curves that illustrate urban functionality loss and recovery trajectories, to establish the optimal prevention strategy to be adopted.

Keywords Seismic risk prevention; Early recovery; Urban functionality assessment

1. Introduction

Italy faces high seismic risk due to several factors, including a widespread seismic hazard, the high vulnerability of its built environment, and substantial exposure in terms of population density and historical-cultural heritage (Dolce et al., 2021). Since 1950, earthquakes have caused approximately 5,000 casualties and significant economic damage (Coviello and Somma, 2021).

Despite this evidence, the predominant approach to seismic risk management has focused mainly on emergency public actions and the physical restoration of individual assets rather than comprehensive urban prevention strategies. This "territorial compensation" approach entails very high costs in terms of financials and territorial equity (Balducci et al., 2021).

Catastrophic events can significantly impact local communities, and time plays a crucial role, as the speed of recovery is decisive in determining whether community members will decide to stay and rebuild or leave permanently (Arendt and Alesch, 2014). Recovery time, defined as the period needed to restore system functionality to the desired pre-earthquake level, is a variable with high uncertainty and typically depends on several complex factors: pre-event conditions, available resources, and governance (Terzic et al., 2021).

To accelerate post-earthquake recovery, policy initiatives such as the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) have emphasized the potential of stakeholders and communities to become more adaptable through practices and policies aimed at implementing Disaster Risk Reduction (DRR) programs and actions.

Since the 1980s, defining policies and actions for DRR has been the subject of intense technical and scientific experimentation throughout Italy. However, attention has often been limited to prevention interventions primarily implemented on individual buildings. However, protecting entire settlements is unrealistic due to the high costs of interventions, procedural complexity, and the long time required to achieve goals. The challenge, therefore, lies in identifying a minimum system of essential urban functions whose preventive safety measures could reduce urban vulnerability and enable recovery to begin.

The Italian approach to seismic risk prevention in urban areas began to take shape more concretely in this direction after the Abruzzo earthquake on April 6, 2009. Following the consequent massive urban damage, the Italian government introduced a significant funding program of approximately 1.2 billion euros to finance interventions for risk management in seismic-prone territories (Castenetto, 2024). Through the National Plan for Seismic Risk Prevention (PNPRS), the State embarked on an ambitious agenda of Seismic Microzonation investigations, Emergency Limit Condition (ELC) analysis, and structural interventions on buildings. Although the allocated finances represent a small fraction of the expected average annual cost of earthquake damages, the PNPRS is Italy's first national plan considering prevention from an urban planning perspective (Bramerini et al., 2013).

The ELC analysis, focused on validating the emergency management system defined in Civil Protection Plans, aims to verify the existence and consistency of strategic elements in the emergency management system, suggesting intervention priorities to administrators (Tomassoni et al., 2023). The ELC is significant because it represents a step towards reducing urban vulnerability by defining a minimum system of buildings, open spaces, and road networks to be safeguarded to maintain fundamental strategic functions for emergency management.

However, urban vulnerability is a multidimensional concept influenced by building features, functional systems (Braga et al., 2015), and socioeconomic factors (Blackwood and Cutter, 2023). It requires, therefore, a broader vision aimed at maintaining essential settlement functions (Fiore et al., 2018). Following this approach, the Urbisit Project (Cavinato, 2013) extended the concept of building limit states to urban settlements, formulating Urban Limit Conditions (ULCs) as a scale of prevention goals with increasing urban performance to guide seismic risk prevention policies (Bramerini et al., 2013; Basaglia et al., 2019).

In recent years, ULCs have been experimented at both local and national scales. Locally, the 'EQ-DIRECTION' procedure was developed to evaluate a specific ULC aiming to protect essential urban functions necessary for ensuring a rapid return to pre-earthquake conditions (Cattari, 2024). At the national scale, a methodology was proposed to map different ULCs for various earthquake scenarios, estimating the seismic resilience of large-scale communities (Anelli, 2023). Both methodologies, though valuable, have limitations: the first focuses on a specific case study and requires local political involvement, making it difficult to generalize nationally. The second considers only housing as a proxy for urban functionality.

Moreover, ULCs theory has difficulty quantifying performance levels, which range from the worst to the optimal condition—that is, the full recovery of the urban system. This complexity makes it challenging to translate the theory into actionable public policies.

Our work aims at contributing to the debate on urban seismic prevention by proposing i) a new planning prevention instrument for early recovery—the Early Recovery System (ERS)—inspired by ELC and a simplified conceptualization of ULCs, and ii) a methodology to introduce the concept of urban functional recovery assessment. This methodology compares the potential seismic retrofitting of different ERS configurations in a specific risk scenario and provides support for decision-makers.

In this paper, we present: the ERS instrument (Chapter 3) and a set of indicators to evaluate the best ERS configuration and visualize hypothetical post-event recovery trajectories (Chapter 4). We propose a counterfactual experimentation of our methodology on a pilot case study: the city of L'Aquila, severely affected by the 2009 earthquake (Chapter 5).

We want to demonstrate that seismic prevention from an urban planning perspective can guide decision-makers in assessing, a priori, the potential impact of prevention instruments on post-event urban functionality, helping to set intervention priorities and allocate financial resources towards territorial safety goals.

2. Switching paradigm: from building to urban functional recovery

Finding methods to reduce vulnerability and assess the capacity for post-disaster recovery over time is a key motivation for academics and policymakers in promoting community resilience and functional recovery concepts (Mayer, 2019; FEMA, 2021). Over the past few decades, community resilience has emerged as a compelling paradigm to advance DRR initiatives. Generally defined as the ability of a system to prepare for, respond to, and recover from disasters minimizing impacts and damage, the concept has been addressed in extensive literature through two predominant approaches: the socio-economic, focus on the characteristics of local communities (Cutter, 2014; Berke and Campanella, 2006) and the engineering centered on the physical properties of the built environment and its ability to restore functionality over time (Bruneau et al. 2003; Cimellaro, 2016). When applied to urban systems, the concept of resilience often extends beyond physical structures to include the capacity of social, cultural, and economic systems to recover and restore functionality after an earthquake (Burton, 2015; Zhang et al., 2021).

However, improving or building resilience is a process that requires comprehensive and long-term strategic planning. In recent years, the concept of functional recovery has gained attraction as a way to link resilience goals with the design, construction, and retrofitting of individual structures (EERI, 2019; FEMA, 2021). Functional recovery is defined as the post-earthquake state of a building or infrastructure in which its capacity is sufficiently maintained or restored to support pre-earthquake functionality (EERI, 2019). From a public policy perspective, functional recovery should serve as a mechanism for achieving broader community-wide goals. Recent studies (Zhang et al., 2021; Ren et al., 2021) have begun evaluating the functional recovery of building groups at the urban scale, considering both internal factors (building type, age, and function) and external factors (social systems). However, the literature notably lacks consideration of urban planning decisions and practices as a bridge between these internal and external factors.

The built environment plays a socio-spatial role in the urban space, embedded in the lives of local communities. Functional recovery at the urban scale should not be seen merely as the sum of individual buildings' post-disaster functionality. It must also take into account factors such as social networks, accessibility, and a certain level of urbanity, all of which encourage communities to remain in their territories after a disaster.

In this study, we extend the concept of functional recovery to the urban scale by considering an essential urban core of physical elements and their connections, which are necessary for recovery to begin. Given the limited financial resources available, one of the key priorities for decision-makers is identifying, through prevention plans, which buildings and infrastructure are critical for the very early stages of recovery. This selected urban core is treated as a minimum spatial unit to assess urban functionality, which we define as the ability of the urban system to maintain its pre-existing spatial, functional, and relational organization after a disaster. We do not focus on buildings' structural performance, allowing us to maintain a broader perspective on urban planning issues. We strongly believe that just as buildings have different functionality limit states, urban systems may also exhibit varying levels of functionality during recovery, indicating the system's capacity to function after an earthquake.

3. Towards an urban scale prevention instrument: the Early Recovery System (ERS)

Post-earthquake recovery is an evolving process, and while the end goals may be apparent, the path to achieving them is often uncertain. Much depends on how physical reconstruction is approached—whether as a collection of individual building restorations or as part of a comprehensive urban planning strategy. There is also a significant disconnection between response management, which is generally well codified, and the phases of the recovery process. The latter, from the construction of the so-called 'temporary city' to the beginning of recovery and the long-term reconstruction, is often the result of a complex system of decisions and actions, typically implemented on a case-by-case basis over a period ranging from the immediate aftermath to several years later (Coppola et al., 2021).

To bridge short-term response measures with medium- to long-term recovery programmes, the 'Early Recovery' (ER) paradigm (IASC, 2006; UNDP, 2008) was introduced. Although this concept has yet to be fully operationalized, it

primarily focuses on the humanitarian aspects of post-disaster situations, often neglecting the urban planning dimension (Noureddine Tag-Eldeen, 2017). However, without integrating planning expertise into the ER framework, there is a risk of disjointed actions across different post-disaster phases, creating imbalances that could hinder urban development.

Adopting the definition of ER as a multidimensional process that aims at generating self-sustaining, resilient processes for post-crisis recovery, encompassing the restoration of basic services, livelihoods, shelter, governance, the environment, and social dimensions, including the reintegration of displaced populations (IASC, 2006; Cluster Working Group in Early Recovery, 2008), we aim to enhance the ER concept by developing its spatial dimensions. We focused on identifying key services and infrastructures whose immediate usability after an earthquake could be strategic for minimizing common post-disaster effects, such as losses, displacement, and relocation. Observing post-earthquake experiences, and considering that disaster impacts are often more severe in areas with fragile infrastructure, the continuous functioning of basic services, such as healthcare facilities and schools, plays a vital role in strengthening the community's capacity to respond effectively in the aftermath of an event (Burton, 2015; FEMA, 2016; Mutch, 2018; Fontana et al., 2020).

Global campaigns like Hospitals Safe from Disasters (ISDR, WHO, and World Bank, 2009) emphasize the importance of maintaining the functionality, accessibility, and high quality of healthcare facilities after a disaster. These facilities are not only essential for monitoring community well-being (Achour et al., 2014), but communities with a high concentration of primary care facilities generally exhibit better overall physical and mental health, making them more resilient in absorbing and recovering from disasters (FEMA, 2016).

Similarly, integrating the educational sector into DRR strategies is crucial for minimizing a disaster's impact on younger populations, which directly affects the entire community (Tong et al., 2012). Structural improvements to school buildings, combined with enhancing administrators' capacity to maintain cohesion in the school community after a disaster, are key factors (Mutch, 2018). Schools, often centrally located, not only support the well-being of children and young people but also serve as hubs for local social cohesion. As a result, they play a significant role in all phases of the risk management cycle (UNISDR, 2007; ADPC, 2007; GADRRRES, 2022).

Therefore, maintaining pre-existing basic services in situ and preserving their relationship with the territory as part of an interconnected functional system—along with temporary housing plans that respect pre-disaster spatial organization and social networks—form the basis of the Early Recovery System (ERS) concept. Inspired by the ELC prevention instrument, ERS defines a minimum core of elements common to all territories, whose functionality must be preserved to reduce urban vulnerability (Fontana et al., 2024).

Specifically, it comprises i) strategic functions for rescue operations, ii) healthcare facilities, iii) schools, iv) areas for temporary housing, v) the road network that connects these functions, and vi) 'interfering buildings', whose collapse could interrupt system connections.

To define ERS, the first step is to identify the elements and their interconnections on the cartography (Figure 1, Step 1). Depending on the complexity of the road network, the selection of these elements can generate diverse ERS configurations (Step 2), which may change urban functionality levels. To evaluate the best ERS configuration, the different configurations must be assessed on specific risk scenarios (Step 3): for each configuration, the urban functionality loss and the possible recovery trajectory are calculated through a set of indicators (Steps 4). Hypothesizing and assessing different ERS configurations is a way to support policymakers in planning risk reduction strategies and developing intervention programs. While Steps 1, 2, and 4 are the focus of this paper, Step 3 will be explored further in the research process.

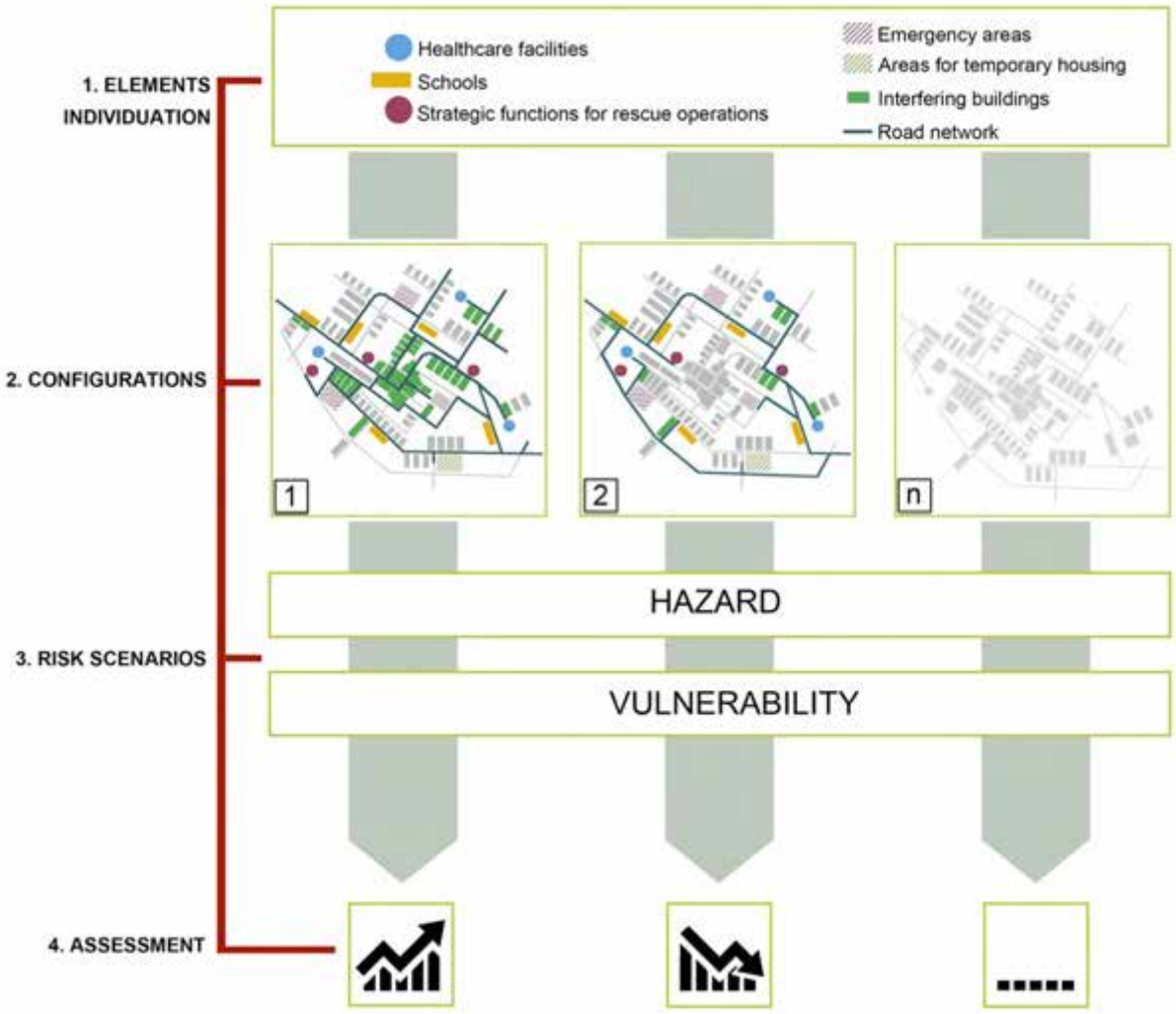

Figure 1. The four steps of ERS planning methodology.

4. A methodology to assess post-earthquake urban functionality

To analyze the urban system's capacity to respond to shocks, we divided it into different functional dimensions that reflect the complexity and multifaceted nature of society (Cutter et al., 2014; Singh-Peterson, 2014; Cimellaro, 2016; Kammouh et al., 2019; Fontana et al., 2020). We identified six dimensions: environmental, housing, school, healthcare, infrastructural, and socio-cultural. To assess the functionality of the urban system and its recovery trends over time, we developed a set of indicators.

According to us, these dimensions help identify the variables that have the most significant impact on the early recovery of a post-earthquake territory and can be directly (healthcare, school, housing, and infrastructural) or indirectly (environmental and socio-cultural) correlated with the ERS elements. To each dimension, we associated a specific urban damage proxy for the loss of functionality measured through 18 indicators (Table I).

For the environmental dimension, we measure the reduction of the environmental balance, a key aspect of the quality of life and human health. To calculate it, we consider two variables: 1) land consumption growth, amplified by the construction of temporary settlements and commercial and facilities areas, and 2) the volume of rubble produced over time from the collapse and/or demolition of buildings. Within the housing dimension, the loss of

functionality is intended as the displacement of households, measured through variables that show the changes in the urban spatial structure due to temporary housing settlements and the consequent relocation of people. This can lead to a loss of community sense and social networks, encouraging the permanent abandonment of places. The school dimension is linked to its usability decrease caused by both service interruption due to building damage and its relocation to a different area. Similarly, the healthcare dimension is linked to the reduction of its usability. In this case, however, it is important to consider not only service interruption and its possible relocation but also the potential post-earthquake performance downgrade or upgrade. For the infrastructure dimension, we measure the reduction in accessibility caused by damage to road infrastructure and the perimeter extension of the 'red zones. ' Finally, for the socio-cultural dimension, fundamental to maintaining and consolidating community identity and sense of belonging, we calculate variables related to the unavailability of cultural heritage and social spaces to measure the loss of socio-cultural networks.

Table I: Selected indicators to describe the loss of functionality in the six dimensions.

URBAN FUNCTIONAL DIMENSIONS	LOSS OF FUNCTIONALITY	INDICATOR	DESCRIPTION	EFFECT
Environmental	Reduction of environmental balance	**Land Consumption**	Expansion of built-up areas, using Corine Land Cover data (hectares)	-
		Volume of Rubble	Volume produced by the collapse of public and private buildings, the demolition of unsafe structures, and public and private building interventions (tons)	-
Housing	Displacement of households	**Displaced Population**	Homeless resident population on total population (%)	-
		Change in the City's Spatial Structure	Average distance of the temporary settlements from the pre-event inhabited areas (meters)	-
		Temporary Settlements Delivery	Temporary settlements delivered to the displaced population (%)	+
		Population Displaced in Hotels	Population displaced in hotels on total homeless residents, weighted based on the distance (%)	-
School	Decreased usability	**Unavailability of School Facilities**	Condemned schools (%)	-
		Repair of the School Function	Reactivated schools, including delocalization and temporary schools (%)	+
		Change of the School service Spatial Organization	Average distance of the new schools from the existing ones (meters)	-
Healthcare	Decreased usability	**Unavailability of Healthcare Facilities**	Condemned healthcare facilities (%)	-
		Repair of the Healthcare Function	Reactivated healthcare facilities, including delocalization (%)	+
		Displacement of Healthcare Facilities	Average distance of the new healthcare facilities from the existing ones (kilometers)	-
		Performance of Post-Earthquake Healthcare services	Value based on the post-earthquake performance of the healthcare service: 0 (no service); 0.2 (medical clinic, ASL); 0.4 (First aid point); 0.6 (Emergency Room); 0.8 (second-level Emergency Admission Department); 1 (first-level Emergency Admission Department)	+

Infrastructural	Accessibility reduction	**Level of Inaccessibility**	Interrupted access to inhabited areas, weighted on residents' number (%)	-
		Red Zone Extension	Ratio of forbidden 'red zone' extension to total urban settlement area	-
Socio-cultural	Socio-cultural relationships loss	**Unavailability of Cultural Heritage**	Condemned cultural building heritage (%)	-
		Unavailability of Sites dedicated to Culture and Social network	Condemned sites dedicated to culture and social network (%)	-
		Repair of Sites dedicated to Culture and Social network	Reactivated sites dedicated to culture and social network, including delocalization (%)	+

4.1 Data collection, aggregation, weighting, and calculation time

After the development of the pre-established risk scenario, all the indicators can be calculated using secondary data sources obtained from open-access databases, primarily from institutional sources. Additionally, information can be extracted from earth observation data to supplement the primary dataset. Each variable is assigned a maximum and minimum value based on the indicator measurement. The calculations for each variable are performed at the local municipal scale. To assess urban functionality, each variable is normalized using a Min-Max rescaling scheme, which allows for the comparison of values across different scenarios and various urban dimensions. This normalization process scales values between 0 and 1, with 0 representing the worst rank and 1 representing the pre-earthquake functionality.

After normalizing the variables, the values are aggregated for each dimension through a simple average. All variables are equally weighted. This decision is based on two main considerations, as argued by Cutter et al. (2010) and supported by the authors: 1) such a method of aggregation is transparent and easier for other potential users to understand and use, and 2) there is no theoretical justification for attributing a hierarchy of importance across indicators. Moreover, all indicators are considered relevant for measuring urban functionality only if observed from an equal and systemic perspective.

The indicators are then calculated over four different time intervals: t=1 (from the earthquake to 1 year after); t=2 (from 1 year to 2 years after); t=3 (from 2 to 3 years after), and t=10 (10 years after).

The first three intervals represent the early recovery period, while t=10 provides an overview of long-term recovery. Calculating recovery at different time points allows for the generation of a recovery curve (see Chapter 5 as an example).

5. L'Aquila after the 2009 earthquake: a counterfactual hypothesis with and without ERS interventions

To test the methodology and evaluate the sensitivity of the chosen indicators to variations in the urban system functionality, the case of L'Aquila, severely damaged after the 2009 earthquake, has been selected as a pilot case study.

With a population of roughly 69,000 inhabitants spread over 470 square kilometers, L'Aquila exhibits a highly fragmented and unbalanced spatial structure. Rebuilt numerous times following earthquakes, its spatial organization has historically centered around two primary systems: a historic center of significant social and cultural value and a vast network of smaller villages.

On April 6, 2009, a seismic event with a magnitude of Mw = 6.3 occurred with the epicenter located approximately 6 km away from the city of L'Aquila. The earthquake severely impacted it and 56 additional municipalities, resulting in 309 casualties and displacing 60,000 inhabitants. A total of 37,000 buildings were damaged, including 34,000 private houses, 1,000 public buildings, and 2,000 buildings of significant historical value (OECD, 2013).

L'Aquila's highly damaged historical center was immediately evacuated, declared 'red zone', and placed under

military control. Residents were rescued and relocated to camps managed by the Civil Protection body or to hotels along the coast. The reconstruction process of the historical center only started in 2012, three years after the earthquake. Consequently, many socio-economic and cultural activities were relocated, and people displaced into temporary settlements scattered and dispersed within the large municipality boundaries (Frisch, 2010).

In this context, we posed the question: To what extent could urban functionality have been preserved if ERS strategy had been implemented before the earthquake?

To address this complex question, we first calculated the indicators based on the current state, considering real damages. We then hypothesized to apply an ERS prevention strategy in a counterfactual manner and calculated the indicators for two hypothetical configurations:

1. ERS1 → connecting elements of the system through the historical town center and relocating temporary housing based on proximity criteria (compact system);
2. ERS2 → connecting elements of the system while minimizing or avoiding passage through the historic town center; temporary housing locations remain unchanged from reality (diffused system).

For each of these configurations and the generation of a recovery curve, we calculated the set of indicators across four different time intervals: t=1 from April 6th, 2009 to March 2010; t=2 from April 2010 to March 2011; t=3 from April 2011 to March 2012; t=10 from April 2019 to March 2020.

For the two hypothetical configurations, ERS1 and ERS2, we calculated the indicators for each interval by subtracting from the real available data the amount derived from the elements potentially retrofitted during the prevention phase to implement the ERS, assuming that the interventions were 100% effective and that there would therefore be no damages that could compromise the functioning of those elements.

For instance, the Red Zone Extension indicator was calculated by measuring the extent of the 'red zone' for each time interval, as defined in various municipal resolutions, in relation to the urbanized area. As the interventions for securing, demolition, and reconstruction proceeded, the boundaries of the restricted zones were updated over time. For the calculation of values in the two configurations (ERS1 and ERS2), the areas occupied by elements included in the ERS were subtracted from these surfaces, considering them as potential safe areas.

Individual values were then aggregated by urban functional dimension. The results for each dimension were visualized using linear graphs illustrating the initial loss of functionality due to the earthquake and potential recovery trajectories over time.

We are aware that the ERS is a complex system (i.e., a system of sub-systems) and that the aggregation of independently calculated indicators may be a forced approximation of reality. In any case, to compare the different configurations in the first instance, we considered ours to be an acceptable approximation.

5.1 Current state: no intervention

Figure 2 illustrates the repercussions of the L'Aquila earthquake on various urban dimensions. The socio-cultural dimension shows the most severe loss: in fact, the historical center, where all the social and cultural activities were concentrated, was completely evacuated and strictly controlled by the institution of the red zone. The historical center began reopening gradually only three years later, exacerbating the impact on social and cultural activities.

The school dimension shows a similar loss, having been heavily affected, with over half of the 36 public schools sustaining significant damage. Students were relocated to temporary school units, located outside the town center, scattered across the suburbs, and often distant from their original locations (on average 700 meters).

Additionally, the environmental dimension exhibits a notable negative trend between t2 and t3. This was primarily due to the extensive construction of the 'temporary city' and the relocation of businesses and services that increased land consumption. Moreover, the long-term physical reconstruction of the historical center resulted in a substantial accumulation of rubble.

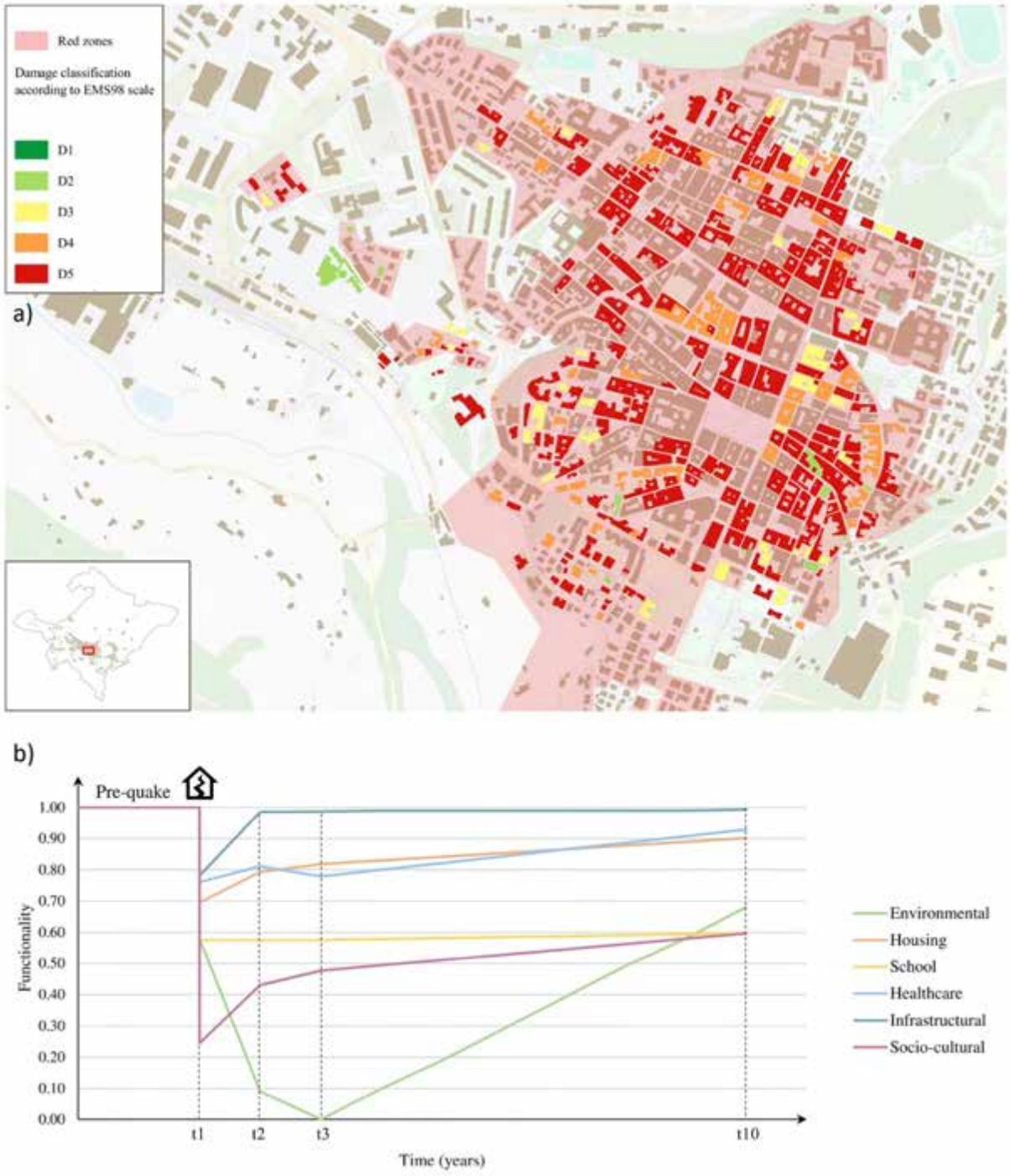

Fig. 2: Map of the damage of private buildings in the historical center of L'Aquila (a); Loss of urban functionality for the current state 'no intervention' (b).

5.2 Configuration 1: ERS1

The ERS1 configuration establishes a network of interconnected elements utilizing a road network through the town center. Figure 3 depicts an excerpt of ERS1, highlighting the elements classified by typologies and a revised demarcation of the 'red zone,' which considers the potential seismic retrofitting of buildings. Given the substantial number of historical buildings involved, implementing a similar intervention program will undoubtedly necessitate a comprehensive planning effort. However, this would promise significant community and financial benefits throughout the long process of post-earthquake reconstruction and recovery.

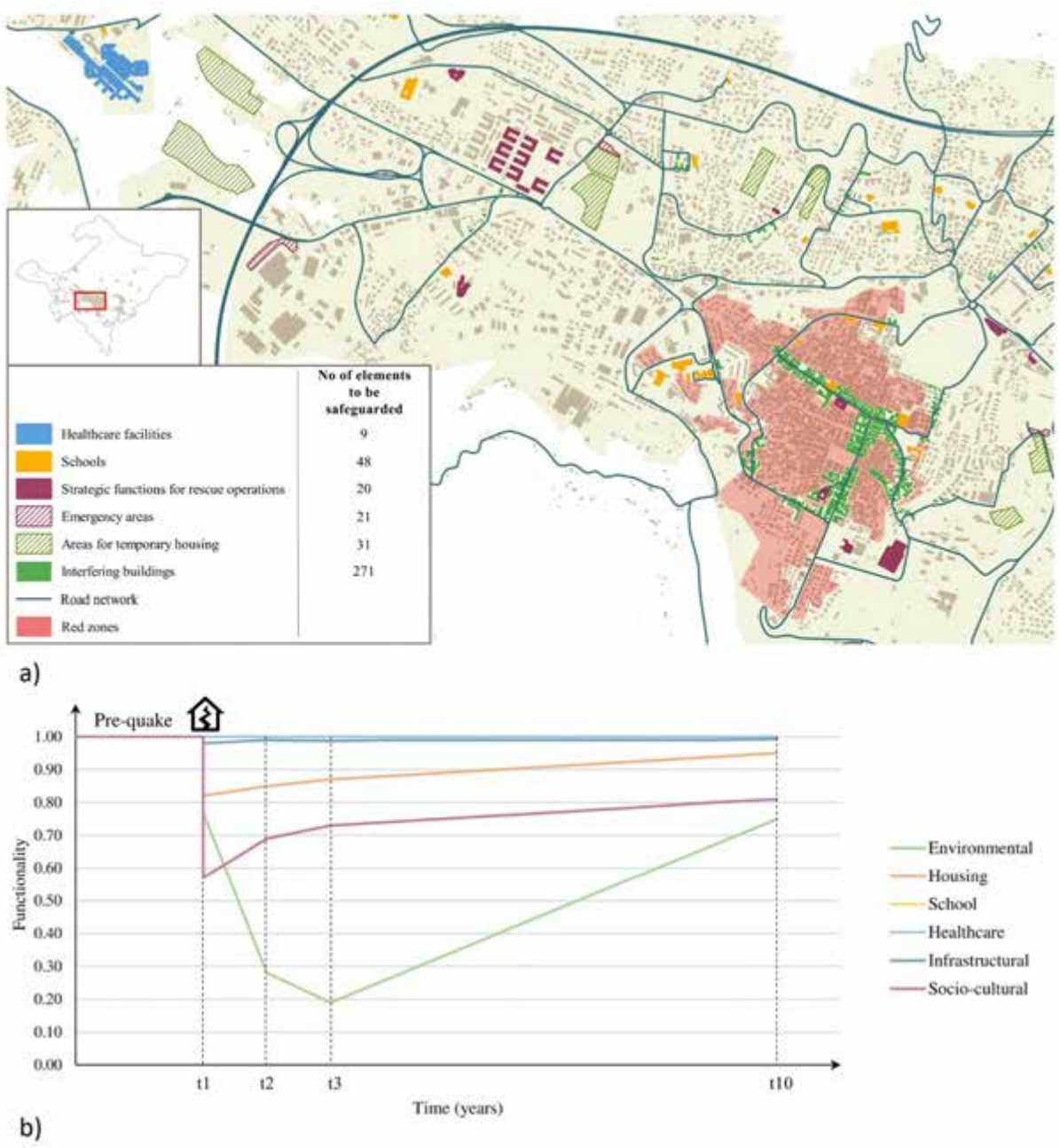

Fig. 3: ERS1. Excerpt of the historical center and surroundings (a); Loss of urban functionality for the ERS1 configuration (b).

During the prevention phase, the potential retrofitting of approximately 350 structural units (public and private buildings), 300 km of roads, and the identification of 31 suitable areas for temporary houses would have helped preserve a significant part of the spatial and relational urban organization. As illustrated in Figure 3, the school and healthcare dimensions would maintain their functionality, while the infrastructural dimension would experience only a minor loss of 0.02. The housing dimension shows a lighter loss compared to the current state (0.18 compared to 0.31) and demonstrates better recovery over 10 years (although the slope of the line remains relatively consistent). The socio-cultural dimension, which includes historical buildings and cultural and social venues, benefits from this configuration, reducing functionality loss from 0.76 to 0.43. The environmental dimension, despite still experiencing significant functionality loss, would also benefit from this configuration, particularly through fewer relocations due to the prevention planning of temporary locations and seismic retrofitting of schools.

5.3 Configuration 2: ERS2

The ERS2 configuration includes the same elements as ERS1, except for the relocation of two buildings for rescue operations outside the town and modified connections between elements outside the center (Figure 4). Additionally, the post-earthquake locations of temporary housing were maintained as determined by government decisions.

With this configuration, the number of potential seismic retrofitting interventions would be significantly reduced, decreasing from around 350 structural units in the previous configuration to approximately 270. The preservation of road infrastructures remains largely unchanged, except for those associated with the historic center.

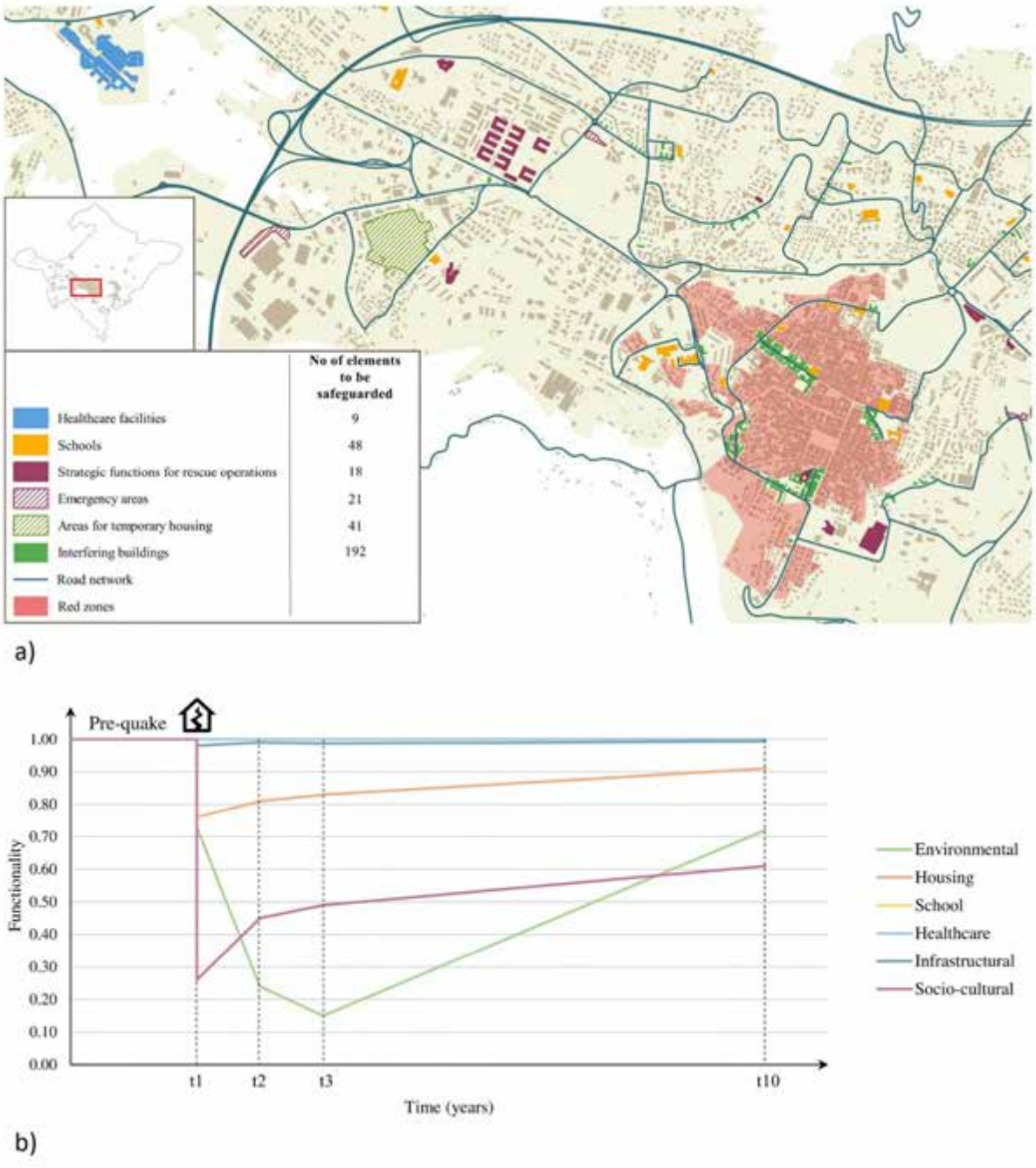

Fig.4: ERS2. Excerpt of the historical center and surroundings (a); Loss of urban functionality in the configuration ERS2 (b).

Like the ERS1 configuration, school, healthcare, and infrastructural dimensions would maintain their functionality in ERS2. However, there is a minor pejorative difference for the housing dimension compared to the previous configuration (functionality loss of 0.24 compared to 0.18). The most significant change occurs in the socio-cultural dimension. By not including the road network within the town center and thus not accounting for interfering buildings, many cultural and social venues would be excluded from ERS2. As depicted in Figure 4b, the socio-cultural functionality curve shows little difference from the current state (0.74 for ERS2 and 0.76 for current state).

5.4 Discussion

In summary, across both ERS configurations, the dimensions directly involved in the selection of system elements (school, healthcare, infrastructural) exhibit very little or no functionality loss. However, the ones indirectly involved still show some loss of functionality, albeit significantly less compared to the current state. Notably, the socio-cultural dimension continues to experience considerable functionality loss in the second configuration (ERS2) due to the absence of a road network within the historic center.

The effects of lacking seismic prevention urban strategies over time are supported by concrete facts. More than 15 years later, the region is still grappling with both physical and socio-economic recovery. L'Aquila's urban system has undergone profound changes in its functional and relational organization, and the overlap between the temporary city and long-term reconstruction has exacerbated socio-spatial imbalances. The reconstruction of public buildings has barely reached 50% of the planned interventions (USRA, 2023), resulting in a scarcity of socio-cultural spaces and the absence of schools within the historic town. The general spatial reorganization, which accelerated a depopulation process already underway before the earthquake, also had significant social impacts, generating collateral effects such as increased land consumption and traffic congestion.

Conversely, the ERS1 configuration suggests that implementing a seismic retrofitting program for the system's elements would have prevented significant damage to the school and healthcare sectors. Additionally, retrofitting the buildings within the historic center—many of which host important social and cultural spaces—would likely have mitigated the loss of functionality in the socio-cultural dimension. This approach would have allowed these functions to continue in situ, without disrupting the city's socio-spatial structure, and would have limited land consumption resulting from temporary relocations.

Regarding the loss of functionality in the housing dimension, since it is not feasible to secure all private residential properties, there is still an evident, albeit limited, loss. The real advantage, therefore, lies in the prevention planning for temporary housing areas, where the choice of locations for new settlements becomes a strategic issue to reduce abandonment processes and excessive new land consumption.

Experimentation on the specific case of L'Aquila post-2009 earthquake allowed us to highlight the strengths and weaknesses of the proposed methodology. Among the weaknesses is the difficulty in obtaining data for calculating the indicators, which did not allow us to detail the various functional dimensions equally and address all characteristic aspects. In addition, the lack of literature on indicators to measure urban functionality, as defined in this paper, made the choice of the indicator set highly experimental.

The absence of existing models in literature pushed us to test the methodology on a specific area already affected by an earthquake, with known effects on the short and long-term reconstruction and recovery processes, to validate the methodology and the set of indicators by comparing them with the state of the art. What emerged is that the proposed variables and the resulting recovery curves seem to reflect the recovery trajectory of L'Aquila. This result allows us to continue the research to abstract the methodology, applying it within a complex framework of risk scenario simulation to support public prevention policies.

6. Conclusions

In this article, we introduced a new prevention instrument for Early Recovery and a methodology to assess urban functionality by comparing different prevention spatial configurations, emphasizing the importance of viewing prevention from an urban planning perspective. Considering that retrofitting the entire urban settlement is unlikely, our approach aimed to identify a proto-system of essential functions, open spaces, and road networks to be preserved to guarantee a minimum level of urban vitality after a major event and foster recovery to begin. In

analogy and continuity with the general structure of the Emergency Limit Condition (ELC) analysis, we developed the Early Recovery System (ERS) instrument. As for the ELC, identifying specific essential elements allows the methodology to be consistently applied across all territories at the national scale.

Through the calculation of a set of 18 indicators, framed into 6 urban dimensions, across four time intervals– t1, t2, t3, and t10 – we generated and compared recovery curves for different ERS configurations (ERS1 and ERS2), providing a visual representation of functionality loss and potential recovery trajectories over time.

The lack of existing models in the literature to measure post-earthquake urban functional recovery from a planning perspective prompted us to conduct a counterfactual experiment using the proposed methodology on a case study that had already been affected by a major event: L'Aquila post-2009.

By comparing the current state with the best ERS configuration (ERS1), we demonstrated the severe long-term impacts on L'Aquila's functionality. In contrast, ERS1 showed potential for significantly preserving urban functionality and reducing long-term disruptions.

The experimentation in a specific area with known effects on short- and long-term recovery processes allowed us to highlight the strengths and weaknesses of the proposed methodology. Despite limitations, the resulting functionality curves reflected L'Aquila's recovery trajectory, validating the methodology's potential.

Now that the assessment methodology has been tested, we aim to further this research by applying it to other Italian territories during peacetime and within a complex risk scenario simulation framework. The ultimate goal is to design an effective urban prevention path to support decision-makers in planning interventions and setting priorities, thereby mitigating long-term urban imbalances in the wake of seismic events.

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Investigation Of Earthquake Damage in Terms of Different Land Covers: 2023 Kahramanmaraş Earthquakes

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Abstract
On February 6, 2023, the Kahramanmaras earthquakes in Türkiye caused great loss of life and property. Studies on earthquake damage in the literature mostly focus on the built-up area, but studies on the land cover are limited. This study examines how earthquake damage differs in different land cover types. Land cover data and earthquake damage data are the main datasets. The areas with the highest damage rates are identified as bare ground, rangeland, and built-up area, respectively. Damage in agricultural and forest areas is lower. The findings show that damage is different for different land cover types. While assessments of earthquake damage are largely based on the built environment, this study reveals that earthquake damage is also important for different land cover types.

Keywords: Earthquake, Damage Proxy map, Land cover, Kahramanmaraş, Türkiye.

Introduction and Literature Review

On February 6, 2023, Türkiye was shaken by two major earthquakes 8 hours apart, with Kahramanmaraş as the epicenter. These earthquakes, with magnitudes of 7.7 and 7.6 respectively, directly affected 11 provinces, Kahramanmaraş in particular, resulting in the loss of more than 50,000 lives and the destruction of approximately 40,000 buildings. Described as the "disaster of the century, " this disaster caused loss of life and property and deeply affected all social, environmental, and spatial systems with its direct and indirect effects. A disaster of this scale reveals the necessity of a multidimensional examination of earthquake impacts and reassessment of existing disaster management approaches.

Earthquakes are important natural phenomena that affect both the physical and natural environment. In the literature, these impacts are mostly addressed on the built environment axis; analyzed through collapsed buildings, infrastructure losses, and human mobility. However, earthquakes can cause damage not only to the built-up area but also to different types of land cover. In this context, determining the damage to different land cover types such as forest, agriculture, rangeland, and bare ground, in addition to built-up areas, is of great importance for a more holistic understanding of the spatial effects of the disaster. This study aims to evaluate the impact area of the disaster from a broader perspective by analyzing the damage following the Kahramanmaraş earthquakes in terms of different land cover types. Relatedly, the question of the study is defined as "*does earthquake damage differ in different land cover types*?".

Studies on the built-up area in the analysis of earthquake damage are intensively included in the literature. These studies range from the building scale to the whole settlement. Studies focusing on the built environment associate earthquake damage with indicators of building height (Armaş et al., 2017), building floor area and building height (Doğan & Kalaylı, 2019), proximity of the building to the epicenter (Sangadji et al., 2023), and building material (Ruiz- Pinilla et al., 2016). In addition, some studies examine earthquake damage by associating natural structure with built environment factors (Sakarya et al., 2024).

Studies on the damage of natural disasters such as earthquakes on land cover other than the built-up area, consider this damage as earthquake environmental effects (Choudhury et al., 2016). Earthquake environmental effects are divided into primary and secondary. Primary effects are such surface ruptures or faulting; secondary effects are such landslides, liquefaction, tsunamis (Boulton et al., 2025; Bilir & İnci, 2024). This two-stage effect causes significant changes in land cover. Studies on the effects of earthquakes on land cover can be evaluated in two groups. While the studies in the first group examine the damage to different land covers after earthquakes

over specific sample areas, the studies in the second group examine the land cover change caused by the damage with long-term data.

Among the first group of studies, Bpulton et al. (2025) examine the damage caused by the Kahramanmaraş earthquakes and find that landslide occurs in forest areas and liquefaction occurs in agricultural areas. Koyanagi et al. (2020) analyze the 2016 Kumamoto earthquake damage to compare forest and grassland cover. According to the results of the study, the damage was high in the grassland. It is also a basic finding that slope is a determining factor in damage.

Among the second group of studies, Xiang et al. (2022) examine the impact of the 2008 China-Wenchuan earthquake at the scale of Sichuan Province. The study, which examines the land cover change between 2011- 2014- 2017- 2020 after the earthquake, finds that earthquake damage is higher where vegetation is high. Ishihara and Tadono (2017) examine the impact of the 2011 Japan earthquake at the Tohoku district scale. The study, which analyzes land cover data for the years 2006- 2011- 2013- 2015, states that earthquake damage differs according to different land covers. While the rice paddy ratio decreases due to the tsunami effect, it is found that the damage to bare land is high in the short term, but in the long term, bare land increases with losses in forest and agricultural land. Wang et al. (2022) examines the 2013 China-Lushan earthquake damage at the scale of Lushan country. In the study comparing land cover data from 2012 to 2020, it is determined that cropland, forest, built-up area, and bare area have changed significantly, and natural ecological restoration is stated as an important recommendation. Karadeniz and Sümbül (2023) compare the land cover in 1990 and 2000 in their study of the 1999 Düze earthquake in Turkey. According to the results of the study, forest and agricultural areas decreased, and built-up areas increased. Balamurugan and Aravind (2015) examine the impact of the 2001 India, Bhuj earthquake in Mundra, Kutch District of Gujarat region. Similar to the results of Karadeniz and Sümbül (2023), it is found that agricultural areas decreased and built-up areas increased in the process. DiCarlo et al. (2015), on the other hand, conduct such a study in the context of the 2015 Nepal earthquakes. Focusing on Dolakha district, the study finds that the agricultural crop pattern has changed.

This study, which examines the damage of the Kahramanmaraş earthquake on different land covers, is similar to the first group of studies mentioned above by examining the short-term post-earthquake data but differs from the studies in this group by analyzing the entire area where the earthquake damage occurred. This points to a gap in literature.

Data and Methods

Two data sets were used in the study. The first data set is land cover. Land cover data for the year 2022 was obtained through the Esri Living Atlas application. This data, created by the remote sensing method, consists of water, forest, flooded vegetation, crops, built area, bare ground, snow/ice, and rangeland land covers. In this study, as most damaged covers, forest area, agricultural area, built-up area, bare ground, and range land, are used. Water, snow / ice and clouds covers are not included

The second data set is the regional damage proxy map. It was produced by the National Aeronautics and Space Administration (NASA). This map detects the change in the surface by comparing the satellite images before and after the earthquake and shows these areas as damaged. The damage proxy map is used in many studies for rapid damage assessment after disasters. By damage proxy map, Agapiou (2020) analyzes the Beirut explosion, Romaniello et al. (2017) evaluate the Haiti earthquake damage, and Nur and Lee (2021) analyze the effects of the 2016, 2017 earthquakes in Korea.

These two datasets were superposed in geographic information system (GIS), and the earthquake damage rate was calculated for different land cover types.

The Kahramanmaraş earthquakes affected 11 provinces; Adana, Adıyaman, Diyarbakır, Elazığ, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye, and Şanlıurfa. The area is officially defined as a disaster region. The scope of the study was determined within the boundaries of the damage proxy map in this disaster region. This area is approximately 58 km² (Figure 1).

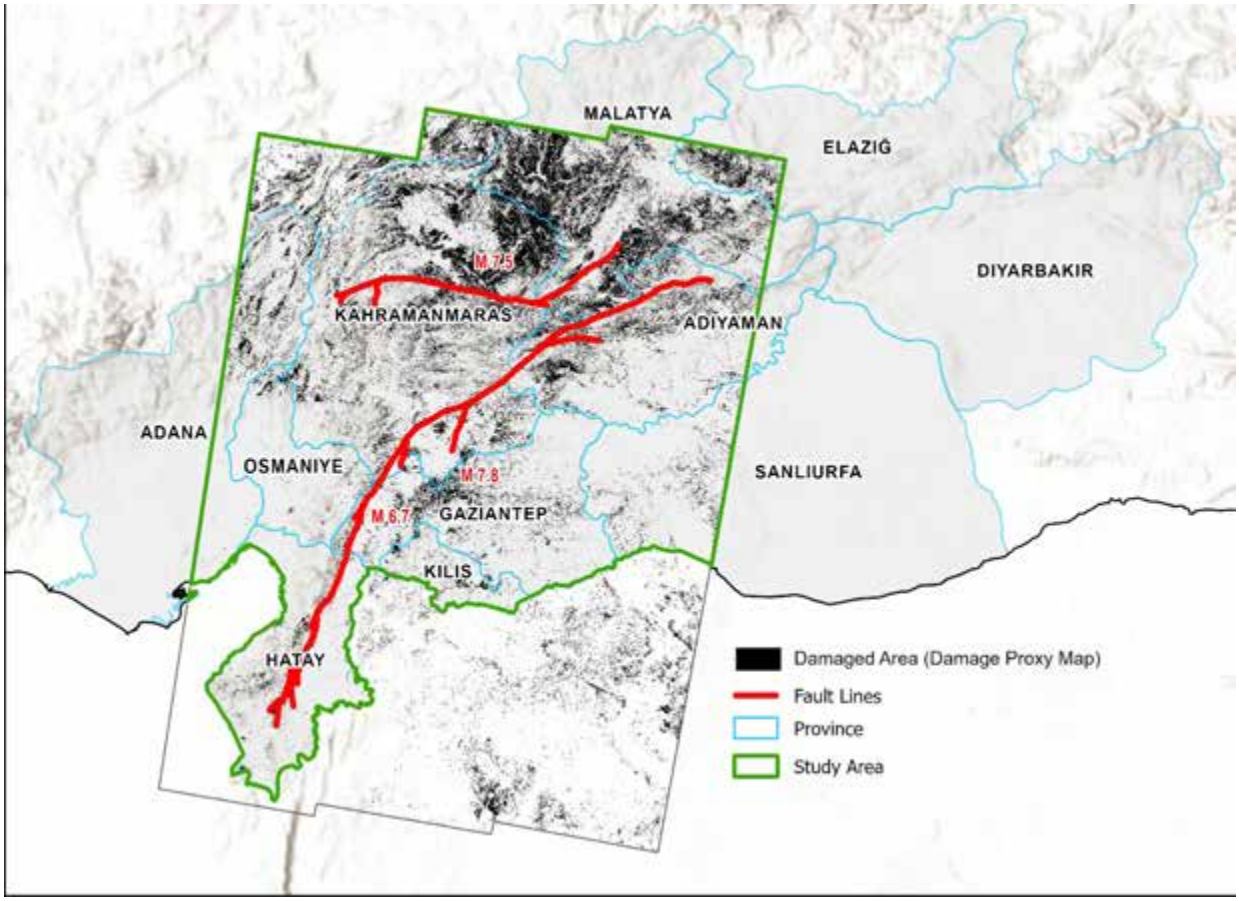

Figure 1: Study area

Findings

According to land cover in 2022, more than half of the area is rangeland. Rangelands are mostly concentrated in the east and north of the study area. The other land cover that has a significant size in the area is agriculture. Agricultural areas are especially dense in the south of the area. Forest areas are in the west of the area in the mountainous region between Hatay- Antakya, and Kahramanmaraş. The provincial centers of Hatay- Antakya, Kahramanmaraş, Gaziantep, and Malatya stand out with their built-up areas (Figure 2; Table 1).

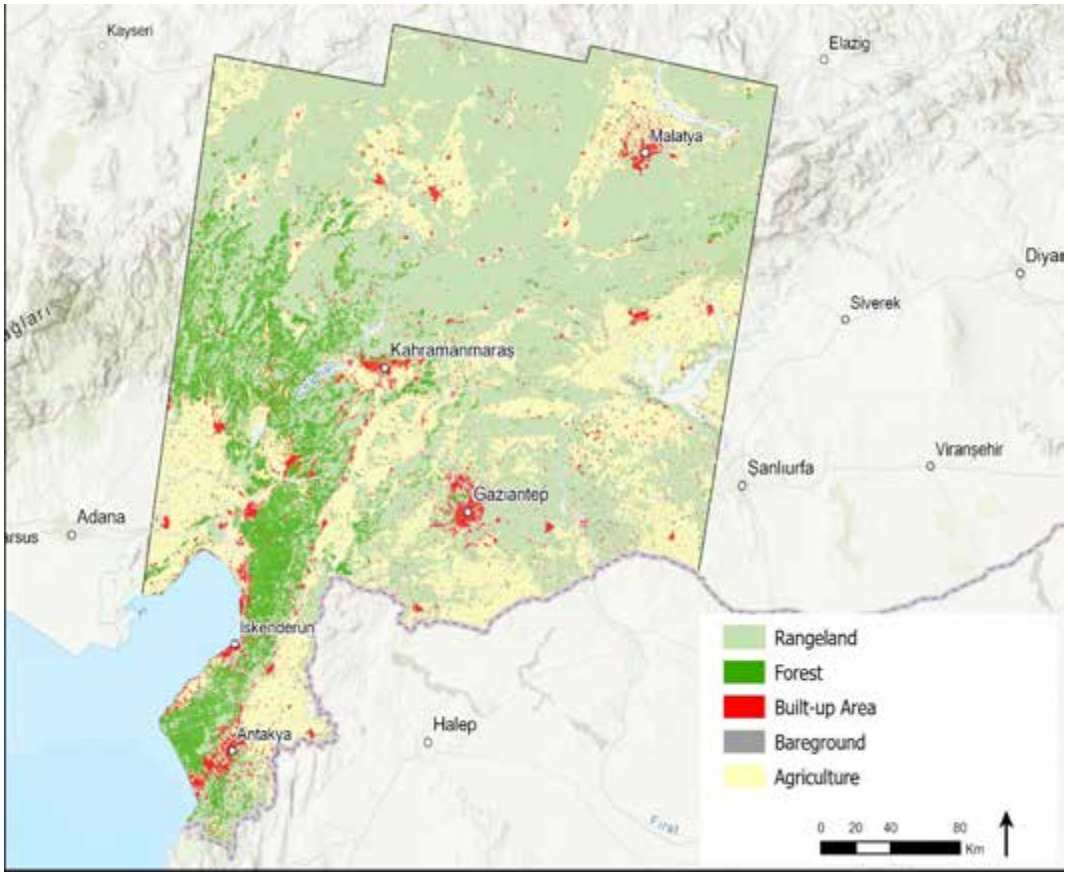

Figure 2: Land covers in the study area

Table 1: Land cover statistics

Land Cover	Area (ha)	Ratio
Rangeland	3.079.870	53%
Forest	595.460	10%
Built-up Area	290.792	5%
Bare Ground	41.453	1%
Agriculture	1.688.550	29%
Water- Snow/ Ice- Clouds	114.952	2%
Total	5.811.077	100%

The damage rate in the study averaged 18 % for the whole area. The land cover classes with the highest damage rates are bare ground, rangeland and built-up area, respectively. Especially in the north of the area where the slope is low, damaged rangeland areas are noteworthy in the region located in the west of Malatya. There are also damaged agricultural areas within these areas.

Damage in the built-up area is concentrated on the route between Hatay, Antakya and Kahramanmaraş, where the fault line also passes.

Damaged forest areas are also located in a limited area along the fault line. In this respect, the fact that the dam-

age is higher in the northern part where the slope is flatter indicates that slope is an important factor, as stated in Koyanagi et al. (2020) (Figure 3; Table 2).

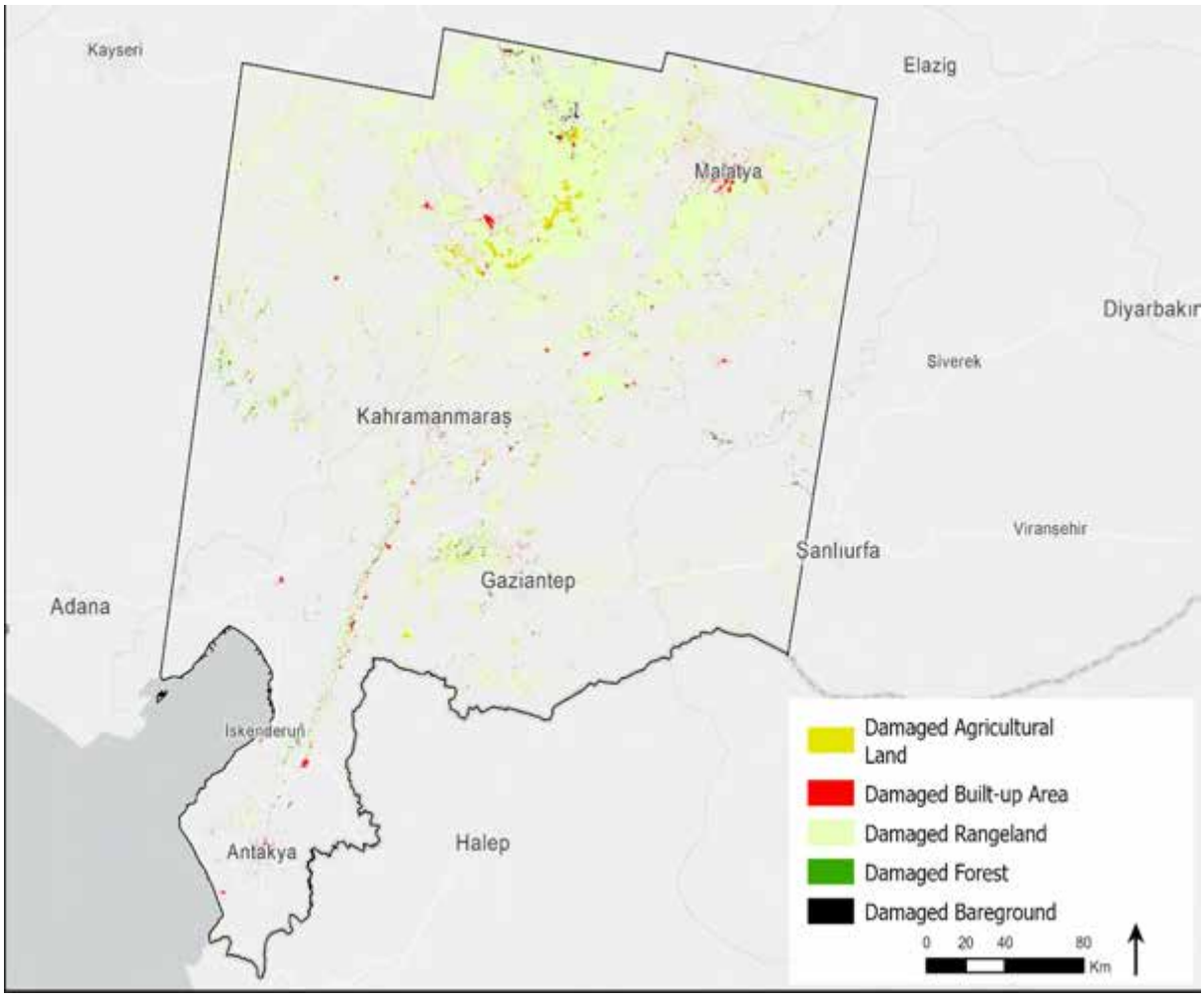

Figure 3: Damaged areas and land covers

Table 2: Damaged area land covers' statistics

Land Cover	Area (ha)	Damaged Area (ha)	Damaged Area Ratio
Forest	595.460	17.983	3%
Agriculture	1.688.550	77.101	5%
Built-up Area	290.792	40.075	14%
Bare Ground	41.453	14.256	34%
Rangeland	3.079.870	896.136	29%
Water- Snow/ Ice- Clouds	114.952		
Total	**5.811.077**	**1.045.551**	**18%**

Conclusion

This study aims to provide a holistic assessment of the spatial distribution of earthquake damages by analyzing the impact of the Kahramanmaraş-centered earthquakes that occurred on February 6, 2023 on different land cover types. The finding that earthquakes directly affect not only the built-up areas but also the natural environment reveals the necessity of considering natural land cover in post-disaster response and recovery strategies.

In the study, the analyses made by overlaying the land cover classes created using Esri Living Atlas data and the damage proxy map produced by NASA in the GIS, show that the highest damage occurs in bare ground, rangeland and built-up area, respectively.

This result indicates that damage varies across different land covers in relation to the research question identified by the study.

The findings reveal that significant damage occurred in rangeland and agricultural areas, especially in the northern parts where the slope is low, and emphasize the role of the morphological characteristics of the natural environment on the earthquake effect. Between Hatay-Antakya and Kahramanmaras, extensive damage was detected in built-up areas located along the fault line.

In the light of the data obtained, it is clear that land use decisions should be revised both in terms of the built-up area and the natural environment. With a disaster risk management perspective, integrating earthquake risk mitigation elements into land use plans can minimize not only loss of life and property but also loss of natural resources.

Damage to rangelands and agricultural areas is also critical for post-disaster food security and rural livelihoods. Therefore, developing policies to protect fragile natural areas will contribute to prevent post-disaster agricultural production losses. Likewise, the limited but strategically important damage to forest areas should be taken into account in terms of the continuity of ecosystem services. To increase the resilience of the natural environment in the face of disasters, more emphasis should be placed on ecological restoration and conservation-based approaches, as mentioned in Wang et al. (2022).

This study has some limitations as it is a short-term analysis with limited data. However, the assessment of damage to different land cover types at the scale of the whole study area differs from the examples in the literature in this respect and fills an important gap. For future studies, monitoring land cover changes using long-term satellite imagery will provide important findings in terms of the extent and significance of damage. For example, determining whether the increase in bare ground areas after the earthquake is related to construction or agricultural transformation in the following years will be of great importance in terms of guiding post-disaster spatial planning.

Furthermore, comparative studies with different types of disasters can reveal how the impacts of disasters on land cover differ from one another. Multidimensional analyses on how disasters such as floods, landslides and fires, as well as earthquakes, cause spatial changes in different cover types will contribute to the reshaping of both risk analyses and post-disaster response plans in a nature-sensitive manner. Such studies will serve as an important guide not only in the academic context but also for policy makers, local governments and disaster management institutions.

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Critical Infrastructures and Their Role in Regional Resilience: Mapping EU Regions

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Abstract
This study assesses the spatial distribution of critical infrastructure and its implications for regional resilience across EU NUTS-2 regions. The study develops a composite indicator for critical infrastructure stock using data on transport, energy, ICT, and public services, capturing both demographic and geographical accessibility. Findings reveal strong spatial disparities, with Central and Northern regions generally better equipped than Southern and Eastern counterparts. A median-split based typology to assess the sufficiency of CI Stock classifies regions into four categories, highlighting that only 9% exhibit high sufficiency across all sectors. Many regions show imbalanced critical infrastructure stock profiles, underscoring the need for multi-dimensional assessment. The study offers a quantitative framework for identifying vulnerabilities and guiding regional policies, stressing the importance of sufficient critical infrastructure, spatial equity, and integrated regional planning in strengthening regional adaptive capacity.

Keywords: Regional resilience; critical infrastructure stock; disaster prevention

1. Introduction

Regions are becoming increasingly interconnected through population mobility, economic flows, and infrastructure systems, forming complex webs of interdependencies that shape both their development trajectories and resilience. As these interregional linkages deepen, the capacity of regions to withstand and recover from disruptive events has emerged as a core concern for planners and policymakers. Within this context, critical infrastructures (CIs) including transport systems, electricity grids, digital networks, and water supply, play an essential role in maintaining societal and economic functioning. These infrastructures not only support the everyday routines of regional life but also underpin the capacity to absorb shocks and ensure continuity during times of disruption. However, their interconnectedness means that the failure of one component may trigger cascading effects across regions, exacerbating crises and magnifying risks (Shi et al., 2021).

Resilience, broadly understood as a system's ability to adapt to change and recover from disturbances (Boschma, 2015), is thus intimately linked to the structure, sufficiency, and interdependency of CIs in the regions. Inadequate backups, spatial inequalities, or an overdependence on single infrastructure hubs can transform localized hazards into systemic breakdowns. Studies highlight that resilience involves networks of linked adaptive capacities, making connectivity crucial as it provides alternative paths during disruptions (Reggiani et al., 2015). However, Reggiani (2022) highlights a key trade-off: highly connected hubs enhance efficiency but risk severe cascading failures when disrupted, whereas decentralized and redundant networks, although less efficient, enhance resilience. Redundancy, originating from ecological studies, refers to having multiple alternatives ensuring continued system function despite disruptions (Galland et al., 2020). For critical infrastructure, redundancy mitigates risks by providing alternative pathways, thus minimizing cascading effects from failures (Bauer et al., 2012; Sheffi, 2005; Akbarzadeh et al., 2017; Forcellini, 2023).

The conceptualisation of what is deemed "critical" infrastructure is not fixed. It is shaped by policy frameworks, academic interpretations, and societal needs. While energy, transport, and ICT are frequently emphasized in both academic and policy discourse, sectors such as education, housing, and healthcare, though vital, are often overlooked (Huddleston et al., 2022; DGAP, 2023). This reflects underlying epistemological and political commitments that determine which systems are prioritised for protection and investment.

This paper aims to address these complexities by mapping the stock of critical infrastructures across EU NUTS-2 regions and exploring their relationship with regional resilience. Instead of focusing on distinct infrastructure failures or individual case studies, we adopt a regional approach. We construct composite indicator of critical infrastructure stock based on availability, sufficiency, and distribution, and assess how these patterns vary across the EU.

By visualising the geography of CI stock and their potential insufficiencies, the study seeks to bridge the gap between theoretical studies and practical planning tools for resilience. Ultimately, this work contributes to emerging debates on how infrastructure systems can support regions in facing future uncertainties through enhancing robustness, improving recovery capacities, or enabling equitable access to essential services.

2. Conceptual Framework

2.1. Critical Infrastructure

Understanding the role of critical infrastructure in shaping regional resilience requires a careful conceptualisation of what these systems are, how they function, and why their presence or absence matters. Critical infrastructures are not just physical networks but systems that enable the delivery of essential services, support social and economic functioning, and influence a region's capacity to respond to disruptions (Deelstra and Bristow, 2023). Their criticality becomes most visible during crises (Steele et al., 2017), when breakdowns in infrastructure; such as electricity failures, blocked transport routes, or collapsed communication networks, can escalate the impacts of hazards and delay recovery (Thévenaz and Resodihardjo, 2010; Ke and Hsu, 2022).

There is no universally accepted definition of critical infrastructure. The term is used across academic disciplines and policy frameworks with varying scopes and emphases. In general, what distinguishes critical infrastructure from "basic" infrastructure is the severity of consequences associated with its disruption. As Burgess (2007) and Gallais and Filiol (2017) argue, infrastructure becomes "critical" when its failure transforms a disturbance into a broader crisis, threatening public safety, economic continuity, and the delivery of core services. The concept of criticality, in this sense, is relational and contingent on both societal needs and political priorities.

Larkin (2013) offers a foundational understanding of infrastructure as systems that enable the operation of other systems. He emphasises that infrastructures are not just technical objects but also social and relational structures. In the case of critical infrastructure, this means recognising the ways in which roads, hospitals, and power grids connect people, places, and institutions; not just materially, but functionally and politically. Infrastructures are embedded in everyday life and often remain invisible until they fail.

Policy definitions of critical infrastructure have evolved in response to changing threat perceptions and disruptive events. The United States was among the first to define and institutionalise the concept in the 1990s, particularly after the Oklahoma City bombing and later, following September 11 attacks, broadened its conception of CI (Moteff, 2007; Zebrowski and Sage, 2017; Collier and Lakoff, 2008). Since then, the list of sectors designated as critical has expanded significantly, including domains such as finance, emergency services, and digital infrastructure (Cybersecurity and Infrastructure Security Agency, 2025). While the U.S. provided one of the earliest formal definitions of critical infrastructure, policies on critical infrastructure in the EU date back to 2004, following key disruptive events such as the 2003 Italian blackout and the 2004 Madrid train bombings. These events prompted the launch of a strategic framework for critical infrastructure protection, which led to the establishment of the European Programme for Critical Infrastructure Protection (EPCIP) and the adoption of Directive 114/2008 aimed at strengthening infrastructure security which focused on transport and energy. However, the more recent CER Directive (2022/2557) reflects a broader view. It includes eleven sectors, such as public administration, healthcare, and the food supply chain, and introduces a shift from protection to resilience (Božović, 2023). The Directive on the Resilience of Critical Entities, effective from 16 January 2023, requires EU Member States to implement national legislation by 17 October 2024. It addresses eleven sectors: energy, transport, banking, financial market infrastructure, healthcare, drinking water, wastewater, digital infrastructure, public administration, space, and food

supply chains (European Commission, 2024). While each member state identifies and protects national critical infrastructures, the EU also promotes cooperative measures for transnational coordination.

Beyond the US and EU, modern definitions of critical infrastructure in various countries are largely similar in scope, most nations include infrastructure for energy, transportation, communications etc. as "critical". A 2023 study by the German Council on Foreign Relations (DGAP) analysing how 100 countries define and perceive critical infrastructure (CI) sectors is illustrating this well. According to the study, the most frequently cited sectors are energy, ICT, and transport, respectively, whereas sectors such as water, food, national security, and research & education are mentioned far less often.

What often differs is priority and emphasis, each state may prioritize certain sectors over others based on its unique needs and risk perceptions, which have the potential to obscure the distinction between infrastructure critical for basic societal survival and that which is deemed critical primarily for a nation state's interests (Newbill, 2019). Moreover, given that most CI systems are owned and operated by private entities, the influence of market and neoliberal governance cannot be overlooked (de Bruijne and van Eeten, 2007). Therefore, it is important to prioritize society's fundamental needs by focusing on a core set of universally critical infrastructures, which extend beyond national boundaries and can be narrower than those broadly defined by state interests (Newbill, 2019). As academic studies have highlighted, infrastructures that are not prioritised in formal frameworks such as housing, education, or childcare may still be essential for maintaining well-being and everyday functioning (Huddleston et al., 2022). The scope of what is considered critical thus reflects political, economic, and epistemological decisions, often influenced by prevailing governance models and private sector interests.

2.2. Regional Resilience and Critical Infrastructure

Resilience, while a debated and multidimensional concept, is broadly understood as the ability of socio-economic systems to adapt to both internal and external changes. Martin and Sunley (2015) conceptualise regional economic resilience as a process comprising four dimensions: vulnerability, resistance, robustness, and recoverability. Vulnerability reflects the extent of exposure to shocks, while resistance denotes a system's capacity to withstand them. Robustness refers to the ability to maintain core functions under stress, and recoverability measures how quickly and effectively a system returns to its prior trajectory. Other scholars, such as Sun et al. (2018), further highlight the role of redundancy and fast recovery mechanisms in building resilience.

Critical infrastructure plays a central role in supporting resilience by enabling continuity in essential services such as energy, transport, and healthcare. Although many studies focus on single sectors such as electricity (Afgan & Veziroglu, 2011), water (Sitzenfrei, 2011; Hwang, 2013), or digital networks (Boh et al, 2023), these analyses consistently demonstrate that infrastructure sufficiency enhances both robustness and recoverability. Some studies note that resilience is not only about infrastructure robustness but also about resourcefulness, and coordination between systems (Hickford et al., 2015). Other studies providing frameworks like the Resilience Measurement Index (Carlson et al., 2012) and spatial vulnerability models (Demirel et al., 2015) aim to quantify infrastructure resilience; yet, a gap remains in cross-sectoral evaluations for wider geographies.

Despite its conceptual richness, the empirical assessment of critical infrastructure (CI) and its contribution to regional resilience remains rather unexplored. Since, critical infrastructure is difficult to measure uniformly across regions, many studies focus on single sectors or isolated case studies which are limiting comparability and generalisability. While monetary values such as investment amounts are commonly used, scholars argue that physical indicators (like kilometres of roads or electricity capacity) provide more meaningful and comparable metrics across regions (Canning, 1998; Bröcker, 2009). However, these are not neutral; they are shaped by geography, urbanisation, and income levels. Data limitations, including the private ownership of many CI systems and security restrictions, further complicate standardised measurement.

A key methodological issue is endogeneity, whether critical infrastructure stock creates resilient regions or resilient regions attract infrastructure. Studies that are focusing on the relationship between regional development

and infrastructure attempt to address this challenge using historical infrastructure paths, planned routes, or inconsequential units approaches (natural experiments) (Redding & Turner, 2014), yet establishing causality remains difficult. Moreover, infrastructure often produces spatial spillovers, benefiting areas beyond their immediate location, and these functional interdependencies are rarely captured in standard models. Although methods like fault tree analysis, input-output models, agent-based simulations, and network modelling are increasingly applied (Chopra and Khanna, 2015; Pant et al., 2015), more comprehensive spatial assessments remain limited.

Building on this literature, this study approaches critical infrastructure as a system of interdependent networks that deliver essential services. Rather than focusing on disruptions or hazard events, the emphasis is placed on infrastructure sufficiency and spatial distribution, what we define as critical infrastructure stock. To this end, we develop a composite indicator for critical infrastructure stock at the NUTS-2 level for EU regions, where data availability and institutional coherence support meaningful cross-regional comparison.

3. Data and Methodology

3.1. Data

Data for this study were collected from a range of publicly available sources, with an emphasis on spatial precision and coverage. Most indicators were collected in georeferenced format and processed using QGIS software to enable spatial analysis and aggregation at the regional level.

- **Transport**: Road and railway networks, stations, and airports were obtained from EuroGlobalMap (2025) and Eurostat GISCO (2013).
- **Energy**: Power plant data (capacity and number) were sourced from the Global Energy Monitor (2024) and OpenStreetMap (2025) for infrastructure components such as powerlines and towers.
- **ICT**: Internet access data were retrieved from Eurostat (2024), expressed as the share of households with internet connection.
- **Public Services**: The number of hospitals and educational facilities was derived from OpenStreetMap (2025), and the surface area dedicated to sports and leisure activities was obtained from the CORINE Land Cover dataset (2018).

Table 1. Data Variables and Sources

CI Sectors	CI Stock Variables	Source	Year
Transport	1. Roads (line) 2. Railways (line) 3. Railway stations (node) 4. Airports (node)	1. EuroGlobalMap 2. EuroGlobalMap 3. EuroGlobalMap 4. Eurostat GISCO Airports 2013 dataset	1. 2025 2. 2025 3. 2025 4. 2013
Energy	1. Power plants (node) 2. Tower/mast (node) 3. Power lines (line)	1. Global Energy Monitor 2. OpenStreetMap 3. OpenStreetMap	1. 2024 2. 2025 3. 2025
ICT	1. Households that have access to internet (%)	1. Eurostat	1. 2024
Public Services	1. Health facilities (node) 2. Schools (node) 3. Sports/leisure activities (polygon)	1. OpenStreetMap 2. OpenStreetMap 3. CORINE Land Cover	1. 2025 2. 2025 3. 2018

The dataset covers 234 NUTS-2 regions. Due to the limitations in data availability and concerns of consistency, some regions that are predominantly islands or overseas territories were excluded from the analysis. These include Ciudad Autónoma de Ceuta and Ciudad Autónoma de Melilla in Spain; Canarias; the autonomous Portuguese regions of Açores and Madeira; and the French overseas territories of Guadeloupe, Martinique, Guyane, La Réunion and Mayotte.

3.2. Methodology

To comprehensively evaluate regional patterns in critical infrastructure (CI) stock, we employed a dual-method approach. The first method involved constructing a composite indicator that synthesizes sectoral CI stock scores (standardized by both population and land area) into a single metric, thereby enabling cross-regional comparison of overall infrastructure levels. The second method builds upon these composite scores by distinguishing between spatial coverage and infrastructure sufficiency relative to population. Through a typology-based classification using median splits, we assigned regions to distinct categories reflecting combinations of high or low spatial and demographic provision within each CI sector. This approach not only reveals underlying patterns of CI distribution but also addresses the key research question: Are there regions that perform strongly or weakly across all dimensions, or do certain regions exhibit mixed infrastructure profiles? For example, a region classified as high per capita and high per land area in transport can be considered both well-connected and accessible, while a region with low per capita but high per land area may possess extensive infrastructure coverage yet still lack adequate provision relative to its population, which an important distinction for assessing resilience. Similarly, in the energy sector, high numerosity but low capacity indicates redundancy but potential underpowering, whereas low numerosity with high capacity suggests robustness but limited redundancy. By integrating these two methods, our analysis aims to provides a more nuanced understanding of infrastructure sufficiency and distribution across regions.

3.2.1. Composite Indicator Construction

In the literature, studies developing datasets covering both geographical and sectoral breadth to enable comparisons across multiple regions and countries are limited. A similar motivation guided Canning (1998) in developing a worldwide infrastructure database. In his study, Canning examines infrastructure stock through physical indicators expressed per land area and per capita. He justifies the use of these physical indicators by highlighting that countries can vary significantly in infrastructure's per-unit costs due to differences in input prices and variations in public sector efficiency. Bröcker (2009) further adds that natural conditions, which may vary not only among but also within countries, can significantly affect infrastructure costs due to natural conditions for example. He provides examples of physical indicators useful for assessing infrastructure stock, such as road and railway length (km) and electricity supply capacity (megawatts).

A more recent study by Nirandjan et al. (2022) provides a global dataset of critical infrastructure (CI) derived from detailed OpenStreetMap (OSM) data, covering seven sectors: transport, energy, telecommunications, water, waste, education, and health. Similar to their Critical Infrastructure Spatial Index (CISI), which aggregates multiple standardized critical infrastructure indicators into composite spatial scores at varying resolutions to reveal hotspots of CI concentration at global scale, our approach involves combining infrastructure metrics standardized per capita and per land area through min-max normalization. In our study, these normalized indicators were further aggregated into a single composite indicator at regional scale, ensuring both demographic accessibility and geographic coverage are comprehensively reflected.

Based on these takeaways from the literature; in order to assess the availability and sufficiency of infrastructure, two standardised measures were calculated for each variable: per capita and per land area. These indicators were first computed individually, then normalised using min-max scaling. The two dimensions were averaged to capture both demographic reach and spatial coverage. For each sector, the standardised indicators were then summed and re-normalised to ensure comparability across regions.

In the case of energy infrastructure, the number of power plants (numerosity) and total installed capacity were evaluated separately by both population and land area. This distinction acknowledges that while large-capacity plants may enhance robustness, they can also introduce vulnerability due to over-reliance on a limited number of high-output facilities. A system dominated by a few large sources may lack the redundancy needed for resilience during disruptions.

For ICT, which consists of a single variable (the share of households with internet access), the indicator was directly standardised. Finally, the four sectoral scores transport, energy, ICT, and public services were combined with equal weights into a single composite index of critical infrastructure stock.

1. Density Calculation: For each indicator (e.g., kilometres of roads and railways, number of hospitals), we calculated values per capita and per square kilometre at the NUTS-2 level.

2. Min-Max Normalisation: Each per capita and per land value was normalised using min-max scaling:

$$x_{capita}^{norm} = \frac{x_{capita} - \min(x_{capita})}{\max(x_{capita}) - \min(x_{capita})}$$

$$x_{land}^{norm} = \frac{x_{land} - \min(x_{land})}{\max(x_{land}) - \min(x_{land})}$$

3. Averaging Spatial and Demographic Dimensions: The two standardised values (per capita and per land) were averaged to reflect both demographic accessibility and spatial coverage.

$$x_{avg} = \frac{x_{capita}^{norm} + x_{land}^{norm}}{2}$$

$$x_{avg}^{norm} = \frac{x_{avg} - \min(x_{avg})}{\max(x_{avg}) - \min(x_{avg})}$$

4. Re-normalisation: These average scores were standardised again to preserve comparability across indicators within the same sector.

5. Sectoral Aggregation: For transport, energy, and public services, the re-normalised values of each indicator were summed and standardised once more to produce a final **sectoral infrastructure score**. ICT, which includes only a single indicator, was directly standardised.

6. Composite CI Score: The four sectoral scores were then summed-up, assigning equal weight to each, and then standardised to form a **total critical infrastructure score** for each region

$$Total\ Score = Transport^{norm} + Energy^{norm} + ICT^{norm} + Public\ Services^{norm}$$

$$Normalized\ Total\ Score = \frac{CI - \min(CI)}{\max(CI) - \min(CI)}$$

3.2.2. CI Stock Classification and Median-Split Approach

As a second step, to interpret regional differences in critical infrastructure stock and identify broader patterns, we implemented a typology-based classification approach. This method aligns with other studies in the literature aiming to spatially classify infrastructure stocks using typological or cluster-based methods (Borgatti, 2008; Onda et al., 2014: Nirandjan et al. 2022).

Instead of relying on unsupervised, data-driven algorithms (such as hierarchical clustering or k-means), which are typically favoured for very large datasets (Xu et al., 2017), we opted to categorize continuous CI scores using a median-split approach. This technique, adopted in previous studies (e.g., Trojanowski et al., 2024; King et al., 2011), facilitates targeted comparison of infrastructure provision patterns across regions and sectors, supporting both spatial and cross-sectoral assessments. While some critiques exist regarding the potential for median splits to reduce statistical power and obscure underlying variation (DeCoster et al., 2011), this method enhances interpretability and is particularly valuable where clear typological distinctions are required and multicollinearity is limited (Iacobucci et al., 2015). Based on the idea that a manual median-split approach ensures results are trans-

parent, directly comparable, and easy to interpret making it particularly suited for policy-oriented assessments we applied median splits to categorize continuous variables for typology construction.

For each sector, we assessed regional infrastructure typologies using median splits of standardized indicators, considering combinations of per capita and per land measures or numerosity and capacity for energy (excluding powerlines and towers). Specifically, for Transport, Energy, and Public Services, regions were categorized into four typological groups (High-High, High-Low, Low-High, and Low-Low) based on these dual axes. For ICT, which relied on a single indicator (household internet access), a simple High vs. Low classification relative to the median was applied.

Subsequently, each region was assigned a score based on its typological classification within each sector: two points were allocated for the highest-performing typologies (e.g., High-High combinations), one point for intermediate typologies (High-Low or Low-High), and zero points for the least sufficient typologies (Low-Low or low ICT access). The sum of these points across all sectors yielded a total CI Stock Typology score for each region, ranging from 0 to 8, thereby quantifying overall infrastructure sufficiency with respect to both spatial and population coverage. Finally, regions were classified into four groups according to their total scores: Low Sufficiency (scores 0-2), Moderately Low Sufficiency (scores 3-4), Moderately High Sufficiency (scores 5-6), and High Sufficiency (scores 7-8).

Table 2. Typology Calculation

CI Stock Typologies per Sector	Points Assigned
High–High (Transport, Energy, Public Services), High (ICT)	2
High–Low or Low–High	1
Low–Low (Transport, Energy, Public Services), Low (ICT)	0

4. Findings

The composite indicator of critical infrastructure stock reveals notable spatial disparities across EU NUTS-2 regions. Regions in Central and Northern Europe, particularly parts of Germany, Scandinavia, and the Benelux countries, consistently show the highest composite CI stock scores, reflecting a combination of transport networks, energy supply, ICT and public service infrastructure. Contrarywise, much of Southern and Eastern Europe, including many regions in Spain, Portugal, Greece, and Eastern member states, appear in the lower ranges of the index. These areas are often characterized by sparser infrastructure networks and lower levels of service provision, especially in transport and public services.

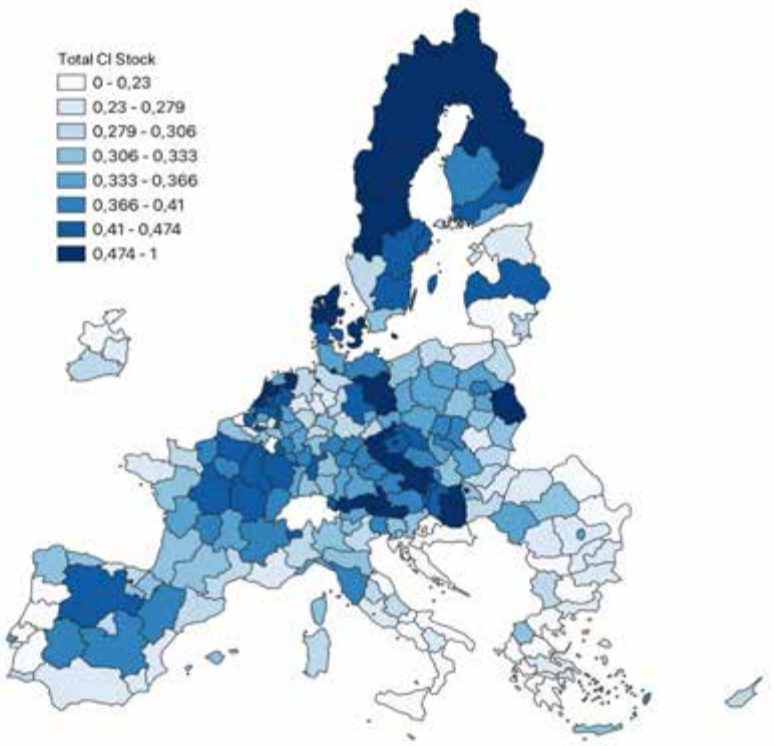

Figure 1. Total CI Stock Scores of NUTS 2 Level Regions in EU

The map further highlights that CI stock is not uniformly distributed even within countries. For instance, certain metropolitan or capital regions may achieve higher scores due to agglomeration effects and concentrated investments, whereas more peripheral or rural areas often lag behind.

Another important insight is that strong performance in one sector does not necessarily correlate with strength in others. For example, Portuguese regions exhibit high scores in energy infrastructure but tend to fall below the EU average in ICT and public services. Likewise, the Andalucía region in Spain demonstrates average performance in energy infrastructure but scores very low in transport and public services which could limit the actual accessibility of these services during critical moments.

To further explore the distribution of CI sufficiency across regions, we applied CI Stock Classification using sectoral medians as reference thresholds. Four categories were defined: High Sufficiency, Moderately High Sufficiency, Moderately Low Sufficiency, and Low Sufficiency.

Figure 2. CI Stock Typologies of NUTS 2 Level Regions in EU

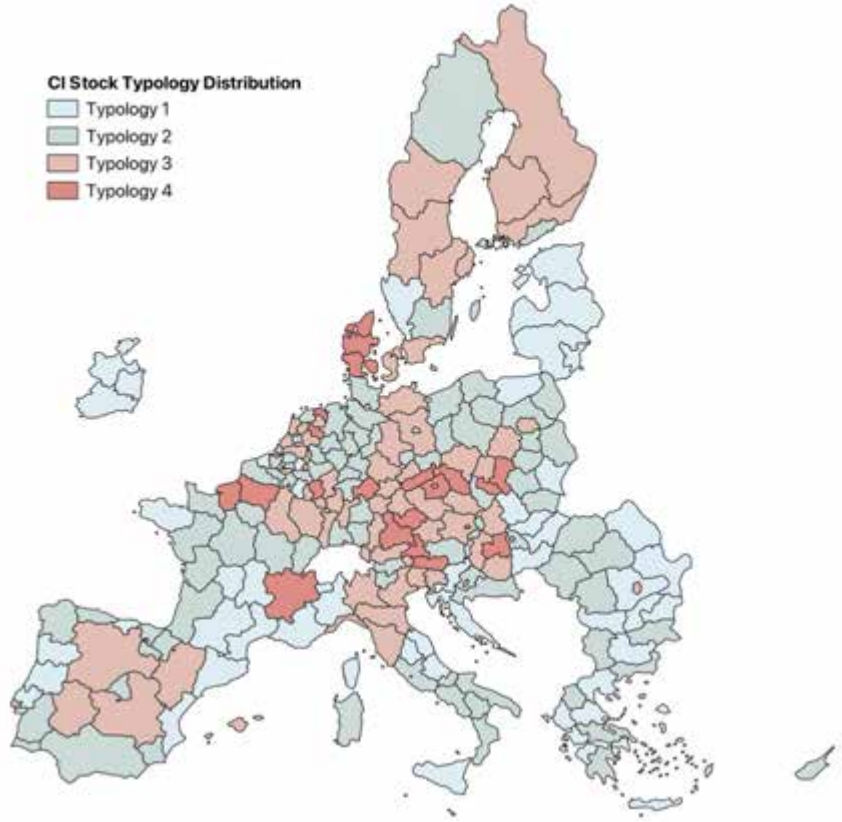

Table 3. Frequencies of CI Stock Typologies

CI Stock Typologies	Frequency	Percent
1. Low Sufficiency (0-2 points)	53	22.65%
1. Moderately Low Sufficiency (3-4 points)	92	39.32%
1. Moderately High Sufficiency (5-6 points)	68	29.06%
1. High Sufficiency (7-8 points)	21	8.97%
Total	234	100.00%

The distribution of CI Stock Typologies indicates that the majority of regions fall into the lower sufficiency categories. Specifically, 22.7% of regions are classified as having low sufficiency (0-2 points), while 39.3% are in the moderately low sufficiency group (3-4 points). Moderately high sufficiency (5-6 points) is observed in 29.1% of regions, and only 9% of regions achieve high sufficiency (7-8 points).

This pattern suggests that a significant proportion of regions have limited or only moderate levels of critical infrastructure provision, with relatively few regions exhibiting comprehensive infrastructure sufficiency across all dimensions. The findings highlight potential disparities in infrastructure availability and point to areas where targeted policy interventions may be necessary to enhance regional resilience.

6. Discussion

The findings highlight significant cross-regional variation. While some regions exhibit balanced and robust infrastructure profiles, many show asymmetries or sector-specific gaps. Importantly, the clustering analysis reveals that most regions fall within moderate sufficiency categories, combining strengths in some sectors with weaknesses in others. This diversity underscores the need for differentiated policy approaches and reinforces the argument that contribution to regional resilience cannot be determined by single-sector performance but by the interplay of multiple critical infrastructure systems.

Within Central Europe, capital regions such as Berlin, Prague, and Vienna emerge as concentrated CI hubs. High scores in these areas may partly reflect their political, economic, and institutional centrality. These regions have historically benefited from sustained investment, higher population densities, and strong institutional frameworks that support infrastructure expansion and maintenance. Similarly, certain peripheral regions in Nordic countries as parts of Sweden and Finland also exhibit high infrastructure scores. This could be attributed to their large geographic size and the extensive spatial coverage of infrastructure, especially transport systems connecting distant settlements to central nodes. A closer look reveals that these regions perform well in the transport and energy sectors, reinforcing the interpretation that both spatial reach and redundancy contribute to their higher resilience potential.

When comparing the composite infrastructure score map with the sufficiency classification, a broad west–south divide remains visible; however, several regional-level differences emerge. At first glance, these may appear to result from the exclusion of electricity line data in the second analysis. Yet, closer inspection reveals deeper structural nuances. For instance, Latvia appears relatively well-positioned in the composite CI stock map, but falls into the Low Sufficiency category upon typology classification. This reflects that while infrastructure quantity may be present, its relative redundant capacity across all critical infrastructure sectors may still be low. Similarly, while regions in Sweden and Finland continue to score high in the composite CI stock indicator, the sufficiency classification reveals certain shifts. These changes suggest that although these regions benefit from high overall CI levels, they may not consistently score high across all four sectors, which indicates insufficiencies in planning. In contrast, Danish regions display more stable patterns across both maps, suggesting a more uniformly distributed and sufficient critical infrastructure stock.

Regions with low CI sufficiency, particularly in Southern and Eastern Europe, may face serious challenges in service continuity and recovery under disruptive conditions. In contrast, capital cities and some larger northern areas benefit from higher levels of sufficiency, though even these may be reliant on centralised nodes or infrastructure corridors that pose vulnerability in cases of failure.

A study by Stanickova & Melecky (2018), built a broad composite index of regional resilience, the most resilient regions were largely in Northern and Western Europe – Scandinavian countries and Western EU regions scored the highest on the resilience index. By contrast, the least resilient were concentrated in the south: the authors note that the "southern circuit" (Portugal, Spain, Italy and Greece) showed the lowest resilience scores among EU regions. The findings in our paper similarly reveal a north/centre–south divide excluding Spain. However, this difference can also be explained by the fact that certain southern European regions have invested in extensive transport and energy networks (partly through Cohesion Policy), so they may not rank at the very bottom in our study based on critical infrastructure. Our findings for Finland and Sweden, on the other hand, invite a reflection on the argument made by Pursiainen (2018), who highlights an emergence of a Nordic model of critical infrastructure resilience. This "nordic model" is characterised by redundancy, preparedness, multi-actor cooperation, and a stronger focus on maintaining functionality over protecting specific assets. According to his study, the Nordic approach combines robust public institutions with cross-sectoral coordination and adaptive governance. These structural and institutional features may help explain the higher infrastructure scores and relative consistency observed in regions of Finland and Sweden in our analysis.

8. Conclusion

This study investigated the distribution of critical infrastructure stock across EU NUTS-2 regions, employing a composite indicator encompassing four essential sectors: transport, energy, ICT, and public services. CI indicators were standardized by both population and land area, ensuring that both demographic accessibility and spatial coverage were taken into account. In a subsequent analytical step, regions were classified into four distinct categories based on sectoral median thresholds, allowing for a nuanced comparison of infrastructure sufficiency across the European context.

The findings reveal significant spatial disparities. While some regions (particularly in Central and Northern Europe) exhibit consistently high critical infrastructure scores, others, especially in Southern and Eastern Europe, show notable gaps or unbalanced profiles. Regions located in central Europe like Berlin, Vienna, Prag and parts of Sweden and Finland benefit from high spatial reach and sufficiency, particularly in transport and energy. In contrast, Southern regions may have strong energy capacity due to natural resources but often underperform in transport and public services. A key insight is that strength in one sector does not guarantee strength in others. Many regions exhibit a mix of high and low performances, highlighting the need for just critical infrastructure provision and regional planning. The classification results confirm this: only 9 percent of regions fall into the high sufficiency category, while nearly one-quarter face serious gaps. Most regions occupy an intermediate space, with strengths in some areas but weaknesses in others.

However, this study has limitations and the principal limitation concerns data availability. Critical infrastructure data is often difficult to access due to security concerns and the fact that much of it is managed by private entities. While the use of OpenStreetMap (OSM) data is common in similar research, its reliability may be affected by its reliance on user-contributed reports, highlighting the need for further data verification. The predominance of private sector operation in many CI sectors also presents a significant barrier to accessing comprehensive open data.

Furthermore, as previously discussed, the definition and prioritization of what constitutes critical infrastructure can differ substantially between nation states' agendas. Looking ahead, an important step would be to identify, through broader studies, those critical infrastructure sectors that provide essential services that are mainly for public good and are as independent as possible from state and market interests. On this basis, developing a more expansive composite indicator including additional sectors based on public perceptions of essential services, such as housing or elderly services, could enhance the assessment of CI sufficiency and societal resilience.

Lastly, while this study primarily addresses the sufficiency of critical infrastructure, future research should also examine other dimensions emphasized in the literature, such as connectivity and redundancy, to provide a more holistic assessment of regional resilience. Additionally, future research could benefit from experimenting with alternative clustering methods such as hierarchical clustering, k-means, or density-based approaches to explore whether different techniques yield distinct or more nuanced typologies of CI provision. Comparing results across multiple clustering methods could provide deeper insights into the robustness and sensitivity of regional classifications and their implications for policy.

In sum, this study demonstrates the value of moving beyond single-sector or investment-based assessments toward a more spatially grounded, cross-sectoral understanding of critical infrastructure. The composite indicator developed here offers a useful practical tool for identifying vulnerabilities and guiding resilience-focused regional planning. As regions face growing environmental and socio-economic risks, ensuring the sufficiency of critical infrastructure will be essential for building more resilient regions.

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Track 13

HOUSING AND SHELTER

A Study on Per Capita Housing Status and Living Quality Enhancement in Dashilan Historical and Cultural Block

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Abstracts
Firstly, the experience of improving living quality in the UK, Japan and Hong Kong, China is systematically collated, and based on the experience, the minimum living standards of eight countries, namely, the US, Canada, the UK, Italy, Germany, Japan, South Korea and China, are also collated.Secondly, combining the data from the 7th National Population Census, residents' interviews and field research, we quantitatively assessed the current per capita housing situation in Dashilan in terms of spatial size, basic functional spaces, architectural performance and basic equipments, and the living environment, and found out the gaps between them and the minimum standards of domestic and foreign countries.Finally, it puts forward suggestions for improving the living quality from the aspects of standard setting, housing survey and supervision, dynamic database platform construction, and sustainable updating mechanism.

Keywords: historic and cultural block; per capita housing status; living quality; minimum living standards; residentially vulnerable groups

1. Introduce

With the increase in the total amount of housing construction in China and the continuous improvement of the housing system, the per capita area of housing in cities and towns has reached 40.8 m^2(National Bureau of Statistics, 2021), which is one of the highest in the world, and has basically solved the problem of insufficient housing.However, in the face of the reality of rapid urbanisation and urban population growth, the quality of housing for the urban population is poor, with more than 30% of the resident population lacking a safe, healthy and dignified living environment, a phenomenon that is particularly prominent in historical and cultural districts. Beijing Dashilan Historical and Cultural Block is such a typical neighbourhood, which is confined to multiple reasons such as property rights, cultural preservation, location and funding, making it difficult for the population to be relocated and for the foreign population to gather, in addition to the fact that the current renewal planning is still limited to public space and street facade improvement, and that there is a lack of quantitative assessment of the current housing situation per capita, which does not have a clear grasp of the bottom-line housing needs of the residents, thus influencing the renewal timetable.

<<Universal Declaration of Human Rights>> states that "Safe and affordable housing is a fundamental human right." UN-HABITAT calls on countries to: "Prioritise the needs of the vulnerable groups of people living in housing, establish minimum standards of accommodation acceptable to the occupants and build safe, healthy and sustainable human settlements."To sum up the background, this study quantitatively assesses the current housing situation per capita in the Dashilan Historical and Cultural Block by drawing on the experience of 3 countries in upgrading the quality of housing and the minimum living standards of 8 countries, and makes recommendations.

2 .International Experience in Residential Quality Improvement and Minimum Living Standards

2.1 Experience of improving the quality of living in the UK

The UK housing system consists of three types of housing: owner-occupied housing, social housing and private rented housing.Today, the number of people living in overcrowded, unsafe and unhealthy housing in the UK is decreasing, with overcrowding in only 9 of London's 250,000 homes in 2021 (London, 2021), as a result of the UK Government's efforts in the following 4 areas:

(1) Setting minimum living standards to guarantee a minimum level of safe, healthy, and dignified living.In 1935, minimum space and room standards (collectively referred to as overcrowding standards) were set out in the-

Housig Act-(HA) to guide the assessment of privately rented housing (WILSON W, 2020).The application of the HA was expanded in 1985 to guide all types of housing assessment.In 2004, the <<Housing Health and Safety Rating>> (HHSRS) was added to the HA, supplementing the minimum standards for basic functional space, building performance and basic equipment, and the living environment (GOV.UK, 2022).In 2005 the-Minimum Living Home Standard-(Shelter England, 2005). 2012 saw the launch of a review of standards, repealing (with the exception of the standards in HA) all previous minimum standards. The nationally harmonised-Nationally Described Space Standard-(NDSS) was introduced in 2015 (GOV.UK, 2015). 2021-The Human Habitation Act-re-emphasises the overcrowding standards in HA and the HHSRS as minimum standards for human habitation.

(2) Regular housing surveys based on minimum living standards.Since 1967, the UK government has conducted surveys on housing stock and living environment, once every 5 years before 2000, and once every year thereafter. English Housing Survey (EHS) is organised by local governments, and since 2007, it has been commissioned to a professional survey team, CADS (GOV.UK, 2019).The scope of the EHS survey covers the whole country, with a sample of 6,200 dwellings randomly sampled by region, and residents can also apply for the survey voluntarily through the EHS helpline.The EHS consists of a physical survey and a household questionnaire interview, with approximately 130,000 households interviewed each year.Finally, the results of the survey are evaluated according to the minimum standards in the HA, and then housing security policies are formulated to improve the quality of living.

In 2006, the UK government also introduced the "Housing Health and Safety Rating System", in which local environmental health officers assess the likelihood and severity of the existence of 29 types of potential health and safety hazards in housing once every 2 years, and the system is relatively simple, and households can also make their own assessments in Table 1.According to the severity of the hazards, they are classified into 4 types of risks. For housing with Type 1 risks, a demolition order is issued, and the government is responsible for demolishing the housing and rehousing the occupants who have become homeless due to the demolition of the housing; for housing with Type 2 risks, a no-occupation order is issued, and the government is responsible for repairing and stating that the use of the housing in violation of the rules is a criminal offence; for housing with Type 3 and 4 risks, a "Repair Notice" and a "Danger Awareness Notice" are issued to remind the occupant to carry out repairs to the property, and the property is reassessed after 28 working days (GOV.UK, 2022).

Table 1: Housing health and safety rating system indicators

physiological requirements	1.damp and mould growth; 2.excess cold; 3.excess heat; 4.asbestos and MMF; 5.biocides; 6.carbon monoxide and fuel combustion products; 7.lead; 8.radiation; 9.uncombusted fuel gas; 10.volatile organic compounds
psychosocial requirements	11.crowding and space; 12.entry by intruders; 13.lighting; 14.noise
protection against infection	15.domestic hygiene, pests and refuse; 16.food safety; 17.personal hygiene, sanitation and drainage; 18.water supply
protection against accidents	19.falls associated with baths; 20.falling on level surfaces; 21.falling on stairs; 22.falling between levels; 23.electrical hazards; 24.fire; 25.flames, hot surfaces; 26.collision and entrapment; 27.explosions; 28.position and operability of amenities; 29.structural collapse and falling elements

(3)Focusing on vulnerable groups of residents.For low-income families, it has introduced a "savings deposit, rent-and-buy" policy, under which they can acquire home ownership by paying rent for a limited period of time until the total amount of rent paid equals the total amount of the property; and a "shared ownership" policy, under which they can purchase a part of the house and shared ownership", where by a person buys a part of a house and pays a lower rent for the remainder, with the ownership shared between the Government and the individual; and the provision of housing for older people to help them live independently and reduce social care and health costs (London, 2021).

(4) Effective use of vacant housing.A requirement that homes cannot be left empty for more than 6 months or they will be compulsorily acquired for use as social housing; and incentivising the re-use of empty homes through the introduction of a council tax vacancy premium (London, 2021).According to statistics, the number of empty homes in London in 2021 will be less than 1% of the total housing stock.

2.2 Japan's experience in improving living quality
Japan's housing development can be broadly divided into 3 phases: the phase of housing supply before 1975, the phase of improving the quality of living from 1975 to 2006, and the phase of meeting the diversified housing needs of residents after 2006.

(1) Housing supply phase: "The Public Housing Supply Programme" was implemented to make it the responsibility of local governments to solve the housing difficulties of low-income people, and to systematically provide low-rent public housing for the underprivileged.

(2) Stage of improvement of living quality: housing survey, establishment of minimum living standards, and effective use of vacant housing.In 1950, the Japanese government conducted a housing survey once every 5 years on housing stock and housing use (Ministry of Land, Infrastructure, Transport and Tourism, 2018).In 1976, the Ministry of Land, Infrastructure, Transport and Tourism established the-Minimum Living Standards-as the basis for the housing survey, and gradually reduced the proportion of households that were below the minimum standards (Ministry of Land, Infrastructure, Transport and Tourism, 1976).The 1977 housing survey was supplemented with surveys on satisfaction with housing and the surrounding living environment, the existence of plans for residential improvement, and intentions for residential improvement.The scope of the survey was general housing nationwide, and 10,000 households were randomly sampled from the Housing and Land Statistics Survey and interviewed by questionnaire.

The vacant house survey was started in 1980 and is conducted once every 5 years to obtain basic information on vacant houses nationwide (Ministry of Land, Infrastructure, Transport and Tourism, 2019).Based on the results of the vacant house survey, empty houses that affect the surrounding living environment are scrapped; the government and communities provide a counselling mechanism for owners of vacant houses to reduce the proportion of vacant houses; the government is responsible for repairing and repurposing empty houses with unknown owners into special housing for the elderly, shared housing, temporary housing, or space for public activities, etc.; and support is provided to civil society organisations to collect information and conduct research and study activities through empty houses, and education and publicity activities to propose countermeasures for the reuse of empty houses.

(3) Stage of diversified housing needs: 2021 Introduced the <<Basic Plan for Residential Life>>, raised the <<Minimum Living Standard>>, and specified that in the post-epidemic era, in order to secure remote workspaces and regional workspaces, etc., within residences, we will promote the construction of an integrated residence and home learning environment, as well as promoting the construction of a non-contact environment by promoting the installation of express lockers and automatic faucets, etc.(Ministry of Land, Infrastructure, Transport and Tourism, 2021).

2.3 Hong Kong, China's experience in upgrading living quality
Public housing in Hong Kong is equivalent to subsidised housing in inland China. Public housing is divided into 2 major categories, namely public rental housing and public subsidised sale housing. Public rental housing includes low-cost housing (highly subsidised, low rent) and public rental housing (rent is set according to the cost of the project and the income of the tenants), while public subsidised sale housing mainly consists of Home Ownership Scheme flats and Sandwich Class Housing Scheme flats which are sold at cost, with a low downpayment and no interest payment.

To ensure fair allocation of public housing, Hong Kong has established a stringent application, allocation and

transfer system.The "Spacious Household Policy" stipulates that households with living space exceeding the prescribed standards should be relocated to PRH flats of suitable size, with priority given to seriously over-occupied generously sized households in accordance with the criteria set out in Table 2, by removing from the list of generously sized households families with disabled members or elderly persons aged 70 or above, and placing families with elderly persons aged 60-69 at the bottom of the list of generously sized households to be relocated.The Government has been working on the following measures to improve the living conditions of the elderly"The Rent Allowance for Elderly Scheme" provides cash rent allowance to elderly applicants for renting private flats in lieu of public rental housing allocation."The Shared Elderly Persons Priority Scheme" provides for immediate allocation of public housing to 2 or more elderly persons who agree to share a public housing unit."The Harmonious Families Priority Scheme" requires young families and at least 1 elderly parent or dependent elderly relative to choose to share 1 flat or 2 nearby flats, depending on the choice of districts and the number of flats suitable for the family's circumstances.In 2021, the "Living Space Improvement Transfer Scheme" stipulates that public housing tenants with a per capita living space of less than 7 may apply for transfer, while families with a living space of less than 5.5 are called "crowded households" and are subject to mandatory transfer; for families with persons who are pregnant for more than 16 weeks, wheelchair users, quadriplegics, or those who need long-term dialysis, an additional family member can be counted in the calculation of the per capita area (Housingauthority, 2021).

Table 2: Spacious household standard

Family size (persons)	1	2	3	4	5	6
Spacious Household Standard (m^2)	25	35	44	56	62	71
Priority treatment standard for spacious households (	30	42	53	67	74	85

2.4 International minimum standards of accommodation

Facing the reality of rapid urbanisation and urban population explosion, in order to effectively solve the housing problems of middle and low-income people, the United States, Canada, Italy, Germany, South Korea and other countries have also formulated the minimum living standards, see Table 3.Each country takes the bedrooms, kitchens, toilets, and bathrooms as the mandatory functional spaces, and the availability and working condition of the structural solidity, water supply, drainage, power supply, heating and other equipment as the mandatory indicators.And ventilation, lighting, noise, indoor temperature and air quality have been the focus of housing assessment and investigation in all countries (Zhao, J., 2024).In addition, the UK and South Korea take gender and age differences into account when allocating bedrooms. The overcrowding standard in the UK HA stipulates that married or cohabiting couples, adults aged 21 years and above, a pair of same-sex adolescents aged 10-20 years old, and a pair of children aged under 10 years old (irrespective of gender) should be allocated a separate bedroom; in Korea, the-Minimum Living Standard-stipulates that couples share a bedroom, children over 6 years of age are separated from their parents, children of opposite sexes over 8 years of age are separated from each other, and elderly parents have a separate bedroom.

Table 3: Minimum residential standards in force at home and abroad

Nations	Standard time and name		Living area						
		Family size (persons)	1	2	3	4	5	6	
America	1994MPS	Total living area	14	23	33	40	47	54	
		Bedroom area	6.5	11.2-9.8-	15.9-13-	——			
Canada	2012MHHS	Total living area	13.5	22	32	39	46	54	
		Bedroom area	4.5-3.5-	9-6.5-	13.5-9.5-	——			
UK	2015NDSS	Total living area	30{35.5}	38	46	53	65	74	
Italy	1975IM	Total living area	21	28.5	36	43.5	51	58.5	
		Bedroom area	6.8-3.5-	10.5	14.2	——			
		Living room area	——	6.7	10.5	10.5	——		
		Kitchen area	3.3	3.3	4.5	4.5	——		
		Toilet area	4.2	4.2	6.8	6.8	——		
German	2018HBO	Area of use per capita	9-6-						
Japan	1976	City centre	Total living area	13.5[18.8]	21	28.5	36	42	50
		Suburbs		28[32]	41	56	68	78[92]	84[97]
	2021	City centre		18.8	22.5	30-26-	37.5-34-	45-41-	52.5-49-
		Suburbs		30	41	56-49-	71-64-	86-79-	102-94-
South Korea	2004		Total living area	12	20	29	37	41	49
	2011		Total living area	14	26	36	43	46	55
			Family composition	Single	Couple	Couple + children		Parents + couple + children	
			Number of bedrooms	1	1	2	3	3	5
			Bedroom area	5.7	8.1	——			
			Kitchen area	2.4	3.0	3.0	3.0	3.5	3.5
			Kitchen form	K	DK	DK	DK	DK	DK
			Toilet area	4.1	6.5	6.5	9.2	10.5	13.2
China	2010Beijing		House type	Single dwelling type	Small sleeve type	Intermediate sleeve type	Large house style	——	
			Total living area	22	29	36	43	——	
	2010Shenzhen		House type	Type A	Type B	Type C	Type D	Type E	——
			Total living area	26	36	49	60	68	——
	2011Shanghai		House type	Type|		Type		——	
			Total living area	|26	26-38	≤45	≤45	——	
	2023Hongkong		Area of use per capita	7					

Note: Note: ① The full name of MPS is Minimum Property Standards; MHHS is Minimum Housing and Health Standards; IM is Istruzioni Ministeriali; HBO is Hessische Bauordnung. ② The unit of area is m^2.③ In (), it means that there are children living in the house, [] there are elderly people, and {} there are wheelchair users.④Total living area in the US and Canada includes bedroom, living room, kitchen-cum-dining room, and bathroom; PM includes bedroom, living room, kitchen, bathroom, and storage space; NDSS includes bedroom, living room, kitchen-cum-dining room, bathroom (toilet and shower), and storage space; Italy includes bedroom, living room, kitchen, bathroom, and storage space; Japan includes bedroom, living room, kitchen, dining room, bathroom, and storage space; South Korea includes bedroom, living room, kitchen, dining room, bathroom, and storage space; and Japan includes bedroom, living room, kitchen, dining room, bathroom, and storage space.space; Korea includes bedroom, living room, kitchen (or kitchen-cum-dining room), bathroom; China includes bedroom, living room, kitchen, dining room, bathroom.⑤"K" refers to kitchen, and "DK" refers to dining room and kitchen; ⑥the 1976 Japan and 2004 Korean minimum standards are intended to be compared with the current standards.

3. Per capita housing situation in the Dashilan Historical and Cultural Block

3.1 Study area and data

Dashilan is the most central block of the Chinese capital and the traditional commercial centre of old Beijing, as well as one of the first batch of Chinese Historical and Cultural Block, adjacent to Tiananmen Square and the National Centre for the Performing Arts, and an integral part of Beijing's Central Axis, in Fig. 1. Dashilan covers an area of about 1.26km^2 , and there are 3886 courtyards and 114 hutongs in the neighbourhood, which have retained the intact spatial texture of the courtyards and the hutongs.By the end of 2020, the resident population in Dashilan will be about 29,000 (including 58% of aborigines and 42% of foreigners), with the household population 1.75 times the resident population, the elderly aged 60 or above accounting for about 26% of the resident population, and the population with bachelor's degree or above accounting for only 20%, so that ageing and low education have turned Dashilan into a depression of human capital.

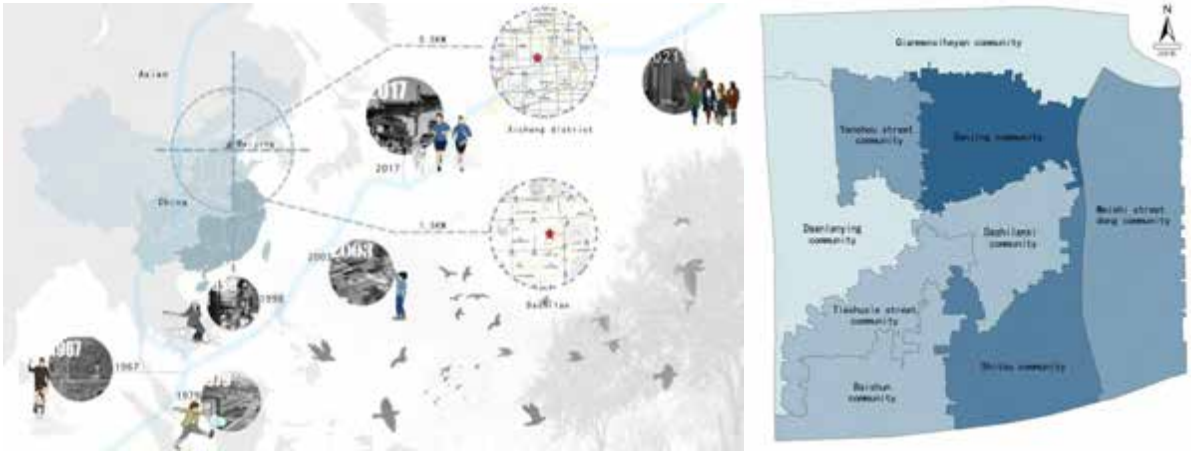

Fig. 1 Location map of Dashilan

This study used 3 types of data: the 7th National Population Census (the 7th Census), resident interviews and field research.The 7th Census took the zero hour of 1 November 2020 as the standard time point to census the population of mainland China, and the data of the 7th Census used in this study were provided by the Bureau of Statistics of Xicheng District, Beijing.Between November 2021 and June 2022, the research team visited households and organised more than 20 resident interviews, to obtain the opinions and needs of the residents.

This study mainly adopts the GIS analysis method, which imports the spatial units of the compounds during the 7th Census survey into GIS and transforms them into the form of shp data, and associates the population and spatial data based on the community code (Adcode) and the building code (BuildingNo), and then accurately assigns the population information to the compounds in which they reside, in order to assess the current status of the per-capita housing in each compounds.

3.2 Space size

3.2.1 Per capita living space

The living space of Dashilan residents is seriously insufficient, overcrowding is common, in Fig. 2., and living in an overcrowded environment for a long period of time will seriously jeopardise the physical and mental health of the residents (Susanto, D., 2022).The per capita living area of the resident population in Dashilan is 6.98m^2, and the median per capita living area is 7.5m^2 and the plural is 7.5m^2.Compared with the per capita minimum standards of various countries, it is lower than the America's 14 m^2, Canada's 13.5 m^2, the UK's 22 m^2, Italy's 21 m^2 ,Germany's 9 m^2, Japan's 18.8 m^2, South Korea's 14 m^2, Hong Kong, China's 7 m^2, of which about 50% of the residents' per capita living space is lower than Hong Kong's "squeezed households" standard of 5.5 m^2 Of these, about 50% of the residents have a living space per capita that is less than the Hong Kong "crowded household" standard of 5.5 m^2 and 86% of the residents have less than the standard parking space area of 12.5 m^2 for a private car.In addition, China's statistical yearbook shows that in 1989, China's urban per capita living area of 10.4 m^2, 2021 Beijing urban

per capita living area of 25 m^2, Dashilan as the location of China's capital city's most central block, the average per capita area even less than China's average level in 1989.

There is a big difference in the per capita living space of different groups, in Fig. 3. The per capita living space of the aborigines is 8.1 m^2, while the per capita living space of the foreign population is only 5.7 m^2, and the living space of the foreign population is even more narrow compared to that of the aborigines.The per capita area of households with infants and young children under the age of 6 is 6.3m^2, that of households with elderly people over the age of 60 is 9m^2, that of households with elderly people over the age of 80 is 11.8m^2, and that of households with disabled people is 7.6m^2.Among the disadvantaged groups, the living space of the senior elderly is relatively spacious, but it is still below the minimum standard of each country.

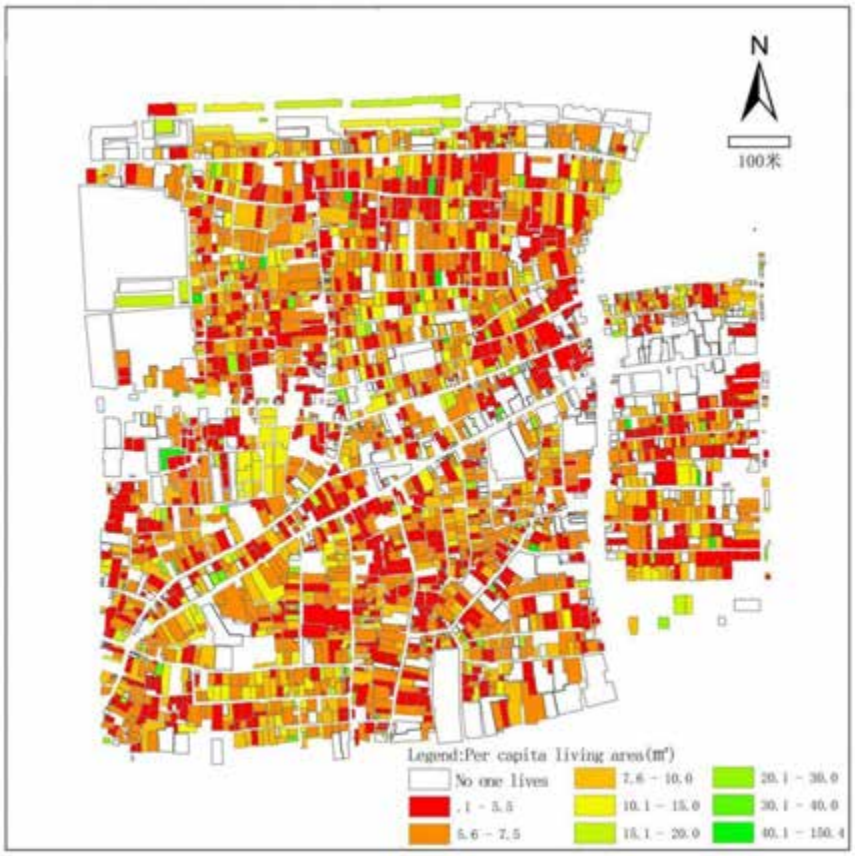

Fig. 2 Distribution map of per capita living area in courtyard

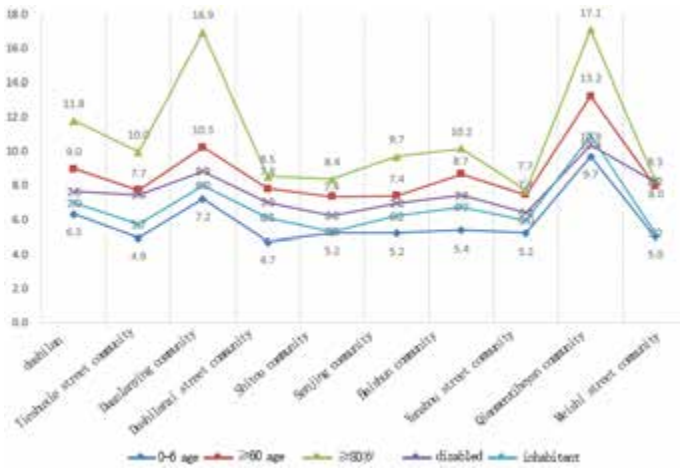

Fig. 3 Per capita living area of different groups

3.2.2 Number of rooms per capita

The overcrowding in Dashilan is again reflected in the number of rooms per capita, which is 0.55, with 79 of the resident population failing to meet the minimum standard of one room per capita, as shown in Fig. 4. In addition, as shown by the number of rooms per capita, which is 0.55, households do not take into account the differences in age and gender in the allocation of rooms; after all, not all people living in Dashilan are couples.

There are also differences in the number of rooms per capita among different groups, as shown in Fig. 5. The number of rooms per capita for the indigenous population is 0.6, while the number of rooms per capita for the foreign population is 0.5, and both the per capita living area and the number of rooms per capita of the foreign population are smaller than those of the indigenous population.The number of rooms per person in households with infants and young children under 6 years of age is 0.5, the number of rooms per person in households with older persons over 60 years of age is 0.7, the number of rooms per person in households with older persons over 80 years of age is 0.8, and the number of rooms per person in households with persons with disabilities is 0.7. Among the vulnerable groups, only infants and young children have rooms per person that meet the minimum standards of each country.

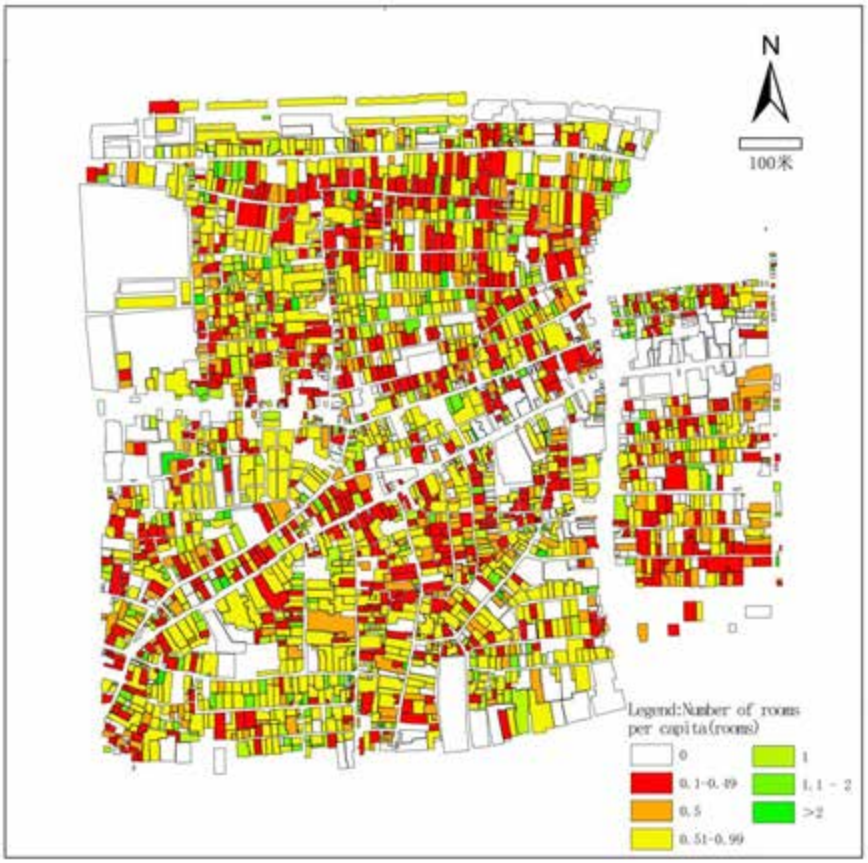

Fig.4 Distribution of the number of rooms per capita by courtyard

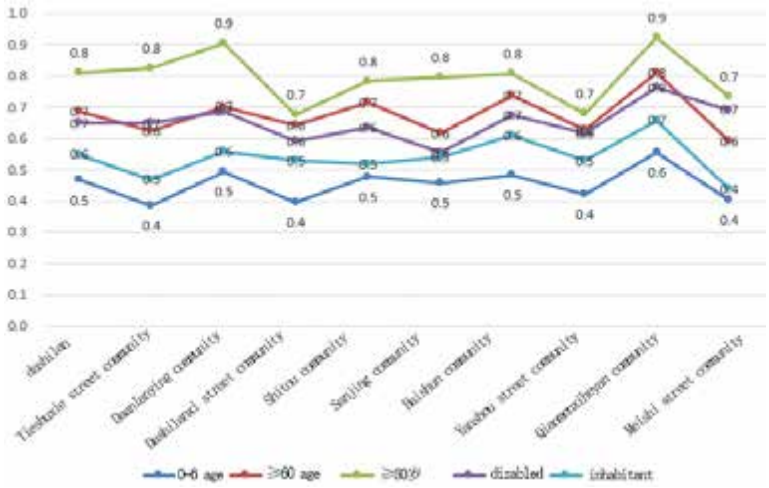

Fig. 5 Number of rooms per capita for different groups

3.3 Basic functional space

3.3.1 Kitchen

In all countries, separate kitchens are a mandatory basic functional space, while only 50 of households in Dashilan have a kitchen.Households in Dashilan are predominantly 2-3 person in size, with 0.55 rooms per person, indicating that a high proportion of households with kitchens have kitchens integrated with bedrooms.In addition, the field study found that some households have kitchens in the hutongs because of limited living space; if such kitchens were not counted, less than half of the households in Dashilan would have independent kitchens.

3.3.2 Toilet and bathing facilities

States have also made toilets and bathrooms mandatory basic functional spaces and stipulated that at least one separate toilet should be guaranteed in every housing unit.Only 18 of households in Dashilan have a separate toilet, and 75 have bathing facilities, but bathing facilities are not the same as separate bathrooms.In the symposium on "whether to support the inclusion of toilets in the courtyard/household", 11 residents expressed their views, of which 10 did not support the inclusion of toilets in the courtyard/household and 1 was neutral.The reasons for this are, on the one hand, that the living space is too small, and on the other hand, that the public toilets in Dashilan can cover all the courtyards within 80 m,in Fig .6. Therefore, whether or not to promote the use of toilets in courtyards/households in the near future should be assessed in the light of the needs of the residents and the availability of funds.

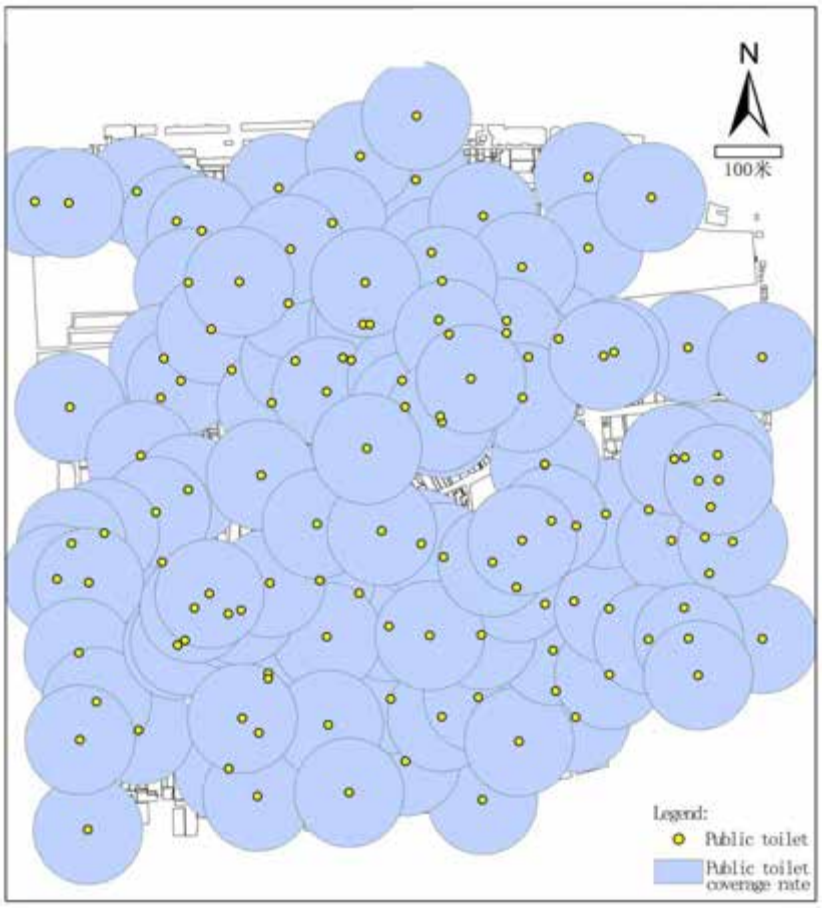

Fig. 6 80m coverage of public toilets

3.4 Building performance and basic equipment

3.4.1 Structural safety

Dangerous housing refers to the structure has been seriously damaged or load-bearing components have been dangerous components, at any time may lose the structural stability and load-bearing capacity, can not guarantee the safety of residence and use of the house, based on the degree of damage to the house will be divided into 5 categories of dangerous houses, 1 category of dangerous houses with the greatest degree of damage.Dashilan has 1,406 dangerous houses, accounting for 37% of the total compound of Dashilan (4, 5 types of dangerous houses mainly), private houses in dangerous houses accounted for a slightly higher proportion of about 51%, public houses accounted for 49%.In 87% of the dangerous houses, there are still residents living there, 27% of the dangerous houses have infants and young children living there, and 23% of the dangerous houses have elderly people over 80 years old living there, in Fig. 7.

Detailed analysis of the 61 randomly selected courtyards in the field study found that due to the long-term lack of maintenance and risk prevention awareness, some buildings in the block have more serious roof leakage phenomena and component collapse hazards, and the tilt rate of some building walls is even greater than 2%, which seriously exceeds the upper limit of the hazardous conditions stipulated by various national norms, and is very likely to damage the persons and properties safety of block residents in the event of torrential rains, high winds, continuous rain and other weather conditions.

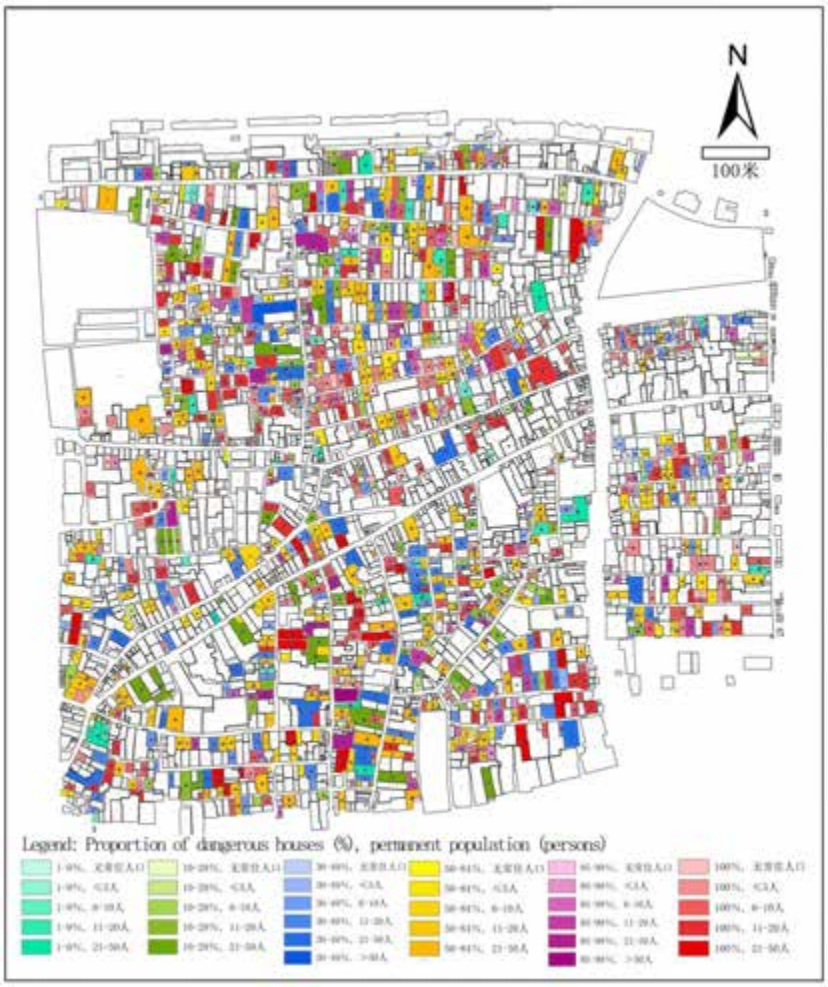

Fig. 7 Proportion of resident population in courtyard with different degrees of dangerousness

3.4.2 Water supply and heating equipment

Minimum standards in each country stipulate that water supply is a basic requirement for normal residential life, and the water supply in Dagestan is good, with 93% of households having piped water and 7% having no piped water.

Studies have shown that living in temperatures below 16°C for long periods of time during the winter months increases the risk of respiratory and cardiovascular diseases significantly in older people (Appolloni, 2021).We compared the indoor temperatures in a random sample of 10 compounds with those in urban buildings and found that the average indoor temperature in Dashilan in winter was only 5°C.The reason for this is that Dashilan was converted from coal to electricity in 2019, but some residents only heat their homes at night when they sleep because they cannot afford the high cost of electricity.

3.5 Living environment

The overall living environment in Dashilan is poor.Through household visits and resident meetings, we collected a total of 2,613 residents' opinions and demands on the living environment, and used GIS to group residents' opinions into the courtyard units they lived in, in Fig. 8. Residents mainly reflected indoor humidity, poor indoor lighting, frequent termite and rat infestation, waste accumulation encroaching on the courtyard, water accumulation and ice in the courtyard, noise nuisance from commercial operations and housing construction, and poor neighbourly-known neighbourhood relations.etc.For example, one resident reported: "The interior is very humid, the walls are mouldy, the air does not circulate, and you can only turn on the lights during the day when you can't see the light."

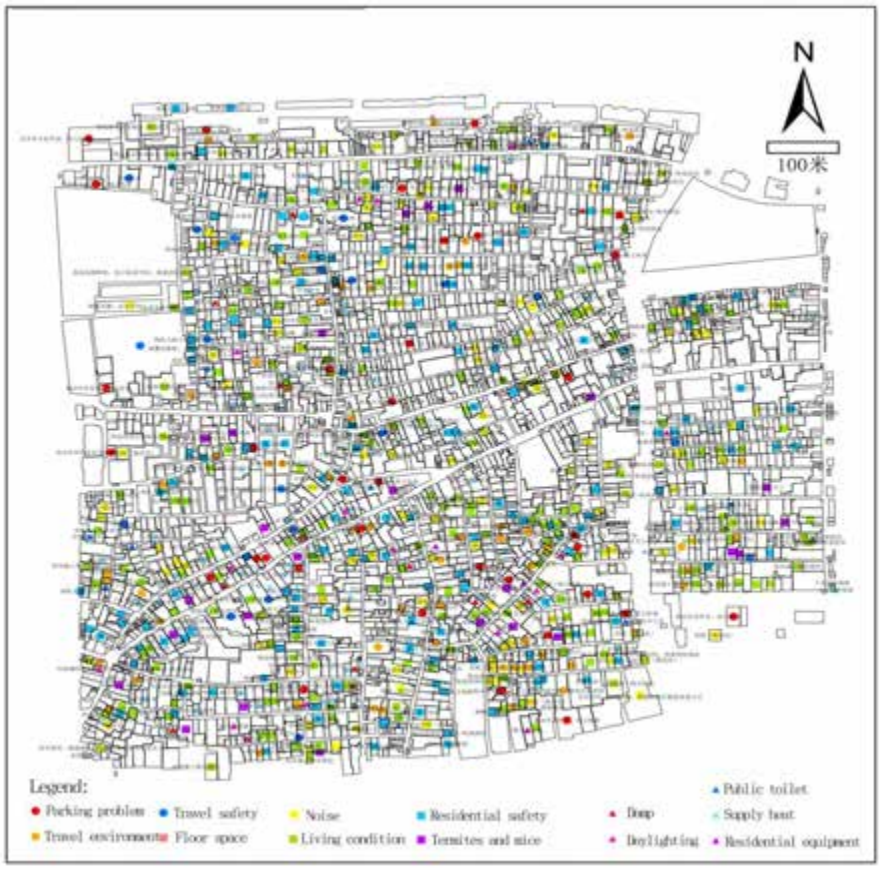

Fig. 8 Distribution of views of the people

4. Suggestions for improving the living quality of Dazhalan Historical and Cultural Quarter

4.1 Establishment of minimum occupancy standards for historic and cultural districts

Due to the lack of minimum living standards for historic and cultural block the minimum standards for ordinary urban housing in various countries were used for the assessment.However, it should be noted that housing in historic and cultural block has a unique historical background, spatial texture and structure, so the minimum living standards for historic and cultural block should be formulated by taking into account the special spatial form of the housing in historic and cultural block, the housing stock, as well as the human body size, activity characteristics and family structure of the inhabitants.Based on the current per capita housing situation, housing stock, spatial form of Dashilan, as well as the family structure and needs of the residents, this study initially proposes the minimum living space standards in Table 4, taking bedrooms, kitchens, bathrooms (including toilets and baths), and storage spaces as the mandatory basic functional spaces.

Table 4: Minimum living space standards for Dashilan

Family size (persons)	Bedroom area (m²)	Kitchen area (m²)	Toilet area (m²)	Storage space area (m²)	Area per capita (m²)
1	4.5	2.5	2	1	10
2	10	2.5	2	1.5	8
3	15.6	3	2.4	1.5	7.5
4	21.9	3.7	2.4	2	7.5
5	28.6	3.7	3.2	2	7.5

4.2 Housing survey and supervision

A survey on the current status of housing per capita is conducted every 2 years based on the minimum living

standards, including spatial size, basic functional space, building performance and basic equipment, living environment, and housing opinions and needs.At the same time, a survey of vacant housing is conducted once a year.Residents and social organisations are allowed to assess the current housing situation on their own, as well as to conduct surveys of vacant houses.

The minimum living standards will be used as the basis for the vacating of housing in historic and cultural districts (including application for rent refund, application for rent exchange, and application for improvement). For example, in the case of application for rent exchange, 3 categories of families will be divided into those who are far below the minimum standards, those who happen to meet the minimum standards, and those who are far above the minimum standards, and a differentiated housing area subsidy policy will be formulated; in the case of application-based improvements, reference is made to Hong Kong's public housing allocation system, with priority given to improving the living conditions of households below the minimum standard and those belonging to disadvantaged groups, and mandatory relocation is made for households that seriously fall below the standard.

Use the minimum standard of accommodation as the basis for tenancy management, prohibit the renting of housing below the minimum standard, and impose administrative penalties or fines on landlords who rent out housing in violation of the regulations.

4.3 Dynamic database platform construction

Using GIS to build a dynamic database platform for different subjects to use together. Overlay the spatial mapping map, census information, housing survey information, etc., and build a street-lane-courtyard-house-people database platform. The street office and the responsible planner are responsible for regularly updating the database platform, dynamically monitoring, scientifically planning and accurately managing, and quantitatively evaluating the per capita housing situation in Dashilan for a long time, so as to realize "one base map" and promote the improvement of living quality.

4.4 Sustainable updating mechanism

The Government is playing a leading role in upgrading residential quality, and is constantly improving the mode of public participation, implementing updates that reflect public opinion and respond to people's livelihoods, and integrating "top-down" and "bottom-up" approaches.The Government will also insist on population depopulation, while at the same time resolving the problem of "separation of people and households", optimising the age structure of the neighbourhoods, and introducing excellent industrial resources such as high-end cultural and creative industries, scientific and technological innovations, residence and tourism, so as to enhance the economic vitality of the block.Promote the revival of Dashilan's history, culture and common people's spirit, and promote the "cultural industry in the community" and "cultural activities in life" mode of block renewal.

5. Conclusion

This study systematically collates the experience of the UK, Japan and Hong Kong, China in improving living quality, and finds that they are all based on bottom-line thinking, and improve living quality by setting minimum living standards, housing surveys, paying attention to the disadvantaged groups of people living in the area, and making effective use of vacant housing.Based on this, we also collated the minimum living standards of various countries and assessed the current per capita housing situation in Dashilan, and found that there is still a big gap between the per capita housing level and the international minimum standards, and then put forward 4 aspects of enhancement suggestions.

This study hopes to reveal the housing problems that exist in Beijing's historical and cultural blocks by assessing the current per capita housing situation in Dashilan, a typical historical and cultural block, and suggests that a minimum housing standard should be guaranteed through housing surveys and regulation based on minimum living standards.The limitation of this study is that it only focuses on the housing problems that exist in the actual physical space, and does not explore the housing problems that exist in the areas where the government has

introduced the "housing vacate" policy and the "symbiotic courtyard" and "translocation courtyard" policies, and we should further explore the fundamental demands behind the residents' apparent discourse in the future.

Note

①All the areas in the text are the actual use areas calculated according to the horizontal projection lines of the walls inside the house.
②The pictures in the text are all drawn by the author
③Tables 1-3 are sequentially derived from the literature (GOV.UK,2022), (Housingauthority,2021), (Zhao, J., Xiong, W. and Rong, Q.,2024)

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An Assessment on Provincial Differentiation of Housing Problem in the Turkish Case

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Abstract
Housing has emerged as a prominent urban problem in Türkiye during recent decades. Despite its quantitative overproduction, homeownership percentages have significantly decreased from 2002 to 2025, especially among low- and middle-income groups. This decrease turns the housing problem into a near-crisis situation. Most studies focus on this problem at the national level and overlook provincial differentiations. This study addresses one dimension of this gap by analysing the provincial distributions of residential ownership status profiles. By using hierarchical cluster analysis, it identifies spatially differentiated profiles across Türkiye. Contrary to expectations, the analysis reveals that "higher socio-economic development often correlates with lower homeownership". The study argues for reformulating housing policy through flexible, context-dependent, province-level strategies rather than national approaches.

Keywords: housing problem; residential ownership status; socio-economic development; provincial differentiation

1. Introduction

Apart from being a shelter, housing has many different functions. It serves socio-cultural functions to perpetuate social relations and to reproduce the urban environment, while concurrently it has economic functions as a product, a consumer good, an investment tool for appropriating speculative value increases, and a financial security tool, especially in economic crises (Tekeli, 2010). Since these functions, particularly socio-cultural ones, have diverse influences on the physical and psychological well-being of individuals, housing emerges as a critical topic in the realm of human rights.

Following World War II, the right to housing gained legal and international recognition as a part of social and economic rights. As it is declared in the Universal Declaration of Human Rights (Article 25/1), "[e]veryone has the right to a standard of living adequate for the health and well-being of himself and of his family..." (UN, 1948). This standard of living not only includes food, clothing, medical care, and other necessary social services but also housing.

Housing as a fundamental component of cities is crucial for individuals since it influences nearly every aspect of daily life. It not only protects individuals from the undesirable effects of the environment but also provides a private space to achieve a sense of privacy. Safe and stable housing enables the reproduction of different social relations and encourages stronger social networks and community involvement, while frequent relocations or housing insecurity can disrupt relationships, routines, and sense of belonging. Housing expenditures, whether in the form of rent or mortgage, frequently constitute the largest household expenses. These high costs can limit expenditures on other necessities, such as food, healthcare or education, leading to economic strain. Adequate housing provides a safe, clean environment that fosters both physical and psychological health, whereas poor conditions can lead to stress, illness, and long-term health problems. Furthermore, its location affects not only access to essential services such as education, employment, healthcare, and public transportation, thereby influencing life opportunities, but also daily routines, including commuting time, which in turn impacts overall quality of life.

Due to this foundational role, the housing problem, which encompasses any obstacle hindering individuals from accessing safe, affordable, and adequate housing, has always been a significant priority on national agendas. The objectives to deal with this problem are similar: to produce sufficient housing for the increasing populations, to ensure equal opportunities for various socio-economic groups in accessing housing, and to offer a diverse range of housing options that meet different needs (Alkan and Uğurlar, 2015:5). Since varying development levels

and socio-economic structures differentiate the level of housing problems from country to country, countries are expected to formulate their own context-dependent strategies by approaching the housing problem, taking their unique circumstances into account.

These context-dependent strategies should commence with the (re)definition of the housing problem. This study is such an attempt to redefine the housing problem in Türkiye by taking into account the provincial differences in residential ownership statuses. There are, actually, numerous studies examining housing problems in the Turkish context. Some of these studies have regional or provincial concerns, although they are not interested in residential ownership statuses. Conversely, the other studies focusing on residential ownership statuses mostly consider this problem at the national level without questioning regional or provincial differentiations. The first group of studies misses one of the basic dimensions of the housing problem, while the choices of the second group create an illusion as if the housing problem is the same everywhere and the high level of socio-economic heterogeneity at the national level is not reflected in the housing problem. To overcome these problems, this study aims to analyse provincial differentiations of residential ownership statuses and reveal whether their spatial repercussions are similar in developed and underdeveloped parts of Türkiye.

The study has three sections following the introduction. The second section first discusses the historical development of the housing problem in Türkiye. In the second part of this section, there is a general and quantitative description of the recent housing problem. With this description, it becomes possible to present different dimensions of the housing problem. The third section consists of two parts that focus on analysis. In the first part, there is a hierarchical cluster analysis of the residential ownership status profiles in each province. This analysis generates clusters of provinces based on the similarities in their profiles. This part concludes with a visualisation of the clusters using cartographic resources. In the second part, these clusters are simultaneously evaluated with the socio-economic development levels of provinces to ascertain whether there are spatial correlations between residential ownership statuses and those development levels. Assuming that the national housing policies are predominantly inefficient, the fourth and last section discusses the basic aspects of a housing policy that takes into account provincial differentiations.

2. A General and Quantitative Description of the Housing Problem in Türkiye

Housing has always been one of the significant urban problems in Türkiye. This problem has existed since the early Republican period. It possesses, however, distinct characters across different periods.

In the early Republican period, the housing problem was not very severe. During this period, Türkiye was mainly an agrarian society with a markedly low rate of urbanisation. Due to the low levels of demand for urban land, its speculative value was not very high, leading to significantly reduced housing production costs. Under these circumstances, local authorities had the opportunity to provide affordable urban land for urban development where individuals can construct their residences (Tekeli, 1982).

After World War II, urbanisation increased significantly. This rapid urbanisation triggered not only an increase in the housing demand but also a decrease in the amount of suitable land for residential development, hence raising urban land prices. Considering these changes, self-housing could not become a viable option for middle- and low-income groups anymore. Housing cooperatives appeared as an alternative for housing production for middle-income groups. Two laws, Law No: 634 on Condominiums, enacted in 1965, and Law No: 775 on Squatters, enacted in 1966, facilitated the production of housing through cooperatives (Özkan, 2009). Low-income groups, on the other hand, started to produce informal housing (Alkan and Uğurlar, 2015), in the form of either squatter units or shared title deed residential units.

In the 1980s, liberal macroeconomic policies and open market conditions began to exacerbate the housing problem in Türkiye (Alkan and Uğurlar, 2015). The central government established the Mass Housing Development Administration in 1984 to assist housing cooperatives. In the 1990s, however, the Housing Development Administration was compelled to limit the budget for cooperatives because the budget designated for mass housing

was reduced. These financial problems led to a decrease in the number of housing cooperatives (Özkan, 2009).

During the 2000s, the high market interest rates and consequently the increasing cost of establishing housing cooperatives became the main reason why these cooperatives started to lose their importance. Another reason is the emergence of profit-driven and speculative housing production for middle- and low-income groups (Özkan, 2009). Nonetheless, they are limited in numbers. This phenomenon explains why rental housing emerged as the main reply to housing problems for these income groups. However, the central and local governments have not prioritised the provision of rental social housing (Balamir, 1999), and their limited attempts to regulate rents have proven ineffective in addressing excessively high housing rents.

Since the early Republican period, the primary approach to addressing the housing problem encompasses two dimensions: increasing housing supply with different types of housing supply models and enhancing homeownership rates.

In the first dimension, namely the intention to increase the housing supply, Türkiye demonstrated a notable increase. Quantitatively, there has been an overproduction of legal housing. Concerning illegal housing, the overproduction of housing may be anticipated to be considerably greater. Due to an excess in housing production, approximately half of the households live in relatively new residential buildings constructed since 2001 (TUIK, 2021). According to Alkan (2015), the amount of housing production is approximately two times bigger than the actual needs in years 2011 and 2012; yet it became three times bigger in years 2013 and 14. Türel and Koç (2015) have similar statements about the overproduction of housing in Türkiye, and they assert that the reason for this overproduction is the limited control over the housing sector. However, since this overproduction is only for high-income groups, it could not be a comprehensive solution to the housing problem.

The second dimension focuses on the intention to enhance homeownership rates. Despite the overproduction of housing, homeownership rates, especially for low-income groups, have been steadily declining. The cause of this decline is not only the inadequacy of their capital for housing but also their restricted access to financial credit supports (Türel, 1996). This reduction has been very pronounced over the past two decades. From 2002 to 2023, the homeownership rate in Türkiye has decreased from 73.1% to 56.2% (Gökçe, 2024:141). According to the Survey on Building and Dwelling Characteristics, the decrease in the homeownership rates is slightly less, 60.7% in 2021 (TUIK, 2021). Although there is no consensus on the exact numbers, these decreases become noteworthy when the increase in the population and the decline in the average household sizes are considered. Namely, between the years 2002 and 2023, the overall population of Türkiye increased by 27.3% (UNPD, 2024), while the average household size dropped from 4.16 to 3.14 individuals (Yükseler, 2004; TUIK, 2023). This means that the number of households had increased from 16,117,788 to 27,188,655 in the same period. Evaluating all these numbers concurrently, it becomes possible to state the number of homeowners increased by approximately 3,500,000, while non-homeowners increased by approximately 7,500,000.

The quantitative changes have adversely affected individuals, especially low-income groups, as indicated by numerous research studies (Bayraktar and Yılmaz Bakır, 2019; Alkay and Övenç, 2019). The overall homeownership rate has decreased from 61.1% to 56.1% due to the gradual increase in housing prices between 2014 and 2024. This decrease is not uniform across all income groups. The homeownership rate among high-income groups has decreased from 65.4% to 61.4% in the same period. For middle-income groups, the change has been from 58.6% to 56.3%. Although the decreases are 4.0% and 2.3%, respectively, low-income groups have declined by 12.0%, from 57.8% to 45.8% (10Haber, 2025). The data clearly indicates that the housing problem in Türkiye is intensifying. This housing problem progressively moves towards a near-crisis situation due to the persistent rises in the cost of housing construction and prices, drastic decreases in purchasing power, and significant reductions in mortgage accessibility.

3. Provincial Analysis of the Housing Problem: Focus on Homeownership Rates

As previously stated, there have been significant decreases in homeownership rates in Türkiye during the past two decades, prompting numerous studies. These studies, however, are very general and draw deductions mostly at the national level, which fails to elucidate the spatial differentiations of homeownership.

This does not imply the absence of housing studies at regional or provincial levels. There are a limited number of such studies in the Turkish context. One of those limited studies focuses on both the changes in construction costs and housing price index in seven Turkish metropolitan cities and housing affordability in NUTS1 regions (Alkay and Övenç, 2019). Another study analyses the relationship between housing prices and inflation in seven selected NUTS2 regions (Teke İlhan and Gökçe, 2023). The last study concentrates on clustering the provinces with reference to the similarities in housing demand (Akay, Çelik and Kıral, 2019). While these studies assess regional and provincial differences and similarities in housing regarding certain aspects, they neglect to address residential ownership statuses. The studies concerning homeownership, conversely, do not consider their regional or provincial differentiations (Aydın, 2019).

This study aims to bridge this research gap in the Turkish context. It distinguishes itself by offering a spatialised understanding of homeownership in Türkiye, demonstrating that considering housing problem at the national level obscures critical provincial differentiation. This spatial insight is considered a starting point for effective housing policy formulation. In this framework, the study first analyses the provincial differences in residential ownership statuses and then co-evaluates these findings alongside the socio-economic development levels of Turkish provinces.

3.1. Provincial Differentiations of Residential Ownership Statuses

Studying residential ownership statuses spatially in Türkiye is challenging due to data limitations. The 2021 Survey on Building and Dwelling Characteristics conducted by the Turkish Statistical Institute enables, however, studying them at the provincial level. The survey provides a cross-tabulation of four residential ownership statuses, namely homeowners, tenants, others[1], and unknown, for each province. This cross-tabulation delineates distinct profiles of residential ownership statuses for each province. However, cluster analysis can detect the similarities and differences among these profiles.

Cluster analysis is an exploratory statistical method that forms groups according to similarities in the characteristics of multivariate data (Härdle and Simar, 2003; Jobson, 1992; Gore, 2000). Hierarchical cluster analysis is one of the most advantageous methods in cluster analysis, as it does not require presumptions regarding the number of clusters (Sharma, 1996). There are different types of hierarchical cluster analysis, including single linkage (nearest neighbour), centroid clustering, and Ward's method, which differ from each other in the linkage criteria they use. This study employs Ward's Method due to its suitability for spatial analysis (Levent, 2007).

The dendrogram (Figure 1) created using Ward's Method in IBM SPSS Statistics Version 23[2] shows that there are four groups based on how similar the residential ownership statuses are (Table 1).

In the first cluster (C1), the average percentage of homeowners is 64.8%, above the national average by 4.1%. The cumulative percentage of homeowners and others[3], who do have similar ways of approaching housing, is 75.7%.

1 There are two groups of individuals within the "others" category. The first group comprises those occupying lodging houses owned by the state, municipalities, or companies. These individuals mostly do not pay housing rents, or very limited housing rents below market rates. The second group comprises those occupying mother's/father's houses, houses owned by relatives/friends, caretaker's residential units, waqf houses, or disaster houses, all of whom do not incur rental expenditures.

2 Square Euclidean distance is used as the measure by applying Ward's Method.

3 Homeowners and others are evaluated together, as their percentages exhibit significant parallelism across all clusters. In clusters with a high percentage of homeowners, there is also a high percentage of others, or vice versa. The reason for this parallelism is the similarity between homeowners and others who typically do not incur rent or have minimal housing expenditures akin to homeowners. Since these expenditures account for limited shares of their consumption expenditures, they do not generate

Conversely, the average percentage of tenants in this cluster is 22.2 %, the lowest among the other clusters.

The second cluster (C2) has a character similar to the first cluster (C1). The average percentages of homeowners and others in the second cluster exceed national averages, while the average percentage of tenants is below those averages. Nonetheless, the deviations from the national average percentages are not as pronounced as those in the first cluster (C1). Moreover, the cumulative percentage of homeowners and the others in this second cluster (C2) is 72.4%, slightly lower than the cumulative of the first cluster (C1).

The third cluster (C3) comprises solely two provinces, namely, Ankara and İzmir. They are the second and third biggest and most developed provinces in Türkiye. The average percentages of homeowners and others are, respectively, 60.1% and 8.3%. In this third cluster (C3), the average percentage of homeowners is slightly lower than in the clusters (C1 and C2), while the average percentage of tenants is somewhat higher than the national average. The cumulative percentage of homeowners and the others is also lower than the one at the national level. The percentage of the unknown category is the lowest in this category[4].

The fourth cluster (C4) only includes İstanbul, and it has fundamentally a similar profile to the third cluster (C3). Nevertheless, the percentages of homeowners and others are lower, while the percentage of tenants is much higher compared to the third cluster (C3). The size of the province likely explains why only one province forms a cluster in the dendrogram. Approximately 16.3% of all homeowners in Türkiye reside in this province.

Mapping these clusters on a provincial map illustrates the provinces with high and low percentages of homeowners, tenants, and others (Figure 2). As mentioned before, the biggest cluster (C1) has 55 provinces, predominantly medium-size and small provinces. These provinces are located in the Inner Anatolian, Eastern Anatolian, and South-eastern Anatolian regions and in the eastern parts of the Aegean region. The second cluster (C2) includes 23 provinces, most of which are coastal provinces. The eight provinces in the Black Sea regions can be regarded as exceptions. Instead of these eight coastal provinces, this cluster includes eight inland provinces, namely Denizli, Eskişehir, Konya, Kayseri, Kahramanmaraş, Gaziantep, Şanlıurfa, and Diyarbakır, where provinces are governed by the metropolitan municipalities. What is intriguing is that this cluster (C2) includes only the provinces with metropolitan municipalities. There are only four provinces with metropolitan municipalities outside this cluster, namely Erzurum, Malatya, Van, and Mardin, located in the Eastern and South-eastern Anatolian regions. There are two clusters (C4 and C3) where average percentages of homeowners are less than the national average percentage. Actually, there are only three provinces, namely İstanbul, Ankara, and İzmir, in these two clusters; yet, they contain approximately 32.1% of all residences.

budgetary problems for them. Consequently, others are similar to homeowners more than the tenants, although they do not own a house.

4 Within these clusters, the unknown category is different than the other categories. The percentages in the clusters are comparatively low; thus, it can be deemed a somewhat ineffective category in generating the clusters. Additionally, the average percentages of this category fluctuate in clusters. The average percentages are below the national average in the first cluster (C1) and the third cluster (C3). It is exactly the same in the second cluster (C2). In the fourth cluster (C4), however, the average percentage of the unknown category is more than the national average percentage. These explain the exclusion of the unknown category from the evaluations.

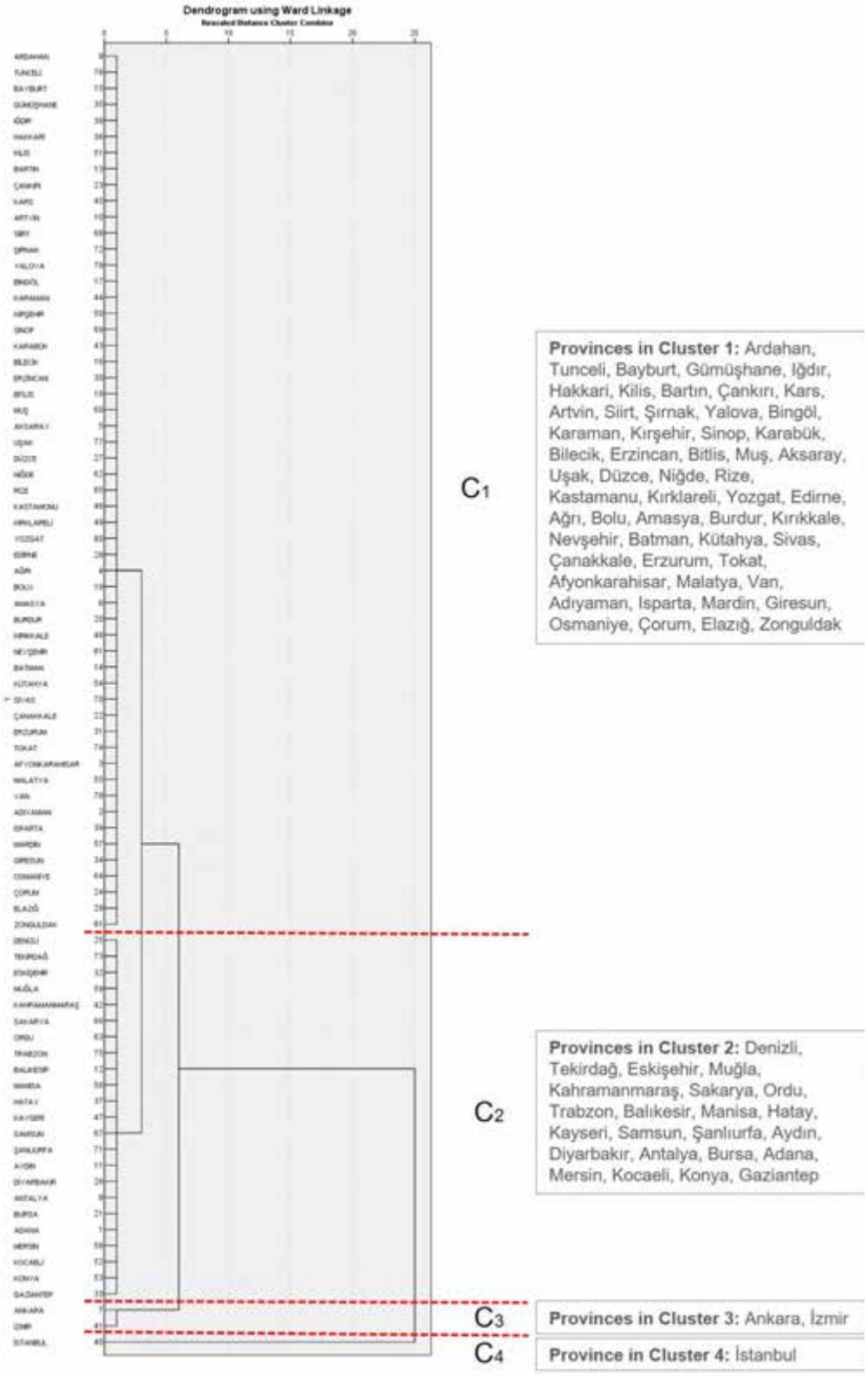

Figure 1. Dendrogram presenting the Clusters of the Residential Ownership Status Profiles

Table 1. Cluster Profiles of Residential Ownership Statuses

Clusters		Homeowners	Tenants	Others	Unknown
C1	Percentage (%)	64.8	22.2	10.9	2.2
	Total (55 provinces)	4,168,838	1,410,546	687,455	136,400
	Average	75,797	25,646	12,499	2,480
C2	Percentage (%)	62.7	25.3	9.7	2.3
	Total (23 provinces)	6,682,231	2,806,643	1,055,612	249,845
	Average	290,532	122,028	45,896	10,863
C3	Percentage (%)	60.1	29.9	8.3	1.8
	Total (2 provinces)	2,032,271	1,010,792	27,5416	58,700
	Average	1,016,136	505,396	137,708	29,350
C4	Percentage (%)	52.6	37.1	7.5	2.8
	Total (1 province)	2,501,473	1,763,740	356,488	133,385
Türkiye	Percentage (%)	60.7	27.6	9.4	2.3
	Total	15,384,812	6,991,720	2,374,972	578,329
	Average (81 provinces)	189,936	86,318	29,321	7,140

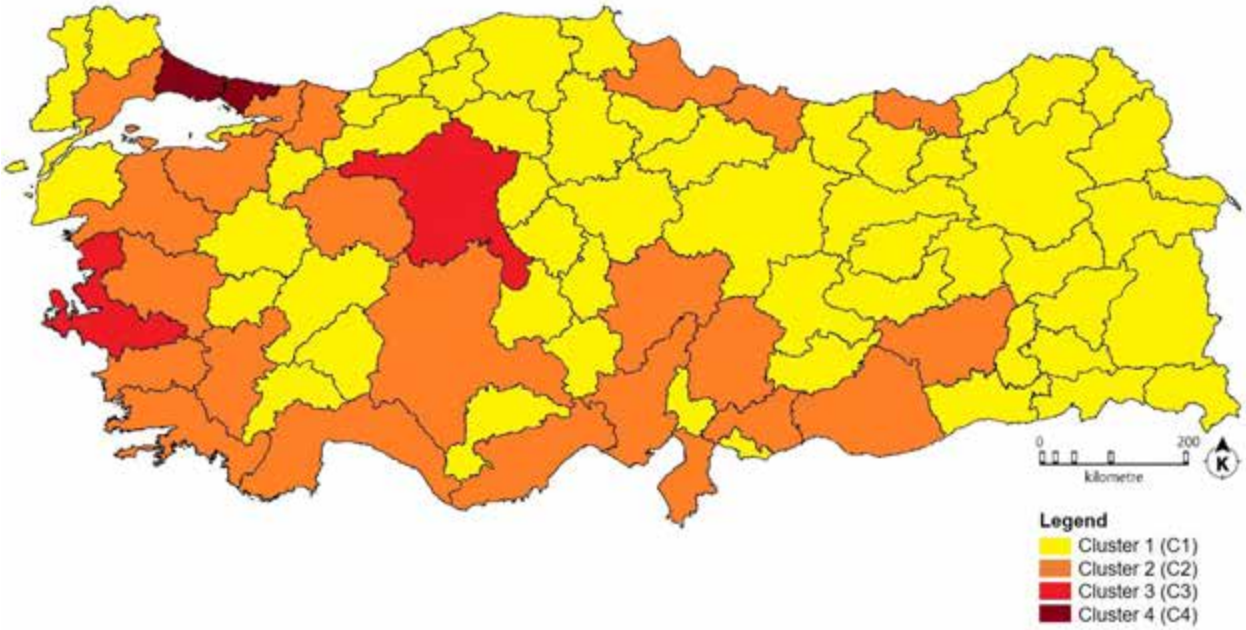

Figure 2. Provincial Differentiation of the Profiles of Residential Ownership Statuses

3.2. The Relationships Between Residential Ownership Statuses and Socio-Economic Development Levels

The provincial distribution of similar profiles of the residential ownership statuses provides a spatial description concerning the housing problem. To better understand this distribution and generate further explanation, it should be co-evaluated with different domains such as population dynamics, environmental risks, and infrastructural capacity. The socio-economic development levels of provinces are one of those domains, and this study proceeds with it.

The official study on socio-economic development levels is the Study on Socio-Economic Development Ranking of Provinces and Regions (SEDI-2017), which was conducted by the Ministry of Industry and Technology in 2019. Based on the official data from 2017, the study measures the relative development levels of all provinces across Türkiye. The data used in the preparation of this study is classified as demography, employment, education, health, competitiveness, innovative capacity, finance, accessibility, and quality of life variables (Sanayi ve Teknoloji Bakanlığı, 2019). The study is not only for identifying regional disparities but also for defining an information base for regional planning studies and public investment allocation. The output of the study is the socio-economic development ranking of provinces, which can also be represented spatially (Figure 3).

According to this map, there is a clear east-west divide in Türkiye. The eastern part of Türkiye is underdeveloped, while the western part is comparatively developed. Nonetheless, this split is not a pure divide. In the eastern part, there are four developed provinces, namely Samsun, Trabzon, Rize, and Gaziantep. The first three provinces are in the Black Sea region, while Gaziantep is located in the South-eastern Anatolia region. Similarly, there is one underdeveloped province, Afyonkarahisar, located in the western part of Türkiye.

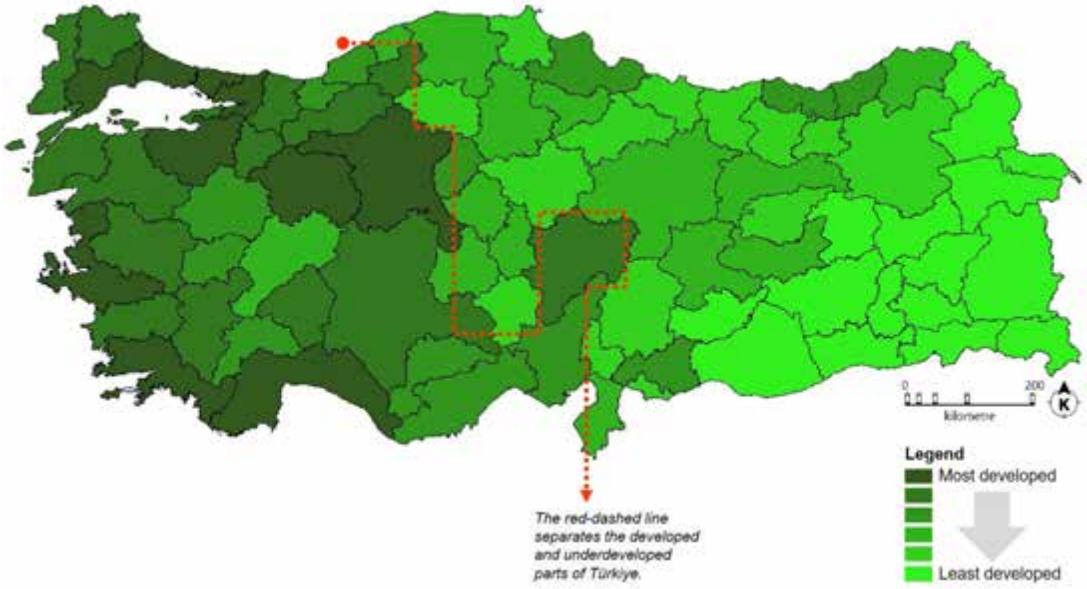

Figure 3. The Socio-Economic Development Levels of Turkish Provinces (SEDI-2017)

When the clusters are co-evaluated with the west-east divide, it can be easily stated that the majority of provinces of the first cluster (C1) are mainly in the underdeveloped part of Türkiye (39 out of 55 provinces). This cluster possesses the lowest average score calculated for the socio-economic development rankings of provinces, namely -0.360. In this cluster, however, the percentages of the homeowners and the others are relatively high. The results show that the percentage of homeowners in the underdeveloped part Türkiye is higher than expected. On the contrary, approximately 65.2 % of the provinces of the second cluster (C2) are in the developed part of Türkiye. For this cluster, the average score calculated for the socio-economic development rankings of provinces is 0.483, which is comparatively high relative to the overall score. What makes this cluster intriguing is that the percentages of homeownership in its provinces are slightly higher, although these provinces are mostly in the developed part of Türkiye. The remaining clusters (C3 and C4) encompass the most developed provinces; yet, the

percentages of homeowners are significantly low, while those of tenants are high (Table 2).

Table 2. Relationships Between Clusters and Socio-Economic Development

Cluster	Provinces in the Developed Part (n)	Provinces in the Underdeveloped Part (n)	Total Number of Provinces (n)	Average Scores for the Socio-Economic Development Rankings
C1	16	39	55	-0.360
C2	15	8	23	0.483
C3	2	-	2	2.322
C4	1	-	1	4.051
Türkiye	**34**	**47**	**81**	**0.002**

There are three basic findings of the co-evaluation of residential ownership statuses and the socio-economic development levels of provinces.

Firstly, there is a negative correlation between socio-economic development levels and the number of homeowners and a positive correlation between socio-economic development levels and the number of tenants. The higher the positions in the socio-economic development ranking, the lower the percentages of homeownerships. This negative correlation makes housing primarily a problem for developed provinces in Türkiye.

The second finding is another negative correlation between the number of residences and the number of homeowners. Despite the substantial quantity of residences in big metropolitan cities, the percentage of homeowners remains comparatively low. This negative correlation demonstrates that an increase in housing supply does not correspond to an increase in homeownership percentages.

The third finding is the exceptional areas in the synthesis map (Figure 4). These exceptional areas can be classified into two categories: the provinces in the developed part of Türkiye that are similar to the provinces in the underdeveloped part of Türkiye and the provinces in the underdeveloped part of Türkiye that are similar to the provinces in the developed part of Türkiye.

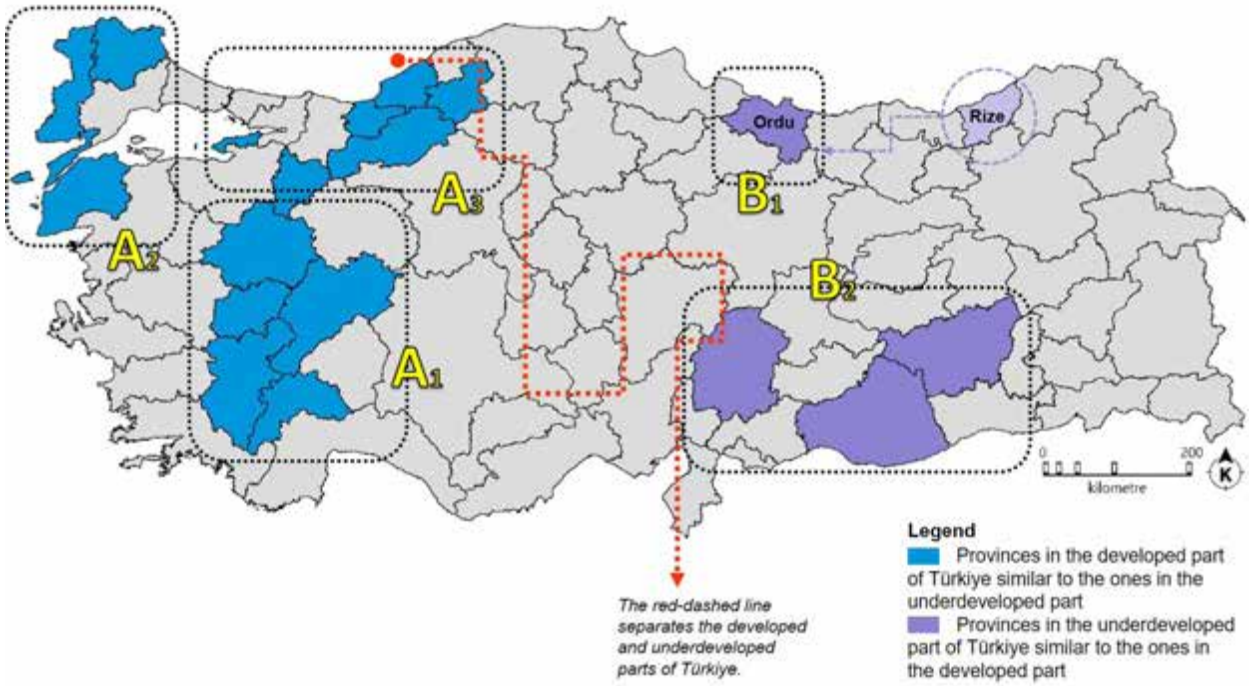

Figure 4. The Synthesis Map

The first category consists of three groups. The first group (A1) contains five provinces from the eastern part of the Aegean region and the northern part of the Mediterranean region, namely, Kütahya, Uşak, Afyonkarahisar, Isparta, and Burdur provinces. Afyonkarahisar province is in the fourth socio-economic development rank and is the least developed province in the western part of Türkiye. Its socio-economic development score is less than the overall average of Türkiye. This group has an average socio-economic development score of 0.240 but an average percentage of homeowners of 65.8%. The second group (A2) contains the Kırklareli, Edirne, and Çanakkale provinces in the north-western part of Türkiye. Although they are in the second socio-economic development rank and have an average socio-economic development score of 0.546 (higher than the average of the second cluster in Table 1), their average percentage of homeowners is 65.7% (higher than the average of the second cluster in Table 1). In short, this group includes well-developed provinces with high homeownership percentages. The third group (A3) is located in the western parts of the Marmara region and contains the Zonguldak, Karabük, Düzce, Bolu, Yalova, and Bilecik provinces. These provinces belong to either the second or the third socio-economic development ranks, with an average socio-economic development score of 0.526 and an average percentage of homeowners of 63.0%.

The second category includes the provinces in the underdeveloped part of Türkiye that resemble those in the developed part of Türkiye. Such a pattern with Samsun, Trabzon, Rize, and Gaziantep provinces exists on the map of socio-economic development levels, as explained before. Within the synthesis map, while the Rize province is excluded, the Ordu (B1), Kahramanmaraş, Şanlıurfa, and Diyarbakır provinces (B2) are included. It seems as if the Ordu province appears instead of Rize province. While the former one has a metropolitan municipality, the latter one does not. The Kahramanmaraş, Şanlıurfa, and Diyarbakır provinces are all located in the South-eastern Anatolian region. Once again, the provinces have metropolitan municipalities.

4. Conclusion

This study has aimed to understand provincial differentiation of the housing problem in Türkiye by co-evaluating the residential ownership statuses and the socio-economic development levels of provinces.

There are several limitations that emerged during the course of this study. First, the data on residential owner-

ship statuses vary across different studies, which creates inconsistencies in comparative analysis. This study utilises the official data provided by the 2021 Survey on Building and Dwelling Characteristics, which, while comprehensive, may not align with other data sources. Second, the socio-economic development data are drawn from the Study on Socio-Economic Development Ranking of Provinces and Regions (SEDI-2017), which, although the most recent available, is outdated and may not properly capture the existing socio-economic context. Third, the classification of provinces as developed and underdeveloped provinces is relatively simplistic and includes a few notable exceptions that are challenging to elucidate. Additionally, the study does not account for rural-urban distinctions within provinces, even though ownership patterns may significantly differ between these areas. The practice of averaging ownership percentages and socio-economic scores within clusters has the potential to blur internal variations and lead to overgeneralised conclusions. Finally, although housing ownership statuses can be meaningfully evaluated through various provincial lenses such as population dynamics, environmental risks, or infrastructural capacity, this study limits its scope to socio-economic development levels, which narrows the range of contextual factors considered in the analysis.

Despite the number of these limitations, the findings of the study reveal a striking and counterintuitive pattern: higher socio-economic development often correlates with lower percentages of homeowners and higher percentages of tenants. This negative correlation challenges the conventional belief in the domain of housing that economic development naturally leads to improved homeownership rates. Furthermore, the findings indicate that an increase in housing supply, especially in metropolitan areas, does not automatically lead to increased homeownership, particularly among low-income groups.

One of the fundamental dimensions of Türkiye's housing problem is the significant inequality in access to housing across different income groups. While the national policy framework has succeeded in achieving a quantitative increase in housing production, this production has disproportionately served high- and middle-income groups. The most disadvantaged individuals, namely low-income groups, encounter growing exclusion from homeownership due to high mortgage rates, limited savings, and the absence of sufficient rental support from the central and local authorities.

Except for the extraordinary post-earthquake situations, Türkiye has structured its housing policy as a centralised framework. It mostly fails to accommodate the regional and provincial differentiations that may arise mainly with socio-economic development levels, population dynamics, environmental risks, and infrastructural capacity. This study focuses on the co-evaluation of the provincial differentiations of the residential ownership statuses and the socio-economic development levels of provinces. Such an evaluation assumes that the solution to the housing problem should be proposed not at the national level but at the provincial level, and housing policy should be reformulated through provincially differentiated lenses. This reformulation means a change of intention from rigid, national, and "one-size-fits-all" types of housing policies to flexible, provincial, and context-dependent strategies that are sensitive to local socio-economic realities.

The reformulation should start with a comprehensive assessment of provincial needs. With this assessment, it is possible to develop tailored housing strategies for special purposes. For instance, a province with high homeownership rates but insufficient housing stock may focus on supply-side interventions, whereas provinces with low homeownership rates may benefit from financing programmes for the availability of affordable housing for both the potential homeowners and tenants.

In sum, this study represents a minor attempt to develop a spatial understanding of the housing problem by focusing on the co-evaluation of residential ownership statuses and the socio-economic development levels of provinces. By acknowledging that its content is insufficient to comprehend the complex and multidimensional housing problem in Türkiye, it may inspire future studies that can integrate different domains such as environmental risk, urban-rural dynamics, and infrastructural capacity into this provincial lens. With the help of those studies, it becomes possible to effectively address the growing housing problem in Türkiye and develop a more holistic and equitable housing policy.

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The Social Reflections of Neoliberal Policies, Planning Legislation, and Housing in the Istanbul Metropolitan Area

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Abstract
This study aims to examine the social impacts of legal regulations introduced in Turkey's housing and planning legislation between 2002 and 2024, with a specific focus on Istanbul. Conducted in two stages based on document analysis and literature review, the research evaluates the legislative changes during this period and their social repercussions. The findings reveal that these regulations have led to consequences such as displacement, social fragmentation, loss of sense of belonging, gentrification, and the weakening of public interest. The study emphasizes the need to reconsider planning policies in light of the principles of spatial justice and social inclusivity.

Keywords: Neoliberal policies; social dimension of the planning legal framework; Istanbul Metropolitan Area.

Introduction

The 2000s marked a period in which neoliberal policies became spatially embedded in Turkey, leading to significant transformations in planning legislation and a restructuring of planning institutions. During this time, extensive legal arrangements were implemented to facilitate real estate investments, construction processes, and land supply in favor of market actors. Central institutions were granted considerable authority and resources, resulting in a centralization of the planning process. In particular, the establishment of the Ministry of Environment and Urbanization in 2011 further expanded the central government's planning powers while narrowing the jurisdiction of local authorities. The legislative changes in planning and the rapid increase in construction driven by growth strategies based on the construction sector have, rather than resolving economic, spatial, and social issues, exacerbated them—especially increasing the social costs for low-income groups and, after 2020, for segments of the middle class. These problems have manifested more severely in major cities such as Istanbul (Alkay, 2020; Balaban, 2012; Balaban, 2021; Çoban, 2012; Keleş, 2014; Şengül, 2009).

The aim of this study is to examine the social implications of legal reforms in planning legislation during the 2000s—a period when neoliberal policies were spatially institutionalized and the new government pursued a construction- and housing-oriented economic agenda—within the Istanbul Metropolitan Area. Structured in two stages based on document analysis, the study covers the 22-year period between 2002 and 2024. In the first stage, legislative reforms from 2002–2010 and 2010–2024 are examined in detail. In the second stage, the study analyzes the literature based on field research conducted in the Istanbul Metropolitan Area.

The modern city constitutes one of the primary arenas of conflict between the often contradictory interests of different social groups (Şengül, 2009). These divergent interests and objectives form the basis of socio-spatial transformation. As an extension of the construction sector—where such conflicting interests are highly concentrated—the housing sector has rapidly transformed urban space and continues to do so. The groups that suffer the most from this transformation compel a critical interrogation of the concept of urban justice. According to Soja (2009), the state plays a pivotal role in the realization of urban justice. Fainstein (2014) defines the just city through the principles of equity, democracy, and diversity. Lefebvre (2013) argues that prioritizing the exchange value of urban space over its use value constitutes the foundation of urban injustice and inequality. For Harvey (1973), the use value of housing lies in its ability to meet fundamental needs such as shelter, belonging, and security. In contrast, the exchange value of housing is determined not only by its basic production costs—such as materials and labor—but also by added elements like credit interest and land rent (Harvey, 1973). Moreover, housing can function as a status symbol, representing wealth and power, and thus carries a prestige value. Which of these values comes to the fore is determined by the political agenda; under contemporary neoliberal policies,

exchange and prestige values have gained prominence (Aslan, 2019). As a result, housing has increasingly been transformed from a basic need into an investment commodity driven by exchange value.

According to Castells, the city is a collective space of consumption, and spatial justice can be achieved when influential actors balance the production of housing and infrastructure. Additionally, social movements and equilibrium within society play critical roles in ensuring urban justice. The failure to establish such balance leads to social (e.g., lifestyle, ethnicity, race, religion), economic (e.g., income-based), and socio-spatial discrimination and exclusion (Şengül, 2009). This dynamic erodes interactions among different social groups, eventually severing already fragile social ties and exacerbating intergroup conflict in contemporary cities (Kurtuluş, 2005).

Harvey (1973) emphasizes that achieving social justice depends on the fair and equitable distribution of the surplus generated through cooperative production (Harvey, 1973; Giritlioğlu & Özden, 2020; Şengül, 2009). Within this framework, policies that prioritize the use value of housing emerge as crucial for fostering urban justice. This study aims to analyze whether the existing legal and institutional framework safeguards the right to housing for broad segments of society, and whether it encourages production models based on use value that can counter the commodification of housing as an investment object.

Changes in the Legal Planning Framework in Turkey during the 2000s

The 2000s represent a period of major transformation in Turkey's planning legislation and institutional structure (Alkay, 2020). During this time, the implementation of neoliberal policies and the new government's construction-driven economic agenda necessitated a strong public apparatus. The Housing Development Administration of Turkey (TOKİ), originally established in 1984 and later restructured as a more autonomous body in 1990, gained substantial power especially after a series of legal reforms introduced from 2003 onward (Oluğ, 2015).

To facilitate real estate and construction investments—particularly the supply of land in favor of market actors—comprehensive legislative changes were made to the planning framework. These reforms granted extensive authority and resources to central institutions, leading to a more centralized structure in the planning system (Balaban, 2012).

Period of 2000–2010

Following the 2001 economic crisis, the stock market collapsed, while interest rates, inflation, and unemployment increased. As a result, early general elections were held, and the 2002 elections resulted in a strong single-party government (Kapusızoğlu, 2011). Instead of pursuing a long-term policy to address the country's structural problems, the new government adopted a growth-oriented, construction-based policy. Due to its strong interlinkages with other sectors, the construction and housing sector was regarded as a driving force for rapid economic growth—a sort of growth engine (Balaban, 2021; Yeşilbağ, 2016). Within this framework, housing and construction investments, urban transformation, and the Housing Development Administration of Turkey (TOKİ) became prominent. In accordance with the Squatter Housing Law No. 775, planned land supply was implemented to eliminate unhealthy settlements and ensure orderly urbanization (Ataöv & Osmay, 2007; Şenyapılı, 2006). An Emergency Action Plan concerning urbanization was formulated, aiming to construct 250,000 housing units within the first five years, with a total of 500,000 units projected to begin construction by 2011. To accelerate housing and construction processes, the legal framework of planning and the structure of TOKİ were revised, granting TOKİ significant authority (Justice and Development Party, cited in Ulusoy, 2020).

Throughout this period, extensive deregulation efforts were undertaken to facilitate real estate and construction investments, including granting certain public institutions unlimited authority in planning (Balaban, 2012; Balaban, 2021; Alkay, 2020). There were 76 legal arrangements containing deregulation measures. The first group of these (26 out of 76) redistributed authority among state institutions for the preparation of land use and urban development plans. Specific institutions were authorized to prepare land use plans for designated areas. For example, Law No. 5398 of 2005 authorized the Privatization Administration to prepare zoning plans for state-owned properties included in the privatization program. Law No. 4957 of 2003 transferred the authority for urban

development plans in tourism regions from local governments to the Ministry of Culture and Tourism. Law No. 5162 of 2004 granted TOKİ the authority to prepare all types of plans on lands transferred to its ownership. These legal changes aimed to shift planning authority from local governments to central authorities to facilitate a faster planning process for investments.

The second group of legislative changes (17 out of 76) that eased the urban planning framework granted certain public institutions unlimited planning powers. For instance, the Ministry of Public Works and Settlement was authorized to prepare development plans without being bound by the rules and conditions of existing urban planning legislation. These measures aimed to bypass or simplify existing planning regulations and development controls for specific projects and investments.

The second form of deregulation involved legal arrangements concerning public lands and properties. A significant portion of these reforms aimed to facilitate the sale of public lands and properties for development projects or private investments. For example, Law No. 4916 of 2003 authorized the Minister of Finance to revoke the designation of public property and put it up for sale at any time (Balaban, 2011; Balaban, 2012; Balaban, 2021).

Law No. 5216 on Metropolitan Municipalities, enacted in 2004, abolished the concept of adjacent areas and expanded zoning plan boundaries. Amendments to the Land Office Law and the Mass Housing Law through Law No. 5273 (2004) allowed for the transfer of treasury lands to TOKİ without charge. The 2005 "General Regulation on the Production, Allocation, Leasing, and Sale of Land, Housing, and Workplaces by Municipalities" granted municipalities the authority to provide land and housing to meet housing needs. Under this regulation, municipalities were permitted to engage in joint projects and establish partnerships with TOKİ and other relevant public institutions (Uyanıker & Alkay, 2019).

In 2005, Law No. 5366 on the Preservation by Renovation and Use by Revitalization of Deteriorated Immovable Historical and Cultural Assets was enacted with the aim of preventing or eliminating urban decay in historically and culturally significant areas, and to meet the increasing demand for housing in parallel with population growth in cities. Urban transformation projects under this law were intended not only to preserve and revitalize historical and cultural assets, but also to create residential, commercial, and social infrastructure areas and to take measures against disasters. Article 3 of the law states that municipalities may carry out urban transformation projects in cooperation with TOKİ (Kaplan, 2017).

In parallel with international markets, demand for real estate and real estate investments increased significantly. In response to these developments, the Capital Markets Board of Turkey (CMB) officially introduced the definitions of "valuation expert" and "real estate valuation company" in 2001 through the communiqué titled "*Communiqué on the Principles Regarding Companies to Provide Real Estate Valuation Services within the Framework of Capital Markets Legislation and Their Listing by the Board.*" The enactment of Law No. 5582 in 2007, titled "*Law on Amendments to Various Laws Regarding the Housing Finance System,*" along with subsequent regulations by the CMB, institutionalized real estate valuation as a specialized profession (Büyükkaracığan, Altınışık & Uzun, 2017).

Real Estate Investment Trusts (REITs), which were initially introduced through legislation in 1995 as a means to bring transparency and address financing challenges in the real estate market, also evolved during this period under the regulatory authority of the CMB. The real estate sector's central role and macroeconomic conditions played a significant role in the development of REITs (Büyükkaracığan, Altınışık & Uzun, 2017). REITs became prominent actors in urban transformation processes due to their tax exemptions and financial advantages. Simultaneously, TOKİ (the Housing Development Administration of Turkey) strengthened its cooperation with the private sector by engaging in housing production through models such as "revenue sharing" and "land-for-flat" agreements with large construction firms (Bektaş, 2021).

However, the 2008–2009 mortgage crisis in the United States and related global financial turmoil also affected Turkey, leading to a decline in demand for real estate and a drop in property prices. To promote homeownership

among middle- and low-income households, Law No. 5582 on Housing Finance (Mortgage Law), enacted in 2007, introduced a system with favorable conditions—such as a 20% down payment and repayment periods extending up to 10 years—supported by low interest rates (Alkan, 2015; Alkay & Övenç, 2019; Büyükkaracığan, Altınışık & Uzun, 2017).

A key characteristic of the post-2001 crisis period was the central positioning of the construction and housing sector as a driver of economic growth. Housing production was supported through urban transformation and large-scale projects, and the planning system underwent significant deregulation to accelerate this process. The transfer of planning authority to central government institutions led to the marginalization of local governments in decision-making processes, contradicting the principles of democratic governance endorsed by the European Charter of Local Self-Government. Housing supply policies were shaped not according to local needs and priorities but through a technocratic approach, emphasizing economic growth and capital accumulation over the right to housing. As a result, the exchange value of housing was institutionally prioritized over its use value.

Post-2010 Period

With the Decree Laws No. 644 and 648 enacted in 2011, the Ministry of Environment and Urbanization was granted extensive authority, including:

- the preparation and implementation of physical plans of all types and scales;
- the ability to conduct, commission, and approve surveys, maps, zoning plans, and parceling plans and amendments for public lands and areas authorized by the Council of Ministers;
- the authority to issue building permits and occupancy permits ex officio in cases where local administrations fail to do so within two months from the application date;
- and the power to conduct, commission, approve, expropriate, and implement all types and scales of plans and projects within special project areas and those carried out by the Housing Development Administration (TOKİ), as well as to issue permits and establish condominium ownership.

These changes marked a significant centralization of planning authority and a reduction in the powers of local governments. The 2012 Law No. 6306 on the Transformation of Areas Under Disaster Risk enabled institutions and private actors to reintroduce plots located in built-up areas back into the market. TOKİ's responsibilities regarding urban transformation were considerably expanded, further aligning urban policy with a centralized governance model. Similarly, Law No. 6292 allowed for the registration of 2B forest lands, effectively increasing the amount of land available for housing production.

The merging of TOKİ with the Land Office and Emlak Konut and its incorporation into the Ministry of Environment and Urbanization through the 2018 Decree Law No. 703 significantly increased its institutional power and centralized structure. Although the stated aim of these legal and regulatory changes was to create a rapid planning system that considered market mechanisms and minimized planning-related financial burdens, the outcome has been a highly centralized, fragmented, hierarchical system marked by uncertainty and low institutional reliability. The planning system has evolved into one in which actors operate according to their economic and political power (Alkay, 2020; Giritlioğlu, 2022; Kuran, 2022; Uyanıker & Alkay, 2019).

This centralization has undermined the coherence of planning decisions. As authority was transferred to investment-oriented institutions, the overall control and coordination of planning processes diminished. The legal and institutional transformations between 2002 and 2024 and their concrete applications in the Istanbul Metropolitan Area are examined in this study through a review of empirical research in the literature, with attention to their social implications. Following the introduction of the Presidential Government System in 2018, the trend toward centralization in planning and housing policies intensified. The Ministry of Environment and Urbanization became directly affiliated with the Presidency, and its oversight and steering capacity over institutions such as TOKİ and Emlak Konut increased. Decision-making processes became less subject to institutional plurality and public oversight, concentrating power in the executive branch. This shift led to an urban policy framework that is increasingly detached from democratic participation and local needs. The post-2018 era can thus be

characterized as one in which technocratic planning approaches were institutionally reinforced and market-oriented mega-projects were prioritized (Alkay, 2020; Giritlioğlu, 2022; Kuran, 2022; Uyanıker & Alkay, 2019).

Taken together, these legal reforms and institutional transformations demonstrate that the planning system has been shaped more by market dynamics and centralized political authority than by social needs. The loss of local authority, the weakening of democratic accountability, and the delegation of planning to technocratic mechanisms have resulted in the exclusion of vulnerable and low-income groups from decision-making processes. Consequently, these developments have deepened inequalities in urban space, institutionalized spatial injustices, and caused severe issues in access to housing, property, and the right to the city—especially in metropolitan contexts such as Istanbul. In this regard, analyzing not only the legal framework introduced between 2002 and 2024 but also its exclusions and tangible manifestations in urban life is essential for understanding its broader societal implications (Alkay, 2020; Giritlioğlu, 2022; Kuran, 2022; Uyanıker & Alkay, 2019).

Societal Impacts of the Legal Reforms Implemented Between 2002 and 2024 in the Istanbul Metropolitan Area
In parallel with the legal regulations enacted after the year 2000, both the policies aimed at the provision of new housing and the interventions in existing residential areas have deepened the socio-spatial segregation among income groups in Istanbul. This process has led to the spatial fragmentation of different social groups within the city, the displacement of lower-income groups, and the acceleration of gentrification dynamics.

In parallel with the legal regulations introduced during this period, closed and secured housing projects, typically targeting middle- and upper-income groups, have further reinforced spatial segregation, while also restricting the use of public spaces and weakening social interaction within the city.

Urban Transformation Practices in Istanbul under Laws No. 775, 5366, and 6306
The Küçükçekmece Ayazma–Tepeüstü Urban Transformation Project, implemented between 2004 and 2007 under Law No. 775 on Slums through the cooperation of TOKİ and local governments, is one of the first examples in Istanbul where an informal settlement community was collectively displaced and resettled. This transformation process, which affected approximately 1,440 households and 7,800 individuals, not only involved a physical spatial intervention but also led to the dissolution of social fabric and transformation of everyday life practices. The community relocated to the housing units constructed by TOKİ in Bezirgânbahçe lost their networks of solidarity due to the spatial constraints and social isolation imposed by gated community life. Targeting a predominantly Kurdish population, this intervention revealed not only the economic but also the cultural and identity-based dimensions of urban transformation.

The process also significantly limited the displaced community's access to urban opportunities, particularly hindering the use of public space and sustainability of social life for women and children. Households relocated to a peripheral area with limited transportation options suffered substantial losses in their daily routines and economic activities. This situation demonstrates that displacement is not merely a change of physical space but also a rupture in social and cultural terms. Moreover, the community's exclusion from decision-making processes during the transformation highlights the technocratic implementation of the intervention, disregarding participatory planning principles (Tok and Oğuz, 2013; Uzunçarşılı Baysal, 2013; Waite, 2023).

Under Law No. 5366 on the Renewal, Protection, and Use of Deteriorated Historical and Cultural Real Properties, the Sulukule Urban Transformation Project, carried out through a TOKİ–local government partnership, drastically transformed the spatial, social, and cultural fabric of Sulukule—one of the oldest known Roma settlements in the world after India. The project triggered a gentrification process in the area inhabited by the Roma community, causing a rise in property values and rental prices, which made it impossible for existing residents to remain. According to the legal regulations, individual homeowners and tenants were offered housing units in TOKİ's Gaziosmanpaşa–Taşoluk site without down payment and with 180-month installments. However, low-income Roma households could neither afford the monthly payments nor cover the maintenance costs of these units, leading to their inability to remain in the new housing.

In addition, due to incompatibility with apartment living and the peripheral location of the new settlement, many Roma residents returned to neighborhoods surrounding Sulukule. A significant portion of the newly built housing units in Sulukule was rented out to migrants who could afford the higher rents. During this process, Fatih Municipality's construction of a sliding iron gate to separate the transformed area from the remaining Roma-inhabited zone symbolically marked both physical and social segregation. Thus, the project is regarded as an institutionalized practice of spatial segregation and social exclusion (Fareghi Bavilolyaei and Ökem, 2018; Uçan Çubukçu, 2011; Uysal, 2012; Yalçıntan and Çavuşoğlu, 2009).

Similarly, under Law No. 5366, the Tarlabaşı Renewal Project was implemented with the support of the Ministry of Environment by the Istanbul Metropolitan Municipality and the Beyoğlu Municipality. The project aimed to transform the area into a new urban structure consisting of luxury housing, offices, shopping centers, cafés, and hotels through phased residential renewal (Kuyucu and Ünsal, 2010). The Tarlabaşı Renewal Project represents an intervention aimed at radically altering the existing socio-economic structure of the area. This transformation process led to the displacement of Roma, Kurdish, immigrant, and low-income groups, and the area was reimagined as a residential and touristic destination catering to higher-income groups. In this context, the project is considered a typical example of gentrification, reflecting the spatial exclusion of disadvantaged urban communities from the city center and the capital-driven revaluation of urban land (Sakızlıoğlu, 2020; Tsavdaroglou, 2020).

Under Law No. 6306 on the Transformation of Areas Under Disaster Risk, in the Tozkoparan Neighborhood—redeveloped in cooperation with the Ministry of Environment, Urbanization and Climate Change, Istanbul Metropolitan Municipality (IMM), and Güngören Municipality—the promise of "on-site transformation" could not be fulfilled. The high costs and payment conditions of the newly offered housing units made it impossible for low-income groups to continue living in the area. Throughout the process, objections raised by the beneficiaries and collective resistance from the local community brought the social legitimacy of urban transformation policies into question. Lawsuits and protests filed against the project revealed not only the physical but also the political and legal dimensions of the transformation. Furthermore, as in many other urban transformation projects, the expropriation processes were widely criticized for being arbitrary and lacking transparency (Çınar Erdüzgün and Çınar Yöreş, 2019; Duman and Coşkun, 2016).

Also under Law No. 6306, Fikirtepe was declared a "risky area" in 2013, and demolition began in 2014 through a partnership between the Ministry of Environment, Urbanization and Climate Change and TOKİ. The transformation process introduced an entirely new urban scenario, radically different from the area's existing physical, social, and economic structure. The planning approach adopted aimed to attract middle- and upper-income groups to the region and transform the area's previously negative image and low socio-spatial status. The Fikirtepe Urban Transformation Project, dominated by luxury and branded housing developments, aspires to offer a self-contained living environment where users can meet all their basic needs without leaving the project area. According to the Fikirtepe Regional Report by REIDIN, the average unit sales price, which was around 2,000 TL per square meter in 2005, exceeded 8,000 TL by 2017, while rental prices rose from 500 TL to 1,500 TL (Bülbül Akın and Türkün, 2019; Köseoğlu and Sönmez, 2022; Tarakçı, 2021; Uyanıker, 2020).

The examples discussed demonstrate that urban transformation policies are not limited to the physical reproduction of space but also lead to the dissolution of social fabrics, the deepening of identity-based divisions, and the erosion of spatial justice. A key commonality across these processes is the displacement of low-income and vulnerable communities to peripheral areas, thereby reproducing urban inequalities and poverty. Particularly in state-led projects, the use of legal instruments prioritizes market-driven rent extraction over the principle of public interest, revealing a contradiction between transformation processes and the principles of justice and participation. In this context, the displacement of squatter settlements, historic neighborhoods, and areas inhabited by disadvantaged groups under the guise of urban renewal can be interpreted as one of the most pronounced manifestations of neoliberal urbanization practices.

Other Regulatory Arrangements, Financial Instruments, Public-Private Partnerships, and Large-Scale Projects

Although the 2007 Housing Finance System Law No. 5582 (the Mortgage Law) was enacted to facilitate housing access for low- and middle-income groups, its implementation in Istanbul failed to deliver the expected social benefits. In theory, the mortgage system aimed to ease homeownership through low-interest, long-term loans. However, due to Istanbul's high housing prices and the required 20% down payment, low-income groups were largely unable to benefit from this system. Mortgage loans were predominantly utilized by high-income or at least upper-middle-income households. Housing increasingly became a form of "financial investment," where appreciation and profit potential outweighed the use value of the home.

Mortgage-based housing finance significantly increased household indebtedness and created economic vulnerability, particularly for the middle class. When analyzing the distribution of mortgage homeowners in Istanbul, it is evident that those taking out large loans were concentrated in districts such as Beşiktaş, Şişli, and Sarıyer, while those with lower amounts were located in areas like Silivri, Sultangazi, and Şile. This demonstrates a strong socioeconomic link between access to credit and spatial preferences, highlighting how inequality is spatially manifested. Studies also show that the average income level of mortgage recipients was 6.3 times higher than the minimum wage. Therefore, it can be concluded that the system did not offer an accessible housing solution for low-income groups; instead, it promoted financialization by increasing household debt (Alkay & Övenç, 2019; Aslan, 2019; Büyükkaracığan et al., 2017).

In the 2000s, alongside newly enacted regulations in Turkey, new financial and structural models that enabled partnerships between the private sector and TOKİ (Housing Development Administration of Turkey) were developed in the field of housing production. In this process, especially the revenue-sharing and construction-rights-in-return-for-land models came to the fore as key methods for utilizing public land and integrating private capital into the process. The legal basis for these projects was laid by the 2004 Law No. 5162, which granted TOKİ the authority to make and implement all types of plans, and the 2004 Law No. 5273, which enabled the transfer of Treasury-owned lands to TOKİ free of charge by amending the Land Office and Housing Development Laws.

The 2005 "General Regulation on the Production, Allocation, Leasing, and Sale of Municipal Land, Housing, and Workplaces" granted municipalities the authority to produce land and housing. Moreover, Law No. 4916 paved the way for the use of public lands in joint ventures with the private sector, thus providing a legal basis for the development of public-private partnership models on public land. In addition, Real Estate Investment Trusts (REITs) were enabled to become influential actors in urban transformation processes (Alkay, 2020; Giritlioğlu, 2022; Kuran, 2022; Uyanıker & Alkay, 2019).

In this context, the Zorlu Center project is a large-scale mixed-use development (residential, shopping mall, hotel, and cultural center) constructed in central Istanbul along the Levent-Zincirlikuyu corridor, on the former site of the General Directorate of Highways. One of the key legal instruments that enabled this project was Law No. 4916, enacted in 2003. This regulation facilitated the sale and transfer of publicly owned properties and created a legal framework for opening state-owned investment lands to the private sector. The Zorlu Center plot was sold to the Zorlu Group through privatization under this law. The project significantly altered the spatial structure and social fabric of the area. Due to its design catering to high-income groups, it led to the socio-economic exclusion of lower- and middle-income residents in the surrounding neighborhoods and deepened socio-spatial segregation. Furthermore, the commercialization of public spaces and their transfer to private control transformed forms of urban belonging and social interaction (Özoral, 2015).

The Varyap Meridian project, developed through the partnership of Varyap and Emlak Konut REIC, was built near the Ataşehir Financial Center and was planned as a mixed-use development, offering residential, office, and commercial spaces. Designed with a sustainable architectural approach and awarded a LEED certificate, the project features high-rise, modern towers aimed at high-income segments. The Ataşehir Financial Center, where the project is located, was declared by the Council of Ministers in 2009. Subsequently, with Decree Laws No. 644 and 648 enacted in 2011, extraordinary planning powers were granted to the Ministry of Environment and

Urbanization, thereby removing the area from the jurisdiction of local governments. In this context, the allocation of publicly owned land by Emlak Konut to private developers through revenue-sharing models reflects the process of transferring public assets into private profit. Key criticisms of the project include the lack of integration with the local community, the creation of a gated and inward-looking settlement, a significant increase in the local population, inadequate infrastructure and public amenities to support this population, and increased pressure on transportation networks (Aslankan, 2019; Kurultay & Peksevgen, 2012).

The Başakşehir and Kayabaşı projects, jointly carried out by the Ministry of Environment and Urbanization, TOKİ, and Emlak Konut REIC, were designed as large-scale housing developments where the private sector participated via revenue-sharing models. Located in the northwestern development corridor of Istanbul, these projects aimed to provide both social housing for low- and middle-income groups and luxury housing for high-income groups within the same development. The administrative infrastructure for these projects was shaped by the post-2010 merger of TOKİ with the Land Office and Emlak Konut, and its subordination to the Ministry via Decree Law No. 703. In particular, the "Yenişehir" urban center was established in the Kayabaşı area. However, in practice, a clear physical and social separation between social and luxury housing areas has been observed. Criticisms include inadequate public spaces, the peripheral location causing transportation issues, and other social problems. The projects have also been critiqued for their gated residential forms and for the marginalization of social housing residents (Baş & Yüzer, 2015; Doğan & Özbayraktar, 2023).

In settlement areas along the northern corridor such as Arnavutköy, Tayakadın, and Göktürk, intensive residential and mixed-use projects have been planned on the grounds of proximity to the airport. These projects, developing around Istanbul Airport, are predominantly implemented by private sector contracting firms under the guidance of the central government and within a supportive legislative framework. Key actors in these projects include the Ministry of Environment, Urbanization, and Climate Change, which holds substantial planning authority; as well as publicly affiliated entities such as TOKİ and Emlak Konut GYO, which play active roles in land allocation and implementation processes. Mega projects like Istanbul Airport have been constructed through decisions made at the central level that contradict the 1/100,000-scale Istanbul Environmental Plan. Subsequently, special plans were prepared for these areas, and development was directed without adherence to established planning principles. Furthermore, the conversion and market opening of 2B forest lands into title deeds under Law No. 6292 expanded the project zones in the northern corridor. In addition, influenced indirectly by İGA (Istanbul Grand Airport) -the company that built and operates Istanbul Airport- contractor construction firms and real estate investment trusts also play significant roles in projects in the surrounding areas. In the planning processes, higher-level documents such as the Istanbul Environmental Plan have been disregarded, and development has been steered through special plans prepared by central actors, considerably limiting the influence of local governments (Erbaş, 2018; Özalp & Sönmez, 2022).

The legal and institutional foundation of this development was primarily established by Law No. 4916. This law facilitated the sale and transfer of Treasury-owned immovables for public investments, paving the way especially for large-scale projects. Additionally, Law No. 6292 enabled the sale of 2B lands that had lost their forest status, marking a significant step that facilitated the opening of ecologically sensitive northern areas to development. The Ministry of Environment and Urbanization, established under Decree Law No. 644 and later granted expanded authorities by Decree Law No. 648, has assumed direct responsibility for preparing and approving plans at all scales, institutionalizing a centralized planning practice. Accordingly, planning processes around Istanbul Airport have largely been conducted outside the scope of local governments and under the supervision of central actors. The exercise of these authorities must be understood not only within the scale of planning but also in the context of the capital-driven spatial restructuring of the urban environment. In housing production, investor demands and market dynamics have been more decisive than local priorities and social needs. The narrowing of local governments' authority has led to a decline in democratic oversight of planning processes, resulting in negative outcomes such as weakened spatial justice for established residents, deficiencies in social infrastructure, and disruptions in essential services like transportation. Moreover, direct interventions by the central government beyond the planning framework have led to the loss of important natural assets and the transfer of public lands

into private ownership, generating high social costs that threaten ecological sustainability and social cohesion in the long term. Opening ecologically sensitive areas such as northern forests, water basins, and agricultural lands to development poses serious challenges to both ecological sustainability and climate resilience. Additionally, the population movements toward these regions have produced a form of spatial expansion disconnected from the city and lacking adequate urban services. Consequently, the settlement development around Istanbul Airport stands out as an example where centralized planning powers are concentrated, public lands are opened to market-based use, and ecological values are subordinated (Erbaş, 2018; Özalp & Sönmez, 2022).

These projects demonstrate that large-scale residential and mixed-use developments, which have accelerated in Istanbul in recent years, not only transform the physical environment but also reshape the social fabric. Developed through public-private partnerships, these projects highlight problems such as spatial density, social segregation, limited public spaces, and insufficient ecological sensitivity, which deepen class-based, spatial, and cultural divides in the city. This situation raises critical debates regarding urban cohesion, social justice, and quality of life.

Discussion and Conclusion

This study aims to examine the social implications in Istanbul of the legislative changes in planning regulations enacted between 2002 and 2024. During this period, characterized by the spatialization of neoliberal policies, the right to housing has shifted from being a fundamental social need to a vehicle for investment, a symbol of social status, and a means of generating profit. As Lefebvre (2013) emphasized, the prioritization of exchange value over use value in urban spaces has become a key driver of urban injustice and inequality. The transformation experienced in Turkey during the 2000s is marked by a restructuring of planning legislation in favor of capital interests and the centralization of planning processes (Alkay, 2020; Balaban, 2012).

The document analysis conducted within the scope of this study evaluates the periods 2002–2010 and 2010–2024 separately, analyzing the content and orientation of legislative amendments introduced during these years. Subsequently, the social effects of these transformations in the Istanbul Metropolitan Area are assessed comprehensively through field-based literature studies. The findings reveal that the legal reforms in question have exacerbated inequalities, social exclusion, displacement, and spatial polarization in urban areas, particularly through urban transformation practices and new housing developments. Especially gated, high-density residential projects targeting middle- and upper-income groups have reproduced social segregation, undermined neighborhood culture, and contributed to the detachment from public spaces (Çınar-Erdüzgün & Çizmeci-Yöreş, 2019; Kılıç & Ayataç, 2019; Sönmez, 2019).

Displacement has become widespread, particularly in the context of urban renewal projects involving low-income neighborhoods, forcing long-time residents to relocate to the urban periphery, thereby losing their social ties and historical sense of belonging. In this context, social fragmentation has become apparent not only in luxury residential developments but also in mixed-use projects that include social housing; spatial proximity has failed to ensure class integration. The concept of public interest has emerged as a central point of contention in many projects due to insufficient public spaces, restricted accessibility, and the dominance of private interests. The loss of social cohesion has manifested itself in the weakening of communal life, neighborhood solidarity, and public interactions in newly developed settlements.

The effects of gentrification have been particularly pronounced in centrally located and prestigious areas, where the exclusion of low-income groups has coincided with an intensification of housing production for wealthier populations. As housing production has increasingly been shaped by principles of economic accessibility, fragmentation based on income levels within the urban space has deepened. Consequently, housing has become a difficult necessity not only for vulnerable groups but also for the middle class. This has created a serious social problem in terms of both the right to the city and the right to housing (Bülbül-Akın & Türkün, 2019; Doğru, 2021; Ayhan, 2019). Reforms at the legislative level have treated urban space primarily as a source of investment and profit, a perspective that has undermined social cohesion, reduced quality of life, and intensified social alienation.

One of the study's limitations is its exclusion of first-hand narratives, lived experiences, and micro-level comparative case analyses from groups directly affected by the legal reforms in Istanbul. However, this limitation also presents an opportunity for future research. In-depth interviews and ethnographic studies with individuals residing in various socio-economic regions of Istanbul can offer more nuanced insights into the everyday effects of legislative changes. Furthermore, comparative analyses of similar legal transformations in different cities could enhance understanding of both the diversity of legal implementations and the varied forms of spatial injustice they produce.

In conclusion, it is evident that the transformation of planning legislation must be addressed in alignment with the principles of social equity, spatial justice, and the right to the city. This study is significant in that it reveals the social implications of the spatial manifestations of neoliberal policies, particularly those stemming from legislative changes in housing and planning. By analyzing the effects of Turkey's rapidly evolving planning regulations between 2002 and 2024 on a major metropolis like Istanbul, the study interrogates contemporary and critical issues such as displacement, social fragmentation, loss of social cohesion, and gentrification. In this respect, it offers both a theoretical and practical foundation for re-evaluating justice, equity, and the public interest in urban planning. Moreover, by providing a comprehensive assessment of the role of local governments, trends in centralization, and the class character of housing production, the study contributes to future legislative reforms and academic research in this field.

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Housing Justice in Urban Regeneration from a Hierarchical Perspective: Practice and Reflection on the Case of Nanjing, China

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Abstract
This study explores housing justice in China's Urban Regeneration, specifically through the "Housing Justice-Spatial Hierarchy" framework in Nanjing's Xiaosongtao Lane project. Departing from Western paradigms, it emphasizes justice within China's state-led, collective-interest-oriented context, highlighting distinct challenges and practices. The research reveals how distributive, procedural, and recognition justice dynamically interact across urban, community, and building scales. Key findings include the efficacy of "one-household, one-policy" and "courtyard negotiation" for resident participation and refined governance. Xiaosongtao offers a unique "local solution" for historic urban areas, balancing preservation, residents' diverse needs, and economic viability. However, tensions persist, particularly regarding economic burdens for vulnerable groups and the depth of resident influence in core decisions.

Keywords: Housing Justice, Urban Regeneration, Spatial Layering, Hierarchical Analysis, Nanjing Xiaosongtao

1. Introduction

1.1 Research Background and Problem Formulation: Housing Justice Challenges in Urban Regeneration

Global urban development paradigms have shifted from high-speed outward expansion to the regeneration of existing urban stock, making community transformation a core contemporary issue. Following a period of rapid urbanisation, China has also entered an era focused on its existing building stock, where the effective regeneration of residential settlements and the enhancement of public well-being are crucial. Within this context, non-traditional historic districts, in particular, often face problems such as environmental degradation due to aging infrastructure, outdated facilities, and a lack of essential services. The regeneration of these areas involves navigating multiple demands, policy conflicts, and resource negotiations. More critically, urban regeneration profoundly impacts residents' life chances, social networks, and cultural memories, bringing housing justice to the forefront as a central concern. Inadequate regeneration methods frequently expose disadvantaged groups to risks of involuntary relocation, escalating living costs, and social network disruption, thereby exacerbating urban spatial inequality and revealing underlying structural in justices. These issues urgently demand a systematic and equitable response.

Existing research has addressed various dimensions of housing justice, including distribution, procedure, and recognition; however, these studies predominantly offer single-dimension analyses and lack an integrated perspective. Furthermore, few studies have systematically examined the spatial distribution and interaction mechanisms of these justice dimensions within the urban regeneration process. Urban regeneration is a complex practice characterised by the intertwining of multi-scale spatial dynamics and governance forces. Consequently, housing justice issues are transmitted and often distorted across multiple levels, including urban policy, community governance, and architectural design. For instance, land policies at the urban level influence the initial conditions for justice; negotiation mechanisms at the community level determine the scope for participation; and spatial design at the architectural level shapes daily living experiences. Therefore, a comprehensive understanding of the generative mechanisms of justice issues is difficult to achieve from a single level or through abstract principles alone.

This study posits that the realisation of housing justice is a spatial and hierarchical process. It requires concrete practical analysis to understand how different justice dimensions interact—synergizing or conflicting—at the distinct levels of the urban, community, and building. To this end, this research aims to construct and apply an analytical framework that integrates multidimensional justice perspectives with hierarchical analytical methods. Through an in-depth case study of the Xiaosongtao area in Nanjing, this study seeks to reveal the complex

mechanisms and practical logics of housing justice in the regeneration of China's non-traditional historical settlements. The objective is to provide both theoretical and practical insights for understanding and promoting housing justice in the context of urban regeneration..

2. Theoretical Perspectives and Analytical Framework

2.1 Justice in Urban Regeneration: Dimensions, Interactions, and Considerations in the Chinese Context

As a significant practice that reshapes urban space and social structures, the ethical implications of urban regeneration have garnered increasing academic attention. The regeneration process is not merely concerned with improvements to the physical environment; it also profoundly affects resource distribution, social power dynamics, and the well-being of residents. Research widely indicates that while regeneration can improve living environments, it may also produce inequitable outcomes such as involuntary relocation, the severance of social networks, the destruction of local culture, and even the "gentrification" affecting original inhabitants. In this context, positioning "Justice" at the core of urban regeneration research and practice has become a critical benchmark for evaluating the value and sustainability of regeneration projects. However, the central question, "What constitutes just regeneration?" continues to evolve in both theory and practice.

"Housing Justice," as a core component, presents unique characteristics in its conceptualisation and pathways to realisation within China's specific socio-cultural and institutional contexts. While Western Justice theories often emphasise individual rights, market mechanisms, and legal procedures, discussions of housing justice in China must be more deeply embedded in the state-led urban development model, the policy orientation towards "people's well-being" (民生), traditions of collectivism and community consultation, and the complex logic of property rights and resource allocation under the socialist market economy system. Therefore, building upon common justice dimensions such as distribution, procedure, and recognition, this section pays particular attention to the specific manifestations and challenges of these dimensions in China's urban regeneration practices. This approach aims to construct a more context-sensitive analytical framework for subsequent research.

2.1.1 Single-Dimension Focus: Distributive, Procedural, and Recognition Justice in Housing

Existing research on housing justice and justice often approaches the issue from distinct yet interrelated dimensions, with distributive justice, procedural justice, and recognition justice as three core perspectives. In the context of urban regeneration in China, the specific manifestations and focal points of these dimensions differ.

(1) Distributive Justice: Focusing on the Rational Allocation of Housing Resources and Opportunities

Distributive justice is foundational to housing justice research, centering on how the benefits and burdens of housing resources, related public services, and urban regeneration outcomes are equitably distributed among different social groups. This concerns not only "who gets what quality of housing" and the associated cost-benefit sharing but is also, in the Chinese context, closely linked to the state-led housing security system, the complexity of historical property rights (e.g., the coexistence of public, reformed, and private housing), and distinctive Chinese policy practices such as "resettlement before relocation".

A key focus of current research on distributive housing justice is the "adequacy and comprehensiveness of compensation," which extends beyond singular material criteria, revealing inherent complexities and challenges. Numerous studies demonstrate that focusing solely on explicit indicators like housing sise and monetary compensation is insufficient to cover the full spectrum of losses residents incur due to relocation or community restructuring. Non-material losses—such as the disruption of social ties, dilution of cultural identity, and reduced spatial convenience—have emerged as crucial but often overlooked indicators of distributive justice. Their effective assessment and compensation pose a common challenge for academics and practitioners alike (Du et al., 2022).

Simultaneously, the "spatial dimension" of housing allocation has received increasing emphasis. This highlights the close connection between housing and location choices, access to quality public services (such as education, healthcare, and transportation), and the resultant development opportunities and social interaction spaces. The

aim is to promote the elimination of spatial segregation and opportunity deprivation arising from housing location disparities, fostering a more equitable allocation of urban resources (Feitosa et al., 2024). This requires housing allocation policies to transcend individual housing units and focus on equitable resource distribution and spatial inclusiveness for the entire community. Furthermore, the pathways and challenges of remedial allocation mechanisms (e.g., preferential rehousing rights, targeted subsidies) designed to redress historical injustices caused by discriminatory policies or unfair planning (such as the historical "redlining system") for specific groups have also become an important frontier in distributional justice research(Thurber et et al., 2024).

Despite considerable advances in distributional justice research, a persistent practical challenge is how to scientifically quantify and integrate multiple distributional factors (especially non-material socio-cultural factors). Another is ensuring that distributional outcomes genuinely benefit the most vulnerable groups within a complex market and policy environment, avoiding elite capture and the "egalitarian trap".

(2) Procedural Justice: Ensuring Inclusiveness and Transparency in Housing Decision-Making Processes
Procedural justice focuses on the justice of housing-related policymaking, planning, and project implementation processes. It emphasises that all stakeholders, especially disadvantaged groups, should have equal opportunities for participation, full access to information, and the ability to exert substantial influence on decision-making (Healey, 1997). Its core lies in ensuring openness, transparency, and empowerment in the decision-making process, positing that a fair process is a necessary prerequisite for achieving a just outcome. In China, the practice of procedural justice is often associated with government-led multi-party consultation mechanisms, innovations in grassroots community governance (e.g., "courtyard consultation meetings" and "residents' councils"), and the challenge of balancing efficiency with guaranteed participation.

However, the practice of procedural justice in housing is fraught with tensions and dilemmas. Research commonly reveals a significant gap between 'formal participation' and 'substantive impact'. Information asymmetries (e.g., professional jargon in planning schemes that is difficult for ordinary residents to understand), power imbalances (e.g., the dominant role of developers or government in agenda-setting and decision-making), and technological and cultural barriers often lead to the marginalisation of disadvantaged groups' voices, reducing participation to a "formalism" devoid of substance(Shahrad et al., 2025). Therefore, enhancing procedural justice hinges on marginalised groups to transition from passive recipients to active negotiators. This includes not only improving their access to information and comprehension, and ensuring their bargaining power in multi-party negotiations, but also establishing effective channels for conflict resolution and grievance redress, as well as ensuring the possibility of power-sharing and co-decision-making at the institutional level(Wang & Xu, 2024).

Additionally, some studies have begun to focus on the role of emotions in participation (Cao et al., 2024) and the unique value of informal community networks and 'bottom-up' advocacy planning (Hewidy and Harsia, 2025) in compensating for the shortcomings of formal procedures. These informal approaches aim to promote substantive justice by lowering participation barriers while increasing the depth and trust involved in the process. The fundamental challenge for procedural justice research lies in how to strike a delicate balance between pursuing administrative efficiency and ensuring broad, deep participation; how to design decision-making mechanisms that accommodate a plurality of voices while effectively reaching consensus; and how to genuinely internalise the concept of procedural justice into daily governance practices.

(3) Recognition Justice: Respecting Identities, Cultures, and Experiences Related to Housing
Recognition justice is a relatively new but increasingly important dimension in housing justice theory. It moves beyond material distribution and procedural participation to focus on societal respect for and acknowledgment of the identities, cultural values, lived experiences, and deep connections of different groups—especially marginalised ones—to specific spaces. This serves as a means of resisting stigmatisation, symbolic violence, and exclusion from power (Honneth, 1995; Fraser, 2003). In China's urban regeneration, recognition justice is particularly reflected in the protection of the overall character of historical districts and specific period architectural styles, the continuation of traditional neighborhood lifestyles and public interaction spaces, the incorporation of indig-

enous residents' "local knowledge" and collective memory, and respect for and responsiveness to collective sentiments associated with "unit" (单位) cultures and compound memories formed in specific historical periods.

In the housing field, the core research agenda for recognition justice exhibits rich connotations. First is the deep integration of cultural identity and spatial representation. Research emphasises that housing policy, planning, and design must transcend purely functionalist considerations to actively respond to residents' diverse cultural backgrounds and lifestyle needs. By demonstrating respect for the cultural practices, religious beliefs, and collective memories of specific groups in housing design and community building, their identity, dignity, and sense of belonging to the community can be ensured(Mosseray et al., 2025). Second is the practical exploration of historical memory and restorative recognition. In response to housing trauma caused by historically unjust policies (e.g., apartheid, forced evictions) affecting specific communities, recognition justice advocates for publicly acknowledging historical mistakes, establishing memorial mechanisms, and implementing compensatory or preferential resettlement policies to repair community trust and promote social reconciliation(Thurber et al., 2024). Third is the legitimisation of experiential knowledge and the establishment of epistemic justice. Recognition justice forcefully challenges the monopoly of expert discourse in housing decision-making, advocating that residents' "local knowledge" and real needs, based on long-term life experiences, be considered legitimate and valuable bases for decision-making. This promotes "knowledge justice" in planning and research.

However, in practice, research on recognition justice also faces significant challenges: how to translate the abstract principle of recognition into concrete policy tools and spatial intervention strategies; how to avoid the pitfalls of "symbolic recognition" and ensure that recognition is combined with practical resource redistribution and power restructuring; and how to effectively promote social cohesion while respecting cultural pluralism, thereby avoiding the potential "paradox of recognition".

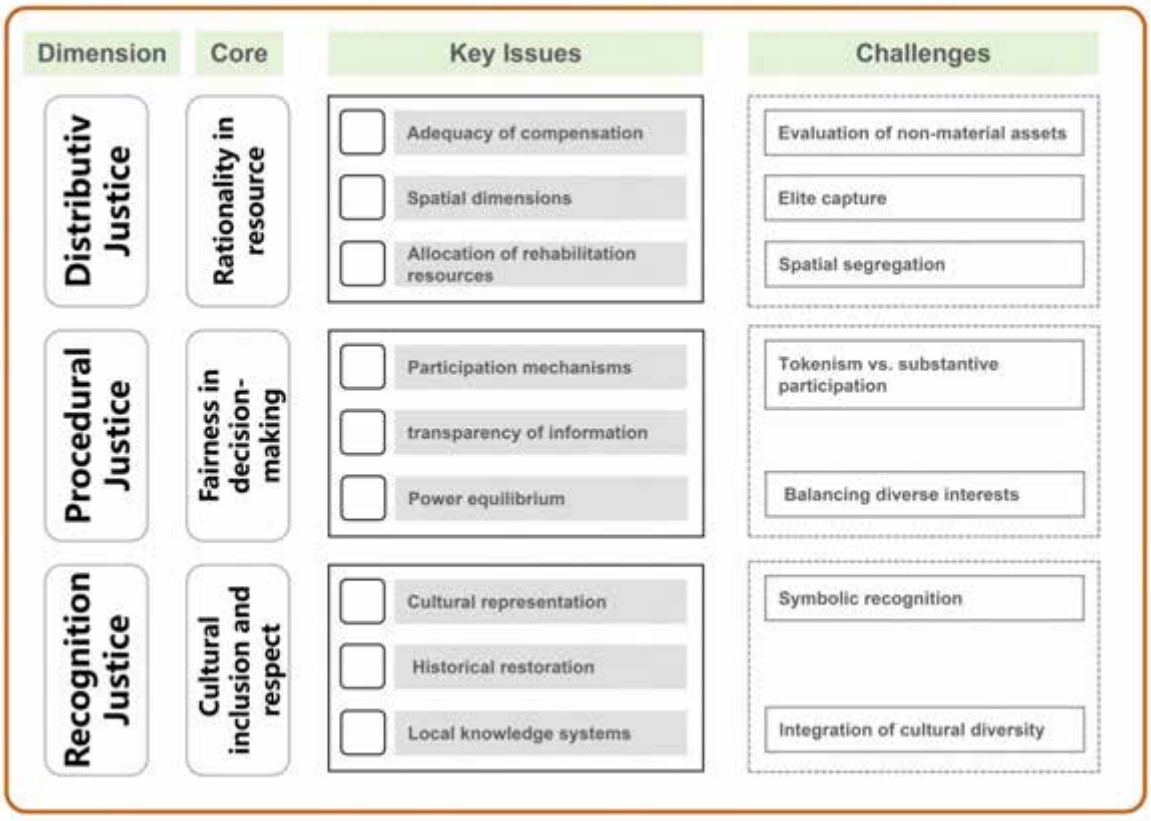


Figure1. Three Dimensions of Housing Justice

2.1.2 Integration of Multidimensional Perspectives: Towards Dynamic and Interactive Housing Justice
Given the inherent complexity and multifaceted nature of housing justice and justice, particularly in China's context of rapid development and profound transformation, the limitations of a one-dimensional analytical framework have become increasingly apparent. Consequently, a growing body of research advocates for adopting a multidimensional and integrated perspective, wherein distributive, procedural, and recognition justice are viewed as an organic, interrelated, and dynamically interacting whole.

Research indicates that justice in housing resource allocation is profoundly affected by the inclusiveness of housing decision-making processes; processes lacking full consultation or transparency tend to result in housing allocation programs that are more likely to deviate from justice goals, especially to the detriment of disadvantaged groups (Schmitt & Weck, 2024). Concurrently, the recognition of specific resident groups' identities and needs directly reshapes the pattern of allocation and spatial design of housing resources. For example, if the special needs of particular groups (recognition justice) can be incorporated into the planning, design, and allocation of housing resources (distributive justice) in subsidised housing or community regeneration projects, the dignity and quality of life for these groups can be significantly enhanced.
However, inherent tensions and conflicts often exist between different dimensions of justice in housing policy and practice. For instance, in urban regeneration involving housing demolition and resettlement, the pursuit of adequate procedural consultation and interest balancing may prolong project cycles, thereby affecting the immediate distributional justice for a segment of the population urgently needing transitional or resettlement housing(Johnson & Wang, 2024). Similarly, specialised housing design catering to the housing practices of specific cultural groups (recognition justice), while enhancing cultural sensitivity, might also affect the overall availability or inclusiveness of affordable housing due to increased costs (distributional justice). This potential conflict among multiple dimensions necessitates an understanding and practice of housing justice that transcends static standards and possesses the capacity for dynamic adjustment. This is especially crucial in the real-world context of urban regeneration in China, which is often characterised by tight schedules, intensive tasks, and extremely complex stakeholder interests.

Drawing on concepts from the Capability Approach and the Dynamic Justice Framework (DJF)(Weghorst et al, 2024), studies suggest that achieving housing justice requires attention to the differing core demands of various groups at different life stages or in specific housing situations, and the corresponding adjustment of policy priorities and resource allocation strategies (Kimhur, 2022). Therefore, understanding and promoting housing justice and justice in urban regeneration requires moving beyond static judgments of a single dimension towards a dynamic, interactive, and integrated view of justice. This obliges researchers and practitioners to focus not only on "what to share" and "how to share" (distributive justice), and "who participates" and "how to participate" (procedural justice), but also on "who is seen" and "whose values are respected" (recognition justice). It also requires an in-depth analysis of how these three dimensions shape each other, interact, and collectively determine the final housing justice outcome within specific social, economic, and institutional contexts.

2.2 Hierarchical Analytical Perspectives: Understanding Systemic Justice Challenges (Space-Specific)
Urban regeneration is not a singular, homogenous intervention but a systematic project involving different spatial scales, multiple actors, and complex socio-economic relationships. The complexity of housing justice, one of its core issues, stems not only from the intertwined influence of multiple justice dimensions but also from its inherent spatial attributes and multi-scale characteristics. Housing inequities often manifest uniquely at different spatial levels (e.g., regions, cities, neighborhoods, and individual building units). The interactions and shaping influences of policies, resources, power, and the built environment across these levels form complex causal chains and influence mechanisms (Harvey, 1973; Lefebvre, 1991). Thus, a systematic understanding of, and effective intervention in, housing justice requires moving beyond single-scale or "de-spatialised" approaches to an analytical perspective that can endogenously accommodate and resolve this spatial complexity.

2.2.1 Theoretical Origins and Practical Necessity of Hierarchical Analysis
Adopting a hierarchical perspective to analyze housing justice issues is rooted in a profound understanding of

the interaction between space and social relations, and it resonates with the complex governance realities of China's urban regeneration practices.

(1). Theoretical Origins: Space as a Container and Shaper of Social Relations
Theoretically, urban space is not a homogenised backdrop but is structured by different levels of power relations, institutional arrangements, and social interactions (Lefebvre, 1991). Housing, as a key social resource and spatial entity, sees its distribution, access, and experience deeply embedded in these multi-level spatial structures. From national-scale laws and regulations, to urban-scale planning controls, to community-scale governance rules, down to building-scale spatial design, each tier embodies specific resource allocation logics, power mechanisms, and spatial production processes. These collectively shape residents' housing opportunities, experiences, and even their socio-economic status. Hierarchical analysis provides an effective framework for decoupling and systematically examining these key processes and elements that operate at different, interrelated spatial scales to influence housing justice (Brenner, 2001). It prompts us to operationalise abstract justice principles in concrete spatial contexts, asking: "Where does injustice occur?", "Who benefits or suffers at what spatial scale?", and "How do interventions at different spatial scales affect the overall pattern of justice?".

(2). Practical Necessity: The Hierarchical Governance Characteristics of Urban Regeneration in China
In practice, China's urban regeneration is characterised by a distinctive hierarchical governance model that combines top-down policy transmission with bottom-up feedback and consultation (Wang et al., 2021). Macro-guidelines at the national level (e.g., the principle of "Retain, Renovation, Demolition and Donstruction" – must be translated into specific local policies and planning indicators by provincial, municipal, and district governments (urban level). The implementation of these policies and indicators necessitates complex negotiations and interactions with community organisations, development agencies, and local residents on specific project sites (community level). The final outcomes of regeneration are then materialised in the form of concrete architectural space and living quality (building level).

The challenges of housing justice therefore manifest differently at various levels:
At the urban level, it may involve the uneven regional distribution of subsidised housing and the concentration or exclusion of high-quality public resources.

At the community level, it may relate to procedural injustices in demolition and resettlement processes, lack of participation in public space creation, or the disruption of social networks due to regeneration.

At the building level, it may concern the universality and inclusiveness of housing design, variations in spatial quality, or the neglect of specific groups' needs.

A single-scale analysis, whether focusing on macro policies or micro practices, can hardly capture the transmission, distortion, and cumulative effects of justice issues across these different spatial levels, risking what Brenner (2001) terms "scale blindness". As Swyngedouw (2004) points out, the "cross-scale reconfiguration" (rescaling) between local actions and broader scale contexts is key to understanding contemporary urban governance. Thus, adopting a hierarchical analytical perspective can more clearly reveal how housing justice issues are constructed, amplified, or mitigated within the particular governance structure of urban regeneration in China.

2.2.2 Hierarchy in This Study: Focusing on Policy-Governance-Space Interactions
Based on the aforementioned emphasis on the spatiality of housing justice, and drawing upon common practices in urban geography, planning, and governance studies, this research focuses its analysis of housing justice in urban regeneration on the following three core, interrelated levels that effectively reflect mechanisms of spatial influence:

• **Urban Level:** Encompasses macro policies, strategic planning, and resource allocation rules led by national and local governments. This level influences the initial allocation of housing resources, regional equalisation of

opportunities, and the establishment of fair starting points for projects. The focus is on how land policy, housing supply structure, infrastructure accessibility planning, and the designation of historical and cultural preservation zones shape the urban's overall housing justice ecology.

• **Community Level:** Involves meso-level governance, consultation, interest coordination, and environmental improvement within the scope of a specific project or land parcel. This includes local government, community organisations, residents, development entities, and other stakeholders. It serves as a key arena for the implementation of macro-policies, multi-interest negotiations, and the realisation of procedural justice. The focus is on how program development, resident participation mechanisms, demolition and resettlement negotiations, community public space and amenities, and social network maintenance affect the experience of justice within the community.

• **Building Level:** Relates to micro-physical space, architectural design, technology application, and their direct impact on residents' daily living experience and the degree to which diversified needs are met. This is the direct carrier for the materialisation of justice concepts and individual perception. The focus is on how justice and empowerment at the micro-level are reflected in unit typology, spatial quality, public area design, material choices, spatial adaptability, and residents' autonomy in design and use.

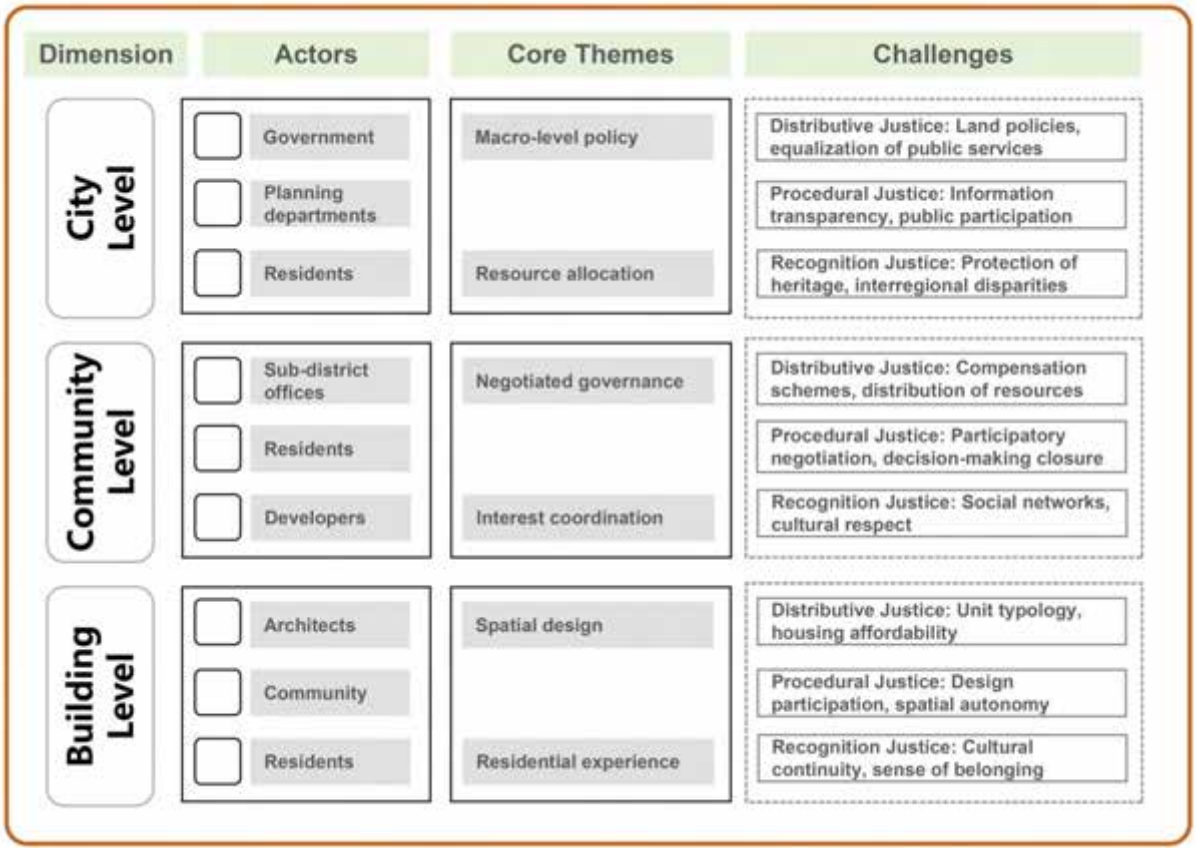


Figure2. Three Dimensions of Urban Spatial Analysis

2.3 Analytical Framework: Integrating Housing Justice Dimensions and a Tiered Perspective

To combine the understanding of core housing justice dimensions (Section 2.1) with the hierarchical approach to analysis (Section 2.2), and to construct a specific analytical tool for subsequent case studies, this study proposes the "Hierarchical Framework for Housing Justice" (see Table 1).

Table 1: Hierarchical Framework for Housing Justice

Level of Analysis	Key Actors	Key Arenas	Focus Areas	Distributive Justicce	Procedural Justice	Recognition Justice
Urban	Government ; Urban Master Plan	Macro Policies & Regulations	Structural resource allocation; justice in policy starting points; Legitimacy of macro-rules	• Justice in resource allocation • Public service equalisation • Fair cost and benefit distribution	• Transparency of decision-making information • Early public participation • Monitoring of policy implementation	• Recognition of historical/ cultural values • Consideration of regional/group differences
Community	Street/Neighborhood administration,Residents,Community planners	Consultation platforms, Project programs	Meso-governance processes; Mechanisms for interest harmonisation; Effectiveness of community participation	• Justice of entitlement programs • Community resource sharing • Balance in interest negotiations	• Inclusivity of consultation platforms • Justice of consultation rules • Constraints on community decision-making	• Maintenance of social networks • Respect for lifestyles/ cultures • Atmosphere of trust and cooperation
Building	Designers,Builders,Residents (users)	Architectural spaces	Micro-spatial quality; Living experience; User empowerment	• Guarantee of living space • Spatial quality and efficiency • Housing affordability	• Participation in design process • Autonomy in space use • Transparency of technical information	• Meeting diverse needs • Spatial expression of identity/culture • Guarantee of residential dignity

This framework is the central methodological tool of this study. Its core purpose is to systematically "locate" and "dissect" housing justice issues in urban regeneration. It systematically couples the core dimensions of housing justice (distributive, procedural, and implicitly, recognition justice) with the three core analytical levels of urban regeneration (urban, community, and building). The aim is to reveal the specific manifestations of housing justice issues at different spatial scales, as well as their intrinsic correlations and transmission mechanisms.

3. Case Study: Hierarchical Housing Justice Practices in the Regeneration of Xiaosongtao, Nanjing

This study selects the urban regeneration project of Xiaosongtao in Nanjing as a representative case to analyze the mechanisms and complexities of housing justice in the regeneration of non-traditional historical settlements in China, applying the hierarchical housing justice framework developed previously. Located in the core of Nanjing's old urban, the Xiaosongtao project is a typical case that combines historical and cultural values with pressing challenges related to residents' livelihoods. Its regeneration process spans multiple levels, from macro-policy guidance to micro-spatial implementation, and involves dynamic interactions among the government, residents, planners, developers, and other actors. This provides a rich empirical basis for examining the impacts of different practice layers on housing justice.

3.1 Research Design and Case Overview

3.1.1 Selection and Application of Research Methods

This study employs a combination of case study methodology and spatial analysis to explore housing justice practices in the regeneration of non-traditional historical settlements through multi-dimensional empirical analysis. Based on field research, the study utilises in-depth interviews (with residents, planners, government officials, and other key actors), participatory observation (e.g., of community councils, consultation mechanisms), and analysis of planning texts and spatial data (e.g., planning indicators, architectural designs) to systematically collect empirical data across social, spatial, and economic dimensions. The case study focuses on policy, governance, and spatial interactions at the "urban-community-building" levels, integrating methods such as spatial morphology comparisons and functional layout optimisation analysis, to dissect the specific practices of hous-

ing justice within the hierarchical framework as demonstrated by Xiaosongtao's "localised response".

Figure3. Aerial View of the Xiaosongtao Lane Site before Urban Regeneration

3.1.2 Case Overview

The Nanjing Xiaosongtao Lane Regeneration Project is situated in the core area of Nanjing's old urban, covering approximately 10,100 square meters. The buildings primarily consist of high-density, ground-floor brick and wood structure lilong-style residences from the Republican Era (1912-1949). Some buildings possess historical and cultural value. However, the overall living environment required significant improvement, facing issues such as aging infrastructure, insufficient public services, diverse and complex property ownership (including historical private houses, early housing reform units, and tenants, with a notably aging population of property owners), and certain safety risks. (See Figure X for the location and pre-regeneration condition of the case study area).

In 2020, guided by Nanjing Municipality's "Guiding Opinions on Urban Regeneration of Residential Lots," which advocates a principle of "retain, renovation, demolition and construction" ("留改拆建") applied differentially, the Xiaosongtao site commenced its regeneration. It was positioned as a pilot project to explore an "organic regeneration" path characterised by "government guidance, market operation, and multi-stakeholder participation". The Xiaosongtao case reflects common characteristics of current urban regeneration in China, especially in historical urban areas:

Figure4.Surrounding Conditions of the Project **Figure5.**Aerial View after Update

• **Market-oriented operation under government guidance:** The project is guided by the government (with urban, district, and street-level linkage) in planning, policy support, and overall supervision. Simultaneously, a state-owned platform company (Nanjing Historic Urban Area Protection and Construction Group Co., Ltd.) was introduced as the primary implementation body, exploring market-oriented mechanisms in old urban regeneration(Chen et al., 2025).

• **Complex property rights structure and diversified social demands:** The historical diversity of housing property rights, coupled with social networks and neighborhood sentiments formed by original residents over time, made interest coordination and social relations maintenance crucial aspects of the regeneration process.

• **Policy orientation of "people-oriented" and "prioritizing livelihood improvement":** In the current stage of urban development, the transformation of non-traditional historical settlements is accorded significant importance for improving public well-being. Upgrading living conditions and safeguarding residents' rights and interests became key objectives of project implementation.

• **In-depth participation of grassroots governance and construction of consultation mechanisms:** Project promotion relied on the deep involvement of the grassroots governance system (street and community administrations), seeking to build consensus and ensure smooth implementation through a multi-party consultation platform.

Therefore, the regeneration practice in Xiaosongtao represents an important local endeavor to balance multiple goals—historical preservation, livelihood improvement, and economic feasibility—and to explore pathways for achieving housing justice within China's specific institutional and cultural context. Its strategic choices and practical effects offer valuable references for understanding similar regeneration projects.

3.2 The Urban Hierarchy: Reconciling Justice in a Macro Framework

Urban-level planning and policies established the macro framework, basic principles for resource allocation, and value orientation for the regeneration of Xiaosongtao Lane. These had a guiding influence on subsequent paths and specific measures to achieve housing justice at the community and building levels.

Figure6. Framework of Urban-Level Justice Dimensions and Spatial Practices

3.2.1 Resource Allocation under the "Retain, Renovation, Demolition, and Construction" Approach: Balancing Historic Preservation Priorities with Distributional Justice

Facing challenges of high protection requirements and limited development space in neighborhoods with historical elements, Nanjing's municipal policies of "organic regeneration" and "retain, renovation, demolition and construction" provided a somewhat flexible guiding framework for resource allocation to Xiaosongtao at the urban level. This aimed to balance the rigid constraints of historical landscape protection with residents' urgent needs for improved living conditions. The Nanjing Xiaosongtao Unit (NJZCA030) Detailed Control Plan explicitly mandated the preservation of existing street texture, scale, and interface of Xiaosongtao Lane, listing several buildings for retain, repair, or reconstruction. This urban-level consideration of recognition justice for the historical lineage controlled the overall development intensity of the site through planning controls (e.g., setting a cap on the floor area ratio for new residential sites).

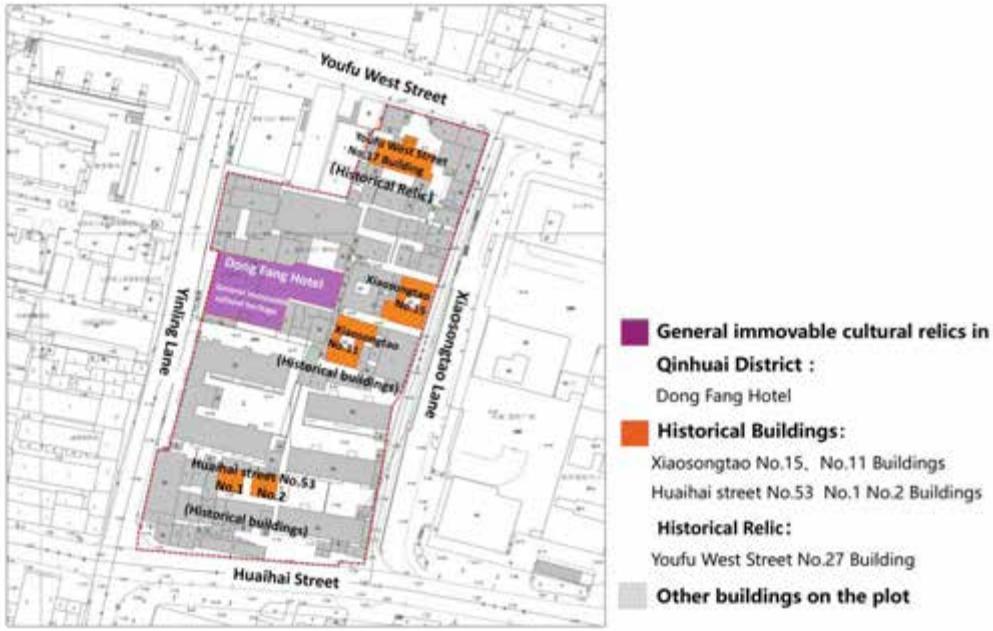


Figure7. Historical Elements of Xiaosongtao Lane Site

This "conservation-first" strategy reflects respect for the urban's historical fabric. Concurrently, the plan permitted a moderate increase in development intensity on suitable sites (e.g., the floor area ratio of some mixed commercial and residential sites was slightly higher than that of purely residential sites). Floor area ratios for different sites were set distinctively, aiming to provide a degree of economic support for the district's overall regeneration and reserve space for improving indigenous inhabitants' living conditions and public service facilities. For example, the floor area ratio for new residential sites (e.g., NJCa03019-11) was controlled at ≤2.0 to ensure harmony with the surrounding historical environment, while for some mixed commercial/residential sites in better locations with relatively less impact on the landscape (e.g., NJCa03019-26), it was set at ≤2.6.

A key aspect of resource allocation justice at the urban level is how to effectively allocate resources under limited planning conditions, balancing investment in historic landscape conservation with satisfying residents' diverse housing needs. This includes avoiding situations where an overemphasis on low-density protection renders regeneration projects economically unviable, potentially transferring excessive renovation costs to original residents. This requires careful, fine-grained consideration. Decisions at this level also cascade down, affecting the design of compensation and resettlement programs (distributive justice) at the community level and the extent of spatial improvements at the building level. (Reference to floor area ratio adjustment in the Nanjing Xiaosongtao Unit (NJZCA030) Detailed Control Plan).

Figure8. Comparison before and after Adjustment of Plot Ratio in the Previous Plan Nanjing Xiaosongtao Unit (NJZCA030) Detailed Control Plan

3.2.2 Refined Governance Procedures under the "Organic Regeneration" Framework: Policy-Led Construction of Procedural Justice

The regeneration of Xiaosongtao Lane adhered to the "organic regeneration" concept promoted by the urban of Nanjing, emphasizing a shift from "large-scale demolition and construction" to "refined management". The urban-level policy framework (e.g., the "Guidelines for Urban Regeneration of Residential Lots") established general principles of "government-led, market-operated, public participation, and professional collaboration." This laid a systematic foundation for the Xiaosongtao project to conduct multi-stakeholder consultations at the community level, fostering procedural justice.

In the planning approval process, designating the project as a "Model Old Neighborhood" and emphasizing "fine-tuned regeneration" encouraged the full consideration and incorporation of views from street and community administrations, residents, property rights units, and professional teams (e.g., architects, planners) in the design and implementation of the specific plan. In the Xiaosongtao project, the architectural team played a "full-process role from pre-planning, planning and design to post-implementation management" and undertook "community building and public participation" work. This reflects urban-level procedural recognition and support for professional engagement in grassroots consultation. This procedural design, combining "top-down" policy guidance with "bottom-up" practical exploration, aimed to enhance the scientific basis, democratic nature, and local adaptability of regeneration decision-making, thereby promoting justice at the procedural level.

3.2.3 Value-Oriented Revitalisation of Historical Lineage: Incorporating Residents' Life Imprints in Recognition Justice

At the urban level, the regeneration of Xiaosongtao not only pursued the retain of physical form but also strove to integrate the urban's historical narrative with the imprints of residents' lives. This reflects a recognition of local identity and residents' emotional connection to place, contributing to recognition justice.

Figure9. Remodeling of 27 Youfu West Street

The plan's "maximum preservation" of Xiaosongtao Lane's existing street texture, scale, and interface, and the "in-situ preservation and restoration" of historical buildings such as No. 27 Youfu West Street (as shown in Figure 9), are direct manifestations of the urban's recognition of its historical and cultural value. Furthermore, the orientation of urban regeneration was not to "museumise" historic districts but to reintegrate them into contemporary urban life through functional implantation and spatial revitalisation. For example, at the urban planning level, some preserved buildings were permitted to introduce cultural, creative, or small-scale commercial functions related to community life, provided their appearance was maintained. This aimed to restore neighborhood vitality and provide residents with new spaces for interaction and experience. This strategy sought to protect historical "symbols" while recognizing residents' rights to be present and use the space as "subjects of life". The urban's advocacy for an "efficient space and open architecture concept," and design guidelines such as "solving the diversified living space needs of special-needs households by raising the floor height," also reflect concern for residents' specific living needs and quality of life improvement.

However, a critical consideration for the urban in pursuing recognition justice is how to acknowledge historical and cultural values while ensuring that regeneration outcomes benefit the original community and avoid the negative effects of "gentrification".

3.3 The Community Level: Shaping Justice in Consultative Governance

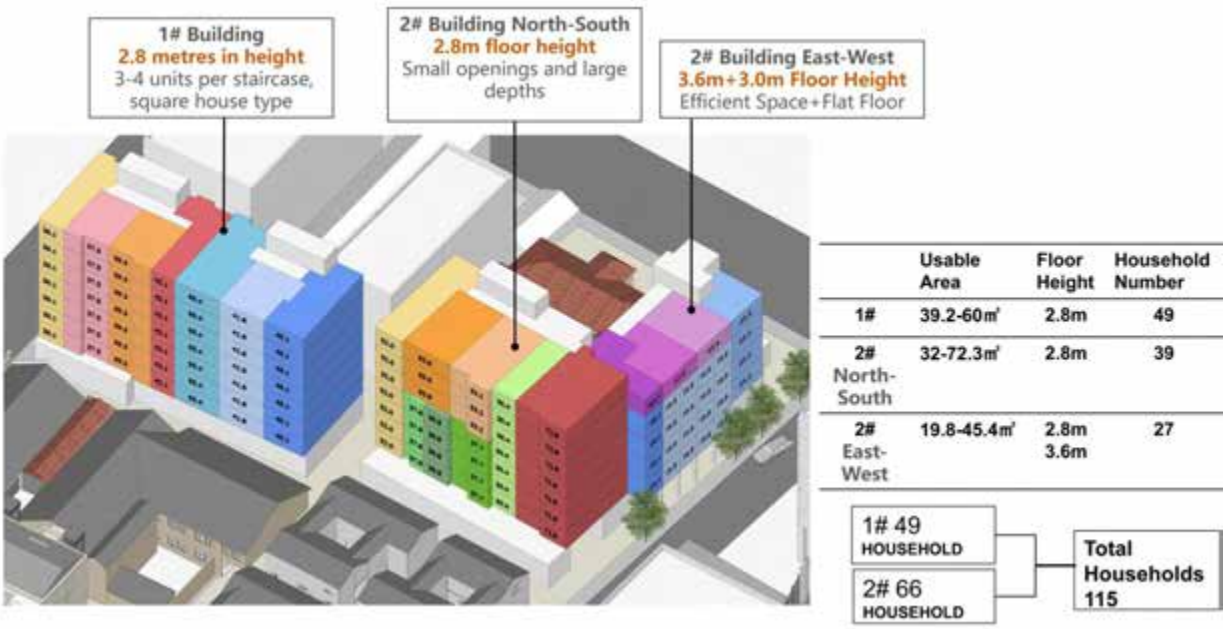
The community level is the key arena where urban regeneration policies are translated into concrete practices and where multiple interests engage in direct dialogue and negotiation. In the regeneration process of Xiaosongtao Lane, community-level governance practices actively responded to and attempted to resolve complex housing justice challenges across the three dimensions—distribution, procedure, and recognition—by constructing a multi-party consultation platform, exploring refined interest adjustment programs, and focusing on the maintenance of social and cultural capital.

Figure10. Framework of Community-Level Justice Dimensions and Spatial Practices

3.3.1 "One Household, One Policy" and Multiple Choices: Exploring Distributional Justice in Refined Compensation and Resettlement

Facing the complexity of housing ownership and diverse resident demands in the Xiaosongtao area, community-level regeneration governance did not adopt a "one-sise-fits-all" approach to compensation and resettlement. Instead, it actively explored and practiced a "one household, one policy" (一户一策) fine-tuned program for rights and interests, striving to achieve more targeted distributive justice.

For residents with different property rights (e.g., private housing, early housing reform units, tenants), family structures (e.g., elderly families, multigenerational families, single youths), and affordability levels, the community working group, in collaboration with a professional team, provided over 50 options(Aliprantis et al., 2023). These included monetary compensation, off-site resettlement, and in-situ rehousing (with various unit types and appropriate area improvements). This "menu-style" program design granted residents a degree of autonomy in choice, avoiding the sense of being "averaged out" or "deprived" that a single standard might cause. For instance, elderly residents with a strong desire for in-situ living were given priority for on-site relocation with suitable age-friendly modifications. Families needing improved living space were offered the possibility of increasing their area within policy limits, supplemented by a reasonable cost-sharing mechanism.
In formulating compensation standards, beyond statutory assessment procedures, the community level also attempted to introduce more flexible value recognition methods. For example, considerations included the property's locational value, historical contributions (for some early residents), and potential non-material losses from relocation (e.g., operational losses, disruption of social networks). This aimed to align the compensation scheme more closely with residents' actual experiences and reasonable expectations.



	Usable Area	Floor Height	Household Number
1#	39.2-60㎡	2.8m	49
2# North-South	32-72.3㎡	2.8m	39
2# East-West	19.8-45.4㎡	2.8m 3.6m	27

Figure11. Resettlement Housing Program Table

This refined "one household(Bao et al., 2024), one policy" approach, while increasing governance costs and negotiation difficulty, was centered on recognizing individual differences and striving for more substantive distributional justice through differentiated resource allocation. The project's ultimate achievement of 100% sign-up from property-owning households reflects the efforts of all parties to reach an allocation acceptable to the majority of then-current residents through negotiation.

3.3.2 "Courtyard Consultations" and Professional Empowerment: Building Procedural Mechanisms for Inclusive Participation

At the community level, the Xiaosongtao Project emphasised constructing a multi-level, multi-form consultation platform to ensure procedural justice. This highlighted active interaction and continuous consultation among multiple actors, including residents, community managers (street and neighborhood committees), representatives of the implementing body, and professionals (architects, planners).

In addition to district-level policy briefings and resident representative meetings, more targeted consultation activities were conducted in "courtyard" or building-based consultation meetings. According to statistics, since the project's inception, over 28 formal courtyard consultation meetings were held to discuss program interpretation, express demands, and mediate conflicts.

Figure12. Consultative Meeting

These small-scale consultation units, organised and coordinated by community managers, ensured effective information transmission and orderly progress of consultations. Representatives of the implementing body directly participated in dialogues, explaining program details and policy boundaries to residents and listening to feedback. Faced with complex planning programs and policy provisions, ordinary residents often experience an information disadvantage. Against this backdrop, the architectural team actively assumed multiple roles—as interpreters of policy, translators of technical language, and facilitators of multi-party communication—thereby enhancing inclusive participation. They "established close contact with residents to understand their living habits and transformation needs," explained the program in an accessible manner, assisted residents in articulating their needs, and fed representative needs and reasonable suggestions back into the design and decision-making processes.

As the most direct stakeholders, residents' opinions and demands were the starting point and core content of the consultation. For example, repeated discussions and revisions on issues such as the relocation transition period, details of compensation standards, and types of return housing allowed residents' reasonable demands to be reflected in program optimisation(Zhang & Wang, 2024). The deep engagement and interactive learning of all actors throughout the project led to dynamic adjustments in the planning and design program. This iterative consultation process reflects the program's adjustment and adaptation under pressure, enhancing decision-making flexibility and responsiveness to on-the-ground needs.

By constructing this small-scale, multi-round, professionally empowered consultation mechanism with multiple actors, community governance in Xiaosongtao endeavored to break down information barriers and balance power relations. It enabled more residents to substantively participate in regeneration decisions closely related to their interests, thereby promoting procedural justice and providing practical support for establishing "a more inclusive, transparent, and substantively influential consultative governance platform".

3.3.3 "Neighborhood Living Rooms" and the Continuity of Memory: Practices for Reinventing Community Identity and Recognition Justice

Beyond physical space improvement, Xiaosongtao's regeneration practice also carefully responded to residents' valuation of original social networks, local culture, and emotional identity at the planning and design level. It was committed to laying the groundwork for recognition justice (at the community level) and fostering a sense of community identity in the community's future(Rahimi & Alavi, 2024).

During conceptual iterations, the project team recognised that the core of organic urban regeneration lies in the relative stability of property rights, considered key to maintaining the texture, spatial appearance, and "local vibrancy" (烟火气) of the old urban. Therefore, while respecting existing property rights, the regeneration program focused on enhancing the community's public nature and cultural identity through spatial design.

In response to the lack of public space in non-traditional historical settlements, the regeneration plan consciously incorporated shared spaces such as "neighborhood living rooms," "shared courtyards," and community activity rooms. These are envisioned as future carriers for residents' interaction and cultural inheritance. The plan's concepts of preserving and repairing public facilities that carry collective memories, incorporating local cultural elements into new spaces, and considering the continuation of original neighborhood relationships in resettlement all reflect a forward-looking acknowledgment of the community's history and its residents' emotions. These community-building planning ideas, centered on respecting residents' original lifestyles, community belonging, and the sense of life carried by stable property rights, aimed to further enhance the community's social resilience post-regeneration. Whether these planned shared spaces and community-building concepts can effectively activate neighborhood interactions and gain acceptance from residents in the future will be an important test of the degree of recognition justice achieved and remains to be seen in subsequent practice.

3.4 Architectural Hierarchies: Materializing Spatial Empowerment and Justice

The building level is the material carrier for the final realisation of housing justice concepts, directly related to residents' daily life experience, living quality, and identity. The regeneration practice in Nanjing's Xiaosongtao Lane, through refined spatial utilisation, inclusive design participation, and skillful translation of local cultural veins in micro architectural space design, actively explored effective paths to achieve housing justice and improve quality of life within the historical texture. It also attempted to respond to the specific housing needs of disadvantaged groups in its design.

Figure13. Framework of Building-Level Justice Dimensions and Spatial Practices

3.4.1 Balancing "Livability" and "Economy": Efficient Use of Small Spaces and Quality Assurance

Facing the reality that original housing in the Xiaosongtao area was generally small and partially dysfunctional, the architectural-level regeneration design was committed to maximizing residents' basic living needs through efficient utilisation and quality assurance within limited space, while also considering the economics of regeneration costs.

One of the design highlights was the adoption of the 3.6-meter-height "high-efficiency unit design" in some units of the new Building 2. Designers expanded usable space within standard floor areas (e.g., approximately 40-60 square meters) using techniques like staggered floors, partial mezzanine levels (e.g., raised sleeping or storage

areas), integrated furniture, and vertical storage. For example, a standard one-bedroom unit was optimised into a more functional one-bedroom plus multifunctional area, or designed to accommodate more family members within the same area, responding to situations where some original residents had larger households and limited living space.

Figure14. Partial Floor Plan

On the basis of ensuring structural safety, the regeneration design emphasised improving basic living qualities such as lighting, ventilation, sound insulation, and thermal insulation, seeking to achieve independent, hygienic, and functional kitchen and bathroom facilities. For example, technical measures like rationally designing window-to-wall ratios, adopting energy-saving window and door materials, and installing additional external wall insulation were used to improve the living comfort of the original old housing. These designs aimed to safeguard basic living functions and enhance spatial quality while endeavoring to control construction costs, seeking a better balance between livability and affordability, thereby responding to distributive justice requirements at the micro-level.

3.4.2 Co-creative Design and Individualised Adaptation: Exploring Procedural Justice with Resident Participation

To ensure that renewed housing could effectively support residents' diverse lifestyles and practical needs, Xiaosongtao Lane actively introduced resident participation mechanisms into the architectural design and renovation process. This gave residents a certain degree of influence on design and autonomy in spatial adjustment, especially for rehousing relocated households, and focused on providing diversified unit type programs.

Through various forms of household interviews and discussions, the design team gained an in-depth under-

standing of the specific housing needs of different families (including the elderly, disabled, and other disadvantaged groups). Guided by the "one household, one policy" principle, these needs were transformed into specific spatial solutions(Nourian et al., 2023), which in itself constituted an important practice of procedural justice at the architectural level. Consequently, for the two new multi-story residential buildings on the Xiaosongtao site, the design team planned nearly a dozen unit types, ranging from 19 square meters (sufficient for basic living) to over 70 square meters (relatively generous). This diversified "menu" of unit types was designed to maximise the match with different family structures, population sises, and the actual conditions of original living spaces.

In addition to providing a series of well-designed standard unit options, the project also granted residents a degree of influence and autonomy in their own living space arrangements, offering flexibility between standardised design and individual needs. For instance, residents were allowed to choose from pre-designed options for interior decoration materials and the configuration of some non-load-bearing walls, or to make limited personalised adjustments, provided safety and overall appearance were maintained. This "bottom-up" feedback mechanism enhanced the local adaptability of the design program. The architectural regeneration process in Xiaosongtao Lane thus transformed from a unilateral "provision" by designers to a process where residents became design participants with a certain degree of voice, enhancing the adaptability of the final space and residents' sense of identity.

3.4.3 Translation of "Old and New Symbiosis" and "Memory of Place": Recognizing Local Identity in Architectural Discourse

While pursuing modern residential functions, the architectural regeneration of Xiaosongtao Lane also attached great importance to respecting and translating the local historical lineage and memory of place(Thaler et al., 2025). It strove to embody the recognition of residents' identity and local characteristics in the architectural vocabulary of new or renovated buildings.

Building components with historical value from the area (such as old bricks, tiles, stone slabs, and wooden beams) were, where conditions permitted, collected, restored, and reused, skillfully integrated into the design of new buildings or landscapes. This "new life for old materials" approach perpetuated the historical memory of the place at a material level, enabling residents to feel a familiar "old flavor" in the new environment—a recognition of their emotional memory and cultural roots. Notably, the renovation and reuse design for No. 15 Xiaosongtao retained its courtyard layout and original structure and façade, focusing on public reuse of the space and allowing for various functions, including community service facilities, knowledge-based creative industries, and cultural consumption venues.

Figure15. Patio space before #15 remodel vs #15 Remodeled Patio Space

In terms of forms, materials, and colors of newly built or reconstructed buildings, the project focused on drawing inspiration from traditional Nanjing dwellings, modernizing their translation and expression. This attempted to create a spatial environment that not only met modern living needs but also evoked place memory, carried local

culture, and strengthened residents' identity. For example, design elements like roof forms, courtyard layouts, and door and window styles drew on traditional features but utilised new materials and techniques to achieve both "spirit and form" rather than simple retro imitation. These designs responded to residents' deep-seated emotional needs and sense of cultural belonging, representing a concrete expression of recognition justice at the architectural level. For long-time elderly residents, retaining familiar architectural elements and spatial ambiance was particularly important to help them establish continuity and a sense of belonging in their new living environment. However, whether this translation of culture and memory can be understood and recognised by all residents, especially the younger generation or newly relocated individuals, needs reinforcement through community activities and cultural heritage initiatives.

4. Discussion and Conclusions

Based on the theoretical perspective and hierarchical analytical framework of housing justice and justice, this study conducted an in-depth case study of the Xiaosongtao Lane urban regeneration project in Nanjing. The aim was to reveal the specific manifestations, internal correlations, and realisation mechanisms of housing justice at different spatial levels in the regeneration of non-traditional historical settlements in China. This chapter synthesises the preceding analysis, discusses the main findings, theoretical contributions, and practical implications of the study, and points out its limitations and future research directions.

4.1 Key Findings: Characteristics of Housing Justice Practices under Tiered Interaction

The regeneration practice of Xiaosongtao Lane vividly demonstrates that housing justice in urban regeneration is not a static, single-dimension goal. Instead, it is a complex process where the three core dimensions—distribution, procedure, and recognition—are dynamically interwoven and interact across the three spatial tiers of the urban, community, and building.

1. The Transmission of Power and Resources Between Levels Shapes the Boundaries and Paths for Realizing Justice:

(1) **Top-down Impacts:** urban-level macro-policies and plans (e.g., prioritizing historic preservation, controlling floor area ratios) directly set the "ceiling" for resource allocation at the community level and the scope of negotiable issues. For example, the urban's justice-oriented approach to recognizing historical contexts limited development intensity through planning controls. While this protected the landscape, it also increased pressure on the project's economic balance, which in turn posed challenges for distributional justice in compensation and resettlement standards at the community level, and constrained possibilities for large-scale spatial upgrading at the building level. Similarly, the urban-level procedural framework of "government-led(Liu et al., 2025), professional collaboration" provided a legitimizing basis for community-level consultation and participation, but also limited the substantive boundaries of its deliberations.

(2) **Bottom-up Feedback and Adaptation (Limited):** Although Xiaosongtao was a pilot project, residents' demands and consultation outcomes at the community level (e.g., strong demand for a "one household, one policy" program, modifications to specific unit designs) did have a substantial impact on the dynamic adjustment of the project's program. For instance, residents' demands for high-efficiency unit designs and barrier-free facilities, collected through multiple rounds of "courtyard consultations" at the community level (procedural justice), directly influenced design plans at the building level (distributive and recognition justice), enhancing the local adaptability of the finalised space. However, whether this feedback can be institutionalised and upwardly influence policymaking for subsequent similar projects at the urban level remains to be seen.

(3) **Synergy and Conflict Between Levels:** Refined governance mechanisms at the community level (e.g., the in-depth involvement of community planners and architects) effectively promoted residents' participation depth and voice (procedural justice) in the architectural design process, bridging the gap between professional expertise and residents' needs. Simultaneously, however, the pursuit of a high degree of personalisation and quality enhancement at the architectural level (e.g., diversified unit types and reuse of old materials

under the "one household, one policy" approach) significantly increased coordination difficulty at the community level and the overall economic costs of the project (a challenge to distributive justice).

2. Uniqueness of the "Localised Response"

(1) **Connotation and Practical Characteristics of "Justice" in the Chinese Context:** Unlike Western societies, which typically focus more on individual rights protection and market-driven procedural justice, the practice of "justice" demonstrated by Xiaosongtao is more profoundly marked by China's national conditions. Firstly, government leadership and a focus on public well-being are distinctive features. The government consistently played a central role in goal-setting, resource input, and process regulation, with enhancing people's livelihoods and maintaining social stability as important value orientations. This often prioritised considerations of distributional justice (such as refined rehousing through "one household, one policy," and high-efficiency unit design to meet actual housing needs), striving to achieve "tangible and perceived justice outcomes". Secondly, traditions of collective bargaining and community-based governance continue to play an important role in China's grassroots governance(Li & Wang, 2023). Mechanisms like "courtyard consultations" reflect efforts to balance individual interests within a collective framework, emphasizing community consultation to resolve conflicts and build consensus, which contrasts with Western models that often emphasise more atomised individual participation. Thirdly, the dynamic balance between efficiency and justice is a common challenge for urban regeneration in China. Xiaosongtao's pursuit of a 100% signing rate reflects both respect for and absorption of individual demands, as well as grassroots governance's consideration of efficiency and overall project progress.

(2) **Differences in Justice Issues Compared to Western Urban Regeneration:** In Western urban regeneration, vigilance against gentrification, correction of market failures, and protection of ethnic minority and marginalised groups' rights are often the focus of justice discussions. In the Xiaosongtao case, although it also faced issues of resettling disadvantaged groups and community identity, the core conflicts and resolution paths are more characteristic of the Chinese context. For example, the complexity of historical property rights issues (intertwining public, reformed, and private housing) is rarely seen in Western cities, making the starting point and program design for distributional justice extremely complex. Additionally, China's policy of "preservation, renovation, demolition and construction" in regeneration, as well as the trade-offs between historical and cultural preservation and modern residential function enhancement, are unique. While the West often emphasises interest regulation through strict legal frameworks and market mechanisms, China relies more on government administrative control, policy guidance, and negotiation and mediation approaches reflecting local practices.

(3) **Characteristic Justice Issues in the Historical Dimension:** Situated in a historic district, Xiaosongtao's justice challenges are naturally overlaid with a historical dimension. The first is balancing historical and cultural heritage preservation with residents' modern needs. A core feature is how to meet residents' needs for more comfortable and modern living spaces (distributive justice) through design innovations like "high-efficiency unit designs," while preserving historical features (a manifestation of recognition justice). Secondly, it involves recognizing "local knowledge" and residents' historical sentiments. Xiaosongtao's attempts to "revitalise old materials" and perpetuate place memory reflect respect for the cultural ties and emotional belonging that residents formed with a particular space over time. Thirdly, it pertains to maintaining historically formed neighborhood relationships. Considering "group relocation" in the resettlement process and attempting to continue social networks of acquaintances also reflects Chinese society's emphasis on "relationships" and community harmony in regeneration(Gao & Bai, 2024). These historical considerations enriched the connotation of justice and raised higher requirements for regeneration strategies and methods.

4.2. Theoretical and Practical Insights

(1) **Theoretical Contributions:**Through the empirical analysis of the Xiaosongtao case, this study validates and deepens the analytical framework for housing justice that integrates three levels ("urban-community-build-

ing") and three dimensions ("distribution-procedure-recognition"). It explains the complex interaction and transmission mechanisms among various levels and dimensions of justice, providing a theoretical tool for understanding housing justice beyond a one-sided perspective. Concurrently, applying justice theory to the specific context of urban regeneration in China reveals its theoretical explanatory power and on-the-ground practice characteristics. It highlights the localised features of housing justice's realisation paths, core contradictions, and evaluation criteria within China's specific institutional background—characterised by strong government dominance, complex historical property rights structures, policy logics oriented towards "public well-being" and "harmony and stability," and a grassroots governance culture emphasizing collective bargaining. This contributes empirical evidence for developing a more inclusive and locally adapted justice theory for urban regeneration and echoes the literature's call for attention to specific justice practices in the Chinese context.

(2) **Practical Implications:**The Xiaosongtao project offers multiple insights for the regeneration of historic residential areas:For Policymakers: Recognise the systemic and hierarchical nature of housing justice in regeneration. Grant localities and communities greater practical flexibility under macro policy frameworks, establish smooth upward and downward feedback mechanisms, and seek a dynamic balance among multiple goals. For Planners and Architects: Integrate justice concepts throughout the entire design process. Assume multiple roles as spatial designers, technical supporters, and communication facilitators, respecting professional judgment while fully incorporating residents' "local knowledge". For Community Managers and Implementation Agents: Strive to build more inclusive, transparent, and influential platforms for consultation and governance. Fully harness the enthusiasm of multiple actors, emphasise procedural justice and the universality of outcomes, and pay attention to the integration and sustainable development of the renewed community.

4.3 Dilemmas and Challenge

The urban regeneration experience in Xiaosongtao, while offering valuable insights, also highlighted several persistent dilemmas and challenges inherent in striving for housing equity. Rigid urban-level historic preservation mandates, coupled with the financial pressures of project self-balancing, constrained the potential for enhancing distributional justice; "premium" improvements, necessary for some upgrades, remained a significant financial burden for certain households in need. Furthermore, while the "one household, one policy" approach aimed for tailored solutions, questions persist regarding its capacity to ensure substantive "equivalence" across diverse programs. In terms of procedural justice, although consultative mechanisms were established, residents' substantive influence was often confined to specific aspects of the project, seldom extending to core decision-making processes. Finally, the long-term realization of recognition justice—manifested in the sustained, effective use of community shared spaces and the genuine establishment of cultural identity—hinges on continuous, subsequent investment in community building and governance, the enduring effects of which are yet to be determined.

To address these limitations and to further advance the understanding of housing justice in urban regeneration, future research could be pursued along several key avenues. Firstly, conducting cross-case comparative studies is crucial to test the broader applicability of the analytical framework and to identify context-specific variables influencing equity outcomes. Secondly, undertaking long-term tracking and comprehensive post-renewal assessments will be vital to understand the far-reaching impacts of renewal interventions on housing equity and community well-being. Thirdly, there is a need to explore innovative mechanisms for promoting justice, including the study of effective pathways to enhance housing justice by integrating emerging governance tools and participatory approaches. Such research will be instrumental in developing more robust strategies for creating fairer, more inclusive, and sustainable living environments in the ongoing process of urban transformation..

In summary, the regeneration practice of Nanjing's Xiaosongtao Lane is a valuable attempt to explore housing justice in historical urban areas in China during a specific period. Its experience demonstrates that realizing housing justice is a process of multi-party participation, dynamic adaptation, and continuous improvement.

This requires ongoing exploration and optimisation of strategies based on respecting history, prioritizing public well-being, and balancing interests. Future urban regeneration practice and academic research should continue to deepen the understanding of housing justice's complexity. Particularly in China's unique socio-cultural and institutional context, the focus should be on how to construct more locally adapted paths to justice realisation, with a view to jointly promoting the creation of fairer, more inclusive, and more sustainable living environments.

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Transitional housing. Adaptive and Sustainable Design Strategies for Gaza Strip Reconstruction

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Abstract
This paper presents the experience of Università Iuav di Venezia as a consultant to UNDP/PAPP in developing design strategies for a transitional community neighborhood in the Gaza Strip. Recognising the complexity of the humanitarian crisis and the challenges posed by protracted and evolving conflict, the paper proposes an adaptive and replicable design framework. The strategy shifts from a rigid conventional top-down model to an adaptive, bottom-up methodology, introducing design processes guided by a cohesive urban vision. The strategy proposed involves an integrated and incremental set of phased interventions, implemented through a community-based and area-based approach. The outcome is a transitional community neighborhood designed to meet immediate recovery needs while facilitating long-term reconstruction efforts. The proposed transitional housing system provides a medium-to long-term solution, with the potential to evolve into permanent housing or public services according to contextual needs. Flexibility remains a core design principle, enabling site-specific urban configurations tailored to the distinctive characteristics of different locations within the Gaza Strip.

keywords: transitional housing; early recovery; community-based approach; sustainable reconstruction;

Introduction

The paper presents a transitional community neighborhood design developed by a joint team from the Università Iuav di Venezia[1] as part of a collaboration with the United Nations Development Programme / Programme of Assistance to the Palestinian People (UNDP/PAPP) – the UN Office established through the UN General Assembly Resolution 33/147 of 20 December 1978, which called upon UNDP to «improve the economic and social conditions of the Palestinian people [...]»[2].

Within this framework, Università Iuav di Venezia conducts research on planning and design strategies aimed at supporting UNDP through in-depth knowledge and on-the-ground experience in urban and territorial transformation processes, with a particular focus on post-conflict reconstruction. The results of this research, carried out by a team of researchers and expert consultants, were recently published in the book *Proactive Reconstruction* (2025), presented at the 2025 Venice Biennale of Architecture.

A recent follow-up phase of the research focuses on the development of a transitional[3] community neighborhood, conceived as a pilot project to test and verify design hypotheses related to technological solutions that enable high levels of flexibility, adaptability, and incremental development. The pilot project will act as a testing ground for fully constructed building elements, with subsequent possible large-scale applications.
The approach is intentionally tentative and empirical. The project remains open to plural design expressions, strongly shaped by the changing and evolving needs of different population groups. Thus, flexibility and adaptability are precisely the qualities that enable the project to integrate insights proposed by local communities, local authorities, and international non-governmental organizations. Implementing a pilot project is crucial, as it permits the testing of key assumptions and the rectification of any potential shortcomings.

The research aims to provide an alternative design to the prevailing standard of transitional sheltering response in emergency contexts. Currently, sheltering solutions are built within a short time frame and then rebuilt or upgraded multiple times on the same site due to the protracted nature of displacement situations and the delay in implementing formal reconstruction (Picker and Pasquetti, 2015; Agier, 2002). In contrast, our research introduces an alternative approach that starts with the construction of a structure capable of evolving over time: initially addressing urgent, short-term emergencies and progressively adapting to meet long-term necessities. The temporal dimension is inherent in the project's process-driven character.

This processual approach starts from the recognition of the impossibility of outlining a fixed design solution and rather embraces the role of the designer as a definer of spatial principles (Gregotti, 1966) and of urban metamorphosis (Albrecht and Benevolo, 1990; Benevolo 1996) within a range of infinite variations.

Given the geopolitical uncertainties in the Middle East and the ongoing devastation affecting not only the Gaza Strip but also parts of the West Bank – particularly within the Palestinian territories – identifying suitable locations for the placement of the designed units remains challenging. However, mathematical models, applied through

1 Namely, the Urbicide Task Force and C.SCARPA research centers (www.urbicide taskforce.iuav.it; www.iuav.it/it/strutture-e-reti-di-ricerca/centro-superiore-c.scarpa).

2 The UNDP Programme of Assistance to the Palestinian People, established under UN General Assembly Resolution 33/147 (1978), aims to improve the socio-economic conditions of Palestinians and support the establishment of a viable state capable of ensuring development and resilience. Key interventions focus on governance, enhancing justice, cohesion, and institutional reform; economic empowerment through sustainable, self-reliant poverty reduction; environmental improvements in water, services, and climate adaptation; and infrastructure development in energy, transport, housing, education, and healthcare for marginalized areas.

3 "Transitional housing or transitional community neighbourhood" generally refers to an intermediate housing or neighbourhood solution for displaced people between emergency shelter and long-term accommodation for displaced people, considering three different types of solutions at different times. In this paper, however, "transitional" is understood as a gradual process of stabilization—on the same structure from temporary shelter to increasingly stable—and as a potential transformation of these spaces into public areas and services following reconstruction.

automated and parametric approaches, can provide valuable support in planning reconstruction processes in advance, while anticipating issues related to urbanization dynamics.

Design choices are inherently influenced by the characteristics of the territory in which a project is located. These factors include topographical conditions, location, climate, economic factors, and larger socio-political dynamics. For example, to design interventions in the Gaza Strip today means responding to a complex web of regulatory, logistical, and material limitations, including above all the policies enforced by the Coordinator of Government Activities in the Territories (COGAT). Among its many roles, COGAT controls the flow of goods into Gaza, including construction materials labeled as "dual-use": items that could have both civilian and military applications, and are therefore subject to strict restrictions. This regulatory context became a key element of the transitional community neighbourhood. Materials have been selected not only for their capacity to be sourced and manufactured locally, as well as strengthening the local labor economy, but also because they comply with the restrictions imposed by COGAT. Therefore, constraints were reframed as an opportunity to introduce innovative, context-sensitive features into the transitional housing model. The design process must therefore remain context-specific, taking into account local conditions striving, as much as possible, for an adaptive design strategy.

Reconstruct in Uncertainty / A revised/An evolving approach to reconstruction
The research on the transitional community neighborhood is based on broader investigations conducted at Iuav since 2016, which has focused on methods and forms of urban and housing reconstruction following natural disasters or conflicts (Galli, 2024).

The comparative analysis of reconstruction processes, in both quantitative and qualitative terms, has provided valuable benchmarks for refining future reconstruction patterns. However, the unprecedented scale of current destructive phenomena calls for innovative solutions capable of putting past lessons into practice.

In fact, we are witnessing a substantial change in the form of conflict, or of perpetual instability (non-peace), which sees a progressive increase in the involvement of civilians, both victims and targets, compared to the past. The consequence is that cities have become the preferred battlefields, and their destruction, via ground or air, has become a primary strategic goal for military and political purposes.

This condition leads to the reemergence of the term "urbicide" in urban discourse, defined as the deliberate violence against cities, their destruction, and the intentional elimination of physical space, collective memory (Caro, 1974; Bogdanovic, 1993; Ribarevic-Nikolic and Juric, 1992; Graham, 2005), as well as the displacement, fragmentation, or erasure of the communities that inhabit them.

When comparing these past events with the current situation, it is important to note that historical urban reconstructions, particularly those following World War II, typically occurred once a period of pacification had been achieved. While the planning for reconstruction often began and even progressed during wartime, with a prime example being the drafting of the London Plan developed while London was experiencing significant bombing from the Blitz, the actual rebuilding largely commenced after hostilities ceased.

Unlike past eras, the persistent and ever-changing nature of contemporary conflicts means that planning for reconstruction solely after peace is secured is no longer a viable approach.

Gaza, sadly exemplifies this reality. If the conflict is viewed not solely through the lens of the most recent war between Israel and Hamas, but rather as an escalation within the broader Israel-Gaza conflict, or even as a phase of the ongoing Israeli-Palestinian conflict, its implications become more evident. As a result of this protracted violence, eight United Nations Relief and Works Agency (UNRWA) refugee camps were established in the Gaza Strip, most of them between 1948 and 1952, following the 1948 Arab-Israeli War.

In the face of this protracted conflict (Azar *et al.*, 1978), the fundamental assumptions for both an emergency-type response and traditional reconstruction efforts no longer hold true. Protracted displacement and extended stays in refugee camps have marked the failure of emergency-oriented responses, leading to various forms of waste from social, environmental, economic, and urban perspectives.

At the same time, traditional top-down reconstruction efforts do not meet the circumstances needed for success, due to both the geopolitical uncertainty required to ensure the viability of such operations and the exceptional scale of destruction of the urban fabric.

We therefore advocate an alternative reconstruction approach - one that does not forgo a long-term perspective - while enabling rapid interventions, based on updated data, guided by parametric calculations, and that is capable of adapting to unforeseen changes.

Data-driven Approaches to Urban Recovery in Conditions of Prolonged Uncertainty

In response to these complex challenges of post-conflict reconstruction under conditions of prolonged uncertainty, a new methodology has been evolving — one that advances the integration of parametric design logic within spatial data infrastructures to support real-time, evidence-based urban recovery. This approach reflects a broader trend in urban planning toward computationally enhanced decision-making, in which geospatial technologies and algorithmic models are employed to simulate, evaluate, and iteratively refine planning strategies in dynamic, data-intensive environments (Batty, 2013). These tools provide a rapid and objective means of supporting complex decision-making processes. While they cannot substitute for on-the-ground surveys, they offer valuable insights during the earliest stages of response. These systems are increasingly able to synthesise heterogeneous datasets, from satellite imagery and cadastral maps to demographic surveys and on-the-ground observations (when available), into coherent and actionable spatial intelligence. Within this context, two computational modules were designed and tested to support recovery planning through a structured, data-driven methodology. Specifically in the Gaza Strip — one of the most severely impacted and densely populated crisis regions — these tools provide a valuable framework for planning amidst extreme infrastructural devastation and persistent geopolitical volatility.

The first — the Land Selection Module — is a powerful analytical tool designed to identify appropriate sites for transitional shelter and the relocation of displaced communities. It is grounded in physical and social recognition processes, implemented through a complex, multi-level evaluation process. At the physical level, the module operates at the urban scale to assess damage severity using high-resolution satellite imagery and orthophotos. This analysis is based on a standardised classification system applied to a 250-meter grid, resulting in a damage-density matrix that ranks areas according to the extent of destruction and the concentration of affected populations. The results are then cross-referenced with land ownership information—specifically prioritising public or semi-public lands, such as government or *waqf*[4] parcels, to identify legally and procedurally viable sites for immediate intervention. From a social perspective, the module incorporates principles of community attachment by prioritising areas that allow displaced populations to return as close as possible to their original homes. The main objective is to preserve existing social relationships and support the stability of cultural and communal life. The result is an interactive heatmap that highlights and ranks potential intervention areas according to socio-spatial relevance toward a recovery-oriented planning strategy.

The first simulation was performed using only two space layers: damage assessment and land ownership. Although these serve as a solid starting point, a more accurate and better-adapted application would require

4 According to Muslim law, *waqf* refers to the act of relinquishing the benefits or income derived from an owned asset, so that it can be used for a good cause or public benefit. The person who makes the *waqf* retains legal ownership of the asset, but its use is permanently dedicated to a charitable purpose. The asset, often land or property, cannot be sold or inherited once it becomes *waqf*, even though it still legally belongs to the person who made the donation. David Santillana, *Istituzioni di diritto musulmano malechita*, Roma, Istituto per l'Oriente, 1938, II, pp. 412–451.

additional spatial variables. To name just a few: proximity to functioning or partially damaged infrastructure, access to public services, or buffer zones from the Israeli-controlled border could drastically improve the accuracy of the outcome. A key feature of the module is its capability to apply different weights to the chosen parameters and sub-criteria, enabling decision-makers and planners to adjust the influence of individual parameters according to shifting operational conditions or specific planning agendas. This flexibility preserves the entire tool's applicability despite political and humanitarian uncertainty while maintaining a data-driven approach and strategic consistency.

Based on these outputs, the second module — the Neighbourhood Simulation Module — enables the investigation of context-driven sheltering solutions. Instead of forcing a single solution on all, it provides an opportunity to test a variety of spatial typologies: modular units, tents, prefabs, caravans, etc, despite the constraints and possibilities of a given site. This module supports quick and easy comparative analysis of planning scenarios based on a multi-criteria assessment, in order to identify the most sustainable and operationally feasible spatial configuration.

The two modules provide a flexible yet methodologically rigorous technological infrastructure that can easily adjust to shifting conditions and still remain consistent with long-term strategic goals. More than technical instruments, the Land Selection and Neighbourhood Simulation modules are "knowledge systems"—translating uncertainty into an organised, transparent, and public urban reconstruction procedure.

In addition to simulating initial emergency responses, it would be beneficial to implement the platform for the reconstruction and development phase, too. By adjusting data and criteria, it can serve as a valuable tool for coordinating all actors involved in reconstruction. It can function as an open online space accessible to a variety of users and be user-friendly, including the local population with whom programmatic decisions can be shared, donors to ensure transparency of funds, as well as technicians and researchers.

A Bottom-up Strategy

The coordination of reconstruction efforts becomes a crucial dimension of the process. While parametric tools can significantly support such coordination, what can truly shift the paradigm is, above all, an approach grounded in small, self-contained units, whose aggregation will ultimately lead to comprehensive reconstruction. For this reason, the luav design strategy—an alternative to standard emergency strategies—advocates for a bottom-up approach composed of small-scale interventions applied at both the architectural and urban scale.

At the architectural scale, transitional community neighborhoods are conceived as pieces of urban fabric designed to host small communities. These neighborhoods are initially composed of housing units, each hosting around 12 people and arranged along a main street. Gradually, an increasing number of housing units expand around the existing structures, extending onto contiguous plots of land.

At the following stage, some rooms of the housing unit can be reconverted into public facilities such as markets, taking advantage from the facing on the street frontage. Gradually, other houses can be converted at the ground floor into public facilities such as schools or small clinics, while inhabitants relocate to upper levels. The ground floor of the building can thus evolve over time, scaling its equipment and facilities to the community's needs.

Different communities may inhabit different transitional community neighborhoods, constructed in parallel. The overall process resembles, in fact, the development of multiple pilot projects; rather than the execution of a single, unified plan, resulting in a potentially heterogeneous outcome.

The strategy adopts a bottom-up approach, conceptualized and implemented directly with and by the local community. It emphasizes the self-organization of a local workforce, positioning community members as active agents in the reconstruction process through participatory design mechanisms (Lozano, 1990). This method

seeks to respond to the needs and aspirations of local populations by fostering inclusive and context-sensitive planning.

The incremental and evolutionary structure is not designed for unlimited growth. There is, in fact, an optimal dimension, an urban and human scale, that limits the growth of the neighborhood. The optimal dimension has been researched over time by architects and planners, and almost all agree that the neighborhood should extend at a maximum of 500 meters in radius, conferring on the neighborhood, or cell, a walkable scale (Piacenti, 2024).

At the urban scale, the strategy envisions a cellular pattern made of neighborhood or urban cells, a constellation of small or micro cities, defined and polycentric multifunctional units, interspersed within green and productive zones, with a certain degree of autonomy and capable of mutual interaction. This configuration can be reached through an area-based approach that focuses on a specific, defined geographic area as the primary unit for planning, implementation, and coordination, rather than focusing solely on specific sectors (such as health, education, or transportation). It is a decentralization strategy of financial resources and infrastructure that enables simultaneous interventions across multiple areas, thereby optimizing the use of time and fostering more rapid recovery and reconstruction.

The bottom-up approach attempts to go beyond the standard and common reconstruction process, which operates by layers and delegates or assigns to specialized offices the planning of a specific area of expertise (e.g., health or education, or roads).

In the complex society of our contemporary era, it is necessary to work on approximation and uncertainty, making it preferable and safer to experiment on a small scale rather than to reason on the understanding of increasingly unpredictable global phenomena. The approach functions as a dynamic design system, intended to manage urban transformation through the deployment of specific components that catalyze positive environmental change. It acknowledges the necessity for ongoing adaptation and refinement in response to external pressures and evolving conditions.

Permanent Temporariness: Transitional Housing

Within this broader framework of dynamic urban transformation, transitional housing emerges as a key field for experimentation and innovation. It marks a significant paradigm shift from the conventional emergency shelters typically used in post-conflict contexts[5]. First, the structure is designed to maximize flexibility to accommodate different unit sizes, housing options, and functional uses (Figure 1).

Units can consist of one or two floors (in accordance with adopted technological solutions) and adjusted to meet the needs of single or multi-generational families. A comparative analysis between transitional housing solutions and traditional shelters reveals that, at an early stage (t), the accommodation capacity of both types can be equivalent. However, considering an evolutionary time frame (t), while conventional structures tend to maintain an unchanged number of inhabitants, the modules proposed by our research demonstrate greater flexibility and adaptability. These allow for a potential increase in the accommodated population, responding dynamically to any new or different needs of the settled population. The housing module is conceived according to a principle of incrementality, so as to allow progressive adaptation to the housing needs of the families welcomed in the emergency phase, foreseeing the possibility of elevation to accommodate new members and support the natural evolution of the family unit.

According to the most recent data (2024) from the Palestinian Central Bureau of Statistics (PCBS) on household composition, the average size in the Gaza Strip was 5.3 people. The predominant type of housing across the five governorates (Gaza, North Gaza, Khan Yunis, Deir al-Balah, and Rafah) revealed that the apartments were the most common, accounting for 77.8% of all households. This was followed by independent houses (21%), villas (0.2%), and other types, such as independent rooms, tents, caravans, or barracks, which together accounted for

5 see: Corsellis, T., & Vitale, A. (2005). Transitional Settlement: Displaced Populations. Oxfam GB.

around 1% (based on 2020 data). In 2022, the PCBS recorded an average of 3.5 rooms per housing unit and an average occupancy of 1.7 people per room; however, a significant proportion—ranging from 36% to 40%—lived in dwellings with more than two people per room. The most severe overcrowding was observed in independent rooms and unconventional housing, where over 60-70% of families lived with more than three people per room.

In the 2024 annual report published by PCBS, most households in Gaza are identified as nuclear families, typically consisting of parents and children, but a significant portion are extended families, often including grandparents, uncles, and aunts, due to social traditions and economic necessity. A growing number of female-headed households has been recorded, particularly following the 2023–2024 escalation and the loss of male breadwinners. Displaced households have become increasingly common, often consisting of merged or recombined family units living in temporary shelters or host families' homes (PCBS, 2025).

As previously mentioned, the project is based on the principle of incremental flexibility. This applies not only to the speed with which it responds to the housing emergency but also to its ability to adapt over time to the community's future needs as well as the entire population. For example, structures designed with a modular system from the outset can be converted into public spaces to serve the community. Thanks to their modularity and reversibility, the housing modules can be repurposed for different functional configurations, even for public use, such as clinics, classrooms, market spaces, and other urban services.

A further key element characterizing the project proposal regards the courtyards (both private and public) that increase the quality of life for the inhabitants and provide outdoor spaces for meeting and conviviality that are usually lacking in standard housing solutions. Courtyard buildings, in fact, ensure high-quality space and climatic performance. Roofs are also a potential advantage: initially configured as mere roofs, they can be imagined as terraces providing each unit with a private outdoor space.

The mentioned adaptability and incremental nature of the project concern not only the capacity to respond to changing housing needs or to allow for future reconfigurations, but also the construction process of the housing modules. The building structure is conceived according to a multiscalar and incremental ratio, and takes the form of a frame structure enclosed with lightweight walls, such as fabric or tarpaulin walls, that, in an emergency phase, can immediately provide displaced persons with safety and protection from the elements.

In later stages, the progressive integration of more stable building components, such as prefabricated panels instead of tarpaulin walls, allows the structure to evolve, challenging the notion of the city as a stable and permanent entity. The phases of emergency and reconstruction follow one another seamlessly.

Future reconfigurations are permitted and guaranteed by the adoption of off-grid technologies such as waterless WCs, solar and photovoltaic panels, and rainwater harvesting.

The adoption of these off-grid systems eliminates the need for extensive underground infrastructure and, more importantly, significantly increases the flexibility and reconfigurability of spaces for various functions beyond just housing. This is because it removes the constraints imposed by traditional plumbing stacks, drainage columns, and other fixed utility connections.

Currently, some of these systems are expensive, especially their more advanced versions. However, it's also true that substantial investments from various actors are typically available during the initial construction phases of refugee camps. Furthermore, the larger the scale of intervention, the more accessible these new technologies become. Therefore, new refugee camps could be transformed into experimental laboratories for innovative and low-energy impact technologies.

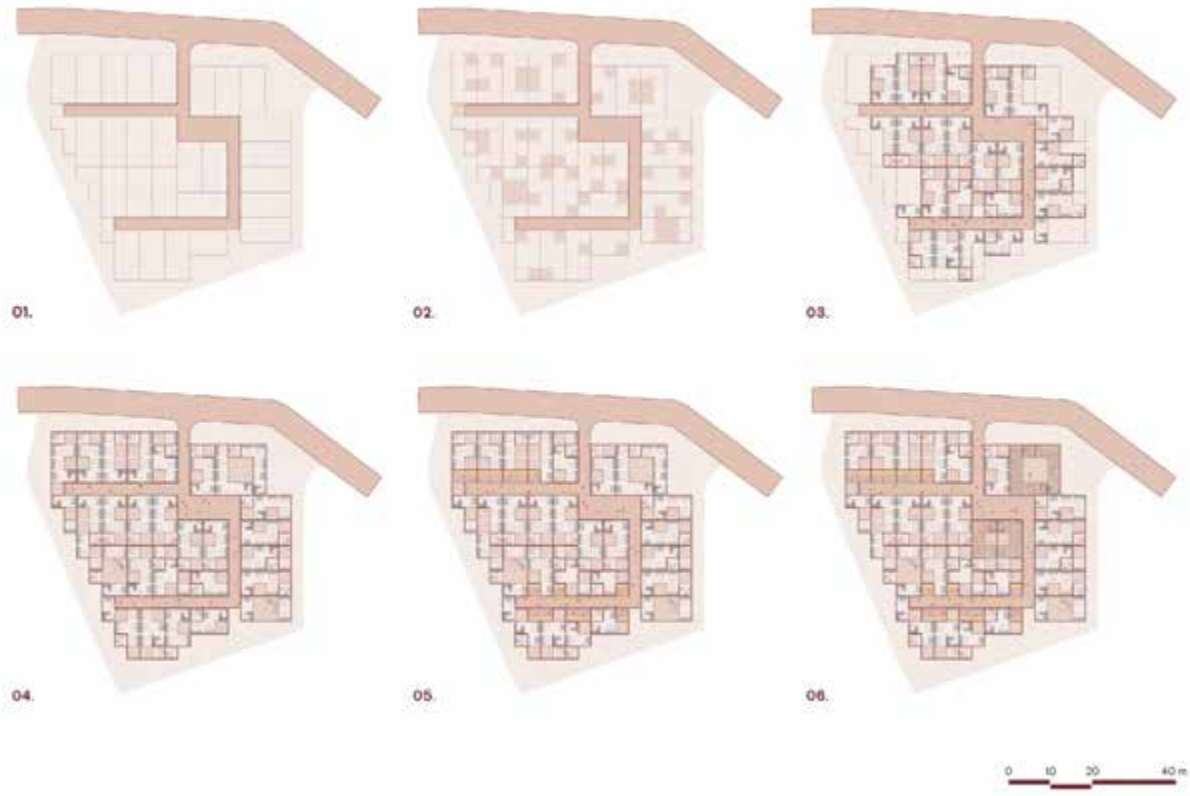

Figure 1: Transitional community neighborhood implementation process: 1) Plot definition; 2) Open space definition; 3) First housing units; 4) Housing unit development; 5) Markets; 6) Facilities.

Transitional Housing as an Alternative to Refugee Camps

The transitional housing approach offers several advantages compared to the current model of standard refugee camps. Originally conceived as temporary solutions for accommodating displaced people during emergencies, refugee camps tend, as a matter of fact, to assume a long-term character and frequently evolve into stable communities that increasingly reflect urban contexts, far exceeding their intended function (Picker and Pasquetti, 2015). Over time, these refugee camps have transitioned from tents or emergency shelters to more permanent structures, often built with concrete and steel. Examples include Dadaab in Kenya, Cox's Bazar in Bangladesh, and several Palestinian Refugee Camps established in Lebanon, Jordan, Syria, the Gaza Strip, and the West Bank in response to the 1948 exodus (*Nakba*). This physical and spatial consolidation reveals the inefficiency of prefabricated shelters—which are designed for short-term use but have been inhabited for decades—and the gradual deterioration of the living conditions of refugees. Moreover, camp growth and development usually occur spontaneously. Camps are therefore disorganised and fragmented in terms of services and infrastructure as demonstrated by the case of the Zaatari refugee camp, which has expanded over a period of thirteen years to become a complex community with its own social, economic, and urban characteristics, but also with important management problems (wastewater, electric grid, etc.). These examples demonstrate the importance of accepting indeterminacy and adopting principles of flexibility in designing resilient communities. Michel Agier's notion of "city-camps" (Agier, 2002) aptly captures this transformation, emphasizing the convergence between camps and cities. Nevertheless, refugee camps continue to be conceived primarily as provisional spaces for humanitarian intervention by international organisations, failing to adequately engage with their long-term urbanising dynamics. According to the 2005 UNHCR *Handbook for Planning and Implementing Development Assistance for Refugees Programmes*, planning is categorized into three distinct phases: "short-term humanitarian

and transitional planning," "multi-year development planning," and "macro-policy and global development." However, these phases are often treated as separate frameworks with discrete objectives, whereas, in practice, the processes of emergency response, recovery, and long-term development tend to overlap and evolve fluidly over time (Duffield, 2013). In this context, time emerges as the critical factor shaping the consolidation and normalization of what were initially intended to be temporary emergency camps.

In contrast, the transitional housing approach avoids land waste, allowing for integration with the existing urban fabric and helping to prevent sprawl and uncontrolled expansion.

It also offers advantages from a social point of view, involving refugees as active participants in the reconstruction process by building their own homes or working for construction companies and material production factories; after an initial phase of assistance, they can become productive members of society. At the same time, it creates jobs and employment opportunities for local people, contributing to the revitalization of the local economy. Additionally, transitional housing is a more economically competitive alternative to refugee camps because the short lifespan of prefabricated shelters contrasts with the prolonged duration of many camps. This discrepancy can lead to significant savings in resources and costs.

Given that refugee camps tend to last for several decades, and given the possibility that their structures may be transformed to meet new needs, one of the fundamental aspects concerns land ownership issues. If the neighborhood cannot be established on public land, it is necessary to adopt a system that ensures the protection of pre-existing property rights both during the transitional phase and in the subsequent phase of consolidation. In addition to official documentation regarding land ownership, local practices and any forms of collective or communal land use must also be taken into account in order to ensure fair treatment of the rights of both refugees and landowners.

Incremental Housing Prototype

In post-conflict reconstruction, the selection of appropriate technologies addresses complex challenges involving social, economic, technological, and logistical aspects. Resource scarcity–especially the limited access to construction materials, energy, and water–hampers rebuilding efforts. In the context of Gaza, these issues are intensified by COGAT's policy regulation of the entrance of all goods into the Gaza Strip, including items designated as "dual-use." The list includes items that are broad categories, further constraining reconstruction. Therefore, the search for alternatives strongly depends on specific constraints, in addition to a relief analysis of the area, a market analysis, and a review of administrative and organizational factors that affect the accurate choice of technology.

Emerging research highlights the potential of lightweight, modular materials that are easy to transport and assemble. These alternatives offer a flexible, cost-effective response suited to unstable environments and limited industrial capacity, providing a promising pathway for sustainable reconstruction in constrained and ever-changing settings (Johnson, 2007; Caron and Kelly, 2008).

The layout of the transitional community neighborhood is based on a regular structural bay of 3 meters (Figure 2). The modular, point-based structure allows for the expansion of units in both directions.

The standard residential unit measures 6 x 12 metres and comprises six 3 x 3 meters rooms and 18 square meters of open space, distributed in one or two courtyards. The structural frame is designed to accommodate up to two levels, hosting up to 12 people.

Given the regular structural frame, it is possible to divide or combine multiple housing units to meet diverse needs. This flexibility addresses situations like overcoming an emergency, which requires an increase in per capita living space, or accommodating growth in family size.
The structure is able to expand and transform in response to territorial specificities and social dynamics, acting

as a generative matrix of a new urban model. Designed according to an incremental and multi-scalar logic, the structure is configured in the early stages of recovery as a light device and then evolves into a more stable and permanent structure in the subsequent phases.

This standard layout enables high residential density, required by the densely populated environment, recognizing an increased value for open space. Moreover, it shapes an introverted urban form, which is not new in the context of the Arab city. Historically, organic growth and gradual transformation have characterized cities in this region. As happened 1.000 years ago, we imagine that this process of growth can gradually reshape the geometric urban fabric of the new city to the point of totally camouflaging the new structure on the historical built environment. The simple structure can morph into a city, temporally articulating the space.

There is quite a bit more to these processes than simply a change in physical form and urban morphology. Unimagined uses and patterns can arise in dense urban conditions.

Urban design can be adapted to the specific characteristics of each site and replicated across various areas in the Gaza Strip or other territories, generating site-specific urban configurations, a city that builds and regenerates itself.

At both scales of intervention, the strategy is incremental. This means that the risks of incorrect development forecasts are minimized, ensuring the functioning of the urban cell or a small residential neighborhood at every stage of its evolution.

Figure 2: Plan of incremental housing aggregation example.

Fiberglass Technology

To support this incremental approach, the choice of construction technology plays a pivotal role. The structure proposed is based on the use of lightweight fiberglass, which fulfills two key functions: it enables rapid construction within a timeframe comparable to early recovery interventions, while providing housing units with the lifecycle of a permanent building and dignified living conditions (Figure 3).

We can compare the current proposal with two different alternatives: prefabs (including C-boxes, readapted containers, modular housing units, etc.) and recovery using traditional technologies (concrete structures with brickwork). Prefabs can be bought on the market and installed easily and quickly on-site following approval. They have an estimated cost of around 2450-400 dollars per square meter, but come with a limited lifecycle (from 5 to 15 years of expected life). At this stage, plans for their disposal and replacement with more permanent solutions cannot be made. Prefabs also do not provide high-quality space, either in terms of private living space or public space. These solutions are not particularly suitable for the climate (corrosion, heat, etc.), and sometimes require shared facilities such as kitchen and bathroom services. Traditional technologies have limited feasibility of implementation in the short term due to materials shortages (concrete, iron, etc.), restricted site access, and unclear property definitions. In the longer term, the use of traditional technologies will face further limits due to the necessity of heavy machinery (cranes, mixers, etc.) and the high water consumption.

The advantages of fibreglass can be grouped into seven principal categories: flexibility, effortless construction, efficiency, durability, feasibility, collective engagement, and convenience.

The fiberglass structural design is inherently modular and scalable, enabling it to accommodate a wide range of unit sizes, residential typologies, functional programs, and user modifications. Both public and private spaces are conceived as multifunctional and temporally adaptable, allowing customization based on evolving needs and available financial resources, including materials, finishes, and technological solutions.

The construction methodology prioritizes simplicity and speed. Fiberglass structures can be assembled rapidly without the use of cranes or heavy machinery and, in many cases, without the need for preliminary site leveling. Selected components can be preassembled to further accelerate on-site construction, making the process more accessible and feasible even under resource-constrained conditions. The system is designed for deployment using unskilled or semi-skilled labor, fostering inclusivity and enabling community-based implementation. Moreover, the use of lightweight materials facilitates easy disassembly, relocation, and reassembly, thereby extending the functional utility of each structural unit.

In terms of efficiency, the project could offer housing with superior acoustic and thermal insulation, anti-seismic structures, and sustainable features like rainwater collection and renewable energy supply. Its layout ensures security, privacy, and comfort, while courtyard buildings enhance spatial quality and climate performance.

The use of fiberglass components — characterized by a lifecycle of 25 to 30 years — elevates the typology from temporary shelter to semi-permanent housing. This shift redefines the concept of transitional housing by embedding longevity and sustainability into its core. Involving local people in designing and building temporary housing not only aligns with local needs and preferences but also fosters a sense of ownership and place. Furthermore, components are reusable, recyclable, and integrated into new life cycles, reducing material waste and environmental impact over successive housing cycles.

The project complies with the regulatory framework of COGAT and leverages construction materials that are readily available on local and international markets. This ensures ease of implementation within existing legal and logistical constraints. The structural materials are readily available on the market and could be produced locally in a second phase. The potential for local production in later phases further enhances economic sustainability. While fiberglass is the preferred material for the pilot phase, alternative materials such as steel, concrete, and recycled rubble may be employed to suit contextual and economic variations, thus increasing the adaptability

and scalability of the project.

The construction of temporary housing generates new skills through training and employment opportunities for local people. Community participation is central to both the design and implementation processes, ensuring that the final built environment reflects the lived experiences, cultural practices, and aspirations of its users.

From an economic perspective, the long lifespan of fiberglass structures makes them a cost-effective solution within a long-term planning framework. Although the pilot phase exhibits a higher cost per square meter due to limited-scale production, this figure is expected to decrease significantly in full-scale deployment scenarios, where economies of scale can be leveraged. Indeed, considering the entire life cycle, the proposed solution offers clear advantages in terms of cost. The prefab modules most commonly used for the construction of refugee camps have a service life of approximately fifteen years, according to technical documentation provided by the manufacturers. However, as early as the third to fifth year after installation, these prefab units require significant maintenance interventions, primarily due to water damage. The most frequent repair works concern roofs, which are damaged by rain, as well as the flooring and walls, which deteriorate due to heavy use and rising damp. The proposed solution involves the use of materials with significantly greater durability. Although this requires a higher initial investment, it ensures a lower overall cost when the full life cycle of the shelter is considered.

Moreover, the holistic inclusion of both private and public covered spaces in cost assessments underscores the project's value as a complete urban system rather than a collection of discrete housing units.

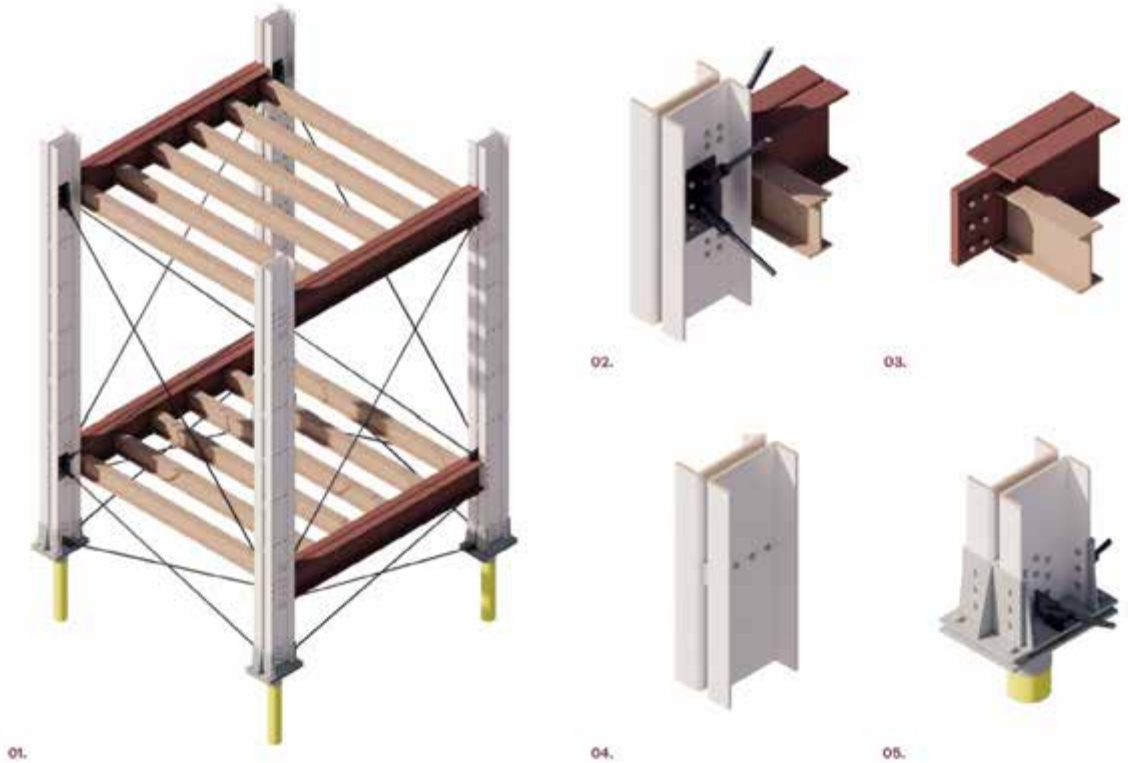

Figure 3: Transitional housing structure and details: 1) Pultruse Structure; 2) Main beam and column connection; 3) Secondary beam connection; 4) Spacer plate between columns profiles; 5) Column base plate;

Designing for Transition in an Age of Instability

While awaiting reconstruction for the Palestinian population, the reasoning developed for the specific case of the Gaza Strip can be projected to many other contexts and situations. The possibility of replication appears evident in all other contexts of post-conflict reconstruction, as low-level, low-intensity, persistent conflicts are increasingly envisioned to be the pattern of the future (Kaldor, 1999).

Currently, 56 armed conflicts are underway in the world: the Myanmar conflict, the insurgency in the Sahel, the Sudanese conflict, the Russo-Ukrainian War, and the Ethiopian civil conflict, to mention the major ones. Overall, the ongoing conflicts involve 92 countries – almost half of all countries worldwide – and have displaced over 100 million people.

Increasingly, violence is directed against civilians, and the scale of forced population displacement per conflict is increasing.

Beyond refugees, there are many other categories of people involved in displacement dynamics and unstable contexts. This includes migrants, as well as residents of areas facing pressures such as climate change, social issues, extreme urban and demographic growth, inequalities, criminality, and inadequate urban planning (Albrecht and Galli 2023).

All these pressures challenge permanence as a default condition for cities. This open-ended time of modes of living needs a design. It is thus imperative to think about inhabiting as a fact of transition and subject to change, and to plan the process and forms of its implementation.

The combined impacts of conflict, disaster, climate change, and social and economic pressures paint a difficult scenario for "our common future"[6] and call for a transition to new models capable of transforming this overwhelming sum of pressures into design factors. Urban areas are at the center stage of such a transition, being at the same time the areas most responsible for the current risks (70 percent of global emissions, 50 million urban inhabitants involved in war, a projected 216 million climate migrants), those benefiting from the current paradigm (50 percent of the global GDP comes from 380 cities, 83 percent of scientific products and patents), those more involved by future modifications (sea level rise alone will threaten 800 million people by 2050), and are, quite possibly, a significant part of the solution.

In conclusion, these arguments move beyond business-as-usual intervention protocols and offer an updated approach to early recovery and reconstruction. This approach emphasizes temporariness as a core design factor, without abandoning design practice and the pursuit for an urban form, even amid the uncertainties of habitation duration.

Acknowledgments

The reasoning presented in this article is the result of research applied to the specific case of Gaza, developed through the collaboration with UNDP/PAPP. This partnership provided access to various working and study materials, including existing plans, ongoing plans, as well as data on refugee camps developed by UNHCR, and also facilitated connections with NGOs, local technicians, and local authorities.

The ongoing collaboration between PAPP and Iuav facilitates an iterative refinement of the strategy through continuous engagement with a broad range of stakeholders. This process ensures contextual relevance by incorporating feedback from institutional partners and external experts. Developed jointly with UNDP/PAPP, key national institutions, and specialized consultants, the project embodies a dynamic and participatory approach, characterized by ongoing consultation and stakeholder involvement.

6 Gro Harlem Brundtland, "Our Common Future: Report of the World Commission on Environment and Development" (United Nations, 1987).

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Planning for Compact Cities: The Interplay of Housing Provision and Urbanisation[1]

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Abstract
Due to its role as a major driver of urbanisation, housing provision should be given significant attention in contemporary debates on compact urbanisation policies. However, housing systems' relationship with planning is often opaque, characterised by informal institutions and planning practices. We discuss the opportunities provided by housing system theory concepts – particularly the housing provision chain – as a powerful aid in analysing public action in planning and the resulting modes of urbanisation. We provide the case of Croatia to demonstrate the ways in which the trajectory of the housing system influenced and was influenced by spatial planning practice, and how it can account for apparently paradoxical and unsustainable urbanisation outcomes, hinting at the potential of housing policies to achieve compact urbanisation objectives.

Keywords Housing Systems; Housing Provision; Spatial Planning; Croatia; Planning practices

1. Introduction

Recent policy discussions at the level of the EU and some of its member states on the introduction of quantitative targets to contain land take (ESPON, 2024) appear to loom over another great European challenge – that of housing affordability. Questions are being raised over the way housing provision will be impacted by and respond to restrictions in the supply of developable land (Evers, Katurić and Van Der Wouden, 2024). These discussions present an opportunity to rethink the ways in which housing provision, spatial planning, and the resultant modes of urbanisation are interlinked and to sharpen our conceptualisations of their mutual relationships in different characterised by diverse planning and housing systems.

The concern with land take and soil sealing and the policy initiatives such as "no net land take" originate in environmental policy, but strongly impact spatial planning (Tennekes and Evers, 2024; Evers, 2025)the European Union has affected spatial planning in the member states through its environmental policies. To investigate the mechanism by which EU policy becomes joined up to spatial planning, we invoke the concept of 'coupling' from systems and organizational\nscience. We show that coupling is established not only at the EU policymaking level (e.g. within a directive's text. Spatial governance and planning authorities - whose practices are in often oriented toward growth - will increasingly need to adapt their practices to promote more compact urbanisation. A great deal of spatial planning researchers and professionals may share this ambition, as the concerns with social, economic, and environmental costs of "urban sprawl" and the benefits of compact urban planning are widespread in planning literature. However, achieving these ambitions in practice is all but simple.

Firstly, taking stock of all relevant drivers influencing the demand for and supply of developable land is made difficult by their multiplicity and heterogeneity. Some drivers can be directly controlled by public policy; a part of those are accounted by spatial planning policy (zoning, urban regeneration), but decisions impacting these drivers are also made in other policy sectors, which may not be well-coordinated with spatial planning – for instance, transport infrastructure, public transport, agriculture, property taxation, territorial governance and inter-municipal competition. Some drivers cannot be directly controlled by legislation and regulations, and those

1 The abstract was originally submitted with the title "Homeownership and Urban Sprawl: Spatial Planning in Croatia's Post-Socialist Housing System"

include demographic changes, dynamics of the economy, and preferences of consumers and enterprises (Colsaet, Laurans and Levrel, 2018).

Secondly, spatial planning inevitably involves trade-offs between competing claims on the use of limited space. Different economic and policy sectors require land to operate, and spatial governance and planning has the final, formal say on what land is allocated to which use. As part of its broad overview of the sustainability of urbanisation in Europe, the ESPON project SUPER (2020) conceptualised these concerns as trade-offs between the three dimensions of sustainability – social, environmental and economic. In the report, three ideal-typical modes of urbanisation[2] – compact, polycentric and diffuse – were weighed against each other along the dimensions of sustainability. To take the example of housing, as one of the sectors which compete for land, SUPER's assessment found that urban containment policies, theoretically, cause housing prices to rise as land supply is decreased, which could negatively affect social sustainability due to reduced affordability. However, compact urbanisation contributes positively to other aspects of social sustainability, such as more equitable spatial distribution of public services, as well as environmental and social sustainability through several mechanisms (e.g. by preserving ecosystems in unbuilt areas or contributing to agglomeration economies). Conversely, diffuse urbanisation could positively contribute to housing affordability, while negatively impacting many aspects of the social, economic, and environmental dimensions.

To understand why planning systems produce certain modes of urbanisation, one should ask how these trade-offs are managed in practice in a particular context. European spatial governance and planning systems exhibit significant variation in their capacities to control spatial development, in formal tools which they use to regulate urbanisation, in levels of flexibility and certainty, and in the less formal practices and institutions through which they operate. (ESPON, 2018; Berisha et al., 2021, 2024), as well as in the relationship between spatial planning and property rights (Hartmann et al., 2025). Trade-offs are made most explicitly in planning systems traditionally seen to belong to the comprehensive integrated family, but they are also, naturally, made in other systems, where the influences of different policy areas and the rationales of trade-offs may be less explicit.

Especially the latter group of cases, turning the researcher's attention to these practices and informal institutions would lead to enhanced understanding of the planning system's operation – knowledge which may pay off by helping to design more effective policies. Aspirations of planners and policymakers often run afoul of the institutions in which they operate (Dembski, 2025). New regulations designed to boldly alleviate systemic issues are put forward with normative optimism, only to find that "changes in planning law are unsuccessful if they are not congruent with informal and formal institutions at the 'street-level' and if there is a lack of sufficient incentives to change the behaviour of local actors." (Buitelaar, Galle and Sorel, 2011, p. 928). If newly introduced compact city policies are to avoid that fate, their design should be more grounded in the qualitative understanding of institutions. The SUPER report conceptualised varied planning systems as a "black box of local practices," which, in a particular territory, "converts" land supply and demand into specific urbanisation outcomes through its decision-making process. Understanding, conceptualising, and empirically studying planning systems entails prying the lid off the "black box" to reveal the formal and – crucially - informal institutions which determine how trade-offs are made in a particular context and which may make or break attempts at policy reform.

In this paper, we argue that this should be done to qualitatively understand the relationship between planning and housing provision. Housing is a major driver of urbanisation, which is why it is important to understand how it factors in planning trade-offs in different territories. The answers are invariably very far from the simplistic relationship between housing land supply and demand. To begin the analysis, we start with the postulates of housing system theory, a well-developed body of work that explores the ways through which housing is embedded in wider welfare regimes. Specific relations between the state, market and family - which form deep-seated, structural factors in a society – condition particular systems of housing provision. They are composed of varied

2 Instead of *urban sprawl* or *land take*, the authors of SUPER use *urbanisation* to refer to the expansion of built areas. As a more analytically precise term unburdened by negative connotations, it facilitated the multi-dimensional evaluation undertaken by the project. Our paper adopts this terminology.

arrangements between land supply, the scale at which housing is produced, the profit regime of developers and builders, modes of public value capture and opportunities by actors in housing provision to extract developer gain. Conceptualised in this way, the components of housing provision clearly hold great relevance for planning and modes of urbanisation. Spatial governance and planning tools in a given system enable or inhibit the forms which various dimensions of housing provision will take, and, conversely, planning systems and their tools are shaped by the broader housing system. Modes of housing provision are central to housing system literature and its classifications of housing systems, but explicit links between housing system theory and the form of urbanisation to which it housing provision is inextricably tied remain underexplored.

We argue that there is potential in applying housing regime theory to spatial planning as a way to explicitly conceptualise those planning practices and institutions that often work in a hidden way, sometimes producing counter-intuitive outcomes and frustrating attempts at reform – such as the turn to more compact and resource-efficient urbanisation. The next section seeks out the links between housing and planning systems, after which those links are examined empirically in the case of Croatia, where the transformation of the housing system since the 90s produced changes in the prevailing modes of urbanisation, leading to pervasive diffuse development, contrary to stated objectives of national policy.

2. Housing system theory: exploring the links between housing provision, spatial planning and urbanisation

Housing system theory has been developed since the 1990s as a response to the limitations of earlier comparative housing research. At the time, much of the literature either lacked a coherent theoretical framework or was dominated by convergence theories, which assumed that globalisation would lead all developed countries toward a uniform, market-oriented housing model. This perspective tended to dismiss national differences as mere bumps on the road toward a homogenised housing system in all developed countries (Kemeny and Lowe, 1998). Some housing scholars discovered welfare regime theory as a powerful foundation to explore housing systems. Applying to housing the concepts from Esping-Andersen's The Three Worlds of Welfare Capitalism (1990), the approach explored the enduring influence of deep-seated institutional and societal structures on housing systems. This approach has since been developed by a range of scholars (e.g. Matznetter, 2002; Allen et al., 2004; Arbaci, 2007, 2019; Mandič, 2012; Stephens and and Sunega, 2015; Hoekstra, 2020; Stephens, 2020)2007, 2019; Mandi\\uc0\\u269{}, 2012; Stephens and and Sunega, 2015; Hoekstra, 2020; Stephens, 2020 who have explored the ways in which housing systems are embedded within broader welfare regimes.

Within this framework, three broad regime types are typically identified: liberal, corporatist, and social-democratic. The strand of literature focusing on housing provision developed the idea that each regime type is associated with distinct configurations of housing provision, which can be analysed through four key dimensions: promotion, production, land supply, and consumption (Barlow and Duncan, 1994). These dimensions form what is often referred to as the housing provision chain. The structure of this chain determines the extent to which promoters and producers are able to capture development gains, and it reflects the broader political and institutional context in which housing is provided.

In liberal regimes (most frequently associated with English-speaking countries), housing provision is typically dominated by large private developers who both promote and build housing speculatively for the market. These actors are able to capture substantial development gains. In contrast, social-democratic regimes (most prominent of which are the Nordic countries) tend to tightly control development gains through a combination of public land ownership, binding zoning regulations, and non-profit housing promotion. These systems aim to decommodify housing by limiting its exposure to market forces and ensuring access based on need rather than ability to pay. In corporatist regimes (usually encompassing Central European countries), decommodification and control of development gain are partial, less overt and less ideologically symbolic. Self-promoted housing is a frequently encountered method of partial decommodification.

Understanding the dominant modes of housing provision in a given context is essential for assessing the degree of commodification or decommodification within the housing system, which is a central concern of welfare re-

gime studies. However, the housing provision framework also offers valuable insights into other areas of urban development, including spatial planning and urban form.

For example, Arbaci (2007, 2019)including for the first time Southern Europe. It investigates the ways in which the diverse housing systems, embodied in wider welfare regimes, shape and reflect different principles of stratification, and consequently, it reveals the different ways in which the resulting mechanisms of differentiation crucially influence the scale and nature of patterns of ethnic and socio-spatial segregation, particularly among low-income and vulnerable groups. Spatial and social dimensions of segregation are disentangled in each welfare/housing regime (four ideal-typical clusters has used housing system theory to explain patterns of socio-spatial segregation in Southern European countries. She argues that the prevalence of familialistic housing systems, which are characterised by limited direct public intervention in housing, the prevalence of self-promoted and self-built dwellings, high rates of homeownership and intergenerational transfers of housing wealth, has produced distinctive forms of urban segregation that differ markedly from those observed in other parts of Europe. These patterns cannot be understood without accounting for the role of housing provision in shaping the spatial distribution of social groups.

This line of inquiry builds on earlier work on Southern European housing systems (Allen et al., 2004; Allen, 2006) who examined how Southern European countries were able to meet massive post-war housing demand without direct state involvement. Their answer lies in the widespread practice of self-promotion, which was facilitated through indirect state support. Authorities often chose to ignore informal housing promotion and to zone sufficient land for development, thereby enabling rural-urban migrant households to mobilise family resources and construct their own homes. This led the authors to employ the concept of public action, which focuses on the horizontal coordination of policy areas and includes not only direct interventions but also indirect actions and strategic inaction. In this view, what is left unregulated or unenforced can be as significant as formal policy measures.

In exploring and theorising planning systems it is difficult to account for such indirect action or even inaction - not least because of the often-opaque nature of planning practices, which demand a researcher's substantial qualitative familiarisation with the workings of the planning system in a particular context, leading to case studies providing the most insights. In planning literature, the influences on planning beyond the formal regulations and plans have been theorised through the concepts of planning cultures (Knieling and Othengrafen, 2009; Sanyal, 2025) and institutions (Buitelaar, 2007; Buitelaar, Galle and Sorel, 2011; Salet, 2018). The former refers to "the beliefs, discourses and behaviours of practitioners and depositories of technical knowledge in shaping the concrete practices through which spatial governance and planning systems make their purposes operational" (Berisha et al., 2021, p. 3), and the latter attempts to understand planning through rules and norms that condition the relationships between subjects, such as governments, businesses and citizens, which refers to both formal rules, such as regulations and zoning plans, as well as informal norms.

Housing system theory can provide a powerful lens through which to interpret these dynamics. By linking housing provision to broader institutional arrangements, it allows researchers to explain specific planning practices and outcomes that might otherwise appear idiosyncratic or contradictory. Rather than treating such cases as anomalies, the theory enables a more systematic understanding of how housing and planning systems co-evolve. In the remainder of this paper, offer the case of Croatia to illustrate the application of housing system theory to explain planning institutions and concepts. We begin by examining the formal regulations that shape urbanisation and the ways in which planning authority is exercised in practice. We then turn to the housing provision system, tracing its transformation over time and analysing how it has influenced and been influenced by spatial planning practices.

3. Housing systems, spatial planning and urbanisation: The case of Croatia

3.1 Croatian spatial governance and planning system and practices

According to the Physical planning act (Official Gazette 153/13 - 67/23), the 556 municipalities of Croatia are responsible for zoning land within their territories and granting building permits based on zoning plans. These municipal spatial development plans are binding and there is little room for negotiation or discretion in the permitting process. The plans define the boundaries of the building area of a settlement (građevinsko područje naselja, GPN), which functions as an urban growth boundary. Residential development is strictly prohibited outside of this delineated area. Within the GPN, land is further categorised into developed and undeveloped parts, with the latter representing the reserve of greenfield land for future urbanisation. In theory, this system provides municipalities with considerable autonomy in shaping urban development. However, in practice, it has led to the widespread zoning of large reserves of undeveloped land, often far exceeding the volume of development that could be realistically expected based on declining or at best stagnant demographic projections (Vlada RH, 2021).

A second policy area highly influential in determining the mode of urban development is the provision of communal infrastructure. Municipalities are responsible for developing and maintaining local infrastructure, including roads, sewage systems, electricity grids, and public lighting (Utilities act, Official Gazette 68/18 - 145/24). To finance these services, they levy communal contributions (a one-time fee paid by developers) and communal fees (a recurring charge for property users). The former represents the only land value capture mechanism available in the planning system. However, the communal contribution is typically lower in peripheral areas of a settlement, effectively subsidising infrastructure provision for greenfield development. Moreover, the scope of infrastructure required to develop the undeveloped part of the GPN is minimal - usually limited to road access, sewage facilities, and electricity - without obligation to provide public green spaces, schools, healthcare facilities, or public transport. The financial burden of even this limited infrastructure is likely considerable. Although comprehensive data is lacking, it can be inferred that the costs are often not fully covered by the collected fees. Some municipalities have recently raised their communal contributions in response to inflation, despite the political unpopularity of such measures, indicating that communal infrastructure costs can indeed pose a significant strain on municipal budgets.

Despite the considerable freedom theoretically afforded by the planning system for municipalities to shape the urbanisation of their territories, municipalities across Croatia appear to converge on similar, unsustainable urbanisation practices - i.e. zoning of excessive amounts of developable land which invites diffuse urbanisation and subsidising infrastructure for peripheral development. The outcome of this convergence is the proliferation of diffuse urbanisation, with many newly-constructed settlements lacking services and requiring residents to depend on personal vehicles in meeting their basic needs (Šišak and Lukić, 2025). This process of metropolitanisation should not be equated with the development of idyllic middle-class suburbia of the Western European imagination. Aside from the lack of urban amenities, the urban form, while still dominated by single-family houses, is increasingly influenced by the construction of medium-sized and large apartment buildings of urban character, frequently criticised for their impact on the character and identity of the periurban landscape (Svirčić Gotovac, 2015).

This prevailing mode of urbanisation has been criticised as unsustainable, both by the broader community of spatial experts, as well as national spatial planning authorities (Croatian Spatial development Institute, 2017; MPGI, 2021; Vlada RH, 2021). This critique is particularly striking given the country's demographic trends: since 1990, Croatia has experienced continuous population decline, even in its major cities. The only areas showing modest population growth are the peri-urban zones of large cities, yet even there, the increases are marginal. Nevertheless, diffuse urbanisation continues unabated, suggesting a disconnect between formal policy goals and actual planning outcomes. This disconnect between formal policy documents and practice clearly points to hidden structural factors, informal institutions shaping practices. We argue that the housing system has much to do with it. next is an overview of housing provision forms, using the framework of Barlow and Duncan (1994)

3.2 Housing provision and urbanisation: During and after socialism

In Croatia, which was then a federal republic of Yugoslavia, the second half of the 20th century was marked by massive rural-urban migrations corresponding to rapid industrialisation. The state and the social sector (a specific feature of Yugoslav socialism, run by nominally worker-managed enterprises, many of which were large and economically and politically influential) attempted to alleviate chronic urban housing shortages by acting as promoters of housing (Tandarić, Watkins and Ives, 2019). Housing production under this system was entrusted to large construction companies, and the separation meant that builders collected little development gain. Instead, their profitability depended on productivity improvements, which they pursued through innovations such as modular construction, standardised layouts, and economies of scale (Marčetić, 2020). Land for development was provided by local authorities, who possessed the legal authority to expropriate - with compensation - land which they designated for urban expansion (Krtalić, 2004). This took place on agricultural land at the edges of cities, where most plots were small and privately owned. The combination of large-scale construction and land readjustment enabled by expropriation powers led to state/social sector promoted housing to take on a compact form. Regarding consumption, the produced housing units were allocated to tenants under a system of occupancy rights - a tenure that, while not equivalent to ownership, was highly secure, inheritable, and associated with minimal rents that often failed to cover long-term maintenance costs (Marčetić, 2020).

Despite these efforts, the state-social housing system was unable to meet the full extent of housing demand. Allocation rules tended to favour skilled workers, leaving large masses of formerly rural, generally unskilled workers to fulfil their housing needs in a most un-socialist way – through private investment into self-promotion, the practice of privately financing and constructing their own homes (Marčetić, 2020). More than a half of dwellings constructed in Croatia during the socialist period were self-promoted (Čaldarović, 1987). To construct their dwellings, households commissioned small-scale private builders or constructed the dwellings themselves. For that reason, the buildings took the form of single-family houses. Land supply was concentrated on the edges of urban areas where land was not immediately nationalised and could hence be bought from private owners. However, no land readjustment mechanisms were applied, and the resulting settlements followed the fragmented, inherited patterns of agricultural land parcels. This made the provision of public infrastructure and services highly challenging. By simultaneously acting as promoters, builders and customers, households captured development gain in a manner that can be interpreted as a form of partial decommodification (Katurić, 2016; Katurić, Simov and Gregar, 2018).

A significant portion of this self-promoted development was informal - constructed on legally owned land but without the necessary permits and often in violation of zoning regulations. Authorities, aware of the limitations of the state-social sector, largely turned a blind eye to these practices. Over time, many of these informal developments were legalised on a piecemeal basis. This dynamic bears a strong resemblance to housing systems in Southern Europe, where informal self-promotion was similarly tolerated and even indirectly supported by the state. During this period, land markets remained underdeveloped, constrained by legal restrictions and a chronic undersupply of housing. Both occupancy rights in the state-social sector and private ownership in the self-promoted sector offered secure tenure, and both systems were primarily oriented toward fulfilling immediate housing needs rather than generating profit.

The break-off from Yugoslavia and its move away from socialism saw significant changes to housing policies enacted during the 1990s, and initiated a transformation of the overall housing system. One of the most consequential reforms was the "give-away" privatisation of the state and social sector housing stock. Tenants were allowed to purchase their homes at deeply discounted prices, and most did so, motivated by the uncertainty of the transition period. This policy, rooted in neoliberal ideology, also served a pragmatic function: it acted as a "shock absorber" for the anticipated social and economic upheavals of the post-socialist transition, including rising unemployment, growing inequality, and the retrenchment of the welfare state. This massive transfer of housing represented a step toward establishing an asset-based welfare system (Zrinščak, 2003; Mandič, 2010, 2017). Homeownership became the dominant and most secure tenure, while public rental housing was residualised and private rental markets remained poorly regulated, often informal, and lacking in tenant protections.

This shift affected the housing provision system, which gradually transformed and took on more speculative features. State-social promotion ceased. Large construction companies were fragmented and downsized due to the collapse in demand for large-scale housing projects. The shift toward homeownership had profound implications for housing production. With the cessation of state-social promotion, large construction companies were fragmented and downsized due to the collapse in demand for large-scale housing projects (Marčetić, 2020). Simultaneously, legal reforms strengthened individual property rights and curtailed the ability of public authorities to expropriate land. Even land readjustment tools, which could have enabled municipalities to coordinate infrastructure provision while preserving private ownership, remained absent from the legal framework (Krtalić, 2004). The informality of self-promoted housing from the socialist period was systematically resolved by the government's concerted effort to legalise the housing stock built without the required permits. While informal self-promoted homeownership was sustained in the socialist period through ignoring or even tacit approval, the systematic legalisation undertaken between 2011 and 2018 sanctioned all prior construction, while sending a strong signal that future illegal construction would not be accepted. A large portion of the self-provided housing stock was thus legitimised, facilitating its inclusion into the by then already developed housing market (Habrun, 2018).

The housing provision system which emerged in this period can be seen as a continuation of the poorly regulated self-promoted sector of the socialist period. Land supply was entirely left to the multitude of small-scale landowners, and in absence of land readjustment mechanisms, the availability of solely small, individual parcels for development stimulated small-scale housing production. The growing sector of private builders – a continuation of the small private enterprises building for the neds households in the socialist period - increasingly also operated as promoters, developing housing with the sole intention of rapid sale on the market. The new, speculative housing provision mechanisms permitted developers to extract development gain. Self-promotion also remained present, albeit less frequently through self-building (Rodik, Matković and Pandžić, 2019), as households continued to seek more affordable means of gaining ownership over a dwelling by extracting some of the development gain themselves.

Overall, the transformation of the housing system in Croatia was characterised by increased commodification, driven by speculative behaviour among firms and a growing societal reliance on homeownership as a form of asset-based welfare. This shift was not entirely new but rather an evolution of the socialist-era system, which had already established secure tenures and a strong cultural preference for homeownership. In the post-socialist context, housing increasingly became a vehicle for investment and savings. Households began to leverage their real estate assets through tourism rentals, a practice that initially emerged in small coastal municipalities but has since expanded to larger coastal cities and the capital, Zagreb (Vizek, Barbić and Časni, 2024). Since the early 2000s, mortgage credit has played an increasingly important role in facilitating access to homeownership, further embedding housing within financial markets and reinforcing its role as a cornerstone of household welfare.

4. Discussion

Having described the Croatian spatial governance and planning system and its outcomes on the mode of urbanisation, as well as the systems of housing provision and their embeddedness in an evolving housing system, we turn to the questions posed in the first two chapters: we discuss how the apparently paradoxical spatial planning practices observed across Croatian municipalities can be conceptualised and explained by institutions which are significantly conditioned by the housing system, which shapes both the housing needs and the forms of housing provision through which these needs are fulfilled.

The introduction of real estate markets and the development of speculative mechanisms in housing provision led to increases in housing unaffordability, while the housing system simultaneously incentivises households to purchase housing, despite the great expenses of doing so. The specific system of housing provision through which the need for homeownership can be fulfilled is highly influenced by the path-dependent development from the largely informal self-promoted modes of the socialist period. The small scale of production and lack of land

readjustment tools led to the predominance of development on individual plots, whose spatial structure reflects the patterns "inherited" from previous, agricultural uses.

Seen in this light, municipal zoning practices can be understood as a crude form of decommodification adapted to the capacities of local governments and the housing system's structures. Seeking to increase land supply by permitting development over large, mostly agricultural areas and, thus, reducing land prices can be seen as an overriding objective. This objective also accounts for communal infrastructure policies which enable greenfield development and reduce infrastructure cost for the developer – but not the municipality. However, the lack of public value capture mechanisms frustrates this objective. Speculative pressures in land provision are allowed to run unhindered. By selling plots at prices reflecting the "highest and best use", landowners pocket development gain without hindrance and pass the costs on to producers and consumers. When housing is produced by speculative builders, they also extract development gain by selling constructed units at the highest price the market will bear, placing great strain on households of lower and increasingly those of medium incomes.

Besides making land cheaper as a tradeable commodity, the zoning practices of municipalities also seek to enable self-promotion on inherited, previously agricultural land. This permits local residents to avoid the costs extracted by speculative land transactions and market developers. Such practices can be considered as a form of decommodification, allowing households - including those to whom market purchase would impose an unbearable strain - to attain the indispensable status of homeowners. However, as the "site selection" for self-promotion of inherited land is essentially random, housing provided in this way is often located in rural areas, lacking proximity to urban amenities, which can only be accessed by car, which leads to the well-known social and environmental costs of car-centric development in periurban regions.

The widespread availability of developable land can be conceived of as an institution of contemporary Croatian planning. Throughout the country, citizens expect their municipalities' planning departments and elected local governments to make land available for development and keep infrastructure cheap (and just sufficient to enable access by car to urban amenities in more central locations). Local authorities are happy to provide these, using spatial governance and planning as a part of their limited toolkit to improve the living conditions of their citizens as best as they can and – hopefully - even to attract new residents. These institutions of the more broadly understood planning system explain the central government's reluctance to enact stricter urban containment policies and the ineffectiveness of those initiatives which are put in force. It also paints a pessimistic picture for the prospects of potential European land take containment legislation in Croatia. Taking the established institutions and their political significance into account, there can be no doubt that their disruption would induce political resistance potentially fatal to the policy's objectives.

However, understanding spatial policies through their drivers in the wider sphere of housing systems points to a way out of this lock-in. Directing policy efforts at housing rather than land use may prove a more effective, though laborious and (at least in the case of Croatia) poorly explored path. Public action in housing should overcome its uncritical assumptions and seek to transform the housing system in such a direction to enable decommodified, secure and affordable provision of housing beyond market-based homeownership; if reliance on unsustainable urbanisation practices is to be avoided, stimulating more varied arrangements between housing promotion, production, land supply, and consumption should be the aim – for instance, through introducing land readjustment, robust cost rental and other non-profit forms of promotion, and sustainable regeneration of brownfield sites and deteriorated urban housing in compact urban cores.

5. Conclusion

This paper offered housing system theory and the housing provision concept as a valuable analytical tool for understanding spatial planning practices and the often-opaque institutional arrangements that shape them. By examining the case of Croatia, we have demonstrated how the housing system, through its structural features and historical trajectory, induces municipalities to adopt similar spatial governance and planning policies, even when these policies are socially, economically, and environmentally unsustainable.

Our analysis has shown that the Croatian planning system's tendency toward diffuse urbanisation is not merely a result of weak regulation or poor implementation, but is deeply embedded in the institutional logic of the housing system. The legacy of self-promotion, the dominance of homeownership as the only viable tenure, and the absence of mechanisms for land readjustment and public value capture all contribute to a planning environment in which municipalities are incentivised to zone generously and subsidise greenfield development. These practices are further reinforced by citizens' expectations and the limited fiscal and institutional capacities of local governments.

We have also highlighted why central government policies aimed at curbing these practices often encounter difficulties in design and experience lacklustre implementation. Planning regulation must take careful account of the institutional context in which it operates. Housing system theory offers a promising framework for doing so, which is why further work on introducing housing systems theory in planning literature and spatial planning institutions and practices in housing literature would be welcomed.

The conclusions drawn from the Croatian case may be especially relevant to other contexts characterised by widespread self-promotion, binding zoning regulations, and an oversupply of developable greenfield land. These features are common in Southern and Southeast European countries, whose housing systems have been variously described as Mediterranean/ familistic and post-socialist, and whose planning systems are often classified as conformative or belonging to the urbanism family. However, the issues of land oversupply, diffuse urbanisation, and rising housing unaffordability are by no means confined to these regions.

We suggest that more explicit and systematic study of the often opaque ways in which housing systems interact with planning institutions and practices - and how these interactions shape the resulting modes of urbanisation - could yield valuable insights for a broader range of European contexts. By prying open the "black box" of local planning practices and examining the institutional logics that underpin them, researchers and policymakers alike may be better equipped to design interventions that are more effective and also more attuned to the complex realities of urban development.

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Predicting Housing Prices: The Case of Ankara Housing Market

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Abstract
The housing market is crucial for economies, especially in Türkiye, where economic instability has caused rising housing prices. This study aims to predict trends in the city's rental market using a dataset of 20,000 listings. By using advanced data analysis and machine learning, the research seeks to identify patterns and forecast rental price movements, benefiting households and policymakers. Valuing housing is complex due to its varied characteristics, prompting the use of hedonic pricing theory. This involves a regression model that links housing prices to their features. While traditional linear regression has been used, non-linear machine learning models often provide more accurate predictions. The research offers a framework for predicting housing market trends and fostering equitable urban development, addressing housing needs in Ankara and beyond.

Keywords: Housing Price Prediction, Housing Affordability, Machine Learning, Türkiye, Ankara

1. Introduction

Accurate estimation of house prices is crucial for a broad spectrum of stakeholders across multiple sectors. In this context, not only households but also a diverse range of actors—including landlords, investors, real estate agents, financial institutions and government bodies—require reliable housing price information for their respective purposes. As a critical sector and a major driver of economic activity, the housing market holds significant importance in nearly all economies, and Türkiye is no exception. The country's ongoing economic instability has further heightened the housing sector's relevance.

Given its pivotal role in the Turkish economy, the performance of the housing market is essential not only for ensuring macroeconomic stability but also for addressing issues of housing affordability. However, house prices in Türkiye tend to be volatile, fluctuating in cycles of rise and decline. Despite this, in major cities such as İstanbul, Ankara and İzmir, prices have shown a consistent upward trend. According to a report from the Central Bank of the Republic of Türkiye in April 2025, the Housing Price Index increased by 32.9% in nominal terms. Analysing the housing price indexes for Istanbul, Ankara, and Izmir reveals that in March 2025, prices increased by 2.7%, 2.8%, and 0.2%, respectively, compared to the previous month. Year-over-year comparisons show that index values increased by 34.4%, 41.9%, and 30.9% in Istanbul, Ankara, and Izmir, respectively. In April 2025, the Consumer Price Index recorded an annual change of 37.86%, according to the Turkish Statistical Institute (TURKSTAT, 2025). When comparing nominal housing price growth to consumer inflation, Ankara stands out because its housing prices have increased slightly more than the inflation rate. The widespread price increase across Türkiye, especially in Ankara, has intensified the focus on monitoring changes in housing prices and addressing affordability issues.

This study focuses on Ankara, the nation's capital, as a case study to forecast housing market trends across nine districts. It utilizes a comprehensive dataset comprising 20,000 rental listings collected from a prominent real estate platform. The dataset includes key property features such as price, type, number of rooms, floor area, age, floor level, and geographic location. By applying advanced data analysis and machine learning techniques, this research aims to uncover patterns in rental price behaviour and generate predictive insights. These findings are expected to contribute meaningfully to urban planning strategies and the formulation of effective housing policies.

The remainder of this paper is organized as follows: Section 2 provides a brief review of previous research on housing price estimation, outlining the theoretical and empirical framework for the analysis developed in Rosen (1974). In Section 3, the data and methodology used in this study are described. Section 4 presents and discusses

the empirical results. Building on these findings, Section 5 offers a discussion of the results, while Section 6 outlines the policy implications and concludes the paper.

2. Estimation of Housing Prices

Understanding house price trends and producing accurate estimates are also critically important from the perspective of urban planning and development (Kang et al., 2021). However, predicting housing prices is a complex and multifaceted task, as it involves a combination of structural, economic, social, locational, and market-related attributes that must all be considered during valuation processes (Mankad, 2022). This complexity has led many studies on housing prices to rely heavily on hedonic pricing theory (Crespo & Gret-Regamey, 2013).

The initial formal contribution to hedonic price theory was made by Court in 1941, who developed a hedonic price index for automobiles (Bartik, 1987). Two primary approaches have significantly influenced the theoretical development of hedonic prices. The first approach is based on Lancaster's consumer theory (1966), while the second stems from Rosen's model (1974) (Chin & Chau, 2003). Malpezzi (2003) points out that Lancaster advanced microeconomic theory by focusing on the demand side of the market, emphasizing that utility is derived not from the goods themselves but from their characteristics. The Hedonic Price Model, first formalized by Rosen in 1974, conceptualizes a product as a bundle of characteristics, each contributing to its overall price. As Rosen (1974) explains, "Hedonic prices are defined as the implicit prices of attributes, derived from the observed prices of differentiated products and the specific quantities of characteristics associated with them." In simpler terms, a house's price reflects the cumulative implicit value of its individual features, which cannot be priced independently. A hedonic equation is essentially a regression model that relates a house's price to its various characteristics. A differentiated product is defined by a vector of attributes Z = (z1, z2, ... zn), where each zi represents a specific attribute. The market price of a product can thus be expressed as a function of its attributes, p(z) = p (z1, z2, ... zn). This means that the price of the house, p(z), is a function of its characteristics. To estimate the implicit prices of individual attributes, Rosen proposes a regression-based approach where product prices are regressed on their characteristics. This estimation process represents the first step in Rosen's two-stage hedonic pricing model.

The application of the hedonic price model to the housing market is based on several fundamental assumptions. One is the heterogeneity of housing products. Malpezzi (2003) discusses that hedonic models arise due to heterogeneity in the market, including both heterogeneous housing stock and heterogeneous consumers. Housing products are considered heterogeneous due to their differences in locational, structural, or neighbourhood attributes. Each house possesses a unique set of characteristics that influence its value. Also, a house is a long-lasting good that has a significant lifespan, allowing houses of varying ages to coexist within the same market. Furthermore, certain features of a house may be valued differently depending on the geographical location. Homebuyers have distinct utility functions that lead them to value different characteristics across houses differently, in addition to the problem of the presence of different characteristics across houses (Sirmans, Macpherson, and Zietz, 2005).

Another theoretical construction underlying this approach is the "implicit market." The concept of implicit markets refers to the processes of producing, exchanging, and consuming commodities that are primarily (and perhaps exclusively) traded in "bundles" (Sheppard, 1999). This means that implicit markets refer to situations where individual components of a product are not sold separately, but rather as part of a bundle. Some goods, such as automobiles, workers, and houses, can be grouped into a single "market," despite their heterogeneous nature. These markets can't be analysed with traditional economic models because they don't have a single price; instead, they feature a range of prices based on quality and characteristics. The hedonic approach addresses this by suggesting that these goods comprise aggregates of homogeneous parts. While the overall bundle may lack a uniform price, the individual attributes share a more consistent price structure (Sheppard, 1999).

In earlier research, the hedonic pricing model—typically based on linear regression and estimated using Ordinary Least Squares (OLS)—has been widely used to predict housing prices. However, the relationship between property

values and their determining factors is often nonlinear and more intricate than linear models can adequately capture (Sheppard, 1999). Key issues such as model specification methods, multicollinearity among independent variables, interactions between predictors, heteroscedasticity, non-linearity of relationships, and the presence of outliers can substantially undermine the model's reliability and effectiveness in accurately assessing housing values (Limsombunchai, 2004). To address rising prediction errors and heteroscedasticity at higher price levels, the hedonic pricing model is often utilized in a semi-logarithmic form (Goodman & Thibodeau, 1995; Sirmans, Macpherson, and Zietz, 2005; Fletcher, Gallimore, and Mangan, 2000). While the semi-logarithmic form helps mitigate heteroscedasticity and capture some non-linearity, several studies have pointed out its limitations. They have limited flexibility in modelling complex, non-linear interactions between housing attributes and prices. In response, various alternative modelling approaches have been developed, many of which offer significant advantages over traditional methods. Recent studies have shown that non-linear models utilizing machine learning techniques provide more accurate and reliable predictions. These models improve upon standard approaches by learning directly from data and continuously refining their predictive capabilities. Among the most commonly used and effective machine learning algorithms for housing price prediction are artificial neural networks, gradient boosting, and random forests.

This study focuses on using random forest machine learning techniques for predicting house prices. Random Forest is a powerful classification algorithm that enhances predictive accuracy by averaging outcomes from multiple decision trees, each trained on different subsets of the dataset (Adetunjia et al., 2022). It uses a process called bagging, or bootstrap aggregating, to train individual trees on random samples. This approach reduces overfitting and improves the robustness of the model. As an ensemble model, Random Forest combines predictions from various trees using majority voting or averaging, resulting in higher accuracy than a single decision tree. This method is particularly effective for large datasets with complex relationships, revealing intricate patterns among the features (Truong, Nguyen, Dang, and Mei, 2020).

3. Data and Methodology

The dataset for this study is sourced from hepsiemlak.com, a prominent real estate platform in Türkiye. It consists of 19,333 house-for-sale advertisements collected in June 2024. This dataset includes key information such as property prices, the number of rooms, the gross area of the house, the floor, the age, housing types (including flat, residence, detached house, etc.), and the neighbourhood in which it is located (Table 1).

Table 1. List of Attributes

Attribute Name	Data Type	Description
price	int64	House price
totalRooms	int64	Number of total rooms (3, 4, etc.)
area	int64	Area of the house (gross)
floor	int64	The floor it is located on
age	int64	Age of the house
housingTypes	int64	House's type (flat, residence, detached house, etc.)
neighborhood	object	The neighborhood in which it is located
district	object	The district in which it is located

The dataset was thoroughly examined for outliers using the Interquartile Range (IQR) method. An outlier, denoted as x, is identified if it falls outside the established boundaries. Specifically, this occurs when the value of x is lower than the lower quartile minus 1.5 times the IQR or higher than the upper quartile plus 1.5 times the IQR. This systematic approach enhances the understanding of the data's distribution and helps maintain the integrity of the analysis. After applying this method to the price column of the dataset, a total of 790 outliers were identified

and subsequently removed. This process significantly enhanced the quality of the dataset, which now comprises 18,543 entries.

The data on Ankara's housing stock, collected during the first stage of the study, encompasses a total of 22 districts, as shown in Table 2. However, it is evident that sufficient data could not be obtained, particularly from districts outside the central areas. Consequently, the focus of the study was narrowed to the central districts, which have a more substantial representation of the housing stock. As a result of this process, the dataset was reduced to 16,903.

Table 2. Number of data by districts

District	Mean	Median	Count
AKYURT	2975304.71	2300000.00	105
ALTINDAG	2748210.51	2500000.00	2072
AYAS	2935608.70	2200000.00	23
BALA	3445678.57	2870000.00	28
BEYPAZARI	2369473.68	2250000.00	57
CAMLIDERE	4478571.43	3450000.00	7
CANKAYA	4430305.93	3850000.00	2190
CUBUK	2353887.32	1765000.00	213
ETIMESGUT	3793351.95	3150000.00	1305
GOLBASI	4057836.86	3500000.00	803
GUDUL	5377500.00	4250000.00	8
HAYMANA	2587500.00	2050000.00	4
KAHRAMANKAZAN	3790614.04	3250000.00	57
KECIOREN	2916656.11	2575000.00	2396
KIZILCAHAMAM	4172359.75	4422292.00	24
MAMAK	2509282.10	2250000.00	2320
NALLIHAN	2052571.43	1893000.00	7
POLATLI	2281024.48	1995000.00	1103
PURSAKLAR	3225362.48	2690000.00	2356
SEREFLIKOCHISAR	1611250.00	1325000.00	4
SINCAN	2448722.26	2195000.00	2637
YENIMAHALLE	4033203.88	3650000.00	824

This study employs a comprehensive methodological framework that incorporates both linear regression and random forest models to predict local housing prices. The linear regression model assumes a straightforward linear relationship between the dependent variable and the explanatory variables. In contrast, the random forest model leverages an ensemble learning approach, using multiple decision trees to capture complex interactions and non-linear relationships within the data. The effectiveness of both models is assessed by comparing their prediction accuracy through metrics such as mean absolute error and R-squared values. This comparative analysis aims to enhance our understanding of which model provides superior forecasting capability for local housing markets.

4. Empirical Results

Exploratory data analysis is a crucial preliminary step prior to developing a regression model. Figure 1 illustrates the average housing prices across various districts in Ankara using a grayscale colour scheme to represent price levels. Darker shades correspond to higher average prices, while lighter shades indicate lower ones. According to the map, Çankaya, Gölbaşı, and Yenimahalle stand out with significantly higher average housing prices compared to other districts. In contrast, Etimesgut, Pursaklar, and Keçiören fall into the mid-priced category, represented by medium gray areas. The lightest shades mark the most affordable districts, which include Altındağ, Mamak, and Sincan.

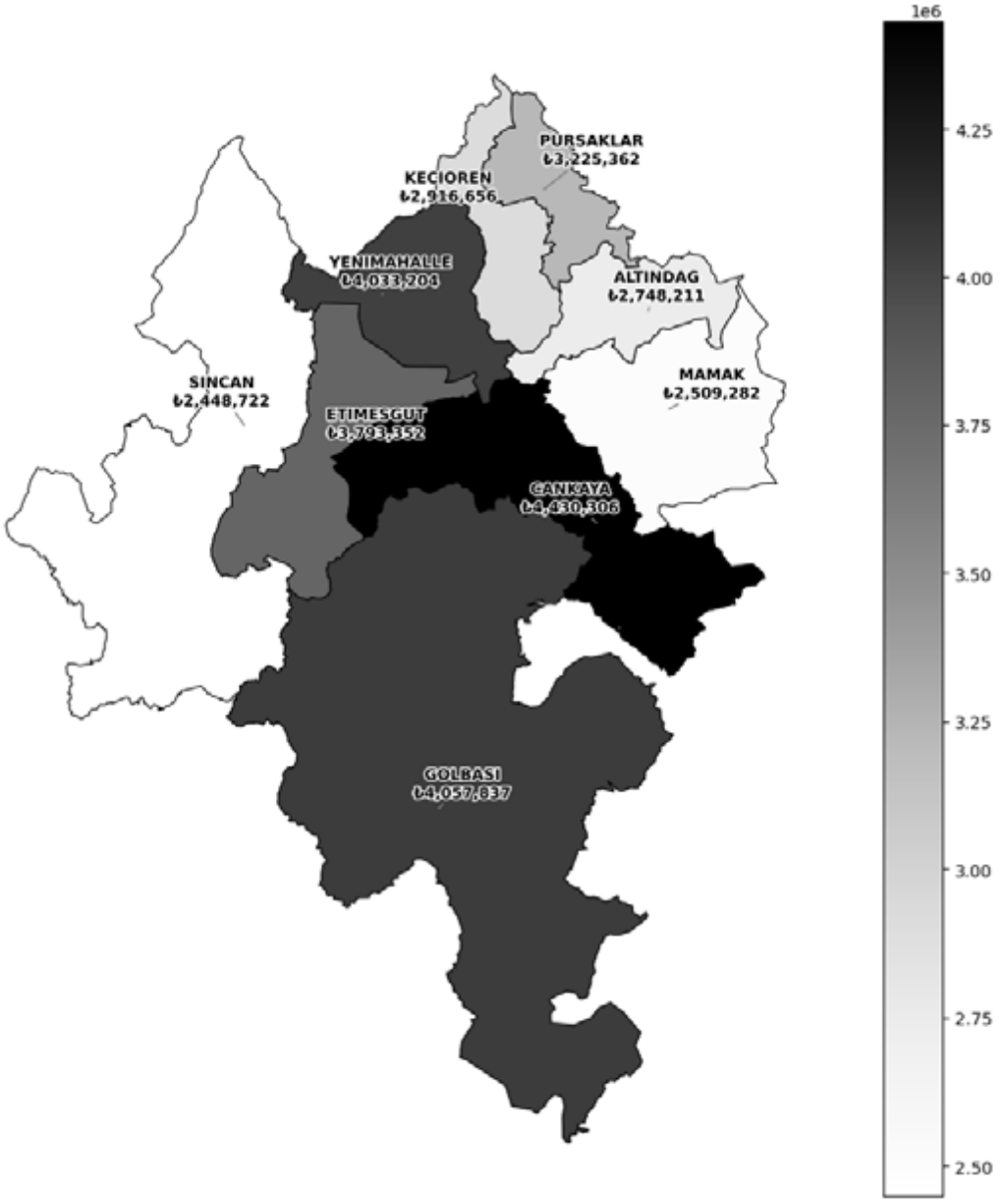

Fig. 1. Average Price by Districts

Figures 2, 3, 4, and 5 compare the distribution of price with its log-transformed counterpart, log Price. The histograms in Figures 3 and 4 reveal a pronounced right skew, while the Q-Q plot shows significant deviations from a normal distribution, especially in the tails. This indicates that the price distribution is not normal. In contrast, the histograms in Figures 5 and 6 appear more symmetrical and bell-shaped. The Q-Q plot for the log-transformed

prices aligns much more closely with the theoretical normal line, exhibiting only minor deviations in the tails. This suggests that log-transformed housing prices (log Price) is approximately normally distributed.

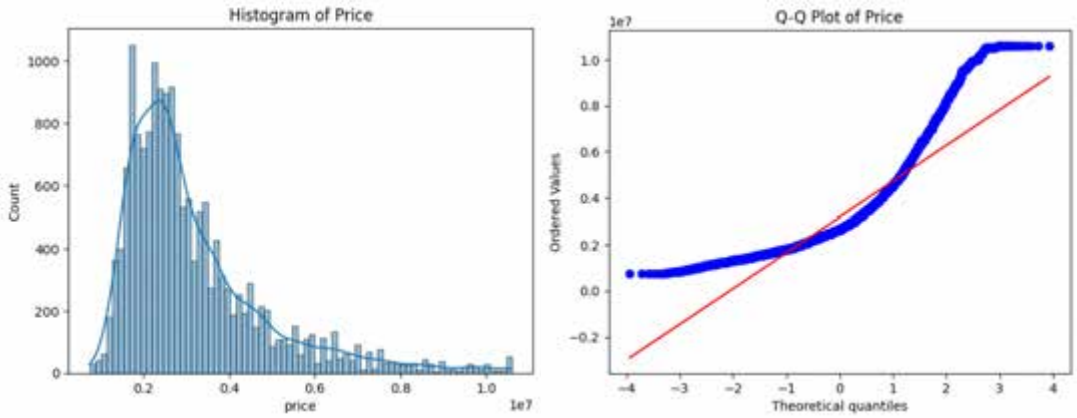

Fig. 2 and 3. Histogram and Q-Q Plot of Price

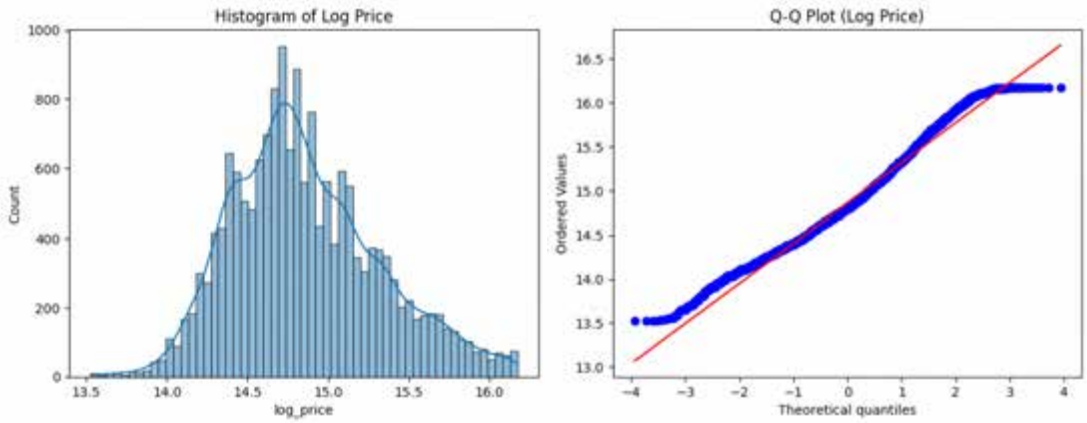

Fig. 4 and Fig. 5. Histogram and Q-Q Plot of Log Price

Figure 6 presents a box plot illustrating the distribution of log-transformed housing prices (log Price) across various districts in Ankara. The x-axis represents the log Price, while the y-axis lists the districts. Each box depicts the interquartile range (IQR), which captures the middle 50% of the data. The horizontal line within each box indicates the median log Price for the corresponding district. The whiskers extend to show the range of values excluding outliers, which are represented by individual circles.

According to the plot, there are significant variations in housing prices across 9 districts. Çankaya emerges as the most expensive district on average, characterized by a wide price range and a substantial number of high-end outliers. Sincan, Mamak, and Altındağ appear as the most affordable districts, with lower median log Prices. Etimesgut and Yenimahalle fall into the mid-range category, exhibiting moderate price levels along with some variability. Districts such as Pursaklar and Altındağ display tighter distributions, suggesting relatively more homogeneous housing markets in those areas.

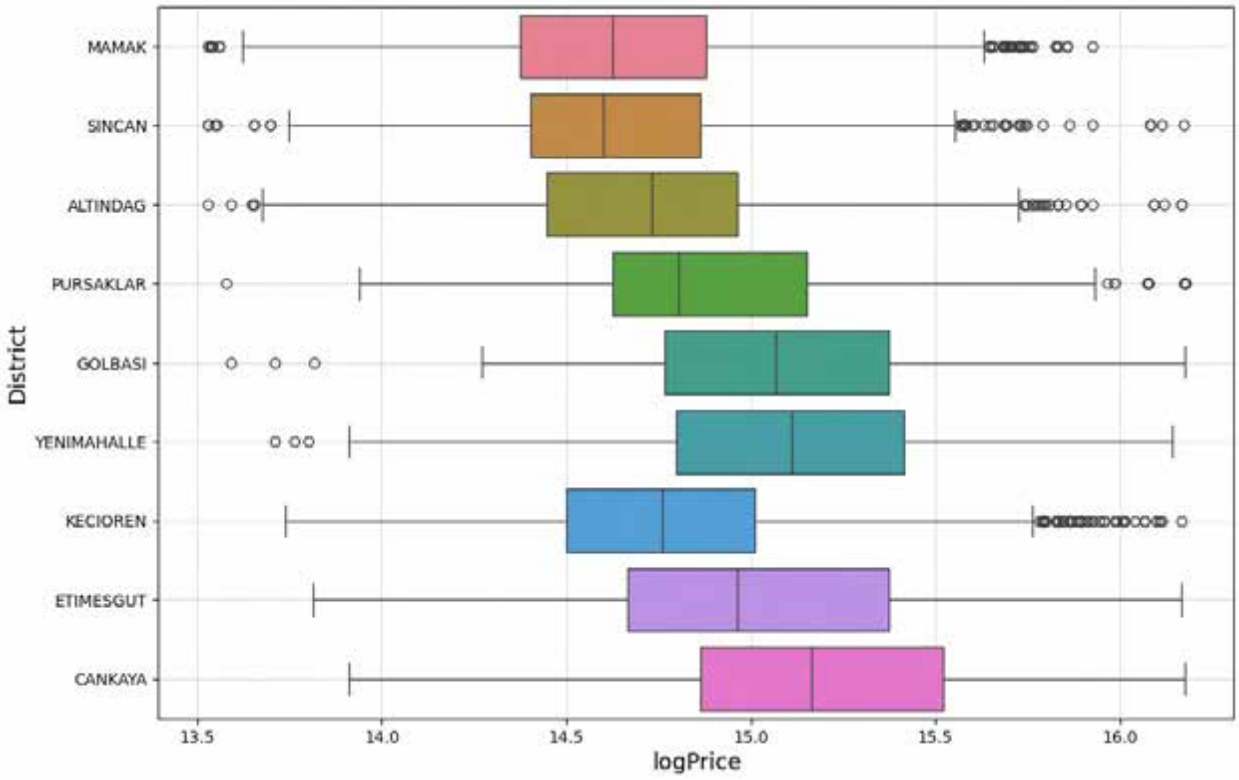

Fig. 6. District Log Transformation of price

Figures 7 and 8 illustrate the overall distribution of unit prices, which follows a right-skewed pattern. The average unit price is approximately ₺23,300, while the median is ₺20,562. This difference suggests that some high-priced properties are elevating the average price. Among the districts, Gölbaşı and Çankaya have the highest average unit prices, indicating they feature more upscale or premium housing markets. In contrast, Sincan, Mamak, and Altındağ are among the most affordable districts. Additionally, Gölbaşı exhibits the greatest price variability, indicating a wide range of property types, while Sincan shows more consistent pricing. These trends underscore significant spatial disparities in housing costs across the region.

	count	mean	std	min	25%	50%	75%	max
unit_price	16903.0	23304.551620400423	10621.32212196031	1664.5833333333333	16581.14035087719	20562.5	26600.0	211111.11111111112

Fig. 7. Descriptive Statistics for Unit Price

	count	mean	std	min	25%	50%	75%	max
ALTINDAG	2072.0	20429.4477690962	7387.4215255031395	3200.0	15500.0	19090.909090909092	23500.0	108333.33333333333
CANKAYA	2190.0	33475.56164597417	14128.748510837346	10000.0	24044.471153846156	30000.0	39800.0	211111.11111111112
ETIMESGUT	1305.0	26583.541578259985	9818.183830033804	7996.666666666667	19150.0	24305.555555555555	32954.545454545456	66250.0
GOLBASI	803.0	37239.66147111162	15597.817484212028	1664.5833333333333	25912.962962962964	35000.0	45313.725490196084	105555.55555555556
KECIOREN	2396.0	20424.769618286788	6615.683964992601	7867.647058823533	16067.994505494506	19449.928977272728	22970.299145299145	66666.66666666667
MAMAK	2320.0	18757.841455021917	6225.121634379179	7796.0	14800.0	17500.0	21111.11111111111	63425.92592592593
PURSAKLAR	2356.0	21417.222962977292	6049.403558462423 5	4625.0	17619.047619047 62	20454.545454545456	24000.0	74561.40350877192
SINCAN	2637.0	18046.518339128776	5104.756206356405	2343.75	14666.666666666666	17158.333333333332	20400.0	66000.0
YENIMAHALLE	824.0	28127.407760100305	11265.089033059183	9000.0	20996.913580246914	25714.285714285714	32222.222222222223	100000.0

Fig. 8. Descriptive Statistics for Unit Price by Districts

Before constructing the models, it's crucial to preprocess the data to improve the models' ability to learn patterns effectively. Specifically, numerical values were standardized to bring them into a comparable range, which aids in achieving better convergence during training. Meanwhile, categorical values, such as those in the district column, were transformed using one-hot encoding, which generates binary variables for each category.

The correlation matrix (Fig. 9) offers valuable insights into the relationships between various housing characteristics and their impact on pricing. It shows that price correlates moderately to strongly with area (m²) at 0.58 and with total rooms at 0.45. This correlation indicates that larger homes tend to command higher prices in the housing market. Additionally, there is a significant negative correlation of -0.24 between price and building age, suggesting that newer properties generally have higher prices. This trend can be attributed to the modern amenities and superior construction standards often found in newer homes, making them more attractive to buyers. Moreover, the high correlation of 0.82 between area (m²) and total rooms raises concerns about multicollinearity, which should be carefully considered in predictive modelling. Multicollinearity can obscure the true relationships between independent variables and the dependent variable, leading to less reliable predictions. Upon further examination of the data, it becomes clear that specific property types display distinct pricing trends. For example, villas show a positive association with price, likely due to their luxury appeal and larger lot sizes. In contrast, flats exhibit a negative correlation with pricing, which may reflect their smaller size or less desirable features compared to other property types. Locational differences also play a significant role in pricing dynamics. Certain districts, such as Çankaya, are positively correlated with higher prices, presumably because of their central location, better amenities, and perceived prestige. Conversely, areas like Sincan and Altındağ show negative relationships with price, which may be linked to socioeconomic factors, market demand, or varying levels of property development in those districts. This pricing disparity highlights the importance of location in housing prices.

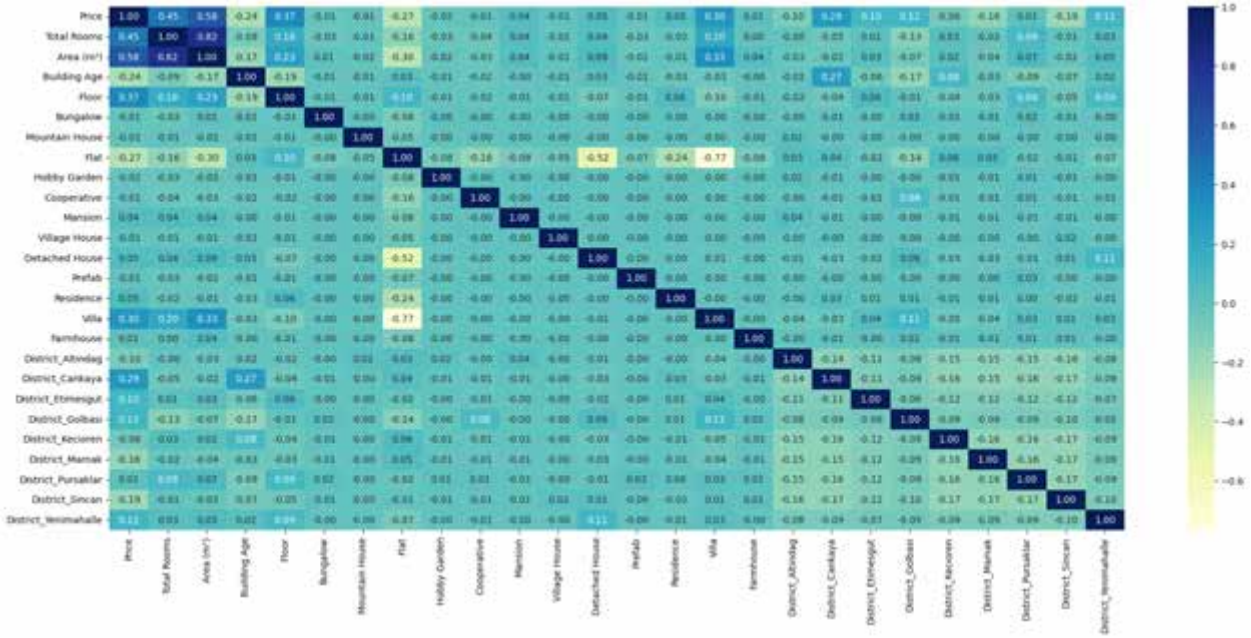

Fig. 9. Correlation Matrix

4.1. Baseline Model Results

In the study, a baseline model was developed to compare linear and random forest models. This baseline model predicts housing prices based solely on the average price per neighbourhood. The results of the model are presented in Table 3. It has a Mean Squared Error (MSE) of approximately 1.7 trillion, indicating a substantial average error in squared units. The Root Mean Squared Error (RMSE) is around 1,310,163, which represents the average prediction error in actual price units—this is quite high and suggests that the model lacks precision. The R-squared (R^2) value is 0.367, meaning the model explains only about 39.9% of the variance in housing prices.

This implies that while neighbourhood averages provide some predictive power, the baseline model is relatively weak, and more sophisticated modelling, such as using multiple features, is necessary for improved accuracy.

Table 3. Baseline Model Results

Mean Squared Error	1,716,527,408,237.00
Root Mean Squared Error	1,310,163.00
R-squared	0.3998

Figure 10 shows predicted housing prices versus actual prices. The red dashed line indicates where predictions would perfectly align with actual values. Many points are close to this line, suggesting reasonably accurate predictions, but there's more variability at higher price ranges. This indicates the model is less precise with expensive properties, reflecting some significant under- and overestimations. While it captures the general trend, it shows room for improvement through additional features or more complex modelling techniques.

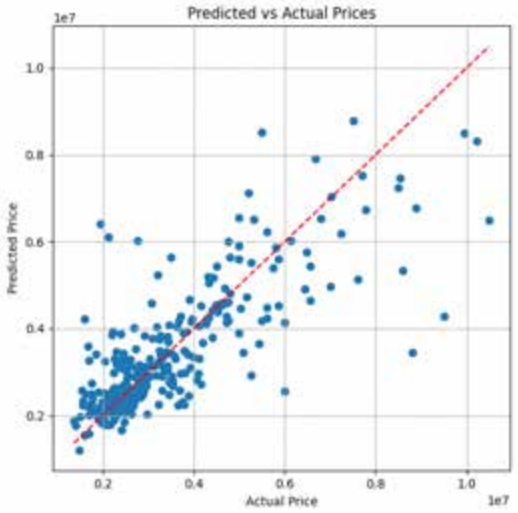

Fig. 10. Baseline Model Predicted and Actual Price

4.2. Linear Regression Results

In the second phase of the study, housing prices were assessed using a linear regression model. The outcomes of the model are outlined in Table 4. The Linear Regression model exhibits a moderate level of predictive performance, with an R-squared value of 0.6108. This indicates that approximately 61% of the variability in housing prices can be explained by the model's features. However, the high Mean Squared Error (over 1.1 trillion) and a Root Mean Squared Error of about 1,045,316 suggest that the model's predictions significantly deviate from the actual prices in absolute terms. This level of error may be considerable, depending on the typical price range in the dataset. Overall, while the model identifies some meaningful trends, its precision is limited, indicating significant room for improvement. This could potentially be achieved through the use of more advanced modeling techniques or enhanced feature engineering.

Table 4. Linear Regression Results

Mean Squared Error	1,092,686,523,151.36
Root Mean Squared Error	1,045,316.47
R-squared	0.6108

Figure 11 illustrates the predicted housing prices compared to the actual prices generated by the Linear Regression model. There is a general upward trend, indicating that the model captures some relationship between the features and the target variable. However, the predictions tend to cluster within a narrower price range. Notably, the model underestimates the prices of high-end properties while overestimating some lower-priced ones. This is evident as many data points significantly deviate from the red dashed line, which signifies perfect prediction. The scatter of points, particularly at both the high and low ends of the price spectrum, visually reinforces the earlier numerical evaluation, highlighting the model's difficulty in accurately capturing the full variability of housing prices.

Fig. 11. Linear Regression Predicted and Actual Price

Applying a logarithmic transformation to the target variable (price) in the linear regression model resulted in a slight improvement in explanatory power, with the R^2 value increasing from 0.6108 to 0.6168. More significantly, the Root Mean Squared Error (RMSE) experienced a dramatic decrease from over 1 million in raw prices to just 0.28 on a log scale. This indicates a substantial reduction in relative error. The findings suggest that the model is more effective at predicting proportional (percentage) differences in price rather than absolute price values. Additionally, log transformation stabilizes variance and diminishes the impact of extreme outliers, leading to more consistent predictions across various price ranges. Although the log price transformation slightly improved the model's predictive accuracy (as reflected by a higher R^2 value), converting the predictions back to actual price values resulted in significantly inflated estimates. This suggests that while the log transformation helps with model fitting, it may distort the predicted values when inverse-transformed, especially in the presence of skewed data or outliers. For this reason, the actual price value was used as the dependent variable in the study instead of the log transformation of the price.

4.3. Random Forest Results

In the third phase of the study, housing prices were evaluated using a random forest model (see Table 5). The Random Forest Regressor model, after undergoing hyperparameter tuning, achieves an R^2 of 0.7233. This indicates that the model explains approximately 72% of the variance in housing prices, which is a significant improvement over linear regression. The model's Root Mean Squared Error (RMSE) is around 881,343 reflecting a lower average prediction error and demonstrating its ability to effectively manage the complexity and nonlinearity of the housing data. When compared to the untuned version, which had an R^2 of 0.7227 and an RMSE of approximately 882,200 the tuning process has resulted in a modest improvement. Overall, this tuned Random Forest model provides robust and reliable results for predicting property prices.

Table 5. Random Forest Results

Mean Squared Error	776,765,523,406.89
Root Mean Squared Error	881,343.02
R-squared	0.7233

Compared to the linear regression model, the scatter plot for the Random Forest Regression (Figure 12) shows a more accurate alignment of predicted prices with actual prices, particularly for mid- to high-range properties. While both models display some spread, the Random Forest's predictions are generally closer to the diagonal reference line, indicating improved accuracy. It captures nonlinear relationships better, reducing systematic underestimation of expensive properties seen in the linear model. Although slight over- and under-predictions remain, especially at the extremes, this plot visually confirms that Random Forest provides a more reliable fit than linear regression in modelling complex housing price patterns.

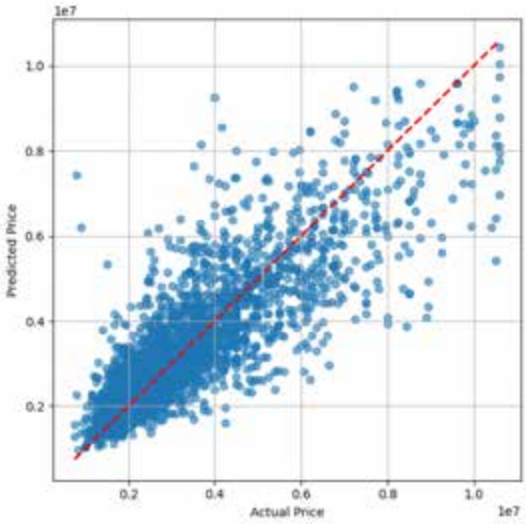

Fig. 12. Random Forest Predicted and Actual Price

5. Discussion

This study aims to achieve a more precise estimation of housing prices by utilizing advanced analytical methods. To accomplish this, it compares both linear and non-linear specifications of the hedonic price model, a widely recognized framework in housing market research. Table 6 compares actual housing prices with predictions made by Linear Regression and Random Forest models across the 15 most expensive neighbourhoods. The Linear Regression model tends to underestimate housing prices, particularly in high-value areas such as Fatih Sultan, Mutlukent, and Çukurambar. This indicates the model's limitations in capturing non-linear patterns and extreme values. In contrast, the Random Forest model provides more accurate and stable predictions, often aligning closely with actual prices and even slightly overestimating in some cases, such as in Koru. This suggests that the Random Forest model is better suited for capturing the complex relationships present in housing data and performs more robustly in high-price segments. However, both models exhibit certain deviations from actual prices, which highlights opportunities for further improvement.

Table 6. The comparison Linear Regression and Random Forest Prediction with Actual Price

Neighborhood	Actual Price	Linear Regression Prediction	Random Forest Prediction
Fatih Sultan	9,850,000	6,378,664	7,845,811
Mutlukent	8,600,000	5,563,571	6,469,399
Çukurambar	8,525,000	5,180,941	5,590,277
Üniversiteler	8,500,000	4,030,711	4,646,521
Emniyet	8,475,000	6,275,043	6,284,633
Koru	8,450,000	4,414,746	3,867,666
Kızılırmak	7,833,333	5,140,973	6,797,407
Alacaatlı	7,815,000	5,886,321	6,887,986
Koparan	7,700,000	10,320,204	9,194,666
Bademlidere	7,606,250	7,221,187	7,895,229
Yaşamkent	7,180,000	7,017,621	7,152,333
Bağlıca	6,740,580	4,632,440	5,920,819
Malıköy	6,649,166	6,962,850	6,251,322
Bahçelievler	6,587,500	4,444,840	5,760,515
Beştepe	6,500,000	4,066,717	5,365,666

Based on the results of the predictive modelling, housing affordability in Ankara varies significantly across neighbourhoods. Certain neighbourhoods, such as Fatih Sultan, Mutlukent, Üniversiteler, and Çukurambar, consistently show high actual prices, indicating low affordability, particularly since the model tends to underestimate these values. This underestimation may be due to unobserved amenities or factors that contribute to desirability, which are not fully captured by the model's features. Additionally, the substantial prediction errors in high-priced neighbourhoods suggest that affordability challenges in these areas may be more severe than initially indicated by the data. In contrast, the model performs better in moderately priced neighbourhoods, which may imply more predictable and accessible housing conditions in those locations. To enhance the analysis and provide a more comprehensive understanding of affordability across the city, incorporating socioeconomic indicators such as household income, employment rates, and demographic characteristics would be beneficial.

The analysis indicates that the neighbourhoods with the highest housing prices—Kızılırmak, Çukurambar, Üniversiteler, Mutlukent, Yaşamkent, Koru, Alacaatlı, Fatih Sultan, and Bağlıca—are clustered along the Eskişehir Road, to the west of the city centre. It can also be inferred that the properties in the adjacent neighbourhoods of Çayyolu and Beytepe are unaffordable. Furthermore, high housing prices are observed in the neighbourhoods located west of the Konya Road, which serves as one of Ankara's main transportation axes. These neighbourhoods include Beştepe, Emniyet, İşçi Blokları, and Çiğdem. In Gölbaşı, the neighbourhoods of Ballıkpınar, Hacılar, Tulumtaş, and Koparan also experience elevated prices. This trend can be attributed to the fact that the housing typologies in these areas are primarily detached homes.

The analysis highlights a concerning trend of increasing housing unaffordability in Ankara, especially in neighbourhoods along the Eskişehir and Konya Road corridors. These areas, known for their high-income residents and mainly planned developments with detached single-family homes, have seen substantial increases in property prices in recent years. As a result, housing in these districts has become prohibitively expensive for middle- and lower-income residents. This ongoing rise in housing costs worsens spatial inequality throughout the city. Not only is housing affordability compromised, but the diverse socio-economic backgrounds that once characterized

these neighbourhoods are also increasingly at risk. The current scenario in Ankara highlights a significant trend of urban segregation, where many individuals find the aspiration of owning a home increasingly out of reach. This reality not only deepens existing social divides but also inhibits community cohesion, ultimately impacting the overall cohesion within the city.

6. Conclusion

Given the increasing economic pressures and rising housing prices in Turkey, especially in Ankara, it has become crucial to develop accurate and effective methods for predicting housing market trends. To monitor housing market dynamics, the hedonic price model has long been used to monitor housing market dynamics. However, this model has some structural limitations. Predicting housing prices is challenging. The Central Bank of Türkiye has published a Residential Property Price Index monthly since 2010 to monitor price movements, but it only includes dwelling units valued for housing loans, representing just 35–40% of the market (Özdemir Sarı, 2019). This limits its effectiveness in capturing the overall housing market dynamics. Traditional hedonic price models often use linear regression methods, which fail to account for the complex, non-linear relationships between housing prices and their attributes. This study proposes an innovative approach aimed at refining housing price estimates by effectively addressing the inherent limitations of traditional hedonic models and significantly enhancing the representativeness of the data utilized. Through a comprehensive analysis that compares linear regression and random forest methodologies, the findings indicate that the random forest model consistently yields superior predictive accuracy and reliability.

The findings highlight growing concerns about housing affordability in Ankara, revealing significant disparities between neighbourhoods. Wealthier districts along the Eskişehir and Konya Road corridors—such as Fatih Sultan, Çukurambar, Mutlukent, and Alacaatlı—consistently show high property prices, which predictive models often underestimate. This discrepancy indicates that these areas likely possess unmeasured qualities, such as better amenities or prestige, that structural features alone do not capture. Consequently, affordability in these neighbourhoods is probably even lower than suggested, creating barriers for middle- and low-income households. Additionally, the concentration of high-priced, low-affordability neighbourhoods in the western and southwestern parts of the city reveals a trend of spatial and socioeconomic segregation. The increasing exclusivity of these areas, combined with rising prediction errors in high value zones, suggests a widening gap in access to housing. To fully understand and address this issue, future modelling efforts should incorporate socioeconomic indicators and neighbourhood-level attributes. Doing so would help capture the complex nature of urban housing markets and support more informed urban planning and policy decisions aimed at improving housing accessibility and equity.

The current analysis relies solely on structural characteristics of housing and neighbourhood as a binary variable. Incorporating additional location-specific and neighbourhood attributes, such as proximity to amenities, schools, public transportation, crime rates, and green spaces, has the potential to significantly enhance the accuracy of the predictive model. Urban housing markets exhibit considerable complexity, rendering them ineffective as a singular, homogeneous market. This complexity arises from a variety of factors, including socioeconomic diversity, varying demand and supply dynamics, and distinct local regulations. As a result, making predictions tailored to specific sub-markets within the urban landscape can lead to improved prediction rates and more reliable insights into housing trends and pricing fluctuations.

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Nigerian Housing Development Policies Impact on Lagos Housing Deficit (1960 – 2020) A Critical Literature Review)

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Abstract
This paper critically examines the evolution of housing development policies in Lagos, Nigeria, from 1960 to 2020, and their subsequent impact on the housing deficit in the region. The literature review integrates various scholarly sources that explore the historical context, the emergence of different housing policies, and the effectiveness of these strategies in addressing the housing gap in Lagos. This research finds out and evaluates the predominant housing development strategy within the housing development phases, and its implementation in Lagos Nigeria,
The findings highlight that despite numerous policies implemented by the Nigerian government, the housing deficit remains a persistent challenge due to issues at the level of execution, funding, and gaps between the policies and the populace. This research aims to contribute to the understanding of how policy evolution shapes housing development and proposes recommendations for more effective approaches in the future.

Keywords: Housing: policies, development, deficits, challenges, implementation

1.0 INTRODUCTION

The evolution of housing development policies in Lagos has been driven by the city's rapid population growth and urbanization since Nigeria's independence in 1960. The migration of people seeking better opportunities has intensified the housing deficit, leading to a series of policy interventions aimed at providing affordable housing solutions (Owolabi et.al 2023; Heinrich Böll Stiftung 2023). Despite the efforts, Nigeria faces a housing deficit of around 22 million, with Lagos accounting for approximately 4.7 million of these figures (World Bank, 2023; Oluwatayo & Amole, 2021; Heinrich Böll Stiftung 2017, 2023). The cost of housing continues to rise, making it unaffordable for low and medium-income earners. Over the years, five National Housing Development Phases from 1960 to 2020 have attempted to address the housing gap, but many planned housing units were never constructed.

State-initiated housing in Nigeria began during the colonial era, particularly after the 1920s bubonic epidemic in Lagos. Housing projects were initially targeted at expatriates, leading to the creation of Government Reserved Areas. Direct Housing Construction emerged as a predominant strategy for low-cost housing schemes. This approach, along with Site and Services strategies, has remained prevalent (Bello, 2019; Ayoade & Onifade 2020; Chinwe 2015). Other strategies include Slum Clearance and Resettlement and Core Housing/Incremental Housing (Olotuah, Taiwo 2015; Ibimilua & Ibitoye 2015; NBRRI 2013). However, these initiatives have not effectively reduced the housing deficit.

Currently, approximately 60% of Nigeria's population lives in urban centres, with most state-led housing interventions focused on these areas (World Bank Data, 2024). Lagos, as the case study for this research, exemplifies the urban housing crisis. The paper evaluates the various housing development phases to identify the predominant strategy implemented during each period and assess its effectiveness. Despite the numerous policy phases, the critical question of how to reduce the housing gap and provide affordable housing for urban middle-income and low-income demographics remains unanswered. This research aims to trace the missing links in the effectiveness of Nigerian housing development policies from 1960 to 2020, using Lagos as a case study. The study benchmarks each housing development phase against the realization of estimated housing stocks to understand the practical outcomes of stated policies.

2.0 METHOD AND DEFINITIONS

2.1 Method

This publication is conducted using critical literature analysis (Rachel R.N 2024, Jack Caulfield 2025) by reviewing literatures and analysing the key thread of thought regarding housing development policies and deficits in Nigeria and Lagos City to identify the way forward in the Nigerian context.

The data collection process in the literature review is structured around this main theme of evaluating the successive housing development policies in Nigeria and finding the predominant housing policies, this enabled to trace the missing link in the effectiveness of the Nigerian Housing development polices 1960-2020, with Lagos as case study. Within the context of the literature reviews, the following questions served as guiding compass; What lead to the initiation of each housing development phases and the proposed number of housing units that were planned for each phase? How the realizations and the non-realization of stated housing stocks for each housing development phase has led to the current housing deficits? How the patterns of the relationship between the challenges of each predominant housing strategy have evolved over time to the current housing backlogs? How the predominant housing strategies has been operationalized in Lagos Nigeria within the time frame 1960 – 2020. The literature comes from peer-reviewed outlet such as journals, conference proceedings, book chapters, also included were other documents from organizations, government parastatals, and research institutions within housing research framework. These questions were the key words that were used for data collection, from the bulk of search results, the total of the cited references was eventually reviewed, and this led to the conclusion and findings.

2.2 Case Study

The case studies within the context of this research refers to the studied literatures and the geographical urban context of Lagos city with respect to its housing polices and deficits.

Research identifies Lagos as a significant case study due to its rapid urbanization and housing deficit. As Africa's largest city and projected to be the world's largest by 2100, Lagos' housing policies have evolved since the colonial era and the establishment of the Lagos Executive Development Board in 1948 (World Bank, 2023; Victor, 2022; Ayoade & Onifade, 2020).

The city was central to the First National Housing Development Scheme from 1962 to 1968 and has seen various state-initiated housing policies since 2000 (Olotuah & Taiwo, 2015; UNHabitat, 2015; Aduwo et.al, 2016).

2.3 Definition of Terms

2.3.1 Housing

According to the Nigerian National Housing Policy Handbook (2010), housing involves providing safe, comfortable, functional, affordable shelter within a neighbourhood, supported by continuous maintenance. Housing includes sustainability attributes like energy efficiency and resource conservation for improved quality of life (Nigerian Government, 2007). UN-Habitat (2022) defines housing as a physical structure providing shelter and necessary services for health, security, and well-being. The World Health Organization (WHO, 2021) emphasizes housing's role in public health, considering the residential environment and its impact on well-being. The Universal Declaration of Human Rights states that adequate housing is a fundamental right for health and well-being (United Nations, 1948). Overall, housing encompasses social, economic, and environmental aspects contributing to the quality of life.

2.3.2 Housing Development Policy

Researchers such as Moore 2019, Schmidt 2023 asserts that housing development policy consists of laws, regulations, and administrative practices aimed at producing and delivering housing. It provides guidelines and goals but does not specify detailed strategies, establishing limits for discretionary actions. The primary goal of Nigeria's national housing policy is to make decent shelter available and affordable for all. It addresses land ownership, housing finance, and construction and delivery (Nigerian Government 2007). A policy requires a strategy

for enforcement to achieve the intended programmes of action.

2.3.3 Housing Deficit

Housing deficit refers to the gap in the number of houses needed to accommodate a population (Moore 2019). It includes inadequate shelters and overcrowded conditions. The deficit can be measured annually or as a backlog. It is also defined as the difference between households and permanent dwellings and can be estimated for a specific period or date.

In Lagos, 75.0 per cent of the housing deficit affects families earning less than three times the minimum wage (World Bank 2020)

3.0 RESULTS

Housing is a critical issue in Nigeria, driven by rapid urbanization and population growth. The country's housing deficit is estimated to be around 22 million units, placing immense pressure on housing markets (Akeju, 2007). This demand has led to informal settlements, inadequate housing conditions, and overcrowding. Challenges include inadequate funding, high building material costs, lack of infrastructure, and inefficient policies (Ibem & Amole, 2010). The underdeveloped mortgage market and complex land tenure systems, governed by the Land Use Act of 1978, further complicate housing development (Omirin, 2002). Bureaucratic delays and inconsistent government policies also hinder progress.

Successive Nigerian governments have introduced initiatives to improve housing. The National Housing Policy (NHP), revised in 2012, aims to provide affordable, sustainable housing by encouraging private-sector involvement and public-private partnerships. The Federal Mortgage Bank of Nigeria (FMBN) was established to provide long-term credit facilities to mortgage institutions. The National Housing Fund (NHF), managed by the FMBN, encourages Nigerians to contribute towards homeownership (Akinmoladun & Oluwoye, 2007). However, the effectiveness of these policies is limited by corruption, fund mismanagement, and the NHF's inability to meet housing finance demand (Olotuah & Bobadoye, 2009).

Mass housing schemes like the Federal Housing Authority (FHA) estates aim to provide affordable homes to low- and middle-income earners. Despite efforts, the number of houses built remains insufficient to meet the housing deficit (Ibem, 2011). Private-sector involvement through public-private partnerships (PPPs) has increased, with projects like Lekki Gardens and Eko Atlantic City addressing urban housing needs (Olayiwola, Adeleye, & Ogunshakin, 2005). However, private developments often cater to higher-income groups, excluding many low-income earners (Makinde, 2014).

To address the housing crisis, experts advocate sustainable policies targeting urban low- to middle-income earners, such as slum upgrading and urban renewal, to improve informal settlements (Ibem & Aduwo, 2013).

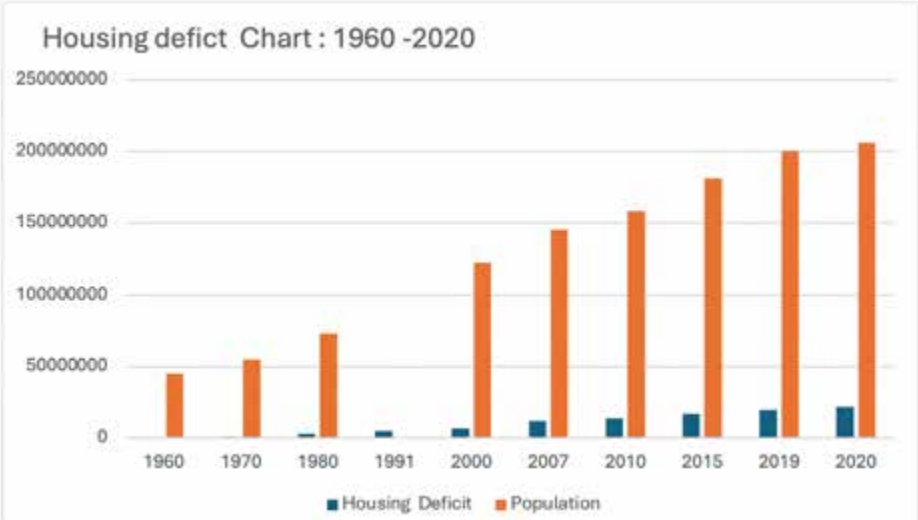

Figure 1. Housing deficit trend chart in Nigeria between 1960-2020
Sources: FMWHN (2007), Aribigbola (2008), Ibem (2011), UNHabitat (2006,2015), World Bank (2016), Pison (2019), Federal Mortgage Bank of Nigeria (2020); Adeoye et al. (2020), Statista (2024)

Private-sector developments often cater to higher-income groups, excluding most Nigerians (Makinde, 2014). Experts recommend sustainable policies targeting urban low- to middle-income earners, such as slum upgrading and urban renewal, to improve informal settlements (Ibem & Aduwo, 2013). By providing essential infrastructure like roads, water, and electricity, the government can significantly enhance living conditions for millions residing in informal housing, addressing the widespread housing crisis in Nigeria (Ibem & Aduwo, 2013).

3.1 History of National Housing Development Policy Phases in Nigeria (1960-2020)

Ayoade, A. & Onifade, V. (2020) stated that the Nigerian Public Housing involvement began in the colonial time following the 1920s eruption of the bubonic epidemic in Lagos. During the period 1900 – 1960, government involvement was targeted particularly on the delivery of accommodation for foreign personnel and selected native personnel-the government did not attempt to provide housing for the public. Since the independence of Nigeria in 1960 the government had adopted various strategies in its intervention in housing. The Federal Government has over the years made substantial allocations to the housing sector in the various National Development Plans (Olotuah O, Taiwo A.A ;2015).

Table 1: Housing deficit trend in Nigeria between 1960-2020
Sources: Federal Ministry of Housing (2007), Aribigbola (2008), Ibem (2011), UN-Habitat (2006,2015), World Bank (2016), Pison Housing Company (2019), Federal Mortgage Bank of Nigeria (2020); Adeoye et al. (2020), Statista (2024)

PHASE	YEAR	HOUSING DEFICIT	NATIONAL POPULATION	HOUSING POLICY
First National Development Plan (1962-1968)	1960	500,00	45,000,000 million	Direct Housing Construction
	1970	1 million	55,000,000 million	
Second – Fourth National Development Plan (1970-1985)	1980	3 million	73,000,000 million	

Fifth National Development Plan (1962-1968)	1991	5 million		Site and Services Housing Policy + Direct Housing Construction
	2000	7 million	122,000,000million	
	2007	12 million	145,000,000 million	
	2010	14 million	158,000,000 million	
	2015	17 million	181,000,000 million	
	2019	20 million	200,000,000 million	
	2020	22 million	206,000,000 million	

3.1.1 The First National Development Plan (1962-1968): Adoption of Direct Housing Construction

The First National Development Plan was Nigeria's inaugural attempt at systematic economic planning after gaining independence in 1960. The plan aimed at transforming the economy from a colonial-dependent structure into a more diversified and self-reliant one. It focused on industrialization, agriculture, transportation, education, and urban development, with significant allocations to infrastructure and social services (FRN,1981). Housing was a component of the broader urban development agenda, reflecting the growing demand for residential accommodation due to rapid urbanization, particularly in Lagos. The effort of government at housing provision was focused principally on Lagos, the then capital city of Nigeria, as it became the centre of economic activities under the development plan, the city attracted a significant influx of migrants from rural areas seeking better economic opportunities. This migration led to a population surge in Lagos, causing an unprecedented demand for housing. By the mid-1960s, Lagos' population had nearly doubled, putting immense pressure on the city's infrastructure and available housing (Mabogunje,1990). The government recognized the need to address this housing crisis, but the rapid rate of urbanization outpaced development efforts.

The Federal Government proposed the construction of 61,000 housing units but only 500 units (less than 1%) were built. The political chaos and the resulting civil war (1966-1970) contributed to the marginal progress recorded during this period.

Under the First National Development Plan, the Nigerian government-initiated housing projects to address the urban housing shortage. The Lagos Executive Development Board (LEDB) played a central role in implementing these projects. One of the notable projects was the construction of low-cost housing estates, such as the Surulere Housing Estate, which was developed to provide affordable housing for middle- and low-income earners. Despite these efforts, the number of units produced was insufficient to meet the growing demand.

The housing estates built during this period provided some relief but were largely inadequate for Lagos' rapidly growing population.

This resulted in total of 60,500 housing deficit backlog in Lagos Nigeria, according to Macrotrend, (2024), the total population growing from 926,000 – 1,353,000 during this time frame.

The First National Development Plan laid the groundwork for future housing policies in Lagos, even though its immediate impact on housing supply was limited. The period highlighted the need for more comprehensive urban planning and a targeted housing policy. It also set the stage for subsequent development plans, such as the Second National Development Plan (1970-1974), which gave greater emphasis to housing and urban development, attempting to address the deficits left by the first plan.

3.1.2 Second National Development Plan (1970-1974): Development of Estates

The Second National Development Plan (1970-1974) followed the first national development plan with the aim of addressing the country's post-civil war reconstruction and economic development needs. This plan aimed to improve various sectors, including housing, infrastructure, and industry, with Lagos being a focal point due to its status as the economic hub and the capital at the time.

In Lagos, the federal government initiated several housing programs under the Plan. For instance, the Federal Housing Authority (FHA) was established in 1973 to oversee housing development across the country, with Lagos being a major beneficiary due to its status as the capital. The FHA's early interventions included the construction of large public housing estates aimed at providing affordable homes for low- and middle-income earners.

One of the notable housing projects initiated during this period was the construction of FESTAC Town, designed as a residential area for participants of the 1977 Second World Black and African Festival of Arts and Culture (Omirin, 2002). Although FESTAC Town was planned during the 1970-1974 development period, its completion occurred later. Still, the town represents the impact of federal planning and urban development policies initiated under the Second Plan.

The Federal Government initiated the National Housing Programme and Direct house construction for the public during the Second Development Plan Period. It planned to build 59,000 housing units throughout the federation. In that plan period government also established the National Council on Housing which consisted of all State Commissioners of Works and Housing. Monies allocated by the federal government and some state governments were negligible while some states did not allocate money for such programs.

The impact of the Second National Development Plan on Lagos' housing sector was mixed. While the government made significant strides in constructing public housing estates, the population growth in Lagos, driven by rural-urban migration, far outpaced the available housing stock. Between 1963 and 1974, Lagos experienced a population explosion from about 665,000 to over 1.4 million people (Mabogunje, 1990). This rapid growth led to severe housing shortages, despite the government's efforts.

The Plan's focus on state-driven housing schemes reflected a broader national strategy of public sector involvement in housing delivery. However, bureaucratic inefficiencies, poor implementation, and corruption marred the realization of many of the ambitious housing projects (Agboola, 1997). As a result, housing deficits in Lagos continued to grow, leading to the proliferation of informal settlements and slums across the city.

Nevertheless, the development plan did have lasting impacts on Lagos' urban landscape. Large-scale public housing estates such as Surulere and Dolphin Estate are products of the government's post-civil war efforts to provide mass housing for Lagosian (Onibokun, 1985). These estates helped shape the city's urban development pattern, though they ultimately fell short of solving the housing crisis.

3.1.3 Third National Development Plan (1975-1980): Mortgage Loan and Public official quarters

In the Third Development Plan government pledged to provide housing for all income groups, especially low-income groups, and to ensure that average urban workers did not pay more than 20% of their monthly income as rent.

The thrust of the government's effort was the direct construction of housing units at the Federal and State levels, increased construction of quarters for public officials, and expanded credit facilities to enhance private housing construction.

A target of 202,000 housing units was set by the Federal Government of Nigeria (FGN), however, the actual number of units constructed was 28,000 which was only 14% of the target set (FGN, 2004) or about 3% of the actual housing shortage of 867,000 by 1975 (Benjamin, 2000).

3.1.4 Fourth National Development Plan (1981-1985): Affordability and citizen participation

The Fourth National Development Plan witnessed a housing provision drive based on the concept of affordability and citizenship participation, this was necessary because of economic difficulties, particularly after the oil bust of the early 1980s, affected housing policies, and the government introduced Structural Adjustment and Economic Liberalization Program (SAP), this reduces the government's ability to fund large-scale housing projects

diminished, leading to a shift in focus towards private sector participation.

The government planned the construction of 160,000 housing units nationwide between 1979 and 1983. It proposed the construction of 2,000 houses for each of the then 19 states and Abuja annually, out of which 80% was earmarked for low-income earners. By 1983 only about 20% of the set target was achieved (FGN, 2004, Olotuah 2020).

The second phase of the housing program (with a target of 20,000 dwellings to be built all over Nigeria) was initiated mid-way through the first phase. It did not take off in several states mainly because of undue politicization and the uncooperative attitude of the state executives.

Precisely 47,500 housing units were built across Nigeria, and 2,634 housing units were built in Lagos Nigeria, and Lagos population grew from 2,736,00 to 3,500,000 during this time frame.
The planned housing unit to be built in Lagos during this phase was 10,000 units, however 2,634 housing units were realised, this created a backlog of 7,366 housing units

3.1.5 Fifth National Housing Policy Phase (1984 -2020 – till present): Combination of Strategy
The strategies of the government in the realization of its housing programs changed in 1984 from direct housing construction to the provision of sites and services. The sites-and-services program was handled by the Federal Ministry of Works and Housing. Between 1984 and 1988, the ministry developed 20 estates with 11,393 serviced residential plots.

In 1991 the Federal Government formulated the National Housing Policy, the goal of which was to ensure access to adequate and affordable housing for all Nigerians by the year 2000. Towards achieving the goal of the National Housing Policy, it was estimated that a total of eight (8) million housing units would be required to cater to the existing and future needs of the population. These were further broken down into five million for the urban areas and three million for the rural areas. Eight hundred thousand (800,000) housing units were estimated to be constructed yearly to meet this need.

In 1994 the Federal Government initiated a new housing scheme and proposed to build 121,000 housing units in state capitals where housing needs were acute. Only 1,114 housing units were completed (in Kado Estate Abuja) and commissioned on 15 December 1994 (Benjamin, 2000).

In 2004 the Federal Government proposed the construction of 18,500 housing units throughout the federation, with at least 500 units in each of the states of the federation and the Federal Capital Territory. The program took off in April 2005 in Ekiti State.

The major thrust of the Fifth National Housing Policy was the development of a housing finance system geared towards ensuring an enabling environment for the generation of housing finance, with the private sector as the main source. For the realization of this objective, the National Housing Fund (NHF) was established by the enactment of Decree No. 3 of 1992. Decree No. 82 of 1993 reorganized the mortgage industry with the deconsolidation of the Federal Mortgage Bank of Nigeria (FMBN). The NHF was established primarily to address the constraint of the mobilization of long-term funds for housing development and to nurture and maintain a stable base for affordable housing finance. Thus, it was to facilitate the mobilization of low-cost funds as long-term loans for building, purchasing, and improving houses.

The poor performance of the National Housing Policy in meeting its set goals and objectives led to a comprehensive review, which culminated in the Housing and Urban Development Policy of 2002. The new National Housing Policy was proposed in 2002, and its first draft came into publication in January 2004. The 2002 National Housing Policy was aimed to increase housing supply, provide affordable housing, increase Public-Private Sector Participation and land reforms, but these were not achieved because many of the housing projects catered more to the middle and high – income groups

Table 2: showing housing backlogs from unrealised housing plans
Sources: Lagos State Government (1960), Olotuah (2006,2020), Olotuah & Bobadoye (2009), UN-Habitat (2006), World Bank (2016), Pison Housing Company (2019) Federal Mortgage Bank of Nigeria (2020)

NR.	TIME FRAME (NATIONWIDE)	PLANNED (NATIONWIDE)	REALISED (LAGOS)	DEFICIT (LAGOS)	POLICY
	1962-1968: **The First National Development Plan**	61,000 housing units in Lagos Nigeria	500 Units	60,500 housing units	
	1970-1974: **The Second National Development Plan**	59,000 housing units throughout the federation	Not accounted	100,000 – 150,000 Housing units	
	1975-1980: **Third National Development Plan**	202,000 housing units	28,000 housing units	174,000 housing Unit	Direct Housing Construction
	1981-1985): **The Fourth National Development Plan**	160,000 housing units nationwide	2,634 housing units were built in Lagos	250,000 housing units	
	1984 -2020: **The Fifth National Development Plans (The National Housing Policy Phase)**	adoption of site and service scheme 121,000 housing units in state capitals 18,500 housing units throughout the federation, with at least 500 units in each of the states of the federation and the Federal Capital Territory.	20 estates with 11,393 serviced residential plots. 1,114 housing units were completed (in Kado Estate Abuja) and commissioned on 15 December 1994 The program took off in April 2005 in Ekiti State.	500,000 – 3.5 million housing units	Direct Housing Construction + Site and Services Housing Policy

3.2 EVOLUTION OF HOUSING DEVELOPMENT IN LAGOS CITY

3.2.1 Lagos City: Urbanization, Housing Development and Government Actors

Lagos, Nigeria's commercial center, faces significant housing challenges, including a shortage of quality housing, infrastructure, overpopulation, poverty, and inequality. These issues have led to high rents, overcrowding, slums, and substandard housing (Housing and SDG IN Urban Africa, 2021). Urbanization is characterized by high population densities, urban sprawl, and informal settlements, with about 66% of residents living in slums lacking basic services (UN-Habitat, 2020). Estimates indicate a housing deficit of over 3 million units (Olotuah, 2016), exacerbated by rapid growth, high land prices, and ineffective housing policies.

Before 1928, planned residential areas in Lagos were limited to Ikoyi, Apapa, Ebute Metta, and Yaba. Ikoyi housed expatriates, while the other areas had some planned road networks. Lagos Island's indigenous housing was unplanned and overcrowded, leading to influenza epidemics and bubonic plague between 1924 and 1930. The Lagos Executive Development Board (LEDB) was established in 1928 to clear slums and relocate families to Surulere. Planning authorities have since become important in metropolitan Lagos.

The Ikeja Area Planning Authority (IAPA) was created in 1956 to control development outside the Federal Capital Territory. In 1958, the Western Nigeria Housing Corporation was established to provide housing finance. In 1972, the LEDB, IAPA, and Epe Town Planning Authority merged to form the Lagos State Development and Property Corporation (LSDPC) to improve efficiency in the housing sector (Lagos State Government, 2022).

The Jakande administration (1979-1983) implemented a massive housing development program, but rapid population growth and economic challenges, including the introduction of the SAP in 1986 and increased petroleum fuel prices in 1994, have exacerbated housing issues. The federal government's 1994 National Housing Scheme for Lagos has stalled due to rising building material costs. Despite five phases of the National Housing Development Plan (1962-2020), affordable housing for middle and low-income residents remains an unresolved issue, with a housing deficit of around 4.7 million units in Lagos (Heinrich Boell Foundation, 2017, 2023).

3.2.3 Lagos Housing Development Distribution

Lagos is divided into two main areas: the Island, with affluent neighbourhoods like Ikoyi, Victoria Island, and Lekki, and the mainland, which has middle-class areas like Surulere, Yaba, and Ikeja, alongside informal settlements. The Island is known for luxury developments driven by high land values (Aluko, 2011). Rising housing costs on the mainland push middle-income earners to less-serviced areas (Ajibola et al., 2012). Housing development in Lagos is unequal, reflecting socio-economic disparities. Government efforts often exclude the urban poor, while private sector focus on luxury housing exacerbates inequality. Addressing these housing challenges requires more inclusive policies and equitable development distribution.

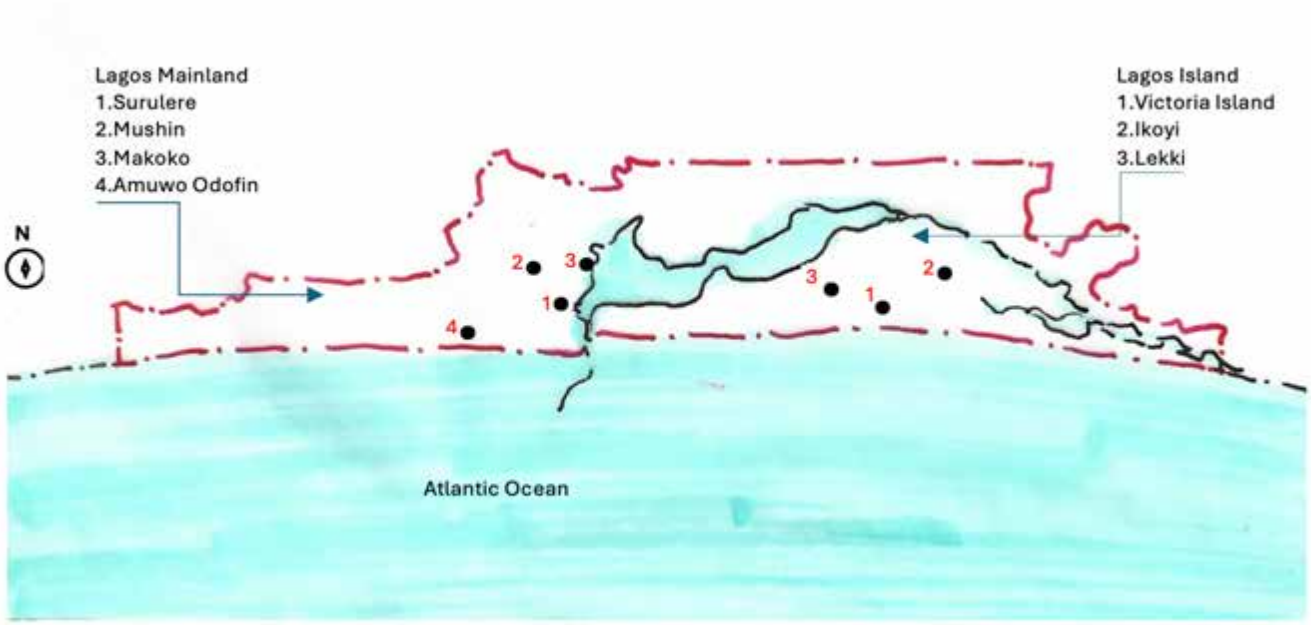

Figure 2. Map of Lagos showing Island (High Income earners areas - Victoria Island, Ikoyi, Lekki) Mainland (Middle income areas-Surulere, Yaba, Ikeja, Low-income areas – Mushin, Ajegunle, Makoko) and the distribution of the post-independence housing projects within the city
Source: Authorial image

3.3 THE PREDOMINANT HOUSING POLICIES AND PROGRAMMES IN LAGOS (1960 – 2020)

From the forgoing evaluation of the five successive housing development policies phases, and how the unrealised housing unit target led to the accumulated deficit, one can see that the two predominant housing development policies are Direct Housing Construction and Site-Services System of housing development has been used so far in Nigerian and as well in Lagos City, this is further established what researchers such as Egidario B. Aduwo, Patrick A. Edewor, Eziyi O. Ibem (2016) stated , that successive governments in Nigeria have since the mid-1920s engaged in different strategies in attempts to resolve urban housing challenges confronting low-income earners, and these strategies are the two predominant housing development strategies are Direct Housing Construction and Site -Services Policy.

3.3.1 DIRECT HOUSING CONSTRUCTION

3.3.1.1 Slum Clearance and Resettlement Strategy

Slum clearance or slum evacuation is an urban renewal strategy aimed at redeveloping low-income settlements into new developments or housing. This method has long been used to rebuild urban areas (Young 2016). Slum upgrading, another approach, aims to address legal, physical, social, and economic issues in an area. This includes legalizing land tenure and improving infrastructure and services, which fosters a sense of ownership and investment among residents (City Alliance 2024).

Slum upgrading involves repairing and renewing areas to prevent further deterioration. It is a cooperative effort between the state and residents, where the state provides serviced sites for residents to design and build their own housing (Amany Ragheb; Rsha El-Ashmawy, 2021). The approach became popular in Africa in the 1970s and 1980s, heavily influenced by the World Bank's views on minimal state involvement and community participation. However, Werlin (1999) argues that relying on a minimal and often weak state to address slum issues is an illusion, and there are reservations about the effectiveness of community participation (Adama 2020).

In Lagos, Nigeria, from 1960 to 2020, slum clearance and resettlement projects reflected the city's rapid urbanization and the challenges of managing informal settlements. These efforts have often been characterized by a tension between urban modernization goals and the needs of the city's poor. While there have been attempts to improve living conditions through upgrading and resettlement, these efforts have frequently fallen short, leading to ongoing housing and urban development challenges.

Implementation of Slum Clearance and Resettlement Strategy in Lagos
Obalende and Mushin Slum Clearance Attempts(1960s-1970s): In the late 1960s, the Lagos Executive Development Board (LEDB) initiated early attempts at slum clearance, focusing on areas like Obalende and Mushin. However, these efforts were relatively small in scale and often displaced residents without providing adequate resettlement options.

Maroko Evictions (1970s-1980s): One of the most significant slum clearance projects occurred in 1990, under the military regime of General Raji Rasaki. The government forcibly evicted over 300,000 residents from the Maroko slum, located in a prime area close to Victoria Island. The stated aim was to reclaim the land for development and address environmental concerns. The Maroko evictions were highly controversial, criticized for their brutality, lack of proper resettlement, and the failure to provide adequate compensation. The cleared land was later developed into high-end real estate, highlighting the socio-economic divide in Lagos.

Olusosun and Other Clearances (1990s – 2000s): As Lagos continued to grow, more slums were targeted for clearance. The Olusosun slum, located near the city's main landfill, was one such area. Evictions were often justified on the grounds of environmental health and urban renewal, though they frequently led to displacement without adequate alternatives for the residents.

Makoko and Otodo-Gbame Evictions (2012,2017): High-profile evictions in areas like Makoko (a waterfront slum) and Otodo-Gbame highlighted ongoing tensions between slum residents and the state. In 2012 and 2017, these communities faced forced evictions, often justified by the government as necessary for environmental reasons or urban development. These evictions were widely criticized by human rights organizations for their lack of due process and failure to provide resettlement options.

Badagry and Ikorodu Resettlement Program (2010s – 2020s): In recent years, there have been some efforts to provide resettlement for displaced communities, but these have often been inadequate. New resettlement areas, such as those in Badagry and Ikorodu, are usually far from the city centre, lacking basic infrastructure, and often fail to meet the needs of displaced residents.

Overall, slum clearance and resettlement projects in Lagos have been characterized by a tension between the goals of urban modernization and the needs of the city's poor. While there have been attempts to improve living conditions through upgrading and resettlement, these efforts have often fallen short, leading to ongoing challenges in housing and urban development.

3.3.1.2 Core Housing Strategy
Core housing policy refers to the set of principles, strategies, and measures implemented by governments and institutions to ensure that citizens have access to adequate, affordable, and safe housing. It is a key component of social policy aimed at addressing housing needs, reducing homelessness, and ensuring that housing is accessible to all socio-economic groups, particularly vulnerable populations. (OECD 2021, UN -Habitat 2020, World Bank 2020)

The core housing strategy evolved significantly in Lagos between 1960 - 2020 due to various factors, including population growth, urbanization, economic changes, and government policies Despite government efforts, informal and incremental housing development which is a parallel self-made system emerged as a solution to the housing deficit. Individuals and communities began building homes in phases, often starting with basic struc-

tures and gradually improving them as resources allowed.

Implementation of Core Housing in Lagos
Surulere, Ikeja and Shomolu Housing Estates (1960-1979): The Nigerian Building Society (NBS) and Lagos Executive Development Board (LEDB) played significant roles in housing provision, this LEDB was tasked with initiation of the construction of low-cost housing estates like Surulere, Ikeja, and Shomolu under the National Housing Program (NHP) to address housing shortages.

Low-Cost Housing Schemes (1980 – 1999): The 1980s and 1990s were marked by economic instability, structural adjustment programs (SAPs), and military rule. These factors hindered large-scale housing development. The Federal Government launched the Low-Cost Housing Scheme, targeting middle- and low- income earners. However, the program was hampered by corruption and mismanagement, therefore due to the inadequacies of government housing schemes, many Lagos residents turned to self-help housing strategies. This period saw a significant rise in informal settlements, with residents building incrementally as resources became available.

Increase of incremental Housing and beginning of high-end developments (1999-2015)
The return to civilian rule in 1999 brought renewed attention to housing, with the government recognizing the need for more sustainable urban development strategies. The Government initiated the 2002 National Housing Policy which emphasized private sector involvement and encouraged public-private partnerships (PPPs) in housing delivery. However the private sector involvement focused on high-end housing development such as Lekki Peninsula Development, this led to the persistence of informal settlements, such as Makoko, reflected the ongoing reliance on incremental housing. Residents continued to build and expand their homes in stages, often without formal approval or infrastructure.

Home Schemes and Incremental Housing (2015 – 2020) The Lagos State Government introduced policies aimed at improving housing supply, such as the Lagos State Home Ownership Mortgage Scheme (Lagos HOMS). However, these initiatives primarily benefited the middle and upper classes. Despite modernization efforts, the gap between housing demand and supply remained vast. Incremental housing remained a common strategy for the urban poor, with many of these building on the city's outskirts in areas with limited infrastructure.

The core housing strategy in Lagos has largely been shaped by the challenges of rapid urbanization, economic fluctuations, and inadequate government interventions. Incremental housing has played a crucial role in accommodating the city's growing population, particularly for low-income earners. While government policies have attempted to address housing shortages, the informal and incremental approach remains a dominant method for many Lagos residents, reflecting both the resilience and challenges of urban living in Nigeria's largest city

3.3.2 SITES-AND-SERVICES STRATEGY
Site and Service housing policy, used in developing countries, provides low-income families with plots of land equipped with basic infrastructure like roads, water, sanitation, and electricity, allowing them to build homes incrementally (UN-Habitat 2011, World Bank 2002). In Lagos, Nigeria, this strategy addresses urbanization challenges, housing shortages, and informal settlement growth. First introduced in the late 1960s and early 1970s, influenced by global urban planning trends and organizations such as the World Bank, the approach involved providing serviced plots with essential infrastructure, leaving housing construction to beneficiaries. Despite varying success from the 1960s through 2020, the goal was to offer cost-effective housing solutions by enabling families to construct their homes over time, adapting to their financial capabilities (UN-Habitat 2011, World Bank 2002).

Implementation of Site and Services Policy in Lagos Nigeria
FESTAC Town and Satellite Town Project (1970s - 1980s): In the 1970s, Lagos saw its first major Sites-and-Services projects. The Lagos State government, in partnership with the Federal government and international donors, developed several such projects. Notable examples include the FESTAC Town project and the Satellite Town scheme.

Despite good intentions, the projects faced significant challenges. The allocation of serviced plots was often marred by corruption and political interference, leading to the exclusion of low-income earners, the primary target group. Additionally, many allocated plots remained undeveloped for years due to a lack of financial capacity among allottees to construct houses.

Lagos Metropolitan Development (1990s - 2000s): By the 1990s, the effectiveness of the Sites-and-Services strategy was increasingly questioned. The focus shifted towards more comprehensive urban renewal programs that involved not just the provision of serviced plots but also the direct construction of housing units by the government or private developers. The World Bank continued to support Sites-and-Services projects in Lagos, but with a renewed emphasis on integrating these with broader urban development programs, including slum upgrading and the provision of social services. Projects like the Lagos Metropolitan Development and Governance Project (LMDGP) in the early 2000s included elements of the Sites-and-Services approach.

Resurgence and Modern Applications (2010s - 2020): From the 2010s to 2020, Lagos saw renewed interest in the Sites-and-Services strategy due to rapid population growth. The government recognized the limitations of market-driven housing solutions and incorporated the strategy into broader urban development policies. Modern applications focus on creating sustainable communities with pre-established infrastructure, as seen in projects like Eko Atlantic City. However, challenges such as land acquisition, financing, and effective public-private partnerships persist. Critics argue the strategy may not adequately support low-income groups without more support. The Sites-and-Services strategy in Lagos highlights the broader urbanization challenges in Nigeria. For success, it needs a holistic approach that integrates housing with social, economic, and environmental planning (UN-Habitat 2011, World Bank 2002).

4.0 CONCLUSION

This study emphasizes that housing development policies in Lagos have been crafted in response to disease outbreaks, rapid urbanization, population growth, and socio-economic challenges such as inequality and poverty. These policies are shaped by a combination of international frameworks, national government initiatives, and local interventions aimed at addressing housing deficits and improving living conditions.

Analysing the National Housing Development Policy in Nigeria from 1960 to 2020 reveals ambitious plans often hindered by inadequate implementation and socio-economic challenges. Lagos, as the epicentre of Nigeria's urban growth, illustrates the complexities of addressing housing in a rapidly expanding metropolis. While there were periods of progress, persistent housing deficits and increased rural-urban migration highlight the challenges. The direct housing construction policy, particularly in terms of slum upgrading and resettlement, has faced resistance due to social inequality and the disintegration of social networks. The Site and Service housing policy, which faces challenges like land acquisition and ineffective public-private partnerships, offers liberty in construction choices and has seen less resistance, leading to the development of satellite towns that help decongest Lagos City.

The rapid urbanization of Lagos led to increased housing demand, but the supply was insufficient, resulting in the growth of informal settlements. Despite government efforts, the housing deficit continued to grow significantly. During 1962–1980, Lagos' population grew from 926,000 to 2,572,000, with 28,500 housing units realized, leaving a backlog of 234,500 units.

The Structural Adjustment Program (SAP) of the mid-1980s exacerbated economic hardships, reducing the government's capacity to invest in housing. Increased private sector involvement often catered to higher-income earners, leading to high-cost private housing estates, while the housing needs of the lower-income population remained unmet. The urban population of Lagos grew from 2,736,000 to 14,368,000 within this period, with only 2,634 housing units built out of the planned 299,500.

Slum clearance often led to the disintegration of community networks and social support systems, exacerbating

poverty and homelessness. The new developments replacing slums were usually unaffordable for original residents, increasing economic inequality. However, some slum clearance efforts allowed for better urban planning and reduced environmental degradation, although often resulting in new slums due to inadequate resettlement plans.

The core housing strategy in Lagos has been shaped by rapid urbanization, economic fluctuations, and inadequate government interventions. Incremental housing has played a crucial role in accommodating the city's growing population, particularly for low-income earners. While government policies have attempted to address housing shortages, the informal and incremental approach remains dominant, reflecting both resilience and challenges in urban living.

The Sites-and-Services strategy in Lagos, providing plots with infrastructure for incremental housing construction, has had mixed results. While contributing to urban development and infrastructure provision, it has not fully addressed the housing needs of the growing population, especially the urban poor. For effectiveness, this strategy needs to be part of a broader, inclusive urban planning framework, ensuring affordable finance access, transparent allocation processes, and strong institutional support.

In conclusion, the key impacts of housing policies in Lagos from 1960 to 2020 illustrate the need for more inclusive, sustainable, and well-implemented policies to address the housing needs of all residents, particularly the urban poor. Future research could focus on how these predominant housing policies can be further operationalized on a global and local scale within the context of urban housing provision.

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Ownership Dynamics of Low-Income Households Under Iran's Mehr Housing Policy (IMHP) (The Case Study of 13 IMHP Residential Complexes in Babol and Babolsar, Iran)

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Abstract
Iran's Mehr Housing Policy (IMHP), implemented since 2007, represents the Iranian government's most extensive intervention aimed at providing affordable housing for over two million low-income households. This study examines the effectiveness of IMHP as a home-ownership-centric model through a case study of 13 IMHP residential complexes in Babol and Babolsar (3,031 units). Using quantitative methods, including field surveys and statistical analysis, the research reveals significant gaps between policy objectives and outcomes, with only 27% of units remaining occupied by target beneficiaries. The findings show that some low-income owners rented out their units (23%) or resold them in the informal market (26%) despite resale restrictions. The study advocates for context-based, mixed-tenure solutions that integrate ownership and rental options while accounting for informal housing dynamics.

Keywords: Iran's Mehr Housing Policy (IMHP); Affordable Housing; Ownership Dynamics; Low-Income Households; Informal Market.

Introduction

Housing policies play a critical role in addressing the shelter needs of low-income households, with varying models adopted across different socio-political contexts. The relationship between public housing policies and ownership presents several challenges, often stemming from the tension between the goals of providing affordable housing for low-income households and the realities of market dynamics, socio-economic factors, and policy implementation (Phang & Pacey, 2018; Aalbers, 2016; Rolnik, 2013; Rohe, Van Zandt, & McCarthy, 2002).

Homeownership-centric policies, prevalent in liberal welfare states such as the U.S. and UK, emphasize private ownership as a means of wealth accumulation and social stability (Rohe & Lindblad, 2013; Ronald, et al., 2015; Rohe & Stewart, 1996; Wainer & Zabel, 2020). In contrast, rental-centric models, dominant in corporatist welfare states in Northern Europe like Germany and the Netherlands, prioritize long-term affordability and tenant protections (Scanlon, et al., 2014; Whitehead, et al., 2016; Kemeny, 2006; Ronald, 2008; Kemeny, 1995). The effectiveness of these models remains contested, with scholars debating whether homeownership truly benefits low-income households or exacerbates financial vulnerability (Arundel & Ronald, 2021; Aalbers, 2016; Rohe & Lindblad, 2013).

Iran's Mehr Housing Policy (IMHP), one of the largest social housing initiatives in the Middle East, represents a large-scale effort to promote homeownership among low-income groups through subsidized housing units, akin to homeownership-centric policies. Homeownership rates in Iran declined from 89% in 1976 to 69% in 2006. Under the IMHP, over two million units have been built since 2007 on both state-owned and private land to increase homeownership rates, particularly for low-income households.

Affordable housing, as defined by Freeman and Schuetz (2017), must be sold or rented at below-market prices and occupied by households below a defined income threshold. To achieve this, IMHP employed several implementation tools, including state loans, allocation of state-owned land, building permits on inexpensive suburban plots, and legal and bureaucratic facilitation for applicant registration. More than a decade after the delivery of IMHP units to target households, this study examines the policy's effectiveness in achieving its goals. Specifically, it addresses the question: *Has IMHP, as a homeownership-centric model, led to the ownership and occupancy of housing units by low-income households?*

This study analyzes IMHP through the lens of comparative housing policy frameworks, engaging with two central tensions in contemporary housing scholarship: first, the position of IMHP between homeownership-centric and rental-centric welfare models (Ronald, et al., 2015; Scanlon, et al., 2014; Whitehead, et al., 2012; Kemeny, 2006): and second, the challenges of maintaining affordability in public housing systems for target households amid market-driven resale dynamics (Freeman & Schuetz, 2017; Aalbers, 2016; Hackworth, 2014; Rohe & Lindblad, 2013).

Empirical studies highlight that public housing units are increasingly treated as financial assets, leading to speculation and price inflation that exclude low-income groups (Aalbers, 2016). Market mechanisms often transform public housing into a commodity, benefiting investors rather than low-income residents (Rolnik, 2013). Public housing policies may also displace low-income residents, creating housing more attractive to middle- and high-income buyers (Hackworth & Smith, 2001), or result in mixed-income neighborhoods (lees, 2008). Market incentives encourage low-income owners to resell or rent their units at market prices for profit. Consequently, many public housing programs impose resale restrictions to ensure units remain affordable for future low-income households (Phang & Helble, 2016). These restrictions, commonly used to maintain affordability, have varying impacts on neighborhood stability and socio-economic integration (Rohe, et al., 2002). In some cases, they lead to vacant units (Han, 2014), while in others, they enable low-income households to benefit from housing market gains (Phang & Pacey, 2018) However, they do not account for the effectiveness of informal market practices.

It is expected that IMHP, as a homeownership-centric model, has increased ownership rates among low-income households, given its implementation tools for providing affordable housing and resale restrictions—though the impact of the informal market remains to be analyzed.

This exploratory study employs quantitative methods (field surveys and statistical tests) to investigate ownership dynamics in 13 IMHP housing complexes in Babol and Babolsar, Iran. Using proportional stratified sampling and systematic sampling, 335 questionnaires were distributed across 3,031 IMHP units. The study analyzes vacancy rates, rental trends, and informal resale markets to determine whether IMHP effectively serves its target households or inadvertently facilitates speculative practices.

Finally, this study makes three key contributions to planning theory and practice:

1. It provides empirical evidence on the implementation gaps of large-scale housing programs in Middle Eastern countries.
2. It analyzes how informal market practices subvert formal policy instruments.
3. It offers a critical assessment of homeownership promotion as a poverty alleviation strategy.

Housing Policies and Tenure Typologies

Different housing policies are pursued in various countries, generally to meet the housing needs of low-income groups. Housing-welfare models vary across countries: the asset-based welfare model in the USA and UK (Ronald, 2008); the rental-as-welfare model in Germany (Ronald & Doling, 2010); the family-as-welfare model in Japan and South Korea (Doling & Ronald, 2014; Ronald & Jin, 2010); and state-led ownership in China (Zhou & Ronald, 2017). Most countries have focused on "homeownership" policies to address the housing needs of low-income households, while the "private rental sector" operates as well(Schwartz, 2021; Whitehead, et al., 2016) some countries have turned to "social housing" and "social rental systems" to ensure low-income households meet their housing needs, particularly in Europe and East Asia (Scanlon, et al., 2014; Phang, 2007). Earlier, Kemeny (2006; 1995) distinguished between dualist and unitary rental markets:

- "Dualist rental markets" are found in liberal welfare states (e.g., the U.S., UK), where a small, residual social rental sector exists alongside a dominant profit-driven private rental market. Social housing is stigmatized, and homeownership is promoted as the norm.
- "Unitary rental markets" are found in corporatist welfare states (e.g., Sweden, Germany), where social and private rental sectors compete on equal terms, leading to higher-quality, cost-rental housing.

Kemeny (1992) argues that housing systems are socially constructed, shaped by political ideologies rather than purely economic forces. For instance, the promotion of homeownership in Anglo-Saxon countries reflects neoliberal individualism, whereas rental parity in Nordic countries aligns with collectivist welfare principles. Kemeny defines "path dependency," meaning historical policy choices constrain future reforms. For example, once homeownership becomes entrenched, shifting to rental-based systems becomes politically difficult (Bengtsson, 2009). For this reason, in dualist rental markets, governments try to increase homeownership, while in unitary rental markets, governments focus on social renting. Therefore, various models can be classified into two main categories: homeownership-centric models and rental-centric models.

Homeownership-Centric Models

Homeownership-centric models have benefits and consequences, varying significantly across countries due to differences in housing policies and market conditions. Increasing homeownership rates is the main goal of many housing policies worldwide. In the USA and UK, Southern and Eastern Europe, West Asia, and the Middle East, various housing policies have been designed and implemented based on homeownership.

There are some infamous examples of public housing failures, such as the Pruitt-Igoe and Cabrini-Green projects in the USA and the Aylesbury Estate in the UK. These large-scale public housing projects, despite being owned by poor households, have suffered from concentrated poverty, crime, stigma, poor maintenance, and economic isolation (Jacobs, 1961; Newman, 1972; Venkatesh, 2000; Lees, 2008; Schwartz, 2021). After the failure of large-scale public housing projects, approaches shifted to other forms of intervention in the USA, such as the HOPE VI program, which replaced distressed public housing with mixed-income developments but still emphasized homeownership (Schwartz, 2021).

Homeownership has had different impacts on low-income households. On the one hand, it has improved self-esteem and life satisfaction (Rohe & Stegman, 1994b), civic engagement and social capital (Rohe & Stegman, 1994a), long-term community ties (Rohe & Basolo, 1997), neighborhood stability (Rohe & Stewart, 1996), and wealth-building (Rohe & Lindblad, 2013; Phang, 2004). Wainer and Zabel (2020) illustrate how low-income households that transitioned from renting to homeownership experienced significant gains in wealth compared to households that remained renters.

On the other hand, homeownership has caused low-income households to face unexpected repair costs, predatory lending, foreclosure risks (Rohe & Lindblad, 2013; Rohe & Watson, 2007), and purchases in disadvantaged areas (Rohe & Lindblad, 2013). Aalbers (2016) explains how public housing units in Europe and North America are increasingly treated as financial assets, leading to speculation and price inflation that exclude low-income groups. Rolnik (2013) argues that the privatization of public housing and the introduction of market mechanisms have turned public housing into a commodity, often benefiting investors rather than low-income residents. Lees (2008; 2003) highlights how public housing redevelopment in cities like London and New York often results in mixed-income housing, but low-income residents are frequently excluded due to rising costs and eligibility criteria. Hackworth (2007; 2002) explains how public housing policies in the U.S. lead to neighborhood redevelopment, which can displace low-income residents and create housing more attractive to middle- and high-income buyers. Moreover, some studies highlight declining access to homeownership, particularly among younger generations, due to financialization and market liberalization (Arundel & Ronald, 2021) and increasingly favor older, wealthier cohorts, deepening generational inequality (Lennartz, et al., 2016).

Comparing different European models shows that high homeownership rates (as seen in Southern Europe) can create market inflexibility; countries such as Spain (with a homeownership rate of 85%) suffered more during the financial crisis, whereas balanced tenure systems like Germany (with a homeownership rate of 43%) are presented as models with lower ownership but stable renting and greater resilience (Scanlon & Kochan, 2011; Whitehead, et al., 2012). Ronald (2008) challenges the dominant ideology that promotes homeownership as a universal ideal, arguing that it is deeply embedded in welfare and social policies, often exacerbating inequality. Lees (2021) criticizes policies favoring homeownership, which she argues exacerbate housing unaffordability. She discusses how

new-build luxury developments, often marketed to investors, reduce the availability of affordable rental housing. She contends that the financialization of housing, where homes are treated as assets rather than places to live.

Table 1: Benefits and consequences of homeownership.

Homeownership	
Benefits	**Consequences**
self-esteem and life satisfaction (Rohe & Stegman, 1994b)	Financialization (Aalbers, 2016)
civic engagement and social capital (Rohe & Stegman, 1994a)	Displacement (Hackworth, 2007)
long-term community ties (Rohe & Basolo, 1997)	Generational inequality (Arundel & Ronald, 2021).
neighborhood stability (Rohe & Stewart, 1996)	unexpected repair costs, predatory lending, foreclosure risks (Rohe & Lindblad, 2013; Rohe & Watson, 2007)
wealth-building (Wainer & Zabel, 2020; Phang, 2004; Rohe & Lindblad, 2013)	purchases in disadvantaged areas (Rohe & Lindblad, 2013)

Most critiques of homeownership, such as financialization, displacement, and gentrification, stem from the resale of units by initial owners. Therefore, many public housing programs impose resale restrictions to ensure that units remain affordable for future low-income households. Affordable housing, as defined by Freeman and Schuetz (2017), must be sold or rented at below-market prices and occupied by households below a defined income threshold. However, market incentives encourage owners to resell or rent their units at market prices to earn profits.

Successful public housing policies often include strict eligibility criteria, robust oversight, and measures to prevent resale or exploitation. For example, Singapore's Housing and Development Board (HDB), despite critiques of homeownership in Europe and North America, has been successful in ensuring homeownership for a large portion of its population (over 90%) through policies like mandatory savings via the Central Provident Fund (CPF), subsidized housing loans, and resale restrictions. The government ensures affordability through income-based subsidies, price controls, and long-term leases. Comparing Singapore's public housing resale policies, which allow for limited profit-making, with U.S. policies that often impose stricter resale restrictions, shows how Singapore's approach has enabled low-income households to benefit from housing market gains (Phang & Helble, 2016; Phang & Pacey, 2018).

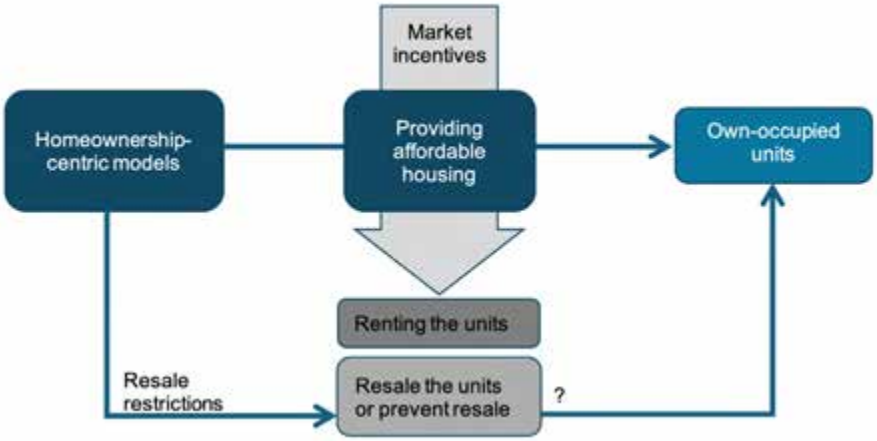

Figure 1: How market incentives encourage the rental or resale of units in homeownership-based models, undermining public housing goals.

Public housing units may be resold or rented at market rates, benefiting investors rather than low-income households (Aalbers, 2016; Rolnik, 2013), so resale restrictions enable low-income households to benefit from housing market gains (Phang & Pacey, 2018). resale restrictions are often imposed to maintain affordability, but their effectiveness varies widely. In some cases, resale restrictions lead to vacant units or disincentivize maintenance (Han, 2014). Rohe et al. (2002) highlight the trade-offs between preserving affordability and allowing homeowners to benefit from market appreciation. Low-income households often rely on home equity as a primary source of wealth, but resale policies affect their ability to accumulate wealth through homeownership. While resale restrictions can help maintain affordable housing stock, they may limit neighborhood turnover, restrict wealth-building potential for low-income households, and propel them into informal markets.

Rental-Centric Models

In various countries, a combination of tenure types—homeownership, private renting, and social housing—is in operation. Homeownership is not the only aspect of housing policy. It is necessary to consider a combination of various tenure types across different contexts. Some countries have a large private renting sector, while others have social renting systems. In the US and UK, homeownership and private renting are the most common tenure types, and high homeownership rates depend on mortgage reliance and family gifts. In contrast, Germany and the Netherlands have a strong rental sector and a legacy of social housing. Each has benefits and consequences that should be considered. Rental-centric models prevent the resale and rental of affordable units in the market by promoting social renting instead of homeownership and private renting.

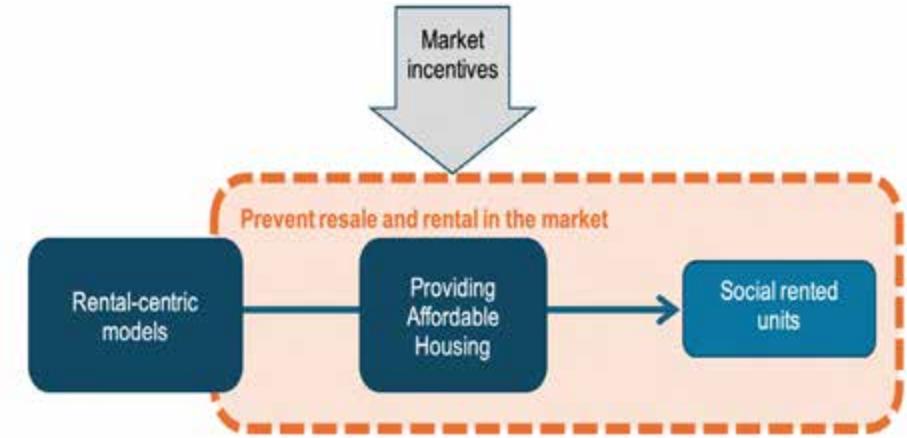

Figure 2: Rental-based models aim to prevent units from being resold or rented on the market.

Kemeny (1995) argues for a shift from market-oriented housing policies to a more social rental model, emphasizing the importance of long-term affordability and tenant rights. Ronald & Kadi (2018) defend social housing and discuss how declining homeownership has led to a resurgence of private renting, often under precarious conditions, and critique deregulation and the erosion of social housing. Schwartz & Meltzer (2015) illustrate the growing affordability crisis in rental markets, particularly in high-cost cities like New York. They argue that high rent burdens correlate with poor health outcomes, emphasizing the need for expanded rental assistance (e.g., Housing Choice Vouchers) and stronger tenant protections. Oxley (2004) argues that social housing is a vital tenure for providing affordable and secure housing. He critiques the overemphasis on homeownership in UK housing policy, arguing that it has often been promoted at the expense of other tenures and can lead to market instability and affordability crises, particularly for lower-income households. Oxley & Smith (1996) acknowledge the growing importance of private renting but highlight its shortcomings, including insecurity and high costs. They believe that social renting should be expanded rather than diminished through right-to-buy policies, which have reduced social housing stock.

Whitehead et al. (2016) and Scanlon (2014) in their comparative study of public housing in Europe, found that countries with strong social welfare systems, such as Austria and Denmark, were more successful in providing affordable housing to low-income groups compared to countries with market-driven approaches. They highlight the growing importance of the private rented sector (PRS) in housing markets, particularly in high-demand cities like London, and note that private renting is no longer just a transitional tenure but a long-term solution for many households, including families. However, they critique the private rental sector for its insecurity, high costs, and variable quality.

Table 2: Comparing tenure typologies: homeownership-centric vs. rental-centric models

	Country	Owner-Occupied	Private Rented	Social Rented	References
Most homeownership -centric	USA	~65% (→)	~30% (↑)	~5% (↓)	HOME VI program, Housing Choice Vouchers (Scanlon, et al., 2014)
	UK	~63% (↓)	~20% (↑)	~17% (↓)	Affordability crises, Buy-to-Let market, Right-to-Buy policies (Ronald & Kadi, 2018; DKM, 2014; Scanlon, et al., 2014)
	Germany	~45% (↓)	~40% (↑)	~15% (↓)	Strong rental sector, tenant protections (Scanlon, et al., 2014; Ronald & Doling, 2010; Whitehead, et al., 2016)
Most rental-centric	Netherlands	~55% (→)	~15% (↑)	~30% (↓)	Social housing legacy, privatization (DKM, 2014; Scanlon, et al., 2014; Whitehead, et al., 2016)

Social housing also has its consequences. For example, units may fall into disrepair due to inadequate funding for maintenance or lack of ownership incentives (Rohe, et al., 2002), or some units built in remote or undesirable locations remain unoccupied due to poor location, lack of demand, or restrictive policies (Han, 2014). Unlike European social housing, Singapore's system was able to address these consequences by making public housing aspirational—even middle-income households live in HDB flats (Phang & Helble, 2016). In Singapore, a small rental sector exists for the lowest-income households, but the focus is on ownership to prevent welfare dependency (Phang, 2007). Phang & Pacey (2018) critique Singapore's minimalist rental sector, which serves only the poorest while reinforcing ownership as the norm. Low-income households without family support may fall through the cracks, as rental supply is tightly rationed.

Iran's Mehr Housing Policy (IMHP)

Iran's housing policies have historically emphasized homeownership over rental solutions, such as housing construction, housing loans, and public-private projects to meet housing needs. According to the last official housing census, 60% of housing units in Iran are owner-occupied versus 31% private rented units. The remaining units often belong to state-owned organizations such as state factories and state universities for the residence of their employees or students. In this sense, Iran's housing market aligns with Kemeny's theory (2006; 1995) of "dualist rental markets," where a small, residual social rental sector exists alongside a dominant profit-driven private rental market and homeownership is promoted as the norm. Similarly, we can see both the asset-based welfare model (like the USA and UK) with high homeownership rates and a large private rental sector (Ronald, 2008), and the family-as-welfare model (like Japan and South Korea) with family assistance to young couples (Ronald & Doling, 2010; Ronald & Jin, 2010).

Iran's Mehr Housing Policy (IMHP) is the largest large-scale social housing initiative launched by the government in 2007 under President Mahmoud Ahmadinejad. IMHP was designed to provide affordable housing for low-income

households by leveraging government resources and private sector participation. Under the IMHP, the government provided free or low-cost land to developers to build housing units. The program aimed to build over two million housing units across Iran, particularly in suburban and less-developed areas. IMHP units were sold at below-market prices, with long-term, low-interest installment plans (up to 15 years) and were given to first-time homebuyers.

The official housing census of Iran showed that homeownership rates had declined from 89% in 1976 to 69% in 2006 (Figure 3). The decline in homeownership over the last decades resembles trends in countries such as the UK (with a liberal market) and the Netherlands (with strong social renting). But despite privatization and market-driven policies in these countries, Iran's government decided to build over two million units to increase homeownership rates, especially for low-income households since 2007, under the IMHP. Nevertheless, the decline in homeownership continued in the next decade, falling to 60%, while private rented units increased to 31%. Thus, the change in the combination of owner-occupied and rental-occupied units under IMHP differs from other countries where market-driven policies were implemented.

IMHP units were constructed in all provinces of Iran, particularly in Mazandaran Province, where 65,000 units were built to accommodate around 200,000 residents. Of these, almost 21,000 units were organized in residential complexes, and the rest were standalone buildings. Under the IMHP, 14 residential complexes with around 3,300 units were built in Babolsar and Babol, where this study was conducted.

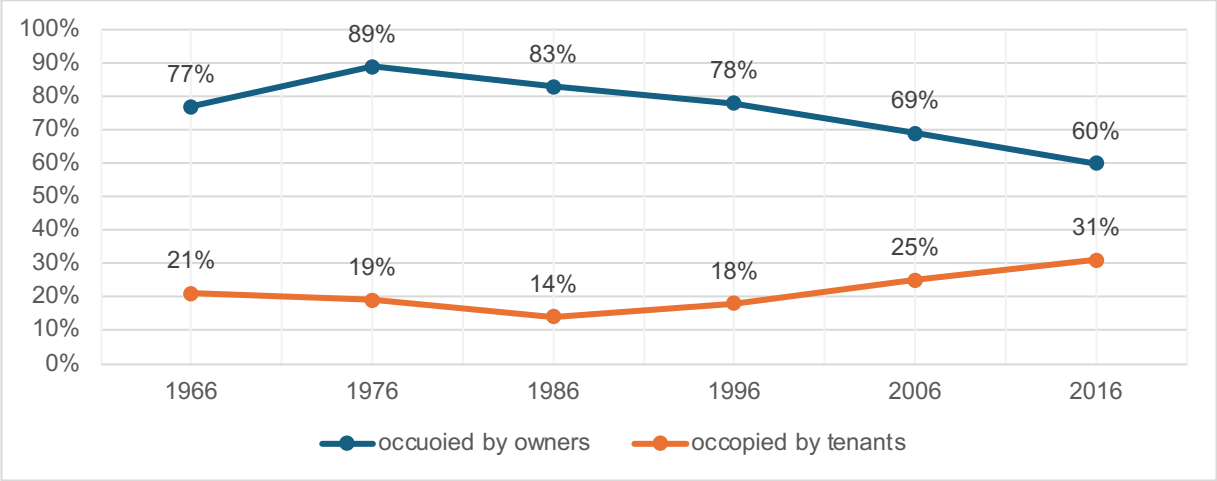

Figure 3: Percentage of units occupied by owners and tenants in Iran, 1966-2016.
Source: Iran's statistical center; https://amar.org.ir/statistical-information/catid/3108

Homeownership by low-income households was the main goal of the IMHP. The government wanted to provide affordable housing and ensure occupancy by low-income households. To achieve this, they employed several implementation tools, including: provision of state loans, allocation of state-owned land, building permits on inexpensive suburban plots, legal and bureaucratic facilitation, applicant registration, and resale restrictions. It was expected that most IMHP units would be occupied by low-income households and none would be resold, although some would likely be rented out.

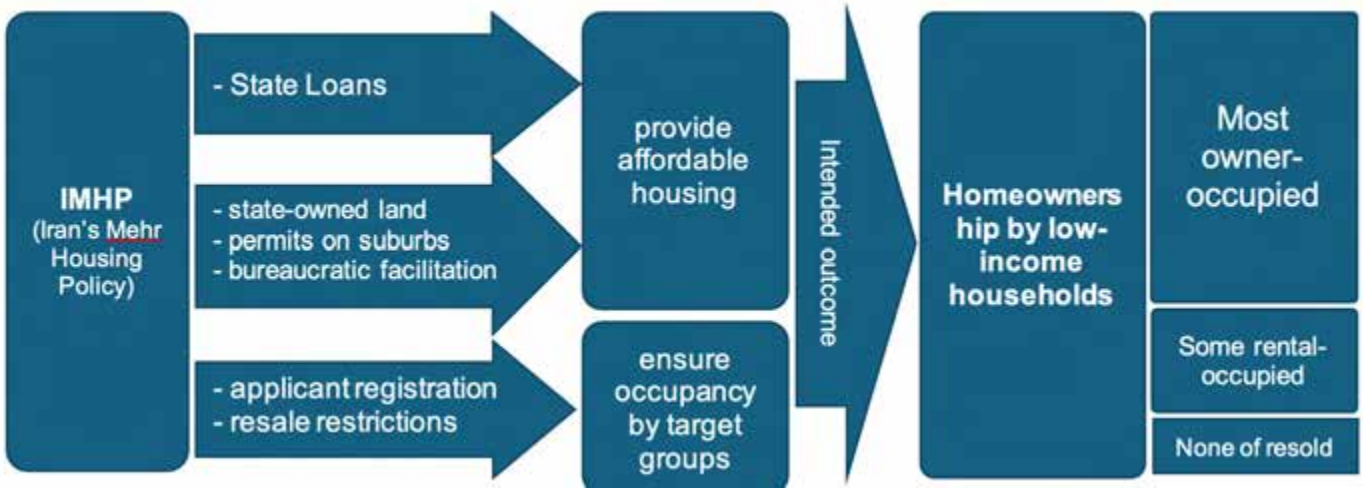

Figure 4: IMHP and its implementation tools to provide affordable housing.

Therefore, the intended outcomes of IMHP were:
- Provide affordable housing;
- Homeownership by low-income households;
- Most owner-occupied, some rental-occupied;
- State loans, state-owned land, permits on suburbs, bureaucratic facilitation;
- Applicant registration and resale restrictions to ensure occupancy by target groups;
- No resale of units.

Methodology

Given the goals of IMHP and the research questions of this study, we needed to determine which units were occupied. If a unit was vacant, follow-up visits were conducted to confirm its vacancy status. We decided to investigate housing complexes that were more accessible for subsequent field surveys. We selected 13 IMHP housing complexes[1] in two cities of Mazandaran Province, Babol and Babolsar, comprising 3,031 units: Mehshahr (No.1), Kiamehr (No.2), Omid Oshib (No.3), Arezoo (No.4), Velayat (No.5), Golsar (No.6), and Farzanegan (No.7) in Babol; Moalleman (No.8), Talash (No.9), Narenjestan (No.10), Danesh (No.11), Andisheh (No.12), and Persia (No.13) in Babolsar (Figure 3). Some of these complexes are located inside the administrative municipal boundary, and some are outside. These complexes varied significantly in ownership—state-owned versus self-owned.

In the initial phase, we conducted a pilot survey using systematic sampling methodology. From each residential complex, we selected 20 samples to estimate the rate of vacant units. The distribution of questionnaires followed a carefully designed protocol to ensure sampling homogeneity across all complexes. When initial visits identified vacant units, follow-up visits were conducted to determine whether these vacancies were temporary or permanent. This phase revealed an average vacancy rate of 24% across all complexes, with notable variations between different developments. For instance, the Golsar (No.6) and Omid Oushib (No.3) complexes in Babol demonstrated near-complete occupancy (100% and 95%, respectively), while the Persia (No.13) and Narenjestan (No.10) complexes in Babolsar showed significantly higher vacancy rates (58% and 45%, respectively).

The second phase involved a more detailed survey to collect additional variables of interest, including ownership patterns and tenancy characteristics. Due to the differences between complexes, we employed stratified ran-

1 . There are totally 14 IMHP housing complexes in Babol and Babolsar, but only we were permitted to do survey in 13 complexes.

dom sampling with proportional allocation to enable meaningful cross-complex comparisons.

Table 3: Total sample size using proportional stratified sampling

Target Population	Occupied Units (%)	Sampling Population	Margin of Error (d)	Probability (pq)	Confidence Level (Z)	Sampling Method	Sample Size
3,031 households	75.8%	2,296 households	0.05	0.25	95%	Stratified random (proportional)	330 samples

Our sampling framework accounted for a target population of 3,031 households, with a 75.8% occupancy rate (2,296 occupied households). Initial calculations suggested 330 samples were required (see Table 3). However, after refining the proportional allocation, the final sample size was adjusted to 346 to ensure optimal distribution (see Table 4).

Table 4: Refined sample allocation by residential complex

No.	Complex Name	City	Total Units	Occupied (%)	Stimate of Occupied Households	Final Samples
1	Mehrdasht	Babol	346	80%	277	40
2	Kiamehr	Babol	320	81%	260	39
3	Omid Oshib	Babol	300	95%	285	38
4	Arezoo	Babol	240	85%	205	27
5	Velayat	Babol	168	79%	133	20
6	Golsar	Babol	144	100%	144	21
7	Farzanegan	Babol	120	82%	99	17
8	Moalleman	Babolser	298	67%	199	21
9	Talash	Babolser	186	81%	151	28
10	Narenjestan	Babolser	320	55%	175	24
11	Danesh	Babolser	294	69%	202	32
12	Andisheh	Babolser	120	80%	96	20
13	Persia	Babolser	175	42%	74	19
Total			3,031	75.8%	2,296	346

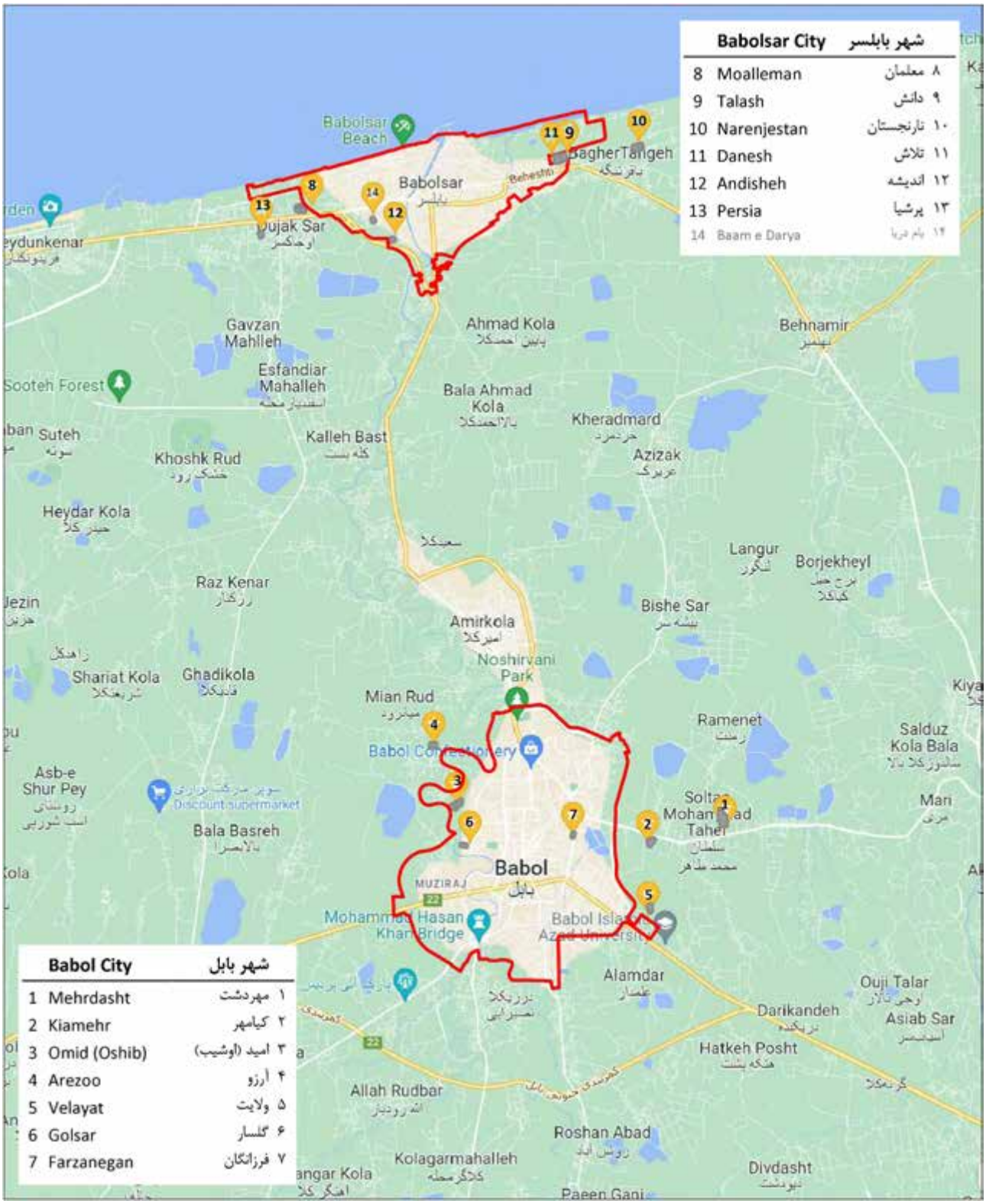

Figure 5: The location of 13 IMHP housing complexes in Babol and Babolsar.

Thus, this exploratory study employs quantitative methods (field surveys and statistical tests) to investigate ownership dynamics in IMHP housing complexes in Mazandaran Province. Using proportional stratified sampling and systematic sampling, 346 questionnaires were distributed across 13 IMHP housing complexes in Babol and

Babolsar, encompassing 3,031 housing units.

IMHP's Non-Occupied Units

To answer the research questions, we analyzed the field survey data in four steps. First, we need to know what rate of IMHP units haven't been occupied in different complexes?

The main goal of IMHP was to provide housing for low-income groups solely for residential purposes. Vacant units represent wasted resources and fail to address housing needs. Therefore, if IMHP units were vacant, the goal of this policy was not achieved. The results of the pilot survey show that in some complexes, the rate of non-occupied units was very high, for example, 58% in Persia (No.13) and 45% in Narenjestan (No.10). (Both of these complexes are located outside the border of Babolsar City.) Regardless of the causes, these units were out of reach of target groups, so the goal of IMHP was not achieved in these complexes. In contrast, the lowest rate of vacant units was in Golsar (No.6) and Omid Oshib (No.3)—both located inside the border of Babol City. It seems that complexes located at the top of Figure 6 were more successful in achieving the goals of IMHP. In total, 24% of IMHP units were vacant, indicating that a quarter of IMHP goals were not met.

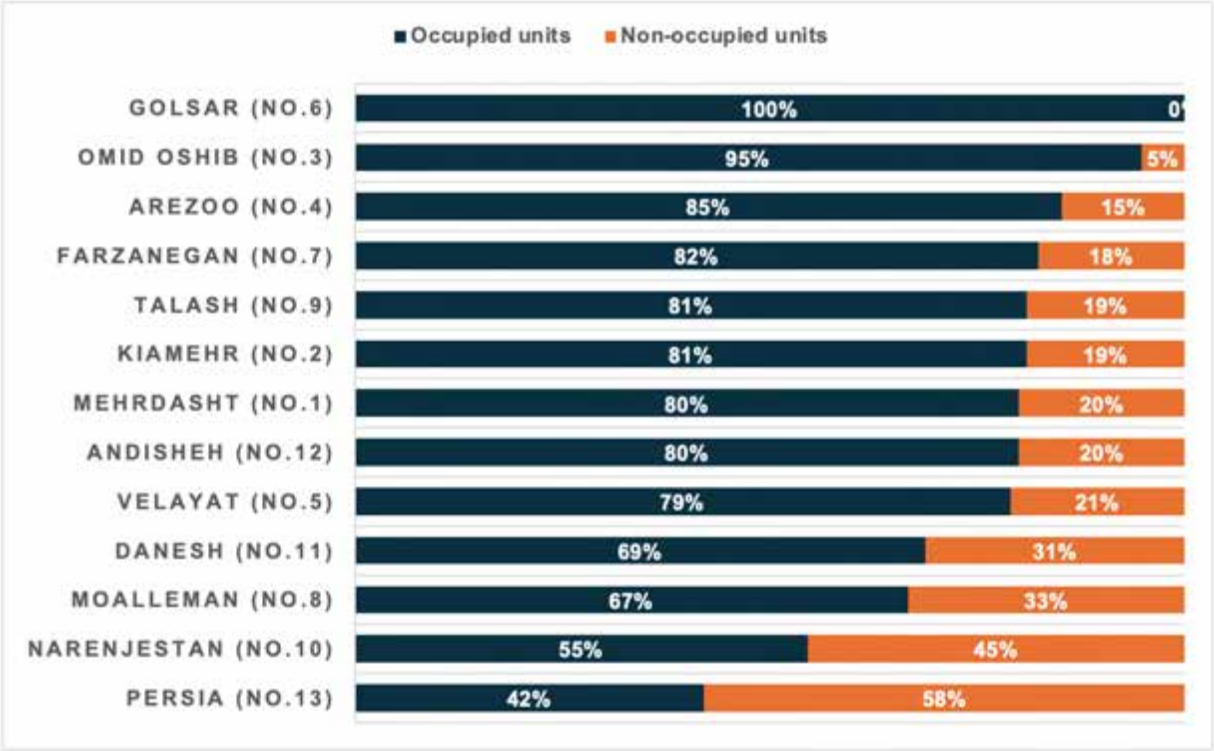

Figure 6: Percentage of non-occupied units in each IMHP complex.

IMHP's Rented Units

Iran's housing policy focused on ownership by low-income groups, not tenancy. Therefore, if owners rent their units, it indicates they need money for monthly household expenses, not a home—which contradicts IMHP goals. In the second step, we need to know what rate of IMHP units were rented in different complexes. As shown in Figure 7, the highest rate of rented units was in Moalleman (No.8)—located outside Babolsar's border—where 54% of units were rented. In this complex, only 13% of units were occupied by owners, placing it at the bottom of the chart. Next, in Andisheh (No.12)—located inside Babolsar's border—40% of units were rented. In contrast, the lowest rates of rented units were in Mehrdasht (No.1) at 12% and Persia (No.13) at 13%. In the rest of the complexes, the rate of rented units ranged between 19% and 27%. In total, 23% of IMHP units were rented to earn profit.

Overall, 52% of IMHP units are owner-occupied, which is lower than the national homeownership rate (60% in 2006).

The rate in 5 complexes is close to 60%, while the rate in 5 others is below 47% due to the large number of vacant and rental units. Only 3 complexes have over 68% owner-occupied units. Therefore, it seems IMHP, as a homeownership-centric model, has not succeeded in increasing the homeownership rate.

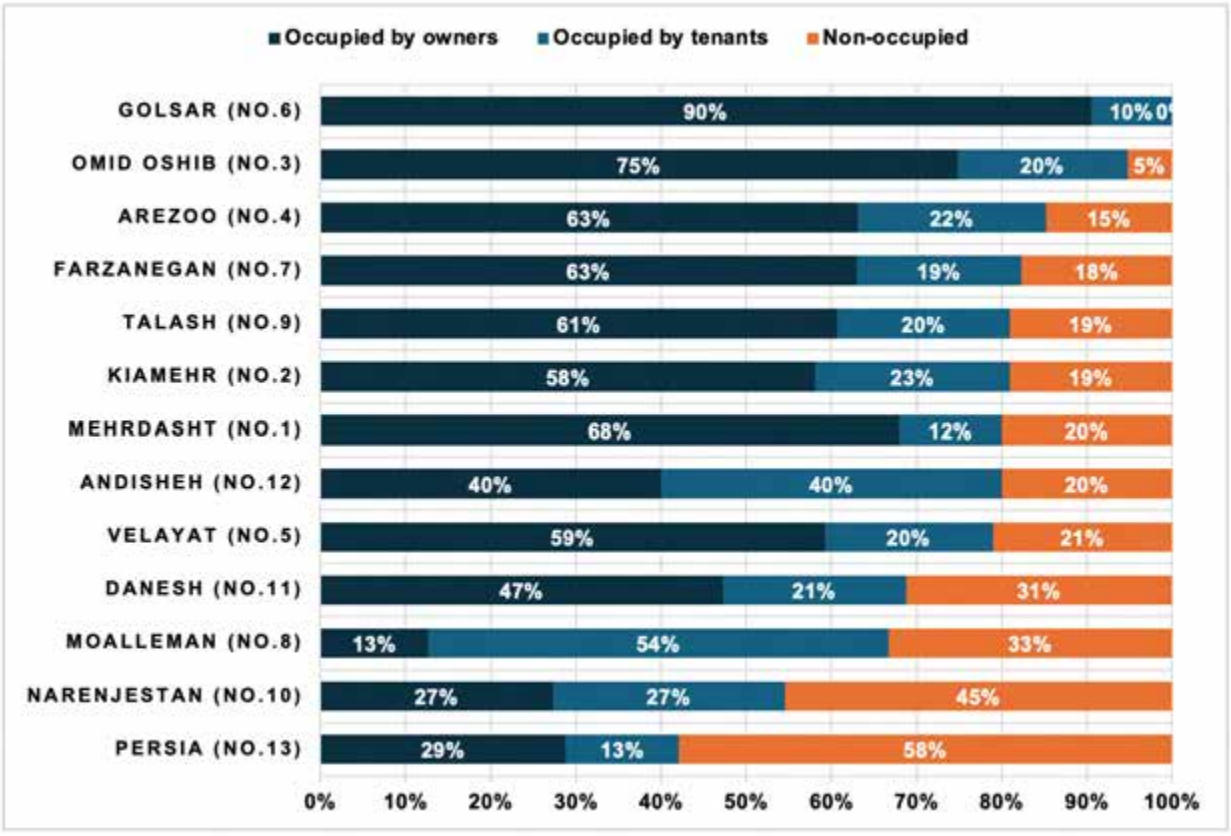

Figure 7: Percentage of units occupied by owners and tenants in each IMHP complex.

IMHP's Resold Units

To ensure units were occupied by low-income households and not resold, IMHP used applicant registration and resale restrictions. If units were resold to new owners, IMHP goals were not achieved. Therefore, in the third step, we have to know what rate of units were occupied by new owners who have bought their units later outside the IMHP mechanism? Observations showed that IMHP units were resold in informal markets despite resale restrictions. As a specific example, Golsar (No.6) appeared to be the most successful complex due to its low rented units (10%) and no vacant units, but it was determined that 80% of units were resold and occupied by new residents. In this case, IMHP units became a trade commodity for low-income households who profited from the difference between affordable housing prices and market rates. Similarly, in Arezoo (No.12), half of the units were resold to new owners in the informal market.

In total, the survey results show that 26% of IMHP units were resold by low-income households to others in the informal market. After subtracting resold units, the homeownership rate declines to 27%.

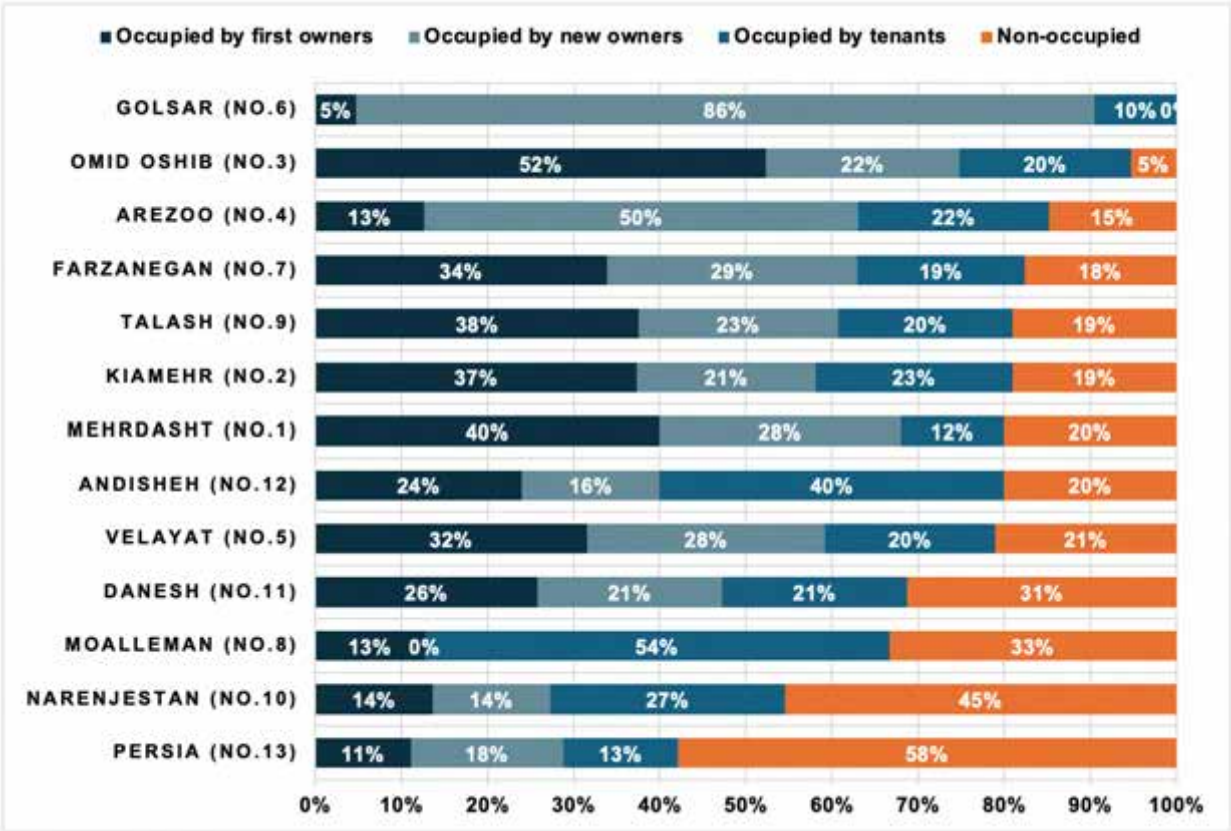

Figure 8: Percentage of units occupied by new owners in each IMHP complex.

IMHP's Occupied Units by Target Groups

In total, 24% of IMHP units were vacant, 23% were rented to earn money, 26% were resold by low-income households to new owners, and only 27% were occupied by target groups (see Figure 9). In Omid Oshib (No.3), over half of the units were occupied by first owners who were target groups, making it the only IMHP complex with a home-ownership rate above 50%. In the rest of the complexes, this rate was below 40%. At the bottom of the chart (see Figure 8) there are six complexes below the average, indicating they were unsuccessful in achieving IMHP goals.

Table 5: Comparison of IMHP units with highest rates.

Highest Rates of			
Vacant Units	**Rented Units**	**Resold Units**	**Own-Occupied Units by Target Groups**
Persia (No.13): 58%	Moalleman (No.8): 54%	Golsar (No.6): 86%	Omid Oshib (No.3): 52%
Narenjestan (No.10): 45%	Andisheh (No.12): 40%	Arezoo (No.4): 50%	Mehshahr (No.1): 40%

The context of various cities can impact the outcomes of public housing. In this case, IMHP's outcomes in Babolsar and Babol were very different, despite their proximity (less than 30 km apart). Babolsar is a touristic coastal city near the Caspian Sea, while Babol is a central plains city. The percentage of homeownership/rental units likely differs between these cities. Comparing the data from Babolsar and Babol (see Figure 9) shows that the rate of vacant units in Babolsar was higher than in Babol (36% versus 15%). Additionally, the rate of rented units in Babolsar was higher than in Babol (28% versus 18%). In other words, the goal of IMHP was not achieved for two-thirds of the units in Babolsar. In Babol, it appeared that 67% of units were occupied by IMHP target groups, but the results showed that half of these were resold in the market, with new owners replacing the target groups. In Babol, 34% of units were resold to new owners, compared to 16% in Babolsar. Finally, it can be stated that only 33% of units in Babol and 21% of units in Babolsar reached the target groups in line with IMHP goals.

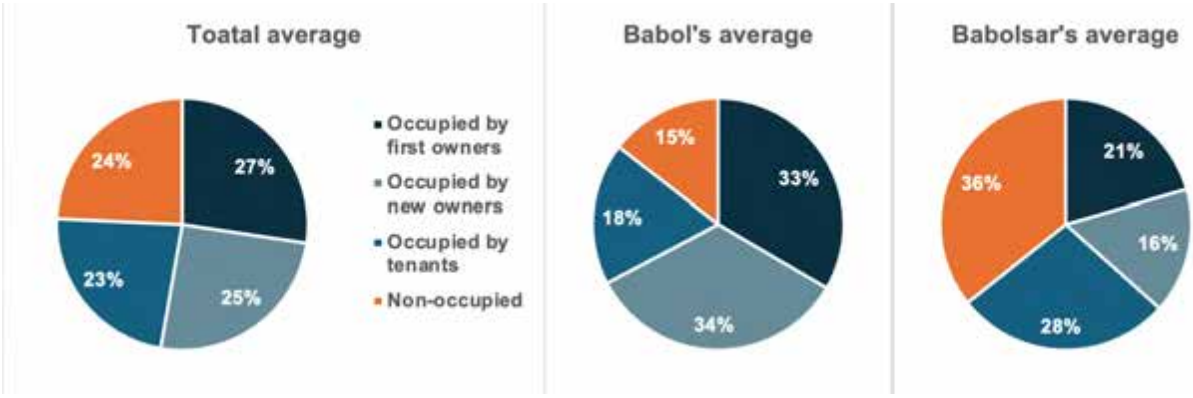

Figure 9: Comparison of the rate of units occupied by new owners between Babol, Babolsar, and total average.

Discussion

The findings reveal significant discrepancies between IMHP's objectives and actual outcomes, reinforcing critiques of homeownership-centric models (Ronald, et al., 2015; Scanlon, et al., 2014; Whitehead, et al., 2012; Kemeny, 2006). While the policy aimed to provide affordable homeownership for low-income households, only 27% of units were occupied by the intended beneficiaries. A substantial portion (24%) remained vacant, suggesting inefficiencies in allocation or locational disadvantages (Han, 2014). In particular, in two cases—Persia (No. 13) and Narenjestan (No. 10)—vacancy rates were 58% and 45%, respectively. These complexes are located outside Babolsar City's urban boundary, where poor accessibility and undesirable locations exacerbate vacancies.

Additionally, 23% of units were rented out, indicating that financial incentives led low-income owners to treat IMHP housing as income-generating assets rather than permanent residences—a phenomenon observed in other homeownership-centric models (Arundel & Ronald, 2021; Aalbers, 2016; Scanlon & Kochan, 2011). Specifically, Moalleman (No. 8) and Andisheh (No. 12) had the highest rental rates (54% and 40%, respectively). Both are located in Babolsar, a tourist coastal city, highlighting how the region's socio-economic context influences rental trends.

Most strikingly, 26% of units were resold, bypassing IMHP's resale restrictions. This aligns with critiques of homeownership policies in which subsidized housing becomes commodified, benefiting initial buyers rather than sustaining long-term affordability (Wainer & Zabel, 2020; Rolnik, 2013). However, a key difference in Iran is the existence of an active informal market, where bureaucratic resale restrictions alone cannot counter market incentives. The case of Golsar (No. 6), where 80% of units were resold, exemplifies how market incentives distort policy goals. These findings echo Singapore's experience, where resale restrictions balance affordability with wealth accumulation (Phang & Pacey, 2018), but unlike Singapore, IMHP lacked robust enforcement mechanisms.

Geographical disparities further highlight policy shortcomings. Babolsar, a tourist coastal city, had higher vacancy (36%) and rental rates (28%) than Babol, suggesting that demand-side factors (e.g., seasonal migration, investment speculation) influenced occupancy. Conversely, Babol's lower vacancy rate (15%) masked high resale

activity (34%), revealing that even occupied units often deviated from policy intent.

Comparative analysis suggests IMHP's dualist rental market structure (Kemeny, 2006; Bengtsson, 2009) exacerbated these issues. Unlike unitary rental systems (e.g., Germany's social renting), IMHP's reliance on homeownership without complementary rental safeguards left low-income households vulnerable to market pressures. The policy's failure to curb informal resales mirrors challenges in liberal markets, where financialization displaces target beneficiaries. Finally, three key discussion points emerge from our analysis:

• **The Paradox of Homeownership Promotion:** The data show that only 27% of units remained with original low-income beneficiaries, challenging the homeownership-centric model. This aligns with Ronald's (2008)critique of the "homeownership ideology," where policy instruments become disconnected from household realities. The high resale rates (26%), particularly in Babol, demonstrate what Bengtsson (2009) terms the "asset-based welfare trap"—where subsidized housing becomes a liquid asset rather than stable shelter.

• **Informality and Governance Challenges:** The prevalence of informal resales despite formal restrictions reflects broader debates about state capacity in Iran. Bureaucratic controls alone cannot counter market incentives, and community-level enforcement is often lacking. Policy instruments assume formal market behaviors that do not align with local realities.

• **Spatial Mismatches and Policy Design Flaws:** The stark differences between Babol (15% vacancy) and Babolsar (36% vacancy) highlight the importance of locational factors in housing policy success. The higher rental conversions in Babolsar (28% vs. 18% in Babol) further illustrate how tourist economies distort housing markets in ways that homeownership-centric policies cannot address.

While this study provides critical insights into IMHP's implementation gaps, several limitations must be acknowledged:

• **Sample Scope:** The analysis focuses on two cities (Babol and Babolsar), which, while illustrative, may not capture regional variations in Iran's housing markets. Future studies could expand to other IMHP projects in Mazandaran Province and other provinces of Iran to test generalizability.

• **Temporal Dynamics:** The study examines a snapshot of IMHP outcomes. Longitudinal tracking of units (e.g., resale price trends, generational transfers) would reveal whether deviations from policy goals intensify over time.

• **Policy Context:** The findings reflect IMHP's performance under specific economic sanctions and inflation rates in Iran. Comparative studies in stable economies could disentangle policy flaws from macroeconomic shocks.

Conclusion

This study demonstrates that Iran's Mehr Housing Policy (IMHP), as a homeownership-centric model, has achieved only 27% of its objectives across 13 case studies in Babol and Babolsar, while 73% of IMHP units were either vacant, rented, or resold. High vacancy rates, rental conversions, and informal resales indicate systemic flaws in targeting, enforcement, and market regulation.

The IMHP case studies reflect several critical lessons for housing policy and planning practice:

• Challenges the universality of homeownership as a welfare tool;

• Highlights the need to conceptualize informality as integral to policy frameworks;

• Demonstrates the centrality of spatial equity in policy design.

We argue that while homeownership has benefits, it is not a sufficient solution to the housing affordability crisis. We advocate for a context-based, balanced approach and propose the following policy recommendations for housing policymaking and implementation in Iran:

• **Understanding informal market mechanisms**: Formal bureaucratic regulations alone cannot achieve housing policy goals.

• **Hybrid tenure models**: Introduce affordable rental options alongside ownership to diversify housing solutions.

• **Consideration of socio-economic realities**: Economic conditions and social priorities of Iranian households significantly influence housing policy outcomes.

• **Context-based policymaking and urban planning**: Differences in cities, locations, and communities must be considered in policy design.

Ultimately, IMHP's mixed results highlight the need for adaptive housing policies that balance ownership incentives with protections against market exploitation. Further research should explore participatory approaches, where beneficiary feedback informs policy adjustments to enhance effectiveness and equity. Housing policies should choose between rigid idealism and adaptive pragmatism. IMHP's legacy should inform Iran's next steps—not as a failure, but as a catalyst for systemic reform.

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Track 14

ETHICS, VALUES AND PLANNING

Planning for gender health justice: A scoping review and research agenda

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Abstract:
Urban planning plays a crucial role in advancing social justice, public health, and gender equity in parallel. Increasingly, scholars are investigating the field's potential to simultaneously enhance outcomes across all three areas through planning for gender health justice. This scoping review assesses the extent to which planners are incorporating gender in healthy cities scholarship, including current work already being done in this area and gaps where further research is needed. Our analysis suggests that planners are making progress on violence against women in public spaces and planning deficits related to women's unpaid care labor. However, our review also indicates that further research is needed to address more diverse forms of gender violence, expand the scope of gendered health issues being investigated, and incorporate a more holistic understanding of gender identity. Based on these findings, we outline an integrated research agenda designed to support planning scholars in advancing gender health justice.

Keywords: gender, health equity, healthy cities, social justice

Introduction:

The purpose of this scoping review is to develop a holistic research agenda to bolster urban planners' capacity to advance gender health justice. Although gender health equity is a strong focus in other fields like public health and social work, we argue that, on the whole, the field of urban planning could do more to take responsibility for its capacity to influence gendered health outcomes. We believe that planners have a unique and vital role to play in addressing gender health disparities because the urban built environment plays a role in creating and perpetuating these disparities. At the same time, urban planning and policymaking can facilitate better health outcomes and advance gender health justice. To that end, we argue that urban planning researchers can and should play a critical role in addressing gender health inequities in our communities.

Through a scoping review of planning literature, which was recently published with the Journal of Planning Literature, we explore the extent to which planning scholarship incorporates a gender-sensitive approach towards planning for healthy cities (Kinder & Spence, 2025). We uncover key gaps in this area and use them to build out a preliminary gender health justice research agenda for planning scholars focused on addressing diverse forms of gender violence, expanding understandings of gender health disparities beyond health disparities associated with mothering, and integrating the health needs of transgender and nonbinary populations.

Methods:

Our findings are based on a scoping review of planning literature published in the last decade. Our scoping review followed the recommended multi-stage reflexive approach, which consists of (1) research question formation, (2) search strategy, (3) evidence screening and selection, (4) data extraction, and (5) data analysis (Arksey and O'Malley 2005; Peters et al. 2020; Tricco et al., 2018). As a first step, we formulated our research question as: to what extent does urban planning incorporate gender in efforts to plan for healthy cities?

In the second phase, search strategy, we reviewed peer-reviewed articles published in English between 2014 and mid-2024 with a triple focus on planning, health, and gender in the Global North. We used the Web of Science database to search for articles, following the precedent of other recent planning literature reviews (Kim 2023; Lee et al. 2024; Xiao and Watson, 2019). In order to find articles that focused on planning, health, and gender, we searched for articles that included the term "health" as well as one or more of the following gender-related terms: "gender", "women", "woman", "girl", and "transgender". In order to retain our focus on planning literature,

and in keeping with other recent planning literature reviews (Hartt et al., 2024; Pothukuchi, 2021), we searched a hand-selected list of the top 35 planning journals as identified by Goldstein and Maier (2010). Next, following another recent precedent (Kim, 2023), we conducted a second search of the same terms in journals included within Web of Science's predefined regional and urban planning category. This search strategy resulted in a total of 1,567 articles that merited possible inclusion in this review.

As part of the third phase, evidence screening and selection, we uploaded RIS data for these 1,567 articles into Rayyan, an application that facilitates literature review screening. After reviewing the titles and abstracts of each article and removing duplicates, we reached agreement on 109 articles that merited possible inclusion in this review. In order to assess whether each article contained a significant triple focus in all three of our focus areas (planning, health, and gender), we carefully reviewed the full text of each article. This process resulted in a mutually agreed upon list of forty-one articles to be included in this scoping review.

The fourth phase, data extraction, revealed a number of interesting themes. The forty-one articles included in this review represent a diverse range of planning and health topics. With a total of 121 co-authors and very little overlap between authors and articles, it is clear that there is a growing scholarly community interested in planning for gender health justice. Moreover, more than two-thirds of our sample were published within the last five years, suggesting a recent increase in research interest on this topic. However, there was less diversity in publication sources: just twelve journals published the entirety of planning for gender health justice scholarship in the last ten years.

Table 1: Journals included in this scoping review.

Journal	Number of articles
Landscape and Urban Planning	7
Urban Studies	6
Cities	5
Housing Policy Debate	4
Transportation Research Part A - Policy and Practice	4
Environment and Planning C - Politics and Space	3
Environment and Planning A - Economy and Space	3
Journal of the American Planning Association	2
Journal of Urban Affairs	2
Environment and Planning E - Nature and Space	1
Urban Planning	1
Urban Affairs Review	1

The geographic focus of the articles was more or less evenly distributed between Europe and North America, with a small number focused on Australia.

Table 2: Geographic focus of articles included in this scoping review.

Geographic Focus	Number of articles
Europe	19
North America	18
Australia	3
Europe & North America (dual focus)	2

The articles were also roughly evenly split between qualitative and quantitative methods..

Table 3: Methods used by articles included in this scoping review.

Methods	Percentage of articles
Qualitative methods	56%
Quantitative methods	44%

The most common planning topics in this review were transportation and public safety. The remaining articles considered housing, urban green space, right to the city, economic development, care planning, energy planning, climate adaptation planning, indigenous planning, neighborhood planning, healthy city planning, land use, and gentrification.

Table 4: Planning topics included in this scoping review.

Planning topic	Number of articles
Transportation	10
Public safety	8
Housing	5
Urban green space	4
Right to the city	2
Economic development	2
Care planning	1
Energy planning	1
Climate adaptation planning	1
Neighborhood planning	1
Healthy city planning	1
Land use	1
Gentrification	1
Indigenous planning	1

The most common health topic by far was violence, following by wellbeing, reproductive health, and the health benefits of nature. Other health issues explored included environmental justice, physical activity, healthcare, urban health, aging, mortality, disability, and healthy cities.

Table 5: Health topics included in this scoping review.

Health topic	Number of articles
Violence	17
Reproductive health	4
Wellbeing	4
Health benefits of nature	3
Environmental justice	3
Physical activity	2
Aging	1
Disability	1
Healthcare	1
Mortality	1
Urban health	1
Healthy cities	1
Mental health	1

Most articles had a primary gender focus on women, with some articles exploring issues pertinent to girls and transgender individuals.

Table 6: Gender focus of the articles included in this scoping review.

Gender focus	Percentage of articles
Women	90%
Older women	2.5%
Girls	2.5%
Transgender	2.5%
Women and transgender (dual focus)	2.5%

After conducting the initial data extraction, we used NVivo – a qualitative data analysis software program – to code the articles during the fifth phase, data analysis. We coded the articles based on key themes identified during the third and fourth phases, including violence, social reproductive, health issues unrelated to violence or social reproduction, gender identities other than cisgender women, and mentions of planning as a determinant of health. We then analyzed the coded material to develop the research agenda presented in this paper.

Conceptualizing gendered violence beyond the gender fear gap:
The first component of our gender health justice research agenda is the opportunity for planning research to conceptualize planning's role in gendered violence beyond women's fear of unknown assailants in public space. As the focus of seventeen articles – over 40% of our sample – violence was by far the most commonly researched gendered health issue in this scoping review. This research reveals the value of investigating violence as an expression of gendered health disparities from a health perspective. At the same time, it reveals opportunities for the field to expand its understanding of gender violence.

The articles in this review often discuss violence in the context of the "gender fear gap" (Jiang et al., 2014), which is framed as women's disproportionate experiences of fear in public spaces compared to men (Agusti et al., 2022; AitBihiOuali & Klingen, 2022; Navarrete-Hernandez et al., 2021). Specifically, this gap focuses on women's fear of harassment and assault by strangers in public spaces, leading many to "restrict their mobility, to varying degrees, because they feel afraid" (Sandberg & Ronnblom, 2015, 2665; see also Lee et al., 2018). The gender fear gap compromises women's right to the city by creating "fear-based exclusion" from urban locations and resources (Loukaitou-Sideris et al., 2024, 212; see also Biswas & Sweet, 2024). This exclusion in turn limits women's access to education and employment opportunities, directly and indirectly compromising their health and wellbeing (Agusti et al., 2022; AitBihiOuali & Klingen, 2022; Navarette-Hernandez et al., 2021).

The gender-fear gap is an important issue for planners to reckon with. That said, the overwhelming emphasis on the gender-fear gap in planning scholarship on gendered health issues reveals a missed opportunity to engage with other types of gendered violence. We found evidence that this hyper-focus on women's fear of unknown male assailants in public spaces is matched by a near total-silence on other forms of gender violence that are also heavily influenced by urban infrastructure and policymaking.

Some planners are reluctant to address intimate partner violence, arguing that "it is inappropriate and naive to expect violence indoors should be tackled by urban planners" (quoted in Sweet and Escalante, 2015, 1831). However, other research included in this review reveals that urban planning and policymaking shapes gendered vulnerability to IPV. One area that is notably influenced by planning is housing. Access to high quality, affordable, and stable housing is critical to avoiding, escaping, and recovering from IPV (Ballen et al., 2024; Martino et al., 2020; Thomas et al., 2020). However, emergency and affordable housing is often located in areas with limited access to economic opportunities or public transit due to zoning laws and housing market conditions, despite the fact that women are more likely to be low-income and less likely to access a private vehicle (Ballen et al., 2024; Fan et al., 2016; Martino et al., 2020). These inadequacies "could mean the difference between gaining employment, education, or social support and hence not returning to an abusive partner" (Martino et al., 2020, 4; see also Thomas et al., 2020).

This is where planners have an opportunity to play a role in preventing and responding to IPV. Rethinking housing, land use, and transportation policies could be an act of violence prevention championed by planners, changing the current reality in which "violence and housing instability combine to become a major cause of poor health in women" (Martino et al., 2020, 2).

In addition to IPV, this scoping review revealed opportunities for planners to address the gendered components of structural violence. Due to the feminization of poverty, women "more often reside in socioeconomically deprived areas" (Johansson & Haandrikman, 2023, 1242) and "bear the brunt of poor environments" (Navarrete-Hernandez et al., 2021, 2). Women, therefore, are disproportionately impacted by the "slow violence" of extreme urban disinvestment (Vasudevan & Smith, 2020; see also Moffett-Bateau, 2024), which exposes residents to air pollution, water contamination, and unsafe housing, in combination with limiting access to health promoting resources like accessible and affordable grocery stores, green spaces, and housing. Women are also disproportionately exposed to neighborhood violence in these areas, resulting in chronic stress which, when "sustained over a long period of time, can make residents more vulnerable to disease and more susceptible to negative coping behaviors" (Zuberi et al., 2016, 548).

Other examples of structural violence often neglected by planners include transphobic harassment in public spaces (Smith et al., 2023), the "hypercriminalization" of Black women living in gentrifying areas (Versey, 2023), the gendered dimensions of Islamophobic hate crimes (Hancock et al., 2018), and poor public housing conditions (Moffett-Bateau, 2024).

Taken together, this evidence suggests that planners recognize violence as an important planning-related gendered health issue. While most of this research focuses on the gender fear gap, emerging research demonstrates opportunities for planners to play an increased role in addressing the gendered dimensions of interpersonal and structural violence.

Conceptualizing gendered health disparities beyond caregiving:
Our next finding concerns reproductive labor, which was a dominant framework within the planning literature on gendered health disparities. Twenty-nine articles – nearly 70% of our sample – invoke women's gendered role as caregivers as a primary frame of reference. What this invocation does, either implicitly or explicitly, is equate "gender" as a frame of analysis with "cis women engaging in mothering tasks", which then implies that gendered health disparities are health disparities related to the act of mothering. While we recognize the importance of care work as a factor in gendered health outcomes, we also argue that planning researchers should expand their conceptualization of gender health disparities beyond disparities associated with parenthood and caregiving. For instance, planners should attend to health disparities that affect younger and older women outside of childbearing years, health disparities that affect women regardless of whether or not they are parents, and health disparities specific to transgender and/or nonbinary gender identities.

The overwhelming focus of the articles that invoke caregiving is on mothers caring for minor children. In this context, care refers to the labor that is "necessary to maintain existing life and reproduce the next generation" (Binet et al., 2023, 284), which is disproportionately performed by women (Morris, 2018). Caregiving is an important gendered health issue for planners to reckon with. Although this work—and the infrastructure necessary to support it—has historically been undervalued within national governments (Horton 2022) and spatial policymaking (Martino et al. 2020), emerging research demonstrates that "the crisis of care is an urban planning problem" in that care became harder, more complex, or compromised "when environmental components for care were absent, inadequate, inaccessible, or spatially disconnected," and that planning can address these barriers by making care visible and valued "in the design and evaluation of policies and interventions in the built environment" (Binet et al. 2023, 284). This infrastructure could improve women's health—not just the health of their dependents—directly through improved access to safe mobility, healthy food, and medical care, as well as indirectly through increased access to health promoting resources related to economic advancement and leisure pursuits (Binet et al. 2023; Colley et al. 2022).

Transportation planning researchers are making notable progress on this issue. Multiple articles in this scoping review concern the ways in which car-oriented land use and transportation planning "reinforces traditional gender relations" and their associated gender health disparities by connecting men to better paid, commuter-based employment, while leaving more care-burdened women with few options beyond underpaid, local, part-time work work (Giacomantonio et al. 2024; Lee et al. 2018; Navarrete-Hernandez et al. 2021; Sandberg and Ronnblom 2015; Sandow et al. 2014). Moreover, transportation systems center the needs of male commuters more than female caregivers, who tend to take more frequent and shorter trips, often in the context of chauffeuring children and/or trip chaining (AitBihiOuali and Graham 2021; AitBihiOuali and Klingen 2022; Giacomantonio et al. 2024; Johansson and Haandrikman 2023; Lee et al. 2018; Navarrete-Hernandez 2023). Researchers call on planners to redesign transportation systems to better accommodate the needs of caregivers, which would support their health and the health of their dependents (AitBihiOuali and Graham 2021; AitBihiOuali and Klingen 2022; Giacomantonio et al. 2024; Johansson and Haandrikman 2023; Lee et al. 2018; Navarrete-Hernandez 2023). We strongly support research at the intersection of planning, health, and caregiving, even as our second finding in this area calls on planners to address gender health disparities that affect women and gender minorities regardless of whether or not they are caregivers.

Although many studies in this review both explicitly and implicitly connect gendered health disparities to women's roles as mothers, others demonstrate that inequitable health outcomes impact women regardless of whether or not they are parents. These studies reveal that, even without caring for minor children, women still experience increased health risks associated with climate change (Amorim-Maia et al. 2023), substandard housing (Morris 2018), aging in place (Byles et al. 2018), food systems (Amorim-Maia 2023; Versey 2022), disabling environments (Fabula and Timár 2018; Martino et al. 2020), and neighborhood disinvestment (Lee et al. 2018; Moffett-Bateau 2024). Regardless of their status as caregivers, women have less access to the health promoting benefits of public space (Navarrete-Hernandez et al. 2021), green space (Colley et al. 2022), urban cycling (Giacomantonio 2024), paid work (Agustí et al. 2022; Ballan et al. 2024), and homeownership (Morris 2018). Additionally, women with or without children in the home appeared to receive the fewest benefits from and were exposed to

the greatest risks associated with gentrification (Versey 2022) and super-commuting (Morris 2018; Sandow et al. 2014; Kroesen 2022). In addition to planning for care infrastructure, this research presents important opportunities for planners to develop more diverse responses to gendered health injustices.

One way to respond to this call is for planning researchers to expand their research to include health disparities impacting older women and girls, who are less likely to care for minor children. While a majority in our sample address the health needs of mothers, very few investigate gendered health outcomes experienced by older women and girls. These articles include research on the positive health impacts of schoolyard greening which "stimulates physical activity, but only in girls" (van Dijk-Wesselius et al. 2018, 23), and the need to develop cycling infrastructure and programming tailored to the needs of adolescent girls (Giacomantonio et al. 2024). On the other end of the age spectrum, "gendered disadvantage across the lifecourse means that women may not have been as well set-up in later life, and hence have fewer resources" to manage the health challenges associated with aging (Byles et al. 2018, 921). Our findings suggest that older women's and girl's specific health needs are underconsidered in planning literature, offering a ripe opportunity for planning researchers to make an impact towards gender health justice.

Conceptualizing gender beyond the cisgender binary:
Another response could be to expand research on planning for the health needs of transgender and non-binary populations. This research is urgently needed given concerns that "systemic cissexism, transmisogyny, and transphobia" in urban planning and related fields "produces marginalisation across public institutions and spaces" including "housing, transportation, and facilities" (Smith et al. 2023, 2). Although numerous articles included in this scoping review mention these groups in passing, these mentions are usually found in the "limitations" section. Just two articles in our sample retain a significant focus on transgender identity (Chlala, 2020; Smith et al., 2023).

While few in number, these studies highlight several areas in which planning research could help the field to more effectively address the health of transgender communities. One area is transportation, which is important given that "transgender and gender-nonconforming individuals" have been found to "experience frequent sexual harassment in transit environments" (Loukaitou-Sideris et al. 2024, 216). Another area involves affordable housing, which matters because, in the U.S., "transgender people ... are four times more likely than cisgendered people to live in poverty, with nearly one-third of Black and Latinx transgender people living on less than $10,000 a year" (Chlala 2020, 1185). A third area is accessible public space, which planning could improve through ordinances requiring or incentivizing "public, accessible, gender neutral toilets in shops and restaurants near the entrance to the building from the open space" (Smith et al. 2023, 5). In all these areas, in addition to producing co-benefits that improve health outcomes for mothers, older women, low-income women, immigrant women, disabled women, and women of color, these planning priorities could disproportionately benefit transgender and nonbinary people, and they could be tailored with those groups in mind (Smith et al. 2023).

Conclusion:
Planning is a determinant of health, and planners have a critical role to play in advancing gender health justice. In this scoping review, we find that planners are making important progress in this area, especially around resolving gendered health disparities related to the gender fear gap and health needs related to caregiving. While these contributions are important and beneficial, we cannot stop here. We have identified critical opportunities for planners to expand their research and advance gender health justice in the process. Specifically, we urge planning researchers to investigate a wide range of gender violence topics including interpersonal violence and structural violence, to expand their focus on gendered health issues beyond disparities associated with caregiving to include girls and older women, and to holistically incorporate the health needs of transgender and nonbinary individuals.

Expanding planning research on gender health disparities to include these health topics and identity groups can enable the field to develop actionable infrastructure and policy recommendations advancing gender health equity in communities across the world. In sum, we applaud the valuable contributions urban planning is already making towards addressing gender health disparities, and we urge the field to scale up these efforts by embra-

cing an expanded research agenda for gender health equity.

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Appendix:

Articles included in this scoping review		
Name	**Author(s)**	**Year**
Gender differences between the emotions experienced and those identified in an urban space, based on heart rate variability	Agusti et al.	2022
The impact of the MeToo scandal on women's perceptions of security	AitBihiOuali and Graham	2021
Inclusive roads in NYC: Gender differences in responses to cycling infrastructure	AitBihiOuali and Klingen	2022
Seeking refuge? The potential of urban climate shelters to address intersecting vulnerabilities	Amorim-Maia et al.	2023
Supporting the housing needs of domestic violence shelter residents: Considerations for survivors with and without disabilities	Ballan et al.	2024
Fracking and epistemic injustice: A feminist critique of knowledge formation	Beebeejaun	2024
The urban infrastructure of care planning for equitable social reproduction	Binet et al.	2023
Reimagining the urban through agency as healing justice: Stories from Kolkata and Chicago	Biswas and Sweet	2024
Changes in housing among older women: Latent class analysis of housing patterns in older Australian women	Byles et al.	2018
Misfit medicine and queer geographies: The diverse economy and politics of cannabis in carceral Los Angeles	Chlala	2020
Who benefits from nature? A quantitative intersectional perspective on inequalities in contact with nature and the gender gap outdoors	Colley et al.	2022
Beyond safety: Refusing colonial violence through indigenous feminist planning	Dorries and Harjo	2020
What limits Muslim communities' access to nature? Barriers and opportunities in the United Kingdom	Edwards et al.	2023
Violations of the right to the city for women with disabilities in peripheral rural communities in Hungary	Fabula and Timar	2018
Waiting time perceptions at transit stops and stations: Effects of basic amenities, gender, and security	Fan et al.	2016
Women's safety perception assessment in an urban stream corridor: Developing a safety map based on qualitative GIS	Gargiulo et al.	2020
Bicycle facilities and women's cycling frequency - An intersectional analysis of gendered travel behaviour	Giacomantonio et al.	2024
Banlieusardes claiming a right to the City of Light: Gendered violence and spatial politics in Paris	Hancock et al.	2018

Financialization and non-disposable women: Real estate, debt and labour in UK care homes	Horton	2022
Taking back the night? Gender and the contestation of sexual entertainment in England and Wales	Hubbard and Colosi	2015
A dose of nature: Tree cover, stress reduction, and gender differences	Jiang et al.	2014
Gendered fear of crime in the urban context: A comparative multilevel study of women's and men's fear of crime	Johansson and Haandrikman	2023
Working from home during the corona-crisis is associated with higher subjective well-being for women with long (pre-corona) commutes	Kroesen	2022
The "transportation disadvantaged": Urban form, gender and automobile versus non-automobile travel in the Detroit region	Lee et al.	2018
Documenting #MeToo in public transportation: Sexual harassment experiences of university students in Los Angeles	Loukaitou-Sideris et al.	2024
Utilitarian bicycling and mental wellbeing role of the built environment	Ma and Ye	2022
Planning with care: Violence prevention policy at the intersection of invisibilities	Martino et al.	2020
"I can't vote if I don't leave my apartment": The problem of neighborhood violence and its impact on the political behavior of Black American women living below the poverty line	Moffett-Bateau	2024
Is a fixer-upper actually a downer? Homeownership, gender, work on the home, and subjective well-being	Morris	2018
Building safer public spaces: Exploring gender difference in the perception of safety in public space through urban design interventions	Navarrete-Hernandez et al.	2021
"I don't think we'll ever be finished with this': Fear and safety in policy and practice	Sandberg and Ronnblom	2015
Is your commute killing you? On the mortality risks of long-distance commuting	Sandow et al.	2014
Planning in the "LGBTQ capital": Choreographing transgender in and out of policy	Smith et al.	2023
To recognize the tyranny of distance: A spatial reading of Whole Woman's Health v. Hellerstedt	Statz and Pruitt	2019
On pathways and agreement: Objective and perceived accounts of neighbourhood attributes and their associations with mental health during pregnancy	Subiza-Perez et al.	2023
Bringing bodies into planning: Visceral methods, fear and gender violence	Sweet and Escalante	2015
No easy decisions: Developing an evidence-informed process to allocate housing choice vouchers to survivors of intimate partner violence	Thomas et al.	2020
The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study	Van Dijk-Wesselius et al.	2018
The domestic geopolitics of racial capitalism	Vasudevan and Smith	2020
Gentrification, health, and intermediate pathways: How distinct inequality mechanisms impact health disparities	Versey	2023
Neighborhoods, race, and health: Examining the relationship between neighborhood distress and birth outcomes in Pittsburgh	Zuberi et al.	2016

Track 15

PROPERTY MARKET ACTORS

The financialisation of actors, practices and instruments. Insights from Milano's urban market

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Abstract
Financialisation has become increasingly relevant in urban studies, highlighting the growing role of financial actors, practices and instruments which are shaping cities. Milano has a unique position as a middle-size and gateway city located between Continental and Mediterranean Europe and these circumstances made it a magnet for institutional investment. This research investigates such financial mechanisms in Milano, considering the global and European influence pressuring Milano's urban development, planning, and governance. Drawing on empirical studies and existing research, it analyses investment patterns, actor strategies, and regulatory frameworks. This study adopts an interdisciplinary approach to reveal the complex ties between finance and urban transformations, aiming to support equitable, sustainable development and contribute to both academic and policy debates.

Key Words: Financialisation, Milano, Real estate markets

Full Text

Over the past decades, the concept of 'financialisation' has gained prominence in urban studies, reflecting the growing influence of financial actors, practices, and instruments in shaping major urban markets. This phenomenon, as explored by scholars such as Epstein (2005), Leyshon and Thrift (2007), Krippner (2011), Christophers (2011), Gotham (2012), Raco et al. (2019), and Aalbers (2019), reflects the pivotal role of real estate investments and financial strategies for the management of built environment and urban development.

Relevant academic studies have shown that real estate markets are globally interconnected yet locally grounded and geographically heterogeneous (Holm et al., 2023; Van Loon et al., 2017). In the current economic phase, the financialisation of real estate has turned the sector into a central pillar of the entire financial market, accounting for more than 70% of global investment (Barnes et al., 2016). Accordingly, real estate represents one of the most significant investment asset classes, contributing roughly 10% of global GDP and underpinning unprecedented growth in terms of value and investment volumes, especially in emergent financial hubs (Singapore, Dubai, Doha etc.) (Bracken et al., 2021).

Focusing on the principal cities for the attractiveness of such investments, comparative analyses illustrated that property value trends before and after the pandemic (2018-2022) (Parker, 2021; Bracken et al., 2021; Holzhey et al., 2022) exhibit a moderate risk of a 'housing bubble,' with overvaluation ranging between +0.5% and +1.5%. This risk, however, is mitigated by transnational investment flows entering and exiting the continental financial systems of the EU and the US. These flows, facilitated by the financialisation of real estate assets, effectively neutralise the cyclical nature of the major property markets (Holzhey et al., 2022; Barnes et al., 2016).

Despite the COVID-19 pandemic, particularly housing prices in the Eurozone and financialisation have stabilized or even boosted investment volumes, displaying resilience amid economic turbulence which is supposed to increase over the upcoming years due to the announced interest rate cut (ECB, 2025).

As Volpi (2024) pointed out, the geopolitical influence exerted by the major asset management firms, the so-called "Big Three" (BlackRock, Vanguard, and State Street), is also significantly impacting real estate, particularly through the financial instruments that underpin major urban development initiatives. Specifically, the hegemonic control these financial funds wield over leading credit rating agencies enables them to shape perceived investment risk (Agnew, 2012) associated with securitizations, mortgages, licenses, and other instruments tied to real estate assets. Moreover, the trading of equity stakes in key institutional investors, banks, and corporations

involved in territorial transformation (e.g., BlackRock's holdings in UniCredit, Intesa Sanpaolo, and Atlantia in Italy) entails substantial implications for agglomerated economies, real estate actors and planning tools dealing with real estate markets.

Within this context, the mobilisation of investments is not exclusively driven by returns or risk diversification, but also by the power relations embedded in the geopolitical positioning of cities within the real estate arena. According to Budenbender et al. (2017), real estate represents a case of 'geopolitics of the multiple' in which real estate markets are both shaped by and shaping the circulation of capital, intertwined with soft power and low-geopolitics strategies of cities (Agnew, 2012).

Moreover, the implicit subordination of local and national governments to the capital mobilised by the real estate sector led to a geopolitically reconfiguring its sphere of influence, generating high returns and new specialities, horizontally, across socioeconomic activities, and vertically, across diverse territorial contexts. Clear examples of such dynamics are the participation of municipal delegates in real estate fairs and events.

Following these premises, this ongoing research aims to explore the interrelationships among planning and economics studies to promote new pathways for equitable urban development in an increasingly financialised landscape. Within this context, it frames the nature and characteristics of real estate financialisation in Milano by examining on the one hand, urban planning and policy instruments, and, on the other, data from real estate investment funds.

In other words, building on solid research (Anselmi & Vicari, 2020; Conte & Anselmi, 2022; Bortolotti, 2023) and empirical analysis conducted with State datasets on property transactions, this study is unveiling the multifaceted financialisation processes influencing Milano's urban market by addressing the patterns and impacts of property investments in urban development and real estate management; the regulatory, programming, and planning instruments that enable real estate finance; and the roles, perceptions and strategies of the key actors operating in this arena.

This research focuses on Milano, an emblematic city for contemporary urban transformation in Southern Europe and aims to uncover the intricate connections between global predatory financial mechanisms and local urban development related to capital accumulation liberated by Milanese households and enterprises. In this regard, this working paper tackles the specificity of Milano in being a gateway city as middle size metropolis geographically and geopolitical bridging Continental and Mediterranean Europe, two fundamental elements which made Milano a magnet for institutional financial investment and enormously renovated the city in comparison to the rest of the country.

In this complex scenario, the Milanese market stands out as the only nationally relevant example for at least three key reasons. First, although it is not the capital city, Milan accounts for almost 50% of national real estate investment (Banca d'Italia, 2023). Looking solely at the large-scale developments listed in the Atlas published by the Municipality of Milan, investments are estimated to exceed €21 billion (Assolombarda, 2024), some of them like the Milano Innovation District, the Milano Santa Giulia or Milano Sesto are absorbing capital investments exceeding €5 billion euros each. Furthermore, despite the broader European crisis in real estate investment attractiveness, caused by inflation and rising construction costs, the city progressively welcomed an average of 50 new foreign multinational companies every year (Assolombarda, 2024). Also, as Conte & Anselmi (2022) highlighted, flagship projects such as Porta Nuova and CityLife exemplify how financialisation materialises into the urban fabric, channelling capital that, in turn, generated €600 million in investment in the commercial real estate sector alone (office, retail, hospitality) in the past year (Assolombarda, 2024).

Second, despite its size Milan has experienced a level of penetration by international institutional and sovereign wealth funds comparable only to global/globalised cities. This has increased both the reputation and influence of these global actors in the city's governance (Anselmi et al., 2020; Mosciaro, 2021; Conte et al., 2022). In this regard,

Italy's austerity policies and the limited spending capacity of local governments have made financialisation a geostrategic lever through which the Municipality of Milan has enhanced attractiveness, competitiveness, and interdependency (Koelemaij et al., 2023; Derudder et al., 2020; Taylor et al., 2004). The ensemble of such trends massively shaped the investments in urban regeneration, particularly in large brownfields.

Third, the entanglement of trans-scalar financial and geostrategic interests in the real estate market has been enabled by the Municipality of Milan's urban policies over the past decades (Bortolotti, 2023). These policies have involved a variety of fiscal, procedural, and regulatory instruments, including the planning ones. In particular, the mix of interviews and desk analysis on planning documents, permits and agreements revealed that such mechanisms have been made possible, on the one hand by national legal frameworks that favoured the entry of foreign investment funds (Modiano et al., 2023) – as occurred at the European level (Holm et al., 2023) – and, on the other hand, through a certain market-led use of spatial action plans and program agreements already encompassed by the Milanese planning system.

Among the major brownfields unlocked between the 1990s and 2010s—thanks to the privatisation of public companies and Italy's adoption of the euro and, in particular, to the financialisation of real estate, there are the projects of Porta Nuova and City Life: the 34-hectare Porta Nuova district was redeveloped with over €2 billion in investment, attracting prominent international players (Conte et al., 2022), including the Texan global development firm Hines and the Qatar Investment Authority, one of the most relevant institutional investors in the world. Similarly, the 36-hectare CityLife project redeveloped the former trade fair site through a vehicle company led by a consortium of insurance companies headed by Generali and including global financial giants like Allianz and PWC which (together) invested over €1 billion (Conte et al., 2022).

However, the involvement of foreign capital in major urban development and regeneration projects extends beyond these most known examples. The Australian firm Lendlease, alongside Hines, one of the world's largest developers, has announced investment plans for two major districts: the 100-hectare Expo area (MIND), in partnership with the Canadian Pension Plan Investment Board, and the 120-hectare Santa Giulia district (MSG), in partnership with the German fund CTS Eventim. These investments amount to €4.5 billion and approximately €4 billion, respectively (Gervasoni et al., 2024). Hines is also the leading developer of the 150-hectare Milano Sesto mega-project, delivered on the former Falck industrial sites in Sesto San Giovanni, with an initial investment of €1.5 billion in partnership with other national and international actors (Savini et al., 2016).

Parallel to American and Australian investments, some Canadian, Chinese, French, Dutch, Israeli, English and German entities have also attempted to redevelop strategic urban sites, especially for transforming them into retail, education and office locations. Our recognition mapped the intensive activity of qualified institutional investors like, among others, the Dutch pension fund PPGM, the Canadian speculative fund Colliers, the German giant Patrizia, as well as the British fund Savills or the well-known Saudi Arabia Public Investment Fund or the Tel Aviv Investments.

As observed by Briata et al. (2023), Milan is increasingly becoming a destination for luxury tourism elite residential living and customised global investments. This change has been made possible by the alignment of real estate interests of some of the wealthiest Italian families with those of international institutional investors creating unprecedented alliances. Considering 10 pilot flagship projects delivered through significant ad hoc planning and financial tools, our analysis revealed unprecedented partnerships among local and global key investment groups and élites. Moreover, by focusing on a quantitative dimension, the delivery of such urban regenerations apparently caused enormous increases in real estate investments, values and volumes in the respective surrounding areas, in some cases exceeding 100% in comparison to the trends affecting the past ten years.

The sum of these processes reflects how the intertwining of financialisation, real estate management and urban development has generated a 'cascade effect' for magnetising the capital into the city and determining Milan's primacy in the Italian real estate landscape, transforming it into a global node within the urban global network,

despite its relatively small size.

Overall, this research project assumed an interdisciplinary approach, drawing from urban planning, geo-economics, and real estate studies, to provide a comprehensive framework for understanding the financialisation complex in Milano. The insights achieved by observing how global investments are channelled into the Milanese urban market confirm how institutional players strategically deliver capital investments over urban nodes (Holm et al., 2023).

To conclude, the financialisation of real estate assets appears to be designed to establish a form of hegemony within the property sector and urban governance patterns, raising the necessity to pursue policy measures for reinforcing urban sustainability, equity, and resilience. As Jessop (2016) points out, market-oriented strategies represent an incomplete attempt to reconcile social contradictions, often resulting in ambiguity with respect to legitimacy, politicisation, and performativity. In Milan, such ambiguities are reflected in the tension between the attraction of global investment and rising social polarisation, as a growing share of the population is expelled from the city to the wider metropolitan region. These dynamics are caused by multiple phenomena, but local governments can potentially do more to prevent the negative effects of financialisation and further findings of this research will offer practical insights into navigating these challenges in Milano and similar urban contexts worldwide.

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The State as an Entrepreneur Who Transforming Public Spaces: The Case of Zeytinburnu Fabrika-i Humayun

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Abstract
This study explores the privatisation of public lands under neoliberal policies and the evolving role of the state through entrepreneurial approaches, using the Zeytinburnu Fabrika-i Hümayun as a case. Over time, the state has shifted from serving the public good to prioritising capital interests, centralising authority in the process. Institutions like TOKI have transferred public lands to the private sector via opaque procedures and public-oriented discourse. In the examined case, a state-owned factory site was transformed into a luxury housing project by TOKI and its subsidiary Emlak Konut REIT. Although the process followed legal steps, its legitimacy remains questionable. Ultimately, the project restricts public access, serving as an example of dispossession framed as serving collective national interest under neoliberal urban governance.

Keywords: Neoliberal urbanisation, state, privatisation, planning and public interest, Zeytinburnu Fabrika-i Hümayun.

Introduction

The phenomenon experienced worldwide after the 1980s and defined as neoliberalism is based on the reproduction of capital through urban space. In this process, the retreat from the welfare state, privatisation, the intensification of international capital flows, and growing competition among countries, regions, and cities have led to a redefinition of the relationships between institutions, economic actors, nation-states, local governments, and financial capital, initiating a restructuring phase within the capitalist system (Peck, Theodore and Brenner, 2009). In line with the collaboration between the state and capital, land use and construction conditions have been developed to serve the interests of the dominant classes and the groups that benefit directly or indirectly from economic growth. This has triggered the reproduction of the built urban environment (Fainstein, 1994; Sengül, 2009; Uzbek and Dinçer, 2009; Logan and Molotch, 2013; Penpecioğlu, 2013). By enacting the legal regulations required by the neoliberal economic order, the state plays a guiding role in the redistribution of wealth (Bayırbağ and Penpecioğlu, 2017). This process—driven by legislation, fragmented planning decisions, and the expanding powers of central government—has brought forth one of the most striking developments: the commodification of public goods and services. The privatisation of public enterprises and infrastructure, which Sato (2000) defines as dead capital, and their conversion into liquid capital, represents a major obstacle to access to public services for disadvantaged groups, further reinforcing commodification.

In the phenomenon described by Peck and Tickell (2002) not as the neoliberalisation of the city but rather as the urbanisation of neoliberalism, the state and capital reshape the city by producing functionally, socially, and spatially differentiated and privatised areas. Without doubt, the formation of interest networks in the distribution and redistribution of resources, and the generation of multiplier effects, make this process possible. According to regime theory, which explains the reproduction of the urban environment and the role of the state within it, governance is defined by the formation of mutually beneficial networks through which actors pool their resources to act in alignment with their overlapping expectations (Fainstein, 1994; Uzbek and Dinçer, 2009). At this point, urban spatial transformation is financed through state-backed debt, and the state transforms from a social-democratic entity into one that supports capital by providing the necessary infrastructure and financing to enhance capital profitability (Harvey, 2013).

Within the framework of these conceptual assessments, this study focuses on the reflections of neoliberal urbanisation policies in Turkey, particularly in the context of Istanbul, by addressing the privatisation of public lands. The main research questions of the study are: Who are the actors involved in the privatisation of public lands in Istanbul? What is the role of the state in this process? And to what extent does the outcome align with the concept of public interest? Accordingly, the privatisation processes of public lands and their spatial implica-

tions will be examined across Istanbul. The case of the Zeytinburnu Fabrika-i Hümayun will be analyzed in terms of: the privatisation of the site, the legal and planning process, the actors involved, spatial impacts, and the issue of public benefit.

In conclusion, perceiving the city as an investment space leads to the convergence of actors with overlapping expectations. Legal regulations enacted by the state, special planning and construction provisions, and loans and funding provided by public banks give rise to new urban forms on privatised public lands—driven by the private sector's profit expectations. Housing, commercial, office, and accommodation developments, designed to attract high-income groups and foreign investors, generate enclaves that are alienated and disconnected from the urban whole. Meanwhile, the question of what constitutes the public good remains a fundamental dilemma within this process.

Entrepreneurial Intervention and Istanbul in the Context of Neoliberalism

Neoliberalism began to emerge toward the end of the 1970s, following the decline in the profitability of industrial production that had risen during the modernist era and the crisis of Keynesian welfare structures, which emphasised state intervention in the economy (Clarke, 2005; Bahçeci, 2017). According to Brenner and Theodore (2005), neoliberalism represents a market-driven process of social and spatial transformation. In this neoliberal era, the state has moved away from its role as a market regulator and has increasingly become a facilitator of the market, with the notion of public interest being replaced by the logic of capitalist production (Smith, 2002).

Within the scope of neoliberal urban policies, two key concepts emerge depending on the purpose and scale of interventions related to capital-oriented spatial decisions: the entrepreneurial city and the entrepreneurial state (Campbell, Tait and Watkins, 2016). Drawing on Jessop (1997), the distinction between these two can be defined as follows: when urban space is selected as a site of intervention for the flow of capital and local government becomes the primary actor, this reflects the entrepreneurial city; when the central state plays the entrepreneurial role by selecting urban space as a field of intervention to ensure the continuity of capital, this is referred to as the entrepreneurial state. What both concepts share is that space becomes a target of intervention, and capital acts as the driving force behind this intervention (Figure 1).

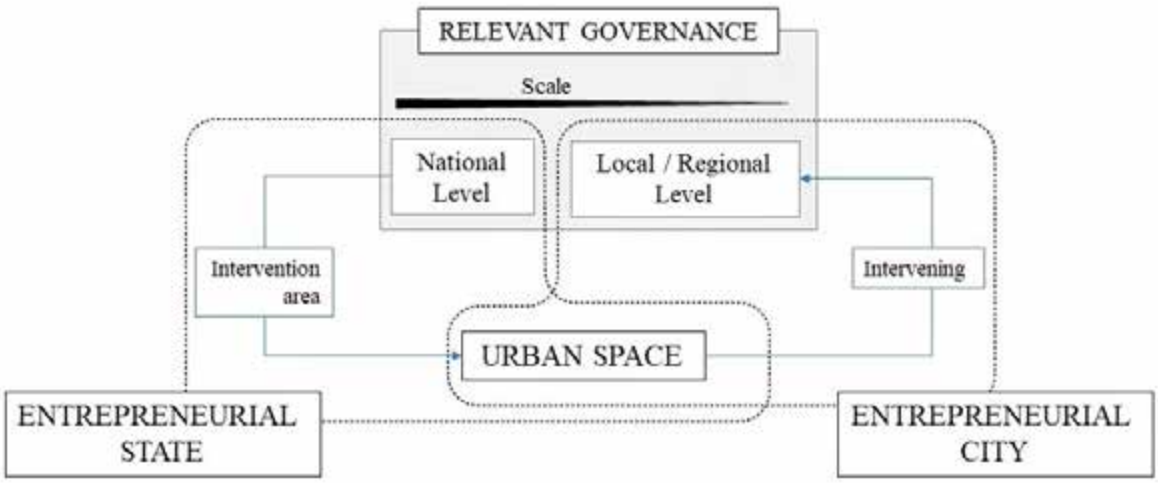

Figure 1 The relationship between the role of the state and spatial transformation (developed by the authors with reference to Jessop, 1997)

In this context, in order to stimulate capital accumulation by enhancing the economic attractiveness of cities (Eraydın and Altay, 2011) and transforming them into investment areas, actors such as real estate developers, local business communities, media institutions, etc., focus on expanding and transforming cities (Logan and Molotch, 1987). This is because investments in metropolitan areas are cyclical. Investments in housing areas attract

further investments in transportation, infrastructure, and new housing, thereby creating multiplier economies (Turok, 1992; Jessop, 2000; Brenner, 2003; Moulaert, Rodriguez and Swyngedouw, 2003).

The state guides the distribution of wealth through three main categories: legislation and legal regulations, fragmented planning decisions, and the expanding powers of the central government.

"The first category is the commodification of public goods and services. This includes the privatisation of public lands under the discourse of national common interest, the steering of investments through infrastructure projects such as highways and airports, and the privatisation of public services (electricity, water, natural gas, etc.) (Smith, 2002; Roy, 2009; Goldman, 2011). The transformation of public enterprises and infrastructure—referred to as 'dead capital' by Sato (2000)—into liquid capital through privatisation constitutes a key aspect of the commodification of public services and poses a significant barrier to disadvantaged groups in accessing these services."

The second category refers to the state's enforcement through market mechanisms, or the creation of new markets through capital's pressure on the state (Harvey, 2017–2020), or the generation of expectations (Aalbers, 2013; Bayırbağ and Penpecioğlu, 2017). This situation, referred to as 'forced marketisation,' takes place through the reproduction of the built urban environment by means of subsidies such as tax reductions and rent support offered by the state to attract entrepreneurs. In this context, the expectation generated—particularly by the middle class—regarding the 'financialisation of the housing market' raises property values and reshapes the rent map of the city, thereby triggering new expectations. This anticipation has altered the real estate landscape within cities, played a key role in the repeated production of space, and in the displacement of social groups and urban functions. Since the 1990s, city centers have thus become arenas where forms of creative destruction have emerged (Kurtuluş, 2006; Peck, Theodore and Brenner, 2009; Günay, 2012; Brenner and Theodore, 2005; Brenner and Keil, 2013; Penpecioğlu, 2013).

The third category consists of state-led practices that result in the displacement of the urban poor in line with renewed and rising land values. This category is defined by dispossession through transformation/displacement rather than improving the living conditions of the population—what Shindler (2017) refers to as 'planetary urbanisation' or Southern urbanisation, and Caldeira (2016) describes as 'peripheral urbanisation' (Akın, 2022).

Although the concepts used in entrepreneurial interventions in space differ, they all share a common feature: the use of space in line with the interests of capital (Jessop, 1997). The role of the state in this context is multifaceted. At times, the state acts as a partner in public-private partnerships focused on investment and economic development (Jessop, 1997), and at other times as a regulator that removes legal barriers such as laws and planning in order to pave the way for capital (Yalçınkaya and Taşçı, 2017). In each of these roles, the state commodifies space, often privatizing publicly owned urban land and infrastructure areas (Serin, Smith and McWilliams, 2020). In doing so, it may establish new institutions or transform existing ones (Yalçınkaya and Taşçı, 2017).

Public lands that are privatised are often used for large-scale commercial projects that do not serve any public function. These projects treat their surroundings as a scenic element while themselves disrupting the integrity of the urban landscape. Such interventions are often made boldly, without consulting the ideas of users living in or around the space, and by displacing them (Ravenhill, 2018). Many of these large-scale projects, often labeled as 'flagship' developments, are justified through public narratives that promote the idea that the place gains recognition and its exchange value increases through urban revitalisation (Harvey, 2015). These projects are thereby legitimised within society (Jessop, 1997; Shin, 2009). Uzbek and Dinçer (2009) interpret these legitimisation efforts through the concept of 'urban politics' in the context of the relationship between governance, capital, and society. According to them, governance has three main objectives: being 'public,' 'voter-based,' and 'entrepreneurial.' In order to legitimise its decisions, governance must focus on both political and economic dynamics and maintain a balance between them. This is because it needs voter support to stay in power politically, and financial backing from the private sector to ensure economic continuity. While one side emphasises the 'use value' of space, the other prioritises its 'exchange value'.

The Changing Role of the State and Governance Mechanism in Entrepreneurial Intervention

The governance model and spatial decisions in entrepreneurial interventions vary depending on scale. In processes involving local governments, particularly in the context of competitive cities, actors representing different collective wills and identities may participate (Jessop, 1997), and the process can proceed in a more transparent and public-oriented manner. However, in cases where the central government acts as an entrepreneur, the state may participate in the process as a parastatal entity (Goldman, 2011), potentially leading to more disruptive outcomes. In other words, the process can vary depending on the intervening party and the underlying dynamics. Goldman (2011) explains the entrepreneurial transformation of cities in two ways: through their engagement in dialogue with international institutions to form transnational policy networks, and through the creation of powerful new 'parastatal' institutions to reduce the bureaucratic hurdles that might otherwise slow the process.

One of the most significant works on the transformation of space is undoubtedly Marx's Labor Theory of Value. According to Marxist urbanism, during the transformation process, either space is produced or commodities are produced from space. When space is produced, use value takes precedence; when space is commodified, exchange value comes to the fore. Use value refers to fulfilling human needs, such as housing use, whereas exchange value focuses not on the social function of the space, but on its market price (Okyay, 2008; Büyükcivelek, 2021). The neoliberal state prioritises exchange value over use value, which ought to be preserved for the public good, thus initiating the commodification of space and, consequently, society's alienation from space. The concept of alienation—defined by Bayırbağ and Penbecioğlu (2017) as both a universal mechanism that facilitates capital accumulation and a tangible outcome with negative psychological/emotional effects on individuals and communities—leads them to propose limiting the privatisation of urban land and public/common spaces in order to protect living environments on a public scale within the urban political system.

The state's attempt to extract value varies depending on the condition of the space. If a space is classified as land, its value is shaped by land use and building regulations; if there is a structure on it, then the characteristics of the building and parcel, as well as its relative locational advantage, become important in generating value (Büyükcivelek, 2021). The privatisation of valuable public lands for projects targeting high-income groups brings about socio-spatial inequality. While the most accessible, central, and scenic areas of the city are allocated to high-income groups, areas lacking these qualities are left to lower-income groups.

Privatisation of Public Lands and Urban Space Debates: The Case of Turkey and Istanbu l

In this context, the subject will first be addressed in terms of legal and institutional structuring after 1980, and then specifically through the case of the Zeytinburnu Fabrika-i Hümayun.

TOKİ, which was established in 1984 under the Prime Ministry to address the housing problems of middle- and low-income groups (Bartu Candan and Kolluoğlu, 2010), was restructured by the central government after the 2000s to become the country's most powerful real estate developer and a key actor in the construction of the neoliberal regime. In addition to establishing a land/housing market for low- and middle-income households, the institution was also tasked with the privatisation of valuable public lands, thanks to its broad regulatory and financial powers (Kuyucu and Ünsal, 2010; 1485). In short, TOKİ also assumed the role of a property transfer instrument by transferring state-owned treasury lands into private ownership. Acting as the flagship in the housing sector, TOKİ and its subsidiary Emlak Konut played a decisive role in the sector—especially after the 2008 crisis—through mega-projects supported by legal and institutional regulations. Particularly through state measures such as VAT reductions, housing mobilisation campaigns, and the provision of low-interest housing loans via public banks (Yeşilbağ, 2020), an artificial economy was created.

Privatisation within the Framework of Legal and Institutional Structuring

In the privatisation processes, numerous legal regulations have been enacted to make lands suitable for capital interests. According to national legislation, the privatisation of public lands is primarily carried out either through the 'Privatisation Administration (PA)' under Law No. 4046 on the Implementation of Privatisation Practices, or through the TOKI under Law No. 1164 on Land Production and Utilisation (Figure 2).

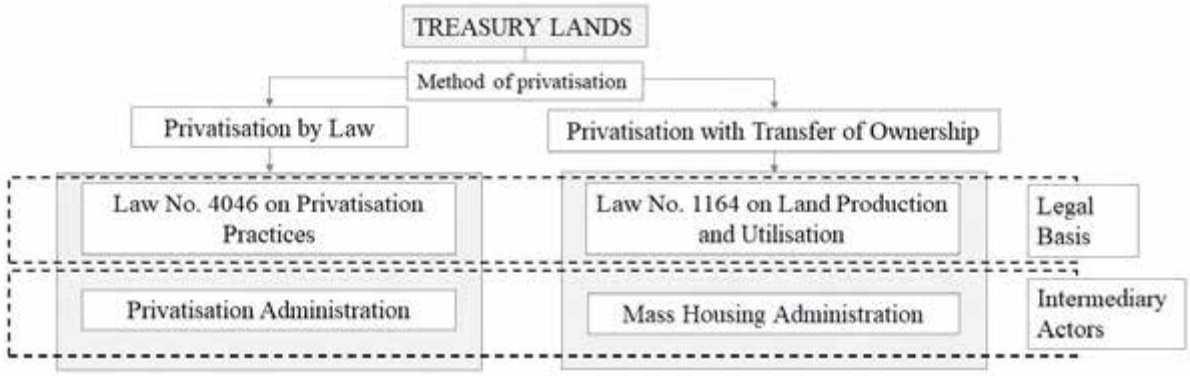

Figure 2 Legal background of the privatisation of Treasury lands

The privatisation of public lands by the PA is carried out under Law No. 4046 and Presidential Decree No. 703. The transfer of treasury lands to TOKI free of charge for investment purposes is conducted under Law No. 1164. According to this law, with the approval of the Presidency, the ownership of immovable properties belonging to the Treasury or to be registered in the name of the Treasury can be transferred to TOKI without charge. Another process that places treasury lands under TOKI's control is the protocols signed between public institutions and TOKI While privatisation decisions made by the Privatisation Administration are published in the Official Gazette, lands transferred to TOKI are not publicly announced.

In 2003, under Law No. 4698, the duties and authorities of the dissolved Housing Undersecretariat were transferred to TOKI. In the same year, amendments were made to the Mass Housing Law through Law No. 4966, and a provision was added allowing TOKI to make profit-oriented investments and establish companies for this purpose. In 2004, with Law No. 5162, TOKI was granted the authority to prepare, have prepared, and amend development plans of all types and scales, provided they do not disrupt environmental and zoning integrity, and to unilaterally implement plans not approved by relevant municipalities. With these powers, it can be interpreted that TOKI, as an extension of the central government, holds authority to plan above local governments (Akın and Özdemir, 2010). In 2005, further amendments were made to Law No. 5018, excluding TOKİ from the Court of Accounts financial oversight (Bahçeci, 2018: 145). This led to a further decline in transparency and limitations on accountability. In 2008, with Law No. 5793, TOKI's powers were expanded again, granting it full authority to prepare and approve all types of plans at all scales and to override the rights of announcement, publication, and objection by local authorities (Bahçeci, 2018: 146). In 2018, with Presidential Decree No. 703, TOKI was removed from the Prime Ministry's jurisdiction and placed under the Ministry of Environment and Urbanisation. The decree also transferred the authority over the sale of all movable and immovable properties belonging to public administrations within the general budget to the Ministry of Environment and Urbanisation.

Emlak Konut, which was established in 1953 to contribute to planned urbaniation and play an active role in housing production, was a subsidiary of Emlak Bank. Following the transfer of Emlak Bank's shares to TOKI and the subsequent closure of the bank, Emlak Konut was transformed into a Real Estate Investment Trust (REIT) in 2002 and became a subsidiary of TOKI (Pınar, 2019; Erdoğan, 2021). One of the duties of Emlak Bank, which was founded in 1949, was to provide affordable housing for citizens without homes (Law No. 4847, Article 2). Today, as a REIT, Emlak Konut's authority is regulated by the Capital Markets Board within the framework of the Capital Markets Law (Pınar, 2019). Emlak Konut REIT holds the highest market value among REIT, with a market value that doubles that of the company ranked second (Erdoğan and Özaslan, 2021).

What Akın and Özdemir (2010) stated about TOKI — that although it was established with the fundamental aim of producing healthy, livable urban environments to meet the housing needs across the country, it acts like a profit-oriented private sector investor by producing housing as an investment tool — also applies to Emlak Konut

REIT. As a result, this indicates that the state's role in the real estate sector has also become centralised and that it operates within the sector as an entrepreneurial actor.

The Transformation Process of the Zeytinburnu Fabrika-i Hümayun

The Zeytinburnu Fabrika-i Hümayun, also known as the 1st Army Zeytinburnu Heavy Maintenance and Repair Factory or the Zeytinburnu Iron Factory, was planned in 1843 (Directorate of State Archives, document no. 1259) and began production in 1846. It was established to meet the basic needs of the military and bureaucracy in line with the industrialisation goals of the period, to reduce dependency on European goods, and to minimise the outflow of resources abroad (Yıldırım, 2015). The factory was used for purposes such as smelting iron ore, casting iron and steel, manufacturing iron cannons, producing new steam engines, or repairing and maintaining existing steam and other types of machinery. The production of cartridges—which gave its name to the area now known as 'Fişekhane'—began in 1881 with the establishment of the Cartridge Manufacturing Plant (Kırlı, 2022).

These buildings, constructed in the mid-19th century, constitute not only a form of production but also an industrial cultural heritage site that includes registered (listed) structures. While the ownership of the land belongs to Emlak Konut REIT, easement rights over the land were granted to the Özak–Yenigün–Zilyan partnership, allowing the construction of new buildings on the site, and the restoration of the registered structures was assigned to Özak REIT. Özak REIT, having undertaken the restoration process of the registered buildings, also acts as a conservation easement stakeholder in the process. The restoration of these listed structures and their repurposing with new commercial functions can be considered an example of Morris's (2015) interpretation of conservation easement rights as a neoliberal instrument.

The factory was established in the Kazlıçeşme area on the shore of the Sea of Marmara, in Istanbul's Zeytinburnu district. This location provided logistical advantages—such as proximity to railways, highways, and seaways—for the transport of raw materials and the shipment of manufactured goods (Figure 3).

Figure 3 Location of the study area

The factory site is located within the tourism center area declared as the Istanbul Ataköy Tourism Center by the Council of Ministers Decision No. 87/11608 in 1987. At the boundary of the study area lies the buffer zone of the Istanbul Land Walls Conservation Area, which was designated as a World Heritage Site in 1985. Due to its proximity to the historic city center and its location within a tourism center area, it has become a site that offers accom-

modation opportunities and is attractive from a touristic perspective (Figure 4).

Figure 4 Study area and its surroundings

Among the registered structures on the site, the fountain was registered on 09.04.1989 under decision number 1043; while the Accounting Office and Gate, Water Tower, Workshops and Warehouses, Turkish Bath, Company Command building, another fountain, and the Armored Vehicle Maintenance Workshop were registered on 25.10. 1989 under decision number 1401 (Real Estate Valuation Report, 2014). Of the seven registered structures, the Water Tower, Bathhouse, Workshops and Warehouses, and the Armored Vehicle Maintenance Workshop are still standing today (Figure 5).

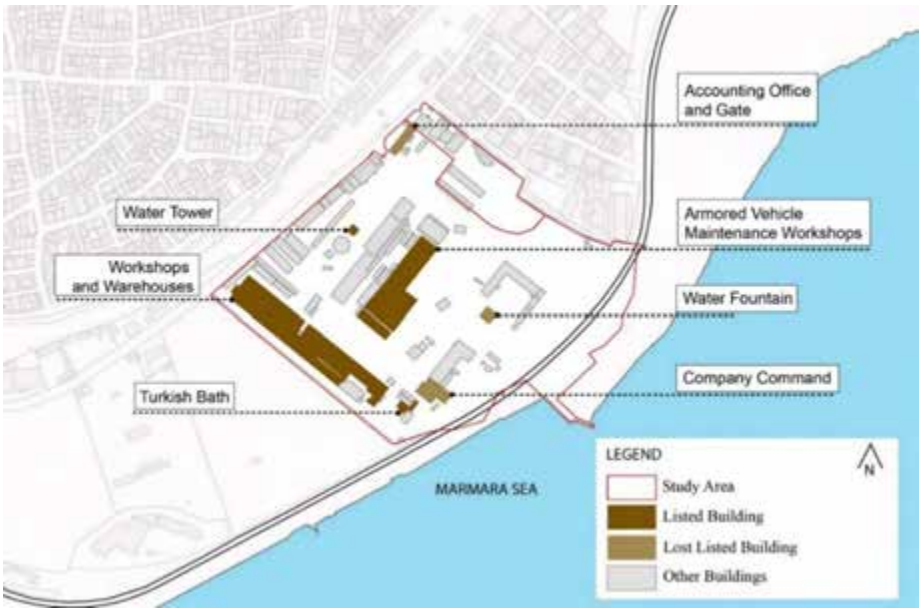

Figure 5 Cultural Heritage Elements in the Area (according to the 2014 site plan)

The Transformation Process from Public Land to Private Housing Project

In the Ataköy Tourism Center, which was designated in 1989, a 1/5000 scale Master Zoning Plan for the Ataköy Tourism Area was prepared by the Ministry of Culture and Tourism in 1998. In this plan, the site was assigned the functions of 'Tourism + Commerce + Accommodation + Recreation,' as well as Vocational High School, PTT (Post Office), and Daily Recreation. The revised plan was republished in 2001, maintaining the same functions; however, the 20-meter-wide road forming the northeastern boundary of the parcels was not shown. In the 2006 Istanbul Ataköy Tourism Center Master Zoning Plan, since the land was registered under the Ministry of National Defense, it was designated as a 'Military Zone' (Ministry of Environment and Urbanisation, 2018).

The first initiative for the transfer of ownership came from the Istanbul Metropolitan Municipality (IMM). According to a protocol signed with the Ministry of National Defense in 1990, the transfer of ownership to IMM was requested, and a letter was sent to the Conservation Board. In the letter, it was requested that the registered structures on the site be excluded from the construction area. In 1991, the Conservation Board stated that it would not be appropriate to predetermine building densities in an area where historical artifacts are heavily concentrated. Subsequently, a preliminary project for the site was submitted to the Conservation Board, and in 1992, the Board approved the project in terms of its principles and construction density (Ministry of Environment and Urbanisation, 2018).

In 2000, the Istanbul No. 1 Directorate of the Board for the Protection of Natural Assets approved the demolition of the 'Company Commande', whose measured drawings had been taken, due to security concerns. In 2008, the Istanbul No. IV Regional Board for the Protection of Cultural and Natural Assets stated that, in terms of Law No. 2863, there was no legal objection to the sale or lease of one of the parcels. In the same year, the Board's letter also requested that the Pay Office Building, which lies on a road according to the plan and is a registered cultural asset, be preserved and the plan be revised to ensure its conservation in situ, without demolition. During construction activities in 2014 and 2015, additional remains were uncovered and registered for protection (Ministry of Environment and Urbanisation, 2018).

In November 2013, a decision was made designating the parcels as residential, commercial, and tourism areas, based on a plan approved by the relevant ministry and later posted by the Provincial Directorate of Environment and Urbanisation in 2014. A lawsuit demanding the annulment of the plan was filed by the Istanbul Branch of the Chamber of City Planners (TMMOB) and the Istanbul Metropolitan Branch of the Chamber of Architects (TMMOB), and the court subsequently annulled the plan (Mimarist, 2017). Following the objection, the 1/5000 and 1/1000 scale zoning plans were revised and re-posted. In 2015, many buildings within the area were declared 'at risk' by Zeytinburnu Municipality in accordance with Law No. 6306. That same year, an application was submitted to the Regional Conservation Board, which approved the demolition of the structures on the condition that the registered heritage buildings would not be damaged.

In the updated Implementation Zoning Plan Report for the relevant parcels in 2018, the area was designated with a Residential + Commercial function, and the building density was reduced. The report states that opinions were obtained from the relevant Cultural Heritage Conservation Board for the relocated registered buildings, and from the Transportation and Traffic Commission for the new road alignment. Following the plan, lawsuits were filed by the Chamber of Architects (TMMOB) and the Chamber of City Planners (TMMOB) against the Ministry of Environment and Urbanisation, after which a new plan was prepared and posted. Although the 2020 plan appears similar to the 2018 plan, a change in ownership among the stakeholders was made.

The Privatisation Process of Public Property

One of the parcels within the study area was allocated to the Land Forces Command in 1955 by the Treasury of Finance for public service purposes. The transfer of ownership of the factory site to TOKI was carried out based on a protocol signed between TOKI and the Ministry of National Defence in 2006 (Ministry of Environment and Urbanisation, 2018). Under this protocol, it was agreed that the immovable properties on the site would be transferred to TOKI in exchange for the construction of a police station (Emlak Kulisi, 2012).

According to the 2013 valuation report, one of the parcels was owned approximately 97% by TOKI and 3% by the Treasury of Finance, while the other parcel was owned 5/8 by the Treasury and 3/8 by TOKI (Nova Real Estate Valuation Report, 2013). The land, which originally belonged to the Turkish Armed Forces / Ministry of National Defence and was later transferred free of charge to TOKİ, was tendered by Emlak Konut REIT and sold to the Özak–Yenigün–Zilyan partnership. Under the revenue-sharing model of the construction project, it was agreed that 37% of the revenue would be allocated to Emlak Konut REIT (Çakıroğlu, 2022).

These two parcels, owned by the Treasury of Finance and TOKI, were divided into eight parcels in 2018, with six of them remaining within the project area. When the ownership status was examined in 2020, it was found that the area, originally consisting of seven parcels, had been subdivided into thirteen parcels, and the ownership distribution had changed (Figure 6).

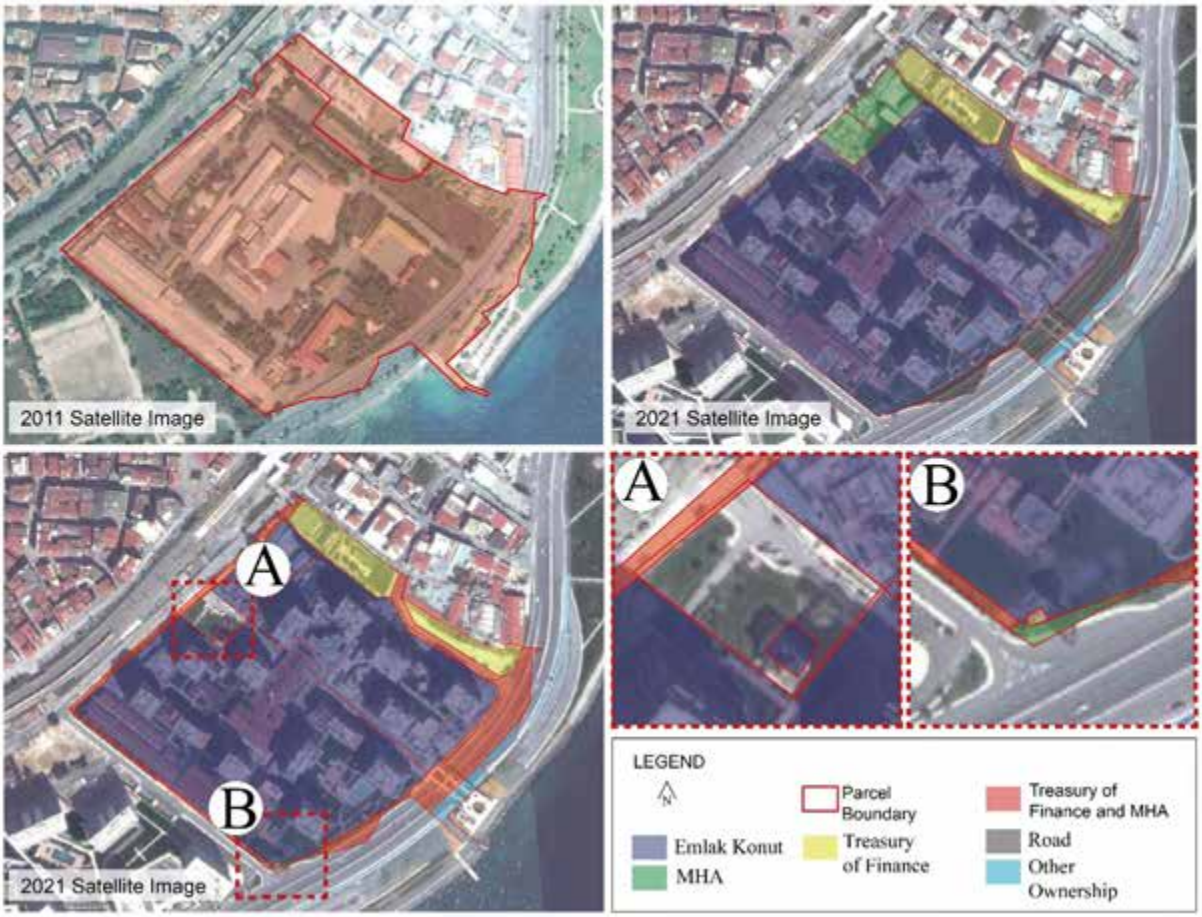

Figure 6 Subdivision of Parcels and Ownership Changes in 2018 and 2020
(Prepared with reference to TKGM, Ministry of Environment and Urbanisation, 2018 and 2020)

An approximate 10% increase was made to the total parcel area in 2018. With this addition, according to the latest ownership records, Emlak Konut's land area was expanded, but its ownership share decreased. In contrast, both the ownership area and share of TOKI and the Treasury of Finance increased. As a result, two parcels belonging to TOKI were transferred to Emlak Konut, while the newly created small and inefficient parcels were allocated to the Treasury of Finance and TOKI (Figure 6; picture A and B).

While the ownership structure involves Emlak Konut REIT, TOKI, and the Treasury of Finance, the project tender was won by the 'Özak – Yenigün – Ziylan Ordinary Partnership,' and the construction process has begun. Özak REIT was established in 1995, and Yenigün in 1973, both being construction firms. Ziylan Real Estate, on the other hand,

was founded in 2014, and the Büyükyalı project is the only joint project of these three companies. The inclusion of Ziylan Real Estate—a newly established firm—in the project suggests that it entered the construction sector with the support of the more established and experienced firms. In other words, this project introduces a new construction company into the sector that aims to make a name for itself. More comprehensively, this is a process in which Özak REIT—ranked 9th in market value—and the other two construction companies utilised publicly owned land to further expand in the sector, following a tender opened by Emlak Konut REIT, the company with the highest market value (Erdoğan and Özaslan, 2021).

Changing Function: From Factory Site to Housing Project

In 2016, when construction of the project began, Özak REIT launched a design competition for the planning of the site, and as a result, the architectural design was awarded to the British architecture firm Chapman Taylor (Karakoç, 2016). It was initially announced that blocks ranging from 5 to 17 storeys would be constructed, not exceeding 55 metres in height so as not to disrupt the silhouette (Karakoç, 2016); however, the final height reached 70 metres. This suggests that the initial narrative may have been constructed merely to avoid public backlash. The same applies to the registered heritage structures. Although it was stated that they would be preserved in situ, four of them were relocated. The registered structures within the study area were restored, but many were moved to other parts of the site. The Company Command Building was relocated near the Accounting Office Building, and its original location was opened to new development. The registered Gate was moved to the northwest of the building, while a fountain structure was reconstructed to its southwest. Artefacts uncovered during construction are now displayed to the west of the Armoured Vehicle Repair Workshop. The remaining registered buildings remain in their original locations (Figure 7).

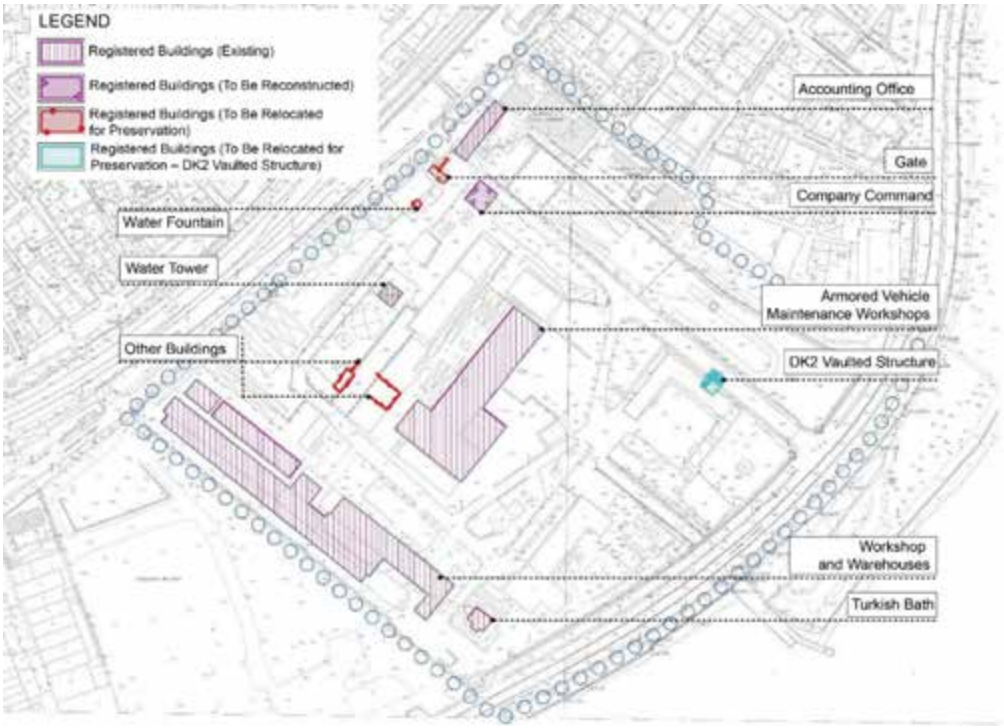

Figure 7 Registered Buildings Sketch (Ministry of Environment and Urbanisation, 2018)

The relocated Company Command was moved to the same parcel as the Accounting Office and is now used for educational purposes on this parcel, which has been designated with an educational function. The Water Tower has been restored and is exhibited, while the other registered remains discovered on-site are displayed in their existing condition. It is understood that two additional underground levels have been constructed beneath the single-storey Armoured Vehicle Maintenance Workshop, and multiple functions such as retail, cafés, restaurants,

exhibitions, and cultural and artistic activities have been added. Similarly, an additional underground level has been added beneath the Workshop and Warehouse building, which is now used as a commercial space. In addition to these, an underground parking facility is also present.

Conclusion

In this study, which examines the changing role of the state under neoliberal policies, the case of the Zeytinburnu Fabrika-i Hümayun is used to illustrate how the state, acting as an entrepreneur, has taken on a role that serves capital interests rather than the public good. As a central authority, the state established the Privatisation Administration and restructured the already existing TOKI to function as parastatal institutions in order to facilitate privatisation. TOKI, as one of the main actors in this process, was granted broad powers by law, enabling the non-transparent and gratuitous transfer of treasury land ownership. By transferring ownership to its subsidiary Emlak Konut REIT and awarding tenders to construction firms, the result has been the development of luxury housing projects and the use of public land for non-public purposes. Except for objections raised by the Chamber of Architects and the Chamber of City Planners (TMMOB), no other formal opposition was made during the transformation of the factory site into a housing project, which is now fully completed.

The area, declared a 'Tourism Center' in 1987, was initially targeted for a housing project by the Istanbul Metropolitan Municipality (IMM), acting as a local state with an entrepreneurial role aiming to transform Istanbul into a global city. However, the housing project was ultimately completed under the initiative of the central government following the centralisation of authority after the 1990s. Decisions regarding the registered heritage structures were made with the approval of the relevant Regional Conservation Board. The process appeared to comply with legal procedures on the surface. This was because the central government played a proactive role by establishing in advance a legal framework that would allow the process to proceed smoothly—resulting in a structure that was not necessarily lawful in spirit, but had legal backing.

The transformation of a publicly owned land, originally used for the public good, was legitimised by promoting the idea that the area would remain publicly accessible under its new function. However, the limited number of shared spaces was equipped with luxury consumption venues. In this process, the public land was used in line with capital interests—despite the public—through the Özak-Yenigün-Ziylan Ordinary Partnership, which won the tender opened by Emlak Konut REIT. This constitutes a clear example of an alienation process through public dispossession.

In 2018, the ownership of the 'Residential + Commercial' and 'Residential + Tourism' zones belonged to Emlak Konut REIT, while the 'Education Area' and 'Religious Facility Area' were under the ownership of TOKI. By 2020, a small portion of the 'Residential + Commercial' area owned by Emlak Konut REIT had fallen outside the parcel boundary, while the 'Education Area' and 'Religious Facility Area' previously owned by TOKI had been transferred to Emlak Konut REIT. Additionally, part of the road area outside the project site was transferred to TOKI. As shown in Figure 6, narrow and inefficient strips of land—publicly used but not functionally viable—were transferred to TOKI's ownership. This way, the proportion of public facilities, which should have been preserved for public use, was maintained on paper.

Originally established as a state institution to provide housing for middle- and low-income groups, TOKI has gradually evolved into a parastatal organisation. Nevertheless, the Keynesian narrative that TOKI continues to build housing for low-income groups is still maintained, which helps preserve its perceived legitimacy in the public eye. On the other hand, TOKI continues to auction off publicly owned treasury lands and real estate, while applying the method of urgent expropriation for social housing projects. In doing so, it relies on Presidential Decrees for legal legitimacy.

While the factory site once held use value on behalf of society, its prestigious location has made its exchange value more significant for capital. Instead of being regarded as part of the industrial heritage that reflects a particular historical period, the registered structures on the site have been transformed into commodities intended

to provide visual pleasure for users and visitors. In a city like Istanbul—where even adequate gathering spaces for earthquakes cannot be designated despite the urgent seismic threat, and where 1.3 million housing units are considered risky and 230,000 buildings are in need of immediate transformation[1]—it is ethically unacceptable for a public space that should serve the common good to be used for capital interests, against the public interest. As long as the growth-oriented approach of neoliberal policies continues, such capital-driven practices that sideline public benefit will also persist. For this reason, the state must recall its public responsibilities, and society must recognise and demand its fundamental human rights through active engagement and resistance.

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Track 16

FOOD

Dynamic Analysis of Cultivated Area-Food-Population System in Shrinking Rural Areas of Northeast China and Its Planning Strategies

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Abstract
Rural population decline, an inevitable outcome of urbanization and socioeconomic progress, critically impacts national food security through interactions within the cultivated area-food-population system. This study examined Northeast China, a region emblematic of rural depopulation, to analyse systemic dynamics using 2000–2020 census data. Spatial shrinkage patterns were mapped and categorized, revealing key trends. Proposed strategies advocate proactive "smart shrinkage" aligned with demographic shifts: enforcing farmland protection, enhancing black soil conservation, optimizing agricultural layouts, and boosting grain productivity. These measures aim to harmonize population-land-grain coordination, balancing strict resource governance with regional integration. Findings provide actionable guidance to advance sustainable rural-urban synergies, ensuring resilient food systems amid demographic transitions in Northeast China.

Keywords: rural population shrinkage; food security; cultivated area-food-population system; Sustainable Food Planning; Northeast China

1. Introduction

The development of urbanisation has facilitated the flow of production factors between urban and rural areas, disrupting the original internal equilibrium mechanism that maintained the mutual adaptation of agriculture, peasant communities, and rural settlements. This transformation has altered the relatively closed, land-dependent traditional rural development model characterised by self-sufficiency, gradually fostering more open urban-rural social relations. However, the conflicts arising from rapid large-scale urbanisation have exacerbated the "agriculture, rural areas, and farmers" issues (Zhang et al., 2022). Since China's reform and opening-up, with pivotal milestones in 1995 (economic system transformation) and 2014 (comprehensive deepening reforms), rural population dynamics have evolved through three distinct phases: gradual development, mass migration, and citizenisation of agricultural migrants (Guo, Zhou and Liu, 2020). Contemporary rural regions now demonstrate persistent population decline, with issues such as rural depopulation and hollowed villages attracting increasing scholarly attention. The outflow and shrinkage of rural populations have become inevitable phenomena in the process of socioeconomic development, leading to a shortage of rural labor and an imbalance in rural economic structures, also serving as key issues for alleviating human-land tensions and achieving high-quality development in rural territorial systems (Guo, Zhou and Liu, 2020; Dong et al., 2023). These changes adversely impact food production and security, emphasizing the need to investigate the effects of population decline on farmland protection and food production, particularly in regions such as Northeast China, which is characterized by vast agricultural land and significant rural population decline, while maintaining exceptional agricultural productivity as a vital grain production base (Zhang et al., 2023). The region shoulders dual strategic responsibilities, such as black soil conservation for sustainable farmland management and safeguarding national food security. Therefore, it is necessary to study the degree of rural population shrinkage and the challenges it brings to the dual tasks of protecting cultivated land and ensuring food security.

Current research on rural population contraction primarily focuses on three dimensions: village hollowing quantification, rural population shrinkage measurement methodologies, and empirical case studies. Some scholars have evaluated rural hollowing patterns across national, provincial, and county-level scales (Long, Li and Liu, 2009; She and Qiu, 2024; Zhang et al., 2024), analysing formation mechanisms and proposing governance strategies. Comparative studies drew lessons from developed nations (e.g., USA, Japan, South Korea, Germany, UK) in addressing ageing, low fertility rates, and rural shrinkage (Xiao, Zhang and Liu, 2022; Zhang, Li and Bai, 2022; Feng

et al., 2022). Other investigations examined spatial-temporal patterns of population outflow rates (Guo, Zhou and Liu, 2020), categorised settlement evolution types, and discussed rural human settlement space planning strategies guided by "smart shrinkage" (Zhao, You and Chen, 2015). Existing methodologies predominantly employed qualitative case analyses or quantitative indices assessing natural, social, and economic dimensions of rural vitality, or referring to the definition of "shrinkage" in the study of shrinking cities (Liu and Yang, 2017; Ma, Li and Zhang, 2021), used indicators such as the rate of change of rural permanent population in a certain period and the average annual change of rural permanent population to characterize the degree of rural population shrinkage (She and Qiu, 2024). However, limited attention had been paid to the interaction between rural demographic contraction and the cultivated area-food system. While human geography research has conceptualised the Cultivated Area-Food-Population Complex System (Bao and Fang, 2007), with subsequent studies applying coupled coordination models to analyse regional system evolution (He et al., 2016; Aimaiti, Tuoheti and Xu, 2020; Yang et al., 2016), the mechanisms linking rural depopulation with land-food system dynamics remain underexplored.

To address this gap, this study focused on Northeast China, a region emblematic of rural population shrinkage, as the research area. Through typological identification of population contraction patterns and systematic analysis of its cultivated area-food-population system dynamics, I discussed planning interventions to support synergistic development of high-quality urbanisation and rural revitalisation in this strategic agricultural zone.

2. Definition of concepts

2.1. Rural Shrinkage

The concept of "rural shrinkage" derives from its urban counterpart, "urban shrinkage" (Dong et al., 2023). In American rural demographic studies, analogous terms include "population decline" (defined as the population in 2010 decreasing by more than 25% compared with the historical peak) and "population loss" (referring to sustained demographic decreases across both 1990–2000 and 2001–2010 periods) (Xiao, Zhang and Liu, 2022). Chinese scholars define shrinking villages as rural settlements experiencing either a permanent resident population smaller than the registered population or persistent population decline during urbanisation and agricultural modernisation, accompanied by vacant or derelict residential buildings (Jiao and Zhang, 2021). Population loss constitutes the most direct and effective measurement indicator of shrinkage phenomena (Ma, Li and Zhang, 2021). Building on the research results of existing scholars on rural shrinkage and China's census-based urban-rural classification criteria, this study operationalised rural shrinkage from a demographic perspective, specifically denoting sustained reductions in permanent rural populations across two consecutive decades: 2000–2010 and 2010–2020.

2.2. Cultivated area-food-population system

The cultivated area-food-population system refers to a complex territorial system grounded in the exploitation and utilisation of cultivated area resources, with grain production, consumption, and circulation as its core processes, and the fulfilment of human dietary needs as its ultimate objective. Within specific regional contexts, both the quantity and quality of cultivated area determine grain output, while the interplay between grain production and population dynamics governs per capita grain availability (Bao and Fang, 2007). Coordinated development of this tripartite system manifests through (Yang et al., 2016):

- Effective regulation of sustained population growth;
- Maintenance of population density on cultivated land within its carrying capacity thresholds;
- Dynamic per capita grain availability consistently exceeding dietary demand;
- Preservation of arable land quality achieved without ecological degradation .

3. Data and method

3.1. Study area and data sources

This study focused on Northeast China's Heilongjiang, Jilin, and Liaoning provinces, with county-level administrative units (counties and county-level cities) as analytical subjects. Based on 2020 administrative boundaries, I integrated historical data from 2000-2020 after accounting for jurisdictional adjustments and data availability constraints. Four newly established counties of Tangwang County, Fenglin County, Daqingshan County and Nan-

cha County in Yichun City, Heilongjiang Province were excluded, resulting in a final dataset of 143 county-level units.

The county-level administrative unit vector data used in this study came from the Third National Land Survey database in 2020. Population data came from county-level demographic statistics from the Fifth (2000), Sixth (2010), and Seventh (2020) National Population Censuses. Cultivated area data came from the cultivated land area of "China Agricultural Statistical Yearbook" (2001), the 2010 data of the Second National Land Survey data (https://gtdc.mnr.gov.cn/Share?UiNMsBTfPrya=1712637735952#/secondSurvey) verified with the China Annual Cultivated Land Dataset (CACD) (https://doi.org/10.5281/zenodo.7936885) released by Dr. Tu Ying in Professor Gong Peng's team at Tsinghua University with a resolution of 30m×30m, and the 2020 data of the Third National Land Survey data (https://gtdc.mnr.gov.cn/Share#/thirdSurvey). The grain production data for 2000 and 2010 were derived from the "China County Statistical Yearbook" (2001, 2011), and the grain production data for 2020 were derived from the statistical yearbooks and the statistical bulletin on national economic and social development of various provinces and cities .

3.2. Method

3.2.1. Rural Shrinkage Measurement

This study firstly identified persistently shrinking rural areas through sustained reductions in permanent rural populations across two decadal intervals (2000-2010 and 2010-2020), using triennial census data, then calculated the average annual change rate of rural permanent population in each county from 2000 to 2020. The population outflow rate of each county was calculated using the permanent population in rural areas and the rural registered population in 2010. The two indicators were combined to characterize the degree of rural shrinkage in Northeast China. The formulas were as follows:

$$= \left(\sqrt{\quad_{2}/\quad_{1}} - 1\right) \times 100\%$$

Where: S_i was the average annual change rate of the rural permanent population of the i county (city) in a certain period, P_{i1} and P_{i2} represented the rural permanent population of the county (city) at the beginning and end of the period respectively, and n was the interval year.

$$= (1 - \quad / \quad) \times 100\%$$

Where: R_i was the population outflow rate of county (city) i, H_i and P_i represented the number of rural registered population and rural permanent population of the county (city) respectively.

3.2.2. Rural Shrinkage Typology

Building on existing literature and Northeast China's demographic trends, county-level rural shrinkage was classified into four types according to dual thresholds of annualised rural population change rate (S_i) and population outflow rate (R_i): In-migration Shrinkage (R_i<0), Moderate Shrinkage (0<R_i≤50%, -3%<S_i≤-1%-,) Severe Shrinkage(0<R_i≤50%, S_i≤-3%), Critical Outflow Shrinkage (R_i>50%).

4. Dynamic analysis of the rural cultivated area-food-population system in Northeast China

4.1. Analysis of changes in total volume

4.1.1. Rural population dynamics

Between 2000 and 2020, Northeast China's county-level rural population declined sharply from 41,450,985 to 25,178,835, a decrease of 39.26% and an average annual growth rate of about -2.46%. This demographic shrinkage exhibited accelerating negative growth trends, with Heilongjiang Province experiencing the most pronounced decline, particularly during 2010-2020, where annualised population loss rates exceeded regional averages.

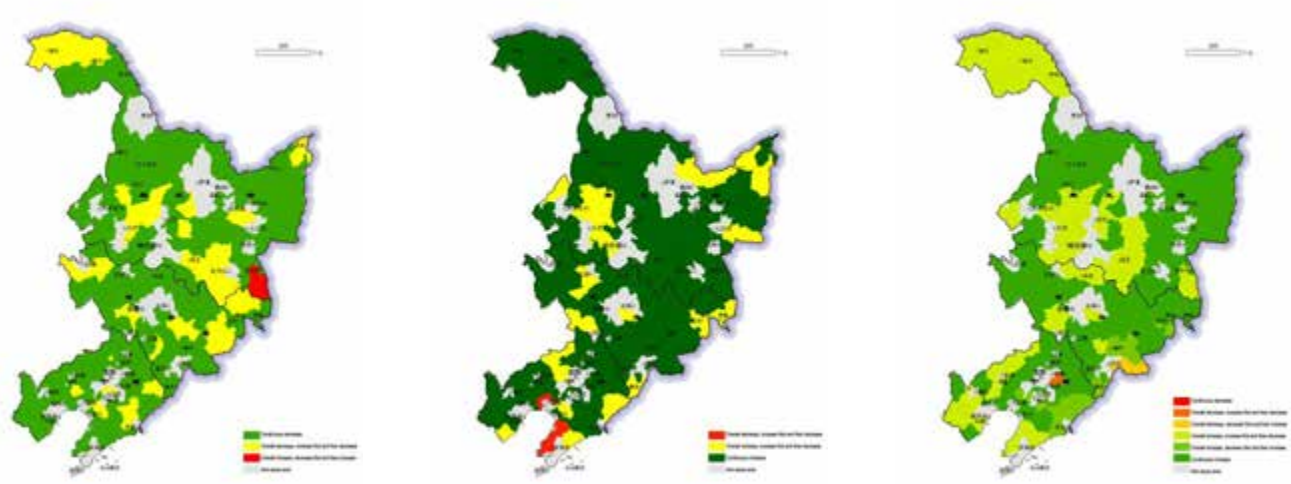
4.1.2. Cultivated land area dynamics

From the perspective of the total scale of cultivated land, the cultivated land area in counties and villages in

Northeast China increased significantly from 2000 to 2020, with a total increase of 106,331 square kilometers, a growth rate of 69.49%. From the perspective of spatial distribution, the cultivated land area of most county units in Northeast China continued to grow, and showed a concentrated and contiguous distribution state. Only the cultivated land area of four county-level units, namely Wafangdian City, Changhai County, Panshan County and Gaizhou City, decreased, and they were concentrated in the Bohai Rim region. Although the total amount of cultivated land in some counties (cities) increased, their cultivated land area decreased in the past decade and was relatively scattered in space. Overall, the protection of cultivated land in Northeast China has achieved good results in terms of quantity and scale.

4.1.3. Grain production dynamics

Grain output in Northeast China surged by 175.57% over the study period, with a relatively large growth rate from 2000 to 2010 and a slowed-down rate from 2010 to 2020, which was related to the reduction of agricultural labor force, the stabilization of cultivated land area and planting structure due to the intensified population loss in Northeast China. In terms of grain production pattern, Heilongjiang Province was the main grain production area in Northeast China, and grain output has basically remained above 50% of the total in the study area. From the perspective of the spatial distribution of changes in grain output, 62.24% of counties continued to increase, and only 5 counties (3.50%) had a decrease in grain output in 2020 compared with 2000, which were scattered around the provincial capital, coastal and border forest areas, attributable to industrial restructuring and topographic constraints.



(a) Rural population (b) Cultivated land area (c) Food production

Figure 1. Changes in the total amount of the rural cultivated area-food-population system in Northeast China

4.2. Per capita/unit analysis

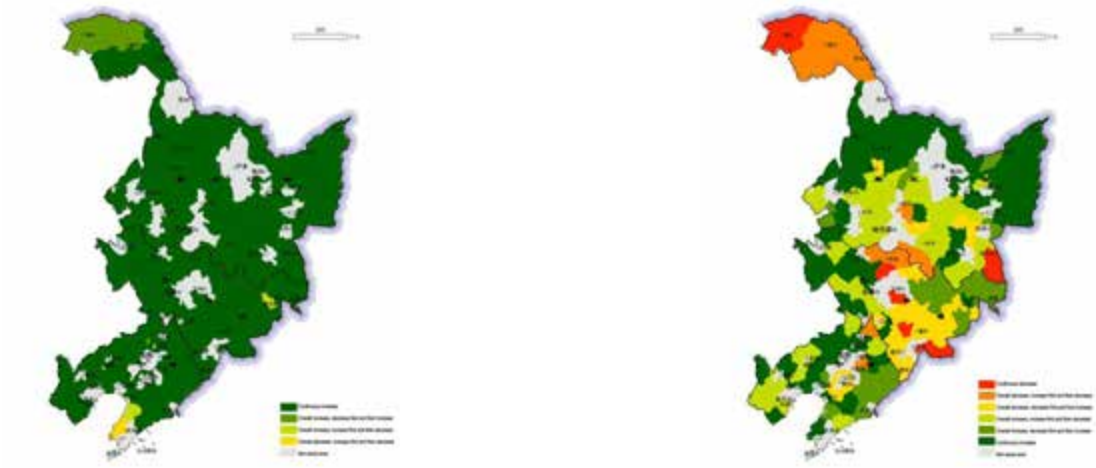
4.2.1. Per capita cultivated land dynamics

Between 2000 and 2020, county-level per capita arable land area in Northeast China exhibited consistent growth, with Heilongjiang Province recording the most pronounced expansion and persistently exceeding the regional average. Spatially, over 95% of counties demonstrated sustained growth in per capita arable land availability, and other counties showed minor volatility, with only the per capita arable land area of Wafangdian City decreasing. This trend reflected the inevitable outcome of rural population contraction coupled with intensified cultivated land conservation measures.

4.2.2. Grain output per cultivated land area dynamics

Grain yield per unit cultivated area across Northeast China increased markedly during 2000-2020, with Heilongjiang Province leading at 90.24% growth, followed by Liaoning Province (72.91%). From the perspective of county

differences, the cultivated land efficiency of 37.76% of counties continued to improve, 37.76% increased with fluctuations, and less than 1/4 of counties decreased, forming two relatively concentrated groups in the Daxing'anling Prefecture and the central-eastern Jilin Province. Spatial patterns revealed optimal productivity concentrated in contiguous agricultural zones consisting of southwestern Heilongjiang Province and western Jilin Province, and plains in northern Liaoning Province and eastern Heilongjiang Province. These high-yield regions benefited from large-scale contiguous farmland conducive to modernised agricultural practices.



(a) Per capita cultivated land area (b) Grain production per land area

Figure 2. Changes in the per capita/unit index of rural cultivated area-food-population system in Northeast China

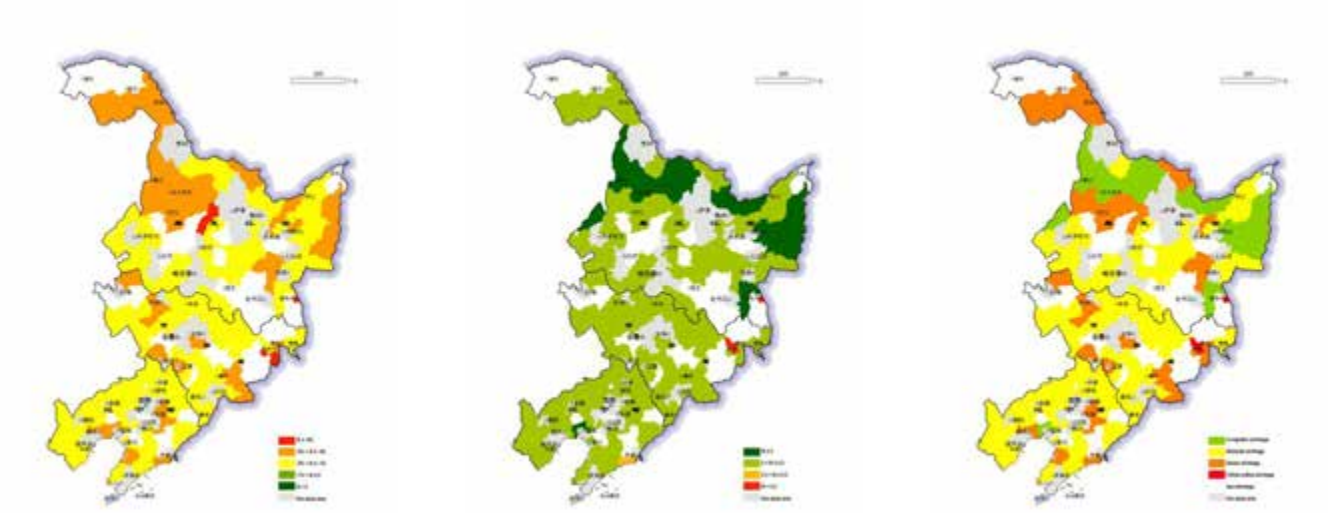
5. Analysis of the types and characteristics of rural population shrinkage in Northeast China

5.1. Identification of the scope of rural population shrinkage

Between 2000 and 2020, 113 county-level units in Northeast China, accounting for 79.02% of the study area, exhibited sustained rural population decline. Among them, there were 35 in Liaoning Province, 31 in Jilin Province, and 47 in Heilongjiang Province, accounting for 85.36%, 79.49% and 74.60% of the total number of study units in each province, respectively. This demonstrated pervasive rural shrinkage across the region, with Heilongjiang Province bearing the largest number of county-level units with rural population shrinkage, and Liaoning Province had the highest proportion of county-level units with rural population shrinkage.

5.2. Classification of rural shrinkage types

Integrating annualised rural population change rate (S_i) and population outflow rate (R_i), four rural shrinkage types emerged, with moderate shrinkage as the main rural shrinkage type in Northeast China, including 73 county-level units, accounting for 64.60% of the total shrinkage units, followed by 25 severe shrinkage units (22.12%), 13 in-migration shrinkage units (11.50%) and 2 critical outflow shrinkage units (1.77%). Spatial patterns showed that, the moderate shrinkage counties were mainly concentrated and contiguous in space, mainly distributed in the southern part of Heilongjiang Province, most of the counties in Jilin Province and Liaoning Province. Besides, the severe shrinkage counties were scattered in the three provinces of Northeast China. The in-migration shrinkage counties were mainly distributed in the northern part of Heilongjiang Province, and there were also scattered points in the eastern part of Heilongjiang Province and the southern part of Liaoning Province. The critical outflow counties were scattered and the number was the smallest, with only two units in Suifenhe City, Heilongjiang Province and Yanji City, Jilin Province. In general, the phenomenon of rural population shrinkage in counties in Northeast China was common, and the rural shrinkage situation in the north part was more severe than that in the south.



(a) Annualised rural population change rate from 2000 to 2020 | (b) Rural population outflow rate in 2010 | (c) Rural shrinkage type

Figure 3. Distribution of rural shrinkage types in Northeast China

5.3. Characteristics of the cultivated area-food-population system in Northeast China's shrinking rural areas

As demonstrated, Northeast China's rural areas exhibited accelerating population shrinkage alongside expansions in cultivated land area, which was changing inversely compared with rural permanent population, and intensifying spatial disparities in grain production efficiency. The dependence of food production on cultivated land resources was increasing. The four identified rural shrinkage typologies (in-migration, moderate, severe, and critical outflow) manifested distinct systemic characteristics within the cultivated area-food-population system, as synthesised in Figure 4.

Figure 4. Table of characteristics of the cultivated area-food-population system in Northeast China's shrinking rural areas

Type	Number of counties	Characteristics of the cultivated area-food-population system	Distribution
In-migration shrinkage	13	• The rural population has decreased, with increased area of cultivated land and improved efficiency of cultivated land. • Food production was less dependent on population and cultivated land resources. • The concentration of cultivated land in plain areas was conducive to large-scale production, and the improvement of agricultural technology level was the key to maintaining system stability.	Plain arable land in the northern-eastern border counties of Heilongjiang Province.

Moderate shrinkage	73	• The rural population has decreased, with increased cultivated land area. • The efficiency of cultivated land has mainly increased, with the efficiency of cultivated land in counties bordering provinces declined in recent years. • Food production was less dependent on the rural population, showing regional differences in the degree of dependence on cultivated land resources, with the main trend being a decrease in dependence.	Plain arable land in southern Heilongjiang Province, and most counties in Jilin Province and Liaoning Province.
Severe shrinkage	25	• The rural population has decreased, and the cultivated land area has increased. • There were large regional differences in cultivated land benefits. • Food production was less dependent on the rural population. • Natural geographical characteristics caused food production to rely more on cultivated land resources. Attention should be paid to the coordination of cultivated land protection and ecological security.	Scattered distribution, mainly in forest areas, mountainous areas and protected areas.
Critical outflow shrinkage	2	• The rural population has decreased, and the cultivated land area has increased. • The dependence of food production on cultivated land resources has decreased. • Non-agricultural counties with scarce cultivated land resources have developed other industries based on their port advantages.	Border port cities, such as Suifenhe City, Heilongjiang Province, and Yanji City, Jilin Province.
total	113		

6. Planning and regulation strategies for the cultivated area-food-population system in Northeast China's shrinking rural areas

Effective governance of he cultivated area-food-population system necessitates ensuring regional food self-sufficiency, maintaining systemic equilibrium, and coordinating tripartite relationships (Bao and Fang, 2007). As China's primary grain production base, Northeast China secures national food security while requiring targeted interventions to harmonise demographic, land-use, and agricultural dynamics, to acknowledge the inevitable trend of rural population shrinkage, to preserve precious and limited arable land resources, to promote technological progress and enhance food production capacity, so as to achieve the goal of sustainable development.

6.1. Proactive Smart Shrinkage Strategies Aligned with Demographic Trends

Planning should first establish awareness of rural shrinkage, correctly understand the inevitability of rural shrink-

age, abandon the traditional notion of development based on population size, clarify the main theme of "smart shrinkage" (Zhao, You and Chen, 2015), and attach importance to the creation and maintenance of rural vitality (Zhang, 2016). In order to address the coexistence of waste and insufficient supply of public services and generally low quality in rural shrinking areas, it is advised to optimize resource allocation and explore the establishment of a wide-area joint system of local living circles with urban-rural linkage allocation (Zhang, Li and Bai, 2022). The economic function, social structure and spatial evolution of rural areas are deeply influenced by factors such as the natural resource conditions and agricultural foundation of the village itself, the economic location and urbanization development stage, the intensity of interaction between grassroots governance and urban-rural elements, and the level of urban and rural infrastructure and public services (Zhang and Sun, 2019). Therefore, we should respect regional differences and formulate differentiated development paths based on local conditions such as the type of rural shrinkage and natural-economic factors.

6.2. Rigorous cultivated area conservation and black soil enhancement

China's farmland protection has gone through three major stages, from focusing on quantity protection to giving equal weight to quantity and quality, and to the "three-in-one" protection of quantity, quality and ecology. A series of farmland protection systems have been established, including farmland occupation and compensation balance, farmland use control, farmland quality acceptance, permanent basic farmland protection, black soil protection, land development, consolidation and reclamation. Planning should strictly adhere to the awareness of farmland red lines, implement the strictest farmland protection system, and curb the reduction of farmland area. Aiming to improve the quality and benefits of farmland, it is advised to increase the protection of black soil, strengthen agricultural land remediation and high-standard farmland construction, orderly promote rotation and fallow. To strengthen the coordinated protection of farmland and surrounding ecosystems, and to build a healthy and stable farmland ecosystem, are also essential to food and farmland security. By utilising the new generation of information technology to promote the informatization of land and resources, the department of natural resources could timely and effectively track and monitor changes in farmland area and quality.

6.3. Agricultural restructuring for systemic productivity gains

As the national strategic grain base, Northeast China Region needs to build an awareness of serving the implementation of major national strategies, and promote regional agricultural development in a coordinated manner. Planning should adhere to systematic thinking, optimize the agricultural pattern according to the differences in resource endowments in the region, promote cross-county and cross-provincial land resources and grain production coordination, to achieve win-win cooperation. It is also advised to adjust the production structure through reforming the farming system, to establish an ecological agricultural pattern that matches agricultural productivity with resource and environmental carrying capacity, to introduce advanced technology, modern equipment, management concepts, etc. into agricultural production to develop modern large-scale agriculture, so as to achieve the objective of enhancing the overall efficiency of grain production.

7. Conclusion

Rural population contraction constitutes an inevitable urbanisation outcome rather than rural decline. Stabilising the cultivated area-food-population system in rural area, which is an important carrier for ensuring China's food security and sustainable development of land space, remains critical for achieving high-quality development and urban-rural coordination under the general trend of population shrinkage. Northeast China has the dual typicality of rural population shrinkage and cultivated area-food-population system coordination. It is necessary to follow the trend of depopulation to shrink smartly, to strictly protect the stability of the amount of cultivated land and improve its quality, to promote the sustainable development of agricultural production in a regional integrated system, aiming to promote the coordinated development of high-quality new urbanization and rural revitalization in the Northeast China to achieve sustainable development and ensured food security in the face of ongoing demographic and socioeconomic changes.

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Informing Sustainable Regional Food Chains through Serious Games: The Play Marmara "Food"

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Abstract
The food system generates one-third of global GHG emissions, with urban regions playing a key role in climate challenges. In Türkiye, the Marmara Region—home to over 25 million people—faces mounting pressure on its food systems due to rapid urbanization, land-use change, and environmental degradation. Despite its agricultural potential, the region experiences declining farmland and water quality. The Play Marmara Food game, developed within the MARUF initiative by Play the City, addresses these challenges through a serious game format. It brings together stakeholders from various sectors to simulate scenarios, visualize data, and co-develop sustainable strategies. This study evaluates the game's role in fostering collaboration and informing food supply chain design to enhance regional sustainability.

Keywords: sustainable regional food systems; food security; supply chains; city gaming; serious game

1. Introduction

The global food system is increasingly recognized as a critical contributor to the climate crisis. According to the Food and Agriculture Organization (FAO), nearly one-third of all human-induced greenhouse gas emissions stem from the production, distribution, and consumption of food (Crippa et al., 2021). However, environmental impact is only one facet of a much broader crisis. Hunger and food insecurity—once on the decline—are rising again worldwide. The FAO reports that the global prevalence of undernourishment (PoU) increased from 8.0% in 2019 to 9.8% in 2021, reversing years of progress and raising doubts about the effectiveness of current food governance models (FAO, 2022a).

This troubling trend signals a deeper systemic problem. Food security depends heavily on access to freshwater, affordable energy, and stable logistics networks- all of which are increasingly vulnerable in a world beset by climate disasters, conflicts, and pandemics (FAO, 2015). Moreover, the inefficiency of current food systems is staggering: nearly 30% of global energy is consumed by food systems, and 38% of that energy is used to produce food that is ultimately wasted (Cuellar & Webber, 2010).

Recognizing this, the United Nations included "Zero Hunger" among its Sustainable Development Goals (SDG 2), acknowledging the need for a multidimensional approach—one that combines food security with social protection, infrastructure investment, and the establishment of sustainable production and distribution systems. The food crisis, fundamentally, is not just about scarcity; it is about the unsustainability embedded within the way we currently produce, distribute, and govern food.

Against this backdrop, regional food systems offer a potential path forward. They can shorten supply chains, promote local resilience, and create opportunities for integrated planning tailored to specific socio-ecological contexts. Yet building such systems requires inclusive governance, data-informed planning, and collaboration across diverse stakeholders- ranging from producers and cooperatives to municipalities, NGOs, and consumers.

Serious game is a structured, interactive method that allows stakeholders to explore real-world challenges in a simulated environment. This paper examines a serious game developed for Türkiye's Marmara Region, *Play Marmara Food*, which seeks to enhance stakeholder dialogue, simulate food system dynamics, and inform strategies for more sustainable regional planning.

The Marmara Region, Türkiye's most populous and industrialized area, plays a dual role as both economic

powerhouse and key agricultural zone. However, it faces mounting challenges related to land-use conflict, environmental degradation, and supply chain fragmentation. This study explores how *Play Marmara Food*, developed by Play the City within the MARUF initiative, facilitates collective problem-solving and knowledge exchange.

The paper proceeds as follows: Section 2 outlines the theoretical foundations of sustainable regional food chains and serious games. Section 3 describes the food system dynamics in Marmara. Section 4 details the game's methodology and design. Section 5 presents the game outcomes and participant insights, as well as discusses the implications for participatory governance and food policy. The final section concludes with recommendations for future applications and research.

2. Theoretical and Methodological Framework

2.1. Sustainable Regional Food Chains

Sustainable regional food chains refer to interconnected systems of food production, processing, distribution, consumption, and waste management that operate within a defined geographical region and are guided by principles of environmental stewardship, social equity, and economic viability. These systems aim to minimize environmental impact while promoting local economic development and food sovereignty (Sonnino et al., 2016).

While the concept of regional food systems offers a sustainable alternative to globalized food chains, their development is constrained by structural and operational challenges, as noted in recent literature and policy frameworks:

- **Land Use Conflicts:** Rapid urbanization often leads to the loss of fertile agricultural land, particularly in peri-urban regions, compromising local food production capacity (FAO, 2023b). This is exacerbated by weak land-use policies and competing economic interests.
- **Governance Fragmentation:** Regional food systems typically span multiple administrative jurisdictions, creating coordination difficulties and regulatory inconsistencies (Moragues-Faus & Morgan, 2015). The absence of integrated food governance hinders systemic change.
- **Logistics and Infrastructure Gaps:** Many regional supply chains lack the infrastructure necessary for efficient and competitive operation, including cold storage, processing facilities, and short distribution networks, coordination issues between transport providers and both small- and large-scale food facilities often result in costly delays and inefficiencies (Day-Farnsworth &Miller, 2014). This limits their scalability and integration into broader markets.
- **Market Access Barriers:** Small-scale producers often face challenges in accessing mainstream markets due to limited bargaining power, lack of certification, and low investment in marketing and technology (Kneafsey et al., 2013). These barriers can reduce the economic viability of regional systems.
- **Environmental Pressures**: The current global food system contributes significantly to climate change, biodiversity loss, and resource depletion. Food production is responsible for approximately one-third of global anthropogenic greenhouse gas emissions (Crippa et al., 2021), with a significant portion attributed to livestock farming and deforestation (Kler et al., 2022; Shabir et al., 2023).
- **Vulnerability**: External shocks such as pandemics and armed conflicts exacerbate food system fragilities. The COVID-19 pandemic and the war in Ukraine, for example, disrupted supply chains, increased food and energy prices, and significantly worsened global hunger and food insecurity (FAO, 2022; Abay, 2022; WFP, 2022). These crises have also emphasized the heavy dependence of food systems on freshwater and affordable energy, heightening their vulnerability (FAO, 2015).
- **Information Deficits:** Data on regional food flows, environmental impacts, and land productivity are often fragmented or outdated, hampering evidence-based planning and policy interventions (FAO, 2023a).
- **Food Waste and Resource Inefficiency:** The energy used to produce the 24.4 billion pounds of dairy products discarded annually in the U.S. alone could meet the world's daily energy needs (Cuellar & Webber, 2010). Reducing such inefficiencies is key to building more sustainable food systems.

To effectively address these multifaceted challenges, integrated and participatory planning approaches have

gained prominence. The City Region Food System (CRFS) framework developed by FAO and RUAF advocates for multilevel, multistakeholder governance to facilitate food system transformation through collaborative and context-specific strategies (FAO, 2023b).

Participatory tools such as serious games provide innovative formats for convening diverse actors, enabling experiential learning, system mapping, and collaborative strategy development (Devisch et al., 2018). By simulating real-world conditions and visualizing complex interdependencies, serious games allow stakeholders to explore alternative futures, test trade-offs, and co-create actionable solutions.

In this context, the Play Marmara Food game exemplifies an applied method that aligns with theoretical and policy frameworks emphasizing collaboration, systems thinking, and integrated governance. By employing serious games as a participatory method, it supports consensus-building and facilitates dialogue across traditionally siloed sectors, making it a relevant methodological tool for informing regional food policy and sustainability planning.

2.2. Serious Games in Planning and Governance

"Serious games" are interactive experiences designed for a primary purpose other than pure entertainment, typically learning, decision-support, or social change (Abt, 1970). Building on Abt's foundational work, later frameworks describe serious games as the fusion of a *serious* dimension (an explicit real-world objective) and a *game* dimension (rules, feedback, voluntary play) (Djaouti et al., 2011).

Across these forms, games share a common structure of *means* (tools, rules), *goals* (desired outcomes) and *feedback* loops that allow iterative experimentation (Parlett, 1999; Crawford, 1983). This structure makes them attractive for planning tasks where complex systems and competing interests must be explored in a "safe-to-fail" environment.

The planning field has a long tradition of using game-based methods to test policies and accelerate stakeholder learning (Mayer, 2009). Notable precedents include:

Urban growth & land-use games: Workshop-based table-top games that let citizens allocate housing, green space and infrastructure, these tools help reveal trade-offs between density, mobility and environmental quality (Sousa et al., 2022).

- **Infrastructure & mobility games**: Metro-planning games in Singapore and transit-oriented-development role-plays in Europe allow transport agencies to co-design route scenarios with residents, balancing capacity, cost and equity. (LTA Connect, 2019; ULI, n.d.)
- **Climate & resource games**: The *World Climate* negotiation game and the *Food Chain Reaction* scenario game engage national delegates, NGOs and private firms in exploring emissions pathways or global food shocks, underscoring supply-chain interdependencies. (Sterman et al., 2015; WWF, 2016)
- **Local food-system games**: Municipal initiatives such as the "City Region Food System Game" (FAO/RUAF pilots) guide diverse actors through sourcing, processing and waste loops to co-create resilient regional strategies. (Cities 2030, n.d.)

These precedents demonstrate that game mechanics—whether as turn-based strategy, real-time simulation or facilitated role-play—can translate technical data into tactile experiences that catalyse dialogue across disciplinary and institutional silos.

Before using serious games in planning, it's important to understand that they have both strengths and weaknesses. The same game elements that help people learn and work together can also make things seem simpler than they really are or lead to biased results. Knowing both the benefits—like testing ideas and learning together and the risks, like depending too much on models or needing a skilled facilitator, helps planners use these games more effectively.

Table 1: Strengths of Serious Games as Tools for Participatory Planning

Strengths	Planning value	Key references
System visualisation & experimentation	Players can rapidly test "what-if" scenarios, seeing consequences of land-use or supply-chain choices without real-world risk.	Mayer (2009); Crawford (1983)
Stakeholder engagement & dialogue	Games level power asymmetries, giving community members, NGOs and officials equal turns and shared visual cues, which improves mutual understanding.	Sousa et al. (2022); Djaouti et al. (2011)
Learning & capacity-building	Embedded feedback, scoring and reflection foster deeper retention of planning principles, logistics constraints and policy trade-offs.	Laamarti et al. (2014)
Data integration	Real-life data (e.g. GIS data, statistics), emissions inventories or cost tables can be encoded as game parameters, turning abstract numbers into tangible decisions.	Abt (1970); Parlett (1999)

Play Marmara Food leverages a table-top game to visualize regional food supply chains, logistics challenges, and policy levers. By embedding Marmara-specific data sets, such as drought and erosion risks, and agricultural land use, into an iterative, multi-round game, it builds on the recognized strengths of serious games, including experimentation and dialogue.

- Co-design with planners and technical experts ensures model accuracy and relevance.
- Transparent rulebooks and debrief sessions uncover assumptions and encourage reflection.
- Scalable, data-driven outputs translate game actions into GIS layers and policy briefs, bridging the gap between play and governance.

As a result, the game acts both as a tool to help participants understand complex food-system dynamics and as a decision-support mechanism that directly informs MARUF23's regional action agenda for "Resilience and Beyond".

3. The Marmara Region Food System: Context and Challenges

3.1 Regional Profile

Located in northwestern Türkiye, the Marmara Region spans approximately 67,000 square kilometers and is home to over 25 million residents, making it the country's most densely populated and industrially developed region. Metropolitan hubs such as Istanbul, Bursa, Kocaeli, and Tekirdağ serve as the primary economic engines, due to their concentration of manufacturing industries, international trade links, and advanced logistics infrastructure (MMU, 2024).

This demographic and industrial intensity has significantly reshaped the urban–rural interface. Rapid urbanization and infrastructure expansion have led to increased competition for land and water resources, placing mounting pressure on regional food systems. Agricultural zones are being converted into residential and industrial areas, resulting in a steady decline in cultivable land and threatening long-term food security.

Despite these challenges, the region retains considerable agricultural potential. Fertile alluvial plains, a temperate climate, and access to river basins and coastal ecosystems make it suitable for cultivating a diverse range of crops, including cereals, fruits, and industrial crops. However, this agricultural base is increasingly at risk. Key threats include industrial pollution, unsustainable groundwater extraction, and climate-related stressors such as droughts and irregular rainfall patterns. These conditions are eroding the region's agroecological resilience and undermining sustainable food production (FAO, 2022b).

3.2. Overview of the Food System in the Marmara Region

The Marmara Region faces a complex set of challenges that threaten the sustainability and safety of its food system. Environmental degradation and food safety concerns are particularly acute. For instance, unregistered fertilizer use and the improper disposal of waste generated during olive production, such as olive black water discharged into the sea, contribute significantly to soil and water pollution, posing serious risks to human and ecosystem health (Ozturk et al., 2021).

In addition to plant-based agricultural risks, livestock farming is a major contributor to nutrient pollution. A recent study by Yaylı, Aydoğdu, and Kılıç (2024) assessed the pollution load from livestock manure across the Marmara Region between 2013 and 2022. The total estimated nutrient load was 25,497.5 tons, with nitrogen constituting 90.6% and phosphorus 9.4% of the total. Balıkesir emerged as the province with the highest contribution, while Yalova recorded the lowest. The study also revealed that cattle farming is the primary source of diffuse nutrient pollution. These findings emphasize the urgent need for improved waste management practices and integrated agri-environmental planning to mitigate the long-term impacts of livestock-based agriculture.

Another pressing issue is the rapid and often unregulated conversion of agricultural land for urban, industrial, and infrastructural development. Between 2000 and 2020, the Marmara Region lost thousands of hectares of productive farmland -particularly in peri-urban areas of Istanbul and along coastal zones- primarily due to urban sprawl (MMU, 2024). This process not only diminishes local food production capacity but also fragments ecological corridors essential for biodiversity, pollination, and microclimatic regulation.

Furthermore, intensive land use and unchecked industrial discharge have contributed to the degradation of soil and contamination of groundwater resources. Excessive application of chemical fertilizers and pesticides, compounded by poor wastewater management, has led to declining soil fertility and polluted aquifers, factors that directly compromise long-term food safety and agricultural productivity. A study by Varol and Tokatlı (2021) in the İpsala district of northwestern Türkiye, an area with a long history of intensive agriculture, found seasonal fluctuations in toxic metal concentrations in groundwater. While contamination levels remained below official drinking water limits, the results underscore the cumulative risks of persistent environmental pressures on regional water quality.

In terms of logistics, the Marmara food system is characterized by a fragmented and inefficient supply chain. Multiple intermediaries, lack of transparency, and weak coordination among actors contribute to post-harvest losses and price volatility, disproportionately affecting small- and medium-scale producers as well as low-income consumers. A regional analysis by the United Nations Development Programme (2021) further supports this observation, identifying rising logistics costs, insufficient technological infrastructure, and limited predictability as key barriers to supply chain efficiency in the region. These issues significantly hinder the ability of local producers to access broader markets and compete with industrial-scale operations.

Given these intertwined challenges, there is a growing recognition of the need for a governance model that is not only integrated but also participatory. International practice points to the City Region Food System (CRFS) perspective put forward by FAO and RUAF, which frames the metropolitan and rural hinterland as a single functional area and emphasizes nested, multi-stakeholder decision-making (FAO, 2023b). As Mäntysalo (2005) argues, effective planning should move beyond interest-based negotiation and aim for mutual understanding and cooperation among stakeholders. Participatory planning processes must be rooted in local realities, beginning at the street

or neighborhood scale and expanding to citywide and regional frameworks. Clearly defining stakeholder roles, decision-making scales, and engagement mechanisms is essential to ensure transparency, accountability, and legitimacy in food system governance.

Building a sustainable and resilient food system in the Marmara Region therefore requires the adoption of multi-scalar, inclusive strategies that address both environmental and socio-economic dimensions, essentially aligning with the integrated agenda championed by the CRFS approach. This includes reducing the environmental burden of agricultural production, improving food safety standards, and enhancing access to nutritious food for vulnerable populations. Ultimately, the transformation of the Marmara food system holds strategic importance not only for regional economic development and public health but also for the broader goal of inclusive and sustainable social development.

4. The Play Marmara Food Game

4.1. Purpose and Development

Play Marmara is a serious game developed through a collaboration between the Marmara Municipalities Union and Play the City, starting in 2018. It debuted at MARUF19 as Turkey's first regional development game. Grounded in real-world data and the methodology of serious gaming, Play Marmara was used as a participatory planning tool to envision sustainable urban and regional futures. The session brought together regional mayors, development agency leaders, practitioners, academics, and university students. This interactive experience at MARUF helped further conversations about the regional development of the Marmara Region.

The most recent comprehensive planning effort for the Istanbul Metropolitan Area dates back to 2005. Given the complexity of managing such a vast urban system, planners and authorities have long acknowledged the need for strategies that operate at both national and regional levels. In recent years, Turkey has been working toward a national spatial planning agenda. Critical regional issues, such as economic development, transportation, ecology, disaster risk, coastal management, and protected areas, demand an integrated planning approach. However, the availability of regional data and the challenge of coordinating across governance levels remain significant obstacles. Play Marmara introduces a novel method to address these issues by allowing key development stakeholders to engage with realistic, data-driven scenarios that simulate multi-level governance processes (MMU, 2019).

The game was first introduced at the Marmara Urban Forum (MARUF) in 2019, focusing on future strategic investments in the region.

Figure 1: Play Marmara 2019 Game Session

The second edition, *Play Marmara 'Sea'*, held in 2021, convened experts from national and local government to collaboratively assess and set priorities for the Marmara Sea Conservation Action Plan.

Figure 2: Play Marmara 'Sea' Game Session

The third edition, *Play Marmara 'Food'*, centers on regional food supply chains, enabling participants to co-design a sustainable food system for the Marmara region.

Figure 3: Play Marmara Food - Mayors Session

4.2. Game Design Methodology

The Play Marmara Food game was designed as a serious game to explore the future of food systems in the Marmara Region through stakeholder collaboration, scenario building, and data-driven decision-making. The game's methodology integrates real-world datasets, stakeholder roles, and interactive tools to support strategic planning for sustainable food systems.

Data collection:
Play Marmara Food was built on a composite geodatabase assembled from seven primary sources: NUTS-2 development-agency strategies; ministry datasets on agriculture, trade, and environment; Copernicus land-use layers; the Greenpeace "How to Feed Istanbul?" inventory; and the Marmara Municipalities Union (MMU) spatial framework. This multi-scalar evidence base captures production volumes, logistics nodes, land-degradation risks, and consumption patterns, providing the empirical boundary conditions that underpin every decision made during play.

Scenario construction and simulation logic
Play Marmara Food unfolds over four iterative rounds, each corresponding to a classic policy cycle stage- diagnosis, strategy design, collaboration, and evaluation. Core parameters (e.g., pollution, energy usage, freight distance) are embedded in *Food-Chain ID* and *Action* cards. Card effects are expressed as additive or multiplicative modifiers on six sustainability indicators -Solidarity, Biodiversity, Technology, Economy, Policy and Healthy Food- mirroring multidimensional evaluation frameworks used in regional planning.

Stakeholder representation and role schema
The stakeholder ecology is reproduced through six Role Cards -local government, producer, cooperative, logistics firm, large-scale retailer/consumer, and NGO- mapped to five sub-regional teams (West Marmara, Istanbul, South Marmara, East Marmara I and II). This taxonomy corresponds to the actor categories observed during field interviews and MARUF participatory sessions, ensuring face validity and role fidelity. Role asymmetries (e.g., fiscal capacity of municipalities, perishability concerns of producers) are encoded as differential starting resources and constraints.

Analogue game components
The material set comprises:

Gameboard a 1 : 125 000 GIS-derived map (240 × 400 cm) printed on a raised table, with GIS data to represent the region's agricultural and urban landscape. It features key land-use types such as orchards, cultivated fields, olive groves, and other agricultural zones, alongside urban settlements marked with logistics centers and wholesale markets. In addition, the map highlights environmentally sensitive areas, including zones with high erosion risk and regions vulnerable to desertification, offering players a realistic spatial context for making decisions related to sustainable land management.

Food-Chain ID Cards offer detailed insights into the supply chains of key agricultural products in the Marmara Region. Covering a variety of crops- including sunflowers, olives, wheat, and grapes- these cards represent the region's most widely produced and consumed items, as well as those grown using different techniques. Each card outlines the technical steps of production and highlights specific challenges associated with both durable and perishable goods, helping players better understand supply chain dynamics.

Action Cards include seventy (70) cards that allow players to express their ideas about the future of food systems. These cards are organized into key categories- production, consumption, logistics, waste, and supply- enabling players to explore different stages of the food chain and propose innovative strategies. Each card is a visual representation of food policies and innovative practices referenced in international reports, turning complex strategies into accessible and actionable game elements.

Collaboration Cards prompts that reward inter-regional alliances with extra actions.

Scoreboard sheets large-format sheets on which facilitators record indicator tallies at the end of each round.

4.3. Game Process
The game session begins with a structured briefing, during which participants are introduced to the regional

food system's core challenges and the sustainability indicators embedded in the game. Participants then select stakeholder roles—such as local government, producer, cooperative, logistics firm, large-scale retailer/consumer, or NGO- based on their professional background and area of interest (MMU, 2024).

The gameplay consist of four rounds (see Figure 4):
(1) Choose Your Team and Product, **(2)** Sustainable Food Chain, **(3)** Collaboration, and **(4)** Evaluation and Expert Review.
1. Choose Your Team and Product: Participants form sub-regional teams and select a key agricultural product, such as wheat, olives, strawberries, based on regional characteristics. Each team locates relevant production clusters on the map and places the corresponding Food-Chain ID Card onto the game board.

2. Sustainable Food Chain: Teams use Action Cards to develop a regional supply chain strategy, selecting interventions like "Organic Fertiliser," "Cold-Chain Logistics," or "Food Literacy Campaigns." Each card influences participants to consider trade-offs and synergies among social, environmental, and economic outcomes.

3. Collaboration: Teams negotiate strategic alliances using *Collaboration Cards*, enabling them to pool infrastructure investments or co-develop solutions such as R&D centers or logistics hubs. These alliances unlock bonus actions, reinforcing the importance of inter-regional cooperation and shared resource planning.

4. Evaluation and Expert Review: At the conclusion of gameplay, indicator scores are transferred on the scoreboard sheets. A panel of food-system experts then reviews the results, offering feedback on the feasibility, equity, and innovation of each team's strategy. These reflections inform subsequent policy briefs and knowledge dissemination efforts.

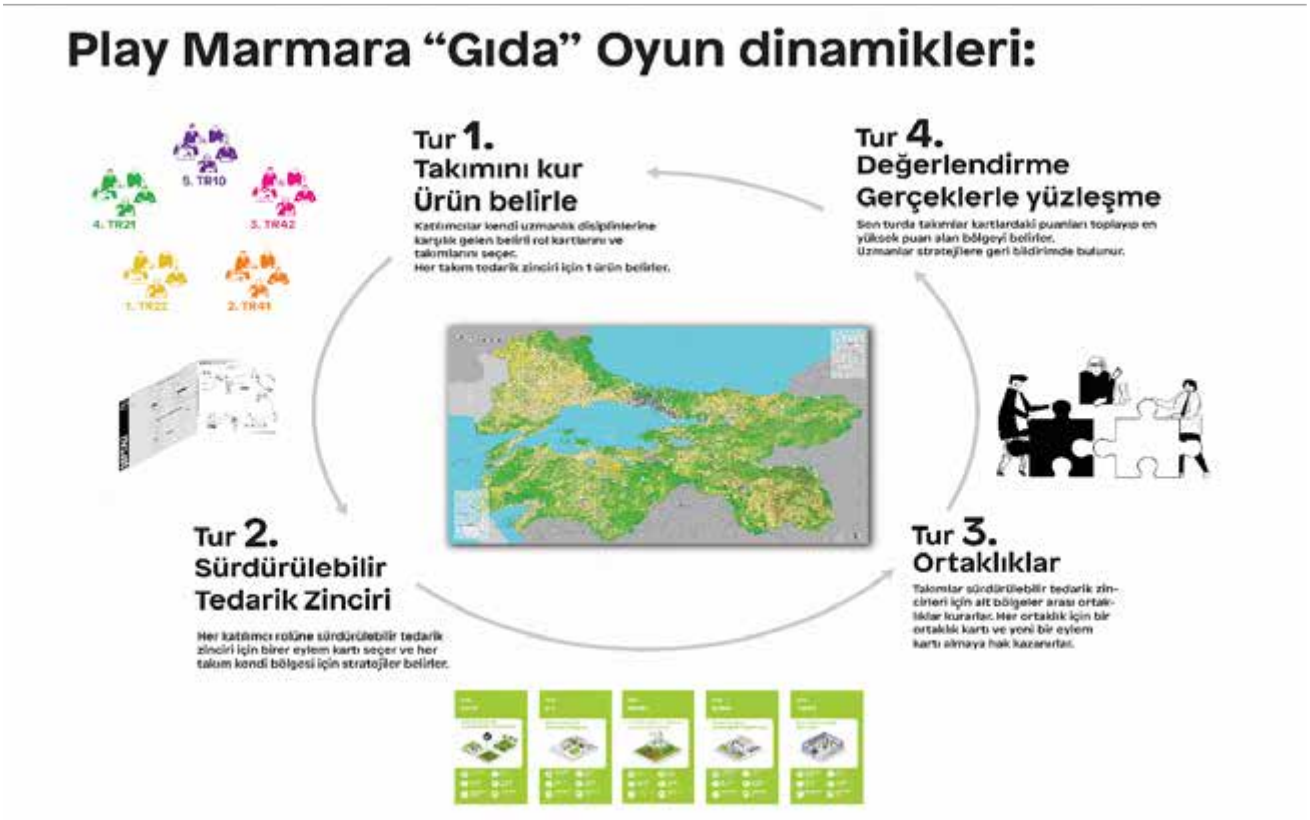

Figure 4: Play Marmara Food Game Dynamics

This four round structure reproduces the iterative nature of strategic planning while keeping total playtime to approximately 90 minutes. This format helps participants explore systemic interdependencies, test decisions, and co-develop actionable insights for regional food planning.

Collectively, the methodology and process position Play Marmara Food as a rigorously grounded, yet highly interactive, decision-support system capable of translating complex agri-food data into shared strategic visioning for the Marmara Region.

4.4 Game Results and Insights

Between 4–5 October 2023 the Play Marmara Food was played in five facilitated, table-top sessions: one *Mayors' Session*, two *Experts' Sessions* and two *Open Sessions* during MARUF23. In total, the exercise convened two metropolitan mayors, food-system specialists, NGO representatives, game designers, academics, and architecture/urban-planning students- a deliberately hybrid audience that mirrored the diversity of the regional food system. (Özdarendeli, 2024)

In each session, participants formed sub-regional teams and selected one agricultural product- such as wheat, olives, or strawberries- based on their sub region . They were asked a common guiding question: *"How can we make the journey of this product from farm to table cleaner, fairer, and more profitable?"* Guided by their regional data, teams selected a range of Action and Collaboration Cards and sketched quick strategic plans for sustainable supply chains.

Across those sessions participants generated more than forty distinct strategy cards and drafted a dozen inter-regional partnerships. Four themes surfaced repeatedly, whatever the product or sub-region:
- smarter logistics and infrastructure (e.g., "Smart Logistics Village");
- circular-economy and waste solutions (compost, biogas, blockchain audits);
- multi-stakeholder governance platforms (food-policy councils, regional regulations);
- youth and community incentives (young-farmer co-operatives, food-literacy programmes).

The exercise also revealed gaps: when teams' strategies were scored against six indicators—Solidarity, Biodiversity, Technology, Economy, Policy, Healthy-Food— most points accumulated in Technology, Economy, and Policy, while Healthy-Food and Biodiversity lagged, signalling issues that merit greater policy attention.

The Table 2 condenses the most prominent strategies that emerged in the final expert/open sessions, showing how different actor constellations tackled distinct products yet converged on similar leverage points; smarter logistics, circular practices, new governance platforms, and community-focused incentives.

Table 2: Sub-Regions, Products and Key Outcomes of Play Marmara Food

Sub-region / Actor	Product	Key actions selected	Impact
Istanbul team	Wheat	*Smart Logistics Village*, *City Farm*, *Food Literacy Training*, *Intl. Trade Networks*	Cut freight emissions, shorten producer–consumer link, boost export value

South Marmara team	Tomato	*National Food-Waste Plan*, *Drought-Resistant Crops*, *Local Incentive Packages*, *Regional Supply-Chain Rules*	Waste minimisation, climate resilience, rural jobs
West Marmara team	Sunflower	*Organic Fertiliser*, *Food Networks*, *Food Policy Council*, *Urban-Ag Zoning*	Regenerative soils, direct marketing, governance hub
East Marmara I & II teams	Strawberry	*Food Incubation Centre*, *Blockchain Waste Audit*, *Young-Farmer Cooperatives*, later paired with *Organic Fertiliser Export* and *Irrigation Optimisation*	Tech-driven transparency, youth entry, nutrient cycling

5. Discussion

Participatory planning has evolved far beyond public hearings and consultation forms. Contemporary approaches- especially those inspired by collaborative planning theory- increasingly emphasize co-creation, experiential learning, and stakeholder empowerment (Innes & Booher, 2004; Sanoff, 2000).

The *Play Marmara Food* game embodies these principles. It provides a "safe-to-fail" environment where actors from different backgrounds negotiate priorities, test scenarios, and reflect on trade-offs. This aligns with Habermasian ideals of deliberative dialogue that seeks understanding, not dominance (Mäntysalo, 2005).

As highlighted by scholars such as Tan (2016) and Hirscher (2017), serious games can serve as generative tools for urban and regional governance. They stimulate creative thinking, foster trust, and visualize complexity in ways traditional methods often cannot. Additionally, they can help resolve participation fatigue by offering more engaging, hands-on formats (Agger, 2012).

The gameplay process yielded actionable insights for regional planning:
- Serious games democratize planning by enabling diverse actors to engage on equal footing.
- The use of real-world data enhances the credibility and policy relevance of the scenarios explored.
- Structuring gameplay into planning-cycle stages reinforces institutional learning.
- It can be used to guide future policy and investment priorities.

These findings point to the broader potential of serious games as complementary instruments within participatory governance frameworks. As cities and regions grapple with climate-driven uncertainty and systemic food insecurity, tools like *Play Marmara Food* offer a promising model for inclusive, data-informed, and collaborative policymaking.

Despite their promise, serious games are not without limitations:
- **Facilitation quality matters:** Outcomes depend on how well facilitators guide discussions and debriefing.
- **Scalability requires adaptation:** Different regions may need contextual reconfiguration of rules, roles, and data.
- **Decision influence is indirect:** While games can inform policy, translating outcomes into formal governance processes remains a challenge.

Nonetheless, *Play Marmara Food* demonstrates that game-based methods can meaningfully contribute to collaborative planning, resilience-building, and sustainable food system design- especially in regions facing the kinds of multidimensional stressors seen in Marmara.

6. Conclusion

Play Marmara Food shows that a data-driven, multi-stakeholder game can support serious regional planning. This paper set out to examine how the Play Marmara Food serious games can inform the design of sustainable food chains in Türkiye's Marmara Region. Three main insights emerged.

1. Game-based dialogue works. Bringing mayors, public officers, NGOs, academics, designers and students to the same table turned abstract policy goals into concrete, crop-specific strategies. Shared priorities- smarter logistics, circular use of waste, new food-governance bodies and youth incentives- surfaced across all five sessions.
2. Data unlocks meaningful dialogue. Because every card and map layer came from lengthy research, participants could see how their choices would play out on the ground, not just in theory. This turned the game into a live testing arena for policies already anchored in regional statistics and GIS layers.
3. Scoreboards expose blind spots. Technology, economy and policy actions scored high, but "Healthy Food" and "Biodiversity" lagged. This highlights the need for future policy cycles and future game iterations to give equal weight to nutrition and ecosystem health.

The draft actions and collaborations produced in the sessions can be translated directly into the Marmara Municipalities Union's forthcoming regional food strategy. Results are context-specific; testing the model in other Turkish regions would show how adaptable the rules and data needs are. Follow-up research should monitor whether game-generated ideas- such as circular compost loops or food-policy councils-are adopted and with what effect.

Comprehensive data did not slow the process; it made meaningful play possible. Future iterations should deepen health and biodiversity metrics, but the current game already offers a tested, evidence-based format that MMU and other regional bodies can adapt when drafting formal food-system strategies.

To conclude, Play Marmara Food demonstrates that serious games can move beyond public engagement and act as practical decision-support tools. By linking real data, diverse actors and clear scoring, the game offers a scalable method for crafting evidence-based, collaborative food policies in regions facing complex agri-food challenges.

Acknowledgements

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The Evolution Characteristics and Planning Regulation of the Population-cultivated land-food (PCF) system in Rural Counties of China

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Abstract
Industrialization and urbanization have profoundly transformed China's county-level population structures, land-use patterns, and food production systems. Variations in natural conditions and urbanization levels have resulted in uneven spatial distributions of population, cultivated land, and food production. Exploring the dynamic evolution of this system in China's counties and formulating targeted planning and regulatory strategies hold significant theoretical and practical value. This study aimed to reveal the internal dynamics of the PCF system through an analysis of its evolution across 1,848 county-level units (excluding urban areas) during 2000, 2010, and 2020. After evaluating system coordination and classifying rural areas into distinct types based on coupling modes though an indicator system, the study proposed targeted planning and regulation strategies for counties with differing coupling modes, emphasizing system coordination.

Keywords: Food Security; Population-Cultivated Land-Food System (PCF System); Urbanization and Rural Development; Planning Strategies

1. Introduction

Food security is related to the national economy, people's livelihood and sustainable development, and is a necessary guarantee for China's modernization. The population-cultivated land-food (PCF) system is a complex system based on the development and utilization of arable land resources within a certain geographical area, with food production, consumption and circulation as the central links, and the ultimate goal of meeting human food needs (Bao and Fang, 2007). As a bridge connecting cities and villages, the dynamic evolution of the population, cultivated land and food system in the county is not only related to the sustainable development of the rural economy, but also directly affects the country's food security and the stable development of society. Therefore, it is of great theoretical value and practical significance to deeply study the evolution characteristics of the rural population - farmland - food system in China's counties and explore the corresponding planning and regulation strategies.

With the continuous development of industrialization and urbanization in China, the population structure, land use and grain production patterns of counties and villages have undergone profound changes. Overall, due to different natural conditions and urbanization levels, the regional distribution of population, cultivated land and grain production in China is uneven. The per capita cultivated land generally shows a distribution characteristic of less in the east and more in the west (Ge, Long and Yang, 2018), and the per capita grain output also shows a characteristic of more in the central and western regions and less in the east. The national grain output and cultivated land area are mainly concentrated in the middle and low-level economic development areas (Wang et al., 2024). Different regions are facing pressure on cultivated land and grain production due to differences in population demand. Rapid urbanization has caused China's rural population to continue to move to cities, resulting in a shortage of rural labor and more unbalanced regional development, which has had a certain impact on agricultural production and food supply (Mu and Lin, 2020). At the same time, the reduction of rural cultivated land resources and the intensification of the "non-grain" and "non-agricultural" trends have also challenged the stability and sustainability of grain production (Zhang et al., 2023). On the one hand, county villages are still an important space for China to carry out grain production functions and rural labor. How to ensure food security and coordinate the relationship between population , cultivated land and food systems? On the other hand, villages in different regions are affected differently by the evolution of urban-rural relations, forming different

development opportunities and conditions (Zhang and Sun, 2019). How to combine past research on rural classification development with the characteristics of county rural economic and social development to carry out more targeted classification planning and regulation of villages has become an urgent problem to be solved.

2. Theoretical basis

This study aimed to reveal the internal laws and dynamic mechanisms of the population-cultivated land-food (PCF) system in Chinese counties and villages through the analysis of its evolutionary characteristics, and to provide corresponding planning, regulation and guidance for rural types with different systemic coordination characteristics. In the semi-open population-cultivated land-food complex system, the cultivated land area and its cultivated land planting structure, grain planting area and multiple cropping index in different regions affect the efficiency of cultivated land, thus determining the grain output. Grain output and the number of permanent residents determine the per capita grain possession. Regions where the per capita grain possession is greater than the per capita grain demand become the main grain production areas, dividing the pattern of grain input and output. The cultivated land area and the number of rural population determine the per capita cultivated land area, reflecting the possibility of large-scale production of cultivated land in the region. In the process of urbanization, the population continues to move and the land use type continues to transform, resulting in the continuous changes in the county's permanent population, rural population and cultivated land area, which are the main driving forces for the dynamic evolution of the population-cultivated land-food system, as shown in Figure 1.

Based on this system, the article firstly sorted out the evolution process of county rural population-cultivated land-food system, and analysed the main factors affecting their evolution. Then the main indicators reflecting the coordination of the PCF system, such as per capita cultivated land area and per land grain output, were adopted to analyse the change coupling model in rural areas of counties across the country. Based on the differences in the types of change coupling patterns, targeted planning and regulation strategies were proposed to provide theoretical support and practical guidance for the sustainable development of county rural economy and national cultivated land and food security.

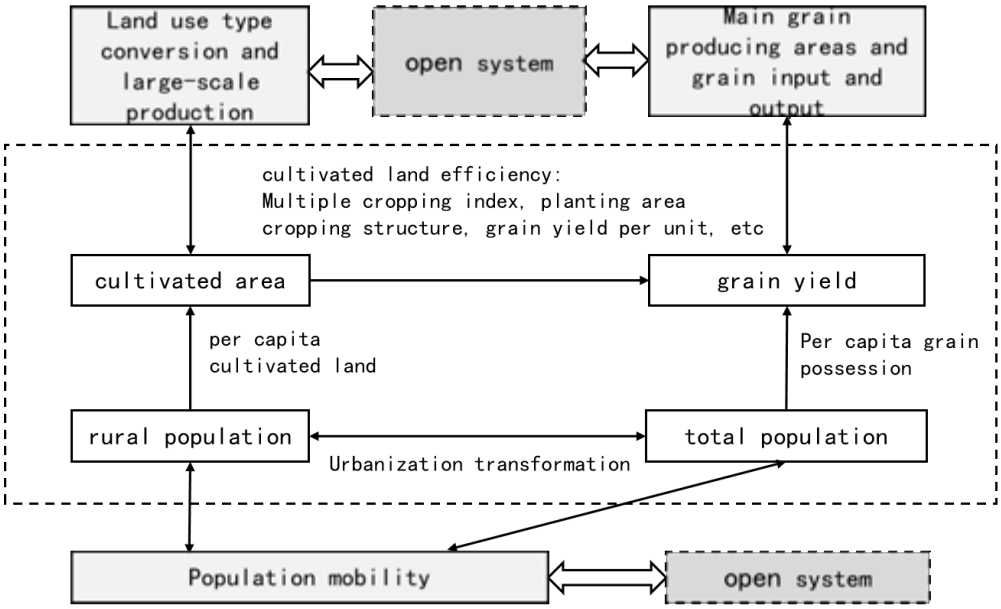


Figure 1 Population-arable land-food system operation mechanism diagram

3. Research Methods

3.1. Study area

The research object consisted of 1,848 county-level units. This study was based on the administrative divisions of 2020, integrating counties and county-level cities. Four prefecture-level cities without county-level administrative regions (Dongguan City and Zhongshan City in Guangdong Province, Danzhou City in Hainan Province, Jiayuguan City in Gansu Province), as well as the Hong Kong Special Administrative Region, the Macao Special Administrative Region, and Taiwan,were were excluded. In addition, due to the missing values of individual variables in some administrative units, the number of samples finally included in the research analysis was 1,848 .

3.2. Data sources

The county-level administrative unit vector data used in this study came from the Third National Land Survey database in 2020. Population data came from county-level demographic statistics from the Fifth (2000), Sixth (2010), and Seventh (2020) National Population Censuses. Cultivated area data came from the cultivated land area of "*China Agricultural Statistical Yearbook*" *(2001)*, the 2010 data of the Second National Land Survey data (https://gtdc.mnr.gov.cn/Share?UiNMsBTfPrya=1712637735952#/secondSurvey) verified with the China Annual Cultivated Land Dataset (CACD) (https://doi.org/10.5281/zenodo.7936885) released by Dr. Tu Ying in Professor Gong Peng's team at Tsinghua University with a resolution of 30m×30m, and the 2020 data of the Third National Land Survey data (https://gtdc.mnr.gov.cn/Share#/thirdSurvey). The grain production data for 2000 and 2010 were derived from the "*China County Statistical Yearbook*" *(2001, 2011)*, and the grain production data for 2020 were derived from the statistical yearbooks and the statistical bulletin on national economic and social development of various provinces and cities .

3.3. Research methods

3.3.1. Standard deviation ellipse

The standard deviation ellipse is a spatial statistical method widely used to describe the spatial distribution characteristics of geographical elements, and it depicts the spatial morphological characteristics of geographical elements such as centrality, spread, and directionality. This study constructed standard deviation ellipses of rural population, cultivated land area, and grain output in counties across the country from 2000 to 2010 and from 2010 to 2020, to analyze the spatial-temporal evolution of rural population, cultivated land area, and grain output.

3.3.2. Variation of coupled mode measurement

This study measured the changing coupling pattern of rural PCF system elements based on the change rate of per capita cultivated land area and per-acre grain output in counties across the country from 2000 to 2010, 2010 to 2020 , and 2000 to 2020.

$$GRit=(Git-Gi0)/Gi0$$

$$LRit=(Lit-Li0)/Li0$$

Where: i represented the county; GRit and LRit represented the change rates of per capita cultivated land area and per-land grain output in county i in year t respectively; Gi0 and Git represented per capita cultivated land area in county i in the base year and year t; Li0 and Lit represented per-land grain output in county i in the base year and year t.

Four coupling types could be divided according to the different changes of per capita cultivated land area and per-land grain output in different stages:

- If GRit>0 and LRit>0, the per capita cultivated land area and per-land grain output of the county were in the "same increase" mode.
- If GRit>0 and LRit<0, the per capita cultivated land area of the county increased and the per-land grain output decreased.
- If GRit<0 and LRit>0, the per capita cultivated land area of the county decreased and the per-land grain output

increased.

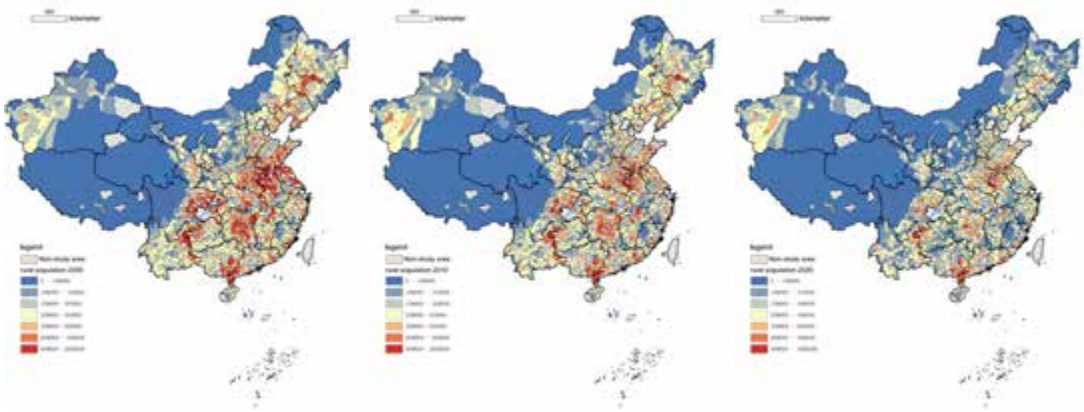
• If GRit<0 and LRit<0, the per capita cultivated land area and per-land grain output of the county were in the "same decrease" mode.

4. Analysis on the spatial-temporal evolution of PCF system in counties

4.1 . Dynamic changes in the total amount

4.1.1. Dynamic characteristics of rural population in counties

In the two decades since 2000, the number of rural populations in all regions of the country has shown a straight-line downward trend. The total rural population has decreased from 6.092×10^{8} to 3.8046×10^{8}, a decrease of 62.45% of the original. Among them, the rural population reduction rate in the central region and the northeast region were relatively high, at 42% and 39% respectively, while the rural population reduction rate in the western and eastern regions was about 34%. From 2000 to 2020, China's urbanization has made great progress, and the central-western regions have become the largest rural population transfer and outflow areas, with significantly decreased rural population. However, due to the geographical location of the western region being farther away from the main inflow areas of the eastern population, the industrial model was more backward, and the rural population base was large. After population mobility, it was still the region with the largest rural population. In addition to being affected by urbanization, the reduction of rural population in the northeast region was also related to the large-scale mechanization transformation of agricultural production. The eastern region was mainly undergoing its own urbanization process, and most of the rural population was converted into urban population on the spot, and the number of rural population continued to decline. While the total population of the country was increasing, the large-scale reduction of rural population has brought challenges to food production.



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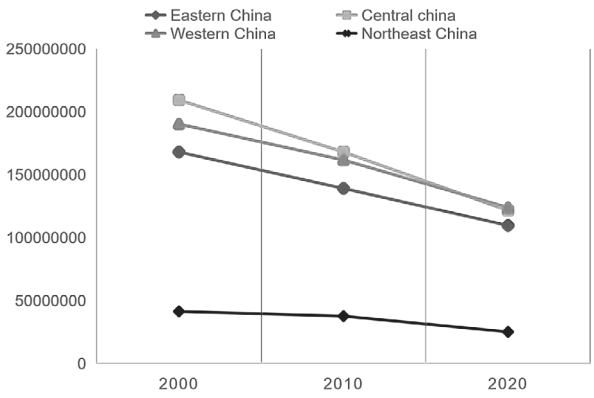
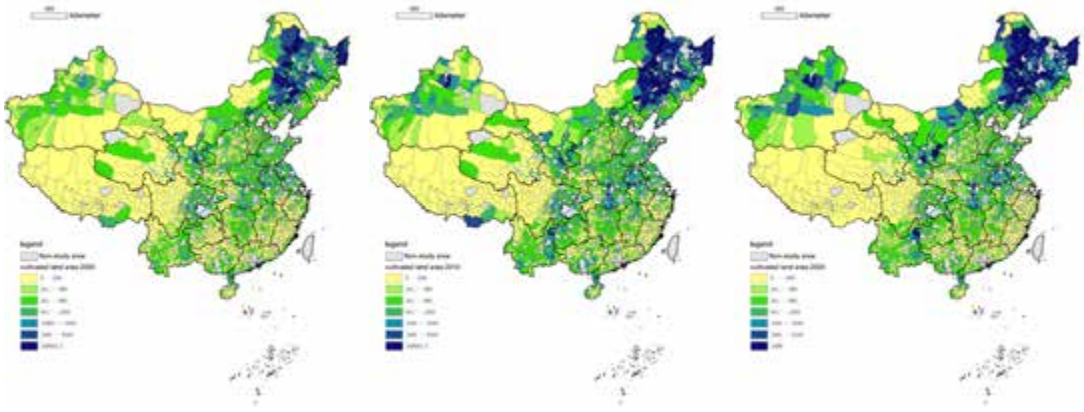


Figure 2 The spatiotemporal evolution of rural population

4.1.2. Dynamic characteristics of cultivated land in counties

The changes in cultivated land area in counties in different regions of the country were quite different. Except for the eastern region, the cultivated land area in counties in other regions has increased. Among them, the western region and the northeastern region have shown a continuous growth trend, which was related to the low urbanization level in the western region and the fact that agricultural planting was still the main industry. Affected by the profound impact of the project of returning farmland to forest and grassland since the development of the western region, the growth rate of cultivated land area in the western region has gradually slowed down. Thanks to the good natural farming conditions, the northeastern region has become the most important grain production base in China. With the continuous increase of China's population, the demand for grain has also increased accordingly, and the cultivated land area in the main grain-producing areas of the northeast has increased significantly. The cultivated land area in the central region first increased and then decreased, which was related to the adjustment of the industrial structure in the region and the rapid development of urbanization occupying a large amount of cultivated land. The eastern region has a dense population and a high level of urbanization. The continuous agglomeration of population has generated a greater demand for construction land. At the same time, the rapid economic development has continuously increased the value of land, transformed land use, and continuously reduced the cultivated land area. Although the cultivated land area in the country has increased slightly overall, the distribution of cultivated land has become more unbalanced.



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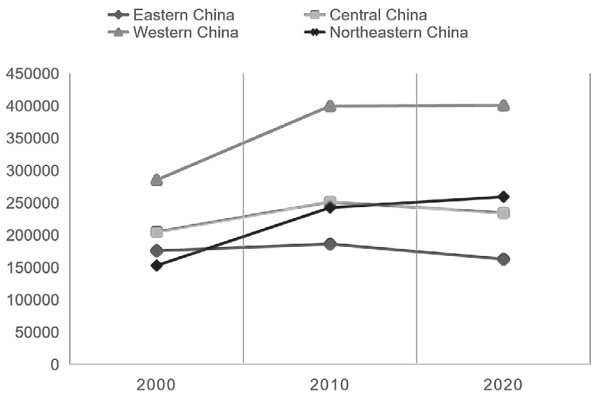
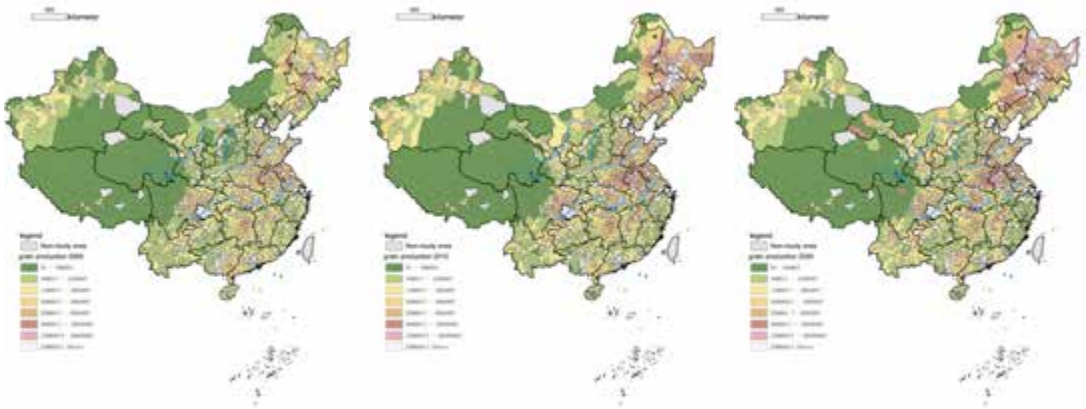


Figure 3 Spatial and temporal evolution of cultivated land area

4.1.3. Dynamic characteristics of grain output in counties

The national grain output showed an overall growth trend between 2000 and 2020 (Figure 4). Due to the rapid development of urbanization and the adjustment of industrial structure, the eastern region has insufficient potential for growth in grain output, while the grain output in other regions has increased significantly. The

large-scale increase in grain output under the condition of no significant increase in the overall cultivated land area showed that China had improved the multiple cropping index and grain farming technology level, and the average grain output per land had increased. It was also affected by relevant agricultural benefit policies, and farmers' enthusiasm for growing grain has increased. After 2010, the increase in grain in various regions slowed down simultaneously, which was greatly affected by the change in farming structure. With the development of the economy and the improvement of people's living standards, people's demand for agricultural products has become more diverse, and the development trend of "non-agriculturalization" and "non-grainization" was obvious. It could be seen that both market factors and national policies had a great impact on grain production, and reasonable macro-control by the state was needed to ensure the stability of grain production.



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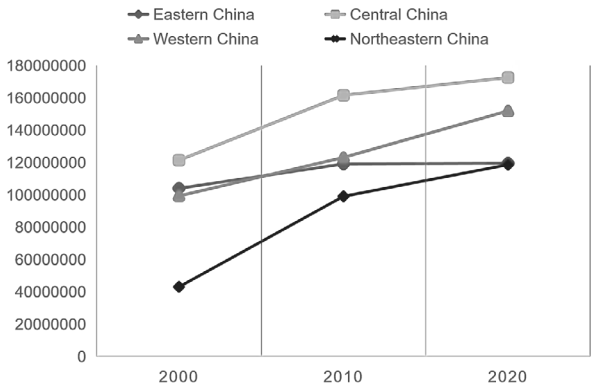
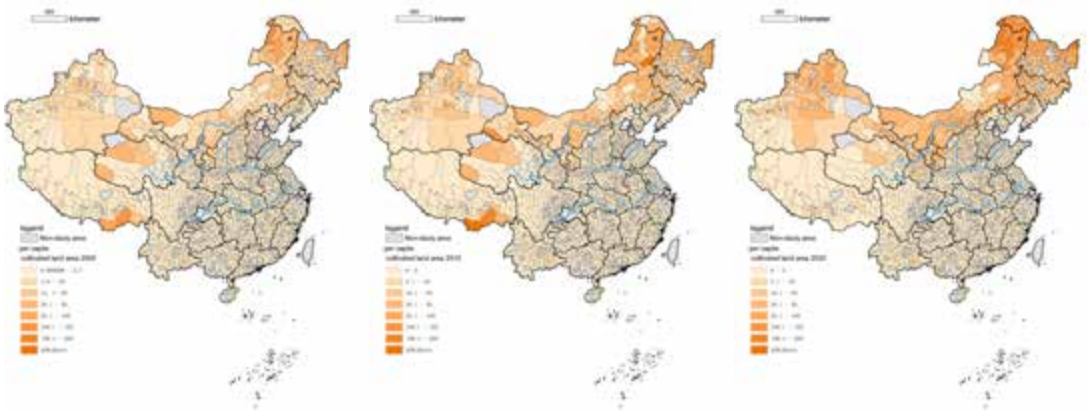


Figure 4 Spatial and temporal evolution of grain production

4.2 . Dynamic changes in per capita/unit amount

4.2.1. Changes in per capita cultivated land area

The per capita arable land area of the rural population in counties has increased overall, with the average value increasing from 2.78 mu in 2000 to 6.79 mu in 2020, which was related to the large-scale loss of rural population in the process of urbanization. The center of gravity of per capita arable land area continued to move to the northeast. The northern part of the Northeast, central Inner Mongolia, and the eastern part have vast land and sparse population, good farming conditions, and have always been areas with large per capita arable land area. While Central China, East China, and South China were densely populated, with a high level of urbanization, and arable land was facing great pressure. There was a spatial dislocation between areas with abundant per capita arable land and areas with concentrated populations and developed economies in China.



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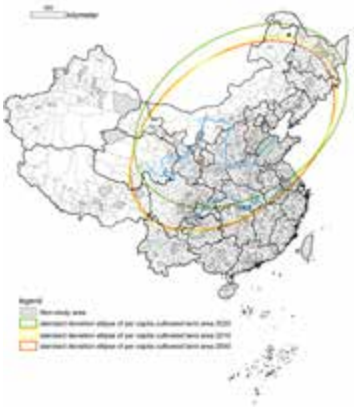
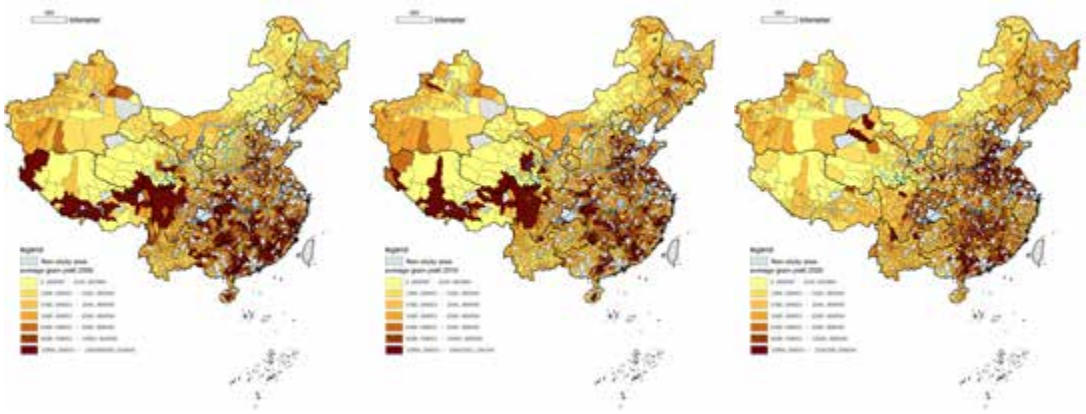


(d)standard deviation ellipse of per captia cultivated land area

Figure 5 The spatiotemporal evolution of per capita cultivated land area

4.2.2. Changes in grain output per county area

The per capita grain output in counties across the country varied greatly. With the same area of arable land, the grain yield per unit area in the eastern regions such as East China and South China and the middle reaches of the Yangtze River in the central region was relatively high, which was the focus of per capita grain output in China. This was related to the suitable climate and topographic conditions in these regions, the high grain multiple cropping index, the long history of farming, the good economic development, and the advanced agricultural technology. As an important grain export base, the Northeast region had a large total grain output, but due to the cold climate conditions and the vast area of arable land, the per capita grain output was not as good as that in the eastern region. Since different regions had different production characteristics, we should further improve the level of planting technology and increase the per capita grain output so as to ensure food security.



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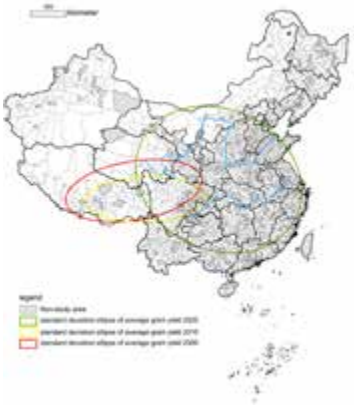

(d)standard deviation ellipse of average grain yield

Figure 6 Spatial and temporal evolution of average grain yield

5. Classification of coupling patterns of PCF system in counties

In the complex system of population-cultivated land-food, population and cultivated land are more important factors of change. The per capita food output and demand in different regions are different, but they can be regulated and redistributed through market operations and national policies. The per capita arable land area of rural population and per-land food output more accurately reflect the development potential and production level of regional food production from the perspectives of "who will cultivate the land", "how much land there is", and "how efficient the cultivated land is", which is related to the national food production security. Therefore, the following focused on analyzing the coupling types of per capita arable land area and per-land food output in counties in different regions across the country, and provided feasible strategic suggestions for the development of food security in the process of new urbanization.

Based on the measurement of the coupling pattern of changes in per capita cultivated land area and per-land grain output in counties across the country, four classifications were produced: the "simultaneous increase" pattern; the "reduction in population, reduction in land, and increase in grain" pattern; the pattern in which per capita cultivated land area in rural areas increased and per-land grain output decreased; and the "simultaneous decrease" pattern.

The first is the "simultaneous increase" model of increasing per capita cultivated land area and per-acre grain output in rural areas. From 2010 to 2020, this type of county units accounted for about 38.1% of the total, mainly

concentrated in Northeast China, North China, Jianghuai region, eastern Inner Mongolia, northern Shaanxi, Hunan and parts of Jiangxi Province. These areas were relatively traditional agricultural areas with good natural conditions and a long history of grain farming, and still maintained a certain growth rate of cultivated land area. At the same time, in the process of local urbanization and population flow to neighboring developed eastern regions, the local rural population has continued to decline, resulting in a continuous expansion of per capita cultivated land in rural areas. The advancement of agricultural technology and the use of mechanized production have led to a rapid increase in grain output and a simultaneous increase in per-acre grain output. This type of county should seize the advantages of grain production, make full use of natural conditions, further promote large-scale mechanized grain production, and assume the role of the main force in ensuring national food security and food supply.

The second is the "reduced population, reduced land, and increased grain" model, where the per capita cultivated land area in rural areas decreased and the per-land grain output increased. From 2010 to 2020, this type of county units accounted for about 22.4% of the total, mainly distributed in the middle and upper reaches of the Yellow River and the southwestern regions of Yunnan, Guizhou, Sichuan, and Guangxi. These areas were mainly Gobi deserts and mountains. Desertification and rocky desertification have greatly affected grain planting. In the process of ecological and environmental protection in China in recent years, many low-quality cultivated lands in these areas have been reasonably retired, and the cultivated land area has continued to decrease. Under the condition of generally improved grain planting technology, the per-land grain output has increased. At the same time, due to problems such as transportation and terrain, these areas have lagged behind in social and economic development. There were still a large number of rural population engaged in the primary industry. The speed of land retirement was faster than the speed of rural population loss, and the per capita cultivated land area in rural areas showed a downward trend. This type of county should promote the coordinated development of urbanization and ecological and environmental protection, increase investment in agricultural science and technology, continuously improve the efficiency of cultivated land, and achieve green and efficient development.

The third is the pattern of increasing per capita cultivated land area in rural areas and decreasing per-land grain output. From 2010 to 2020, this type of county unit accounted for about 34.5% of the total, mainly distributed in Northwest Sichuan, Xinjiang and most areas of the southeastern coastal areas. Northwest Sichuan and Xinjiang have turned to the planting and processing of specialty agricultural products in recent years because the ecological environment was not suitable for grain production. While the cultivated land area has increased, the grain output has decreased. In addition, the rapid loss of rural population has led to an increase in per capita cultivated land area in rural areas, but a decrease in per-land grain output. Due to the rapid speed and high level of urbanization in the southeastern coastal areas, while the cultivated land has been transformed into other types of land use and the grain planting area has been reduced , the transformation of rural population into citizens has been more rapid, resulting in an increase in per capita cultivated land area and a decrease in per-land grain output under the condition that the rural population, cultivated land and grain output have decreased in the same direction. Regions with this pattern should vigorously develop intensive agriculture and invest more labor, capital and technical support in limited cultivated land areas.

Fourthly, the "simultaneous reduction" type, where the per capita cultivated land area in rural areas decreases and the per-acre grain output also decreases. This type of county unit had the least number of units, accounting for about 5% of the total from 2010 to 2020, and was scattered in the northeastern part of Zhejiang Province, the southeastern part of Fujian Province, and parts of northern Tibet. These areas were also facing a triple reduction in rural population, cultivated land area and grain output, but due to the rapid urban construction and industrial transformation in recent years, the reduction in cultivated land area and grain output was more obvious. Regions with this model should further optimize the planting structure and increase the grain self-sufficiency rate.

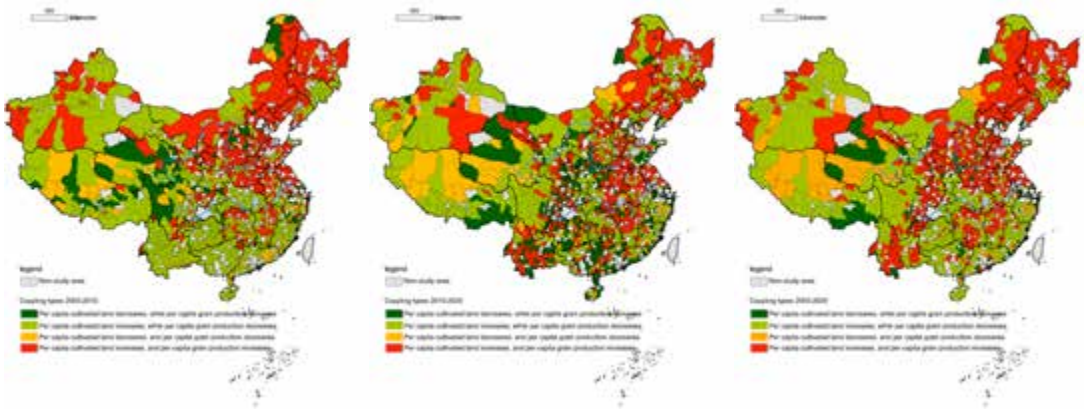

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Figure 7 Spatial distribution of coupling types of per capita cultivated land area and per-acre grain output in China

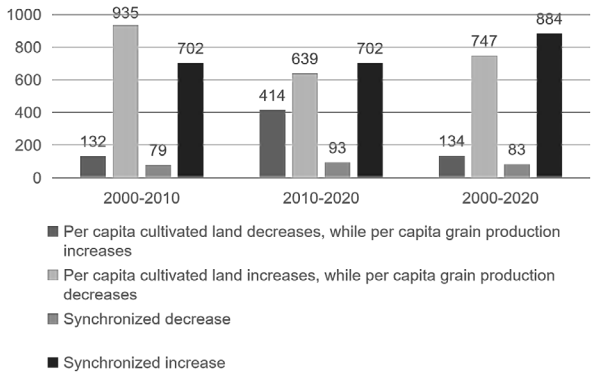

Figure 8 Distribution of coupling types between per capita cultivated land area and per-acre grain output in China

The characteristics and distribution types of the four modes can be summarized as shown in the following table:

Figure 9. Characteristics of coupling types between per capita cultivated land area and per-acre grain output in China

Dynamics of per capita cultivated land area	+	-	+	-
Dynamics of grain output per land area	+	+	-	-
Quantity ratio	38.1%	22.4%	34.5%	5.0%

Distribution	Northeast China, North China, Jianghuai region, eastern Inner Mongolia, northern Shaanxi, Sichuan, Hunan, and parts of Jiangxi Province	Middle and upper reaches of the Yellow River , Sichuan, Yunnan , Guizhou, Guangxi and other regions	Northwest Sichuan, Xinjiang and other areas; Most areas along the southeast coast	Yangtze River Delta and southeast coastal areas
Characteristics and causes	Good natural conditions and a long history of farming made it suitable for large-scale mechanized grain production.	The primary industry was still the main industry, and a large number of rural populations developed agriculture.	The ecological environment was not suitable for food production, so it is advised to turn to the cultivation and breeding of special agricultural products with the decreasing rural population.	The economy was relatively developed, the proportion of cash crops in the planting structure had increased, and the industry has transformed and developed.

Annotations: "+" is for "increase"; "-" is for "decrease".

6. Discussion and conclusion

6.1. Discussion

This study analyzed the dynamic change process and system coordination type of the population-cultivated land-food system in the rural counties of China from the perspective of "spatiotemporal evolution-change coupling-classification regulation", providing a reference for promoting the sustainable development of the rural economy in the counties and the national farmland and food security. Rural areas have important agricultural production functions and ecological product values. In the semi-open complex system of population-cultivated land-food in rural areas, the interaction between various elements promotes agricultural production progress and the balance of food supply and demand, and maintains the dynamic and coordinated evolution of the system, which is of great significance for ensuring national farmland and food security. This study analyzed the dynamic evolution characteristics and change coupling types of the rural population-cultivated land-food system in the rural counties of China, comprehensively considered factors such as natural geographical conditions, resource endowment differences, and county main functions, and proposed differentiated planning strategies for rural areas in counties with different change coupling modes from the perspective of population-cultivated land-food system coordination, including:

(1) The counties, with per capita cultivated land area and per capita grain output in rural areas increasing simultaneously, covered the main grain-producing areas and traditional agricultural areas in China, and were important responsibility areas for ensuring the country's cultivated land and food security. First of all, it is advised to base on the excellent natural resource endowment, strictly adhere to the red line of cultivated land, strictly implement the cultivated land protection system, strengthen soil protection and improvement, so as to achieve the dual guarantee of the quantity and quality of cultivated land resources, and ensure the sustainable

development of grain production. The outflow of rural population and urbanization provide possibilities for large-scale agricultural production. State-owned farms in some areas have the foundation for developing large-scale and mechanized grain production. By strengthening the introduction of agricultural talents and agricultural technology training, the capacity and efficiency of grain production can be enhanced, with the planting structure and grain production structure optimized to cultivate high-quality commercial grain varieties, thereby improving the quality and market competitiveness of grains. At the same time, in response to the trend of rural population decline, efforts should be made to promote the transformation of identity farmers into professional ones, strengthen the introduction and training of agricultural technical labor, improve the professional quality and skills of agricultural practitioners, ensure the supply and stability of technical agricultural labor, and better adapt to the situation of grain production.

(2) For counties where the per capita cultivated land area in rural areas has decreased and the per capita grain output has increased, the contradiction between agricultural resource utilization and the fragile ecological environment is the fundamental factor affecting the high-quality development of agriculture, and it also brings the dual pressure of cultivated land protection and ecological security. Therefore, it is of great importance to solve the problem of coordination between food security and ecological protection, reduce the loss of cultivated land and the destruction of the natural environment, attach importance to the ecological value of cultivated land, and implement the “three-in-one” cultivated land protection strategy of quantity, quality and ecology in the face of rigid resource constraints, so as to promote the sustainable utilization of cultivated land resources and high and stable grain yields. Relying on the long-term traditional agricultural foundation and relatively intensive agricultural labor resources, efforts should be made to improve agricultural technology and farmers’ skills through training and skills support, and improve the efficiency and quality of grain production. In combination with natural geographical characteristics and natural resource endowments, it is advised to optimize the planting structure and adjust the breeding methods according to local conditions, and improve the comprehensive benefits of agricultural production through the development of characteristic agriculture and ecological agriculture, so as to achieve system coordination and economic, social and ecological win-win results.

(3) In counties where the per capita cultivated land area in rural areas has increased and the per capita grain output has decreased, the long-term rapid urbanization of the population has led to a tense relationship between people and land in rural areas, and the trend of cultivated land becoming non-grain is obvious. Therefore, on the basis of keeping the red line of cultivated land to curb resource loss, attention should be paid to the decline in grain output caused by factors such as the loss of agricultural labor and natural conditions. Economically developed regions with special resources are encouraged to adjust appropriate agricultural planting structures, make full use of precious cultivated land resources, develop diversified and efficient characteristic rural industries and intensive agriculture, and optimize the industrial structure in rural areas. It is suggested that through measures such as policy support, industrial assistance, and agricultural services, a better entrepreneurial environment and development opportunities should be provided. Agricultural infrastructure should be strengthened, rural infrastructure and public services improved, and the quality of life and social environment in rural areas enhanced. This will attract urbanized population to return to their hometowns for employment and entrepreneurship, thereby revitalizing rural areas. Meanwhile, other suggestions include actively integrating into the national unified market, promoting the complementary development of grain crops and cash crops, in order to achieve stable cultivated land and sustainable agricultural development.

(4) Counties where the per capita cultivated land area and per-acre grain output decreased simultaneously are mainly in areas with relatively mature urbanization. The primary industry is no longer the main industry in the region, and cultivated land was constantly replaced by other land use types in the process of urbanization. Therefore, in response to the reality of the increasing pressure on cultivated land resources, it is urgent to optimize the allocation of land resources, avoid excessive occupation and destruction of cultivated land resources, further curb the reduction of cultivated land area, and enable the region to maintain a certain grain production capacity and grain self-sufficiency rate. At the same time, it is necessary to improve the urban-rural relationship in the county and surrounding areas , promote the orderly flow and optimal allocation of urban and rural resource

elements, promote urban-rural integration and complementary development, and achieve coordinated and stable regional population-cultivated land-grain systems.

6.2. Conclusion

From 2000 to 2020, the number of rural population in all regions of the country has been declining in a straight line, with the rate of decrease showing a regional pattern of high rate in the central and northeastern regions and relatively low rate in the eastern and western regions. The changes in cultivated land area in counties in different regions of the country varied greatly. Except for the eastern region, the cultivated land area in counties in other regions has increased, and the distribution of cultivated land has become more unbalanced; grain output has shown an overall growth trend, with insufficient growth potential in grain output in the eastern region and significant growth in grain output in other regions. From the perspective of average quantity, the per capita cultivated land area of the rural population in counties across the country has increased overall, and the center of gravity of per capita cultivated land area has continued to move toward the northeast; the per capita grain output of counties varies greatly, with higher grain yields in eastern regions such as East China, South China and the middle reaches of the Yangtze River in the central region, which was the center of gravity of per capita grain output in China.

The coupling patterns of population-cultivated land-food system changes reflected by the per capita cultivated land area and per-land grain output in rural areas were mainly manifested in four types, showing certain differences in spatial pattern distribution. Specifically, the "simultaneous increase" pattern was mainly concentrated in Northeast China, North China, Jianghuai region, eastern Inner Mongolia, northern Shaanxi, Hunan and parts of Jiangxi, mainly in traditional agricultural areas. The "reduced population, reduced land, and increased grain" pattern of reduced per capita cultivated land area and increased per-land grain output in rural areas was mainly distributed in the middle and upper reaches of the Yellow River and Yunnan, Guizhou, Sichuan, Guangxi and other regions in the southwest, which were greatly affected by desertification and rocky desertification. The pattern of increased per capita cultivated land area in rural areas and reduced per-land grain output was mainly distributed in northwest Sichuan, Xinjiang and other regions and most areas of the southeast coastal area, where population urbanization was faster than land urbanization. The "simultaneous reduction" type was scattered in northeastern Zhejiang Province, southeastern Fujian Province, and parts of northern Tibet.

Based on the establishment of a dynamic evolution analysis framework for a semi-open complex system of population, cultivated land and food, this study analyzed the characteristics of changes in total amount and in per capita/unit amount of the population-cultivated land-food system in China's county-level rural areas, and proposed differentiated planning strategies for county-level rural areas with different change coupling patterns from the perspective of population-cultivated land-food system coordination, which could provide theoretical significance and practical reference value for ensuring China's cultivated land and food security, supporting the high-quality promotion of new urbanization and agricultural modernization based on counties.

Acknowledgement

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Exploring the food-climate nexus through a justice lens: insights from urban experimentations.

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Abstract
Several cities are adopting re-localized food systems as a vehicle to achieve climate mitigation and adaptation objectives, implementing initiatives like productive nature-based solutions, plant-based food procurement, sustainable food environments, net-zero food waste strategies, and more (IPES Food, 2023). However, despite the potential of these urban experimentations to bridge food and climate sustainability, the urban sustainability literature has largely overlooked the food-climate nexus as a critical arena for achieving place-based sustainability, and for addressing socio-ecological justice. Highlighting this gap, this reflective paper examines how cities are experimenting with a new socio-ecological agenda at the cross-roads between food and climate, positioning themselves as potential agents of transformative change within this nexus. Through theoretical discussions and empirical vignettes, the paper particularly highlights key tensions in combining diverse dimensions of justice through the food-climate nexus.

For a time, we had come to believe that civilization moved in the other direction—making the impossible first possible and then stable and routine. With climate change, we are moving instead toward nature, and chaos, into a new realm unbounded by the analogy of any human experience (David Wallace-Wells, 2020, The Uninhabitable Earth).

Keywords: Urban food planning, urban climate action, food-climate nexus, governance experimentations, justice

Introduction

Climate change is undoubtedly one of the most pressing challenges of our time. Given the increased frequency and impact of socio-ecological crises – and in light of contested discourses around the adequacy of timeframes, scales, and scopes of action (Scoones et al., 2020) –, a sense of urgency and uncertainty permeates perceptions about the future of society and urban areas (Wallace-Wells, 2020). In this context, scientists and experts have been emphasizing the urgent need to act in order to reduce greenhouse gas emissions, given the already devastating effects caused by global warming to our planet (IPCC, 2023). This call for action demands 'deep, rapid, and sustained global greenhouse gas emissions reduction (that) can limit future changes', given that 'adaptation options that are feasible and effective today will become constrained and less effective with increasing global warming' (IPCC, 2023, p.18).

The link among diverse (urbanisation-related) socio-ecological systems – such as land-use, transport, energy, housing, building stock etc. –, and the climate emergency is becoming part of common knowledge, at least in the discourse. Within those socio-ecological systems, food systems are increasingly regarded as major contributors to global anthropogenic greenhouse gas emissions, with food production alone responsible for approximately one-third of global emissions (Garnett, 2011; IPES Food, 2016). To this adds the impact of other food chain activities, not least food waste, given that around one-third of all food produced for human consumption (approximately 1,300 million tons per year) goes to waste all along the food supply chain (FAO, 2022).

Acknowledging this reality of crisis and emergency, since at least three decades, literatures on climate urbanism and urban climate planning have started to highlight the role of cities as providing responses to the climate emergency, through diverse modes of urban climate action. Particularly, this literature recognises how urban areas have become pivotal in governance and planning efforts aimed at meeting the Paris Agreement targets of limiting global warming to below 1.5°C or 2°C (Bulkeley et al., 2012; Busch et al., 2018). To stress this aspect, authors such as Bulkeley (2021) have emphasised a shift in urban climate planning and governance approaches occurring over the past three decades. This passage has brought urban climate action from a sporadic type of intervention based on the voluntary or informal engagement of municipal authorities, to an increasingly 'strategic' approach, where urban climate planning becomes part of the programmatic agenda of cities with respect to priorities of economic and urban development (Bulkeley, 2021, p. 267). Moreover, what distinguishes contemporary modes of approaching urban climate action, according to the author, is the increased accent on the cli-

mate-connected city. Climate-connected urbanism invites to think urban climate action as intrinsically related to issues such as urban consumption of goods and services, wider sustainable development agendas (biodiversity, energy, water, food systems, ...), and issues of social justice.

In this context of enhanced claims for connected action, this paper argues that the food-climate nexus has not received adequate attention. Particularly, urban sustainability scholarship has so far missed to explore the interrelation between food and climate as an arena of urban sustainability governance and planning, and as a testing ground for a connected eco-social justice agenda. Particularly underexplored issues are: a) the key tactics adopted by place-based initiatives to implement and govern sustainability actions at the cross-road of the climate-food domains, and b) the pathways pursued by actors to address different dimensions of justice, including distributive, procedural, recognition and restorative justice (de Bruin et al., 2024). To address these aspects, this paper will draw on insights from literature spanning both the urban food and climate (justice) domains. First, the paper will draw from work on climate urbanism, planning, and mundane innovations (Castán Broto, 2020; Robin and Castán Broto, 2021) to shift the focus from mitigation or adaptation as policy frameworks, to the understanding of the innovative and transformative potential of on-the-ground actions (see section 2). Second, the analysis will argue about the emergence of a recent wave of urban food movements visibly linking food systems to climate action through place-based experiments and higher scale networks (IPES Food, 2023; the Barcelona Climate Challenge) (see section 2.1). Bringing on board critical insights on justice from the urban food and climate literatures (Amorim-Maia et al., 2022; Avelino et al., 2024; de Bruin et al., 2024), the analysis will then sheds light on combing diverse dimensions of justice through the food-climate nexus (section 3). Starting to connect theoretical reflections to empirical evidence, this contribution will briefly illustrate few examples of urban (planning) experiments at the food-climate intersection spanning different sections of the urban food system. Particularly, the paper highlights how these initiatives enact sustainability governance strategies and deal with issues of justice as outlined above (section 4). Based on the analysis, the paper will conclude by highlighting the importance of learning from place-based practices, and understanding justice as a dynamic and continuously negotiated nexus (section 5).

2. Experiments in climate urbanism and planning

Climate governance has typically been shaped by international multilateralism and the leadership of nation-states, reflecting the global nature of climate challenges and the need for coordinated response (Bulkeley et al., 2014). Forums like the United Nations Framework Convention on Climate Change (UNFCCC) have been providing platforms for negotiating agreements such as the Kyoto Protocol and the Paris Agreement, which establish emission reduction targets on a country level. In this context, the year 2015 has constituted a pivotal moment, where through the adoption of the Paris Agreement, national states have come together to commit to limiting the rise in global temperatures to well below 2°C above pre-industrial levels, while also striving to restrict the increase to 1.5°C by the end of the century (see for instance, D' Amico, 2024). The year 2015 also marked a symbolic moment for urban climate action. In fact, the Paris Agreement, including in particular the publications and assessment`s reports that followed, highlighted the specific role that cities can play in deep decarbonisation strategies, by leveraging key urban infrastructures such as the built environment, energy, as well as land and food systems (Babiker et al., 2022; D' Amico, 2024).

To a good extent, urban climate action and experimentation have also emerged to compensate for the lack of clear leadership, responsibility, and institutional commitment of the national level, ushering urban leaders and actors to stand at the forefront of the 'race' against the catastrophic effects of climate change (Bulkeley and Betsill, 2005).

In tandem with these processes, a critical rethinking of concepts and imaginaries such as 'the sustainable city' – along with the urban sustainability agendas that have been emerging in cities – has stimulated a growing body of research on urban climate governance and planning, signing the establishment of 'climate urbanism' as an emerging field of studies (Bulkeley et al., 2012; Castán Broto et al., 2020). Climate urbanism deals with the uptake of the ecological emergency at the city scale through several critical lenses. Among these lenses are the analysis

of drivers and incentives of cities to engage in urban climate governance and planning, mobilizing policy frameworks such as urban climate adaptation or mitigation plans (Bulkeley et al., 2012). Furthermore, early studies in the field have dealt with the engagement of cities in a multi-level climate governance also by means of city networks allowing to experiment within the urban arena, or transfer lessons learned between cities (Bulkeley and Betsill, 2005; Smeds and Acuto, 2018). Furthermore, critical lenses have analysed the entanglement of (neoliberal) urbanization processes with ecological issues, and the social and environmental externalities produced by those dynamics (Long and Rice, 2019).

Yet, particularly in the aftermath of the 2015 Paris Agreement, the climate urbanism scholarship has begun to analyse climate change governance beyond formal political arenas, looking at 'the multiplicity of urban experiments' happening on the ground and analysing their impact in the socio-material and political makeup of the city (Smeds and Acuto, 2018, p 550). As such, the focus has moved from mitigation or adaptation as policy or planning frameworks towards the understanding of the innovative and transformative potential of on-the-ground actions (Castán Broto and Bulkeley, 2013; Castán Broto et al., 2020) This shift has led to the recognition of how, aside from strategic frameworks and grand narratives, climate action is negotiated through place-based sites of experimentation and innovation, where experiments in climate planning could act as catalysts of social and urban change (Robin and Castán Broto, 2021). In this context, the literature has focused on experimentation as both, a planning tactic and a mode of governance that allows to craft adaptive and context-specific solutions that are targeted to local conditions while taking global objectives into account (Castán Broto and Bulkeley, 2013; Smeds and Acuto, 2018). Contrary to overarching planning strategies or policy framework, experimentations target place-specific infrastructures, such as transport, energy, housing, or food, as vehicles for deep decarbonisation dynamics.

It is argued that, what it may appear as a fragmented and piecemeal approach to urban change, constitutes instead a reality in which change is driven by a diversity of actors, sectors, and scales as catalyst of place-based transformations, leveraging concrete sites and specific infrastructure systems (Kivimaa et al., 2017). In this background, pioneer work on mundane innovations has proposed an approach to urban change which goes beyond a modernist understanding of a homogeneously defined urban future, privileging instead a post-colonial conception of transformative innovations as coming from situated practices of actors and communities, which can inspire other agents and scales (Castán Broto, 2020; Robin and Castán Broto, 2021). Recently, prominent scholars within the climate urbanism debate have highlighted the emergence of a new wave of climate change governance, which is increasingly 'climate connected' (Bulkeley, 2021). This means that the connection of climate with other spheres of urban life, with other policy and planning areas, and with pressing issues of social justice is increasingly relevant, as it would allow place-based experiments to gain traction, expand their focus, and increase their impact across policy domains and spatial-institutional scales. These aspects need to be further explored by the climate urbanism and the urban sustainability scholarship at large.

2.1 Building a food and climate partnership through urban-driven experiments

Not dissimilarly to the climate urbanism debate, over the last few decades, literature on urban food governance and planning has also shed light on the numerous urban food 'experiments' that have spread around the world, ranging from urban food strategies, to food policy councils, to multi-city food policy networks, and the like (Sonnino, 2016; Moragues-Faus, 2021). Overall, literature has regarded urban food as a distinct sphere of action where struggles to accelerate food system change towards greater sustainability and justice are negotiated (Moragues-Faus, 2020; Sonnino and Coulson, 2021). On the one hand, urban food movements and scholarly research have been concerned with the challenge to legitimize local food action as a self-standing area (or arena) of urban sustainability, and as a legitimate urban planning domain (Pothukuchi and Kaufman, 2000). On the other hand, the literature has long argued for overcoming silos thinking and moving beyond compartmentalised approaches to the food question. This means considering how food can work in synergy with other urban planning and policy areas, among the most cited being land use, health, social services, education (HLPE, 2024). In fact, due to the multifunctional and multi-layered nature of food, accent has been given to integrated and systemic approaches that could create bridges between actors, municipal departments, and policy areas (Mansfield and Mendes, 2013;

Sonnino, 2019; Sonnino et al., 2019). This integrated work entails not only embedding a food system lens within municipal jurisdictions, but also showing how working on food can help urban actors to address other transition objectives, not least urban resilience and climate adaptation (Ballamingie et al., 2020).

However, due to the often precarious and voluntary nature of food action in cities, experiments with policy integration are still at their infancy in many contexts. Changes in political cycles or socio-economic downturns are among the factors creating challenges to ensure the continuity and survival of food planning and governance structures (see among others, Manganelli, 2025). Furthermore, despite the numerous studies advocating for nexus approaches between food and other socio-ecological systems (Wahl et al., 2021), empirical evidence is lacking concerning concrete challenges and pathways to enable synergies across domains. As a consequence, there are missing opportunities to learn how 'experiments at the nexus' work in place-specific realities, and, more specifically, how interventions enacted in a crucial planning and governance sphere can foster productive externalities in other domains, helping to strengthen key sustainability agendas in the city (Zerbian, 2024). Such a process passes through the reflexivity of actors involved in concrete 'experiments' concerning challenges to surmount and pathways to pursue in order to engender transformative action 'at the nexus'. In short, in light of claims for the climate-connected city or for 'de-siloed' approaches to food, research is needed that provides a deep understanding of how urban food governance and planning can synergise with other urban transition arenas – climate change being particularly key – and, most of all, how this synergistic action can usher from transformative innovations happening on the ground.

I argue that opportunities to make advancements in this direction are already there, emerging, among others, from a recent wave of urban food movements visibly linking food systems to climate action and planetary health objectives. Despite being under-researched in their transformative potential, these movements encompass a diversity of local initiatives, but also scalar processes that, while stemming from food system´s activities, are inherently at the intersection of food and climate, also including interconnected issues of planetary justice and human health (IPES-Food, 2023). Emerging experiments are diverse and involve different activities and areas of the food and urban systems. They range from experiments in using land for agroecological food production, to the scaling out of productive nature-based solutions and biophilic urbanism initiatives, to the movement on plant-based food procurement, work on sustainable food environments and the last food mile, to net-zero food waste strategies, among others. Some of these experiments are enabled by institutionalised planning frameworks at the local level – such as urban food strategies, or urban climate plans (Mahmoud, 2025) – while other initiatives emerge from the outside with the potential to influence institutional frameworks.

In particular, some of the urban areas where these movements occur have joined city networks intersecting both areas: food and climate. These networks include the Milan Urban Food Policy Pact (MUFPP), the Barcelona Challenge for Good Food and Climate, and the latest C40 Network's 'Good Food Cities Declaration', urging city partners to 'deliver sustainable food policies in order to achieve a Planetary Health Diet'. The years 2020-2021 have been particularly crucial in pushing these networks and movements to build coalitions. At that time, around 120 local and regional governments created an alliance in order to shape a common agenda for climate-oriented food system transformation. In 2021 this agenda was officially launched at the global climate conference COP26 in Glasgow (UK). Named as 'the Glasgow Food and Climate Declaration' (GlasgowDeclaration.org), this multi-city pact calls for responsibility in 'reducing greenhouse gas emissions from urban and regional food systems in accordance with the Paris Agreement and the Sustainable Development Goals' (see IPES-Food, 2023, p.10) and invites to shape policy frameworks, governance mechanisms and coordinated action to that purpose. Following the COP26, the 7th Global Forum of the Milan Urban Food Policy Pact was held in Barcelona in 2021, giving place to the so-called 'Barcelona Climate Challenge' (thebcnchallenge.org). The latter is regarded as a step to implement the objectives of the Glasgow declaration. It provides local authorities with support to calibrate and measure their actions at intersection of food and climate. Several actors and networks support the Challenge, including the Barcelona City Council, the Spanish municipal agro-ecology network 'Red de Municipios por la Agroecología' , the Milan Urban Food Policy Pact, C40, the French network 'Terres en villes' and the UK multi-city food policy network 'Sustainable Food Places'.

We could advance the hypothesis that the emergence of these movements – including initiatives such as actors' coalitions, pacts, and declarations around the food-climate nexus – indicates a growing momentum and multi-actor engagement aimed at advancing the climate-food agenda. To build on this momentum, what is needed is a systematic and up-to-date understanding of how these and other initiatives work to overcome siloed actions, create bridges between the sustainability spheres of food and climate, and practically operationalize a multidimensional justice agenda.

3. Informing the food-climate nexus through a justice lens

Socio-ecological theories including work on urban political ecology, environmental justice, but also literature on justice in planning (Fanstein, 2017), have taught us how any initiative seeking to engender meaningful socio-ecological change in complex social and urban settings, has to deal with issues of justice (Manganelli, 2024). Thus, deepening the understanding of the transformative role of on-the-ground 'experiments', work on justice has advanced, intersecting with both, the food and the climate debates (Avelino et al., 2024; de Bruin et al., 2024).

Inspired by civil rights movements and struggles for racial justice in the US, pioneer studies on environmental justice have mainly focused on the analysis of ***distributive justice*** issues, namely the (un)fair distribution of the effects of environmental actions across communities (Schlosberg and Collins, 2014). Early contributions on food justice have advanced a similar focus, understanding justice mostly in terms of 'ensuring that the benefits and risks of where, what, and how food is grown and produced, transported and distributed, and accessed and eaten are shared fairly' (Gottlieb and Joshi, 2010:6). After all, when considering food chains, questions such as how communities get access to food, who is exposed to the greatest disadvantages in access, what are the distributional effects of given food policies, and so on, acquire preeminent attention.

Yet, from the early focus on distribution, the environmental justice debate has over time moved in the direction of embedding multiple dimensions of justice, englobing in particular ***procedural and recognition justice*** (Fraser, 2008; Schlosberg, 2013; Schlosberg et al., 2025), the other two pillars of the environmental justice framework. As scholarly contributions highlight, procedural justice has notoriously been a rather underplayed dimension in the food debate that has long overlooked the importance of politicising decision-making processes (Duncan and Claeys, 2018). Procedural justice, indeed, focuses on how decisions are made and who is included or excluded in decision-making arenas regarding food or climate actions. Recognition justice involves acknowledging who is the real subject of injustices and tackling structural determinants of those actors in disadvantaged positions (De Bruin et al., 2024).

Essentially, the consolidated literature on environmental justice has shown how justice is played out at the intersection of different dimensions. Focusing on the triad distribution, procedural and recognition justice has the value to highlight how actors need to mediate among these different aspects (Schlosberg et al., 2025). Specifically, focusing on distributive issues alone without considering who is included and who is excluded in the first place, risks to induce a reductionist consideration of justice. In the same vein, focusing mainly on establishing procedural arrangements, such as mechanisms for civil society participation, politicisation and control, without attention to how this leads to fairer outcomes, would be a missed opportunity to substantiate justice.

While this literature on justice has put preeminent focus on social aspects, one of the key contributions of the climate urbanism and climate justice debate is to bring to the fore a relational perspective that encompasses ***the ecological*** dimension of justice as linked to the social, but also in possible tension with it (Pineda-Pinto et al., 2021). Based on a relational approach encompassing nature and earth, 'just sustainabilities' perspectives, for instance, have highlighted the need 'to ensure a better quality of life for all, now, and into the future, in a just and equitable manner, while living within the limits of supporting ecosystems' (Agyeman et al., 2016: p. 28). Going deep into diverse relational and ecological perspectives on justice would over-exceed the scope of this paper. However, it is important to highlighting how sub-literatures within environmental justice – such as materialist-feminist perspectives on justice – have acknowledged that, in a world of deep planetary relations and inter-dependencies, theories of justice should be grounded in situated knowledge and practices (Olazabal et al. 2021), specifically ac-

knowledging the place that humans inhabit in the world together with other human and non-human elements. **Ecological justice** then indicates a process of establishing relationships of care with nature and 'the environment', avoiding exclusively anthropocentric perspectives on justice.

These insights could be developed further into an approach to justice at the nexus, nurtured by theories that avoid both dichotomic and universalistic understandings of justice. Nexus justice draws attention to the interconnections between various dimensions of justice and how these unfold within place-specific initiatives. This perspective allows to examine not only how different types of experiments emerge and scale at the intersection of food and climate, but also how, driven by ecological ambitions and environmental targets, they attempt to implement a nexus justice lens. Such a lens connects different policy spheres and multiple dimensions of justice - particularly linking ecological (planetary) justice with social (human) justice.

4. Some empirical examples emerging from cities

What follows constitutes a very explorative illustration of how some of the above insights and concepts can be applied to the analysis of emerging food-climate experiments at the nexus. Without any ambition to provide an exhaustive picture, this section illustrates examples of experiments emerging in different city contexts – i.e. Brussels, New York, and Milan, – and in different sections of the food system, including in particular food production, food procurement, and waste recovery-redistribution.

Data on experiments in these city contexts are mainly retrieved by means of desk research, secondary literature review, personal knowledge networks and, in the case of Brussels, by means of primary research conducted in that context up to the year 2022. These cities were chosen as they belong to some of multi-city networks on food and climate highlighted in section 2.1 (MUFPP, C40, ICLEI..). Furthermore, these cities demonstrate engagement in both climate and food justice action. They show a diversity of food-climate experiments and engage with social and ecological justice dimensions. Each of the following sub-sections illustrates with one city context and experiment.

Vignette 1. The Brussels' Capital-Region: creating an agroecological food hub

The context of Brussels is a rather instructive one from a perspective of food planning innovations and their connection to ecological and climate agendas. Being for several time relatively understudied by the urban food planning scholarship, the Brussels' Region has instead demonstrated a rather good degree of institutional leadership in food issues, combined with a rather dynamic bottom-up engagement in alternative food initiatives (Manganelli, 2020). Particularly, since the official approval of a food strategy in 2015, key institutional actors in the Brussels' Region have been providing steady support for food system's re-localisation. Ecological considerations have been a foundational element in the development of Brussels' food movement. The initial wave of bottom-up mobilization in the early 2000s was largely driven by agroecologically engaged citizens and farmers, as well as by participants in alternative food consumption networks who laid the groundwork for the broader movement (Manganelli, 2020). The key institutional leader of the Brussels' food movement has been the agency of Environment (Bruxelles Environnement), at the forefront of actions related to greening, biodiversity, waste management, public procurement, and responsible consumption in the Region. Several local experiments can be identified in Brussels that connect food and climate agendas, including studies producing evidence on the environmental impact of the food chain in terms of greenhouse gas emissions (see studies connected to the Brussels' Strategie GoodFood). This section, in particular, illustrates an experiment promoting agroecological peri-urban food production and food system re-localisation, called the Boeren Bruxsel Paysans (see Manganelli and Moulaert, 2019). Activated in 2015 thanks to funding received from the European Regional Development Funds, this 'experiment' is a pilot project that involves practices of land restoration and re-conversion to promote agroecological farming activities. It also involves the creation of a re-localised hub for food processing and transformation, refurbishing pre-existing infrastructures. Agroecological farming activities have been implemented in two plots of publicly owned land in the Municipality of Anderlecht, at the outskirts of the Brussels-Capital Region. Since the genesis of the project, the ecological argument related to food system re-localisation, and to the promotion of more resilient and sustainable farming practices, has been rather strong. In this background, the genuine will of public land

owners (i.e. the Municipality of Anderlecht) to use available public land in a different way than urbanisation and soil consumption, was also pivotal to enable the project. Further actors involved in the experiment, including in particular the organisation Terre en Vue, were essential to provide evidence about further accessible and available land for local agroecological producers in the Region.

More than just a project, or experiment, we could argue that through time the Boeren Bruxsel Paysans has constituted an advocacy platform around access to land, agroecological farming practices, and the provision of shorter supply chains. At present, this experiment counts 10,57 hectares of land mobilised for local agriculture; 30 agro-ecological farmers and 25 small processors that were involved in training activities (see Boeren Bruxsel Paysans' documentation). Overall, this coalition of actors has undoubtedly played a role in influencing regional discussions around access to land, and, potentially, in showing a different model of land use and land development for Brussels and its outskirts. One of the key processes initiated by this project is the development of the Municipality of Anderlecht's Climate Action Plan 2023–2030, with a particular focus on reducing greenhouse gas emissions through the promotion and production of low-carbon food.

In summary, this initiative shows how ecological justice arguments related to soil restoration and land reconversion in urban-peri-urban areas, together with the social challenge of supporting small producers, provided a strong narrative to motivate the genesis and role of this experiment. Far from constituting an isolated case, the Boeren Bruxsel Paysans should be regarded in conjunction with similar dynamics going on in Brussels and in other contexts. Given the growing number of urban greening plans and nature-based solutions emerging in response to climate adaptation targets (Mahmoud et al., 2025), there is an opportunity to explore how experiments in re-localized food production can leverage the broader set of frameworks and windows of opportunity created by this expanded climate agenda.

Vignette 2. New York City: combining ecological and social justice objectives through Good Food Purchasing
New York City (NYC) is considered as pioneer in urban food planning, embracing a progressive and systemic vision around food system transformation (Cohen and Ilieva, 2021). Issued in 2010, comprehensive visions and reports such as FoodNYC and FoodWorks show a clear orientation towards a food system approach. Such an approach argues for an integrated food policy that considers the different stages of the food system and examines the ways in which NYC is actually fed (Morgan, 2025). In 2021, the mayor's Office of Food Policy – i.e. the office responsible for food policy-making and for the orchestration of different agencies in the city – launched a food plan called 'Food Forward NYC'. This plan designs a ten-year roadmap aiming 'to reach a more equitable, sustainable, and healthy food system by 2031' (see the Food Forward NYC's plan). In 2023, Mayor Adams also launched the city's climate plan – called PlaNYC, showcasing political engagement in climate action. New York City's leadership has clearly demonstrated its commitment to food and climate goals, notably by joining the Cool Food Pledge in 2021. This global initiative, launched by the World Resources Institute, invites cities and institutions to reduce greenhouse gas emissions from the food they serve by 25% by 2030, using 2015 as the baseline year (Cohen, 2023). This commitment is reinforced in the PlaNYC, which raises the target to 30% emissions reductions by 2030, engaging relevant city agencies such as schools, hospitals, jails, social centres, etc. (IPES-Food 2023, p. 23).

Within this background, City's decision-makers have become conscious about the transformative power that the public sector can leverage thorough sustainable food purchasing (Morgan, 2025). Particularly, this vignette briefly elaborates on the NYC's Good Food Purchasing program as a vehicle for combined food and climate action. The Good Food Purchasing is a public procurement program launched at the local level but responding to a wider national public procurement framework (Morgan, 2025). NYC initially joined the program in 2018, with two agencies participating – the Department of Education and NYC Health and Hospitals. The initiative later expanded to include seven city agencies (Morgan, 2025). In 2022, Mayor Adams reinforced this commitment by signing Executive Order 8, which formally institutionalized the Good Food Purchasing Program (see NYC Food Policy's web sources). Kate MacKenzie, the executive director of the mayor's Office of Food Policy, refers to the food purchasing program as 'an enormous lever for change and critical tool for equity', able to 'deliver higher-quality food and make progress on climate, animal welfare, workers' rights and supporting minority and women owned business'

(Mayor's Office of Food Policy, 2021).

In fact, what is interesting about the Good Food Purchasing program, is the clear orientation towards climate mitigation while also keeping attention to social justice objectives. This is achieved by the set-up of clear ecological and social values, or principles, on which basis establishing a methodology that allows to evaluate the program and track progress through time (Cohen, 2023). Those values and principles draw inspiration from the nationally networked Good Food Purchasing Program. First, the principle of environmental sustainability, which implies establishing a metrics to monitor which food is supplied by public caterers and what is environmental impact of different food types in terms of greenhouse gas emissions. As highlighted by various sources, longitudinal monitoring of this metric enables an assessment of how well food purchasing aligns with climate objectives, and serves to incentivize the adoption of lower-emission, climate-conscious choices (Cohen, 2023; IPES-Food, 2023). Second, the value of supporting local economies while fostering inclusivity. This is achieved by privileging food that is 'grown, processes, manufactured, or distributed' by businesses or enterprises located in the City or in the State of New York (see NYC Food Policy's web sources), while also keeping attention to gender and cultural aspects (by for instance privileging businesses run by women, or people self-identified as indigenous, or minorities). Third, setting quality standards regarding nutrition (e.g. minimum requirements in terms of fruits, vegetables, low-processed plant-based proteins, etc.). Fourth and fifth, the attention to animal welfare (e.g. reporting purchases of animal proteins) and worker's rights (raising transparency and monitoring conditions of food workers and laborers, in all parts of the food chain, in accordance to national laws on labour standards) (see NYC Food Policy's web sources). Finally, a further overarching principle is the one of transparency, i.e. the provision of publicly accessible data concerning monitoring and progress.

The above is a short overview of an 'experiment' whose impact certainly needs deeper evaluation and research. Yet, this experiment provides an inspiring practice of a publicly led program which clearly stands at the nexus of climate and food justice objectives. What needs further deepening are aspects such as the capacity and impact of such a program through time, the challenge of running a clear monitoring framework, and the ways in which this experiment can be further empowered thanks to the connection with the program at the national level. Rather than considered in isolation, this experiment should be regarded within a wider set of practices and movements towards universal and climate-consious public procurement (Morgan, 2025).

Vignette 3. Milan: achieving climate and social targets through the Food Waste Hubs

Having examined experiments in land use and public procurement, this vignette turns to another strategic dimension of the food system with potential to advance both climate and food security objectives: the recovery and redistribution of food waste. Specifically, it focuses on initiatives developed in the context of Milan as illustrative examples. Milan is considered as a further 'best practice' when it comes to leadership in food policy and food governance (Calori et al., 2015). Key institutional steps in food policy development occurred around the year 2014, when the Milan Municipality and the Cariplo Foundation (a key private foundation in the city), launched a study about the Milan urban food system. On this basis, in 2015 actors' consultations led to the development and approval of a food policy for Milan (Food Policy di Milano). In a move comparable to New York City's approach, 2017 saw the establishment of a Food Policy Office (Ufficio Food Policy) within the Deputy Mayor's cabinet, tasked with coordinating and implementing food policy across municipal departments. Among the priority axes of the Food Policy are: ensuring healthy food and sufficient drinking water for all; promoting the sustainability of the food system; Promoting food literacy; tackling food waste; and promoting scientific research in the agro-food sector (see Food Policy's documentation).

In this background, this vignette deals with experiments in food waste as a testing ground for the food-climate nexus, particularly focusing on emerging social and ecological justice aspects. An illustrative case in point is the so called 'Food Waste Hubs' pilot project, activated in Milan a few years ago. Food Waste Hubs is a network of neighbourhood spaces and infrastructures for the collection and storage of surplus food from various retail outlets, including in particular large-scale retail (information retrieved from the Municipality of Milan). Specifically, each hub sources surplus food primarily from supermarkets and workplace canteens, providing it to local NGOs,

community initiatives, and food security organisations that support the neediest members of the community. This experiment started in 2017 as a pilot project, product of the collaboration between the Municipality of Milan, the Cariplo Foundation, the organisation 'Assolombarda' (a consortium of enterprises operating in the Milan Metropolitan area and its province) and the Politecnic University of Milan. The first hub was implemented in 2019 in the 'Isola' district of Milan. In 2021, another hub was established as a sort of consolidation of the experimental phase. From that year on, a father expansion phase occurred, with the creation of other hubs, up to the most recent phase that integrates new actors such as municipal markets (information retrieved from the Municipality of Milan and Polytechnic University of Milan's website sources about the experiment).

The year 2021 was a key moment in the young trajectory of the Food Hubs' experiment. In that year, the city of Milan obtained a reward of 1 million pound (1.17 million euros) in the first edition of the Earthshot price, a global environmental award established in the UK. The Food Hub's project was awarded within the category 'Build a Waste Free World' (see earthshotprize.org). The award could channel further resources that allowed to amplify and further integrate the experiment. In particular, the key actors participating in the project sought not only to create new food hubs and involve more actors; they also pursued the creation of stronger networks among the different actors involved in various food waste hubs, aligning them towards shared ecological and social objectives.

The Food Waste Hubs is one among the several examples of initiatives at the food-climate nexus addressing complex challenge of food sustainability and fight against food waste as an ecological target, while also promoting food equity. Aspects of social justice are addressed by tackling distributive and procedural issues such as improving fragile people´s access to dignified food; scaling out the approach socially and spatially in the city; and by using food as a vehicle for sociability and dignity, by shaping community food infrastructures. At the same time, the experiment could serve as a demonstration platform that put accent on the ecological impact produced by food waste and thus, on the opportunity to take action in this direction. A short account of the impact of this experiment in the year of 2021 tells that across all active Food Hubs at that time, 1,386 tonnes of food waste were recovered, thereby preventing an estimated 3,188 tonnes of CO_2e emissions. According to these data, these efforts facilitated the redistribution of several hundred thousand surplus food items to approximately 27,000 individuals experiencing vulnerability, corresponding to an estimated 1.23 million meals (source: earthprice.org).

There are of course critical questions that can be posed to this experiment. On the one hand, as the NYC's vignette suggests, measuring the impact of this kind of initiative in terms of emissions' savings would require a systematic tracking which measures progress through time. Furthermore, there are questions related to the resourcefulness of this project and its capacity to last in time so as to exercise an impact. Finally, a deeper engagement with the challenge of social justice raises the critical question of the extent to which emerging experiments work in address the underlying determinants that shape access to good and healthy food for individuals in vulnerable situations (HLPE, 2024). Taking these issues into account, one could argue that an experiment of this kind serves to highlight food waste as a critical arena for aligning food and climate objectives, with the potential to synergize with broader urban initiatives such as circular economy strategies and climate action plans.

5. Conclusions: ways forward

This reflective paper has claimed for a deeper account of the interrelation between food and climate as a critical arena for urban sustainability governance and planning. Taking inspiration from the climate urbanism, food governance, food and climate justice debates – but also from real-life movements and practices emerging from cities –, this paper has shown how the climate-food nexus serves as a site for situated experimentations and place-based innovations emerging from the ground-up (Castán Broto, 2020). In this background, this paper has also suggested integrating a nexus-justice approach where aspects of ecological justice could be regarded in synergy (or, sometimes, tension) with social justice dimensions, providing potential arguments for the out-scaling or up-scaling of experiments at the food-climate nexus.

While this contribution has only provided a brief illustration of initiatives in different city contexts and in diverse areas of the food system, there is surely scope for wider theoretical and empirical research. Indeed, further lines

of research could go in the direction of identifying various typologies of food-climate experiments in different contexts, looking at the challenges to connect these sustainability fields and engender systemic and transformative action in both domains. Further research could also explore how city actors and other players are trying to build methodologies in order to track progress and measure achievements in terms of climate objectives and ecological justice targets. Moreover, other studies could mobilise critical lenses that explore the challenges to attend different dimensions of social and ecological justice, and how this justice nexus could create potential contradictions in situated experiments. In conclusion, this paper invites to explore the potential of food as a testing ground for the climate-connected city (Bulkeley, 2021), and of climate as a fertile terrain in which transformative food system goals can be further advanced.

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How Local Policies Transform Foodscapes, Influence Dietary Shifts, and Reduce Emissions: Insights from Six Mediterranean Sub-Regions in France

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Abstract
Although foodscape planning is increasingly recognized as a critical component of sustainability transitions, it remains an emerging field of research and practice. Existing studies often overlook the multifaceted role that local food planning can play in shaping the physical, economic, and socio-cultural dimensions of foodscapes. This paper examines how recent local food policy initiatives are reconfiguring foodscapes across six Mediterranean sub-regions in France. Using a mixed-methods approach, it combines an analysis of locally implemented policies with survey data on evolving food practices. The findings reveal a growing emphasis by local authorities on socio-cultural and cognitive interventions, which are associated with modest dietary shifts aligned with environmental objectives. These results offer insights into how local food planning can more effectively support the adoption of sustainable diets.

Keywords: Food environment, Urban-rural planning, Climate change, Environmental Food Behaviour Index

1. Introduction

The current food system remains largely unsustainable due to its significant contribution to major 21st-century challenges, including climate change (Mbow et al., 2019) and the rise of diet-related diseases such as diabetes and cancer (Thavarajah, 2018). Transitioning toward more sustainable diets is therefore essential to address the public health crisis and substantially reduce greenhouse gas (GHG) emissions (Poore and Nemecek, 2018). Governments at all levels have the capacity to play a pivotal role in initiating this transition (Temme et al., 2020). Yet, despite the profound implications of food systems for both sustainability and public health, food planning at the local level only emerged as a distinct field in the early 2000s (Pothukuchi and Kaufman, 2000). Since then, numerous cities and regions have intensified their engagement in food system transformation by signing international commitments such as the Milan Urban Food Policy Pact (MUFPP, 2015) and the Glasgow Declaration (2021). These initiatives aim to leverage local food planning as a tool to reduce emissions and offer more sustainable food options to local populations. However, limited research has examined how such policies concretely transform local foodscapes, influence food environments, or shape residents' eating habits.

The High-Level Panel of Experts on Food Security and Nutrition defines food environments as "the physical, economic, political, and socio-cultural context in which consumers engage with the food system to acquire, prepare, and consume food" (HLPE, 2017). In academic research, the term foodscapes is increasingly preferred, as it emphasizes the territorial dimension of food environments and how they are actively shaped by local practices, political institutions, and economic systems (Vonthron et al., 2020). Numerous studies have demonstrated that food choices are shaped less by individual decisions alone than by the surrounding foodscapes, including factors such as retail outlets, urban design, and even walkability (Carrus et al., 2018). However, this literature has predominantly focused on the spatial dimension of foodscapes, mapping retail outlets such as supermarkets or fast-food chains using geospatial methods (McKinnon et al., 2009; Herforth and Ahmed, 2015; Vonthron et al., 2020), and evaluating their public health implications (Adam et al., 2016; Liu et al., 2016; Cooksey-Stowers et al., 2017; Wilkins et al., 2019; Méjean and Recchia, 2022). These studies are often situated in urban contexts (Mattioni, 2021; Méjean and Recchia, 2022) and tend to overlook the broader range of tools through which urban and rural planning can shape foodscapes, not only physically, but also economically, culturally, and cognitively. In contrast, cities and municipalities increasingly mobilize a wider set of instruments that extend beyond spatial accessibility (Morgan and Sonnino, 2010; Morgan and Santo, 2018; Mattioni, 2021). For instance, Barbour et al. (2021) demonstrate, in their review of Milan Urban Food Policy Pact signatories, that the most common measures implemented have focused on public procurement, sustainability guidelines in school meal programs, and the promotion of

urban agriculture. In many of these initiatives, the emphasis on promoting local food stands out as a central objective. However, despite its strong symbolic and political appeal, prioritizing local products has shown limited or ambiguous environmental benefits (Majewski et al., 2020), underlining the need for more ecologically robust and evidence-based local policies.

In the French context, local policymakers have several tools at their disposal to influence foodscapes and dietary behavior. These tools include organizing events focused on sustainable food, regulating food advertising, and managing food waste. They also oversee food procurement for public institutions such as school canteens. Additionally, policymakers work to protect farmland and promote short food supply chains, aiming to improve access to local and sustainable products. To coordinate these actions and align them with sustainability goals, a new policy instrument called Territorial Food Projects (Projets Alimentaires Territoriaux, PAT) was introduced in 2014 (Maréchal et al., 2018). These projects aim to promote local governance over both sustainable food production and consumption. Municipalities involved in PATs are required to consult local stakeholders and develop action plans that address various levers of transformation, including local production and distribution, equitable access to sustainable food, and the reduction of food waste. Environmental objectives are also integrated, with actions targeting reduced food waste, development of agroecology, lower food transport emissions, and the promotion of sustainable practices such as reduced meat consumption and increased procurement of organic products, especially in public canteens. These local policies thus have the potential to promote innovative approaches that address not only the physical aspects of food environments but also their economic, socio-cultural, and cognitive dimensions, thereby encouraging dietary transitions with lower environmental impacts. While several studies have demonstrated that PATs contribute to farmland preservation, the development of urban agriculture, and the expansion of local and organic food procurement, their broader impacts on dietary practices and environmental outcomes remain underexplored (Lulovicova and Bouissou, 2024). Consequently, there is an urgent need to evaluate the impact of such local policies on food behaviors more systematically (Hawkes et al., 2017). Existing studies have primarily focused on emblematic or experimental cases, such as school canteens in Galicia (Perez-Neira et al., 2021) or in Mouans-Sartoux (Lulovicova and Bouissou, 2023), which have shown promising results in terms of both diet and environmental impact. However, these cases are often unrepresentative, thus limiting the generalizability of their findings. This research addresses that gap by examining the evolution of local food planning initiatives, and the dietary changes associated with them in six Mediterranean sub-regions of France. We adopt the concept of foodscape as a heuristic tool to explore the spatial, economic, socio-cultural, and cognitive dimensions of food consumption within the studied territory, and to evaluate how local policies may influence these dimensions. The following sections present the study area, and the methodology used to assess recent food planning initiatives, including the development of a food questionnaire and an Environmental Food Behaviour Index. This is followed by an analysis of the potential of these initiatives to reshape various dimensions of local foodscapes, of dietary changes toward environmental sustainability in the study area, and of territorial differences related to the development of local planning approaches.

2. Methodology

Study area and policy analysis

France is considered a pioneer in the development of local food initiatives, owing to its strong historical and cultural attachment to local agriculture and food products (Bessière, 1998). Since 2014, the expansion of such initiatives has accelerated through the national policy supporting the development of Territorial Food Projects (PATs), which are local food planning tools implemented at the municipal or regional level. Their main objective is to support the relocation of sustainable agriculture and food systems through coordinated action among public and private stakeholders. These developments provide an interesting context for examining how food planning influences foodscapes.

In the Alpes-Maritimes department, located in southeastern France, agricultural activity has declined in recent decades due to urbanisation and the growth of tourism along the French Riviera (Voiron and Liziard, 2008). Nevertheless, the department stands out with a relatively high number of PATs. One PAT operates at the departmental scale, five at the sub-regional level, corresponding to agglomerations or inter-municipal structures, and three at

the municipal level. Some municipal areas are therefore influenced simultaneously by three PATs operating at different territorial levels: municipal, sub-regional, and departmental. Among these, six initiatives are officially recognised as level 2 by the French Ministry of Agriculture, indicating the adoption of an operational action plan. Two additional projects, currently at level 1, are expected to achieve level 2 status shortly. This configuration makes Alpes-Maritimes one of the most advanced departments in France in terms of PAT deployment. However, two sub-regional areas within the department have not yet engaged in any PAT initiative. Geographically, the western part of the department is more actively involved, with full PAT coverage. In this area, four intercommunalities have formed a collective structure known as CAP AZUR, to coordinate ecological transition efforts, including sustainable food systems, in a coherent and integrated manner (Figure 1). In addition, the southern coastal area of the department is highly urbanised, in contrast with the northern area, which is predominantly rural due to the presence of the southern Alps, characterised by high altitudes and steep slopes. These geographical contrasts may influence food access and perceptions.

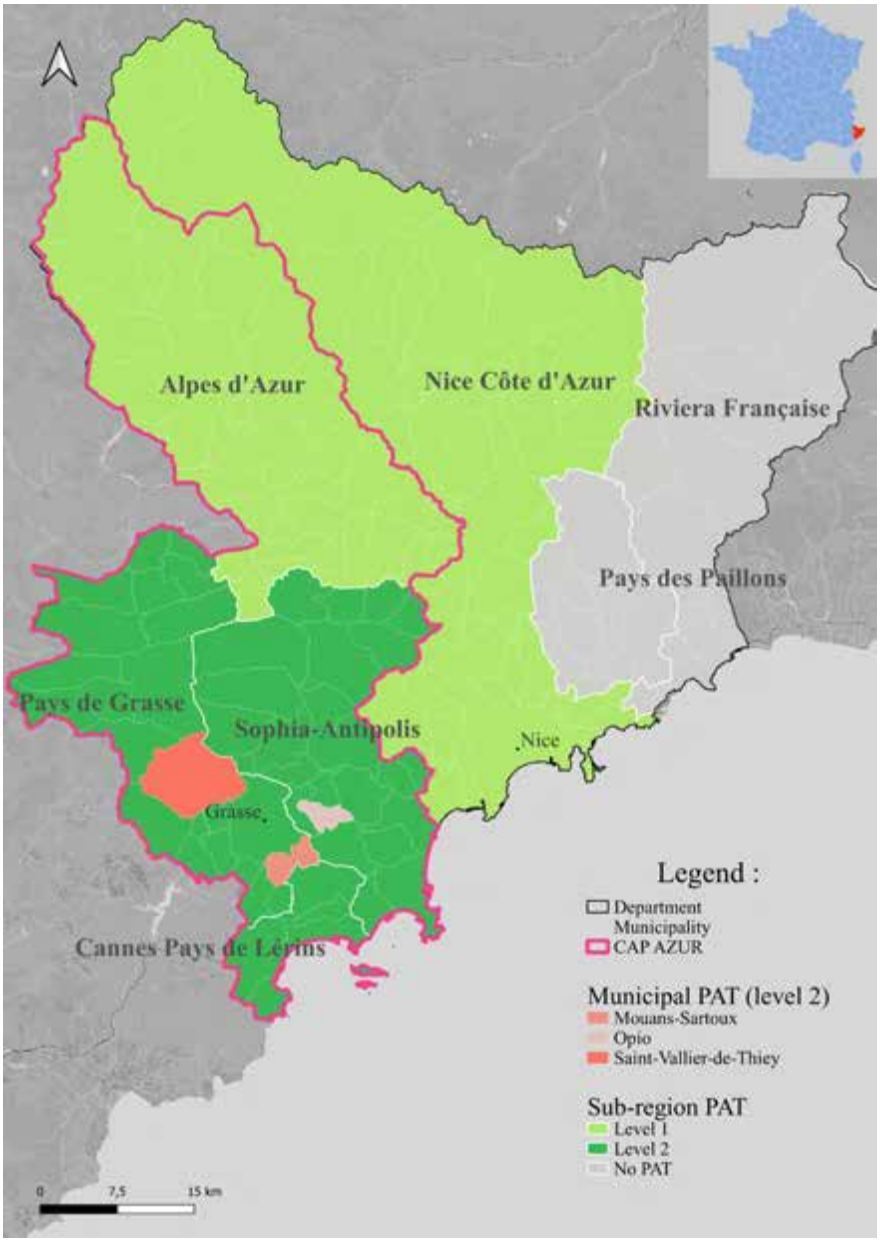

Figure 1. Map of the Department of Alpes-Maritimes and its Food Territorial Projects (PAT).

The scope and nature of food-related initiatives that local decision-makers can undertake through a PAT action plan vary depending on the territorial scale. For example, under French law, municipalities are responsible for public procurement in primary school canteens, while departments manage canteens in high schools. Municipalities also directly oversee local urban planning and are therefore key actors in agricultural land preservation and food retail distribution. Sub-regional authorities typically handle waste management, including food waste, whereas departments are in charge of economic development. Despite these differences, all PATs in the study area share common objectives. They aim to support local, organic, and extensive farming, promote short supply chains, and encourage sustainable dietary practices through educational events, challenges, and policy interventions. For the purpose of the policy analysis, this paper focuses exclusively on territories that are covered by a municipal and/or a sub-regional PAT. The assessment of the departmental PAT is not included, as the objective is to compare the diversity of actions implemented in different local contexts within the same department.

The policy analysis followed a two-step approach. First, a review of existing literature on local food policies was conducted to identify the types of interventions available to local authorities that influence food environments and foodscapes. Key references included works by Morgan and Santo (2018), Sonnino et al. (2019), Barbour et al. (2021), and Brocard and Saujot (2023). This step provided a framework for assessing how local authorities act on the physical dimension of foodscapes, such as market infrastructure or food access, the economic dimension, including subsidies and pricing strategies, and the socio-cultural and cognitive dimensions, through educational campaigns or public food procurement. In the second step, we conducted interviews with local policymakers and analysed the action plans of each PAT. This qualitative investigation aimed to assess the degree of intervention in each of the four foodscape dimensions mentioned above. The findings from this policy analysis are further compared with data on the evolution of local dietary practices in the department, in order to explore any possible links between territory, public action, and dietary change.

Food Questionnaire and Environmental Food Behaviour Index

To examine dietary shifts toward environmentally sustainable practices, we adapted a food behaviour questionnaire developed by Lulovicova and Bouissou (2023). The adapted version collects data on respondents' municipalities, socio-economic characteristics, food purchasing motivations, and self-reported behavioural changes related to environmental sustainability. Evolution is measured over the past five years, corresponding to the launch of most regional PAT interventions. Respondents were asked whether they had participated in locally organised sustainable food events or challenges, frequented municipal farmers' markets, received food aid coordinated by local authorities, or were parents of schoolchildren enrolled in institutions where sustainable food supply initiatives had been implemented.

To evaluate the environmental implications of these reported dietary changes, an Environmental Food Behaviour Index (EFBI) was developed. While numerous studies have documented the environmental impacts of changing food consumption patterns (e.g., Scarborough et al., 2014; Aguiar et al., 2021), no single composite indicator currently captures the full spectrum of food behaviours associated with positive environmental outcomes. Existing indexes tend to focus either on nutritional adequacy or broader notions of sustainability, such as the Comprehensive Diet Quality Index (Toujgani et al., 2024), the Diet Quality Index-International (Tharrey et al., 2024), or adherence scores to specific dietary models like the MEDI-LITE Mediterranean Diet Index (Baudry et al., 2023). The EFBI was constructed to capture behavioural changes that are both likely to be influenced by local foodscape transformations and relevant to reducing environmental degradation, particularly in relation to climate change (Culliford and Bradbury, 2021; Marty et al., 2022). Ten food-related behaviours were selected to build the EFBI, based on their documented environmental significance. These include:

(1) a shift in the types of food retail outlets visited (e.g., from supermarkets to organic shops or fresh markets),
(2) changes in transport modes used for grocery shopping (e.g., switching from motorised to non-motorised transport),
(3) reduction in meat consumption,
(4) reduction in ultra-processed food consumption,
(5) increased consumption of organic products,

(6) increased consumption of seasonal products,
(7) increased consumption of locally sourced products,
(8) reduced reliance on packaged foods,
(9) reduction in household food waste, and
(10) adoption of individual or collective composting practices.

Each behaviour was scored as follows: +1 for a shift toward more sustainable practices, 0 for no change, and –1 for a shift toward less sustainable practices. The final score for each participant therefore ranged from –10 (less sustainable shift across all behaviours) to +10 (more sustainable shift across all behaviours). For example, if a participant switched from using a car to cycling for grocery shopping, but did not change any of the other nine behaviours, they would receive +1 point for the transport indicator, 0 for the others, and a global score of 1. The scoring system does not apply weightings based on the magnitude of environmental impact for each behaviour. Both the composite EFBI and individual behaviour-specific scores were used in subsequent statistical analyses to compare behavioural patterns across territories. The aim was to assess the extent and nature of dietary transformations in relation to sustainability and local context.

The questionnaire was administered between March and May 2025, with distribution coordinated by local authorities. It was disseminated through food-related territorial networks, including urban gardening groups, participants in locally organised food challenges, and parents of school-aged children. It was also shared via social media platforms operated by territorial stakeholders and published in local newspapers. A total of 2,411 fully completed responses were collected. To reduce potential self-selection bias, 60 additional respondents were interviewed in public spaces across the study area. Despite these efforts, the final sample exhibited notable demographic imbalances: women represented 77.8% of respondents (compared to 52% in the general population), individuals aged 35–49 accounted for 38.1% (vs. 22%), and 44.3% held at least a master's degree (vs. 13%). These biases are consistent with prior research showing that women and more educated individuals are more likely to respond to food-related surveys and adopt sustainable food behaviours (Culliford and Bradbury, 2021; Konttinen et al., 2021; Marty et al., 2022). To enhance the representativeness of the descriptive results, raking calibration was applied to adjust sample weights. This statistical method aligns the marginal distributions of gender, age, and education level with those of the local census population, iteratively adjusting the weights to reduce sampling bias (Deville and Särndal, 1992; Deville et al., 1993). Behavioural changes were further analysed by comparing sub-populations across distinct territorial contexts. Comparisons were conducted between participants and non-participants in public sustainable food initiatives (e.g., parents benefitting from sustainable school catering, participants in food- or agriculture-related events, recipients of subsidised sustainable food aid, and regular users of municipal markets), between the western (more intervention-rich) and eastern (less intervention-intensive) parts of the department, and between urban and rural populations, as foodscape accessibility has been shown to influence dietary behaviours (Hawkes et al., 2017; Tharrey et al., 2024). Only changes (positive or negative) in behaviour were included in the analysis; behaviours reported as unchanged were excluded. Due to the non-normal distribution of EFBI scores and the use of independent group comparisons, the Mann–Whitney U test was employed for statistical inference. The statistical analyses were conducted on unweighted data, as the distributions of gender, age, and education level were similar across all sub-populations studied. While these comparisons offer insight into behavioural trends across territories, they do not establish causality. As the data are self-reported and observational, the observed associations should be interpreted with caution and considered indicative rather than conclusive.

3. Results

Systemic Food Planning Assessment

Based on a review of both scientific and grey literature, a list of potential interventions available to local decision-makers was compiled. These interventions target the physical, economic, socio-cultural, and cognitive dimensions of foodscapes. Potential actions on the physical environment include support for local sustainable agriculture, the development of short supply chains, the establishment or improvement of local food markets, organic or environmentally sustainable retail outlets, restaurants, and public canteens, as well as enhanced ac-

cessibility to these infrastructures. Economic interventions encompass measures such as ensuring affordable access to sustainable food products, creating urban gardens to increase the availability of fresh fruits and vegetables, subsidising food aid and community associations, and reducing the cost of higher-quality food in public canteens. Interventions addressing the socio-cultural environment include regulating food advertising, promoting sustainable food offerings, implementing training programs in local institutions, and fostering positive narratives around local, organic, plant-based, and seasonal food consumption. Cognitive interventions, closely linked to the socio-cultural dimension, primarily consist of awareness-raising initiatives and educational campaigns, both within schools and across the broader public sphere.

Within the study area, interventions were identified across six of the seven sub-regions. The sub-region of Pays des Paillons, located in the eastern part of the department, did not exhibit any identifiable policies capable of influencing its foodscape and was therefore excluded from the analysis. Also in the eastern part, the sub-region of Riviera Française, although not engaged in a Territorial Food Project (PAT), introduced some sustainable agriculture-based policies over the past five years, which were included in the assessment. In addition to the analysis of the six sub-regional PATs, three municipalities in the western part of the department that had formally initiated PATs were also examined. In all six sub-regions and the three PAT municipalities, at least one of the potential interventions identified in the literature was implemented over the past five years (Table 1). The most frequently observed actions involved public awareness initiatives related to agriculture and efforts to develop local agricultural production. These were followed by actions aimed at strengthening short supply chains, with the dual goal of reducing both transportation distances and food prices, as well as diverse forms of intervention in school canteens. In the latter, initiatives included educational campaigns targeting pupils, training programs for school catering staff, and sustainability-oriented procurement practices, such as increasing the share of organic and local products and reducing the consumption of ultra-processed and animal-based foods. Urban gardening initiatives were identified in approximately half of the territories studied. These actions involved the allocation of public space and the provision of materials or financial support to local gardening associations. By contrast, interventions in retail environments, such as the regulation of fast-food outlets or food marketing practices, the improvement of food-related infrastructure, and the promotion of affordable food retail options were rare or entirely absent.

Overall, among the various interventions implemented within the PATs and the studied territories, the physical dimension of foodscapes appears to focus more heavily on agricultural production than on consumption spaces, such as food retail outlets. This pattern may reflect both the limited availability of local agricultural supply and the political priority given by local authorities to expanding such supply. Observed economic interventions tend to be indirect, primarily involving the promotion of short supply chains and support for urban gardening. While these efforts contribute to enhancing food system sustainability, they only partially address affordability concerns regarding access to healthy foods. In contrast, the socio-cultural and cognitive dimensions are the most actively developed, with a clear emphasis on information-based strategies designed to raise awareness and reshape food norms. From a geographical perspective, the western part of the department, where most PATs have been implemented, appears to be the most active. These areas displayed a greater diversity of interventions, reflecting a more comprehensive engagement with food system transformation. As nearly all sub-regions include both urban areas in the south and rural zones in the north, no clear distinction could be made between policies implemented in urban versus rural settings.

Table 1. Local government interventions across foodscape dimensions in Alpes-Maritimes. Yellow fields indicate implemented interventions; dimensions are grouped by territorial and geographical level.

Territorial level	Geographical situation	Authority	Physical environment						Economic environment				
			Support local sustainable agriculture	Create or improve local food markets	Promote organic or sustainable retail outlets	Provide sustainable meals in public canteens	Regulate fast-food outlet density	Improve access to food infrastructures	Support affordable and sustainable retail outlets	Establish urban gardens	Subsidise sustainable food for disadvantaged groups	Develop short supply chains	Implement equitable prices of sustainable meals in canteens
City-level	West (CAP AZUR)	Mouans-Sartoux	■	■	■	■	■			■	■	■	■
		Saint-Vallier-de-Thiey	■	■		■			■	■	■	■	
		Opio	■			■				■		■	■
Sub-regional-level		Pays de Grasse	■			■				■		■	
		Sophia-Antipolis	■									■	
		Cannes Pays de Lérins	■									■	
		Alpes d'Azur				■					■		
	East	Nice Côte d'Azur	■			■				■		■	
		Pays des Paillons											
		Riviera Française	■										

Territorial level	Geographical situation	Authority	Socio-cultural environment				Cognitive environment	
			Restrict advertising of unhealthy or unsustainable foods	Promote sustainable food in schools and institutions	Foster positive narratives around sustainable food	Train and mobilize food actors in public institutions	Strengthen sustainable food education in schools	Raise public awareness about sustainable diets
City-level	West (CAP AZUR)	Mouans-Sartoux	■	■	■	■	■	■
		Saint-Vallier-de-Thiey		■	■	■	■	■
		Opio		■		■	■	■
Sub-regional-level		Pays de Grasse		■			■	■
		Sophia-Antipolis						■
		Cannes Pays de Lérins		■				■
		Alpes d'Azur		■	■	■	■	■
	East	Nice Côte d'Azur		■				■
		Pays des Paillons						
		Riviera Française						

Environmental Behaviour Shift and Territorial Differences

The political efforts observed in the department to promote more sustainable food systems appear to have been accompanied by modest behavioural changes among the population. These dynamics are illustrated in Figure 2. According to the weighted sample, 56.7% of respondents reported at least one positive change in their food-related practices, 36.8% reported no change, and fewer than 10% indicated a negative shift across the ten assessed behaviours. The weighted global score, corresponding to the mean number of positive behavioural changes, was 2.02. Most individuals adopted between one and six environmentally beneficial behaviours, although a small number declared improvements across all ten. Negative changes were relatively rare, and no respondent reported more than eight regressions (Figure 2a).

Among the most frequently reported positive changes was a reduction in the consumption of ultra-processed foods, declared by 39.4% of the weighted sample, followed by a decrease in the intake of animal-based products (31.3%). A substantial proportion of respondents (ranging from 19.7% to 30.1%) also reported a shift toward organic, local, and seasonal products, a reduction in the use of food packaging, and the adoption of composting practices. In contrast, changes in mobility practices related to food shopping remained limited: a large majority of respondents (91%) continued to rely primarily on motorised vehicles. Similarly, transitions toward alternative food retail outlets (such as organic stores or fresh markets) were infrequent, with 79.9% of respondents reporting no change in these behaviours. The most common negative shifts involved a reduction in the consumption of seasonal and organic products, observed in 6.4% and 6% of respondents, respectively (Figure 2b)

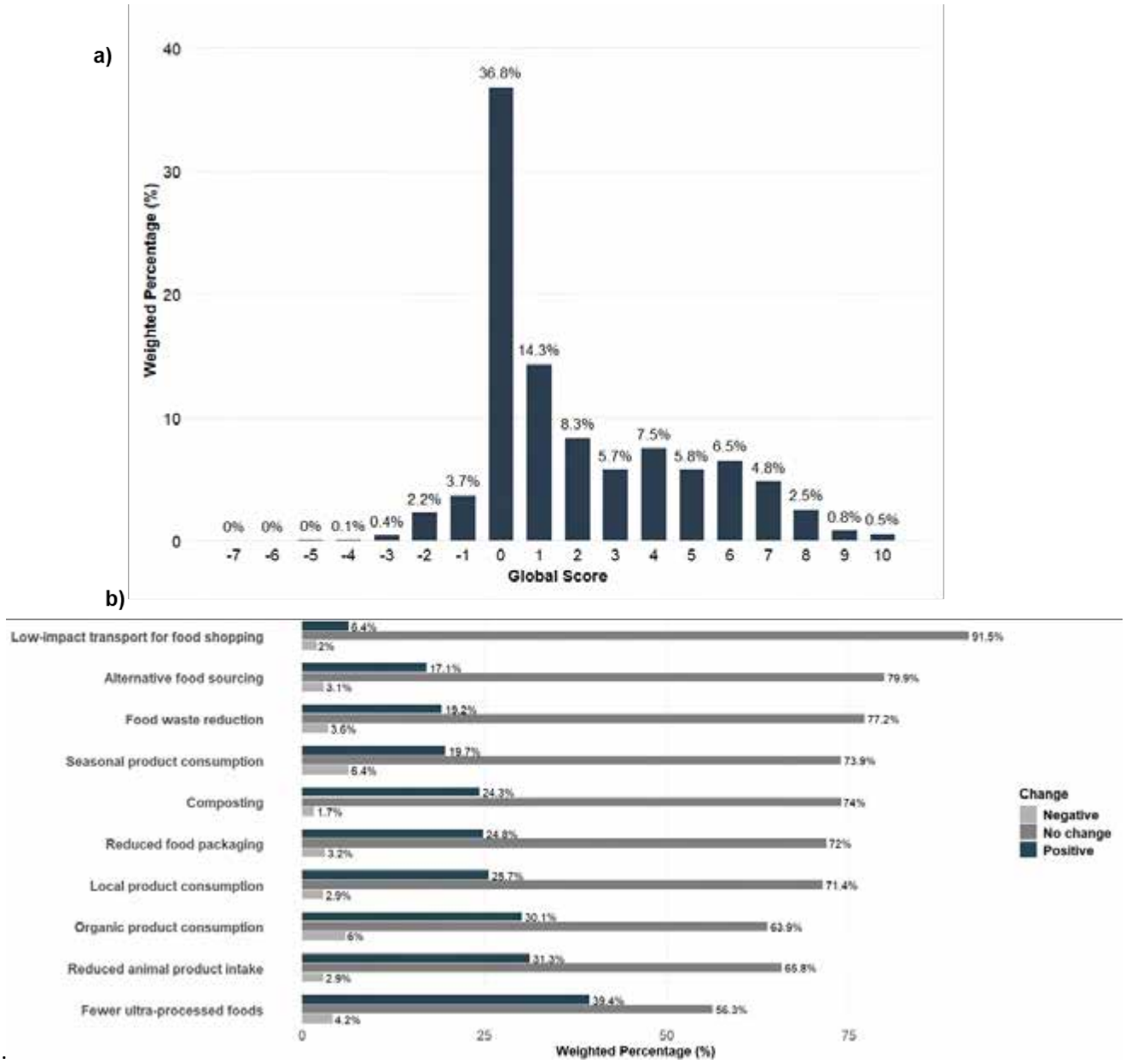

Figure 2. Environmental Food Behaviour Index: (a) Weighted distribution of global scores, with 0 representing no change, and positive or negative values indicating the total number of environmentally beneficial (positive) or detrimental (negative) behavioural changes reported. (b) Weighted percentage of respondents reporting negative, no, or positive changes for each of the ten assessed environmental behaviours.

Statistically significant variations were identified across different sub-populations within the department. As illustrated in Figure 3, the degree of behavioural change differed according to individuals' exposure to local food-related policies and their location within the territory. Three comparative sub-group analyses were conducted:

(a) respondents benefiting directly or indirectly from local interventions (e.g., parents of schoolchildren),
(b) residents of the western sub-regions, characterised by a more dynamic policy environment, versus those in the less advanced eastern sub-regions, and
(c) urban versus rural populations.

The first comparison revealed substantial differences in the evolution of food-related behaviours between individuals benefiting from local food policies and those who were not. Statistically significant differences were observed in seven out of ten behavioural categories, as well as in the global score summarising the total number of positive changes. Although shifts towards low-impact transport for food shopping and increased consumption of organic and seasonal products did not show statistically significant differences, average scores for these behaviours remained consistently higher among policy-exposed respondents. This trend also reflects a lower prevalence of negative or unchanged behaviours, and a higher proportion of positive changes within this group (Figure 3a). In contrast, the west–east comparison revealed minimal differences. Residents of the western sub-regions, where food policies are generally more advanced, exhibited slightly higher average scores across all behaviours, including the global index score. However, these differences were not statistically significant overall. Only two behaviours showed significant variation: greater adoption of low-impact transport in the east, and more widespread composting in the west. Overall, the magnitude of difference between eastern and western regions was notably smaller than that observed in the policy exposure comparison (Figure 3b). Conversely, the comparison between rural and urban populations revealed clear differences in behavioural change patterns. Statistically significant disparities were observed in several areas, including the use of low-impact transport for food shopping, reduced consumption of animal products and ultra-processed foods, increased consumption of organic and seasonal products, and composting practices. For most behaviours and the global index score, urban respondents reported higher levels of positive change, although not all differences reached statistical significance. Among the significant changes, urban residents generally scored better, except for composting, where rural residents reported more substantial improvements (Figure 3c).

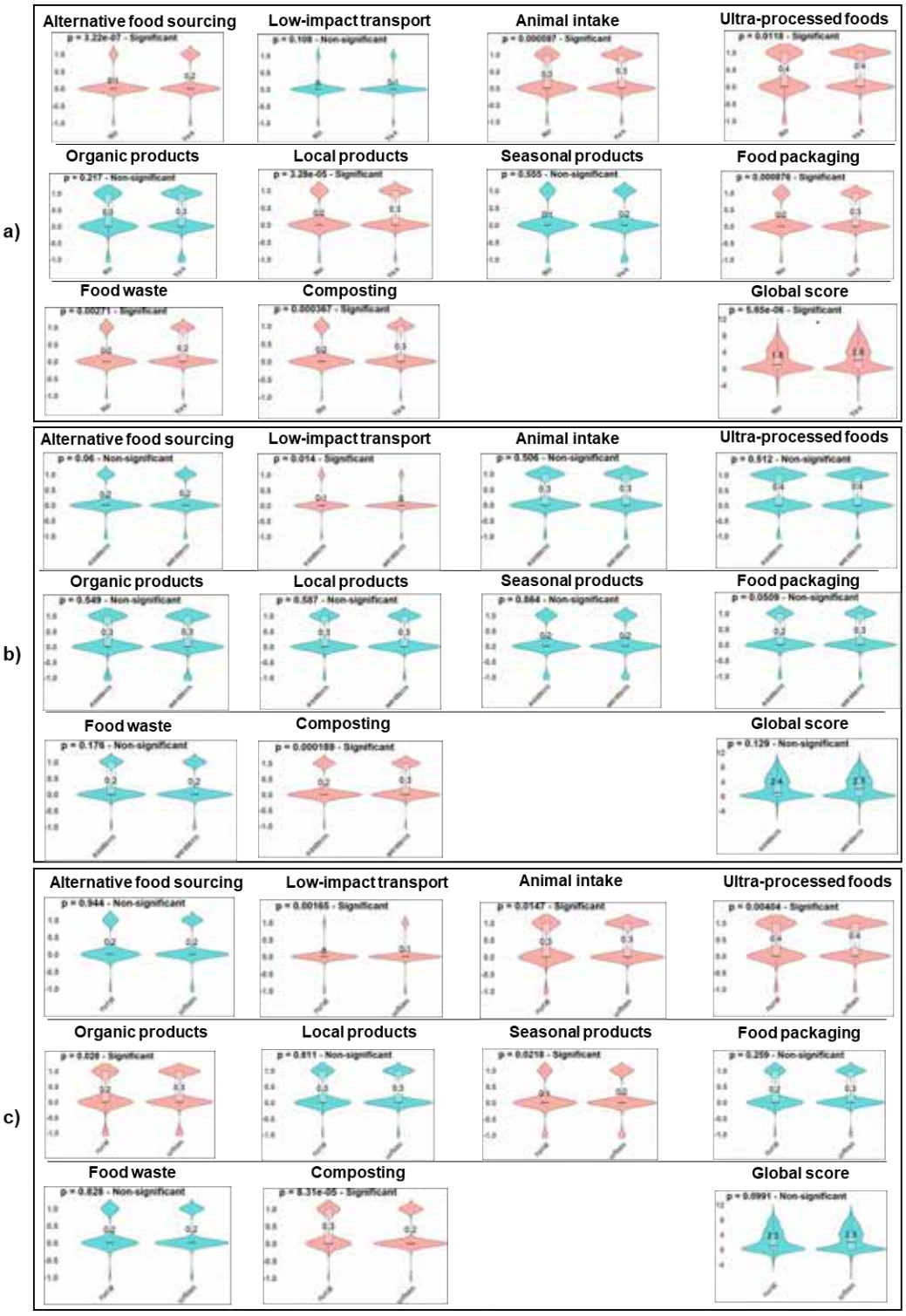

Figure 3. Differences in behavioural change scores across three comparisons: (a) Participants exposed vs. not exposed to local food policy interventions, (b) Residents of western vs. eastern sub-regions, and (c) Urban vs. rural inhabitants. Violin plots show the distribution of individual scores (–1 = negative change, 0 = no change, +1 = positive change) for each behaviour. Plot width reflects response density; mean scores are marked. The global score (ranging from –8 to +10) represents the average number of behavioural changes per respondent within each group. Statistically significant differences ($p < 0.05$) are shown in pink, non-significant ones in blue.

4. Discussion and Conclusion

As revealed in the initial qualitative analysis of local public policies, recent strategies increasingly aim to foster a culture of sustainable eating through awareness campaigns, educational initiatives, school canteen programs, and the development of local food networks. This shift underscores the growing recognition that sustainable food planning cannot rely solely on supply-side measures but must also engage with consumption practices and the social norms that underpin them. Some territories, particularly at the municipal level, appear to be specifically targeted by initiatives designed to construct a positive narrative around sustainable food. This observation is consistent with findings from previous reviews of national public policy interventions (Capacci et al., 2012; Temme et al., 2020; Macura et al., 2022; Ran et al., 2024), which show that informational approaches and educational programs, especially in schools, are the most widespread. Our results are therefore not surprising, given that local initiatives are often embedded within broader national frameworks (Barbour et al., 2021). However, while existing studies on foodscapes predominantly focus on spatial features and the development or transformation of food outlets, the informational and symbolic levers deployed in the studied territories remain relatively underexplored. These interventions tend to rely on non-intrusive, "soft" policy instruments such as informational campaigns, which, although well-intentioned, may not be considered sufficient to trigger substantial behavioural change (Capacci et al., 2012; Mattioni, 2021). By contrast, more tangible, physical foodscape interventions identified in the study area occur at the level of agricultural production, through support for local farming or urban agriculture initiatives. Such changes to the built environment can serve as sources of knowledge and awareness, potentially encouraging healthier and more sustainable food choices (Liu et al., 2016). Nevertheless, like information-based interventions, their broader impact on environmentally relevant consumer behaviours remains largely unexplored and warrants further investigation.

Although the emergence of local sustainable food policies is increasingly well documented, the behavioural transformations associated with them are more difficult to measure. The results of the second step of our analysis demonstrate encouraging signs of behavioural shifts toward greater sustainability in the study area. The most commonly observed changes concern the reduction of ultra-processed and animal-based food consumption, two behaviours with high potential for improving both health and environmental outcomes (Kesse-Guyot et al., 2021). To a lesser extent, significant increases in the consumption of organic, seasonal, and less-packaged products may also contribute to biodiversity preservation, greenhouse gas emission reductions, and natural resource conservation. Despite this, it remains difficult to directly attribute these changes to the expansion of local food planning initiatives. The findings illustrate that behavioural differences are most pronounced among respondents who report having benefited from local policy interventions, primarily parents of schoolchildren, highlighting a potential correlation between policy exposure and behavioural change. It may be hypothesised that recent efforts by local authorities to promote sustainable food publicly are contributing to the emergence of a collective imaginary around environmentally responsible consumption, which, in turn, is helping to shift norms and practices (Robinson et al., 2014). Yet, no substantial differences were found between the western, more policy-active part of the department and the eastern sub-regions, suggesting that positive changes in the overall population may be concentrated within specific social groups. Only two behaviours, low-impact transport and composting, showed significant differences between the west and the east. This can be attributed to the fact that the western sub-sample includes a higher proportion of rural residents, who exhibited lower positive change in transport habits but greater improvements in composting. These patterns are consistent with the rural–urban comparison. Both differences can be explained by spatial inequalities: first, limited access to food retailers in rural areas may reduce the feasibility of low-emission transport modes; second, the greater uptake of composting may reflect increased access to gardens in these areas. Beyond these, our analysis also revealed that an increase in consumption of organic and seasonal foods and reductions in animal and ultra-processed foods, were less frequent in rural areas. These findings corroborate previous research highlighting more pronounced shifts in urban food environments (Hawkes et al., 2017; Tharrey et al., 2024), further underscoring spatial disparities in access to sustainable food transitions. Overall, territorial disparities appear to be non-negligible, suggesting that, beyond known cultural or motivational differences (Guiné et al., 2021), regional and political contexts may also play a significant role in shaping dietary change.

Nonetheless, some behavioural patterns remained consistent across all population segments, regardless of territorial or socio-demographic characteristics. This may reflect broader societal shifts in favour of less processed, more plant-based, and fresher diets, as has been observed in national surveys for parts of the French population (Kesse-Guyot et al., 2021). The absence of clear differences between the policy-rich western sub-regions and the eastern ones also aligns with findings suggesting that informational interventions are only significantly effective when combined with changes in the physical and economic environment, and when implemented in a coordinated, multi-level, and multi-setting approach (Temme et al., 2020; Macura et al., 2022). This level of integration is not yet present in most parts of the studied territory. Consequently, echoing calls from other scholars and practitioners, we argue that to achieve more substantial and widespread progress toward sustainability, local decision-makers must move beyond "soft" informational tools that place the burden of change primarily on individuals. Instead, they should consider implementing more "structural" or "hard" policies that reshape the food environment itself or ideally, a combination of both (Hiller-Brown et al., 2017; Mozaffarian et al., 2018; Mattioni, 2021). These may include regulatory measures (e.g., limits on fast-food outlets and their advertising), economic incentives (e.g., subsidies for sustainable retail infrastructure and improved access to sustainable products for disadvantaged populations), or spatial interventions (e.g., integrating food access considerations into zoning plans). Such actions could complement existing measures and awareness campaigns and make sustainable choices more accessible and default.

It is important to note, however, that our results are based on self-reported data, which may be subject to social desirability bias and intention–action gaps that must be considered when interpreting the findings (Blanke et al., 2022). Although we observed higher positive scores among participants exposed to local food policies, causality cannot be assumed. Individuals already interested in sustainable diets may be more likely to be aware of or benefit from such policies, introducing a potential selection bias. Moreover, food behaviours are shaped by a complex interplay of factors, including socio-demographic variables, personal histories, identities, values, cultural norms, and health events (Furst et al., 1996; Dubuisson-Quellier and Gojard, 2016), and cannot be attributed to policy levers alone. Access to sustainable food is also not evenly distributed, and current interventions may benefit some groups more than others. This is particularly evident in the urban–rural disparities identified in this study. Food planning should therefore be viewed as a means of enabling equal access for all, rather than as a set of prescriptive behavioural instructions. This preliminary assessment thus calls for further research to deepen the analysis of food category-specific changes, explore comparisons across population subgroups, examine underlying motivations, and estimate potential environmental impacts (e.g., GHG emissions). Future research could also compare findings with national or European datasets, such as the NutriNet-Santé cohort (Toujgani et al., 2024). A longitudinal or quasi-experimental design would likewise be valuable in assessing causal relationships and the long-term influence and diffusion of local food policies.

To conclude, this study highlights the central role that local food planning can play in advancing sustainable food systems and contributing to broader climate goals. Our findings show that foodscapes are not static; they are co-produced through public interventions, individual behaviours, and spatial inequalities. Local food planning can serve as a lever to reshape these landscapes over time. While planners and municipalities increasingly recognise the importance of integrating food systems into both urban and rural planning agendas, substantial gaps remain in understanding how to effectively influence food behaviours. Addressing these gaps is essential for achieving long-term environmental, health, and social objectives. Although the concept of the foodscape is still evolving in the literature and the hypotheses emerging from this study require further testing, this research offers novel insights into the complex interrelations between food, place, and people. By examining how regional food policies intersect with environmental goals and behavioural change, it contributes to the growing body of scholarship calling for systemic, place-based approaches to food planning. These findings can help align regional food strategies with broader frameworks such as the EU Green Deal and the Paris Agreement and offer actionable pathways for cities and regions committed to advancing food sustainability in the context of climate change.

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Reconfiguring Food Systems in Egypt's Nile Delta An Agroecological Approach to Delta Urbanism

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Abstract
This paper examines the spatial dynamics of wheat production in Egypt's Nile River Delta, a region vital to national food security yet increasingly threatened by urban expansion and ecological degradation. In response to rising import dependency, the Egyptian government has launched large-scale infrastructural initiatives such as the New Delta project and the world's largest wastewater treatment facility. Using a Delta Urbanism and agroecological planning framework, this study employs layered spatial mapping to analyse land use, irrigation infrastructure, transport networks, and settlement patterns. Findings highlight the limitations of techno-centric desert reclamation strategies and the vulnerabilities of smallholder-based systems. The study advocates for spatially integrated and ecologically adaptive planning approaches, the reintegration of agriculture into urban peripheries and the reconfiguration of food, water, and land systems in deltaic territories.

Keywords: Nile River Delta, food systems, agroecology, Delta Urbanism

Introduction

Wheat is a fundamental crop intricately embedded in the social, political, and spatial fabric of Egypt, particularly within the Nile River Delta. This region, among the most fertile agricultural areas globally, is surrounded by arid landscapes where ancient Egyptians first developed settled agriculture and practiced large-scale farming (Al-Riffai, 2015).

Wheat remains Egypt's most significant crop, with approximately 1.4 million hectares cultivated annually. It is crucial for both household food security and national stability, followed by maize, clover, vegetables, and rice (Molle, 2018). Despite its historical significance and deep cultural roots in the Delta, Egypt has been the world's largest wheat importer since 2007–2008 (Al-Riffai, 2015). The country produces only half of the 20 million tons it consumes, with the remainder imported through a highly resource-intensive supply chain (Asseng et al., 2018). Efforts to expand wheat cultivation in "new lands" have yielded modest increases in production (just 1.9% annually over 2000–2020), insufficient to reduce import dependency below 50% (Gebeltová et al., 2023).

Figure 1: Wheat farmer in the Nile River Delta
source: Baltimore, 2023

Food security and water scarcity remain among Egypt's most pressing challenges. These are exacerbated by saltwater intrusion, uncertain Nile flows, and potential flash floods linked to the Grand Ethiopian Renaissance Dam (Hamada, 2017). Resource scarcity prompts debates on crop reallocation, favoring lower water-demand crops with higher economic value. Simultaneously, recent food crises triggered by the Covid-19 pandemic and the Russia–Ukraine war have reignited discussions on the need for national self-sufficiency in strategic crops like wheat and maize. Egypt's water requirements for wheat under climate change are projected to rise only marginally (2–3% by 2040), yet this increase will not match the escalating demands of a growing population (Hamada, 2017).

In response, Egypt has embarked on ambitious infrastructural strategies, such as reclaiming desert lands and developing the New Delta adjacent to the existing one. While these mega-projects may seem appropriate responses to food insecurity, they have raised scientific concerns about their long-term socio-environmental consequences (Sarant, 2017). This study aims to critically analyze current conditions in the Nile Delta through the lens of wheat cropland distribution, urban expansion, infrastructural development, irrigation, and logistics. It seeks to illuminate pathways for a systemic redesign of the region's agricultural infrastructure as a viable alternative to large-scale reclamation in arid zones. The analysis considers the intertwined dimensions of water, food, mobility, and spatial planning while addressing the ecological, political, and policy contexts influencing wheat cultivation.

Wheat holds strategic and historical importance and, in Fernand Braudel's terms, may be considered Egypt's "crop of civilization" (Braudel, 1979). Egypt follows a tri-seasonal cropping system: winter, summer, and Nili (late summer). Wheat is cultivated as a winter crop, sown between October and December, and harvested by May (Amer, 2017). If wheat was at the center of Egypt's ancient civilization, the deltaic landscape was its spatial foundation. Understanding the interdependencies among water infrastructure, urbanization, cropland allocation, and food transport is central to designing agroecological and spatially adaptive food system reforms.

The Nile Delta is not only Egypt's most fertile region but also its most densely populated. It houses over half of the country's population (Haars et al., 2016), with more than one-fourth living in areas at risk of inundation from a 2-meter sea-level rise. These zones include critical food-producing territories. Even a 0.5-meter sea-level rise would result in the loss of 13% of agricultural land in the Delta. Sea-level rise, increased droughts, and uneven water resource allocation among agriculture, industry, and urban areas pose severe threats to food production in this critical landscape and make it crucial to investigate these territories.

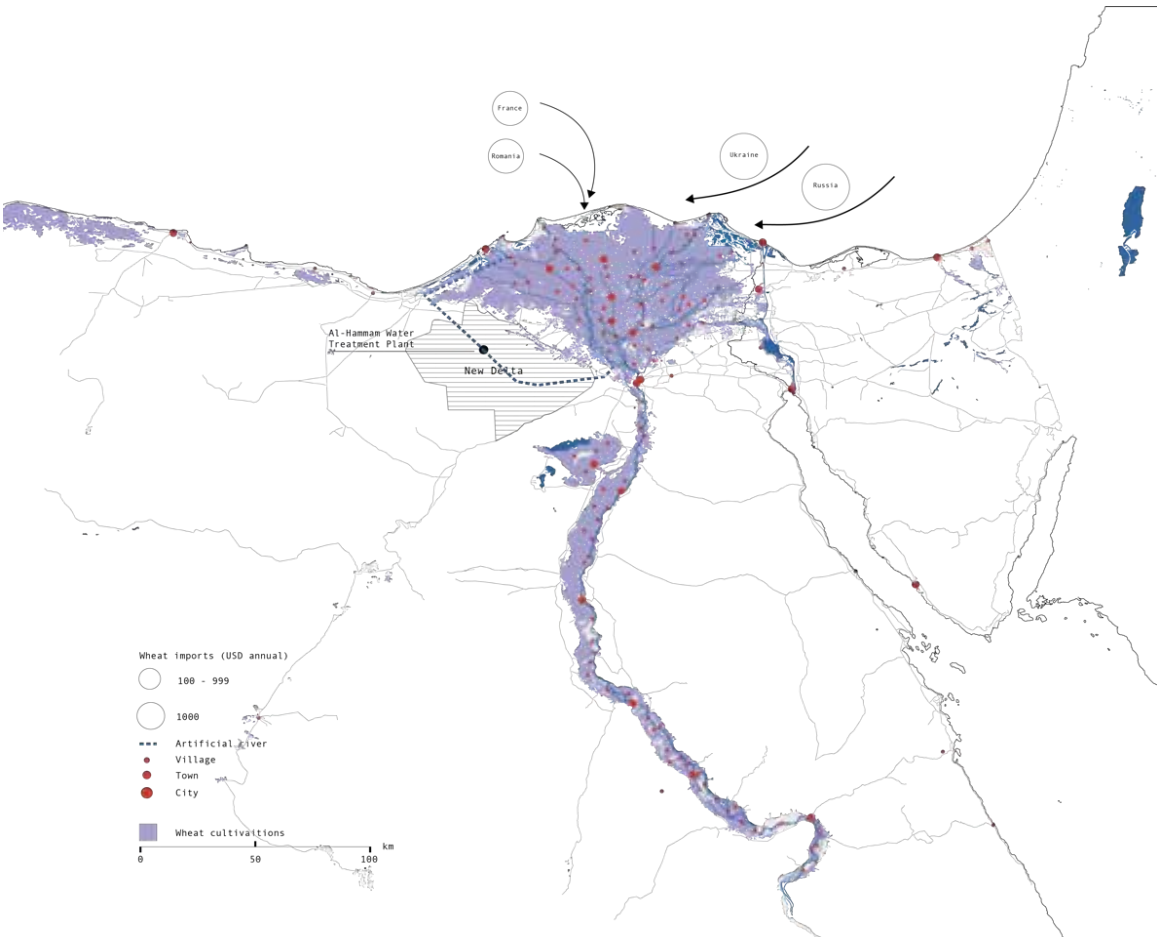

Figure 2: Wheat cultivation allocation in the Nile River Delta, major wheat imports, settlements and New Delta Project
source: Arbara & Hooimeijer

Future transformations and the new Delta project
Recent long term-transformation plans and governmental ambitions to grow strategic crops and particularly wheat include cultivating the arid lands, reclaiming the desert and expanding towards the Sinai Peninsula, west of the Nile Delta (Hegazy & Mohamed, 2023). The project was announced in 2021 by the Egyptian President Abdel Fattah al-Sisi, declaring the expansion of the Nile Delta in a project that involves the reclamation of an area of 9.300 km^2 for agricultural production, cultivation, sorting, packaging and manufacturing. The project aims to re-direct water for irrigation from one of the two branches of the Nile, the Rosetta branch. For this purpose, 50 km long pipes are being constructed along the Mediterranean coast and redirected towards the desert.

"The New Delta is one of the giant projects that will increase the cultivated area in Egypt by more than 1 million feddans.... The new cultivated lands will be planted with strategic crops such as wheat, corn, and vegetables."
El Sayed El Quseir, Minister of Agriculture and Land Reclamation, Egypt

(New Delta, 2025)

Additionally, water will be redirected from upstream to complete the 114 km long waterway that will shape Egypt's largest river (Egypt Independent, 2023). The infrastructural works include 22 kilometers of pipes below ground that transport groundwater, agricultural and drainage water and the river's open part of 92 kilometers.

Wastewater will be treated in what will be the largest treatment plant globally, the Al-Hammam water treatment plant with a capacity of 86.8 m³ per second. In terms of transport infrastructure, the project is located along the Rod El Farag-El Dabaa axis road, a main entrance to Cairo and distributor of food supply (Khatib & Alami, 2024).

Figure 3: The New Delta infrastructure
Source: Khatib & Alami (2024)

This project, called the New Delta, upon completion, will be nearly half of the size of the existing Delta (see Figure 2). There have been doubts that the 1.5 Million Feddan Project of reclaiming the desert will address food crises in Egypt and improve wheat production. Mega Construction Projects (MCPs) represent a strategic option towards achieving sustainable development objectives in developing countries (Othman, 2013).

The narrative of taking over desert land and expanding agriculture and cities in arid lands, has accompanied Egyptian modern history development, although it is questionable how much of the reclaimed land is cultivated. Reclaimed and cultivated land will demand a long period of time to reach a profitable agricultural production with certain impacts on sustainability (Sims, 2014).

Reclaimed desert lands include just a small amount of wheat cultivation of around 11% where large scale and highly mechanized agricultural techniques are being used. Most of the wheat production in Egypt continues to occur in smallholder farms and within the deltaic are of the Nile (Barnes, 2022).

The project comes as a response to the food shortage, increased import prices and reduced available land that the Nile Delta is facing in Egypt. However, it is questionable whether the New Delta Project and other past and future reclamation projects in the desert will address food crises in Egypt and improve wheat production. Experts argue that cultivating the desert is not a sustainable solution but rather an option that comes with high logistical and environmental costs (Luo et al., 2020). Only a small proportion of this newly reclaimed projects in Egypt's desert are located in a place to be irrigated by the Nile River - the remaining area will use water from the Nubian Sandstone Aquifer System, one of the world's largest fossil aquifers lying beneath the Western Desert and parts of Sudan Chad and Libya (Sarant, 2017). Expanding cropland territories towards arid regions comes also with strategies of creating new urban centers in arid regions (water demands will increase). Governments indisputable rationale for food security are used for the implementation and expansion of irrigation projects. The expansion of production on arid lands is rarely contradicted with its ambitions for a high-value, export-oriented agriculture.

Methodological and Conceptual Framework

This paper adopts an agroecological perspective to investigate the spatial, environmental, and infrastructural interrelations shaping the Nile Delta. The methodological foundation is anchored in the framework outlined by Arbara and Hooimeijer (Arbara & Hooimeijer, 2025) which integrates the principles of Delta Urbanism with spatial design and systems analysis. Delta Urbanism offers a transdisciplinary approach that bridges research-by-design with spatial diagnostics to examine productive landscapes within deltaic environments.

The methodology incorporates several interrelated components:

Layered Mapping: Drawing on Meyer and Nijhuis (2010, 2014), this approach visualizes spatial overlaps between wheat cultivation areas, water infrastructure, urban expansion, and climate-related risks. It allows for a nuanced spatial interpretation of current conditions and future trajectories.

Historical trajectories: This traces the long-term development of infrastructural interventions and their environmental implications, from early engineered landscapes to contemporary megaprojects (Braudel, 1996; Hooimeijer et al., 2021). Understanding these historical trajectories is crucial to situating current transformations within a broader socio-ecological continuum.

Agroecological approaches and socio-political landscapes of wheat: By adopting agroecological approaches in urbanism (Molina et al., 2020; Tornaghi & Dehaene, 2021), the study examines socio-political drivers and proposes strategies for integrating food production into multifunctional landscapes. It identifies synergies and trade-offs across variables such as water usage, crop selection, and land suitability, offering pathways for food system transitions rooted in territorial resilience. It also explores the socio-political relevance and importance of wheat for food security touching upon policies of food in the Egyptian context.

By combining these analytical tools, the framework enables a reconceptualization of the Nile Delta not merely as a territory in crisis, but as a dynamic landscape with embedded potential for agroecological transformation. It supports the design of adaptive, spatially integrated strategies that reconcile productivity, equity, and ecological sustainability.

Historical Trajectories of Agricultural and Infrastructural Expansion in the Nile Delta

Human intervention in Egypt's agricultural landscapes has a deep-rooted history, particularly in efforts to extend cultivation into "new lands." Contrary to common perception, the expansion of agricultural areas and establishment of new towns did not begin in the post-1952 era. As Sims outlines, this trend dates back to at least the early 19th century (Sims, 2014). Under the rule of Muhammad Ali, a wave of infrastructure projects and institutional reforms initiated Egypt's modern agricultural transformation, supported by economic and governance frameworks designed to increase cultivable land. By 1820, two million feddans were being cultivated along the Nile, reliant on seasonal flooding. At the time, the population remained below three million. By 1952, cultivated land had increased to over six million feddans, facilitated by the introduction of perennial irrigation, and the population had grown to 19 million (Sims, 2014).

However, the first major engineered interventions in the Nile Delta date even earlier to approximately 1780, when the Ottoman state undertook a series of projects aimed at expanding cultivation into barren or degraded areas. These early efforts mark the onset of large-scale infrastructural manipulation of the delta's hydrology. A pivotal development followed in 1830 with the construction of the Mohamed Ali seawall, designed to safeguard fertile lowland agricultural areas from seawater intrusion (Haars et al., 2016; Warner et al., 2010).

Over the following centuries, infrastructure projects of increasing scale continued to reshape both the physical and socio-spatial fabric of the Nile Basin. The Aswan High Dam, completed in the 20th century, and the Grand Ethiopian Renaissance Dam, nearing completion, exemplify the geopolitical and ecological stakes of river engineering in the region. While Grand Ethiopian Renaissance Dam's primary function is hydroelectric generation, it is expected to impact sediment transport and water availability downstream, contributing to heightened tensions among Ethiopia, Sudan, and Egypt.

Moreover, the modern Nile system is characterized by a vast, human-made waterway network that has severely disrupted natural sediment flows. These modifications have rendered the river virtually sediment-free by the time it reaches the Delta, with significant implications for agriculture, fisheries, and coastal stability (Syvitski & Kettner, 2011).

Taken together, these historical and ongoing infrastructural interventions illustrate a broader transformation of the Nile Basin. Wetlands and coastal dunes have been systematically converted into farmland and urban zones, underscoring the entanglement of environmental engineering, agricultural policy, and transboundary water politics in one of the world's most hydrologically and geopolitically complex regions.

Spatial layers approach

To unravel the contemporary agrarian crisis in Egypt, a spatial layer's approach that considers overlapping geographies of crop cultivation, infrastructure, ecological dynamics and urbanization processes is key to unveil the complexity of interrelated challenges. The map (Figure 4) visualizes four key spatial layers that structure the dynamics of wheat production and land reclamation in Egypt today. Urbanization processes, cropland configuration, deltaic dynamics and transportation systems are the main layers considered and analyzed below.

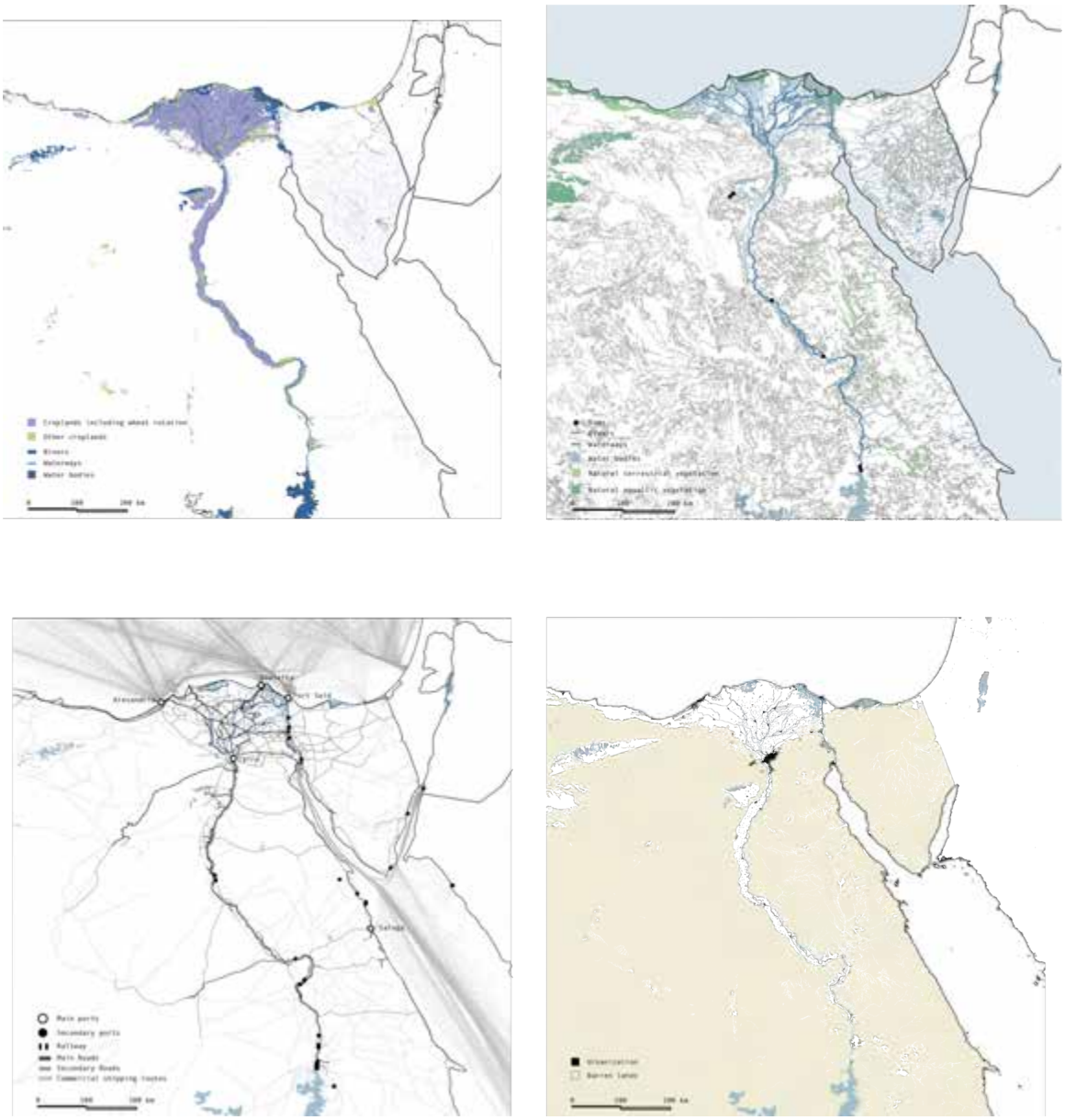

Figure 4: Spatial layers of cropland configuration, deltaic dynamics, transportation and urbanization patterns in the Nile River Delta
source: Arbara & Hooimeijer, 2025

Urbanization
"Due to sea-level rise, out of a total area of 25,000 km^2, between 1,800 and 4,500 km^2 of crop land may be lost by the year 2100. At the same time, urban expansion will claim between 12,500 to 25,000 km2 of the delta." (Rashid, 2023)

The Nile River Delta comprises both the world's longest river as part of one of the oldest deltas with highly fertile and productive agricultural soils while shaping one of the most extensive urban networks and being home to almost half of Egypt's population. In the River Delta, extensive urbanization appears to be over five times more of a challenge to cultivable land than climate change. Looking back, only in the past 50 years population growth along with urban expansion led to a decrease of agricultural land per capita by two-thirds (Sarant, 2017). The massive population increase occurred through formal and informal urbanization. Formal, located mostly in building new communities in the desert and informal, with taking over adjacent land on agricultural areas. The fact that this land was already equipped with water and electricity infrastructure in relation to the high land prices made informal expansion popular amongst poor communities (Salem et al., 2020). Also, the recovery of resettlement land projects to relocate agricultural lands in the past have not been successful, as only half of designated resettlement land has been utilized.

Urban growth occurs in the Nile River Delta either by filling the gaps between urban and rural areas and villages or by following existing road infrastructure. In some cases, even canals of the irrigation infrastructure are being covered by rapid urban expansion (Alfiky et al., 2012).

Figure 5: Farmland decrease in the Nile River Delta
source: Landstat image gallery, NASA

Figure 6: Farmland expansion to the Desert
source: Landstat image gallery, NASA

Cropland configuration: wheat cultivation areas
Agricultural land in the Nile River Delta is a patchwork of small fields, connected by 40.000 kilometers of irrigation canals. Most farmlands range from 0.5 to 2 hectares and farmers may own small parcels of land scattered across different field with the average being around one hectare (Sarant, 2017). Wheat is mostly produced by smallholders in small-scale irrigated farms the "old lands" (Al-Riffai, 2015, Abdalla et al., 2023). In 2015, wheat was grown on 4.3 million small farms (FAO, 2015, Barnes, 2022). Wheat is the crop which takes over the largest surface cultivated during the winter period (around 60%), planted in the months of October to December and harvested from April to May (Nasr, 1955).

Wheat occupies more than half of the cultivated winter area (Negm, 2019). According to an extensive survey taking place in 1998, most wheat farmers where practicing wheat farming as their main activity along with other occupations including work in the public and service sector (Kherallah et al., 1999). Also, part of their yield was dedicated to proper consumption while the remaining one was sold to the government. Agricultural activities in the Nile River Delta follow still low-tech methods, with sowing and harvesting in many farms that lie between the Aswan High Dam and Cairo occurring by hand and in small scale farms (Barnes, 2022).

Over the past years average farm size has decreased significantly; this land parcellation of farms makes design and planning of the water management systems challenging and is a result of rapid population increase and the inheritance system. Farm size has decreased from 6.3 feddan (a feddan is 1.03 acres) in 1950 to 3.2 feddan in 1960 and to 2.1 in 2000 (Negm, 2019).

Also, the small size of the agricultural plots comes with poor economic benefits and increased challenges of management for farmers; consequently, they seek to convert the lands into urban (Salem et al., 2020).

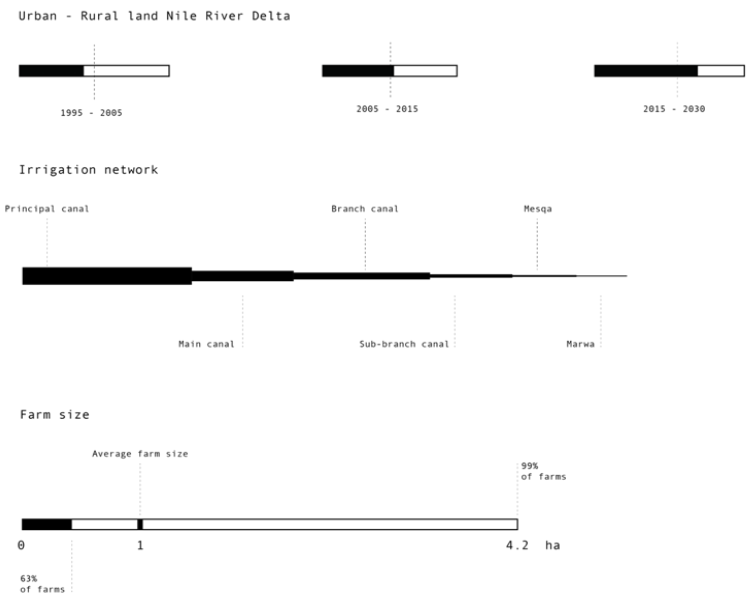

Figure 7: Infographics on Urban – rural land expansion, Irrigation network and farm size in the Nile River Delta
source: Arbara & Hooimeijer

Deltaic dynamics and water infrastructure
In no other country, perhaps, is the identification between water, irrigation, and agriculture as strong as in Egypt (Molle, 2018). As stated in almost every research paper on the Nile River Delta, it is the Nile that, being the source of 96 percent of Egypt's water, allows for life in Egypt to happen (Barnes, 2014). As rainfall is not enough at no part of the Delta to support agriculture, intensive agricultural production is only possible by irrigation (Finch, 1918). Irrigation in the Nile River Delta involves a complex case, both for its size and structural organization (Molle et al., 2019). Its size extends over 20.000 kilometers of a dense network of canals that provide water to croplands of nearly two million farmers (Rap & Dutta, 2013). All types of irrigation technology can be found, from gravity and sprinklers to drip and pivot, using water pressurized by individual pumps or collective pumping stations (Molle, 2018).

The conventional structure of the distribution involves five levels. First, the main feeders (rayah), main canals (primary), branch canals (secondary), mesqa (tertiary) and marwa (quaternary field ditches) (Molle et al., 2019). The structure is not always straightforward, as branch canals may fork out and have subbranches and others might be relatively small, serving 500 feddans. The names are connected to the legal status of the canals: branch canals are public property, whereas mesqas are located on private land, thus owned and maintained by farmers.

Water is traditionally distributed between branch canals based on a rotatory system (5 days on and 5 off in summer, 5 days on and 10 days off in winter). Efficiency, equity, and timing are key issues in water management in understanding how water is distributed upstream (the ministry) and downstream (individuals or groups of farmers) (Molle et al., 2019).

Amongst the main problems of the current irrigation system is the uneven distribution and allocation of water resources between those at the head and end of the canals. Those at the heads of the canal complain not having enough water to grow the crops they would want, those at the end have no water at all and have to cope with an increased uncertainty of water availability (Barnes, 2014).

The management costs and water scarcity led to irrigation reforms in the form of infrastructural improvement

and water management like the Irrigation Improvement Project (IIP) launched in 1987 and expanded to the Integrated Irrigation and Management Project (IIMP) (Molle et al., 2019; Rap & Dutta, 2013). However, the system can still be considered as lacking in using efficient the available resources; research showed that crops only use 47 % of the irrigated water, the rest is lost through the extensive drainage systems. (Haars et al., 2016) "Irrigation improvement projects" aimed at providing a better, more continuous flow and deal with uncertainty of water availability by stabilizing the supply into (secondary) branch canals from where collective pump stations would then deliver water at the tertiary level (mesqa).

For the water demands, also a better monitoring of the crop allocation could turn out to be a useful method to utilize the resources as different crops would require each different amount of water. Crop water needs differ with wheat water needs ranging from 450mm to 650 mm during a growing season. The range for cotton would be 700-1300 mm and 1500-2500 for sugarcane (Amer, 2017).

After rice and sugarcane, maize, wheat and berseem are the highest water consumers per crop in the Nile delta (Amer, 2017). When perennial irrigation was introduced, crop alteration between two crops per year became possible and is the most common strategy while there are three growing seasons: winter from November to May (shitwi), summer from April/May till October (sefi) and the Nili period which goes from July/August to October.

Wheat, similar to maize, is cultivated mostly under surface irrigation with a low application efficiency (ea) of around 60% (Ouda et al., 2014). Changing the irrigation to sprinkler for wheat could increase this application efficiency from currently 60 to 80% under sprinkler irrigation (Ouda et al., 2014). To be able to expand cropland areas, a transition from traditional irrigation systems to modern ones is put in place. Irrigation to drip and sprinkler irrigation has initiated as a pilot project. However, since less water comes through the drainage water (agricultural runoff) it contains higher concentration of salt. Questions on water use efficiency rise: currently there might be a lot of water lost in the actual plot from the irrigation method, but the overall system is quite efficient as higher part runoffs are then being reused in lower parts. With the drip irrigation system there might be less water lost but the loss then may be a lot higher in salt concentration.

"The seasonal rhythm of the delta climate is such that more than one crop can be taken per year provided that adequate water is available; perennial irrigation as a result of the storage of flood waters for gradual dispersal in irrigation rotations made possible the practice of multi-cropping"(Nasr, 1955). Also, more than three-quarters of the land of wheat farmers is irrigated by a pump from a canal (Kherallah et al., 1999). Other strategies of modernizing the irrigation system have been the installation of subsurface drainage in some areas and not in others which has contributed into creating lines of inequality. Farmers not having access to subsurface drainage consider not having access to drainage if only supported by drainage ditches. Having or not access to subsurface drainage is not related to having enough water, but to being able to remove excess water from the system (Barnes, 2014).

"The quantity of water that reaches the Delta depends on how much has been released from the High Aswan Dam (HAD) and how much has been consumed for human and agricultural purposes along the Nile Valley. This second term varies with cropping patterns but is relatively stable since all return flows end up back in the river" (Kebede et al., 2014).

Transportation of wheat and storage

Until the 1950s, Nile and its canals served as a transport route for goods with around 25% of them being transported via the River. The transportation has shifted significantly since then, with the Nile transportation today accounting for 1%, despite the two main inland waterways (Damietta and Rosetta), offering all year-round navigation (Redeker & Kantoush, 2014). Trucks, railway cars, and barges play a vital role in moving wheat (Barnes, 2022). The waterways are used, however, for touristic purposes (with the touristic cruises) and to some extend for the transportation of commodities even though no large-scale transportation with barges is happening. Permission from the government has been stated as part of the reasons (FAO, 2015). Also, no sea transportation from the Nile

abroad is taking place; while there are no wheat exports, large amounts of wheat are imported arriving through sea routes in one of the ports of Damietta, Port Said or Alexandria.

Wheat produced in the Nile River Delta is first transported in sacks to large open areas with dirt floor, known as shonas. These are then gradually transported and stored in silos before being milled into flour (Barnes, 2022). Researchers have pointed out lacunas in the grain storage and transportation infrastructure of Nile River Delta. It is estimated, that due to long distance transportation in unrefrigerated flatbed trucks carrying overflowing crates, more than one third of carried goods does not arrive in healthy conditions at the final destination as trucks often cover distances of more than 900 km. Also, shonas, unlike silos, that offer a better control of atmospheric conditions, storage in shonas often comes with risks of exposure in humidity, increased temperatures and contamination by dirt and stones (Barnes, 2014).

Figure 8: Harvested wheat seeds transport
source: Baltimore sun, 2023

Agroecological approaches and future pathways

Wheat is mainly consumed in Egypt in the form of bread called aish baladi, a staple for its population, as Egyptians obtain approximately one-third of their caloric intake mainly in the form of bread or other wheat-based food. Until the 1970s, Egypt produced most of its wheat having a self-sufficiency ratio of around 70 percent (Chapin Metz, 1990). This declined significantly in the coming years so that by the mid-1980s, only a fifth of the wheat was produced in Egyptian territories (Barnes, 2022). Following the agricultural liberalization in the 1990s and the 1987 reforms on converting a state dominated agricultural sector into a more market oriented economy, domestic wheat production returned into meeting about half of the country's needs (Kherallah et al., 2000). Despite this, population increase is putting pressure in wheat gaps which are facing an increasing trend in Egypt with the government announcing that incentives for farmers would be given in order to increase the country's wheat production (Abdalla et al., 2022). However, so far, while a massive economic budget of the Egyptian state was allocated to subsidize the wheat supply chain, from producers, milling, bakeries and end consumers, smallholder farmers have remained largely neglected in this process.

Wheat is key not only to ensure food security but also political stability in the country; food riots, as a result of a cut on subsidies that were called also "bread riots" were the reason for social unrest in 1977. In the Egyptian revolution of 2011, "Bread, freedom and social justice" was part of the main messages with bread being one of the core demands of the population (Abdalla et al., 2022).

Rising inflation has brought up new policies on providing discounted bread to the majority of the population (more than 70 million) through a food subsidy program starting on January 2023 with prepaid food cards (Henda-

wi, 2023). With Russia and Ukraine being amongst the biggest import suppliers of wheat for the country (85% of wheat imports in 2021 came from there), the Russian Ukraine war has added to the wheat crisis and vulnerability of the food system in Egypt (Abdalla et al., 2022).

Wheat is historically and politically a crucial commodity in Egypt; with future predictions indicating that wheat demand will increase twofold by 2050, wheat becomes a crucial crop to examine within the context of the Nile River Delta. The ministry of Agriculture is responsible for managing the production of this crop which is considered a strategic crop for the country (Barnes, 2022). All cultivated wheat in the Nile River Delta either remains at the farmers household consumed mainly in the form of bread, or returns into being government – subsidized bread, sold across the country's bakeries. Egypt does not export any wheat.

Figure 9: Queuing for subsidized food (Baladi Bread)
source: Sarant, 2017

The challenges facing wheat production and consumption in the Nile Delta necessitate a shift away from techno-centric approaches toward agroecological and spatially integrated planning. Deltaic regions demand tailored strategies that reconcile hydrological processes, land-use pressures, and socio-political objectives. The paper summarizes four main strategies: (1) reintegrating agriculture into urban peripheries to mitigate land loss from sprawl, (2) restoring sediment flows through reassessment of upstream dam operations and the implementation of nature-based solutions, and (3) designing multifunctional infrastructures that simultaneously serve ecological and food security functions (4) re-evaluating the structure of Egypt's food systems, food accessibility and export-import dynamics.

Addressing wheat supply requires a combined approach expanding cultivated areas, enhancing productivity, and minimising food loss, implementing food policies (Yigezu et al., 2021). When considered through the lens of delta ecosystems and long-term sustainability, this approach challenges short-term, human-centred planning paradigms. Large-scale projects like the New Delta may be avoidable if existing food systems, land use, and distribution infrastructures are redesigned. A systemic, cross-sectoral transformation across spatial scales is essential for sustainable food security in the region (see Figure 10).

Figure 10: Spatial impacts and changing dynamics of wheat landscapes across scales in the Nile River Delta
source: Arbara & Hooimeijer, 2025 adopted from Kuzniecow Bacchin (2015)

A first step towards this direction would be to better integrate current hydrological cycle and water dynamics within the built environment. In Egypt, the Nile is considered often as the only valley. Yet, there are a series of wadis which often remain disregarded (Malek & Redeker, 2020). In place of single, large desert reclamation projects, the potential to integrate wadis as cultivated landscapes and propose an alternative design model for desert cities exists (Malek & Redeker, 2020). At the same time, spatial planning and design strategies for the rapid formal and informal urbanization that control unregulated urban expansion shall be set. The National Urban Policy for Egypt to transition towards compact cities with adequate density, services and resource efficiency (Alternative Policy Solutions | Developing a National Urban Policy for Egypt: Towards Compact Cities, Egypt Vision 2030 and the National Strategic Development Plan 2052) are steps towards limiting the unregulated expansion of urbanization. Also, considering the expansion on arid lands, which currently focuses a lot on creating land for cultivation, uses that require less intensive water use could become the prior strategy if developing these areas, keeping the agricultural land in the fertile soils of the delta (Sarant, 2017). Linking back to the initial theoretical framework, research showing that already cultivated land is to a larger extend more fertile and thus should not be reallocated raises again the question of whether ambitions of reclaiming desert land are and to what extend a valid solution
.
Irrigation and drainage infrastructure is another complex, linked to spatial, political and socioeconomic dynamics aspect of food systems. Changes in the irrigation system involve three levels; first, operational (upgrading the infrastructure/technologies in place), second operating on solving inequalities (who has access, how much and when to resources) and third, ensuring that existing water infrastructure will not be impacted by expanding urbanization. On the first, modernizing the Marwa hydraulic system from open canals to pipelines or lined canals is one step which affects also water rights and access to resources. In fact, pilot studies showed an increase in income and cropped feddan and equal access to water resources for all farmers (Modernizing Irrigation Improved Water Security for Farmers in Egypt, 2020). The installation of electric pumps instead of diesel ones and a systematic rotation of irrigation showed that end tailers receive better water flow (85% from 50% before) (Barnes, 2014). Also, modernizing the equipment (pipeline irrigation compared to earth Marwa canals) makes it easier for female farmers to operate and participate in the process. Lastly, ensuring that irrigation canals will be properly maintained and protected by increasing urbanization is another key strategy.

Changing crop sequence from cultivation of one and two crops per year to three crops per year winter, fall then summer crop or winter, early summer then late summer crop can help in solving food gaps problems in Egypt

(Amer, 2017). Climate change impacts will still be present in agricultural production and differ between crops, crop cultivars as well as cropping systems (Nkwasa et al., 2023). Yet, cultivar adaptations into triple-cropping systems instead of single-cropping ones will mitigate crop yield reduction (Nkwasa et al., 2023).

Farm configuration and ownership models play a significant role in how wheat croplands are linked to the social, economic and spatial dynamics of the delta. Over the past years, smallholders have been negatively impacted by long term policies and governmental decisions, leading them to a decreased wheat production (Abdalla et al., 2023). Changes in policies such as the declared by the Ministry of Supply and Internal Trade price, regulations on production costs (pesticides, fertilizers, seeds) which are currently at unaffordable rates for smallholders as well as access to knowledge and information are steps taken to enhance productivity and willingness to grow wheat at a smallholder level (Abdalla et al., 2023). Also, the fact that farmlands are small and fragmented means that selling them for urban is easier and at the same time, that production costs and machinery are more challenging for farmers of a small plot of land. With increasing land fragmentation and decreasing farm size in the old lands, a better monitoring of land conversion from agricultural to urban would be necessary and at the same time, changes in the nature of cultivating wheat productive territories to support ecosystem services should be implemented. Changing wheat cultivation methods from cultivation in basins or on narrow rows to raised beds is another strategy to cope with saving on water resources. Additionally, raised beds cultivation has shown to be more efficient not only in water but also nitrogen and soil quality (Amer, 2017).

At another level, structural changes to synergize wheat cultivation with existing transport and storage infrastructure in the Delta is perhaps amongst the most important steps towards a more sustainable food system. Road infrastructure improvements along with including the water transportation and advances in the current, poorly maintained shona storage system could significantly lessen the gap of food losses in the deltaic area.
Lastly, for structural changes to happen in the wheat production and the food system overall, all of the aforementioned steps will have to be synergized with the deltaic dynamics of the Nile River Delta. Sediment deficit and shortage of freshwater supply along with rising sea levels and salinity are putting great stress on resources, questioning for how long engineering efforts will prevent the disappearing of the Nile River Delta.(Redeker & Kantoush, 2014) Strategies on urbanizing arid lands, outsourcing of agricultural activities, changes in cultivation are amongst future scenarios but as much as the interlinked threads of food scarcity, water scarcity and energy scarcity have to be addressed at the local and territorial dynamics these have to be addressed at a planetary scale.

Conclusion

The transformation of Egypt's wheat landscapes is both a reflection of centuries-old practices and a test of contemporary governance, planning, and sustainability strategies. While mega-infrastructure projects like the New Delta symbolise ambition, they often overlook the nuanced and systemic challenges embedded in food, water, and land management. Rather than defaulting to techno-centric fixes, this study argues for agroecologically grounded planning which recognizes the Nile Delta's spatial, ecological, and cultural fabric. Future strategies must integrate multifunctional land uses, promote urban–agricultural synergy, and ensure that policy and investment support smallholder farmers who form the backbone of Egypt's wheat production. Improving irrigation efficiency, restoring sediment cycles, enhancing local storage and transport infrastructure, and addressing land tenure issues must collectively underpin any meaningful reform. Ultimately, designing resilient delta food systems will require moving beyond short-term self-sufficiency goals to long-term ecological and social sustainability in Egypt's most critical agricultural heartland.

The transformation of Egypt's wheat landscapes is not merely a technical endeavor but a deeply socio-political and ecological challenge. Large-scale infrastructural projects like the New Delta present ambitious visions but fall short in addressing systemic vulnerabilities of water and land use. Adopting agroecological approaches within the framework of Delta Urbanism provides a pathway for designing resilient, adaptive food systems in deltaic regions.

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Empowering Women through Food Production from the Perspective of Cooperatives

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Abstract
Cooperatives are increasingly seen as alternatives to profit-driven food systems, offering economic and social inclusion for disadvantaged groups, particularly women. This study examines women's perceptions and experiences within food production cooperatives in Türkiye, focusing on the Antalya Köy Pazarı Women's Cooperative. Drawing on participant observation and semi-structured interviews, the study explores motivations for participation, daily impacts, and cooperative operations. Findings indicate that economic independence is the primary motivator, but social benefits such as confidence-building, knowledge sharing, and community engagement are equally significant. Women's cooperatives emerge as key mechanisms for fostering empowerment, enhancing well-being, and strengthening women's roles in both family and society. The research highlights the transformative potential of cooperatives as inclusive and sustainable models in food systems.

Key words: Food Production Cooperatives; Gender Equality; Economic Empowerment

1.Introduction

Since the onset of industrialization, the traditional corporate model has dominated food production and distribution, often prioritizing profit over social and environmental concerns. However, in recent years, there has been a growing interest in alternative business models that emphasize community-oriented, environmentally friendly, and socially conscious approaches to food systems. While not a new concept, cooperatives have emerged as prominent alternatives to conventional structures in the food sector (UN, 2023).

By nature, cooperatives aim to support the interests of all members—producers, workers, or consumers. They offer opportunities to empower local communities, promote sustainable agricultural practices, and build a more inclusive and equitable food system. Unlike centralized corporate decision-making, cooperatives operate through democratic processes, positioning them within the scope of social entrepreneurship.

Feminism, as a movement advocating for gender equality and women's empowerment, plays a significant role in women's cooperatives. Emerging in the 19th century, feminism evolved through various phases. Liberal feminism was one of the earliest strands, highlighting women's secondary position in society and calling for equal participation. In contrast, Marxist feminism explains women's oppression through modes of production and patriarchal labor relations, where women's labor is appropriated by male figures (Black, 1984; Taş, 2016).

A core goal of feminism is women's economic independence, which requires equal access to education and skill development. Women's cooperatives serve as platforms where women gain control over their labor, access learning opportunities, and improve their skills. Beyond economic empowerment, these cooperatives enhance women's social participation, self-confidence, and access to networks and resources.

In Türkiye, women's cooperatives operate under the Cooperative Law No. 1163 (KEİG, 2018). However, due to traditional gender roles, they are often treated as a distinct category with a strong emphasis on local development and women's socio-economic inclusion. The Marmara Region hosts the highest number of women's cooperatives (Table1), followed by the Mediterranean, Black Sea, and Central Anatolia regions.

Table1. Geographic Distribution of Women's Cooperatives in Türkiye (Şahankaya Adar et al., 2023).

Geographical Area	Active	Passive
Marmara	182	3
Aegean	130	-
Central Anatolia	157	1
Mediterranean	154	-
Black Sea	155	-
Eastern Anatolia	89	-
Southeast Anatolia	73	-
Total	940	4

An important milestone in this field was the "Empowerment of Women through Cooperatives" project (2021–2024), jointly implemented by the Ministry of Agriculture and Forestry and the General Directorate on the Status of Women. Co-financed by the EU, this initiative led to the formation of the Women's Cooperative Network. Member cooperatives are active in areas such as production, services, marketing, and other sectors. Among them, production cooperatives are most common (Url-1).

This study aims to understand the relationships that women establish with food production cooperatives and the role these organizations play in their lives. The central research question is: "What are the perceptions and experiences of women members of food production cooperatives regarding their cooperatives?" Antalya, one of Turkey's major agricultural cities, was selected as the research site. Of the 22 women's cooperatives operating in Antalya, 15 are engaged in food production, with four located in Kepez, a socioeconomically disadvantaged district. While there is a growing body of literature on women's food production cooperatives, each cooperative and its members have unique experiences and relationships with their organization. This diversity underscores the importance of examining cooperatives within their specific socio-spatial contexts. Accordingly, this research adopts a qualitative, phenomenological design, and selects the Antalya Köy Pazarı Women's Cooperative as a case study. Data were collected through participant observation and semi-structured interviews with cooperative members, and analyzed using content analysis. The experiences of cooperative members are categorized into three main themes: motivation, impact on daily life, and cooperative operation.

2.Methodology

2.1 Research Context and Case Selection

This study adopts a phenomenological qualitative research design to explore the lived experiences of women engaged in a food production cooperative in Antalya, Türkiye. Phenomenology is particularly suitable for understanding how individuals perceive, interpret, and make sense of specific phenomena through their personal experiences (Tekindal & Uğuz Arsu, 2020). The selected case is the Antalya Köy Pazarı Women's Cooperative, established in 2019 in partnership with the Kepez Municipality. This cooperative produce and sells a variety of natural food products, including honey, tahini, molasses, vinegar, and gluten-free flours. The phenomenological approach enables an in-depth exploration of the subjective meanings that cooperative members assign to their roles and involvement in the organization.

2.2 Data Collection

Data were gathered through semi-structured interviews and participant observation. Two interview protocols were designed: one for founding members (management) and one for cooperative workers. The questions were grouped into thematic blocks covering general background, motivations, daily life impact, and roles within the cooperative (Table 2).

Table 2. Semi-Structured Interview Question Groups

Group Code	Question Groups	Focus of Questions
A2	Cooperative foundation, motivation and operation	Reason for founding Why a women's cooperative Challenges during establishment Current problems Decision-making processes How it changed your life Part of daily routine Being a woman Being a female entrepreneur Reactions from others Relationships among members Impact on women's lives Unforgettable memory Future goals Previous life How it changed How she feels Workload Reactions from others Daily routine Decision to join Motivation Why a women's cooperative How she defines it Social relationships with co-workers Responsibilities Cooperation and mutual support What it brought to you Current problems Unforgettable memory Future goals
A3	Impact on daily life	
A4	Role in the cooperative	
B2	Impact on daily life	
B3	Motivation and expectations	
B4	Role in the cooperative	

Three women with varying roles within the cooperative participated in the study: one manager, one producer, and one social media coordinator. Due to scheduling and accessibility constraints, two interviews were conducted by phone and one was conducted in person at the cooperative's production site. Interview durations ranged from 32 minutes to 79 minutes, with an average length of 59 minutes. All interviews were audio recorded with the participants' consent and later transcribed. Informal communication prior to interviews helped establish rapport. To support the interviews, participant observation was conducted at the cooperative's production site. This method allowed the researcher to gain contextual insights into daily operations, interpersonal dynamics, and the physical environment in which the cooperative operates. Field notes were taken during the visit, which enriched the interpretation of the interview data.

2.3 Sampling Strategy

A purposeful sampling strategy was employed to select participants who could provide rich and relevant insights into the cooperative experience. A chain sampling technique was applied, whereby initial contact with a key informant led to the recruitment of additional participants. The sample included individuals with diverse roles

and experiences within the cooperative to ensure a variety of perspectives.

2.4 Validity, Reliability, and Ethical Considerations

To ensure credibility, two qualitative techniques was applied through multiple data sources (interviews, observation). Interview questions were derived from both literature and field knowledge. Member-checking was informally conducted by maintaining open channels with participants for follow-up clarification. Audio recordings were transcribed, and coding consistency was ensured through iterative reading.

Ethical approval was not required for this study. However, verbal consent was obtained from both the cooperative and individual participants. Participants were informed about the study's aims, and interviews were conducted in spaces and times they found comfortable. Audio recordings were made with permission; otherwise, notes were taken during the conversation.

2.5 Data Analysis

Thematic analysis was employed using both inductive and deductive approaches. Transcripts and field notes were coded and categorized using MAXQDA 2024. Codes were grouped into three main themes: Motivations, Impacts on Daily Life (Figure 2), and Cooperative Operation (Figure 3).

•Motivations included both social (e.g., solidarity, socialization, environmental values) and economic drivers (e.g., financial independence, employment) (Figure 1).

Figure 1. Motivation Theme Hierarchical Code Model

•Impacts on Daily Life covered perceived benefits (e.g., personal development, social relationships), responses from family/community, and peer interactions at the workplace.

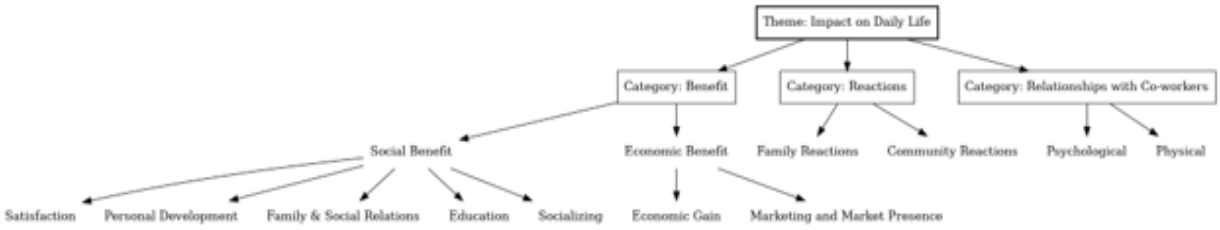

Figure 2. Impacts on Daily Life Theme Hierarchical Code Sub-Code Model

•Cooperative Operation explored internal organization, roles, challenges (e.g., market competition, lack of external support), and collaboration mechanisms.

Figure 3. Cooperative Operation Theme Hierarchical Code Model

These themes reflect the complexity of women's engagement in food production cooperatives, encompassing both personal transformations and institutional constraints.

3.Findings

A word cloud was generated based on the transcripts of the interviews. The visualization was created using MAXQDA, which analyzes all the words in the uploaded document. Accordingly, in the creation of the word cloud, the interviewer's statements were excluded, and only the participants' expressions were considered. Different grammatical forms of the same word were merged. As expected due to the nature of the study, the most prominent words in the cloud are "cooperative" and "woman." Additionally, words such as "production," "market," and "product" also stand out, aligning with the research topic. These are followed by possessive terms like "own," "mine," and "we." Furthermore, words such as "more," "big," "as much as," "included," "a lot," and "now," which imply a forward-looking perspective or comparisons between past and present, are also highlighted. This indicates that participants tend to interpret their relationship with the cooperative through a sense of ownership and temporal comparison (Figure 4).

Figure 4. Word Cloud

The findings of the study were coded under three main themes: Motivation, Impact on Daily Life, and Cooperative Operation, as described in the previous section. A code cloud was created based on the frequency of these codes (Figure 5). In this visualization, green tones represent codes under the Motivation theme, blue tones represent codes under the Impact on Daily Life theme, and red tones represent codes under the Cooperative Operation theme. The most frequently repeated color in the code cloud is blue, indicating that the Impact on Daily Life theme contains more codes and sub-codes compared to the other themes.

Figure 5. Code Cloud

3.1. Motivations

Under the theme of Motivation, the study primarily aims to answer the research sub-questions regarding participants' perceptions of the cooperative and their reasons for joining. The findings are grouped into two main categories: **economic motivation** and **social motivation.**

Although one might expect economic concerns to be the primary reason for joining the cooperative, "solidarity and mutual support" emerged as a crucial underlying factor for women's participation. Within the dimension of economic motivation, the sub-code economic independence was frequently emphasized. For the participants in this study—already engaged in production prior to joining—the concept of economic independence is interpreted as the ability to earn income through their own labor.

Many of the women had previously sold products at the Antalya Village Market but remained financially dependent on their spouses or families. Participation in the cooperative enabled them to achieve economic autonomy. According to Participant 1 (K1), women who previously sold their goods at prices far below market value through informal channels started to sell at market prices through the cooperative. Moreover, the cooperative's policy of purchasing unsold goods provided an additional economic incentive.

Another economic factor mentioned was education and employment. Although not a primary motivation for joining the cooperative, participants acknowledged receiving training as part of state- or municipality-supported initiatives. The fact that all participants were already producers before joining suggests that economic motivation stemmed more from a desire for independence from male-dominated financial structures than from an intent to enter employment from scratch.

The code with the highest number of references under the Motivation theme is solidarity and mutual support, which falls under social motivation. Participants frequently emphasized the significance of producing together and being united. The word cloud (Figure 4) also highlights the prominence of the collective identity expressed through the term "we." While economic concerns were motivating factors for Participants 1 and 2, Participant 3 joined the cooperative solely to support the other members.

Socialization also emerged as a motivational factor. The importance of socialization is partly due to participants already knowing each other through the market setting before the cooperative was formed. During the interviews, participants noted that they also interact outside the cooperative—visiting each other, meeting at the office, and developing close bonds. This suggests that socialization and solidarity are intertwined and mutually reinforcing motivations for participation. The women perceive the cooperative and the village market as an integrated space for social engagement.

3.2. Impact on Daily Life

The theme Impact on Daily Life aims to understand how women cooperative members experience the cooperative and how it is reflected in their daily lives. This theme comprises the categories of Benefit, Relationship with Co-workers, and Reactions. The category Benefit includes two subcategories: Social Benefit and Economic Benefit. The findings suggest that the women's food production cooperative primarily contributes to social benefits in members' lives.

Key codes under social benefits include satisfaction, personal development, and socialization, while education and family and social relations are mentioned less frequently. Participants 1 and 3 stated that being part of the cooperative provides them with a sense of satisfaction. For Participant 1, this satisfaction is related to professional achievements, while for Participant 3, it is rooted in social fulfillment. Participant 2 sees the cooperative, especially the office setting, as a space for socializing and meeting friends. Participants emphasized that the training received during the cooperative's founding phase significantly contributed to their personal development and boosted their self-confidence.

Regarding family and social relations, participants shared stories of other cooperative members. One participant referred to a member with a child with disabilities, stating that the cooperative not only provided economic benefits but also improved family dynamics and the member's self-esteem.

The most prominent code under Economic Benefit is marketing and market presence. Women's cooperatives have enabled producers—who previously sold only within limited, informal networks—to reach broader audiences and gain brand visibility. Participation in the cooperative has also integrated women into the formal economy. Thanks to the cooperative's structure, women no longer worry about selling their products; knowing their products will generate income through the cooperative enhances the significance of earning through one's own production.

Although the relationship between members and their colleagues is categorized under both psychological and physical aspects, the psychological connection cannot be separated from the social benefits. Cooperative members do not view their colleagues merely as coworkers, but as part of a community. This strong bond stems from prior acquaintances and the small size of the group. The challenges faced during the cooperative's founding also reinforced their sense of belonging.

Under the category Reactions, participants reflected on the support (or lack thereof) from their families and communities. Many mentioned that joining the cooperative was a joint family decision. They stated that family support was essential for maintaining membership. Notably, some women who were initially involved had to leave due to lack of support from their husbands. This highlights that family backing—especially spousal support—is crucial for women's continued participation. Participant 1 emphasized that women understood the expenditures required during the cooperative's early phase, but their husbands often lacked patience. Families that were initially skeptical became more supportive once women began generating income, thus increasing the women's influence within the household.

3.3. Cooperative Operation

Under the theme Cooperative Operation, two primary categories were identified: Support and Collaboration, and Challenges. According to the coding, these two categories are distributed relatively equally. This theme covers aspects of the cooperative's internal functioning that do not directly align with the first two themes (Motivation and Impact on Daily Life), thereby addressing more operational and structural dynamics.

Within the Support and Collaboration category, the most prominent code is projects and grants. This is followed by roles within the cooperative and organizational model and personal resources and informal networks. Participants emphasized that receiving government support during the establishment phase made being a woman an advantage rather than a disadvantage. This reflects the structural challenges women often face in society and within their families, positioning external support as a key enabler for women's collective entrepreneurship.

Under the Challenges category, lack of community support emerged as the most frequently mentioned issue. Participants often referred not only to their own experiences, but also to those of former members who left the cooperative during its early stages, highlighting a strong emotional attachment and the social impact of those departures.

Other recurring challenges—market competition, financial support, production space, and consumer profile—are intrinsic to the broader dynamics of cooperatives in general and women's cooperatives in particular. These include limited competitiveness against large brands, financial dependence on internal resources, low consumer awareness, and limited purchasing power in the local market.

Despite these practical barriers, lack of community support stands out as a particularly significant issue for women's cooperatives, indicating the socio-cultural resistance that women face when entering public and economic spaces as independent actors.

4. Conclusion

This study aims to explore the perceptions and experiences of women who are members of food production cooperatives. The findings indicate that women's cooperatives not only contribute to members' economic empowerment but also provide significant social benefits. Participants perceive the cooperative as a major part of their social lives and fulfill their social needs through it. In the case examined—comprising women who were already engaged in production before joining the cooperative—it was observed that those who received family support were more likely to remain in the cooperative, reporting strengthened relationships with their families and communities, along with increased self-confidence. Conversely, members who lacked family support tended to withdraw from the cooperative, highlighting the critical role of the family in shaping women's economic and social engagement.

Overall, the findings reveal that women's food production cooperatives have positive impacts on members' economic, social, and personal well-being. Moreover, for cooperative members, the cooperative and their colleagues hold meaning beyond economic income. Considering women's roles within the family and society, these cooperatives emerge as vital social enterprises that promote women's participation in the economy and strengthen their positions in both familial and societal contexts.

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Understanding the role of diverse cities for sustainable food security: a socio-ecological governance framework

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Abstract
Amid urgent socio-ecological challenges – including persistent food insecurity and planetary health crises – cities are confronted with the mounting challenge of guaranteeing access to healthy and sustainable food for all (HLPE, 2024). Thousands of urban food initiatives, policies, and strategies have emerged in the last decade to incorporate food related concerns into urban agendas Yet, despite growing calls for integrated and de-siloed approaches, existing conceptual frameworks and practical approaches do not adequately account for the diversity urbanisation processes and related socio-ecological dynamics. Focusing on urban infrastructures and form, networked resource flows, socio-ecological dynamics, and governance dynamics as interconnected 'layers', this paper proposes a socio-ecological approach to urban food system governance which takes the complexity and diversity of urban contexts into serious account.

Keywords: Urban food systems; urban food governance; socio-ecological dynamics; diverse cities

Introduction

Urban food system action is undergoing a critical phase. As currently discussed in scientific and policy circles, the necessity to bring the food system at the center stage of urban sustainability and equity agendas has never been so pressing (Hawkes, 2023). In fact, in an increasingly urbanized world, cities constitute important loci of food consumption, and also active drivers of food system transformations (HLPE, 2024). Urban areas, in particular, account for the highest proportion of global food insecurity, with about 1,7 billion over 2.2 billion of moderate to severe food insecure people living in urban and peri-urban environments (FAO. 2023a; HLPE 2024). As cities are fed by long food supply chains, problems of obesity and bad nutrition are further aggravated by the availability of highly processed food at low costs, often at the expenses of people in precarious socio-economic conditions. In diverse cities, urban food environments are permeated by heterogeneous food infrastructures, where public markets and regional food hubs coexist, compete, or hybridize with conventional food retail and supermarket stores (HLPE, 2024). At the urban margins, the rural-urban interface is continuously negotiated due to dynamics of urban expansion causing land encroachment and undermining prime agricultural areas (López-García et al., 2024). These and other factors hint at the relevance of urbanization processes in both, generating key food systems' problems, but also providing levers to address critical challenges related to sustainable and equitable food production and provisioning.

Recognising the linkages and tensions between urban dynamics and food systems, the urban food literature has underscored the need for policy integration and for adopting systemic approaches to address food systems and urban sustainability problems (Sonnino, 2023). In particular, some authors have set the stage by proposing analytical frameworks tailored to define food systems and describe the interaction among their components, activities, and drivers (Ericksen, 2008; Tefft et al., 2021). Other scholars have focused on how municipal governments attempt to implement a systemic approach, by integrating food system work in the organisational and institutional functioning of the city (Mendes, 2008). More recently, frameworks such as the city-region's food systems have provided further perspectives for an integrated and systemic action (Blay-Palmer et al., 2018). Rather than considering the city as a confined entity, this framework observes how food systems' processes, activities, and flows, dynamically interact with specific urban and peri-urban realities, and rural hinterlands (Krähmer et al., 2024). Additionally, informed by a place-based and socio-ecological perspective, recent contributions in the

debate have argued for an inclusive 'framework for food system transformation that integrates ideas of sustainability co-benefits, spatial linkages, social inclusion and sectoral connectivities' (Sonnino and Milbourne, 2022 p. 915).

While the above contributions offer valuable analytical advancements and propose integrative action-oriented frameworks, very often real-world practices do not align with established principles, or with desirable end-states. In fact, experiments of policy integration are still at their infancy. Local authorities still face challenges to legitimize their action and to exercise a systemic approach, given the precarious status of food governance and policy-making in cities (Doernberg et a., 2019). Furthermore, innovative food governance spaces, such as urban food strategies or food policy councils, that have quickly spread around the globe, face hard times to navigate complex urban dynamics and to deal with the political economy and ecology of cities at different governing scales (Moragues-Faus, 2021). These problems are further aggravated by the current situation of crisis, economic downturn, and geopolitical instability. As a result of these processes, even pioneer cities engaged in urban food system action have been experiencing critical times, as the cases of Toronto in Canada, or Ghent in Europe testify (Manganelli, 2025). Taking this reality into account, we argue that a reflexive step is needed in urban food system action. This reflexive account should take stock of the progress made so far, but also re-evaluate how urban food governance and policy spaces can better deal with contemporary challenges posed by diverse urbanization dynamics. More specifically, we argue that many of the challenges faced by urban food governance and policy actors arise from a persistent neglect of the diverse processes of urbanization - both in the way urban food systems are conceptualized and in the design of city-led responses to food security. By proposing a socio-ecological approach to urban food system governance, this paper aims to take an initial step toward a more integrative analysis that better reflects the complexity and diversity of urban contexts.

To address these issues, the paper is structured as follows. Section 2, after the introduction will provide a socio-ecologically oriented definition of urban food systems' governance, stemming from an understanding of urban food systems as socio-ecological systems that necessarily hybridize with key urban dynamics (the political economy and ecology of the city). This approach allows to identify key layers, or markers, which stand at the intersection of food and urban systems, and can be regarded as strategic points of intervention for an urban food system action. In section 3 these layers will be further broken down into key monitoring indicators, as examples of elements that urban food actors can assess in order to calibrate adapted food security policies, able to tap into key urban dynamics. Some of these dynamics go beyond the food system itself and yet significantly affect food system processes and outcomes in cities. Based on the above insights, section 4 discusses how urban food security governance and policy-making can address key trends characterizing diverse urbanization processes, by prioritizing some of these layers and indicators, or addressing their intersection. Section 5 concludes on how research and action can move ahead towards a better (re)consideration of urban dynamics and trends in urban food system action.

2. Towards a socio-ecological approach to urban food systems' governance

Drawing from a variety of disciplines – including geography, sociology, economics, political science, environmental science, health and community studies, and urban planning, among others –, the food systems' literature has engaged with conceptualizing and analysing the complex interactions among actors, activities, processes, and outputs, that characterize the food system (for a synthesis see, for instance, Battersby and Watson, 2019; Moragues-Faus et al., 2023). At their core, food systems have been defined as including 'the range of activities in the production, processing, distribution, marketing, preparation, consumption and disposal of goods that originate from agriculture, forestry or fisheries, including the inputs needed and the outputs generated' (Tefft et al., 2021, p. 4). In characterizing how the food system works, studies have started to incorporate socio-ecological systems' approaches, which typically look at the ecological and at the social components as interconnected and co-evolving dimensions (Folke et al., 2003; Frank et al., 2017; Hebnick et al., 2021). In particular, focus has been on

delineating the interaction among components (or sub-systems), their activities, inputs and outputs, but also on situating food systems within a broader array of agents, institutions, environmental and social interactions (Ericksen 2008). As Teff et al. (2021) suggest, such interactions involve 'the people and institutions that initiate or inhibit change in the systems as well as the sociopolitical, economic and technological environments in which these activities take place. (...) Urban food systems, specifically, hone in on activities that occur in and/or impact urban and periurban areas' (Tefft et al., 2021, p. 4). As this definition by Teffts et al. (2021) indicates, most (urban) food systems' characterizations treat key socio-ecological dynamics – including socio-economic conditions, socio-cultural dynamics, and biophysical processes –, as external elements affecting or impacting on food systems. On its side, the urban dimension is mostly regarded in locational or spatial terms rather than properly integrated in a socio-ecological account of food system governance (Moragues-Faus and Battersby, 2021, HLPE, 2024). As a result of these tendencies, there is lack of clarity concerning how to properly connect key socio-ecological dynamics and related socio-material flows, to the specificity of urban food systems and their governance constellations.

Recognizing these gaps, the urban food debate has provided further perspectives to embed the characterization of urban food systems within a broader socio-ecological and place-specific approach. Some of these scholarly contributions also address governance or, as highlighted below, suggest useful directions for a socio-ecological governance perspective (Sonnino and Milbourne, 2022). Analyses of urban food flows, for instance, connect food system activities with the metabolism of cities, assessing the potential environmental or social impact of the urban circulation of food production, import-export, processing, distribution, consumption and disposal (Guibrunet et al., 2024). A further perspective is the City Region Food System (CRFS) approach, introduced about a decade ago by the FAO and the RUAF Foundation (REF) (Blay-Palmer et al., 2018; Forster et al., 2015). Specifically, CRFS' frameworks shed particular light on morphological and geographical aspects of the urban, by stressing the need to address specific urban and peri-urban patterns characterizing large or medium-size cities, looking at the interrelation of urban, peri-urban, and rural food system flows (Blay-Palmer et al., 2018). At the same time, the framework suggests going beyond a bounded conception of the city-region, looking at how flows of resources, material, human activities, and non-human elements, connect with wider institutional scales and spatial processes (Krähmer et al., 2024). Underlining the need for a 'more thorough and deeper engagement with the spatial complexity of food systems' (Sonnino and Milbourne, 2022, p.916; see also Vincent and Feola, 2020), further studies have mobilized the notion of place to 'conceptualize and tackle the interwoven socio-ecological issues that affect the food system' (ibid. 2022., p. 915). According to these and other perspectives, adopting a place-based approach would not only allow for a better comprehension of how broader social and ecological dynamics (e.g. socio-economic, cultural, biophysical processes), intersect with food system activities and their material and infrastructural dimensions, in specific urban realities (HLPE, 2024). It would also allow for a better contextual understanding of power dynamics and institutional processes driving urban food systems' governance (Sonnino and Milbourne, 2022). In fact, while socio-ecological system approaches tend to consider governance in normative and abstract terms, as an exogenous force steering food systems, other perspectives such as place-based governance and political ecology, show how governance, power, and institutional dynamics are deeply embedded in metabolic resource flows and in hybrid socio-ecological dynamics characterizing the urban sphere (Moragues Faus and Mardsen, 2017; Heynen et al., 2006).

In synthesis, what we learn from the above analysis is the need for a governance approach that: a) engages with the material, morphological, and infrastructural conditions of cities (space and place, urban infrastructures and form); b) considers the connection of food flows with wider material and immaterial flows (people, ideas, resources); and c) integrates the analysis of key socio-ecological dynamics with the functioning of urban and food systems.

2.1 Depicting key features of a socio-ecological governance approach

Over time, literature on urban food governance has proliferated and a myriad of studies have addressed governance processes or dynamics in a plurality of initiatives, empirical contexts, and types of processes (Doernberg et al., 2019; Haysom, 2015; Moragues-Faus et al., 2022). On a basic level, governance can be defined as 'all modes of governing encompassing activities carried out by different actors to guide, steer, control, or manage the pursuance of food system outcomes in a specific urban area' (Moragues-Faus and Battersby, 2021, p. 5). As food governance studies develop, however, we notice a double tendency, or risk. In particular, on the one hand, when governance is applied to the study of specific initiatives or sectors of the food chain – including urban food production (Ferreira et al., 2018), short food supply chains (Manganelli and Moulaert, 2018), public procurement (Sonnino, Torres and Schneider, 2014), or urban food policies (Moragues-Faus and Morgan, 2015), among others – the risk is to adopt a too narrow focus, which misses a comprehensive, socio-political and socio-ecological understanding of food system processes. On the other hand, food governance studies based on socio-ecological system approaches tend to regard governance in terms of mechanisms, or most appropriate modes of governance such as 'rules, institutions and practices that set limits and govern the behaviour of individuals, CSOs and private sector actors' (Tefft et al., 2020, p. 4). In this case, governance is treated in an abstract, system-focused, and normative way, with poor connection with socio-ecological, socio-political and power dynamics – including conflicts between urban development agendas and interests – related to specific urbanization processes.

In particular, while most of the urban food governance literature addresses governance from within food initiatives or food systems' activities, it is also necessary to draw from perspectives that start from the urban, considering the relation to food. Specifically, drawing from place-based and territorial approaches to governance allows to shed light on how governing actors and institutions relate to the materiality of the city (Latham and McCormack, 2004), and specifically, how they deal with urban infrastructure and its form (McFarlane and Rutherford, 2008; Monstadt et al., 2022; Rutherford, 2014; Tozer, 2019). 'Urban infrastructure and form' encompasses physical elements such as land, built-up and open spaces, parks and green areas, transport networks, but also public markets, food distribution networks, and other relevant food infrastructures (Marsden et al., 2018; Clark et al., 2021). In mediating the everyday life of citizens, urban infrastructures are equally conditioned by wider socio-ecological dynamics (i.e. dynamics related to population movements, urbanization processes, the provision of services, utilities, and economic activities), but also by the politics of urban planning and design institutions in charge of managing growth, deciding on infrastructural investments, channeling development through zoning designations and urban planning guidelines, or allowing for the opening of food markets in urban space (Cabannes and Marocchino, 2018). Therefore, place-based approaches that examine the spatial dynamics of urban infrastructure provision, as well as the politics and governance of the built and unbuilt urban environment – should be integrated as a layer into the analysis and monitoring of urban food system governance.

Urban infrastructures are not just physical entities in urban space. Rather, infrastructures' networks articulate and mediate the dynamic circulation of material and immaterial flows, such as people, ideas, technologies, and material resources (Monstadt, 2009). Governance lenses based on urban metabolism and urban political ecology provide useful insights to disentangle the hybrid socio-ecological flows of food and relevant resources, the connection between food and other flows, and their relation of material flows (resources) with immaterial dynamics (power geometries and governance dynamics) (Heynen et al., 2006; Swyngedouw and Kaika, 2014; Moragues-Faus and Carroll, 2018). At a broad level, urban political ecology allows us to grasp how the interplay of ecological, economic, political, cultural, and social processes – here collectively referred to as socio-ecological dynamics – shapes patterns of access to and distribution of resources within urban areas (Heynen et al., 2006). An illustrative example concerns the interaction between socio-ecological dynamics such as migration patterns and ethnocultural diversity, and global trade mechanisms that govern food imports and exports. These dynamics collectively influence both the types of food available and the characteristics of food environments in specific urban settings. Furthermore, urban political ecology and the politics of urban metabolism allow to grasp the uneven

pattern of distribution and access to key resources – including food –, and how governance institutions relate to the monitoring and provisioning of fair access to resources. Relatedly, while the tendency is to look at flows in a disconnected way, political ecology lenses allow to link food flows with other types of networked resource flows, by for instance observing the relation of public transport provision with food accessibility, or the linkages between energy poverty and food poverty (HLPE, 2024). These considerations allow to integrate a further layer in the socio-ecological governance framework, which can be summarized as 'networked resource flows', i.e. the governance of circulation, provision of, and access to material and immaterial flows such as food, water, waste, energy as well as capital, people, and knowledge.

It is clear how looking at urban infrastructures and form, and networked resource flows allows to shed light on the political economy and ecology of those actors and institutions that are often beyond food-related agendas, and yet have a considerable impact on food system dynamics and the governance of food in the city. What also emerges from the above analysis is how urban infrastructures and form, and networked resource flows, and related governance dynamics, interact with wider socio-ecological dynamics (i.e. biophysical processes related to climate, environment, land and biodiversity; socio-cultural and social dynamics related to population movements, social composition, cultural diversity; the structure of the economy; the access to basic utilities and services). The challenge is to make the depicted socio-ecological governance approach operational. To sketch some directions on this, Section 3 outlines a brief methodological perspective for translating these various 'layers' of the approach into measurable indicators for monitoring urban food systems. Section 4 then discusses how governing actors and institutions can practically apply these indicators in policy and planning processes.

3. Socio-ecological monitoring indicators for food system action

It can be argued that a social ecological characterization of urban food system governance can serve different purposes and can be applied to different contexts. In this paper, we show how the identification of the urban, food system, and governance 'layers` outlined in the above section can serve as a cornerstone for developing an urban food system monitoring framework; an ongoing challenge in urban food system governance processes (Zerbian et al., 2024). In this case, the four layers – socio-ecological dynamics, urban infrastructures and form, networked resource flows and (food) governance dynamics – were used as a guiding structure to identify relevant indicators to develop an assessment framework that operationalizes the evaluation of urban food systems from a socio-ecological and urban perspective. Its overarching aim is characterizing urban food systems whilst measuring the progress of different actions or strategies undertaken to improve the local food system and its governance.

The development of this framework followed a modified Delphi method (Fitch et al., 2001), which involves an initial literature review for potential indicator selection, followed by an iterative survey and consultative process to propose a final indicator set. The process of identifying and outlining these indicators was carried out between 2023 and 2024. It included three steps, outlined as follows.

The first step focused on identifying indicators relevant to a socio-ecological perspective through a structured review of both scientific and grey literature. This included peer-reviewed articles, documents and reports that propose, and/or review indicators sets for urban sustainability and urban food systems sustainability. As outlined above, the identified layers were used as guiding objects to analyse literature sources (38 in total) and extract a first set of potential indicators. After removing duplicates and analysing the suitability of indicators, a total of 266 potential indicators were identified as relevant to operationalise the identified 'layers', organised in relevant dimensions.

In a second step, the identified indicators were tested in the Spanish context, being this context familiar to most of the authors, in order to determine whether issues of data availability would arise in their application, leading

to a first reduction of the indicator set. This meant identifying potential data sources for each indicator using local, national and European databases. This process was conducted for five Spanish cities showing a considerable dynamism in urban food system action, i.e. Madrid, Valencia, Barcelona, Valladolid, Córdoba. Indicators were retained based on criteria such as ease and cost-effectiveness of measurement, availability of a clearly defined methodology, and the capacity to support consistent and comparable data analysis. Preference was given to standardised indicators, or in cases where this was not possible, indicators were normalised to ensure comparability. Indicators for which no reliable data could be obtained were excluded from the list. This process yielded a final set of 88 indicators used in the following step.

The third methodological step was the application of a slightly modified Delphi survey that consisted of sharing with a group of experts, henceforth referred to as panellists, the list of identified indicators for evaluation (Campbell et al., 2002). The aim of such a process is to form a consensus among selected panellists based on their expertise in the field . A total of 33 potential panellists were contacted, composing a heterogeneous panel in terms of professional sectors, including representatives of the public and civil society sector and expertise across food system areas. Twenty-two expert panellists accepted to participate, of which 50% were women and 50% men. Panellists were invited to rate the preliminary indicators throughout two rounds of reviews, based on online questionnaires, with a final face-to-face panel meeting in which the panellists were supposed to discuss and re-rate each indicator. This process led to a final list of 99 indicators, validated and approved by the panel. Table 1, at the end of Section 4, provides examples of core final indicators for each layer and the related dimensions.
While the methodological steps based on the revised Delphi process have been completed, further work is ongoing. This includes testing the indicators in a broader range of European cities, refining the selected indicators, and prioritizing key monitoring elements based on data availability, actionability, and the spatial scale required for observation. Despite the work-in-progress, the following section presents initial insights into the implications for food system action, particularly in relation to governance and policy-making.

4. Dynamizing urban food systems' governance: monitoring indicators as levers for action

Based on the socio-ecological layers delineated above, urban and food system indicators can help to generate knowledge and to indicate pathways for action in different ways, opening up different spaces for reshaping urban food governance. On a first level, each layer of indicators can be analysed independently, as a source of knowledge, and a basis for action on food and urban systems. For instance, the socio-ecological dynamics' indicators are 'more-than-food' indicators that help to understand key dynamics and trends characterizing the city, thus suggesting how food governance and policy-making can leverage them (see also table 1 for a synthetic overview). Within this sub-set, for instance, indicators related to the dimension "economy" are tailored to assess the economic and employment basis of a city; the key sub-sectors, industries, services, driving the urban economy; whether certain sectors or economic trends such as tourism, knowledge economy, financialization, are prevailing over others with potential repercussions on urban food environments, or on import-export relations (HLPE, 2024). Furthermore, the dimensions of "social justice", "demographics", or "health and diet" provide complimentary knowledge about issues such as the level of food insecurity, and data about related determinants of socio-economic inequalities, including gender, level of income, housing insecurity, demographic composition, socio-spatial segregation, and the prevalence of obesity and diabetes across the urban population. This sub-set of socio-ecological indicators are of great importance to both, tailor food security actions, but also bring food action well beyond food and the urban level (Moragues-Faus and Battersby, 2021; Haysom, 2022). In fact, showing the incidence of indicators deriving from those dimensions can allow to build arguments for connecting food with other urban programs and policies, including social welfare programs, public policies and expenditures around health, and so on.

Similarly, indicators related to the layer urban infrastructures and form help to assess the qualities of food and non-food infrastructures (land, green and biodiversity spaces, design and planning, etc.). Specifically, indicators

deriving from the sub-dimension 'design and planning' address issues such as the rate of land consumption over the years (and how this affects urban, peri-urban and regional environments), but also the different uses of land, including for instance what land in the city is scheduled for urban development over the available land. The knowledge generated can allow for establishing dialogue with planning authorities concerning pathways for urban densification, or modes of acting on the urban form to integrate food infrastructures such as community gardens, fruit trees, or urban orchards. It can also suggest pathways for building synergetic action between urban greening and climate adaptation (e.g. through urban greening, nature-based solutions and biodiversity enhancement) and urban agriculture strategies. Moreover, indicators related to the dimension of 'food infrastructure' – including the (lack of) availability and distribution of public markets, food coops, food hubs, food processing and distribution facilities –, shed light on the material basis for calibrating food policy action.

As anticipated in section 2.1, the layer networked resource flows provides further knowledge on the socio-metabolic dimension of food and urban systems. Data on energy consumption for instance can shed light on the carbon footprint of food production, transportation, consumption, and disposal activities, thus helping to identify high-impact areas for decarbonization (IPES-Food, 2023). Indicators on waste – especially those focusing on organic and food waste – can reveal inefficiencies at the consumption level. This can potentially help to link these data to circular policies or programs activated in the city. Data about water flows, such as the amount of water used by (urban) agriculture or other food chain activities, can inform circular and climate adaptation policies, especially in a drought-prone city. Finally, the layer governance dynamics invites to focus on the different actors and agencies shaping urban food governance dynamics, highlighting gaps or missing links concerning existing food governance structures, financing sources, and important issues related to institutionalization and the integration of food in other policies (see table 1).

Yet, as the above analysis suggests, besides working in a standalone manner, the four types of socio-ecological layers, their dimensions, and the related indicators, are more productively analysed in their interrelations. Indeed, functioning like a matrix, key sources of knowledge and levers of action lie at the intersection of various layers and indicators, especially considering their implications for food governance and policy-making, and thus posing particular attention to the connection with governance dynamics (see table 1). Specifically, connecting the layer urban infrastructures and form to the layer governance dynamics raises questions concerning what actors at different levels are driving changes in key urban infrastructures and form and how this is impacting food system outcomes in a specific city. Concretely, indicators such as the distribution of public food markets in the city, the presence of active school food programs per number of inhabitants, or the distribution of producers-consumers networks, could be revelatory of values, actors, modes of community engagement that lie behind the presence and distribution those infrastructures. This source of knowledge allows to calibrate the type of intervention needed in terms of, for instance, public support for food markets or retail stores providing fresh food, sensitization actions, or incentives in terms of distributional patterns. Analogously, actors promoting urban agriculture and greening strategies could consider the availability and quality of the land-infrastructure and the presence of urban planning directions concerning urban expansion or land preservation, in order to propose integrated strategies for the scaling out of food production and greening in the city. Potential synergies between the areas of food and greening could be found especially in a city where greening or climate adaptation strategies are particularly high on the agenda, as recent studies on greening strategies in European cities show (Mahmoud et al., 2025).

Connecting the layer networked resource flows with governance dynamics opens up questions concerning what actors, values, and institutions, at various scales and in different sectors, influence the circulation of capital, human, discursive, and material flows in a specific city, and the implication of this for food governance and policy-making (see table 1). Analysing these aspects means understanding more thoroughly the connections between, for instance, the flow of people in a city (tourists, visitors, temporary workers, minorities, ethnic groups)

and the diffusion of particular food flows and practices such as food away from home, or the creation of particular food environments shaping the city (HLPE, 2024). Furthermore, looking at critical material resources and infrastructures in the city allows to establish connections between apparently unconnected flows and sectors, and their implication for governance (see section 2.1). One illustrative example is the analysis of food system actors and activities that contribute to food waste generation in the city, along with strategies for engaging diverse stakeholders across sectors. In fact, addressing food waste prevention, recovery, and reuse offers a valuable opportunity to connect with multiple actors, infrastructures, and resource flows. For instance, discarded, unsold, or surplus food can be repurposed through community-based initiatives, such as community kitchens. These spaces not only support food redistribution and social assistance, but also foster community building, public awareness, temporary employment opportunities, and intercultural exchange (Gennari and Tornaghi, 2020). Furthermore, composted organic waste can be re-used in urban-peri-urban agriculture activities as soil fertilizer; or it can be recovered for energy generation through anaerobic digestion facilities, producing biogas that contribute to power the built environment.

Finally, highly relevant questions emerge from the connections between socio-ecological dynamics and governance dynamics. In fact, looking at socio-ecological dynamics raises questions concerning what actors and processes (operating in different sectors, spaces and scales) are shaping the socio-ecological dynamics of the city, from its economic basis, to demographics or social justice factors, and how these factors can be leveraged in food governance and policy-making (see table 1). In fact, elements such as food environments, food retail, as well as the price, accessibility, and availability of fresh food options can be highly affected by factors such as demographic composition, population movements, or touristification dynamics, among others (HLPE, 2024). At the same time, tourism can be also a driver of employment, specifically in the food and catering sectors, and a potential lever for sustainable practices involving food (see for instance Bottiglieri et al., 2016, on the example of Turin). Thus, there is space for public actions tailored to understand how touristic facilities (restaurants, canteens etc.) can engage in fair trade and sustainable food practices, including adapting food catering and service facilities to quality labelling standards (see the example of Brussels-Capital Region's GoodFood label). Further examples are interventions in the sphere of tourism and culture that can target the refurbishment and re-valorisation of local farms or food infrastructure facilities for eco-tourism practices. These considerations are particularly relevant for cities and regions that are heavily dependent on tourism, as is the case for many urban areas across Europe (Aguilera et al., 2021). Moreover, socio-ecological dynamics related to social justice factors (food insecurity, socio-economic inequalities) and health factors (prevalence of obesity and diabetes), can provide strong hooks for linking food with other structural programs and policies. Comparative urban analyses revealing a significant prevalence of obesity or diabetes in specific cities can offer robust evidence for positioning food as a strategic entry point in the design of social and public health prevention strategies. Such findings have the potential to mobilize higher levels of governance and institutional support around targeted interventions. Examples are health-related food environment policies at the national or EU level discouraging unhealthy food options and stimulating fresh food environments as a health prevention measure (Schneider et al. 2023).

Table 1. Synthetic overview of key layers, dimensions, and indicators, with resulting priorities and questions for urban food governance and policy-making.

Layer (and dimensions)	Examples of indicators connected to dimensions	Emerging priority areas for food governance and policy-making	Key overarching questions
Socio-ecological dynamics (social justice; demographics; economy; land, environment and biodiversity; health and diet)	*Social justice:* -Population rate at risk of poverty -Percentage of population that are food insecure or hungry -Beneficiaries of food assistance in cash or kind *Demographics:* -Immigration rate; -Demographic composition *Health and diet:* -Prevalence of obesity and overweight in children and adults; -Prevalence of Type 2 diabetes *Land, environment and biodiversity:* -Total GHG emissions per capita (including the food sector) -Areas dedicated to the preservation of agro-ecological diversity *Economy:* -Distribution of Employment by Sector in the Municipality -Employment in the agri-food chain -Relative contribution of tourism to the municipality´s economy (…)	- Understanding how demographic, health, and social justice dynamics intersect with food, and how food can serve as a pivotal element in shaping socio-economic measures and public health prevention policies; -Connecting food with environmental actions especially qualifying cities affected by environmental dynamics and/or engaged in greening / climate adaptation strategies; -Understanding how key economic sectors or dynamics of economic restructuring affect urban food environments, drive food demands and import-export relations, but also provide hooks for creating job opportunities in the food sector and incentivizing food sustainability actions	-What actors and processes (in different sectors, spaces and scales) are shaping the socio-ecological dynamics of the city, from its economic base to demographics or social justice factors and what are the possible implications and hooks for food action?

Urban infrastructure and form (transport network, design and planning, food infrastructure, green spaces and parks)	Transport network: -Access to public transport -Length of the bike network Design and planning: -Population density -Ratio of land consumption rate to population growth rate Food infrastructure: -Total agricultural area per 100,000 inhabitants -Number of community gardens and urban agriculture projects -Number of municipal and collective food processing and distribution infrastructures Green spaces and parks: -Green areas per capita -Proximity to green areas (…)	-Connecting urban agriculture and food interventions to wider urban planning, zoning, and design directions and strategies (including anticipating and influencing those strategies) - Understanding the key actors, values, and factors that affect the availability and expansion of food infrastructures as key to developing targeted types of interventions -Connecting food with the scaling out of greening interventions/ foreseen planning measures on green areas and open spaces	-How do different types of actors and values shape what urban infrastructure and form look like, and, particularly urban food infrastructures? -How can this open up opportunities for targeted interventions through food?
Networked resource flows (energy, waste, food, water)	*Energy:* -Energy consumption -Fuel poverty -GHG emissions in key sectors/ activities of the food chain *Waste:* -Urban solid waste generated; -Municipal waste recycling rate -Number of circular programs and initiatives on food loss and waste *Food*: -Local production and consumption of basic food -Ration of food exports-imports *Water:* -Per capita water consumption -Draught frequency (…)	- Understanding potential connections, synergies, or missing links between food and other metabolic flows -Shaping interventions that provide ground for win-win solutions among different sectors (e.g. food, waste and energy) -Linking food with wider circular economy strategies of the city	-What and how do different actors and processes (operating in different sectors, spaces and scales) influence the circulation of capital, human, discursive, and material flows within cities, including food? -How can this open up opportunities for targeted connecting food to other flows and sectors?

Governance dynamics (actors and networks; policies; participation, transparency, inclusion; finance)	*Actors and networks:* -Presence of an active multi-stakeholder food planning and policy structure - Presence of an active municipal inter-departmental body for food policy and programming *Policies:* -Presence of food as a key pillar of: city sustainability strategy; city planning strategy; municipal health and social welfare strategy; integrated urban strategy -Presence of healthy and sustainable food in the sustainable procurement policy *Participation:* -Representation of specific vulnerable groups in food governance bodies *Finance:* -Municipal budget dedicated to healthy and sustainable food -Commitment to sustainable public procurement (…)	- Understand the degree and modalities through which an integrated food governance and policy-making approach is institutionalized in cities -Envisioning pathways to integrate food in broader urban policies and sectors based on needs and strategic opportunities -Strengthen public engagement in food through key levers (e.g. public procurement; municipal support to markets and retail serving fresh food)	-What are the different actors and agencies shaping urban food governance dynamics within and beyond food?

5. Conclusions: re-considering the urban in urban food system action

When dealing with governance, the use of tools and notions such as 'indicators', or 'food system monitoring' or 'progress' may be perceived as uncomfortable or misleading. In fact, dealing with indicators may appear to divert attention away from deeply qualitative dimensions characterizing governance dynamics and policy actions – including actors' relations, conflictive values and ideologies, power dynamics, institutional processes –, towards the measurement of quantitative aspects such as data, progress, or performance. Yet, our idea is that the process of developing and employing indicators is not solely a matter of data generation; besides, it is a knowledge-building and reflexive process that supports collective action toward the achievement of more sustainable and genuinely transformative urban food systems' outcomes.

More generally, what this paper aimed to convey is the necessity to develop a broader socio-ecological approach to the understanding of food, urban systems, and their governance (Moragues-Faus and Zerbian, 2025, in progress). Drawing from place-based, political economy, and socio-ecological governance approaches was pivotal to identify key layers, connected dimensions, and observable indicators, which could help to envision key governance priorities and areas of intervention at the intersection between food and urban systems. Consequently, embedding urban food action within key urban and socio-ecological dynamics characterizing diverse cities can help local authorities to link food with other sustainability agendas and policy areas at the urban and wider spatial-institutional scales. This is a crucial process that enables food system action to become more inclusive, systematic, and, at the same time, strategically oriented and transformative (Moragues-Faus and Battersby, 2021; Moragues-Faus et al., 2023). We believe that the analysis presented in this paper provides pathways for further research and action on food and urban systems. In particular, questions arising at the intersection of multiple layers offer new opportunities to examine how food system governance is embedded within place-specific urban dynamics, the types of conflicts it may encounter, and the ways in which it can become meaningful and relevant to diverse actors, in-

frastructures, and processes. In conclusion, this paper invites further research into how urban food governance spaces can more effectively engage with the key socio-ecological and economic dynamics that shape diverse urban contexts. This is crucial for advancing food system action beyond its current status as a policy niche, towards a genuinely transformative approach.

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Urban Agriculture and Multispecies Commoning in Public Housing Regeneration: Rethinking Ecologies of Care in Scampia

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Abstract
In an era of planetary crisis, urban planning must move beyond extractive models toward regenerative approaches grounded in care and multispecies coexistence. This paper explores the contradictions and potential of embedding urban agriculture within public housing regeneration, focusing on Scampia (Naples), a district marked by socio-spatial marginalization. Analyzing the ReStart Scampia project, which proposes a system of cultivated fields, urban forests, and collectively managed green areas, this study reframes urban agriculture as a tool for multispecies commoning rather than a symbolic greening strategy. Drawing on urban political ecology and post-growth theory, the paper interrogates governance structures and asks: can urban agriculture foster socio-ecological justice in marginalized neighborhoods? Can it support post-anthropocentric planning practices through bottom-up land stewardship and care? The case offers insights for rethinking ecologies of care in public housing.

Keywords: urban agriculture; public housing regeneration; open spaces; multispecies commoning; care ecologies

1. Introduction: Beyond Greenwashing in the Age of Crisis

In the context of climate emergency, deepening inequalities, and growing social disconnection, urban planning is increasingly called upon to rethink its tools and paradigms. Recent years have witnessed the proliferation of discourses on care, regeneration, and ecological transition within policy and planning frameworks, yet the operationalization of such principles often remains superficial. In particular, urban greening strategies promoted in public housing neighborhoods tend to instrumentalize ecological rhetoric while maintaining extractive, top-down governance models.

This paper addresses these tensions through a critical reading of urban agriculture as a field of both appropriation and potential resistance within regeneration processes. Focusing on the district of Scampia in Naples, Italy—long stigmatized as a marginal territory yet undergoing a major transformation—the study reflects on the contradictions and opportunities arising when agriculture is mobilized as a tool for regeneration. Drawing on the ReStart Scampia project, it interrogates the extent to which urban agriculture can activate new ecologies of care, enable multispecies forms of commoning, and challenge the growth-oriented logic embedded in redevelopment plans.

To do so, the paper draws from the fields of urban political ecology, post-growth urbanism, and critical planning studies, proposing a situated and relational approach to public housing regeneration. It explores how urban agriculture may contribute to the reconfiguration of urban metabolism and the emergence of regenerative socio-spatial practices—particularly in territories historically marked by structural neglect and speculative planning. The aim is to offer both a critique and a possible reframing of the role of agriculture in post-growth urban transitions.

2. Theoretical framework: Post-growth urbanism and multispecies care

To critically engage with the promises and limits of urban agriculture in regeneration contexts, this paper situates its analysis within the frameworks of post-growth urbanism and urban political ecology. Post-growth thinking calls into question the centrality of economic expansion in urban development, advocating instead for regenerative, care-based alternatives (D'Alisa et al., 2015; Latouche, 2009). This perspective aligns with critiques of mainstream sustainability, which often fail to challenge extractive logics or engage with the socio-political dimensions of ecological transformation.

Urban political ecology offers a complementary lens by foregrounding the power relations embedded in the production of urban nature (Heynen et al., 2006; Swyngedouw, 2004). Within this field, urban agriculture emerges as a site of contested governance, capable of reproducing existing inequalities or opening space for alternative socio-ecological relations.

Building on these perspectives, the paper introduces the notion of multispecies commoning as a critical tool to reframe urban agriculture beyond anthropocentric and managerial paradigms. Drawing from Massimo De Angelis' work on the commons as sites of social cooperation outside capital (De Angelis, 2017) and Laura Centemeri's concept of ecological care as a relational and situated practice (Centemeri, 2015), multispecies commoning foregrounds the entanglements of human and non-human actors in the production and stewardship of shared environments.

This approach resonates with feminist and post-humanist theories of care (Puig de la Bellacasa, 2017; Haraway, 2016), emphasizing interdependence, vulnerability, and the material conditions necessary for living together in damaged worlds. In this sense, urban agriculture can be reimagined not only as a source of food or greenery, but as an infrastructural practice through which ecologies of care and non-extractive relationships are cultivated.
The next section outlines the methodological approach adopted in this research, grounded in situated knowledge, critical engagement, and a commitment to interrogate institutional narratives from within.

3. Methodology: Situated urban political ecology and critical engagement
This research adopts a situated and critically engaged methodology, drawing on the author's direct involvement in the ReStart Scampia project as a researcher and planner. Rather than claiming external objectivity, the study embraces a reflexive stance, recognizing the complexities and tensions of operating within institutional frameworks while maintaining a critical perspective.

Data collection combined ethnographic observation, informal interviews, and document analysis. Fieldwork was conducted intermittently between 2022 and 2024, with particular attention to public meetings, design workshops, and moments of negotiation between planners, local actors, and municipal institutions. As such, the methodology integrates both emic and etic perspectives: it considers the internal logics and aspirations of the project while foregrounding its political and socio-ecological implications.

This embedded approach allows for an analysis that is both grounded in practice and theoretically informed. It also reflects a commitment to what Haraway (1988) terms "situated knowledge": knowledge that is partial, embodied, and accountable. Rather than offering a universal assessment of urban agriculture, the paper focuses on the specific configurations, conflicts, and imaginaries that emerge in the Scampia context—viewing them as entry points to broader questions around commoning, care, and post-growth urbanism.

Beyond its epistemological implications, this methodological positioning can be understood as a political and performative act: a way of "staying with the trouble" (Haraway, 2016) rather than escaping into abstraction. Engaging with urban transformation from within entails embracing uncertainty, ambivalence, and the everyday negotiations that shape socio-ecological realities. In this regard, method becomes more than a tool for knowledge production—it becomes a terrain of situated intervention, echoing Stengers' (2018) call for "slow science" and Shotwell's (2016) invitation to cultivate "imperfect solidarities." By remaining attentive to the frictions, alignments, and silences encountered in the field, the research aims not only to interpret but also to modestly interfere with the conditions of possibility for more just and livable urban futures.

Figure 1 - Schematization of the project by levels.

The ReStart Scampia project, which constitutes the primary empirical basis of this study, is the outcome of a collaboration between the Municipality of Naples and the Department of Architecture (DiARC) at the University of Naples Federico II. The project was developed as a technical and economic feasibility plan for the redevelopment of the "Lotto M" in Scampia, where the last remaining buildings of the infamous Vele complex are located. The DiARC team—led by Enrico Formato and composed of Marianna Ascolese, Eduardo Bassolino, Gilda Berruti, Alberto Calderoni, Pasquale De Toro, Gianluigi Freda, Giuseppina Mari, Federica Palestino, Michelangelo Russo, Ludovica Battista, Luca Boursier, Augusto Fabio Cerqua, Nicola Fierro, and Bruna Vendemmia—proposed a vision that reactivates the area's historical rural identity through a new system of fields and open spaces. This design aims to transform the degraded landscape of the Vele into a more fertile, socially sustainable, and livable environment.

This situated approach also reflects a broader commitment to engage with space not merely as a neutral container but as a terrain of rights that are enacted through embodied practices. As Formato (2023) argues, rights in the city do not pre-exist spatial practices but emerge from them—a process of claiming and shaping space through everyday gestures of care, resistance, and transformation. In this sense, gardening in Scampia is not only ecological but also political: a form of commoning that produces alternative ways of inhabiting and regen-

erating urban territory.

4. Contested Regeneration: Scampia between Ecological Rhetoric and Commoning Practices

Scampia, a district in the northern periphery of Naples, has long epitomized the contradictions of modernist public housing and the socio-spatial marginalization it often engenders. Designed in the 1960s as part of a utopian vision for urban expansion, it became globally infamous for its failed megastructures, institutional abandonment, and stigmatizing media narratives. In recent years, however, Scampia has been at the center of an ambitious regeneration effort, culminating in the ReStart Scampia project, a strategic framework that seeks to transform the area through a combination of demolition, new housing, and ecological requalification.

ReStart Scampia includes a proposal to reconvert open spaces into a system of urban agriculture fields, forestation areas, and collectively managed green commons. While the inclusion of urban agriculture signals a shift toward ecological sensibilities in planning, it also raises important questions about the role of such interventions in shaping new territorial imaginaries. Are these cultivated landscapes meant to function as genuine infrastructures of care and commoning, or do they risk reproducing a sanitized, greenwashed version of redevelopment?

Drawing from direct involvement in the planning process, this section unpacks the internal tensions within ReStart. On one hand, the project attempts to foreground community participation and environmental restoration; on the other, it remains embedded in bureaucratic procedures and aesthetic logics of urban decorum. The agricultural component, in particular, oscillates between symbolic landscaping and the potential for more radical, situated experiments in land stewardship. Design workshops and participatory meetings reveal divergent expectations: while some institutional actors frame agriculture as a beautifying tool or social inclusion device, grassroots groups and informal gardeners express a more grounded interest in autonomy, food production, and environmental justice.

Figure 2 - General project plan.

These frictions expose the limitations of institutional planning when it comes to nurturing regenerative practices from below. ReStart Scampia thus becomes a field of negotiation where the possibilities of multispecies commoning must contend with the constraints of technical planning, fragmented governance, and limited political imagination.

5. From Urban Greening to Commoning: Negotiating Agriculture in Public Housing

Beyond formal plans and institutional frameworks, a multiplicity of informal gardening practices already inhabit the open spaces of Scampia. These gestures—often modest, ephemeral, or spontaneous—enact a relational and situated form of care for the land. They also materialize what Formato (2023) defines as "diritti che si producono nello spazio": rights that are not granted from above but created through embodied, everyday engagements with space. By cultivating small plots, reactivating unused land, or informally organizing green commons, residents perform acts of spatial claim-making that challenge extractive paradigms and articulate a politics of regeneration from below. These practices resonate with the notion of multispecies commoning, as they involve entanglements with plants, animals, and soil in the production of shared ecologies of care.

In the ReStart Scampia project, urban agriculture is framed as a central element of the regeneration strategy. The masterplan envisions the creation of cultivated fields, food forests, and community-managed green areas as tools for activating social inclusion and ecological transition. However, the integration of these elements within a broader institutional framework reveals tensions between symbolic greenwashing and transformative commoning.

On one hand, the agricultural vision embedded in the project is unprecedented for Naples' public housing contexts, signaling an institutional openness to rethinking the urban metabolism and fostering new forms of ecological engagement. The plan explicitly moves beyond ornamental greening, recognizing the productive, relational, and educational potential of cultivated land. It also references concepts such as circularity, biodiversity, and soil regeneration, suggesting a shift from static landscaping to dynamic socio-ecological systems.

Figure 3 - Axonometric design view.

On the other hand, the actual governance model remains largely centralized. While the project mentions participatory management and local stewardship, the mechanisms for such involvement are vague or postponed to future implementation phases. This creates a disjuncture between the transformative narratives surrounding the project and the persistence of technocratic planning logics. The risk is that agriculture, instead of becoming a tool for commoning, is absorbed into a managerial apparatus that maintains control over land and decisions.

These ambiguities have concrete implications. During public meetings and workshops, local actors—residents, associations, informal gardeners—expressed both enthusiasm and skepticism. While some embraced the idea of reconnecting with land through structured initiatives, others questioned the feasibility and sincerity of institutional proposals, especially in light of past failures. Moreover, the spontaneous gardens and informal cultivations already present in the area are largely overlooked in the official design, raising concerns about erasure and displacement.

By situating agriculture within a commoning framework, this paper argues for a more radical rethinking of public housing regeneration. Rather than inserting predefined green infrastructure, urban planning should recognize and support existing ecological practices, enabling a shift from green compensation to collaborative, multispecies stewardship. This implies reworking the planning process itself—its timelines, governance structures, and epistemologies—toward more open-ended, caring, and accountable models.

6. Commoning beyond participation: informal practices of care and cultivation

The promises of participation and community involvement often invoked in regeneration discourses risk being co-opted into top-down planning agendas. In the case of Scampia, while the ReStart project formally integrates participatory components, its institutional framing still reflects the asymmetries of power and expertise characteristic of conventional urban development. However, alongside and beyond these official processes, a range of informal practices has emerged—suggesting alternative ways of inhabiting and cultivating space that do not rely on formal recognition.

Field observations and conversations with local residents revealed a number of grassroots initiatives involving the appropriation, cultivation, and care of small plots of land, often without authorization. These acts—ranging from self-managed gardens to the planting of fruit trees and spontaneous composting—constitute a dispersed but significant ecology of commoning. Although modest in scale, they express relational modes of engagement with the soil and with more-than-human life, offering a quiet but powerful critique of neglect, abandonment, and technocratic planning.

Such practices align with what Centemeri (2015) describes as "ecological care": a form of everyday engagement that emerges from lived experience and local knowledge rather than from formalized sustainability agendas. These gestures may be invisible or illegible to planners, yet they point toward different regimes of value and stewardship. They also reflect what De Angelis (2017) calls the "commons" as a space of social reproduction—where value is generated through cooperation, not extraction.

In this light, urban agriculture becomes a contested terrain, where institutional designs and spontaneous experiments coexist, overlap, or come into tension. By paying attention to these frictions and to the knowledge embedded in informal practices, planners may begin to reimagine regeneration not as the implementation of a predefined plan, but as a process of learning with and from situated forms of communing

7. Conclusions: Toward situated ecologies of post-growth regeneration

This paper has argued for a situated and critical understanding of urban agriculture as a potential catalyst for post-growth regeneration in public housing contexts. Moving beyond the dominant paradigms of greening and participation, the case of Scampia illustrates how agriculture can become a terrain of both conflict and care, institutional design and informal experimentation. Rather than merely implementing green infrastructure, the challenge lies in recognizing and nurturing the situated ecologies—human and more-than-human—that already inhabit these spaces.

By foregrounding the notion of multispecies commoning, the paper has sought to expand the conceptual and practical horizons of urban regeneration. Drawing on local gestures of ecological care, it suggests that alternative forms of value, cooperation, and stewardship may emerge from below, offering a counter-narrative to technocratic or growth-driven approaches. These informal and often invisible practices, while fragile and fragmented, embody a different politics of urban space—one grounded in relation, attention, and interdependence. Planning for post-growth cities demands not only new tools but new sensibilities. It requires planners and institutions to engage with the messy, contested, and affective dimensions of urban life—to see regeneration not as a linear process of improvement, but as a terrain of negotiation, translation, and collective inquiry. In Scampia, the soil tells stories of abandonment and extraction, but also of resilience and imagination. Listening to these stories, and allowing them to inform our practice, may be the first step toward more just and regenerative futures.

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Track 17
PUBLIC SPACE

Operationalizing Justice: Ethical Frameworks for Adaptive Planning in the Age of Planetary Crisis

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Abstract
As planners strive to ensure justice and equity in the long term, they are confronted today with the unprecedented immediate dual challenge to meet the immediate demands posed by associated crises, such as climate change, social inequality, or economic instability. These crises often iterate upon one another, deepening pre-existing inequalities, and thus require planners to engage with ethical principles in a critical way as a guide for transformative action. This paper presents a study of the practical implications of justice in planning, pointing out the particular difficulty when it comes to reconciling varying interests and ideals in urban societies. Following that, he analyzes several of the case studies on postindustrial urban areas and those most immediately impacted by climate change, covering three primary facets: (1) the ethical foundations influencing decision-making in planning, (2) approaches of embedding the values of justice and inclusivity into adaptive planning strategies, and (3) means by which conflicting societal priorities can be mediated. It emphasizes participatory practices, interdisciplinary collaboration, and robust governance as critical mechanisms for aligning ethical commitments with actionable solutions. Distributive, procedural, and recognition-based justice theories offer critical insights into integrating justice into planning efforts at local and systemic levels. It also underscores the importance of fostering resilience and inclusion, particularly for marginalized populations, while tackling broader challenges posed by planetary crises. This analysis ultimately links theory to practice by developing recommendations for planners, policymakers, and other stakeholders who have committed themselves to advancing justice at a time that changes quickly in an ever more uncertain world.

Keywords: Ethical Urban Planning; Adaptive Planning; Climate Justice; Spatial Justice; Participatory Planning

Introduction

The 21st Century brought several crises that have accumulated to a common challenge found in urban planning: climate changes, social inequality, and an unstable economy. The technocratic growth-centric paradigm implied by traditional planning models has proved inadequate in dealing with these multifaceted crises. Thus, there is an urgent need to explore new planning approaches through ethical frameworks that will put issues of justice, equity, and sustainability at the forefront.

The increasing frequency and intensity of climate-related disasters accentuate the urgency of planners adopting ethical frameworks oriented towards justice and equity. Traditional planning models, commonly technocratic and growth-oriented, have proved insufficient in addressing the complex interrelationships of environmental, social, and economic problems. Indeed, the need for a paradigm shift towards more participatory planning approaches has never been so pronounced. The use of ethics in planning practice cannot simply be an intellectual exercise but must develop into a practical necessity. As cities balance immediate needs with long-term sustainability, planners must grapple with embedding justice into urban development strategies so that the voices of the disadvantaged are not merely heard but contribute to shaping the planning process.

This paper seeks justice operationalization within adaptive planning through the investigation of ethical frameworks, which would guide planners in traversing the complex new terrain offered by contemporary urban challenges. The theoretical assumptions, as well as practical applications of a study, aim to undertake the journey of incorporating justice into planning processes, leaving behind hagglers who will be effective and equitable in planetary crisis responses. Furthermore, transforming planners from the direct archetype of top-down models into facilitators of change would change the role of planners, considering that it is a morphing trend. It would

require a deep understanding of the ethical dimensions of planning and a commitment to embedding justice at the core of urban development strategies. The same flow of ideas contributes to the ongoing discourse on how ethics should be tied to planning, highlighting the need for practices not to be disconnected from the broader values of society as well as their meaningful imperative to building resilient, inclusive communities in the face of global challenges.

Theoretical Framework: Dimensions of Justice in Planning
Planning Justice is primarily comprised of three important dimensions: distributive, procedural, and recognition dimensions.

Distributive Justice: Regarding allocation of resources, services, and opportunities. In this sense, planning aims at ensuring equal distribution of benefits and burdens across various communities, especially the marginalized groups (Fainstein, 2010).

Procedural Justice: Pertaining to fairness and inclusiveness in decision-making processes. That means giving emphasis to participatory mechanisms where voices of all stakeholders at different levels could be involved in planning decisions (Healey, 1997).

Recognition-Based Justice: Understanding and respecting the different identities, experiences, and knowledge systems of all individuals in a community. It straightens the way for planners to consider and actively oppose systemic biases and ensure that marginalized voices become not merely spoken but valued (Schlosberg, 2004).

Work to embed these dimensions into the fabric of planning practice calls for an all-encompassing approach that crosses traditional techniques and places ethics at the center of the planning process. Space justice complements the previous dimensions of justice but stands distinctively as one of the concerns of urban planning. Space justice concerns distributing spatial resources equitably and organizing space appropriately so that all people in society have equal access to life-sustaining services and opportunities. This emphasizes the extent to which spatial inequalities often reflect social and economic inequalities. In addition, the multifacetedness of such dimensions clearly emphasizes the challenges involved in operationalizing justice in planning. Thus, while one pursued emancipation through distributive adjectives, there could be need for some reforms in procurement procedures to provide more inclusive participation; while recognition-based justice emphasizes the need for cultural sensitivity and acknowledgment of diverse worldviews as city space is shaped.

Intergenerational justice should be taken into account as well, especially concerning climate change and sustainability. Intergenerational justice recognizes that planning decisions should not infringe upon the ability of future generations to meets their needs. It thus requires thinking ahead to formulate planning policies that balance current development goals with long-term environmental stewardship and resilience. Bringing these dimensions together offers an integrated framework within which planners are most likely to address ethical challenges that may arise with urban development and create environments that function as equitably as inclusive.

Methodology
A qualitative research methodology including case studies, policy analysis, and stakeholder interviews is what the research borrows to understand the application of ethical frameworks to adaptive planning. These case studies include postindustrial urban areas and communities that experience climate changes disproportionately, providing an insight into the challenges and opportunities associated with operationalizing justice in diverse contexts. Additionally, participatory action research (PAR) methods are employed to enhance understanding of ethical frameworks in adaptive planning (Mehan and Mostafavi, 2024). PAR embodies co-learning and power sharing between researchers and other residents, underscoring mutual empowerment. In this way, the research process itself is imprinted with the very principles of justice and inclusion.
Data collection drew on a combination of document analysis-including planning policies, reports-and semi-

structured interviews with planners and policymakers, and community representatives. This approach provides a more comprehensive understanding of ethical influences on planning decisions and their practical implications for justice-oriented programming.

The thematic coding, identifying patterns and themes in relation to the integration of justice in planning processes, guided the analysis. This would allow for the development of best practices, barriers, and facilitators in embedding ethical frameworks into adaptive planning initiatives. Triangulation of data from various sources increases reliability and validity of results from the study that provide nuanced perspectives on operationalization of justice in urban planning. The study also makes use of scenario planning techniques to analyze possible futures and the consequence of alternative planning decisions. It allows them to envisage more informed and ethical decision- making processes in uncertainty and complexity by framing in different assumptions the potential consequences that really could turn out.

Case Studies

1. Urban Regeneration during the Post-Industrial Era

Indeed, city planning institutions that have gone through the transition of industrial economies face new barriers of contradictions in town planning. A case is the restoration of the abandoned areas for more active functionality or for generating other uses. One possibility is using heritage industrial sites to bring together cultural conservation and the development of communities. However, without ethical standards, these actions will put the communities at risk of gentrification and displacement.

From 1986 onwards, it transformed into a cultural and creativity site involving museum facilities and design centers, as well as public spaces, as most adaptations of industrial sites are termed in the successful adaptive reuse of industrial heritage. The redevelopment process emphasized that the community would own the project and, therefore, would ensure that it met local requirements and aspirations.

It would be possible to argue here that the first redevelopment of Docklands in Melbourne purposely ignored community interests in favor of the corporate commercial activities. Because of the result of this kind of treatment-a lack of affordable housing and community facilities-revisions were made in planning approaches to direct attention to inclusive planning processes.

Through distributive and recognition-based justices, regeneration planners guarantee that regeneration initiatives enrich people, set up cultural identities, and spur inclusive economic development within their areas. Such planning processes would lead to gathering local wisdom that, in turn, would lead to increased ownership among the community members on the redeveloped efforts. For instance, adaptive reuse has changed the Zollverein Coal Mine Industrial Complex in Essen, Germany, into a nexus of culture and creativity while economic revitalization stirs. Extensive community engagement ensured that redevelopment efforts tied in well with local needs and aspirations (UNESCO, 2001).

If we relate these situations with the case of Docklands, Melbourne, especially regarding how the place was to undergo development, it can be noticed that some specific exclusion meant for planning is not present. The initial redevelopment plans for Docklands that fell short of including the community were amended or remodeled to fit the centers of importance such as affordable housing, public spaces, and community facilities (City of Melbourne, 2020).

2. Climate Change Adaptation in Vulnerable Communities

Among the communities that suffer the most from climate change effects are poor and disadvantaged groups, as they suffer from low-quality infrastructure and resource constraints. Adaptation planning in such a context shall be prioritized on procedural justice, ensuring that adaptation strategies are co-built with the input of community members.

The planning processes that include local knowledge and experiences into their procedures are more relevant

and effective for adaptive measures. Different ethical frameworks guide planners to redress the systemic inequities that exists with respect to resilience in inclusive and context-sensitive approaches.

In Bangladesh, the traditional practice of floating garden construction, locally known as 'baira', is favored in flood-prone areas for crop cultivation. These gardens consist of aquatic plants like water hyacinth, which make them a sustainable alternative food and income source for climate change-afflicted communities. Community-based adaptation projects in Bangladesh have enabled local people to build and run such climate-resilient practices as floating gardens and the construction of raised houses. All these methods highlight the importance of participatory planning and using indigenous knowledge in strengthening community resilience (Sunder, 2020).

Under the initiative of Rebuild by Design in the United States, since Hurricane Sandy, some communities went into partnership with their peoples to co-create resilient infrastructures. Among the projects that came out of this is the development of New York's "Big U," which is a "superstorm" project that has integrated social, environmental, and economic in addressing climate vulnerabilities (Rebuild by Design, 2014).

Strategies for Operationalizing Justice in Adaptive Planning
To make justice operational in adaptive planning requires diverse approaches, entailing participatory approaches, interdisciplinary collaboration, ethical evaluation, and capacity development. These strategies seek to ensure that processes of planning are equal, inclusive, and attuned to the different needs of communities.

1. Participatory Planning
The first step to developing equitable planning outcomes is to engage all stakeholders in the decision-making process. Participatory planning is used as an umbrella term for a range of tools such as community workshops, participatory mapping, and digital platforms used to carry out inclusive engagement. For example, participatory mapping gifts the people to be planned for with the ability to communicate their own experiences and knowledge toward the planning process, nurturing a sense of ownership and ensuring development in accordance with local needs. Since the advent of such digital tools as interactive mapping platforms and online forums, wider opportunities for community engagement opened up, increasing accessibility and efficiency (Mehan and Stuckemeyer, 2023).

Participatory planning nurtures transparency and accountability in the planning process. Should community members be involved from the start, planners will be able to nipping in the bud potential conflicts that may arise during implementation. And, in this collaborative culture, trust is born, which is indispensable in the long life of any planning activity. In addition, participatory planning can lead to innovative solutions that are highly customized to respond to context. It is often community members who can bring in understanding of local challenges and opportunities that external planners may not pick up on. This local knowledge can then be harnessed for more nuanced planning purposes that respond to the real concerns and aspirations of that community.

2. Interdisciplinary Collaboration
These points address how different disciplinary inputs, such as the sociology, environmental science, economics, and urban planning inputs to the discussions, will help in addressing the difficult issues concerning urbanism. Interdisciplinary collaboration enhances planning approaches by ensuring that both the social, environmental, and economic approaches are included in the discussions as important understandings in the dimensions of urban development. Such collaboration easily defines the development of holistic solutions that are more resilient and adaptable.

In practice, however, collaboration across disciplines improves the effectiveness of both policy making and implementation. Environmental science, for instance, located within the realm of urban planning in broad land-use practices, identifies principles of use in sustainability along with an economic analysis to define the financial viability of the proposed approaches. The sociological viewpoint explains dynamic equity with respect to decisions on planning and further legitimates a just approach in creating such policies (Mostafavi et al., 2024).

Such teams can also spark innovation by coupling different methods and perspectives. This cross-fertilization of ideas may lead to creative approaches not likely to be imagined within a single-discipline framework. Such pluralistic collaboration must be encouraged institutionally, with mechanisms for interdisciplinary training and otherwise facilitating the communication of professionals from different fields.

3. Ethical Impact Assessments

While planning impact assessments may be supplemented with ethical considerations to help planners anticipate and prevent the emergence of injustices from their planning decisions, ethical impact assessments span more than such analyses. Benefits and burdens are to be distributed equally among different community groups. Development should not disproportionately disadvantage marginalized populations, a preventive step towards accountability or transparency, which can see planning practices align with values of social justice.

In fact, ethical impact assessments may serve public engagement because they would draw the stakeholders into the assessment process, while people would be able to learn how different groups of citizens value issues and priorities and even reach equitable results because of their involvement thus adding legitimacy to the planning decision and strengthening its credibility in the eyes of the citizenry.

One more thing is that ethical impact assessments lend themselves to the identification of negative side impacts associated with planning actions-for example, evictions or environmental degradation. Through systematic assessment of these potentials, planners may evolve them into strategies meant to be proactive in handling impacts and ultimately strengthening urban development in sustainability and justice.

4. Capacity Building

Through education and provision of resources, communities are empowered to gain skills for effective participation in planning processes. Capacity building is about training, support, and creating a local leadership structure such that community members engage meaningfully in decision-making. By building the community capacity of planners, procedural justice is advanced, and long-term community resilience is created, enabling communities to adapt to new realities and challenges (Mehan, 2024a; 2024b).

These capacity-building activities could take the form of workshops, mentorships, and technical assistance in the best case. Such activities empower community members with knowledge of planning processes that otherwise may seem too technical to grasp. In addition, capacity building of community-based organizations can give marginalized communities an opportunity to voice themselves and for their perspectives to be considered in planning decisions.

Furthermore, capacity building adds another dimension of sustainability to the processes of planning. Where communities have skills and knowledge to manage and maintain projects, they tend to take ownership of those projects and see to it that these efforts survive. Such ownership can also lead to increased civic engagement, which in turn strengthens social capital within communities.

5. Integration of Technology

Technology can enable better transparency and inclusiveness in the planning processes. GIS, along with other dot offerings, helps communities visualize what planning proposals are about, give feedback, and monitor implementation mechanisms; all these add up to participatory planning. For instance, participatory GIS integrates input from the "community by allowing its members to provide spatial data and local knowledge that led to better-informed and fair decisions."

Through use of technologies, efforts aimed at popularizing community engagement may stretch farther into the reach of individuals who may otherwise not make it to a venue to attend a meeting (Mehan, 2024c). Surveys online, virtual town halls, and interactive mapping are some alternative channels through which diverse voices

can be ensured to be heard.

However, the issue of a digital divide must also be raised when incorporating technology into a process of planning. One way to prevent the exclusion of groups at technological disadvantage is by ensuring equal access to digital tools as well as training on their application (Kozlowski et al., 2020). The planner will have to keep the 'gate' on such disparities wide open for proactivity in bringing forth digital inclusion.

6. Institutional Reforms

Such institutional reforms should also lay the groundworks for planning policies and frameworks that integrate ethical considerations for justice in adaptive planning. These include creating guidelines and standards that would prioritize justice, equity, and sustainability, as well as forming accountability mechanisms that would ensure that such ethics are met.

Changing structures of institutions would involve modifying planning regulations to require equity assessments, creating independent agencies to guarantee compliance with ethical standards, and promoting a culture of continuous learning and reflection among planning organizations. Internalizing these changes would, in fundamental part, awaken in the planning process now-making ethics a part of the pre-institutionalized process.

Further, institutional changes have meant enhanced interagency collaboration as well as coordination, thus mitigating silos often seeming barriers to comprehensive planning. Integrated approach would suffice for institutions in devising effective mechanisms for addressing the complex and interconnected problems of urban communities.

Discussion and Conclusion

The operationalizing process of justice in adaptive planning requires a major shift away from orthodox, top-down outlooks to inclusive, bottom-line practices that rely on ethics. Planners need to grasp the struggle produced by a juxtaposition of competing interests and ideals to balance off efficiency against equity. Ethical frameworks are meant to mediate these conflicts, thereby directing planners to judge their decisions as much by application ability as by justness. Therefore, the operationalization of justice in adaptive planning theory should rather see a practical face-up, as supposed by a variety of real cases.

Take for example the city relocation of Newtok in Alaska following erosion brought on by climate change. It exquisitely demonstrates the interlaced web of issues linked to climate adaptation. Substantial federal funding notwithstanding, the community ended up struggling with issues like substandard infrastructure and interagency coordination problems, which speaks loudly to the requirement of a developed ethical framework in planning methods.

The ACT Initiative in Delhi represents a new approach to urban resilience. ACT strives at making responsive and sustainable urban systems to fight the climate challenge in a collaborative manner with various stakeholders. This goes to show that planning activities aligned with justice could be realized by means of participatory planning and interdisciplinary collaboration.

On the other hand, developing mini-forests in Uttar Pradesh under the Upvan Scheme speaks about integrating natural solutions in urban planning. By promoting green cover, these programs contribute to ameliorating the urban heat island effect that is a real menace for densely populated areas. This kind of program further speaks about distributive justice because it attempts to assure equal benefits from the environment.

In the United States, cities are increasingly integrating justice in climate planning. Several studies have analyzed climate action plans from the 100 largest cities in the United States and found that quite a few justice principles had been incorporated into their climate mitigation strategies, with tools such as equity assessments and community engagement frameworks being used. Such practices point in the direction of increasing awareness

toward the importance of procedural and recognition-based justice considered by urban planners. Moreover, sponge cities in China epitomize cutting-edge urban flood management. Through redevelopment of the green infrastructure, these cities seek to absorb and reuse rainwater, thereby alleviating flooding and enhancing ecological biodiversity. This model exemplifies how ethics in urban design can promote sustainable and resilient communities.

These aforementioned examples show the many sides of justice in adaptive planning. Given their case-study perspectives, they urge the embedding of ethical framework considerations into planning processes to meet the multifaceted challenges posed by climate change and urbanization. Armed with the lessons derived from the real-world instances discussed, planners can formulate strategies that would be workable, fair, and inclusive.

Embedding these ethical frameworks in adaptive planning is certainly given priority to deal with the multifaceted challenges of this century. Set against them, planners could make just, fair, and sustainable strategies that could lead to improved community resilience and recognition of cultural values. The case studies discussed herein shed light on their usefulness in grounding future planning on these principles.

In summary, what this means is the operationalizing of justice in highly adaptive planning needs an abiding set of ethical principles, which includes inclusivity, equity, and sustainability. Planners can embark on the path of participatory planning, interdisciplinary collaboration, and nature-based solutions as they develop strategies that tackle the immediacy of climate change and urbanization, while paving an additional path toward long-lasting resilience and social justice. The experiences of the likes of Newtok, the initiatives from ACT, and the Upvan Scheme will provide invaluable lessons toward that end in seeking equitable and sustainable urban outcomes.

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A Study on the Supply–Demand Relationship of Recreational Services Supported by Ecological Public Spaces: A Case Study of Nanjing, Jiangsu Province, China

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Abstract
This study explores the supply-demand dynamics of recreational services in Nanjing, China, using 2020 data on land use and population. Key findings include: (1) A spatial mismatch exists between high-demand and high-supply areas. (2) Expanding the accessible radius from 2 km to 10 km improves the supply-demand balance, reducing deficit areas and unmet needs. (3) Nanjing's districts are classified into four types—locally satisfied, medium-distance satisfied, long-distance satisfied, and unsatisfied—with tailored planning recommendations. The study advocates for rational ecological land planning, decentralized management, and enhanced ecological compensation and economic cooperation to ensure fairness in recreational services and promote green development, offering insights for urban planning and ecological civilization.

Keywords: Ecological public space; Supply-demand relationship; Planning and management; Recreational services

I. Introduction

Recreational services, as a vital component of cultural services within ecosystem services, significantly contribute to enhancing human well-being (Li Xiang et al., 2019). However, amid economic development and rapid urbanization, the supply-demand contradiction of regional recreational services has become increasingly pronounced, manifesting distinct temporal and spatial characteristics. To date, research on the evolving supply-demand dynamics of recreational services remains limited, with most studies employing semi-quantitative methods that fail to effectively align regional supply and demand in both time and space. Consequently, there is an urgent need to advance research in this area. This study quantitatively assesses the supply, demand, and balance of recreational services, while leveraging spatial analysis techniques to illustrate the spatial distribution characteristics of the supply-demand relationship within the study area from a geographical perspective. This approach enhances the intuitiveness and comprehensibility of the findings, establishing a foundation for subsequent investigations into the changing patterns of supply-demand balance and offering targeted recommendations to improve these dynamics. Focusing on Nanjing City as a case study, this research examines the supply-demand conditions of recreational services within the ecosystem services of its 11 administrative districts in 2020. By employing methods such as supply-demand measurement assessments and spatial analysis, the study analyzes the supply-demand situation across these districts during this period and explores the spatial distribution characteristics of recreational services in each administrative district in 2020. Investigating the spatial supply-demand features of regional recreational services provides a practical basis for urban land planning and ecological civilization construction, addressing urban residents' aspirations for an improved quality of life and, in turn, elevating their well-being.

II. Theoretical Foundation and Literature Review

Ecosystem Services (ES) refer to the diverse benefits that ecosystems provide to humanity. Since its introduction in the 1990s, this concept has emerged as a research hotspot across disciplines such as ecology, economics, and environmental management. This chapter reviews the literature from four key perspectives—concept definition, supply-demand relationships, types and characteristics, and assessment methods—to establish a theoretical foundation for subsequent research.

2.1 Concept Definition of Ecosystem Services

The concept of ecosystem services was first articulated by Costanza et al. (1997), who defined it as the material and non-material support humans derive from ecosystem functions. This definition gained broad acceptance within the academic community and was further refined by the United Nations Millennium Ecosystem Assessment

(MA, 2005) as "the benefits ecosystems provide to humans," highlighting their direct and indirect contributions to human well-being. Subsequent studies by TEEB (2010) and USEPA (2012) emphasized that ecosystem services encompass a wide range of economic, social, and ecological benefits, underscoring their role as a cornerstone of human welfare.

2.2 Evolution of Supply-Demand Relationships

Research on ecosystem services has progressively evolved from focusing solely on supply to analyzing the balance between supply and demand. Xiao Yu and Xie Gaodi (2003) pioneered the exploration of spatial flows in ecosystem services, elucidating the linkage between supply and utilization. Zhen Lin (2008) defined demand as the consumption and appropriation of ecosystem services in human production and daily life. Li Shuangcheng (2019) proposed a comprehensive service process comprising formation, transportation, and consumption. Wolff (2015) highlighted that service flows connect supply areas to beneficiary regions, transforming ecosystem outputs into usable products for humans. Mou Xuejie and Wang Xiahui (2019) differentiated between direct consumption (e.g., provisioning services) and indirect consumption (e.g., regulating and cultural services), noting that supporting services are indirectly manifested through other service types.

2.3 Types and Characteristics of Ecosystem Services

The classification of ecosystem services provides a critical basis for their assessment. Daily (1997) categorized them into three groups: providing material resources, sustaining life systems, and enhancing life enjoyment. Costanza (2017) expanded this framework, identifying specific services such as food production, climate regulation, waste treatment, nutrient cycling, and recreational activities. Drawing on the MA classification, Wu Xiao and Zhou Zhongxue (2019) classified urban green infrastructure services into regulating, cultural, and supporting categories. Geng Nianzi and Zheng Hua (2023) outlined key characteristics, including quality dependence, spatial heterogeneity, scale correlation, and trade-offs and synergies. Guo Baoxiang and Nie Yuming (2022) observed that service distribution tends toward "spatial homogenization" as scales expand, emphasizing the significance of scale in analysis.

2.4 Development of assessment methods

The development of assessment methods is a core component of research on the supply and demand relationship of ecosystem services, for which scholars have developed a variety of methods. Indicator assessment methods quantify ecosystem services by constructing an indicator system, for example, (Layke et al. 2009) assessed provisioning, regulating, and cultural services, but demand indicators are relatively understudied (Fu Berger et al., 2017). The ecological modeling approach is favored for its ability to reveal ecological processes, and commonly used models include the InVEST model, the SolVES model, and the ARIES model, of which the InVEST model is suitable for water resources and environmental quality assessment due to low data requirements (Ma Lin et al. 2017), but its algorithms are relatively simple and require field data validation (Huang Conghong et al. 2013); The SolVES model focuses on the social value assessment of cultural services, quantifying aesthetic and leisure values through public surveys (Huang Conghong et al., 2013); the ARIES model, on the other hand, is suitable for comprehensively assessing supply and demand, but its application is limited due to its complexity and closed nature (Huang Conghong et al., 2013). The value assessment method quantifies the value of services through monetization, such as the unit area value equivalent factor method proposed by Xie Gao Di et al. (2015), which was pioneered by Costanza et al. (1997) and later optimized to adapt to China's national conditions (Xie Gao Di et al., 2008), and the unit service function price method is divided into the real market method, the alternative market method, and the virtual market method, which are applicable to different types of services (Liu Yao et al. 2017). In addition, the participatory method and empirical statistical modeling method are also important tools, in which the expert assessment matrix method (Burkhard, 2009) assesses supply and demand through expert scoring, which is simple to operate but highly subjective; the questionnaire survey method can accurately reflect the demand, but the cost is high and the scope is limited (Yan Yan et al., 2017); and the empirical statistical modeling method assesses the balance between supply and demand by using socio-economic data, which is easy to get the data but ignores ecological processes (LarondelleN et al., 2016). Each of these methods has its own advantages and disadvantages, and researchers need to choose appropriate assessment tools according to specific objectives and conditions.

III. Overview of the Study Area and Data Sources

3.1 Overview of the Study Area

Nanjing Nanjing City, as the capital of Jiangsu Province, is situated in the southwestern part of Jiangsu and the lower reaches of the Yangtze River. Its geographical coordinates range from 31°14'N to 32°37'N and from 118°22'E to 119°14'E. The city's maximum east-west extent is approximately 70 kilometers, while its maximum north-south extent is about 150 kilometers. On the municipal plane, Nanjing exhibits a pattern of being elongated from north to south and narrow from east to west, with a total area of 6,587.04 square kilometers, encompassing 11 districts and one national-level Jiangbei New Area. In recent years, the Nanjing Municipal Party Committee, Municipal Government, and planning and construction departments have successively announced and implemented a series of highly targeted initiatives to strengthen the development of urban green spaces and ecological infrastructure, thereby enhancing Nanjing's cultural appeal and quality of life.

In 2002, the "Green Nanjing" strategy was implemented, and in 2004, Nanjing launched the "Greening the Old City" campaign (Li Zhong, 2006). By the end of 2021, the city's built-up area achieved a green coverage rate of 44.96%, a green space rate of 40.79%, and a per capita park green space of 16.18 square meters, all ranking among the highest in cities of similar type across China. With the rapid development of the economy and society, residents' living standards have continuously improved, leading to a growing demand for recreational services. Particularly in the context of urban expansion, urban residents have an increasingly urgent need for nearby natural environments, cultural experiences, and other recreational services. However, due to constraints in urban planning and land resources, the supply capacity of recreational services in Nanjing has not kept pace with demand, and in some respects, has even declined. This has resulted in a significant contradiction between supply and demand. Meanwhile, with the improvement of transportation infrastructure, residents' travel options have become more diversified. In addition to traditional modes such as walking and cycling, transportation options like metro, buses, taxis, and ride-hailing services have provided greater convenience to residents. Consequently, as the accessible range of residents' recreational activities has expanded, the spatial layout of the supply and demand for recreational services in Nanjing has adjusted accordingly (Tong Liga et al., 2013).

3.2 Research Data

In this paper, we utilized various data, including land use and population spatial data.
(1) Regarding the 30m land use raster data for Nanjing City in 2020, this information was obtained from the Resource and Environment Science Data Center of the Chinese Academy of Sciences. In the process of creating "China's 20th Century LUCC Spatiotemporal Platform," Liu Jiyuan and his team referenced the LUCC classification system.
Based on the actual conditions of the study area, land use was meticulously categorized into eight distinct types, including paddy fields, dry land, forest land, grassland, water bodies, wetlands, construction land, and bare land.
(2) Regarding population spatial data: These data were based on 1km grid information from the Science and Environment Data Center of the Chinese Academy of Sciences.

3.3 Research Methods

1. Quantifying the Supply of Recreational Services

Past research has primarily focused on areas such as oceans, marine landscapes, urban greening, and forests, with the aim of assessing the potential value of these ecosystems in providing leisure and recreational services. Therefore, this study identifies ecological lands such as forests, grasslands, water bodies, and wetlands as specific areas capable of offering leisure and recreational services.

This research project plans to use a **1km×1km grid structure** as the primary research framework and conduct an in-depth analysis of five different modes of transportation: walking, cycling, electric vehicles, public transportation, and self-driving. During this research, **2 km, 5 km, and 10 km** were selected as the accessible radii for ecological lands, assuming that within a specific grid, ecological lands can provide various leisure and recreational activities to residents within that radius. At the same time, residents within the grid are also eligible to access all ecological lands within that radius (Tao Qin et al., 2021). The calculation process is as follows:

(1) The ecological land within the grid can provide recreational services to each person within the radius.

$$Ai=Si/Pi \quad (1)$$

where Si is the area of ecological land in grid i, Pi is the total population within the reachable radius corresponding to grid i, Ai is the per capita usable area of ecological land in grid i.

(2) In the grid environment, people can experience the services = services provided by all ecological lands within the accessible radius.

$$RSi=\sum kAj \times POPi \quad (2)$$

where RSi is the supply of recreational and leisure services in grid i; j is all the grids within the corresponding buffer radius of grid i; and POPi is the total number of people in grid i. When the reachable distance is not considered, i.e. when the reachable distance is 0km, the supply of recreational and leisure services is the ecological land area of the grid.

2. Quantifying the Demand for Recreational Services

Based on previous studies (Prance GT et al., 2014; Xie Zilai, 1999), this research establishes the per capita ecological land standard as **60 m²/person** and defines the demand for recreational services as:

$$RDi=60 \times POPi \quad (3)$$

where RDi denotes the demand for recreational and leisure services in grid i.

3. Assessment of Supply and Demand of Leisure and Recreation Services

This research program is based on the research method proposed by Zhao et al. (2015), which uses the metric of supply-demand ratio (R) to quantify the supply-demand balance of leisure and recreation services. In the case where the R value exceeds 1, the supply and demand in the study area shows a surplus situation, which means that the supply exceeds the demand, thus making the supply and demand of leisure and recreation services perform quite well; in the case where the R value reaches 1, the supply and demand in the study area reaches equilibrium, which means that the supply and demand are equal; in the case where the R value is lower than 1, the supply and demand show a deficit situation, which represents that the demand exceeds the supply, thus creating an imbalance between the supply and demand for leisure and recreation services.

$$Ri=RSi/RDi \times 100\% \quad (4)$$

where Ri denotes the ratio of supply and demand of leisure and recreation services in grid i.

IV. Research Results and Analysis

4.1 Recreation and leisure service supply in Nanjing under different accessible radius of each administrative district

In 2020, the highest value of leisure and recreation service supply of ecological land in Nanjing is 1.0404km². In terms of spatial distribution, the supply of leisure and recreation services in Nanjing shows different characteristics under different reachable radius, but with the expansion of reachable radius, the distribution of the supply of leisure and recreation services in Nanjing gradually expands and tends to be uniform. Under 0km accessibility radius, the supply of leisure and recreation services in Nanjing shows the characteristics of high in the south and low in the north, and the supply of Gaochun District, Lishui District and Yangtze River Valley in the south is especially high, while the supply of ecological land in the central urban area and Liuhe District is relatively small; under 2km accessibility radius, the supply of leisure and recreation services in Nanjing tends to be scattered, but it is still concentrated in Gaochun District, Lishui District and Yangtze River Valley in the south,

and the supply of Luhe District is still relatively small. The supply is still relatively small; under the 5km and 10km accessibility radius, the supply of leisure and recreation services in Nanjing tends to be uniform, but the supply in Luhe District in the north is still small compared with other administrative districts.

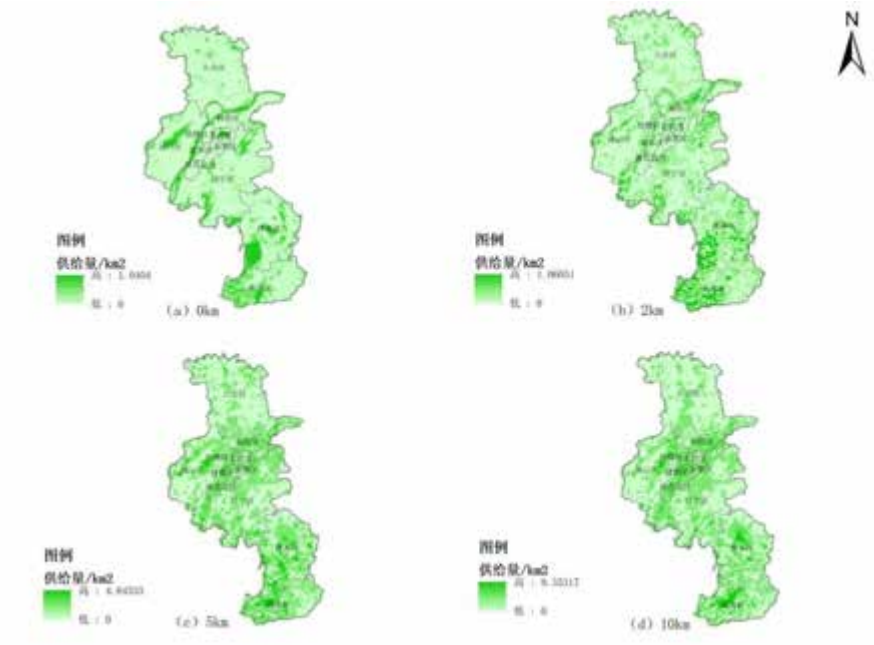

Figure 1 Supply of Leisure and Recreation Services under Different Reachable Radii in Various Administrative Regions of Nanjing City in 2020

4.2 Demand for Leisure and Recreation Services in Various Administrative Districts in Nanjing

In 2020, the highest value of leisure and recreation service demand for ecological land in Nanjing is 1.78503km². In terms of spatial distribution, the demand for recreational and leisure services is higher in the central region and relatively lower in the north and south regions. The core urban areas of Nanjing are the main concentration of high-demand zones, such as Gulou, Qinhuai, and Jianye Districts. These administrative districts have good economic development and convenient transportation, and due to the large proportion of built-up land, this has led to a large increase in the population, and consequently, a rise in the demand for recreation and leisure services. Liuhe District is the main distribution area of low-demand zones, Jiangning District, Lishui District and Gaochun District. These administrative districts are sparsely populated and have low population density, thus the demand for leisure and recreation services is low.

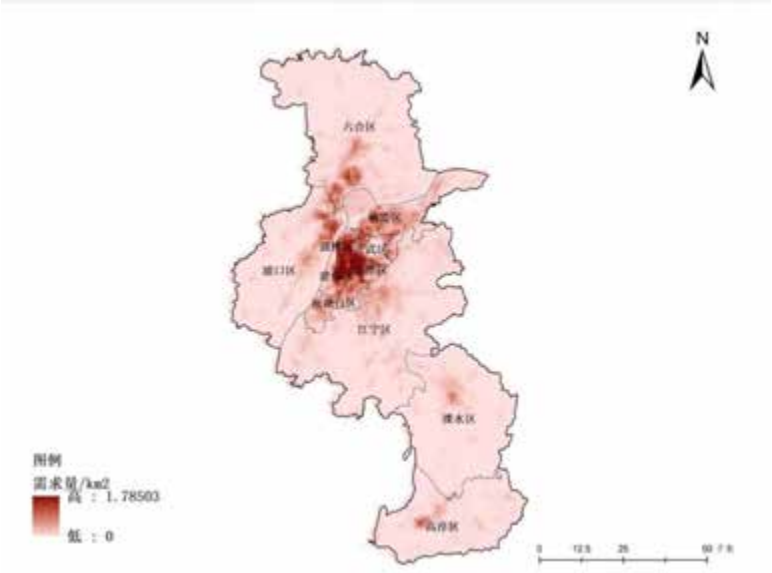

Figure 2 Demand for Leisure and Recreation Services in Various Administrative Regions of Nanjing City in 2020

4.3 Supply and demand of leisure and recreation services in Nanjing administrative districts

In 2020, the supply and demand of recreational and leisure services in Nanjing's ecological land under different accessible radii showed different characteristics, with significant heterogeneity in the spatial distribution of supply and demand, and an obvious mismatch in the location between areas of high supply and high demand, resulting in a serious spatial mismatch problem. Under 0km and 2km reachable radius, the supply of central and northern administrative districts and southern Gaochun district of Nanjing is much smaller than the demand, while the supply of Lishui district is much larger than the demand; under 5km and 10km reachable radius, the supply of central and northern administrative districts of Nanjing is much smaller than the demand, while the supply of southern Jiangning, Lishui and Gaochun districts is much larger than the demand. Overall, when the reachable radius gradually expands from 2km to 10km, the relationship between supply and demand in Nanjing is gradually improving, the deficit area continues to shrink, and the number of people failing to meet the demand for recreation and leisure services is also gradually decreasing. However, the central administrative districts of Gulou, Qinhuai, Jianye and Xuanwu have a small area of ecological land due to the concentration of population, and the number of people with unmet demand for recreation and open space services is decreasing.

However, Gulou District, Qinhuai District, Jianye District and Xuanwu District in the central part of the city have a small area of ecological land due to the concentration of population, so the decrease in the number of people with unmet demand for recreational and leisure services is relatively flat, and the relationship between supply and demand is always in a deficit. Under the 0km reachable radius, the deficit ecological land area for leisure and recreation services in Nanjing is 48.35%, and the deficit population is 82.79%; under the 2km reachable radius, the deficit ecological land area for leisure and recreation services in Nanjing is 65.1%, and the deficit population is 94.67%, which further aggravates the contradiction between supply and demand; under the 5km and 10km reachable radii, the deficit ecological land area for leisure and recreation services in Nanjing is 65.1%, and the deficit population is 94.67%, which further aggravates the contradiction between supply and demand. In 5 and 10km accessible radius, the deficit ecological land area of leisure and recreation services accounted for 24.52% and 21.63% respectively, and the deficit population accounted for 68.12% and 64.11% respectively, the supply and demand relationship improved significantly, and the relationship of leisure and recreation services in Gaochun District turned from deficit to surplus, the overall supply and demand relationship of leisure and recreation services in Nanjing is better, and the leisure and recreation services provided by ecological land basically meet the demand of the people.

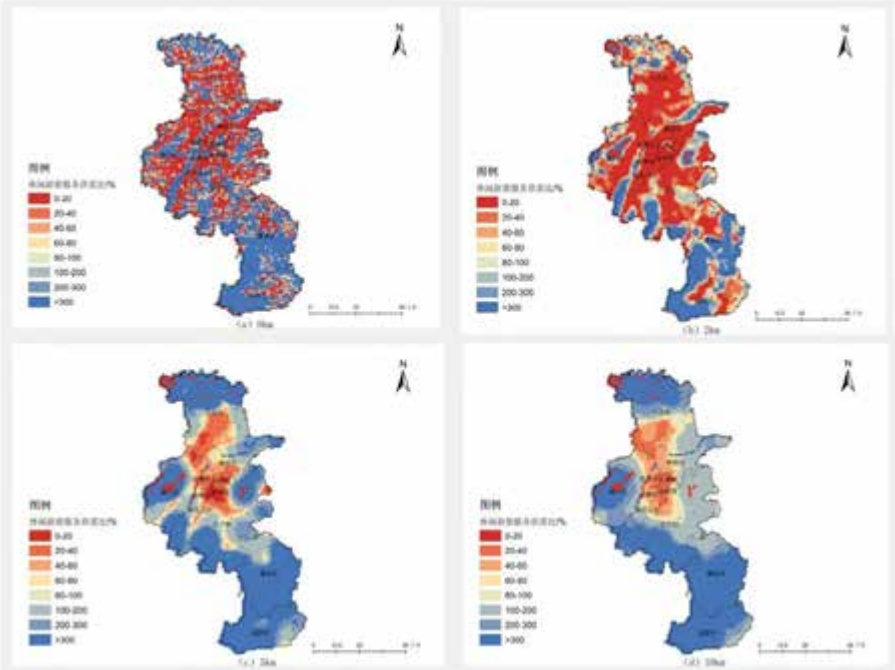

Figure 3 Supply and demand ratio fleisure and recreation services under different reachable radii in various administrative regions of Nanjing in 2020

4.4 Analysis of the changing pattern of supply and demand of recreational and leisure services in Nanjing's administrative districts

The city center is generally the most prosperous area for economic, cultural and transportation development of a city. Under the background of industrialization, the proportion of ecological land has been decreasing, and as the proportion of construction land gradually rises, the number of leisure and recreational services that can be provided by ecological land also decreases accordingly. At the same time, due to the high population density in the urban core area, the residents have a high demand for quality life, which, of course, covers the urgent need for leisure and recreation services. On this basis, the study selects the grids with more than 50% of built-up land in Nanjing as the research objects, and statistically analyzes their supply and demand ratios of leisure and recreation services under different accessible radii, in order to demonstrate the supply and demand situation of leisure and recreation services in various administrative districts in Nanjing. Considering the changing pattern of supply and demand of leisure and recreation services in Nanjing under different conditions of reachable radius, this study divides the administrative districts of Nanjing into four different categories.

Locally satisfied administrative districts refer to the administrative districts with supply and demand ratios close to 100% under the 2km accessibility radius, and there is one such district, i.e. Lishui District. Lishui District has a large area of ecological land and a good relationship between the supply and demand of leisure and recreation services. It should continue to maintain this favorable trend and vigorously develop tourism and ecological industries to meet the increasing demand of residents for leisure and recreation services.

Medium-distance-satisfying administrative districts refer to those administrative districts with balanced supply and demand within a 5km accessibility radius, and there are three of them, mainly located in the suburbs of Nanjing. Some of these administrative districts have a large area of ecological land, but the population density of the area is small, the total demand for recreational and leisure services is low, and the layout of ecological land is unreasonable, so that residents can enjoy the recreational and leisure services provided by ecological land less conveniently, such as in Gaochun District, while some of the area of ecological land is smaller, but the population density of the area is even smaller, such as in Pukou and Jiangning Districts. In the future ecological land use planning, not only should the decentralized layout of green spaces in the administrative districts be

strengthened to enhance the accessibility of the region, but the supply of recreational and leisure services in the deficit areas of the region should also be expanded, e.g., by adding more recreational and leisure venues.

Distance-satisfying administrative districts refer to those administrative districts where a balance between supply and demand exists within a 10-km accessible radius, of which there is one, i.e. Qixia District. The relatively small area of ecological land in Qixia District has resulted in a serious imbalance between supply and demand of leisure and recreational services. Therefore, the construction of pocket parks should be actively promoted and a dedicated tourism line should be established with the geographically close Liuhe District to meet the diversified demand for leisure and recreation services of residents in Qixia District.

Unsatisfiable administrative districts refer to areas where the supply and demand for leisure and recreation services is always below 100% within an arbitrary radius, and there are 6 such districts, which are mainly concentrated in the central urban area of Nanjing, and the leisure and recreation services provided by ecological land in the area are always unable to satisfy the demand of the residents. These districts should develop areas that can provide leisure and recreation services without affecting the city's economic development, create pocket parks and micro-green spaces, expand leisure and recreation spaces within the neighborhoods, and increase the area's green coverage rate, so as to improve the contradiction between the supply and demand of leisure and recreation services in the area and enhance the well-being of the residents.

District Name	0km	2km	5km	10km
Gaochun District	45.92	24.35	504.53	867.11
Gulou District	54.93	3.91	36.3	40.66
Jian YE District	22.63	4.88	45.8	49.41
Jiangning District	82.17	13.75	149.98	154.31
Lishui District	94.05	14.35	288.42	392.65
Liuhe District	44.11	9.68	60.11	65.05
Pukou District	56.71	13.54	146.67	145.14
Qixia District	51.52	11.36	93.57	100.97
Qinhuai District	18.65	1.18	19.22	44.55
Xuanwu District	42.96	3.96	41.01	57.58
Yuhuatai District	25.26	7.93	85.89	91.11

Figure 4 Supply and demand ratio fleisure and recreation services under different reachable radii in Nanjing administrative region in 2020

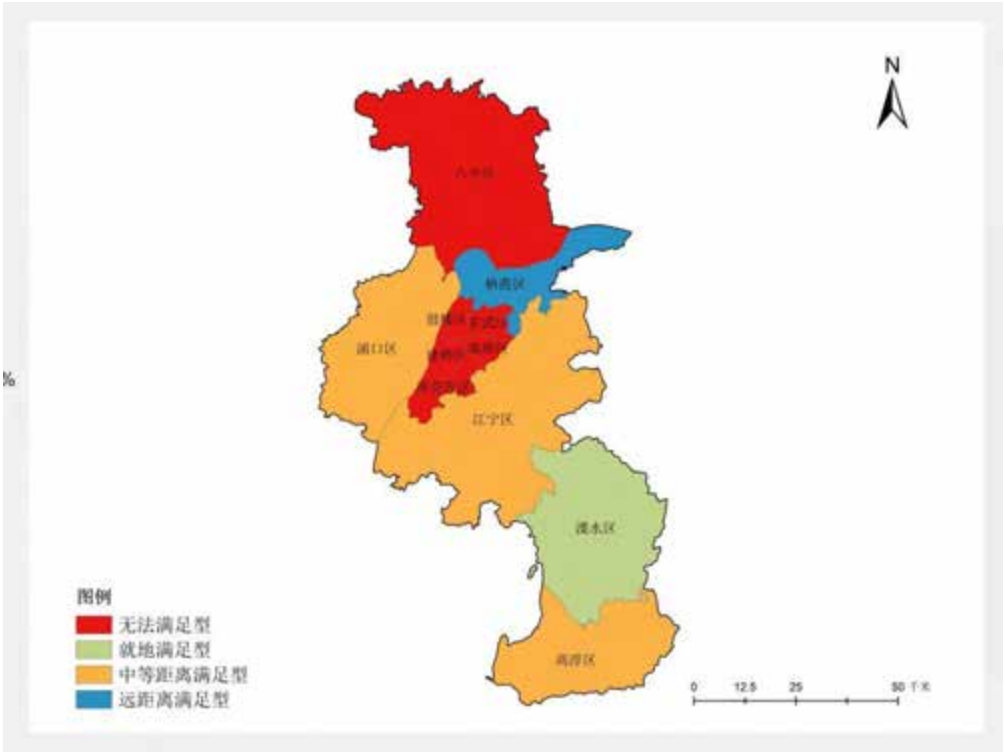

Figure5 Supply and Demand of Leisure and Recreation Services in Various Administrative Regions of Nanjing City in 2020

V. Conclusion and Outlook

This study utilizes land use and demographic data, and utilizes a methodology for assessing the supply and demand relationship of regional recreational and leisure services under different accessibility radii. It also examines the changes in the supply and demand relationship of recreational and leisure services in various administrative districts of Nanjing in 2020, and explores the spatial distribution of the supply and demand relationship under different accessibility radii, and the following are the main findings:

The supply and demand relationship of leisure and recreation services in Nanjing is characterized by very obvious regional characteristics, which is mainly closely related to the geographic location, population density, ecological land layout and urban planning of different regions. Firstly, high demand areas are mainly concentrated in the administrative districts of the city center. These districts are usually the centers of economic, cultural and social activities, attracting a large number of people to gather. Due to the limited nature of land resources, the area of ecological land in these districts is relatively small, and the construction of leisure and recreational facilities is also restricted. As a result, despite the high demand for leisure and recreation services, the supply is relatively low, leading to an imbalance between supply and demand. In contrast, high supply areas are located in the urban outskirts. These areas are less densely populated and relatively rich in land resources, and hence have more space for leisure and open space facilities. However, the layout of ecological land in these areas may not be rationalized. For example, some of the recreational open spaces may be too dispersed or far away from the residential areas, making it inconvenient for residents to use them. In addition, some of the leisure and open spaces may lack the necessary ancillary facilities and services, thus affecting their service quality and attractiveness.

When the reachable radius gradually expands from 2km to 10km, the supply and demand relationship in NJ shows a significant improvement. Such an improvement is mainly manifested in the gradual reduction in the size of the deficit area and the continuous decline in the number of people with unmet demand for leisure and recreation services. Firstly, the expansion of the accessibility radius means that residents can enjoy leisure and

recreation service facilities more conveniently, and service areas that might have been difficult to reach due to long distances are now within reach due to the expansion of the accessibility radius. As a result, the imbalance between supply and demand in the service areas has been effectively alleviated, and the size of the deficit areas will naturally be reduced accordingly. Secondly, with the reduction in the size of the deficit areas, those residents who were originally unable to enjoy leisure and recreation services due to the distance problem are now provided with more choices and their needs are better met, thus the number of people with unmet demand for leisure and recreation services is also decreasing. In addition, the expansion of the radius of accessibility may bring about a series of knock-on effects. For example, as the accessibility of service facilities improves, more people may be willing to visit these facilities for consumption, thus further stimulating the development of related industries. At the same time, the utilization rate of service facilities will also be improved, which will help to achieve optimal allocation of resources.

Based on the spatial distribution characteristics of leisure and recreation services in Nanjing administrative districts under different accessibility radii, we subdivided them into four different categories of areas: locally satisfied, moderately satisfied, distantly satisfied, and unsatisfied, and put forward targeted development proposals respectively. The supply and demand of leisure and recreation services in locally satisfying and moderately satisfying regions are relatively balanced, and can meet the basic leisure and recreation needs of residents, and the creation of urban "green space" should be continuously strengthened to enhance the connection with the city center administrative region, and create a more attractive leisure and recreation brand by combining with the regional characteristics; the long-distance satisfying and unable to satisfy regions should strengthen infrastructure construction and rationalize the distribution of leisure and recreation services. Distance-supporting and non-supporting regions should strengthen infrastructure construction, rationalize the distribution of ecological land, improve connectivity and accessibility between different administrative regions, and at the same time, strengthen ties and cooperation with the outside world, introduce high-quality recreation and leisure resources and technologies, and promote the improvement of the relationship between supply and demand of regional recreation and leisure services.

At the same time, this study is innovative in terms of research perspectives and ideas: on the one hand, it fills the gap of research on the supply and demand relationship of recreation and leisure services at the level of city districts; on the other hand, it systematically analyzes the characteristics of changes in the supply and demand and puts forward suggestions for improvement, which is of practical guidance significance. However, there are some shortcomings in the study: the assessment of supply is only based on area, ignoring the quality of service; road accessibility is not taken into account, which may overestimate the actual supply; the determination of the accessible radius does not adequately reflect the willingness of the residents to travel; and the standard of demand lacks uniformity. Future research should construct a comprehensive supply evaluation system, introduce road accessibility analysis, incorporate residents' willingness to travel surveys, and improve the demand volume standard, in order to enhance the scientific and applicability of the assessment and provide more accurate support for urban planning.

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Evaluating Public Space Resilience: an index and a case study

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Abstract
Urban resilience is a critical concept in urban planning, yet it often blurs the line between crisis-triggering events and adaptive processes. To address this, the concepts of multiresilience and multiadaptation clarify how public spaces can handle multiple, overlapping risks. Multiresilience focuses on restoring pre-crisis conditions through inclusive, place-specific strategies, while multiadaptation emphasizes adjusting to unforeseen risks by achieving a new, often improved, equilibrium. This study introduces the Multiadaptation Place Index (MPI), a tool developed under the PRIN 2020 SUMMA research project to measure the adaptability of public spaces. The MPI assesses physical, social, and infrastructural factors to guide planners in designing inclusive, flexible interventions. The Hudson River Park in New York serves as a key case study, illustrating how adaptable urban spaces can enhance resilience and liveability under multi-risk scenarios.

Key words: Public space, resilience, liveability, inclusion

Main factors resilient planning

The implementation of resilient planning necessitates a shift from traditional, top-down approaches to more flexible, inclusive, and iterative processes. Key factors in this approach include inclusivity, flexibility, redundancy, diversity, and local knowledge (Banica et Al., 2020; Cutter et Al., 2003; Davoudi et Al., 2012). Inclusivity in planning ensures that all voices are heard, and the needs of marginalized groups are addressed. This can be achieved through participatory planning processes that engage community members in meaningful ways. Workshops, questionnaires, public consultations, and collaborative platforms can facilitate this engagement, allowing stakeholders to contribute their knowledge and perspectives. In areas facing multiple and overlapping risks—such as climate change, economic shocks, and social instability—inclusivity becomes even more critical, as it allows for the identification of vulnerabilities that may otherwise be overlooked and for the co-creation of solutions that are context-specific and equitable.

Flexibility in urban planning involves designing infrastructures and policies that can be easily adapted or modified in response to changing conditions. This might include the use of modular construction techniques, adaptable public spaces, and policies that can be updated based on new information or emerging risks. Flexibility ensures that urban systems remain responsive and resilient in the face of uncertainty. In multi-hazard environments, flexibility is essential to accommodate the dynamic nature of risks, where simultaneous or sequential shocks (such as floods followed by disease outbreaks) demand rapid and coordinated responses.

Redundancy involves creating multiple pathways and backup systems to prevent total system failure. In practice, this might mean designing urban transportation networks with multiple routes and modes of transport, ensuring that critical services like healthcare and communication have backup systems, and developing decentralized energy systems that can operate independently in case of a central grid failure. Redundancy in multi-risk contexts enhances the capacity to absorb disturbances without catastrophic collapse and provides the time needed to implement recovery measures.

Diversity in risk management strategies increases the likelihood that at least some solutions will be effective in any given scenario. This could involve a mix of structural and non-structural measures, such as building flood defences while also enhancing natural floodplains, promoting economic diversification to reduce reliance on a single industry, and fostering social networks that can provide support during crises. Diversity strengthens adaptive capacity by offering a portfolio of responses, reducing the risk of overdependence on any single system or approach (Benedict et Al., 2006; Jabareen, 2013). Local Knowledge and Practices are invaluable resources for urban resilience. Traditional and local knowledge often contain insights into sustainable practices

and risk management that have been developed over generations. Integrating this knowledge with modern technologies and practices can lead to more culturally appropriate and effective solutions. In multi-risk settings, local knowledge can reveal interconnections between hazards that are not always captured by scientific assessments, providing a more holistic understanding of vulnerability and resilience. Furthermore, resilience in multi-risk environments is defined not only by the capacity to withstand individual hazards but also by the ability to navigate the interactions between them. This requires a systemic perspective that accounts for cascading effects, compound risks, and long-term transformations. Adaptation, in this context, entails iterative learning processes, where actors engage in cycles of experimentation, monitoring, and adjustment. Adaptive governance mechanisms—such as flexible regulatory frameworks, polycentric institutional arrangements, and cross-sectoral coordination—play a crucial role in enabling timely and effective responses to complex risk landscapes.

Moreover, building resilience in places exposed to multiple hazards necessitates fostering social resilience, which includes strengthening community networks, enhancing social capital, and promoting inclusive decision-making. Socially resilient communities are better able to mobilize collective resources, disseminate information, and maintain trust in times of crisis (Birkmann, 2013; Bohland et Al., 2019; David, 2006; Folke, et al., 2010; Horton et Al., 2015; Meerow et Al., 2016). To design effectively in these places, an appropriate methodology must be used. This methodology, developed within the framework of the SUMMA research project PRIN2020 #20209F3A37, will be presented below, along with the Multiadaptation Place Index case studies and the core principles for multiadaptation design.

Multiadaptation Place Design

The methodology created to evaluate spaces subject to multiple risks is structured into ten precise phases: six dedicated to analysis and four to strategic planning. Its primary aim is to uncover current or potential hazards—whether separate or interconnected—that may impact public spaces, while also tracing their root causes, assessing users' perceptions, and proposing adaptive interventions to upgrade both resilience and quality. This process produces two detailed mosaics and the Multiadaptation Place Index (MPI). One mosaic consolidates all gathered data on risks, contributing factors, and perceptions; the other offers proposals for adaptation and enhancement. The MPI gauges a site's capacity to cope with multiple hazards while improving its assets.

The opening phase focuses on diagnosing the area to identify present or foreseeable urban hazards, using a standardized observation tool that classifies risks as minor, moderate, or critical. The risks observed may range from physical decline, environmental degradation, socio-cultural threats, human-induced hazards, and seismic dangers to public health issues, poor quality of life, insecurity, and erosion of local identity. The objective is to build a detailed risk profile by systematically mapping and categorizing these aspects.

In the subsequent stage, attention shifts to evaluating the drivers and conditions that shape or might shape these risks. Qualitative observation helps expose underlying factors, such as how mismanaged waste amplifies environmental harm or how fragmented social ties exacerbate insecurity. This phase is key to capturing the intricate relationships within the urban fabric.

The third stage assesses the impacts of risk overlap in a single location, compiling a database that logs each risk, its interplay, and the magnitude of cumulative effects, graded as low, medium, or high. For instance, an area facing both seismic threats and identity loss may struggle to function as a communal space, as insecurity and detachment erode its role. This offers a quantitative grasp of how layered risks undermine urban vitality and shapes targeted remedies.

Step four collects data on risk perception via surveys, exploring how individuals interpret and experience these hazards, whether they consider them transient or entrenched, and how they believe they can contribute to mitigation. The survey covers overall site impressions, evaluations of specific risks, their perceived permanence, and ideas for civic involvement, plus feedback on space quality.
The fifth phase entails reviewing existing plans, strategies, and policy tools relevant to the area, compiling a

mosaic that visualizes ongoing measures across sectors and scales. This informs the orientation of future actions.

The sixth stage identifies key local assets, from heritage landmarks to open areas, parks, and historical urban patterns, blending their presence and functions to evaluate both their value and adaptability. A neglected historic square, for example, may hold potential for revival through targeted upgrades. This produces a mosaic visualizing these quality features and functions as a foundation for future proposals.

Phase seven integrates the entire body of findings—identified risks, drivers, survey outcomes, and quality components—into a composite mosaic, creating a panoramic view of the multi-risk environment and offering a critical reference for planning.

In step eight, the process assesses the adaptability of the space using the composite mosaic, spotlighting zones where flexible transformation is feasible and where urgent action is needed to boost usability and safety. For example, an overlooked green area may be earmarked for community resilience initiatives. This stage leads directly to the formulation of the MPI.

The ninth step devises Multiadaptation interventions tailored to the areas highlighted previously, aiming both to tackle present and future risks and to enrich public space quality. This culminates in a mosaic displaying specific, context-sensitive strategies for urban renewal, ensuring a coherent and comprehensive approach to resilience.

The final phase calculates the Multiadaptation Place Index, which appraises how well urban subareas can respond to concurrent hazards, including unforeseen disruptions.

The MPI is a robust tool to assess the multi-resilience and adaptive capacity of urban settings. It delivers a holistic diagnosis of how effectively different zones manage risks, considering unanticipated changes. The index evaluates key aspects: risk exposure, adaptive capacity, response strategies, recovery potential, and participatory engagement.

Risk exposure gauges how intensely an area faces diverse hazards—natural (earthquakes, floods), socio-economic (poverty, unemployment), or related to urban liveability (health, accessibility, green spaces). Adaptive capacity refers to how social, economic, spatial, and infrastructural systems adjust to changing conditions. A city with dense social ties, varied economies, and resilient infrastructure typically scores high.

Response mechanisms assess the adequacy of risk management plans and grassroots initiatives, measuring their effectiveness across scenarios. Recovery potential captures a place's ability to bounce back and sustain functionality post-shock, influenced by resource availability, institutional strength, and infrastructure resilience, turning crises into opportunities for cultural and social regeneration.

Participation measures how extensively stakeholders—from government bodies and businesses to communities and individuals—engage in resilience strategies. High participation levels point to an inclusive, collaborative mode of adaptation, enhancing co-design with all actors involved.

Accordingly, the MPI is computed using the comparative assessment derived from the composite mosaic in step eight, spotlighting areas with the most significant adaptive potential. Key variables include actual and perceived risks, underused public spaces, streets suitable for pedestrian and cycling routes, tangible and intangible cultural resources, and nearby but connected public spaces.

Each factor is weighted (1–5), and the final score reflects the difference between the risk load and flexibility assets, yielding an index between 1 and 50, where 1 signal minimal potential and 50 maximal potential. For example, an area facing environmental, depopulation, and isolation risks totalling 15, but with 50 points in adaptive resources, scores 35 (50-15). This quantifies a site's capacity for dynamic adaptation and improvement. The MPI can be

applied across contexts to guide resilience strengthening. In a coastal city battling sea-level rise and economic decline, the MPI can help pinpoint vulnerable zones and craft tailored solutions, like coastal defences or economic diversification. In fast-expanding cities, it can highlight gaps in housing, public services, and sustainability, shaping interventions such as affordable housing, vibrant public spaces, and green infrastructure.

Case study

In order to both experiment the method and the relative MPI-Multiadptation Place Index, the case of the renovated Hudson River in New York will be reported.

New York City, in the last years is facing major risks from climate change: rising sea levels, more frequent extreme weather events, and urban heat island effects continually threaten the city. To confront these challenges, New York has crafted and carried out a set of resiliency strategies designed to prepare the city for future climate impacts while safeguarding residents and vital systems. These efforts centre on strengthening infrastructure, enhancing adaptive capacity in neighbourhoods, and embedding sustainability in urban policies.

One of the key approaches for climate resilience in New York City is the "OneNYC" plan, launched in 2015 and updated in 2019. This plan's goal is to make the city fairer, greener, and stronger against climate risks ahead. A critical part of OneNYC (New York City Mayor's Office of Sustainability, 2020) is reducing threats posed by rising sea levels and storm surges. As reported by the New York City Panel on Climate Change (NPCC), sea levels around the city could rise up to 30 inches by 2050. To address this, the city has invested in coastal defence projects, notably the East Side Coastal Resiliency (ESCR) project, a $1.45 billion undertaking to reinforce lower Manhattan against storm surges and rising tides. Besides coastal defences, New York has also prioritized green infrastructure to tackle flooding, heat hazards, and enhance urban quality of life. Green infrastructure includes the use of natural systems like parks, green roofs, and rain gardens to absorb rainfall and lessen pressure on city sewers during storms. This strategy not only limits flooding but also cools areas affected by the urban heat island effect, where dense built environments retain heat and increase temperatures. The Resilient Waterfront initiative in New York City is a cornerstone of the city's wider strategy to confront climate change, guard against sea-level rise, and reduce the effects of extreme weather. With more than 520 miles of shoreline, New York is acutely exposed to climate risks, as highlighted by the destruction caused by Hurricane Sandy in 2012. In response, the city has launched multiple strategies to reinforce its waterfront, improve public access, and sustain economic activity. One of the centrepiece projects is the East Side Coastal Resiliency (ESCR) project, a $1.45 billion investment blending flood defence infrastructure with upgraded public amenities along the waterfront. Spanning East 25th Street to Montgomery Street in Manhattan, the project integrates levees, floodwalls, and deployable barriers engineered to withstand a 100-year flood, aiming to shield at-risk neighbourhoods while maintaining public access to waterfront parks and recreation.

Beyond engineered defences, the city has focused on restoring natural ecosystems, which act as living barriers against storm surges. These ecosystems not only buffer floodwaters but also boost biodiversity and strengthen the city's resilience.

Additionally, the Waterfront Revitalization Program (WRP) embeds climate resilience into land-use planning, ensuring that future developments along the shoreline are designed to endure projected climate stresses. This includes requirements for higher building elevations and the adoption of green infrastructure to better manage stormwater and lower flood risks. Bike lanes also play an essential role in New York's green infrastructure agenda. Expanding the protected bike lane network promotes cycling, cutting car dependency and lowering greenhouse gas emissions. Furthermore, more bike lanes help calm traffic, improving safety for cyclists and pedestrians alike. The use of permeable pavement in some lanes allows rainwater to infiltrate the ground, relieving pressure on the city's drainage system and aiding in flood control. By encouraging cycling as a sustainable transport option, New York not only reduces its carbon footprint but also develops a more resilient transportation system capable of weathering climate disruptions. Indeed, New York's green infrastructure plans extend far beyond traditional parks, encompassing waterfronts and urban spaces like parklets, bike lanes, and pedestrian plazas. The inclusion

of these kind of public spaces constitutes a comprehensive approach to not only manage climate risks but also to enhance the quality of life for the city's residents. These urban design features foster healthier (Sepe, 2023), more liveable communities, while also contributing to New York's long-term sustainability and resilience in the face of increasing climate challenges. By leveraging every available space, whether it's a former parking spot, a small alley, or a city street, New York is leading the way in rethinking how cities can adapt to a changing climate while improving urban life.

This approach not only mitigates flooding but also helps to lower temperatures in areas affected by the urban heat island effect and improve urban health and liveability. A key example is the Green Infrastructure Program, which has already implemented hundreds of green projects across the city, reducing flood risks and improving urban air quality (Horton et Al., 2015; New York City Department of City Planning, 2021; New York City Environmental Protection, 2020; New York City Mayor's Office of Recovery and Resiliency, 2020; New Yorkers for Parks, 2001; Vardı Topal, Franck, 2023).

Hudson River Park

Hudson River Park stretches along the west side of Manhattan, from 59th Street down to Battery Place. Covering 550 acres of land and water, this unique park is the second-largest park in Manhattan after Central Park (New York City Department of City Planning, 2021; Pallarés, 2021).

As regard the first step of the protocol, the identified risks are the following.Hudson River Park, situated directly on the waterfront, is particularly vulnerable to flooding during extreme weather events. The low-lying sections of the park, particularly those close to historic piers, are at a high risk of inundation during storms.

The second identified risk is the urban heat island effect. Surrounding buildings, roads, and other urban infrastructure absorb and retain heat, causing temperatures in the park to rise significantly, especially during summer months. The park's open layout, while ideal for recreational activities, provides little protection from the heat in certain sections.

The third risk is the overcrowding. The park's pathways, particularly the bike lanes and pedestrian paths, is sometimes congested, especially on weekends and during events. This foot traffic could reduce the quality of the visitor experience and put strain on the park's infrastructure, from benches to lawns to waterfront facilities. After identifying the main risks, it is crucial to analyse the factors that contribute to or amplify these risks in Hudson River Park.

Proximity to the Hudson River, while offering opportunities for recreation, is also the primary factor contributing to flooding and coastal erosion. Its location directly exposed to the river makes the park vulnerable to storm surges and rising sea levels.

Global climate change is already having a tangible impact on New York City, and Hudson River Park is no exception. The effects of climate change, particularly rising sea levels and increasing storm intensity, are making coastal flooding more frequent.

Much of the park's infrastructure, including the renovated historic piers and bike paths, is subject to wear and tear due to exposure to natural elements.

Fig.1 New York, Hudson River Park (Source: Marichela Sepe Archive's)

Fig.2 New York, Hudson River Park view (Source: Marichela Sepe Archive's)

Fig.3 New York, Hudson River Park detail (Source: Marichela Sepe Archive's)

Frequent storms and erosion can accelerate the deterioration of structures, making them vulnerable to more significant damage.

In the third step, we analyse how risks might coexist and interact in Hudson River Park, creating potentially more severe effects when occurring simultaneously.

Flooding + Coastal erosion: when flooding and erosion occur simultaneously, they can cause significant damage to the park's infrastructure. Areas along the river, already subject to erosion, become more vulnerable during floods, and storm surges can accelerate the loss of land along the park's coast.

Flooding + Crowding: during extreme weather events like storms, the park may become impassable or dangerous for visitors. Crowding can hinder evacuation and emergency management, making it difficult to protect citizens who use the park as a temporary shelter or escape route.

Extreme heat + Crowding: during summer heatwaves, the risk of heat-related problems increases significantly, especially in crowded areas like Hudson River Park. The lack of shade and the large number of visitors can create no too liveable conditions, particularly for the elderly and children.

In the Risk Perception Questionnaires step, questionnaires were administered to 50 users of the place aging between 30 and 65 years old to assess how visitors to Hudson River Park perceive the risks of flooding, erosion, overcrowding, and extreme heat in the park.

Results of questionnaire showed that visitors are aware of the flooding risks, especially after events like Hurricane Sandy, but awareness of the long-term risks associated with climate change may be less widespread.

Many visitors see crowding as an annoyance rather than a safety risk, underestimating the importance of proper crowd management, especially during emergency events.

Finally, the perception of heat risks is underestimated, with many visitors not fully understanding the dangers of heatwaves, particularly in highly frequented public spaces.

In the step 5, Analysis of Plans, Programs, and Policies were identified. Hudson River Park benefits from several plans and programs designed to improve its resilience, many of which are part of New York's broader coastal

resilience strategy. These include the following. Hudson River Park Trust Initiatives: the Hudson River Park Trust, the entity that manages the park, has implemented various measures to enhance the park's resilience. These include creating flood-resistant infrastructure and protecting natural areas from erosion. The Lower Manhattan Coastal Resiliency Project: as part of the broader Lower Manhattan Coastal Resiliency initiative, this project involves developing flood barriers along the coastline, including parts of Hudson River Park. The goal is to protect both public and private infrastructure from storm surges and rising sea levels. The NYC Climate Resiliency Initiatives: the City of New York has developed a climate resilience plan that includes measures to protect urban green spaces like Hudson River Park from flooding and other extreme weather events. These plans involve improvements in green infrastructure, such as the installation of sustainable drainage systems and the reinforcement of coastal areas (New York City Department of City Planning, 2021; New York City Environmental Protection, 2020; New York City Mayor's Office of Recovery and Resiliency, 2020).

As regard, step 6: Potentialities and Qualities, the Park has many piers of the park and many large public spaces. Furthermore, there is both a beautiful natural environment and a beautiful skyline with the main skyscrapers view. The park's natural areas, such as the wetlands and planted areas along the river, are valuable resources for absorbing rainwater and improving urban biodiversity. There are also many equipment and furniture for free time and sport activities, and off-leash spaces for dogs. Finally, Hudson River Park, with its location and ecological features, is an ideal site for educational programs on climate change and sustainability. Visitors could learn more about environmental challenges through informative installations and educational tours.

In step 7 multi-risks areas are identified, including: coastal flood zones, namely the sections along the lower piers and close to the river would be highlighted as areas subject to more frequent flooding; the crowding areas, namely the high-traffic areas, such as those around recreational piers and bike paths, would be marked as risk zones for crowd management; the erosion hotspots, namely the sections of the park most exposed to coastal erosion would be mapped to identify where structural interventions are needed to prevent future damage.

The multi-adapting areas identified in step 8, include as follows. Multifunctional piers: piers that could be adapted to withstand flooding, with spaces that can be temporarily submerged during storms and used for events and activities during the rest of the year. Adaptive green zones: the park's green areas, particularly the planted sections along the coast, could be transformed into flexible zones, where flood-resistant vegetation and natural drainage interventions can help mitigate flood risks.

Based on the previous steps, the identified multi-adaptation project interventions include measures for water management. This could involve installing systems to collect and manage rainwater along pedestrian paths and bike lanes during storms. Additionally, flood-resistant zones could be created by designing adaptable spaces that can temporarily flood during storms, reducing the risk to surrounding areas. Another intervention is the installation of movable barriers: temporary barriers along the park's coastline that can be raised during storms to protect critical infrastructure and visitors.

The collected information enabled the calculation of the Multiadaptation Place Index (MPI) of step 10 of the protocol, a tool designed to assess the resilience and adaptive capacity of complex urban contexts (Sepe, 2023; Sepe, 2024). This is calculated using the assessment derived from the risks and highlighting the areas with the greatest adaptive potential. The first phase, focused on risk identification, highlights three primary hazards affecting Hudson River Park. These include flooding and sea-level rise, where the low-lying areas and historic piers face particular vulnerability during extreme weather events; the urban heat island effect, driven by surrounding dense infrastructure and a lack of shade in some sections, leading to significant temperature increases during summer months; and overcrowding, where the park's bike and pedestrian paths often experience congestion, particularly on weekends or during events, which strains the park's infrastructure and diminishes visitor experience.

In the second phase, it was observed that the park's proximity to the Hudson River, while offering recreational opportunities, also makes it highly susceptible to flooding and coastal erosion. Moreover, the park's infrastructure

is subject to wear from constant exposure to natural elements, heightening the risk of accelerated structural deterioration.

The risk perception among users revealed widespread awareness of flooding, but an underestimation of the risks linked to crowding and extreme heat, underscoring a gap in public understanding of these hazards.

The park's potentialities and qualities, highlighting multifunctional piers adaptable to controlled flooding, adaptive green zones planted with flood-resistant vegetation and equipped with natural drainage, a wide range of recreational facilities, off-leash areas for dogs, and significant potential for environmental education programs addressing climate change and sustainability.

In phase seven, risk mapping highlights coastal flood zones concentrated around the lower piers, crowding-prone areas along the recreational piers and bike paths, and erosion hotspots located along the waterfront, pinpointing where future structural interventions will be most needed.

Phase eight delineates multi-adaptation areas, such as multifunctional piers that can be submerged temporarily during storms and serve as event spaces in calmer periods, and adaptive green zones designed to absorb excess rainwater through resilient vegetation and natural drainage systems.

The calculation of the MPI results as follows. Risk exposure is rated medium-high due to the combination of flooding, erosion, and heat, with a weight of 10 out of 25. Risk perception is rated medium-low, with a weight of 5 out of 25. The potential, qualities, and flexibility are considered high, reflecting all the existing features, with a score of 50 out of 50.The final score combines the sum of perceived and real risks (15 points) and potential and qualities and flexible areas (50 points), yielding the MPI as 50 (adaptation) minus 15 (risk), equaling 35. This score places Hudson River Park within the high adaptive potential range on a 1–50 scale, signaling its strong capacity to absorb shocks and adapt. This result underscores Hudson River Park's role not merely as a recreational green space but as an emblematic urban site demonstrating how parks can play a pivotal role in metropolitan resilience, helping to mitigate climate risks while enhancing quality of life.

Furthermore, the park's ability to balance social functions—such as sports, leisure, and gathering—with ecological functions—such as biodiversity enhancement and rainwater absorption—positions it as an advanced urban laboratory of multiadaptation, representing a best practice in the design of resilient cities.

Core principles

The diverse case studies used to test this methodology have been instrumental in formulating core principles for multiadaptation planning. These principles are grounded in the notion that risks can be reframed as opportunities to reevaluate and strengthen the qualities of a territory, establishing resilience as a cornerstone of sustainable regeneration. The case studies include Cittaducale and Leonessa in Lazio, alongside Siena, Naples, Paris, Madrid, Copenhagen, and New York. These locations were selected due to the presence of various actual or potential risks: Cittaducale and Leonessa are vulnerable to earthquakes and population decline; Siena, Naples, and Madrid's historic centres grapple with the impacts of mass tourism and globalization; Copenhagen and New York confront flood threats and the erosion of local identity; while Paris faces challenges related to flood and overtourism.

Risk identification should encompass both isolated hazards and combinations of potential simultaneous events. This integrated perspective allows planners to anticipate complex situations where different risks overlap. For example, a city may confront floods, declining liveability, and infrastructure breakdowns all at once. By examining risks holistically, planners can develop more cohesive resilience strategies, using tools like risk matrices and scenario modelling to rank and address threats effectively.

Grasping how people perceive risk is a fundamental aspect of hazard analysis. This requires carefully crafted surveys that capture the subtle differences in how diverse user groups understand and respond to threats.

These instruments should be inclusive, ensuring representation across age, gender, social class, and cultural background. The insights gathered can shape communication strategies and interventions that are more responsive to community concerns and expectations.

Special attention must be paid to vulnerable populations—such as the elderly, children, people with disabilities, and those with chronic health issues—both when assessing risk perception and when designing adaptive measures suited to their needs. These groups typically face heightened exposure and have fewer resources to cope. Adaptation efforts should therefore include provisions like accessible shelters, priority evacuation plans, and tailored healthcare services. Direct engagement with these communities is crucial to understand their needs and to integrate their input into planning.

Surveying urban assets—such as heritage sites, materials, and infrastructure—is essential for designing multi-resilience and adaptation initiatives. These elements should be viewed not as constraints but as opportunities to improve urban liveability. For example, historical buildings can be retrofitted to withstand hazards without sacrificing cultural value, while public parks can double as flood retention areas. Embedding these qualities into resilience planning both preserves local identity and enhances the city's aesthetic and functional appeal.

Continuous monitoring of multi-resilience projects is necessary to anticipate abrupt changes and respond sustainably. This involves deploying advanced technologies—like sensors, satellite monitoring, and data analytics—to observe environmental shifts and urban dynamics in real time. Establishing urban observatories or resilience hubs can help collect and analyse this data, providing early warnings and supporting proactive action. Regular reviews and updates of resilience plans, informed by current data and stakeholder feedback, are also key to maintaining effectiveness.

Flexibility is a fundamental feature of any multi-resilience or adaptation strategy. It must be conceived across scales (from the building to the metropolitan level) and across domains, integrating urban, social, economic, cultural, and ecological dimensions. A flexible urban plan, for example, might include modular housing systems, adaptable green spaces, and policies that permit the swift reallocation of resources during crises. This multi-layered flexibility enhances a city's capacity to adjust to evolving challenges.

The adaptability of public spaces can be greatly strengthened by providing adequate pedestrian and cycling networks. Such infrastructure promotes versatility, accessibility, and broad usability across diverse populations. Encouraging active transportation also advances environmental sustainability by cutting emissions, reducing congestion, and fostering healthier lifestyles. Designing public spaces with these goals in mind helps create dynamic, inclusive environments that support social interaction and improve quality of life.

Accessibility must be prioritized in the design of all public spaces. This means ensuring that every publicly intended area is usable by individuals of all ages and abilities. Eliminating architectural and physical barriers is crucial for enabling access for people with disabilities, seniors, parents with strollers, and others with specific mobility needs. Early-stage design considerations should include ramps, lifts, tactile surfaces, clear signage, and attention to sensory aspects like lighting and acoustics. A strong commitment to inclusivity fosters social participation and integration, creating genuinely open environments.

Multi-resilience and adaptation projects cannot be uniformly applied, even when sites face similar hazards. Each location—whether a historic district, suburban neighbourhood, or redevelopment zone—has distinct features that must be respected. Tailoring interventions to the local context ensures cultural appropriateness, social acceptance, and technical feasibility. For instance, in a historic centre, flood mitigation might focus on preserving architectural heritage, whereas in a suburb, it may emphasize green infrastructure for stormwater management.

Communicating risks, hazards, and resilience plans effectively is essential and should be tailored for audiences of all ages and abilities. Using diverse communication channels—visual materials, interactive media, and clear,

jargon-free language—helps ensure broad accessibility. Public campaigns, educational initiatives, and community workshops can enhance understanding and engagement. Establishing feedback channels is equally important, allowing residents to share concerns and contribute to shaping resilience efforts.

Leveraging emerging technologies is key to improving risk communication. Tools such as Geographic Information Systems (GIS), mobile applications, and social media platforms enable the rapid and precise dissemination of information. For example, GIS can generate interactive hazard maps, mobile apps can deliver real-time alerts, and social media can support two-way communication between authorities and residents, facilitating both outreach and feedback.

Ensuring the transparency and wide dissemination of adopted or planned measures is critical. This can be achieved through dedicated web platforms, mobile apps, social media, sensor networks, and interactive mapping tools. Providing open access to resilience strategies, resources, and emergency protocols builds trust and keeps communities well-informed. Web portals can offer comprehensive documentation; apps can tailor alerts and guidance; and sensors paired with interactive maps can deliver real-time updates on environmental and infrastructure conditions, empowering citizens to make informed decisions during crises.

The integration of a quantitative assessment through the Multiadaptation Place Index (MPI) is crucial. Calculating the MPI enables planners to measure the adaptive capacity of urban areas in the face of multiple risks by synthesizing data on hazards, resources, and flexibility. This index provides an evidence-based foundation for prioritizing interventions and tracking progress over time, supporting more precise and impactful planning decisions.

Redundancy must be embedded into resilience strategies as a core principle. Incorporating overlapping systems and fallback mechanisms—such as multiple transport routes, decentralized energy grids, and backup communication networks—ensures that critical functions are maintained even when one component fails. Redundancy enhances a system's capacity to withstand shocks and reduces the likelihood of cascading failures during crises.

Diversification is essential for strengthening resilience across sectors. Promoting a varied mix of economic activities, social networks, ecosystem services, and infrastructural solutions reduces dependency on single systems and increases the likelihood that some components will continue functioning during disturbances. For example, combining grey and green infrastructure for flood management or fostering economic sectors beyond tourism helps cities better cope with uncertainty and evolving threats (Pelling, 2011; Slovic, 2000; Vale, 2014).

Observation on the MPI

The application of the Multiadaptation Place Index (MPI) to Hudson River Park provides an insightful quantitative and qualitative assessment of the park's resilience and adaptive capacity in the face of multiple risks.

The MPI was developed as part of a comprehensive protocol to evaluate spaces subject to multiple, often overlapping hazards. In the case of Hudson River Park, the assessment followed a sequence of diagnostic phases, beginning with the identification of three primary risks: flooding and sea-level rise, the urban heat island effect, and overcrowding. These hazards not only pose independent threats but also interact, creating compound risks such as flood-induced infrastructure failure or heat-related health crises intensified by crowding. This layered risk landscape underscores the importance of using a tool like the MPI, which integrates diverse data to yield a holistic resilience profile.

A critical observation from the MPI analysis is the park's medium-high risk exposure, rated at 10 out of 25. This score reflects the park's inherent vulnerability to environmental hazards and exposure to storm surges. Additionally, the surrounding dense urban environment amplifies heat retention, while heavy usage patterns contribute to infrastructural wear and crowding-related challenges. Importantly, the MPI framework does not

stop at measuring risks alone; it pairs this evaluation with an analysis of adaptive potential.

One of the most significant findings of the MPI assessment is the high score (50 out of 50) attributed to the park's potential, qualities, and flexibility. These assets not only enhance ecological resilience but also support social well-being, making the park a dynamic site for climate education and public engagement.

The MPI further captures the perceptual dimension of risk, as revealed through user surveys. While park users demonstrated relatively high awareness of flooding risks—likely influenced by collective memory of events like Hurricane Sandy—perceptions of overcrowding and heat risks were considerably lower. This mismatch between actual risks and public awareness highlights the importance of integrating risk perception into resilience assessments. By accounting for both objective hazards and subjective experiences, the MPI enables planners to design interventions that are not only technically effective but also socially meaningful.

The final MPI score for Hudson River Park was calculated by subtracting the combined risk score (15) from the adaptation score (50), yielding a total of 35 on a scale of 1–50. This places the park within the "high adaptive potential" range, signifying its robust capacity to withstand shocks, recover from disturbances, and transform over time. This result positions Hudson River Park as a best-practice model for multifunctional urban spaces that balance environmental, social, and infrastructural resilience.

Another key observation is that the MPI does not merely function as a static measurement tool but as a dynamic guide for future action. By mapping multi-risk zones (such as flood-prone waterfronts, overcrowded pathways, and erosion hotspots) alongside multi-adaptive areas (like flexible piers and green zones), the MPI points to specific spatial priorities for intervention. For Hudson River Park, this means focusing on enhancing flood management systems, expanding shaded and permeable surfaces, improving crowd management strategies, and developing public education initiatives on climate risks.

The MPI also promotes a systemic understanding of resilience, emphasizing not just the park's ability to resist individual hazards, but its capacity to navigate the complex interactions among them. This requires ongoing monitoring, iterative learning, and cross-sectoral collaboration—elements that are embedded within the MPI's multidisciplinary approach. Furthermore, the MPI's integration of ecological, social, and infrastructural variables makes it particularly well-suited for multifunctional spaces like Hudson River Park, where diverse functions coexist and reinforce each other.

The application of the MPI to Hudson River Park demonstrates how this tool can offer a comprehensive resilience assessment that integrates risk exposure, adaptive capacity, flexibility, and public perception. As climate change continues to reshape cities worldwide, tools like the MPI is useful for guiding interventions that are adaptive, inclusive, and forward-looking, transforming public spaces into vital assets for urban resilience.

Conclusion

The case of Hudson River Park in New York City illustrates the importance of adopting a multiadaptation approach in the design and management of urban public spaces exposed to multiple risks. As shown by the analysis, the park faces a complex risk landscape—including coastal flooding, erosion, the urban heat island effect, and overcrowding—which are increasingly intensified by global climate change. However, what emerges most significantly from this study is not only the park's vulnerability but its considerable potential as a resilient and adaptive urban space.

A key conclusion from this research is that resilience planning in urban environments like Hudson River Park requires a shift away from traditional, top-down approaches toward more inclusive, flexible, and iterative processes. This shift is essential to adequately address the dynamic and interconnected nature of risks facing urban areas today. Inclusivity, as underscored in contemporary resilience literature (Banica et al., 2020; Cutter et al., 2003; Davoudi et al., 2012), must become a cornerstone of resilient planning. This means that the engagement

of diverse stakeholders—including local communities, visitors, marginalized groups, and institutional actors—should not be a mere formality but an integral part of decision-making processes. Participatory mechanisms such as surveys, workshops, public consultations, and co-design platforms can help uncover overlooked vulnerabilities and generate locally relevant solutions. Furthermore, Hudson River Park's multifunctional piers, adaptive green zones, and potential for temporary floodable spaces exemplify how flexibility can be translated into physical infrastructure. Policies should similarly allow for adaptability, enabling the park's management to adjust operational strategies as new risks emerge or as conditions change over time. Hudson River Park also benefits from a combination of engineered interventions and nature-based solutions. This portfolio approach reduces dependency on any single measure and improves the park's capacity to respond to a wide range of contingencies.

The methodology employed offers a robust framework for diagnosing complex risk environments and identifying adaptive capacities. The ten-phase protocol—spanning from risk identification and analysis of drivers to perception assessment, quality evaluation, risk mapping, and the formulation of adaptation strategies—provides a holistic approach that balances technical, social, and ecological dimensions. The MPI, by quantifying the difference between risk exposure and adaptive assets, delivers an evidence-based assessment of a site's resilience potential. In the case of Hudson River Park, the final score of 35 out of 50 places the park in the high adaptive potential category.

The broader lessons drawn from this case resonate with international experiences in resilience planning, as seen in the SUMMA research project and other case studies across Europe and North America. Whether in Cittaducale and Leonessa confronting seismic risks, or in Copenhagen and Paris addressing flooding and overtourism, the principles of inclusivity, flexibility, redundancy, diversity, and local knowledge remain central to effective adaptation.

In conclusion, Hudson River Park stands not merely as a green recreational space but as an emblematic case study for urban resilience and adaptive design. It demonstrates how parks and public spaces can move beyond their traditional roles, becoming good practice for sustainability, liveability, and climate adaptation.

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Urban Street Space in Planning Transformation: Analyzing and Optimizing the Quality Differences between Subjective and Objective Perspectives—A Case Study of Xi'an

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Abstract
As the most common public spaces, urban streets are not only vital for daily activities but also a direct reflection of the quality of the urban environment and the inclusiveness of society. In the face of multiple challenges such as global climate change, resource crises, and social inequality, enhancing the spatial quality of urban streets has become crucial for improving environmental sustainability, social inclusiveness, and livability. However, most existing research focuses on either objective environmental features or subjective perceptions, often overlooking the systematic differences between these two aspects and their profound impact on spatial design and planning decisions. In the context of rapid urbanization, how to scientifically and quantitatively identify the differences between subjective and objective quality and develop targeted optimization strategies remains a critical issue that needs urgent attention.

In this study, an innovative spatial quality evaluation framework based on multi-label classification is proposed, integrating deep learning technology and semantic analysis methods. Using the MIT Place Pulse dataset, which includes 110,988 street view images, the Microsoft TrueSkill algorithm quantifies six subjective perception scores for streets, including safety, comfort, and richness. Additionally, using the Cityscapes dataset and the Mask2Former algorithm, the objective features of 28,662 streets in the central area of Xi 'an are semantically segmented, and eight landscape element indicators are extracted from four dimensions: safety, comfort, richness, and convenience. The study reveals that (1) the spatial quality of the main urban area of Xi' an exhibits significant spatial heterogeneity and stratification in both subjective perception and objective physical environment dimensions, with higher scores in the core urban area compared to the peripheral areas. (2) There are significant differences in subjective and objective evaluations across different regions, with weak overall correlation between the two, and some administrative districts even showing statistically significant negative correlation. (3) Most streets exhibit inconsistencies between subjective and objective evaluations, particularly those where 'subjective is better than objective' and 'objective is better than subjective,' with a low proportion of streets achieving high consistency in both subjective and objective evaluations. Therefore, improving the quality of urban streets requires not only focusing on the construction of 'hard environments' but also emphasizing the coordinated optimization of subjective experience and social environment. Through quantitative analysis, this study reveals the key deviations and optimization paths of street space from subjective and objective perspectives, which provides practical basis and theoretical enlightenment for street planning and design under the background of rapid urbanization, and helps to build more inclusive and livable urban public space.

Key words: urban street quality, perceptual difference, deep learning

1. Introduction

As urbanization continues to deepen, street spaces, which are the most immediate public areas in residents 'daily lives, have become a key indicator of a city's livability, sustainability, and social inclusiveness. Streets not only serve as transportation hubs but also function as multifaceted spaces that integrate social, cultural, and ecological elements. Their design and management significantly impact residents 'quality of life and the city's image (Jacobs, 2012; Montgomery & John, 1998). In recent years, with the growing emphasis on a 'people-centered' approach, urban planning and design have increasingly recognized the importance of street spaces in enhancing urban vitality and social interaction (Yu, Zhang, & Zeng, 2019).

Although the measurement of street space quality has become a research hotspot, existing studies still face two main limitations: first, methods that focus primarily on physical environments overlook the importance of residents' subjective perceptions; second, perception studies based on questionnaires or expert ratings lack large-scale, efficient quantitative tools, making it difficult to adapt to rapidly changing urban environments (Tang & Long, 2019; M. Wang et al., 2022). Therefore, there is an urgent need to develop a street space evaluation framework that integrates both subjective and objective perspectives, combining scientific rigor with practical applicability, to reveal systematic differences across various dimensions and provide theoretical foundations and practical approaches for optimizing street design.

This study focuses on the main urban area of Xi 'an City as the empirical region, integrating deep learning and semantic segmentation technologies to develop a street space quality evaluation system that combines subjective and objective perspectives. On one hand, it extracts the physical environmental characteristics of streets using street view images and artificial intelligence algorithms; on the other hand, it quantifies residents'

perceptions of the safety, comfort, and richness of streets through a subjective perception model. By comparing the spatial distribution characteristics of the two types of evaluation results, this paper aims to reveal the discrepancies and coupling relationships between the subjective and objective perspectives of urban street spaces, and to propose targeted optimization suggestions, providing new ideas and practical references for the transformation and upgrading of urban street planning.

2. Literature review

2.1 Physical environment measurement method

In recent years, with the advancement of street view imagery and deep learning technologies, significant progress has been made in the objective measurement of street space quality. Researchers commonly use platforms like Google Street View, Baidu Street View, and Tencent Street View to obtain images of neighborhoods and employ deep convolutional neural networks (such as SegNet and DeepLab V3) for semantic segmentation, thereby quantifying physical elements such as green vegetation, openness, and interface transparency (Biljecki & Ito, 2021; Tang & Long, 2019). This automated image recognition and data analysis method has significantly improved measurement efficiency and has shown good accuracy and consistency in multiple empirical studies. Moreover, GIS and spatial network analysis remain crucial tools for assessing the physical characteristics of streets. By quantifying indicators such as building height, road width, street connectivity, and node density, researchers can construct accessibility models to analyze traffic efficiency and spatial organization (Harvey & Aultman-Hall, 2016). Building on this, the integration of multi-source data has become a new trend, including the integration of street view images, 3D building data, POIs, and LBS to establish systematic street quality assessment models (L. Zhang, Ye, Zeng, & Chiaradia, 2019). Data fusion not only enhances the expression ability of indicators, but also enables the dynamic capture of the spatio-temporal evolution characteristics of street space, which provides support for long-term monitoring and optimization.

2.2 Pedestrian subjective perception and multi-dimensional evaluation model

In contrast to the physical environment measurement, the subjective perception of street space has gained increasing attention. Traditional methods often rely on questionnaires and expert ratings, focusing on residents 'psychological perceptions of safety, cleanliness, and human scale. However, sample representativeness and survey costs have become major bottlenecks for their widespread application (Du & Huang, 2022). In recent years, some studies have introduced social media text and sentiment analysis, using big data processing to capture residents' daily expressions of their preferences for the street environment. To integrate both subjective and objective perspectives, Wan et al. proposed the '5D+3S' model, which combines physical indicators such as design, density, diversity, accessibility, and transportation distance with perceptual dimensions like sociality, safety, and state, reflecting both the structural characteristics of street space and the complexity of human experience (Wan, Lu, & Sun, 2022). Technically, some studies have integrated street view image recognition and expert scoring to create semi-automated, multi-dimensional perception rating systems, enhancing the efficiency and reliability of data acquisition. Additionally, research on human-scale urban morphology emphasizes the profound impact of visual continuity, scale sense, and proportional relationships on perceptual experiences (Ye, Zeng, Shen, Zhang, & Lu, 2019). Du and Huang further empirically analyzed the relationship between leisure sports activities of the elderly and street quality, and found that green rate and sidewalk design had a significant positive effect on improving subjective satisfaction, which confirmed the value of environmental perception in the construction of healthy cities (Du & Huang, 2022).

3. Research areas and methods

3.1 Research area

This study focuses on the quality differences between subjective perceptions and objective environments in street spaces within the main urban area of Xi 'an, a city in Northwest China. Xi' an is a key hub for regional economic, cultural, and technological development. In recent years, with the upgrading of urban functions, the implementation of the 'Belt and Road' initiative, and the deepening of the national central city construction, the city's space has rapidly expanded, with the built-up area surpassing 10,000 square kilometers and a permanent population exceeding 12 million. As the population and construction density continue to rise, the urban spatial

structure has shown a clear trend of concentric distribution and functional differentiation (Lin, Xiping, Junyi, Yongyong, & Zhiyuan, 2025).

In the process of urban spatial evolution, old urban areas, constrained by early planning, commonly face issues such as narrow streets, outdated facilities, and enclosed interfaces. In contrast, new urban areas boast higher standards and environmental advantages in street design, greenery configuration, and openness. This structural difference is not only evident in physical space but also profoundly influences residents' subjective experiences and daily behaviors. The growing gap between subjective and objective evaluations has gradually intensified the perception inequality and functional imbalance within cities. To gain a deeper understanding of the multidimensional aspects of street space quality and their optimization directions, this paper focuses on areas with high street density and frequent population activity in the main urban area. By integrating deep learning algorithms and semantic recognition technology, it quantitatively extracts environmental elements of streets and introduces a multi-label perception scoring system to explore the perceptual characteristics and optimization paths of street space at different scales. The aim is to provide theoretical support and practical references for enhancing urban spatial quality and traffic equity (W. Zhang, Chen, & Tian, 2025).

Figure 1. Scope of the study

3.2. Research methods

To support the quantitative assessment of street space quality and the systematic comparative analysis from both subjective and objective perspectives, this paper constructs a multi-source data system that includes built environment characteristics and perception evaluation information. The main data types include road network data, street view images, point of interest (POI) data, administrative division data, and subjective perception evaluation data. The sources, collection times, and processing procedures of each type of data are detailed in Table 1.

Regarding objective variables, the basic road data is sourced from OpenStreetMap (2021 edition). By extracting street centerlines, performing topological repairs, and manually correcting Gaode satellite images, the accuracy and usability of the road network structure are ensured. Street view images are collected from the Baidu Street View Open Platform, with sampling points set at intervals of 50 meters within the study area, resulting in a total of 289,664 images (1024×512 resolution). For sections with missing data, 360 Maps is used to supplement the data. Image processing employs a Mask2Former deep learning semantic segmentation model to extract key visual elements such as sky, greenery, and building interfaces, which form the basis for constructing a visual environment index system for street spaces (Li et al., 2022). POI data is obtained through the Baidu Map API, covering 18 categories of urban functional facilities, including dining, shopping, accommodation, education, and healthcare, to measure the functional mix and service accessibility of streets. Administrative boundary base map data is sourced from the National Basic Geographic Information Public Service Platform, uniformly projected into the WGS_1984 coordinate system using ArcGIS 10.7, ensuring spatial consistency and overlay compatibility across different data sources.

In the construction of subjective perception variables, the study incorporates the Place Pulse 2.0 dataset and its accompanying model developed by the Massachusetts Institute of Technology (MIT) Media Lab (MIT Media Lab). This model constructs a subjective evaluation framework covering six core dimensions: 'sense of security,' 'livability,' 'activity level,' 'wealth,' and 'sense of prosperity' through a paired comparison scoring mechanism. Using the Microsoft Trueskill algorithm, this paper ranks and normalizes image scores, and based on the model's output, it generates six categories of subjective perception scores for street images in Xi' an's main urban area, quantifying residents' emotional experiences and psychological perceptions of the street environment (Wang, Han, He, & Jung, 2022).

In the process of constructing the variable system, this paper integrates existing research findings and urban spatial quality theories to select eight key objective indicators from four dimensions: safety, comfort, richness, and convenience. Additionally, six subjective perception scores generated by the Place Pulse model are introduced, forming a multidimensional quantitative analysis framework for street space (see Table 2). Each indicator clearly defines its meaning, calculation method, and direction, comprehensively covering key factors such as spatial visual characteristics, traffic environment, functional diversity, and human scale. This provides a systematic and logical variable foundation for subsequent empirical analysis (L. Zhang et al., 2019).

Table 1 Multi-source, multi-scale data types, sources and processing

data name	data sources	acquisition time	data handling
Road network data	Open Street Map	December 2024	After the road centerline is simplified and extracted by manual, the topology is checked and verified with reference to the Gaode satellite image
Street View data	Baidu Open Street View Map platform	December 2024	The Baidu Street View API was invoked to collect 289,664 static panoramic images with a spacing of 50 m and a size of 1024 x 512 pixels. Then the Mask2Former semantic segmentation model was used to segment the street view images.
Interest Point (Point of Interest, POI) data	Baidu Map	December 2024	The geographic information interest point (POI) data was obtained from Baidu Map API. According to the research needs, 18 kinds of POI data such as food, hotel and shopping were obtained within the research scope and its surrounding area. The data contained industry categories, names, addresses, administrative areas and other information.
MIT Place Pulse Data set	MIT Media Lab Developed Place Pulse projects	December 2024	The Microsoft Trueskill algorithm was used to calculate the corresponding perception scores of six dimensions, and the model was trained to predict the scores of six perception dimensions on the streets in the central urban area of Xi 'an.

Table 2 Subjective perception indicators and calculation methods

dimension	metric	computational method	weight	direction
safety	sense of security	The "safety" dimension score of street view images is evaluated based on Place Pulse model, and the weighted average of multi-angle image scores is obtained to obtain the perceived safety score of street segments.	0.1717	+
degree of comfort	Sense of oppression	The weighted calculation was carried out based on the negative score results of "livability" and "safety" dimensions of Place Pulse model, and the lower the value was, the stronger the depression was.	0.171741	-
	aesthetic feeling	The "aesthetics" dimension of Place Pulse model is used to score the perception, reflecting residents' subjective evaluation of the visual image of the street. The higher the score is, the stronger the aesthetic sense is.	0.1037	+
rich	Liveliness	The "activity" dimension of Place Pulse model is used to score the perception, which reflects residents' subjective evaluation on the visual image of the street. The higher the score, the higher the activity.	0.3285	+
	Boredom	The perception score of the "boredom" dimension of Place Pulse model reflects residents' subjective evaluation on the visual image of the street. The higher the score, the higher the boredom degree, which is a negative factor.	0.1194	-
convenience	A sense of affluence	Based on the "sense of wealth" dimension score of Place Pulse model, the building material, facade decoration complexity and high-end commercial POI density are taken as auxiliary factors for comprehensive calculation.	0.0759	+

Table 3 Objective environmental indicators and calculation methods

dimension	metric	computational method	weight	direction
safety	Vehicle interference	The degree of influence of motor vehicle traffic on pedestrian activity is measured by the number of vehicles in the unit.	0.0016	-
	Road surveillance	Assess the safety of a street, known as the "eyes on the street," by counting the number of surveillance facilities or pedestrians and shops on either side of the street.	0.1954	+
degree of comfort	Visibility over the sky	The proportion of the visible sky in the street space is calculated to reflect the degree of visual openness. The proportion of the sky in the total pixels is calculated through street view image analysis.	0.1809	+
	High viewership ratings	The proportion of green vegetation in the street view is calculated to reflect the greening degree of the street. The proportion of green pixels in the total pixels is calculated through street view image analysis.	0.0861	+
rich	Interface transparency	Measures the transparency of the facade of buildings on both sides of the street, i.e. the proportion of transparent or translucent parts (such as Windows, porches). Through street view image analysis, the proportion of transparent area to total facade area is calculated.	0.2945	+
	Interface richness	Evaluate the detail and diversity of the facade of buildings on both sides of the street. This can be measured by calculating the types and numbers of facade elements, such as decoration, material changes, etc.	0.0951	+

convenience	Walkable accessibility	Measures how easily pedestrians can get from a street to various facilities (such as stores, public transport stops). It is usually calculated by calculating the number and distance of various facilities within a certain range around the street, combined with the street connectivity index.	0.1449	+
	Function mix	The diversity of land use around the street is evaluated. The information entropy formula is usually used to calculate the proportion and distribution of different functions (such as residential, commercial, office, etc.) land use around the street.	0.0014	+

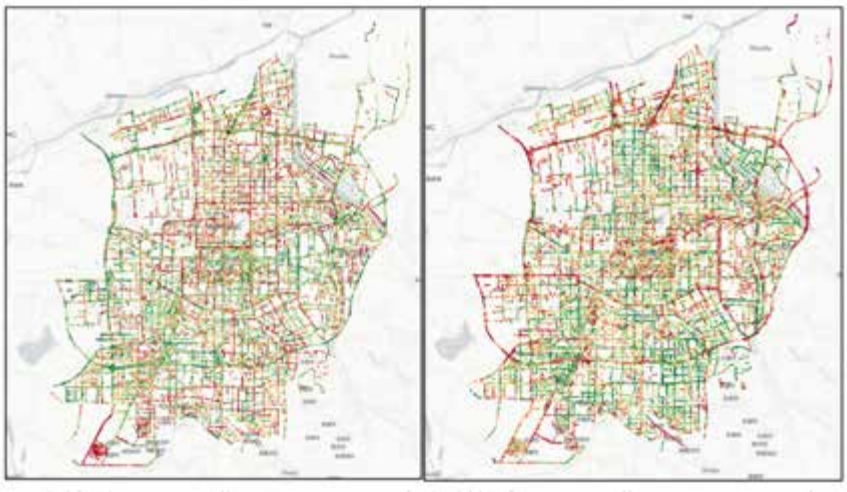
4. Results and analysis

4.1 Spatial distribution characteristics of comprehensive scores

To comprehensively reveal the overall distribution characteristics of the spatial quality of streets in Xi 'an's main urban area from both subjective and objective perspectives, this paper uses multi-source data and entropy value method weights to calculate the subjective and objective comprehensive scores for each street, and conducts spatial visualization analysis. As shown in Figure 2, the left figure (a) presents the subjective street quality measurement results, while the right figure (b) shows the objective street quality measurement results.

From the overall distribution pattern, both subjective and objective scores indicate that the main urban area of Xi 'an exhibits significant spatial heterogeneity and a layered structure. In the city's core areas, such as Beilin District, Lianhu District, and parts of Yanta District, streets generally score high. The high-score segments (primarily green) are concentrated in the city center, indicating that the core urban area offers high spatial quality in terms of both residents 'perceptions and physical environment. In contrast, the outer areas of the city and some newly developed zones have generally lower street scores, with red and yellow sections being more densely distributed. This suggests that these areas need significant improvement in both residents' perceptions and physical environments.

It is worth noting that while the overall trends in subjective and objective distribution are consistent, there are still some differences. For instance, some newly developed peripheral areas have seen improvements in physical space indicators, such as wider roads and better pedestrian accessibility, but the subjective perception scores have not improved accordingly, indicating that residents' subjective experiences of the street environment still need further enhancement. Moreover, some older areas, despite less favorable objective indicators, have relatively higher subjective scores due to their strong historical and cultural atmosphere or community sense of belonging, reflecting the complex spatial characteristics of perceptions and evaluations of street quality from both subjective and objective perspectives.



a. Subjective street quality measurement results b. Objective street quality measurement results

Figure 2 Measurement results of street quality

4.2 Analysis of differences among different administrative regions

To systematically reveal the differences in street spatial quality among different administrative districts in Xi 'an's main urban area, this paper combines the results of both subjective and objective comprehensive scoring (see Table 4). Subjectively, Chang 'an District, Lianhu District, Beilin District, and Weiyang District stand out, with average scores of 0.4282,0.4249,0.4237, and 0.4249, respectively, significantly higher than those of Xincheng District, Baqiao District, and Yanta District. This trend suggests that core urban areas and regions with mature public service facilities and earlier development better meet residents' subjective expectations for safety, aesthetics, and vitality. For instance, Chang 'an District has actively promoted ecological livability and the creation of cultural streets in recent years, significantly enhancing residents' sense of belonging and satisfaction. In contrast, Xincheng District and Baqiao District have lower subjective evaluations, indicating that some emerging areas still face challenges in improving public space quality and have not yet effectively met residents' demands for a high-quality street environment. Notably, the standard deviation of subjective scores across districts is concentrated between 0.03 and 0.04, suggesting that there is still some variation in quality within each district, particularly in Xincheng District and Baqiao District, where internal spatial differences are greater than in core urban areas like Beilin.

From the perspective of objective comprehensive scores, Beilin District, Chang 'an District, and Yanta District rank at the top, with average scores of 0.1294,0.1295, and 0.1274, respectively, higher than peripheral areas such as Xincheng District, Weiyang District, and Baqiao District. These districts excel in physical dimensions like green coverage, street transparency, and pedestrian accessibility, reflecting significant achievements in urban governance and the enhancement of public space environments. Additionally, the standard deviation analysis indicates that the internal fluctuations in the objective scores of Beilin District and Chang' an District are relatively small, suggesting a balanced physical quality of their streets. In contrast, Xincheng District and Baqiao District exhibit higher score dispersion, indicating significant internal differences in spatial development. Some areas still face issues such as strong motor vehicle interference and closed interfaces, requiring urgent intervention and improvement.

Further comparison of the comprehensive scores of subjective and objective indicators reveals a certain degree of synergy and discrepancy between residents 'perceptions and the physical environment in different districts. For instance, Beilin District and Chang' an District have highly aligned subjective and objective scores, indicating that improvements in the physical environment can effectively enhance residents 'spatial satisfaction, making these areas typical examples of successful urban space governance. In contrast, Yanta District shows a situation where objective evaluations lead but subjective experiences are weak, suggesting that merely improving the physical environment is insufficient to significantly enhance residents' sense of gain and happiness. Additional improvements are needed in human-centric aspects and social interaction. Meanwhile, Xincheng District and Baqiao District have low scores in both subjective and objective indicators, indicating that they need to improve in both spatial quality construction and residents' perception.

Table 4 Statistical table of subjective and objective comprehensive scores of each administrative region

canton	Subjective mean	Subjective standard deviation	Objective mean	Objective standard deviation
new city zone	0.4170	0.0360	0.1380	0.0323
Weiyang District	0.4249	0.0394	0.1348	0.0321
Baqiao District	0.4202	0.0366	0.1349	0.0342
Beilin District	0.4237	0.0335	0.1294	0.0287
Lianhu District	0.4249	0.0386	0.1364	0.0335
Chang'an District	0.4282	0.0386	0.1295	0.0288
Yanta District	0.4188	0.0337	0.1274	0.0292

4.3 Subjective and objective coupling and deviation analysis

According to the results of the correlation analysis (see Table 5), there is a weak negative correlation between the subjective and objective comprehensive scores of street spatial quality in the main urban districts of Xi 'an City. Except for Beilin District, the Pearson correlation coefficients for the other districts are all negative and highly statistically significant ($p < 0.001$). Notably, the negative correlation is most pronounced in Weiyang District (-0.290), Xincheng District (-0.220), and Baqiao District (-0.205), with an average correlation coefficient of-0.196 across all districts. This indicates that improvements in the physical environment of streets have not consistently led to an increase in residents' subjective perceptions, suggesting that the subjective and objective evaluation systems exhibit a certain degree of independence in spatial dimensions, and even show a clear divergence trend in some areas.

To further clarify the structure of the discrepancy between subjective and objective evaluations, this paper constructs four coupling types based on subjective and objective scores (see Table 6). The 'subjective superior to objective' type (high-low) has the highest proportion at 29.56%; followed by the 'highly consistent' type (low-low) and the 'objective superior to subjective' type (low-high), with proportions of 27.76% and 25.87%, respectively; only 16.81% of the streets achieve a 'highly consistent' type (high-high). This indicates that less than 20% of the street spaces have seen simultaneous improvements in both subjective perception and objective quality, while most streets exhibit varying degrees of discrepancy between subjective and objective evaluations.

The above results indicate that in the process of enhancing the quality of street space in Xi 'an's main urban area, residents 'perceptions have not fully aligned with the objective improvements. In areas with a strong sense of community or historical and cultural ambiance, despite relatively weaker physical environment indicators, residents' subjective evaluations are more positive, showing a 'high-low' type deviation. Conversely, in newly developed or renovated areas, although the physical environment has significantly improved, residents 'subjective satisfaction has not significantly increased, resulting in a' low-high 'type deviation. This phenomenon suggests that urban spatial governance should not solely rely on the improvement of' hard environment 'indicators but should also focus on the collaborative shaping of' soft environment 'factors, such as residents' emotions, social

interactions, and cultural belonging.

In summary, the interplay between subjective and objective evaluations reveals the intricate mechanisms behind enhancing spatial quality, underscoring the importance of a people-centered approach to governance that focuses on perception. Future strategies for optimizing urban street spaces should focus on a two-way feedback mechanism that integrates 'physical improvements' with 'perceptual responses,' aiming to enhance both functional rationality and emotional experiences, thereby promoting a dual improvement in high-quality public spaces and urban well-being.

Table 5 shows the correlation coefficient and significant p value of subjective and objective comprehensive scores

canton	Pearson correlation	Significant p values
Beilin District	0.025	0.094
Lianhu District	-0.157	<0.001
new city zone	-0.22	<0.001
Weiyang District	-0.29	<0.001
Yanta District	-0.187	<0.001
Chang'an District	-0.143	<0.001
Baqiao District	-0.205	<0.001
The average of the region	-0.196	<0.001

Table 6 Statistical table of subjective and objective comprehensive score deviation types

Type of bias	sample number	percentage
Subjective superiority over objective (high-low)	19351	29.56%
High consistency (Low-Low)	18173	27.76%
Objective superiority over subjective type (low-high)	16938	25.87%
High consistency (4-5)	11003	16.81%

5. Conclusion

This paper focuses on the main urban area of Xi'an City, utilizing multi-source spatial data and deep learning algorithms to develop a street spatial quality evaluation system that integrates subjective perception with objective built environment. It conducts a systematic analysis of the urban street environment from dimensions such as spatial layout, regional differences, and the coupling relationship between subjective and objective perceptions. The main conclusions are as follows:

From an overall spatial perspective, the street space quality in Xi 'an's main urban area exhibits significant spatial heterogeneity and stratification in both subjective and objective dimensions. The core urban areas, such as Beilin District, Lianhu District, and Chang 'an District, stand out with high scores in both subjective and objective evaluations, characterized by a dense concentration of high-quality streets that highlight the spatial advantages of historical urban areas and well-developed public service zones. In contrast, the scores for the city's periphery and some newly developed areas are relatively low, indicating room for improvement in street environment optimization and resident satisfaction.

(2) There are significant differences between different administrative regions. Chang 'an District, Lianhu District, Beilin District, and Weiyang District have performed well in overall subjective comprehensive scores, indicating that these areas have not only improved their spatial environment but also better met residents' psychological expectations for street safety, vitality, and aesthetics. In contrast, Xincheng District, Baqiao District, and parts of Yanta District have performed poorly in both subjective and objective scores and internal balance, suggesting they still face the dual challenges of spatial quality differentiation and insufficient resident perception.

(3) The overall relationship between the subjective and objective evaluation systems is weakly negatively correlated. Pearson Correlation analysis indicates that in most areas, the correlation between subjective and objective scores is low, and in some areas, there is even a significant negative correlation. This suggests that improvements in physical space do not directly enhance residents' subjective satisfaction. Subjective perceptions are significantly influenced by cultural background, social relationships, and individual experiences, indicating a high degree of independence and complex coupling between subjective and objective evaluations.

From the analysis of subjective and objective bias types, only 16.81% of the street samples achieved 'high-high consistency,' while nearly 60% of the streets exhibited inconsistencies between subjective and objective evaluations. Among these, the 'subjective superiority over objective (high-low)' and 'objective superiority over subjective (low-high)' types were more prevalent, reflecting residents 'reliance on soft elements such as cultural environment and community belonging, as well as the disconnect between physical environmental improvements and psychological perceptions. In particular, in some newly developed areas, even with significant improvements in the physical environment, residents' subjective sense of gain remains lagging, highlighting a gap between 'hard environment' and 'soft experience' in current urban spatial governance.

6. Discussion

This study integrates deep learning technology with multi-source spatial data to systematically reveal the spatial distribution patterns, regional differences, and coupling deviation characteristics of urban street spatial quality in both subjective perception and objective environment dimensions. The findings indicate that while the continuous optimization of the physical environment forms the foundation for enhancing urban spatial quality, the transformation of the 'hard environment' alone is insufficient to fully meet the increasingly diverse and personalized subjective needs of residents. Many street samples exhibit a mismatch between subjective and objective evaluations, highlighting that 'soft environment' elements such as social and cultural atmosphere, community belonging, and public participation play a crucial role in influencing residents 'sense of gain and spatial identity. This finding underscores the need for urban spatial governance to shift from a single functional physical perspective to a human-centered approach that integrates perceptual experiences, promoting a systematic transformation of urban renewal from' object-oriented 'to' people-oriented. 'In future urban renewal and spatial optimization processes, it is essential to focus on the coordinated regulation of differences between regions and within areas, driving the dual improvement of the physical environment of streets and the enhancement of residents' subjective experiences, gradually achieving the goal of constructing high-quality, balanced urban public spaces.

However, this study still has certain limitations. Firstly, while the Place Pulse model has improved the efficiency of measuring subjective evaluations, its predictive outcomes are limited by factors such as image acquisition methods, algorithm training biases, and cultural context differences, making it difficult to fully represent

individual perceptions in real-world scenarios. Secondly, the study uses Xi 'an's main urban area as a case for empirical analysis, and its conclusions need further validation and expansion across different city types and social structures.

Future research can expand in two directions: first, by integrating field surveys and online questionnaires with other sources of subjective data to enhance the authenticity and representativeness of the model in perception evaluation; second, by incorporating time-series street view images and dynamic perception data to conduct a longitudinal analysis of urban spatial quality, exploring the temporal evolution mechanisms and influencing factors of both subjective and objective evaluations. This will help develop more precise and actionable strategies for urban spatial optimization, providing a solid theoretical foundation and practical approach to creating fair, efficient, and livable urban public spaces.

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Designing Accessibility Public Spaces in Old City Communities Based on the Outdoor Activity Characteristics of People with Disabilities: A Case Study of Chengxian Street Community in Nanjing

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Abstract
Urban accessibility construction from a global perspective emphasizes the enhancement of inclusiveness and equity in cities. Community public spaces, as central hubs of daily life, serve as crucial entry points for advancing urban accessibility initiatives. With the aging population and a growing number of individuals with disabilities, the creation of barrier-free environments in the older urban areas of Chinese cities has become a focal issue. This involves analyzing the outdoor activity characteristics (frequency, type, and scope) and variations among individuals with differing mobility levels in these communities, as well as exploring the relationship between outdoor activities and community public spaces. Based on these findings, strategies for enhancing accessibility in public spaces within older urban areas can be developed.

This thesis employs questionnaire surveys and in-depth interviews to examine the accessibility needs of community public spaces for individuals with disabilities and propose targeted design strategies. Specifically, it focuses on the Chengxian Street community. First, 35 valid questionnaires were collected through surveys, behavioral observations, and interviews with all disabled residents in the community. Additionally, 78 travel trajectories were recorded and analyzed, with the temporal and spatial distributions visualized using ArcGIS. Second, the research identifies key patterns based on travel frequency, destinations, and needs, uncovering trends in time-sequenced travel, spatiotemporal circulation, and public space usage behaviors. These findings highlight significant challenges in the accessibility of community public spaces. Finally, the study proposes an inclusive design framework for improving public space accessibility, addressing five dimensions: target orientation, standard setting, spatial siting, spatial layout, and accessibility facilities. By considering the behaviors and needs of vulnerable groups, this framework seeks to advance the construction of inclusive, safe, and sustainable cities and communities.

Ultimately, the thesis revisits the social model of disability studies, offering actionable strategies to enhance the accessibility of public spaces for disabled communities and contributing to the broader goal of fostering equitable urban development.

Key words: Community Public space, Accessibility Strategies, Characteristics of outdoor activities, Disability

1. Introduction

According to United Nations statistics, the global population has exceeded 7 billion. Alongside population aging and the increasing prevalence of functional impairments related to chronic diseases and age-related conditions, over 1 billion people worldwide—approximately one-seventh of the total population—are currently living with some form of disability. This number is projected to rise to over 2 billion by 2050 (United Nations, 2022). In this context, developing sustainable and equitable accessibility systems within urban environments to enhance outdoor participation opportunities for persons with disabilities has become a pressing challenge for social inclusion and sustainable development. Numerous studies have confirmed that moderate outdoor activity offers substantial health benefits for individuals with disabilities. It not only improves cardiorespiratory fitness and physical coordination but also alleviates feelings of isolation and promotes mental well-being (Derakhshan, 2024; Hirvensalo, 2000; Ramlagan, 2013). However, people with disabilities continue to face multiple barriers to outdoor engagement, including environmental, social, and personal constraints (Heath, 2012; Derakhshan, 2024). As a result, their frequency and duration of outdoor activities are significantly lower than those of individuals without disabilities (Shelby, 2025), leading to an infringement on their equal right to outdoor participation (Kapsalis, 2022). In everyday life, persons with disabilities often limit their activities to the vicinity of their residences. Consequently, the 500-meter radius surrounding one's home plays a critical role in determining activity opportunities and overall quality of life (Katayama, 2023).

As the most immediately accessible form of public space, community outdoor areas are pivotal in facilitating social inclusion and improving the quality for people with disabilities. Ward Thompson (2013), through an extensive study on the relationship between outdoor environments and population activity levels, emphasized

that when an environment lacks the necessary functional attributes and appeal for specific user groups, their opportunities for activity diminish accordingly. Therefore, outdoor spaces within communities must be systematically designed and functionally organized to serve the needs of disabled populations. Empirical evidence shows that well-designed community spaces can effectively increase daily walking frequency, enhance physical health, and provide greater opportunities for social interaction and mental wellness among people with disabilities (Sara, 2025). However, in China's older urban neighborhoods, community outdoor spaces often fall short in terms of supply, spatial quality, and functional diversity, thus failing to meet the multifaceted needs of disabled users. Enhancing the accessibility of public spaces in these areas is essential to promoting urban inclusiveness and achieving spatial equity.

Current research predominantly focuses on infrastructure development (Xia, 2019; Chen, 2023), service accessibility, or community participation (Jin, 2023), while insufficient attention has been paid to improving public space inclusiveness through spatial design and environmental creation. To address this gap, this study selects the Chengxian Street community—representative of older residential areas in Nanjing, China—as a case study. Through fieldwork and analysis of the activity patterns of persons with disabilities, the study identifies the types and characteristics of their daily outdoor activities. Based on these findings, it proposes practical and targeted spatial strategies for accessible public space design, aiming to inform the development of more inclusive and equitable community environments.

2. Research Design

2.1 Study Area

This study selects the Chengxian Street community, located in Xuanwu District, Nanjing, as a typical case study (Figure 1). Covering an area of 0.8 square kilometers, the community is rich in historical and cultural heritage. The surrounding eastern ring area, where Chengxian Street is situated, has been designated as one of the key zones for urban renewal in Nanjing. Before the 1990s, the community primarily served residential and educational functions. With the acceleration of urbanization, commercial services gradually emerged along the street.

In recent years, the proportion of elderly and disabled residents in the community has continued to rise. Statistics show that in 2015, residents aged 60 and above accounted for approximately 24.09% of the total population (Li & Li, 2019), indicating a clear trend of population aging. The community is characterized by narrow streets, dense traditional commercial activities, and an aging built environment, lacking basic accessibility infrastructure. These features reflect the typical spatial characteristics of older urban neighborhoods, making Chengxian Street an appropriate and representative subject for this research.

Fig.1. Scope of the study

2.2 Assessment of Mobility Capacity Among Persons with Disability

According to China's Practical Evaluation Standards for Persons with Disabilities and the national standard Classification and Grading of Disabilities for Persons with Disabilities (GB/T26341-2010), China divides the types of disabilities into six categories, namely, visual disability, hearing disability, speech disability, physical disability, intellectual disability, and psychiatric disability; and each category of disability is divided into four grades according to its severity, with Grade 1 being extremely severe disability, Level 2 being severe disability, Level 3 being moderate disability, and Level 4 being mild disability. Disability, Level 3 as moderate disability, and Level 4 as mild disability.

In this study, to explore the activity characteristics of the disabled group in outdoor public space, it is necessary to reclassify the group in combination with the ability to travel, to more clearly identify the differences in their functional needs for spatial services. Based on the above criteria and combined with the results of field research, this paper classifies the traveling ability of disabled people into three categories: the first category is the group of fully autonomous travelers, which has strong spatial perception and mobility and can complete the travel activities independently, mainly including people with hearing disabilities, speech disabilities, and part of the people with mild physical disabilities. The second category is the limited autonomous traveling group, which has some independent traveling ability but needs to rely on auxiliary tools or environmental guidance to travel, typically represented by people with moderate to severe physical disabilities or people with visual impairment. The third category is non-autonomous or accompanied travel groups, which are difficult to complete travel activities on their own, and usually need to be accompanied by family members, caregivers, or volunteers, and mainly include groups of people with multiple disabilities of the first level of intellectual disability and mental disability. For individuals with multiple disabilities, their ability to travel is assessed based on the most severe of their disabilities (Figure 2).

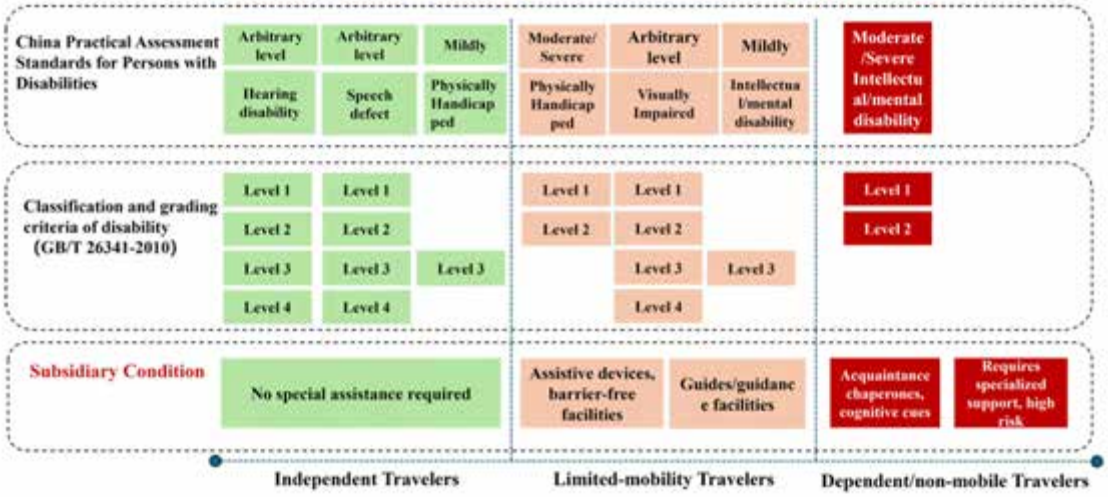

Fig.2. Basis and results of classification of persons with disabilities

First, what are the characteristics (frequency, type, and range of activities) and differences in outdoor activities of people with disabilities with different mobility abilities in old communities in old urban areas? What is the relationship between the outdoor activities of people with different mobility abilities and the accessibility of community public space? Through the systematic analysis of the above questions, this paper aims to reveal the interaction mechanism between community space and the daily behavior of disabled groups and provide empirical evidence for the subsequent proposal of targeted barrier-free space creation strategies.

2.4 Research Program

This study adopts diversified research methods, mainly including field observation, questionnaire research, and semi-structured interviews. Before the formal research, the research team first made several field visits to the

Chengxian Street community in Nanjing to sort out the public spaces within the community where people with disabilities can carry out outdoor activities, and the screening criteria included whether there were basic facilities such as benches and walking paths. A total of 34 representative outdoor public spaces were identified and categorized into three categories based on their spatial form and service radius: unit-port spaces, small activity venues, and centralized activity venues (Figure 3). The study collected information on the outdoor activities of people with disabilities through activity logs, which were used to analyze their activity characteristics and differences. The activity logs cover dimensions such as respondents' basic information, start and end time of the day's outdoor activities, activity content, destination, and mode of travel. The survey was conducted in July and October 2024 under suitable weather conditions (sunny days and 20-30°C). In the activity log survey, this research process is user-centered and guides the respondents to review the previous day's outdoor activity matters, time, and route to restore their life events as much as possible. The researcher supported the recording through notes and audio recordings to enhance the completeness and accuracy of the data. At the community level, with the assistance of the Chengxian Street Community Service Center, the person in charge of this study called 55 people with disabilities in the Chengxian Street community to participate in the research; 55 questionnaires were distributed, with 54 validly recovered, and activity logs were issued to 35 of them who are now living in the Chengxian Street community. After the data collection, the authors analyzed the characteristics of the frequency, type, and scope of outdoor activities of the disabled according to the content of the questionnaires and activity logs.

Fig.3. Distribution of public spaces in the study area

3. Characterization of Outdoor Activities for People with Disabilities

3.1 Social Characteristics of the Disabled Population

This study collected outdoor activity logs from all individuals with disabilities residing in the Chengxian Street community. Among them, 24 individuals belonged to the fully autonomous travel group, 25 to the limited autonomous travel group, and 5 to the non-autonomous or accompanied travel group. Given the difficulty in obtaining analyzable outdoor activity trajectories from individuals who are entirely immobile, this paper focuses on the first two groups—those with some degree of travel capability—for analyzing the behavioral characteristics and patterns of their outdoor activities.

The social profile of the surveyed disabled population is summarized in Table 1. The results indicate a marked aging trend within the disabled community of Chengxian Street, with individuals aged over 60 accounting for more than 60% of the total. Among those under 60, only 16.7% are capable of independent travel, suggesting that even the younger segment of the disabled population includes a considerable proportion of individuals with severe impairments.

In terms of age distribution, individuals aged 60–69 comprise the largest group of those able to travel

independently. Regarding gender, male participants generally demonstrate stronger mobility capabilities than their female counterparts. As for household structure, the majority of persons with disabilities live with their spouses or children—an arrangement associated with higher levels of mobility. Additionally, nearly 80% of respondents have lived in the community for more than eight years, and among them, 38.9% possess the ability to travel independently.

Table 1 Statistics on Social Characteristics of Respondent Population with Disabilities

Classification	Subcategory	All persons with disabilities		Independent Travelers		Limited-mobility Travelers		Dependent/non-mobile Travelers	
		Quantities	proportions	Quantities	proportions	Quantities	proportions	Quantities	proportions
Totally	—	54	100	24	44.4	25	46.3	5	9.3
Age	Below 60	21	38.9	9	16.7	7	13	5	9.3
	60-69	20	37	13	24.1	7	13	0	0
	70-79	10	18.5	2	3.7	8	14.8	0	0
	≥80	3	5.6	0	0	3	5.6	0	0
Gender	Male	34	62.9	14	25.9	16	29.6	4	7.4
	Female	20	37.1	10	18.5	9	16.7	1	1.9
Housing Structure	Living with a partner's son or daughter	43	79.6	19	35.2	19	35.2	5	9.2
	Living alone	6	11.1	4	7.4	2	3.7	0	0
	Other	5	9.3	1	1.9	4	7.4	0	0
Duration of Residence	1-3 years	5	9.3	2	3.7	2	3.7	1	1.9
	4-7 years	6	11.1	1	1.8	5	9.3	0	0
	More than 8 years	43	79.6	21	38.9	18	33.3	4	7.4

3.2 Classification of Outdoor Activities of People with Disabilities

To collect data on outdoor activity patterns, this study adopted and adapted the structure of the Activity Log Questionnaire for Beijing Residents developed by Chai Yanwei et al., supplemented by insights from preliminary observations. Outdoor activities were categorized into three main types, further divided into 12 subcategories. Daily activity logs were compiled accordingly, recording the start and end times, travel locations, and specific content of activities (Table 2).

Analysis of activity duration data for the three major categories reveals a consistent temporal pattern in outdoor activity among persons with disabilities. On average, participants engaged in 2–3 outdoor trips per day, primarily concentrated in three-time windows: 8:00–10:00, 14:00–16:00, and 19:00–21:00. Total daily time spent outdoors typically ranged from 6 to 8 hours, with activities most commonly involving leisure exercise, grocery shopping, and other basic errands (Figure 4). These findings indicate a certain degree of regularity and continuity in the outdoor activity needs of this population.

According to the questionnaire data, most individuals with disabilities rely on family members for accompaniment during outdoor activities, though there are notable individual differences in travel capacity. Among the first group

(fully autonomous travelers), 62.5% reported that they could complete outings independently. Their average duration per trip exceeded two hours, and they went out more than seven times per week. Their activities were relatively diverse, including shopping, walking, and completing daily errands—reflecting a broad range of functional needs for public space.

In contrast, individuals in the second and third groups were more dependent on companions or assistive devices during outings, and their mobility was closely linked to environmental safety, infrastructure accessibility, and community support systems. These contrasts highlight a marked differentiation in how people with varying mobility capacities interact with and rely on community public space services (Figure 5).

Table 2 Classification of behavioral activities of persons with disabilities

Type of activity content	Activity content subcategories
1. Recreational Activities	1-1 Walking
	1-2 Chatting(sunbathing)
	1-3 Playing Chess, Cards, and Mah-jongg
	1-4 Dancing, doing exercises
	1-5 Sports (fitness equipment, hiking)
2. Productive Activities	2-1 Work
	2-2 Go home
3. Life- Service Activities	3-1 Grocery Shopping
	3-2 Shopping and spending, errands
	3-3 Picking up and dropping off children
	3-4 Taking care of parents
	3-5 Hospital Visits

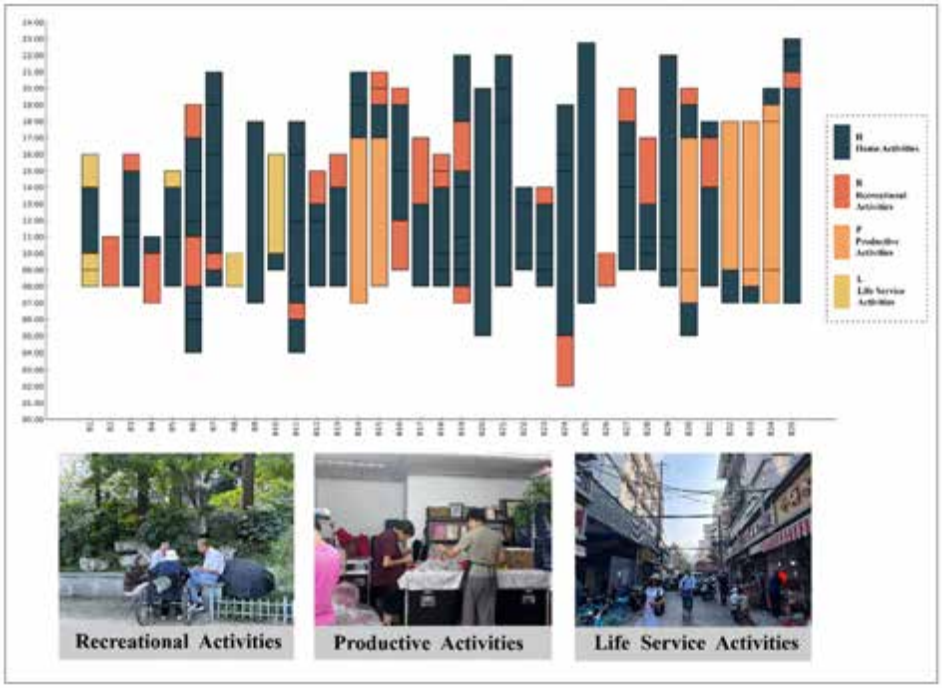

Fig. 4. Schematic diagram of activity sequence statistics for persons with disabilities in residential areas

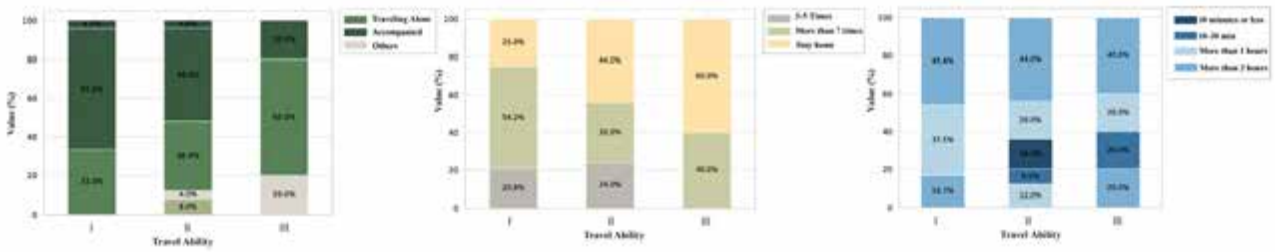

Fig. 5. Characteristics of activities of persons with disabilities of different mobility

3.3 Behavioral Characteristics of Outdoor Activities Across Different Mobility Impairment Groups

To further investigate differences in daily activity patterns among persons with varying levels of mobility impairments, this study selected three representative individuals from the research community and analyzed their behavior across five key dimensions: trip duration, travel destinations, travel modes, types of activities, and whether they traveled alone or with others.

The results reveal significant distinctions in both activity patterns and spatial use among the three mobility groups. Individuals in the first group (fully autonomous travelers) demonstrated high variability and diversity in their daily movements. Their activities primarily included life-related and leisure tasks such as square dancing, walking, chatting, playing cards, or chess. These activities covered a broad spatial range, were highly mobile, and were predominantly carried out on foot. Their preferred activity locations were large public spaces, such as Pearl River Plaza and Heping Park.

In contrast, individuals in the second group (limited autonomous travelers) exhibited more regular and constrained activity patterns. Their activities were largely confined to the community or its immediate surroundings, typically following a fixed routine path between their residence and workplace. Recreational and daily living activities were relatively infrequent. Common activities included light exercise, walking, and sitting, usually conducted along accessible routes near residential areas, such as the banks of the Pearl River.

For the third group (non-autonomous or accompanied travelers), daily activity was markedly limited. Their outings occurred infrequently, usually lasting no more than two hours, and were concentrated during morning or evening hours. Their activity spaces were confined to the immediate vicinity of their buildings—such as the area downstairs or open spaces between buildings. These activities were mostly sedentary, including sunbathing or sitting quietly. The limited spatial mobility and low interaction frequency highlight the significant challenges this group faces in accessing public space and engaging in daily social interaction.

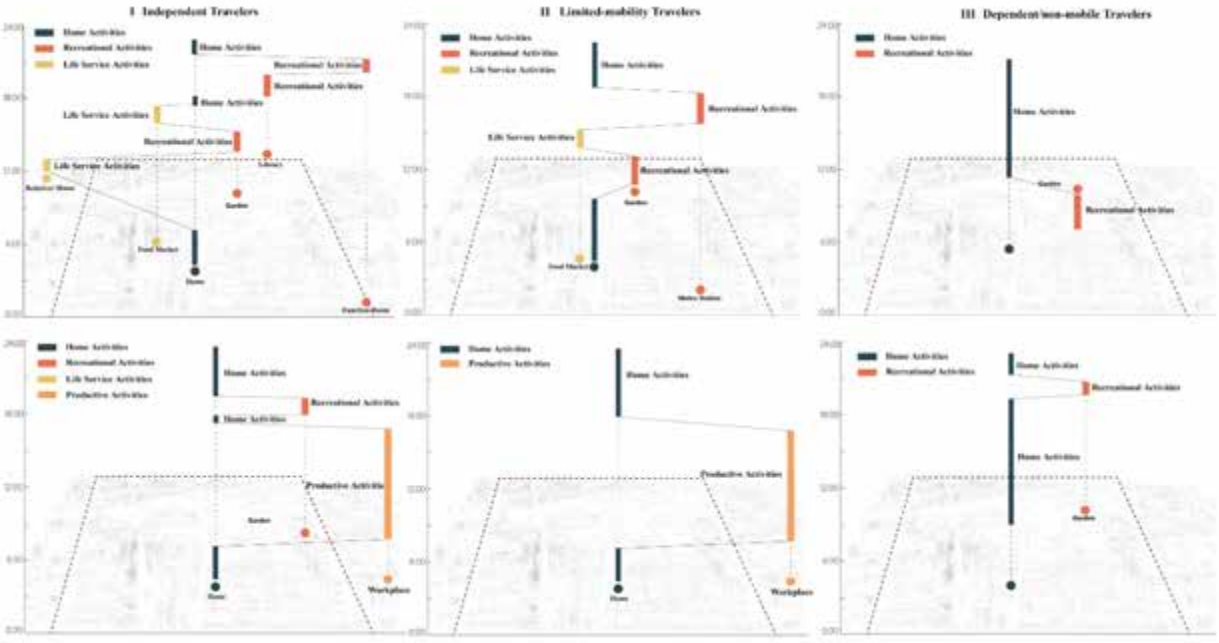

Fig. 6. Schematic diagram of behavioral path analysis for three groups of persons with disabilities

3.4 Public Space Accessibility: Supporting Factors Influencing Outdoor Activities

To further examine how public space accessibility supports or constrains outdoor activity among different categories of people with disabilities, this study combines sample interviews with spatial path analysis to track and document the actual travel trajectories of individuals with disabilities in the Chengxian Street community. By integrating the activity logs of 78 disabled residents and mapping their movement patterns and trajectory densities using ArcGIS, the analysis reveals that travel routes significantly influence the selection of activity destinations. High-frequency paths include Nicco Lane, Tiger Bridge, Xiaosajiao Lane, and Chengxian Street, where adjacent public spaces exhibit a strong capacity to attract activity.

Further analysis highlights clear differences in path selection and activity clustering across mobility groups. Fully autonomous travelers show a wide distribution of paths, with activity points primarily located along the Pearl River and in Heping Park. Limited autonomous travelers tend to cluster around accessible nodes along the Pearl River that are closer to residential areas. Non-autonomous travelers, however, demonstrate low path density, with activities largely confined to the empty spaces beneath or between residential buildings—underscoring their restricted spatial accessibility.

Field observations revealed that one of the main constraints limiting outdoor activity among persons with disabilities is the incomplete and poorly connected system of accessibility infrastructure within the community. On one hand, the Chengxian Street community has implemented some basic barrier-free facilities (Figure 7), including ramps and handrails at entrances to banks, supermarkets, and parks, which generally meet design standards. On the other hand, problems persist, such as irregularly installed ramps, missing or loose handrails in inter-building spaces, and broken pathways that compromise the functionality of the infrastructure. Moreover, blind walkways are often obstructed or discontinuous—affected by parked vehicles, encroachment from non-motorized vehicles, or a complete absence along major thoroughfares—making it difficult for individuals with disabilities to safely and smoothly access public activity spaces within their daily walking range.

Overall, while the Chengxian Street community has made preliminary efforts to establish basic barrier-free infrastructure, the overall connectivity, continuity, and human-centered design of these facilities remain

insufficient. Deficiencies in inter-building links, path integration, and infrastructure usability continue to limit the travel radius and frequency of outdoor activities for certain groups of people with disabilities, adversely affecting their quality of daily life.

Fig.7. Distribution of Barrier-free Facilities in Chengxian Street Community

4. Accessibility Design Strategies for Community Public Spaces in Old Urban Areas

As the primary setting for daily activities among persons with disabilities, the accessibility of community public space is not only a matter of individual well-being but also a critical indicator of spatial inclusiveness and urban equity. In older urban areas, challenges such as limited space, outdated infrastructure, and fragmented layouts often hinder the ability of community public spaces to effectively meet the diverse needs of people with disabilities.

Based on the behavioral analysis of disabled groups with varying mobility capacities in the Chengxian Street community, this study identifies distinct patterns of stratification and spatial circling in outdoor activities. The extent to which individuals are restricted from participating in public space activities varies considerably depending on their level of mobility. Improving accessibility in old urban neighborhoods requires solutions that are feasible under constrained conditions. The design focus should shift from merely providing accessible facilities to establishing a holistic, adaptive relationship among people, activities, and environments.

Targeted and precise design strategies not only serve a wider range of users but also improve the cost-effectiveness of renovation investments, ensuring that the benefits of urban renewal are distributed more equitably among all persons with disabilities. Based on the research findings, this paper proposes a set of strategies for improving accessibility in community public spaces within old urban areas.

4.1 Clarify positioning goals and respond to the needs of special groups

Currently, communities in old urban areas often fail to adequately address the specific needs of persons with disabilities in the planning of outdoor activity spaces. Poor site compatibility and incomplete facilities significantly

limit the feasibility, frequency, and comfort of their daily outdoor activities. For instance, residents are frequently required to bring their tables and chairs for chess and card games, and rehabilitation and exercise equipment is insufficiently provided, which restricts regular participation.

It is recommended that, based on the observed activity types among people with disabilities—and considering the overlapping needs of the elderly—community parks, plazas, fitness corners, and overhead floors of residential buildings should undergo systematic upgrades with barrier-free design principles. Key design considerations include: Installing accessible entrances, ramps, and continuous handrail systems to ensure smooth mobility for wheelchair users and individuals with walkers; Providing appropriate facilities such as seating, shading structures, and level, non-slip surfaces to support the creation of micro-activity spaces that promote rest, interaction, and social engagement.

4.2 Categorize Configuration Standards to Improve Space Suitability

Beyond fitness activities, most daily community activities lack clear spatial allocation standards, leading to a mismatch between facility supply and actual user demand. To address this issue, targeted spatial and facility configuration strategies should be developed based on the nature of different activity types. For space-dependent activities—such as chess, card games, and rehabilitation exercises—the required area can be estimated using the formula: activity unit area × number of participants. Essential equipment (e.g., tables and chairs) should be provided in group-based units to support such interactions.

For activities with high spatial sensitivity but low facility dependency—such as sitting, strolling, and informal leisure—designers should focus on optimizing spatial qualities. Key considerations include: Route continuity, to ensure seamless movement; Microclimatic comfort, such as adequate shading, ventilation, and sunlight exposure; and Visual accessibility, which contributes to safety, comfort, and the psychological ease of navigation for people with disabilities. By categorizing activity types and aligning spatial standards accordingly, the suitability and effectiveness of public space configurations can be significantly enhanced.

4.3 Layered Distribution Strategy to Optimize Spatial Allocation

Findings from this study indicate that outdoor activities among persons with disabilities exhibit distinct spatial circling characteristics. Individuals with full mobility tend to have a wider activity radius and greater spatial mobility, those with limited autonomy are primarily concentrated around the periphery of residential areas, while non-autonomous individuals are largely confined to spaces immediately adjacent to their homes—such as ground-floor areas and inter-building open spaces. In the context of spatial renewal in old urban areas, it is essential to recognize these mobility-based differences and apply layered and circle-based design principles to improve the efficiency and equity of space utilization.

First, high-intensity activity spaces should be preferentially located near community service nodes—such as fresh markets, senior centers, kindergartens, and green areas—to enhance spatial efficiency and encourage shared use across different population groups. Second, for low-mobility groups, micro-space design should be strengthened through targeted improvements in resting spots, including better seating, ground surfacing, and shading systems in frequently used areas like ground-floor terraces and building entrances. Finally, when larger open spaces such as parks and plazas already exist within proximity to the community, spatial resources should be functionally integrated through enhanced pathway accessibility and wayfinding systems. This approach avoids redundant construction while improving the connectivity and coherence of the overall spatial system.

4.4 Optimize the Functional Layout and Enhance Flexibility of Use

Outdoor activities are often accompanied by a variety of behavior combinations, placing higher demands on the multifunctionality and adaptability of public space. Traditional barrier-free design tends to focus solely on the primary activity areas while overlooking the continuity and support of adjacent activity zones and auxiliary facilities. This fragmented approach frequently results in reduced usability and limited participation opportunities. It is recommended that, from a holistic spatial planning perspective, barrier-free design should encompass three

interrelated types of functional spaces: firstly, Primary activity areas – the central spaces where most community activities occur; Secondly, Related activity areas – supporting zones such as spectator seating, resting areas, and access points connected to transportation; and thirdly, Auxiliary function areas – spaces that house public service facilities, such as restrooms, water stations, or information kiosks.

The accessible design of these spaces should be planned as an integrated system to ensure continuity, coherence, and flexibility. Enhancing the interconnection between these functional components will improve spatial usability, especially for persons with disabilities, and foster more inclusive and engaging community environments.

4.5 Improving system integration and enhancing accessibility continuity

As communities in old urban areas are limited by uneven distribution of facilities, narrow scale, spatial fragmentation, and other problems, people with disabilities face the barrier of being accessible but not connected in the process of using public space. To address this problem, the layout of barrier-free facilities should be optimized at the system level to build a continuous and clear barrier-free access network, covering infrastructure such as passages, ramps, and blind corridors; to enhance the accessibility of paths between activity nodes and residential areas, with particular attention to the height of the curb, lighting, and signage systems; and to promote the design of barrier-free transitions between buildings and open spaces, eliminating obstacles such as height differences, steps, and thresholds, to ensure travel Continuity.

5. Conclusion

Taking a typical residential community in the old urban area of Nanjing as a case study, the study focuses on the behavioral characteristics of outdoor activities of the disabled group in the community public space, identifies three main types of activities through a combination of activity logs and questionnaires: leisure activities, productive activities, and living activities, and further explains the differences in the characteristics of outdoor activities of the disabled in terms of the dimensions of demographic attributes, activity time, and spatial distribution. It is found that people with disabilities have a high dependence and sensitivity to the venue environment in the process of participating in outdoor activities and that there are significant deficiencies in the accessibility, comfort, and adaptability of facilities in the existing public spaces in old urban areas. Based on the results of empirical research, this paper proposes accessibility design strategies for community public spaces in old urban areas from five aspects: clarifying the target positioning, formulating configuration standards, optimizing the spatial distribution, improving the flexibility of the functional layout, and reinforcing the integration of the facility system. The strategy emphasizes the starting point of the difference in mobility of people with disabilities and takes into account the needs of other mobility groups such as the elderly, and improves the overall efficiency and fairness of the use of urban space while guaranteeing the right to basic activities. By building a more inclusive community public space system, accurate support for diverse groups can be realized under limited resources, avoiding the waste of resources and management burden brought by exclusive facilities.

This study proposes a preliminary strategy based on a sample of communities in the old city of Nanjing, which is of practical significance for understanding the pattern of outdoor activities of people with disabilities and guiding the renewal of spaces. However, due to the significant differences in the demographics, spatial patterns, and social support systems of people with disabilities in different cities, the characteristics of their outdoor activities may be diverse. In the future, the study can further expand the sample area, pay attention to the dynamic changes of the needs of people with disabilities in different periods, and explore how to acquire the outdoor activity needs of people with disabilities in advance and flexible adaptation strategies, to respond to the needs of diversified groups of people more effectively. Through the construction of an adaptive and sustainable human-centered spatial system, it is expected to promote the transformation of public space from basic barrier-free construction to a higher level of comprehensive inclusion and to realize a more socially equitable and sustainable path of urban renewal.

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Public spaces as agents of inclusive and sustainable urban transformations. The case study of "Xersonisos tis Panagias" in Kavala, Greece

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Abstract
Even though public spaces reshape urban areas and act as sites of hope, we note significant differences in their role in small and big urban areas. Considering the important challenges encountered worldwide, the paper tries to answer the question of how public spaces in small and medium-sized cities could work as agents of inclusive and sustainable urban transformations and thus lead to positive changes in the development of urban areas. The choice of the case study "Xersonisos tis Panagias" in the city of Kavala in Northern Greece was based on the necessity to propose a planning methodology for public spaces which focuses on existing local power dynamics as a means towards an inclusive and equitable living environment for the inhabitants of these areas.

Key words: public spaces, urban areas, sustainable development, inclusion, Kavala (Greece)

Introduction

At the international level public spaces play a key role in the development of urban areas as they act as places for social encounters, political contestations and cultural events (Siláči and Vitková, 2017). Since the ancient times in Greece and in Rome public spaces, in the form of forums and "agora", were areas where people were gathering in order to take decisions about the governance system or to organize cultural events as we can see in examples of medieval cities in Western Europe (Flohr and Zuiderhoek, 2024). At the same time many political contestations take place in streets, squares and parks showing the close connection between grass-root movements and open-air urban spaces where people can easily gather and express their social and political beliefs (Pereira-Zazo and Torres, 2019). In many cases starting from political contestations in the 1950s and 1960s, such as May 1968 in France and the manifestations in USA regarding the War in Vietnam, as well as the more recent manifestations during the period 2010-2020 in several countries of South Europe and Asia (Spain, Greece, Turkey) focusing on economic policies, it is evident that public spaces could reshape cities by bringing together people from different social classes who fight for their own "right to the city" (Harvey, 2008).

Sustainability in all three dimensions (social, economic, environmental) is part of the design of public spaces as they play a key role in cities' transformations in the 21st century. In social sustainability reports and in documents of international organizations such as the Agenda 2030 it is stated that public spaces play a central role in shaping social interactions among cities' inhabitants, foster equity while at the same time environmental sustainability and economic development is linked to their organisation and functions (UN, 2015). It is clear that international organisations such as the United Nations and World Bank are interested in promoting sustainable development conditions worldwide through the design of public spaces, but we should underline the fact that many cities luck funds for the development of such operations or do not have highly experienced executives for the design and implementation of public spaces' policies (El-Kholei and Yassein, 2022). Another concern is about the main focus of public spaces' policies promoted by international organisations, as they often prioritize green washing and gentrification and do not focus on the social dimension of sustainability which could bring social equity and cohesion in all parts of a city and the world (Çetin et al, 2023).

Despite their different form and functions public spaces can reshape urban areas and act as sites of hope, especially in underdeveloped territories where there is need for spaces for recreation and gathering (El-Bardisy, 2024). We should underline the different role of public spaces in small and big urban areas as well as areas of the Global North and Global South (Landman and Mady, 2022). Questions related to climate change and world warming are more evident in big urban areas and thus the planning of public spaces inside these areas and their design are considered as measures for improving environmental conditions (Vukmirovic, Gavrilovic and Stojanovic, 2019). On the contrary, in small urban areas as well as in areas of the Global South the main focus in the planning and design of public spaces is the revitalisation of territories that were neglected or polluted for several years in order to reintegrate them into the urban fabric (Jaszczak et al, 2021). While the main focus of such operations seems to be the well-being of cities' inhabitants it is important to note their high cost and the subsequent gentrification of territories where people with low incomes used to live (Bélanger, 2007). The beautification of neglected territories through the design of public spaces together with the construction of office buildings and commercial centres leads to a swift in the social tissue, by bringing into these areas people with high incomes and leaving behind people that were born and raised there (Gutiérrez, 2024).

Considering the important challenges encountered worldwide in the design and strategic planning of public spaces, the paper focuses on the role of public spaces in small and medium-sized cities, especially to the ones affected by socio-economic and environmental problems. How could public spaces in small and medium-sized cities work as agents of inclusive and sustainable urban transformations and thus lead to positive changes in the development of these urban areas? Small and medium-sized cities often face challenges such as the loss of local population due to the closure of local enterprises, schools and health facilities (Bowns, 2013). In several cases such as deindustrialised cities in West European Countries they lack the necessary funds for their redevelopment based on the three pillars of sustainable development (social equity, environmental protection, economic development) (Atolia et al, 2020). Under these conditions it seems critical to propose redevelopment policies which prioritize the design and planning of public spaces, as public spaces are often combined with the creation of shops and enterprises as well as the construction of housing (Cromwell, 2018). However, we should underline the need to propose redevelopment policies which consider the local characteristics (social, economic, environmental) and avoid green washing and gentrification policies.

The main purpose of the paper is to question the appearance of planning methods and tools for the redevelopment of small and medium-sized urban areas which focus on the design of public spaces while maintaining the characteristics of the local tissue. Which are the characteristics that define the identity of urban areas and need to be considered during the processes of design and planning of public spaces? In our methodology we identified three main categories based on the toolkits of international organisations such as the United Nations (UN, 2015), researchers-practitioners (Gehl, 2010) and groups of academics, "Critical Heritage Studies" (Harrison et al, 2023) in order to analyse the design and planning of public spaces as a process that fosters social equity, protects the environment and cultural heritage and brings economic prosperity in areas facing economic and social difficulties. It is important to mention that the identification and analysis of the special characteristics of urban areas (social, cultural, economic, environmental) alongside the development of planning strategies that focus on these characteristics could potentially enhance social cohesion and economic development as they are retrofitted processes (Urban Initiative, 2024).

Methodology

The research method used was the descriptive-analytic. The descriptive method was used in order to define planning methodologies for the design of public spaces. Our main hypothesis is that the design of public spaces should be the basis for the redevelopment of areas facing socio-economic and environmental difficulties, as usually around public spaces we can find commercial and recreation activities as well as residential and office units. At the same time, in contemporary urban design and city planning policies (urban ecology, environmental urban planning and design) public spaces are designed as spaces that reintegrate nature into the urban fabric. This means that in these spaces we can find a significant number of trees and plants, while in certain cases

polluted natural elements existing in cities, like streams, are restored and re-integrated into the urban fabric.

Neglected urban spaces, such as urban voids usually resulting from deindustrialisation or from the closure of local enterprises are nowadays re-designed as public spaces in order to re-integrate them into the urban fabric. These spaces are also linked to economic recession and environmental degradation especially the former industrial lands. In certain cases, they are occupied by homeless people and immigrants, while contractors, investors and local authorities show a particular interest to build them in order to boost the local economy of cities facing social and economic difficulties. In this context the reconversion and transformation of urban voids into public spaces offers a second life to places that were underdeveloped and neglected for several years due to socio-economic problems. Our hypothesis is that the redevelopment of urban voids as public spaces and their subsequent integration into the urban fabric is not only a measure towards environmental sustainability and resilience, but it can also serve as a measure to solve social conflicts as public spaces in underdeveloped areas are places for social encounters and sports and recreation activities.

Another point to underline in contemporary practices for the design of public spaces, related to "Critical Heritage Studies" and to the protection of urban and cultural landscapes, is the planning of public spaces in areas with a significant number of historical buildings and monuments as a measure that allows the better understanding of the city's landscape. In dense urban areas historical buildings and monuments cannot be usually identified as next to them are built contemporary buildings, while narrow streets block the view towards the buildings. Public spaces like squares and small parks as well as large streets that are easily crossed by pedestrians, which are found in front of historical buildings and monuments, seem to improve the inhabitants and visitors experience in understanding the different historical eras of cities. Taking this into consideration, our third hypothesis is that the planning of public spaces in historical cities' districts, characterised by their unique urban, historical and cultural identities, could act as a measure for a new city-branding as they facilitate urban mobility by foot and bicycle and thus lead to a discovery of the cities' hidden urban past.

The analytic method was used in order to develop our strategy and model for the development of small and medium-sized cities facing socio-economic difficulties based on the design and planning of public spaces in neglected urban voids. The method proposes an experimental approach in the design of public spaces and their relationship with the surrounding urban environment based on the case study of "Xersonisos tis Panagias", a neighbourhood in the city of Kavala in Northern Greece. Our proposal was developed during an urban design studio named 'Public Spaces' at the School of Architecture of Democritus University of Thrace, which emphasises on the design of small public spaces in dense urban areas as measures that lead to urban sustainability and resilience. At the same time semi-structured interviews were conducted with local elected officials and inhabitants in order to take into consideration their needs and expectations for the development of their city. We suggested a development scenario for the city of Kavala, based on the reconversion and transformation of neglected urban voids as public spaces, which focuses on measures such as: 1) the increase of green spaces inside the city, 2) the use of bicycle in urban mobility as well as the mobility by foot, 3) the revalorisation of historical buildings, monuments and landmarks through the design of public spaces, 4) the planning of open-air spaces for recreation and sports activities as well as 5) the connection of the new public spaces in the 'Xersonisos tis Panagias' neighbourhood with the existing ones especially to the ones in strategic areas of the city of Kavala.

For the development of our scenario for the city of Kavala we took into consideration existing power dynamics of the city and the region of East Macedonia and Thrace in which administratively is part the city of Kavala. It is important to mention that the region of East Macedonia and Thrace is among the less developed at national (Greek) level and is characterised by deindustrialisation and the closure of local enterprises. Despite the above weaknesses of the region, the presence of Democritus University of Thrace (DUTH) in six cities of the region (Drama, Kavala, Xanthi, Komotini, Alexandroupoli, Orestiada), including Kavala, is among the strong points of the area as it brings people from other cities in a region affected by deindustrialisation and population decline. The ports in the city of Alexandroupoli and Keramoti, a small town in the outskirts of Kavala, the airports in the city of Alexandroupoli and Xrisoupoli, a small town in the outskirts of Kavala, as well as Egnatia Odos, a highway that

connects the north part of Greece with neighbouring countries create the conditions for the development of the cities of the region based on commercial and retail activities. We should also mention the presence of important natural parks inside the region, including three Natura Zones in Evros, Rodopi and Xanthi, which consist of its internal dynamics, and the presence of the Greek Muslim Community in neighbouring cities of Kavala (Xanthi and Komotini) posing challenges regarding the support of ethnic minorities and the enhancement of social cohesion through the design of public spaces.

The case study: the city of Kavala in Northern Greece and the 'Xersonisos tis Panagias' neighborhood

The city of Kavala is located in the north part of Greece, in the region of East Macedonia and Thrace, with an area of 351.35 square kilometres (Greek Statistical Institute, 2015). It is built near the Aegean Sea, close to the island of Thassos (Figure 1). Based on the 2021 population census, the Municipality of Kavala has 66,376 inhabitants (Greek Statistical Institute, 2021).

Figure 1. Kavala's location on the map of Greece. In detail the cities of the Kavala regional unit, whose capital is the city of Kavala, and the neighboring regional units. Source: Greece-map.net

As most of the Mediterranean cities it is affected during summer by heat waves while during the winter it is often affected by snowstorms originating from the north part of Europe. Kavala is characterised by its dense urban fabric and the absence of open green public spaces especially in the neighbourhoods that were built during the Ottoman era. We can distinguish the old city surrounded by the city's castle (Figure 2), built during the Ottoman Era and where it is located the "Xersonisos tis Panagias" neighbourhood, from the expansions built during the 19th and 20th century which are located near the city's harbour (Figure 3).

Figure 2. Kavala's waterfront. In the photo we can distinguish the city's castle in the back of the picture and city's harbour in the front. Source: www.travel.gr

Figure 3. Kavala's panoramic view. In this panoramic view of the city, we can distinguish in the right and left corner of the photo the contemporary city. At the centre we can see the 'Xersonisos tis Panagias' neighborhood, an urban area built during the Ottoman era, surrounded by a castle in order to keep it safe from pirates' attacks. Source: Alexandros Mpantogias

After the Greek Turkish War of 1919–1922, the city of Kavala entered a new era of prosperity and development due to the industrial and agricultural activities (Karagiannakidis and Likourinos, 2009). Kavala became greatly involved and developed further in the processing and trading of tobacco mainly with European countries (Theodoridou and Moustaka, 2013). Many buildings related to the storage and processing of tobacco from that era are preserved in the city and act as landmarks of the city's past. As most of the Greek cities, especially small and medium-sized, Kavala faces in the 21st century the consequences of deindustrialisation and the closure of local enterprises, despite the fact that the presence of university departments in the area increases the local inhabitants' incomes due to apartments' rentals.

"Xersonisos tis Panagias" neighbourhood is located in the city of Kavala in the region of East Macedonia and Thrace in Northern Greece, an area that maintains its physical and social characteristics since the era of Ottoman Empire and which is nowadays used as a space for recreation and leisure. The limited number of open green public spaces in the city of Kavala as well as the special characteristics of 'Xersonisos tis Panagias' are better represented on the following map (Figure 4) and photos where we can identify the relationship between open and built spaces. The 'Xersonisos tis Panagias' neighbourhood is characterized by its narrow streets, the absence of open green public spaces and the organic and dense urban fabric which better corresponded to the needs of city's inhabitants during the 18th and 19th century (Figure 5).

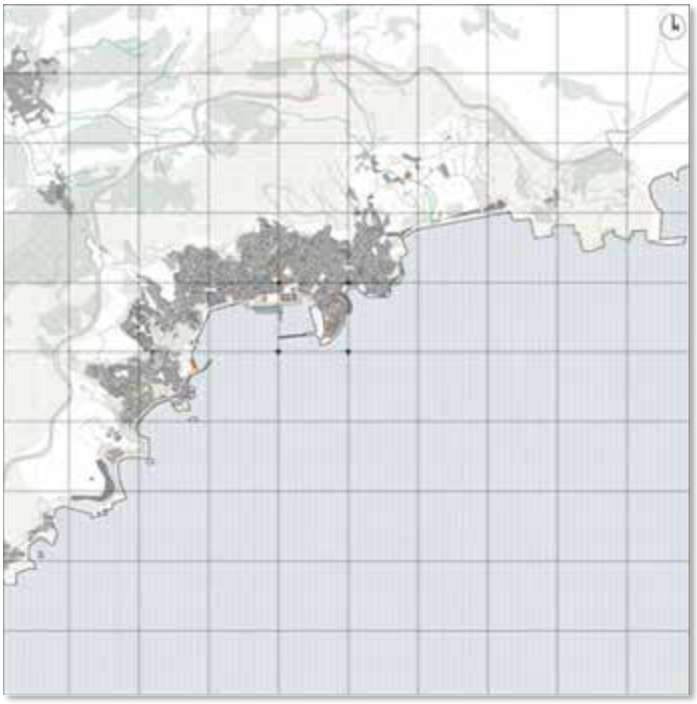

Figure 4. Kavala's built and open spaces. In this map, we can see that most parts of the city of Kavala are built, and the only unbuilt public spaces are around the city's harbour. Source: Alexandros Mpantogias

Figure 5. The 'Xersonisos tis Panagias neighbourhood' in the city of Kavala. In this photocollage, we can see the different urban characteristics of the neighbourhood where it is clear the absence of open green public spaces. Source: Alexandros Mpantogias

During our field research in the city and particularly in the 'Xersonisos tis Panagias' neighbourhood we identified several neglected urban voids, that are nowadays not well integrated into the city fabric, either because they are closed and not accessible, or because they are not well designed in order to accommodate open-air events for the inhabitants and visitors of the city (Figure 6).

Figure 6. Existing urban voids in the 'Xersonisos tis Panagias neighbourhood'. In the photo they are represented neglected urban voids in the 'Xersonisos tis Panagias' neighbourhood which were identified during the field research in the city of Kavala, and which were proposed to inhabitants, local authorities and students at the School of Architecture of DUTH for re-design as public spaces. Source: Varvara Toura

These voids are around the main street of the neighbourhood, Poulidou street, where we can also find small cafés and restaurants, several souvenirs shops for the tourists, monuments such as the Imaret, a building used as an orphanage during the Ottoman era and which is nowadays restored and reconverted into a luxury hotel, schools, small public spaces such as squares and local landmarks such as the lighthouse (Figures 7, 8, 9, 10).

Figure 7. Urban void closed to the Imaret building in the 'Xersonisos tis Panagias neighbourhood'. In the photo we can see a typical use of the unbuilt spaces or the neighbourhood as parking lots. Source: Varvara Toura

Figure 8. Urban void between two housing units in the 'Xersonisos tis Panagias neighbourhood'. In the photo we can see that nature in the form of grass and trees is present in certain urban voids of the neighbourhood. Source: Varvara Toura

Figure 9. Urban void closed to a small café. In this case the urban void is found in an area of the neighbourhood that has designed public spaces such as a small square. It is clear the absence of designed spaces for parking the vehicles and for this reason urban voids, designed public spaces as well as Poulidou street are used as parking lots. Source: Varvara Toura

Figure 10. Urban void closed to Kavala's lighthouse. In our field research in the city, we observed several spaces such as schoolyards, which even if they are designed, they are not used due to their materials (concrete) are their internal organisation and functions. Source: Varvara Toura

The Poulidou street as well as the identified urban voids were part of our development plan for the city of Kavala which is based on the re-design of urban voids as public spaces and their re-integration into the urban fabric.

Outcomes-Results

The urban voids identified inside the 'Xersonisos tis Panagias' neighbourhood have different characteristics. Several of them are relatively big spaces such as the schoolyards, while the unbuilt spaces between existing buildings are considered as small spaces. At the same time in cases where the urban void is a private property there are fences and the space is not accessible. In other cases, such as the Poulidou street and existing small squares and parks which are nowadays not used by inhabitants as they luck urban equipment (benches, pergolas for protection against sun during summer), the spaces are public and accessible. We should also note the different importance of these urban voids, as in several cases they are located close to old buildings dating in the 19th century, which act as living memorials of the city's past, or to monuments such as Imaret, a building dating from the Ottoman era which is unique for its organisation in open and closed spaces. These urban voids are used in different ways. In several cases they are used as places for parking vehicles (they are not designed as parking lots, but they are rather spaces that inhabitants and visitors of the neighbourhood use to park their vehicles). In other cases, they act as small places for social encounters, especially the small squares and schoolyards which are used by young people and children in order to play or to practice sports. From the above spaces we distinguished the designed public spaces such as small squares and schoolyards as they could easily be re-designed and re-integrated into the urban fabric. Still, the analysis of the interviews with local elected officials and inhabitants revealed the necessity to reconsider these spaces according to sustainability and resilience criteria as they are closed spaces or not appropriately designed to accommodate social encounters and for these reasons they are not used by inhabitants and visitors of the neighbourhood.

Our proposal for the re-design of neglected urban voids in the 'Xersonisos tis Panagias' neighbourhood as public spaces included measures to improve the basic problems identified in the area which are measures for the presence of green spaces inside the city, for urban mobility (by bicycle and by foot), for the revalorisation of historical buildings, monuments and landmarks, for the planning of open-air spaces for recreation and sports activities and for the connection of the new public spaces in the 'Xersonisos tis Panagias' neighbourhood with the existing ones especially to the ones located in the harbour of Kavala. The activities and equipment inside the old and new public spaces were decided together with the inhabitants of the neighbourhood in order to foster the dialogue between professionals and citizens and to create the conditions for the public acceptance of our development plan for the city of Kavala. The basic idea was to propose rather simple solutions that could be easily adopted and built by the Municipality of Kavala and to avoid complicated and expensive technical measures. The materials and the vegetation that were proposed (wood, stone, ceramic tiles, pine trees, plane trees) they are all local in order to reduce the cost of the project in an area facing significant socio-economic difficulties.
Concerning mobility measures, we have already mentioned that most of the urban voids of the neighbourhood are used as parking lots for the vehicles of inhabitants and visitors while at the same time the main street of the neighbourhood Poulidou does not have pavements as the neighbourhood was built before 1923, the year of changes in urban planning regulations in Greece (Figure 11).

Figure 11. Existing streets in the 'Xersonisos tis Panagias' neighbourhood. The spaces that are used as informal parking lots are marked in grey colour. We can note that Poulidou street as well as most of the urban voids of the neighbourhood are nowadays used as parking lots and thus do not allow social encounters for the neighbourhood's inhabitants. Source: Alexandros Mpantogias

This means that inhabitants and visitors of the neighbourhood have difficulties crossing streets by bicycle or as pedestrians. Our main strategy was to propose the redesign of several main streets of the neighbourhood as Dutch Woonerfs, including Poulidou street (Figure 12).

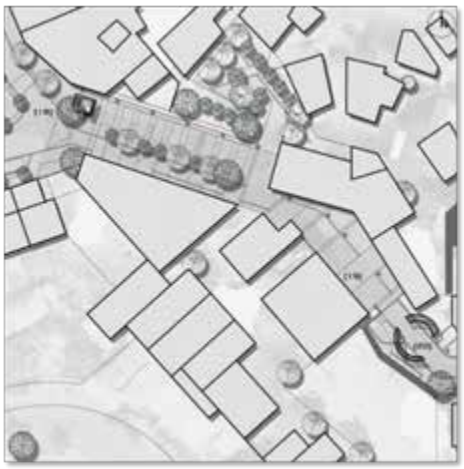

Figure 12. Proposal for the redesign of Poulidou street as a Dutch Woonerf. Trees, pergolas and benches can be found in the new design of the street creating the framework to boost social and environmental sustainability conditions, while small areas of the street are used for parking vehicles. Source: Alexandros Mpantogias

The Woonerf design solves the problems of traffic, pollution and safety by transforming urban streets into shared green spaces (small urban parks) where pedestrians and vehicles can actually co-exist in an optimal balance. Through it, they can be improved local community's quality of living and road safety in the city. The redesign of the main street of the neighbourhood, Poulidou, as a Woonerf allows the expansion of the public spaces on the street level, where vegetation and urban equipment create social and environmental sustainability conditions.

The 'Xersonisos tis Panagias' neighbourhood is among the older neighbourhoods of the city characterised by its buildings which dated on the 19th century. At the same time as the neighbourhood was developed in different

eras (byzantine-ottoman-1923 and onwards), we can find significant monuments such as the Imaret building which was used in the Ottoman era as orphanage and local landmarks as the lighthouse (Figure 13). Nowadays, the main problem in the observation of the city's landscape is the difficult identification of the local landmarks and monuments as they are located too close to contemporary buildings or in closed and not accessible spaces. Several of them, like the local lighthouse, are not accessible to inhabitants and visitors as they are part of closed spaces.

Figure 13. Existing land uses in the 'Xersonisos tis Panagias' neighbourhood. In orange and light brown colour are represented the landmarks and monuments of the area. The organic and dense urban fabric dating on the Ottoman era as well as the construction of new buildings since 1923 does not allow nowadays the observation and identification of landmarks and monuments. Source: Alexandros Mpantogias

In our strategy for the revalorisation of these spaces we considered that the notions of sustainability and resilience are connected to an urban landscape where all phases of the city's history are present and repurposed alongside contemporary needs (small commercial and recreation activities). The redesign of the exterior and interior open spaces of landmarks and monuments (Figure 14) by proposing suitable vegetation (tall trees) and urban equipment (pergolas and benches) highlights the unique historical characteristics of the above spaces and offers a different experience in the discovery of the city.

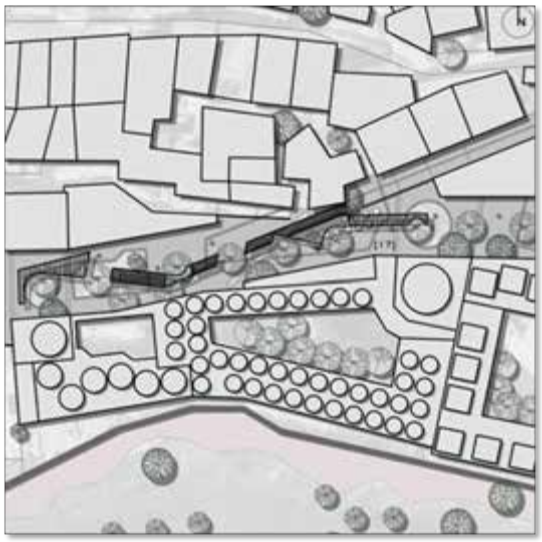

Figure 14. Proposal for the redesign of the exterior open-air spaces of the Imaret Building. Even though Imaret is nowadays restored and transformed into a luxury hotel it is still considered as a landmark of the city and a monument showing the design of public buildings during the Ottoman era. The redesign of the public space outside the building focused on creating a space from which inhabitants and visitors of the neighbourhood would observe the building's main façade while the proposed urban equipment (pergolas and benches) allows the organisation of small festivities by inhabitants. Source: Alexandros Mpantogias

As we have previously mentioned the city of Kavala and particularly the 'Xersonisos tis Panagias' neighbourhood have a limited number of open green urban spaces compared to the city's-built spaces (Figure 15). The city's organisation and the land uses in the 'Xersonisos tis Panagias' neighbourhood resulted from the arrival in the region of East Macedonia and Thrace of refugees from Anatolia region after 1923 (end of Greek-Turkish war) which had as a result the increase of housing needs. In the years following the Second World War and especially in the late 1970s the city expanded in the areas near the harbour affecting also the unbuilt urban spaces in the 'Xersonisos tis Panagias' neighbourhood. The city's limited number of open green urban spaces has as a result the increase in local temperature during summer. We should also note the difficulties that face the inhabitants and visitors of the 'Xersonisos tis Panagias' neighbourhood during summer, regarding the use of the existing open public spaces as there aren't many trees or pergolas in order to lower the temperature.

Figure 15. Existing open green urban spaces and trees in the 'Xersonisos tis Panagias' neighbourhood. The primary note from the analysis of the map of open green urban spaces is that their presence in the 'Xersonisos tis Panagias' neighbourhood is around landmarks and public buildings such as schools and the local lighthouse. On the contrary in areas with private buildings (housing units) we can note only the presence of several trees in streets. Source: Alexandros Mpantogias

During the discussions with local elected officials and inhabitants we noted their willingness to increase the presence of trees and vegetation in the area as they could improve air quality and act as a natural protection during the heat waves in summer and rain and snowstorms in winter. At the same time in Agenda 2030 and in studies of Jahn Gehl it is mentioned that the presence of open green spaces in an urban area could act as measures for improving inhabitants' well-being resulting from the improvement of air and water quality (Gehl, 2010 and UN, 2015). For this reason, it was important to suggest in our development plan the redesign of the public spaces of 'Xersonisos tis Panagias' neighbourhood based on the increase of plants and trees as measures against climate change and extreme weather conditions especially in summer. We should remind that Kavala is located in the Mediterranean region, close to the sea, and is affected in summer by extreme heat. At the same time pergolas were proposed in several areas of the neighbourhood, including the Poulidou street and schoolyards, that are exposed to sunlight in order to lower temperature during summer (Figure 16).

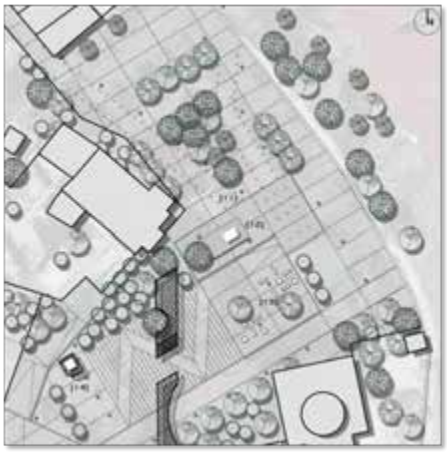

Figure 16. Proposal for the redesign of an existing small square in the 'Xersonisos tis Panagias' neighbourhood. The former design of the square did not include a significant number of tall trees and affected social encounters during summer due to weather conditions. Our proposal included pergolas in areas exposed to sunlight and tall trees in areas that inhabitants use for social encounters. Source: Alexandros Mpantogias

Another problem identified during our field research in the city of Kavala is the disconnection between the different public spaces of the city and especially to the ones located in the peninsula of Kavala which is consisted in its upper part by the 'Xersonisos tis Panagias' neighbourhood and the city's harbour in the lower part. The existing stairs that connect the public spaces of the peninsula were built by the inhabitants in former decades based on their need to have access to the city's harbour and sea. This need was highlighted during the interviews with the inhabitants as well as their thoughts about a safer way to connect the public spaces of the peninsula based on contemporary technical standards. In our development scenario we proposed a vertical connection between the public spaces located in the peninsula of Kavala, the connection is located near the city's lighthouse, in order to facilitate mobility, to increase the number of open public spaces (the vertical connection is a form of public space) and to allow the circulation of air and sunlight in an area (schoolyard) that is nowadays closed (Figure 17).

Figure 17. Proposal for a vertical connection of public spaces of the peninsula of Kavala. The vertical connection is proposed in an area with a significant architectural and historical value and for this reason our basic concern was to propose a solution based on the above special features. The proposal includes the creation of a small balcony in order to increase the area of the public space of the city's lighthouse and a small staircase which will be used by the inhabitants when they want to reach the public spaces in the city's harbour.
Source: Alexandros Mpantogias

Sustainability and resilience are nowadays connected to recreation activities and sports practice as human health and well-being are among the goals of the Agenda 2030 of the United Nations (UN, 2015). The main problem that we identified during our field research was the absence of recreation and sport facilities in the 'Xersonisos tis Panagias' neighbourhood, which could facilitate social interactions and inhabitants' well-being. Inhabitants of the neighbourhood and particularly teenagers and families with young children have expressed during our interviews their need for spaces where they could practice sports or use them in order to organise open-air festivities. During our field research we also noted that inhabitants and visitors of the neighbourhood face difficulties using existing sport facilities, as they are often located in closed spaces (schoolyards) and they are not well maintained. In our development scenario for the 'Xersonisos tis Panagias' neighbourhood and the city of Kavala we considered human health and well-being as key elements of urban sustainability and resilience and for this reason, we suggested the redesign of existing closed (there is a fence around them) open-air spaces like schoolyards as public spaces (Figure 18). This measure, the planning of open-air spaces for recreation and sports activities, could potentially increase social encounters and improve the health and well-being of inhabitants and visitors of the neighbourhood.

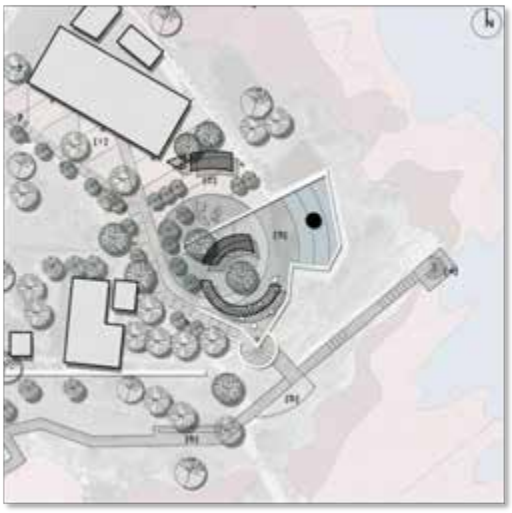

Figure 18. Proposal for the redesign of a schoolyard where it is located Kavala's lighthouse. The existing schoolyard is a closed space not well integrated into the city fabric. The use of concrete in an open-air public space increases temperature during summer, thus not allowing the practice of sports. The schoolyard is designed as a public space for all inhabitants, not only young people, by proposing a small playground for young children and equipment for open-air sports practice. In the same space we can also find pergolas and tired seating which could be used by the inhabitants for organising open-air festivities. We should also note the suggestion for tall trees and plants as natural protection for sunlight and heat during summer.
Source: Alexandros Mpantogias

Discussion

The study of a real-world setting with particular characteristics (socio-economic difficulties, small number of public spaces) revealed the necessity to consider the planning of public spaces in poor small and medium-sized urban areas as a transformative agent which seeks to contribute to a more liveable urban future by combining measures of social and environmental sustainability. Public spaces could act as agents of inclusive and sustainable urban transformations when local elected officials and inhabitants work together with researchers and practitioners in their design processes and try to find solutions that fit not only to technical standards but also to the needs of communities. It is important to mention that this democratic procedure, which can sometimes take the form of co-design and co-production and not only inhabitants' consultation, in small-scale public spaces' projects acts as an urban laboratory for the design and testing of solutions that could later be implemented at city level (the design methodology and planning tools in a small park could also be used in the design of a big park or central square). As we have mentioned in a different section of the paper, the cost of operations in public spaces is an issue to consider when proposing development scenarios in small and medium-sized cities facing socio-economic difficulties. The discussions with local authorities and especially with the inhabitants allow to propose policies and measures that are closer to their expectations and needs, while the socio-economic analysis of the local urban context allows to adjust these policies and measures to the economic dynamics of the city. Good design of public spaces does not mean expensive and complicated technical solutions but rather proposals inscribed in the local social, economic, environmental and cultural urban context.

Another issue to further consider through the design of public spaces and their role in cities' development is urban identity. We saw in the analysis of the case study and the subsequent proposal for 'Xersonisos tis Panagias' public spaces that the particular characteristics of the urban landscape are reflected in the design of public spaces. Historical buildings, monuments and landmarks that have shaped the cities' history are not only living memorials of the different eras of the cities but are also vital elements for contemporary urban life as they are often restored and reused. Their easy identification on urban fabric, achieved through the design of neighbouring public spaces who should be opened and accessible, has as a result a different experience

in cities' discovery by locals, researchers and visitors. Through these planning policies on public spaces, they could be identified significant cities' districts and define around them protection zones in order to protect them from mass-tourism and overscale construction projects that seem to not respond to the cultural and historical characteristics of these urban areas. On the contrary small-scale economic activities such as shops could be found inside these zones as they are necessary for inhabitants (groceries, bakeries). In cases of cities with a high unemployment rate these small-scale economic activities could also serve as measures for facing the difficulties in the local economic context.

To go further on the field of urban sustainability and resilience and the relationship between built spaces and open public spaces we should underline that measures and policies in favor of nature's integration into the urban fabric should be proposed and implemented in dense urban areas based on the local characteristics of each area (urban, environmental, social, economic) to effectively propose solutions that benefit local communities. These measures and policies should put forward the relationship between the built environment and open public spaces and try to find a balance between them in order to improve socio-economic and environmental conditions. At the same time designers, practitioners and local authorities should carefully consider that the integration of the natural element in the design of public spaces, when it is carefully planned, could have positive effects on the temperature inside cities and water and air quality. Public spaces design, organisation and functions based on environmental sustainability criteria could reshape urban areas of the Mediterranean region that are exposed to extreme weather conditions (heat waves) during summer. For this reason, it is important to consider the design and planning of public spaces as a process inscribed in the fields of urban sustainability and resilience as open public spaces like squares and parks serve also as places for social encounters that boost citizens' health and well-being and solve social problems.

In many cases of deindustrialised cities, and especially in small and medium-sized cities of this category where the local economy is primarily based on industrial activities, social problems appear after their deindustrialisation related to the high unemployment rate. This local economic context combined with the loss of local population who moves in other areas in order to find work has as a result the recession of certain urban areas who are trying to find a new identity (social, economic, cultural) in order to increase their population and improve the living conditions of the local population. Public spaces could play a key role in the development strategy of these cities, as we have previously seen in the case study of Kavala a medium-sized city affected by deindustrialisation and the loss of local population. The creation of community conditions (people who have the same goals and needs), in urban districts that are most affected by economic recession, could be achieved through the design of public spaces as these spaces act as places for social encounters where people with different social and ethnic backgrounds gather and spend time with other people. The organisation of festivities and small cultural events in public spaces by the inhabitants of these districts, could serve as a means to bond their relationships and act together in issues related to social, economic and environmental policies of their municipalities. At the same time the design of public spaces in a way that helps the practice of sports (human health) and the organisation of small cultural events by the inhabitants (recreation activities that boost human well-being) are part of the Agenda 2030 (UN, 2015) and should be taken into account by practitioners and local elected officials in order to create inclusive and sustainable urban conditions in areas facing socio-economic difficulties.

Urban mobility is also a question related to the design of public spaces as it affects the form and functions of cities as well as inhabitants' health and well-being. Public spaces and urban mobility are intertwined concepts that significantly impact urban planning and sustainable development. Public spaces, such as parks, streets, and squares, serve not only as gathering places but also as crucial components of the urban mobility landscape. They facilitate movement and connectivity, shaping the daily experiences of city dwellers. The sustainability of urban environments relies heavily on the relationship between mobility and public spaces. Walking and cycling contribute to reducing carbon emissions and congestion, making urban areas more liveable. Integrating green transportation options, such as bike lanes and pedestrians' zones, into the public space design can facilitate this shift towards a sustainable mobility model. Urban planners and researchers often face the challenge of balancing the competing needs of mobility and public space usage. For instance, reducing the traffic of vehicles in

favour of pedestrian-friendly routes can improve the experience of public spaces, but it may also raise concerns about accessibility for those reliant on cars. Measuring the sustainability of public spaces and mobility systems remains a complex task. New and existing sustainability indicators need to account for the multifaceted impacts of urban design in public spaces, such as social engagement, environmental resilience, and economic viability especially for small and medium-sized areas facing socio-economic and environmental difficulties.

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Reshaping Urban Spaces: Exploring the Role of Temporary Public Open Spaces in Alleviating Land Pressure in Hong Kong

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Abstract
As urban land scarcity intensifies, Temporary Public Open Spaces (TPOS) offer flexible solutions to meet growing spatial and social demands. This study explores the role of TPOS in addressing the societal impacts of land scarcity in high-density cities, focusing on Hong Kong. Using a qualitative approach, it comprises a literature review, interviews, and comparative analysis of three case studies. The research identifies key characteristics and practices of TPOS, emphasising how different models vary in their social contributions. Findings provide practical insights into optimising TPOS design, governance, and integration into urban planning. The study contributes to a deeper understanding of how TPOS can support inclusive, adaptive public space strategies in dense urban contexts.

Keywords: Public Open Spaces; Temporary Urbanism; Urban Planning

1 Introduction

As urban areas continue to expand and populations increase, the availability of land becomes a scarce resource (Hee & Ooi, 2003; Tang & Wong, 2008). This has significantly changed how urban spaces are designed and utilised (McIntyre, 2009). Temporary uses for public spaces have gained recognition as an essential strategy for revitalising cities and have been widely incorporated into urban policies to address the limited space issue (Fernandez & Mozas, 2021; Andres & Kraftl, 2021). Temporary Public Open Spaces (TPOS) have emerged as a flexible alternative to manage the growing demands on urban areas with limited available land (Bragaglia & Caruso, 2021).

Hong Kong, as a high-density city, exemplifies the growing challenges of providing public open spaces. Initially, the Hong Kong Planning Standards and Guidelines (HKPSG) set a target of 2 square metres of open space per person (DevB, 2015). However, as public demand for quality open spaces has risen, the Hong Kong 2030+ initiative proposed increasing this target to 3.5 square metres per person (DevB, 2021). Despite this aim, a report by Civic Exchange in 2017 shows that the actual provision averages only 2.7 to 2.8 square metres per person.

To alleviate the pressures of urban density, the Planning Department of Hong Kong issued the *Reimagining Public Spaces in Hong Kong – Feasibility Study* (DevB, 2023), which reviews public open space policies in other high-density cities worldwide and summarises emerging global trends in open space planning. The study emphasises the importance of developing innovative, flexible public open spaces, specifically highlighting adaptive strategies like tactical urbanism and time-sharing of space as quick-win solutions to optimise existing spaces. For instance, the study suggests embracing tactical urbanism to create transient open spaces and repurposing underutilised or obsolete spaces. This reflects the Hong Kong government's encouragement of innovative approaches to public open space usage and its commitment to fostering community identity through public participation and flexible spatial solutions (DevB, 2023).

In response to rising public demand and scarce land resources, Hong Kong primarily manages buildable land through permanent grants to the private sector or government allocations for long-term development. Yet before these developments commence, the government often designates specific land parcels for temporary recreational use, maximising available land while addressing supply constraints (Lu, 2023). According to GovHK data (2017), approximately 748 temporary land allocations, covering around 76 hectares, have been established for temporary open spaces.

Despite government efforts to designate temporary public spaces, there are ongoing concerns regarding the quality and sustainability of these spaces (GovHK, 2017). These issues highlight the need for further research into

their design, management, and potential contributions to urban life. This study aims to explore how TPOS can help mitigate land scarcity in high-density cities like Hong Kong.

The research begins with an in-depth theoretical exploration, analysing the definition and main types of temporary use within the framework of temporary urbanism and its role in alleviating land pressure. These insights are integrated with the current state of TPOS in Hong Kong, examining existing policies and measures to summarise the characteristics of TPOS in the unique context of Hong Kong.

Additionally, the study conducts an analysis of three representative cases of temporary public space use in Hong Kong to uncover valuable insights into how these practices inform the design and governance of TPOS. Ultimately, this research aims to refine the theoretical framework of TPOS, offering structured recommendations for their planning and management within Hong Kong's unique urban landscape, and providing guidance for future public open space planning in high-density cities. Specifically, this study focuses on three main research questions:

1. What are the key characteristics and practices of temporary uses of public open spaces in high-density urban areas like Hong Kong?
2. How do different types of TPOS perform in addressing the social impacts of land scarcity in high-density cities?
3. How can insights from temporary uses of public open spaces inform the development of TPOS in Hong Kong?

2 Literature Review

2.1 Temporary Use of Public Open Space under Temporary Urbanism

To address the growing demand for urban public open spaces, the need for cost-effective, rapid, and tailored solutions to repurpose vacant areas has become increasingly urgent, leading to the emergence of the concept of temporary use strategies (Colomb, 2012; Haydn & Temel, 2006; Oswalt et al., 2013). By providing a flexible alternative to traditional development, temporary use offsets the rigidity of long-term formal plans and offers opportunities to experiment with informal, improvisational, and spontaneous innovations (Galdini, 2020), demonstrating significant benefits for social life. As a result, it has become an emerging trend and innovative strategy for reimagining urban spaces, increasingly integrated into urban policies and considered a key feature of urban planning (Andres & Kraftl, 2021; Bragaglia & Rossignolo, 2021; Dubeaux & Cunningham Sabot, 2018).

Temporary use refers to unconventional and informal spatial activities occurring within limited timeframes, differing from the typical urban development cycle (Oswalt et al., 2013; De Smet, 2013). It represents an adaptive, flexible form of urbanisation that aligns spaces with evolving demands and fosters stakeholder consensus (Bishop & Williams, 2012; Bembennek, 2008). As a development-oriented practice, temporary use explores spatial potential while reflecting a gradual integration of grassroots activities into institutional frameworks (Lehtovuori & Ruoppila, 2012; Hou, 2020).

2.1.1 Typologies and Characteristics of Temporary Use

Temporary use, a key practice in temporary urbanism, is defined by temporality and flexibility. While its short-term nature is often seen as a limitation, scholars argue it unlocks unique opportunities unattainable through long-term processes (Madanipour, 2018; Haydn & Temel, 2006). Particularly in high-density cities, temporary use empowers low-cost, low-risk experimentation, providing insights for public open space planning and management.

Andres and Zhang (2020) classify temporary urbanism into bottom-up, top-down, and hybrid modes. Bottom-up approaches, driven by communities, address immediate social needs, enhancing participation and offering ideas for activating TPOS. Top-down strategies, led by governments or institutions, align with broader urban development goals such as cultural industry promotion (Colomb, 2017), providing structured solutions for TPOS requiring rapid deployment and resource optimisation. Hybrid models encourage collaboration among stakeholders, bridging community-driven and institution-led initiatives to mitigate tensions and improve

planning efficiency (Lehtovuori & Ruoppila, 2012). This typological framework highlights temporary use's temporality, flexibility, and collaborative potential, offering a foundation for systematic TPOS policy design.

2.1.2 Alleviating Land Pressure through Temporary Use

Temporary use plays a pivotal role in high-density cities as a cost-effective and flexible spatial strategy, alleviating land pressures through short-term interventions. Its low-cost, low-risk, and time-sensitive nature effectively addresses spatial and temporal gaps in traditional urban planning (Galdini, 2020). By preventing land degradation or unauthorised occupation, temporary use offers transitional solutions for vacant sites awaiting permanent development (Bishop & Williams, 2012; Németh & Langhorst, 2014).

Socially, temporary use fosters inclusivity and enhances the urban quality of life. By responding swiftly to community needs, it strengthens social cohesion, fosters consensus, and reduces barriers for non-profit organisations and grassroots participation (Andres & Kraftl, 2021; Tardiveau & Mallo, 2014). It also encourages citizens to reimagine urban spaces dynamically, inspiring adaptive and innovative uses (Madanipour, 2018).

Economically, temporary use revitalises underutilised land, reducing uncertainties in long-term planning through experimental approaches. This strategy increases land value and attractiveness by allowing iterative feedback for development processes (Ferreri, 2015; Mulgan et al., 2007). Flexible management also optimises land for short-term gains while offering insights for future investments (Florida, 2002).

From a governance perspective, temporary use provides an experimental platform for validating urban policies and strategies. It enables resource optimisation and attracts investors through short-term pilot projects, thus bridging the gap between temporary and long-term urban developments (Stevens & Ambler, 2010; Bragaglia & Rossignolo, 2021).

2.2 Temporary Public Open Spaces in Hong Kong

Hong Kong exhibits highly concentrated urban characteristics, including density, complexity, and verticality (Shelton et al., 2011). However, this level of intensity is often driven by economic motives, with a focus on maximising profits (Tieben, 2016). Under a system of public land ownership, the Hong Kong government's land lease system has constrained the development of public open spaces (Tang & Wong, 2008). For a long time, the government has generated revenue through the transfer of land use rights, making land allocation a significant source of income (Legislative Council Secretariat (LEGCO), 2016). Within this model, dominated by "revenue generation through land management," land-use planning is often regarded as a solution-oriented tool to resolve land disputes among interest groups and local bureaucracies (Bristow, 1984). Public open spaces are seen as additional costs for the government to provide and maintain, which has negatively affected their planning and design (Tang & Wong, 2008).

Over the past few decades, the traditional planning role of public open spaces has gradually diminished, with responsibilities increasingly shifted to the private sector. This has led to the privatisation of public open space functions (Cuthbert & McKinnell, 2001). In the 1980s, the government introduced the "Private Development Public Open Space" (POSPD) policy, encouraging the private sector to provide open spaces for public use within or around their buildings in exchange for higher building density allowances in certain high-density areas. This was intended to compensate for the shortage of public open spaces through private sector participation (GovHK, 2012). However, this incentive mechanism further prioritised economic benefits over community needs, failing to truly address the public's demands (Yu, 2018).

Hong Kong's public open space planning policies are inadequate, and the shortage of facilities has raised social concerns (Siu & Huang, 2015). The availability of public open spaces in many areas falls far below the standard of 2 square metres per person set by the Planning Department (Gilges, 1998; Zhang, 2015). Compared to other Asian metropolises, Hong Kong ranks among the lowest in this regard (Lai, 2017). The government has gradually recognised the important recreational role of public open spaces in high-density urban environments. It has

established HKPSG to provide a fair basis for reserving land for recreational facilities and open spaces, guiding their planning and design (GovHK, 2015). Most public open spaces in Hong Kong are managed by the Leisure and Cultural Services Department (LCSD). Due to limited funding, they often adopt generic approaches to the planning and design of various spaces, prioritising low maintenance costs, which fail to meet residents' comfort needs (Lai, 2017). Under the guidelines of the Hong Kong Public Health and Municipal Services Ordinance, the usage of these spaces is also strictly regulated, limiting the potential for development in the use of public open spaces (Carlow, 2013).

Against this backdrop, TPOS have emerged as an important tool to address land pressures. TPOS in Hong Kong refers to recreational land temporarily allocated by the government before permanent development takes place. Their uses are diverse, including green spaces, playgrounds, and rest gardens (GovHK, 2021). In Hong Kong, developable land is typically allocated through the private sector for permanent projects or managed by government departments (GovHK, 2017). However, this land management approach sometimes results in transitional land being temporarily left idle. This may occur due to issues such as planning, demand, insufficient funding, or land ownership, causing the originally planned permanent development projects to be delayed. To make more effective use of these temporarily vacant land resources, the government tends to allocate them for temporary or short-term uses to ensure the maximisation of land value (Lu, 2023).

According to data from the Development Bureau in 2017, the Lands Department allocated 748 temporary sites, covering a total area of approximately 760,000 square metres, for use as TPOS. Recreational land is often prioritised for temporary use because it aligns with the planning principles of the Outline Zoning Plan (OZP) and is considered a "permitted use" in almost all zoning categories. These spaces not only serve as transitional arrangements during urban land redevelopment but also alleviate the shortage of public open spaces to some extent (GovHK, 2017). When designating temporary recreational land in a particular area, the government considers multiple factors, including the size and timeline of developable land, the surrounding environment, and residents' needs (GovHK, 2017).

The "temporary" nature of TPOS leads to ambiguities in their functions, designs, and user perceptions. In some cases, the lifespan of temporary spaces is comparable to that of permanent open spaces (Lu, 2023). The planning and management of TPOS in Hong Kong have attracted increasing attention, as their usage periods often exceed their intended temporary status. Long-term use has raised concerns about maintenance quality and whether these spaces can adequately meet community needs and expectations (GovHK, 2017).

3 Research Methods

Based on the discussion above, this study examines three specific cases of temporary public space use in Hong Kong: Central Harbourfront Event Space, Sham Shui Po Underbridge Night Market, and Hong Kong Cultural Centre Piazza. These locations were chosen for their diversity in spatial functions, governance models, and user engagement, representing different approaches to temporary public open space utilisation in high-density urban settings.

The case study will rely on existing literature and secondary data analysis, including government documents, official reports, media releases, and news articles. Additionally, 15 brief semi-structured interviews will be conducted with various
stakeholders—five for each site—involving venue managers, event organisers, event staff, security personnel, and regular space users (Figure 1). Thematic analysis will be employed to explore stakeholders' perspectives on the following areas: a) their relationship with the space, b) their views on the temporary use activities and participation processes, and c) their suggestions for improving the facilities and management of temporary activities (Tsiolis, 2017).

By integrating secondary sources with first-hand insights from stakeholders, this study aims to gain a

comprehensive understanding of the opportunities and challenges associated with the temporary use of public open spaces in Hong Kong.

Location	Interviewee Type	Number
Central Harbourfront Event Space	Event Staff	2
	Security Personnel	1
	Users	2
Hong Kong Cultural Centre Pizza	Event Staff	2
	Users	3
Sham Shui Po Night Market	Event Organizer	1
	Vendors	2
	Users	1
Total		15

Figure 1. The categorization of interviews, own processing

4 Case Study

4.1 Central Harbourfront Event Space

The Central Harbourfront Event Space is a prominent open space located in the Central waterfront area of Hong Kong, widely recognised for hosting temporary public events and activities (Figure 2). It was designated as part of the government's commitment to urban revitalisation and public engagement along Victoria Harbour. As a strategic element of the "Harbourfront City Vision," the site was allocated within the reclamation area of Central Harbourfront to serve as a flexible space for community activities and public interactions (DevB, 2021). Officially established in 2014 under the guidance of the Development Bureau, the site was entrusted to Central Venue Management Limited (CVM) for operational management, becoming one of Hong Kong's most iconic public open spaces for temporary events.

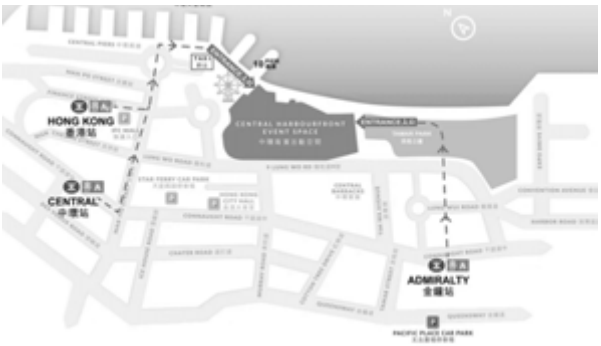

Figure 2. Map of the Central Harbourfront Event Space, CVM 2024
Figure 3. Map of rentable sections, CVM 2024

4.1.1 Operating Model and Stakeholder Relations

The Central Harbourfront Event Space operates under a public–private collaboration model. The Development Bureau serves as the primary government authority, overseeing overall planning and formulating usage policies to ensure the space aligns with public interests and urban development objectives (CVM, 2024). Concurrently, the Hong Kong government has established the Harbourfront Commission as a non-statutory advisory body to

regularly assess and monitor the space's management, ensuring openness and multifunctionality (LEDGO, 2024).

On the private sector side, the operational responsibilities are undertaken by Central Venue Management Limited (CVM), which handles day-to-day operations, event planning, and site maintenance. The event space is divided into four designated areas (Figure 3), catering to public events of various scales. Event organisers can obtain venue rental permits by submitting applications to CVM. CVM operates in accordance with an agreement signed with the Development Bureau and complies with recommendations and public service objectives set by the Harbourfront Commission. It is required to submit regular operational reports to the government (CVM, 2023), ensuring that events held at the venue meet community cultural and economic needs while supporting charitable activities (DevB, 2024).

In this operational framework, government institutions like the Development Bureau and the Harbourfront Commission play policy coordination and advisory roles, while the private company CVM, as the primary operator, collaborates with community groups, non-governmental organisations (NGOs), and commercial entities (Figure 4).

The Central Harbourfront Event Space operates with a structured and efficient management system. During events, security personnel explained that they do not directly interact with venue managers, as arrangements are pre-coordinated by event organisers. "*The process was relatively smooth without major communication issues.*" (Interview, Security Personnel) This indicates that the operational workflow, including venue rental and security coordination, relies on a relatively well-established management system. Clear allocation of resources and responsibilities between the venue managers, event organisers, and security teams facilitates smooth event execution.

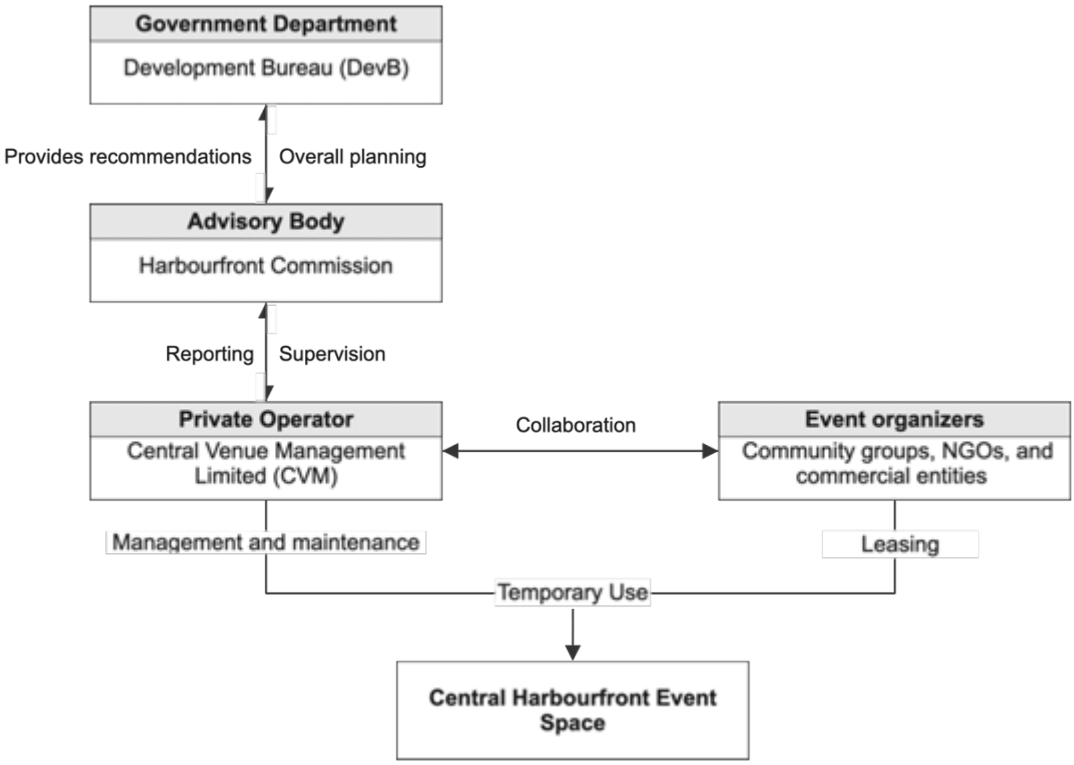

Figure 4. Flowchart of the operating model and stakeholder relationships, own processing

However, the space's operational flexibility reveals gaps in infrastructure that could hinder user experience during adverse conditions. A staff member responsible for maintaining order and ticketing during a temporary event further noted, "*Since the entire area is an open outdoor space, rainy days can be quite troublesome. We can only work in plastic raincoats, which adds challenges to maintaining order. I hope the venue managers can provide temporary rain shelters, such as tents.*" (Interview, Event Staff) While the space's open nature offers flexibility, it also lacks infrastructure to address unforeseen weather conditions.

The space's temporary policies have also been praised for promoting vibrancy and inclusivity, enabling diverse public engagement (Figure 5). A regular visitor who comes almost daily shared, "*The government policies provide considerable freedom. As long as you don't interfere with others, they don't overly restrict spontaneous activities.*" (Interview, Users) This user mentioned witnessing numerous temporary events, which he believes have enriched the space's functionality and attracted more public engagement.

Figure 5. Temporary activities at the Central Harbourfront Event Space, CVM 2024

The Central Harbourfront Event Space has a structured management model with clear delineation of roles and efficient processes from venue rental to event management. However, gaps in spatial planning remain, particularly the lack of adaptive facilities for weather contingencies.

4.2 Hong Kong Cultural Centre Piazza

The Hong Kong Cultural Centre Piazza is located in Tsim Sha Tsui and serves as one of the key venues for cultural and artistic activities in Hong Kong. Originally established alongside the Hong Kong Cultural Centre to provide an open public space for leisure and cultural engagement, the piazza's use has diversified over time due to the growing demand for multifunctional public spaces. Recognising its potential, the government divided it into four sections to host different types of temporary activities to enhance its utility and public engagement (Figure 6). According to the Leisure and Cultural Services Department, the piazza has become a prominent venue supporting diverse cultural, artistic, and community events (LCSD, 2024).

Figure 6. Map of the Hong Kong Cultural Centre Piazza, LCSD 2024

4.2.1 Operating Model and Stakeholder Relations

The Hong Kong Cultural Centre Piazza is managed entirely by LCSD, whose responsibilities include venue rental approvals, daily maintenance, and event management. The use of the piazza primarily involves event organisers, such as community groups, charitable organisations, and private enterprises, who directly apply to LCSD for venue rental. Organisers must submit detailed proposals ensuring compliance with government regulations. LCSD provides a streamlined application process to facilitate efficient approval (LCSD, 2024).

Additionally, LCSD actively organises temporary events in collaboration with charitable associations and community organisations, launching creative markets to provide platforms for young artisans and offering performance spaces for people with disabilities, exemplifying the piazza's inclusivity and diversity as a public space (LCSD, 2024). One organiser noted, *"The open layout and multifunctional design of the piazza greatly facilitate events, particularly as its cultural atmosphere attracts a significant number of participants."* (Interview, Event Organiser) This collaborative model ensures the piazza's cultural vibrancy while allowing LCSD to balance commercialisation with public service needs (Figure 7).

Figure 7. Temporary activities at the Hong Kong Cultural Centre Piazza, LCSD 2024

Temporary activities in the piazza were generally well received by users. Residents living near the piazza stated, *"This space has become part of my daily running route, and the temporary activities held here haven't interfered with my routine. If there were free events, I would make a special trip to participate."* One resident also suggested adding drinking fountains to better serve outdoor exercise enthusiasts (Interview, Users).

While the government's top-down vision emphasises cultural promotion and multi-functionality, feedback from both event organisers and individual users reveals additional layers of consideration. Event organisers highlight the importance of flexible layouts for large-scale cultural events, whereas individual users stress the need for practical amenities like drinking fountains to support everyday activities. Therefore, although the temporary pattern of public open space use in the piazza is well-positioned to meet broad cultural and community goals, challenges remain in aligning the space's offerings with the practical needs of its diverse user base.

4.3 Sham Shui Po Underbridge Night Market

The Sham Shui Po Night Market, located under the Tung Chau Street Flyover, is a three-day temporary market held before the Chinese New Year, representing a grassroots initiative to revitalise underutilised urban spaces in Hong Kong. Emerging naturally in the early 2010s, the night market was initiated by community organisations and street vendors. It is the first Chinese New Year night market in recent years to be driven by grassroots organisations and granted legal operating status, symbolising a new direction in grassroots action and the utilisation of urban public spaces. Without proactive government planning, the night market evolved through collective action and self-organisation, exemplifying a bottom-up approach to temporary public space usage. This process not only heightened public awareness of temporary spaces but also became a significant attempt to reutilise public spaces in land-scarce Hong Kong.

4.3.1 Operating Model and Stakeholder Relations

Figure 8. Flowchart of the operating model, own processing

The operation of the night market involves multiple stakeholders, including government departments, community organisations, and street vendors. The preparation of the night market is typically led by community organisations, which conduct user surveys and draft detailed proposals to assess market demand and feasibility. Following this, vendors need to apply for relevant permits and licences from various government departments, including the Food and Environmental Hygiene Department (FEHD), the Lands Department, and the Environmental Protection Department, which are responsible for examining food safety, land use, and environmental management, respectively (FEHD, 2024). Finally, the legalisation of the night market also requires submission to the district council for discussion and approval (Figure 8). During the operation of the night market, the government does not participate in direct management. Community organisations play a central role, not only coordinating the government's approval process but also overseeing the practical operations of the night market, such as site planning, stall allocation, and communication with vendors.

Although the government has long advocated for transforming underutilised public spaces into marketplaces, including district-led initiatives to establish legal open-air bazaars and night markets, the process remains challenging for vendors (LEGCO, 2015). One organiser stated, "The process for legal operation is complex and lengthy. We had to communicate repeatedly with multiple departments to obtain approval" (Interview, Organiser). Some vendors who considered organising a legal night market ultimately gave up due to the cumbersome application process. *"I once thought about organising a temporary market, but the application process was too complicated, so I abandoned the idea,"* one vendor shared (Interview, Vendors). Another vendor added, *"The government has not provided any policies or assistance to support bottom-up approaches. We are left to navigate in the dark on our own"* (Interview, Vendors).

Compared to Hong Kong's highly commercialised urban spaces, many people appreciate the atmosphere here (Figure 9). During the Chinese New Year holidays, when most shops are closed, such a temporary night market provides convenience for residents. A regular visitor to the night market remarked, *"This is a unique space where you can truly experience Hong Kong's local culture."* (Interview, User)

Figure 9. Sham Shui Po Underbridge Night Market during Chinese New Year, Initium Media 2017

The operating model of the Sham Shui Po Night Market illustrates how bottom-up space utilisation can intersect with the government's top-down regulatory framework. While the legalisation of the night market faces institutional obstacles, the coordination by community organisations and active participation of vendors have made this space a significant example of temporary public open space in Hong Kong. However, despite the government's stated intentions to promote legal night markets, procedural barriers continue to impede progress. The disconnect between the government's top-down regulatory approach and the grassroots needs of vendors underscores ongoing challenges. Without streamlined policies and improved infrastructure support, the long-term sustainability of such initiatives remains uncertain.

5 Discussion

Under the theoretical framework of temporary urbanism, the study of TPOS in Hong Kong reveals a policy-driven and systematic approach to temporary land use. Managed and allocated by the Lands Department, Hong Kong's TPOS aligns with the top-down governance model characteristic of temporary urbanism (Colomb, 2017). This reflects an institutionalised response to land scarcity in high-density urban environments, demonstrating how temporary use can be formalised as part of urban policy to address immediate spatial needs while awaiting long-term development.

The three cases examined in this study represent distinct approaches to the temporary use of public open spaces in Hong Kong. Each case highlights unique operational models that respond to urban land scarcity in specific ways while grappling with contextual challenges.

The Central Harbourfront Event Space operates under a public-private partnership model, managed by a private company under the guidance of the Development Bureau. Transformed from reclaimed land into one of Hong Kong's most prominent public open spaces, its flexible usage enhances urban attractiveness and economic value (Florida, 2002). The structured operational model supports large-scale cultural and recreational events, showcasing efficient event coordination and resource allocation. However, reliance on temporary infrastructure reveals limitations—such as inadequate shelter for inclement weather—restricting its usability for everyday activities.

The Hong Kong Cultural Centre Piazza, fully managed by the Leisure and Cultural Services Department (LCSD), exemplifies a centralised governance model. It integrates temporary activities into cultural infrastructure, offering free venues to disabled individuals and emerging artists, thereby improving urban quality of life and social inclusivity (Andres et al., 2021). The streamlined application process facilitates a range of events, balancing cultural promotion with public service objectives. While organisers value the flexible layout for cultural events, users often highlight practical concerns—such as the need for drinking fountains—demonstrating the ongoing challenge of aligning multifunctional policy ambitions with daily user needs.

In contrast, the Sham Shui Po Night Market represents a grassroots, bottom-up initiative, led by community organisations and vendors. It offers a low-cost platform that enriches dense urban environments and strengthens community cohesion (Németh & Langhorst, 2014). By repurposing underutilised spaces, the night market provides community-centric responses to peak demand periods such as the Lunar New Year, highlighting civic adaptability and collective agency (Tardiveau & Mallo, 2014). Public feedback underscores the value of participation in reshaping urban space; however, long-term sustainability is constrained by fragmented oversight and complex licensing procedures. The lack of institutional support underscores the challenges grassroots TPOS face within Hong Kong's regulatory framework.

Collectively, these cases illustrate the potential of TPOS in responding to urban land scarcity, while underscoring the need for more adaptable infrastructure, simplified regulatory frameworks, and collaborative governance models to maximise their sustainability and inclusivity. Limitations in Central Harbourfront and Cultural Centre Piazza demonstrate the importance of balancing flexibility with practical functionality. Meanwhile, the Night Market reveals a pressing need for institutional mechanisms that better support community-led initiatives. Across all cases, a disconnect between top-down planning visions and ground-level user feedback highlights the necessity of incorporating diverse stakeholder voices into the design and governance of TPOS.

6 Conclusion

This study investigates the role of TPOS in addressing land scarcity in high-density urban environments such as Hong Kong. Through a combination of theoretical research under the framework of temporary urbanism and case studies of three distinct sites, the research identifies how varying governance models and operational approaches influence the performance and challenges of TPOS. The findings highlight a mismatch between the government's planning aspirations and the practical needs of users, pointing to both opportunities and

obstacles in the effective implementation of TPOS strategies.

The study demonstrates that Hong Kong's TPOS policies reflect a structured attempt to incorporate temporary spaces into urban planning. This involves balancing the adaptability required for temporary use with the rigidity of formalised governance systems. By examining the city's approach, key insights emerge: the importance of stakeholder collaboration, the necessity of flexible and inclusive infrastructure, and the value of simplified administrative mechanisms. Acknowledging gaps in public engagement and service provision, this research suggests that the TPOS framework would benefit from enhanced responsiveness to community-driven initiatives that harmonise policy intent with on-the-ground application. Such improvements could improve alignment between centralised planning and the evolving needs of diverse urban users, fostering more sustainable and impactful space management.

The research holds practical implications for refining the TPOS system in Hong Kong, providing insights into how temporary land use can be optimised to address urban pressures. It underscores the potential of TPOS to bridge short-term spatial demands and long-term urban development goals, and calls for a more adaptive, inclusive approach to public space management in high-density cities.

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Urban Green Areas as a Tool for City Care: Insights from Medium-Sized Italian Cities

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Abstract
This paper introduces a research methodology to investigate the impact of urban green areas on human health, focusing on medium-sized Italian cities. Recognizing the critical link between urban environments and health outcomes, particularly concerning non-communicable diseases exacerbated by urbanization, the study employs concepts of spatial justice, place-based health, and environmental vulnerability. The methodology involves calculating the Normalised Difference Vegetation Index from satellite imagery, determining Pro Capita Green Space, and estimating Real Accessibility to urban parks within a 15-minute walk. Applied to six diverse Italian cities, the analysis reveals varying distributions and accessibility of green spaces, highlighting the influence of historical urban layouts, population density, and natural features on environmental equity. The findings underscore the importance of strategically integrated urban green infrastructure for promoting public health.

Keywords: Green Areas; Public Health; Accessibility; Medium-sized City; Climate Change

Introduction

This paper aims to propose the research methodology developed in the first phase of *Urban green infrastructure, policies on green spaces and health outcomes*, a European Union-Next Generation EU funded research project, which aims to investigate the impact that green areas in urban contexts can potentially have on physical and mental human health.

The relationship between human health and green areas is a dialectical pairing that has always characterized the theoretical and operational interest of urban planning since the formation of the modern discipline. The relentless urbanization processes of recent decades have further prompted the scientific community to explore the relationship between urban areas and citizens' health. On the one hand, urbanization has been shown to facilitate access to health services and offer greater social and employment opportunities. On the other hand, urban environments tend to be less conducive to health, increasing the incidence of chronic diseases, particularly cardiovascular, respiratory, and mental disorders.

Urban environments play a significant role in influencing the risk factors for noncommunicable diseases (NCDs), which include cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes. These conditions are largely driven by behavioral and environmental factors that are often intensified in cities. Air pollution—both indoor and outdoor—is a major environmental risk in urban areas, contributing to millions of NCD-related deaths each year.

In addition, urban settings often promote unhealthy lifestyles, such as poor diets, physical inactivity, tobacco use, and harmful alcohol consumption. These behaviors increase metabolic risk factors like high blood pressure, obesity, elevated blood glucose, and abnormal blood lipids, all of which are linked to a higher incidence of NCDs.

Socioeconomic disparities in cities further exacerbate the problem, as low-income and marginalized populations may have less access to healthcare, healthy food, green spaces, and opportunities for physical activity. To combat the NCD burden in urban areas, it is essential to implement cross-sectoral policies that promote healthy environments, improve access to preventive care, and reduce exposure to risk factors (WHO, 2024).

The idea that space influences well-being is therefore not new, but it has been rediscovered through interdisciplinary research over the past two decades. From a geographical perspective, concepts such as *spatial justice, place-based health, and environmental vulnerability* have made it possible to go beyond an exclusively clinical approach, instead considering health as a shared goal across multiple disciplinary fields (Cummins et al., 2007). A much-discussed and debated concept in the literature, *spatial justice* in this context refers to the equitable distribution of resources and opportunities across different territories. Spatial justice does not merely involve considering social justice *in* space, but rather recognizing the active role that space plays in producing both justice and injustice:

"everything that is social (justice included) is simultaneously and inherently spatial, just as everything spatial, at least with regard to the human world, is simultaneously and inherently socialized" (Soja, 2010, p. 5).

In the specific case of the relationship between territory and health, spatial justice implies that access to healthcare services, green spaces, and infrastructure that promote a better quality of life should not depend on a person's geographic location, as this creates direct injustices and indirect implications for their health. One example is the differing opportunities between rural and urban areas: while both face similar challenges, they respond differently to significant issues such as healthcare access, promoting active mobility policies, and fostering social cohesion. This concept has been explored in recent studies highlighting the role spatial inequalities play in shaping the health of rural populations (Martino et al., 2024).

The concept of *place-based health* supports the connection between people's health and the specific characteristics of the places where they live, work, and interact. This includes factors such as air quality, access to healthy food, neighborhood safety, and the availability of spaces for physical activity. Inequalities in these environmental factors can lead to significant health disparities across different communities. For example, low-income populations often live in areas with less access to health-promoting resources, contributing to poorer health outcomes (Diez Roux, 2016; Boyd et al., 2023).

Another key concept guiding this research is *environmental vulnerability*. This refers to the capacity of territories to suffer harm due to exposure to various types of stress, including environmental and social changes, and conversely, to their lack of capacity to adapt to such changes. This vulnerability is often the result of political decisions and urban planning that fail to consider the needs of territories and their populations, especially the most vulnerable ones. Geographic studies have shown how such decisions contribute to significant disparities in health across different geographic areas (Anderson et al., 2025).

The organization of urban space, the distribution of services, the quality of infrastructure, and the presence of green areas are not neutral elements, but rather determinants of physical and mental health—particularly for older adults (Xu et al., 2023). Cities do not merely host the elderly; they shape their life experiences, either amplifying or mitigating risks. To promote a better quality of life during aging, it is essential to integrate health and psychological dimensions with spatial and environmental ones.

This idea is supported not only by territorial studies but also by the evolving definition of health itself. Since its founding in 1948, the WHO has defined health as "a state of complete physical, mental and social well-being

and not merely the absence of disease or infirmity." This individual-centered definition has given way to the concept of health as *Global Health*, placing strong emphasis on inequalities. The AIDS epidemic in the 1980s highlighted how human health is closely linked to environmental, social, and cultural factors. Since the 2000s, the concept of *One Health* has entered the public health discourse, connecting human health with that of animals and the planet. In recent years, particularly due to the effects of the Anthropocene, a paradigm shift has become necessary to counter a socio-economic system that neglects human, environmental, and planetary well-being—while generating socioeconomic and health inequalities—through the *Planetary Health* approach.

It is also useful to clarify the notion of *health determinants*, particularly within public health: these are elements that, directly or indirectly, significantly impact quality of life and include everything that can contribute to improving or worsening individual health conditions. A highly illustrative and well-known framework (figure 1) was published in 1991 by Dahlgren and Whitehead, which describes the role of social determinants of health, highlighting their cascading influence from general socioeconomic, cultural, and environmental conditions down to the individual, through various layers that also include the urban environment (Capolongo and D'Alessandro, 2017).

Figure 1: the role of social determinants of health. Dahlgren and Whitehead, 1991 (as cited in Dahlgren and Whitehead, 2021)

The work is based on the premise that urban green spaces must be easily accessible to all population groups and equitably distributed throughout the city. The links between urban greenery and health have been demonstrated by numerous scientific publications and reports (Kondo et al., 2018; WHO Regional Office for Europe, 2016). This contribution aims to present an analysis of the distribution and accessibility of urban green spaces in six medium-sized Italian cities, which serve as case studies for the research. This mapping enables reflections on the spatial configuration of urban greenery and its ease of access. It is considered that this aspect should be seen as a priority when addressing the issue of nature in urban contexts and its impact on human health. In particular, these areas are an essential component of outdoor public spaces and services, providing an ideal setting for the equitable and just promotion of health for all members of the community.

Methodology

The methodological approach is divided into three phases. Firstly, the Normalised Difference Vegetation Index is calculated. This index is based on the analysis of satellite images and provides an overview of the greenery within the municipality. In the next stage of the process, the Pro Capita Green Space is calculated, which highlights the surface of green space per inhabitant. Finally, the estimation of real accessibility is provided, indicating the

walking distance to urban green areas.

The Normalised Difference Vegetation Index (NDVI) is an index that facilitates the identification of vegetated areas through the utilisation of multispectral remote sensing images. In this analysis, the images are derived from ESA's Sentinel-2 satellites. Sentinel-2 satellites boast a temporal resolution of five days and are equipped with the MSI (MultiSpectral Instrument). This instrument is capable of acquiring four bands in the visible and near-infrared with a spatial resolution of 10 metres, six bands in the infrared with a spatial resolution of 20 metres, and three bands with a resolution of 60 metres. Two bands (band 4 and band 8) with 10 metres of geometric resolution are utilised in the calculation of the NDVI. The index is derived from the ratio between the difference and the sum of the radiation reflected in the near infrared and red, as outlined in the following formula:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

The index has a range of values from -1 to 1: negative values are typically indicative of anthropogenic areas or water, while positive values are indicative of areas with vegetation. The raw images, collected during the period spanning from January to December 2023, have undergone a process of correction to compensate for the presence of clouds or snow. Subsequent to this preliminary processing, the formula for calculating the NDVI is applied to each pixel of each raster image. The final processing of the data is a composite image with aggregated average values.

The NDVI index can be utilised as a foundational metric in the calculation of another indicator, which is instrumental in ascertaining citizens' exposure to green space and acquiring data pertaining to the spatial organisation of the case studies. The index in question is the Pro Capita Green Space (PCGS) index (Aryal et al., 2022), which quantifies the amount of green space (in m2) available per inhabitant. The designated case study areas were subdivided into a hexagonal grid measuring 60 metres. The formula is as follows:

$$PCGSi = \frac{Gi}{PNi}$$

- is the total area of green spaces (m2) in in zone
- is The total population of zone

The number of inhabitants was estimated based on data from the 2021 ISTAT Permanent Population Census. For each hexagon, the resident population was calculated using geoprocessing and proportions.

The initial two index encompass all green areas within municipal boundaries, incorporating agricultural areas, parks, and woodlands, among others. In order to investigate the relationship between population and green areas from the point of view of accessibility, only urban parks were selected in this last phase of the methodology. The methodology for deriving Real Accessibility (RA) catchment areas involves the integration of morphological data with road networks, barriers and population data, and the association of different travel costs depending on the characteristics of the area (Romo et al., 2022). The scenario modelling is based on a maximum distance from green areas of 15 minutes walking (Moreno et al., 2021). Speeds were diversified according to the characteristics of the terrain, starting from a speed considered average, which is strongly influenced by factors such as age, physical condition, etc. (Giuliani et al., 2021). The speeds set are as follows:

• 5 km/h on roads/pavements without obstacles;
• 4 km/h on rural paths and built-up areas where there may be obstacles;
• 2 km/h in rural areas outside and away from roads.
The methodology calculates the distance of 15 minutes, at the speeds indicated above, from the centroid of the

green area. The decision to utilise the centroid was necessitated by the lack of data concerning actual access to the selected urban parks (Giuliani et al., 2021). The following data were utilised in the calculation:

- The centroid of urban parks.
- The 10x10 m Digital Terrain Model (DTM) produced as part of the INGV's TINITALY project (Tarquini et al., 2023).
- The build-up areas obtained from the Lazio Region Land Use Map (2012) and the Tuscany Land Use and Land Cover Map (2019).
- The road network, extracted from the OpenStreetMap (OSM) database.
- The elements that act as barriers to pedestrian movement: motorways, railway lines, lakes and the hydrographic network.
- The census sections of the ISTAT Permanent Population Census of 2021.

The processing was conducted utilising the open-source software GRASS GIS, with particular reference to the r.cost module (Sacchelli et al., 2013; Becker et al., 2017; Cadez et al., 2023). The module facilitates the calculation of cumulative travel costs on the pixel matrix, with the calculation initiated from the centroids and a threshold time of 15 minutes. The matrix calculation is based on an anisotropic friction map that combines morphological data and barriers. The barriers element indicates the designated pedestrian thoroughfares, while the first element modifies walking speed according to gradients (Tobler, 1993). Consequently, the maximum velocity is attainable on level terrain and declines exponentially as the gradient rises, with a threshold limit of 30°. Beyond this limit, crossing is prohibited. The result of the r.cost module is a map with accumulation times commencing from the centroids of the nearest urban parks, as well as a map of the accessibility basins identified for each urban park. The accessibility basins model can be utilised to identify the population residing within a 15-minute radius of green areas.

Case studies

The municipalities of Arezzo, Siena, Grosseto, Latina, Viterbo, and Rieti, located across Tuscany and Lazio, were selected for this research due to their classification as medium-sized cities. Italy is predominantly composed of such cities, which often exhibit complex territorial dynamics while having limited tools to address them. These six cities offer a diverse mosaic of demographic, environmental, and cultural characteristics, with significant differences shaped by geography, history, and economic orientation.

Arezzo, with approximately 99,000 inhabitants, lies in eastern Tuscany, nestled among green hills and along the Arno River. Its historic center is rich in medieval and Renaissance heritage, and the municipal territory features a balance between woodland, agricultural, and urbanized areas. Tourism maintains a steady presence throughout the year, driven by historic events such as the *Giostra del Saracino*.

Siena has around 53,700 residents in its urban core, with a greater metropolitan area exceeding 98,000 inhabitants. It is renowned worldwide for its perfectly preserved medieval historic center, recognized as a UNESCO World Heritage Site. The territory, hilly and relatively small (118 km²), also includes valuable rural and wine-producing areas. Tourism, strongly tied to the *Palio di Siena* and its university tradition, is a key component of the local economy.

Grosseto, home to about 82,000 people, is located on the Tyrrhenian Sea and lies within the Tuscan Maremma region. Its historic center, enclosed by 16th-century hexagonal walls, is entirely pedestrianized. The territory is characterized by a significant presence of protected areas, including the Maremma Natural Park, which features beaches, Mediterranean scrubland, wetlands, and wildlife habitats. Tourism is closely linked to these natural features.

Latina, with approximately 116,000 residents, is a relatively young city, founded in 1932 during the reclamation of the Pontine Marshes. The municipality spans a vast flat and agricultural area, which also includes part of the Circeo National Park, featuring valuable environments such as Lake Fogliano and coastal dunes. Tourism is

growing and focuses on beach destinations (like Capoportiere and Foce Verde), as well as nature-based and food and wine experiences.

Viterbo, with a population of around 67,000, is located in the historical region of Tuscia. Its historic center is one of the largest and best-preserved in Lazio, rich in medieval palaces and Etruscan remains. The surrounding hilly and forested territory includes thermal areas and nature reserves. Tourism is strongly influenced by the *Macchina di Santa Rosa*, a spectacular religious tradition, as well as the thermal baths and wellness-related routes.

Rieti, finally, with about 47,700 inhabitants, is set in the Rieti Plain at the foot of Mount Terminillo. The municipal territory offers a remarkable environmental variety, including mountains, hills, lakes, and nature reserves such as those of the Lungo and Ripasottile Lakes. The *Cammino di Francesco* (Path of Saint Francis), which passes through the so-called Holy Valley, is also of great importance. Tourism is focused on wellness, spirituality, and outdoor activities, particularly hiking and winter sports.

Data analysis and discussion

The NDVI map of Arezzo (figure 2) reveals a landscape predominantly characterised by a high presence of green, particularly in the areas surrounding the primary urban centre. The presence of dark green shades, which are indicative of very healthy and dense vegetation, is pervasive in the areas outside the central built-up area. The green infrastructure is characterised by large continuous blocks of high NDVI surrounding the city, including forests and large agricultural fields. Within the primary urbanised area, the presence of greenery is considerably lower, a reflection of the density of buildings and impervious surfaces. However, there are some linear green areas that penetrate the urban fabric. The primary urbanised area exhibits a distinct and irregular pattern characterised by low NDVI values, suggesting a high concentration of human activity.

The NDVI map for Grosseto (figure 2) reveals a landscape predominantly characterised by moderate to high green in its surroundings, which is indicative of substantial agricultural activity. The chromatic variations in green that characterise the peripheral regions of urban areas tend to exhibit a paler intensity when compared to the verdant shades typically associated with dense forest ecosystems. This phenomenon is particularly evident in the expansive cultivated fields that are commonly present in these peripheral regions. The green infrastructure in the surrounding areas is characterised by a high degree of structuring, exhibiting clear rectangular patterns that are indicative of substantial agricultural plots. Within the confines of the primary urbanised area, the NDVI values are low, creating a pronounced contrast with the rural environment. The transition from urbanised areas to agricultural land is clear. The primary urban centre exhibits minimal green values.

The NDVI map for Latina (figure 2) reveals a landscape predominantly characterised by moderate and widespread greenery in non-urbanised areas, primarily attributable to substantial agricultural activity. The chromatic variations in green exhibited a high degree of uniformity across the expansive rural regions. The green infrastructure in the surrounding areas is characterised by a distinct grid pattern, indicative of highly organised agricultural fields. The urbanised area itself is more extensive and less densely populated than other cities, with a presence of lighter green areas within the urban boundaries. This suggests a more integrated approach to green spaces in residential or public areas. The primary urban zone is distinguished by its low NDVI values. However, the irregular and fragmented nature of its outer boundary, characterised by numerous smaller pockets of low NDVI extending outwards into the rural landscape, suggests a fragmented urban development pattern rather than a single, compact core. The widespread and geometrically organised agricultural patterns in the surrounding areas are a distinctive feature. The presence of lighter green areas interspersed within the urban fabric could imply a design that incorporates more internal green elements than older, more compact cities.

The NDVI map of Rieti (figure 2) demonstrates the city's deep embedding within a lush, topographically complex landscape. Outside the urban boundaries, the predominant colouration is dark green, indicative of elevated NDVI values and dense natural vegetation. The green infrastructure is characterised by extensive, contiguous expanses of forest. Urbanised areas are smaller and more irregular in shape, conforming to the contours of the terrain and

often appearing to be nestled between these large green masses. The built-up areas of the city demonstrate a low NDVI. However, the influence of the rugged morphology is evident, with green areas interspersed with or immediately adjacent to urban areas. The urban footprint is fragmented due to the topography of the surrounding area, which is mountainous and densely vegetated. The pronounced visual contrast between the compact urban settlements and the expansive dark green natural environment is a salient feature. This underscores a context in which the challenge may reside in optimising access to the abundant natural greenery that surrounds the city, whilst concomitantly integrating small accessible green areas within the confines of the urban footprint.

The NDVI map of Siena (figure 2) reveals a city situated within a landscape of considerable diversity, marked by a combination of dense natural vegetation and intensive agricultural activity. The topographical map is characterised by an alternation of dark green areas, indicative of forests, and light green areas representing cultivated land. The green infrastructure encompassing Siena is characterised by an intricate network of wooded areas and agricultural fields, which reflect the undulating topography of the region. The overall vegetation is high in density but heterogeneous in its distribution. The primary urban nucleus is highly distinctive, exhibiting a dense and compact historic core with minimal vegetative cover. The urban profile of Siena is characterised by its irregular and organic nature, with strips of lower vegetation extending outwards into the landscape. This morphology is indicative of development that is closely linked to the natural territory. The transition from high urban density to varied green spaces is evident in the immediate outskirts of the city. The map provides a clear visual representation of the historical compactness of Siena's urban core, where the NDVI highlights a minimal presence of internal greenery.

The NDVI map for Viterbo (figure 2) reveals a landscape that combines the moderate green of agricultural fields with areas of vegetation exhibiting a higher NDVI index. The chromatic variations in green are notable, with a predominance of lighter hues when compared to the darker tones characteristic of densely wooded areas. The green infrastructure in the wider area around Viterbo consists of a combination of defined agricultural plots and darker, less structured patches of green. The primary urbanised area exhibits a low NDVI index, which is characteristic of an urban centre. The presence of several distinct, smaller pockets with low NDVI indices has been identified in the surrounding area, indicative of satellite developments or specific land uses.

Two dominant landscapes can be identified around the case study cities. The municipalities of Arezzo, Rieti and Siena are characterised by a landscape dominated by natural greenery, featuring extensive forests and undulating hills covered with vegetation. The urban form of Rieti and Siena is significantly influenced by the topography of the area, with cities often developed along or within natural green spaces. Arezzo also benefits from a rural fringe rich in vegetation, although its immediate urban surroundings show agricultural patterns rather than dense forests. In contrast, Grosseto, Latina and Viterbo are situated in the plains, which are characterised by their flatter topography and intensive cultivation. The surrounding area is characterised by extensive greenery, predominantly comprising agricultural fields.

There is a correlation between the urban topography and the NDVI index. Arezzo, Grosseto and Siena exhibit a markedly distinct central urban core, characterised by a consistently low surface permeability index (NDVI), indicative of a high concentration of impervious surfaces. This phenomenon is especially evident in Siena, a city with a historically dense and compact urban structure. Despite the presence of green belts in these cities, a paucity of green space within the urban centre is evident. The city of Latina is distinguished by its diffuse urban form and the presence of clearly delineated green areas that appear to be more interspersed within its urban boundaries. This finding indicates a shift towards a more modern approach to urban planning, one that incorporates a greater proportion of green spaces within residential areas.

As previously mentioned, the PCGS (figure 3) is particularly useful for analyzing the spatial distribution of urban greenery, supporting territorial planning, and assessing environmental equity among urban areas. The map presented here applies a similar method for calculating the PCGS, translating NDVI values into a pro capita measure of actual green cover over land and population, in support of ecological and urban planning analyses

at the local scale.

The three maps offer a comparative overview of the distribution of urban green space per capita (PCGS) in the municipalities of Siena, Arezzo, and Grosseto, highlighting both territorial similarities and differences in the per capita availability of green areas.

Siena displays a fairly uniform distribution of green space per capita, with a wide presence of low-density areas (light-colored hexagons) that maintain a decent amount of greenery. However, the urban center appears to have less green space per capita, likely reflecting the demographic concentration in the historic core and the compactness of the medieval urban fabric. Peripheral and hilly zones offer more abundant green space per person but are not always densely populated.

Arezzo, in contrast, presents a more uneven pattern. Areas with a high per capita green space (dark purple tones) emerge in scattered and peripheral locations, while many central areas show medium or low values. The broader and more mixed territorial morphology—urban, agricultural, and hilly—seems to influence the PCGS distribution more significantly, highlighting a certain fragmentation in green space access.

Grosseto stands out for a wider presence of dark-colored hexagons, indicating high green space availability per capita across many areas, especially along the coast and in the southwestern periphery. This is likely linked to low settlement density and the significant presence of natural and protected areas, such as the Maremma Regional Park. However, there are also hexagons with no coloration (indicating no population), revealing vast uninhabited green zones.

In comparative terms:

• Grosseto appears to have the highest per capita green space, due to its large area and low population density in many sectors;
• Siena is more balanced overall but penalized in its central areas by the density of its historic urban structure;
• Arezzo shows greater spatial heterogeneity, reflecting a more fragmented distribution of greenery in relation to population.

In summary, PCGS proves to be an effective tool for capturing spatial inequalities in urban green space provision. The maps reveal how population density, historical urban layout, and the presence of natural areas significantly affect the availability of accessible green space per inhabitant—insights that are highly relevant for urban planning and environmental equity.

As for the cities in Lazio, Viterbo shows a fairly balanced distribution of per capita green space, with numerous dark green hexagons spread across almost the entire territory. This indicates a good availability of green areas per inhabitant, even near the urban center. Both central and peripheral areas display relatively homogeneous levels, suggesting a moderate population density and a significant presence of natural or agricultural spaces. White hexagons, indicating areas with no population, are present but not predominant.

Rieti is characterized by a more fragmented distribution. While some peripheral areas show a high availability of green space, certain central hexagons lack color, pointing to large uninhabited or very sparsely populated zones. Compared to Viterbo, per capita green space is often high but less evenly distributed and more concentrated in specific areas.

Latina presents a more uneven situation, with less green space per capita. A wide presence of light green hexagons suggests lower availability of green areas for inhabitants in many parts of the city. White areas are also relatively widespread, indicating uninhabited zones. Coastal and southern areas appear to be slightly better equipped with green space per capita, possibly due to the presence of natural or agricultural areas. However,

overall, the map shows a lower level of green space compared to Viterbo and Rieti, likely linked to higher urban density or urban planning less focused on green infrastructure.

In conclusion, Viterbo emerges as the area with the best per capita green space, thanks to a more consistent distribution and a good balance between population and green areas. Rieti stands out for its abundant but scattered green spaces, with many uninhabited areas reducing the average impact on the resident population. Latina appears to be the most disadvantaged in terms of PCGS, with a more irregular distribution and generally lower levels of green space per inhabitant.

The Real Accessibility (figure 4) analysis yielded the results presented in Table 1, particularly in the final two rows. A significant proportion of the population in all six cities resides within a 15-minute walking distance of an urban park. Grosseto and Siena demonstrate the highest percentages, at 86% and 84%, respectively, with Arezzo and Viterbo following closely behind at 80%. Latina has the lowest coverage, at 75%, although this still represents a substantial three quarters of its population. Especially in the case of Latina and considering the NDVI results indicating a more spread-out urban layout, it is possible that urban parks are less evenly distributed within the city. The average travel time to reach the nearest urban park is low in all cities, ranging from 8 minutes and 55 seconds (Siena) to 11 minutes and 21 seconds (Viterbo). This finding serves to substantiate the hypothesis that access is efficient for the population within the 15-minute catchment area. Despite its complex topography, as highlighted in the NDVI analysis, Siena shows the fastest average travel time. This finding suggests the hypothesis that the city's urban parks are strategically or historically well integrated into its dense urban core. Viterbo has the longest average travel time, which may be influenced by the greater dispersion of urban parks compared to population centres, as indicated by the substantial non-vegetated area observed in its NDVI map. There is a considerable degree of variability in the absolute number of urban parks, ranging from 41 in Viterbo to 155 in Latina. The average size of these parks is subject to variation. Grosseto has the largest average park size (8,685 m^2), while Siena and Rieti have the smallest average sizes (4,618 m^2 and 4,708 m^2 respectively). A comparison of the number of parks and population coverage reveals certain observations. Latina has the highest number of green areas (155), but the lowest population coverage (75%). This finding suggests that, despite the presence of numerous parks, their distribution or individual size may not be optimally aligned to serve the city's population in an efficient manner. Siena has a modest number of parks (99) with the smallest average size, but achieves excellent demographic coverage and the fastest average travel time. This suggests that the organisation of its parks is highly effective. Grosseto demonstrates a high level of coverage (86%) with an average number of parks (99), yet the largest average size. This suggests a reduced number of parks, but larger ones that are well positioned to serve a significant portion of the population.

Table 1: Real Accessibility data for the six cities

	Arezzo	Grosseto	Latina	Rieti	Siena	Viterbo
Population (total)	96.527	81.412	127.732	45.169	52.991	66.365
Surface (km^2)	385	474	278	206	119	406
n° of green areas	143	99	155	55	99	41
Average surface green areas (m^2)	7.165	8.685	5.421	4.708	4.618	8.186
Population (15 min)	77.206 80%	69.719 86%	96.225 75%	37.794 84%	45.542 86%	52.895 80%
Average time (min)	10' 20''	9' 26''	9' 01''	10' 05''	8' 55''	11' 21''

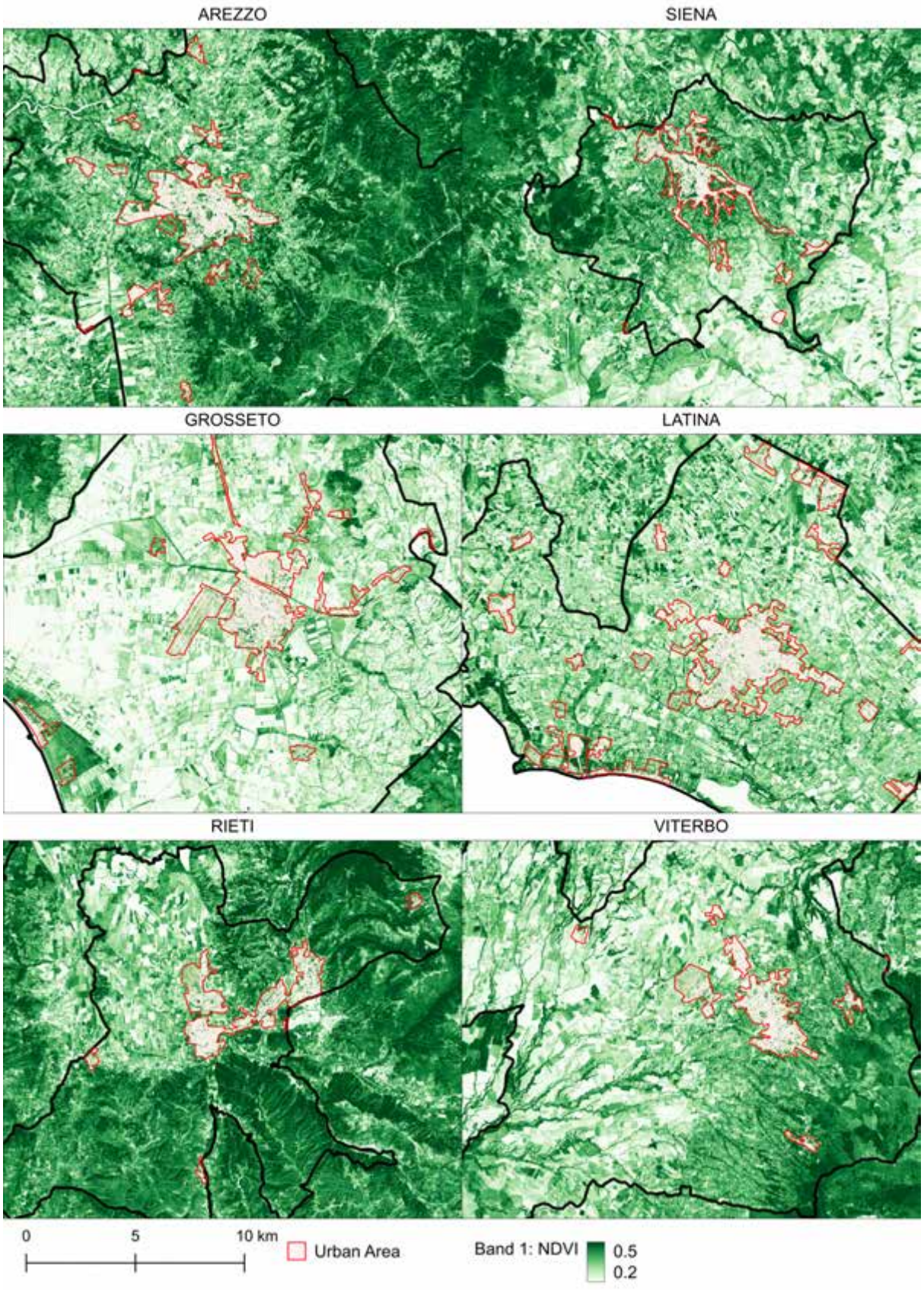

Figure 2: NDVI maps for the six cities

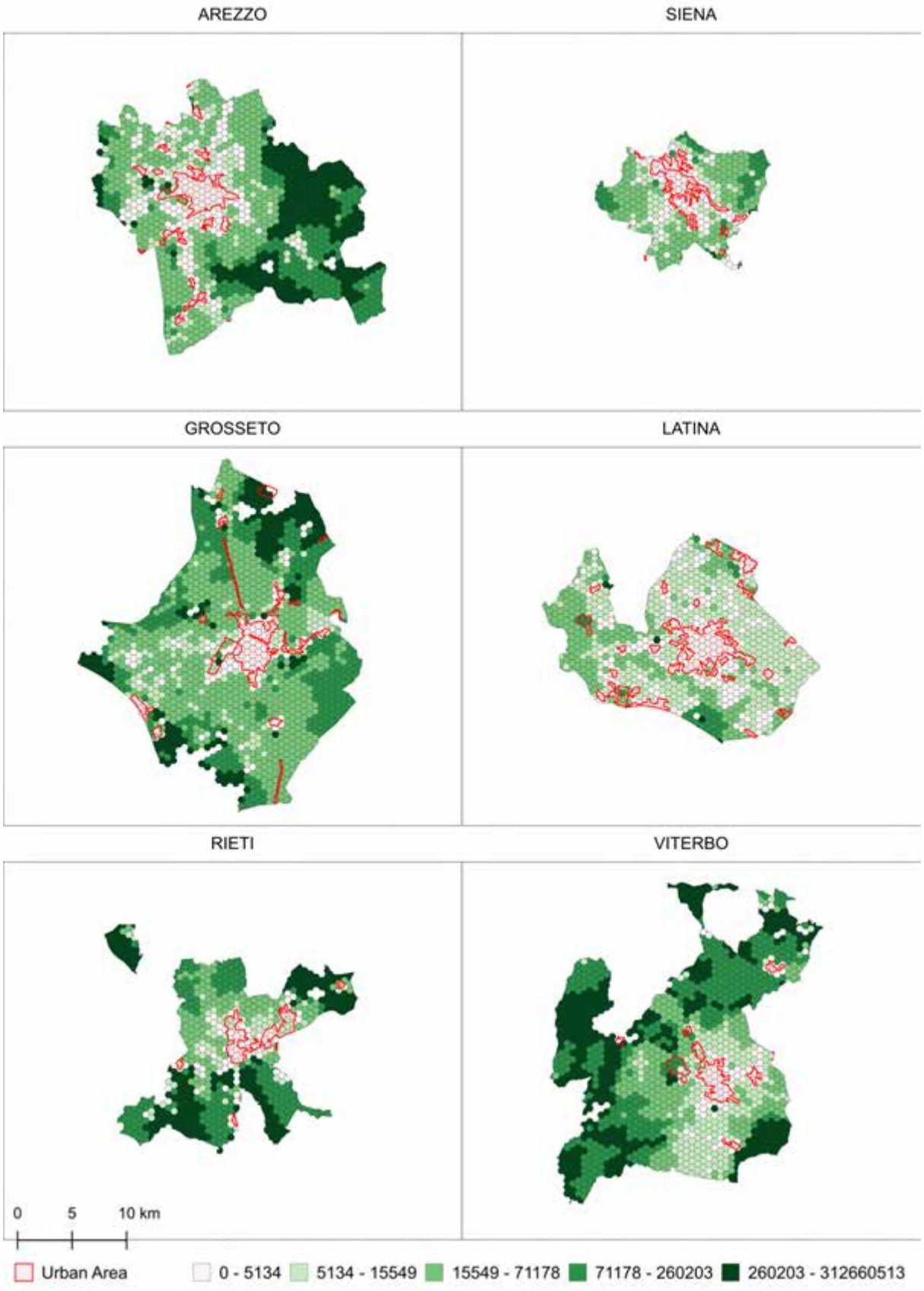

Figure 3: PCGS maps for the six cities

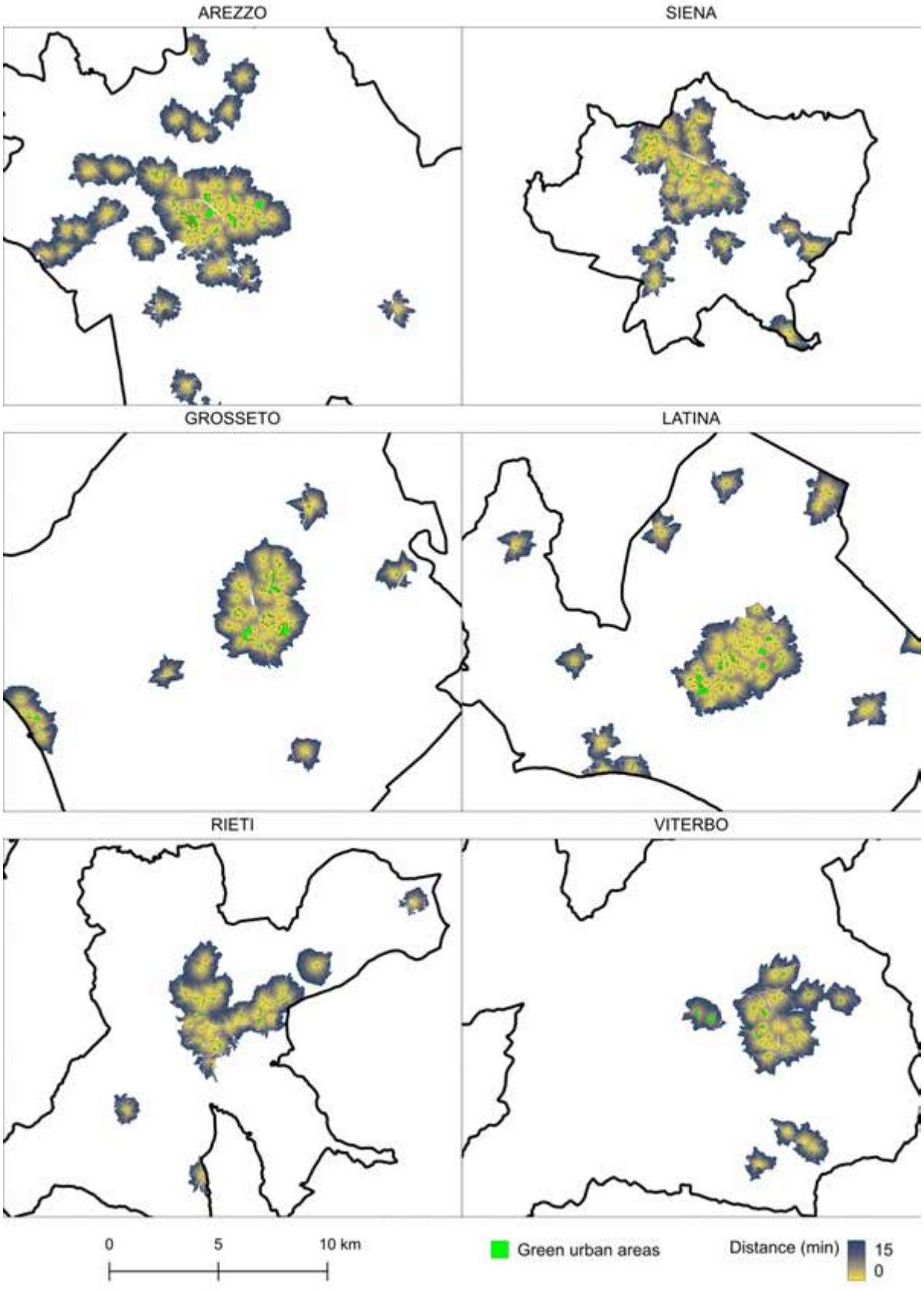

Figure 4: Real Accessibility maps for the six cities

Conclusion

The study outlines a methodology for evaluating the distribution and accessibility of urban green spaces in medium-sized Italian cities, highlighting their importance for public health and urban planning. Recognising that health is linked to environmental, social and cultural factors, the study adopts a broader approach that embraces concepts such as spatial justice, place-related health and environmental vulnerability, moving beyond a clinical perspective. The growing trend of global urbanisation necessitates a thorough investigation into how urban planning and the provision of green infrastructure can enhance citizens' health.

The methodology includes calculating NDVI, green space per capita (PCGS) and real accessibility estimates to provide information on the spatial configuration and ease of access to urban green spaces in the six cities studied: Arezzo, Siena, Grosseto, Latina, Viterbo and Rieti. NDVI analysis revealed distinct patterns influenced by topography and historical urban development. Cities such as Arezzo, Rieti and Siena are immersed in naturally green landscapes, while Grosseto, Latina and Viterbo are characterised by flatter, predominantly agricultural environments. A correlation was observed between urban topography and NDVI, with densely populated historic centres presenting low green cover. This underlines the need for more integrated green spaces within central urban areas.

The PCGS analysis also revealed disparities in the distribution of green spaces. Grosseto, with its low population density and large protected areas, had the highest amount of green space per capita. Despite its densely populated historic centre, Siena showed a more balanced distribution, although it was penalised in the central areas. Latina, in contrast, appeared to be the most disadvantaged in terms of PCGS, suggesting a lack of integration of green infrastructure in urban planning. Analysis of actual accessibility indicates that a substantial proportion of the population in all six cities has access to urban parks within a 15-minute walk. Despite its complex topography, Siena recorded the shortest average travel time to parks, suggesting effective strategic positioning. Although Latina has the highest number of parks, its lower coverage in terms of population indicates that quantity does not equate to optimal accessibility, suggesting issues with the distribution or size of individual parks. Grosseto, with its larger average park sizes and high coverage, demonstrated an effective balance between park size and strategic positioning.

In conclusion, this research reinforces the idea that urban green spaces are important for physical and mental health, especially for vulnerable groups. The methodologies employed provide policymakers and urban planners with tools to assess existing green infrastructure and inform future development strategies. Understanding the nuances of green space distribution and accessibility in different urban contexts enables cities to progress towards a more equitable and health-friendly environment, in line with the evolving concept of health as a common goal influenced by environmental and social factors. Future research could build on these methodologies by incorporating socio-demographic data at a more detailed level, enabling the identification of specific populations with limited access to green spaces and the development of more targeted interventions.

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Fostering Multicultural Integration in Transforming Context: Community Participatory Museum as a Bridge

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Abstract
To explore how the physical environment, community programs, and Individual Characteristics influence cultural adaptation among Korean immigrants in a transforming district of Qingdao, China. Using a mixed-methods approach combining PLS-SEM modeling and interviews, the research identifies intercultural interaction as a key mediating factor linking space and adaptation. While environmental and programmatic improvements enhance place-based belonging, meaningful integration relies on active engagement across cultural boundaries. To support this, the study proposes the Community Participatory Museum (CPM)—an embedded, co-created public space where residents collaboratively share stories and express cultural identities. This research contributes to urban planning and migration studies by revealing how spatial-social mechanisms can foster intercultural understanding and adaptive inclusion in multicultural communities.

Keywords: Cultural Adaptation; Cross-cultural Communication; Community Participatory Museum; Public Space Design; Community Participation

Introduction

In the context of globalization, the issue of community integration among cross-cultural immigrant groups has attracted growing scholarly and policy attention.An increasing number of foreigners are living, studying, and working in Chinese cities, and their levels of adaptation in language, culture, and social life directly influence the harmonious development of multicultural communities(Li, 2022)(Lo et al., 2005).Qingdao, a coastal city with frequent China–South Korea exchanges, provides a compelling case. Since the establishment of diplomatic relations between China and South Korea in 1992, a substantial influx of South Korean individuals and enterprises has formed distinctive economic and community networks characterized by Korean cultural features(Zhou & Tang, 2023).

For a long time, Korean enclaves in Qingdao have largely exhibited a pattern of “parallel adaptation,” in which immigrant communities are physically embedded in the urban fabric but remain socially and culturally isolated from local society. Daily life among Korean residents is often centered around ethnically bounded commercial systems and language environments, resulting in limited contact with local Chinese residents and restricted cultural identification and emotional attachment(Zhou & Tang, 2023).While this model initially facilitated cultural continuity and living convenience, it also hindered intercultural contact, contributing to misunderstandings and latent tensions.

The 2008 global financial crisis marked a turning point. With the withdrawal of some Korean enterprises and the restructuring of local labor markets, many Chinese residents experienced economic disconnection from the Korean community, which intensified social discontent and ethnic divisions (Fan, 2009). As labor and land costs in Qingdao continued to rise, further business relocations led to a gradual contraction of the Korean population. These changes imposed mounting transformation pressures on the community’s function, population composition, and spatial structure (Sun, 2009).

Under these circumstances, the parallel adaptation model has become increasingly untenable, prompting some Korean residents to undergo “passive integration” and even take the initiative to learn Chinese and participate in local affairs.(Jang, 2012) At the same time, the spatial characteristics of Korean enclaves have evolved into a “hybrid of ethnic commerce, aging residential buildings, and weakly connected neighborhoods.” Public activity spaces in these communities are typically confined to narrow sidewalks, scattered stone tables and benches, or small open areas in front of shops—spaces that lack greenery and fail to support the everyday, spontaneous interactions needed for intercultural engagement. Consequently, they fall short of realizing the community

cohesion and cultural integration potential embedded in public space(Chen and Fang, 2024) .

Amid ongoing urban renewal and growing calls for multicultural inclusion, it remains an open question whether spatial interventions can serve as effective bridges for cultural adaptation.

This study aims to address the following key questions:

To what extent do the physical environment and activity arrangements of community public spaces influence South Korean residents' cultural adaptation to local society?

Does intercultural interaction mediate the relationship between spatial conditions and cultural adaptation?

How can spatial design and planning strategies be leveraged to improve community interaction structures and foster deeper cultural integration between ethnic groups?

1. Literature Review

1.1 Internationalised Communities

Internationalised communities refer to neighbourhoods formed by people from various countries and regions, characterised by multicultural backgrounds and a relative degree of autonomy. They represent micro-units of urban internationalisation and serve as indicators of a city's globalisation level(Völker et al., 2007). With the deepening of China's reform and opening-up and the continuous advancement of urban internationalisation, an increasing number of foreigners have relocated to Chinese cities in recent years, forming distinctive internationalised communities (Lv and Guo, 2019).

However, internationalised communities in China are currently confronted with a range of governance challenges. As Zhao and Qi (n.d.) observe, the degree of participation by foreign residents in local governance remains limited. Moreover, Wang (2011) points out that the shortage of community staff with cross-cultural communication skills, alongside the scarcity of multicultural integration programmes, further exacerbates difficulties in fostering inclusive community environments.

A defining feature of internationalised communities is the achievement of harmony between local and foreign cultures, rather than merely focusing on the number of foreign residents(Chua, 2013) It is essential to respect community differences and foster competitiveness and cohesion by revitalising existing resources and enhancing new elements (Wang and Yang, n.d.).

1.2 Cultural Adaptation

The concept of cultural adaptation, as originally proposed by Robert Redfield and colleagues in 1936, refers to the process through which individuals or groups from different cultural backgrounds undergo changes in their cultural patterns due to sustained and direct intercultural contact and interaction, with reciprocal influence on both sides involved(Redfield et al., 1936). While numerous migration theories—such as the neoclassical theory, the new economics of labour migration, and the world systems theory—have focused on the economic determinants of migration, they often neglect political, cultural, and social dimensions. However, the cultural adaptation trajectories of migrant groups vary significantly due to differences in national cultures, ethnic characteristics, and levels of socio-economic development.

Among the theoretical frameworks that have profoundly influenced the study of immigrant integration, three stand out: assimilation theory, multiculturalism, and the segmented assimilation model. Assimilation theory, argues that immigrants are expected to relinquish their original cultural identities and merge—either actively or passively—into mainstream society(Rudmin, 2003). In contrast, multiculturalism promotes cultural diversity and suggests that immigrants can retain their native cultural traits while simultaneously adapting to the host culture, highlighting the importance of social inclusiveness(Zhou and Li, n.d.) .The segmented assimilation model,

on the other hand, suggests that integration outcomes are shaped by a combination of socio-economic factors, human capital, policy frameworks, and cultural dynamics, resulting in varied modes such as active integration, passive integration, and selective integration (Junger-Tas, 2001).

Further, the bicultural identity integration theory regards cultural adaptation as a dual-dimensional interactive process involving the maintenance of one's heritage culture and the adoption of the host culture. It also emphasises that the host society's receptiveness plays a decisive role in shaping immigrants' adaptive outcomes.

Recent studies on the cultural strategies of transnational migrants have further categorized international communities into typologies such as "self-segregation," "parallel adaptation," and "active integration" (Li, 2022). Notably, "active integration" and "parallel adaptation" are not mutually exclusive; rather, they represent hybrid approaches where certain cultural boundaries are retained while integration is gradually pursued. Robust social interactions have been identified as important catalysts for cultural adaptation (Zhou and Li, n.d.).

Zhou and Tang (2023) indicate that the level of overall integration among South Koreans in China remains limited. Similarly, Sun (2009) examined the cultural adaptation processes among Koreans in Qingdao, identifying their transitional and "floating" adaptation characteristics. However, most existing studies have primarily focused on psychological and sociological mechanisms—such as language proficiency, social support networks, and identity negotiation—while paying relatively little attention to the spatial dimension of adaptation processes (Li, 2003).

Emerging research has started to incorporate public space into the analytical framework of cultural integration. Scholars argue that at the community level, spatial environments and cultural events serve not only as settings for daily life but also as platforms for social interaction, cultural expression, and consensus-building. Particularly in ethnic enclaves, the structure and attributes of community space may constitute critical triggers for fostering intercultural encounters and facilitating psychological adaptation(Binyi and Mwanza, 2014).

1.3 Community Space and Social Interaction

Community space refers to the facilities and spatial configurations designed to facilitate convenience, interaction, and shared use among residents. It embodies both materiality and a complex network of functions and organisational relations, conveying communal values through its spatial characteristics. The configuration and accessibility of such spaces are shaped by natural conditions, social needs, and levels of economic development. Simultaneously, community space is also a socially constructed entity, continually shaped by prevailing beliefs, interests, and aspirations(Theodori, 2005). In essence, community space serves as a locus where the identity of the community is spatially manifested, incorporating both physical and social dimensions.

Previous studies have demonstrated that community public spaces characterised by multifunctionality, inclusiveness, and social accessibility can effectively reduce psychological boundaries between different social groups, enhance the frequency of interpersonal encounters, and promote mutual understanding. For immigrant populations in particular, such spaces represent not only sites of everyday activity but also arenas for emotional attachment and a key pathway for cultural adaptation.

Social interaction comprises both physical and non-physical exchanges between two or more individuals(Hillery Jr., 1955). Empirical evidence indicates that the physical environment and activity programming within community spaces exert a positive influence on patterns of social interaction. By optimising spatial arrangements and offering attractive, participatory programmes, it is possible to foster more frequent and meaningful exchanges among community members (Qi et al., 2024). For instance, (Sirgy et al., 2008)observed that improved community services contribute to higher resident satisfaction.

Despite these insights, several notable gaps remain in current research. First, spatial structure and behavioural interaction are often analysed in isolation, lacking integrative cross-level theoretical frameworks. Second, community-based cultural programmes are frequently treated as informal or supplementary variables, with

limited empirical validation or quantitative modelling. Third, the mechanisms through which place-based interventions—such as participatory cultural initiatives or small-scale community installations—facilitate intercultural integration have yet to be systematically theorised.

Addressing these gaps requires a more holistic and interdisciplinary approach that links spatial design with social practice, and that treats community space not merely as a backdrop, but as an active medium through which inclusion, identity, and integration are co-produced.

2 Research Framework

2.1 Research Background and Case Selection

In response to the increasing need to understand the spatial foundations of intercultural adaptation, this study investigates the relationship between community space and cultural adaptation by focusing on a representative Korean enclave in Qingdao. Employing Partial Least Squares Structural Equation Modelling (PLS-SEM)(Fornell and Bookstein, 1982), the study systematically tests the pathways through which physical environment, community activities, and user characteristics influence intercultural interaction and patterns of cultural adaptation. A spatial integration strategy is proposed, centred on the concept of a "Community Participatory Museum" (CPM). The research aspires to extend existing theoretical models of urban cultural adaptation from a predominantly psychological perspective to a spatial one, while also offering practical guidance for cross-cultural urban governance through spatially grounded interventions.

This study selects the Xianggang Road Community in Qingdao's Shinan District as its empirical case. Administered by the Xianggang Zhonglu Subdistrict Office, the community is located in the core area of Fushan Bay and is designated in the 14th Five-Year Plan and Vision for 2035 of Shinan District as a priority zone for the development of "international-style neighbourhoods." Strategically situated, the community borders the coastline to the east, connects with Qingdao's major commercial centre to the south, and adjoins key administrative zones to the north. Notably, in 2004 the community established China's first Foreign-related Civil Mediation Committee, demonstrating its pioneering role in internationalised community governance.

The Xianggang Road Community covers an area of approximately 1.28 square kilometres, with a population of 12,570 across 4,898 households, of whom 6,500 are registered residents. The community comprises 18 residential compounds, including Panhaimingren Plaza, Luxin Changle Garden, Kaijin Garden, Minjiang Garden, and Yuanyang Garden—all of which reflect a high standard of residential development. Since the early 1990s, Qingdao has maintained robust economic and cultural exchanges with South Korea. The Xianggang Road area has gradually attracted Korean immigrants and enterprises, forming an ethnic landscape centred on Korean schools, churches, restaurants, and beauty salons. Korean residents are predominantly concentrated in the northern residential blocks, where ethnic commercial elements such as Korean restaurants, convenience stores, and salons are prominent. In contrast, the central and southern areas are characterised by a more mixed-use commercial layout with weaker ethnic features, reflecting a spatial gradient in both function and identity.

Comparative analysis of Point of Interest (POI) data from 2012 and 2023, together with field observations, reveals a clear transformation in the spatial structure of commercial areas within the community. The Korean commercial cluster, once concentrated in the northern residential zone, has been gradually displaced by large-scale mixed-use complexes such as AEON Mall and Hisense Plaza. This shift illustrates both diversification in commercial composition and a contraction of ethnic Korean economic influence. The spatial restructuring has important implications for the cultural adaptation of Korean residents: it has reduced dependency on ethnic-specific commercial infrastructures, while simultaneously increasing spatial encounters and opportunities for interaction with local Chinese residents. These evolving spatial conditions provide an empirical basis for shifts in cultural identity formation and behavioural integration.

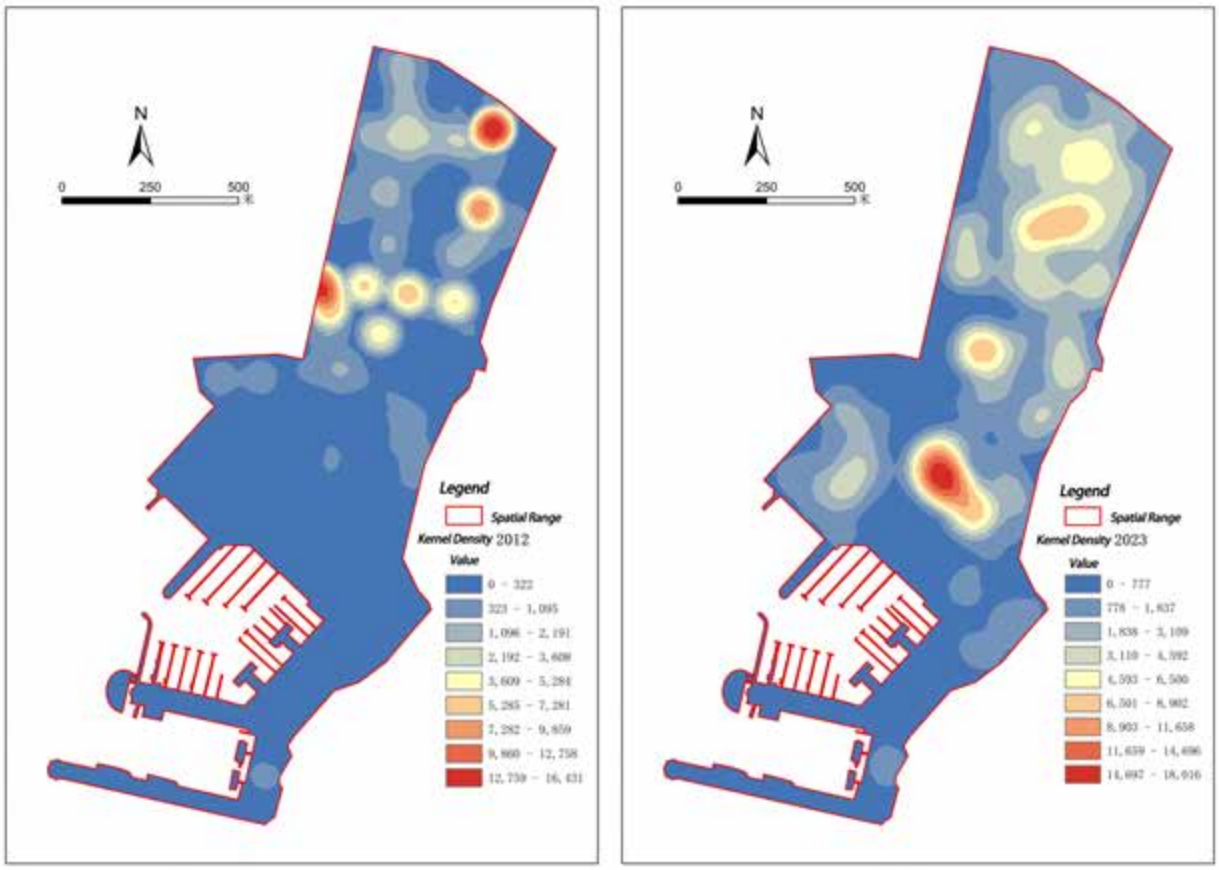

Figure 1. Comparative Kernel Density Maps of POIs in 2012 and 2023 (From Gaode Map)

Given these characteristics, the community—currently undergoing dual processes of social and spatial transformation—constitutes an ideal empirical setting for examining the dynamic interrelations between space, interaction, and adaptation. Its fragmented public space structure, multifunctional and mixed-use commercial corridors, and multiple low-threshold community nodes conducive to everyday encounters collectively render it a naturally occurring laboratory. These spatial features afford unique analytical value for investigating how multicultural integration mechanisms are shaped and negotiated in urban contexts.

2.2 Research Design and Data Collection

This study adopts a mixed-methods approach, integrating GIS spatial analysis, on-site observation, structured interviews, and questionnaire surveys to collect 55 valid samples covering South Korean, Korean-Chinese, Japanese, and Chinese residents. Drawing on existing research variables, the study employs the PLS-SEM method to statistically test the model hypotheses. Data collection was conducted from March to May 2024 and included the following three main components:

Spatial Mapping: GIS tools were used to annotate the distribution of commercial and open spaces and evaluate the accessibility and visibility of community interaction nodes.

Field Observation: Behavioral patterns and social usage in public spaces were recorded across different time periods and user groups.

Structured Questionnaire Survey: To avoid data bias, this study administered questionnaire surveys to community residents over a 12-day period from March 19 to March 30, 2024. The survey employed simple random sampling

and was conducted through both face-to-face and online methods. A five-point Likert scale (1 = strongly disagree, 5 = strongly agree) was used. A total of 55 valid questionnaires were collected, including 33 Chinese residents, 18 South Korean residents, and 2 each from North Korean and Japanese residents. The sample covered youth (18–35 years old, 34.5% of the sample), middle-aged (36–59 years old, 34.5%), and elderly groups (60 years and above, 30.9%). Additionally, statistics showed that over 40% of respondents had lived in the community for more than three years.

Hypotheses and Variables:This study examined multiple independent variables, including the physical environment, community activities, and user characteristics, with the dependent variables being cultural adaptation and cross-cultural social interaction. The selection of dependent variables was based on existing research findings. The independent variables, such as the physical environment, activity programs, and individual characteristics, were derived from relevant literature, field investigations, and interviews with space managers. The dependent variables related to cross-cultural social interaction included "frequency of cross-cultural interaction," "sense of companionship," and "degree of social relationships." Cultural adaptation factors included "cultural assimilation," "cultural integration," and "active participation." These variables were identified through an analysis of previous studies.

Table 1. Latent Constructs and Their Observed Indicators

Latent Variable	Rigorous Definition	Observed Variables (Indicators)
Physical Environment	The physical characteristics and design quality of public spaces in residential communities, including their support for social interaction, multifunctional use, and cultural inclusivity.	INT: Spatial interactivity (whether the space facilitates spontaneous interactions among residents) MULTI: Spatial multifunctionality (whether the space supports leisure, socializing, entertainment, and other functions)
Community Activities	Various public cultural and social activities organized for residents, including local festivals and cross-cultural exchange events, with a focus on frequency and interactivity.	FREQ1: Frequency of traditional festival activities (e.g., Spring Festival, Mid-Autumn Festival) FREQ2: Frequency of cross-cultural exchange activities (e.g., Sino-Korean Cultural Festival)
Individual Characteristics	Residents' participation in community spaces and activities, measured by frequency and duration, reflecting active use and engagement..	UTM: Weekly participation frequency (number of engagements per week) TRM: Duration per visit (time spent in public spaces or activities per session)
Intercultural Social Interaction	The quality of social interactions between Korean and local residents in a cross-cultural community setting, including breadth of social relationships, sense of companionship, and active engagement.	REL: Degree of social relationships (extent of connections with residents from different cultures) CMP: Sense of companionship (belonging and identification within the community) ENG: Frequency of intercultural interaction (willingness and behavior in actively engaging in exchange activities)

Latent Variable	Rigorous Definition	Observed Variables (Indicators)
Cultural Adaptation	The degree of cultural integration and sense of belonging among Korean and local residents in the Qingdao community.	CAI: Cultural assimilation (feeling of adapting to local cultural life) CBI: Cultural integration ("I can maintain my own culture while integrating into the local community") AP: Active participation ("I am willing to participate in cultural activities with local residents")

Based on theoretical review and field observations, the following structural hypotheses are proposed:
H1a: The physical environment has a positive effect on intercultural social interaction.
H1b: The physical environment has a positive effect on cultural adaptation pattern.
H2a: Community activities have a positive effect on intercultural social interaction.
H2b: Community activities have a positive effect on cultural adaptation pattern.
H3a: Individual characteristics has a positive effect on intercultural social interaction.
H3b: Individual characteristics has a positive effect on cultural adaptation pattern.
H4: Intercultural social interaction has a positive effect on cultural adaptation pattern.

Here, intercultural social interaction is set as the key mediating variable, and its mediating pathways between the physical environment, community activities, Individual characteristics, and cultural adaptation are examined.

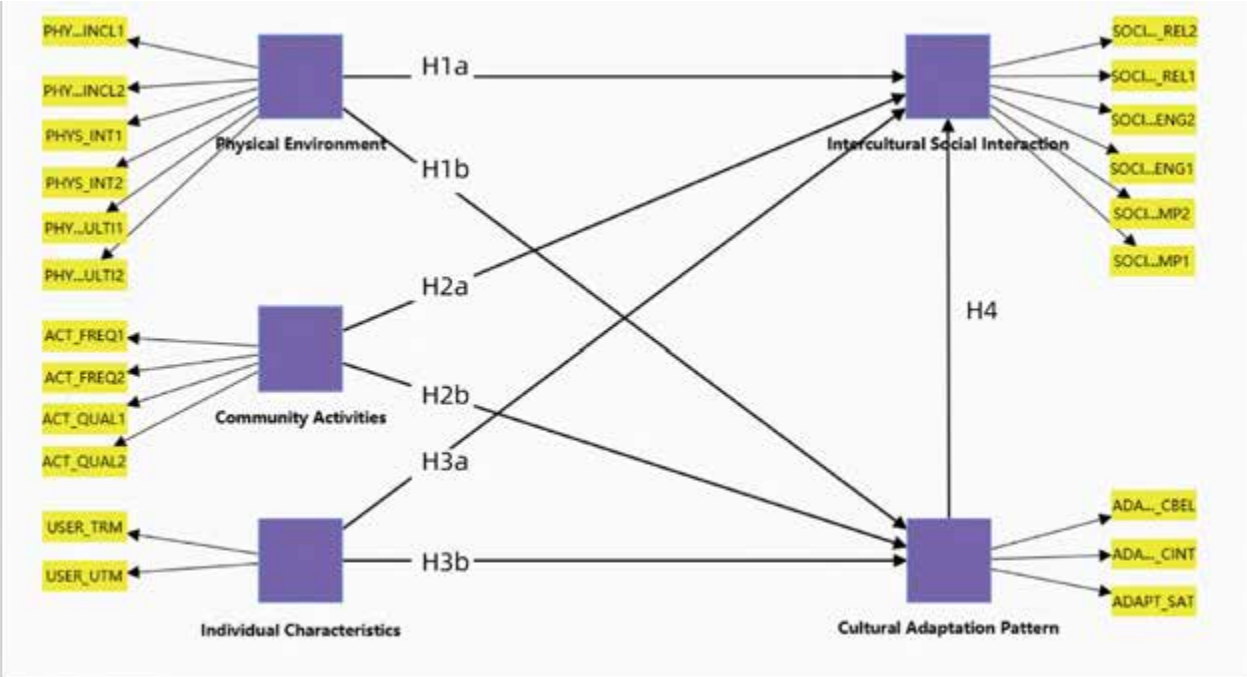

Figure 2. Structural Model of Intercultural Adaptation Pathways

2.3 Analytical Methods and Results

Following the two-step PLS-SEM analytical framework, we sequentially evaluated the measurement model and structural model, with modeling and estimation conducted using SmartPLS 4.09.

Table 2. Reliability and Validity Assessment of Latent Constructs

Latent Variable	Cronbach's Alpha	CR (Composite Reliability)	AVE (Average Variance Extracted)	HTMT (Heterotrait-Monotrait Ratio)
Physical Environment	0.829	0.875	0.591	0.682
Community Activities	0.813	0.874	0.635	0.715
Individual Characteristics	0.744	0.831	0.558	0.647
Intercultural Social Interaction	0.861	0.904	0.703	0.732
Cultural Adaptation Pattern	0.832	0.889	0.627	0.698

Prior to examining the structural paths, we first assessed the reliability and validity of the measurement model. As shown in the table, all latent variables demonstrated composite reliability (CR) values exceeding 0.83 and average variance extracted (AVE) values above 0.55, meeting the convergent validity criteria. Although one indicator loading for Individual characteristics was slightly below 0.7, the overall CR and AVE values satisfied the requirements, justifying its theoretical retention. Furthermore, all heterotrait-monotrait (HTMT) ratios were well below the 0.9 threshold, confirming satisfactory discriminant validity among constructs.

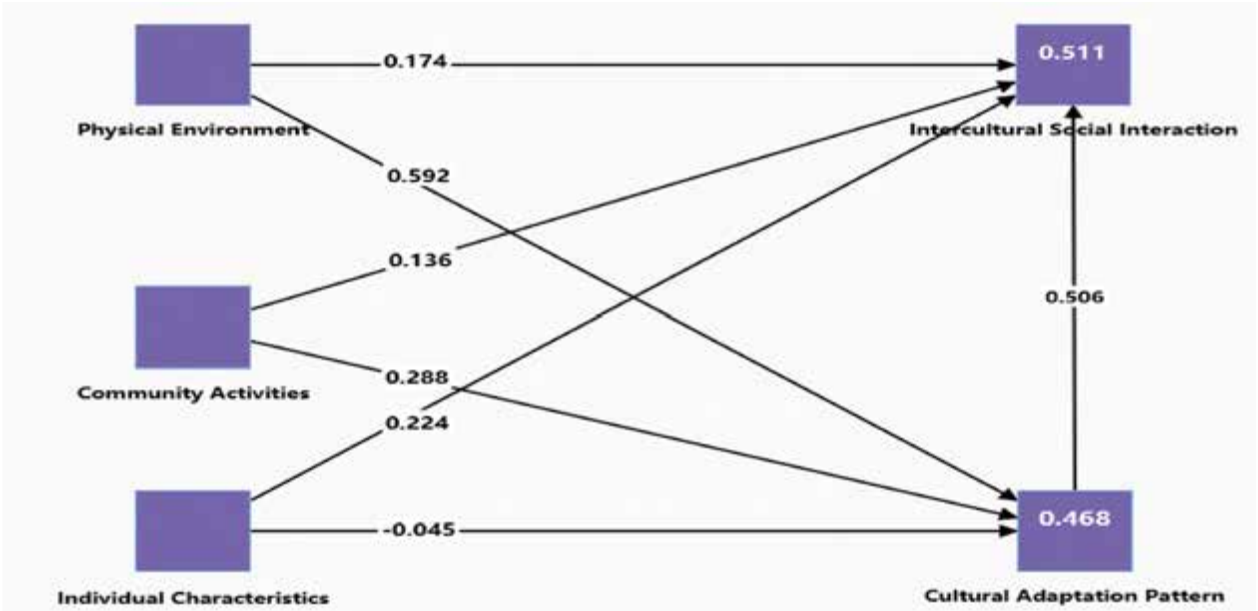

Figure 3. Path coefficient analysis of the model
($p < 0.05$, $t > 1.960$)

Table 3. Path coefficient analysis of the model

Path	Standardized Coefficient (β)	t-value	p-value	Verification
H1a: Physical Environment→ Intercultural Social Interaction	0.174	1.606	0.108	Reject
H1b: Physical Environment→ Cultural Adaptation Pattern	0.592	8.000	<0.001	Accept
H2a:Community Activities→ Intercultural Social Interaction	0.136	1.311	0.190	Reject
H2b: Community Activities→ Cultural Adaptation Pattern	0.288	3.142	0.002	Accept
H3a: Individual Characteristics→ Intercultural Social Interaction	0.224	2.182	0.029	Accept
H3b: Individual Characteristics→ Cultural Adaptation Pattern	-0.045	0.411	0.681	Reject
H4: Intercultural Social Interaction→ Cultural Adaptation Pattern	0.506	4.332	<0.001	Accept

The results indicate that the physical environment has a significant positive effect on cultural adaptation pattern ($\beta = 0.592$, $p < 0.001$) but no significant impact on intercultural social interaction ($\beta = 0.174$, $p = 0.108$). This suggests that high-quality community spatial environments can effectively enhance immigrants' local emotional attachment and life satisfaction, yet they are insufficient on their own to directly catalyze cross-cultural contact behaviors. Particularly under conditions of "parallel adaptation," the physical environment is perceived more as a structural condition ensuring convenience and safety rather than as a social medium fostering interaction.

Similarly, community activities demonstrate a significant positive effect on cultural adaptation pattern ($\beta = 0.288$, $p = 0.002$) but fail to significantly influence intercultural interaction ($\beta = 0.136$, $p = 0.190$). This implies that while activity frequency may be high, deficiencies in cross-cultural orientation, shared participation mechanisms, and language collaboration limit their effectiveness in promoting interaction.

In contrast, Individual characteristics exhibits a significant path effect on intercultural interaction ($\beta = 0.224$, $p = 0.029$) but no direct significant effect on cultural adaptation pattern ($\beta = -0.045$, $p = 0.681$). This indicates that individuals' open behaviors and spatial usage willingness serve as prerequisites for interaction, while the realization of cultural integration still requires psychological internalization through authentic cross-cultural communication processes.

Most crucially, intercultural social interaction significantly influences cultural adaptation pattern ($\beta = 0.506$, $p < 0.001$). Further mediation analysis confirms that intercultural social interaction fully mediates the individual characteristics → intercultural social interaction → cultural adaptation pattern path ($p = 0.044$). The indirect effects of physical environment and community activities on cultural adaptation pattern through intercultural social interaction are marginally significant ($p = 0.075$; $p = 0.067$), suggesting that these external variables partially influence cultural adaptation by facilitating interaction mechanisms that translate into emotional and cognitive cultural integration.

This study further validates the robustness of these findings through model quality assessment metrics. The R^2 values indicate moderate explanatory power for endogenous variables (intercultural social interaction = 0.511; cultural adaptation pattern = 0.468), while the Q^2 values (intercultural social interaction = 0.312; cultural adaptation pattern = 0.395) are all above zero, demonstrating good predictive relevance. Additionally, f^2 effect size analysis reveals that physical environment has a large effect on cultural adaptation pattern, intercultural social interaction a medium effect, and individual characteristics a small effect on intercultural social interaction, underscoring the central role of physical environment and interaction variables in the model.

Building on the quantitative analysis, this study integrates interview data from representative residents to deepen the understanding of the relationship between spatial perception differentiation and cultural adaptation behaviors. For instance, regarding the question of whether "community commercial facilities reflect ethnic elements," residents in different areas exhibit distinct perceptions: those near Fanhai Celebrity Plaza and Minjiang Second Road generally report a decline in "Korean-style" facilities, whereas residents around Zhangzhou Second Road and Zhongshang Plaza note an increase in new Korean-themed stores. This indicates that ethnic spatial elements are not uniformly distributed; their accessibility and visibility are influenced by geographic location and commercial resource clustering.

In interviews, Mr. B, who operates a Korean convenience store, mentioned considering introducing Chinese products due to declining customer traffic, reflecting "cross-cultural adaptation" in business strategies. Ms. C pointed out that an increasing number of Korean residents are proactively seeking language learning and daily interaction opportunities, signaling behavioral willingness shifts. Meanwhile, Mr. T, a local resident, expressed dissatisfaction with late-night operations of some Korean restaurants and a tendency to avoid commercial facilities with prominent Korean signage, highlighting mainstream residents' spatial resistance to overly strong ethnic atmospheres.

Collectively, spatial reconfiguration reflects not merely commercial renewal but a realignment of immigrant cultural strategies, interaction frequency, and psychological belonging. The actual occurrence of intercultural interaction depends not only on space and behavior but also on the interplay of cognition, emotion, and social mechanisms.

In summary, within the Hong Kong Road community, the physical environment and community activities exhibit significant positive effects on cultural adaptation patterns but show no direct influence on intercultural social interaction. This suggests that while spatial and activity-based interventions can foster psychological safety and a sense of belonging, they do not necessarily trigger genuine social engagement.

In contrast, individual characteristics significantly facilitates interaction but lacks a direct path to cultural adaptation, indicating that individual actions are more likely to create contact opportunities, whereas adaptation itself must still be achieved through interaction mechanisms.

Notably, the driving force behind individual characteristics-induced interaction is often not cultural interest or identity-based motivation but rather external factors such as the decline of ethnic commercial facilities and reduced daily convenience. Some Korean residents in the community are compelled to engage with local resource systems to meet daily needs, thereby "passively" opening possibilities for cross-cultural contact. This behavioral restructuring, prompted by structural changes, reveals that the relationship between space, behavior, and identity is not linear but rather marked by friction and transformation.

Therefore, policy and design strategies should not merely focus on "improving spatial quality" or "increasing activity frequency" but must identify genuine behavioral drivers and psychological thresholds. It is recommended to embed low-threshold, co-creative cultural triggers—such as "community participatory museums" or micro-collaborative installations—to reshape interaction pathways among residents. Additionally, language mediation, identity negotiation, and shared narrative platforms should be leveraged to transform "contact" into "meaningful

engagement," ultimately fostering cultural adaptation and emotional integration within a multicultural community.

3 Design Proposal

Based on the aforementioned findings, this study proposes a site-specific spatial intervention strategy grounded in the concept of a community participatory museum. Unlike traditional top-down curated museums, this approach is embedded in daily community life, aiming to empower residents with the agency to "narrate stories, express identities, and co-curate exhibitions." It serves as a cultural infrastructure emphasizing co-creation, sharing, and consensus-building.

3.1 Design Concept

Inspired by the television drama *Reply 1988*, which resonates with both Chinese and Korean residents, and incorporating the local community's memory resources and practical needs, the design is conceived as a "distributed micro-space system" composed of 12 multifunctional nodes. These nodes are strategically positioned at alleyway corners and between commercial blocks, featuring a semi-permanent structure. They are co-built, co-managed, and co-curated by residents, forming a spatial narrative centered around "shared living memories."

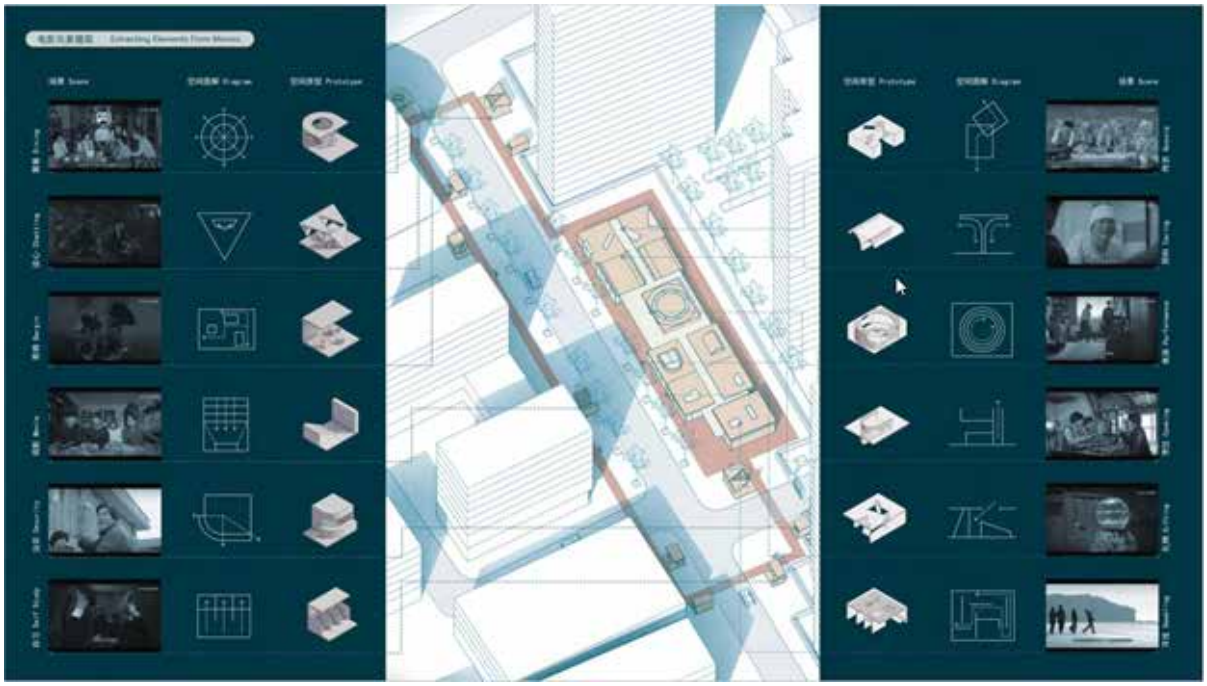

Figure4. Functional Unit Example

3.2 Specific Spatial Combination Logic and Design

The "narrative acupuncture" intervention strategy is adopted to achieve precise activation of community gaps and potential spaces without disrupting the original spatial layout. The design emphasizes mild materials, bilingual signage, human-scale dimensions, and interactive mechanisms.

Figure 5. Interior Module Design

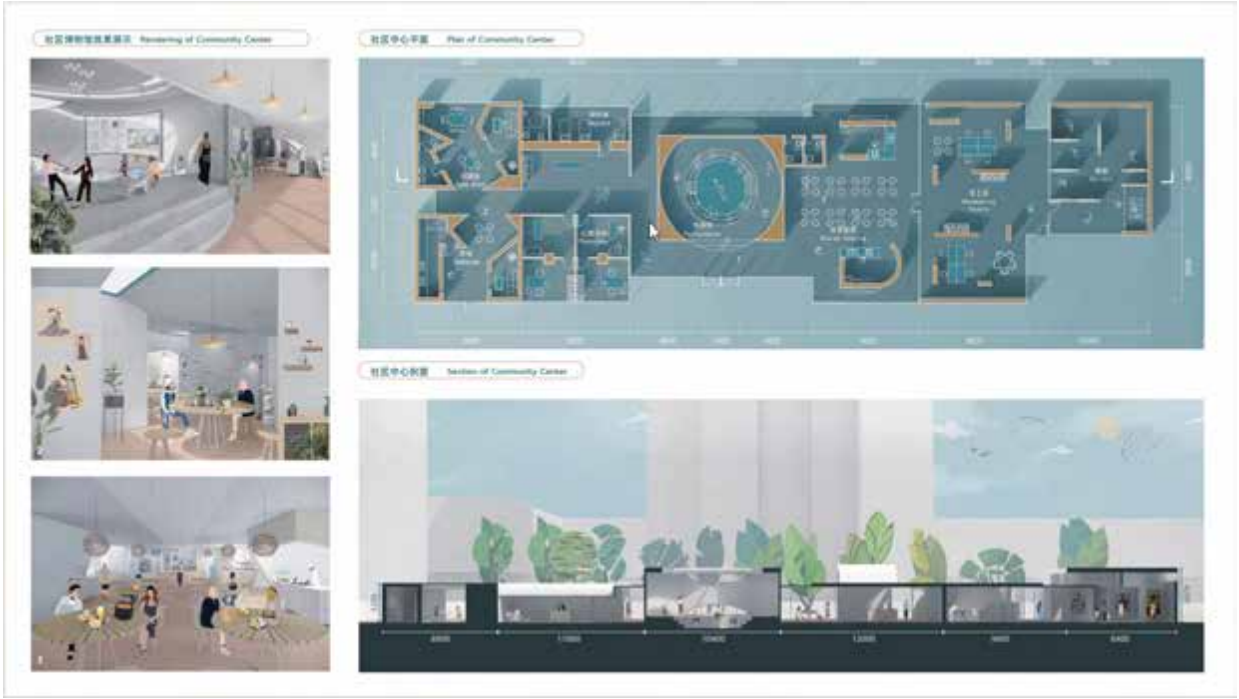

Figure 6. Interior Perspective Views and Spatial Layout

Figure 7. Exterior Module Design

4 Research Significance and Outlook

This study takes a typical Korean immigrant community in Qingdao as a case study, constructing a structural path model that encompasses the physical environment, community activities, user characteristics, cross-cultural interactions, and cultural adaptation patterns. Through PLS-SEM empirical analysis, it reveals how spatial factors influence cultural integration through social interaction mechanisms. Compared to previous adaptation studies that predominantly focused on psychological dimensions, this research integrates spatial design, behavioral participation, and interaction processes into a unified theoretical framework, expanding the boundaries of urban multicultural governance research.

On a practical level, the study finds that cultural adaptation does not stem directly from physical spaces or activity provision but requires genuine and sustained cross-cultural interactions. This conclusion provides insights for community planning and policy-making, emphasizing the importance of balancing "spatial interventions + interaction mechanisms." The proposed "community participatory museum" strategy further demonstrates how micro-spatial interventions can facilitate identity negotiation and cultural co-creation, offering an actionable design prototype for multi-ethnic cohabitation areas.

Future research could expand in three directions: (1) introducing a temporal dimension to conduct longitudinal tracking analysis of cultural adaptation; (2) comparing mechanism differences across cities and groups to enhance the model's generalizability and flexibility; and (3) incorporating social media data to explore the impact of "digital-spatial" dual interactions on integration pathways, responding to rapidly evolving urban contexts and technological environments.

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Over the rainbow: Urban oasis as an inclusion hub

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Abstract
Focusing on the case of a new urban oasis in Belgrade (2024), situated on the site of a Drop in Shelter for the street children, the paper examines a relationship between marginalised group(s), neighbourhood community and multidisciplinary professionals, involved in a project launched by the EUNIC Serbia and the Goethe-Institut. The project involved a group of the second-year undergraduate students of the University of Belgrade - Faculty of Architecture working on a proposal for a unique hub of/for social inclusion, safety and inter-neighbourhood interaction. The selected case is presented through the lenses of educational process, highlighting the synchronisation between the expected environmental and social outcomes, a comprehensive participation of future users (marginalised children and local community) and the estimated/achieved sustainability of the implemented project.

Keywords: Integration, Inclusion, Public Space, Children, Education.

Introduction

The cities exposed to multiple transitional flows have been facing various challenges which especially affect vulnerable and marginalised groups. The strong division between the winners and the losers of the neoliberal mechanisms reflects in urban setting and its public spaces, where the discrepancies between the reality and the globally announced imperatives of sustainability, resilience, equity and justice become extremely visible (World Cities Report, 2024). Belgrade, the capital of Serbia, represents one of the multilayered examples of this practice, fuelling the atmosphere of growing uncertainty, far away from the postulates defined by SDGs, 2030 Agenda or the New European Bauhaus framework.

Highlighting the case of a new urban oases (2024), situated on the site of a Drop in Shelter for the street children, the paper presents a process of a studio project, based on a relationship between marginalised group(s), neighbourhood community and multidisciplinary professionals, all involved in an initiative launched by the EUNIC Serbia (European Union National Institutes for Culture) and the Goethe-Institut. Conducted in cooperation with the Center for Youth Integration, the Belgrade International Week of Architecture (BINA), the Italian Institute of Culture, the Embassy of Portugal, as well as a group of the second-year undergraduate students of the University of Belgrade - Faculty of Architecture, this endeavour triggered the transformation of a small open space into a new hub of/for social inclusion, safety and inter-neighbourhood interaction. Having in mind that street children represent one of the most vulnerable groups, often threaten by socioeconomic inequalities, violence and the lack of any kind of support, their education, safety and healthcare could be challenging or non-existent. Therefore, any action directed toward the improvement of this damaging condition should be based on the set of policies which provide functional support systems, as well as equally accessible resources (Sovacool et al., 2022).

Following these recommendations, the project and its inclusiveness were elaborated through several phases

related to research, design, implementation and the promotion of achieved results. The integrative potential of the upgraded space was emphasised during all organised events - from participatory workshops, lectures, exhibitions, to presentations and public gatherings. The newly created public node was conceptualised and shaped according to the specific needs of identified users, representing a common good for the entire local community. Consequently, the design program stimulates exploration, play and learning through the application of art, ecology, recycling and digitalisation. As a new popular place, the urban oasis should also raise both the environmental awareness and the quality of space while connecting the different groups in their personal experiences.

The important segment of this initiative represented the work of students which was constantly exposed to both professional and public evaluation. Therefore, the educational process and the applied methodological approach had to correspond with expected environmental and social outcomes, while the participation of future users (both the marginalised children and the local community) stimulated a balance between the detected neighbourhood dynamic and the anticipated project sustainability.

The theoretical drivers

Grounded in the concept of social production of space (Lefebvre, 1991) and the concept of social capital (Putnam, 2000), the process conducted within the studio project continuously emphasised the role of integrative potential of public spaces, within the boundaries defined by socio-economic context and the networks of trust, cohesion and exchange within a community (Whyte, 1980; Castells, 2000). The shared development vision, which would stimulate inclusion and transmission of ideas and practices, represented a project necessity leading toward green transition, long-term sustainability and the integration of marginalised children into local community.

The ideas and methods based on tactical urbanism (Lydon and Garcia, 2015), participatory design (Muller and Kuhn, 1993; Bannon and Ehn, 2012) and situated design (Simonsen et al., 2014) were used as a framework for human-centered approach which included affordable, responsive and flexible spatial interventions in order to create engaging public node - an urban oasis which instigates spontaneity and a higher level of accessibility for all interested parties. Both problem- and project-based learning were incorporated into studio curriculum, ensuring a dynamic setting which encouraged students to obtain multidisciplinary knowledge, increase their creative abilities and develop self-esteem and confidence when dealing with real-life problems and challenging situations (Frank and Barzilai, 2006; Barrett and Moore, 2011).

The idea of urban oasis was considered as a multipurpose stage and a medium for both social and environmental themes, acting as an open public space which supports diversity but also provides informality and equality in communication and use (Oldenburg, 1991). Furthermore, the issues of environmental awareness and microclimate quality were considered as an additional level of future cooperation and understanding between local users - from inhabitants and the Shelter beneficiaries to experts and local government. In line with this aspect, the importance of environmental issues was highlighted during the iterative process of studio work, especially the problems of pollution, climate shift and declining biodiversity. The students had an insight into the Value-Belief-Norm (VBN) approach (Stern et al., 1999), the concept of green transition (Mol & Sonnenfeld, 2000; Geels, 2002) and the ecological modernisation theory.

In the direct interaction with street children the students were able to identify a number of challenges which this sensitive group of users has to face every day - from violence and exploitation, to inadequate access to food, education and healthcare. Consequently, the design of a new urban oasis, based on co-creation, co-production and co-benefits, had to address all these issues in local context, overcoming the occasional hostility of neighbours. Social integration with and beyond neighbourhood was stimulated, while the introduction of green spaces was used as a tool for reinforcing the overall sense of belonging through a playful design and various types of activities. These changes could attract new artistic and educational programs, also acting as mediums of inter-institutional cooperation.

Urban oasis: identification, interaction, integration

The project entitled 'Belgrade urban oases' was initiated at the beginning of 2024, by a team of several institutions led by the EUNIC Serbia and the Goethe-Institut. Targeting three typologically diverse sites, which were selected before the application process, the main idea was to increase their spatial comfort, as well as environmental and social sustainability. Characterised by different problems, these (mostly neglected or underdeveloped) open spaces became unique polygons for activation, upgrading and/or renovation which was supposed to improve their condition while increasing a general wellbeing of both immediate beneficiaries and local communities. The project initiative also included the students of two faculties of the University of Belgrade - the Faculty of Architecture and the Faculty of Forestry, which contributed to several phases of the project - from the process of design to implementation.

The site of the Shelter for Street Children (Krfska Street, No. 7a) represented one of these potential urban oases, offering a small open space positioned within the building plot, perpendicular to two parallel streets (Figure 1). Due to its specific position between two public buildings and the lack of any physical barriers which would separate it from the public space of streets, this L-shaped open space represented also a specific corridor (especially during the non-working hours of the Shelter), used as a shortcut between two streets, or a gathering (noisy) spot for local teenagers, often causing official complaints of the neighbourhood. Consequently, the idea was to provide a redesign of this urban pocket, in accordance with a specific set of needs expressed by the direct users - the street children from different age groups (up to 18 years). Additionally, it was necessary to instigate a higher level of social inclusion with(in) neighbourhood, increase the overall safety and decrease the level of hostility, often expressed by local residents. The future urban oasis also anticipated other roles - from the stage for various activities, events and gatherings, a generator of positive identity and pride, to the instrument of ecological and aesthetic transmission, exchange and awareness.

Figure 1. The site of the Shelter for Street Children.

The partners in charge of this oasis were the Center for Youth Integration (as the umbrella organisation coordinating the activities of the Shelter), Belgrade International Week of Architecture (BINA), Goethe-Institut, Italian Institute of Culture, Embassy of Portugal and the University of Belgrade - Faculty of Architecture. The students involved

in the project attended the second year of bachelor studies (2023/24) and their work was conducted within the studio supervised by Professor Dr. Aleksandra Stupar (assistant Aleksandar Grujičić), representing a segment of the course entitled Sustainable Urban Communities (Professor Dr. Ksenija Lalović). Considering the complexity of this project, as well as the number of involved participants, the process was based upon an elaborate timeline, which enabled an intensive collaboration of all partners and involved actors, facilitated participative design and stimulated efficient implementation supported by the immediate users (Figure 2).

Figure 2. The project time-line.

The work on urban oasis used a problem-based approach, which also had an important educational and experiential dimension - both for the students of architecture and the street children/teenagers. It stimulated their mutual bonding, understanding and trust, resulting in a number of creative ideas, later used in the final draft. The theme conditioned the concept of an open-ended project due to a dynamic in-situ context which demanded flexibility and collaboration of all involved parties.

The closer involvement of students started in February 2024, at the beginning of spring semester. Their first task related to the overall topic and the selected site was the analysis of local context which revealed the status of activities, environment, local community and the Shelter beneficiaries - their needs, expectations and mutual interactions. SWAT matrix was used for the classification of results and a further decoding of the ongoing processes in the space, while an elaborated insight into communication flows and existing multileveled networks provided conceptualisation of possible channels of integration, collaboration and exchange. The connection between the direct and the indirect users of space, students and educators was also established, tracing the path for upcoming participative activities. The final outcome of this phase represented a data-base of relevant examples which were assessed according to their specificities and the potential benefits for project context.

The importance of similar experiences, as a possibility for a know-how exchange, was emphasised by a lecture delivered online by Dr. Valentina Talu, a researcher at the University of Sassari (Department of Architecture, Design and Urbanism) and a co-founder and administrator of the spin-off company Tamalacà Srl. Organised by the Italian Institute of Culture in April 2024, the lecture entitled Tactical Urbanism and City Tailored to Children highlighted

the importance of a synergy between theory and practise, local circumstances, available budget and preferred outcomes. It was followed by a discussion which raised issues related to the detected problems of participation process and implementation, legislation drawbacks, funding, sustainability, maintenance, neighbourhood safety, social cohesion and integrative potential (Figure 3). The studio data-base was enriched by the recommended material from the platform Tactical Urbanist's Guide and the e-book The City at the Eye Level for Kids (Danenberg at al., 2018).

Figure 3. The online lecture Tactical Urbanism and City Tailored to Children by Dr. Valentina Talu. Photo: Aleksandar Grujičić.

After this thematic introduction, the students participated in a workshop which was organised on the site of the Shelter and the future urban oasis. The aim of this step was to establish a face-to-face interaction with both the immediate users and their supervising team, while identifying their needs, preferences, dynamic of their daily/seasonal activities and the problems affecting their integration into the neighbourhood (e.g. hostility, prejudice, rejection, segregation). During the workshop, which was also assisted by the BINA representatives, the attention of all participants was directed toward several issues - physical, functional and social limitations of the space, expected/preferred flexibility, environmental upgrading and its sustainability. Students prepared various examples of successful design possibilities as an input (playgrounds and playground equipment, landscape, urban gardens, urban furniture, textures, colours and shapes etc.). Both digital and analogue formats were used as initiators for discussion, creative process and the evaluation of preferred elements and activities. The duration of the workshop was estimated by the supervisors from the Shelter and conditioned by the attention span of involved children and teenagers. The outcomes outlined the possible directions of spatial conceptualisation - urban oasis as a generator, transmitter and display of sustainable and integrative practices and exchange (Figure 4). The collected material and ideas produced by both users and students created a starting point for defining the main goals and design principles.

Figure 4. The first participatory workshop at the Shelter. Photo: Aleksandar Grujičić.

According to the initial findings of the first workshop students developed their conceptual solutions in an iterative process which relied on both the participative and situated design methods. Studio work enabled elaboration of collected ideas and the first public presentation of 23 students' posters, organised in front of the Shelter and in the adjacent park, triggered a positive response from the local community. Children from the neighbourhood and their parents also showed interest in the proposed designs and took part in an informal discussion and interviews. Consequently, the information gathered through the interaction with neighbours, Shelter beneficiaries, supervisors, as well as occasional passers-by, contributed to a common system of values (Figure 5). This public event, partially conducted on the site of the future urban oasis, contributed both to the increased inclusiveness of design process and the further elaboration of exhibited proposals. They were evaluated by simple voting/ rating process (with colourful stickers), not only by Shelter users, but also visitors and observers. As a result, a list of most desirable spatial and functional elements was created, directing the next phase of project elaboration conducted during the last few weeks of spring semester.

Figure 5. Public discussion during open-air exhibition. Photo: Aleksandar Grujičić.

The last phase of design, concluded in the end of May 2024, was presented during the 19th Belgrade International Architecture Week - as the exhibition held on the premises of the Shelter and a public lecture related to all activities within the Belgrade Urban Oases project. The exhibition displayed in June 2024 included a simple voting process and a discussion with users and the neighbourhood which led to the selection of six projects and main design elements (Figure 6). Their authors (students Tamara Šuljagić, Tatjana Paunić, Katarina Rančić, Marko Šepa,

Katarina Nikolić, Đorđe Lazarević) were chosen as a team for project elaboration, coordinated by their supervisor and a BINA representative.

Figure 6. The exhibition during the 19th Belgrade International Architecture Week. Photo: Aleksandar Gazibara

The finalisation of project design was conducted during summer, while the implementation of the project was scheduled for October and November 2024. The selected team described the new urban oasis as a 'place of fun'. Intended for both the Shelter users and the neighbourhood, spatial upgrading enables exploration, learning, relaxation and play, simultaneously increasing environmental awareness, sense of belonging, as well as spatial, social and ecological responsibility.

The outcome

During the implementation, the main construction works were focused on the pedestrian corridor between two buildings which was improved by the ACO drainage system and painted (MAPEI) by the Shelter children, with the support of students and the BINA team. The painted drawings represent a result of a series of creative workshops organised by Dušana Nikolić from the Architecture studio for children La Villette, with the assistance of student Tamara Šuljagić. This activity had an important symbolical significance depicting mutual effort and creativity of all involved children. It also contributed to the evolving identity of urban oasis, open to the Shelter users, but also to the neighbourhood. The oasis was additionally upgraded by the wooden decking with integrated benches and planters, creating a flexible area for different kinds of events, gatherings and concerts. New green walls/ fences were included, as well as a projector and a white board on the outer wall of the Shelter, new trampoline and chairs (Figure 7).

Due to weather conditions and approaching winter months only a part of planting activities was completed. However, the space got new trees and some plants, while the remaining vegetation has been added during

Spring 2025. This intervention also improved the overall atmosphere and comfort, strengthening the link to nature while enriching green infrastructure of the area.

Figure 7. New urban oasis as a node of social interaction, learning, fun and environmental responsibility. Photo: Aleksandar Gazibara.

The activities of the urban oasis, as well as the experiences gained in its space, are regularly shared via digital media. The Shelter users are encouraged to contribute with their own posts which promote activities and features of the space. Due to additional funding from the Ministry of Culture of the Republic of Serbia the online accessibility and digital skills of children have been improved. Consequently, new possibilities for learning, exchange and promotion of successful practices on various digital platforms and social networks have been open, but with a controlled approach, especially important for marginalised children. Additionally, project visibility has been increased enabling more intensive participation of the public, as well as the introduction of numerous environmental themes which could be presented and/or tested within the urban oasis.

In total, the project initiative included about 200 participants, several institutions (Municipality Zvezdara, Beograd put, Public Company - Greenery Belgrade, Ministry of Culture of the Republic of Serbia) and donor companies (MAPEI, ACO). During the active period of 2024 (April to November) many activities were organised and successfully realised, gathering over 840 participants. Students were actively involved until the end of spring semester, while the selected team of students-authors continued their work until November in various capacities.

Conclusion

The problem-based approach used for the conceptualisation and design of a new urban oasis in Krfska street was user-oriented and adjusted to transformative imperatives embedded in the project application of the Belgrade Urban Oases. The studio work with the students of the Faculty of Architecture was structured around several phases and core activities which ensured elaboration, multidisciplinary effort and a high level of collaboration between various actors. The urban co-creation method was applied in order to produce a coherent and sustainable solution based on active user participation, real-time experiences and iterations within a constant design focus (Hertzum, 2014). The importance of situated design - related to context, knowledge and action, was also emphasised as a way toward lasting sustainability of the implemented spatial intervention.

The established node for multiple mutual interaction and integration, conceived as an urban oasis, provides a setting for numerous community activities which could have a positive impact on both the neighbourhood and the Shelter users. Although it is still early to conduct an elaborated evaluation of the achieved results, the event organised during the 20th BINA festival (May 2025) enabled a survey of the current situation. During the annual

celebration of the Center for Youth Integration/Shelter a photo exhibition dedicated to the Oasis was launched, gathering children, employees and other interested guests. They provided their personal insight into several aspects of the established public space commenting its quality (functional, aesthetic and environmental), activity content, (un)fulfilled expectations, frequency of use, ideas for further upgrading and the achieved exchange with neighbourhood.

The feedback is mostly positive, especially from the direct users and participating institutions. According to them, the space of urban oasis has become an attractive outdoor spot, a new feature for positive identification, pride and empowerment of the marginalised Shelter children. They appreciate its flexibility and the vibrant appearance of colourful pedestrian corridor, the wooden decking of the plateau, greenery and new urban furniture with integrated plants and trees. This setting influences their environmental awareness, instigating interest in gardening (planting, watering, cleaning, watering etc.) and overall well-being. The neighbours of the Shelter also noticed better design and maintenance, which attracts local children.

However, some problems were also mentioned, mainly caused by the public character of the place, especially after working hours of the Shelter. Consequently, the problematic evening noise created by various groups of local teenagers (who occupy the wooden deck after school) can be solved by additional enclosures of the space which will be locked during evening, preventing uncontrolled trespassing. This intervention could be realised during 2025, due to the next phase of funding, provided by the Goethe-Institut. In the meantime, it is important to keep the momentum of activities, supporting the social and environmental sustainability of the oasis.

Although the project represents a specific booster for the inclusion of marginalised children into environmental practices, their position in the green transition should be further empowered. Previously detected hostility of the neighbourhood could be diminished through common actions focused on environmental challenges and maintenance of green infrastructure, while the cooperation with students should be developed and eventually directed to similar transformative projects. Their mutual experiences and reflections, as a unique collaborative learning process, could gradually become an example of successful practise and an encouragement for equally sensitive contexts, willing to discover their environmental consciousness.

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The Path of Land Use Control for Urban Development and Construction Projects in Germany

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Abstract
As global urban development transitions from quantitative expansion to qualitative enhancement, land use patterns grow increasingly intricate, necessitating sophisticated regulatory mechanisms. Germany, recognized for its mature development control system, has established an integrated framework combining public construction law, development guidance planning, and permit-based enforcement. Through systematic analysis of Germany's urban land governance evolution, this study examines the synergistic interplay between legislative mandates, planning instruments, and regulatory oversight. It further explores the transferable value of Germany's model through four critical dimensions: clear objectives, robust legal foundations, comprehensive control tools, and refined implementation methodologies, offering actionable insights for achieving sustainable and orderly urban growth worldwide.

Keywords Land use control; German planning system; Zoning; Urban Development

Introduction

As global urban development shifts to a refined phase, land use grows more diverse and complex, with stock development and urban regeneration becoming crucial strategies. Nations face the shared challenge of balancing functional integration with conflict avoidance in urban land use control, while ensuring land use flexibility over its entire life cycle.

Germany, the pioneer in development zoning control, has established a robust system by integrating public construction law, development guidance planning, and construction permits. This system effectively regulates urban construction and use, offering strong support for achieving spatial planning goals and maintaining urban development order.

1. The Evolution of German Land Use Control

1.1 The Origin of Zoning

In the second half of the 19th century, German cities rapidly developed and expanded due to the Industrial Revolution. Municipal authorities started to use spatial planning and legislation to regulate urban growth. The 1862 Berlin City Binding Land-Use Plan and the *1868 Baden Grand Duchy's Road Red Line Law Fluchtliniengesetz* were landmark events in modern urban spatial control. The 1891 Frankfurt *Graded Building Ordinances (Staffelbauordnungen)* marked the birth of German "zoning." It divided cities into residential, industrial, and mixed - use zones, specifying the characteristics, uses, maximum building height, density, and distance between buildings in each zone. Subsequently, the *Graded Building Ordinances* spread rapidly in Germany, with many cities adopting zoning rules. For example, the *1935 Local Construction Ordinance* divided urban land into six functional zones, such as mixed - function and residential areas, guiding the layout of manufacturing, housing, and service functions. It also established ten intensity zones with building density decreasing from 60% to 10% and linked them to functional zones. These regulations embodied the "functional zoning" concept, preventing industrial and residential mixing, controlling development intensity, and ensuring good lighting and ventilation for housing, thereby improving urban living conditions and enhancing public health.

1.2 The Establishment of Development Control Methods and Systems

After World War II, West Germany began national urban construction legislation. The *1960 Federal Building Act (BBauG)* and the *1962 Federal Land Utilization Ordinance (BauNVO)* standardized development plan preparation, marking the establishment of modern German development control. The two laws and the resulting development plans continued the zoning approach of the *Graded Building Ordinances*, forming a refined "land use + building

function" dual - layer mixed - use control system. Under the *Federal Land Utilization Ordinance*, urban development areas are divided into four types: residential (W), mixed (M), industrial (G), and special construction zones (S). Each is further subdivided into several development sites. For instance, industrial zones (G) are split into commercial and industrial zone (GE) and industrial zone (GI). The regulations specify the permissible building functions on each site, guiding their layout. To distinguish primary and supporting functions, permissible construction functions are categorized into "allowable" and "allowable under special circumstances." The restrictions can apply to building types like residential or commercial buildings, or to business types such as retail or catering. They can also limit facility scale, service targets, and external impacts, such as "local - serving" shops or "non - disturbing" handicrafts. Moreover, development plans can set special regulations for specific areas or building parts.

1.3 The Evolution of Development Control Requirements

Over the past five decades, German development control has been continuously optimized based on new planning concepts and has responded to emerging issues. Initially, influenced by the *Athens Charter*'s functional zoning concept, it focused on separating residential and industrial uses to address environmental degradation caused by industrialization. As the service sector grew and vibrant urban life gained recognition, promoting job - housing integration and orderly functional mixing became significant. The *Land Utilization Ordinance* 's evolution reflects this shift. In the 1962 version, only accessory residences like dormitories were allowed in core zone (MK) areas. The 1968 version added "residences above the floors specified in the development plan," and the 1990 version further permitted "other residences meeting the size requirements of the development plan." In 2017, the *Federal Land Utilization Ordinance* introduced the "Urban-Style Zone (MU)" as a new development category, facilitating higher-density, functionally flexible, and spatially coordinated integration of residential and non-residential uses.

2. Development Control Tools and Their Roles

Germany's development control system operates through a coherent regulatory framework integrating public building regulations, development guidance planning, and construction permits Figure 1. This integrated approach ensures comprehensive implementation of development control objectives. Statutory building regulations establish foundational constraints, while development guidance planning translates these requirements into site-specific zoning schemes through adaptive refinement. Construction permits enforce regulatory compliance throughout both construction and operational phases, thus establishing a closed-loop management cycle that maintains system integrity.

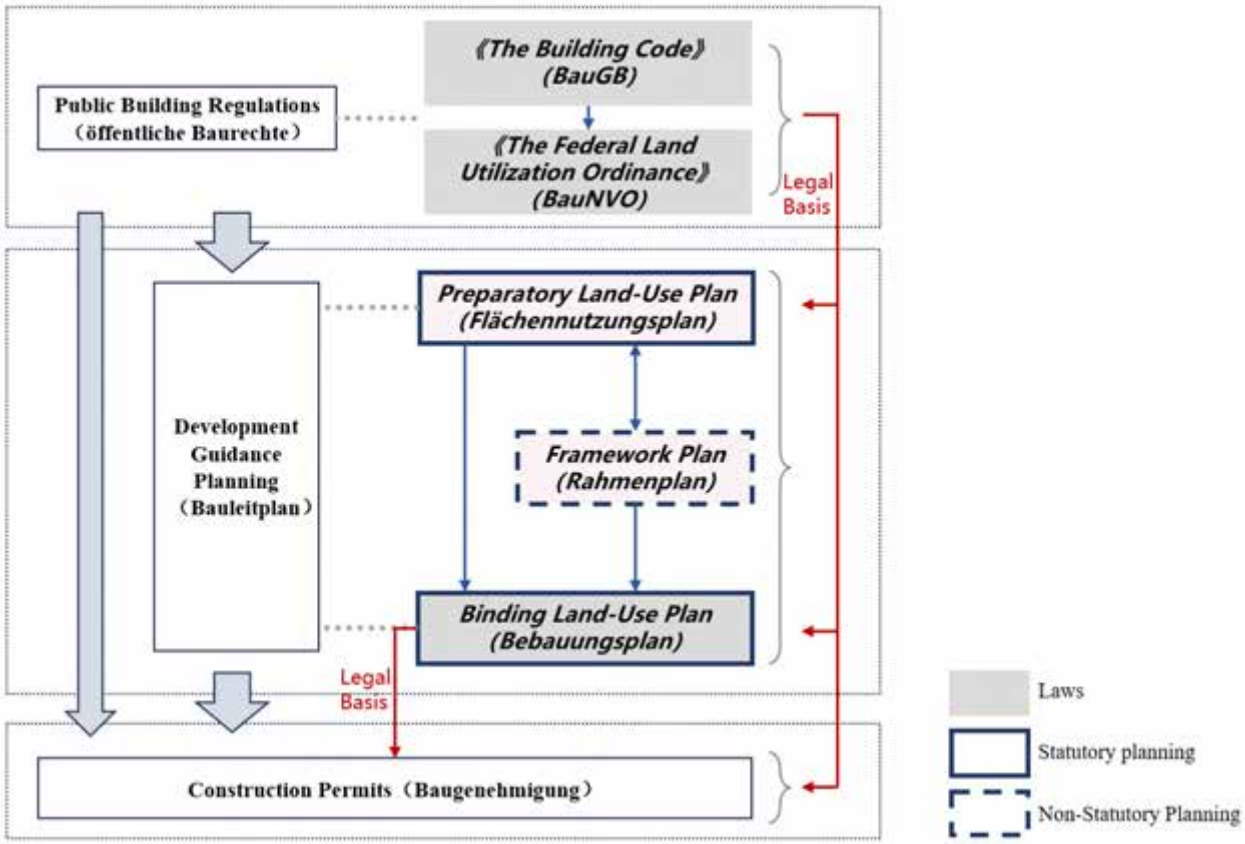

Figure 1: The System of Development Control Tools in Germany

2.1 Public Building Regulations

Public building regulations primarily encompass the *Building Code (Baugesetzbuch, BauGB)* and the *Federal Land Utilization Ordinance (Baunutzungsverordnung, BauNVO)*. These laws provide the overarching framework and general rules for the management of development, construction, and use. In addition to these key regulations, other rules at the federal, state, and municipal levels also play a role in this process.

2.1.1 The Building Code

The Building Code (Baugesetzbuch, BauGB) was established in 1987 through the codification of the *Federal Construction Act (Bundesbaugesetz, BBauG)* and the *1971 Urban Development Promotion Act (Städtebauförderungsgesetz)*. Comprising nearly 300 articles, it provides a comprehensive legal framework for urban development in areas such as spatial planning, land management, planning permission, and renewal measures. The Code defines Preparatory Land-Use Planning (Flächennutzungsplan) and Binding Land-Use Planning (Bebauungsplan) as "development guidance planning" (Bauleitplanung) and specifies their tasks, definitions, purposes, contents, and preparation methods. It serves as the legislative basis for the *Federal Land Utilization Ordinance (Baunutzungsverordnung, BauNVO)* and municipal-level Binding Land-Use Plans. Additionally, the Code clarifies the types of development and construction projects, stating that functional conversion, new construction, and reconstruction all fall under this category. Generally, Binding Land-Use Plans form the fundamental basis for granting construction permits for development and construction projects.

2.1.2 TheFederal Land Utilization Ordinance

The *Federal Land Utilization Ordinance (Baunutzungsverordnung, BauNVO)* is a core legal tool for development control in Germany. The regulations consist of four main chapters, which cover the types of development sites, the scale of construction uses, construction methods and scope, as well as the management transition and

connection before and after regulation revisions. The provisions on development - and - construction - use control are mainly concentrated in the first chapter and include the following three aspects. First, the regulations define the types of development zones and sites. According to these four types of development areas, the *Federal Land Utilization Ordinance* revised in 2021 stipulate 12 types of land zoning Figure 2 . Second, they set out the main uses and permissible buildings for most development sites and clarify these as part of Binding Land-Use Plans Figure 3 . Third, they authorize Binding Land-Use Plans to adaptively adjust the general regulations in the *Federal Land Utilization Ordinance* for specific sites. According to Article 1, Paragraph 7 of these regulations, Binding Land-Use Plans can make special provisions for the use of specific parts of buildings on development sites. For example, they can specify that permissible buildings are only allowed under special circumstances or not allowed at all, and they can restrict the use of specific building facilities to certain locations, all based on special urban - construction reasons.

Main Category	Subcategory	Overview
Residential Area (W)	Small Residential Zone (WS)	Includes residential buildings, private gardens, and small-scale agricultural or horticultural establishments
	Pure Residential Land (WR)	Residential use without disturbance
	General Residential Zone (WA)	Mainly for residential use and regionally oriented local supply
	Special Residential Zone (WB)	Mainly for residential use; in areas of excessive development; may set minimum housing quotas
Mixed Construction Area (M)	Village Zone (MD)	Allows agricultural and forestry enterprises as well as non-intrusive commercial activities
	Village Residential Zone (MDW)	Allows residential and non-intrusive agricultural, forestry, and industrial activities
	Mixed-Use Zone (MI)	Allows residential and non-intrusive commercial activities
	Urban-Type Zone (MU)	Allows residential functions as well as non-intrusive commercial, social, cultural, and other facilities
	Core Zone (MK)	Allows commercial activities and economic, administrative, and cultural center facilities
Industrial Area (G)	Commercial and Industrial Zone (GE)	Allows non-intrusive industrial activities
	Manufacturing Zone (GI)	Allows industrial activities not permitted in other construction areas
Special Construction Area (S)	Special Development Zone (SO)	Areas with special regulations according to Articles 2-10 of the Building Code

Figure 2: The 12 types of land zoning stipulated in the German Building Use Regulations

Development and Construction Areas	Land Zones	Permitted Building Types	Building Types Permitted under Special Conditions
Mixed Area (M)	Mixed-Use Zone (MI)	1. Residential buildings 2. Commercial and office buildings 3. Retail, catering, and hospitality services 4. Other commercial and industrial activities 5. Office, religious, cultural, social, health, and sports facilities 6. Horticulture 7. Gas stations 8. In areas primarily designated for commercial and industrial use, the purpose and scope can extend beyond the core area's entertainment industry	In areas primarily designated for commercial and industrial use, the purpose and scope can extend beyond the core area's entertainment industry
	Urban-Type Zone (MU)	1. Residential buildings 2. Commercial and office buildings 3. Retail, catering, and hospitality services 4. Other commercial and industrial activities 5. Administrative offices, religious, cultural, social, health, and sports facilities	1. Entertainment industry, as well as 2. Gas stations
	Core Zone (MK)	1. Commercial, office, and administrative buildings 2. Retail, catering, hospitality, and entertainment services 3. Other non-disruptive commercial and industrial activities 4. Religious, social, health, and sports facilities 5. Gas stations equipped with parking structures and large parking lots 6. Residences for guards, security personnel, owners, and operational managers 7. Other residences in accordance with the scale specified in the construction plan	1. Gas stations not listed in item 5 of the left column 2. Residences not listed in items 6 and 7 of the left column

Figure 3: Permitted and Specially Permitted Building Types in the Mixed Construction Area (M)

2.2 Development-Guidance Planning and Framework Planning

According to the *Building Code*, development control is a crucial task of both Preparatory Land-Use Planning and Binding Land-Use Planning. Binding Land-Use Planning provides the legal foundation for development control, while the Preparatory Land-Use Plan guides the preparation of Binding Land-Use Plans. In Germany, Framework Plan (Rahmenplan), a non-statutory planning layer, is frequently employed in key areas to integrate Preparatory Land-Use Planning and Binding Land-Use Planning.

2.2.1 Preparatory Land-Use Plan (Flächennutzungsplan)

Pursuant to §5(1-2) of the *Building Code (BauGB)*, the Preparatory Land-Use Plan (Flächennutzungsplan) establishes the land-use framework for municipal development. It articulates municipal authorities' comprehensive development intentions by designating zoning typologies and land-use categories across development sites. While binding on governmental administrative actions, these provisions lack direct enforceability over private development activities.

Municipalities typically adapt land-use categories from the Federal Land Utilization Ordinance (BauNVO) to local contexts. Berlin exemplifies this through its quadripartite residential zoning classification reflecting development intensity gradients (Figure 4). Others like Munich directly specify development-site typologies within their

Preparatory Plans. Select cities including Berlin further prescribe linear spatial configurations for specialized uses, such as primary commercial corridors.

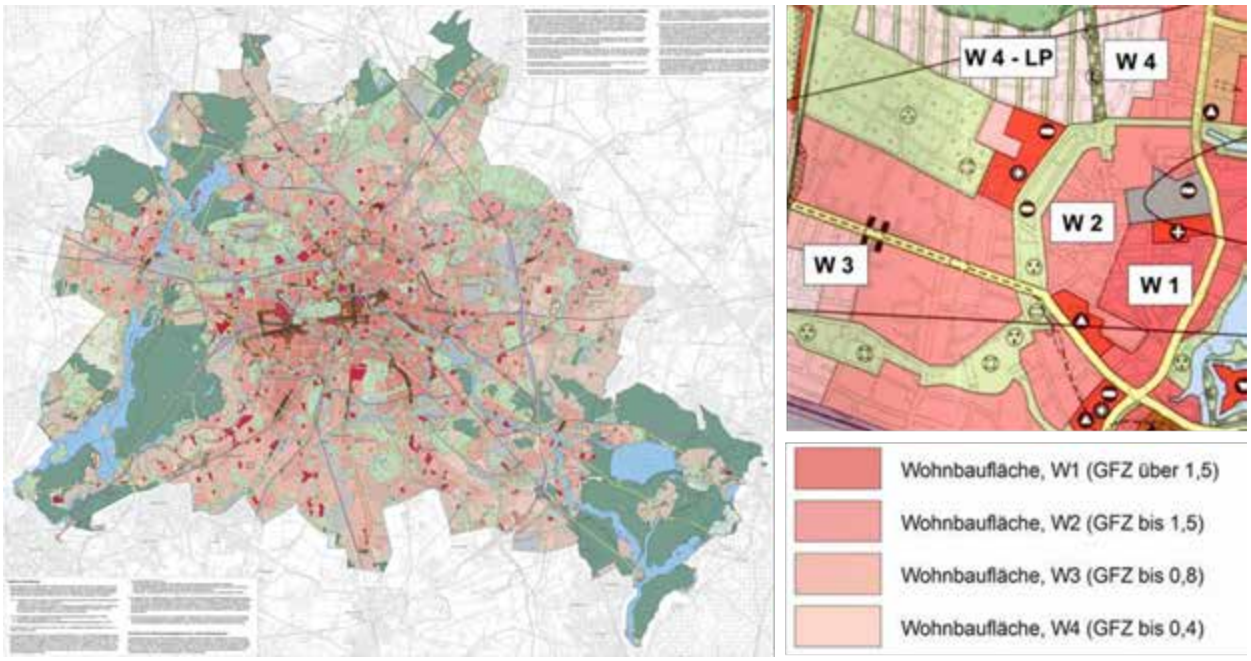

Figure 4: Preparatory Land-Use Plan Flächennutzungsplan of Berlin

During Germany's extensive growth phase, major cities updated Preparatory Plans at 15-20 year intervals. In the current redevelopment era, most municipalities have discontinued comprehensive Preparary Plan revisions. Instead, they implement incremental amendments guided by urban development strategies, key-area framework plans, and neighborhood-scale development concepts responsive to grassroots initiatives.

2.2.2 Framework Plan (Rahmenplan)

Framework Plans operate as flexible non-statutory instruments bridging Preparatory and Binding Land-Use Plans. Their primary function is defining meso-scale development objectives for both greenfield and urban regeneration areas through systematic spatial frameworks. These integrate five core dimensions: spatial configuration, functional organization, building morphology, open-space networks, and transportation systems.

Most Framework Plans prioritize development-site allocation and utilization guidance with methodologies varying according to planning objectives. For new development areas Munich's Riem Conference City emphasizes rational functional zoning while Hamburg's HafenCity focuses on intra-zone functional integration. In renewal contexts Stuttgart's City Core Framework directs controlled functional mixing while enhancing central residential capacity. These outputs support Preparatory Plan adjustments and provide technical guidance for Binding Land-Use Plan preparation.

2.2.3 Binding Land-Use Plan (Bebauungsplan)

The Binding Land-Use Plan (Bebauungsplan) functions as a legally binding local ordinance that specifies land-use parameters for individual plots, ensuring sustainable urban development aligned with public interest and social equity. It constitutes the statutory basis for building construction, renovation, land transactions, management, expropriation, and consolidation. A core mandate involves regulating development and construction by defining the scope and typology of developable sites within the plan area, while adaptively refining building-use provisions stipulated in the *Federal Land Utilization Ordinance (BauNVO)*. All provisions derive authority directly from the *Building Code (BauGB)* and *BauNVO*.

Binding Land-Use Plans are categorized by content and formulation method into three distinct types: Qualified Plans (Qualifizierter Bebauungsplan), which regulate use types and development intensity parameters; Project-Based Plans (Vorhabenbezogener Bebauungsplan), formulated through developer-municipality agreements under Development and Infrastructure Plans (Vorhaben- und Erschließungsplan); and Simplified Plans (Einfacher Bebauungsplan), applied when Qualified Plan criteria remain unmet. Qualified Plans are typically initiated by municipalities without predetermined developers, prioritizing public welfare through market-neutral standards. Project-Based Plans conversely reflect collaborative development between public authorities and private entities, balancing communal interests with market responsiveness. Critically, all plan types incorporate flexible use provisions to accommodate functional conversions and evolving project demands during operational phases.

2.3 Construction Permits

Development projects encompassing new construction, renovation, demolition, or functional conversions require mandatory construction permits under Article 29 of the *Building Code (BauGB)*. Prospective developers must formally submit a construction application (Baugesuch) to the competent authority prior to commencing work. This triggers a comprehensive review of public-law compliance, wherein authorities verify adherence to safety protocols, environmental safeguards, aesthetic coherence, and functional viability standards before granting authorization.

Conformity with designated uses in the Binding Land-Use Plan (Bebauungsplan) constitutes a foundational permit prerequisite, with approval pathways diverging according to plan typology. Qualified Plans necessitate demonstrable alignment between project proposals and both the Binding Land-Use Plan and supplementary construction regulations. For Project-Based Plans, compliance must extend concurrently to the Binding Land-Use Plan and the ratified project infrastructure plan (Vorhaben- und Erschließungsplan). In localities governed by Simplified Plans or entirely lacking Binding Land-Use Plans, Article 34 BauGB enables permit issuance where developments harmonize with neighborhood characteristics.

Critically, the flexible regulatory framework established by the *Federal Land Utilization Ordinance (BauNVO)* and Binding Land-Use Planning allows existing developed sites to secure construction permits without formal plan amendments. This procedural efficiency sustains continuous land-use governance throughout the asset lifecycle while maintaining regulatory integrity.

3. Zoning Control Objectives and Technical Methods

German urban land-use control, particularly the general-use regulations in the *Federal Land Utilization Ordinance (BauNVO)* and the specific-use regulations in Binding Land-Use Plans, is designed to guide rational functional zoning and orderly integration. It divides urban land into functional zones dominated by living, working, and leisure to prevent functional conflicts. Each zone ensures its main function while allowing complementary functions. This enhances the utilization of building facilities in construction and use, meets the needs for functional conversion, and promotes effective functional integration. These features are evident in the differential control requirements for residential, industrial, and service facility-related land-use types, as well as in specific cases.

3.1 Protecting Residential Ambience and Guiding Functional Integration

Residential function is the core of urban areas. Currently, it is crucial to ensure the comfort and privacy of residential communities and buildings while preventing interference from other business types. At the same time, to enhance urban vitality, inclusion, and creativity, it is necessary to reasonably guide the orderly integration of residential and non-residential functions.

Germany has established various use zones through its land - use control system, creating a graded - mixed - use pattern for residential and non - residential functions. This pattern, supported by refined protection measures, achieves balanced development. The residential - and mixed - use construction - land types in Germany exhibit a “graded-mixing” characteristic, with the compatibility of different land - use building functions gradually shifting from strict protection of the residential atmosphere towards promoting functional mixing. Pure residential land

(WR) prioritizes the protection of residential functions, with small - scale local services like commerce requiring special permits. General residential zone (WA) focuses on local service facilities. Urban-type zone (MU) has high functional flexibility with a high proportion of residential functions. Mixed-use zone (MI) requires a rough balance between residential and other uses. Core zone (MK) has a subordinate residential function, ensuring diverse integration through scale - limit regulations and restricting residential layout to avoid interference. For instance, Berlin's I-16 Binding Land-Use Plan stipulates that the residential function around Leipzig Square must account for at least 20% and specifies the minimum vertical elevation for residential placement. The "graded-mixing" of residential and other urban functions creates diverse scenarios, enhancing the habitability of residential environments and promoting the composite utilization of urban spaces.

In Binding Land-Use Planning, supplementary measures are often introduced to coordinate the relationship between residential and non-residential functions and to safeguard the quality of the residential environment. Specifically, certain exclusions for building facilities or limitations on the location of non-residential functions are imposed to prevent interference with residential areas. Meanwhile, horizontal and vertical spatial separation, as well as building protection, are utilized to mitigate the impact of high-intensity activities and traffic noise on residential spaces.

3.2 Internal Combination and External Coordination of Industrial Functions

The industrial function serves as a pivotal driver of urban development. In the realm of industrial land-use control, Germany takes into account a multitude of factors. It caters to the locational and space-environmental requirements of diverse industrial sectors, including manufacturing, storage and transportation, R&D offices, and business offices. Moreover, it coordinates the relationships between different industries and between industrial and urban functions to minimize interference. Additionally, it integrates upstream and downstream industrial chains, jointly plans office, R&D, and manufacturing facilities to foster industrial synergy, and guides the integration of industrial functions with residential and other functions to enhance urban vitality.

To accommodate the needs of industrial clusters, Germany has established two types of industrial-use construction lands: the Commercial and Industrial Zone (GE) and the Industrial Zone (GI). The Commercial and Industrial Zone (GE) is designed for enterprises with minimal environmental impact, such as manufacturing, office operations, warehousing, and utilities. These enterprises typically generate low levels of noise, dust, and odors, allowing them to be situated adjacent to or mixed with residential or mixed-use areas. In contrast, the Industrial Zone (GI) permits all types of enterprises, including heavily polluting ones like chemical plants and power stations. This zone is generally separated from residential or mixed-use areas to mitigate potential environmental and health risks.This zoning strategy, which is based on the environmental impact of enterprises and the local land-use integration needs, effectively balances industrial development with urban environmental quality.

In terms of commercial and office functions, the Mixed-Use Zone (MI), Urban-Type Zone (MU), and Core Zone (MK) all primarily accommodate these uses while also permitting other commercial and industrial facilities. The Core Zone (MK) enforces stricter environmental-impact requirements on enterprises, prohibiting significant interference. In special cases, the General Residential Zone (WA) can host commercial and industrial activities that do not cause significant interference. This use-control framework provides flexible and inclusive spaces for the layout of commercial, office, small manufacturing, and handicraft activities, thereby promoting the integration of industrial functions with other urban functions.

3.3 Hierarchical and Categorical Management of Service-Supporting Functions

Germany employs a hierarchical and categorical approach to manage service-supporting functions, encompassing commercial, social life, and specific service facilities. This approach standardizes these functions in terms of category, scale, and spatial layout, thereby balancing service convenience with the avoidance of use-interference to enhance facility efficiency and sustainable operation capacity.

In the realm of use control, residential, mixed, and industrial zones are assigned different priorities to optimize

functional integration and minimize conflicts. Mixed zones feature relatively flexible regulations to accommodate a diverse array of public service needs. Residential zones, in contrast, are subject to more stringent restrictions to safeguard against potential interference from commercial and industrial activities. Industrial zones, meanwhile, adhere to strict requirements to ensure professionalism and minimize environmental impact.

From a multi-dimensional perspective, Germany enhances planning precision and efficiency by specifying service targets, scales, business types, and adjusting licensing levels. Binding Land-Use Plans focus on the spatial layout of service facilities, often prohibiting residential use on building ground floors to promote orderly distribution along public activity areas. They also consider service radii and market laws to improve residents' lives and community vitality while ensuring facility operation efficiency. Furthermore, plans maintain flexibility to adapt to dynamic construction and operational needs.

4. Insights from Germany's Urban Development Control

Germany's mature urban development control system offers valuable lessons for achieving sustainable and orderly urban growth, characterized by its clear objectives, robust legal foundation, comprehensive toolkit, and refined implementation methods.

4.1 Clear Objectives and Control Principles

As a key mechanism ensuring the orderly development of urban space, Germany's urban development control prioritizes rational functional zoning and promotes functional integration. This approach effectively balances multiple objectives and development needs.

Functional zoning focuses on preventing industrial pollution from impacting other urban functions, strictly protecting residential areas to ensure a high quality of life for residents. Simultaneously, functional integration considers the blending of diverse functions within public activity centers and across different industrial sectors, fostering vibrant and dynamic urban spaces. Germany further enhances this approach through a tiered framework for residential-nonresidential functional integration tailored to specific contexts. This methodology facilitates effective spatial connectivity between functions while preventing mutual interference.

These principles not only meet urban development demands but also create a land use pattern that serves urban residents and other market and societal actors. By doing so, it enhances the efficiency of infrastructure and public services, contributing to the overall sustainability and livability of urban areas.

4.2 Robust Legal Foundation

Germany's urban development control system boasts a robust legal foundation, providing strong support for urban planning and sustainable development. Centered around the *Building Code (Baugesetzbuch)* and supplemented by the *Federal Land Utilization Ordinance (Bundesbaunutzungsverordnung, BauNVO)*, these legal instruments work in tandem to form a well-structured and coordinated legal framework. This framework ensures the scientific nature and effective implementation of urban planning. Other countries can draw on the rigor and coordination of Germany's legal system to enhance the standardization of their own planning controls.

4.3 Comprehensive System of Development Control Tools

Urban development control relies on the close cooperation of diverse instruments including policies, spatial planning, and permits. Germany integrates land use control into these mechanisms, coordinating them through functional zoning and integration principles to form a comprehensive system. This operational framework functions through three interconnected components: First, foundational legislation such as the *Building Code (Baugesetzbuch)* and *Federal Land Utilization Ordinance (Bundesbaunutzungsverordnung, BauNVO)* explicitly defines spatial planning mandates, content parameters, and control objectives. Second, local spatial plans translate these legal requirements into practice while simultaneously providing feedback loops for refining control measures. Third, construction permits enforce regulatory compliance throughout both construction and operational phases, ensuring continuous implementation of control standards.

For nations seeking to enhance their land planning systems, Germany's model demonstrates how synchronizing control instruments through unified objectives, standardized technical approaches, and integrated administrative procedures can significantly elevate the precision, rigor, and normative standardization of regulatory planning controls.

4.4 Refined and Efficient Development Control Methods

Development control regulations and technical methods are crucial for ensuring effective land use control. Germany's sophisticated land use control system incorporates several key features contributing to its success:

1 "Land Use + Building Function" Framework: The system categorizes land into types that permit mixed building functions. This framework defines the suitability and compatibility of uses and specifies primary and accessory functions. This supports appropriate functional zoning and integration while allowing flexible conversion of building uses.

2 "Type of Building Facility + Additional Constraints" Approach: Constraints are specified based on the type of building facility, precisely preventing functional interference. This ensures different uses can coexist without negatively impacting each other.

3 "General Regulations + Specialized Requirements" Method: Combines general rules with specific requirements tailored to particular contexts, guaranteeing both control precision and adaptability. This reduces administrative costs while maintaining flexibility and responsiveness to local needs.

Many countries can learn from Germany's advanced practices in these areas. By adapting these methods to their specific national contexts, they can enhance their control capabilities, refine land use control instruments, achieve efficient urban development, and promote coordinated urban growth.

5. Conclusion

Germany's development control system offers an instructive model for global spatial planning governance. Through rational functional zoning and integrated land-use coordination, it synthesizes statutory frameworks, spatial planning instruments, and permitting mechanisms into a cohesive regulatory ecosystem. This system balances public welfare imperatives, market dynamics, and developmental needs by integrating precise yet adaptable technical methodologies with clear planning directives, thereby enabling effective construction land management. As cities worldwide transition from quantitative expansion to qualitative enhancement—with urban regeneration and stock redevelopment emerging as dominant strategies—Germany's experience delivers actionable insights for international practice.

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Comparative Analysis of Legal Frameworks and Reform in Global Urban Planning Systems: Insights from 'Planning Regulation-Constrained' and 'Development Order-Guided' Models in the Stock Era

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Abstract
This study examines global urban planning systems through a comparative analysis of two governance models: the Planning Regulation-Constrained (Germany, USA, Japan) and Development Order-Guided (UK, Singapore, Hong Kong SAR) approaches. Focusing on six jurisdictions—Germany, USA, UK, Hong Kong SAR, Japan, Singapore—it analyzes their legal frameworks, regulatory tools, and approval mechanisms to assess efficacy in the era of urban stock optimization. Findings reveal inherent tensions between the two models: rigid rules ensure certainty but hinder adaptation, while discretionary systems offer flexibility but risk fairness deficits. Hybridization emerges as imperative, blending as-of-right permissions with contextual discretion. For China's dual system, reforms are proposed—multi-tiered laws, dynamic use packages, streamlined approvals, and collaborative governance—to balance public interest and market dynamism for sustainable urban regeneration.

Keywords Development Control; Planning Systems; Comparative Study; Stock Era

1 Introduction

In this age of accelerated global urbanization, urban planning and land - use management are confronted with increasing challenges. Urban planning systems globally are caught in a fundamental dilemma: achieving legal certainty while allowing adaptive flexibility in development control. These systems generally utilize statutory plans to control land development, but differ significantly in their governance logic. Depending on the relationship between statutory plans and development control, two archetypal models can be identified. The "Planning Regulation - Constrained" Model, as seen in Germany, the US, and Japan, grants as - of - right development permissions via codified rules like zoning ordinances. In contrast, the "Development Order - Guided" Model, pioneered by the UK, Singapore, and Hong Kong SAR, relies on discretionary administrative decisions based on broader policy frameworks.

This study conducted a comparative analysis of six representative countries or regions: New York City (USA), Germany, the United Kingdom, Hong Kong SAR (China), Japan, and Singapore. It concentrates on three key aspects: legal frameworks governing planning hierarchies and authority, regulatory tools enabling land - use control and zoning, and approval mechanisms for development permits. By analyzing the operational logic of each model and assessing their effectiveness in tackling stock - era challenges such as fragmented property rights and the demand for functional hybridity, the study aims to shed light on how global systems balance regulatory certainty and dynamic responsiveness. The insights gained are intended to inform the development of planning governance paradigms that are legally robust yet dynamically adaptive.

2 Dual Models of Urban Planning Systems: Characteristics, Logic, and Evolution

The urban planning system of every country encompasses various forms of planning across multiple top-down levels, all of which include statutory plans for development control. These statutory plans determine the content and procedures that land development and construction projects must follow to obtain planning permission. Based on the relationship between statutory plans and development control, urban planning systems can be divided into two primary models: the "Planning Regulation-Constrained" model and the "Development Order-Guided" model. The Planning Regulation-Constrained model is primarily represented by the zoning systems of Germany (Bebauungsplan), the United States (Zoning), and the Netherlands. Conversely, the Development Order-Guided model is typified by the systems of the United Kingdom and Singapore. Simultaneously, these two traditional models are continuously evolving and refining, gradually incorporating features from each other to form more flexible hybrid models.

Aspect	Planning Regulation-Constrained Model	Development Order-Guided Model
Control System	Strict rule-based control system represented by Zoning.	Due process control system based on case-by-case discretion.
Decision Mechanism	Direct authorization	Administrative licensing
Key Characteristics	Plans act as legal documents, directly authorizing landowners to exercise development rights compliant with zoning regulations. Legitimate development activities are protected by law; compliance automatically grants permission.	Development control is not rigidly tied to plans. Statutory plans serve as *one basis* for development control. Planning permission can even be granted in the absence of a plan.
Representative Countries/Regions	United States, Netherlands, Japan	United Kingdom, Singapore, Hong Kong SAR, China

Figure 1: Comparative analysis of the two modes

2.1 Planning Regulation-Constrained Model: A Strict Rule-Based Control System Represented by Zoning
The Planning Regulation-Constrained regulatory system originated in countries that had developed administrative law or possessed written constitutions defining rights and property rights. Following Napoleon I's conquest of continental Europe, the Napoleonic Code was applied across European nations, establishing administrative legislation and constitutions that explicitly defined powers and corresponding obligations. The defining characteristic of this planning control system is its regulation of development activities through legal statutes. Planning regulations explicitly stipulate the rights and obligations of individuals, as well as the limitations imposed on those rights. The planning systems of most European Union countries, the United States, and Japan derive from this model.

Within the Planning Regulation-Constrained system, development control is based on plans prepared or enacted in advance. The plan itself constitutes a legal document, establishing "As-of-Right" development through regulatory means. It directly authorizes landowners to exercise development rights compliant with zoning regulations via prior authorization. This model emphasizes strict rules and certainty, prioritizing the protection of private property. Development activities conforming to zoning regulations are both protected and constrained by law; compliance automatically grants permission. A local government's refusal of such development constitutes an infringement of private property rights and is subject to appeal. Planners reviewing individual development applications generally possess no discretionary power.

The Planning Regulation-Constrained system is planning-led, extending planning into implementation. Once a plan is approved, it is implemented primarily through building development permits, making development control over land activities relatively straightforward. Plan preparation in this system typically occurs at two levels:1) Strategic Plan at the City-Wide Level: Reflects the municipal government's strategic vision and intent for spatial development and land resource allocation. Examples include Germany's Flächennutzungsplan (Preparatory Land-Use Plan) and the United States' Comprehensive Plan. 2) Statutory Implementation Plan: Legally binding plans for execution, such as Germany's Bebauungsplan (Binding Land-Use Plan, often abbreviated as B-Plan) and the United States' Zoning Ordinance.

Within this system, statutory plans serve as instruments for precisely realizing planning intentions at the legal level. Consequently, they must explicitly specify land-related indicators such as plot boundaries, permitted land uses, floor area ratio (FAR), development density, etc. Statutory plans are enacted through legislative procedures, acquiring legal force and serving as the basis for granting planning permission. Before a plan is finalized, any urban construction activity lacks legal protection. After plan adoption, any necessary adjustments must follow statutory procedures. These procedures vary depending on the nature of the adjustment and are often highly complex, sometimes even identical to the process of statutory enactment itself. Therefore, the Planning

Regulation-Constrained system demands a high standard of plan preparation; plans must be highly operational to serve as the statutory basis for development control.

2.2 Development Order-Guided Model: A Due Process Control System Based on Case-by-Case Discretion

The Development Order-Guided planning system is rooted in the tradition of common law. Its core philosophy recognizes the significant uncertainty inherent in future urban development, arguing that it is impossible to anticipate all potential scenarios for planning applications. Rigid planning would struggle to guide concrete practice effectively. The United Kingdom, along with countries and regions adopting British planning practices, such as Singapore and Hong Kong, originate from this model.

The UK established the foundation for this system with the Town and Country Planning Act 1947. This landmark legislation transferred all future development rights on private land to the state, effectively "nationalizing" development rights and instituting a "development permit" system. Unlike the self-enforcing nature of US zoning, development rules within UK local plans serve as reference points in planning permission decisions. Planning authorities possess discretionary power to consider other material considerations. Concurrently, the UK central government established general development rules (e.g., Permitted Development Rights), granting direct permission for minor development activities and compatible changes of use.

Within the Development Order-Guided system, development control is not rigidly tied to statutory plans. Statutory plans constitute only one basis for development control; planning permission can even be granted in the absence of an adopted plan. In practice, regulating development activities in this model relies more heavily on factors other than the plan itself. Factors influencing planning permission decisions include legislation, regulations, governmental planning policy documents, and local development characteristics. Furthermore, planning departments hold significant discretionary power. When reviewing individual development applications, they can attach specific planning conditions, and, where necessary, even modify certain stipulations of statutory plans.

Compared to statutory plans in the Planning Regulation-Constrained model, those in the Development Order-Guided model offer considerable flexibility. Taking the UK's "Local Development Framework" (LDF) as an example, a key characteristic is its legal establishment of mechanisms enabling plans to react swiftly to unforeseen events and developments. When unexpected circumstances necessitate plan modifications, only the specific paragraphs or sections of the LDF requiring adjustment need amendment, or an "Action Plan" can be prepared – avoiding the need for a comprehensive revision of the entire plan. This functions akin to a folder where new content can be added at any time, embodying its flexible and open nature.

For specific development activities, countries employing the Development Order-Guided model grant greater discretionary power to planning permission approval bodies and officials. This avoids the excessive rigidity and inflexibility often associated with blueprint-style planning. However, extensive discretion also introduces uncertainty. Consequently, such systems necessitate effective oversight and constraint mechanisms. For instance, while UK local planning authorities possess discretionary power over development applications, the existence of the Planning Inspectorate system provides oversight. When disputes arise between local planning authorities, developers, residents, or other stakeholder groups regarding a specific project, a Planning Inspector can intervene in the permission process for that particular development.

Ideally, regions implementing the Development Order-Guided planning system should meet the following conditions:1) Possess a comprehensive urban planning legal framework and related legislation. 2) Establish effective oversight and constraint mechanisms. 3)Employ highly qualified and professional management personnel.

2.3 Convergence and Evolution of the Two Models

The two planning control models each possess distinct characteristics, advantages, and disadvantages. Within

the Planning Regulation-Constrained system, statutory plans constitute the core basis for development control. To safeguard individual rights and ensure planning certainty, this system tends to employ specific regulations, such as density and floor area ratio (FAR), to establish quantifiable development limits, emphasizing regulatory rigidity and legal authority. Conversely, the Development Order-Guided system prefers broadly interpreted principles to maintain planning flexibility, thereby granting the system greater elasticity and adaptability. However, each system has its limitations: overly rigid restrictions can lead to inflexibility, while overly broad policy interpretations may leave policymakers and applicants lacking clear guidance for specific cases. Overall, the Planning Regulation-Constrained system reflects more administrative-level decision-making, whereas the Development Order-Guided system embodies more policy-level considerations. The practical differences between these two systems are significant.

The Planning Regulation-Constrained system excels in transparency and certainty but often lacks flexibility and adaptability. Its stringent restrictions may fail to achieve desired spatial forms, potentially resulting in outcomes misaligned with public expectations or satisfaction. On the other hand, the Development Order-Guided system can adapt to rapidly changing needs and development pressures. However, this system may suffer from insufficient transparency and uncertainty. Its high degree of flexibility and discretionary power can sometimes lead planning authorities to overlook the interests of the state or societal groups during decision-making, raising concerns about the fairness and rationality of planning outcomes.

In practice, both systems have evolved organically, incorporating elements and strengths from one another beyond their traditional foundations. For instance, the United Kingdom, drawing on its administrative law tradition, safeguards procedural rigor through detailed and transparent processes. The United States' zoning system has undergone significant reforms, introducing mechanisms such as Transferable Development Rights (TDR), Form - Based Codes, Zoning Variances, and Incentive Zoning. These additions infuse flexibility into the traditionally rigid zoning framework and offer effective tools for managing public facility provision and historic district preservation. Japan has developed a development control system with inherent flexibility, tailoring the zoning model to its national context. Meanwhile, Singapore, while inheriting the British system, has evolved a dynamic management framework centered on its Master Plan.

Today, the regulatory models in most countries and regions exhibit compatibility with *both* systems. Hong Kong SAR, China, exemplifies this hybrid approach: its land lease system primarily utilizes the Development Order-Guided mode, while its statutory plans operate in a planning-led manner, effectively leveraging the strengths of both models to form a hybrid development control system. For Mainland China, the decision-making mechanism for project development aligns with the Development Order-Guided system, employing an administrative licensing system where planning permission must be sought for authorization. Simultaneously, the *regulatory detailed plan* () adopted in Mainland China draws heavily from the US zoning-based development management system, exhibiting characteristics of the Planning Regulation-Constrained model.

Therefore, selecting New York (USA), Germany, the United Kingdom, Hong Kong SAR (China), Japan, and Singapore as comparative case studies is justified. This selection considers both the similarities these regions share within the spectrum of urban planning systems and their distinctive characteristics. Analyzing these cases offers valuable insights for refining the planning regulatory framework in Mainland China.

3 Comparative Analysis of Legal Frameworks and Regulatory Tools

The planning system generally encompasses three categories of regulatory tools: legislation, zoning regulations, and planning/building permits. These tools work in concert to achieve refined regulatory governance.

3.1 Legal Framework

Given that land development involves the rights and interests of multiple stakeholders—government, market, and society—a fundamental regulatory framework must be established through legislation. Most of the legal systems of the countries/regions all comprise two tiers: "primary legislation" and "secondary legislation".

Primary legislation serves as the core framework governing the overall system, supplemented by multiple pieces of secondary legislation that address specific issues with precision.

Jurisdiction	Primary Legislation & Regulations	Level of Authority
Germany	**Federal Building Code (*Baugesetzbuch - BauGB*)**	**Federal Legislation**
	Land Utilization Ordinance (*Baunutzungsverordnung - BauNVO*)	Federal Regulation
	State Building Code (*Landesbauordnung - LBO*) (e.g., for specific federal states)	State Legislation
	Binding Land-Use Plan (*Bebauungsplan - B-Plan*)	Municipal Regulation
Japan	**City Planning Act (*Toshi Keikaku Hō*)**	**National Legislation**
	Building Standards Act (*Kenchiku Kijun Hō*)	National Legislation
	Land Readjustment Act (*Tochi Kukaku Seiri Hō*)	National Legislation
	Urban Redevelopment Act (*Toshi Saikaihatsu Hō*)	National Legislation
	New Urban Area Development Act (*Shin Jūtakuchi Seibi Hō*)	National Legislation
	Urban Regeneration Special Measures Act (*Toshi Saisei Tokubetsu Sochi Hō*)	National Legislation
	Local City Planning Ordinance (*Chiho Toshi Keikaku Jorei*)	Local Regulation
	Local Construction Ordinance (*Chiho Kenchiku Jorei*)	Local Regulation
New York City, USA	**New York City Zoning Resolution**	**Local Regulation**
	Standard State Zoning Enabling Act (Model Act adopted by NY State)	State Legislation
	Standard City Planning Enabling Act (Model Act adopted by NY State)	State Legislation

Jurisdiction	Primary Legislation & Regulations	Level of Authority
Hong Kong SAR, China	**Town Planning Ordinance (Cap. 131)**	**SAR Legislation**
	Town Planning Regulations	SAR Regulation
	Town Planning (Appeal) Regulations	SAR Regulation
	Town Planning (Compensation) Regulations	SAR Regulation
	Town Planning (Application for Permission to Develop) Regulations	SAR Regulation
Singapore	**Planning Act (Cap. 232, 1998 Rev. Ed.)**	**National Legislation**
	Planning (Master Plan) Rules	National Regulation
	Planning (Development) Rules 2008	National Regulation
	Planning (Use Classes) Rules	National Regulation
	Planning (Development of Land Authorisation) Notification	National Regulation
United Kingdom	**Town and Country Planning Act 1990 (Core legislation; note: 1947 Act was foundational)**	**National Legislation**
	The Town and Country Planning (General Permitted Development) Order (England) [Year] (GDPO)	National Regulation
	The Town and Country Planning (Use Classes) Order [Year] (UCO)	National Regulation
	The Town and Country Planning (Development Management Procedure) (England) Order [Year]	National Regulation
	Local Development Orders (LDOs)	Local Regulation
	Neighbourhood Development Orders (NDOs)	Local Regulation

Figure 2: Primary Legislation and Regulations by Jurisdiction

The primary tasks of legislative tools include authorizing zoning regulations and land-use controls, providing general management rules, and specifying approval requirements.

(1) Authorizing Zoning Regulations and Land-Use Controls

Defining and authorizing zoning regulations is a fundamental task of the legal framework, typically stipulated by primary legislation. Legislation explicitly mandates that land-use control through zoning regulations is conducted according to law. From a global perspective, legislation universally emphasizes the critical role of use-based zoning control in achieving the rational allocation and sustainable utilization of spatial resources for urban development land. Legislation authorizes, often through enabling provisions, the competent authority,

preparation requirements, and content for implementing zoning regulations (see Table X). By establishing mandatory authorizations, legislation ensures the preparation and enforcement of zoning regulations, thereby solidifying the foundation for land-use control.

For example, the United States, through Article 1 and Article 2 of the *Standard State Zoning Enabling Act* (federal model legislation adopted by states), authorizes local governments to undertake zoning. Empowered by this authorization, local governments implement differentiated management based on land use distinctions. Different zones are subject to differentiated development standards, while zones of the same type adhere to uniform control standards. Regulation focuses on core indicators such as building height, total floor area, bulk, location, and permitted uses. Germany's Federal Building Code (*Baugesetzbuch - BauGB*), specifically §1, §5, and §9, establishes that controlling development uses is the core task of both the preparatory land-use plan (*Flächennutzungsplan*) and the binding land-use plan (*Bebauungsplan - B-Plan*). These plans function synergistically: the preparatory plan provides the basis for the binding plan, requiring a comprehensive overview of urban land-use types, while the binding plan focuses on specifying the precise types and scale of permitted development uses.Japan's City Planning Act (*Toshi Keikaku Hō*), under Article 8 and Article 15, stipulates that within City Planning Areas, Urban Plans (*Toshi Keikaku*) can designate various zones and districts, including Use Districts (*Yoto Chiiki*), Special Use Districts (*Tokutei Yoto Chiiki*), Height Districts (*Takasa Chiiki*) or High-Use Districts (*Kodo Riyo Chiiki*), and Special Blocks (*Tokutei Gaiku*). The Urban Plan specifies the types, locations, and boundaries of these zones and districts.

The authorization granted by legislation defines the applicable scope and boundaries of land use, providing precise guidance and clear legal basis for subsequent management.

Jurisdiction	Legal Basis	Plan / Zoning Name	Preparing Body	Key Content Requirements
Germany	Federal Building Code (*Baugesetzbuch*), **§1, §5, §9**	**Building Guidance Plans** (*Bauleitpläne*): - Preparatory Land-Use Plan (*Flächennutzungsplan*) - Binding Land-Use Plan (*Bebauungsplan*)	**Municipal Government** (*Gemeinde*)	- **Preparatory Plan:** Overview of land-use types for urban development across the entire municipal area. - **Binding Plan:** Specification of permitted development uses (type and scale); building methods; permissible/non-permissible development plots; building layout; etc.
Japan	City Planning Act (*Toshi Keikaku Hō*), **Art. 8, Art. 15**	**Zones and Districts** (*Chiiki Kuiki*)	**Municipal Government** (*Shichōson*)	Within City Planning Areas, Urban Plans must designate: - Use Districts (*Yoto Chiiki*) - Special Use Districts (*Tokutei Yoto Chiiki*) - Height Districts (*Takasa Chiiki*) / High-Use Districts (*Kodo Riyo Chiiki*) - Special Blocks (*Tokutei Gaiku*) Plans must specify: **type** (including specific purpose for Special Use Districts), **location**, and **boundary** of each zone.

United States	*Standard State Zoning Enabling Act*, **Sec. 1, Sec. 2** (Adopted by state legislatures)	**Zoning**	**Local Government** (City/County)	Local legislatures may divide territory into districts of appropriate **number, shape, and area** to achieve the Act's purposes. Regulations may control: - Construction/alteration/repair of buildings/structures - Land use Regulations must be **uniform** within each district but may **differ** between districts.
Hong Kong SAR	Town Planning Ordinance (Cap. 131), **Sec. 3, Sec. 4**	**Statutory Plans**	**Town Planning Board** (TPB)	Plans may depict or stipulate: - Streets, railways, major transport facilities - Zones/areas for residential, commercial, industrial, or other specified uses **Any matter** may be expressed via diagrams, illustrations, notes, or descriptive text – all integral to the plan.
Singapore	Planning Act (Cap. 232), **Sec. 5, Sec. 6, Sec. 8**	**Master Plan**	**Urban Redevelopment Authority** (URA)	The approved Master Plan comprises: - Authorized maps - Written statement Proposed revisions may include: - Rezoning - Changes to plot ratios (FAR) - Amendments to written statements - Designation of conservation areas

Figure 3: Authorization of Zoning/Land-Use Plans by Jurisdiction

(2) Providing General Management Rules

Legislation provides unified standards and general management rules for land-use control, establishing clear regulatory guidance. The combined management approach focusing on "Land Use + Building Function" requires stipulation within these general rules. Benchmark countries and regions typically define these within secondary legislation.

For instance, Germany's Land Utilization Ordinance (*Baunutzungsverordnung - BauNVO*), Articles 2 to 9, defines types of development land and the building facility uses permitted (or permitted under exceptional circumstances) within each land-use category.Japan's Building Standards Act (*Kenchiku Kijun Hō*), Article 48, specifies the permissible building scope within the land uses designated under the *City Planning Act*.New York City's Zoning Resolution, notably Chapters 2 (§2), 3 (§2), and 4 (§2), clearly defines permissible building uses and detailed control requirements within each land-use zoning district.

These provisions ensure the standardization and normalization of regulatory activities, provide clear guidance and general principles for urban development, and enhance regulatory efficacy.

(3) Specifying Approval Requirements

Legislation establishes a detailed legal framework for the application and approval of planning permission, ensuring transparency and impartiality in the approval process. Key requirements specified in legislation typically include scope and types of permits, application procedures, procedures for permit modifications, and approval criteria. Examples include Singapore's Planning Act, Part III "Development and Subdivision of Land", which outlines the types of permits and corresponding application procedures. Japan's City Planning Act, Chapter 3, Section 1 "Regulation of Development Activities, etc.", specifies the procedures for permit applications, criteria for development permission, procedures for permit modifications, and requirements for project completion inspections. New York City's Zoning Resolution, Chapter 7 "Administration", details requirements for zoning enforcement, administration and amendments, zoning variances, special permits, authorizations, and certifications. By establishing strict approval procedures, legislation provides clear legal grounding for the approval process, ensuring the effective implementation of land-use controls.

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3.2 Zoning Regulations

The primary task of zoning regulation preparation is to guide rational land zoning. As a vital urban planning tool, its universal principle lies in rationally dividing and controlling urban space by explicitly defining land development uses. This aims to optimize urban functions, achieve efficient resource utilization, and foster coordinated social, economic, and environmental development. Both domestically and internationally, the core task of zoning regulation preparation focuses on land-use zoning for urban areas, guiding orderly urban development, safeguarding public interests, accommodating sustainability requirements, and ensuring land-use rationality for the city's long-term healthy development.

The hierarchical structure of zoning regulations falls into two categories: single-tier and multi-tier systems. In Germany, a multi-tier system is used, with the Preparatory Land-Use Plan (Flächennutzungsplan - F-Plan) providing an overview of land uses for urban development across the entire municipality, indicating the overall development intent and guiding the preparation of the Binding Plan. The Binding Land-Use Plan (Bebauungsplan - B-Plan) then regulates the specific development uses for individual plots in the form of local regulations, serving as the direct basis for permit approvals.

Single-tier examples include Japan's Use Districts (Yoto Chiiki), Hong Kong SAR's Use Zones (within Statutory Plans), New York City's Zoning, Singapore's Master Plan, and China Shanghai's three-tier Territorial Spatial Planning System comprising the "Master Plan," "District Plan," and "Regulatory Detailed Plan".

Regarding the legal nature of zoning regulations, they generally fall into two categories, both serving as a basis for permit approvals. Statutory Plans are documents with legal force that guide development control, such as Germany's Preparatory Land-Use Plan (F-Plan), Singapore's Master Plan, and Hong Kong SAR's Statutory Plans. Statutory Plans That Are Also Regulations possess the dual nature of being both the planning document and the legally binding regulatory instrument itself. Examples include Germany's Binding Land-Use Plan (B-Plan) (Municipal Regulation), New York City's Zoning Resolution (Local Regulation), and Japan's Use Districts System (established by the City Planning Act and implemented via local ordinances)

3.3 Planning and Building Permits

(1) Defining Development Activity

Definitions of "development" share common core elements across different countries and regions, specific phrasing and emphases vary according to local contexts and planning management needs. Generally,

"development" encompasses activities such as new construction, renovation, expansion, functional conversion (change of use), and demolition. Internationally, change of use is universally treated as development, requiring planning permission or building permits.

Jurisdiction	Legal Basis	Specific Definition
Germany	Federal Building Code (*Baugesetzbuch - BauGB*), **§29**	Construction of new building facilities; modification or functional conversion (*Funktionsänderung*) of existing buildings; large-scale earthworks (*Erdaufschüttungen*), excavations (*Aushub*); quarrying (*Gewinnung von Bodenschätzen*).
Japan	City Planning Act (*Toshi Keikaku Hō*), **Art. 4**	"Development Activity" (*Kaihatsu Kōi*) refers to changes to the nature of land division (*tochi kukaku-sei no henkō*) undertaken primarily for the construction of buildings or specified structures (*tokutei kōbutsu*).
New York City, USA	Zoning Resolution, **§12-10**	"Development" on a zoning lot or part thereof includes: (a) Construction of a new building or other structure; (b) Relocation of an existing building or other structure to another zoning lot; or (c) Establishment of a new open use (*excluding* accessory uses). Alterations within the scope of §11-23 (Demolition and Replacement) are deemed development.
Hong Kong SAR, China	Town Planning Ordinance (Cap. 131), **Sec. 1A**	"Development" means the carrying out of building, engineering, mining, or other operations in, on, over, or under any land, or the making of any **material change** in the use of any land or buildings. A material change includes the deposit of materials on land, regardless of prior use for deposit, if the deposit increases in area, height, or quantity.
Singapore	Planning Act (Cap. 232), **Sec. 3**	"Development" means the carrying out of any building, engineering, mining, **earthworks**, or other operations in, on, over, or under any land, or the making of any **material change** in the use of any building or land.

Figure 4: Conceptual Definitions of "Development" Across Jurisdictions

In Mainland China, "" (*kāifā* - development) has not been formally established as a statutory term within planning laws, policies, or planning documents. Urban-rural planning management has long centered on the concept of " (*jiànshè* - construction). For instance, within the permit system, the " (Land Use Planning Permit) and " (Construction Engineering Planning Permit) are key statutory documents. Article 40 of China's *Urban-Rural Planning Law* stipulates: "For the construction of buildings, structures, roads, pipelines, and other engineering projects within urban and town planning areas, the construction unit or individual shall apply to the competent urban-rural planning department of the city or county people's government, or the town people's government designated by the people's government of the province, autonomous region, or municipality directly under the Central Government, for a Construction Engineering Planning Permit." This defines the legal scope of "" (*jiànshè* - construction).

However, the concept of "construction" (*jiànshè*) essentially represents only one specific type of activity within the broader scope of "development" (*kāifā*). It has a relatively narrow focus, primarily emphasizing physical building activities. It fails to comprehensively encompass broader development activities such as changes of use or functional conversions. Particularly within the context of territorial spatial planning, where planning objectives are more diverse and management elements more complex, the limitations of the "construction" concept become increasingly apparent. It struggles to meet the demands of multi-objective planning and multi-faceted management.

(2) Permit Types

Regarding permit types, all regions have Building Permits to regulate specific construction proposals. Some countries and cities also have Planning Permits to authorize development proposals from a planning perspective. International experience reveals two primary management process types:

'Building Permit' System (Planning Regulation-Constrained Model - e.g., Germany, New York):Employs blueprint-style planning defining use zones. The plan itself is a legal document, establishing "As-of-Right" development through regulation.Grants landowners the right to develop land compliant with the plan via prior authorization. Legitimate development is protected by law; compliance automatically grants permission.Once the plan is approved, implementation primarily occurs through Building Permits.If development deviates from the plan or necessitates plan adjustments for other reasons, it requires following statutory procedures for zoning variances or special permits.

'Planning Permission + Building Permit' System (Development Order-Guided Model - e.g., UK, Singapore, Hong Kong SAR):Planning control relies on case-by-case administrative discretion. Development control is not rigidly tied to statutory plans.Statutory plans serve as only one basis for control; planning permission can even be granted *in the absence* of an adopted plan.Regulating development relies more heavily on other factors (legislation, regulations, government policy documents, local development characteristics) than the plan itself.Planning authorities hold significant discretionary power. They can attach specific planning conditions to permissions and, where necessary, modify stipulations of statutory plans when reviewing applications.

Mainland China's current system resembles Model 2, employing "Planning Permits + Construction Permits". However, it incorporates localized procedures such as land grant contracts and property rights registration, adding complexity, particularly for functional adjustments.

(3) Permit Categories
Permit requirements can be categorized into Conventional Permits and Exempt Permits. Exempt Permits grant authority for certain development activities with minimal external impacts to proceed without applying for planning permission. Most countries requiring planning permission explicitly define development activities eligible for exemptions.

• **Singapore**: Establishes an "Exemption List" outlining minor developments or construction works that do not require planning approval or a permit from the Urban Redevelopment Authority (URA).

• **Hong Kong SAR**: Beyond Conventional Permits, many changes of use do not require planning permission. Hong Kong classifies all land uses into 18 Broad Use Classes. Once planning permission is granted for a specific Broad Use Class, any use within that class can be changed to another use within the same Broad Use Class without requiring a new planning application.

• **Japan**: Only development activities exceeding a specific scale threshold require a Development Permit. The City Planning Act clearly defines activities subject to Development Permit regulation, primarily including development over 1,000 m² in urbanization promotion areas (UPA). This threshold is lowered to 500 m² in existing built-up areas within the three major metropolitan areas. In principle, all development activities within urbanization promotion areas (UPA) and urbanization control areas (UCA) require a Development Permit. Development activities over 3,000 m² in non-designated city planning areas and quasi-city planning areas also require a permit. Development activities deemed publicly beneficial (e.g., libraries) with no adverse impact on surrounding land use, and those below the specified scale threshold (such as small-scale changes of use), do not require a Development Permit and can proceed as long as they comply with relevant regulations

4 Comparative Analysis and Reform Implications: Towards a Regulatory System Balancing Precision and Adaptability
Within the global urban planning domain, regulatory systems continue to evolve primarily within the dual framework of the "Planning Regulation-Constrained" and "Development Order-Guided" models. However, as urban development enters the stock era, both models face pressures for transformation. This chapter aims to provide a systematic and in-depth comparative analysis of these two models, examining their institutional efficacy, legal tools, and practical challenges. Building on this analysis, it proposes optimization pathways applicable to the

planning regulatory system in Mainland China.

4.1 Re-evaluating Model Efficacy: The Trade-off Between Certainty and Adaptability

The Planning Regulation-Constrained model, exemplified by Germany and the US, demonstrates significant strengths in legal certainty and efficiency. For instance, Germany's *Binding Land-Use Plan (B-Plan)* and the US *Zoning Ordinance*, as direct authorization documents, grant "As-of-Right" development for compliant activities, substantially reducing approval process costs. However, this model has limitations; its rigid rules can lead to spatial governance failures. In New York, zoning proved slow to respond to mixed-use demands, resulting in the redevelopment of old industrial areas becoming trapped in a "compliant yet functionally mismatched" dilemma. In Germany, amending a B-Plan requires complex procedures, including municipal council votes, severely delaying the renewal of historic districts.

The Development Order-Guided model, typified by the UK and Singapore, excels in dynamic adaptability. The UK's paragraph-based amendment mechanism for its *Local Development Framework* allows adjustments only to changed sections. Singapore employs an "Exemption List" to exclude temporary structures and minor alterations from permitting, effectively enhancing responsiveness. Nevertheless, the exercise of discretionary power carries fairness risks. In Hong Kong SAR, the planning permission process has exhibited bias towards high-value commercial uses (e.g., hotels), sparking community protests. In the UK, a lack of transparency in local discretion has exacerbated conflicts between developers and residents. Thus, while both models have merits, a single model struggles with the complexities of the stock era. Consequently, integrating "rule precision" with "procedural adaptability" becomes an imperative choice.

4.2 Core Challenges of the Stock Era

Contemporary global urban regeneration faces significant challenges rooted in fragmented property rights, growing demand for functional mixing, and high institutional costs. In high-density built-up areas, such as Shanghai's Lilong alleyway housing or Tokyo's Shitamachi downtown, traditional zoning struggles to balance compensation standards among numerous stakeholders. Japan's Urban Regeneration Special Measures Act attempts to introduce third-party assessments, but controversies persist. Meanwhile, the dynamic integration trend of living-working-innovation spaces challenges the logic of single-use zoning. New York zoning only began piloting "Work-Live Districts" in Manhattan in 2021, reflecting a lag in responding to mixed-use needs. Additionally, the lengthy and cumbersome procedures for amending zoning regulations create severe misalignment with the market's demand for rapid iteration. For instance, in Mainland China, adjusting a Regulatory Detailed Plan requires an approval period of 6-12 months.

4.3 Lessons Learned and Optimization Pathways

Based on the systematic analysis and comparison of the two models, and taking institutional optimization in Mainland China as an example, the following pathways are proposed for refining urban planning regulation:

Drawing on international experience and adapting to China's context, establishing a four-dimensional reform framework encompassing "Law - Tools - Procedures - Governance" is crucial.

Based on the systematic analysis and comparison of the two models, and taking institutional optimization in Mainland China as an example, the following pathways are proposed for refining urban planning regulation. Drawing on international experience and adapting to China's context, establishing a four-dimensional reform framework encompassing "Law - Tools - Procedures - Governance" is crucial.

(1) Multi-tiered Legal Framework: Enact a national-level Territorial Spatial Planning Law establishing foundational rules. At the local level, introduce supplementary Administrative Technical Regulations featuring a "Negative List + Flexible Conversion" mechanism to enhance legal flexibility and adaptability.

(2) Innovative Regulatory Tools: Introduce Dynamic Use Packages, designating "Innovation Mixed-Use Zones"

allowing flexible configuration of residential, commercial, R&D, etc., based on actual demand. Establish a Refined Exemption Mechanism with a "Minor Renewal List" to fully unleash the vitality of micro-regeneration. Pilot Development Rights Banking, drawing on the US TDR model to balance conservation and development.

(3) Streamlined Approval Procedures: Implement an "Online Permit Platform" to drastically reduce approval cycles to under 30 days. Establish an Independent Planning Inspectorate dedicated to arbitrating property rights disputes, enhancing the fairness and efficiency of approvals.

(4) Governance Model Transformation: Shift from traditional administrative control towards collaborative contracting. Incorporate Public Facility Provision Clauses within land grant contracts. Institute a "Community Planner" system to foster multi-party consensus and synergistic action.

The ultimate goal is to achieve a precise balance between safeguarding public interests and meeting dynamic market demands through an institutional design of "Rigid Bottom Lines + Flexible Space". This will build an urban planning regulatory system that is both nationally appropriate and internationally competitive, providing a robust foundation for sustainable urban development.

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Comprehensive Evaluation of Child-Friendly Public Spaces: The Zümrütevler Case as Istanbul's First Permanent Two-Stage Street Transformation

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Abstract
In rapidly urbanizing cities, creating child-friendly public spaces is essential for supporting children's independent mobility, safety, and well-being. Child-centred street transformations, often implemented through phased tactical urbanism approaches, aim to reconfigure vehicle-dominated areas into inclusive, pedestrian-friendly environments. This research critically evaluates the Zümrütevler Square transformation in Istanbul using a multi-scale framework covering process, neighbourhood context, and design details. The study broadens its scope by incorporating user behaviour analysis alongside design criteria, offering deeper insights into the lived experience of the space. Findings highlight successful participatory design and iterative adaptation but reveal limitations in sustaining child-friendly identity post-implementation, constrained child visibility, and institutional fragmentation. The study underscores the importance of integrating flexible, context-sensitive criteria and behavioural observations to enhance long-term child-friendly urban interventions in dense metropolitans.

Keywords: child-friendly; street transformation; public space; design guidelines; user behaviour

Introduction

In today's rapidly evolving urban landscapes, the well-being and development of children are increasingly central to city planning agendas. By 2030, it is estimated that 60% of the global population will be under the age of 18, highlighting the urgent need to consider children's needs in urban development. Urban environments play a pivotal role in shaping childhood experiences, and access to safe, engaging public spaces is essential for their physical, mental, and social well-being. As cities densify and open spaces become more limited, the question of where and how children can play and move safely gains critical importance. Contemporary shifts in neighbourhood dynamics have led to a reduction in outdoor spaces and limited children's independent interactions with their environment. While the value of child-friendly public spaces has long been recognised, creating and sustaining them in densely built environments has become increasingly challenging. For instance, the Welsh Assembly (2002) emphasises that play is fundamental for children's development and that communities should provide environments that support play opportunities.

The concept of a child-friendly city has gained significant attention, representing a broader movement toward creating urban spaces that are not only safe and accessible but also enriching for children's cognitive and social development. Urban designers, architects, and local governments are increasingly recognising children as essential urban actors, advocating for policies and designs that address their unique needs. Krysiak (2020) underlines that when children are ignored in the design process, they are effectively excluded from urban life, limiting their opportunities for growth and participation. One key strategy in advancing child-friendly urbanism is the transformation and pedestrianisation of streets—the very first public spaces children experience. These projects often begin with temporary interventions, using a phased or tactical urbanism approach. This allows cities to pilot changes, observe user reactions, and adapt plans before committing to permanent transformations. In this framework, streets are reimagined as accessible and stimulating spaces for children's daily activities, safe movement, and social interaction.

A prominent example of this strategy is the Zümrütevler Square transformation project in Istanbul, Türkiye. Implemented in two stages, this initiative converted a vehicle-dominated area into a pedestrian-friendly public square. It represents a pioneering case of phased child-friendly urban intervention in Türkiye, particularly significant given the city's high population density and limited open space. Such projects not only provide physical improvements but also aim to shift public perceptions, promote non-motorised mobility, and foster inclusivity, especially for vulnerable groups such as children, the elderly, and those with limited mobility. However, while

phased strategies offer flexibility and encourage public participation, they also present challenges in maintaining the integrity of the original design vision during the transition to permanent implementation. Revisions made for regulatory, political, or budgetary reasons may compromise the child-centred intent, raising questions about the sustainability and long-term effectiveness of such interventions. This study explores whether child-friendly environments created through phased street transformations retain their intended qualities once they are permanently implemented. The primary focus is on assessing both the child-friendliness and sustainability of these transformed spaces. The key research questions are:

- What methods and criteria can be used to measure child-friendliness at different scales?
- How do planning and design decisions at each stage affect the use and perception of space?
- Can spaces temporarily designed to be child-friendly retain their effectiveness after becoming permanent?
- How can sustainability be ensured in long-term child-centred street design?

This research centres on street transformations within metropolitan areas, with Istanbul as the main case context. It examines how car-dominated urban design limits children's mobility, safety, and access to social space, and how phased urban interventions can offer more inclusive alternatives. The study particularly investigates Zümrütevler Square, offering a detailed case analysis to evaluate the design and implementation process, as well as the space's current performance. The scope also includes a review of international urban design guides and case examples from other cities, which inform the evaluation framework used in the fieldwork. The study adopts a case study approach structured across three spatial levels:

- The transformation process (planning, decision-making, and implementation strategy)
- The neighbourhood scale (surrounding land use, accessibility, safety)
- The design detail scale (materials, play elements, inclusivity)

Evaluation criteria are synthesised from five international child-friendly street design guides and adapted to suit the local context. Fieldwork combines qualitative and quantitative methods, including document analysis, stakeholder interviews, field measurements, pedestrian counts, and behavioural mapping. This multiscale and interdisciplinary approach supports a comprehensive evaluation of both the child-friendliness and sustainability of the space, contributing a replicable framework for future urban design research and practice.

Children in Public Spaces

In modern societies, it is commonly believed that children today are more privileged than previous generations due to access to technology and a wide range of leisure activities available after school and on weekends (Freeman & Tranter, 2012). However, this perception raises a critical question: Are today's urban environments truly more beneficial for children, particularly regarding their ability to move freely and independently within the city, or are they still reliant on adult supervision? (Freeman & Tranter, 2012). Understanding how children interact with urban spaces begins with identifying the public environments they use outside the home. Public spaces—such as squares, boulevards, streets, playgrounds, and in-between areas—are more than physical locations; they are social and functional hubs that support daily life, infrastructure, and community interaction (UN-Habitat, 2020). Among these, streets are especially significant, forming the primary network for urban mobility and access, directly influencing how people navigate and connect within cities (GDCI, 2019).

The term "Child-Friendly Cities" was first introduced at the 1996 Habitat II Conference in Istanbul, which led UNICEF to launch the Child-Friendly Cities Initiative (CFCI) in the same year (UNICEF, n.d.). The initiative was designed to help local governments implement the UN Convention on the Rights of the Child by addressing children's needs at the municipal level. Over time, CFCI has evolved into a global platform involving not only local authorities but also NGOs, the private sector, academia, media, and children themselves, promoting collaborative efforts for more inclusive urban environments (UNICEF, n.d.). Although initially targeted at large urban centres, the initiative has extended its influence to smaller towns, encouraging the integration of children's rights into urban policies. The CFCI defines child-friendly cities as those that support children's rights across various domains—including

play, safety, green space, and access to services—many of which are directly linked to urban design (UNICEF, n.d.). Aligned with the UN Sustainable Development Goals, particularly Goal 11, CFCI promotes urban strategies that prioritize inclusivity, safety, and sustainability. Through the provision of playgrounds, green areas, and safe streets, the initiative contributes to making cities healthier and more accessible for children (UNICEF, n.d.).

Cities that provide safe environments, accessible amenities, and pedestrian-oriented infrastructure significantly reduce children's risk of injury. A child's ability to walk or play safely near home reflects a higher urban safety level and contributes to their physical, emotional, and cognitive well-being. Designing cities with children's needs in mind enhances inclusivity and benefits all residents. While inclusivity remains a major challenge in urban planning, prioritizing child-friendly environments—through safe streets, accessible green spaces, and improved public services—offers a promising approach. Thus, child-oriented design should ensure safe mobility, access to play and learning spaces, school routes, and inclusive public areas.

Child-Centred Street Transformation

With the rise of private vehicle use in the mid-20th century, urban residential design began to prioritize drivers' comfort over pedestrian needs (Krysiak, 2021). According to a report by the Gehl Institute and BvLF (2018), streets should not be limited to corridors of movement but reimagined as active public spaces, particularly for young children who often have limited mobility and rely on streets to access public life. Despite growing awareness of the long-term environmental, economic, and health drawbacks of car-centric planning, its impacts on children's daily experiences have only recently gained attention (Krysiak, 2021). The decline in street play has weakened children's relationship with public space, a contrast to previous generations. Moreover, increased car dependency exacerbates inequalities, as not all children have access to private transport or adult accompaniment, limiting their autonomy in traffic-heavy areas.

The restriction of Children's Independent Mobility (CIM), largely due to the dominance of vehicles on urban streets, not only increases the risk of traffic accidents but also reduces children's visibility in public spaces, heightening parental fears such as "stranger danger" (Freeman & Tranter, 2012). This aligns with Jane Jacobs' concept of "eyes on the street," where fewer people—especially children—lead to less natural surveillance and diminished street vitality. Limited street access prevents children from developing road safety skills and disconnects them from urban life. As a result, children miss out on the joys of walking, exploration, and forming a spatial connection with their neighbourhood, fostering a more isolated and sedentary lifestyle (O'Brien, 2003).

Designing streets with children in mind enhances mobility and inclusivity across age groups. Former Bogotá mayor Enrique Peñalosa emphasizes that the presence of children in public spaces is a key indicator of urban liveability, highlighting the importance of predictable and safe traffic environments (Gill, 2017). Transforming streets to allow safe walking and play opportunities empowers children, reduces parents' need to chauffeur them, and strengthens neighbourhood ties through increased social interactions. Krysiak (2021) urges planners and designers to reconsider why urban streets often prioritize vehicle efficiency over children's well-being. Promoting active mobility through thoughtful design not only benefits children but also supports a more cohesive and playful urban fabric by reinforcing community bonds and creating healthier public spaces.

Freeman and Tranter (2012) demonstrate that increased vehicle use over time has led to a decline in children's independent mobility (CIM), reducing opportunities for risk assessment and developmental growth through everyday routines like street crossing. Their findings also indicate a shift in travel modes, with a significant rise in private car use and a corresponding decline in walking and public transport among children (Freeman & Tranter, 2012, pp. 187–188).

The dominance of motor vehicles on urban streets significantly impacts traffic safety for all residents, especially children. Increased vehicle presence and fears of "stranger danger" have reduced children's independent mobility, a critical issue considering that road crashes are the second leading cause of death among children aged 5–14, emphasizing the need for integrating traffic safety into child-friendly urban design (Welle et al., 2015).

Traffic safety concerns extend beyond children, affecting vulnerable populations such as low-income groups, the elderly, and individuals with disabilities, due to insufficient infrastructure and limited mobility options (Welle et al., 2015). The reduction of pedestrians on streets decreases indirect supervision of children, further limiting their street use and independence. Neighbourhoods are generally defined as areas reachable within a 20-minute walk, a benchmark for liveability and equity in urban design (Gürdoğan, Gürdoğan & Thomsen, 2020). To promote pedestrian-friendly neighbourhoods, streets should be redesigned with a focus on walkability, especially in low-traffic areas, using cost-effective interventions (Gürdoğan et al., 2020). The ITDP's "Pedestrian First" project underscores walkability's benefits for equity, resilience, environment, health, economy, and social cohesion (Url-13). Short distances to facilities, notably schools, are vital for children's mobility; walking rates decline sharply beyond 0.5 km, with car use increasing past 1.6 km (Barker, 2006). Policies such as local speed limits and traffic calming can enhance children's independent mobility (Freeman & Tranter, 2012). The "Pedestrian First" initiative also recommends mixed-use development, improved public transport integration, smaller blocks for pedestrian permeability, and expanded car-free zones to support child-friendly neighbourhoods (Url-13). Child-focused street transformations, including temporary closures and permanent design changes, are emerging policy tools worldwide to promote child-friendly cities. Tactical urbanism, defined as low-cost, scalable, short-term interventions with long-term goals, facilitates such transformations by enabling community involvement and testing design possibilities before permanent implementation (Lydon et al., 2011; Yassin, 2019; Silva, 2016). This approach bridges bottom-up and top-down efforts, enhancing governmental and citizen collaboration for successful urban change (Yassin, 2019). Koçaş and Kısar Koramaz (2024), who examined the child-friendly approaches of different administrations, found that involving children and caregivers in the process is a common practice; however, their strategic approaches vary, and this diversity contributes to more inclusive urban designs.

Temporary street transformations gained increased attention during the COVID-19 pandemic, as reduced vehicle traffic and the heightened need for outdoor play spaces near residential areas encouraged the use of streets as playgrounds for children. Tactical urbanism methods facilitate low-cost, temporary street closures that activate public spaces and reprioritize street use. For example, Bristol's "Play Street" initiative exemplifies how such interventions can be implemented with minimal resources (Playing Out, 2014). The concept of play streets, however, dates back to the early 20th century, pioneered by Joseph Lee and gaining legislative support through the 1938 Street Playgrounds Act in the UK. This act permitted local authorities to temporarily close streets to traffic to provide safe play areas for children. Although popularity declined mid-century due to increased car usage and urban transformation, a resurgence has occurred since 2008, driven by community initiatives and government backing, highlighting the social and health benefits of play streets.

Permanent street transformations include the development of "home zones" or 'Woonerf,' a concept originating in the Netherlands and widely adopted in Europe. These shared streets balance the needs of pedestrians, cyclists, children, and drivers by incorporating traffic-calming measures such as reduced speed limits, signage, speed bumps, and street curvature to slow vehicle movement (Lydon, 2011). Woonerfs eliminate curbs to create multifunctional community spaces, with elements like trees and planters serving as natural barriers to maintain low vehicle speeds. Participatory approaches involving residents and children in design activities, such as the Sustrans DIY Streets project, foster greater community ownership and efficacy (Url-2). Signage marking shared zones helps inform drivers of the pedestrian priority (Url-3). A phased design strategy, or "transformation rehearsal," is another approach for permanent street changes that emphasizes gradual implementation and stakeholder involvement. This method allows residents, local authorities, and NGOs to collaboratively refine designs before major investments, facilitating data-driven decision-making and enhancing community participation (Gürdoğan et al., 2020).

Design guidelines serve as critical frameworks for achieving and evaluating child-friendly street designs, facilitating both the design process and the assessment of implemented spaces. Five distinct design guides, developed for various countries and global contexts, provide diverse perspectives on creating child-centred neighbourhoods and public areas. Among these, three guides were prepared with consultancy from the Bernard van Leer Foundation, which supports governments worldwide in enhancing wellbeing for young children and

their caregivers. Additionally, design guides from organizations such as UN-Habitat, ITDP, and WRI contribute further global and regional insights, enabling a comprehensive comparison of child-friendly urban design approaches.

Methodology

Five different child-friendly urban design guides were reviewed, with parameters from three guides selected for direct inclusion in the methodological framework due to their systematic structure and the clarity and measurability of their criteria. All three were developed under the consultancy of the Bernard van Leer Foundation, providing diverse perspectives across different scales, enabling a multi-scalar comparative evaluation. Although the other two guides were not directly included in the methodology, they contributed conceptually by offering complementary insights. The parameters from the three selected guides were compiled, systematically analysed, and grouped, consolidating overlapping or conceptually similar criteria into singular evaluation parameters, while unique parameters were retained individually. Criteria related to the decision-making process were mainly drawn from the NACTO & GDCI (2019) and the Government of India (2019) guides, as no transformation process criteria were found in the Government of Israel (2023) guide. Ultimately, seven key parameters, shown in Table 1, for the decision-making process in creating child-friendly spaces were identified and used as process evaluation criteria within the research methodology.

Table 1 Compilation of the parameters for the decision-making process from the child-centred design guidelines.

NACTO & GDCI (2019)	India (2019)	Israel (2023)	The Parameters for Evaluation
Prepare an action plan.	-	-	Prepare an action plan.
Collaborate with multiple stakeholders.	Collaborative efforts, alliances for public spaces, and self-directed initiatives	-	Fostering inclusive participation through partnerships and collective action
Involve children and caregivers in the process.	-	-	Involve children and caregivers in the process.
Experiment with various analysis and decision-making methods.	A combination of short-term, hands-on action, and long-term strategies	-	Adaptive planning, balancing experimental approaches
Showcase possibilities.	Quick trial-and-error solutions	-	Encourage experimentation through temporary interventions and showcase potential solutions
Temporarily open streets to children.		-	
-	Oversight and coordination of place	-	Oversight and coordination of place
-	Evaluation of expenses and advantages	-	Evaluation of expenses and advantages

Child-focused design guidelines outline parameters for developing child-friendly neighbourhoods, emphasizing both macro-scale elements such as accessibility and land use that address the needs of children and caregivers, as well as micro-scale details like façade treatments and vehicle restriction measures. Neighbourhood-scale criteria support inter-scale evaluation by integrating broader environmental factors—including the quantity and proximity of green spaces, playgrounds, and schools relative to the transformed street area—thereby facilitating

a comprehensive assessment of child-friendliness beyond isolated street interventions. Parameters from three child-focused design guides were compiled, as shown in Table 2, revealing thematic overlaps such as clustering to reduce travel distances and the presence of nearby child-friendly facilities. These overlapping criteria were consolidated into unified parameters, streamlining the evaluation framework and demonstrating how multiple design guides converge on similar priorities for creating child-friendly urban environments. Also, the parameters are categorized into groups such as land use and accessibility, vehicle and pedestrian traffic and activity analysis enabling organized evaluation of related details.

Table 2 Compilation of neighbourhood scale criteria obtained from three different child-centred design guides.

<table>
<tr><th>NACTO & GDCI (2019)</th><th>India (2019)</th><th>Israel (2023)</th><th>The Parameters for Evaluation</th></tr>
<tr><td rowspan="4">Reduce trip journey by clusters</td><td>Minimum 300 m to existing open spaces</td><td rowspan="2">Near child-friendly facilities</td><td rowspan="4">Reduce trip journey with keeping the distances (minimum 300 m to open spaces, nursery school, health facilities, and minimum 600 m to primary school)</td></tr>
<tr><td>Minimum 300 m to nursery school</td></tr>
<tr><td>Minimum 600 m to primary school</td><td rowspan="2">Open spaces for play near home</td></tr>
<tr><td>Minimum 300 m to existing health facilities</td></tr>
<tr><td>Local mobility parks</td><td>-</td><td>-</td><td>Local mobility parks</td></tr>
<tr><td>Low speed regions in child-densed areas</td><td>Set speed limits</td><td>Traffic-calming measures</td><td>Traffic-calming measures</td></tr>
<tr><td>Pedestrian-first or car-free zones in pedestrian densely areas</td><td>Prevent unnecessary traffic</td><td>Encourage walking</td><td>Pedestrian-first zones to encourage walking</td></tr>
<tr><td>Low-emission zones</td><td>-</td><td>-</td><td>Low-emission zones</td></tr>
<tr><td></td><td>Active facades</td><td>-</td><td>Active facades</td></tr>
<tr><td></td><td>Windows and main doorways</td><td>-</td><td>Windows and main doorways</td></tr>
</table>

Three distinct design guidelines centred on children and their caregivers provide detailed parameters for creating child-friendly streets. These parameters, synthesized and simplified in this section, culminate in a consolidated list of 36 criteria essential for child-friendly street design, as shown in Table 3. The 36 detailed parameters from child-focused design guides encompass elements like floor materials, borders, and dimensions. These parameters are categorized into groups such as pedestrian crossings, walk paths, urban furniture, play opportunities, green spaces, and design materials, enabling organized evaluation of related details. The analysis reveals that certain details appear across multiple categories; for instance, obstacles are addressed both in pedestrian crossing parameters and in considerations impacting sidewalk comfort and accessibility for disabled users. Furthermore, the guidelines include precise measurements related to seating elements, emphasizing their spatial relationships with surrounding features such as trees and playgrounds. This comprehensive detailing ensures that design elements are evaluated holistically, accounting for their multifunctional impacts within the urban environment. By integrating overlapping criteria, the consolidated parameter list provides a structured framework for assessing and guiding child-friendly street design across multiple facets.

Table 3 Compilation of design scale criteria obtained from three different child-centred design guides.

NACTO & GDCI (2019)	India (2019)	Israel (2023)	The Parameters for Evaluation
Short crossings at least 1.8 m wide, and ideally 2.4 m wide)	-	-	Short crossings at least 1.8 m wide, and ideally 2.4 m wide)
Frequency of crossings (every 50 to 100 m, no more than 200 m)	Crossings with regular intervals	Street-height crosswalks (every 50-100 m)	Pedestrian crossings every 50 to 100 m
Legible crossings (markings should be at least 3 m wide)	Visible and bright colored crossings	-	Visible, wide and bright crossings
At-grade crossings (a rised to match the sidewalk level)	-	Raised crosswalks	Raised crosswalks
Visibility of crossings (No parking within 6 to 8 m of intersections, stop bars at least 3 m from crossings, and minimize visual obstructions within 3 to 5 m of crossings)	No obstruct on crossings	Accessible crosswalks	No parking within 6 to 8 m of intersections, stop bars at least 3 m from crossings, and minimize visual obstructions within 3 to 5 m of crossings
	Parked cars far away		
-	Visible corners	Expanded street corners	Visible corners
Clear walkpath (at least 1.8–2.4 m wide in residential settings, 2.4–4.5 m wide in downtowns, school zones, or commercial areas)	-	Continuous, accessible and obstruct-free pathways	Continuous, accessible and obstruct-free pathways (at least 1.8–2.4 m wide in residential settings, 2.4–4.5 m wide in downtowns, school zones, or commercial areas)
Pedestrian ramps (maximum slope of 10%, ideally 8%)	Inclination ramps	-	Ideal pedestrian ramps (maximum slope of 10%, ideally 8%)
-	Chicanes	-	Chicanes
Street furniture zone on sidewalks	-	Recreational and street furniture zones	Street furniture zones
Appropriate seating dimensions	Bench types, seating with free space at least 1.8 meters	-	Appropriate seating dimensions
Variation of seating materials		-	
Enough seatings (every 50 to 100 m)	-	-	Enough seatings (every 50 to 100 m)
Seating in various locations	-	-	Seating in various locations
-	Seating with shading	-	Seating with shading
-	Seating with shelter and protection	-	Seating with shelter and protection
Street lighting	Low-level lighting	-	Appropriate lighting
	Lighting with regular interval (at least every 30 m)	-	
	No shadow zones	-	

Wayfinding	Eye level of 95 cm	-	Child-friendly wayfinding solutions
	Bright and recognizable objects with interval	-	
	Landmarks	-	
Trash cans	-	-	Trash cans
Public toilets	-	-	Public toilets
Drinking fountains	-	-	Drinking fountains
Wi-fi and charging	-	-	Wi-fi and charging
-	Shading and cooling elements	-	Shading and cooling elements
Incorporate art and play with seatings	-	-	Incorporate art and play with seatings
Different types of learning	-	-	Different types of learning
Creative play opportunities	Playful furniture	Play elements	Creative play opportunities
	Pop-up playing	Steps for play and rest	
Buffer zone at sidewalks	Various plant zones	-	Plant zones in different places
Plant more trees		-	
Co-locate nature		-	
Consider children's height for connection with nature	Different height trees	-	Different height trees for kids to enjoy
Kids engaging with natüre		-	
Plant species for kids		-	
Room for insects and spiders	-	-	Room for insects and spiders
-	Indigenous and local species	-	Indigenous and local species
-	Retain existing trees	-	Retain existing trees
Engaging surfaces on sidewalks	Colorful patterns	-	Engaging colorful, different patterns on sidewalks
	Different types of patterns	-	
	Sidewalk games	-	
-	Avoid uneven ground cover materials	-	Child-friendly ground cover materials
-	Child-friendly materials	Anti-slip materials for strollers	
-	No obstruct in public realm	-	No obstruct in public realm
-	Obstacles between different pavements	-	Obstacles between different pavements
-	Low fences	-	Low fences
-	Boulders with min 1.2 m spacing	-	Boulders with min 1.2 m spacing

The study establishes two main objectives: identifying parameters for assessing the processes and design details of child-friendly street transformations, and defining methods for measuring these parameters. The literature review provides a foundation by examining the concepts of child-friendly cities and streets, incorporating various design guidelines focused on children. Methodologically, evaluation criteria are derived by synthesizing common and unique elements from multiple child-centred design guides, despite differences in scale, to suit the research focus. The evaluation approach encompasses three spatial scales: the decision-making process, neighbourhood context, and detailed design implementation. Process evaluation parameters, developed from three design guides, assess the sustainability of the transformation's child-friendly identity, with data gathered via interviews and document analysis. Neighbourhood-scale evaluation considers environmental factors such as green spaces and facilities to contextualize the transformation within a broader child-friendly setting, utilizing land use and accessibility analyses. Design detail evaluation employs 36 criteria grouped into categories like pedestrian crossings and urban furniture, measured through field observations and spatial analysis. Scoring systems are applied across all scales to quantify success, integrating qualitative and quantitative data to comprehensively evaluate the Zümrütevler child-friendly street transformation. In addition to these quantitative measurements and evaluations, a more comprehensive investigation was conducted by incorporating user observations, which provided critical insights into how the design elements function in practice. On January 13, 2025, user behaviour was monitored for 15 minutes between 14:35 and 14:50, followed by a pedestrian flow analysis conducted from 15:00 to 15:15. This period was intentionally selected to coincide with the time students leave school and return home. Data collection methods for this phase included measurement, pedestrian counting, photography, and detailed field notes, enriching the analysis of the design components with direct user interaction data.

Results

The Pedestrian Safety Transformation Trial (Yaya Güvenliği Dönüşüm Provası) was implemented by Maltepe Municipality in partnership with IMM and Superpool, under the guidance of NACTO-GDCI, as part of the Urban95 initiative led by BvLF (Superpool, 2020). This program encourages urban planners and community leaders to reconsider city environments from the viewpoint of a three-year-old child, approximately 95 centimetres tall (BvLF, 2021). The transformation of a chaotic intersection into Zümrütevler Square, a pedestrian-friendly public space, was documented in the report "Zümrütevler Square (2020)." The pilot area was selected due to limited park and open space availability, and the project prioritized redesigning pedestrian crossings and intersections along children's daily routes to school, emphasizing child-centric and pedestrian-friendly design (Superpool, 2020).

Figure 1 Child-friendly street transformation processes in Zümrütevler Neighbourhood: pre-project, rehearsal phase, post-permanent implementation (Superpool, 2022).

The project unfolded in two stages: an interim phase involving temporary measures such as asphalt painting and movable street furniture to allow assessment before permanent interventions, and a final phase with lasting modifications completed in August 2020. The interim implementation began on October 18, 2019, and lasted approximately six months. Differences were observed between pedestrian crossing layouts in the interim and permanent phases, with the total number of crossings reduced from eight to four in the final design (Superpool, 2020).

Figure 2 Comparison of pedestrian crossings after rehearsal and permanent implementation (Superpool, 2020).

Post-transformation data indicated that 1,075 m² of vehicle lanes were converted into pedestrian paths, with 550 m² becoming public spaces. The area gained green spaces and transitioned from a traffic junction to a fully accessible square. Usage increased significantly: the number of people in the square rose by 72%, babies and young children increased by 3.5 times, children aged 5-12 doubled, and the elderly population grew tenfold. Pedestrian crossings increased by 21%, sidewalk use by 30%, and children's independent mobility improved by 43%, with 89% of this occurring in safe zones (Superpool, 2020).

According to the data obtained from open sources and interviews with project coordinators that include detailed explanations of the project process, the transformation process was evaluated according to the parameters determined in the research methodology section. With the two-phased design approach implemented in the Zümrütevler neighbourhood, the street transformation application was one of the actions of a higher scale decision. The decision to transform this area was taken in line with the need and it became the first square of the neighbourhood. When the whole process, including the rehearsal process and the current situation, is considered, the data obtained from open sources and the interviews with the institutions show that other parameters were provided for the transformation process.

A cross-scale evaluation of the neighbourhood surrounding the child-friendly street transformation in Zümrütevler was conducted to assess land use, accessibility, traffic calming measures, and street activity. The land use and accessibility analysis revealed that although the case study area is within walking distance to certain child-related facilities such as open spaces and nurseries, large portions of the neighbourhood lack adequate pedestrian access to kindergartens, health facilities, and open spaces within recommended distances. Primary schools have better coverage due to wider accessibility ranges, but overall, the neighbourhood fails to meet accessibility criteria and does not include local mobility parks or similar child-oriented spaces, resulting in a zero score in the accessibility evaluation.

Traffic calming measures were found to be limited primarily to the immediate vicinity of Zümrütevler Square, with speed limits mostly adhering to the general 50 km/h standard elsewhere. Pavement treatments aimed at increasing driver awareness are scarce, and no additional pedestrian-priority or low-emission zones exist within a 250-meter radius. These findings indicate that traffic interventions are insufficient to support a child-friendly environment beyond the square itself. Conversely, the analysis of street activity indicated a predominance of active frontages supported by mixed-use land and pedestrian presence, fulfilling vitality criteria. Although some residential streets with high garden walls reduce child-friendliness, this issue is limited in extent. Overall, vitality parameters are satisfied. However, when combined, the evaluations demonstrate that the neighbourhood largely fails to meet the comprehensive criteria for a child-friendly environment, with deficiencies in accessibility and traffic calming measures being the main limitations.

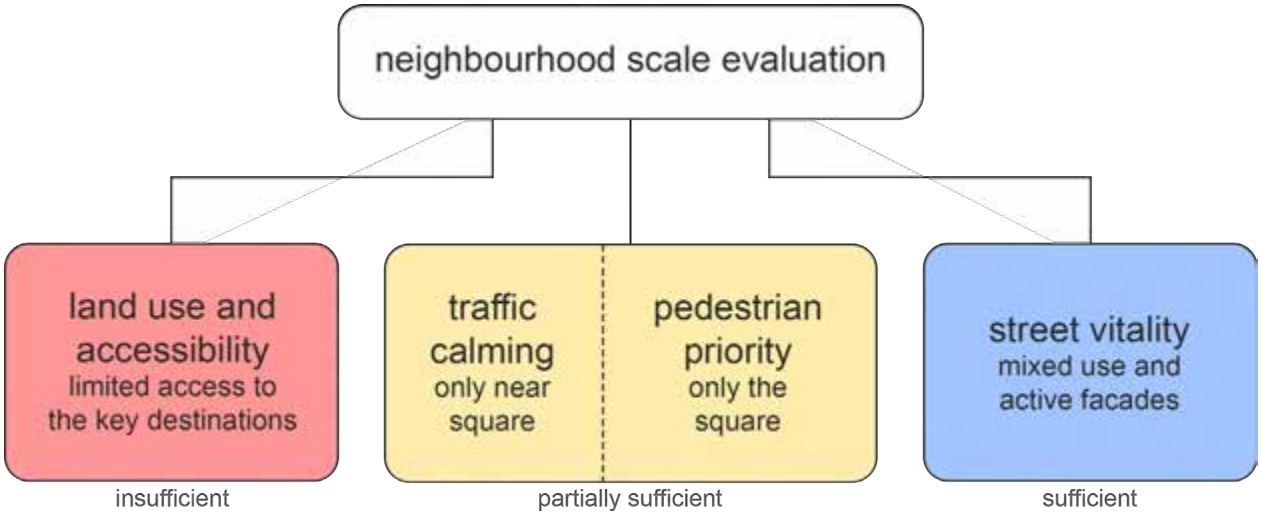

Figure 3 Diagram showing the outcomes of the neighborhood-scale evaluation

The detailed assessment of design elements in the Zümrütevler Square transformation area reveals variable adherence to established child-friendly design standards. Pedestrian crossings comply with minimum width requirements and are adequately spaced within the transformed zone. However, their diminished visibility due to fading and limited presence beyond this immediate area negatively impact pedestrian safety and accessibility. Field observations demonstrate a preference among pedestrians for crossing at informal locations rather than designated crosswalks, exposing a disconnect between intended design and actual user behaviour.

Sidewalks generally offer sufficient width and are mostly unobstructed, with ramp slopes aligning with accessibility norms. Nonetheless, the presence of bollards on ramps hinders ease of use for disabled individuals, marginally reducing overall sidewalk effectiveness. Urban furniture, though limited in quantity, serves its purpose by fostering social interaction through strategically arranged seating. Play opportunities, integrated alongside seating areas and including artistic features, meet all relevant design criteria; however, child usage of these spaces was notably scarce, potentially attributable to parked vehicles affecting perceptions of safety and spatial quality. Green elements demonstrate diversity in plant species and buffer zones. Regarding design materials, bollard placement conforms to standards, yet surface treatments lack child-friendly qualities and do not provide sufficient textural differentiation, fulfilling only half of the evaluated material parameters.

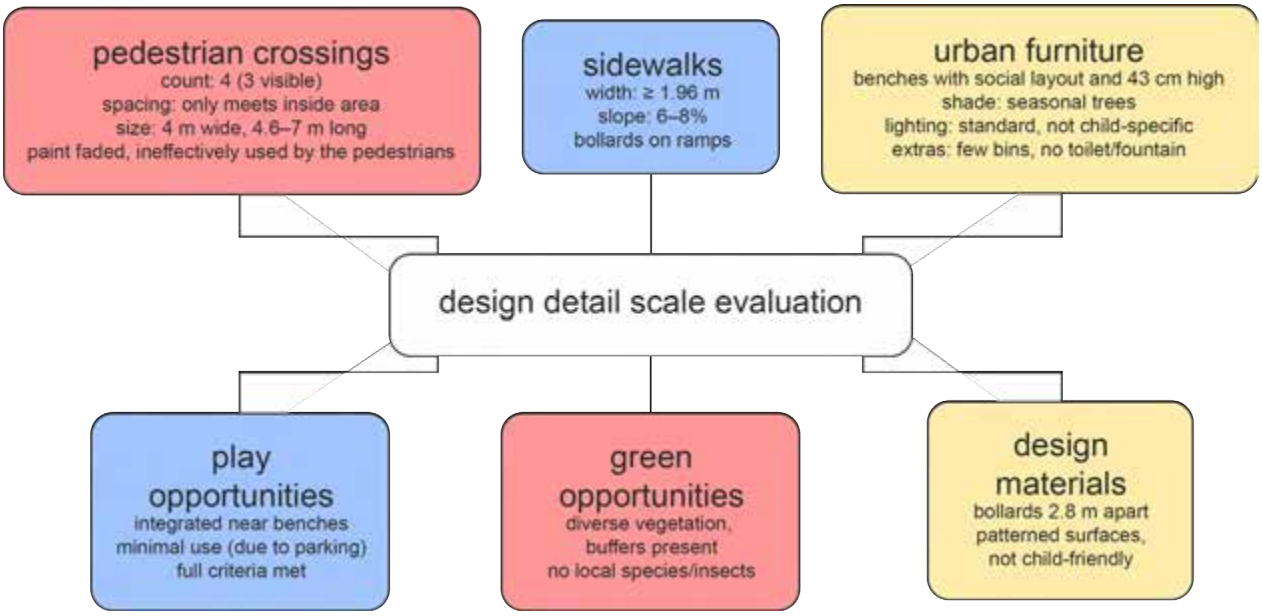

Figure 4 Diagram showing the outcomes of the design detail evaluation

Overall, while the transformation reflects commitment to several child-friendly design principles, significant shortcomings remain in accessibility, material selection, and user-centric functionality. The adequacy of applying all child-friendly parameters universally within the area merits reconsideration, especially considering user behaviour patterns. Although foundational progress toward a child-friendly environment is evident, further enhancements are necessary to fully support independent and safe mobility for children.

In addition to the design criteria evaluations, the interaction between design elements and actual users was examined through field observations. User movement patterns and preferred directions within the area were recorded, with results illustrated in Figure 5, showing frequently used pedestrian routes during the observation period. The majority of users passing through the space were caregivers accompanied by children and individuals returning from shopping. The timing of the observation supports the conclusion that children and their caregivers primarily use the area as a transit route.

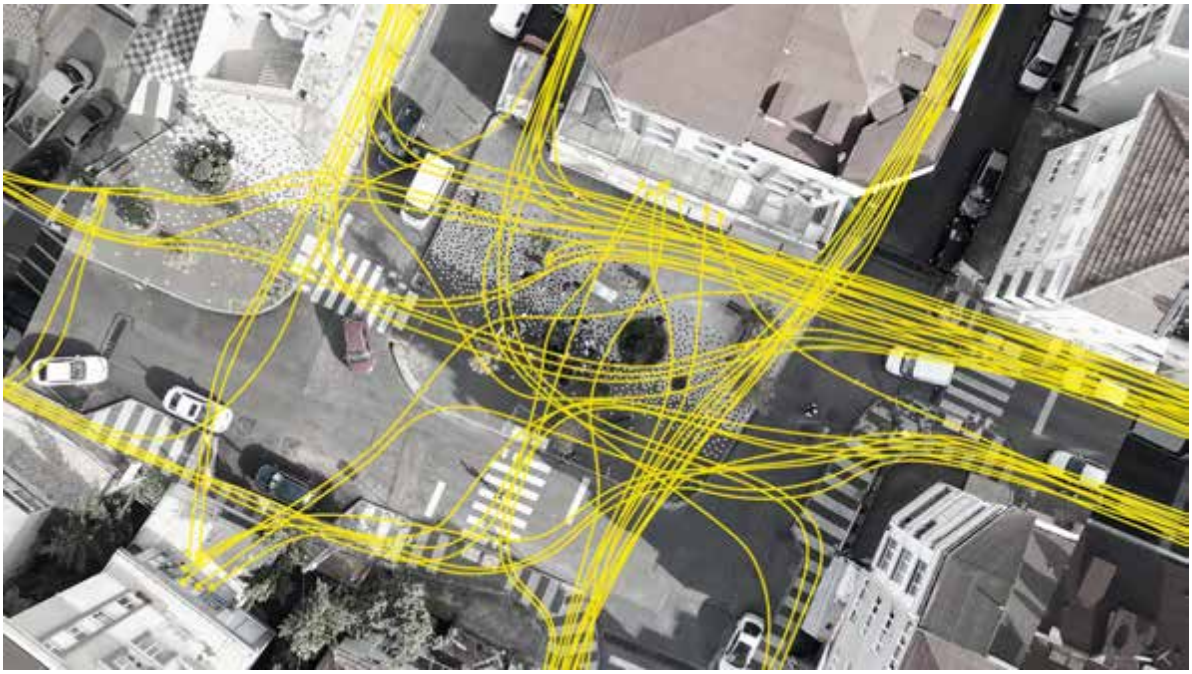

Figure 5 User flow map

Although Figure 5 suggests broad usage of the square, the presence of parked vehicles significantly obstructs pedestrian circulation and undermines the space's child-friendly qualities. As depicted in Figure 6, pedestrians must navigate around parked cars when crossing streets to access the square, reducing comfort and safety.

Figure 6 Users cannot use the area comfortably due to the parked cars

Further photographic evidence gathered outside observation periods indicated that some pedestrians, including those with children, chose to walk along vehicular roads instead of using the open square, as shown in Figure 7. Improper pedestrian crossing behaviours were also documented, highlighting non-compliance with intended pedestrian pathways.

Figure 7 Pedestrians not using the pedestrian crossings

A behavioural map (Figure 8) representing sitting and standing activities during the observation period shows standing users predominantly engaged in socializing near seating elements. These social interactions were primarily carried out by older male individuals, as documented in Figure 9. Notably, these frequent users were not caregivers accompanying children, the primary target group of the child-friendly design.

Figure 8 User behaviour map

Figure 9 Elderly people using the area for rest and chatting

Evaluation of the transformed area from the perspective of children and caregivers revealed that the space functioned almost exclusively as a passageway, as confirmed by measurements and photographic records (Figure 10).

Figure 10 Photographing the use of a passageway by children and caregivers

The combined findings from behavioural observation and pedestrian flow analysis reveal a significant gap between the intended child-friendly design objectives and actual usage patterns. Despite being designed to facilitate stationary, interactive activities for children and caregivers, the space predominantly serves as a transit corridor. Persistent vehicle presence and pedestrian pathway misuse further detract from the space's functionality as a child-friendly public environment. These results indicate a need for additional design interventions to better support and encourage the intended user groups.

Discussion

The child-friendly street transformation in Zümrütevler Neighbourhood was critically examined through a multi-scale lens encompassing the process, neighbourhood context, and detailed design elements, following the evaluation framework outlined in the methodology. The analysis reveals that while the project demonstrated sensitivity to local context and engaged stakeholders actively at the project level, it failed to establish meaningful connections with broader neighbourhood infrastructure and urban policy agendas.

At the process scale, the initiative employed a phased, inclusive, and flexible design strategy that leveraged data insights and fostered collaboration among institutions. Although there was no overarching higher-level planning directive guiding the intervention, the project successfully coordinated diverse stakeholders and ensured the participation of children and caregivers in shaping the outcome. The iterative rehearsal phase was particularly influential, facilitating design adjustments and enhancing community buy-in—highlighting the practical benefits of tactical urbanism approaches in child-focused urban interventions.

In contrast, the neighbourhood-level evaluation exposes significant gaps. Accessibility assessments indicate that most residential areas remain beyond a reasonable walking distance to key child-oriented facilities, while traffic calming measures are confined to the immediate project boundaries. Nonetheless, the presence of relatively active street frontages offers some support for children's independent movement. This juxtaposition reflects a critical disconnect between targeted site-specific improvements and the absence of integrated, systemic planning at the neighbourhood scale.

Regarding design details, the spatial elements only partially meet child-friendly urban design benchmarks.

Although infrastructural components such as sidewalks, ramps, crossings, and urban furniture generally adhere to established technical criteria, observed user behaviour reveals a misalignment between intended design purposes and actual use patterns. The space predominantly functions as a thoroughfare for children and caregivers rather than a place for gathering or play, with frequent informal crossing indicating concerns related to safety and usability. Moreover, the pervasive presence of vehicles and scarcity of playful amenities further restrict children's autonomous engagement. These observations emphasize that adherence to technical standards alone is inadequate; successful child-friendly environments require design approaches that respond meaningfully to lived experience. Ultimately, the findings suggest that enhancing spatial quality must be complemented by coordinated, cross-scale strategies that harmonize physical interventions with everyday behaviours to truly realize child-friendly urban spaces.

Conclusion

The concept of child-friendly cities encompasses multifaceted dimensions and requires comprehensive approaches to effectively promote children's independent mobility and well-being in urban environments. Local governments increasingly pursue child-friendly street transformation projects, underpinned by the prevailing conviction that creating safe, accessible, and health-promoting urban spaces for children contributes to the formation of healthier societies. However, the complexity of sustaining the child-friendly identity beyond initial design stages remains a significant challenge, necessitating critical examination of relevant parameters and practical obstacles throughout the transformation process.

This study contributes to this discourse by conducting a rigorous, multi-scale evaluation of the child-friendly street transformation in Zümrütevler Square, selected as a case study. The research framework incorporated assessment at three interconnected scales: the process level, the neighbourhood context, and the detailed design components. This layered analytical approach not only advances the understanding of child-friendly urban interventions but also foregrounds the necessity of examining interactions across scales to reveal systemic strengths and weaknesses. The development of an original, criteria-based evaluation tool derived from existing design guidelines enabled a nuanced analysis of spatial and procedural aspects of the transformation, while direct incorporation of user behaviour observations ensured that the evaluation extended beyond normative design standards to include lived experience.

A key finding relates to the applicability and relevance of child-friendly design parameters across all scales and contexts. While many criteria are well-established within the literature and provide essential benchmarks, the Zümrütevler case exposes critical tensions regarding their universal applicability. Several parameters, though theoretically sound, proved difficult to implement or maintain consistently throughout the transformation phases, raising important questions about their flexibility and contextual suitability. This insight suggests that future frameworks should incorporate adaptive, context-sensitive criteria that account for diverse urban realities and evolving user behaviours, rather than relying solely on rigid, one-size-fits-all standards.

Regarding the visibility and presence of children within the transformed space, observations revealed a notable deficiency. Despite the project's explicit child-focused intentions, actual child presence and engagement in the area remained limited. The square was predominantly used as a transitional passage by children and caregivers rather than as an interactive, playful environment. This gap between design intention and on-the-ground reality signals a need to critically reconsider not only physical design elements but also socio-environmental factors that influence children's visibility and autonomy in public spaces. Issues such as vehicular dominance, perceived safety concerns, and spatial constraints emerged as significant deterrents to sustained child use, underscoring that child-friendliness must encompass both physical and behavioural dimensions to be truly effective.

The process evaluation further highlighted institutional and procedural complexities that influence project outcomes. The involvement of multiple authorities with overlapping jurisdiction over the site created challenges in coordination, leading to compromises in design cohesion and implementation consistency. This institutional fragmentation underscores the importance of establishing clear governance frameworks and collaborative

mechanisms to streamline decision-making and maintain the integrity of child-friendly objectives. Moreover, the phased approach, which included a rehearsal stage applying tactical urbanism principles, was instrumental in refining the design and fostering public acceptance. However, the research identified a missed opportunity in not conducting a second rehearsal phase, which could have allowed for iterative testing and incorporation of feedback based on revised design alternatives. Evaluating rehearsal phases explicitly within the criteria framework emerges as a critical area for future research and practice, as it holds potential to significantly enhance the adaptability and success of child-friendly transformations.

In sum, this study affirms that multi-scale, integrated evaluations are essential for a holistic understanding of child-friendly urban interventions. Evaluations that combine technical design criteria with empirical user behaviour analysis provide richer insights and more actionable knowledge than those relying solely on normative standards. Furthermore, the findings underscore the necessity to critically assess the feasibility and relevance of design parameters in varied contexts and to maintain child visibility and engagement as central goals. The role of institutional coordination and iterative, participatory design processes—particularly the rehearsal phases—must be emphasized in both research and practice to support sustainable child-friendly environments.

Finally, the transformation of Zümrütevler Square, as one of Turkey's pioneering projects integrating tactical urbanism with permanent implementation in a dense metropolitan context, offers valuable lessons for urban policy and design. It highlights that successful child-friendly street transformations require long-term commitment, cross-sectoral collaboration, and a continuous feedback loop that integrates design adaptation with lived realities. Future studies should expand on the rehearsal phase's role and explore adaptive criteria frameworks to enhance applicability across contexts. Such comprehensive approaches are imperative to advancing child-friendly urbanism and fostering inclusive, healthy cities for all generations.

Acknowledgements
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Evaluation of Emotional Attachment Characteristics of Urban Vitality Complexes Based on EW-GRA-TOPSIS Model in the Context of Stock Renewal: A Case Study of Five Typical Urban Complexes in Beijing and Shanghai

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Abstract
Creating vibrant urban spaces is key for urban renewal. Emotional attachment is also a vital feature of urban vitality. This study quantifies the emotional attachment between people and the built environment as an evaluation index of the dynamic space of small-scale cities. Based on the theory of emotional attachment, an index system was constructed and applied to the five dynamic urban renewal complexes in Beijing and Shanghai. SPSS was used for data analysis, and an improved TOPSIS model combining entropy weight and grey relational analysis for evaluation. Results show the built environment can enhance urban vitality through emotional attachment. Material characteristics deepen emotional experiences, while non - material ones dynamically influence vitality. The study expands the quantitative framework for urban vitality research and offers methodological references for urban space renewal and design.

Keywords: emotional attachment; urban vitality evaluation; EW-GRA-TOPSIS evaluation model

1. Introduction

1.1. Research Background

Urban renewal, as a long-term strategic planning for China's urban development and construction, has gradually become an important topic of study and concern for scholars in recent years (Cheshmehzangi et al., 2023). Specifically, China's urbanization has entered the stage of upgrading existing resources, responding to the development goals of achieving high-quality human life and the development connotation (Pan and Du, 2021), and creating urban vitality spaces is crucial for urban renewal research and practice (Kang, Fan and Jiao, 2021; Guo et al., 2022). By constructing refined urban complexes to renovate the existing architectural environment, it has become an effective way to create these spaces (Wei and Wang, 2024b). Currently, there are many successful cases of transforming old buildings and industrial areas into representative urban vitality complexes in first-tier cities such as Beijing, Shanghai, and in new first-tier cities such as Chengdu, Nanjing, and Chongqing (Zhuang et al., 2019; Du, Du and Wang, 2022). For example, there are the Longfusi Street and Langyuan Station in Beijing, and EKA Art District in Shanghai. In addition, the guiding strategy of "reducing quantity and improving quality" in urban renewal in the 2021-2025 national spatial planning policy of Beijing indicates that small-scale, gradual and decentralized spaces are indispensable components of urban vitality research and design, and further research and development in this regard are needed. At the same time, in the digital era, people's requirements for urban architectural environments have already evolved from basic functional needs to advanced emotional attachments (J, 2022; Zhang, 2023), and the realization of urban vitality also requires considering the emotional interaction between people and the architectural environment (Cao, Deng and Song, 2023; He et al., 2023).

Therefore, it is necessary to establish a small-scale urban vitality space research and evaluation method represented by urban renewal complexes. The theory of emotional attachment provides a theoretical basis for studying the characteristics of emotional attachment between people and the architectural environment and constructing measurement indicators, and the multi-criteria decision-making (MCDM) method represented by TOPSIS provides tools for scientific evaluation of emotional attachment levels. Combining the theoretical basis and method tools can construct an emotional vitality evaluation method for urban renewal complexes. This study selects five representative urban renewal complexes in China's first-tier cities as examples to verify the effectiveness of the above urban vitality emotional attachment evaluation method, including the Longfusi Street and Langyuan Station in Beijing, EKA Art District in Shanghai, Columbia Circle and Raffles City Changning in Shanghai. First, based on the theory of emotional attachment, a scale is constructed to measure the emotional

attachment characteristics of specific built environment characteristics and is used to measure the dimensions and degrees of specific architectural environment space characteristics of the five complexes. Then, based on the constructed attachment evaluation index system, the scale data is processed using SPSS software, and the improved TOPSIS (technique for order preference by similarity to an ideal solution) method, combined with EW (entropy weight) and GRA (grey relationship analysis), ranks the urban vitality levels of the five complexes from the perspective of emotional attachment. Finally, the evaluation results are combined with the correlation analysis results of the scale data to further explore the commonalities and differences in spatial characteristics that promote emotional attachment in the five complexes and obtain method guidance for urban vitality complex renewal design.

1.2. Literature Review

The concept of emotional attachment has been proposed and extensively discussed by scholars across multiple disciplines, including psychology, human geography, architecture, and urban planning. This body of research primarily investigates the interconnections among emotions, cognition, behavior, and spatial entities. Among these discussions, place attachment theory serves as a theoretical framework that systematically examines various influencing factors and constructs an index system to measure different individuals' emotional attachments to specific architectural environments (Ekkekakis, 2013). In the process of developing multidimensional emotional attachment measurement scales, researchers in psychology and human geography have systematically explored the principles and internal mechanisms underlying emotional attachment, emphasizing distinct indicators that enhance such attachment (Manzo et al., 2020; Lewicka, 2011). It is precisely through this multidimensional index system construction that the integration of perspectives from multiple disciplines is highlighted, addressing the current lack of an emotional dimension in urban vitality research and providing a quantitative methodology for assessing emotional attachment between individuals and small-scale architectural environments. In recent years, designers and researchers with multidisciplinary backgrounds have developed a series of emotional attachment scales to evaluate the attachment between people and specific architectural environments, applying these scales to studies on buildings and urban public spaces both domestically and internationally (Zhang & Zhuang, 2017; Birnbaum et al., 2021). These scales encompass physical characteristics of the architectural environment, such as material, form and structure, and color, as well as social and cultural attributes, including sociability, territoriality, and uniqueness. In the digital era, research has further expanded to investigate the interactivity and variability of architectural environments (Zhang et al., 2022). A range of research findings have demonstrated the reliability and validity of these scales, thereby partially addressing the deficiency of quantitative methods for measuring emotional attachment in architectural environment research and offering a methodological framework for assessing emotional attachment in small-scale built environments.

One of the critical factors influencing urban vitality is the comprehensive understanding of the term "vitality," which should be considered in conjunction with emotional attachment. As a prominent theorist and activist in urban studies, Jane Jacobs, an advocate for "urban vitality," defined it as the capacity of a space to attract and accommodate diverse human activities (Dogan and Lee, 2024). She posited that vibrant urban spaces are characterized by physical environments that foster positive emotions among individuals. Maas described urban vitality as the quality of space encompassing people, activities, and the physical environment where these activities occur (Jacobs, 1961). Following extensive scholarly exploration of urban vitality from various perspectives and spatial scales, it has consistently been linked to the built environment and the interactions between users, people, space, and the utilization of spatial places (Mouratidis and Poortinga, 2020; Pan, Zhu, and Zhang, 2023). Consequently, urban complexes have emerged as effective subjects for studying urban vitality. In the digital era, achieving urban vitality necessitates heightened attention to the growing emotional needs of individuals (Zhang and Zhuang, 2017). The development of urban vitality spaces stems from multi-dimensional interactions between people and the built environment, with satisfying people's emotional demands for space constituting one of its core connotations. With advancements in data mining and analysis technologies, research on urban vitality primarily focuses on impact indicators and the construction of corresponding measurement frameworks, along with associated data metrics. Recently, scholars in urban and architectural studies have engaged in in-depth investigations of urban vitality from multiple angles, utilizing geographic big data and urban population

data to explore its manifestations in street networks and population mobility across large-scale spaces (Lan et al., 2020; Fang, He, and Wang, 2021). These studies emphasize broader spatial scopes, and the indicators used in evaluation systems tend to be geographical, social, and economic in nature. Some researchers focus on more human-centric indicators, such as POI data, mobile signal data, road street view images, or audio-related factors, to examine the level of urban space vitality at specific spatial scales (Wu and Niu, 2019; Gomez-Varo et al., 2024; Wei and Wang, 2024a; Duan et al., 2025). Others concentrate on specific functional spaces as indicators of urban vitality and their role in driving positive urban development (Chen et al., 2022). Researchers are gradually shifting their focus toward user-oriented spaces, emphasizing real interaction experiences and emotional connections within urban environments under the current trend of urban vitality research. In conclusion, the study of urban vitality should prioritize the characteristics of small-scale architectural environments while addressing the emotional attachment perspective in urban vitality research.

In order to further evaluate the vitality characteristics and levels of different urban spaces, this study selected the TOPSIS method and its modified version, so as to measure and comprehensively evaluate the urban vitality level based on the requirements of this study. The method adopted in this research belongs to a multi-criteria decision-making method system (MCDM), making the process of evaluating the vitality of urban spaces more scientific, transparent, and participatory (Krohling and de Souza, 2012). The TOPSIS (technique for order preference by similarity to an ideal solution) method was developed by Hwang and Yoon in 1981 and is used to create positive and negative ideal solutions, and then compare the differences between alternative solutions and ideal solutions (Hwang and Yoon, 1981). Since the TOPSIS method can fully utilize the information in the original data and is more understandable and accurate in revealing the detailed advantages and disadvantages of each specific feature, it has been applied in the assessment of urban spaces in multiple dimensions and scales, especially in evaluating various complex urban spaces closely related to user behaviour. For example, the TOPSIS method is widely used in macroscopic urban vitality studies, coupling geographic big data with indicators closely related to human activities to quantify and measure the comprehensive urban vitality index (Zhang, Yang and Wang, 2021). The TOPSIS method is also applied in the research of urban resilience and urban sustainability, by constructing an evaluation system covering multiple dimensions such as economy, transportation, and ecological environment, to comprehensively measure the urban characteristics and their degrees within the regional scope (Xun and Yuan, 2020; Zhao, Ma and Lin, 2022). EW (entropy weight method) and GRA (gray correlation method) are always combined as part of this method to assign weights to indicators and improve the accuracy of the evaluation process (Zhang et al., 2018; Rao and Gao, 2022; (Hu et al., 2022). Besides the above macro-level evaluations of the city, the improved TOPSIS method is also used to evaluate and study the design methods of small-scale built environments, such as landscape performance and the relative performance of community renewal projects (Zhu et al., 2019; Shen et al., 2022). However, in the research on urban vitality, few studies have applied TOPSIS and its improved methods to evaluate the impact of specific architectural environment characteristics on users' emotional experiences. Emotional experience, as one of the indispensable components of urban vitality, this study focuses on people's emotional experiences in the exploration of urban vitality spaces.

1.3. The Main Goal of the Paper

In the context of existing space renewal, the design and research of dynamic spaces need to focus on people's current real needs. Moreover, in the current digital era, people's emotional demands for space have gradually become the key to constructing dynamic spaces, and meeting people's emotional demands for space has become a major goal of creating dynamic spaces. Based on this, this study, at the methodological level, improved the traditional TOPSIS method to an EW-GRA-TOPSIS evaluation method applicable to the small-scale built environment characteristics that the study focuses on, and focused on people's place attachment to small-scale built environment characteristics in urban dynamic spaces. Based on this goal, an index system for evaluating the emotional attachment between people and urban dynamic spaces was constructed. In the theoretical aspect, this study supplements the discussion on the emotional attachment between people and small-scale architectural environment characteristics in urban dynamic research. In the practical aspect, taking five representative urban renewal dynamic complexes in first-tier cities in China as examples, the evaluation index system and EW-GRA-TOPSIS evaluation method constructed in this study were applied to prove their scientific

validity. Based on the above, this study has three corresponding innovation points. The improved TOPSIS method using entropy weight method and combined with grey correlation method increases the scientific validity of the quantitative evaluation method, enabling the methodology to be innovated. Attention is paid to the emotional attachment of small-scale built environment characteristics as an important component of urban dynamic, and in the theoretical aspect, this study supplements the perspective of emotional attachment in urban dynamic research. In addition, the method and theory are applied to the complex assessment of the interaction between people and architectural environment, focusing on how small-scale architectural environment characteristics promote people's emotional attachment to urban dynamic spaces.

2. Materials and Methods

2.1. Study Areas

This study selected five representative and distinctive urban vitality complexes in China's first-tier cities that have been successfully renovated and put into use in recent years. These five research objects are all located in Beijing and Shanghai, namely the Longfusi Street, Langyuan Station in Beijing, EKA Art District, Columbia Circle, and Raffles City Changning in Shanghai. All five complexes were renovated based on the original buildings. Among them, the original built environment of Beijing's Longfusi Street, Shanghai's Columbia Circle, and Raffles City Changning belong to historical districts, while Beijing's Langyuan Station and Shanghai's EKA Art District were transformed from old industrial areas and buildings. Through a series of meticulous architectural and environmental renovations, these five vibrant complexes have presented unique charm in terms of architectural details and space creation. Currently, these five vitality complexes are important urban public spaces that attract people to experience in the city. The carefully crafted various built environments and small-scale architectural environment details play an important role in the emotional interaction with users. More attractive vitality spaces provide various emotional experiences, allowing people to gain more emotional interactions in the real space. It is precisely due to these characteristics that these five complexes become the research objects of this study. The basic conditions and architectural environment characteristics of each complex are as follows.

Table 1. Overview of the basic conditions and characteristics of the five urban renewal complexes.

City	City Level	Name of Complex	Renovation Period	Characteristics of the Original Built Environment	Characteristics of the Redeveloped Built Environment
Beijing	First tier	Longfusi Street	2012-2019	Longfusi Street is an old commercial area with a long history of business and many years of operation, surrounded by hutong residential areas.	Create a cultural architectural complex and a youthful urban dynamic space with complete business facilities, which echoes the historical traditions of the original commercial space.
Beijing	First tier	Langyuan Station	2017-2022	The old warehouse area of the Beijing Textile Factory features a strong industrial architectural complex and a distinct industrial street pattern. The surrounding natural environment is good.	A dynamic complex integrating commercial, office and supporting facilities, with a distinct industrial style. The materials, forms and structures echo the original industrial style.
Shanghai	First tier	EKA Art District	2021-2023	Formerly known as Shanghai Navigation Instrument General Factory, the old factory buildings and industrial area have been well preserved, and the elements of the navigation industry have also been well maintained.	EKA Art District retains the original road network and layout structure of the factory area, transforming it into an international community that integrates experiences, social interaction, consumption and office functions. It also retains many maritime and marine elements.
Shanghai	First tier	Columbia Circle	2016-2024	Located at the junction of the three historical and cultural preservation areas of Hengfu Road, Yuyuan Road and Xinhua Road, it contains many historical buildings and retains the cultural atmosphere.	This urban lifestyle collection includes 3 historical buildings and 11 industrial renovation buildings. The diverse buildings collectively form a unified cultural space.
Shanghai	First tier	Raffles City Changning	2012-2017	Raffles City Changning was formerly the site of Shanghai Saint Mary's Girls' School. Located in the Zhongshan Park business district, the building complex occupies the main space.	With its unique charm that combines historical cultural connotations with the trendy and fashionable atmosphere, the historical buildings of "Four Towers and One Building" complement the modern commercial buildings.

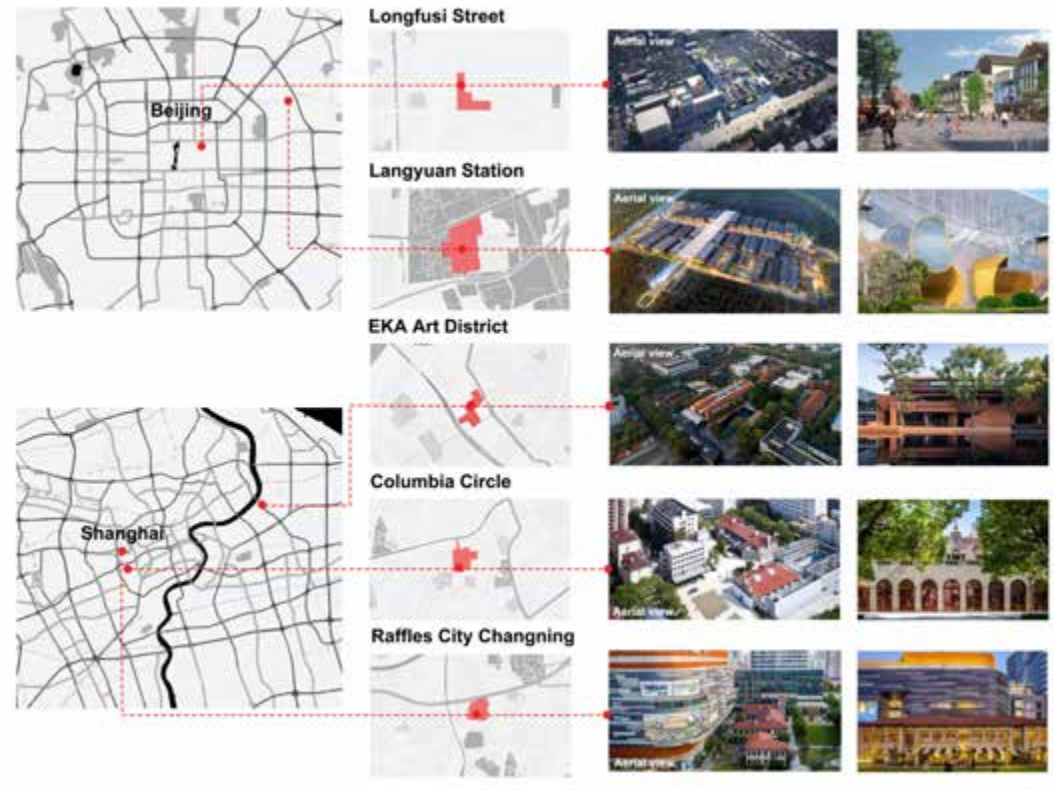

Figure 1. Location and features of the five urban renewal complexes

2.2. Data Sources

In line with the research requirements, the research team selected and developed a scale of emotional attachment in accordance with emotional attachment theories. Through the use of this scale, an assessment of the dimension, degree, and intensity of emotional attachment between individuals and the built environment across the five aforementioned complexes was carried out by the team from July to October 2024. The team members successively conducted on-site research at various research sites in Shanghai and Beijing, ensuring that each team member had a certain level of familiarity with each commercial complex. To ensure the reliability of the data, young people aged 18-35 were randomly selected from the five complexes to participate in the filling of the research scale on-site. Finally, the number of valid scales collected in the five complexes were as follows: 130 in Longfusi Street, 129 in Langyuan Station, 130 in Columbia Circle, 130 in Raffles City Changning, and 130 in EKA Art District.

2.3. Build a Methodology

2.3.1. The Construction of Emotional Attachment Scale and Indicators of Evaluation Index

In order to explore the dimensions, degrees of emotional attachment of people to five urban renewal complexes, as well as the intensity of their attachment to specific built environment characteristic, this study combined the place attachment scale, PANAS scale, and a newly-constructed and tested scale of attachment intensity for specific built environment characteristics to conduct research on the emotional attachment of these five urban renewal complexes. The reliability and validity of this scale have been confirmed by a series of architectural environment researches at home and abroad. Therefore, the indicators in the above scales can also be used as evaluation indicators for the emotional attachment characteristics of the urban renewal complexes to assess them.

In order to explore different emotional attachment characteristics from different perspectives and research needs, multidisciplinary researchers have constructed a series of scales. Among them, Scannell and Gifford, based on previous research, proposed the organizational framework of person-process-place (PPP) to explain the attachment mechanism and constructed the related place attachment scale (Scannell and Gifford, 2010). The PPP PA scale emphasizes the importance of the built environment in the attachment process and is consistent with our research purpose both in content and practicality. Therefore, it was adjusted in the study and used as part of the scale to measure the degree of attachment. In addition, the positive and negative analysis scale (PANAS) was used in the study to explore people's attachment to the five urban renewal complexes. The last part of the scale aims to explore the influence of built environment features and also serves as an indicator in the evaluation process. Based on the characteristics of the five urban renewal complexes and the demands of this study, the evaluation indicators include: material, colour, natural elements, form and structure, privacy, diversity, sociability, territoriality, playability, uniqueness, and changeability. The analysis of scale intensity uses the Likert scale to quantitatively measure the intensity, with a score of 1 indicating almost no emotional attachment to the indicator and a score of 7 indicating a strong emotional attachment. The analysis process uses SPSSPRO and SPSSAU to process the data collected from these scales, including the comprehensive degree and attachment intensity represented by the basic indicators. In addition, SPSS was used for correlation analysis (Spearman) to explore the correlations between attachment, positive and negative emotions, and specific built environment features. The results of each indicator are used in the subsequent evaluation process to rank the five complexes and are analysed and interpreted based on the subsequent correlation analysis results.

2.3.2. The Evaluation Method of Improved TOPSIS Combining Entropy Weight and Grey Relational Analysis

The degree and intensity of people's emotional attachment to the dynamic spaces of a specific city depend on the established scales and evaluation indicators. Although the reliability and validity of the aforementioned scales have been confirmed by relevant research and have mature application experience (Zhang et al., 2022; Zhang et al., 2022), due to certain objective reasons such as the subjectivity of researchers and experimenters and the differences in scale data, the reliability and validity of the aforementioned scales may still be affected, to some extent, affecting the accuracy of the evaluation of people's emotional attachment to the dynamic spaces of the city. To avoid this uncertainty in the evaluation system and its resulting impact, this study uses the entropy

weight (EW) method to assign weights to the aforementioned indicators based on their scores and combines the single evaluation method TOPSIS and the grey relation analysis (GRA) to improve the original single evaluation method (Zu et al., 2021), hoping to enhance the objectivity of the evaluation of the attachment to the urban renewal complex in this study.

1. Entropy Weight Method: Determining the Weight of Indicators
When determining the weights of evaluation indicators, the entropy weight method is adopted instead of the Delphi method or the Analytic Hierarchy Process (AHP) to help improve the subjectivity of the traditional TOPSIS method, making it more objective when simultaneously evaluating interrelated objects. The improvement of this method has been successfully applied by many researchers in urban space evaluation and related studies, avoiding certain degrees of subjective bias in the research. This study needs to assess the emotional attachment of multiple urban vitality complexes in Beijing and Shanghai. The weights of each evaluation indicator are determined through the entropy weight method (EW). The main steps are as follows:

There are mmurban vitality complexes to be evaluated and nn built environmentrelated evaluation indicators for each urban complex in this study, and the nn -th analysis indicator of the mm evaluation objects is marked as $c_{ij}c_{ij}$ (1≤ii≤mm , 1≤jj≤nn), and the judgment matrix $C = (c_{ij})_{m\times n} C = (c_{ij})_{m\times n}$ is expressed as:

$$C = \begin{pmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{mn} \end{pmatrix} C = \begin{pmatrix} c_{11} & \cdots & c_{1n} \\ \vdots & \ddots & \vdots \\ c_{m1} & \cdots & c_{mn} \end{pmatrix} \quad (1)$$

where $c_{ij}c_{ij}$, 1≤ii≤mm , 1≤jj≤nn, mm = 5, nn = 14
The judgment matrix $C = (c_{ij})_{m\times n} C = (c_{ij})_{m\times n}$ is standardized according to the 0-1 transformation, and the standardized matrix $C' = (c'_{ij})_{m\times n} C' = (c'_{ij})_{m\times n}$.

$$C' = \begin{pmatrix} c'_{11} & \cdots & c'_{1n} \\ \vdots & \ddots & \vdots \\ c'_{m1} & \cdots & c'_{mn} \end{pmatrix} \quad C' = \begin{pmatrix} c'_{11} & \cdots & c'_{1n} \\ \vdots & \ddots & \vdots \\ c'_{m1} & \cdots & c'_{mn} \end{pmatrix} \quad (2)$$

In this study, negative affect is regarded as negative indicator, while all other indicators are considered as positive affects. The positive indicators are preprocessed using formula (3), and the negative indicators are preprocessed using formula (4).

$$c'_{ij} = \frac{c_{ij} - \min\limits_i c_{ij}}{\max\limits_i c_{ij} - \min\limits_i c_{ij}} \max_i c_{ij} \neq \min_i c_{ij}$$

$$c'_{ij} = 1 \max_i c_{ij} = \min_i c_{ij} c'_{ij} = 1 \max_i c_{ij} = \min_i c_{ij} \quad (3)$$

$$c'_{ij} = \frac{\max\limits_i c_{ij} - c_{ij}}{\max\limits_i c_{ij} - \min\limits_i c_{ij}} \max_i c_{ij} \neq \min_i c_{ij}$$

$$c'_{ij} = 1 \max_i c_{ij} = \min_i c_{ij} c'_{ij} = 1 \max_i c_{ij} = \min_i c_{ij} \quad (4)$$

Calculate the proportion $q_{ij} q_{ij}$ that the ii-th urban vitality complex occupies in the jj-th indicator. The formula is as follows

$$q_{ij} = \frac{c'_{ij}}{\sum_{i=1}^{m} c'_{ij}}, i = 1,2,\cdots,m; j = 1,2,\cdots,n q_{ij} = \frac{c'_{ij}}{\sum_{i=1}^{m} c'_{ij}}, i = 1,2,\cdots,m; j = 1,2,\cdots,n \quad (5)$$

Calculate the entropy value $E_j E_j$ of each indicator, the formula is as follows:

$$E_j = -k \sum_{i=1}^{m} q_{ij} \ln q_{ij}, j = 1,2 \cdots, n E_j = -k \sum_{i=1}^{m} q_{ij} \ln q_{ij}, j = 1,2 \cdots, n \quad (6)$$

where $k = \frac{1}{\ln m}, 0 \le E_j \le 1 k = \frac{1}{\ln m}, 0 \le E_j \le 1$
Calculate the weight of each indicator. The information entropy redundancy $d_j d_j$ is calculated by the following formula:

$$d_j = 1 - E_j, j = 1,2 \cdots, n d_j = 1 - E_j, j = 1,2 \cdots, n \quad (7)$$

Based on the information entropy redundancy $d_j d_j$, calculate the weight $\omega_j \omega_j$ of the jj-th indicator, and the formula is as follows:

$$\omega_j = \frac{d_j}{\sum_{j=1}^{n} d_j}, j = 1,2 \cdots, n \quad \omega_j = \frac{d_j}{\sum_{j=1}^{n} d_j}, j = 1,2 \cdots, n \quad (8)$$

Based on the index values of 14 evaluation indicators in the emotional attachment evaluation index system for urban renewal vitality complexes in 5 cities of Beijing, this article calculates the weights of each evaluation indicator according to the aforementioned steps.

2. Improved TOPSIS Method with GRA

The calculation process of the improved TOPSIS method is as follows: Firstly, the positive and negative ideal solutions for the emotional attachment of urban renewal complexes are determined through the traditional TOPSIS method. Secondly, the GRA method is used to compare the scores of each evaluation indicator of each complex with the positive and negative ideal solutions. Finally, the grey correlation degree between urban renewal complexes is determined and the intensity of emotional attachment of each urban renewal complex is ranked based on the results. The main steps are as follows:

Standardize the matrix $C = (c_{ij})_{m \times n} C = (c_{ij})_{m \times n}$ to get a standardized matrix $X = (x_{ij})_{m \times n} X = (x_{ij})_{m \times n}$, where $x_{ij} x_{ij}$ is calculated as follows:

$$x_{ij} = \frac{c'_{ij}}{\sqrt{\sum_{i=1}^{m} c'^{\,2}_{ij}}}, 1 \le i \le m, 1 \le j \le n \qquad x_{ij} = \frac{c'_{ij}}{\sqrt{\sum_{i=1}^{m} c'^{\,2}_{ij}}}, 1 \le i \le m, 1 \le j \le n \tag{9}$$

The weight vector $\omega_j\omega_j = (\omega_1,\ \omega_2 \ldots \omega_3 \ldots \omega_n \omega_1,\ \omega_2 \ldots \omega_3 \ldots \omega_n)$ obtained in Equation (8) is multiplied by the standardization matrix $X = (x_{;;}) \qquad X = (x_{;;})$ to get a weighted standardization matrix as follows:

$$Y = \begin{pmatrix} \omega_1 x_{11} & \omega_2 x_{12} & \cdots & \omega_n x_{1n} \\ \omega_1 x_{21} & \omega_2 x_{22} & \cdots & \omega_n x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \omega_1 x_{m1} & \omega_2 x_{m2} & \cdots & \omega_n x_{mn} \end{pmatrix} = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{pmatrix}$$

$$Y = \begin{pmatrix} \omega_1 x_{11} & \omega_2 x_{12} & \cdots & \omega_n x_{1n} \\ \omega_1 x_{21} & \omega_2 x_{22} & \cdots & \omega_n x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \omega_1 x_{m1} & \omega_2 x_{m2} & \cdots & \omega_n x_{mn} \end{pmatrix} = \begin{pmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{pmatrix} \tag{10}$$

The positive ideal solution $y^+ y^+$ and negative ideal solution $y^- y^-$ is calculated as follows, where $J^+ J^+$ is the set of positive indicators while$J^- J^-$ is the set of negative indicators:

$$y^+ = \left[\left(\max_{1\le i\le m} y_{ij} \ \middle|\ j \in J^+\right), \left(\min_{1\le i\le m} y_{ij} \ \middle|\ j \in J^-\right)\right] = (y_1^+, y_2^+, \cdots, y_n^+)$$
$$y^+ = \left[\left(\max_{1\le i\le m} y_{ij} \ \middle|\ j \in J^+\right), \left(\min_{1\le i\le m} y_{ij} \ \middle|\ j \in J^-\right)\right] = (y_1^+, y_2^+, \cdots, y_n^+) \tag{11}$$

$$y^- = \left[\left(\min_{1\le i\le m} y_{ij} \ \middle|\ j \in J^+\right), \left(\max_{1\le i\le m} y_{ij} \ \middle|\ j \in J^-\right)\right] = (y_1^+, y_2^+, \cdots, y_n^+)$$
$$y^- = \left[\left(\min_{1\le i\le m} y_{ij} \ \middle|\ j \in J^+\right), \left(\max_{1\le i\le m} y_{ij} \ \middle|\ j \in J^-\right)\right] = (y_1^+, y_2^+, \cdots, y_n^+) \tag{12}$$

In this article, the positive ideal solution $y^+ y^+$ refers to a fictional urban renewal complex that has the best ability to foster emotional attachment and the highest level of emotional attachment. The negative ideal solution $y^- y^-$ represents the worst option, which has the poorest ability to foster emotional attachment and the lowest level of emotional attachment.

Calculation of distance between each complex and the positive ideal solution $r_i^+ r_i^+$ and the negative ideal solution r_i^- r_i^-. $r_i^+ r_i^+$ ($r_i^- r_i^-$) is the Euclidean distance, $r_i^+ r_i^+$ ($r_i^- r_i^-$) is lower, indicating that the complex is closer to the positive (negative) ideal solution, while the emotional attachment intensity is higher (lower).

$$r_i^+ = \sqrt{\sum_{j=1}^{n} \left[\left(y_{ij} - y_j^+\right)\right]^2}, 1 \le i \le m, 1 \le j \le n \qquad (13)$$

$$r_i^- = \sqrt{\sum_{j=1}^{n}\left[\left(y_{ij} - y_j^-\right)\right]^2}, 1 \le i \le m, 1 \le j \le n \quad (14)$$

Calculation of the grey relational degree:

$$d_{ij}^+ = \frac{\min\limits_i \min\limits_j \left|y^+ - y_{ij}\right| + \rho \max\limits_i \max\limits_g \left|y^+ - y_{ij}\right|}{\left|y^+ - y_{ij}\right| + \rho \max\limits_i \max\limits_j \left|y^+ - y_{ij}\right|} \quad (15)$$

$$d_{ij}^- = \frac{\min\limits_i \min\limits_j \left|y^- - y_{ij}\right| + \rho \max\limits_i \max\limits_j \left|y^- - y_{ij}\right|}{\left|y^- - y_{ij}\right| + \rho \max\limits_i \max\limits_j \left|y^- - y_{ij}\right|} \quad (16)$$

$$d_i^+ = \frac{1}{n}\sum_{j=1}^{n} d_{ij}^+, 1 \le i \le m \quad (17)$$

$$d_i^- = \frac{1}{n}\sum_{j=1}^{n} d_{ij}^-, 1 \le i \le m \quad (18)$$

where $\rho\rho$ = 0.5, $d_i^+ d_i^+$ is the grey correlation degree between the evaluation indicators and positive ideal solution, $d_i^- d_i^-$ is the grey correlation degree between the evaluation indicators and negative ideal solution.

Dimensionless processing weighted the distances $r_i^+ r_i^+$ and $r_i^- r_i^-$ and the grey correlation d_i^+ and d_i^- d_i^+ and d_i^-:

$$R_i^+ = \frac{\max r_i^+ - r_i^+}{\max r_i^+ - \min r_i^+}, 1 \le i \le m \quad (19)$$

$$R_i^- = \frac{\max r_i^- - r_i^-}{\max r_i^- - \min r_i^-}, 1 \le i \le m \quad (20)$$

$$D_i^+ = \frac{d_i^+ - \min d_i^+}{\max d_i^+ - \min d_i^+}, 1 \le i \le m \quad (21)$$

$$D_i^- = \frac{d_i^- - \min d_i^+}{\max d_i^- - \min d_i^+}, 1 \le i \le m \quad (22)$$

Perform intervaliation processing on the data, where $a = 1,\ b = 2a = 1,\ b = 2$:

$$R_i'^+ = a + \frac{(b-a)(R_i^+ - minR_i^+)}{maxR_i^+ - minR_i^+} \quad (23)$$

$$R_i'^{-} = a + \frac{(b-a)(R_i^- - minR_i^-)}{maxR_i^- - minR_i^-} \quad (24)$$

$$D_i'^{+} = a + \frac{(b-a)(D_i^+ - minD_i^+)}{maxD_i^+ - minD_i^+} \quad (25)$$

$$D_i'^{-} = a + \frac{(b-a)(D_i^- - minD_i^-)}{maxD_i^- - minD_i^-} \quad (26)$$

Integrate the above dimensionless distance and dimensionless grey correlation degree results:

$$S_i^+ = \alpha R_i'^{+} + \beta D_i'^{+} S_i^+ = \alpha R_i'^{+} + \beta D_i'^{+}, 1 \le i \le m, 1 \le i \le m \quad (27)$$

$$S_i^- = \alpha R_i'^{-} + \beta D_i'^{-} S_i^- = \alpha R_i'^{-} + \beta D_i'^{-}, 1 \le i \le m, 1 \le i \le m \quad (28)$$

where S_i^+ (S_i^-) S_i^+ (S_i^-) represents the comprehensive relation between complex C_iC_i and the positive (negative) ideal solution.

$$\alpha + \beta = 1 \alpha + \beta = 1, \alpha\alpha > 0, \beta\beta > 0$$

Calculation of the relative closeness $A_i^+ A_i^+$ of the urban vitality complex

$$A_i^+ = \frac{S_i^+}{S_i^+ + S_i^-}, 1 \le i \le m \quad (29)$$

The higher the $A_i^+ A_i^+$, the closer the urban renewal complex C_iC_i is to the positive ideal solution, indicating that its ability to promote emotional attachment is better, and the intensity of emotional attachment is also higher. By calculating, the comprehensive relative compactness of each urban renewal complex can be obtained, and this indicator can be used to rank the degree of emotional attachment of the urban vitality complexes.

2.3.3. Methodology Framework

This study mainly conducts an analysis and evaluation of the emotional attachment of the small-scale built environment of urban renewal complexes. Based on the measurement of attachment degree, dimension and intensity, it uses the logical path of " criteria establishment-methodology construction-results processing " of the emotional attachment theory to evaluate the emotional attachment of urban renewal complexes. At the same time, it comprehensively analyze the value of specific built environment characteristics by combining the results of scale analysis.

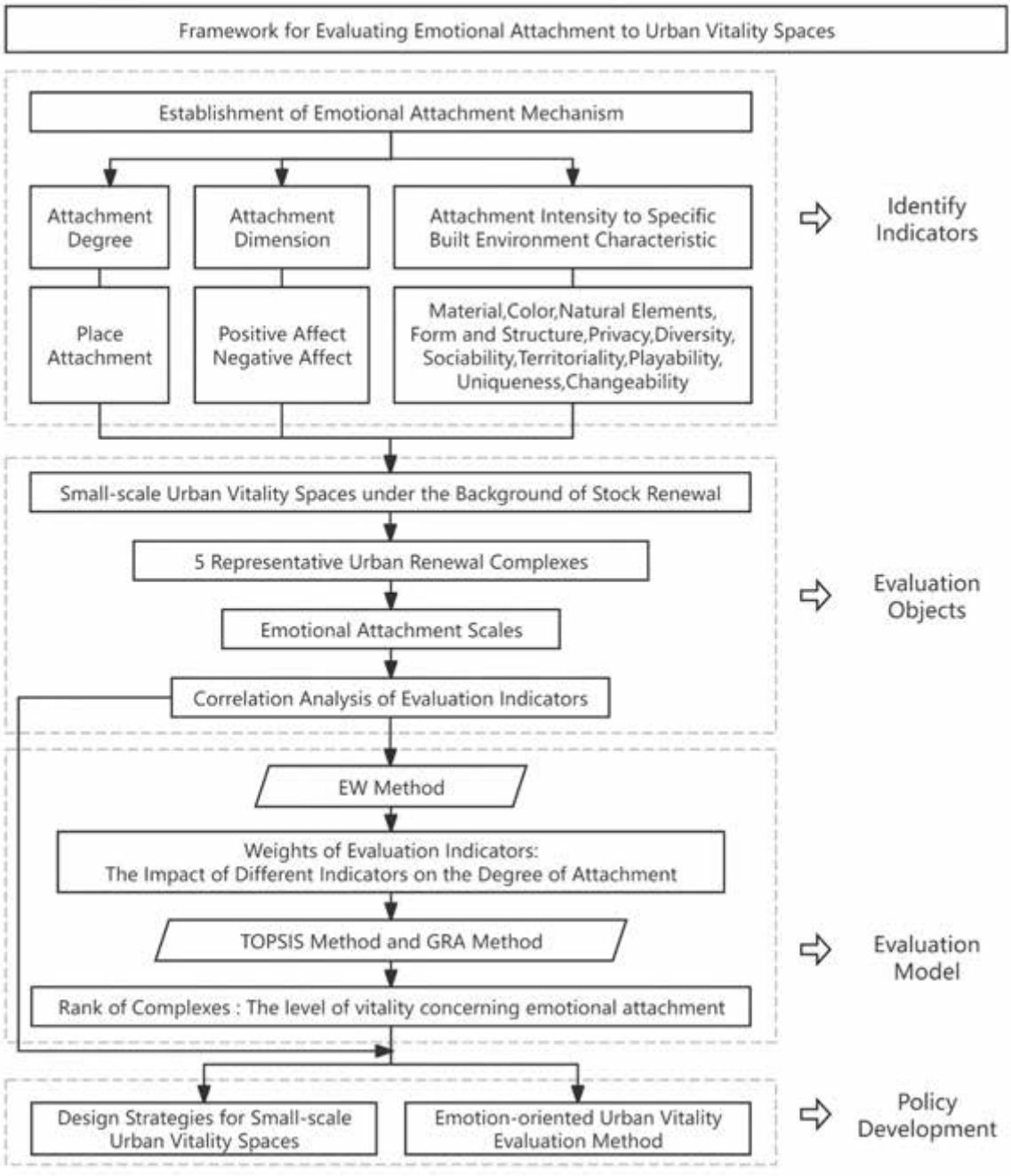

Figure 2. Flowchart of the proposed framework.

3. Results

3.1. The Analysis and Calculation Results of Emotional Attachment Scale and Emotional Attachment Evaluation Indicators

3.1.1. Calculation Results of Emotional Attachment Indicators of the Five Complexes

The overall data of each emotional attachment index for the five complexes are shown in Table 2. The attachment degree scores for these five urban vitality complexes by people all exceeded 3.5, indicating that people have a strong emotional attachment to these complexes, and from the standard deviations, it can be found that the

degree of attachment varies greatly among different people. Regarding the attachment dimensions of the five complexes, from the average values, the score of positive affect is significantly higher than that of negative affect, indicating that the positive affect people receive is more obvious than the negative affect. The value of the standard deviation indicates that people have almost the same feelings in these complexes. As for the intensity of people's attachment to specific architectural environment characteristics, the mean results show that people generally have a strong emotional experience of architectural environment characteristics, which once again proves that specific architectural environment characteristics play an important role in generating people's emotional attachment. Taking the various indicators based on the emotional attachment assessment system dimensions as the indicators of the EW-GRA-TOPSIS method, further demonstrates the urban vitality of the five complexes.

Table 2. Results of emotional attachment indicators of the five complexes.

Emotional Attachment Index		Longfusi Street		Langyuan Station		EKA Art District		Columbia Circle		Raffles City Changning	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Attachment Degree	Place Attachment	3.74	0.98	4.07	0.89	4.15	0.97	4.21	1.02	4.01	0.97
Attachment Dimension	Positive Affect	2.17	0.76	2.42	0.67	2.51	0.73	2.39	0.69	2.39	0.66
	Negative Affect	1.21	0.35	1.20	0.33	1.24	0.38	1.22	0.36	1.25	0.37
Attachment Intensity to Specific Built Environment Characteristic	Material	4.17	1.49	4.52	1.53	5.17	1.39	5.08	1.63	4.83	1.63
	Color	4.61	1.63	5.33	1.40	5.62	1.23	5.35	1.49	5.12	1.47
	Natural Elements	4.28	1.66	5.10	1.58	5.39	1.46	5.17	1.77	5.09	1.57
	Form and Structure	4.64	1.52	5.26	1.31	5.62	1.36	5.34	1.50	5.11	1.43
	Privacy	4.07	1.67	3.86	1.57	4.16	1.57	4.25	1.58	4.13	1.72
	Diversity	4.64	1.65	5.16	1.41	5.37	1.41	5.02	1.48	5.04	1.54
	Sociability	4.67	1.57	4.98	1.39	5.00	1.53	4.50	1.67	4.72	1.62
	Territoriality	4.24	1.67	3.92	1.49	4.47	1.62	4.50	1.75	4.67	1.51
	Playability	3.71	1.60	3.97	1.48	4.20	1.68	3.51	1.68	4.15	1.62
	Uniqueness	4.50	1.63	4.88	1.50	5.41	1.36	5.07	1.51	4.77	1.67
	Changeability	4.43	1.68	4.80	1.43	5.13	1.51	4.52	1.67	4.63	1.59

3.1.2. Calculation Results of Correlation Analysis of Five Complexes

Conducting correlation analysis to further explore the contribution degree of each specific architectural environment characteristic to the degree and dimensions of emotional attachment. The correlation results of the five complexes are shown in Table 3-7. It is obvious that the place attachment of people to the five complexes is positively correlated with positive emotions (0.595 **, 0.595 **, 0.582 **, 0.500 **, 0.558 **). Regarding attachment intensity to specific built environment characteristic, they are positively correlated with the overall emotional attachment in the 5 complexes. The results of describing the architectural environment material characteristics of all five complexes (including material, color, form and structure) are significantly positively correlated with local attachment, because they all have relatively high correlation coefficients, 0.01 (two-tailed). The architectural environment materials of the complexes are elements that people are easy to perceive and build emotional attachment. These coefficients to some extent reflect the value of architectural environment materials' characteristics in emotional attachment. For the social and interactive features of the complexes (including privacy, diversity, sociability, territoriality, playability, uniqueness and changeability), the results are positively correlated with emotional attachment in general, and different indicators reflect the different influences of different complexes on emotional attachment. For example, compared with the other three complexes, the sociability of Langyuan Station and EKA Art District is less correlated with place attachment (0.372 **, 0.355 **), which may be due to the fact that these two complexes are commercial blocks updated from old industrial areas, and compared with the other three complexes, these two complexes have more diverse business types and people's activities with the space are more diverse. It may be because of the richness of the space that the interaction mode here not only stops at interpersonal socialization. The results show that in the five complexes, color is closely related to form and structure (0.675 **, 0.633 **, 0.683 **, 0.571 **, 0.709 **). It indicates that in the design and construction of these urban vitality complexes, the attractive design of form and structure fully utilizes rich colors to express, jointly creating a city vitality space that can evoke people's emotional resonance.

Table 3. Correlation coefficients between different attachment indicators of Longfusi Street

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Place Attachment	1													
2	Positive Affect	0.595**	1												
3	Negative Affect	-0.120	0.258**	1											
4	Material	0.626**	0.350**	-0.216*	1										
5	Color	0.524**	0.314**	-0.192*	0.767**	1									
6	Natural Elements	0.444**	0.261**	-0.238**	0.616**	0.674**	1								
7	Form and Structure	0.526**	0.276**	-0.180*	0.699**	0.675**	0.583**	1							
8	Privacy	0.476**	0.310**	-0.056	0.544**	0.477**	0.553**	0.554**	1						
9	Diversity	0.479**	0.343**	-0.228**	0.509**	0.547**	0.498**	0.604**	0.538**	1					
10	Sociability	0.499**	0.374**	-0.170	0.458**	0.464**	0.276**	0.451**	0.401**	0.700**	1				
11	Territoriality	0.448**	0.326**	-0.144	0.463**	0.433**	0.368**	0.391**	0.406**	0.371**	0.480**	1			
12	Playability	0.428**	0.353**	-0.170	0.324**	0.300**	0.276**	0.355**	0.303**	0.379**	0.463**	0.429**	1		
13	Uniqueness	0.524**	0.320**	-0.167	0.605**	0.604**	0.520**	0.594**	0.407**	0.647**	0.559**	0.315**	0.347**	1	
14	Changeability	0.350**	0.314**	-0.055	0.368**	0.350**	0.314**	0.449**	0.422**	0.598**	0.520**	0.344**	0.337**	0.535**	1

*. p < 0.05 (2-tailed), **. p < 0.01 (2-tailed).

Table 4. Correlation coefficients between different attachment indicators of Langyuan Station

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Place Attachment	1													
2	Positive Affect	0.595**	1												
3	Negative Affect	-0.107	0.158	1											
4	Material	0.468**	0.437**	-0.100	1										
5	Color	0.475**	0.330**	-0.205*	0.511**	1									
6	Natural Elements	0.541**	0.427**	-0.091	0.476**	0.641**	1								
7	Form and Structure	0.485**	0.392**	-0.087	0.540**	0.633**	0.571**	1							
8	Privacy	0.391**	0.223*	-0.069	0.380**	0.236**	0.401**	0.389**	1						
9	Diversity	0.510**	0.285**	-0.109	0.404**	0.496**	0.447**	0.472**	0.451**	1					
10	Sociability	0.372**	0.137	-0.071	0.301**	0.393**	0.410**	0.421**	0.130	0.551**	1				
11	Territoriality	0.449**	0.288**	-0.060	0.302**	0.320**	0.375**	0.265**	0.266**	0.340**	0.418**	1			
12	Playability	0.328**	0.247**	-0.111	0.201*	0.235**	0.287**	0.278**	0.391**	0.399**	0.369**	0.470**	1		
13	Uniqueness	0.489**	0.430**	-0.016	0.348**	0.475**	0.432**	0.442**	0.348**	0.590**	0.485**	0.441**	0.461**	1	
14	Changeability	0.295**	0.270**	-0.107	0.253**	0.246**	0.270**	0.268**	0.246**	0.429**	0.374**	0.508**	0.384**	0.598**	1

*. p < 0.05 (2-tailed), **. p < 0.01 (2-tailed).

Table 5. Correlation coefficients between different attachment indicators of EKA Art District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Place Attachment	1													
2	Positive Affect	0.582**	1												
3	Negative Affect	0.017	0.187*	1											
4	Material	0.488**	0.353**	0.012	1										
5	Color	0.519**	0.480**	-0.017	0.639**	1									
6	Natural Elements	0.405**	0.432**	0.061	0.518**	0.603**	1								
7	Form and Structure	0.496**	0.438**	0.015	0.652**	0.683**	0.597**	1							
8	Privacy	0.330**	0.393**	0.028	0.378**	0.423**	0.398**	0.341**	1						
9	Diversity	0.374**	0.447**	0.064	0.512**	0.517**	0.406**	0.369**	0.443**	1					
10	Sociability	0.355**	0.431**	0.029	0.345**	0.331**	0.312**	0.268**	0.414**	0.632**	1				
11	Territoriality	0.209*	0.308**	0.061	0.382**	0.325**	0.450**	0.330**	0.329**	0.389**	0.461**	1			
12	Playability	0.306**	0.333**	-0.030	0.400**	0.289**	0.184*	0.194*	0.342**	0.425**	0.507**	0.430**	1		
13	Uniqueness	0.337**	0.385**	0.029	0.468**	0.430**	0.411**	0.513**	0.403**	0.594**	0.493**	0.522**	0.472**	1	
14	Changeability	0.391**	0.476**	0.069	0.406**	0.487**	0.323**	0.431**	0.501**	0.530**	0.587**	0.363**	0.420**	0.549**	1

*. p < 0.05 (2-tailed), **. p < 0.01 (2-tailed).

Table 6. Correlation coefficients between different attachment indicators of Columbia Circle

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Place Attachment	1													
2	Positive Affect	0.500**	1												
3	Negative Affect	0.021	0.316**	1											
4	Material	0.445**	0.154	0.054	1										
5	Color	0.456**	0.171	-0.077	0.654**	1									
6	Natural Elements	0.409**	0.230**	-0.094	0.464**	0.558**	1								
7	Form and Structure	0.504**	0.264**	-0.063	0.658**	0.571**	0.615**	1							
8	Privacy	0.399**	0.243**	-0.068	0.362**	0.388**	0.416**	0.414**	1						
9	Diversity	0.423**	0.214*	0.009	0.466**	0.438**	0.472**	0.553**	0.561**	1					
10	Sociability	0.440**	0.295**	-0.019	0.288**	0.236**	0.288**	0.370**	0.385**	0.552**	1				
11	Territoriality	0.497**	0.266**	-0.017	0.384**	0.353**	0.264**	0.393**	0.361**	0.353**	0.488**	1			
12	Playability	0.301**	0.221*	-0.118	0.306**	0.365**	0.347**	0.344**	0.332**	0.429**	0.376**	0.374**	1		
13	Uniqueness	0.492**	0.309**	0.088	0.449**	0.286**	0.367**	0.443**	0.456**	0.659**	0.418**	0.457**	0.451**	1	
14	Changeability	0.382**	0.179*	-0.020	0.405**	0.267**	0.320**	0.440**	0.428**	0.564**	0.377**	0.233**	0.509**	0.612**	1

*. p < 0.05 (2-tailed), **. p < 0.01 (2-tailed).

Table 7. Correlation coefficients between different attachment indicators of Raffles City Changning

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Place Attachment	1													
2	Positive Affect	0.558**	1												
3	Negative Affect	0.135	0.302**	1											
4	Material	0.426**	0.358**	-0.027	1										
5	Color	0.525**	0.333**	-0.121	0.749**	1									
6	Natural Elements	0.381**	0.365**	-0.066	0.626**	0.672**	1								
7	Form and Structure	0.484**	0.372**	0.038	0.625**	0.709**	0.656**	1							
8	Privacy	0.328**	0.162	-0.021	0.396**	0.511**	0.558**	0.428**	1						
9	Diversity	0.454**	0.374**	-0.052	0.555**	0.657**	0.656**	0.580**	0.523**	1					
10	Sociability	0.446**	0.367**	-0.102	0.400**	0.493**	0.449**	0.450**	0.355**	0.631**	1				
11	Territoriality	0.490**	0.304**	0.033	0.463**	0.489**	0.412**	0.508**	0.351**	0.547**	0.670**	1			
12	Playability	0.305**	0.300**	0.001	0.354**	0.400**	0.374**	0.323**	0.427**	0.594**	0.540**	0.373**	1		
13	Uniqueness	0.510**	0.396**	0.010	0.427**	0.533**	0.602**	0.537**	0.465**	0.599**	0.536**	0.430**	0.471**	1	
14	Changeability	0.451**	0.279**	-0.032	0.369**	0.526**	0.554**	0.403**	0.448**	0.581**	0.551**	0.494**	0.475**	0.680**	1

*. p < 0.05 (2-tailed), **. p < 0.01 (2-tailed).

3.2. The Results of the Emotional Attachment Evaluation of Urban Vitality Complexes Using EW-GRA-TOPSIS Method

Based on the index data collected and calculated above for the five complexes, the model for evaluating the emotional attachment to the built environment of urban vitality complexes, which was established in Section 2.3 using the EW-GRA-TOPSIS method, was applied to assess the emotional attachment level of these five complexes.

3.2.1. Calculation of the Weight of Each Indicator

The decision-making matrix CC is constructed, standardized, and normalized in line with Equations (1) – (4). The entropy value E_jE_j and weight $\omega_j\omega_j$ for each indicator of the five complexes are derived through Equations (5) – (8). The detailed outcomes are presented as follows.

Table 8. Weight of each indicator.

Evaluation Index	E_j	ω_j
Place Attachment	0.985	0.066
Positive Affect	0.986	0.062
Negative Affect	0.979	0.092
Material	0.982	0.077
Color	0.985	0.064
Natural Elements	0.985	0.064
Form and Structure	0.985	0.063
Privacy	0.985	0.064
Diversity	0.986	0.062
Sociability	0.981	0.084
Territoriality	0.984	0.068
Playability	0.981	0.082
Uniqueness	0.984	0.070
Changeability	0.981	0.084

3.2.2. Calculation of the Positive and Negative Ideal Solution of Each Indicator

Following the standardization and weighing of matrix CC in accordance with Equations (9) and (10), the ideal positive and negative solutions for each indicator are determined via Equations (11) and (12). The resulting data is outlined below.

Table 9. Positive ideal solution and negative ideal solution of each indicator.

Evaluation Index	Positive Ideal Solution	Negative Ideal Solution
Place Attachment	0.132	0.066
Positive Affect	0.123	0.062
Negative Affect	0.183	0.092
Material	0.154	0.077
Color	0.128	0.064
Natural Elements	0.127	0.064
Form and Structure	0.126	0.063
Privacy	0.127	0.064
Diversity	0.125	0.062
Sociability	0.167	0.084
Territoriality	0.136	0.068
Playability	0.164	0.082
Uniqueness	0.140	0.070
Changeability	0.167	0.084

3.2.3. Calculation of the Distance from the Emotional Attachment of Each Urban Vitality Complex to the Positive and Negative Ideal Solution

After calculating and normalizing the distance between the emotional attachment of each urban vitality complex and the ideal solution using Equations (13), (14), (19), and (20), the results are presented below.

Table 10. Distance from the emotional attachment of each complex to the positive and negative ideal solution.

Urban Vitality Complex	R_i^+	R_i^-
Longfusi Street	0.377	0.460
Langyuan Station	0.426	0.402
EKA Art District	0.236	0.613
Columbia Circle	0.443	0.437
Raffles City Changning	0.651	0.246

3.2.4. Calculation of Grey Relational Degree of Each Urban Vitality Complex

Using the results from the calculation of positive and negative solutions in Section 3.2.2, the grey relational degree of each urban vitality complex is determined and normalized through Equations (17), (18), (21), and (22). The findings are presented below.

Table 11. Grey relational degree of each complex.

Urban Vitality Complex	D_i^+	D_i^-
Longfusi Street	0.433	0.413
Langyuan Station	0.414	0.416
EKA Art District	0.594	0.319
Columbia Circle	0.442	0.420
Raffles City Changning	0.304	0.614

3.2.5. Calculation of the Relative Closeness and the Rank of Each Urban Vitality Complex

Based on Equations (27) and (28), the relative closeness of each complex is calculated by determining $S_i^+ S_i^+$ and $S_i^- S_i^-$. Then, the emotional attachment level of each complex can be ranked. The results are shown below.

Table 12. Relative closeness and the vitality evaluation rank of five complexes.

Urban Vitality Complex	S_i^+	S_i^-	A_i^+	Rank
Longfusi Street	0.446	0.395	0.530	2
Langyuan Station	0.408	0.421	0.492	4
EKA Art District	0.603	0.278	0.685	1
Columbia Circle	0.439	0.432	0.504	3
Raffles City Changning	0.275	0.633	0.303	5

The results show that EKA Art District ranked first among the five complexes, indicating that the level of emotional attachment it established between people and urban complexes was the highest among the five complexes. Longfusi Street and Columbia Circle ranked second and third respectively in the assessment, with their scores being relatively close and both higher than 0.5 (0.530 > 0.504 > 0.5). Raffles City Changning ranked last, indicating that people's emotional attachment to this architectural environment was relatively low. In the next part, we will combine the above correlation analysis and field research results to explore further reasons for this.

4. Discussion

In previous studies, there were not many that focused on the relationship between the built environment at a small scale and the emotional attachment of users. This was due to the relatively difficult acquisition of data. Previous studies on urban vitality usually adopted quantitative data mining and other methods to conduct research, which made it difficult to focus on specific small-scale urban vitality spaces and also difficult to focus on the dimensions and levels of emotional interaction between people and the built environment. Therefore, this study focuses on small-scale urban complexes with representative significance in first-tier cities under the background of urban renewal in China. It conducts research on urban small-scale vitality spaces from the perspective of emotional attachment, and attempts to achieve a scientific and objective study of the emotional attachment dimensions and levels of urban vitality spaces through the construction of quantitative research methods. The research results and the practical process of method construction are as follows.

4.1. The Value of Architectural Environment Characteristics in Establishing Emotional Attachment in Urban Vitality Spaces

The data results show that the built environment characteristics of EKA Art District performed the best in terms of emotional attachment, with the highest score and higher than 0.5 (0.685). EKA Art District is a city complex built on the original industrial factory site through re-design and renovation. It retains the original road network and layout structure of the factory area. Based on the relevant analysis results in Section 3.1.2, the built environment characteristics of this commercial complex play an important role in building the emotional attachment of users. The color, form and structure of the complex, as well as the place attachment, show a significant positive correlation (0.519**, 0.496**, 0.488**), indicating that the original industrial-style spatial forms and structures with industrial characteristics in the industrial-old-site renewal complex have played a role in promoting emotional attachment for this type of urban dynamic space. There is a significant positive correlation between color with form and structure (0.683**), further indicating that the use of industrial-style materials such as rusted steel plates, with their color providing people with deep memories and forming unforgettable emotional experiences. Longfusi Street and Columbia Circle ranked second and third in the assessment, with their scores higher than 0.5 and a certain gap from the first-ranked complex (0.530, 0.504). Based on the correlation results analysis, it can be inferred that the architectural environment characteristics of these two complexes also made significant contributions to promoting emotional attachment. Specifically, the material characteristics of Longfusi Street (including material, color, form and structure) were superior to Columbia Circle (Longfusi Street: 0.626**, 0.524**,

0.526** > Columbia Circle: 0.444**, 0.456**, 0.504**). To a certain extent, it indicates that in the process of renewing a historical district into a complex, the comprehensive application of materials that echo traditional design styles helps people build emotional attachment to this type of complex. Columbia Circle innovatively used new materials, forming a unique style of dynamic complex.

Langyuan Station ranked fourth in the assessment, with a score slightly lower than 0.5 and similar to that of Columbia Circle (0.492). According to the correlation analysis, it can be inferred that the architectural environment characteristics of this complex also made a certain contribution to promoting emotional attachment. Specifically, diversity, natural elements, and form and structure with place attachment show a positive correlation (0.510**, 0.541**, 0.485**). As a city complex built on the original industrial factory site through re-design and renovation, unlike EKA Art District prominent contribution of color and material to the built environment and place attachment, Langyuan Station's application of diversity and natural elements effectively enhanced the spatial vitality of this complex.

Raffles City Changning ranked last among the five complexes in the emotional attachment assessment. Based on the correlation analysis, color, form and structure, as well as uniqueness are positively correlated with place attachment (0.525**, 0.484**, 0.510**), while privacy and playability have the weakest correlation with place attachment (0.328**, 0.305**). This might be related to the unique new architectural enclosure of Raffles City Changning that surrounds the historical buildings in the overall layout of the space. Such a spatial layout is relatively simple, with fewer spatial changes, resulting in insufficient privacy. Compared to other complexes, the transformation of spatial levels in Raffles City Changning is simpler, making the game nature of the complex relatively weak.

Overall, the architectural environment characteristics of the five commercial complexes all play a role in promoting emotional attachment, creating spaces with urban vitality through different design methods. The contribution of specific features to the process of people forming place attachment with different complexes varies, possibly related to the original distinctive style of the complexes.

4.2. The Application of the Emotional Attachment Evaluation Results in the Study of Urban Vitality

Under the background of stock renewal, the design of urban vitality spaces shares many similarities in strategies and techniques with the previous designs that focused on emotional attachment. Previously, we believed that the emotional attachment scale and evaluation results, due to their uniqueness, were difficult to reflect the characteristics of other urban architectural environments such as urban vitality. However, through the above exploration, it can be shown that the newly built small-scale urban vitality spaces significantly promoted the construction of emotional attachment in terms of architectural environment characteristics. Therefore, the specific value research results of this study on the various features of urban vitality spaces not only focus on the exploration of the emotional attachment dimension, but also reflect the degree and characteristics of urban vitality in the process of constructing new urban vitality spaces.

This study innovatively applies the emotional attachment scale to the small-scale assessment of urban vitality spaces and effectively quantifies the emotional attachment data into the assessment results of small-scale and architectural environment characteristics of urban vitality spaces. The attachment scale and evaluation results help reveal the small-scale urban vitality elements that are closer to people's daily lives, and also take into account some aspects of the large-scale urban vitality space assessment. For example, from the perspective of emotional attachment, the material, color, natural elements, as well as the form and structure that people can directly touch and feel are important components of the vibrant urban environment at the small scale. These indicators are rarely used for evaluation in large-scale urban vitality studies. However, the diversity, sociability, and territoriality, which are the overall social interaction characteristics of the environment, can be extended to large-scale urban vitality studies. There is a significant correlation between the diversity and sociability of multiple complexes and their uniqueness, especially in the EKA Art District and Longfusi Street complexes with high attachment levels, which indicates the important role of such emotional attachment measurement

indicators applicable to large-scale spaces in the evaluation system, and proves that such indicators are also important indicators for evaluating urban vitality.

In the future research and design of small-scale urban vitality spaces, the method constructed in this study can not only be repeatedly verified in the research process, but also be quantitatively measured the vitality level of emotional attachment in the evaluation process. It can also further explore the correlation between emotional attachment and architectural environment characteristics. The relevant results of this study can be used as a reference for the design and renovation of small-scale urban complex spaces to create more architectural environments that focus on people's emotional experiences, thereby stimulating the space to exhibit long-term and diverse vitality.

4.3. Promote the Application of Quantitative Methods in the Research and Assessment of the Vibrant spaces in Small-Scale Cities

In current urban research, the quantitative methods for studying urban vitality are mostly manifested as collecting multi-dimensional big data to construct corresponding evaluation systems. Such methods are mainly used to explore large-scale areas within a certain region and the city as a whole. In the context of stock renewal, the small-scale urban vitality space research has more direct significance in enhancing the spatial experience of users compared to the macroscopic regional vitality evaluation. Since the vitality of small-scale spaces comes from the interaction between people and the specific characteristics of the architectural environment, and emotion is one of the core dimensions of vitality formation, the quantitative measurement method of the emotion attachment scale formed by multidisciplinary researchers provides a quantitative approach for the analysis of small-scale vitality spaces. When examining urban vitality in small-scale architectural environments, the emotion attachment method is used both as a theoretical guide and as a quantitative tool. Based on the results of the attachment scale, the improved TOPSIS method is then used to further evaluate the relative levels of emotional attachment in different vibrant complexes. The single TOPSIS model, when calculating scores and standardizing, assumes that the weights of each indicator are the same, which cannot well reflect the objective situation of the data. Therefore, this study selects the EW method to change the weight settings of the indicators in the emotion attachment scale analysis, and assigns different weights to different indicators based on the actual obtained emotion attachment scale data. Additionally, the GRA method is combined to compensate for the inherent shortcomings of the TOPSIS model, making the final constructed EW-GRA-TOPSIS evaluation method more complete. This method has the advantage of combining qualitative and quantitative analysis, considering people's perception of spatial characteristics and emotional needs in the evaluation of small-scale vitality spaces, and using precise mathematical methods for quantification, making the evaluation results clearer. This evaluation system is widely applied to the comparative evaluation of spatial vitality of multiple urban complexes, thereby providing scientific, reasonable, and practical guidance and strategies for urban vitality space design, construction evaluation, and optimization.

5. Conclusion

In the context of stock update, in the existing research fields of urban vitality, there is a lack of design and evaluation methods for small-scale vitality spaces at the research scale. In terms of research dimensions, people lack attention to the advanced needs of people's emotional attachment to specific and vibrant spaces. Therefore, in response to the lack of attention to the emotional dimension and insufficient quantitative research in the study of small-scale urban vitality spaces, this paper proposes a methodology applicable to the exploration and evaluation of small-scale urban vitality spaces, and selects five representative vitality urban complexes in two representative first-tier cities in China as examples to conduct field research and data analysis using this method. Based on the analysis of the experimental process and results, the main results of this study are summarized as follows:

1) In the small-scale spatial dimension, the basic material characteristics of the built environment (including material, color, natural elements, form and structure) play a significant role in stimulating urban vitality. According to the results of this study, their mechanism of promoting urban vitality through emotional attachment is

presented in the following ways. Firstly, based on the manifestation of the basic characteristics of material, such as the texture and color of the material themselves. During the interaction with the vitality complex, people can directly understand the logic of space construction. The cognition of the most basic material characteristics of the complex itself is the foundation for people to establish place attachment and is also a necessary condition for the complex to generate vitality. Secondly, the combination and connection of material elements with the original characteristics of the complex. For example, complexes like EKA Art District and Langyuan Station, which are based on the renovation of industrial buildings, retain the street layout, old materials and original architectural structures. The industrial structure has a certain influence on the re-construction of the vitality space. At the same time, natural elements also have an impact on the vitality level of most complexes. People's affinity for nature makes natural elements crucial in the process of forming emotional attachment.

2) The diversity and frequency of various activities carried out by people in the vitality complex to some extent reveal the social interaction nature of this urban complex, including privacy, diversity, sociability, territoriality, playability, uniqueness, and changeability. The results show that from the perspective of emotional attachment, they play an important role in promoting spatial vitality. At the same time, from the perspective of vitality evaluation, these characteristics have a significant positive correlation with attachment. In the complexes with relatively high vitality evaluation rankings, territoriality and uniqueness have a certain correlation with attachment, indicating that regionalism and uniqueness have an impact on the vitality level of the complex. However, in the complexes with lower rankings, the correlations between privacy and playability and attachment are weaker, indicating that privacy and playability also affect the social interaction nature of the complex and thereby affect the vitality situation of the complex.

With the advancement of emotion measurement and data mining technologies, the acquisition of data on people's emotional attachment to the built environment has become increasingly abundant, and the update of open-source data for various scales of urban spaces has accelerated. The integration and analysis of emotional and spatial data have become more convenient, laying the foundation for the widespread application of this research method. This method can be flexibly replicated to different urban vitality spaces and, through comparative tests, promote continuous improvement. In terms of data collection, in addition to traditional scales, multiple-modal technologies such as wearable physiological monitoring devices, eye trackers, and portable electroencephalogram equipment can be utilized to enhance the accuracy of indicators; when applying this method, the evaluation indicators and weights of the built environment should be dynamically adjusted according to the characteristics of the research area. The research methodology of this method differs from traditional urban vitality assessment methods in terms of perspective and scale, focusing on people's emotional experiences in urban vitality spaces. By leveraging objective data analysis, it aims to explore design and construction strategies for enhancing environmental emotional attachment. The place attachment theory plays a crucial bridging role here, especially in small-scale spaces, effectively converting subjective emotions into quantitative data. Through in-depth analysis of emotional attachment data, this method accurately quantifies the emotional attachment degree and vitality level of complexes and their built environments, and scientifically and objectively analyzes the influence mechanism of architectural environment characteristics on emotional experiences, providing innovative ideas and practical references for the all-round development of future urban vitality spaces with humanistic orientation.

The application of this method in current research has not yet reached a very mature stage. Its depth and breadth need to be expanded. On one hand, with the help of new technologies for collecting and analyzing emotional data, more emotional attachment indicators such as physiological data can be added. In this way, researchers can observe more objectively the impact of indicator changes on the evaluation of urban vitality spaces and architectural environment characteristics. On the other hand, the continuous upgrading of this type of method can be applied to multiple small-scale urban vitality complexes in different cities, widely comparing experimental results and verifying, and upgrading this type of method.

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Rethinking Urban Living Environments: Investigating the Influence of Built Environment Features on Physical Activity Levels – Evidence from a Cross-Sectional Study in Ankara, Türkiye

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Abstract
Built environment (BE) epidemiologists aim to elucidate the pathways through which BE characteristics are linked to the prevalence of chronic diseases. Our study identifies the direct and indirect effects of urban living environments on overall perceptions of physical health. Our cross-sectional geospatial study involved 4015 residents of Ankara. We fitted multinomial logit models to assess relationships between residents' locations, demographic and socioeconomic statuses (SES), obesity prevalence, PA levels, life satisfaction, and evaluations of urban living environments and overall health perception. We found significant relationships between BE characteristics and health perception, particularly with SES, age groups, green space availability, environmental perception, PA levels, and obesity prevalence. Our findings provide evidence of the relationship between public health policy and urban design and planning.

Keywords: Healthy Neighbourhood Planning, Physical Activity, Public Health

1. Introduction

Cities consist of living environments with different built environment characteristics, which inherently present complex and multidimensional structured environments formed from various processes. While some areas are healthy, safe, and attractive, integrated with urban activities, others are unattractive due to a lack of infrastructure, open and green spaces, and urban services. In developing countries, particularly in fast-growing, high-density cities that receive constant immigration, such areas are more common due to uncontrolled, spontaneous development. Restructuring these areas and transforming them into sustainable, livable, walkable, high-quality, and healthy environments is gaining importance both in Türkiye and worldwide. This study aims to link the overall health assessment of individuals with built environment characteristics, physical activity levels, and obesity prevalence, while controlling for the confounding variables of demographic and socioeconomic status.

The built environment characteristics should enable individuals to prioritize a healthy and active lifestyle while meeting their basic needs, such as shelter and nutrition. Thus, the importance of the relationship between city planning, urban design, and public health is revealed. Although central and local governments have existing practices, producing new approaches that are more comprehensive, location-specific, multi-level, multi-sectoral, participatory, and community-oriented should be the priority. To have a healthy city that supports physical activity, citizens do not need high-cost residential projects; public interventions to increase the presence of walkable, mixed-use, and accessible green areas in living environments will increase overall health perception along with physical activity and contribute to reducing NCDs in society.

The promotion of physical activity — walking, cycling, sports participation, and the broader dissemination of active recreational pursuits — is recognized as a critical component within the framework of the United Nations Sustainable Development Goals (SDGs). This emphasis reflects not only its profound health implications but also its substantial social and economic benefits. Specifically, it aligns with and advances the objectives of SDG 3 (Good Health and Well-Being), SDG 11 (Sustainable Cities and Communities), SDG 13 (Climate Action), and SDG 17 (Partnerships for the Goals).

In this context, the research questions are as follows:
- How do built environment characteristics, socioeconomic statuses, physical activity, and BMI levels influence

overall health perception?
- What are the significant urban planning policies that enhance the perceived health of individuals?

2. Literature Review

Scientific studies have shown that the characteristics of a built environment significantly influence the lifestyle and preferences of its inhabitants and effective urban public health policies can effectively manage these factors (Bennett et al., 2024; Sarkar and Webster, 2017). Cities are composed of neighbourhoods with various built environments and geographical characteristics developed and controlled by city plans. These environments are complex and multidimensional, forming different morphologies and plan periods.

Increased population growth, extensive migration from rural areas to cities, rapid urbanization, and the close relationship between social welfare and neighbourhood quality have heightened the significance of health for societies. Among the Sustainable Development Goals (SDGs) of the United Nations, SDG3 Healthy Individuals and SDG11 Sustainable City and Living Spaces are the two goals that cities have to adopt along with the quality they provide to support 'health' and 'well-being' (Ramirez-Rubio et al., 2019; WHO, 2023). In particular, following the COVID-19 pandemic, the quality of neighbourhoods has become increasingly important, and guidelines have been established to plan and design them through city plans and design (Mouratidis and Yiannakou, 2022). Healthy cities have become the focus of urban planning, and built environment characteristics have gained importance.

Walkable, accessible, mixed-use neighbourhoods supported by robust urban infrastructure are essential for physically active and healthy living (Cerin et al., 2018), and therefore require a new examination of the specifics of socio-spatial attributes of urban living. The physical setup of the neighbourhoods, including residential density, land use diversity, accessibility, centrality, availability of health infrastructure, and sufficiency of green spaces, define the level of physical activity (PA) and health (Sarkar et al., 2014; Ho et al., 2023; Lai et al., 2023; Italia, 2001). A city should offer walkable urban areas and ample spaces supporting mobility; the built environment appears to decrease physical inactivity, thus eliminating the risk factors of NCDs (Haskell et al., 2009). In this context, the planning and design strategies of neighbourhoods ensure the control of the demographic structure and socio-economic and environmental elements and will be effective in promoting health and mitigating the risks, such as physical inactivity (Haskell et al., 2009) that underlie non-communicable diseases (NCDs).

NCDs are responsible for 74% of the death rates in the world (WHO, 2023) and 90% of deaths in Europe (EEA, 2020). NCDs are increasingly responsible for 70-80% of European health costs (EC, 2020). For example, worldwide, adult obesity has more than doubled since 1990, and adolescent obesity has quadrupled; in 2022, 1 in 8 people in the world were living with obesity (WHO, 2024). The environmental relationship between inactivity and obesity has been discussed elsewhere (Gray et al., 2018), but in this paper, we aim to focus on a method to differentiate the neighbourhoods according to the factors known to be associated with PA.

This study shows that some characteristics, in particular land use diversity, health facility infrastructure, and green space size, play a significant role in identifying an urban pattern and are the products of different plan periods, which can influence the physical activity levels of its inhabitants.

Adequate housing involves evaluating the living unit as a physical entity within its environment and as a qualitative, complex formation that encompasses social, economic, and psychological aspects. In this context, the neighbourhood becomes a priority for investment to meet the needs of its residents. It has a fundamental impact on determining the quality of life for an individual (Pacione, 2003). Urban living conditions affect both their physical and mental health (Handy et al., 2002). For example, to promote healthy aging, public housing neighbourhoods should include more accessible spaces and community facilities along walking paths to support PAs and daily needs (Ho et al., 2023).

In transportation and built environment research, some scholars have classified how the physical attributes of neighbourhoods can be evaluated (Ewing and Cervero, 2010; Handy et al., 2002). Initially, they specified these

attributes as density, diversity, and design (Cervero and Kockelman, 1997), and this has been expanded by adding destination accessibility and distance to transit features (Ewing and Cervero, 2001). Next, the affiliation of these attributes with physical activity, walking, and mobility has been specified. It was found that physical activity is directly related to land use diversity, density of road network intersections, presence of urban green areas, distance to public transportation stops, and the number of destinations within walking distance (Ewing and Cervero, 2010; Zhang et al., 2022). In addition, green space size and its accessibility, the presence of green areas, opportunities and land use variability in a neighbourhood, and urban sprawl are specified as other influential factors on physical activity and physical and mental health (Carmona, 2019).

In a recent study, when examined in terms of urban health, eleven dimensions appear: i) housing and land use diversity (mixed-use), ii) accessibility, iii) access by public transportation, iv) design of movement networks, v) attractiveness of active transportation modes, vi) density, vii) distribution of labor force, viii) management of demand for urban services, ix) destination proximity, x) disaster mitigation, xi) distributed interventions and resources (Giles-Corti et al., 2022).

Physical activity is one of the most prominent healthy lifestyle behaviors in preventing both physical and mental diseases, including reducing the risk factors for NCDs, including obesity and type II diabetes, and one of WHO's main strategy recommendations for 'Healthy Cities' is to create a physical and social environment that supports physically active life (WHO, 2018). Neighbourhoods that support physical activity will enhance healthy living and should be accessible to all segments of society, particularly women, children, individuals aged 65 and above, and those in special needs groups who are considered disadvantaged. In settlements where all segments of society have equitable access to high-quality neighbourhoods and where individual and social interests are balanced, the sense of belonging towards the living environment will increase, and the quality of life will be high. In our analysis, the neighbourhood characteristics that support physical activity have been identified through variables derived from the literature review.

3. Methodology

The survey took place between 21 December 2021 and 15 March 2022, and 4015 interviews were reported to be valid. They are distributed across 76 neighbourhoods in Ankara. The research employed a spatial sampling strategy, where neighbourhoods were classified by specific factors linked to physical activity and well-recognized in the literature. The clustering criteria covered key variables: Built Environment Variables (Residential Density, Average Building Height, Average Building Volume, Green Space per Capita (km²/person), Green Area Ratio (green area / total area)), Street Network / Accessibility Variables (FAR (Floor Area Ratio), MAD1000 (Mean Angular Distance within 1000 m), MAD5000 (Mean Angular Distance within 5000 m), TPBtA1000 (Total Pedestrian Betweenness within 1000 m), TPBtA5000 (Total Pedestrian Betweenness within 5000 m)), Local Health Services Variables (Number of Physicians (per 1000 inhabitants), Number of Family Health Centers (FHCs) (per 1000 inhabitants)), Centrality Variables (Number of Chain Markets (per 1000 inhabitants), Number of Food & Beverage Establishments (per 1000 inhabitants), Number of Pharmacies (per 1000 inhabitants)), Land Price (TRY). We used clustering techniques – the Elbow method and specified 7 clusters. The total population, the share of population, the sample size, and the actual distribution of the interviews across clusters are shown in Table 1.

Table 1. Population (2020), Share of Population, Sample Size, Actual Distribution of Interviews by Clusters

Cluster	Population 2020	Share of Population	Sample Size		Actual Distribution of Interviews	
			Number	%	Number	%
1	1,393,621	0.28	929	23.23	953	23.74
2	326,598	0.07.	450	11.25	420	10.46
3+7*	39,286	0.01	176	4.40	177	4.41
4	1,112,234	0.22	830	20.75	828	20.62
5	1,217,823	0.24	869	21.73	878	21.87

6	898,796	0.18	746	18.65	759	18.90
Toplam	4,988,358	1.00	4000	100.00	4015	100.00

* The clusters are merged due to the size and proximity of cluster 3 and 7.

Figure 1 illustrates the locations of the selected neighbourhoods in the Ankara study area. These neighbourhoods are selected based on their cluster and socioeconomic (SES) status. The sample included households from across all neighbourhoods.

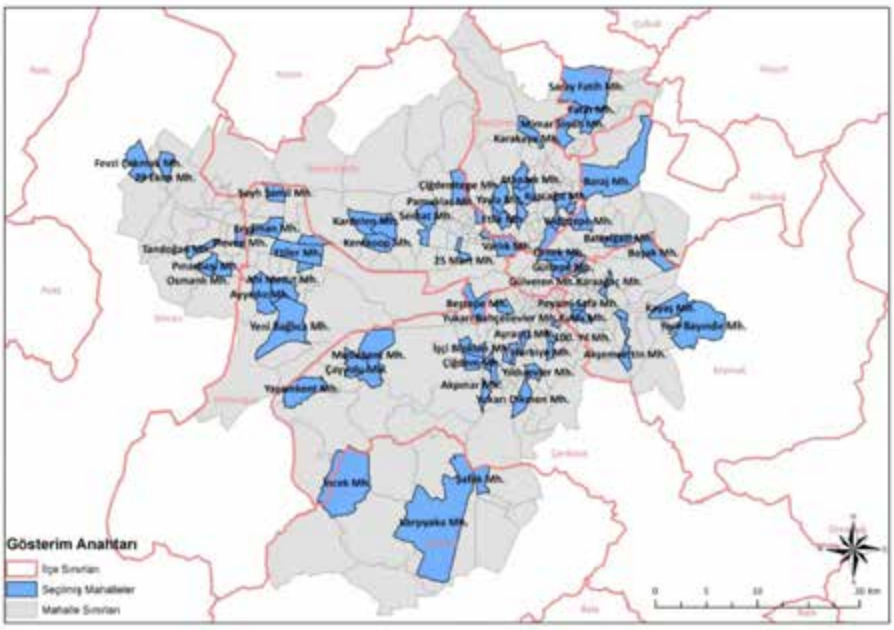

Figure 1. Selected Neighbourhoods in the Study Area

The dependent variable (overall health perception) was classified into three nominal categories ("good and very good", "moderate", and "bad and very bad"). The analysis required the relational statistical assessment of independent variables (built environment characteristics, physical activity levels, obesity prevalence (assessed by BMI) along with confounding factors of demographic and socioeconomic statuses. The model estimates the probability of each category relative to a reference category, based on the independent variables. In our analysis, we chose "bad and very bad condition" as the baseline.

4. Multinomial Logistics Model Results: Health Perception

Tables 2 and 3 show the output of a multinomial logistic regression model (MNL) where the dependent variable, overall health assessment, has three levels: bad/very bad (the reference category), moderate, and good/very good. In the model, the independent variables explain how and whether built environment characteristics, socioeconomic status (SES), age, physical activity level, green space, environmental attitude, obesity prevalence (assessed by Body Mass Index), and life satisfaction are related to perceived overall health assessment.

Table 2 illustrates how the selected independent variables affect individuals' probability of health assessment in the moderate category compared to the reference category, which is the perception of "bad and very bad". For example, individuals' SES and age groups affect their overall health assessment. Individuals with lower SES are 16% less likely to have moderate level health assessment (B=-0.175, p<0.001, Exp(B)=0.840); individuals of higher age groups are 21.6% less likely to have moderate level health assessment (B=-0.244, p<0.001, Exp(B)=0.784). Individuals with moderate levels of physical activity have 2.7 times the odds of being in the moderate health assessment category compared to the reference group (B=0.955, p<0.001, Exp(B)=2.705). Similarly, individuals who perceive their urban living environments negatively are 55% less likely to perceive their health as medium

compared to the "bad" and "very bad" perception categories (B = -0.796, p < 0.001, Exp(B) = 0.450). This suggests that individuals who perceive their urban living environments positively are more likely to have a more favorable perception of their overall health status. The Body Mass Index (BMI) significantly shows that people with low BMI (18-24.99-underweight and normal weight) have 2.9 times the odds to have moderate level health perception (B = 1.072, Exp(B)=2.922, p<0.001) and surprisingly, individuals with higher BMI (25-29.99-overweight) also have 2.2 times the odds to have moderate level health perception (B = -0.777, Exp(B)=2.175, p<0.001).

Table 2. Multinomial Model Results (Overall Health Assessment is at Moderate Level)

Parameter Estimates									
Overall Health Assessment		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Moderate	Intercept	3.169	0.510	38.585	1	0.000			
	Education	-0.073	0.089	0.670	1	0.413	0.930	0.780	1.107
	SES	**-0.175**	**0.055**	**10.059**	**1**	**0.002**	**0.840**	**0.754**	**0.935**
	Age Grouped into 4 Classes	**-0.244**	**0.094**	**6.663**	**1**	**0.010**	**0.784**	**0.651**	**0.943**
	[Greenspaceref=1.00]	-0.113	0.171	0.433	1	0.510	0.893	0.639	1.250
	[Greenspaceref=2.00]	**-1.341**	**0.321**	**17.392**	**1**	**0.000**	**0.262**	**0.139**	**0.491**
	[Greenspaceref=3.00]	0[b]			0				
	[EnvironmentAttitude=1.00]	**-0.799**	**0.194**	**16.907**	**1**	**0.000**	**0.450**	**0.307**	**0.658**
	[EnvironmentAttitude=2.00]	0.141	0.218	0.420	1	0.517	1.152	0.751	1.767
	[EnvironmentAttitude=3.00]	0[b]			0				
	[PhysicalActivityLevel=1.00]	**0.995**	**0.175**	**32.324**	**1**	**0.000**	**2.705**	**1.920**	**3.813**
	[PhysicalActivityLevel=2.00]	**0.593**	**0.274**	**4.694**	**1**	**0.030**	**1.809**	**1.058**	**3.092**
	[PhysicalActivityLevel=3.00]	0[b]			0				
	[BMI=1]	**1.072**	**0.220**	**23.701**	**1**	**0.000**	**2.922**	**1.897**	**4.499**
	[BMI=2]	**0.777**	**0.203**	**14.715**	**1**	**0.000**	**2.175**	**1.462**	**3.236**
	[BMI=3]	0[b]			0				
	[LifeSatisfaction=1.00]	**-0.796**	**0.307**	**6.733**	**1**	**0.009**	**0.451**	**0.247**	**0.823**
	[LifeSatisfaction=2.00]	**-0.893**	**0.290**	**9.489**	**1**	**0.002**	**0.409**	**0.232**	**0.723**
	[LifeSatisfaction=3.00]	0[b]			0				

a. The reference category is: bad/very bad.

b. This parameter is set to zero because it is redundant.

Table 3 shows that individuals with a health perception have a higher probability of being in the "good" and "very good" categories compared to those with "bad" and "very bad" perceptions. The results show that, across age groups, individuals' overall health assessment is 50% times less likely to be in the "good/very good" category (B = -0.690, p < 0.001, Exp(B) = 0.502). Individuals who do not have green space in their urban living environments are 52.8% times less likely to be in "good/very good" category (B=-0.750, p<0.001, Exp(B)=0.472). Individuals who perceive their urban living environments negatively and at moderate level are less likely (81% and 37.4% times respectively) to perceive their health at "good/very good" level compared to "bad" and "very bad" assessment categories (B=-1.662, p<0.001, Exp(B)=0.190; B=-0.469, p<0.001, Exp(B)=0.626).

Table 3. Multinomial Model Results (Overall Health Assessment is at Good/Very Good Level)

Parameter Estimates									
Overall Health Assessment		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
Good/Very Good	Intercept	4.337	0.507	73.090	1	0.000			
	Education	0.167	0.089	3.540	1	0.060	1.181	0.993	1.405
	SES	-0.067	0.055	1.485	1	0.223	0.935	0.839	1.042
	Age Grouped into 4 Classes	**-0.690**	**0.094**	**53.603**	**1**	**0.000**	**0.502**	**0.417**	**0.603**
	[Greenspaceref=1.00]	0.066	0.172	0.149	1	0.699	1.068	0.763	1.495
	[Greenspaceref=2.00]	**-0.750**	**0.301**	**6.198**	**1**	**0.013**	**0.472**	**0.262**	**0.853**
	[Greenspaceref=3.00]	0[b]			0				
	[EnvironmentAttitude=1.00]	**-1.662**	**0.194**	**73.496**	**1**	**0.000**	**0.190**	**0.130**	**0.277**
	[EnvironmentAttitude=2.00]	**-0.469**	**0.217**	**4.668**	**1**	**0.031**	**0.626**	**0.409**	**0.957**
	[EnvironmentAttitude=3.00]	0[b]			0				
	[PhysicalActivityLevel=1.00]	**0.841**	**0.176**	**22.940**	**1**	**0.000**	**2.320**	**1.644**	**3.273**
	[PhysicalActivityLevel=2.00]	**1.041**	**0.267**	**15.166**	**1**	**0.000**	**2.832**	**1.677**	**4.782**
	[PhysicalActivityLevel=3.00]	0[b]			0				
	[BMI=1]	**0.910**	**0.218**	**17.437**	**1**	**0.000**	**2.484**	**1.621**	**3.808**
	[BMI=2]	**0.458**	**0.200**	**5.218**	**1**	**0.022**	**1.580**	**1.067**	**2.340**
	[BMI=3]	0[b]			0				
	[LifeSatisfaction=1.00]	0.166	0.304	0.297	1	0.586	1.180	0.650	2.144
	[LifeSatisfaction=2.00]	**-1.321**	**0.291**	**20.602**	**1**	**0.000**	**0.267**	**0.151**	**0.472**
	[LifeSatisfaction=3.00]	0[b]			0				

a. The reference category is: bad/very bad.

b. This parameter is set to zero because it is redundant.

Individuals who do not have green space (Greenspaceref=2) in their urban living environments are 70.7% less likely to have "bad" and "very bad" health status (B= -0.750, Exp(B)=0.293, p<0.001). Individuals with negative life satisfaction are 73.2% less likely to have good or very good health perceptions (B= -1.321, Exp(B) = 0.267, p<0.001).

5. Discussion: Potentials and Challenges for Urban Living Environments

Built environment characteristics and socioeconomic factors (such as education, socioeconomic status), lifestyle preferences (physical activity levels, BMI) have a significant impact on overall health assessment. Individuals with SES levels times higher perceptions of good and very good health. Individuals with lower BMI have a significant relationship with health perception. Similarly, physically active individuals are more likely to have moderate to "good" or "very good" health perceptions. Individuals with lower life happiness also have a similar effect on health perception.

These findings, in line with the World Health Organization's health determinants (WHO, 2018) and the "Health in All Policies" approach, demonstrate that health outcomes cannot be attributed solely to the health sector; instead, socioeconomic and physical environmental factors play critical roles. Similarly, the social determinants framework, as emphasized by Wilkinson and Marmot (2003), has highlighted the significant impact of education, income, environmental quality, and social support mechanisms on health. The findings of this study also support the propositions in the literature, indicating that urban planning, education, and social welfare policies should be addressed together in health improvement strategies, particularly in urban areas.

This evidence-based research supports a holistic framework that enables the development of healthier societies by transforming the social and physical environments in which individuals live. The focus should be at the community level rather than solely on individual behavioral change.

This holistic approach will enable the construction of healthier societies by transforming the social and physical environments in which individuals live, rather than focusing solely on individual behavioral change. Some of the significant policies can be listed as follows:

- Increasing investments in education, supporting programs for lifelong learning, and improving individuals' health literacy
- Prioritizing physical environmental criteria such as walkability ease of access and proximity to green areas in urban planning,
- Developing mechanisms to strengthen life satisfaction and social connectedness through community-based interventions,
- Establishing multi-sectoral collaborations to promote healthy weight management and physical activity.

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Bridging Rural and Urban Dynamics within the Framework of Rural Gentrification: Urladam as a Transformative Public Space

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Abstract
This paper explores the role of artistic practices in rural transformation, regarding their influence on rural gentrification and spatial dynamics in particular. Urladam, an art space located in Urla, is examined as a threshold where rural and urban, public and private, and artistic and communal dimensions intersect. Through a hybrid methodology, including archival review, spatial analysis, mapping, and interviews, the study evaluates Urladam's architectural setting and public presence.

Findings suggest that Urladam operates as a transitional zone where artistic engagement contributes to reconfiguring rural identity. The paper underscores the potential of art spaces in re-shaping inclusive rural development, and question their role in socio-spatial change and inequality.

It illustrates how art mediates spatial transition and fosters dialogue between contrasting rural-urban identities.

Keywords: Rural Gentrification, Art Spaces, Threshold, UrlaDam

1. Introduction

Rural areas, once viewed primarily as peripheral, low-density agricultural zones, have increasingly become central sites in global economic and spatial transformations. Far from being passive landscapes, these regions now host complex networks shaped by cultural, economic, and political dynamics. Across the globe, including Türkiye, rural territories are being reshaped by processes such as counter-urbanization, real estate speculation, and the cultural industries, prompting new forms of investment, lifestyle migration, and cultural production. As rural gentrification intensifies, rural spaces have become contested terrains where traditional identities, market forces, and new socio-spatial imaginaries intersect.

The district of Urla, located along the Aegean coastline of İzmir-Türkiye, exemplifies this rural transformation. Originally characterized by its agricultural and coastal heritage, Urla has increasingly attracted white-collar professionals and cultural entrepreneurs seeking alternatives to metropolitan living. The COVID-19 pandemic further accelerated this shift, amplifying desires for proximity to nature, flexible spatiality, and cultural immersion. In this context, cultural venues such as art spaces have proliferated, transforming not only the aesthetic landscape, but also the social and symbolic dynamics of rural life.

This paper examines Urladam, a contemporary art space situated in Urla, through the conceptual lens of the "threshold." Drawing from Stavros Stavrides' theoretical framework, thresholds are understood not merely as transitional boundaries, but as spaces of encounter, where distinct social, cultural, and spatial domains are negotiated. Urladam, in this regard, operates as a site where the rural and the urban, the traditional and the contemporary, the private and the public come into contact. The study explores how such an art space mediates socio-spatial dynamics associated with rural gentrification, contributes to community engagement, and influences cultural identity within its locale.

Rather than presenting a data-driven case analysis, this paper offers a theoretical and conceptual reflection grounded in broader research. It investigates how contemporary art spaces in rural contexts may function as semi-public environments, shaping new modes of visibility, participation, and cultural production. By focusing on Urladam, the study asks: To what extent can an art space act as a transformative public realm within a rural gentrification process? What forms of publicness does it enable, and for whom?

These questions are addressed through an interpretive reading of the literature and field experience, while empirical data and detailed case analysis are reserved for forthcoming academic publications. This methodological choice enables a focus on the theoretical relevance of the process, drawing from the recently completed master's thesis *"URLADAM: Investigation into Emerging Rural Artification"* (Izmir Institute of Technology, 2025). The study contributes to broader debates on public space, cultural production, and rural transformation, offering insights into how art can intervene in the redefinition of the rural as a lived and represented space.

In order to explore how such an art space navigates its role within rural gentrification, the next section outlines the conceptual lens of "threshold spaces." This framework draws from interdisciplinary literature on spatial theory and cultural production, offering a foundation for analyzing Urladam's positioning at the intersection of rural identity and contemporary artistic practices. To investigate how an art institution like Urladam navigates its role within ongoing processes of rural change, the next section elaborates the concept of "threshold spaces." This framework unveils interdisciplinary literature on spatial theory and cultural production, including the spatial triad of Keith Halfacree (2006), Henri Lefebvre's (1991) concept of lived space, and Nancy Fraser's (1990) idea of subaltern counterpublics. Together, these insights provide a foundation for a deeper understanding of how contemporary art engages with rural gentrification and socio-spatial reconfiguration.

2. Conceptual Framework: Threshold Spaces and Publicness

This section explores the conceptual framing of "threshold spaces" to analyze the transformative role of art institutions, particularly Urladam, within the processes of rural gentrification and socio-spatial transformation. Art spaces, when situated in rural contexts, not only function as platforms for cultural production but also operate as mediating environments that engage with local identities, economies, and spatial configurations. Building upon the insights of scholars such as Stavros Stavrides (2010, 2016), Henri Lefebvre (1991), and Keith Halfacree (2006), this study positions Urladam as a spatial threshold that connects traditional rural character with emerging dynamics of urban cultural production. Within this framework, the concept of "threshold" is employed to describe spaces of transition, sites that simultaneously separate and connect divergent socio-spatial domains. The threshold is thus not a fixed border but a dynamic zone of interaction, negotiation, and transformation. The integration of art spaces into rural environments contributes to the redefinition of these locales, a process often catalyzed by counter-urbanization and rural gentrification. This dual dynamic migration from urban centers and the attraction of investment, alters the cultural, social, and spatial fabric of rural areas. In this sense, art spaces are not passive reflections of change but active agents in producing new meanings, practices, and representations of rural life.

In Urladam's case, its architectural flexibility, hybrid programming, and public accessibility position it as a site of both cultural production and social engagement. Through exhibitions, community events, and participatory practices, Urladam facilitates encounters between diverse user groups and fosters the visibility of emergent identities and narratives. Its existence exemplifies Nancy Duxbury's (2011, 2020) argument that rural cultural practices are not merely residual or traditional but actively shape new forms of localized resilience and identity.

Furthermore, this conceptual framing draws upon Adorno and Horkheimer's (2002) critique of the culture industry to interrogate how art spaces participate in commodification processes. Urladam's hybrid model, balancing between market pressures and inclusive cultural production, enables a more nuanced understanding of how rural art institutions negotiate their roles within capitalist dynamics without fully succumbing to them. The tension between artistic autonomy and market integration becomes particularly significant in rural contexts

where economic infrastructures are fragile.

This study also considers how Urladam diverges from the "White Cube" paradigm (O'Doherty 1986) by resisting spatial and ideological neutrality. Instead of isolating artworks within sterilized environments, Urladam incorporates contextual references, local materials, and flexible spatial arrangements that reflect its embeddedness within the community. This spatial strategy enhances its function as a threshold, allowing for site-responsive engagements and multi-directional flows between the institution and its surroundings.

Through this conceptual lens, Urladam is analyzed as a site of spatial negotiation, socio-cultural interaction, and economic integration. It serves as a node in wider artistic and cultural networks while remaining grounded in its immediate rural environment. By operating within this threshold zone, it becomes a space where urban desires, rural traditions, and contemporary cultural practices converge.

In doing so, this section lays the groundwork for section 3, where Urladam's spatial configuration, public representation, and everyday interactions will be analyzed through a three-fold methodological lens. The goal is to trace how the conceptual framework of "threshold" becomes materially and experientially embodied in Urladam's architecture, programming, and role within Urla's evolving socio-spatial context.

3. Rural Context and the Rise of Contemporary Art in Urla

Urla is located 38 km from the city center of Izmir and plays a significant role in the province's urban Situated on the western edge of İzmir and covering 728 square kilometers, Urla has become a focal point of rural transformation in Türkiye. Its strategic location, Mediterranean climate, and historical depth have long shaped its identity; however, recent demographic and socio-spatial shifts have redefined its role within the regional context. According to the Turkish Statistical Institute (TUIK), Urla's population grew from 62,439 in 2016 to 77,599 by 2023, a 24.5% increase reflecting broader post-COVID trends of urban-to-rural migration.

Figure 3.1. Location of Urla District
(Source: Google Earth Software and QGIS).

Traditionally rooted in agriculture and coastal trade, Urla's economy and spatial configuration evolved through various historical layers, from Ionian settlements to Ottoman-era migrations. This multi-layered heritage is visible in its built environment and agrarian practices, particularly olive oil and wine production. The contemporary restructuring of Urla's identity is not only material but also symbolic, shaped by shifting class dynamics and cultural investments.

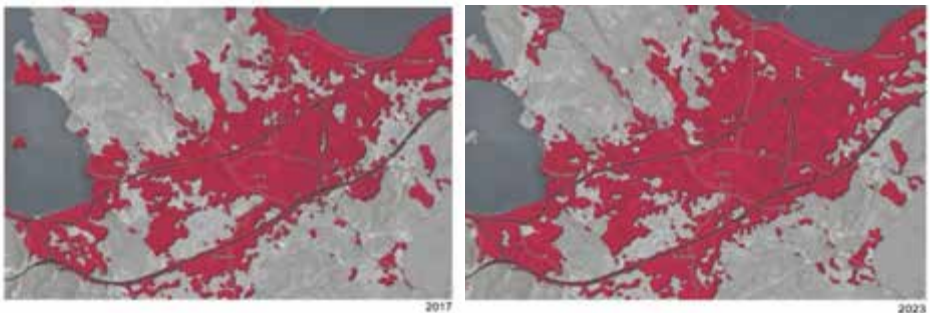

Figure 3.2. Population Change between 2017 and 2023
(Source: TUIK).

In recent years, Urla has attracted cultural entrepreneurs, artists, and white-collar migrants seeking alternatives to urban life. This transformation is particularly evident in the rise of gastronomic tourism, art venues, and boutique accommodations. Initiatives such as the Urla Vineyard Route (Urla Bağ Rotası), organic food markets, and Michelin-starred restaurants reflect a shift toward curated rural lifestyles. Yet, these developments have also fueled property speculation and displaced traditional communities, an unmistakable marker of rural gentrification.

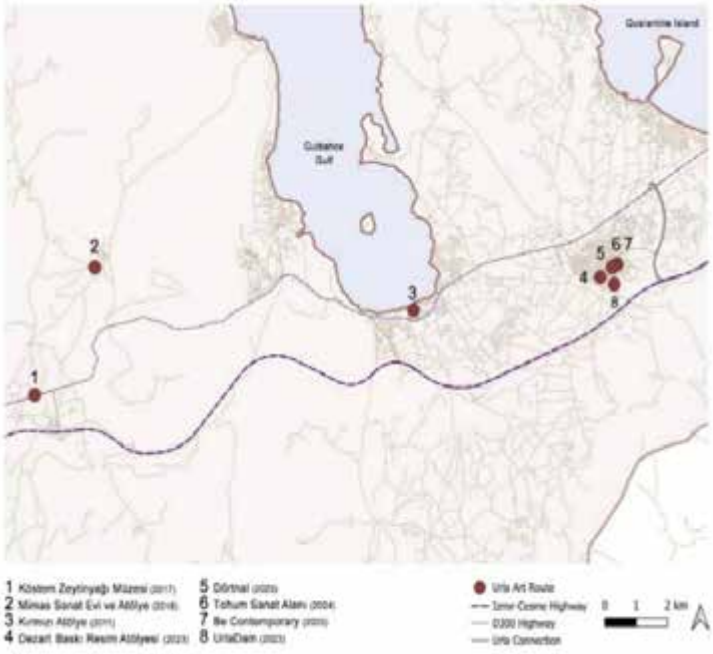

Figure 3.3. Location of Urla Art Spaces
(Source: Google Earth Software and QGIS).

Urla's emerging cultural infrastructure includes a network of decentralized art spaces that engage with both local heritage and contemporary practices. Institutions such as Köstem Olive Oil Museum, Mimas Art House, and UrlaDam contribute to a multi-layered cultural ecosystem. These venues not only support artistic production but also play a role in spatial redefinition, shaping new patterns of cultural participation and visibility.

UrlaDam, in particular, represents a large-scale intervention into the rural cultural landscape. Founded in 2023, the venue integrates performance spaces, workshops, and accommodation facilities within a single compound.

Positioned at the intersection of rural heritage and contemporary cultural production, it exemplifies the duality of cultural revitalization and exclusivity. While offering opportunities for creative engagement, UrlaDam also underscores key tensions around publicness, commodification, and social inclusion.

This evolving cultural scene calls for a nuanced assessment of how creative industries reshape rural space, not just economically, but socially and symbolically. The next section delves deeper into UrlaDam's representational strategies and everyday practices, exploring how its operations reflect and negotiate broader dynamics of rural transformation.

4. UrlaDam and the Everyday: Threshold Public Space in a Cultural Campus

This section examines Urladam as a lived and represented rural cultural public space, drawing upon Keith Halfacree's (2006) triadic model of rural space, which comprises material practices, representations, and everyday experiences. Rather than serving as a neutral space for artistic display, Urladam functions as a site where cultural identity, publicness, and rural transformation intersect.

From Henri Lefebvre's (1991) perspective of "lived space," Urladam's spatial organization and programming generate opportunities for encounter and interaction. Open-air stages such as Ağaçlı Sahne and modular venues like Hangardam promote flexible and accessible forms of engagement, allowing artistic practices to merge with the rhythms of everyday rural life. Events such as exhibitions, concerts, workshops, and children's programs support this integration of art into daily experience. Brian O'Doherty's (1986) critique of the "white cube" further contextualizes Urladam's rejection of traditional gallery neutrality.

Founded in 2023 by renowned Turkish actors Ercan Kesal and Nazan Kesal, Urladam emerged from the couple's vision of establishing an independent arts space rooted in Urla's unique cultural and ecological landscape. While Ercan Kesal is primarily known for his appearances in television and cinema, Nazan Kesal is a prominent figure in Turkish theater. During interviews conducted with Ercan Kesal on August 14, 2024, as part of this study, the founder emphasized the significance of İzmir and Urla as places of cultural inspiration and personal renewal (Kesal Ercan 2024). He noted that the couple began spending more time in Urla during the COVID-19 pandemic, which eventually led to the idea of creating a cultural campus in the region (Kesal Ercan 2024). This direct engagement enabled a deeper understanding of the intentions behind the formation and spatial design of the space. As a private enterprise, Urladam was established with the aim, in Ercan Kesal's words, of creating a place where people can spend time freely, relax, and engage in artistic production (Kesal Ercan 2024). Its design highlights the connection to the rural environment through the use of natural materials and open spaces, promoting local participation. This contributes to a more open, locally grounded mode of artistic production.

Architectural and symbolic choices, such as the naming of spaces like the Sabit Kemal Bayıldıran Library, shape the venue's identity and suggest links to specific cultural narratives. While these associations enrich the space's meaning, they may also reflect selective curatorial visions shaped by personal or philanthropic influence.

The semi-private nature of Urladam introduces tensions between accessibility and exclusivity. Although many events are free of charge, features such as a luxury cafe and on-site accommodation imply a dual audience: one that is local and community-focused, and another that is more affluent and mobile. This dynamic raises important questions about who participates in cultural life, and under what conditions.

Figure 4.1. View of UrlaDam from above
(Source: Izmir.Art, 2024).

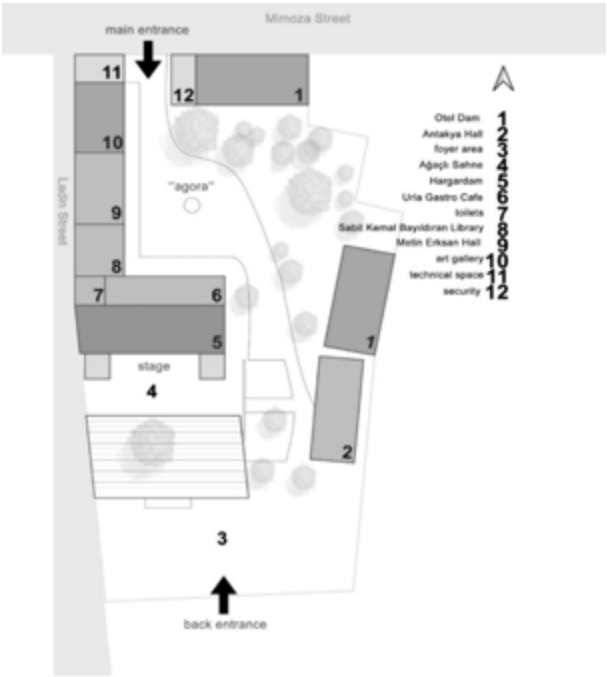

Figure 4.2. Non-scaled Plan Indicating Functional Areas.
(Source: Created by the author).

In spatial terms, Urladam's design contributes significantly to its threshold character. The site is anchored by two main entrances, one facing Mimoza Street and the other connected to a secondary parking area, linked by a clearly defined circulation axis that organizes access and movement. These physical boundaries demarcate the internal campus from its surroundings, generating a sense of both inclusion and separation. Upon entering through the main gate, visitors encounter a central plaza organized around a decorative fountain and red basalt paving stones. Surrounded by multifunctional structures, this semi-enclosed space functions as an informal gathering point and transitional zone.

The spatial configuration reflects various embedded thresholds: the Art Gallery, a single-story exhibition space with a skylit steel roof that echoes the "white cube" typology, establishes a zone of aesthetic focus. Nearby structures such as the Metin Erksan Hall (a small-capacity venue used for talks, screenings, and workshops) and the Sabit Kemal Bayıldıran Library (a poetry-focused library and intimate reading space) provide more dialogic and discursive environments. Gradual elevation changes across the site, especially from the Hangardam (a large, single-story multipurpose indoor hall with a stage used for fairs and screenings) toward the open-air Ağaçlı Sahne (an outdoor stage integrated into the sloped landscape, with seating organized around a preserved tree for concerts and performances) support fluid yet layered experiences of movement and encounter. Notably, the arched stone entrance leading into Ağaçlı Sahne physically marks a passage from the public plaza to the event space, reinforcing spatial symbolism.

The Antakya Hall (a single-story venue with a stage located near the exit and accommodation area) and the adjacent foyer area (a grass-covered transitional space used for pre-event gatherings and sponsor installations) further exemplify how function and spatial sequencing contribute to the condition of threshold. Material choices also reinforce this layered threshold quality. The reuse of local stone, red basalt pavement, and wrought iron details evoke vernacular aesthetics while reinforcing site-specificity. Meanwhile, preserved trees integrated into the design, such as those embedded within the seating rows of Ağaçlı Sahne, blur the boundary between natural and constructed environments.

These design strategies enhance both the temporal and social dimensions of threshold space: while visitors may arrive for a scheduled performance, they often linger—perhaps spending time at the Urla Gastro Cafe (a semi-open cafe overlooking the central plaza), interacting with artists staying at the Otel Dam (a two-story accommodation unit serving both resident artists and guests), or browsing a book fair between concerts. Events such as the D&R Book Festival or children's painting workshops utilize different segments of the site simultaneously, expanding the experiential depth of the venue. Additional infrastructural spaces such as the technical area (a support zone for logistical and technical needs) and security (the main controlled access point at the Mimoza Street entrance) define the operational thresholds of the site, balancing openness with necessary regulation.

In sum, Urladam exemplifies the evolving character of rural public spaces, neither entirely open nor wholly exclusive, but shaped by spatial design, curatorial decisions, and patterns of social access.

Beyond its spatial configuration and material articulation, Urladam's threshold character is further reinforced by its intensive and diverse programming. Throughout the year, the venue hosts a remarkable number of events, from exhibitions and concerts to workshops, film screenings, and literary festivals. This consistent density of cultural programming not only activates physical spaces but also cultivates a dynamic temporality, one in which the site is continuously reanimated by diverse publics and practices.

Figure 4.3. D&R – UrlaDam Book Festival

Between July and October 2024 alone, Urladam hosted 9 exhibitions, 10 theater and performing arts events, 16 concerts, and 12 distinct types of workshops, amounting to a total of 46 sessions. Additionally, 25 festivals and film screenings and 17 author talks and book signing events were organized across various venues. These events were not always sequential; some took place simultaneously in different spaces across the site. This simultaneity is made possible by Urladam's spatial configuration, which accommodates diverse programming capacities, while one visitor may attend a workshop at Metin Erksan Hall, another might enjoy a concert at Ağaçlı Sahne, and a third may simply have coffee at the cafe. This diverse and continuous event calendar exemplifies the multiplicity and layered temporality of Urladam's cultural life. Its role in Urla's cultural ecosystem reflects both the potentials and contradictions of art-led rural transformation, operating as a threshold that bridges the everyday and the exceptional, the local and the curated, the physical and the symbolic.

The data gathered was further visualized through a spatial circulation analysis, highlighting patterns of movement and interaction across Urladam's venues. This analysis also incorporated insights derived from user feedback and field observations, particularly regarding the frequency of visits to shared spaces like the cafe. It was found that the cafe emerged as one of the most frequently used and crowded spaces, due to its proximity to major event venues and its social function. Visitors often used the cafe after attending exhibitions, concerts, and theater performances, turning it into a central hub for informal interaction. Moreover, due to parking challenges in Urla, Urladam has increasingly functioned as a public site for external visitors, offering both a parking solution and access to its cafe, reinforcing its spatial and social utility. A graphic representation of this circulation analysis is provided below to more clearly illustrate these spatial dynamics.

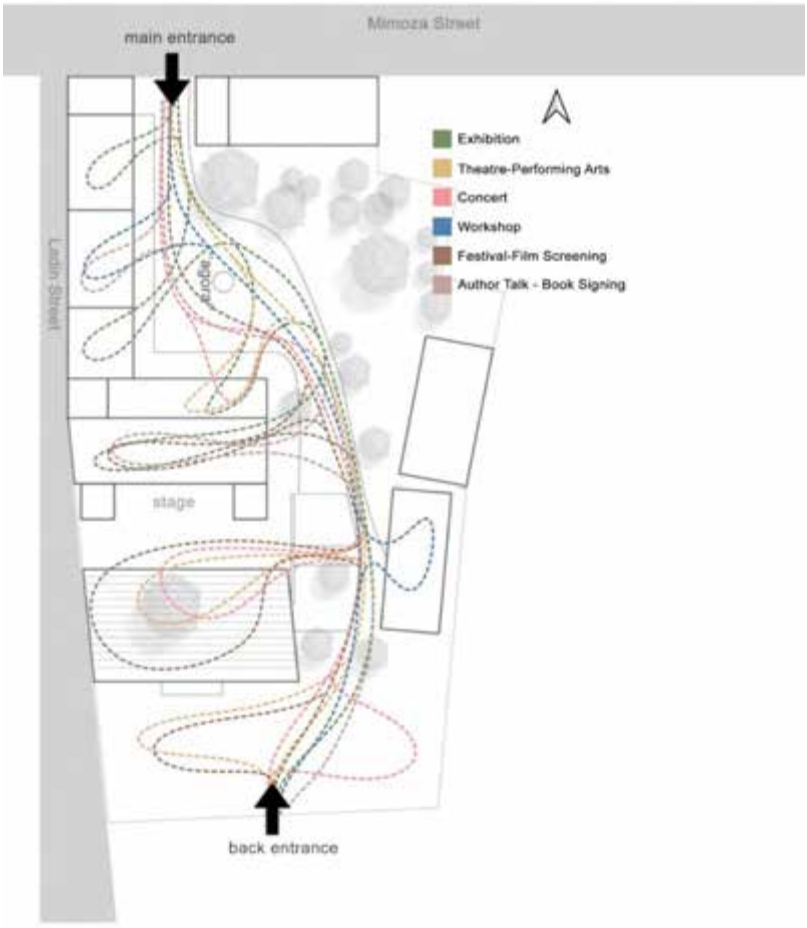

Figure 4.4. Circulation Analysis Based on Spatial Usage Analysis (Source: Created by the author).

In parallel with its spatial circulation and architectural organization, UrlaDam also pursues an aggressive strategy in terms of media visibility. Although in interviews Ercan Kesal emphasized that their primary goal was to let UrlaDam be known through word-of-mouth, the venue actively utilizes platforms such as Instagram, YouTube, and its official website to promote upcoming events, share interviews, and foster audience engagement. These digital platforms serve not only as tools of communication but also as extensions of the venue's publicness in the virtual realm, reinforcing its threshold status by broadening access to its content.

UrlaDam's Instagram account functions as a visual archive, documenting the rhythm of its artistic life through curated photographs and stories, while its YouTube channel hosts interviews, event footage, and commentary, enabling asynchronous participation for geographically distant audiences. This constant digital activity contributes to the emergence of a hybrid public sphere, where physical presence is no longer a prerequisite for participation. In 2023 and 2024, UrlaDam was featured in 22 newspaper articles across local and national media outlets such as Sabah, Milliyet, Karar, HaberEkspres, and GazeteDuvar. This strong media presence demonstrates that UrlaDam aims not only to function as a local cultural center but also to establish itself as a national point of interest within Turkey's cultural scene. Media coverage was particularly amplified during large-scale events like the D&R Book Festival and Urla Jazz Festival, further solidifying the venue's image as a hub of cultural activity.

The strategic integration of both traditional and digital media illustrates how UrlaDam cultivates a multifaceted presence, merging physical, symbolic, and digital thresholds and offering multiple points of access to a diverse audience. This strong media visibility reinforces UrlaDam's role not merely as an event venue, but as a producer

of cultural practices that permeate everyday life. Its presence across both digital and traditional media platforms extends beyond physical events, making visible the intersections between art and daily routines. In doing so, UrlaDam's impact evolves into a deeper "lived space" experience, not limited to a static cultural calendar.

UrlaDam's influence on everyday life in Urla can thus be interpreted through the lens of lived experience and everyday practice. Its diverse programming, ranging from art exhibitions and literary talks to concerts and workshops, establishes a recurring rhythm of public engagement, integrating artistic expression into the routines of local residents and visitors alike. Rather than remaining isolated as cultural spectacles, these activities become woven into the fabric of the town's everyday life, creating shared moments of reflection and participation. In line with this vision, Urladam's owner Ercan Kesal has emphasized that Urladam was intended not only to contribute to cultural enrichment, but also to strengthen social cohesion by functioning as a permeable and inclusive space (Kesal Ercan 2024). This section explores how such experiences resonate with broader debates on rural transformation and the redefinition of public space in contemporary Türkiye.

5. Discussion: Publicness at the Edge of Rural Gentrification

This section critically engages with the concept of publicness within the framework of rural gentrification, drawing upon the theoretical concepts introduced earlier and building on the observations and in-depth interview discussed in the previous section.

Publicness is traditionally associated with accessibility, inclusivity, and collective use. However, in gentrifying rural contexts such as Urla, it becomes a layered construct shaped by economic, cultural, and symbolic power. Rural gentrification initiates spatial and social restructuring through the influx of upper-middle-class populations, leading to rising property values, aesthetic curation, and cultural displacement.

Urladam exemplifies this paradox. As explored in section 4, it functions as a "threshold space" neither fully public nor entirely private, inviting wide participation while embedding selective forms of access. Its architectural configuration, diverse programming, and curatorial framing reflect a model of selective inclusivity: outwardly open, yet subtly aligned with the preferences of culturally privileged groups.

The venue's simultaneous hosting of multiple events, such as workshops, concerts, and literary talks, demonstrates an impressive cultural density. Yet this density does not automatically translate into egalitarian access. While many events are nominally open to the public, their aesthetic, linguistic, and symbolic framing often appeals to urban-educated, mobile demographics. As emphasized by Ercan Kesal in interviews, Urladam was intended to be a space "where one can breathe, create, and rest." But who can afford to breathe there, and who feels invited, remains a socially mediated question.

This duality aligns with Nancy Fraser's (1990) notion of "subaltern counterpublics," where alternative publics emerge within dominant cultural frameworks but remain structurally marginalized. Urladam creates moments for new voices, especially during festivals and workshops, yet it simultaneously participates in hierarchies of taste, access, and legitimacy. Spatial-symbolic elements further complicate the idea of publicness. Open-air stages and features like the preserved tree at Ağaçlı Sahne signal inclusivity, while donor naming, selective cultural references, and visual branding introduce soft exclusions. The spatial circulation study also highlighted the cafe as a central informal gathering point, but its pricing and ambiance arguably cater more to a visitor profile shaped by lifestyle migration than local everyday life. As a whole, Urladam exemplifies how cultural infrastructures can operate as subtle engines of rural gentrification. These spaces do more than host artistic programs, they contribute to shaping cultural legitimacy, aesthetic norms, and everyday rhythms. In doing so, they influence who feels welcome, who belongs, and under what conditions participation becomes possible.

In sum, publicness at the edge of rural gentrification is not a static attribute but a continuously negotiated and contested process. Urladam, as a threshold cultural space, reflects this ambivalence: open yet selective, dialogic yet curated, inclusive in rhetoric yet exclusive in effect. Recognizing this ambivalence is crucial, not to

dismiss such initiatives, but to reframe future strategies in rural cultural development toward equity, grounded participation, and spatial justice.

6. Conclusion

This study set out to explore UrlaDam as a cultural infrastructure embedded in the shifting terrain of rural transformation, offering a nuanced examination of public space, artistic engagement, and social stratification. Through the analysis of spatial, representational, and everyday practices, it has been shown that UrlaDam functions as more than a venue for cultural programming, it is a site where the complexities of publicness, artistic identity, and rural gentrification converge.

Rather than offering final answers, the findings encourage deeper interrogation of the paradoxes within contemporary rural public spaces. While UrlaDam aspires to inclusivity through its programming and open-access philosophy, in practice, the socio-economic and spatial filters embedded in its structure and operation reveal selective modes of participation. Its dual identity as both a public space and a private cultural institution reflects broader tensions in the cultural field, where autonomy, accessibility, and aesthetic value are constantly negotiated.

By operating as a threshold space, between urban and rural, private and public, exclusive and inclusive, UrlaDam highlights the symbolic and material ambiguities of contemporary cultural development. Its visibility in digital media and participation in global cultural networks situates it within a broader system of artification, where aesthetic and institutional logics reshape not only space but also social relations. This contributes to rural gentrification, not merely as a material process of displacement but as a symbolic restructuring of belonging and identity.

In sum, publicness at the edge of rural gentrification is not a static attribute but a continuously negotiated and contested process. Urladam, as a threshold cultural space, reflects this ambivalence: open yet selective, dialogic yet curated, inclusive in rhetoric yet exclusive in effect. Recognizing this ambivalence is crucial, not to dismiss such initiatives, but to reframe future strategies in rural cultural development toward equity, grounded participation, and spatial justice.

As a result, this research underscores the need to approach rural cultural infrastructures with a critical lens, recognizing their potential to generate both engagement and exclusion. The findings suggest that the presence of art in rural areas should not be taken as inherently democratic or transformative, but must be evaluated in terms of who participates, who benefits, and how these dynamics shape rural futures. Ultimately, the case of UrlaDam invites reconsideration of what constitutes a public art space in a rural setting. It raises critical questions about how cultural venues can navigate the fine line between creative autonomy and social responsibility, between curatorial vision and inclusive participation. While the site may offer moments of artistic encounter and cultural dialogue, these are shaped—and at times constrained, by economic, spatial, and symbolic forces.

Rather than concluding the conversation, this paper proposes new lines of inquiry, particularly for future academic work that seeks to align cultural production with principles of spatial justice and social equity. UrlaDam is not simply a site of cultural production, it is a node in the broader reconfiguration of rural space, offering both inspiration and caution in thinking about the future of art, community, and territory.

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Community Reading Spaces as Social Infrastructure: A Case Study of Nanjing

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Abstract
This study conceptualises community reading spaces as essential social infrastructure that promotes spatial justice and social capital. Drawing on case studies from Nanjing, it proposes a three-dimensional interactive framework integrating physical, institutional, and social perspectives to analyse the mechanisms underlying their social functions. Through comparative analysis of three governance models—leading, co-operative, and autonomous—the study explores how different operational logics affect the dual social functions of reading spaces. The findings highlight the complementary logic among governance types and offer theoretical and practical insights into enhancing the inclusivity and relational capacity of urban cultural services.

Keywords: Community reading spaces; Urban governance; Social infrastructure; Spatial justice; Social capital

1. Introduction: Urban Transformation, Community Needs, and the Multifaceted Value of Reading Spaces

Despite the rapid development of modern cities, they face persistent challenges such as social atomisation, weakened neighborhood ties, and the erosion of public life (Putnam, 2000; Giddens, 1991). In this context, reshaping the urban public sphere, fostering community belonging, and strengthening social cohesion have become critical concerns in contemporary urban governance.

In response, the concept of *social infrastructure* has garnered increasing attention from both scholars. It refers to "soft" facilities such as libraries, parks, and community centers that support daily life, promote social interaction, and maintain community networks (Klinenberg, 2018; Latham & Layton, 2019). These spaces serve not only as service providers but also as foundational elements of urban public life (Amin, 2002) and "key sites" for building trust and fostering interaction. Amin (2014) emphasised that "micro-public spheres" and informal everyday interactions are crucial for sustaining urban vitality. Accordingly, the effective functioning of social infrastructure is regarded as a vital mechanism for enhancing community resilience and promoting social equity.

Following rapid urbanisation, Chinese urban communities have increasingly become essential units of social management and public service provision. Concurrently, residents' demands for cultural engagement and public communication spaces have significantly intensified. In response, the government has been actively promoting the construction of a public cultural service system, and initiatives such as *National Reading* have been elevated to strategic national priorities (General Office of the CPC Central Committee & General Office of the State Council, 2015), aiming to enhance national literacy and cultural engagement. Within this framework, *community reading spaces* have emerged as significant focal points, presenting new opportunities for development.

In this paper, *community reading spaces* refer to public-interest venues established by government bodies or civil society organisations within specific localities. These venues provide access to literary and digital resources and offer a range of reading-centered services and activities. They include public libraries, cultural centers, bookstores, airports, cafes, hotels, and other publicly accessible spaces. These spaces prioritise openness and service provision to the general public. Therefore, institutional libraries (e.g., university or school libraries) and private reading spaces are not within the scope of this study.

From traditional grassroots libraries to contemporary "urban study rooms," independent bookstores, and private reading clubs, a diverse and evolving network of community reading services has taken shape. These spaces are entrusted with multiple social functions, including knowledge dissemination, cultural consumption, neighborhood interaction, and community cultural development (Wang Zizhou, 2017). However, the practical mechanism of such spaces remains more complex than anticipated. Challenges such as underutilisation, operational inefficiencies,

and significant disparities in service models, target groups, and social impact persist. These issues highlight the need for in-depth exploration of the material, institutional, and social foundations of these spaces and their interrelations.

In light of these challenges, this study conceptualises community reading spaces as a critical form of social infrastructure and seeks to investigate their underlying mechanisms. By integrating material, institutional, and social perspectives, this research addresses the following core questions: In the context of China's rapid urbanisation and the evolving public cultural service system, how should community reading spaces be understood as urban social infrastructure? What kinds of interaction mechanisms exist among their physical, institutional, and social elements? How do these mechanisms influence their overall social functions? Moreover, how do community reading spaces operating under different governance models differ in achieving these social functions?

2. Literature Review: Fragmented Perspectives and the Need for Integration

Community reading spaces, as integral components of urban social structures and public life, have garnered increasing scholarly attention concerning their planning, spatial construction, institutional governance, and social impact. While research from various disciplinary perspectives has explored their physical configuration, governance mechanisms, and social functions, most studies tend to focus on a single dimension. This narrow focus often fails to uncover the complex interrelations among physical environments, institutional frameworks, and social practices that define their overall effectiveness.

This chapter presents a systematic review of existing literature on community reading spaces and libraries, critically evaluating the contributions and limitations of different analytical perspectives. It highlights the fragmented nature of current research and advocates for the construction of an integrative framework. This theoretical basis informs the subsequent case-based analysis of community reading spaces in Nanjing.

2.1 Physical Perspective: Reading Spaces as Public Service Facilities

As a key aspect of social infrastructure, the physical characteristics of public reading spaces play a fundamental role in determining the fairness of resource allocation and the quality of user experience. Earlier research—particularly in the fields of library science and urban planning—focused on the quantitative assessment of spatial distribution of cultural facilities. Common methodologies included Geographic Information System (GIS) analysis based on service radius, population coverage, and per capita usage area (Cervero, 1998; Johnson, 2010). For example, studies in the UK and Nordic countries have used spatial models to assess alignment between library networks and residential distribution in order to achieve equitable access. In China, Dai Yanqing (2021) used network analysis to assess the accessibility of newly constructed public reading spaces in Changsha and proposed strategies for site selection and coverage optimisation.

In the context of China's push toward standardizing and equalizing public cultural services, researchers have drawn attention to the persistent "reading facility gap" between urban and rural areas and across regions. Ke Ping (2020) discussed fragmentation in the Co-operative governance of urban and rural library systems, advocating for a more integrated service network. Wang Zizhou (2020) examined how spatial restructuring and cultural drivers have facilitated the rise of "urban study rooms."

As the research has evolved, scholars have recognised that spatial accessibility alone is insufficient. The quality of the physical environment also significantly influences readers' usage behavior, spatial attraction, and cultural engagement. Design features—such as interior layout, ambiance, lighting, and functional zoning—shape user experience and the symbolic meaning of space (Aabø & Audunson, 2012; Hille, 2019). Bao Yaming (2021) emphasised that the experiential quality of cultural spaces determines whether they are genuinely "perceived" and "claimed" by users. In response, many contemporary reading spaces are designed with aesthetic appeal, human-centered layouts, and multifunctional facilities (e.g., leisure areas, parent-child corners, cafés) to enhance spatial engagement.

Nonetheless, the physical perspective has its limitations. First, conflating physical proximity with actual accessibility and benefit is misleading. As Wang Xuexi (2023) noted, user experience may still be hampered by barriers such as rigid service rules, exclusionary attitudes, or poor information access. Vulnerable groups may be marginalised due to digital illiteracy or cultural unfamiliarity. Second, this perspective often relies on static indicators, overlooking how space is dynamically occupied, contested, and redefined in daily use. Space should be seen not only as a physical site but also as a platform for social practice and meaning-making. Therefore, evaluating the social functions of social infrastructure requires integration with institutional and user-centered perspectives.

2.2 Institutional Perspective: Reading Spaces as Governance Instruments

The institutional perspective foregrounds the idea that community reading spaces are not merely spatial constructs but institutionalised entities embedded within governance systems, policy frameworks, and resource allocation logics. From this vantage point, their construction and operation are reflections of broader power structures and governance models (Harvey, 1989; Smith, 2002). Key considerations include policy goal-setting, fiscal distribution, inter-agency coordination, and the adaptability of implementation processes.

In China, community reading spaces have predominantly followed a state-led governance logic. National initiatives, such as the *Regulations on Promoting National Reading* and the *14th Five-Year Plan for Public Cultural Service System Development*, advocate for the equalisation of cultural services and emphasise building urban–rural reading networks centered around public libraries. While this model guarantees baseline resource provision, it also faces limitations such as homogeneous services and administrative inefficiency (Ke Ping, 2018; Li Guoxin, 2018). Some local institutions fail to align services with user needs, resulting in "visible spaces with invisible services."

With the rise of "governance modernisation," hybrid governance models featuring multi-stakeholder collaboration have emerged. These include government contracting, NGO operations, and public–private partnerships (He Ze, 2023; Xu Yibo, 2022). For instance, Nanjing Library collaborates with nonprofits and bookstores to operate "urban study rooms," blending public missions with market flexibility via negotiated governance. Similar international examples include Dutch libraries repositioned as social innovation hubs emphasizing local autonomy (Van Melik & Merry, 2022).

This perspective also exposes structural inequalities. Resources are often disproportionately allocated to city centers, leaving peripheral or disadvantaged communities underserved (Wang Hui, 2021). Additionally, vulnerable populations such as seniors, persons with disabilities, and new migrants may lack representation in service planning and policy dialogues (Wang Sufang, 2020; Klinenberg, 2018). Without mechanisms that prioritise equity, community reading spaces risk exacerbating existing cultural disparities (Pateman & Vincent, 2010).

Institutional studies also draw attention to informal implementation dynamics. While policies establish macro-level frameworks, grassroots execution often requires adaptive practices and negotiated coordination by librarians, community workers, and partner organisations (Wang Ting, 2023). Audunson et al. (2020) described how tensions between formal institutions and everyday practices catalyze service innovation—a pattern that also applies to China's evolving reading spaces.

Nevertheless, the institutional lens has its own shortcomings. It tends to prioritise structural analysis at the expense of understanding lived experiences and micro-level interactions. While it highlights power and governance, it may not fully explain how institutions are reinterpreted through everyday practice. Thus, integrating institutional analysis with physical and social perspectives is essential for a more holistic understanding of the social functions of community reading spaces.

2.3 Social Perspective: Reading Spaces as Relational Infrastructure

The social perspective centers on how community reading spaces function as relational infrastructure—facilitating social interactions, fostering community identity, and enabling public cultural participation. This approach shifts attention from static configurations to the dynamic processes through which space fosters relationships and generates social capital.

Klinenberg (2018), in *Palaces for the People*, emphasised that social infrastructure such as libraries and community centers forms essential networks that sustain everyday social life and community resilience. Oldenburg's (1999) theory of "third places" further underscores their role as informal social venues where civic life unfolds beyond home and work. Svendsen (2013), studying Danish libraries, categorised them as incubators of social capital by fostering bonding (in-group trust), bridging (cross-group communication), and linking (institutional trust). Similarly, Aabø and Audunson (2012) found that Oslo libraries served as inclusive platforms for intergenerational and intercultural dialogue.

In China, empirical studies offer localised insights. Wang Sufang (2020) highlighted the inclusive practices of libraries for elderly users, showing how reading spaces enhance their social engagement and well-being. Xiao Qunzhong (2019) used interviews and ethnographic observations to document emotional exchanges and identity formation in "urban study rooms," emphasizing their role in cultivating a sense of place and local belonging.

Viewed through this lens, community reading spaces also contribute to civic cultivation and co-construction of cultural life. Pateman and Vincent (2010) argued that libraries should be sites of participatory democracy—facilitating not just access to knowledge but also critical discourse and civic engagement. Latham and Layton (2019) noted that the cultural value of social infrastructure relies on the "everyday social labor" of users, which requires deliberate planning and continuous support.

However, this perspective is not without its limitations. Some studies idealise the integrative potential of space while downplaying conflicts, exclusions, and underlying power dynamics. Hall et al. (2021) cautioned that even seemingly open spaces may reinforce social boundaries related to class, race, and age. Moreover, while rich in qualitative detail, many studies fail to analyze how social interactions are shaped by spatial and institutional conditions.

More critically, the realisation of the social functions of social infrastructure often hinges on overlooked forms of "emotional labor" and maintenance. As Schloffel-Armstrong (2024) noted, the sustainability of these spaces depends on invisible infrastructures—volunteer networks, emotional support mechanisms, and managerial coordination—that are rarely acknowledged in mainstream analyses. Without considering these support systems, it is difficult to fully understand how reading spaces sustain their social relevance over time.

2.4 Summary and Research Direction

A review of the literature from physical, institutional, and social perspectives reveals that each offers unique theoretical insights into the spatial attributes, governance dynamics, and social functions of community reading spaces. However, their fragmented application results in an incomplete understanding of the multifaceted role of these spaces as social infrastructure. The compartmentalisation of perspectives risks producing reductive conclusions that overlook the complex interactions among constituent dimensions.

This paper therefore proposes an integrated analytical framework centered on the three-dimensional interaction among physical, institutional, and social elements. Inspired by Schloffel-Armstrong et al.'s (2021) model of "library institution–architecture–interaction," this framework conceptualises community reading spaces as dynamic systems. Their social functions are seen as outcomes of the co-evolution of institutional logic (e.g., governance models, policy execution), material infrastructure (e.g., spatial design, accessibility), and social practices (e.g., relationship-building, community embedding).

This study applies the proposed framework to a set of representative community reading spaces in Nanjing, aiming to analyze how different governance models mediate the interplay among space, institutions, and society. The goal is to uncover the mechanisms through which these spaces, as social infrastructure, realise their social value in the context of rapid urbanisation, and to provide theoretical insights and practical recommendations for policy design and implementation.

3. Case Study of Community Reading Spaces

3.1 Theoretical and Analytical Framework

• Three-Dimensional Interaction Mechanism

This paper proposes and utilises the "physicality-institutionality-sociality" three-dimensional interactive mechanism as the core framework for analyzing the operational logic of community reading spaces. This framework transcends the static classification of spatial constituent elements, emphasizing that community reading spaces are not isolated physical facilities constructed in a vacuum. Instead, they are processual fields continuously generated, adjusted, and embedded in residents' daily lives against specific governance and social practice backgrounds. These three dimensions are intertwined, dynamically providing feedback to each other, and collectively shaping the operational logic and social value of community reading spaces as social infrastructure.

Physical Dimension (Physical Environment): Refers to the spatial attributes of community reading spaces, including geographical location, architectural form, internal structure, facility layout, and environmental atmosphere. These material foundations not only determine the accessibility and functional adaptability of the space (Gehl, 2011; Carmona, 2010) but also influence its attractiveness and receptiveness to specific groups (Bao Yaming, 2008).

Institutional Dimension (Institutional Governance): Encompasses institutional elements such as management mechanisms, policy systems, financial support, service models, and responsibility allocation. This dimension determines how spatial resources are deployed, how governing bodies participate, and the degree of user participation and voice (Bovaird & Löffler, 2015; Ostrom, 1990).

Social Dimension (Social Practice): Emphasises practical activities occurring within the space, such as community building, knowledge exchange, cultural participation, and daily interactions. Through these social behaviors, the space is endowed with cultural meaning and transformed into a key field for community interaction and social capital generation (Oldenburg, 1989; Klinenberg, 2018).

The relationship between the three dimensions is not a linear causal chain but a multi-directional, dynamically coupled feedback loop. For example, flexible and diverse physical design can stimulate daily interactive behaviors (Gehl, 2011); open and inclusive institutional arrangements can enhance residents' willingness to participate and sense of belonging (Larsen et al., 2021); and active social practices, in turn, may promote institutional innovation and spatial renewal (Hall, 2020). It is precisely this multi-level, bidirectional interactive mechanism that enables community reading spaces to continuously adapt to social changes and generate lasting social value.

• Dual Social Functions of Community Reading Spaces

As embedded social infrastructure serving public life, community reading spaces carry important social functions and values. This study believes that its core social objectives are mainly reflected in two closely related dimensions: the practice of spatial justice and the promotion of social capital.

Firstly, proceeding from its public attribute as "infrastructure," community reading spaces must respond to the issue of Spatial Justice. As critical geography theory emphasises (Harvey, 1973, 1989; Soja, 2010), space is not neutral but a field where social relations and inequalities are reproduced. Therefore, social infrastructure should aim to eliminate spatial injustice. Drawing on Nancy Fraser's (2008) theory of justice, the practice of spatial justice covers three levels: Distributive, Procedural, and Recognitive. In the context of community reading spaces, this means ensuring fair accessibility of resources (distributive justice), guaranteeing users a voice in

space management and decision-making (procedural justice), and recognizing and accommodating groups with different backgrounds and needs (recognitive justice).

Secondly, from its core attribute of "sociality," the key value of community reading spaces lies in promoting the generation and accumulation of Social Capital. Social capital is regarded as a social resource that connects individuals, enhances trust, and promotes collective action (Putnam, 2000). Community reading spaces, as "social places," contribute to the formation and strengthening of different types of social connections by providing interactive platforms and activity opportunities. According to the classification by scholars such as Putnam and Woolcock (2001), social capital can be divided into three forms: Bonding, Bridging, and Linking, corresponding respectively to connections within homogeneous groups, connections between heterogeneous groups, and connections between individuals/communities and external institutional resources. Community reading spaces enhance the cohesion, inclusiveness, and vitality of communities by promoting these connections.

The practice of spatial justice and the cultivation of social capital are two core social values pursued and generated by community reading spaces as social infrastructure. They are interrelated and together constitute an important perspective for measuring their social functions.

• Realizing Social Functions through Interactive Mechanisms

Community reading spaces, as a type of small-scale social infrastructure deeply embedded in everyday life, possess unique characteristics that make them ideal cases for analyzing how the three-dimensional interactive mechanism contributes to the realisation of the dual functions of social infrastructure: the promotion of spatial justice and the generation of social capital (Klinenberg, 2018; Hall, 2020). The mapping framework constructed in this study aims to reveal how the dynamic interaction among the physical, institutional, and social dimensions drives and shapes the pathways of these two core social values (Schloffel-Armstrong et al., 2021). This analysis adopts a deductive approach to understanding the mechanism, rather than treating spatial justice and social capital as directly quantifiable indicators. By examining how spaces operating under different governance models integrate physical environments, institutional arrangements, and social practices, their differentiated processes of social value generation can be clearly delineated (Fraser, 2008; Putnam, 2000).

The relationship between the three-dimensional interactive mechanism and the practice of spatial justice can be illustrated as follows (Figure1): this mapping highlights the relative emphasis and specific contribution methods of each dimension in advancing the three sub-dimensions of spatial justice.

The physical dimension, especially given the characteristics of community reading spaces being close to residential areas and limited in scale, contributes to distributive justice through site selection (e.g., located at the center of neighborhoods or on street corners) and inclusive design (e.g., age-friendly, child-friendly, and barrier-free features). These micro-level spatial elements directly influence whether different groups can equitably access and utilise public resources (Carmona, 2010; Gehl, 2011).

The institutional dimension supports procedural justice by establishing flattened feedback channels (e.g., online communities, regular exchange meetings) and mechanisms that empower community organisations and residents to co-govern (e.g., resident-led activities, participation in management committees). Pluralistic governance models effectively enhance the capacity for user voice and participatory decision-making in space operation and service planning (Bovaird & Löffler, 2015; Ostrom, 1990).

The social dimension, grounded in the localness and everydayness of community reading spaces, fosters recognitive justice by organizing context-specific activities (e.g., neighborhood storytelling sessions, community cultural salons) and facilitating informal interactions among neighbors. These practices enhance visibility and acknowledgment of diverse cultural expressions and community identities, thereby directly advancing the realisation of recognitive justice (Oldenburg, 1989; Fraser, 2008).

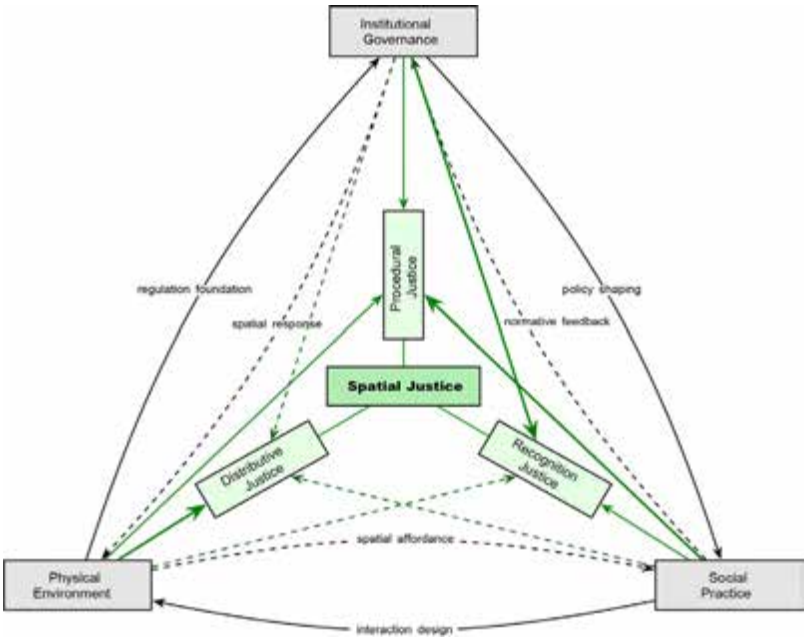

Fig.1. Pathways to Social Functions: Spatial Justice Practice

The relationship between the three-dimensional interactive mechanism and the generation of social capital can be illustrated as follows (Fig.2): this mapping outlines how the interaction across dimensions collectively shapes the formation of bonding, bridging, and linking social capital, with an emphasis on their respective pathways and dynamic mechanisms (Putnam, 2000; Woolcock & Narayan, 2000).

Practices in the social dimension—particularly service activities and community interactions that target specific interests or groups and encourage deep engagement (e.g., regular community reading groups, parent-child co-reading sessions, professional knowledge-sharing events)—serve as key drivers of bonding and bridging social capital. Rooted in shared interests and daily exchanges, these activities create relational platforms for interpersonal connection and mutual trust.

The physical dimension (e.g., open and flexible spatial designs that support informal encounters, such as shared long tables and lounge areas) and the institutional dimension (e.g., low-threshold access policies, institutional support for community-led events, flexible space-use regulations) offer critical yet indirect support for social capital formation. For instance, a welcoming communication corner can spark spontaneous interactions, while inclusive institutional arrangements lower barriers to participation (Gehl, 2011; Gilchrist, 2004).

Furthermore, the institutional dimension—particularly through collaborative operational mechanisms with external community institutions (e.g., local schools, social work stations, non-profit organisations, sub-district offices)—establishes concrete channels for generating linking social capital (Woolcock, 2001). These localised institutional linkages enable community reading spaces to attract external resources and help residents connect to broader networks, thereby strengthening their social connectivity and outward engagement capacity.

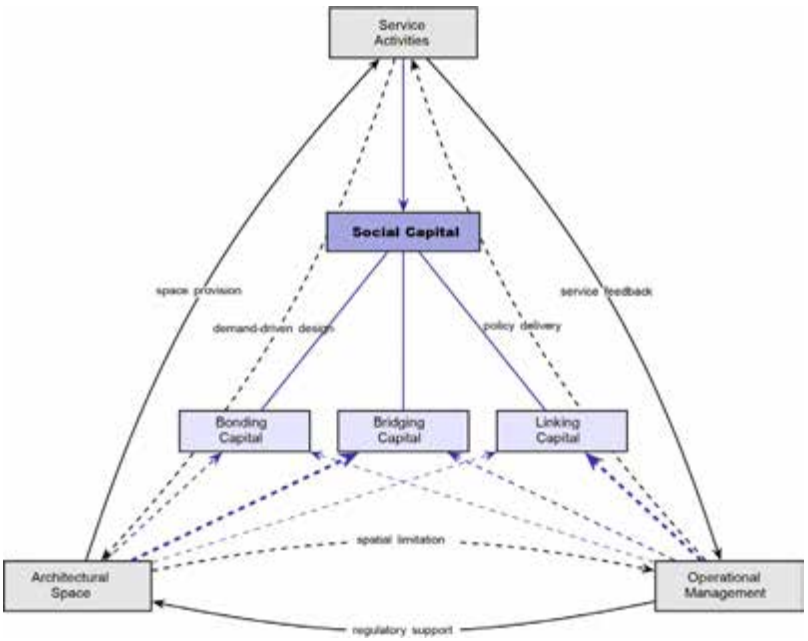

Fig. 2. Pathways to Social Functions: Social Capital Generation

3.2 Case Analysis

To investigate the differentiated realisation paths of the social functions of social infrastructure across various types of community reading spaces, this study adopted the principles of typicality, diversity, and research feasibility in case selection (Flyvbjerg, 2006; Shi Lei, 2016). Drawing on a preliminary investigation into the development status of community reading spaces in Nanjing and informed by the typological analysis of governance models in the literature review, the study constructed a typology framework based on three key dimensions: the level of government support, the degree of integration with the library system, and the extent of collaboration with social actors. These dimensions correspond to distinct institutional driving forces and resource coupling strategies (Bovaird & Löffler, 2003; Zhang Qian, 2021), which shape the institutional characteristics of each case and influence their patterns of interaction with the physical and social dimensions (Ostrom, 1990; Yan Fei, 2017).

Based on this typological framework—and taking into account the representativeness, operational features, and data accessibility of candidate cases—this study selected three representative community reading spaces in Nanjing for in-depth analysis: Jiangsu Writers' Works Hall, Yunji Study, and Wanxiang Study (Table 1). These three cases represent distinct interactive Operational Managements associated with different governance types: government-led (leading type), government–social collaboration (co-operative type), and socially-led (autonomous type). Their significant variation across the three screening dimensions provides a robust foundation for multi-dimensional comparison of interaction mechanisms and the dual functions of social infrastructure—namely, the practice of spatial justice and the generation of social capital.

Table 1. Cases Selection Analysis

Cases	Government Support	Library System Participation	Depth of Social Force Cooperation	Typologies
Jiangsu Writers' Works Hall	Financial + Venue	Nanjing Library Cooperation	Writers' Association Participation	Leading Type
Yunji Study Xuanwumen Store	Policy Guidance	Jinling Library Resource Access	Commercial Brand Led	Co-operative Type
Wanxiang Study	Initial Venue Support	Completely Independent	Brand Independent Operation	Autonomous Type

Case 1: Jiangsu Writers' Works Hall (Leading Type)
•Interactive Dimensions
Architectural Environment: As a thematic venue located within Nanjing Library, the Jiangsu Writers' Works Hall occupies 638 square meters and benefits from the library's prime location and central urban infrastructure (Fig.3 & Fig.4). The interior adopts a "large study room" layout, combining exhibition, reading, and interactive functions. It includes a manuscript exhibition hall, a themed reading zone, and an interactive experience area, displaying over 3,800 works by more than 800 Jiangsu-born authors. Although the space lacks an independent lecture hall, it accommodates large-scale events by utilizing the main library's lecture facility on a rotating basis. Medium-sized events are held by reconfiguring the main hall, while regular small book clubs and new book launches take place in a dedicated conference room. The spatial layout is tailored to serve the pavilion's thematic orientation and activity needs.

Fig.3. Urban Location& Exterior Picture of Case 1

Fig.4. Floor Plan of Case 1

Operational Management: The hall operates under a typical administrative coordination model. Initiated by the Jiangsu Provincial Writers' Association with thematic input, the project was executed through governmental resource coordination and ultimately implemented within Nanjing Library, which handles its daily management. This model, marked by clearly delineated responsibilities and reliance on public funding, ensures stable financial support—its operational costs are embedded in the Nanjing Library's budget system, contributing to long-term sustainability. However, this highly bureaucratic model limits market-oriented flexibility. Resource integration is predominantly achieved through Nanjing Library's local literature system, systematically collecting official literary resources; channels for collaboration with social actors remain relatively limited.

Service Activities: The services are centered on literary materials related to Jiangsu-born writers, emphasizing a regional cultural collection. Its primary audience consists of literary scholars and local culture enthusiasts, particularly middle-aged and senior readers. In addition to permanent exhibitions, it hosts annual public service-oriented cultural events such as literary lectures, book launches, and author meet-and-greets. While weekend events draw more diverse participants, the overall service approach remains rooted in public welfare. Activity formats—typically one-way in nature—are led by the Writers' Association or organised by Nanjing Library. To broaden outreach, a tiered strategy has been adopted, incorporating youth-targeted programming on weekends and holidays while maintaining professional depth in core activities.

Fig.5. Interior Pictures of Case1

• Dual Functions

The leading-type institutional mechanism of this case (government-led, stable finance, library system) directly ensures a superior physical space and rich thematic resources. At a macro level, this contributes to a high degree of distributive justice—the accessibility of specific public cultural resources (Jiangsu writers' works) is guaranteed. However, the interaction between the institutionally set thematic positioning, the limitations of the physical space (insufficient informal communication areas, event venue constraints), and social practices (primarily serving specific groups, one-way output activities) collectively restrict the inclusiveness of resource distribution. For non-literature enthusiasts and residents living relatively far away, its distributive justice is insufficient.

In terms of procedural justice, the highly administrative institutional dimension results in a long decision-making chain for operations, with limited channels for ordinary readers to participate in operational and service content setting, leading to weak user voice. Although collaboration with the Writers' Association and Nanjing Library reflects institutional-level consultation, the lack of a bottom-up user interaction mechanism means that the practice of procedural justice is insufficient.

The presentation of recognitive justice is mainly reflected in the institutional dimension's high recognition of the needs of specific cultural groups (literary researchers, Writers' Association members), providing professional resources and space (physical dimension), and thematic services (social dimension). In recent years, attempts have been made to expand inclusiveness by adjusting physical space (adding a popular reading area) and social practices (holding cross-disciplinary activities), somewhat enhancing the recognition of different groups' needs, but the core positioning still leans towards specific cultural groups.

Regarding social capital, the interaction between the institutionally set public welfare orientation, the social dimension's service content (thematic literature, regular activities), and the target group positioning effectively bonding local literary communities, strengthening the potential for generating bonding social capital. However, the interaction between the physical space design (solemn atmosphere, insufficient informal communication areas) and social practices (daily one-way output primarily) limits the occurrence of spontaneous daily social interactions. Natural interaction among readers from different backgrounds is constrained, and the ability to generate bridging social capital is moderate to weak. The institutional dimension's close ties with academia and the Writers' Association system, as well as the digital resources available through the Nanjing Library platform, construct specific linking social capital. However, due to the administrative nature of the Operational Management, interaction with broader social forces is limited, and linking primarily occurs as structural connections in specific fields.

• Case Summary

Overall, under a leading-type institutional drive, the Jiangsu Writers' Works Hall, with its stable physical and institutional resources, performs outstandingly in ensuring the distributive justice of specific public cultural resources and the bonding capital of specific communities. However, its administrative operation and insufficient social interaction constrain the comprehensive practice of procedural and recognitive justice, as well as the broader generation of bridging and linking social capital. (Table 2)

Table 2. Analysis Summary of Case 1

Dimension	Sub-Aspect	Characteristics	Implications for Spatial Justice	Implications for Social Capital
Institutional	Governance Structure	Government-led; administered by Nanjing Library	Ensures public cultural resource accessibility	Supports bonding within literary institutions
	Resource Integration	Stable public funding; reliance on library systems for official collections	Strengthens distribution of cultural knowledge	Weak external linkage; limited connection to other networks
	User Participation & Co-Governance	Top-down decisions; weak reader engagement mechanisms	Weak procedural justice	Lacks participatory co-governance culture
Physical	Location & Spatial Accessibility	Located in city center; shares main library's spatial advantages	High accessibility for literary users	Excludes residents in non-central areas
	Spatial Layout & Design Features	Thematic, formal layout; lacks flexible or multifunctional spaces	Narrow inclusiveness (recognitive justice)	Hinders adaptation to diverse community needs
	Informal Interaction Capacity	Minimal casual zones; solemn, institutional atmosphere	Constrains interactive use	Weak bridging and linking capital generation
Social	Target Groups	Literary researchers, Writers' Association members, older readers	Recognises needs of cultural niche	Strengthens bonding capital
	Activity Design	One-way activities: lectures, book launches, exhibitions	Weak user engagement; limited feedback inclusion	Inhibits cross-group interaction
	Social Interaction & Inclusion	Occasional outreach efforts; limited informal engagement	Attempts recognitive improvement, but core remains exclusive	Linking capital restricted to institutional domains

Case 2: Yunji Study (Co-operative Type)

• Interactive Dimensions

Architectural Space: Yunji Study Xuanwumen Store is located within the Hengji Center commercial district on Changjiang Road in Xuanwu District, Nanjing. It is situated in a core area along Nanjing's traditional cultural axis, boasting an excellent location and convenient transportation. The Xuanwumen store has a total area of

approximately 400 square meters, arranged in a long rectangular layout (Fig. 6 & Fig. 7). The space is divided into a reading area, a coffee and dining area, a cultural product display area, and an independent small activity space. Some areas feature floor-to-ceiling windows, bookshelf-enclosed seating, and green plant decorations, creating a reading environment that is both quiet and imbued with an urban atmosphere. Its physical space emphasises the integration of "aesthetic experience" and "life scenes," reflecting how new reading spaces accurately respond to the aesthetic and social needs of young consumer groups.

Fig.6. Urban Location& Exterior Picture of Case 2

Fig.7. Floor Plan of Case 2

Operational Management: The Operational Management of Yunji Study can be classified as a "co-operative" path, embodying Co-operative governance characteristics involving local government cultural departments and market entities. The store is operated by Nanjing Yunji Culture Company, with Jinling Library as a partner providing some book resources and lending services. The government is not directly involved in operations but indirectly participates in the public cultural service system through brand co-construction and the embedding of book resources. The source of the venue and the rent mechanism have not been clearly disclosed, but the commercial embeddedness of the study is strong. Relying on the matrix of multiple Yunji Study stores in Nanjing, it constructs an overall operational system through branded service projects. However, most front-desk operational staff are concurrently catering service personnel, with limited public service capabilities. Book lending and reading guidance primarily rely on the books provided by Jinling Library. The space places more emphasis on parent-

child companionship, urban leisure, and cultural consumption, with its public cultural attributes being relatively weaker.

Service Activities: In terms of literature resource allocation, Yunji Study focuses mainly on children's picture books and English original books, also stocking a certain proportion of books about Nanjing city. This is closely related to its core user group positioning: parent-child families (accounting for over 60%) and tourists (reaching over 30% during peak season). In terms of activity model, the study is predominantly venue rental-led, with about 85% of activities hosted by external organisations. The frequency of self-organised activities is low, and activity themes are mostly parent-child reading sessions, etc., with themes being diversified due to external determination. Although the physical separation of the children's area provides a dedicated space for specific groups, the fragmented service characteristic resulting from its scenic area location poses challenges to cultivating reader loyalty.

Fig.8. Interior Pictures of Case 2

• Dual Functions

The physical environment of Yunji Study (scenic area location, commercial aesthetic design) brings high accessibility and attractiveness. Coupled with the institutional co-operative with Jinling Library (providing free book resources), it has, to a certain extent, expanded the breadth of distribution, unexpectedly serving a large number of out-of-town tourists. However, the institutionally set consumption-for-seating policy essentially creates an economic barrier, constraining distributive justice for low-income groups. Simultaneously, the lack of dedicated event space, requiring temporary adjustment of business areas (physical dimension), may also affect the user experience of non-consuming readers.

In terms of procedural justice, the institutional priority of commercial operational logic means that reader demand feedback is mostly conveyed indirectly through consumption behavior, lacking direct mechanisms for participation in operational decision-making. Daily operations are handled by non-professional staff (institutional dimension), which may affect the efficiency of processing professional feedback, leading to a weaker presentation of procedural justice.

The presentation of recognitive justice is strong for specific groups (parent-child families), mainly reflected in the physical space design (physical separation of the children's area) and the service configuration of the social dimension (abundant children's books, frequent parent-child activities) highly matching their needs, providing targeted space and services. However, due to its commercial attributes and focus on specific service targets, the recognition and response to the needs of academic readers, in-depth readers, and other groups are insufficient.

Regarding social capital, the interaction between social dimension services for parent-child families and the physical dimension's children's area design helps attract and form temporary parent-child activity groups. However, there is a lack of sustained institutional support for in-depth community cultivation, limiting the ability

to generate bonding social capital. The physical dimension's scenic location and composite functional design, along with the institutional dimension-led venue rental model that introduces external activities and diverse participants, facilitate chance encounters among readers from different regions and with different purposes. This provides opportunities for establishing weak connections, resulting in a moderate to strong ability to generate bridging social capital. The promotion of linking social capital mainly relies on the institutional co-operative with Jinling Library, enjoying basic resource connections, and establishing Co-operative relationships with external activity organisers. However, this is more of an institutional-level resource connection rather than directly helping ordinary users connect to external high-end cultural or social resources.

• **Case Summary**

Through a government-social co-operative institutional model, Yunji Study leverages the locational and aesthetic advantages of its physical space and introduces market vitality. This effectively expands the physical accessibility of resources (partial distributive justice) and promotes superficial communication among readers from different backgrounds (bridging capital), performing prominently in the recognitive justice for specific groups (parent-child). However, its commercial logic and limited institutional user participation constrain the practice of procedural justice and the generation of bonding capital within in-depth communities. (Table 3)

Table 3. Analysis Summary of Case 2

Dimension	Sub-Aspect	Characteristics	Implications for Spatial Justice	Implications for Social capital
Institutional	Governance Structure	Commercial-led; cooperative with Jinling Library	Enhances distribution range via public-private resource sharing	Enables formal collaboration for resource supply
	Resource Integration	Free book resources from library; consumption-for-seating model	Creates economic thresholds; limits access for low-income users	Institutional support favors event organizers, not individuals
	User Participation & Co-Governance	User needs inferred via consumption; no explicit feedback or decision channels	Weak procedural justice; lacks participatory governance	Limited institutional responsiveness to diverse reader groups
Physical	Location & Spatial Accessibility	Scenic location; commercial aesthetic; highly attractive	High visual/ spatial appeal; broad distribution coverage	Attracts diverse transient users; supports weak tie formation
	Spatial Layout & Design Features	No dedicated event space; flexible use of café areas	Affects reader experience, especially for non-consumers	Restricts bonding via regular, fixed group activities
	Informal Interaction Capacity	Composite functions; adaptable but commerce-oriented layout	Partially inclusive; constrained by business logic	Supports bridging via shared, open use; lacks bonding anchors

Social	Target Groups	Parent-child families are primary audience	Strong recognitive match for select users	Weak toward academic/in-depth users
	Activity Design	Rich parent-child activities; frequent events	Event accessibility high for core groups	High turnover; limited long-term relational development
	Social Interaction & Inclusion	Short-term group cohesion; lacks deep community cultivation	Partial recognitive justice; segment-specific engagement	Weak bonding; moderate bridging; structural linking only

Case 3: Wanxiang Study (Autonomous Type)

• Interactive Dimensions

Architectural Space: Wanxiang Study enjoys a significant locational advantage next to Nanjing University, effectively targeting its core customer group. The interior space is meticulously divided into multiple functional areas, including a shared self-study area, a book lending area (which also functions as a bookstore), a coffee area, an exhibition gallery, a screening room, and an independent space rented out to an external art studio. (Fig.12 & Fig.13) This composite design greatly enhances space utilisation efficiency and provides a physical carrier for different types of reading, learning, leisure, artistic activities, and informal interactions. Its spatial design is full of personality and curatorial sense, aiming to create a unique atmosphere that aligns with its cultural propositions. It is noteworthy that the gallery area is open to the public free of charge, providing a limited point of free public cultural contact.

Fig.9. Urban Location& Exterior Picture of Case 3

Operational Management: Nanjing University Press acts only as the venue provider, while the Wanxiang Study brand is fully responsible for core functions such as book procurement, operational services, and activity planning. This clear division of labor grants the brand high operational autonomy, enabling it to make flexible decisions and quickly respond to market and community needs. Its operation is guided by a distinct cultural philosophy, balancing operational costs through a diverse commercial portfolio including book sales, coffee consumption, membership fees, crowdfunding, and art studio rental, thereby reducing reliance on a single funding source.

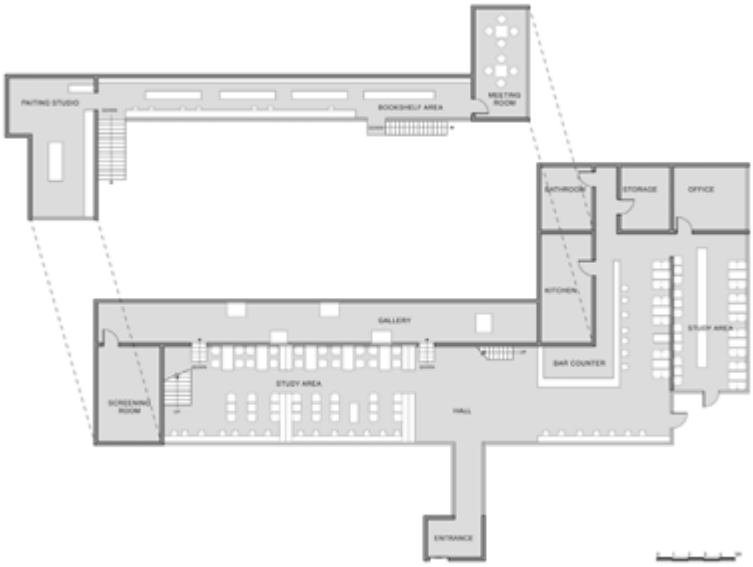

Fig.10. Floor Plan of Case 3

Service Activities: In the social dimension, Wanxiang Study' service configuration reflects a high degree of professionalism and community orientation. Literature resources focus on humanities, social sciences, and independent publications, precisely catering to the interest preferences of its core user group. Its core users are primarily faculty and

Fig. 11. Interior Pictures of Case 3

students from Nanjing University and Southeast University, and activity design is highly diversified and deeply connected with the community. Although many events involve providing venue rental services with content determined externally, Wanxiang Study, through holding activities and curating its own themes, has formed a unique and rich sequence of activities, including book clubs, sharing sessions, small exhibitions, workshops, and film screenings. These activities are not only frequent but also emphasise in-depth interaction and community co-creation, effectively cultivating close-knit communities based on shared values and interests.

• **Dual Functions**

Wanxiang Study' presentation of spatial justice reflects a coexistence of high benefits for specific communities and relatively insufficient inclusiveness. In terms of distributive justice, limited by the physical space volume and the

institutionally set consumption-for-seating policy, the accessibility and coverage of physical space and literature resources are relatively limited, making it difficult to guarantee resource fairness in a universal sense, especially for non-core communities and low-income groups (although the free gallery offers limited compensation). However, its high degree of autonomy under the institutional dimension and user co-construction fostered by the social dimension have built a deeply participatory governance structure, granting users extremely high voice and decision-making power in space operation and activity planning, thereby maximizing procedural justice.

Simultaneously, through highly curated physical space design and service configurations in the social dimension that closely match the needs of the core user group, Wanxiang Study highly recognises and satisfies the needs and identity of specific cultural groups (such as Nanjing University faculty and students, literary communities), providing them with a field where they are highly seen and accepted. Therefore, recognitive justice is very strong. Overall, Wanxiang Study' spatial justice is more manifested in the procedural and recognitive justice constructed by its institutional and social dimensions, rather than in the inclusiveness based on equitable distribution of physical resources.

Wanxiang Study, based on social dimension service activities driven by common cultural concepts, interests, and in-depth interaction, as well as an institutional dimension user co-creation community model, jointly foster an extremely strong capacity for generating bonding social capital, forming high identity and mutual aid networks. Its physical space's composite business format design (such as coffee areas, galleries) and high-frequency, issue-oriented social dimension activities with diverse themes introduced externally attract participants from different backgrounds and professions. This provides a unique platform for intellectual exchange and establishing weak connections, resulting in a strong ability to generate bridging social capital.

Furthermore, relying on the background of Nanjing University Press, the founder's connections, and institutional cooperation with media, academia, and other independent cultural institutions—especially by directly introducing external resources and organisers through the model where activity content is externally determined—Wanxiang Study has built rich external connections. This provides community members with opportunities to connect to higher-level resources and networks, also showing a strong ability to generate linking social capital.

• **Case Summary**
Driven by an autonomous institutional model, Wanxiang Study, with its physical space and social practices highly aligned with community needs, excels in promoting in-depth user participation (procedural justice, recognitive justice) and generating different types of social capital (especially bonding and linking). Its main drawback lies in the resource limitations under its autonomous model, which restricts its performance in inclusive resource allocation (distributive justice). (Table 4)

Table 4. Analysis Summary of Case 3

Dimension	Sub-Aspect	Characteristics	Implications for Spatial Justice	Implications for Social capital
Institutional	Governance Structure	User-led governance; institutional autonomy; community co-construction	Maximises procedural justice; strong user voice	Strong bonding through participatory operation
	Resource Integration	Limited government support; relies on private funding and social networks	Limited distributive justice; access constraints remain	Enables flexible linking with media and cultural institutions
	User Participation & Co-Governance	Users involved in planning and decision-making	Strong bottom-up engagement; highly participatory governance	Fosters deep user ownership and relational commitment
Physical	Location & Spatial Accessibility	Small-scale space; consumption-for-seating policy; free gallery partially compensates	Restricted space access for broader users and low-income groups	Limited inclusiveness; tailored access for core users
	Spatial Layout & Design Features	Curated environment; tailored for university/ literary users	High cultural specificity supports recognitive justice	Reinforces shared identity and cultural cohesion
	Informal Interaction Capacity	Multifunctional layout: café, gallery, book lounge	Encourages spontaneous interaction for targeted groups	Supports both bonding and bridging through semi-public settings
Social	Target Groups	Literary community, university scholars	Strong identity alignment; highly responsive to user profiles	Strong bonding among culturally cohesive groups
	Activity Design	Issue-driven events; external organizer cooperation; diverse cultural themes	Recognises and amplifies cultural plurality; active programming	Bridges communities; deepens trust and reciprocal ties
	Social Interaction & Inclusion	Open platform for dialogue; multi-background participation	Rich recognitive justice; cultural responsiveness	Strong bridging (diverse participants) and linking (external ties)

5. Conclusion and Prospects

5.1 Case Comparison: Complementary Logic of Multiple Types

The three governance models represent distinct institutional configurations that profoundly influence resource allocation, operational logic, and managerial approaches. These institutional differences shape the development of physical space and the structuring of service activities, thereby producing varying strengths and weaknesses in

fulfilling the dual functions of social infrastructure—namely, the realisation of spatial justice and the generation of social capital. Table 778 summarizes the core characteristics of each governance model and their corresponding performance in key dimensions.

The leading type, marked by high institutional centralisation, ensures stable resource input and standardized operational mechanisms. This is reflected in its prime physical location, robust infrastructural support, and a systematic cultural resource collection system. These features significantly enhance distributive justice, ensuring access to public cultural resources and safeguarding the basic cultural rights of specific user groups. However, this model lacks institutional channels for user participation and relies on administratively led, top-down service delivery. The physical environment, while functional, is insufficiently configured to support informal social interaction or diverse engagement, resulting in weaker performance in procedural and recognitive justice. This governance model represents a "top-down" social infrastructure paradigm, with a primary focus on resource provision and institutional order maintenance.

The co-operative type reflects a collaborative governance structure involving both public and private sectors. It typically operates through parallel mechanisms of resource integration, brand co-construction, and service outsourcing. Market participation enhances the spatial design by introducing aesthetic considerations and multifunctional layouts, thereby improving spatial attractiveness and user accessibility. Social practices in this model exhibit higher service diversity and activity frequency, which strengthens recognitive justice and facilitates the generation of bridging social capital. Institutional partnerships with public libraries also partially mitigate deficiencies in cultural coverage and professionalism. However, the dominance of commercial logic may dilute the public-oriented mission, and mechanisms for procedural justice remain limited. This model exemplifies an "embedded" institutional design that seeks to balance resource collaboration with responsiveness to user demand.

The autonomous type is characterized by decentralized governance and strong user agency. This model emphasizes participatory management and community co-creation, with service design closely aligned to the interests and needs of its core user base. Consequently, it demonstrates the strongest performance in procedural and recognitive justice. Moreover, curatorial spatial design and issue-driven programming foster the formation of bonding and linking social capital. However, the lack of institutional support from governmental or library systems constrains its physical space capacity and limits its distributive inclusiveness. This governance path represents a "bottom-up" model driven by community mobilisation and shared cultural identity.

Collectively, these governance models do not exist in isolation but demonstrate a complementary logic in their institutional objectives and operational strategies. The leading type offers broad coverage and foundational guarantees; the co-operative type enhances service diversity and spatial appeal, broadening the potential for superficial social interactions; and the autonomous type prioritizes deep community engagement and user participation, activating the cultural functions of intensive interaction. This complementary interplay is also echoed in international scholarship, such as Tonkiss's (2013) and Mehta's (2014) discussions on "institutional diversity" and "community-negotiated spaces."

Accordingly, the future optimisation of institutional frameworks for community reading spaces should avoid rigid adherence to any single governance logic. Instead, it should strategically combine the strengths of each model: enhancing institutional flexibility and user participation mechanisms within government-led frameworks; integrating public service attributes and professional resources into market-led models; and providing foundational policy support and external resource channels for community-initiated efforts. Through the synergistic coordination of institutional structure, physical space, and social practices, community reading spaces can more effectively fulfill their dual social functions, advancing both spatial justice and the generation of social capital as essential components of new social infrastructure.

5.2 Research Conclusions

• Dual Functions of Social Infrastructure and Three-Dimensional Interactive Mechanism

This research finds that community reading spaces, as a form of social infrastructure, embody the dual functions of providing fundamental public services and fostering social relationship networks. These spaces serve not only as platforms for physical and institutional delivery—guaranteeing daily cultural rights and access to knowledge—but also as relational fields that facilitate neighborhood interaction, collective identity, and trust-building. This dual embeddedness positions them as urban social apparatuses with communicative capacity, organisational capability, and normative orientation.

The realisation of these functions is rooted in the dynamic and synergistic interaction among three dimensions: physical space, institutional arrangements (particularly context-specific governance models in China), and social practices. Case analysis reveals that different institutional logics—such as administrative dominance in the leading type, government–society collaboration in the co-oping type, and community autonomy in the autonomous type—directly shape the accessibility and inclusiveness of physical spaces and guide the design of social practices, thereby determining the specific pathways and performance levels of each model in achieving these dual functions.

• The Synergisation of Spatial Justice and Social capital

The core value of community reading spaces as social infrastructure lies in promoting spatial justice and cultivating social capital. The research emphasises that spatial justice does not solely depend on the balanced distribution of physical space (distributive justice) but must be embedded with dimensions of institutional participability (procedural justice) and responsiveness to cultural identity (recognitive justice).

The Nanjing case analysis (e.g., the autonomous type maximised procedural and recognitive justice, while the leading type focused on the foundation of distributive justice) confirms this. Simultaneously, social capital is not a passive construction of social scenarios but a network of relationships (bonding, bridging, linking capital) dynamically stimulated by physical space forms, institutional arrangements, and user behaviors. Different governance models promote the generation of different types of social capital in differentiated ways by shaping the openness of physical space, institutional openness, and the diversity of social practices (e.g., the co-operative type promotes bridging capital, while the autonomous type strengthens bonding and linking capital). This indicates that spatial justice and social capital, as the two core objectives of infrastructure, are interrelated and synergistically achieved under different practical paths. Their effect depends on whether the three-dimensional elements can be effectively coupled and balance and promote the diverse facets of these two objectives.

• Complementary Logic of China's Pluralistic Governance Models

The Nanjing case study further reveals that against the policy backdrop of China actively promoting pluralistic governance in public cultural services, different governance models such as leading, co-operative, and autonomous types exhibit significant complementary logic. The leading type provides an inclusive foundation, the co-operative type introduces vitality to expand boundaries, and the autonomous type stimulates the deep vitality of communities. This co-existence of multiple paths and complementary patterns provides possibilities for addressing China's diverse community needs. Theoretically, the "three-dimensional interaction—dual functions" analytical framework proposed in this paper offers a new perspective for understanding how social infrastructure plays a composite function at the micro-scale.

At the policy level, it is necessary to move beyond indicator-based assessments and focus on the mechanism design for institutional openness and social embeddedness, and encouraging mixed governance, flexible spaces, and pluralistic participation. Through synergistic complementarity, the value of community reading spaces, as important social infrastructure, can be more comprehensively enhanced to address "spatial injustice" and "social alienation" in urban development. Concurrently, the theoretical perspective and mechanism analysis methods provided by this study can also offer references for research on other types of social infrastructure.

5.3 Research Prospects

This study, based on the "physical-institutional-social" framework, has conducted a preliminary exploration of the interactive mechanism behind community reading spaces. However, the current case selection (only three cases in Nanjing) is limited in quantity and type, failing to fully cover model variations or potential sub-types, and lacks quantitative analysis of the dynamic process of social capital. Based on this, future research needs to expand the breadth and depth of cases, deepen the study of governance models, and strengthen theoretical dialogue. This includes geographical expansion to different cities and regions, inclusion of different community types, identification of more diversified governance practices (such as mixed operations, transformation cases), and more detailed typological research on existing models. At the same time, placing community reading spaces within theoretical dialogues on public space, community governance, etc., aims to construct a more comprehensive and refined classification system of governance models and to verify and improve the theoretical framework.

Secondly, future research should deepen the dynamic process and quantitative analysis of efficacy, and closely connect with practice. The efficacy of community reading spaces evolves dynamically over time, requiring a tracking design to examine the long-term interaction of physical space, institutions, and social practices and their impact on community structure and changes in social capital. Introducing quantitative methods such as social network analysis can systematically depict the composition and dynamics of social capital. At the practical level, research results should be actively connected with departments of urban planning, cultural policy formulation, and community management to provide decision-making support for site selection, design, operation, resource allocation, and efficacy assessment. This will help promote the construction of more vibrant, equitable, and inclusive urban communities and enhance the overall effectiveness of public cultural services.

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The Role of Urban Green Spaces Attributes in Enhancing Leisure Opportunities and Psychological Well-Being Among Older Residents

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Abstract
This study investigates how urban green space (UGS) attributes influence leisure opportunities and psychological well-being among older adults in Hong Kong. Using surveys (n=80) and interviews (n=25) conducted in Morse Park and Fung Tak Park, the research applies the Recreationist-Environment Fit (R-E Fit) model to assess the alignment between park features, older users' needs and psychological well-being. Quantitative findings indicate that accessibility, safety and maintenance significantly contribute to both perceived fit and emotional well-being. Qualitative results further underscore the importance of elderly-friendly facilities, shaded seating, and social functionality. Together, the findings highlight how well-designed UGS can meet both functional and affective needs, supporting active aging in high-density cities.

Keywords: urban green spaces, aging population, psychological well-being, leisure opportunities, Recreationist-Environment Fit

1. Introduction

The world is undergoing a significant demographic shift, with a rapidly increasing number of people entering older age. The United Nations (2023) projects this demographic – often termed the "urban aging" phenomenon due to its concentration in cities – to double by 2050, posing significant challenges for urban planners worldwide. Urban Green Spaces (UGS), such as parks, gardens, and greenways, have long been recognised for their potential to enhance the quality of life for urban residents. For older residents, these spaces are especially vital, often serving as primary venues for immediate recreational opportunities. Studies have long shown that access to green space is tied to better mental health, reduced stress, and sharper cognitive function (Kaplan and Kaplan, 1989). Physical activity in green settings can ease fatigue and lift mood (Bowler et al., 2010; Coon et al., 2011). These spaces are also places of encounter, which help ease loneliness and build a sense of belonging (Jennings and Bamkole, 2019).

Mirroring global trends, Hong Kong is grappling with the implications of a rapidly aging society. Projections from the Census and Statistics Department (2023b) indicate that by 2046, more than one-third of the city's population will be aged 65 or above. This demographic shift brings with it greater demand for healthcare and social services, as well as a need to rethink how public spaces can support later life. Despite the growing body of research on urban green spaces and aging populations globally (Tzoulas et al., 2007; Lee and Maheswaran, 2010; Artmann et al., 2017; Xu, Nordin and Aini, 2022), there remains a critical void in understanding how elderly residents in Hong Kong specifically perceive and utilise these spaces for leisure and well-being. An urgent need exists for a thorough and structured examination of their preferences, limitations, and ways they interact with these environments.

This study focuses on two parks in the Wong Tai Sin district: Fung Tak Park and Morse Park, aiming to address the gap by exploring how urban green space attributes influence the leisure opportunities and well-being of elderly residents. The objectives are threefold:

1. To assess how specific park features relate to physical activity, mental health, and social engagement among older adults.
2. To compare user preferences and usage patterns between the two parks, highlighting both shared needs and site-specific distinctions.
3. To provide evidence-based recommendations for improving the design and management of UGS in high-density urban settings, with a view to supporting aging-in-place and promoting health equity in the context of rapid urban demographic change.

This study is expected to make several contributions to the field of urban planning and gerontology. First, it provides empirical insights into the UGS attributes most valued by elderly residents in a unique high-density context like Hong Kong, informing the design and management of future green spaces to better serve an aging population. Second, the study contributes to the broader understanding of the relationship between urban green spaces, leisure opportunities and well-being among older adults, particularly in the context of a rapidly urbanising and aging society. Finally, the findings offer practical recommendations for policymakers, urban planners, and park managers to create more age-friendly environments that promote active aging and improve the quality of life for older residents.

2. Literature Review

Urbanisation has led to an increasing number of people living in urban environments. By 2014, 54% of the global population lived in urban areas, and this proportion is projected to rise to 66% by 2050 (United Nations, 2014). While urban areas offer many advantages, they also present unique challenges for the psychological well-being of elderly populations. Research has identified several key psychological challenges faced by older adults in urban settings. Among the elderly population, loneliness and social isolation are common issues, with approximately one in four older individuals experiencing social isolation (World Health Organisation, 2021). Major life transitions, such as retirement, illness, the death of a spouse or close friends, can drastically weaken an individual's social network (Nicolaisen and Thorsen, 2016). These events are not merely emotional turning points; they carry long-term health implications. Studies have linked social isolation in later life to a higher risk of cardiovascular disease, depression, and cognitive impairment (National Institute on Aging, 2024).

UGS have become an essential component in addressing the psychological challenges commonly experienced by aging populations. For older adults, psychological well-being is shaped by multiple, interrelated factors—social support, meaningful engagement, and exposure to restorative environments all play a role (Huxhold et al., 2013; Tung et al., 2022; Li et al., 2025). Among the theoretical frameworks that illuminate these restorative processes, two remain foundational: Kaplan's Attention Restoration Theory (ART) and Ulrich's Stress Reduction Theory (SRT). Each offers a distinct lens: ART from a cognitive perspective ; SRT from an affective one. Together, they explain how natural landscapes support mental recovery and emotional balance. Physiologically, exposure to natural environments has been shown to reduce stress responses such as elevated blood pressure and cortisol levels (Ulrich et al., 1991). Psychologically, it alleviates attention fatigue by allowing the brain's directed attention system to rest, while simultaneously fostering a sense of calm and positive affect (Kaplan and Kaplan, 1989).

Importantly, the benefits of UGS extend beyond the psychological. Access to green spaces promotes physical activity, supports informal leisure, and facilitates social encounters. Physically, green spaces provide essential opportunities for walking, jogging, and other exercises, and engaging in such green exercise offers numerous well-being benefits and has been proven through various studies to positively impact both mental and physical health (Pretty et al., 2005; Lahart et al., 2019; Aristi Tsokani et al., 2024). Specifically, green exercise can reduce negative emotions such as anxiety, tension, anger, depression, and fatigue, while also enhancing positive moods and feelings like vigor, comfort, a sense of connection with nature, and relaxation (Li et al., 2022). These spaces also provide opportunities for relaxation, socialising, and participating in recreational activities, which can effectively reduce stress and depressive symptoms while promoting feelings of happiness in later life (Godbey, 1981; Coleman and Iso-Ahola, 1993).

Findings indicate that leisure activities serve as a bridge connecting social relationships and health outcomes among older adults (Chang et al., 2014). Importantly, social connections and relationships are vital for the life satisfaction of older individuals (Chokkanathan and Mohanty, 2017). In particular, engaging in leisure activities fosters involvement, instills purpose, and helps individuals derive meaning from everyday experiences (Yen et al., 2023). Parks, gardens, and other shared green areas serve as informal yet essential sites for interaction among older adults; provide opportunities for community participation, encourage regular contact with peers, and mitigate the risks of social isolation and loneliness (Villeneuve et al., 2023). Scholarly investigations have reliably indicated that senior citizens living in more verdant residential areas are inclined to express more robust social

bonds and lower degrees of loneliness (Maas et al., 2009; Teig et al., 2009). When considered collectively, these outcomes highlight the multifarious benefits of UGS for the well-being of the older adults.

2.3 Theoretical Framework

Person–environment fit (P-E fit) is a foundational concept that is extensively utilised in the field of organizational management. It explains the relationship between individuals and their surrounding environment. A high level of P-E fit is associated with positive outcomes for individuals (Kristof, 1996). Extending this concept to the leisure and recreational domain, Tsaur, Liang, and Lin (2012) pioneered the Recreationist-Environment Fit (R-E Fit) framework. They highlight three distinct types of fit: (1) Supplementary fit refers to the compatibility that arises when recreationists and administrators hold similar values; (2) Demand-Ability fit occurs when the demands of the environment align with the abilities of the recreationists; and (3) Need-Supply fit is achieved when the environment can meet the needs of the recreationists. In the context of parks discussed in this article, the need-supply fit is being assessed. It is achieved when the park environment can meet the needs of the recreationists.

In order to better understand how parks can achieve this need-supply fit, it is essential to examine the attributes of recreational settings that contribute to the overall experience of visitors. Noe and Uysal (1997) introduced a dual-dimensional lens for understanding recreational spaces: instrumental and expressive attributes. In urban parks, instrumental attributes refer to concrete and functional, including elements, such as birdsong, artificial water features, and cultivated vegetation, that create a calming atmosphere conducive to rest and relaxation. Functional infrastructure, for instance, benches, restrooms, and sports equipment, further enhances usability by facilitating physical activity and prolonged stays. Collectively, these features provide the physical conditions through which visitors can achieve specific recreational goals.

Expressive attributes, on the other hand, relate to social interaction and psychological well-being. Parks act as informal social arenas where visitors engage in casual conversations or form spontaneous bonds. As for psychological dimensions, parks allow individuals to temporarily disconnect from daily stressors and reconnect with a slower, more reflective pace of life. In doing so, they promote emotional regulation and mental clarity. A well-functioning park, therefore, is not defined solely by its physical structure but by its capacity to offer a needs-supplies fit. When instrumental and expressive attributes align with users' expectations and preferences, the park becomes more than a physical space.

3. Research Design

This study employs a comparative case study approach to examine how the quality of urban green spaces influences leisure opportunities and psychological well-being among older adults. The research is conducted in Wong Tai Sin District, which has a population of approximately 425,235 as of 2023, comprising 5.4% of Hong Kong's total population (Social Welfare Department, 2021). According to the latest census, 24.5% of the district's population is aged 65 or above, higher than the Hong Kong average of 21% (Census and Statistics Department, 2024). Given its significant elderly population, the district provides an ideal setting for this investigation. The results can function as an essential reference for developing age-friendly communities in other areas.

Two sites in the district were selected: Fung Tak Park and Morse Park. Fung Tak Park, located near a dense residential cluster and historical sites, is a mid-sized park known for its Journey to the West-themed cultural design. Morse Park, in contrast, is one of Kowloon's largest public parks, offering a variety of sports and recreational facilities and broader open spaces. This contrast offers an opportunity to explore how different configurations of park attributes affect user experiences.

Figure 1. Different areas in Fung Tak Park: (a) chess area, (b) exercise zone I, (c) exercise zone II, and (d) a map of the park

Figure 2. Different areas in Morse Park: (e) walking path, (f) seating area, (g) jogging track, and (h) a map of the park

Semi-structured interviews were conducted to explore elderly park users' subjective perceptions of park attributes, whether the park fits their needs and their relation to emotional and psychological well-being. Participants were selected based on the following criteria: (1) aged 65 or above, (2) regular users of either Fung Tak Park or Morse Park (at least once per week), and (3) cognitively able to communicate and provide consent. A total of 25 interviews were conducted, with 13 in Fung Tak Park and 12 in Morse Park. Each interview lasted approximately half an hour and was guided by open-ended questions covering themes such as tranquility, spatial comfort, social interaction, and facility adequacy.

A structured questionnaire was developed to quantitatively measure perceptions of park quality, whether the park fits surveyees' needs and its relationship with leisure opportunities and psychological well-being. Psychological well-being was measured using the validated WHO-5 Well-Being Index (Appendix I) and two questions related to social aspects. The survey was distributed via face-to-face paper forms and was assisted with filling out at both parks in May 2025, targeting elderly users who consented to participate. A total of 80 valid responses were collected through convenience sampling, with an equal distribution between genders: 50% male (n=40) and 50% female (n=40). This balanced gender representation supports the reliability of findings and ensures perspectives from both genders are equally reflected in the analysis.

Interview data were transcribed verbatim, translated from Chinese to English and analysed using thematic analysis. Themes were inductively generated and then categorised under the R-E Fit theory, focusing on how the compatibility between an individual's recreational preferences and environmental characteristics influences their internal states and psychological outcomes.

Survey data were analysed using SPSS. Descriptive statistics summarised demographic profiles and key variables. Independent-samples T-tests compared perceived park quality and well-being scores between Fung Tak Park and Morse Park users. Pearson correlation assessed the relationships between park attributes, R-E Fit and well-being indicators. Where applicable, multiple regression analysis was employed to identify the influence of park attributes and FIT on emotional outcomes.

4. Results

4.1 Demographic information and Usage pattern

Table 1 provides demographic information of respondents from Morse Park and Fung Tak Park. In terms of gender, the respondents are evenly split between male and female, with each group comprising 40 individuals (50% each). The age distribution reveals that the largest group is aged 70-79 years (43.8%), followed by those aged 80-89 years (32.5%), while respondents aged 65-69 years make up 20.0% and those aged 90 years and above account for 3.8%. Regarding living arrangements, 63.8% of respondents live with family, 28.8% live alone, and 7.5% have other living arrangements. In terms of self-rated health status, 43.8% of respondents rate their health as "Fair," 35.0% as "Good," while only 3.8% rate it as "Excellent" and 17.5% as "Poor." Overall, the data highlights a balanced gender distribution, a predominantly older age group, a majority living with family, and a general perception of moderate health status among the respondents. However, the two parks show little difference in the above aspects.

Table 1 Demographic information of the respondents

Characteristics	Group	Morse Park(N=40)	Fung Tak Park(N=40)	Total(N=80)	Percentage (%)
Gender	Male	20	20	40	50.00
	Female	20	20	40	50.00
Age	65-69	10	6	16	20.00
	70-79	17	18	35	43.80
	80-89	11	15	26	32.50
	>/=90	2	1	3	3.80
Living Arrangement	Living alone	12	11	23	28.80
	With family	27	24	51	63.80
	Others	1	5	6	7.50
Self-rated Health Status	Excellent	1	2	3	3.80
	Good	16	12	28	35.00
	Fair	16	19	35	17.50
	Poor	7	7	14	17.50

Table 2 presents the usage patterns of respondents regarding Morse Park and Fung Tak Park. In terms of visit frequency, the most common category is "Very Often (every day or more than 6 times)," accounting for 30.0% of respondents, followed by "Often (5–6 times a week)" at 28.8%. Regarding the duration of stay, the majority of respondents stay for "one to three hours" (55.0%), followed by "four to six hours" (36.3%). In terms of usual activities, "Walking" and "Chatting" are the most popular, each accounting for 21.8% of respondents. "Sitting and resting" is also common at 24.2%, while "Exercise" accounts for 16.1%, "Playing chess/cards" for 8.9%, and "Others" for 7.3%. Overall, the data indicates high visit frequency, longer durations of stay, and a diverse range of activities among park users.

Table 2 Usage pattern of the respondents

Question	Option	Morse Park (N=40)	Fung Tak Park (N=40)	Total (N=80)	Percentage(%)

Average Visits per Week	Rarely (1–2 times a week)	4	6	10	12.50%
	Sometimes (3–4 times a week)	8	14	22	27.50%
	Often (5–6 times a week)	14	10	23	28.80%
	Very Often (every day or more than 6 times)	14	10	24	30.00%
Average Duration of Stay	Less than 1 hour	1	1	2	2.50%
	one to three hours	23	21	44	55.00%
	four to six hours	13	16	29	36.30%
	six hours above	3	2	5	6.30%
Usual Activities(multiple choice)	Walking	15	12	27	21.80%
	Exercise	10	10	20	16.10%
	Sitting and resting	14	16	30	24.20%
	Chatting	13	14	27	21.80%
	Playing chess/cards	4	7	11	8.90%
	Others	9	0	9	7.30%

4.2 Descriptive statistics

By conducting descriptive statistical analysis on the data from Table 3, we found that sense of fit has an average score of 3.94, accessibility is 4.19, safety is 4.00, maintenance is 3.81, WHO-1 is 4.15, and WHO-2 is 3.99. These figures indicate that both parks perform well in several aspects, including environmental fit, accessibility, safety, maintenance, and thus, leading to high well-being scores, all of which show positive evaluations.

Table 3 Descriptive statistics of park attributes, sense of fit, and psychological well-being

Variable	Measurement Item	Morse Park		Fung Tak Park		Overall	
		Mean	SD	Mean	SD	Mean	SD
Park attributes	Accessibility	4.25	0.54	4.13	0.52	4.19	0.53
	Safety	3.90	0.59	4.10	0.59	4.00	0.59
	Maintenance	3.83	0.75	3.80	0.65	3.81	0.70
	Landscapes	3.65	0.74	3.65	0.74	3.65	0.74
	Sound	3.55	0.71	3.60	0.81	3.58	0.76
	Smells	3.45	0.68	3.58	0.81	3.51	0.75
	Seating arrangements	3.88	0.40	3.48	0.78	3.68	0.59
	Shading	3.33	0.89	3.60	0.84	3.46	0.86
	Elderly-friendly facilities	3.68	0.80	3.58	1.01	3.63	0.90
Sense of fit	Facility fit	3.60	0.81	3.48	0.88	3.54	0.84
	Environment fit	4.00	0.45	3.88	0.76	3.94	0.61
Psychological well-being	WHO-1	4.28	0.51	4.03	0.70	4.15	0.60
	WHO-2	4.08	0.66	3.90	0.63	3.99	0.64
	WHO-3	3.63	0.77	3.60	0.63	3.61	0.70
	WHO-4	3.40	0.78	3.33	0.73	3.36	0.75
	WHO-5	3.30	0.79	3.33	0.89	3.31	0.84
	Feeling connected with people	3.73	0.82	3.70	0.88	3.71	0.85
	Feeling less lonely	3.85	0.70	4.05	0.68	3.95	0.69

As shown in Table 4, the correlation analysis in Morse Park significant positive relationships: specifically, between park attributes and participants perceived FIT (r = .547, p < .001), as well as between park attributes and Psychological well-being (r = .467, p = .002). These findings suggest that improved park attributes are associated with both a stronger sense of fit and enhanced emotional experiences for users. Additionally, there was a significant positive correlation between perceived FIT and Psychological well-being (r = .378, p = .016).

For Fung Tak Park, Table 4 indicates that although the correlation between park attributes and Psychological well-being was not significant, there was a significant positive correlation between perceived FIT and Psychological well-being (r = .521, p < .001). A strong positive correlation was also observed between park attributes and perceived FIT (r = .705, p < .001). These findings indicate that park attributes and perceived FIT may positively influence visitors' Psychological well-being, with potential variations between the two parks.

Table 4 Correlation analysis results

	Morse Park(N=40)			Fung Tak Park(N=40)		
	Park attributes	Sense of fit	Psychological well-being	Park attributes	Sense of fit	Psychological well-being
Park attributes	--			--		
Sense of fit	**.547****	--		0.214	--	
Psychological well-being	**.467****	.378*	--	**.705****	**.521****	--

Notes: ** indicates significance at the 0.01 level; * indicates significance at the 0.05 level.

In Morse Park, regression analysis demonstrates, park attributes (B=0.434, p=0.037) positively predict emotional outcomes; however, after controlling for the influence of park attributes, the independent predictive effect of sense of fit on psychological well-being was no longer significant (B=0.157, p=0.314). The regression model has explanatory power (R^2=0.240, adjusted R^2=0.198, F=5.827). This outcome may suggest that the positive impact of park attributes on psychological well-being might largely encompass the explanatory power otherwise provided by sense of fit. This does not negate the intrinsic link between sense of fit and psychological well-being; rather, it suggests that in the specific context of Morse Park, improvements in the park's physical and functional attributes may largely suffice in promoting users' psychological well-being, with sense of fit not demonstrating additional independent contribution within this particular model.

Table 5 Regression analysis results in Morse Park sample

		B (Unstandardised)	Std. Error	β	t	Sig. (p)
(Constant)		1.540	0.651		2.366	0.023
Park attributes		0.434	0.200	0.371	2.168	**0.037***
Sense of fit		0.157	0.153	0.175	1.021	0.314
R^2	0.240					
Adjusted R^2	0.198					
F	**5.827***					

Notes: *** indicates significance at the 0.001 level; ** indicates significance at the 0.01 level; * indicates significance at the 0.05 level. The dependent variable is Psychological well-being.

In Fung Tak Park, regression analysis demonstrates, park attributes (B=0.551, p<.001) positively predict psychological well-being; sense of fit (B=0.254, p<.001) also significantly predicts psychological well-being. The regression model has strong explanatory power (R^2=0.641, adjusted R^2=0.622, F=33.042).

Table 6 Regression analysis results in Fung Tak Park sample

		B (Unstandardised)	Std. Error	β	t	Sig. (p)
(Constant)		0.722	0.370		1.953	0.058
Park attributes		0.551	0.089	0.622	6.172	**<.001****
Sense of fit		0.254	0.066	0.388	3.850	**<.001****
R^2	0.641					
Adjusted R^2	0.622					
F	**33.042*****					

Notes: *** indicates significance at the 0.001 level; ** indicates significance at the 0.01 level; * indicates significance at the 0.05 level. The dependent variable is Psychological well-being.

4.3 Interview interpretation

Unlike the quantitative questionnaire analysis described above, the interview provides more in-depth and rich data that can be used to complement a comprehensive picture of the impact of urban green spaces-parks on the psychological well-being of older residents. The study sites for the interview data remained Morse Park and Fung Tak Park, with a total of 25 older adults interviewed: 12 respondents in Morse Park and 13 in Fung Tak Park. Code A represents Fung Tak Park and Code B represents Morse Park. The data were translated from Cantonese to English. The corpus information was organised and thematically analysed. The results of the analysis were categorised into the following themes: (1) inadequate maintenance and lack of elderly-oriented facilities undermine park usability; (2) park facilities enable social connectivity; and (3) thermal comfort is a prerequisite for park usages. In addition, recommendations for improvement were made from the perspective of older adults.

Theme 1: Inadequate Maintenance and Lack of Elderly-Oriented Facilities Undermine Park Usability

Limitations were frequently noted in both parks. Some respondents criticised the cleanliness of surfaces (B3), insufficient toilets (B2, A11), and lack of elderly-specific facilities (B6, A7). Participants also mentioned long-standing maintenance issues such as unrepaired equipment (B5) and broken amenities (B8). The lack of diversity in facilities was especially apparent when comparing the studied park with others, as B6 mentioned "The place is big enough, but the facilities for the elderly are insufficient and very monotonous, not as diverse as Kowloon Tsai Park. This Park has not been improved for decades and only has some scattered facilities.".

Respondents called for more fitness equipment (B7, A7), soft mats to prevent injuries (A7, A8), and designated activity areas like chess zones (A6).

Theme 2: Park Facilities Enable Social Connectivity

Several respondents described facilities as both functional and socially enabling. For instance,
"I come here to exercise, there is a companion to accompany me and chat." (B8)

"I come here to exercise, ride an exercise bike, and breathe fresh air. Sometimes I chat with friends, sometimes we play together, do exercise together, and it's very happy. (B9)

"I feel happy when I come to the park. I find a seat and chat with old friends. I sit here (in the fitness area), other people see me and chat with me, and then they go to do exercise while I continue to sit here. Chatting with people is relaxing. Before other elderly folks come, I look around. When there is no one to chat with, I automatically doze off. If there are some acquaintances, I chat. Some elderly people are too lonely and there is no one to chat with at home." (A8)

Parks played a crucial role in supporting both solitude and sociability. Participants valued the park as a space where they could choose between interacting or being alone.

"It's not good to be with others all day, and it's not good to be alone. Sometimes I chat, sometimes I watch others play chess, and when I feel bored, I sit down and walk. So this park allows you to choose different social activities. Sometimes you like to be alone, and sometimes you chat with others and watch others play chess." (B2)

"In this park, I found some acquaintances to chat with. Lonely old people are like this. Walking and sitting, and then chatting. If I need to sit, there is a bench. If I like to walk, I will keep walking. If I like to find someone to chat with, I will find someone to chat with." (A1)

Seating areas enabled casual interaction, and inadequate bench availability was cited as a barrier to social exchange. Some respondents suggested enhancements that would increase the social functionality of parks.

"There are not enough benches when needed, like now, which affects chatting and communicating with people." (A5)

"It would be best if there were a bench, two more benches, and a few more tables and benches inside, so that the elderly can sit and chat. The most important thing here is to have a roof over our heads. It would be best if there were some sports equipment for the elderly too." (A12)

These features were seen not just as amenities but as means to anchor social connection in the everyday lives of older adults.

Theme 3: Thermal Comfort is a Prerequisite for Park Usages
Participants consistently emphasised the importance of thermal comfort when using park spaces. For instance,

"There are many shaded areas with trees, so it's not too hot or too shiny." (B2)

"If the sun is too hot, then I can go to a shaded place. There are trees all around." (B3)

"Now the trees are bare and cannot cover the sun. Earlier, the storm knocked down the trees, which were not replanted. We, of course, want the trees to be denser and to provide more shade." (B5)

"I stay in the pavilion when it's sunny and go outside to enjoy the sun when it's cold." (A11)

A6 proposed adding electric fans to improve airflow during hot weather, while A12 underscored the need for "a roof over our heads" to avoid direct sun exposure.

5. Discussions and Conclusions
The psychological well-being of the elderly population is a paramount concern in the context of urban development. This study investigates how the quality of urban green spaces influences elderly residents' sense of fit, thereby enhancing their leisure opportunities and psychological well-being.

Initial analyses of demographic characteristics and usage patterns in Morse Park and Fung Tak Park revealed a sticking consistency between both sites, with minimal variation in gender ratios, age groups, living situations, and self-assessed health showed . The high frequency of park visits (at least five to six times per week) and typical stays (one to three hours) underscore the embedded role of UGS in the daily lives of older adults in Hong Kong. Preferred activities, consistently identified as walking and casual social interactions with peers, further reinforce the centrality of parks as vital spaces for both recreation and informal social engagement among older urban residents, re-underscoring their importance as accessible community hubs in high-density urban settings.

Regarding the general park environment, both sites were rated highly for accessibility and safety, with maintenance and seating arrangements also garnered positive feedback. These elements are instrumental

in shaping perceived usability. As Sugiyama et al. (2010) argue, the psychological well-being of older adults is positively correlated with their perceptions of safety and the functional quality of neighborhood green spaces. Design features such as unobstructed sightlines, well-maintained walking paths, and visible staff presence can significantly reduce environmental anxiety, fostering a sense of autonomy and control beyond mere hedonic comfort. In the case of Fung Tak Park and Morse Park, regular maintenance by the Leisure and Cultural Services Department (LCSD) ensures cleanliness and functionality, contributing to consistently high ratings for environmental quality. Benches are strategically placed along pathways and within shaded zones, providing frequent opportunities for rest and enabling longer, more comfortable visits. Accessibility is another key strength. Because the parks are located within residential neighborhoods and offer several entrances, elderly residents can easily reach and enjoy these green spaces. This aligns with Hong Kong's urban planning principles that prioritise accessibility in residential zones (Planning Department HKSAR, n.d.). Well-lit environments and on-site management, combined with even, obstacle-free paths in both parks, help minimise fall risks, which is crucial for older park-goers. These findings collectively highlight the fundamental importance of well-maintained, safe, and accessible UGS as a baseline requirement for promoting older adults' well-being, particularly in compact urban areas where outdoor leisure options are scarce.

The quantitative findings presented a nuanced picture of the relationships between park attributes, sense of fit, and psychological well-being across the two parks. In Morse Park, there was a significant positive correlation between park attributes and visitors' emotional experiences, suggesting that favorable park features enhance emotional outcomes. In Fung Tak Park, perceived sense of fit was significantly associated with psychological well-being, indicating that engaging in physical activities help improve mental states. Regression analyses further supported these findings. In Morse Park, the characteristics of the park were found to have a positive impact on visitors' emotional states. It highlights how environmental features and facilities can enhance visitors' emotions. Although sense of fit was correlated with emotional outcomes, it did not emerge as a significant predictor in the regression model. Conversely, in Fung Tak Park, both the park attributes and the sense of fit were found to be significant predictors of psychological well-being. This underscores the importance of park infrastructure and opportunities for physical activity in enhancing visitors' mental health.

The findings from Morse Park revealed an interesting discrepancy. Although park attributes and sense of fit were both significantly associated with psychological well-being, the regression analysis failed to identify sense of fit as a significant predictor. This contrasts with the results from Fung Tak Park, where sense of fit emerged as a statistically significant predictor of well-being. One likely explanation lies in methodological sensitivity. Regression models, particularly with smaller sample sizes, are prone to reduced statistical power, which may obscure meaningful predictive relationships. Yet, the presence of significant correlations in Morse Park should not overshadow the substantive implications. They still point to a consistent and theoretically grounded association among park quality, perceived fit, and mental well-being. This suggests that while the strong influence of existing park attributes in Morse Park might largely encompass the explanatory power otherwise provided by sense of fit in the multivariate model, fit remains a crucial underlying component of the overall user experience and well-being pathway. It is plausible that in an environment where fundamental park attributes are already highly favorable (as suggested by the positive general ratings for Morse Park), the direct impact of these attributes on well-being becomes dominant, potentially overshadowing the additional, albeit related, contribution of a perceived fit.

Drawing on the Recreationist-Environment Fit model, our findings collectively illustrate that psychological benefits accrue when individuals perceive congruence between their leisure needs and the characteristics of their environment. This match fundamentally relies on accessible, safe, clean and well-maintained UGS, which form the bedrock of environmental supply. These high quality features enable safe mobility, facilitate meaningful activity, and reduce environmental barriers, thereby cultivating a setting that supports autonomy, ease, and comfort. Older adults who perceive their environment suitable are more likely to engage in activities aligning with their interests and abilities. These repeated positive engagements can then cumulatively foster improved psychological well-being. The quantitative findings from this study reinforce this relationship, indicating that

perceived fit may partially mediate the connection between environmental characteristics and well-being outcomes. This posits that park attributes influence psychological health in two ways: (1) directly through immediate physical conditions ; (2) indirectly through their impact on subjective perceptions of fit. This dynamic is consistent with the core propositions of the Recreationist–Environment Fit (R–E Fit) model (Tsaur et al., 2012).

Extending this mechanism further. Leisure opportunities themselves appear to operate as critical mediators within this process. Specific park attributes, such as well-maintained paths, elderly-friendly facilities, and safe environments, directly provide the necessary space and infrastructure to support various leisure activities. As engagement in these activities expands, psychological needs related to autonomy, competence, and connection are increasingly met. These meaningful experiences reinforce the perception that the park aligns with one's lifestyle and preferences. In turn, this heightened sense of environmental fit contributes to improved emotional and mental well-being. The process reflects a recursive, positive feedback loop: high-quality park attributes promote engagement in leisure, which enhances perceived fit; this improved fit fosters well-being, which then further strengthens users' positive perceptions and sustained use of the space.

Interview interpretations further complemented the quantitative findings. Participants generally appreciated accessible entrances, seating, and safe environments. However, the effectiveness of park facilities was undermined by a lack of adequate facilities for older adults and inconsistent maintenance. These limitations indicate a gap between environmental facilities and user needs, which hinders the park's ability to support sustained and meaningful engagement. The situation is particularly influential in the context of urban parks, where the quality of sports and fitness facilities is vital for older users who depend on this equipment to stay physically active (Chow, 2013; Copeland et al., 2017; Onose et al., 2020). This highlights a crucial practical implication: even generally well-regarded parks can fall short if specific age-appropriate facilities are lacking or inconsistently maintained. Such mismatches reduce the "supply" dimension in the Need–Supply Fit framework, ultimately limiting older adults' opportunities for enriching and health-promoting leisure experiences.

A salient observation from the study is the multifunctionality of specific design elements. Exercise zones, for instance, were not just places for physical activity, but also emerged as points of social convergence. This aligns with Di Bartolomeo and Papa's (2019) observation that physical activity can simultaneously support individual development and foster a sense of community. These spaces enabled users to stay active while engaging with others, illustrating how park infrastructure can meet both personal and social needs. Similarly, seating zones facilitated rest and passive observation, and when designed well, they also enabled conversation. Gehl (2010) proposed that positioning benches at a slightly open angle would allow people to choose whether to sit together or alone, thus facilitating the option for conversation. Seating areas with shade have also been proven to enhance social interactions (Wong, 2019). In addition to meeting immediate physical needs, these spatial features nurtured affective connections. In this way, the parks functioned as a flexible environment that supported both sociability and solitude. This dual functionality reflected a high degree of environmental affordance, facilitating diverse modes of engagement. Crucially, it empowered older adults to regulate their engagement based on personal mood, preference, or physical condition. The flexibility to initiate contact or remain alone contributes meaningfully to their sense of autonomy and overall well-being.

With regard to thermal comfort, the findings indicate a clear preference among older adults for parks that provide ample shaded areas. These physical conditions are a prerequisite for engaging in light physical activity, resting, or remaining in the space for even short durations. When such environmental features are absent, such as inadequate tree cover or exposure to direct sunlight, participants reported avoidance or limited engagement, indicating a clear disruption in perceived fit. The R-E Fit framework helps explain these behavioral patterns by highlighting how environmental insufficiencies inhibit the actualization of recreational intent. Rather than viewing thermal comfort as a background condition, this study reinforces its role as a decisive factor in enabling or constraining elderly park use. This aligns with previous studies that the quality of the outdoor thermal environment is considered a significant factor influencing residents' attendance and activities in open spaces (Martinelli et al., 2015; Shooshtarian et al., 2018).Thermal discomfort does not merely reduce enjoyment;

it obstructs the realization of the park's intended function as a space for leisure, relaxation, and mild exercise.
In conclusion, based on the comprehensive findings of this study, it can be clearly stated that the key attributes of urban parks: general features (accessibility, safety and maintenance), park facilities, and thermal comfort significantly enhance both the sense of R-E fit and the psychological well-being of older adults. These attributes not only directly affect their satisfaction with the park environment, but also indirectly promote their overall psychological health and life satisfaction by enhancing their leisure experience and social interaction opportunities. This study provides valuable empirical evidence for promoting age-friendly urban environments in high-density contexts, emphasising the critical role of well-designed and managed green spaces in supporting healthy and active aging.

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Appendix I: WHO-5

WHO-1	Visiting this park makes me feel happy
WHO-2	Visiting this park makes me feel calm and relaxed
WHO-3	After activities in this park, I feel more energetic
WHO-4	Participating in park activities help me sleep better
WHO-5	I find things that interest me in this park

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Temporary Urbanism in Action: Theme–Neighborhood (Mis)alignment and Visitor Response in Beijing Pop-up Markets

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Abstract
Pop-up markets are increasingly deployed as temporary urban-regeneration tools, yet their capacity to deliver community benefits beyond mere commerce remains uncertain. This study mapped 447 Beijing pop-ups (Dec 2023–Nov 2024) and analysed 25 cases for market-neighbourhood fit. Fifteen-minute walking isochrones intersected Gaode POIs, land-use entropy and VIIRS night-lights; while Xiaohongshu posts provided popularity and satisfaction metrics. Theme vectors for both markets and neighbourhoods were derived via Word2Vec; their cosine similarity measured thematic alignment. Results show that while 80% markets align closely with local amenities, those with greater thematic divergence often achieve higher visitor satisfaction ($p<0.05$). Community-driven, experimentally themed pop-ups can thus act as low-risk prototypes for augmenting neighbourhood services and deepening civic engagement.

Keywords: temporary urban regeneration, pop-up market, urban informatics, neighbourhood.

1. Introduction

Temporary urbanism, commonly manifested through pop-up markets and ephemeral public space interventions, has emerged as a significant yet controversial approach in urban planning and renewal practices. Rooted in tactical urbanism, these temporary interventions are characterized by low-cost, reversible, and quickly deployable projects that allow urban stakeholders to test new functions, assess community acceptance, and respond dynamically to evolving urban challenges (Lydon & Garcia, 2015; Bertolini, 2020). Despite their operational flexibility and popularity, temporary urban projects have attracted criticism, as scholars argue they frequently become vehicles for capital-driven marketing and real estate valorization (Madanipour, 2018).

In the context of China's rapid urbanization and evolving policy landscape, the strategic role of temporary urban regeneration deserves nuanced examination (Gao & Zhang, 2024). The current trend of pop-up markets across the country offers a vivid illustration. These markets try to address issues such as the shortage of urban construction space, lack of funding for large projects, and the promotional needs for small enterprises. Recent initiatives such as China's "15-Minute Community Life Circle" and the incentives of night-time economies underline a growing institutional support for temporary, experiential urban activities. Nevertheless, the potential of these activities to transcend their commercial origins and foster meaningful community engagement and functional diversity remains under-explored.

Addressing this research gap, this study leverages urban informatics methodologies—including spatial analytics, social media sentiment analysis, and semantic modeling—to explore the interplay between pop-up market themes and the daily functional characteristics of surrounding built environments in Beijing. By systematically examining thematic alignment and divergence, this paper aims to clarify whether and how temporary market activities serve as effective instruments for tactical urbanism, fostering greater community satisfaction and resilience through experimental governance. The study period spans from December 2023 to November 2024, and it involves 447 markets for macro-level spatio-temporal analysis and 25 typical cases for in-depth thematic and sentiment analyses. Data sources include pop-up market information from WeChat public accounts, POI data from Gaode Map, and social media data from Xiaohongshu. This study further develops a methodological approach which employs Word2Vec to establish connections between urban built-environment characteristics and thematic content derived from social media, building upon earlier research by Yao et al. (2017). Our findings contribute to ongoing theoretical and practical debates by offering empirically grounded insights into how temporary urbanism principles like pop-up markets can guide the sustainable, community-responsive evolution of temporary urban initiatives.

2. Data

The empirical foundation of this study rests upon a meticulously assembled geospatial and social media dataset, designed to capture both the physical and experiential dimensions of pop-up markets in Beijing. Our spatial dataset comprises 618 pop-up market listings harvested from "Shijihui," a leading WeChat public account renowned for its exhaustive aggregation of Beijing marketplace events. To ensure comprehensive coverage and geographic precision, each listing was geocoded and cross-referenced with the 2024 point-of-interest (POI) database provided by Gaode (Amap), which offers detailed classifications for urban features such as transit nodes, retail outlets, cultural institutions, and life-service venues. Administrative boundaries and road network layers were procured from the Beijing City Lab repository, while OpenStreetMap (OSM) supplemented the street topology data to facilitate high-accuracy routing analyses. The spatial distribution of these markets is shown in Figure 1.

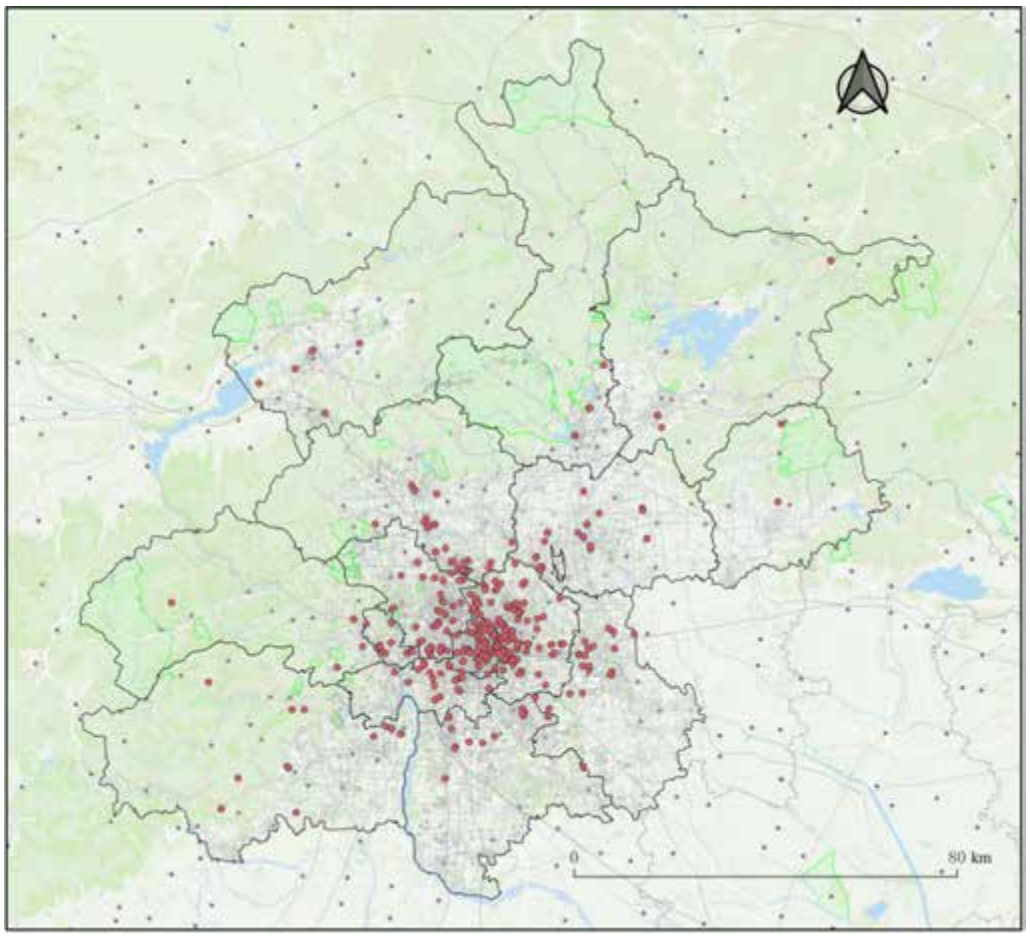

Figure 1. Pop-up markets in Beijing (2023.12-2024.11)

Recognizing the rapid evolution of urban events and to maintain analytical rigor, we confined our study period to December 1, 2023 through November 30, 2024. Markets situated outside Beijing's six core urban districts—Haidian, Chaoyang, Xicheng, Dongcheng, Fengtai, and Shijingshan—were excluded to focus on areas with advanced economic activity, data completeness, and high population densities. This spatial filtering reduced the sampling frame to 447 markets for which we have full environmental characterizations.

To capture the diversity of market typologies, we applied a keyword-based classification schema grounded in extant literature on temporary urbanism. Using descriptors such as "food," "fashion," "used goods," "art," and "comprehensive," each market was assigned to one of five categories: Food & Dining, Fashion, Used Possession, Art & Culture, and Comprehensive. We then executed a purposive sampling strategy by crawling the Xiaohongs-

hu, a popular lifestyle platform and consumer decision-making portal in China, with the query "Markets in Beijing" and manually verifying thematic relevance. From each typology, five spatially representative markets were selected, yielding a subset of 25 case markets (Figure 2) for in-depth thematic and sentiment analyses.

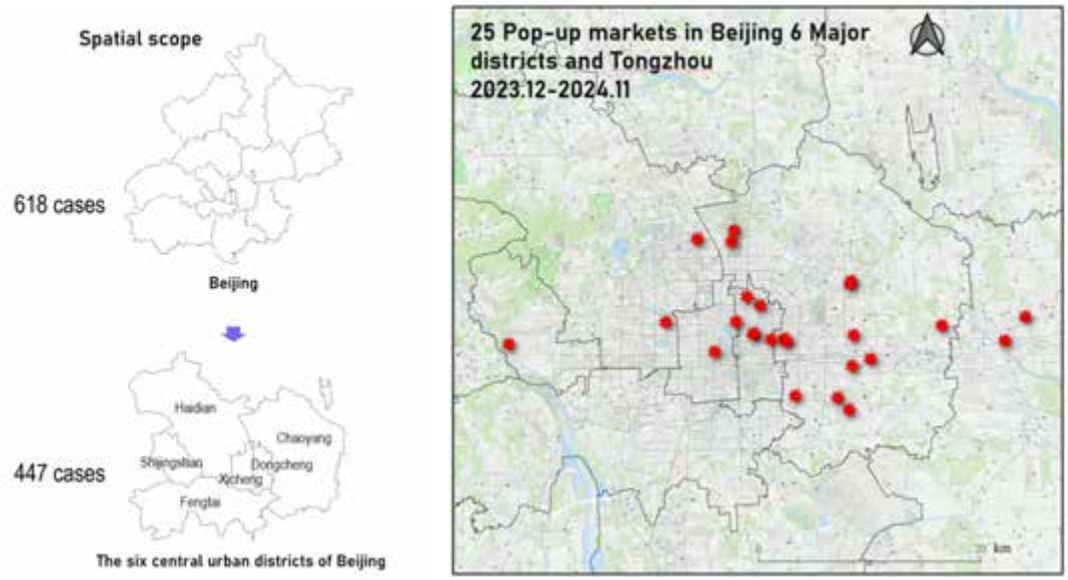

Figure 2. Schematic diagram of the screening of research subjects

Built environment metrics were calculated within a standardized 15-minute walking catchment around each market. Isochrone polygons were generated via the Mapbox API, ensuring alignment in the delineation of pedestrian accessibility zones. Within these isochrones, we extracted counts and spatial distributions of seven POI categories—subway stations, parking facilities, life services, catering venues, retail establishments, science/education/cultural institutions, and parks—using Gaode's developer API. To approximate urban vibrancy, we obtained nighttime light intensity data for the year 2023 from the NPP-VIIRS dataset maintained by NOAA and NASA by Z. Chen et al. (2020). Land use patterns were classified according to the European Urban Land Use Classification (EULUC) schema (Gong et al., 2020), providing a standardized taxonomy for comparative spatial analysis. All geospatial computations, including density metrics (e.g., facilities per square kilometer) and proximity measures (e.g., minimum walking distances to the nearest subway station), were executed in GISpro, with Kepler.gl employed for dynamic visualization of spatial layers and isochronal boundaries.

Social media data was sourced from Xiaohongshu posts associated with each of the 25 case markets. We collected metadata fields including "likes," "shares," "comments," and "collections," along with textual content and timestamps. To control for temporal sampling biases—given that older posts naturally accrue more interactions—we normalized engagement metrics by dividing the aggregate sum of interactions by the total number of posts per market. This yielded a standardized "popularity" score for comparative analysis. Sentiment analysis was performed using SnowNLP, a Python library tailored for Chinese language processing. Each comment's polarity was classified as positive or negative, and an overall "satisfaction" score was defined as the proportion of positively classified comments.

Finally, POI category proportions within each isochrone were converted into weighted semantic vectors to represent neighbourhood functional profiles. These "neighbourhood function" vectors served as the basis for our thematic alignment analysis, linking built environment attributes with pop-up market themes. Altogether, our multi-source dataset integrates spatial, social, and semantic dimensions of urban pop-up markets, forming a robust empirical backbone for subsequent methodological steps.

3.Methodology

This study employs a mixed-methods framework that synergistically combines spatial analytics, social media engagement metrics, and natural language processing to evaluate the thematic alignment between pop-up market offerings and their surrounding neighbourhood functions. Our analytic pipeline unfolds in four principal stages: spatial data assembly and pre-processing, built environment characterization, semantic embedding and similarity analysis, and statistical modeling of environment–experience relationships.

3.1 Spatial Data Assembly and Pre-processing

We began by geocoding the 618 pop-up market entries from "Shijihui" and filtering to the six core urban districts of Beijing. Markets without precise coordinates or outside the study period (Dec 2023–Nov 2024) were excluded, resulting in 447 valid cases. For each market, we generated a 15-minute pedestrian isochrone using the Mapbox API, capturing the realistic reach of on-foot visitors. POI data from Gaode was then spatially joined to these isochrones in GISpro, enabling the calculation of density (e.g., number of catering venues per square kilometer) and convenience (minimum walking distance to key services) indicators. Nighttime light intensity rasters were clipped to each isochrone and averaged to yield a proxy for local urban vibrancy. Land use classifications were overlaid using the EULUC dataset, allowing computation of land use mix indices via the Shannon entropy formula. All spatial operations adhered to a consistent coordinate reference system (WGS 84) and were validated for topology errors.

3.2 Thematic Data Extraction and Embedding

To extract market themes, we scraped the text of Xiaohongshu posts for each of the 25 case markets. Pre-processing included removal of punctuation, emojis, temporal and location markers, and high-frequency non-thematic tokens. Chinese word segmentation was conducted using Jieba, resulting in a clean corpus of thematic keywords. For each market, we identified the top 20 most frequent thematic keywords. We then trained a Word2Vec embedding model with a window size of 5 and vector dimensionality of 200 on the aggregated corpus of all market comments. Each keyword's vector was extracted and the mean across the 20 keywords yielded the "market theme" vector.

3.3 Neighbourhood Function Vector Construction

The neighbourhood characteristics around 25 case markets were analysed as follows. We translated POI category proportions within each market's 15-minute pedestrian isochrone into a semantic representation by first assigning each category a label (e.g., "Dining," "Shopping," "Science, Education & Culture," "Life Services"). Using the pretrained Word2Vec model (Figure 3), we converted each label into its vector embedding and weighted these embeddings by the category's share of total POIs. Summing these weighted vectors produced the "neighbourhood function" vector, which encapsulates the functional character of the neighbourhood surrounding each pop-up market.

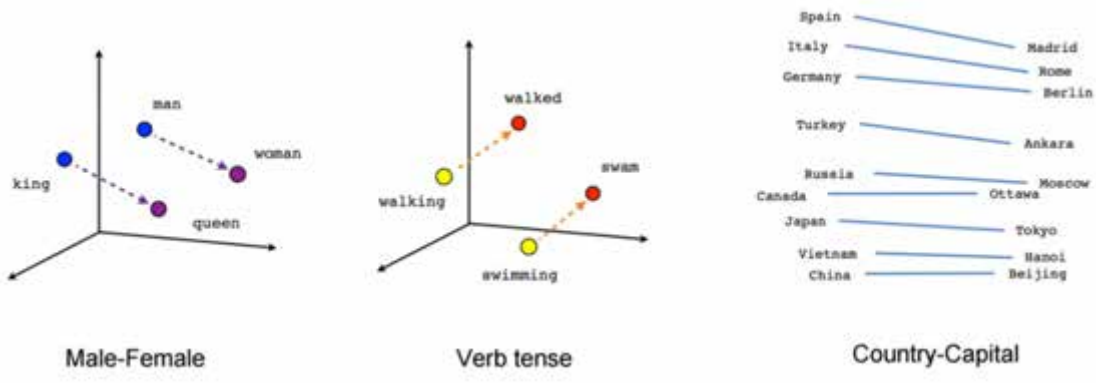

Figure 3. Schematic diagram of Word2Vec method (Ruizendaal, 2017)

3.4 Semantic Similarity and Statistical Modelling

The cosine similarity between each market's theme vector and its neighbourhood function vector served as our quantitative index of thematic alignment, with values ranging from –1 (complete mismatch) to 1 (perfect alignment). To investigate drivers of alignment and market success, we compiled a dataset combining thematic alignment indices, popularity scores (normalized social media engagement), and satisfaction scores (sentiment positivity ratios). All the case markets were divided into two groups based on the median of the alignment score: high consistency and low consistency. A t-test was then conducted on popularity and satisfaction, with $p<0.05$ indicating significant differences. Furthermore, we computed Pearson correlation coefficients to identify bivariate relationships between theme-neighbourhood alignment and the response from the public. The statistical analyses were conducted in Python (pandas, statsmodels), with significance evaluated at the 0.05 level.

By integrating geospatial methodologies, natural language processing, and statistical modeling, a holistic lens was provided for understanding how ephemeral urban events interact with their physical contexts and social perceptions. The dual focus on quantitative indices (e.g., cosine similarity, engagement metrics) and spatial visualizations ensures that our findings carry both empirical precision and practical relevance for urban planners, event organizers, and scholars interested in temporary urbanism.

4. Results

4.1 Macro-Level Spatio-temporal Patterns

All the data of markets advertised at "Shijihui" from December 2023 to November 2024 were collected and analysed, so as to present the duration of each market and the monthly distribution of all the markets throughout the year. The numerical results on the time dimensions are shown in Figure 4.

Figure 4(a). The duration of each market

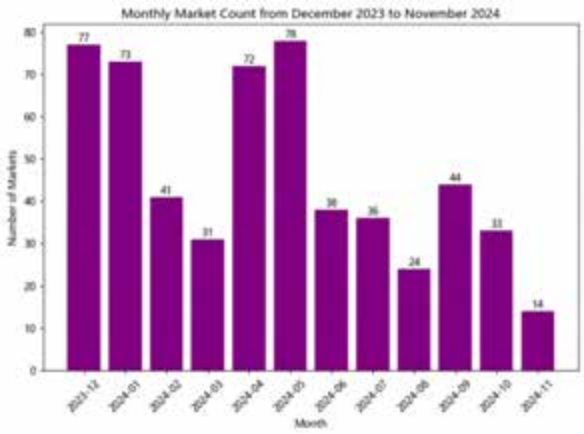

Figure 4(b). The monthly distribution of all the markets throughout the year

As is shown in the figure, markets peaked twice a year, from December to January and from April to May, with low peaks in February and August, which may be affected by the Chinese New Year in February and the summer heat in August. From further analysis of the market holding place, shopping malls are shown to be the main locations for pop-up markets, while office buildings, parks and art & creative parks are also popular venues. For the 447 market in the six main districts of Beijing, a kernel density was done. Results shown that 8 areas, including Qianmen, Longfu Temple and landmark river were concentrated places for temporary markets, as shown in Figure 5.

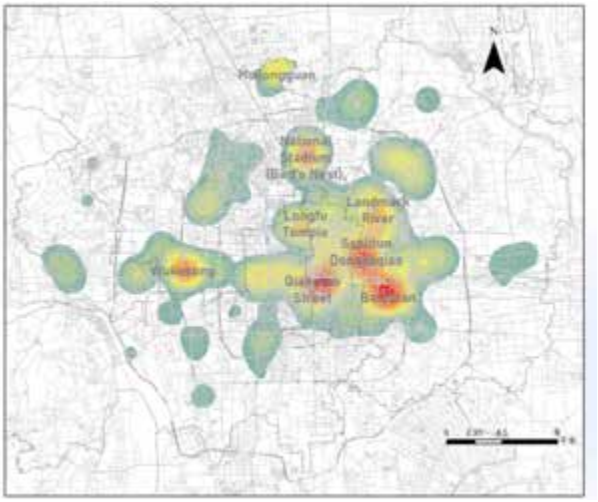

Figure 5. Kernel Density Map of Pop-up markets in Beijing 6 main districts 2023.12-2024.11

Subsequently, a preliminary investigation of the built environment surrounding all market sites was undertaken. Fifteen-minute walking isochrones for the market points were generated through the Mapbox Isochrone API, and the built environment within each isochrone was characterised along four dimensions: transportation, urban function, urban vitality and natural features. The resulting metrics were visualised with Kepler.gl. In the transportation dimension, the closest proximity to subway stations is observed for markets in Dongcheng District, Xicheng District, the western portion of Chaoyang District and the area around Olympic Forest Park, whereas parking facilities are comparatively scarce around market points situated on the northern and southern margins of Xicheng and Dongcheng Districts.

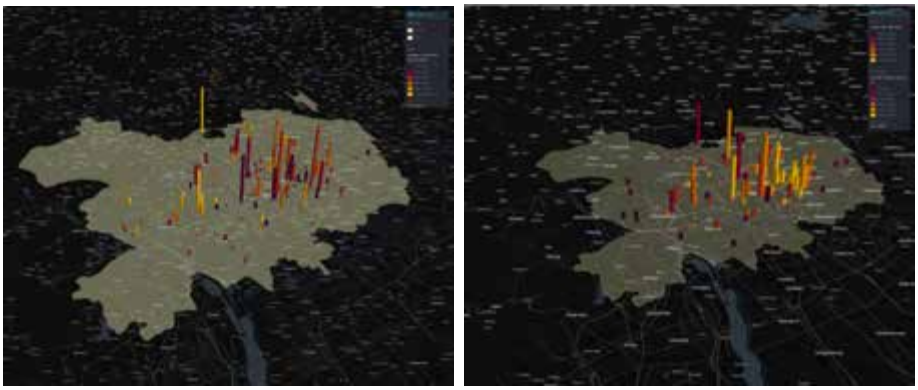

Figure 6. Walking distance to the nearest subway station (left)
Figure 7. Density of parking lots within the isochrone (right)

The markets in Chaoyang District have the most abundant surrounding life service facilities, followed by the markets near Xidan. Nightlife vitality was measured based on nighttime lighting.

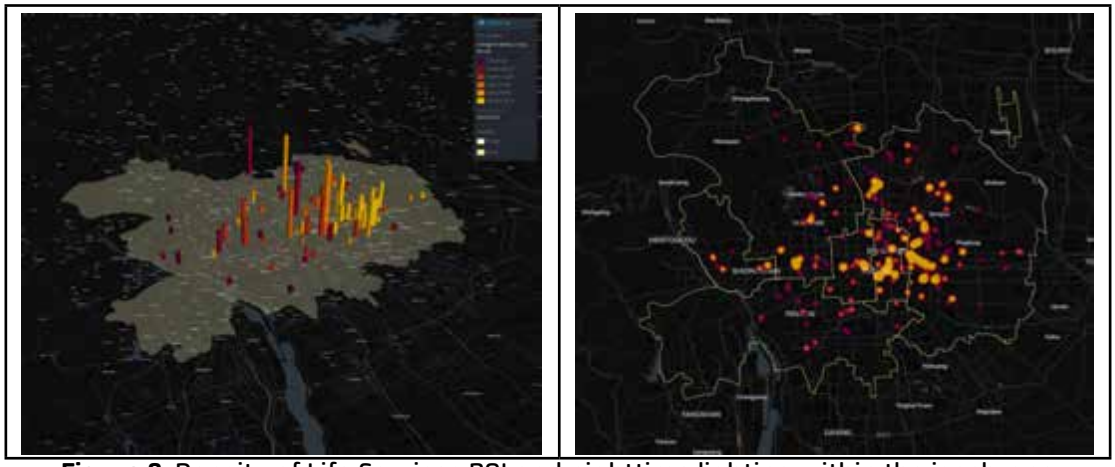

Figure 8. Density of Life Services POI and nighttime lighting within the isochrone

54% of the markets are within 1000 meters of the nearest shopping center, and there are more parks and attractions around the markets in Dongcheng, Xicheng, and Haidian Districts.

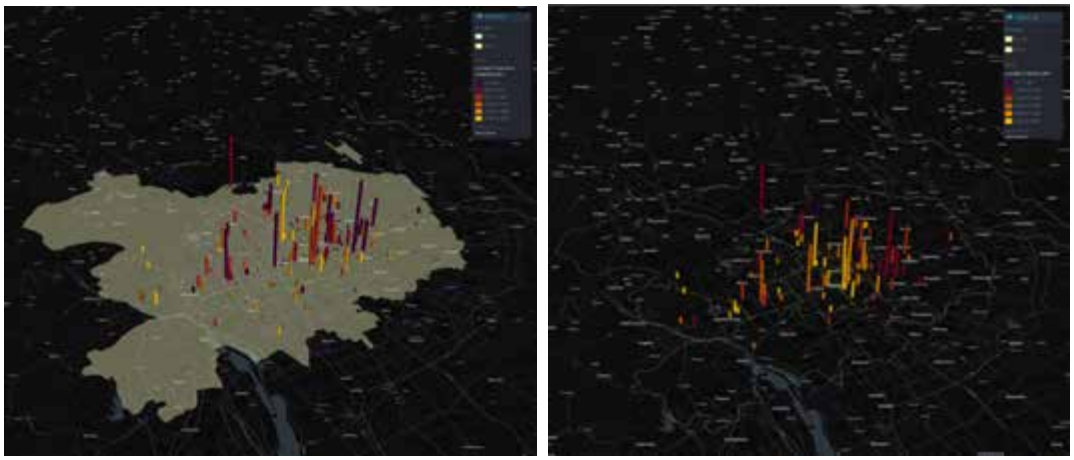

Figure 9. Walking distance to the nearest shopping center (left)
Figure 10. Density of parks within the isochrone (right)

Built-environment attributes were subjected to K-means++ clustering, and a two-cluster solution was identified as optimal. The first cluster is distinguished by higher levels of urban vitality, reflected in a greater density and diversity of facilities, whereas the second cluster is characterised by stronger integration with natural amenities, including a higher concentration of parks and scenic attractions in the immediate vicinity (Figure 11).

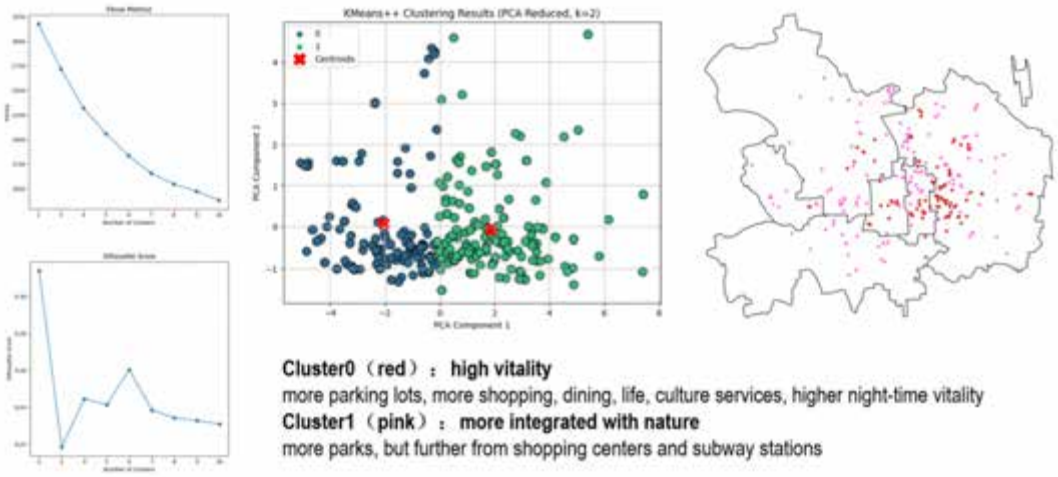

Figure 11. K-means++ Two-Cluster Solution of Market Sites by Built-Environment Attributes

4.2 Micro-Level Market–Neighbourhood Interaction Analysis

4.2.1 Theme-Neighbourhood Alignment Analysis

Table 1 summarises the thematic profile of four representative markets. For each market, the eight most frequent keywords extracted from Xiaohongshu comments are reported together with their raw counts (e.g., "Christmas 113," "Second-hand 220," "Panjiayuan 1133," "Book 638"). These terms constitute the weighted vocabulary that was embedded with Word2Vec to generate a theme vector for every market. The keyword distributions already hint at distinctive positioning: Waste Circulation Plan is dominated by "Second-hand," "Eco-friendly," "Recycling," and "Sustainability," signalling a life-style–oriented, environmental-protection theme, whereas Panjiayuan Night Market features "Night market," "Cultural objects," and "Antiques," underscoring its emphasis on culture and heritage trading. Likewise, Convex and Concave Space shows a design- and art-led orientation, while BIBF International Book Fair centres on book-related culture.

Table 1. Most frequent theme keywords of 4 example markets

Convex and Concave Space		Waste Circulation Plan		Panjiayuan Night Market		BIBF International Book Fair	
Christmas	113	Second-hand	220	Panjiayuan	1133	Book fair	638
Art	70	Eco-friendly	183	Night market	601	Books	408
Check-in	36	Recycling	145	Ghost market	334	Picture books	263
Original	28	Idle items	141	Market	278	Art	246
Jewelry	24	Life	128	Bracelet	241	Book	235
Design	24	Handmade	117	Used goods	168	Publisher	195
Shop exploration	23	Waste	108	Cultural objects	137	Reading	150
Exhibition	23	Sustainability	99	Antiques	118	Design	149

Table 2 presents the functional composition of the neighbourhoods surrounding surveyed markets, with 10 cases as examples. For each site (ID 1–25), the relative proportions of Points of Interest that fall into the four predefined categories—Life Services, Shopping, Science-Education-Culture, and Dining—are listed. The values (e.g., 0.2972 for Life Services at "Convex and Concave Space") are normalised shares that sum to one per row, and were employed as weights in the vector aggregation step when constructing neighbourhood-function theme vectors.

Table 2. Functional composition of the neighbourhoods surrounding surveyed markets

ID	Pop-up Markets	Functional composition of the surrounding neighbourhoods			
		Life Services	Shopping	Science, Education, and Culture	Dining
1	Convex and Concave Space	0.2972	0.2283	0.1764	0.2981
2	Waste Circulation Plan	0.2201	0.2975	0.0869	0.3955
3	Panjiayuan Night Market	0.2968	0.3945	0.0971	0.2116
4	NEEDFLEA	0.2758	0.3271	0.1145	0.2826
5	Dinosaur Vintage Warehouse	0.213	0.3015	0.2525	0.2326
6	Haoqi Retro Market	0.2253	0.2637	0.2857	0.2253
7	Big Doll Freak Market	0.2819	0.3343	0.1094	0.2744
8	BIBF International Book Fair	0.25	0.39	0.1197	0.2362
9	Dongpeng Ghost Market	0.2857	0.0905	0.1714	0.4524
10	Daliushu Night Market	0.2184	0.4885	0.0785	0.2146

Together, the two tables provide the weighted textual inputs required for calculating the cosine similarity between each market's theme vector and the corresponding neighbourhood-function vector, thereby quantifying theme–function alignment. Based on the cosine similarity of word vectors, the theme alignment of 25 markets is shown in Figure 12 below, with different colors representing different market categories (Art & Culture, Fashion, Food & Dining ,Used Possession, and Comprehensive).

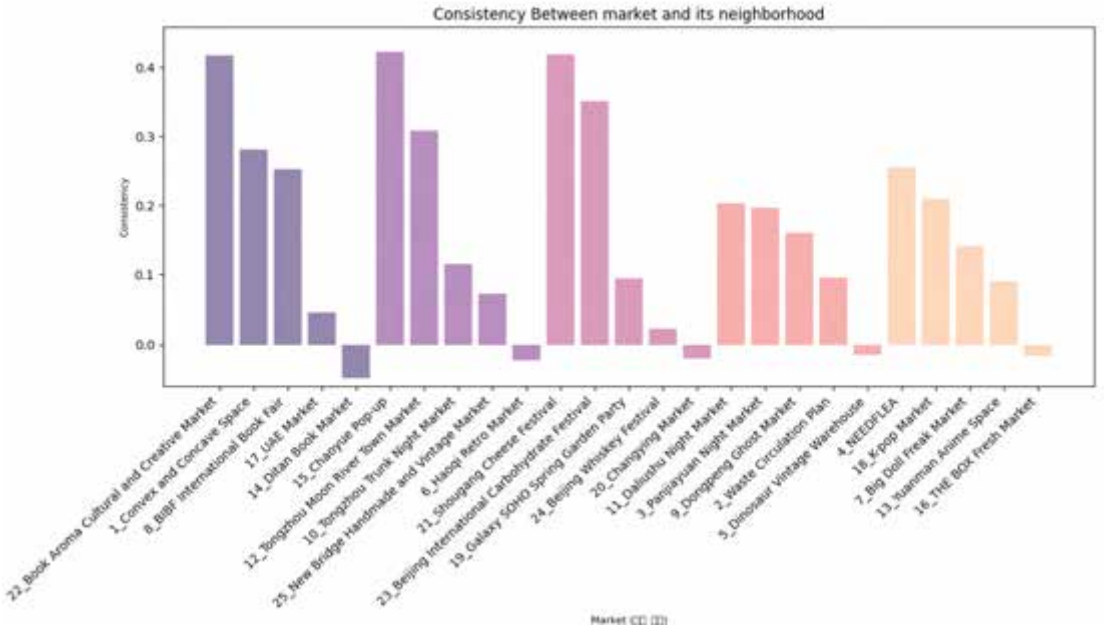

Figure 12. Alignment analysis between market and its neighbourhood

Approximately 80% of the market themes are consistent with the function themes of the surrounding neighbourhoods, while only a small portion of markets have themes that contrast with the typical functions of their neighbourhoods.

4.2.2 Market Popularity and Satisfaction Analysis

The numbers of likes, comments, and shares of 25 marketplaces are collected from Xiaohongshu. The sum of the three types of data is shown in Figure 13 (left), while each of them is shown in Figure 13 (right). We then computed a popularity score for each market:

Popularity scores = Average Likes+Average Collections+
Average Sharings+Average Comments

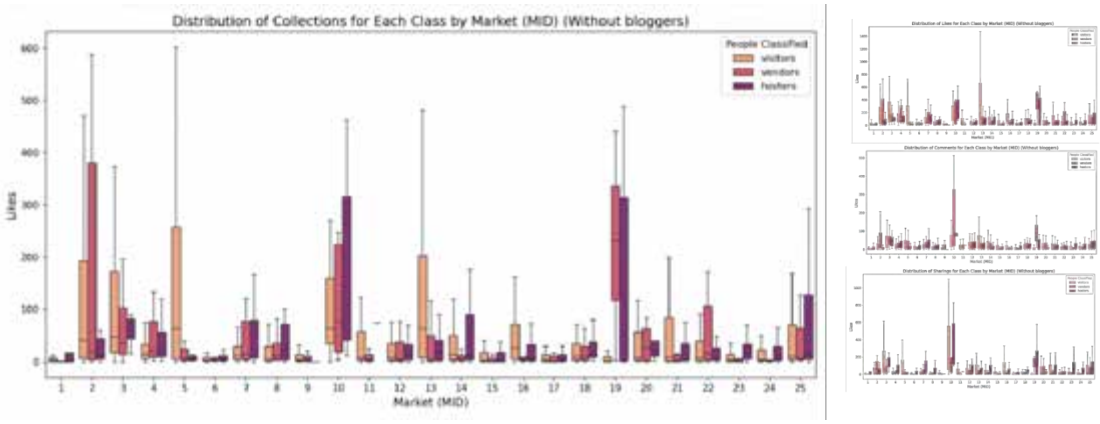

Figure 13. Numbers collected from Xiaohongshu (left) Sum data; (right) likes, comments, shares

Sentiment classification on the comments collected from Xiaohongshu was conducted, and the percentage of positive comments is shown in Figure 14 (left). Furthermore, the results of the word cloud analysis of these positive comments are presented in Figure 14 (right).

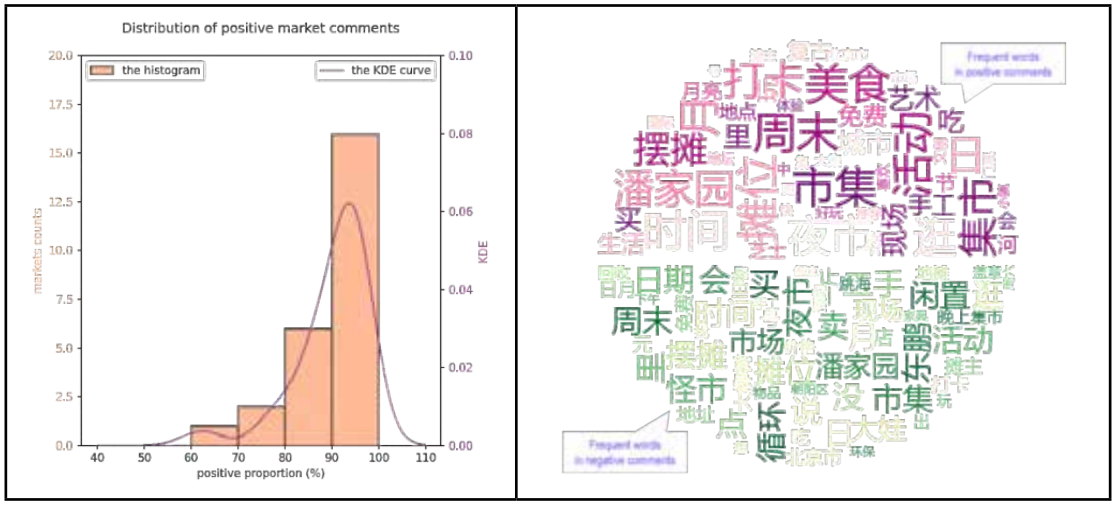

Figure 14 Positive comments analysis (left) Distribution; (right) Word cloud

Most markets have received over 80% positive feedback on social media platforms. Suggested by word-cloud, markets related to second-hand goods and non-mainstream cultures tend to face more negative feedback. This may be due to their purchase of items of poor quality, or difficulty in recognizing the sale of items from some niche cultures. The positive words in the word cloud such as "art," "food," and "events" also partially reflect the reasons why the public loves these markets.

After taking popularity and satisfaction as two criteria for evaluating market success, it can be observed that a large number of markets are in a "high satisfaction, low popularity" state, while no markets exhibit a "high popularity, low satisfaction" condition, as shown in Figure 15. In addition, the geographical distribution of these two factors is shown in Figure 16, with the size of the points representing the popularity of the markets and the color intensity indicating the satisfaction level.

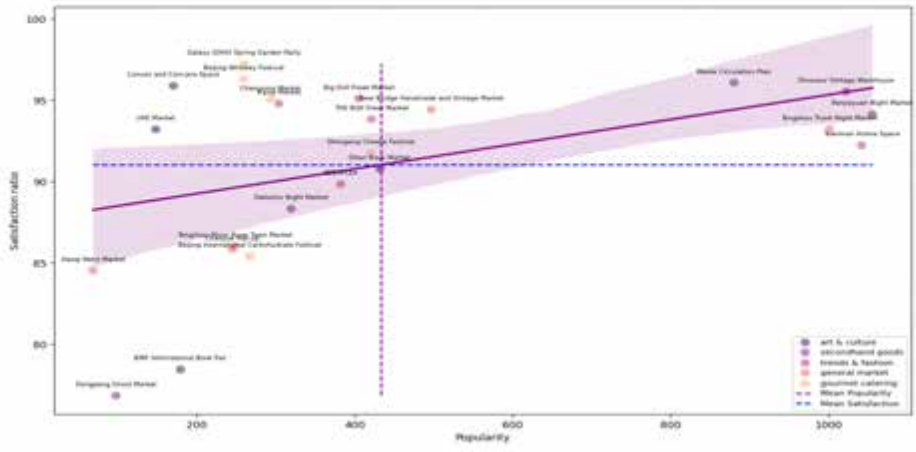

Figure 15. Popularity vs. Satisfaction: Quadrant Map of Pop-up Market Success

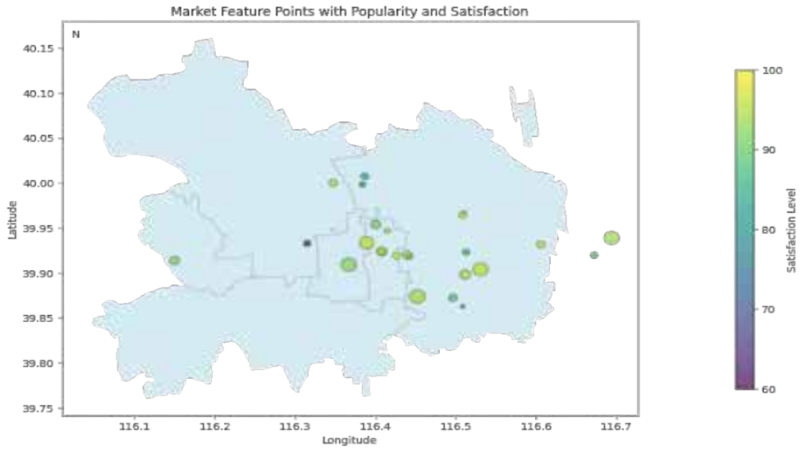

Figure 16. Geographic distribution of two factors

Generally, markets in the city center tend to be more popular, but there are also markets in Tongzhou with similarly significant influence. Furthermore, the distribution of satisfaction levels does not follow a clear geographical pattern.

4.2.3 Correlation Analysis of Alignment, Popularity and Satisfaction

By combining the theme alignment scores of the 25 markets with the two success indicators—popularity and satisfaction—the correlations among these variables can be further analysed. Markets were divided into two groups based on the median of the alignment data: high alignment and low alignment. A t-test was then conducted on popularity and satisfaction, with $p<0.05$ indicating significant differences. The results are shown in Figure 17 below.

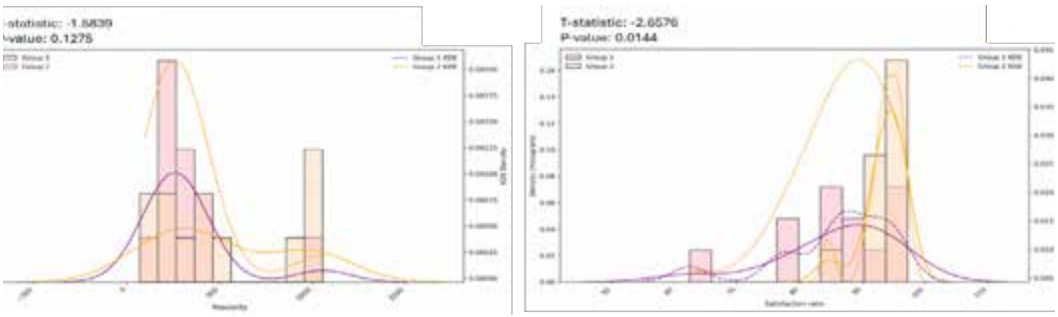

Figure 17. T-test for (left) Popularity; (right) Satisfaction

According to the t-test results, no significant difference was found in popularity between the two groups, while satisfaction showed a significant difference, suggesting that satisfaction is affected by theme alignment score.

Further regression analysis on theme alignment score and market popularity, and that on theme alignment score and market satisfaction are shown in Figure 18, 19, respectively.

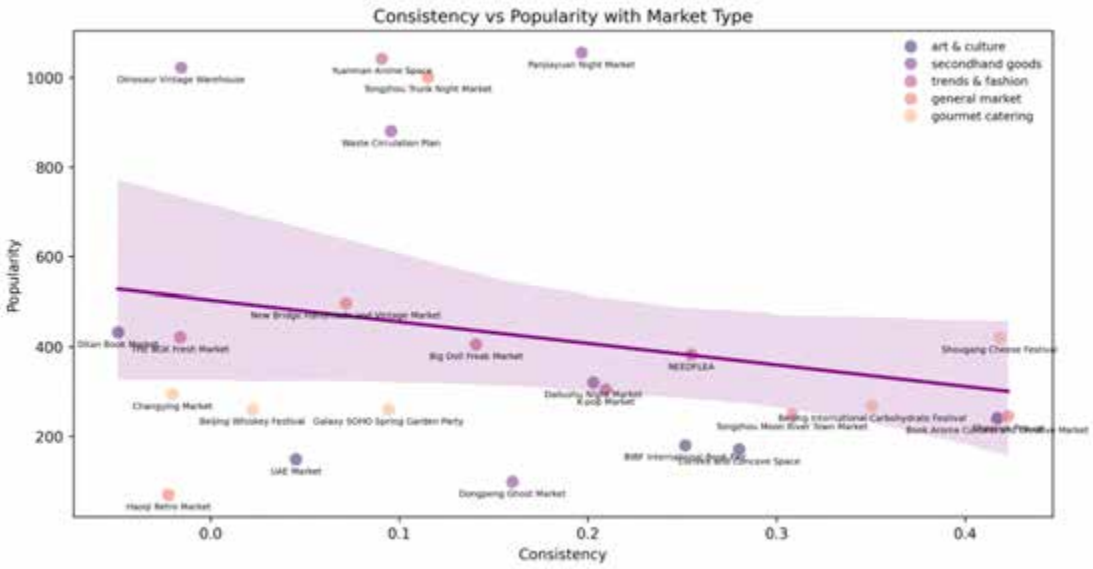

Figure 18. Regression analysis of market popularity and theme alignment

Although the popularity of the markets did not show a good regression relationship with theme alignment, a negative trend between popularity and theme alignment was still evident.

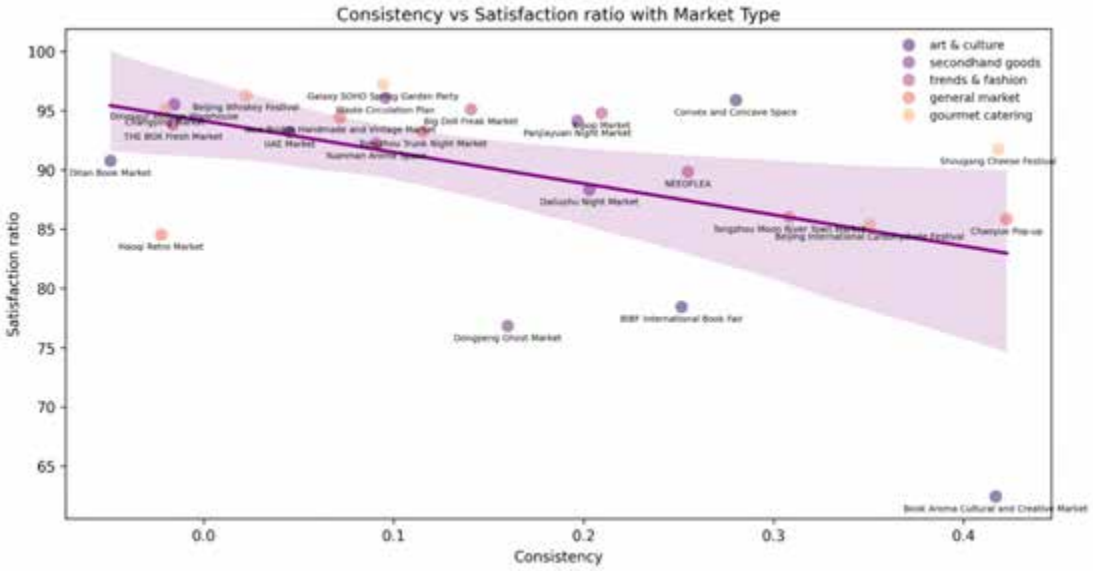

Figure 19. Regression analysis of market satisfaction and theme alignment

A linear regression was observed between satisfaction and theme alignment, indicating a linear negative correlation. This suggests that, while the market theme aligns with the neighbourhood theme in most cases, higher alignment leads to lower market satisfaction.

5. Discussion

This study employs Word2Vec to quantify the thematic alignment between urban pop-up markets and their surrounding neighbourhood functions, revealing that while many markets align closely with local amenities, those with greater thematic divergence often achieve higher visitor satisfaction. This observation invites a deeper exploration into the underlying mechanisms.

5.1 Drivers of Theme-Neighbourhood Alignment

The result of closeness between markets' themes and their neighbourhoods' function is consistent with the current market operation procedures and goals. Recent policy directives including China's "15-Minute Community Life Circle" initiative (Ministry of Housing & Urban-Rural Development, 2021) and a suite of night-time economy revitalisation programmes explicitly encourage the fast-track introduction of pop-up markets into functionally mature commercial nodes. By embedding new activities in areas with pre-existing consumer flows and complementary amenities, local governments can minimise regulatory uncertainty, while operators mitigate sunk-cost risks associated with experimental formats (Warnaby & Shi, 2018).

From the supply side, venue owners and municipal agencies exhibit risk-averse behaviour: projects whose themes match surrounding land uses are more likely to secure temporary permits within the approval cycles mandated by the post-COVID economic stimulus packages (Andres, 2021). Demand-side considerations may reinforce this tendency: compared with experimental themes with relatively high risks, market activities with the same theme as existing urban spaces can reduce the cognitive friction between brands and consumers and increase the consumption conversion rate.

Collectively, these observations suggest that institutional incentives, risk management considerations, and agglomeration economies converge to favour theme–environment alignment in contemporary Chinese pop-up practices.

5.2 Mechanisms Linking Theme Misalignment to Higher Satisfaction

Results from our Word2Vec analysis indicate that lower theme-environment alignment is positively associated with visitor satisfaction. Though this is a counter-intuitive pattern, two complementary theoretical lenses may help to explain it.

First, the "experience-economy" mechanism. Consumer-behaviour research shows that schema incongruity triggers exploratory behaviour, elevates arousal, and deepens memorability (Hirschman & Holbrook, 1982; Raju, 1980). When a pop-up market imports an unexpected theme, it breaks the cycle of habituation that dulls affective responses in routine retail settings. The effect might be amplified when organisers employ immersive staging (multisensory displays, storytelling signage) and interactive programming (hands-on workshops, live performances), thereby moving customers up Pine and Gilmore's (1999) progression of economic value from "service" to "experience". Second, the "functional-complementarity" mechanism. Many inner-city neighbourhoods exhibit mono-cultural retail ecologies. A thematically divergent market can plug latent deficits in cultural, educational, or sustainability-oriented offerings, thereby widening the local service portfolio (Bertolini, 2020) and aligning with Jacobs's (1961) argument that urban vitality thrives on mixed primary uses. This complementary injection not only satisfies unserved needs but also demonstrates, in tactical-urbanism terms, a "minimum viable product" for longer-term place upgrading (Lydon & Garcia, 2015). The resulting diversification helps improve the resilience of the overall commercial ecosystem.

Taken together, these two mechanisms help explain why theme–environment divergence, rather than harmony, can yield superior experiential outcomes in the context of urban pop-up markets.

5.3 Reframing Pop-up Markets: From Marketing Tool to Community Prototype

In the extant literature, temporary urbanism remains a contested field. On the one hand, scholars argue that short-term interventions are frequently co-opted by capital, functioning as low-cost instruments for "filling urban gaps" during periods of economic downturn and for staging future real-estate appreciation, while simultaneously diluting procedural public participation (Colomb, 2012; Douglas, 2018; Madanipour, 2018). In the North-American context in particular, the term pop-up has become almost synonymous with the commercial occupation of vacant premises to attract investors, and is therefore viewed as a potential threat to urban publicness (Baras, 2015).

Conversely, a growing body of research contends that, when framed within the logic of *incremental experimental*

governance (Bertolini, 2020), pop-up markets can act as low-risk "prototypes" for testing novel urban functions and public values. The empirical findings of the present study reinforce this view: markets whose themes diverge markedly from surrounding land-use patterns receive significantly higher visitor-satisfaction scores than markets exhibiting high thematic congruence ($p < 0.05$). This suggests that defamiliarisation and novelty can heighten motivational engagement and place attachment, offering valuable insights for the long-term enrichment of neighbourhood functions.

As discussed in § 5.1, however, pop-up markets in China face potential constraints arising from approval procedures and from the uncertain returns perceived by operators, which explains why truly complementary, "non-matching" markets themes remain scarce. We therefore advocate, drawing on the tactical-urbanism literature, that pop-up markets be reconceptualised as *minimum viable public spaces* (Lydon & Garcia, 2015; Bertolini, 2020). Experimental projects that demonstrably address community needs should receive targeted policy and financial incentives; risk should be distributed among multiple stakeholders; and real-time data monitoring combined with community co-evaluation should determine whether, and how, short-term trials are converted into permanent interventions. *The National 15-Minute Community Pilot Cases* recently issued by Ministry of Commerce of the People's Republic of China already incorporate market events in Nanjing and Wuxi as instruments for optimising neighbourhood-service layouts and enriching everyday experience, with an explicit aim to couple "quality consumption" with "service expansion." This evidences the practical feasibility of the proposed pathway. Under a regime of policy support, dedicated funding and shared risk, pop-up markets can avoid the pitfalls of neoliberal "privatised marketing tools" and instead provide quantifiable, iterative decision inputs for neighbourhood regeneration.

6. Conclusion

This study employs urban-informatics methods to capture the market events in Beijing from 2023 to 2024 over a year, summarizing their timing, aggregation, location types, and surrounding built environmental conditions. The spatial and temporal analyses highlight that flash markets are predominantly short-term events peaking in December-January and April-May, with shopping malls as their primary location. Neighbourhood characteristics shows two clusters by using K-means, with markets in Chaoyang District being notably vibrant with abundant life service facilities, and markets in other districts like Dongcheng, Xicheng, and Haidian sited in a more nature-integrated environment.

Our study further examines the relationship between markets as temporary activities and their host neighbourhoods. By applying the method of sentiment analysis and Word2Vec for content in social media platform, we explore the impact of theme alignment between market themes and the daily functional themes of the surrounding neighbourhood on the success of market events, especially for visitors' satisfaction. The results show that: 1) Themes of the markets are typically aligned with the function themes of their neighbourhoods, reflecting the general understanding of market organizers when selecting locations. 2) However, market satisfaction and popularity are negatively correlated with theme alignment. Markets with themes that differ significantly from the surrounding neighbourhood functions, which account for only 20% of the cases, received higher satisfaction ratings. 3) NLP tools, including word2vec, are effective in bridging physical and virtual spaces, especially for temporary events, considering their nature of interest-oriented and reliance on media advertisements. These conclusions may provide guidance for future research on market site selection and theme choice.

At a practical level, we have elucidated how disparities between market themes and neighbourhood functional areas can bolster market satisfaction. This insight suggests that markets might serve as a potent supplement to temporary business models within neighbourhoods. Our results demonstrate that pop-up markets—recast as minimum viable public spaces—can function as low-risk prototypes that heighten visitor engagement, test missing neighbourhood functions and generate data for long-term improvements, aligning with the existing theoretical framework of tactical urbanism. Implemented under supportive policies, shared-risk financing and real-time evaluation, such experiments can escape the pitfalls of neoliberal "privatised marketing tools" and become a scalable tool for evidence-based neighbourhood regeneration.

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Integrating Energy Performance and Public Space Metrics: A Study from the Perspective of Urban Design

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Abstract
Global warming necessitates energy-efficient urban design. Urban morphology critically impacts both building energy use and public space quality. While prior studies focus on typological parameters (e.g., FAR, density), block-scale energy performance also depends on contextual features like street proportions and public space ratios. This research examines how morphological variations affect energy efficiency and spatial quality by analyzing blocks with identical FAR but differing configurations. Key metrics—alignment ratio, effective street length, and street space density—are evaluated through energy simulations. Results identify specific typologies that simultaneously optimize energy performance and pedestrian experience, demonstrating the potential for integrated low-carbon, human-centric urban design. These findings provide actionable insights for early-stage planning to achieve sustainable built environments.

Keywords:public space; urban form; building energy consumption; performance driven design

Introduction

Global urban populations are projected to reach 68% by 2050, with 2.2 billion additional urban residents concentrated in Asia and Africa (United Nations Habitat, 2022). This urban expansion necessitates increased building construction, resulting in elevated energy consumption and emissions. The built environment currently represents 30% of global final energy use and 26% of energy-related emissions, according to International Energy Agency (IEA, 2022). Despite improvements in energy efficiency per square metre, total building emissions have increased by over 25% since 2000, attributable to a 65% expansion in floor area and growing electricity demand. Building electricity consumption has increased at five times the rate of power sector decarbonisation since 2000 (IEA, 2019). The Paris Agreement (2015)targets – requiring 45% emission reductions by 2030 and net-zero by 2050 – highlight the urgency of urban energy research.

Building energy analysis typically distinguishes operational energy (heating, cooling, lighting) from embodied impacts. According to data from IEA, space cooling demonstrates particular significance, with 2 billion operational air conditioning units globally, 70% of which are residential. Heating accounts for approximately 50% of building energy use worldwide. Effective strategies to reduce operational energy consumption go beyond improving the energy efficiency of heating and cooling systems. They also rely on passive, nature-based, and alternative solutions, including the enhancement of building and district design.

Building energy consumption in urban environments is influenced by multiple factors. Previous research has primarily focused on building-specific elements and parameters, such as the shape coefficient of buildings, envelope materials, and building orientation. However, buildings do not exist in isolation—they are situated within distinct neighborhood contexts, meaning their energy performance is also affected by surrounding environmental conditions. In other words, urban morphological elements equally exert significant influence on building energy consumption patterns. Delmastro et al. (2015) demonstrated that variations in urban form could account for an 11% difference in heating energy use, which increases to 16% when considering solar gain. Similarly, Silva et al. (2017), through a case study of Porto, Portugal, established that urban form could explain up to 78% of the variance in total energy consumption, including heating, cooling, and mobility. The research by Shareef and Altan (2022) demonstrated that a sinuous configuration in urban blocks could reduce building cooling loads by 4.9%.

On the other hand, urban morphological elements constitute essential components of urban design. The control of urban morphology directly and indirectly influences the creation and quality of public spaces, thereby affecting pedestrian experience. Therefore, focusing on urban morphological elements—particularly urban design indicators—can impact urban spatial quality in multiple dimensions and warrants further in-depth research.

Previous studies have explored how urban morphological elements affect building energy consumption across different climate zones, aiming to design low-carbon or even zero-energy urban blocks. However, while pursuing lower energy consumption, the external environments created by certain urban forms are often overlooked.

Crucially, under the same floor area ratio (FAR), different urban forms can produce vastly different qualities of external public spaces. These variations in public space quality profoundly influence urban users, particularly pedestrians, and have implications for spatial equity. Commonly studied urban morphological indicators—such as density, FAR, and building height—fail to fully capture the spatial characteristics of public spaces shaped by urban design.

Urban morphological elements thus exhibit a dual influence, simultaneously shaping both building energy efficiency and the quality of public spaces and pedestrian experiences. While existing research tends to examine these aspects in isolation, practical urban design necessitates an integrated approach that accounts for multiple factors. Unlike studies focusing solely on singular dimensions, this research seeks to bridge energy performance and public space contribution, with particular emphasis on the latter from an urban design—rather than purely technical—perspective.

This study adopts an urban design perspective to identify morphological indicators influencing public space quality, based on a review of urban design guidelines and practices. Three key metrics are proposed: alignment ratio, effective street length, and street space density, to better understand the relationships between building energy performance, public spaces, and urban morphological elements.

Given that total building capacity is typically predetermined in real-world urban design practice, this research conducts a comparative experiment using urban block designs with identical floor area ratios (FAR) but varying public space configurations. By analyzing energy simulation results across different design groups and their corresponding urban design elements, the study explores whether urban design approaches can balance energy efficiency with public space quality, and identifies priority morphological elements.

These findings provide valuable insights for early-stage urban design, encouraging future research to move beyond solely energy-efficient block morphology and equally consider pedestrian experience and public space quality.

Literature Review

Unlike at the building scale, the mechanisms through which block-scale urban form elements influence building energy consumption are markedly more complex. This complexity arises because block morphology not only directly affects a building's passive solar gain and heat dissipation but also indirectly alters energy performance via microclimatic modifications. Consequently, microclimatic impacts must be integral to urban form considerations.

The characterisation and selection of energy-relevant urban form elements vary across studies. Existing research predominantly focuses on four classifications: density measures, geometric measures, land use/cover measures, and typologies (Quan *et al.*, 2021). These categories emerge from systematic syntheses of prior morphological research. While the first three measure types lend themselves to quantitative data analysis, typological approaches better capture urban form complexity. Many studies therefore combine these methods or enhance typologies with context-specific indicators, enabling both relational quantification and practical application for designers.

However, synthesising energy consumption findings for individual factors reveals that most studies preclude direct cross-comparisons of singular morphological variables. Notwithstanding this limitation, our literature review identifies recurrent indicators. Table 1 collates commonly employed metrics for urban form's energy impacts.

Morphological factors in extant research can alternatively be categorised by their descriptive focus:

- Built-environment relations: Floor Area Ratio (FAR), Building Density (BD), Building Coverage Ratio (BCR)

- Non-physical spatial attributes: Open Space Ratio (OSR), obstruction angles, Sky View Factor (SVF)

Whilst both categories influence energy consumption, the second category demonstrably exerts more direct effects on public space quality and pedestrian experience.

Table 1. Morphological indicator choices of some previous research.

Year	Researchers	Location	Indicators
2016	Quan *et al.* (2016)	Shanghai, China	Building density (BD), building height (BH), floor area ratio (FAR)
2018	Javanroodi *et al.* (2018)	Tehran, Iran	Building density (BD), height to width ratio (H/W)
2019	Lima *et al.* (2019)	Maceio, Brazil	Building shape factor (BSF), building height (BH), building density (BD), building orientation (BO)
2021	Mangan *et al.* (2021)	Istanbul, Turkey	Building typology (BT), height to width ratio (H/W), number of floors (NS), building orientation (BO)
2021	Ahmadian *et al.* (2021)	London, UK	Plan depth (PD), number of floors (NS), building density (BD)
2021	Zhang and Gao (2021)	Nanjing, China	Floor area ratio (FAR), surface area ratio (SAR), sky view factor (SVF)
2023	Liu *et al.*(2023)	Jianhu, China	Building density (BD), open space ratio (OSR), shape coefficient (SC), average perimeter-area (PAR)

It is noteworthy that whilst numerous studies examine the impact of urban form at the block scale upon energy consumption, the indicators employed to describe urban form tend to prioritise characteristics of building form, frequently lacking relevant indicators from an urban design perspective. Taking density and floor area ratio (FAR) as examples, utilising merely these two indicator types to describe urban form can yield substantially divergent outcomes owing to variations in building form and layout. These differences manifest not only in the buildings themselves but also influence public space configurations shaped by building forms. Exclusive reliance upon indicators such as open space ratio may inadequately represent actual urban form whilst neglecting pedestrian experience from an urban design standpoint.

Existing urban form descriptors commonly overlook the significance of public space morphology, which holds crucial importance within urban design. Within this context, establishing how public space form influences building energy consumption becomes particularly vital. This proves especially pertinent when the design objective involves creating urban forms that must reconcile energy efficiency with the provision of human-centred, functional public spaces.

Urban design represents a principal methodology for creating and optimising urban public spaces. The urban design process incorporates elements frequently marginalised or entirely disregarded in comprehensive planning and architectural design, including building façade continuity, public space provision, street formation and articulation, alongside street density, amongst others. Consequently, research adopting an urban design perspective can meaningfully address the current knowledge gap regarding how such elements influence energy consumption.

The selection of public space morphological factors may be informed by established street design and urban design guidance. For exemplary high-quality urban spaces, urban design manuals typically furnish explicit directives and design recommendations, regularly incorporating specifications for street space morphology. For instance, the Central Melbourne Design Guide underscores that enhancing both the quantity and quality of public spaces constitutes a central urban design objective. It particularly emphasises that urban development and renewal should privilege walking as the primary transport mode.

At the urban morphology level, this is principally realised through developing laneways and pedestrian connections. The guidelines prescribe that pedestrian connections should not exceed 70 metres separation whilst maintaining minimum 6 metre width. Building volumes ought to align with streets to establish an effective street interface, except where setbacks facilitate plaza creation. The guide promotes appealing colonnades exhibiting height-to-depth ratios of 2:1. Furthermore, street walls should be of reduced height along laneways and streets narrower than 10 metres. Buildings presenting street frontages exceeding 25 metres require subdivision to introduce street façade modulation.

Concerning ground floor levels, the guidelines stipulate that no less than 80% of ground-level frontage facing streets and laneways should comprise entrances or windows, thereby ensuring active frontage. The Central Melbourne Design Guide ultimately defines average urban block length as the mean distance between opposing block sides, measured from laneways and streets.

This integrated approach highlights the necessity of incorporating public space quality considerations within urban design, guaranteeing that energy-efficient, walkable and people-focused spaces receive appropriate priority in urban planning. Correspondingly, the Shanghai Street Design Guidelines (2016) advocate that street spaces should exhibit order, comfort and pleasantness. This is attained through regulating building control lines and alignment ratios, which guarantee a coherent and continuous spatial interface. Through maintaining comprehensive consistency, these guidelines seek to establish foundations for functional spaces that sustain public life and generate walkable urban scales.

Method

To further examine the relationship between urban morphological elements and building energy performance from an urban design perspective, this study employs a set of indicators derived from urban design guidelines that characterise external building spaces. A comparative analysis is subsequently undertaken through a series of simulation experiments, with the overall research methodology and workflow illustrated in Figure 1.

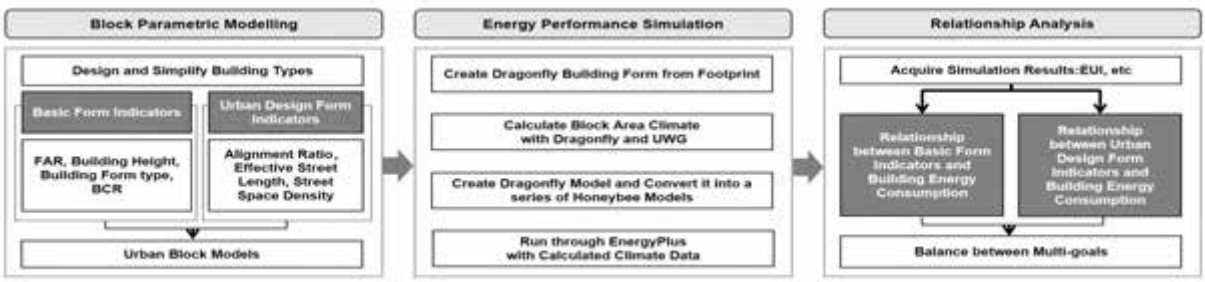

Fig. 1. Workflow of the research process with three stages.

The research comprises three principal stages: block parametric modelling, energy performance simulation, and relationship analysis. The initial stage concentrates on modelling urban forms, which establish the foundation for subsequent energy performance simulations. The results of these simulations then inform the relationship analysis conducted in the final stage.

The primary objective of the first stage involves constructing abstract urban forms and developing their parametric models. A fundamental requirement at this stage ensures all comparative forms maintain identical floor area ratio (FAR) values. This constraint is implemented for three key reasons. Firstly, within practical design processes, urban designers and architects frequently receive explicit, fixed FAR requirements during early planning stages. Secondly, variable control proves essential for isolating effects, with FAR commonly serving as a standard indicator in studies investigating urban form-energy performance relationships. Thirdly, despite FAR uniformity, urban form's inherent complexity permits significant variations in external spatial configurations, rendering these differences crucial components of design decision-making.

To maintain consistent FAR values, this study utilises a typical residential unit as a base model. The unit measures 15 metres in length, with a width of 10.5 metres and height of 3 metres. Through modifications to building heights, typologies and spatial arrangements, six distinct block models exhibiting varying external environmental characteristics are developed, as demonstrated in Figure 2.

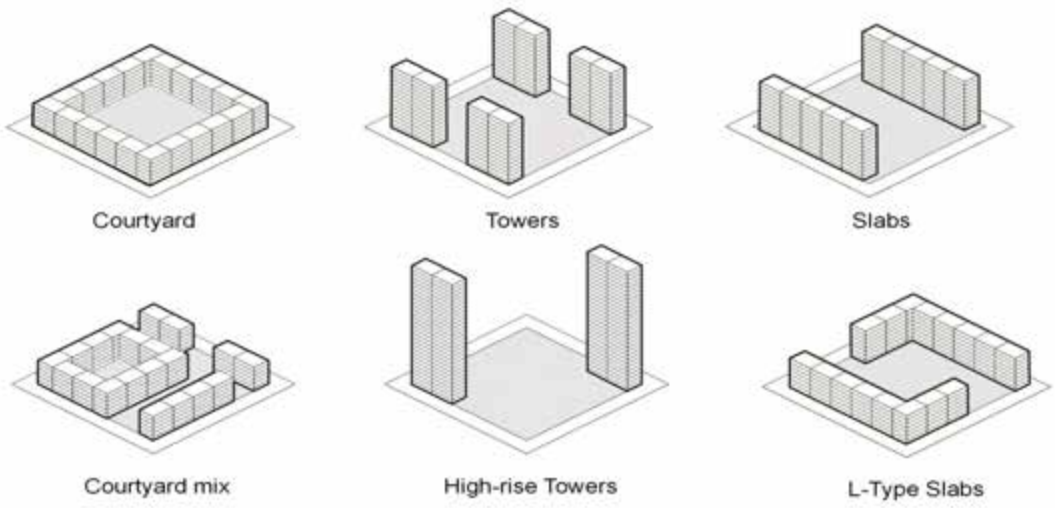

Fig. 2. Residential unit and six block form types.

Situated on identical designated sites, these block models share equivalent FAR values while differing in other fundamental form indicators, summarised in Table 2.

Table 2. Basic form indicators of six types.

No.	Form Type	Site Area	Total Building Area	Building Footprint Area	Number of Floors
C-1	Courtyard	11130.25㎡	18900㎡	3150㎡	6
C-2	Courtyard mix	11130.25㎡	18900㎡	3150㎡	6
T-1	Towers	11130.25㎡	18900㎡	1260㎡	15
T-2	High-rise Towers	11130.25㎡	18900㎡	630㎡	30
S-1	Slabs	11130.25㎡	18900㎡	1575㎡	12
S-2	L-Type Slabs	11130.25㎡	18900㎡	2520㎡	7, 8

Parametric modelling and energy performance simulations are executed based on the defined block forms. While numerous building energy simulation tools exist, determining appropriate methods and tools for block-scale analyses remains crucial. This study implements a workflow centred on Ladybug Tools (Figure 3), operating principally within Rhinoceros and Grasshopper platforms while employing EnergyPlus as the core simulation engine for energy performance analysis.

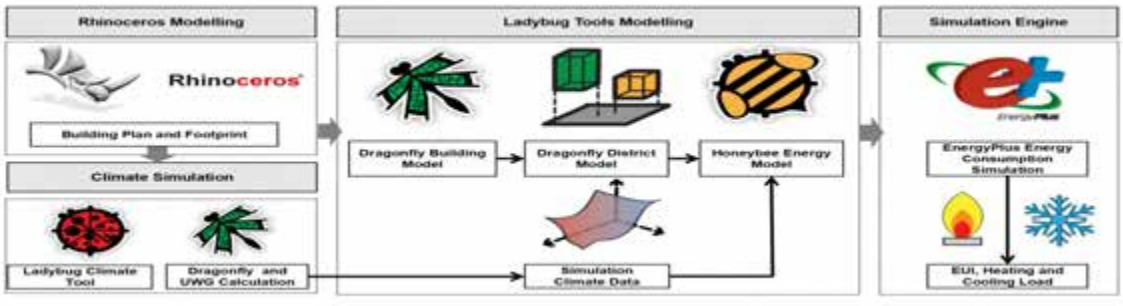

Fig. 3. Energy performance simulation workflow.

Developed by the U.S. Department of Energy, EnergyPlus provides comprehensive simulations of building thermal performance, humidity levels, airflow and lighting conditions. The software incorporates key factors including thermal conduction, air infiltration, solar radiation, lighting and HVAC system performance through its fundamental thermal balance physical model. Unlike simulation engines such as DOE-2 and DeST, EnergyPlus not only ensures thermal balance within rooms but also extends beyond linear time-invariant systems to handle surface convective heat transfer coefficients. Crawley *et al.*(2021) validated EnergyPlus's high precision in building energy consumption simulations through multiple test cases, confirming the reliability of its core algorithms.

To enhance usability, platforms including OpenStudio, DesignBuilder and Ladybug Tools have integrated the EnergyPlus engine within more accessible interfaces. The Grasshopper platform facilitates visual programming through user-friendly plugin tools, with Ladybug Tools serving as a central component. This toolkit comprises four specialised plugins: Ladybug for climate and meteorological analysis with advanced visualisation capabilities; Honeybee for energy performance and daylighting simulations; Butterfly for wind environment analysis; and Dragonfly for urban-scale microclimate and energy performance studies. The current research primarily utilises

Honeybee and Dragonfly for performance simulations.

Compared to alternative EnergyPlus-based tools like OpenStudio and DesignBuilder, Ladybug Tools offers distinct advantages. As a parametric platform, it provides superior comprehensiveness and adjustable flexibility, enabling multi-factor simulation workflows through combined use of its plugins. Consequently, researchers widely employ Ladybug Tools for studies examining solar potential, microclimate, daylighting, energy consumption and their relationships with built morphology. For instance, Rostami *et al.* (2024) applied a Ladybug Tools-UMI integrated workflow to investigate urban canyon solar potential and energy consumption under morphological influences in semi-arid regions. Furthermore, as a Grasshopper plugin, Ladybug Tools demonstrates exceptional usability within established urban design workflows, significantly reducing learning curves while facilitating performance-optimised design operations. These characteristics have led to its widespread adoption in urban morphology-energy consumption research(Feng *et al.*, 2024; Liu *et al.*, 2023; Ibrahim *et al.*,2021) justifying its selection as the primary simulation tool in this study alongside the EnergyPlus engine.

To account for local urban climate conditions, the study employs Dragonfly's integrated Urban Weather Generator (UWG), validated across multiple cities for effective urban weather data adjustment (.Bueno *et al.*, 2013). Using modified climate data, the Honeybee plugin executes EnergyPlus simulations to evaluate block configuration energy performance, generating Energy Use Intensity (EUI) and annual heating/cooling load data. The simulation methodology prioritises result reliability, workflow consistency and parametric form manipulation capacity.

The process utilises Grasshopper's parametric design platform within Rhino to define building site plans, establish volumes through floor height/count parameters, and configure daylighting via window-to-wall ratios (WWR). A Dragonfly model converts into Honeybee models for energy simulations, applying a maximum 0.35 WWR for residential buildings. All block models occupy identical urban contexts to minimise external interference, with Shanghai selected as the experimental location due to its representative ASHRAE 3A (warm and humid) climate classification.

EnergyPlus simulations incorporating Shanghai's climate parameters produce annual EUI data and monthly load outputs. Prior to energy performance comparison, the study defines four urban design form indicators (Table 3) specific to the identified typologies. These indicators focus on building-shaped external spaces, evaluating their capacity to generate sufficient, high-quality public realms.

Table 3. Urban design form indicators.

Indicator	Formula	Connection to high-quality public spaces
Alignment Ratio	$AR = \frac{\sum StreetwallLength}{\sum BuildingSetbackLineLength} * 100\%$	High AR helps to create continuous and enclosure street interfaces, thereby promoting pedestrian activity (2011).
Effective Street length	$ESL = \sum StreetwallLength$	Longer street wall length can enhance the vitality of the street attract more pedestrians to stay(Mehta, 2014).
Effective Street Space	$ESS = \sum ESL * PedestrianSpaceWidth$	Higher effective street space provides more spaces for activities (2013).
Street Space Density	$SSD = \frac{\sum Non\text{-}UrbanSpaceOccupiedByBuilding}{SiteArea} * 100\%$	Higher street space density means more accessible pedestrian spaces for vitality and more pedestrian-friendly environment (Gehl, 2003).

The study examines four key urban design indicators to evaluate block morphology:

Alignment Ratio: This measures the proportion of building street walls aligned with designated setback lines, calculated as the total building street wall length divided by the total setback line length. Urban design guidelines globally emphasise this metric as it quantifies how effectively buildings define street interfaces and contribute to coherent streetscapes.

Effective Street Length: This represents the cumulative length of building façades that actively contribute to high-quality street environments. Streets lacking continuous building interfaces typically fail to generate vibrant public spaces, making this a crucial measure of urban form quality.

Effective Street Space: This indicator calculates the total area of street space bounded by well-defined building interfaces. It measures the spatial extent of streetscapes capable of supporting diverse public activities and pedestrian interactions.

Street Space Density: A novel metric introduced in this research, defined as the ratio of non-building urban space to total site area (illustrated in Figure 4). Higher values indicate more compact, pedestrian-oriented urban configurations where public spaces are efficiently distributed within the block structure. This indicator provides a quantitative measure of urban morphology's capacity to support walkability and public space functionality.

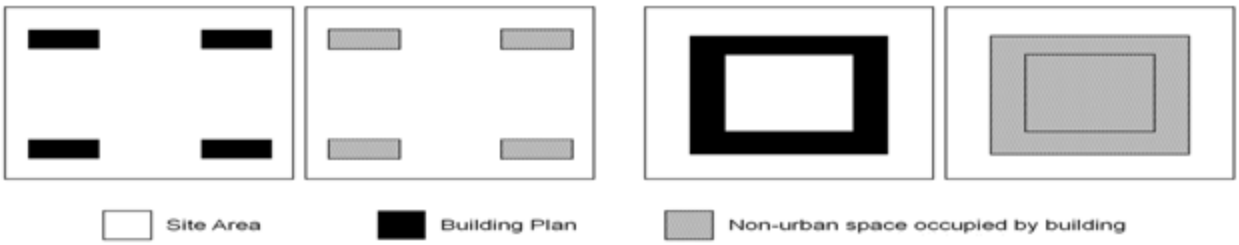

Fig. 4. Definition of street space density.

Table 4 presents the calculated values of these urban design form indicators for each block typology examined in the study. The metrics collectively provide a comprehensive framework for assessing how different urban configurations balance built form with public space quality, particularly in relation to pedestrian experience and spatial usability.

Table 4. Urban design form indicators of six types.

No.	Form Type	Effective Street length	Effective Street Space	Street Space Density	Alignment Ratio
C-1	Courtyard	342m	3820 m²	65.7%	100%
C-2	Courtyard mix	231.5m	3025 m²	65.7%	67.7%
T-1	Towers	120m	1200 m²	11.3%	35.1%
T-2	High-rise Towers	60m	600 m²	5.7%	23.7%

S-1	Slabs	150m	1500m²	14.2%	43.9%
S-2	L-Type Slabs	261m	2810m²	65.7%	76.3%

Results and Discussions

The energy performance simulation results for the six urban form types demonstrate notable variations in energy consumption patterns (Table 5). Among the tested configurations, the C-1 type achieves the lowest Energy Use Intensity (EUI), while the T-1 type exhibits the highest consumption. The Tower-type forms generally show poorer energy performance compared to both Courtyard and Slab types. Analysis of cooling and heating loads reveals C-2 as the most thermally balanced configuration, whereas S-1 displays the most significant load fluctuations, likely due to its complex morphological characteristics.

Table 5. Simulation results of six block types.

No.	Form Type	EUI	Cooling Load	Heating Load
C-1	Courtyard	167.591 KW/m²	52.496 KW/m²	43.411 KW/m²
C-2	Courtyard mix	174.148 KW/m²	53.915 KW/m²	48.267 KW/m²
T-1	Towers	182.791 KW/m²	59.248KW/m²	50.700 KW/m²
T-2	High-rise Towers	181.936 KW/m²	60.094 KW/m²	49.745 KW/m²
S-1	Slabs	170.102 KW/m²	54.854 KW/m²	42.971 KW/m²
S-2	L-Type Slabs	170.641 KW/m²	54.001 KW/m²	44.555 KW/m²

The maximum EUI difference between the highest (T-1) and lowest (C-1) performing types is 9%, indicating relatively constrained performance variations under the controlled study conditions. Notably, certain type pairs demonstrate remarkably similar energy performance, including S-1 and S-2 with nearly identical EUI values, and T-1 and T-2 showing comparable consumption patterns. These similarities presumably result from the shared experimental parameters, particularly the fixed Floor Area Ratio (FAR) and standardized environmental conditions.

When evaluating both energy performance and urban design indicators through a comprehensive ranking analysis (Figure 5), the C-1 type emerges as the optimal configuration, excelling in both energy efficiency and public space quality. In contrast, the T-2 type performs poorest overall, with T-1 following closely behind due to its high energy demands and inadequate public space provision. While S-1 and S-2 demonstrate similar energy performance, S-2 shows superior urban design outcomes through better-defined street interfaces and more generous public spaces.

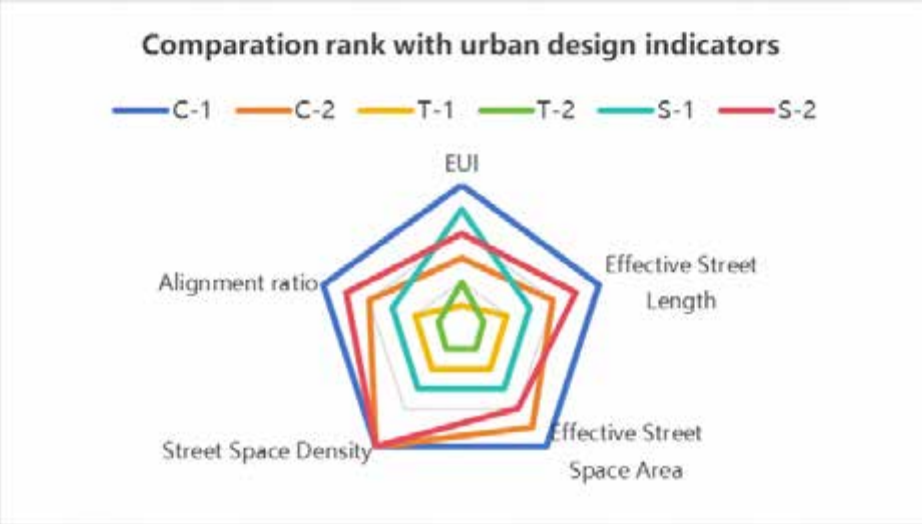

Fig. 5. Comparation rank with urban design indicators.

The comparative analysis reveals that Courtyard-type configurations achieve the best overall balance between energy efficiency and public space quality. Tower types prove least effective across all evaluation metrics, while Slab forms show intermediate performance with potential for further optimization. These findings carry important implications for urban design practice, demonstrating that equivalent FAR conditions can accommodate substantial variations in both energy performance and public space quality across different morphological types.

The study confirms that certain urban form configurations can successfully reconcile energy efficiency with high-quality public spaces, proving this dual optimization is achievable in practice. However, several limitations should be acknowledged, including the simplified morphological representations compared to real urban environments, constrained environmental parameters, focus on relative rather than absolute performance relationships, and exclusive consideration of residential functions. Despite these limitations, the findings provide valuable guidance for early-stage urban design, suggesting designers should prioritize configurations that balance energy performance with public space quality while recognizing these solutions maintain effectiveness across varying FAR conditions. The results substantiate that energy-conscious urban form selection need not compromise public space quality, offering empirical support for more holistic sustainable design approaches. Future research should address the current limitations through expanded typological variety, multifunctional analysis, and real-world validation studies.

Conclusion

Existing research on building energy performance predominantly focuses on architectural characteristics. However, in actual urban and architectural design practice, the preliminary design phase must consider not only building forms but also the configuration of external public spaces shaped by built elements - a fundamental aspect of urban experience. To achieve orderly, comfortable and sustainable urban environments, it becomes imperative to re-examine the urban morphology-energy consumption relationship through an urban design lens.

This study conducted controlled energy simulation experiments across comparative morphological typologies. The results demonstrate that urban form elements and typologies significantly influence building energy performance while exhibiting substantial variation in public space generation capacity. The C-1 typology emerged as optimal, excelling in both energy efficiency and public space provision, whereas T-type forms underperformed across both parameters. Among S-types, while energy consumption remained consistent, urban design indicators showed marked variation. These findings suggest the feasibility of identifying multi-objective

optimised morphological solutions addressable during early-stage urban design. The research provides novel perspectives and indicators to inform future scholarship and practice.

The outcomes offer practical implications for urban designers. During preliminary design phases, prioritising morphological typologies that simultaneously enhance energy performance and public space quality - with minimal FAR dependency - proves achievable. Recommended design approaches include:

When working with predetermined FAR values, designers should favour typologies combining lower energy consumption with high-quality public spaces, as exemplified by Courtyard-type configurations. Where morphological options are constrained, exploring solutions that optimally balance energy and spatial performance within given parameters becomes essential. Crucially, designers should avoid problematic typologies that yield both elevated energy demands and inadequate public space provision.

Future research should investigate larger urban blocks, incorporate diverse programme types, and establish correlations between urban design indicators and energy performance. Addressing these dimensions will facilitate the development of more precise, sustainability-focused urban design guidance. The study demonstrates that energy-conscious urban form selection need not compromise public space quality, providing empirical validation for integrated performance-based design methodologies. Subsequent work should expand typological variety and examine real-world applications to strengthen these findings

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Exploring Meanings and Experiences of Public Spaces: Topic Modelling Insights from Museum Gazhane

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Abstract
Public spaces function as both material and symbolic environments for public life, where individuals construct and share meanings through experience. This study explores the symbolic and experiential meanings of public space by analysing user-generated content about Museum Gazhane. Drawing on 3,025 Google Maps reviews (2021–2024), it adopts a two-stage methodology: Latent Dirichlet Allocation (LDA) is used to detect thematic patterns, which are then interpreted through Critical Discourse Analysis (CDA) to reveal how narratives express social meanings. This integrative approach combines computational scalability with critical depth, enhancing both methodological rigour and interpretive nuance. Findings offer insights into how digital narratives reflect public perceptions and symbolic attachments, while highlighting the value of user-generated content for informing inclusive and responsive public space planning in contemporary cities.

1.Introduction

Public spaces are key components of urban life, enabling social interaction, cultural expression, and everyday functionality (Gehl, 1987; Jacobs, 1961; Neal, 2010). They also serve as symbolic landscapes where collective memory and urban identity are formed (Lynch, 1960; Zukin, 1995; Crilley, 1993). However, the nature of public spaces has become increasingly complex in the contemporary city. Spaces once associated with democratic ideals have been reshaped by the logic of neoliberal urban policies to enhance global competitiveness and create new images for cities (Boyer, 1993; Ercan, 2016; Madanipour, 2000, 2019). Consequently, scholars have renewed their focus on the evolving roles and typologies of public spaces. Yet dominant research approaches often emphasise specific dimensions—such as physical design (Carmona, 2010), governance models (Low & Smith, 2006; Magalhães, 2010), or user behaviours (Whyte, 1980; Shaftoe, 2008)—while underemphasising their symbolic and experiential meanings. Traditional methods such as surveys and interviews also have limitations in capturing the discursive and affective layers of spatial experience, particularly in light of sampling bias and the temporal nature of public life.

This study addresses these methodological gaps by examining digital user reviews as an alternative perspective on public space experiences. Focusing on Museum Gazhane—an industrial heritage site in Istanbul that has been adaptively reused as a cultural public space—the research aims to uncover the key themes and patterns expressed in user-generated content. Drawing on 3,025 Google Maps reviews from 2021 to 2024, the study employs Python-based text mining and Latent Dirichlet Allocation (LDA) topic modelling to analyse how users articulate their experiences, expectations, and symbolic associations.

To enhance both analytical depth and methodological robustness, the study adopts a two-stage interpretive framework. First, Latent Dirichlet Allocation is used to identify the latent thematic structure across the large corpus of user reviews. Second, these topics are subjected to close reading through the lens of Critical Discourse Analysis (CDA) (Fairclough, 2003, 2010; Van Dijk, 1993, 2003; Wodak & Meyer, 2016), enabling the exploration of how meaning, ideology, and power operate within user narratives. Combining topic modelling and discourse analysis provides a systematic yet interpretive approach that bridges the gap between scale and nuance, allowing both macro-pattern detection and context-sensitive interpretation. This integrative strategy not only increases the credibility and reliability of the findings (Jacobs & Tschötschel, 2019) but also contributes to methodological innovation in public space research by responding to the challenge of analysing large volumes of user-generated text without losing discursive richness (Törnberg & Törnberg, 2016; Mullenbach, 2022).

By analysing digital user narratives, this study provides insights into how spatial meanings are constructed through everyday experience, while offering practical implications for the design and management of public spaces in contemporary cities. The central research questions guiding this inquiry are as follows: (1) How is Museum Gazhane represented in user reviews? (2) How do these representations intersect with users' experiential relationships to the space, its historical transformation, and broader context? (3) How might such representations inform the planning, design, and governance of public spaces?

The remainder of the article is structured as follows: Section 2 presents the study's theoretical foundation, including a review of public space roles and the analytical potential of digital user data. Section 3 outlines the methodological process, including data collection, preprocessing, and data analyzing. Section 4 presents the findings of the LDA analysis, organised around five principal thematic clusters. These clusters are interpreted in relation to the sociocultural and political layers of meaning embedded in public spaces. Finally, Section 5 discusses the study's theoretical and practical contributions, reflects on its limitations, and proposes directions for future research.

2. Literature Review

This section presents the study's theoretical foundation, including a review of public space roles and the analytical potential of digital user data.

2.1 The Multifaceted Roles of Public Space

Drawing on critical urban theory, particularly Lefebvre's (1991) notion of the production of space and Massey's (2005) concept of relational space, this study conceptualises public space as a dynamic and contested terrain shaped by social relations, discourses, and everyday practices, rather than as a fixed or neutral container. According to this view, spatial meaning is continuously reconstituted through the interplay of material and symbolic dimensions. Tracing this theoretical lineage historically reveals how the meanings and functions of public spaces have evolved.

Public spaces have historically embodied shifting sociopolitical agendas, evolving from democratic Agora to commodified landscapes shaped by neoliberal urban restructuring (Mumford, 1961; Sorkin, 1992). These spaces have functioned as multilayered constructs in which social relations, cultural representations, political participation, and economic strategies are negotiated and reproduced (Lefebvre, 1991; Madanipour, 1995). Thus, public spaces are not neutral; they reflect and reproduce power relations, embedding inclusive and exclusionary logics. As Mitchell (2003) argues, the question of whose narratives are represented—and whose are erased—ultimately determines which identities are legitimised.

Building on this historical and theoretical foundation, this study conceptualises public space as a multifaceted domain and examines its meanings and lived experiences through five interrelated roles: social, physical, symbolic, political, and economic.

• **Social Role:** Public spaces are vital arenas for collective life. They enable everyday encounters and social interactions that engage people across ethnic, gender, and class lines (Madanipour, 1995; Mehta, 2014). They foster cohesion and the negotiation of difference by supporting both planned and spontaneous interactions (Jacobs, 1961; Sennett, 1971). Thus, they serve as dynamic zones where conflict and consensus coexist, reinforcing social cohesion through continuous, layered exchanges.

• **Physical Role:** Public spaces are integral to the urban fabric, linking streets, squares, and parks to ensure spatial continuity and ecological balance (Carr et al., 1992; Thompson, 1998; Ellis, 1978). The physical design of public spaces, shaped by walkability, openness, and comfort, influences not only mobility and microclimates, but also enhances psychological well-being and patterns of social engagement (Gehl, 2010; Moughtin, 1999; Whyte, 1980). Thus, public spaces serve as structural elements of the built environment and as stages for everyday social life.

• **Symbolic Role:** Public spaces serve as repositories of collective memory, cultural identity, and ideological meaning (Lefebvre, 1991; Mehta, 2023). While Lynch (1960) emphasises the role of urban form and legibility in producing shared meaning, Mitchell (2003) points out that symbolic representation often reflects dominant power structures, thereby marginalising alternative narratives. Everyday practices and shared rituals reinforce a sense of belonging, yet these spaces also become sites of contestation over cultural visibility and historical legitimacy.

• **Political Role:** Public spaces constitute vital democratic arenas characterised by the interplay of power and resistance, the negotiation of social demands, and the continual re-creation of political meanings. By facilitating encounters among strangers and elevating marginalised voices, they foster civic engagement, political expression, and collective identity formation. Their essential role in enabling both solidarity and dissent underscores their democratic necessity (Shaftoe, 2008).

• **Economic Role:** Public spaces have historically functioned as centres of commerce and urban vitality (Lofland, 1971; Thompson, 1998; Gehl, 1996). Beyond direct commercial activity, these spaces generate economic value by attracting tourism, raising property values, and enhancing urban competitiveness (Shaftoe, 2008). However, under neoliberal development, the commodification of these spaces often prioritises exchange value over public use. This exacerbates spatial inequalities and diminishes equitable access.

The interplay of these five roles—social, physical, symbolic, political, and economic—highlights the multifaceted nature of public spaces. These spaces are neither neutral nor static; rather, they serve as arenas of both cooperation and contestation, shaped by overlapping and often competing logics. This conceptual framework enables a systematic analysis of the lived, perceived, and contested meanings attributed to public spaces, and it underpins the methodological approach adopted in this study.

2.2 The Use of Digital Data in Public Space Research

In recent years, an expanding body of literature has recognised social media as valuable data sources capable of addressing the limitations of traditional field-based methods. Social media-derived data can access broader and more diverse user groups than surveys or interviews, while also capturing real-time, everyday experiences. In doing so, they illuminate the layered perceptions individuals hold about public spaces (Sim & Miller, 2019; Cheng et al., 2022). This enables researchers to explore how urban environments are experienced and interpreted through user practices and affective encounters (Liu & Xiao, 2021; Song et al., 2020).

Kaplan and Haenlein's (2010) broad definition of social media—as internet-based platforms enabling the creation and exchange of user-generated content—is adopted here. This encompasses various formats such as blogs, media-sharing sites, and online forums. Similar to traditional mass media, social media influences public perception by framing issues and events (Moscovici & Duveen, 2000). In this study, Google Maps user reviews are utilised as a form of social media data to examine public perceptions and experiences of urban space.

User reviews on platforms such as Google Maps and TripAdvisor have become prominent tools for analysing urban space. Since 2015, Google Maps has surpassed platforms like Yelp and Facebook in terms of data volume and engagement, becoming the most widely used location-based review platform globally (Munawir et al., 2019). Its accessible interface and large user base generate rich data—comprising star ratings, time-stamped narratives, and images—well suited to both quantitative and qualitative analysis.

Studies on urban parks and public spaces have highlighted the analytical value of such data in revealing usage dynamics. For instance, Song et al. (2020) used LDA topic modelling on TripAdvisor reviews of Bryant Park in New York to relate user experiences to spatial quality, offering insights for design and management. In a follow-up study, Fernandez et al. (2022) analysed seasonal variation in perceptions, demonstrating how social media data can track experiential shifts over time. Expanding this approach, Song et al. (2023) combined LDA and qualitative analysis of seven years of High Line Park reviews, illustrating how programming, history, and design influenced user experience.

Other studies have employed similar methods to assess spatial quality and satisfaction. Liu and Xiao (2021) applied text mining and sentiment analysis to Google reviews of parks in Shenzhen, identifying key physical factors—such as landscape quality and amenity diversity—through regression models. Munawir et al. (2019) examined Bandung's thematic parks to explore urban branding effects. In Jakarta, Saragih et al. (2024) used content analysis of Google reviews to identify four dimensions of inclusive design in child-friendly spaces: activity diversity, child infrastructure, environmental quality, and supporting amenities.

Digital user data also offer insight into the symbolic and emotional dimensions of public space. Wang et al. (2020) analysed eleven years of TripAdvisor reviews on the Las Vegas Strip using sentiment analysis and LDA to explore sense-of-place elements such as belonging, identity, and attachment. Similarly, Sohi et al. (2024) employed social network analysis to map perceptions of liveliness, comfort, and safety in Tehran's historic bazaar, informing urban design interventions.

Collectively, these studies demonstrate the methodological flexibility of digital user reviews in analysing spatial perception, usage patterns, satisfaction, and urban identity across scales. Their integration into planning and design offers scalable, real-time, and user-centred insights for data-informed decision-making. However, social media data are not without limitations. As voluntary content, they may lack representativeness—particularly for demographics with limited digital access, such as older adults, low-income groups, or critical voices. These biases underscore the need for reflexive, context-sensitive approaches when incorporating digital data into public space research.

A growing strand of research also highlights the value of combining computational techniques such as topic modelling with interpretive approaches like Critical Discourse Analysis (CDA). While LDA efficiently detects latent patterns across large datasets, it lacks embedded theoretical assumptions about meaning-making. CDA, in contrast, situates textual meaning within broader socio-political and ideological frameworks. The integration of these methods allows researchers to detect, interpret, and critically assess the construction of meaning in discourse, especially in domains such as identity, ideology, and hegemony (Jacobs & Tschötschel, 2019; Törnberg & Törnberg, 2016).

For instance, Jacobs and Tschötschel (2019) demonstrate how topic modelling, when used with appropriate parameters, can strengthen discourse analysis by improving transparency, scaling, and interpretive depth. Similarly, Törnberg and Törnberg (2016) show how combining LDA with CDA enables the exploration of complex ideological intersections—in their case, between Islamophobia and anti-feminism—within massive corpora of online content. Mullenbach (2022) further applies CDA to urban park discourse to reveal how elite narratives around public space planning obscure power asymmetries and environmental injustice, emphasizing the importance of reflexive and critical readings of spatial discourse.

3. Methods and materials

This study adopts a mixed-methods digital research design to examine how public perceptions, representations, and experiences of Museum Gazhane are constructed through online user-generated content. Recognising the increasing relevance of digital platforms as arenas for discourse and meaning-making, the study employs computational text analysis—specifically Latent Dirichlet Allocation (LDA) topic modelling—to uncover latent thematic structures within Google Maps reviews.

The methodological process unfolds in three interrelated stages: (1) the historical and spatial contextualisation of the study site; (2) the systematic acquisition and preprocessing of user review data; and (3) the application of LDA topic modelling to detect and interpret recurring semantic patterns.

This framework facilitates the analysis of large-scale user narratives, offering insights not only into individual experiences but also into broader sociopolitical imaginaries. Through this approach, the study addresses how users evaluate the physical and functional aspects of Gazhane, while also uncovering the symbolic, political, and

emotional meanings embedded in their digital articulations.

3.1 Study Site: Museum Gazhane

Museum Gazhane—historically known as the Hasanpaşa Gasworks—stands out as a critical case due to its transformation from an industrial heritage site into a vibrant public space, reflecting both the challenges and opportunities of preserving historical significance while addressing contemporary urban needs. It offers a unique, multifaceted, and symbolically rich example of the evolving understanding of public space in Istanbul.

The Hasanpaşa Gasworks, established in 1892, served as a vital component of the city's energy infrastructure for several decades (Göklü, 2003). Following its decommissioning in 1993, the site remained in a state of suspension for approximately thirty years. In the early 2000s, efforts to conserve and restore the Gasworks were initiated by neighbourhood-based collective movements. Over time, this initiative underwent transformation under the influence of various institutional actors.

During this period, spatial demands concerning the site centred not only on the right to access and use it, but also on the symbolic meanings shaped through representation and collective memory. The spatial discourses that emerged coalesced around themes such as public rights, cultural heritage, and communal values, significantly contributing to the redefinition of the site's public character. A comprehensive restoration project, completed by the Istanbul Metropolitan Municipality (IMM) in 2021, refunctionalised the site as a "culture- and art-oriented living space" and reintroduced it to the public under the name "Museum Gazhane."

Today, Museum Gazhane functions as a dynamic arena in which the material and symbolic dimensions of public life are continually co-constructed and renegotiated. Its evolution from a grassroots movement to a municipally led project exemplifies the interplay between community-driven efforts and institutional interventions in shaping the symbolic and experiential meanings of public spaces.

Beyond its physical presence, Gazhane's extensive digital visibility—particularly through user reviews on Google Maps—offers a valuable opportunity to investigate how everyday users perceive, interpret, and contribute to the space's evolving significance. This digitally mediated layer of engagement allows for the analysis of affective geographies, representational narratives, and spatial practices as they unfold in real time. As such, it serves as a valuable methodological interface for examining the dynamics of contemporary public space.

3.2 Data Collection and Preprocessing

Data for this study comprised 3,025 user reviews of Museum Gazhane extracted from Google Maps (2021-2024) using the Outscraper tool and Google Maps Reviews API. Automated scraping enabled efficient, large-scale data collection (Munawir et al., 2019; Song & Zhang, 2020).

Only Turkish-language reviews were retained to prioritize local user perspectives. This decision was taken to better reflect local user perceptions and provide a culturally grounded interpretation of spatial experience (Borrego & Comalat-Navarra, 2020). Due to limited advanced Turkish NLP resources, reviews were translated into English using DeepL Translate. Semantic accuracy was ensured through manual verification of a randomized sample and iterative refinement guided by a domain-specific bilingual glossary developed via comparative word frequency analysis.

Translated texts were converted into an analysable format using Python. Standard preprocessing techniques—including tokenization, stop-word removal, stemming, and lemmatization—were applied. The final preprocessed corpus consists of 92,842 words, structured to ensure coherence and interpretability for topic modelling.

3.3 Data Analysis

The analysis proceeded in two main phases: LDA topic modelling and discourse analysis. This two-stage design enabled the detection of latent thematic structures at scale, followed by their context-sensitive interpretation through qualitative techniques.

Phase 1: Topic Modelling

Following the preprocessing phase, Latent Dirichlet Allocation (LDA) was applied to uncover the latent thematic structures embedded within user reviews. LDA, a probabilistic topic modeling technique, automatically infers semantically consistent themes ("topics") from large text corpora by analyzing patterns of word co-occurrence, thereby offering a scalable yet flexible approach to textual analysis (Blei et al., 2003; Song et al., 2020). It is particularly effective for heterogeneous datasets such as user reviews, where meanings emerge from dispersed and context-dependent expressions (Song et al., 2020).

A critical step in topic modelling is identifying the optimal number of topics. The coherence score—evaluating the semantic consistency among a topic's top keywords—is widely used for this purpose, balancing computational robustness with interpretive clarity (Röder et al., 2015). In this study, multiple LDA models were tested across a range of 2 to 30 topics. The five-topic model was ultimately selected based on its highest coherence score and its ability to produce analytically distinguishable outputs.

To enhance interpretability, the model was further refined using saliency and distinctiveness metrics (Chuang et al., 2012). These helped eliminate low-density or overlapping clusters and improved thematic clarity by highlighting conceptually salient groupings of terms.

Phase 2: Interpretive Analysis and CDA Integration

The second phase involved qualitative interpretation of the five topics using a combination of computational outputs and discourse-informed reading. For each topic, word clouds were generated to visualise the most salient terms. Additionally, the top 50 user reviews with the highest probability scores per topic were selected for close textual reading.

In this phase, Critical Discourse Analysis (CDA) was adopted as a guiding interpretive framework. CDA enables researchers to explore how language constructs and reflects social meanings, ideologies, and power relations (Fairclough, 1995). In line with recent methodological advancements, topic modelling and CDA were integrated to maximise both empirical breadth and critical depth (Jacobs & Tschötschel, 2019; Törnberg & Törnberg, 2016). While topic modelling captured recurring discursive patterns across a large dataset, CDA contextualised these patterns, attending to symbolic associations, affective registers, and underlying assumptions embedded in everyday spatial narratives.

Interpretation was anchored in the conceptual framework outlined in the literature review, particularly the five foundational roles of public space—social, physical, symbolic, political, and economic. This alignment ensured that the findings were not only statistically valid but also theoretically meaningful. By mapping each topic onto these conceptual dimensions, the study bridged computational analysis with critical spatial theory to examine how users experience, represent, and evaluate Museum Gazhane.

In sum, this methodological strategy demonstrates the analytical potential of user-generated content when approached through a combined computational–qualitative lens. The integration of LDA topic modelling with discourse analysis not only enhances interpretive validity but also contributes to ongoing methodological innovation in urban studies by offering a scalable, transparent, and critically reflexive tool for investigating public space representations in digital environments.

4. Findings

Using a two-stage methodology combining Latent Dirichlet Allocation (LDA) and Critical Discourse Analysis (CDA), this study identified five thematically distinct topics within Google Maps reviews of Museum Gazhane. These topics reflect diverse user perspectives, ranging from emotional and sensory impressions to critiques of management, multifunctional uses, and symbolic meanings. Each topic is detailed in the following subsections (4.1–4.5), drawing on keyword distributions, word clouds, and close readings of representative reviews.

4.1 Symbolic and Historical Transformation

This topic reflects the transformation of Müze Gazhane from an industrial heritage site to a cultural centre and the social perception of this transformation. The higher salience of terms such as "art," "culture," "Kadıköy," "become," "centre," "gasworks," and "new" in the relevant topic demonstrates the experience of Gazhane's transformation from an industrial past to a cultural attraction centre. The higher distinctive terms in the topic, such as "culture," "restoration," "transform," "hasanpasa," "high," "gasworks," "gas," "meet," "kadikoy," "historical," and "industrial," indicates that users possess a recognition of the historical identity of the area and hold a favourable perspective on its adaptation and reuse (Figure 1).

This thematic structure underscores Gazhane's dual public character: Gazhane serves as a historical symbol of industrial heritage while also functioning as a contemporary living space that fosters art, social interaction, and cultural production. This duality is frequently emphasized by users who define the transformation as a harmonious synthesis of heritage preservation and modern functionality. The transformation of Gazhane has been met with a favourable reception by users, who regard it as a successful integration of historical preservation and contemporary urban adaptation.

Figure 1. LDA Terms for the Topic "Symbolic and Historical Transformation"- overall frequency (left), saliency (centre), and distinctiveness (right)

The social interpretation of Gazhane Museum focuses on issues related to historical significance and cultural functions as well as aesthetic values. Expressions such as "high," "quality," "successful," "breathe," and "need," which are particularly salient in word analyses, point to the high-quality urban environment offered by Gazhane and the community's need for such spaces. The repeated use of the term "quality" in the commentary indicates that Gazhane is recognized for its aesthetic values and spatial design. This contributes to the consolidation of the area's physical and psychological significance. The physical quality of the area is not limited to visual appeal; it also integrates with the spatial experience of users. For instance, assertions such as "It's a very high-quality environment" and "A culture and arts centre of European quality" demonstrate that Gazhane is evaluated not only on a local scale but also according to international standards.

The Gazhane Museum also has a strong perception in terms of local identity and public ownership. The use of keywords such as "neighborhood," "Hasanpaşa," and "Kadıköy" serves to underscore the area's intricate interconnection with its immediate environment. The Hasanpaşa neighbourhood, where Gazhane is located, represents not only the physical location of the venue but also its interaction with the neighbourhood residents and the value it adds to their lives. For instance, the assertion that "This new cultural space in Hasanpaşa has revitalized the neighbourhood" underscores the transformative impact of Gazhane on the local community. The statement, "Having such a place in the heart of Kadıköy is a great opportunity for our neighbourhood," reflects the perception of Gazhane as a public space integrated with local identity. The statements indicate that the

space has been formally accepted by its users, thereby becoming an integral component of its spatial identity. While functioning as a meeting point at the neighbourhood level, the Museum Gazhane is also regarded as a significant cultural focal point for the broader district identity of Kadıköy.

Consequently, this topic positions the Gazhane Museum as a public space where industrial heritage is preserved and reimagined with contemporary cultural functions, thereby strengthening local identity and social ownership. This topic demonstrates the Gazhane Museum's strong integration into contemporary urban life, as evidenced by its preservation of historical identity and its revitalization through cultural functions. Notably, Gazhane has become a meeting point for the local community and a powerful symbol of the evolving concept of public space in contemporary Istanbul.

4.2. Institutional Representation and Public Appreciation

This topic underscores the dual perceptions of Museum Gazhane among users: firstly, as a public-benefit transformation project, and secondly, as a means of institutional representation. Higher salience terms in topic such as "thank," "everyone," "wonderful," "contribute," "IBB," "public," "Ekrem," "city," "work," and "congratulate" reveals a strong sense of public appreciation for the adaptive reuse of the site. The basis for this appreciation is the institutional visibility of the Istanbul Metropolitan Municipality (İBB) and its mayor, Ekrem Imamoğlu. Furthermore, higher distinctive terms in topic such as "feel," "transformation," "preserve," "project," "social," "hope," and "artistic" underscores that this transformation is perceived not only as a physical intervention but also as a symbolic representation of collective hope and social progress (Figure 2).

A review of user comments pertaining to this subject indicates that Gazhane is regarded not solely as a cultural venue, but rather as a public space that is both accessible and inclusive, thereby fostering public life and promoting cultural participation. Key words such as "public," "example," "neighbourhood," "preserve," and "social" emphasize the social dimension of the transformation. Expressions such as "a public facility that enables cultural and artistic activities" and "a space that has been given to the public" highlight its role in democratizing access to art and heritage.

Figure 2. LDA Terms Distributions for the Topic "Institutional Representation and Public Appreciation"- overall frequency (left), saliency (centre), and distinctiveness (right)

However, this positive narrative also reveals a strategic framework of institutional representation. The repeated references to İBB and Ekrem Imamoğlu suggest a discursive correlation between the site's success and a particular institutional identity. The keywords "İBB," "Ekrem," "project," "work," and "contribute" establish the transformation as a municipal achievement. However, the limited visibility of grassroots actors, such as neighbourhood associations and volunteer groups, suggests a discursive asymmetry. The absence of actors such as the Gazhane Environmental Volunteers Association (*Gazhane Çevre Gönüllüleri Derneği-GÇDD*) in the key metrics further underscores this imbalance.

This tension underscores the inherently political nature of public space production. While Gazhane is presented as a space "for everyone," it simultaneously becomes a stage for hegemonic representation. This duality underscores the fact that even physically inclusive spaces may entail representational inequalities. In the case of Gazhane, this contradiction reflects the tension between institutional strategies of legitimacy and the risk of

rendering participatory practices invisible.

This thematic cluster positions Gazhane as a representational area where the performance of political legitimacy, the contestation of participation narratives, and the symbolically curated urban memory are all taking place. The site's transformation, therefore, is situated at the intersection of participatory urbanism and institutional branding. The discourse of "public benefit" suggests inclusive services; however, these often become instrumentalized through institutional narratives, which limit the visibility of grassroots actors and produce imbalances in how public space is discursively constructed. This underscores the imperative for public space production to ensure not only physical accessibility but also equitable representation through voice.

4.3 Multifunctionality and Everyday Engagement

This topic focuses on how users experience Museum Gazhane as a multifunctional public space embedded in the rhythms of everyday urban life. Higher salient terms such as "museum," "exhibition," "library," "science," "visit," "cafe," and "child" unveils the site's dual identity as a nexus for both cultural enrichment and informal social interaction. Higher distinctive terms such as "science," "climate," "cartoon," "student," "charge," and "energy" serves to underscore Gazhane's significant pedagogical function, particularly in cultivating educational engagement among children and their families (Figure 3). The distinguishing characteristic of this topic is its emphasis on programmatic diversity, functional integration, and educational content. Gazhane offers a variety of educational opportunities, including science exhibitions, library spaces, workshops, and interactive activities for children, with the aim of providing meaningful learning experiences.

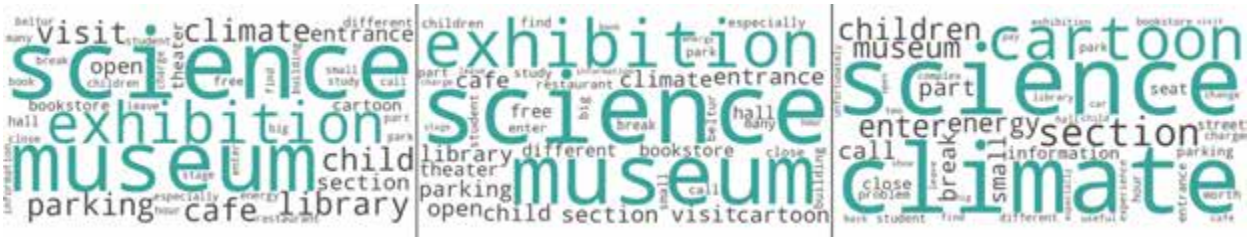

Figure 3. LDA Terms Distributions for the Topic "Multifunctionality and Everyday Engagement"- overall frequency (left), saliency (centre), and distinctiveness (right)

Concurrently, it functions as a site for casual socialization through its cafés, bookstores, and outdoor spaces, enabling users to dwell, rest, and interact. An analysis of user comments indicates that this hybrid structure has transformed Gazhane from a mere site of interest into a space that is actively inhabited and integrated into the daily routines of individuals and families. The repeated use of expressions such as "child," "student," "bookstore," and "cartoon" suggests that Gazhane is regarded as an entertaining and educational environment by younger audiences. Terms such as "library," "study," and "section" underscore the space's capacity to accommodate more deliberate, solitary forms of use, thereby establishing infrastructure for both scheduled programs and impromptu practices. This multifunctionality positions Gazhane as a hybrid spatial form that transcends the conventional visitor-site binary, becoming instead an integral and familiar element of the urban landscape.

Furthermore, the emphasis on accessibility and free entry serves to reinforce the perception of the site as a genuinely public space. The co-occurrence of terms such as "free," "accessible," and "entrance" suggests that initial user impressions are strongly positive, and that the spatial thresholds of the site promote social inclusion. Many users explicitly interpret free admission as an indication of equitable and open service provision, aligning with democratic values of access to knowledge and culture.

Within this theoretical framework, Gazhane emerges as a shared space in which the continuity of everyday life is sustained through intergenerational, multi-purpose engagement. This conception of publicness transcends the conventional boundaries of physical presence, encompassing habitual usage, accessibility, and multifaceted

functions. Gazhane's integration of cultural capital with daily urban practices offers an innovative model of contemporary public space, exemplifying the evolving logic of urban commons in the 21st-century city.

4.4 Democratic Access and Spatial Constraints

This topic reflects the dual role of Museum Gazhane as both a vibrant cultural hub and a space marked by infrastructural tensions. The success of the site in fostering artistic engagement and social interaction is counterbalanced by the challenges posed by overcrowding and spatial limitations. The Gazhane's strategic positioning of itself as a central cultural hub is further reinforced using prominent and salient terms such as "event," "concert," "activity," "free," "atmosphere," and "pleasant." However, distinctiveness metrics reveal a paradox at the heart of its popularity: while the space is celebrated as a dynamic leisure destination, its physical configuration often struggles to accommodate peak demand (Figure 4).

Gazhane's cultural offerings have been the subject of consistent praise in user comments, with users expressing appreciation for the open and inclusive nature of these offerings. The recurrence of terms such as "concert," "theatre," and "free" reflects users' appreciation of its democratizing role in expanding access to the arts. Concurrently, the lexical clusters "atmosphere," "pleasant," "good," "easy," "weekend," "fun," and "locations" serve as indicators of the site's efficacy in engendering an emotionally resonant spatial experience. These associations indicate that Gazhane is not only prized for its high-attendance events, but also for its capacity to host everyday leisure practices such as casual strolls, rest, and informal socializing.

Figure 4. LDA Terms Distributions for the Topic "Democratic Access and Spatial Constraints"- overall frequency (left), saliency (centre), and distinctiveness (right)

However, the co-occurrence of terms such as "crowded" and "tiring" alongside celebratory expressions such as "energy" and "enjoyable" reveals an underlying tension between vibrancy and comfort. While users frequently acknowledge the richness of the programming, they also often offer critiques of the logistical shortcomings that detract from their experience. These critiques posit that Gazhane's spatial design does not always align with the intensity and frequency of its event-based usage. The temporal clustering of events, particularly during weekends and evenings, exerts a significant strain on the space's carrying capacity, thereby highlighting the fragility of the existing infrastructural model. Therefore, there is an urgent need for adaptive systems.

When considered collectively, this thematic cluster positions the Museum Gazhane as an evolving urban gathering space that responds to contemporary needs for cultural enrichment, entertainment, relaxation, and self-expression. The event-oriented model under discussion here illustrates the potential of public spaces to facilitate collective enjoyment and cultural democratization. However, infrastructural constraints—including limited seating, bottlenecks, and overcrowding—also reveal the delicate balance between inclusive access and spatial comfort. In doing so, this topic foregrounds a pivotal challenge in contemporary public space design: the challenge of sustaining high levels of utilization without compromising the very experience that such utilization is intended to enhance.

4.5 Civic Provision and Commercial Use

This topic posits that Museum Gazhane functions as a hybrid public infrastructure, wherein municipal services and commercial amenities converge to create a space that extends beyond conventional cultural programming.

Gazhane has been identified as a node of everyday consumption and leisure due to the prevalence of higher salient terms in the topic, such as "Beltur," "café," "food," "affordable," "service," and "price." The presence of higher distinctive terms such as "reasonable," "tasty," "ambiance," "tea," and "beverages" serves to indicate users' appreciation of affordable prices, perceived quality, and the welcoming atmosphere (Figure 5).

Figure 5. LDA Terms Distributions for the Topic "Civic Provision and Commercial Use"- overall frequency (left), saliency (centre), and distinctiveness (right)

The lexical prominence of "Beltur", Istanbul's publicly-owned municipal enterprise, reveals Gazhane's dual identity as both a public service outlet and a managed consumption zone. The prevailing perspective often portrays cafés and restaurants situated within these locales as instrumental in extending municipal welfare, thereby facilitating more equitable access to leisure activities for the public. The presence of references to ice cream, burgers, and shops serves to underscore Gazhane's function as a social incubator. Within this context, quotidian activities such as dining, imbibing tea, or perusing merchandise can serve as catalysts for impromptu interactions and the establishment of shared practices.

The frequent co-occurrence of terms such as "perfect", "reasonable", "clean", "shop", "taste", "recommend", "staff", "belong", "municipality", and "ambiance" underscores Gazhane's perceived success in blending public service ethics with consumer satisfaction. These observations establish a foundation for exploring its potential as a model for state-led urban hospitality, wherein operational quality, pricing policy, and atmosphere are meticulously curated to foster inclusive public use. The emphasis on cleanliness, staff, and ambiance further illustrates how quotidian managerial elements contribute to the lived experience of public space.

However, several critical points emerge. A review of relevant literature reveals a paucity of indoor seating areas, service bottlenecks, and overcrowding during peak hours, particularly on weekends. These operational frictions indicate that user satisfaction is influenced not only by symbolic or aesthetic qualities, but also by the logistical and infrastructural capabilities of the space. This tension is indicative of broader concerns within the discourse on neoliberal urbanism, where public spaces are increasingly sustained by commercial revenue streams, despite efforts to maintain civic inclusivity.

Within this framework, Gazhane emerges as a hybrid public model, integrating aesthetics, comfort, and accessibility with the demands of sustainable operation. It navigates the intricate boundary between public and private spheres, between service provision and market logic. The site has been described by users as a point of social care, a meeting space, and a comfortable everyday stopover. Gazhane exemplifies an evolving understanding of publicness, one grounded not only in symbolic openness but also in the infrastructural and economic terms through which every day public life is sustained.

4.6 Summary of Key Findings

Through topic modeling and Critical Discourse Analysis, five thematic clusters were identified that reveal the multifaceted ways in which users perceive and engage with Museum Gazhane. These clusters reflect overlapping concerns ranging from symbolic transformation and multifunctionality to institutional critique and spatial constraints, demonstrating how publicness is experienced as a hybrid of social, symbolic, physical, political, and economic dimensions.

Table 1. Thematic alignment of LDA topics with the roles of public space

Thematic Cluster (LDA Topics)	Symbolic Roles			Social Roles			Physical Roles			Political Roles			Economic Roles		
Symbolic and historical transformation	■	■	■	■			■								
Institutional representation and public appreciation	■			■						■	■	■			
Multifunctionality and everyday engagement	■			■	■	■	■	■					■		
Democratic access and spatial constraints	■			■			■	■		■	■				
Civic provision and commercial use				■			■						■	■	■

Rather than mapping neatly onto singular functions, each topic intersects with multiple conceptual roles of public spaces. This multidimensionality illustrates how users' spatial meanings emerge through the interplay of design, discourse, use, and governance.

Table 1 aligns each thematic cluster with the five foundational roles of public space identified in the theoretical framework. This evaluative mapping, based on keyword saliency and interpretive readings, underscores the dialectical relationship between institutional narratives and everyday spatial experiences. It affirms that public space is continuously shaped as a negotiated, dynamic construct.

5. Conclusion

This study examined how users experience, interpret, and represent the Museum Gazhane as a contemporary public space. A two-phase methodology was used to analyse 3,025 Google Maps reviews. First, Latent Dirichlet Allocation (LDA) topic modeling was employed to identify prevalent themes. Second, critical discourse analysis (CDA) was employed to interpret these themes and reveal the social meanings, tensions, and symbolic associations embedded in user narratives.

The five thematic clusters identified—ranging from historical symbolism and institutional representation to multifunctionality and civic-commercial hybridity—reveal how users attach affective, political, and experiential meanings to the space. These representations are shaped by physical conditions and broader discursive dynamics, including municipal visibility, public participation, and market-driven governance. This approach confirms that public perception is not monolithic but rather formed through multiple—and sometimes conflicting—narratives. Representations in user reviews reflect personal encounters and socio-spatial imaginaries, demonstrating that public spaces are produced through the interplay of institutional structures and everyday experiences.

This study makes multifaceted contributions to public space research at the theoretical and methodological levels. First, it provides a comprehensive analytical framework for using user-generated digital content to analyse the experiential and symbolic meanings of public spaces. In this regard, the study proposes an innovative approach that integrates critical space theories, which posit that public spaces are constructed through discourse, with digital data analysis.

The study makes a theoretical contribution by proposing a multi-layered understanding of how public spaces are produced. It posits that user comments serve as indicators of satisfaction and as sources of representations related to abstract values, such as social memory, cultural identity, and spatial justice. The proposed theoretical framework has five dimensions representing the traditional roles of public spaces, thereby establishing a critical and applicable theoretical foundation. As illustrated in Table 1, these five dimensions are closely related to the conceptual framework of the symbolic, social, physical, political, and economic roles of public spaces. Rather than being considered separately, these roles reflect hybrid intersections that confirm the theoretical premise

that public spaces are relational and contested structures. This perspective emphasizes that the meaning of public space emerges through the interplay of institutional narratives and user experiences.

Methodologically, this study shows how combining computational and qualitative approaches can capture complex, digitally mediated spatial meanings. Integrating Latent Dirichlet Allocation (LDA) with Critical Discourse Analysis (CDA) shows how statistical pattern detection can be meaningfully enriched through context-sensitive, theoretically informed interpretation. CDA plays a central role in revealing how public spaces are constructed through discourse by users—not just described, but also symbolically and ideologically framed through everyday language. This model illustrates the potential of integrating digital methodologies with critical social sciences in public space research. Although user-generated content provides scalable, real-time insights, limitations such as digital exclusion and representational bias must be addressed through reflexive interpretation and methodological pluralism.

In practice, this study highlights the importance of incorporating user perspectives into the design, management, and repurposing of public spaces. It demonstrates the potential of an alternative data source for planning practices and offers a structured approach for its integration. Analysing users' experiences and perceptions can contribute to developing strategies that enhance spatial sustainability, social inclusion, and social belonging.

In sum, this study contributes conceptually, methodologically, and practically to the evolving field of public space research. It shows that user-generated narratives are active sites of meaning-making, not just reflections of use. Future research may expand upon this approach through longitudinal and comparative analyses, multi-platform data integration, or integration with ethnographic methods to further explore how publicness is imagined, practiced, and contested in contemporary cities.

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The age-friendly public city: initial reflections of a medium-size city as Bergamo

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Abstract
The demographic trend of aging is a global phenomenon, but it manifests differently across countries. Italy is one of the "oldest" countries in the world, and this phenomenon is even more pronounced in urbanized contexts. At the same time, in Italy, most people over 65 live in medium-sized cities, they continue to age at home and in their neighborhood (Aging in Place). This paper aims to present the first phase of the research funded by the Next-Generation EU initiative, titled "CASA Aging in Cities-Medium: How Housing Conditions and Urban Spaces Can Reduce or Increase Opportunities for Longevity in Health". The research develops a multiscalar and interdisciplinary analytical model to investigate how urban space influences healthy aging and neighborhood attachment, using Bergamo as a representative case of medium-sized Italian cities.

Keywords: Aging in Place, Elderly, Medium-sized City, Neighborhoods, Public Spaces

Introduction: the Role of Territory and the Spatial Dimension in Healthy Ageing

Between 2015 and 2050, the proportion of the global population aged 60 and over is expected to nearly double, increasing from 12% to 22%. By 2030, one in six people worldwide will be over the age of 60. According to recent estimates, the number of individuals in this age group will rise from 1 billion in 2020 to 1.4 billion, and is projected to reach 2.1 billion by 2050. The population aged 80 and over is also expected to triple in the same period, reaching 426 million (WHO, 2024). While global aging is a widespread phenomenon, it presents distinct patterns and challenges across different national and urban contexts.

The concepts of well-being and health are inextricably linked to the territorial dimension, and it was already in the first half of the 19th century that the role of spatial planning in contributing to the establishment of a democratic community became evident (Benevolo, 1963), particularly in addressing the public health issues posed by the emerging industrial cities. Urban planning also plays a pivotal role in this context, given the robust and intricate relationship between the built environment and the health of the elderly. The built environment encompasses factors such as community safety, accessibility to services and environmental quality, which have the capacity

to exert a substantial influence on the health outcomes of the elderly in terms of both physical and mental well-being.

A major recent study based on the UK Biobank (Argentieri et al., 2025) quantified the impact of environmental and genetic factors on the ageing, mortality and incidence of 22 age-related diseases. The study demonstrated that environmental factors have a greater influence on mortality risks than genetic factors (17% versus 2% of variation in risk of premature death can be attributed to environmental factors). Certain diseases, including cardiovascular, respiratory and hepatic pathologies, are significantly influenced by environmental factors, accounting for up to 49.4% of the observed variability. The most significant environmental factors associated with mortality include smoking, socio-economic status, physical activity, sleep quality, social isolation and air pollution. Spatial planning, therefore, plays a key role in promoting health and ageing, often overriding the contribution of genetics. This suggests that spatial planning interventions may have the potential to contribute to the prevention of disease risk, thereby facilitating healthy ageing. Additionally, the promotion of public policies that address socio-economic inequalities, promote healthy lifestyles and improve environmental conditions can have a significant impact on population health.

Italy, which is among the countries with the highest aging rates globally, is experiencing a faster demographic shift than much of Europe. This transformation is particularly evident in urban areas, where the effects of ageing are more pronounced. A considerable proportion of Italy's older population – that is to say, individuals aged 65 and over – reside in medium-sized cities and continue to age in place, remaining in their homes and communities. In such contexts, the spatial and functional organisation of urban environments exerts a substantial influence on the daily lives and health trajectories of older adults. It is crucial to recognise the pivotal role that public spaces play in either facilitating or hindering the routines, mobility, and social engagement of ageing populations.

This article presents the initial phase of an ongoing research project funded by the Next Generation EU initiative, titled CASA Aging in Cities-Medium: How Housing Conditions and Urban Spaces Can Reduce or Increase Opportunities for Longevity in Health. Specifically, the contribution delineates the theoretical and methodological approach that was used to develop a multiscalar and interdisciplinary analytical model to explore how urban spaces influence healthy ageing and the sense of neighbourhood attachment among older adults. The present research focuses on the city of Bergamo, in northern Italy, which is considered a representative case of medium-sized Italian cities. The objective of the present study is to shed light on the impact of urban structure on healthy ageing, and to examine the primary effects that high-quality urban environments have on older demographics.

The objective of the research is to understand the characteristics and effectiveness of public spaces in promoting health and social inclusion. This is achieved by integrating physical, functional, performance (in relation to climatic and environmental factors), and decision-making dimensions. The research also explores the barriers that limit the use of public spaces, such as extreme temperatures or physical obstacles. Moreover, the objective is to unveil the inherent heterogeneity amongst different neighbourhoods within a single city.

The Age-Friendly City

Healthy ageing is recognised as a global priority, as evidenced by the numerous initiatives of international bodies, e.g. The United Nations Decade of Healthy Ageing (2021-2030) (UN, 2020) emphasised the importance of the spatial dimension for the resilience of older communities, particularly in post-pandemic contexts. The Cities for All Ages project (OECD, 2025) reinforced the idea that urban infrastructure can (and should) be an ally of public health. The World Health Organisation's National Programmes for Age-Friendly Cities and Communities (WHO, 2023) also provide guidance on this topic.

The notion of age-friendly cities and communities (AFCC) was first introduced in the inaugural report published in 2007 by the World Health Organisation. The objective of the AFCC concept is to promote urban environments that encourage healthy ageing and to provide support for national programmes that are designed to create more

inclusive and all-age-friendly settings (Torku et al., 2020; Hoof, 2021). The objective of the project is to promote the well-being, health and social participation of older people, with a particular emphasis on enhancing active and independent living within their communities. The model's eight core areas of focus encompass outdoor spaces and buildings, transport, housing, social participation, respect and social inclusion, civic participation and employment, communication and information, and community support services and health. A number of studies have employed this model to assess the efficacy of initiatives implemented within specific territorial contexts. These studies have analysed urban policies and the experience of senior citizens (Perek-Białas et al., 2024; Ivan et al., 2024).

The planning of an age-friendly city is not only concerned with the elderly population; it also brings with it additional benefits, including those of pursuing sustainable urban development goals and fostering the implementation of social inclusion programmes (Han et al., 2021; Buffel et al., 2020). Furthermore, the development of smart cities as AFCC policies exploit technology and innovation (Hoof et al., 2021) is also a benefit. Concurrently, numerous challenges persist in the realisation of an age-friendly city, particularly those related to aspects of social exclusion and economic sustainability (Murtagh et al., 2021). A pertinent example of this phenomenon is the disparities observed between residing in urban and rural environments. It is an established fact that older populations tend to be more concentrated in rural areas. In addition, it is equally well-documented that rural areas tend to have lower income levels, less access to health and social services and higher levels of social isolation. These factors, it can be hypothesised, potentially contribute to the observed variations in health outcomes. A number of studies have indicated that the over 65s residing in urban areas demonstrate superior health in comparison to their counterparts residing in rural areas. The most recent Eurostat report has indicated that the over 65s residing in urban areas are believed to exhibit superior health in comparison to their counterparts residing in rural areas (Eurostat, 2023).

In the context of healthy ageing, it is also beneficial to take into consideration the changes to which the territory is subjected. Since the 1970s, and particularly in recent decades, the phenomenon of gentrification has been a subject that has attracted considerable attention. Indeed, the process of physical and socio-cultural transformation of urban neighbourhoods has been demonstrated to exert a strong influence on the elderly population (Santos et al., 2024).

Elderly People and Climate Change

The concept of 'ageing in place' must be contextualised within the most pressing global public health challenge of our time, namely climate change. It is evident that this crisis will have profound consequences for the health of the population, as it is already exerting a considerable impact on food systems, the increased spread of infectious diseases and growing risks for non-communicable diseases and mental health, rising temperatures, accessibility to certain areas, and extreme weather events (IPCC, 2022). While urbanisation has facilitated enhanced access to healthcare, it has concomitantly precipitated deteriorating air quality and the loss of green spaces. In this regard, the presence of urban greenery and Nature-Based Solutions (NBS) assumes particular significance, given their capacity to offer opportunities for physical activity, stimulate social interaction and community cohesion, and enhance the landscape. These factors have been demonstrated to exert a positive influence on mental well-being (Xu et al., 2023; Zhang et al., 2022). The aforementioned benefits are more pronounced in low-income populations, where green spaces mitigate urban heat islands and provide relief in areas with limited access to air conditioning. Urban planning that incorporates these factors has the potential to reduce inequalities and promote environmental justice, ensuring that all individuals have an equal right to robust environmental protection and to be informed and involved in decision-making processes.

Climate change has the potential to expose the elderly to a multitude of risks, including heat waves, floods, forest fires and air pollution. The impact of these risks on vulnerable populations is compounded by factors such as physical frailty, chronic diseases, social isolation and poverty (Prina et al., 2024; Hua et al., 2024; Gaugler, 2024; Dabelko-Schoeny et al., 2024; Katey & Zanu, 2024). For instance, the presence of urban green spaces has been demonstrated to play a pivotal role in the promotion of healthy ageing, offering a range of physical, mental and

social benefits that are especially pertinent for the elderly population. Individual and societal vulnerabilities have been shown to increase exposure to climate impacts, accelerating the ageing process and necessitating the integration of climate, environmental and social strategies into public policies. It is therefore crucial to promote adaptation approaches that recognise the active role of older people, not only as vulnerable individuals but also as resources for mitigation through their experience, knowledge of sustainable practices and ability to contribute to community initiatives. In this context, active ageing and climate resilience must be addressed in unison, with the involvement of older people in the construction of more inclusive, sustainable communities that are capable of coping with environmental challenges.

Walkability and its Barriers

Walkability, defined as the quality and accessibility of pedestrian environments, constitutes a vital element in the promotion of healthy ageing. For older people, walking is not only a means of transport; it is a fundamental activity that contributes to the maintenance of autonomy, physical well-being, cognitive function and social inclusion. However, the promotion of walking in old age necessitates the establishment of safe, accessible, continuous routes equipped with amenities such as benches, public toilets and green areas (He & He, 2025; Hu et al., 2025; Kim et al., 2024). A plethora of factors must be considered when assessing the walkability and appeal of a given space for older individuals. These include, but are not limited to, safety measures aimed at mitigating the risk of accidents and crime, the presence of wide pavements, the presence of street furniture, the variety of destinations along designated pathways, and the presence of aesthetically pleasing elements such as greenery. The importance of these factors in enhancing the walkability and appeal of spaces for older people has been extensively researched and documented (Appolloni & D'Alessandro, 2023; Bailey-Catalán et al., 2025; Knapskog et al., 2019).

Rising temperatures, exacerbated by climate change and the urban heat island effect (UHI), represent a significant barrier to the utilisation of public spaces by older people. As the global climate continues to warm, high temperatures have been shown to have a detrimental effect on the liveability of urban environments (Cheng et al., 2012; Alnimer et al., 2023). This is due to the fact that high temperatures can inhibit physical activity and outdoor sociability, both of which are fundamental to mental and physical well-being in old age. Excessive heat has been shown to act as an invisible barrier, with both physiological and psychological effects, which are accentuated in urban areas where temperatures can exceed those experienced in rural areas by more than 10 °C (Heisler & Brazel, 2010; Stone et al., 2010). This is due to a reduction in green areas, an increase in impermeable surfaces and anthropogenic emissions. The elderly are among the most vulnerable to the effects of heat, due to lower thermoregulatory capacity, reduced thirst perception and pre-existing chronic conditions (ASUGI, 2020; Ministry of Health & CCM, 2019).

Prolonged exposure to elevated temperatures has been demonstrated to induce a range of physiological responses, including dehydration, syncope, and heat stroke, which can result in an elevated risk of mortality (Ministry of Health & CCM, 2019; IIPH, 2022). In Italy, for instance, research has shown that the mortality rate on the hottest days can increase by up to 20.3% (IIPH, 2022). Furthermore, the impact of heat on mental health has been demonstrated to be a significant contributing factor to the prevalence of anxiety, depression and stress (IIPH, 2022).

In this context, urban design assumes a crucial role: shaded spaces, the presence of vegetation and reflective materials are effective interventions to improve pedestrian thermal comfort and make public spaces accessible even in warmer seasons (Nasrollahi et al., 2020; Jia & Wang, 2021; Huang et al., 2022). The promotion of outdoor living in temperate climates has been demonstrated to be a contributing factor to the maintenance of physical activity, social interaction and, consequently, the health of the elderly population.

Healthy Aging e Vulnerability

A key concept guiding this research is environmental vulnerability. Environmental vulnerability refers to the capacity of territories to suffer damage due to exposure to different types of stress, including environmental and social changes, and vice versa to the consequent lack of capacity to adapt to such changes. This vulnerability

is often the result of political choices and urban planning that has failed to listen to the needs of territories and populations, particularly the most fragile ones. Geographical studies have shown how such decisions contribute to significant disparities in health between different geographical areas (Anderson et al., 2025).

The concept of environmental vulnerability is multifaceted, with numerous factors contributing to its manifestation. The primary factors encompass the degree of urbanisation, as increasing populations migrate to urban areas, resulting in the loss of green spaces and elevated levels of pollution (Sheykhi, 2022). The organisation of urban space, the distribution of services, the quality of infrastructures, and the presence of green areas are not neutral elements, but rather determinants of the physical and mental health of the population, particularly the elderly (Xu et al., 2023).

Cities not only host but also shape the life experiences of older people, amplifying or reducing their risks, and to promote an improvement in quality of life during the ageing process, it is necessary to integrate health and psychological dimensions with spatial and environmental ones. From the perspective of the elderly, the issue of vulnerability has to be addressed in different ways, as a number of characteristics can be used to represent it (Channer, 2020). Low income, for example, which can be configured in terms of economic vulnerability, is a recurring factor in a number of cross-sectional studies aimed at representing the vulnerability of the elderly (Smeeding, et al., 2008; Stewart et al., 2011; Allan et al., 2011; Clarke e Gallagher, 2013). The comprehension of environmental vulnerability necessitates an investigation at multiple levels, including the examination of individual vulnerabilities (i.e. the physical and functional, the economic, and the social) as well as the environmental, institutional, and regulatory aspects.

Individual vulnerabilities encompass not only a potential decline in health, but also in mobility or cognitive abilities, as well as possible mood problems, possibly secondary to a problem of social isolation. Individual vulnerabilities are often compounded by environmental factors, leading to the perception of physical or psychological barriers in one's immediate surroundings. This can result in a sense of restriction in day-to-day activities. These factors have the potential to compromise security and independence, thereby increasing exposure to the risk of an ageing trajectory of frailty (e.g. falls, illness or isolation). As previously mentioned, economic vulnerability refers to the interaction between older people and their environment. This is characterised by a lack of financial resources, which limits the ability of older people to maintain or adapt their homes, access home care services, or meet the costs of daily living. The existence of insecure housing has a detrimental effect on the mental and physical well-being of individuals, giving rise to feelings of uncertainty and chronic anxiety. This, in turn, has a deleterious effect on the quality of life and can result in a trajectory of vulnerability to age-related frailty. Social and relational vulnerability, due to the loss of meaningful ties, withdrawal from community life or the absence of informal support networks, may need to be compensated by an AIP that has social infrastructures (community centres, transport, intergenerational initiatives) capable of supporting active ageing and, above all, of sustaining a culture aimed at promoting an assumption of responsibility by ageing individuals. As previously evidenced, the risk of social isolation and consequent feelings of loneliness can exert a detrimental effect on mental health (Nicholson, 2009).

Measuring Social Vulnerability and the Elderly Population

Vulnerability is an inherently probabilistic concept, expressing the degree to which an individual or group is exposed to harm, i.e. proximity to risk. This phenomenon does not necessarily result from a specific exposure or negative outcome; rather, it is the cumulative outcome of a combination of interdependent factors. These factors include the risk of exposure to a threat, the risk of that threat materialising, and the risk of not having adequate resources to deal with it (Schröder-Butterfill and Marianti, 2006). Consequently, elements such as variability in the probability of exposure, the scope and frequency of threats, and differing capacities to respond and adapt, contribute to varying degrees to determine both the likelihood of negative outcomes and their possible severity. The dimensions of vulnerability have the capacity to interact with each other in a compensatory manner or to reinforce each other, thereby generating different levels of vulnerability with regard to proximity to harm and its intensity. Furthermore, in specific contexts, certain of these dimensions are closely intertwined. For instance,

consider the link between exposure and threat, where it is the context itself that generates the risks and defines who is exposed to them. It is therefore the case that vulnerability is not a static attribute; rather, it is the product of individual and collective life paths. In this sense, past experiences influence the present conditions of exposure and the available "defence" strategies.

The increasing tendency of the population to reside in urban areas is often linked to manifestations of socio-economic disparity, including inequitable access to services, resources, employment prospects and educational opportunities. In this context, the configuration of urban space assumes a key role in determining the living conditions of citizens and their ability to overcome situations of deprivation, both material and social. Consequently, the mapping of social vulnerability, with particular emphasis on its spatial distribution, emerges as a core instrument to enhance comprehension of the population's characteristics and to discern the urban areas most susceptible to social, economic, environmental and epidemic hazards.

Social vulnerability is defined as a condition of deprivation across multiple levels, involving different aspects of daily life and exposing the population to risks related to natural, environmental, socioeconomic and epidemic factors (Davino et al., 2021). These factors encompass job instability, unemployment, inadequate education, substandard housing conditions, overcrowding, domestic violence, chronic diseases, addictions, insufficient access to healthcare services and disabling conditions. This is a complex concept, which requires a synthetic representation through a composite index, capable of integrating a series of elementary indicators through a multidimensional approach. The seven principal dimensions that must be given full consideration for the purpose of constructing the composite index are as follows: housing conditions, social context, social relations, education, labour market, mobility and economic well-being.

The condition of vulnerability that may accompany ageing is not a marginal phenomenon, nor is it univocal. Rather, it recalls a multiplicity of complex and interconnected dimensions, involving individual, relational and contextual aspects. Indeed, the elderly person is confronted with transformations affecting both personal resources and the social and institutional environment in which they are embedded, in a process in which fragility and resilience coexist (Schröder-Butterfill and Marianti, 2006). A plethora of studies have emphasised the central role of social relationships, health and mobility, economic resources, social participation and the quality of the living environment, such as the presence of safe and perceived pleasant neighbourhoods, in the well-being of the elderly (Gabriel and Bowling, 2004).

Vulnerability in the elderly can manifest in various forms, including the fear of premature or degrading death, the absence of adequate physical and health care, the excess or intrusiveness of care, economic disadvantage, social exclusion, loneliness, loss of autonomy, the risk of institutionalisation or homelessness (Schröder-Butterfill and Marianti, 2006). A considerable number of studies have sought to quantify social vulnerability by constructing composite indices. However, the majority of existing indices have been developed for the general population, with only a small number having been designed specifically for the elderly population (Chau et al., 2014).

How to Measure Age-Friendliness and Sustainable and Inclusive Well-Being

In recent years, the reflection on social vulnerability has broadened, moving away from the analysis of structural disadvantage or exposure to critical factors alone towards a more articulated assessment of the extent to which the urban environment favours active, autonomous and healthy ageing.

In this perspective, the studies adopt the age-friendliness paradigm, as promoted by the work of the World Health Organisation (WHO, 2015). These studies aim to assess the extent to which cities are able to respond to the specific needs of the elderly population. Consequently, the emphasis has transitioned from the mere identification of vulnerability to the evaluation of inclusivity within urban contexts. This shift in focus entails the consideration of factors such as accessibility, engagement, subjective well-being, and social cohesion. In the initial document disseminated by the WHO, a methodological framework is proposed for the assessment of urban areas' capacity to cater to the requirements of the ageing demographic. The objective of this study is twofold.

Firstly, it seeks to monitor the implementation of policies inspired by the age-friendliness paradigm. Secondly, it aims to offer a practical tool to support local governments, practitioners and communities in improving the quality of life in urban settings. The system is predicated on a structured set of core indicators, with the potential for supplementation by additional indicators, depending on the local context.

The indicators are divided into three main thematic areas: the first is the accessibility of the physical environment, which includes variables such as the presence and condition of pavements, the availability of public transport and its accessibility, the accessibility of public buildings and the cost of housing in relation to the income of the elderly. Secondly, the inclusiveness of the social environment is considered, with aspects such as participation, perceived respect, involvement in decision-making processes, economic security and access to social welfare services being taken into account. The final component pertains to the impact on the quality of life, in terms of well-being and perceived health. These three dimensions are complemented by equity indicators that detect inequalities between groups of older people according to age, gender, income, geographical area or level of education. The construction of the indicators is based on two main sources of information: local administrative data and surveys on the elderly population. The latter are also useful in capturing the subjective component, such as satisfaction with services and perception of safety. The integration of objective data and subjective perceptions is a key strength of the proposed model. The primary benefits of this approach are threefold. Firstly, it enables the comparison of areas within the same city. Secondly, it facilitates the monitoring of the evolution of age-friendliness over time. Thirdly, it identifies local criticalities.

The interest in more articulated measurement tools is not limited to vulnerability and age-friendliness but extends to the broader concept of sustainable and inclusive well-being, as demonstrated by the growing number of studies that, since the report by Sen, Stiglitz and Fitoussi (2009), have contributed to the development of multidimensional indices. These approaches seek to circumvent the limitations of conventional economic measures by incorporating social, environmental and territorial dimensions, whilst concomitantly focusing on spatial phenomena, local inequalities and interconnections between geographical areas.

The CASA Project

It is from these premises that the CASA (Aging in Cities-Medium: How Housing Conditions and Urban Spaces Can Reduce or Increase Opportunities for Longevity in Health) project was developed, a programme funded by the Next Generation EU initiative. progetto finanziato da Next Generation EU.

The CASA project is an academic initiative that aims to enhance the understanding of the multifaceted dimensions of housing and urban vulnerability in medium-sized Italian cities. A key objective of the project is to analyse the relationship between urban characteristics and the trajectories of potential ageing in senior citizens. The research adopts a case study approach, focusing on the Municipality of Bergamo as a model example. This municipality is notable for its clearly defined spatial, social and institutional characteristics, which serve as a benchmark for understanding urban dynamics. It is regarded as a prototypical “average city,” offering a useful framework for developing analytical and interpretative models that can be applied to a range of urban contexts.

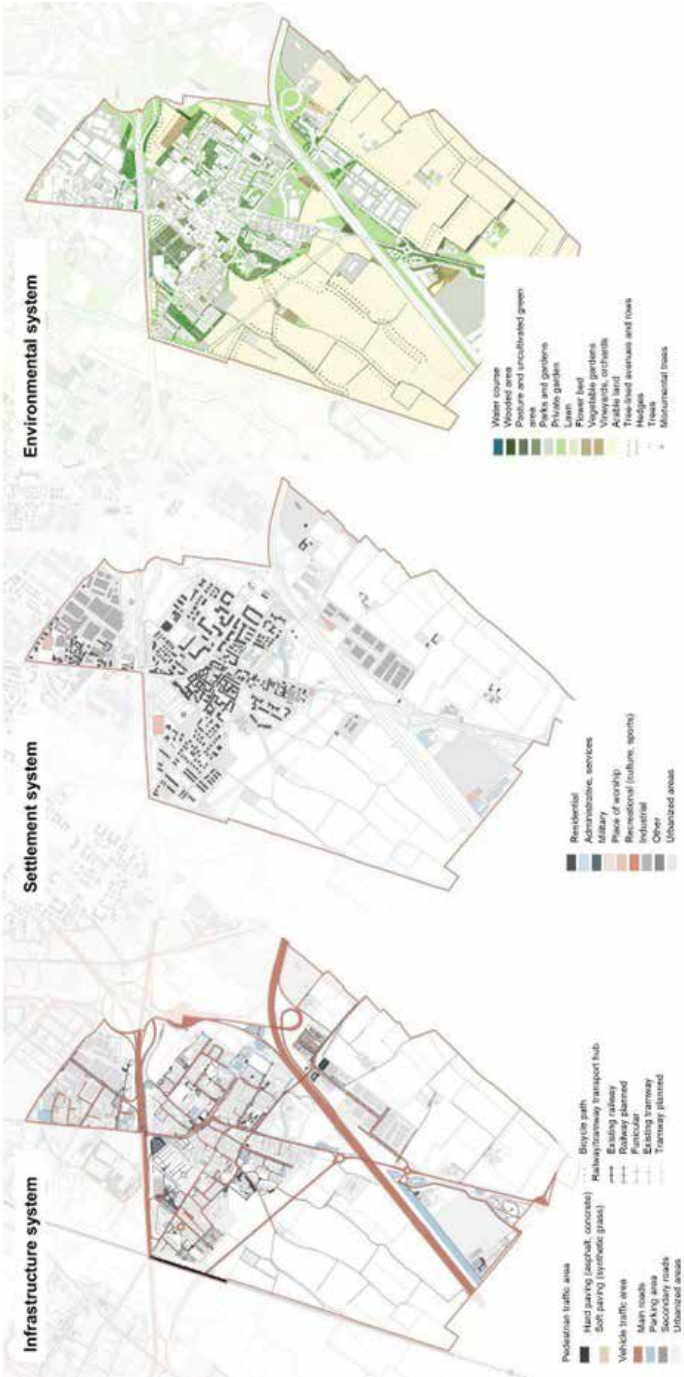
The project identifies a series of socio-economic, socio-demographic and spatial indicators, both at urban and suburban (district) level, referring to the case study of Bergamo. The initial phase of the project entailed the integration of various databases, including municipal ISTAT data, hospitalisation data from the Ministry of Health, and municipal data, among others. A survey is being conducted among the elderly population residing in the municipality, with the aim of understanding the motivations and factors that have influenced their selection of living places for their ageing process. In order to analyse the settlement characteristics of the municipal context and the spatial organisation of the neighbourhoods, reference is being made, above all, to municipal and regional level databases (Open Data and the Geoportal of the Lombardy Region), given the level of detail to be guaranteed. Other national and European sources may be utilised to support and supplement the analysis. These explorations are conducted with the aim of dealing with different thematic levels (e.g. main functions of the building fabric, organisation of public spaces and equipment, mobility networks, ecological-environmental

system) both in order to recognise the characterising elements and conditions of the Municipality of Bergamo, as a city taken as an ideal type and territorial model of reference, and to identify the specific features of each district treated. In the recognition of the settlement characteristics of the spatial areas under analysis, particular attention is paid to the elements and conditions responsible for the worsening of conditions of vulnerability towards the elderly population.

In accordance with the theoretical framework delineated above, a number of key elements for analysis are identified. The factors associated with housing vulnerability can be categorised into three distinct groups: structural factors, which include characteristics such as dwelling size, age, isolation, and security; access to services, which encompasses amenities such as pharmacies, parks, meeting centres, and public transport; and the interplay between vulnerability factors and well-being, encompassing aspects such as psychophysical health and longevity. The spatial analysis is divided into two complementary elements. Firstly, the municipal focus analyses municipal data, demographic and housing-urban variability, and identifies synthetic indicators of vulnerability. Secondly, the focus at the detailed geographical unit is based on the scale of the 22 neighbourhoods of the municipality of Bergamo (Figure 1). Here, the indicators are refined, recording aspects of housing-structural type and access to services and risk conditions. As anticipated, ground temperatures (Figure 2) and ecosystem services (Figure 3) are considered at the neighbourhood scale.

The CASA project aims to achieve an in-depth understanding of the conditions and needs that older persons have in relation to the places where they live and how this relationship may determine longevity in health in average Italian cities. The result of the research will be the production of vulnerability indicators for individuals who experience ageing in their living places on a daily basis. These indicators and their relationship to health will be used to inform elderly people and policy makers with a view to proposing innovative Aging in Place policies.

Figure 1: Three analytical maps of the neighbourhood (infrastructural, settlement and environmental system). a. Infrastructure system: this map illustrates the main mobility and connection infrastructures in the neighbourhood: the main roads and connecting axes are highlighted in dark red, such as roundabouts and strategic crossroads, and the connection with the railway network and suburban roads is also highlighted, indicating the overall accessibility of the area. Infrastructure has a significant impact on the neighbourhood, creating numerous caesuras. b. Settlement system: represents the organisation of the built-up area in the neighbourhood in which densely built-up areas (residential and productive) are shown in dark grey; low-density areas (such as scattered housing or recent expansion) are in light grey. Urban voids, unbuilt areas and residual spaces are noted, which are fundamental for possible urban regeneration strategies. c. Environmental system: map dedicated to natural and environmental elements to highlight ecological corridors and linear vegetation along infrastructures, which play a relevant ecological and landscape role.



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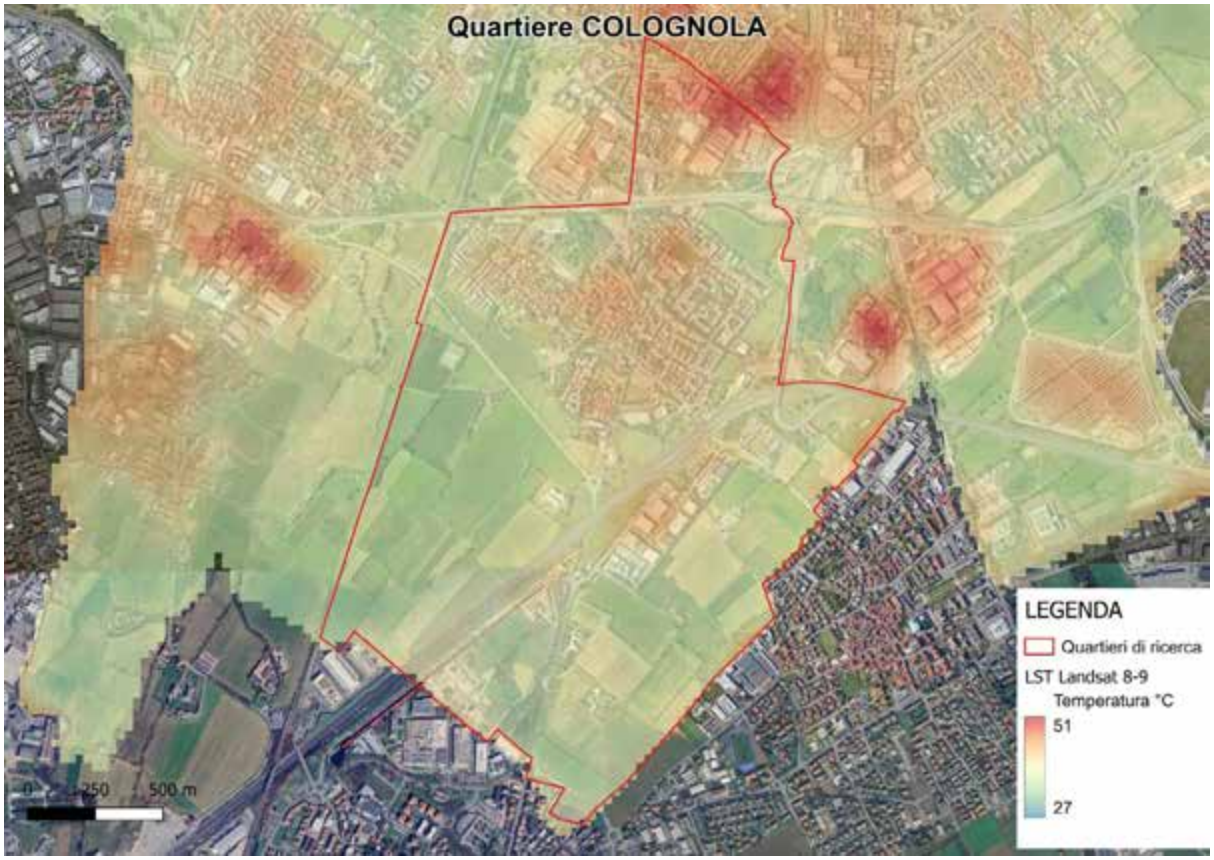

Figure 2: This map depicts the distribution of the ground surface temperature in the Colognola district: the red areas reach high temperatures (up to 51°C), typical of asphalt surfaces, industrial areas and compact urbanisation, which are subject to the heat island effect. The yellow/orange zones indicate intermediate temperatures, often associated with mixed surfaces of buildings and vegetation. The blue areas are the coolest (around 27°C), often coinciding with green areas, parks or agricultural fields. This map makes it possible to assess the critical climatic conditions in the neighbourhood and suggests the importance of mitigation measures through an increase in green areas.

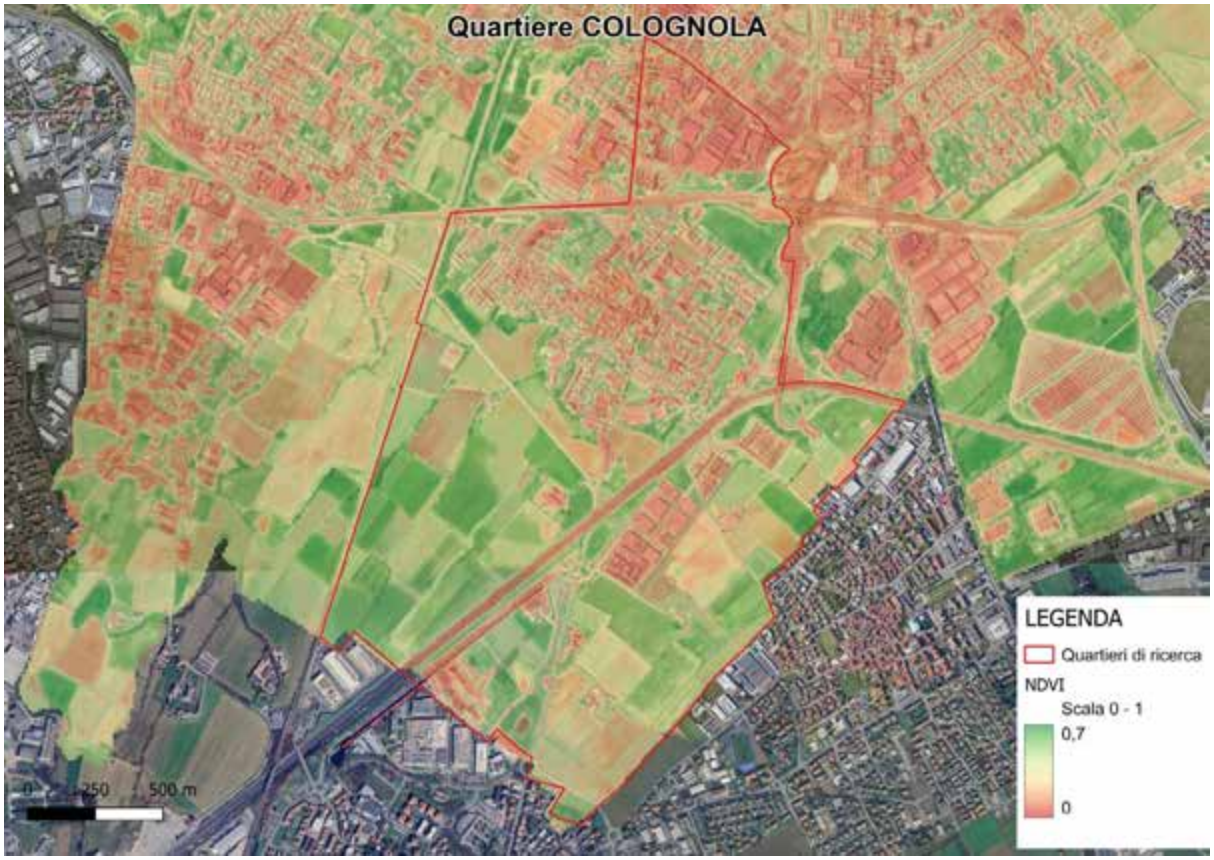

Figure 3: The map shows the vegetation vigour index in the Colognola district. The NDVI varies from 0 to 0.7, where dark green areas indicate lush and healthy vegetation, typical of parks, active agricultural areas or wooded areas; red areas show heavily urbanised or sealed areas, lacking significant vegetation (NDVI ≈ 0); intermediate shades (yellow/orange) represent medium vegetation, such as gardens, hedges or scattered trees.

Conclusion

The rapid ageing of the global population highlights the importance of urban planning and the built environment in promoting healthy ageing. Environmental factors significantly impact the health of the elderly, demonstrating the potential of spatial planning interventions to prevent disease and promote healthy ageing. Italy is experiencing rapid demographic change, particularly in cities, and the organisation of urban environments influences the daily lives and well-being of its population. Public spaces play a key role in this respect, either favouring or hindering the mobility and social engagement of elderly populations.

This paper outlines the initial stage of the CASA project, which examines how urban spaces impact healthy ageing and neighbourhood attachment in medium-sized Italian cities, using Bergamo as a case study. The research aims to understand the impact of urban structure and environments on elderly people, focusing on the effectiveness of public spaces in promoting health and social inclusion while identifying barriers to their use and recognising neighbourhood heterogeneity.

'Ageing in place' is considered in the context of climate change, which poses significant health risks for older people due to rising temperatures and extreme weather conditions. Urban greenery and nature-based solutions (NBS) are vital for encouraging physical activity, social interaction, and mental well-being, particularly in low-income areas. Walkability is vital for the independence and health of older people, yet rising temperatures and the urban heat island effect can hinder outdoor activity and social interaction. Therefore, urban design interventions are essential to improve thermal comfort and accessibility.

A key concept in this research is environmental vulnerability, which describes territories' susceptibility to environmental and social changes. This is often exacerbated by urban planning that neglects the needs of vulnerable populations, inevitably leading to inequalities. This includes individual vulnerabilities (e.g. declining health and social isolation), economic vulnerability (e.g. lack of financial resources) and social/relational vulnerability (e.g. loss of social connections), all of which can be exacerbated by environmental factors. Social vulnerability is measured using an index incorporating factors such as housing, social background, education and economic well-being.

Rather than simply identifying vulnerability, the research assesses urban inclusiveness for active, autonomous and healthy ageing, in line with the WHO's friendly age paradigm. This involves assessing accessibility, engagement, subjective well-being and social cohesion using a framework of indicators and local administrative data, supplemented by surveys of elderly people to obtain objective and subjective perceptions.

Based on these principles, the CASA project aims to gain an in-depth understanding of the conditions and needs of elderly people in relation to where they live, and how this affects their longevity and health in Italian cities. By integrating different databases and conducting surveys in Bergamo, the project identifies socio-economic, socio-demographic and spatial indicators at the urban and neighbourhood levels, focusing on factors that exacerbate vulnerability. Ultimately, the research will produce vulnerability indicators for the elderly, providing crucial information for both this demographic and policymakers to develop innovative 'ageing in place' strategies.

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Public Drinking as a Transformative Practice of Placemaking

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Abstract
Global economic instability is reshaping everyday practices, with public spaces increasingly reflecting this transformation. As rising alcohol prices impact traditional forms of socializing, communities are turning to public drinking as a more affordable alternative. More than just alcohol consumption, public drinking acts as a form of placemaking, transforming streets into social hubs. This study explores the public drinking through "heterotopia" and "third place" theories, focusing on Dr. İhsan Ünlüer Street in Istanbul. Using observation method, the research investigates how the street has shifted from a space of transit to a dynamic site of gathering while also accommodating both unity and conflict.

Keywords: Public drinking, Heterotopia, Third Place, Place making

1.Introduction

Placemaking plays an important role in fostering relationships that enhance social capital and economic opportunities. The way the space is positioned, the location, the spatial attributes of space can be welcoming for new actions and eventually it constructs the place. Today, there are various theories about place, but one of the most significant focuses on maintaining social cohesion and fostering new social capital. As one of the most important examples, Ray Oldenburg published his book The Great Good Place in 1989 and stated that people have places 1. work and 2. home but beside them people also need third places to keep our sanity. As social entities, we need places to bond ourselves with others, or even nature. This third place theory became today's one of major topics in public space to remind ourselves why we need these other places.

1.1.Third Place

In the book, Oldenburg (1989) continues with defining attributes of a 3rd place. Firstly, these third places should have a neutral ground, citizens should be able to come and go whenever they wish. This publicity welcomes all groups of people in public space so the place is always open to new coincidences, and diverse groups feel relaxed to open themselves in this neutrality. Secondly, third place is a leveller. There is no barrier to enter these places like social or economic status, so the social hierarchy is not welcomed in these places. Thirdly, these places have engaging conversations, the primer activity in third place is conversation therefore creating new social bonds. The environment of these places encourages people to communicate rather than hiding in the corners. Moreover, third places are accessible and accommodating, they are open to all so there is no barrier to enter these places. Third places have regulars who make newcomers feel in a welcoming atmosphere and create more regular bonds in the community. These places' decor is warm and it stays away from making people feel like they are in a serious place like work etc. And finally, these places have a light-hearted atmosphere, encouraged with humour and playful conversations. To sum up, third places are such good options to nurture bonds in isolated society. Moreover, these places not only create social bonds but also help to increase productivity of societies by practising non-formal knowledge sharing (Fowler, n.d.).

Today, the existence of third places is more important than ever before for the ability of gathering people from different kinds of groups. Because feeling lonely is becoming a vital issue in societies with the increased usage of social media. According to a survey result from a Health Company in Australia, 41% of young people feel lonely when they see others' social media posts (Hislop, 2024). Likewise, it has been stated that social media has the potential to increase loneliness as it replaces the time devoted to social relationships in the real world (Jia et al., 2024). Addition to these effects of social media, today people are more mobile, communities are shrinking and isolation is increasing while socio-economic problems are emerging. That is why there needs to be more third places in the urban place and people tend to create their own places to relieve these damaging impacts.

In addition to these sources, UNESCO also supports the creation of third places by giving cafes as an example (Oldenburg & Christensen, 2023). Using cafes to work make them more than a place for consumption but also a place for connection, Oldenburg and Christensen claim. However, some states that the concept of third place is not valid for coffee shops since they have already evolved to a place for work (Sandiford and Divers, 2014; Ferreira et al., 2021). Moreover, if somebody wants to work in that coffee shop, proper outfits and some money to spend is mandatory, which makes coffee shops opposed to the idea of accessibility of third spaces. These debates show that third places have fluid characteristics and they overlap different usages from time to time. This function changing is actually connecting third places to another important place theory: heterotopias

1.2. Heterotopias

People want to see the ideal space they dream of in their lives, meaning they wish to reach utopias; however, by their very nature, these utopias are impossible to achieve. To avoid the opposing situations or threats of these utopias as much as possible, they have created heterotopias. Heterotopias, or "other spaces," were first mentioned by Foucault in his architecture lectures and later entered the literature through Of Other Spaces (Foucault & Miskowiec, 1989), leading to various speculations about urban space. Foucault used this term in a spatial sense, but originally, it was a term used in medicine for organs that are not in their proper place. However, after Foucault's analogical approach, heterotopias can now be seen in different fields, such as social sciences, where they are used in the context of migrants (Chambers, 2005; Göker, 2017).

Foucault explains his interest in spatial context by stating that the era he lived in had become the epoch of space. In the Middle Ages, spaces were divided only into religious and workplace settings or into urban and rural areas, whereas today, we witness simultaneous juxtapositions. According to him, these spaces derive their meanings solely from the social interactions they encompass, and based on this, he defines spaces as utopias and heterotopias. These heterotopias disrupt the continuity of everyday life, challenge uniformity, and sometimes emerge as unplanned spaces. According to Göker (2017), these spaces also demonstrate resistance against authority. This claim may not cover the definition fully when thinking about examples that Foucault gave. For example, crime stands opposite to an utopia and prisons were developed against the anti-utopian notion as the heterotopia by the authorities. So, heterotopia can be expected from every part of every culture. This brings us to the first of the six principles of a heterotopia. These principles were defined to distinct heterotopias because even though we experience them in the urban space so frequently, not every place is a heterotopia.

First principle states that heterotopia is a default attribute and every culture have its own heterotopias, which divides them as crisis heterotopias and heterotopias for deviation for primitive and modern societies. Foucault says crisis heterotopias are spaces created to manage the crisis, like exclusive, sacred or forbidden areas. He gives boarding schools for boys as an example since these schools hide the manifestations of sexual virility or honeymoons to hide “deflowering” of young women from the other part of the society. But in time, these crisis heterotopias have left their place to heterotopias for deviation with modernized society. These are places for hiding people who have deviated from the society somehow. Old age is a crisis according to him but in time it changed to a deviation and retirement houses are used to hide this deviation. Just like retirement houses, psychiatric hospitals and prisons are now places for deviation, for hiding one's from society.

Second principle states that the heterotopia can change in time with different functions according to different cultures. For example, cemeteries used to be in the centre, the sacred heart of the town but in time they were pushed out of the city and turned into other-place where people suffer their own miseries far away. As the third principle, heterotopias can juxtapose multiple incompatible places in one space and overlap them, like theatres or cinemas, places where we can see multiple scenes in one night from a box. Fourth principle of heterotopias is that they are most often linked to slices in time. These places can link ancient times with modern projects in museums or libraries, also these places can extinguish time temporarily or create new definitions of time, like festivals. Another principle of a heterotopia is they have the ability to open to penetrate and close to isolate others. To enter a prison, the person should commit a crime and need to obey the system or to enter a hospital, the person should be sick and have insurance. These are solid examples of penetration and isolation but Fouca-

ult also claims that there exist fully open heterotopias but in fact, deep down, they have invisible mechanisms that prevent everyone from penetrating the place. Everyone can get in these places but this is just an illusion for them, they have just been excluded. Lastly, heterotopias "have a function in relation to all space that remains" (Foucault & Miskowiec, 1989). Heterotopia creates two poles in the place: one is creating an illusion that exposes all remaining space, the other is creating another real space that is as perfect as our place is irregular, messy.

To sum up, both third place and heterotopia theories create revolutionary ways of seeing public space and they overlap from time to time in different places of urban areas. While both theories embrace some features of the constructed space, they indicate quite different approaches in some aspects. For example, fluid characteristics of a third place refers to heterotopia's 3rd principle, but at the same time, the welcoming nature of third places is contradictory to partly openness of heterotopias. From Foucault's examples, we see that there are numerous heterotopias and also third places, additionally, new types of them are emerging day by day with the evolving needs of society like coffee shops, even social media (Göker, 2017).

In the light of these indicators given by the literature, this study has endeavoured to search for an unobserved other-place for Istanbul. This other-place created by public drinking practices on the street has been analysed through observation and the intersections with these two theories have been examined. For this purpose, the transformation of two different streets from both shores of Istanbul into a third space has been investigated.

2. Dr.İhsan Ünlüer Street, Kadıköy

Dr. İhsan Ünlüer Street, intersecting with Kadife Street—Kadıköy's most famous drinking spot—is lined with numerous bars. However, most people purchase alcohol from a kiosk at the street's corner. Since the 2000s, rising alcohol prices and an inflationary economy have made dining and drinking out increasingly expensive in Türkiye. In response, this kiosk has become a gathering spot where middle-income adults get tipsy at a lower cost before moving on to their main venue. It has also evolved into a social hub for university students, offering an alternative space for those who cannot afford drinks in pricey bars but still create their own social capital.

Figure 1: Bars, kiosks and the flow of crowded

The observation study in this area was conducted in January between 9:30 - 10:30 PM, with the temperature at 3°C. Before arriving, it was assumed that the cold weather would keep people indoors and that the street would be empty. However, the results of the observation serve as clear evidence of how strong the third space created by Dr. İhsan Ünlüer Street truly is—the street was bustling with people.

Figure 2: People hanging on Dr.İhsan Ünlüer St. next to the kiosk

After 10:00 PM, people who bought alcohol from the kiosk spread out into distinct groups along the street. The densest crowd gathers at the opposite sidewalk of the kiosk at the entrance, and gradually gets spare further up the street. Every available space becomes a spot for socializing over drinks—even the staircases of buildings have turned into informal drinking spaces. University students, often dressed in dark colours, leather jackets, or second-hand clothing, stand in small groups. While they socialize within their circles, they also interact with others who share their broader social habitat. Sometimes people initiate conversations with strangers; sometimes groups merge due to the energy of the crowd and the social ease facilitated by alcohol. The street has become a symbolic space for these spontaneous connections.

On the night of the observation, a group of young people distributing food in memory of the late filmmaker David Lynch's death humorously reinforced this symbolism. It is no coincidence that they chose Dr. İhsan Ünlüer Street in Kadıköy for this niche act. A gathering place for avant-garde, non-mainstream, and marginal groups, this street amplifies social interactions not around a table, but on the sidewalk, driven by the courage that alcohol brings and the collective experience it fosters.

Figure 3: Food sharing in the memory of David Lynch

Young people who buy their drinks from the kiosk at the corner position themselves by leaning against the building walls. The sidewalk is designed to be level with the road, with bollards placed to distinguish the pedestrian area from the vehicle path. Despite being on the same level, these bollards seem to create a psychological sense of boundary for the groups, as their spread naturally stops at these markers.

Figure 4: Standing positions on Dr.İhsan Ünlüer street

The street accompanies multiple groups at the same time. These include individuals or small groups with 2-3 people who gather for pre-drink before heading to the main bar, standing groups of 2-5 who's next destination remains uncertain and crowded long term visitors that can be understood by their sitting on the stairs or the pavement. A key distinction emerges among these groups: their age. While this is not a surprising finding, it can be said that the primary demographic of Dr. İhsan Ünlüer Street's social habitat consists of young people aged 18–25. Although these young people are in space for a long time, they prefer to sit in a circle, closed off from the outside world, so the openness of this group is questionable. In contrast, standing groups, though often also forming a circular arrangement, remain more mobile and accessible to others. This mobility allows for temporary interactions—whether through flirtatious glances exchanged from a distance or through the chemistry of being

in a crowded (Baum & Paulus, 1987; Altay, 1999) space, where alcohol encourages temporary social bonds.

Yet, alongside this sense of collective belonging, this other-space also generates contradictions. Empty bottles are left scattered on the sidewalk, and groups sitting on staircases block the movement of residents, effectively occupying semi-public spaces and stripping locals of their everyday spatial justice. On the other hand, with the solution found by the locals, a completely different area is gradually being formed all over Kadıköy today: stairs with iron fences. These newcomers, who find a place for themselves as the others, create noise, dirt and carelessness for the locals. From this point of view, this heterotopia also evolves into a **place of conflict.**

Figure 5: stairs with iron fences

2.1. Dr. İhsan Ünlüer Street as a Third Place

These findings indicate that all gatherings in Dr.İhsan Ünlüer Street make this street a third place. Firstly, this street welcomes everyone from diverse economic and social groups, like student and middle-income pre-drinkers, and there exists no hierarchy between them. The kiosk makes the street a neutral ground for gatherings and drinking practice, which makes the street a third place as a leveller. Additionally, there is no physical barrier to enter the street. This street is accessible and accommodating for everyone (partly, due to contradicts between locals and public drinkers). It engages new conversations in a playful mood, as seen in the example of the David Lynch memorial. With the help of alcohol, most people are more welcoming than regular times here, but it should be kept in mind that people may feel more relaxed since they believe that they are with people just like them, harmless, standing just for a drink. As another evidence, this place is low profile with murals on the wall, dogs on the street, no extra effort has been made here. There is no clue of any regulated space feeling, moreover, vandalism through graffiti can be mentioned.

Apart from these, due to the methodology, it cannot be said that there are regulars in the place. Maybe bodyguards of nearby bars can be mentioned as regulars but they are not part of drinking / gathering activity. Besides, due to the methodology's limitation, information on whether they feel cosy and at home cannot be obtained. Still, other findings show that this street is highly a third place.

2.2. Dr. İhsan Ünlüer Street as a Heterotopia

The street is for accessibility at first, but in time, it becomes a gathering place temporarily with the help of alcohol. This juxtaposition is observed nearly every night in the street and in the day, everything turns into regular.

Indeed, this place shows the third principle of a heterotopia. In addition, this street might be a place for deviation for low income students who cannot find a proper place to drink which refers to the first principle of being a heterotopia. This time dependent gathering in the street may also change the perception of time especially for long standing people. The night has just started and everything will be decided according to the drinking practice, while people are having fun, time flies. For these reasons, the street shows the fourth principle of heterotopias. Lastly, this street has no barriers, everyone can enter and stand, it looks fully open but deep down, the person needs some qualifications to join this gathering. The way one dresses affects how much people are going to interact with him/her. If the person is too old, or too mainstream, it is a low possibility to feel like he/she is a part of this gathering. This reflects the fifth principle of heterotopias but when being open is the issue, this street never fully encompasses it. This partly closeness also brings new social capitals in the groups. When a girl looks at a boy who dresses just like her (with piercings and dark leather jackets), she creates her categoric knowing about him and being ready to know more about him. This prior knowledge opens up new networks and new relationships.

4. Conclusion

The initial motivation for this study came from an interest in examining the gathering dynamics of different socio-economic groups shaped by two distinct practices on either side of Istanbul: one involving alcohol purchased from a market/kiosk, and the other involving alcohol bought from a bar and consumed out on the street. On the European side (Ahmet Fetgari Street, Şişli), it was previously observed that a newly opened bar initially attracted young people and created a significant gathering space in front of it. However, after the field observations, the bar lost its popularity, and the street no longer fulfilled this gathering function. In contrast, Dr. İlhan Ünlüer Street on the Asian side has consistently maintained its character as a public and "third place" throughout all seasons. This continuity is grounded in the economic rationale behind the street-drinking practice—namely, buying the cheapest alcohol from the kiosk—which makes the space more sustainable as a site of communal activity.

Dr. İhsan Ünlüer Street has become the most famous street for public drinking in Kadıköy in recent years, thanks to its location and the convenience of the corner kiosk. With this high demand, the street has transformed into a potential space for various social gatherings. Its spatial characteristics—such as being right across from Kadıköy's well-known marginal bars like BİNA and Arka Oda, its proximity to other famous bars like Karga and Lal, and the availability of alcohol from the corner kiosk even after 10 PM—make it a frequent choice for middle-income young adults. These factors trigger group behaviour, attracting student groups who prefer not to drink in bars to gather in this space.

As a result of these gatherings, the street, originally designed for transportation, has come to serve a dual function: as a third place that fosters social interactions and as a heterotopia that disrupts conventional spatial norms. This dual identity highlights the fluidity of urban spaces. This transformation has created a public space that fosters the accumulation of social capital, which is essential for the continuity of society.

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The Italian Integrated Water Service as a Promoter of Soil Desealing Processes

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Abstract
Urban soil sealing exacerbates climate change impacts by disrupting the hydrological cycle and increasing flood risks. This paper examines how Italian Integrated Water Service Companies are promoting soil desealing to enhance urban resilience and environmental sustainability. Case studies of MM S.p.A., Gruppo CAP, and BrianzAcque in Lombardy reveal a strategic shift towards implementing Nature-based Solutions and Sustainable Urban Drainage Systems, such as depaving and bioretention areas. Regional policies, like Lombardy's hydraulic invariance principle, and national funding are crucial enablers. While promising, the limited geographical spread of these initiatives underscores the need for broader national adoption and supportive policy frameworks.

Keywords: Integrated Water Service Companies (IWSCs); Nature-based Solutions (NbS); Public spaces; Soil Desealing; Urban resilience

Introduction

The contemporary world is being impacted by the adverse consequences of climate change. The causes of this phenomenon can be attributed to the increase in anthropogenic greenhouse gas emissions (IPCC, 2023). Urban systems have been identified as both the largest generators of these climate-altering gases and the most adversely affected by them (Short & Farmer, 2021). The phenomenon of rising global temperatures, a consequence of climate change, exerts a direct influence on the hydrological cycle. The global nature of the water cycle is evident, yet the utilisation of this resource, its supply, and the associated conflicts are inherently localised phenomena (Menga, 2024). This alteration in the hydrological cycle has been shown to result in increased precipitation intensity and frequency (Trenberth, 2011), leading to flooding and periods of severe drought (Hunt & Watkiss, 2011). This dynamic results in alterations to the distribution of water between the water table and the surface, which in turn has direct consequences for erosion, runoff and water stress experienced by plants (IPCC, 2022).

The disruption of the water cycle is exacerbated by soil consumption, i.e. the expansion of infrastructure and urban areas at the expense of the natural and agricultural systems (European Commission, 2012). A considerable proportion of the soil that is consumed is also sealed. Soil sealing can be defined as the process by which soil is permanently covered by an impermeable artificial material (European Commission, 2012). The impact of soil consumption and soil sealing on water resources is multifaceted. It leads to a reduction in infiltration and increased runoff resulting in an overloading of the sewage system. Secondly, it contributes to a decline in biodiversity both above and below the soil. It also reduces the soil's capacity to store carbon and evapotranspiration. Finally, it disrupts the chemical and biological binding of microorganisms (European Commission, 2012). In 2022, Italy's soil consumption, expressed as a percentage of the total area of "usable" soil in the country, was recorded at 10.16% (SNPA, 2024).

A variety of techniques have been developed for the purpose of enhancing the management of the urban water cycle within urban systems. In particular, Nature-based Solutions (NbS) and Sustainable Urban Drainage Systems (SuDS) have been identified as playing a pivotal role. Nature-inspired solutions (NbS) are defined as interventions that offer multiple benefits with the potential to address environmental challenges (Sowińska-Świerkosza & García, 2022). In addition to economic and environmental benefits, they have the capacity to generate positive externalities from a social perspective (Haase et al., 2017; Bockarjova et al., 2022). SuDS are systems that utilise natural processes, green infrastructure and traditional infrastructure to collect, infiltrate, store, convey and treat rainwater at the location where precipitation occurs (Davis and Naumann, 2017). These natural technologies have the potential to mitigate the impacts of climate change in urban areas, including rising temperatures, flooding risks and droughts (Hobbie and Grimm, 2020). Furthermore, these interventions contribute to increasing the quantity and quality of urban public spaces.

The present contribution aims to explore the ways in which the actions and projects of Integrated Water Service Companies (IWSCs) can promote public space initiatives that enhance resilience to climate change and environmental sustainability.

The analysis will proceed according to threefold criteria. Firstly, a classification of the type of interventions implemented and their relation to other benefits in addition to urban drainage (e.g. temperature regulation, enhancement of urban biodiversity, etc.). Secondly, the identification of regional and local policies that enabled and supported the success of the projects. The final stage of the process is the evaluation of the projects' effectiveness, equity and scalability. The selection of case studies was initially based on three criteria: the strong urbanisation of the optimal territorial areas, the actual role of the IWSCs as a promoter of soil unsealing, and the geographical variety, with the objective of selecting representative cases throughout Italy. Following an initial review of the websites of all Italian companies (approximately 100), only three that were active in soil unsealing were identified, all of which were located in the Lombardy Region. The primary sources of the projects are drawn from grey literature, encompassing project data sheets, information websites, and institutional websites of integrated water service companies, municipalities, and provinces.

The Integrated Water Service (IWS)

The concept of Integrated Water Service (IWS) was born in Italy in 1994 (L. 36/1994), but is currently regulated by the Legislative Decree Environmental Regulations of 2006, which defines it as 'constituted by the set of public services of capture, adduction and distribution of water for civil uses, sewerage and wastewater treatment, and must be managed according to principles of efficiency, effectiveness and economy, in compliance with national and EU regulations' (D. lgs. 152/2006). The Integrated Water Service refers to specific territorial areas, the Optimal Territorial Areas (OTA). These areas are defined - by means of regional laws implementing Law 36/1994 - according to three parameters: (i) respect for the unity of the hydrographic basin or sub-basin or contiguous hydrographic basins; (ii) overcoming management fragmentation; (iii) achievement of adequate management size, defined on the basis of physical, demographic, technical parameters and on the basis of political-administrative subdivisions (Law 36/1994). In some regions, the subdivision follows that of the provinces, while in other cases it follows other territorial requirements. The IIS of a specific OTA is assigned to a service manager, a public or private company. However, there are cases of companies entrusted with the management of multiple OTAs. The managing company takes care of the aqueduct (collection, adduction and distribution) and sewerage (collection, conveyance and purification).

The topic of water sustainability has entered the policies of these companies. A large part of their efforts is dedicated to reducing leakages - the value of which stands at 42.4% in municipal drinking water distribution networks (ISTAT, 2024), optimising monitoring systems and raising awareness of the importance of water as an asset. A strategic shift in focus, away from their traditional core business, has recently been initiated by a number of these companies. This strategic shift is characterised by the promotion and implementation of actions with the objective of enhancing urban drainage systems, mainly on public space. These policies, aimed at achieving a harmonious city-water relationship, are implemented through a combination of conventional 'hard' engineering interventions, e.g. detention basins, and more contemporary and sustainable approaches, e.g. NBS, and SuDS.

Case studies analysis

The three cases examined, which are the only ones identified among those actively involved in sustainable urban drainage improvement measures, are the three companies MM S.p.A., Gruppo CAP and BrianzAcque. Their OTAs are part of two contiguous areas: the Metropolitan City of Milan and the province of Monza Brianza, within the region of Lombardy. It is one of the most urbanised areas in the country, so much so that it is referred to as the "Megalopoli Padana" (Turri, 2000). Within the Italian context, Lombardy stands as a notable exemplar, with a land taken that accounts for 12.19% of the region's total territory (compared to the national average of 7.16%) (ISPRA, 2024). The province of Monza Brianza has consumed 40.78% of the soil within its borders (first in Italy), while for the Metropolitan City of Milan the value stands at 31.88% (third in Italy) (ISPRA, 2024). In 2017, the Lombardy Region adopted a regulation on the principle of hydraulic invariance (R.R. 7/2017). This regulatory framework

pertains to the management of rainwater, with the objective of mitigating water runoff to conventional urban drainage systems. The principle of hydraulic invariance states that the maximum volume of stormwater runoff discharged from urbanised areas into receptors must not exceed the volume that existed prior to urbanisation. The regulation sets out standards for specific categories of building, urbanisation, and infrastructure projects. The application of the regulation has consequences for the entire regional territory, in a diversified way according to the class of criticality.

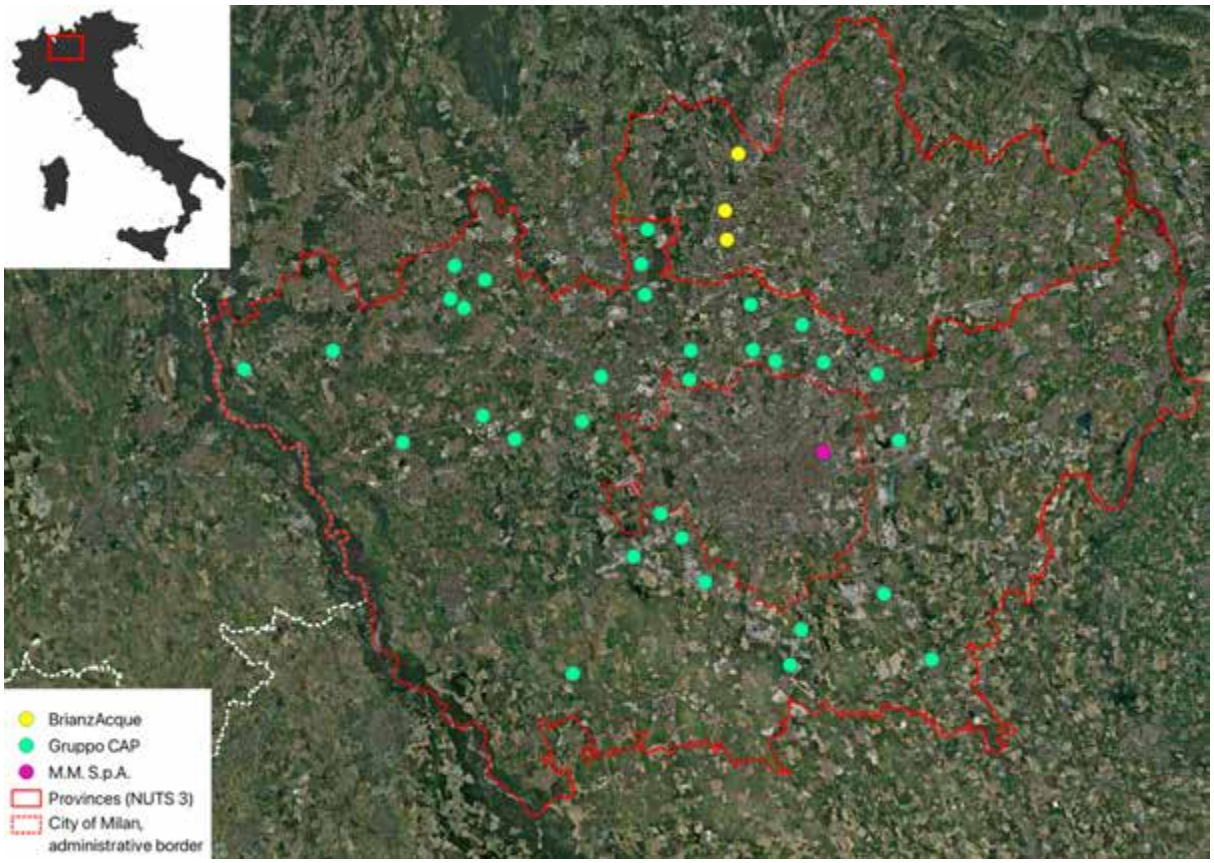

Figure 1: Location of interventions within the Milan metropolitan area. Author's elaboration.

MM S.p.A. and the Municipality of Milan

MM S.p.A. is a multiservice company operating in the fields of engineering (building and infrastructure) and the management of public residential buildings, schools, and sports facilities. It has also managed the Integrated Water Service of the Municipality of Milan since 2003.

The company has developed a first sustainable urban drainage project within the municipality of Milan, in the section of Via Pacini between Via Teodosio and Via Capranica (opened in 2023). The road segment under consideration is approximately 200 metres in length. It contains a central parterre that is free of vehicular traffic, and it is in this area that the intervention is primarily focused. The system is comprised of roadside drains equipped with overflow mechanisms that facilitate the direct conveyance of initial rainfall, which is characterised by elevated levels of pollutants, into the sewer network. Subsequent rainfall is directed towards designated bioretention areas situated within the central parterre of the road, thereby ensuring the effective management of water resources. The division of this sector into three ecological areas was based on the theoretical frequency of flooding and, consequently, the availability of water. The planting of flora was meticulously curated, with a total of approximately ten different species being selected. The implementation of automatic irrigation systems, which are connected to tanks that do not utilise potable water, is also planned to ensure resilience in the face of potential drought periods. The area had previously been used as an unregulated dirt parking area. The

intervention resulted in the creation of new pedestrian pathways, away from vehicular traffic, as well as various elements of street furniture. The construction site also intervened in the side area of the road, with an extension of pedestrian spaces and crossings. Moreover, the intervention has the potential to enhance biodiversity; however, there are concerns regarding its efficacy in mitigating temperature. The area is characterised by the presence of approximately 30-metre-high buildings and a tree-lined landscape, comprising mature, tall species. While the theoretical potential of the new vegetated parterre to contribute to a reduction in total temperatures is evident, further investigations are required to ascertain a significant effect. The objective of the initiative is to extend the pilot project by a further 700 metres.

The company is also undertaking analogous projects in the city of Milan, including those located in Via Guido da Velate and Via Paravia. It is important to note that the municipality has independently concluded additional depaving works within the city. This is indicative of an increasing awareness of the necessity to adopt mitigation and adaptation strategies, particularly within highly urbanised contexts such as Milan.

BianzAcque and the province of Monza and Brianza
BrianzAcque is the public company responsible for the management of the IWS in the province of Monza Brianza, located in the north of Milan. It is responsible for the management of 3,000 kilometres of pipelines, and its annual water supply exceeds 100 million cubic litres, serving a population of 875,000 individuals across 55 municipalities. The model utilised is one of in-house provision, with responsibility for sewerage and purification services also falling within the organisation's remit. The urban drainage interventions promoted by BrianzAcque are underpinned by a circular economy approach, with the overarching objectives of enhancing public space, reducing the risk of flooding and urban heat island phenomena. Three interventions, which were carried out and partially financed by the company, are here illustrated.

The first intervention is situated within the municipality of Cesano Maderno, which has 19,886 inhabitants (ISTAT, 2025), in the western area of the province. The intervention by BrianzAcque, which is based on tree-lined flower beds, rain gardens and drainage systems, concerns a 700-metre stretch of Corso Roma. The project encompasses the construction of 150 square metres of tree-lined pits and 900 square metres of bioretention areas. The financial outlay required for the project is €1.2 million, to be shared between the company, the municipality of Cesano Maderno, and the Lombardy Region. The objective of the project is twofold: firstly, to absorb heavy rainfall by reducing the pressure on the existing sewer network; and secondly, to create new green spaces to contribute to urban well-being.

The second project is focused on the municipality of Meda, which has 11,637 inhabitants (ISTAT, 2025) and is in the western area of the province. The project under discussion pertains to the development of a multifunctional park situated between Via degli Angeli Custodi and Via Giovanni XXIII. The project is composed of four primary interventions: the soil desealing of a parking area with the installation of permeable pavement, the transformation of an undeveloped area into an equipped and accessible park, and the creation of a bioretention area inside the new park. The project will also establish a new network for collecting white water, with the objective of directing it towards the newly developed park. In addition to the planting of 120 new trees, the intervention will enable the sustainable drainage of more than 10,000 m² and the revitalisation and opening to the public of the new park area of approximately 5,000 m². The cost of approximately €700,000 will be covered by BrianzAcque and the Lombardy Region.

The final project in the province of Monza Brianza pertains to the municipality of Boviso Masciago, which has a population of 8,245 (ISTAT, 2025). The '*Facciamo fiorire l'acqua*' (Let's make water bloom) project involves the retrofitting of 800 metres of Via Matteotti, entailing the establishment of small bioretention areas (over 50, with a cumulative surface area of 1850 m²). These areas are designed to collect rainwater and facilitate its gradual infiltration into the soil, thereby mitigating the risk of sewer overloading. The new green elements feature over 60 trees, 100 shrubs and 1700 m² of lawn. The intervention will entail the construction of a new cycle path, the reduction of the carriageway, and the imposition of a 30 km/h speed limit. The funding of over €1.3m was largely financed

by the Lombardy Region as part of the 'Lombardy Plan for Soil Protection and Mitigation of Hydrogeological Risks' project. This intervention is characterised by dual value, namely the improvement of rainwater management on site through the drainage of the sewage system. Conversely, the reduction in the speed limit, the construction of cycle tracks and the substantial increase in green areas have collectively enhanced the urban quality of the area, particularly regarding soft mobility and temperature reduction.

Gruppo CAP and the Metropolitan City of Milan

Gruppo CAP is the company that manages the integrated water service within the Metropolitan City of Milan (excluding the municipality of Milan). In a similar way to previous cases, in addition to the supply, sewerage and purification service, a series of actions aimed at improving urban water management have recently been launched. The first action was in 2018, when the 'Manual on good practices for the use of sustainable urban drainage systems' was published. The document is the result of a collaboration with the Department of Agricultural and Environmental Sciences of the University of Milan. The objective of the document is to identify innovative solutions that will mitigate flood runoff and reduce flood risk in the territory of the Metropolitan City of Milan. With regard to these solutions, the report describes their technical and economic characteristics, highlighting the importance of SuDS as an optimal solution.

The CAP Group launched the '*Milano Città Spugna*' (Milan Sponge City) project in 2021. The project entails the execution of 90 interventions across 32 municipalities. The total cost of the project is estimated to be approximately €50 million, with financing being provided through a call for tenders as part of the National Recovery and Resilience Plan. The CAP Group and the Metropolitan City of Milan submitted the application to the call for tenders 15 days after its publication. This is indicative of the company's and the territory's strategic approach to sustainable urban water management. The significant financial investment facilitates the implementation of interventions with the fundamental objectives of preventing flooding, combating soil erosion and the effects of climate change, decreasing the vulnerability of natural and socio-economic systems, and strengthening territorial resilience.

Due to the volume of data, several simplifications were implemented during the analysis of the 90 projects (table 1). Initially, projects were aggregated on a municipal basis. Consequently, traditional hydraulic engineering interventions, including storage tanks and reservoirs, were excluded from the study. The remaining interventions were classified into four categories: depaving, permeable pavement, renaturalisation, and bioretention system. However, many of the interventions can be attributed to more than one family. For instance, the intervention in Baranzate involves the renaturalisation of a brownfield site and the construction of a bioretention basin. The distinction between the initial two families - depaving and permeable pavement - is determined by the post-intervention use of the area. In the former, the removal of the pavement results in the exposure of the ground, while in the latter, the removal of the impermeable pavement is followed by the installation of a draining pavement. The bioretention family, on the other hand, encompasses all interventions, both large and small in scale, that are designed to conserve water over a period of time by means of slow release into the soil. Examples of such interventions include infiltrating and draining trenches, tree boxes and deep infiltration systems. For each intervention, the specific location (car park, park, square, street) was identified, along with the respective ownership and potential disconnection from the sewerage system.

The interventions have an average size of approximately 16,500 m2. The most compact intervention is in the municipality of San Vittore Olona and encompasses an area of 1,300 m2, incorporating drainage, paving, and infiltration wells within a brief road segment. The most extensive intervention, covering an area of 63,000 square metres within the municipality of Rho, encompasses a range of measures including the removal of paved surfaces and the disconnection of various roads and car parks from the sewerage system, all situated on municipal land. The two interventions illustrated here are also the least (260,000.00 €) and the most expensive (6,000,000.00 €). The ownership of the intervention areas is exclusively public. A total of 17 interventions have been identified, involving the disconnection of the rainwater collection system from the sewer system. The interventions on roads pertain to 10 municipalities and are predominantly focused on permeable pavements and bioretention areas. Those related to squares are 14, with interventions related to draining paving, depaving, and bioretention

areas. Parks were involved in seven municipalities through interventions involving all four families (depaving, permeable pavement, renaturation, and bioretention system). Finally, car parks were the subject of interventions in 17 municipalities, mainly through permeable pavement and bioretention systems.

Table 1: the classification of 'Milan Sponge City' projects

City	Sup. m2	Invest. (€)	Parking	Park	Square	Road	SuDS
Arluno	2.600	500,000	Yes	No	Yes	No	Permeable pavement
Assago	18.000	1,200,000	Yes	No	No	Yes	Bioretention system Permeable pavement
Baranzate	9.600	2,750,000	No	Yes	Yes	No	Renaturalization Bioretention system Permeable pavement
Bollate	24.300	1,500,000	No	No	Yes	Yes	Bioretention system Depaving
Bresso	3.400	375,000	Yes	No	No	No	Bioretention system Permeable pavement
Buscate	20.000	1,000,000	Yes	No	No	No	Bioretention system
Canegrate	13.800	925,000	Yes	No	No	No	Bioretention system Permeable pavement
Cesano Boscone	13.600	1,000,000	Yes	No	No	No	Bioretention system
Cesate	3.500	325,000	No	No	Yes	No	Bioretention system Depaving
Cinisello Balsamo	10.000	1,400,000	No	No	Yes	No	Bioretention system
Cologno Monzese	52.700	4,725,000	Yes	Yes	No	No	Bioretention system Permeable pavement Depaving
Cormano	13.800	1,425,000	No	Yes	No	No	Bioretention system
Cornaredo	5.400	1,500,000	No	No	Yes	No	Bioretention system Permeable pavement Depaving
Corsico	7.800	975,000	Yes	No	No	No	Permeable pavement
Garbagnate Milanese	30.700	1,800,000	Yes	Yes	No	No	Bioretention system Permeable pavement
Legnano	42.800	2,590,000	Yes	No	Yes	No	Permeable pavement Depaving
Marcallo con Casone	7.200	525,000	No	No	No	Yes	Bioretention system
Melegnano	3.900	450,000	No	No	Yes	No	Bioretention system
Opera	29.800	3,100,000	No	No	Yes	Yes	Bioretention system

Paderno Dugnano	25.300	1,680,000	No	No	Yes	No	Bioretention system Depaving
Pieve Emanuele	14.300	1,150,000	Yes	No	Yes	Yes	Bioretention system Permeable pavement
Rho	63.100	6,000,000	Yes	No	No	Yes	Bioretention system Permeable pavement Depaving
Rosate	7.600	950,000	Yes	No	No	Yes	Bioretention system Depaving
San Giorgio su Legnano	9.700	1,500,000	No	Yes	Yes	No	Bioretention system Permeable pavement Depaving
San Giuliano Milanese	19.000	1,400,000	Yes	No	No	No	Bioretention system
San Vittore Olona	1.300	260,000	Yes	No	No	Yes	Bioretention system Permeable pavement
Sedriano	12.700	1,625,000	No	Yes	No	No	Bioretention system Depaving
Segrate	12.000	550,000	No	Yes	No	No	Bioretention system
Sesto San Giovanni	29.000	2,250,000	Yes	No	No	Yes	Bioretention system Depaving
Solaro	10.000	1,600,000	No	No	Yes	No	Permeable pavement Depaving
Trezzano sul Naviglio	7.400	1,125,000	Yes	No	No	Yes	Bioretention system Permeable pavement Depaving
Turbigo	3.000	1,550,000	No	No	Yes	No	Permeable pavement
TOTAL	**527.300**	**50 mil.**	**17**	**7**	**14**	**10**	

Discussion

The present study set out with the objective of investigating the methods by which Italian IWS companies may promote public space initiatives that enhance climate change resilience and environmental sustainability, with a particular focus on soil desealing processes. The analysis was conducted through a systematic process, beginning with the classification of interventions, followed by the identification of enabling regional and local policies, and culminating in the evaluation of project effectiveness, equity, and scalability. The findings from the three case studies – MM S.p.A., Gruppo CAP, and BrianzAcque – operating within the highly urbanized Lombardy Region, demonstrate a strategic shift in the core business of these IWSCs towards sustainable urban water management and the active promotion of NbS and SuDS. The case studies reveal a clear typology of interventions, predominantly focused on depaving, permeable pavement, renaturalization, and bioretention systems.

The success and proliferation of such projects is facilitated by the presence of supportive regional and local policies. The Lombardy Region's adoption of the hydraulic invariance principle (R.R. 7/2017) represents a significant regulatory framework, mandating that stormwater runoff from urbanized areas must not exceed

pre-urbanization volumes. This regional mandate exerts a direct influence on the operational context of IWSCs, thereby encouraging the implementation of SuDS. The elevated land consumption of the target OTAs, attributable to the substantial urbanisation of Lombardy, can also be regarded as a catalyst for the initiation of sustainable urban drainage processes. Furthermore, the financing secured through national recovery and resilience plans, as evidenced by Gruppo CAP's 50 million € '*Milano Città Spugna*' project, underscores the importance of governmental support and investment in scaling these initiatives. The collaborative funding models, involving IWS companies, municipalities, and regional governments (e.g., BrianzAcque's projects), also demonstrate a shared commitment to addressing climate change impacts.

In terms of effectiveness, the projects demonstrate clear potential for mitigating the impacts of climate change. The interventions have been shown to directly address the overloading of sewage systems and the disruption of the water cycle, which is exacerbated by soil sealing. This is achieved by increasing infiltration and reducing runoff. The enhanced green spaces contribute to urban well-being and, in theory, to temperature reduction, though further investigation is sometimes needed to ascertain significant thermal effects. The emphasis on disconnecting rainwater collection systems from sewers in many of Gruppo CAP's projects highlights a direct and effective strategy for improving urban water management.

Regarding the principles of equity and scalability, the extensive implementation of these interventions across multiple municipalities, as exemplified by Gruppo CAP's '*Milano Città Spugna*' project encompassing 32 municipalities, signifies a considerable degree of scalability. The public ownership of intervention areas across all the projects analysed suggests a potential for equitable access to these enhanced public spaces and their benefits. However, a more in-depth examination of the socio-economic status of the neighbourhoods where the interventions take place, alongside monitoring of any gentrification resulting from these interventions, and the active involvement of the community in the project, would be appropriate. A further key consideration is the investigation of citizens' perceptions of the interventions, in terms of tangible improvements in quality of life, increased access to green areas, and reduced flood risk. The identification of only three IWSCs actively involved in soil desealing, all within Lombardy, suggests a geographical disparity in the adoption of such practices across Italy. While Lombardy's high soil consumption rate and pioneering regional regulation make it a natural leader, the region's limited geographical spread indicates a need for broader adoption and policy frameworks in other regions.

The strategic shift evidenced in these IWSCs signifies an awareness of their expanded role that extends beyond conventional water services. By proactively advocating for soil desealing and SuDS, these companies are transitioning towards a more comprehensive approach to urban water management, incorporating ecological and social benefits into their operations. This proactive engagement has the potential to establish IWS Companies as pivotal actors in the fields of urban climate resilience and sustainability. By shifting beyond the mere management of existing infrastructure, they are able to proactively influence and shape the urban environment.

Conclusions

The adverse impacts of climate change, particularly the disruption of the hydrological cycle, in combination with an increased consumption of soil, necessitate innovative urban management strategies. This paper has demonstrated the emerging role of Italian IWSCs as crucial promoters of soil desealing processes and Nature-based Solutions (NbS) within public spaces, thereby enhancing urban resilience and environmental sustainability. The case studies of MM S.p.A., Gruppo CAP, and BrianzAcque in Lombardy illustrate a significant and positive strategic shift in IWSCs operations. These companies are now proactively implementing a range of SuDS interventions, including depaving, permeable pavements, renaturalization, and bioretention systems. These offer multifaceted benefits beyond just urban drainage, such as improved urban biodiversity, temperature regulation, and enhanced public spaces. The success and expansion of these initiatives is strongly supported by regional policies that facilitate them, such as Lombardy's principle of hydraulic invariance, and substantial national funding mechanisms, such as the National Recovery and Resilience Plan. While the examples from Lombardy

demonstrate a promising model for addressing soil sealing and its consequences, the limited geographical spread of such proactive IWSCs across Italy highlights a significant opportunity for broader policy adoption and implementation nationwide.

In conclusion, Italian IWSCs possess the potential to be pivotal drivers in transforming urban areas into more resilient and sustainable environments. The evolution of their role, from that of service providers to that of active promoters of green infrastructure, is imperative in order to mitigate the effects of climate change, foster healthier urban ecosystems, and improve the quality of public life. Future efforts should focus on replicating these successful models across other regions in Italy and strengthening policy frameworks to encourage a widespread integration of soil desealing and NbS into urban planning and water management strategies.

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Public Space as Social Infrastructure for Urban Wellbeing: Transformation and resistance in Protomagias Square, Athens under persistent austerity

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Abstract
Under ongoing multiple-crises conditions, urban transformation threatens public open spaces in Athens, Greece, with commodification, supported by persistent 'austerity urbanism' (Peck, 2012) reflecting broader patterns of uneven geographical development. This paper analyses socio-spatial dynamics in Protomagias Square at Pedion tou Areos park, examining how these interconnected spaces emerged as pivotal sites for contesting socio-spatial inequalities. The study focuses on the square's transformation since 2023, when Attiko Metro S.A. unexpectedly fenced off one-third of the public space for metro construction, storage, and office facilities, shrinking already scarce public space and constraining social life of inhabitants. Through qualitative analysis, the research demonstrates how grassroots resistance creates possibilities for democratic city-making approaches. Findings reveal how public space enclosure represents institutionalised violence against urban commons, while community mobilisation asserts alternative values prioritising care over profit and collective wellbeing over private accumulation.

Keywords: public space, spatial justice, care infrastructure, urban wellbeing

1. Introduction

Southern European cities have been severely impacted by economic austerity, climate-related events, migration flows, and socio-sanitary damages during the COVID-19 pandemic. In this multiple-crises context, public open spaces in Athens become sites of transformation and resistance under ongoing commodification, supported by persistent 'austerity urbanism' (Peck, 2012) reflecting broader patterns of uneven geographical development (Brenner et al., 2010). Since 2010, privatisation and deregulation of planning processes (Gemenetzi, 2021) have impacted public spaces whilst simultaneously catalysing forms of civic engagement and collective action for social inclusion, environmental and spatial justice.

The multiple crises affecting urban communities have created deeper discrimination and inequalities in cities. Neither state nor market policies offer solutions; indeed, substantial scholarship argues these institutions are responsible for generating such inequalities (De Angelis & Harvey, 2014). Due to this accumulation of social, economic, cultural and political crises, the concept of commons and commoning has regained wide acceptance, often incorporated ambivalently within administrative and institutional discourse. De Angelis and Harvey (2014) argue that "in general terms, the commons are social systems in which resources are shared by a community of users/producers, who also define the modes of use and production, distribution and circulation of these resources through democratic and horizontal forms of governance." However, they emphasise that these commons "exist and are produced vis-à-vis a social force, capital, that often demands their cooptation, if not enclosure."

The struggle over Protomagias Square crystallises fundamental contradictions between neoliberal urban governance and collective rights to the city. This public space, situated between Pedion tou Areos park and the former Evelpidon Military Academy complex, has become emblematic of broader processes of urban commodification operating through seemingly progressive cultural programming. Local citizens' initiatives and grassroots organised groups expose the insidious commodification and privatisation dynamics transforming the park, denouncing how private energy corporations and philanthropic foundations appropriate public spaces to advance their "sanitised" vision of urban culture whilst systematically denying permits and support to autonomous citizen-organised cultural proposals.

During crisis conditions, Protomagias Square was profoundly appropriated and transformed by users into a site of collective care, political organisation, and social reproduction essential for community survival. Since 2000, each crisis period—Olympic preparation, austerity-driven renovation, migration management, and pandemic

response—has been mobilised to advance spatial control whilst community resistance has consistently emerged to defend collective use and autonomous organisation.

The case study focuses on the latest transformation since 2023, when almost one-third of the public square was unexpectedly fenced off by Attiko Metro S.A. for construction of the new "Dikastiria" metro station (Line 4), as well as for storage and office space, further shrinking already scarce public space and disabling social life, particularly of disadvantaged inhabitants. This enclosure represents more than technical planning decisions; it constitutes "institutionalised spatial violence"—the systematic appropriation of public space undermining collective well-being whilst serving private and state interests through familiar patterns of crisis-driven privatisation.

This paper demonstrates how the defence of Protomagias Square by the local citizens' initiative '*Εμείς στο Πεδίον του Άρεως*' (We at Pedion tou Areos) represents concrete assertion of the right to the city, challenging dominant planning rationalities whilst prefiguring alternative forms of urban governance based on care, solidarity, and collective self-management. Drawing on theories of socio-spatial justice (Soja, 2010) and biopolitics (Foucault, 1978), the study contributes to understanding how public spaces shape and are shaped by daily negotiations of transformative urban changes under restrictive conditions despite facing what Madden (2022) terms "systemically induced fatigue."

2. Theoretical Framework: public space, care, and urban commons

The theoretical foundation for analysing Protomagias Square builds a coherent argument through four interconnected analytical layers: first, understanding public space as commons through commoning practices; second, examining care as both practice and infrastructure essential for urban life; third, analysing spatial justice and the right to the city as frameworks for understanding urban struggles; and fourth, contextualising contemporary enclosures within broader patterns of capitalist accumulation. This integrated approach demonstrates how public spaces function as essential infrastructure for collective life whilst revealing their vulnerability to appropriation under neoliberal urban governance.

2.1. From public space to commons: commoning as collective practice

Rather than accepting the traditional public-private binary, this study follows Harvey's (2012) insight that commons are defined by relationships where "the social group and that aspect of the environment being treated as a common shall be both collective and non-commodified." This understanding moves beyond legal ownership categories to focus on social relations and practices. Urban space and public space are shaped by social relations as products of human activity, constructing spaces for social, economic and cultural activity whilst simultaneously shaping social relations through embodied space. Harvey (2014) points out that to think of an alternative form of urbanization, it is necessary to build possibilities for an anti-capitalist turn, through recognizing the common and its potency and by starting from a convergence between the microcosm of the body and the macro space of globalization, both as arenas of enactment of the capitalist neoliberal model of production and reproduction

Stavrides (2020) advances this conceptualisation by defining commoning not simply as space-sharing but as "a set of inventive practices and imaginaries that explore the emancipatory potentialities of sharing." These practices create "life in common" through three interconnected dimensions: projective practices pointing toward possible futures, expressive practices articulating shared values, and exemplary practices demonstrating alternative social relations exceeding dominant sociality models.

2.2. Care as infrastructure and political practice

Building on this commons foundation, the analysis incorporates feminist care theory to understand how collective reproduction occurs through spatial practices. The Care Collective's (2020) definition of care as "any labour directed at maintaining or enhancing another's freedom" establishes care as fundamentally political rather than merely personal or domestic, encompassing "social capacity and activity involving the nurturing of all that is necessary for the welfare and flourishing of life."

Feminist scholars including Silvia Federici (2012), Nancy Fraser (2016), Donna Haraway (2016), and Joan Tronto (2017) reveal how capitalism systematically appropriates and commodifies care work whilst rendering it invisible. Fraser's (2016) analysis of capitalism's "crisis of care" demonstrates how social reproduction becomes a site of struggle, whilst Federici's (2012) examination of primitive accumulation shows how commons enclosure specifically targets spaces and practices of collective reproduction.

Berlant's (2016) concept of "affective infrastructure" bridges care theory and spatial analysis by revealing how spaces become "formative of collective life through their material and relational capacities." This framework illuminates "threshold spaces" and "contact points"—intermediate scales of intimacy and encounter enabling experimentation with embodied urban sociality based on care rather than commodity relations.

2.3. Spatial justice and the right to the city

The third theoretical layer establishes spatial justice as the lens through which urban struggles can be understood. Lefebvre's (2016) conceptualisation of the right to the city encompasses both access to urban space and participation in its production, establishing spatial rights as fundamentally democratic. Harvey's (2008) interpretation emphasises this right extends "far more than individual liberty to access urban resources: it is a right to change ourselves by changing the city" through collective political action.

Marcuse's (2009) critical urban theory reveals the right to the city as simultaneously "a cry and a demand"—addressing both immediate material deprivation and broader aspirations for human development. This definition connects survival needs with transformative politics, providing analytical tools for understanding how different groups mobilise spatial issues. Hence, the 'right to the city' assumes a role of resistance to neoliberal urbanism and a transformative potential toward alternative paradigms of production and reproduction of urban space.

Stavrides (2023) advances this framework by arguing that "to reclaim the right to the city means to reclaim the city as a common good, that is, to reclaim the emancipatory power of collective creativity." This understanding positions common space as both domain of urban commoning and formative factor—performed rather than permanently established, existing through sustained commoning practices.

2.4. Enclosures and contemporary capitalist accumulation

The final theoretical layer contextualises contemporary urban enclosures within broader patterns of capitalist accumulation. Drawing on Marx's understanding of primitive accumulation as ongoing rather than historically bounded, Harvey's (2005) concept of "accumulation by dispossession" reveals how "wholly new mechanisms of dispossession" operate through privatisation, commodification, financialisation, and asset manipulation in contemporary contexts.

Christophers's (2018) analysis of land privatisation processes illuminates systematic patterns of disinvestment, devaluation, and eventual private transfer—processes understood as "institutionalised spatial violence" particularly affecting marginalised communities dependent on public infrastructure. Peck's (2012) analysis of "austerity urbanism" reveals how fiscal constraints justify dismantling public services through deliberate disinvestment creating conditions subsequently used to justify privatisation.

In the Greek context, Gemenetzi's (2021) identification of systematic privatisation and planning deregulation since 2010 exemplifies what Klein (2007) terms "disaster capitalism"—exploiting crisis conditions to advance neoliberal reforms that would otherwise face political resistance.

Interpreting Protomagias Square as relational space enables understanding of socio-spatial practices of care, its material and immaterial importance for urban dwellers, especially the most vulnerable, whilst revealing how capitalism extracts value from everyday life through commodification and reconfiguration of social reproduction and its spatial expressions (Fraser, 2022).

3. The Transformation of Protomagias Square: from marginalization to care infrastructure

3.1 Historical context and crisis-driven transformation

Protomagias Square was constructed in the 1980s following urban redevelopment that moved Moustoxidi street underground, creating pedestrian space between Pedion tou Areos park and the former military complex. Prior to the COVID-19 pandemic, the square was primarily used by marginalised communities—migrants, youth, and local residents—for informal activities reflecting broader dynamics of urban marginalisation, where public spaces in central Athens were either heavily commercialised or relegated to use by excluded populations.

The historical trajectory of Pedion tou Areos park reveals systematic patterns of crisis-driven transformation illuminating broader processes of neoliberal urban governance and community resistance. The 2000-2003 period marked a critical turning point when the park became subject to an "urban renewal program" developed for the 2004 Olympic Games, initiating the first phase of systematic enclosure and control. This intervention included installation of barriers, tree cutting, spatial division into four sections, and reduction of entrances from sixteen to four—changes that provoked massive resistance and broad community opposition extending beyond immediate neighbourhood residents.

The 2008-2010 renovation, financed through 10 million euros of European and Greek public funds, represented a second phase of "sanitisation," transforming the park into a liminal space that was "no longer an open space, but not a private space either"—making the park progressively less accessible through gradual exclusion rather than immediate privatisation. The 2013 "cleansing operations" during right-wing and conservative administration exemplified how crisis discourse enables spatial violence, as authorities relocated marginalised populations to Pedion tou Areos under the banner of creating a "clean Athens," effectively using the park as a site of invisibilisation.

However, the 2015 refugee crisis revealed the park's capacity to function as essential infrastructure for collective solidarity when immigrants arriving from Aegean islands established spontaneous encampments in the absence of emergency housing solutions. This period generated positive community mobilisation despite precarious conditions, as local solidarity networks emerged alongside organised security against fascist attacks. The spatial centrality was crucial: "*many local people who were not aware of the situation of the exiles started to get involved" precisely because marginalised populations were too visible in a space located in the centre of Athens.*" (Anna, local resident, 2025)

During that year and the next one, Plateia Protomagias, became an affective space, where local inhabitants established relationships with immigrants and among them, appropriating the public space for solidarity and sharing everyday life, stories, material and immaterial elements. The processes of appropriation of that public space, among others, is understood as a process of creating spaces and conditions for life-sustaining, imagining and materialising everyday care infrastructures.

The 2018 banning of the annual autonomous and sel-organised Indie Free Festival, which had operated for thirty years without official permission, alongside the deployment of "philanthrocapitalism" (Richen and Lola, 2022) with the arrival of Onassis cultural foundation programming, intervening in the Pedion tou Areos Park by using the spaces for artistic installations, represents the most recent phase of transformation where direct state repression combines with cultural programming to neutralise autonomous organising whilst maintaining the appearance of progressive public programming.

3.2 Spatial configuration and zones of activity

Based on field observation, the square's spatial configuration enables diverse simultaneous uses through four distinct but interconnected zones facilitating different forms of collective activity and care:

The Central Open Plaza constitutes the largest area, featuring wide concrete paving appropriated for various sporting activities. This space has been regularly used by South Asian migrant communities for cricket matches,

representing cultural territorialisation that challenges dominant uses of urban space whilst creating visible presence of multicultural community life. The same area accommodates football games by local youth, children's cycling, and gatherings during political events or cultural celebrations.

The Elevated Northern Terrace sits at a higher level adjacent to the Hellenic National Defence College, accessible by wide concrete steps functioning as informal theatre seating. This elevated position provides overview of the entire square whilst creating natural gathering space for larger assemblies, political meetings, and cultural events, accommodating both formal presentations and informal socialising. Moreover, the stairs and ramps that create the various levels of the space are extensively used by youngsters for parkur.

The Platanus Grove features several old platanus trees surrounded by built-in concrete benches that have become the focal point for (mainly) Albanian migrant community's and elder peoples' daily social life. This area has been enhanced through community personal contribution in moveable furniture—plastic and wooden chairs and small tables stored nearby or left there and assembled daily to create flexible seating arrangements for domino games, meals, and extended conversations. Depending on the time, this area is used by different people, including also younger groups usually in the evening. The trees provide essential shade whilst creating a semi-defined area and distinct ambience that facilitates intimate social interaction.

The Southeastern Amphitheatre consists of a small concrete structure with tiered seating, as well as an elevated terrace connected to the amphitheatre, serving multiple functions including casual gatherings, celebrations, and political assemblies. This feature has become particularly important for grassroots political organisations seeking unmediated spaces for collective action, with architectural form enabling both speakers to address audiences and participants to engage in horizontal discussion. This space is highly used by all city dwellers, frequenting the square, especially appropriated by socio-cultural groups organizing various open and free-access events of public interest.

The "corners" along the fenced area separating the playground with the square, there is a corridor with a slightly elevated concrete wall, where informal vendor was demonstrating his products for sale. On the other side as well, right next to the southern entrance from Pedion tou Areos to Protomagias Square, there is another informal vendor, taking advantage of the spatial configuration and creating a "vendor's vitrine" to show his goods.

3.3 Public space as affective infrastructure

After the experience of 2015, Protomagias Square became once again an important point of reference for the local vulnerable and oppressed dwellers. The COVID-19 pandemic fundamentally altered the square's social dynamics when Greece imposed strict lockdown measures in March 2020, including closure of commercial socio-cultural activities and temporary restriction of access to Pedion tou Areos park. Protomagias Square emerged as one of the few remaining accessible public spaces in densely built central Athens, creating conditions for socio-spatial transformation.

The square began accommodating diverse populations across age, cultural, and class lines. Physical activities—soccer, cricket, boxing, walking, running—occupied major portions of the square, whilst social gatherings, discussions, spontaneous concerts, and political assemblies created what residents describe as "collective everyday togetherness." (Anna, local resident, 2025)

Diverse everyday practices transformed the square into infrastructure for collective care and political organisation encompassing multiple interconnected dimensions: **embodied care** through collective physical activity, such as play, parkur and dancing, essential for maintaining mental and physical health; **social care** through regular gathering patterns enabling residents to maintain connections across cultural differences; **material care** through community maintenance of shared spaces and furniture; **cultural care** facilitating intercultural encounters, music events and knowledge exchange; and **political care** encompassing assemblies and solidarity events addressing local and broader social justice issues.

4. Enclosure as institutionalised spatial violence

4.1 The mechanics of patial appropriation

Due to construction works for the new Line 4 extension of Athens Metro, "Dikastiria" Station (Government Gazette D'306/2021), part of public space in front of the Evelpidon building was occupied by Attiko Metro S.A. since 2021 as temporary construction site. The project was undertaken by the AVAX-GHELLA-ALSTOM consortium, to which 8,880 sq.m. of public "free space" where offered, whilst the contracting authority is Attiko Metro S.A., a private law legal entity established under Law 1955/1991 as a public limited company.

Figure 1. *Initial fencing of Plateia Protomagias, source: Official facebook page of the citizens' initiative, published 17 June 2023*

Since May 2023 the consortium has been trying to start the enclosure of the public space, serving for the contruction site without previous notice (Figure 1). On December 21, 2023, residents were confronted with sudden fencing of the square's largest section using concrete bases and temporary plastic mesh. As the citizens' initiative '*Εμείς στο Πεδίον του Άρεως*' (We at Pedion tou Areos) declares "HELLENIC METRO, without any public consultation and with the support of the police, proceeded to fence off the square." The enclosure relates to occupation of spaces in Protomagias Square by Attiko Metro S.A. for installation of offices, car parking and material storage spaces serving company needs. The projected duration coincides with final completion of the project, with current announced projections estimating line delivery in 2029-2030, although member of the local citizens initiative, as well as an engineer working in public infrastructures sector in Athens doubt it "considering the delays and rhythm of construction site this is quite improbable". Although the legal owner of Protomagias Square is the Municipality of Athens, its management falls under the Directorate of Parks and Groves of the Attica Region. However, Regional services were not informed about construction work commencement and fence installation, evident from their allocation of space for summer 2023 events during which Attiko Metro S.A. planned to install permanent sheet metal fencing.

As the D'306/2021 indicates the spaces to be occupied temporarily by the company to serve the construction site are the following (the topographic plan -Figure 2- is part of the official document published by the Government Gazette):

• area 1-2-3-4-1 (total area = 315 sq.m.) on Evelpidon street and Manica street intersection
• area 5-6-7-8-9-10-11-11'-17-18-19-20-21-22-23-24-5 (total area = 5.190 sq.m.) located on the intersection of Evelpidon street and Moustoksidi street
• area 11-12-13-14-15-16-17-11'-11 (total area = 3.375 sq.m.) located on the intersection of Evelpidon street and Moustoksidi street

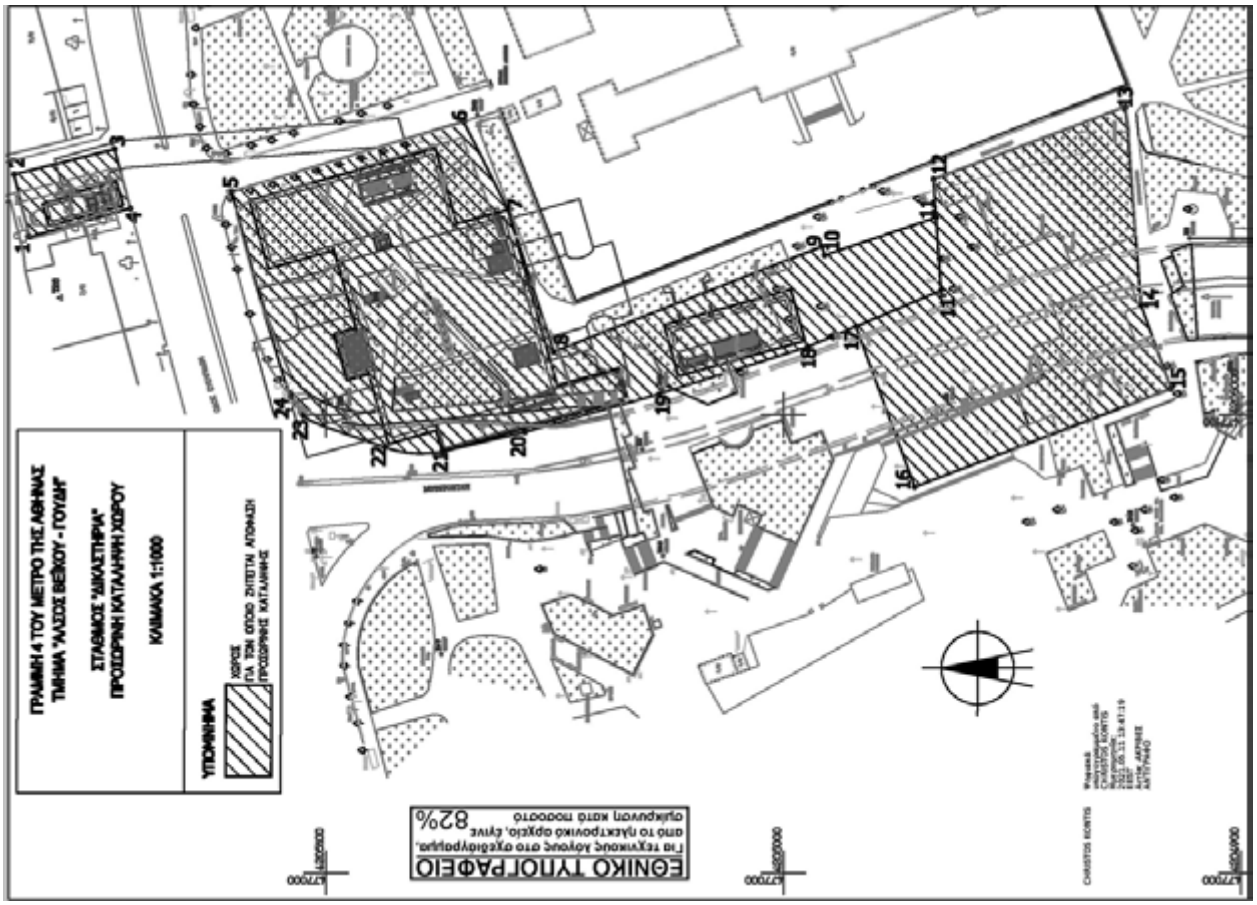

Figure 2. *Official topographic plan indicating temporary occupation for the construction site of Metro Station "Dikastiria", source: ΦΕΚ Δ' 306/01.06.2021, gov.gr*

As the initiative announces (03/04/2024), all these activities are not directly related to the construction works (excavations, etc.) of the specific metro station, they pertain to the general logistical support area for the company instead, including extensive office spaces that could have been housed in any of the many vacant office buildings in the area and beyond. The same issue for the parking, as there is an existing underground parking, serving the Court. This is evidenced by the fact that the fenced-off space is set to remain for the entire duration of the construction project, not only for the period during which works take place at the Dikastiria station. Furthermore, the contract allows for an extension of the fencing period (upon request) in case the project timeline is extended. In Figure 3 the uses in the extended enclosure are indicated: A. rebar processing area, or "ironworks", is one of the heaviest uses planned for the site. B. provision of 8 parking spaces for conventional cars, C. This passage occupies over 200 sq.m. within the fenced area of the square. However, it will not be used permanently for construction purposes; instead, it will remain vacant, merely to be opened once or twice a year to allow military vehicles to pass or park, D. offices of the contractor company 30X8m., E. storage area for materials and equipment.

The initial Environmental Impact Assessment Report provided for the occupation of more than 4,000 sq.m. beyond the original fenced area, including a section of the courtyard of the National Defense School Evelpidon, which is located above the square. After the army's reaction, that section was quickly released, and thus the Government Gazette (ΦΕΚ) for the occupation specified 3.300 sq.m. Following the mobilisations of the citizens another 1.300 sq.m. was freed, reducing the total to about 2.000 sq.m. "In each of these phases, HELLENIC METRO presented the area it intended to occupy as absolutely necessary." (initiative '*Εμείς στο Πεδίον του Άρεως*', 2024)

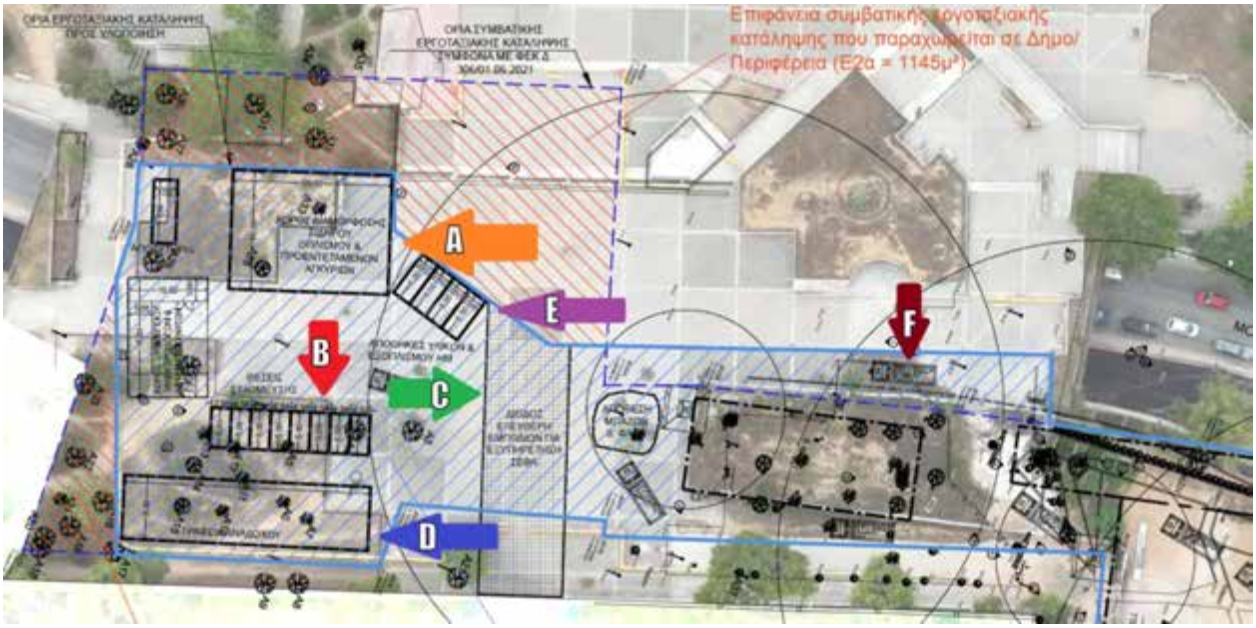

Figure 3. *Uses in the construction site, source: Environmental Impact Assessment Report, official page 'Εμείς στο Πεδίον του Άρεως', author's elaboration*

Document analysis reveals significant discrepancies between legally authorised construction areas specified in Government Gazette D'306/2021 and actual space appropriation. As published by the group '*Εμείς στο Πεδίον του Άρεως*' (2023), the plan (Figure 4) confirms the contractor consortium exceeded legal limits of enclosed area (indicated area with orange line), appropriating vital square portions, "fenced off with unaesthetic and particularly psychologically aggressive metal sheets", for non-essential uses including private vehicle parking despite available underground facilities, material storage accommodatable elsewhere, and temporaryoffice space serving corporate convenience rather than construction necessity.

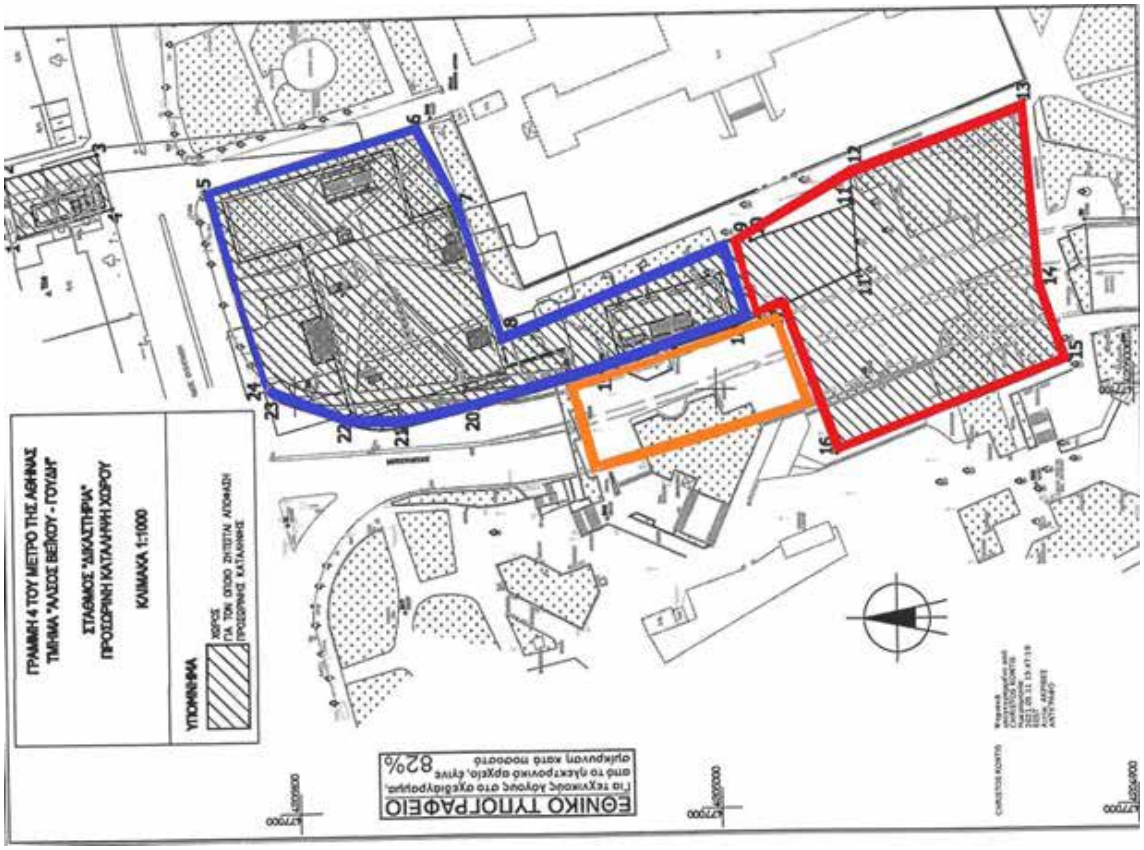

Figure 4. *Topographic plan elaborated by the citizens' initiative, showing in blue the initial construction site (since 2021), in red line the area designated in the Government Gazette (ΦΕΚ), in orange line the non-authorised enclosure established on May 2023*

Furthermore, personal field observation (Figure 5) and measurements on May 24 and 25, 2025, of the site, after the partial removal of the fence from the unauthorised enclosed area, reveal that several minor adjustments to the localization of the fence have been deployed, and the public space remaining inaccessible complies with the normative. Moreover, it is interesting to notice that if comparing the submitted plans of the architectural project, which won the public competition (second prize, by "Tense architecture network" studio) for the metro station "Dikastiria", the area of the station and the respective second entrance are limited to the plots 1-2-3-4-1 and 5-6-7-8- 20-21-22-23-24-5, which do not include the spaces of Protomagias Square.

The above process of public space appropriation illustrates how public-private partnerships enable space appropriation whilst diffusing accountability across multiple institutions, exemplifying Harvey's (2005) concept of "accumulation by dispossession" where public resources transfer to private actors through administrative mechanisms appearing as neutral technical decisions.

4.2 Legal violations and democratic exclusion

The appropriation process reveals fundamental problems in planning procedures enabling space appropriation whilst excluding community participation, representing democratic deficit by design. The selective enforcement of regulations—strict control over community uses whilst permitting corporate appropriation of public space for private parking and offices for Attiko Metro S.A. —reveals the class character of urban governance under neoliberalism. The same authorities that prohibit informal economic activities and regulate community gatherings permit systematic appropriation of public space for private commercial convenience without legal challenge or public justification.

4.3 Destabilising care networks and social infrastructure

The enclosure (even temporary) disrupted "care infrastructure"—spatial arrangements and social networks enabling collective wellbeing and mutual support during the pandemic and beyond. This destruction operated through multiple interconnected mechanisms revealing the inherently violent character of neoliberal space appropriation. The enclosure process, fencing off more public space than the legal and necessary, reveals how spatial control operates as a mechanism for broader social and political exclusion, reinforcing the democratic deficit of the local authorities and the uncaring attitude towards a common good, such as public space. The most affected urban dwellers—migrants engaging in cultural practices, political activists organizing assemblies, families using children's play areas, elders—represent populations whose presence challenges dominant narratives about appropriate uses and urban decorum (order and aesthetic) of central urban space, while their displacement "sanitises" public space for consumption by more privileged populations.

The elimination of cultural spaces displaced practices essential for community identity and social reproduction. The cricket field used by South Asian migrants was eliminated, disrupting cultural practices that had created belonging and provided visible representation of multicultural community life. Reduced open space for children's activities eliminated essential infrastructure for family life, whilst partial enclosure of the Platanus Grove disrupted access to maintained shared furniture and forced relocation of daily social activities.

The extensive fencing created blind-spots and uncomfortable spatial conditions particularly affecting women's safety through creation of narrow, dark, isolated passages between construction barriers and surrounding fencing. As residents report: "The narrow passage between the construction site fencing and the perimeter wall of the National Defence School forms a dark area with no visibility, in an urban area where attacks on women and LGBTQ+ individuals have increased." (initiative '*Εμείς στο Πεδίον του Άρεως*', 2024)

5. Resistance and democratic alternatives

5.1 Citizens' initiative organisation and democratic practice

The response to spatial appropriation by the citizens' initiative '*Εμείς στο Πεδίον του Άρεως*', along with the official and practical support of local associations, such as the Union of Secondary Education Teachers and the Association of Graduate Architects from Higher Education Institutions, demonstrates how communities can mobilise to defend spaces of historical and socio-political significance whilst asserting alternative models of democratic governance based on care, solidarity, and collective participation.

Emerging from longstanding community networks organised around park care and public space defence, the citizens' initiative represents continuity with earlier resistance to privatisation attempts whilst developing new strategies appropriate to current conditions of crisis and state retrenchment. The initiative's organisational structure reflects principles of horizontal democracy and inclusive participation, with regular assemblies held in remaining accessible areas and decision-making processes prioritising consensus over majority rule.

Membership encompasses diverse constituencies including long-term residents, recent migrants, parents with children, elderly users, political activists, and university students, reflecting the square's role as space of encounter across social and cultural differences. Actual participation of users from different backgrounds — especially those more precarious— in a horizontal process, enables intersectionality and shows how defence of public space can tighten social relations and create solidarity across difference whilst challenging dominant models of political organisation.

5.2 Strategies of resistance and rights assertion

The initiative employed multiple interconnected strategies and alternative practices to assert rights meaningful to the community, even when these conflicted with dominant legal interpretations. Their persistent presence and reaction in public space, although tiring, proved to be an effective form of action. By engaging with representatives of local authorities and the regional administration, the citizens' initiative succeeded in validating community claims regarding procedural violations and established important precedents for protecting public space from

arbitrary appropriation. Direct action and physical re-appropriation compelled the contractor consortium to reduce the originally planned fencing by 1,000 square metres, demonstrating the effectiveness of organised resistance in influencing state-corporate decisions. Public education and solidarity-building efforts further exposed the illegality of appropriation while connecting local struggles to broader issues of spatial justice and democratic participation.

Moreover, beyond the attempts to approach local and regional responsible authorities, social mobilisation, by the citizens' initiative '*Εμείς στο Πεδίον του Άρεως*', since the enclosure of the Plateia Protomagias space, was actively organised through various activities and events, informing public opinion, disseminating, reclaiming and reappropriating the right to public space. The frequent occupation of the public space with bodies, politically and socially aligned (Butler, 2018) remains the most powerful act of creating new relational space, caring for and with others for our common goods and demonstrating alternative ways of conviviality, more just and humane.

5.3 Towards alternative urban governance

Regarding the most vulnerable social groups, universal rights such as health, accessibility to water, food and adequate housing, education, an economic activity and participation to the local community life are basic aspects that should be fulfilled through an effective "local governance" (ONU, 2000), based on the decentralization of the administration and the active involvement of the people in the definition and realization of programs of socio-sanitary and financial support. While Athens has seen some efforts to improve local governance, including reforms like the Callicrates program, it still faces challenges related to centralism and the need for greater citizen participation. As Karvounis (2021) identifies "of the most important problem is the democratic deficit of the first level of local governance system" which remains highly centralised – especially after 2019 – in contrast to international trends towards more participatory and accountable local institutions.

The citizens' initiative's response demonstrates concrete alternatives to technocratic planning based on community participation, collective care, and democratic decision-making. Rather than simply opposing inappropriate development, the initiative actively demonstrates alternative approaches to space governance prioritising use value over exchange value and collective wellbeing over private profit.

These practices prefigure what Friedmann (1987) terms "radical planning" that challenges professional expertise with community knowledge whilst asserting collective rights to participate in urban development decisions. The initiative's organisational practices—horizontal decision-making, inclusive participation, consensus-building across difference—demonstrate democratic alternatives to both market mechanisms and bureaucratic hierarchy whilst suggesting possibilities for broader transformation of urban governance.

6. Conclusion: public space, care, and urban transformation

The struggle over Protomagias Square reveals public space as a critical site where fundamental questions of urban governance, social justice, and collective wellbeing are contested. The square's transformation during the immigration crisis and even more during the pandemic into essential social infrastructure demonstrates public space's capacity to function as "affective infrastructure" enabling collective navigation of crisis whilst maintaining social solidarity and political engagement across difference.

The subsequent enclosure by state authorities and private contractors represents systematic appropriation of resources essential for collective reproduction in service of private profit and administrative convenience. This appropriation operates through patterns of disinvestment, devaluation, and privatisation characteristic of austerity urbanism whilst revealing the fundamentally exclusionary character of neoliberal urban development prioritising exchange value over use value and private accumulation over collective wellbeing.

However, organised resistance by the citizens' initiative demonstrates collective capacity to challenge space appropriation whilst asserting alternative approaches to urban governance based on care, solidarity, and democratic participation. Through legal mobilisation, direct action, public education, and alternative

programming, the initiative exemplifies concrete practices of spatial justice asserting collective rights to urban space and its democratic governance whilst prefiguring possibilities for more just and collective, community-based approaches to city-making.

The case reveals how struggles over public space can illuminate and challenge broader patterns of urban inequality whilst creating possibilities for transformation based on alternative values, such as care over profit and a strong sense of conviviality. The right to the city becomes manifest through collective practices asserting these values whilst demonstrating concrete alternatives to dominant urban governance through everyday practices of care, solidarity, and democratic organisation.

The transformation of Protomagias Square during the pandemic demonstrates how public spaces can serve as essential infrastructure for collective reproduction, particularly for communities lacking adequate private space or excluded from commercialised venues. The practices of care that emerged—from informal childcare and elder support to cultural expression and political organising—demonstrate how public space can support "interdependent" rather than individualised approaches to urban life (The Care Collective, 2020).

As cities worldwide confront multiple intersecting crises, the defence of public space becomes essential for building more just and sustainable urban futures. The lessons from Protomagias Square suggest that grassroots mobilisations around spatial justice can serve as laboratories for developing alternative approaches to urban governance that centre collective care and democratic participation whilst challenging the systematic commodification of urban life under neoliberal capitalism. Such experiments in spatial democracy offer crucial insights for building urban futures based on collective wellbeing rather than private accumulation, care rather than competition, and democratic participation rather than centralised technocratic control.

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Exclusion of the vulnerable from public space in the shadow of urban transformation: the case of sex workers in Istanbul's Pera

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Abstract
This study examines the socio-spatial exclusion of sex workers in urban public spaces. It employs a multi-scale analysis of global frameworks and a local case study of Istanbul's Pera quarter. Building on contemporary thinkers' urban democracy and justice theories, the study reveals how urban spaces are frequently governed by majority- and authority-driven norms that marginalise vulnerable groups. Despite the global scale of the sex industry, social stigma and limited regulation perpetuate the spatial exclusion of sex workers. Using a four-step methodology ranging from international policy analysis to site-specific mapping, the study uncovers the impact of urban transformation on the displacement of sex workers in Pera. It argues for inclusive urban policies and spatial justice to ensure equitable access to public spaces for marginalised populations.

Keywords: Sex workers; Socio-spatial exclusion; Urban transformation; Public space; Istanbul

1. Introduction

Neoliberal restructuring and urban growth marginalise disadvantaged populations. This argument establishes a basis for discussions about exclusionary policies and urban justice, highlighting the challenges faced by vulnerable groups in urban areas. Along these lines, this study focuses on the exclusion of vulnerable groups from public spaces.

Before beginning the discussion, it is important to highlight the key conceptual frameworks of justice in relation to space. Henri Lefebvre (1996) argued that space is socially produced, incorporating social relations and boundaries. He also emphasised that space is both a physical entity and an area of political struggle. He considered this to be a key aspect of the concept of the 'right to the city' as a collective right. Lefebvre's concept of the right to the city supports equal participation in the production of space. Urban space is a collective asset and should not be exclusively controlled by the state or private capital. According to him, every individual, regardless of their socio-economic position, should have the right to participate in shaping their living environment.

Taking Lefebvre's definition further, David Harvey (2008) argued that the right to the city includes not only the right to access existing resources, but also the right to transform urban spaces. However, he also claimed that neoliberal urbanisation processes lead to the commodification of space, consequently causing vulnerable groups to be excluded from urban areas. This process further disadvantages vulnerable groups in terms of their well-being and socio-economic conditions. Therefore, Harvey emphasises that urban struggles should create alternative, more inclusive ways of life as an alternative to capitalist modes of production (Harvey, 2003).

Building on this, Susan Fainstein (2010) described the 'just city' approach as a set of urban planning standards that are based on democracy, diversity, and equality. Fainstein examined pragmatic planning strategies that combine Rawlsian ideas of justice with feminist perspectives. John Rawls's (1971) theory of justice has had a significant impact on urban studies. He argues that the transformation process is unfair to minorities. The relocation of

minorities comes at a significant cost. Also Rawls (1971) defended the principles of equality of opportunity and protecting the most disadvantaged groups. Although his individualistic approach to justice has been criticised for inadequately considering group identities, Rawls emphasised that institutions should be designed to protect the most vulnerable groups in order to achieve justice in society (Rawls, 2001).

Iris Marion Young's (1990) work highlights that justice is crucial for understanding the exclusion and spatial oppression experienced by marginalised groups. According to Young, injustice stems from exploitation, marginalisation, cultural imperialism and violence. Marginalised groups often experience multiple layers of socio-economic exclusion.Furthermore, economic inequalities become institutionalised as social disrespect and a lack of recognition (Honneth, 2003). This situation forces vulnerable groups to commit crimes to avoid being cleansed from urban areas, which results in their marginalisation and integration into unsafe environments. Urban transformation appears to be a solution, but it reduces the visibility of problems and creates constraints for vulnerable groups.

Subsequently, the literature argues that urban democracy and justice should encompass both distributive and recognitional aspects. This emphasizes the equitable distribution of resources and accessibility, along with social respect, cultural visibility, and participation in shaping urban life. These frameworks highlight the importance of spatial justice in understanding and reevaluating the consequences of excluding vulnerable groups from urban spaces, narratives, and visions of the future.

In contrast to discussions about the right to the city and spatial justice, Istanbul's urban policy employs neoliberal planning strategies that emphasize tourism, real estate speculation, and middle-class aesthetics. These strategies merge visibility and participation in public spaces with adherence to normative identities. As a result, vulnerable groups are excluded from urban spaces and struggle to establish a place for themselves. Against this backdrop, the study investigates the exclusion of sex workers from urban public spaces.

2. Sex work: conceptual and practical framework

Sex work exists within various sociocultural, economic, legal, moral and sexual contexts, all of which are studied by different social science disciplines. According to Dictionary.com (accessed 27 May 2025), a sex worker is someone who works in the sex industry as a prostitute, porn actress, stripper, nude model or producer of online sexual content. Another definition is 'someone who has sex to earn money and is not married' (Weitzer, 2009). The ILO also defines sex workers as individuals who exchange sexual services for money or goods.

Theory on the definition of sex work is also explored in the literature, focusing on human rights and feminist perspectives. These approaches are based on ideas about human trafficking and sex work as a profession. The definition of sex work lies between these two perspectives. Historically, it was understood as women providing sexual services to men for money; however, recent studies show that sex work is now often performed as a form of self-employment (Bernstein, 2007; Kontula, 2008).

2.1. Definition and historical overview of sex work

Although the assertion that sex work is the 'oldest profession in the world' is frequently repeated, historical records demonstrate that organised forms of prostitution existed in ancient Mesopotamia by 2400 BCE at the latest (Ringdal, 2004). Its history can be divided into four periods: 8,000–500 BCE; 530 CE to the Middle Ages; the Age of Enlightenment; and 1900 to the present day. During these periods, social and legal regulations regarding sex work varied (Ringdal, 2004).

Ancient Rome had licensing and tax regulations for sex work. However, in the Byzantine period, laws were passed that removed sex workers and brothel operators from the capital, freed slaves who had been forced into prostitution and banned sex in public baths (McGinn, 1998). During the Middle Ages, sex workers were severely punished and marginalised. In France, they were mutilated by the Roman army and labelled 'devil women' (Bullough & Bullough, 1978). Between 1350 and the 16th century, sex work in Europe became socially differentiated:

while cities such as Venice established municipal brothels, while France banned them altogether, distinguishing between elite mistresses and lower-class sex workers (Rossiaud, 1988).

In the 19th century, the Netherlands introduced prostitution regulations, but by 1910, brothels were banned as part of a moral reform movement (Van de Pol, 2011). In the early 20th century, sex work policies shifted: the U.S. imposed bans for hygiene reasons (1915), and Germany decriminalised prostitution (1927) (Roos, 2002). In the 1930s and 1940s, wartime regimes reshaped sex work: Japan established military brothels in occupied Asia (1932), while Nazi Germany re-criminalised prostitution in 1942 (Roos, 2002).

Based on the history with a high variety, today, several countries have different laws on sex work. These include banning brothels, implementing regulatory laws, legalising prostitution in specific areas, and criminalising child prostitution between the 1940s-2000s (Weitzer, 2009). Between 2000 and 2022, various countries implemented different regulations on sex work. The Netherlands and New Zealand legalised it, Germany removed its moral condemnation and introduced social insurance for sex workers. Canada criminalised the purchase of sex and Zurich imposed spatial restrictions by limiting prostitution to industrial zones (Wagenaar & Amesberger, 2013).

One considerable conclusion to derive from the analysis of this narrative is that prostitution rises during periods of social upheaval. This is followed by an uptick in epidemics and crime rates. City administrators then develop policies to address these issues, and when these prove insufficient, the cycle repeats when breaking points are reached. (Figure 1). Understanding this cycle is crucial to assessing the effectiveness of sex work policies, as well as how sex work is shaping today.

Figure 1. The cycle of sex work developing parallel to historical processes (produced by the authors)

2.2. Global forms of sex work today

As mentioned above, sex work has existed in various forms in different societies and eras. In each period, it has been examined in different socio-cultural, economic, and legal contexts. This article examines the reflection of sex work in modern society, the experiences of sex workers, and the diversity within the sector under two headings.

2.2.1. Online-based practices

The transformation of communication through technology has increasingly played a role in changing the sex industry. While one group uses technology for direct communication, another uses it to create a barrier between themselves and clients. Online-based practices can be divided into two categories: escort sex work and visual/virtual sex work.

Escort sex work

Escort sex work is commercial sexual activity done in private residences or hotel rooms, where sex workers receive money, gifts, or other material items (ILO, 2018). Unlike sex work on the street, escort work is usually independent or via agencies/digital platforms (Cunningham & Kendall, 2011; Sanders, 2005).

This type of work is embedded within the broader social, economic, and cultural dynamics of the city. From a rights-based perspective, discussions often focus on the need for legal protections, healthcare access, and support services to ensure the safety and autonomy of sex workers (Platt et al., 2018; Benoit et al., 2017). Feminist perspectives on escort sex work vary. Some argue that it can reflect sexual and economic autonomy (Nussbaum, 1998; Grant, 2014), while others view it as part of a system of exploitation and inequality (Barry, 1995; Dworkin, 1981). The varying views on this show the difficulties of interpreting consent and empowerment in the context of sex work.

Visual/virtual sex work

Digital technologies have transformed sex work, enabling new forms of interaction. Visual sex work, defined as the marketing of sexuality online, allows individuals, especially women, to create and distribute content independently via OnlyFans, Twitter, TikTok and other online spaces (Sakallı, 2018). These platforms offer greater autonomy, income potential, and safety, as workers typically operate from self-chosen environments and control their business strategies (Jones, 2020). Digital visibility also contributes to social acceptance of sex work (Blunt & Wolf, 2020).

In contrast, street-based sex work exposes workers to physical risks and social marginalisation. A rights-based approach is needed to ensure the safety, health and labour protections of street sex workers (Kinnell, 2008). While often viewed as exploitative, some feminist perspectives recognise it as a form of agency and economic self-determination (Jeffreys, 1997; O'Connell Davidson, 1998).

2.2.2. Area-based practices

Area-based sex work continues to be carried out using more traditional and familiar methods. In this context, these practices fall into two main categories: street-based and brothel-based sex work.

Street-based sex work (unregulated/informal)

Street sex work, which is often unregistered and unregulated, is defined as the provision of sexual services in public areas such as streets, parks and vehicles. It is particularly prevalent in regions where sex work is criminalised (Kurutkan, 2003). Moreover, street-based sex work, unlike escort services for high-end clients, is linked to lower-cost, more informal conditions and little social protection.

From a social rights perspective, ensuring the safety, health and dignity of street sex workers is paramount. Comprehensive, rights-based approaches emphasise the need for safe working environments, protection from violence and access to healthcare (Kinnell, 2008).

Brothel-based sex work (regulated/formal)
Brothel sex work is legally regulated prostitution where workers are registered and venues operate under specific standards. Such establishments contribute to urban economies through taxation and employment (Aalbers & Sabat, 2012). Despite this framework, sex workers often face social exclusion and restricted access to services and rights. They continue to be marginalised by social stigma and institutional discrimination, despite their legal status (WHO, 2015). From a feminist and human rights perspective, this form of sex work can regulate women's sexuality and reinforce social inequalities. Ensuring equal treatment and dismantling stigma are central to advancing their rights (Aalbers & Sabat, 2012).

Table 1 summarises the four main forms of sex work today: online-based (escort and visual/virtual) and area-based (street and brothel). Online escort work carries a medium risk of exploitation and violence, with low visibility and societal impact. Visual/virtual sex work generally carries a low risk and is considered ineffective. Area-based sex work, particularly street-based and brothel-based work, carries a higher risk of violence and has a more negative impact on society.

Table 1. Summary of the global forms of sex work today

	Type of space	Exploitation 3rd person	Violence risk	Visibility impact	Impact on society
Online-based practices					
Escort sex workers	independent operator, private property, hotel, etc.	medium	medium	low	between ineffective and negative
Visual/virtual sex work	digital platforms, mobile dating apps, social media, pornography, erotic performing arts, etc.	low	low	low	ineffective
Area-based practices					
Street-based sex work	street, car, park, cemeteries, etc.	medium to high	high	high	negative
Brothel-based sex work	brothel	high	high	medium	negative

2.3. Social and legal perspectives on sex work
As the above historical narrative analysis shows, approaches to sex work differ from society to society, depending on historical processes, legal norms and the cultural, moral, economic, and social structures that shape each society's laws and practices regarding sex work. It may be banned or regulated. Attitudes towards sex work have evolved due to crises, wars, changes in society, and value judgments, creating diverse, dynamic ideas of it.

2.3.1. Social perspectives

Marginalisation and exclusion from society make individuals vulnerable to exploitation through human trafficking. In this context, sex work can be considered within two basic frameworks: the human rights struggle of sex workers, and the anti-trafficking rights struggle of individuals victimised within the sex industry (Kilislioğlu, 2020) (Figure 2).

The relationship between sex work and human rights was placed on the global agenda after the UN Convention on Trafficking in Persons and Exploitation through Prostitution in 1949. The topic was discussed in the 1980s due to the impact of the rising feminist movement, HIV/AIDS, and related organisations such as the IOM and ILO (ILO, 2010). Documents including the 1979 CEDAW and the 1989 CRC, raised global awareness (United Nations, 1989). At the 1996 Vienna Conference, prostitution and trafficking were differentiated for the first time, emphasising that all forms of prostitution have the potential for exploitation.

Figure 2. Feminist movement: demonstration (Source: URL-1)

The 2015 "Memorandum of Understanding on Sex Work, Human Rights, and the Law" made three main demands: recognise sex work as a form of labour, end criminalisation, and support sex workers' rights to self-organise (Global Network of Sex Work Projects, 2013). Within feminist theory, discussions on sex work are divided into two main approaches. Radical feminists see sex work as a form of sexual exploitation and advocate prohibiting prostitution (Farley, 2003). Other feminist approaches recognise sex work as legitimate work and advocate for sex workers' rights, adopting a rights-based view (Figure 3).

Figure 3. Women's liberation protest (Source: URL-2)

2.3.2. Legal perspectives

Legal regulations and state policies are based on contrasting approaches that view sex work as either a form of sexual exploitation or a legitimate profession. The three main approaches of criminalisation, legalisation, and liberalisation can be analysed within four legislative models: prohibitive, preventive, regulatory, and decriminalisation (Figure 4).

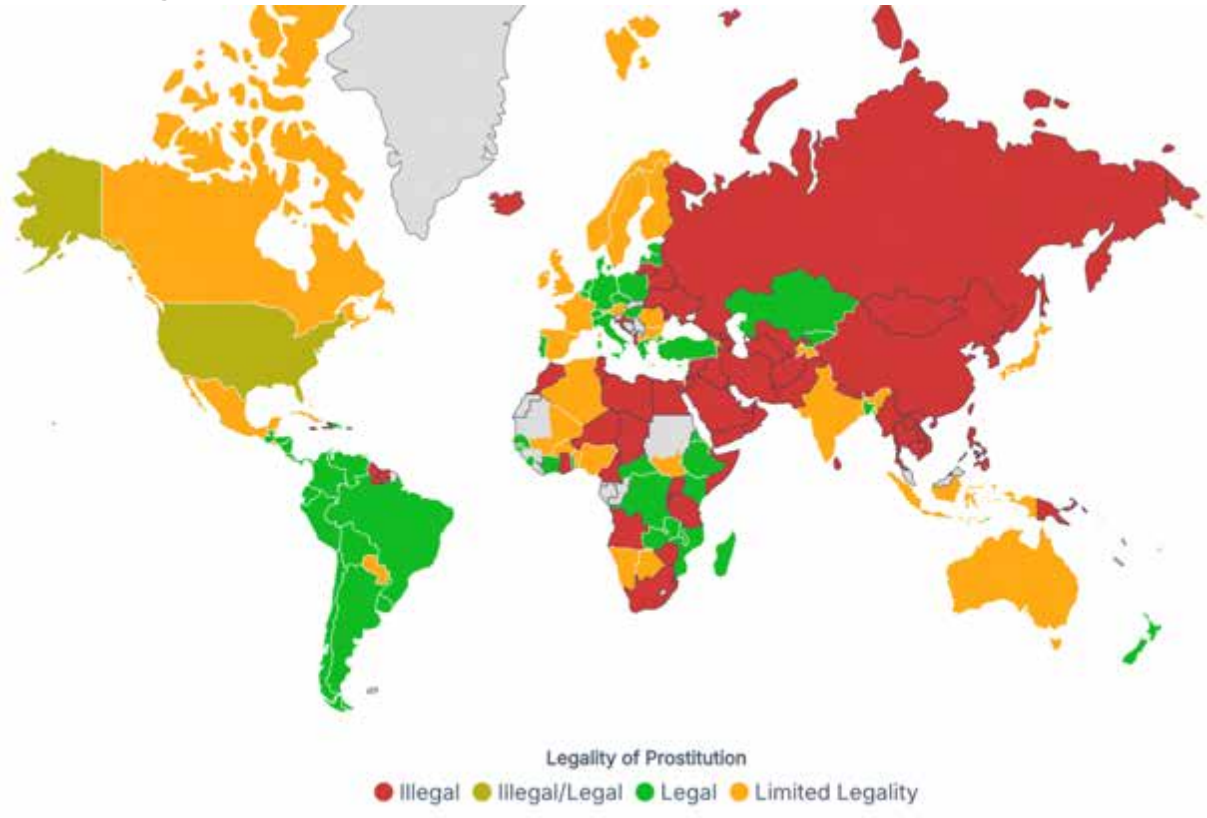


Figure 4. World prostitution policies, 2025 (Source: URL-3)

Prohibitionist model: the Swedish example

The prohibitionist model is a framework that bans all activities associated with the sex industry and penalises those involved. Its main objective is to eliminate gender inequality. Countries that apply the prohibitionist model, which appears in different parts of the world with different content within a similar framework, include the following: Iraq, Iran, Jordan, and Afghanistan in the Middle East; China, North Korea, South Korea, Thailand, Cambodia, the Philippines, Egypt, Uganda, and South Africa in Africa; and Lithuania, Albania, Croatia, and Sweden in Europe (Kilislioğlu, 2020). Here, Sweden has extensive discussion and research on the subject. Prostitution decreased due to Sweden's strict laws, but moved to hotels, restaurants, and online. This has led to unsafe working conditions and criminalisation (Dodillet & Östergren, 2011).

Abolitionist/preventive model: the Canadian example

The abolitionist model focuses on the preparation for sex work rather than the act itself, viewing it as a form of violence and exploitation. It bans advertising prostitution in public spaces, intending to reduce harm to women. Countries that implement this model include Poland, Spain, Portugal, Slovakia, Slovenia, and the Czech Republic in Europe, as well as Canada in North America (Kilislioğlu, 2020). Canada's approach aimed to remove prostitution from public, populated areas, which resulted in a visible decline. However, this shift has led to sex work becoming more hidden and isolated, increasing the risk of exploitation and violence against sex workers. (Benoit et al., 2018)

Regulatory model: the Dutch example

The regulatory model is an approach that partially legalizes and does not penalize sex work within a framework of state-set rules (Kilislioğlu, 2020). It is currently practiced in the Netherlands, Germany, Austria, Hungary, the United Kingdom, Greece, Türkiye, Belgium, Senegal, and parts of Australia and the US, including Nevada. The model's main objective is to control prostitution activities to protect public health.

The Netherlands is one of the most notable practitioners of this model. Although prostitution was technically illegal from 1911 to 2000, the government did not shut down brothels, and strict policies were not effective in fighting crime and exploitation. (Kilislioğlu, 2020). The Netherlands tried to control prostitution by creating tolerance zones, but the results have been negative. In some cases, sex workers have moved outside the tolerance zones and the zones have not fulfilled their function. While consensual prostitution is not a crime in the Netherlands, forced prostitution is (Coy, 2012).

Decriminalisation model: the New Zealand example

The decriminalisation model removes all punitive laws relating to sex work and recognises it as a voluntary profession that cannot be eradicated. New Zealand is the only country to use this model. Its purpose is to reduce social exclusion of sex workers and ensure citizens' rights within human rights (Kilislioğlu, 2020). This approach marks a shift towards recognising sex work as a rights-based profession, improving perceptions of, and the quality of life for, sex workers. However, it has also led to an increase in prostitution, with brothels now limited to four people, and raised crime rates in some areas. This has contributed to serious issues such as child exploitation, particularly in vulnerable regions. (Kilislioğlu, 2020).

3. Reflections of sex work in the Turkish context

The Red Umbrella Sexual Health and Human Rights Association (in short, Red Umbrella) in Turkey defines sex work as the exchange of sexual services for money, including porn, escorting, erotic dancing and massage. In contrast, the Turkish Language Association defines prostitution more narrowly as paid sexual intercourse that violates social norms (Red Umbrella, 2019). Historically, terms related to sex work have reflected societal marginalisation. Examples include 'prostitute', 'whore', 'rent girl' and 'sex worker'. (Açıkalın, 2013). In a narrow sense, sex work involves consensual paid sexual services without coercion.

Historically, sex work in Turkey has taken place on the urban periphery. Istanbul's development can be divided into four periods: 1600–1880, 1881–1950, 1951–2020, and the period since 2020. The legalisation of brothels in 1880 formalised sex work (Belli, 2022). Following the establishment of the Turkish Republic in 1923, legal regulations were introduced in 1926, although efforts to ban prostitution emerged in the 1930s (Wyers, 2017). After 1950, sex work grew in migrant cities, with more brothels and sex workers as consumer culture took off in the 1980s. The 1990s saw an influx of sex workers from the former Soviet Union.

The first NGOs for sex workers were established in the 2000s, and brothels closed during the COVID-19 pandemic, which started in 2020. This process was triggered by that which led to significant changes in the visibility, mobility, and working conditions of sex workers.

The global approach to sex work in Turkey is marked by diversity. State policies are shaped by regulatory models that protect the rights of working women. Some civil society organisations argue for sex workers' rights and the profession's legitimacy, while others seek to reintegrate sex workers back into society.

3.1. State attitudes and legal-administrative policies

The Ottoman Empire adopted France's prostitution regulations in 1858. The Republic of Türkiye adopted them and they were maintained until 2004. In 2004 the law was amended to prohibit prostitution and bargaining but not consensual sexual services by over-21s in private. Those who encourage, mediate, provide a place for or profit from prostitution involving children or adults are penalised under the new code.Articles on human trafficking include provisions to prevent foreigners from being exploited in the sex industry (Kilislioğlu, 2020).

A 2011 report stated that after the 2004 Penal Code, the term "general woman" referred to women who were habitual sex workers, over 21, Turkish citizens, licensed, and employed in brothels (Şimşek, 2022). The Regulation on Combating Venereal Diseases, which took effect in the same year, established responsibilities, including licensing brothels, maintaining records, inspecting prostitution establishments and preventing hidden prostitution. Additionally, the regulation includes providing support to women who do not want to engage in prostitution (Kilislioğlu, 2020).

3.2. Civil society and NGO perspectives

Red Umbrella, Kaos Gay and Lesbian Cultural Research and Solidarity Association (Kaos GL) and the Sexual Education, Treatment and Research Association (CETAD) are among Turkey's non-governmental organisations working on sex work. Red Umbrella defines sex work as a unique form of labour due to its conditions and methods. It is inappropriate to compare it with other labour, not necessarily in terms of legitimacy, but because of its unique nature (Red Umbrella Fund, n.d.). Therefore, regulatory frameworks must be developed with scientific rigour, considering the experiences and needs of sex workers. Underground environments are at high risk of exploitation and abuse without this (Demirtaş, 2021).

Kaos GL recognises sex work as legitimate labour and advocates for the rights of its workers. The organisation emphasises that this profession's individuals require rights-based support and regulations. Kaos GL critiques the concept of public morality, which fuels discrimination and criminalisation of sex workers in the media (Zengin, 2014). Sex workers, who are constantly subjected to interventions as if every one of their actions is criminal and who are portrayed as perpetrators in the media, are not criminals (Yılmaz, 2021).

CETAD, working with the Turkish Ministry of Health and funded by the European Union, promotes gender equality and human rights for sex workers through a project that focuses on respecting their rights, preventing discrimination, encouraging empathy, and getting them involved in society (CETAD, 2021). The project tackles child sex work prevention, victim rehabilitation, and sexual exploitation perpetrator prosecution. These intervention areas are considered crucial.

4. Research design and methodology

By shedding light on the realities and perceptions of this vulnerable group, this study aims to address deep-seated inequalities and advocate for social and spatial justice in the historic Pera quarter of Istanbul. One of the most well-known sex work areas of Turkey and located in central Istanbul, Pera has gone through urban transformations that affected the centuries-old sex work in the area, particularly in the last two decades.

This study uses a secondary qualitative research approach. The methodology is divided into three main phases presented in the sections below. Based on theoretical, social and legal frameworks reviewed above globally and in the Turkish context, the first phase explores the spatial dimensions of sex work within the historical development of the Pera quarter. This was achieved by examining documentaries, historical maps, and archival records. The second phase focuses on analysing urban infrastructure and transformation projects in Pera, paying particular attention to the displacement of sex workers. This phase utilised documentaries, news articles, and official records relating to urban redevelopment initiatives. The final phase synthesises the findings through a layered, CAD-based mapping exercise. This exercise visualises the intersections of sex work nodes in public spaces and urban regeneration projects, as well as the resulting processes of spatial exclusion faced by sex workers.

5. The socio-spatial transformation of sex work in Türkiye: the case of Pera

Istanbul's Beyoğlu district's sex work-related approaches were complex in the late 19th century. Linked to the port in the early Ottoman Empire, the area became a trade hub. In response, the 6th District Municipality, which includes Beyoğlu, implemented pioneering urban reforms. During this period, bachelors and prostitutes were viewed as both undesirable and an essential part of urban life. Rather than banning prostitution, authorities and elites introduced regulations to mitigate its negative consequences, importing the European and French ones.

Ottoman urban reformers considered regulating prostitution as part of their modernisation efforts in adapting to global trade. Conflicts and tensions in evolving public spaces are discussed, particularly due to impoverished women and other recent immigrants. This text examines the policies of social and administrative elites aimed at limiting prostitution's mobility and visibility in urban areas. Sex workers were indispensable to Beyoğlu's urban life, so eliminating prostitution was not considered appropriate. Instead, it was deemed important to keep prostitution out of sight in public and under administrative and medical supervision in designated areas. This was considered a step in preserving society's moral and physical cleanliness. As a result, areas within the city emerged where controlled prostitution could be practised.

Pera, in Beyoğlu, is home to many elites and marginalised people. It starts at Istiklal Street and extends to its surroundings, meeting with Yüksek Kaldırım and Galata, and then Karaköy. Pera, a Greek word meaning 'the other side', has undergone various socio-cultural, economic, and physical transformations.

5.1. Spaces of sex work

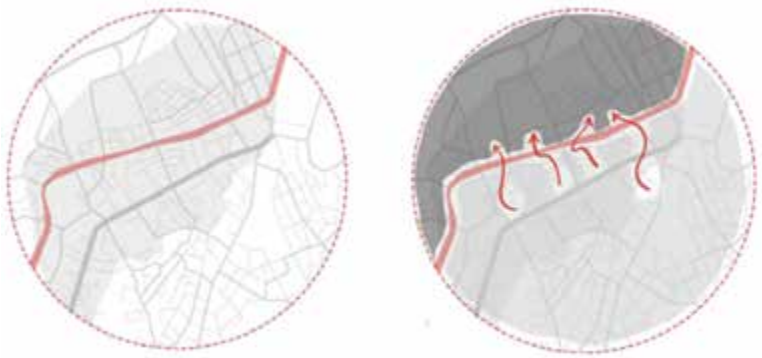
In the urban context, sex work takes place in urban spaces where it has long existed, shaped by both visibility and exclusion. These streets squeezed into the dense and layered structure of the urban fabric and stand out as contested areas where negotiations between bodily autonomy, urban governance and social norms take place.

5.1.1. Public spaces (street-based sex work)

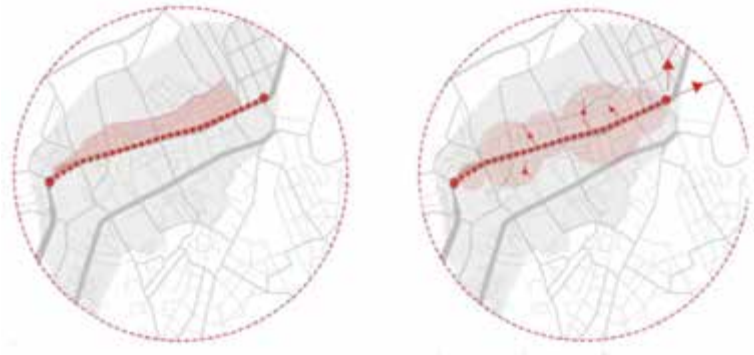
The Pera quarter is located in the tourist and historical centre of Istanbul. For this reason, it is an attractive work area for sex workers, offering high customer potential and ease of access. Additionally, Pera's historical significance and cosmopolitan, open-minded sociological structure have increased social acceptance in the area. Due to the heavy foot traffic on the streets and avenues in and around Pera, sex workers prefer to work in this area, where there is a high customer potential. These areas are densely populated with tourists and locals, who are an important source of customers for sex workers (Erder &Kaşka, 2003).

Tarlabaşı District

After Tarlabaşı Boulevard opened in 1986, groups displaced from gentrifying neighbourhoods in Beyoğlu, such as Cihangir, Asmalımescit, and Galata, settled there (Perouse, 2011; Zengin, 2014). Changes in the 2000s as part of the Urban Transformation and Urban Renewal Project aimed to alter the region's sociological structure, but decreased social control, creating insecurity. Some displaced transgender sex workers continue to work in certain areas of Tarlabaşı due to economic hardship and because they cannot find a supportive community elsewhere. Others have moved to nearby neighbourhoods, such as Elmadağ and Kurtuluş, or to Anatolian cities. The destruction of workplaces has negatively impacted active sex workers (Şentürk, 2011) (Figure 5).



1. Tarlabaşı Boulevard and Tarlabaşı were separated from Beyoğlu 2. Class evacuation

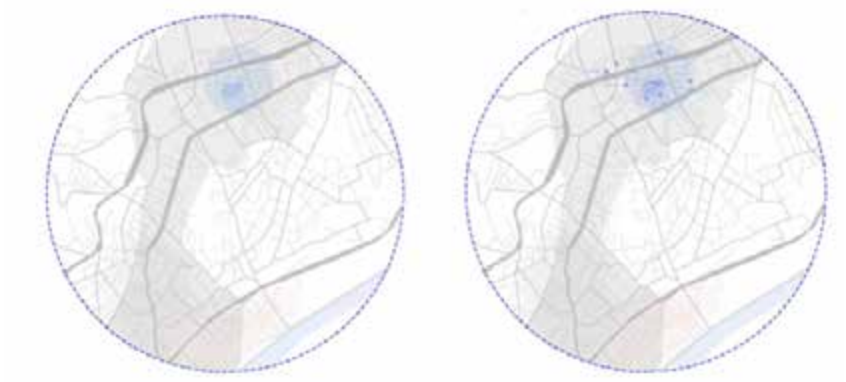


3. Tarlabaşı renewal project 4. Displacement study

Figure 5. Changing spatial dynamics of sex work in Tarlabaşı (produced by the authors)

Küçük Bayram Street

The LGBTI+ Solidarity Association defines this area and surrounding streets have been used since 1947 (Kepenek, 2024). Police raided the area often, but trans women continued to live there. Bayram Street is a memory place for the trans+ movement in Istanbul. There were intermittent raids and attempts to stop activities, but the effective transformation movement came in 2023 with an official closure decision on the grounds of 'hanging from the window.' Some houses were sealed. The 10th Istanbul Trans Week Committee says trans women living here stated that they would not leave because unity and solidarity make them feel safe. They emphasised this with the following statement: "Trans+ people did not and will not leave despite the control mechanisms that try to make trans+ existences invisible" (Kepenek, 2024) (Figure 6).



1. A developing area where trans sex workers are concentrated 2. Police have been trying to defer them constantly with raids, currently most of the houses on this street are sealed. Most of the trans sex workers here have not left their neighbourhoods.

Figure 6. Spatial diffusion of sex work from Küçük Bayram Street (produced by the authors)

5.1.2. Private spaces (brothel-based sex work)

Brothel-based sex work occurs in more controlled and institutionalised private spaces where visibility in public spaces is limited. The Abanoz and Ziba quarters, and especially Zürafa Street, have been areas where brothels are concentrated and sex work has been spatially limited for many years in Istanbul.

Abanoz and Ziba quarters

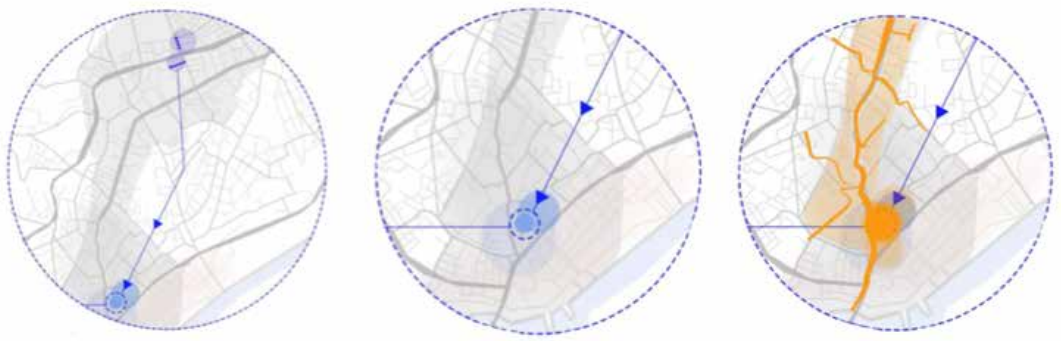
Abanoz and Ziba are among Istanbul's oldest residential areas, with a long history of trade, entertainment, and social activities. Historically, these areas were known for their brothels and street sex work (Aksoy, 1996). This made them a suitable environment for sex workers due to their visibility and security. The first brothel for foreigners living in Beyoğlu was opened in Abanoz Street in 1884. It was later moved to Zürafa Street due to social perceptions and order. Today, Abanoz Street is completely cleaned and included in commercial areas (Figure 7).

1. The first brothel area 2. Increased motivation for brothels
3. Moving the venue and female sex workers to Galata Zürafa street. Trans women continue to provide services on Ziba street

Figure 7. Transformation of Abanoz and Ziba (produced by the authors)

Zürafa Street

It is the most well-known quarter in Istanbul where the first official brothel was established. Alageyik and Yüksek Kaldırım Streets, which connect to Zürafa Street, are also part of this area. Due to its central location and ease of access, Zürafa Street has provided an ideal work area for sex workers. The buildings where the brothels are located provide both visibility and privacy, allowing customers to easily access them. The spatial structure of the area ensures that workers have a safe, economically sustainable work environment (Hubbard, 1999). The goal is to build more modern, tourist-oriented structures in the area and renovate existing structures as part of the Beyoğlu Culture Project, which is analysed in the sections below. However, the arrival of the COVID-19 pandemic has led to the closure of brothels and the spatial displacement of sex workers (Çınar, 2001) (Figure 8).



1. The first official brothel 2. Increased motivation for brothels
3. Inclusion of the place in the Beyoğlu cultural project

Figure 8. Transformation of Zürafa Street (produced by the authors)

General Evaluation

Urban areas historically identified with sex work, such as Pera, Tarlabaşı, Küçük Bayram Sokak, Abanoz and Zürafa, stand out as complex spaces where both visibility and exclusion intersect. In particular, the opening of Tarlabaşı Boulevard in 1986 and the urban renewal projects initiated afterwards transformed not only the physical but also the social structure, causing the displacement of sex workers living in the region. A similar social eviction issue occurred on Küçük Bayram Street; the trans sex work areas that had existed for many years were dispersed with the closure decisions, and this situation led to sex workers working in even more precarious conditions and in a dispersed manner. The brothels operating on Zürafa and Abanoz streets were gradually withdrawn to more isolated and suppressed areas in order to reduce public visibility. Such interventions interrupted the continuity of sex work within the city and weakened the solidarity networks of settled communities. The general map reveals how the place, rights and visibility of sex workers within the city were ignored in the planning processes (Figure 9).

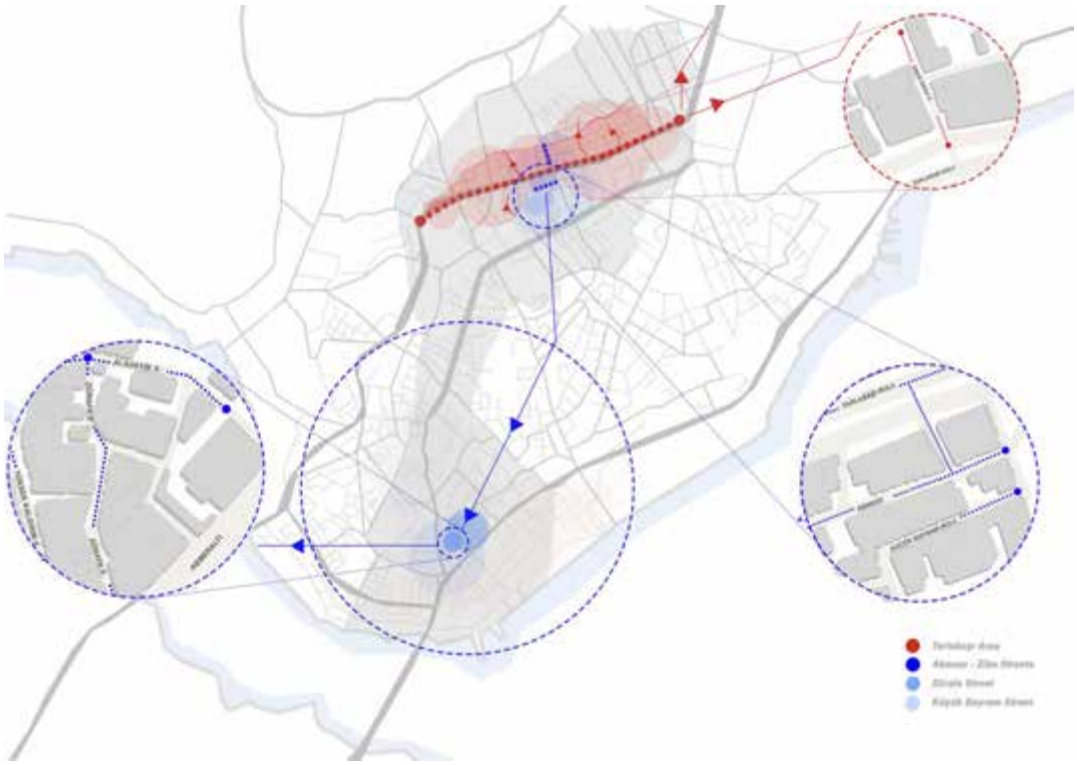


Figure 9. Displacement of sex work in Pera (produced by the authors)

5.2. Urban infrastructure and redevelopment projects affecting sex work

Tarlabaşı and Beyoğlu, located in the centre of Istanbul, are social spaces where vulnerable groups, especially sex workers, survive and build solidarity. However, successive urban interventions—including the Tarlabaşı Boulevard Project, the Tarlabaşı Renewal Project, and the Beyoğlu Cultural Road Project—have reshaped these spaces. These projects aim to transform the areas into socially homogenised urban spaces based on profiteering logic.

These projects exclude sex workers existentially, marginalise them, and displace them. Although the discourse behind these projects—security, culture, tourism, and restoration—is presented as inclusive, the projects cause the erasure of sex workers' spaces of shelter, work, and solidarity from the city centre. Thus, these projects have not only transformed spaces, but also radically limited the right to the city and public visibility of vulnerable communities.

5.2.1. The Tarlabaşı Boulevard Project

The Tarlabaşı region developed as a residential area of Pera in the 19th century. With its multicultural structure, the area hosted many groups and immigrants. However, in the 1980s, the area was defined as a 'decay zone' and targeted because its appearance was said to damage the 'image' of the city centre due to structural deterioration and socio-economic collapse (Candan & Kolluoğlu, 2008). The Istanbul Metropolitan Municipality was established by Law No. 3030, enacted in 1984. Bedrettin Dalan then took office as Istanbul's first mayor. At that time, Dalan's goal for Istanbul was to create an image of it as a 'world metropolis.' To this end, urban transformation projects were initiated (Keyder, 1999).

One of these projects was the Tarlabaşı Boulevard Project, implemented in the 1980s to improve transportation and the area. However, the project has become an ideological intervention rather than merely adding a new transportation line. It interrupted the historical and social integrity and permeability between the Tarlabaşı neighbourhood in Beyoğlu and Pera, creating a permanent separation in the urban fabric. In short, this intervention

should be evaluated not only as physical separation but also as a spatial expression of social exclusion (Figure 10).

Figure 10. Enlargement of the Tarlabaşı Boulevard in 1986-1988 (Source: URL-4)

As a result, a new 'urban gap' emerged in the Tarlabaşı-Pera region, which continues the 19th-century urban fabric. The separation has become more apparent due to the severing of passageways and construction of a high-traffic boulevard (Candan & Kolluoğlu, 2008). On an urban scale, Tarlabaşı's connection to the city centre has been cut off. The area has essentially become Pera's 'backyard,' leading to imbalances in access to social services and being ignored in planning policies (Keyder, 1999). This intervention has made low-income groups, ethnic minorities, and various marginalised communities living in Tarlabaşı even more 'invisible.' Despite being in the centre of the city, these groups have been socially pushed to the margins. Public memory has coded these neighbourhoods as 'out of order,' deepening the socio-cultural separation. Tarlabaşı Boulevard has ceased to be a tool of urban planning and has become a border where urban segregation, socio-economic exclusion, and spatial othering become concrete.

5.2.2. The Tarlabaşı Urban Renewal Project

The Tarlabaşı Urban Transformation Project is another significant example of urban intervention in the Tarlabaşı district that exacerbated social and physical segregation. Tarlabaşı is a district with a dense population of non-Muslims that has experienced demographic changes. Certain communities left the region as a result of political and social events that took place in the 1950s, and immigrants from Anatolia and other disadvantaged groups settled in their place.

In 2006, Tarlabaşı was designated a renewal area under Law No. 5366, which concerns the 'Renovation, Protection, and Revitalization of Worn-Out Historical and Cultural Immovable Assets.' Under this designation, plans were made to build luxury residences, offices, and commercial areas under the name 'Taksim360' in nine blocks of the district (Çiltaş Çatalbaş, 2022). Evacuations began in 2008, and by 2010, a large portion of the district's residents, particularly low-income and uninsured groups, had been forcibly evicted. This urban transformation has attracted high-income groups to the region, altering the economic structure and paving the way for the gentrification of the district. This situation produced a multi-layered practice of exclusion and displacement, particularly affecting long-time sex workers in Tarlabaşı. Tarlabaşı was experienced as a kind of "urban shelter" by sex workers in the region due to the solidarity networks and social relations they had established there. As the visibility of sex work has decreased, sex workers have been further criminalised, erased from the public sphere, and their advocacy for rights has weakened (Figure 11).

Figure 11. Borders of the Tarlabaşı Project (Source: URL-5)

5.2.3. The Beyoğlu Culture Route Project

The Beyoğlu Culture Route Project is a Ministry of Culture and Tourism of Türkiye initiative in Istanbul's Beyoğlu district (Kültür Yolu Festivali, 2025). It aims to create a cultural corridor from Galataport to Taksim. The structures to be restored along the route are discussed in terms of 'Beyoğlu's revival with culture' through museums, art centres, and public events. While Beyoğlu Culture Road restructures an axis covering İstiklal Avenue and the surrounding streets, it aims to remove groups that have historically existed there and often represent the 'invisible history' of the place. The public character of İstiklal Avenue, especially its nightlife, alternative culture, and gender diversity, is changing to a regulated, supervised, and 'clean' cultural area.

The area around Zürafa Street that sex workers have called home and worked in for years has been completely closed. Sex workers have lived and worked on this street for many years. However, with the project, their living spaces and social networks have been fragmented, and their economic and social security has weakened. With the increase in police presence, these areas have been taken under control with a security-oriented approach. In this context, the Culture Road Project also functions as a moral control device while reconstructing the space through culture. Sex workers are both the subject and the target of this moral regime. Thus, urban elitism and a gender regime are reproduced under the guise of 'culture'. This project is not only a cultural investment but also deeply produces spatial injustice.

5.3. A holistic spatial assessment through mapping

The spatial transformation of the streets associated with sex work in the Pera region has been shaped by large-scale urban interventions implemented in different periods, and both the physical environment and the socio-cultural structure have changed radically in this process. The mapping study visualises this transformation process and reveals how space is reproduced not only physically but also socio-politically. When the current locations of sex work areas in three different focal points (Tarlabaşı-Ziba, Zürafa and Abanoz-Küçük Bayram Streets) are examined, it is seen that these areas are shaped by strategies of oppression, eviction and exclusion. Some streets have been completely cleaned, some have continued their existence with controlled visibility, and some have become temporary shelters. As a result of all these interventions, the presence of sex workers in urban space has been systematically limited; their rights to take place in public spaces to shelter have been damaged (Figure 12).

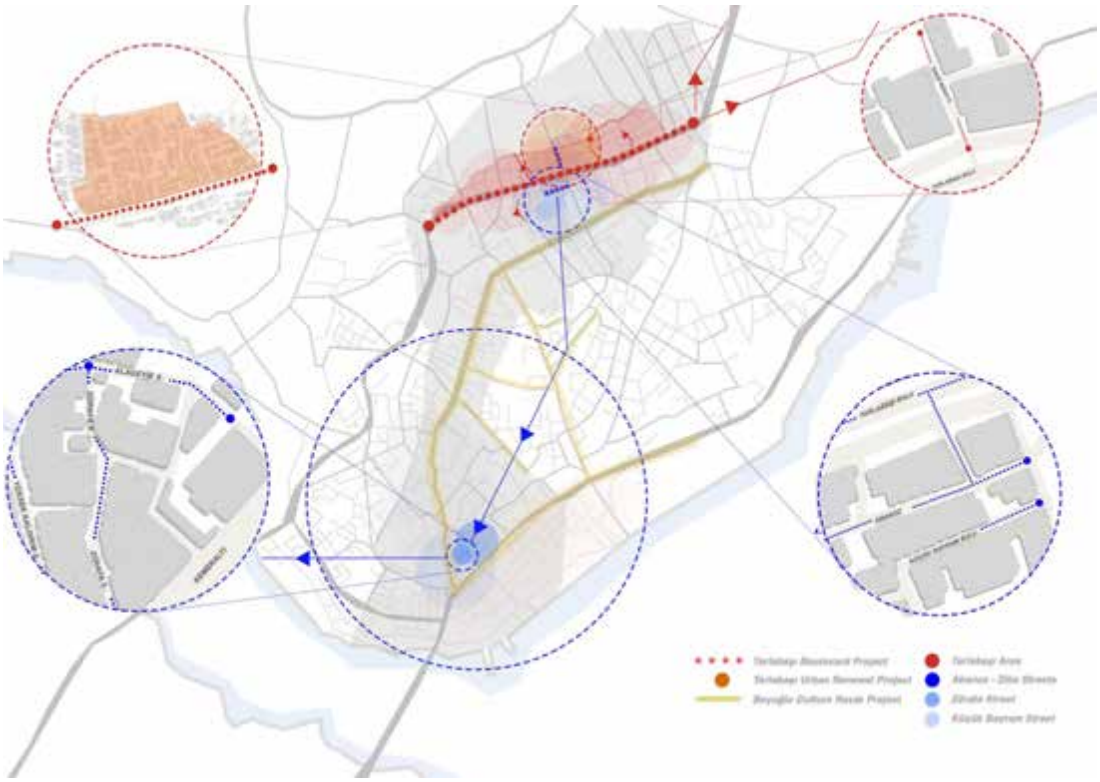


Figure 12. Spatial overlay of sex work spaces with urban redevelopment pressures (produced by the authors)

6. Concluding notes: reflections on urban transformation

Examining historical processes has revealed that prostitution increases significantly during social upheavals such as migration, war, and economic crises. This increase has led to negative consequences, including the spread of epidemic diseases and higher crime rates in cities. In response, city administrators have developed new urban policies to address these issues. However, the inadequacy of these policies has caused these breaking points to reoccur (Figure 13).

This research aims to shed light on the situation of sex workers in Türkiye, particularly those displaced due to changes in the Pera district of Beyoğlu, Istanbul. Pera, a historically diverse neighbourhood, has experienced social and economic shifts, leading to urban policies and the settlement of various ethnic and orientation groups. Emerging problems have triggered further transformations, creating a chain reaction that has shaped Pera's urban landscape.

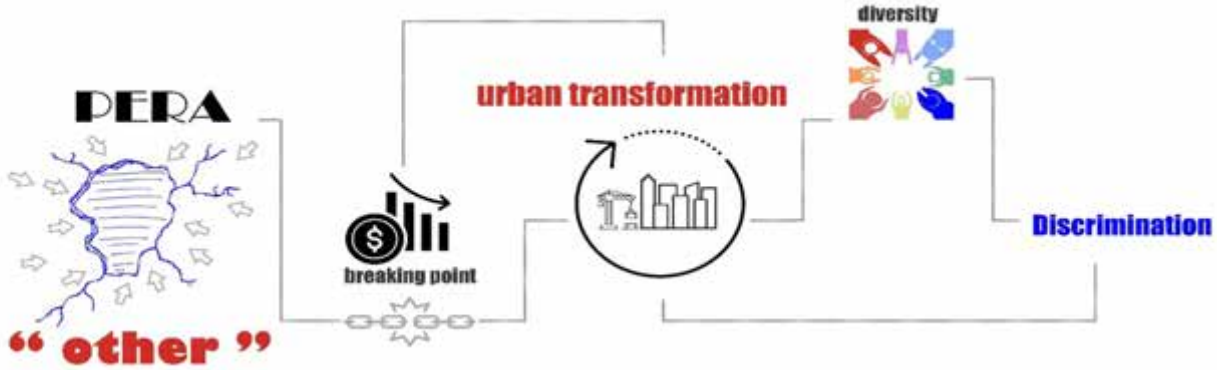


Figure 13. Abstract representation of the urban transformation story of Pera (produced by the authors)

Sex workers play an important role in the socio-cultural and economic dynamics of urban areas. However, they are seen as a problem in the public sphere and are considered one of the most fragile and disadvantaged groups in society. They are viewed as a situation that needs to be removed from city centres. The desire to 'clean up' urban centres and the prohibition and exclusion of sex work result in human rights violations, including economic hardship, lack of housing, and lack of social security for sex workers.

Consequently, efforts should be made to combat negative perceptions, ensure justice in urban transformation processes, develop and improve policy proposals, and raise awareness. This study aims to raise awareness to enable sex workers to achieve better human rights and social justice conditions and to establish a foundation for future work. The results show the gap between urban regulations and the spatial needs of sex workers in Istanbul, highlighting social equity's role in reducing systemic exclusions to encourage more inclusive practices. It thus hopes to enrich the discourse on the sustainable development of public space by advocating for the implementation of inclusive, accessible, and socially equitable spaces.

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Planners and the moral power of the "unpleasant"

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Abstract
Aesthetics are paying increasing attention to negative sensations and to individual judgements that cannot aspire to universal validity, The agreeable or pleasant, and especially its converse the unpleasant, have a considerable motivating power for action, often intertwined with ethical judgment, legitimizing action in the public sphere.

The aesthetic and ethical power of the unpleasant is illustrated by three case studies in Madrid. The first one is tactical urbanism response for street redesign (Vallecas, Arboleda street). The second one (Puerta del Sol) shows the accommodation of the public space to the pressure of touristification, to foster economic opportunities. The third case one (Green Southwest Boulevard) shows the consolidation of pre-existing power relations in response to a blighting process.

Keywords: Aesthetics, planning ethics; unpleasant; pragmatism; public space

The unpleasant as an aesthetic category

Kant paid little attention to what we now call negative aesthetic categories such as the unpleasant, the ugly or the disgusting. His most elaborated reflection on these appears in his *Critic of Judgement (1790, §48)* with an inspiring distinction between the unpleasant (which can be beautifully represented in art objects), and the disgusting (which cannot). Disgust has a sort of imposing nature which cannot be overcome, so that any object attempting to represent it cannot be dissociated with the nature of the object itself. (Kuplen, 2011). Three key features of Kantian aesthetics are positiveness (focus on beauty and the beautiful object), the disinterest of aesthetic judgments and the potential of aesthetic judgments to be universally participated, in spite of their subjective nature.

One of the first attempts to critically analyse negative aesthetic categories comes with Rosenkranz's *Ästhetik des Hässlichen* (1853). The ugly is not the mere opposite of the beautiful, but more precisely the negation of total unity and formal definitude; amorphousness or, in other words, the absence of a boundary to the outside and, internally, the absence of distinction: asymmetry and disharmony turn objects ugly.

Dewey's aesthetics turn the focus from the object to the subject or, better, to their interaction. As Dewey (1934) considers *Art as Experience*, he is placing aesthetic judgments in the humbler realm of contingent human experiences, challenging their pretence for universality and disinterest. Imagination- a human trait that can be developed through education- plays a key role in creating such experiences. For a pragmatist, there are many kinds of aesthetic experience, especially if- as Dewey did- there is no precise definition of the term or restrictions about its appropriate usage. As Shusterman, (2012) puts it, "*not all of the experiences or reactions that we call aesthetic are experiences of pleasure; not only are there bad aesthetic experiences that provide no pleasure (except by the relief of their ending), but there are also valuable aesthetic experiences that cannot be described as pleasurable*". Furthermore, aesthetic experiences can generate from everyday experiences, and are likely to merge with other human experiences, including moral ones.

Dewey's pragmatic aesthetics considerably expands the realm of aesthetic appreciation and gives room to aesthetically reflect on the ugly, the disgusting or the unpleasant (negative aesthetics), the objects and events of everyday life (everyday aesthetics), or interest and action embedded in aesthetic experiences (aesthetic engagement). Berleant develops all these dimensions with the concepts of the aesthetic field (1970), aesthetic engagement (1991), environmental aesthetics (1992) and negative aesthetics (2010). Together, they provide a

unique framework to analyse how the relationship between people and urban places (the built environment) creates an aesthetic experience prone to action.

Miller (2021) summarises the realm of negative aesthetics in Berleant (2010) as what is "*perceptually distressing, repellent, or painful, or [that which] has effects that are harmful or destructive*" and is elusive to rational criticism: "*The aesthetically negative often slips by unnoticed and eludes critical scrutiny, settling into vague discomfiture. Part of this discomfort... may result from the subtle presence of negativity or from the very failure to recognize that aesthetic negativity is indeed present*".... Berleant (2010) notes that, in the context of landscape and built environments, aesthetic negativity often takes the form of aesthetic deprivation. It is not surprising that, for Berleant (2017), the moral and the aesthetic are two dimensions along which negative aesthetics may operate.

Aesthetic engagement becomes for Berleant (2013) as the central concept of an alternative to the aesthetic disinterestedness that was central to traditional aesthetic theory. It emphasises the holistic and contextual character of aesthetic appreciation. The attention of critical scrutiny moves from the aesthetic object to the situations and the ways in which engagement arises. For Berleant, as for pragmatic aesthetics (Shusterman, 1992), aesthetic value involves experience that is somatic and not exclusively psychological.

Forsey (2016) makes a useful distinction between the various categories in negative aesthetics. The ugly- like the beautiful in Kant- has a disinterested note and an ambition for universal validity. The disgusting leads to visceral responses associated to immediate sensorial or somatic reactions that cannot be overcome. The unpleasant, however, has great motivating power together with a modesty well suited to our daily lives; it is an aesthetic category referring to physical sensations that engage our higher faculties, spurring imagination, creativeness and, ultimately, action. The fact that it does not have universalising demands does not mean that the unpleasant is completely subjective: in fact, it can be shared, eventually engaging people in acting together.

The unpleasant is for Forsey (2016) a *catalyser* of aesthetic action. Such call for action is spurred not only from the displeasure it generates, but also from our closeness to it (it forms part of our environment, and even of our everyday, which is not the case for the ugly) and from its relatively manageable size (which is not the case for the disgusting). Furthermore, the unpleasant is often morally charged as a sort of disorder, unbalance or unfairness (such as in contact with dilapidation, dirt, etc.), especially in objects or places shared with others, from our home in which we may receive friends and family to public spaces in the city. That is the intuition Saito (2001 and 2007) develops in its everyday aesthetics, looking at daily events and actions in which the human sensorial faculties are *saliently at stake*. It is also from this perspective that our judgment cannot remain purely personal, and claims some kind of minor generality, getting us involved in a- does not matter how small- community of others.

The moral and the aesthetic experience in the unpleasant

It is well known that for Wittgenstein (1923) "*ethics and aesthetics are one and the same*" (Tractatus 6.421). Appelqvist (2013) explores the sense of such identity. Aesthetics and ethics are equally transcendental and ineffable, because they both look at their respective objects (the work of art or the good life) under the same (*sub specie aeternitatis*) way of seeing, i.e., from outside. Beauty, as happiness, "*relies on the way of looking at the world*". The attitude shared by ethics and aesthetics is a feeling: "*Feeling the world as a limited whole- it is this that is mystical*" (Tractatus 6.45).

Such attitude would require the renunciation to any interest and the renunciation to seeing objects and things from the midst of them, but the latter is precisely the pragmatic understanding of the aesthetic experience and the perspective of the aesthetic engagement. By renouncing to transcendentalism and even to any pretence of universality, the pragmatic approach does not pursue any identification of aesthetics and ethics in the human experience, but this does not mean that some kind of contingent convergence is not possible. In fact, much of modern art includes some sort of ethical claims at their core, and art is eventually seen as a form of self-improvement or cultivation, for example in somaesthetics (Shusterman, 2014) or in the *art of living* pervasive in many Eastern traditions.

The unpleasant arises discomfort, as repeatedly described in works on everyday aesthetics and environmental aesthetics. It arouses our will for action and our longing for change. What is interesting is that such longing is strengthened when intertwined with some sort of ethical judgment. The combination of the feeling of the unpleasant (but not the ugly, which is contemplated without interest or engagement, nor the disgusting, which leaves us paralysed if not running away) with the feeling of the morally wrong (but not the absolutely evil, which can be seen as a particular form of the disgusting, preventing any positive action) is what emboldens the subject to presume that her judgement may have some potential of generality, and what triggers her resolution to act in the public sphere. Note that the merely *unpleasant*- as a personal judgment- hardly legitimizes such action in the public space, although it can certainly move to action in the private sphere: changing the wall colour in my room or tidying up my desk.

It is possible to find ethical considerations as a powerful leverage to trigger action out of an aesthetic experience. Note that the process moving to action is more likely to be triggered by the aesthetic experience, and that ethical considerations subsequently come to further spur the motivation for action. The urban public space is an excellent field to observe such process and the intertwining of aesthetics and ethics.

Such intertwining may be used by planners and by other urban stakeholders to gain support to their proposals for urban interventions. The subjective aesthetic experience of unpleasantness gains in generality when it is compounded with ethical motivations, enabling collective action. Micro-policies in the urban public space, like those addressing street design or mobility management, provide an excellent illustration of such intertwining of an aesthetic experience with ethical values, (1) by strengthening the claim for wider generalization of subjective judgements, and (2) by offering to those engaged in action small wins with immediate (aesthetic) satisfaction and strong ethical symbolism. Ultimately, it is the aesthetic-ethical connection which makes of the urban landscape "*markers of inclusion and exclusion in planning*" (Duncan, 2004) or "*a medium of identity formation and power relations*" (Mitchell, 1994).

Ironically, the theory and practice of planning engaging public spaces have often crystallized in a "dictatorship of the visual" in contemporary beautified cityscapes which, beyond hiding or displacing what is considered as unacceptable, introduce active practice of control over them (De Martine-Ugolotti and Genova, 2025). Modern commercial spaces, over-touristified neighbourhoods and fenced urban developments all share the traits of aesthetically led planning. Needless to say, far from begetting an aesthetic experience in the pragmatic sense, they are firmly imposed on city dwellers and visitors alike with their undisguised pretence of completeness and immobility. Such cityscapes can be not merely ugly but utterly disgusting, especially for those intertwining them with ethical considerations on power and domination. But such negative aesthetic experiences are overwhelming, unlikely to engage the wider array of people necessary to unfetter any collective action.

Current debates on the pervasive touristification of the cityscape can be read from a Deweyean perspective. For residents, familiarity, safety and identity are likely to be key traits in their everyday aesthetic experience. Such everyday traits can also trigger strong aesthetic experiences also in visitors sensitive enough to appreciate them. Aesthetically led planning, however, prefers the shortcut offered by blunt standardization of the public space for its subsequent commercialization. For residents and aesthetically aware visitors, the unpleasant moves to engagement; for massive tourism, it merely reduces commercial value.

The merely unpleasant, on the contrary, belongs to the unstable realm of the provisional; it is perceived as a temporal situation, a work-in-progress waiting- and even urgently calling- for our intervention. Therefore, it can be wishfully manipulated by planners as a way to gain momentum for subsequent collective action. One obvious example is tactical urbanism, especially within highly controversial sustainable mobility policies reallocating the street space. Whereas the negative aesthetic experience resulting from a car-dominated street or square is neutralised by daily routine and by the incremental way in which cars have conquered and transformed the cityscape, the aesthetic perception of the unpleasant by a handful of planners moves them into action, initially just to highlight with some minor painting and cheap street furniture the obvious inconsistencies of the situation.

Important to note that such tactical actions do not create a pleasant perception, very much on the contrary: the clearly provisional and unstable image tactical urbanism creates widens and generalizes an aesthetic experience that calls for subsequent action. But such call for action is not a move back to the original situation, due to the fact that now the unfairness of car-dominance has been taken to the forefront; it is that intertwining between aesthetics and ethics that make it possible to engage and move forward towards an alternative, more permanent (and expensive) design, in which the new power relations established by the tactical intervention are consolidated.

This example shows instability as one key feature of the unpleasant. If unaddressed, the unpleasant may deteriorate into the ugly (blighting). The ugly can claim universality, but it does not call as much for action as for simple cancellation, even if such cancellation is expensive in city planning. In fact, blighting has been profusely used by urban decision makers (and planners) as a strategy to subsequently claim the need to further adapt cities to cars (i.e. by increasing road capacity with expensive tunnels on the pretence of removing traffic from the surface). It is relevant to note that the aesthetic experience of ugliness, or the action for its cancellation, does not intertwine with any ethical considerations.

Planners dealing with the unpleasant: the case of street space

Cities- and particularly urban roads and streets- show how planners make use in different ways of the strength of the unpleasant to mobilize action. In some cases, they actually create the unpleasant as a way to highlight the moral inconsistency of the *statu quo* and to gain momentum for radical changes; in other cases, they provide more or less sophisticated aesthetic criticisms on the urban space, which often remain unnoticed but sometimes push decision makers to act, implementing more or less elitist projects with unexpected outcomes; in some cases, the unpleasant is left untouched by inaction, until it turns into the ugly or even the unbearably disgusting; in this case, the request for action does not come as much from planners as it does from outraged citizens or concerned decision-makers, asking planners for quick and radical change, although without challenging the causes at the root of such ugliness. The combination of the aesthetic power and ethical dimension of the public space is different in each case: respectively, with moral judgment triggering action, with aesthetic judgment claiming moral authority and with aesthetic judgment virtually ignoring moral considerations.

These approaches can be illustrated through three cases studies in Madrid, in which the planning response is ethically charged in different ways. The first case study corresponds to a tactical urbanism response provided by a street redesign in the south of Madrid (Vallecas, Arboleda street) in which power relations are first revealed and subsequently transformed. The second case study (Green Southwest Boulevard, A-5) shows a decades-long strategy of inaction leading to blighting, turning the unpleasant into the socially unbearable, and paving the way to the adoption of solutions based on the consolidation of the existing power relations in the distribution of street space. The third case study (Puerta del Sol) shows how a *beautification* attitude results in the accommodation of the public space to the pressure of touristification, changing power relations on the ethical grounds of fostering economic opportunities.

A similar itinerary is followed below in the description of each of the three interventions. After a short description, the paper examines (1) who are the actors that initially provide the judgment of unpleasantness, (2) what such actors identify with unpleasantness in the site, (3) the character of the moral considerations associated with the aesthetic judgment, (4) the actors whose interests are privileged or relegated by the aesthetic intervention and (5) the costs associated with the intervention.

Figure 1: *Tactical intervention in Arboleda Street, Vallecas District, Madrid (2019)*

Arboleda Street in Madrid provides access from one main transport hub in Vallecas District to a small University Campus, going through a blighted industrial area that has been waiting for decades the implementation of a residential development project. This semi-abandoned street served mostly as an on-street parking area for trucks and cars and induced high-speed traffic for those entering or leaving the Campus by car. The tactical action was implemented in 2018, installing (quite ugly) precast concrete barriers to expand walkways and painting an unprotected bike lane. This was well received by most street users, as well as by district residents, hoping that this would accelerate decisions about the larger regeneration project. Nevertheless, further action to consolidate the new distribution of the street space was postponed until the end of 2024, when the regeneration project for the main lot (*Tubos Borondo*, 137.074 m2, with 11.2 million of public investment) was finally launched. In accordance with such project, the final design of Arboleda street will consolidate the tactical intervention, privileging pedestrians and cyclists.

It is fair to say that the unbalanced distribution of the space in Arboleda street had remained generally unnoticed, until mobility experts and planners highlighted it through their tactical intervention, and the unpleasantness of the place was highlighted with the grey concrete barriers protecting pedestrians. In doing so, these experts and planners visualised how this "no-man's land" had been conquered by cars and trucks, not only neglecting soft modes, but actively expelled them. The aesthetic judgment was strongly intertwined with a moral judgment on the fair distribution of street space; in fact, it was even at the root of the action: the aesthetic unpleasantness was a consequence of wrong decisions in the allocation of the street space. Logically, the tactical intervention (and the subsequent regeneration project) privileges soft mode users as well as future residents, while relegating car traffic and on-street parking. The costs of the tactical intervention stayed in the tens of thousands and the public contribution to the regeneration project is 11.2 million.

Most of the surroundings of the road linking Madrid with the southwest of the country (Extremadura) and Lisbon in the outskirts of Madrid were in the past occupied by large military compounds and agricultural land.

The former were progressively abandoned since the 1980s, and the latter were replaced by high-density low-quality residential compounds since the 1950s. Urban growth, combined with the enlargement of the road to accommodate a motorway in 1968 created a progressively unattainable situation for residents.

At the end of the 1980s, as most of the military compounds had been abandoned, talks about a comprehensive regeneration plan for the whole area (named as *Operación Campamento*) proliferated, although with no tangible results. Traffic on the motorway kept growing and, in 2003, the new elected mayor announced a plan to replace the inner orbital motorway by a tunnel, including a tunnel for the 3 km of the Extremadura motorway closer to the city centre. This would not affect the area of *Operación Campamento*, but raised hopes among residents that a similar tunnel could sometime in future be built to get them rid of the motorway. Nothing happened, however, in the next decades, while residents experienced how their environment continued degrading. Demand management options to substantially reduce car traffic and traffic speed and allowing for the transformation of the motorway into a boulevard were analysed by some planners but such proposals were dismissed not only by decision makers afraid of the reaction of car users, by also by a part of the residents, encouraged by the active lobbying of the construction sector and others pushing for the tunnel option. Finally, in 2022, the project to build a 12-km long tunnel was approved, although only 3.2 km would be built in its first stage, started at the end of 2024, with a cost of € 408 million; the remaining of the 12-km tunnel will need to wait until the regeneration project of the old military sites generates enough cashflow to finance it.

Figure 2: *The A-5 in Batan neighbourhood, Madrid (2024)*

The area had been neglected for decades, since the first urban settlements started at the beginning of the XX century, in what is now known as Colonia Jardín, Batán and Lucero. Batán and Lucero already had a significant population in 1960, and shortly afterwards (1966-68), the road was enlarged and transformed into an 8-lane motorway, in some sections less than 1 meter away from residential buildings. The first buildings in Aluche, another residential development close to the motorway, appear in 1960 and the area is virtually fully consolidated at the beginning of the 1980s.

As traffic grew (and also as more pressing issues such as schools, public transport, basic equipment and parks were addressed), residents became more aware about the unpleasantness-turning-into-ugliness of their cityscape, identified the A-5 motorway as the main source of blighting, and mobilized with demonstrations

starting in the 1990s. They complained about noise, air quality, security and safety concerns, poor lighting of subway pedestrian crossing, and other nuisances linked to the motorway. For those in Madrid not living in the area, the neighbourhoods along A-5 were merely a no-man's land in the outskirts of the capital, very much an unnoticed place. If addressed in the 1990s or in the 2000s, the residents' concerns could still have been addressed with simple traffic and demand management measures to progressively reduce the number of cars and encouraging their users to try the alternative bus, metro and commuter train lines, but when this was tried, in 2018, it was probably too late. By then, the construction coalition had successfully created an alternative vision, replacing the motorway section by a long tunnel, as had been done 15 years ago with most of the inner orbital motorway. In spite of such strong opposition, the municipality introduced a traffic management scheme reducing speeds and capacity, but a change in the municipal leadership resulted in the removal of the concept after only 4 months of operation.

The aesthetic judgment associated to the unpleasant initially referred to the poor living conditions created by the motorway in already socially stressed neighbourhoods.

Surprisingly, as a way to strengthen the claim for the tunnel project, car users were also considered to be treated unfairly should traffic conditions be restricted. This resulted in planners developing a solution primarily addressing car users' interests (a tunnel with similar capacity to the existing motorway) and residents getting rid of the perceived nuisances. The project was named as the Green Southwest Boulevard. What is debatable is whether the resulting green corridor above the tunnel will be able to generate the sort of dynamics and liveability than the transformation of the motorway into a boulevard was expected to launch. Obviously, the costs for the taxpayer skyrocketed to the hundreds of million. The instability leading to radical action, in spite of high costs, grew incrementally due to the inaction of planners and decision makers.

The recent reform of Puerta del Sol can be seen as a good example of the adaptation of the public space to touristification. It could be said that virtually any mayor in Madrid has tried to leave its footprint in Puerta del Sol. A busy (if not messy) irregular crossroads of eleven streets, which took the form of a rectangular square in the XVI century and was transformed into its now characteristic semi-elliptical layout surrounded by homogenous 30-m high white façades in 1860. Since then, multiple reforms adapted this space to the claims of the day: leaving space first to trams and later to cars, setting, displacing or removing fountains and sculptures, placing or removing vegetation and trees... In 2009, after long and costly works to establish a major underground transport hub (including metro and commuter railway lines) and to dedicate most of the space to pedestrians, some thought that the time for reforms was over. And yet... only a four years later, the regional association of architects successfully lobbied the municipality to launch an international competition to redesign the site, on the basis that *Puerta del Sol* was lacking a well-balanced visual image.

Disorder was, therefore, in the essence of the unpleasantness felt by these professional body. No moral considerations were made here, beyond the certainty that "Madrid deserved better". Surprisingly for a call focused on aesthetical considerations, the obvious point that the landmarks located in this square were little more than a bunch of kitsch objects lacking artistic merit was not mentioned at any time by either those asking for action or those participating in the contest. The winning project (subsequently subject to some minor changes at the final implementation stage) provides a clean space, better suited for an occasional visit than for recurrent stand-byers, by rearranging its traditional landmarks. Although not implemented until now, the winning project also intended to replace the main entrance to the underground public transport hub with a more *discreet* one, as if it were better to hide the daily lives of citizens to allow tourists and visitors to enjoy a clean cityscape. The new layout implicitly relegated daily local passers-by and the few remaining residents in the vicinity of the square, while fostering its iconic value for occasional visitors and singular events. No significant changes in mobility behaviour were expected, as the site was already almost fully pedestrianized, although it could be argued that locals would probably prefer to avoid the site and use alternative routes instead of crossing such a space. Tax-payers footed a bill than reached € 12 million. Unpleasantness in this case seems to generate from elitist professional criticism (and ambition to intervene in a highly symbolic space) that allies with the ambition of

decision makers to intervene in such spaces; in fact, this has been a traditional mechanism in the history of urban planning and the source for the creation of both, revered public spaces and wasteful arrangements, the one destined to survive for generations, the latter just waiting for the next politician to convene another international contest.

Figure 3: *Tiding up Puerta del Sol, Madrid (2024)*

Conclusions

The unpleasant can be understood as a key aesthetic category, in spite of lacking the Kantian traits of positiveness, disinterest and universality. In fact, the absence of these traits is what can turn the unpleasant- and more generally *negative aesthetics*- into a leverage for action in planning. For turning into action, the aesthetic judgment of the unpleasant is often intertwined with moral judgments, although in different ways. For example, planners in tactical urbanism often challenge consolidate power relations in the public space and aim at rebalancing them, provisionally with visually unpleasant arrangements to gain legitimacy for such rebalancing as a way to build up the consensus to consolidate the new power relations with more permanent and costly designs. Planners in traffic engineering may prioritise the consolidation of pre-existing power relations, generally favouring car traffic, and use the unpleasant and inaction towards its deterioration as a way to gain support for costly infrastructure solutions preserving car hegemony. Planners following the city beautification tradition may use unpleasantness as a label to use in elitist aesthetic criticism of existing public spaces, to influence decision makers and undertake dubious public space reforms on the ground of fostering economic development opportunities. This has been illustrated by three case studies in Madrid.

Besides showing different ways of identifying the unpleasant to make of it a force for change, the three case studies also show other differences. First, in the different relevance they give to everyday experiences, characterised by the prioritisation they give to certain actors compared to others: Everyday experiences become the focus for planners when residents or daily passers-by are put at the centre. This is pretty much the case in *Vallecas* and much the contrary in *Puerta del Sol* (where the casual experience of tourists or attendants to events is clearly privileged). The third case study (the A-5 motorway) stands somewhere in the middle: residents are given a brand new public space in what used to be a major barrier and a source of nuisance and blight, but planners have not cared much about the residents' everyday practices and how these practices may be affected by the new design; there is not much clue about whether everyday life will go on without making much use of the renovated space or will change in unforeseen ways, for good or bad.

Another difference revealed by the three case studies, closely linked to the ethical dimension, refers to the ambition for transformation of dominance and submission relationships. In the three case studies, mobility and public space distribution are at the centre of the intended actions, although with quite diverse sensitivities. In Vallecas, space reallocation is at the centre of the tactical action and of the subsequent permanent intervention it intends to kick off; therefore, there is a significant change in the dominance relationships, changing priorities from cars and trucks to pedestrians and cyclists. In the A-5 motorway, there is a similar push for change, although with a significant difference: residents and pedestrians (as well as ,eventually, public transport users) are expected to benefit, but without compromising the conditions of car traffic; in fact, the intervention can be better understood as a way to protect the mobility privileges of car users at a moment in which they could be challenged by residents and other actors in the public space. In Sol, the pedestrians-cars relationship had already stopped to be relevant many years ago, and conflicts were now growing between different kinds of pedestrians: close-by residents, daily passers-by, tourists, and occasional attendants of flagship events, with these two already establishing their dominance; the intervention obviously takes sides in their favour.

The case studies also show how the social (and the planners') toleration to the unpleasant is quite different depending on the parts of the city under scrutiny. Central public spaces have historically been the most sensitive places to the criticism of mainstream planners as well as urban designers that see intervention in these areas as an opportunity to gain social prestige. On the contrary, the no-man's land in the outskirts of cities is likely to remain unnoticed for decades, and even when they receive the attention of advocacy planners or the living conditions attain the unbearable sparkling the protests of residents, the planning bureaucracy and decision makers are slow to react. Interestingly, once they receive the attention of a wider group of stakeholders, such places may be perceived by developers and infrastructure contractors as an investment opportunity provided the political and social pressure forces decision makers to poured tax-payers' money in expensive infrastructural solutions, like the A-5 tunnels analysed above, and they actively engage in establishing coalitions to push for such expensive solutions. In short, planners actively participate in the social construction of the unpleasant, although in different ways, and such differences show how planners align with different urban development agendas.

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From Car-Centric to People-Centric: Developing Street Transformations Through Environmental and Community Involvement Approaches

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Abstract
Car-centric urban planning has marginalised the social dimension of the streets and continues to cause various environmental and health issues. Cities have been developing strategies to address those challenges, transforming streets into public spaces that encourage active mobility. However, these efforts often lack participatory processes and heat mitigation strategies, both considered essential in such interventions. This paper proposes a methodology to address those issues, combining citizen science-based methods, such as thermal walks, and technical and administrative expertise. The four-phase participatory framework encompasses citizen engagement, data analysis, co-design of adaptation scenarios and their evaluation, combining the lived experience with the scientific knowledge and administrative considerations. The proposed approach provides inclusive and context-sensitive adaptation scenarios, enhancing both community acceptance and heat stress mitigation.

Keywords: Street transformation; Microclimate; Thermal comfort; Citizen science; Participation

1. Introduction

Most cities today are dependent on motorised transportation and the use of private cars. The role of the street has become predominantly to maximise transportation efficiency, disregarding its social dimension and placing people on the margins of public spaces (Ravazzoli and Torricelli 2017). The car-centric urban planning has caused various issues related to environmental pollution, energy consumption and inactive lifestyles (Nieuwenhuijsen and Khreis 2016; Mueller et al. 2020). To address these challenges, urban planning has recently prioritised a more sustainable, compact development characterised by higher density and diversity and shorter distances (Giles-Corti et al. 2016; Nieuwenhuijsen 2021). However, while this resulted in a decrease in CO_2 emissions and an increase in sustainable mobility opportunities, new issues arose from compact city planning that have detrimental impacts on human health. These include exposure to extreme heat, air and noise pollution, as well as a higher density of motorised traffic (Mueller et al. 2017; Khomenko et al. 2021; Nieuwenhuijsen 2021). In recent years, diverse strategies have increasingly been developed to respond to these problems, focusing on the redevelopment of streets and public spaces and promoting active mobility, in order to create more liveable, human-centred spaces. Reclaiming the spaces dedicated to motorised vehicles allows the transformation of the street function to an open public space that generates different aspects of urban life, affecting the quality of urban spaces, social interaction, physical activity, economic and environmental factors. These strategies vary from single street transformations to more complex urban models such as Superblocks in Barcelona or Low Traffic Neighbourhoods in London. They mainly involve the reduction of motorised traffic, a measure that often faces resistance from residents, making these strategies a controversial topic. Experiences from already implemented strategies strongly highlight the need for the inclusion of citizens in the development of such plans and interventions (Cruz and Paulino 2020; Lunetto et al. 2023; Vásquez et al. 2024). Participatory approaches enable integration of the needs and perspectives of the citizens in decision-making, leading to higher acceptance and usability of public spaces. Citizen engagement in the development of these interventions ensures their alignment with the community's requirements, while addressing the issues of urban development and climate change (Rodriguez and Komendantova 2022; Sondou et al. 2025).

On the other hand, these transformations could help mitigate the heat stress of pedestrians while promoting liveable streets and active mobility (Nieuwenhuijsen 2021). However, there is very limited evidence of thermal comfort considerations in such interventions, often considering the improvements in qualitative terms, without quantifying the actual impacts. This indicates a gap between the research on the issues of thermal comfort and heat mitigation and its implementation in urban planning.

Recognising the importance of the presented issues and their interconnections, this study focuses on the development of a methodology that integrates public participation and heat mitigation into street transformation processes aimed at promoting active mobility.

2. Methodology development

Due to the need to integrate participative processes and thermal comfort into street redesign plans, we propose a participatory framework that brings together citizens, experts and public administration. The framework adopts citizen science-based thermal walks, focusing on dynamic thermal comfort, to assess and measure thermal experience, with the aim of co-designing the adaptation scenarios. The process consists of four distinctive phases that follow after the need for intervention has been identified (Fig. 1).

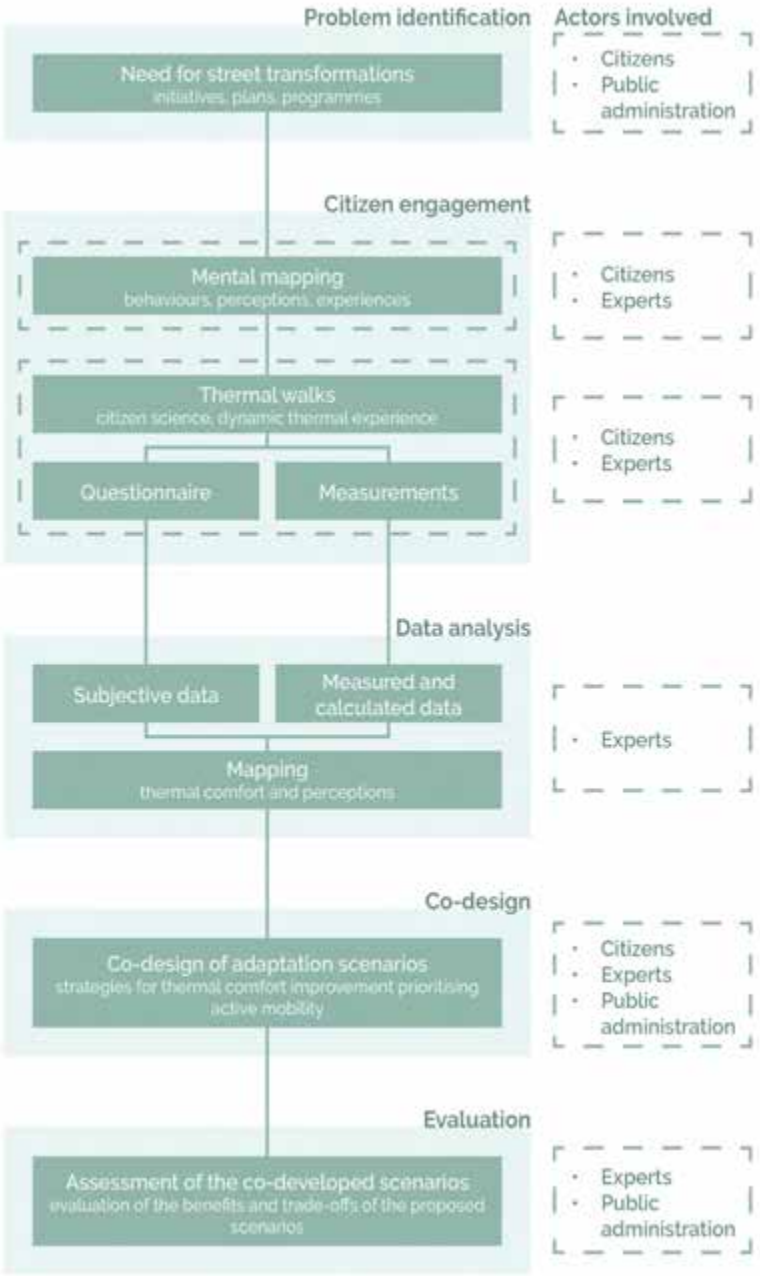

Figure 1. Phases of the proposed framework.

2.1 Citizen engagement

The phase of citizen engagement consists of two main activities – mental mapping and thermal walks. These activities have been used in the literature to examine both subjective thermal perceptions (Moderow et al. 2023; Květoňová et al. 2024) and to investigate dynamic thermal experiences (Vasilikou and Nikolopoulou 2020; Xie et al. 2022). Citizen engagement, especially thermal walks activities, is based on a citizen science approach. Citizen science has increasingly been utilised and studied as a method of empowerment, promoting behavioural change and collective action, while simultaneously increasing knowledge and awareness of the public and crowdsourcing data for research purposes (Sardo et al. 2024). This citizen science approach has been applied in various projects and studies, including microclimate research (Květoňová et al. 2024) and sustainable mobility (Sardo et al. 2024), highlighting the importance of citizen involvement in co-designing projects and policies. Incorporating citizen participation into street redesign processes could promote more inclusive, context-sensitive and scientifically informed urban planning practices.

2.1.1 Mental mapping

Mental or cognitive maps have been used to study people's perceptions of thermal comfort in urban environments, expanding the insights obtained using solely quantitative approaches. This qualitative method captures subjective experiences and behavioural adaptations, drawing on people's experiences to identify hotspots, cool areas, comfortable and uncomfortable spaces (Lenzholzer 2010; Lehnert et al. 2023; Moderow et al. 2023). As such, it serves as a valuable tool in participatory planning and climate adaptation, facilitating public engagement and co-creation (Foshag et al. 2020; Moderow et al. 2023). Cognitive maps emphasise the psychological and contextual aspects of thermal perception, which might differ from the objective data gathered through measurements or remote sensing (Květoňová et al. 2024). One limitation of this method is its tendency to focus on easily accessible or more frequented locations, potentially neglecting peripheral or less familiar areas (Květoňová et al. 2024). Nonetheless, this approach could be interpreted as a means of identifying locations with higher levels of public interest or activity, supporting prioritisation of possible intervention areas based on actual use rather than solely on objective data. Mental maps, combined with quantitative methods, could be instrumental in exploring differences between thermal expectations and thermal sensation and real thermal conditions, enhancing public participation in climate adaptation.

2.1.2 Thermal walks

Studies on microclimate conditions in urban areas often rely on static measurements and models to investigate thermal comfort (Ravnikar et al. 2023; Zhao et al. 2024). However, the static tools fail to account for diverse conditions experienced by humans while traversing urban spaces (Zhao et al. 2024). Dynamic thermal experience is based on different factors, including continuously changing environments (Lau et al. 2019; Zhao et al. 2024), psychological responses (Wang et al. 2022; Zhao et al. 2024), psychological responses (Vasilikou and Nikolopoulou 2020; Dzyuban et al. 2022; Jia et al. 2022; Mohite and Surawar 2024), thermal history and sequence of exposure (Nakayoshi et al. 2014; Xie et al. 2022; Zhao et al. 2024), alliesthesia (Dzyuban et al. 2022; Li et al. 2023; Zhao et al. 2024) and environmental variations (Lau et al. 2019; Lee et al. 2020; Dzyuban et al. 2022; Jia et al. 2022; Li et al. 2024; Mohite and Surawar 2024). To capture these different factors, recent studies have been using the thermal walks method, involving participants in assessing subjective perceptions along routes accompanied by mobile microclimate measuring devices, emphasising the importance of thermal perceptions and sensations for overall thermal comfort (Nakayoshi et al. 2014; Vasilikou and Nikolopoulou 2020; Dzyuban et al. 2022; Xie et al. 2022; Květoňová et al. 2024; Mohite and Surawar 2024). Studies employing thermal walks vary in their methodology, including the number of walks, instruments used and the duration of the study, based on their aims, type of study and availability of participants. Typically, thermal walks studies involve 10-15 participants (Vasilikou and Nikolopoulou 2020; Dzyuban et al. 2022; Květoňová et al. 2024; Mohite and Surawar 2024). Nevertheless, while some studies conduct only a single walk per participant (Dzyuban et al. 2022; Květoňová et al. 2024), others adopt a longitudinal approach with repeated walks across two seasons and multiple times of day (Vasilikou and Nikolopoulou 2020; Mohite and Surawar 2024). Most studies focused on the hottest period of the year, while longer ones considered both cold and warm weather. These methodological differences lead to significant variations in the amount of collected data, ranging from tens to hundreds of measurements and questionnaires.

Citizen science-oriented thermal walks, proposed in this study, have a twofold objective - to collect dynamic thermal experience data and to help raise citizens' awareness of the excessive heat issues and the potential of adaptation strategies, in terms of both the structural modifications, e.g. green infrastructure or changes in materials, and behavioural changes. The walks consist of two main activities, participatory microclimate measurements and a thermal perceptions questionnaire. During the walks, the citizens carry out the measurements using portable devices. Devices used in citizen science projects and experiments with similar aims are mainly low-cost mobile weather stations, measuring essential parameters such as air temperature and relative humidity (Kulkarni et al. 2022; Peña-Rodríguez et al. 2022; Hohenegger et al. 2023; Loglisci et al. 2024). These parameters mainly suffice the objectives of such studies, allowing the collection of the data needed for a better understanding of the weather conditions. However, to ensure the validity and precision of the collected data, additional measurements should be performed using professional equipment, e.g. a professional stationary weather station. The mobile measurements performed by the citizens allow real-time interpretation of the measured values and parameters, enhancing understanding and further raising their awareness of the heat-related issues in the urban areas.

The assessment of the people's perceptions is a fundamental component of the thermal walks. Subjective thermal experience is mainly examined through questionnaires and surveys based on the standards such as ISO 10551:2019 (International Organization for Standardization 2019) and ASHRAE Standard 55 (American Society of Heating 2023). The questionnaire includes personal data such as age, gender, weight, height and clothing information of the participants, in order to better understand the metabolic rates and clothing insulation, which are critical in thermal comfort investigations. To investigate the dynamic thermal experience, the questionnaire should include questions on thermal sensation, comfort and preference in different points of the walk, accounting for variations between different urban configurations and exposure (Vasilikou and Nikolopoulou 2020; Dzyuban et al. 2022; Xie et al. 2022; Mohite and Surawar 2024). Additionally, comparing instantaneous sensations at each point with the whole-trip experience would provide a more comprehensive understanding of the thermal experience during the walks (Zhao et al. 2024).

2.2 Data analysis

The analysis of the data collected through mental mapping and thermal walks follows different steps.

The data collected by the mobile measurement devices should be validated against that collected by the weather station on-site, to ensure their accuracy and reliability. Firstly, the raw sensor data needs to be pre-processed to remove statistical outliers before further analysis is performed (Schilt et al. 2023).

The methods commonly used for data validation between the measurement devices involve statistical validation methods and calibration techniques. Statistical metrics include Pearson and Spearman correlation coefficients, Mean Absolute Error (MAE), Root Mean Square Error (RMSE), sensor bias and regression analysis (Kureshi et al. 2022; Rivera et al. 2023; Schilt et al. 2023). Linear regression and machine learning methods are often used to calibrate low-cost sensors against reference data (Yamamoto et al. 2017; Kureshi et al. 2022).

Data collected from the thermal walks and the weather station could be used for the numerical simulation of thermal conditions. The simulations are often performed using computational fluid dynamics (CFD) software, e.g. ENVI-met, Ansys Fluent, or energy balance models (EBM), such as RayMan, SOLWEIG. These models mainly enable the spatial distribution of the weather parameters, including the calculation of thermal comfort indices such as Physiological Equivalent Temperature (PET), Universal Thermal Climate Index (UTCI) and others. Data obtained from the simulations should be further analysed and validated against the measurements. Methods commonly used for validating simulation performance are based on statistical approaches and metrics, e.g. RMSE, MAE, Mean Bias Error (MBE) (Peng et al. 2023; De Quadros et al. 2024).

Finally, the outputs of the questionnaire could be compared to the measured and simulated data to highlight possible differences between subjective perceptions and objective data. The data could be further analysed to evaluate different factors affecting the judgement of the participants. Scientific literature often employs

statistical analysis methods such as Spearman's correlation (Dzyuban et al. 2022), Pearson's correlation (Ma et al. 2021), path analysis (Chan et al. 2017; Peng et al. 2019; Ma et al. 2021) to understand the relationship between different variables.

The analysed data should be mapped to enable spatial visualisation of the data in different layers, facilitating the further steps of the process.

2.3 Co-design

Co-design is a collaborative approach that unites citizens, experts and public administration in the process of developing street transformation plans based on the knowledge and lived experience. This method gives voice to the community members, empowering them to shape innovative and contextually relevant outcomes and solutions (Echaniz et al. 2022). The importance of this approach is becoming increasingly recognised in urban interventions where the success depends on social acceptance and usability (Lunetto et al. 2023; Vásquez et al. 2024).

This phase involves all relevant stakeholders and community representatives to ensure inclusivity and integration of local values while taking into account technical knowledge and administrative considerations provided by experts and public authorities. The co-design workshops are based on the data and experience collected through citizen science experiments and mapping activities. The workshops are structured in four consecutive sections:

1. Presentation of findings and elaborated data from the previous activities and discussion, allowing all participants to share their personal experiences and insights.

2. Identification of priority areas and challenges for the interventions.

3. Conceptualisation of the possible scenarios and strategies addressing both heat-related issues and active mobility.

4. Refinement of the scenarios with the expert feedback and administrative constraints.

The outcome of the co-design phase is a set of street transformation scenarios that form the base for the evaluation and policy considerations in the following phase.

2.4 Evaluation

The evaluation phase is a crucial component aimed at critically assessing the co-designed adaptation scenarios from technical and socio-environmental perspectives. The scenarios are evaluated not only for thermal comfort improvements, but in a broader framework of benefits and trade-offs that include environmental, economic, social, health and mobility impacts, ensuring feasibility and effectiveness of the solutions. The multicriteria framework reflects the multifunctional nature of street spaces, highlighting the complexity of urban transformations. Due to the need to integrate the previously mentioned aspects and the stakeholder views and opinions, a multicriteria decision analysis (MCDA) approach is adopted. MCDA is a systematic methodology that combines different input factors with the considerations of stakeholders to compare and rank different project options (Huang et al. 2011).

The framework of different impacts is based on different indicators, depending on the types of strategies and interventions in the scenarios. Potential indicators and assessment methods are presented in Table 1.

Table 1. Framework of different impacts, potential indicators and assessment methods.

Impacts	Potential indicators
Environmental	Thermal comfort improvement Biodiversity benefits Air pollution reduction Noise pollution reduction
Economic	Cost of implementation Maintenance costs Impacts on property values Impacts on local businesses' activity
Social	Use of space Inclusivity Accessibility Safety
Health	Physical activity levels Mental health benefits Reduction in heat and air pollution exposure
Mobility	Changes in mobility flows and modes Changes in traffic speed and volume

3. Discussion

The participatory methodology developed in this study integrates thermal comfort considerations and participative processes into the development of street transformation plans. The four-phase framework is based on a holistic approach to urban adaptation, bridging the gap between scientific research, decision-making and local experience.

One of the strengths of this methodology is the combination of qualitative and quantitative approaches. Through citizen science-based thermal walks and participatory mapping, the process captures both subjective thermal experience and objective microclimate conditions. This approach helps translate and reflect the lived experience of the citizens in the design processes, fostering a bottom-up approach. The co-design phase involves citizens, experts and public authorities in the development of adaptation scenarios, enhancing the sense of ownership and legitimacy, essential for the acceptance and long-term success of the projects (Echaniz et al. 2022; Lunetto et al. 2023). The framework is further strengthened by adopting a multicriteria decision analysis approach to evaluate the co-developed scenarios. The comprehensive assessment encompassing environmental, economic, social, health and mobility dimensions, as well as stakeholders' perspectives, highlights various benefits and trade-offs of the solutions while supporting transparency in decision-making (Huang et al. 2011).

Despite its strengths, the methodology has several limitations. Firstly, the reliability of citizen-collected data can vary, especially when using low-cost devices. The framework addresses this issue through validation with professional equipment and calibration, however, the potential for error remains (Kureshi et al. 2022; Schilt et al. 2023). Secondly, a common challenge of participatory processes is ensuring inclusivity and broad participation. Citizen science activities primarily attract individuals already engaged in similar activities or with specific interests, potentially leading to underrepresentation of less vocal or marginalised groups (Květoňová et al. 2024).

The methodology provides opportunities for further research and practice in several ways. Longitudinal studies could use citizen-led thermal walks as a method to assess the impacts of the adaptation strategies after the implementation, enhancing and fostering participatory approaches long-term. Additionally, citizen engagement could be facilitated through the development or integration of digital tools, such as mapping platforms or apps for data collection, thereby enabling the accessibility of the data. Finally, the methodology could be tested across

different contexts, such as diverse climates or socio-economic environments, in comparative studies to help refine it and test its adaptability.

4. Conclusion

The contemporary street designs still prioritise motorised transport infrastructure, neglecting their potential as liveable public spaces. This study proposed a participatory methodology for integrating citizen engagement and thermal comfort considerations into street redesign processes aimed at promoting and encouraging active mobility, addressing the gap between research and its application in urban adaptation plans and strategies. By combining citizen science-based thermal walks, mental mapping, co-design and multicriteria evaluation, the framework unites technical and administrative expertise with lived experience, providing inclusive and context-sensitive adaptation scenarios.

The proposed approach addresses two significant gaps in current urban planning practice – the lack of thermal comfort considerations and the need for citizen participation in decision-making. By involving citizens directly in data collection and scenario development, the framework enhances the scientific basis of interventions while increasing public awareness, sense of ownership and acceptance. The methodology is further strengthened through multicriteria evaluation, assessing environmental, economic, social, health and mobility dimensions, accounting for benefits and trade-offs of each scenario.

While the methodology demonstrates significant potential for creating more liveable and people-centred open spaces, several limitations remain, mainly regarding the inclusivity of participatory processes and technical challenges of data analysis and evaluation. Future work will focus on testing and refining the methodology on a case study of Turin, within the Interreg Alpine Space project COMMONAIR.

Finally, this approach provides the foundation for more inclusive and adaptive urban street transformations. The framework fosters a replicable process that promotes rethinking of the streets as healthier and people-centred public spaces.

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Reclaiming or excluding?
The evolution of waterfront redevelopment and public space in Genoa

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Abstract
This research revolves around how the waterfront redevelopment paradigm has chronologically shifted and its direct impact on public grounds. Increased influence of the market, changing involvement weights of stakeholders, the underlying rationale for waterfront regeneration, and their reflection on the hinterland's spatial and programmatic development of the waterfront projects from the emergence of the phenomenon to the current timespan are discussed by addressing back to the main idea of the "reclaiming waterfronts for the public". This issue is comparatively examined in terms of the redevelopment process of Genoa's urban waterfront to evaluate the public nature of the transformed spaces, from the Porto Antico's regeneration to the ongoing Waterfront di Levante redevelopment project.

Keywords: Urban waterfront redevelopment, publicness, public space

1. Introduction

Waterfronts have long been recognised as an essential component of a city's identity, and they have become heavily influential for cities' economic, social, and environmental improvement. Historically, these areas have created an expanded surface for the interaction of different urban actors and functions, where everyday activities intertwine with the maritime operations. However, the intense spatial occupation of port infrastructure has significantly disrupted this open nature of waterfronts, once enabling fluid interaction between the water and the city. Maritime activities that revolve around the industrial, trade, and transportation functions suppressed the ordinary utilisation that led to the rupture of public life and urban waterfronts.

Following the mid-20th century, the traditional maritime activities experienced a notable decline that decreased spatial needs for maritime operations (Kostopoulou, 2013; Taufen and Yocom, 2021). Particularly, the progress in the naval technologies that require advanced technical infrastructure and the introduction of containerisation to the maritime transportation resulted in the relocation of ports outside the perimeters of the urban areas (Kokot, 2008). While forming the contemporary port infrastructure, the inner-city waterfronts and historical port areas became *"ghost districts"* suffering from industrial structures, refineries, wastes, and pollutants (Hein, 2016). As a result of this circumstance, waterfronts became vacant spaces inside the city. This phenomenon spread to port cities worldwide, signalling the beginning of waterfront rehabilitation projects. In other words, urban planning projects have focused on waterfront restructuring, also referred to in the literature as waterfront *"redevelopment"*, *"regeneration"*, *"revitalisation"*, *"renaissance"*, or *"rehabilitation"* with the primary goal of converting underutilised or abandoned port and industrial areas into vibrant, mixed-use districts that integrate residential, commercial, recreational, and cultural amenities (Kostopoulou, 2013).

Beyond the initial port models that focused on the port development such as "anyport" by Bird (1963), Hoyle (1989) introduced the model of "*Stages in the evolution of port-city interrelationship*" that included *"redevelopment of waterfront"* as a stage in between 1970s-1990s when urban renewal is situated in the original core. Hoyle (2000) expanded the model by introducing the next stage, *"renewal of port/city links,"* from the 1980s, where he emphasised the spatial integration/new connections between port and city via the influence of globalisation and intermodalism, and how port roles are transformed. Subsequently, Schubert (2008) summarised the typical trajectory waterfront regeneration in different stages: initial derelict and disuse of former ports, the relocation of ports outside of urban centres, idle areas and buildings in the former port areas, visioining the potentials of waterfront for reallocation, implementation and re-functioning the area by introduction of new urban/ architectural program and revitalisation. It remarks on the importance of waterfront redevelopment as a crucial

step while examining the port-city relationship.

The early examples of waterfront redevelopment emerged in the North American context, particularly through well-known and highly influential projects that shaped subsequent initiatives. As cities such as Baltimore, Boston, and San Francisco became widespread, waterfront redevelopment projects also gained interest in Europe and later spread to Australia and Asia (Hoyle, 2000). Furthermore, the earlier projects' substantial impact also influenced how the waterfront redevelopment projects would be realised in the upcoming decades, especially with similar urban programs, design approaches, and planning strategies, widely considered in the literature as "*Baltimore syndrome*". The early waterfront redevelopment initiatives primarily aimed to recontextualise the underutilised port areas by introducing various urban functions, including predominantly residential, commercial, recreational, and cultural, mixed-use purposes for reclaiming the edge of the city (Breen & Rigby, 1996). Urban waterfronts have undergone a paradigm shift, moving from being centres of production and transition to spaces mainly focused on consumption and experiences.

Starting from the beginning of the 21st century till the current timeframe in waterfront redevelopment projects points to another important milestone. Alongside the common challenges of urban regeneration under neoliberal policies (Harvey, 2002), the most recent instances of waterfront redevelopment initiatives reflect the significant influence of market pressure and dominance over the primary goals observed in the earlier stages (Bassett, Griffiths and Smith, 2002; Pinto and Kondolf, 2020). In many waterfront redevelopments, the orientation shifted towards economic development to attract investment. Gradually, this augmented influence of the private sector in the current period led to a prioritisation of economic returns over broader community interests, resulting in the development of waterfront spaces that primarily cater to affluent residents, tourists, and consumers (Oakley, 2009; Cheung and Tang, 2015; Avni and Teschner, 2019). These have affected the involvement of private and public sectors, governance, and funding models, which are fundamentally related to waterfront redevelopment projects' spatial, social, and economic outcomes.

The commodification of waterfront spaces has given rise to concerns regarding the accessibility and inclusivity of these areas for all segments of society (Chan, 2020). Especially the discussions around the community ownership and public access rights (Sairinen and Kumpulainen, 2006; Huang et al., 2007; Attia and Ibrahim, 2017) have been the topic of planning conflicts in the waterfront redevelopment projects. Even though waterfronts have been widely considered and experienced as collective areas of the cities, as urban commons (Iovino, 2016), the role of a community in the course of transformation has been overlooked (Cheung and Tang, 2015; Iovino, 2018). This illustrates the significance of examining the public space and the dimensions of publicness in the scope of waterfront regeneration processes to understand shifting paradigms and dynamics for evaluating increased capital pressure and its spatial and programmatic reflections. Such assessment offers insight into the extent to which these spaces serve the needs and interests of the public, promote social equity, and contribute to the overall quality of urban life, and how the assessment could offer insight into the social equity and contribute to the overall development of the urban waterfront and the city.

This paper examines the shifting dynamics in the waterfront redevelopment under the influence of economic priorities and commodification of space, which necessitates an examination of the notion of publicness and the qualities of public space in the context urban waterfronts to understand better the social, spatial, and programmatic implications of waterfront regeneration in the longitudinal term dating back from the first applications till the ongoing projects. Genoa Waterfront is a prime case study investigating these transformations and examining challenges and opportunities associated with balancing economic development and public interests. The issue is assessed through the lens of publicness and the dimensions of publicness to provide a comprehensive analysis of the waterfront redevelopments in different terms but in the same context, as well as their impact on public spaces created and considered in the hinterland of the waterfronts. While investigating the inter-generational implementations, particular attention is given to the narrative, actors, and stakeholders, the process of the projects, and the physical, social, and programmatic outcomes in the selected case study to draw broader conclusions about the nature of waterfront redevelopment and public space.

2. Scope and Context

Genoa's case study was selected because of the multi-layered trajectory of waterfront redevelopment initiatives. The context displays rich examples of different governance and management strategies and the economic infrastructure, representing various public-led and private-led redevelopment schemes. Furthermore, interventions realised in different periods also allowed for the longitudinal study. The temporal scope of the project spans from the Genoa Urban Regulatory Plan in the 1980s to the current time. Similarly, the spatial scope of the project includes Porto Antico, Darsena, Ponte Parodi and the eastern section of Genoa's waterfront in the boundaries of Waterfront di Levante redevelopment -Genoa's former fair area (see Figure 1).

Figure 1: Genoa's waterfront in the spatial scope of the research, edited by the author over the satellite image from Google Earth (February 2025)

This study is grounded in the qualitative framework for examining the contested evolution of Genoa's urban waterfront. The analysis was conducted by reviewing archival documents, policy analysis, interpretive mapping, and spatial assessment based on the ownership, management, accessibility and inclusivity model to investigate the dimensions of publicness more deeply and reveal the patterns of the paradigmatic shift. A wide range of sources, including urban plans (starting from 1980), port plans, design proposals, competition entries, municipal documents, secondary literature and news articles, have been consulted to contextualise the research. Moreover, the mapping process of the different timeframes and diagrammatic representation has been completed via digitalisation of the historic orthophotographies and maps using GIS tools.

3. The Evolution of Genoa's Urban Waterfront Redevelopment

3.1. The Prologue

The emergence of the first waterfront redevelopment attempts can be traced back to *"Il Piano Regolatore Generale della Città di Genova (PRG) 1980"*, which can be regarded as the initial blueprint for the transformation of Genoa's waterfront. This regulatory plan framework followed the municipal approval in 1976 and its subsequent

ratification by the regional authorities in 1980. Considering the neglected waterfronts of the city, Darsena was identified as a place for introducing various urban functions alongside the maritime functions in the city's historic port. The plan aimed to facilitate technological areas, sports areas, and educational activities in the port area (Gastaldi, 2010). This master plan was followed by the "*Studio organico d'insieme del Centro storico*" studies in 1983 by the municipality, with the emphasis on the recovery of the port and the increased interest in the connection of the historic city with its waterfront (Gastaldi, 2010).

Simultaneously, the municipality of Genoa appointed six different architects in the different sections of the waterfront, and the architect Renzo Piano's engagement in the regeneration of the Molo district in the scope of 2.2 hectares of urban area (Tasso, 2015) marked a significant turning point for the urban waterfront of Genoa. Central interventions revolved around the two important topics: recovery of the Molo district and the newly introduced service hub; furthermore, the design included the large square at Via Turati by re-locating the street in subterranean level and introducing three main buildings longitudinal towards the sea that house hotel and conference centre at the docks (Tasso, 2015; Gastaldi and Camerin, 2020). However, the project has not been implemented due to the lack of a financial plan, the issue of scale, and operational struggles (Gastaldi and Camerin, 2020). In summary, this period can be considered the starting point in identifying the waterfront's potential.

3.2. Early Initiatives and Porto Antico Redevelopment

The rest of the 1980s witnessed a growing awareness of the necessity to revitalise the city's waterfront areas, and two different initiatives came to the fore in the historic port. Genoese entrepreneurs introduced the first set of proposals for redeveloping the historic port into a tourist port that accommodates marina and touristic functions. The second set of initiatives was promoted by public administrations, highlighting the creation of a large exhibition area for the Genoa Expo 92' and the enhancement of port activities; even though the primary plans for the exhibition were to locate the exhibition areas outside of the city centre perimeters or introduction of a platform on the sea (Gastaldi and Camerin, 2020). Moreover, it is important to note that both proposed projects shared the exact location and were developed in the same timeframe at the initial stage.

These entrepreneurial plans started with the Newport project designed by P. Gambacciani in 1984, and the project scope included the areas of the historic port from Darsena to Magazzini del Cotone, where Renzo Piano's first proposal was also located. The key element of the project was the programmatic conversion of the docks and elongation of the docks towards the sea that form the marina. The project's program aimed to enhance commercial identity in the historic port by introducing a marina, a hotel, a shopping centre, and entertainment facilities heavily influenced by North American instances (Tasso, 2015). The first scheme was followed by the updated version of the project in 1986, which was predominantly concerned with the economic parameters of the project. The revision was proposed to include reduced boat capacity in the marina, a multifunctional building with a conference centre in Ponte Spinola, and restoration of the Magazzini del Cotone. Although the project had not been realised in the exact location, this created a groundwork for the upcoming development of the Marina Porto Antico at the beginning of the 1990s. The main decision in terms of relocating this development plan arose from the administration's intention to allocate the area for the Expo'92, following the decisions suggested in the "*Triporto*" commission, which was composed of members from regional, municipal, and port authorities in 1986 and later approved in 1988. The tourist port project has been realised in the Ponte Morosini-Ponte Spinola area, accommodating the initially proposed similar functions such as hotel, residences, and commercial services, and designed with a complex connection of piers and four interconnected buildings during the period spanning from 1991 to 1995. The project has been realised with private investment alongside the limited contribution of public funds.

However, at the same year, private bodies and investors suggested the "Portman Project" consist of the famous cone with 262 meter high designed to accommodate hotel functions, the artificial island in the heart of the Porto Antico served as a triangular base for the cone and designed in four different levels with commercial, tertiary, touristic functions. In the following period, due to the increased criticism of the public and concerns regarding the conflict it represents with the port and city plans, the plan was rejected and not realised.

Along with Newport and Portman's project proposals, public initiatives were being discussed for the Molo Vecchio and Magazzini del Cotone area for the international exposition of Genoa in 1992. As mentioned following the approval of the plan that includes the decisions in the commission, situating the exhibition areas in "*Porto Antico*" -the historic port of Genoa- was a result of Renzo Piano's preliminary studies and the proposal of "*Via San Lorenzo al Mare*" connecting the city to the sea in 1984 (Gastaldi, 2010; Gastaldi and Camerin, 2020). The project was designed by considering the San Lorenzo street elongation towards the sea as a new pier to create the central axis from the historic centre to the city's old port with newly introduced commercial and public functions. The project evolved further by changing the axis from via San Lorenzo to via Ponte Reale, modest filling in the docks, and adaptive reuse strategies for the historic warehouse of the "*Magazzini del Cotone*" to house the exposition in 1985. During this period, the officials visited Baltimore to analyse the port redevelopment. They were particularly inspired by the aquarium as a typology for future intervention in the historic port of Genoa (Tasso, 2015). Following the updates of the project in 1987 and the delivery-approval period in 1989, the design of the project was completed with the adaptive reuse of the Magazzini del Cotone as an exhibition centre and conference facility, the construction of the aquarium, and the introduction of commercial activities to the area. Moreover, the total intervention area was 90.000 square meters by considering the transformation of the existing volumes and new structures; the main functions were defined as exhibition spaces for the Expo, conference centre, commercial facilities, aquarium, cinema, and service spaces (Renzo Piano Foundation, n.d). The project has been completed with a public-private partnership, with a predominant share of funding provided by public authorities by the consortium between the Municipality of Genoa, the Liguria Region, and the Genoa Chamber of Commerce under Porto Antico SpA.

Simultaneously, minor interventions were also completed in the Darsena area by the Faculty of Economics's construction and the Maritime Station's renovation at the beginning of the 1990s.

3.3. Strategic Shifts and Unrealised Visions

The designation of Genoa to host the G8 Summit influenced the city's overall development in 2001. The construction of the Biosphere as the last addition to the historic port of Genoa coincided with the time of the event, again designed by Renzo Piano. In the same year, Ponte Parodi was opened for the architectural design competition to evaluate the possibilities for the under-utilised area in the historic port. The competition aimed to redefine the relationship between the city and the port by regenerating the Ponte Parodi area (Ferrari, 2008). The competition was organised by Porto Antico SpA and resulted in the selection of the UNStudio's proposal. The project was designed with a mixed-use approach, including spaces for leisure, culture, commerce, and entertainment, designed like a public square that is formed from a series of surfaces expanding towards the sea and covers the dock area with a total of 23.000 square meters of intervention; however, the project has not been realised because of the planning and financial issues.

The Darsena area, the land-side of Ponte Parodi, has also been undergoing considerations for redevelopment. The Darsena redevelopment project was approved in 2001, as part of the broader Porto Antico plan, to improve the accessibility and attractiveness of the area in the scope of the regeneration plan, thanks to the designation of Genoa as European Capital of Culture in 2004 (Ferrari, 2008). The total intervention covered more than 10.000 square meters of area and involved constructing new buildings, renovating existing structures, and demolishing the selected structures. The most prominent intervention within the project's scope was the Museum of the Sea, designed by Guillermo Vázquez Consuegra, completed in 2004. Among the other interventions, commercial, service, and office spaces have been introduced to the area with private investment.

Another important work in this era, Affresco, designed by Renzo Piano, reconsidered the entire Genoa waterfront in 2004. Piano's design includes several interventions, the most notable of which is constructing an artificial island in front of the city to house the airport and the continuous seafront promenade for enhancing the connection of the waterfront with the city (Ferrari, 2008). The following part of the proposal included new waterfront solutions for maritime and civil functions. This ambitious master plan with a broad vision of waterfront-city connections has gone through two further modifications in the following each year: the second version proposed the

relocation of the airport even further than the previous position towards to sea, the third version enhanced the urban functions in the waterfront over maritime-related program (Gastaldi, 2010). Due to the estimated budget of the project and lack of financial groundwork, the master plan has not been implemented.

3.4. The Blueprint and the Rise of Waterfront di Levante

Following the Affresco proposal, Renzo Piano prepared another master plan, the Blueprint, which focused entirely on the eastern section of the city's waterfront from Porta Siberia to Punta Vagno in 2014. The initial plan proposed the construction of a new navigable canal near the ancient city walls, adjacent to the raised road, obtained through excavating portions of the existing quays and demolishing some abandoned buildings (Rosasco and Lombardini, 2020). The final version of the master plan highlighted ten important considerations that had been discussed during the project phase, and it included a new urban park, improving the connections between the city and the sea, and introducing new residential, commercial, and recreational facilities to the area (Gastaldi and Camerin, 2020). The Blueprint guidelines evolved as a design competition by Genoese local authorities for the municipality-owned areas, predominantly focused on the marina as a former fair area on the city's east coast. However, despite more than seventy international participants, the competition resulted in no selection of the winning proposal in 2016. Nevertheless, Piano's initial design -the Blueprint- was rethought and adopted for the former fair area that created the framework of the project.

The "Waterfront di Levante" project emerged as the following phase of the Blueprint masterplan, spurred by the competition's outcome and the city's evolving urban dynamics (Rosasco and Lombardini, 2020). This updated iteration maintained the core concept of integrating water into the urban fabric, albeit with a reduced building footprint. The project was once again appointed to the Renzo Piano Building Workshop, which further developed the scheme and proposed an integrated approach for the regeneration of the area by addressing the need for open public spaces, improving accessibility, enhancing the marine environment, and creating new economic opportunities (Moretti et al., 2019).

The integration of private investment into the project was coordinated by SPIM SpA, a publicly owned municipal company. Its primary function was to promote the sale and assess proposals related to publicly owned land. The demolition of the existing structures in the former fair area -Pavilion C, Office Building, Pavilion M, Pavilion D-, and excavation for the proposed canal appointed to the developer as additional tasks besides the area's overall development (SPIM Genova, 2018). It has also been stressed that Pavillion B, designed by Jean Nouvel and completed in 2009, was excluded from the sale and the public funds to be allocated for the reorganisation of the transportation infrastructure, demolition of the former NIRA, excavation for the main canal entrance and completion of the urban park that was mentioned at that time as a possible intervention for the upcoming period (SPIM Genova, 2018). Following the sale of the fair area with the conditions outlined, the involvement of private capital makes approximately three-fourths of the redevelopment budget, and the rest of the approximately one-fourth would be covered by the various public investment programmes planned within a legislative term. Overall, this process seems founded chiefly on speculation and the privatisation of public areas: tenders for the concession and/or sale of state property will be issued, risking depleting the public bodies' role (Moretti et al., 2019).

The master plan program includes developing residential, commercial, and cultural facilities and public spaces designed primarily to attract residents and visitors. The project is composed of five different functional lots that include the restoration of the existing sport hall for hosting the indoor sport activities in the first lot, the hotel and student housing approximately 8,900 m^2 in the second lot, residences approximately 15,500 m^2 in the third lot, offices approximately 10,000 m^2 in the fourth lot, and the fifth lot got characterised with the linear urban park nearly covers 16,500 m^2 area; the total intervention area was defined as approximately 115,000 m^2 (Comune di Genova, 2021).

4. Discussion

Genoa's waterfront transformation from the first implementations until now highlights the challenges of balancing urban waterfront enhancement with the preservation of publicness and assurance of public benefits, particularly considering the shifting dynamics between the involvement of public and private sectors. This shift reframes the norm of waterfront redevelopment that started as a waterfront renaissance that aimed to reclaim the waterfronts for the city and resulted in the form of privately developed and managed waterfronts. Therefore, the central concern revolves around who these spaces are for and to what extent they are truly public.

4.1. Narrative and Process

The redevelopment process of Genoa's urban waterfront unfolds a long and complex narrative. The earlier instances in the scope of Porto Antico redevelopment were primarily catalysed by the international exhibition Expo 1992, aimed to promote the activities that respond to the growing tourism demands, overall enhancement of the city's image, improvement of the waterfront usage, and connection of the waterfront with the city. It has been conceived not only as a singular project, but as part of a broader urban regeneration strategy, designed to elevate the city's historic centre and the waterfront. These interventions focused mainly on reclaiming former industrial and port areas for public use. Alongside the waterfront's functional transformation, the port heritage's integration and recovery to host the new functions have formed a maritime collective memory. Therefore, the discourse was centred around the urban reconnection and civic recovery of the port as an integral part of Genoa's urban identity.

The following process encompasses the broader vision of redeveloping Genoa's urban waterfront. The emergence of several master planning initiatives, such as Affresco and Blueprint, primarily reveals the intention for growing interest in the transformation of the overall urban waterfront, from the water towards the land, harmonised with the large-scale interventions. They remained unrealised mainly due to financial constraints.

The Waterfront di Levante initiative illustrates the increasing economisation of the redevelopment narrative in the present era. The main objective is to attract private capital, as evidenced by the increasing emphasis on revenue generation. The outcome is a hybrid narrative that rhetorically emphasises public benefit and connectivity, while spatial outcomes increasingly align with the priorities of private capital and real estate markets.

4.2. Governance, Management, and Actors

Genoa's waterfront redevelopment trajectory illustrates a significant transition from state-led initiatives to complex arrangements involving public-private partnerships, private developers, and semi-autonomous bodies. Initially, local, regional, and port authorities were in charge of planning and funding in the form of public-private partnerships. Yet, the dominance of the investment was mainly over the public, and in carrying out the projects. This term reveals redevelopment attempts in favour of public functions, creating accessible waterfronts and enhancing the maritime heritage with public-oriented approaches. Over time, as priorities shifted towards attracting private investment and promoting economic growth, the public benefits were overlooked, and the primary concern was creating a real estate market in the waterfront. The change can be observed from the state-led Porto Antico redevelopment program to the property-led strategy of the Waterfront di Levante project, even though the initiations of both projects introduced by the public authorities, augmented involvement of the private capital deeply affected, especially the process of transformation and the results. Moreover, rather than creating a balanced relationship between public and private funds, the decision to privatise the process also illustrates the changing vision into an asset management strategy.

The repeated engagement of Renzo Piano as a prime actor for drawing a vision and designing the interventions in the urban waterfront redevelopment plans and projects demonstrates the important role of architecture while re-shaping the contemporary scene in Genoa's waterfront. While the involvement of international firms signals ambitions to create high-profile waterfronts, it also implies the potential risk of homogenising architectural and urban design, potentially marginalising local or regional specificities. However, as a local to the same geography, Renzo Piano contributes a lot to the process of identity-making and maintaining the sense of place in Genoa's

waterfront redevelopment in the redevelopment process of Porto Antico. On the other hand, the Waterfront di Levante project reveals patterns more similar to those in global instances by introducing the high-end design and lacking sensitivity to the existing context. Furthermore, this technocratic approach that dominates recent projects appears to be a retreat from broader civic engagement.

4.3. Contextual Considerations

The contextual considerations start from the selection of the intervention site. The distinct relationships established by the redevelopment of the Porto Antico project, located in the historic port area, were achieved by being part of the broader regeneration plan from both sides of the historic centre and the historic port. A contextually sensitive and spatially integrative approach could be traced from the approach that waterfront was not treated as an isolated intervention, but as a catalyst for the broader revitalisation of the historic urban core, which had suffered from long-term physical and socio-economic decline. The project fosters a dynamic relationship, extending the publicness of the city's historic centre towards the waterfront. This has been achieved by establishing a strong connection between the city's public infrastructure and the public areas introduced within the intervention site to maximise continuity between the waterfront and its hinterland. Intervention partially engages with the urban context constrained to specific parts of the inner urban fabric and responds to the needs of the limited surrounding area (see Figure 2). The project thus exemplifies a market-led regeneration paradigm in which the pursuit of economic optimisation supersedes the imperative for social and territorial cohesion.

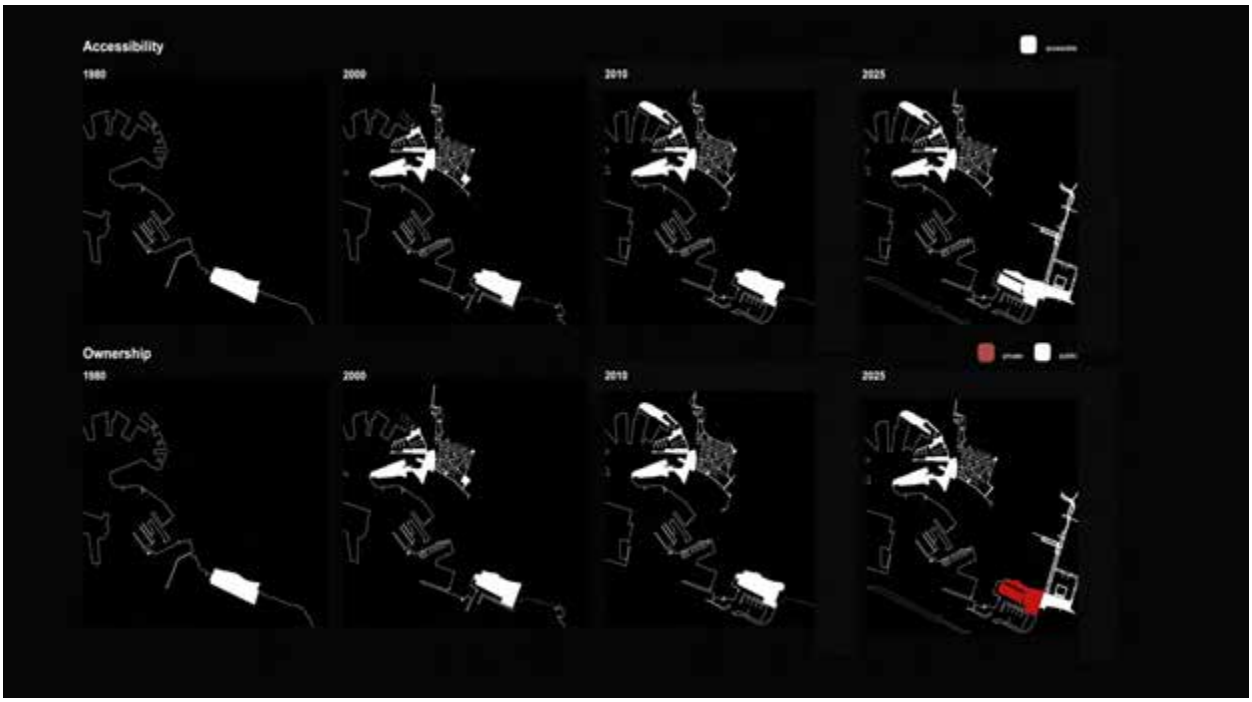

Figure 2: Spatio-temporal shift in Genoa's urban waterfront public ground in terms of accessibility (above), and ownership (below)

4.4. Spatial and Programmatic Outcomes

The physical outcomes of the earlier period applications, realised predominantly with the Porto Antico redevelopment project, were defined by a series of newly constructed or renovated public spaces, including promenades, parks, and cultural amenities. The spatial logic of these interventions generally prioritised public access and connectivity, aiming to create spaces of encounter that broad segments of the population could freely access. The design decision of including the mixture of renovation of the existing historic buildings, harmonised by the new structures that accommodate new typologies and functions, and the arrangement of these components

in the public realm contributed to the success of the early redevelopments on Genoa's waterfront. On the other hand, even though the program was centred on public functions, it is essential to underscore the criticality of the event-led nature of the project, which brings further questions regarding sustaining public engagement in the long term by their limited capacity to generate durable patterns of integration. This reflects a broader tendency characteristic of waterfront redevelopment during that period, leisure-oriented programming, and the prevailing "port-out, city-in" approach (Tommarchi, 2025), which was often questionable regarding the depth and permanence of public engagement.

However, as exemplified by the Waterfront di Levante project, the spatial and programmatic logic is powerfully shaped by commercial imperatives, emphasising attracting private investment and an exclusive user profile. With the introduction of the retail and residential functions, the access and use of spaces are implicitly regulated by market mechanisms. The spatial enclosure and exclusion through high-end residential enclaves, controlled access zones, and commercial programming that privileges affluent users represent the prominent issues in the waterfront redevelopment implementations during late neoliberalism—not only in the architecture of the built environment but also in the carefully curated image of the waterfront as a space of consumption and leisure, further reinforcing the patterns of socio-spatial segregation (see Figure 3).

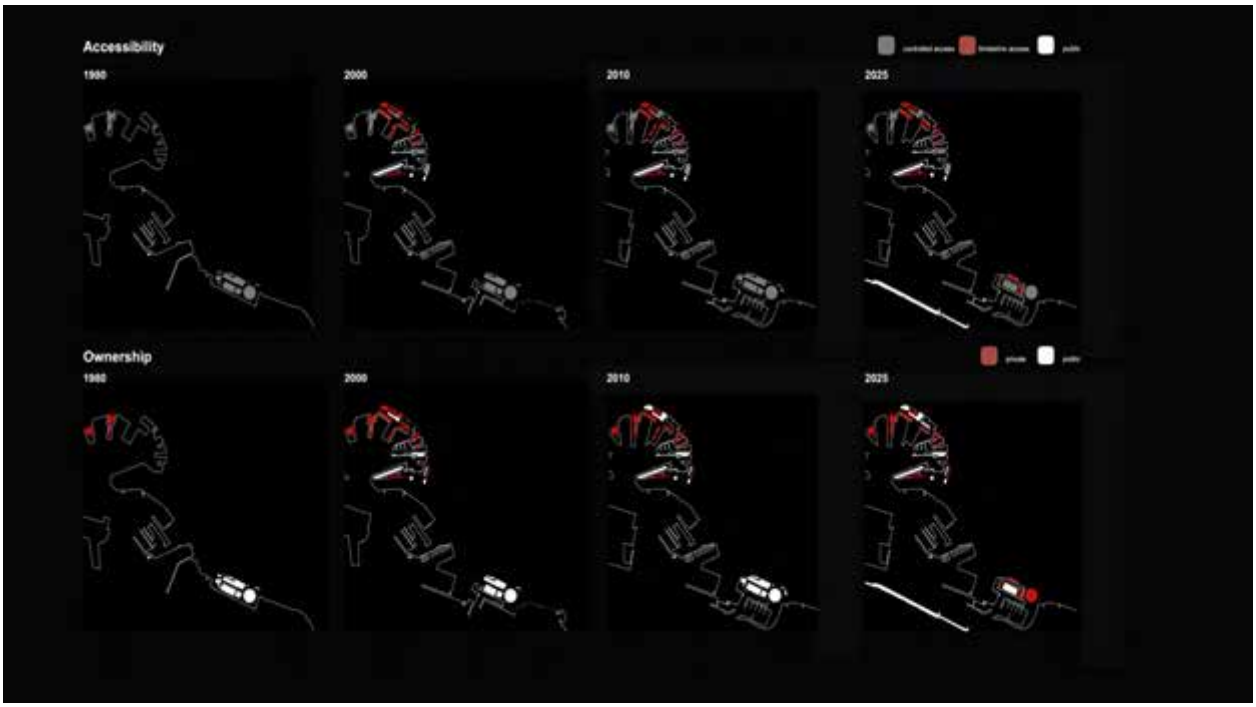

Figure 3: Spatio-temporal change in the built environment in the scope of waterfront redevelopment projects in terms of accessibility (above), and ownership (below)

5. Conclusion

Renzo Piano defines the process of the Waterfront di Levante project by referring to his former project of Porto Antico, and emphasising that Genoa once again "re-conquers the sea" (Minella, 2023). However, the process and results do not reveal similar patterns or attempt to address similar concerns as they were in the initial phases. Prioritising urban reconnection and public engagement with the waterfront has been replaced with market dynamics that eventually lead to spatial and social segregation of waterfronts from urban life and public actors. Therefore, the main motto of the waterfront redevelopment programs was identified with the attempts to reclaim the waterfront for the city and reshape it according to the developer's priorities. All in all, this reveals the dramatic shift in the paradigm of waterfront redevelopment.

The case of Genoa's waterfront reveals how the objectives of such initiatives have transformed in the near history, raising concern over the publicness of the waterfront, and the growing issue of spatial and social exclusion. Even though the recency of the project limits further impact studies in the current timeframe, it sheds light on this global trend of enclaving the waterfronts via exclusive spaces and selected user profiles, illustrating how the phenomenon of waterfront redevelopment has shifted from a public-oriented direction to the opposite.

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Quests for Improving Visual Quality in Streets

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Abstract
The visual quality of streets is an important factor that determines the attractiveness of public spaces. Studies conducted on this subject emphasize the effect of environmental perception and aesthetic evaluation on people and street views. One of the elements that increase the visual quality of streets is the green texture, the seasonal change of trees on streets is also an important component of environmental perception and aesthetic evaluation. Therefore, in order to understand the visual quality of streets, a mixed approach should be adopted that includes not only objective evaluations of physical features but also subjective perceptions of people. The aim of this study is to question the relationship between measurable design qualities (diversity/complexity, green area density, openness ratio, closedness ratio, facade density, and light/shadow effect) that affect visual quality through street views and perceived aesthetic appreciation, taking into account the seasonal changes of street trees.

Keywords: Public space, street trees, visual quality, seasonal differences

1.Introduction

It is stated in the literature that visual quality is an important element of urban design. In particular, it is emphasized that the design elements on the streets and their effects on visual quality should be measured quantitatively. This evaluation should be made in order to contribute to making effective urban design decisions and creating high-quality streets and avenues (Ye et al., 2019, Demir and Gürel, 2024).

However, visual quality is an abstract concept and is usually associated with physical features. However, it is not possible to fully understand people's general perception based on physical features alone. Therefore, when evaluating the physical elements of a space, it is necessary to take into account people's perceptual experiences.

Lothian (1999) suggests a mixed approach where both objective and subjective paradigms are used together to evaluate the visual quality of the natural and built environment. The objective approach views quality as an intrinsic property of the environment, while the subjective approach assumes that quality is a value based on the perception of the observer (Lothian, 1999; Tveit, 2009). Qualitative methods used to evaluate visual quality include surveys, interview techniques, case, and behavioral studies, and aesthetic preference questionnaires. Quantitative methods include approaches such as fractal geometry, visual statistical analysis, the golden ratio, correlation methods, content analysis, Brunswik's lens model, entropy, artificial intelligence, spatial index, and fuzzy logic theory.

In order to develop and improve the visual quality of streets, it is first necessary to determine the elements that affect the visual quality of the streets (Tekel, 2021). Research shows that determining these elements has a significant impact on people's perception and use of the urban environment.

There are many variables and design qualities that affect the visual quality of the built environment. While some of these qualities are measurable, some cannot be. In this research, a query was made on measurable design principles and criteria. The aesthetic evaluation on the streets was examined on the measurable design qualities that affect visual quality, such as diversity/complexity, green area density, openness ratio, closedness ratio,

facade density, and light/shadow effect.

Streets are important public spaces of daily life. The presence of green areas in these spaces is an important factor that increases visual quality (Cooper et al., 2013). Studies suggest that seasonal differences in green areas are an important component of environmental perception and aesthetic evaluation (Junge et al., 2015). Landscape physiognomy can vary greatly depending on seasonal changes, which can affect people's perceptions and preferences. However, few studies have taken seasonal dynamics into account (Palang et al., 2007; Stobbelaar and Hendriks, 2007; Junge et al., 2015).

In the literature, it is stated that comparative studies on visual quality through street images are limited according to different seasons (Palang et al., 2007; Stobbelaar and Hendriks, 2007; Junge et al., 2015). In this study, a detailed literature review was conducted with the keyword "seasonal differences". The total number of sources reached in the WoS (Web of Science) database is 131. The shortcomings in these studies limit our full understanding of how human perception and aesthetic preferences are affected by different seasons. However, it is stated that comparative studies conducted according to different seasons provide important information about how they affect people's perceptions and aesthetic preferences (Zhao et al., 2017; Kuper, 2020).

This study aims to identify design elements that increase aesthetic appreciation on the streets and to understand how these elements are affected by seasonal changes. It also aims to provide a basis for better understanding the impact of seasonal factors on visual quality and aesthetic perception and to develop more effective strategies in public space design.

2.Materials and Methods

This study aims to question the relationship between measurable design attributes (diversity/complexity, green area density, openness ratio, closedness ratio, facade density, and light/shadow effect) affecting visual quality through street views, taking into account seasonal changes in street trees, and perceived aesthetic appreciation. Thus, a mixed approach was adopted, including objective evaluations addressing physical characteristics and subjective evaluations considering aesthetic appreciation in order to identify design elements that increase aesthetic appreciation in streets.

In this context, the method followed in the study was designed in three stages. In the first stage, the study area was determined. Data collection was carried out by taking photographs in the field study. For the photography, first of all, sample streets were determined within the study area and photo shooting points were created.

The study area was determined as Mebusevleri Neighborhood, one of the original neighborhoods of Ankara during the Republican Period, which attracts attention with its tree texture on its streets. All original streets within the neighborhood were included in the sample, and 9 shooting points were determined to reflect these differences from the streets with differences in terms of structure and tree texture. A database was created by taking photos in the winter and summer periods at the created photo shooting points. Impartiality was observed while taking photos from the research area, and no tendency that could affect the participants was shown. In the study conducted by Jiang et al. (2017), it was stated that eye-level photography is widely used by designers, planners, and researchers in obtaining information about green areas and examining human reactions in real environments. In this study, the photos were taken at eye level and from the very center of the streets where the shots were taken.

In the second stage, measurable design qualities that determine the visual quality of the streets (diversity/complexity, green area density, openness ratio, closedness ratio, facade density, and light/shadow effect) and the measurement methods of these qualities were determined. In this context, the photographs obtained were analyzed using fractal and image statistical analysis methods (HarFa v5.5 and Photoshop). Diversity/complexity was analyzed using fractal analysis method; image statistical analysis was used for the analysis of other design

qualities. In addition, the aesthetic appreciation assessment of the sample streets was carried out using the photo-survey method conducted on the obtained photographs. Table 1 presents information on the demographic characteristics of 150 volunteer students who participated in the survey conducted via Google Forms.

Tablo 1. Demographic characteristics of participants

Variable	Category	n	%
Gender	Female	118	78,66
	Male	32	21,33
Department	Architecture	53	35,33
	Urban and Regional Planning	97	64,66
Academic Year	1st year undergraduate	17	11,33
	2nd year undergraduate	16	10,66
	3rd year undergraduate	26	17,33
	4th year undergraduate	57	37,99
	Master's degree	17	11,33
	PhD degree	17	11,33
Total number of participants: 150			

As seen in Table 2, the necessary procedures were applied to the photographs to be used in the analysis.

Table 2. Stages of preparation of street images for analysis.

1. Street images are deleted in PhotoShop software, such as cars, people and clouds.	2. The resolution of the street images was kept constant at 672 × 1200 pixels.	3. The color of the street images was removed and the images were used in grayscale for analysis.	4. For the fractal analysis of street images, black and white images were used.

In the third stage, the relationship between seasonal differences and measurable design attributes affecting visual quality and aesthetic appreciation was statistically analyzed using SPSS program. It was tested with Spearman correlation analysis and measurable design attributes according to seasonal differences were compared using Mann-Whitney U test.

2.1. Fractal analysis

Fractal analysis, which is frequently used in analyzing visual complexity in built environments, provides effective results with morphological measurements (Işınkaralar and Varol, 2023, p.2). Fractal dimension, which is the basic statistical parameter in fractal analysis, measures the ability of a pattern to fill the gaps and therefore the level of complexity. The more complex the pattern, the higher the fractal dimension. The value obtained varies between 0 and 2 (Işınkaralar, 2023).

The complexity of a place depends on the diversity of the physical environment, especially the number and types of buildings, architectural diversity/complexity and ornamentation, landscape elements, street furniture, signs, and human activity (Ewing et al., 2006). In the study of Cooper and Oskrochi (2010), a positive relationship was found between fractal dimension levels and visual diversity/complexity levels. According to the research of Yılmaz (2021), areas with a fractal dimension value of approximately 2 represent complex and rich urban spaces, while areas with a value of approximately 1 represent less complex regions.

In this study, the diversity/complexity values of the sample streets were calculated using the HarFa 5.5 program. According to the study, the fractal dimension values of the street images in the winter season varied between 1.3152 and 1.7758. In the summer season, the fractal dimension values of the street images varied between 1.3473 and 1.7176. The fractal dimension values of the sample street images selected from the study area calculated in different seasons are given in Table 3.

Table 3. Diversity /Complexity analysis of example ımages

Mebusevleri Neighbourhood		
	Winter	Summer
Şerefli St.		
1	BW FD=1,5954	BW FD=1,5127
Ören St.		
2	BW FD=1,6477	BW FD=1,5213

2.2.Image statistical analysis

In this study, measurable design attributes such as green area density, openness ratio, closedness ratio, facade density, and light/shadow effect were analyzed on photographs obtained by image statistical analysis method.

Green area density

Green spaces provide many benefits, such as inspiring an individual's visual aesthetic perception of streetscapes, increasing outdoor time, and preventing stress and negative psychological symptoms (Chen., 2021). The restorative potential of nature has been theoretically and empirically associated with a strong affinity and aesthetic preference for natural environments (Ibarra et al., 2017).

Existing research shows that most studies on the measurement of street trees focus on the "amount of greenery", whereas the assessment of aesthetic qualities is neglected due to methodological shortcomings (Hu et al., 2022).

Figure 1. Green area density (Demir & Gürel, 2024)

In this study, the green area density of sample streets was calculated using the Histogram command in Photoshop software using the Image Statistical Analysis (GIA) method. The total number of green area pixels in the street images was proportional to the total number of pixels in the street images. In the winter season, the green area density of the sample street images varied between 24.54 and 43.53. In the summer season, the green area density of the sample street images varied between 37.38 and 65.12. The green area density values of the sample street images selected from the study area are given in Table 4.

Table 4. Green area density of example ımages (Original, 2024)

Mebuseyleri Neighborhood			
		Winter	Summer
Şerefli St.	1	41.31	65.12
Ören St.	2	36,77	55,82

Openness ratio

Openness refers to the portion of the sky that can be seen from a vantage point, and the height and alignment of building facades directly affect this openness. For example, setbacks create a broad horizon, while dense clusters of tall buildings divide the sky into narrow visual areas.

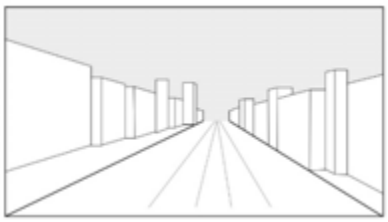


Figure 2. Openness (Demir & Gürel, 2024)

The openness ratio of the sample streets was calculated using the Histogram command in Photoshop software using the Image Statistical Analysis (ISA) method. The total number of visible sky pixels in the street images was proportional to the total number of pixels in the street images. In the winter season, the openness ratio of the sample street images varied between 28.96 and 37.24. In the summer season, the openness ratio of the sample street images varied between 0.7 and 33.05. The openness ratio values calculated for the sample street images selected from the study area in different seasons are given in Table 5.

Table 5. Openness ratio of example ımages (Original, 2024)

Mebusevleri Neighborhood			
		Winter	Summer
Şerefli St.			
1		32.13	5.92
Ören St.			
2		31,79	0,7

Closedness ratio

Closedness refers to the space created by buildings and is related to people's perception of spatial confinement. A well-closed street increases the sense of security and provides more opportunities for physical activities. Therefore, closedness is considered an important feature in street designs.

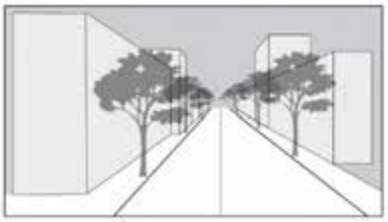


Figure 3. Closedness (Demir & Gürel, 2024)

The closedness ratio of sample streets was calculated using the Histogram command in Photoshop software using the Image Statistical Analysis (ISA) method. The closedness ratio in street images is the ratio of the total number of pixels of visible building facades to the total number of road pixels in street images. In winter, the closedness ratio of sample street images varies between 1.89 and 62.39. In summer, the closedness ratio of sample street images varies between 1.41 and 26.56. The closedness ratio values calculated for sample street images selected from the study area in different seasons are given in Table 6.

Table 6. Closedness ratio of example ımages (Original, 2024)

Mebusevleri Neighborhood	Winter	Summer
Şerefli St.		
1	35,42	7,67
Ören St.		
2	62,39	10,6

Facade density

Studies on street photographs show that measurable design elements such as facade density and the presence of landscape elements play an important role among the factors that determine the aesthetic quality of the street. The facade density of the streets is among the critical elements that determine the characteristics of the space and the integrity of the street wall (Akbaba, 2022).

Figure 4. Facade density (Demir & Gürel, 2024)

The facade density of the sample streets was calculated using the Histogram command in Photoshop software using the Image Statistical Analysis (GIA) method. The facade density in the street images is the ratio of the total number of pixels of the visible building facades to the total number of pixels in the street images. In the winter season, the facade density of the sample street images varies between 0.82 and 19.98. In the summer season, the facade density of the sample street images varies between 0.71 and 7.7. The facade density values calculated for the sample street images selected from the study area in different seasons are given in Table 7.

Table 7. Facade Density of Example Images (Original, 2024)

Mebusevleri Neighborhood	Winter	Summer
Şerefli St.		
1	12,23	2,36
Ören St.		
2	19,98	4,24

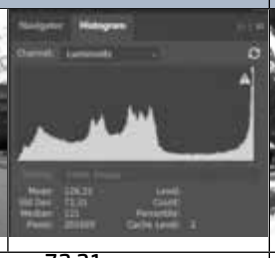
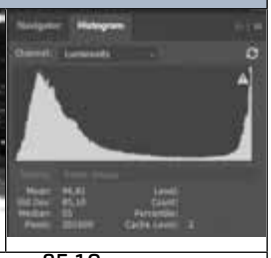
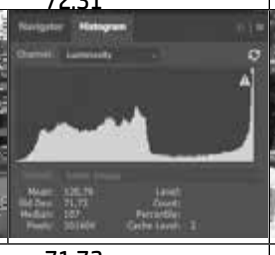
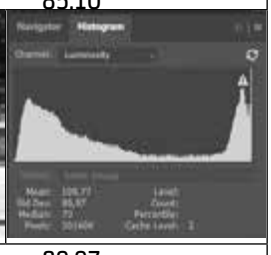
Light / Shadow effect

The effect of light and shadow (contrast) in street images is related to the amount of detail in the image (Kalavı, 2021). According to literature research, light and shadow deeply affect the perceived beauty of street scenes. Properly arranged landscapes and structures, when used in harmony with natural light sources, increase the aesthetic value of the landscape. The correct use of shadows increases the perception of depth and size, increasing visual appeal. Shadows in cities often leave important impressions on individuals. Shadows and light can transform the depth and atmosphere of an area. Street greenery and tree shadows affect thermal comfort and are advocated for the creation of pleasant urban environments. (Demir, 2024)

Figure 5. Light/Shadow effect (Demir & Gürel, 2024)

The light/shadow effect of the sample street images, namely the contrast ratio, was calculated using the Histogram and Luminosity commands in Photoshop software using the Image Statistical Analysis (GIA) method (Table 5.6). According to the table, the light/shadow effect of the sample street images in the winter season varies between 64.17 and 85.78. In the summer season, the light/shadow effect of the sample street images varies between 52.47 and 89.97. The light/shadow effect values calculated for the sample street images selected from the study area in different seasons are given in Table 8.

Table 8. Light/Shadow effect of example ımages (Original, 2024)

Mebusevleri Neighborhood				
	Winter		Summer	
Şerefli St.				
1	72.31		85.10	
Ören St.				
2	71,72		89,97	

Conclusion

Seasonal change of green areas on streets is an important component of landscape perception and aesthetic evaluation in studies on visual quality (Junge et al., 2015). In this context, when the relationship between seasonal differences on streets and aesthetic appreciation values is questioned, it is seen that the summer and winter season averages of the variables are different from each other. It is observed that the aesthetic appreciation average of the summer period is greater than the aesthetic appreciation average of the winter period. When the values of measurable design qualities are evaluated together with aesthetic appreciation, it can be said that when the values of diversity/complexity, green area density, closedness ratio, facade density, and light/shadow effect are high, aesthetic appreciation increases, whereas when the openness value is high, aesthetic appreciation decreases.

• Cooper and Oskrochi (2010) found a positive relationship between fractal dimension levels and visual diversity/complexity levels. In this study, when the relationship between diversity/complexity level (fractal dimension) and aesthetic appreciation was examined with Spearman's Rank Correlation Coefficient analysis, there was no statistically significant relationship between aesthetic appreciation and fractal dimension for the winter season. Similarly, no significant relationship was found between aesthetic appreciation and fractal dimension for the summer season. When the diversity/complexity level in street images in the sample was examined according to seasonal differences, it was shown that there was no statistically significant difference between fractal dimension levels.

• When the green area density is examined, it is observed that the green area density of street images is higher in summer than in winter. According to the correlation analysis, there is no significant relationship between aesthetic appreciation and green area density in winter. However, a positive and significant relationship was found between aesthetic appreciation and green area density in summer. In addition, the comparison of green area density according to seasonal differences was made with the Mann-Whitney U test and the obtained significance value was determined as 0.002 ($P<0.05$). These results show that seasonal changes have a significant effect on green area density.

• When the openness ratio is examined, the openness ratio of street images is lower in summer than in winter. In the correlation analysis, there is no statistically significant relationship between aesthetic appreciation (winter) and openness ratio (winter). Similarly, no statistically significant relationship was found between aesthetic appreciation (summer) and openness ratio (summer). Comparison of openness ratio according to seasonal

differences was made with Mann-Whitney U test and the obtained significance value was determined as 0.002 (P<0.05). This result shows that seasonal changes have a significant effect on the openness ratio. It was observed that the openness ratio was higher in winter.

• When the closedness ratio is examined, it is shown that the closedness ratio of street images is higher in summer than in winter. According to the correlation analysis, there is a positive and statistically significant relationship between the aesthetic appreciation (winter) value and the closedness ratio (winter). However, there is no statistically significant relationship between the aesthetic appreciation (summer) value and the closedness ratio (summer). The significance value obtained as a result of the Mann-Whitney U test conducted to examine the closedness ratio according to seasonal differences was determined as 0.038 (P<0.05). This result shows that there is a significant difference between the closedness ratio depending on seasonal changes. According to the rank average values, it is observed that the closedness ratio is higher in winter than in summer.

• When facade density is examined, it is shown that facade density of street images is lower in summer than in winter. According to the correlation analysis, there is a positive and statistically significant relationship between the aesthetic appreciation (winter) value and facade density (winter). In other words, there is a strong and significant relationship between the aesthetic appreciation values in street images and the facade density in winter. However, there is no statistically significant relationship between the aesthetic appreciation (summer) value and facade density (summer). The significance value obtained as a result of the Mann-Whitney U test conducted to examine the facade density according to seasonal differences was calculated as 0.019. This result shows that the facade density in winter is significantly higher than in summer.

• According to the correlation analysis conducted to examine the relationship between the Light / Shadow effect and aesthetic appreciation, there is no statistically significant relationship between the aesthetic appreciation (winter) value and the light / shadow effect (winter) and between the aesthetic appreciation (summer) value and the light / shadow effect (summer). The significance value obtained as a result of the Mann-Whitney U test conducted to examine the Light / Shadow effect according to seasonal differences was determined as 0.627. This result shows that there is no significant difference between the light / shadow effect level depending on seasonal changes.

As a result, it has been determined that seasonal changes in street trees may affect individuals' evaluation of the visual quality of streets and may lead to differences in measurable design attributes that shape perceptual differences.

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Informal Utilization Characteristics of Underpass Public Spaces in Megacities from the Perspective of Co-Production Theory: A Case Study of Elevated Highway Underpasses in Guangzhou

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Abstract
Under the guiding principle of "People-Oriented Urban Development," public space has become a core focus of urban development in China. As major cities enter a stage of stock-based urban regeneration – emphasized repeatedly at the national level, notably in the 2025 State Council meeting – the potential of under-bridge spaces as public space assets in megacities has garnered significant attention. However, formal regeneration approaches often face prolonged implementation cycles due to complex land rights and the involvement of multiple management departments. In contrast, the informal use of under-bridge spaces (e.g., temporary markets, sports grounds) is widespread yet understudied in large Chinese cities. Based on co-production theory and adopting a socio-spatial perspective, this study investigates multiple cases of informal under-bridge space utilization in Guangzhou, a representative Chinese megacity. The research aims to systematically summarize the core characteristics of such informal use (such as spatial adaptability, actor diversity, and functional dynamics) and reveal the interaction mechanisms among diverse actors in the informal production of space. The findings offer theoretical insights and practical references for overcoming the challenges of formal regeneration and exploring more inclusive and adaptive governance models for under-bridge spaces in megacities within the context of urban renewal.

Keywords: Urban Regeneration; Under-bridge Space; Public Space; Co-production; Informal Use

1 Introduction

The Report of the 20th National Congress of the Communist Party of China emphasises the principle that "a people-centered city is built by and for the people." This signals a paradigm shift in China's urban development philosophy—from incremental, expansion-oriented growth to connotative, human-centered development (Shen, 2019). In this transition, the construction of urban public spaces increasingly responds to citizens' diverse needs. However, central districts of major cities often suffer from inadequate public space supply, spatial mismatch between supply and demand, and significant challenges in spatial supplementation.

In this context, elevated expressways, as critical infrastructures in megacities, have drawn attention in recent urban regeneration initiatives, particularly for the potential reuse of space beneath the overpasses. For instance, the Shanghai Urban Regeneration Action Plan (2023–2025) identifies five major regeneration tasks. Under the third task—"Optimisation of Public Space Facilities"—it proposes upgrading the quality of under-elevated spaces to create high-quality urban public environments (Shanghai Municipal Government, 2023).

Existing domestic research primarily focuses on the formal uses and planning strategies of space beneath elevated roads (Huang, 2019). However, the share of under-elevated spaces that are suitable for formal redevelopment remains limited. Moreover, the formal transformation of such spaces is constrained by complex multi-agency governance, dynamic urban policy adjustments, ambiguous land tenure in certain areas, and potential interference with traffic systems. These challenges result in a rigid and narrowly applicable formal planning framework, with prolonged implementation cycles.

In contrast, the informal uses of under-elevated spaces in megacities can potentially compensate for the limitations of formal redevelopment. Yet, theoretical frameworks for understanding such informal utilisation remain underdeveloped in China. Little attention has been paid to the spatial characteristics, governance mechanisms, and user preferences associated with informal practices in these spaces.

This study seeks to address this gap by drawing on the theory of co-production to examine informal uses of multiple under-elevated spaces in Guangzhou. Adopting a social-spatial negotiation perspective, the paper aims to identify informal use characteristics, spatial structures, and user preferences, thereby contributing

strategic recommendations for revitalising these underutilised spaces within the broader context of urban stock regeneration.

2 Literature Review: Informal Use of Under-Elevated Spaces from the Perspective of Co-Production Theory

2.1 Current Research on the Informal Use of Space Beneath Elevated Roads

International scholarship on the informal use of under-elevated spaces emerged relatively early, with numerous studies affirming the positive effects of such practices under certain conditions. Some scholars argue that temporary uses of space represent innovative and experimental solutions, capable of breathing new life into abandoned facilities while preserving their historical, cultural, and environmental values (Galdini, 2020). These practices, by reassigning function and meaning to otherwise disused areas, contribute strategically to holistic urban regeneration processes (Galdini, 2020).

Research has also highlighted that informal uses of space beneath elevated highways can foster spatial integration between both sides of an overpass. Akinci (2016), for example, points out that while elevated highways fragment urban fabric, the spaces beneath them retain a certain urbanity. Informal everyday activities conducted by local residents under these structures can serve as symbolic and functional urban bridges.

International studies on urban informality primarily examine various forms of informal socio-economic activities, with a focus on their causes, governance models, and impacts. This body of literature also analyses the spatial characteristics of informality across different scales (Guo, 2023).

In contrast, domestic research has largely concentrated on **formal uses** of under-elevated spaces. Informal uses are typically discussed within typological analyses that highlight their **negative effects** and propose regulatory strategies (Liu, 2017). Research on urban informality in China has focused predominantly on the distribution and governance of informal economic activities—such as street vending—within urban villages, sidewalks, and streets. Recent studies have gradually begun to acknowledge the role of informal spatial practices in **complementing formal planning**, exploring governance models under different sociospatial structures (Guo, 2023).

In sum, both domestic and international literature have long recognised the relevance of informal space use in urban regeneration. However, in China, such research remains relatively nascent, particularly with respect to **theoretical understandings** and **spatial characterisation** of informal uses beneath elevated highways.

2.2 Informal Use of Under-Elevated Spaces from the Perspective of Co-Production Theory

The concept of **co-production** was first proposed by economist **Elinor Ostrom** in the 1970s to describe the active participation of citizens in the delivery of public goods and services (Albrechts, 2012). The theory emphasises the collaborative and direct involvement of both public administrators and citizens in managing public spaces, particularly under conditions where state capacity is limited. It proposes that such collaboration often constitutes **an optimal model for spatial regeneration**.

Some scholars argue that urban informality should be taken more seriously during spatial planning processes (Joshi, 2004). Others suggest that informal practices can facilitate co-production between governments and local communities, enhancing public engagement in space-making. The **spatial negotiation** among multiple actors over the informal use of urban spaces, in this view, constitutes a form of co-production in itself (Song, 2016).

Informal use may also serve to **rebalance unequal power relations** between space managers and users by enabling more equitable access to spatial resources (Song, 2016). In the domestic context, scholars have pointed out that informal uses foster **organic spatial growth**, promoting diversity in population structure, spatial morphology, and landscape form (Liu, 2017). Accordingly, how to institutionalise and regulate informal uses without stifling their vitality has become a central concern in contemporary urban planning.

In practice, many international cases of under-elevated space reuse exemplify co-production through **multi-stakeholder participation**. For example, New York City's *High Line Park*—initiated by the non-profit "Friends of the High Line"—transformed an abandoned elevated railway into a celebrated public space. Although the structure was initially slated for demolition due to complaints about unmanaged space below, planners and community members began experimenting with its use and negotiated with government agencies. Since opening in 2009, the park has become one of New York's major tourist attractions and a catalyst for the revitalisation of Manhattan's West Side.

In China, some scholars have also highlighted that the bottom-up adaptation and value redefinition of under-elevated spaces—through user-initiated modifications and cross-sector collaboration—can be viewed as a process of co-production (Li, 2023).

This study investigates **three long-established, functionally stable** cases of informal use beneath elevated highways in Guangzhou. Drawing on co-production theory and employing the **Actor-Network Theory (ANT)** as an analytical lens, it aims to identify the spatial characteristics, usage patterns, and governance logics that underpin the informal reuse of these spaces.

2.3 Informal Use of Under-Elevated Spaces from the Perspective of Co-Production Theory

The concept of **co-production**—also referred to as "collaborative production"—was first introduced in the 1970s by economist **Elinor Ostrom**. It emphasises the active involvement of citizens in the creation and delivery of public goods and services that directly affect their lives (Albrechts, 2012). Ostrom's formulation of co-production underscores the joint and direct participation of public administrators and ordinary citizens in service provision, particularly in the governance of public spaces. Co-production is widely recognised as a potentially optimal approach to spatial renewal, especially in contexts where public authority is weak or fragmented. Some scholars have further argued that informal spatial uses should be taken more seriously during spatial planning processes (Joshi, 2004).

In theoretical research, international studies suggest that informal uses of space can facilitate co-production between governments and communities, thereby activating public participation. The negotiation processes among various actors over informal spatial uses can themselves be understood as **forms of spatial co-production** (Song, 2016). Informal uses may also serve to moderate inequalities in **spatial agency** and **resource access** between space managers and users (Song, 2016). In the domestic context, researchers have observed that informal spatial practices can foster **organic spatial growth**, characterised by functional mix, contextual adaptation, and morphological diversity in population, spatial form, and landscape (Liu, 2017). As a result, the challenge of how to **institutionalise and guide** the orderly development of informal spatial practices has become a key issue in the field of urban planning.

In practice, many international examples of under-elevated space revitalisation have adopted co-production mechanisms involving **multiple stakeholders**. These collaborative efforts often aim to address the scarcity and misalignment of community public spaces. A prominent example is the **High Line Park** in New York City, initiated by the non-profit organisation *Friends of the High Line*. Originally an elevated railway decommissioned in 1980, the structure faced widespread complaints due to unmanaged and underutilised space beneath the tracks. Although there were calls for demolition, local planners began experimenting with new uses and engaged in sustained negotiations with government actors. This process eventually led to the preservation and transformation of the structure into a unique elevated urban park. Since its opening in 2009, the High Line has become one of New York's most popular tourist destinations and has played a pivotal role in revitalising the West Side of Manhattan.

Similar reflections have emerged in Chinese scholarship. For example, Li Zhigang (2023) argues that the spontaneous use, modification, and subsequent renegotiation of space beneath elevated roads represent a **process of multi-actor co-production**. In this study, we examine three long-established and functionally stable cases of informal use beneath elevated highways in Guangzhou. Through the lens of **co-production theory** and

employing **Actor-Network Theory (ANT)** as a methodological framework, we analyse patterns of spatial utilisation and extract key characteristics of informal practices under elevated infrastructure.

3 Empirical Study on Informal Uses of Under-Elevated Spaces in Guangzhou

3.1 Research Scope and Methodology

This study investigates three cases of informal use beneath elevated roads in Guangzhou:

(1) the space beneath the Dongsha Bridge at the intersection with Xixiang Third Road, located at the urban–rural fringe; (2) the underpass space of the Nansha Port Expressway intersecting Xiaozhou East Road; and (3) the ramp space between Yanjiang West Road and Shamei Third Street (Figure 1).
The study adopts a two-scale spatial analysis framework:

① At the neighbourhood scale, we analyse the five-minute pedestrian catchment surrounding each site, focusing on pedestrian flow patterns, land use types, and associated socio-spatial characteristics. ② At the micro-scale, we examine the under-elevated spaces themselves, identifying their physical configurations, patterns of informal use, and associated user groups.

Findings are further interpreted through the lens of **co-production theory**, summarising the typology of informal spatial practices and governance logics involved.

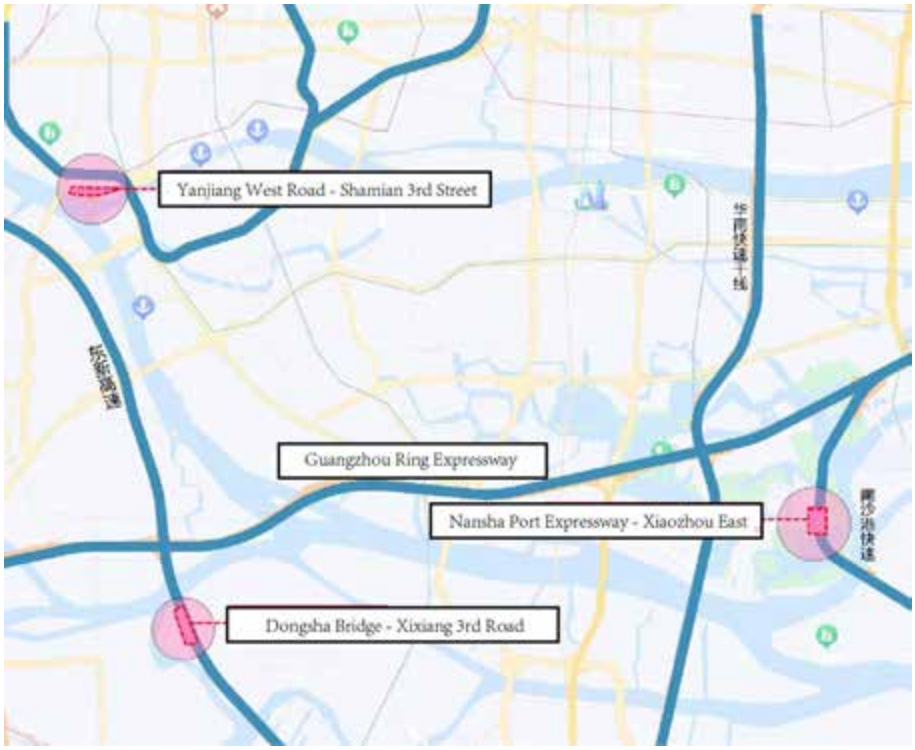

Figure 1 Location map of case study sites: under-elevated spaces in Guangzhou.
Base map source: Baidu Maps; diagram created by the author.

3.2 Nansha Port Expressway – Xiaozhou East Road

3.2.1 Spatial Context and Use Characteristics

The under-elevated space at the intersection of the Nansha Port Expressway and Xiaozhou East Road lies within the Xiaozhou Village Art District. The road bisects the space beneath the overpass into two distinct functional zones (Figure 3):

To the north: a self-organised fruit market initiated by village residents;

To the south: informal artist studios.

These functions are closely linked to the surrounding spatial structure, especially Xiaozhou Village and the nearby Guangzhou Academy of Fine Arts (Figure 2).

Figure 2 Contextual spatial analysis of selected case site.
Base map source: Baidu Maps; diagram created by the author.

Land use analysis within the five-minute pedestrian catchment (Figure 3) reveals a mix of village housing, woodland, and urban green space. Xiaozhou East Road, a minor road, provides the primary access. On-site observations indicate low vehicular traffic and a pedestrian-friendly environment.

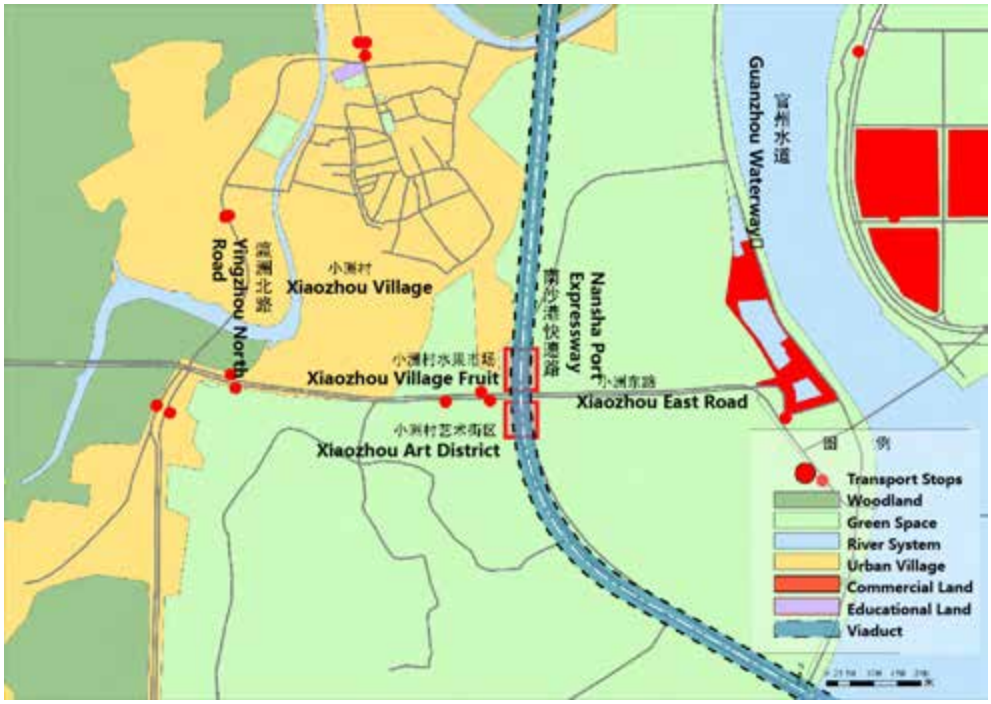

Figure 3 Five-minute walking catchment and land use analysis around the Nansha Port Expressway–Xiaozhou East Road underpass.
Diagram created by the author

The space accommodates two primary types of informal use: fruit vending, which functions as a **consumption-oriented activity**, and artistic production, which constitutes a **culturally embedded use** (Figure 4). These uses have emerged in a self-organised manner and coexist within the same under-elevated zone, creating a unique spatial synergy between everyday livelihood needs and creative practices. The primary user groups include local village residents, fruit vendors, art students preparing for university entrance exams), and young artists affiliated with the nearby Guangzhou Academy of Fine Arts.

Field investigations and interviews revealed that both the fruit market and the artist studios have existed continuously for more than one year and have become routinised components of the local spatial ecology. The site operates on a **full-day temporal cycle**, with peak activity periods observed during early morning (around 6:00 a.m., when vendors set up stalls) and again from late afternoon to early morning, when both vending and artistic activities intensify.

The fruit market is composed of **lightweight, collapsible stalls and mobile furnishings**, allowing vendors to adapt to changing space conditions and respond flexibly to demand and weather. Most of the infrastructure is semi-permanent but easily removable, which reflects the provisional nature of informal commercial activity. On the other hand, the artist studios take the form of **prefabricated panel structures or temporary cabins**, often built with plywood, plastic sheets, or reused materials. These units provide enclosed working environments for sketching, painting, and storage.

Together, these uses reflect **a multi-functional, informally co-produced urban microspace**. The spatial configuration not only satisfies practical needs such as daily food provision and low-cost workspace but also activates the underutilised overpass area with a blend of social and cultural vibrancy. This case illustrates how informality can serve as a tool for spatial optimisation in the context of megacity regeneration and space scarcity.

Figure 4 Top: Xiaozhou Village fruit market; Bottom: Xiaozhou Village art district. *Photographs taken by the author.*

3.2.2 Informal Use as Co-Produced Space

This site exemplifies a relatively complex and dynamic process of spatial production, resulting in a **functionally stable and socially embedded informal configuration**. Located adjacent to Guangzhou University Town but lying outside its formal administrative boundaries, Xiaozhou Village benefits from a unique **regulatory grey zone**. This peripheral positioning allows for greater spatial flexibility and tolerance of informality, as local administrative authorities tend to adopt a more lenient or non-interventionist approach. Such an environment enables organic spatial appropriation and adaptive reuse, indirectly facilitating long-term spatial stability beneath the overpass.

Several key conditions converge to support this stability. First, the area's **relatively low land rent** and **proximity to public transportation nodes** make it an attractive location for young artists, art students, and migrant vendors alike. The village lies only three kilometers from the Guangzhou Academy of Fine Arts, and its accessibility by bus and bike further strengthens its functional ties with the art school. As a result, a **local creative ecosystem** has gradually taken shape. According to field interviews, there are currently **dozens of intensive art training centers** (commonly known as) operating within the village, offering short-term residency, portfolio coaching, and art tutoring services.

The under-elevated fruit market on the north side of the road responds not only to the **everyday consumption needs** of village residents and art students but also plays a **supplementary role in the local art economy**. Fruit

is a recurring subject in foundational art education—particularly in sketching and still-life drawing exercises—which transforms the market into both a consumption space and a symbolic component of the **productive artistic environment**. This co-functionality of consumption and education creates **layered meaning and utility** within the space.

Meanwhile, on the south side of the overpass, the presence of self-built studios, temporary structures, and creative clusters illustrates a bottom-up formation of an **informal cultural district**. These spaces are typically constructed using prefabricated materials, reclaimed wood, or modular panels, and are highly adaptable to changing user needs. Artists, art students, and even part-time instructors from the Academy make use of these spaces for drawing, teaching, exhibiting, and even small-scale commercial work.

Crucially, this spatial arrangement is **not the result of a formal plan** but rather a **co-produced urban microenvironment** formed through the alignment of diverse actor needs—residents, artists, vendors, students, and local governance actors. Each party contributes to the spatial logic through their ongoing use, maintenance, and negotiation. The elevated infrastructure itself—often regarded as residual or dead space—is thus transformed into a **productive, multifunctional, and socially cohesive zone**.

In summary, the Xiaozhou Village case demonstrates how **spatial informality, artistic economies, and everyday consumption can intersect through co-production**, producing a hybrid and resilient public space that challenges the binaries of formal/informal and planned/spontaneous in contemporary urban theory (Figure 5).

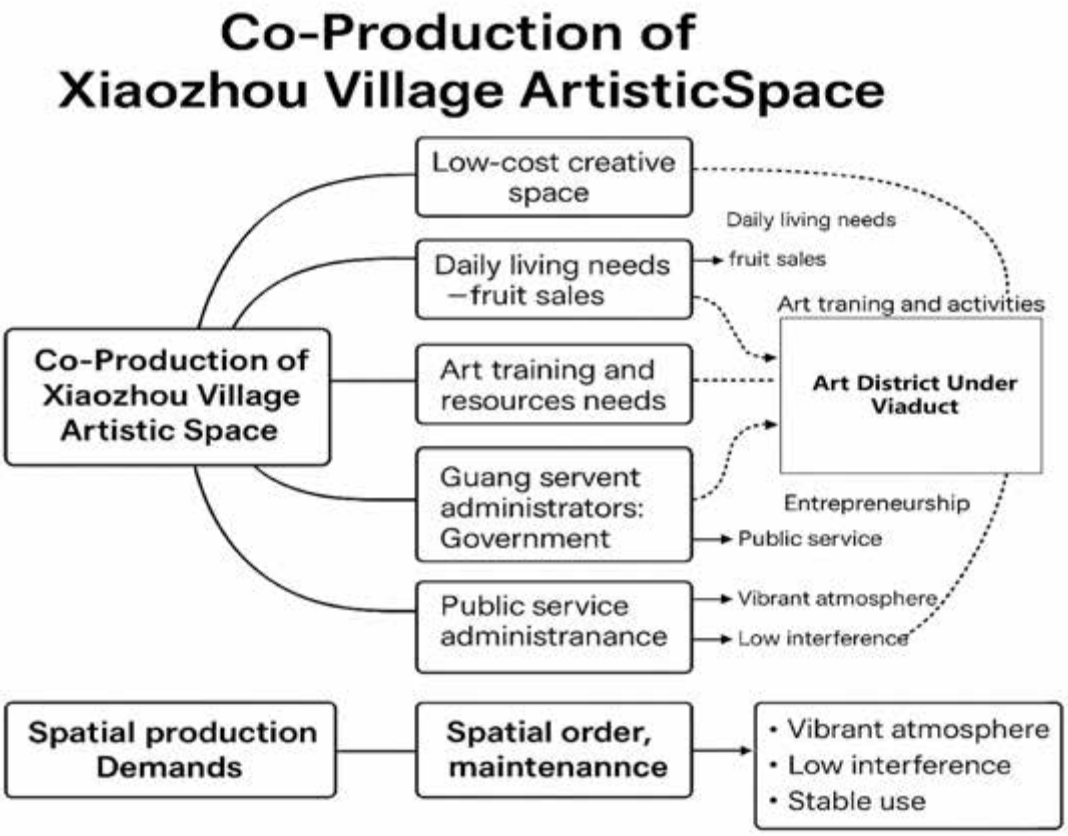

Figure 5 Characteristics of informal use under the Nansha Port Expressway–Xiaozhou East Road overpass. *Diagram created by the author.*

3.3 Dongsha Bridge – Xixiang Third Road

3.3.1 Spatial Context and Use Characteristics

This case involves the under-elevated space beneath Dongsha Bridge at its junction with Xixiang Third Road. A self-organised farmer's market has emerged beneath the structure (Figure 6).

- The eastern side is dominated by rural homesteads ();
- The western side consists of second-class residential land (R2 zoning).

Land use in the five-minute walking radius includes a mix of rural and urban housing, as well as cultivated farmland.

The bridge's clearance reaches approximately 20 metres, providing a rare, sheltered public space. The space's openness and shading qualities are especially valued in the local village context.

Additionally, moderate commuter flows from nearby roads and surrounding residents create a consistent demand for agricultural produce. Informal vending activities have emerged spontaneously over time. Restaurants along the roadside also occasionally encroach into the under-elevated area.

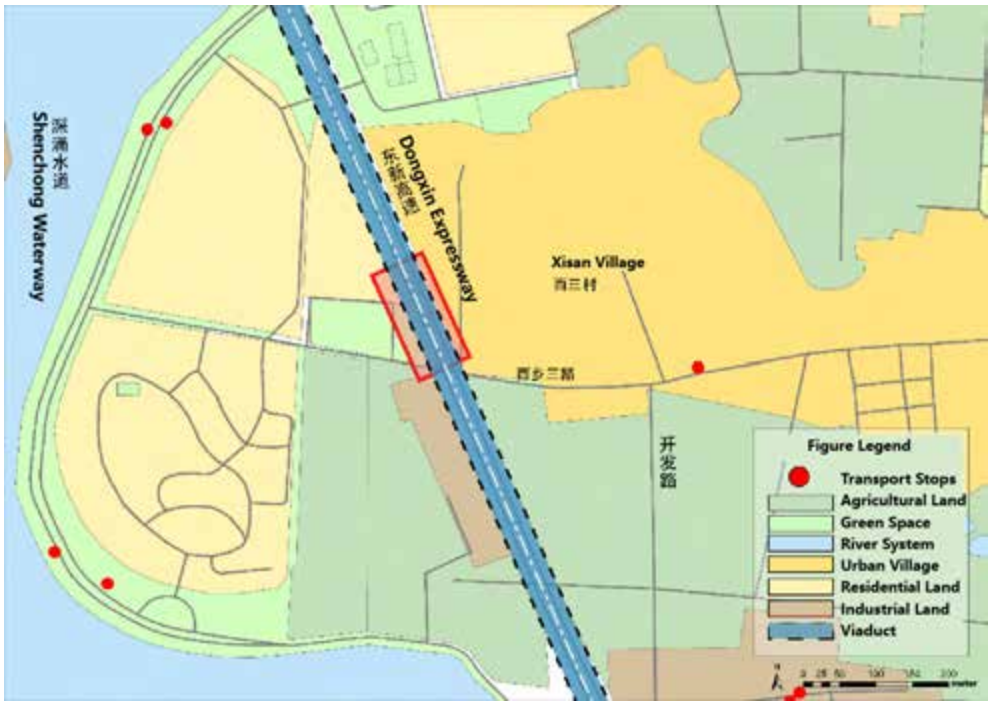

Figure 6 Land use analysis within a five-minute walking radius around the Dongsha Bridge–Xixiang Third Road underpass.
Diagram created by the author,

Figure 7 Informal use of space beneath the Dongsha Bridge–Xixiang Third Road overpass.
Diagram created by the author.

3.3.2 Informal Farmers' Market as Co-Produced Space
In this case, the rural residents of Xisan Village act as the primary initiators of informal spatial use beneath the Dongsha Bridge. Their need to sell surplus agricultural products—often grown in nearby peri-urban plots—naturally intersects with the everyday consumption patterns of passing commuters, local shopkeepers, and nearby residents. This **spatial and economic intersection** has facilitated the spontaneous emergence of an informal farmers' market beneath the elevated infrastructure.

Over time, through repeated transactions and habitual occupation, a **stable, trust-based relationship** has formed between vendors and consumers. The spatial regularity of the market—its specific time windows and physical configuration—has become part of the local socio-spatial rhythm. The elevated bridge structure provides critical environmental affordances: shade from sunlight, shelter from rainfall, and a relatively noise-buffered, open-air environment that does not impede vehicle circulation.

Importantly, the site is characterised by **low vehicular traffic flow and high pedestrian accessibility**, which supports the safe coexistence of informal economic activities and surrounding circulation systems. This case demonstrates how informal markets are not merely the result of economic necessity but are **co-produced through spatial affordances, social routines, and adaptive use of urban residue**. It underscores the planning potential of recognising informal practices as integral components of everyday urban systems.

3.4 Yanjiang West Road – Shamei Third Street
3.4.1 Spatial Context and Use Characteristics
Located on Shamian Island, a protected historical district and renowned tourist destination in Guangzhou, this site consists of a strip of under-elevated leisure space with informal seating and a bar (Figure 9).

The local street network is composed of narrow pedestrian-friendly roads, with walking as the primary mode of transport.

The elevated road above is currently decommissioned, allowing the space below to be fully appropriated for public use.

Visitors to Shamian often complete a loop around the island and stop at the riverside for rest. The underpass area provides essential shade and shelter from intense sunlight. It also hosts performances by local bar musicians, and a bar operates beneath the structure during evening hours.

The government has since incorporated this vibrant underpass space into its planning framework, designating it as a **"high-decibel vitality park"** within the Shamian Park system.

Figure 8 Indicative land use diagram of the ramp underpass at Yanjiang West Road, Shamian Island.}
Diagram created by the author.

Figure 9 Informal activities beneath the Yanjiang West Road–Shamei Third Street overpass. *Photograph taken by the author.*

3.4.2 Informal Recreation as Co-Produced Space

This case illustrates a **multi-actor co-production process** that has gradually stabilised into a vibrant leisure-oriented informal public space beneath the elevated ramp at Shamian Island. The key stakeholders involved can be categorised into three functional groups:

(1) **Space users**, including local elderly residents and domestic or international tourists, who regularly occupy the area for rest and socialisation;
(2) **Space beneficiaries**, particularly bar owners and informal performance groups (e.g., musicians and small bands), who generate cultural and commercial value through spatial use; and
(3) **Space managers**, namely local government departments and park authorities, who adopt a facilitative yet non-intrusive regulatory stance.

The **primary spatial functions** observed in this setting include passive recreation, live music performance, and outdoor food and beverage services. Informal usage patterns typically manifest during evenings and weekends, with actors deploying **movable furniture**, such as tables, chairs, sound equipment, and improvised stages. These temporary spatial interventions occur in response to fluctuating user demand and weather conditions, showcasing a high degree of **spatial adaptability**.

Notably, the local government's regulatory approach is **permissive but observant**. Rather than dismantling or formalising the space, officials have recognised the social and economic vitality generated by informal use. In some instances, they have gone further by incorporating the area into local spatial plans—designating it as a **"high-decibel vitality zone"** that tolerates noise, foot traffic, and spontaneous gatherings.

This governance flexibility has allowed informal space production to **move beyond precarity**, achieving temporal consistency and social acceptance. It also reflects a broader shift in urban governance paradigms—from formal control to **collaborative stewardship of public space**. By enabling spontaneous, low-cost cultural activity to thrive, this case offers a model for how informality and leisure can **coexist within heritage-sensitive, high-value urban environments**, enriching both local identity and the everyday public realm (see Figure 10).

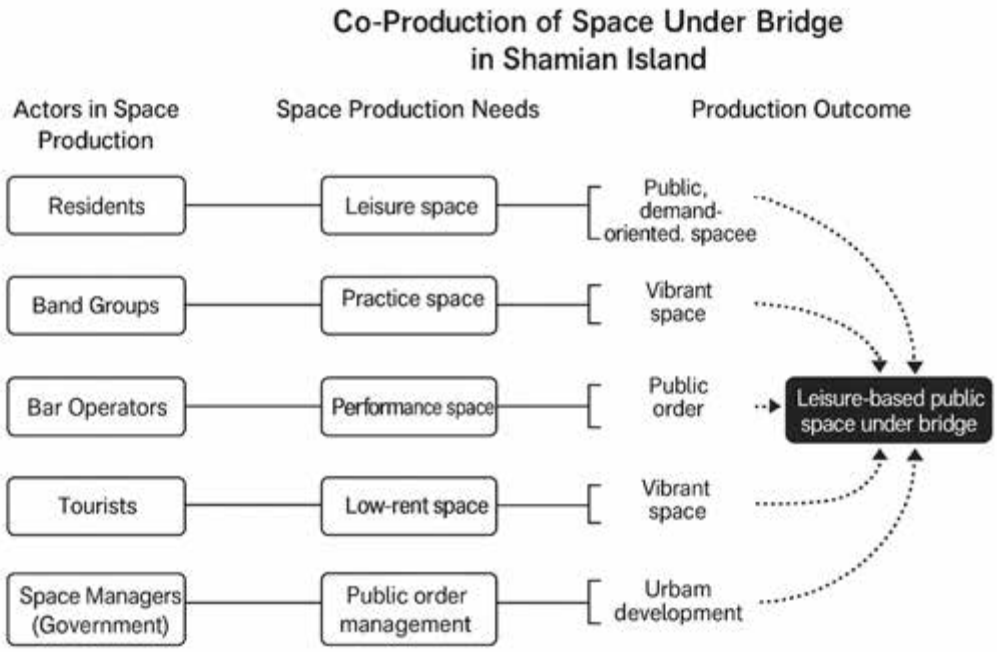

Figure 10 Characteristics of informal use beneath the ramp underpass on Shamian Island.
Diagram created by the author.

4 Insights into Informal Uses of Under-Elevated Spaces in Megacities under Stock-Oriented Urban Regeneration
4.1 Spatial Conditions that Support Overflow Functions from Adjacent Land Uses
Beyond the aforementioned three cases, this study extends the spatial analysis to several other sites across Guangzhou. Findings suggest that relatively stable, long-term informal public spaces beneath elevated highways generally exhibit the following spatial characteristics:

First, land uses on both sides of the overpass typically include **public activity-oriented functions**, with the under-elevated space absorbing overflow public uses. For example, in the Xiaozhou Village case, the art-related land uses west of the overpass—comprising art education industries and proximity to the Guangzhou Academy of

Fine Arts (within 2 km)—feed directly into the underpass art district.

Second, all cases are located within five-minute walking distances from **residential land**, whether in urban core areas or peripheral zones. This implies that continuous residential activity and strong public demand form the social basis for informal space activation, indicating the **necessity of community presence** to sustain use.

Third, suitable under-elevated spaces are generally **safe, calm, and pedestrian-friendly**. In all analysed cases, the relevant spaces are either beneath minor roads or entirely disconnected from vehicular traffic, forming semi-enclosed and stable environments. In the subtropical Lingnan climate, such covered yet ventilated spaces function similarly to traditional **arcades (骑楼)**—offering shade, rain protection, and fulfilling basic outdoor rest and gathering needs.

4.2 Formation of Stable Informal Uses Requires Multi-Stakeholder Spatial Production and Negotiation
The establishment of stable informal public spaces beneath elevated roads inevitably requires **multi-actor coordination**. Therefore, a communicable planning context becomes a prerequisite. The development process often involves four progressive stages:

Problematisation Stage:
Citizens or grassroots users must articulate spatial use needs from the bottom up, or managers must identify latent public functions of the space, initiating informal space formation.
Proposal and Resource Allocation:
Stakeholders collaboratively define the spatial product, identify beneficiaries, and clarify the nature of participation and resource inputs. Interests are negotiated, and actors are empowered to proceed.
Policy Formation Stage:
Based on site surveys and user engagement, public managers coordinate with other actors to formulate directional policies or decisions to support space production.
Maintenance Stage:
Long-term effectiveness of spatial governance must be ensured. Sustained support for spatial producers and responsiveness to evolving needs are essential to preserving stakeholder motivation and action continuity.

A relatively stable informal space emerges only when these stages are successfully completed. The formation mechanism can be summarised by four critical factors:

Top-down institutional design, where enabling policy environments are crafted by the government;
Active participation of community residents as spatial producers;
Supportive spatial production factors, such as nearby universities (e.g., the Guangzhou Academy of Fine Arts), artist communities, and vocational training demands;
Grassroots leadership and collaboration, including resident support and participation by students, artists, and vendors.

4.3 Long-Term Informal Use Relies on Stable Actor Networks
Whether initiated by institutional design, policy incentives, production conditions, or economic interests, **the formation of stable under-elevated informal public spaces requires a robust actor-network**. Key characteristics of such networks are:

Recurring spatial needs from producers, leading to the articulation of spatial use issues. For example, in the Shamian Island case, a senior citizens' band rehearses daily at a fixed time, and the audience that gathers around them further reinforces public demand for informal use.

Consistent and communicative relationships between public managers and spatial users. Effective governance depends on iterative dialogue and responsiveness across different production stages.

These factors help foster **networked co-production**, where the government, community organisations, social groups, and active users form a collaborative ecosystem for public space use.

5 Conclusion

In the context of China's rapid urbanisation, elevated highways have served as a key spatial instrument to support the functional expansion of megacities. However, the majority of under-elevated spaces remain **inactive and underutilised**. With increasing pressure for spatial intensification and rising public expectations for high-quality urban spaces, the potential of underpass spaces for adaptive reuse is becoming more evident.

Nevertheless, current informal uses are largely **sporadic and uncoordinated**, occurring in isolated pockets. There is still a pressing need to construct **scalable and replicable models of flexible spatial governance**. Such models should allow for formal recognition, support, and guidance of grassroots-driven informal practices within the broader framework of **People-Oriented Urbanism (人民城市).**

6. Discussion

This study explored the informal utilisation of under-elevated spaces in Guangzhou through the lens of co-production theory, using three representative cases—Xiaozhou Village, Dongsha Bridge, and Shamian Island. The findings provide critical insights into how spontaneous, actor-driven uses can evolve into functionally stable public spaces. Here, we reflect on the broader theoretical and practical implications of the research.

6.1 Rethinking Informality as a Strategic Layer of Urban Public Space

Conventional urban planning tends to regard informality as a disorderly or transitional phenomenon. However, our findings suggest that in the context of spatial scarcity and rigid institutional frameworks, informal uses can fill important spatial, social, and economic gaps. The analysed cases demonstrate that informal uses under elevated infrastructure are not merely adaptive; they are co-constructed by overlapping needs, negotiations, and routines across multiple stakeholders. Such bottom-up practices can be viewed as **strategic layers** of urban functionality rather than marginal exceptions.

6.2 Co-production as a Mediating Mechanism for Space Governance

Through Actor-Network Theory (ANT), we identified that the co-production of under-elevated informal spaces involves iterative interactions among residents, artists, vendors, tourists, and public managers. This reveals that governance of urban space need not be exclusively top-down; rather, it can emerge through negotiation, adaptation, and shared responsibility. In particular, the local government's flexible management style—by tolerating or even facilitating such uses—can stabilise informal activities without formalising them entirely. This suggests an **institutional space for negotiated informality** that may be more resilient than rigid spatial interventions.

6.3 From Fragmented Practice to Typological Recognition

Despite their ad hoc origins, the three case studies exhibit recurring spatial typologies:

Creative-cultural spaces (e.g., Xiaozhou Village),
Informal vending and micro-economies (e.g., Dongsha Bridge),
Leisure-based activation (e.g., Shamian Island).

Each typology reflects not only spatial conditions (e.g., shade, access, enclosure) but also **relational configurations** among actors. Recognising these patterns offers a potential pathway to shift from fragmented interventions to **typological recognition and planning integration**. Future urban design frameworks could include under-elevated zones as experimental zones for semi-formal co-production, especially in high-density contexts.

6.4 Limitations and Further Research

This study is limited to three qualitative case studies within one metropolitan context. Although the co-production framework proved effective in interpreting spatial and social dynamics, further research could:
Extend comparative analysis to other Chinese megacities or global south contexts;
Incorporate quantitative assessments of spatial performance and user behaviour;

Explore legal and planning instruments for formal–informal hybrid governance models.

Note

[1] Informal Use:
In this paper, "informal use" refers to urban spatial activities that arise spontaneously and contingently, without explicit official planning control or formal authority intervention.

[2] Urban Residual Space :
In *The Death and Life of Great American Cities* (1961), Jane Jacobs questioned conventional urban renewal models and introduced the concept of urban residual spaces, such as "urban dead zones" and "dead corners." In this study, residual space primarily refers to linear spatial remnants generated during urban development processes that remain underutilised.

[3] Co-production:
Co-production (also referred to as "collaborative production") is a key concept proposed by economist Elinor Ostrom in the 1970s. It emphasises that citizens can play an active role in the production of public goods and services that significantly affect their lives (Albrechts, 2012). This concept is extended in this study to frame the informal use of space.

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After COVID-19: Urban Parks as Catalysts of Hope for the Common Good – The Costa Rican Case

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Abstract
Urban parks in Costa Rica, though limited in number, are widely frequented and have gained importance since the COVID-19 pandemic, with over half of visitors reporting increased use. This study investigates perceptions of metropolitan parks as spaces of well-being after the pandemic. Data were gathered in 2024 through walking interviews in the country's three largest metropolitan parks, differentiated by age groups, and analysed using thematic and geospatial methods. Findings reveal that parks are deeply valued for recreation, social interaction, and emotional support, especially among older adults and active users. However, concerns persist about safety and deteriorating infrastructure due to underfunding. The study underscores urban parks' vital role in fostering resilience, social connection, and collective well-being in post-pandemic urban life.

Keywords: post pandemic, urban parks, parks reappreciation, Costa Rica.

Introduction

During the COVID-19 pandemic, urban parks played a crucial role in supporting overall well-being and maintaining social connections, even amidst physical distancing measures (Powers, Pitas and Mowen, 2022). These green spaces offered a vital outlet for physical activity, stress relief, and safe social interaction during an unprecedented global health crisis. However, the extent to which parks can fulfil these roles effectively depends significantly on the quality of their infrastructure. Well-designed, accessible, and well-maintained facilities are essential for enhancing user experiences and encouraging frequent visitation. Moreover, diverse and inclusive infrastructure can support a wide range of recreational, social, and cultural activities, thereby meeting the varied needs of different community groups (Heckert and Bristowe, 2021).

Urban parks in Costa Rica are scarce but widely used by people of all ages. Following the COVID-19 pandemic, more than 50% of visitors to the country's main metropolitan parks reported an increase in their visitation frequency (Barrantes-Chaves, Centeno-Mora and Cruz-Zúñiga, 2024; Barrantes-Chaves, Cruz-Zúñiga and Centeno-Mora, 2024). This paper explores how their visitors perceived those places as agents of well-being, both before and after the pandemic, this is done through georeferenced walks with park's users (Evans and Jones, 2011; Barrantes-Chaves, 2025). The findings suggest that urban parks are highly valued for recreation and social interaction, particularly by older adults and individuals engaging in outdoor sports. Participants reflected on their experiences before and after COVID-19, highlighting how they have come to reappreciate these spaces. Key themes that emerged included social interaction, infrastructure, and available facilities. However, concerns were raised regarding safety and the deterioration of park infrastructure due to insufficient funding, which has negatively impacted services and amenities.

Both adults and older adults expressed their challenges and expectations for the future, emphasizing how urban parks have helped them navigate the social and emotional effects of the pandemic. These spaces have facilitated the creation of new support networks and reinforced their role as essential resources for collective well-being.

COVID-19 and Urban parks as space for hope.

Certain design features are especially important for specific groups of park users, particularly when it comes to encouraging walking and regular use. For instance, older adults often have specific needs that must be considered in park design. Key elements such as gentle slopes, shaded areas provided by tree cover, smooth and stable walking surfaces, and easy, direct access from parking lots are critical to ensuring comfort, safety, and accessibility for this demographic (Paudel *et al.*, 2023). When these features are thoughtfully incorporated, parks become more inclusive and supportive of active aging and overall public health.

Wong (2009) argues that older adults tend to use parks more intensively than other age groups, highlighting the important role these spaces play in their daily routines and overall well-being. However, accessibility remains a key factor in their usage patterns. Zhang et al. (2022) found that older adults generally prefer not to walk more than 15 minutes to reach a park, indicating that proximity is crucial in determining whether they will actually make use of these public spaces. This suggests that urban planning efforts should prioritise the equitable distribution of parks within walkable distances, particularly in neighbourhoods with a high proportion of older residents.

Internal accessibility within parks is equally essential, particularly for older adults and individuals with limited mobility. Ensuring that paths, facilities, and recreational areas are easily navigable can significantly enhance the usability and inclusiveness of these spaces. Initiatives aimed at improving accessibility often focus on upgrading infrastructure and providing services that accommodate people with disabilities, such as smooth pathways, ramps, accessible restrooms, and seating areas (Pivetta *et al.*, 2020).As a result, the emphasis on accessibility has driven continuous improvements in park design and management. These enhancements not only promote greater inclusivity but also contribute positively to public health and quality of life, especially for vulnerable populations (Santana-Santana, Peña-Alonso and Pérez-Chacón Espino, 2020). Importantly, when public spaces are designed with the needs of older adults, children, and people with limited mobility in mind, they ultimately benefit everyone. Universal design principles create environments that are safer, more comfortable, and more welcoming for all users, regardless of age or ability.

While the need for improved infrastructure in parks is undeniable—particularly to enhance accessibility and inclusivity—it's important that such developments are thoughtfully planned and not result in the overbuilding of unnecessary structures. Excessive or poorly integrated infrastructure can detract from the natural character of green spaces and reduce their appeal. In fact, research has shown that many park users, often express a strong preference for walking through natural environments such as forests and wooded areas (Matasov *et al.*, 2023), where the experience of tranquillity and contact with nature is prioritized over built features. Therefore, park design should strike a careful balance between providing essential amenities and preserving the natural landscape to support users' psychological well-being and desire for authentic outdoor experiences.

Although existing research has recognised the importance of urban parks during the COVID-19 pandemic, few studies have captured the evolving emotional, social, and functional perceptions of park users in the post-pandemic context, particularly through in-situ (Zhang and Li, 2023), qualitative, and geospatial methods in underrepresented regions like Central America. Even fewer have focused on how older adults and vulnerable groups articulate aspirations, perceived safety, and accessibility barriers, all of which are essential for inclusive urban policy and design.

In this regard, this article aims to explore how urban parks in Costa Rica have been reappreciated as essential spaces for social interaction, emotional resilience, and public well-being in the aftermath of the COVID-19 pandemic. By analysing georeferenced walking interviews conducted with adult and older adult users in the country's three main metropolitan parks, the study seeks to uncover how different age and gender groups perceive these spaces, the challenges they encounter, particularly in terms of safety and infrastructure, and the aspirations they hold for more inclusive and accessible urban environments.

Methods

Data were collected through walking interviews conducted in 2024 across Costa Rica's three largest metropolitan parks. In each location, two separate walks were undertaken—one with participants under the age of 65 and another with participants aged 65 and above. These walks were tracked using Global Positioning System (GPS) devices and synchronised with audio recordings to accurately document spatial and verbal data.

The walking interview recordings were transcribed and subsequently analysed using thematic analysis, following the methodological framework proposed by Braun and Clarke (2006). The identified themes were coding and then georeferenced using Geographic Information Systems (GIS) to spatially represent participants' experiences and perceptions within the park environments.

In addition, each participant was provided with a printed map of the respective park and a set of colour-coded stickers representing different levels of fear. Participants were asked to place these stickers on the map to indicate areas where they felt varying degrees of safety or vulnerability. This process generated a series of visual data outputs, including maps illustrating the intensity of fear and others depicting a broader spectrum of emotional responses experienced throughout the parks.

The participants were regular users of the three metropolitan parks included in the study. Recruitment was carried out through collaboration with park administrative staff and local community organisations, including organised user groups and neighbourhood associations.

Administrative officers played a crucial role in identifying frequent visitors and initiating contact with potential participants. Established community networks further supported the recruitment process by ensuring diverse representation across age groups and user experiences. Each walking interview consisted of groups ranging from five to fifteen participants. This approach allowed for the inclusion of individuals with varying degrees of familiarity and engagement with the park spaces, thereby enhancing the richness and depth of the data collected.

Results and discussion

Table 1 presents a breakdown of comments by gender (Women and Men), age (Older adults and adults) and sentiment (Positive, Neutral, Negative), categorised by thematic areas related to a park. For example, the category General Aspirations (GA) reflects desires for the park's future and potential improvements. Infrastructure (IN) refers to its physical features, while Interaction with the park mainly relates to activities taking place within it. Maintenance (M) concerns keeping the park in good condition. The Pandemic (P) category includes memories of COVID-19 and the park's role during that time. Perception of safety (PS) captures feelings related to crime and how vulnerable people feel in the park. Lastly, Perception of the environment (PE) involves the experience of moving through the park and includes elements such as vegetation, built structures, sounds, and the overall atmosphere.

Table 1. Summary of comments within the three analysed parks.

Category	Positive comments (N=282)		Neutral comments (N=558)		Negative comments (N=486)	
	Women	Men	Women	Men	Women	Men
General Aspirations (AG)						
Older Adults	2.66%	0.00%	5.26%	1.39%	1.36%	1.39%
Adults	2.66%	2.13%	4.68%	0.46%	2.73%	0.46%
Infrastructure (IN)						
Older Adults	19.15%	11.70%	9.65%	18.98%	25.45%	18.98%
Adults	2.66%	10.64%	9.06%	15.74%	15.00%	15.74%
Interaction with the Park (IP)						
Older Adults	7.98%	1.06%	15.50%	1.85%	3.64%	1.85%
Adults	7.98%	3.19%	14.33%	6.94%	4.09%	6.94%
Maintenance (M)						
Older Adults	5.85%	2.13%	2.63%	2.78%	3.64%	2.78%
Adults	0.53%	3.19%	1.17%	3.70%	5.45%	3.70%
Pandemic (P)						
Older Adults	0.53%	0.00%	7.31%	0.00%	0.91%	0.00%
Adults	2.13%	2.13%	2.92%	0.00%	0.45%	0.00%
Perception of Safety (PS)						
Older Adults	12.77%	10.64%	10.53%	30.09%	22.73%	30.09%
Adults	9.57%	18.09%	6.43%	12.50%	7.73%	12.50%
Perception of the Environment (PE)						
Older Adults	19.68%	15.96%	5.26%	3.70%	3.64%	3.70%
Adults	5.85%	19.15%	5.26%	1.85%	3.18%	1.85%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

General Aspirations

Within this category, women contributed a higher proportion of positive and neutral comments than men. The theme centres on aspirations and visions for the future of the park, including proposed interventions aimed at improving its attractiveness and functionality. One female participant, for instance, expressed a desire to repurpose underutilised areas, suggesting their transformation through aesthetic enhancements:

"If a space like this is not going to be used, gardens can be created — something with greater visual beauty."

This perspective invites broader reflection on the adaptive potential of public spaces and the importance of responsive design in addressing the changing needs of communities. It also highlights the need to consider the interplay between aesthetic, recreational, and social dimensions in urban planning. The proposal to enhance visual appeal through the creation of gardens not only responds to concerns about underuse but also underscores the role of beauty and environmental quality in shaping public experience and promoting well-being. In this regard, it is crucial to incorporate infrastructure that is adaptable to diverse user needs, along with improved safety measures — including the reduction of concealed or poorly visible areas and the provision of comprehensive facilities with integrated support services. (Zhang et al., 2022).

Infrastructure and maintenance

Infrastructure was one of the most frequently discussed topics, generating both positive and negative feedback. Within this category, older women shared more positive comments than any other demographic group. In contrast, adult women under 65 offered fewer positive remarks compared to men in the same age range.

A recurring complaint focused on one of the free-entry parks (La Sabana), where users must pay to use the toilets while parking remains free. One adult female participant remarked:

"The toilet over there next to La Sabana charges a fee, and it makes much more sense to charge for parking than for the toilet, as using the toilet is a physiological necessity — not everyone will have the money to pay for it."

Charging for toilet access can disproportionately affect vulnerable populations — such as low-income individuals and children — who may not be able to afford the fee. It also reflects urban policy choices that appear to prioritize car users over pedestrians and public health.

Another frequent concern involved the poor condition of pavements and footpaths. One older male participant commented on this issue during a visit to La Paz Park in August 2024:

"These pavements are a disaster. You should see how people fall and trip. They had done just some patchwork repairs..."

This highlights ongoing issues with accessibility and safety — particularly for older adults, who have become some of the most frequent park visitors since the pandemic (Barrantes-Chaves, Cruz-Zúñiga and Centeno-Mora, 2024). For many in this group, the park serves as an important space for socialising and maintaining physical and mental well-being. However, damaged or poorly maintained walkways can pose a serious risk of falls and injuries, undermining the park's role as a safe and welcoming environment. Addressing these issues is essential to ensure the space remains inclusive and secure for all users, especially older adults.

Conversely, well-designed park pathways can significantly encourage physical activity among older adults. As one older male participant observed during a visit to La Sabana Park in September 2024:

"Very nice for people who ride bicycles or who want to come and run among the trees."

This positive remark underscores the value of well-maintained infrastructure in promoting active lifestyles and meaningful contact with nature. His appreciation suggests that the park supports inclusive recreational activities — such as cycling and running — within a natural setting that enhances the overall experience.

Regarding maintenance, older women tend to express more positive comments compared to other age groups. In contrast, women under 65 are more likely to offer negative feedback than other participant groups. This difference may reflect varying expectations or experiences with park upkeep across age demographics.

For example, one older female participant praised recent improvements, saying:

"They installed that over there — that basketball court was just newly built, very nice. That one as well. Look at the condition of this soccer field. Everything is lovely. Over there, look — the maintenance is excellent. Just look at the grass."

Her remarks highlight an appreciation for visible efforts to maintain and upgrade park facilities. This positive feedback suggests that good maintenance resonates strongly with some visitors, particularly older women, who may value well-kept spaces for recreation and socialising. Research has highlighted the disproportionate impact of the pandemic on older adults; however, there remains a lack of public policies that promote inclusive design and the development of age-friendly cities (Buffel et al.,2023).

Interaction with the Park and Perception of the environment

In terms of social interaction, women—both under and over the age of 65—tended to express more positive views about the park as a space for connection and shared experiences than their male counterparts. One adult woman in La Sabana described:

"These are free, accessible entertainment spaces where you do not have to pay an entry fee or do a lot to enjoy yourself. You can even bring your own food. You can have a good time — even if there are concerts, you can listen from outside if your group is not going in. There is plenty to do: play sports, eat, watch, talk."

She highlights how these parks are intentionally inclusive, offering a welcoming environment for people of all socioeconomic backgrounds. She emphasises their appeal as spaces for casual, low-pressure recreation, where people can participate in communal activities or simply enjoy the atmosphere—even without engaging directly in formal events like concerts. This perspective underscores the importance of informal, spontaneous social interactions, especially for individuals or families with limited financial resources.

Men also expressed positive views about the parks, particularly in relation to their role as communal gathering spaces. One older male participant at El Este Park remarked:

"We celebrate birthdays and weddings here..."

This comment highlights the park's function as a vital and inclusive setting for family and community celebrations. Figures 1 and 2 illustrate various views of the park, including the designated area used for weddings and other social events. The images reflect a forested and tranquil environment conducive to relaxation and connection. For older adults in particular, such accessible public spaces are essential for sustaining social bonds and commemorating significant life milestones. These parks thus operate not only as recreational environments but also as meaningful venues for collective memory, identity, and intergenerational engagement.

Figure 1 and **2**. Views from El Este park.

Another significant aspect of public space design is the incorporation of natural elements—such as water—which can enhance both social interaction and emotional well-being. In this context, an older female participant reflected during the walking interview in El Este Park in July 2024:

"I love it, the river sounds so beautiful."

This comment illustrates the profound impact of sensory experiences in public spaces. Elements such as the sound of flowing water, the presence of greenery, and an overall sense of tranquillity contribute to feelings of peace, joy, and connectedness to the natural environment. For many older adults, these features offer a soothing retreat from urban stressors and play a vital role in promoting psychological well-being. Such observations suggest that aesthetic and sensory dimensions can be just as important as physical infrastructure in shaping meaningful and enjoyable experiences in public parks. This supports existing research indicating that natural settings may, in some cases, hold greater significance than built amenities (Matasov *et al.*, 2023).

However, in parks where lakes form a central part of the landscape, user perspectives are more divided. While some individuals value these features as untouched natural spaces, others express a desire for them to serve a

more recreational purpose. One older male participant, speaking about the lake in La Paz Park, during the walking interview in August 2024, stated:

"It's nice, but what's missing is recreation — recreational activities, little boats or something like that."

His response reflects an appreciation for the lake's aesthetic qualities while simultaneously identifying a lack of opportunities for active engagement. The suggestion to incorporate amenities such as small boats indicates a desire for age-appropriate, interactive features that move beyond passive enjoyment. This underscores the importance of recreational infrastructure that supports light physical activity, social participation, and meaningful interaction — all of which are crucial to promoting healthy ageing and fostering inclusive community environments. Figures 3 and 4 provide visual representations of the lakes referenced in his comments. As depicted, there is a noticeable absence of leisure-oriented activities surrounding these water bodies. However, it is also important to acknowledge that environmental factors—such as water contamination—may limit the feasibility of direct human interaction with natural features. In this regard, planning policies that incorporate community participation are crucial for guiding future administrative decisions about the park. For example, decisions concerning the management of the lakes could lead to public dissatisfaction if not properly addressed, as a lack of community engagement has been shown to negatively impact park usage (Kyriakidis et al.,2023).

Figure 3 and **4**. Lakes from La Paz Park.

Taken together, these insights suggest that successful public spaces for older adults should strike a balance between calm, sensory-rich environments and opportunities for gentle recreation and interpersonal connection. Designing spaces that support both contemplation and active engagement may better meet the diverse needs of older populations and foster more inclusive, age-friendly public environments.

Perceived Safety

Fear of crime remains a persistent concern among both men and women. Negative perceptions regarding safety were more frequently expressed than positive ones, particularly in parks with free public access. For instance, an older man in La Paz stated:

"Well, it's just that I don't come at night. If I did, it would feel really unsafe. Of course, at night it becomes dangerous — after 7 p.m., this place is not safe."

This comment illustrates a perceived temporal shift in the safety of public spaces, where environments are considered acceptable during daylight hours but become threatening after dark. The interviewee draws a clear boundary: the space is usable by day but effectively off-limits at night. This perception underscores the significance of lighting, surveillance, and active community presence in shaping the experience of public spaces across different times of day. Figures 5 and 6 illustrate participants' perceptions of safety in La Paz Park during daytime (Figure 5) and nighttime hours (Figure 6). The comparison clearly indicates a heightened fear of crime

after dark, particularly in areas located farther from the main streets, where visibility and public presence are reduced.

Figure 5. Map illustrating the intensity of perceived fear during day as reported by users during walks-along in La Paz Park, conducted in August 2024.

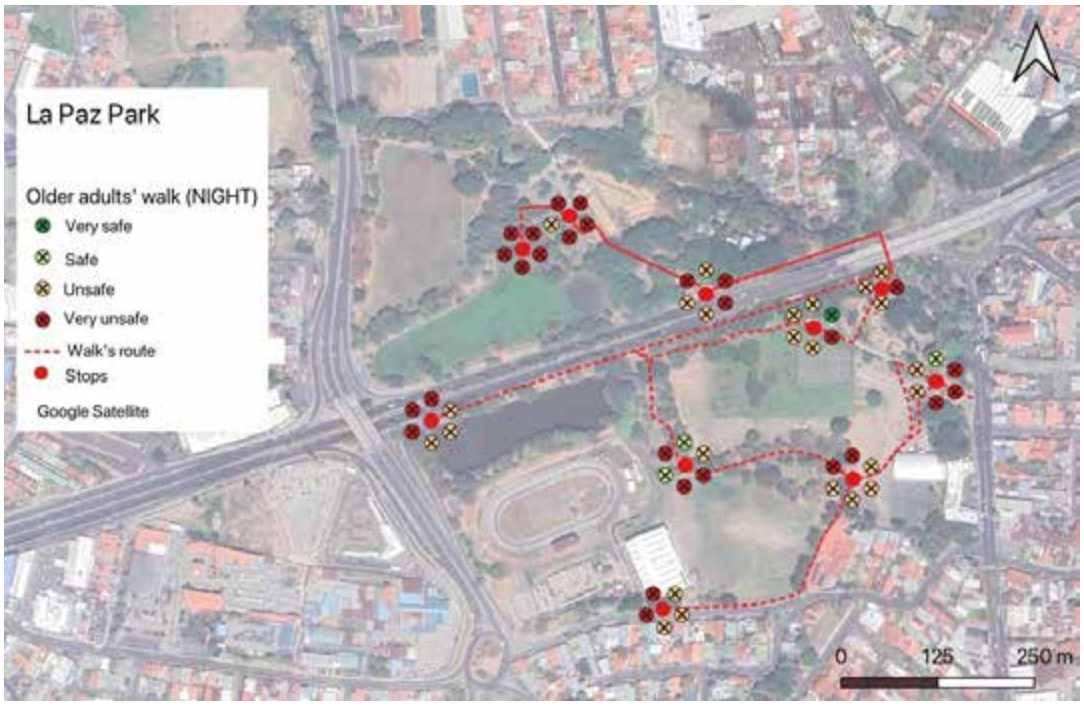

Figure 6. Map illustrating the intensity of perceived fear during night as reported by users during walks-along in La Paz Park, conducted in August 2024.

Despite concerns related to safety during nighttime hours, certain elements were identified as mitigating these fears. During a walking interview conducted in La Sabana Park in September 2024, an adult female participant observed:

"Just the fact that you see the police nearby already makes you feel a bit safer. Also, there are always lots of children around, which makes the environment feel more friendly — and because it's close to the street."

This reflection suggests that visible indicators of oversight—such as police presence—can reduce anxiety and enhance the perceived security of a space. The presence of children is highlighted as a further reassuring factor, symbolising normalcy, vitality, and a family-friendly environment. Such humanising features contribute to an emotional sense of safety beyond mere physical protection. The reference to proximity to the street introduces the idea that openness and integration into the urban fabric—rather than isolation or enclosure—foster greater comfort and perceived accessibility. In this regard, prior research within the Costa Rican context has demonstrated that the normalisation of gating contributes to a feedback loop that reinforces fear of crime, thereby intensifying perceptions of insecurity in the surrounding areas (Barrantes-Chaves, 2024).

Similarly, another woman interviewed in El Este Park expressed:

"I feel that it feels safe because... well, first of all, there are people who work here, and also there are structures around, so you kind of feel surrounded by things that give you the sense that if something were to happen, there would be support."

Here, safety is associated with the visible presence of workers and structural features within the park. These individuals may function as informal stewards or guardians, whose presence implies oversight and the potential for assistance if needed. Moreover, the respondent points to the psychological impact of the built environment: being "surrounded by things" conveys a sense of enclosure, familiarity, and orientation. Such spatial features enhance perceived safety by reducing feelings of exposure and isolation, instead offering cues of support and surveillance.

Overall, these findings underline the critical role of intentional design, visible care, and social presence in cultivating a sense of safety in public spaces. The physical and social composition of these environments significantly shapes users' emotional and psychological experiences, particularly in relation to fear, comfort, and belonging.

Pandemic Impacts on Public Space Use

During the COVID-19 pandemic in Costa Rica, many public parks were either entirely closed or only partially accessible due to lockdown restrictions. For families in vulnerable communities, these parks functioned as essential green spaces—effectively their only access to nature—yet became inaccessible under public health measures. Reflecting on this experience, an older male participant at La Paz Park recounted:

"Well, I used to come to the park during the pandemic, and the police made me leave. I told them, 'Look, there's no one around — I need to breathe, get some fresh air.' They said to me, 'You cannot, do it around the neighbourhood instead,' and I responded, 'No, because I have a broken ankle and the pavement and asphalt hurt me too much. I need to do it on the grass.'"

This testimony reveals the tensions between pandemic-era public health enforcement and the specific needs of individuals, particularly those with mobility issues or chronic health conditions. The speaker's account underscores how uniform, top-down regulations—though well-intentioned—can unintentionally marginalise vulnerable populations. The reference to the physical pain caused by hard surfaces highlights the role of design and materiality in shaping accessibility. Parks, typically associated with health, recovery, and inclusion, were paradoxically rendered off-limits during a period when their therapeutic value may have been most urgently needed. This example emphasises the importance of empathy and flexibility in urban governance, particularly

in times of crisis.

However, the pandemic also led to some lasting, positive behavioural shifts. Two women interviewed in separate parks offered reflections on changes in public space use:

A female adult in La Sabana noted:

"What I think is that during the pandemic people had more time to dedicate to physical activity, and after the pandemic they kept that routine. So, there are more people exercising now than before the pandemic."

Similarly, a female adult in El Este observed a dramatic increase in visitation:

"Definitely. Much more. But, I mean, what can I say? About 300% more. After the pandemic."

These comments point to a durable transformation in the way public spaces are valued and used. The first highlights the role of the pandemic in catalysing new health-related behaviours, particularly physical exercise, which in many cases have persisted beyond the period of lockdown. This supports broader arguments about the importance of habit formation and access to supportive environments for long-term public health outcomes. The second, with its emphatic estimation of a "300%" increase in visitation, reflects a renewed public appreciation for parks as vital spaces of recreation, wellbeing, and social interaction, this aligns with previous research indicating that, following the COVID-19 pandemic, there has been an increased appreciation of urban parks. (Soares and Brasil, 2020; Wu et al., 2023).

Taken together, these narratives illustrate how the pandemic redefined public parks—not merely as sites of leisure but as critical urban infrastructure supporting physical, mental, and emotional resilience. The growing reliance on such spaces has, in turn, generated increased expectations that they remain open, inclusive, and well-maintained in order to meet heightened and sustained public demand.

Conclusions

The findings from this study highlight the multifaceted roles that urban parks play in the lives of diverse user groups, particularly older adults and women. Participants' aspirations for the future of these spaces underscore a desire for more responsive and inclusive urban design — one that balances aesthetic enhancements with functional utility. The recurring call to transform underused areas into visually appealing gardens, for instance, reflects broader public interest in making parks both more beautiful and more inviting. These visions suggest that public spaces should not be static but adaptive, evolving with community needs and expectations, and incorporating both sensory experiences and recreational functions.

Infrastructure and maintenance emerged as both enablers and barriers to inclusive park usage. While older women tended to express greater satisfaction with maintenance efforts, inconsistencies in infrastructure — particularly the condition of walkways and the policy of charging for toilet access — reveal underlying inequities. These issues disproportionately affect vulnerable users, such as older adults, people with mobility challenges, and low-income visitors. Conversely, positive feedback regarding well-maintained amenities, such as cycling paths and sports courts, suggests that quality infrastructure can significantly enhance engagement and well-being. The differential experiences across age and gender groups further illustrate how park infrastructure and maintenance are not neutral but have socially differentiated impacts that must be considered in future planning.

Finally, the COVID-19 pandemic reshaped the public's relationship with green spaces, illuminating both their essential function and the limitations of current governance frameworks. While restrictions rendered parks inaccessible for many, the crisis also fostered long-term behavioural shifts, including increased rates of exercise and park visitation. These changes reaffirm the vital status of parks as everyday public infrastructure supporting physical, mental, and social resilience. As expectations for access, safety, and quality rise, it is imperative for

urban policy to integrate inclusive, health-promoting, and flexible design strategies that recognise public spaces not merely as recreational luxuries, but as foundational components of equitable, age-friendly cities.

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Visual Perception of Universal Design Interventions for World Heritage Sites: Case of Istanbul Historic Peninsula

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Abstract
Universal Design is defined with seven principles for enhancement of inclusivity for various fields of design. Some enhancements are especially aimed to be visibly highly noticeable, so they can be used intuitively, self-directing the audience with added visibility and attention. However, when it comes to urban heritage sites visual unity and coherence brings heritage value. Therefore, potentially the addition of highly visible indicators might be contradicting with the idea of the nature of interventions. Core tension of this study is the conflicting nature between inclusive urban design applications and conservation policies for World Heritage Sites where minimum intervention aimed. In-depth interviews with users of public spaces in Historic Peninsula Istanbul conducted, results will be discussed to reach parameters for universal design tools for heritage sites.

Keywords: Inclusivity, Public Space, World Heritage Sites, Accessibility, Universal Design

Introduction

Universal Design refers to designing environments and services to be usable by all people to the greatest extent possible. In the context of World Heritage Sites (WHS) protected under UNESCO's World Heritage Convention applying UD principles means making historical urban environments inclusive for people with disabilities, the elderly, and other disadvantaged groups. Yet this must be done sensitively so as not to compromise heritage integrity or authenticity (WHC, 2025) defined as Outstanding Universal Value. The Historic Peninsula of Istanbul, consists of four districts that covered the WHS (Topkapı Archaeological Park, Süleymaniye District, Zeyrek District, and City Walls) selected as the case study area since the sites are both home for millions of residents plus millions of tourists visiting every year. Historic core with its narrow-cobbled streets and dense tourism make accessibility a challenging question itself as well as universal design. "Should demands for access for all be ignored to satisfy calls for heritage conservation, or vice versa?" is the core question and efforts for new approaches recognise that both goals may coexist (McClelland, 2022).

Scope and Aim

This paper studies how universal design principles can be applied in urban design, management and planning for World Heritage sites to enhance inclusivity without losing the heritage integrity. Istanbul's Historic Peninsula selected as a case study area and the study aims to find out the visual perception of inclusivity interventions in physical space and how public spaces in historic urban districts can be modified with respect to the parameters that the study will explore. The study investigates the research question of Is it possible and if so how it is possible to integrate inclusive design to urban heritage sites especially World heritage sites so that the outstanding universal value would not be comprimised? Literature review starts with bibliometric analysis with searching keywords world heritage sites and inclusive design in both Scopus and Web of Sciece platforms. The sources found are briefly referd part of the literature review and the methodology is conducted in accordance with the priliminary research. Methodology of the study is consisting of two parts where methodwise extensive and intensive research approaches for social sciences reseach by Sayer (2010) is adopted and withing that procedings paper the intensive research part is conducted and the first part resullts are given place. In-depth interviews are conducted with a small group of participants as the intensive research where the extensive research approach is planned as the second part of the further studies as a more integrative and comprehensive approach. Core

argument is shaping around the fact that with universal design it is possible designing environments usable by all people, for people with disabilities, the elderly, families with children and so on while respecting historic character. Special attention is given to visual perception tools such as interpretive signage, tactile maps, guided transitions, and multi-sensory wayfinding, discussing how they can be adapted in heritage contexts. After the in-depth interview is decoded and analyed the main themes will be listed to construct the parameters for inclusive design in heritage areas. Historic urban areas such as the zones mentioned part of Istanbul's Historic Peninsula are complex urban settings to bring together public and stakeholder engagement together for public good and also another question of ethics of the subject embedded at the core of the world heritage as the words meanings trying transfer the messege of the site is not just a property of a country or a specific city yet they belong to all human-kind; even the ones who are not born yet.

Focusing on the core conflicts mentioned above study aims to find how to enhance the visual perception of the inclusive design indicators for a public space with an urban heritage value; especially for the World Heritage Sites without causing disturbance on the value of the site?". While maintaining the main emphasis on universal design principles, how can site-specific urban design solutions can apply and how they will be perceived by the users of public space is the scope of this research. After the case study finally the results and conclusion aim to discuss and find out the possible parameters for universal design tools specifically of heritage sites.

Literature Review

Urban heritage conservation and accessibility are traditionally seen as separate goals, but growing consensus questions otherwise as mentioned. Universal design extends beyond basic accessibility standards; it is an inclusive philosophy is changing the heritege preservation perspectives as well. For 2030 Unesco and WHC is determining strategices for cultural inclusion as well as sustainability and accessibility. Capacity building is another important part highligthed under the inclusivity framework for heritage conservation in real life practices (UNESCO WHC, 2025).

Importantly, UD is distinguished from merely meeting minimum accessibility codes. While accessibility often focuses on enabling people with disabilities to use a place (usually via specialized features like ramps or lifts), UD assumes the primary design solution accommodates everyone. In other words, where accessibility might add a separate solution, The inclusive design approach means that installations (e.g. elevator, ramp, signage) benefit not only disabled persons but all users, thus investing in universal access yields broad social and economic benefits (Darcy, 2006).

Applying UD in heritage sites raises concerns about preserving authenticity and integrity. International charters that heritage places should retain their historical fabric, which can conflict with modern interventions. However, recent thinking suggests that inclusion is part of sustainability and continuity of heritage. UNESCO and ICOMOS support integrating disabled access into cultural heritage as part of living heritage preservation. For example, UNESCO's "Making Culture Accessible" initiative notes that cultural heritage sites should be experienced by all and that existing infrastructure should be adapted for both disabled and non-disabled. (UNESCO WHC, 2025) A Norwegian government report on heritage and universal design likewise asserts that everyone "expects to be able to experience monuments and sites in an equal manner" and encourages local solutions that balance access with conservation (Norvegian Ministry of Environment et al, 2010) This affirming with thoughtful design, inclusivity can be built into heritage environments without undermining their values.

On the other-hand the application itself is also a challenge even if the aim is constituting this basis of awareness of inclusive design. Urban heritage areas present specific challenges: they often have uneven terrain, narrow streets, cobblestones, stairs, and tightly spaced buildings. Diken and Onur (2022) observe that streets and public spaces in historic city sites seldom incorporate UD principles due to "topographic problems and inadequacies in existing traditional areas" Integrated approaches – such as pedestrianizing streets, improving pavements, and designing public furniture accessibly – are recognized as part of sustainable urban heritage management.

Heritage sites are mostly sites that are unfamiliar to many visitors being there the fisth time in their lives. Therfore wayfinding is one of the key concepts of visual perseption related to space. Visual perception tools such as signage, maps, digital media guide visitors through complex historic environments. Adapting these tools universally means considering diverse sensory and cognitive needs.

Traditional signage at heritage sites must balance readability with aesthetics. To serve all visitors, interpretive signs should use high-contrast, large fonts on plain backgrounds, avoiding visual clutter. Importantly, signs can include tactile elements and Braille. Multisensory tools are other important concept of visual perseption of the inclusivity tools as the would be integrated to the actual physical site. Multisensory features do not compromise heritage imagery; rather, they enrich engagement. A heritage site could pilot such an accessible sign in a courtyard or entrance area to enhance inclusivity. Even digital displays (e.g. touchscreen kiosks) can follow principles of universal design as they should have audio output, haptic feedback, and simple interfaces compliant with universal design standards.

As mentioned above orientation in a heritage district can be challenging due to irregular layouts. At this point the Tactile (3D) surfaces or maps placed at key nodes can visually impaired visitors. These maps generally use raised contours and textures for buildings and terrain, often accompanied by Braille labels. They must be located at accessible height and located at logical transitions (e.g. station exits, major squares). For universal design, the same map should be usable by all: e.g., a map with clear pictograms and text can serve general visitors, while the raised features serve visually impaired users as referring to Equality principle of universal design.

İnalhan and Ergeneoğlu (2010) define disabled customer's market is an important niche market for the tourism industry. "A Disabled person's willingness to travel may vary according to their hearing, speaking, seeing, or orthopedic disabilities. Therefore, people's disabilities should be considered when designing indoor" (Kahraman, 2019, p.5). In a historic site, moving from one space to another (e.g. from street to building interior, or between elevations) can be disorienting if not handled well. Universal design advocates "same route" access, meaning everyone should follow the same circulation path. For example, a grand museum entrance should have a ramp integrated alongside steps, rather than a hidden side entrance. At Hagia Sophia or Topkapı Palace, this could mean designing unobtrusive ramps at entrances so that wheelchair users and those with strollers enter through the main gate. Similarly, textured paving or gentle level changes can signal transitions between public squares and building forecourts. "All users follow the same routes through the site" and that primary entrances should have no step (National Park Service, 2025). Lighting and subtle wayfinding markers (e.g. distinct floor patterns) can guide visitors smoothly without altering historic thresholds.

Methodology and Case Study

As the study uses a qualitative review of relevant literature, policy documents, and case reports, supplemented by illustrative examples from Istanbul's Historic Peninsula; both white literature and grey literature; to construct the foundation of the in-depth interview questions the visual perseption, world heritage sites and inclusive design are taken as key themes. Key sources include academic studies on accessibility, UNESCO guidelines and decisions, engineering and design reports on the Istanbul Historic Peninsula. The discussion is organised thematically: first reviewing universal design concepts in heritage contexts, then examining visual perception and wayfinding adaptations, and finally analyzing Istanbul-specific challenges and practices. This approach highlights both theoretical guidance and concrete urban design interventions.

Figure 1 Istanbul Historic Peninsula World Heritage Site Zones. (WHC, UNESCO, 2025 retrieved from https://whc.unesco.org/en/list/356/maps/)

Istanbul's Historic Peninsula faces typical constraints of a layered heritage environment: ancient Byzantine walls, Ottoman mosques and palaces, mixed-use bazaars, and a labyrinthine street network. These physical conditions, plus heavy tourism, create both barriers and catalysts for universal design. Over recent decades, local planners have pursued projects that implicitly apply universal design and inclusivity principles, starting with integration of public transportation, pedestrianisation, enhanced wayfinding systems and maybe last but not the least important one as the social inclusion indicators.

Public transportation is one of the major determinents of accessibility and inclusivity as the ramps and related assistive layout is missing in most of the public transit stops and stations (Evcil, 2009). This might bring the thought of most people with disability do not feel welcomed or do not feel they have the chance to join city life and leave their homes. Pedestrianisation is another aspect of accessibility studies, on contrasting levels; with groups supporting the idea or opposing to this particularly. Between years 2005–2012 Istanbul undertook major pedestrianization in the Peninsula. Streets were repaved with smooth granite, obstacles removed, and service corridors As a result, bollards, curbs and barriers that once hindered wheelchairs were gradually. Many people opposed to the projects as the retail sectors are mostly negatively effected by those kind of physical interventions (Öztaş and Akı, 2014).

Results and Discussion

The study adopts two partile method combinin extensive and intensive resarch methods as Sayer (2010) defines. This part of the study focusing on the background of the subject and tries to understand the mechanisms and

perception, awareness and social structure behind inclusivity on site. As a part of this intensive approach the Google Earth street view tool is used for the digital documentation of the physical structure and its change through time. For example a related image is given at Hagia Sophia adjacent street between 2023-2024 there had been an implementation on the pavements with high contrast level yellow pavement lines paninted on the street to draw extra attention to the level differences on the road and pedestrianised area (Please see figure 2 and figure 3).

Indepth interviews showed that 5 particepents all mentioned the tactile pavements and yellow lines used for visual impairments yet did not notice the info desks or other supportive indicators. The emphasis is mostly on the visually impaired and the wheelchaire users when disabilies are concerned. Neuro-diversity is totally neglected none of the participants know the topics and its relationship to the inclusivity or universal design.

Figure 2 Additional Attention Yellow Path is added at 2023 and 2024 in Sultanahmet District (Photo produced by Buse Ceren Ener using the digital source Google Earth)

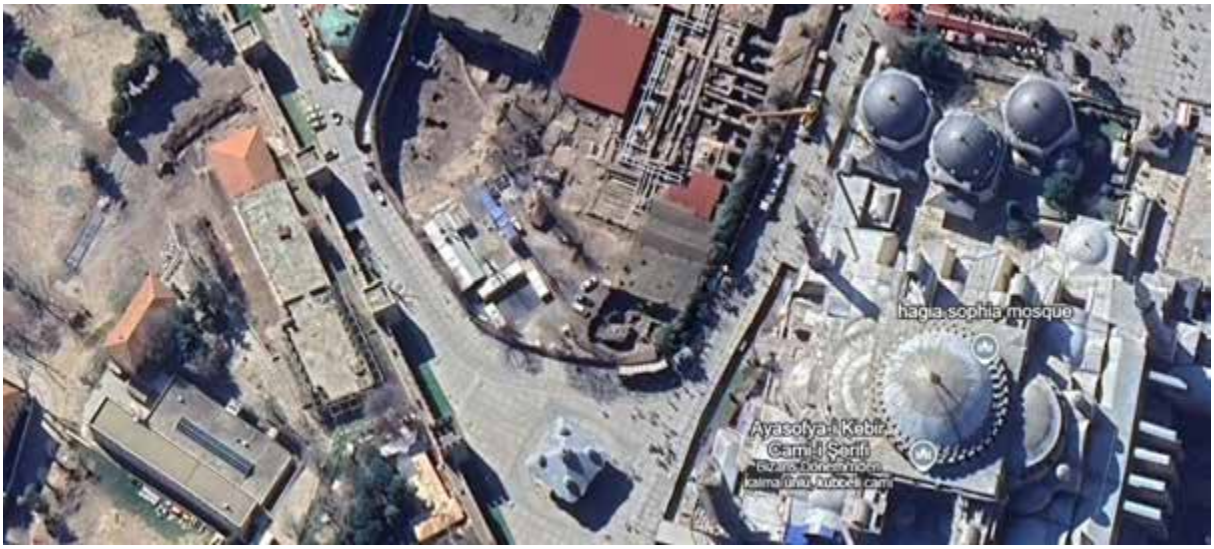

Figure 3 Additional Attention Yellow Path is added at shown near Hagia Sophia, years 2023 and 2024 in Sultanahmet District (Photo produced by Buse Ceren Ener using the digital source of Google Earth)

Conclusion

This study can be taken as a priliminary study, a first step towards an extended further researches on the site. Its importance lies at the future attributes where future social inclusion and capasity building is on the agenda. To sum up all this, it should be underlined again that UNESCO World Heritage status imposes strict conservation regulations that often require heritage authority approval for any physical interventions, including accessibility features, to ensure they are reversible and visually unobtrusive. As this applies all world heritage sites the case study area Istanbul is particularly difficult to be approached as the metropole has over 15 million residents and numerous visitors. Institutional coordination is another major challenge, as overlapping responsibilities between municipal, district, and national agencies can delay universal design (UD) projects. Should also adress the main limitation is that since İstanbul is a very complex case to study it is difficult to take visual perception as an indepentent attribute.

Socially and economically, universal design presents clear benefits: it enhances tourism by expanding accessibility for international visitors while also improving quality of life for residents, including the elderly and pregnant women. Evidence from other heritage cities shows that accessible environments contribute to increased tourism satisfaction, dwell time, and spending in heritage zones.

Universal design offers a path to greater inclusivity at heritage sites like Istanbul's Historic Peninsula while upholding conservation goals. The principles of UD – equitable use, perceptible information, tolerance for error, etc. – can be applied in urban heritage planning to create spaces and tools that welcome all visitors. Key strategies include designing shared accessible routes, deploying multisensory interpretive media, and carefully integrating access features into historic contexts (UNESCo, 2025). Although challenges exist (physical constraints, regulatory complexity, institutional coordination), the opportunities are significant: enhanced visitor experience, compliance with human rights frameworks, and alignment with sustainable development goals. Future efforts should focus on comprehensive management plans that explicitly incorporate universal design, continued stakeholder engagement, and pilot projects showcasing innovative wayfinding technologies. By doing so, Istanbul can become a model for how World Heritage Cities. "Disability ought to be regarded as an instance of diversity, not as a limitation" says Falt and Manocha, (2019) addressing India's perspective as many other countries that now opening inclusivity universal design and heritage horizons, for further studies and geographies.

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Track 18

TOURISM

Mass Tourism in Malia: Towards a Decolonial Model for the Lassithi Plateau

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ABSTRACT
This paper explores how mass tourism operates as a neo-colonial mechanism in the Malia region of Crete, and whether degrowth can serve as a decolonial alternative for the Lassithi Plateau tourism development, located 20km away. Combining desk and action research, the study investigates how tourism-driven urbanisation, cultural commodification, and extractive infrastructure perpetuate economic and spatial inequalities. In contrast, the Lassithi Plateau showcases that cultural background, agricultural activity, and community agency offer fertile ground for a degrowth-based tourism model. Based on local findings and international case studies, this research examines whether a community-led framework could comprise a viable alternative for future tourism development. Despite structural challenges, degrowth tourism emerges as a strategy for restoring cultural identity, reclaiming autonomy, and resisting capitalist extraction in tourism-dependent regions.

KEYWORDS: Mass tourism, Neo-Colonial, Degrowth, Community, Cultural Landscape

INTRODUCTION

Tourism has been a vital part of the Greek economy since 1930, shaping its cultural identity and contributing to economic development (Karvounis, 2021). Post-war years saw significant growth in the tourism domain with US investments through the Marshall program[1] , establishing a tourism industry aligned with Western Standards. The GNTO[2] organisation in 1951 marked the beginning of a systematic development contributing to economic reform and modernisation of the state (Tournikiotis and Monemvasitou, 2012).

The inflow of foreign currency significantly influenced the Greek economy's exchange rate and contributed to its stability (Karvounis, 2021). This affected the cultural interpretation of Greece, aiming to attract high-income tourists. Ancient Greek civilisation and local traditions were selectively integrated with the expectations of modern living standards, forming a "new cultural identity" (Tournikiotis and Monemvasitou, 2012). Moreover, constructing a "touristic brand", commodifying on landscape and planetary commons, the sun and the sea, exposed the Greek periphery, particularly the islands and areas with valuable natural beauty, to tourism development (Tournikiotis and Monemvasitou, 2012). The gradual tourism-led urbanisation transformed the landscape, especially from the 1970s, when mass tourism emerged, until its exaggeration in the 1990s (Andriotis, 2001).

Today, the legacy of early tourism strategies is still visible in Crete, where tourism remains a dominant economic force. The region of Malia has been exposed to tourism investments, intensive urbanisation of coastal areas, appropriation and privatisation of the landscape, and the commodification of culture. Traditionally based on agriculture and fishing, its local economy shifted to the tertiary sector, and mass tourism significantly shaped its cultural landscape (Andriotis, 2001).

In contrast, the Lassithi Plateau, 20 km south of Malia, remains an untouched area of natural beauty, with the economy still rooted in agriculture. Mass tourism in the late 1970s prompted internal migration from the Plateau to emerging tourist hubs along the island's northern coast, particularly in Malia (Terkenli and Bellas, 2007), impacting its cultural landscape. The Plateau, formerly known for its traditional windmills and agricultural life, is experiencing socioeconomic degradation and demographic reduction. The gap between the two regions is widening due to the coastal zone development, underscoring the need for sustainable and balanced growth in alternative tourist models.

1 The US provided economic aid to Western Europe post-war, with Greece being notably influenced by Truman's 1947 governance, bringing the country under western influence (Beckmann, 2012).
2 Greece's National Tourism Organisation.

This research aims to investigate how mass tourism functions as a neo-colonial mechanism in the case of Malia and whether Degrowth could operate as a Decolonial practice, suggesting an alternative tourism model for the case of the Lassithi Plateau. The research questions to frame are the following.

1. How does mass tourism operate as a neo-colonial mechanism, and how does it affect the spatial and cultural transformation in the Malia region?
2. What are the further implications for the cultural landscape in the Lassithi Plateau?
3. Could a tourism model based on degrowth principles offer a decolonial alternative for the Lassithi Plateau's future tourism development?

METHODOLOGY

This research employs a qualitative and interpretive methodology that combines desk research, field-based action research, and comparative case study analysis. The desk research component involved an extensive review of academic literature, statistical reports, and policy documents related to tourism development in Greece, spatial planning in Crete, and theoretical frameworks of neocolonialism and degrowth. This established the historical and conceptual context of the study and informed the critical reading of institutional strategies and tourism narratives.

The choice of Malia's case, based primarily on desk research, was necessary to understand how mass tourism dynamics impacted the Lassithi Plateau's socio-economic structure and cultural landscape over the years.

The action research occurred in the Lassithi Plateau through a two-week field visit organised within the programs of MaULP[3] and IMSDP[4] of KU Leuven. During the fieldwork, our team, comprised of 13 students, young researchers, and two supervisors, conducted semi-structured interviews, unofficial conversations, and ethnographic observation, participating in local events. Residents, farmers, craftspeople, and representatives of community associations and local authorities became part of the research. The time was limited, but the findings were valuable. The interviews were not formally coded but were treated as narrative and contextual material. They contributed to comprehending locals' perspectives and interpretations of the Plateau's cultural landscape, its transformation, the historical importance of the windmills, and their vision or concerns about tourism and development. Through a careful reading process highlighting repeated concepts, values, and tensions, these local narratives were thematically interpreted, providing findings about locals' future tourism vision and windmills' role.

This interpretative approach prioritised the lived experience and the community voice, serving as a decolonial praxis (Mignolo and Walsh, 2018) in which the lived experience adds essential value to the research. Our interaction with locals let us better understand the dynamics of the place and the community. This aided in exposing the rooted cultural logic and collective memory that formed the Plateau's identity and potential, and comprehending the locals' vision for their place.

Moreover, two case studies from Ecuador, where Indigenous communities have implemented degrowth-aligned tourism models that emphasise community ownership, environmental stewardship, and cultural regeneration, were also examined using a comparative lens. This comprehensive framework for evaluating other development models and these scenarios critically examines the potential and limits of using comparable models in the context of Crete.

The methodological elements offer a multi-layered understanding of tourism's political, cultural, and spatial aspects. They enable a grounded analysis of how local communities in Crete might resist extractive tourism through culturally embedded and environmentally conscious development models.

3 Master of Urbanism, Landscape and Planning.
4 International Module in Spatial Development Planning.

MASS TOURISM AND DEGROWTH

How does mass tourism function as a neocolonial mechanism, impacting spatially and culturally the Malia region? Neocolonialism refers to continuing colonial power dynamics through indirect economic, cultural, and spatial control (Childs and Williams, 1997). As a globalised industry, mass tourism often perpetuates these dynamics by fostering economic dependency, commodifying local cultures, and reshaping physical spaces to serve external interests (Butcher, 2020). Degrowth arises as a critique of the neocolonial practice in mass tourism, aiming to explore a decolonial alternative for future tourism development in the Lassithi Plateau.

Mass tourism as a Neocolonial Mechanism in Shaping Space and Culture

Historically, tourism has been utilised by imperial forces to maintain power, modernise economies, and legitimise colonialism in former colonies. Mass tourism, developed by a small elite in industrialised countries, was celebrated for granting access to leisure activities to the working class (Butcher, 2020). This phenomenon has expanded globally since the 1960s, driven by transnational corporations, fostering labor exploitation, cultural commercialisation, and spatial inequalities (Williams, 2012; Butcher, 2020; Linehan, Clark and Xie, 2020).

Spatially, mass tourism reflects colonial urban segregation by privatising and commodifying planetary commons, intensifying urban expansion, and internal migration (King, 1976, 1989; Karvounis, 2021). While culturally, mass tourism incorporates Orientalist[5] narratives by romanticising and commodifying local cultures, and shaping identities through Eurocentric standards and capitalist consumption culture (Childs and Williams, 1997; Mason, 2006; Baylis, Smith and Owens, 2023). Thus, mass tourism functions as a contemporary tool of neocolonialism, sustaining imperialist values of control, exploitation, and profit extraction (Karvounis, 2021).

Mass tourism, a neocolonial phenomenon, significantly impacts space and culture by introducing a new cultural service-based economy based on foreign and domestic private investments, capitalist consumption culture, and global trends. In 2023, the economy of Crete Island depended on tourism to the extent of 70%, while it accounted for 26% of the annual revenue distribution of international incoming tourism (Ikkos and Koutsos, 2024).

The Malia region has experienced rapid growth, with the coastal area now dominated by large-scale resorts and medium-scale hotels (Figure 1). This has changed radically its cultural landscape, renegotiating its place identity to align with mass tourism's leisure and consumption culture. Malia has become a popular destination for young tourists, promoting capitalist consumption and global lifestyle trends. However, the tension between traditional values and Western culture is evident, with local cultural distinctiveness often being overshadowed by urban lifestyle or commercialised traditions (Terkenli and Bellas, 2007). The commodification of natural landscapes, historical sites, and religious architecture superficially interprets the place's history and culture, highlighting the mutual influence of space and culture.

5 Edward Said's concept of Orientalism influenced post-colonial space and culture by portraying the "Orient" as inferior, legitimising imperialist policies, and reinforcing Western self-perceptions, thereby distorting traditional cultures (Childs and Williams, 1997; Baylis, Smith and Owens, 2023).

Figure 1: Large and Medium Scale Hotels and Resorts in Malia (Hersonissos and Malia Tourism Development [Mp4], 2025)

Degrowth as a Decolonial Tourism Practice

Decolonial theory aims to expose the colonial roots of mass tourism and its impact on Western societies and culture. It advocates for placing life in the center of thinking and practice, enforcing local communities' ways of living, detached from the internalised colonial roots (Mignolo and Walsh, 2018).

Degrowth critiques extractivism's logic, the economy-centered development, and incorporates decolonial perspectives by supporting a collective shift toward post-capitalist paradigms. It prioritises well-being, ecological balance, and community autonomy over economic accumulation. The concept of "growth" is not demonized. Redistributing "growth" would allow less developed regions to evolve and overdeveloped ones to decelerate, bridging the gap between them. It suggests different political and economic structures where top-down and bottom-up initiatives complement each other (Fletcher et al., 2019).

As Latouche argues Western economic expansion, driven by extractive industries like mass tourism, negatively impacts cultural landscapes and suppresses local communities (Latouche, 2004). Decolonial features of degrowth emphasise reducing economic reliance on extractive industries like mass tourism. It suggests a collective tourism model focusing on steady, qualitative development within a post-extractive economy that measures growth in community resilience, autonomy, environmental balance, intercultural exchange, and not in GDP (Chassagne and Everingham, 2019). Thus, a "communing tourism" model involving community-driven governance through cooperatives and associations could promote a low environmental footprint, sustainable production and consumption patterns, and equal redistribution of goods and costs within the community (Fletcher et al., 2019).

Malia's cultural landscape has been dominated by mass tourism, though degrowth offers a potential alternative. It re-conceptualises tourism as a beneficial tool for local communities, preventing colonisation of pure regions like the Lassithi Plateau. This approach emphasises environmental preservation, cultural integrity, and community empowerment as key to a future decolonial tourism.

MASS TOURISM MECHANISM IN MALIA

The Greek periphery transitioned towards tourism development in the 1970s due to its reliance on the tertiary sector and growing demand for Western European holidays and leisure activities (Andriotis, 2001). The mass tourism model standardised package holidays, making the Mediterranean coast and islands attractive destinations (Butcher, 2020). Despite facing infrastructure, transportation, and connectivity challenges (Buhalis, 1999), Crete remains an attractive international tourist destination (Figure 2), consistently ranking first in global tourism revenue until 2023 (Insete, 2021).

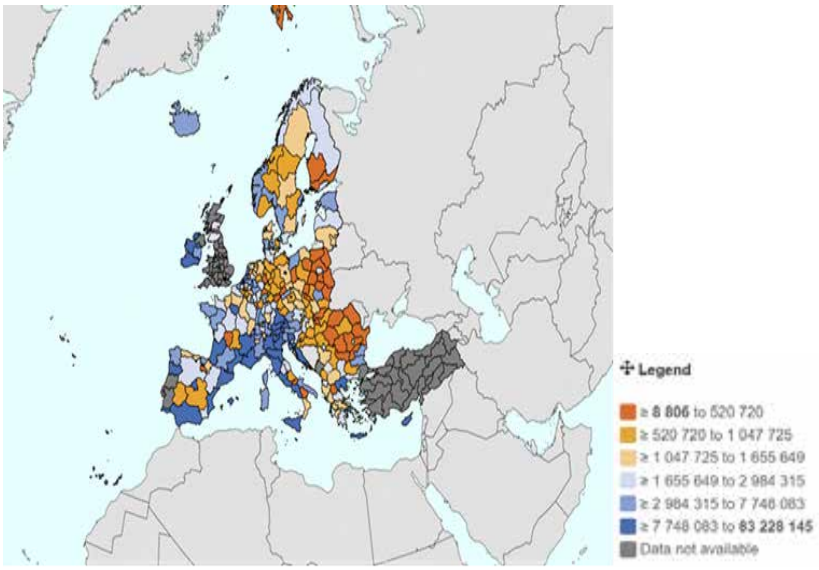

Figure 2: Foreign Overnight Stays in 2023 (Eurostat, 2025)

Tourism-Led Development and Spatial Transformation

Tourism growth in Crete has led to significant infrastructural projects, altering the island's socioeconomic trajectory and landscape. The economy heavily relies on tourism, attracting public and private investment in infrastructure to accommodate visitor flows and stimulate market activity (Andriotis, 2001).

The northern part of Crete (Figure 3), facing the European mainland, has become a focal point for such investments, including the BOAK highway, the Heraklion port, and the Heraklion New Airport (Figure 4) (Andriotis, 2001). That spatially impacted Malia Starting in the 1970s, it underwent a rapid spatial reconfiguration that grew more intense in the 1980s and 1990s. The accompanying urban expansion was catalyzed by infrastructural connectivity and tourism growth. As illustrated in cartographic materials, construction gradually concentrated along coastal zones and road networks, progressing steadily in subsequent decades (Figures 5 and 6).

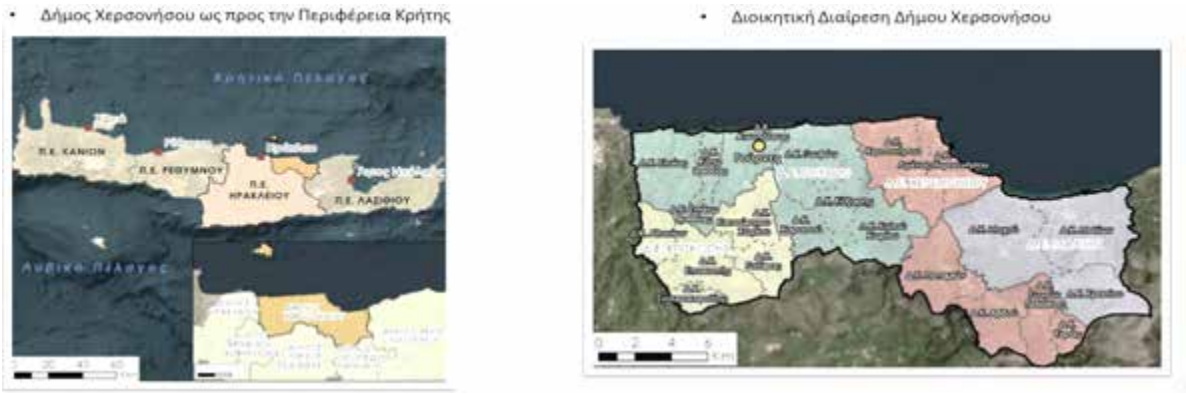

Figure 3: Location of the Malia region in Crete (Ministry for the Environment and Energy and Technical Chamber of Greece, 2024)

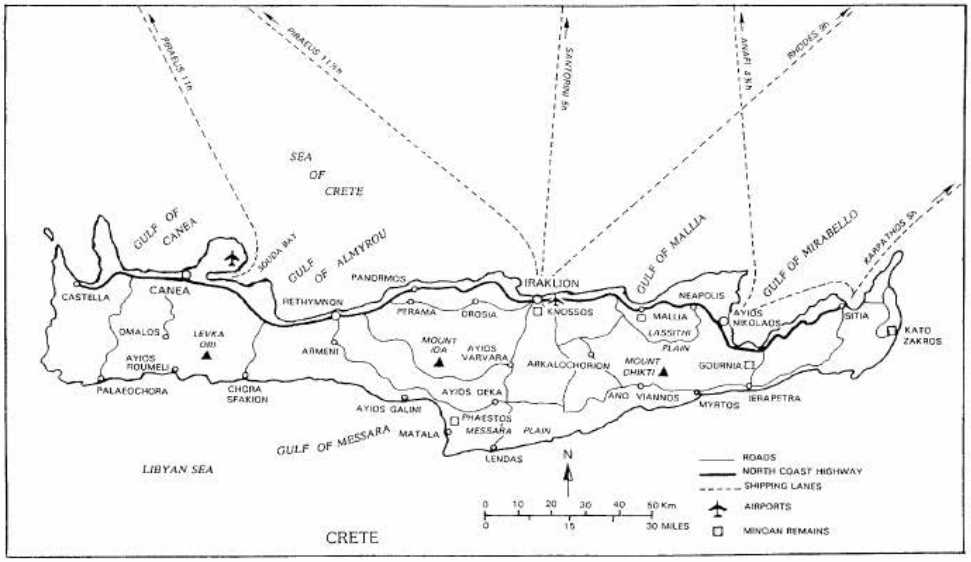

Figure 4 Map of Crete

Figure 4: Large-Scale Infrastructure Projects in the Northern part of Crete (Andriotis, 2001)

The construction of an international airport in Kastelli, is expected to accelerate development and connect Crete's northern and southern areas. The airport, strategically located at the boundary of the Heraklion and Lassithi regions (Figure 5), is the second largest in Greece (Herakion International Airport, 2025). Such public-private infrastructure development projects reveal deeper economic dependencies, reinforcing neocolonial dynamics through indirect economic control (Buhalis, 1999). This is also indicated in the airport company's ownership, which is distributed among shareholders, including the Hellenic Republic (45.9%), GEK TERNA Kastelli S.M.S.A. (32.5%), and GMR Airports Greece S.M.S.A. (21.6%) (Heraklion International Airport 2025), with the GEK Terna Group contributing as well 55% to the BOAK highway extension in Crete (GEK Terna, 2018). It is thus questionable who these projects serve, and what criteria guide their design and implementation.

Figure 5: New Airport in Kastelli and its proximity from Malia and the Lassithi Plateau (Google Maps, 2019)

Tourism-led investments have significantly reshaped the built environment in Malia, with the first hotel built in the 1960s near the coast (Figure 6) (Explore Crete, 2014). Today, it hosts numerous all-inclusive hotels and resorts

(Figure 7), several held by domestic and foreign parties. Smaller family-run lodgings continue to exist inland, exhibiting various levels of tourism growth. Crete has consistently attracted domestic and foreign investment, particularly in high-end tourism facilities, maintaining strong market performance. Despite mass tourism's critique of seasonal limitations, Crete continues to be portrayed as a resilient market for tourism growth (Gov, 2024).

Figure 6: Malia Coastal Urban Expansion in 1966 (Hellenic Military Geographical Service, 1966)

Figure 7: Malia Coastal Urban Expansion in 2024 (Google Maps, 2019)

In 2024, the Heraklion prefecture had 509 registered hotel units, 373 of which are located in the municipality of Hersonissos (Ministry for the Environment and Energy and Technical Chamber of Greece, 2024). While the total number of accommodations on the island has grown by only 5% over the past decade, a 68% increase in 5-star hotels (Figure 8) indicates a clear trend toward luxury and all-inclusive development (Hellenic Chamber of Hotels, 2024). Although luxury tourism may appear distinct from mass tourism, its scale and capacity contribute to a high-volume, high-impact tourism consumption model.

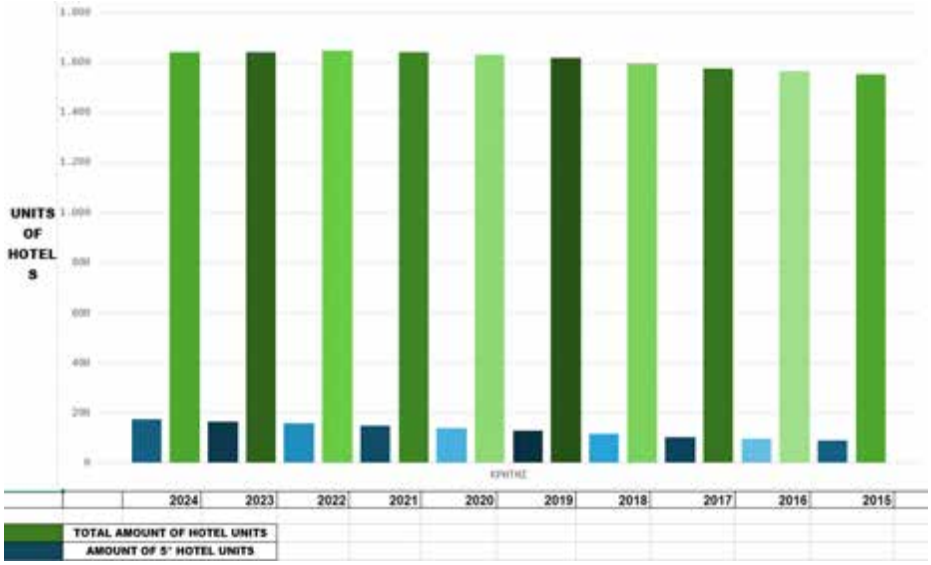

Figure 8: Total amount of Hotel Units & 5 Star Hotel Units in Crete (2015-2024) (Hellenic Chamber of Hotels, 2024)

The lack of early strategic planning allowed economy-driven tourism expansion. The spatial impact of investments increased the market interest, structuring urban growth accordingly. In the 1970s, national planning policies focused on economic gains through coastal development and construction incentives, such as grants and tax breaks (Andriotis, 2001). In the 1990s environmental considerations were introduced, but tourism investment continued in facility upgrades (Andriotis, 2001; Mason, 2006). These policies reflected centralised decision-making, detached from local community dynamics and rooted in monetised conceptions of growth.

Moreover, transitioning to the tertiary sector set tourism as a central pillar. Policies in the mid-1970s encouraged small-scale construction and hospitality enterprises, leading to internal migration of the rural population to profitable coastal zones like Malia (Andriotis, 2001). According to locals of the Lassithi Plateau, many families relocated to Malia to capitalise on land ownership and invest in tourism-related businesses. By the 1990s, nearly 40% of Crete's population was employed in the tourism sector (Andriotis, 2001), reflecting a broader rural-to-urban demographic shift (Figure 9) (Kotzamanis and Androulaki, no date).

Πίνακας 3: Ο πληθυσμός της Ελλάδας κατά βαθμό αστικότητας (%)

	Εκατοστιαία κατανομή			
Έτος απογραφής	Αστικός	Ημιαστικός	Αγροτικός	Σύνολο
1853	7.1	13.5	79.4	100
1856	6.8	12.6	80.6	100
1861	8	15.8	76.2	100
1870	9.6	13.6	76.8	100
1879	10.5	14	75	100
1889	15.1	14	70.9	100
1896	15.7	14.2	70.1	100
1907	16.4	12.5	71.1	100
1920	22.9	15.2	61.9	100
1928	31.1	14.5	54.4	100
1940	32.8	14.8	52.4	100
1951	37.7	14.8	47.5	100
1961	43.3	12.9	43.8	100
1971	53.2	11.6	35.2	100
1981	58.1	11.6	30.3	100
1991	58.9	12.8	28.3	100
2001	59.7	13.1	27.2	100

Πηγές : ΕΣΥΕ, Στατιστικές Επετηρίδες της Ελλάδος, διάφορα έτη.

Figure 9: Rural & Urban Population Transformation in Greece (Kotzamanis and Androulaki, no date)

Contemporary tourism planning acknowledges past overdevelopment while promoting new strategies for diversification models. The current Strategic Planning and Operational Program for Crete and the Local Urban Plan of Hersonissos emphasise alternatives, such as agro-tourism and mountain tourism, integrating natural and cultural assets to extend the tourism season year-round. However, they include strategies, continuing supporting large-scale investments, prioritising the upgrade or creation of 3, 4, and 5-star hotel units, and encouraging land uses related to leisure, cultural parks, and marinas (Figure 10) (Gov, 2024; Ministry for the Environment and Energy and Technical Chamber of Greece, 2024).

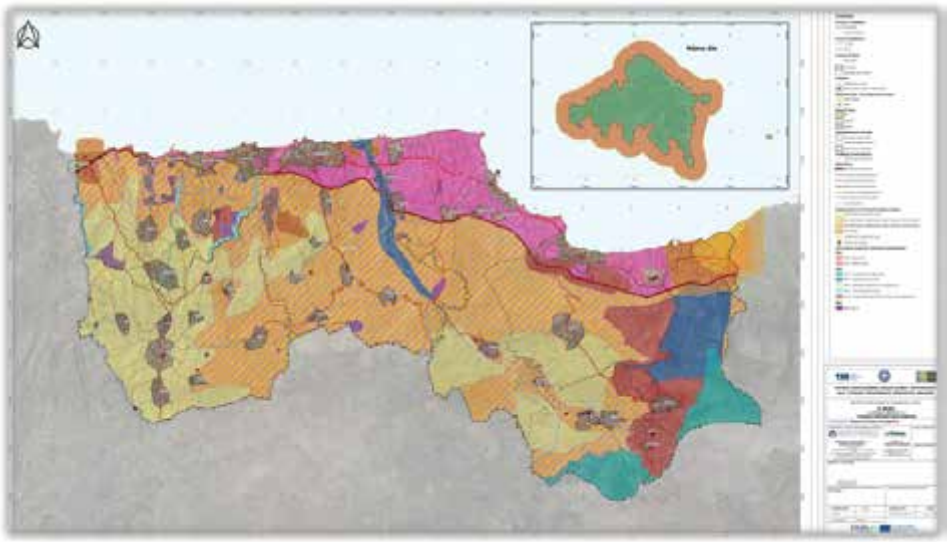

Figure 10: Tourism Development Zone, Intense Intervention Scenario. (Ministry for the Environment and Energy and Technical Chamber of Greece, 2024)

Therefore, tourism and infrastructure development in Malia reveal a spatial landscape significantly influenced by investment, policy, and market-driven demands. This sustains a tourism model still rooted in patterns of exclusivity, dependency, and unequal growth, even with strategic planning changes towards alternatives.

Tourism Labor Force and Social Dynamics Impact

Crete heavily depends on the tourism industry, embracing the imperatives of economy-led growth, perpetuating spatial and cultural inequalities. Culture is understood as the agent (Smith, 2013), the mediator that transforms space in response to the needs of local society (King, 1976). Thus, in the case of Malia, culture subsequently adapted to serve these demands.

Malia's tourism follows market dynamics, fostering a capitalist consumption culture. The local population and seasonal workers form the labour force that supports this system (Williams, 2012; Linehan, Clark and Xie, 2020). Demographic trends and the seasonal fluctuations in the population of the Hersonissos municipality underscore the role of tourism. In 2021, the permanent population numbered 27,220, characterised by a strong youth presence and a high proportion of two- and single-member households, most employed as wage or salary earners. During the same year, the seasonal population, including visitors, seasonal workers, and permanent residents, reached 59,699, doubling the local population (Ministry for the Environment and Energy and Technical Chamber of Greece, 2024).

This disparity reveals a service-based, seasonal economy where employment is precarious and tightly bound to mass production and consumption, increasing competition and raising concerns about working conditions (Andriotis, 2003). The region's 18.7% permanent population, primarily European immigrants, indicates a mobile labour force, concentrating predominantly in Malia and Hersonissos (Ministry for the Environment and Energy and Technical Chamber of Greece, 2024).

While the tourism industry generates employment opportunities, it imposes a capitalist-oriented work culture that profoundly affects the lives of the permanent population. Seasonality introduces distinct temporal rhythms, rising to two parallel realities (Terkenli, 2005). During the tourist season, places and people become commodified. Economic dependency intensifies livelihood risk throughout the year, reinforcing pressure to meet tourists' expectations and demands. This opportunistic work culture fosters impermanence, weakens local ties, and contributes to a fragmented sense of community and place.

Staged Authenticity and Capitalist Consumption Culture in Malia

Beyond its labor dynamics, tourism promotes a narrative of cultural authenticity. Local traditions, cuisine, landscapes, and heritage are commodified for tourists. Local culture becomes a curated product, projecting simplified, often romanticised versions of history and identity (Linehan, Clark and Xie, 2020).

The representation of Greece to foreign visitors has been tied to its ancient civilisation. Archaeological sites have been preserved and marketed since the beginning of systematic tourism development, forming a central element of the national identity (Tournikiotis and Monemvasitou, 2012). In Malia, the Minoan civilisation remains a major tourist attraction. According to the Strategic Planning & Operational Program for the Region of Crete 2024–2028 (Gov, 2024), Crete is described as:

"...a fusion of cultures such as the Minoan, Byzantine, Roman...which, combined with its landscapes and recreational opportunities, is often chosen by tourists...as a destination of cultural interest and holidays."

Another cultural representation that mass tourism promotes is linked to the commercialisation of the planetary commons. Regional authorities' survey confirms that visitors widely perceive Crete as a destination of "Sun–Sea–Relaxation" (Gov, 2024), which is reinforced by the promotion of all-inclusive hotels and resorts along the Malia

coastline. Current tourism development plans do not challenge this triptych; they propose strategies to extend the tourist season throughout the year. The plan states:

"The Region of Crete is aware that the 'Sun and Sea' model will remain dominant... However, the uniqueness, and diversity of the destination 'Crete' is a 'treasure', and if we reintroduce it to the world, we will gain forever."

Therefore, the Strategic Planning & Operational Program for the Region of Crete 2024–2028 suggests the "Brand Equity" strategy, aiming to promote a "new" cultural value in tourism, which taps into localised "brands" of each area's unique characteristics and products. It targets "qualitative" tourism and private investment to enhance competitiveness, diversity, and innovation (Gov, 2024). The represented culture is designed to appeal to the ideal tourist, whose preferences guide how place identity is framed and marketed to drive economic growth. Authenticity is constructed through experiences tailored to visitor expectations and reproduced by local industry actors. Thus, profit becomes a principle (Childs and Williams, 1997), and cultural expression is subordinated to marketability.

Mass tourism introduces as well a new cultural identity rooted in capitalist consumption, modernity, and Eurocentrism[6]. In the post-war period, the GNTO employed modernity as a tool of "civilisation" for local populations (Tournikiotis and Monemvasitou, 2012). Today, it is reflected in consumerism and the adoption of globalised lifestyle standards.

Malia comprises a popular international youth tourism destination known for its nightlife, drug use, clubbing, and sex tourism. Foreign and Greek tour operators promote these experiences, targeting specific tourist groups. A micro-network of local business operators guides tourists to select venues and organises high-attendance events (Party Hard Travel, 2024). The often-accompanying violent behavior places considerable pressure on the local community (Terkenli and Bellas, 2007). Alternative package tours that market "adventurous" experiences, such as safari day trips to natural areas like the Lassithi Plateau, also raise concerns. The landscape and surrounding villages become spectacles for the tourist gaze, with little regard for the local community's lived reality or meaningful engagement with the place.

The Strategic Plan for Tourism Development in Crete (2024–2028) acknowledges the importance of tourist profiles, aiming to attract visitors from Europe, the USA, China, and Israel with higher educational and socio-economic backgrounds. These groups are perceived as more receptive to personalised, alternative tourism models such as agrotourism (Gov, 2024). Thus, even if the plan proposes a hybrid tourism system, incorporating alternative models to extend the tourist season, it does not address the structural issues of mass tourism, merely commodifying culture, landscape, and resources.

THE CULTURAL LANDSCAPE OF THE LASSITHI PLATEAU

The Lassithi Plateau, located 20 km south of Malia, is part of NATURA 2000 preservation since 1997 (Natura 2000, 2025), with an economy still rooted in agriculture. Situated at an altitude of 820–870 meters, it is surrounded by 11 villages (Figure 11) (General Secretariat for Spatial Planning & Urban Environment, 2024) arranged in a circular formation. It is known for its unique cultural landscape, which is historically tied to the 1950s, when 10,000 windmills on the plateau indicated the intense agricultural activity of the period (Demelis, 2017).

6 Eurocentrism is the belief that Europe serves as the primary reference point for understanding world history, civilisation, and human progress, often evaluating other societies based on their European models (Baylis, Smith and Owens, 2023).

Figure 11: Lassithi Plateau Map (Google Maps, 2019)

These windmills were an inventive industrial accomplishment based on a design created by Emmanuel Papadakis, a carpenter from the village of Psychro. His concept significantly enhanced the irrigation water pumping operation compared to the traditional Venetian water systems. The windmills (Figure 12) supported the growth of a self-sufficient local economy, based on vegetable production, while strengthening the community's ties to the land and developing a shared cultural identity ingrained in the local memory (Zaimakis et al., 2022).

Figure 12: Lassithi Plateau Windmills (National Index of Intangible Cultural Heritage, 2025)

The locals describe this period as a milestone in their communal life. At that time, livelihood was rooted in land cultivation and farming, with nearly every family in the surrounding villages owning a plot of agricultural land. The last windmill technician of Tzermiado village mentioned that families would contact him to build a windmill on their land, which typically took up to three days. While local artisans handled technical maintenance, each family was responsible for the daily operation of the windmills (Local No 1 and Local No2, 2025).

This shared responsibility fostered a collective consciousness, reflected in social interactions and the spatial

practices of the community. For example, when wind conditions were strong, neighbors would furl the sails of vulnerable windmills, even if they did not own them. They added as well that people cooperated closely, often sharing labor and agricultural products. (Local No 1 and Local No2, 2025). They mention:

"Back then, we didn't have extra labour hands. We cooperated, helping each other with agricultural work..."

Spatially, plots of land were not fenced, which endures today, symbolising deep mutual trust and a strong sense of place cultivated through communal living (Local No 1 and Local No2, 2025).

The community's well-being, self-sufficiency, and locally rooted economy, centered on family needs, cooperative use of windmills, and a collective sense of belonging, illustrate context-specific practices adapted to local conditions. These practices align with the principles of degrowth, which emphasise ecological sustainability and social cohesion (Kallis, Varvarousis and Petridis, 2022).

Impacts of Development Dynamics on the Lassithi Plateau's Cultural Landscape

The installation of the electrical grid in the 1960s, the introduction of new technologies, the rise of mass tourism along Crete's northern coast in the 1970s–1990s, and increasing urbanisation during the same period contributed to the transformation of the Lassithi Plateau's cultural landscape.

Depopulation was the first significant consequence, affecting the cultural agents of the landscape. Larger villages such as Tzermiado and Agios Georgios absorbed populations from smaller settlements, but both have experienced over 40%—50% depopulation since the 1960s (Figure 13). A few villages, such as Psychro and Kaminaki, indicated slight increases in active population due to their proximity to the tourist attraction of Dikteon Cave, but this was not sustained (Zaimakis et al., 2022).

The evolution of the population of the Plateau over time (1900-2011)

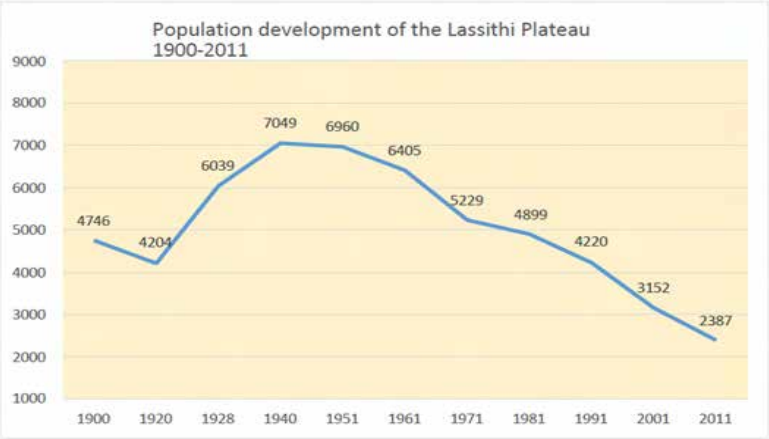

Figure 13: The Evolution of the Lassithi Plateau's population (1900-2011) (Zaimakis et al., 2022)

According to the 2021 census (ELSTAT, 2021), the Lassithi Plateau has 2,438 people, slightly increased from 2011 (ELSTAT, 2021). It has the highest employment rate among its economically active population (92%) despite having the lowest population density in the region (18/km²) (Zaimakis et al., 2022). This highlights a paradox: a productive core persists despite aging and population loss, especially in agriculture and tourism.

The second major shift came in 1965, when high-power water pumps replaced traditional windmills (Figure 14) (Demelis, 2017). The initial strong community relationships, maintained by a sustainable, circular system, were upset by the simultaneous collapse of windmills and population.

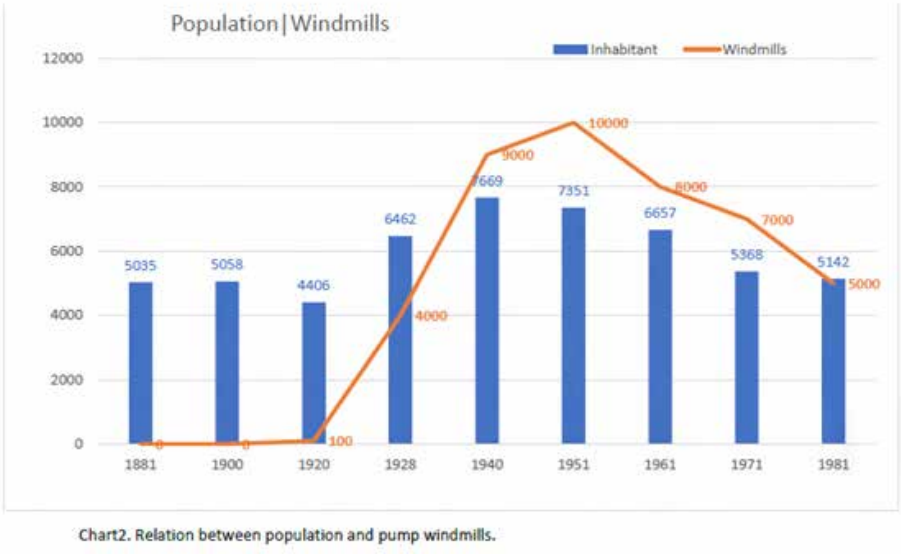

Figure 14: The Relation between Population and Windmill Transformation (Demelis, 2017)

Today, half the permanent population is economically inactive, while the active labour force is evenly split between the primary and tertiary sectors (Figure 15). However, the principles of agricultural work have changed. According to the farmers' union representative, depopulation and aging have led to the accumulation of land in the hands of a few full-time farmers. As he puts it:

"At least the plain is cultivated. Because if it's not rented, it'll be empty within a year."

Economic profitability is essential, and adopting modern irrigation technologies helps reduce costs and boost productivity.

"Being on an island increases costs for both farmers and stockbreeders... but product prices don't increase accordingly... but still, our products are worthwhile, so they sell" (Interview No.9, 2025).

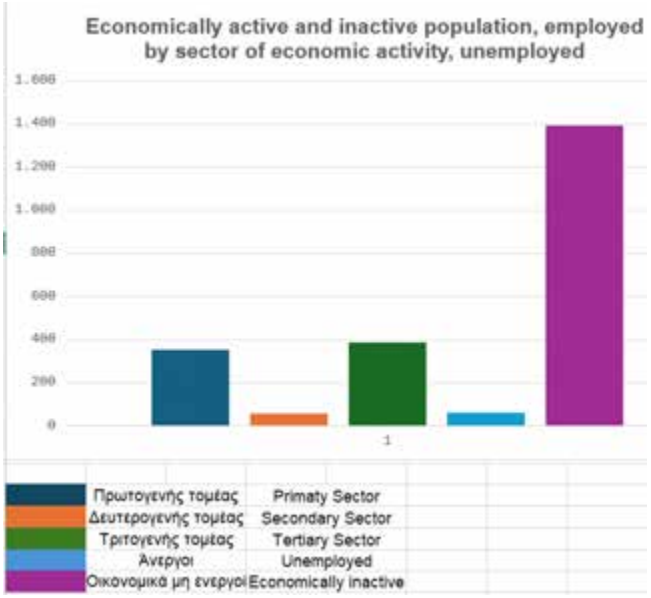

Figure 15: Economically Active and Inactive Population by Economic Sector (ELSTAT, 2021)

Few windmills remain, and most are in poor condition. According to a local mechanical engineer, only 150 have been restored to serve as tourism attractions and are no longer functional (Interview No.2, 2025; Interview No.9, 2025). The once vibrant cultural landscape of the Plateau has been reshaped by modernisation and economic growth, reflecting a detached relationship with the land (Figure 16).

Nevertheless, based on observations during the action research, the agent of culture is still present. Community ties remain visible through events and festivals organised by cultural associations and the municipality, the existence of an agricultural cooperative, and even informal gatherings at village cafés (kafenia). Most of the residents address depopulation as a significant challenge for the future. While some express hope that young people will return, others acknowledge outmigration as necessary due to limited employment opportunities and services.

Figure 16: Lassithi Plateau 2025 (Research Group's Own)

This raises questions: Are current tourism strategies sufficient to revitalise the area? And what role can the windmills play in this?

Tourism Development Strategies and Challenges in the Lassithi Plateau

The Strategic Planning & Operational Programme for Crete 2024-2028 aims to extend the tourism season by promoting alternative tourism forms based on site-specific characteristics and local products. These alternatives emphasise agro-tourism and eco-tourism, under a globally competitive tourism market branding "CRETE" (Gov, 2024).

For the Lassithi region specifically, the proposed strategies include (Karagiannis and Centre for Technological Research of Crete, 2024):

- Attracting investment for agrotourism development
- Supporting the primary sector by certifying and promoting local products within the tourism industry
- Promoting and protecting traditional settlements and fostering self-sustaining tourism centers
- Utilising areas of outstanding natural beauty
- Protecting forests and creating recreational parks for ecotourism

While expanding the tourism industry toward alternative models could benefit local employment and population retention, the current strategy remains profit-oriented, prioritising the needs and experiences of tourists. A revealing example is the phrase: "If the locals don't have a good time, the visitors won't have a good time either" (Gov, 2024). This framing subtly positions locals as a means to enhance the tourist experience, reducing their well-being to a functional index of visitor satisfaction.

Further evidence of the emphasis on growth is seen in references to large-scale infrastructure projects scheduled for completion between 2027 and 2030. The only concern noted is the potential for an "unpleasant image" of the island during the construction phase, mitigated by assurances that the infrastructure will match that of the tourists' home countries (Gov, 2024).

The SWOT Analysis included in the Strategic Plan for Crete 2024–2028 (Gov, 2024) highlights several structural weaknesses and threats accordingly:

- "Spatial over-concentration – Inadequate institutional and regulatory framework – Vulnerability of the Cretan landscape – Vulnerability of the tourism product – Fragmented actions and initiatives"
- "Deterioration of tourism resources – Exceeding carrying capacity and overtourism – Climate change – Rising costs – Abandonment – Weakening of the countryside"

At a policy level, the New Special Spatial Framework for Tourism 2024 lacks an overall development strategy and fails to address spatial over-concentration in line with carrying capacity indicators. Environmental priorities and landscape protection are also underestimated, considering promoting large-scale hospitality infrastructure in sensitive zones, such as islets or small islands. Moreover, supporting significant investments in small-scale regions redirects financial inflows away from the local economy and dismisses the long-term impacts on landscape, culture, and community (Spilanis, 2024).

The tourism development approach faces challenges due to misalignment between central and regional authorities. Lassithi Plateau's proximity to the Kastelli airport poses risks to capital-driven tourism dynamics. The lack of site-specific strategies and an adequate policy framework raises concerns about tourism's impact on local communities and landscapes. Considering that permission to install large-scale wind turbines in the Lassithi Plateau, a Natura 2000 zone, has already been approved, indicating no prevention towards extractivist processes (INSIST, 2018), increases the concerns about future development plans.

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Regarding the windmills and their contribution to tourism development, local authorities and residents highlight their significant role in attracting visitors. They have shaped a distinct cultural identity, remaining deeply embedded in the collective memory of the local population. The iconic "postcard" image of the Plateau from the 1960s reinforces the community's vision for reviving the area as a thematic cultural park.

Local interviewees say restoring traditional windmills can rebuild the cultural landscape and revive local identity. This is perceived as an optimistic scenario for the future development of the villages. The municipality supports a model of slow tourism, with the proposed thematic park showcasing aspects of traditional agricultural life and windmill operation (Interview No.4, 2025; Interview No.6, 2025; Interview No.8, 2025; Interview No.9, 2025). A local stated (Interview No.9, 2025):

"The windmills are the identity of the Plateau...I would like to see the Plateau revitalised, with twice as many people living here. People from Heraklion who own property in the area should return and invest in it, maybe develop a windmill park for tourists, with cafés and taverns, so that visitors say: 'I'm going to the Plateau to stay, relax, and have a good time.'"

Although restoration efforts have occurred in the past, the lack of funding, specialised technicians, and ongoing maintenance has prevented them from continuing (Interview No.2, 2025). A complete restoration of the roughly

1,000 windmills on the Plateau could support an application for inclusion in UNESCO's list of Intangible Cultural Heritage. Such recognition would help protect the area from unregulated tourism expansion and encourage sustainable development strategies centered on environmental, cultural, and landscape preservation (World, 2018).

The tourism industry presents potential development, but the lack of a clear policy framework and profit-driven strategies prioritise tourist needs over local community well-being. Despite windmill restoration and possible UNESCO recognition, the process risks romanticising and modifying the cultural landscape for tourism purposes, highlighting the need for a reconceptualised tourism development model.

DEGROWTH AS A DECOLONIAL ALTERNATIVE FOR TOURISM DEVELOPMENT IN THE LASSITHI PLATEAU

Since tourism operates within an extractive capitalist system, suggesting alternatives to mass tourism is questionable regarding their contribution to a sustainable development model. Considering the landscape transformation of Malia and the upcoming risk for Lassithi Plateau due to the new airport or the wind turbines project, degrowth tourism could prevent these implementations and benefit the community, as happened in the following cases in Ecuador.

Degrowth Tourism: Indigenous Cases in Ecuador

Degrowth suggests a post-extractive economy prioritising community resilience and well-being, environmental balance, and intercultural exchange (Chassagne and Everingham, 2019). This system could better absorb tourism alternatives. Two Ecuadorian cases demonstrate how Indigenous communities utilise tourism to boost their local economy and prevent the construction of large-scale infrastructure projects that could harm nature and the environment.

Cotacachi canton[7], an ecological reserve in the UNESCO Biosphere Reserve, has implemented a tourism model based on an "anti-growth" concept to counter large-scale mining activities and protect nature and community well-being. The initiative includes eco-tourism and agro-tourism alternatives, empowering the community. The local government supports micro-scale enterprises and ensures development meets community needs. Planning strategies include strengthening ecotourism networks, cultural exchange, promoting reforestation, and environmental education. This case demonstrates how top-down and bottom-up mechanisms can promote tourism for economic and social development.
(Chassagne and Everingham, 2019).

The Añangu community in the Napo River implemented a tourism model called "Community-Owned Tourism" (COT) in 2007, which aimed to reclaim full ownership after financial mismanagement with cooperative NGO's. The COT aimed to limit migration, retain youth through tourism education, and provide employment opportunities tailored to local values. Tourism also helped redefine local culture through community-curated experiences, while revenues from tourism funded conservation efforts and small-scale renewable energy projects. Decision-making was done through monthly assemblies with equal participation, communal rules, and work parties to ensure collective responsibility (Renkert, 2019).

Both cases reveal tourism's benefits to local communities, advocating for their needs and preserving environmental values. Profit becomes a means rather than a goal, supporting projects that contribute to local autonomy.

Reconceptualising Tourism in the Lassithi Plateau

Despite contextual differences between the Lassithi Plateau and the case studies, several local elements form a fertile ground for a degrowth-oriented tourism model. These include:

7 The subdivision of a country based on political or administrative factors.

- Historically rooted culture of sharing is still evident among locals
- Strong sense of place
- Slow pace of life
- Collective action through the villages' Cultural Associations, the Farmers' Union, and the Lassithi Mountaineering Club
- Community self-sufficiency, grounded in land fertility and local production
- Desire to reclaim and preserve the cultural landscape
- Locals' desire for youth return

Drawing on the Plateau's natural beauty, agricultural activity, and lifestyle, tailored models of agro-tourism and eco-tourism could be developed in line with degrowth principles. A community-led cooperative could manage tourism locally, ensuring that decisions prioritise community well-being. This cooperative would represent local interests in dialogue with municipal or regional authorities, mediating an autonomous and bottom-up governance.

Collaboration between this cooperative and existing local groups, such as the Cultural Associations, the Farmers' Union, and the Lassithi Mountaineering Club, could strengthen community empowerment. This would encourage participatory governance and collective agency by uniting these actors within a self-sustaining system. Such an initiative could promote cultural exchange, local food products, and ceramics, thereby supporting the local economy. Considering the environmental advocacy of the Mountaineering Club, an active voice against industrial renewable energy developments[8] (Interview No.8, 2025), educational activities alongside organised hiking trails could be developed to raise environmental awareness among residents and visitors.

Regarding rebuilding the Plateau's cultural landscape and identity, a local mechanical engineer suggests that updated versions of traditional windmills could be reintroduced to pump underground water, a plentiful resource in the area (Interview No.2, 2025). Integrating this water system into the agricultural sector would revive the cultural landscape, serve the local economy through autonomous food production and consumption systems, and aid tourism by attracting visitors.

Collaboration with top-down governance structures is also crucial. As Vourdoubas argues, the active participation of local authorities, businesses, residents, and tourists is necessary to balance economic activity with sustainability. At the policy level, he advocates for eco-taxes, caps on tourist numbers to maintain sustainable levels, and restrictions on hotel development. Furthermore, a shift from quantity to quality in tourism could be incentivised through support to local tourism agents promoting eco-friendly models that encourage longer stays and higher visitor spending (Vourdoubas, 2025).

Thus, the Lassithi Plateau provides a promising context for a degrowth-tourism approach, enhancing the local economy and reclaiming community autonomy. Nonetheless, significant challenges must be acknowledged. As Buch-Hansen and Nesterova highlight, transitioning toward degrowth requires transformation across four interconnected planes[9]: material interactions with nature, social interactions, societal structures, and inner being. Implementing initiatives that challenge deeply rooted capitalist and individualistic structures is complex and demands personal commitment and a shared vision within the community. Degrowth, in practice, necessitates combining of bottom-up action and supportive eco-social policies (Buch-Hansen and Nesterova, 2023). Moreover, it remains a philosophical ideal rather than a widely adopted policy practice. The lack of detailed policy frameworks, concrete implementation strategies, and multi-scalar governance mechanisms presents significant ob-

8 Large-scale renewable energy resources.

9 Four planes emphasise the importance of reducing waste and pollution, promoting empathy and respect in social interactions, reducing competition and inequality, and personal transformation towards self-transcendence (Buch-Hansen and Nesterova, 2023).

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stacles to a systemic transition (Fitzpatrick, Parrique and Cosme, 2022).

Consequently, the degrowth tourism model offers a promising vision, but its implementation remains uncertain. Rethinking tourism through a degrowth lens could offer locally beneficial mechanisms resisting extractivism and empowering communities for greater autonomy.

DISCUSSION

The study examines the relationship between tourism, space, and culture in Malia, revealing that mass tourism operates as a neo-colonial mechanism, reshaping the landscape and influencing local identity. The Lassithi Plateau, on the other hand, retains context-specific elements that align with degrowth principles, such as collective memory, sense of place, sharing culture, ecological awareness, and a slower pace of life. This presents a fertile ground for participatory governance, cultural resilience, and autonomy, encouraging the reconceptualisation of an economically viable and socially and environmentally recovering tourism model.

However, structural barriers exist, as current policy frameworks focus on attracting private investment and increasing tourist numbers. International case studies from Ecuador show that degrowth-inspired tourism is feasible and successful when rooted in community governance and supported by inclusive state policies. Thus, while the Lassithi Plateau faces challenges, it holds unique potential for embracing degrowth in tourism, reimagining development from the perspective of community well-being and ecological integrity.

CONCLUSIONS

The research suggests a decolonial approach to tourism, contrasting the neo-colonial mass tourism model in Malia. The Lassithi Plateau presents an opportunity for degrowth tourism, but challenges like lack of coherent policy and capitalist culture hinder its implementation. Combining community-driven initiatives with top-down policy frameworks could challenge extractivist models and promote community autonomy, offering a hopeful alternative to profit-driven tourism development.

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Exploring the genuine flavours of Tehran's cafes: a postmodern destination for tourism

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Abstract
Globalisation and multiculturalism have significant impacts on food culture worldwide. Iran, with its diverse climate and local cuisine, has a rich variety of cooking styles. However, the situation is different in major bustling cities like Tehran; fast-food and routine restaurants that serve the same foods are primarily ordinary, and some traditional foods are also served. Meanwhile, some Western-style restaurants serve the most popular international foods. Here, some cafes play a different role as a third place.

This research aims to explore the role of Tehran's cafes in promoting and expanding Iranian local cuisine as a tourism destination. It was conducted using a qualitative approach, incorporating ethnography, and involved 22 locations with their users at the centre of Tehran city.

The research outcome reveals that in recent years, some of these cafés have profoundly impacted the introduction of local and traditional Iranian foods and beverages to tourists and new generations, while also serving as a reminder to elders. Some 'home cafés' symbolise the connection between yesterday and modern life: a postmodern destination. The main themes derived from the study portray these places as authentic, friendly, aesthetic, and creative, with a cultural vibe, highlighting the lost aspects of the city and the importance of cafés in preserving our past.

Keywords: gastronomy tourism, postmodernism, café culture, third place, conservation

1. Introduction

Food occupies a crucial position in local communities, cultural identities, and daily life. The use of regional and natural ingredients, distinct cooking styles, and even the choice of cutlery are central to this culinary tradition. However, international brands and cooking methods, particularly fast food, have become increasingly prevalent even in small towns worldwide. These modern influences, along with the global proliferation of food brands, often overshadow traditional local cuisines. In response, some communities are striving to reconnect with their culinary roots by reimagining traditional styles and creating welcoming spaces for diverse groups. These semi-public venues aim to foster connections that extend beyond routine conversations, addressing the limitations often found in fully public spaces. They also contribute to reviving the often-overlooked histories and cultures of the area, fostering a sense of belonging. As Ray Oldenburg describes, such places can evoke a sensation of being both at home and away from home, which he refers to as a "third place." Today, the necessity of these social spaces is increasingly recognised.

Even when the COVID-19 lockdowns commenced, a reporter from Boston inquired whether we believed third places would return. We responded confidently with a "Yes!" as we understood that online meetings and virtual happy hours could never substitute for in-person interactions (https://unesco.org). The swift rebound from COVID-19 indicates that the tourism market and industry, as well as many governments at various levels, have not yet acknowledged the importance of redirecting tourism growth (Butler, 2024). Herein, the vital role of these spaces, not merely as venues to serve specific items, but as social hubs, is evident in our currently isolated societies. Some of these spaces are not only welcoming to the locals but also cater to contemporary tourists.

This transition stems from recent changes in tourism concepts and cultural developments in our contemporary era. We are moving beyond traditional or even modern definitions of our needs, social lives, tourism, and other aspects of human experience. These encompass interdisciplinary terms that reflect current diversity and provide practical ideas for navigating daily life in this age of variety. This research aims to explore the current land-

scape of tourism and the role of one of the prominent examples of third places—cafés—in shaping gastronomy tourism in central Tehran, the capital of Iran. As the country's pioneering modern city, Tehran is witnessing new trends and diverse demands that seek to respond to its dynamic atmosphere.

1. The Era of Diversity: Postmodernism

Postmodernism is a set of conditions that currently influence all aspects of contemporary life, and whether we like it or not, it will continue to have this impact (Ward, 1997: 304). Although postmodernism emerged from various architectural movements and theorists in this field, Jean-François Lyotard is one of its most essential philosophers. He rejects the authoritarian view of history and society, which he refers to as meta-narratives (Lyotard, 1984). In his view, if we want to summarise the term postmodern as much as possible, it can be defined as a distrust of meta-narratives. For Lyotard and other intellectuals concerned with the ideal of freedom, only small narratives (Petits récits) and the proliferation of meanings are compelling in the postmodern era. Lyotard's postmodern mission is to oppose totalitarianism and totalising ideologies and to avoid the longing for unity (Nesbitt, 1997: 63-66).

Over the last two decades, instead of critical writers on modern urbanism directly engaging with postmodern texts, the emphasis on the effects of the modern approach to urbanism and the criticisms directed at it has led to the creation of works that explore the relationship between the city and its inhabitants, striving to create spaces that encourage greater public presence. One notable example of these works is Michael Sorkin's Twenty Minutes in Manhattan (2009), which, influenced by Jane Jacobs, describes the author's walks in Manhattan. He believes that modernity, influenced by science, has consistently faced ethical challenges and attributes the excessive focus on functionalism to this issue. In the writings of Jan Gehl (1987, 2010, 2013), the prevalence of car-centric spaces, resulting from modernist urban planning, is critiqued, highlighting the importance of pedestrians and urbanism that prioritises people.

One of the primary characteristics of postmodern urbanism is contextualism, which encompasses historical, physical, social, and public culture, in contrast to modern urbanism, which relies on a break from the past (Ellin, 1999: 185). Meanwhile, figures such as Jacobs, Mumford, Lynch, and others emphasised the importance of understanding the reality of the contemporary city. In contrast to the rupture of modernity, they also examined the matter of historical continuity within urban spaces. Another significant work from this period is Jonathan Raban's book, Soft City, published in 1974. Harvey describes this work as follows: "Soft City, written at that time, is a presumptive text that should not be interpreted as anti-modern; rather, it serves as a vital acknowledgement of the arrival of the postmodern era" (Harvey, 1990: 6). In this text, Raban provides a unique portrayal of life in his city, London. According to Harvey, Soft City outlines the concept of the postmodern city, and its depiction of urban life reflects the inherent and conditional aspects of becoming postmodern (Stevenson, 2014).

A part of this perspective relates to the evolving concept of the city. In the postmodern cultural context, the city, according to Castells (1989), has become a "collective organisation of consumption." Here, a duality emerges where the boundary between an alternative culture opposing the dominant culture, in its criticism of tradition or consumerism, can itself reproduce another pattern of consumption. In this pattern, even "simplicity" as a value becomes a commodity, which is often available only to a limited group. This notion recalls the saying, "I'm not rich enough to live simply," or the English proverb, "I'm not rich enough to buy cheap things," both of which emphasise the importance of quality over quantity. This perspective values and upholds high-quality, durable goods from the past. A lifestyle is celebrated and perpetuated in which "tradition" is revived through nostalgia; shops selling nostalgic items and spaces become popular, and the representation of everything is both marketable and priced. The closer the represented commodity is to its original form, while discarding the unpleasant aspects of tradition, the more it becomes accepted. Consequently, cultural items that revitalise traditions to meet current needs and lifestyles, rather than opulent spaces, are increasingly appealing due to their simplicity and are in demand among certain groups of people, primarily because of a growing awareness of climate challenges. After considering the effects of modernity and the use of machinery, along with the increase in air pollution, even some city dwellers are striving to reduce their carbon footprint by dining out less at restaurants and opting for

fast food alternatives, choosing to cycle and utilise public transport, prioritising their health, thereby transforming their everyday lifestyle. This shift also affects visits to other spaces and tourism cultures.

In terms of tourism, postmodern tourism is another term that warrants specific research (see Pecheniuk & Kiziun, 2022). Still, it can be briefly described as an open approach to different cultures, embracing pluralism, relativity, and diversity (Uriely, 1997). This approach utilises new methods to collect information about destinations and devises innovative journeys and paths rather than traditional ones. This reflects the growing tendency to seek individualised services and remain in small-scale enterprises (Ateljevic & Doorne, 2000). In this context, postmodern tourism encompasses specialised experiences, the rising attraction of nostalgia and heritage tourism, the growth of nature-focused tourism, the emergence of simulated tourism environments, and a variety of tourist experiences and motivations (Uriely, 1997). Post-tourists primarily consist of middle-class individuals who view oppositional travel as a valuable cultural experience and seek to differentiate themselves from conventional, modern, and mass tourists (Dujmović & Vitasović, 2015). In this study, the emphasis is on "postmodernism" as a "condition" and its impact on tourism destinations, approaches and the "cultural turn", as cultural scholars have mentioned (Jameson, 1998; Alexander, 1988) and not precisely on "postmodern tourism" as a specific term. One of the main changes in tourism definitions in the postmodern condition is the consideration of new categories and the importance of culture. One of them is food, cuisine, or gastronomic tourism, which is primarily characterised by its cultural aspects.

2. Gastronomy tourism

Gastronomy tourism centres on travel experiences focused on food and related activities. This form of tourism encompasses authentic, traditional, and innovative culinary experiences, including visits to local producers, attendance at food festivals, and participation in cooking courses (https://www.unwto.org/glossary-tourism-terms). Nowadays, tourism is facing various challenges, including climate change and environmental issues; thus, traditional concepts of tourism are no longer sufficient. Most approaches aim to make tourism more sustainable; consequently, new movements and activities are emerging. One aspect is that they pay greater attention to details and tourism businesses. Food and cuisine have always been inseparable from tourism. This is why "Gastronomy tourism", as a professional term in the tourism sector, is on the rise. Many international organisations are providing data on these perspectives, such as the United Nations tourism ambassadors for Sustainable Tourism, who come from diverse fields, including sport, entertainment, business, gastronomy, and more. As leaders in their respective fields, they volunteer their time and voices to amplify the message of tourism for sustainable development and equal opportunity. In recent years, the number of ambassadors has continued to grow, reflecting the sector's significance and diversity (https://www.unwto.org/un-tourism-ambassadors). Considering gastronomy as one of the tourist attractions, it is not solely about the dishes served, but also about the place and the people who are the hosts. From east to west, numerous efforts are made to create a positive impression for patrons as they enter, even if they are merely visiting for a meal. This experience is realised when all elements align—from the physical environment to the tastes and aromas, the hosts' behaviour, and the lasting memories formed in that space. That is why every detail matters here: the designs, plates, cutlery—everything, as if one is a guest in a thoughtfully prepared welcoming home (Figure 1).

Figure 1. A sample of a home café in Moscow, serving traditional foods and desserts with homely cutlery and décor (photo from the author's archive, June 2018)

One of the well-known examples of gastronomy and tourism in Iran is Rasht, which has been recognised as a Creative City[1] of Gastronomy by UNESCO since 2015. The Heritage Museum emphasises the importance of traditional cultural expressions, such as crafts, folk art, and gastronomy, with a particular focus on the distinctive cooking techniques that use Gamaj clay pots. Gastronomy plays a vital role in fostering community ties and facilitating intercultural and intergenerational conversations, while also serving as a significant catalyst for sustainable connections between urban and rural areas and promoting economic growth. To support this initiative, the city offers long-term loans designed to assist farmers. Furthermore, Rasht offers numerous workshops and vocational training opportunities in gastronomy, highlighting the sustainable production and consumption of nutritious food (https://www.unesco.org/en/creative-cities/rasht). As a Creative City of Gastronomy, Rasht aims to establish a local food museum to preserve and showcase traditional Guilanese food products and recipes, highlighting the region's indigenous culinary heritage.

Figure 2. Rasht's local foods (https://Isna.ir)

1 . For further reading on this concept, refer to "The Rise of the Creative Class" by Richard Florida.

The remarkable thing is that some of these spaces transcend mere establishments for food and drink; they serve as a creative central hub for gathering, experiencing, chatting, and fostering a sense of belonging. They are welcoming and enjoyable places for newcomers and locals alike. Over the years, sociologists and urban scholars have studied these spaces and proposed a new term to describe them, emphasising their characteristics. In the following, the concept of "third place" is described as one that can connect gastronomy tourism and urban studies within the cultural context.

3. Third place

While people in a bustling city spend time commuting and are occupied with work, some welcoming places open their doors to visitors, catering to the desires of both citizens and newcomers alike. A simple place to relax, chat with others, unwind from a hectic day, and enjoy the tastes and smells. Somewhere away from home, yet with the feeling of being at home. As urban sociologist Ray Oldenburg described, these places are the great and good places, the "third place".

He describes seven features for the third place, which include the following items (Oldenburg, 1991; Carmona, 2007):

1. As a Leveller, 2. Conversation is the primary activity. 3. Accessibility and accommodation. 4. The regulars. 5. A low profile. 6. The mood is playful. 7. A home away from home. This is a place that is generally inclusive and open to the public, with no official criteria for exclusive membership. People often select their companions, friends, and acquaintances from those who are socially akin to their class. The finest characteristic of a third place is conversation. Lively, exciting, and engaging talk, accompanied by smiles, winks, handshakes, pats on the back, and various gestures, serves as an initial indicator of the joy of being in a third place. This enthusiasm is maintained and sustained through enjoyable and entertaining conversations.

Third places that provide the best and most comprehensive services are those where people can go at any time of day or night, confident they will encounter familiar faces or someone to converse with. In fact, for anyone wishing to visit a third place, accessibility, location, and the time of use are highly important. A third place, as a physical space, is often straightforward. These venues, with simple decorations and comfortable, homely, informal furnishings, promote equality among all and foster numerous social interactions. Part of this lack of pretence also encompasses clothing; patrons do not come here to change or dress up as they might at home, but rather attend as they are. The overall atmosphere of a third place is not serious. It is characterised by enjoyment and harmony, with the motivation to continue being together. Therefore, anxiety and dissatisfaction have no place in such environments. Finally, while there may be distinctions between a home, defined as the centre of family life and a social unit formed by collective living, and a third place, the third characteristic of a home as "a loving environment" aligns well with most third places. Psychologically and in terms of the emotional support it offers, a third place closely resembles a good home. These places serve as venues for meeting, connection, and socialising. People typically visit locations that resonate with their self-image, self-concept, and social values. When individuals encounter a place that supports their social values, it is classified as a type of "meaningful" third place (Sugiyama et al., 2015, cited in Joo, 2020: 337).

Many third places are viewed as facilitators for fostering relationships through formal or informal activities, providing a physical space for building communities within society and enhancing social cohesion (Cabras & Mount, 2017: 72). These locations aim to offer meaningful design that resonates with users who understand and appreciate these values. This is how the interactions formed in these spaces enable one customer to influence another. The shared values and sense of loyalty among the patrons of these places reinforce the feeling of a common purpose in cultivating this community, bringing people closer together (Meshram & O'Cass, 2018).

Oldenburg's examples of third places include public spaces such as parks and plazas, as well as commercial spaces like cafés and pubs. This concept has also been applied to other semi-public places, including libraries, markets, chain restaurants, and even virtual spaces (Dolley, 2020: 3). Additionally, various studies from around

the world have examined other examples of the third place in their respective countries (Wohl, 2016; Dolley, 2020; Farash Khiabani & Shahabian, 2019). Many of these studies demonstrate that the connections formed in third places enhance relationships within neighbourhoods and various social groups, reduce loneliness and isolation, and foster a sense of security and belonging (Dolley, 2020: 3).

4. Methodology and background

Among the various research methods, this study employs a qualitative approach grounded in Creswell's five-category classification (Creswell, 2007). Of these five qualitative methods, this research selects ethnography as its approach. This research design facilitates broader investigations of individuals in diverse societies at both the city level and on smaller scales. As a qualitative approach, it centres on the stories shared by participants (Pardo & Prato, 2018: 38). In the urban context, urban ethnography emerged as a research method within the sociology department at the University of Chicago (Ocejo, 2013: 4-5).

It is essential to consider several key points during the ethnographic process. Time and its management are among the most critical factors, as the risk of inconclusive research is prevalent in ethnographic studies. Therefore, a specific timeframe should be established for this study. One of the most critical considerations in applying ethnographic methods is how to conduct the study from the outset to the conclusion. Thus, the process of implementing the method and the relationship with the ethnographer must be taken into account. A defining characteristic of the ethnographer is their long-term presence in the research context. In this study, considering that the researcher has been a frequent user and actively engaged in the studied spaces for over 10 years, spending considerable time in these environments and having served as a manager of one of these spaces for several years, along with previous studies conducted about these spaces, provides a strong foundation for familiarity with the places and their patrons. Following this, the research process is well-designed and illustrated in Figure 3.

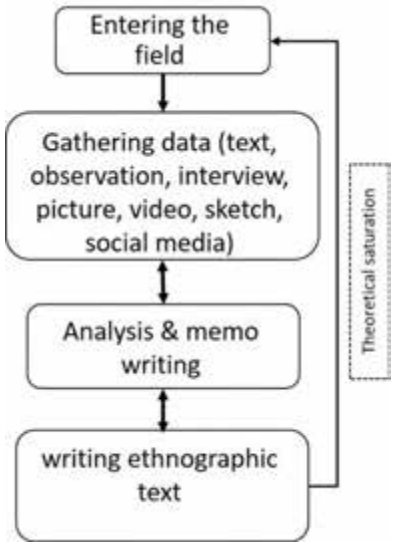

Figure 3. The process of applying the ethnographic approach (Farash Khiabani, 2021)

In applying the method within the cultural context of Tehran's central area, alongside the researcher's deliberate observations, 22 semi-structured, in-depth interviews were conducted. It is essential to note that the conditions and interviews carried out during the research process prompted the researcher to utilise snowball sampling, also known as network sampling or chain referral sampling. This method entails introducing the next member or case after establishing a connection with one of the initial cases (samples) (Blaikie & Priest, 2018). The process of data analysis and coding in this research is depicted in Figure 4. Moreover, all diverse outputs of ethnographic work, despite their differences, involve producing text that includes ethnographic analysis not only as a cognitive activity but also as a form of writing (Hammersley & Atkinson, 2007: 190). Thus, generating an ethnographic text is a key outcome of this research, which details the situation and functions of the studied locations.

• Interpreting and contextualising findings

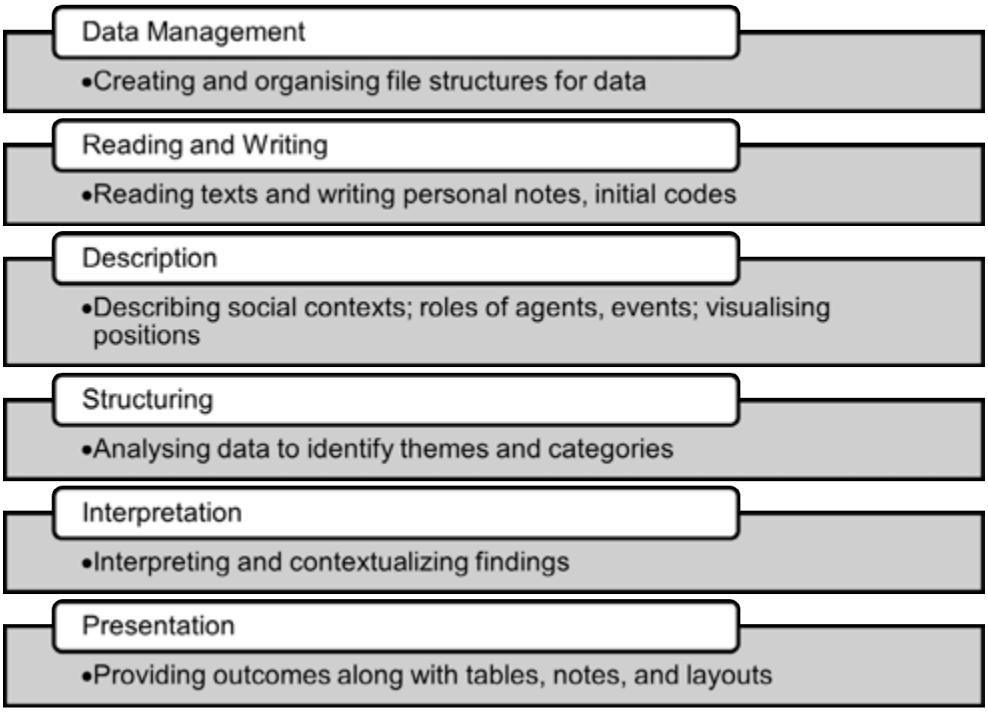

Figure 4. Data analysis and presentation based on the ethnographic research (based on Creswell, 2007).

Before exploring the contemporary cafés in Tehran, it may be beneficial to review various activities in cafes, their significance as tourist attractions, and their potential for future studies based on texts as this journey unfolds.

4.1. The potential of cafes

In the book 'The Starbucks Experience', the concept of the 'third place' is frequently referenced. While this book discusses the experience of this globally renowned coffee brand, the various store experiences worldwide affirm the brand's role as a third place from the author's perspective. Not only are the managers aware of this, but many customers across the globe also view these stores as their second home or the third place after home and work. Essentially, people enter environments where they feel personally valued and respected, fostering meaningful connections. Everything the coffee shop does is geared towards ensuring customers have a positive and perhaps joyful experience, whether it involves purchasing a quality drink or a food item. This third place must cultivate warmth and unique intimacy that set it apart from the first two places where most people reside, namely home and workplace (Michelli, 2006: 29). This is the very point that Christopher Alexander emphasises in his early sketches for the design of Lintz Café. He views the building as a place for ordinary people to rest. Every room, porch, and window is thoughtfully selected to create a comfortable environment—a place where each individual can feel completely at home (Alexander, 1981: 22).

Lintz Café is nestled in nature, embodying a distinctive identity shaped by its local surroundings. Referring to identity as the 'spirit', it is believed that the designer does not need to assign an abstract, intrinsic spirit to a place to create coherent meaning. In describing this place, Schulz considers the study of a locale as an examination of the events and occurrences that transpire there; thus, a collection of happenings, shapes, colours, smells, and textures forms the character or identity of a place. He establishes a connection between architecture, place, and cultural identity, asserting that the experience of being in a place is an experience of perceiving its meaning (Norberg-Schulz, 2000). These descriptions of certain well-known Western cafés serve as an introduction to high-

light their importance as essential and notable attractions. In the following, Tehran's cafés and their potential are viewed as inviting spaces for various groups.

4.2. Tehran's cafes

In numerous studies, Tehran is examined as a representation of political and social power (Farash Khiabani, 2021). The citizens of Tehran, possessing various forms of economic, social, and cultural capital, exhibit a significant degree of social control. A large portion of the country's population, comprising students or individuals with a university education and thus capable of influencing the masses, resides in this city. Cultural diversity and varying lifestyles should also be taken into account, as they contribute to the social fabric of this city. Conversely, Tehran's status as the capital and its centralist policies have fostered the multiculturalism of society, with the process of modernity being adopted here earlier than in other parts of Iran. In recent years, the renovation of old houses and shops for new commercial purposes has gained momentum, particularly in central Tehran. Recognising the value of these spaces and the interest from various artistic and cultural groups has significantly influenced this trend. The relationship between this perspective and the tourism sector is evident, as similar spaces can be found in cities such as Rasht, Isfahan, and Shiraz. These cities are part of an active tourism network rich in nostalgic signifiers and elements of Iranian identity, from architecture to cuisine. Tehran, along with the creation of small cultural spaces, presents imaginative and often fantastical representations of each of these cities.

In the history of this city, as the host of Iranian modern cafés (Figure 5), these establishments became venues for intellectuals and their gatherings. The modernisation process enabled women to visit cafés, transforming them into spaces that were no longer exclusively for men (Farash Khiabani & Goldar, 2024; Shahri, 1992)

Figure 5. Loghanteh Café, the symbol of Iranian modern Café, was located in the central district of Tehran during the Pahlavi period, as documented by the author from the Loghanteh Café Museum's archives in Tehran.

Tehran's cafés serve as valuable social hubs for local communities and are among the most popular tourist spots in Iran; however, they are unfortunately overlooked by the government. Despite this neglect, these venues, cherished by their patrons and supported by the private sector, have the potential to act as urban catalysts. By changing our perspective on them and recognising their capabilities, they can have a significant impact on the community. Since the 2010s, cafés have emerged as key symbols of contemporary culture, often maintaining a strong connection to historical identity with the aid of social media. Elements such as the cafés' interior and exterior design, including furniture, cutlery, and cuisine, significantly influence the business and are vital for attracting customers. The Digital Revolution has eliminated barriers, allowing cafés to cater to a broader audience beyond just students or specific social classes; they now accommodate families and people of various ages and backgrounds (Farash Khiabani & Goldar, 2024).

In Tehran, traditional Iranian buildings feature inward-facing courtyards, various rooms, porches, and balconies that protect against street noise, ensuring privacy and tranquillity. Cafés, galleries, bookstores, and mixed cultural spaces opening in old mansions represent new concepts that primarily change function without altering

the core elements of the original design and all building spaces during the reuse process. The narrative of space is equally significant. Some have been designed or created by renowned artists (such as the No. 14 gallery, by Nezam Ameri, a student and colleague of Frank Lloyd Wright), while others have left a lasting impression in users' minds. Regrettably, some of these spaces are losing their identity due to government mismanagement, and the private sector has been increasingly active in recent decades. By repurposing these locations as cafés or cultural hubs, a vibrant tourism movement is emerging in the central area of Tehran (Figure 6).

Figure 6. Reconstruction of a house and reusing it as a café (a sample of home-café) in the centre of Tehran by traditional and authentic Iranian items (photo by the author, April 2025)

One of the main special features of these places is their menu, which serves traditional Iranian foods and drinks. More so than typical restaurants, they offer local dishes from various regions of Iran, spanning from the north to the south (Figure 7). They celebrate the value of local or seemingly simple foods, such as Ab-Dugh-Khiar, Panir-Bureshte, and Baghali-ghatogh from Northern Iran, Bandari sandwich from the south, and Gheime-nesar from the centre, among others. Even some of the items that serve both cold and hot drinks are traditional Iranian items that are not easily found in other countries.

Figure 7. Panir boreshteh and Mirzaghasemi, Northern Iranian traditional foods, served in one of the central home-cafes in Tehran (Photo by the author, May 2025)

5. Discussion

This study's examination of Tehran's contemporary cafes reveals a tourism destination that emphasises a specific type of tourism: gastronomy. This cultural aspect serves as one of the attractions of these spaces, showcasing all their cutlery, accessories, furniture, and more (Figure 8). These destinations offer opportunities for postmodern tourism, thanks to their diverse attractions, including local interactions, historical sites, varied tourist demographics, authentic experiences, nostalgia, and small-scale businesses. By analysing customers' and visitors' perceptions of Tehran's contemporary cafes, particularly home cafes, over the past decade on social media (primarily through Instagram in Iran), we aim to uncover insights into the destination's image, including any shifts from traditional or luxury restaurants to a friendly, cosy, homely experience.

The account given by the sample interviewee about their experience at one of the locations during a semi-structured interview is as follows:

(A one-hour conversation with a 35-year-old woman):

"Whenever I have free time between my activities and since there's no chance to go home, the best option is to visit a café, enjoy a comforting drink or meal, read a book, have an engaging experience, and pass the time until my next task. The cosy atmosphere of this café makes it feel less formal than a restaurant. I love the aroma of coffee, traditional foods, and the rows of books nearby. Those who arrive here typically seek culture, a sense of familiarity, and a friendly atmosphere. Although my home is on the north side of the city (Pasdaran), I travel to the city centre for work, to visit cafés, and to socialise. This area is more my hangout spot; I feel a stronger connection with the people here. Music has also influenced my attraction to this environment; it is calming".

Figure 8. The collection of traditional kitchen items in Khaneye 1308 Café in Tehran (photo from the author's archive, January 2022)

Even during special periods like Ramazan, some café menus have changed to serve traditional items, regardless of whether one is fasting or not; these fresh and nostalgic offerings can capture customers' attention (Figure 9).

Figure 9. Persian Eftar in a café, special foods for Ramazan (Sangak bread, cheese, date, zoorbia bamie, soup and a cup of tea) (Photo by the author, April 2025)

5.1. Coding process

It is important to note that in qualitative research, the researcher employs classification-based reasoning alongside intuitive and implicit interpretations to identify findings that appear similar or evoke a sense of likeness, allowing for their grouping (Saldana, 2013: 14). Thus, the coding process can be tailored to align with the specific needs of the study (Ibid: 102). Table 1 illustrates the coding process employed in this research, as described in the methodology section, which facilitates the emergence of categories and themes, ultimately culminating in a

textual description of the cafés studied, along with the cultural context that develops within them.

One of the key features of the third type of spaces examined is the potential for dialogue and interaction within these environments. Cafés lead the way in this aspect. They have successfully attracted a diverse clientele across various age groups. Notably, those cafés situated in historic houses with open spaces and courtyards have managed to maintain a vibrant atmosphere and enjoy greater popularity compared to others that lack such elements. Beyond facilitating conversations among acquaintances, these spaces also promote interactions with strangers, fostering the formation of new connections. Social tables, individual and co-working areas, social tables, and conversations following meetings all provide opportunities for interaction among individuals who may not know each other. These venues create an environment conducive to familiarity and dialogue around shared interests. They play a significant role in shaping identity, while also being influenced by the identities of their users. This reciprocal relationship is highly effective in the development and evolution of these spaces.

Table 1. A sample of the coding process

Initial Coding	Categories	Themes
Chatting	Conversation	Authenticity
Conversation		
Friendly space	Entertaining and nice	Aesthetic
Laughter and happiness	Enjoy, Openness	
Calm environment	Peaceful	Friendly
Serene atmosphere		
Cozy place		
Free costume	Safety	Creativity
No unwelcome gazes or disparaging remarks in contrast to other public or semi-public spaces	Freedom	
Acting freely, without any authority	No judgement	Cultural vibe
Different groups	Variety, Diversity	
Easy to get by public transport or on foot	Accessibility	
Nostalgic items: cutlery, cups, plates, furniture,	Nostalgia	
Original tastes and smells	Originality	
Traditional and folk music	Genuineness	
Homy styles and smells	Identity	
Well-designed (building, furniture, cutlery, etc.)	Creativity Beauty	
Close to the essence of nature in the area, such as having a yard, flowers, and ponds	Natural and fresh	

Many of the dishes served in these cafés showcase authentic recipes from various Iranian regions, often presented in traditional settings. The café format lends validation to their authenticity. Furthermore, the inclusion of a selection of Iranian cold and hot beverages, crafted from herbal extracts, enhances the cafés' menus, making them exceptional, genuine, and diverse. These offerings are seldom found in luxury restaurants, allowing tourists to experience the authentic flavours of Iran. The cafés create a remarkable environment for new generations to connect with their cultural heritage while catering to contemporary needs, establishing them as post-modern destinations. The primary themes identified through the coding process characterise these venues as authentic, aesthetically mindful, creative, and friendly, all wrapped in a vibrant cultural atmosphere.

5.2. The ethnographic text

Elaboration and description of the study's findings, along with drafting the text, are considered critical stages in the ethnographic research process. In this method, the ethnographer, much like a writer, must craft a compelling narrative. The author's preferences and skills greatly influence the language and style employed in the writing. This text can take various forms, including a tale, description, analysis, interpretation, or thematic narration (Creswell & Poth, 2018: 442-443). While the primary draft of the text arising from this research is extensive, a sample paragraph summarising the key findings is provided below:

In today's Tehran, many downtown cafés have transformed into more than just establishments along the street; they have become homes away from home. These cafés seamlessly blend various activities, evolving into vibrant social and cultural hubs. They host exhibitions, sell cultural and artistic products, and provide spaces for dialogue and connection, offering a cosy and inviting atmosphere. These venues embody a particular way of life, serving not only a diverse selection of food and drinks but also functioning as platforms for interaction and conversation.

Several of these cafes are situated in historic buildings that resonate with Iranian identity, where the atmosphere, music, furniture, and decorations highlight traditional Iranian elements. Others are strikingly modern, embodying Tehran's contemporary character. Despite their visual disparities, all these establishments strive to be vibrant gathering places for socialising, storytelling, and the affirmation or reconstruction of cultural identity. Additionally, each cafe caters to its specific audience.

A notable aspect of these cafes is their function as places for a brief respite and relaxation. A primary reason for their widespread popularity is the prevailing sense of simplicity and intimacy within their atmosphere. From the exterior façade to the interior design, furnishings, details, and even the staff's attitude, there is an aura of authenticity and modesty. Luxurious or ostentatious elements have no place here. These characteristics contribute to making these spaces feel more like "homes." As a result, the food culture in these cafes often embodies a sense of homeliness and reflects local values.

Traditional Iranian beverages, including herbal syrups and native distillates from various regions, are favoured over sodas and modern drinks. Alongside international cuisines, local dishes from different Iranian ethnic groups are served, enriching the menu. Iranian stews and even forgotten recipes, which are seldom found in restaurants, play a crucial role in enhancing the dining experience. Older patrons visit these establishments to relive nostalgic memories and enjoy flavours that evoke their childhood homes, reminiscent of their grandmothers' cooking. Meanwhile, younger generations seek to connect with a bygone era, immersing themselves in the food and ambience of neglected spaces as they craft their own Iranian identity within a vibrant modern city, essentially searching for a piece of home.

In today's world, these cafés go beyond being simple establishments for dining and refreshments; they embody a "third place"—an enriching experience that few other venues can provide. These spaces offer a harmonious blend of colours, aromas, and flavours, set against an authentic backdrop enriched by the depth of Iranian culture, lending a greater significance to the experience.

6. Conclusion

Over the past two decades, cafés have become one of the main attractions and tourist destinations in the heart of Tehran. The recognition of the importance of Iranian vernacular architecture has spurred a movement to renovate historic buildings into vibrant cultural spaces and cafés. This repurposing of heritage homes not only helps in preserving the city's historical elements—both tangible and intangible—but also enriches the urban landscape. The flourishing economy has fuelled the aspirations of these café ventures, transforming them into sought-after locales.

These inviting venues offer a unique ambience that feels like home, allowing patrons to escape the chaos of the city. Visitors can engage with their surroundings, participate in informal activities and conversations, and connect with a diverse range of social groups. Cafés provide a sanctuary from modern loneliness, fostering a sense of security and belonging within the community. Notably, it is not just the architecture and physical features that attract visitors; the food, tableware, décor, and intricate details of culinary traditions are also celebrated, nurturing a deep appreciation and respect for the culture.

For many, these cafés evoke a sense of nostalgia, reminding them of the traditional Iranian image of old brick houses surrounded by lush gardens filled with fresh food and beverages. For newer generations, they symbolise a sense of meaning, identity and belonging to a setting that contrasts with their previous environments. While many cafés have devoted patrons, they also foster a welcoming atmosphere for newcomers. The establishments in historic Tehran serve a crucial function as tourist attractions, having evolved to accommodate contemporary demands in culinary offerings and cuisine. This adaptability not only enhances the cultural landscape but also fosters an environment that is both vibrant and inviting. By blending innovation with authenticity, these venues create a rich and immersive experience for visitors, thereby contributing significantly to the city's unique cultural identity.

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Research on the Correlation Between Tourists' Facial Emotion Perception and Street Spatial Elements Through Deep Learning: A Case Study of Traditional Tourism-Oriented Villages in China

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Abstract

The tourism-driven revitalisation of traditional villages has become a significant pathway to achieving historical and cultural heritage preservation and promoting rural revitalisation in the new era. Among these efforts, constructing the regional characteristics of the built environment in villages is a critical aspect of revitalisation. Tourists' emotional perceptions during their spatial experiences in tourism villages serve as an important evaluation metric for the localization characteristics of the space. This study investigates the correlation mechanisms between 13 spatial elements—such as spatial organization, morphology, and interface—and tourists' emotional types and intensity preferences based on the distribution characteristics of tourists' emotional perceptions in the street spaces of tourism villages. Facial expression images of tourists in different village streets were collected via smartphone photography, and a deep learning model, YOLOv5, was trained using a manually labeled dataset to recognize and quantify four types of emotions: smile, surprise, calm, and negative emotions. To enhance recognition accuracy, the model's performance was improved using techniques such as RGB value adjustment, flipping, and augmentation. Subsequently, a multiple regression analysis was conducted to identify the street space elements influencing tourists' emotional perceptions. The results indicate that the proposed model optimization methods effectively identified tourists' emotions under various scenarios with high accuracy. Regression analysis revealed that spatial segmentation factors of streets had a regression coefficient of 0.184, making it a key factor affecting tourists' perceptions. The findings identified five typical street space elements that positively influence tourists' emotions. Based on these results, recommendations for optimizing street space to enhance tourists' perceptions were proposed, offering support for improving street space tourism experiences and promoting the sustainable development of traditional villages.

Keywords: Facial expression perception; Deep learning; Alley space; Tourist Emotions; Yuan Family Village

1. Introduction

With the rapid development of tourism, the revitalisation of traditional village tourism has become an important way to preserve historical and cultural heritage and promote rural revitalisation. In this process, the construction of village built environment with regional characteristics is an important link. The emotional perception of tourists in the physical space experience of tourism villages has received increasing attention from researchers as an important indicator for evaluating spatial regionalisation characteristics. Since the 1960s, with a rethinking of modern urban planning dominated by functional zoning, there has been a growing emphasis on diverse and vibrant urban spaces [1]. Vibrant cities and streets enhance the happiness of residents and social cohesion[2] Urban street vitality has become an important indicator for assessing the attractiveness and potential of urban neighbourhoods for sustainable development[3] . Many design theories have been proposed to create a vibrant urban street space and a growing body of methodological and empirical research has been conducted on the role of relevant physical environment variables, such as street interface continuity, greening ratio, ground floor interface transparency, and commercial density, in fostering street activities and vitality[4]. It is postulated that AI may also be employed in the monitoring of human activities in urban settings. For instance, Yamadaetal. employed Deep Learning to assess the impression of a city, while Liuetal. utilised machine learning to construct buildings dedicated to the evaluation of the quality of maintenance management. Furthermore, technologies for the monitoring of shop-goers using cameras installed in shops are becoming increasingly feasible[5]. Existing research has mostly focused on the economic and socio-cultural impacts of tourism, with less attention paid to tourists' emotional responses in specific spaces. However, emotional perception, as a core component of tourists' experience, Not only affects tourists' overall impression of a tourist village, but also directly relates to their satisfaction and willingness to return. Therefore, it is of great theoretical and practical significance to explore the association mechanisms between the spatial organisation, morphology, and interface of streets and lanes and tourists' emotional types and intensity preferences.

2. Materials and Methods

2.1 Materials

Yuanjia Village, situated in Liquan County, Xianyang City, Shaanxi Province, is one of the second batch of traditional villages included in the list of traditional villages in China. It is a natural village with a long history in the Guanzhong area of Shaanxi Province(Figure 1). The location and layout of Yuanjia Village are centred on the base of the village, with a landscape pattern that reflects the traditional Chinese landscape pattern of "Facing the sunny side and backing the shady side, backed by mountains and facing water" This was a pattern that is typical of the Guanzhong area, and it was one that Yuanjiacun has better preserved and continued. The village was surrounded by mountains and by blue water. Secondly, Yuanjia Village was a popular tourist destination. As of 2023, the number of tourists visiting Yuanjia Village annually exceeded 8 million, with the village's annual tourism output value exceeding RMB 1.2 billion. [6]making it one of the villages with the highest number of annual visitors in the Shaanxi region. Based on the annual increase in tourist visitation and tourism revenue, Yuanjia Village was one of the traditionally successful villages in tourism transformation. The substantial number of tourists provided universality and data credibility for sampling to simulate and test tourist perceptions.

Therefore, the research focused on six typical streets within the core scenic area of Yuanjia Village (as shown in Figure 1): namely, Ancestral Hall Street (CT=248m), Muslim Quarter Street (HM=156m), Snack Street (XC=428m), Sanqin Ancient Street (SQ=704m), Academy Street (SY=413m), and Kangzhuang Old Street (KZ=383m).

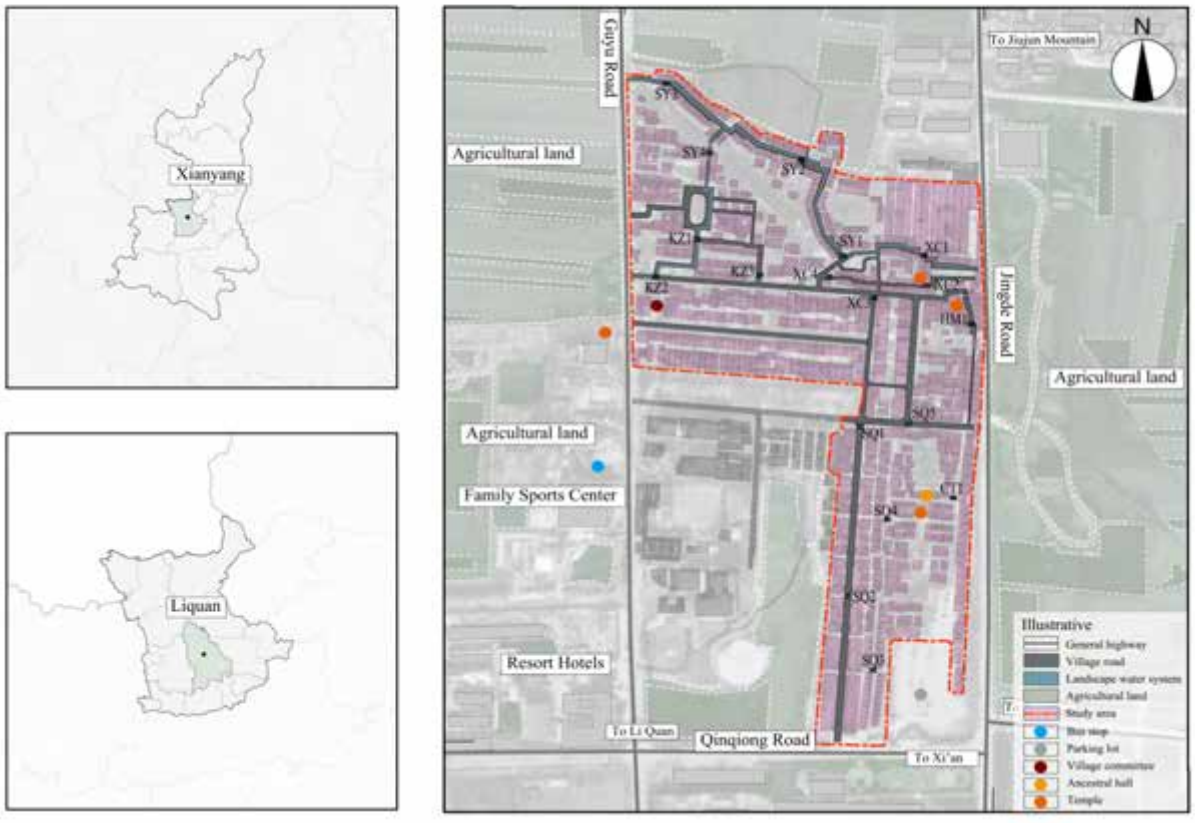


Figure 1 Location and Layout Plan of Yuanjia Village

2.2 Methods

Building upon previous studies, this paper proposes an improved YOLOv5 recognition model and pathway designed to more accurately and comprehensively capture facial information from photographs. Furthermore, it correlates optimised subjective perception values of tourist emotions with built environment contexts. Through multiple regression analysis, the study aims to explore the impact of the optimised approach on facial expressions and emotions of tourists in spatial environments.

2.2.1 Facial expression recognition based on YOLOv5

YOLO, as a mature algorithm in the field of deep learning, has demonstrated superior performance and practical feasibility in numerous domains and real-world applications. The facial expression analysis component of this study drew inspiration from the research of Shungo Noji[7], Liu[8], leveraging deep learning algorithms. By training deep learning models with real-world photos of different time periods and age groups, the study aimed to enhance the accuracy of facial expression recognition for specific populations in a designated area (where the images were collected). Furthermore, in subsequent experiments, the study hypothesized smile rates among different populations at various locations. In this study, the YOLOv5 model was employed (The YOLO-v5 model, which is based on a real-time object detection algorithm). The YOLO network was optimised to minimise the loss function as the training objective to achieve object detection. The YOLO network consisted of convolutional layers specifically designed for object detection tasks and included three key modules as illustrated in Figure 1: 1. Backbone network: This module was used to extract generic feature representations and served as a high-performance classifier network. 2. Neck network. The three convolutional networks collaborated to produce the final output of object detection results. In this training session, we employed common data processing techniques such as Shungo Noji. This included adjustments to the data such as angle rotation, flipping, and slight changes in colour and brightness to achieve more robust results. The model was pretrained using the COCO dataset and further fine-tuned and trained using a proprietary dataset. The proprietary dataset used in this experiment consisted of 1006 images collected in the autumn of 2023, with a resolution of 3840 x 2160 pixels. 85% of these images were used as the training dataset, and 15% were used as the test dataset to validate the efficiency and accuracy of the model.

In this experiment, the processed dataset underwent various data augmentation techniques, including colour variations, image flipping, and image overlays. Mild colour adjustments were applied, encompassing changes in brightness, contrast, and saturation to simulate different lighting conditions, thereby enhancing the model's adaptability to various lighting environments. Additionally, horizontal and vertical flipping of images was performed to help the model better handle variations in object orientations and improve its recognition capability. Through image overlays, we merged two or more images to create more complex scenes. This method helped the model learn how to accurately identify and locate objects amidst complex backgrounds and multiple object occlusions. These data augmentation techniques effectively increased the diversity and complexity of the training data, significantly boosting the model's robustness and generalization ability. This enhancement allows the model to more accurately detect and classify target objects in practical application scenarios of this experiment.

Emotions including Smile, Lugh, Neutral, and Negative Emotion were identified and quantified to determine the facial expression recognition across various street locations. This process culminated in calculating the subjective smile rate (E) for different streets by integrating the total number of recognized expressions, as detailed in the formula.(1):

$$E=(\sum Smile + \sum Lugh)/(\sum Smile + \sum Lugh + \sum Neutral + \sum Negative\ Emotion)$$

2.2.2 Selection and calculation methods of influencing factors

This study drew inspiration from previous research on measurement systems for street and lane indices[9[10], and integrated with the spatial characteristics of Yuanjiacun's streets and lanes, established an index system influencing tourists' emotional perception. These influencing factors were categorized into three aspects: spatial form, spatial function, and spatial interface (Figure 2).

Primary indicator	Secondary indicators	Description	Labeled Name	Assignment Description
Street scale and form	Scale of streets	Width	KD	/
		Ratio of street height to width	GKB	Average building height on both sides/street width
	Street of morphology	Relationship of Streets to Landforms	JX	Responding to the terrain
		Ground Level Elevation	DMTS	Whether the height difference between the transition space and the street space is significant
	Transition space	Space Separation	KJFG	Significant height difference between transitional space and street space
Street floor characteristics		Façade Setbacks/Extensions	LMHT/WY	Separation of spaces from the street through parapets, low walls, planters
	Permeability	Longitudinal Subgrade	ZSDM	ground-floor openings/extension to interior
		Longitudinal cross roads	ZXJCDL	Vertical alleyway entrance at ground-floor
	Curvature	Straight bottom elevation	PZDCLM	Vertical projection of ground-floor elevation is straight
		Curvature Curvilinear ground-floor	QZDCLM	ground-floor façade is clearly angled, projecting or recessed
Lane space function	Type of business	Six business types: hotel, food, shopping, attractions, entertainment, and public services	F	Assign values 1-6
	Business density	Density of commercial POI points per 10m street buffer zone	FD	FD=?POI_num/Road_length
	Business mixing degree	Street mix (diversity) is the mix of vitality-related POIs in the Street buffer.	FH	FH(X) = -?P(xi)logP(xi) (i=1,2,..n)

Figure 2 Classification and Assignment of Street Space Element Data

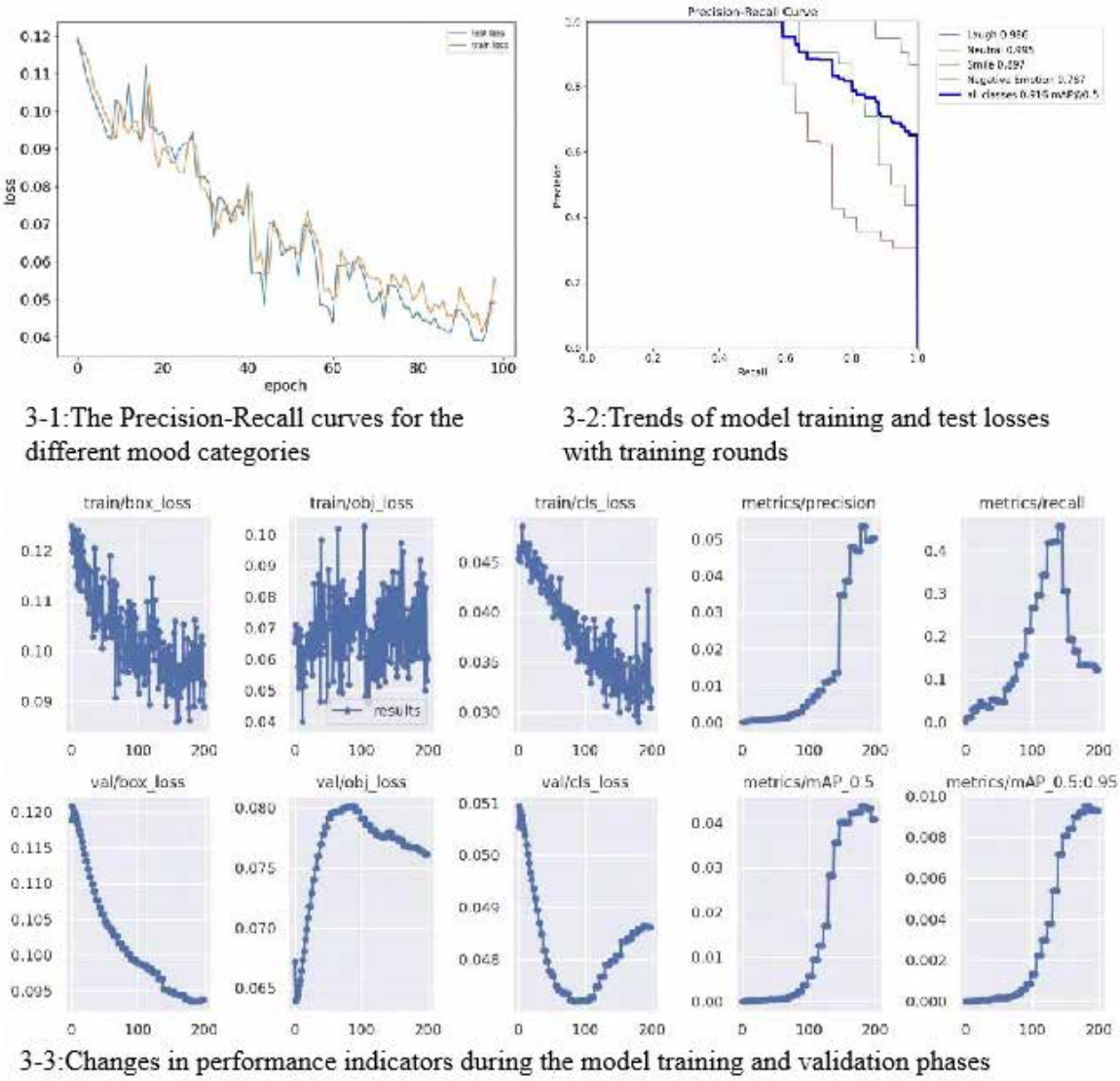
3. Discussion

3.1 A more efficient method for facial expression recognition

This study utilized Anaconda3 to construct the environment, ensuring stability and independence during model training and execution. Additionally, labelImg Python scripts were employed for manual annotation, and annotations were cross-checked by fellow research lab members to guarantee dataset accuracy. The implementation was based on the PyTorch framework, and training and testing were conducted on a single NVIDIA RTX A5000 GPU. To optimize the network, we utilized stochastic gradient descent (SGD) optimizer with a learning rate of 0.01 and momentum of 0.9.

To overcome challenges such as a small private dataset, significant outdoor lighting variations, and complex backgrounds, data augmentation techniques were employed. These included deformation, adjusting RGB values, flipping, and overlaying methods to enhance model robustness by augmenting the dataset. In terms of model performance metrics analysis, we achieved relatively high average precision (AP) values, indicating stable performance on the test data. The deep blue line in Figure 1 represents the average of the four classification results. Through multiple validations, AP values consistently exceeded 0.9, meeting the experiment's precision requirements (Figure 3-1). Additionally, Figure 3-2 illustrates the loss values during the training process. The experiment utilized test loss X and Y axes to monitor performance changes, aiming for minimal validation loss. As shown in the graph, with increasing epochs, the loss gradually decreased, indicating effective training.

In conclusion, graphical representations of AP values and loss values demonstrated expected progress in model training. Significant improvements in classification accuracy and continuous reduction in loss values validate the effectiveness of our approach.



3-1:The Precision-Recall curves for the different mood categories

3-2:Trends of model training and test losses with training rounds

3-3:Changes in performance indicators during the model training and validation phases

Figure 3 Detection of Tourist Facial Expressions Using Recognition Models

The graph depicted various performance metrics of our model during the training and validation phases (Figure 3-3). The horizontal axis represented training epochs, while the vertical axes indicated loss values and performance metrics. The graph was divided into two rows: the upper row illustrated performance on the training data, and the lower row showed performance on the validation data. Throughout the training process, both train/box_loss and train/cls_loss steadily decreased as training epochs progressed, indicating ongoing improvements in bounding box prediction and classification accuracy. Despite fluctuations, train/obj_loss exhibited an overall decreasing trend, signifying a reduction in object detection loss. Precision (metrics/precision) and recall (metrics/recall) on the training data demonstrated noticeable upward trends, underscoring enhanced precision and comprehensiveness in detection and classification tasks. During validation, significant declines were observed in both val/box_loss and val/cls_loss, further confirming the model's efficacy during training. However, val/obj_loss initially showed a minor increase followed by a decline, suggesting potential early-stage overfitting. Average precision on the validation set (metrics/mAP_0.5 and metrics/mAP_0.5:0.95) progressively improved, particularly within stricter threshold ranges (0.5 to 0.95), indicating consistent performance across diverse evaluation criteria and effective detection of various data types. In summary, these findings from the graphical representations underscored the anticipated advancements in model training, with enhancements observed across both training and validation metrics over successive epochs, validating the efficacy and resilience of our methodology.

Although there remained scope to enhance accuracy in recognizing negative emotions, this was attributed to the limited number of data samples for negative emotions and the imbalance in quantities across different data types. Overall, these metric fluctuations reflected effective training of our model and a steady improvement in performance. Despite fluctuations during training, the model consistently demonstrated strong learning capability and adaptability on both training and validation data, suggesting its potential for achieving favorable outcomes in practical applications ()

Figure 4 Target Recognition Performance of the YOLO-v5 Model in Different Scenarios

3.2 Spatial Distribution of Tourists' Emotions in the Streets and Alleys of Yuanjia Village

Based on the results of emotional recognition: In the SY area, the smile rate among tourists peaked at 35% in the afternoon, while negative emotions accounted for approximately 40%(Figure 5). This suggests that tourists' perception of the SY street area is average. In the XC area, the proportion of smiles and happiness was highest in the morning, reaching approximately 80%, with negative emotions accounting for about 20%. This indicates that tourists' perception of the XC street area is very positive. In the KZ area, smiles and happiness were most prevalent in the morning, accounting for approximately 50%, with negative emotions at about 25%. This suggests that tourists' perception of the KZ street area is relatively positive. In the CT area, the highest proportion of smiles and happiness occurred in the morning, reaching about 40%, while negative emotions made up around 30%. This indicates that tourists' perception of the CT street area is average. In the SQ area, smiles and happiness were most prominent in the morning, accounting for about 35%, while negative emotions reached approximately 40%. This suggests that tourists' perception of the SQ street area is relatively poor. In summary, emotional recognition revealed that the XC street area had the highest positive emotional perception (happiness and smiles), while the SQ street area had the lowest. Additionally, this method not only provides insights into the emotional perception of entire streets but can also statistically analyze the emotional distribution of specific sections within a street.

Figure 5 Spatial Distribution Of Tourist Sentiment Recognition Results

3.3 Analysis of the Correlation Between Smile Rate and Street Space

This study built upon the research methodology of Xu, Fang[11], Liu Y., et al. Aesthetic evaluation of streets and analysis of influencing factors based on deep learning and multi-source data: A case study of Shanghai. Int. Urban Plan 2023, 38(06), 48–58.]], as well as Liu Y. et al., employing multiple linear regression analysis to explore the correlation between smile rate and street spatial elements. By utilizing the optimised YOLOv5 model, the study achieved a more precise and detailed quantification of tourists' emotional responses across various street spatial locations. Combined with (Equation 1), this methodology assigned quantitative values to distinct street spatial locations. Subsequently, the influence of street spatial indicators on the evaluation of spatial perception was analyzed using multiple linear regression through SPSS. The corresponding formula is as follows:

$$E=\beta 0+\beta 1*GKB+\beta 2*KD+\beta 3*ZSDM+....+\beta 13*FD+e \qquad (1)$$

The regression analysis included coefficients through, with representing the constant term and denoting the error term. Post-regression diagnostics indicated that the tolerance values, calculated as, were all greater than 0.1, confirming the absence of multicollinearity among the independent variables. The Durbin-Watson statistic for the model was 1.429 (Table 1), suggesting that the assumption of independence in the residuals was met; The coefficient of determination (F=5.031, P=0.000<0.05) indicated that the model possessed limited explanatory power (Table 2. While a statistically valid model was constructed, its interpretability was moderate.

In summary, the analysis of the smile rate and the spatial correlation of the street reveals the following:

(1) Various elements of the spatial environment influence tourists' emotions, although the extent of this impact is relatively limited. The constructed regression model exhibits an R^2 value of 0.198, indicating that the current spatial elements account for only a small proportion of tourists' emotional perception. To enhance the explanatory power of the model, incorporating additional street spatial elements could be considered to expand the range of influencing factors. Alternatively, future studies could explore other dimensions or variables that might have a stronger impact on tourists' emotions.

(2) Based on the Beta coefficients, KJFG emerges as the primary factor influencing tourists' emotional percep-

tions, followed by KD, which also has a significant impact (Table). This finding differs from previous research. A possible explanation is that tourists tend to experience heightened expectations and positive emotions when transitioning to the next street space, leading to generally higher recognition data during the analysis. The FD factor also exhibits a strong influence, suggesting that higher commercial density within the street can enhance tourists' positive emotions. However, the Beta coefficient for ZXJCDL is -0.227, indicating a negative impact on tourists' emotions. This may be attributed to the vertically intersecting streets, which fail to evoke favorable emotions. By contrast, winding streets appear to provide a more engaging and emotionally positive experience for tourists during their visits.

In conclusion, this study's findings are based on the existing data on tourists' emotions and the spatial organization, morphology, and interface elements associated with street spaces as discussed. The analysis identified five typical street spatial elements—F, FD, QZDCLM, KD, and KJFG—that have a positive impact on tourists. These elements could be prioritized in street space construction and planning to increase their proportion, enhance functional diversity, and improve the quality of transitional spaces between streets. Such measures would contribute to enriching the street space experience and promoting the sustainable development of tourism-oriented traditional villages.

Table 1 Model summary

Model	R	R 2	Adjusted R 2	Standard Skewness Error	Durbin-Watson
1	0.445a	0.198	0.159	0.069929	1.429
a. Predicted value: (constant), F, DMTS, GKB, LMHT_WY, ZSDM, JX, KJFG, QZDCLM, FH, FD, ZXJCDL, KJFG, KD					
b. Dependent variable: E					

Table 2 Analysis of variance (ANOVA) [a]

Model		Sum of Squares	df	Mean Square (MS)	F	Significance
1	Regression	0.295	12	0.025	5.031	0.000b
	Residuals	1.193	244	0.005		
	Statistics	1.488	256			
a. Predicted value: (constant), F, DMTS, GKB, LMHT_WY, ZSDM, JX, KJFG, QZDCLM, FH, FD, ZXJCDL, KJFG, KD						
b. Dependent variable: E						

Table 3 The results of linear regression analysis between tourist behavior perception and street space elements

Model	Unstandardized Coefficients		Standardized Coefficients	T	Significance	Collinearity statistics	
B	Standard Error	Beta			Tolerance	VIF	

	(constant)	0.183	0.052		3.486	0.001		
	F	0.002	0.005	0.022	0.369	0.712	0.901	1.110
	FD	0.087	0.089	0.119	0.976	0.330	0.221	4.518
	FH	-0.121	0.082	-0.156	-1.477	0.141	0.293	3.415
	ZSDM	-0.026	0.011	-0.156	-2.331	0.021	0.731	1.368
	ZXJC DL	-0.035	0.011	-0.227	-3.270	0.001	0.680	1.471
1	QZDCLM	0.006	0.013	0.041	0.498	0.619	0.475	2.106
	GKB	-0.010	0.006	-0.188	-1.698	0.091	0.269	3.723
	KD	0.003	0.002	0.147	1.284	0.200	0.252	3.967
	JX	-0.027	0.012	-0.168	-2.274	0.024	0.602	1.661
	DMTS	-0.005	0.012	-0.025	-0.388	0.698	0.765	1.308
	KJFG	0.032	0.013	0.184	2.531	0.012	0.625	1.600
	LMHT_WY	0.000	0.013	-0.001	-0.016	0.987	0.774	1.292

a. Dependent variable: E

4.Conclusions

In addition to being influenced by the spatial environment, tourists' emotional perceptions are affected by various other factors, such as their personal mood, conversations with companions, and weather conditions. This study proposes a novel method for identifying emotional states through image-based deep learning, enabling a detailed depiction of tourists' emotional feedback and changes during their visits. This approach offers a new tool for evaluating and providing feedback on spatial environments. By analyzing the distribution characteristics of tourists' emotional perceptions in the street spaces of tourism villages, this study explores the correlation mechanisms between 13 spatial elements—including spatial organization, morphology, and interfaces—and tourists' emotional types and intensity preferences. Through multiple regression analysis, it was found that the spatial segmentation factor of streets had a regression coefficient of 0.184, making it a key determinant of tourists' perceptions. Additionally, five typical street spatial elements were identified as having a positive influence on tourists. Based on these findings, this study proposes optimization strategies for enhancing tourists' emotional perceptions within street spaces. These recommendations aim to improve the street experience and support the sustainable development of traditional villages.

Acknowledgement

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Correlation Between Street Space and Tourist Behavior in Tourism-Oriented Traditional Villages Under Distinct Development Models: A Case Study of Yuanjia Village, Shaanxi Province

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Abstract
Tourism development in traditional villages acts as a critical catalyst for local economic development, functions as an essential foundation for the conservation of historical and cultural heritage, and operates as a strategic mechanism for advancing rural revitalization. In recent years, alongside China's rapid economic growth and urbanization, traditional villages have confronted the dual pressures of modernization while simultaneously embracing unprecedented developmental opportunities. Tourism development in traditional villages plays a pivotal role in safeguarding cultural heritage. Leveraging tourists' experiential engagement in traditional villages to achieve the conservation and promotion of historical and cultural heritage under tourism-driven economic frameworks constitutes a critical strategy for the protection and sustainable development of tourism-oriented traditional villages. In the development of tourism-oriented traditional villages, distinct development models exert differential impacts on the functional integration of traditional cultural elements with modern tourism services in village streets and their corresponding spatial configurations, thereby shaping tourists' behavioral characteristics. Investigating this perspective constitutes a critical component in achieving the aforementioned objectives. Current research predominantly focuses on analyzing street space and tourist behavior under singular development models, yet it lacks a holistic exploration of how multiple development models organize the interplay between traditional cultural elements, modern tourism functions, and morphological configurations in tourism-oriented villages, as well as their collective impact on tourist behavior. This study addresses this gap by examining Yuanjia Village in Shaanxi Province, China, with a specific focus on street spaces under three development models: village collective-led development, developer-led development, and village-enterprise cooperative development. It investigates the correlation between the functional complexity and morphological diversity of street spaces and key tourist behavioral metrics—including walking speed, dwell time, and interaction patterns—across these development paradigms. In data collection, street space elements—comprising 13 objective indicators related to the integration of traditional cultural and modern tourism functions, as well as morphological diversity—were assessed through POI data crawling, field surveys, and scoring-based categorization, while behavioral metrics, including tourist walking speed, dwell duration, and interaction patterns, were captured via fixed-point video recordings to construct a composite subjective behavioral index. In data analysis, a multiple regression model was constructed to examine the relationships between tourist behavior and street space elements, enabling a quantitative assessment of the relative impacts of traditional cultural and modern tourism spatial elements on tourist behavior across distinct development models. Leveraging the empirical findings, this study further conducted a granular dissection of the causal mechanisms underlying the interplay between street space configurations and tourist behavior under the three development paradigms, thereby uncovering the nuanced interaction mechanisms inherent to these dynamics. This study applies a systematic analytical framework that integrates both subjective and objective elements, bridging the research void on the interplay between street space organization and tourist behavioral dynamics under multiple development models within an integrated tourism-oriented traditional village. It further delineates how the coordinated organization of multi-modal street spaces can harmonize tourism-driven growth with the safeguarding of cultural heritage. Methodologically, this study introduces a quantitative approach combining fixed-point video recording and POI data crawling, which enhances the comprehensiveness and precision of data acquisition. thereby providing a methodological framework for spatial-behavioral research in tourism-oriented traditional villages.

Keywords: Tourist Behavior; Street Space; Shareholding Cooperativ

1. Introduction

In recent years, the Chinese government has introduced pivotal policy documents such as the Guidelines for Promoting Sustainable Rural Tourism Development and the 14th Five-Year Plan for Tourism Development, outlining explicit directives for rural tourism and revitalization. These policies emphasize core principles including "inheriting and promoting outstanding rural culture," "highlighting the cultural distinctiveness of rural tourism," and "preserving rural characteristics." Driven by these initiatives, the rural tourism industry has experienced rapid growth, with substantial capital inflows significantly boosting local economies. However, this capital-driven development model has also generated pronounced negative externalities, notably homogenization issues such as over-commercialization, convergence of development approaches, and redundancy in tourism offerings, ultimately leading to monotonous visitor experiences and the erosion of rural identity. This phenomenon has gar-

nered significant scholarly attention. Early research predominantly focused on the positive economic impacts of tourism, but since the 1960s, scholars have increasingly examined its ecological consequences. The seminal work of Wall and Wright (1977) conceptualized the "tourism environment" as natural ecosystems and rigorously analyzed impact mechanisms, methodologies, and environmental carrying capacities[1]. Subsequent studies expanded these discussions, with recent scholarship prioritizing the balance between economic, environmental, and social outcomes in sustainable development[2]. Notably, research on tourism's socio-cultural impacts has gained momentum, emphasizing resident attitudes, community perceptions, and evolving tourist behaviors—reflecting heightened concerns for cultural heritage preservation and vernacular authenticity[3].

In recent years, China's rural tourism development has exhibited a marked shift toward sustainability and place-based differentiation[4]. Against this backdrop, traditional villages such as Xidi[5]and Hongcun[6] in Anhui Province have garnered significant attention for their unique spatial value and sustainable development models. Academic research has advanced multidimensionally: theoretically, scholars employ the "spatial genome[7]" framework to decode vernacular spatial characteristics; methodologically, studies tracking tourist behavior[8] and emotional perceptions[9] reveal interaction mechanisms between built environments and visitor experiences[10]; and design-wise, innovative concepts such as regional identity integration, scale moderation, and user-need alignment[11] have been proposed. Furthermore, an increasing number of studies are exploring spatial environment design methods from the perspective of tourist behaviour. These studies suggest that tourist behaviour is influenced by a combination of individual tourism purposes, the built environment[12], the social environment[2], social governance[13] and other factors. Scholars have approached this topic from dual perspectives: On one hand, studies analyzing tourists' spatial usage patterns and behavioral activities[14] have elucidated the interplay between built environments and visitor behaviors [15]. On the other hand, research examining behavioral metrics like dwell time, walking speed, and spatial vitality has informed evidence-based design principles for optimizing pedestrian-oriented environments. On the other hand, studies analyzing behavioral metrics such as dwell time, walking speed [16], and spatial vitality [17], alongside their interactions with the built environment, have proposed critical design principles for pedestrian-centric spaces. However, current research exhibits significant limitations: most studies focus on spatial analyses or behavioral observations under irregular development models, lacking systematic comparisons of functional hybridity and morphological diversity across development paradigms. Furthermore, they fail to thoroughly investigate the specific mechanisms through which these spatial characteristics influence tourist behavior. This research gap critically impedes a holistic understanding of the spatial-behavioral interaction mechanisms in tourism-oriented traditional villages.

Building on this foundation, this study selects Yuanjia Village in Shaanxi Province as a representative case. Through POI data crawling and field surveys, we quantified 13 functional and morphological indicators of street spaces under three development models: village collective-led development, developer-led development, and village-enterprise cooperative development. Concurrently, fixed-point video recording technology was employed to document tourist behavioral metrics, including walking speed, dwell duration, and interaction patterns. This integrated approach establishes a hybrid analytical framework that synthesizes subjective behavioral data with objective spatial parameters. This study utilises a multiple regression model to quantitatively analyse the intensity of the influence of street space elements on tourists' behaviours under different development modes and their intrinsic mechanisms. This analysis addresses a research gap concerning the interaction between street space and tourists' behaviours in traditional villages under the background of multi-modal development. The study provides a theoretical basis and a practical guide to the planning and management of tourist-type traditional villages. Methodologically, the integration of POI (Points of Interest) data with video analytics techniques enhances the comprehensiveness and precision of data acquisition, offering novel methodological frameworks for advancing research in this domain. The present study aims to reveal the influence of different development modes on the street space of traditional villages and tourists' behaviours. To this end, the functional organisation and morphological characteristics of the street space under the three development modes will be systematically examined, and their correlation with tourists' behaviours will be analysed. The study will provide a scientific basis for balancing the cultural protection and economic benefits in the development of tourism to promote the sustainable development of traditional villages.

2. Study area and target audience

Yuanjia Village, situated in Liquan County, Xianyang City, Shaanxi Province, constitutes the second group of traditional villages to be included in the Chinese traditional villages list. It is a natural village with a long history in Guanzhong, Shaanxi Province. Yuanjia Village has a significant number of tourists. As of 2023, Yuanjia Village has witnessed annual tourist visits exceeding 8 million, with its total annual tourism output value surpassing 1.2 billion Chinese yuan[18], establishing itself as one of the villages in Shaanxi Province with the most consistent visitor numbers throughout the year. The year-on-year growth in tourist visits and tourism revenue demonstrates that Yuanjia Village has emerged as a representative case of traditional villages achieving successful tourism-oriented transformation. The substantial visitor influx provides robust support for data collection on visitor behavior. Furthermore, the spatial configuration of Yuanjia Village's streets and alleys has evolved organically alongside the village's developmental trajectory. Notably, the tourism-oriented street spaces originated from early initiatives by the collective shareholding cooperative, particularly the Snack Street (XC) and Kangzhuang Street (KZ)The sustained year-on-year growth in tourist visits and tourism revenue positions Yuanjia Village as a paradigmatic case of traditional villages achieving successful tourism-oriented transformation. The substantial visitor base provides a robust empirical foundation for behavioral data collection, while the spatial evolution of its street network reflects adaptive development aligned with phased growth strategies. Specifically, the tourism-oriented street system originated from early-phase initiatives led by the collective shareholding cooperative, including the Snack Street (XC) and Kangzhuang Street (KZ). This developmental trajectory progressed to an intermediate phase characterized by land lease agreements to address financing constraints, enabling external developers to independently construct heritage-themed commercial spaces such as Sanqin Ancient Street (SQ); The later phase witnessed collaborative developments between the village collective and external developers, yielding culturally hybrid spaces such as the Academy Street (SY), Hui Muslim Cultural Street (HM), and Ancestral Hall Street (CT). The collective shareholding cooperative model, unique to rural tourism street development, exhibits distinctive spatial production characteristics and operational mechanisms that diverge fundamentally from urban development paradigms. In contrast, the developer-led model epitomizes conventional urban development approaches, often plagued by homogenization and unsustainable overexploitation of cultural resources. The joint venture development model embodies hybrid urbanization characteristics, reflecting a coordinated approach that integrates rural-urban spatial governance. Accordingly, this study conducts an empirical investigation across six street spaces representing Yuanjia Village's three development models (Figure 1). Tourists across these streets were selected as study subjects, with spatial metrics including architectural interfaces, pedestrian flows, and cultural signage systematically documented and statistically analyzed. This study focuses on examining street spaces under distinct development models in Yuanjia Village. Within its physical built environment, these three models are interwoven, with each manifesting unique spatial configurations, operational mechanisms, and visitor engagement patterns that collectively shape heterogeneous experiential landscapes. Analyzing variations in visitor experiences holds critical implications for evaluating and reflecting on existing built environments, offering empirical insights and transferable frameworks for implementing moderate tourism development strategies in traditional villages.

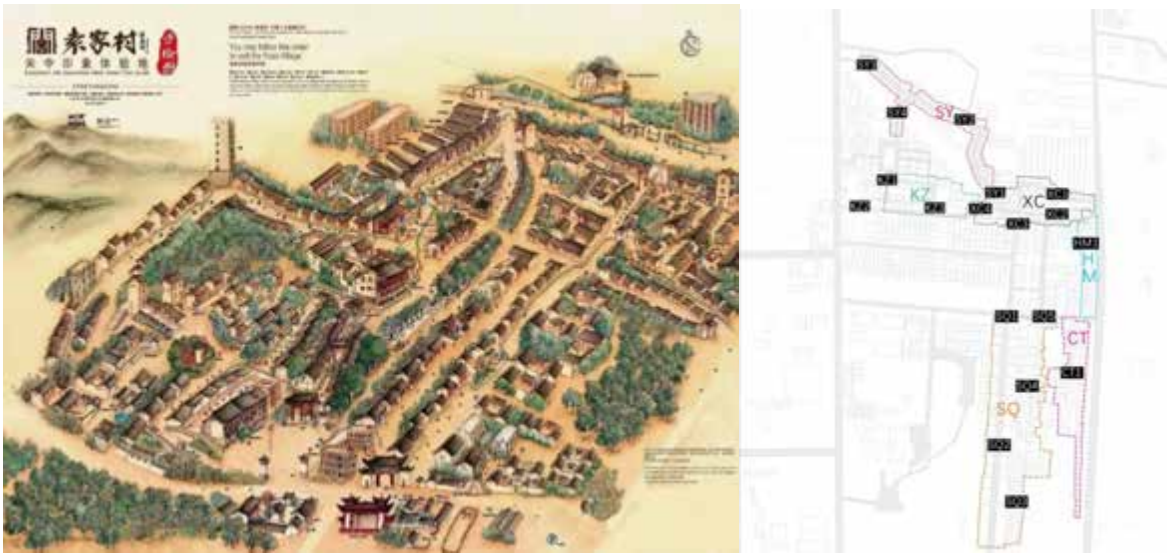

Figure 1 Yuanjia Village Illustrated Map (Left: Source: Yuanjia Village) and Key Street Plan(Right: Source: Author)

3. Research Methods

This study employs Yuanjia Village in Shaanxi Province as a case study, integrating fixed-position video recording with POI data analysis to systematically examine the dynamic interplay between street spatial configurations and visitor behavior patterns across three distinct development models: collective shareholding cooperative development, developer-led independent development, and joint venture collaborative development (as illustrated in Figure 2). The data collection protocol involved selecting representative streets under different development models within the core tourist area as observation sites. Between August and October 2024, video recording sessions were systematically conducted across weekdays and holidays using temporal segmentation (09:00-13:00; 13:00-17:00). Each observation site captured 5-10 minute behavioral episodes sampled hourly, ensuring temporal validity and comprehensive coverage of activity patterns. Video analytics were employed to extract behavioral metrics including pedestrian walking speed (calculated via fixed-distance traversal time), dwelling duration, and interactive acts such as consumption behaviors, photo documentation, and scenic observation. Concurrently, through the integration of POI data scraping and field investigations, thirteen quantitative indicators were systematically assessed to characterize the functional composition, environmental performance, and morphological patterns of street spaces. The analytical framework incorporates multiple regression modeling to quantify the influence of spatial metrics on behavioral characteristics, complemented by comparative analysis to unravel the mechanistic variations across distinct development paradigms. This research pioneers the integration of behavioral observation and spatial quantification methodologies, establishing an empirical foundation for spatial optimization in traditional village tourism development while also advancing a transferable methodological framework for related interdisciplinary studies.

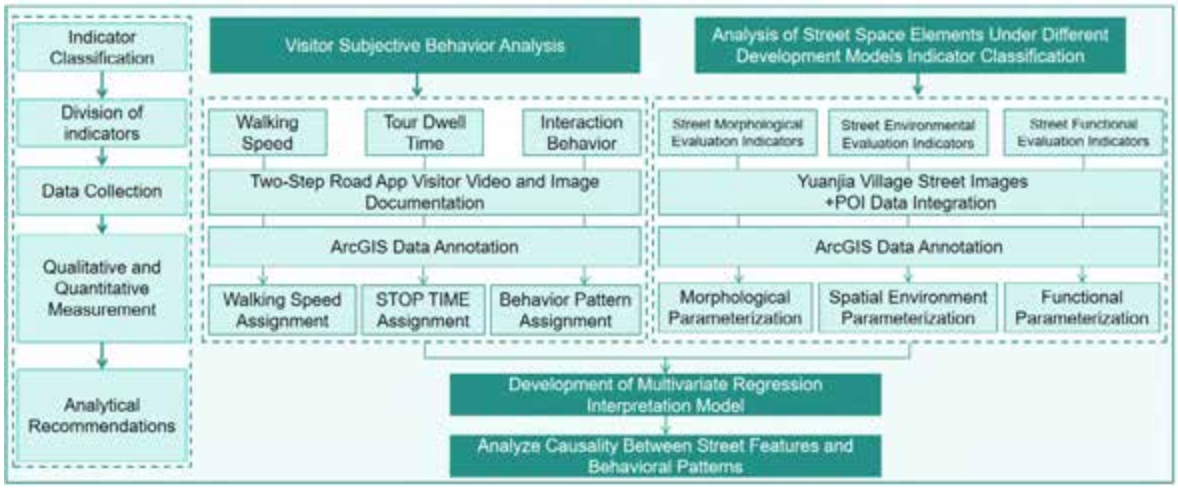

Figure 2 Methodological Framework

3.1 Construction of Perceptual Behavioral Metrics for Visitors

3.1.1 Assigning values to visitors' walking speed, length of stay and interaction pattern indicators

The post-processing of video recordings combined with crowd analytics yielded three principal behavioral metrics: walking speed (S), dwelling duration (D), and interaction patterns (J). Walking speed was categorized as slow pedestrian movement (<0.8 m/s), moderate pace (0.8–1.2 m/s), and accelerated transit (>1.2 m/s). Dwelling duration thresholds were defined as short-term stays (0–5 minutes), medium-term engagement (5–10 minutes), and prolonged occupation (10 minutes). Interaction patterns were quantified through proportional distributions of activity typologies across street segments, including commercial transactions, cultural engagements, and social congregation behaviors. The statistical outcomes of walking speed (S), dwelling duration (D), and interaction patterns (J) were systematically categorized and ranked using the Natural Breaks (Jenks) classification method. This analysis accounted for spatial heterogeneity across distinct street segments and temporal variations between morning and afternoon periods. A weighted ordinal scoring system (1, 3, 5, 7, 9) was applied to quantitatively characterize behavioral-spatial correlations, with values calibrated through iterative field validation cycles to reflect empirical observations of pedestrian-environment dynamics.

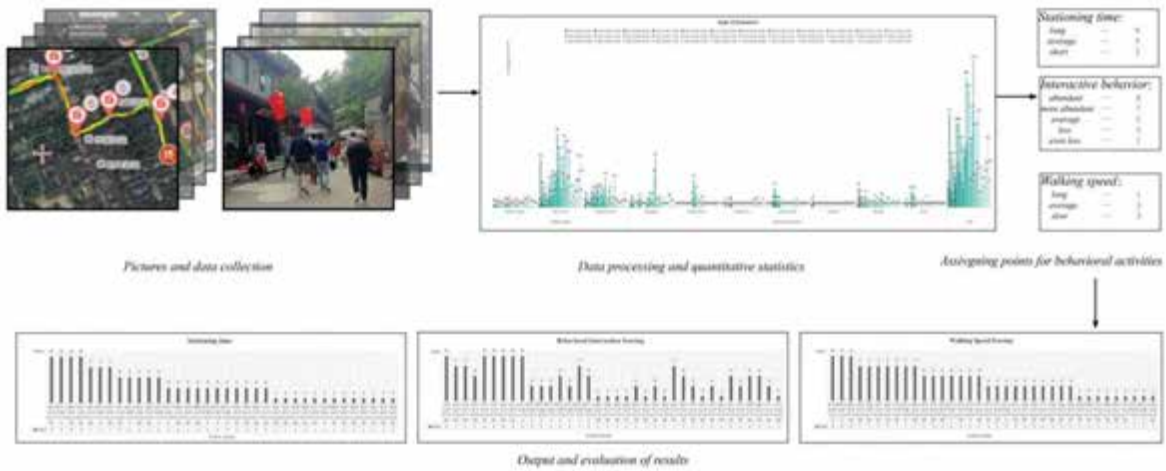

Figure 3 Behavioural and spatial data collection processes

3.1.2 Aggregate Subjective Behavioural Characteristics Index of Tourists

The composite subjective behavioural profile index (P) of tourists was influenced by walking speed (S), dwell time (D), and interaction mode (J). The amalgamation of the tourist interviews and the extraction of the subjective perception weights of these three factors (β1 = 0.18, β2 = 0.35, and β3 = 0.47) resulted in the formulation of a formula for calculating the subjective behavioural index (see Equation1). This subjective behavioural score was then used to correlate to the POI crawl points. It is evident that elevated scores on the Subjective Behavioural Characteristics Index (P) are indicative of enhanced behavioural dynamism, thereby signifying that visitors encounter a more positive experience in the village's street and shop environments.

"P=β1*S+β2 *D+β3*J" (1)

3.2 Indicators of spatial environment elements in streets

In this study, the work of Xu Leiqing [14], Zhang Zhang [8], Long Ying [20] and other experts in the field of street index measurement systems is referred to, in addition to the research group [9] in the Yuanjia Village street spatial elements of the system based on the proposed spatial elements of the index for the different development modes. In consideration of the aforementioned references and the premise of data availability, the indicators affecting the evaluation of street characteristics are classified into three major categories and 13 subcategories (see Figure 4). The first element to consider is the street spatial morphology, which includes the street width, street morphology, morphology scale, height-to-width ratio, and openness, amongst other factors. The second element is indicators of the street environment category, including street furniture and the green water system. The third element is indicators of the street functionality category, including the catering function, the entertainment function, leisure shopping function, attraction function, and accommodation function of the locality.

Category	Indicators	Label Name	Description	Scoring
Morphological Indicators	Overall Spatial Form (Length-Width Ratio)	CKB	Linear street form	1 (Linear Type)
			Enclosed street form (tending to cluster)	3 (Cluster-Leaning Linear)
			Independent clustered space	5 (Cluster Type)
	Single Store Scale	GM	Floor area ≤ 100㎡	1 (Small Floor Area)
			Floor area > 100㎡	3 (Large Floor Area)
	Distinctive Features	TSFM	Modern urban style, non-local materials	1 (Weak Distinctiveness)
			Guanzhong rural characteristics, locally sourced materials	3 (Strong Distinctiveness)
	Height-to-Width Ratio	GKB	Average building height / street width: ≥2	1 (Weak Enclosure)
			Average building height / street width: 1–2	3 (Medium Enclosure)
			Average building height / street width: 0–1	5 (Strong Enclosure)
	Interface Openness	OD	OD = Open length / Total interface length: 0–0.25	1 (Compact Interface)
			OD = Open length / Total interface length: 0.25–0.5	3 (Moderate Interface)
			OD = Open length / Total interface length: 0.5–0.75	5 (Open Interface)
Environmental Indicators	Modern Street Furniture	ZYBD	Street furniture (tables, chairs, sunshades, etc.)	1 (None)
				3 (Available)
	Local Characteristic Furniture	DYTSBS	Traditional items (millstone, roller, oil press, etc.)	1 (None)
				3 (Available)
	Landscape Environment	JGSX	Water features, greenery	1 (None)
				3 (Available)
Functional Indicators	Dining Function	CYGN	Diverse foreign cuisines (Korean, Western, desserts, etc.)	1 (None)
			Local specialty cuisines (noodles, spicy noodles, dumplings, etc.)	3 (Available)
	Entertainment (Gaming Experience)	YLGN	Foreign entertainment (haunted houses, amusement parks, live-action CS, etc.)	1 (None)
			Local experiential activities (tea drinking, opera, etc.)	3 (Available)
	Leisure & Shopping Function	XXGW	Foreign goods (accessories, toys, general merchandise, etc.)	1 (None)
			Local specialty goods (chili powder, yogurt, tofu, sesame twists, etc.)	3 (Available)
	Scenic Tourism Function	JDLY	Modern artificial attractions	1 (None)
			Historical-cultural attractions (Temple of Wealth, Guanyin Temple, Qin Qiong Tomb)	3 (Available)
	Accommodation Function	ZSGN	Foreign modern lodging (large hotels)	1 (None)
			Local characteristic lodging (Guanzhong-style hotels, designer B&Bs, rural homestays)	3 (Available)

Figure 4 Indicators of the spatial environment elements of streets and description of the assigned values

4. Result

4.1 The analysis of visitor behavioral characteristics derived from empirical data collection

This study employs temporal-spatial sampling analysis of visitor behavior video data from Yuanjia Village (10:00-13:00 and 13:00-17:00 daily, with hourly sampling of 5-10 minute segments), yielding 1,112 valid visitor trajectories through behavioral recognition algorithms and manual verification. The data reveals pronounced disparities in visitor distribution across streets with distinct development models: Collective Shareholding Cooperative-led Food Streets demonstrated the strongest visitor attraction, accounting for 47.3% of total footfall. Collaborative Development Streets (SY/CT/HM) collectively captured 27.4% of visitor flows. Developer-operated Heritage Commercial Street (SQ) showed the lowest engagement at 25.3%, indicative of potential cultural authenticity dilution in externally managed spaces. With regard to behavioural characteristics, the movement status data of 755 visits revealed the walking rate characteristics, while the stopping status data of 357 visits (see Figure 5) was used to analyse the length of stay and interactive behavioural patterns (see Figure 6). This data collection scheme lays a solid empirical foundation for subsequent in-depth analysis of tourist behavioural characteristics. Statistical analysis of visitor behavioral data in Yuanjia Village reveals distinctive patterns across three dimensions: walking speed, dwelling duration, and interactive behaviors. Regarding locomotion metrics, Snack Street (XC/KZ) exhibits the highest proportion of slow-paced pedestrians (≤0.8 m/s: 10.5%), significantly exceeding Sanqin Ancient Street (SQ: 5.1%) and collaboratively developed streets (SY/CT/HM: 5.4% combined). Notably, SQ demonstrates an exceptional prevalence of rapid pedestrian movement (>1.2 m/s: 8.9%), far surpassing the global average (1.7%), while collaborative development streets display polarized speed distribution (≤0.8 m/s: 23% vs. >1.2 m/s: 1.7%). In temporal engagement patterns, Snack Street achieves superior visitor retention (69.27% dwell ≥10 minutes),

contrasting sharply with SQ's transient visitation profile (≤5 minutes: 43.75%; ≥10 minutes: 8.33%). Regarding interaction patterns, the Snack Street (XC/KZ) with its diversified commercial ecology fostered multifaceted tourist engagements, whereas the monofunctional SQ Street exhibited pronounced behavioral homogenization in visitor activities. These findings provide empirical evidence for understanding behavioral divergences across development paradigms and offer critical insights for optimizing tourism spatial planning through context-sensitive design interventions.

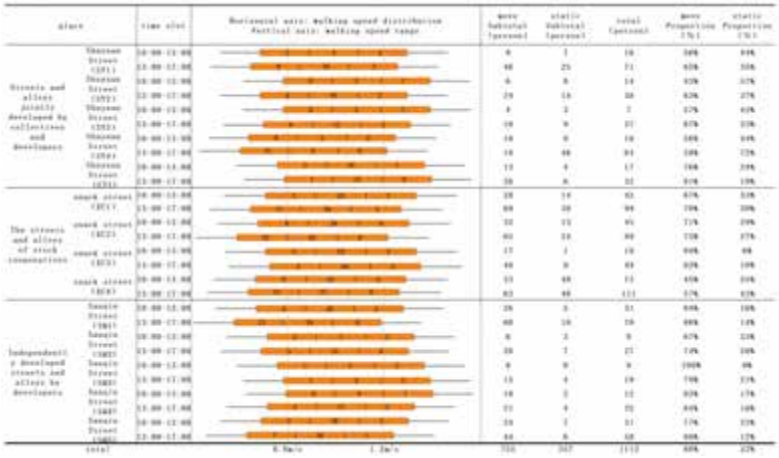

Figure 5 Walk and Stay Recognition Statistics

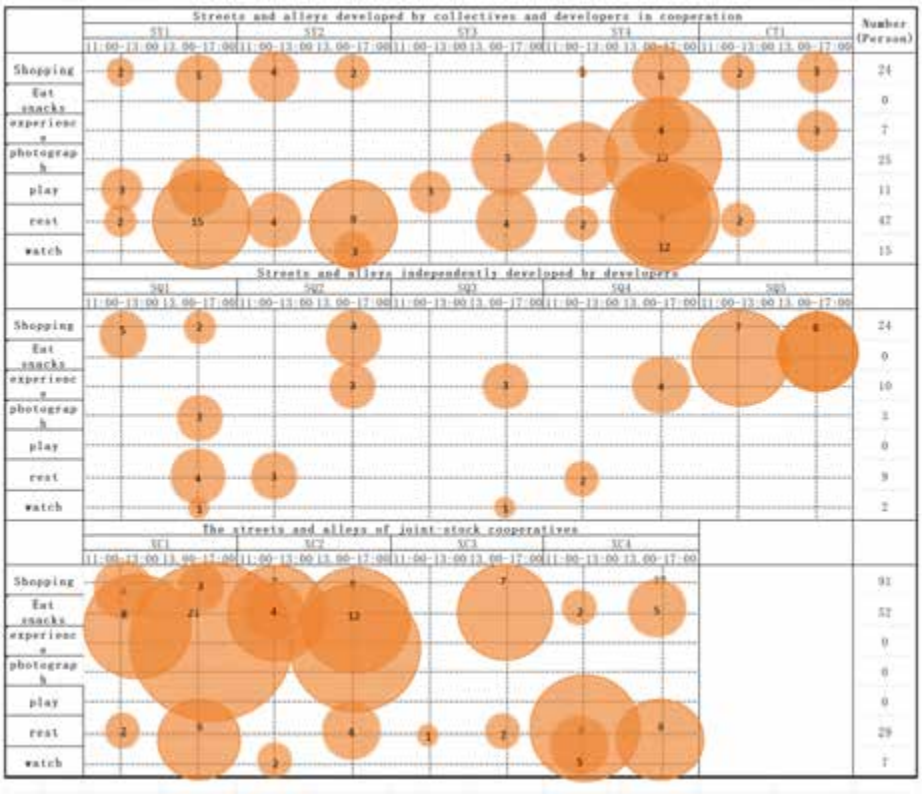

Figure 6 Visitor Interaction Behaviour Statistics

4.2 Analysis of behavioural and spatial elements based on multiple linear regression

This study extends the methodological frameworks established by Xu [19] , Fang [20], and Liu et al. through a multiple linear regression analysis to investigate correlations between the Subjective Behavioral Vitality Index (P) and

streetscape elements under distinct development models. Field-derived spatial metrics were quantified using a weighted scoring system calibrated via the Natural Breaks (Jenks) classification method. Following Equation (2), statistical modeling was conducted in SPSS (v26.0) to assess the impact of street indicators on visitor behaviors:

$$E_n=\beta_0+\beta_1*CKB+\beta_2*GM+\beta_3*TSFM+....+\beta_{13}*ZSGN+e \quad (2)$$

Where, En is the relationship between the subjective behaviour index and the street index under the three development modes (E_1 represents the independent development mode of the developer; E_2 represents the cooperative development mode of the village collectives and the developer; E_3 represents the development mode of the village collective share cooperatives). β1-β13 are the regression coefficients Beta, β0 is the constant term, and e is the error term.

After establishing the multiple regression models for the three development models, the overall tolerance values were all greater than 0.1 , indicating that there was no covariance; the models D-W met the data independence requirements (Table 1); and the three models were statistically significant as detected by ANOVA analysis (Table 2).

Combined with Table 3 Behavioural and spatial data collection processes, this can be illustrated by the analysis of the spatial correlation between the composite behavioural index E and the three types of streets:

(1) The currently constructed indicators of spatial elements of streets have an impact on the subjective behaviour of tourists, but the degree of influence is not high enough. The regression model we constructed has a high R2 value and fair interpretability. It can be shown that the currently constructed spatial elements influencing tourists' subjective behaviours are more appropriate. Subsequently, more street spatial elements can be added to enrich the influence factors, and on the other hand, research can be carried out on other dimensions affecting tourists' behaviour.

(2) The spatial analysis of the developer-independent development model street shows that the JGSX element has the most significant impact on the perception of tourist behaviour (Beta=0.366), followed by the ZYBD element (Beta=0.096). This finding is at variance with established research, verified by field observation that the landscape water system area does effectively promote tourists to stay and rest, while the influence relationship of other morphological and functional elements is relatively ambiguous. It is worth noting that exotic goods shopping (XXGW) and attraction tourism functions (JDLY) also show high influence, and the research data show that such functions have special attraction to children groups (participation rate of 78%), while adult tourists mainly play the role of accompanying. Most alarmingly, the shop size element (GM) showed a significant negative effect (Beta = -0.763), indicating that too large a shop area would undermine tourists' perception of the appropriate scale of the countryside, a finding that is highly consistent with the results of the spatial experience assessment. In the street space of the cooperative development model between village collectives and developers, the recreational function element (YLGN) has the most prominent influence on tourist behaviour (Beta=0.719), followed by the ZSGN element (Beta=0.635). Meanwhile, the neighbourhood business (ZYBD) and attraction tourism function (JDLY) also showed moderate influence. However, the catering function element (CYGN) produced a negative effect (Beta=-0.294), and in-depth analyses revealed that the catering business operated by multiple small developers under this model lacked regional characteristics, resulting in lower satisfaction with the visitor experience. This phenomenon confirms the importance of localised operations in rural tourism development.

(3) In the street space of the village collective share cooperative development mode, the open space design element (OD) has the most significant influence (Beta=0.723), especially the open space in the east entrance area can effectively promote tourists to stay and take photos. The speciality food and beverage element (CYGN) also showed strong influence (Beta=0.527), contrasting with the other two development patterns. Further analysis reveals that the separate block space element (CKB) significantly lengthens visitors' dwell time) and increases the frequency of interactive behaviours through the creation of a meandering touring dynamic line in conjunction with the featured snacking function. The successful practice of this model fully demonstrates the value of

synergistic optimisation of spatial form and territorial function. (3) In the street space of the village collective share cooperative development model, the influence of the open space design element (OD) is the most significant (Beta=0.723), especially the open space in the east entrance area can effectively promote tourists to stay and take photos. The speciality food and beverage element (CYGN) also showed strong influence (Beta=0.527), contrasting with the other two development patterns. Further analysis reveals that the separate block space element (CKB) significantly lengthens visitors' dwell time) and increases the frequency of interactive behaviours through the creation of a meandering touring dynamic line in conjunction with the featured snacking function. The successful practice of this model fully demonstrates the value of synergistic optimisation of spatial form and territorial function.

(4) In summary, the index system of street spatial elements constructed in this study demonstrates good explanatory power, especially the successful identification of key influencing elements under different development modes. The research findings not only provide empirical evidence for rural tourism spatial planning, but also highlight the importance of synergy between the elements of regional characteristics and spatial form design. It is suggested that the follow-up study can be carried out in two aspects: firstly, to expand the indicators of spatial factors, especially to increase the influencing factors of socio-cultural dimensions; secondly, to carry out a longitudinal tracking study to examine the characteristics of the influence of the factors in the temporal order of change.

Table 1 Model summary

Model	R	R 2	Adjusted R 2	Standard Skewness Error	Durbin-Watson
E1	0.803a	0.645	0.131	1.44501	1.602
E2	0.646a	0.417	0.188	1.108	2.548
E3	0.984a	0.899	0.826	0.85896	1.817

a. Predicted value: (constant), TSFM, GKB, YLGN, GM, OD, ZYBD, DYTSBS, XXGW, CKB, JGSX, JDLY, CYGN, ZSGN
b. Dependent variable: P

Table 2 Analysis of variance (ANOVA) a

	Model	Sum of Squares	df	Mean Square (MS)	F	Significance
E1	Regression	34.082	13	2.622	1.256	0.374b
	Residuals	18.793	9	2.088		
	Statistics	52.875	22			

		E2				
		Regression				0.082b
		29.022				
		12				
		2.232				
		1.819				
	Residuals	40.496	33	1.227		
	Statistics	69.518	46			
	Regression	117.912	13	9.07	12.293	0.000b
E3	Residuals	13.281	18	0.738		
	Statistics	131.193	31			

a. Predicted value: (constant), TSFM, GKB, YLGN, GM, OD, ZYBD, DYTSBS, XXGW, CKB, JGSX, JDLY, CYGN, ZSGN

b. Dependent variable: P

Table 3 The relationship between tourist perception and street space elements under three development modes

	Model B	Unstandardized Coefficients		Standardized Coefficients	T	Significance
		Standard Error	Beta			
E_1	(constant)	7.379	2.679		2.755	0.022
	DYTSBS	-0.895	0.489	-0.447	-1.830	0.101
	JGSX	0.554	0.463	0.336	1.197	0.262
	ZYBD	0.215	0.556	0.096	0.387	0.707
	CKB	-0.779	0.791	-0.389	-0.985	0.350
	GM	-1.256	0.416	-0.763	-3.016	0.015
	GKB	-0.043	0.345	-0.033	-0.126	0.903
	TSFM	-0.107	0.629	-0.040	-.170	0.869
	OD	-0.896	0.897	-0.241	-0.999	0.344
	CYGN	-0.714	0.612	-0.449	-1.168	0.273
	YLGN	-0.582	0.493	-0.291	-1.181	0.268
	XXGW	0.185	0.539	0.092	0.343	0.739
	JDLY	0.206	0.897	0.092	0.230	0.823
	ZSGN	0.019	0.973	0.010	0.020	0.985

E_2	(constant)	3.849	1.865		2.064	0.047
	DYTSBS	0.432	0.366	0.291	1.181	0.246
	JGSX	-0.317	0.303	-0.261	-1.045	0.303
	ZYBD	-0.082	0.318	-0.057	-0.257	0.798
	CKB	0.262	0.425	0.201	0.616	0.542
	GM	-0.216	0.264	-0.137	-0.818	0.419
	GKB	0.016	0.237	0.014	0.069	0.945
	TSFM	-1.534	0.680	-0.248	-2.256	0.031
	OD	-0.297	0.297	-0.207	-1.000	0.324
	CYGN	-0.383	0.362	-0.294	-1.058	0.298
	YLGN	1.033	0.570	0.719	1.811	0.079
	XXGW	0.308	0.320	0.244	0.963	0.343
	JDLY	0.237	0.239	0.194	0.989	0.330
	ZSGN	0.795	0.469	0.635	1.695	0.099
E_3	(constant)	-4.452	1.605		-2.774	0.013
	DYTSBS	0.066	0.357	0.026	0.186	0.855
	JGSX	0.122	0.251	0.062	0.487	0.632
	ZYBD	0.991	0.291	0.324	3.411	0.003
	CKB	0.932	0.398	0.452	2.341	0.031
	GM	0.481	0.367	0.236	1.309	0.207
	GKB	-0.184	0.119	-0.157	-1.540	0.141
	TSFM	1.301	0.472	0.311	2.759	0.013
	OD	1.127	0.233	0.723	4.842	0.000
	CYGN	-1.470	0.591	0.527	-2.487	0.023
	YLGN	0.208	0.306	0.089	0.680	0.505
	XXGW	-0.919	0.449	-0.375	-2.045	0.056
	JDLY	0.216	0.208	0.099	1.043	0.311
	ZSGN	0.728	0.464	0.297	1.570	0.134

5. Discussion

5.1 Analysis of the environment and behaviour of the developer-independent development model

Launched around 2010, the developer's independently developed SQ Street adopts a typical urbanisation development pattern, presenting the following characteristics: in terms of the physical environment, the uniform building materials and construction pattern form a large-scale frame structure (building height of 12-15 metres), resulting in a serious homogenisation of the street space (similar shop sizes and repetitive functions); in terms of the spatial form, the 400-metre-long rectilinear layout In terms of spatial form, the 400-metre-long rectilinear layout, together with the street aspect ratio of 0.83-1.16 (the widest being 8.88 metres and the narrowest 4.7 metres), conforms to the theoretical comfort zone, but due to the lack of local characteristic elements and rest nodes (the interface spaciousness value is only 0.16), the actual experience is monotonous and tedious. Behavioural data show that this development mode has brought significant negative impacts: visitors' walking rate is significantly accelerated (>0.8m/s accounted for 24%, much higher than other types of streets), the type of interactive behaviour is the most homogeneous (reduced by 58% compared to the collective model of the village), and stopping to watch and experience activities have almost disappeared. The reason for this is that the developer is only responsible for the construction of the house without participating in the later operation and

management, leading to serious competition in homogenisation of the industry (72% duplication rate with the existing business in the village), which not only destroys the original vernacular landscape, but also fails to form an effective commercial synergy effect. This purely commercialised development model of 'build-and-sell' has ultimately created a 'dilemma' space that lacks both rural characteristics and urban commercial vitality, providing an important case for reflection on traditional village tourism development.

5.2 Behavioural analysis of the co-development model between village collectives and developers

Although HM, CT, and SY Streets were developed in partnership between the Village and the developer between 2012 and 2016, the spatial construction still has the developer's uniform housing pattern, which is constructed using homogeneous brick-variegated antique structures, and the functional division of the housing is homogeneous due to the constraints of the construction space. The functionality of the street is intermediate between the functions of the two development modes. The business types in this part of the street are a mix of snacks from Guanzhong and other parts of the country, but the participation of local villagers is low and mostly in the form of recruitment. The SY Street and CT Street (including shops of gold and silver jewellery, ceramic bottles and porcelain, milk tea and beverages, cultural and creative toys, etc.) It is an exhibition of all kinds of gourmet products and raw materials processed and sold in factories across the country, and the commodities and spaces are uniform, forming a single commercial function. Tourist behavioural interactions were not only homogeneous but also produced a low number of types. In particular, visitors to CT1 not only stayed for a short period of time but also had fewer interactive behaviours. Secondly, the overall spatial intensification and sense of place of HM, CT and SY Streets, which were developed by the village collectives in cooperation with the developers, did not result in a large number of interactive behaviours and stops by tourists as in the case of XC and KZ Streets.

5.3 Environmental and Behavioural Analysis in the Village Collective Share Cooperative Model

Yuanjia Village has successively set up eight workshop co-operatives since around 2012, including oil workshop, tofu workshop, yoghurt workshop, chili workshop, mash workshop, vermicelli workshop, vinegar workshop and flour workshop, and the operators of these co-operatives, all of whom are craftsmen imported from the neighbouring villages and towns, have been gradually integrated into the tourism development and social life of Yuanjia Village. The deep localisation of commercial functions has been realised, and this composite mode of development has enabled XC Street and KZ Street to display significant environmental advantages: in terms of spatial form, the curved and folded street layout of the 'zigzag shape' (different from linear streets such as SQ Street), together with the distinctive spatial organisation of the 'shop in front and factory at the back' not only optimise the visitors' gastronomical experience of the dynamic line, but also promote the natural slowing down of walking speed; in terms of interface design, the eastern entrance is green, and the eastern entrance is green, with a green area on the east side of the street, which is the most beautiful. In terms of interface design, high openness areas such as the green landscape at the east entrance (KZ3) and the open space for tea breaks (XC4) provide material carriers for visitors' gathering and interactive behaviours. Behavioural data show that the frequency of visitor interaction in the XC1 (13:00-17:00) and XC2 (10:00-13:00) areas is significantly higher than that in the other streets, with the highest proportion of behavioural types focusing on snack tasting and photo-taking. This organic spatial form formed by villagers' independent deliberation avoids the standardised drawbacks of the foreign development model, and ultimately presents a quality experience effect with the richest variety of interactive behaviours (32% more than the cooperative/independently developed streets), and the longest length of stay of the tourists (on average, 40% longer than that of the other streets), which confirms the unique value of the localised development model in preserving the characteristics of the villages and enhancing the quality of the tourists.

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of spatial form, the curved and zigzag street layout in the shape of a zigzag (as opposed to linear streets such as SQ Street), together with the characteristic spatial organisation of a 'shop in front and a factory at the back' not only optimise the dynamic line of the visitor's culinary experience, but also promote the natural slowing down of the walking speed; and in terms of interface design, highly open areas such as the green landscape at the eastern entrance (KZ3) and the open space for tea breaks (XC4) provide material carriers for visitor gathering and interactive behaviours. In terms of interface design, high openness areas such as the green landscape at the east entrance (KZ3) and the open space for tea breaks (XC4) provide material carriers for visitors to gather and interact with each other. Behavioural data show that the frequency of visitor interaction in the areas of XC1 (13:00-17:00) and XC2 (10:00-13:00) is significantly higher than that of the other streets, with the highest percentage of behavioural types dominated by snack tasting and photo taking. This organic spatial form formed by villagers' independent deliberation avoids the standardised drawbacks of the foreign development model, and ultimately presents a quality experience effect with the richest variety of interactive behaviours (32% more than the cooperative/independently developed streets), and the longest length of stay of the tourists (on average, 40% longer than that of the other streets), which confirms the unique value of the localised development model in preserving the characteristics of the villages and enhancing the quality of the tourists.

In summary, the empirical analysis of the three modes of tourism development in Yuanjia Village yielded the following important findings in terms of the two dimensions of spatial environment characteristics and tourists' behavioural responses (Figure 7). First, the development mode led by the village collective joint-stock cooperative shows significant advantages, as its characteristic functional configuration (eight local workshops), intensive spatial form (the 'back' layout), and rich rural environmental atmosphere together shape the spatial characteristics of the streets and lanes in a 'small but exquisite' way, which encourages tourists to form a slow tour, a long stay, and a rich and interactive behavioural pattern. Secondly, the developer-independent development mode shows the opposite characteristics, with standardised functional configuration, low intensive spatial form and a weakened sense of rural environment, forming a 'big and wide' spatial interface without special features, which leads to the behavioural characteristics of tourists' quick passage, short stay and limited interaction. It is worth noting that the model of cooperation between the village collective and the developer shows an intermediate state, although the functional configuration has certain characteristics (integration of Guanzhong and national snacks), but due to the lack of spatial form intensification (uniform antique structure) and insufficient environmental creation, the visitors' behaviours are characterized by the transition of medium-speed visits, short stays, and medium interactions. The comparative analysis of these three models clearly reveals the mechanism by which the choice of development model influences the quality of the spatial environment and then significantly regulates the characteristics of tourist behaviour, providing an important typological reference for rural tourism spatial planning.

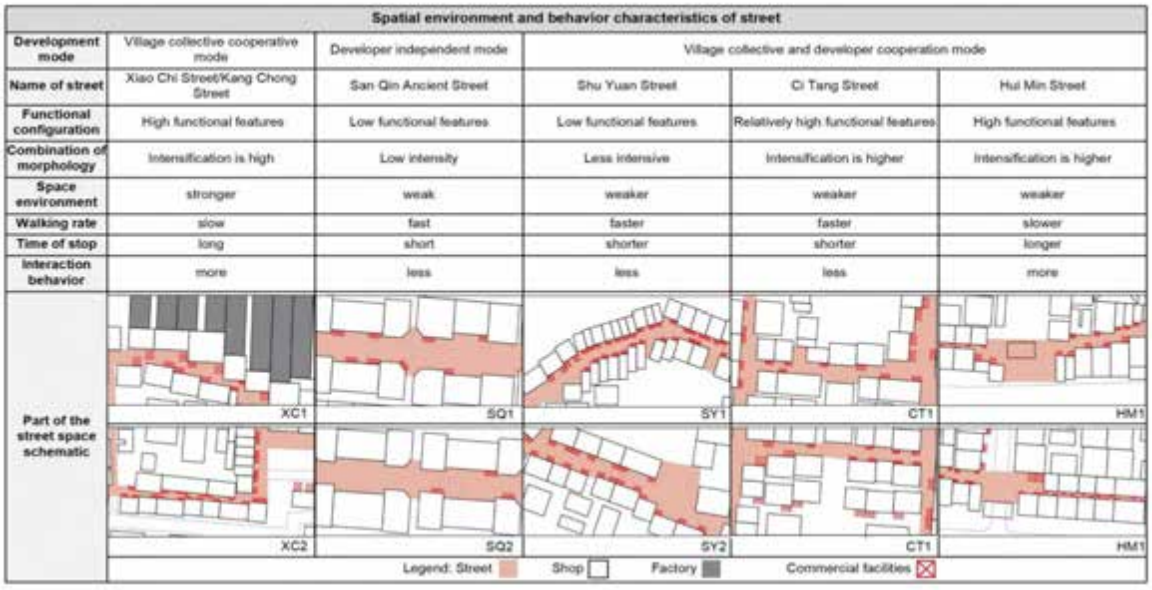

Figure 7 Spatial and Behavioural Characteristics of Streets under Different Development Patterns

5. Concluding remarks

China's rural tourism is in a stage of rapid development, but the destruction of rural landscape brought about by large-scale development and construction is often irreversible. Through a comparative analysis of the three development modes of Yuanjia Village, this study finds that the current mainstream blueprint planning (including the developer-led mode) is difficult to be effectively adjusted after completion due to the short construction period and large investment; while the villagers' self-organised incremental development mode demonstrates a significant dynamic adaptability advantage, which is able to continuously optimise the spatial layout and configuration of the industry according to the actual demand. It is worth noting that China has not yet established a perfect normative system for the construction of tourist-type villages, which directly leads to the lack of regional characteristics and spatial homogenisation (the duplication rate of SQ Street's businesses in this study is as high as 72%).

This study takes the built street space under different development modes in the countryside as the object, and constructs 13 objective element indicators in three aspects of street environment, function and form elements. Combined with the behavioural characteristics, we recorded the walking speed, length of stay and interaction mode of tourists through the video fixed-point filming, and constructed the comprehensive subjective behavioural characteristics indicators. The multiple regression model is used to analyse the influence between physical and spatial elements and behaviours under different development modes, and to analyse the reasons. The empirical evidence shows that intensive spatial patterns can increase tourists' interactive behaviours, regional characteristic functional layouts can enhance tourists' motivation, while excessive homogeneous spatial divisions can limit the diversity of tourists' behavioural activities. These findings provide important insights for rural tourism planning: firstly, a development model dominated by regional characteristics and moderately commercialised should be established; secondly, differentiated spatial modules should be designed for different types of tourists - for the gourmet tasting area, it is recommended to adopt a 'zig-zag' layout (with an openness of 0.4-0.6) and to install street furniture (spacing of 5-8m) to enhance the stay behaviour (Figure 8); for the recreation and leisure area, it is possible to arrange homogeneous spaces with a larger scale of division to facilitate the organisation of small open space functions; or multiple homogeneous group spaces can be combined into a larger space that can provide a variety of recreational possibilities. On the other hand, Yuanjia Village XC Street and KZ Street innovatively adopt the spatial organisation mode of 'shop in front and factory at the back' (Figure 9), which realises the industrial mode of 'integration of the three industries and local development' by integrating

the raw materials of agricultural products from the surrounding areas (from the neighbouring villages and Yixia Town, etc.), and then directly displaying them for sale after they are processed and produced in the village. This organic spatial combination of 'factory-shop-street' (represented by vinegar workshop, oil workshop, etc.) not only reconfigures the production and consumption space of traditional villages, but also significantly improves the enthusiasm and interactive experience of tourists. This study not only provides a quantitative basis for the spatial planning of rural tourism, but also points out the direction for the improvement of the construction evaluation and feedback mechanism, which is of great theoretical and practical value for the promotion of the sustainable development of rural tourism.

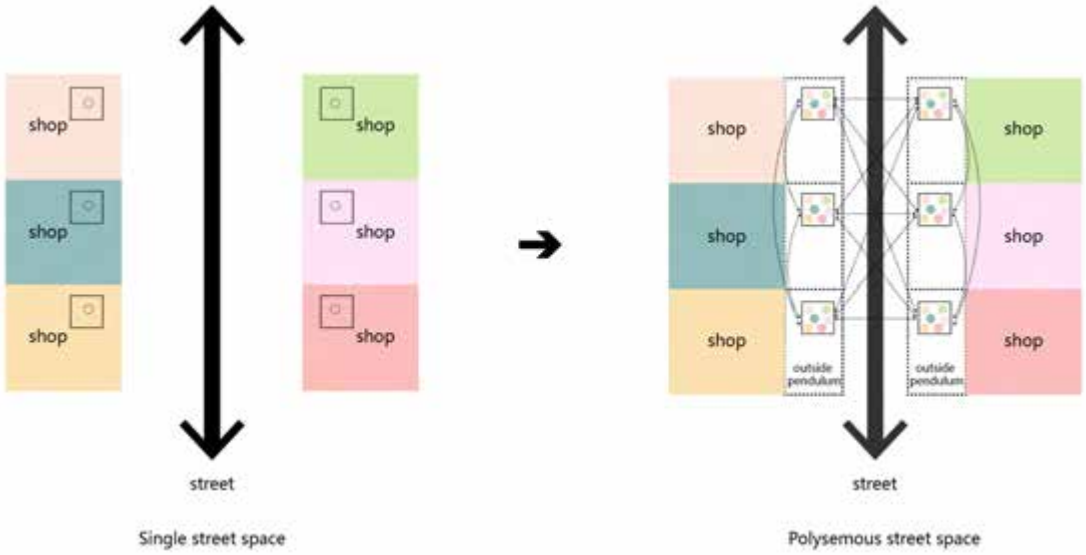

Figure 8 Schematic of commercial street furniture space in Yuanjia Village

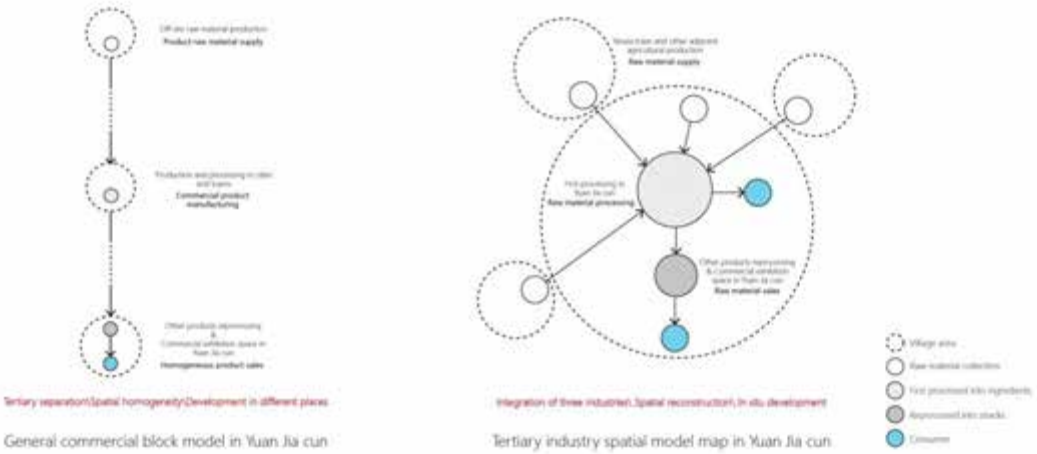

Figure 9 Spatial Organisation Patterns of Streets and Alleys in Yuanjia Village

Acknowledgement
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Research on the Construction of City Walk Tourism Routes from the Perspective of Cultural Heritage Conservation: A Case Study of Beiyuanmen Historic and Cultural District in Xi'an

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Abstract
The immersive tourism model represented by City Walk is reshaping the spatial narrative logic of historic districts. Additionally, the spatial organization of tourism routes faces multifaceted contradictions. Taking Beiyuanmen as a case study, this research employs space syntax analysis to deconstruct spatial morphological characteristics, constructs a supply-demand-balanced cultural heritage display route by integrating GIS-based spatial accessibility simulations with tourist behavior preference mining via social media semantic analysis. The research ultimately develops a heritage conservation-oriented route construction methodology, forming a new paradigm that harmonizes "heritage conservation, tourist behavior matching, and urban form adaptation." This framework aims to provide replicable strategies for revitalizing cultural heritage in historic districts, enhance tourists' recognition of heritage values, and promote sustainable cultural preservation.

Keywords: cultural heritage conservation; historic and cultural districts; City Walk; tourism route

1.Introduction

1.1 Research Background

Within the era of deep integration between culture and tourism and the vigorous development of the experience economy, immersive tourism models epitomised by "City Walk" are rapidly emerging. These models profoundly intervene in and reconstruct the spatial narrative logic of historic districts. This pedestrian practice, emphasising locality, a slow pace, and deep engagement, theoretically offers opportunities to revitalise cultural heritage and enhance public understanding of a place's historical stratification and cultural diversity. It achieves this by guiding tourists to intimately engage with the fabric of the streets and alleys through physical perception and interactive experience.However, in practice, the high-intensity influx of visitors and consumption-oriented focus spurred by the City Walk trend can readily, in the absence of effective guidance and regulation, catalyse the homogenisation and superficial expansion of commercial activities within historic districts. The rapid proliferation of numerous homogeneous trendy establishments and fast-food style cultural consumption spaces into the original urban fabric not only dilutes the district's unique historical ambiance and cultural authenticity but may also fragment or even distort its inherent historical and cultural context. This poses potential threats and challenges to the preservation environment of physical relics, the continuity space for intangible cultural traditions, and the living networks of local communities.Xi'an Beiyuanmen Historic and Cultural District, as the core area of the Huifang Quarter, bears profound historical sedimentation and distinctive ethnic cultural characteristics, serving as a vital living heritage landmark in the ancient capital of Xi'an. With City Walk increasingly becoming its dominant tourism experience, the pressing challenge is how to systematically design tourism routes that fulfil tourists' demands for deep engagement while effectively safeguarding the core value of the district's cultural heritage. This necessitates balancing commercial vitality with cultural authenticity for the sustainable preservation and development of the area.This research is grounded in this context, aiming to explore strategies for constructing City Walk tourism routes from the perspective of cultural heritage preservation.

1.2 Problem Statement

Three principal contradictions exist within the current City Walk routes of Beiyuanmen:The paradox between heritage display and preservation;The contestation for space between tourists and residents;The imbalance between route design and urban form.

1.2.1 The Paradox of Heritage Exhibition and Preservation

Current spatial organisation practices for tourism routes frequently encounter a profound "heritage paradox": to enhance visitor immersion and appeal, route design tends to concentrate and intensively showcase core cultural heritage nodes—such as historic buildings, distinctive sites, and traditional activity points—in high-density sequences. However, this intensive, high-frequency exhibition and utilisation of cultural heritage, when lacking refined regulation and carrying-capacity assessment, readily exceeds both the physical load-bearing thresholds and cultural resilience boundaries of the heritage assets themselves and their environments.This manifests in three primary ways:Material Degradation: Sustained dense footfall on fragile historic fabric—including ancient structures, pavements, and architectural components—accelerates their wear and even induces structural damage.Cultural Commodification: Traditional activities originally rooted in community daily life become simplified, staged, or even alienated into performative spectacles to cater to tourist experience and consumption demands, stripping them of their native cultural context and social function.Spatio-Temporal Disruption: Overemphasis on guiding visitors towards specific cultural symbols (e.g., mosques, traditional snack workshops) causes abnormal spatio-temporal clustering of crowds. This not only disrupts residents' daily routines and the solemn ambience of religious activities but may also displace authentic community functions.Consequently, resolving this paradox by exploring how to achieve synergy between "bearable display" and "dynamic preservation" at the spatial organisation level constitutes the core challenge and critical breakthrough point of this research.

1.2.2 The Spatial Contestation Between Tourists and Residents

The spatial organisation of City Walk routes also acutely instigates a more micro-level and intense spatial contestation within historic districts: an ongoing conflict and struggle between tourists' demands for immersive experiences and the spatial entitlements of local residents in their daily lives. This contestation extends far beyond mere physical crowding; fundamentally, it concerns the competitive usage and meaning-making over finite, highly valued spatial resources.On one hand, the narrow historic lanes and alleys that serve as the primary conduits for City Walks become inundated with visitors during peak periods. This directly encroaches upon the essential circulation and lingering spaces required for residents' daily activities—commuting, socialising, goods transportation, children's play—resulting in reduced mobility efficiency, diminished quality of life, and even safety hazards. Residents are thus compelled to either adjust their routines to avoid tourist surges or relinquish customary uses of public spaces, constituting an invisible erosion of their autonomy over daily life.On the other hand, the pursuit of "authentic" experiences inherent to City Walk often drives tourists to seek out spaces perceived as embodying "local life." Persistent gazing, photography, and even uninvited close observation not only intrude upon residents' sense of privacy and security but also risk creating cultural discomfort and imposing secularisation pressures on community sacred spaces. This occurs when tourist behaviour clashes with local cultural customs or religious sensibilities.Consequently, a core challenge in constructing City Walk routes lies in how spatial organisation and visitor flow management can effectively identify, respect, and safeguard residents' spatial rights. This necessitates seeking a dynamic equilibrium between tourists' experiential rights and residents' right to inhabit their living environment, thereby preventing the cultural heritage site from being transformed into a unidimensional tourist consumption space.

1.2.3 Imbalance Between Route Design and Urban Morphology

The prevailing City Walk route organisation model faces a fundamental structural misalignment: a profound disconnect exists between its premeditated, highly linearised touring logic and the intrinsic, organically complex "courtyard-alley-market" spatial morphology and functional organisation of the Beiyuanmen Historic and Cultural District. This imbalance not only diminishes visitors' perceptual depth but also risks distorting the district's spatial logic and exacerbating the aforementioned contradictions.Spatial Scale and Rhythm Conflict:Beiyuanmen's charm, honed over centuries of organic growth, lies in its multi-layered, networked, and densely collaged spatial fabric. This fabric emerges from the interplay of narrow winding alleys, inwardly focused courtyard units, and spontaneously evolved mixed-use market nodes. However, many City Walk routes—designed for efficiency and "check-in" coverage—over-simplify or artificially straighten this natural grain, imposing one or more clear, coherent, directionally explicit, and relatively broad touring arteries. This artificial linearisation:Concentrates pedestrian flows and commercial opportunities excessively along these primary routes,Marginalises second-

ary alleys and courtyard entrance spaces that harbour authentic living scenes and cultural nuances,Deprives visitors of serendipitous discovery through autonomous exploration and "getting lost,"Inhibits nuanced perception of micro-spatial layers and comprehension of the district's holistic organicity. Functional Disruption of the "Courtyard-Alley-Market" Organism:The district's "courtyard-alley-market" structure is inherently an organic entity where three functions—residential courtyards, social circulation alleys , and commercial market spaces—are spatially nested and dynamically balanced. Linear routes reduce this complex system to a "consumption conveyor belt," funnelling visitors rapidly from one commercial point to the next. This undermines the route's potential function as a framework for understanding the district's:Historical stratification,Social structure,Underlying spatial logic.Consequently, transcending simplistic linear sequencing to explore a route organisation model that:Is grounded in the "courtyard-alley-market" archetype,Respects the inherent networked spatial character,Encourages non-linear exploration and multi-layered perception,—is essential for constructing City Walk routes that genuinely align with cultural heritage preservation objectives and profoundly activate the district's distinctive appeal.

1.3 Research Aims

Building upon a critical analysis of Beiyuanmen Historic and Cultural District's core challenges under the City Walk phenomenon—namely the paradox of heritage exhibition versus preservation, the spatial contestation between tourists and residents, and the misalignment between route design and urban morphology—this research aims to transcend conventional tourism route planning paradigms. It seeks to move beyond singular efficiency-oriented approaches or static preservation mentalities by constructing a City Walk route system centred on the synergistic trinity of "Heritage Preservation – Tourism Experience – Community Coexistence".This system constitutes not merely a spatial superimposition of routes, but an adaptive framework integrating multidimensional elements, including:Spatial organisation,Activity programming,Interpretative information,Management and regulation.Its fundamental objective is to achieve, within the context of Beiyuanmen—a characteristic high-density, living, dynamic, multi-ethnic historic district—a dynamic equilibrium and long-term mutual reinforcement between:The sustainable safeguarding and transmission of cultural heritage, andThe high-quality development of tourism.

2.Literature Review

2.1 Cultural Heritage Preservation and Tourism Utilisation

The preservation and rescue of cultural heritage constitute a vital component of human civilisation and strategies for sustainable societal development, representing a collective societal obligation. Presently, China faces issues such as constructive damage and tourism-induced degradation in the balance between protecting cultural heritage and its exploitation for tourism purposes (ZHENG Xiaoxie). As historic districts, primarily valued for their historical and folk-cultural resources, become highly sought-after tourist destinations, scholars like YANG Guosheng caution against prioritising economic gains from tourism utilisation at the expense of damaging cultural heritage under the guise of economic development. Consequently, the regenerative utilisation of cultural heritage aims precisely to re-establish cognitive or emotional connections between the general public and heritage assets, enabling heritage to represent the identity of non-authoritative stakeholders, including residents and tourists; moreover, enhancing heritage tourism experiences can be regarded as a key metric for successful regenerative utilisation (ZHANG Jianwei). Building upon this, scholar ZOU Han proposes the concept of the "heritage trail," a regional linear cultural heritage conservation method applicable to smaller-scale historic areas. This involves planning and constructing tourist routes that link and integrate multiple cultural heritage resources, establishing visitor nodes and providing services. Similarly, "cultural routes" and "heritage corridors" emphasise the historical and cultural value of heritage while prioritising balance with economic benefits and socio-environmental value, though operating at larger scales. The former typically spans regions or nations, connected by cultural dissemination and dialogue, whereas the latter, operating at an intermediate scale, often integrates cultural resources to form linear landscapes connecting urban clusters or cities. This represents a lower-intensity tourism development approach, suitable for protection strategies involving "temporary retention, refurbishment and appropriate facility addition" within historic areas, exerting minimal impact on local livelihoods and lifestyles.

2.2 The Spatial Narrative Turn in City Walk

Spatial narrative, a method that combines a structural system of events arranged along the axis of time and causal logic with a spatial juxtaposition system characterized by coexistence and synchronicity, is described as a 'spatiotemporal complex.' (Xiao Jing) argues that current cultural heritage protection is increasingly showing a trend towards narrative and cognitive spatiotemporal positioning. The goal of protection is to restore abstract history and humanistic values to a complete spatiotemporal entity through the integration of spatial and landscape remains and their associated texts, allowing people to more intuitively, deeply, and systematically perceive, understand, and grasp the traces and interconnections left by human activities in both the spatiotemporal and conceptual worlds.Specific methods: On one hand, (Zhuang Xiaoping) developed a 'value cognition depth map' using 'historical richness' and 'time depth' as indicators to quantitatively assess the value of ancient city heritage. On the other hand, (Li Yuan) identified visual preference as the key factor influencing tourists 'decision-making and proposed a method for simulating pedestrian flow and optimizing tourist routes []. Thus, the spatial narrative shift initiated by City Walk is not merely an innovation in tourism products but a profound transformation in the perception and revitalization of historical districts. Using' walking 'as a medium and' narrative' as a link, it creatively integrates the spatial elements of cultural heritage with the needs of tourism development in a dynamic cultural experience space.

3.Methodology

3.1 Research Area

The Beiyuanmen Historical and Cultural Block, located in the northwest of Mingcheng District, Xi'an, is the area with the highest concentration of Muslim residents in Xi'an. Having experienced development from the Tang, Song, Yuan, Ming and Qing Dynasties to modern times, it preserves still the traditional 'seven temples and thirteen wards' layout of the Ming and Qing periods. The public spaces within the block, shaped by historical layers across different eras, have gradually formed the current appearance of the block. These public spaces are living elements that have continuously evolved in the daily lives and activities of Muslim residents. The existing types of public spaces mainly include public buildings (such as the Drum Tower, the City God Temple), mosques, and historical lanes.

3.2 Data Sources

Spatial data: CAD topographic maps, POI (Points of Interest) data.

Behavioural data: Over 200 travel notes from social media were selected by searching keywords like 'Beiyuanmen' and 'city walk' on Xiaohongshu. The places where visitors frequently appear in their daily routines are ranked as Shajin Bridge, Beiyuanmen, Guangji Street, North Guangji Street, Dapi Courtyard, Xuexi Alley, Muslim Street, Miao Hou Street, Gao Family Courtyard, Xi Yang Market, Huajue Alley, Xiaopi Courtyard, Great Mosque, Bell Tower, Xiaoxue Alley, Damai Market Street, Guangming Alley, Mai Xiang Street, Huajue Alley Mosque, Xuexi Alley Mosque, Bell and Drum Tower Square, Lianhu Park, and Hongbu Street. The main purposes for visitors to enter the block are to experience the food, history, Islamic culture and the local atmosphere.

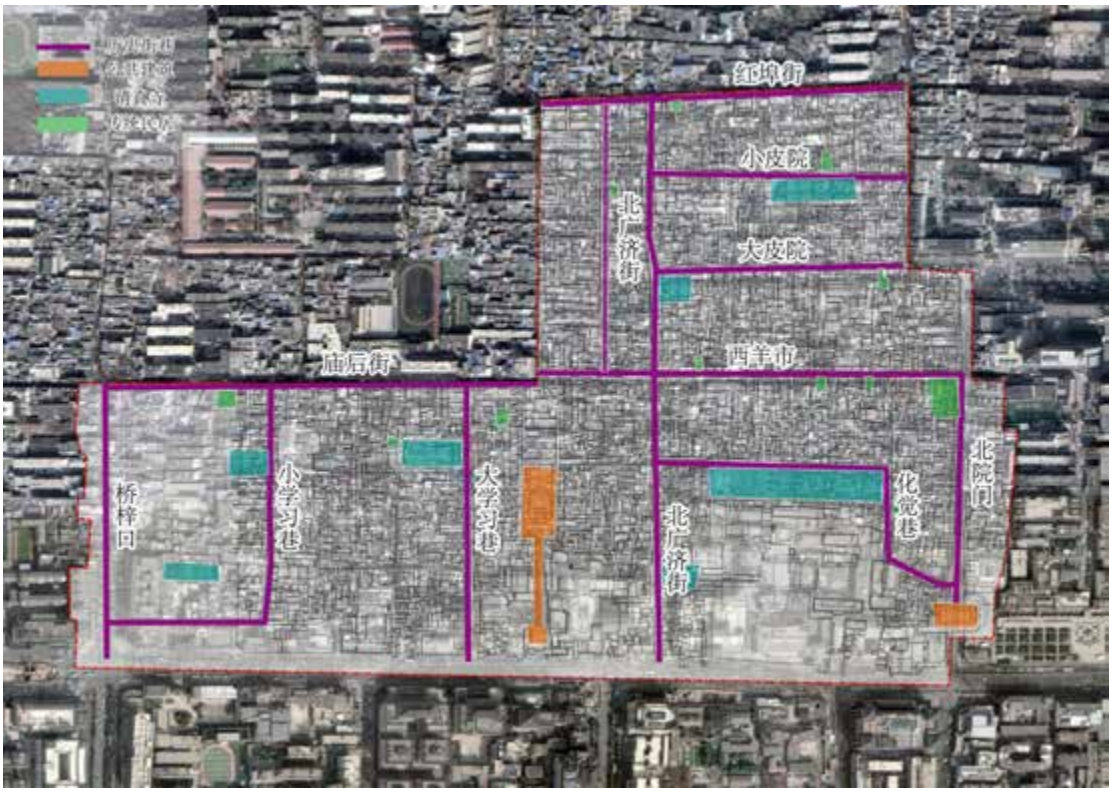

Figure 1 Research scope of Beiyuanmen Historical and Cultural Block

3.3 Technical Framework

This study applies a progressive technical route of spatial computation - behaviour sensing - semantic mining - intelligent optimisation. By integrating multi - source data and coordinating multiple models, it accurately analyses the spatial genes of the Beiyuanmen block, tourist behaviour patterns, and cultural cognition characteristics. Thus, it offers scientific evidence for creating a City Walk path system that integrates heritage conservation, tourist experiences, and community coexistence.Firstly, using the depthmapX platform to construct a block axis model and calculate key indicators to precisely identify the disharmonious areas between current paths and the block's natural texture.Secondly, in ArcGIS10.6 software, based on social media geographical tags and field observation points, applying kernel density estimation to generate tourist spatial aggregation heatmaps. Overlaying the distribution of heritage itself and local residents' living service facilities to visually present heritage display and commercial homogenisation expansion hotspots.Then, utilising travel notes published on social media to extract the main subjects tourists focus on, conducting visual - association to identify cultural cognition breakpoints and reveal tourists' perceptual blind spots of the block.Finally, performing multi - objective constraint optimisation of the historical and cultural block City Walk path.

4.Results

4.1 Spatial Form Characteristics

This study uses axial analysis and segment analysis. Axial analysis assesses the integration and connectivity of the Beiyuanmen Historical and Cultural Block, while segment analysis evaluates the selection of streets within the block. To begin, the research defines the spatial boundary. It extracts the street network of the block using CAD software based on the current situation, simplifies it to straight lines, exports it as a dxf - format file, and finally imports it into Depthmap software for spatial analysis of the block.

Integration, a key indicator of space syntax theory, reflects the accessibility of nodes in a spatial system and the closeness of their connections. It indicates the total steps needed to traverse all nodes from a starting point. A higher integration value signifies greater street accessibility. In the Beiyuanmen Historical and Cultural Block, Guangji Street has the highest integration, followed by Hongbu Street and Miao Hou Street. These streets are the most visited due to their excellent accessibility.Choice, the frequency a space appears on the shortest topological paths, is closely related to traffic potential. A higher choice value means more traffic and greater potential to attract people and vehicles. Some areas with high choice values but low integration are essential for local residents' daily activities, leading to their high traffic despite lower integration.Connectivity, the number of nodes connected to a specific node, indicates the spatial connections. Guangji Street has the highest connectivity in the block, followed by Xi Street, Hongbu Street, and Miao Hou Street. Other streets have lower connectivity due to numerous "T" intersections, causing traffic disruption and visual obstruction.

Figure 2-1 Integration

Figure 2-2 Choice

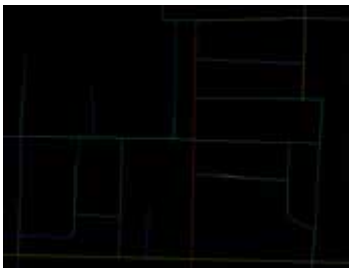

Figure 2-3 Connectivity

4.2 Heritage Perception Characteristics

The hotspots for heritage perception in the Beiyuanmen Historical and Cultural Block include historical and cultural heritages such as the Drum Tower and Guangji Street, as well as historical lanes with rich culinary culture like Xi Yang Market and Shajin Bridge. The City God Temple and Huajue Alley Great Mosque in the block attract a small number of tourists, while other cultural heritages are less known. Areas such as Qiaozikou, Damai Courtyard, Xiaopi Courtyard, and Hongbu Street, along with other mosques, are cold spots for heritage perception and are mostly visited by tourists seeking an in - depth experience of the local cultural atmosphere.

Firstly, this study conducted a Kernel Density Analysis of POIs in the Beiyuanmen Historical and Cultural Block, covering cultural heritage, public facilities, daily services, shopping, leisure, and dining services that cater to both residents and tourists. The results show that residents' daily and leisure services are mostly marginalised into non - core peripheral areas due to tourism - related space encroachment, with only a few shared public facilities evenly distributed. Tourists' activities mainly focus on historical lanes and cultural heritage sites, leading to a proliferation of shopping and dining services along these streets, which in turn crowds out residents' living spaces. Specifically, shopping services are concentrated in Beiyuanmen, Xi Yang Market, and North Guangji Street, near the Bell and Drum Towers, attracting tourists who mainly engage in superficial sightseeing. Dining services are mainly found in North Guangji Street, Shajin Bridge, Dapi Courtyard, and Miao Hou Street, which are more integrated into the local community and attract tourists seeking an in - depth experience.Secondly, through an analysis of travel notes posted on social media, including a word frequency analysis, it was found that the most frequently mentioned locations by tourists are "Shajin Bridge" and "Beiyuanmen", representing the block's culinary and cultural heritage highlights respectively. Other keywords often mentioned by tourists are related to various foods, reflecting the block's strong appeal to tourists through its ethnic culinary culture. Additionally, many historical lanes within the block are frequently mentioned, indicating that each lane has its own unique characteristics and points of interest, such as Guangji Street's culinary attractions and Beiyuanmen's shopping spots. Furthermore, an analysis of the correlations within social media travel notes reveals that tourists are particularly interested in experiencing the atmosphere of Xi'an's indigenous historical lanes. Several historical lanes and culinary elements are closely watched by tourists. Currently, the tour routes within the Beiyuanmen Historical and Cultural Block are closely related to historical and cultural heritage, historical lanes, and culinary culture.

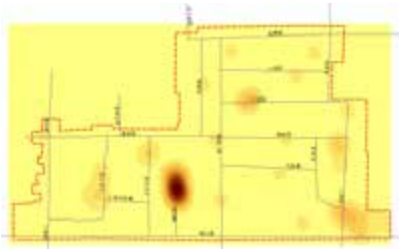

Figure 3-1 Cultural Heritage

Figure 3-2 Public Facilities

Figure 3-3 Life Service

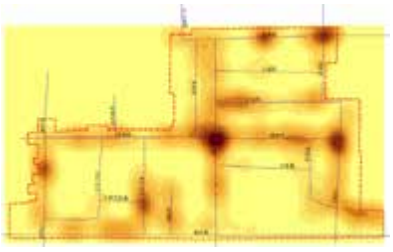

Figure 3-4 Shopping Services

Figure 3-5 Recreation Services

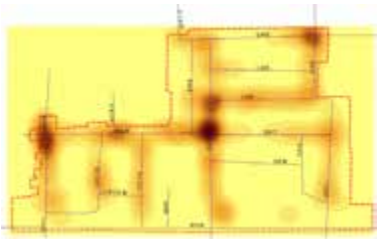

Figure 3-6 Dining Services

Figure 3 Service Facility Analysis of Beiyuanmen Historical and Cultural Block

Figure 4 Social Media Travelogue Text Word Frequency Analysis

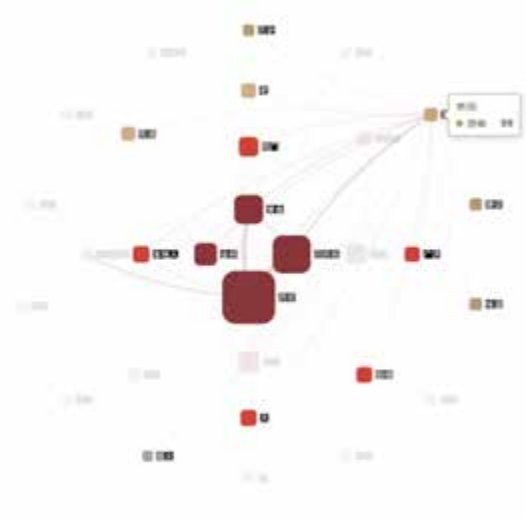

Figure 5-1 Tourist Relevance Analysis

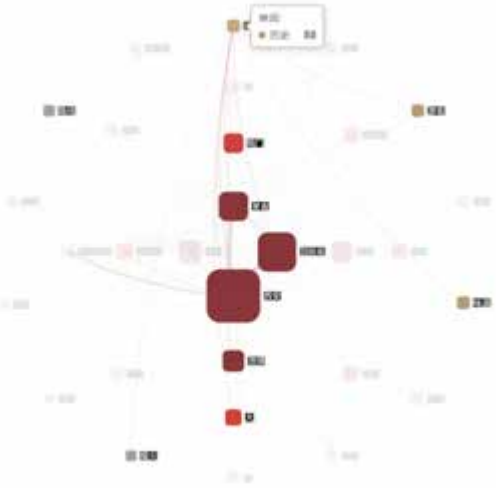

Figure 5-2 Historical Relevance Analysis

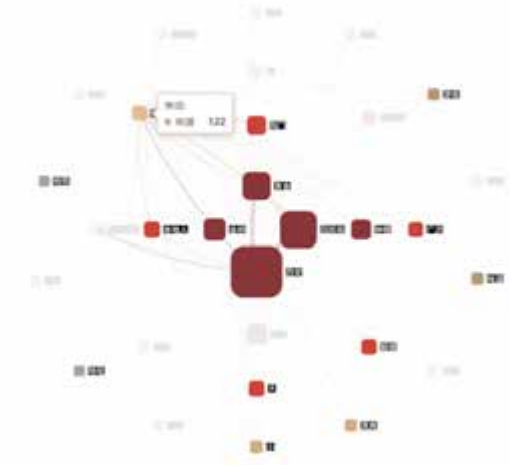

Figure 5-3 Street Relevance Analysis

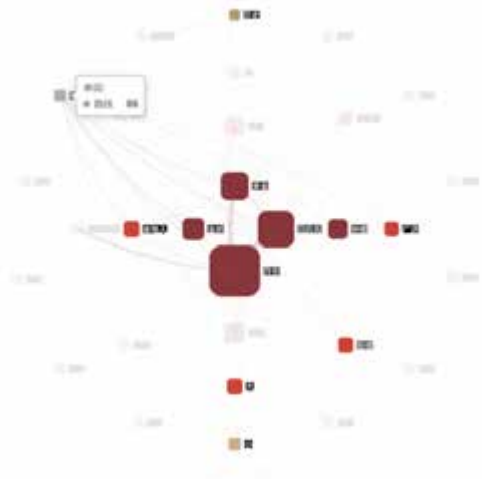

Figure 5-4 Route Relevance Analysis

Figure 5 Social Media Travelogue Text Relevance Analysis

4.3 Route Optimisation Plan

This paper proposes a "double loop" system for the City Walk tourist route in the Beiyuanmen Historical and Cultural Block. The main loop links core heritage sites, while the micro loop offers an in - depth experience within residential courtyards.The main loop, combining cultural heritage and halal food experiences, starts at the Drum Tower and follows a circular route. It links the "seven temples and thirteen wards" spatial pattern, enhancing the historical block's spatial experience. About 2.5 km long, it takes 2 - 3 hours and covers 90% of core resource spots.The main loop starts at the Drum Tower, goes through Huajue Alley, Xi Yang Market, Beiyuanmen, Gao Family Courtyard, Miao Hou Street, City God Temple, and back to the Drum Tower. Along the way, there are cultural spots like the Huajue Alley Mosque and Gao Family Courtyard. For food, places like Jia San Guan Tang Bao and Shaanxi Thirteen are included. Eco - friendly facilities like solar - powered charging seats are also available. Themed routes are offered at different times, integrating scattered historical fragments into a circular path for a hands - on experience of the block's cultural genes.There are two micro loops. One is the community culture experience route on the northeast side. It starts at Guangji Street, goes through Xiao Pi Courtyard, Mai Xiang Street, Beiyuanmen, and the Drum Tower, allowing participation in community activities and experiencing the halal community culture. The other is the halal food culture experience route on the west side. It starts at Guangji Street, goes through Miao Hou Street, Da Mai Market Street, and Shajin Bridge, where tourists can taste the food of century - old shops.

5.Discussion

5.1 Balancing Heritage Protection and Display Mechanisms

As a traditional settlement area in Xi'an Mingcheng District with distinctive local features, the Beiyuanmen Historical and Cultural Block preserves historical spatial texture since the Tang Dynasty and carries unique Hui Fang ethnic culture and market life traditions. The City Walk route aims to balance heritage protection and public display, and resolve the conflict between protection rigidity and utilisation flexibility.Core protection zones, covering sites like the Gao Family Courtyard and Huajue Alley Mosque, follow the minimal - intervention principle, focusing on static display and cultural interpretation.Style - coordination zones, including Ming and Qing streets like Xi Yang Market, allow moderate commerce but with strict business control, aiming for themed commercial experiences.Update - transition zones involve other general streets, which undergo minor changes to embed cultural spots.Also, to prevent tourist overcrowding on main streets, themed routes guide visitors to secondary streets. This spatial - temporal narrative reconstruction of cultural understanding eases core zone pressure and activates the block's heritage value.

5.2 Community Participation Implementation Path

The sustainability of heritage protection and display relies on community residents shifting from "managed objects" to "main participants". Beiyuanmen Block has designed multi - level and practical implementation paths for social participation to establish a real "bottom - up" co - governance mechanism. This ensures residents are not only cultural inheritance carriers but also decision - makers, interpreters, and beneficiaries of tourist routes. Firstly, local residents are recruited as City Walk guides to share their personal memories of the block's evolution, enhancing visitors' cultural experience.Secondly, intangible cultural heritage workshops are set up. With small scale, appointment - based, and in - depth interaction principles, these workshops avoid performance and commercialisation, aiming to restore historical scenes of value and offer deep cultural exchanges.Lastly, local shops are certified. Those using traditional crafts and highly rated by visitors and residents are added to the City Walk recommendation list. This safeguards the block's cultural authenticity against mass tourism and strengthens visitors' identity recognition during travel interactions.

6.Conclusion

Through integrated and innovative adaptive spatial strategies for high - density multi - ethnic blocks, this study builds an assessable, operable, and promotable City Walk route planning and management paradigm. First, it resolves the heritage protection - development paradox by suggesting a mechanism. Second, it reconciles tourist - resident spatial games to safeguard community spatial rights. Third, it bridges the route - spatial - form gap, creating an embedded network route. This paradigm serves Beiyuanmen Block's sustainable development and offers theory and practice references for similar global heritage sites, proving protection and development

can be dynamically balanced and mutually reinforcing through smart spatial interventions. However, given the unique spatial forms and routes of historical blocks with different cultural attributes, City Walk planning and management must be tailored to each block's specific characteristics.

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Identification of Spatial Conflicts between Tourists and Local Residents: Based on "Nanjing Travel Pitfall Avoidance" Posts on Rednote

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Abstract
This study identifies spatial conflicts between tourists and local residents in Nanjing using Rednote "Nanjing Travel Pitfalls" posts, applying AI-based natural language processing and spatial analysis. Findings show: (1) Conflicts are "localised concentration and overall dispersion", with high-intensity zones in multifunctional areas like Laomendong and Xinjiekou; (2) Conflicts fall into three types: High-Intensity Clustered Type, Intersecting and Compressed Type, and Low-Frequency, High-Sensitivity Type; (3) Residents' perceptions focus on old town living spaces, tourists' are more dispersed, yet both align on key areas; (4) Social media amplifies conflicts via algorithmic recommendation and emotional contagion. The study suggests shifting from conflict control to spatial regeneration, promoting coexistence through time-sharing and community negotiation. It contributes theoretical and methodological insights to digital-era urban tourism governance.

Keywords: Spatial conflict; Social media; Urban tourism; Xiaohongshu; Nanjing

1 Introduction

With the ongoing popularisation, routinisation, and digitalisation of tourism activities, urban tourism spaces are undergoing unprecedented reconstruction. This transformation is evident not only in the shifting behavioural patterns of tourists but also in the blurring of traditional boundaries between tourism spaces and everyday living spaces. Through digital platforms such as Rednote, tourists now independently plan their itineraries, extending their activities beyond conventional scenic zones and increasingly embedding themselves into the daily spatial routines of local residents. While this spatial reconstruction enriches the diversity of tourism experiences, it simultaneously gives rise to new forms of spatial conflict. The recent surge of "Travel Pitfall Avoidance" posts on social media platforms like Rednote offers a vivid and direct reflection of these emerging conflicts. These user-generated contents not only document specific instances of spatial conflict, but also reveal deeper divergences in spatial use ideologies between tourists and residents. Systematic analysis of such content contributes to a more nuanced understanding of the challenges urban space governance faces in the digital age.

As an interdisciplinary research subject, the concept of spatial conflict has been continuously refined through academic inquiry. It has often been understood from a resource competition perspective, where incompatible demands for space among different groups generate conflict (Cocklin, 1988; Biagini, 1993). In the Chinese academic context, this concept has been further localised and expanded. One perspective emphasises the scarcity of spatial resources, portraying spatial conflict as a form of opposition during resource allocation (Zhou et al., 2012). Another interpretation draws attention to divergent development ideologies, which may lead to spatial imbalances and thus to conflict (Cheng, 2013). A more integrative approach sees spatial conflict as the result of intertwined processes, including resource redistribution, relational shifts, and value redefinitions (Chen et al., 2015). Overall, spatial conflict can be understood as a state of disharmony arising when multiple interest groups compete over established spatial resources and perceive their interests to be compromised. In this study, spatial conflict specifically refers to the tensions and oppositions between tourists and local residents that emerge within defined spatial and temporal contexts, due to discrepancies in resource usage, behavioural norms, and cultural understanding.

A review of existing literature reveals three prominent limitations in current research on tourism-related spatial conflict. First, in terms of research perspective, most studies have focused on specific types of tourism communities or rural destinations. A typical example is the analysis of multi-group conflict in Xijiang Qianhu

Miao Village, which sheds light on spatial dynamics within ethnic tourism settings (Liu and Zhao, 2021). However, comparative research in urban tourism contexts remains limited. Second, from a methodological standpoint, although some scholars have made progress in exploring spatial conflict mechanisms—particularly in tourism communities—the dominant reliance on qualitative analysis persists, with quantitative methods receiving less attention (Pan, 2021). Third, regarding data sources, most studies continue to depend on traditional methods such as surveys and in-depth interviews. While emerging research has begun incorporating data like GPS-tracked tourist mobility, concerns about data authenticity and representativeness remain(Li, Xie and Wang, 2018). Furthermore, social media data—rich in real-time, user-generated sentiment and spatial expression—has not been fully leveraged. These methodological limitations hinder a comprehensive understanding of the dynamic and evolving nature of spatial conflict in contemporary urban tourism spaces.

In response to these gaps, this study selects Nanjing as a representative case and uses the most viewed "Nanjing Tourism Pitfalls" posts on Rednote as its primary dataset. These posts offer unfiltered, real-time insights into tourists' and residents' emotional reactions and lived experiences of spatial conflict. By employing a mixed-methods approach that integrates qualitative content analysis and quantitative spatial analysis, the study systematically examines the characteristics of spatial conflict in the context of urban tourism. Specifically, it analyses these characteristics from three key dimensions: overall spatial distribution, dominant functional zones, and core subject object perspective. The study seeks to uncover the mechanisms driving the emergence of spatial conflict and to clarify the mediating role of social media—particularly through algorithmic recommendation systems and affective transmission—in amplifying these conflicts.

2 Methods

This study draws on data from the Chinese social media platform Rednote. Using Python-based web scraping techniques, we collected posts published before 5 April 2025 that contained keywords such as "Nanjing Travel Pitfall Avoidance", ranked by popularity. The initial dataset comprised 220 entries. Following manual screening to remove neutral or positive content, 181 negative posts were retained as valid samples for further analysis. To distinguish between different subject perspectives, user identities were classified as either tourists or local residents based on IP location metadata and profile information available on user homepages.

2.1 Spatial conflict point identification

The identification of spatial conflict points involved a hybrid method combining artificial intelligence (AI) technologies and manual verification. Natural Language Processing (NLP) techniques based on the DeepSeek model were employed to analyse post content, enabling the automated extraction of location-specific keywords that exhibit spatial characteristics—e.g., well-known tourist destinations such as "Fuzimiao" (Confucius Temple).

To ensure the precision of spatial identification, a three-stage manual verification process was subsequently implemented:

- Correction of non-standard toponyms – colloquial or abbreviated terms (e.g., "Nanbo") were matched with their full official names (e.g., "Nanjing Museum");
- Elimination of vague spatial references – imprecise descriptions such as "a mall in the city centre" were excluded;
- Removal of irrelevant or erroneous geographic information – spatial references lacking clear or accurate locational meaning were discarded.

2.2 Measurement of spatial conflict intensity

User interactions on the Rednote platform primarily include four forms: likes, favourites, comments, and shares. These metrics not only reflect the communicative popularity of a given post but also indirectly indicate the level of public attention and perceived impact associated with specific spatial conflicts. To quantify spatial conflict intensity, this study adopts a two-step approach: first, a weighted formula is developed to calculate the comprehensive heat value of individual posts based on the differential characteristics of each interaction type;

second, the total conflict intensity of each spatial conflict point is calculated by aggregating the heat values of all related posts.

(1) Calculation of post-level heat value

A weighted formula was established to determine the composite heat of each post:

$Post_Heat_i = 0.2 \times Likes_i + 0.1 \times Favorites_i + 0.4 \times Comments_i + 0.3 \times Shares_i$

where $Post_Heat_i$ denotes the heat of post i, and $Likes_i$, $Favourites_i$, $Comments_i$, and $Shares_i$ represent the corresponding interaction counts (Table 1).

Table 1 Weight design based on interaction behaviour characteristics

Interaction Type	Interaction Features	Weight
Likes	- Indicates user attention or recognition. - Often passive behaviour ("casual likes"). - May reflect content utility rather than stance on conflict. - Limited validity in capturing conflict intensity.	0.2
Favourites	- Represents archiving or bookmarking intent. - Primarily reflects the perceived usefulness of information. - Weak temporal association with conflict immediacy; exhibits a lag effect.	0.1
Comments	- Requires active engagement via text input. - Directly reveals depth and contentiousness of discourse. - Serves as the primary arena for local–tourist confrontation. - High indicator of conflict intensity due to two-way interaction.	0.4
Shares	- Captures the extent of information diffusion. - Greater share volume suggests broader public impact. - While motivations vary, sharing amplifies conflict exposure.	0.3

(2) Calculation of spatial conflict intensity

For a specific spatial location L, conflict intensity is computed by aggregating the comprehensive heat values of all posts associated with that location. This cumulative figure reflects the extent of public attention, emotional engagement, and discursive activity tied to the identified conflict site.

$$\text{Conflict_Intensity} = \sum_{i=1}^{n} (0.2 \cdot \text{Likes}_i + 0.1 \cdot \text{Favorites}_i + 0.4 \cdot \text{Comments}_i + 0.3 \cdot \text{Shares}_i)$$

(3) Classification of spatial conflict intensity levels

Based on the distribution of calculated values, spatial conflict intensity is categorised into five levels. The maximum observed intensity value is 42,406.6, and the minimum is 3.6. Classification criteria are presented in Table 2.

Table 2 Classification of spatial conflict intensity levels

Conflict Level	Value Range	Data Characteristics
Low	3.6 – 1,000	Scattered, low-engagement interactions; predominantly neutral content with minimal contentious expression.

Moderately Low	1,000.1 – 5,000	Occasional controversial topics; limited discussion scope; participants express fragmented, non-confrontational views.
Moderate	5,000.1 – 15,000	Emergence of polarised viewpoints; regionalised discussion patterns; significant increase in interaction frequency.
Moderately High	15,000.1 – 30,000	Sustained multi-group discussions; heightened emotional expressions; accelerated information diffusion.
High	30,000.1 – 42,406.6	Large-scale cross-community discourse; featured discussions on mainstream platforms; heightened need for content regulation.

2.3 Spatial analysis

This study employs ArcGIS 10.8 to conduct multi-level spatial analyses, including global spatial autocorrelation and kernel density estimation. These methods collectively uncover the spatial distribution patterns of tourism-related conflict.

Global spatial autocorrelation analysis utilises Moran's I index to evaluate whether conflict intensities exhibit clustering, dispersion, or randomness across space, thereby offering a macro-level perspective on the spatial configuration of tourism conflict in Nanjing.

Kernel density estimation visualises the spatial concentration of conflict points by calculating their frequency per unit area. This generates a continuous density surface, illustrating the spatial gradient of conflict intensity, identifying core conflict zones, and revealing potential diffusion pathways. This provides a valuable foundation for understanding the spatial propagation mechanisms of tourism-related conflict.

3 Research findings

3.1 Overall spatial distribution characteristics of conflict

(1) Spatial distribution patterns

The spatial distribution of conflict points between tourists and local residents in Nanjing exhibits a pattern of localised concentration and overall dispersion (Figure 1). Conflict hotspots are primarily clustered in two key areas: (1) the historic inner city, particularly around Xinjiekou and Laomendong; (2) the Zhongshan Scenic Area, located outside the old urban core. These zones serve as major tourist attractions while simultaneously functioning as vital public spaces for residents' daily activities.

In addition, sporadic conflict points are distributed throughout the central urban area beyond the old city, including locations such as Yuhuatai, Guochuangyuan, and Suojincun. Beyond the central districts, isolated instances of spatial conflict are also observed in the Niushou Mountain Scenic Area. This spatial pattern suggests that conflict emerges not only in core tourist zones but also in areas where daily residential life intersects with tourism activity, highlighting the complex socio-spatial entanglements within the urban tourism landscape.

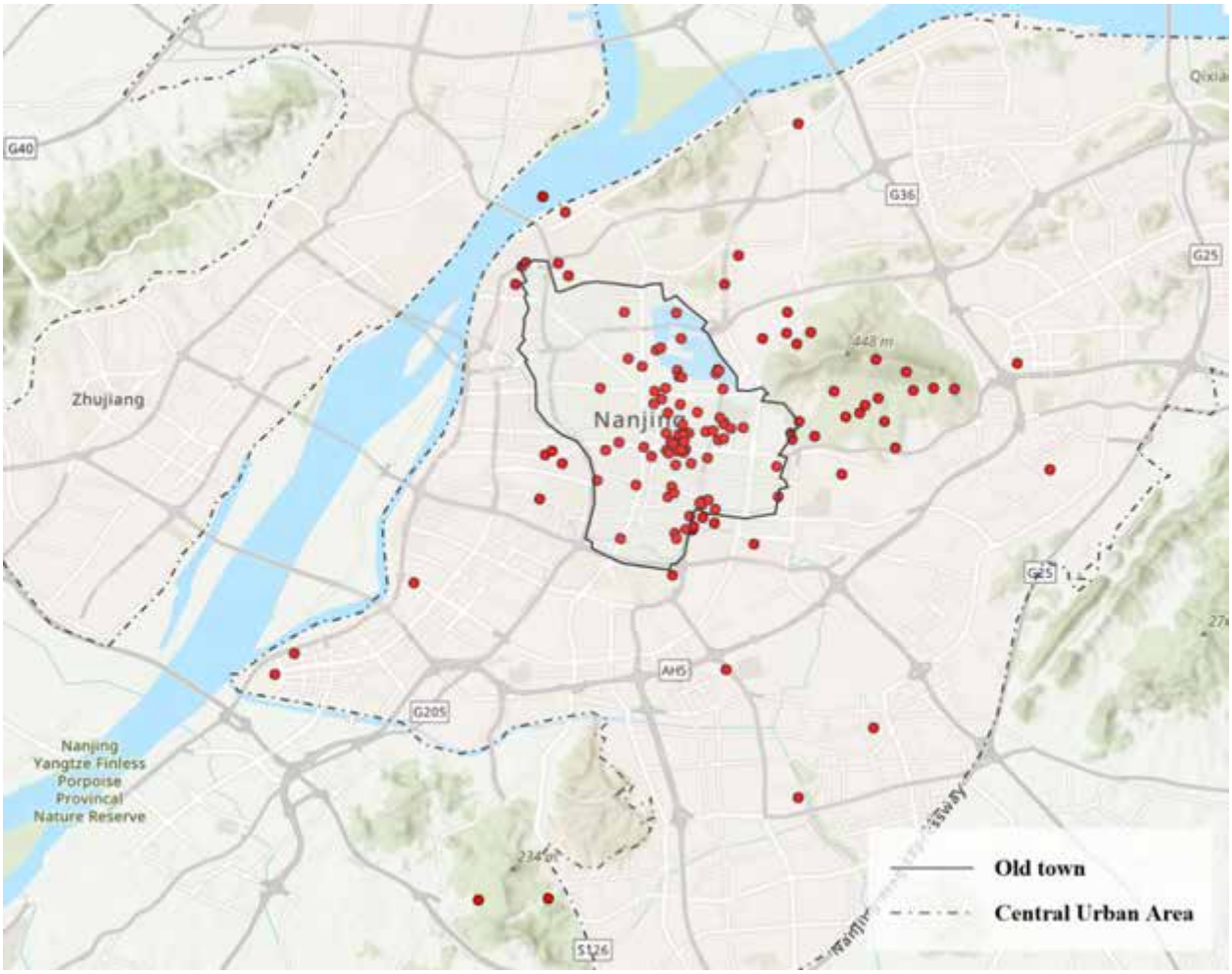
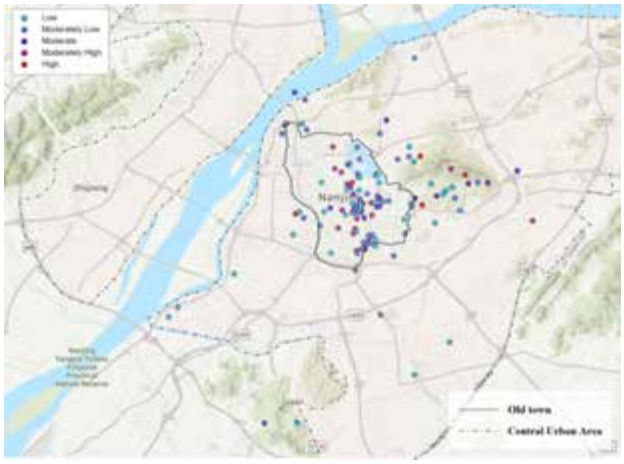


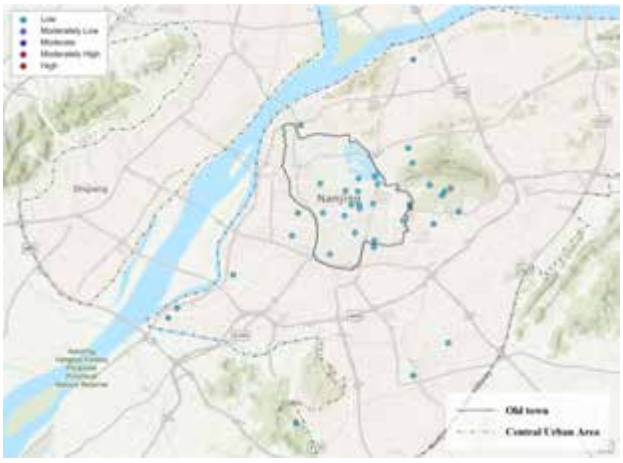
Figure 1 Spatial distribution of conflict points in Nanjing

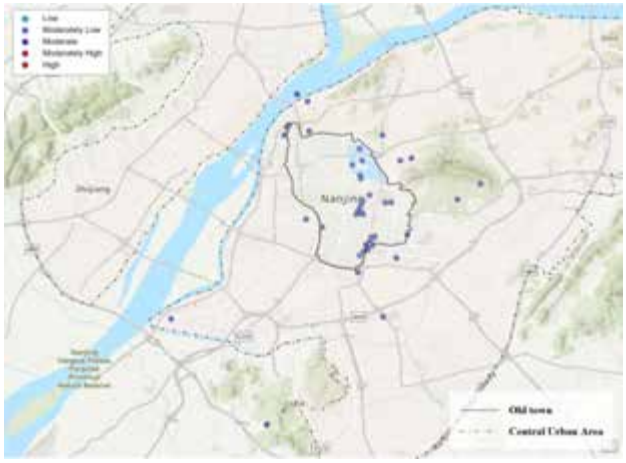
Further analysis of spatial conflict intensity reveals that 38% of identified conflict points fall within the "moderate" to "high" intensity categories (Figure 2). These points are predominantly concentrated in Nanjing's old city centre and the Zhongshan Scenic Area. Specifically, seven locations—Laomendong, Xinjiekou, Jiming Temple, Nanjing Museum, Xuanwu Lake Park, the Memorial Hall of the Victims in Nanjing Massacre, and the Sun Yat-sen Mausoleum—are identified as sites of "high-intensity" spatial conflict. These areas are characterised by both high tourist footfall and the convergence of multiple urban functions, including culture, commerce and recreation.

Conflict points with "moderately low" intensity are mainly concentrated in Laomendong and Xinjiekou districts, reflecting periodic and localised tensions. In contrast, "low-intensity" conflict points are more diffusely distributed across the old city, indicating a spatial diffusion pattern from the core to the periphery. This outward dispersal trend corresponds with a gradual decline in both conflict frequency and intensity as distance from the city centre increases.

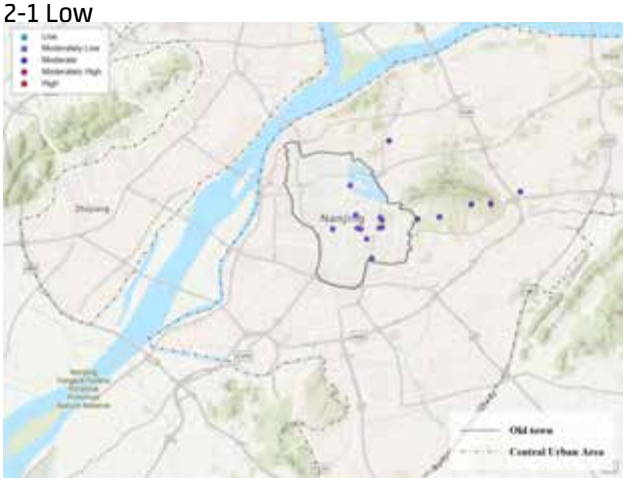


2-1 Low

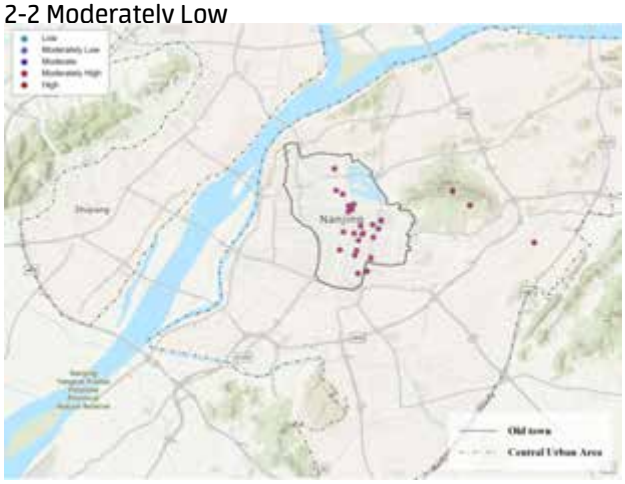




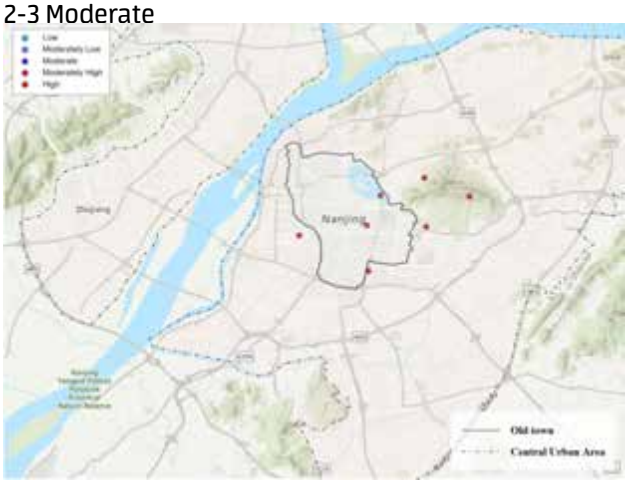
2-2 Moderatelv Low



2-3 Moderate



2-4 Moderately High



2-5 High

Figure 2 Spatial distribution of conflicts across intensity levels in Nanjing

(2) Spatial autocorrelation characteristics

The results of the global spatial autocorrelation analysis (Table 3) indicate that the overall distribution of tourism-related spatial conflict intensity in Nanjing exhibits a significantly dispersed pattern. Specifically, "high-intensity" and "low-intensity" conflict points tend to be spatially separated, rather than concentrated in particular areas.

Table 3 Results of global spatial autocorrelation analysis

Indicator	Value	Interpretation
Moran's I	-0.084664	Indicates a slight overall spatial dispersion (negative spatial correlation). High- and low-intensity conflict points are spatially distinct.
z-score	-2.024578	Deviates significantly from the mean of a normal distribution, confirming negative spatial correlation.
p-value	0.042911	Less than 0.05, indicating statistical significance.

3.2 Spatial conflicts under differentiated functional domains

(1) Typological classification and functional characteristics

Based on the dominant function of each spatial conflict location, a typological approach was adopted to classify conflict sites into eight categories (Table 4).

Table 4 Typology of spatial conflicts based on dominant functional attributes

Type Code	Type Description	Examples
T1	**Commemorative and Exhibitory Spaces**: Public spaces primarily focused on historical commemoration and cultural exhibition.	Nanjing Museum, Memorial Hall of the Victims in Nanjing Massacre
T2	**Tourist Attractions**: Nationally rated A-level scenic spots and other major tourism destinations.	Laomendong Historic District, Yihe Road Historic District, Sun Yat-sen Mausoleum
T3	**Commercial Consumption Areas**: Modern commercial complexes centred on shopping and consumer activities.	Golden Eagle International, The Mixc Mall, Greenland Zifeng Tower
T4	**Creative-Cultural Spaces**: Areas combining cultural industries with lifestyle experiences.	Librairie Avant-Garde, Guochuangyuan Innovation Park
T5	**Food and Leisure Spots**: Locations attracting visitors primarily for distinctive local cuisine and social consumption.	Hongfu Noodle Shop, Volcano Izakaya
T6	**Everyday Living Spaces**: Traditional residential communities and daily life areas.	Taogu New Village, Hongmiao Community, Kexiang Alley
T7	**Transport Nodes**: Key metro stations and major road intersections within the city.	Nanjing Yangtze River Bridge, Wutong Avenue, Beijing East Road

T8	**Scenic Parks**: Open green spaces focused on ecological leisure and recreation.	Hongshan Forest Zoo, Mochou Lake Park

(2) Spatial distribution characteristics

A systematic analysis of the 125 identified spatial conflict points (Figures 3 and 4) reveals significant variations in terms of quantity, conflict intensity, and spatial clustering across different dominant functional types.

In terms of quantity, spatial conflicts associated with Tourism Attractions (T2) far exceed those of other categories, totaling 35 cases, which accounts for 28% of the total sample. This suggests that although urban tourism space is becoming increasingly diversified, traditional tourist sites remain the primary arenas for spatial conflict. Food and Leisure Spots (T5) and Everyday Living Spaces (T6) registered 27 and 18 conflict points, respectively. This pattern indicates a growing tendency for contemporary tourism activities to penetrate the quotidian spaces of city life. By contrast, Creative Cultural Spaces (T4) exhibited the lowest number of conflict points (only 2), a phenomenon that may be attributed to their niche positioning and the relatively higher cultural literacy of their visitors.

In terms of conflict intensity, "high-intensity" conflicts are predominantly concentrated in Tourism Attractions (T2) and Commemorative and Exhibitory Spaces (T1). For instance, traditional sites such as Laomendong have experienced disruptions due to excessive tourist density, resulting in spatial disorder. Similarly, institutions like the Nanjing Museum and the Memorial Hall of the Victims in Nanjing Massacre manifest conflicts between visitor behavior and the solemn atmosphere required by such spaces. "Moderately high-intensity" conflicts, meanwhile, are more frequently observed in Transport Nodes (T7) and Food and Leisure Spots (T5). In the former case, conflict points such as Xinjiekou Station and Zhangfuyuan Station indicate that the urban commuting system has become a critical locus of tourism-induced spatial tension. In the latter case, disputes often arise from issues related to service quality, taste expectations, and pricing strategies.

In terms of spatial clustering, Tourism Attractions (T2) exhibit a dual-core agglomeration pattern, with concentrations in both the Zhongshan Scenic Area and the Laomendong Historic District. This indicates considerable spatial conflict pressure on traditional tourism zones. Commercial Consumption Spaces (T3) and Food and Leisure Spots (T5) together form a "composite conflict zone" around Xinjiekou, underscoring the spatial competition generated by multi-functional convergence in commercial centers. Everyday Living Spaces (T6) present a single-core clustering pattern centered in the Gulou District, where dense historic alleys and a rich local lifestyle atmosphere have recently attracted heightened attention from external tourists. This area's high concentration of long-term residents has further intensified the tensions between tourism practices and daily urban life.

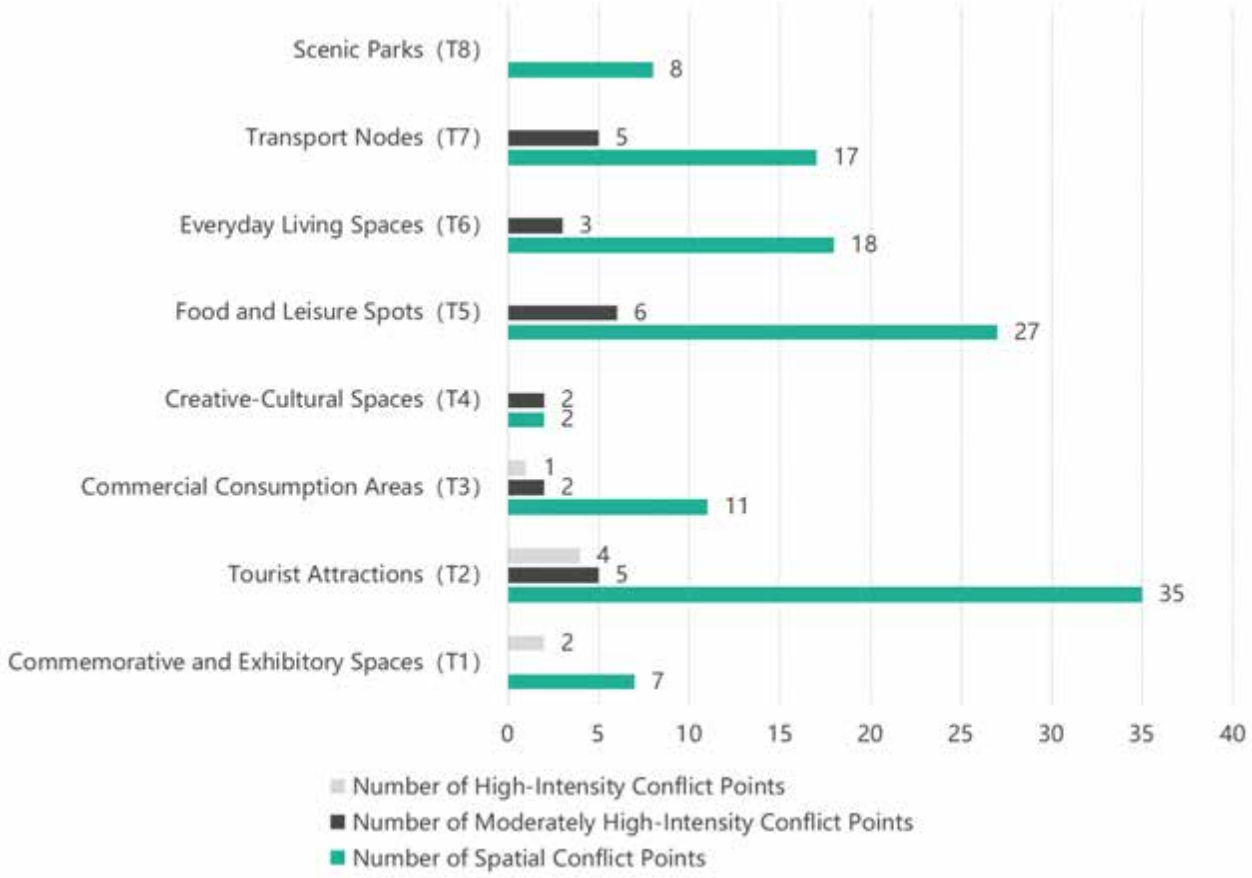
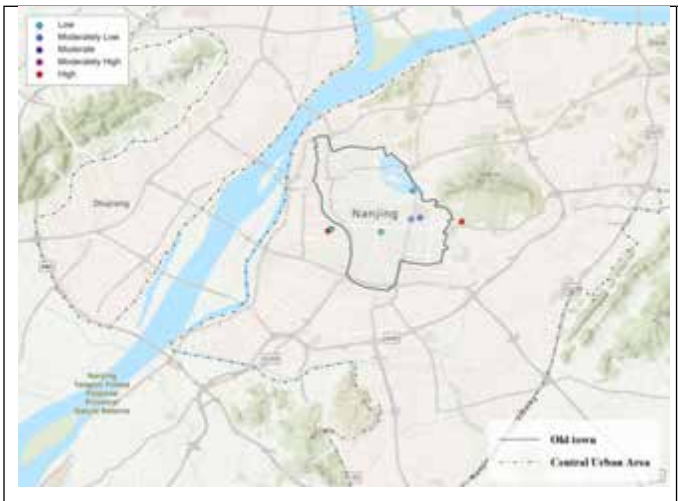
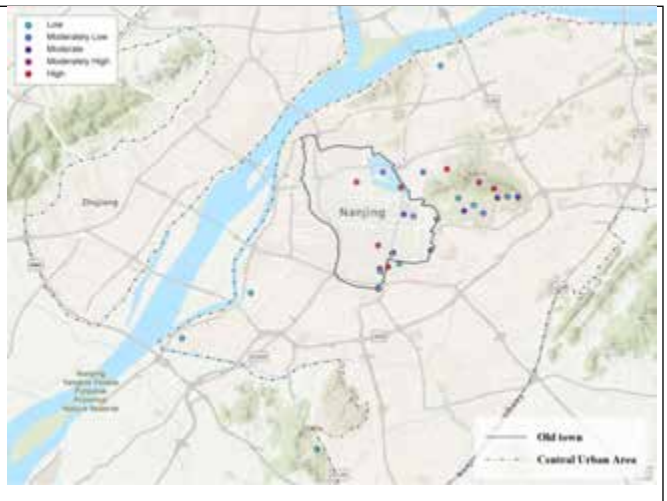


Figure 3 Statistical distribution of spatial conflict points



T1-Commemorative and Exhibitory Spaces



T2-Tourist Attractions

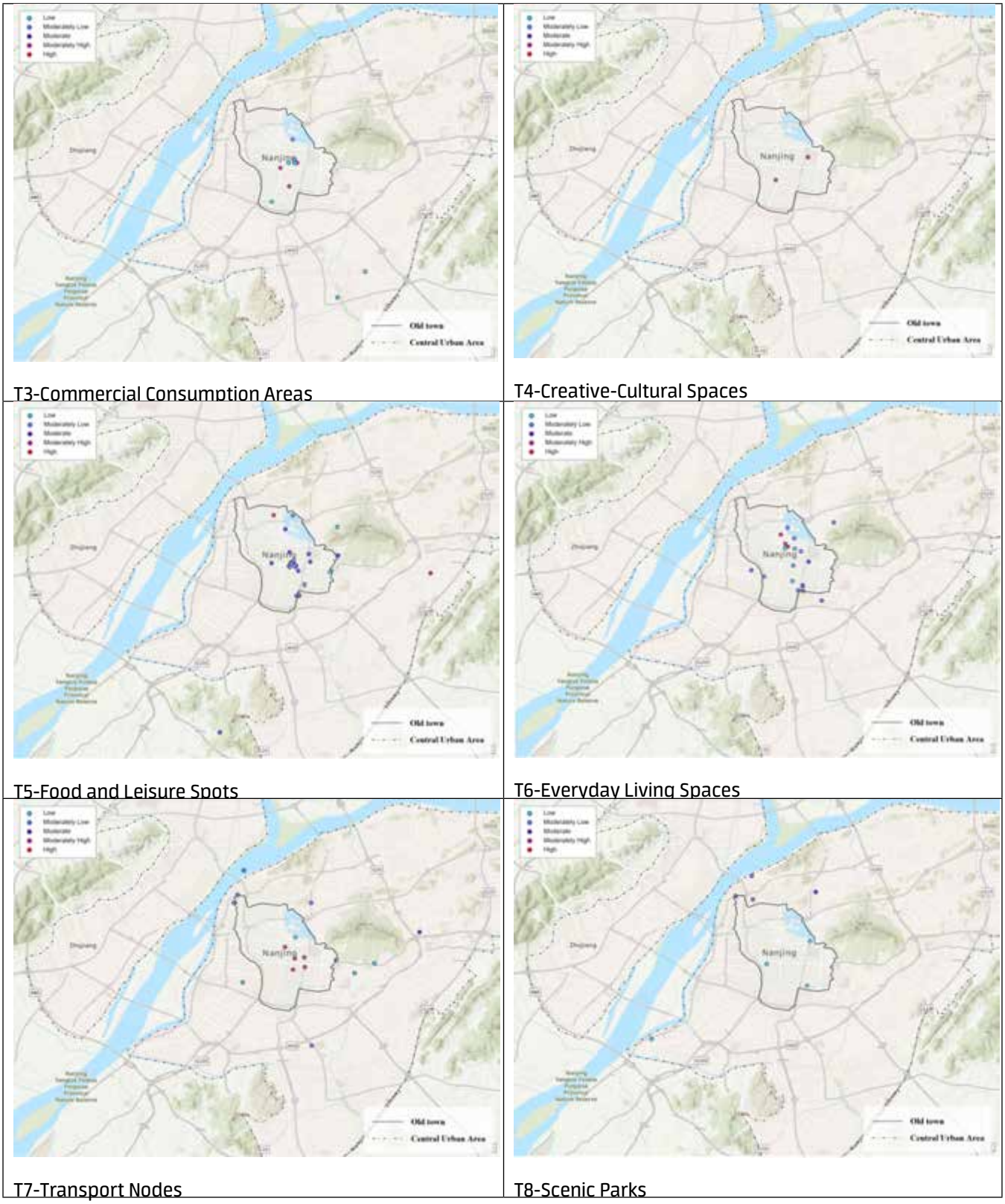


Figure 4 Spatial distribution of conflicts by dominant functional type

(3) Spatial conflicts and dominant functional types

Based on the typological classification and spatial distribution characteristics of conflict points, this study identifies three typical patterns that reflect the relationship between dominant functional types and the manifestation of spatial conflicts in urban tourism areas:

High-intensity clustered type: Tourist Attractions (T2), Food and Leisure Spots (T5)

This type of conflict pattern predominantly occurs in areas with the highest concentration of tourists and the most diverse range of tourism-related activities. These zones exhibit a high number and intensity of spatial conflict points, accompanied by a significant degree of spatial clustering. Representative cases include Laomendong, Sun Yat-sen Mausoleum, Xuanwu Lake, and the Xinjiekou commercial district. The conflicts in these areas are primarily driven by overcrowding, disruption of spatial order, and overloading of local resources, resulting in high-pressure scenarios. As such, these zones represent the primary risk areas in terms of urban tourism-related spatial tensions.

Intersecting and compressed type: Everyday Living Spaces (T6), Transport Nodes (T7)

This pattern mainly arises in urban spaces originally serving daily residential or transit functions. In recent years, such spaces have increasingly been integrated into the exploration-oriented tourist routes, such as "citywalk", due to tourists' growing interest in local lifestyles and authenticity. The overlap of spatial use between residents and visitors generates tensions rooted in mismatched temporal rhythms, spatial behaviors, and normative expectations. Typical examples include residential alleys in the Gulou District and metro station areas in the urban core. These spaces become points of friction as tourism penetrates into everyday life zones, challenging traditional patterns of use and social norms.

Low-frequency, High-sensitivity type: Commemorative and Exhibitory Spaces (T1), Creative-Cultural Spaces (T4)

Although conflicts in this category occur less frequently, the spaces involved carry strong symbolic and emotional significance, thus requiring a higher degree of behavioral regulation. When visitors' actions deviate from the cultural or normative expectations embedded in these spaces, even a limited number of conflict events can trigger strong emotional reactions and widespread public scrutiny. Notable examples include the Memorial Hall of the Victims in Nanjing Massacre and the Vanguard Bookstore. These spaces typically exhibit characteristics of "high sensitivity and low tolerance," where symbolic disruption outweighs quantitative frequency, and thus represent a unique and particularly delicate form of spatial conflict.

3.3 Spatial conflicts from the perspective of different actors

(1) Local residents

From the perspective of local residents, spatial conflicts are primarily concentrated in the eastern part of Nanjing's old city (Figure 5), generally forming a dual-core spatial distribution characterized by "one primary, one secondary" conflict center (Figure 6). The Xinjiekou area emerges as the most prominent conflict zone perceived by residents. As the commercial, transportation, and employment hub of Nanjing, Xinjiekou plays a crucial role in residents' daily commuting, consumption, and social interactions. However, the continuous influx of tourists has disrupted the balance of spatial usage, leading to intensified pedestrian congestion, overcrowding in public spaces, and frequent noise pollution. These disruptions have significantly lowered residents' tolerance for tourism-related activities in the area.

Laomendong constitutes the second core of perceived conflicts among residents. As a traditional neighborhood that retains both historical character and everyday life patterns, Laomendong has undergone a process of tourism-oriented transformation, which has attracted large volumes of visitors. Nevertheless, this has also triggered residents' discontent toward the "touristification of living spaces." The frequent overlap between visitor behavior and community life results in persistent intrusions on residents' privacy, tranquility, and daily routines, turning the area into a typical hotspot of "shared space conflict."

Notably, nearly all "moderate-to-high intensity" conflict points perceived by residents are concentrated within the old city boundaries. This highlights residents' heightened sensitivity and defensive responses to disruptions in their daily living environments.

In summary, residents' perception of spatial conflict primarily stems from the ongoing disturbance of established living patterns caused by tourism activities. The spatial distribution of these conflicts is concentrated in areas with dense residential functions and high tourist footfall, showing pronounced features of spatial centrality and conflict intensity.

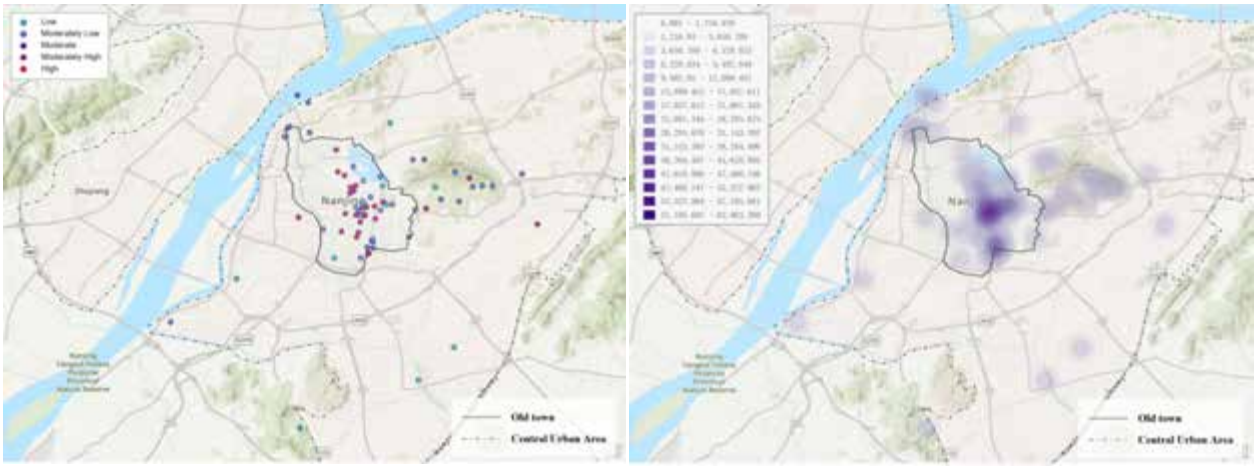


Figure 5 Spatial conflict distribution and intensity from the perspective of local residents

Figure 6 Kernel density analysis of spatial conflicts from the perspective of local residents

(2) Tourists

Unlike local residents, tourists exhibit a more dispersed perception of spatial conflicts (Figure 7), which overall presents a "one primary, three secondary" four-core distribution pattern (Figure 8). The Xinjiekou area remains the principal conflict perception zone for tourists, which aligns closely with the perspective of local residents. As a key node for shopping and transportation interchange—and often the first impression space encountered by tourists—this area bears significant functions related to public service provision and urban image. However, the coexistence of mixed spatial functions, unclear signage systems, insufficient service facilities, and aging infrastructure tends to generate a sense of disorientation during tourists' initial experience, thereby intensifying their perception of spatial conflict.

Similarly, the Laomendong area is another zone where tourist and resident conflict perceptions significantly overlap. As a historical district that attracts prolonged tourist visits, tourists often express concerns about the increasing commercialization, spatial homogenization, and excessive crowding. These issues, when intertwined with residents' resentment toward the "touristification" of their living space, highlight the area's typical "shared space conflict" characteristics.

The Presidential Palace–Kexiang neighborhood represents a boundary zone where tourism and everyday life are densely interwoven. Tourists frequently enter residential courtyards by mistake, generate noise, or loiter for extended periods during their visits, often resulting in friction with community life. On one hand, such behaviors may lead to discomfort or embarrassment for the tourists themselves; on the other, they further exacerbate residents' dissatisfaction with tourism-induced disruptions.

The Zhongshan Scenic Area, as a suburban-oriented core attraction with abundant natural and cultural resources, also emerges as a conflict zone during peak seasons. Despite its significance, the site suffers from inadequate navigation systems and severe congestion, which degrade the overall visitor experience and prompt short-term conflict perceptions.

In general, spatial conflict perceptions among tourists mainly stem from their immediate experiences with services, information, and spatial order in unfamiliar environments. These perceptions are spatially dispersed, with a clear multi-core structure, and the intensity of perceived conflict tends to be moderate and fragmented. This distribution stands in sharp contrast to the local residents' concentrated and high-intensity conflict patterns, revealing the differentiated mechanisms through which distinct user groups engage with urban space.

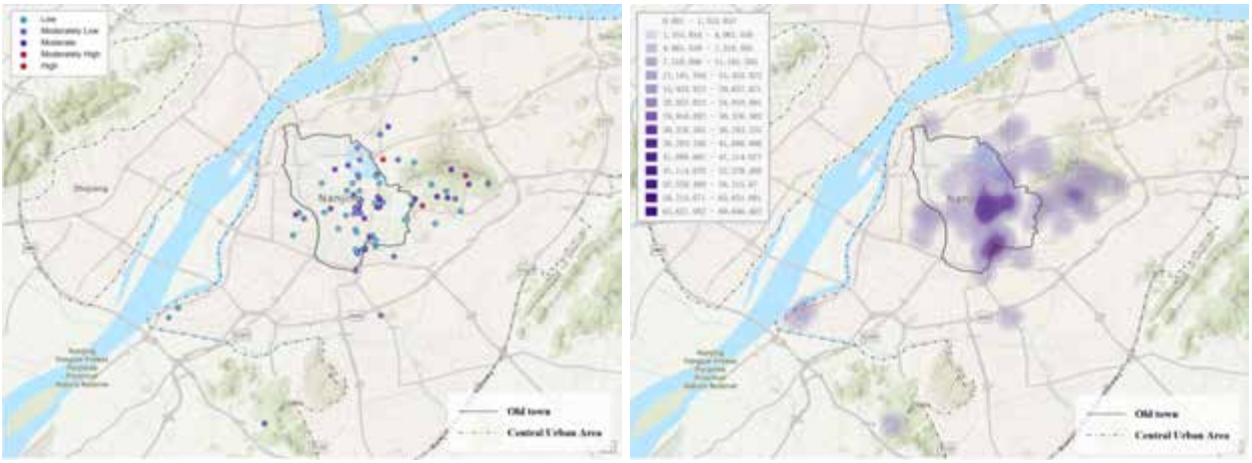


Figure 7 Spatial conflict distribution and intensity from the perspective of tourists
Figure 8 Kernel density analysis of spatial conflicts from the perspective of tourists

(3) Comparative differences

In terms of the number of spatial conflict points, tourists identified a total of 87 conflict locations, significantly more than the 73 points identified from the perspective of local residents. This discrepancy suggests that tourists, due to their broader activity trajectories in an unfamiliar city, are more prone to encounter experiential friction during movement, consumption, and interaction, thereby exhibiting a heightened sensitivity to spatial conflicts.

Regarding conflict intensity, local residents' perceptions are mainly concentrated within the old urban core, demonstrating a "high-intensity, high-density" clustering pattern. In contrast, the "high-intensity" conflict points perceived by tourists are more often located in peripheral scenic areas and key urban nodes, forming a distribution characterized by "high-value points, wide-area coverage." This reflects tourists' wider spatial scope and more scattered conflict experiences compared to the residents' localized concerns.

From the perspective of spatial structure, residents' perception of conflict presents a "concentrated" pattern, revealing their strong desire to protect the stability of specific everyday living spaces. Conversely, tourists' conflict perception shows a "dispersed" pattern, often emerging as incidental friction encountered during the tourism mobility process. The root of this divergence lies in differing urban space usage logics: residents emphasize the continuity and order of daily life, while tourists prioritize the completeness and comfort of short-term experiences.

Despite these differences, both groups show high levels of agreement in their conflict recognition within certain critical urban spaces (Figure 9). For example, Xinjiekou, as a multifunctional urban core where commercial,

transportation, and employment functions overlap, and Laomendong, a historic district where everyday life and tourism are tightly intertwined, are both frequently cited by residents and tourists alike. These areas jointly constitute the most prominent zones of spatial conflict in the city.

Overall, spatial conflict is not merely a manifestation of behavioral friction at the individual level. More profoundly, it reflects the tensions and coordination challenges among different social groups in the process of "sharing the city." Understanding these differentiated perceptions is crucial for formulating inclusive and responsive urban planning strategies.

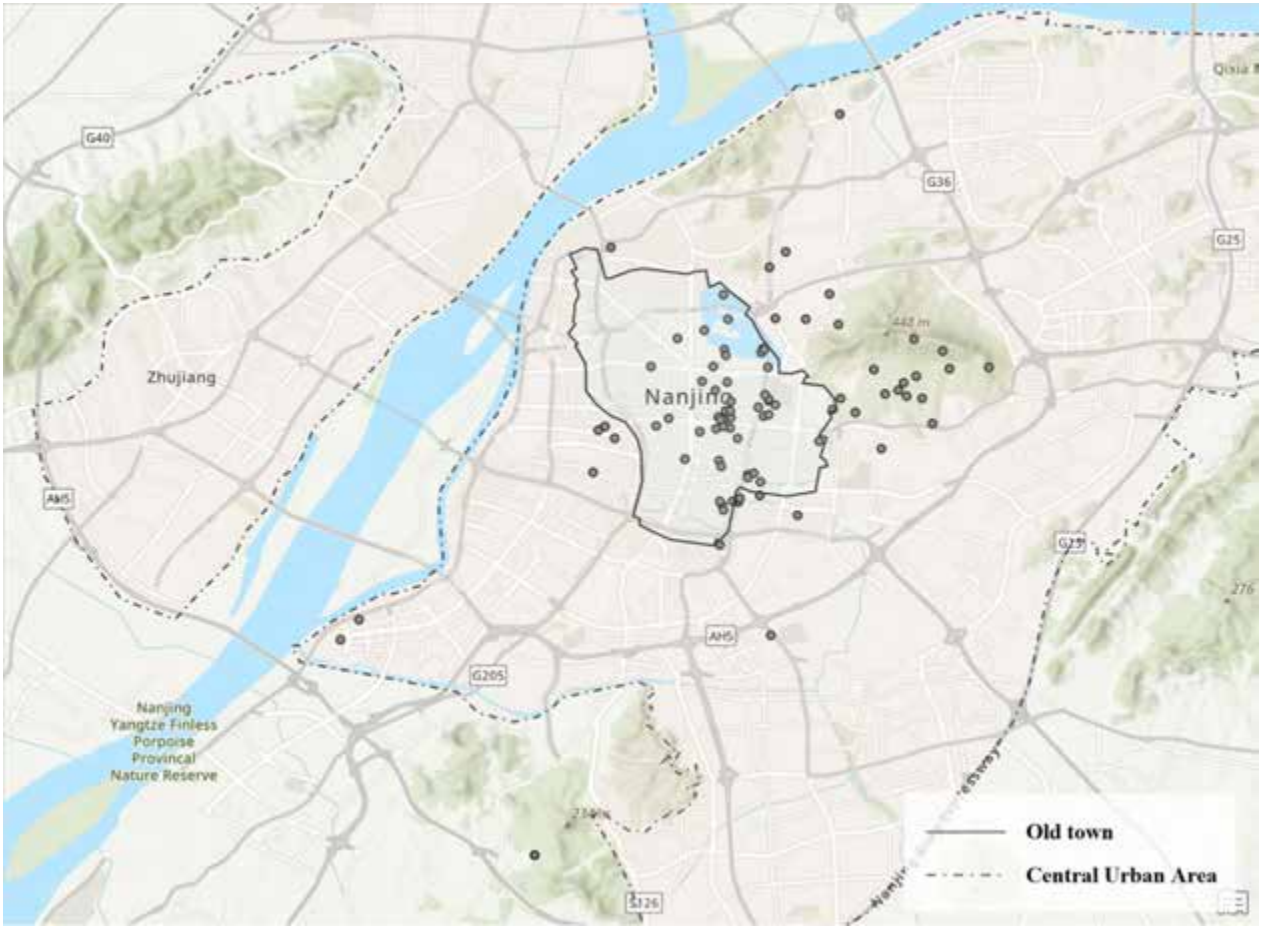


Figure 9 Shared conflict points from different actor perspectives

4 Discussion and Conclusion

4.1 The mechanism of spatial conflict generation: The interaction among structure, action, perception, and platform

Spatial conflicts in tourism are not merely the accumulation of isolated and accidental incidents; rather, they represent a systemic phenomenon embedded within the city's spatial structure, social behavior patterns, and digital platform mechanisms. To develop a more systematic understanding of the logic behind conflict generation, this study draws on Henri Lefebvre's theory of the "production of space" to construct a three-dimensional model encompassing the structural layer (representational space), the action layer (spatial practice), and the perceptual layer (representations of space).

At the structural level, urban planning regulations, tourism development policies, and the functional layout of

space provide the institutional and material foundations for spatial conflicts. In Nanjing—particularly within the old city—there exists a high degree of overlap between historical heritage and modern urban functions. Residential, transportation, commercial, and tourism activities coexist and often overlap, intensifying competition over space and increasing conflict intensity. Additionally, the lack of clear functional zoning, imbalances in infrastructure allocation, and uneven distribution of tourism resources all contribute to spatial tension and functional antagonism.

At the action level, spatial practices by diverse actors form the behavioral mechanisms through which conflicts emerge. Tourists, guided by social media platforms, tend to follow hotspot-driven routes of exploration, while local residents utilize the same spaces according to the rhythms of daily life. These two user groups differ significantly in their behavioral tempo, adherence to spatial norms, and expectations of space. Urban governance often lags behind these spatial dynamics; the boundaries of regulation remain ambiguous, and management mechanisms struggle to respond effectively. Meanwhile, the algorithmic recommendations, tagging systems, and hotspot aggregation functions of platforms further guide and reinforce individual spatial preferences, exacerbating tensions in space usage.

At the perceptual level, spatial conflicts are constantly generated and amplified through individual experiences, cognitive dissonances, and emotional expressions. Tourists who encounter negative experiences frequently share them on social media using warning-laden terms such as “red flags” or “traps,” turning their posts into user-generated content that enters the public opinion sphere. Local residents, feeling the encroachment of tourists, develop psychological defenses toward their living spaces, which often manifest as cognitive opposition to tourist activities. These emotional narratives and cognitive divergences overlap and reinforce one another within the digital environment, amplifying awareness and perception of conflict.

Social media platforms, as deeply embedded spatial agents, play a dual role in the conflict generation process. On one hand, they transform fragmented individual experiences into collective perceptions, enabling originally dispersed tensions to be “tagged” and “mapped,” thereby acquiring characteristics of public dissemination and cognitive stability. On the other hand, through mechanisms such as trending lists, check-in culture, and personalized recommendations, platforms reconstruct tourists’ spatial imaginaries and anticipated pathways, intensifying the spatial burden and disorder in hotspot areas and giving rise to new conflict nodes.

Therefore, the generation of spatial conflicts in tourism should not be oversimplified as a result of governance failure or individual misbehavior. Instead, it should be understood as a continuous negotiation among multiple actors within urban space over resource allocation, behavioral norms, and cognitive orders. Urban space is not a neutral physical container but a socially produced space constantly shaped through institutional structures, behavioral interactions, and emotional expressions. In this evolving spatial production, the mechanisms of digital platforms have emerged as indispensable participants in governance and influential forces in reshaping urban order.

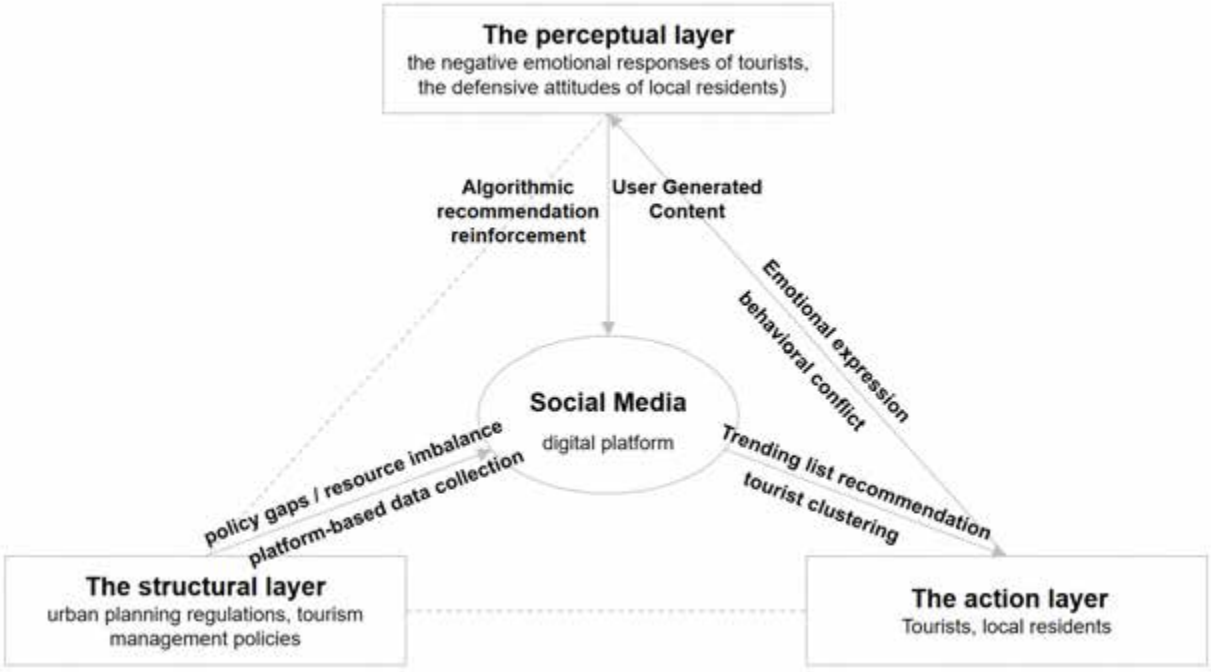


Figure 10 The mechanism of spatial conflict generation: the interaction among structure, action, perception, and platform

4.2 Governance shift of spatial conflicts: From passive management to spatial regeneration

In response to the growing prevalence of spatial conflicts in urban tourism areas, urban governance urgently needs to shift from a passive logic oriented toward emergency response and control to a proactive pathway of spatial (re)production centered on promoting coexistence. This transformation entails a systematic advancement in four key dimensions: enhancing spatial carrying capacity, optimizing behavioral guidance mechanisms, strengthening data feedback capabilities, and embedding adaptive renewal strategies—collectively shifting the governance paradigm from problem patching to spatial activation.

Enhancing the spatial carrying capacity and dynamic adaptability of high-intensity conflict zones. In high-conflict areas such as Xinjiekou and Laomendong, integrated strategies combining "micro-renewal" and "refined governance" can be employed to improve pedestrian accessibility, introduce temporary rest nodes, and incorporate flexible space-use mechanisms. These measures strengthen the area's resilience to high-density flows. During peak periods, time-sharing policies can be introduced to dynamically regulate tourist volume and mitigate disruptions to residents' everyday lives.

Recognizing and softly managing "gray conflict spaces." These spaces—typically found in residential alleys, transit hubs, or other non-typical tourist zones—often feature blurred functional boundaries and insufficient formal governance, making them potential blind spots for conflict generation. Soft spatial interfaces, participatory community co-management, and strengthened behavioral guidance can improve local self-regulation. For example, establishing "quiet hours," enhancing the readability of wayfinding systems, and creating communication platforms between residents and tourists can reduce friction.

Integrating social media feedback mechanisms into spatial governance frameworks. A dynamic feedback loop—consisting of conflict detection, consensus-building, and behavioral intervention—can be developed by incorporating platform-generated data. Real-time monitoring of spatial hotspots, semantic intensity, and actor

profiles enables early warning systems and cross-sectoral response, facilitating a shift from static regulation to adaptive coordination.

Embedding the governance of tourism-related spatial conflicts into broader urban renewal and regeneration strategies. Addressing spatial conflict can become a critical entry point for reactivating urban vitality and reconstructing publicness and collective identity. High-intensity conflict zones can serve as experimental fields for governance innovation, where cultural nodes, public art, and local life scenes are embedded to foster incremental, flexible renewal of old neighborhoods. This approach cultivates a public space culture grounded in humanistic care and shared values. The governance mindset thus transitions from "controlling space" to "empowering space," fostering a symbiotic relationship among tourism, everyday life, and urban development, and steering cities toward a more resilient and inclusive model of coexistence-oriented governance.

4.3 Reframing spatial conflict: From "Avoidance" to "Coexistence"

By analyzing the spatial semantics and typologies of UGC content categorized under "Nanjing Tourism Red Flags" on the Xiaohongshu platform, this study uncovers three emerging characteristics of urban tourism spatial conflicts under the influence of digital platforms:

Decentralized and fragmented conflict distribution. Spatial conflict is no longer concentrated in traditional tourist attractions but is widely dispersed across everyday alleys, transportation nodes, and consumption-oriented spaces. This fragmented pattern reflects both the increasing normalization of tourism within everyday urban life and the amplification effect of social media platforms that bring visibility to non-traditional tourist spaces.

Diversification and heterogeneity of conflict types. This study identifies three typical spatial conflict patterns: "High-intensity clustered type," "Intersecting and compressed type," and "Low-frequency, High-sensitivity type". These typologies reveal the complex interplay between tourist mobility patterns, residents' daily rhythms, and spatial governance logic. Each conflict type differs in its mechanism of emergence, spatial attributes, and emotional feedback, requiring tailored governance strategies rather than a one-size-fits-all approach.

Platform-mediated differentiation of perceptions and amplification of emotions. Social media platforms have transformed both the generation and dissemination of spatial conflict. Individual experiences are rapidly aggregated into collective perceptions, while behavioral frictions are compounded by perceptual divergences and emotional expressions, resulting in an emotionally charged digital public sphere. Differences in spatial expectations, cognitive tensions, and imagined orders between residents and tourists are continuously constructed and intensified through platform-based narratives.

Taken together, spatial conflicts in Nanjing's tourism context can no longer be treated as manageable "issues" within the purview of a single administrative department. Rather, they represent a complex phenomenon shaped by institutional logics, behavioral patterns, and media mechanisms. Social media platforms are no longer mere amplifiers of conflict—they have become deeply embedded actors in the (re)construction of spatial order.

Future urban spatial governance must move beyond traditional frameworks of physical space and administrative zoning, and instead, respond to the embedded mechanisms of platform-mediated spatial order. This study's empirical analysis of tourism-related spatial conflicts in Nanjing presents a multidimensional portrait of how urban conflict is produced in the platform era, offering both theoretical grounding and practical insight for constructing a "coexistence-oriented" governance system.

Further research could deepen this inquiry by integrating data across multiple platforms, tracing temporal evolution trajectories, and examining micro-scale individual behaviors, thereby enriching our understanding of how digital media intervenes in the production of urban space and the transformation of spatial conflict.

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Assessment and Optimization of Sustainable Tourism Planning for Suburban Rural Areas of Metropolitan Fringe Areas Based on Ecological Landscape Unit Division: Evidence from Huanglongxian, Nanjing

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Abstract
The rapid acceleration of urbanisation in China has led to the emergence of many big cities, which has greatly affected the development of tourism in the surrounding areas. As Metropolitan Fringe Areas increasingly serve as popular short-term travel destinations, the adjacent villages confront unprecedented developmental opportunities and challenges. This study examines the Paifang community in Jiangning District, Nanjing, China to investigate ecological landscape assessment and strategic tourism planning within the context of a sustainable tourism framework in Metropolitan Fringe Areas. First, this research delineates the landscape ecological units of the Paifang community and assesses ecological sensitivity. Through a combination of technical research, field surveys, and in-depth interviews, this study analyses the expectations of both residents and tourists, proposing targeted tourism planning strategies.

Keywords: Urban suburbs; Landscape ecological units; Sustainable rural tourism; Machine learning

1. Introduction

Urban areas worldwide have been steadily expanding, often at the expense of natural and semi-natural land (Martellozzo et al., 2018). The current "Rural Revitalization" strategy is continuously advancing across China, and a consensus has been reached: to rationally plan the spatial layout of urban and rural construction with holistic thinking and promote integrated urban-rural development. This implies that the models and experiences of urban construction cannot be directly applied to rural construction. As a special ecological-production-living space, rural areas need to build a harmonious relationship between humans and nature, organically integrating ecological and social systems (Central Committee of the Communist Party of China & State Council, 2018). However, as metropolitan fringe areas increasingly serve as popular short-term travel destinations, villages face unprecedented developmental opportunities and challenges. This involves the interaction and contrasting relationship between human activities and natural landscapes in rural areas. The penetration of tourism consumption culture has precipitated spatial alienation, manifesting through phenomena such as village relocations and population displacement (He et al., 2022). If the natural, historical, and cultural environment cannot be protected, there can be no expectations for sustainability in destination areas (Khizar et al., 2023). To mitigate both positive and negative impacts on residents' quality of life (QOL) arising from unsustainable over-tourism, it is essential to implement effective control measures (Mihalic et al., 2021). As a model for sustainable tourism development, alternative tourism emphasises the necessity of harmonious coexistence between tourism initiatives and rural communities based on ecological protection and cultural respect. Localised analysis of existing ecological and cultural resources is a prerequisite for the effective implementation of alternative tourism. The rural landscape is a spatial representation of the composite ecosystem comprising the social, humanistic, economic, and natural environments of the countryside, possessing dual characteristics of humanity and nature (Wang & Liu, 2003). On the one hand, the organisation and assessment of the current situation are crucial, and the scientific delineation of landscape ecological units is a fundamental prerequisite for regional research and environmental development. On the other hand, against the backdrop of accelerated urbanisation nationwide, how to maintain the diversity of regional characteristics in rural areas and carry out sustainable tourism development is a common issue faced by urban-rural planning and sociology(Zhang, 2021).

2. Development History and Current Situation of Huanglongxian

2.1 Overview of the Study Area

This study focuses on the Paifang Community, situated in the Jiangning District of Nanjing City, Jiangsu Province, China (Figure 1). The research aims to explore methodological approaches for delineating landscape ecological

units within rural environments, thereby contributing to strategies for sustainable rural development.

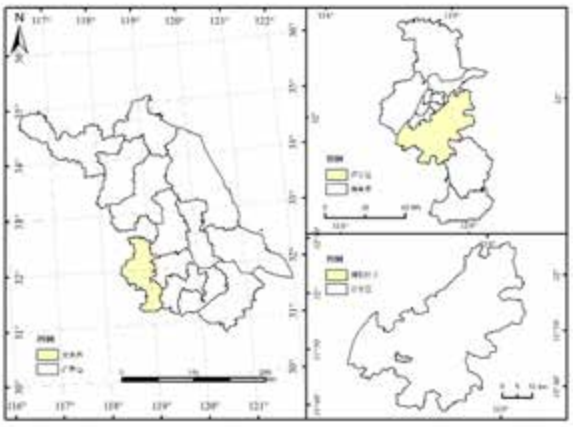


Figure 1. Location map of the study area.

Jiangning District of Nanjing belongs to subtropical monsoon climate, which is rich in plant resources and forms various types of landscape ecological environment. Paifang Community is located in the southeast of Jiangning Street, Jiangning District, Nanjing, with a total area of 8.2 square kilometers. It belongs to hilly and mountainous villages, and the western tourist corridor line passes through the territory. With beautiful scenery, beautiful environment and rich resources, the community is the location of beautiful countryside-Huanglongxian Tea Culture Eco-tourism Village. With the deepening of rural tourism development, the natural scenery and human activities in this area have more overlap, so it has high research value and reference significance.

2.2 Development History of Rural Tourism in Huanglongxian

The evolution of rural tourism in Huanglongxian can be divided into four distinct phases:

Initial Stage (Pre-2013): At this early juncture, Huanglongxian was a relatively impoverished mountainous village whose primary economic activity centred on tea cultivation. Its development was hindered by limited transportation infrastructure and weak public services.

Transformation and Enhancement Phase (2013–2016): Leveraging its unique landscape resources, the area underwent infrastructure and environmental improvements driven by coordinated efforts at district, street, and village levels. During this phase, the tea industry and tourism began to develop simultaneously, initiating what has been termed the "beauty economy."

Upgrading and Expansion Phase (2017–2020): This period was marked by efforts to deepen the integration of cultural elements. Key strategies included the construction of the "Rural +" industrial chain, the establishment of an ecological tea industry system, and the development of clustered guesthouses. Organised cultural events contributed to tourism brand-building and furthered the integration of various sectors.

Consolidation and Innovation Phase (2021–present): Since 2021, ongoing efforts have aimed to improve the ecological environment further. Initiatives such as the "toilet revolution" and "waste revolution" were implemented, alongside the development of sewage treatment infrastructure. Concurrently, traditional cultural practices, including tea culture, have been revitalised and incorporated into the tourism offering, enriching its cultural dimensions.

Community engagement has played a pivotal role in this development process. For instance, the spontaneous signing of the "Villagers' Environmental Protection Pact" has demonstrated enhanced local participation, contributing to co-creation and shared benefits. The historical trajectory of rural tourism in Huanglongxian highlights the critical importance of governmental guidance, ecological prioritisation, cultural revitalisation, industrial in-

tegration, and community participation. These elements collectively offer valuable insights for the sustainable development of rural tourism within the broader framework of China's rural revitalisation strategy.

3 Ecological Landscape Unit Delineation

3.1 Necessity of Delineating Rural Landscape Ecological Units

As previously mentioned, rural areas, as places with dual attributes of "space" and "resources," closely link human activities with the natural environment, while also possessing unique ecological conservation functions and potential for sustainable development. Consequently, there is a relatively rich variety of ecologically functional land use types within the rural landscape environment. However, changes in the land use structure of villages and towns have led to landscape fragmentation, resulting in a decline in the "sense of place" and "sense of belonging" in rural areas (Guo et al., 2013), loss of regional characteristics, and homogenisation of landscape features (Chen, 2012). The scientific protection and moderate development of rural landscapes are the developmental direction for rural construction. On the other hand, in rural areas, even the same type of land use can exhibit differences in ecological characteristics due to variations in area, hydrological climate, elevation, and vegetation cover. Therefore, to conduct a classified analysis of the landscape ecology of different regions within the study site, considering natural geographical conditions, climatic factors, locational environment, and the current vegetation conditions of different areas, the study area should be divided into different ecological units. This paper explores the integration of Python programming language with traditional landscape unit delineation techniques, aiming to obtain more objective results for landscape ecological unit delineation.

3.2 Existing Methods for Delineating Landscape Ecological Units

The concept of a "unit" originates from a fundamental concept in the modern scientific and technological system, representing a self-contained system with relative independence and function. It possesses basic characteristics such as systematism and self-containment, and when applied, the research object is considered as a whole or system (Wang et al., 2020). Ecological spatial units are landscape constituent units that must be recognised in the landscape design process and are also the most commonly used and studied scale types in landscape planning and design (Wang, 2018). Ecological unit mapping has become a fundamental method and tool for various planning and evaluation studies (Zhao, 2012). A landscape unit usually refers to the smallest unit expressed in landscape mapping, i.e., the spatial extent enclosed by baselines representing landscape characteristic types. In image maps, a landscape unit refers to the smallest homogeneous polygon that can be distinguished at a specific spatial resolution (Lou, 2016). A landscape ecological unit is a research unit generated by combining the resource base of geographical space with scale characteristics.

The application of research methods based on landscape ecological units is more common in urban landscapes and natural landscapes. With the vigorous progress of rural construction, landscape ecological units have emerged as a research perspective and entry point in rural landscape studies. Unlike landscape patches in purely natural environments, a village ecological unit is a composite ecosystem integrating natural, artificial, and social elements (Kang & Wang, 2019). Therefore, the method for delineating rural landscape ecological units lays the foundation for further research.

Currently, there are few existing methods for delineating landscape ecological units, and most focus on purely natural landscapes and urban landscapes. Research on rural landscapes is relatively preliminary. For instance, Gao Tian et al. (2010) summarised the history and methods of ecological unit mapping (Gao et al., 2010), including selective ecological unit mapping and comprehensive ecological unit mapping. Kang Yuan et al., in their study of Xiuri Village on the Qinghai-Tibet Plateau, mentioned the wisdom of constructing village ecological units, building the concept of village ecological units from an ecological perspective, and dividing them into residential landscapes, production landscapes, and cultural landscapes. They considered the village ecological unit as a multi-functional complex with humans as the main theme, with the research primarily focusing on local production and living areas with higher human congregation. Similarly, in the research on rural settlement ecological units by Wei Yanyan et al., while dividing them into geographical, landscape ecological, and human settlement units, they also combined macro-, meso-, and micro-perspectives (Wei et al., 2018). However, this approach faced

issues such as irregular boundaries when spatial lines overlapped and insufficient research precision. Another example is the Wusheng County unit delineation method conducted by Wang Zhifang et al. in 2020 (Wang et al., 2020), which utilised SPSS for data processing. However, due to limitations in computing power and data volume, it only studied three aspects: elevation, slope, and land use. The delineated grids were also relatively large, leading to problems such as irregular regional shapes, inconsistent areas, or unclear boundaries, which increased the workload for subsequent tasks.

3.3 Innovative Method for Delineating Landscape Ecological Units

The delineation of landscape ecological units requires the establishment of evaluation criteria. The same piece of land is often influenced by multiple factors; therefore, a single evaluation criterion is not suitable for delineating rural landscape ecological units. Referring to the characteristic evaluation factor system for rural landscape sensitivity assessment (Wang et al., 2021), standards for landscape unit delineation are established (Figure 2).

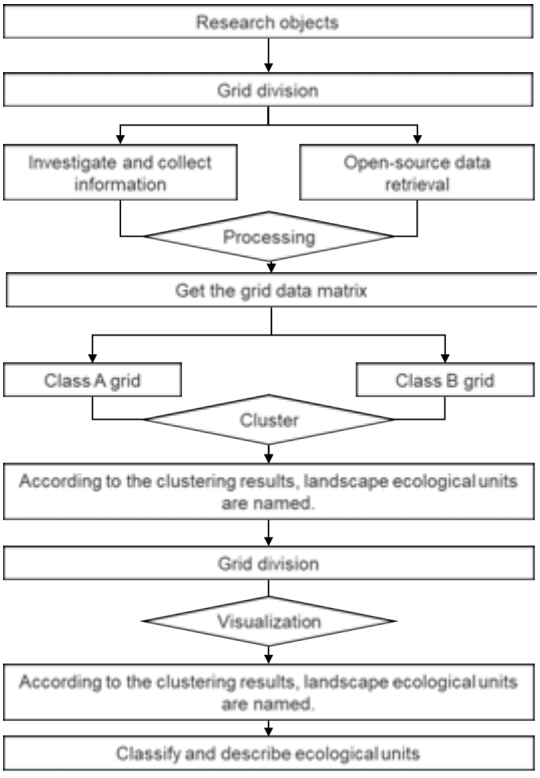


Figure 2. Technical route.

According to the definition and properties of landscape ecological units, the evaluation factors and data types generally considered for the study area include nine items: land use type, presence of surface runoff, flow rate, average temperature, annual precipitation, average elevation, slope, soil sensitivity, and vegetation cover. When there is no surface runoff or no significant surface runoff within the study area, the number of items actually considered for data clustering is six.

3.4 Grid Division and Data Linking

3.4.1 Fishnet Tool

For the study area of Paifang Community, based on the formulae: unit side length$x = \frac{L}{n}$, and total number of units $y = \frac{H}{x}$, it can be deduced that a 10m10m grid precision is suitable for this research object. According to the grid standard, the fishnet tool in ArcGIS was used to divide the bounding rectangle of Paifang Community into a grid (Yang et al., 2019), forming a total of 3530*5640 cells, establishing a system with individual cells of 10m*10m

(Figure 3). Fishnet labels corresponding to the geometric centre of each cell were created and designated as the sampling points for the cells. Finally, empty cells within the bounding rectangle were removed (Figure 4).

Figure 3. Matrix grid.

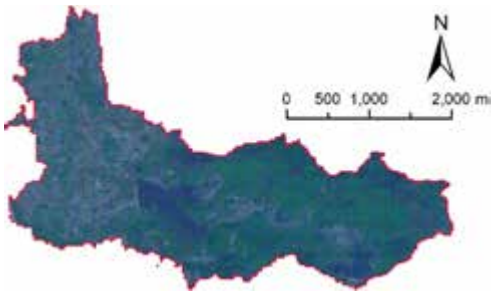


Figure 4. Study area grid.

3.4.2 Data Collection and Determining Factors

The data sources for this study include locally provided materials, field surveys, and satellite open-source data obtained from relevant public data websites. The finally collected effective geographical data include seven categories: elevation, slope, vegetation, temperature, precipitation, land use type, and soil sensitivity. Among these, the temperature data had poor precision and could not form regional differences, so it was excluded. Therefore, a total of six data items were studied.

Multi-band image maps of satellite remote sensing data were obtained from the Geospatial Data Cloud. The data were imported into ENVI. According to the formula in the research method of Li (Li et al., 2003):

$$\mathrm{NDVI} = \frac{\mathrm{float(b4)} - \mathrm{float(b3)}}{\mathrm{float(b4)} + \mathrm{float(b3)}}$$

data such as NDVI vegetation cover (FVC) were calculated. The obtained raster data were imported into ArcGIS and converted to vector data under the WGS_1984 coordinate system.

Where b1, b2, b3, and b4 represent four bands respectively (Figure 5):

Figure 5. Band Correspondence Table

Band	Colour	Wavelength (μm)	Application
Band-1	Blue	0.45-0.52	Water bodies, shallow water underwater features
Band-2	Green	0.52-0.60	Green reflectance of healthy vegetation, distinguishing vegetation types
Band-3	Red	0.63-0.69	Plant classification, distinguishing artificial land feature types
Band-4	Near IR	0.76-0.90	Distinguishing vegetation types, delineating water body boundaries

Taking Paifang Community as the research object, the main determining factors to be considered are six categories (Figure 6 -11): The terrain of Paifang Community is low in the west and high in the east, with the lowest elevation at 13.7m and the highest at 197m. The study area includes small reservoirs and mountainous landforms, with significant topographical variations. Therefore, elevation and slope are considered influencing factors. The

location experiences abundant rainfall and distinct seasons, with good soil conditions; thus, precipitation and vegetation cover are also influencing factors. Among the determining factors obtained from field surveys and literature review, the above four categories are continuous data, while land use type and soil sensitivity are discrete data. Clustering is based on continuous data. Therefore, discrete data need to be stratified and named 1, 2, 3... where the order does not represent priority but is only used for calculating Euclidean distances in the subsequent computational procedures. This method is flexible in determining factor weights, which are often determined based on the current situation and development needs of the study area. For simplicity, this paper sets all weights to $\varphi_i=1$.

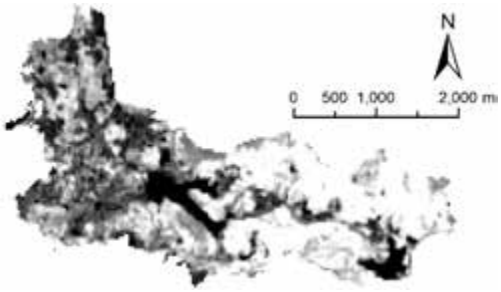


Figure 6. Vegetation cover.

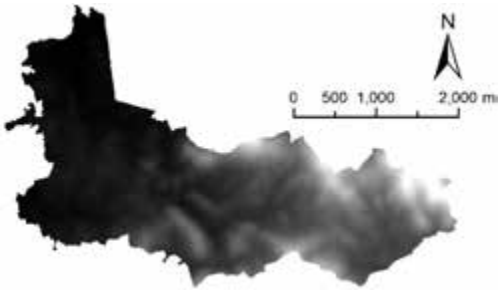


Figure 7. Elevation.

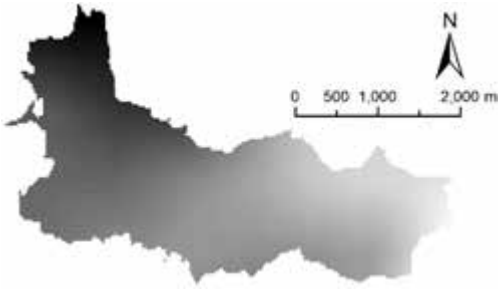


Figure 8. Precipitation.

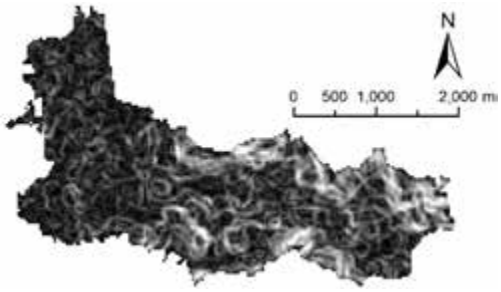


Figure 9. Slope.

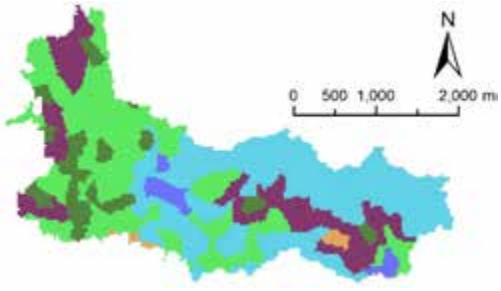


Figure 10. Land use.

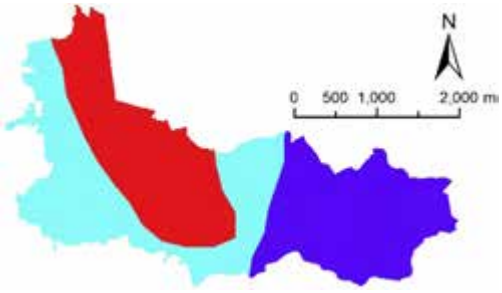


Figure 11. Soil sensitivity.

3.4.3 Grid Classification

As mentioned earlier, the size of the divided grid cells is 10m*10m. To make the delineation of ecological units more precise, this study primarily identifies and classifies two types of grid cells during the division phase: Type A grid cells, where the internal functions, composition, and morphology are relatively consistent; and Type B grid cells, where these aspects show significant differences. In this ecological unit delineation, the bound-

ary lines of different land uses were first identified to distinguish Type B grid cells. Since grid cells located on boundary lines contain two or more types of land use and exhibit high complexity, these cells were classified as Type B grid cells using GIS. The remaining grid cells within the area, containing only a single land use type, were classified as Type A grid cells.

3.4.4 Clustering Process

Taking the geometric centre of each 10m*10m grid cell as a sampling point, the spatial join tool in GIS was used to obtain various data for each sampling part. On the one hand, the data were standardised and outliers filtered to verify data integrity. On the other hand, discrete data were integrated, ultimately yielding the corresponding determining factor data for each grid cell.

In this process: first, randomly select an arbitrary number k (representing the final number of rural landscape unit types for the research object), and denote the k centres as μ_1 ,μ_2,..., Second, the mean of each cluster object is substituted into the group formula as

$$\mathrm{Dis}_j = \sqrt{\sum_{i=1}^{n} \varphi_i (x_i - \mu_j)^2} \quad ,$$

$$\mathrm{D}=\min \mathrm{Dis}j.$$

Calculate the Euclidean distance (Dis) of each object to these central objects, and reclassify the corresponding objects based on the minimum distance D. Then, calculate the cluster centre μ_k^m (the mean of all objects in that cluster) for each newly formed cluster. This process is repeated until the sum of squared errors (SSE) standard measure function begins to converge (Figure 12). The calculation formula is as follows:

$$\mathrm{E} = \sum_{i=1}^{k} \sum_{p=x_i} |p - \mu_i|^2$$

Where: E is the sum of squared errors for all objects in the database; p is a point in the space of the object; μ_i is the mean of cluster xi (both p and μ_i are multidimensional) (Chen et al., 2017).

Clustering was performed on the 6 types of data for Type A grid cells, and obtaining the results (Figure 13). After multi-point verification and troubleshooting, the clustering determining factors were improved. Finally, geographical information (longitude, latitude) was listed separately as a division factor to avoid a scattered distribution of results, thereby obtaining the final clustering result for Type A grid cells. On this basis, for the clustering of Type B grid cells, the item “included land use types” was added, resulting in a unit division result characterised by linear and point-like patterns. The clustering results for Type A and Type B were combined according to geographical information to obtain the final ecological unit delineation result (Figure 14). This includes 16 types of Type A landscape ecological units and 10 representative Type B ecological units.

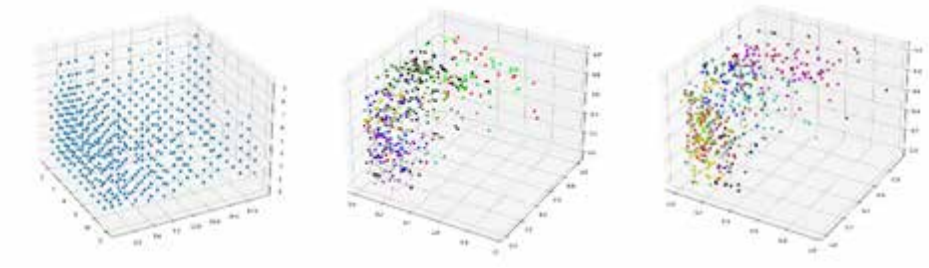


Figure 12. 3D model of the clustering process.

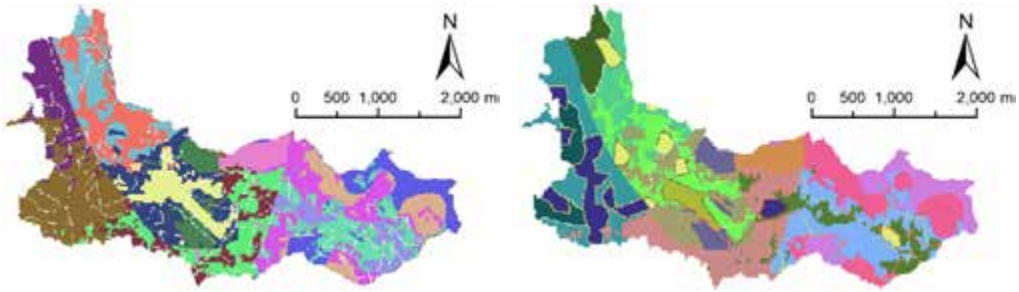


Figure 13. Type A clustering results without latitude and longitude.
Figure 14. Final clustering results incorporating latitude and longitude.

The division of ecological units in nature reserves can be classified according to the natural zoning method and the kilometre grid method (Zhou, 2006). Considering the complexity of rural areas, this paper, based on the kilometre grid, divides the rural research object into several unit grids, and then conducts ecological resource investigation, data registration, and comprehensive evaluation for each one.

During the process of equally dividing the study area, issues related to grid scale, number of grids, grid shape, and differentiated processing between grids are involved. For grid shape, considering the universality of the research object, the grid is defined as a regular quadrilateral. Simultaneously, the grid scale is defined as

$$x = \frac{L}{n}, \quad y = \frac{H}{x} \cdot n$$

Where x is the side length of a single grid, y is the total number of grids, L is the length of the long side of the bounding rectangle of the study area, H is the length of the short side of the study area, and n is the number of grids in the direction of the long side. In the division phase, two types of grids are identified: Type A grids, where the internal functions, composition, and morphology are relatively consistent, and Type B grids, where the internal functions, composition, and morphology show significant differences, thereby reflecting the differentiated processing between grids. Among these, Type B grid data, due to the complexity of the plots, include two or more types of land use and are all located on irregular boundaries. Therefore, data collection for Type B grids, in addition to the aforementioned conventional 9 data items, should also include the number of land use types

contained within a single grid range. For example, if a grid plot includes cultivated land, water bodies, and forest land (three types of land use), then the number of land use types is 3.

Finally, a matrix is initialised to store the data for each grid, including the grid's serial number and corresponding item data. According to the different types of items, the delineated landscape grids are divided into two parts for clustering.

4. Delineation and Evaluation of Ecological Units

4.1 Description of Ecological Unit Delineation Results

4.1.1 Naming and Description of Type A Landscape Ecological Units

The ecological unit delineation results are shown in Figure 16. Combining the type and position of the units, they are named sequentially from top to bottom, left to right as A1, A2, A3... As a relatively large-scale comprehensive evaluation result, the ability to accurately describe each ecological unit becomes an important criterion for judging the accuracy of the ecological unit delineation. After summarising the characteristic descriptions in the table (Figure 15), it can be found that various types of landscape ecological units have certain differences but often exhibit internal correlations, following the laws of land use type transformation and the spatial-temporal dynamic evolution mechanism of rural landscapes constituted by the functional transformation of "production-living-ecological spaces" (Fan et al., 2022). According to the complex intersecting conditions of different landscape ecological units, it reflects that natural conditions endow landscape ecological units with uniqueness and regionality, and also reflects the multi-functionality and inclusive uses of rural landscapes.

Figure 15. Description of Type A Units

Unit No.	Characteristics
A1	Paddy field with low elevation, gentle terrain, low soil sensitivity, and low precipitation.
A2	Villager residential area with low elevation, gentle terrain, low soil sensitivity, and low vegetation cover.
A3	Mixed area of dry land and residential land with low elevation, gentle terrain, high soil sensitivity, low precipitation, and low vegetation cover.
A4	Dry land area with low elevation, gentle terrain, low soil sensitivity, low precipitation, and high vegetation cover.
A5	Villager residential area with low elevation, gentle terrain, high soil sensitivity, low precipitation, and low vegetation cover.
A6	Mixed area of dry land and residential land with low elevation, gentle terrain, low soil sensitivity, low precipitation, and low vegetation cover.
A7	Dry land area with low elevation, distinct topographical undulation, low soil sensitivity, high precipitation, and high vegetation cover.
A8	Paddy field area with low elevation, gentle terrain, high soil sensitivity, low precipitation, and low vegetation cover.
A9	Forested land with high elevation, distinct topographical changes including slopes, high soil sensitivity, high precipitation, and high vegetation cover.
A10	Forested land with high elevation, distinct topographical changes including slopes, low soil sensitivity, high precipitation, and high vegetation cover.
A11	Forested land with high elevation, distinct topographical changes including slopes, medium soil sensitivity, high precipitation, and high vegetation cover.

A12	Paddy field with low elevation, gentle terrain, low soil sensitivity, and high precipitation.
A13	Paifang Reservoir, with strong topographical and landform characteristics.
A14	Area dominated by forested land with low elevation, gentle terrain, high soil sensitivity, and relatively high vegetation cover.
A15	Vegetation cover area with relatively high elevation, gentle terrain, medium-high soil sensitivity, and low precipitation.
A16	Forested land area with very high elevation, distinct topographical changes, medium soil sensitivity, abundant precipitation, and high vegetation cover.

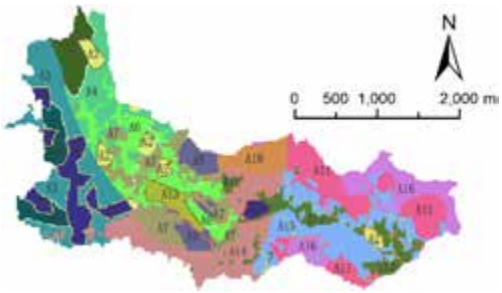


Figure 16. Type A unit numbering and selected points.

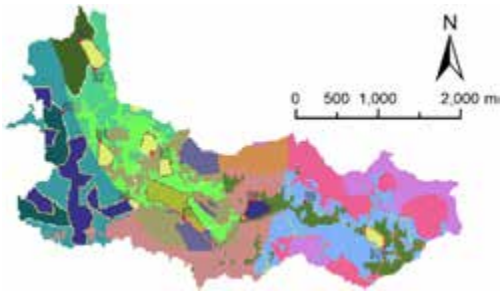
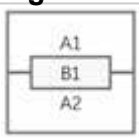
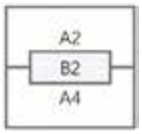
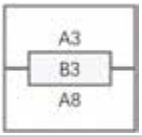


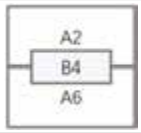
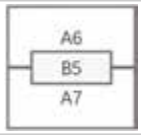
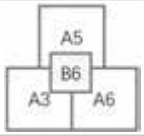
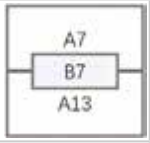
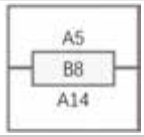
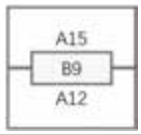
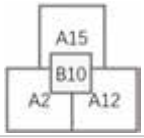
Figure 17. Type B unit numbering and selected points.

4.1.2 Naming and Description of Type B Landscape Ecological Units

The ecological unit delineation results are shown in Figure 17. Combining the features and position of the units, they are named sequentially from top to bottom, left to right as B1, B2, B3... Due to the generation method of Type B grids, these grids are small in area, elongated in shape, and diverse in type. In reality, various types of Type B ecological units share certain commonalities. They are classified and refined into ten representative units, and the table (Figure 18) below explains their characteristics and positional relationships. Type B units often exhibit characteristics of linear continuity and overall fragmented distribution. Typically, Type B landscape ecological units located at boundaries have greater landscape richness, biodiversity, and spatial diversity compared to Type A units. Their geographical location and environmental attributes often show strong similarity and dependence on adjacent Type A landscape ecological units. For example, Type B units adjacent to both villager residential areas and natural environments usually exhibit significant internal variation.

Figure 18. Description of Type B Units

Unit No.	**Figure**	Characteristics
B1		Interface between paddy fields and villager residential areas; low soil sensitivity, gentle terrain, low annual precipitation within the study area.
B2		Mixed land use of dry land and villager residential areas; at the boundary of high and low soil sensitivity, gentle terrain, distinct variation in vegetation cover within the unit, low annual precipitation.
B3		Interface between paddy fields and dry land; significant variation in soil sensitivity within the unit, but overall low sensitivity. Low vegetation cover, low annual precipitation.

B4		Mixed land use of dry land and residential areas; no significant changes in climatic and topographical conditions. Minimal variation in vegetation cover within the unit, low annual precipitation.
B5		Mixed land use of dry land and residential areas; low soil sensitivity, low elevation, distinct topographical undulation, distinct variation in vegetation cover within the unit, relatively drastic changes in precipitation.
B6		Mixed land use of dry land and residential areas; drastic changes in soil sensitivity, including high, medium, and low categories; no significant changes in climatic and topographical conditions.
B7		Interface between dry land and reservoir/ponds; strong landform characteristics, distinct topographical undulation, high vegetation cover, high annual precipitation.
B8		Boundary land use between residential areas and forested land; located in an area with high soil sensitivity, gentle terrain, distinct variation in vegetation cover within the unit, high annual precipitation, distinct landform changes.
B9		Boundary land use between paddy fields and forested land; high elevation, drastic changes in soil sensitivity, located in mountainous terrain, high vegetation cover, high annual precipitation.
B10		Interface land use among forested land, sparse woodland, and residential areas; distinct topographical changes, distinct variation in vegetation cover within the unit, diverse soil sensitivity, high annual precipitation.

4.2 Landscape Unit Evaluation

4.2.1 Ecological Gene Evaluation

This ecological unit delineation covers Type A and Type B landscape ecological units. Type A units are larger and relatively complete in form, with varying natural element characteristics such as elevation, terrain, soil sensitivity, precipitation, and vegetation cover. For example, A1 is a paddy field with low elevation, gentle terrain, low soil sensitivity, and low precipitation, reflecting the uniqueness and regionality of natural conditions, and follows the laws of land use type transformation and the spatio-temporal dynamic evolution mechanism of rural landscapes constituted by the functional transformation of "production-living-ecological spaces." Type B landscape ecological units are small, elongated, and fragmented in distribution. Typically, Type B units located at boundaries exhibit more complex landscape richness, biodiversity, and spatial diversity. Their geographical location and environmental attributes show strong similarity and dependence on adjacent Type A units. For instance, B1, at the interface of paddy fields and villager residential areas, has low soil sensitivity, gentle terrain, and low precipitation, demonstrating the multi-functionality and inclusive uses of rural landscapes. Overall, this reflects the complex intersecting conditions of the regional ecosystem.

4.2.2 Village Layout Gene Evaluation

The layout of Huanglongxian Village changes dynamically with the terrain, conforming to the traditional layout principle of "concealing wind and gathering qi" (Xiong et al., 2023). The village site selection exhibits a strong affinity for water, belonging to a dispersed layout, built along the foot of hillsides. The building layout is primarily guided by water systems and road orientations, generally presenting a strip-like pattern. The internal road network structure of the village is dendritic, with residences distributed along the main road. As the residential distribution changes, the main road further branches into many vine-like subsidiary roads, and residences in ad-

jacent areas are interconnected. Alleyways are often formed spontaneously by the passage between residences, without fixed planning traces. It is precisely because of this characteristic of alleyways that they embody ingenious spatial planning and human-oriented design concepts.

4.2.3 Architectural Gene Evaluation

Figure 19. Pedestrian Street.

Figure 20. Waterside residences.

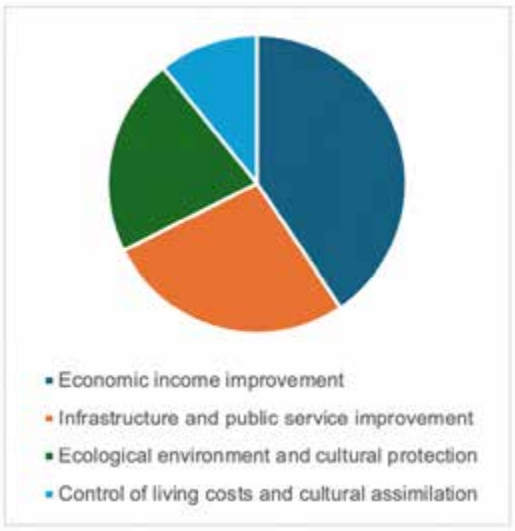
The residential architecture of Huanglongxian Village, influenced by traditional culture and hilly terrain (Figure 19), exhibits a style that is robust and simple, with a composed and introverted temperament. It possesses both the dignified grandeur of northern architecture and the delicate finesse of southern architecture. In terms of overall layout, the village's residential buildings demonstrate characteristics of adapting to the terrain and respecting nature (Figure 20). In terms of planar layout, they feature flexibility in scale and adaptation to local conditions. In terms of spatial structure, they highlight diverse forms and rigorous construction.

5. Sustainable Tourism Planning Strategies

Finally, based on the classification and evaluation of landscape ecological units, this study combines field surveys and in-depth interviews to thoroughly analyse the needs and expectations of residents and tourists in Huanglongxian Village. On this basis, the following targeted tourism planning strategies are proposed, aiming to construct a tourism model adapted to diverse tourist experiences while promoting local economic development, ecological protection, and cultural preservation.

5.1 Analysis of Resident and Tourist Needs

Through in-depth interviews and field surveys, pie charts illustrating the distribution of resident and tourist expectations were compiled (Figure 21-22).



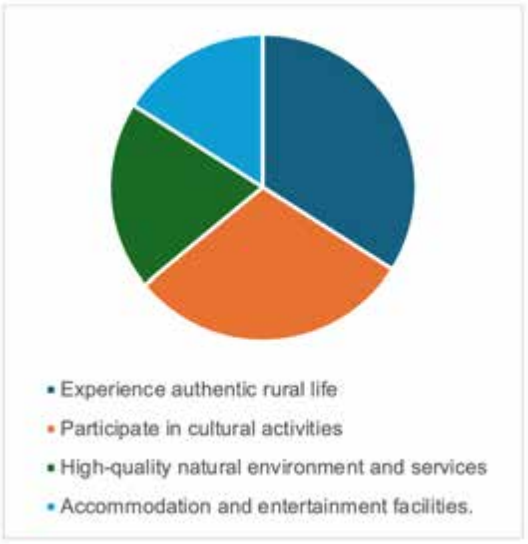


Figure 21. Distribution of resident expectations. **Figure** 22. Distribution of tourist expectations.

Residents of Huanglongxian Village generally expect tourism development to bring about an increase in economic income, while also hoping for improvements in infrastructure and public services, such as healthcare and education. Furthermore, residents show a strong sense of identification with protecting the local ecological environment and cultural traditions, but also express concerns that excessive tourism development may lead to rising living costs and cultural assimilation. On the tourist side, the main demands are concentrated on experiencing authentic rural life, participating in rich cultural activities, and enjoying a high-quality natural environment and tourism services. The needs of different types of tourists also vary; for example, leisure-oriented tourists pay more attention to the comfort of accommodation and entertainment facilities, while cultural experience-oriented tourists show strong interest in local historical buildings and tea culture.

5.2 Tourism Planning Strategies

From a sustainable development perspective, the linear and fragmented development of tourism spaces should be replaced by a cohesive strategy that integrates ecological protection and cultural revitalisation. In Huanglongxian, where rural tourism has developed for over five years, it is essential to re-examine the excavation of local culture and encourage greater public engagement. Based on this, five strategic directions are proposed: establishing ecological buffer zone standards, diversifying tourism products, enhancing community participation, developing a sustainable development assessment system, and strengthening brand identity.

It is essential to clearly define the ecological core zones of Huanglongxian according to the result of ecological units, such as the Paifang Reservoir and its surrounding forests, designating them as ecological protection areas. Designate these as ecological protection zones, restrict development and construction activities, and formulate strict environmental management measures to ensure the stability of the ecosystem and biodiversity. By setting up ecological trails, viewing platforms, etc., allow tourists to appreciate the natural beauty without disturbing the ecology, thereby enhancing ecological protection awareness. Simultaneously, conduct ecological education activities to popularise ecological protection knowledge among tourists and residents, promoting harmonious coexistence between humans and nature. Research has shown that the participatory management of eco-cultural trails enhances conservation outcomes while educating visitors (Lukoseviciute et al., 2024).

To maintain appeal and competitiveness, explore the connotations of Huanglongxian's tea culture and She eth-

nic culture to develop diversified tourism offerings. In addition to existing tea picking and processing experiences, in-depth tea culture-themed tour routes can be introduced, including visits to ancient tea gardens, learning about tea history, and studying tea art. Combined with the historical buildings and folk customs of the She ethnic village, create culturally distinctive experience projects, such as She ethnic song and dance performances and traditional handicraft making. Furthermore, develop rural leisure and holiday products, construct high-quality guesthouses and resorts, and provide services such as hot spring therapy and agricultural experiences to meet the needs of different tourist groups. Product diversification and culturally embedded experiences have proven effective in revitalising rural tourism destinations (Garau, 2015; Costantino et al., 2022).

Engaging local residents in tourism planning and operations enhances ownership and sustainability. Establishing a local tourism association, providing skills training, and implementing benefit-sharing mechanisms ensure fair economic returns and cultural continuity. Scholars argue that participatory frameworks are essential for the long-term management of cultural landscapes (Selman, 2004) and for achieving inclusive heritage tourism (Li and Hunter, 2015). At the same time, establish a reasonable benefit distribution mechanism to ensure that residents can obtain fair economic returns from tourism development, thereby enhancing their sense of belonging and satisfaction.

A sustainable tourism development assessment framework should evaluate environmental quality, economic benefits, social equity, and cultural preservation. The indicator system should include aspects such as tourism economic income, residents' quality of life, ecological environment quality, and cultural inheritance status. Based on the assessment results, timely adjust tourism planning and policy measures to ensure that tourism development is coordinated with ecological protection, cultural preservation, and social progress. Simultaneously, publicly disclose the assessment results to accept public supervision, improving the transparency and credibility of tourism development.

To establish a strong tourism identity, Huanglongxian should develop a distinct brand that integrates its tea heritage, She architecture, and local values. Branding elements such as logos, slogans, and cultural events reinforce recognition and pride. Sustainable tourism branding fosters long-term loyalty and encourages resident participation in cultural protection (Su et al., 2016; Landorf, 2009). When residents recognise the unique value of their local culture, they will more actively participate in cultural inheritance and protection, forming a virtuous cycle.

6. Conclusion

By employing a scientific ecological landscape unit division method combined with post - research surveys and interviews to comprehend diverse expectations, we aim for these strategies to enhance understanding of alternative tourism in rural development and boost Huanglongxian's sustainable tourism.

However, the research has limitations. The article's judgment factors, though broadly covering influential ones, lack detailed clarification due to data limits. The studied area's limited natural features result in an under - detailed determination factor system, like vegetation types and water conditions. Future regional analyses should adjust to local conditions, selecting suitable variable evaluation factors for more targeted outcomes. As China's rural construction evolves, there's a need for more theoretical reflection. Future large - scale machine learning could help create digital platforms for this research method.

In summary, these strategic tourism plans can help Huanglongxian Village achieve sustainable tourism development that meets residents' and tourists' needs, offering useful experience for metropolitan fringe area rural revitalisation.

Declaration of competing interest
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Annotate:
Source of charts: The charts in this paper are all compiled and drawn by the author, and the satellite remote sensing image is from the sky map (January 14, 2021).

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Research on the Measurement and Evaluation of the Development Performance of the Red Cultural Tourism Space in Hadapu Town based on AHP and Fuzzy Comprehensive Evaluation Method

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Abstract
As an important supply strategic position during the Long March of the Chinese Workers' and Peasants' Red Army, Hadapu Town has obvious red cultural characteristics, and its red cultural tourism development has a certain source of customers. However, since the red cultural tourism in the town is still in its early stages, in view of a series of problems such as unreasonable industrial structure, lagging infrastructure, insufficient development funds, single homogeneous tourism products, and insufficient interaction between urban and rural areas, this paper selects the evaluation indicators of the spatial development performance of red cultural tourism in Hadapu Town based on national standards, relevant specifications and expert consultation, and constructs a relevant evaluation system on this basis. By introducing the AHP hierarchical analysis method, the criterion layer, indicator layer and factor layer of Hadapu Town are weighted and calculated to obtain indicators at all levels. At the same time, the fuzzy comprehensive evaluation method is introduced to construct a fuzzy evaluation set. On the basis of single-factor evaluation of secondary indicators, the fuzzy evaluation of the indicator factors at different levels of the development performance of Hadapu Town is carried out layer by layer, and the results of the assignment of indicators at four levels of the development performance of red cultural tourism in Hadapu Town are summarized in combination with the grade assignment. Through the comparative analysis of various indicators, the comprehensive level of the overall development performance of Hadapu Town is finally evaluated and obtained. It is hoped that it will point out the direction for further enhancement and improvement of the red cultural tourism space in Hadapu Town, and at the same time serve as a demonstration to drive the sustained, healthy development and vitality of other towns with red cultural tourism resources, provide more optimized strategies, and explore the establishment of a long-term mechanism for the protection and transformation of red cultural tourism towns.

Key Words: AHP; Fuzzy Comprehensive Evaluation Method; Hadapu Town; Red Cultural Tourism; Urban Development Performance

Introduction

The construction of characteristic small towns is an inevitable path for China's urbanization process. Its development is based on a comprehensive consideration of the social and economic level. It promotes characteristic development by tapping the value of urban resources, which conforms to the law of urbanization in the new era. In order to promote its standardized and healthy development, a number of policy documents have been issued at the national and provincial levels to improve the quality of development and make it an important carrier of regional economy. At present, many provinces have formulated construction standards, covering qualitative and quantitative indicators such as infrastructure, ecological protection, cultural excavation, industrial scale and social influence; the academic community is also conducting research on the evaluation system of characteristic small towns.

Hadapu Town is a small town located in the northwest of Dangchang , Gansu. It has been a key point of Gansu-Sichuan trade since ancient times. It was named after the post station established during the Ming and Qing Dynasties. It was once a medicinal material distribution center on the ancient Tea-Horse Road. As a " gas station " and an important decision-making turning point during the Long March of the Chinese Workers' and Peasants' Red Army, it carries the red gene of the great rejuvenation of the Chinese nation. In modern times, it has been recorded in history for its key role in the Long March: In September 1935, the Central Red Army broke through the natural barrier of Lazikou and entered Hadapu, where they rested, replenished supplies and obtained key intelligence. Mao Zedong convened a meeting of cadres above the regiment level at Guandi Temple and clearly put forward the strategic policy of " going to northern Shaanxi " for the first time , laying the foundation for the victory of the Long March. This historical moment not only reversed the revolutionary situation, but also made Hadapu one of the core symbols of the spirit of the Long March .

The core resource of Hadapu, Red Army Street (formerly known as " The First Street of the Long March of the Chinese Workers' and Peasants' Red Army "), is the most complete cluster of revolutionary sites in China: 382 original shops are distributed on the 1,200-meter street, including more than 10 national cultural relics such as Yihechang Pharmacy (Former Residence of Mao Zedong), Postal Agency (Site of Intelligence Discovery), Guandi Temple (Former Site of Decision-making Meeting). Its unique value lies in the protection of authenticity and dynamic inheritance: the street continues its commercial function to this day, integrating historical memory into contemporary life with innovative forms such as " Red Army Guokui " and " Red Army Liangfen " and the live-action drama "Red Star Shining over Hadapu".

In recent years, Hadapu has achieved revitalization by relying on the " red-green integration " model (red cultural tourism + Guan'egou ecological scenic spot). The opening of the Lanzhou-Yuxi Railway in 2017 broke the traffic bottleneck, the number of tourists surged, and the memorial hall received more than 3 million people in total; in 2021, it was selected as a key construction area of the " Long March National Cultural Park ", and Shangjie Village was rated as a pilot for red beautiful villages. Through cooperatives, it developed Red Army courtyards, homestays, and cultural and creative products to drive villagers' income. Its development results were listed as "National Red Tourism Typical Cases " . In 2020 , it became the only town selected in Shaanxi Province, confirming the feasible path of red resources empowering rural revitalization. However, the rapid urbanization development has also faced many challenges for Hadapu . For example, the lack of interaction between urban and rural areas and the regional linkage bottleneck: the " point linkage " with the Guan'egou scenic spot is significant, but the full-area integration mechanism is not yet mature ; Hadapu Town's infrastructure lags behind: it is manifested in insufficient carrying capacity, which restricts the upgrade of tourism experience ; insufficient development funds , imbalance between protection and development, and insufficient innovation momentum ; tourism products are single and homogeneous , the industrial chain is shallow, and competitiveness is declining . Under so many challenges , Hadapu Town urgently needs to guide construction with scientific planning concepts and optimize spatial layout by utilizing its own resource endowments. Based on the theory of new urbanization , this paper analyzes the current development characteristics of red cultural tourism in Hadapu Town , and based on practical problems, constructs a red cultural tourism development performance evaluation index system and evaluation model in Hadapu Town from a multi-dimensional level . After conducting empirical research, it proposes a suitable development model and corresponding planning improvement strategy for the red cultural tourism space in Hadapu Town . It aims to provide reference and practical basis for the further improvement of the red cultural tourism space in Hadapu Town (Rogersons. 2019) .

1. New Urbanization Theory and Red Culture Tourism Planning

1.1 New urbanization theory

Urbanization is a development process involving multi-dimensional transformation of social structure, system, culture, etc (Mandelbaum, 1996). After the reform and opening up, extensive urbanization has intensified the contradiction between urban and rural areas, giving rise to economic and ecological problems, prompting the country to propose a new urbanization strategy with people as the core. This strategy regards characteristic small towns as urban-rural connection hubs and regional transformation platforms, and promotes coordinated urban and rural development and factor agglomeration through differentiated industry cultivation (avoiding experience copying) and resource integration to build a characteristic system, ultimately achieving the goal of livable, green and sustainable urbanization (Mc Gehee & Andereck. 2004).

1.2 Coupling of new urbanization and red cultural tourism planning

The new urbanization strategy and the national red cultural tourism planning are coupled through the "space-industry-governance" triple achieve coordinated development . In terms of spatial coupling , red resources are mostly distributed in small towns in old revolutionary areas (such as the Dabie Mountain area). New urbanization uses characteristic towns as nodes, integrates scattered sites to form regional cultural and tourism belts (such as the Huanggang-Xinyang-Lu'an red tourism circle), and simultaneously improves urban functions. For industrial coupling , the focus is on breaking through the traditional ticket economy, extending the red industry chain (cultural and creative, homestay, digital experience), driving agricultural product sales and employment (such as

Hong'an County's " red IP + specialty " model), and promoting urban industrial upgrading. In terms of governance coupling , through cross-departmental coordination (such as the provincial red tourism special team) and revenue sharing (community dividends) and other mechanisms, the problem of resource division is solved to achieve a win-win situation for cultural inheritance and improvement of people's livelihood. The essence of the two is to use culture and tourism as a link to transform the soft power of red culture into hard support for urban development, and promote the revitalization of old areas and urban-rural integration.

2. Current status of red cultural tourism development in Hadapu Town

2.1 Insufficient interaction between urban and rural areas, and the overall integration mechanism is not yet mature

Green Ecological Scenic Area in Hadapu Town has formed a preliminary linkage with the Hadapu Red Cultural Town. Tourists often visit the Hadapu Memorial Hall after visiting Guanegou, but the reverse diversion effect is weak. For example, Hadapu receives nearly 3 million tourists per year, but most tourists only stay for a short time and fail to effectively attract consumption links such as accommodation and catering in Guanegou.

The industry collaboration is shallow and the value chain integration has not been formed. The specific manifestation is that the two places only stay at the route recommendation level in the combination of "red and green resources" and have not built an industrial complementary chain. For example, the traditional Chinese medicine industry in Hadapu (such as the Qikun Logistics Base) focuses on planting and warehousing, and has not been deeply integrated with the health tourism in Guanegou; the local specialties sold in Guanegou homestays are mostly from other places, and local agricultural products (such as Hadapu traditional Chinese medicine) have not been included in the tourism commodity system.

Deep-seated institutional and planning obstacles, brand marketing is done independently. Guan'egou focuses on "health and wellness secrets", Hadapu emphasizes "red gas station", but no unified IP has been established in the county. Take the "May Day" event in 2025 as an example: Guan'egou launched cable car discounts and traditional Chinese medicine therapy; Hadapu held a food festival alone. The two themes are unrelated and failed to form a "red and green integration" package product.

2.2 Lagging infrastructure and insufficient carrying capacity restrict the upgrade of tourism experience

Weak transportation connection . Although the opening of Lanzhou-Chongqing Railway in 2017 significantly improved external accessibility, the internal transportation system of the scenic area is still imperfect . For example, the railway station to the core scenic area (Red Army Street, Memorial Hall) relies on sightseeing trains for transportation, with limited trains and tight capacity during peak seasons, and tourists are often stranded; the internal pedestrian path of Red Army Street is narrow (5-6 meters wide) , and the flow of people is congested during peak hours, affecting evacuation efficiency and tour comfort.

Accommodation and service facilities are in short supply . During the peak tourist season, the hotel occupancy rate exceeds 100%, but the town has less than 2,000 standardized accommodation beds, forcing tourists to travel back and forth on the same day or to go to the county seat, weakening their consumption potential; the coverage rate of public toilets, rest areas, and barrier-free facilities along Hongjun Street is low, limiting the reception capacity for elderly tourists and groups.

Smart construction lags behind . There is a lack of real-time passenger flow monitoring and online reservation and tour guide systems around the scenic area, and management relies on manual scheduling, resulting in chaos on peak days such as July 1st when more than 3,000 individual tourists pour in every day.

2.3 Insufficient development funds , imbalance between protection and development, and insufficient innovation momentum

First, there is a gap in the funds for the protection of revolutionary resources . For example, although the renovation of the appearance of 443 households on Hongjun Street has been completed, some shops in the

late Qing Dynasty have structural problems due to disrepair. Special repair funds rely on allocations from higher authorities, and local supporting capacity is weak; the digital protection of revolutionary cultural relics (such as the original copy of the Ta Kung Pao and Red Army equipment) is slow, and the coverage rate of constant temperature and humidity equipment is less than 30%.

Secondly, the industry investment channels are single . For example, cultural tourism projects mainly rely on government subsidies (for example, the start-up capital of the village-run cooperative is only 830,000 yuan), and the participation of social capital is low, resulting in the long-term shelving of planned projects such as the Red Theater and the Long March Theme Hotel; specialty stores (Red Army Shoe Factory, Liangfen Shop) are small in scale and lack brand incubation funds. Gao Yueju Cloth Shoe Factory produces 20,000 pairs of shoes a year but is unable to expand its production line, which restricts the employment-driven effect.

In addition, investment in innovation and research and development is insufficient . Live-action dramas such as "Red Star Shining over Hadapu" rely on villagers' amateur rehearsals, and professional upgrades such as editing, directing, lighting, and special effects are difficult to advance due to lack of funds, weakening cultural expression.

2.4 Tourism products are homogeneous , the industrial chain is shallow, and competitiveness is declining

The sightseeing-oriented products are similar . For example, the core experience is still limited to site visits (Yihechang Medicine Store, Guandi Temple) and static exhibitions, which are highly similar to the red scenic spots in the surrounding areas, and tourists stay for only 2-3 hours; the live performances are concentrated on historical scenes such as "Go to Northern Shaanxi" and "Welcome Relatives in Hada Puli", lacking technological empowerment (such as AR battlefield restoration and immersive narrative), making it difficult to attract young customers.

Product development is rudimentary . Specialties are mainly snacks such as " Red Army Liangfen " and " Guokui " and handmade cloth shoes. The design lacks in-depth IP exploration and is highly homogenized. Cultural and creative products are limited to low value-added categories such as badges and manuals, and the " Hadapu " brand system has not been formed.

The industry linkage is superficial . For example, the " red + green " model only stays in the promotion of Guanegou joint tickets, and no cross-scenic area theme routes (such as " Long March Trail + Ecological Hiking ") are designed, and the tourist conversion rate is less than 20%; the integration of agriculture and tourism is weak, and local medicinal materials such as angelica and astragalus have not been transformed into special health products, missing the opportunity to experience " red study + traditional Chinese medicine culture " .

3. Measurement and evaluation of the development performance of the red cultural tourism space in Hadapu Town based on AHP and fuzzy comprehensive evaluation method

In view of the problems existing in the planning of the red cultural tourism space in Hadapu Town , this paper attempts to quantitatively examine the problems by constructing an evaluation system for the red cultural tourism space in Hadapu Town, so as to comprehensively evaluate its development quality level, clarify the specific reasons that affect the development results, and provide direction for the future tourism development strategy of the town. Specifically, a development performance evaluation index system for the red cultural tourism space in Hadapu is constructed from the aspects of town construction, tourism development, human settlement environment and policy environment, in order to systematically analyze its development deficiencies.

3.1 Selection of evaluation system indicators

3.1.1 Basis for indicator selection

(1) National, provincial and municipal standards and assessment criteria

In 2016, the State issued the document "Guiding Opinions on Accelerating the Construction of Beautiful Characteristic Towns (Cities)", which mentioned that the development and reform departments at all levels should learn from the experience of Zhejiang Province's characteristic towns and strive to create a number of

beautiful characteristic towns (cities) with emerging industry clusters, traditional industry upgrades, flexible systems and mechanisms, strong cultural atmosphere, and beautiful ecological environment. The "National Tourism Standardization Development Plan (2016-2020)" deepened and standardized the standards for tourism development from the national, local, and industry levels. Subsequently, various provinces and cities successively issued plans and standards for the evaluation of characteristic towns. The Zhejiang Provincial Quality Supervision Bureau issued the "Characteristic Town Evaluation Standards" and took the lead in issuing local standards for the evaluation of characteristic towns. It clearly stipulates the development, creation and naming standards of characteristic towns, and proposes a characteristic town evaluation index system including common indicators and characteristic indicators. Starting from the four dimensions of industry, function, form and system of characteristic towns, three-level indicators for the evaluation of characteristic towns are set for different industrial types of tourism towns, and the assessment content and standards of indicators at all levels are clarified. Chongqing has proposed the "3+3" construction and development goals in the construction of characteristic towns. The "3 characteristics" refer to the characteristics of industry, style and function, plus the "3 clusters" refer to the clustering of space, industry and population. Sichuan Province has issued detailed standards for evaluating the development quality of cultural tourism towns. The scoring criteria involve resources, industry, planning, management, and the construction and comprehensive benefits of the town's tourism image, which can conduct a more comprehensive and systematic quality assessment of tourism towns. In terms of tourism evaluation, according to the normative information mastered by this study, it also includes the classification and evaluation standards of the quality level of tourist attractions and the construction and service level of smart tourism, which also provide a standard basis for the selection of performance evaluation indicators for the development of Hadapu Red Cultural Tourism Town.

(2) Research on the evaluation system of tourist towns

At present, some scholars have conducted research on the evaluation index system of characteristic small towns, including research on ecological construction evaluation , maturity evaluation , core competitiveness , and sustainable evaluation of characteristic small towns. The research on relevant rating index systems will provide a theoretical basis for the construction of this study on the performance evaluation system for the development of tourist small towns (Han, 2023).

3.1.2 Indicator selection

Tourism towns are a comprehensive development system, involving many and complex factors affecting urban development. The purpose of constructing the index system in this study is to evaluate the development performance level of tourism towns. The characteristics and laws of urban development should be followed in the construction of the evaluation system for the current status of urban construction, and the selection of indicators should be able to reflect the personality and characteristics of tourism towns. Therefore, based on the understanding of the development characteristics of tourism towns through questionnaire surveys and data collection and reading, this study mainly takes the evaluation rules of cultural tourism towns in Sichuan Province as the main basis, combines the existing national and local relevant standards and the theoretical achievements of the academic community on the evaluation system of tourism towns, and proposes a preliminary Hadapu tourism town development performance evaluation index system. After consulting the expert questionnaire, the original evaluation system content is adjusted to finally determine the overall framework of the Hadapu tourism town development performance evaluation system. The overall framework consists of four layers. The first layer is the target layer, namely the performance evaluation of the development of the red cultural tourism space in Hadapu Town ; the second layer is the criterion layer, which is divided into four dimensions: resource value , tourism development level , economic and social benefits, management and sustainability ; the third layer is the indicator layer, which is mainly a further refinement of the criterion layer, including 10 indicator layers: tourism resources, cultural protection, infrastructure, transportation facilities, tourism supporting functions, human living environment, industrial development, social impact, government support and planning management; the fourth layer is the element layer, which is composed of specific element contents.

Table 1 Judgement System of of Hadapu Red Culture Tourism

Target layer	Criteria Level A	Indicator layer B	Feature layer C
Performance evaluation of red cultural tourism space development in Hadapu Town	A1 Resource Value	B1 Tourism Resources	C1 The richness of red culture themed tourism activities
			C2 Variety and richness of red cultural tourism products
			C3 Construction of Hadapu Red Town and Guanegou Special Scenic Spot
		B2 Cultural Protection	C4 Protection level of tangible cultural heritage
			C5 Inheritance level of intangible cultural heritage
			C6 Continuity and integrity of cultural space
	A2 Tourism Development Level	B3 Surrounding Infrastructure	C7 Number of red cultural facilities
			C8 Number of red cultural tourism service facilities
			C9 red culture theme guide system settings
		B4 Surrounding transportation facilities	C10 Traffic accessibility
			C11 Parking convenience
			Construction status of C12 scenic sightseeing road, etc.
		B5 Tourism Support Function	C13 B&B/Hotel Service Level
			C14's professionalism and service level
			C15 Construction level of smart scenic spots
		B6 Living Environment	C16 Landscape greening coverage of built-up areas in towns
			C17 Waste transfer and treatment rate
			C18 Rainwater and sewage treatment rate
	A3 Economic and social benefits	B7 Industrial Development	C19 Number of people employed in the tourism industry
			C20 Annual income from tourism
			C21 Average length of stay of tourists
		B8 Social Impact	C22 Popularity of tourist attractions
			C23 Community participation in tourism projects
			C24 Tourist growth rate after the opening of Lanzhou-Chongqing Railway
	A4 Management and Sustainability	B9 Policy Support	C25 Special Fund Investment
			C26 Completeness of planning documents
		B10 Planning and Management	C27 Balance between development intensity and ecological carrying capacity
			C28 Planning Innovation

3.2 Evaluation technology path

3.2.1Model building

Regarding the development performance evaluation of the red cultural tourism space in Hadapu Town, since the evaluation index system involves multiple indicators, most of the indicators tend to be qualitative and the factor information is fuzzy, that is, the indicators are easily affected by the subjective cognitive level of the respondents. Therefore, in order to improve the scientificity and objectivity of the evaluation process , this study uses the fuzzy comprehensive evaluation method to obtain the fuzzy membership of each factor indicator through the hierarchical analysis method, and then conducts a comprehensive evaluation of the index system based on this result, which can more scientifically and reasonably determine the development of the red cultural tourism in Hadapu Town .

3.2.2 Determination of index weights based on analytic hierarchy process

The analytic hierarchy process (AHP) is a multi-objective decision-making method proposed by TLSaaty in the 1970s and is suitable for complex system evaluation. Its core is to decompose the decision system into a multi-level structure, compare factors pairwise by constructing a judgment matrix, calculate the weights of factors at each level and test the consistency, and finally obtain the comprehensive weight ranking of each factor. The main steps include: establishing a hierarchical model, constructing a judgment matrix, single-level ranking and

consistency test, and combining weight calculation and ranking.

The main steps of the hierarchical analysis method are: (1) Establish a hierarchical structure of goals ; (2) Construct a judgment matrix: Use the 1-9 scaling method to compare the indicators at the same level in pairs to form a judgment matrix that reflects the relative importance; (3) Calculate the weight coefficient: Calculate the eigenvector of the judgment matrix and normalize it to obtain the weight of each indicator; (4) Single-level sorting and consistency test: Calculate the maximum eigenvalue, consistency index CI and consistency ratio CR (CR=CI/RI, RI is obtained by looking up the table). When CR≤0.1, the judgment logic is considered reasonable (consistency is acceptable), otherwise the matrix needs to be adjusted; (5) Overall hierarchical sorting and consistency test**: Calculate the composite weight of each level of indicators to the overall goal, and perform a similar consistency test.

3.2.3 Comprehensive evaluation of tourist towns based on fuzzy comprehensive evaluation method

The fuzzy comprehensive evaluation method is based on the membership theory of fuzzy mathematics and is applicable to problems where the evaluation factors are fuzzy and difficult to quantify. Its core steps are: ① Determine the factor set U: including all evaluation indicators (multiple levels can be set).

② Determine the comment set V: define the evaluation level and its score (usually 3-5 levels). ③ Determine the weight vector W: obtain the weight of each factor by methods such as hierarchical analysis. ④ Construct the membership matrix R: element rij represents the degree of membership of factor ui to level vj (0-1). ⑤ Perform fuzzy synthesis: calculate the comprehensive evaluation vector C = W · R. ⑥ Calculate the evaluation results: the weighted average method is often used to calculate the final score P.

3.3 Comprehensive evaluation of overall development performance

3.3.1 Calculation of indicator weights

According to the idea of analytic hierarchy process, a hierarchical model of the evaluation object is constructed. The Delphi method is used to obtain the importance of the indicator elements of the evaluation hierarchy. The Delphi method is an expert scoring method. It divides the relative importance of the indicator elements based on the scaling method, designs an expert scoring consultation questionnaire, and sends questionnaires to experts and scholars in the research topic field. The questionnaires are divided into two channels: online and offline. According to the distribution and collection of questionnaires, a total of 18 valid questionnaires were obtained. Because the invited scoring experts have studied and published relevant research results in the fields involved in the research topic of this study, the questionnaire data obtained has a certain authority and can support the empirical research of this study on the research object. Using the analytic hierarchy process auxiliary tool, the recovered questionnaire data on the indicator element scoring questionnaire are statistically classified, and the data are sorted and consistency tested to obtain the indicator weight coefficients corresponding to the indicators at each level.

1. Criteria layer weight calculation

At the criterion level, through the auxiliary calculation of the hierarchical analysis method software tool, the weight coefficients of the judgment matrix of the four levels of indicators, namely resource development, urban construction, comprehensive benefits and institutional management, in the performance evaluation index system of Hadapu tourism small town development are calculated, and a consistency test is carried out.

Table 2 Judgment matrix and weight values of criterion level indicators

index	Resource Value	Tourism development level	Economic and social benefits	Management and Sustainability	Weight
Resource Value	1	3	3	4	0.5082
Tourism development level	1/3	1	3	1	0.2121
Economic and social benefits	1/3	1/3	1	1/2	0.1061
Management and Sustainability	1/4	1	2	1	0.1735
When the maximum eigenvalue λmax=4.1550 and n=4, CR=0.0580 < 0.10, the consistency test of the judgment matrix passes, and the obtained weight is valid.					

2. Indicator layer weight calculation

Through the auxiliary calculation of the hierarchical analysis method software tool, the weight coefficients of the judgment matrix of the two indicators of tourism construction and cultural protection in the resource development level are calculated, and the consistency test is carried out.

Table 3. Indicator layer (resource value) judgment matrix and weight value

Resource value (A1)	**Tourism resources**	**Cultural Protection**	**Weight**
Tourism resources	1	2/3	0.4
Cultural Protection	3/2	1	0.6
When the maximum eigenvalue λmax=2 and n=2, CR=0.0000 < 0.1, the consistency test of the judgment matrix passes, and the obtained weight is valid.			

Table 4. Judgment matrix and weight values of indicator layer (urban construction)

Tourism development level A2)	**Surrounding infrastructure**	**Surrounding transportation facilities**	**Tourism supporting functions**	**Living Environment**	**Weight**
Surrounding infrastructure	1	3	3	1/2	0.3092
Surrounding transportation facilities	1/3	1	2	1/3	0.1501
Tourism supporting functions	1/3	1/2	1	1/3	0.1056
Living Environment	2	3	3	1	0.4351
When the maximum eigenvalue λmax=4.1222 and n=4, CR=0.0458 < 0.10, the consistency test of the judgment matrix passes, and the obtained weight is valid.					

Table 5. Judgment matrix and weight values of indicator layer (economic and social benefits)

Economic and social benefits (A3)	**Industry Development**	**Social Impact**	**Weight**
Industry Development	1	3	0.75
Social Impact	1/3	1	0.25
When the maximum eigenvalue λmax=2.0000 and n=2, CR=0.0000 < 0.10, the consistency test of the judgment matrix passes, and the obtained weight is valid.			

Table 6. Judgment matrix and weight values of indicator layer (management and sustainability)

Economic and social benefits (A4)	Policy support	Planning Management	Weight
Policy support	1	2	0.6666
Planning Management	1/2	1	0.3334
When the maximum eigenvalue λmax=2.0000 and n=2, CR=0.0000 < 0.10, the consistency test of the judgment matrix passes, and the obtained weight is valid.			

Through the auxiliary calculation of the hierarchical analysis method software tool, the weight coefficients of the judgment matrix of 28 element indicators in the four levels of resource value, tourism development level, economic and social benefits, management and sustainability were calculated, and the consistency test was carried out.

Table 7. Indicator layer (resource value) judgment matrix and weight value

Tourism resources (B1)	The richness of red culture themed tourism activities	The variety and richness of red cultural tourism products	Construction status of Hadapu Red Town and Guanegou characteristic scenic spot	Weight
The richness of red culture themed tourism activities	1	7	5	0.7235
The variety and richness of red cultural tourism products	1/7	1	1/3	0.0833
Construction status of Hadapu Red Town and Guanegou characteristic scenic spot	1/5	3	1	0.1932
When the maximum eigenvalue λmax=3.0658 and n=3, CR=0.0633 < 0.10, the consistency test passes and the obtained weight is valid.				

Table 8. Judgment matrix and weight values of indicator layer (cultural protection)

Cultural Protection (B2)	Protection level of tangible cultural heritage	Inheritance level of intangible cultural heritage	Continuity and integrity of cultural space	Weight
Protection level of tangible cultural heritage	1	5	4	0.685
Inheritance level of intangible cultural heritage	1/5	1	3/2	0.1729
Continuity and integrity of cultural space	1/4	2/3	1	0.1424
When the maximum eigenvalue λmax=3.0444 and n=3, CR=0.0427 < 0.10, the consistency test passes and the obtained weight is valid.				

Table 9 refers to the judgment matrix and weight values of the element layer (surrounding infrastructure)

Surrounding infrastructure (B3)	Number of red cultural facilities	Number of red cultural tourism service facilities	Guide system settings under the red culture theme	Weight
Number of red cultural facilities	1	3	2	0.5131
Number of red cultural tourism service facilities	1/3	1	1	0.2381
Guide system settings under the red culture theme	1/2	1	1	0.2488
When the maximum eigenvalue λmax=4.0341 and n=3, CR=0.0128 < 0.10, the consistency test passes and the obtained weight is valid.				

Table 10 refers to the judgment matrix and weight value of the element layer (surrounding transportation facilities)

Surrounding transportation facilities (B4)	Transportation accessibility	Parking convenience	Construction status of scenic sightseeing trails, etc.	Weight
Transportation accessibility	1	3	5	0.6333
Parking convenience	1/3	1	3	0.2650
Construction status of scenic sightseeing trails, etc.	1/5	1/3	1	0.1062
When the maximum eigenvalue λmax=3.0387 and n=3, CR=0.0656 < 0.10, the consistency test passes, and the obtained weight is valid.				

Table 11 Judgment matrix and weight values of the index element layer (tourism supporting functions)

Surrounding transportation facilities (B5)	B&B/hotel service level	Professionalism and service level of interpretation	The level of smart scenic spot construction	Weight
B&B/hotel service level	1	2	1/3	0.2461
Professionalism and service level of interpretation	1/2	1	1/4	0.1975
The level of smart scenic spot construction	3	4	1	0.5564
When the maximum eigenvalue λmax=4.0818 and n=3, CR=0.0360 < 0.10, the consistency test passes, and the obtained weight is valid.				

Table 12 refers to the judgment matrix and weight value of the element layer (human living environment)

Surrounding transportation facilities (B6)	**Landscape greening coverage degree of town built-up area**	**Waste transfer and treatment rate**	**Rainwater and sewage treatment rate**	**Weight**
Landscape greening coverage degree of town built-up area	1	3	3	0.5961
Waste transfer and treatment rate	1/3	1	2/3	0.229
Rainwater and sewage treatment rate	1/3	2/3	1	0.1749
When the maximum eigenvalue λmax=3.0183 and n=3, CR=0.0176 < 0.10, the consistency test passes and the obtained weight is valid.				

Table 13 refers to the judgment matrix and weight values of the factor layer (industrial development)

Surrounding transportation facilities (B7)	**Number of people employed in the tourism industry**	**Annual income from tourism**	**Average length of stay of tourists**	**Weight**
Number of people employed in the tourism industry	1	1/6	1/3	0.096
Annual income from tourism	6	1	3	0.653
Average length of stay of tourists	3	1/3	1	0.251
When the maximum eigenvalue λmax=3.0183 and n=3, CR=0.0176 < 0.10, the consistency test passes and the obtained weight is valid.				

Table 14 refers to the judgment matrix and weight values of the factor layer (social impact)

Social Impact **(B8)**	Popularity of tourist attractions	Community participation in tourism projects	Tourist growth rate after the opening of Lanzhou-Chongqing Railway	**Weight**
Popularity of tourist attractions	3/2	1	1/2	0.2854
Community participation in tourism projects	1	2/3	1/2	0.218
Tourist growth rate after the opening of Lanzhou-Chongqing Railway	2	2	1	0.4966
When the maximum eigenvalue λmax=3.0183 and n=3, CR=0.0176 < 0.10, the consistency test passes and the obtained weight is valid.				

Table 15 refers to the judgment matrix and weight values of the factor layer (policy support)

Economic and social benefits (B9)	Special fund investment	Completeness of planning documents	**Weight**
Special fund investment	1	2	0.6666
Completeness of planning documents	1/2	1	0.3334
When the maximum eigenvalue λmax=2.0000 and n=2, CR=0.0000 < 0.10, the consistency test of the judgment matrix passes, and the obtained weight is valid.			

Table 16 refers to the judgment matrix and weight values of the element layer (planning management)

Economic and social benefits (B10)	Balance between development intensity and ecological carrying capacity	Planning innovation	**Weight**
Balance between development intensity and ecological carrying capacity	1	2	0.6666
Planning innovation	1/2	1	0.3334
When the maximum eigenvalue λmax=2.0000 and n=2, CR=0.0000 < 0.10, the consistency test of the judgment matrix passes, and the obtained weight is valid.			

According to the above method, the indicators at each level in the performance evaluation index system of tourism small towns development are analyzed.

The weight coefficients are calculated, w1 represents the weight coefficient of the criterion layer, w2 represents the weight coefficient of the indicator layer, and w3 represents the weight coefficient of the factor layer. The actual weight calculation formula of each indicator element in the performance evaluation index system for the development of tourist towns is: $wj = w1 * w2 * w3$ The final weight table of indicators at all levels in the performance evaluation index system for the development of tourist towns is obtained.

Table 17

Target layer	Criteria Layer	Indicator layer	Feature layer	Weight
Performance evaluation of red cultural tourism space development in Hadapu Town	Resource Value 0.5082	Tourism resources 0.3049	The richness of red culture themed tourism activities	0.2089
			The variety and richness of red cultural tourism products	0.0527
			Construction status of Hadapu Red Town and Guanegou characteristic scenic spot	0.0433
		Cultural Protection 0.2033	Protection level of tangible cultural heritage	0.1471
			Inheritance level of intangible cultural heritage	0.0169
			Continuity and integrity of cultural space	0.0393
	Tourism development level 0.2121	Surrounding infrastructure 0.0656	Number of red cultural facilities	0.0324
			Number of red cultural tourism service facilities	0.0191
			Guide system settings under the red culture theme	0.0141
		Surrounding transportation facilities 0.0318	Transportation accessibility	0.0202
			Parking convenience	0.0083
			Construction status of scenic sightseeing trails, etc.	0.0034
		Tourism supporting functions 0.0224	B&B/hotel service level	0.0114
			Professionalism and service level of interpretation	0.0078
			The level of smart scenic spot construction	0.0032
		Living Environment 0.0923	Landscape greening coverage degree of town built-up area	0.055
			Waste transfer and treatment rate	0.0211
			Rainwater and sewage treatment rate	0.0161
	Economic and social benefits 0.1061	Industry Development 0.0796	Number of people employed in the tourism industry	0.052
			Annual income from tourism	0.0076
			Average length of stay of tourists	0.02
		Social Impact 0.0265	Popularity of tourist attractions	0.0058
			Community participation in tourism projects	0.0076
			Tourist growth rate after the opening of Lanzhou-Chongqing Railway	0.0131
	Management and Sustainability 0.1735	Policy support 0.1157	Special fund investment	0.0771
			Completeness of planning documents	0.0386
		Planning Management 0.0578	Balance between development intensity and ecological carrying capacity	0.0169
			Planning innovation	0.0143

Judging from the weight of the evaluation system, the core of the development of tourist towns is resource development (with the highest proportion), which is the foundation of tourism development. The key lies in exploring resource value and cultural connotation. The second is the level of tourism development, whose material space level directly affects the tourist experience and environmental quality. The third is management and sustainability. As an operational guarantee, efficient macro-management can improve service quality and tourism image. Finally, economic and social benefits reflect the fundamental purpose of developing tourism - improving economic benefits, industrial vitality and social influence. Overall, the weight and importance of resource development and town construction are significantly higher than institutional management and comprehensive benefits.

3.3.2 Fuzzy comprehensive evaluation

In order to ensure the data accuracy of the fuzzy evaluation matrix of the development performance of Hadapu Red Cultural Tourism Space, this study selected four types of evaluation subjects: master and doctoral students in related fields, local government staff, business operators and tourists, and balanced subjective bias through multi-perspective combination. The fuzzy comprehensive evaluation method was used to first conduct a single factor evaluation on the secondary indicators, and then synthesize them step by step, and finally obtain the comprehensive level of overall development performance.

(1) Determine the review set V

In order to make the research evaluation results more intuitive, this study defines the evaluation set of tourism town development performance as

U = {very good, good, average, poor, bad}, that is, the evaluation results are divided into five levels according to the development status of the town in each indicator factor:

Table18: Fuzzy evaluation comments

Rating	Level connotation description
very good	Meeting development requirements
better	Basically meet the development requirements
generally	Partially meet development requirements
Poor	Many parts have not yet met the development requirements
Difference	Development requirements not met

(2) Single factor fuzzy relationship evaluation

Through online and offline questionnaires and interviews with experts, business operators, tourists and some government staff, the data results were sorted and classified, and the initial quantitative values of various indicators of urban tourism development performance were obtained. A total of 142 questionnaires (or interviews) were issued, and 120 valid content was collected. The following is a summary of the corresponding content and the final data normalization.

Table19:

Indicator layer	Feature layer	very good	better	generally	Poor	Difference
B1 Tourism Resources	C1 The richness of red culture themed tourism activities	0.2	0.4	0.6	0	0
	C2 Variety and richness of red cultural tourism products	0	0.2	0.5	0.3	0
	C3 Construction of Hadapu Red Town and Guanegou Special Scenic Spot	0.3	0.4	0.3	0	0
B2 Cultural Protection	C4 Protection level of tangible cultural heritage	0.3	0.4	0.3	0	0
	C5 Inheritance level of intangible cultural heritage	0.05	0.3	0.6	0.05	0
	C6 Continuity and integrity of cultural space	0.1	0.6	0.2	0.1	0

B3 Surrounding Infrastructure	C7 Number of red cultural facilities	0.1	0.6	0.3	0	0
	C8 Number of red cultural tourism service facilities	0	0.2	0.7	0. 1	0
	C9 red culture theme guide system settings	0.1	0.5	0.4	0	0
B4 Surrounding transportation facilities	C10 Traffic accessibility	0.4	0.5	0.1	0	0
	C11 Parking convenience	0.2	0.5	0.3	0	0
	Construction status of C12 scenic sightseeing road, etc.	0.15	0.5	0.35	0	0
B5 Tourism Support Function	C13 B&B/Hotel Service Level	0	0.2	0.5	0.3	0
	C14's professionalism and service level	0. 1	0.3	0.5	0.1	0
	C15 Construction level of smart scenic spots	0	0.2	0.7	0.1	0
B6 Living Environment	C16 Landscape greening coverage of built-up areas in towns	0.2	0.5	0.3	0	0
	C17 Waste transfer and treatment rate	0.1	0.6	0.3	0	0
	C18 Rainwater and sewage treatment rate	0.1	0.7	0.2	0	0
B7 Industrial Development	C19 Number of people employed in the tourism industry	0.05	0.4	0.35	0.2	0
	C20 Annual income from tourism	0	0	0.7	0.3	0
	C21 Average length of stay of tourists	0	0.1	0.6	0.3	0
B8 Social Impact	C22 Popularity of tourist attractions	0.2	0.4	0.2	0.2	0
	C23 Community participation in tourism projects	0.1	0.4	0.4	0.1	0
	C24 Tourist growth rate after the opening of Lanzhou-Chongqing Railway	0.1	0.5	0.4	0	0
B9 Government Support	C25 Special Fund Investment	0.1	0.6	0.3	0	0
	C26 Completeness of planning documents	0.1	0.5	0.4	0	0
B10 Planning Management	C27 Balance between development intensity and ecological carrying capacity	0.1	0.3	0.5	0. 1	0
	C28 Planning Innovation	0	0	0.7	0.3	0
reason						

Based on the collected original data, the interviewees' scores were weighted and the single-factor fuzzy relationship matrix R of Nanniwan tourist town was obtained.

Table 20

Indicator layer	Feature layer	very good	better	generally	Poor	Difference
B1 Tourism Resources	C1 The richness of red culture themed tourism activities	0.1 6 50	0.16 83	0.6667	0.0000	0
	C2 Variety and richness of red cultural tourism products	0.0000	0.2083	0.4583	0.3333	0
	C3 Construction of Hadapu Red Town and Guanegou Special Scenic Spot	0.2 8 00	0.4167	0.29 33	0.0000	0
B2 Cultural Protection	C4 Protection level of tangible cultural heritage	0.0417	0.2500	0.6250	0.0833	0
	C5 Inheritance level of intangible cultural heritage	0.1905	0.4 285	0.1905	0.1905	0
	C6 Continuity and integrity of cultural space	0.0417	0.6250	0.2917	0.0833	0
B3 Surrounding Infrastructure	C7 Number of red cultural facilities	0.1250	0.5833	0.2500	0.0000	0
	C8 Number of red cultural tourism service facilities	0.0833	0.1750	0.7417	0.0000	0
	C9 red culture theme guide system settings	0.0 834	0.5000	0.4167	0.0 000	0
B4 Surrounding transportation facilities	C10 Traffic accessibility	0.3667	0.5583	0.1750	0.0000	0
	C11 Parking convenience	0.3333	0.4167	0.2500	0.0000	0
	Construction status of C12 scenic sightseeing road, etc.	0.2 0 17	0.5000	0.2 9 83	0.0000	0
B5 Tourism Support Function	C13 B&B/Hotel Service Level	0.000	0 .0083	0.5000	0.2917	0
	C14's professionalism and service level	0.0417	0.3750	0.5417	0.0417	0
	C15 Construction level of smart scenic spots	0.0000	0.2583	0.6167	0.0833	0
B6 Living Environment	C16 Landscape greening coverage of built-up areas in towns	0.0417	0.5417	0.3333	0.0833	0
	C17 Waste transfer and treatment rate	0.0000	0.6250	0.2500	0.1250	0
	C18 Rainwater and sewage treatment rate	0.0833	0.6250	0.2917	0.0000	0
B7 Industrial Development	C19 Number of people employed in the tourism industry	0.167 6	0.3667	0.4667	0.0000	0
	C20 Annual income from tourism	0.0000	0.6800	0. 320 0	0.0000	0
	C21 Average length of stay of tourists	0.0000	0.1667	0.5417	0.2917	0

B8 Social Impact	C22 Popularity of tourist attractions	0.0833	0.5833	0.3333	0.0000	0
	C23 Community participation in tourism projects	0.2667	0.4 000	0.3333	0.0000	0
	C24 Tourist growth rate after the opening of Lanzhou-Chongqing Railway	0.0 832	0.5000	0.4167	0.0000	0
B9 Government Support	C25 Special Fund Investment	0.2083	0.5417	0.2500	0.0000	0
	C26 Completeness of planning documents	0.1250	0.2813	0.4687	0.1250	0
B10 Planning Management reason	C27 Balance between development intensity and ecological carrying capacity	0.0 4 33	0.2917	0.6250	0.0 4 00	0
	C28 Planning Innovation	0.0000	0.0000	0.7142	0.2858	0

According to the fuzzy relationship matrix of indicator factors, the single factor evaluation matrix of each secondary indicator in the development performance evaluation system of Hadapu tourism town can be calculated in turn. Combined with the weight coefficients of each level in the evaluation indicator system calculated in the previous article, a fuzzy comprehensive evaluation of the development performance of tourism towns is carried out. First, a fuzzy comprehensive evaluation is carried out based on the fuzzy matrix of the factor level indicator factors. Taking the single factor fuzzy relationship of the B1 indicator tourism construction as an example, the numerical matrix is arranged and calculated. According to the previous pages of the article, the weight coefficients of indicators at all levels are obtained by using the hierarchical analysis method to determine the weight coefficient of tourism construction factors : W 1 = [0.7235, 0.0833, 0.1932] . Then the fuzzy evaluation value of tourism construction (B1) index factor is C 1 = [0.1990, 0.5802, 0.1930, 0.0278, 0.0000] , according to the maximum membership principle , the membership of the evaluation result belonging to " good " is the largest, and the development of Hadapu's red cultural tourism construction is judged to be good. By analogy , several other values are obtained and their memberships are judged in turn. Finally, the red tourism cultural space development performance value S of Hadapu Town is S=C*V T, and its final value is 2.1667. According to the overall development performance evaluation table of tourist towns, the comprehensive level of the development performance of the red tourism cultural space in Hadapu Town can be divided into intervals. The final evaluation results show that the red tourism development performance evaluation of Hadapu is 2.1667 points.

Table 21

Comprehensive evaluation valueS	**(4,5]**	**(3,4]**	**(2,3]**	**(1,2]**	**(0,1]**
Level	Very good performance	Better performance	Average performance	Poor performance	Poor performance

4. Facilitation and discussion

The comprehensive rating of tourism development in Hadapu Town is "average", indicating that the regional competitiveness is weak and the driving force for sustainable development is insufficient, and it is urgent to make up for the shortcomings. Analysis at the criterion level: Resource development scored the highest, showing that it relies on resource advantages to drive the economy; comprehensive benefits and institutional management are second, reflecting the effectiveness of policy guidance and industrial integration; urban construction scored the lowest, reflecting that service facilities and levels need to be improved. Analysis at the indicator level: Cultural protection, community functions and planning management scored high (>2.5 points), highlighting

cultural heritage and residents' benefits; human settlement environment performance is low, the main reason weight is small and urban and rural development is uneven. This analysis clarifies the direction for subsequent improvements. The strategies are as follows:

The following is a detailed supplement to the optimization strategy for the red cultural tourism space in Hadapu Town, Gansu Province. Combined with the actual development needs and successful experiences of the local area, a specific implementation plan is proposed:

① Space optimization: expand the Red Army Street Cultural and Creative Zone and add immersive experience projects

Implementation path:

Site protection and scene restoration - Based on the renovation of the existing Red Army Street (443 households and 46,600 square meters have been renovated), the "Red Army Life Experience Area" will be expanded to restore the post office, pharmacy, cooperative and other scenes from the Long March period, and use AR technology to display historical events (such as the Red Army's rest and recuperation, the expansion of the Red Army and the establishment of the government) to enhance tourists' sense of involvement.

Immersive performance upgrade - relying on the successful experience of the existing live-action drama "Red Star Over Hadapu", a night light and shadow theater will be added, using 3D projection technology to present dynamic historical stories on the walls of the revolutionary ruins; a "role-playing" project will be developed, where tourists can change their clothes and participate in interactive tasks such as "raising food to support the front" and "military-civilian carnival" to deepen their experience.

Expansion of cultural and creative consumption space - setting up a "Red Cultural and Creative Workshop" to centrally display and sell special products such as Hadapu medicinal incense and Red Army snacks, and opening a DIY experience area (such as printing Red Army slogan cloth bags and making Chinese herbal medicine sachets) to extend tourists' stay.

Expected effect: Enhance the depth of tourists' immersive experience and drive secondary consumption; the average length of stay per visitor is expected to be extended by 1.5 hours, and the proportion of cultural and creative income will increase to 30% of total revenue.

② Industrial linkage: Deepen the "red + green" model (the joint ticket system bundles the Guanegou Scenic Area)

Implementation path:

Route design and joint ticket mechanism - launch the "red and green dual-core" joint ticket (Hadapu Memorial Hall + Guanegou Scenic Area), integrate the transportation connection services within 36 kilometers, and design a one-day tour route of "red education in the morning and ecological sightseeing in the afternoon". Cooperating travel agencies launch packages including transportation, explanations, and meals, with a 20%-30% discount.

Resource complementarity and brand linkage - add a Hadapu Red Culture Exhibition Corner in the Guanegou Scenic Area, and simultaneously broadcast a promotional video of the natural scenery of Guanegou on the Red Army Street; jointly organize theme activities (such as the "Retracing the Long March and Exploring Guanegou" hiking race) to share customer traffic.

Data sharing and precision marketing - establish a scenic spot passenger flow data intercommunication platform, analyze tourists' preferences and push customized itineraries (such as recommending the "Red Script Killing + Forest Study" combination to the study team).

Expected results:

The tourist mutual guidance rate will be increased by 40%, and the joint ticket coverage rate will exceed 60%; in 2023, the tourism revenue of Guanegou will reach 3.9 billion yuan, and after the linkage, the number of tourists in

Hadapu is expected to increase by 25% annually.

③ Community empowerment: Promote the "cooperative + farmer" model (refer to the operation experience of the live-action drama in Shangjie Village)
Implementation path:
Professional operation of cooperatives - copy the model of Shangjie Village Tourism Cooperative (which has attracted more than 50 villagers to participate in performances and increased annual income by 20,000 yuan per person), establish a town-level tourism cooperative alliance, and unify the management of the three major sectors of performances, homestays, and agricultural specialties. Set up a "Red Skills Training Fund" to regularly carry out tour guide, handicraft, and performance training.

Diversified business model shareholding and dividends - Encourage farmers to invest in cooperatives with idle houses and land:

The performing arts group recruits villagers to participate in live-action performances (e.g. the newly added "mass actor" position in "Go to Northern Shaanxi") and distributes dividends according to the number of performances; For the homestay group, the cooperative uniformly renovated the residential houses on Hongjun Street and created the "Hongjun Inn" brand (currently there are more than 60 rooms). Farmers can get 60% of the profits by investing in the houses they own.

In the production and marketing group, the cooperative centrally purchases local specialties (Red Army jelly, Chinese medicinal materials), packages them into "Long March Grain Packages" gift boxes, and sells them online through live broadcasts (referring to Gaolan County's "agricultural network terminal + e-commerce" model).
Governance coordination mechanism - promote the "Longnan Civil Direct Talk 1234 Working Method", and the party branch of the cooperative will regularly hold villagers' meetings to coordinate issues such as income distribution and service quality to ensure farmers' voice.

Expected results:
It has mobilized more than 200 farmers to participate, with an average annual increase of 30,000 yuan per household; the village's collective economic income has increased by 50%, forming a closed loop of the "performing arts - homestay - specialties" industrial chain.

Through the linkage of three major strategies, Hadapu can build a development model of "deepening of red scenes - integration of red and green resources - long-term community benefits", promote the transformation and upgrading of red culture from "sightseeing and checking in" to "experience and get rich", and provide a paradigm for the revitalization of the old revolutionary areas in Northwest China.

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Planetary Gentrification of Rural China: the case of *yangjiale*

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Abstract
Yangjiale is a form of homestay in Mount Mogan Village, Zhejiang Province, China. Newcomers from surrounding metropolises rented abandoned village houses in the local area, turning them into BnB, thus initiating a form of rural tourism called *Yangjiale*. Later, Indigenous Mount Mogan people, who lived in the surrounding cities, returned to their places of origin to exploit the new opportunities given by *yangjiale*. After a fast period of initial growth, such a new form of rural tourism began to cool down, possibly due to the progressive loss of the quality experience made available in the early years of *yangjiale*. This paper offers an overview of the phenomenon since its inception, focusing on the land use change associated with it associated. First historical data about the location of y*angjiale* homestays was retrieved from local administrations and verified by fieldwork conducted in 2024. The complied dataset allowed for longitudinanl understand of the locational patterns in the evolution of *yangjiale* services from 1934 to 2022 second the land-use change analysis with a focus on Mout Mogan Town administrative area was made possible via secondary data provided by the local administration, rendering the territorial transformation occurring from 2006 to 2020. Further investigation considered the planning scheme, released in 2021 with 2035 horizon. The findings reveals a progressive shrinkage and fragmentation of agricultural land. In contrast, the areas designated for orchards, tea plantations, and gardens have shown a notable increase. Rural residential areas have continued to expand, indicating a growing trend in continue expansion. The emergence and development of y*angjiale* can be explained in light of a global gentrification process, which shows the urban entrepreneurial consciousness generated by the combination of international market forces and the new possibilities given by digital platforms. Thus, the process of touristification in rural China can be discussed as a form of counter-urbanization driven by the platform economy.

Keywords: *Yangjiale*, touristification, counter-urbanization, urban entrepreneurialism, planetary gentrification, consumerism, platform economy

1.Background

Rural areas have become an important part of China's economic revitalization. In order to improve the infrastructure of these areas and stimulate economic activities, China has introduced various policies, including the Ten Million Project and Beautiful Countryside initiatives. Inspired by China's ongoing rural revitalization policy, the picturesque rural homestays at the foot of Mogan Mountain in Zhejiang Province, near Shanghai, have brought significant changes to the entire Chinese homestay industry.

In the 18th century, especially between 1891 and 1894, American missionaries promoted the beauty of Mogan Mountain to the West through newspapers (Liu, 2025). This publicity attracted many Western dignitaries who built summer villas here, including representatives from the United States, Britain, Germany, Russia and other countries. In addition, due to Mount Mogan's proximity to Shanghai and its beautiful scenery, many Chinese celebrities during the Republic of China period also came here. Those who built villas here included Huang Li, the then mayor of Shanghai, as well as various politicians, intellectuals, financiers and missionaries. Notably, Chiang Kai-shek, the top leader of the Republic of China, and his wife Soong Mei-ling also built villas and lived here. Today, 250 modern villa buildings are preserved in Mount Mogan (Liu, 2025). After the peak of villa construction during the Republic of China, the hotel industry in Mount Mogan ushered in a recovery in 2007. At that time, a young South African working in Shanghai discovered the area and opened the naked castle homestay. This homestay brought considerable income to the homestay industry and attracted other non-Chinese people to open their own homestays in Moganshan. For example, a Frenchman named Stuart built a successful mountain homestay in the area (Liu, 2025). Many non-Chinese people began to rent abandoned farmhouses from local farmers and renovate them into homestays. This led to the birth of the homestay brand *yangjiale*, which represents the

understanding of the homestay model by non-Chinese people. This model is in sharp contrast to the previous concept of *nongjiale*, *nongjiale* refers to the simpler homestay services provided by Chinese farmers, who mainly decorate houses and provide farmhouse dishes (Zhang et al., 2019). The creation of the *yangjiale* homestay brand marks the first stage of its development, namely the *yangjiale* stage. The term *yangjialelization* summarizes the phenomenon of *yangjiale* BnBs and the various impacts it has produced (Song & Neisch, 2025). The second stage of *yangjiale* and *yangjialelization* originated from the success of the first batch of non-Chinese BnB founders. This attracted designers and senior professionals from major cities around Moganshan, such as Shanghai, Hangzhou, and Nanjing. Many of them have deep roots in Mount Mogan and gradually moved to big cities for development as they grew up. This group of country gentry from surrounding cities has become the second generation of the *yangjiale* market. They usually rent abandoned village houses from local farmers, or use their own houses in their hometowns, and transform them into new BnB projects after careful decoration and design. To a certain extent, they continue the management and design concepts of the first generation of non-Chinese BnB founders. Their efforts to transform and integrate into the market are not only popular, but also have far-reaching impacts. Among them, Da Le Zhi Ye co-founded by Ji Xiaoxiang and Yang Mohan is one of them. Ji Xiaoxiang and Yang Mohan were both born in Mount Mogan and graduated from the Department of Architecture and Planning of Tongji University in Shanghai. This homestay has become a model project for the development of the second generation of Chinese country gentry in the *yangjiale* market (Song & Neisch, 2025). The third generation of *yangjiale* homestays is mainly composed of local farmers from the Mount Mogan area and residents of Moganshan County. Inspired by the success of the first and second generation founders of *yangjiale*, many local farmers with innovative thinking and ability learned from the management experience of early homestay operators and began to renovate their own houses and independently operate homestays. Typical cases in this stage include Xipo founded by Qian Jiliang, a native of Moganshan County, and Mount Mogan Mansion founded by local villager Zhu Jindong. The first generation of *yangjiale* homestays flourished from 2007 to 2012, the second generation emerged from 2013 to 2015, and the third generation emerged from 2016 to 2017 (Song & Neisch, 2025). In the third stage, the two-wheeled homestay industry gradually emerged.

2. Literature Review

Planetary gentrification is a new concept that represents the latest global theoretical development since Ruth Glass proposed the concept of gentrification in 1964 (Glass, 1964). Glass's critique has evolved into a global postcolonial challenge to the cognitive violence of Western imperialism, a neoliberal theory of human competition rooted in 19th-century social Darwinism and eugenics. In the article "Resisting Global Gentrification: The Value of Survival in the Struggle to Defend Homeland", the concept of plantetary gentrification is explored, pointing out that the international community's resistance to gentrification is intensifying. This resistance is considered a key struggle for social justice in global cities. The author examines global resistance to gentrification by re-examining the value of survival and advocates learning from different contexts in the ongoing challenges brought about by global gentrification (Loretta Liss, Sandra Annuziata, Clara Rivas-Alonso, 2017). Patrick Rérat interprets the literature on gentrification with spatial capital as the center and expands this concept to a global scale (Patrick Rérat, 2018). Elvin Wyly argues that the global communication technology revolution, known as "cognitive capitalism" and "borderlessness", is enabling a multicultural interweaving. This phenomenon clearly reflects the changing class dynamics of urban space, which adapt to multiple factors such as urban history, sociocultural differences, state power, and local resistance (Wyly, 2015). Cross-border gentrification is a contemporary form of urbanization that narrows the rental gap by attracting high-income immigrants from Nordic and North American countries (Matthew Hayes & Hila Zaban, 2020). There are many cases of gentrification and regional upgrading in both urban and rural areas of China. However, there are few studies on global gentrification in rural China. This study will focus on the cases of global gentrification in rural areas of developed China, as this represents a clear research gap.

Exploring neoliberalism in the Chinese context, especially in the rural context, is a growing trend in domestic research. Anita Koo (2021) explores the neoliberal experiences of rural migrants in her book Individualized Negotiations in Neoliberal China: Youth Transformation in a New Generation of Rural Migrants. Lu Xinyu (2024) further explores the relationship between collectivism and neoliberalism in rural China in his study Neoliberalism or New

Collectivism in Rural China. He argues that Chinese neoliberalism functions as a form of collective capitalism and emphasizes that China faces the challenge of balancing liberal and social democratic demands while ensuring a common minimum standard of living. Yang Zhan and Xiaoxi Tong (2018) also focus on the manifestation of market neoliberalism among rural migrant populations. In addition, some scholars have explored the connection between the rise of rural areas as centers of post-carbon transformation and neoliberalism (Marsden, 2016). However, there is little research analyzing the neoliberal characteristics of rural commercial activities in China.

Many Chinese studies on transnationalism have explored the identities of Chinese and foreign Chinese during the Huaqiao Festival (Louie, 2008), the identities and transnational experiences of students participating in transnational education (Jiang, 2021), and the identity issues faced by transnational migrants who obtain flexible citizenship through education (Yang & He, 2024). However, few studies have explored the issues of transnationalism that emerge in rural China, such as how villagers view foreign entrepreneurs and how their self-identity evolves in this process. In addition, many studies have explored whether traveling to Africa and accepting infrastructure assistance from other countries represent neocolonial behavior. In contrast, there is a lack of literature on the potential neocolonial impact of Western entrepreneurial immigrants bringing lifestyle changes to rural eastern China.

This paper aims to fill the gap in the study of the planetary gentrification theory in rural China. This paper explores the application of neoliberal theory to rural commercial activities and homestay tourism in China. In addition, this paper examines the concepts of neocolonialism and transnationalism in the context of Moganshan, a rural area in eastern China.

3. Research Objectives

Taking Mogan *yangjiale* as an example, this paper explores the perspective of understanding the phenomenon of Mogan *yangjiale* and its rural global gentrification process.

The phenomenon of Mogan *yangjialelization* refers to the influx of a large amount of non-Chinese capital into the Chinese market, which has caused a strong response and has become a benchmark for Chinese homestays, while also promoting changes in the national homestay industry. As a unique phenomenon, *yangjiale* deserves attention and scholars who study the development trend of Chinese rural areas. In addition, *yangjiale* is also a case of global capital entering developing countries and promoting comprehensive regional upgrading. Examining the phenomenon of *yangjiale* from an international perspective helps us understand how Chinese rural areas continue to develop and evolve under the influence of global gentrification.

Understanding the dynamics and interactions between different stakeholders in the *yangjiale* ecology.
By studying the interactive ecology between various stakeholders in *yangjiale* and its *yangjialelization* process, we can gain a deeper understanding of how these stakeholders interact and influence each other. Their interactions constitute the overall ecological framework of *yangjiale*, allowing us to understand how different stakeholders are interconnected in the *yangjiale* interest ecological network. By exploring the mutual influence and relationship between *yangjiale* stakeholders, we can gain a clearer understanding of the Mogan *yangjiale* phenomenon. This understanding can serve as a new economic case to examine the development of rural tourism in China, while also providing insights into the current status of rural spatial development in China and serving as an example of how global gentrification is eroding rural areas in the Global South and Southern China. Ultimately, this study deepens our understanding of how global gentrification theory manifests itself in the real world.

Investigate the spatial influence of various stakeholders on the development of Mount Mogan *yangjiale* in the process of rural planetary gentrification.

Based on the background of urban planning, we investigated the mechanism of mutual influence between the stakeholders of Mount Mogan *yangjiale*. This analysis helps us understand how different stakeholders affect

the changes in local space during the development of *yangjiale* Homestay and its transformation into *yangjiale* Homestay, and gain insight into the role of various stakeholders in the transformation of rural space in the process of planetary gentrification.

4. Research hypothesis and arguments

4.1 Hypothesis

Yangjiale, Moganshan, is experiencing a process of rural global gentrification.

This paper hypothesizes whether *yangjiale* has triggered some form of global gentrification in the region and plans to verify this hypothesis through interviews and research on land use changes.

4.2 Arguments

Mount Mogan *yangjiale* is a political arena where stakeholders such as indigenous people, tenants, government and electronic platforms are interdependent, reflecting the influence of neoliberalism, neocolonialism, transnationalism and government in the context of eastern China.

The rise of Mount Mogan *yangjiale* is influenced by multiple factors. As one of China's most economically developed urban agglomerations, the Yangtze River Delta Economic Development Zone demonstrates how rural development fits in with national development goals. The development of Mount Mogan *yangjiale* also reflects the broader direction of rural development in China. Given China's important position in East Asia and the Global South, this case study highlights rural development models and trends that may be applicable to moderately developed developing countries in East Asia and the Global South, including China. The case study of Mount Mogan *yangjiale* is highly representative. It successfully established its own brand through non-local investment and operation, attracting capital and experienced professionals from the Yangtze River Delta region. This strategy enabled the brand to develop, ultimately leading to the booming homestay industry in the Mount Mogan area and profoundly influencing and changing the landscape of homestays in China. Mount Mogan *yangjiale* represents the intersection of various rights and stakeholders. Ideologically, it is a testing ground for neoliberalism, neocolonialism, transnationalism, and government practices in East Asia and rural China. In addition, it serves as a platform for the expression of multiple rights discourses.

The following diagram (Figure 1) shows the relationship between the various stakeholders involved in the construction of Mount Mogan *yangjiale*. As the manager of local development, the government plays a vital role in nurturing various innovative business enterprises, including the design and operation of local farmhouses that originally inspired the mountain homestay model. This also covers the various forms of rural entrepreneurship that emerged during the mountain homestay process, including the digital nomad self-media entrepreneurship that later emerged among migrant workers in nearby large cities. In addition, the government has set standards for the height and number of rooms in homestays, aiming to protect the environment and help the many farmers who opened homestays inspired by early homestays. The government has developed a set of guidelines to standardize and unify the exterior design of homestays, aiming to create a more cohesive and aesthetic collective homestay environment. The government has also cooperated with several domestic travel websites (such as Booking.com, Qunar, and Fliggy) to hold a series of lectures and small workshops. These activities invite villagers and homestay operators to participate and help them learn how to create attractive slogans and videos for online travel platforms. Participants will also learn the skills of organizing events and live broadcasts to attract a larger online consumer group. The situation of local farmers is a process of constantly adapting to changes and coexisting with outsiders who bring capital and knowledge. Starting with the *yangjiale* initiated by outsiders who arrived in Mount Mogan, local villagers gradually accepted and began to learn from them. They accepted new lifestyles, such as drinking coffee, and began to cooperate with outsiders, renting out their dilapidated village houses at low prices for long-term use, allowing them to operate and design homestays. As the *yangjiale* model was promoted nationwide and achieved market success, local villagers began to participate more fully in it and learn from this model. As *yangjiale* became an important local industry, many young and middle-aged people who left Mount Mogan to work returned to the countryside. They began to get involved in the homestay industry or related fields, becoming housekeepers, managers, etc. of homestays. The development of *yangjiale* also led

to the growth of local villagers' income. Farmers' awareness of investment and entrepreneurship gradually increased, and many houses were rented to homestay operators, realizing the value of the houses. In the popular Yu Village, villagers also began to use the land to earn lucrative parking fees. Over time, the villagers learned to live in harmony with young people who returned from large IT companies in surrounding cities such as Hangzhou and Shanghai. Many entrepreneurs in industries such as self-media have begun to choose picturesque villages as mobile office locations. As the *yangjiale* model gradually heats up and the market gradually cools down, the hospitality of the villagers is particularly important, and they create a warm environment for newcomers. The founders of local homestays have experienced three generations of inheritance and development. Many homestay entrepreneurs cooperate with local small businesses, such as jointly promoting the use of local agricultural and sideline products. In addition, a large number of homestays use online platforms to promote their brands and attract a large number of customers. The rural homestay industry is also undergoing a platform transformation. While these local homestays are booming, the government has also vigorously supported the rise of large-scale hotel industries. These international hotels provide standardized services, causing many homestay operators to feel that their business has been impacted. Therefore, large-scale hotel development projects vigorously promoted by the government have formed competition with the local homestay industry. At the same time, with the success of homestay brands such as Naked Castle and Da Le Zhi Ye incubated by *yangjiale*, many homestays have begun to establish chain operation models in scenic spots in other regions and develop homestays similar to *yangjiale*. In addition, some local governments, such as the Ningxia Xiwei region in central and western China, are working hard to create homestay clusters to attract customers and stimulate the local economy. To this end, they actively introduced the chain homestay brand incubated by *yangjiale* and operated it at a significantly reduced cost. Platformization, that is, the rise of Internet platforms, has had a significant impact on the local government of Mount Mogan area. This cooperation includes promoting unique local homestays in Mount Mogan.

From an ideological perspective, Mount Mogan is an active arena for the intersection and expression of various rights and ideologies, showing the interaction and status of multiple rights discourses in rural areas in the Yangtze River Delta region of eastern China. First, the influx of migrants into the rural market and the establishment of new homestay models mark an important step in neoliberalism's attempt to penetrate China's marginal rural areas, especially in typical Chinese neoliberal cities such as Shanghai. As a form of neocolonialism, tourism is largely dominated by ideologies rooted in the perspectives of the West and the world's North. The process of villagers accepting and absorbing foreign ideas and lifestyles has both neocolonial and postcolonial characteristics. For example, local farmers simply copy or imitate the business models and management practices introduced by migrants, which can be seen as a form of modern neocolonialism and postcolonialism. However, neocolonialism has undoubtedly provided opportunities for cities and regions in the global South, such as the Moganshan region, to develop a vibrant homestay industry cluster using local resources. It is worth noting that after the epidemic, many of the original non-local entrepreneurs left, leading them to re-acquire the homestay brands they originally founded. This suggests that the profit maximization stage of foreign homestays may have ended, highlighting the original non-local people's perception of neocolonialism. Their actions can be interpreted as a kind of speculation in the global South in the context of global gentrification. In addition, the rise of foreign homestays is also deeply influenced by globalization and transnationalism. However, the local government has cleverly seized this global opportunity and turned it into a competitive advantage. Initially, abandoned houses in prime locations were rented out at very low prices to the first non-locals eager to set up homestays, a strategy that continues to attract more innovators of the foreign homestay model. The local government actively cooperated with these initial creators and took various measures to enhance the local visibility and influence. These measures, including leveraging the personal connections of non-local homestay creators and obtaining recognition from prestigious publications such as The New York Times, have greatly contributed to their achievements.

Yangjiale embodies the characteristics of neo-colonialism and rural green gentrification, while creating profits for local villagers and promoting rural green gentrification.

The emergence of the *yangjiale* homestay model has completely changed the traditional farmhouse model. By integrating high-end design, personalized operations, and the beautiful local natural scenery, the *yangjiale*

model provides a rural experience that is in stark contrast to the earlier simple farmhouse model. This business model was developed by a group of people from large Chinese cities such as Shanghai who were eager to experience the natural scenery around Moganshan. They have lived in metropolises such as Shanghai for a long time and realized that Moganshan not only has a convenient geographical location but also has amazing natural scenery. They used their own resources and knowledge to create the *yangjiale* model and successfully attracted the attention of the market. Initially, when these outsiders chose the site, they were warmly welcomed by the local government, allowing them to rent village houses in prime locations at very low prices. The *yangjiale* model embodies how the global elite from the Global North can invest in the Global South region to appreciate, a process often associated with planetary gentrification. After establishing the *yangjiale* model, these people not only introduced a new business model, but also brought the Global Northern lifestyle and philosophy to rural communities in China's Yangtze River Delta. Local farmers readily accepted these changes, and their enthusiasm for learning skills such as coffee making and English grew. This interaction between Chinese resources and foreign capital can be seen as a strong neo-colonial color; however, the villagers did benefit from it. Abandoned village houses that were once considered worthless began to generate long-term rental income. In addition, the popularity of the *yangjiale* model has also created a large number of jobs, including positions as homestay cleaners. Many villagers have also borrowed from the *yangjiale* model to improve their homestays, and residents in popular areas have begun to charge high parking fees due to the increase in tourists.

By comparing the land use change map of Yangjiale in the past 15 years (Moganshan County Government, 2006; Moganshan County Government, 2021), it can be seen that the Ten Million Project launched by the government in 2003 laid the necessary foundation for the development of *yangjiale*. In addition, the booming *yangjiale* industry has also significantly affected the lives and vitality of local farmers. The development of tourism has also quietly changed the overall lifestyle in rural areas (Figure 1).

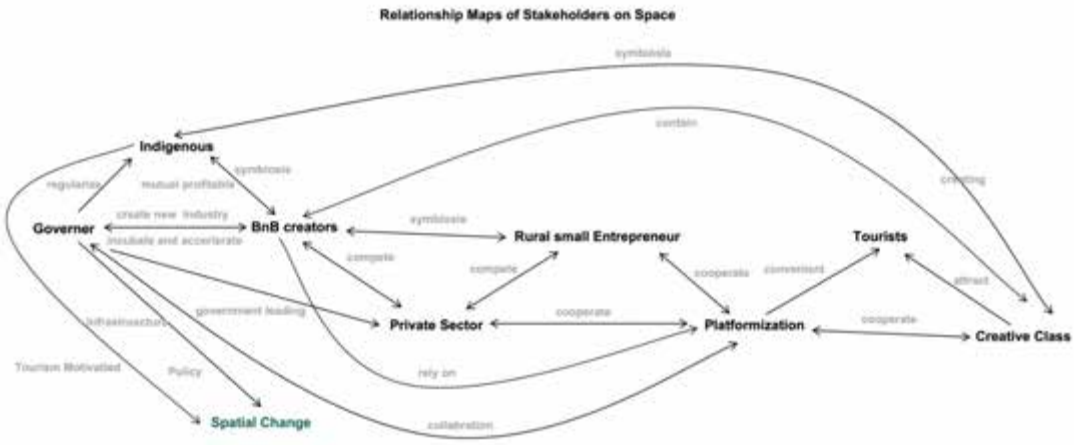

Figure 1. Relationship Map of stakeholders in Mount Mogan Yangjiale on space

Government-led tourism projects and products launched by large private enterprises are undermining the profitability and development of the localized, grassroots *yangjiale* homestay model. This situation is closely related to the broader regional upgrading and rural gentrification process.

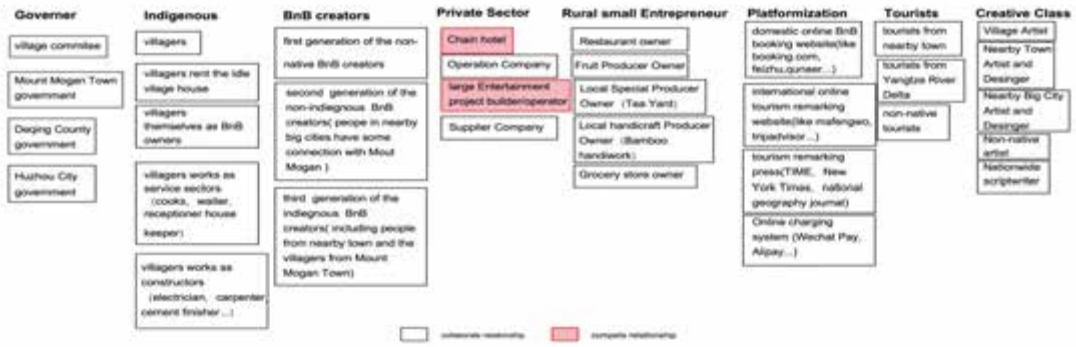

Figure 2. Relationship Map of stakeholders in Mount Mogan yangjiale

During the development of *yangjiale*, especially in the years after the epidemic, the local government leadership changed and introduced various international hotel brands in order to highlight its political achievements. However, these top-down international hotels compete with *yangjiale's* unique local hotel model (Figure 2). Many consumers believe that international hotels of the same price offer more complete and standardized services. As a result, these international hotels have attracted a large number of old customers of *yangjiale*, causing dissatisfaction among local homestay operators. They believe that the government's introduction of international hotel brands has disrupted the grassroots homestay ecosystem of *yangjiale*. In addition, the entry of international hotels has also triggered the phenomenon of tourism gentrification in the area. These hotels are often isolated from the surrounding rural environment, exacerbating the local gentrification phenomenon and separating new developments from existing communities.

4.3 Research Questions
What is the global gentrification process in *yangjiale* Village?
By examining the gentrification process in *yangjiale*, this paper provides a deeper understanding of the region itself and the wider global gentrification phenomenon. This will provide a relevant empirical case for the study of global gentrification in the Global South and help to analyze the levels and dynamics of this process in East Asia in more depth.

In the process of rural planetary gentrification, how do different stakeholders interact to shape the social ecology of *yangjiale*?

By examining the interactive ecological network of *yangjiale* stakeholders, this paper has a deeper understanding of the formation background, formation process and development context of *yangjiale*. This will help to more clearly understand the mechanism behind *yangjialelization* and deepen the comprehensive grasp of this phenomenon.

What are the spatial impacts of these interactions and dynamics in the process of gentrification of rural *yangjiale*?
By examining the interactions and participation of stakeholders in the process of *yangjiale* occurrence and *yangjialelization*, the focus of the study is shifted to the disciplinary context of urban studies.

5.Methodology
Interview
This study included two semi-structured interviews. The first interview was conducted in the summer of 2023 with 61 participants (N=61), including 19 tourists, 11 villagers, 8 village-level organization staff, 11 BnB owners, 8 small and micro business owners (such as coffee shops and agricultural product owners), 2 Moganshan County Government staff, and 2 operating company employees. The second interview was conducted in the summer of 2024 (N=4) and focused on four BnB owners and managers.

Spatial analysis

This study examines the changes in land use during the 15-year development of *yangjiale* BnB in Mount Mogan area. The study was conducted by communicating with local government departments and collecting online information. Through communication with government departments, we obtained the Moganshan County Master Plan 2021-2035 and the Moganshan County Text Atlas 2006-2020. The analysis focused on comparing the changes in land use planning maps to evaluate the changes in industrial land spatial use in Mount Mogan area during the 15-year development of *yangjiale* BnB.

Field investigation

This study conducted two field surveys in the summer of 2023 and the summer of 2024 to gain an in-depth understanding of the current status of the local homestay industry, understand the attitudes of local residents and government officials toward the *yangjiale* homestay industry, and understand the actual situation and business model of local homestays through personal experience.

6.Analysis and findings

In order to more effectively describe the *yangjiale* phenomenon and the characteristics of its various stages, this paper adopts the SCEEP model (Figure 3). This model mainly draws on the STEEP model, which outlines the sustainability of enterprises. The STEEP model contains five quadrants: social quadrant, technological quadrant, economic quadrant, environmental quadrant and political quadrant. The SCEEP model replaces the technical quadrant with the cultural quadrant.

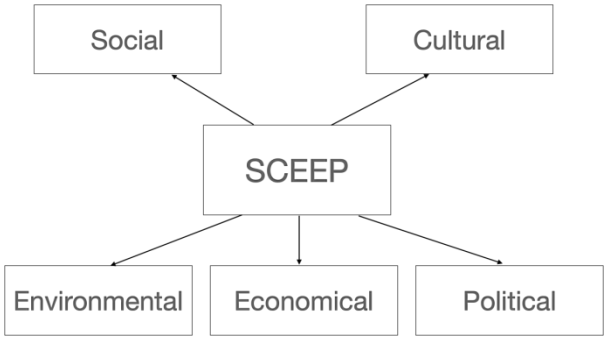

Figure 3. SCEEP model

The five quadrants of SCEEP represent the following areas: S stands for society, including demographic influences, income distribution, education, population development and security, covering social aspects such as family, friends, colleagues, neighbors and the media. C stands for culture, covering factors such as language, religion, customs, traditions and values, as well as gender, attitudes, lifestyles and consumption trends. The first E stands for economy, involving factors such as economic growth, inflation, interest rates, exchange rates, taxes, unemployment, income levels, business cycles, world trade and resource availability. The second E stands for environmental factors, including materials and resources, waste disposal, emission regulations, energy, transportation routes, life cycle, and the impact of issues such as ozone layer depletion and global warming. Finally, P stands for politics, covering policy frameworks, labor market policies, government regulations, competition supervision, legislation, political stability, tax policies, trade barriers, safety requirements and subsidies. Each quadrant plays a vital role in our understanding of the various influences and interactions in *yangjiale* society.

	Definition
Social	demographic influences, income distribution, education, population development, security. Aspects within society such as family, friends, colleagues, neighbors and the media.
Cultural	language, religion, customs, traditions, and values, sex and gender, attitudes, lifestyles, consumer trends.
Political	policy frameworks, labor market policies, government policies, competition oversight, legislation, political stability, tax policies, trade barriers, security requirements and subsidies.
Economical	economic growth, inflation, interest rates, exchange rates, taxation, unemployment, income, business cycles, world trade and resource availability.
Environmenatl	material, resources, disposal, emission regulations, energy, transport routes, life cycles, effects of the ozone hole and global warming.

Figure 4. Definition of SCEEP model

Through the SCEEP model, we can fully understand the characteristics of the development of Yangjiale, the phase characteristics and the relationship between the stages (Figure 5). Using the SCEEP model to describe the characteristics of *yangjiale* in different stages, we can find several aspects. In the first stage, before 2007, *yangjiale* was in its embryonic stage. From a social perspective, the rise of *yangjiale* was influenced by the influx of the middle class in neighboring metropolises and a lifestyle trend known as neo-colonialism. This trend, influenced by Western culture, triggered a wave of lifestyle entrepreneurship in China. This period can be seen as a manifestation of the global gentrification process in rural eastern China. From a cultural perspective, the Western middle class began to reshape the pastoral utopia in the farmhouses in the east, integrating local customs and combining local and Western utopian ideals. Initially, the exploration of *yangjiale* attracted only a few non-locals who were eager to experience the wildness. Unlike large standardized international hotels, *yangjiale* BnBs focus on anti-standardization, private customization and a sense of community, *yangjiale* cleverly combines globalization and localization, embodying the concept of glocalization. There are also historical precedents. Many non-Chinese people were attracted by reports about Mount Mogan and went to Mount Mogan to build villas, which reflects the tradition of historicism in the process of globalization. From a political perspective, the Ten Million Project launched in 2003 laid the foundation for infrastructure construction in rural areas, providing the necessary transportation networks, roads and transportation facilities to support the growth of tourism. From an economic perspective, the early success of *yangjiale* BnB benefited from the gathering of high-spending people in the surrounding urban agglomerations. *Yangjiale* is located in the mountainous area closest to Shanghai and is surrounded by one of the most affluent consumer groups in mainland China, the Yangtze River Delta urban agglomeration, which benefits from its inherent source of customers. In addition, the low long-term rent of village houses also made the founders of the first batch of *yangjiale* lucrative. The consumer groups in Jiangsu, Zhejiang and Shanghai are deeply influenced by consumerism and show a tendency to high-priced, experiential and conspicuous consumption. From an environmental perspective, the successful establishment of *yangjiale* BnB in the early stage had a positive impact on the surrounding environment and laid the foundation for future development.

From 2007 to 2015, it was the second stage of the *yangjialelizatin* phenomenon, when a large amount of Chinese mobile capital poured into the market. From a social perspective, the foreign homestay areas began to show agglomeration effects, and the platform model gradually emerged. During this period, *yangjiale* also developed their own local homestay brands and opened chain homestays in various places to achieve expansion.

From a cultural perspective, during this period, a large amount of Chinese capital poured into the homestay industry, and the participation of gentry in surrounding large cities also accelerated the localization process of homestays. In addition, many creative classes moved from urban centers to rural areas to participate in rural development, demonstrating their entrepreneurial spirit. At the policy level, underdeveloped areas continued to send representatives to Mount Mogan to learn from experience and invite local homestay brands to take root in their rural tourism areas at the lowest cost to attract consumers. Rural governments in central and western regions also actively developed local homestay groups through various forms of cooperation. At the economic level, *yangjiale* attracted a large amount of domestic capital during this period. With the rise of the Mount Mogan homestay industry, the cooperation between the government and homestay brands has also increased, which has promoted young people who have gone out to work to return to their hometowns to start businesses. The cooperation between the Internet economy, homestay brands and local governments is also gradually emerging, such as web page recommendations, online publicity training camps, etc. On the environmental level, the second phase of *yangjiale's* development has entered a climax, and the establishment of many homestays has effectively promoted regional upgrades and improvements in the rural environment.

After 2015, *yangjialelization* entered the third stage, and a large number of local farmers began to participate in the *yangjiale* market, and many copycat homestays also appeared. From a social perspective, the problems of homogeneity and market saturation were more obvious at this stage. From a cultural perspective, the entrepreneurial spirit of the villagers was highlighted at this stage. In response to the homogeneity problem, the government proposed a themed operation model, encouraging each homestay to create a unique theme to attract specific consumer groups. In addition, the government has established cooperative relationships with many IoT tourism platforms. From an economic perspective, the *yangjiale* reached the stage of commercialization at this stage. In order to pursue consistency in economic interests, the characteristics and products of Mount Mogan were commercialized and lost their authenticity. From an environmental perspective, tourisitification was particularly prominent at this stage, and the entire area experienced an upgrade due to tourism development. However, with the development of *yangjiale*, the natural landscape that was originally free to enjoy became exclusive to homestays, and the cost of getting close to nature also increased.

	Social	Cultural	Political	Economical	Environmental
First Phase (Before 2007)	Mobility of jacent metropolitan world middle bourgeoisies Lifestyle New-colonialim Planetary gentrification	Combination of Native and Western Utopianism Anti-standardization and private customization and clubbing Glocalization Historicism of Globalization Disneyfication	Government infrastructure development	Natural High Consumer Group Global Regional Rent Gap Consumerism of natural environment	Infrastructure improvements
Second Phase (2007-2015)	Agglomeration Effect platformization Local brand breeding B&B chains	Lobalization Urban Entrepreneurship of the Local Creative Capitalist Class	Governments of underdeveloped regions cooperate to join B&B brands Central and western Chinese government to develop tourism B&B clusttering	Attracting domestic capital Government and B&B Brands Collaboration Return of local labor Internet platform economy	Regional renewal and upgrading of the countryside
Third Phase (After 2015)	homogenization oversaturation	Urban Entrepreneurship of Local Villagers	thematic promotion of Government Cooperation between Governments and the Internet platform economy	commodification	Touristification

Figure 5. SCEEP of different stages of yangjiale

The study shows that the various characteristics and phenomena in different stages are interrelated (see Figure 6). In the first stage of *yangjialelization*, the global mobility of middle-class elites created opportunities for neo-colonialism and spread Western lifestyles at the social level. In this stage, foreign homestays may be experiencing the so-called planetary gentrification, which is attributed to their unique economic location and natural scenery. The Ten Million Project launched by the government in 2003 supported the improvement of regional infrastructure, enabling foreign homestays to drive regional development in the subsequent stage. From an economic perspective, the consumer groups in the Yangtze River Delta region have formed a desire for natural experience-based conspicuous consumption. As *yangjialelization* entered the second stage, the rise of industrial clusters laid the foundation for the rise of the platform model. The initial stage of *yangjialelization* attracted capital and nurtured the potential for further localization. The homestay brands that landed in the Mount Mogan area were successful in the market and began to expand in the form of chain homestays. This success has stimulated the interest of central and western regions to cooperate with the government and local homestay brands (such as the Chinese version of *yangjiale* homestay brand Da Le Zhi Ye. In the third stage of *yangjiale*, platformization brought challenges such as homogeneity and market oversaturation. In the second stage, the influx of returning youth stimulated the entrepreneurial spirit of farmers and laid the foundation for growth in the third stage. The initial disneyfication trend of *yangjiale* influenced the government's subsequent development plans. The cooperation between the government and the Internet platform reflects the evolution

of the Internet economy, transforming regional development into rural transformation and ultimately achieving tourism development in the third stage..

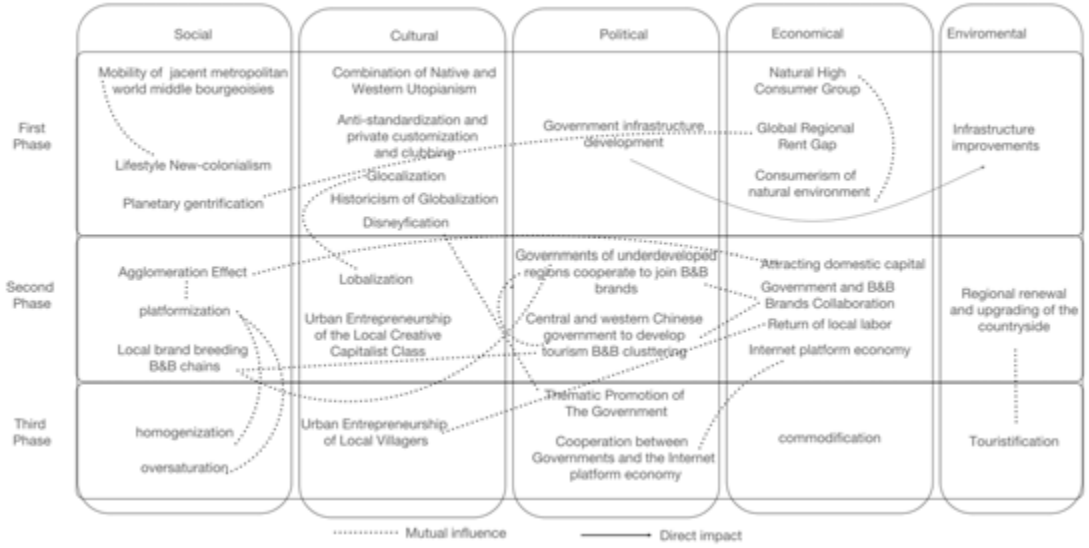

Figure 6. relationships of different stages of yangjiale

Comparing the changes in *yangjiale's* land use planning over the past 15 years, especially the land use planning of Moganshan County from 2006 to 2020 and from 2021 to 2035 (see Figures 7 and 8), the cultivated land area is decreasing and becoming increasingly fragmented.

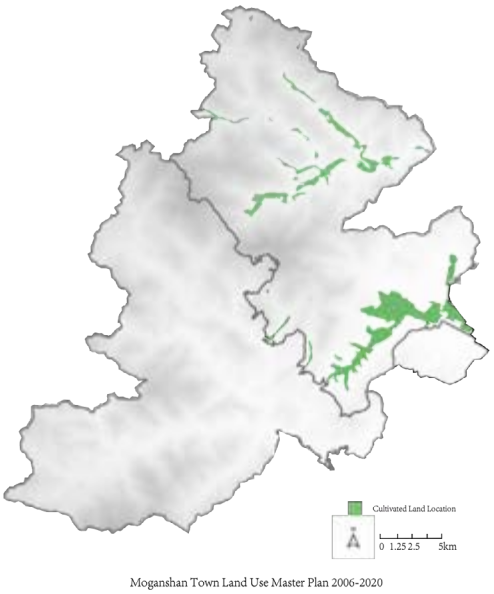

Figure 7. Moganshan Town Land Use Master Plan 2006-2020

Moganshan Town Master Plan 2021-2035

Figure 8. Moganshan Town Land Use Master Plan 2006-2020

Analyzing the relationship between stakeholders and land use change in *yangjiale*, it can be found that villagers' participation in homestay tourism has reduced the importance of cultivated land, leading to the separation of cultivated land and homestay development areas. The emergence of platform-based homestay clusters has further accelerated this development. In addition, the clustering of homestays has enriched the lives of villagers and expanded their living areas to more scenic places. At the same time, under the promotion of the government, the original central area of Moganshan County was designated as the Moganshan Scenic Area, and the size of the town has been reduced (see Figure 9).

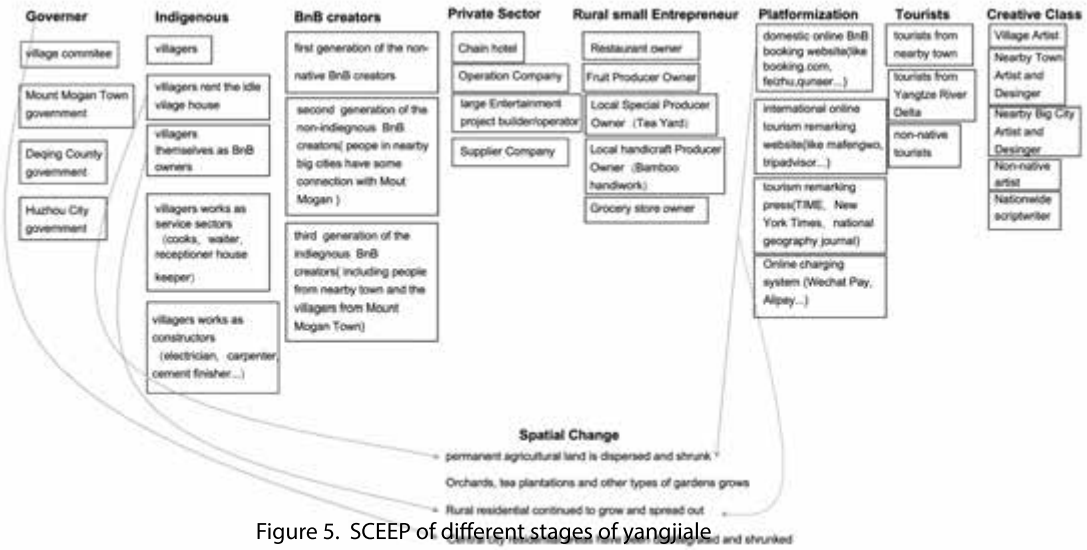

Figure 5. SCEEP of different stages of yangjiale

Figure 9. Stakeholders' impact on Yangjiale in space

In summary, *yangjiale* has gone through three different stages of change, with stakeholders both supporting and competing with each other, forming a unique business model and ecosystem. The SCEEP model can succinctly describe the characteristics of these three stages and highlight the causal relationship between them. Government planning documents reflect the changes in local land use in *yangjiale* over the past 15 years. Combining this information and combining it with the stakeholder relationship map, we can further analyze how different stakeholders in *yangjiale* affect the land use pattern in Mount Mogan.

7.Impact, signifiance and future directions

Understanding and studying the Mogan *yangjiale* BnB industry will help us better understand the implementation of policies such as China's beautiful countryside construction.

By studying the development history of the *yangjiale* BnB industry, we can have a deeper understanding of the direction and model of China's rural economic development, especially in the Yangtze River Delta region. This study will also help understand China's agricultural policies such as the Beautiful Countryside and the Ten Million Project aimed at promoting rural development and reform.

Given that the development of *yangjiale* has benefited from foreign investment, studying this region helps us understand the dynamics of village development and gentrification in the Global South.
The background and development of *yangjiale* show how global capital and talent invest and start businesses in developing countries in East Asia. Mogan *yangjiale* is an excellent case study to examine the global gentrification process in East Asian villages. By observing and studying Mogan *yangjiale*, we can gain a deeper understanding of the impact of global gentrification on rural China in the broader context of East Asia.

Yangjiale's case study can provide a reference for rural development in other underdeveloped regions of China and in the global South.

Yangjiale's successful experience can provide valuable reference for other regions, including Africa, Southeast Asia, and any country that hopes to promote rural economic development through homestay tourism. By sharing *yangjiale*'s story through academic research, we can help other rural areas develop local economies and improve the livelihoods of local farmers in a similar way.

Future research directions include exploring the rural economic development model in Zhejiang Province, examining the identity formation process of the Mount Mogan *yangjiale*, predicting the overall development trend of the Mount Mogan *yangjiale* studying the counter-urbanization and rural digital nomadism phenomena in the Mount Mogan *yangjiale* industry, and examining how Mount Mogan *yangjiale* can serve as rural spaces to ease the tension between elitism and populism in today's world.

The key directions of future continuous research are as follows: As the leader of China's rural economy, how can Zhejiang build a sustainable rural economic model and effectively narrow the urban-rural gap? The rural economic development model of Zhejiang is the focus of future research. As mountain tourism destinations that have not yet established a dominant position in the surrounding economic circle, Moganshan and *yangjiale* have become models of Chinese tourist homestays. This study will explore in depth how they successfully cultivate local identity. The inspiration of this study on shaping local identity will provide reference for other regions to shape their own identity and regional brand and establish the cognition of landmark buildings in the minds of consumers. The development of *yangjiale* has attracted a large number of young and middle-aged people from rural areas to urban employment, resulting in the phenomenon of counter-urbanization in some rural areas. Research on this counter-urbanization trend is another important research direction in the future. In the post-epidemic era, the development of *yangjiale* has declined; however, more and more residents of Mount Mogan and *yangjiale* are integrating into the local community. A new type of maker group has emerged among the residents of Mogan Village, known as digital nomads. They live in surrounding metropolises, but choose to move to the countryside to work in mobile offices or start their own media businesses. The rise of this group, as well as

the future of rural development and innovative human settlements, represents an important research direction. *Yangjiale* is a model of cooperation and symbiosis between foreign elites and local grassroots farmers, which has promoted the success of the homestay industry and comprehensive industry reform. Given the ongoing debate and tension between elitism and populism, case studies from villages and foreign homestays provide an opportunity to bridge these differences and promote mutual learning and cooperation and symbiosis between the two groups.

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The messy interplay between forces of resistance and forces for change in territorial transitions: A case study of an Alpine ski resort

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Abstract
Winter tourism and its associated development has reshaped mountain communities of France and established itself as a major economic engine at a micro and macro scale. However, ski resorts built around this economic model are facing an increasingly uncertain snow future, especially at mid-mountain altitudes. In this paper, we examine the case of a mid-mountain community in the Alps that initiated a collaborative planning effort to decide the fate of their loss-generating ski lift equipment. This case illustrates that climate change adaptation is not a mere question of pecuniary or normative decisions. Rather, to better understand the forces at play, we take a territorial transitions approach to examine the multi-scalar inertial forces in the material, institutional, and ideal dimensions of this community.

Keywords: winter tourism, climate change, territorial transitions, French Alps, mid-mountain ski resort

1. Introduction

Fluid mechanics provides an apt analogy for what many territories are facing in terms of direct and indirect impacts of anthropogenic global warming—it defines three flow phases: laminar, turbulent, and transitional. Laminar flow mirrors harmonious territorial operations, turbulent flow represents chaotic and unpredictable disruptions of territorial systems, and transitional flow reflects territorial systems between the former two regimes, oscillating between stability and instability. In this paper, we focus on the French Alps, which exemplify a transitional "flow" (territorial) phase. In France—a country facing average temperatures increases greater than Europe and the world, on average (FAO, 2023)—areas at greater altitude are facing even faster warming than those at lower altitudes (Adler et al., 2023). Thus, the mountains of France are seeing decreasing snowpacks, especially at mid-altitudes, and increasing uncertain snow regimes (Dayon et al., 2018; Gerbaux et al., 2020). This poses an existential problem in many communities whose economies were built around ski resort tourism (Spandre et al., 2019; Steiger et al., 2019; François et al., 2023; Berard-Chenu, Métral and Cognard, 2024; Bonanomi et al., 2024).

For better or for worse, these mountain communities offer an opportunity to gain important lessons for areas around the world that are facing economic transitions as a direct or indirect impact of climate change. In an essay about declining tourism prospects due to increasingly uncertain snowpack of mountain territories built around ski resort tourism, Bourdeau (2009) describes the French Alps as a "laboratory of post-tourism experimentation." The author hypothesises that with climate change, mountains could return to a pre-ski development model of the mountain is the summer vacation destination of the coming decades, supporting this hypothesis through evidence of growing residential transition of mountain tourist areas, lifestyles that support more place-based activities, and a declining interest in long-distance travel (Bourdeau, 2012). Whereas this represents a rather radical interpretation of the tourism and population signals in mountain territories, it does however represent one bookend scenario of possible futures for individual ski resort villages among a plethora of possible trajectories based on climate, economic, and cultural forces. For the ski resort villages most impacted by these exogenous forces, there is a clear role for planning in directing these territories through their transitional phase towards stability (laminar) and away from instability (turbulent).

Post-modern planning has produced a fractalized landscape of many normative (post-positivist) theories (Allmendinger, 2002). In its essence, normativity in planning is driven by what we should do because it's the right thing to do for the future (Healey, 2003), although there are many arguments to be made around the meanings hidden behind each loaded word. In contemporary times, we have an unequivocal global consensus based on

decades of research that indicates that we should adapt to climate change impacts because it is the right thing to do for the future (IPCC, 2023). Yet, we also have ample evidence that, on a global scale, governments are not meeting the pace and scale of adaptation needs (Berrang-Ford et al., 2021). Zooming into the local-level, there may be a plethora of valid reasons (Rittel and Webber, 1973) why climate adaptation measures are difficult to implement, inadequate, or ineffective (including important cultural, psychological, and political reasons). Nonetheless, it raises the question of whether our current planning paradigms are equipped to address contemporary challenges effectively, both in terms of scale and pace, to find stability with future climate regimes. Indeed, Pavoni et al. (2024, p. 1) pose a critically relevant question to planners: "What if the problem with planning was its very relation with normativity and future?" Indeed, planning is challenged by the very nature of adaptation, which cannot be confined to frameworks and requires a constant process of learning and adjustment.

While there are many strands of post-positivist planning theories, collaborative planning remains a dominant theory in post-modern planning (Tewdwr-Jones and Allmendinger, 2002). In this paper, we aim to take a closer look at the collaborative planning processes relation with normativity and the future to understand some of the tangible and less tangible elements that constrain outcomes (i.e., non-transformative planning efforts that do not seem to meet climate adaptation needs). Pavoni et al. (2024) interrogate these notions of normativity and the future, suggesting planning "not as a strategy to act in the present in order to build a different future, but rather as a strategy to release in the present those futurial presences...that are already there." Our goal of this paper is to examine how collaborative planning can be used to help release a territory from its inertial forces that transcend our abstractions of the future, and at the same time manage transitions without necessarily transforming all outputs.

In this paper, we consider a collaborative planning process taking place in the Chartreuse Mountains of the French Alps. La Montagne Autrement 2030, is a local effort focused on the ski resort village of Saint-Pierre-de-Chartreuse (SPC) concentrating on an imminent and divisive decision facing the community on what to do with their ski lift equipment. We aim to take a closer look at the tangible and less tangible elements that can constrain territorial transitions and the role of the collaborative planning effort.

2. Background

2.1. Setting the scene: the rise of winter tourism in France

It is no coincidence that the growth of winter sports tourism corresponds to the mechanisation and motorising of snow removal equipment in the wake of the world wars, but the idea and allure of ski sports was slowly being developed and implanted into the imaginaries well before. In France, we can trace some of the major factors that contributed to the rise of ski tourism and the eventual widespread establishment of ski resorts across high altitude spaces (Figure 1). With the establishment of the first ski clubs at the end of the 19th century and beginning of the 20th century, the Alps played a major role in the rise of ski in France and the eventual establishment of the first generation of ski resorts. During WWII under the Vichy Regime, mountains were used as a 'tool' for the masculinisation of young boys under an educational philosophy emphasising physical fitness and outdoor training, again with a focus on the Alps. Following the war, populations movements towards economic opportunity led to a trend of rural flight and decline in agriculture that impacted mountain territories.

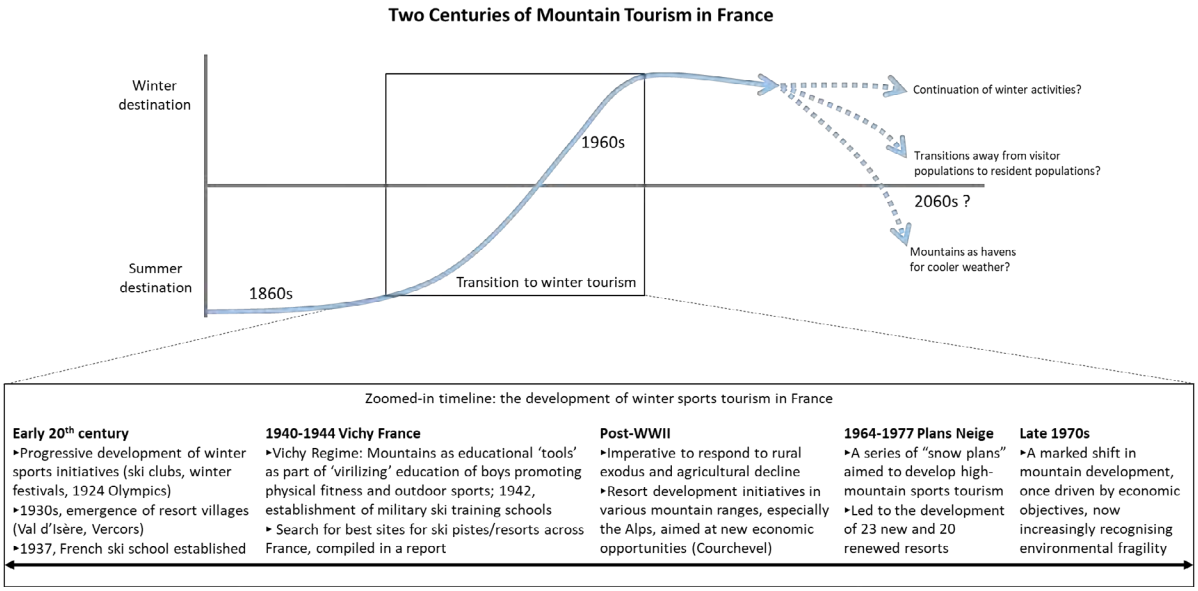

Figure 1. The shift of mountains in France from summer destinations to winter destinations was driven by the alignment of many events over the course of nearly a century. Ski and winter tourism remains important to the economy and culture in France. However, despite the strong heritage of ski resort development, the future of winter tourism is becoming increasingly uncertain with climate change. The future of individual ski resorts is contextual, with some ski resorts continuing investments in ski tourism with success, while others are phasing out ski.

In recognising the potential of winter tourism as a means to boost the economy in these mountain territories, the French government began identifying locations favourable to skiing and investing in infrastructure, leading to the so-called second generation of ski resorts similar to Courchevel (Cumin, 1974). The continuing rise in the popularity of skiing, its marketing, continued technological improvements of ski infrastructure and the profitability of the ski resorts eventually set the stage for the emergence of the Plans Neige by the French government and the emergence of a third generation of ski resorts. These were a series of "Snow Plans" starting in 1964 that outlined widescale development of purpose-built ski resorts, called integrated resorts often built ex-nihilo with the developer playing a major role (Perret, 1992). Between 1964 and 1977, the Plans Neige led to the wide-scale development of many new ski resorts and the renewal existing resorts. By the late 1970s, the development frenzy driven by the Plans Neige was waning, as the initial motives—curbing rural exodus and boosting mountain economies—were challenged by new concerns. Ski resort expansion faced growing criticism, not only for its environmental impacts from unbridled urban planning and enormous accommodation capacities but also from external actors who promoted efforts to restore local control and create more balanced development. Land was increasingly designated for protection through National Parks, in attempting to counterpoise tourism-driven economic growth with environmental safeguards. Nevertheless, ski resort development continued into the end of the 20th century even if at a slower clip.

2.2. The writing "in the snow"

The imprint of ski and winter mountain tourism since its accession in the mid-20th century remains strong. However, across France, as well as Europe and in many places around the world, ski resorts with winter sports-based economies are facing existential questions about their future with an increasingly uncertain snowpack (Steiger et al., 2019; François et al., 2023; Dumont et al., 2025). While many ski resorts use snowmaking and snow grooming to ensure continuous operations in spite of decreasing snow conditions (Damm, Köberl and Prettenthaler, 2014; Schlegel and Schuck, 2024), there are many questions about its continued function as climate change impacts continue to amplify (Spandre et al., 2019; Berard-Chenu et al., 2021; Morin et al., 2023; Scott, Knowles and Steiger,

2024). Indeed, without snowmaking, François et al. (2023) estimate that with 4°C warming, 98% of ski resorts across 28 European countries are at a very high risk for snow supply. Whereas, the number drops to 71% with snowmaking, but raises very serious questions about the its contribution to the vicious cycle of electricity and water demand, carbon footprint, and further contributions to local impacts and global warming, by becoming maladaptive strategies.

With the recognition that the French ski business model is becoming increasingly financially and environmentally unsustainable for many ski resorts (Cour de comptes, 2024), questions emerge about the future of these mountain spaces. Diversification has long been and continues to be a strategy for shifting away from a dependence on winter sports tourism, especially for mid-mountain ski resorts that are on the frontlines of global warming impacts (Achin, 2015; Rouch, George and Rieutort, 2022; Steiger et al., 2024). However, in the process of moving away from a solely ski-based economy, it is important in the planning of such transitions to consider the wider territory and not just the ski resort concerned (Achin and George-Marcelpoil, 2013), as well as other socio-cultural forces beyond tourism that play a role in reshaping these territories in transition (Bourdeau, 2012, 2021).

3. Methodological Notes

3.1. Defining territorial transitions

Taking a broad historical view of a territory allows us to trace major transitions and the forces that shaped them, as seen in the rise of winter tourism in France. However, when it comes to adapting to climate change, the past not only sets constraints on future possibilities but also interacts with dynamic factors that shape the range of viable solutions (Haasnoot et al., 2020). This is referred to as "path-dependency," which helps understand the possible range of strategies for addressing climate change for a given context. Within path dependency, there may be instances of adaptation inaction or maladaptation that create "lock-in." Lock-in describes how rules, land-use patterns, and infrastructure can lock a system into a trajectory that is costly to change (Abel et al., 2011). When certain actions are implemented on top of existing structures or an adaptation opportunity is missed, it is not only potentially locked in for its lifecycle, but the surrounding values, knowledge, and institutions tend to continue to uphold and reproduce that trajectory (Meynard et al., 2018). In a similar vein to collaborative planning, Garrelts and Lange (2011) propose that process-oriented bottom-up approaches can help tackle the spatial and temporal complexities among diverse actors posed by path dependency.

However, climate change adaptation is in many ways fundamentally different from adapting to climate impacts on winter sports tourism, where the existential threat from climate impacts is imposed on an economy from which a space is built rather than the space on which the economy depends, for the former. Thus, in planning for futures of ski-reliant communities, we are particularly concerned with creating pathways for social and economic sustainability (Gill and Williams, 2018). To clarify the meaning behind the word 'territory,' we adopt the approach as defined by Pachoud, Koop and George (2022). The authors explain the concept of the territoire rooted in French geography (Lajarge and Sadoux, 2023) as an interaction between its material, institutional, and ideal dimensions, which serves as a framework for understanding how human activities shape and are shaped by multi-scalar contexts. The authors argue that although geography scholars tend to use the concept to understand dynamics of a territory over short time spans, the concept can also be used to understand potential pathways toward sustainability. The three dimensions can thus help us understand the dynamic nature of the territory: the material, which includes all physical human and non-human elements like resources, infrastructure, and land use; the institutional dimension, which encompasses the formal and informal structures of governance whose role is to organise and manage space while balancing social interests; and the ideal dimension that reflects the cultural, emotional, and social values ascribed to a space by its inhabitants (ibid).

In this paper, we explore the question of inertial forces in the territory that act to either resist or direct change. Mahoney (2000) describes social inertia as processes that are set into motion towards a particular outcome that stay in motion and continue to track that outcome. Some explain the persistence of social structures in terms of reproduction, in that institutions reproduce themselves over time for social stability, causing self-reinforcement that resists directional changes, even if the status quo is unsuitable for the present or future (Barnett et

al., 2015; Brulle and Norgaard, 2019). There are a number of case studies in the literature that name inertia as an impediment to adaptation action, especially related to the persistence of modernist engineering approaches in institutional cultures and development regimes of territories (Harries and Penning-Rowsell, 2011; Taylor, 2016; Meng et al., 2022; Robert, Quercy and Schleyer-Lindenmann, 2023). For this paper, we are particularly interested in the framework laid out by Munck af Rosenschöld, Rozema and Frye-Levine (2014) that connects the concept of inertia to new intuitionalist literature, which we will describe further in Section 3.3.

3.2. Where does "economics" fit in?

Hagimont (2020) describes the case of the development of tourism in the French Pyrénées with the onset of ski tourism to illustrate, on the one hand, the commodification of the human-nature relationship, and on the other hand, the disconnection of all that is less desirable in such a relationship (as rural life in the mountains at the turn of the 20th century was a hard living). The early successes of ski tourism set the stage for viewing mountain territories as areas that could be planned, controlled, and commodified, and no doubt contributed to solidifying the imaginaries supportive of the planification of mountain territories for ski tourism in the mid-20th century via the Plans Neige. Indeed, with the building of transport infrastructure and mechanised snow management equipment, the very relationship with snow for mountain residents radically transformed for many mountain residents from an encumbrance to a potential source of revenue. The heritage of the Plans Neige has ensured France as a major international ski destination (2nd to the United States) with mountain tourism accounting for more than 20% of the overnights stays even as visitor numbers have been in the decline for the past decade (Cour de comptes, 2024).

In contrast, Vindevoghel (2024) describes a 21st century view of rural mountain areas of France providing a key opportunity for reconnecting the human-nature relationship towards sustainable transitions in order to move past the legacy created by the Plans Neige. However, the commodification of snow for now is still a major economic mechanism for many mountain communities. Complicating matters further, France has a specific system of ski area governance. Unlike many countries, which have fully or mostly privately operated and managed ski resorts, France considers ski lifts a form of public service. As a result, local authorities with ski areas choose to either manage their own ski area or delegate management to a private entity via a process known as a public service delegation (Cour de comptes, 2024). Therefore, local authorities may be eligible for subsidies under public policy schemes regardless of their size or financial viability. Public funding for tourist activities shifts costs from users to taxpayers, raising legal concerns about financing public industrial services, financial risks for authorities if businesses fail, and questions about the appropriateness of public spending (ibid).

France's model of treating ski lift equipment as public service infrastructure, necessitates decision-making across the material, institutional, and ideal dimensions. For example, a private owner and operator of ski lift equipment might prioritize operational decisions based primarily on demand and return on investment—keeping decision-making largely within the material dimension—as is the case in the North American ski resorts (Knowles, 2019). Ski lift equipment as public infrastructure introduces additional institutional and societal considerations that shape governance beyond pure market forces. Where market forces play a downsized role, institutional and ideal dimensions can play a large role in driving decisions about the future of ski lift equipment. Thus, planning for the future of French ski resort towns better fits under the framework of new institutional economics and understanding the associated transaction costs of planning (Shahab, 2022). As Alexander (1992) explains, economic and political markets they represent an aggregate of self-interested decisions; however, interorganisational systems need planning because transaction costs are inherently high.

3.3. Evaluating territorial inertia

Since market decisions are not the key decision-making mechanism for French ski resorts, understanding inertial forces can a useful guide to planning, especially where there is not concrete objective. Munck af Rosenschöld, Rozema and Frye-Levine (2014) offer a framework pulling from new institutional literature to understand institutional inertia and climate change policy implications. The authors define five mechanisms producing institutional inertia: costs, uncertainty, path dependence, power, and legitimacy. In this paper, we examine how inertia

presents itself in the case of a ski resort village. We first make the case that the decision for the future of the ski lift equipment is not solely a cost-benefit ratio decision. We describe a collaborative planning process underway that enables collective decision-making over the future of the ski lift equipment and, beyond that, how the community wishes to define the future habitability of their village. We use the framework outlined in Table 1 to evaluate inertia, with collaborative planning as a strategy to mitigate inertial forces.

Table 1. Five mechanisms of institutional inertia and collaborative as a potential strategy to address them. Adapted from Munck af Rosenschöld, Rozema and Frye-Levine (2014).

Inertia generating mechanism	Collaborative planning strategy
Costs - coordination expenses and other transaction costs that can be less visible but discourage action	Although coordination expenses may increase in the short-term, shared resources can reduce overall transaction costs and coordinated efforts can reduce long-term monetary costs.
Uncertainty - incomplete information that rationalises postponement of action	Bringing diverse stakeholders together allows for a broader exchange of knowledge, making risks clearer and alleviating hesitation to action.
Path dependence - self-reinforcing mechanisms that lock institutions into past decisions, technological systems, practices, and discursive frameworks, making change difficult despite evolving challenges	Collaborative planning enables institutions to assess and challenge entrenched practices, opening pathways for innovation and reducing reliance on outdated systems or practices.
Power - embedded in social structures, relationships, and discursive frameworks that reinforce institutional arrangements, making resistance to change a result of entrenched interests rather than rational calculations	As multi-stakeholder processes, collaborative planning can challenge dominant interests that resist change and create momentum for more equitable strategies.
Legitimacy - institutional norms and power structures determine which climate policies are accepted or resisted, often reinforcing existing economic and political interests instead of driving meaningful change	Consensus-driven approaches build trust and reinforce the legitimacy of climate policies, ensuring they are widely accepted and implemented rather than dismissed or blocked by political or economic interests.

These mechanisms of territorial inertia either reinforce resistance to change, favouring the status quo, or can diminish in favour of transitioning to a changed state. This dynamic can be expressed as:

$$I_{\text{status quo}} > I_{\text{change}}$$

Where represents the sum of inertial forces. For a territorial transition to occur, inertial forces must reach a critical mass[1], leading to a directional inversion toward change:

$$I_{\text{status quo}} < I_{\text{change}}$$

At this threshold, transition becomes the favoured course of action, where there is no longer enough resistance to maintain the territorial status quo. However, as long as the path dependency, power, and legitimacy are each greater in the status quo than that of the potential changed state, and conversely, if the costs and uncertainty in the status quo are each less than that of a changed state, the status quo is favoured. The inertial forces within the same territorial state can accordingly be represented as the sum of costs (C), uncertainty (U), path dependency (D), power (P), and legitimacy (L):

1 Territorial changes may unfold over years or decades. For example, in the case of the transition of mountain areas in France transitioning from summer to winter destination (Figure 1), there was an amalgamation of many events that led to this overall transition.

$$I = D + P + L - C - U$$

Applying this framework can help identify forces that may be contributing to the territorial resistance to change, even where transition would otherwise, from an outsider's perspective, be the logical course of action.

4. Case Study

4.1. Research context: Saint-Pierre-de-Chartreuse/Le Planolet

Located in the Alps of Southeastern France, Saint-Pierre-de-Chartreuse-Le Planolet (SPC) is a mid-mountain ski resort community with a population of less than 1000 residents (INSEE, 2023). SPC is located in the Chartreuse Mountains about 25 km north of the City of Grenoble and about 35 km south of Chambéry. As with many ski communities in France, SPC started to develop in the early 20th century and became a ski resort village in the 1950s, with major re-investments in the 1980s and 90s. The area features 26 trails covering 35 km, served by 14 ski lifts and three access points, with altitudes ranging from 900m to 1789m at the Scia summit. As a mid-sized resort with a capacity of nearly 3,000 persons per kilometre per hour, it caters to both families and seasoned skiers.

However, several metrics indicate a delicate financial situation. Over the past 15 years (2015-2023), the ski resort attained an average annual revenue of €1.4 million, with a peak of €2 million during the particularly snowy winter of 2008-09. Between 2015 and 2020, it recorded an average of 130,000 skier-days per season, while the domain was operational for an average of 73 days per year. Despite these figures, the resort faces a negative operating leger, burdened by €2 million in loan repayments, worsened by an aging lift system with high maintenance costs and an oversized fleet compared to similar resorts (Chambre régionale des comptes, 2023).

Furthermore, regional plans create a contradictory structure for economic diversification in the face of climate change. SPC is located within the Auvergne-Rhône-Alpes administrative region (AURA), which provides oversight and planning for the broader regional area in coordination with local entities. Climate change adaptation efforts in the AURA region overwhelmingly prioritise snow security and winter activity safety, with nearly three-quarters of its funding commitments directed toward maintaining ski resort viability rather than diversifying tourism options. For instance, the Region's Mountain Plan (2016-2021) allocates €49.8 million for snow security and €4.5 million for tourism diversification. Similarly, while the Tourism Plan emphasises diversification, its focus on valley areas where there is one or more resorts means that a majority of its budget goes towards ski resorts. Given the high costs of ski infrastructure maintenance, it is reasonable that a significant portion of the budget is allocated to its upkeep; however, this continued investment reinforces a persistent focus on traditional winter tourism (i.e., reinforces path dependency) rather than broader adaptation strategies (Chambre régionale des comptes, 2024).

The SPC ski resort has long struggled to establish stability, with some investments proving unsuitable for the station's scale and capabilities. The municipality of SPC is one of 17 that make up the Communauté de communes Cœur de Chartreuse (CCCC), an intercommunal federation of municipalities. Over the past 20 years, the ski area's management has shifted between local authorities, joint public operations, and private operators, testing various governance models before returning to control under the CCCC in 2023. In fact, the Regional Chamber of Accounts for AURA conducted an audit of the management of the Saint-Pierre de Chartreuse-Planolet ski area syndicate for the period 2009 to 2014 (before the CCCC took oversight) (Chambre régionale des comptes, 2016). According to the report, the financial situation of the SPC ski area syndicate at the time was already exceedingly precarious, with debt levels exceeding 18 years of gross self-financing capacity and making it nearly impossible to secure loans for necessary future upgrades and maintenance of its outdated infrastructure. These financial difficulties had already emerged during the previous syndicate's management of the ski area, ultimately leading to its dissolution and the transfer of authority to the CCCC.

Although five ski lifts are currently not in service, they still impose financial obligations due to ongoing loan and insurance costs. However, restoring them to operational status and ensuring compliance with regulations comes

with a hefty price tag (Table 2). While management by the CCCC enables a broader territorial view[2], they lack the financial resources to support the ski lift deficits of SPC and has yet to devise a clear plan for either adapting or ending operations. Today, the local community has embraced a collective planning effort to confront their climate realities and economic pressures linked to the uncertainty of ski operations. This case highlights the co-existence—and at times, strong opposition—between forces of resistance to change and transformation, while demonstrating the importance of collective planning in reshaping actors' imaginaries about transitions before implementing conflict-minimizing adaptive actions.

Table 2. Out-of-commission ski lifts in the SPC ski area and their associated situations (figures presented at a public meeting in Saint-Pierre-de-Chartreuse, 6 December 2024).

Ski lift	Current situation	Re-commissioning costs and procedures
Scia chairlift	• **Not in use since March 2020** • Suspension of operation • Safety order, March 2026	Estimated re-commissioning costs at **€350,000**
Essarts gondola lift	• **Not in use since March 2020** • Suspension of operation • Safety order, March 2025	Estimated re-commissioning costs at **€820,000** (without an update of equipment)
Fraisses chairlift	• **Not in use since March 2020**	At least the major inspections order of 2022 and 2023 need to be implemented
Combe de l'Ours chairlift	• **Not in use since February 2023** • Major inspections order over 3 years: phase 1 completed in 2022, phases 2 and 3 incomplete	For a return to service: completion of inspections order, compliance audit, and tower diagnostics. Remaining cost of order and re-commissioning estimated at over **€400,000**

4.2. A collaborative planning effort (La Montagne Autrement 2030)

The Montagne Autrement 2030 initiative, spearheaded by local authorities including the CCCC and the municipalities of SPC and Saint-Pierre-d'Entremont (SPE), has provided a platform for reflecting on the future of the ski domain amid the challenging context outlined in section 4.1. This collaborative initiative stands out as a distinctive and exemplary approach to territorial transitioning, conceived in response to the financial difficulties of the SPC ski domain and the declining snowfall at mid-altitude. A bottom-up effort in 2020 debuted this effort, which has brought together various stakeholders—including local public actors, residents, business owners, and economic actors—to discuss not only the future of the ski area but also the broader evolution of the local tourism offering. Through sustained dialogue, this diverse coalition of participants has explored ways to shape a tourism model that aligns with emerging challenges and opportunities (Figure 2). As part of this effort, the EU-funded Interreg TranStat project (Transitions to Sustainable Ski Tourism in the Alps of Tomorrow)[3] designated SPC as a 'Living Lab,' actively exploring innovative strategies in climate adaptation and sustainable tourism, where the project seeks to promote new models of Alpine development and transition in the face of changing climate. The TranStat project aims to helping provide the collaborative effort with information about economic realities, environmental concerns, and evolving visitor expectations.

2 In the CCCC territory, there are a range of Alpine and Nordic resorts, several of which are managed by associations through delegated management or private operators (e.g., Le Granier, Les Egaux).

3 https://www.alpine-space.eu/project/transtat/

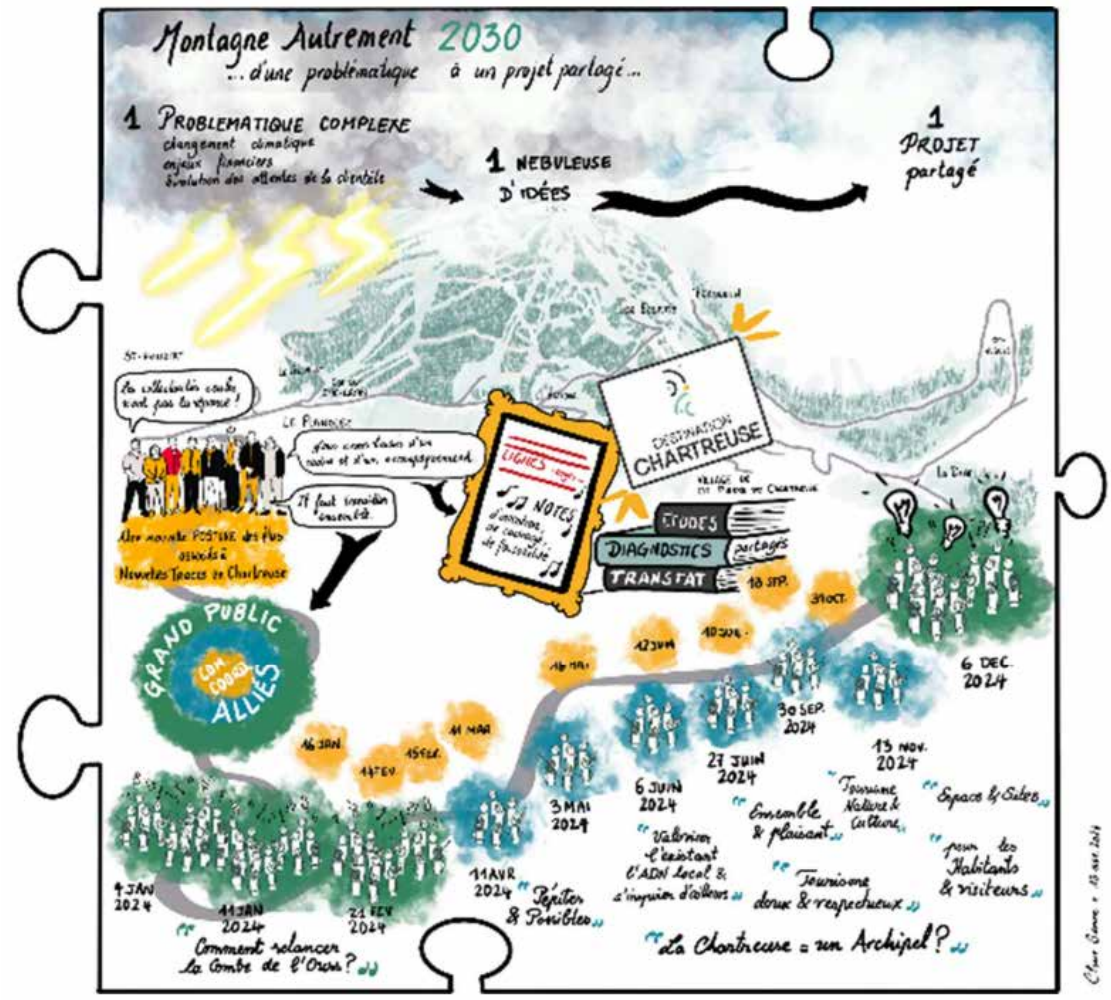

Figure 2. A facilitator-artist's rendering of the collaborative planning process, La Montagne Autrement 2030. Illustration by Claire Simon.

This collaborative process ultimately led to a scaled-down ski domain, now managed by two separate entities under public service delegations, marking a pivotal shift in the governance model. The association Nouvelles Traces en Chartreuse has taken charge of five ski lifts in Le Planolet sector, while the private operator Stass' manages five lifts in the Essarts sector, both under five-year agreements. The decision not to reopen the chairlifts and cable car was driven by financial constraints, as the costs of inspections and refurbishment far exceeded available funding. However, the CCCC has now commissioned a feasibility study to explore the sale and dismantling of these lifts, aiming to ease financial strain and ensure long-term economic viability. This transition reflects a broader shift toward a four-season tourism model, prioritising sustainability, cost reduction, and adaptability. The ongoing debate among stakeholders—between those who view the closures as an opportunity to innovate and those who struggle to let go of the past—illustrates the deep emotional attachment to traditional ski operations, requiring a transformation of imaginaries to embrace new possibilities.

Beyond infrastructure adjustments, the Chartreuse region has embarked on a broader ecological transition, seeking to redefine its tourism identity amid climate uncertainty. This vision-building effort is exemplified by the Chartreuse à +4°C initiative, launched building on the work of the TranStat project and La Montagne Autrement 2030, which brings together scientists, policymakers, and local residents to collectively reimagine life in the mountain territory under a +4°C scenario. A participatory event held in 2025, fostered discussions on

adaptation strategies, exploring alternative economic models, environmental conservation efforts, and the future of mountain landscapes through design fiction workshops. These efforts reflect an intentional shift toward integrating local knowledge, science, and community engagement, ensuring that transitions are inclusive and forward-thinking rather than reactive. The transformation of actors' imaginaries—encouraging stakeholders to visualise new futures beyond the reality of today—is crucial to building a resilient, adaptive Chartreuse, where tourism can flourish year-round while preserving both economic stability and ecological integrity.

4.3. Beyond the numbers: the 'invisible' costs of adaptation

Taking a simplified view of the situation in Saint-Pierre-de-Chartreuse (SPC), focusing primarily on financial considerations. The real monetary costs of maintaining the status quo—keeping the ski lift equipment non-operational—are significantly higher than dismantling and selling the infrastructure. Likewise, recommissioning the lifts would not provide a long-term return on investment, yet some stakeholders still advocate for reopening them. If we consider only financial aspects, the logical course of action would be dismantling and selling the ski equipment, as such:

$$C_{\text{recommission}} \gg C_{\text{status quo}} \gg C_{\text{decommision}}$$

However, since this decision has not yet been made, other inertial forces—beyond costs—are clearly influencing the continuation of the status quo. In terms of status quo (SQ) versus change (Ch), this suggests (building on section 3.3):

$$I_{SQ} + C_{SQ} > I_{Ch} + C_{SQ}$$

Or:

$$(D_{SQ} + P_{SQ} + L_{SQ} - U_{SQ}) > (D_{Ch} + P_{Ch} + L_{Ch} - U_{Ch}) \underbrace{-(C_{Ch} - C_{SQ})}_{\text{net positive}}$$

Since C_{SQ}-C_{Ch} is net positive, given that dismantling and selling the ski lifts is the least cost-depleting option, financial logic alone would dictate their removal. However, the decision remains unresolved, suggesting that other forces in the status quo (left-hand side) have a greater overall value. It should be recognised that the costs associated with the ski equipment represent the most significant tangible financial burden compared to other expenses borne by various local actors. However, additional costs also play a role, such as the time and resources invested in the collaborative planning efforts, which require coordination across multiple stakeholders. Furthermore, decisions about the ski lifts have a cascading effect, influencing economic structures that still rely on these assets in various ways. While these inertial forces related to institutional and individual actors could be examined as well, the focus here remains on how broader financial and socio-economic dynamics shape decision-making within the territory.

Beyond financial constraints, uncertainty is a key factor, closely tied to the future climate and socio-economic scenarios. The TranStat project seeks to reduce these uncertainties, offering knowledge on climate impacts and socio-economic implications of different pathways. Similarly, publicly provided cost data helps mitigate financial uncertainties, offering stakeholders greater clarity. Legitimacy, in turn, is tied to uncertainty—the status quo is familiar, making it inherently legitimate. The collaborative planning effort and the transparent dissemination of information serve to enhance legitimacy, a crucial factor in securing socio-institutional support for transition. In SPC, this process has been bottom-up, placing the decision of legitimacy in the hands of the public, rather than solely policymakers. This also connects to power dynamics. By fostering a bottom-up decision-making model, local leadership acknowledges the role of legitimacy in community-led planning while also distributing power among local actors. In contrast, other ski resorts may experience heavy lobbying pressures, which do not seem prevalent in SPC. Historically, initiatives like the *Plans Neige* followed a top-down model, where State power was used to push through ski resort development. Finally, path dependency plays a significant role in shaping this process. The legacy of the ski domain—its historical role, socio-economic ties, and ingrained expectations—con-

tinues to exert influence, reinforcing resistance to change even when economic logic suggests otherwise. Even still, the Chartreuse à +4° demonstrated that ski does not have a strong presence, if any, in the residents' long-term vision of the habitability of their community.

5. Concluding Remarks: Inertial Forces as an Impediment to Transitions

The evolution of mountain territories has long been shaped by the collective imaginary built around ski resorts and their associated economies, a legacy reinforced by decades of investment and infrastructure planning. However, as financial difficulties, shifting environmental conditions, and uncertain transition models challenge the future viability of these ski domains, the question of territorial inertia becomes central to understanding the pace and feasibility of change. Factors such as economic debt, social ties, and environmental impact contribute to this inertia, making transitions complex and slow-moving. The key to facilitating successful planning efforts lies in identifying critical moments along the trajectory of these stations—moments where intervention could have the greatest impact in overcoming inertia and steering toward a more sustainable model. Without this strategic foresight, planning efforts risk being reactive rather than proactive, limiting their chances of meaningful success.

The interplay between transaction costs and local imaginaries further illustrates why change remains contested. In Saint-Pierre-de-Chartreuse, for instance, the financial burden of maintaining non-operational ski lifts outweighs the cost of dismantling them, yet this purely economic reasoning does not dictate outcomes. Instead, the cultural and emotional significance of the ski infrastructure continues to carry as much weight as structured planning efforts, leading some to describe this phase as a grieving period rather than a transition. While perceived transaction costs often constrain change, cases like Chartreuse à +4°C reveal that when residents are freed from immediate financial concerns and encouraged to imagine the future without real-world limitations, they engage with transition more fluidly. These two collaborative efforts highlight a broader truth: successful adaptation requires both pragmatic planning and a transformation of collective imaginaries embedded in territorial transitions. Moving beyond incremental shifts, communities must consider what timescales allow transitions to occur without being stalled by inertia yet remain tangible enough to be actionable within present-day realities.

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Examining the Phenomenon of Overtourism in the Context of Local Community Perception: The Case of Bodrum.

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Abstract
The concept of "overtourism," introduced by Claudio Milano in 2017, refers to the unsustainable growth of mass tourism and its negative impacts on local communities. These include overcrowding, traffic congestion, seasonal economic dependency, housing pressure, environmental degradation, and reduced contributions to the local economy. Such pressures often lead to social discomfort, loss of belonging, and displacement. Since the 2000s, studies have increasingly focused on how residents perceive these impacts. This study aims to measure the level of overtourism in Bodrum, a key tourist destination in the Mediterranean, by adapting international overtourism indicators. Using surveys and statistical data, it identifies the physical, economic, social, and environmental pressures experienced by locals. The findings contribute to developing strategic planning approaches for more sustainable tourism governance in overburdened coastal settlements.

Keywords: overtourism; tourism capacity; tourism impact studies; local community perception; sustainable tourism

Introduction

Although the concept of overtourism is relatively recent, the impacts of tourism on settlements have been studied since the 1960s, initially with an economic focus, later expanding to environmental concerns. The social dimension, particularly local perceptions, gained attention in the 2000s, culminating in the emergence of overtourism as a distinct concept in 2017.

Dodds and Butler (2019) argue that the rise of overtourism stems from the public's growing opposition to tourism and the widespread transformation of once-untouched areas into tourist destinations. Milano, Cheer, and Novelli (2018) emphasize the importance of local perspectives, identifying key indicators such as overcrowding, housing pressure, environmental degradation, and economic leakage.

Koens et al. (2018) note that these impacts are no longer confined to Europe, increasingly affecting vulnerable coastal and heritage destinations globally. As a response, various international organizations now promote locally tailored indicators and management strategies aimed at balancing visitor experience with resident well-being. The first step in addressing overtourism, however, is to define and measure its presence. This study aims to fulfill that step for Bodrum. (Kuduban, Yerliyurt, 2023)

The Concept of Overtourism

In the literature concerning the impact of tourism on settlements, tourism was historically an activity exclusive to noble families between the 14th and 17th centuries. After World War II, during the period from the 1960s to the 1980s, tourism emerged as a tool for economic development. Consequently, early tourism research predominantly stemmed from economic sciences, focusing on tourism's positive effects as a means to justify steps toward economic growth By the 1980s and 1990s, the rise of mass tourism movements driven by globalization and neoliberal policies transformed tourism into an industry, resulting in significant changes in its impacts. Consequently, literature during this period began to critique the environmental issues associated with the large-scale movements generated by mass tourism. (Postma, Schmuecker, 2017).

Since the early 2000s, the growing emphasis on sustainability and the widespread adoption of strategic planning approaches have led to a more comprehensive examination of tourism's effects. Research during this period expanded to include not only economic impacts but also physical and social dimensions. Nevertheless, environmental impacts continued to be a dominant topic in the literature.

Post-2010, influenced by postmodern movements, approaches emphasizing the social presence of a place rather than viewing it solely as a destination for consumption gained prominence. This period saw an increased focus on the social impacts of tourism, particularly from the perspective of local communities. These discussions, often highlighting negative aspects, coincided with the emergence of the concept of overtourism.

In 2018, the UNWTO defined overtourism as "the impact of tourism on a destination or its parts that excessively influences residents' perceived quality of life and/or visitors' experiences" (UNWTO, 2018). Consequently, overtourism has become a significant focus in contemporary tourism literature. While settlements are expected to have some degree of flexibility in accommodating varying and diverse populations, the tourism sector, once seen as a relatively sustainable development model and an economic driver following the 2008 financial crisis, has undergone substantial changes with the integration of mass tourism into modern conditions. (Postma, 2013)

One of the most distinctive and visible elements of overtourism is the significant shift in local residents' perceptions of tourism. Gürsoy and Rutherford argue that successful tourism development largely depends on local community support (Gürsoy & Rutherford, 2004). Similarly, Ap emphasizes that local communities play a crucial role in determining the success or failure of the tourism industry (Ap, 1992). Thus, local residents may either shape, facilitate, or oppose tourism. They may support tourism if they perceive it as contributing to their well-being or develop negative attitudes toward tourists. The concept of overtourism first emerged in Barcelona, a prominent tourism destination. Claudio Milano of the University of Barcelona was the first to define the term in 2017. Milano noted that by the 2010s, many destinations had reached capacity saturation. The term was initially used by Spanish citizens and later by residents of Venice and other major destinations to express dissatisfaction with tourism's impacts. Milano described overtourism as the negative perception created by unsustainable tourism activities on local communities (Milano, 2017). Since 2018, local residents, civil society organizations, academics, and urban activists have expressed their reactions in various ways. For example, key tourist destinations such as Barcelona, Ibiza, Palma de Mallorca, Malta, Florence, and Venice published a manifesto outlining their concerns and demands. From a social and perceptual perspective, the continuous sharing of urban space between locals and tourists in daily life has increasingly caused discomfort among residents

In pioneering research, Jordan, Pastras, and Psarros emphasized that overtourism fundamentally results from mass tourism. They argued that the presence of large groups of tourists in settlements for certain periods creates density-related issues, particularly seasonal imbalances. They identified insufficient infrastructure and services to meet seasonal demand, alongside the uncontrolled consumption of available services, as both a cause and a consequence of overtourism (Jordan, Pastras, & Psarros, 2018).

Many measurable different indicators are used in researchs. An important outcome of any evaluation of overtourism is the lack of a universally accepted set of indicators. This prevents effective evaluation of destinations that are either at risk of overtourism or have already entered into overtourism. In this context, indicators should be specialized according to the characteristics of the settlement (Peeters et al., 2018; Milano et al, 2018; Kim et al, 2020). Alongside these statistics, which are key components of overtourism, it should not be overlooked that the local population's perspective on this situation is also one of the most important indicators. For this reason, surveys and in-depth interview studies are increasing. After the investigations, the goal is to identify the level of overtourism and problematic areas, and to generate input for strategies.

As a result, the necessity of a management strategy to ensure the sustainability of tourism has been emphasized in the literature since the early stages. This strategy primarily involves the identification of area-specific indicators and the development of strategies based on the analysis of these indicators. In this regard, the strategy

sets of organizations such as UNWTO, TRAN, Responsible Tourism Partnership, ENAT, and IUCN and many more are very important; (Goodwin, 2017; Koens, 2018; Postma, Papp, 2018; Koens, Papp, Postma, 2018; Peeters et al, 2018)

Case Study

a) Destination Selection

The top three tourism destinations of national and international significance in Turkey are Istanbul, Antalya, and Muğla (Çakir Zeytinoğlu and Sadiç, 2013). This can be examined through various data such as the number of accommodation facilities, bed capacity, and statistics from the Ministry of Culture and Tourism. These three coastal provinces, being areas with various disaster risks, rich cultural heritage, and ecological diversity, appear to be worth testing in terms of the perception of the local population, which is a key indicator of overtourism. While Antalya and Muğla stand out with sea, sun, and sand tourism, Istanbul is known for cultural tourism. In this context, it can be said that Antalya and Muğla exhibit the indicator of excessive dependency on a single season, which is an important indicator of overtourism, while Istanbul has a tourism dynamic spread across all four seasons.

The primary reason for choosing Muğla over Antalya between the two provinces is that the bed capacity per capita criterion in Muğla indicates that locals and tourists encounter each other more frequently in the urban space. Selected critera are shown in the following table. [Table 1 near here]

Table 1. City selection index

City	The Number of Accommodation Facilities Per Resident Population	The Number Of Beds Per Resident Population	Coastline Length (km)
Antalya	4,166,471,961	4.16	630
İstanbul	5,935,467,777	59	614
Muğla	4,436,673,377	4.43	1479

Formula Used: Value: x; Normalized value: y; Smallest value of the data series: minimum; Largest value of the data series: maximum: y= (x-minimum)/(maximum-minimum)

Muğla, with a coastline of 1.114 km, has a population of 1,066,736 (TURKSTAT, 2023). Located in the NUTS 1 level classification of Turkey, Muğla lies between the coordinates 36° 17' and 37° 33' North latitude and 27° 13' and 29° 46' East longitude. Situated at the southern tip of Western Anatolia, Muğla covers an area of 13,338 km². As mentioned earlier, tourism in Muğla is concentrated in coastal settlements, and therefore, the issue of over-tourism primarily affects these areas. Bodrum, Marmaris, and Fethiye are significant tourism destinations both for Turkey and Muğla. For the fieldwork, the selected district was determined through an evaluation of Muğla's coastal districts. The main reason for evaluating the coastal districts is that Muğla has a tourism structure dominated by sea-sun-sand tourism, while rural characteristics are observed as one moves inland from the coast. District selection criterias are;

- Resident Population Size (TUIK)
- Presence of Cultural and Natural Heritage Areas (Protected areas, conservation areas, national parks, museums, archaeological sites, etc.)
- Tourism Bed Capacity
- Number of Accommodation Facilities (Operating Certificate + Investment Certificate)
- Second Home Population Projection for 2025 (Territorial Plan, 2016)

Results are shown in the following table and map. [Table 2 and Figure 1 near here]

Table 2. District selection index

Districts	Arithmetic Mean
Bodrum	**91,963**
Fethiye	64,045
Marmaris	40,974

In the next step, to measure the perception of the local community, a sample representing the entire settlement was determined, and an evaluation was conducted at the scale of coastal neighborhoods in Bodrum. To determine the sample area for the field study, five statistically accessible criteria were identified for the Bodrum district, and an expert opinion analysis was conducted using the "Online Delphi Technique" with experts from academia, the sector, and institutions. The research questions of the project were given to the experts, and the question, "How important do you think these parameters are in answering the research question?" was asked. Based on the selected parameters and results, a new index study was conducted in 28 coastal neighborhoods out of 56 neighborhoods in Bodrum. The results are shown in the table [Table 3 near here] According to these criteria and the multipliers determined by the experts, the top three neighborhoods with the highest over-tourism pressure were selected as the areas for the survey studies and in-depth interviews.

Table 3. Neighborhood selection index

Project Area Neighborhood Selection Criteria	Importance Coefficient According to Expert Opinions
Population Density	1
Average Population Growth Rate (2018-2022)	0,6
Change in the Number of Accommodation Facilities (2019-2022)	0,4
Coastal Length	0,1
Tourism Facility Bed Capacity	0,3

Formulas Used a) Value of the Observation: x, Mean of the Data Series: μ, Standard Deviation: σ Z = (x - μ) / σ b) Value: x, Normalized value: y Minimum value of the data series: min Maximum value of the data series: max y= (x-min)/(max-min)

The neighborhoods identified as the highest in over-tourism pressure were "Çarşı (0.24 points), Tepecik (0.21 points), and Gümbet (0.16 points)" neighborhoods, which are considered the center of Bodrum. [Table 4 near here] The field study was conducted in these neighborhoods.

Table 4. Overtourism levels of neighborhoods

Bodrum Coastal Neighborhoods	Overtourism Level Score
Çarşı	**0,24**
Tepecik	**0,21**
Gümbet	**0,16**

b) Bodrum, Turkey

Bodrum is one of the most tourism-intensive settlements in Turkey and the Mediterranean region, primarily known for sea-sun-sand and yacht tourism. With a history dating back 5,000 years, formerly known as Halicar-

nassus, it is both a significant cultural heritage site and a fragile ecological zone.
The town gained prominence in the 1980s with growing tourism investments, which led to rapid spatial expansion. This growth has significantly exceeded the area's carrying capacity, triggering substantial changes in land use, water resources, and ecological integrity. Between 1990 and 2018, urban land expanded by over 1,000 hectares, with a 330% increase in spaces dedicated to tourism and second homes (Arslan & Örücü, 2019). Bodrum's official population in 2023 was 198,335, but this number swells to approximately 500,000 during the summer months (TURKSTAT, 2023). The rise in tourism and seasonal migration has led to issues such as water scarcity, traffic congestion, infrastructure strain, and loss of biodiversity due to construction in conservation areas. The neighborhoods of Çarşı, Tepecik, and Gümbet stand out as the most over-touristed zones. Çarşı and Tepecik form the historic and cultural core of the city, located within a 3rd-degree archaeological site, while Gümbet, a natural bay, lies within a designated natural conservation zone. These sub-regions reflect global tourism hotspots characterized by high environmental sensitivity and historical value, now facing challenges of unplanned growth and unsustainable tourism development.

c) Survey

To reveal the local perceptual response to unsustainable tourism activities, over-tourism indicator sets were analyzed and adapted according to the specific dynamics of the study area. The diagram shown in Table 5 illustrates the relationship between the survey questions and indicator categories. In addition to these questions, the survey included questions to better understand the profile of the respondents. A filter was applied to ensure that the respondent resided in Bodrum. Along with questions about the respondent's profession and educational background, the question "Does anyone in your family work in the tourism sector? How many people?" was also asked. The main purpose of this question was to determine whether the involvement of the respondent or their family members in the tourism sector influences their perspective on the questions related to the impacts of tourism on the settlement. The core sample group of the research was selected to represent all segments of the local population in Bodrum to analyze the local perception of tourism. The survey sample consisted of 50% women and 50% men. When looking at the age distribution of the group, 26% of the respondents were in the 18-29 age range, 27% were in the 30-39 range, 22% were in the 40-49 range, 17% were in the 50-60 range, and 8% were in the 60-70 range. This distribution provided an opportunity to evaluate the impact of tourism on different age groups more comprehensively.

Table 5. Survey Questions Categories

Indicator Category	Focus of Survey Questions
Social Structure Perception	Safety, sense of belonging, local-tourist interaction, cultural impacts, desire to relocate
Economic Structure Perception	Job opportunities, seasonal instability, rising housing costs, cost of living, local benefit
Physical Structure Perception	Overcrowding, adequacy of public spaces, traffic, transportation, infrastructure strain
Environmental Structure Perception	Urbanization of natural areas, pollution levels, aesthetic change, impact on olive groves

Survey Findings

The findings indicate that excessive tourism in Bodrum exerts significant pressure on the physical, environmental, economic, and social structures of the city. Statistically significant results from factor analysis, regression, and ANOVA tests, along with qualitative insights from in-depth interviews, reveal how local perceptions vary based on education and length of residence.

1. Physically, Bodrum's infrastructure struggles to cope with seasonal population surges. Key issues include overcrowding in public spaces, traffic congestion, water shortages, and restricted access to the coastline. In-

terviewees highlighted infrastructure deficits and unregulated growth, while long-term residents were more sensitive to service inadequacies.

2. Environmentally, overtourism contributes to pollution, ecological degradation, and increased disaster vulnerability. Rapid urbanization, construction in fragile areas, and unplanned coastal development have altered local microclimates and increased water scarcity. Local perceptions show that urbanization and environmental pressures are felt more acutely by long-term residents.

3. Economically, although tourism creates jobs and stimulates local markets, it simultaneously raises the cost of living and fosters inequality. Real estate prices and basic goods costs have increased, especially during the tourism season. Residents reliant on tourism income expressed dissatisfaction, noting that perceived economic gains do not translate into better quality of life. Seasonal dependency and the "all-inclusive" model have also weakened local businesses.

4. Socially, overtourism leads to a weakened sense of belonging, identity loss, and discomfort toward tourists. Statements like "I feel like a foreigner in my own town" had high factor loadings. Issues such as rising crime, exclusion from tourism planning, and loss of cultural values exacerbate this. Educated and long-term residents report lower trust in governance and higher discomfort. Local movements like the "Free Beaches Movement" reflect emerging resistance to overtourism's social impacts.

Overall, the findings suggest that excessive tourism in Bodrum deteriorates local life quality across multiple dimensions. Sustainable, inclusive tourism strategies are urgently needed to safeguard the city's identity, environment, and long-term livability.

Conclusion

Overtourism, driven by seasonal overcrowding and unbalanced economic dependence, has increasingly transformed tourism-dependent settlements, particularly coastal areas like Bodrum. Once shaped by small-scale, interactive tourism, Bodrum has evolved into a destination marked by infrastructure strain, seasonal unemployment, environmental degradation, and social tensions.

This study confirms that Bodrum has reached its carrying capacity. Local residents report serious challenges, including:

- Seasonal overuse of infrastructure (water, waste, transport),
- Displacement of public spaces by private tourism enterprises,
- Rising living costs,
- Environmental degradation,
- Lack of effective governance tools such as a tourism master plan or accurate statistical monitoring.

Current indicators are insufficient due to gaps in data on second-home ownership and informal employment. This undermines efforts to monitor or manage overtourism effectively. A national level, flexible but binding tourism strategy is urgently needed. Local planning tools such as Integrated Coastal Area Management Plans and Transportation Master Plans should include mandatory environmental and social impact assessments. Additionally, alternative tourism models and strict visitor caps should be considered in saturated areas. Policies must also protect local businesses and housing markets from displacement pressures, particularly in zones affected by platforms like Airbnb. Ultimately, planning must prioritize local communities as core stakeholders. Sustainable tourism requires participatory governance, fair distribution of benefits, and protection of local residents' quality of life. The findings of this study offer a roadmap for designing context-specific strategies in Bodrum and other regions vulnerable to overtourism.

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Traveling for Celebrities: Fandom Tourism and the Creatively Repurposing of Urban Spaces

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Abstract
In recent years, celebrity-related travel across cities in China has increased markedly, reflecting emerging trends where consumption converges with production, and emotional attachment intersects with community participation. This article proposes the concept of fandom tourism to address the limitations in existing popular culture and media tourism literature, particularly in accounting for fans' active cultural and spatial practices. Based on exploratory interviews with Chinese fan travellers, the study identifies key patterns of fandom tourism, examines the affective and community-driven decision-making processes underlying travel behaviour, and explores how such practices contribute to the re-inscription and symbolic revalorisation of urban space. The fandom tourism framework offers a critical conceptual lens for understanding the affective economies and participatory dynamics that shape contemporary popular culture-induced mobility.

Keywords: fandom tourism; cultural consumption; urban regeneration; tourism behaviour; China

"Travelling for concerts" has become a popular tourism pattern in China (He and Fu, 2024). Besides attending performances, travellers would often explore the host city and enjoy local cuisine. A growing number of people—especially celebrity fans—are now willing to travel to another city for a single event. According to the China Association of Performing Arts, the total box office revenue of offline performances in 2024 reached nearly 580 billion Chinese Yuan (approx. 81 billion USD) (Zheng, 2025). Over 60% of attendees at large-scale events such as concerts were from outside the host city (Zheng, 2025), indicating that more than half of the audience consisted of non-local tourists. This influx of visitors has brought significant economic benefits to host destinations, with total audience-related spending exceeding 2000 billion Chinese Yuan (approx. 280 billion USD) (Zheng, 2025). This emerging consumer trend, which integrates cultural consumption and tourism activities, has drawn increasing attention from municipal cultural and tourism departments across China. In collaboration with the local service industry, tourism sector, and performance organisers, these departments are upgrading urban hospitality services and infrastructure to attract more audiences, fans, and visitors (Zhou and Zhou, 2024)

This form of tourism driven by cultural, or media consumption is not a new phenomenon. As early as the 1980s, researchers observed that television and drama series could motivate audiences to visit filming locations and influence their travel decisions (Nakayama, 2021). This type of travel behaviour was conceptualised as film (induced) tourism and has since attracted sustained attention within tourism studies. Later, the impacts of novels (Reijnders, 2011; Belarmino, 2023), anime (Jang, 2020), sports competitions (McManus, 2020), and music festivals (Kinnunen & Honkanen, 2021) on tourism experiences was also acknowledged. Popular culture and media products could act as key drivers of tourism. In response to this widespread phenomenon, several interdisciplinary frameworks have been developed, such as content tourism and event tourism. The former emphasises the cross-media experiences offered to tourists through the integration of various media forms—such as films, television series, manga, anime, novels, and video games—with real-world destinations (Graburn and Yamamura, 2020). The latter focuses on planned events that are strategically developed and marketed in an integrated manner, including commercial, sporting, and festival activities (Getz, 2008).

These concepts and frameworks are typically defined around specific media products or events, as these serve as the core motivational forces behind such forms of tourism. The impetus usually stems from audiences' or fans' desire to establish a physical connection with beloved celebrities or media personas. For example, American fans of Japanese anime may travel to Japan to visit locations featured in the animations (Clyde, 2020), while

Chinese fans of Korean idols often take photos outside their favourite idols' entertainment agencies in Seoul (Li et al., 2025). These meaningful sites are perceived as unique attractions—or even secular "sacred places." For fans, travel becomes a form of pilgrimage, a notion widely discussed in tourism studies (Reijnders, 2010; Goh, 2014; Clyde, 2020; Waysdorf, 2021; Li et al., 2024). However, existing research has primarily examined fan tourism through a consumerist lens, overlooking fans' active role as producers within these practices.

More specifically, fans would not merely visit sacred sites—they actively participate in creating them (Jang, 2020). For instance, fans may collaborate with cafés near concert venues to stage themed exhibitions, temporarily transforming these otherwise ordinary spaces into fan-relevant "attractions." For those seeking a deeper connection with their favourite celebrities and fellow fans, such temporary sites often hold greater appeal than official tourist attractions—even when they have no actual interest in the café itself. Fans who visit these spaces typically take photos, socialise, and share content on social media, collectively imbuing the site with symbolic meaning. Through these shared cultural practices, fans could construct new sacred spaces out of otherwise unrelated urban settings.

This highlights how fans' active involvement could blur the boundaries between tourists, media content, and destinations—posing a challenge to existing theories that primarily focus on media-induced tourism. Furthermore, while current frameworks emphasise the emotional bond between individuals and media personas/products, they may fail to account for the significance of fan-to-fan relationships and fan community dynamics in shaping travel motivations and practices. Therefore, it is necessary to develop a new framework centred on fandom to better account for these complex tourism behaviours and experiences.

Fandom functions as an affective community, offering both emotional and practical spaces for fans to engage in production and consumption. It operates not only as a site of collective meaning-making, but also as a network of intimate relations (among celebrities, fans and communities) (Jenkins, 1992; Hills, 2002). In China, the fan economy is rapidly expanding, with fan-organised activities becoming increasingly diverse and visible. Fans actively appropriate urban spaces and transform otherwise ordinary places into new fandom attractions through their practices. As both consumers and producers, fans engage with the cultural functions of the city while simultaneously contributing to its spatial and symbolic renewal. These dynamics cannot be adequately explained by existing frameworks such as content tourism or event tourism.

To address the gaps in existing research, this study proposes a theoretical framework of fandom tourism, offering an exploratory overview of this emerging phenomenon. First, the study identifies three primary types of fandom tourism activities, outlines their key characteristics, and provides a foundation for understanding the structure of fandom tourism. Second, it examines the mechanisms behind fandom-related travel decisions, particularly those shaped by affective consumption and community-based interaction. Third, the study highlights how fans engage with and reconfigure urban infrastructure and physical space, offering new perspectives for understanding destination image formation.

Importantly, this research situates the entire fan travel experience within an integrated framework, rather than focusing solely on aspects directly linked to media texts or products.

Literature Review

Fan and Fandom

What is a fan? The term fan is derived from the abbreviation of fanatic, which in turn comes from the Latin word fanaticus, carrying connotations of religious devotion, fervour, or even madness (Jenkins, 1992). While this etymology implies a somewhat negative and pathologising view, such stereotypes have been increasingly challenged and corrected by the rapid development of fan studies. Scholars in media and audience studies have emphasised the distinctions between fans and general audiences or consumers. Fans are often seen as loyal audiences (Kozinets, 2001), or in some cases, excessive consumers (Fiske,1992)—individuals who are intensely devoted to, or enthusiastic about, specific figures such as celebrities, actors, films, or more broadly, media content

and public figures, and who engage with these objects of affection in active and participatory ways (Kozinets, 2001; Yan and Yang, 2021).

This distinction has been attributed by media psychology researchers to various emotional mechanisms, including empathy (Taylor, 2015), worship (Chen et al., 2022), a sense of belonging (Fong, 2020), identification (Kim and Manoli, 2022), attachment (Stever, 2011), involvement (Bee and Havitz, 2010), and loyalty (Stevens and Rosenberger, 2012). In other words, emotional connection lies at the heart of what defines a fan. Motivated by such affective bonds, fans often develop intense feelings of intimacy and commitment towards celebrities or media characters—despite not having any real-life interaction with them—and are willing to offer various forms of support (Tukachinsky, 2010). Scholars have conceptualised this as an emotional connection that resembles real-world social relationships, with one crucial difference: it is non-reciprocal. Information, emotion, and resources typically flow in one direction—from the fan to the media persona. As such, these intimate yet one-sided relationships are referred to as parasocial relationships (Horton and Whol,1956).

This perspective helps explain why fans often engage in what might be termed "excessive consumption"—because such acts are understood not merely as purchasing behaviour, but as meaningful expressions of support. For example, repeat purchasing is a common practice among fans of East Asian idol groups, where individuals may buy dozens of copies of the same album to help their idols climb sales charts (Bai, 2021). Within parasocial relationships, fans are emotionally invested in the success and well-being of their favourite media figures (Tukachinsky, 2010), and this affective bond becomes a key driver of their consumption patterns and decision-making. Another way to understand excessive consumption is through the fan's desire to interact with and deepen their relationship with the media persona (Rubin and McHugh, 1987; Tukachinsky, 2010). However, given the non-reciprocal nature of parasocial ties, such desires cannot be fulfilled through direct exchange. Instead, fans repeatedly engage with media products—re-watching, re-purchasing, and re-circulating content—to sustain and simulate connection.

However, the media industry can only provide a limited range of content for specific fan groups, which often fails to satisfy the full spectrum of desires embedded in parasocial relationships. As these relationships are constructed within the fan's imagination, some fans attempt to bring their imagined connections into the physical world. For instance, they may visit celebrities' former workplaces, favourite restaurants, or hometowns (Yan et al., 2024; Li et al., 2025). Such practices help bridge the gap between fantasy and reality by providing tangible experiences that anchor intangible emotions, thereby creating a sense of closeness. Fans often describe these journeys as acts of pilgrimage, and particular sites become sacred because they hold deep symbolic meaning (Jang, 2020; Li et al., 2024). The notion of "pilgrimage" is widely recognised across global fan cultures (Jang, 2020).

Consumption is not the only way fans seek connection with media figures—they also engage in creative production. Fans often appropriate original media texts to produce new content, such as writing sequels to a TV series after its conclusion. Jenkins (1992) describes such activities as part of participatory culture, in which fans actively participate in textual construction and content creation. Fans are thus both consumers and producers. This creative practice also extends to place-making: fans may designate previously unrelated locations as sacred sites through ritualised visits and symbolic validation via social media (Li et al., 2024).

The creation of such "sacred spaces" is rarely an individual act; rather, it is often a collective endeavour within the fandom community. Through negotiation, sharing, and imitation, ordinary locations are imbued with meaning, sanctified, and granted a sustained cultural presence. The fandom community not only operates as a site of symbolic production (Jenkins, 1992), but also as a network of intimate relations, since fans form parasocial relationships not only with media figures but also with each other (Elfving-Hwang, 2018). Hills (2002) conceptualises fandom as an affective community, one that provides both emotional and practical space for fan-based production and consumption. Sacred sites, for example, are collectively recognised, sustained, and re-signified through repeated visits and ongoing acts of communal interpretation.

In sum, fan practices are rooted in emotional attachment and forms of intimacy—both between fans and media figures, and among fans themselves. These cultural practices blend consumption and production, driven by a fundamental desire to translate imagined meanings into real-world experiences.

Media and Tourism

In media studies, visiting sites associated with beloved celebrities or media content is commonly regarded as a form of fan practice. In tourism studies, however, such activities are conceptualised as a specialised form of tourism. One of the earliest frameworks to enter the field was film (induced) tourism (Lexhagen, Ziakas and Lundberg, 2023), defined as "visitation to sites where movies and TV programmes have been filmed, as well as to tours to production studios, including film-related theme parks... (any) tourist activity associated with the film industry, be it on-site in the field, or at (or near) the production studio" (Beeton, p. 11). This concept sparked widespread scholarly interest, especially in relation to its economic impact—such as the role of film in shaping destination image and marketing (Vagionis and Loumioti, 2011; Busby & Haines, 2013; Camprubi, 2020) —as well as its influence on tourists' decision-making processes (Frost and Laing, 2015; Waysdorf and Reijnders, 2019; Zhou et al., 2023).

Subsequent studies have shown that the intersection between media content and tourism extends well beyond film, encompassing sports (McManus, 2020), music (Roberts, 2014), literature (Belarmino, 2023), video games (Thompson, Taheri and Scheuring, 2022), and manga/anime (Clyde, 2020). Audiences and fans of these different media forms often travel to relevant destinations in pursuit of experiences associated with particular content, subcultures, or celebrities (Lee, Bai and Busser, 2019). Accordingly, the field has seen the emergence of new subcategories such as sports tourism, literary tourism, video game-induced tourism, and animation tourism.

These forms of tourism are generally defined by their specific motivating media content. Some involve visiting fixed, long-term, and relatively static attractions—such as film locations—while others are driven by short-term, temporary, or cyclical events, such as the Olympics or music festivals. In response, some scholars have proposed the concept of event tourism to describe travel motivated by planned and strategically marketed events, including festivals and celebrations, entertainment, and leisure events, political or state occasions, scientific and artistic gatherings, commercial and corporate events (e.g. conferences, conventions, expos, and exhibitions), as well as personal milestones such as weddings or fan-based social activities (Getz, 2008). In short, event tourism focuses on the planned and integrative development and promotion of events (Getz, 2008).

Some scholars have argued for a more integrated approach that brings together different types of popular cultural content under a unified analytical lens. One prominent interdisciplinary framework is contents tourism, originally introduced by the Japanese government as a strategy to stimulate regional tourism. It refers to tourism that is wholly or partially motivated by narratives, characters, locations, and other creative elements found in various forms of popular media—including films, television dramas, manga, anime, novels, and video games (Graburn and Yamamura, 2020).Contents tourism emphasises the multi-platform use of the same content across different media formats (Lexhagen, Ziakas and Lundberg, 2023), and treats the site itself as a form of media, highlighting the importance of transmedia experiences for tourists (Graburn and Yamamura, 2020). For example, a novel, its manga and anime adaptations, and the real-world locations depicted across these formats can all be understood as part of the same content universe. In addition, some scholars have proposed the broader concept of popular culture tourism in an effort to encompass the wide-ranging intersections between popular media and the tourism industry (Lexhagen, Ziakas and Lundberg, 2023).

Fandom and tourism behaviours

Although these different types of tourism are defined in various ways, one prominent research focus across the literature is their economic impact. It is widely acknowledged that such niche or media-induced forms of tourism tend to generate positive economic outcomes, partly because associations with popular culture can enhance a destination's perceived distinctiveness (Lexhagen, Ziakas and Lundberg, 2023). This perceived uniqueness can directly or indirectly influence both travel intentions and decision-making. For instance, Lee, Scott and Kim (2008) found that celebrity attachment positively affects fans' familiarity with and intention to visit destinations

linked to those celebrities—such as their hometowns or filming locations—which in turn influences their travel decisions. In addition to directly motivating travel, media content may also indirectly shape tourism intentions through its influence on destination image and place attachment (Yen and Croy, 2016; Wong, Song, and Zhang, 2021; Lexhagen, Ziakas and Lundberg, 2023; Zhou et al., 2023).

However, not all studies report positive correlations. Rajaguru (2014) for example, found that although respondents reported emotional connections with Korean actors in media content, this did not significantly influence their intention to travel to South Korea. Similar findings have been echoed elsewhere: while film can play a significant role in shaping the travel decisions and experiences of certain tourists, for many others, film remains a minor or negligible factor in travel decision-making (Busby & Klug, 2001; Croy & Heitmann, 2011; Heitmann, 2010; Lee, Bai and Busser, 2019)—even when it positively affects destination image (Croy 2007).

One possible explanation for these discrepancies is that different samples may yield different measurements of media content's influence on tourism decisions (Yen and Croy, 2016). Lee and Yoo (2015) argue that fans with higher fandom levels tend to show greater loyalty toward both the destination and celebrity-related activities. This suggests that it is insufficient to treat tourists, fans, and general audiences as a homogenous group when analysing media-related travel behaviour. Even among travellers emotionally connected to specific cultural content, the degree of fandom matters. For instance, highly devoted fans may revisit the same destination repeatedly, viewing the experience as a form of homecoming (Waysdorf and Reijnders, 2019)—a behaviour rarely observed among casual viewers or less engaged fans.

Importantly, the "black box" in existing research is not limited to treating fans and general audiences as undifferentiated. Waysdorf (2021) raises a crucial question about how tourists interpret the tension between media representation and reality. While travel offers fans an opportunity to connect the sacred spaces of media texts with real-world environments (Reijnders, 2011; Waysdorf, 2021), a gap always remains. Waysdorf (2021) highlights the role of individualised imagined experiences, whereas Belarmino (2023) focuses on shared experiences constructed within fan communities. These findings underscore the fact that fans, as tourists, are not merely consumers—they are also producers. They may even create new destinations, such as turning subway advertisement boards featuring beloved characters into newly recognised sacred sites through collective ritual and social media recognition (Jang, 2020). Moreover, Belarmino (2023) notes that more creatively engaged fans behave differently during travel compared to casual fans or general audiences.

In discussing the limitations of contents tourism, Graburn and Yamamura (2020) point out that fans' active forms of production blur the boundaries between tourism producers and consumers, destabilising the clear-cut roles of tourist, content, and destination. This makes it difficult to explain such phenomena solely through the lens of contents tourism. Nor do other existing frameworks sufficiently address this gap. These observations reinforce the need to construct a new framework centred on fandom. Current research has yet to fully explore how fan emotions shape travel decision-making. The dual role of fans as both consumers and producers during travel also warrants greater scholarly attention. Furthermore, fans often travel not as isolated individuals, but as members of a fandom community, sharing affect, coordinating actions, and co-creating experience. Such communal travel practices differ significantly from those of conventional tourists. Existing theoretical models remain limited in their ability to account for these affective, collective, and participatory travel experiences rooted in fandom communities.

Methods

Building on the identified gaps in the existing literature, this study explores travel experiences driven by fandom as a core motivational force. It focuses on three key aspects: (1) the individual and collective experiences that fans undergo during travel; (2) the role of multiple forms of intimacy—including but not limited to relationships between fans and celebrities, between fans themselves, and between fans and their wider communities—in shaping travel decisions; and (3) how fans engage with and utilise urban space in the course of their travels.
The research concentrates on tourism activities within the context of Chinese fandom culture. Accordingly, the

sample consists primarily of celebrity fans based in China. Participants were recruited through open calls on social media platforms and snowball sampling. The selection criteria were: (1) participants must be long-term fans of a specific celebrity; and (2) they must have undertaken at least one instance of cross-city travel primarily motivated by participation in celebrity-related activities. Given the exploratory nature of the study, in-depth interviews—an approach well-suited for understanding how phenomena operate and how different factors are interrelated—were employed for data collection (Denscombe, 2021).

The research draws on semi-structured interviews with 16 participants, focusing on their most memorable travel experiences. Topics discussed included their fandom histories, the celebrities they support, the activities that motivated their travel, their interactions with other fans, the overall travel experience, their decision-making processes, and their emotional responses. Interviews continued until no new insights or information were emerging. Interview durations ranged from 45 to 90 minutes, totalling 973 minutes of recorded data. The participants were fans of a range of public figures, including idols, actors, singers, musical theatre performers, and athletes. The collected data were coded and analysed using thematic analysis. This process led to the identification of three main types of fandom tourism activities, as well as the mechanisms that underpin how these activities structure the fan travel experience.

Findings

Three types of activities in fandom tourism

Based on the level of direct association with celebrities, this study identifies three typical types of activities within fan tourism: core activities, related activities, and other activities, ranked from highest to lowest in terms of their proximity to the celebrity figure. This categorisation forms the foundation for understanding the structure and behavioural logic of fan tourism.

1. Core Activities

Core activities are the primary motivators of fan travel. They are directly related to the celebrity and typically form the most fixed and non-negotiable part of the travel itinerary, regardless of a fan's level of enthusiasm. Examples include concerts, sports events, fan meetings, and other occasions involving direct physical presence or interaction with the celebrity. These events are usually organised by official entities or authorised representatives and take place in formal, large-scale venues such as cultural and sports complexes. As such, they place specific demands on a city's infrastructure and event-hosting capacity.

2. Related Activities

Related activities revolve around the core event but are indirectly linked to the celebrity and more directly associated with the fandom community. One common example is the creation of new sacred sites, such as temporary exhibitions about the celebrity held in cafés near concert venues. These sites typically feature fan-generated content, serve as spaces for social interaction, and are actively shared through social media. Such activities are often the result of collective fan production and are accompanied by rituals and group dynamics rooted in the fandom community. They fulfil a strong social function and generate demand for communal spaces. Emotional interaction is central to these activities, and their occurrence is closely linked to the fan's level of engagement and the accessibility of the venue. These activities are typically organised either by fans or by event organisers and often take place in public urban spaces near the core event, such as commercial districts, parks, or open plazas.

Related activities reflect more complex forms of community participation and meaning-making. Fans creatively reinterpret urban spaces, turning them into new "attractions" or sacred sites that become significant within the shared narratives of the celebrity, the fans, and the fandom community.

3. Other Activities

Other activities refer to elements of the fan travel experience that are not directly connected to either the celebrity or the fandom community. These typically include visiting local attractions, shopping, or engaging in social

interactions with non-fans. These parts of the itinerary tend to be more flexible and are entirely controlled by the individual fan. Interestingly, even during these more conventional tourist activities, fans may incorporate elements of fandom—such as carrying printed images of their favourite celebrity and taking photos with them at landmarks. In such cases, urban spaces are used for their original functions, but may still acquire secondary symbolic meanings.

Although these activities resemble conventional forms of tourism, many fans report experiencing higher levels of enjoyment and relaxation during them. The blend of everyday tourism practices with subtle fandom expressions adds an extra emotional layer to the travel experience, making even ordinary moments feel more meaningful.

The structuring mechanisms of fandom tourism

1. Community interaction and emotional reward models in fandom tourism

This study finds that an individual's fandom level is a decisive factor in shaping their fandom tourism itinerary, as it is closely tied to what can be described as a community interaction–emotional reward model. Three typical fan types were identified:

1.1 Active content producers

These fans take on organising and content-creating roles within fandom communities and are often perceived as opinion leaders. They tend to gain attention by providing scarce resources—such as exclusive celebrity updates, high-quality images, or video content—or by coordinating community efforts. Their decisions around travel are often influenced by how they use and maintain cultural capital within the fan community. Beyond interactions with the celebrity, the emotional reward for this group is derived from building and sustaining influence within the fandom.

1.2 Highly engaged social participants

This group forms the core of the active fan base. They engage in practices such as creating fan support materials, participating intensively in fan-related social interactions, and exchanging gifts. Their emotional rewards are largely drawn from a sense of identity, belonging, and active participation within the fan community, in addition to their admiration for the celebrity.

1.3 Experience-oriented individual fans

These fans are more passive in community engagement and primarily act as consumers. While they may not actively contribute to or maintain a position in the fan community, they are by no means rare. Their emotional reward is primarily derived from the celebrity and from their own travel experiences, rather than from social interaction within the fandom.

2. Influencing mechanisms behind the distribution of activities in fandom tourism

The way in which the three types of fandom tourism activities are distributed within an itinerary is influenced by three major factors: individual fan attributes, travel duration, and destination characteristics.

2.1 The influence of fandom level on activity distribution

Fandom level influences identity formation and determines a fan's emotional needs, shaping their preferences for community interaction and emotional reward. These factors, in turn, influence how much time and energy is invested in different types of activities:

- Fans who engage in content production tend to focus intensely on core activities, closely following the celebrity's schedule. Their itineraries are usually fixed and streamlined.
- Fans who are socially motivated invest more time in related activities, such as community rituals and social events, in addition to attending core events.
- Experience-oriented fans, while still attending core activities, tend to allocate more time and energy to other activities like sightseeing and shopping. Their decision-making more closely resembles that of general tourists—though interestingly, they report greater enjoyment and relaxation during fandom tourism compared to

conventional travel.

2.2 Travel duration
The amount of time available for travel directly affects the arrangement of activities. While core activities are fixed and form the primary motivation for travel, the time available beyond these events varies among fans and enables different levels of participation in related and other activities. Although energy levels and personal stamina also play a role, in general, longer trips allow for greater flexibility and a wider variety of engagements.

Most core activities (e.g. concerts, fan meetings) are scheduled on weekends to maximise attendance. As a result, many fans opt for short trips lasting one to two days. However, trips lasting three days or more allow fans to engage in more diverse, loosely structured activities, resulting in richer travel experiences.

2.3 Destination characteristics
The type of city influences the physical and cultural infrastructure available to support different types of activities. Urban environments with a well-developed commercial landscape, strong tourist appeal, and convenient services offer more opportunities for related and other activities. Moreover, fans' perceptions of the destination—shaped by its reputation, accessibility, and consumption options—also affect how they plan and anticipate their trip.

3. Spatial distribution mechanisms of activities in fandom tourism
The spatial distribution of activities in fandom tourism is shaped by both the location of core event venues and their relationship to urban public and commercial spaces. These factors determine the range and positioning of fan activities. In addition, fandom level, travel duration, and the quality of urban infrastructure jointly influence the degree of spatial dispersion and the number of activity cores. Overall, the findings suggest that the spatial layout of fandom tourism activities emerges from situated behavioural choices and path constructions under specific event-driven, social, and geographical contexts.

At the foundational level, the location of core activity venues—and their proximity to public and commercial spaces—forms the primary structure of spatial distribution. Large-scale cultural facilities such as concert arenas, stadiums, exhibition centres, or sites directly associated with celebrity appearances (e.g. filming studios, commercial events, broadcasting stations) serve not only as geographical anchors but also as emotional centres for fandom communities. These venues, when coupled with adjacent public spaces (e.g. plazas, metro stations, green spaces) and commercial establishments (e.g. shopping malls, cafés, restaurant clusters), shape patterns of fan aggregation and dispersion. On this structural base, a fan's level of enthusiasm influences the overall extent of spatial activity.

Furthermore, fandom level, travel duration, and urban infrastructure collectively determine the extensibility and structure of spatial activity. Fans with more time and higher mobility—particularly in geographically larger cities—are more likely to move across multiple areas and change accommodations, thereby forming secondary activity clusters and additional cores. The quality of urban infrastructure significantly affects the feasibility and efficiency of such inter-district mobility.

More specifically, in cities with well-developed infrastructure and abundant tourism resources, fans are more likely to distribute their activities across different areas. This results in a shift from a single-core spatial model to a multi-core networked pattern. In contrast, in smaller or resource-constrained cities, fan activity tends to remain highly concentrated around a single core location.

The impact of fandom tourism on urban space and the construction of city image
Fandom tourism affects urban space on multiple levels. These impacts range from the utilisation and reconfiguration of urban infrastructure and physical space to fans' subjective impressions and emotional attachment to the city. The study finds that the spatial distribution and experiential depth of the three main types of fandom

tourism activities directly shape how fans move through, perceive, and relate to the urban environment. Specifically, core activities establish the baseline expectations for the city, related activities drive micro-renewals of urban space, and other activities influence the upper limits of city image construction and play a key role in inspiring intentions to revisit.

Core activities place concrete demands on a city's infrastructure and governance capacity. On the one hand, large-scale events such as concerts and fan meetings are typically held in major cultural complexes—stadiums, arenas, and performance halls—which require advanced logistical support, including crowd management, security, and technical facilities. These events also test the city's ability to deliver effective transport, service provision, and public order. On the other hand, even smaller-scale events such as programme recordings or commercial appearances still rely on basic infrastructure and urban governance. The fan experience at core activities establishes their baseline evaluation of the destination. In other words, if significant negative experiences occur during these events, they can strongly diminish both overall satisfaction and emotional assessment of the city.

Related activities are often held in commercial and public spaces surrounding core venues and involve creative repurposing of urban infrastructure. These include spontaneous fan gatherings, merchandise exchanges, and social rituals such as group check-ins. Usually organised informally by fandom communities, these activities are temporary and highly interactive. They not only generate short-term increases in foot traffic in commercial and public areas, but also hold potential to stimulate micro-scale urban renewal. In post-industrial cities, such activities may provide new models for space activation beyond top-down planning. Some Chinese cities have already seen such practices emerge: in certain commercial centres, management collaborates with fan groups by providing venues for fan events and organising themed campaigns—such as playing celebrity-related songs and videos on birthdays or offering fan merchandise in exchange for in-store purchases. These models demonstrate alternative pathways for urban revitalisation and spatial reproduction through fan-driven participation.

Other activities play a particularly distinctive role by contributing to fans' emotional experience and shaping their impression of the city. Unlike traditional tourism, where sightseeing is often the main purpose, fans treat core activities as emotional anchors, which lowers expectations and removes pressure from the rest of the itinerary. As a result, fans are able to explore the city more casually, without the rigid time management and checklist mentality typical of conventional tourism. Even highly structured travellers report this sense of unplanned enjoyment. This freedom leads to moments of serendipity and unexpected joy, significantly enhancing fans' overall impression of the city. In this sense, other activities provide emotional surplus value, allowing fans to form unique affective connections and place-based attachments through spontaneous discovery.This mechanism suggests that the quality of urban services, atmosphere of local neighbourhoods, and lived texture of everyday life become key elements in shaping the city's image and encouraging return visits in the eyes of fandom tourists.

Conclusion

Similar to existing tourism frameworks, fandom tourism is also goal-oriented, with core activities remaining the primary motivation for travel. These core activities are centred around specific times, locations, and organisers, and are characterised by temporality, spatial concentration, and site-specific presence. Like other forms of event-driven tourism, they are influenced by uniqueness and non-repeatability. However, in fandom tourism, the emphasis is not on conventional events or media content per se, but rather on their close association with the celebrity figure and their perceived authority.

At the same time, as with contents tourism, many activities in fandom tourism are not strictly dependent on scheduled events. Instead, they are often driven by affective identification with the celebrity, symbolic meaning, and shared recognition within the fandom community. In addition, fandom tourism also generates economic and social impacts on destination cities. On the one hand, it brings short-term economic stimulation with potential for long-term conversion, demanding both consumption and experiential engagement. On the other hand, it contributes to the accumulation of emotional and brand memory within the destination.

In the context of post-urbanisation, many cities face challenges of transformation and spatial reorganisation. As a driving force for urban optimisation, cultural consumption has become a core element of the "beyond-growth" framework. This study develops an analytical model to better understand fandom tourism and its impact on urban space. Fandom tourism offers potential pathways to improve public services, revitalise underused urban spaces, and support the integration of cultural and tourism industries, while also advancing knowledge of contemporary travel behaviour and sustainable development.

From the perspective of urban development, fandom tourism provides an alternative lens through which to understand contemporary mechanisms of urban cultural production. In the post-urbanisation context, traditional capital-driven models of urban growth are increasingly revealing structural limitations, while lifestyle-oriented development logics centred on cultural consumption are gaining traction. Such logics suggest that urban regeneration need not rely solely on top-down planning. This study fills a gap in empirical research on fandom tourism in China and contributes theoretically by distinguishing fandom tourism from contents tourism and event tourism. It highlights three key features: emotional motivation, spatial creativity, and intensive community interaction. This framework offers a useful analytical tool for examining how different types of cultural consumers shape urban space, contributing to future research in urban cultural studies and tourism behaviour.

From a practical standpoint, this research provides policy insights for cultural tourism and urban regeneration in large Chinese cities during the post-urbanisation stage. Urban managers and tourism stakeholders should recognise and leverage fandom activity as a new tourism resource. By providing appropriate public spaces, infrastructural support, and policy guidance, cities can unlock the economic potential of fandom-based tourism. This not only enriches the city's cultural functionality but also offers new strategies for reactivating urban space and advancing sustainable development under the beyond-growth paradigm.

That said, the study has certain limitations. First, the number of semi-structured interview participants is relatively limited, which may introduce sampling bias. Second, the current analysis does not fully account for the differentiated manifestations of fandom tourism across city types or its long-term impacts. Future research could expand the sample size and apply this theoretical framework to larger-scale behavioural studies. In addition, adopting a longitudinal perspective and conducting comparative analyses across different cities or regions would offer a more comprehensive understanding of the spatial and social implications of fandom tourism.

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Navigating the University-Tourism Nexus: Employing Participatory Strategies for Liveability in Sorrento

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Abstract
The interplay between universities and their diverse urban environments presents both unique opportunities and challenges. This case study explores how university-led participatory strategies address the tourism–liveability nexus in the small city of Sorrento, facing increasing pressure from overtourism, rising housing costs, and resident displacement. Through a Human Rights Practicum students engaged residents, municipal authorities, and businesses in co-designing place-based solutions. Using surveys, interviews, and workshops, the initiative identified key challenges—including housing affordability, infrastructure strain, and lack of community voice—and proposed actionable responses grounded in human rights principles. The project demonstrates the power of integrating academic instruction with participatory practice to foster engagement, policy innovation, and resilience. It offers a scalable model for aligning tourism development with community well-being in small cities worldwide.

Keywords: Sustainable Tourism, Human Rights, Urban Regeneration, Small Cities, Participatory Practice

Introduction

The intricate relationship between universities and their host urban environments necessitates a balanced approach that leverages the opportunities presented by these institutions while mitigating potential challenges, particularly in tourism-dependent locales (Silvestrelli, 2012). This study delves into the application of participatory practice methodologies within a university classroom setting to address pressing issues in Sorrento, a city grappling with the dual pressures of a burgeoning tourism sector and the imperative to maintain a high quality of life for its residents (Zarb & Jones, 2017). It examines how best to mitigate challenges while building on opportunities using participatory practice approaches in the university classroom (Larty, 2021).

In Sorrento – a coastal city on Italy's Bay of Naples – tourist arrivals have surged significantly over the past decade. In 2016, Sorrento welcomed approximately 640,000 tourists; by 2018, nearly 9.9 million travellers passed through Naples Capodichino Airport reflecting the region's growing appeal (ISTAT, 2023). This "overtourism" trend raises urgent questions about liveability and human rights in the city. Long-time residents voice concerns that allude to crowded public spaces, rising prices, and loss of cultural identity. While national officials have sometimes downplayed overtourism –claiming "too much tourism" (Positanonews, 2025) is not a real problem – local experiences strongly contradict this statement. Sorrento faces challenges that mirror those of larger metropolitan destinations (Aragú et al., 2021). These are tied to rising housing costs, exacerbated by the growth of short-term rentals and growing pressures of tourists on city infrastructure. These dynamics have strained local residents, many of whom struggle to remain in their communities due to financial pressures and limited housing availability (Kennedy, 2020).

The pedagogical strategy employed in this study integrates theoretical instruction with hands-on participatory activities, fostering collaborative relationships between the university community and various local stakeholders, with the aim of developing viable solutions to identified issues (Consilvio, 2024). Sorrento's unique position as a small destination city renowned for its rich cultural heritage and a dynamic tourism industry makes it an ideal case study for exploring the complexities of balancing economic development with the well-being of local communities (Lalicic, 2019).

Through Leveraging participatory approaches, the study highlights the integration of university populations, residents, municipal authorities, and other relevant stakeholders to co-create solutions that balance the needs of locals with the demands of tourism (Innella et al., 2024). Key findings from surveys and interviews reveal that residents feel underrepresented in decision-making, with many voicing concerns about the prioritization of tourism over local needs. By promoting open dialogue, fostering community engagement the research identified and presented possible solutions, such as improving regulations on short-term rentals, implementing rent controls, enhancing public transportation, and developing a place-based, interactive responsible tourism campaign as a catalyst for education, awareness, and larger human-centred urban regeneration projects (Innella et al., 2024).

Moreover, the study underscores the importance of embedding human rights principles—such as the right to housing and cultural participation—into policy frameworks to ensure equitable outcomes (Greene, 2011). Through student coursework using in-depth exploration of human rights law, participatory practice, and sustainable development principles, students utilized their curriculum in theory and practice to engage directly with the Sorrento community in their university neighbourhood. The Service-Learning (Saija & Pappalardo, 2024) course design and place-based engagement serve as a conduit to foster strong bonds within the community through research, data collection, group discussion, and surveys.

Co-design and co-creation are powerful tools that require collective brainstorming, cooperation, and collaboration. These types of exercises use real-world examples and case studies to build a sense of problem ownership (Cruz et al., 2022) and motivation, shaping the students as part owners of the Peninsula's problems, but also key players in the solution for its resilience. This case study demonstrates that participatory practice is an effective and necessary tool for creating sustainable and inclusive urban environments, especially in small cities, offering a model for other destinations grappling with similar challenges (Arellano et al., 2016). Through collaboration and innovation, Sorrento has the potential to reconcile the needs of its residents and its role as a global tourist destination through a participatory system approach that fosters long-term bonds with tourists, residents, higher education institutions (Barnet et al., 2021), and their students.

This paper illustrates the beginning two semesters of the action-research project engaging the international student population, local residents, and Sorrento's municipal authorities. In Fall 2024, the Human Rights Practicum course focused on diagnosing Sorrento's tourism impacts through a human rights lens (Lucia et al., 2021). While in Spring 2025, building off those findings, students co-designed Sorrento Saggia – Be Sorrento Smart, a responsible tourism campaign aimed at building local partnerships, improving awareness, and fostering coexistence between visitors and locals. The title "Sorrento Saggia" (Italian for "wise Sorrento") captures the campaign's ethos of being "smart" tourists who respect the host community. This unique approach leverages participatory methods to bridge theoretical insights and practical solutions.

The significance of this case study is twofold. First, it applies a human rights-based approach to urban tourism, aligning local challenges with fundamental rights such as housing, culture, and participation. Sorrento's situation exemplifies how unchecked tourism can infringe on residents' rights – from the right to adequate housing and standard of living to the right to partake in cultural life (Milano et al., 2019). Second, it situates these local efforts within the broader discourse of sustainable urban planning. International agendas like the UN Sustainable Development Goals (e.g., SDG 11 on sustainable cities) emphasize inclusive, participatory planning and the balance between economic development and quality of life (Trane et al., 2023).

This paper reviews the methodology of the participatory activities conducted. It then synthesizes key findings from the Fall 2024 research on Sorrento's tourism challenges, grouped into four themes: affordable housing, community engagement, mobility & infrastructure, and cultural sustainability (Innella et al., 2024). Subsequently, it describes the Spring 2025 work undertaken to create a 'Vision Brief' for the Sorrento Saggia campaign through PAR, co-design and co-creation processes, including the resulting "10 Easy Ways to be Sorrento Smart" guidelines for visitors. A discussion section connects these results to human rights principles and sustainable plan-

ning practices – critically examining successes, limitations, and the path forward for Sorrento. These methods not only provide valuable insights into the concerns and priorities of local residents but also serve as platforms for education and capacity building, empowering community members to actively participate in shaping the direction of tourism development (Ginanjar, 2023).

Methodology

Community involvement in tourism planning is essential for fostering sustainable benefits and ensuring the industry's long-term viability, yet it faces challenges in developing countries due to operational, structural, and cultural obstacles (Reindrawati, 2023). Effective community participation requires empowering residents in tourism development, although achieving genuine participation can be difficult without such empowerment. Successful community involvement can be achieved through social empowerment, which enhances residents' self-esteem and enables them to support tourism development (Rachmawati et al., 2022).

This study employed a Placed-based System approach employing Participatory Action Research (PAR) with co-design and co-creation frameworks in which students, residents, and officials collaboratively investigated problems and devised solutions. Rather than a traditional top-down research project, the process was iterative and co-creative (Ward et al., 2024), blending qualitative and quantitative methods over two academic semesters.

Fall 2024 – Human Rights Practicum:

In the first phase, a class of international students at Sant'Anna Institute in Sorrento undertook a practicum course with the goal to "learn where we live" by examining how human rights concepts manifest in the local context of Sorrento's tourism economy (Bianchi et al., 2024). Students first familiarized themselves with international human rights law and frameworks (e.g., the Universal Declaration of Human Rights and relevant covenants) and studied global cases of tourism-related rights challenges. With this foundation, they turned to Sorrento, conducting surveys and interviews with local residents to gather first-hand perspectives.

Approximately 50 residents from Sorrento and nearby towns in the Sorrentine Peninsula participated, providing insights into tourism's impacts on their daily lives. The survey instrument included both closed (Figure 1) and open-ended questions designed to elicit opinions on tourism's impacts on housing, infrastructure, culture, and quality of life (Wang & Wang, 2018). In addition, semi-structured interviews were carried out with a subset of stakeholders, ranging from young professionals and small business owners to long-time residents.

The data collected were then analysed through the dual lenses of human rights and urban liveability. Students coded interview transcripts to identify recurring themes and specific human rights articles implicated. For instance, a comment about unaffordable rent was linked to UDHR Article 25 - right to an adequate standard of living, while remarks about exclusion from decision-making evoked UDHR Article 21 - right to participate in government (United Nations, 1948). This grounded approach ensured that local voices drove the problem identification. Finally, students conducted a brief literature and precedent review to see how other tourist cities have tackled similar issues (e.g., Amsterdam's regulations on short-term rentals). The Fall phase culminated in a presentation of findings and preliminary solution ideas to local government officials, including the Deputy Mayor and community representatives.

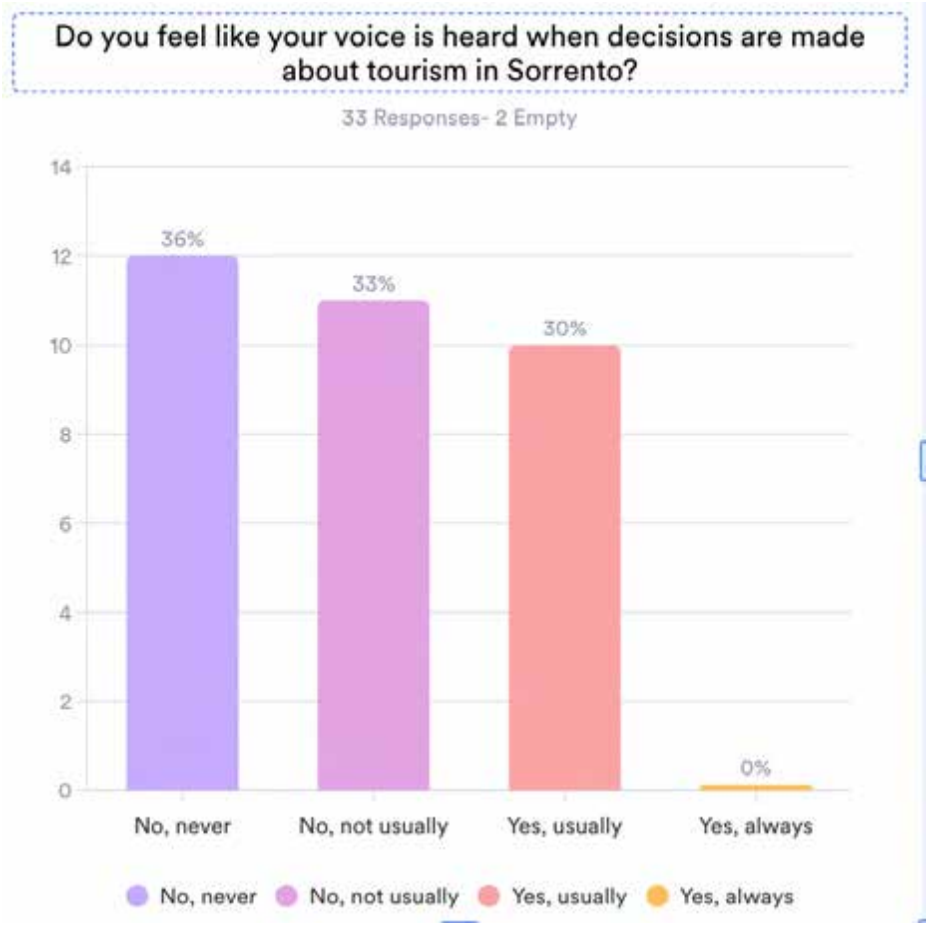

Figure 1. Fall HR Practicum Survey (generated with Jotform)

Spring 2025 – Sorrento Saggia Campaign Design:
The second phase shifted from analysis to solution-building. A new group of students, with continuity from the fall, engaged in a project-based course to create an actionable responsible tourism campaign proposed as "Sorrento Saggia – Be Sorrento Smart" with the focus on place-based cultural-driven storytelling. The pedagogical approach this semester was explicitly co-creative and multi-method. It included:

• **Participatory Co-Design Workshops:** Students and instructors facilitated brainstorming sessions to develop the campaign concept. Techniques like Business Model Canvas (Echavarria et al., 2022) exercises were used to map out the value proposition, target audiences, key partners, and resources for the campaign. This helped ensure the proposed solution was grounded in local reality and feasible (Figure 2).

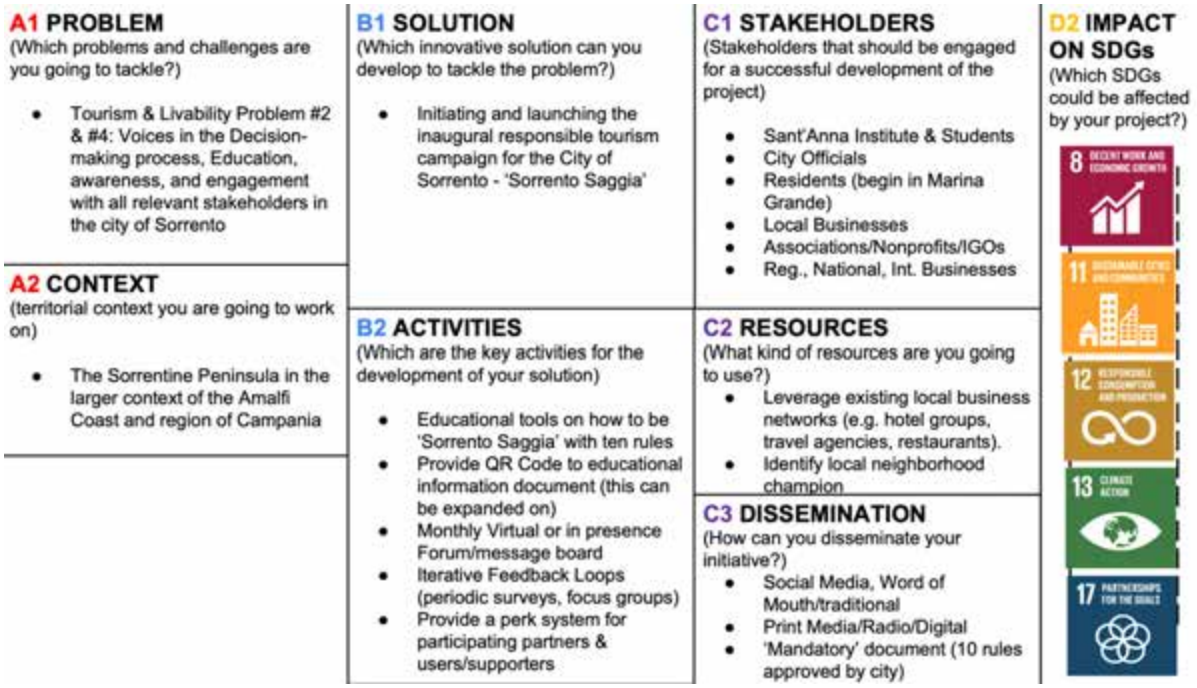

Figure 2. Sorrento Saggia Adapted Business Model Canvas from "Decision-making" for Sustainable Development Goals Course – Politecnico di Torino.

• **Stakeholder Analysis & Power Mapping:** Building on political science frameworks (e.g., Dente's (2014) model of actor resources (Konstantinidis et al., 2021)), the class identified key stakeholder groups and analysed their levels of interest and power regarding tourism management. Stakeholders ranged from political actors to special interest groups (local business owners, tourism operators), general interests (the resident community at large), and experts (NGOs, academic institutions). By categorizing stakeholders and the resources they control (political, economic, legal, cognitive), students gained insight into potential allies and barriers for the campaign. A classic power-interest matrix (Cottafava & Corazza, 2020) was constructed to visualize where to focus engagement: for example, local residents and business owners have high interest in liveability issues, but varying degrees of power to influence policy; the municipality has high power but needed to be convinced to prioritize human-centred tourism (Figure 3).

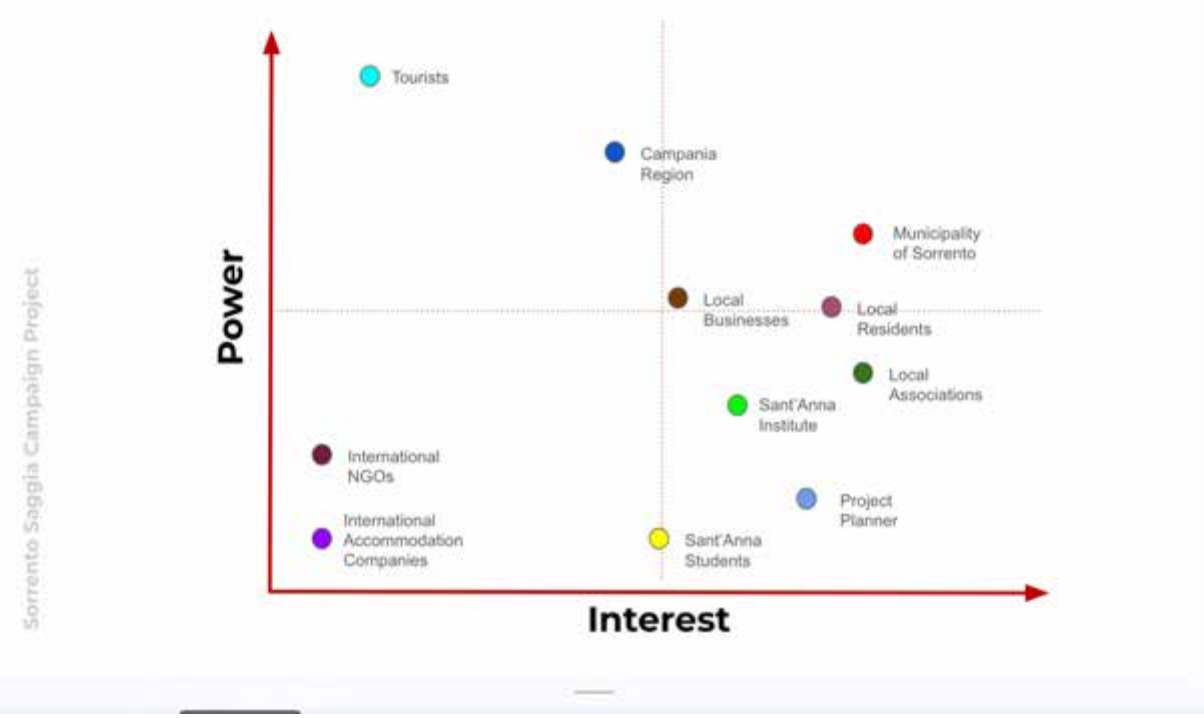

Figure 3. Stakeholder Power-Interest Matrix

• **Follow-up Interviews and Surveys:** To design effective campaign messages, the students conducted additional interviews with stakeholders, particularly those in the tourism sector, to gather feedback on proposed ideas. In total, 8 in-depth interviews were carried out in Spring 2025 with individuals representing different roles – such as a hotel employee, a travel agency owner, a vacation rental manager, a student program coordinator, and local business owners. These interviews were less about diagnosing problems (as that had been done in fall) and more about co-envisioning solutions and gauging stakeholders' willingness to collaborate. For instance, interviewees were asked how tourists could be educated to respect local norms, or what incentives might encourage businesses to support the campaign.

• **Place-Based Systems Approach:** Throughout, the project was guided by a place-based perspective – meaning it sought solutions tailored to Sorrento's specific cultural and geographic context, rather than one-size-fits-all fixes. This involved site visits to areas like Marina Grande (a traditional fishing village in Sorrento) where the university is located, as well as the residence of many of the students. This localized the initiative as deeply as possibly for students to observe tourist-local interactions in their own neighbourhood, and mapping of "hotspots" where conflicts or overcrowding were most pronounced.

Using these methods, the Spring team developed the content and implementation plan for Sorrento Saggia. The campaign was envisioned as a partnership between the city government, local businesses, community organizations, and tourists themselves. The mixed-methods approach – combining community-based research in fall with co-design and stakeholder engagement in spring – exemplifies how universities can serve as facilitators in complex urban issues. It allowed for continuous feedback loops: preliminary solutions were adjusted based on stakeholder input, increasing local buy-in. The methodology's participatory nature is itself a finding – it modelled the inclusive decision-making that residents had illustrated a greater need for in their community.

Findings: Tourism Impacts and Liveability Challenges in Sorrento
The Fall 2024 research revealed a nuanced picture of how tourism growth has affected Sorrento's liveability. Four interrelated challenge areas were identified, each linked to residents' enjoyment of their rights and quality of life. These are:

(1) Affordable Housing
In response to the housing crisis, the Fall 2024 practicum explored various **policy options and best practices**. Students presented a menu of regulatory ideas gleaned from other cities: for example, short-term rental caps as implemented in Amsterdam, (Tedds et al., 2021), stricter licensing and primary residence requirements for rental hosts, zoning restrictions to protect residential zones, and even community-driven solutions like Community Land Trusts (Phang, 2018; Williams, 2018) to secure affordable units. They also discussed how cities like Vienna invest in government-subsidized housing to keep prices stable. While local Sorrento officials have been limited by current national and regional regulations these examples provide a roadmap. Any durable solution will likely require applying a bidirectional action of top-down policy (e.g., regional law to limit short-term rentals) and bottom-up action (e.g., locals forming cooperatives to buy and rent homes at affordable rates). The immediacy of the issue is, however, very clear. Without intervention, Sorrento risks losing its local community, thereby also losing the authentic character that draws visitors to the peninsula initially.

(2) Voices in the Decision-making Process
The second major theme was a feeling among residents of being excluded from decision-making about Sorrento's future. Over two-thirds of surveyed citizens reported (Figure 1) that they do not feel heard by local government on tourism and liveability issues. Many believed that tourists' needs may often be put before their own in municipal priorities (Aragú et al., 2021). Notably, some respondents observed that during local elections and political discourse, the problems of overtourism or housing seldom receive serious attention – politicians rarely mention these issues, focusing instead on the benefits of tourism. This has fostered a sense of disconnect and disempowerment among the public.

During stakeholder interviews in Spring 2025, this theme of voice re-emerged. For instance, the CEO of Fondazione Sorrento (a local cultural foundation) stressed the importance of Sorrentini youth having an active role in changing the public perception of their city. He introduced the idea of "turismo versus turismi" – suggesting that there isn't a single monolithic tourism, but multiple ways tourism can manifest, and that locals and tourists must collaborate to shape a diversity of experiences. Implicit in his view is that local voices (especially young people's voices) should help redefine Sorrento not just as a mass-tourism hotspot but as a living city with artistic, cultural, and educational dimensions. This perspective bolsters the argument that participatory approaches are not just feel-good extras, but central to rebalancing tourism on more equitable terms.

In summary, the research highlighted a democratic deficit in Sorrento's tourism governance. Addressing it will require effort both from the government to actively solicit and listen to citizen input (Innella et al., 2024) and from residents to organize and articulate their demands. The Sorrento Saggia campaign itself was partly an answer to this: a citizen-aware initiative that could amplify local perspectives. By involving residents in the creation of the campaign (PONTIKAKIS et al., 2024), the project attempts to embed local engagement as a cornerstone of the solution.

(3) Strains on Mobility and Infrastructure
Addressing mobility issues requires both supply-side improvements that call for better transport services, infrastructure upgrades and demand management through controlling the flow of vehicles and people (Ebbesson, 2022). Sorrento's relatively small geographic footprint means creative solutions. Some are already in use in limited ways, such as electric minibuses or timed entry to certain areas (ZTL zones). However, it is still not enough supply to support the demand of the transportation infrastructure (PONTIKAKIS et al., 2024), especially during high tourist traffic months. Involving residents in designing these solutions – for instance, consulting them on which streets could be pedestrianized without hurting local access – will be crucial, in creating buy-in and ownership

for any future proposed solutions. The measures must aim to benefit locals as well as enhance the tourist experience by alleviating the frustrations of congestion (Coni et al., 2020).

(4) Cultural and Environmental Impacts.
The fourth challenge area revolves around the **preservation of Sorrento's cultural heritage and environment** in the face of mass tourism. Sorrento is steeped in intangible cultural heritage – from the evening passeggiata (leisurely stroll) tradition to its culinary and artisanal practices. Residents are proud of these traditions, yet many fear that excessive tourism is diluting its authenticity (Wang et al., 2022) and putting natural sites at risk. The Sorrentine Peninsula's unique ecosystem (cliffs, marine areas, lemon groves) is under pressure. Issues raised included litter and waste management challenges (Saija & Pappalardo, 2024), strain on water resources in high season, and damage to trails or beaches from overuse.

While most locals acknowledge tourism's importance to Sorrento's economy, many fear that without intervention the city may lose the character and culture (Kennedy, 2020) that makes it so unique and attractive to visitors. The challenge is how to channel tourism in a way that enhances rather than erodes local culture and environment. In Fall 2024, students highlighted that Sorrento needs to find a balance where tourism and local quality of life "thrive in unison." This aligns with the concept of human-centred tourism, which was notably being discussed in the region under the banner "Umanesimo nel Turismo" (Humanism in Tourism). In fact, in April 2025 a summit of Amalfi Coast mayors resulted in the "Carta di Amalfi," (Positanonews, 2025) a charter pledging a new humanistic approach to tourism focusing on people and cultural respect. Such high-level commitments show the growing recognition that tourism must be reoriented to value community and culture alongside profit.

The project's findings contributed to this dialogue by identifying specific local cultural values to safeguard. For example, the tradition of the evening passeggiata was repeatedly mentioned as something tourists should respect and even participate in, rather than disrupt. Likewise, cultural sites like Marina Grande's fishing village or historic monasteries should not be treated as mere backdrops for Instagram, but as living communities (Acampa et al., 2020).

To address these issues, the proposed solutions centred on education and mutual respect – essentially, fostering a two-way awareness: educating tourists about local norms and encouraging locals to engage with visitors in sharing their culture (Panneels, 2023). This leads directly into the Sorrento Saggia campaign, which was the actionable outcome focusing largely on this domain of awareness (Thojampa et al., 2023) drafted an initial "10 Rules" list for responsible tourist behaviour based on survey feedback. These rules (elaborated in the next section) include cultural etiquette like respecting local customs, being mindful of noise, learning a few Italian phrases, and so forth. The underlying principle is that if tourists adjust their behaviour — even just a little — negative impacts can be mitigated, the visitor experience can be enriched, and bridges can be built on which locals feel less estranged in their own community.

It is worth noting as well that the cultural sustainability is also tied to housing and community: if local families and youth are forced out by costs, who will carry on traditions? The economy relies heavily on tourism, but the community also will not survive without conscious efforts to maintain local life. The mutual dependency (Kennedy, 2020) of locals and tourism means solutions must be holistic, inclusive, and innovative.

The Sorrento Saggia campaign attempts to operationalize many of the insights gathered by the Fall 2024 and Spring 2025 student cohorts, particularly by focusing on awareness, education, and stakeholder partnership (Andreoni et al., 2024) to make tourism more responsible and human centred. Drawing on the challenges identified in the Fall 2024 practicum, the Spring 2025 team further developed the initial **"Sorrento Saggia – Be Sorrento Smart,"** (Figure 4) idea into a pilot campaign aimed at promoting responsible tourism and improving coexistence between tourists and locals in Sorrento. The campaign's name uses the Italian word saggia (wise) to encapsulate the idea of a "smart" tourist – one who is mindful of their impact and engages positively with the community. The campaign's content and strategy were co-created with local input and seeks to initially address the issues

of housing, voice, mobility, and culture through the lens of awareness and behaviour change.

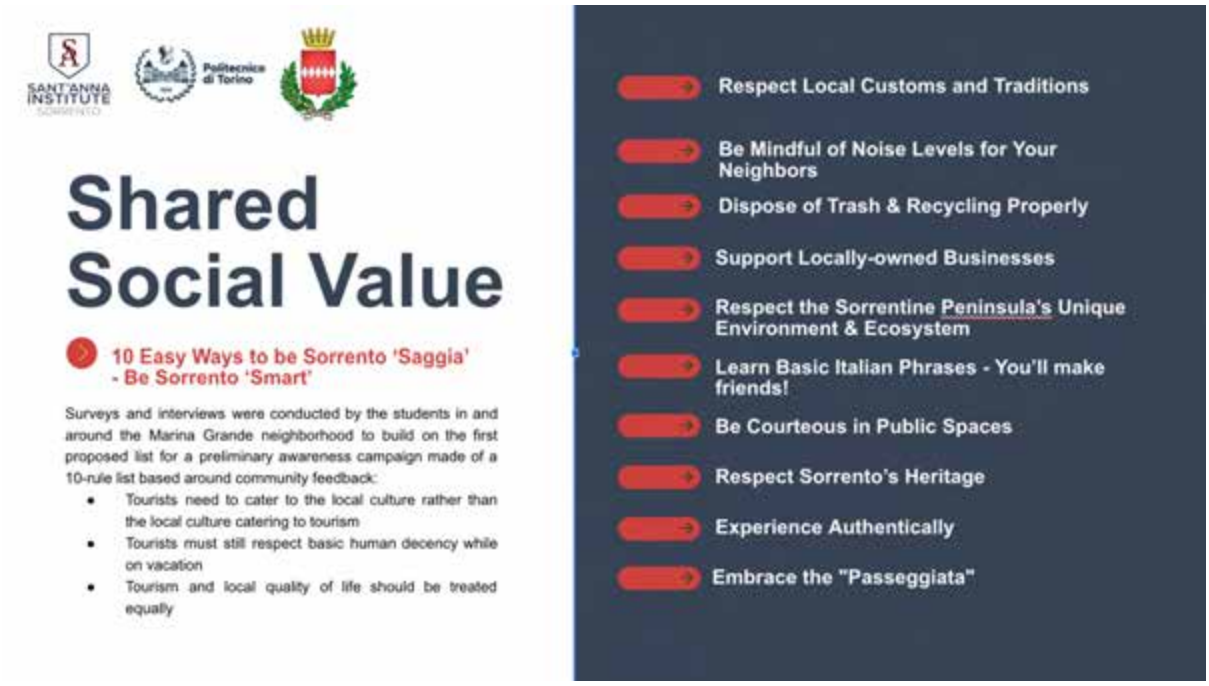

Figure 4. Current draft of '10 Easy Ways to be Sorrento Saggia – Be Sorrento Smart!"

This decalogue of good tourist behaviour is meant to be simple, positive, and empowering rather than scolding (Pisters et al., 2019). The tone is "Be Sorrento Smart," implying that smart travellers get a better experience by following these tips, and locals benefit too. Notably, many of the rules echo the issues discussed earlier: for instance, supporting local businesses can mitigate the dominance of outside investors (connecting to housing economics), proper trash disposal helps environmental sustainability, and courtesy/noise awareness addresses social frictions (Panneels, 2023). The rules also implicitly promote human rights values: e.g., respecting heritage ties into the right to culture, supporting local economy touches on the right to work and decent livelihood for locals, etc (Sarid & Goldman, 2021).

Stakeholder Partnerships and Participatory Implementation

Beyond messaging, Sorrento Saggia was conceived as a partnership-based **initiative**. Recognizing that no single entity can solve overtourism, the campaign proposed a network of collaborators (Cruz et al., 2022):

• **Municipal Government:** The City of Sorrento's buy-in is crucial for legitimacy and resources. The campaign was to be presented to the mayor and council (indeed, the project's final deliverable was a Vision Brief for the municipality). The hope is that the city would formally endorse Sorrento Saggia, perhaps integrating it with the official tourism promotion strategy. Support could include modest funding for materials, placement permission for posters, and encouragement of participation (e.g., Mayor publicly urging businesses to join).

• **Local Businesses:** Hotels, restaurants, shops, and tour operators are on the frontlines of tourist interactions. The campaign sought to create a **coalition of businesses** that commit to promoting responsible tourism – for instance, by displaying the Sorrento Saggia logo and rules, offering information to customers, or even providing small incentives (Innella et al., 2024). One idea raised was a "Sorrento Saggia Card" or stamp program. Tourists who follow certain good practices (like using recycling bins or visiting a local cultural event) could get stamps or points redeemable for discounts at participating businesses. An Airbnb manager liked the idea of a benefits card, noting it would drive conscious tourists to those businesses and reward good behaviour. While a full-fledged rewards system might be complex to implement initially, even symbolic gestures (a free limoncello after a tourist

fills a recycling bag, for example) can gamify (Kavouras et al., 2023) responsible behaviour.

• **Educational Institutions:** Sant'Anna Institute and possibly local schools can sustain the campaign's momentum. Students can continue as volunteers or interns to run social media, conduct surveys with tourists about their awareness, and update campaign content, supporting iterative feedback loops (Larty, 2021) for initiative evolution and long-term resilience. The involvement of youth not only provides manpower but also keeps the initiative innovative. The Fondazione Sorrento CEO explicitly noted the importance of youth engagement for shifting perceptions, and indeed younger locals can be great ambassadors if empowered.

• **Community and Associations:** Local civic groups (environmental clubs, cultural associations, neighbourhood committees) were identified as key partners. For example, a local fishermen's association in Marina Grande could co-host an event where tourists are invited to a morning of fishing and beach cleaning – exemplifying rules from the list like respect the environment, and experience authentically. These types of grassroots events provide concrete action under the campaign umbrella (Arellano et al., 2016).

• **Tourists themselves:** Uniquely, Sorrento Saggia considers visitors not just as targets to educate, but as potential allies. The campaign encourages a view of tourists as temporary citizens who can contribute positively (Corte et al., 2018). Mechanisms for feedback were suggested, such as a QR code on the poster linking to a short survey or pledge: "Sign the Sorrento Smart Traveller Pledge". Tourists who take the pledge to follow the rules might get a digital certificate or be featured (with permission) as example travellers on social media. The point is to create a sense of community among responsible tourists, turning it into a type of movement that transcends the borders of the Sorrentine peninsula even after they have returned home (Pasquinelli et al., 2021). In an era when travellers increasingly seek meaningful, sustainable experiences, this could tap into an existing segment of conscientious tourists.

The implementation plans emphasized starting with a pilot in one neighbourhood — Marina Grande was chosen due to the University's 'home' location, its historical significance, and resident-tourist character. There, the campaign could be rolled out in a contained setting, refined, and then scaled up across Sorrento and potentially to nearby towns in the peninsula and Amalfi Coast. The place-based strategy (Grieco et al., 2024) aims to utilize informed tailored messaging for the community, leveraging feedback from the residents as campaign components are rolled out.

Human Rights and Urban Sustainability Framing

What distinguishes Sorrento Saggia from a generic "respect the city" campaign is its explicit rooting in human rights and sustainability principles. The educational materials don't overtly lecture about UN articles to tourists but kept the principles as a guiding framework (United Nations, 1948):

• By promoting respect for local culture, the campaign helps uphold the right of locals to enjoy their culture (UDHR 27) and combats the alienation overtourism can cause.

• Emphasizing support for local businesses touches on the right to work and favourable conditions (UDHR 23) for Sorrentini – the campaign indirectly advocates livelihoods by steering tourism revenue to those who live and work here.

• The focus on mutual respect and dialogue echoes the right to freedom of expression and information (UDHR 19) – encouraging open cultural exchange between locals and visitors. It's about sharing the "story" of Sorrento in an inclusive way.

• Environmentally, respecting the ecosystem aligns with the right to health (clean environment as part of well-being) and with SDG 11's sustainability targets.

The campaign also unites with the emerging regional policy context. The "Carta di Amalfi" signed in April 2025 signalled a commitment from local leaders to human-centric tourism (Positanonews, 2025). Sorrento Saggia could be seen as a ground-level implementation of those positive ideals – turning words into action in the city of Sorrento. If successful, the Sorrento Saggia campaign could serve as a model for other Amalfi Coast towns (Positano, Amalfi, etc.) which share similar issues. A bottom-up approach from a small city (Pignatelli et al., 2023) like Sorrento can be an example for larger destinations – a living laboratory for managing overtourism in a way that major cities might learn from (Barnet et al., 2021).

The Municipality of Sorrento is expected to continue its active role in the initiative, including assistance with local promotion, identifying key performance indicators, and maintaining long-term collaboration on sustainable tourism programs.

Potential Impact and Sustainability of the Campaign
While Sorrento Saggia was in a proposal/pilot stage by Spring 2025, its anticipated impact can be considered. The campaign set a goal of achieving visible changes within 1–2 years, such as improved tourist behaviour, stronger local-business-tourist networks, and enhanced community pride. Even partial uptake and adoption of the campaign could yield benefits:

- If even 30% of tourists read and heed the 10 rules, that might significantly reduce complaints about noise or litter.
- If a dozen key businesses actively promote the campaign, others may follow, creating a tipping point where responsible tourism becomes part of Sorrento's brand – its story and identity.
- By establishing an iterative management and feedback loop, the campaign can adapt and possibly expand into broader initiatives – for instance, feeding into discussions of establishing "tourist carrying capacity" limits or new city ordinances (with public backing).

A critical factor is measurement (Jurado et al., 2012). The plan includes tracking certain indicators: number of businesses participating, number of tourists signing the pledge or engaging online, changes in resident satisfaction (perhaps through follow-up surveys). Over time, more concrete metrics like reduction in waste or noise complaints could be examined. Though these are challenging to attribute directly to a campaign, they help in evaluating overall progress.

Sorrento Saggia is not a cure-all for larger planning issues like housing affordability – those require policy innovation and adaptive governance. However, it addresses the softer side of the problem: culture, awareness, and the social contract between hosts and guests. By improving the daily micro-interactions between tourists and locals, the campaign can alleviate tension and build goodwill that makes bigger changes possible (Consilvio, 2024). For instance, a community that sees tourists willing to adapt might be more unified in pushing for housing regulations, knowing the goal is not to stop tourism but to ensure its respectful and balanced.

In summary, the Sorrento Saggia campaign represents a practical output of the participatory process (Cruz et al., 2022). It translates abstract human rights and liveability concerns into tangible actions for everyday life in a tourist city. Its collaborative formation is as important as the content – the process empowered stakeholders, creating a sense of shared ownership of Sorrento's future (Barnet et al., 2021).

Human Rights as a Framework for Urban Tourism:
One of the project's key contributions is framing tourism impacts in terms of human rights. This lens proved effective in Sorrento by re-centring the conversation on people rather than just economics (Pasquinelli & Trunfio, 2020). Often, tourism development debates get reduced to metrics like visitor numbers, revenue, or GDP contribution.

By contrast, a rights-based approach asks: How are residents' rights and needs being affected? In Sorrento, this

meant recognizing housing as a right, elevating the importance of cultural life for community identity, and asserting that locals should have a say in policies (Brewer & Kliewer, 2023).

Participatory Planning and Co-Creation: The process used in Sorrento underscores the value of participatory planning in tackling complex urban issues. The active engagement of students, who acted as neutral facilitators and researchers, helped bring out community voices that might otherwise be ignored (Collins et al., 2022).

Balance of Power – Challenges in Implementation: Despite the positive aspects, one must critically acknowledge the **power dynamics** and potential challenges. While students and community members can propose and pilot solutions, lasting change in Sorrento will depend on those in power – local government, regional authorities, tourism businesses – taking up and institutionalizing measures (Greenway, n.d.). Housing affordability, for example, ultimately requires policy changes (like those mentioned: caps or incentives for long-term rentals) that only officials can enact.

Scalability and Sustainability: Another point of discussion is how scalable and sustainable these participatory efforts are. The Human Rights Practicum and subsequent project were academic exercises with limited duration (Flanagan et al., 2019). For the impact to last, local institutions need to absorb and continue the work. Encouragingly, the involvement of entities like Fondazione Sorrento and interest from the mayor's office (who received the final presentations) suggest potential for institutionalization (Ivona et al., 2019).

One possibility could be establishing a permanent working group or forum on Sustainable Tourism in Sorrento, possibly chaired by the municipality but with citizen and business representatives, and perhaps advised by academics and/or technical experts. This group could continue monitoring issues and implementing initiatives like Sorrento Saggia.

In terms of geographic scalability, Sorrento Saggia could be adapted by other towns along the Amalfi Coast, which would benefit from a regional coherence (especially since tourists often visit multiple towns along the Amalfi Coast). The DMO (Destination Management Organization) being created for the Sorrentine Peninsula is a key opportunity (Positanonews, 2024). While DMOs traditionally focus on marketing, modern ones also manage sustainability. Feeding the lessons of this project into the DMO's strategy (e.g., making responsible tourism a core pillar) could amplify its reach.

Theoretical Implications for Sustainable Urban Planning: The challenges Sorrento faces are a microcosm of urban tourism in historic cities worldwide – from Venice and Barcelona to Bali and beyond. The interplay between tourism and housing gentrification, infrastructure stress, and cultural change is widely recognized in literature on "touristification" and "overtourism." Giovanna Russo Krauss's study (2019) of Capri highlights how excessive luxury tourism altered the island's cultural landscape over time.

Sorrento adds to discourse by providing a case where stakeholders are actively responding with a rights-based narrative. It supports the argument that sustainable urban tourism requires integrating planning disciplines with community development (Esposito, 2023). Urban planners often deal with land use, transportation, etc., while tourism management deals with marketing and service. The transdisciplinary approach in Sorrento blends these by treating tourism as an integral part of city planning (Rogerson, 2019) that must include residents' voices. The project can thus be seen as a practical application of the theory of collaborative planning (Healey, 1997) in a tourism context – where diverse actors negotiate and co-create urban policy.

Community Empowerment and Social Cohesion: A positive, if intangible, outcome of the participatory process is increased community empowerment and potentially social cohesion (Anderson & Jung, 2023). Knowing that their concerns were studied and presented to city officials may give residents a sense that change is possible. Also, the narrative shift from "tourists vs locals" to "tourists and locals vs the problem", while subtle can shift perspective and inspiration when it comes to problem ownership. By casting irresponsible tourism behaviours and lack

of planning as the problem – not tourism or tourists inherently – the campaign frames it as a solvable issue with everyone's cooperation (Bianchi et al., 2024).

Monitoring Human Rights Fulfilment: By explicitly referencing human rights (like housing, culture, work) in local discussions, Sorrento sets a precedent for possibly monitoring tourism impacts against rights indicators (Cole & Eriksson, 2010). For instance, the city could track whether the percentage of resident population is stabilizing (or still declining) as one measure of the right to housing/local residency or survey their satisfaction with access to public spaces (right to leisure and culture). These could become indicators in the city's urban plan or the DMO's performance metrics, ensuring that tourism is always evaluated in terms of community well-being, not just economic output.

Conclusion & Limitations

Sorrento's journey through the Fall 2024 Human Rights Practicum and Spring 2025 Sorrento Saggia campaign demonstrates a promising pathway for tourist cities seeking liveability (Bizzarri & Micera, 2021). By diagnosing tourism's impacts through a human rights lens and actively involving the community in crafting solutions, Sorrento has begun to reclaim the narrative of its future – striving to ensure it remains both a welcoming destination and a fulfilling home.

The project balanced theory and practice (Ranieri et al., 2023): principles like the right to housing and cultural life were translated into concrete actions like rule lists, forums, and partnerships. This showed that human rights need not remain abstract in local governance; it can directly inform city policies and visitor conduct (Arnstein, 1969). Meanwhile, students and residents working side by side exemplified how universities can serve their host communities, acting as catalysts and mediators in complex urban issues.

Limitations: It's important to candidly acknowledge some limitations of this study and project. The sample size of surveys and interviews was relatively small and may not capture all perspectives (e.g., perhaps not many voices of hotel developers or big tour operators, who have a stake too). As a student-led project, it may have gaps in expertise – professional urban planners or economists might refine some proposals. The campaign's efficacy is unproven as of this writing; it is based on theories of behaviour change and anecdotal support, but whether it truly changes tourist behaviour remains to be seen. There's also the issue of language and cultural barriers – many international tourists may not speak English or Italian well enough to engage deeply with the campaign content. Thus, materials need to be multilingual and culturally sensitive (something the team considered by planning translations).

Critical Next Steps: For Sorrento, a key next step is to integrate these efforts with formal policy. One suggestion is for the city to declare an objective like "Make Sorrento a model of responsible tourism by 2030" and outline actions in its strategic plan (Piano Urbanistico Comunale). This could secure funding and continuity. Additionally, pushing for the region (Campania) to pilot tourist zoning or rental limits in Sorrento could complement grassroots actions on housing. The synergy of top-down and bottom-up is needed: neither community campaigns nor regulations alone will suffice. As an analogy, public health issues are tackled with education campaigns and laws; similarly, overtourism may require soft measures like Sorrento Saggia and hard measures like limits on cruise passengers or Airbnb permits.

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Exploring the Politics of Gastronomy Tourism and Gentrification Nexus: Gastro-Driven Development and Peri-Urban Geographical Change in the case of Urla Izmir

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Abstract
This study examines the intersection of gastronomy tourism, gentrification, and reverse migration in Urla, a peri-urban area in İzmir. It introduces "gastro-driven gentrification" to explain how culinary tourism reshapes space, fuels property speculation, and displaces long-term residents. While promoting economic growth and global visibility, these changes intensify socio-spatial inequalities and cultural commodification. Reverse migration accelerates transformation by bringing affluent newcomers focused on lifestyle over local identity. The study highlights tensions between development, justice, and sustainability, situating Urla's case within broader tourism and environmental crises. By situating Urla's transformation within the broader context of planetary crises and unsustainable tourism trends, it calls for sustainable planning that balances growth with cultural authenticity, ecological resilience, and spatial equity.

Keywords: Gastronomy Tourism, Gastro-Driven Gentrification, Reverse Migration, Peri-Urban Transformation, Urla Izmir

1. Introduction

Gastronomy tourism has emerged as a significant global trend, intertwining culinary experiences with cultural exploration in both urban and rural contexts. Over recent decades, this relationship between tourism and gastronomy has undergone remarkable transformations, driven by globalization, technological advancements, and a growing demand for authentic and localized experiences, making gastronomy play a crucial role in tourism planning and destination branding, making it an essential focus for understanding socio-spatial and economic dynamics (Pérez et al., 2024). Food, as a universal cultural and social phenomenon, continues to influence urban life profoundly. According to Sasaki Report (2014), which tried to answer, "What makes a city great?", 82% of urban residents value their city's culinary offerings, while 41% highlight food and restaurants as essential aspects of their consumer activities and 46% go out of their neighborhood to try a new restaurant, demonstrating food's role as a major driver of social and economic interactions.

This article focuses on the relationship between gastronomy tourism, gentrification, and reverse migration in peri-urban geographies. The dual connection between tourism and gentrification offers a compelling framework for analysis. Gravari-Barbas and Guinand (2017) suggest that tourism both results from and facilitates gentrification, a dual process, evolving through different phases as neighborhoods transform. Early stages of gentrification often stimulate tourism, while more advanced phases may resist further tourism-driven developments. Within this context, Clark's (2005) definition of gentrification becomes particularly relevant. It emphasizes two key dimensions: demographic shifts in land-users, closely tied to migration, and physical transformations of the built environment, reflecting changes in urban geography. These processes take on unique forms in peri-urban areas, as Lees (2011) points out, where "different forms of gentrification emerge in different places at different and indeed the same times," underscoring the spatial complexity of gentrification in these intermediate spaces between urban and rural settings.

Despite extensive research on tourism's role in urban gentrification and economic development in urban (Gravari-Barbas & Guinand, 2017; Cocola-Gant, 2018) and rural (Xu, Wang, & Zhang, 2022; Ma & Su, 2023) context, significant gaps remain in the literature. Peri-urban geographies, which are the regions that blend rural and urban characteristics, have been relatively overlooked, even though they are uniquely positioned to exhibit mixed land

uses, dynamic demographics (Rajendran et al., 2024), and the overlapping influences of urban and rural transformations. Furthermore, while tourism-driven gentrification has been well-documented in urban centers (Bourlessas et al., 2021; Lütke & Jager, 2021), and relatively less-documented in rural (Nemes & Tomay, 2022), limited attention has been given to how gastronomy tourism, particularly through high-end establishments like Michelin-starred restaurants, drives gentrification and socio-spatial inequalities in peri-urban areas.

This study aims to address these research gaps by analyzing the dynamic interplay between gastronomy tourism, gentrification, and reverse migration in the peri-urban context of Urla, Türkiye. Through a critical examination of how Michelin-starred restaurants act as catalysts for spatial and socio-economic transformation, the research contributes to a deeper understanding of the socio-spatial impacts of gastronomy tourism. It also evaluates the implications of these transformations for urban justice, particularly in terms of inclusion, displacement, and accessibility.

The research is guided by three primary objectives: (1) to explore the relationship between gastronomy tourism, gentrification, and reverse migration; (2) to analyze how these processes transform peri-urban geographies; and (3) to evaluate the socio-spatial impacts of gastronomy tourism. Central to this exploration is the fundamental research questions: How are the co-constitutive relationships between gastronomy tourism, reverse migration and gentrification processes have been established? and how does this relationships transform peri-urban geography in the case of Urla, İzmir?

By addressing these objectives and questions, the study not only contributes to the theoretical discussions on tourism and gentrification; but also provides practical insights as well into the socio-economic and spatial dynamics of peri-urban areas. This research is particularly relevant in understanding how gastronomy tourism reshapes local geographies and offers a framework for ensuring more equitable and sustainable development in rapidly transforming regions like Urla.

2. Theoretical Framework

Tourism has long been a driver of socioeconomic and spatial transformations, but its impact on gentrification is increasingly nuanced and multifaceted. Tourism gentrification, as defined by Cocola-Gant (2018), is a process where the influx of visitors disrupts the existing population's right to remain in place. In advanced economies, this phenomenon is often framed through a cultural economy lens, emphasizing the consumption patterns of tourists and gentrifiers who share similar tastes and spaces. In contrast, in peripheral economies, tourism gentrification is heavily influenced by state and private capital initiatives aimed at creating destinations as a means of economic development. Across these contexts, tourism reshapes urban and rural spaces, often leading to residential, commercial, and place-based displacement. Residential displacement occurs as housing is increasingly converted into tourist accommodations, while rising land values accelerate commercial displacement by replacing local stores with visitor-oriented amenities. These processes are accompanied by place-based displacement, where local residents experience tensions as their neighborhoods are transformed into spaces primarily designed for tourism consumption (Cocola-Gant, 2018). Collectively, these changes drive socio-economic inequalities, such as reduced housing accessibility and economic restructuring, while altering spatial landscapes, including the transformation of agricultural and commercial spaces.

Tourism itself is evolving in response to changing consumer demands, technological advancements, and the proliferation of low-cost airlines. Traditional forms of tourism, which prioritized visual observation, have given way to a growing desire for immersive, multi-sensory experiences that foster deeper connections with destinations (Gálvez et al., 2017). This evolution has significant implications for gastronomy tourism and its role in gentrification. High-end dining establishments, such as Michelin-starred restaurants, and viticulture activities have played a critical role in the typology of gastronomy-driven gentrification, raising important questions about how these spaces contribute to displacement and broader socio-spatial transformations.

The role of restaurants on gentrification has been evaluated with different accounts. Restaurants play a significant role in shaping gentrification processes through their cultural, social, and economic impacts on neighborhoods. For example, Hyde's (2014) research from the Downtown Eastside of Vancouver highlights how restaurants frame notions of "authenticity" and "ethical entrepreneurialism" in ways that attract affluent newcomers while reshaping the symbolic value of low-income areas. These establishments, often praised for their eclectic and casual gourmet offerings, reflect broader shifts in high-status consumption from exclusivity to populism. They also underscore tensions between achieving cultural distinction and addressing structural inequalities in gentrifying neighborhoods. Similarly, according to Zukin et al., (2015), online restaurant reviews, such as those on Yelp, contribute to gentrification by constructing positive or negative perceptions of neighborhoods, thus influencing economic investment. Reviews often valorize "authentic" cuisines and locales in ways that favor affluent.

Food, as Lütke and Jager (2021) suggest, transcends its physical purpose, serving as a cultural and spatial force that can create displacement atmospheres. Within these atmospheres, food culture becomes a form of symbolic capital, enabling privileged consumers to assert social distinction and facilitating broader urban development projects (Bourlessas et al., 2020; Kinkaid and Platts, 2024). The quest for authenticity, often tied to food culture, is a powerful driver of urban economic growth and socio-spatial differentiation (Zukin, 2010; Rossi, 2017/2022). Gastronomy tourism, by responding to this demand for authenticity, not only transforms culinary landscapes but also catalyzes gentrification processes.

The dynamics of authenticity and food consumption further illuminate the complexity of urban culinary geographies. Ritzer's (1993) concept of "McDonaldization" captures the standardization and predictability of fast-food culture, appealing to the Fordist "McBody" consumer (O'Neill, 1999, as cited in Bell, 2002). In contrast, the post-Fordist "la petite bourgeoisie nouvelle" (Bourdieu, 1979, as cited in Stock and Schmiz, 2019) consumer seeks authenticity, scarcity, and distinction through high-end, artisanal food experiences. These twin modalities—McDonaldization and authenticity—are interdependent, defining each other through their oppositional characteristics while shaping the socio-spatial dynamics of urban foodscapes (Bell, 2002).

Several key concepts help elucidate the relationship between gastronomy tourism and gentrification. The concept of "foodification," introduced by Bourlessas et al. (2021), critiques the growing emphasis on food culture in urban environments and its gentrifying consequences. Their study on Turin's Porta Palazzo highlights how high-end food spaces create a "displacement atmosphere" through three interrelated elements: discourse, materialities, and practices.

Discourses of food quality and urban regeneration stigmatize traditional markets as outdated, while the aesthetic and material transformation of food venues appeals to affluent consumers seeking distinction. These shifts are accompanied by changes in consumption patterns, favoring knowledge-based, sedentary experiences in new eateries and bars, ultimately contributing to broader urban gentrification and the exclusion of marginalized communities. Complementing this, Lütke and Jager (2021) propose the concept of "gastrofication," emphasizing how the proliferation of gastronomic venues reshapes neighborhoods by catering to elite tastes. While they argue that gastrofication alone does not trigger gentrification, it functions as a key component within broader structural and commercial redevelopment. In a rural context, Nemes and Tomay (2022) analyze the transformation of Hungarian villages into "gastro villages," showing that while gastro-tourism brings economic benefits—such as rising visitor numbers, real estate values, and business activity—it also produces challenges like population displacement, socio-economic inequality, and "split realities" between tourism and local life. The authors stress the need for neo-endogenous development strategies that integrate tourism with local sustainability, cautioning that without such measures, gastro-tourism risks eroding the very cultural and social foundations that make rural destinations attractive in the first place.

When we approach the issue in peri-urban contexts, the initial movement of population in gentrification process takes on a different form as reverse migration. As many study indicate a defining characteristic of gentrification is the migration of middle-class individuals into economically disadvantaged neighborhoods (Lütke and Jager,

2021). Nemes and Tomay (2022) also identify the first stage of gastronomy-driven gentrification as initial attraction due to the unique gastronomic offerings. For a peri-urban or rural context, this movement takes place from metropolitan or urban to peri-urban or rural, which means "reverse migration". As another form of migration, amenity migration which is described as "the movement of largely affluent urban or suburban populations to rural areas for specific lifestyle amenities" (Abrams et al., 2012) gives insight for understanding this type of population movement as well. According to Takahashi et al. (2021), food is an important common value of this type of migration. Nemes and Tomay (2021), similarly, highlights the role of food and gastronomy in creating a romanticized rural idyll, which appeals to urban tourists seeking slower, more authentic experiences.

A cultural political economy perspective provides a valuable framework for analyzing these dynamics, particularly in peripheral regions such as the Mediterranean. As Cocola-Gant (2018) notes, tourism gentrification in these regions has been underexplored compared to studies of advanced capitalist cities in the global North. By examining gastronomy-driven gentrification in the peri-urban context of Urla, Türkiye, this study highlights how cultural and economic processes converge to reshape local geographies.

Within this context, the key indicators of gastro-driven gentrification include the presence of gastronomy-related planning actions, the rise of Michelin-starred restaurants, the increased tourism revenues, the commercialization of local culinary heritage, and the proliferation of gastronomy-related events such as food festivals. These processes are accompanied by economic transformations, including rising property values and shifts in business types, as well as social impacts, such as demographic changes and socio-economic inequalities. Physical transformations, such as land-use changes and urban planning interventions, further illustrate the profound effects of gastronomy tourism on peri-urban geographies. Together, these interconnected processes provide a comprehensive framework for understanding the socio-spatial dynamics of gastronomy-driven gentrification.

3. The Case Study: Urla, İzmir

Urla in the city of İzmir, with its population of 77.599 (TURKSTAT, 2023), a district in western Türkiye, is located within the Aegean Region. Situated approximately 35 kilometers from İzmir's city center, Urla occupies a strategic position along the southern coast of the İzmir Peninsula, extending from coastal regions to inland areas (Fig. 1). Known historically for its olive groves, viticulture, vineyards, and maritime activities, Urla's significance as a center of commerce and agriculture dates back to ancient times (Urla Şarapçılık, n.d.). Today, Urla exhibits a distinct peri-urban character, blending rural and urban features, making it an ideal site for analyzing the socio-spatial dynamics of peri-urban transformations. Its recent evolution into a hub for gastronomy tourism and reverse migration has accelerated significant changes in its socioeconomic and spatial structures, offering valuable insights into the complex interplay of tourism, urbanization, and gentrification.

The genesis of Urla's gastronomic transformation is deeply rooted in planning initiatives and infrastructural developments spanning decades. Planning decisions from the 1950s onward illustrate Urla's shifting identity. During this period, the district's agricultural character began to integrate with a second-home-focused structure, driven by İzmir's coastal development strategies. The 1955 İzmir Master Plan further reinforced Urla's connectivity to İzmir along the Çeşme-Pınarbaşı axis (Güner, 2006), while the 1973 İzmir Master Plan designated the district and its surroundings as key areas for tourism (Arkon & Gülerman, 1995) and second-home production, solidifying its identity as a summer resort destination.

The 1980s marked a turning point with the planning of the İzmir-Çeşme Highway. With the opening of the Çeşme Highway in 1994, this infrastructure development significantly enhanced Urla's accessibility, catalyzing an influx of second-home developments along its coastline (Güner, 2006). The leading factor in the district behind the second-home dominated development, especially from the mid-1990s and rapidly increasing from the 2000s to the present, is the İzmir-Çeşme Highway passing through the district of Urla (Can et al., 2018). Although its center is approximately 40 km far from the city center of İzmir, Urla has become an accessible site of living, thanks to the construction of the highway in the mid-1990s.

Figure 1. The Location of Urla

Zoning laws enacted during the same period accelerated speculative real estate activities, transforming the district's spatial dynamics and by the late 1990s, Urla's rural identity began to erode, with luxury housing projects and gated communities driving rural transformation and early stages of gentrification (Avar et. Al, 2024). The establishment of the İzmir Institute of Technology (İZTECH) in 1992, further contributed to these shifts, increasing the young population and employment opportunities, while fostering socioeconomic changes (Can et al., 2018).

In the 2000s, Urla began to attract high-income groups as a desirable living space. Efforts to revive traditional agricultural activities, particularly viticulture and olive groves, were initiated under sustainable development strategies led by the İzmir Development Agency (İZKA) and İzmir Metropolitan Municipality (Avar et. Al, 2024). These strategies emphasized Urla's gastronomic potential and introduced projects promoting sustainable tourism and agrotourism, leading to the rise of high-end wineries, luxury restaurants, and countryside hotels, which have become defining features of Urla's transformation as well as seasonal festivals promoting local products, such as the Artichoke Festival and Herb Festival (Avar et. Al, 2024). These developments reinforced Urla's reputation as a center for gastronomy and tourism.

By 2013, the establishment of the Urla Vineyard Road marked a significant milestone, attracting luxury wine producers and high-end gastronomic establishments. Events organized to promote local culinary heritage, including thematic festivals, contributed to the region's identity as a gastronomic destination. "The Peninsula Sustainable Development Strategy" (IZKA, 2014) further positioned Urla vision as "an alternative living city with its natural texture intact, cultural richness preserved, planned, contemporary culture and art city, world-renowned for its olive oil and wines, prominent for agrotourism and gastronomy tourism, developed sea tourism, productive and participatory."

In Izmir Regional Plan (IZKA, 2015), Urla was identified within regional settlement belt together with Torbalı, Kemal-

paşa, and Aliağa. Together with these districts, Urla was planned as a regional growth focus which are districts that are the gateway to the region, where certain service functions are concentrated and developed to serve their surroundings and where innovative sectoral formations with high added value are supported.

The COVID-19 pandemic in 2020 accelerated reverse migration trends (the highest annual growth rate in last 15 years in 2021 with 4,58% (TURKSTAT, 2023)), with many individuals relocating from urban centers like İzmir to Urla in search of lifestyle changes. This shift coincided with the district's emergence as a global gastronomy tourism destination, marked by the opening of Michelin-starred restaurants and the growing popularity of local vineyard houses, wine production facilities, and farm-to-table restaurants. These developments have solidified Urla's position within the international gastronomy tourism market, aligning with sustainable gastronomy principles that prioritize the use of local products and traditions.

In 2023, when the Michelin guide included İzmir and Bodrum in its selection for the first time outside of Istanbul in Türkiye, Urla achieved significant success by receiving 6 Michelin stars alone. This accomplishment is particularly noteworthy when compared to Athens, a city with a population of 5.5 million, which received five Michelin stars in 2019. This distinction underscores Urla's emergence as a significant gastronomic destination, highlighting the region's dedication to culinary excellence and its potential to rival established European culinary hubs (Özkök, 2023a). At this point, Urla has 10 Michelin-starred restaurants.

In current conditions of urban development, Urla serves as a microcosm for understanding the impacts of gastronomy tourism on peri-urban geographies. Its evolution reflects the complex interplay between infrastructure development, planning decisions, reverse migration, and the commodification of local culture. The district's rise as a gastronomy hub, particularly through the influence of Michelin-starred restaurants, exemplifies how tourism can drive significant socioeconomic and spatial transformations in peri-urban contexts. As such, Urla offers a valuable case study for exploring the intersections of tourism, gentrification, and urban justice in rapidly transforming regions.

4. Methodology

This study employs a qualitative case study methodology to explore the interrelated dynamics of gastronomy tourism, gentrification, and reverse migration in the peri-urban context of Urla, Türkiye. The case study approach is particularly suited to uncovering the complex, place-based interactions between socio-economic processes and spatial transformation.

Data were gathered through a combination of secondary sources, including planning documents, regional development reports, academic literature, and statistical data from institutions such as TURKSTAT, the Ministry of Culture and Tourism, and the İzmir Metropolitan Municipality. These sources of data provided insights into demographic shifts, economic indicators, and tourism development patterns.

To analyze spatial change, land cover data from ESRI for the years 2017 and 2023 were used. GIS-based visual analysis was conducted to identify changes in built-up areas, cropland, rangeland, and tree-covered zones. This spatial data supported the assessment of land use transformations linked to tourism and urban expansion.

By triangulating spatial, statistical, and conceptual data, the methodology aims to reveal the socio-spatial consequences of tourism-driven transformation in peri-urban areas, with Urla serving as a representative and timely case.

5. The Transformation of Urla Within the Broader Contexts of Gastronomy and Gentrification

5.1. Socioeconomic Indicators

Urla has undergone significant demographic, socioeconomic, and spatial transformations in recent decades, driven by an influx of upper-middle-class counter-urbanizers (Avar et al., 2024) and a burgeoning gastronomy tourism sector. These changes have redefined the district's identity and dynamics, positioning it as a prominent

peri-urban destination. The demographic growth in Urla has been remarkable. Its population increased from 26,066 in 1980 to 77,600 in 2023, reflecting a steady rise over the decades (TURKSTAT, 2023).

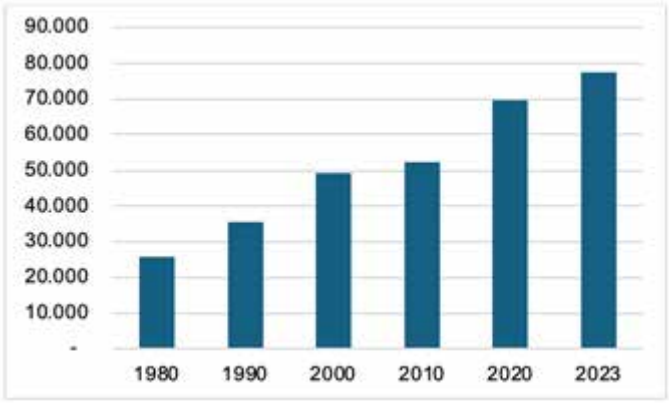

Figure 2. Urla Population Change Between 1980 - 2023

This growth accelerated particularly after the COVID-19 pandemic in 2021, outpacing comparable peri-urban districts such as Çeşme. The influx of counter-urbanizers, predominantly white-collar professionals commuting from İzmir, has been a key driver of this population increase (Avar et al., 2024). These newcomers have brought with them higher education levels and a relatively affluent socioeconomic profile, contributing to Urla's distinction as more developed in terms of education and socio-economic status compared to Türkiye's and İzmir's averages. In terms of the rate of university and postgraduate students, Urla ranked 6th with 30.6% in 2020, the year the pandemic began, as of 2023 Urla ranks 4th with 34,5%, among the districts of İzmir, after the central districts of Güzelbahçe, Karşıyaka and Narlıdere (İzmir Büyükşehir Belediyesi, 2023). However, while Urla surpasses Çeşme in education levels, it lags behind in overall socio-economic status as measured by wealth indicators (Endeksa, n.d.).

Socio-economic data further illustrate Urla's evolving profile. According to the Socio-economic Development Index (SEGE), Urla ranked 32nd among 858 districts in 1996, 43rd in 872 districts in 2004 (T. C. Devlet Planlama Teşkilatı, 1996 / 2004), dropped to 93rd in 2017, and climbed back to 59th in 2022 (T. C. Sanayi ve Teknoloji Bakanlığı, 2017 / 2022). These fluctuations reflect both the challenges and opportunities associated with its rapid transformation.

The district's fertile lands, close proximity to İzmir, and the migration of middle and upper-income groups have fostered rural entrepreneurship, altering livelihoods in the countryside and driving economic diversification (Güçü, 2022). The rise of gastronomy tourism has also contributed significantly to Urla's development. The number of facilities with operation and investment certificates grew from just two facilities with 154 beds in 2012 to 21 facilities with 514 beds in 2023, illustrating the rapid expansion of tourism infrastructure (T.C. Kültür ve Turizm Bakanlığı, 2023). This development has been accompanied by the establishment of high-end wineries, restaurants, and farm-based businesses, further solidifying Urla's status as a gastronomic hub. However, this growth has also driven significant changes in the real estate market. Between 2018 and 2024, the square meter prices of houses for sale in Urla increased by 1,432%, nearly double the rate observed in Çeşme (Endeksa, n.d.), highlighting the intense speculative pressures on Urla's land market (Uştuk, 2024).

These economic and demographic shifts have not been without consequences for native residents. The influx of affluent settlers, particularly from İstanbul, has created an expensive standard of living that many long-term residents find difficult to sustain. Rising land and rental prices have contributed to the displacement of native inhabitants, driven in part by what Uştuk (2024) describes as an "exile strategy" employed by new elite settlers to fulfill their gentrification demands. This gentrification process, coupled with the increasing commodification of local culture and heritage, has reshaped Urla's socio-spatial fabric.

In sum, Urla's transformation over the past decades illustrates the multifaceted impacts of counter-urbanization, rural entrepreneurship, and gastronomy tourism. While these developments have brought economic growth and enhanced its cultural appeal, they have also exacerbated socio-spatial inequalities and raised critical questions about sustainability and inclusivity. As the district continues to evolve, the tension between preserving local identity and accommodating the demands of its affluent newcomers will remain a key challenge.

5.2. Spatial Indicators

The spatial transformation of Urla, influenced by gastronomy tourism and related development, reveals significant changes in land use, particularly in agricultural and rangeland areas. While agricultural production continues on some lands, rural livelihoods are increasingly diversified with new functions such as consumption and experience, which are associated with the growing gastronomic sector (Güçü, 2022). However, these shifts in land use reflect a broader trend of changing priorities in rural areas, where production is supplemented by tourism and leisure activities.

Between 2012 and 2021, Urla's total agricultural land decreased significantly, shrinking from 9,421 hectares to 6,869 hectares, marking a substantial reduction in the district's agricultural footprint (Urla Belediyesi, 2015; T.C. Tarım ve Orman Bakanlığı İzmir İl Müdürlüğü, 2023). This trend highlights the increasing pressure on agricultural land as it is repurposed for urban development and tourism-related activities.

In order to understand the effects of these changes on the peri-urban geography of Urla, land cover change was analyzed using land cover data for the years 2017 and 2023 obtained from ESRI. When examining land use changes across the entire district between 2017 and 2024, built areas increased by 18%, reflecting the district's rapid urbanization. Concurrently, cropland decreased by 27%, while rangeland saw an 8% decline, and tree-covered areas increased slightly by 5% (Table 1). These changes underscore the competing demands on land as urban development and tourism infrastructure expand at the expense of agricultural and grazing areas.

Table 1. Urla District Land Cover Change (2017-2023)

	Built Area	Crops	Rangeland	Trees
2017	7.629	3.332	26.830	35.063
2024	9.041	2.426	24.675	36.954
Percentage Change	18%	-27%	-8%	5%

The land cover maps of 2017 and 2023 visually reinforce these trends. The expansion of built-up areas, particularly around Urla's urban core and coastal zones, is clearly observable, signaling intensified urbanization. Simultaneously, there is a noticeable reduction in cropland and rangeland, especially in peripheral and formerly agricultural zones, indicating the displacement of productive land uses. While there is a slight increase in tree-covered areas, the overall trend reflects a shift away from traditional agricultural and pastoral land uses toward residential, touristic, and leisure-oriented development. This spatial reconfiguration highlights the competing pressures on land and the transformation of Urla's peri-urban geography under the influence of gastronomic and lifestyle-oriented change.

6. Discussion and Conclusion

Urla's transformation illustrates how gastronomy tourism, when combined with reverse migration and planning strategies, can rapidly reshape peri-urban geographies. The concept of gastro-driven gentrification captures the dynamics at play—where high-end restaurants and lifestyle-driven newcomers contribute to rising land values, changing land use patterns, and the displacement of long-term residents.

While these developments have boosted Urla's global visibility and economic appeal, they have also intensified

socio-spatial inequalities and placed pressure on agricultural landscapes. Land cover analysis confirms a shift from productive uses to consumption-oriented spaces, reflecting broader tensions between development and sustainability.

Ultimately, Urla's case underscores the need for planning approaches that prioritize spatial justice, ecological preservation, and community inclusion. Without such efforts, gastronomy-led growth may deepen inequalities and erode the very cultural and environmental assets it seeks to celebrate.

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Cultural route perspective: heritage tourism value evaluation and route optimization of the Silk Road (Shaanxi section)

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Abstract
Spanning millennia, the Silk Road connected Eastern and Western civilizations. Xi'an served as its eastern terminus, while the Shaanxi province segment stands as the core protection zone for the route. Existing research often focuses on isolated heritage sites, neglecting their historical links to the route and undermining its cultural integrity.From the perspective of cultural routes, the study identifies 82 potential heritage sites and establishes a three-tier evaluation system. The tourism value of each heritage resource is quantified through an analytical model incorporating historical significance, route connectivity, and visitor experience metrics. Through quantitative analysis, we assess their tourism value and optimize routes to enhance visitor experiences, strengthen cultural coherence, and offer a model for global cultural route tourism planning.

Keywords: cultural routes, silk road, tourism value evaluation

1. Introduction

The Silk Road emerged during the reign of Emperor Wu of the Western Han Dynasty (141–87 BC), with its eastern terminus at Han Chang'an City (present-day Weiyang District, Xi'an) [1]. As the historical starting point and core economic zone of the Silk Road, Shaanxi Province hosts an extensive network of routes and abundant cultural heritage along its course, bearing witness to the thoroughfare's origins, growth, and prosperity [2,3]. In recent years, the rapid expansion of cultural heritage tourism has seen a proliferation of Silk Road-themed cultural tourism projects. However, existing tourism activities remain predominantly concentrated at iconic heritage sites such as the Big Wild Goose Pagoda and Little Wild Goose Pagoda, resulting in tourists' limited ability to grasp the overall historical context and cultural connotations of the Silk Road systemically.

As a key catalyst for socioeconomic development, tourism activities undertake a dual mandate: cultural heritage dissemination and heritage conservation. While existing research on Silk Road heritage tourism has focused primarily on heritage value, tourism development, and tourist experience, comprehensive investigations into the intrinsic value of heritage tourism remain limited [4]. Conducting systematic evaluations of heritage tourism value not only clarifies development potentials but also identifies challenges in historical and cultural heritage management, enabling the formulation of targeted activation strategies.

As a distinct category of cultural heritage, cultural routes embody the exchange of cultures, ideas, knowledge, and values arising from human cross-regional interactions, forming dynamic systems intertwined with their historical contexts and cultural legacies. The Silk Road, as a paradigmatic cultural route heritage, not only exhibits the characteristics of conventional cultural heritage but also demonstrates distinct integrity and systemicity owing to its linear spatial configuration.

Current academic research on the tourism value of the Silk Road primarily relies on theoretical frameworks for evaluating traditional cultural heritage. However, it fails to fully address the unique attributes of linear cultural heritage, which differ from dotted and planar heritage forms, and lacks a holistic perspective in the value assessment process [5,6]. Consequently, developing a tourism value evaluation model aligned with the characteristics of cultural route heritage represents a critical theoretical priority in contemporary heritage tourism research.

This study focuses on the Shaanxi segment of the Silk Road, constructing a three-tier evaluation system—comprising target layer, criterion layer, and index layer—tailored to the tourism value assessment of cultural route heritage. By integrating the analytic hierarchy process (AHP) and geographic information system (GIS) technology, we conduct systematic value assessments for 82 heritage sites in Shaanxi. On this basis, we optimize tourism

route planning through spatial visualization tools, aiming to expand heritage experience options for tourists and enhance their holistic understanding of the Silk Road's historical connotations. The research results provide theoretical support and practical guidance for the sustainable development of heritage tourism in the Shaanxi segment of the Silk Road.

2. Research methods and data sources

2.1 Evaluation method of heritage tourism value

This study employs a mixed-methods approach, integrating qualitative and quantitative research, to systematically develop an evaluation system for the heritage tourism value of the Silk Road (Shaanxi segment). In the qualitative research stage, a systematic literature review is conducted to synthesize international cultural heritage protection frameworks and relevant domestic and foreign research, from which initial evaluation indicators are extracted. Building on the typical characteristics of cultural routes, such as historical continuity and spatial connectivity, characteristic indicators are systematically refined and expanded through thematic analysis. The process concludes with multiple rounds of expert consultation using the Delphi method, ultimately leading to the establishment of an evaluation system comprising 4 criterion layers and 12 index layers. During the quantitative research phase, the Analytic Hierarchy Process (AHP) is employed to assign weights to evaluation indices, while kernel density estimation and weighted overlay analysis using the ArcGIS platform are utilized to visually represent the assessment results. The study culminates in the optimization of cultural tourism routes based on the evaluation outcomes.

2.2 Evaluation index data sources

The research data is sourced from multiple verified channels, including (1) topographic maps obtained from the Standard Map Service System of the National Administration of Surveying, Mapping and Geoinformation; (2) road network data provided by the Resource and Environmental Science Data Center of the Chinese Academy of Sciences; (3) heritage site lists and attribute information derived from the Shaanxi Provincial Cultural Relics Bureau's cultural relics census; (4) POI data for public service facilities such as dining, hotels, and parking lots collected via the Baidu Maps platform; (5) historical records including Hanshu and Tangshu retrieved from the Chinese Basic Ancient Books Library; (6) and results from structured questionnaires administered to experts and tourists.

3. Construction of tourism value evaluation system

3.1 Selection of evaluation indicators

In constructing the evaluation index system, this study adheres to the principles of hierarchy, guidance, and simplicity, adopting a three-tiered structure consisting of a target layer, criterion layer, and index layer. This framework ensures both systematic evaluation and precise measurement across hierarchical levels. The target layer focuses on assessing the heritage tourism value of the Silk Road (Shaanxi segment) through a cultural route lens. The criterion layer delineates key evaluation dimensions, while the index layer operationalizes these dimensions into quantifiable metrics. The final index system was finalized via the Delphi method, involving multiple rounds of expert consultation for indicator screening and categorization. The evaluation index system is presented in Fig. 1.

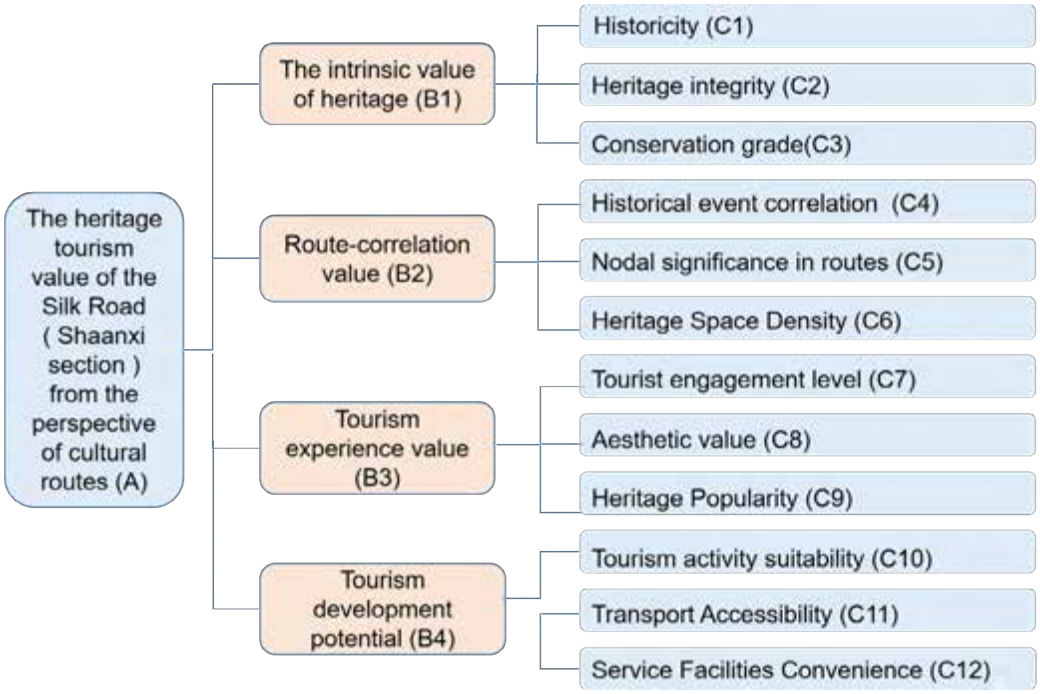

Figure.1 Evaluation System for the Tourism Value of the Silk Road Heritage in Shaanxi from the Perspective of Cultural Routes

The intrinsic value of heritage (B1) manifests its irreplaceable and essential worth as a self-contained entity. Drawing on the cultural significance framework outlined in ICOMOS' Barra Charter (2013) [7], the criterion layer identifies indicators across three dimensions: Historic Evidence, Material Fabric, and Social Connections. The Historicity of heritage carry the Silk Road's diachronic value, while its Heritage integrity dictates the preservation state of these value-laden material carriers. conservation grade reflects societal institutional recognition of heritage value, serving as an important marker of the social consensus surrounding its cultural significance.

Route-correlation value (B2) constitutes the core dimension of heritage evaluation from the cultural route perspective. Its indicators encompass Historical event correlation, Nodal significance in routes,and Heritage Space Density. The historical event correlation index measures the extent to which a heritage site is connected to major historical processes. Drawing on Norbert Schulz's Place Theory [8], historical events infuse spaces with spiritual connotations, as the occurrence of significant historical milestones often endows specific locations with cultural significance transcending their material form. The nodal significance in routes assesses the functional role of heritage sites within the network, evaluating their position and influence in facilitating historical interactions and exchanges along the route. Building upon the central place theory in transportation geography [9], key nodes along cultural routes often exhibit higher accessibility and functional complexity, serving as critical markers of the routes' historical development and evolution. The heritage Space Density enables the quantification of spatial continuity along the route [10]. The spatial density index of heritage sites is derived using kernel density analysis in ArcGIS, calculating the number of heritage sites per square kilometer and their nearest neighbor index to determine the final evaluation score.

Tourism experience value (B3) evaluates heritage tourism products from the tourists' perspective, encompassing three indicators: Tourist engagement level, Aesthetic value, Heritage Popularity. Drawing on the World Tourism Organization's (UNWTO, 2018) research on tourist behavior, which indicates that 73% of travelers prefer culturally iconic destinations [11], popularity serves as a measure of public awareness of heritage and directly influences tourists' decision-making [12]. Engagement reflects the depth of tourists' participation and is a key metric for assessing the effectiveness of heritage tourism development [13]. Building on Berlyne's Aesthetic Response The-

ory (1971), visual stimuli directly impact tourists' emotional arousal and willingness to stay [14]. Heritage sites with stronger aesthetic appeal evoke tourists' aesthetic pleasure through visual salience, thereby enhancing the overall experience quality [15].

Tourism development potential (B4) are evaluated through three key dimensions: Tourism activity suitability, Transport accessibility, and Service facility convenience. Tourism activity suitability systematically assesses the environmental carrying capacity of the heritage site's surrounding area, reflecting the feasibility of developing heritage tourism under the premise of ecological sustainability and serving as a foundational indicator for tourism construction planning. Transport accessibility is measured by using ArcGIS to calculate the proximity of heritage sites to various road networks (expressways, national highways, provincial roads), thereby evaluating the ease with which tourists can reach their destinations. Service facility convenience, positively correlated with tourism experience quality, is determined through Kernel Density Estimation to analyze the agglomeration patterns of catering, accommodation, medical, and other supporting facilities, providing a quantitative measure of regional service accessibility [16].

3.2 Determination of index weight

In evaluation systems, index weights are quantitative values assigned to reflect the relative importance of each indicator, representing their contributions to the overall assessment [17]. Each weight is normalized such that the sum of all weights equals 1 (or 100%). Here, we employ the analytic hierarchy process (AHP) to determine index weights. First, a judgment matrix was constructed using the 1–9 scale method, and questionnaires were distributed to 24 experts specializing in tourism planning, heritage protection, and related disciplines. Twenty valid responses were received, yielding an 83.3% response rate. Consistency of the judgment matrices was verified using Yaahp software, confirming that all matrices satisfied the consistency ratio criterion [18]. Arithmetic means of the valid weighted judgments were calculated to derive the final weights for each index element, presented in Table 1.

Table 1. Weighting of Heritage Tourism Value Indicators

Criterion layer	Indicator layer	Weight	Scoring standard				
			20	40	60	80	100
Heritage ontology value (B1) (0.21)	Historicity (C1)	0.06	Ming-Qing dynasty	Song-Yuan dynasty	Sui-Tang dynasty	Wei jin southern and northern dynasties	Han Dynasty and before
	Heritage integrity (C2)	0.07	Only the remains of the site	Local retention	Subject retention	Relatively complete	Complete
	Conservation grade (C3)	0.08	Unrated	Municipal	Provincial	National	World-class
Line correlation value (B2) (0.31)	Historical event correlation (C4)	0.12	Very poor	Poor	General	Important	Very important
	Nodal significance in routes(C5)	0.11	Very poor	Poor	General	Important	Very important
	Heritage Space Density (C6)	0.08	The nearest neighbor index (NNI) of cultural heritage points was calculated using kernel density analysis and normalized.				
Tour experience value (B3) (0.22)	Tourist engagement level (C7)	0.09	Very poor	Poor	General	Important	Very important
	Aesthetic value (C8)	0.07	Very poor	Poor	General	Important	Very important
	Heritage Popularity (C9)	0.06	Unknown	Regional famous	Province famous	Country famous	Word famous
Tourism exploitation condition (B4) (0.26)	Tourism activity suitability (C10)	0.10	Very poor	Poor	General	Suitable	Very suitable
	Transport Accessibility (C11)	0.10	Very poor	Poor	General	Suitable	Very important
	Service Facilities Convenience (C12)	0.06	Very poor	Poor	General	Convenient	Very convenient

The results show that the connectivity of routes has the highest weight, which validates the core perspective of the cultural routes theory. The value of heritage is not only reflected in individual characteristics but more importantly in its interconnections within the route system. Meanwhile, the relatively high weight of tourism development conditions also indicates that, on the premise of prioritizing protection, rational tourism utilization is an important means of realizing the inheritance of heritage value.

4. Heritage identification and tourism value evaluation

4.1 Potential Heritage Identification

This study systematically compiles official datasets, including the Shaanxi Province Unmovable Cultural Relics List (2020 Edition), to conduct a comprehensive inventory of cultural heritage resources in Shaanxi Province. Multi-source data cross-validation ensures that each potential heritage site satisfies the following criteria: (1)

possesses physical remains confirmed by field surveys; (2) has complete cultural relics archive records; and (3) its historical context is traceable to periods relevant to the Silk Road. Extending spatial analysis across the entire province of Shaanxi to account for historical variations in the Silk Road's cultural influence, we identify heritage elements significantly associated with the route. A total of 82 core heritage sites are selected, including seven inscribed in the Silk Road: The Road Network of the Chang'an-Tianshan Corridor World Cultural Heritage list.

Table 2. Statistics of Potential Heritage Sites

Serial number	Heritage name	Dynasty	Seat	Type
1	Dayan Pagoda	Tang	Xi'an city	Ancient architecture
2	Small Wild Goose Pagoda	Tang	Xi'an city	Ancient architecture
3	Han Chang'an City Site	Western Han	Xi'an city	historic urban archaeological sites
4	Xingjiao Temple Pagoda	Tang	Xi'an city	Ancient architecture
5	Tomb of Zhang Qian	Han	Hanzhong city	Ancient burials
6	Maoling Mausoleum	Western Han	Xianyang city	Ancient burials
7	kumarajiva dagoba	Tang	Xi'an city	Ancient architecture

4.2 Evaluation of heritage tourism values

Using the evaluation framework for the heritage tourism value of the Silk Road (Shaanxi segment) established above, assessments are categorized as quantitative or qualitative based on data type. Quantitative indicators encompass C1 (Historicity), C3 (Conservation grade), C6 (Heritage Space Density), C11 (Transport Accessibility), and C12 (Service Facilities Convenience). For C1 and C3, data derived from the authors' field surveys and literature reviews were processed in SPSS for sorting, calculation, and dimensionless normalization [19]. Spatial analyses for C6, C11, and C12 were performed using ArcGIS 10.8. Specifically, C6 employs kernel density estimation to quantify heritage clustering (Fig. 2(a)), while C11 utilizes multi-ring buffer analysis (3,000m/5,000m/10,000m/20,000m) to calculate road network coverage (Fig. 2(b)) [20]. C12 integrates POI kernel density and entropy weight methods to assess service facility distribution intensity (Fig. 2(c)) [21].

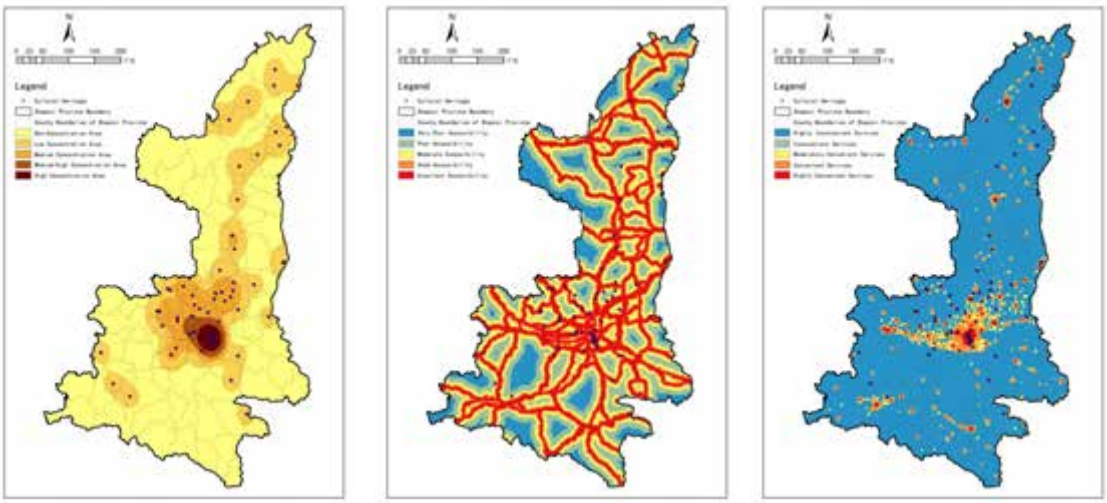

Figure 2. (a) Spatial Density Evaluation of Heritage Sites (b) Road Network Accessibility (c) Service

Facility Convenience Assessment

Qualitative indicators encompass C2 (Heritage integrity), C4 (Historical event correlation), C5 (Nodal significance in routes), C7 (Tourist engagement level), C8 (Aesthetic value), C9 (Heritage Popularity), and C10 (Tourism activity suitability). C2, C4, and C5 were determined via the Delphi method, involving three rounds of Likert 5-scale scoring by six experts with expertise in Silk Road heritage. For C7–C9, data were collected through online surveys, yielding 36 valid responses. C10 was assessed using the Limits of Acceptable Change (LAC) framework, where three ecological experts integrated remote sensing imagery, field monitoring data, and construction carrying capacity analyses to evaluate biological sensitivity [22].

4.3 Analysis of value evaluation results

Using the developed comprehensive evaluation framework, this study systematically assesses the tourism value of 82 heritage sites in the Shaanxi segment of the Silk Road, classifying them into three categories based on weighted scores (Fig. 3).

Figure 3. Statistical Results of Heritage Evaluation

Class I Heritage (≥80 points) includes 9 sites, comprising 11.0% of the total. These are core heritage sites with outstanding historical value and tourism development potential, such as the Han Chang'an City Ruins (92.6 points) and the Giant Wild Goose Pagoda (92.4 points). These sites hold an irreplaceable important position in the development of Silk Road tourism. Class II Heritage (70-80 points) includes 30 sites, accounting for 36.6%. These sites have medium tourism value and can serve as important supplements to the Silk Road tourism routes, such as Zhang Qian's Tomb (79.2 points) and the Daxingshan Temple (79.2 points). Class III Heritage (≤70 points) includes 43 sites, accounting for 52.4%. These sites have relatively limited tourism development value and can be considered as optional visiting points.

Spatially,Class I Heritages exhibit pronounced clustering, predominantly concentrated in the core region of Xi'an (Fig. 4). Class II Heritages are primarily distributed in peripheral regions of Xi'an and Xianyang cities, while Class III Heritages are scattered along historical ancient roads. This distribution pattern strongly aligns with the historical commercial routes and regional development priorities of the Silk Road, reflecting the intrinsic link between heritage value and historical context.

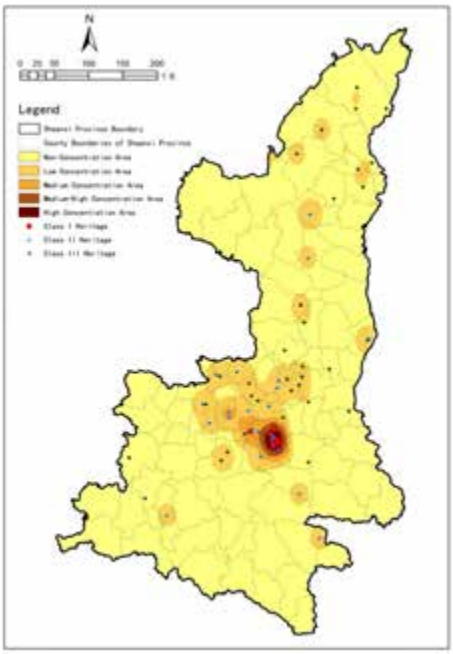

Figure 4. Comprehensive Heritage Evaluation Results

5. Optimization of tourist route

Leveraging systematic evaluations of 82 heritage sites, this study uses ArcGIS network analysis tools to incorporate national and provincial transport network data (expressways, national highways, provincial roads) to optimize Silk Road tourism routes. By designating Class I Heritage sites as mandatory nodes and Class II and Class III Heritage sites as optional nodes, and optimizing for the shortest path while integrating constraints such as road classification and traffic capacity, we employ ArcGIS network analysis to model route configurations. Following iterative model runs and manual refinement, a complete cultural tourism route for the Silk Road (Shaanxi segment) is finalized (Fig. 5). The route efficiently connects 9 core heritages, 12 secondary heritages, and 8 tertiary heritages, enabling systematic exploration of diverse heritage resources and immersive engagement with the historical and cultural continuum of the ancient Silk Road.

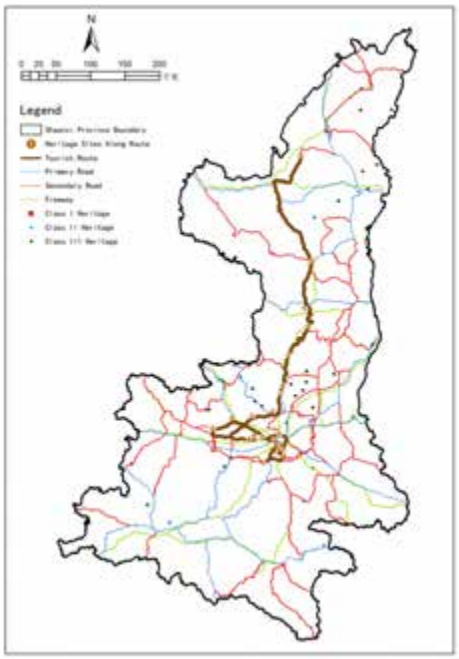

Figure 5. Cultural Tourism Route of the Silk Road (Shaanxi Section)

6. Conclusion

This study introduces an innovative framework for evaluating heritage tourism value, systematically constructing a multidimensional assessment system. Compared with conventional approaches, it features three distinct advances: (1) Emphasizing the overall value of cultural routes, it quantifies the historical connections between heritage sites and routes, fully presenting the characteristic of cultural routes that "the whole is greater than the sum of its parts." (2) It establishes a multidisciplinary evaluation dimension, comprehensively considering factors such as nodal significance in routes, tourism development, and visitor experience need. (3) By utilizing the ArcGIS platform for geospatial quantitative analysis, it significantly enhances the scientific rigor of evaluations.

This study still has limitations, including insufficient objectivity in the evaluation process and limited representativeness of evaluation subjects. Future research should focus on improving quantitative methods for indicators, establishing a multi-stakeholder participation mechanism, and expanding the scope of case applications. These improvements will enhance the scientific rigor and generalizability of the evaluation system, thereby providing more robust theoretical support and practical guidance for the sustainable development of cultural route heritage tourism.

AUTHOR INFORMATION

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Special Session 1

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Energy Justice in Underprivileged Neighbourhoods: Reimagining Energy Transitions Through Community Storytelling

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Abstract
Achieving just energy transitions in underprivileged neighbourhoods is essential for sustainable urban renewal yet remains difficult. Residents often face energy injustices due to unaffordable and inaccessible renewables. Structural inequalities further limit collective action and community cooperation, depriving inhabitants of the resources and opportunities needed to develop their capabilities. While energy justice literature addresses distributional, recognitional, and procedural inequalities, it often overlooks deeper constraints on people's agency. In response, this paper proposes storytelling as a creative and participatory method to strengthen agency in underprivileged neighbourhoods. Storytelling enables residents to imagine alternative futures, build shared narratives, and engage with energy transitions on their own terms. This conference paper offers an initial exploration of how this approach can inform future research in the Watersportbaan neighbourhood.

1. Introduction

Achieving fair and inclusive urban energy transitions is a pressing societal challenge, particularly in inner-city underprivileged neighbourhoods. While the energy justice literature addresses distributional, recognitional, and procedural inequalities, it often overlooks deeper constraints on people's agency. We argue that agency represents a critical "missing foundation" in the energy justice framework. It falls short in addressing structural barriers that constrain residents' capacity to act. In underprivileged neighbourhoods, where residents struggle with immediate survival needs, deteriorating housing conditions, social stigmatization, and uncertain futures, the ability to envision and participate in long-term energy transitions is severely limited.

Drawing on feminist ethics of care, we explore storytelling as both a methodological tool and a means to strengthen agency among marginalised communities. Storytelling can make energy systems more visible and relatable, democratise energy conversations by lowering barriers to participation, and help communities envision alternative futures beyond current constraints.

The empirical research is situated in the Watersportbaan neighbourhood in Ghent, Belgium, characterised by high-rise social housing, deteriorating living conditions, and planned large-scale redevelopment. Through exploratory fieldwork, we identify key narratives that reveal the complex socio-spatial dynamics shaping residents' relationship with energy systems and their capacity for engagement.

The scope of this paper encompasses two interconnected objectives: first, to establish the theoretical foundation for why storytelling represents a transformative tool that can address the agency deficit in current energy justice frameworks; and second, this paper aims to present our initial findings through a collection of key narratives that illustrate the complex socio-spatial dynamics limiting residents' energy agency, and demonstrate how storytelling can engage with and potentially transform these constraints. Rather than presenting definitive conclusions, this paper establishes the groundwork for future co-creation activities where these exploratory narratives will be developed into community storylines to eventually be meaningfully implemented into the neighbourhood energy transition plan, ultimately contributing to more just energy futures.

2. Energy justice

Energy justice is defined as "a global energy system that fairly distributes both the benefits and burdens of energy services, and one that contributes to more representative and inclusive energy decision making" (Sovacool et al., 2017, p. 677)2017. The concept is rooted in environmental justice literature, which was initially used by researchers and activists to uncover the uneven distribution of environmental risks from hazardous facilities, disproportionately burdening people with lower incomes or people of colour (Carley and Konisky, 2020; Iwińska, Lis and Mączka, 2021). Energy justice is gaining popularity in academic literature (Jenkins et al., 2021). The concept has been widely used for energy scholarship in humanities and social sciences, as energy justice is a helpful concept for dissecting the different justice dimensions of various energy-related issues (Iwińska, Lis and Mączka, 2021).

Typically, energy justice literature deals with three tenets of justice. Distributional energy justice refers to the equal distribution of risks and benefits, procedural justice to open-decision making processes, and recognitional justice to the recognition of underprivileged groups (Walker and Day, 2012). These tenets are deeply tied to another, as an inequitable distribution, a lack of recognition and limited participation can influence another, further (re)producing (energy) injustices (Schlosberg, 2004).

Higher risks of energy injustices are reported in relation to the energy transition. The transition may, at least on the short term, lead to higher costs, due to new investments in infrastructure or technology, causing distributional energy injustices. Higher costs may impact low income households more, who often already pay a larger share of their income on the energy bill (Walker and Day, 2012; Carley and Konisky, 2020). This may be compounded even more, as low income households are likely to live in lower efficiency housing, with outdated energy consuming technologies or heating (Walker and Day, 2012). Additionally, distributional injustice has been discussed in the context of employment losses in declining carbon-intensive industries, such as the coal mining industry (Carley and Konisky, 2020). Although clean energy industries are expected to create more job opportunities, those that currently hold jobs in carbon-intensive industries will still be deeply affected (Carley and Konisky, 2020).

Recognitional injustices are a consequence of social groups being overlooked and stigmatised. As Fraser (1995, p. 69) argues, a lack of recognition is foundational to distributional inequalities. Concerning energy transitions, processes or disrespect, stigmatisation and othering (Jenkins, Sovacool and McCauley, 2018) in policies, laws or professional practices cause vulnerabilities to stay invisible. This leads to the reproduction of marginalisation instead of the targeting of needs (Willand, Torabi and Horne, 2023)this study explores the role of trusted in termediaries in recognising and identifying hidden energy vulnerability. Hidden energy vulnerability is the propensity of households to experience harm from energy deprivation because their situation is not captured by common indicators of energy poverty or because they do not request help. Previous research has focused on datadriven, systematic strategies to identify households in hidden energy vulnerability, however, there is little un derstanding of the opportunistic ways that affected households may be identified through intermediary social networks.","-container-title":"Energy Research & Social Science","DOI":"10.1016/j.erss.2023.103013","ISSN":"22146296","journalAbbreviation":"Energy Research & Social Science","language":"en","page":"103013","source":"DOI.org (Crossref. Epistemic injustice is a particular form of recognition-based injustice. It is the consequence of unfairly dismissed credibility due to prejudice, or of people lacking tools or concepts to understand or express their experiences. This results in specific forms and outputs of knowledge that often outweigh other valuable forms of knowledge, such as local or experiential knowledge (Gürtler, 2023).

Procedural justice refers to fair and equitable institutional processes, including access to information, access to (meaningful) participation in decision-making and access to legal processes (Walker and Day, 2012). Policies regarding the energy transition often remain untransparent, with little inclusion and participation in decision-making of various stakeholders, especially low income households (Stojilovska, 2023).

Energy justice offers a multifaceted framework to analyse and shape both the justice aspects of the current energy system and the transition to sustainable energy. While this framework has gained significant traction,

critics have pointed to several limitations of the framework as well, which are discussed below.

2.1 Limitations in the current application of energy justice & gaps in addressing structural inequalities
Several scholars have discussed the entailing limitations of the energy justice literature. Sovacool et al. (2017) criticise the field's western theoretical orientation and the too narrow focus on anthropocentric relations. Damgaard, McCauley and Reid (2022) argue that while energy justice is useful for analysing institutions and policy decisions, its focus on individual rights overlooks relationality and interdependence as core aspects of existence. It moreover lacks a strong theorization of responsibility (Damgaard, McCauley and Reid, 2022), an important gap as energy initiatives increasingly aim for more active energy citizenship (Beauchampet and Walsh, 2021; Biresselioglu et al., 2024). Bouzarovski and Simcock (2017) note the absence of spatial dimensions, proposing an explicit spatial focus through the concept of spatial justice.

Healy and Barry (2017, p. 452) point to a critical gap in the energy justice concept in addressing power relations: "While a number of scholars assert that politics is a critical component in the transitions approach, it is largely missing from much of existing analysis of socio-technical energy transitions and the energy justice literature". Haldar, Grillitsch and Bazaz (2024) critique the energy justice framework for neglecting human agency in sociotechnical transitions, highlighting insufficient engagement with political economy paradigms that reproduce injustices.

Lee and Byrne (2019, p. 2) argue that the three-tenet approach fails to address the "political and economic forces that routinely produce energy injustice". By prioritizing "tailpipe problems" like accessibility and affordability, it neglects deeper structural and ideological factors, such as the bias toward large-scale technical solutions, distanced decision-making from local communities, technocratic interpretations of sustainability, and path dependencies, that perpetuate inequality. Similarly, Elmallah, Reames and Spurlock (2022) emphasise that current energy justice literature inadequately connects to policy and systemic change. They argue that energy inequities are caused by underlying structures and institutions, and that the energy justice framework falls short to challenge the capitalist roots of energy and climate injustice.

These critiques reveal that the current energy justice literature, while valuable, fails to adequately address structural power relations, spatial inequalities, and the role of agency in enabling or constraining participation in energy transitions. This is particularly true in underprivileged urban areas, where marginalisation is spatially and socially embedded (Verlooy et al., 2024). In the next section, we argue that agency is a missing yet essential foundation for a more just energy transition.

3. Agency, the "missing foundation" problem in underprivileged neighbourhoods
In this article we focus on complex inner-city neighbourhoods that have been characterised as underprivileged, due to a lack of access to resources and opportunities and compounding processes of marginalisation (Counted and Newheiser, 2023). We emphasise how structural barriers in underprivileged neighbourhoods affect people's capacity to act. The literature elucidates that structural injustices can lead to a lack of a sense of agency, resulting in a sense of powerlessness (Gaupp, Constantino and Pereira, 2023). We argue that agency represents a crucial "missing foundation" in energy justice discourse, particularly in underprivileged contexts.

This absence of agency is embedded in geographically differentiated so-called "opportunity structures" (Roberts, 2009; Bouzarovski and Simcock, 2017), that constrain residents' capacity to envision and participate in neighbourhood energy transitions, ultimately leading to energy injustices. In underprivileged neighbourhoods, socio-material inequalities manifest in several ways: low-income inhabitants more often occupy poor quality, low energy efficiency housing, in need of retrofitting and equipped with outdated heating systems (Bouzarovski and Simcock, 2017). Without the financial means to improve energy performance, residents are effectively locked into energy-poor conditions.

Beyond material deprivation, socio-spatial factors further restrict agency. Dense urban morphologies, resulting

in a limited availability of public space and private space, and a high proportion of renters, can collectivity restrict the opportunities for integrating renewables (Middlemiss and Gillard, 2015; Knox, 2019; Derkenbaeva et al., 2022; Verlooy et al., 2024). In addition to these constraints, the literature highlights how misrecognition and the stigmatisation of disadvantaged areas contributes to their neglect in policy and planning processes (Hastings, 2009; Walker, 2009). These neighbourhoods are often associated with negative, stigmatised identities, which not only affect how they are served, but also how residents perceive themselves and their communities. The internalization of stigma can lead to community disengagement, reducing levels of civic participation and weakening connections both within the community and with outsiders (McNamara, Stevenson and Muldoon, 2013). The socio-spatial contexts in underprivileged neighbourhoods are not just backdrops but active components shaping what people perceive as possible. Marginalisation in these contexts may lead to a diminished sense of agency, but it can also constrain the imagination of the underprivileged, making it more difficult to envision alternative future trajectories. Poverty impacts people to focus on short-term goals to secure 'basic' necessities to survive (Counted and Newheiser, 2023). This results in lower expectations for the future, which may be particularly problematic in the context of energy transitions, projects that inherently rely on long-term visions. Moreover, residents are frequently left out of energy-related initiatives due to limited access to relevant information or decision-making processes, which are typically dominated by institutional actors. This disconnect reinforces the exclusion of those already disadvantaged and limits their ability to shape or benefit from local transitions (Walker, 2009).

Finally, these issues are often compounded by risks of displacement. Urban regeneration and energy transition initiatives, when not carefully designed, can fuel gentrification pressures and lead to the exclusion of long-term residents (Golubchikov and O'Sullivan, 2020). In this context, energy transitions risk reproducing spatial and social injustices, rather than resolving them.

To conclude, in underprivileged neighbourhoods, agency – the capacity to make purposeful choices and shape outcomes (Gaupp, Constantino and Pereira, 2023) – is absent and undermined. However, agency is crucial in transformation processes (Westley et al., 2013). At the individual level, agency is shaped by self-awareness and self-knowledge (Novalia et al., 2020). Agency becomes most powerful when it transcends the personal and becomes collective. When individuals pool their knowledge, skills, and resources to actively shape their shared future they can form "transformative agency", which can trigger large societal change (Gaupp, Constantino and Pereira, 2023).

Despite this, current energy initiatives have largely overlooked the role of agency, limiting just transitions. While initiatives such as Renewable Energy Communities (RECs) and Positive Energy Districts (PEDs) claim to enhance participation and tackle energy poverty, their capacity to do so in marginalised contexts remains limited. Although these models promote prosumership and community involvement (Hanke and Lowitzsch, 2020), their implementation often fails to reach those most affected by energy injustice (Hanke, Guyet and Feenstra, 2021). Hanke, Guyet and Feenstra (2021) refer to the "romanticised narrative" of energy communities, while they overlook structural challenges underprivileged communities may face for benefiting from these initiatives. They report that general outreach activities, as well as engagement with underprivileged groups fall short, due to a discrepancy between the recognition of these groups' specific needs and the actual implementation of tailored communication and engagement strategies. Goedkoop and Devine-Wright (2016) emphasise that a crucial step is frequently overlooked: the need to build mutual trust. On the one hand, there is often a lack of confidence in the capacities and agency of residents; on the other, insufficient support from developers or governmental actors can further erode cooperation.

We conclude, based on the research by Hanke et al. (2021), that while energy justice frameworks have thoroughly explored issues of distributional, recognitional, and procedural inequities, they have paid too little attention to the deeper constraints on people's capacity to act, particularly in underprivileged neighbourhoods, where limited agency fundamentally hinders participation in energy transitions. This argument is supported by Damgaard, McCauley and Reid (2022) who argue that for the concept of energy justice to apply, it should emphasise the nec-

essary interconnection of rights, responsibility and agency. This integration is particularly relevant for addressing energy vulnerability, as it acknowledges that enhancing agency requires not just recognizing rights but also enabling responsibilities and capacities for action. Just energy transitions require a focus on people's agencies and relations (Sol Cueva, 2025).

4. Researching with care: a narrative approach

Just energy transitions require a fundamental shift in thinking and practice, driven by collaborative and proactive decision-making processes (Williams and Doyon, 2019). Advancing energy justice requires centring historically excluded voices and prioritising bottom-up perspectives (Elmallah, Reames and Spurlock, 2022). This entails restructuring institutional systems, including how research funding is distributed, how scholarly work is published, and the methodologies employed in energy research, in order to support inclusive and equitable transitions. It requires transformative and emancipatory approaches (Elmallah, Reames and Spurlock, 2022).

We advocate for inclusive, creative, and participatory approaches to energy futures, engaging more directly with everyday lived experiences. Strengthening transformative capacity requires participatory co-creation that recognises individuals as agents of change (Ziervogel, Cowen and Ziniades, 2016). Co-producing knowledge helps overcome stigma by sharing local experiences and leveraging individual actions (DellaValle and Sareen, 2020). True participation treats stakeholders as knowledge holders and experts, valuing diverse wisdom beyond tokenistic involvement (Turhan, Şorman and Larsen, 2018). This may slow development but offers a more equitable pathway to energy justice.

This connects to researching with care, a feminist approach to knowledge production that foregrounds responsibility, relationality, and attentiveness to those being researched (Brannelly, Barnes and Tronto, 2022). This is vital in marginalised contexts, where information is often extracted from communities without return. Residents in marginalised neighbourhoods frequently experience epistemic injustice (Fricker, 2007), where their knowledge and experiences remain invisible due to a lack of interpretive frameworks. Researching with care aims to turn these injustices. It centres on marginalised voices, with experiential and local knowledge at the core of research. By placing lived experiences of oppression, marginalization, and resistance at the centre of knowledge production. Furthermore, it emphasises the need of the researchers recognizing conducting research is itself entails responsibilities, that it should strive towards social change. This requires participatory research methodologies that aim to include the voices of people who have been silenced, muted or devalued (Brannelly, Barnes and Tronto, 2022).

4.1 storytelling for underprivileged neighbourhoods

Against this backdrop, we turn to storytelling as a method that, unlike more traditional single disciplinary interpretative lenses, can reintroduce the messiness of thought, belief, action, emotion and value in living together in the technological world. Storytelling starts from the narratives people craft about their lives, embraces complexity and foregrounds the interconnections between people, places, and experiences. It offers a pathway towards epistemic justice (Brannelly, Barnes and Tronto, 2022).

Storytelling holds methodological and transformative value. It can serve as a tool to stimulate agency among residents (Jørgensen, 2022; Ortiz, 2022) because it enables communities to challenge stigmatised identities and to envision alternative futures (Goldstein et al., 2013; Ortiz, 2022). As energy concepts increasingly emphasise decentralised systems and active citizenship, storytelling helps transform community members from passive consumers to active agents. As Sol Cueva (2025) research with market vendors demonstrated, participants in the storytelling game portrayed themselves as active agents, involved in designing and troubleshooting energy systems, reflecting a shift toward more empowered roles in energy transitions. At the same time, storytelling is a powerful methodological tool for researcher as it can mobilise for social change. In this way, storytelling serves a dual purpose: it contributes to strengthen agency at the community level while also providing a participatory, relational method of research, that aligns with the ethics of care (Brannelly, Barnes and Tronto, 2022).

Storytelling emphasises the act of crafting, of the performance, how a story evolves, based on audience, purpose, and context, and how that can be told in different ways, depending on the context (Sol Cueva, 2025). There are several reasons why storytelling can be an interesting method for just energy futures. Stories are more fixed data points, they help to communicate, influence or engage with different audiences (Moezzi, Janda and Rotmann, 2017).

First, storytelling can emphasise the relational nature of energy and highlight the social dimension of too one-sidedly approached technical systems. Current visions of energy futures often rely on computational models and expert-driven, technocratic methods centred on economic trends and infrastructure. These narrow approaches can exclude diverse voices and result in incomplete, homogenised visions. In response to growing dissatisfaction with these dominant representations, storytelling signals a broader epistemological shift, away from abstract experimentation, expert-driven narratives and a focus on technological innovations. Instead, storytelling can be a tool than can capture the complexities of energy systems and transitions and its interconnection with everyday life (Sol Cueva, 2025). Stories can connect energy with the lived experiences, emotions, aspirations, and struggles of underprivileged communities, enabling a deeper understanding of how infrastructures, fuels and technologies are (and will be) produced, provided, used, and perceived within a given society (Sol Cueva, 2025). This helps to understand that energy use is socially and culturally situated, and that people use energy in different ways depending on their lives, habits, and needs. Yet many policies and technologies treat everyone the same, as if one solution fits all. Interventions respond to a particular way of “the problem” with energy use, instead of looking at how systems could better support daily life. Stories challenge this, understanding energy use in different contexts, and supporting better design interventions (Lockton, Renström and Bowden, 2014).

A second advantage of storytelling is its ability to make energy more visible. Since energy is often perceived as hard to grasp, stories can help to ground it in tangible experiences, helping people to "see energy” (Miller et al., 2015) and bringing policies closer to the public. Moreover, stories offer what Miller et al. (2015, p. 67) call "linguistic currency", to discuss technical issues in more accessible ways. This creates lower-threshold platforms for participation, engaging underprivileged communities in “speaking energy” (Miller et al., 2015, p. 67). Energy literacy significantly impacts public acceptance and participation in transition initiatives (Awolesi, Salter and Reams, 2024).

Third, storytelling has the power to bring people together by creating space for a multiplicity of voices and perspectives, challenging current “mess first, fix later” approach often seen in energy policymaking (Turhan, Şorman and Larsen, 2018). It helps to focus on the neglected things, and to include marginalised perspectives to share counter-narratives (Sol Cueva, 2025). Miller et al. (2015) emphasise that stories can open the conversation to participation by people who may not otherwise feel competent, which can help bring together a wide range of knowledge, insights and perspectives. This helps to democratise the conversation on energy transitions (Sol Cueva, 2025). Furthermore, storytelling holds interdisciplinary and transdisciplinary value. It can engage diverse people with different kinds of knowledge from various fields and with different roles, such as policymakers, industry representatives, and community members (Winskel, 2018; Sol Cueva, 2025). In doing so, storytelling blurs the boundary between lived experiences and expert data (Ottinger, 2017). Storytelling can moreover be a valuable method for bringing communities closer together and building a shared identity. Different stories can contribute to build a collective narrative, that provides insights into the beliefs, values and lived experiences of a community (Miller and Bridger, 2019; Sol Cueva, 2025). In that sense, storytelling can facilitate collaboration. When communities engage in storytelling, they also engage in mutual learning, about their community, technologies and energy practices (Sol Cueva, 2025). This process can support community building (Smith et al., 2017), fostering a sense of collective ownership.

Fourth, storytelling highlights the significance of local contexts in shaping energy systems (Sol Cueva, 2025), which is gaining more and more attention in current policy frameworks, such as Positive Energy Districts (Derkenbaeva et al., 2022), that however have difficulty being implemented in more underprivileged areas (Hearn et al., 2022; Verlooy et al., 2024) due to systemic socio-economic inequalities and socio-spatial complexities. In that light, storytelling can be a tool that helps to anchor energy transitions in local realities (Devos, De Blust and

Desmet, 2018), making it a valuable approach for addressing the implementation gap in marginalised areas. As Devos, De Blust and Desmet (2018, p. 7) argue, "narratives can be a powerful tool to bridge the gap between social and spatial research and local knowledge".

Fifth, storytelling can support imagination, helping underprivileged communities to envision alternative future trajectories (Sol Cueva, 2025). By adopting more fluid and non-linear conceptions of time, storytelling may enable communities to transcend their current constraints or circumstances. It enables them to envision new possibilities, reconnect with past aspirations, and envision radically different futures (Moezzi, Janda and Rotmann, 2017; Sol Cueva, 2025). This ability is particularly valuable in energy futures research, where the aim is often to envision transformative changes (Sol Cueva, 2025).

5. Case Study Watersportbaan

Dedicated to performing doing care-full research, we distance ourselves from social sciences that decontexDedicated to performing doing care-full research, we distance ourselves from social sciences that decontextualise research. Knowledge is inherently situated, rooted in the relational and material conditions that make it possible (Puig de la Bellacasa, 2017). As such, our research does not begin from pre-defined "gaps" in the academic literature. Instead, we align with the view that meaningful research questions often arise from "the real life of affected people", (Brannelly, Barnes and Tronto, 2022). From 2024 till 2025 we have indulged in our case study Watersportbaan, in Ghent, Belgium, having conversations with inhabitants, social welfare workers, energy experts and government officials.

Watersportbaan houses social tenants in high-rise modernist apartment blocks constructed in the 1960s. Residents face ongoing marginalisation and stigmatisation, compounded by deteriorating living conditions. Many of the apartments are in urgent need of renovation, with upcoming redevelopment plans likely to result in large-scale displacement and uncertain housing situations. Additionally, the area is marked by significant challenges related to liveability. Increasing reports of garbage accumulation, crime, feelings of insecurity, noise pollution, squatting, substance abuse, mental health issues, and homelessness reflect a growing sense of social and infrastructural neglect. Furthermore, people working and living in the neighbourhood have highlighted a sense of isolation, partly attributed to the design of the high-rise housing blocks, which limit opportunities for interaction between neighbours. This is further exacerbated by the deteriorating state of public spaces, which lack accessible, welcoming communal or meeting areas. Consequently, the area is characterised by low levels of social capital, foundational for collective action (Ziervogel, Cowen and Ziniades, 2016).

Transformative changes are planned in Watersportbaan, including the construction of a fossil-free heat grid and renovation and demolition of the social housing blocks, leading to large scale relocations of current inhabitants. A visioning plan for the area has described several ambitions that may contribute to transform the neighbourhood to a fossil free environment (Vervloesem et al., 2024). One of the ambitions is to further research and set up a collective heating network on residual heat. Currently this plan, despite still being in an early phase, is initiated by large scale institutions in the neighbourhood, such as the hospital, university campus and the social housing association. In addition to this, the plan envisions the sharing of locally produced renewable energy across the neighbourhood, potentially through the creation of an energy community that enables more equitable distribution. Moreover, the energy transition is seen not merely as a technical or environmental shift, but also as a social lever: a means to empower residents and encourage energy-conscious behaviour. Despite these promising ambitions, such as creating an energy community (Vervloesem et al., 2024), interviews lay bare that there are multiple challenges that may come across in the energy transition of the area.

In Watersportbaan, the energy transition is currently run by large institutional stakeholders that are residing in the area, planning a heating network. However, this risks occurring "over the heads" of residents, with little genuine involvement from those most affected. The social complexities surrounding energy transition and energy poverty remain largely invisible to the institutional frontrunners currently leading renewable energy initiatives in the area. These organizations demonstrate limited insight into residents' actual needs, wishes, or capacities,

often underestimating the potential contributions residents could make if meaningfully engaged. Simultaneously, social welfare workers emphasise that for many residents, the energy transition feels like a distant concern, far removed from their immediate challenges and daily realities. The persistent stigmatization of the neighbourhood and its residents further complicates engagement efforts. As we have discussed above, this can lead to community disengagement and undermine solidarity (McNamara, Stevenson and Muldoon, 2013).

5.1 Situating the research in Watersportbaan

Watersportbaan's current energy future is mainly determined by institutional stakeholders, with residents having little say in their neighbourhood's energy transition, leading to institutional stakeholders overlooking their social realities and impact of the transition on daily life. A storytelling approach emerged as a fitting and necessary method to make visible the complex, situated experiences of underrepresented communities and to democratise energy transition discourses.

To set up storytelling as the research methodology, we follow a similar approach as Devos, De Blust and Desmet (2018) that is based on three iterative phases: 1) identifying narratives, 2) co-constructing storylines and 3) strategic implementations. For the scope of this conference paper, we will focus on the first step, identifying narratives.

As Devos, De Blust and Desmet (2018) describe, entering a neighbourhood requires exploratory research to "get a grip" on its conditions. This was done as part of the CO2PED research project, by conducting interviews, workshops, and organising neighbourhood walks (2024-2025). Based on this, we identified community narratives (phase 1) in relation to energy transitions. These narratives are constructed on 'meta' themes that consistently emerged during the various conversations we had in and about the neighbourhood. They provide a lead for further research and dialogue in the next stages of the CO2PED research project in co-constructing storylines and strategically implementing storylines (phase 2 and 3). In the next section, we deconstruct five narratives from Watersportbaan, connecting them to energy injustices. Drawing on our theoretical framework, we argue that storytelling holds significant potential in addressing the injustices that these narratives lay bare, by enhancing community agency.

5.1.1 Identifying narratives in Watersportbaan

5.1.1.1. narrative 1 – lacking neighbourhood services and meeting spaces

One of the dominant narratives emerging from the exploratory fieldwork in Watersportbaan revolves around the lack of neighbourhood services and meeting spaces. Residents and social welfare workers repeatedly mentioned the absence of places where people can informally gather, share experiences, or simply spend time together. This lack of shared space not only limits opportunities for building social cohesion but also contributes to a broader sense of fragmentation and isolation in the neighbourhood.

Interestingly, the presence of a collective laundromat, one of the few (semi)public spaces in the area, is a narrative that can spark conversations. This symbolises a dependency on shared facilities, reflecting the broader housing model idea in the neighbourhood that is built around collectivity and sharing. However, more and more, this collectivity is disappearing. The laundromat also highlights the everyday use of energy, embedded in routines, which opens up avenues for discussing energy as part of daily life. The laundromat furthermore offers a space for casual encounters and conversations in a rather isolating neighbourhood. However, criminal activity is increasing around the laundromat, moreover, washing here is quite expensive. Therefore, the space is losing its popularity. These seemingly mundane moments reveal deeper socio-spatial dynamics: the limits of public infrastructure, the social consequences of housing precarity, and the reliance on collective systems in a context where collectivity is not meaningfully supported.

Storytelling can make visible the relational and situated nature of energy, revealing the complex interconnection of energy with everyday life. Current energy transition models tend to rely on abstract simulations and expert-led forecasting tools, which overlook the complexity of people's everyday realities (Sol Cueva, 2025). In contrast, storytelling allows us to explore how people in Watersportbaan use, experience, and interpret energy

differently, shaped by their specific housing conditions, cultures, socio-economic situations and socio-spatial situations. Furthermore, researching with care aims to make visible what is often made invisible and devaluated, such as washing as housework.

5.1.1.2. narrative 2 – deburdening social renters

Another dominant narrative used by policymakers, the housing corporation or energy experts is the need of deburdening the inhabitants, by reducing the responsibilities, pressures, or expectations placed on them. The planned implementation of a heating network, while intended to contribute to more sustainable energy provision, is mostly discussed in highly technical terms, dominated by expert-led discourse and engineering logic. Residents so far have not been involved in this process. They argue that social renters must be completely deburdened, however, this has contributed to the idea that that energy systems are "not for them to understand or question", and that "experts know best".

This approach can be seen as patronizing. It risks underestimating the knowledge and capacity based on lived expertise of local inhabitants. This technocratic approach ignores the socio-cultural dimensions of energy use, reducing residents to passive recipients of infrastructure rather than active participants in shaping their energy futures. As a result, engagement can be discouraged, with eroding agency as a consequence.
Storytelling can help to reframe the technical conversation, to make energy more visible and relatable, not as an abstract system, but as part of everyday life. In a neighbourhood where many feel excluded from formal planning processes, this is particularly important. Stories about comfort, cold, control, costs or worries can help residents to articulate their needs, experiences, and priorities. These stories surface understandings of energy systems that are often dismissed as anecdotal and irrelevant, yet they are important for designing just interventions. Moreover, storytelling resists the potential patronising logic of deburdening through valuing input based on local experiences.

5.1.1.3. narrative 3 – lacking sense of collectivity

There is a narrative in Watersportbaan of lacking collectivity, which limits the neighbourhood's ability to engage in community-driven energy transitions. As we discussed earlier, Watersportbaan is marked by limited meeting spaces and a lack of infrastructure that boosts social interaction. Residents and social workers repeatedly spoke of a widespread sense of disconnection, not only from one another, but also from the future of the neighbourhood. This is closely tied to the morphological layout of the area: high-rise social housing blocks with vertically compartmentalised corridors limit interaction between neighbours. The declining public space contributes to feelings of isolation and disconnection. Both inhabitants and other stakeholders involved in Watersportbaan feel that this neighbourhood is isolating, which, as a result, undermines social cohesion, vital for collective agency.

At the same time, Watersportbaan has evolved into what might be described as a marginalised tenant enclave. Residents live in deteriorating apartments, with outdated energy infrastructures. They face social stigma attached to poverty and public housing. Coupled with the looming uncertainty of future renovations and possible relocation, this erodes place-based attachment. With little sense of belonging and minimal incentive to engage in collective projects, it becomes increasingly difficult to imagine a shared energy future.

In this fragmented social context, storytelling holds transformative potential. It can create inclusive spaces for dialogue where a multiplicity of voices and perspectives are not only welcomed but actively shape the conversation. Stories open up energy conversations to those who may not feel competent to participate, thus lowering the barrier to engagement and democratising the discourse. Storytelling enables residents to build a collective narrative that reflects shared concerns, values, and hopes. In doing so, storytelling can function as a community-building practice in Watersportbaan, capable of strengthening collective identity and agency.

5.1.1.4. narrative 4 – "no man's land"

The area in Watersportbaan has been narrated as being a "no man's land" (Vervloesem et al., 2024). The neighbourhood's isolating feel, as described above, due to lacking services, high rise fragmentation, and neglected

public space in between the high-rise towers. However, due to its morphology, multiple opportunities arise for sustainable energy infrastructures.

Beyond the physical landscape, this “no man’s land” narrative also reflects deeper mismatches. There is a disconnect between local needs and the objectives of supra-local actors involved in neighbourhood transformation. Large stakeholders, including housing providers and policy institutions, often pursue energy transition goals, such as the implementation of heating networks or district-wide retrofits, without grounding them in the realities of local life. As a result, energy-related decisions are driven by abstract targets or financial incentives, while local knowledge and everyday energy needs remain undervalued or ignored. Social welfare organisations, which could potentially play a key bridging role, face limitations: energy transitions are treated as technical domains outside their expertise, and they lack the resources, time, and mandate to engage meaningfully.

In this context, storytelling can be a method that can re-anchor energy transitions in local realities, showing that neighbourhoods are not “blank slates”. Storytelling helps to bridge the gap between expert-led visions and local, experimental knowledge, creating space for residents, social workers, and overlooked voices to express their energy needs and aspirations in accessible ways. Storytelling supports the significance of place in shaping energy systems, enabling to approach energy transition in a context-sensitive way. Moreover, by allowing for diverse perspectives and counter-narratives to be shared, storytelling challenges power asymmetries. It can help build mutual understanding among residents, social actors, and institutional stakeholders, creating a common ground where collaboration becomes possible.

5.1.1.5. narrative 5 – living in limbo

Another dominant narrative that emerged during our fieldwork in Watersportbaan relates to the difficulty of involving residents in shaping the energy future of their neighbourhood. As the literature suggested, poverty tends to orient people's attention toward short-term survival, making it harder to invest in or even imagine long-term goals. This disengagement is further deepened by the uncertainty surrounding large-scale renovation and relocation plans in the neighbourhood. The apartments in Watersportbaan are in urgent need of renovation. Many residents of social housing live with the expectation that they may soon have to move, as their homes are scheduled for demolition or upgrading. This "living in limbo" creates a fragile connection to place and very little incentive to participate in decisions that shape the future of the area.

In this context of uncertainty and the resulting disengagement, storytelling can offer more than just a method for collecting data, it can be a tool for reclaiming imagination and reconnecting people to future possibilities. Storytelling can allow communities to envision alternative trajectories beyond their current constraints. Especially when people are “living in limbo,” storytelling provides a way to move beyond linear conceptions of time, empowering residents to hold on to past aspirations, interpret the present differently, and creatively imagine new futures.

Storytelling can help to break through deterministic narratives of decline. It can revisit hope, shifting the focus from imposed futures toward those imagined by the community itself. Whether grounded in actual life experiences or speculative scenarios, stories can inspire agency and support a sense of ownership over the future, even in a context marked by displacement and instability.

5. Conclusion & planned research

This paper examined energy justice limitations in addressing structural barriers faced in underprivileged neighbourhoods during energy transitions. While the three-tenet approach offers a valuable framework, it often overlooks the foundational issue of limited agency in marginalised communities. In these neighbourhoods, residents face compounding processes that restrict their capacity to envision and participate in energy transitions: socio-material inequalities manifest in poor housing conditions, dense urban morphologies limit renewable integration opportunities, stigmatization leads to community disengagement, and institutional stakeholders often

implement initiatives with limited understanding of residents' needs.

Guided by feminist care ethics, our research in Watersportbaan (Ghent, Belgium) reveals a significant disconnect between institutional energy transition ambitions and local realities. We propose storytelling as a transformative methodology that can strengthen collective agency by emphasizing energy's relational nature; making energy more visible and accessible; creating platforms for multiple voices; highlighting local contexts; and supporting the imagination of alternative futures. Storytelling positions community members as active participants rather than passive consumers, bridging the gap between transition plans and local knowledge.

This paper only describes the first stage of a research trajectory that will unfold in future research in Watersportbaan. We identified five key narratives in this neighbourhood—lacking neighbourhood services, disempowering deburdening approaches, eroding collectivity, a "no man's land", and uncertain living conditions—that erode community agency. We highlighted how storytelling may counter these dominant narratives. In the second phase of our research, we plan to use these narratives as conversation starters, co-constructing storylines with inhabitants, aiming to eventually strategically implement them into the neighbourhood transition plan. Based on the personal stories and experiences of residents we have collected by initiating low-tech actions, we aim to break stereotypes and narrow the gap between the policy makers, social housing associations and energy experts initiating the energy transition of Watersportbaan.

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Special Session 2

A Community Out of the Box: Understanding Flexibility and Justice through Self-organised Housing in the Netherlands

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Abstract
The article examines the Roma community at De Witte Plas, Netherlands, as a case study of informal, self-organised housing practices that resist dominant corporate systems. Through a combination of fieldwork, design-driven research, and collaborative workshops, the study explores how community members creatively reconfigure containerised housing using recycled materials and digital platforms. Framed through the dual meaning of flexibility, the article argues for informality as a strategic, emancipatory paradigm. It proposes a reconceptualisation of migrant workers' housing that highlights user autonomy, adaptability, and social embeddedness, challenging the limitations of institutionally regulated models like flexwoningen.

Keywords: flexibility, self-design, workers' housing

Introduction

In their book *Informal City: Caracas Case*, Brillembourg and Klumpner investigate the informal processes supporting spontaneous urbanisation, seeking to identify the implicit logics and structures that organise what might initially seem as disorder (Brillembourg, Klumpner, 2005, pp. 16-23). Crucial to their analysis is the concept of flexibility, framed as a model of self-organised development that challenges conventional planning approaches and is manifested in the adaptive construction practices characteristic of informal settlements (Brillembourg, Klumpner, 2005, pp. 248-259).

In recent times, however, the concept of flexibility has shifted to a more restrictive meaning, primarily addressing housing emergencies. Temporary, mobile, modular, containerised, and prefab became synonyms of flexible. In the Netherlands, *flexwoningen* (flexible housing) are designed to accommodate migrant workers and defined by containerised and temporary nature. These units can be "moved, stacked, connected, or split," provided that at least "one of the following aspects is temporary: the house itself, the occupation through temporary lease, or the location" (Housing Expert Team, 2021). This narrow definition, focused on mobility and temporariness, implicitly excludes user adaptation and self-design.

The efficiency criteria of *flexwoningen* and the design of dormitories as simulacra of vacation accommodations enable employment agencies to consolidate their pervasive presence and maintain constant surveillance. By reducing inhabitants to a condition of "bare life" (Agamben, 1998, pp. 21, 169-170), workers' housing seems instrumental in developing a disciplinary code to educate the workforce. Agencies control workers' lives through inspections, warnings, and organising shifts and transport via algorithms. These coercive practices reveal the oppressive and panoptical nature of workers' housing, where hyper-rationalised layouts amplify workers' stress (Sgolacchia, 2023). A relevant example is the orthogonal grid layout of mobile home parks, which enables a complete view (fig. 01). Security officers and agencies' personnel can monitor the entire outdoor area simply by walking along the site's perimeter, while the layout offers no blind spots in the field of view of surveillance camera. This spatial arrangement transforms the campsite into a fully observable environment, revealing the disciplinary logic embedded in its design.

Stichting Normering Flexwonen (SNF) regulates the architectural standards of migrant workers' housing, defining the "minimum requirements for liveability," such as square meters per person, cupboard volume, and bed dimensions (SNF, 2022, pp. 5-8). A prefabricated mobile home, which workers usually call a "bungalow" or "chalet," typically includes three bedrooms, a bathroom, and a living room with an open kitchen, housing three to four people. In this type, the SNF estimates the minimum space for a single room at 3.5 m^2, specifying that such fig-

ures are largely based on guesswork and intuition.[1] This approach reveals SNF's insensibility to the lived realities and needs of inhabitants, regulating only the minimum thresholds for liveability.

By contrast, the Roma community at De Witte Plas, a campsite in North Brabant, close to the Belgian border, represents an emblematic case of informal spatial reconfiguration and self-designed housing, subverting dominant corporate architectures in the Netherlands. Mario and Lavi, two Roma individuals from Bistrita-Năsăud county in Romania, arrived in the Netherlands in 2020.[2] After initial work experiences under the control of recruitment agencies, they emancipated themselves finding alternative accommodation outside the agencies' system and living with their children, who are excluded from workers' dormitories and often left in the country of origin. Having reached an agreement with De Witte Plas campsite owner, they settled there with their families and invited relatives and fellow villagers from across Europe. Currently, the Romani community comprises almost three hundred residents at the campsite of which nearly a hundred primarily work as pickers at Bol.com, a major Dutch webshop, in its distribution centre in Waalwijk. Functioning as a de facto trade union, the community collectively negotiates directly with factory management on specific requests and employment conditions.[3] The community's informal approach is exemplified by their resistance to the dormitory labour regime and their self-construction of homes, adapting and extending standard containerised units to house newcomers (fig. 02).

Objectives

The article explores the Roma community's practices within broader theoretical debates on flexibility and informal architecture, emphasising their relevance in reimagining contemporary urban forms. These practices, including self-planning, recycling and sourcing building materials, and the negotiations of labour conditions, challenge the rigid models of workers' housing conceived and imposed by agencies and regulated by SNF.

By actively subverting the formal systems that govern their lives, the Roma community embodies Adrian Forty's concept of "flexibility as a political strategy" (Forty, 2000, p. 147). According to him, this notion of flexibility emerged as a countermeasure to the capitalist control of space, which limits individual freedom by compartmentalising domestic life, leisure, and work into distinct functional zones, transforming them into commodified spaces with exchange value (Ibidem). Forty analyses the Situationist International's "appropriation of existing buildings with predetermined uses" in the late 1950s and Henri Lefebvre's "resistance to dominated space" theorised in his 1974 book, The Production of Space (Ibidem). These examples demonstrate a collective pursuit of "freedom of use," promoting the reinterpretation of buildings and cities beyond their prescribed functions (Ibidem). In this sense, flexibility is not merely an architectural feature of buildings, but a political act to adapt spaces for diverse everyday uses.

The main hypothesis of the article is that, by rejecting the compartmentalisation of life into rigid functions, typical of *flexwoningen* designed to optimise profit and control labour, the community's informal strategies demonstrates how workers' housing can be reconfigured into adaptable, circular, and participatory frameworks that better respond to the inhabitants' needs. In other words, how containerised housing types can be repurposed into truly flexible dwellings.

The community's approach emphasises the appropriation and transformation of existing buildings and resources by users, who apply flexibility and multifunctionality as tools of collective care and resistance. The article seeks to position these self-organised practices as an emancipatory response to the pervasive systems of control embedded in the Dutch corporate housing regime, while also integrating the community's practical, tacit knowledge into architectural research.

1 Interview with Jolet Woorders, the secretary of SNF, 8 December 2022.
2 Interview with Mario, 2 July 2022.
3 Ibidem.

Furthermore, the article argues for a reconceptualisation of the boundary between formal and informal architecture, proposing a hybrid paradigm in which user autonomy, adaptability, and social embeddedness are central to the design of inclusive environments.

Methods

The adopted method combines field study and design-driven research. Data were collected through spatial analysis and fieldwork conducted in the spring of 2024, including a series of qualitative interviews at De Witte Plas campsite with the inhabitants. In addition, a 12-minute documentary filmed on site offers a visual impression of community life.

Engaging in a research-by-design process involves using design not just as a problem-solving activity or a means of architectural production, but as a method for inquiry and exploration.[4] Collaboration with the Romani community took the form of workshops focused on their spatial practices, emphasising the role of negotiations and the potential of their architectural tacit knowledge. As part of this process, I briefly reconstructed the community's informal approach, particularly their strategy for extending containerised units and optimising resource flows. Drawing, as a visually-oriented experience, served as a medium for mutual learning and knowledge exchange during these workshops.

To develop the design-driven investigation, I selected a specific case study: the home of Mario's family, which exemplify a typical construction process initiated by Roma people at the campsite. Mario methodically organised the project into five phases: purchasing a mobile home on the site, storing building materials, preparing the extension, constructing internal partitions, and installing a roof. This progression illustrates the transformation of a rigid, containerised unit into a self-designed, adaptable dwelling, highlighting the community's capacity to manage complex logistical operations and produce sustainable, inhabitable space (fig. 03).

A defining feature of the Roma community's informal approach is their strategic activation of existing logistical functions embedded within digital platforms. As Clare Lyster argues, apps that mediate between users and urban systems offer an interesting model for sharing infrastructure and goods (Lyster, 2016). The community's use of classified advertising platforms such as Marktplaats and Facebook Marketplace, augments access to recycled building materials and second-hand furniture. They benefit from these platforms to employ the material surplus of other users, selecting listings within a 50 to 100 kilometre radius of De Witte Plas, and linking otherwise disconnected basements, storages, and depots into a distributed supply network. The community subverts the platforms' profit-driven models, which rely on listing fees, advertising, and subscriptions, by sourcing materials free of charge, typically from private homeowners, and bypassing paid services entirely.

The construction of Mario's home exemplifies the community's resourcefulness and its strong collective commitment. The project involves eight months of planning, namely researching, negotiating, purchasing, transporting, and storing materials, followed by one-month of on-site construction. Mario, his son Edy, and other community members rolled up their sleeves to participate, transforming the project into a shared endeavour and a powerful symbol of self-sufficiency.

Discussion

This building process illustrates two key outcomes. First, it disrupts the agency-imposed logic of containerised housing by demonstrating how rigid, prefab units can be reconfigured into adaptable dwellings. Second, it emphasises the broader social cohesion that emerges from these construction efforts. The focus extends beyond individual homes to include forms of social aggregation and collective infrastructure within the campsite. At De Witte Plas, the Roma community has established mutual aid systems, collective bargaining practices, and knowledge-sharing networks, functioning as a civic organisation. These mechanisms challenge the isolation typical of migrant workers' housing and their impact contribute to include forms of social aggregation and the creation of

4 The research-by-design method is extensively investigated by the CA2RE+ seminars. See for instance one of the publications: *CA2RE+ Delft Recommendation, Book of Proceedings*, (TU Delft: Open Publishing, 2023).

shared facilities within the campsite. Considering the lack of formal public spaces, shared outdoor areas of the campsite have been informally repurposed for rituals, celebrations, religious ceremonies, and communal childcare, creating vital nodes of everyday life and cultural expressions.

To better understand this self-organised process, the notion of the architect as a bricoleur, as developed by Irénée Scalbert, provides a clear analogy for understanding the Roma community's informal. Scalbert describes the bricoleur as "at once designer, builder, and user," characterised by "improvisation, resourcefulness, and adaptability," someone who creates something new using whatever materials or tools are at hand, often operating outside formal, conventional practices (Scalbert, 2011). He introduces this figure from Claude Lévi-Strauss's distinction between the bricoleur and the engineer, developed in his 1962 book La Pensée Sauvage (The Savage Mind): while the engineer subordinates materials to a predefined project, imposing a conceptual framework on reality, the bricoleur, by contrast, adapts their design to a specific and limited inventory and recycles the remains of older projects in response to present needs (Ibidem).

Like Scalbert's *bricoleur*, the Roma community operates in an environment of constraint, where access to conventional building materials and institutional support is limited. They creatively respond to these limitations reconfiguring available resources through online platforms and adapting second-hand materials and tools to fit their immediate needs. This process mirrors the bricoleur's method of assembling disparate elements into a coherent whole, constructing meaningful spaces from what others might consider unusable or insignificant. This ability to work fluidly with what is at hand demonstrates a deep flexibility, a peculiar quality of Scalbert's *bricoleur*.

De Witte Plas emerges as a key site of alternative and informal architecture, shaped by what Edwin Buitelaar calls the "spontaneous order" of a "free society." This concept stands in contrast to a "designed order," which typically involves nationally-operating developers, active land-use policies, and formal zoning regulations (Buitelaar, 2020, pp. 38-39). Spontaneous order, by contrast, relies on minimal and generic building regulations (Ibid.). In such contexts, social and spatial order emerges organically, without a central organising authority, and inhabitants establish rules to prevent unjust actions between individuals (Ibid.). At De Witte Plas, familial and neighbourly connections among residents help regulate relations and prevent injustices, reinforcing the principles of spontaneous order and showing its practical implications in creating a just and supportive community.

Scholars argue that institutional frameworks must meet certain justice requirements, such as establishing fundamental freedoms and equal rights (Buitelaar, 2020; Moroni, 2019). In this particular conceptualisation of the just city, the Roma community achieved a significant progress when they successfully registered their residency with the municipality of Schijf in 2020.[5] This registration marked a key moment, as the spontaneous order at De Witte Plas emerged primarily from the community's own initiative rather than from institutional planning. Nevertheless, the municipality played a crucial role by formally recognising and certifying the community's desire to reside at the campsite, thereby guaranteeing their freedom of choice.

Conclusions

The findings reveal the Roma community's capacity to negotiate autonomy within the constraints of global logistics and labour systems. Their housing practices, rooted in circular economy principles and participatory design, demonstrate how informal architecture can create adaptive, fair, and resilient environments. This case study contributes to understanding informality as a strategic paradigm, offering insights into the transformative potential of grassroots action. It suggests urban planning frameworks that foster community agency, flexibility, and sustainability, redefining justice and equity in spatial arrangements.

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5 The old leadership of the Schijf municipality was kind and supportive, unlike the new one that has been intolerant for two years.

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Images

Fig. 01 Typical mobile home park to accommodate migrant workers, North Brabant region, Netherlands. Photo by the author.

Fig. 02 Roma community at De Witte Plas camsite, North Brabant region, Netherlands. Photo by the author.

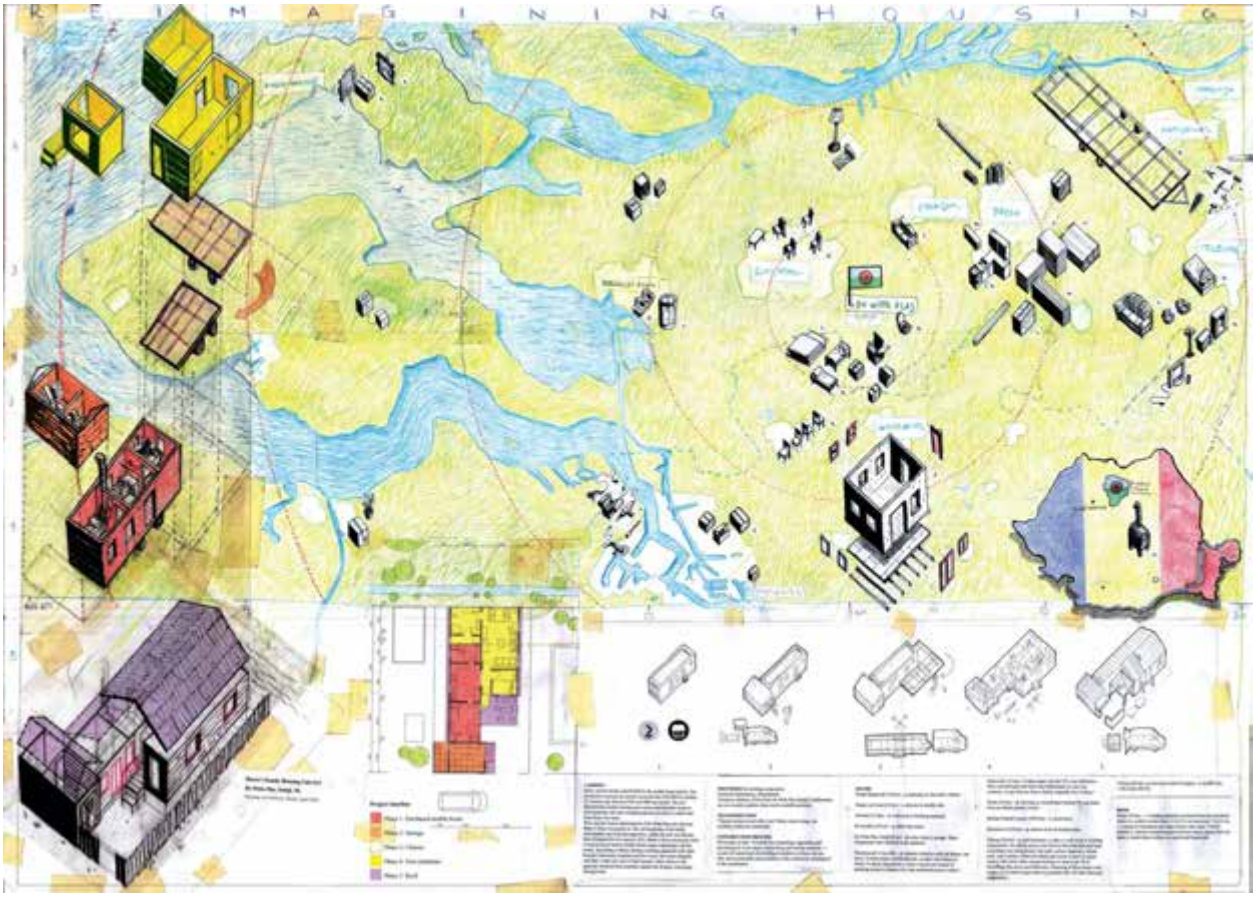

Fig. 03 Outcome of the design-driven research and collaborative workshops at De Witte Plas. Drawing by the author.

AESOP 2025 CONGRESS
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Water justice, scarcity and environmental flows. The case of Marseille

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Abstract
In the context of the present global ecological crisis, water emerges as one key element to take care of for avoiding a planetary ecocide. The link between water scarcity, justice and environmental flows is explored, opening to a more-than-human perspective and recognising the connection between water biopolitics and urban design. The Mediterranean context is identified as a hotspot for investigating these intertwined themes, with the city of Marseille as a relevant case study. The territorial scale water system is described in relation to water justice, present conflicts and future perspectives. Finally, the features of the urban area are presented in relation to issues and opportunities linked to possible transformations towards a more circular and just water metabolism for the city and the surrounding territory.

Keywords: urban political ecology; water biopolitics; ecological commoning

Introduction

An unprecedented anthropogenic water crisis is hitting the planet, with a responsibility for spatial design disciplines that is strongly related to distribution and justice, and that requires re-thinking some of our perspectives on water management. After exploring the global context and the Mediterranean region, the city of Marseille is investigated for its paradigmatic water system and challenges driven by growing scarcity. The choice of a city as study case is related to the fact that urban areas – albeit in connection with their 'planetary hinterland' (Brenner & Katsikis 2020) – are more than ever the hotspot of energy consumption and global warming generation, so that for imagining a more sustainable future we need to investigate urban environments and metabolism. More-than-human justice perspective is introduced starting from the concept of 'environmental flows', not only for taking 'water's side', but also because in urbanism this perspective is emerging as a key "to avoid a planetary ecocide" (Fieuw et al., 2022). For a comprehensive understanding of the city's ecologies and flows it is then fundamental to enlarge the scope of urban ecology studies to the territorial context (Grulois et al., 2018). For this reason, examining water justice issues with a spatial lens requires to embrace a wide enough area – in relation to water catchments – rather than concentrating on a 'city proper' close-up. At the same time, the shapes, the devices, the surfaces and the materiality of the city – and of landscapes and infrastructural systems – define the environment and the possible flows of water, other matters, and lives. For these reasons it is interesting to look at multiple scales, considering certain city spaces, the urban metropolitan area, and the wider territorial context.

Water scarcity in the global and Mediterranean context

In the context of the present ecological crisis and worsening global warming, addressing the issue of water justice, access and distribution is most compelling. Freshwater is a biologically necessary and irreplaceable substance for all terrestrial life, so that its access is universally considered a basic need and a fundamental human right. The attention towards this theme is underlined by its prominent involvement in international programmes and policies. Indeed, one of the Sustainable Development Goals (SDGs) agreed by the United Nations in 2015 is specifically dedicated to freshwater access ('Goal 6: Ensure availability and sustainable management of water and sanitation for all') and water availability is closely connected to most other SDGs' themes[2], which

1 This paper and related research have been conducted during the Italian inter-university PhD course in sustainable development and climate change (link: www.phd-sdc.it)

2 Survival of life on Earth is undeniably linked to water, therefore any quest for sustainability needs to take its availability and quality into account. In particular, it can be argued that at least 14 out of 17 SDGs have strong connections with water distribu-

are dealing with food, health and equality, energy and goods production, ecosystems, sustainability and climate (UN, 2024a). Furthermore, one of the nine 'Planetary Boundaries' set for monitoring the anthropogenic pressure on the so-called Earth system is 'Global freshwater use' (Rockström et al., 2009), more recently reframed as 'Freshwater change' in order to "comprehensively reflect anthropogenic modifications of Earth system functions of freshwater changes[3]" (Richardson et al., 2023). Also in this case many of the other 8 indicators have a strong connection with water depletion or with its renewal cycle, as on top of being related to the availability of freshwater for human consumption, they also affect climate regulation and ecosystems[4].

Given this framework, when tracking the overall progress of the SDGs and the anthropogenic pressure on the Earth system it seems clear that present policies and actions are ineffective: the latest SDGs progress report states that "the world is severely off-track to achieve the 2030 Agenda" (UN, 2024b), and 6 out of 9 Planetary Boundaries were transgressed as of 2023, delineating a worsening trend compared to previous updates and reflecting "unprecedented human disruption of Earth system" (Richardson et al., 2023). If we look at the Freshwater change indicator, globally "Transgressions of both the blue and green water boundaries occurred a century ago", however according to this world-scale quantitative approach the control values haven't reached the 'High risk zone' yet (ibid.); moreover, looking at a more comprehensive perspective on water and sanitation actions' progress, the latest SDGs report by the UN (2024b) states that "None of the SDG 6 targets are on track to be met", with some of them improving too slowly and others stagnating or even regressing, including exposure to water stress. In the end, despite the recognition conceded by official international organisations and the academic world, "The world is facing an unprecedented water crisis. [...] one-quarter of the world's population [is] currently exposed to extremely high water stress annually" (Kuzma et al., 2023).

In the referenced documents the concept of 'water stress' refers to a condition in which water availability (also in terms of quality and ecological flows) cannot cover the "human and ecological demand" in a given moment; 'water scarcity' is instead the mid-term occurrence of a stress condition, a "consequence of anthropogenic impacts on the availability of water resources" happening when human exploitation of water exceeds the sustainable supply in a context (EEA 2021). Water scarcity is therefore directly linked to anthropic processes and their environmental pressures. For this reason, while drought events (essentially linked to precipitation deficit) can exacerbate water shortages, the concept of water scarcity is the preferred lens for investigating the territorial dynamics of dryness as linked to spatial transformations. It follows that understanding the relationship between water distribution, its depletion, and the climate-related dynamics that undermine its availability is of foremost importance – and it is fundamentally a matter of justice: "the scarcity at the heart of the global water crisis is rooted in power, poverty and inequality, not in physical availability" (UNDP, 2006, p.2).

The Mediterranean region is a particularly relevant study area for the relationship between global warming related

tion and ecosystems, including: 1. No Poverty, 2. Zero hunger, 3. Good Health and Well-being, 5. Gender Equality, 6. Clean Water and Sanitation, 7. Affordable and Clean Energy, 8. Decent Work and Economic Growth, 9. Industry, Innovation and Infrastructure, 10. Reduced Inequalities, 11. Sustainable Cities and Communities, 12. Responsible Consumption and Production, 13. Climate Action, 14. Life Below Water, 15. Life on Land. On top of this, also Education and Peace (Goals 5 and 16) are cited as key elements in the UN 'World Water Development Report 2024: Water for Prosperity and Peace' (UN, 2024a)

3 "streamflow [is used] as a proxy to represent blue water (surface and groundwater) and root-zone soil moisture to represent green water (plant-available water). […] The new green water component directly accounts for hydrological regulation of terrestrial ecosystems, climate, and biogeochemical processes, whereas the blue water component accounts for river regulation and aquatic ecosystem integrity" (Richardson et al., 2023)

4 "Global manipulations of the freshwater cycle affect biodiversity, food, and health security and ecological functioning […]. Threats to human livelihoods due to deterioration of global water resources are threefold: (i) the loss of soil moisture resources (green water) due to land degradation and deforestation, threatening terrestrial biomass production and sequestration of carbon, (ii) use and shifts in runoff (blue water) volumes and patterns threatening human water supply and aquatic water needs, and (iii) impacts on climate regulation due to decline in moisture feedback of vapor flows (green water flows) affecting local and regional precipitation patterns." (Rockström et al., 2009). Freshwater use/change is therefore linked to: Climate change, Biogeochemical flows (and previously chemical pollution), Biosphere integrity (previously biodiversity loss), Land system change.

climate change, water scarcity and water justice. According to the 6th IPCC report (2023, p. 2253) "climate models consistently project regional warming at rates about 20% above global means and reduced rainfall (-12% for global warming of 3°C)", so that the area can be considered a 'climate change hotspot', also "due to the high exposure and vulnerability of human societies and ecosystems to these changes"; the report particularly underlines the resulting water-related issues, for "rising temperatures trigger extensive [...] evaporation [which] leads to shrinking water resources on land, direr soils, reduced river flow, and significantly longer and more intensive drought spells". Associated risks include "important and increasing water shortages, already experienced by 180 million people" and "growing demand for water by agriculture" (IPCC, 2023, p. 2254), on top of the reduction of all wet surfaces and related ecosystems. The projections draw the worrying picture of a region severely affected by water scarcity, with higher demand also due to an increasing population and mainly located in coastal areas, where sea level rise will entail additional scarcity dynamics linked to aquifers and soils salinisation and loss of terrestrial ecosystems (MedECC, 2020). The MedECC report (ibid., p 206) also notes that "future increase in human activities [...] may have more impact on water demand than climatic changes", underlying the anthropic source of water scarcity, where (anthropogenic still) global warming is only a worsening factor.

Water (in)justice and biopolitics, a spatial perspective

In the Mediterranean, as elsewhere and globally, water availability is unequal at the regional scale – with around 73% of renewable freshwater resources held by northern countries (MedECC, 2020) – as well as within societies and territorial ecologies. Indeed, the IPCC (2023) observes how water and food scarcity affects disproportionately women and children in urban areas, and especially disadvantaged social groups. This inequality is worsened by 'climate injustice' (Otto, 2025), which links the impact of global warming and social injustice from the global to the local scale, as for example vulnerable communities can often afford to inhabit only the highest risk (and cheapest) areas: there is therefore a strong link between these dynamics and spatial justice issues (Soja, 2010). The unequal water distribution and quality that are provided (for example to low-income areas and informal settlements) are a form of social and spatial injustice, so that in the context of global warming and increasing scarcity, water justice (Boelens et al., 2018) becomes a central issue to climate, social and spatial (in)justice: water is so vital that "hydraulic infrastructures can shape social relations and mediate power" (Mukerji, 2022). Forms of social and spatial injustice are complex and rooted in the present socioeconomic and ecologic system of power – defined by Moore (2017) as Capitalocene – and its pervasive planetary production dynamics, linked to the exploitation of 'nature' (i.e. land, materials, flows) and lives (Brenner & Katsikis, 2020; Patel & Moore, 2020). These processes have consequences on spaces at different scales, bringing forward the political nature of spatial transformation. As Soja (2010) points out we are 'spatial beings', as we exist in space, shape and are shaped by space, therefore spatial transformations are inherently political, and they influence (in)justice relations. Territorial transformations linked to water become a crucial lens for investigating spatial justice, as much as the spatial perspective is fundamental for describing and tackling the theme of water justice.

While water control has always been a key concern for societies, growing scarcity dynamics are triggering novel social and geopolitical conflicts worldwide – and at the same time water deprivation is being used as a weapon (Secchi, 2010; UN, 2024a), as in this moment in the Mediterranean, within a long tradition of colonial territorial processes. It is important to notice that the use of water as a population control tool (hence biopolitical, in the Foucault's sense) isn't an incidental event, and it can be linked to the development of territorial rationales instead – which in certain contexts are constructed for and by colonial exploitation practices (Bandieramonte, 2013). Indeed water systems, in terms of infrastructures and governance, need to be "critically scrutinized in terms of their attempts at governing life and the distinctions they make between different forms of lives", as water and its allocation is "inherently political and, more specifically, biopolitical" (Hellberg, 2018, p.1). Spatial design disciplines – and European urbanism in particular – take part in this biopolitical action, planning such infrastructures on top of defining populations' spatial distribution and land use (Secchi, [2014] 2015), therefore 'making space' for humans and non-human lives and matters alike.

Water justice and environmental flows

The study of the relationship between water scarcity and spatial justice should not actually be restricted to the

human society, as freshwater is essential to all terrestrial life forms, and their survival (human species included) depends on the biosphere as a whole. From this point of view, it can be noticed that actions and projects related to water biopolitics often represent an example of multispecies injustice, as 'water justice' (and water distribution) are mostly linked to human needs and consumption. This is part of the same anthropocentric perspective entailed in the concepts of 'resources' and 'scarcity': these cannot be applied to the territory unless a human relationality is put in place (Dematteis, 2014). The two concepts are therefore relational – a 'resource' exists when it is functional to a demand, and it is 'scarce' only when there is not enough for satisfying a certain demand – and exist because of the dualistic society/nature 'metabolic rift' at the base of capitalist exploitation (Moore 2014). Forms of water (in)justice that go beyond human consumption can be searched in the concept of 'environmental flow', which since the 1980s has emerged to determine the 'minimum' river flows for maintaining the riverine ecosystem; the concept has since then evolved, and while initially it was limited to defining the minimum water stream necessary for the survival of a particular species, it came to encompass multiple aspects of a river's 'health', including indicators such as the interaction with the surrounding terrestrial environment, water quality, sediment presence, temperature and human pressures (Morrison & Bray, 2019). The point of view (which is the same of the mentioned notion of 'water stress' that also includes "ecological demand" – EEA 2021) expressed in the 'environmental flow' related literature is anyway anthropocentric and deterministic. In this literature, the river's 'health' is important because it is related to its 'direct and indirect' benefits for humans, which comprehend the 'Ecosystem Services' (ES) provided to human society (Gebreegziabher et al., 2023); the determination of what is the minimum flow for a river to be 'in good health' infers that the river should be measured and that a certain amount of water in it can be 'enough' or not for a function defined by humans.

It has been argued that a change in perspective by embracing multispecies justice is key to achieve also a fair society (Chao, 2022), therefore we need to enlarge the scope of spatial and water justice for a truly and comprehensively sustainable future. The yet more inclusive and open concept of more-than-human justice can enlarge justice's subjects from the biosphere to also include water itself. More specifically, a 'political ecology of things' perspective can foster an ethical behaviour towards the world as a whole, because harming one part of the interconnected 'web' means harming oneself; widening and changing the notion of self-interest may be a positive way to change our way to inhabit the planet, opposite to the "image of dead and thoroughly instrumentalized matter", i.e. resource to be exploited and consumed (Bennett, 2010, p. X). In this perspective, water and its agency should be regarded as a 'vibrant' matter with a value in itself that transcends the functions linked to anthropic processes: rather than calculating a minimum 'environmental flow' that is strictly functional to human processes, we may have to reflect on how to limit ourselves to a 'minimal extraction flow' while aiming at a 'non extractive metabolism' altogether as a form of care towards the water systems and related ecologies. Indeed human action can also be positive with regards to water ecologies, with actions that reinforce and extend the interaction between soil and water instead of letting it run off quickly; these practices (for example traditions linked to water retention and oases formation in dry climates) have aspects of circular metabolism, as sustainable use of freshwater allows for its renewal while keeping an ecological balance (Watson, 2019) in antithesis with linear extraction and depletion metabolic processes of modern western urban areas.

In recent decades, juridical systems around the globe have increasingly recognised water bodies' rights with the intent of protecting their ecosystems, as part of a wider trend that is granting legal rights to the environment. For example, New Zealand, India and Colombia have recognised a number of rivers as 'legal persons' – with a common feature, the existence of 'environmental water managers', human groups that advocates for the non-human subject's interests and rights (O'Donnell, 2018). In modern legal systems, water bodies can paradoxically weaken their stand by achieving such rights, for example with a "shift in language used to describe the aquatic environment, from a legitimate need for water to 'just another user' of water" (ibid.), therefore it's complicated to grant more-than-human water justice even when water bodies enter the society's juridical system of rights. Environmental water managers are part of broader and complex governance systems, often working within frameworks such as multi-actor river contracts, in which water use conflicts arise and are settled by stakeholders – with legal regulations often lacking some aspects of protection, for example in relation to groundwater pollution or the comprehensive dynamics of catchment areas. A universal perspective on water justice that would include

this matter in all its states and gradients as present in the 'critical zone' (Latour, 2014) may help protecting water more than the recognition of 'personal' legal rights of one single water body. Once water's necessity to all organisms is recognised and its existence is considered as a common good, a 'recommoning' (Geagea et al, 2024) approach in which water in all its forms is managed and taken care of collectively may be more effective than the single 'juridical' approach. A novel perspective, strongly connected to spatial justice (Soja, 2010; Swyngedouw, 2004), could include democratizing the water (eco)systems management, with city residents (of all kinds) take part with their own agency in relation to water – which can be linked to water retention, depuration, infiltration, and not only social governance and distribution – and stop being considered as mere 'consumers'.

Water scarcity or abundance? The case of Marseille

The worrying climate projections for the Mediterranean expect "future annual and summer warming rates are projected to be 20% and 50% larger than the global annual average, respectively" (IPCC, 2023, p 2237) which come together with lower freshwater availability. And although drier climates (and many worrying scarcity dynamics) are located on the south side of the sea, "summer warming is projected to be particularly strong in the north" side (ibid.), where societies and territories are built on the basis of water abundance coming from the Alps, now endangered. As glaciers are quickly disappearing, it becomes interesting to study the dynamics of water scarcity, extraction and injustice in a context on the north side of the Mediterranean, which will have to evolve and adapt its water uses and water-related spaces. The MedECC report (2020, p. 200) states that "for the Durance River in southern France, regulated by large reservoirs, decrease of mean annual renewable water resources has been demonstrated, with a decrease in summer low flows, associated with a greater pressure on water demand". The Durance, main tributary to the Rhone, is the river that provides freshwater to the whole arid Provençal coastal region where Marseille, the second city of France and main centre of the area, is located. This region is characterised by the lack of major surface water bodies and limited groundwater reservoirs, but paradoxically Marseille seems not to be affected by water scarcity even during the worst drought periods (Jean, 2011), thanks to the water infrastructure system constructed since the XIX century (Figure 1).

The city benefits from an abundant freshwater supply of the best quality (often proudly defined 'the best of France'), mainly coming through the Canal del Marseille, which since 1849 brings water from the Durance River to the city. The tradition of modern water infrastructures in this region, started with the Craponne Canal (1554-1559), built in order to introduce irrigation to the dry Crau plain. The 80km long Canal de Marseille was constructed after a centuries-long history of studies and proposals by many technicians, who tried to defy the complex region's orography for reaching Marseille and putting an end to its thirst (Jean, 2011). After a few projects that were trying to build a unique canal for both Aix and Marseille, finally the city took a historic decision in 1834, the titanic infrastructure had to be built 'at any cost'. The canal would indeed mark the city's history, landscape, architecture, and identity (ibid.), while also transforming the land uses of the surrounding territory with the introduction of widespread irrigation (Vidal-Naquet, 1993). The Canal de Marseille has undergone multiple modifications and technical improvements, but its substance hasn't changed to this day. The territorial water system instead has greatly evolved, especially in the second half of the XX century, with the construction of the Canal EDF (Electricité de France), the Canal de Provence, and several storage basins (constructed and managed by EDF) on the Durance and the Verdon, its main tributary (Jean, 2011). These infrastructures, which came after the 1955 law for the hydroelectric management of the rivers' system, on top of energy production and water distribution have the goal of regulating floods and drought effects by storing considerable amounts of alpine freshwater that can then be used during dry spells. At the same time, they have heavy consequences on the rivers' ecosystems, so that most of the water of the catchment area is now diverted from the riverbeds.

The EDF Canal's main function is hydroelectricity production, although it is also used as the main derivation from which other canals draw their water. The Canal de Provence is mainly distributing water to the coastal area urban centres, and to agricultural and industrial users as well, via a network that is mostly pressurised, making it extremely 'efficient' by minimizing leaks (ibid.). This system creates a total disconnection between the catchment areas and the territory: the Durance-Verdon system has most of its water subtracted, and the infrastructural system bypasses the surrounding landscapes for the benefit of anthropic consumption especially in urban areas,

while for example the smaller rivers of the Marseille area do not supply water to the city since the beginning of the XX century. This dynamic rises questions about water justice at the territorial scale, where the metropolitan area of Marseille is the main user of water and energy in the region: a concentrated abundance that creates injustice and scarcity dynamics for a wider territory.

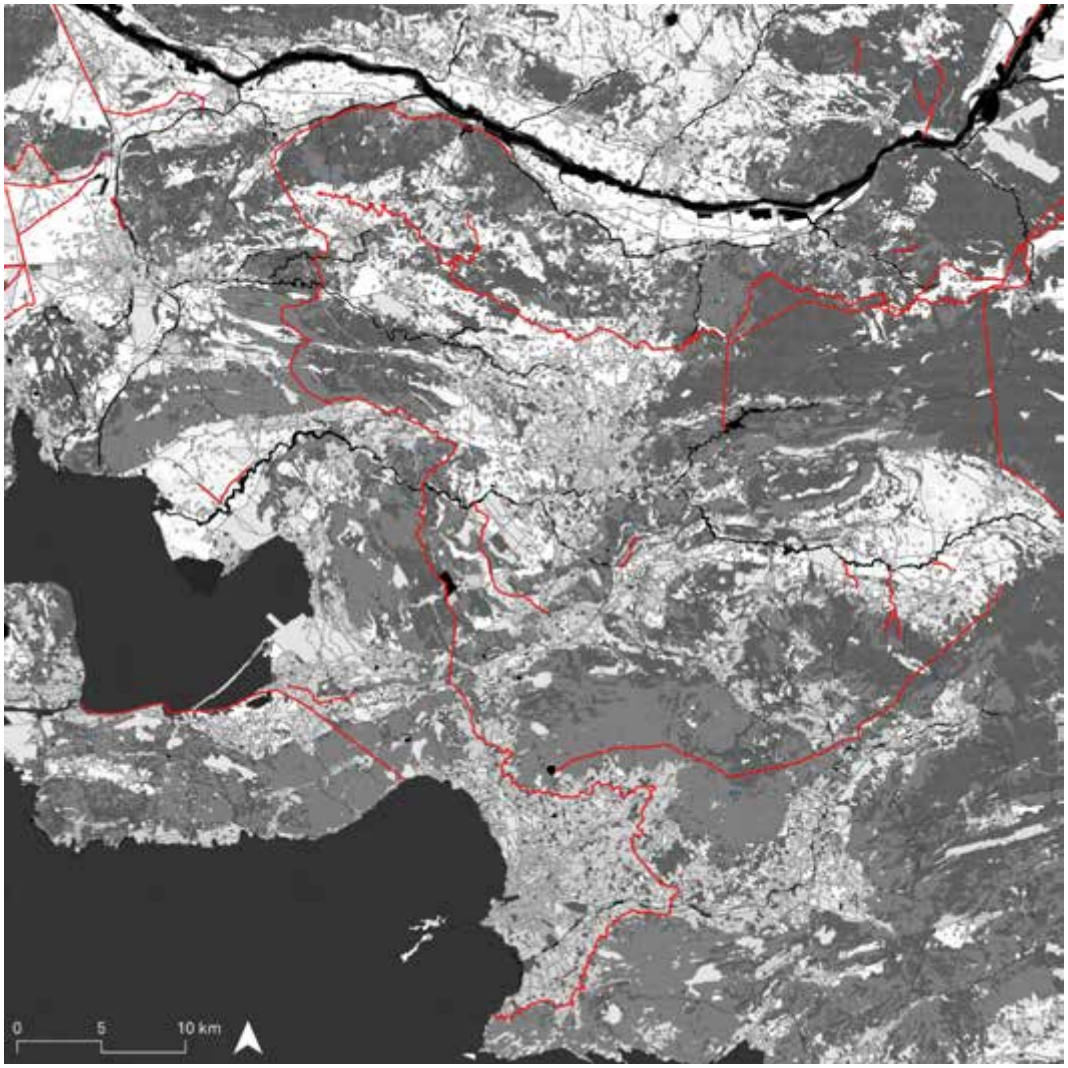

Figure 1. Systems of water in the territorial context of Marseille. Legend: urban areas, light grey; main water canals, red (EDF canal excluded, black); freshwater to sea water, from black to dark grey; forests to grasslands, from dense to light hatching. N. Russolo

Conflicts at the territorial scale

Already at the end of the XIX century, before the most substantial post-1955 works, the water abstraction imbalance gave rise to increasing conflicts, especially linked to the agricultural production. The irrigation issues during dry spells became very divisive, so that in 1907 a law established the 'Commission Exécutive de la Durance' (CED), with the goal of defining and regulating every (anthropic) water needs and rights along the river's course (Dumoullin et al., 2022). Thanks to the evolving negotiated distribution principles and to the large alpine reservoirs, human consumers' conflicts are basically not an issue anymore – although more than 70% of the irrigate surfaces are outside of the river basin. The Durance River instead, doesn't have a legal personality, lacking full representation for its environmental flows needs, which are regulated and protected by a complex governance system that since 2008 includes a river contract. The SMAVD (Syndicat Mixte d'Aménagement de la Vallée de la Durance) is the multi-actor institution responsible for the river contract and for the basin's monitoring and planning, comprehending

a vast array of stakeholders; the institution monitors and rules the allocation of water (SMAVD, 2020). While the SMAVD is working towards a better management of the Durance and its environmental needs[5], the priorities of the river basin system are hydroelectric production – the EDF infrastructure produces here 35% of the region's energy, with 15 power plants between the highest Serre-Ponçon reservoir and the Étang de Berre, and 8 more in the basin (Dumoullin et al., 2022) – and human consumption, to the point that the infrastructures extract by far most of the Durance's water flow. This unbalance causes a heavy alteration of the river's hydromorphology, with a worrying biodiversity and ecological continuity loss, as 68 barriers are present along its course (Étang Nouveau 2013). The environmental flow of the Durance is connected to many ecosystems in a vast territory, starting from the large and complex riverbed and its alluvial plain and aquifer. As most of the water extracted from the river is discharged into the brackish Étang de Berre wetland via the EDF Canal, the environmental seawater/freshwater balance of the étang is heavily disrupted. The smaller inflow from the Durance to the Rhone is also substantially changing the main river's environmental flow in its last section, on which the Camargue delta system depends.

A few years before the establishment of the Durance river contract, a conflict that entangles human use, wetland advocacy and ecological survival questioned the artificial canals' system flows. The 'Syndicat professionnel coordination des pecheurs de l'étang de Berre et de la région' (Coordination of the professional fishermen's union of the Étang de Berre and of the region) brought EDF to the European Court in 2003 because of the disturbance of the brackish environment of the Étang de Berre water body, winning a historic stance for the protection of the étang's ecosystem balance[6]. After the ruling, in 2006 EDF has modified the last part of the infrastructure so that one part of the freshwater goes back to the low Durance course in Mallemort (Figure 2); this was coupled with a better control of industrial and urban wastewater discharge, and has seen an improvement in flora and fauna in the étang (Étang Nouveau 2013).

The effects and perspectives of global warming are worsening existing conflicts and issues related to water scarcity and justice. In particular, with a temperature increase of 1 to 3°C, around year 2050 the Durance system (and therefore the whole PACA Region) is going to dispose of circa 30% less freshwater compared to 1980-2009 levels (Sauquet et al., 2015). At the same time water demand is supposed to increase consistently in the area because of a combination of rising evaporation and anthropic consumption (ibid.). One example of crisis moment, that is projected to become much more frequent in the next years, is represented by the 2022 drought, during which around 1200 water courses in France went dry, resulting in potentially irreversible habitat loss, on top of substantial damages to agricultural and hydroelectric production. (Bertrand et al., 2023). In the Durance river basin, an exceptionally dry period started in January of that year and transformed into a harsh drought coupled with heatwaves from April and throughout the end of the summer; in that period, the river lost around half of its water flow (SMAVD, 2023). In the aftermath of this dry spell the region's farmers denounced the fact that most of the system's water is still invariably discharged into the Étang de Berre: a foolish waste from their perspective, linked to the unequal territory's energy demand.

5 www.smavd.org – Among the objectives of the river contract, there are also "finding a new morphological balance for the riverbed" and "managing the alluvial plain by conciliating uses and resource's preservation" (SMAVD, 2020, author's translation)

6 The ruling of case C-213/03, Judgment of the court 15 July 2004 requires "prohibiting […] the discharge into a saltwater marsh communicating with the Mediterranean Sea of substances which, although not toxic, have an adverse effect on the oxygen content of the marine environment." Documentation available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:62003CJ0213

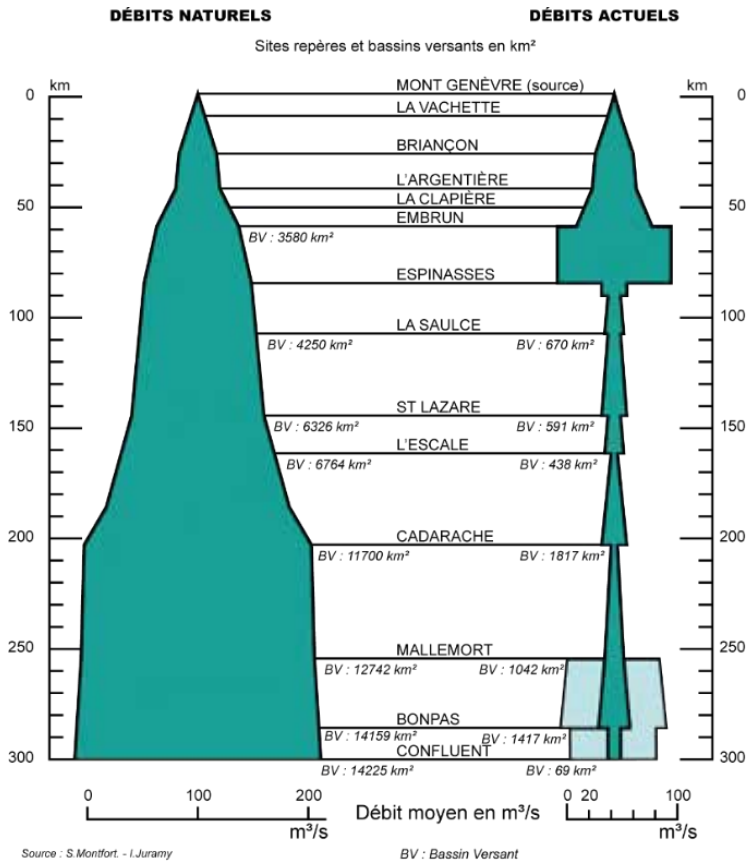

Figure 2. The flow diagrams show how more than 90% of the 'natural' average flow of the Durance has been diverted from its riverbed with the post-1955 EDF works (solid colour, original diagram from Juramy & Montfort, 1987). The lighter part of the right side diagram represents the 2400 million of m^3/ year flow returned to the Durance in Mallemort since 2006 (Étang Nouveau, 2013)

The extremely heavy withdrawals create imbalances that aren't limited to the distribution of freshwater. The weakened Durance stream struggles to transport sediments along its complex riverbed, so that water ecologies along its course are being additionally interrupted, and the lack of sediments' discharge into the Camargue delta through the Rhone is contributing to the coastal retreat of the low-lying brackish wetland; furthermore, silt discharge into the Étang de Berre is additionally unbalancing its environment (Balland et al., 2002). Another important aspect is linked to alluvial aquifers, which would normally be recharged by the river and give water back in its lower flow moments with a balancing effect on the ecosystem (Morizot & Husky, 2024); the Durance's alluvial aquifers – once a substantial freshwater reservoir – are suffering from depletion and from a rising pollutants' concentration, both due to the severely drained river (Étang Nouveau 2013).

Because of the heavy infrastructures and alterations, the Durance is classified as a 'Masse d'Eau Fortement Modifiée' (MEFM), and therefore according to the EU Water Framework Directive[7] it must be restored to a 'good ecological potential' within 2027. This necessity raises questions about the priorities of the territorial water system, where the granted 'environmental flow' isn't enough for the river ecosystem: can the system move towards the perspective of a 'minimal extraction flow'? The issue of a different distribution in water uses for a more sustainable territorial footprint is very complex. To give one example, hydroelectric power is the 1st 'renewable' energy production in France and worldwide, and once the (environmentally costly and disruptive) infrastructure is built its footprint is very low. On top of that, hydropower doesn't suffer from the constant availability fluctuations

7 2000/60/EC of the European Parliament. Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex-:32000L0060

of wind and solar energy – until a prolonged drought, or structural water cycle modifications such as glaciers disappearance, arrive. In the perspective of a drier future for the region, a sustainable territorial metabolism project and river future requires re-thinking water and energy use, and therefore a negotiation of 'new social alliances' extended to matter (Secchi, 2011; Bennett, 2010) which should take into account degrowth propositions (Koller, 2020). The extractive paradigm of the Capitalocene for the Marseille urban/territorial water system is based on the existence of 'cheap nature' (Patel & Moore, 2020) at the regional scale, that involves artificial basins in the alps, impressive infrastructures, and heavily anthropized urban grounds that don't take good care of the water of the urban area.

Urban water, spaces and ecologies

The relationship of Marseille with water has completely changed since the Canal de Marseille was completed, with a celebration that included the construction of the magnificent Palais Longchamp, and the abandonment of the city's rivers for relying only on the territorial extractive infrastructure. With the alarming perspective of diminishing regional freshwater resources due to global warming (and the shrinking Alps' glaciers) while scarcity dynamics driven by water consumption are being accentuated – for example due to a growing number of data centres in the city – the imperative is finding strategies towards a more sustainable urban ecology and water footprint. This means a change in the territorial water metabolism, abandoning the current linear/extractivist practices and looking for opportunities of circular dynamics (Grulois et al., 2018).

The main element of the Marseille local water system is the Huveaune river, often mistaken for a stream or a canal, or even unknown by the some of the city's population. Its presence is linked to the only substantial valley which breaks the hills' crown that surround the city. This morphological feature, together with the presence of other towns along the river, made it the preferential axis for mobility infrastructure and industrial development. The presence of water is of course a fundamental asset for manufactures, taking advantage of the river's freshwater by consuming it, withdrawing it for plants' cooling, and discharging waste. Indeed for many years, the urban water courses were used as untreated industrial wastewater collectors, with serious pollution consequences. In 1972, because of the high levels of pollution, the Huveaune was diverted towards Cortiou in the Calanques National Park, with a moveable dam stopping its course and a doubling of the underground canal that was already discharging urban wastewater in Cortiou; this presents multiple problems, especially in terms of ecological continuity (EPAGE HuCA, 2015), thus creating an even more radical disconnection between the city and its waters. On top of this, with an apparent paradox for a city deprived of water, Marseille often experiences flooding events in case of substantial rainfall, because of the highly sealed soils: only 12% of the ground in the metropolitan area's urban spaces isn't sealed and can support vegetation or water infiltration (agaM, 2020). As the precipitations quickly saturate the drainage network, the polluted water coming from rain and runoff is directly discharged into the sea together with the Huveaune, which re-gains its original riverbed as soon as it reaches a flow of 30 m^3/s (EPAGE HuCA, 2015).

The presence of water courses within the urban area could be an occasion for rethinking the city-water relationship – in a different urban ecological perspective (Orff, 2016) that includes more-than-human water and spatial justice, where urban soils can be transformed to support life and interact with water. Once the pollution dynamics are halted, the urban rivers and their surrounding alluvial plains have the biggest potential for welcoming and expanding ecologies: giving more space to water and connected ecosystems could become part of a larger phytoremediation process for Marseille, where polluted urban surfaces now intoxicate water runoffs. The freshwater inflow from the Huveaune and the other minor rivers could be used for non-drinking urban water needs, starting to move away from the solely linear territorial scale metabolism that is now present. Revealing superficial water flows in connection to situated depaving of the urban ground may help managing rainwater (avoiding its total inclusion in the sewage system) and foster urban ecologies, also helping the creation of a better urban environment in response to a hotter climate[8]. At the same time, a new awareness of urban water, at present completely hidden from sight and discourse (Kaika, 2005) may help recognise the global

8 A number of EU-funded projects are experimenting on the relationship between water, urban comfort and the environment, for example Cool Noons https://coolnoons.interreg-euro-med.eu/

necessity of a new ecological balance with the larger territory related to flows – with possible connections to social movements interested in environmental justice that are already active in the city. In an urban area where spatial justice is a complex theme (ETH, 2020), citizen groups are advocating for river ecosystems to be preserved and restored, as with the Ruisseau des Aygalades, which crosses some of the most deprived neighbourhood in the north of Marseille. The project for a new park along the water course[9] is going to positively transform the urban landscape, with the risk of a gentrification processes that must be controlled for avoiding the worsening of spatial injustice. Also the Huveaune River is interested by a project, this time at the metropolitan scale and essentially linked to active mobility, which also includes some river 'renaturation' sites, called Voie Verte de l'Huveaune (Huveaune greenway)[10]. The potential linked to wider action on water ecosystems suggests that the river spaces could undergo a more substantial transformation, linked to slowing down and reinforcing its flow and ecologies (Morizot & Husky, 2024). As for centuries Marseille has only counted on its groundwater reservoirs for its urban freshwater (Vidal-Naquet, 1993), by taking good care of water from the territorial and metropolitan scale to the materiality and pollution of urban surfaces the city aquifers may also come back as a tool helping the local water needs, in connection with the renewed city's rivers. A systemic change with the introduction of local water sources may configure a hybrid collaboration between centralised large-scale infrastructure and decentralised water systems (Wong et al., 2020), that can be an important occasion for designing a better urban environment while 'making space' for ecosystems.

An open ending

In the territorial context of Marseille, the main urban area is the biggest water consumer, therefore domestic and urban water-efficient measures including diffused building-scale reservoirs and recycling devices (Correljé & UNEP, 2008) could be an important contribution towards a more sustainable water footprint. These practices should be coupled with the described wider urban and territorial transformations that can take advantage of the local water presence in a regenerative way, in a new environmental and spatial justice perspective. The associations and citizen groups already present in the city, who are working on the themes of water and the environment, represent a great potential of social interaction and ownership in the perspective of a water recommoning process (Geagea et al, 2024), that may become a first step towards of a wider ecological commoning future for urban ecologies.

A re-design for better and comprehensive water justice will have to take into account the ground's materiality and relationship with the rivers, their alluvial aquifers and groundwater systems. On top of the spatial modifications, a successful strategy for a more sustainable urban water footprint will have to include the social and more-than-human justice aspects within a renewed governance. In this perspective, the city-centred water withdrawal from the Alps may find a new balance between urban water use and the territorial needs, starting to reconcile local ecologies with their water systems.

While water is a fundamental resource for a sustainable future, the current trend is of accelerating its consumption and depletion. We must be aware that the present global water crisis can't be solved by a small amount of water reuse, as it necessitates a radical change in the way 'resources' are extracted and consumed especially since the exponential increase of energy and goods production that happened during the XX century. Water is now widely extracted and consumed like many other externalities, but being a vital necessity, it should be managed like a universal 'commons' (Harvey, 2011). This perspective must enter the urban design discourse, as its availability is strongly connected with spatial justice for the society and beyond. In the Marseille area, water is locally present but for the last century it has not been part of the city's metabolism. There are possibilities for the metropolitan area to take advantage of local freshwater reservoirs for a new urban ecology, and these should be investigated in order to mitigate the water scarcity and injustice dynamics that affect the wider territory.

9 https://www.euromediterranee.fr/projets/le-parc-du-ruisseau-des-aygalades
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Re-mining Punta Corna. A Laboratory on the Local Impacts of the Critical Raw Materials Act in the Alpine Region

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Abstract
The transition to a clean energy economy requires securing critical minerals—such as nickel, copper, and cobalt—vital for low-carbon technologies. The EU Critical Raw Materials Act (2023) promotes domestic sourcing to reduce reliance on external suppliers. Our investigation explores the environmental and socio-economic impacts of renewed extraction in Europe, focusing on Italy, which holds 16 of the 34 listed materials but has seen no active metal mining since the 1970s. Using Punta Corna, a former cobalt mine in the Alps, as a case study, we analyze tensions between extractivist strategies and local economies based on tourism. Through cartographic analysis, we contrast industrial development with protective territorial approaches, raising questions on sustainability, peripheralization, and governance. The findings illuminate broader trade-offs in implementing green transitions within contested Alpine landscapes.

Keywords: re-mining, alpine region, territorial patrimonialisation, extractivism, depopulation

Introduction

The transition to a clean energy economy requires secure access to critical minerals—such as nickel, copper, and cobalt—which are indispensable to advanced technologies and low-carbon infrastructures. The European Critical Raw Materials Act (2023) addresses this imperative by promoting the domestic extraction, processing, and recycling of such materials, with the aim of strengthening the EU's strategic autonomy[1] while reducing its dependence on external suppliers. This paper explores the environmental and socio-economic implications of renewed extractive activities in Europe, focusing in particular on Alpine landscapes. Among European countries, Italy presents a particularly relevant case: despite possessing 16 of the 34 critical raw materials listed in the CRMA, the country has not hosted active metal mining operations since the 1970s.

Our investigation centres on the Italian government's current strategy, which aligns with European directives and proposes the reopening of former mines and the exploration of new sites, especially in the Alpine regions. This strategy is paralleled by the necessity of substantial investments to recover industrial and technological capacities eroded over decades. A particularly emblematic case is that of Punta Corna, once the largest cobalt mine in Europe, which today represents a critical site for interrogating the tensions between extractivist development and alternative local economies grounded in tourism, environmental valorisation, and territorial patrimonialisation.

Through cartographic and discursive analysis, we examine the conflicting narratives surrounding these mining

1 Strategic autonomy refers to the European Union's capacity to act independently in key policy areas—such as defence, energy, technology, and industrial supply chains—without excessive reliance on external powers. Originally developed in the context of security and defence, the concept has expanded in recent years to include economic and technological dimensions, particularly in response to geopolitical instability, global supply chain disruptions, and the growing rivalry with China and Russia. Within the framework of the Green and Digital Transitions, strategic autonomy has become central to EU policy discourse, justifying initiatives like the Critical Raw Materials Act as means to reduce vulnerability and strengthen Europe's resilience in a rapidly changing global landscape.

initiatives. On one side stands a re-emergent extractivist paradigm; on the other, what Boltanski and Esquerre (2019) term the "enrichment economy", oriented around ultra-protective territorial strategies and the valorisation of heritage, landscape, and place-specific assets. These competing visions raise fundamental questions concerning the sustainability of new extractive projects and their alignment with the values and aspirations of local communities, often situated on the margins and affected by processes of depopulation and infrastructural retreat.

By framing Punta Corna as a case study, we argue that it serves as a privileged lens through which to understand the socio-political and territorial impacts of the Critical Raw Materials Act. The site functions as an experimental laboratory where local fears and hopes surrounding extractive futures materialise, offering broader insights into the contradictions embedded in Europe's green transition and the contested geographies of sustainable resource governance.

In this context, the reactivation of mining frontiers in the Alps occurs not in a vacuum, but amid rapidly accelerating climatic and ecological changes. As one of the fastest-warming regions in Europe, the Alpine space is experiencing the retreat of glaciers, permafrost thaw, and hydrological shifts that threaten both ecosystems and livelihoods. These transformations form the critical backdrop against which new extractive activities must be assessed.

The paper is structured in four main parts. Part 1 introduces the European Critical Raw Materials Act (CRMA) within the broader framework of the green transition, outlining its objectives, regulatory mechanisms, and geopolitical implications. Part 2 turns to the Italian context, describing national strategies for the reactivation of mining activities and the tensions these raise with existing territorial models centred on heritage, tourism, and environmental valorisation. Part 3 shifts the focus to the Alpine region, analysing how renewed extractive pressures intersect with accelerated climate change and historically stratified landscapes. Part 4 presents the case study of Punta Corna, examining local conflicts, governance asymmetries, and the competing visions for development in marginal mountain areas. The conclusion reflects on the broader stakes of extractive reterritorialisation in Europe, advocating for more situated, democratic, and ecologically attuned approaches to resource governance.

1. The Critical Raw Materials Act and the Return of Mining in Europe

In her State of the Union address of September 2022, President von der Leyen, while addressing Europe's dependence on Russian gas, also drew attention to the risk of overreliance on third countries for the supply of rare earths. On that occasion, she announced the forthcoming European legislation on strategic raw materials: the so-called Critical Raw Materials Act (CRMA). This strategy aims to reinforce the European supply chain through a combination of trade agreements with countries such as Canada, Japan, and Vietnam; the promotion of material recycling; and—most controversially—the development of new mines within EU borders and the reopening of old mining sites ("re-mining") using advanced technologies.

In March 2023, the European Commission outlined the contents of the CRMA, whose main goal is to guarantee a "secure, diversified and sustainable" supply of critical raw materials—resources deemed essential for both the green and digital transitions. One of the key aims of the CRMA is to reduce Europe's excessive dependence on a single supplier country, in line with the broader objective of strengthening the EU's strategic autonomy in an increasingly unstable geopolitical landscape. At present, the EU's dependence on imports is both acute and highly concentrated: 98% of its heavy rare earths and 99% of light rare earths, along with 93% of magnesium, come from China; 68% of cobalt is imported from the Democratic Republic of Congo; 78% of lithium from Chile; 71% of phosphorus from Kazakhstan; 64% of bauxite from Guinea; and 62% of antimony from Turkey (Il Sole 24 Ore 2023a) (as shown in Fig.1). This reliance on non-European suppliers raises not only questions of strategic vulnerability but also significant ethical and environmental concerns. For example, cobalt extraction in the DRC has repeatedly been linked—by Amnesty International and other organisations—to child labour, human rights violations, and severe environmental degradation (Martin Sanchez, Gori Nocentini 2025).[2]

2 Almost three quarters of the world's cobalt production takes place in the Democratic Republic of Congo. Most mining

Fig. 1. Main suppliers of critical raw materials to the European Union. Source: European Council.

The European response is twofold: to increase extraction and processing capacity within its own borders, and to diversify its international supply base. The EU's approach to critical raw materials also includes a stated commitment to minimising environmental externalities and promoting circularity across the value chain. The CRMA sets out three primary targets for 2030: at least 10% of the critical raw materials consumed within the EU should be extracted domestically (up from the current 3%) (Bourgery-Gonse 2023); 40% should be processed within Europe; and 15% should be sourced from recycling activities (Circular Economy Network 2023). The regulation also stipulates that no more than 65% of the EU's annual consumption of any given strategic raw material should be supplied by a single third country—an objective that, as previously noted, remains far from being achieved.[3] The Act also updates the list of critical raw materials, identifying 34 substances, 16 of which are classified as "strategic"—including copper, cobalt, lithium, natural graphite, nickel, and rare earths.[4].

operations are controlled by large multinationals, mainly Chinese, but at least 20% of the exported material comes from 'artisanal' mines that use child labour and do not respect elementary labour and human rights conditions.

3 Other measures envisaged in the framework of the Critical Raw Materials Act are: the simplification and acceleration of regulations for extraction projects: a maximum of 24 months for extraction permits and 12 months for processing and recycling permits; simplified procedures supported by easier access to funding lines; greater coordination between Member States in order to have an accurate picture of national reserves; investment in research and training with the creation of a Raw Materials Academy to develop the new skills needed by workers engaged in this sector. In addition, measures are planned to increase recycling rates and the use of secondary raw materials.

4 In the European Commission's draft regulation, there are 34 'critical raw materials': antimony, arsenic, bauxite, baryllium, bismuth, boron, cobalt, coking coals, copper, feldspar, fluorspar, gallium, germanium, hafnium, helium, heavy rare earth elements, light rare earth elements, lithium, magnesium, manganese, natural graphite, nickel - battery grade, niobium, phosphorite, phosphorus, platinum group metals, scandium, silicon metal, strontium, tantalum, titanium metal, tungsten, vanadium. Of these 'critical'

In its communication A Secure and Sustainable Supply of Critical Raw Materials in Support of the Twin Transition (European Commission 2023a), the EU provides projections that illustrate the dramatic rise in demand for these materials: demand for rare earths is expected to increase 4.5 times by 2030 and 5.5 times by 2050, while lithium demand—primarily driven by the growth of electric vehicle batteries—is forecast to rise elevenfold by 2030 and seventeen fold by 2050. As with other domains of the green transition, the implementation of this new EU framework for critical raw materials reveals that the transition—often portrayed as clean, sustainable, and immaterial—is, in practice, underpinned by extractive logics that produce tangible and far-reaching effects on European territories, economies, and ways of life (Martin Sanchez, Gori Nocentini 2025).

2. Re-mining Italy: National Strategies and Territorial Contradictions

Despite the near-total dismantling of its mining sector over the past five decades, Italy remains geologically endowed with a wide array of minerals now considered strategic under the European Critical Raw Materials Act (CRMA).[5] According to official data from the Ministry of Enterprises and Made in Italy, the country holds confirmed or potential availability of 16 out of the 34 critical raw materials listed in the regulation. However, the extractive industry—particularly in the field of metal mining—underwent a gradual and definitive decline during the 1970s, due to a combination of increasing labour costs, growing technical and financial challenges linked to deep extraction, and the broader economic crisis triggered by the oil shocks (Madeddu 2020). Since then, metal extraction has effectively ceased, and Italy has become fully reliant on imports to meet its industrial and technological demands.

In this context, the CRMA has provided renewed impetus to national discussions on resource sovereignty and strategic autonomy. The Italian government, through the Ministry of Enterprises and Made in Italy and the Ministry of the Environment, has outlined a strategy aimed at mapping disused or dormant extraction sites, with the goal of reopening or activating new ones in response to the anticipated surge in demand for strategic materials. This mapping process—entrusted to ISPRA within the framework of the PNRR-funded GeoSciencesIR programme—has resulted in the development of the GeMMA database, a national inventory of geological, mining and environmental data presented in early 2024 (ISPRA 2024).

According to this updated national dataset (refer to Fig.2), Italy hosts around 900 sites historically associated with metal extraction, none of which are currently active. At present, only feldspar and fluorite—non-metallic but CRMA-listed materials—are being commercially extracted. These minerals are essential for the ceramic, glass, and electronics industries. In particular, the fluorite mine of Genna Tres Montis in southern Sardinia—currently undergoing restructuring—is expected to become one of Europe's most significant sites (Ispra, 2024). Other formerly productive fluorite mines, especially in Lombardy, Trentino, Lazio, and Sardinia, are being reassessed, as the market price of fluorite has quadrupled since the 1990s (Il Sole 24 Ore 2023a)).

raw materials, 16 are considered 'strategic': bismuth, boron-metallurgical grade, cobalt, copper, gallium, germanium, lithium-battery grade, magnesium metal, manganese-battery grade, natural graphite-battery grade, nickel-battery grade, platinum group metals, rare earth elements for magnets (Nd, Pr, Tb, Dy, Gd, Sm, and Ce), silicon metal, titanium metal, tungsten.

5 With a law of 1982, the Italian state attempted – unsuccessfully – a revival of the sector by deploying substantial public resources to support activities from mining research to production (Madeddu, 2020).

Fig. 2 Cartographic representation of identified critical raw material reserves across the Italian territory. Source: ISPRA, 2024. TO BE UPDATED

While active extraction of metallic critical raw materials is currently absent, ISPRA's data confirm the presence of numerous promising deposits. Copper, for instance—crucial to both energy systems and digital infrastructures—is documented in the Colline Metallifere, the Ligurian-Emilian Apennines, the western Alps, Trentino, Carnia, and Sardinia. Manganese was historically extracted in Liguria and Tuscany. Tungsten, often found alongside lead and zinc, is present in Calabria, Sardinia, and the central-eastern Alps. Cobalt is found in Sardinia and Piedmont, where the deposit at Punta Corna has been explicitly identified as a site of strategic relevance at the European scale (ISPRA 2024). Other resources include magnesite in Tuscany, magnesium salts in the Venetian Prealps, and bauxite in Apulia and northwestern Sardinia, particularly at the Olmedo site, the last operational metal mine in the country before its closure.

The Alpine arc, in particular, re-emerges as a key spatial node in this renewed extractive geography. From Friuli-Venezia Giulia to Piedmont, passing through Trentino-Alto Adige, Veneto, Lombardy, and Liguria, northern Italy hosts a significant share of the country's identified strategic resources. In Liguria, the well-known titanium deposit located within the Beigua Regional Natural Park—a UNESCO Geopark—is currently excluded from development due to environmental concerns. In the Veneto region, deposits of blende, pyrite and mixed sulphides, magnesium salts, clay, cement marl, baryte mines, and deposits of betontite, bleaching earth, refractory earth and kaolin are currently explored for a reopening. Abandoned in the 1950s they are located in areas of high landscape, naturalistic and tourist interest (Corriere del Veneto 2023, 2024). In parallel, new extraction frontiers are emerging in geothermal contexts: recent studies have confirmed the presence of lithium in geothermal fluids across Tuscany, Lazio, and Campania, with multiple research permits issued in 2023, especially in the Lazio region (Il Sole 24 Ore 2023b).

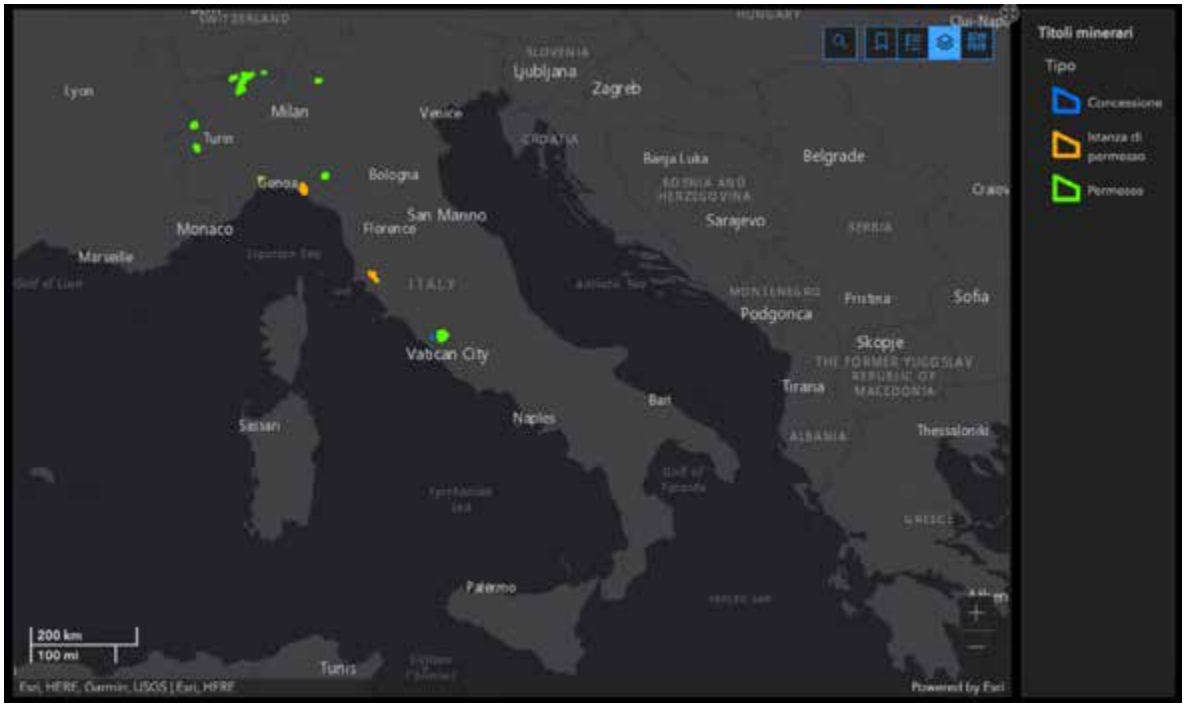

Fig. 3. Mining titles: concessions, permit applications, and permits. Source: ISPRA, 2024. TO BE UPDATED

These developments are now feeding into the elaboration of Italy's forthcoming National Mining Strategy, mandated by EU Regulation 1252/2024 and assigned to ISPRA through Decree Law 84/2024. This strategy is expected to define a comprehensive framework for the evaluation, prioritisation, and potential reactivation of mining operations, marking a shift from decades of abandonment to a new phase of institutional and economic attention to subsoil resources.

However, the reopening of mining sites in Italy after decades of inactivity raises a number of issues regarding the long-term sustainability of such projects and their compatibility with the development trajectories and imaginaries of local communities. For instance, mining appears in clear tension with the broader economic repositioning that Italy has undergone in recent decades—a shift that Boltanski and Esquerre (2019) define as the transition toward an economy of enrichment. This model marks a rupture with the Fordist paradigm of mass production that characterised the post-war period, and instead centres on niche markets and high-end goods, whose value is tied less to functional utility than to uniqueness, authenticity, and territorial specificity (Martin Sanchez, Gori Nocentini 2025).

In this context, patrimonialisation has increasingly become a strategic tool for territorial development. It seeks to identify and mobilise undervalued or overlooked resources—be they historical, cultural, or environmental—and turn them into economic assets. Often, this results in the transformation of dormant heritage into active heritage, enabling actors to appropriate and even reconfigure history in order to increase the perceived value of goods and services. As Boltanski and Esquerre (2019) note, this process tends to strip concepts such as heritage, identity, tradition, and memory of their inherent ambiguity and complexity, recasting them instead as instruments of market differentiation (Ibid.).

Against this backdrop, the return of extractive activities not only disrupts the symbolic coherence of such strategies, but poses deeper contradictions regarding the role and meaning of territory in contemporary Italy. As Pank (2022) reminds us, the production of operational landscapes for mining requires profound transformations in material arrangements, value systems, and property regimes. These are not merely technical operations, but political reconfigurations—often at odds with the logics of territorial enhancement and with the forms of economic life currently dominant in many of the areas targeted by the CRMA.Yet, the reactivation of mining frontiers in the

Alps does not occur in isolation. These developments unfold within a context marked by increasing ecological vulnerability and climatic instability (Longhin, 2025), which profoundly shape the implications of extractive activities in these territories.

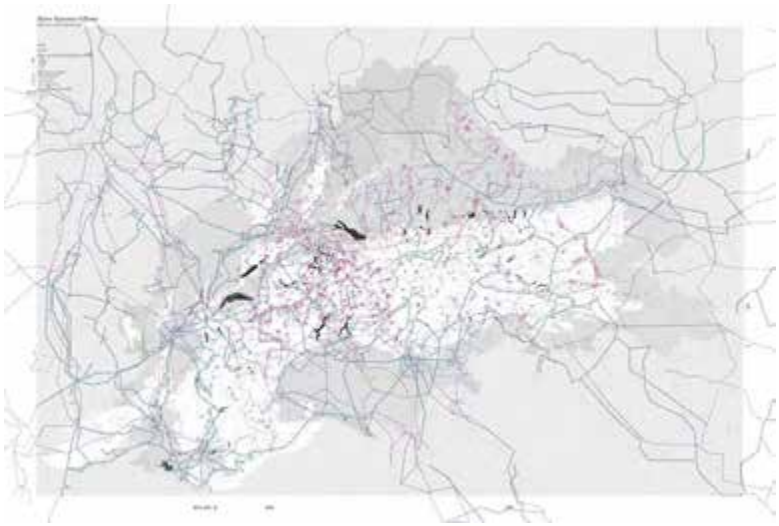

Figure. Cartography of the Alpine Operationalising Landscape. Author's elaboration, 2025. TO BE UPDATED

3. The Alpine Landscape at the Crossroads: Extractivism and Climate Dynamics

Over the past decades, the Alps have become a paradigmatic site for observing the entangled effects of climate change and extractive development. In this mountainous region—characterized by steep topography, fragile ecosystems, and historically layered forms of human appropriation—the accelerating retreat of glaciers, permafrost degradation, biodiversity loss, and the intensification of extreme weather events are reshaping both ecological processes and the viability of long-standing economic activities (Cherisch et al., 2015, Longhin, 2025). Climate change here is proceeding at more than twice the global average, with temperatures in the Alps rising by nearly two degrees over the past 150 years (Permanent Secretariat of the Alpine Convention, 2019a; 2022). These environmental shifts converge with deeper structural transformations in land use and territorial economies, placing new pressure on already fragile alpine regions (Longhin, 2025).

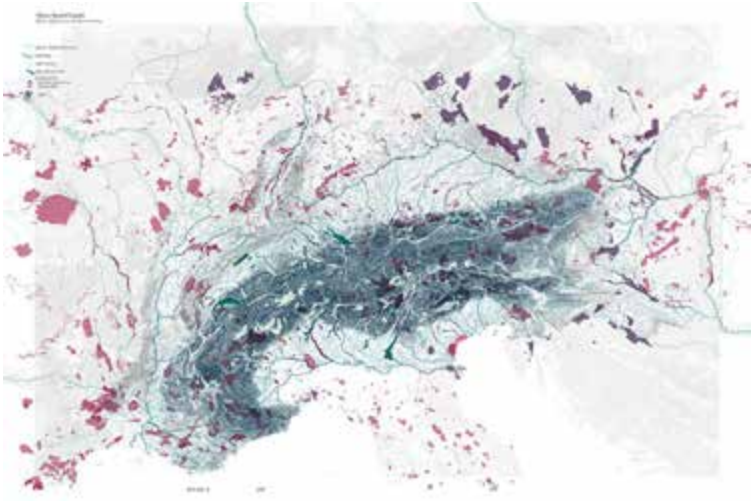

Figure. Cartography of the Alpine Spatial Capital. Author's elaboration, 2025. TO BE UPDATED

Among the most emblematic of these pressures is the resurgence of mining, which is increasingly promoted as a strategic response to Europe's demand for critical raw materials (CRMs). In recent years, extractive activities have re-emerged not only as an economic opportunity but as a geopolitical imperative, reframing peripheral mountain territories as potential resource frontiers in the green transition. Yet these dynamics are not new. Across the Alps, extractive infrastructures—ranging from mineral quarries to hydropower networks—have long left material and symbolic imprints, inscribing the landscape with layers of industrial heritage and unresolved socio-environmental tensions. The historical development of alpine regions is inextricably linked to extractive logics: mining, forestry, water appropriation, and later, tourism and industrialization, have all contributed to the transformation of the alpine space into a complex operational landscape (Modica, 2022, Longhin, 2025).

This landscape, far from being a neutral container for development, reflects the cumulative impacts of extraction and the often-conflicting interests inscribed within it. Alpine valleys, in particular, bear the marks of infrastructural and territorial regimes that have alternated between periods of exploitation, abandonment, and selective reinvestment. Brownfield sites, depopulated mining villages, and residual industrial infrastructures stand as material evidence of cycles of accumulation and neglect, often concentrated in areas with limited political voice. Today, the push toward a new mining economy risks reproducing these asymmetries under the banner of sustainability and energy transition. In this sense, the Alps can be read not only as a hotspot of climate vulnerability, but also as a testing ground for the contradictions of contemporary extractivism: where green imperatives collide with local ecologies, contested legacies, and demands for environmental justice (Longhin, 2025 forthcoming).

Understanding the transformations underway in the Alps thus requires a multi-scalar reading—one that situates renewed extractive pressures within broader climatic, economic, and political shifts. It also demands critical engagement with the histories sedimented in alpine landscapes, which continue to shape the possibilities and limits of territorial futures. The mining resurgence is not happening in a vacuum: it is embedded in long-standing territorial imaginaries, institutional fragilities, and the socio-material residues of previous extractive cycles. As such, it calls for planning and design approaches that are not only technically adaptive, but historically and ecologically situated.

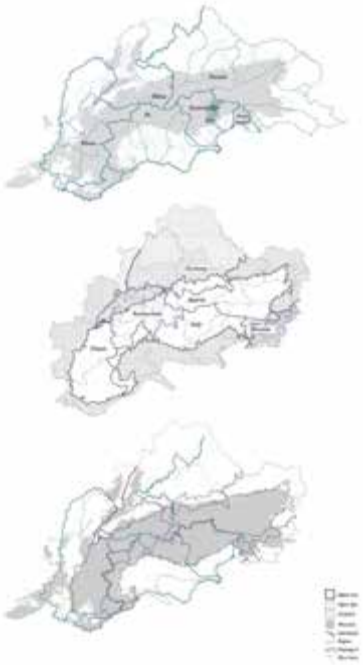

Figure. The legislative subdivisions of the Alpine Space. E. Longhin's elaboration, 2021. From: The Machine in the Mountain, PhD IMAGE TO BE UPDATED

4. Punta Corna: Between Neo-Extractivism, Depopulation, and Territorial Valorisation

Punta Corna, a peak in the Piedmontese Graian Alps rising to 2960 metres, offers a paradigmatic example of the dynamics shaping many Italian mountain regions. Situated in the Lanzo Valleys, between the Viù and Ala valleys, this territory has followed a markedly different trajectory from neighbouring areas such as the Susa Valley, where the Agnelli family initiated mass winter tourism in the 1930s through the development of the winter resort town of Sestriere. In contrast, the Lanzo valleys have seen limited touristic infrastructure and investment. Their economy remains fragile, supported in part by slow and nature-based tourism, as well as a high incidence of second homes. Traditional practices such as sheep farming and the seasonal use of malghe—high-altitude pastures used for summer grazing and artisanal cheese production—continue to play a central role in local livelihoods (Figure to be integrated here).

Within this seemingly pastoral context, the Piedmont Region granted in 2019 an exploration licence for cobalt, nickel, copper, silver, and associated minerals at Punta Corna to the Australian company Altamin. Altamin is a so-called junior miner, focused on a limited number of targeted projects involving exploration and prospecting activities. In Italy, the company operates through two subsidiaries—Strategic Minerals srl and Energia Minerals srl—and is involved in four active projects. Its most advanced initiative, concerning zinc extraction in Gorno (Bergamo province), was rejected in June 2022 by the Ministry for Ecological Transition (Pons 2022). At Punta Corna, however, the exploration licence was renewed in December 2022.

Contrary to appearances, mining is not a recent phenomenon in this area. Between 1753 and the 1930s, Punta Corna hosted what was, at the time, Europe's largest cobalt mine. Many of the settlements in the area originated from this mining economy (Forti 2023). Initially used as a pigment, cobalt lost economic relevance with the introduction of synthetic dyes in the early twentieth century, leading to the mine's decommissioning. However, cobalt has since become central to a wide array of industrial applications, owing to its distinctive chemical and physical properties. Today, it is employed in the production of superalloys for jet engines and gas turbines, in high-performance permanent magnets, in high-strength cutting tools, as well as in chemical processes such as the synthesis of adipic acid for nylon production. Cobalt's strategic value has increased significantly in recent decades due to its role in lithium-ion batteries for portable electronics, electric vehicles, and other clean energy technologies. With the EU's planned phase-out of petrol and diesel vehicles by 2035,[6] cobalt demand is expected to rise sharply. It is therefore not surprising that, as early as 2020, the European Union classified cobalt as a strategic raw material—alongside lithium, coltan, and rare earth elements—in support of both the green and digital transitions.

The Punta Corna deposit lies between two municipalities in the Lanzo Valleys: Usseglio and Balme. These local governments have expressed diverging positions regarding the potential extractive redevelopment of the site. Their respective stances are emblematic of the broader debate over development strategies in contemporary mountain areas: on one side, a model rooted in extraction and energy production—a legacy of modern industrialisation; on the other, a model aligned with Boltanski and Esquerre's (2019) economy of enrichment, centred on niche markets, tourism, and territorial patrimonialisation.

In the municipality of Usseglio, the legacy of modernity is embodied by the large dam built in the 1930s for hydroelectric production, which gave rise to the artificial Lake Malciaussia and submerged the original village bearing the same name. The construction, emblematic of early twentieth-century modernisation, brought roads, a railway, and new employment opportunities to the Lanzo valleys.[7] Today, the Usseglio administration views the prospective reopening of the cobalt mine as a potential catalyst for revitalising a region suffering from

6 The European Parliament on 14 February 2023 gave final approval to the measure banning the sale of vehicles with combustion engines from 2035. The measure is part of the 'Fit for 55' package to halve pollutant emissions in the EU by 2030 and sets a target of zero emissions from new cars and vans for sale in the EU from 2035.

7 Cf. A. De Rossi. The construction of the Alps. The twentieth century and Alpine modernism (1917-2017).

infrastructure deficiencies—particularly digital connectivity[8]—and long-term depopulation (Forti 2023).[9] Mining, from this perspective, is seen as complementary rather than antagonistic to existing economic activities such as tourism. However, significant frictions emerge between mining ambitions and the region's orientation towards tourism, environmental conservation and heritage-based development. The environmental and spatial impacts of mining—long the subject of extensive critical scholarship[10]—are difficult to reconcile with the experiential and ecological qualities that sustain mountain tourism (Martin Sanchez, Gori Nocentini 2025).

In stark contrast, the municipality of Balme, located on the Val d'Ala side of Punta Corna, passed a resolution in June 2020 opposing Altamin's exploration activities (Pons 2022). Balme's local economy revolves around nature-based tourism and environmental valorisation. One of its areas, Pian della Mussa, has been part of the European Natura 2000 Network since 2016. Yet Balme is not devoid of extractive activity: the Pian della Mussa Srl company bottles spring water in the area. However, this activity is framed as compatible with the landscape and falls within the logic of the economy of enrichment—relying on the symbolic and ecological value of place, and oriented towards niche, high-quality production. From this perspective, mining represents a radical disruption to the narratives and uses of territory that have underpinned Balme's development strategy.

Still, processes of territorial patrimonialisation are not without their contradictions. Designating a landscape as a heritage asset necessitates its valorisation (Lazzarotti 2003), which can lead to the commodification of territorial identity and the marginalisation of other narratives and uses. While official recognition—such as inclusion in the Natura 2000 Network—may support local development, it can also result in what D'Eramo (2017) calls iconic reduction: a flattening of territorial complexity into standardised images tailored to tourism. Moreover, the protocols for environmental protection may exclude local actors from participatory forms of territorial transformation, as Vassallo and Martin Sanchez (2022) have argued.

Balme thus stands as the site of a profound and unresolved tension between two contrasting territorial visions. The mountain, once conceived as a productive landscape, is now framed primarily as a space to be preserved—even if this means restricting opportunities for change. In such a scenario, combating depopulation appears contingent on strengthening infrastructures that could attract new residents and support the tourism sector.

What this case study illustrates is the absence of a shared vision for Punta Corna's future. In Usseglio, the mining project is seen as compatible with existing economic practices and potentially able to attract investment and development. In Balme, by contrast, the mine is viewed as fundamentally incompatible with the territorial model based on conservation, tourism, and symbolic valorisation. Yet both municipalities share a concern with reversing demographic decline and revitalising local economies and welfare—whether through new industrial activities or enhanced touristic appeal (Martin Sanchez, Gori Nocentini 2025).

Finally, the divergent local perspectives on Punta Corna's future—brought to the fore by the mining project—currently lack a meaningful space for deliberation. The project itself exemplifies a top-down policy dynamic: rooted in a European regulatory framework (the CRMA), implemented by two national ministries, and executed by a private actor operating under a regional licence. Local governments, by contrast, are relegated to a consultative role and hold no real decision-making power (Forti 2023). This asymmetry raises pressing questions not only about governance and legitimacy, but about the actual capacity to imagine and construct plural, situated futures

8 On the state of digital infrastructures in the Italian Alpine territories with a specific focus on Piedmont, see F. Cavallaro & A. Dianin, Beyond the transport infrastructure: the paradigm of accessibility.

9 In Usseglio there are 200 residents (as of 31 December 2019) with an advanced average age. On the depopulation issues of Italy's inner areas, see A. De Rossi ed., Riabitare l'Italia. Le aree interne tra abbandoni e riconquiste; Italian National Network of Young Researchers for Inner Areas Committee, Inner Areas in Italy. A testbed for analysing, managing and designing marginal territories.

10 See M. Arboleda, Planetary Mine. Territories of Extraction Under Late Capitalism; M. Bjornerud, Timefulness How thinking like a geologist can help save the world; N. Brenner & N. Katsikis, Operational landscapes: hinterlands of the Capitalocene; J. Sordi, L. Valenzuela & F. Vera, The Camp and the City: Territories of Extraction.

for marginalised territories (Ibid.).

Conclusion

This article has examined the socio-environmental and territorial implications of renewed extractive strategies in Europe through the lens of the Critical Raw Materials Act and its potential implementation in the Italian Alpine context. By focusing on the case of Punta Corna—a former cobalt mine now identified as a site of strategic interest—the analysis has traced how European green transition agendas become materially and spatially articulated in marginalised mountain regions. These agendas are not merely technical responses to supply chain vulnerabilities but are embedded in specific territorial configurations, historical trajectories, and socio-political tensions.

The Alpine arc—already under significant pressure from accelerated climate change, infrastructural obsolescence, and demographic decline—emerges as a critical arena for interrogating the contradictions of contemporary extractivism. In this context, the promise of re-industrialisation and strategic autonomy coexists uneasily with alternative territorial economies rooted in tourism, ecological valorisation, and patrimonialisation. As demonstrated, the logics of extraction and enrichment not only diverge but also expose deep-seated asymmetries in governance, wherein supranational imperatives and corporate actors hold disproportionate influence over processes of territorial transformation.

The Punta Corna case foregrounds the limitations of existing policy frameworks in addressing the multiplicity of values, claims, and temporalities that characterise alpine landscapes. It highlights the absence of meaningful deliberative mechanisms for local actors, who are often confined to consultative roles within broader top-down governance structures. In this sense, the reactivation of mining frontiers raises not only environmental and economic questions but also those of democratic legitimacy, distributive justice, and spatial equity.

Rather than treating mining as an inevitable corollary of the green transition, this analysis calls for more situated, historically informed, and democratically grounded approaches to resource governance. This entails recognising the Alps not simply as repositories of strategic materials, but as complex and contested territories shaped by layered histories of appropriation, resistance, and reconfiguration. In this light, the future of sites such as Punta Corna will depend less on their geological potential than on the capacity of planning, design, and policy to engage with the plural vulnerabilities, identities, and aspirations of the regions they seek to reshape.

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Designing Good Life for All. Explorations on a Fragile Neighbourhood in Trieste

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Abstract
Across Europe, interrelated crises – economic, environmental, social, and demographic – are increasingly undermining quality of life in urban contexts, with direct implications for the affordability of everyday living, and the resilience of the public welfare system. This paper investigates the evolving dynamics of multifactorial poverty, vulnerability and fragility within cities. Urban space is conceptualised as a 'capacitating' infrastructure – one that enables individuals, regardless of their socio-economic condition, to pursue flourishing lives. From this standpoint, urban design must transcend the conventional binary of domestic versus public space and instead embrace a networked approach that integrates housing, welfare services, and collective spaces into more accessible, personalised, and innovative support systems. These theoretical reflections are applied to an 'inner periphery' of Trieste – a medium-sized Italian city facing population ageing and decline, economic hardship, gentrification, and increasing strain on welfare provision. The research focuses on the urban district named Barriera Vecchia and its transformation into a *supportive and de-fragilising* neighbourhood. The methodology employed comprises: (i) stakeholder engagement through the organisation of discussion events and participatory placemaking initiatives; (ii) data analysis on housing conditions and the socio-demographic profiles of residents; (iii) spatial mapping of resources and criticalities – including the distribution of facilities and open spaces, and their inclusiveness and usability in relation to mobility, accessibility, and environmental quality; and (iv) the development of a local masterplan aimed at strengthening the connections between collective assets and service networks for vulnerable populations.

Keywords: Housing affordability; Fragility; Trieste.

1. Introduction

Today, in Europe, multiple ongoing crises – economic, environmental, social, and demographic – are significantly impacting the quality of life in urban areas. These crises have direct consequences on both *life affordability* – understood as the cost not only of housing but of living conditions as a whole – and the resilience of welfare systems, which are expected to support individuals in achieving and sustaining adequate living standards. In fact, the goals of sustainability, inclusivity, and accessibility 'for all' have become key themes in many urban regeneration projects and urban design guidelines (among the others: Gehl, 2010; UN-Habitat, 2018; Sim, 2019), with the aim of fostering human-scale environments that are responsive to the needs of persons of all ages and diverse social, economic, gender, and cultural backgrounds. However, the translation of these goals into concrete local actions often suffers from vagueness and generality, or, in the worst cases, from a lack of careful selection of the specific places and processes on which to intervene. In the absence of spatially guided and well-inte-

grated management of the various urban policies that these actions – often designed according to a top-down approach – are expected to coordinate and synthesise, there is a recurring risk of generating depoliticised decision-making processes and producing *negative externalities*. Chief among these is the displacement of residents in favor of real estate-led valorisation processes (Swyngedouw, 2007; Checker, 2011; Bunce, 2017; Anguelovski et al., 2018). These considerations highlight the urgent need for a project-based reflection on the spatial conditions of well-being and well-living, their multiple dimensions, and the policies, actions, and actors involved in ensuring their just implementation 'in place'.

This paper stems from the activities developed within the project *iNEST – Interconnected Nord-Est Innovation Ecosystem* – Spoke 4 (2022–2025), co-financed by Italy's EU-funded National Recovery and Resilience Plan (PNRR). The Research Topic, coordinated by the University of Trieste and entitled *Solutions to Improve the Well-being and Quality of Life of Fragile Groups*, focuses on the multifactorial distress affecting urban populations in many European cities, including small and medium-sized ones. The occasion for a deeper and place-based reflection is provided by 'research by urban design', conducted with the students of the fourth year of the full cycle degree in Architecture of the University of Trieste (academic year 2024-25) in an 'inner periphery' of Trieste, a medium-sized city in the Northern part of Italy. Specifically, the second paragraph of the paper critically examines the different terms – poverty, vulnerability, and fragility – that are commonly used today to describe the conditions affecting large parts of urban populations. Their meanings, along with their theoretical and operational implications, are considered from the perspective of urban regeneration, with particular attention to the relationship between individual living spaces and collective spaces at the neighborhood scale. The underlying hypothesis is that the *city can act as a capacitating and de-fragilising spatial and social infrastructure*. The third paragraph describes a number of quantitative and qualitative surveys, data and indicators helping investigate the various spatial conditions of fragility and de-fragilisation, including housing and living affordability, access to school facilities and food, climate and environmental comfort, and inclusive accessibility and usability of spaces and services. These tools are described through practical examples of their application in mapping, policy design, and urban regeneration processes. The fourth paragraph examines the design work conducted in Trieste's Barriera Vecchia neighbourhood. It discusses the involvement of local stakeholders and the use of spatialised data and information to identify and represent various forms of fragility, along with the ways they manifest in specific locations within the urban context. The paragraph also outlines the steps taken towards the development of a masterplan aimed at transforming Barriera Vecchia into a *supportive and de-fragilising* neighbourhood. This is conceived as a design exploration and strategic framework intended to revitalise public spaces, collective facilities, and services, with particular attention to the needs of vulnerable populations. Finally, the conclusions outline key theoretical and practical insights for a de-fragilising approach to urban design and policy-making.

2. Poverty, Vulnerability, and Fragility in Urban Contexts

What follows is a brief exploration of the concepts of poverty, vulnerability, and fragility, with a focus on how their meanings have evolved toward the recognition of complex and stronger synergies between the conditions of individuals and households and their living environments. While these terms and their related analyses still primarily belong to the socio-economic fields of research and practice, the aim here is to emphasise, on the one hand, their connection with the *physical organisation of urban contexts*, and on the other, their *multifactoriality*, that is the interplay of factors impacting on individuals' everyday lives. This perspective helps highlight the multiple – social, economic, and spatial – dimensions of urban distress, as well as the need for inclusive and resilient planning beyond mere physical renewal and valorisation of specific urban areas.

2.1 Terms in Evolution: from Measurement to Meaning

Poverty is generally understood as a *condition of deprivation* – specifically, the lack of material resources necessary to meet basic needs. This condition undermines the ability and opportunities of individuals and households to build and sustain their quality of life and well-being over time. From an economic perspective, three notions of poverty are widely recognised in institutional statistics and data sources: 'absolute poverty', 'relative poverty',

and 'subjective poverty' (ISTAT, 2024; Saraceno, 2023, 2025; EUROSTAT, 2025a)[1]. While the first two imply statistical measurement and appraisal, the third involves a strong personal component, as the identification of a minimum threshold required for a decent life is obtained through interviews and questionnaires addressed to target groups. However, defining poverty solely in economic terms is reductive (Sen, 1976; Bourguignon and Chakravarty, 2003; Aaberge and Brandolini, 2015). Poverty has long been recognised as a multifaceted phenomenon, typically rooted in multiple causes and affecting not only an individual's economic condition but also various interrelated *dimensions of quality of life* – including immaterial, relational, and contextual assets. As a result, its social outcomes may vary significantly depending on the specific location and spatial context (Desmond, 2023; Gallo and Bonacini, 2023; Caritas Italiana, 2024).

From this perspective, a number of agencies and research institutions have challenged the conventional concept of poverty by incorporating dimensions related to various aspects of everyday quality of life. For example, the *Global Multidimensional Poverty Index (MPI)*, developed by the Oxford Poverty & Human Development Initiative (OPHI), is a widely used measurement of acute multidimensional poverty. Its datasets – spanning from 2011 to 2023 – cover more than 100 countries worldwide, allowing for comparisons over time. The MPI combines traditional poverty metrics with indicators of deprivation organised into three dimensions: i) Health (nutrition, child mortality); ii) Education (years of schooling, school attendance); iii) Living Standards (cooking fuel, sanitation, drinking water, electricity, housing, and assets such as a car, bicycle, phone, television, or computer) (UNDP and OPHI, 2024; Lemmi, 2025). All these elements are, to varying degrees, directly linked to spatial planning and welfare policies. Closely related and complementary to this tool is the *Human Development Index* (HDI), developed by the United Nations since 1990 to evaluate key parameters that contribute to human well-being. The focus shifts from a 'lack-based' lens to the analysis of the assets and opportunities that enhance material well-being. Like the MPI, the HDI also incorporates three main dimensions: i) A Long and Healthy Life (measured by life expectancy); ii) Knowledge (measured by years of schooling); iii) A Decent Standard of Living (measured with reference to inequalities in income distribution) (Fig. 1). HDI indicators not only reflect the availability, quality, and accessibility of the physical components of collective facilities, but also emphasise that people and their capabilities – not economic growth alone – should be the ultimate criteria for assessing a country's development (UNDP, 2025).

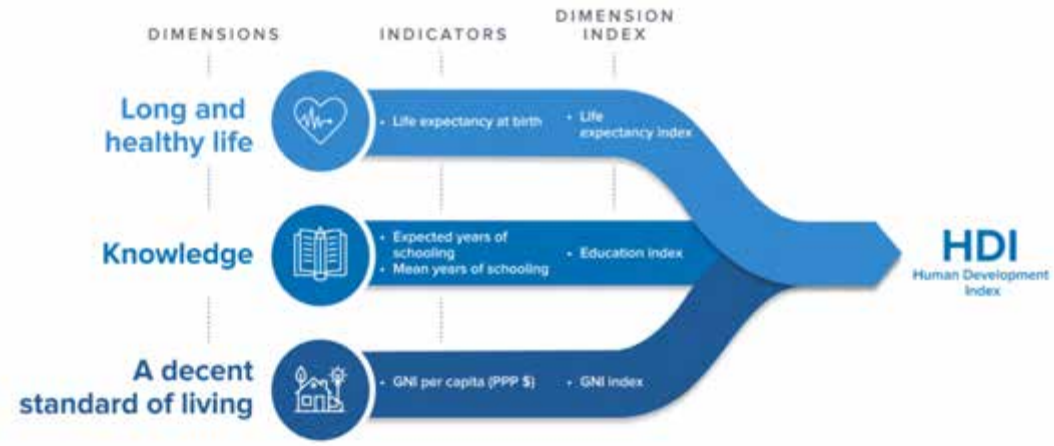

Fig. 1. Human Development Index dimensions and indicators (Source: UNDP, 2025).

1 'Absolute poverty' is defined as the inability to meet one or more basic needs for a period sufficiently long to threaten or seriously compromise survival. It is measured with reference to the economic capacity to cover the cost of a standard basket of essential goods and services (such as housing, food, healthcare, clothing, etc.). A person or household is conventionally considered 'relatively poor' if their available income (or consumption) falls below half – or, in some cases, 60 percent – of these average (or median) per capita values in a given reference area. Finally, the starting point of the assessment of 'subjective poverty' is individuals' perception – what circumstances they consider indicative of a state of poverty, whether related to income levels, lack of certain goods or opportunities, both material and relational.

HDI is largely based on the widely debated *Human Development Approach* (HDA) (Nussbaum, 2011), first conceptualised in economics by Nobel laureate Amartya Sen, and later applied across diverse research fields. According to HDA, also known as the *Capability Approach*, "well-being" is framed in terms of "functionings" (Sen, 1985) – that is, whether a person is able to 'be' (e.g., well-nourished, sheltered, healthy) and 'do' desirable things (e.g., work, receive an education, participate in community life). An individual's "quality of life" is thus defined through their freedom of choice and personal responsibility (Nussbaum and Sen, 1993). In this sense, "capability" refers to the real opportunities that individuals have to accomplish what they value; it denotes the various combinations of functionings (beings and doings) that a person can achieve, reflecting their freedom to lead one type of life or another (Sen, 1989; 1992). Conversely, "poverty" is understood as a deprivation of capabilities – "the failure of the ability to achieve precisely those things that are ultimately important" (Drèze and Sen, 1989, p. 45) – often resulting in social discrimination and marginalisation. A meaningful response to poverty and its multiple dimensions therefore involves expanding the *choices and capabilities* that individuals can access and put into practice to lead lives they have reason to value. Within this perspective, the economic component is only one dimension of a broader equation balancing failures and opportunities where spatial conditions that can enable or hinder individuals' capabilities should be evaluated, particularly in relation to access to housing, education, social and healthcare services.

The term *vulnerability* also refers to a person-centred approach – the condition of 'being vulnerable' – emphasising the *exposure* of individuals or communities to risks such as displacement, environmental hazards, or socio-economic shocks, combined with a limited capacity to cope with or recover from them often due to pre-existing personal conditions such as gender, age, health status, or disabilities (Martinuzzi and Lahoud, 2020). The underlying assumption is that managing vulnerability-related risks is a critical concern for urban governance and a range of public policies and interventions, including spatial planning and design. Over time, this concept has been applied to various fields – from socio-economic studies to political science (e.g., 'social' and 'institutional' vulnerability) – but has more recently been used to highlight the impacts on populations and their overall living conditions of natural disasters, public health crises, and climate change (Biswas and Nautiyal, 2023). Today, vulnerability is increasingly recognised as a *constitutive concept of contemporary societies and cities* (Beck, 1992; Jabareen, 2015), fostering a deeper understanding of risk itself, its spatial and multidimensional implications and consequences, its potential to exacerbate existing inequalities in specific places, and the ways in which urban contexts and their inhabitants can adapt to uncertainty and threat. If vulnerability is defined as a reduced capacity of a person or group to anticipate, withstand, and recover from the impacts of natural or human-made hazards, then this capacity is also closely linked to the availability and accessibility of urban infrastructures and services. As a consequence, and from a spatial perspective, vulnerability can also be framed as a matter of location and disadvantaging configuration of an urban context – such as limited disposal of housing, facilities, and services; poor environmental comfort; gender segregation; or barriers to an inclusive use of urban resources. This conceptualisation is directly linked to the notion of spatial inequality and, by contrast, to the development of more just cities and planning strategies (Fainstein, 2010).

Finally, *fragility refers to a precarious and uncertain condition* – whether affecting individuals and households, communities, physical spaces, or institutional systems – that is *susceptible to breaking under external pressures*. Such susceptibility derives from the intersection of intrinsic characteristics with social, demographic, economic, political, and policy-related factors (EURISPES, 2018). It can ultimately manifest in, for example: loneliness and unstable family conditions; ageing and health problems; insecure and low-paid employment; unaffordable housing and living costs; as well as ineffective sectoral organisation of public institutions also linked to shortages of funding and personnel. Reaching a peak during and immediately after the Covid-19 pandemic, the use of the term fragility has increased in the academic discourse, including spatial planning and urban design. In this context, it specifically refers to the condition of an entity (e.g., a territory, a city, a society, a person or a group, a set of public and private institutions and actors) that may collapse even under minimal stress or retreat in the face of ordinary and minor challenges, due to the rigidity and inflexibility of its conditions, the lack of external support, as well as insufficient infrastructures and networks that might otherwise help develop new capacities, equilibrium, and resilience (Blečić and Cecchin, 2016; Sendra and Sennet, 2020; Pasqui and Curci, 2021; Curci and

Chiffi, 2024). "Interestingly enough, something fragile is not necessarily vulnerable if it is protected from certain external events or agents able to potentially trigger or accelerate its breaking process" (Chiffi and Curci, 2019, p. 56). Here again, space plays a dual role: both as a driver of fragility and as a device that can help mitigate it. From this duality stems the concept of "antifragility" and its use to highlight the possibility of gaining positive outcomes after a shock in an uncertain situation (Taleb, 2012; Aven, 2015). Since not all uncertainties can be prevented, the idea behind antifragility is not just to survive trauma, or simply improve the performance of a given system in response to a shock, but to reinvent and evolve the system as a whole.

2.2. Space as a Capacitating and De-Fragilising Infrastructure

When defining "a new urban question" at the beginning of the 2010s, Bernardo Secchi identified three fundamental aspects of the issue: mobility as the right to accessibility, the consequences of climate change, and social inequalities and exclusion (Secchi, 2010). In line with the theoretical framework of the "right to the city" – from Lefebvre (1968) to Castells (1972) and Harvey (2013) – the city is portrayed as a space where people come together, but also one where they are divided and marginalised due to disparities in work opportunities, access to goods and services, cultural and religious backgrounds, and conflicts among diverse social groups. Even when considering only the modern history of city-making and urban governance, spatial and planning tools have had direct and often disastrous consequences on mechanisms of confinement and segregation between "rich" and "poor" populations, typically favouring the former and displacing the latter. Again, the term "poor" refers not only to those with limited financial means, but also to individuals who cannot enjoy essential facilities (such as healthcare and education) due to locational barriers or uneven service distribution; who face limited access to social support; and who are stigmatised because of the bad living conditions or negative reputation of their residential areas. Therefore, spatial policies bear significant responsibility in addressing inequality and rebalancing urban territories from both social and economic perspectives (Secchi, 2013).

Starting from these considerations, the hypothesis here is that spatialising poverty and vulnerability in the urban context can enable a reinterpretation of the relationship between fragility and space – one in which urban environments are conceived as *capacitating infrastructures*, where all individuals, regardless of their material, social, or physical conditions, can live a good life and achieve personal fulfilment. Accordingly, urban design is called to move beyond the dichotomy between 'individual space' (within the home) and 'collective or common space' (understood as the sum of open areas and public facilities), toward a *networked and integrated conception of indoor and outdoor living environments*. In this conception, the arrangement and design of urban spaces are oriented towards enhancing the effectiveness and personalisation of a plurality of welfare provisions – ranging from housing and traditionally defined collective facilities, to other types of equipment and services, such as those dedicated to food production and distribution, or to the creation of climate-resilient environments. This also includes their interrelationships and conditions of both physical and organisational accessibility. Furthermore, this perspective – drawing on the Capability Approach – invites rethinking urban space and welfare by recognising *individuals as active agents* of change, rather than passive recipients of predefined benefits (Sen, 1999). This implies building a collaborative framework in which institutional, social, and personal capitals are jointly mobilised. Accordingly, public welfare is called to expand and integrate its spheres of action, joining forces with other stakeholders and the inhabitants, and transforming facilities from isolated delivery points of standardised services into proactive devices. These spaces should interact with a diverse range of other collective places, enabling healthy and care-full practices to be tailored to individuals' needs, bodies, and lifestyles, also through social interaction, mutual support, and the shared performance of outdoor activities (Marchigiani, 2022a).

In essence, rather than conceptualising antifragility as a form of preparedness to confront unexpected crises and potentially benefit from them, the focus is here on the de-*fragilisation of individuals' and households' conditions of vulnerability*. These conditions often stem from various forms of deprivation and are closely intertwined with the spatial settings of living environments. The process of de-fragilisation is pursued by intervening in space from a *person-centered perspective*, through the development of new social and spatial infrastructures. The underlying assumption is that an integrated organisation and configuration of urban space and essential services can help prevent fragility from becoming a manifest, disruptive, and persistent condition. This design operation

should begin with the collection and critical interpretation of both quantitative and qualitative information about the population living in a specific urban context, gathered through indirect and direct observation, listening, and participatory processes. The aim is to identify the "dispositions" (or predispositions) individuals possess to either cope with or succumb to the emergence of critical conditions (Choi, 2008). However, this commitment is far from straightforward. While it promotes the recognition and enablement of individual capabilities, social activation, and collaboration between institutions and residents, it also requires careful attention to avoid the pitfalls of a *new humanistic functionalism* (Bianchetti, 2016). Indeed, when based on a superficial collection of data and indicators, there is a risk of inadvertently reinforcing forms of spatial or social determinism. This, in turn, may lead to the reimposition of rigid standards and urban design metrics, reducing people – and their everyday, embodied experience of living spaces – to mere statistical and functional units (Bianchetti, 2023).

3. Mapping Plural Fragilities as a Tool to Address Urban Policy Design

Within the framework of the iNEST research, mapping is a key tool. Its role is complex and multifaceted: i) to spatialise the overlap between quantitative data and experiential knowledge; ii) to investigate the relationships between places and people, identifying the concrete spatial dimensions of various forms of poverty, vulnerability, and fragility; and iii) to select locations where different types of fragility converge, which therefore require special attention to improve living conditions in specific urban areas.

Spatial analysis and visualisation of multiple deprivations are receiving increasing attention worldwide. This growing interest reflects the need to better understand and make unequal living conditions visible, as well as the processes that produce them. Such analyses can support public institutions in resource allocation, land management, and policy design (Martínez et al., 2016). In Italy, two particularly noteworthy examples are the *Mapping Inequality* research platform (Vinci et al., 2025) and *MappaRoma* (Lelo et al., 2019, 2021; MapparomaLab, 2025). The former offers a georeferenced "Atlas of Urban Inequalities", exploring this issue in several large Southern European cities – specifically Palermo and Naples – using small-scale indicators from various domains, including income distribution, housing conditions, access to fundamental services and facilities, and exposure to environmental risks. The latter is an in-depth analytical project focused on the Rome metropolitan area. Drawing on datasets at both municipal and sub-municipal levels, *MappaRoma* brings together a wide range of data to highlight the spatial distribution of social, demographic, economic, planning, and political differences. Both initiatives are of considerable interest for their capacity to construct a spatialised knowledge base that underpins innovative methods and tools aimed at mitigating the spatial inequalities produced by urban policies and at informing future urban transformations. This holistic approach proves particularly effective at the scale of the entire city or metropolitan area, as it facilitates the comparison and superimposition of multiple layers of information, enabling a deeper understanding of the diverse, and at times contradictory, forms that urban inequalities assume across time and space.

The following paragraphs explore in greater depth how various concepts and dimensions related to poverty, vulnerability, and fragility can be interpreted in spatial terms, and in relation to more specific spatial features. The focus is primarily on a selection of European and Italian experiences, ranging from observatories and atlases to analytical and interpretative efforts aimed at supporting urban policies and regeneration projects. Their relevance to iNEST research lies in the attempt to spatialise and interrelate different types of data and information, with a view to their potential application at the scale of *urban sectors and neighbourhoods.*

3.1. Housing Location Affordability

In contexts marked by multiple crises and overlapping factors that undermine the quality of life in urban areas, the fulfilment of the right to adequate housing (Kenna, 2012; The Shift, 2025) should be regarded as a cornerstone of welfare policies, future EU priorities, and planned investments (Vlad, 2024). Across Europe, *housing poverty* manifests itself in a wide spectrum of situations, ranging from extreme forms of exclusion and deprivation to more widespread conditions of housing insecurity. These are often driven by an insufficient supply of public rental housing – both social and 'very social' – as well as by rising rents in the private market (Tosi, 2017; Bricocoli

et al., 2021; Fondation Abbé Pierre and FEANTSA, 2024; Marchigiani and Novak, 2024). Moreover, *affordable housing* is not only a fundamental welfare provision that helps prevent the risk of homelessness, but also, as described by Habitat for Humanity, "a ladder out of poverty for families" (2021, p. 5). Ensuring stable residency is, in fact, a basic prerequisite for the enjoyment of a broader range of civil rights, public services, and social support – including political representation, employment, healthcare, and education.

However, the very concept of *housing affordability* is increasingly being called into question, as its definition is recognised as multifaceted and not easily measurable through simple parameters (Peverini, 2023). The traditional threshold – set at 30% of the ratio between housing costs (whether rent or mortgage) and total household income – rises to 40% when all housing-related expenses are taken into account. To more thoroughly investigate households' ability to access adequate housing in suitable locations and at acceptable costs, a variety of measurements and indicators have been developed, as evidenced by international statistical platforms and observatories (EUROSTAT, 2025b; OECD, 2025). These tools help construct a picture of the varying degrees of *housing poverty and vulnerability*, though some limitations persist in terms of data collection and interpretation (OECD, 2021). Considering the general conditions of both the supply and demand sides, quantitative methods for measuring housing affordability rely primarily on indicators related to real-estate values, rental costs, housing maintenance expenses, and households' disposable income. Other indicators – such as the overcrowding rate, measures of housing quality, and subjective perceptions of affordability – can offer a more nuanced picture of housing's impact on residents and their increasing *social fragilities*, including the negative effects of limited space and overcrowding on health and well-being. However, such indicators rely on data that are more complex to collect, often requiring qualitative methods like interviews and questionnaires (Heylen, 2023). In fact, the quality and adequacy of housing in relation to the needs and resources of households vary significantly according to cultural differences, age, and family composition (which are becoming increasingly unstable due to demographic shifts and rising divorce rates), job and income security (highlighted by the growing number of 'working poor'), and the burden of inflation reducing the purchasing power of households' wages (Marchigiani and Novak, 2024). Moreover, when housing affordability is understood as a component of the overall cost of living within a given urban context, it encompasses not only rent or property prices but also broader living expenses. To effectively inform supportive housing policies, affordability must therefore be assessed in relation to the availability, accessibility, and public character of a wider range of services. This highlights its strongly *site-specific nature* and the need for a closer, more integrated investigation of local spatial, social, and economic conditions.

From this perspective, recent experiences highlight innovative approaches focused on *location affordability*, understood as encompassing the spatial dimensions and conditions of affordability, and highlighting a strong link between housing, urban planning, and urban welfare policies – for example, those related to transport planning, land use, and the broader supply of affordable rental housing. However, the call for a more comprehensive analysis – as evidenced by theoretical models and frameworks developed globally – has so far resulted in only a limited number of practical initiatives (Mullinere and Maliene, 2012; Peverini, 2023; HUD, 2025). Among them there is OCA – *Osservatorio Casa Abbordabile* (Observatory for Affordable Housing), an initiative jointly promoted in Milan by the Politecnico di Milano and third-sector organisations. OCA draws attention to housing affordability as the relationship among individual or household income, the cost of accessing housing (whether for rent or purchase), and a wider set of conditions related to spatial location. The mapping and analysis of various public datasets (ISTAT, MEF, and OMI)[2] highlight how inequalities in access to different types of housing supply (including social and regulated rental housing, tourist accommodation, and short-term rentals) by a growing variety of social demand (from long-term residents to students and workers) are closely connected to commuting patterns and costs, measured in terms of both transport expenses and travel time. These investigations are carried out not

2 ISTAT is the Italian National Institute of Statistics; it collects and analyses data on various topics, including the socio-economic conditions of the population and the housing stock (https://www.istat.it). MEF is the Italian Ministry of Economy and Finance, which provides data on the incomes declared by individuals (https://www.mef.gov.it). Finally, OMI, the Italian Real Estate Market Observatory, collects and disseminates real estate quotations for defined homogeneous territorial areas within each municipality, indicating a minimum/maximum range of market and rental values per square metre, based on property type and condition (https://www.agenziaentrate.gov.it/portale/schede/fabbricatiterreni/omi).

only within the administrative boundary of the municipality of Milan but also in its wider regional context, where housing values have skyrocketed and people with average or low incomes can no longer access the inner-city housing market, while the supply of council housing remains stagnant (DAStU et al., 2025; Bricocoli et al. 2025). Given that housing policy is currently limited to the municipal scale, this insight is crucial for reorienting interventions at a broader territorial level, thus opening up new perspectives for future decision-making.

What can be learned from ongoing reflections and experiences is that a more complex and integrated framework of housing affordability indicators and indexes – along with related data sources and operational procedures for analysing, cross-referencing, and interpreting them – are necessary to support the implementation of multilevel urban policies and spatial regeneration strategies at the regional, urban and local scales. The pandemic and, more recently, the decline in living standards and broader processes of social fragilisation, have shown that the private space of the home (when available!) is not, in itself, sufficient to ensure a decent life. In fact, housing vulnerability goes beyond the mere availability of affordable housing. It requires a closer examination of living patterns and household compositions, which are becoming increasingly less standardised, as well as of individuals' levels of autonomy, including considerations related to social, health, and age conditions. These factors demand careful assessment of the spatial qualities of housing with respect to the size and configuration of households, as research activities within the *UAH! Unconventional and Affordable Housing project* (2023–25) are attempting to demonstrate (Aa.Vv., 2025)[3]. UAH! operates at the intersection of urban and architectural design of individual and shared spaces within the home, collective spaces and equipment at the neighborhood scale, public housing policies, and informal practices carried out by residents in collaboration with a variety of institutional, community and third-sector actors.

3.2. Schools and Urban Learning Contexts

Within the framework of essential services aimed at reducing vulnerability and fragility through the creation of spatial and social infrastructures complementing the home environment, access to schools and education represents a fundamental condition for enhancing individual capabilities and acquiring the knowledge and skills necessary for autonomous living. In contrast, *educational poverty* refers to the lack of opportunities for children and adolescents to learn, grow, face life's challenges, and develop their talents and aspirations (Save the Children, 2014). Driven not only by insufficient provision (in terms of quantity and distribution) of facilities, educational poverty is also linked to cultural disparities among household groups, the duration and quality of education, and spatial accessibility to schools. In this regard – in Italy as well as all over Europe – early school leaving and competence levels measured by standardised tests serve as key indicators (European Commission, 2024). From this perspective, educational poverty is also recognised as a root cause of unemployment and social exclusion (European Commission, 2015).

In relation to these issues, in 2014 Save the Children Italia developed an *Index of Educational Poverty* (IPE). In 2019, the IPE was applied to monitor the Italian context, highlighting relationship with social inequalities and their spatial distribution across the country. The indicators used refer not only to the availability of educational spaces in a given area, but also to directly associated facilities (e.g., school canteens, libraries, gyms, courtyards) and the frequency with which they are used by children (Save the Children, 2014; Openpolis and Con i Bambini Impresa Sociale, 2019). In addition, the IPE considers the range of activities children engage in outside of school, either during or after school hours – such as visiting museums and exhibitions, going to the cinema, to sports facilities and libraries. This assessment not only examines the availability of basic school services – highlighting which areas within a city or region lack adequate provision – but *also establishes a strong connection between the school system and other urban facilities*, evaluating their attractiveness and suitability for children and young people. From this perspective, what matters is how schools are used and how they support access to other urban services, as well as how they serve the community and how open they are to different user groups at various times of the day, week, and year (Gammino, 2024). Here, again, spatial organisation and setting of these facilities at territorial,

3 UAH! is co-financed by Italy's EU-funded National Plan for Recovery and Resilience (PNRR). The partners are DAStU of the Politecnico di Milano (leader partner, coord. Gennaro Postiglione), Università di Trieste (coord. Elena Marchigiani), and Università e Politecnico di Bari (coord. Daniele Petrosino).

urban and local scales constitute pivotal issues.

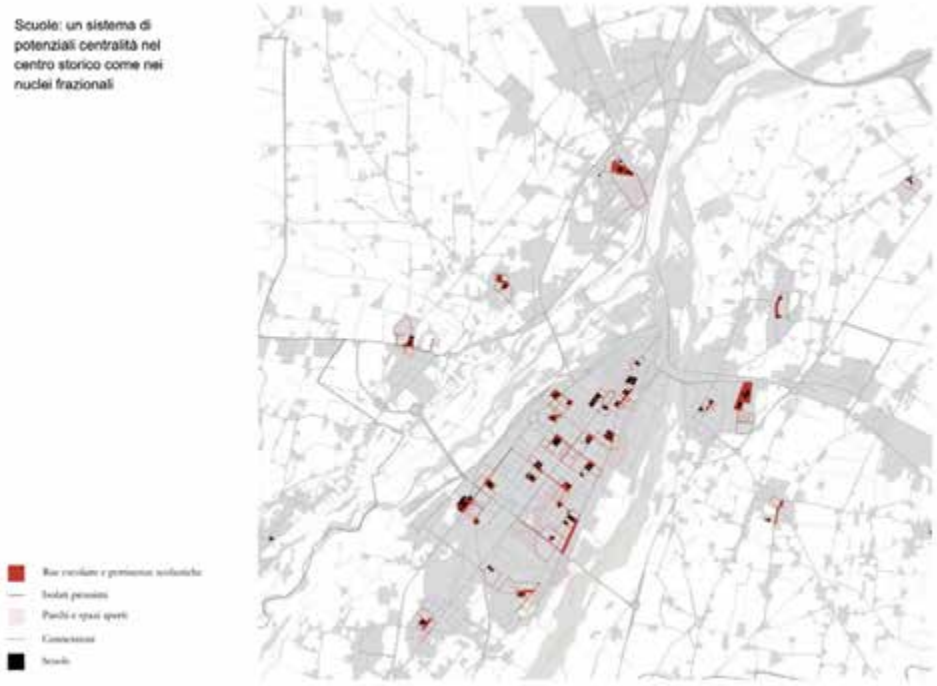

Fig. 2. Schools: a system of potential hubs in the historical centre and in the external neighbourhoods. Urban and territorial strategic regeneration strategy for Sustainable Cuneo city (Source: Renzoni and Vassallo, 2021b).

The importance of planning and design of educational spaces in reducing urban and social fragilities is not a new concept. In Western contexts, schools have long been recognised as focal points within neighbourhoods or urban areas, and as tools for equitably equipping different parts of the city while fostering cohesive local communities. More recently, their relevance has been revitalised worldwide within the '15-minute City and Neighbourhoods' concept (Moreno, 2024). In parallel, school facilities have been examined from a spatial perspective as catalytic elements within the network of urban welfare spaces. In a growing number of European experiences, the role of *learning contexts* is not limited to school buildings alone, but extends as well to streets and public spaces understood as part of a collective educational infrastructure fostering independence (among the others: Ward, 1973; Ceppi and Zini, 1998; Kyttä, 2004; Munarin et al., 2011; Marchigiani, 2022b; Renzoni and Savoldi, 2022).

From this perspective, among the most advanced experiences aimed at supporting urban policies and design strategies, there are those recently developed by research groups at the Politecnico di Milano and Politecnico di Torino. These studies focus on various Italian metropolitan and medium-sized cities in the Lombardia and Piemonte regions, investigating the connections between educational facilities, urban accessibility systems, and other urban services (Renzoni et al., 2021a; Pileri et al., 2022; Renzoni and Savoldi, 2023; Savoldi and Baldissera, 2025). Specifically, within the studies for the strategic plan of Cuneo, four guiding principles are recognised. They focus on: open and public spaces; cultural heritage; social and healthcare services (crucial in the context of an increasingly ageing population); and school facilities, in relation to their surrounding spaces. As part of the masterplan for the regeneration of the urban fabric, the school hubs connect their associated facilities and courtyards to streets and spaces nearby, structuring a potential network of 'school roads' that is porous, liveable, and safe for people of all ages (Renzoni et al., 2021b) (Fig. 2).

3.3. Food Atlases

Another domain of welfare aimed at supporting socio-economically fragile individuals is access to healthy, affordable food, as well as the infrastructures related to its production and distribution. The lack of such conditions is referred to as *food poverty* – a complex phenomenon that has been exacerbated and diversified by recent crises, even in advanced capitalist countries. In contexts such as Italy, the problem lies less in the availability of food than in the access to a healthy and adequate diet. This reflects the paradox of *scarcity in abundance*, defined as "the impossibility for parts of the population to access adequate nutritive resources despite their (over)abundance in the context where they live" (Maino et al., 2016, p. 26; translated by the authors). Food poverty is also defined as "one of the most severe and comprehensive forms of material deprivation, leading to the inability to obtain or consume food of adequate quality or quantity in socially acceptable ways" (Toldo et al., 2023, p. 141). These definitions capture the phenomenon's multidimensional nature: material deprivation, social exclusion from food-related practices, and psycho-emotional effects such as stigma and shame from relying on public aid.

However, the difficulty of situating food poverty within a unified critical framework makes it equally challenging to measure and assess its multidimensional nature. Available data are often fragmented and focus almost exclusively on economic dimensions, failing to fully capture the phenomenon – particularly from a spatial perspective. This gap has contributed to framing food poverty merely as a condition of need, thereby obscuring the issue of access to food as a fundamental right. In Italy, a significant attempt to address these limitations has been undertaken by ActionAid. In its most recent report, three tools are used to investigate food poverty: the Material and/or Social Food Deprivation Index (DAMS); the risk of food poverty; and relative food poverty (Ciancimino and Sensi, 2024). The report highlights how food poverty is shaped by multiple factors – including education, housing conditions, and access to the labour market – as well as by demographic characteristics, and the resources available in local contexts. It also raises critical questions about the adequacy of a response system based solely on material aid, particularly in cases not linked to extreme deprivation. Finally, the report underscores the urgency of developing local monitoring systems that consider not only food affordability, but also diet quality, food literacy and well-being, and the role of social participation in food practices.

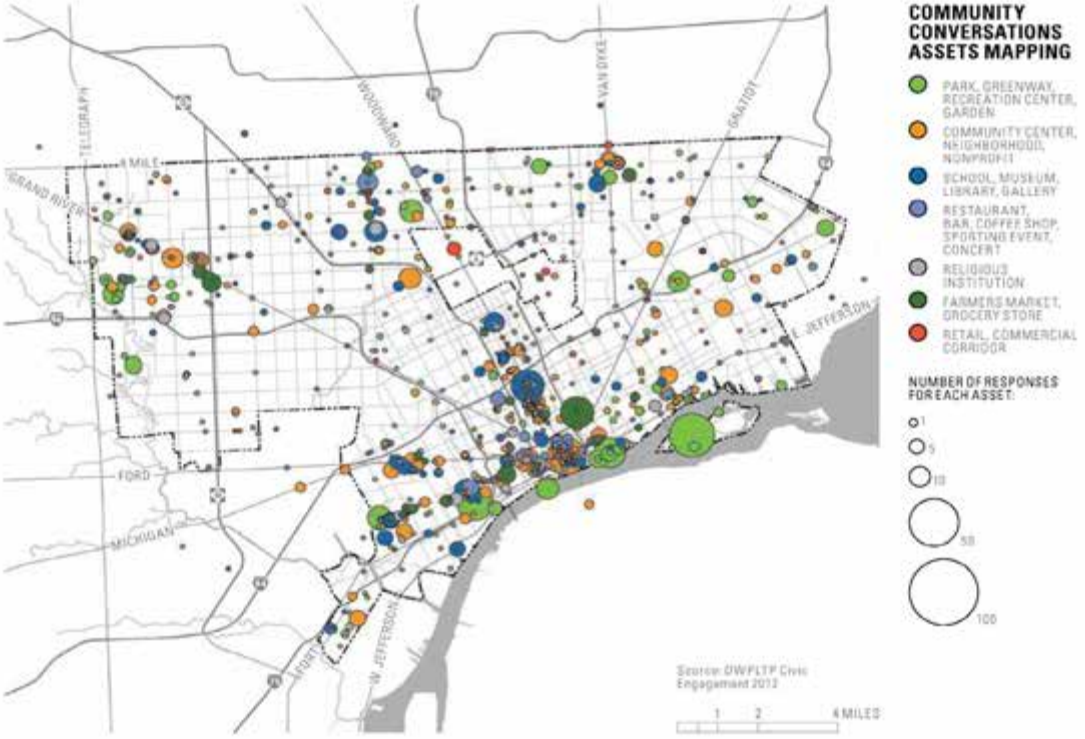

Fig 3. Food and social facilities: supports for transforming neighbourhoods (Source: Detroit Future City, 2012).

In this framework, the concepts of *food empowerment and food environment* play a major role. The latter – understood as the set of conditions that enable or constrain food choices – specifically highlights the importance of urban space. This approach was already evident in the Strategic Framework Plan for Detroit, developed to address urban shrinkage and severe social and economic crises (Detroit Future City, 2012). Within this plan, urban agriculture and the reclamation of vacant lots are recognised as key interventions; furthermore, this tool envisions a multi-scalar network of food-related spaces and landscapes – from home gardens to farms linked to employment districts and food processing industries – as a cornerstone of a more resilient and equitable urban structure (Fig. 3). In fact, mapping food retail and distribution alone is insufficient to fully define a local food environment. A comprehensive understanding also requires the integration of spatial accessibility (e.g., the territorial distribution of food-related services – from supermarkets to open-air markets) with indicators such as food affordability, local food production, and the presence of solidarity networks. Within the *Atlante del cibo* (Food Atlas) of Rome metropolitan territory (Marino et al., 2022), this spatial approach makes it possible to identify 'food blackout areas', characterised by a systemic disruption in food access. In these areas, the intersection of multiple forms of fragility – economic, productive, spatial, and social – leads to a complete breakdown of local food systems, leaving communities without adequate support (Bernaschi et al., 2023).

3.4. Climate-proof cities and neighbourhoods

Especially in densely built urban contexts, *climate vulnerability and fragility* are today key issues that must be urgently addressed. This is particularly relevant for urban planning and design interventions in consolidated and highly 'mineral' urban districts, where natural elements are scarce. Southern Europe is mostly affected by three climate-related phenomena: heatwaves, or prolonged periods of above-average temperatures; heavy rainfall leading to flash flooding; and droughts, which contribute to wildfires and put pressure on water supplies (European Environment Agency, 2024). The effects of heatwaves and heavy precipitation are amplified where soil sealing is widespread and there is a lack of natural elements and vegetation. These hazards have a significant impact on the *comfort and health of urban dwellers*. In particular, prolonged heat stress, associated with rising temperatures and exacerbated by the urban heat island effect, can severely affect individuals already suffering from health problems, older adults, and children. Furthermore, these risks are heightened in situations of housing overcrowding and poor-quality dwellings. It is therefore not surprising that, within the broader context of the ecological and climate crises, the interrelation between environmental well-being and individual health is increasingly recognised as a matter of spatial justice and welfare. This recognition calls for an integrated policy framework situated at the intersection of spatial and environmental planning and social welfare – commonly referred to as 'ecosocial policies' (Carrosio and De Vidovich, 2023).

From a spatial planning and design perspective, enhancing green provision – encompassing tree cover and permeable green surfaces – emerges as a strategic intervention. In this regard, the implementation of Nature-Based Solutions (NBS) provides a practical and integrative approach to improving the functionality of green and open space networks, as well as mobility infrastructures within urban neighbourhoods, thereby linking urban regeneration with climate adaptation goals (Farlè, 2020). However, precisely because such interventions can significantly enhance quality of life in urban areas, 'urban greening' initiatives may also contribute to rising property values, reduced affordability of housing and public services, and the onset of gentrification processes that disproportionately affect socioeconomically vulnerable populations (Checker, 2011; Anguelovski et al., 2018). As such, these initiatives must be critically and contextually assessed to mitigate potential adverse social impacts.

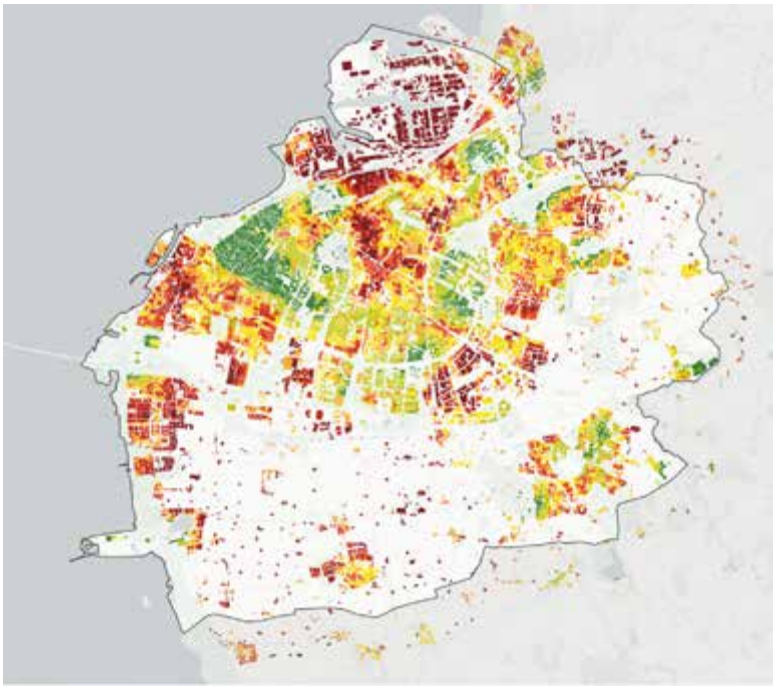

Fig. 4. 3+30+300 rule scores for buildings in Malmö, Sweden. Green and yellow indicate buildings and areas that meet or exceed the criteria, while orange and red highlight those with insufficient scores (Source: Konijnendijk et al., 2025).

Among NBS, depaving and the 3-30-300 rule have recently gained prominence in academic debate and design practice. While the former is a method aimed at improving soil permeability, the latter functions both as an index for assessing the quality of green spaces and as a strategic framework for territorial and urban planning (UN-ECE, 2021). Introduced in 2021, the 3-30-300 rule promotes healthier urban environments through a principle of redistribution: "ensuring that every resident can see at least three mature trees from their home, lives in a neighbourhood with 30% tree canopy cover, and has access to green space within 300 metres" (Konijnendijk, 2021). The Yggdrasil project, developed as part of the Nordic Council of Ministers' Vision 2030 initiative, represents one of the first attempts to extend the 3-30-300 concept at an interregional level across the Nordic countries (Denmark, Norway, Sweden, Finland, and Iceland). This experience demonstrates how data from various international databases can be harmonised – for example, using the World Cover map by the European Space Agency to analyse tree canopy cover, and OpenStreetMap to assess mobility and accessibility in relation to the availability of green infrastructure in urban contexts (Konijnendijk et al., 2025) (Fig. 4). Notably, the study also highlights access to green spaces and trees in connection with dimensions of socioeconomic vulnerability, visualising potential disparities between areas with differing income levels, employment rates, and proportions of migrant populations.

At a neighbourhood scale, the City of Paris has implemented various NBS strategies within the framework of the *OASIS Schoolyard Programme*. In response to increasingly severe heatwaves in the urban environment, the project transforms schoolyards within disadvantaged neighbourhoods from hard-surfaced, enclosed spaces into green, open areas. Funded by the EU Urban Innovative Actions (UIA) programme, this pilot initiative involving a number of schools was carried out as part of the *Paris Resilience Strategy* addressing climate adaptation at multiple levels across the metropolitan area (Sitzoglou, 2020; Resilient Cities Network, 2025). A key concept behind this project is that green schoolyards are designed not only as a response to escalating climate threats, but also as a tool to foster inclusivity within local communities. The schoolyards remain open after school hours, serving as neighbourhood pocket parks for the most vulnerable residents.

3.5. Inclusive Spatial Accessibility

Spatial accessibility is here understood as the set of spatial conditions that enhance individuals' ability to move independently on a daily basis from their homes to workplaces, public spaces, and essential facilities. This fundamental quality of urban environments enables people – regardless of their age, gender, health, income, or social status – to lead autonomous and healthy lives, actively participate in society, and shape their own conditions of well-being and social interaction. However, the physical layout of cities often hinders access to essential services (such as education and healthcare), due to their dispersed location, the absence of pedestrian infrastructure or public transport links, and the presence of architectural and urban barriers (Marchigiani, 2023). Moreover, conditions of so-called accessibility poverty exacerbate social and economic inequalities, resulting in territorial segregation and the marginalisation of both people and places. In this regard, spatial accessibility – being a "capital" that can help or prevent a full performance of a person's capabilities (physical and social, economic and cultural) (Kaufmann, 2011; Marchigiani, 2022a) – becomes a matter of urban justice and a key component of urban equity and inclusiveness.

Addressing these challenges requires a shift in perspective beyond the spatial distribution of services and facilities. Accessibility encompasses not only the availability and geographical placement of these assets, but also their functional quality, user-friendliness, and systemic connectivity. Additionally, the health implications of active mobility should not be overlooked, as they play a pivotal role in individual and public health outcomes. Environmental sustainability is likewise a key consideration, since the implementation of integrated and low-impact mobility systems contributes significantly to reducing the environmental footprint associated with conventional, car-dependent transport modes. From this perspective, services and facilities must not only be accessible, but also reachable and effectively interconnected via safe, comfortable, and adequate routes. The concept of *proximity* thus assumes a central role (Gall, 2024), yet it needs a robust design framework capable of guiding interventions within a comprehensive vision for urban planning and regeneration (Marchigiani and Bonfantini, 2022). Beyond physical distance, several additional factors must be considered, including average travel time (whether on foot, by bicycle, or via public transport), the availability and quality of transit options, the presence of physical and perceptual obstacles, safety conditions, and the degree of alignment with users' needs. Specifically, the provision of barrier-free, walkable environments is highly important for individuals with different types of fragility. In fact, understanding the impacts of accessibility poverty requires particular attention to the groups most affected. Vulnerable populations – such as children and, more notably, persons with motor, sensory, or cognitive disabilities, whether permanent or temporary – are disproportionately impacted (World Health Organization, 2001). For these individuals, accessibility is a determining factor for social participation itself. Moreover, the likelihood of experiencing disability increases with age, making this a critical consideration in the light of current demographic trends within Europe (Eurostat, 2024).

Therefore, by adopting a Universal Design (UD) approach (Müller, 2023), urban space should be organised and reconfigured through the lens of bodily diversity and inclusivity (Bianchetti, 2020). Furthermore, limitations in accessibility should be regarded as design opportunities to reconsider the relationships between mobility, local economies, social practices, and the spatial distribution of essential services. Enhanced access to key facilities supports the development of *person-centred and place-based welfare systems*; thus, inclusive accessibility emerges as a strategic instrument for addressing complex territorial and social vulnerabilities. Orienting urban planning and regeneration around accessibility entails the involvement of multiple stakeholders and requires strong public leadership and coordination, whereas spatial connections between public facilities should serve as the *backbone of an urban infrastructure* capable of generating positive impacts across multiple scales and fields of action (Marchigiani and Basso, 2021). The liveability of streets – aimed at promoting safe and slow mobility – is a central concern. This calls for the implementation of a range of interventions, including pedestrian zones, 30 km/h speed limits, and the redesign of pavements and crossings, to help reduce conflicts between travel modes and improve accessibility for individuals with mobility impairments.

Several recent initiatives embody these principles. Notably, FVG *Accessibile* – a project developed by the Italian Friuli Venezia Giulia region in collaboration with the Universities of Trieste and Udine, and the Regional Informa-

tion Centre on Architectural Barriers and Accessibility – has established an ICT-based mapping system focused on the spatial and functional components of the urban environment, with accessibility assessed through Universal Design (UD) lens (Regione Autonoma Friuli Venezia Giulia, 2025). This initiative aims to integrate representations of facilities and public buildings, streets and connecting spaces, alongside the identification of various types of indoor and outdoor obstacles and barriers, in order to detect critical issues and support integrated planning processes. In this context, accessibility emerges as a cross-cutting concept that links spatial comfort, social welfare, and the effective usability of urban spaces and services (Marchigiani et al., 2022). Among the various approaches used to assess accessibility to essential facilities through active mobility, the *Inclusive Accessibility by Proximity Index* (IAPI) emerges as another valuable and context-sensitive tool for informing urban planning strategies aimed at promoting more inclusive and sustainable urban environments. This was demonstrated through its application at the neighbourhood scale in the city of Bologna. The IAPI is based on a comprehensive set of data sources and indicators relating to: the technical performance of pathways; traffic safety and road impacts; the safety and social appeal of public spaces; the design and diversity of public spaces and the built environment; and the accessibility of public and collective services, assessed using isochrone-based methods. The result is a synthetic representation of accessibility levels to essential services at the local scale, enabling the identification of potential issues related to both service provision gaps and the perceived quality of cycling and pedestrian routes, open and built spaces (Lanza et al., 2023).

The relevance of this integrated approach is clearly demonstrated in the Site-Specific Assessment *Guidelines* (UN-Habitat, 2020), where "suitability maps" are employed to visualise urban accessibility and usability within a neighbourhood, in order to support the development of inclusive and sustainable mobility 'for all' (Fig. 5).

Fig. 5. The network of services and facilities at the neighbourhood scale (Source: UN-Habitat, 2020).

4. Design Explorations in Trieste: Toward a Supportive and De-Fragilising Neighbourhood

The opportunity to test the concepts and methodologies outlined thus far was provided by *research by urban design* conducted in the district of Trieste called Barriera Vecchia, within the activities of an Urban Planning Atelier at the University of Trieste. Owing to time constraints and the design-oriented nature of this experience, the development of complex indicators was not entirely feasible. The investigation therefore focused on the material quality of urban spaces. This shift, however, enabled emphasis on a layer of analysis that is often still superficially addressed in the aforementioned studies.

Specifically, the work pursued two main objectives. The first was to experiment with approaches for analysing

the quality of everyday life in an urban district that is characterised by the coexistence of multiple forms of fragility. This was achieved by systematising methods and tools that are rarely integrated into mainstream urban design practices. The second objective was to develop a design masterplan to transform this urban sector of Trieste into a *supportive and de-fragilising neighbourhood*. The aim was to enhance existing spatial and social assets, amenities and resources – improving the environmental performance of collective spaces, and proposing the implementation of new services to support overall upgrading of living quality and affordability. This was addressed through listening to and collaboration with public authorities, and third-sector organisations. The work employed both qualitative and quantitative data and information, with the purpose of rethinking the forms and methods of spatial regeneration. Overall, the intention was to foster social and institutional innovation capable of preventing and mitigating the emergence and escalation of conditions of vulnerability.

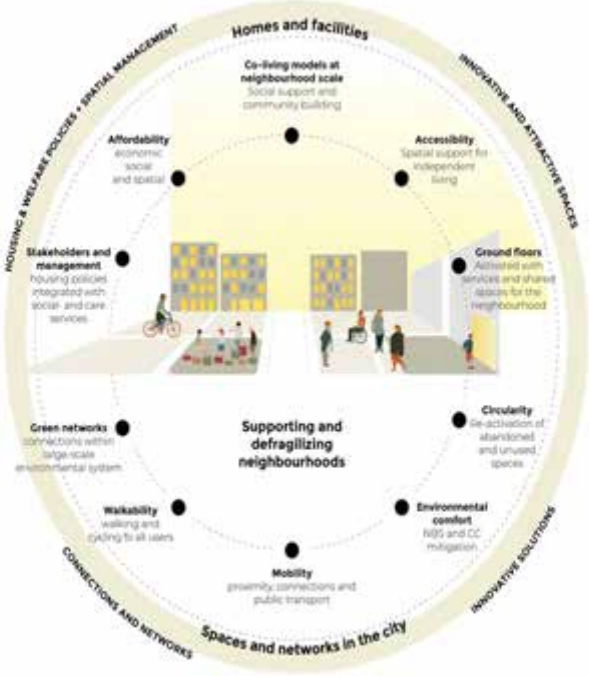

Fig. 6. Supporting and de-fragilising neighbourhoods: domains and actions (Author: Teresa Frausin).

More broadly, by integrating multiple domains of quality assessment – including uses and users, amenities, comfort and safety, the green environment, and accessibility – the organisation of the city into supportive and de-fragilising neighbourhoods provides a spatial framework for the integration of housing and facilities (Fig. 6). This approach focuses on lived spaces beyond individual dwellings, specifically on public and collective spaces conceived as enabling infrastructures capable of hosting collaborative practices and supporting place- and people-sensitive spatial and policy design. However, before outlining the overall process, it is necessary to clarify its context and the rationale underpinning its design outcomes.

4.1. Working in the Inner Periphery of a Medium-sized city

Trieste is located on Italy's north-eastern border and currently has a population of approximately 200,000 inhabitants. It is a *medium-sized city*, occupying a spatial and functional position distinct from both large metropolitan areas and suburban, inner, or marginalised territories. These characteristics, along with their specific contextual conditions, have made medium-sized cities – and the so-called *intermediate urban areas* – a focus of recent Italian research, as well as of experimentation with more context-sensitive planning and design approaches and tools (see, among others, Lanzani and Curci, 2018; Gabellini et al., 2023; Renzoni et al., 2023; Caramaschi et al., 2024; Lanzani, 2024a).

While Trieste shares with other medium-sized cities across the country population stagnation/decrease and demographic change, some of these trends are particularly pronounced here, making the capital of the Friuli Venezia Giulia region stand out in the national context. Notably, acute patterns of population ageing combine with a significant presence of migrants and individuals with a migration background. These dynamics contribute to a growing segment of the population experiencing social and economic hardship, placing considerable strain on local welfare services. At the same time, the effects of 'touristification' – including rising real estate values – are undermining housing affordability. This is further exacerbated by strong housing demand from temporary populations, particularly a large number of university students and researchers (Marchigiani, Novak, 2024).

Fig. 7. The neighbourhood of Barriera Vecchia within the city of Trieste (Source: Google Earth, edited by the authors).

Within the city, the research focused on a semi-central area (Barriera Vecchia), extending east of the historic centre and constituting its contiguous expansion dating from the late 19th and early 20th centuries (Fig. 7). Data collected by the municipal administration as part of the newly established RUPA – *Osservatorio Rigenerazione Urbana e Politiche Abitative* (Observatory for Urban Regeneration and Housing Policies) (Comune di Trieste, 2025) indicate that this area is characterised by a very high concentration of foreign residents, a significant presence of working-age individuals comparable to that of elderly persons, and a predominance of single-person households. The area's attractiveness is strong among young persons, who frequently choose this neighbourhood as their place of residence. This preference is linked to the fact that, despite its close proximity to the city centre, property values in Barriera Vecchia remain moderate to below average in terms of residential sale and rental prices, and are lower than those recorded in adjacent districts. However, this occurs within a broader context of significantly low household incomes compared to other parts of the city.

Owing to these dynamics, Barriera Vecchia can be defined as a specific articulation of the concept of *inner periphery*. While this concept is predominantly applied to suburban and rural contexts within the scope of European territorial cohesion policies (Ietri and Pagetti, 2019; Oppido et al., 2023; Galderisi and Limongi, 2024), it nevertheless provides a valuable interpretative framework for understanding disparities that also emerge in the most densely urbanised areas. The marginality of Barriera Vecchia does not stem from a condition of remoteness from more central and economically dynamic districts, to which it is in fact close and well connected by local public transport, nor – as will be shown in the following paragraphs – from a lack of facilities and services, which it actually has in abundance. What contributes to defining its marginality are: a high use value connected to a significant presence of individuals and groups in vulnerable or fragile conditions – related to age, health, social isolation, the burden of caregiving responsibilities, and low income; the lack and poor maintenance of pedestrian

areas, which compromises the creation of social spaces and inclusive accessibility; and widespread conditions of physical decay or underuse of individual residential buildings, often linked to poor energy performance and a spatial layout of housing units that does not reflect the actual composition and size of households.

4.2. Masterplanning as a Framework for Multiple Fields of Public Action

Over time, public intervention in Barriera Vecchia has consisted of a few fragmented initiatives focused on the refurbishment of individual spaces, while the low market value of private properties has made substantial renovation efforts economically unfeasible. Today, designing and managing renewal and retrofitting processes in urban areas where precarious conditions and multiple forms of fragility – affecting both the spatial environment and its inhabitants – are concentrated, demands more careful consideration of the appropriate scales, locations, and approaches to regeneration.

From this perspective, a preliminary and significant issue addressed by the research concerned the development of an approach for constructing a tool capable of 'translating' a regenerative design vision. This refers not merely to a device aimed at defining the location and spatial extent of individual interventions, the types of assets specifically involved, or their predominant uses. Rather, the work carried out with students was directed towards the definition of a *comprehensive masterplan*, complemented by design explorations focused on strategic themes and spatial systems of sites. This approach reflects a practice now adopted not only in academic settings but also within more institutional domains of urban and spatial planning. An example is the concept of "local strategies" included in the Town Plan approved in Bologna in 2021. These are described as "figurative guidelines for steering actions in the territory that aim to connect, relate, and create synergies between parts of the city, places of public life, and sites of memory and sedimented identity. [...] They indicate requirements and performances to be ensured in the transformation of urban spaces, without prefiguring their final form" (Comune di Bologna, 2021; translated by the authors).

A deeper reflection is nevertheless required on the meaning ascribed here to the term 'masterplan'. Specifically, it is understood as a tool for defining and guiding regeneration processes that are sensitive to both place and people, particularly within already-inhabited urban contexts equipped with infrastructure but marked by severe and interrelated forms of precarity. The aim of such processes should be not only to counteract fragility, but also to empower individuals and strengthen their relational and spatial capabilities. A central element in the development of the masterplan is the existing infrastructure of public spaces – that is, the set of social, health, and educational facilities; places dedicated to the distribution and shared consumption of healthy food; existing open and green spaces, their connections and conditions of environmental and climatic comfort. An equally strategic move consists in uncovering and integrating other 'opportunity spaces', actions, and actors, in response to social needs that have not yet been adequately addressed by public policies.

Moreover, in developing the masterplan, the approach should not be confined to data collection and 'external' analyses, nor to the identification of a few prominent sites for selective action. Likewise, processes of listening, collaboration, and participation should not be relegated to a merely instrumental role aimed at mitigating conflicts arising from top-down strategies. Rather, the masterplan is conceived here as a process of immersion in place, involving interaction with local stakeholders and residents, and aimed at identifying the multiple domains of integrated public action – also extending beyond the scope of urban planning and design – upon which future spatial transformations and welfare policies may be grounded.

4.3. The Tale of a Process Toward a Place- and People-Sensitive Regeneration

The masterplanning process comprised several key steps, which are briefly outlined in the following paragraphs, with a focus on their principal findings and conceptual frames. The initial stage involved engaging with and listening to local stakeholders; it provided valuable insights and concrete indications. Building on this, both quantitative analyses and qualitative investigations were carried out, drawing on the systematisation and interpretation of available data, site surveys, and technical readings of spaces and their uses. This process led, on the one hand, to the development of an information base essential for the spatial representation of various dimensions

of fragility – referring to social and education facilities, as well as to food provision, climate and environmental comfort, mobility, and accessibility – and, on the other, to the identification of critical issues and opportunities that informed the masterplan's strategic orientation.

4.3.1. Listening: In-depth Engagement with Place and Stakeholders

The listening phase involved a diverse range of stakeholders operating at both urban and neighbourhood scales. These included public institutions – such as the Agency for Public Housing (ATER), the Public Health Authority, and the Social and Urban Planning Departments of the Municipality of Trieste – with a central role played by the Public Company for Personal Services (ITIS), a social and healthcare hub deeply embedded in the local care infrastructure. Third-sector organisations were also engaged, particularly those specialised in support policies for individuals facing multiple vulnerabilities (e.g., Caritas Trieste, Lybra social cooperative, and San Martino al Campo). Additional participants included bank and social foundations, trade associations, labour unions, students, and local residents.

Specifically, at the urban scale, the process was carried out by the University research group through the organisation of two round tables on housing conditions in Trieste, direct dialogue with key actors, and in-depth interviews with various subjects. These activities addressed key challenges, in particular the role of public residential assets as catalysts for urban regeneration, the provision of adequate affordable rental housing, and the development of integrated service systems. In parallel, at the neighbourhood scale, a more in-depth listening process and a placemaking event involving residents – conducted in collaboration with other ongoing projects related to the healthcare system – enabled the identification and *mapping of local needs and challenges*.

Within these activities, particular attention was paid to factors influencing well-being, such as healthy lifestyles, economic security to meet basic needs, and the ability to move freely in order to access public spaces and amenities. Additionally, a strong desire emerged for a sense of identity and belonging, intergenerational social interaction, and access to education that promotes autonomy. Several critical issues were also identified, including spatial barriers to mobility, poor safety conditions in open spaces, and social isolation. Finally, this collaborative process facilitated the shared mapping of collective neighbourhood spaces with high potential for community use, alongside existing cultural, sports, healthcare, and community facilities that can be networked, reactivated, or – when privately owned – opened up to the neighbourhood through shared use. Overall, this phase laid the foundation for the development of genuinely place-based urban analyses and design approaches, aimed at more accurately responding to the actual needs of the community.

4.3.2. Data Analysis: Housing Spaces and Dwellers

As part of the masterplanning process, a further step involved a more precise delimitation of the field of technical analysis and intervention, based on the spatial configuration of the Barriera Vecchia neighbourhood and its actual patterns of use. This stage revealed a mismatch between, on the one hand, the boundaries of administrative and statistical areas – used to collect data on housing characteristics, sociodemographic profiles, household income, and property values – and, on the other, the complex topography of Trieste, where steep gradients often make places that are close in planimetric terms effectively distant and inaccessible (Fig. 8). This process underscored the inherent difficulty of translating city-level statistical data into more accurate, localised applications.

Fig. 8. Barriera Vecchia neighbourhood (in red). On the left, the city topography; on the right, the boundaries of administrative districts
(Source: Urban Planning Atelier, the University of Trieste, 2024-25).

Specifically, the processing of municipal registry data (Anagrafe comunale), based on administrative divisions, proved insufficient to capture socioeconomic phenomena at the neighbourhood scale (Comune di Trieste, 2025). Similarly, data on property values (from the Real Estate Market Observatory – OMI 2024) and income levels (Personal Income Tax, IRPEF – MEF 2023, based on areas defined by postal codes) remain tied to relatively large zones, which do not correspond to the spatial articulation of the territory. As such, they can be used to indicate median values and general trends, but not for detailed spatial analyses. It was therefore decided to rely on the spatialisation of data provided by ISTAT (Italian National Institute of Statistics), as their level of detail – structured at the scale of census tracts – allows for closer observation of local dynamics. Due to the high settlement density in the central area of the Municipality of Trieste – and Barriera Vecchia in particular – census tracts often correspond to individual urban blocks[4]. ISTAT data enable a specific focus on the age structure of the population, household composition, presence of foreign residents, as well as the distribution of dwellings and number of rooms per unit. Overall, despite numerous limitations, their GIS-based mapping and comparison – when possible – with other available datasets prove highly effective in visualising key issues and facilitating cross-analysis between different topics.

The analyses conducted in this way show that the Barriera Vecchia accounts for 11.2% of the Municipality of Trieste's population (22,192 residents) compressed in just over 1% of the city's total surface area, with a residential density amounting to 214.7 inhabitants per hectare – approximately ten times higher than the municipal figure. The average age of the population is 46 years, compared to 49.5 at the city scale, and the 25-64 age group accounts for 65.7% of the area's residents, as opposed to 52.6% in the wider municipality. However, this should not overshadow the significant presence of older residents: more than a quarter of the population is over 65 years old. This pattern is consistent with the demographic structure of Trieste, where over-65s represent 28% of the total population. The analysis of household composition shows that Barriera Vecchia is predominantly characterised by single-person households or those with two members, accounting respectively for 55.0% and 23.4% of the total. There is also a significantly higher proportion of foreign residents (21.5%) than in the rest of the city

4 In fact, ISTAT data are not without their challenges. On the one hand, reconstructing time series – for example, between the last two available censuses (2011 and 2021) – is difficult due to changes in boundary definitions. On the other hand, working with spatial units that do not correspond to sub-municipal administrative boundaries requires substantial data processing efforts.

(11.2%), with a major concentration in the 30–54 age group (10.0%).

Taken together, the analyses developed from ISTAT and MEF data outline a territorial context characterised by a generally younger population and smaller household units than in nearby districts and the city, set within a high-density urban environment marked by conditions of social and economic fragility. Building on the spatial representation of this quantitative information, a map was produced to highlight the tension between the characteristics of the 'containers' (the dwellings and their dimensional configurations) and the 'contents' (namely the people who inhabit them). This map illustrates the subdivision of the Barriera Vecchia neighbourhood into distinct 'Areas' (Fig. 9). The northernmost part of the district (Areas 1, 2) is mainly characterised by the presence of single-person households and large-sized dwellings, which are, however, mostly vacant or occupied by non-residents. This suggests a prevalence of short-term rental arrangements, likely for students or tourist accommodation. The central portion of the neighbourhood (Areas 3, 4, and 5) presents a significant concentration of foreign residents, working-age individuals (25-64 years), elderly people, and relatively large families living in dwellings of varying sizes, though predominantly small. Lastly, in the southern portion (Areas 6, 7), larger households generally prevail, with a significant proportion of foreign residents and co-residents living in small dwellings.

The marked internal differentiation of Barriera Vecchia offers valuable insights for identifying design issues and potential sites of intervention – ranging from domestic environments to public spaces and support services for the most vulnerable groups. For instance, the presence of very large families living in small apartments, or multiple single-person households aged 20-35 sharing the same dwelling, underscores the importance of relational spaces outside the home and the need to strengthen links with socio and educational facilities. Similarly, the concentration of elderly residents living in large dwellings shows a potential for new living arrangements – such as intergenerational co-housing – and for home-based support models that extend beyond the dwelling to encompass a broader network of external services.

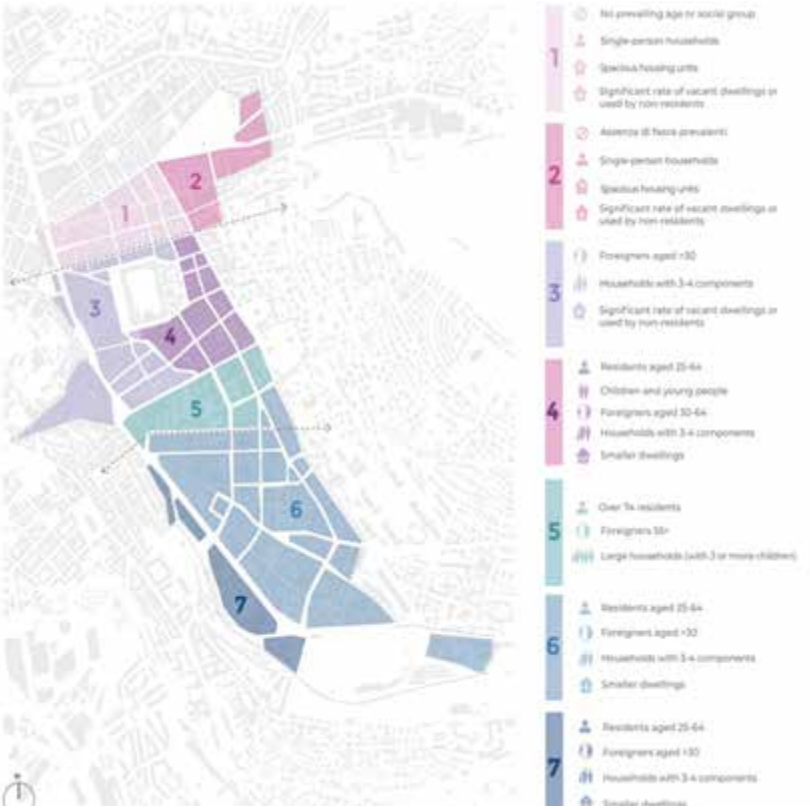

Fig. 9. Containers and contents. Map of the sociodemographic and housing conditions analysis (Source: Urban Planning Atelier, the University of Trieste, 2024-25).

4.3.3. Fieldwork and Site Analysis: Supportive Spaces

In parallel with desk-based work, on-site observations and surveys were conducted. The focus was on the distribution and physical setting of amenities, different forms of mobility – particularly pedestrian – public open spaces, green areas, council housing estates, and buildings providing various types of assisted living for the most vulnerable populations managed by public institutions and third-sector actors. The neighbourhood was investigated at various times of the day, throughout the week, and across different seasons, in order to capture uses, everyday practices, and both critical and potential spaces. This close-up perspective enabled a field-based validation of the data and brought them into dialogue with the material reality of the space.

The site reveals itself as rich in various types and spatial patterns of facilities and services. These elements are understood as supportive spaces – resources that constitute a significant asset not only for the neighbourhood itself, but also for adjacent areas of the city. Across the district, these spaces are concentrated in three main clusters, with educational, social and health facilities serving as key reference points. Each cluster is surrounded by a range of additional amenities and is enlivened by residents' everyday practices. Specifically, in the northern sector, two school hubs are located next to pedestrian areas. In the central sector, a cluster combines social and health services with a diverse set of educational buildings. Finally, in the southern portion, a network of schools and valuable community spaces – including parish sports facilities and a municipal recreational centre offering after-school and summer programmes for children and young people – is situated between two main groups of council housing (Fig. 10).

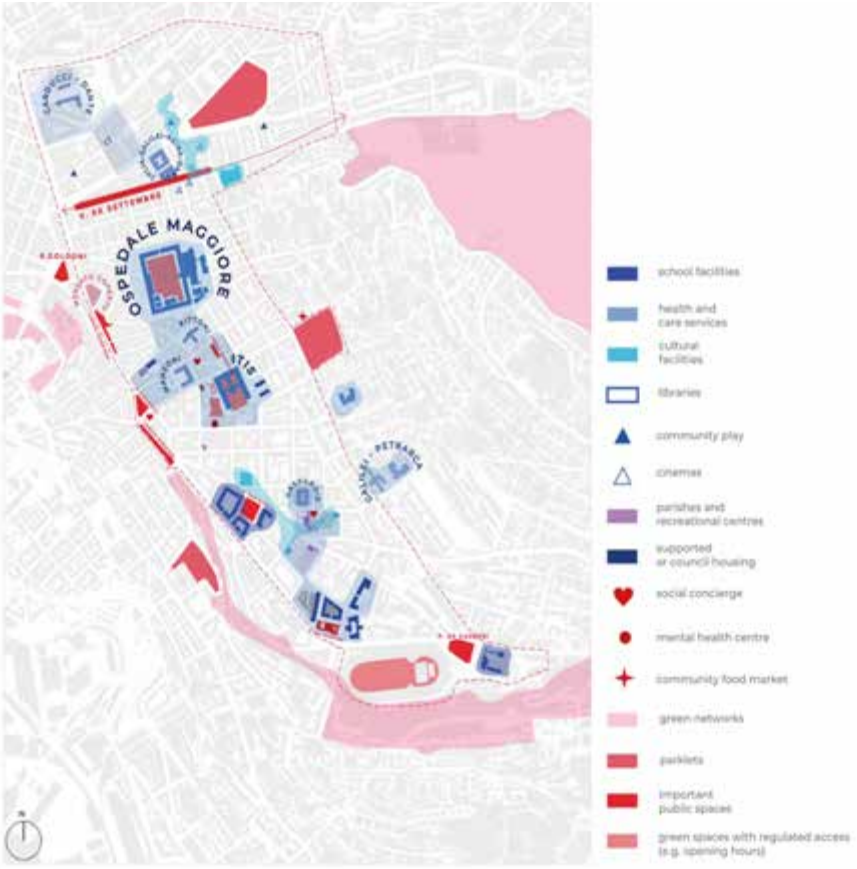

Fig. 10: Supportive spaces. Clusters of facilities and services
(Source: Urban Planning Atelier, the University of Trieste, 2024-25).

However, these well-equipped clusters do not function as integrated systems but rather resemble a *loose constellation of separate buildings and spaces.* Weak and fragmented mobility and environmental networks – comprising scattered tree-lined paths and the peripheral location of major green areas often with restricted access – limit the movement between facilities. In many cases, particularly near heavily trafficked roads or poorly designed spaces, the road infrastructure itself constitutes a physical and perceptual barrier. In parallel, the neighbourhood as a whole is characterised by a lack of squares and meaningful public open spaces, which are largely confined to a few spots along the main road running along the western edge of the site. These areas primarily function as public transport hubs or informal market spaces during limited hours of the day. Indeed, despite the richness of available facilities and services, this part of the city suffers from a pronounced lack of accessible, high-quality public space (Fig. 11). Dominated by car traffic and extensively paved and sealed, the neighbourhood is poor in terms of permeability, environmental comfort, and microclimatic resilience. Consequently, it faces significant limitations both in accessibility and in its capacity to adapt to climate-related challenges, particularly regarding the impacts on the most vulnerable population groups – such as the elderly and children.

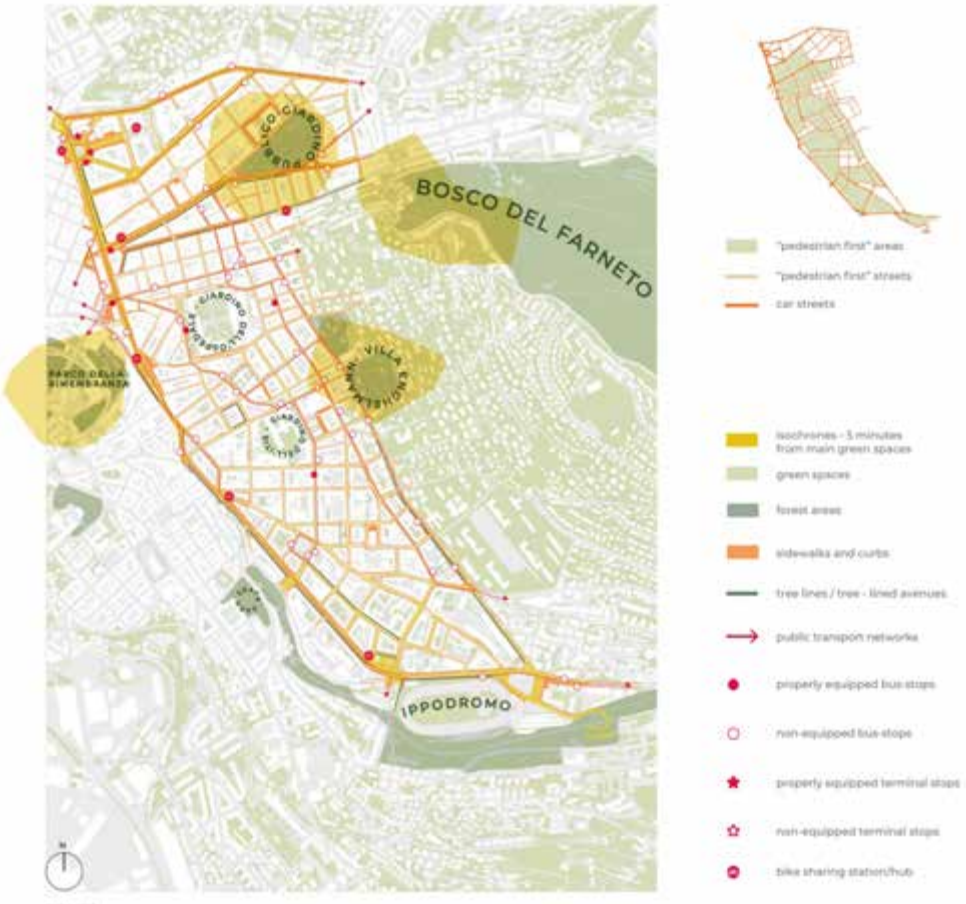

Fig. 11. Roads and green spaces. A poor supply of soft mobility and environmental networks (Source: Urban Planning Atelier, the University of Trieste, 2024-25).

4.3.4. Masterplan: Connections and Insertions

Building upon the key information and issues previously outlined, the masterplan articulates a comprehensive vision that integrates strategic frameworks with localised actions aimed at reducing the neighbourhood's vulnerability (Fig. 12). These spatial systems and interventions are contextualised in relation to two core strategies.

The first strategy centres on *spatial connections*, aiming to transform open areas within the neighbourhood into

a system of genuinely public spaces that promote soft and sustainable mobility, foster relationships between facilities and among residents, and are reimagined as resilient infrastructures capable of mitigating flooding and urban heat island effects. The focus is on the road network and associated urban spaces, currently heavily impacted by car traffic – both from stationary (parked) and circulating vehicles.

The reorganisation of the isotropic street grid into a hierarchical system – distinguishing between major thoroughfares and finer-grained, capillary routes – enables the definition of spatial 'quadrants' (clusters of urban blocks), within which internal areas can be freed from car dominance. Drawing inspiration from Barcelona's *superilla* model (Adjuntament de Barcelona, 2025), this restructuring allows for restricted vehicular access, the creation of pedestrian-only pathways and zones, and the introduction of traffic-calming measures. These interventions are instrumental in reclaiming space for connections between housing and services. Furthermore, mobility corridors and inner courtyards are transformed into porous environments, redesigned with green and permeable elements that also enhance overall environmental comfort. In parallel, the main mobility axis – which defines the western boundary of the study area and links the railway station, historic centre, and the wider Barriera Vecchia neighbourhood with the more porous southern zones (including the racecourse and public housing blocks) – is redesigned. Currently a high-speed and hazardous road, it is reconfigured as a sequence of articulated spaces for both movement and social interaction. Along this axis, existing open areas are transformed into a series of distinct public squares connected to key service hubs within the study area. Meanwhile, underused or poorly conceived spaces – such as vacant lots, oversized car parks, asphalted surfaces, and outdated mobility infrastructures (e.g., a petrol station in the southernmost portion, planned for relocation) – are reorganised and repurposed.

All interventions operate at a *fine-grained, interstitial scale:* reclaiming pedestrian zones and pavements; redesigning public transport stops as elements that support active mobility and function as comfort-enhancing landmarks; and reconfiguring building courtyards — in some cases making them accessible or traversable. These spaces, currently dominated by impermeable surfaces, are reimagined as shared environments for residents, accommodating micro-facilities, areas for play and wellbeing, and green, permeable landscapes.

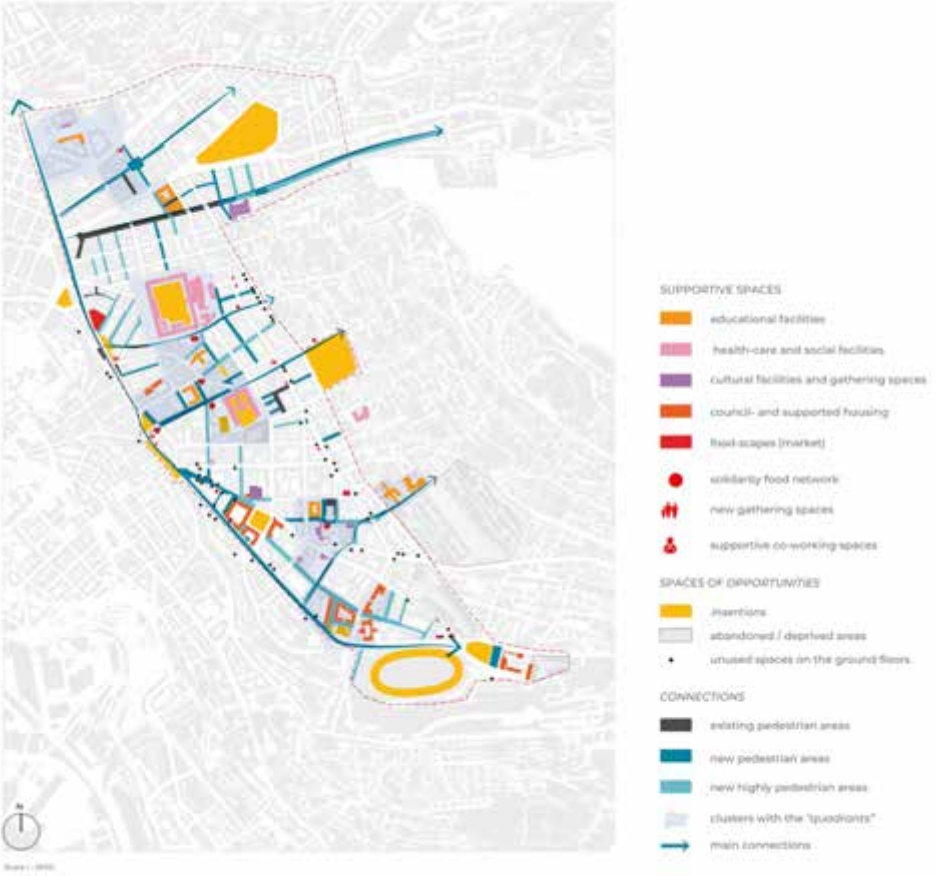

Fig. 12. Masterplan. Connections and intersections: supportive spaces and spaces of opportunities. (Source: Urban Planning Atelier, the University of Trieste, 2024-25).

The second strategy consists of *insertions* of new uses and activities, often through the repurposing of underused or vacant spaces as catalysts for more liveable and enriched urban conditions. It primarily focuses on the reconfiguration of areas situated within or adjacent to public facilities, integrating them and enabling their systemic use through the connections provided by the broader pedestrian mobility system. This approach aims to strengthen the service network and improve its *isotropy* by activating spaces currently perceived as critical (e.g., abandoned stalls inside the food market), and by reorganising functions associated with existing facilities into a 'spatial infrastructure' accessible at different times of the day and by a diverse range of users (e.g., canteens, libraries, gyms, sports equipment, conference rooms).

Specifically, a first type of intervention involves rethinking the spaces adjacent or within the plots of schools and healthcare centres. The redesign of thresholds, entrances, courtyards, and fences aims to better connect buildings with their surroundings, with particular attention to the needs of vulnerable users, especially older adults and children. In parallel, vacant ground-floor areas are conceived as extensions of the domestic sphere and reprogrammed with activities that support residential life (e.g., shared kitchens, self-managed nurseries and after-school services). These indoor and outdoor dimensions are brought into dialogue, fostering spatial and functional integration as well as new activities and social practices.

A second type of intervention – closely linked to the mobility reorganisation – reconfigures key open spaces as inclusive areas designed for diverse uses. One example is the new pedestrian route connecting the hospital, schools, and care facilities in the central sector of the neighbourhood. New uses include temporary markets, play areas, accessible public transport stops, and community-oriented facilities.

Finally, the project envisions new systems of open spaces and an environmental network, connecting to major green areas located on the perimeter of the neighbourhood that are currently segregated or inaccessible due to topographic constraints. Enriched by tree lines, rain gardens, and targeted depaving, these systems are imagined to host micro-functions that also encourage inclusive and intergenerational practices — for example, new sport facilities, playgrounds, and sheltered seating areas.

5. Conclusions

In inner suburbs and semi-central urban contexts, which are vulnerable both to becoming natural areas of expansion for ongoing real estate valorisation processes in the adjacent areas, and to the displacement and filtering up of resident populations, a central issue is how to *avoid regeneration that fosters gentrification*. This should be achieved primarily, if not exclusively, by promoting projects and initiatives with a strong ecological value that specifically address vulnerable groups living in these areas – in terms of housing provision, service typologies, and connections among public spaces (Lanzani, 2024b, p. 177). From this perspective, the masterplan (and the entire process oriented towards its design), developed through the research activities carried out in the Barriera Vecchia district, is conceived as a tool which aims to support "a much stronger public action", "contrary to neoliberal rhetoric and partly also to the more radical ideas of do-it-yourself urbanism" based on the poor resources of even those struggling to independently manage their lives (Ibid.).

Another lesson learned from the iNEST research in Trieste is that, when working in highly sensitive and fragile social and spatial contexts, there is a strong need to integrate analytical surveys, direct observation, and interaction with local institutions, stakeholders, and inhabitants who live and operate in these areas on a daily basis. While general data frameworks and observatories are useful for guiding action at the broader urban system scale, at the local level what is also needed is a closer, design-oriented perspective aimed at defining *unconventional spatial solutions* – solutions capable of responding to emerging social needs, accommodating new collective practices, and fostering a deep integration across diverse urban policy domains, from housing to the wider spectrum of welfare.

Within this process, the existing facilities and services – their further development through new insertions and additions, their connection via spaces capable of ensuring widespread and inclusive accessibility, and the creation of new synergies with interventions aimed at reducing soil sealing and re-vegetating urban surfaces – are of considerable importance. Together, these elements can shape a *framework of spatial and social infrastructures* designed to alleviate the sociodemographic and economic vulnerabilities that increasingly affect large segments of the urban population. These infrastructures – composed of public spaces and amenities – not only respond to social needs arising from the growing and multifaceted vulnerabilities of individuals and families, but also enable and foster new institutional and grassroots practices. At the same time, thinking in terms of infrastructures – understood as continuous and interconnected systems – invites a rethinking of the design process itself: its methods and aims, and particularly its role as a pivotal mechanism for the de-sectorialisation of the many and diverse public policies addressing different forms of vulnerability, ranging from urban planning to public works and mobility, and from education to social and healthcare services.

One final clarification is, however, necessary: the major omission in this narrative is housing itself. Policies aimed at affordable housing – particularly in the rental sector – capable of addressing sociodemographic and economic distress are indispensable. The approach adopted in the development of the masterplan should therefore be understood as one component within broader pathways of public policy innovation, aiming to refocus regeneration efforts on space and people, and encompassing *both the internal and external environments of the dwelling.*

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The Old Town of Taranto. Reclaim neglected spaces to challenge narratives of decline

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Abstract
This paper examines the precarious spatial and social condition of Taranto's Old Town, affected by a radical process of abandonment and subsequent ruination. Part 1 provides a historical overview of Taranto's transformation from a small coastal settlement into a contemporary sacrifice zone for global industrial interests. Part 2 offers an in-depth focus on the Old Town, tracing its enduring condition of spatial injustice across history and analyzing how successive waves of industrial development and demographic shifts have progressively marginalized the area and made it a symbol of socio-economic exclusion and infrastructural decay. Part 3 briefly explores grassroots spatial practices active within the Old Town, which reclaim neglected or underused spaces, generating alternative cultural and social dynamics that contest dominant narratives of abandonment and decline.

Keywords: Taranto, Taranto's Old Town, Sacrifice Zones, Toxic Legacies, Post Disaster

1 - Taranto: ascent and decline of a 'platform city'.

Taranto is a port city in Southern Italy that underwent an extensive modernization and industrialization process in the first half of the 20th century, which radically altered its scale and modes of existence, transforming a small-sized coastal town into a node of heavy production on a global scale.

The industrial turn shaped a parabolic trajectory in the city's urban development — marked by a phase of rapid ascent followed by decline over the course of a century — heavily influenced by state-led projects that deeply affected both the social and spatial composition of the city.

Today, the entire territory is compromised by a stratification of contaminations — inscribed in the sea, air, soil, and subsoil — legitimized by a hegemonic narrative that frames territorial development as inevitably dependent on industrial growth. These legacies extend beyond the physical boundaries and imagined narratives of a specific site or case study, often revealing the ways in which an era is perceived by its actors, both in its continuities and in its ruptures (Brenu, Pessina, Tiganea, 2024). In this sense, Taranto's toxic legacy is closely intertwined with the techno-optimistic imaginary of industrial modernity, which has produced uneasy and often intangible heritages, functioning as collective objects of inquiry, conflict, debate and, at times, denial.

With regard to its spatial structure, Taranto presents itself as a 'platform city', extensively top-down planned, where multiple systems can be identified (Curci, Geroldi, 2020), each operating at very different scales (see Figure 1).

Within the urban system, two distinct types of city can be recognised: the dense, pre-industrial fabric (comprising the Old Town and the nineteenth-century grid) and the post-war expansion, dispersed and fragmented into spatially separate areas and satellite districts.

The system of productive and military infrastructure, on the other hand, consists of the steel industrial area, petrochemical plants, industrial port, naval arsenal, and military bases. These occupy vast portions of the city, forming enclaves entirely inaccessible to its inhabitants.

Figure 1. Taranto, satellite view

1.1 - Historical overview of a radical transformation

The urban development of Taranto is closely linked to the continuous demographic accelerations following the Unification of Italy, radically and rapidly transforming its urban structure. The first of these took place between the late nineteenth and the early decades of the twentieth century, when, following the establishment of the military base and naval arsenal, the city's population doubled, rising from around 30,000 in 1881 — with 80% residing in the Old Town — to approximately 60,000 by 1911. The city's military specialization also led to significant growth during the wartime and interwar periods, with an increase of roughly 100,000 inhabitants between 1911 and 1951. This phase corresponded to an expansion of the city towards the mainland, one of the direct consequences of which was the depopulation of the Old Town. (Curci, Geroldi, 2020)

Following the industrialisation process initiated by the naval arsenal, in the post-war period Taranto was designated as one of the main industrial hubs of Southern Italy within the regional development strategies promoted by the Cassa del Mezzogiorno. The complex programme of industrialisation in the Mezzogiorno represented one of the most extensive public interventions ever undertaken by a state in post-war Europe to reduce internal regional disparities. What appears paradoxical is that, in the long term, these interventions failed to achieve their intended goal of economic convergence. Instead, they ultimately registered a reversal of the trend, bringing the regional gap back to its initial levels[1]. This tendency is not unique to Southern Italy but reflects a broader

1 "Yet, to this day, the economic gap between the North and South of the country has not narrowed and, in some areas, has even widened: in 2019, the GDP (at current prices) of the eight southern regions accounted for 22% of the national total, less than the 24% recorded in 1951. Nor are there improvements in terms of resident population: in 2019, per capita GDP in the South was still just over half (55%) of that of the Centre-North, only slightly higher than the 53% recorded in 1951 (SVIMEZ, 2011; 2020). However, the invariance of these aggregate figures conceals very different trends over time. In the first thirty-five years after World War II, there was a significant reduction in socio-economic disparities between the South and the Centre-North of the country, but from the 1980s onward, this convergence 'came to a halt,' and the gaps began to widen again, in some cases returning to levels seen in the early 1950s." (Martinelli, 2020)

stagnation in regional convergence processes observed in most Western European countries since the 1990s. (Martinelli, 2022)

The construction and expansion of the steel industry, alongside the development of the port, an oil refinery, and a cement factory, produced significant social and territorial impacts, giving rise to conflict between influential state powers and local institutions. (Coppola, D'Ovidio 2018). During this phase, the city continued to grow, gaining approximately 50,000 more inhabitants between 1961 and 1981. However, this demographic growth never halted the depopulation of the Old Town, which became increasingly intense and irreversible.

In 1982, Taranto reached its peak population of 244,798 residents, after which it began to shrink. With an economy based on industrial monoculture, the city was unable to withstand the negative effects of the steel crisis. Today, both unemployment rates[2] and population numbers are returning to the levels of the pre-industrial period (Santa Cruz Grau, 2014).

1.2 - From Techno-optimism to the awareness of sacrifice

At the time of the construction of the steel plant, in the early 1960s, a transformation occurred that was not only spatial and economic, but also cultural: the myth of industry — as the city was being reshaped — took root and gained strength (Leogrande, 2018), supported by an extensive media propaganda campaign.

However, the initial enthusiasm was soon overshadowed by the disproportionate expansion of industrial infrastructure. In 1968, Italsider (the Italian steelmaking company) proposed extending the steelworks from 528 to 1,500 hectares, overriding both the municipal master plan and the 1961 industrial development plan. Prioritizing logistical concerns, the state-owned company advanced plans to expand toward the port and city. The so-called raddoppio — effectively a tripling of the plant's surface area — provoked resistance from parts of the local political establishment. In January 1971, the municipal administration denied Italsider a construction permit for the port works, citing incompatibility with urban planning regulations (Giannì, Migliaccio 2016).
In 1972 the journalist Antonio Cederna used for the first time the word "disaster" to refer to the city of Taranto. In the pages of Corriere della Sera[3], Cederna described what was happening in Taranto as

> a truly barbaric process of industrialisation. A state-participated industrial enterprise, with an investment of almost 2,000 billion lire, which had not yet considered even the most basic anti-pollution measures, nor planted a single tree to protect the poor residents of the downwind working-class neighbourhoods.

Despite this, in the mid-1970s, the expansion was eventually executed (through an injunction decree issued by the Committee of Ministers for the Mezzogiorno) bringing the number of direct employees to an exorbitant 22,000, with a further 14,000 employed in around 400 subcontracting companies[4]. This expansion further increased the size of the factory, laying the foundations for an industrial gigantism that today contributes to making the city a "complex problem" (Balducci, 2020). Indeed, in the following decades, the multiple effects of industrial overloading gradually began to surface, fuelling a multidimensional crisis characterised by the simultaneous presence of environmental and public health issues. In 1990, the Ionian area, together with several neighbouring municipalities, was declared an "area of high environmental risk" by the Italian Ministry of the Environment (at the time, it alone produced 92% of the dioxin emissions in Italy). In 1995, with the privatisation and sale of the steel plant, environmental concerns intensified and became a widely shared social issue. However, it was only in 1998 that official documents acknowledged the existence of a severe environmental and public health crisis. In 2008, the Apulia regional government approved a law establishing emission thresholds for industrial pollutants in the atmosphere, particularly for dioxins, assigning enforcement responsibilities to ARPA (the Regional Environmental Protection Agency) which was obliged to suspend polluting production in the event of violations. Epidemiological

2 C. Bechis, 'Taranto, con la crisi 1 su 3 è senza lavoro', Corriere del Mezzogiorno, 04/03/2010
3 Antonio Cederna, Taranto in balia dell'Italsider, Corriere della Sera, 13/04/1972.
4 data from Istituto Tagliacarne; OECD, 2016

studies revealed that the incidence rates of respiratory, cardiovascular, and cancer-related diseases in the Taranto area were significantly higher than the national average (Greco 2020).

Nowadays, Taranto is un-famous for being one of Italy's most known environmental disasters. On January 2022, a U.N. report on human rights[5] included the city in the list of "sacrifice zones": areas where vulnerable and marginalized communities are exposed to extreme levels of pollution and toxic contamination. The term originated in the cold war era, when it was used to describe areas rendered uninhabitable by nuclear experiments and, according to the report,

> today a sacrifice zone can be understood to be a place where residents suffer devastating physical and mental health consequences and human rights violations as a result of living in pollution hotspots and heavily contaminated areas.

From the perspective of collective awareness, the UN report had a significant impact on the population, as it was an official and formal acknowledgment of such a condition. However, it is important to highlight that, in the preceding decade, several researchers and activists had already been denouncing evidence of a sacrificial process. In 2019, Lidia Greco, Professor of Economic and Labour Sociology at the University of Bari, wrote:

> [...] within the dynamics of capitalism and the industrial division of labour, certain areas and social groups are sacrificed in the name of broader processes that enable and sustain the very possibility of accumulation. In this sense, Taranto constitutes a sacrificial area. Rather than taking shape as a social conflict centred on environmental justice [...] the conflict in Taranto tends to manifest as a post-political issue. Here, the absence of accountability and strategic visions is combined with the search for an almost exclusively technical and scientific solution to the problem, one focused on the physical limits of growth, territorial degradation, and resource scarcity, without questioning the aims and values of the development model affecting the area and the way its costs and benefits are distributed. In Taranto, however, it is not merely a question of creating a world compatible with life and capable of sustaining it; it is also about representing and interpreting reality as a whole, giving it meaning primarily through the creation of bonds among individuals who find in it the reason for their existence.

In the current context, one of the most difficult challenges lies in seeking a balance between health, employment, and the environment. The pursuit of environmental justice must begin with the recognition of the inherently political nature of the issue, which involves not only the workers but also the various social groups that collectively bear the social costs of industrial overloading.

2 - The Old Town: isolated both physically and socially

All the massive transformations induced by the industrial development profoundly reshaped the territory in a very short time, layering new lifestyles and urban practices onto pre-existing ones. In this process, certain parts of the city and groups of inhabitants were left behind, to the extent of becoming sorts of residual wastes produced by the voracity of radical transformation. The most significant case is represented by the island of the Old Town. Commonly referred to as "Città Vecchia" by the inhabitants of Taranto, the Old Town is the original settlement of the city, located on a small, narrow island (approximately 25 hectares) that extends longitudinally along an East-West axis, separating the open sea from a smaller inland lagoon, and connected to the mainland on both sides by two bridges (See Figure 2). The trajectory of its urban history is closely intertwined with the broader impacts that industrialisation — and its subsequent decline — have had on the city's social and spatial organisation (Coppola, D'Ovidio 2018).

5 United Nations, General Assembly, The right to a clean, healthy and sustainable environment: non-toxic environment. Report of the Special Rapporteur on the issue of human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment, 12/01/2022

Figure 2. The island of the Old Town, satellite view

2.1 - Story of an exodus

Due to a particular combination of historical events and geographic configuration, Città Vecchia has always been marked by conditions of social disparity and spatial injustice. For centuries, the island was subjected to extremely high population density, as a result of military regulations that prohibited urban expansion beyond its fortifications. Demographic growth in the 18th and 19th centuries eventually rendered the confines of the Old Town excessively narrow: by the second half of the 19th century, approximately 25,000 inhabitants were concentrated within the island.

Amidst this condition of extreme density — which left no room for open spaces for social interaction — two distinct urban areas can still be identified, both spatially and socially. The upper part overlooks the open sea and is characterised by a more spacious urban fabric, with large residential palaces that once housed the city's wealthier classes. The lower part, also known as la marina, developed along the inland lagoon (the Mar Piccolo) and took the form of a dense maze of small, tightly packed dwellings built on an artificial extension of the island. This part of the Old Town — which, in the pre-industrial period, was mainly inhabited by fishermen and the working class — has long been affected by precarious living conditions, and still today, following the processes of ruination and abandonment of the island, remains the most severely impacted by the city's recent crisis.

The problem of overcrowding in Taranto's Old Town, along with the difficult sanitary and hygienic conditions it entailed, remained a constant feature of the city's history from at least the second half of the eighteenth century until the 1950s (Lapesa 2011). After visiting Taranto at the end of the eighteenth century, the Swiss traveller Carl Ulysses von Salis-Marschlins noted:

> Eighteen thousand inhabitants are crammed onto this small rock, in houses so tall and so tightly packed one against the other that the streets are rendered dark, exceedingly narrow, and uncomfortably windswept. To this, one must add a dreadful paving, especially along the Via della Marina, which [...] is impassable due to its filth and stench. This quarter provides overwhelming evidence that the city is far too

populated for the extent of its territory.

About half a century later, in 1844, Giuseppe Costa, commissioned by the Società Economica di Terra d'Otranto to collect statistical information on the city, observed:

> Given the limited perimeter of the city for the size of its population, the shortage of space is compensated by multiplying the floors of the dwellings. Nevertheless, the number of inhabitants far exceeds the capacity of these homes, and as a result, they live in extremely cramped conditions.

In such a context, it became necessary to adopt an expansion plan aimed also at addressing the island's severe sanitary conditions, which had been further exacerbated by overcrowding. Meanwhile, in 1882, the Italian Parliament approved the construction of what would become the largest naval arsenal in the country, to be located near the newly planned urban expansion, while additional civilian production areas were established on the mainland to the west of the island.
In this phase of urban development, the Old Town played a highly marginal role, while rapid and uncontrolled growth took place in the Borgo Nuovo — beyond the bridge to the east of the island — which first attracted the upper and middle classes (See Figure 3).

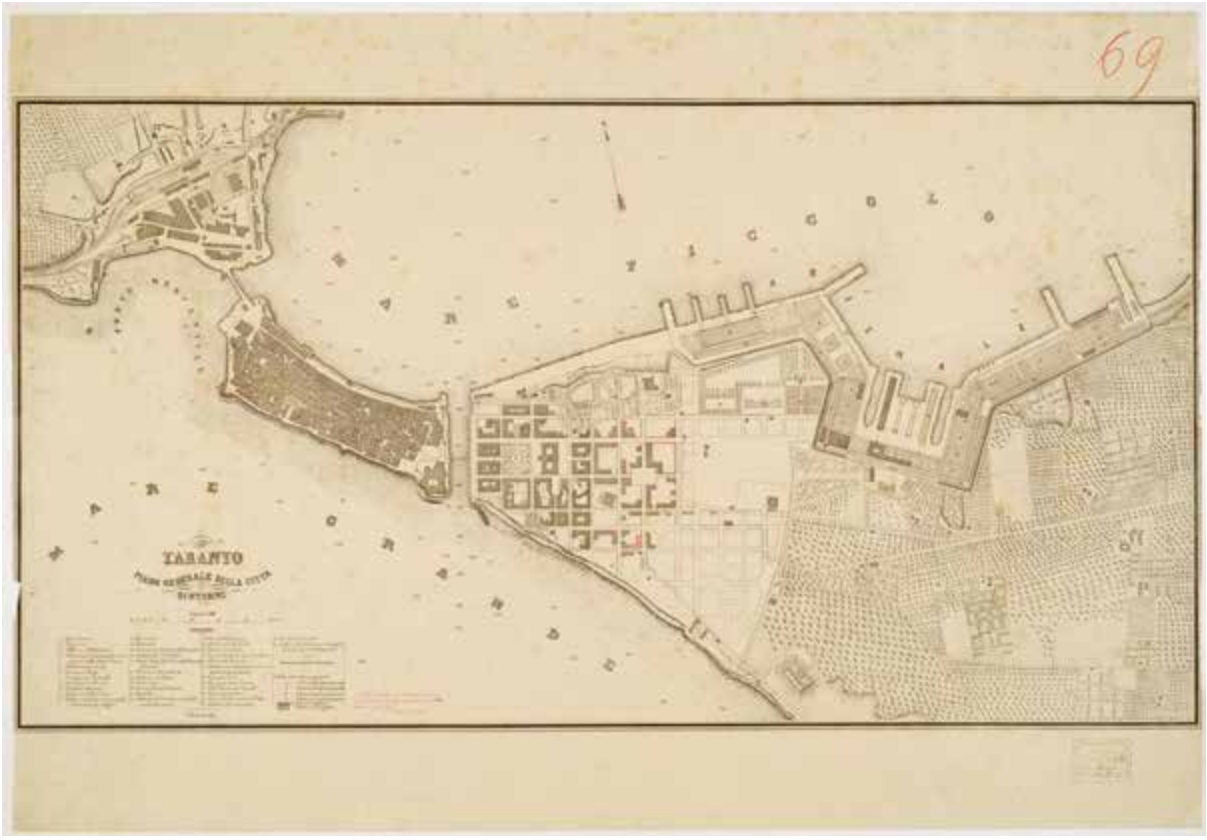

Figure 3. Taranto, general plan of the city. Istituto Geografico Militare, 1889

Finally, in the post-war era, the Old Town experienced a significant diaspora. By 1969, population data already recorded 15,861 residents, the majority of whom were employed in fishing and the construction industry[6]. As the island was gradually abandoned, a large number of new social housing complexes were built on the city's

6 Franco Blandino, Relazione Illustrativa del Piano Particolareggiato per il Risanamento e il Restauro Conservativo della Città Vecchia (Illustrative Report of the Detailed Plan for the Rehabilitation and Conservation Restoration of the Old Town), Municipality of Taranto, 1971.

periphery, fueling the growth of the so-called "Città Nuova" — the modern expansion area, which today is by far the largest both in terms of surface area and population.

Depopulation steadily increased until 1975, the year of the tragic "Vico Reale collapse", when a three-story building fell down, claiming the lives of six people. The incident had a strong emotional impact and was widely covered by the media, contributing to a stigmatizing narrative about the entire neighborhood. At the same time, it triggered a process of structural monitoring of unsafe buildings, whose data were used to justify top-down depopulation policies. A so-called "sanitization" program, promoted by the government, forced the remaining residents to relocate to newly built districts through expropriation procedures. As a result, today the majority of the abandoned — and thus physically deteriorated — housing units, many of which have since collapsed, are publicly owned[7] (see Figures 4, 5).

Figure 4. Taranto, top view of the Via di Mezzo enclosed area. ph. Pierfrancesco Lafratta

Figure 5. Taranto's Old Town. View from a rooftop. ph. Pierfrancesco Lafratta

At present, the Old Town of Taranto counts approximately 2,500 inhabitants. Among the most severe outcomes of the prolonged depopulation process is the structural collapse of abandoned buildings. By 2011, it was estimated that one out of every three structures was no longer suitable for habitation (ANCSA 2017). In this regard, the historic core of Taranto represents one of the most physically compromised urban centers in Italy, second only to L'Aquila following the 2009 earthquake. A substantial portion of the island is now rendered inaccessible due to the deteriorating condition of vacant properties. Over the years, the municipal administration has progressively erected walls to isolate unsafe areas, effectively fragmenting the urban fabric. These enclosures impede free

7 According to data provided by the Municipality of Taranto (Gazzetta Amministrativa), over 1,600 properties in the Old Town are owned by the municipality. Of these, 1,338 are residential buildings.

circulation through the island and oblige remaining residents to navigate around large restricted zones, further exacerbating the spatial and social fragmentation of the area. (see Figures 6, 7).

The walls that partially conceal the perception of urban disaster — together with the steel structures encaging abandoned buildings to prevent their collapse — have become a stable and defining feature of the Old Town's urban landscape for over fifty years. These interventions, rather than representing a coherent risk management strategy, appear to embody a form of institutional disengagement from a condition of structural fragility that has become deeply embedded over time.

This widespread perception of institutional inaction is further reinforced by the fact that not only has the residential architectural heritage been left to a gradual and unchecked process of ruination, but buildings of recognized historical and cultural value have been subjected to the same fate. A clear example of this is the case of the Church of San Paolo, dating back to the 15th century, long abandoned and closed to the public. In February 2011, part of its perimeter wall and a section of the dome collapsed onto the street below, dramatically exposing an advanced state of material decay[8]. (see Figure 8)

Figure 6. Taranto's Old Town, via Duomo. A wall seals off an uninhabited area
source: Google Street View

8 Redazione, Crolla chiesa di San Paolo: c'è un ferito, Corriere del Mezzogiorno, 11/02/2011

Figure 7. Taranto's Old Town, via Duomo. A wall seals off an uninhabited area source: Google Street View

Figure 8. The state of the Church of San Paolo 14 years after the collapse

2.2 - Informal strategies to deal with social-spatial fragility

This combination of forced abandonment, physical fragmentation, and persistent lack of care in the Old Town is closely connected to the social fragility and fragmentation of its inhabitants. Within such a context, informal and illegal activities found fertile ground, further fueling a stigmatizing narrative that portrayed the Old Town as a criminal ghetto. Over the years, the area gradually came to be perceived as a dangerous and unsafe place.

The Old Town and its problems receive little attention in the national media, overshadowed by the prominent and complex issues surrounding the fate of the steelworks plant, whose implications extend far beyond the local level and the city of Taranto itself. Yet, the Old Town accumulates and stratifies deep contradictions and opportunities, making it a remarkable place — a condenser of unexpected and powerful possibilities to produce a rupture within a dominant narrative, one that today remains narrowly focused on the fate of the steelworks (Pucci, 2020).

Recently, the interweaving of industrial, environmental, and social crises — combined with the site's strategic value — has turned Taranto into the object of nationally scaled policy interventions. Within these frameworks, the regeneration of the Old Town has often assumed a symbolic role in narratives of the city's rebirth[9]. In recent years, the historic centre has experienced a limited flow of investment, primarily linked to the Urban II Initiative, whose implementation nonetheless produced mixed outcomes (Santa Cruz Grau, 2014), with regeneration projects concentrated in areas directly affected by tourist presence and the opening of a few new commercial activities (Coppola, D'Ovidio 2018). It is important to recognise, however, that despite funding schemes and planning initiatives, the Old Town continues to experience persistent demographic stagnation and multidimensional crisis. At present, notwithstanding the numerous building renovation projects currently underway, no policy framework has been established that actively incorporates the involvement of local residents, either in participatory terms or through employment opportunities directly connected to urban regeneration processes. Conversely, one of the most prominent policy measures introduced in recent years has been the so-called "Case a 1 euro" (one-euro homes) programme, which, through a series of public calls, allows private individuals to acquire vacant properties within the Old Town at a symbolic price, conditional upon the demonstration of both the technical and financial feasibility of their restoration projects. This policy mechanism, however, is structurally exclusionary with respect to the existing local population, which remains largely unable to access either the financial capital required or the complex bureaucratic, technical, and administrative procedures necessary for participation.

And yet, within this condition of spatial and social degradation — and in the broader inadequacy of official recovery policies — the Old Town represents an extremely vital context in terms of the diversity of urban practices enacted within it. What might appear as an atmosphere of abandonment and stagnation is, in fact, beneath the surface and largely invisible to institutional scrutiny, a theatre of informal and often submerged spatial practices. These are predominantly forms of spontaneous self-organisation, emerging as necessary strategies to compensate for the persistent absence of institutional care and public services.

In a context marked by widespread physical ruination, where spaces for daily life and social interaction have become scarce and precarious resources, some of the most significant practices involve collective actions that — with different degrees of informality depending on the social groups and needs involved — activate processes of reclaiming and reappropriating residual and unused spaces. At an informal level, a multiplicity of dynamics can be observed, reflecting a specific spatialisation of the local social infrastructure (Lo Re 2023): housing occupations, informal exchanges of public housing units through verbal and trust-based agreements between relatives and acquaintances, mutual support practices targeting the most socially vulnerable, self-managed recuperation of public spaces, and the addition of informal storeys to existing buildings.

In parallel with these practices, which are closely linked to the organisation and social reproduction of the most fragile social groups, examples of social mobilisation and civic activism emerge, aimed at providing responses and alternatives to material and social degradation. These initiatives operate by connecting and enhancing environmental and relational-cultural resources (Berardi, Castronuovo 2017). Through these actions, forms of belonging are constructed and alternative imaginaries shaped, attempting to overcome the recurring rhetoric of disadvantage and marginality.

In the next section, I focus attention — through three examples — on practices of commoning and grassroots regeneration carried out by interdisciplinary groups of inhabitants and cultural workers. These initiatives have

9 "Since 2015, an extraordinary mobilization of state powers and resources has been launched through the establishment of multilevel governance mechanisms. An "Institutional Development Contract" (CIS) was created, managed by a state-controlled agency (Invitalia). Within this broader framework, the city was also asked to develop a "Plan for the recovery, regeneration, and enhancement" of the Old Town, for which an ideas competition was announced in 2015. To implement the measures outlined in this framework, state funds were allocated for port development, environmental remediation, the construction of new services and housing, and the regeneration of the historic center." (Coppola, D'Ovidio 2018)

experimented with models of social and cultural innovation, placing at the centre of their interventions the recovery, participatory management, and re-signification of underused spaces within the Old Town of Taranto.

3 - Collective practices of space reclamation. Three case studies

Within the context of the ongoing environmental, economic, political — and consequently social — permacrisis in which the city of Taranto appears to be 'stuck', the latent potential of abandoned and physically degraded spaces in the Old Town represents an opportunity to imagine and experiment with alternative forms of living, social relations, and work.

The practices discussed here are united by a reclamation of urban space in which the use of the discarded and the residual performs a dialectical function in relation to the imposed economic development model (Lo Re 2023). In this sense, the projects do not merely aim at the functional recovery of underutilised spaces, but contribute to promoting a process of collective emancipation by fostering a renewed imaginary of the Old Town — shifting its image from a stigmatised and marginalised area to a contemporary laboratory of social and cultural innovation.

In the first case, I delve into the spatial practice of the Labuat collective through an in-depth exploration of 'Park Urka!', a project that re-signified a residual urban void by promoting a process of active listening and co-design with the social groups involved in the area.

The second case is the Domus Armenorum project: an attempt — led by a mixed group of residents and cultural practitioners — to consolidate the (already existing) practice of collective management of a deconsecrated church through the institutional recognition of the space as a common good.

The third case is Post Disaster Rooftops, an interdisciplinary project positioned at the intersection of artistic activism and culture-led urban regeneration, which temporarily transforms the rooftops of the Old Town into spaces for conversation and artistic production, fostering a critical debate on the condition of the city.

It is important to note, in analysing these practices, that a significant number of the people involved — in more or less direct ways depending on the specific case — have been part of a regional network supported by a particularly productive period of youth policies implemented by the Apulia Region between 2005 and 2015. This policy context promoted the emergence of an interconnected ecosystem of bottom-up, culturally driven urban regeneration initiatives through public funding, networking platforms, and capacity-building programmes[10].

3.1 - LABuat and the "Park Urka!" project

The first case concerns a series of initiatives carried out by the cultural association LABuat, composed of young architects and cultural practitioners from Taranto. The association was established within the framework of the "Principi Attivi" call (1st edition) promoted by the Apulia Region, "with the aim of redeveloping urban spaces through concrete, collectively significant interventions"[11].

LABuat operates through co-design workshops involving local communities, conceived as tools to trigger tentative transformations, reveal hidden situations, and open up new possible trajectories. The group's statement reads as follows:

10 Since 2005, the Apulia Region has developed a new political strategy focused on local development, culture, and youth. EU structural funds were used innovatively to boost the local economy through tourism and the creative industries. Over the years, a system of sectoral programs and integrated local strategies fostered widespread creativity, cultural centers, and creative enterprises across the region. Initiatives like Principi Attivi and Bollenti Spiriti (from 2008) and Pugliesi Innovativi (from 2015) supported entrepreneurial projects in areas such as natural conservation, knowledge-based local development, social inclusion, and cultural, technological, and social innovation. Funding, training opportunities, mentoring, and public workshops were essential components of these programs, promoting a multifaceted idea of development combining economic growth, community empowerment, self-entrepreneurship, and urban regeneration.

11 from LABuat website - https://labuat.wordpress.com/

LABuat aims to promote a process of citizen participation around the reclaiming and reappropriation of the city and its public spaces. The city should communicate to its inhabitants the joy of inhabiting, the pleasure of belonging to a place and a community, as well as memory and desire. LABuat seeks to disseminate this message through tangible actions related to the regeneration and management of urban spaces, and their improved use through the installation of temporary and/or permanent structures, with the goal of creating new opportunities for encounter and conviviality, and establishing new conditions of livability in otherwise abandoned or underused places.

The group presents itself as a multidisciplinary, non-profit organization whose projects focus on participation, active citizenship, environmental sustainability, and local development, actively involving actors and communities typically positioned at the margins of public discourse and decision-making.

Although primarily concentrated in the Old Town, LABuat's spatial practice has extended to other areas of the city as well. Among its initiatives located within the Old Town, a particularly relevant case study is the Park Urka! project — a spatial transformation process combining grassroots urban regeneration and tactical urbanism. The project is noteworthy for two main reasons. Firstly, for the emphasis placed on relational processes aimed at developing a spatial practice oriented toward a co-design model. Secondly, for the symbolic value of the site itself — an empty space created by the collapse of a building in the very area historically marked by the tragic collapse of Vico Reale. In this sense, the project intervenes in the re-signification of a difficult, or even dark, heritage and proposes the imaginary of a possible "new beginning"[12] (See Figures 9, 10).

Figure 9. Making of the Park Urka! project, 2009

12 translation for "rinascita", used by Labuat in the project description on their website.

Figure 10. Park Urka! opening, 2009

In engaging with the Old Town both spatially and socially, the group deliberately chose to intervene in a marginal, discarded space — an urban void without a defined function, yet informally appropriated in various ways, from a children's play area to a site for illegal waste dumping.

> We believed that the only viable path was to reclaim an abandoned space and turn it into a field for practical and manual experimentation, directly involving local residents and, above all, the youngest members of the community. The aesthetic quality of the final outcome was not our primary concern. What mattered was the process of dialogue, exchange, and collective construction that, for days, kept us working together from morning to evening in those spaces with the residents of Via Cava. In those September days, we had the opportunity to deepen our understanding of the Old Town and grasp some of its underlying issues through the simple observation of everyday habits.
>
> [...]
>
> It was through the children that we learned the first issue to be addressed in that open area was the paving, since the combination of poor cement quality and steep incline made it impossible for them to even play a basic game of football.

As a result of these observations, the intervention consisted in levelling the uneven surface of the "square" and placing playground elements along the edges of the space, in order to allow for football games. Although the wooden playground components were vandalized shortly after installation, the square is still used today by local children, who have renamed it "il Campetto" - the little football pitch (See Figure 11).

Figure 11. "Il Campetto" in 2018 (9 years after Labuat intervention) source: Google Street View

3.2 - Domus Armenorum

The second case of interest - which includes (among others) the Labuat association - is the collective management of the Church of Sant'Andrea degli Armeni, a small deconsecrated church "embedded" among the buildings of Piazza Monteoliveto in the Old Town. The project, named Domus Armenorum, represents a (partially successful) attempt to formalize an existing practice of re-appropriating a disused public asset by citizen committees and cultural activists from the city. On the project's social media pages, it states:

> The project was born out of the spontaneous collaboration of local residents, architects, and cultural heritage professionals. It aims to foster a model of recovery and participatory management of the widespread cultural heritage of Taranto's Old Town, much of which lies in a state of abandonment, with the goal of preventing its loss and promoting its integrated enhancement.

The small church was originally part of a larger complex that included a rectory and a sacristy. These adjacent structures were recently acquired and incorporated into a hospitality facility (the Hotel Residence Sant'Andrea degli Armeni), while the church's main hall—restored with public funds in 2008 and subsequently forsaken—became the focus of a series of initiatives aimed at its valorization, promoted by local residents, neighborhood committees, cultural associations, NGOs, foundations, and individual citizens.

The use of the church, almost exclusively dedicated to public events of community interest, was "regulated" by an informal set of guidelines that spontaneously emerged over time through collective co-management practices. These simple principles included basic rules such as being fully autonomous in organizing the events and cleaning the space after use.

After several years of informal and entirely self-organized co-management—without the involvement of the local administration—a group of activists, including residents and young members of the LABuat association, promoted an attempt to formalize this practice by seeking official recognition of the church as a relational good (Berardi, Castronuovo 2017). In 2014, the association sent a letter addressed to various institutional bodies potentially concerned with the matter, stating:

> LABUAT Association's proposal is to experiment with new forms of preservation, enhancement, and participatory management of the diffused cultural heritage within the island, starting with what we consider a 'good practice' already in place: the 'spontaneous care' undertaken by local residents and qualified cultural

practitioners for the church of Sant'Andrea degli Armeni. This care practice is something the association intends to encourage and support through the DOMUS ARMENORUM project.
[...]
At present, no institution, of any nature, formally claims responsibility for the architectural asset, generating a bureaucratic deadlock and a lack of interlocutors, which limits the feasibility of projects and significantly slows down processes of enhancement. In the meantime, a group of local residents continues to take care of the sixteenth-century church on a voluntary basis, viewing it as an essential component of the quality of the urban space, preserving it from deterioration and informally ensuring its cleanliness, maintenance, and accessibility for both tourism and socio-cultural purposes.

The aim of this initiative was therefore to promote the full and effective public use of the site — while respecting its historical and artistic significance and ensuring its preservation — through the self-training of citizens capable of providing services within a framework of reciprocity. The experience of revitalizing, enhancing, and collectively managing the church of Sant'Andrea degli Armeni generated a process of participatory urban regeneration and contributed to the wider revitalisation of the neighbourhood. Additionally, the LABuat association organised a self-financed construction workshop aimed at providing the church with the necessary furnishings to host community events.

By 2017, the direct management of the site involved ten island residents (six of whom lived in Piazza Monteoliveto) and three local associations, which enabled the site to open for approximately two hundred days a year (Berardi, Castronuovo 2017).

Today, the participatory management of the site continues, albeit with fluctuating intensity depending on the availability of endogenous and exogenous resources, while the Domus Armenorum project has expanded the scope of its actions by integrating the church into a broader network of cultural and natural heritage sites across the territory.

Figure 12. Taranto, Old Town, Piazza Monteoliveto
(church of Sant'Andrea degli Armeni on the left)
source: google street view

Figure 13. Live arts event at Sant'Andrea degli Armeni

Figure 14. Live arts event at Sant'Andrea degli Armeni

3.3 - Post Disaster Rooftops

The third case, in chronological terms, is Post Disaster Rooftops, a platform for artistic and cultural production set on the rooftops of Taranto's Old Town. The project — which I am personally involved in as a co-founder — was initiated in 2018 by the independent initiative of a group of architects and designers from Taranto and its surrounding areas. All of them had been directly or indirectly involved in practices, projects, and organisations supported by the Puglia Region's youth policies in the previous decade.

The initiative was driven by an urgent need to move beyond a pervasive sense of resignation, which had emerged in the wake of the exhaustion of both these public policies and the bottom-up initiatives that had animated the Old Town in preceding years. That same year, the Italian government had sold the local steel industry to a

foreign corporation, and The New York Times published an article depicting Taranto as a fading city, an emblem of Western political failure[13]. Post Disaster Rooftops arose, in part, as a response to this suffocating narrative that had settled over the city following its intense media exposure in 2012[14].

As suggested by its name, the project rests upon two intertwined notions that together shape and synthesise the format of the practice: one of a critical nature, articulated through the cultural provocation embedded in the idea of the post-disaster; and one of a spatial nature, through the concept of rooftops, understood both as a physical platform and as an elevated, situated vantage point from which to observe and reflect upon global processes.

By creating temporary installations on the rooftops that combine scenographic and functional elements, the collective Post Disaster — which later took its name from the project itself — transforms existing spaces, amplifying their performative and relational potential (see Figures 15, 16, 17). Within these spaces, artists and researchers are invited to develop context-related projects, based on their own media and disciplinary practices, while engaging in dialogue and collaboration with local artists and cultural practitioners.

Each edition of the project addresses distinct yet interconnected themes, all informed by the city's ongoing condition of crisis (e.g., the relationship between nature and culture; territorial subalternity; the notion of monstrosity, etc.). The project's ephemeral nature is compensated by the creation of a multimedia archive that collects and preserves the content produced during the live events in the form of texts, images, videos, and sound recordings.

The rooftops are reimagined as relational spaces within a specific urban context — the Old Town of Taranto — where public space is largely denied by physical barriers of various forms. In contrast, within the hyper-dense urban fabric of the island, rooftops constitute a potential network of visually (and, in some cases, even physically) interconnected spaces offering sites for encounter and sociality, a sort of diffused common.
In the project's statement, it reads:

> PDR interprets rooftops as unconventional urban spaces — suspended between public and private — free from the main hegemonic forms of control. Climbing up onto the roofs of Taranto's Old Town provides an overview of a traumatised city. But it also offers an opportunity for healing, a privileged point of view from which to collectively imagine possible futures, starting from those buildings still standing.

13 Peter S. Goodman, Italy Is Having an Election. Most Italians Are Too Depressed to Care. The New York Times, 27/02/2018

14 In 2012, Taranto's environmental crisis reached a peak of public attention following an investigation by the Public Prosecutor's Office, which led to the seizure of ILVA steel plant's hot area facilities and the arrest of several executives and owners. The charges included environmental disaster, food contamination, manslaughter, and corruption

Figure 15. Post Disaster Rooftops EP02, Taranto, 2019. Ph Pierfrancesco Lafratta

Figure 16. Post Disaster Rooftops EP03, Taranto, 2022. Ph Gabriele Fanelli

Figure 17. Post Disaster Rooftops EP05, Taranto, 2025. Ph Cosimo Calabrese

Originally conceived as a fully self-funded initiative, starting 2022 Post Disaster Rooftops progressively evolved into a project supported by national, regional, and European funding. Each edition is articulated through two complementary and interdependent phases.

The first consists of a production phase of spatial and relational nature, aimed at generating the material and social infrastructure necessary for the programme to unfold. This phase establishes a context-specific collaboration with the local communities inhabiting Taranto's Old Town, whose participation is integral to shaping the spatial configurations and relational dynamics of the project.

The second phase takes the form of a live, public programme — composed of site-specific artistic interventions, conversations, and performances — designed to engage both the neighbourhood's residents and a wider urban and regional audience.

Depending on the availability and nature of the spaces hosting the practice, the public programme can vary in both form and duration — ranging from a very dense, week-long sequence of events to a more extended schedule unfolding over several months, featuring individual contributions on a weekly basis. For instance, the fifth edition, recently held in April 2025, concentrated a particularly dense programme within two weeks, including: four artist residencies followed by site-specific live events; two sound performances; a temporary exhibition; a public poster campaign in the city; four thematic talks.

Over the years, Post Disaster Rooftops has experimented with different spatial and organizational models. One particularly significant case concerns the rooftop of the Galilei School gymnasium, a structure built in the late 1970s following the demolition of a decaying building. Although originally conceived as a public space, complete with an external staircase, the rooftop has never been publicly accessible (except for a very brief squat in the 1990s). In 2022, after opening a dialogue with the municipal administration, the collective managed to obtain a

temporary agreement for the use of the space. This allowed for a steady presence and a series of cultural initiatives, briefly transforming the rooftop into a vibrant meeting point for the city's creative community (See Figure 18). However, in 2025, after the mayor's resignation and the appointment of a technical government, the authorization was formally withdrawn, abruptly interrupting the project. This episode exemplifies the structural fragility of cultural practices in geographically and politically marginal contexts, where local administrations often lack the autonomy and stability to support long-term civic initiatives.

Figure 18. Post Disaster Rooftops EP03, Taranto, 2022. Ph Pierfrancesco Lafratta (rooftop of the Galilei School gymnasium)

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Mobile justice in the face of climate change on the North Adriatic coast.

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Abstract
The North Adriatic coast has been profoundly shaped by centuries of interaction between human activity and natural dynamics, with major transformations accelerating since the 19th century. Today, this territory faces escalating risks, intensified by climate change and decades of extractive development. This paper adopts the lens of mobility justice to analyze the region's vulnerabilities and opportunities, focusing on three river transects: Stella, Corno-Aussa, and Natissa. Combining historical analysis, policy review, fieldwork, and design experimentation, the study explore a transition from rigid, unsustainable models toward adaptive, plural, and regenerative futures. It positions urban and territorial design as strategic tools to redistribute spatial opportunity, restore degraded ecologies, and ensure fair access to mobility and resources. The resulting project scenarios offer site-specific strategies that integrate climate resilience, intermodal connectivity, and ecological restoration, reimagining the North Adriatic as an amphibious, relational landscape shaped by both human and more-than-human agency.

Keywords: Climate Change; Mobility, Mobile Commons; Spatial Justice; Adaptation

Introduction

The North Adriatic coastline has experienced profound transformations since the late 19th century, shaped by the dynamic interplay between human interventions and natural processes. Early land reclamation projects converted wetlands into arable land, while the development of coastal tourism and the expansion of infrastructure for the terrestrial movement of people and goods further reconfigured the region's landscapes and economies. Today, this territory is confronted by multiple, intersecting crises: declining agricultural productivity, the exhaustion of mass beach tourism, and ongoing demographic shrinkage. These challenges are compounded and increasingly intensified by the accelerating impacts of climate change, which will be particularly intense on this low-lying coast, where lagoonal, deltaic, estuarine, and artificially reclaimed landscapes coexist and overlap.

These challenges resonate with the three interrelated crises identified by Mimi Sheller (the climate, the urbanization, and the refugee crisis), which she argues are deeply interconnected and rooted in a shared structural cause, what she terms "the politics and power relations of (im)mobilities" (Sheller, 2018: 1). In response, she calls for a move beyond "sedentary theories of justice", advocating instead for a perspective that treats "injustice as an unstable configuration that moves across scales and realms" (Ibid: 33). Thus, with respect to earlier frameworks of spatial justice (Soja, 2010) and the just city (Fainstein, 2010), themselves grounded in foundational work from the 1960s onward (Lefebvre, 1968; Harvey, 1973), Sheller proposes to use a mobile ontology that allows justice to be understood not as a fixed condition, but as a dynamic process of emerging relationships that re-make spaces and subjects.

Such a reconceptualization requires expanding the very subject of justice to include diachronic processes, different spatial scales, and the interplay of different phenomenons and subjects. As some authors have pointed out, this entails recognizing non-human beings as legitimate agents (Barry, Suliman, 2023; Scott, 2020), as well as acknowledging the intricate interrelations between various types of flows, both human and non-human (Allievi, Bernardi, Vineis, 2023). At the same time, it is important to recall that connectivity has long been a core principle in landscape ecology and a key guideline for maintaining ecosystem health (Brodie et al., 2025), and, by extension, planetary health (Horton, Lo, 2015; Nishi, Hashimoto, 2022).

Drawing on the concept of mobility justice, Sheller (2018) argues that patterns of mobility, unevenly distributed across social and spatial domains, are shaped by both historical and contemporary power relations. Building on this framework, this paper first examines how the territory of the North Adriatic coast has been reshaped over the centuries, with particular attention to the transformations of the last 150 years. We explore how different processes of modernization have significantly altered both local ecosystems and the anthropic use of the land, as well as the movements of human and non-human actors. This analysis is based on a review of existing literature and the interpretation of historical cartographic sources. In the second part of the paper, we turn to current plans and policies concerning mobility and ecology, focusing on three territorial transects that follow the courses of the Stella, Corno-Aussa, and Natissa rivers. This part of the research is based on a combination of qualitative methods, including interviews with local actors, site visits, and a review of regional and local planning documents. Finally, a third section of the paper explores future possibilities for these territories through the lens of urban design and planning. This exploration is based on a series of projective scenarios developed during a design workshop with PhD students in urbanism and urban planning, who envisioned adaptive and just futures for the region through site-specific proposals. Together, these approaches offer a grounded perspective on how mobility justice can inform spatial and environmental planning in a context marked by multiple, overlapping crises.

(Im)mobility of the North Adriatic Coast

The Italian stretch of the North Adriatic coast is characterized by a flat, sandy landscape interspersed with lagoons, estuaries, and low-lying wetlands. However, this present configuration is a relatively recent outcome of centuries of intertwined natural processes and human interventions (Gelichi, Ferri, Moine, 2017; Fontana, Rocchi, 2021). These transformations took place within what is often referred to as the land-sea interaction (LSI): the interplay of biogeochemical processes and socio-economic dynamics (Kidd, Jones & Jay 2019).

Until the Roman period, the coasts and lagoons remained sparsely populated. Major settlements such as Aquileia and Concordia Sagittaria were established just beyond this marshy fringe, on more stable inland terrain. With the decline of the Roman Empire, infrastructure and settlements were gradually abandoned. Populations progressively migrated toward the coastal and lagoon areas, giving rise to a dispersed archipelago of cities, ports, and rural communities sustained by water-based mobility (Auriemma, Maggi, 2013; Gasparri, Gelichi, 2024). The emergence of Venice as a maritime power during the Middle Ages gave centrality to the lagoon system. The Serenissima Republic embarked on major hydraulic interventions, including extensive river diversions, to protect the Venetian lagoon as a vital strategic and commercial asset. Meanwhile, the northern coastal territories became increasingly marginal, often relegated to extractive uses. These transformations imposed a more rigid territorial configuration, at least within the Venetian lagoon, while maintaining its amphibious character (D'Alpaos, 2010; Dorigo, 1994; Fassetta, 1977).

A radical transformation of the region's spatial and ecological configuration began in the 19th century, driven by a series of interconnected modernization processes. Chief among these were the land reclamation projects, which gained significant momentum following Italian unification. Enabled by mechanized pumping systems and sustained public investment, particularly after the enactment of the Baccarini Law in 1882, vast wetlands were drained and converted into productive farmland. These efforts also led to a notable reduction in malaria, an endemic disease that had long afflicted the region (Novello, 2009; Vallerani, 2008).

Much of the reclaimed land lay below sea level, and its productivity increasingly depended on a complex, energy-intensive drainage system. This process, alongside the expansion of agriculture and urbanization, led to the gradual loss of the region's amphibious ecology, which had included spring-fed wetlands, toward the mountains, coastal lagoons and marshes, toward the coast, and a band of forested areas between them. As a result, the historical fluidity that once characterized the region was progressively and rigidly fixed within an artificially regulated landscape.

This "terrestrialization" of the coastal territory unfolded in parallel with the rise of mechanized mobility. The construction of major railway lines reshaped patterns of access and movement across the region. In the following decades, the mass adoption of the automobile spurred the development of an extensive road infrastructure, gradually supplanting the once-vital network of inland waterways. Improved terrestrial accessibility, combined with the eradication of malaria, laid the ground for the explosion of coastal tourism in the 20th century, particularly in the post-WWII economic boom. The coastline was rapidly transformed into a corridor of leisure urbanization. Former fishing villages and dune landscapes were reimagined as tourist enclaves. Lignano, Bibbione and Caorle, among others, saw exponential growth driven by hotel development, second homes, marinas, and camping villages. What began as scattered, informal initiatives soon became systematized through zoning regulations, public incentives, and private investment. However, this urbanization came at the cost of coastal dynamism. Rigid defense structures were built to protect settlements and infrastructure, effectively freezing the coastline and disrupting its natural sedimentary processes (Battigelli, 2007; Fontolan, Bezzi, Pillon, 2011; Perelli, 2005).

Finally, another process of development reshaped the coast: industrial production and port logistics. The most emblematic case is Porto Marghera, which embodied the modernist vision of coastal industrialization. Further east, the area around the Marano-Grado lagoon saw the rise of Torviscosa, a company town established under Fascism for cellulose production, and the development of Porto Nogaro as a regional logistics hub. These sites introduced new forms of mobility, primarily of goods and labor, but also intensified environmental degradation and social transformation. The fragile ecosystems of the lagoons, already under pressure from land reclamation and tourism, were further compromised by pollution, dredging, and the hardening of waterways for navigation. These historical processes have produced a landscape marked by mobility injustice, in which the expansion of land-based mobility for goods, tourism, and other motorized flows has come at the expense of traditional communities, non-motorized forms of transport, and ecological systems, all of which have become increasingly immobilized. Today, the consequences of this historically embedded immobility are becoming ever more apparent. The coastal territory, rendered artificially static and rigid, is now under growing pressure from climate change, facing threats such as sea-level rise, land subsidence, erosion, salt wedge, and storm surges. A region once defined by fluidity and adaptability has become fragile and exposed.

This requires acknowledging that past development paths have unevenly distributed mobility, access, and environmental risk, privileging extractive flows and economic gain over ecological integrity and collective wellbeing, often provided by welfare spaces and policies. The resulting landscape bears multiple layers of injustice: ecological degradation, infrastructural exclusion, socio-economic marginalization, and the erosion of traditional knowledge and relationships with the land. Rethinking its future demands more than technical adaptation; it calls for a fundamental shift in how mobility is understood and distributed, and for a reframing of territorial planning and design through the lens of spatial justice.

Planning coastal futures: climate and mobility policies across three transects in Friuli Venezia Giulia

The Northern Adriatic coast is currently facing crucial challenges related to climate change, encompassing environmental management and sustainable mobility. While institutional awareness of climate risks is growing and several promising initiatives are emerging, policies and plans at the regional, supra-local, and local levels still struggle to integrate these issues in a coherent and coordinated manner. Their translation into concrete actions is further hindered by administrative fragmentation and ongoing institutional changes, which undermine the capacity of local governments to develop and implement effective policies.

In the case of Friuli Venezia Giulia, these dynamics are particularly evident. Hydraulic planning and management, entrusted to the Eastern Alps River Basin Authority (Autorità di Bacino Distrettuale Alpi Orientali) and the regional land reclamation consortia (Consorzi di Bonifica), focus primarily on infrastructure security and efficiency, lacking a systemic approach to climate change. Regional planning consists of a fragmented array of documents, sometimes offering conflicting guidance. Important steps have included the adoption of the FVGreen strategy in 2023, followed by a Regional Strategy for Sustainable Development (Strategia Regionale per lo Sviluppo Sostenibile, SRSvS), and the 2018 approval of a Regional Landscape Plan (Piano Paesaggistico Regionale, PPR), which proposes networks to restore ecological connections, promote sustainable mobility, and enhance cultural heritage. Along these lines, the 2022 Regional Cycling Mobility Plan (Piano Regionale della Mobilità Ciclistica, PREMOCI) focuses on cycling infrastructure and its integration with public and waterborne transport. In contrast, the Regional Infrastructure Plan (Piano Regionale delle Infrastrutture, PRITML, 2011) and the Public Transport Plan (Piano Regionale del Trasporto Pubblico Locale, PRTPL, 2013) promote high-speed mobility, with a strong emphasis on logistics and conventional transport. The region's main urban planning instrument, however, is severely outdated, dating back to 1978, with only partial attempts to update it in recent years (Marchigiani, in press).

At the local level, municipalities in Friuli Venezia Giulia are often small and seldom coordinated by stable supra-local entities. This limits their administrative and planning capacities. The Region has launched initiatives to encourage municipalities to adopt climate action plans, particularly by supporting the drafting of Sustainable Energy and Climate Action Plans (SECAPs or PAESC in Italian). Nonetheless, relatively few municipalities have completed them. Several interesting initiatives have also been launched through European research and territorial cooperation programs, which have enabled experimentation with innovative tools in areas such as integrated coastal and marine zone management, the protection of natural reserves, the valorization of ecosystem services, sustainable tourism, and intermodal water-land mobility. Among these, the Wetland Area Contract for the Marano and Grado Lagoon stands out as a pioneering initiative that brought together local administrations in a collaborative framework to safeguard the lagoon's socio-ecological systems.

To better understand local dynamics of transformation, we carried out an in-depth analysis of three territorial transects along the course of three rivers, extending from their outlets to the sea, passing through the lagoon, and reaching back into the low Friulian plain up to the *risorgive* zone. These transects illuminate emerging challenges linked to climate change, demographic decline, and economic transitions in agriculture, logistics, and tourism. They also reveal how spatial injustices are produced and addressed. Yet, amidst these pressures, some promising local initiatives suggest potential pathways toward more just and sustainable transitions.

The **Stella** River transect navigates a landscape where nature conservation, water governance, and local development intertwine. In its upper reaches between Codroipo and Pocenia, the river retains much of its natural character, flowing through biodiverse wetlands recognized by the European Commission. Since the early 2000s, local governments in Rivignano-Teor have implemented ecological restoration projects, notably the LIFE S.T.A.R. initiative. These efforts enhanced the river corridor's resilience and spurred low-impact tourism: bike paths, canoe access, eco-lodging, and agri-tourism services have flourished. However, downstream, the river enters a rigidly controlled reclamation zone with intensive agriculture and engineered drainage, increasingly vulnerable to climate change. The Foci dello Stella Nature Reserve protects the river mouth, but stronger interventions are needed. In Lignano Sabbiadoro, a major seaside resort, mobility challenges persist due to car dependency and seasonal congestion, despite some green initiatives. This area underscores the urgent need for a new paradigm of mobility justice, one that values ecological integrity, local knowledge, and equitable access to the landscape.

The **Corno** and **Aussa** rivers trace a different path, shaped by industrialization, environmental degradation, and socio-economic decline. In their upper stretches, natural habitats like the Paludi del Corno biotope benefit from conservation projects such as LIFE Friuli Fens. Downstream, however, the rivers become heavily canalized and surrounded by industrial infrastructure. Torviscosa, a legacy of Fascist-era industrial planning, has long been a pollution hotspot. Despite partial closures and its designation as a national contaminated site (Siti di Interesse Nazionale, SIN), remediation remains contested. Porto Nogaro adds complexity: originally a sugar export hub, it

is now a multimodal industrial port. While it sustains employment, it exacerbates congestion, land-use conflicts, and pressure on the lagoon ecosystem.

The **Natissa** transect connects Aquileia and Grado through a corridor of significant archaeological, ecological, and hydrological value. Aquileia has adopted a sustainable planning approach aimed at enhancing and preserving its archaeological heritage while better integrating it into the urban fabric and everyday life. In this context, mobility is treated as a key strategy. Strategic documents, such as the SLOW Aquileia vision, propose rerouting a regional road to create more space for pedestrians and sustainable transport. The Natissa River plays a central role in this strategy, with bank reinforcement projects and the introduction of a public boat service linking Aquileia to Grado, a coastal town situated on an island between the lagoon and the sea. Grado faces serious challenges, ranging from the pressures of mass seasonal tourism to escalating climate risks such as sea-level rise and storm surges. Some measures have been introduced, including Variant No. 34 to the municipal land use plan, which prohibits the construction of underground parking and limits further urban development tied to tourism. Additionally, a recently approved mobility plan promotes sustainable transport and aims to reduce space allocated to private vehicles. However, despite these efforts, the town still lacks a comprehensive and integrated climate adaptation strategy.

In conclusion, while the three transects share overarching challenges, each reveals distinct dynamics: the Stella transect highlights a disconnect between upstream ecological restoration efforts and downstream vulnerabilities linked to mass tourism and industrial agriculture; the Corno-Aussa area exemplifies spatial and environmental injustice shaped by extractive flows and heavy infrastructure; the Natissa corridor demonstrates the potential to integrate cultural heritage, ecological sensitivity, and mobility innovation, while also exposing the limitations of fragmented, small-scale responses to systemic climate threats. Despite these challenges, the research suggests that alternative futures are thinkable and possible. Such futures must be built on a rebalancing of mobility systems, one that values slowness, intermodality, and ecological connectivity alongside speed and efficiency. They must also be grounded in place-based knowledge, empowered by local actors, and attentive to the more-than-human agencies that shape and sustain these landscapes.

Rethinking the North Adriatic through mobility justice: urban design as a tool for adaptive futures

The increasing pressures that affect the North Adriatic lowlands call into question long-standing assumptions about how territories are inhabited, used, and connected. These challenges demand a deeper reconsideration of how spatial justice is conceived and enacted, moving from adaptive transformation to more radical transformative projects (Fedele et al. 2019). The following project-based exploration of the Stella, Corno-Aussa, and Natissa river corridors reflect upon the possibility of an urban and territorial design approach rooted in relational ecologies and integrated mobilities. The projects were built around two main hypotheses. The first is the need to expand sustainable mobility, such as walking, cycling, public transport, and waterborne transit, while increasing intermodality, with the goal of reducing fast mobility, particularly private car use. This draws on Sheller's (2018) interpretation of Illich (1974), who argued that slow mobility is inherently more equitable and sustainable than fast mobility. The second hypothesis is the need to reclaim a more amphibious and adaptive territory, one that gives more space to water and, in doing so, enhances the role of water-based mobility. Such a reconfiguration will not only improve ecological health and connectivity but also increase resilience to the transformations expected under climate change.

The territory along the **Stella** river reveals the essential role of water in sustaining both the ecological life and the cultural memory of this landscape. In recent decades, however, this delicate system has been destabilized and it is further threatened by climate change. The project reimagines the Stella River as an amphibious corridor, capable of absorbing and responding to hydrological fluctuations while supporting new socio-ecological practices. From its springs to its coastal mouth, the Stella becomes an integrated system of ecologies, mobilities, and new circular economies. In the northern stretches, valuable habitats are expanded and connected, reclaiming land from intensive agriculture and restoring the ecological continuity of the river. Toward the mouth, traditional farming is replaced by ecologically adaptive agricultural mosaics, including halophytic cultivation and aquacul-

ture systems, structured to operate within variable water regimes. Mobility, in turn, is reconceptualized as an intermodal, slow, and low-impact network. Cycling infrastructure and intermodal hubs encourage a shift away from car dependency, promoting accessibility while minimizing environmental cost.

The **Corno-Aussa** transect presents a landscape historically shaped by extraction and infrastructural fragmentation, where the pressures of industrial development have left behind damaged ecosystems and marginal communities. Here, the project envisions a phased territorial park aimed at environmental compensation and adaptive climate regeneration. The strategy recognizes the debts owed to both human and non-human communities and proposes spatial repair through ecological restoration and expanded public access. Central to this reimagining is the enhancement of river corridors as vectors of ecological recovery and active mobility. New bicycle and pedestrian paths reconnect fragmented habitats, while soft mobility on land and water is supported by intermodal hubs and equipped landings. This layered infrastructure responds to the needs of local communities, while strengthening ecological connectivity. The final phase of the project envisions the return of amphibious ecosystems and seasonal flooding cycles, thus transforming past damage into future potential.

In the **Natissa** transect the increasing pressure of mass tourism, climate-related risks, and infrastructural congestion demands a new mobility regime capable of mitigating anthropogenic impacts while supporting sustainable livelihoods. In this context, mobility becomes a strategic entry point to imagine and implement an integrated transition. The proposal identifies four amphibious hubs as anchor points in a renewed intermodal network linking buses, bicycles, and ferries. This system would offer a viable alternative to car use, supporting both residents and visitors while alleviating seasonal congestion and pollution. Car traffic in central Grado and Aquileia would be limited to residents, while improved canal networks and a new intermodal node at Cervignano station would enhance regional accessibility. At the same time, the progressive flooding of saline-compromised agricultural areas is proposed to create a new ecological corridor along the Aquileia coast. This would link up with the Anfora canal and surrounding wetland systems, generating ecological value, buffering climate risks, and creating a basis for a new model of sustainable tourism.

Across these three river systems, urban and territorial design serve as tools to operationalize mobility justice, not only by redistributing access to infrastructure and space, but by reconfiguring the relationships among humans, non-humans, water, land, and movement. The goal is not to preserve an existing equilibrium, but to cultivate adaptive, just, and plural futures in a region where stasis is no longer viable.

Conclusions

Viewed through the lens of mobility justice, the North Adriatic emerges as a territory shaped by centuries of profound transformation. Rather than a landscape to be preserved unchanged, it should be understood as a dynamic laboratory for climate resilience, mobility reconfiguration, and ecological renewal, especially in light of the disruptions brought by climate change. Mobility justice serves here as both a diagnostic lens and a generative framework: it reveals how territorial arrangements have produced exclusion and vulnerability, while also opening pathways for spatial practices grounded in care, repair, and cohabitation. Within this perspective, mobility is redefined as a collective resource and a driver of ecological and social regeneration at the territorial scale. The proposed design scenarios outline strategic interventions that redistribute spatial opportunities, prioritizing environmental stewardship and social equity. They emphasize the need to move beyond fragmented or sectoral solutions toward an integrated, multi-scalar approach that weaves together climate adaptation, heritage enhancement, ecological restoration, and infrastructural innovation. The goal is not to preserve an unsustainable status quo, but to embrace transformation, designing for resilience, adaptability, and justice in the face of ongoing change. The scenarios developed along the Stella, Corno-Aussa, and Natissa river corridors are more than speculative proposals; they offer tangible spatial imaginaries and strategic tools for navigating uncertainty and cultivating resilience. By expanding the scope of justice to include more-than-human actors, evolving ecosystems, and historically marginalized places, this approach invites planners, policymakers, and communities to reimagine the North Adriatic not as a fixed coastline to be defended, but as a fluid, amphibious commons.

Importantly, the reflections presented in this text were developed within the framework of a research project funded by the National Recovery and Resilience Plan (PNRR).[1] Our approach interpreted the PNRR's goal of reducing territorial disparities (which brought substantial resources to Italy) through the lens of mobility and access justice. We focused on reducing inequalities not only between north and south, or center and periphery, but also in terms of everyday access to services, infrastructure, housing, and employment. In this view, minimizing mobility injustice in daily practices becomes just as crucial as addressing broader territorial imbalances.

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Civic peri-urban: repositioning peri-urban urbanization in new forms of inter-generational co-ownership.

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Abstract
The essay investigates the regenerative potential of peri-urban areas by examining the relationship between in-between spaces and civic uses, moving beyond functionalist perspectives toward an ecocentric and collective understanding of space. Reinterpreted as practices of "living uses," collective uses emerge as a lever for establishing metropolitan eco-public networks and reconstructing a public fabric of rights and relationships. Detached from proprietary and extractive logics, the peri-urban is framed as a plural civic space of care and co-production, where common goods are held in diffuse ownership and constitute a form of spatial capital. Through regulated and inclusive practices, a process of "re-landscaping" is envisioned—reassembling existing elements into qualitative relationships—thus countering the commodification of space and advancing access to fundamental rights in both urban and peri-urban contexts.

1. Introduction

Peri-urban territories are complex socio-spatial configurations that challenge the dichotomous theoretical categories of urban and rural inherited from classical urban theory. They represent the local-scale outcome of spatial restructuring processes in which decentralization, deconcentrating, and territorial dispersion are organically intertwined. These phenomena are observable both in the distribution of built functions and densities, as well as in demographic dynamics and extractive processes that subordinate these areas to infrastructures functional to urban performance. This results in spaces where long-term co-evolutionary processes (i.e., landscape) are absent, with specific identities having been dissolved within a few decades, and where the ecological context becomes a tool of the present's transience.

The complex peri-urban geography reflects the emergence of a multipolar spatial organization, where residual space is both a frontier to be shielded from further urbanization and a porous "ecotone" open to new forms of use and sociality. Resisting the externalization processes and extractive urban dynamics implies a reorientation toward redistributing rights, aiming to establish a negotiation space where urbanity is capable of recognizing an ecological context beyond the contingencies of present-day needs. It is an open process with local communities to overcome hierarchical and anthropocentric visions, seeking to build an intergenerational co-ownership rooted in socio-ecological relationships, as also affirmed by Article 9 of the Italian Constitution. This article links the protection of the environment, biodiversity, and ecosystems to the rights of future generations.

This calls for a paradigmatic shift away from the individualistic conception of space, anthropic pressure, and ecological fragmentation, toward new collective rights based on the recognition of shared practices and living uses, capable of overcoming the dualism between city and nature, society and ecology conceived as separate spheres. The reference is to the tradition of civic uses, which, in their original form, share the functional character (space of performance) with the peri-urban fringe. Current legislation replaces this functional nature with the valorization of ecological-environmental protection, in which intergenerational co-ownership is inspired by values of territorial inclusivity (Mangone, 2022).

2. Threshold Territory: Rethinking the Urban-Rural Continuum

For a long time, the city was defined in opposition to the countryside, through a sharp dichotomy that identified spatial and social boundaries as clearly distinct. However, contemporary processes have radically transformed this configuration, making it increasingly difficult to establish where the city ends and where what was once

considered "other" begins.

Recent transformations have dissolved traditional boundaries between urban and rural, center and periphery, local and global scale, giving rise to hybrid, fragmented, operational, and interconnected landscapes—often elusive and hard to define (Brenner, 2014).

It is not just the city that changes, but the very way we conceptualize the urban: no longer as a bounded and delimited spatial entity, but as a set of relations and logics that extend beyond classical morphology. In this context, not everything is urban, but everything is driven by the urban (Brenner, 2009). The city as we knew it dissolves —along with its natural outside— into a complex and multiscalar system of heterogeneous territories, connected through flows, infrastructures, and functions distributed discontinuously (Soja, 2007).

A new urban dimension emerges, a diffuse and polycentric organism that unfolds through diversified forms, roles, and landscapes. Urbanization shifts from the metropolitan model toward regional and planetary processes, reflecting global dynamics but materializing locally in in-between contexts: blurred, liminal territories where urban expansion absorbs and transforms rural space, reducing the city-countryside divide to an increasingly tenuous threshold.

The peri-urban space takes shape as a dynamic and unstable threshold, a hybrid field in which the dichotomies between urban and rural dissolve. In this complex landscape, a geography of atopos emerges —marked by the absence of formal coherence, stable historical ties, and durable future projections— resulting in a precarious, present-oriented dimension (Formato, 2012).

This is a space where the "technical activation" of norms flattens the territory, endowing it with a reality of its own akin to that of a commodity (Capone, 2020), producing spatial forms often detached from any intentional planning (Koolhaas, 2006).

In these once marginal spaces, strategic functions consolidate, demographic gradients re-balance, and lifestyles between center and periphery converge. Peri-urbanization and the hyper-urbanization of flows contribute to the decline of space as an ordering category, increasingly replaced by networked and relational logics (Amin & Thrift, 2002).

Low-density expansions, topological fractures, and infrastructural discontinuities compose a dispersed mosaic stretching beyond the established city limits. This is neither simple suburbanization nor the classic middle-class residential periphery (Fasciano, 2003), but rather a liminal territory where rural, natural, and urban components overlap in continuous tension (Errington, 1994). These zones, described by Mininni (2005) as the "third territory," form a "bridge space" (Ferretto et al., 2013) between urban density and the rarefaction of agricultural landscapes—an emerging figure in the ongoing regionalization of the urban.

Such spaces function as urban ecotones: gradual transitions between different settlement systems that lack clear continuity. These are threshold spaces in a flexible and permeable continuum, where spatial transformations respond to polycentric dynamics, no longer legible through binary categories (Simon et al., 2006). Koolhaas (2006) describes this as a formless proliferation, where urban design dissolves into the casual addition, into the unintentional assemblage of heterogeneous fragments. The result is a landscape where action blurs with outcome, hierarchy with accumulation.

The peri-urban thus becomes symptomatic of a new multipolar territorial organization, in which urban functions tend to decentralize and redistribute unevenly. It is within these territories that extended urbanization (Wandl et al., 2014) begins to unfold—a fragmented spatial configuration that overlays agricultural landscapes, deeply altering their functions.

The privatization of land, the transformation of collective usage rights into exclusive ones, and the enclosure of common resources (Harvey, 2003) act as accumulation by dispossession devices, reshaping forms of living and production. This produces a stark discrepancy between quantitative growth and socio-environmental quality, between urban development and ecological sustainability.

The absence of a coherent institutional framework—one that often continues to classify these areas as merely agricultural—hinders access to services and limits spatial quality, preventing these territories from expressing their potential as sites for alternative living models and emerging practices. Demographic changes, evolving occupational patterns, the conversion of productive activities, and the increasing role of market logics produce a constantly reconfiguring space, where the urban-rural divide loses its analytical relevance (Webster, 2002).

Resource pressure and intensive infrastructuring create growing competition in land use, accelerating territorial marginalization. The scarcity of essential services, lack of public transportation, and dependence on private mobility (Rojas-Caldelas et al., 2008) make these territories structurally subordinate to urban systems. At the same time, they absorb informality and leftovers, hosting residual functions unwanted or unsustainable in the core city (e.g., landfills, recycling centers, shopping malls, peripheral industrial sites).

Here, soil degradation, biodiversity loss, and the breakdown of ecological networks become tangible indicators of an environmental crisis triggered by unregulated urban expansion (Allen, 2006).

Yet peri-urban spatiality is not a void to be filled nor a mere byproduct of urban growth. Rather, it is a space constituted through complex relations—marked by overlapping attachments, by centripetal and centrifugal forces, and by forms of specialization that make it a territory with uncertain vocation (Pareglio, Pozzi, 2013). While some configurations resemble uniform sprawl, others appear as cellular fabrics or linear development corridors along major infrastructures (Simon et al., 2006). In all cases, peri-urban areas are shaped by forces that render them unstable, unequal, and layered.

From this perspective, peri-urbanization dynamics are not simply spatial phenomena but interpretive keys for understanding contemporary territorial restructuring and its social, economic, and ecological implications.

These transitional zones between city and countryside are now actual territorial devices that reflect the evolution of the post-metropolis, where urban space dissolves into networks, flows, and functional fragmentation (Simon et al., 2006). Borders no longer delimit—they articulate, defining new thresholds of interaction among interconnected territories.

Peri-urban areas thus emerge as territorial figures dense with ambiguity—not reducible to traditional spatial categories, but rather to be interrogated for their capacity to shape new geographies of dwelling. Any project must begin with the recognition of their hybrid, ecotonal, and unstable nature.

3. Mapping the Peri-Urban

The peri-urban is configured as a space dense with fragments, the result of stratified sedimentations and transformations, reflecting one of the most emblematic structural conditions of contemporary territories. It expresses, often in ambiguous and unresolved forms, the social, economic, and functional discontinuities that traverse postmodern urban geographies, highlighting the crisis of traditional categories such as centre and periphery.

In an attempt to interpret the tensions that run through these territories — between demolitions and reconstructions, abandonments and reuses — it is useful to recall the two opposing tendencies described by Bernardo Secchi in Prima lezione di urbanistica (2000), which can also be applied to peri-urban spaces. On the one hand, there is a position that seeks to re-establish clear boundaries, separating the city from what is perceived as an indistinct background, restoring order and form, tracing historical arrangements or containment policies. On the other, there is an interpretation that rejects any clear boundary, conceiving space as part of an urban continuum

in which every attempt at formal distinction proves artificial. Both interpretations, however, according to Secchi, reflect a deeper difficulty that we could interpret as the inability to construct interpretative grammar capable of capturing the specificities of the peri-urban as an interstitial territory, structurally hybrid and in constant redefinition.

Minnini (2013) proposes reading the peri-urban space through the categories of transcalarity and proximity, with particular attention to open space, understood as a fundamental element in the emancipation process from modernist models and in the re-foundation of the contemporary city, fragmented and plural. This approach invites us to free urban design from sectoral logics, recognising the landscape as a new infrastructure capable of ensuring greater freedom of movement and autonomy in constructing an individual habitat, while embedding it within a collective idea of territory.

In the Piano Paesaggistico Territoriale Regionale (PPTR) of Puglia, the peri-urban is recognised as the space where recent transformations most visibly reveal the criticalities generated by the contemporary city. These are areas that must be removed from the logic of randomness, from the unlimited availability for use and consumption, and from the dissipation of symbols and resources, to be reinterpreted through an attribution of meanings arising from experience, restoring their role in the ongoing transition. These are spaces to be made useful again, starting from a pact that re-establishes symbolic, alimentary, recreational, hygienic, and experiential exchanges between city and countryside in a multilevel perspective. This vision is based on a strategy of agrourbanisme inspired by Alberto Magnaghi's theories on self-sustainable regional development.

The definition of the field of existence of the peri-urban takes shape through an anthropo-geographical interpretation that constructs a taxonomy of settlement morphologies, positioned between city and countryside, and understood as active components of this pact. The labels campagna abitata, campagna urbanizzata, campagna del ristretto, and campagna profonda express the intention to name things in order to understand their problems. In these contexts, one finds loosely woven fabrics such as public peripheries or allotments lacking a clear relationship with the street; formations in an uncertain state, often artisanal or residential, destined to remain incomplete; linear settlements that urbanise extra-urban roadways; large-scale tourist platforms and dispersed coastal landscapes tied to seasonal use of second homes.

In the Linee guida per le aree della dispersione insediativa e per le aree del periurbano (DiCEM, 2004), developed in 2024 by the Campania Region in collaboration with the Dipartimento delle Culture Europee e del Mediterraneo (DiCEM), the peri-urban space is described as an "orphan of landscape." This definition underscores the inability of such territories to continue representing the cultural and symbolic values that once structured the relationships between space and society. From this, emerges the urgency to elaborate new imaginaries capable of interpreting ongoing transformations and reflecting the culture of our time.

This is a territoriality largely generated by the unintended outcomes of planning — a "territoriality without authorship" that now calls to be rethought and reconfigured through a renewed urban and landscape project. From this perspective, the peri-urban is interpreted as a strategic resource for the city and its inhabitants, particularly where it is managed by active forms of agriculture and by new rural actors who live and produce in the campagna di prossimità, contributing to the challenges of ecological transition.

In these Linee guida, the peri-urban is conceived as a spatial device interposed between the urban periphery, scattered settlements, and adjacent rural spaces: a condition of thirdness — neither city nor countryside — outlining a landscape proposition for the contemporary condition. In this view, a different critical geography is affirmed, one capable of including the hybridised territories of the agrourbano. This is a space that once again becomes available for renegotiating the relationship between city and countryside through the valorisation of open proximity spaces, generated by agriculture which, as in Campania, has not been marginalised with respect to urban fringes, but rather retains a strong productive capacity and a potential regenerative function.

The theoretical perimetral definition structured by the Linee guida per le aree della dispersione insediativa e per le aree del periurbano considers several territorial and demographic factors that define a transition zone between city and countryside, represented by a "geometric band" surrounding urbanised areas. The thickness of this band varies according to the municipal population: 100 metres for municipalities with fewer than 2,000 inhabitants; 200 metres for those between 2,000 and 15,000; and 500 metres for those with more than 15,000 inhabitants. Urbanised areas exclude surfaces smaller than 5 hectares for municipalities under 2,000 inhabitants; 25 hectares for those between 2,000–15,000; and 50 hectares for those above 15,000. These exclusions derive from the fact that such areas do not present sufficient significance in generating the peri-urban.

Thus, in this study, the peri-urban area of Campania is represented by: a 100-metre transition band for municipalities with fewer than 2,000 inhabitants; a 200-metre band for municipalities with between 2,000 and 15,000; and a 500-metre band for municipalities with more than 15,000 inhabitants.

Prior to the study developed for the Linee guida, a further investigation was conducted within the preliminary studies for the Piano Paesaggistico Territoriale Regionale della Campania by the Dipartimento di Architettura (DiARC) of the University of Naples "Federico II" (Attademo et al., 2022). This study, carried out at the regional scale, introduces a set of composite indices that can be replicated in other contexts and applied at more local scales to deepen territorial specificities.

The mapping of peri-urban space is based on three main indicators: the density gradient, anthropic pressure, and ecosystem fragmentation.

The density gradient is the initial indicator, useful for excluding extreme situations by distinguishing what is unequivocally urban from what falls within areas of high ecological value or biodiversity reserves. This indicator allows for the identification of significant thresholds, isolating portions of territory with characteristics attributable to the rural.

Anthropic pressure (Angelini et al., 2018) represents the level of disturbance exerted by human activities on non-urbanised biotopes, within the physiographic landscape units. It is assessed by considering the "biotope constraint," that is, the intensity of disturbance due to proximity to anthropised environments such as intensive agricultural areas, quarries, fallow lands, industrial zones, brownfields, and other artificialised spaces. This index also captures the diversity of land uses typical of peri-urban contexts.

Ecosystem fragmentation describes the process of progressive reduction and isolation of natural and semi-natural environments, largely driven by urban expansion and the growth of infrastructural networks. This phenomenon negatively impacts ecological continuity, reducing the size of patches unaltered by artificial elements and fragmenting them into smaller and more isolated units. Evaluation is conducted using the effective mesh density index (Seff) proposed by Jaeger (2000), which measures the density of ecologically functional meshes interrupted by infrastructural barriers and land artificialisation.

The combined analysis of these three indices, through cartographic overlay techniques, enables a synthetic and integrated representation of the peri-urban interface, highlighting both its criticalities and its potential in terms of ecological and design-based reconfiguration.

4. A New Peri-Urban Civic Space

Exploring the nexus between the peri-urban and civic uses requires a shift away from a utilitarian-functional perspective toward one of meaning—repositioning peri-urban urbanization within a framework of shared land, understood as co-owned in its modes of use and across species, intergenerational in scope, and transcending the temporality of utility. This connection can be critically examined by contrasting the distinctive traits of the peri-urban fringe—as a space of performances—with some fundamental aspects of civic use.

Civic and collective uses, reinterpreted as categories of use of goods functional to the enjoyment of fundamental rights, act as triggers for systemic regeneration processes through spatial concretizations capable of recovering "living uses" (Capone, 2016). These practices reveal the regenerative potential of peri-urban areas and support the formation of eco-public networks at the metropolitan scale as incubators of new urban civic spaces (Formato, 2021).

As contemporary spaces where dichotomies and binaries thin out in extractive processes, in-between territories absorb the full extent of individualism, reflecting the prevailing climate of exaggerated exaltation of private property. This tends to "realize a society entirely governed by private law, one that does not admit exceptions to the primacy of the market, not even for the collective rights of the constitutional state" (Capone, 2016: 622). In this setting, solidarity is replaced by competition over scarce and inadequate resources (Bauman, 2005)—a hallmark of neoliberal society that acts through the decontextualization of relational meaning and territorial specificity.

The erosion of identity traits—understood as values sedimented over time—allows us to observe space as a medium for uncovering customary practices that have historically characterized the collective use of land and resources (Capone, 2020). However, the concept of identity often ties civic use and even temporary enjoyment to select groups of "original communities" and "claimants, falling within, and naturally residing in a specific territory" (Di Genio, 2019). Thus, considering the peri-urban as a space devoid of long-term processes (landscape), or rather as a space where such processes have been dissolved within decades, necessitates a focus on the "practice of use" (Capone, 2016). This practice breaks free from the "straitjacket of exclusive ownership," dissolves the individualistic approach to spatial use, and allows us to "extend the notion of civic uses in the more general form of collective uses, with their recognition in specific usage regulations—of buildings and urban spaces—restoring collective access to goods functional to the exercise of fundamental rights" (Capone, 2016). This perspective emerges when civic uses are viewed as a "convenient expression" extending the legal institution to the entire territory, not only to agricultural and forested areas.

It is therefore necessary not to consider civic uses strictly as a legal institution (as established by Law 1766/1927), which excludes a large number of "living uses"—new forms of collective usage that demand a constitutionally oriented generalization within the very notion of civic use, extending such usage to urban or quasi-urban areas. Moreover, civic and collective uses represent social and fundamental rights—personal, individual, collective, and diffuse—which benefit both the individual and the community (Di Genio, 2019). They are connected to environmental protection (Judgment 156/1995) and landscape preservation (Judgment 310/2006), as well as to the preservation of such uses and the democratic principle of participation in decision-making processes, as expressions of a collective capital that ties land ownership to the community (Di Genio, 2019).

Thus, it is essential to approach this institution from the perspective of "collective rights" (rights of use and enjoyment) that "belong to a community of inhabitants, or to an undifferentiated collective of citizens residing in a given locality" (Capone, 2016). A community of inhabitants is understood as a "plural and complex social reality, constituted through acts of care and the reproduction of common goods" (Capone, 2020).

These collective rights, as a category encompassing both ancient and more recent uses, enable the conceptual generalization and spatial extension of the content of civic uses through specific usage regulations—bringing back to the fore public life and the social function of goods, their public destination, and space itself (solidarity, subsidiarity, and the free development of the individual and social formations).

What emerges is a counterpoint that shifts the understanding of civic use away from its original economic-productive configuration—now superseded by ecological-environmental protection (Mangone, 2022)—and toward a notion of "practice of use" that is not resolved in exclusive ownership, that breaks with the individualistic approach to spatial use, and that challenges processes of spatial irrelevance. It allows for both a conceptual generalization and a spatial extension of the notion/institution of civic use into its broader form of collective uses and their formal recognition.

The resulting project is a space with diffuse ownership of goods, moving beyond identity-based belonging and instead ensuring accessibility, inclusivity, impartiality, and usability—countering the exclusive use driven by the "proprietary-exclusionary paradigm" (Capone, 2016). The aim is to promote "plastic and open communities" (Capone, 2020), rooted in the territory through acts of care and relational production—communities that consider goods within their ecological context and beyond the provisional nature of the present. This perspective overcomes the modernist logic of spatial reproduction, in which "space becomes real only through transformation and commodification" (Viganò, 2023), and instead proposes a form of "spatial capital" understood as a "stock of collective resources." This capital transcends utilitarian and functional dimensions, becoming a collective heritage that accumulates and develops over time as the result of multiple and heterogeneous intentions, held in both intimate and collective dimensions.

The collective use of space constructs relational networks through a doubly creative action: the production of common goods and the generation of their reference communities (Capone, 2020). It allows for a shift from "self-assertive values" (competition, expansion, domination) to "ecocentric values" based on interdependence: from hierarchies to networks (Capra, 2001). This outlines a project of peri-urban "re-landscaping" through spatial practices that counter the "speculative supremacy of the conceived" (Capone, 2020), invoking the social function of space as established by the Constitution. It envisions a peri-urban territory no longer available for extractive processes, but one in which quantitative dimensions have already been exhausted and must now be reassembled into qualitative relations.

This closure becomes an opening toward regenerative potential—configuring metropolitan-scale eco-public networks as incubators of new urban civic spaces (Formato, 2021), and an assemblage of spatial concretizations capable of recovering "living uses" (Capone, 2016: 621). Rebuilding a public fabric of civic and collective rights, practices, and spaces enables the connection between landscape protection (Judgment 310/2006) and the democratic principle of participatory decision-making. It expresses a form of collective capital that ties land ownership to the community (Di Genio, 2019) and removes peri-urban landscapes from any further permanent development or degradation. This "re-landscaping" process transforms already-consumed quantities into new qualitative assemblages through spatial practices that counter the "speculative supremacy of the conceived," ensuring that "technical activation" (Capone, 2020) of regulations does not flatten space into a consumable commodity.

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Special Session 6

Spatial Planning and Metropolitan Governance to face Flood risk in the new Climate Change context: A comparison between Eurodelta Megaregion and Valencia metropolitan area

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Abstract
Resilience has become a topic of increasing importance, gaining presence in debates on spatial planning. It refers to the capacity to resist, to maintain vital functions and identity, but also the capacity to go forward, to learn, to build back better, to become more efficient and more functional in face of risks or shocks like flooding, which is being experienced in Europe with greater frequency and more impact. From this definition, this paper focuses on two cases of flood risk management at metropolitan level -Eurodelta Megaregion in The Netherlands and the Metropolitan Area of Valencia in Spain- with the aim to show learned lessons and to identify and propose recommendations regarding innovative and more effective planning procedures and frameworks to improve the resilience-related governance across scales, sectors and actors at metropolitan level.

Keywords: Resilience management; Flood risk; Climate-resilient spatial planning; Metropolitan governance.

Introduction

Resilience has become a topic of increasing importance due to the succession of more frequent crisis phenomena and the emergence of future uncertainties, gaining presence in debates on urban and regional policy and planning (Davoudi, 2012; Tasan-Kok et al., 2013; Greiving, 2018; Marom & Shlomo, 2024). According to Pascariu et al. (2022), 'resilience' is not just the capacity to resist, to maintain vital functions and identity, but also the capacity to go forward, to learn, to build back better, to become more efficient and more functional in face of risks or shocks. This resilience is not only innate or given, but can also be trained, for which policies, plans and programs, with the participation of epistemic communities and communities of practice, with a leading role for citizens who become familiar with risk and its management in each living space.

The management of resilience is related thus to a mix of techniques (planning tools) and patterns of governance (stakeholder management) in face of two main types of risks or changes, namely: abrupt "shocks" that disrupt everyday life for a limited period of time (e.g., an earthquake or a pandemic); and enduring "stresses" or crises that put systems under constant pressure (e.g., climate change or aged infrastructures), leading to overloads

that can severely restrict sustainable development in the long term (Coaffee et al., 2018). Among these risks, flooding is being experienced in European countries with greater frequency and more impact. This can be due to different reasons such as climate change; deficiencies in infrastructure and its management and maintenance; the complexity of stakeholder roles and responsibilities; a lack of clarity and willingness to accept responsibility; and a lack of understanding flood risk (Local Government Association[1]). However, risks can be estimated, and the impacts can be significantly mitigated, so response and recovery can be more effective and efficient. In this vein, resilience highlights the need to be prepared to anticipate, react and adapt to changes, especially to those that could produce critical impacts on a territory. As a result, the scale of places, their governance and spatial planning become a crucial issue for managing resilience. Spatial planning at metropolitan level is thus an important basis to make steps forward to an appropriate metropolitan governance in soft spaces but also in formally constituted metropolitan areas. That is asking for collaborative approaches to address complex challenges, redefining governance and planning practices beyond traditional administrative boundaries.

To identify and propose recommendations regarding innovative and more effective planning procedures and frameworks to improve the interplay across scales, sectors and actors, this paper focuses on two cases of flood risk management at metropolitan level in Europe, namely: the Eurodelta Megaregion (Netherlands) and the Metropolitan Area of Valencia (Spain). Both, The Netherlands (in past 2010 decade) and the Valencia region (more recently in past October 2024 but with a long history of centuries on this matter), have heavily suffered the effects of floods due to extraordinary rainfalls intensified by the climate change, causing very important damages at personal, economic, facilities and infrastructure levels. Both are also cases of informal metropolitan areas, where natural events are asking for governance beyond formal borders.

So, the objective of this paper is to highlight the need to strength a territorial culture and to develop institutional capacity to respond in a coordinated manner to these phenomena at metropolitan scale. By shifting the focus toward the changing roles of planners and citizens, the emergence of frameworks of interinstitutional cooperation beyond administrative borders, and of new types of solutions and adaptation measures (e.g., nature-based solutions), the paper sets the basis to spark a dialogue on innovative approaches to resilience.

The paper is structured as follows: in the next section we introduce the case of Eurodelta Megaregion, providing a general description of the area, the main water-related threats and challenges, and of the different measures adopted regarding flooding. The second section provides the same analysis focusing on the case of the Metropolitan Area of Valencia. A comparison of both cases is conducted in section 3 according to the analytical framework proposed, searching for similarities and differences among cases. Finally, the paper ends with a set of recommendations and final conclusions regarding the interplay between spatial planning and metropolitan governance to face flood risk in a new climate change context.

1. The case of Eurodelta Megaregion (the Netherlands)

Eurodelta is a densely urbanised megaregion with approximately 45 million inhabitants, also known as the "Rhine-Scheldt Delta". It is a transnational[2] and a polycentric region spanning parts of the Netherlands, Belgium (Flanders), and Germany (North Rhine-Westphalia), home to major port cities like Rotterdam and Antwerp, acting as a crucial gateway to the continent (Gerretsen et al., 2017). It is shaped by a shared historical background and the socio-economic philosophy referred to as the "Rhineland model" (Braun, 2020). So, strategically embedded within the Trans-European Transport Network (TEN-T), the Eurodelta functions as a key node in the global flow of goods, services, and knowledge. In addition, it positions itself as an innovative, sustainable, and inclusive delta-region, aiming to lead in climate-resilient infrastructure development while improving the quality of life for its

1 See: https://www.local.gov.uk/topics/severe-weather/flooding/flood-and-coastal-erosion-risk-management/flood-risk-and-flood-risk

2 Other transnational megaregions in Europe, such as the Øresund region (Malmö and Copenhagen), the Euregio Maas-Rhine, and the Danube Region, offer comparable cases where cross-border integration presents both challenges and opportunities for collaborative spatial governance.

population (SURE, 2020).

However, within the Eurodelta, there is no single, formal metropolitan region encompassing the entire megaregion. Instead, metropolitan governance operates at multiple scales. It functions as a polycentric network of cities with shared challenges, intensive interactions, and strategic cooperation, rather than as a unified administrative entity (ASSET, 2025; METREX SURE Expert Group, 2019; SURE, 2020). They promote cooperation models capable of managing interdependencies, coordinating cross-border policies, and facilitating effective spatial planning in areas with fluid, overlapping jurisdictions (ESPON Project[3]). Nonetheless, the Eurodelta's potential remains constrained by political fragmentation. Realising its advantages requires a shift toward flexible governance beyond traditional borders and institutional inertia.

1.1. Climate and governance-related challenges at metropolitan scale

Eurodelta is characterised by its low-lying river basins of the Rhine, Meuse, and Scheldt, and its low-lying deltaic landscape through its direct connection to the North Sea. Its strategic location and economic importance have historically driven significant spatial development, often at the expense of natural flood retention areas. This particularly confronts an urgent imperative for climate-resilient spatial planning (METREX SURE Expert Group, 2019). This unique geographical setting, while historically a source of prosperity due to fertile lands and navigable waterways, also presents inherent vulnerabilities, particularly to flooding. Eurodelta's complex administrative fragmentation, socio-economic and cultural values as well as environmental fabric requires a highly integrated and cooperative approach to spatial planning and governance, especially in the face of escalating climate change impacts (Deltametropool[4]).

Figure 1. Water Network in the Eurodelta
Source: Vereniging Deltametropool, Provincie Gelderland, & Provincie Zuid-Holland. (2017).

3 See: https://www.espon.eu/projects/territorial-governance-non-standard-geographies-nostageo and https://www.espon.eu/priorities/thematic-action-plans/governance-of-new-geographies

4 See: https://deltametropool.nl/projecten/a-economic-strong-just-and-climate-proof-eurodelta/

The Eurodelta region has a long and often dramatic history of confronting the threat of flooding, a challenge that has been significantly exacerbated by climate change. Historically, the primary concern stemmed from storm surges from the North Sea and high river discharges. Major flood events throughout history, such as the devastating 1953 North Sea flood in the Netherlands, have profoundly shaped the region's approach towards water management. This event, which caused widespread destruction and loss of life, served as a catalyst for the development of ambitious, large-scale engineering projects like the Delta Works[5], aiming to provide a robust physical defence against the sea.

In climate terms, beyond the immediate threat of flooding, the region grapples with a complex array of climate-induced challenges. Salinisation, the increasing salt content in soil and water, poses a growing problem in low-lying areas, threatening agricultural productivity. Concurrently, increasing drought conditions in higher-lying parts of the Eurodelta impact agriculture and business activities. Land subsidence, the gradual sinking of land, further exacerbates these issues, causing damage to foundations and infrastructure. The increasing frequency of extreme weather events and erratic river discharge patterns introduce new layers of complexity, intensifying the pressure on existing systems (RLI[6]). These environmental shifts are not isolated; they create spatial conflicts, notably between agriculture and nature, as adaptation strategies often require changes in landscape structure and management that lead to competition for land (Blom-Zandstra et al., 2009). The region also faces the challenge of developing new residential areas that are energy-efficient and resilient to drought, heat, and heavy rainfall, alongside integrating renewable energy infrastructure without compromising existing landscapes or public acceptance (Nabielek et al., 2023).

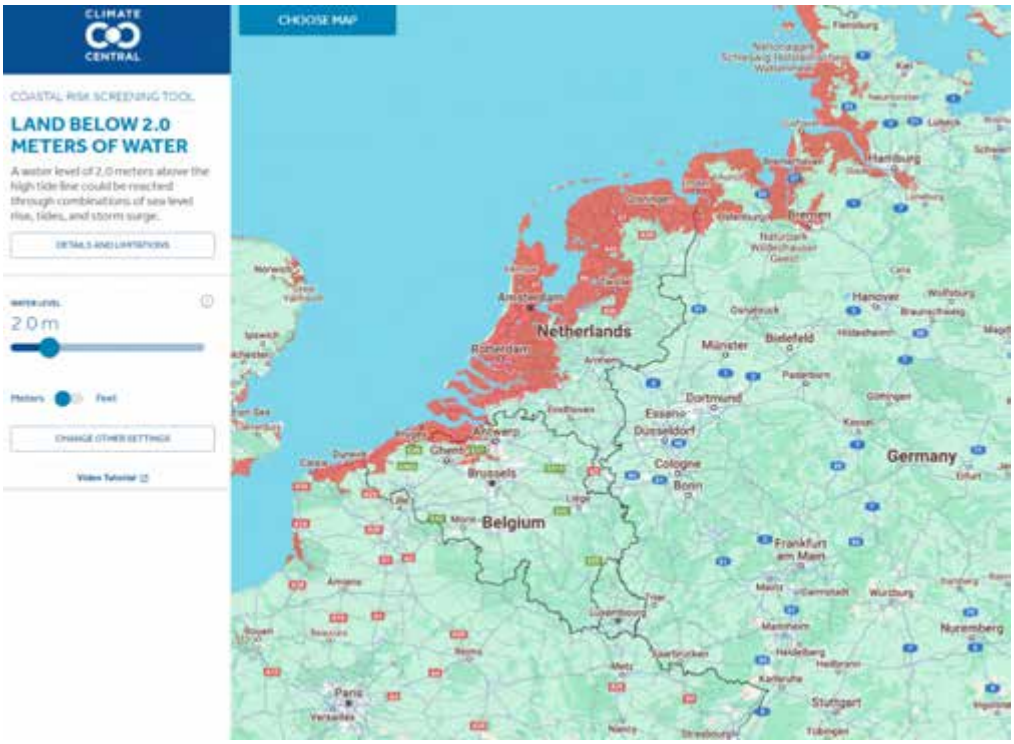

Figure 2. Coastal risks of Eurodelta with 2.0 m sea level rise
Source: Climate Central. (n.d.). Coastal Risk Screening Tool: Land projected to be below annual flood level in 2050. Retrieved May 22, 2025, from https://coastal.climatecentral.org/map/

The Eurodelta's aspiration to become a sustainable and globally competitive megaregion is persistently chal-

5 See: Rijkswaterstaat. (n.d.). De Deltawerken. Available at: https://www.rijkswaterstaat.nl/water/waterbeheer/bescherming-tegen-het-water/waterkeringen/deltawerken [Accessed: 29 May 2025].

6 see: https://www.rli.nl/sites/default/files/Rli%202024-02%20Klimaatadaptatie%20ENG%20def%20interactief.pdf

lenged by fragmentation across administrative, sectoral, value-based, and spatial planning dimensions. These divisions obstruct coordinated spatial development and weaken the region's capacity to address shared challenges effectively. Administratively, the Eurodelta spans multiple national jurisdictions, including the Netherlands, Belgium, Germany, and northern France. Each of these territories is governed by distinct legal systems and planning traditions. This institutional diversity hampers policy alignment and reinforces siloed decision-making. Although the European Union promotes a more integrated spatial planning approach, the rigidity of national frameworks and the protection of institutional interests often inhibit genuine cross-border collaboration (ESPON, 2025a; ISOCARP, 2025).

Sectoral fragmentation is equally pronounced. Despite a dense and advanced infrastructure network, the region suffers from disjointed mobility systems and policy mismatches, particularly in transport and energy. These inefficiencies undermine EU climate objectives, as spatial demands from energy transition and circular economy initiatives increasingly compete for limited land (ESPON, 2025b; Blom-Zandstra et al., 2009). Value-based fragmentation further complicates the planning landscape. Divergent stakeholder interests, such as those between private capital and public equity, create tensions in the implementation of shared sustainability goals (Deltametropool, 2022; Mikaelsson & Lager, 2024). Spatial planning and governance fragmentation is also driven by divergent planning systems, regulatory tools, and institutional capacities. The lack of a unified vision or binding cross-border frameworks results in policy misalignment and inconsistent implementation across borders. This hinders coordinated responses to transnational challenges like urbanisation, climate adaptation, and infrastructure modernisation. So, moving forward, flexible but formalised governance mechanisms are essential to foster coherence, enable joint action, and realise the Eurodelta's long-term spatial potential.

Furthermore, the challenges are compounded by interconnected socio-ecological factors. The transition to a circular built environment, for example, demands physical space for new infrastructure such as circular construction hubs and material storage. This adds to existing spatial pressures from climate adaptation and energy transition (INTERREG Europe, 2025[7]). These interdependencies mean that addressing one issue in isolation often creates new conflicts or intensifies others. Success in climate adaptation is therefore inseparable from managing broader societal transitions. Non-climate drivers such as population growth, demographic ageing, and rising inequality further amplify climate vulnerabilities, with at-risk groups disproportionately exposed to heat and other hazards (Ministry of Infrastructure and Water Management, 2023).

Finally, the ongoing housing expansion and energy transition, while vital, can increase exposure to climate risks if not coordinated through integrated spatial planning (Ministry of Infrastructure and Water Management, 2023). Addressing these challenges requires a holistic approach that accounts for trade-offs and co-benefits, moving beyond fragmented planning. The core obstacle is not a lack of recognition or vision, but the limited political and institutional capacity to implement integrated strategies amid competing economic interests and entrenched land-use practices. This necessitates stronger regulatory tools and a cultural shift across authorities, businesses, and the public to prioritise water and soil systems as foundational planning principles (Jaap de Graeff, Agterberg, et al., 2024).

1.2. Climate-resilient spatial planning and governance practices

Deltametropolis Association was established in 1996 as a collaborative initiative by the four mayors responsible for spatial planning in Amsterdam, Rotterdam, The Hague, and Utrecht, collectively known as the Randstad. Its objective was to develop a spatial strategy aimed at transforming the Randstad into an urban complex of international significance: a European Delta Metropolis. Conceived as an informal collaboration, the association operates as a non-profit, non-governmental, and member-based organisation. The concept of spatial planning in the context of Deltametropolis extends beyond its physical dimensions, it represents an ideal and a mode of thinking. It emphasises a focused and reflective approach to metropolitan development, driven by long-term societal interests. This includes addressing pressing contemporary challenges such as the energy transition, urbanisation, and climate adaptation.

7 See: https://www.eurometrex.org/new-interreg-europe-project-announced-for-a-eurodelta-spatial-strategy/

The Dutch Delta Programme was officially launched in 2010 as a long-term national strategy to protect the Netherlands from the growing risks of climate change, including sea-level rise, river flooding, and periods of drought. The programme was initiated following the recommendations of the second Delta Committee, which was established in 2007 in response to increasing scientific evidence of climate-related threats to the country's low-lying and densely populated regions (REF[8]). Since the beginning of the Delta Programme, the indication towards cross-border coastal water management started getting some attention. Since 2015, with the Paris Climate Agreement, Deltametropolis Association, together with METREX and some urban metropolitan regions of the Netherlands, Germany, Belgium, initiated the conversations and possibilities to work together voluntarily on the cross-border Eurodelta scale and named it Strategic Urban Region of Eurodelta (SURE) Network.

Figure 3. Strategic Urban Region of Eurodelta (SURE) Network
Source: Braun, C. (Ed.). (2020, October). Eurodelta - SURE: Strategic Urban Region Eurodelta – Roadmap. METREX, City of The Hague, City of Amsterdam, and Province of South Holland. https://deltametropool.nl/publicaties/roadmap-eurodelta-sure-2020/

The Dutch Delta Programme highlights the critical role of spatial adaptation in ensuring that the Netherlands becomes climate-proof and water-resilient by 2050. It promotes coordinated action among municipalities, water boards, provinces, and the national government to address water-related challenges such as flooding, drought, heat stress, and waterlogging. Spatial planning in the Netherlands has long been deeply intertwined with water management. Historic land reclamation and polder development required a highly coordinated approach to land use, resulting in a planning tradition that integrates flood risk assessment and water infrastructure from the outset. Within the Eurodelta, water governance operates through a multi-level structure involving national, regional, and local authorities.

8 See: https://english.deltaprogramma.nl

The Dutch Water Boards -Waterschappen- are a distinctive example of functional governance. With autonomous taxing authority and direct responsibility for managing dikes, water levels, and water quality, they have cultivated a strong territorial culture of water awareness and shared responsibility. Comparable regional and local bodies exist in Flanders and North Rhine-Westphalia, though typically within broader provincial or state governance frameworks. While differing in institutional autonomy, these entities collectively reflect a commitment to integrated and locally rooted water management across the Eurodelta. Bringing together the many separate authorities and governments, as well as the citizens in the diverse Eurodelta region, can be quite difficult. However, everyone shares common ground due to similar water-related challenges like flood risks.

a) Professional approach and community engagement
Building on the existing formal governance structures and exploring with new informal ways of working, the Eurodelta also relies on "soft spaces"—flexible, non-statutory zones of collaboration that transcend administrative boundaries. These spaces enable actors to address shared challenges, such as flood risk or climate adaptation, where rigid jurisdictions fall short. The Strategic Urban Region Eurodelta (SURE) network exemplifies this approach. It serves as a collaborative platform for urban and spatial planning professionals, facilitating cross-border dialogue and coordination. SURE promotes a vision of a borderless, sustainable megaregion by aligning efforts across mobility, spatial development, climate adaptation, and the circular economy, advancing integrated solutions beyond institutional silos.

In recent years, resilience planning in the Eurodelta has undergone a significant transformation, shaped by lessons from past floods, heightened climate awareness, and the region's spatial dynamics of its transboundary setting. Rather than relying solely on defensive infrastructure, the region is moving toward integrated, adaptive strategies that combine spatial planning, ecological restoration, and stakeholder collaboration. This shift reflects a growing recognition that border regions require flexible, cross-jurisdictional solutions tailored to their layered governance contexts (Maila, 2025). The following initiatives and instruments illustrate this transition, showcasing a range of experimental and institutional efforts aimed at enhancing climate resilience, spatial quality, and cross-border cooperation across the Eurodelta in the field of flood risk management.

For instance, the International Commission for the Protection of the Rhine (ICPR[9]) has been a long-standing initiative facilitating cooperation among Rhine-bordering countries to manage water quality and flood risks. This framework has significantly improved the river's ecological status. Still, climate change and increased industrial activities present new challenges, requiring adaptive management strategies. The ICPR could evolve further by strengthening data sharing, harmonizing regulations, and enhancing stakeholder participation to effectively address contemporary water management issues.

Another example is the NEB Bauhaus of the Seas Sails – Delta Grenspark Groot Saeftinghe project. This New European Bauhaus initiative explores innovative approaches to coastal and estuarine development by integrating nature, culture, and community engagement. The Delta pilot at Grenspark Groot Saeftinghe acts as a testing ground for adaptive strategies that balance ecological restoration with economic activities and connect global perspectives with local needs. The project actively engages local communities, who share knowledge passed down through generations of living with water and brings in practitioners and policymakers to discuss future trends and scenarios for the delta. Young planners, designers, and architects then develop new scenarios, which are presented back to the communities to foster understanding of their future involvement in delta decisions. While this project fosters interdisciplinary collaboration, its long-term success hinges on sustained stakeholder engagement and the ability to scale its solutions, with the complexities of cross-border governance and spatial planning still needing to be addressed.

b) Risk management and interinstitutional cooperation
Given the numerous administrative boundaries, a multi-level collaboration framework is crucial for developing

9 See: International Commission for the Protection of the Rhine (ICPR). (n.d.). Home. Retrieved from https://www.iksr.org/en/

and implementing cohesive strategies. We can see strong examples of this in action with initiatives like the Benelux Union and the EGTC Linieland van Hulst en Waas. The Benelux Union, encompassing Belgium, the Netherlands, and Luxembourg, has a rich history of intergovernmental cooperation spanning over 75 years, often serving as a blueprint for broader European integration. It provides a vital platform for collaborating on shared challenges such as climate change, energy transition, and mobility, leading to policy harmonization and joint projects. However, the Union's effectiveness can sometimes be hampered by differing national interests and administrative complexities. Enhancing its capacity to implement and monitor cross-border initiatives would undoubtedly strengthen its role in fostering regional integration and resilience.

Similarly, the EGTC Linieland van Hulst en Waas demonstrates the practical application of European Groupings of Territorial Cooperation (EGTCs). EGTCs offer a legal framework that empowers regional and local authorities to undertake joint projects. This particular EGTC, situated along the Dutch-Belgian border, is a prime example of how such a framework can facilitate concrete cross-border collaboration within the Eurodelta, working towards a shared spatial strategy and partnership. It focuses on improving spatial quality, preserving cultural heritage, and enhancing housing and liveability in the historically and ecologically significant Linieland region. To fully realize the potential of this pioneering cooperation model, strengthening institutional mandates and ensuring stable financial support are critical.

c) Solutions and adaptation measures
The solutions of water management in the era of climate change require a shift in thinking, robust adaptation measures, moving beyond traditional approaches to embrace more dynamic and ecologically integrated strategies. A prime example of such a paradigm shift is the Netherlands' "Room for the River" program. This initiative redefines flood management by actively creating space for rivers to safely overflow during periods of high water, thereby significantly reducing flood risks. This program moved beyond solely defensive measures to strategically allocate more space for rivers, linking water safety directly to spatial quality, social issues, and broader economic and ecological improvements. Room for the River approach embodies the long-standing Dutch tradition of "making work with work," seizing opportunities presented by the interventions to achieve multiple benefits. However, adapting and replicating this model in other parts of the Eurodelta demands careful consideration of local contexts and existing governance structures.

One major challenge is the difficulty in scaling localized successes to a megaregional level. Furthermore, there is a consistent need for more integrated spatial planning that fully incorporates climate change adaptation. Current planning often remains siloed within national or even sub-national boundaries, leading to fragmented efforts that may not effectively address transboundary water management issues and adaptive decision-making and governance. The harmonization of legal and regulatory frameworks across borders remains a slow process, which can impede the implementation of comprehensive adaptation measures.

2. The case of Valencia metropolitan area (Spain)
The metropolitan area of Valencia is a functional system made up of 44 municipalities with a population of 1.635.239 inhabitants in 2024, that could be enlarged in a second crown up to 66 municipalities and 1.8 inhabitants (Valencia Metropolitan Spatial Plan). The recent catastrophic flooding experienced on October 29, 2024, affected the south part of the metropolitan area, which is called "Horta Sud" county -comarca-. The "Horta Sud" is made up of 20 Valencian municipalities[10] and has a long-standing organizational and cultural history in the region. It is the second most populated county, with 454,668 inhabitants, and the most industrialized of the Valencian region.

It worths noting that traditionally there have been some tensions between the municipalities and the city of Valencia regarding the expansion of power of the capital city over time (Fundació Horta Sud). Only in the period 2015-2023 was a more cooperative approach attempted between the capital city and its surrounding municipal-

10 The 20 municipalities are the following: Alaquàs, Albal, Alcàsser, Aldaia, Alfafar, Benetússer, Beniparrell, Catarroja, Lloc Nou de la Corona, Manises, Massanassa, Mislata, Paiporta, Picanya, Picassent, Quart de Poblet, Sedaví, Silla, Torrent and Xirivella.

ities. Moreover, the general feeling is of a certain failure in terms of metropolitan governance, largely due to the absence of coordination and cooperation mechanisms between administrations and departments in the area (Romero et al., 2023). This is the context to be considered when assessing the consequences and the responses to the recent flooding in the "Horta Sud" within the metropolitan area of Valencia.

2.1. Climate and governance-related challenges at metropolitan scale

The recent flooding had an enormous impact at different levels, namely: emotional (loss of homes and a sense of vulnerability and helplessness), social (228 deaths), economic (between 0.1 and 0.2% of Spanish GDP in the fourth quarter of 2024, according with the Valencian Institute of Economic Research –IVIE), and environmental (landscape disorder and the spread of industrial and urban waste into the natural environment).

Figure 4. Areas affected by the flooding of October 29, 2024 in Valencia and surroundings
Source: Valencian Cartographic Institute.

The natural origin (physical conditions) that caused floods is well known. So is the disorderly way in which the territory has been occupied in a metropolitan space that has been configured around Valencia, connecting the surrounding cities and towns, all of them within a unique agricultural landscape (Farinós Dasí, 2021).

In climate terms, the floods of October 29th coincided with extraordinary rainfall associated with the frequent high-altitude cut-off low -DANA- conditions, typical of autumn in the Valencian Region. However, this time the rainfall was of an unknown nature and intensity, not in terms of total rainfall (there have been higher ones in the past) but rather in terms of the intensity of the rainfall in one hour (184.6 l/m2/h in the municipality of Turís, total 700 mm of rainfall this day). This intense rainfall in one place and within the short span of just one hour was due to a completely extraordinary atmospheric situation: quasi-stationary convective trains were generated, allowing low pressure systems to reactivate without moving, remaining in the same location, vertically above places where these highs accumulated. These depression systems are associated with climate change and the progressive warming of the Mediterranean (>3ºC), which provides energy and humidity to the air masses coming from the Sahara that cross the sea. When they touch land and collide with the first mountain ranges near the coast,

they rise and precipitate, potentially reaching altitudes of 5,500 meters with the high-altitude cut-off low, which triggers their ascent and the precipitation of all water vapor they have accumulated on their journey.

These meteorological conditions combine with coastal geomorphology characterized by the presence of broad alluvial plains that rapidly transition to interspersed wetlands. This area has been intensively exploited for agriculture and transformed into residential, industrial, infrastructure, and tourism uses. This has profoundly transformed the natural drainage system, which, in a layered form, sought its outlet to the sea, using the Albufera lake as a natural drainage area south of the city of Valencia.

However, the floods of October 29th were not due to the rainfall — in many, not a single drop was recorded— but rather to the intense flooding in the pre-coastal mountain ranges. In these extreme events, small rivers, ravines, and dry riverbeds with steep gradients abruptly channel the intense runoff. The high-water speeds (up to 15 km/h) leave very little time for the lower course of the river populations to react to these sudden and ephemeral floods. All of this poses a clear natural threat to the city and the metropolitan area.

This threat has been exacerbated in recent decades by increased exposure due to massive urban and infrastructure growth between 1966 and 2007, which has been carried out in a poorly organized and environmentally integrated manner. These land development processes also include the development of a new artificial channel in the final course of the Turia River, as it comes in the metropolitan area, diverting it away from the city, as reaction to the floods suffered by Valencia in 1957 (Figure 5).

Figure 5. Valencia and its County Urban Master Plan (1966)
Source: https://www.upv.es/contenidos/CAMUNISO/info/U0684629.pdf

Thus, from a hydraulic perspective, the problem shifted to the towns south of this artificial channel; the same areas where most of the new industrial and infrastructure developments are concentrated (westward, toward Madrid, and southward, toward Alicante), according to the Valencia urban master plan approved in 1966. Since then, and even before, there have been a series of urban, territorial, hydrological, and emergency planning instruments that have attempted to give coherence to these growths by integrating flood risk into the equation. However, despite the unsuccessful attempt at the Metropolitan Coordination Standards (1988), neither their ap-

plication nor the practical results have been as necessary, as discussed below.

2.2. Climate-resilient spatial planning and governance practices

The establishment of economic activities is taking shape as a fragmented set of facilities, with significant conurbations along the main road infrastructure and access routes to towns, without supra-municipal coordination or shared structures, and with a strong component of tertiary and service-industrial activity alongside productive companies. In many cases, these areas are constrained by infrastructure or other urban development projects. Moreover, the buildings in these areas did not develop typologies designed to withstand the risks of flooding, both materially and humanly. The increase in artificialized land in all municipalities, including those prone to flooding, has exacerbated the effects of the recent DANA.

The consequences of the floods arise thus in a context of a lack of a supra-municipal coordination body for environmental and urban planning, a situation that leads to the need for a comprehensive planning model between Valencia and the region. Some of the issues that have emerged regarding the management of resilience and the spatial planning approach are presented below:

a) Professional approach and community engagement

The disaster has sparked intense debate and reaction among citizens, the media, and among experts, technicians, and professionals (see the interprofessional manifesto led by FUNDICOT[11]). Proposals and courses of action have begun to be discussed and put forward by these stakeholders, which can be classified into three stages: before a flood (prevention); during the flood (response, related to the established warning systems and planned management and evacuation plans); and post-disaster recovery (reconstruction and rebuilding). In this third stage, it is important to promote adequate communication and understanding among the population of the risks they face, and to promote a so called "territorial culture" to strengthen both the awareness and the relationship between the population and its territory in functional terms, as well as between professionals and decision-makers (last responsible of applied measures).

Before the flood, the work of professionals should be related to the improvement of meteorological and hydrological information systems; while during the flood, and in relation to emergency plans, the work of planning professionals must contribute to a better integration between territorial and urban planning and civil protection. Finally, in the post-recovery period, the work of professionals is clearly related to the development and selection of alternative courses of action. Reality shows that this is much more important in the former than in the latter, where political criteria prevail. This has been the case of the two expert committees organized separately by the Valencian regional government (outsourcing their work to consulting firms, about which little is known today) and the Spanish government after the disaster. In this second case, on May 29, seven months after the floods, the Ministry of Ecological Transition presented its "Plan to Improve Flood Resilience in the Affected Territory" at the Polytechnic University of Valencia. However, the presence of political representatives was predominant during the event compared to the presence of experts, which was reduced to the final roundtable. Moreover, this program includes various types of actions in flood-prone areas of the Júcar-Turia river system, but most of them infrastructure-related and involving public hydraulic works funded by the national government (for an estimated value of €470 million) to minimize the impact of future flooding.

b) Risk management tools and interinstitutional cooperation

Prevention and adaptation aim to anticipate and avoid or reduce impacts. Prevention is more efficient than recovery and mitigation. It is therefore a matter of planning; and of implementing what is planned. This requires a) an appropriate regulatory and instrumental framework (clear definition of tasks, resources and responsibilities); b) political and administrative will and leadership; c) a society and citizens aware of risks and sensitive to the problem; and d) patterns of repeated interaction between actors and smooth channels of communication. Regulating land use according to flood risk is key, integrating urban and hydraulic variables into territorial and

11 See: https://www.fundicot.org/wp-content/uploads/2024/12/MANIFIESTO-Interprofesional-INUNDACIONES-OCTUBRE-2024-revisado-diciembre-1.pdf

hydrological planning documents. To achieve this, collaboration between the three administrations affected is essential: water, land, and civil protection.

Spatial planning is particularly relevant as it goes beyond the strict scope of hydrological planning for potentially floodable areas, encompassing broader areas with important functions of water capture, retention, and use (crops, forested areas, artificial areas, etc.). Once the catastrophic process begins, it is the systems, structures, protocols, and decision-making within Civil Protection that must take action to protect the potentially affected population and assets, in close collaboration with the population at risk. Therefore, it is important that territorial and urban planning identify and regulate evacuation corridors and refuge areas for displaced persons, which must be included in Civil Protection emergency plans.

In the case of the Valencia metropolitan area, although there is no metropolitan spatial plan (now under development), there are urban master plans for all the municipalities within the area, and a flood risk prevention sectoral spatial plan (Plan de Acción Territorial de carácter sectorial sobre prevención del Riesgo de Inundación en la Comunitat Valenciana -PATRICOVA-) at the regional level, approved by the Valencian Government in 2015 (updating its first version from 2003). There is also a Flood Risk Management Plan -PGRI- at national level (from 2016), for which the Spanish Ministry of Ecological Transition is responsible through the Júcar Hydrographic Confederation, which developed it. The PGRI, as well as the obligation to prepare a risk map to define the Areas of Significant Potential Flood Risk (ARPSI), have their origin in the Directive 2007/60/EC of the European Parliament and of the Council, of 23 October 2007, on the assessment and management of flood risks, which was transposed into Spanish legislation by Royal Decree 903/2010, of 9 July, on the assessment and management of flood risks.

The PGRIs are led by the water authority of the Government of Spain, but are developed with the participation of national, regional, and local institutions and territorial authorities, and include several public consultation and participation procedures. In the case of Valencia, the PGRI of the Júcar River (which includes the Turia river) is aligned to all the instruments: PATRICOVA (which incorporates its own mapping of areas classified as at risk of flooding in the Valencia Autonomous Region), the Civil Protection Master Plan of the Valencian Region government, and, at the municipal level, the urban master plans.

At the Spanish level, the 2016 Regulation on the Management of Public Hydraulic Domains -RDPH- incorporates limitations on land uses in flood zones. It also established that all Spanish Autonomous Communities (namely, the regional level of government) must adapt their land use and urban planning laws to the new flood regulations, for which a Technical Guide was prepared by the Ministry. To this end, they had to modify and adapt territorial and municipal planning that planned future urban developments in flood zones or preferential flow zones (defined, respectively, by Articles 14 and 9.2 of the RDPH). In the Valencian case, the former were delimited when the Júcar PGRI defined the aforementioned ARPSI; for the latter, Article 9 bis prohibits building on them on rural land (with some exceptions, which ultimately becomes their Achilles' heel in terms of compliance).

However, coordination between administrations and the adjustment of different instruments did not occur in a region like Valencia, which has had real estate development and tourism as two important pillars of its economy. This is also because, according to the PATRICOVA, risk maps must be done at the municipal level, although its Article 11.4 also opens the possibility, on a secondary basis, of a supra-municipal level.

c) Solutions and adaptation measures

Integrated flood risk management should focus on sustainable water management and measures that strengthen the resilience of nature and society to extreme weather events. However, traditional public works are often the most popular demands immediately after a disaster strikes. They are often effective in the short term, but less so in the medium and long term; they are more expensive than other types of measures and can create a false sense of security among the population.

These demands for mitigation public works at the territorial level (because at the urban level, mitigation actions and the protection of buildings and people are beyond dispute) focus on the construction of dikes and dams,

maintaining the functionality and/or increasing the capacity of existing riverbeds and channels (increasing the space for water in some of the upper or middle sections of the channels), and refurbishing linear transport infrastructure that can act as a barrier and worsen the effects of flooding. In this sense, the new channel of the Turia River has proven efficient in the task for which it was designed, and it protected the city on its right (northern) bank, but its southern wall acted as a dike for overflowing flows from adjacent basins on the left bank (such as the Pozalet-Saleta ravine system), worsening the situation in these areas. Nor can the Poyo Ravine, where intensive work is being done to restore and artificially condition the riverbed (in contrast to its ecological restoration), guarantee sufficient capacity to handle peak runoffs of more than 2,228,904 m3/s.

This leads us to the need to combine Nature-Based Solutions with other more adaptation-focused measures within a metropolitan Green Infrastructure (Muñoz and Doménech, 2011) through coordinated action at the supra-municipal level, of a metropolitan nature and under the hydrological criteria of the river basin authority, in combination with subregional spatial plans (Farinós Dasí et al., 2024). Some of these Nature-Based Solutions suitable for the case of Valencia are:

• Expanding the floodplain, returning (regenerating) more of the riverbed.

• Managing water with vegetation that facilitates infiltration processes: regenerating riparian forests and river headwaters, thus reducing flow and surface runoff speed.

• Controlling erosion and achieving healthy soils through terraced cultivation systems and "temporary" groundcovers, planting fast-growing plants (legumes or grasses) and then incorporating them as organic matter.

• Reserving areas as floodplains in case of emergency: river parks in the city and in built-up areas, flooding productive agricultural spaces in case of emergency (as has traditionally happened in the Valencian orchard within the current metropolitan area of the city), establishing appropriate compensation mechanisms.

• Become fluffy the soil, allowing water retention and infiltration into the subsoil, combining this with water storage facilities on the surface or in the subsoil of the floodplain (reservoirs that can be used in times of scarcity).

3. Results

The comparison of Eurodelta region and the Metropolitan Area of Valencia on climate-resilience and flood risk management revels several similarities and differences at the same time. In order to systematically assess the measures regarding resilience management (focus on flood risk) and spatial planning at metropolitan level, we have conducted a comparative analysis based on the following dimensions: a) Professional approach and community engagement; b) Risk management tools and interinstitutional cooperation; and c) Solutions and adaptation measures. The aim is to learn about governance and planning practices beyond traditional administrative boundaries (metropolitan scale) to face flooding.

a) Professional approach and community engagement

This dimension addresses the role of practitioners and citizens to face flood risk at metropolitan scale. It is worth noting here that the use and management of land to face flooding often implies limiting business activities, infrastructures developments as well as has impact on agricultural activities, and this introducing new layers of complexity. In Valencia, the engagement of the community and practitioners is heavily growing, but still lacking strong influence on final decisions, since the recovery process remains highly politicized (based more on politics than in appropriate policies in the right time). On the contrary, in the Dutch case the adoption of New European Bauhaus initiatives implies an innovative approach to coastal and estuarine development by integrating nature, culture, and community engagement. The Delta pilot at Grenspark Groot Saeftinghe also acts as a testing ground for adaptive strategies that balance ecological restoration with economic activities and connect global perspectives with local needs. Here, local communities share their knowledge achieved through generations regarding living with water and brings in practitioners and policymakers to discuss future trends and scenarios for the

delta.

These initiatives exemplify how knowledge sharing between experts and local communities can lead to stronger, more trusted land and water management plans. However, despite these positive efforts, scaling successful local projects into consistent, joined-up strategies between levels and sectors; e.g. across the entire Eurodelta megaregion remains a significant hurdle.

b) Risk management tools and interinstitutional cooperation
This dimension focuses on the existence of planning tools and partnerships beyond institutional borders to manage resilience and flood risk. Effective risk management and coordinated action across multiple levels of governance are essential for addressing the complex, interconnected challenges, especially those related to water. However, both territories experience fragmentation across administrative, sectoral, value-based, and spatial planning dimensions. On the one hand, the Eurodelta face distinct legal systems and planning traditions from different countries. On the other, the case of Valencia, even if it is circumscribed to one single country, also presents high complexity and institutional resistances because of the very competitive political and territorial dynamics between the different levels of government concerned and reluctance towards the power of the city of Valencia on the part of the metropolitan municipalities when designing and implement policy solutions. As well as between hydrological and spatial planning, respectively in hands, of the Spanish national and Valencian regional governments. This institutional diversity hampers policy alignment and reinforces siloed decision-making; despite the normative, legal fand instrumental framework is very clearly established in the Spanish case. So, main challenge, in this case, are not structural conditions of governance, but procedural ones (governance practices, both institutional coordination and cooperation, but also bottom-up from increasing public participation).

Nonetheless, in the case of Eurodelta resilience planning has undergone a significant transformation, shaped by lessons from past floods, heightened climate awareness, and the region's spatial dynamics of its transboundary setting. The Strategic Urban Region Eurodelta (SURE) network exemplifies this approach, promoting a vision of a borderless, sustainable megaregion by aligning efforts across mobility, spatial development, climate adaptation, and the circular economy, advancing integrated solutions beyond institutional silos. Besides, the creation of the Deltametropolis Association (1996) provides basis for informal collaboration to address pressing contemporary challenges. This is also the case of the Dutch Delta Programme (2010), that promotes coordinated action among municipalities, water boards, provinces, and the national government to address water-related challenges such as flooding, drought, heat stress, and waterlogging.

At formal level, both the Benelux Union and the EGTC Linieland van Hulst en Waas initiatives demonstrates the practical application of European Groupings of Territorial Cooperation (EGTCs), which offer a legal framework that empowers regional and local authorities to undertake joint projects. Both (formal and informal) initiatives are examples of institutional efforts to bring together the many separate authorities and governments and competing public-private interests to make them sharing to some extent common ground due to similar water-related challenges. On the contrary, coordination between administrations and the adjustment of different planning instruments do not occur in Valencia, which has had real estate development and tourism as two important pillars of its economy, ahead of environmental issues.

c) Solutions and adaptation measures
This dimension focuses on the type of interventions or solutions adopted to prevent, react and recover from flooding at metropolitan scale. Due to their great vulnerability to flood risk, both have adopted adaptation measures that have required great investments and additional land for essential infrastructure, including dyke reinforcement, river expansion, and water storage facilities. However, in recent years, resilience planning in the Eurodelta has undergone a significant transformation, shaped by lessons from past floods, heightened climate awareness, and the region's spatial dynamics of its transboundary setting. Rather than relying solely on defensive infrastructure, the region is moving toward integrated, adaptive strategies that combine spatial planning, ecological restoration, and stakeholder collaboration.

In this vein, a prime example of such a paradigm shift is the Netherlands' "Room for the River" program, which redefines flood management by actively creating space for rivers to safely overflow during periods of high water, thereby significantly reducing flood risks. This program moved beyond solely defensive measures to strategically allocate more space for rivers, linking water safety directly to spatial quality, social issues, and broader economic and ecological improvements. Valencia, one step behind, also is moving in this direction, despite today, being so present the catastrophic effects of floods in citizens' memory, the approach to flood risk management is more focused on traditional public works (business as usual, also from an economic model point of view). This type of measures is predominant compared to nature-based solutions to face flooding.

Conclusions

The objective of this paper has been to highlight the need to strength a territorial culture and to develop institutional capacity to respond in a coordinated manner to these phenomena at metropolitan scale. By shifting the focus toward the changing roles of planners and citizens, the emergence of frameworks of interinstitutional cooperation beyond administrative borders, and of new types of solutions and adaptation measures (e.g., nature-based solutions), the paper sets the basis to spark a dialogue on innovative approaches to resilience. Hence, the lessons learned from the cases lead us to elaborate a series of recommendations that are summarised below.

Drawing insights from the case of the Eurodelta and the Dutch Delta model, the following recommendations are put forth for climate-resilient spatial planning in this transnational megaregion:

• A core ambition must be to profoundly integrate water and soil systems as guiding principles for all spatial development. This means placing natural systems at the very heart of land-use decision-making, especially given the Eurodelta's inherent vulnerability to sea-level rise, flooding, and subsidence.

• To overcome "spatial lock-in" is critical to implement robust planning frameworks, clear regulatory tools, and targeted financial instruments that genuinely support adaptive land use. Areas currently designated for housing, logistics, or industry, even with existing development pipelines, must be re-evaluated for climate adaptation to enhance long-term resilience. Incentives, such as compensation for converting vulnerable land to nature-based solutions, can help align long-term resilience goals with economic pressures. Stronger policy support is essential to ensure water and soil systems decisively shape land allocation and development.

The role of spatial planners and citizens within the Eurodelta must fundamentally evolve. They are no longer merely technicians or inhabitants but must become coalition builders, navigators between institutions, and facilitators of multi-stakeholder dialogues. Their capacity to work across administrative and sectoral boundaries, aligning policies and maintaining momentum in long-term planning processes, is paramount (Maila, 2025). Furthermore, social equity must become central to spatial planning. Climate adaptation measures must actively address inequality, ensuring that vulnerable populations are not disproportionately exposed to risks like extreme heat or flooding. Planners need to integrate social analysis and values into their work, guaranteeing that adaptation strategies benefit all communities, particularly those with the least capacity to act independently.

In this evolving landscape, Research by Design (RbD) is increasingly a valuable method for addressing complex spatial challenges. Throughout the Eurodelta, this approach enables planners and stakeholders to explore future scenarios through creative design processes, combining technical, social, and spatial perspectives to imagine alternative land uses and policy solutions. The full potential of RbD, however, will only be realized when supported by institutions capable of translating its innovative ideas into formal decision-making.

Finally, planning within the Eurodelta must explicitly reflect the interconnected and cross-border nature of its challenges. As an integrated system of rivers, transport networks, and economic flows that extend across national lines, planning must be grounded in functional realities rather than rigid administrative boundaries

(Allmendinger & Naughton, 2010). Effective megaregional planning therefore demands long-term coordination, shared political will, and planning frameworks that operate across jurisdictions. "Planning without borders" is not merely necessary but increasingly urgent for building resilience at the scale where impacts are most deeply felt.

In the case of Valencia, the flood shock has sparked a broad public debate among scientific experts, the media, citizens, administrations, decision-makers, and private sector stakeholders about what lessons can be learned from what happened on October 29, 2024. Firstly, having regulations and rules in place to ensure adequate risk management, the following are recommended:

• Improved understanding of natural processes, this mean to give priority to meteorological alerts; have real-time information on the hydrological status of riverbeds during periods of extraordinary rainfall; adopt an updated flood hazard and risk mapping adapted to the new context of Climate Change, which considers future scenarios and is coordinated (better a single system) among the various responsible administrations, paying special attention to metropolitan areas due to the impact of flooding on them; and launch environmental and risk education campaigns.

• Coherence between spatial planning and risk management: controlling land-use changes in accordance with water regulations in a systemic approach, especially for the population and critical infrastructure, which are increasingly located in metropolitan areas. It makes no sense to delimit risk areas at the municipal level when runoff flow behaviour is completely inconsistent and exceeds the boundaries of each city.

• Establish as a priority responsibility of any government the proper coordination of the administrations involved in hydrological, spatial planning and risk management.

• Flood risk management requires effective governance approaches: it is not just a technical matter of building flood defences and developing flood warning systems. This means the need to consider not only political sensitivity, but to maintain open channels of communication between political decision-makers, technical staff, and subject matter experts.

Finally, political scientists identify other reasons for the failure of current democratic systems to adequately respond to the climate crisis, namely:

• The capacity of democratic decision-making to consider the medium and long term.
• Power issues and the influence of well rooted interests on political decisions.
• The extent to which citizens' views and values are considered in democratic decision-making.

As Driessen et al. (2016) point out, social and institutional factors often create strong barriers to the successful implementation of risk management systems.

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Special Session 8

Decolonial Strategies for Urban Greenery: Insights from Reimagining Planning Through Epistemic Pluralism in Kumasi

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Abstract
In the context of global crises, the field of urban planning is critiqued for reproducing unsustainable practices and excluding non-Western epistemologies. This paper explores how Indigenous knowledge practices in Kumasi, Ghana, reveal alternative value systems for planning rooted in relationality, reciprocity, and care. The study draws on fieldwork carried out through community engagement activities, foregrounding the voices of local actors who are often marginalised in planning discourses. Conducted within a transnational North-South university research collaboration, the research examines how engaging with epistemic pluralism can inform more just and inclusive planning processes. By framing planning as a cultural and value-laden practice, the paper contributes to the growing call for decolonising planning practices through the recognition of diverse knowledge systems.

Keywords: urban greening, epistemic pluralism, decolonisation, community engagement

Introduction

Addressing global environmental challenges requires a comprehensive, interdisciplinary approach that critically engages with the limitations of Euro-modern frameworks and dominant Western scientific knowledge systems. In the urban planning context, achieving transformative outcomes entails confronting the enduring influence of colonial legacies, which often sustain standardised, unsustainable practices at the expense of context-specific and locally grounded solutions. These structures – manifested in dynamics such as the privileging of dominant knowledge systems, the alignment of decision-making with financial interests, and the marginalisation of alternative epistemologies – have been the subject of critique for their tendency to overlook the inherent complexity of ecosystems. By overlooking this complexity, the structures rest on a separation of human and nature rather than symbiotic coexistence (Watson, 2019). The prevailing constraints of Western epistemology are evidenced by the eviction of Indigenous peoples in the name of modern conservation, despite the symbiotic relationship between Indigenous communities and nature that has been in place for millennia (Watson, 2019; Chilisa, 2017). The marginalisation of traditional ecological knowledge (TEK), particularly as expressed through Indigenous epistemologies, calls for renewed attention to its relevance in addressing environmental challenges. Engaging with knowledge systems beyond the Western scientific tradition can offer valuable insights and contribute to more inclusive and context-sensitive understandings of sustainability (Robinson, 2004). The question arises as to how these insights of epistemic pluralism could be applied in the context of reimagining transformative planning practices in urban environments.

As Escobar (2018) suggests, exploring alternative epistemic frameworks beyond the Western tradition can open up new possibilities for novel thinking. This includes engaging with relational ontologies rooted in communities that resist dominant development models – what Escobar refers to as "worlds in struggle" (p. 68). Relational ontology emphasizes the interconnectedness of all living and non-living entities, shaping understandings of existence and knowledge through relationships rather than separation. In contrast to the Western emphasis on individualism and rational thought – often framed through ideas such as "I think, therefore I am" – relational worldviews view identity as emerging from collective relations and mutual responsibilities (Chilisa, 2017). While Indigenous relational ontologies tend to prioritize holism, process orientation, and community, Western ontologies often focus on atomism, output orientation, and individual agency (Andersen & Gabel, 2023). These comparisons are informative as the contrasts are substantial. Concurrently, the interpretation of binaries is exemplary of Western ontology, in contradistinction to inclusive approaches. As Andersen and Gabel (2023, p. 66) argue, the creation of a binary separates and fixes in time and space systems that can otherwise never be separated or fixed. Among other scholars (e.g. Escobar, 2018), they advocate the recognition of ontological and epistemological pluralism.

A decolonising approach to planning brings the marginalised voices and epistemologies to the centre (Simonds & Christopher 2013; Chilisa & Tsheko, 2014). Ontological design, as referred to by Escobar (2018), facilitates ways of imagining design practices that contribute to restoring and sustaining people's agency in their territories and cultures by incorporating culturally specific practices, worldviews, and values into planning processes and solutions. In the planning process, the decolonising approach is a theoretical positioning that guides the methodologies applied to validate traditional knowledge and practices that have been accumulated over generations but are yet excluded from the discourses (Kovach, 2010; Chilisa, 2017). The integration of social and cognitive justice as a fundamental principle in the planning process requires a substantial reorientation of the prevailing rationalist and modernist cultural framework from which contemporary planning originated and within which it continues to function (Escobar, 2018).

The case study presented in this paper explores a process-oriented approach to urban planning that facilitates a platform for ontological and epistemological pluralism. By examining local knowledge practices in Kumasi, Ghana, the study aims to reveal alternative value systems for planning amid planetary crises. The case study is set in the city of Kumasi, the capital of the Ashanti Kingdom, which is one of the largest Indigenous socio-political entities in sub-Saharan Africa. The Ashanti Kingdom has maintained its authority through both British colonial rule and the post-colonial era of modern Ghana. The Asantehene, the King of the Ashanti people, along with the Asanteman Council, continues to wield significant influence over cultural, spiritual, and political life. These traditional institutions are the subject of profound respect and play a vital role in customary governance, particularly in matters related to land tenure, communal identity, and dispute resolution (Hollmén et al., 2025).

The Ashanti capital, Kumasi, was initially founded in the midst of a tropical forest and given the reputation of the Garden City of West Africa. Since then, it has undergone significant urban expansion and now accommodates approximately four million people. Despite growing developmental pressures, the city continues to reflect a dual governance structure in which customary authority and formal state institutions coexist. This duality has a significant impact on planning practices, offering opportunities for the integration of Indigenous knowledge systems into urban development frameworks. Yet, the rapid expansion of the Kumasi metropolis in recent decades has led to the encroachment of traditional villages and their absorption into the urban fabric (Quagraine, 2011). This transformation has contributed to the systematic marginalisation and erosion of traditional knowledge within the metropolitan area. The erosion of traditional knowledge signifies a gradual disconnection from the collective worldview and cultural heritage that has been accumulated over generations. Traditional ecological knowledge evolves from local context in direct contact with nature and provides solutions to local challenges while fostering a symbiotic relationship between all living and non-living (Chilisa & Tsheko, 2014; Watson, 2019). The knowledge, rooted in the local ecosystem, has been mitigating climate challenges for thousands of years and has the capacity to inform planning for climate resilience (Watson, 2019).

Indigenous knowledge systems are inherently participatory, emphasizing the central role of community engagement in shaping ethical and environmental practices. As Adom (2016) notes, such knowledge has historically provided a foundation for moral behaviour within traditional Ghanaian communities. He links the rapid decline in biodiversity to the erosion of these systems, framing environmental degradation as a fundamentally social issue. By influencing collective behavioural patterns, he argues, traditional ethics can be leveraged to address contemporary ecological challenges. Building on this perspective, the case study examines how participatory planning processes in Kumasi might incorporate Indigenous epistemologies into urban planning practice. In this manner, it seeks to conceptualise the city and its futures by exploring cultural connections that extend beyond the limitations imposed by the colonial legacy. This approach facilitates the identification of the constraints imposed by contemporary Western planning principles and provides a framework for exploring potential directions for transformative planning practices in the context of urban development.

North-South University Collaboration

In recent years, the role of North-South university collaborations has gained increasing recognition as a vital mechanism for fostering mutual understanding, advancing decolonial knowledge production, and promoting

culturally relevant research practices. The case study is set within the framework of a collaborative endeavour between Aalto University in Finland and Kwame Nkrumah University of Science & Technology (KNUST) in Kumasi, Ghana. That collaborative endeavour was initiated in 2022 within the framework of the Interplay of Cultures Studio, a master-level course organised by the World in Transition Research Lab at Aalto University (Hollmén et al., 2025). Rooted in the thematic areas of global sustainability and cultural locality, the collaboration emphasises cultural exchange and seeks to deepen awareness of local urban qualities through intensive fieldwork in Kumasi. At the core of this partnership lies a commitment to transforming traditionally hierarchical North-South relations by establishing spaces for integrating cultural knowledge with global knowledge, thereby ensuring that research outcomes remain relevant and accountable to local communities (Chilisa & Tsheko, 2014). This approach is consistent with the broader calls for co-production methodologies in university partnerships, emphasising the significance of experimentation and adaptability in engaging with local communities (Ferlicca & Pedro, 2024). Moreover, universities are gaining recognition as impartial platforms with the potential to encourage discourse, foster capacity-building, and establish partnerships that promote social justice. This positions academic collaborations as pivotal actors in the realm of transformative urban practices (Ferlicca & Pedro, 2024).

Kumasi Trees – Project of the Hearts

Since 2023, Aalto University and KNUST have been engaged in collaborative efforts in a project entitled 'Kumasi Trees – Project of the Hearts'. The project has been embraced by the Asantehene, the King of the Ashante, since its outset as a celebration of his 25-year reign in 2024. The project is founded on the principle of multistakeholder engagement, with the overarching aims of (1) introducing practices to replant trees in urban areas and re-invigorate the urban trees and greenery, and (2) securing the preservation of the trees for future generations by embedding their maintenance into the cultural habits and practices of the city dwellers and authorities alike (Hollmén et al., 2025).

The concept of the Garden City of West Africa is frequently associated with the terminology that Queen Elizabeth II employed during her visit to Kumasi in 1961. In addition, a connection has been established with the 1945 Master Plan of Kumasi, as designed by Maxwell Fry and June Drew. This plan is widely regarded as being inspired by the Garden City movement, which was developed by the British urban planner Ebenezer Howard (Quagraine, 2011). The title of the Garden City of West Africa has thus acquired a colonial connotation. Nonetheless, the designation 'Garden City' had been attributed to Kumasi for a considerable period prior to the visit by Queen Elizabeth II or the 1945 Master Plan, as evidenced by the writings of John Maxwell in 1928 (Maxwell, 1928). Moreover, a depiction of Kumasi encircled by tropical forest and featuring street trees that provide shade for the residents was already introduced at the beginning of the 19th century (Bowdich, 1819, p. 321-323). This observation, in conjunction with the historical narrative of Kumasi being established 'under a Kum tree' (the meaning of Kumasi in Twi), suggests an Indigenous concept of a Green African City, prior to the introduction of the imported associations with the Garden City movement, laden with colonial connotations. The re-establishment of this concept could facilitate the creation of a decolonising strategy for urban greening in Kumasi.

To foster long-term commitment to the care and maintenance of trees and urban greenery, the Kumasi Trees project seeks to restore and strengthen the Indigenous human-nature relationship rooted in Ashanti traditions (Adom, 2016). This is pursued through a multi-faceted, multi-stakeholder approach involving participatory activities and community engagement. Acknowledging the enduring environmental and structural impacts of colonialism is crucial, as these legacies continue to shape urban landscapes long after formal colonial rule ended (Leanui & Burgess, 2023). Such recognition creates space to imagine Indigenous futures free from colonial influence and to develop alternative concepts that can inspire more inclusive and context-sensitive urban planning. The decolonial approach employed in the Kumasi Trees project is characterised by a seamless integration of knowledge creation and action, emphasising a holistic and inclusive methodology that transcends the conventional divide between theory and practice. The participatory methodology is employed in order to ground the project in the local socio-cultural context and thereby enhance the social and environmental resilience of the area. Subsequent to this process, the project aspires to catalyse local action for enhanced environmental sustainability and social justice. The objective of the project is to illustrate a transformative planning process that

can be adapted and initiated by all levels of society within their own contexts.

Methodology

The Kumasi Trees project facilitates the integration of Western scientific knowledge systems and Indigenous knowledge systems, as well as knowledge production methodologies, within a framework that aims to decolonise research and planning processes. The decolonising model for research process proposed by Simonds and Christopher (2013, p. 2185) involves the conduct of research with Indigenous communities, placing Indigenous voices and epistemologies at the core of the research process. In the process of adapting the model to the context of urban planning, a range of qualitative and experimental methods are proposed. Eurocentric research methods and participatory action research methods have been the subject of critique on account of their exploitative nature and tendency to focus exclusively on identifying the unmet needs of communities without seeking to initiate change in the situation (Chilisa & Tseko, 2014). Furthermore, these methods are criticised for their emphasis on external solutions to challenges, thereby facilitating further colonisation of Indigenous communities (Archibald & Davidson, 2023; Chilisa & Tseko, 2014). In light of this, change-oriented approaches have been proposed that position communities as knowers, aiming to foster self-discovery through the imaginative processes of dreaming and envisioning futures – developed in dialogue with strategies for realisation and action (Chilisa & Tseko, 2014).

The ontological, epistemological, and axiological positionality of the project design has a foundational impact on the methodological choices made in the process of collecting and analysing data (Cyprian, 2023). In the context of Western scientific and academic frameworks, Indigenous knowledge systems have historically been marginalised and overlooked. Consequently, the notion of Indigenous research methodologies has only fairly recently emerged as a subject of academic discourse, particularly within the scope of participatory dialogue (Cyprian, 2023; Chilisa, 2017; Kovach, 2010). Within the discourse, the argument is posited that methodologies which are of benefit to Indigenous nations, communities, and people must be utilised, irrespective of their ontological and epistemological background. Furthermore, it is asserted that the development of an ethical research relationship is of greater importance than the manner in which data is collected. (Andersen & Gabel, 2023) In this case study, the methodological decisions are employed to facilitate the integration of marginalised knowledge systems with dominant knowledge systems through decolonising the process.

Case study: 2025 Fieldwork in Kumasi

The fieldwork, which was organised in March 2025, involved an international and multidisciplinary cohort from Aalto University and KNUST. The Aalto cohort comprised nine international master's students, two teacher/researchers, and a professor. All members of the cohort were from the fields of architecture and landscape architecture. A total of 24 participants and multidisciplinary support from seven faculty members from the fields of architecture, sociology, horticulture, Indigenous art and technology, and African studies, participated in the programme from KNUST. Moreover, the programme benefited from the assistance of the Manhyia Palace of the Asantehene, and Manhyia Palace Museum during the fieldwork.

At the inception of the 2025 fieldwork programme, the cohort was assigned a task of creating a transformative concept plan for a streetscape situated along a primary route extending from the Kumasi International Airport to Manhyia Palace. Notwithstanding the exclusive nature of the assignment, which was to enhance the aesthetic appeal of a given thoroughfare, the approach adopted was designed to emphasise inclusivity, cultural significance, and community commitment, in accordance with the principles of the Kumasi Trees project.

The 1.1 km-long streetscape, which was referred to subsequently as the Manhyia Corridor, was identified as having profound cultural significance, accommodating both commercial and residential areas, and functioning as a heavily trafficked main road that occasionally facilitates royal processions. The corridor functions as a culturally significant locale, embodying the Indigenous leadership and cultural pride within the local social context. The cultural significance provided an entry point for engaging the local small business owners and residents along the corridor in the creation of the transformative concept plan. The transformative concept plan aimed to

integrate climate adaptation initiatives with the strengthening of socio-cultural identity in the urban landscape. At the conceptual level, the Manhyia Corridor was connected to a broader strategy of urban greening, with the objective of extending green spaces to all access roads entering Kumasi, thereby creating a network of green corridors throughout the city. Nevertheless, the focus of the participants' work during the three-week fieldwork period remained on the Manhyia Corridor.

Methods

The Interplay of Cultures studio course at Aalto University commences annually in January. The preliminary phase is oriented towards deepening the understanding of the themes of the prerequisite courses for the studio, including issues of global development, decolonisation, and culturally informed architecture. The objective of this phase is to enable students to develop the conceptual tools required to identify how cultural values and assumptions are embedded within methods and theories, and to recognise the value of non-Western methods and theories (Simonds & Christopher, 2013). The re-orientation and positioning exercises continued upon arrival in Kumasi in March and upon meeting with the local peers. In the initial meetings, a series of exercises were scheduled to promote team cohesion in the context of intercultural relations, facilitating re-orientation, and establishing a shared vision. The preliminary stage of the collaborative fieldwork is of fundamental importance in establishing a shared comprehension of the project's methodology and principles, of ethical partnerships among the Aalto and KNUST participants, as well as in the context of community engagement, and ultimately, the success of the forthcoming weeks of work (Hollmén, 2018; Lenzerini, 2011; Andersen & Gabel, 2023). The participants from Aalto and KNUST were also prepared with academic research ethics, culturally appropriate research methods, and information regarding the project site.

During the site visits to the corridor leading from Manhyia to the airport, the experiences of the residents and users were examined by studying actions and interactions in their naturally occurring setting to gain a deep understanding of the locale. The physical infrastructure along the streetscape was examined by encompassing ethnographic methods, including observations, field notes and diary, photographs, videos, audio recordings, and mapping. A conversational method was employed in order to gather the experiences of 29 residents, employees, and business owners located along the street. A dialogic approach, characterised by open-ended and semi-structured questioning, was employed to encourage storytelling about participants' relationship with the living environment. The conversational interview enabled the interviewee to direct the discussion towards subjects of relevance to their perspective, thereby mitigating the interviewer's capacity to steer the narrative towards issues deemed significant from the interviewer's perspective and own worldview (Kovach 2010; Chilisa, 2017). The emphasis placed on the role of community members as the expert knowers of the local context is a key aspect of the framework, which is designed to facilitate process-oriented research activities. In this framework, community members are engaged to enhance the existing features of the living environment, rather than merely defining primary issues for external resolutions. Depending on the interviewee, the conversations were conducted in English or Twi and subsequently translated to English for further analysis. The utilisation of the native or common language facilitated the employment of terminology and proverbs that are pertinent to the local context, including native plant species, specific occasions, and intangible heritage, which would only be comprehensible to individuals who possessed the culturally specific knowledge. Therefore, the Aalto and KNUST participants were divided into small groups with the objective of fostering intercultural diversity and ensuring that each group contained at least one participant who spoke Twi. The interviews were all recorded, and the transcripts were translated into English for analysis. The possibility of losing culturally specific information during the translation phase was mitigated by having a local expert panel review and supplement the field data during the following fieldwork phase.

Subsequent to the site visits, the collected data was converted into a digital format, systematically organised, and preliminary analyses were conducted within the student groups. The student groups presented and discussed their findings with a board consisting of faculty members from Aalto and KNUST participating in the project and the curator of the Manhyia Palace Museum. The purpose of the presentations was to seek further validation of the data and to gain a deeper cultural and context-specific understanding of the site before moving

to the initial design stage. Prior to the conceptualisation of design interventions, it was fundamental to ensure that these were derived from the culture, traditions, and lived experiences of the local community. This approach was deemed essential to guarantee the relevance and utility of the proposals for the local population, as more comprehensive co-design was not feasible to be organised within the limited time frame of the three-week fieldwork. By the end of the fieldwork, the transformative concept plan of Manhyia Corridor was presented to the leadership of KNUST to seek administrative approval and further processing in the administration. While the field work in Kumasi was brought to a conclusion at this point in time, it should be noted that the project will continue to be pursued in subsequent instances.

The field data collected during the fieldwork constituted the foundation for the analysis conducted for this paper. The findings, which comprised 29 conversational interviews of residents, employees, and business owners located along the street, supported by field notes and observations, were subjected to a thematic analysis through a qualitative coding process. The grouping of the themes that emerged from the interviews into thematic categories resulted in the identification of the six main categories, which are discussed in the following section. Following this, the categories and findings will be discussed in parallel with culturally specific knowledge and global literature.

Results

1. Indigenous Leadership as the embodiment of the culture

"You see, when you come to the Ashanti region, it is a place of culture and Manhyia Palace is the culture itself." Interviewee 7, a local employee

"I believe that when the King gives an order asking people to make sure their animals do not become a threat to the success of the project, the people will obey." Interviewee 2, a local business owner

"Because dignitaries use the Dichemso route, planting trees along the road will provide a beautiful scenery. And will restore Kumasi's reputation as the Garden City." Interviewee 23, a local resident

The interview data revealed a strong connection between Indigenous leadership and a deep sense of cultural pride and dignity within the community. Unlike elected political governance, Indigenous leadership was perceived as less subject to public scrutiny, suggesting a different form of legitimacy rooted in tradition and cultural continuity. In this context, hierarchical structures based on top-down authority appeared inapplicable, with leadership viewed instead as relational and embedded in communal values. In conceptualising alternative futures devoid of colonial influence, the significance of Indigenous leadership remains paramount. Moreover, the shared sense of cultural pride and unity identified through the interviews offers a valuable entry point for fostering community engagement and long-term commitment. Such engagement supports the cultivation of cultural integrity, which is essential for context-appropriate urban development.

2. Abandonment of traditions due to urbanisation

"Yes, they have some rivers in the forest in which they pour libations, and that is why the forests have been so well preserved." Interviewee 7, a local employee

"As you can see the neem tree over there people come and cut it to treat malaria. These trees have some hidden medicinal purposes that is unknown to us as of now." Interviewee 15, a local resident

"The city has become so busy that people don't even pay attention to them [trees]." Interviewee 1, a local business owner

The interview data revealed that urbanisation has impacted many traditional practices and partially lead to the abandonment of traditional practices, knowledge, and epistemics in urban settings. A minority of respondents identified customs that they considered to be covered by traditional knowledge. However, the majority of

respondents indicated that traditional knowledge existed but was ignored. In this regard, the most frequently cited subjects among respondents focused on spirituality and nature. Such practices are indicative of an acknowledgement of spiritual values, including the tradition of having a designated day of the week on which to refrain from entering the forest, and the utilisation of traditional medicine. However, the responses also revealed a disconnection from the natural environment and an unfamiliarity with a holistic understanding of natural processes. The two natural areas within the designated planning area are physically separated from the surrounding environment by high walls, the primary purpose of which is to restrict interaction with the natural area. The walls were referred to as a source of security, as the wooded areas were perceived as dangerous due to the encroachments that had taken place there during the past few years. Secondly, they also function as a preventative measure against the informal spread of business into the area. One interviewee cited a phenomenon that has also been observed in other parts of the city, wherein natural areas are regarded as undeveloped land that could be utilised for urban development purposes.

3. Cleaning up the beauty of the Garden City

"About 20 years ago, when I was young, when we were talking about Kumasi. It was quite a garden city, because it was one of the cleaner cities in Ghana." Interviewee 7, a local employee

"In some places of the city they can claim the title 'The Garden City', but not even the road where the King passes can claim that title." Interviewee 2, a local business owner

The most distinctive feature of the field work site is the pollution of the soil and water bodies, a phenomenon that is also prevalent in much of the city of Kumasi. In the responses to the interviews, littering and environmental pollution were associated with a lack of collective concern and a rejection of traditional practices. The responses further emphasised the correlation between the concept of cleanliness and the beautification of the environment, as well as the perception of the Garden City.

The high volume of waste was also linked to the flooding issues along the streetscape, as the accumulation of refuse in the gutters resulted in overflow of water and waste materials onto the street level. In certain interviews, the construction of a bridge was proposed as a solution to the challenges posed by flooding. The restoration of the natural environment to serve as a non-polluted, flood-prone zone was a consideration in one interview. In accordance with this observation, the interviews revealed that the presence of fallen leaves on the ground was perceived as a stress-inducing factor. This perception has resulted in the decision to remove trees in close proximity to private residences or commercial establishments. These two cases demonstrate a dissociation from natural processes and a tendency to adopt modern urban solutions that prioritise the separation of humans from nature.

4. Urban space as a facilitator of cultural connectivity

"Cultural parks where the children could go and talk to the elders would be useful. The elders would be able to educate them and tell narratives and stories about the culture. - - This would be useful for the parents who are busy at work." Interviewee 3, a local business owner

"It would be good to have intergenerational parks with artworks that depict the Ashante culture. I believe this will help children to learn the culture as well." Interviewee 2, a local business owner

"Green signifies hope, and I am willing to give hope to my community." Interviewee 23, a local resident

The interviews revealed a disconnection within the cultural continuum, raising concerns about the transmission of cultural knowledge to younger generations. In the course of dialogues concerning aspirations for the urban environment, respondents emphasised a framework for the transmission of cultural knowledge through oral tradition between generations. Furthermore, the presence of Ashanti cultural symbols, such as adinkra, in the street scene to spread cultural awareness and create a sense of community was considered important. In addi-

tion to the utilisation of symbols, dance, and movement were identified as significant modes of communication.

5. Urban services for contemporary needs

"I'd love to see trees, but as a businessman, I'm concerned they could affect my business. If the trees are too big or planted too closely together, it could reduce parking space for buyers with cars. I suggest considering this carefully and providing additional lighting too." Interviewee 9, a local business owner

"The problem will be cattle destroying the plants. So, until we solve that issue, plants will hardly survive." Interviewee 3, a local business owner

"Beyond the environmental solutions, the park will provide jobs for the people and revenue for the government. So, I am in full support." Interviewee 10, a local employee

The interview data demonstrated an emphasis on both traditions and cultural practices, as well as modern needs and practicalities. The long distances to parks and other amenities were perceived as challenging in terms of transportation as well as in establishing social connections. Parks were regarded as providing opportunities for households to send their children to learn and spend time in a safe environment while attending to work. A further requirement for urban services identified was for enhanced security measures in the area, with particular reference to street lighting and pedestrian crossings. In addition, there was a need for improvements to public waste management services. In order to ensure the preservation of vegetation, the necessity to implement sheltering structures to protect against the presence of cattle and goats in the street was also discussed.

The primary issue concerning the vegetation is the limited space available for planting and the maintenance of the trees. The interviews revealed a concern regarding the spatial demands of trees, which were considered to be encroaching upon the already confined street layout. This was a particularly pressing concern for small business owners and employees, who expressed apprehension that the trees would compromise their visibility for potential customers or existing parking spaces near their premises. The intense competition to attract customers and the visibility of the formal and informal businesses along the main road have motivated the business owners to place the items for sale on the street for customers to see. During the discussions, there was a certain degree of hesitancy regarding the prospect of sharing the space with a tree; however, this hesitancy was mitigated by the consideration of potential benefits, such as shade, that the tree could offer to the business. The primary concern expressed in the interviews was the potential impact on livelihoods. This was accompanied by a complementary discourse centring on the prospective employment opportunities associated with urban green spaces.

6. A maintenance strategy based on reciprocity

"We care less, because it is not my property. But we have to care about our environment, because if there are any sicknesses, any diseases, we will catch them." Interviewee 7, a local employee

"The previous tree planters did not educate us on what to do. They just planted and left it. I think you should educate us on what to do. Whether we should water it or you will do the watering." Interviewee 12, a local employee

"I'm concerned with maintenance issues. If there should be trees, the community should be engaged to take care of them, they should have a sense of ownership. This would happen by making them feel like they are part of the project or maybe employ them." Interviewee 1, a local business owner

"We used to have a Town Council, 'Tankas', responsible for cleaning gutters and the environment, but that no longer exists." Interviewee 7, a local employee

The subject of previous tree-planting efforts along the road was a recurrent theme in the interviews. The inadequate maintenance and oversight that followed the previous planting initiative by the party responsible for planting the seedlings have resulted in several factors contributing to the mortality of the seedlings. These

factors include dehydration, consumption by goats and cattle herded along the road, and removal by local residents. The discussions revealed a consensus among the local business owners and residents that the most effective strategy for ensuring the success of a tree-planting initiative is to engage or employ community members to take care of the trees. Upon questioning, the majority emphasised their commitment to take care of the trees planted in front of their businesses or accommodations, if they were engaged in the project during the planning stage and received sufficient instructions for doing so. The analysis revealed that the primary concern expressed by respondents was related to the prospect of eviction and subsequent exclusion from the project, suggesting a potential link between these concerns and the reluctance to participate in tree-planting initiatives.

In conclusion, the interview data revealed that the profound link between Indigenous leadership and cultural identity provides an entry point for community engagement in Kumasi, particularly in relation to stimulating cultural connectivity in urban greening initiatives. The deterioration of cultural connectivity and identity is perceived to be due to urbanisation and the urban lifestyle. However, the interview data also show a sense of pride and commitment to strengthening cultural identity. The setting has the potential to facilitate an urban transformation that is deeply rooted in cultural heritage and traditional knowledge. This transformation would respond to the contemporary needs of residents as part of the urban ecosystem and would envision an Indigenous future disconnected from colonial associations. Thus, it cultivates social and spatial justice while restoring the regenerative relationship between humans and nature.

Discussion

Decolonial Strategy for Urban Greening in Kumasi

The historical encounters with the forthcoming colonial ruler, dating back to the 19th century, have had a significant impact on the urban landscape of Kumasi. The colonial administration has leveraged the built environment to demonstrate and maintain its dominance, both physically and psychologically (Yeboah, 2019). The destruction and reconstruction of urban and rural communities in accordance with imperial principles has resulted in the loss of traditional building expertise (Swithenback, 1969), thereby contributing to the discontinuity in the transmission of traditional knowledge. As demonstrated in the results of interviews and observations conducted in the field, the most prominent contradiction with the Indigenous epistemology is the evident absence of symbiotic coexistence with nature. In the field study site, the evidence of this is apparent in the extractive consumption of natural resources, the pollution of the environment, the separation of the natural environment from the human, and the incapacity to perceive the functioning of the ecosystem and the effects of one's own actions as part of the complex system. Yeboah (2019) observes that, in the colonial era, urban and land use planning was primarily oriented towards the economic benefits of the colonial power. Moreover, since the colonial power presented itself as the owner of the land, it was able to instigate invasions on terms of its choosing (Yeboah, 2019). This may have contributed to the erosion of the sense of ownership and connection to the territory felt by local communities. Furthermore, it has resulted in a legacy of overlapping land-use planning structures and exploitative practices in Kumasi.

The objective of the case study is to illustrate how urban planning can function as a decolonising and transformative action that is reflective, restorative, and regenerative. Such action would be characterised by its deep roots in heritage, its strategic leverage of existing resources, and its imaginative vision for unique futures that promote environmental and social justice. This shift in approach, from owners of the land to stewards, necessitates a re-evaluation of the metanarrative that constructs the planning principles and structures. As Salami (2014) notes, to facilitate a change in structure, it is necessary to first alter the existing narrative around that structure. Salami (2014) continues to elaborate that unethical knowledge production only results in the generation of unethical knowledge. In the urban planning context, the exclusion of the voices of Indigenous communities will further marginalise communities through biased practices (Simonds & Christopher, 2013). Planning, when approached as a process-oriented action, has the capacity to employ methodologies that are suitable in the local context. Such methodologies contribute to restoring and sustaining people's sense of agency in their territories and cultures. This is achieved by incorporating culturally specific practices, worldviews, and values into planning

processes and solutions (Escobar, 2018).

The city of Kumasi has an ontological essence that has been shaped by its location in a fertile region surrounded by tropical forest. The landscape was once dominated by large trees, which created a canopy over the city. The notion of a subsequent Garden City is arguably conceptually misguided, as in a Western context, a garden is generally perceived as a constructed and sustained environment, a subordinate to human action. However, in the case of Kumasi, it can be argued that vegetation was an inherent feature of the environment from the outset. This paper outlines a decolonial strategy to urban greening in Kumasi that moves beyond Western epistemics and aims to restore its glamour as a Green African City that stems from the local ecosystem and forms the foundation for traditional knowledge and practices. As previously outlined, the application of traditional ecological knowledge has been instrumental in informing the design of climate-resilient systems for multiple generations (Watson, 2019). Despite being largely overlooked and ignored, it is crucial that the potential is re-evaluated in terms of restoring more symbiotic coexistence with nature, as traditional knowledge has the capacity to evolve with time and adapt to shifting circumstances (Adom, 2016). In light of the contemporary planetary crises, which manifest across all geographical locations, this represents a shared responsibility for universal engagement with local solutions that respond to local context-specific challenges.

As posited by Maldonado-Torres (2016), the decolonial movement is distinguished by a holistic integration of knowledge and action. A decolonial and transformative planning cannot be considered the responsibility of a single individual or entity; rather, it may involve a dynamic interaction between organised communities, social movements, academic institutions, and governmental authorities. This interactive process enables overcoming the dichotomy of bottom-up (autonomy) versus top-down (institutionalisation) and moves towards an understanding of a co-produced urban process as described by Ferlicca & Pedro (2024). This approach to planning is characterised by a process-oriented and change-focused methodology, informed by existing capacities, identities, value systems, and practices in a culturally specific manner. The framework has the capacity to facilitate the revitalisation, restoration, and protection of valued entities and to establish more meaningful connections with other relevant systems (Chilisa, 2017). As Chilisa (2017) asserts, this approach aims to restore dignity and integrity that have been compromised by colonial practices.

In the context of planetary crises, embracing epistemic pluralism is not only an ethical imperative but also a practical one. By foregrounding Indigenous knowledge systems as legitimate sources of planning knowledge - rather than marginal ones - the planning field can begin to dismantle fixed epistemic hierarchies and open itself up to alternative urban futures. As Chilisa (2017) reminds us, methodologies grounded in African knowledge systems can decolonise sustainability science and recalibrate global knowledge relations. In this light, Western planning traditions must approach non-Western urbanisms with humility and curiosity, ready to learn from ways of knowing that challenge dominant assumptions and expand the repertoire of planetary planning possibilities (Robinson, 2004).

Conclusions

This paper has explored how Western-centric knowledge systems in urban planning often marginalise Indigenous epistemologies, reinforcing unjust and extractive practices. Utilising Kumasi as a case study, the research underscored the significance of process-oriented planning founded on epistemic pluralism as a decolonising approach. The findings of the fieldwork conducted in this area demonstrate a considerable erosion of cultural identity and connectivity, which appear to be largely attributable to rapid urbanisation. This transformation has had detrimental effects on the environment and Indigenous knowledge systems alike, which are deeply embedded, place-based forms of knowledge developed in intimate relation with local ecosystems. Despite their marginalisation, these systems offer valuable insights for climate-adaptive planning by providing contextually relevant, socio-culturally attuned solutions. The analysis emphasises the significance of acknowledging planning as a practice that is inherently embedded within and driven by cultural values. The adoption of this alternative approach to urban planning has the potential to create opportunities for transformative action. It facilitates the incorporation of existing socio-cultural structures, addresses local needs, fosters individual and collective

agency, and challenges prevailing colonial structures. Acknowledging the complexities of multi-stakeholder engagement, the study also sheds light on the challenges associated with incorporating diverse epistemologies into mainstream planning processes. Nevertheless, it asserts the critical need for future planning efforts to consciously reflect on the epistemic frameworks that guide methodological choices. The continued exclusion of non-Western ways of knowing risks reinforcing systemic biases and further marginalising already vulnerable communities. This, in turn, further diminishes the shared ownership and exacerbates the environmental destruction of urban areas, thus weakening the liveability of cities. In conclusion, it can be posited that the incorporation of principles inherent to Indigenous knowledge systems – such as process orientation, holism, and collectivism – can catalyse genuinely transformative planning processes. These approaches have the potential to initiate locally grounded action, strengthen community ownership, promote spatial justice, and inspire ecologically regenerative practices. The establishment of a decolonised planning framework that values epistemic diversity is both possible and essential for the fostering of equitable and sustainable urban futures.

Contributors
The Kumasi Trees Project is a multistakeholder strategy for re-greening the city of Kumasi. In addition to the authors, the Kumasi Trees framework has been co-created by an interdisciplinary team of academics, with vital and substantial contributions from University Teacher Taru Niskanen from Aalto University and Professor Daniel Duah, Dr. Alexander Marful, Dr. Irene Idun, and Professor Esmeranda Manful from Kwame Nkrumah University of Science & Technology (KNUST).

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Special Session 9

Accounting beyond boundaries: Exploring consumption-based carbon approaches in Paris and Gothenburg

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Abstract
This article examines how Paris and Gothenburg have integrated Consumption-Based Carbon Accounting (CBCA) into local climate governance. As cities increasingly confront emissions beyond their borders, CBCA offers a framework to address the carbon impacts of urban consumption. Through a comparative qualitative case study, the research identifies 16 enabling conditions for CBCA implementation, organized into four themes: (1) data transparency and accessibility, (2) institutional and technical capacity, (3) political legitimacy and stakeholder engagement, and (4) multi-level and cross-sectoral support. The findings reveal how different governance models - Paris's institutionalized approach and Gothenburg's pioneering model - can both foster CBCA adoption. This study contributes to understanding the political, institutional, and participatory dynamics that enable cities to engage meaningfully with consumption-based emissions.

Keywords: Consumption-based carbon accounting; Carbon neutrality; Climate governance

1. Introduction

As cities around the world increasingly commit to achieving carbon neutrality, they rely on greenhouse gas (GHG) inventories to assess their emissions and guide climate action. These inventories are typically structured around internationally recognized frameworks, such as the Global Protocol for Community-Sc ale Greenhouse Gas Emission Inventories (GPC)[1], that primarily rely on a production-based carbon accounting (PBCA) methodology (Harris et al., 2020). However, a growing body of academic literature and policy discourse has highlighted the limitations of PBCA, arguing that it captures only a partial representation of urban emissions (Balouktsi, 2020; Millward-Hopkins et al., 2017; Pellan et al., 2024). In particular, PBCA overlooks the substantial carbon footprint embedded in goods and services consumed by urban populations but produced outside city boundaries. On the contrary, consumption-based carbon accounting (CBCA) estimates the life-cycle emissions of goods and services consumed within a city's boundaries, regardless of where those emissions occur geographically offering a more comprehensive and equitable framework for addressing urban GHG emissions, incentivizing the adoption of policies that promote less carbon-intensive consumption (Grasso, 2016; Lombardi et al., 2017). The claim for the switch towards a more CBCA-focus framework is especially relevant in high-income cities in Europe and North America, where local production-based emissions have declined due to deindustrialization, while consumption-based emissions continue (Millward-Hopkins et al., 2017).

Despite its appeal, the implementation of CBCA remains limited and uneven. Most existing research focuses on methodological and technical challenges (i.e., data availability, input-output modeling), while the political and governance dimensions are mostly studied at the national level. Therefore, the governance dimensions of CBCA at the city level remain largely underexplored, particularly with regard to the political, institutional, and organizational conditions that enable its operationalization within local governments.

This article seeks to address this gap by asking the following research question:
What are the governance conditions that enable cities to implement consumption-based carbon accounting and associated policies to reduce emissions?

To answer this question, the article conducts a comparative case study of two European frontrunner cities – Paris and Gothenburg - which have formally adopted CBCA approaches and integrated consumption-based targets

1 Global Protocol for Community-Scale Greenhouse Gas Inventories: https://ghgprotocol.org/ghg-protocol-cities

into their climate strategies. By analyzing these two cases, the study identifies key enabling governance conditions, ranging from data systems and institutional capacity to political leadership and stakeholder engagement.

The article is structured as follows. Section 2 reviews the terminology and key concepts. Section 3 outlines the methodological approach, including the case selection and analytical framework. Section 4 presents the empirical findings, identifying five thematic clusters of governance enablers. Finally, Section 5 discusses the broader implications of the findings for climate governance and outlines directions for future research.

2. Definition and key concepts

It is essential to define the key terms used throughout this study, as terminology in the field of urban carbon accounting is often used interchangeably or inconsistently.

Most GHG reporting frameworks currently focus on territorial or production-based emissions (Harris et al., 2020). PCBA is a method for quantifying GHG emissions that attributes all emissions to the country, region, or organization where the emissions physically occur during the production of goods and services (Franzen & Mader, 2018). At city level, these emissions largely correspond to Scope 1 of the GPC – meaning emissions from industrial activity, transportation, energy use in buildings, and waste management (Balouktsi, 2020; Fan & Guan, 2025). However, PBCA overlooks the embodied emissions in imported goods and services, which can be considerable, particularly in high-consumption urban contexts with limited local production.

In contrast, CBCA allocates emissions to the final consumers of goods and services, regardless of where in the world those emissions occur along the supply chain. This approach accounts for all emissions generated throughout the supply chain, including production, transportation, and distribution (Volden, 2018). It closely aligns with what is considered Scope 2 and Scope 3 emissions under the GPC framework.

The GPC categorizes emissions as follows:

- Scope 1: Direct emissions from sources located within the city boundary (e.g., local transport, buildings, industry).
- Scope 2: Indirect emissions from the consumption of grid-supplied electricity, heat, steam, and cooling within the city.
- Scope 3: Other indirect emissions that occur outside the city boundary as a result of activities within the city

While Scope 3 provides the most comprehensive perspective on urban emissions, it remains largely optional and is often excluded from official city-level inventories or only partially addressed. As a result, most cities continue to focus on reducing production-based emissions, leaving a significant portion of their carbon footprint unaccounted for (Millward-Hopkins et al., 2017). This gap has crucial implications for the effectiveness of urban climate strategies, particularly in "consumer cities" such as those in Europe, where a significant share of emissions stems from imported goods and service (Harris et al., 2020). Furthermore, it is argued that integrating consumption-based accounting, and particularly Scope 3 emissions, into local governance is critical for developing more effective and equitable climate mitigation strategies. A full accounting of urban emissions - beyond territorial boundaries - enables better-targeted policies that reflect the real carbon emissions drivers in service-oriented urban economies.

To explore this shift, the article focuses on the governance conditions necessary to support the integration of CBCA into city-level climate policy. Governance here is understood in a broad sense, encompassing formal and informal norms, procedures, institutions, and instruments that structure decision-making and implementation processes (Grasso, 2016). As Grasso underlined in his study on the political feasibility of CBCA, governance mechanisms for consumption-based accounting may not yet be fully established or even conceptualized. In this study, governance will be analyzed as a multidimensional framework - including policies, institutional structures, political will, and administrative practices - that can either enable or hinder the implementation of CBCA.

3. Study framework

This study draws upon data originally collected in a broader comparative research project that analyzed the barriers to implementing consumption-based carbon accounting (CBCA) in 17 European cities. These cities were purposefully selected to ensure diversity in terms of geographical location, size, and climate policy maturity. Within this wider research effort, certain cities stood out as exemplary cases in integrating CBCA into their local climate governance frameworks. Among them, Paris and Gothenburg were identified as particularly progressive to advance CBCA and have been chosen for a more in-depth comparative study case study on the governance conditions. Drawing from the main study, the authors formulated a set of hypotheses regarding the political, institutional, and technical enablers necessary for successful CBCA integration. These hypotheses guided the subsequent research design and data analysis strategy.

3.1 Main hypotheses

Two principal hypotheses shaped the analytical framework of this study. The primary hypothesis argues that the successful implementation of CBCA at the city level is contingent upon a combination of enabling governance conditions. These include high institutional capacity, strong data transparency, stakeholder legitimacy, and effective multi-level coordination. The second hypothesis states that the successful implementation of CBCA at the city level is contingent upon a combination of enabling governance conditions. These include high institutional capacity, strong data transparency, stakeholder legitimacy, and effective multi-level coordination.

Each of these hypotheses is underpinned by theoretical and empirical insights from climate governance literature and were broken down into more specific analytical categories, as described below.

High institutional capacity

It is anticipated that cities advancing CBCA possess robust institutional capacity. This includes not only administrative competence and specialized staff, but also financial resources sufficient to develop and sustain complex policy instruments such as CBCA.

Data availability and transparency

An expected key enabling factor is the presence of mechanisms to gather, estimate, and communicate consumption-based emissions data. This may involve standardized methodologies, collaboration with national statistical agencies or academic institutions, and innovative approaches to address data gaps. Moreover, transparency in how data are collected and what they represent is considered essential for credibility and stakeholder engagement.

Political legitimacy

Successful implementation is also linked to the legitimacy of CBCA within the local governance ecosystem. Two factors are anticipated to support legitimacy, measurable targets and the active engagement of both internal and external stakeholders in shaping and delivering on the policy objectives.

Multi-level coordination and stakeholder engagement

Effective coordination across governance levels; horizontal (within municipal departments), vertical (with regional or national authorities), and cross-sectoral (with businesses and civil society), is assumed to be a central enabler. The engagement of diverse stakeholders is also crucial to reinforcing legitimacy and ensuring long-term policy durability.

3.2 Research design

From the broader dataset of 17 European city case studies, Paris and Gothenburg were selected for deeper qualitative analysis. The selection was guided by their advanced engagement with CBCA defined here as going beyond compliance with national or EU mandates. Another selection criterion was for the city to have a consumption-based emissions reduction goal that does not only encompass organizational emissions (i.e., from the municipality) but also include city-wide emissions in their climate targets.

Semi-structured interviews were conducted with key stakeholders involved in the climate governance of each city. Interviewees were initially identified through the NetZeroCities (NZC) platform and selected based on their role and knowledge of CBCA implementation. Complementary to the interviews, documentary analysis was conducted on municipal climate action plans, technical reports, and official data-sharing agreements. During the initial research, a codebook was developed. As this research was exploratory, an inductive coding approach was preferred to discover unexpected themes and patterns and limit researcher bias. These codes were then refined through an iterative validation process involving a second researcher, ensuring inter-coder reliability and interpretative coherence.

From the results of the coding of the main research data, an initial focus was placed on the codes that reflected governance enablers. This preliminary review made it possible to identify recurring patterns and key governance conditions necessary for the implementation of consumption-based carbon accounting (CBCA). These conditions form the analytical framework presented in the results section. Subsequently, a comparative analysis was conducted by reviewing all codes linked specifically to the interviews from Paris and Gothenburg. This step aims to identify the concrete governance mechanisms present in these two cities, which are considered frontrunners in CBCA. Additional patterns that complemented the initial findings were identified through this city-specific review. Finally, a close re-examination of the interview transcripts for both cities was carried out to validate and deepen the analysis of the governance conditions that have facilitated progress on CBCA at the local level.

Table 1: Summary of Interviews Conducted in Paris and Gothenburg

City	Date	Duration
Paris	19-07-2024	45:58
Gothenburg	07-08-2024	53:28

The transcription of the interviews conducted in Paris and Gothenburg serve as the primary empirical basis for this study and directly inform the analysis of governance conditions for implementing consumption-based carbon accounting (CBCA). In addition to the interviews, several key documents provided by the municipalities were analyzed, including, the Paris Climate City Contract (CCC), the Paris Climate Action Plam, the Gothenburg CCC. Further desk research was also conducted to clarify specific aspects of local governance and policy context not directly covered in the interviews or official documents.

It is worth noting that, throughout the research process, the terms consumption-based carbon accounting (CBCA) and Scope 3 emissions were frequently used interchangeably by stakeholders. While technically distinct, in this context they were often treated as synonymous in practice and discourse.

3.3 Paris and Gothenburg case studies

Paris and Gothenburg were selected as case studies due to their advanced commitments to climate action, particularly regarding the integration of consumption-based carbon accounting (CBCA) into their urban climate strategies.

Table 2: Key Climate Commitments of Paris and Gothenburg

City	Covenant of Mayors adhesion	Date of CCC publication	Consumption based objectives
Paris	2008	2024	Achieve carbon neutrality, including consumption-based emissions, by 2050
Gothenburg	2009	2024	Reduce per capita consumption-based emissions to 1.9 tCO_2e by 2050

Paris emerged early in the research as a leading example, having set an ambitious carbon neutrality target that explicitly includes Scope 3 emissions. Its 2018 Climate Action Plan and subsequent strategies reflect a compre-

hensive approach, integrating both territorial and consumption-based emissions into its monitoring and objectives. As stated in the Plan:

"Through the Climate Plan, the City of Paris has set an ambitious objective to reduce its carbon footprint by 80%. In this way, it is going beyond the legal requirements by integrating indirect emissions that come mainly from aviation, the production of goods, and the food consumed in Paris. To attain this target, the City of Paris plans to encourage the aviation and food industries in particular to make their practices more sustainable" (p.92)

Gothenburg also represents a strong case, albeit with a slightly less integrated approach than Paris. Nevertheless, it has set clear and measurable targets for reducing consumption-based emissions. The city aims to lower per capita consumption-based emissions to 3.3 tonnes by 2030, 3.5 tonnes by 2035, and 1.9 tonnes by 2050. These goals encompass all goods and services consumed by residents, regardless of where the emissions occur, and imply an annual reduction of approximately 7.6%.

4. Results

4.1 Initial Coding Results

The initial coding process based on the original codebook revealed several recurring governance conditions that enable the implementation of Consumption-Based Carbon Accounting (CBCA). This led to the identification of 16 enabling conditions, organized across four overarching themes: (1) Data transparency and accessibility, (2) Institutional and technical capacity, (3) Political legitimacy and stakeholder engagement, and (4) multi-level and cross-sectoral support. These enabling conditions are presented in the framework below:

Table 3: Enabling Governance Conditions for CBCA Implementation

Themes	Enabling Conditions	Explanation
Data transparency and accessibility	Standardized process	The city has established procedures for collecting and/or analyzing consumption-based emissions data
	Innovation	The city uses alternative data collection approaches where direct data is missing
	Data agreements	The municipality has institutional arrangements with external actors (e.g., private companies, agencies) for data sharing
	Open access	When working with an external stakeholder to collect the data, the city has access to the datasets and methodologies used
Institutional and technical capacity	Dedicated expertise	The municipality has in-house staff or department with expertise in CBCA
	Human and financial resources	The department in charge of the carbon accounting has sufficient technical, administrative, and financial resources
	Strategic cross-departmental collaboration	All relevant departments are being included in CBCA implementation
Political legitimacy and stakeholders' engagement	Strong political mandate	The political commitment goes beyond minimal compliance, supporting ambitious CBCA targets
	Clear communication	There are active efforts to explain CBCA logic and relevance to stakeholders
	Historic commitment	The city has a long-standing engagement in climate action
	City wide and multi-sectoral targets	The consumption-based emissions targets address a broad range of emission sources within the scope of the entire city
	Stakeholders' inclusion	The municipal strategy plans for the engagement of external actors (e.g., citizens, business)

	Clear framing of the objective	A numerical objective with a timeframe is set out from the reduction of consumption-based emissions. This objective is written in the Climate Plan.
Multi-level and cross-sectoral support	National level support	The national ecosystem is favourable of the implementation of CBCA
	Horizontal coordination	Formal agreements are being signed with other public or private organisations allows to enlarge the scope of committed actors

The following sections detail how each theme is manifested in the case studies of Paris and Gothenburg, with insights triangulated through case analysis and complementary data sources.

4.2 Data transparency and accessibility

Four factors have been identified as enabling conditions for CBCA implementation: (1) Standardized data collection and analysis, (2) Use of innovative methods to fill data gaps, (3) Existence of formal data-sharing agreements, (4) Open access and transparency in data communication.

Standardized data collection and analysis processes

A standardized data collection and analysis process appeared essential to strengthen the legitimacy of the accounting process. One the one hand, Paris utilizes the nationally standardized Bilan Carbone methodology developed by ADEME[2], ensuring consistency across French cities and reinforcing data legitimacy. The city also relies on INSEE[3] for robust demographic and economic statistics critical to emissions estimation, especially for sectors like food. Paris estimates average daily meal consumption based on residential and commuting populations to approximate food-related emissions. As expressed in the interviews, the existence of national level process allows to strengthen the legitimacy: *"It's good to have in France this "Bilan Carbone" methodology, because then every city would use the same rate for emissions. So, it gives more legitimacy as well for these figures."*

Gothenburg, while lacking standardized local systems, leverages data provided by the Stockholm Environment Institute (SEI), which, for all cities in Sweden, broke down national data to postal code areas, using market segmentation and local adjustments. However, Gothenburg notes this approach is externalized and lacks sufficient clarity. They also work with a state-sponsored research institute to calculate the impact of food consumption. Therefore, Gothenburg relies on externalized processes, carried on by research institutions, and unified at a national level.

Innovative Approaches

Paris uses innovative methods for categories with data gaps. For example, freight emissions are estimated through regional surveys and applying proportional calculations to allocate emissions to the city. The city also calculates material usage based on construction waste data: *"We do the math from the waste to upstream, because we don't know the amount of materials purchased. So we estimate it from construction waste."*

Gothenburg began with a bottom-up approach in 2008, assessing household consumption categories using available data, despite its fragmented nature. As exposed in the interview: "*We used like more of a bottom up approach that we looked at on various consumption categories and which day-to-day had available and tried to see how difficult the households in Gothenburg consumed and what the emissions were from the different groups*". Nowadays, this work still complements SEI's data.

Formal data-sharing agreements

These data sharing agreements appear to be particularly done with the air travel industry. Paris has a formal

2 ADEME (Agence de l'environnment et de la maîtrise de l'énergie) : French Environment and Energy Management Agency

3 INSEE: French National Institute of Statistics and Economic Studies

agreement with Aéroports de Paris (ADP), providing free annual data on air travel by Parisians, including departure and arrival information. On the other hand, Gothenburg previously received local air travel data from the airport, but this was discontinued due to political sensitivities, highlighting the fragility of this type of voluntary agreement.

Open access and transparency
In the case of Paris, getting the data from national institutions guarantees the transparency of the processes and access to the data sets. However, Gothenburg, while benefiting from SEI's mapping tools, notes that the opacity of the underlying model makes it hard to explain variations between areas, illustrating a trade-off between using relying on an external stakeholder and transparency; *"It's a little bit of a black box. It's a bit difficult to explain why some areas are higher in emissions and some are not"*,

4.3 Institutional and technical capacity
The institutional and technical capacity depends on 3 enabling factors: (1) Dedicated expertise within the municipality, (2) Human and financial resources, (3) Cross-departmental collaboration.

Dedicated expertise within the municipality
Paris also works with the Association Bilan Carbone (ABC) association, a national organization that trains professionals on carbon inventories and methodologies, ensuring the upskill process in French municipalities. Furthermore, the city also created a Department for Ecological Transition and Climate in 2022 to oversee its Climate Action Plan. This department monitors actions across administrative departments, conducts greenhouse gas emissions assessments. Gothenburg has a small, dedicated team, with one or two people focusing specifically on carbon accounting, led by a climate strategist responsible for monitoring emissions. *"We have people working with the carbon accounting, but it's not a big team. It's one or two people that are really working with this in detail."*

Cross-departmental collaboration
Both cities are involving a large number of departments into the strategy to reduce consumption-based emissions. **Paris** promotes shared responsibility by involving various departments and external partners. Carbon accounting data is shared internally to build awareness and ownership: "We try to involve all the stakeholders of the municipality. So we have different ways to raise awareness and to discuss with them". **Gothenburg** collaborates with departments like transport and procurement, though it acknowledges that challenges remain: "There is some collaboration with the transport department and with the procurement department, because their decisions have a big impact on emissions." The CBCA strategy is embedded in the normal environmental governance in Gothenburg: *"The City's climate goals are deeply embedded in its ordinary governance structures, notably outlined in the Environmental and Climate Program, backed by a broad political consensus. Central to this program is the aim for near-zero emissions, driving action across all municipal administrations"*.

4.4 Political legitimacy and stakeholders' engagement
Seven enabling conditions emerged: (1) Strong political mandate, (2) Clear communication, (3) Historic climate commitment, (4) City-wide, cross-sectoral scope, (5) Inclusion of external stakeholders, (6) Legitimacy through leadership and continuity.

Strong political mandate
Both cities have a strong political support that goes beyond the mandatory obligations in terms of climate engagements, as highlighted in the interview: "We have a very ambitious climate plan, and the mayor is very committed to including all emissions, not just the ones happening inside the city." Indeed, Paris's commitment to carbon neutrality by 2050 includes scope 3 emissions. The interviewees also highlighted the role of the COP21 Conference in Paris, and the mayor's leadership as a formal president of the C40 network, as key factors explaining Paris high-level commitment.

Gothenburg has robust, cross-party political support for its 2030 goal of near-zero carbon footprint, targeting both territorial and consumption-based emissions. *"The City's climate goal for 2030, 'a carbon footprint close to zero,' has robust support from a broad political majority, and is particularly highlighted by The Environment and Climate Programme for the City of Gothenburg 2021-2030."* However, as underlined by the interviewee, it might be more complicated to get a political consensus about the methods to adopt to reach the emissions reduction objectives: " *It was quite universal support for these kind of goals, and there have been some discussions when it comes to like individual choices when it comes to like food or what politicians should not do when it comes to emissions related to citizens. But the goals in themselves and not so much discussion".*

In both cases, the cities are pushed by what could be called a moral obligation, as expressed by Gothenburg in the following quote: "We thought we also have an obligation to see how we affect the other parts of the world through our consumption".

Clear communication
Paris actively communicates the importance and methodology of CBCA to stakeholders, both inside and outside the municipality, to foster understanding and engagement:
"We explain to them that it's not just about the emissions from buildings or transport in Paris, but also about what we consume, like food, clothing, and electronics."
"We have meetings and workshops to explain the logic of including consumption-based emissions and why it's important for the city's climate goals." Gothenburg supports public participation, but less detail is available regarding structured communication campaigns.

Historic commitment:
The fact that both cities have been leading on climate action and consider as "champion" is perceived as a clear enabler, pushing cities to further extend their actions towards Scope 3 emissions. Paris has demonstrated a long-standing commitment to greenhouse gas accounting and climate action, reflected in the establishment of specialized departments and the use of standardized methodologies. The city began assessing the impact of its activities in terms of greenhouse gases as early as 2004 and published its first comprehensive greenhouse gas assessment in 2006, identifying key emitting sectors and establishing a knowledge base for further action. They were also calculating the carbon footprint of the city since 2004: *"We were already known as a leader on climate for for a long time, and that's what we want to still carry on".*

Gothenburg began measuring consumption-based emissions in 2008, integrating scope 3 in climate policy despite limited data at the time: *"We had our first time goal for the city, we chose to include the consumption emissions also, even though we had very little data or anything on it".* Initially, the city was separating between territorial and consumption-based emissions before adopting the scope 1, 2, 3 framework as part of their involvement with the Covenant of Mayors and other reporting schemes.

City-wide and cross-sectoral focus
Both Paris and Gothenburg have adopted climate strategies that extend well beyond municipal operations, encompassing a wide range of emissions sources, including those linked to citizen behavior, urban infrastructure, and procurement practices.

In Paris, the city's climate policy is explicitly designed to address emissions across all sectors - not just those occurring within city boundaries. This includes emissions from energy, transport, food, construction, and the consumption of goods and services by Parisians. As one official explains, *"The city's climate plan covers all emissions, including those from energy, transport, food, construction, and even the consumption of goods by Parisians."* Another emphasizes the city's broader scope: *"We don't just look at what happens inside the city boundaries. We want to reduce the footprint of everything Parisians consume, even if it happens outside Paris." The ambition is clear and comprehensive: "Our goal is to reduce all emissions by 100%, not just the ones we control directly."*

Similarly, Gothenburg has adopted a wide-ranging climate objective that integrates both territorial and consumption-based emissions. As described by a city representative: *"The climate goal of the City of Gothenburg has a broader scope than required in the Mission. The goal targets emissions from both a territorial and a consumption-based perspective."* At the organizational level, Gothenburg closely monitors emissions associated with municipal procurement. The city has conducted a detailed analysis of all its programmatic requirements, comparing them against a national emissions database that calculates greenhouse gas intensity per monetary unit. This allows the city to assess the carbon impact of everything it purchases: *"We did this analysis on all our programme requirements, checking them against the database that has data on emissions per krona or monetary unit in Sweden."* As one official notes, this gives the municipality considerable influence: *"We have much more say in what we as a city consume and procure, and we can do much more with that."*

At the citizen level, Gothenburg also aims to capture emissions associated with individual consumption. While recognizing limitations in influencing certain areas - such as the embedded emissions in imported goods - the city still exerts significant control through local systems: *"When it comes to what our citizens consume, we still have a lot of say in how our transport system is set up and our energy system within the city, but not so much when it comes to the cost of goods and services.". To operationalize this broad approach, Gothenburg has developed a climate program structured around seven strategic focus areas - or "strategies"* - that require radical transformation.

Stakeholders inclusion:
Both Paris and Gothenburg prioritize inclusive governance by actively engaging a wide range of stakeholders in their climate initiatives - from large corporations and public institutions to local associations and citizens.

In Paris, the city has developed a collaborative framework to bring together stakeholders from across sectors. One key initiative is the Pacte Action-Climat-Biodiversité (Climate Action–Biodiversity Pact), a publicly available charter that outlines stakeholder commitments and reinforces transparency. *"It's like a kind of charter that some actors and stakeholders agree to sign to say that they will work alongside the city to implement measures that have an impact on the carbon footprint of the city."* The pact not only encourages joint action but also provides open access to information about partners and their objectives. Among the participating actors are major energy providers such as **GRDF** and **EDF**. As one official described, *"We have big energy companies like GRDF, EDF... the idea is to embark all of them and to share experience and good practices between all of them."* This approach reflects a deliberate effort to keep institutionalizing cooperation and knowledge exchange across organizational boundaries.

In Gothenburg, a similarly inclusive approach is taken, particularly with local associations and community-based actors. The city provides targeted support mechanisms that encourage grassroots involvement in climate work. For instance, associations, including sports organizations, can apply for municipal grants to fund environmental initiatives. *"You can, as a sports association, ask the city for grants for doing that kind of work, and you can get access to the city's buildings"*, explained one representative. Notably, these programs have been expanded to include organizations working on issues such as circular economy, allowing for greater diversity in the types of projects supported: *"We extended those programmes to associations that want to work with circular economy issues and things like that."*

Clear objectives
The presence of clearly defined goals - particularly those that are quantitative and time-bound - plays a fundamental role in enabling consumption-based climate action (CBCA). These objectives serve not only as guiding principles but also as concrete benchmarks that drive prioritization, mobilize resources, and ensure accountability. In both Paris and Gothenburg, long-term climate ambitions are formally documented in strategic plans, providing an essential foundation for implementing CBCA measures.

In Paris, the city's objectives are explicitly articulated in the Climate Action Plan and the Climate, Air, and Energy

Plan (PCAET). These plans commit Paris to reducing all local emissions - including both territorial and consumption-based - by 100% in the long term. More specifically, the city aims to cut total emissions (including consumption-based ones) by 40% by 2030 and by 80% by 2050, relative to 2004 levels: *"Paris established targets in its Climate Action Plan to decrease territorial and consumption-based emissions (the Paris carbon footprint) to 40% below 2004 levels by 2030 and 80% below 2004 levels by 2050."*[4]

Similarly, Gothenburg has committed to a clear and ambitious consumption-based emissions reduction pathway. Its goals are both quantified and tied to a defined timeline, providing a strong political mandate for CBCA implementation. By 2030, the goal is to reduce consumption-based greenhouse gas emissions to 3.3 tonnes CO_2e per person per year, down from a baseline of 9.25 tonnes in 2017. This requires an annual reduction rate of at least 7.6%. The final goal is to reach 1.9 tonnes CO_2e per person per year by 2050.

4.5. Multi-level and cross-sectoral coordination

The successful implementation of CBCA depends significantly on coordination across multiple levels of government and sectors. This is enabled by two key factors: a supportive national governance system and a horizontal coordination across sectors and stakeholders.

National governance ecosystem

Paris benefits from a strong national framework that provides substantial institutional support for implementing CBCA. National-level entities - including government agencies, research institutions, and statistical offices - supply cities with the methodologies, data, and standards necessary for consumption-based carbon accounting. These tools not only strengthen the technical foundation of Paris's climate policy but also lend political legitimacy and coherence to local actions. In contrast, Gothenburg operates within a more fragmented national governance context. While it receives technical support from organizations such as the Stockholm Environment Institute (SEI) - which plays a crucial role in developing methodologies for CBCA - there is no formal governmental mandate or support at the national level for consumption-based accounting.

Horizontal coordination

Both cities also rely heavily on horizontal coordination, meaning collaboration across sectors and with various public and private stakeholders.

In Paris, this is exemplified by initiatives such as the Pacte Action-Climat-Biodiversité, an open, online charter where stakeholders voluntarily commit to actions aligned with the city's climate goals, as explained above. Similarly, in Gothenburg, CBCA is not the responsibility of a single department but is instead embedded across the city's governance structures. The Environment and Climate Program for 2021–2030 was adopted by a wide political majority and applies to all city departments and city-owned companies. This ensures that the goal of reducing consumption-based emissions is shared across the entire municipal apparatus.

5. Discussion

This study identifies two contrasting yet complementary models of consumption-based carbon accounting (CBCA) governance: Paris's institutionalized model and Gothenburg's pioneering approach. These cases illustrate that there is no singular pathway to implementing CBCA. Instead, diverse strategies - shaped by political cultures, institutional configurations, and external support systems - can all serve as viable routes to operationalizing this ambitious climate accounting framework.

5.1. Two different models: Institutionalized vs. Bottom-up CBCA Approaches

Paris advances CBCA within a highly institutionalized and nationally supported governance environment. It benefits from a structured ecosystem comprising national research institutions (e.g., INSEE, ADEME, ABC), legal mandates, and standardized methodologies, which provide a robust backbone for methodological consistency and policy legitimacy. CBCA is embedded within the city's broader climate strategy, supported by cross-sectoral coordination and formal target-setting. This reflects what Bulkeley and Kern (2006) describe as "governing through

4 Paris Climate Action Plan

enabling," where higher-level institutions provide cities with tools and frameworks for climate action. In contrast, Gothenburg exemplifies a more bottom-up, pioneering approach. Despite the absence of strong national mandates or standardized frameworks, the city has pushed CBCA forward through close partnerships with expert institutions like the Stockholm Environment Institute (SEI), bottom-up data collection, and partnerships with local institutions. The reliance on external actors has enabled methodological innovation and credibility, though it also introduces potential vulnerabilities in terms of continuity, autonomy, and long-term data governance. Studies shows that, while introducing expertise and standardized methods, the reliance on external stakeholders also include challenges in maintaining consistent methodologies over time, risks of data discontinuity if external partnerships dissolve, and potential limitations on local autonomy and data ownership (Fünfgeld & McEvoy, 2012; Turnhout et al., 2016).

5.2 The Role of National Ecosystems

These two cases highlight the enabling role, but not deterministic function, of the national ecosystem. While Paris's success is deeply tied to a supportive national framework, Gothenburg demonstrates that local innovation can substitute for national direction. Paris thrives in an ecosystem with clear national institutions and policies that underpin CBCA, from macroeconomic data (INSEE) to methodological standards (ADEME). The relationship between national frameworks and local climate action is well documented in the literature. National institutions can provide essential data, methodological standards, and legitimacy, enabling cities to develop robust climate policies (Bulkeley & Kern, 2006; Kern & Bulkeley, 2009).

Conversely, research shows that cities can also innovate in the absence of strong national direction by leveraging local academic and technical expertise. For example, Gothenburg does not benefit from national institution data but draws on the academic expertise of the SEI. However, such innovation may be less stable or scalable without institutionalized national support (van der Heijden, 2019; Castán Broto & Bulkeley, 2013).

5.3 Political framing and target settings as a key enabler towards CBCA

A shared enabler in both contexts is the framing of CBCA through clear, time-bound targets embedded in official climate strategies. Paris aims to reduce territorial and consumption-based emissions by 80% from 2004 levels by 2050. Gothenburg targets a per capita reduction to 3.3 tonnes CO_2e by 2030. The literature demonstrates that setting ambitious and specific targets not only structures implementation but also acts as a powerful tool for political mobilization, stakeholder engagement, and accountability (Rogge & Reichardt, 2016; Hsu et al., 2020).

Closely tied to target-setting is the integration of CBCA across departments and sectors. Paris exhibits more formalized coordination through interdepartmental mechanisms and city-wide climate charters. Gothenburg relies on horizontal integration, embedding CBCA objectives across all departments and city-owned companies through its Environmental and Climate Program (2021-2030). This integration ensures that scope 3 data informs procurement, planning, and budgeting processes which are key for mainstreaming beyond symbolic commitments. The mainstreaming of CBCA objectives across municipal departments and city-owned companies, as seen in both Paris and Gothenburg, is also recognized as a best practice for effective climate governance (Bulkeley & Kern, 2006; Reckien et al., 2018).

5.4 The crucial role of stakeholder engagement

Stakeholder engagement is central to the legitimacy, operationalization, and sustainability of CBCA governance. In Paris, structured participation is institutionalized through the Pacte Action-Climat-Biodiversité, a publicly accessible charter that mobilizes actors across sectors, from energy companies to grassroots organizations. This charter formalizes commitments, ensures transparency, and reinforces co-responsibility. It embeds climate action within a network of shared governance, illustrating that a broad societal buy-in is needed in order to carry out actions to counter consumption-based emissions. Gothenburg mainly focus on society organizations, sports associations, and NGOs are encouraged to align with the city's environmental objectives through financial support and access to public infrastructure. This fosters bottom-up engagement and reflects a high-trust model of participatory governance. The city has expanded its collaborative programs to include circular economy initia-

tives, highlighting the dynamic evolution of stakeholder roles in CBCA. Such bottom-up approaches are shown to be effective in mobilizing local actors, fostering innovation, and ensuring that climate actions are contextually relevant and widely supported (Aylett, 2015; Arnouts et al., 2012).

5.4 Normative Framing and Cities as Global Climate Actors

The deliberate inclusion of consumption-based emissions in local climate plans reflects a normative redefinition of urban responsibility. Rather than limiting themselves to territorial emissions under their direct control, both Paris and Gothenburg embrace a broader ethical mandate that connects local governance to global sustainability. This shift positions cities not as passive implementers but as active shapers of post-territorial climate governance. This framing aligns with emerging literature on cities as global actors (van der Heijden, 2019).

Therefore, it can be argued CBCA equips cities with tools to address climate change systemically but also imposes new demands. Cities must negotiate responsibilities beyond their formal jurisdictions, build internal expertise, and ensure accountability for emissions they do not directly control. To succeed in this role, they require enhanced support - access to funding, methodological guidance, and platforms for international collaboration. The cases of Paris and Gothenburg reinforce the view that cities can lead in addressing global challenges when empowered with the right frameworks and coalitions. Their experiences suggest that CBCA is not just a technical exercise but a transformative approach to rethinking urban sustainability and governance in the age of climate crisis.

Conclusion

This article has examined the governance conditions of consumption-based carbon accounting (CBCA) through an in-depth comparison of Paris and Gothenburg, two cities that, despite distinct institutional contexts and levels of national support, each have advanced ambitious and pragmatic CBCA strategies. The findings reveal that while Paris operates within a highly institutionalized, nationally backed model and Gothenburg advances a more bottom-up, normatively driven approach, both demonstrate that local governments can lead on scope 3 emissions governance, even in the absence of a harmonized international framework.

The Paris case illustrates the strengths of a mature governance ecosystem where national institutions provide the methodological and legal infrastructure necessary to support robust CBCA integration. In contrast, Gothenburg shows that municipal innovation, when coupled with collaboration with expert institutions, can pioneer new methodologies and mainstream CBCA into city operations, even with limited national guidance. Across both cases, the success of CBCA governance is tied not only to technical capacity or institutional design, but also to the political and ethical reframing of urban climate responsibility. By choosing to include emissions beyond their direct territorial control, both cities expand the boundaries of local climate governance toward a more globally accountable model. Clear targets, cross-sectoral integration, and meaningful stakeholder engagement emerge as critical levers for embedding CBCA within policy and society. At the same time, the analysis underscores the fragility of such efforts when they rely too heavily on individual champions, external expertise, or voluntary mechanisms. To sustain and scale CBCA, cities need institutional safeguards such as binding mandates, integrated planning processes, and sustained national support. Moreover, the broader governance landscape must evolve to recognize and support cities as global climate actors, providing the financial and technical resources needed to monitor, manage, and reduce consumption-based emissions.

Ultimately, the Paris and Gothenburg experiences show that CBCA is not only a technical tool but a political and ethical project. It calls for reimagining the role of cities in a globally interconnected carbon economy and for crafting governance arrangements that enable urban actors to lead climate action far beyond their borders. CBCA thus offers a vital lens through which to rethink both the responsibilities and the capabilities of cities in the age of planetary crisis.

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Special Session 12

Evaluating the 15-Min City Concept in Ankara: Resident Perceptions of Accessibility in Çankaya and Keçiören

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Abstract
The concept of 15-minute cities has gained global attention as a sustainable urban planning model aimed at creating cities where residents can access essential services and amenities within a 15-minute walk or bike ride from their homes. This model emphasizes accessibility, reducing reliance on cars, and fostering more livable and inclusive urban spaces. This study explores the perceived accessibility of two districts in Ankara, Türkiye (Çankaya and Keçiören) through the lens of the 15-minute city framework.

The findings contribute to the growing discourse on sustainable urban mobility and the practical realities of implementing the 15-minute city concept in diverse urban environments.

Key Words: 15-Minute City, Resident Perceptions, Ankara Urban Planning, Çankaya District, Keçiören District

1. INTRODUCTION

The 15-Minute City concept focuses on ensuring that residents can reach key services—such as employment, shopping, healthcare, education, and recreation—within a 15-minute walk or bike ride from their homes (Moreno et al., 2021). Rooted in long-standing urban planning principles, including human-scale development, density,

diversity, adaptability, proximity, digital integration, and connectivity, the model supports social, economic, and environmental sustainability (Khavarian-Garmsir et al., 2023b; Jiang et al., 2024). It seeks to improve urban liveability, resilience, and public health, particularly in the aftermath of the pandemic and in line with Smart and Green Transition goals (Allam et al., 2022; Shoina et al., 2024; Moreno et al., 2021).

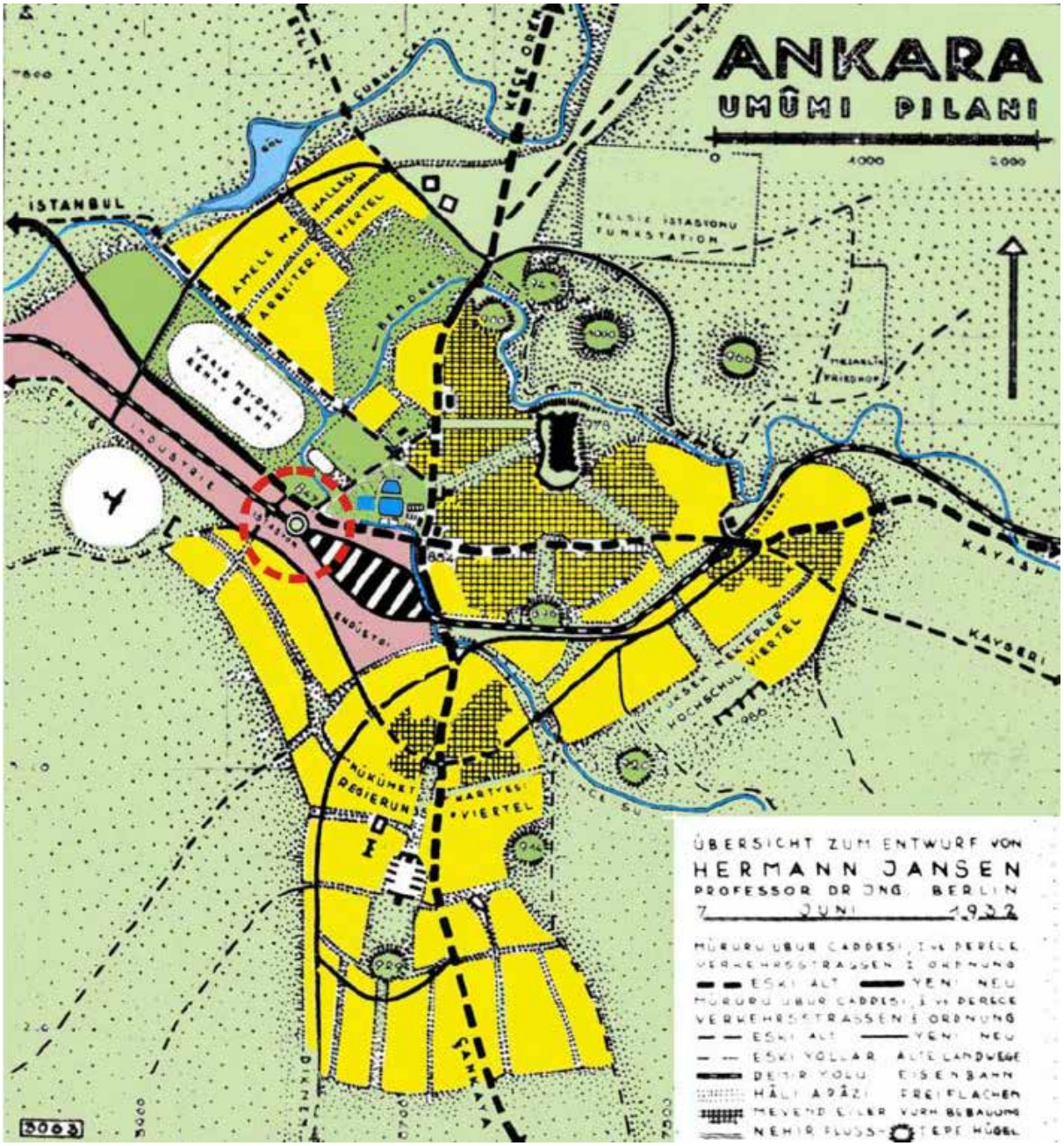
A growing number of cities are embracing the 15-Minute City model, customizing it to align with their specific urban histories and requirements. Case studies emphasize the need for contextual adaptation, highlighting that successful implementation depends on cross-disciplinary collaboration, strategic resource management, and active citizen participation (Pozoukidou & Chatziyiannaki, 2021; Shoina et al., 2024; Di Marino et al., 2022). For instance, cities like Oslo and Lisbon have experimented with integrating flexible workspaces and improving public transport access, although challenges persist in achieving an equitable distribution of services and amenities (Di Marino et al., 2022).

The rest of the paper is organized as follows: In Chapter 2, the applicability and perceived relevance of the 15-Minute City concept within the context of Ankara, Türkiye, focusing on two socio-spatially distinct districts: Çankaya and Keçiören are given. Drawing on historical planning precedents such as the 1927 Jansen Plan, the research examines how the 15-Minute City concept framework—which emphasizes accessibility, proximity, mixed-use neighborhoods, and human-scale development—resonates with Ankara's evolving urban form and contemporary challenges. In Chapter 3, the preliminary resident perceptions in both districts are assessed through a contextual lens where we expect that residents in Çankaya to support the model but raise concerns about affordability and digital expectations, whereas Keçiören's residents are expected to view the 15-Minute City concept as a much-needed strategy for equity, though tempered by skepticism over implementation and accessibility. The paper concludes with the Chapter 4, where reinterpreting the 15-Minute City concept through Ankara's planning history provides an opportunity for inclusive, sustainable, and resilient urban transformation, particularly when guided by neighborhood-specific strategies and participatory approaches.

2. THE 15-MINUTE CITY CONCEPT IN ANKARA'S PLANNING HISTORY

Revisiting the 15-Minute City framework offers an opportunity to reorient Ankara's urban development toward more human-scaled, sustainable, and resilient patterns, particularly through the revitalization of inner-city neighborhoods, integration of transit-oriented development, and promotion of local services. In this way, the concept can serve both as a critique of past deviations and a strategic lens for future planning.

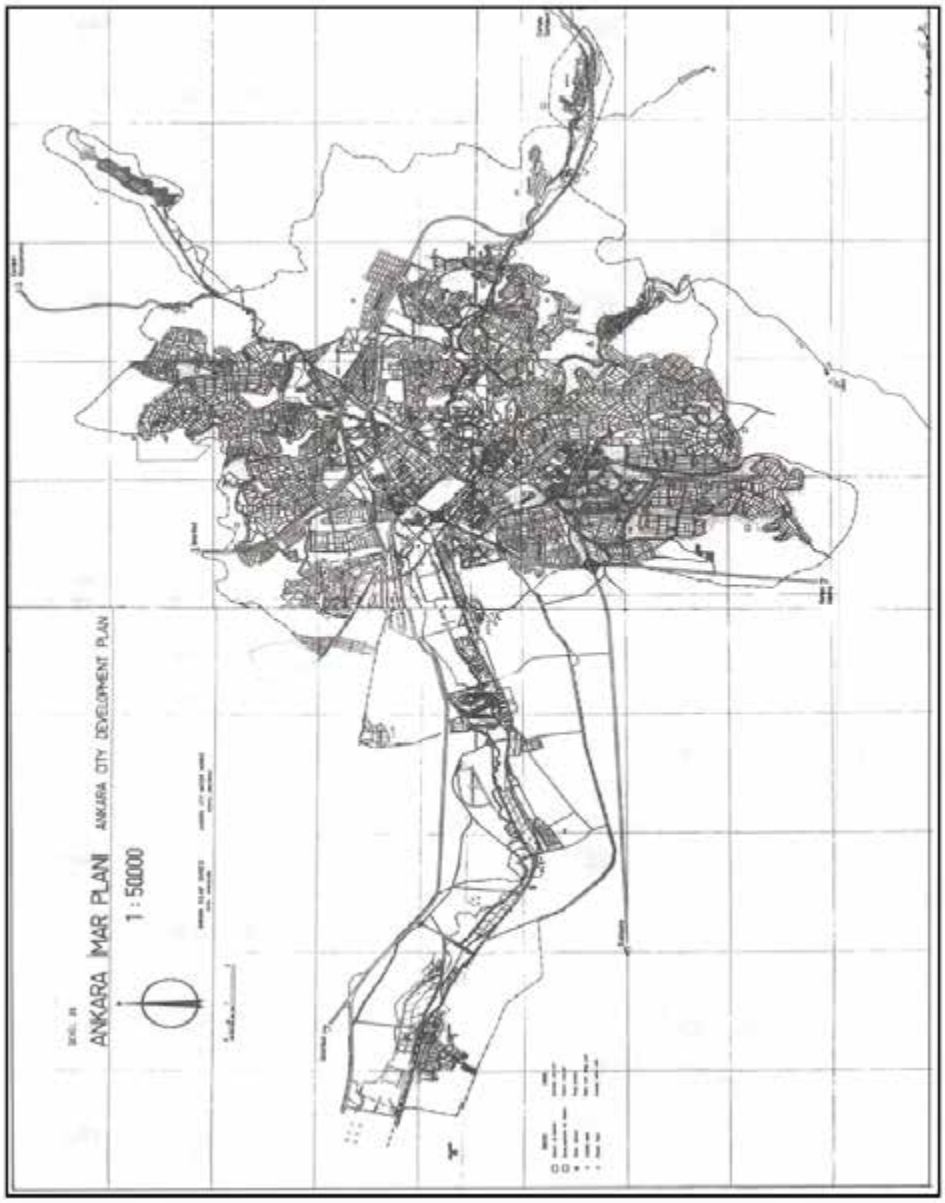
The 15-Minute City concept, with its focus on proximity, accessibility, and mixed-use neighborhoods, resonates with key aspects of Ankara's historical urban planning—particularly the early Republican-era visions that emphasized planned growth, functional zoning, and neighborhood units.



Plan 1. The 1927 Jansen Plan of Ankara (Source: Jansen Plan)

In the 1920s, as the newly founded Republic of Türkiye designated Ankara as its capital, the city was envisioned as a modern, efficient, and rational urban center. The 1927 Jansen Plan exemplified this vision by proposing a well-structured capital featuring green areas, pedestrian-friendly neighborhoods, and accessible public services—an approach that resonates with contemporary 15-minute city principles. As one of Ankara's earliest and most significant planning initiatives, the plan aimed to establish a polycentric layout defined by functional zoning, integrated green networks, and mahalle-based neighborhood units that fostered walkability and community interaction. The foundational ideas behind this plan—particularly the focus on human-scale design, spatial proximity, and public infrastructure—closely align with the core concepts of the 15-Minute City model.

However, despite these promising foundations, Ankara's urban development over the 20th century gradually veered towards mono-functional zoning, and sprawling expansion, leading to increased car dependency. The city's growth was increasingly characterized by automobile-oriented suburbs, fragmented urban patterns, and rising spatial inequality—departing significantly from the original planning vision.

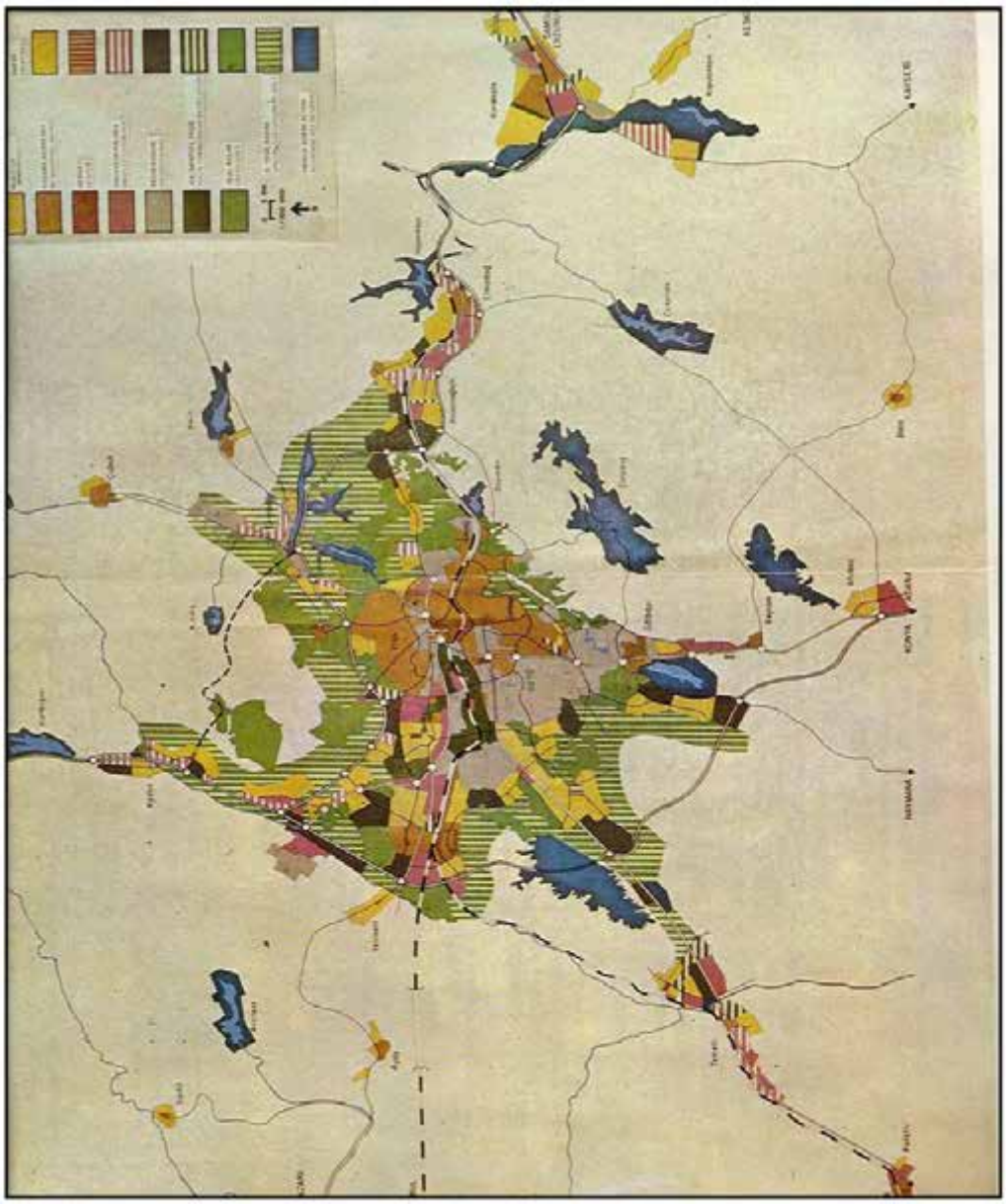


Plan 2. Yucel-Uybadin Plan of Ankara-1950 (Günay, 2012)

The rapid urbanization of Turkey that followed the 1950s, along with speculative land practices and the widespread emergence of gecekondu (informal housing) areas, eroded the initial vision of an integrated and accessible urban fabric.

The third plan sought to preserve the culturalist vision established in the first plan. It aimed to halt further urban growth and densification but ultimately failed by disregarding the underlying societal dynamics, leading to the city's transformation. As a result, the city's dual social structures began to shape its physical form. Apartment buildings in formally planned housing areas and informal, low-rise squatter settlements emerged as the dominant urban patterns, reflecting socio-economic divides. The once-envisioned garden city gave way to a city of

apartment blocks, while the intended green belts were overtaken by informal housing, marking the beginning of a conflict between planned and unplanned development. Over time, this tension led to a complete overhaul of the urban fabric, where the ideal of a modern, orderly city was replaced by a more disordered and chaotic reality. (Günay, 2012).



Plan 3: The structural plan of Ankara-2015 (Günay, 2012)

The Ankara 2015 Structural Plan introduced policies aimed at guiding urban growth toward the city's outskirts. It is notable for its clear definition of the urban center, its recognition and integration of squatter settlements, and its strategy to allocate urban land for the middle class. The Metropolitan Office Plan also sought to address the needs of middle- and lower-income populations by promoting a balance between residential areas and employment opportunities. In contemporary Ankara, however, increasing car dependency, fragmented urban infrastructure, and unequal access to public services have led to pronounced spatial and social disparities—particularly between well-connected central neighborhoods and marginalized peripheral zones. As a result, many residents face long daily commutes, limited access to green space, and a lack of local services—challenges that the 15-Minute City approach is specifically designed to overcome (Günay, 2012).

3. PERCEPTIONS IN CANKAYA AND KECİÖREN DISTRICTS ABOUT 15-MINUTE CITY

We conducted so called Walk-Aong Interviews (WAI) in two districts of Ankara to have a better insight into local perceptions about accessibility and walkability within these districts. WAI are part of are part of the methodological repertoire of empirical social and geographical research which focus on the spatial and social environment. As a mobile method, they allow to gain valuable insights into experiences, perceptions and impressions of different target groups. With an interviewer and one researcher, capturing the observer's perspective, the method of walk-alongs interviews obtain a variety of impressions to analyse perceived accessibility within the framework of the 15-Minute City (Van Hecke et al., 2016; King & Woodroffe 2017; Amaya et al. 2024). Before doing that, some visits to the districts gave some preliminary perceptions about the Çankaya and Keçiören, two of Ankara's most prominent and contrasting districts, are likely to generate different perceptions and responses to the 15-Minute City concept, shaped by their socio-economic characteristics, urban form, topography, accessibility patterns, and service distribution.

In the rest of the study, some preliminary results are presented shortly.

3.1 Çankaya: Supportive but Selective Perceptions

Çankaya is one of the most central and densely populated districts of Ankara, serving as a key administrative, residential, and cultural hub of the city. Characterized by a diverse urban fabric, the district includes a mix of governmental institutions, educational facilities, residential neighborhoods, and commercial zones. While Çankaya offers relatively better access to public services and infrastructure compared to many peripheral districts, the findings of this study reveal that significant barriers to walkability persist, particularly for vulnerable groups such as the elderly and families with children.

The district's varied topography, including steep slopes and elevation changes, presents considerable challenges for pedestrian mobility. Despite its centrality, many neighborhoods within Çankaya exhibit damaged sidewalks, obstructed walking paths, and insufficient pedestrian infrastructure. These issues are further exacerbated by a lack of accessible public amenities—such as parks, rest areas, and recreational spaces—which limits the appeal and practicality of walking, especially for older residents. Families with children also reported concerns regarding safety and comfort when navigating the urban environment on foot, often citing inadequate integration between pedestrian paths and public transportation.

Overall, while Çankaya remains a vital part of Ankara's urban landscape, the district's walkability is hindered by a combination of physical, infrastructural, and planning-related challenges. Addressing these concerns through inclusive urban design and integrated mobility planning is essential for enhancing the quality of life for its diverse population.

The preliminary results for the implementation of 15-min city concept in planning

Lifestyle Compatibility: Many residents — particularly those living in central neighborhoods — already enjoy key features of the 15-Minute City, such as pedestrian-friendly environments, local cafés, bookstores, and cultural venues. As such, the model may be viewed as an affirmation of their existing urban lifestyle and values.

High Awareness and Receptivity: Given the districts highly educated and often progressive demographic, the group tends to support sustainability-focused, human-centered urban strategies.

Concerns Around Gentrification and Affordability: Despite general support, there are reservations that enhancing amenities and public spaces could accelerate gentrification, leading to increased housing costs and reduced affordability for existing residents.

Expectations for Smart Urban Solutions: Within a tech-literate population, there is an expectation that implementation will incorporate digital tools such as mobile mobility platforms, real-time public transit updates, and intelligent urban infrastructure.

Emphasis on Green and Cultural Connectivity: Particular attention may be given to improving access to green spaces and cultural amenities within walking distance — especially in older neighborhoods where such features are unevenly distributed or deteriorating.

3.2 Keçiören: Mixed and Needs-Based Perceptions

Keçiören is one of the most populous and socially diverse districts, with a predominantly residential and conservative profile. Keçiören is one of Ankara's largest and most vibrant residential districts, home to a diverse community with varied mobility needs. The district's topography includes gentle slopes and some elevation changes, which, together with its evolving pedestrian infrastructure, shape residents' everyday walking experiences. While many neighborhoods in Keçiören offer walkable areas, some aspects of the pedestrian environment present opportunities for enhancement to better accommodate all users.

The certain sections of sidewalks could benefit from maintenance and occasional widening to improve accessibility and comfort. The integration of pedestrian pathways with public transportation is an area where further development may support more seamless mobility, especially for families with children. Additionally, while Keçiören offers a range of public spaces, increasing the availability and accessibility of parks, resting areas, and recreational facilities would further enrich the pedestrian experience.

Despite these areas for growth, there is an interest in sustainable transportation options and expressed openness to improvements such as safer cycling routes and pedestrian-friendly crossings. These insights highlight the potential for thoughtful, community-informed planning initiatives to strengthen walkability and enhance quality of life in Keçiören.

The preliminary results for the implementation of 15-min city concept in planning are as follows:

Call for Equitable Service Provision: The 15-Miniute City concept is slowly gaining recognition among citizens.

Skepticism Rooted in Past Experience: Given a history of underinvestment and top-down planning processes, there may be widespread skepticism about the feasibility of implementing the model effectively.

Prioritization of Core Infrastructure: There is a technological innovation center in Keçiören. It helps embracing advanced technological tools. Residents are likely to prioritize tangible improvements in public transport, pedestrian safety, street maintenance, and basic infrastructure.

Need for Accessible Social and Cultural Facilities: There may be a pronounced demand for community-oriented spaces that support family life, youth engagement, and religious or cultural activities —s paces that foster everyday social interaction and cohesion.

Affordability as a Central Concern: A key expectation is that any new amenities or services introduced as part of the 15-Minute City approach remain financially accessible to all residents, avoiding cost-driven exclusion or displacement.

4. CONCLUSION

The study highlights the importance of considering local context and resident perceptions in urban planning, and it calls for a more inclusive approach to designing cities that truly prioritize accessibility for all citizens.

Reintroducing the core principles of the 15-Minute City into Ankara's current urban planning framework presents a valuable opportunity to tackle longstanding urban challenges. Enhancing the function of neighborhood centers as versatile hubs for essential services can help reduce travel distances and stimulate local economic development. Strengthening infrastructure for active transportation — such as pedestrian pathways and cycling routes — and integrating these with public transit systems aligns with both the foundational ideas of the Jansen

Plan and today's sustainability imperatives. Furthermore, leveraging digital technologies, including GIS-based accessibility assessments and participatory planning platforms, can support more responsive, data-informed decision-making that addresses neighborhood-specific needs.

The 15-Minute City also offers timely solutions for Ankara's climate adaptation and post-pandemic recovery efforts. By fostering compact, inclusive, and mixed-use urban forms, the model can help lower carbon emissions, improve public health outcomes, and reinforce social cohesion. In this context, it serves not only to rectify previous shortcomings in urban development but also as a strategic framework in alignment with global priorities such as the Smart and Green Transition and the United Nations Sustainable Development Goals.

At the district level, applying a context-sensitive lens is essential. Planning narratives must reflect the distinct needs, perceptions, and lived realities of each district.

In sum, the 15-Minute City should not be viewed as a novel planning doctrine for Ankara but rather as a contemporary reinterpretation of the city's historical planning aspirations. Grounding this concept in the values of proximity, accessibility, and resilience offers a promising path toward a more just, sustainable, and livable future for Türkiye's capital city.

Acknowledgement
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A More-Than-Human Approach to Storytelling for Landscape Planning: Interactions Between Artificial Intelligence and Problem Structuring Methods

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Abstract
This paper explores how a More-Than-Human approach can reshape storytelling for landscape planning by integrating Artificial Intelligence (AI), as a tool for co-producing multispecies narratives, and Problem Structuring Methods (PSMs), as participatory methods for addressing complex, multidimensional issues. Within this context, the concept of More-Than-Human-Rights offers a legal and ethical framework that supports entanglements between human and non-human agents. To operationalise these theoretical statements, the case study "Mytilus in Fabula" in the Campi Flegrei area is examined, where humans and non-humans co-construct relational landscape narratives. The findings from this theoretical and practical inquiry open a path to the development of more inclusive, equitable, and multispecies planning practices capable of addressing contemporary ecological challenges.

Keywords: More-Than-Human Rights, Interspecies Justice, Ecological Ethics, Situated Knowledge, AI Ethics

Introduction

In recent years, our perception of landscapes has undergone a profound transformation, reflecting shifts in cultural, environmental and scientific paradigms (Antrop, 2014). These paradigms influence the way we interpret and understand our surroundings. Historically, landscapes are valued for the benefits they provide to society, whether these are material or immaterial (e.g. cultural identity, the aesthetics of a place, or recreational opportunities) (Tempesta, 2006). Conventional methods of storytelling and planning in complex landscapes include, among others, Ecosystem Services (ES) (Díaz et al, 2015), Landscape Services (LS) (Termorshuizen & Opdam 2009; Bastian et al. 2014) and Landscape Characteristics Assessment (LCA) (LU et al, 2022), are based on an anthropocentric vision. Although these approaches adopt different logics, they aim to interpret and attribute value to the environmental, cultural, social, perceptual and identity dimensions of a territory. They are characterised by their ability to synthesise and classify the elements that make up a landscape, thus facilitating decision-making processes (Van Eetvelde & Antrop 2009; Haines-Young & Potschin 2011; Vallés-Planells, Galiana & Van Eetvelde, 2014). However, despite their analytical and managerial strengths, they tend to overlook the intrinsic and ecological value of landscapes by focusing primarily on nature's contributions to human well-being. This limited viewpoint neglects the coexistence and interaction of human and non-human entities within territories (Liew & Sundaram, 2009; Cerreta 2010; Montuori, 2013), revealing a need for more integrated, interdisciplinary strategies that embrace multispecies perspectives and promote holistic visions of the human–nature relationship.

In response to the limitations of conventional models, a paradigm shift has been proposed to recognise and integrate the diverse perspectives, memories, and experiences that shape a place's identity. Rather than being considered merely an aesthetic framework, landscapes are now recognised as living, complex entities resulting from the constant interaction between natural and human elements (Council of Europe, 2000). This evolutionary perspective recognises landscapes as continuously evolving systems in which the ecological, social, and cultural dimensions are interconnected and influence each other (Palola, Bailey & Wedding, 2022). Understanding the landscape as a complex, multi-level system enables us to address contemporary environmental and social challenges by promoting an integrated, sustainable approach.

Within this context, the More-Than-Human approach (Haraway, 1985) offers an innovative and critical perspective that challenges the anthropocentric vision. Adopting this approach to landscape planning means recognising

the agency of non-human subjects (e.g. ecosystems, animal and plant species, physical and technological infrastructures) in shaping planning processes (O'Connor & Kenter, 2019). It entails conceiving non-human elements of the landscape as active co-agents in producing environmental, ecological, and social effects (Dürbeck, 2015).

In this context, storytelling (Bulkens, Minca & Muzaini, 2015) emerges as an act of world-making. It uncovers and communicates diverse narratives, values, and relations within the landscape, helping to interpret and actively shape our understanding of landscapes. Recognising storytelling as foundational to planning strategies, this research focuses on its potential to gather and celebrate both individual and collective narratives, not only from institutional actors and experts, but also from those who inhabit and interact with places in their everyday lives, including, in mediated ways, non-human beings. In a More-Than-Human approach, storytelling opens up the planning process to sensitive and relational forms of knowledge (Boros et al, 2024). Storytelling provides a lens through which we can interpret the interdependence between human beings, non-human life forms, and the material elements of a given territory.

Nowadays, storytelling has recently received a powerful boost through the rise of tools like Artificial Intelligence (AI). Among its many capabilities, AI offers innovative ways to represent narratives in more creative, immersive, and dynamic forms. By harnessing its diverse functionalities, AI opens new possibilities for reimagining how stories are told, understood, and shared. In this evolving scenario, the integration of AI with participatory approaches marks a significant shift (Birhane et al., 2022; Delgado et al., 2023; Sacco et al, 2023). New frontiers in AI research emphasise inclusivity, encouraging the integration of diverse perspectives into the design and development of AI systems (Arora, 2024) (Mauri et al, 2024). This fosters an environment that welcomes different voices, counter-narratives, and plural interpretations of complex issues.

Central to this approach is the recognition that identifying the topic, clarifying underlying conflicts, defining relevant data, and determining how to collect and interpret it are all crucial steps in the process. Problem Structuring Methods (PSMs) play a crucial role in this context. These methods are particularly valuable for engaging with the wicked nature of complex, multidimensional issues by supporting the definition of the initial decision problem (Christie 2023; Moallemi et al, 2023). Rather than seeking a single, definitive solution, PSMs aim to deepen our understanding of the problem by incorporating a range of viewpoints (Mingers & Rosenhead, 2004). They help uncover hidden dynamics and encourage the exploration of multiple interpretative lenses. The goal is not simplification, but rather the deliberate complexification of the context, observing it from various angles until the most appropriate framing or action can be chosen based on the specific circumstances (Rosenhead, 2006). At the heart of this study is the intention to explore how PSMs and AI can expand and operationalise a More-Than-Human approach to landscape knowledge and evaluation (Figure 1). Despite their potential, the integration of AI and PSMs remains an underexplored area. Only a limited number of scholars have ventured into this intersection (Sacco & Poli, 2024a), and this research project seeks to contribute to that emerging field.

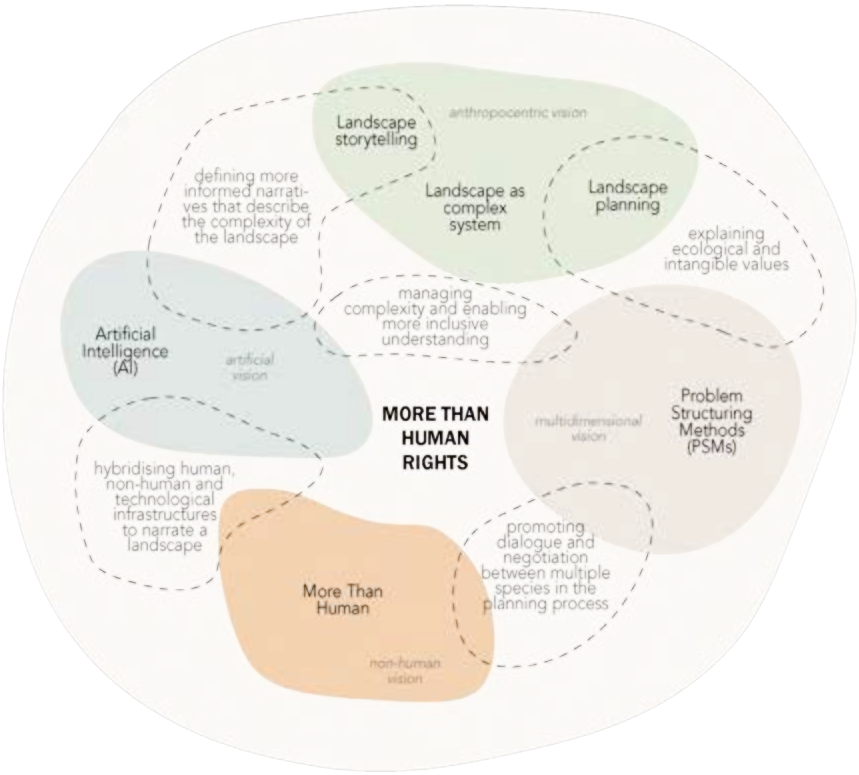

Figure 1: A More-Than-Human-Rights Framework

By doing so, it aspires to lay the foundation for a transformative shift in how landscapes are narrated, interpreted, and assessed, moving beyond anthropocentric paradigms and promoting a more relational and interconnected understanding of landscape complexity.

The concept of More-Than-Human-Rights (César Rodríguez-Garavito, 2024) offers a unifying lens through which to integrate AI, More-Than-Human perspectives, Problem Structuring Methods (PSMs), and landscape storytelling. It proposes a normative stance grounded in spatial justice and recognises the rights of non-human agents, such as ecosystems, species, and material entities, to shape and participate in the configuration of the landscape. This perspective calls for the construction of alternative, inclusive storylines. AI can play a critical role in co-producing these narratives by analysing, visualising, and amplifying overlooked voices and patterns. At the same time, PSMs offer methodological support to define the context: framing the issues, mapping conflicts, identifying actors (human and non-human), and exploring values. Together, AI and PSMs provide a powerful toolkit to foster more equitable and multispecies planning practices that reflect the true complexity of our shared environments.

The contribution is organised as follows: Section 2 delves into the exploration of the More-Than-Human approach and its interactions with AI and PSMs; in Section 3, the concept of More-Than-Human-Rights is introduced, with the aim of enhancing the relational and multispecies dimensions in decision-making processes. Section 4 presents the case study of Mussels Tales, in the Campi Flegrei area, to exemplify the concrete application of the discussed theories. Finally, the last Section envisions some conclusions and future perspectives of the research.

Toward a More-Than-Human Planning Practice

The More-Than-Human paradigm emerges as a critical response to the anthropocentric and dualistic epistemol-

ogies that have long dominated Western thought, particularly those that establish rigid separations between nature and culture, subject and object, human and non-human (Houston et al, 2018). Rooted in the work of Donna Haraway (1985) and developed across a range of interdisciplinary domains, including eco-critical theory, posthumanist philosophy, indigenous cosmologies, and science and technology studies (Daigle, 2022), the More-Than-Human paradigm offers a conceptual and ethical reorientation of how to understand life, agency, and planning. This paradigm should be understood as a pluralistic and generative field of inquiry that brings together a heterogeneous constellation of approaches. These approaches foreground the agency, vitality, and subjectivity of More-Than-Human actors (e.g. animals, plants, fungi, soils, waters, infrastructures, and technologies) as co-constitutive agents in the production of social and ecological realities (Dowling, 2016). Central to More-Than-Human thinking is the rejection of hierarchical ontologies. Posthumanist theorists, such as Manuel DeLanda, advocate for a "flat ontology" (Ash, 2020), in which all entities, regardless of their human or non-human status, possess the capacity to affect and be affected. This ontological flattening challenges landscape planning and design disciplines to reconsider how decisions are made and whose voices are included in the decision-making process. In parallel, Scott Gilbert's work on symbiotic biology (Gilbert, 2024) underscores the interdependent nature of life, highlighting that no organism exists in isolation; all beings are entangled in webs of mutual reliance and co-evolution. Within this expanded panorama, storytelling acquires critical epistemological and political significance (van Hulst, 2012). It is no longer merely a tool of representation, but a situated ecological practice, one that enables the articulation of lifeworlds, affective ties, and embodied knowledges often excluded from formal planning processes. Storytelling becomes an act of care, memory, and resistance (McDowell, 2022). It offers a means of reimagining landscapes through the eyes, experiences, and rhythms of both human and non-human actors. Haraway's (2016) notion of multispecies narratives invites scholars and practitioners to construct narratives that do not centre exclusively on the human subject but instead weave together the perspectives and agencies of other beings. These narrative forms challenge the reductive, technocratic, and often colonial gaze of mainstream spatial planning by foregrounding place-based, experiential, and affective knowledge systems. They contribute to what can be termed ecologies of attention (Ganteau, 2024), practices that cultivate attunement to the complex entanglements that constitute lived environments. These perspectives are deeply resonant with indigenous cosmologies, which have long upheld relational and reciprocal understandings of the world. Unlike the extractive logics of settler-colonial modernity, many indigenous traditions recognise the agency of rivers, mountains, animals, and ancestral territories (Acharibasam et al, 2024). Adopting this viewpoint on landscape means engaging in counter-narrative practices that resist the commodification of nature and promote alternative modes of knowing and dwelling. In this context, situated narrative techniques (Livholts, 2020) offer a means to express values that are often non-monetary and non-quantifiable, such as belonging, spirituality, affective attachment, and intergenerational memory, which are vital to sustaining the vitality of landscapes (Grieco et al, 2024). As such, situated narrative techniques become powerful tools in advancing a More-Than-Human approach to planning. They challenge anthropocentric logics and invite planners to engage with landscapes as relational fields shaped by diverse forms of life. Thus, narrative becomes a situated form of building planning process, capable of informing decision-making processes that are attentive to multispecies justice, grounded in place-based knowledges, and responsive to the complex web of ecological interdependencies. A More-Than-Human-informed planning practice shifts away from a model of designing for communities, implicitly human and often elite, toward a participatory, multispecies co-design process grounded in attentiveness, care, and relational responsibility. This entails not only listening to human voices but also developing methods and sensibilities for interpreting and incorporating the "voices" of rivers, animals, fungi, or even infrastructures. It calls for an expanded notion of participation that moves beyond stakeholder consultation to include More-Than-Human worlds as legitimate agents in shaping futures.

Entangling AI, PSMs, and More-Than-Human Worlds in Landscape Planning

If storytelling can be conceived as a critical method for activating More-Than-Human approaches to landscape planning, then the integration of Artificial Intelligence (AI) and Problem Structuring Methods (PSMs) offers a compelling horizon for expanding these practices. Both AI and PSMs operate at the interface of complexity, uncertainty, and pluralism, and as such, they present valuable tools for designing planning processes capable of acknowledging and engaging More-Than-Human entanglements. AI, broadly understood as the development of

computational systems capable of perceiving and acting upon their environments, has rapidly extended its role in both urban and landscape planning (Son et al, 2023). Applications include land-use optimisation, predictive modelling of urban growth, climate adaptation strategies, and the management of mobility systems (Fernberg & Chamberlain 2023). Advanced forms of AI, such as generative models, Natural Language Processing (NLP), geospatial AI (GeoAI), and computer vision, are increasingly capable of supporting new forms of landscape planning intelligence (Frazier & Song, 2024). These tools enable the extraction of patterns, the integration of heterogeneous data sources, and the simulation of possible futures. NLP allows for the interpretation of narratives embedded in texts, oral histories, and social media, surfacing perceptions, values, and emotions tied to place (Chowdhary, 2020). Generative AI can construct alternative scenario narratives, such as responses to climate-induced disruptions or species extinction. GeoAI and computer vision contribute to interpreting spatial data, landscape imagery, and acoustic biodiversity signals, offering powerful means to analyse cultural ecosystem services and non-human presence (Janowicz et al, 2023).

In parallel, PSMs offer a dialogical and participatory framework for navigating wicked problems, characterised by uncertain knowledge, conflicting values, and the impossibility of linear or optimal solutions. Rooted in systems thinking and operational research, PSMs, developed by Rosenhead (1996), Mingers and White (2010), Ackermann (2012), and Midgley et al. (2013), create space for multiple stakeholders to collectively construct models of shared understanding. PSMs are particularly effective in contexts where data is lacking, variables are multiple and interconnected, and solutions cannot be univocal or linear (Cerreta & De Toro, 2012). In the field of landscape planning, these conditions are commonplace. Particularly in landscape planning, where interests and ontologies often diverge, PSMs help mediate between competing definitions of the problem and facilitate inclusive, negotiated forms of action. When brought together, AI and PSMs can be seen as mutually reinforcing instruments for navigating complexity and enabling inclusive sense-making (Sacco & Poli, 2024b). AI provides analytical depth and the ability to model large-scale dynamics; PSMs ground those insights in situated deliberation, supporting ethical reflexivity and plural value negotiation.

Both have the potential to serve not only human stakeholders but, if reimagined, also More-Than-Human agencies, making visible the values, relations, and entanglements of non-human life forms that have historically been excluded from planning discourses. Nonetheless, both AI and PSMs are developed within anthropocentric knowledge systems and risk reproducing forms of reductionism or instrumentalisation. AI, in particular, can replicate human biases embedded in training data or overlook forms of knowledge that resist quantification (Aquino, 2023). Although PSMs are open to a plurality of perspectives, they are still methods designed by and for humans, which carries the implicit risk of reducing non-human agency to a mere instrument for anthropocentric purposes (Kim, 2020). Addressing these limitations requires a shift in how these tools are conceptualised and used within planning practice. An ethical approach is needed that considers privacy, landscape impacts and shared responsibility between human and non-human actors (Papagiannidis, Mikalef & Conboy, 2025). Reimagining AI through a More-Than-Human lens means going beyond simulation and optimisation toward forms of technological mediation that recognise non-human entities (Hupont et al, 2024), rivers, pollinators, mycelial networks, and atmospheric systems, as agents with communicative potential. AI models could be trained not only to detect ecological changes but to translate them into relational signals that carry meaning within planning processes. Generative AI, for instance, might be employed to construct multispecies narratives, grounded in ecological data and enriched with speculative imagination, to render visible the co-presence and co-dependence of multiple life forms (Arif, et al, 2020). In parallel, PSMs could be extended to facilitate multispecies dialogue, using techniques that map not just human concerns but also the values, needs, and vulnerabilities of non-human actors. Through various and innovative approaches (proxies, sensors, bioindicators, and artistic methods), More-Than-Human entities can be positioned as participants in planning conversations. These adaptations challenge the boundary between knowledge and ethics, opening planning to interspecies negotiation (Lopez et al., 2025).

Advancing toward a More-Than-Human planning paradigm necessitates the development of participatory, hybrid processes that weave together the analytical power of AI with the ethical reflexivity, interpretive depth, and speculative imagination offered by PSMs and narrative methodologies. The objective is to cultivate relational

intelligence and ecological ethics, including values of kinship, responsibility, reciprocity, and care (Tran et al, 2024). This convergence of AI, PSMs, and More-Than-Human thought confronts a profound question: How can planning tools encode and respond to the ethical demands of more-than-human life? What forms of representation, narration, and decision-making can support coexistence and mutual flourishing across species boundaries?

Addressing these questions calls for a radical reorientation of planning imagination, one that acknowledges that landscapes are not passive spaces to be managed, but living, contested, and co-produced territories shaped by many kinds of intelligence.

More-Than-Human-Rights: A Legal-Ecological Framework for AI and PSMs Integration

The concept of More-Than-Human-Rights (Rodríguez-Garavito, 2024) provides a powerful framework for integrating the technical capacities of AI and the deliberative structures of PSMs within a shared ethical and political horizon. While these tools originate from different epistemological traditions, AI from computational logic and automation, PSMs from participatory systems thinking, they can be productively aligned through the lens of More-Than-Human-Rights, which demands new forms of representation, recognition, and responsibility for non-human entities in decision-making processes.

In this light, More-Than-Human-Rights becomes the normative glue that binds AI and PSMs into a shared project of interspecies justice (Celermajer et al, 2021). AI contributes the capacity to sense, model, and simulate More-Than-Human presence, detecting patterns and generating data-rich ecological narratives. PSMs, in turn, provide the scaffolding for structuring dialogue, negotiating values, and legitimising decisions in a pluralistic context. Together, under the umbrella of More-Than-Human-Rights, these approaches constitute a hybrid planning toolkit for the Anthropocene, one in which non-human life is not only ethically acknowledged but legally and methodologically integrated into landscape governance. This shift in perspective responds to a growing recognition in recent decades that dominant legal frameworks, centred on individual rights and anthropocentric assumptions, are insufficient for addressing ecological crises (Fukurai & Krooth, 2021).

As emphasised by environmental scholars and legal theorists (Fensterseifer et al, 2024), there is a pressing need to advance a conception of rights grounded in relational responsibility and ecological interdependence. More-Than-Human-Rights proposes an expansion of legal standing to include non-human entities as subjects of rights. As César Rodríguez-Garavito, founder of the More Than Human Life - MOTH project (Rodríguez-Garavito, 2024), notes, the emphasis must move beyond the static "Rights of Nature" to a more dynamic and reciprocal framework that foregrounds human-nonhuman entanglement (Gilbert et al, 2023).

Several legal developments across the globe reflect this emerging paradigm. Ecuador's 2008 Constitution enshrines the rights of Pachamama to exist, persist, and regenerate its vital cycles (Berros, 2015). Bolivia's Law on the Rights of Mother Earth defines nature as a "collective subject of public interest", establishing legal recognition for ecosystems (International Rights of Nature Tribunal, 2020). In New Zealand, the Te Urewera forest and Whanganui River have been granted legal personhood through bicultural legal arrangements that draw from Māori worldviews, which see these landscapes as living ancestors (Bieluk, 2020). In Europe, Spain's Mar Menor lagoon became the first European ecosystem to receive legal personality, following a citizen-led initiative that involved over 500,000 people (Krämer, 2023). The new law recognises the lagoon's rights to exist, evolve, and be restored, and establishes a participatory governance model involving institutions, civil society, and scientists.

These examples signal a shift in legal consciousness: from viewing the landscape as a passive stage for human activity to acknowledging it as a legal-ecological commons, a co-produced and shared domain of rights, responsibilities, and care (Pelizzon, 2023). This reframing raises critical questions about representation: who is entitled to speak for trees, rivers and mushrooms?

In New Zealand, representation is entrusted to bicultural governance bodies reflecting Indigenous knowledge

(Stewart, 2018). Elsewhere, theorists such as Klaus Bosselmann (Bosselmann, 2021) have advocated for "ecological guardians" or "trustees" to act on behalf of planetary commons, potentially under the auspices of the United Nations. The UN's Harmony with Nature programme (Assembly, 2010), launched in 2009, embodies this ambition by promoting Earth Jurisprudence (Cullinan, 2023) and supporting legal recognition for Nature and the establishment of a new governance system to protect common goods.

In this context, More-Than-Human-Rights opens a conceptual space in which AI and PSMs can converge, encouraging a new interpretative approach to the landscape, leading to alternative and plural descriptions and promoting more inclusive and responsible landscape planning. AI tools can act as mediators of non-human signals, interpreting forest acoustics, soil conditions, or hydrological patterns and translating them into meaningful inputs for governance (Alotaibi & Nassif, 2024). These computational insights, while powerful, gain full relevance when embedded within PSM-based participatory processes that facilitate dialogue, deliberation, and value negotiation across diverse human and non-human actors.

By adopting More-Than-Human-Right as a guiding logic, it is possible to move from purely advocacy-driven approaches to speculative and systemic forms of governance, ones capable of representing not only human interests but also multispecies concerns.

To explore how this framework might unfold in practice, the following section presents an experimental workshop designed to examine whether, and how, such a process can support deliberation on multispecies justice and ecological responsibility. It illustrates how the concept of More-Than-Human Rights can inform the co-design of more inclusive landscape storytelling practices.

Mytilus in Fabula: a More-Than-Human Rights Workshop in Bacoli

The Mussels Tales design research laboratory, part of the PNRR CHANGES project (Cultural Heritage Active Innovation for a Next Generation Sustainable Society), is promoted by the Department of Architecture (DIARC) at the University of Naples Federico II. It aims to develop innovative methodologies for enhancing cultural heritage in the Campi Flegrei area, an ecologically, geologically, and culturally significant landscape. Mussels Tales explores generative, relational, and sustainable approaches to historic productive landscapes. Rather than treating the landscape as a passive backdrop or monument, it is framed as a living, open system shaped by ecological, historical, and design processes.

The project focuses on the Fusaro area, specifically the Borbonico Park, the Casina Vanvitelliana, and the Cassone, an ancient mussel storage facility now in ruins. These sites will be temporarily reactivated through a site-specific artistic installation, conceived as a relational device to host public activities, workshops, and collaborative explorations.

One of the initiatives, part of this laboratory, is an experiential, participatory activity titled Mytilus in Fabula, grounded in a More-Than-Human Rights perspective. This approach recognises landscapes as dynamic ecosystems composed of interdependent human and non-human agents. The activity uses PSMs, such as collective mapping, identity-based role-play, and co-creation, to frame complex territorial issues and stimulate inclusive dialogue. Participants engage in an exploratory walk along Lake Fusaro, designed as a game of impersonation. Each participant receives a character card, generated with the aid of AI, that assigns them the identity of an agent within the ecosystem (e.g., mussels, fish, birds, plants, or even pollutants like plastic). These cards help reveal the relational logic of the environment, encouraging participants to explore the lake's diverse habitats: urban, lakefront, coastal, and woodland, through the eyes of their assigned agent. As they walk from the Casina Vanvitelliana to the Cassone, participants collect signs, traces, and observations tied to their agent's habitat. Without revealing their identity, they contribute clues that support a shared reconstruction of the local ecosystem. This final co-creation moment, held at the Cassone, becomes a decision-support platform, allowing the group to visually and narratively model the network of relationships and tensions at play.

By combining AI-generated identities with participatory PSMs, the activity helps translate the abstract notion of More-Than-Human-Rights into a tangible process of collective sense-making. It foregrounds the perspectives of non-human entities and reframes landscape storytelling as a pluralistic, equitable process. Moreover, the workshop format fosters awareness, empathy, and responsibility toward all forms of life, human and non-human, while broadening civic engagement in environmental governance. In this way, Mytilus in Fabula transforms the More-Than-Human Rights framework into operational practice, opening up space for more inclusive, relational, and responsive ways of caring for contemporary landscapes.

Conclusions

This research highlights the urgent need for a radical transformation in how landscapes are narrated, interpreted, and valued, calling for a shift away from anthropocentric paradigms and towards a more relational, multispecies, and interdependent worldview.

By embedding AI and PSMs into the design of participatory activities, the More-Than-Human-Right framework encourages new modes of representation and imaginative identification with non-human entities, thereby deepening ecological awareness. This complex framework invites planners and researchers to reconsider their practices, not just by integrating more complex data, but by actively listening to the "voices" of multiple beings and by rethinking what counts as knowledge, agency, and justice in territorial governance. Such a framework not only redefines methodological tools; it also demands a new human sensibility, an openness to perceiving and cohabiting change with care.

The Campi Flegrei case study embodies this methodological synthesis: here, human perspectives are intentionally reframed in favour of non-human points of view, paying attention to the relational dynamics that foster collective intelligence across species and material forms. In the Campi Flegrei context, the Mytilus in Fabula initiative provides a concrete case of how participatory and AI-enhanced storytelling can converge to reveal neglected ecological relationships. It proposes an expanded conception of landscape as a site of ecological entanglements, rather than as a neutral or passive backdrop for human activity. The operationalisation of a More-Than-Human Rights framework calls for a rethinking of the planner's role, from that of a neutral technician to an ecological mediator capable of navigating affective, historical, and multispecies relationships. In this view, the landscape is interpreted as a web of memories, conflicts, and co-evolving dynamics.

However, translating this framework into practice faces several significant challenges. One central issue is the representation of non-human entities: how can planners and designers include these agents without reducing them to simplistic symbols or anthropomorphic caricatures? There is also the deeper difficulty of translating this conceptual richness into institutional practice, given that current regulatory and planning frameworks are deeply rooted in human exceptionalism and often lack the cultural and legal tools needed for recognising non-human agency. Moreover, the inclusion of More-Than-Human perspectives raises questions about voice, translation, and legitimacy: how can their needs and rhythms be made legible within decision-making systems structured around human priorities?

Addressing these questions requires a profound recalibration of what participation means in planning. It demands that we go beyond human-centred consultation and representation, instead developing systems that can sense, interpret, and respond to the expressions of non-human life. Here, PSMs offer participatory and iterative frameworks capable of dealing with the messy, uncertain, and pluralistic nature of planning in ecologically entangled worlds. When expanded to incorporate non-human considerations, PSMs can help reframe planning problems to include ecological limits, multispecies dependencies, and non-verbal forms of expression. By synthesising large-scale datasets and simulating potential futures, AI can help planners and communities explore alternative scenarios that centre ecological integrity and multispecies justice. These tools allow for more dynamic storytelling practices, where landscapes are not merely planned or managed but narrated through the interactions, rhythms, and histories of human and non-human actors alike.

Crucially, this shift could reorient global planning frameworks, such as the 2030 Agenda and the Sustainable Development Goals, away from instrumental logics and toward a recognition of non-human entities as co-inhabitants and co-authors of spatial futures. It reframes planning not as a tool for managing nature, but as an ethical and creative process of co-existence, one that acknowledges the agency of all life forms and the entanglement of human wellbeing with planetary vitality.

In conclusion, adopting a More-Than-Human lens invites us to reimagine planning as a cultural and ethical practice of listening, interpreting, and co-creating with the More-Than-Human world. It proposes new politics and poetics of landscape, ones grounded in relationality, care, and multispecies coexistence, and committed to recognising the rights, needs, and contributions of all beings, defining some innovative perspectives on landscape planning.

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Assessing Climate Change Adaptability and Risk in Italian Territories Using Open Data

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Abstract
This study evaluates climate adaptability and risk across Italy using two open-data-based indices: the Climate Change Adaptability Index (CCAI) and the Climate Change Risk Index (CCRI). The CCAI measures resilience by balancing climate exposure (e.g., heatwaves, droughts) with adaptive capacity indicators (e.g., tree cover, soil permeability). The CCRI combines similar climate hazards with socio-economic vulnerability. Results reveal strong regional disparities as northern Italy shows greater adaptability, while southern regions face heightened risk. The territorial disparities are visible as well since inner and peripheral areas consistently exhibit lower adaptability and higher risk, while intermediate and metropolitan zones show more mixed profiles. This dual-index approach integrates environmental and socio-economic dimensions, offering a replicable method for territorial assessments. Findings show the value of open data and cross-sectoral governance for guiding sustainable, resilient urban and regional adaptation policies.

Keywords: Climate change adaptability, climate change risk, territorial sustainability, open data, Italy

1. Introduction

1.1. Territorial challenges of climate risk and adaptability

Italy's geographical diversity and socio-economic disparities led to an uneven territorial exposure and responsiveness to climate risks (CMCC and Enel Foundation, 2021). These risks are accelerated by global climate change, particularly within the Mediterranean Basin, identified as one of the most climate-sensitive areas globally (Medri *et al.*, 2013)

Temperature increases and hydrological stress are key climate threats. Projections indicate a potential +5°C rise in average temperature by 2100 under high-emission scenarios (Representative Concentration Pathway, RCP8.5 (Riahi *et al.*, 2007), with corresponding increases in hot and dry days and the intensification of heatwaves and droughts, especially in southern Italy and small islands. Precipitation patterns are expected to become more erratic, but the trend underlines a general increase of the intensity of rainfalls both in the North and South of Italy and seasonal declines more pronounced in central-southern Italy during summer and increased rainfall in northern regions during winter. These changes exacerbate Italy's already stressed water resources, particularly during summer months when demand from agriculture, industry, energy, and tourism peaks (Spano D., 2020).

These changes in the climate conditions also worsen the hydrogeological risks affecting Italy's territory, particularly vulnerable to geo-hydrological instability, including floods, landslides, and soil erosion. Approximately 91% of Italian municipalities are already exposed to this kind of hazards, and 94% are classified as at risk because of both natural and anthropogenic factors (Spano D., 2020). The increasing frequency of short, intense rainfall events makes the instability of fragile areas worse, especially in the Alpine and Apennine regions (CMCC and Enel Foundation, 2021).

Exposure is another key challenge. Italy is one of the most exposed countries in Europe to flood-related hazards with potential infrastructure losses ranging from €1.5 to €15.2 billion annually under high-emission climate scenarios in the period 2071-2100. (Spano D., 2020). Sea-level rise further threatens coastal zones, particularly in the northern Adriatic, while critical sectors such as agriculture and tourism face declining productivity and revenue due to shifting climate conditions (Medri *et al.*, 2013).

The evolving concept of territorial resilience, as proposed by Brunetta et al. (2019), emphasizes a proactive, integrated, and co-evolutionary approach to spatial planning. It advocates for a shift from reactive risk mitigation to adaptive strategies that incorporate socio-ecological and technological systems (SETS), focusing not only on physical robustness but also on institutional capacity, social learning, and cultural assets (Brunetta *et al.*, 2019).

In this context, there is a growing need for more informed planning approaches that integrate data-driven tools to support climate risk mitigation. Such methods are essential for identifying vulnerable areas, prioritizing interventions, and guiding territorial policies that are responsive to evolving environmental pressures.

These territorial and climatic challenges must also be viewed through the lens of vulnerability and risk theory. According to the IPCC (Intergovernmental Panel on Climate Change (IPCC), 2023), vulnerability encompasses exposure, sensitivity, and adaptive capacity, combining both external pressures and internal system characteristics. According to Füssel and Klein (Füssel and Klein, 2006), exposure refers to the extent of hazard contact, while sensitivity and adaptive capacity define a system's ability to respond. Evolving assessment frameworks (Bruno Soares *et al.*, 2012; Peng *et al.*, 2024) increasingly adopt integrated approaches that consider both socio-economic and ecological dimensions. This study aligns with this perspective, emphasizing the need to address both environmental stressors and social fragilities when assessing territorial climate resilience.

1.2. Role of Open Data in climate assessment

Open data plays an increasingly vital role in climate assessment by enhancing the transparency, replicability, and scale of data-driven analyses. In the context of climate change, especially for countries like Italy with strong regional variability, open data enables localized, evidence-based planning while fostering participatory and inclusive decision-making (Grinspan and Worker, 2021).

Beyond their analytical power, open data initiatives support democratic and cross-sectoral engagement. They allow various actors, e.g., planners, researchers, NGOs, and local authorities, to interpret, validate, and reuse the data for both policy and advocacy purposes (Open Governmental Partnership, 2024). Initiatives like OS-Climate, the Net-Zero Data Public Utility, and Dataland have demonstrated how neutral and collaborative data platforms can fill information gaps while reducing reliance on proprietary datasets (United Nations Environment Programme, 2024). This kind of platforms promote integrity, accessibility, and neutrality along with values essential for effective climate governance.

Despite the big potential of open access dataset for describing climate conditions and trends, their accessibility and usability can be lacking for non-experts. Moreover, the comparison of environmental data with other context-related conditions, such as socio-economic and infrastructural ones, may be relevant for taking comprehensive and informed decisions, based on the development of composite indices able to interrelate data from these different domains. Open-access datasets allow for the integration of environmental, socio-economic, and infrastructural information, which is essential for developing composite indices like in this contribution.

1.3. Aims and objectives

This study aims to develop a national-scale, open-data-based framework to assess climate change adaptability and risk across Italian territories. By utilizing datasets that are publicly accessible and easy to use for decision makers, researchers, as well as other professions who takes role in planning, we construct and apply two composite indices i.e., the Climate Change Adaptability Index (CCAI) and the Climate Change Risk Index (CCRI) to support spatialized, evidence-based planning. These indices were developed in a broader study under the framework of the GRINS (Growing Resilient, Inclusive and Sustainable) project, financed by the National Recovery and Resilience Plan (NRRP) in Italy. The objective is to identify regional and territorial patterns of exposure to climate-related hazards and adaptive capacity in order to underline climatic vulnerabilities that also consider other context-re-

lated variables, with the final aim of informing policy responses and prioritize place-based strategies.

More broadly, the study seeks to demonstrate how open data can be effectively operationalized in climate assessment, highlighting both the analytical potential and the structural limitations of this approach. In this framework, the research outcomes contribute to ongoing discussions on transparent, scalable methodologies for climate adaptation and territorial resilience planning.

The paper is structured as follows. Section 2 presents the materials and methods, including the GRINS main features and aims, open data sources, and the construction of the two composite indices i.e., CCAI and CCRI. Section 3 discusses the main results through a territorial lens, highlighting patterns of adaptability and risk across macro and micro typologies. It also includes a cross-index analysis to synthesize findings and identify most vulnerable areas related to climate conditions. The paper concludes by reflecting on the methodological strengths and limitations of the approach, emphasizing the value of open data in supporting spatially informed climate adaptation strategies.

2. Material and Methods

This study adopts a composite index approach to assess climate change adaptability and risk by integrating climate-related and socio-economic indicators. Moving from theoretical and empirical literature (Papathoma-Koehle *et al.*, 2016; Zhao *et al.*, 2020) key variables were identified that reflect either increased fragility (or risk) or adaptive capacity. Indicators such as temperature anomalies, duration of hot periods, and consecutive dry days capture exposure to climate hazards, while permeable soils and vegetation cover represent adaptive assets (Carter, 2018). Socio-economic conditions further influence local vulnerabilities and are embedded in the composite framework. The following subsections detail the taxonomy adopted (Section 2.1), open data sources and indicators (Section 2.2), and the structure of the indices (Sections 2.3 and 2.4).

2.1. Territorial classification developed in GRINS project

The project GRINS (Growing Resilient, Inclusive and Sustainable) (GRINS Foundation, n.d.) is part of an extended partnership funded under the National Recovery and Resilience Plan (Piano Nazionale di Ripresa e Resilienza, PNRR) by the Italian government and the European Union. It aims to create an open-access data platform supporting economic and financial sustainability of territories through research, policy analysis, and evaluation. GRINS is composed by nine spokes, conceived as sub-domains dedicated to address specific topics and produce related data. The present work was developed under Spoke 7 - Territorial sustainability, which aims to investigate and assess territorial disparities, vulnerabilities and gaps to orient more effective policies and actions.

Within Spoke 7 one important analytical output was the development of the "GRINS taxonomy", a methodological approach aimed at classifying Italian territories based on their functional and spatial characteristics. This taxonomy is developed by integrating multiple classification systems, including the National Strategy for Inner Areas (Strategia Nazionale per le Aree Interne,SNAI), the classification of metropolitan areas produced by the National Institute of Statistics (ISTAT), and the OECD Functional Urban Areas (FUAs) framework (Caramaschi *et al.*, 2024). The methodology used the municipal classification dataset of all Italian municipalities provided by ISTAT, which comprises population density and territorial boundaries, for dividing the municipalities into three main macro-classes as follows (see Figure 1a):

1. Inner Italy (Italia Interna), representing peripheral and ultra-peripheral areas identified by elaborating and enriching the National classification of inner areas given by SNAI (2014 and 2020).
2. Intermediate Italy (Italia di Mezzo), which encompasses territories that fall between inner and metropolitan areas. These include medium-sized cities, metropolitan fringes, and urban-rural continua.
3. Metropolitan Italy (Italia Metropolitana), including municipalities that are part of metropolitan areas or classified as Functional Urban Areas (FUAs).

Beyond these three macro-classes, the GRINS taxonomy foresees thirteen distinct sub-classes across the three

macro-classes (see Figure 1b), providing a nuanced understanding of specific territorial differences and dynamics. These include:

- **Inner Italy**: 1.1.1 Inner, remote and sparsely populated area; 1.1.2 Inner and remote area with medium population density; 1.2.1 Sparsely populated inner area closest to a metropolitan area; 1.2.2 Inner area with medium population density closest to a metropolitan area.
- **Intermediate Italy**: 2.1.1.1 Sparsely populated mountain/inland hill urban-rural continuum; 2.1.1.2 Mountain/inland hill urban-rural continuum with medium population density; 2.1.2.1 Sparsely populated coastal and/or lowland urban-rural continuum; 2.1.2.2 Coastal and/or plain urban-rural continuum with medium population density; 2.2 Medium-sized city or non-FUA capital; 2.3 De facto or de jure metropolitan fringe.
- **Metropolitan Italy**: 3.1.1 De facto metropolitan centre; 3.2.1 De jure and de facto metropolitan area (not capital); 3.2.2 Metropolitan capital.

This classification system serves as the foundation for identifying socio-economic and environmental vulnerabilities, including climatic vulnerability, covering the whole Italian territory but providing data at municipal scale and across the different territorial classes. The final goal is to ease the definition of targeted territorial policies and sustainable development strategies.

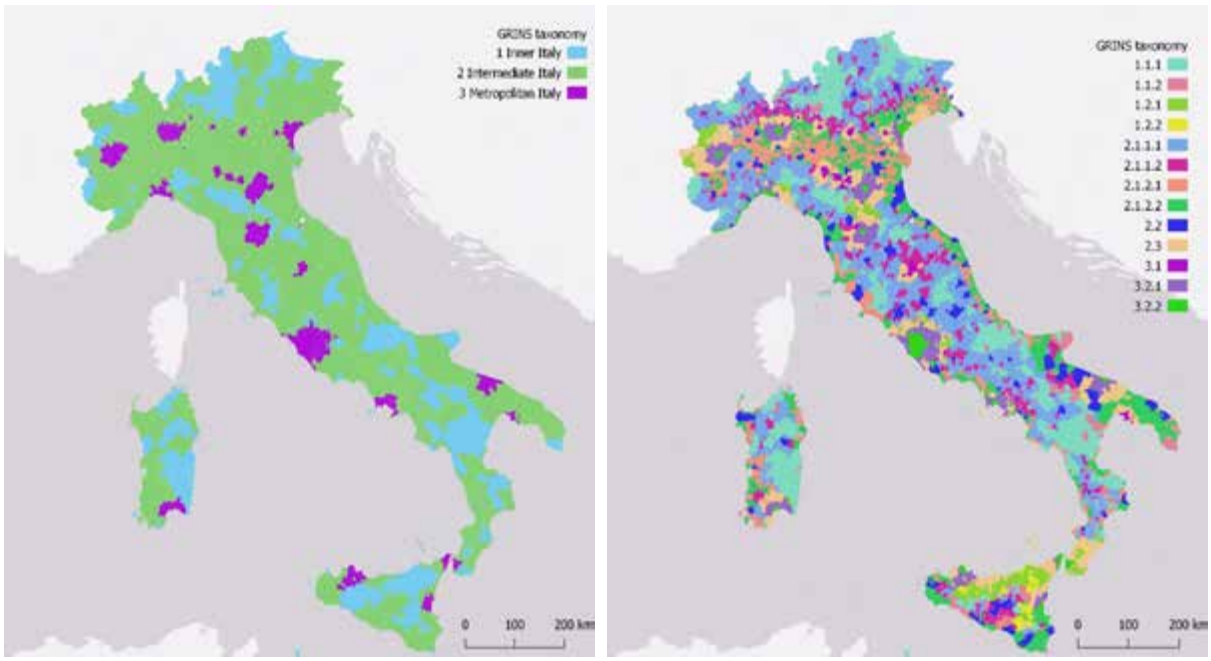

Figure 1. Taxonomy of Italian municipalities, developed within the GRINS project. (a) macro classes and (b) micro-classes. The classification system distinguishes three macro territorial categories (Inner, Intermediate, and Metropolitan Italy) and 13 micro-classes (produced after (Caramaschi *et al.*, 2024))

2.2. **Open Data Sources and indicator Selection**

The construction of both composite indices, i.e., CCAI and CCRI, relied on the selection of key indicators that are accessible, spatially detailed, and relevant to climate-related exposure, adaptive capacity, and socio-economic vulnerability. In order to develop robust and replicable indices, open datasets are prioritized with national coverage and adequate spatial granularity, preferably at the municipal (LAU) or provincial (NUTS3) level.

To ensure consistency and comparability, all data were pre-processed and harmonized. This involved normalization, imputation of missing values, and alignment of temporal and spatial resolutions. While most socio-economic indicators were available at the municipal level through ISTAT (Italian National Institute of Statistics), climate variables required further adaptation, often drawing from higher-resolution grid or provincial-level data.

The initial step was to identify the data needed and seek for the data sources. The most relevant datasets are identified ensuring high spatial and temporal resolution (see Tables 1 and 2) were sourced from national and international open databases including:
- ISTAT (Italian National Institute of Statistics): comprising many datasets for describing socio-economic data, including population density and income levels.
- Copernicus Climate Change Service: Climate-related variables, including temperature trends, heatwave duration, and precipitation data.
- EDJNet (European Data Journalism Network, i.e., a network of media organisations from across Europe, producing and promoting data-driven coverage of European issues, including environmental datasets): Surface temperature map of each municipality.

The sources of each datum, both temporal and territorial coverages, are provided in Tables 1 and 2.

While open data provides a transparent and accessible foundation for territorial analysis, their use introduces certain methodological considerations that required adaptation. The availability and quality of data were not uniform across all indicators and regions. For instance, some datasets, particularly climate variables like temperature trends and heatwave duration, were available at a high spatial resolution (provincial or grid-based), while socio-economic data from ISTAT often had a finer municipal-level granularity.

To address these challenges, the methodology was adapted by employing harmonization techniques to align indicators with differing spatial and temporal resolutions. For variables lacking high-resolution data, provincial-level indicators were aggregated or downscaled as proxies to ensure consistency within the composite indices. Despite these limitations, reliance on open data remains essential for fostering replicable and inclusive research.

2.3. **Climate Change Adaptability Index (CCAI)**

CCAI aims to provide a general measure of the level of response of environmental/anthropogenic factors to climate effects affecting a given territory, by adopting a balanced assessment between factors that are positive for adaptation to climate change and factors that hamper adaptation. The index has been calculated by considering the previous works (i.e., (Assumma *et al.*, 2019; Brunetta *et al.*, 2018) which was transposed in the climate domain, by considering indicators provided by different sources. Basically, the adopted method aims at calculating two synthetic indexes that respectively measure the exposure (E) of the socio-ecological system, and its adaptive capacity (A) by adopting a general perspective. This means considering climatic factors that might influence different spheres, such as the environment as well as the society. The index does not aim at being totally exhaustive in terms of indicators adopted (whose selection is influenced by data availability), however it is a valuable tentative to synthesize any vulnerabilities that can be further investigated.

Table 1. Indicators used to construct the Climate Change Adaptability Index (CCAI), including temporal and territorial coverage, units of measurement, and data sources. The composite index (I.1) is calculated based on five indicators (I.1.1–I.1.5).

Index	Code	Indicator Name	Temporal Coverage	Territorial Coverage	Unit	Data Source
1 CCAI	I.1.1	Consecutive days without rain	2021	Provincial (NUTS3)	n of days	ISTAT
	I.1.2	Duration of hot periods	2021	Provincial (NUTS3)	n of days	ISTAT
	I.1.3	Average temperature increase (1960-2018)	2018	Municipal (LAU)	°C	EDJNet
	I.1.4	Tree canopy density	2018	Municipal (LAU)	%	COPERNICUS
	I.1.5	Permeability	2018	Municipal (LAU)	%	COPERNICUS

The exposure component (E) is derived from the normalized values taking the municipal scale as base to have values between 0 and 1 of following indicators:

- **1.1 Consecutive days without rain**, i.e., maximum number of consecutive days in the year with daily rainfall less than or equal to 1 mm.
- **1.2 Duration of hot periods**, i.e., number of days in the year in which the maximum temperature is above the 90th percentile of the distribution in reference climatological period (1981-2010), for at least six consecutive days.
- **1.3 Average temperature increase from 1960 to 2018**, i.e., temperature variation occurred between the mean temperature values for the two decades considered (1961-1970 and 2009-2018).

The adaptive capacity component (A) is calculated from the normalized values of followings:
- **1.4 Tree canopy density**, i.e., tree cover density represents the percentage of a surface area covered by trees and vegetation in relation to the total surface area.
- **1.5 Permeability mean percentage value of permeable surfaces in a given area**, i.e., calculated by considering the complementary percentage of imperviousness provided by the HRL Copernicus dataset Imperviousness density.

CCAI, is calculated following the Equation through combining these two indexes:

$$CCAI = (A - E) / (A + E)$$

Positive values mean a prevalence of A; negative values mean a prevalence of E. Consequently, the more the negative value, the high the vulnerability.

2.4. **Climate Change Risk Index (CCRI)**
The Climate Change Risk Index (CCRI) captures the intersection of climate hazards and socio-economic vulnerability, highlighting regions where fragile socio-economic conditions are most impacted by increasing climatic extremes. As already anticipated climate risk is a combination of local hazards, exposure, and vulnerability and drought and warming represent the most critical challenges in Italy (Papathoma-Koehle *et al.*, 2016; Zhao *et al.*, 2020).

Therefore, the Climate Change Risk Index (CCRI) integrates exposure to those two climate-related hazards with socio-economic vulnerability to assess the overall risk faced by different territories. While CCAI aims to assess the above-mentioned climate hazards in relation to the adaptation response present in different contexts, CCRI aims to compare the climate hazards with the socio-economic vulnerability, in order to underline how the socioeconomic sphere is at risk in terms of climate change hazards. Therefore, climate change risk index indicates how much climate change hazards impact the socio-economic sphere of the territory, highlighting situations of greater risk and therefore more fragile situations. The index is calculated by averaging the combined exposure indicators with the socio-economic vulnerability index (SEVI), a composite indicator that captures the underlying susceptibility of communities to these hazards.

Table 2. Indicators used to construct the Climate Change Risk Index (CCRI), including temporal and territorial coverage, units of measurement, and data sources. The composite index (I.2) is based on three climatic stress indicators and one socio-economic vulnerability index (SEVI) (I.2.1–I.2.4).

Index	Code	Indicator Name	Temporal Coverage	Territorial Coverage	Unit	Data Source
2 CCRI	I.2.1	Consecutive days without rain	2021	Provincial (NUTS3)	n of days	ISTAT
	I.2.2	Duration of hot periods	2021	Provincial (NUTS3)	n of days	ISTAT
	I.2.3	Average temperature increase from 1960 to 2018	2018	Municipal (LAU)	°C	EDJNet
	I.2.4	Socio-economic vulnerability index (SEVI)	2019/2022	Municipal (LAU)	NA	Authors' elaboration

Formally, the index considers three exposure indicators and the socio-economic vulnerability index:
- **2.1 Consecutive Days Without Rain i.e.,** the maximum number of consecutive days in a year during which daily rainfall is less than or equal to 1 mm. Longer dry spells increase the exposure to drought conditions, impacting water availability and agriculture, and thus elevating climate risk.
- **2.2 Duration of Hot Periods, i.e.,** the number of days in a year where the maximum temperature exceeds the 90th percentile of the baseline climatological period (1981–2010) for at least six consecutive days. Prolonged heatwaves intensify exposure to extreme heat, posing threats to human health, infrastructure, and ecosystems.
- **2.3 Average Temperature Increase from 1960 to 2008, i.e.,** measures the **temperature variation** between two reference decades (1961–1970 and 2009–2018). An increase in average temperature signifies long-term warming trends, contributing to heightened exposure to climate-related hazards such as heat stress and altered precipitation patterns.
2.4 Socio-economic vulnerability index (SEVI), a composite indicator developed by the authors to capture territorial socio-economic fragility. It is calculated as the weighted average of four normalized variables: (1) old-age dependency ratio, (2) gross available income per capita, (3) employment rate (age 20–64), and (4) education level (lower secondary school attainment).

The result provides a comprehensive measure of the overall climate change risk, highlighting areas where climatic extremes intersect with fragile socio-economic conditions.

3. Results and Discussion

3.1. Climate Change Adaptability Index (CCAI)

The Climate Change Adaptability Index (CCAI) provides a measure of territorial resilience by balancing exposure to climate risks with the adaptive capacity. The results reveal significant disparities in adaptability across the national territory, with clear differences between northern and southern Italy, also confirming what was found in another recent study (Medri *et al.*, 2013).

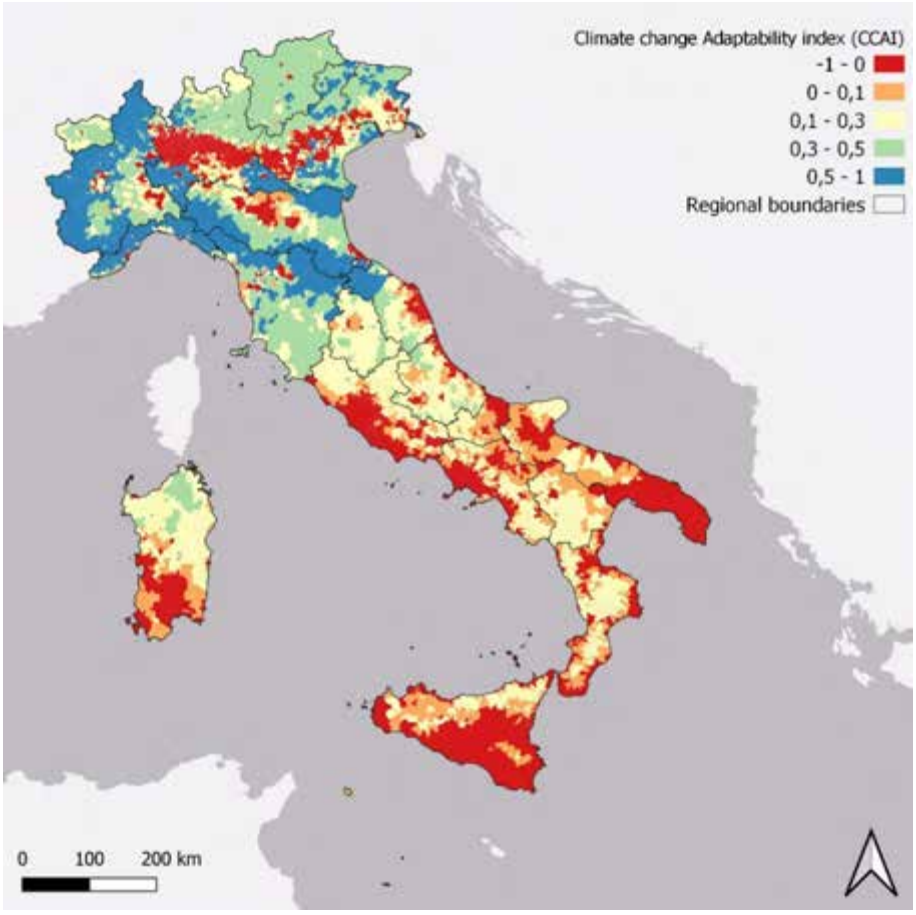

Figure 2. Climate change adaptability index (CCAI) across Italy. Higher index values indicate stronger natural and infrastructural capacity to buffer climate stress, particularly visible in northern and mountainous regions. Lower scores in southern and urbanized areas reflect limited adaptive assets and higher exposure to climatic hazards.

The spatial distribution of the CCAI scores, as presented in Figure 2, shows a clear contrast between northern and southern Italy. On one hand, territories with higher scores, primarily located in northern regions, exhibit favourable conditions such as dense tree canopy coverage and high soil permeability, which enhance natural climate resilience. These areas, including parts of the Alpine and pre-Alpine zones, benefit from robust governance and active climate action strategies, reflected in their positive index values. Conversely, regions in southern Italy and the islands show significantly lower scores due to prolonged droughts, higher exposure to heatwaves, and sparse natural buffers such as vegetation and permeable soils. Municipalities in regions like Sicily and Calabria recorded particularly negative index values, highlighting the urgent need for targeted interventions.

Table 3. Average values of the Climate Change Adaptability Index (CCAI) and its component indicators (1.1 to 1.5) across different territorial typologies in Italy. Values are shown for each typology and sub-typology, including inner, intermediate, and metropolitan areas.

Territorial Typology	1.1	1.2	1.3	1.4	1.5	CCAI
1 INNER ITALY	29	16	2.2	39	39	0.26
1.1.1 – Inner, remote and sparsely populated area	28	16	2.2	99	41	0.34
1.1.2 – Inner and remote area with medium population density	29	19	2.34	95	32	0.07
1.2.1 – Sparsely populated inner area closest to a metropolitan area	31	19	2.1	90	36	0.09

1.2.2 – Inner area with medium population density closest to a metropolitan area	29	15	2.07	73	40	0.05
2 INTERMEDIATE ITALY	25	12	2.07	94	29	0.19
2.1.1.1 – Sparsely populated mountain/inland hill urban-rural continuum	26	14	2.06	98	40	0.34
2.1.1.2 – Mountain/inland hill urban-rural continuum with medium population density	25	12	2.03	84	38	0.16
2.1.2.1 – Sparsely populated coastal and/or lowland urban-rural continuum	25	12	2	96	11	0.26
2.1.2.2 – Coastal and/or plain urban-rural continuum with medium population density	25	13	2.06	90	12	-0.13
2.2 – Medium-sized city or non-FUA capital	28	12	2.06	74	20	-0.11
2.3 – De facto or de jure metropolitan fringe	25	12	2.01	85	16	0.03
3 METROPOLITAN ITALY	28	14	2.2	85	23	-0.17
3.1.1 – De facto metropolitan centre	22	11	2.14	89	25	-0.17
3.2.1 – De jure and de facto metropolitan area (not capital)	24	12	2.21	85	23	-0.16
3.2.2 – Metropolitan capital	33	17	2.06	74	17	-0.44

When analysed through the territorial typologies, Inner Italy shows mixed results as it can be seen in Table 3. Inner, remote, and sparsely populated areas (1.1.1) have a relatively positive score of 0.34, benefiting from natural assets such as forests and low urban density. However, Inner areas with medium population density closest to metropolitan zones (1.2.2) record a score of only 0.05, reflecting challenges tied to urban pressure and limited natural buffers. Similarly, Intermediate Italy demonstrates variability, with sparsely populated coastal and lowland urban-rural continuums (2.1.2.1) scoring 0.26 due to moderate adaptive assets, while urban-rural plains (2.1.2.2) face negative adaptability (-0.13) due to land-use pressures. Metropolitan Italy, while economically strong, exhibits clear vulnerabilities. Metropolitan capitals (3.2.2) report the lowest adaptability scores (-0.44), driven by high exposure and urbanization. Overall, the findings confirm that the adaptive capacity plays a critical role in building territorial resilience to climate risks. Regions with natural assets such as forests and permeable soils demonstrate higher adaptability, while urban and coastal areas, particularly in southern and metropolitan contexts, exhibit negative scores driven by high exposure and limited adaptive measures. Targeted interventions such as reforestation, sustainable land management, and climate governance improvements are essential for reducing vulnerabilities, particularly in areas identified as high-risk zones.

3.2. **Climate Change Risk Index (CCRI)**

The Climate Change Risk Index (CCRI) captures the intersection of climate hazards and socio-economic vulnerability, highlighting regions where fragile socio-economic conditions are most impacted by increasing climatic extremes. Climate risk emerges from a combination of local conditions, including hazards, exposure, and vulnerability. In the Italian context, drought and warming represent the most critical challenges, necessitating the consideration of indicators such as temperature increase, duration of hot periods, and consecutive days without rain to assess both current conditions and future projections (Papathoma-Koehle *et al.*, 2016; Zhao *et al.*, 2020) While the CCAI previously assessed climatic hazards in relation to adaptive capacity, the CCRI focuses on how these hazards intersect with socio-economic vulnerability. This comparison highlights how territorial risks are magnified by fragile socio-economic conditions, such as low income, employment rates, and aging populations. Consequently, the CCRI underscores regions where climate change hazards exert the most significant pressure on the socio-economic sphere, identifying situations of heightened risk and territorial fragility that require urgent intervention.

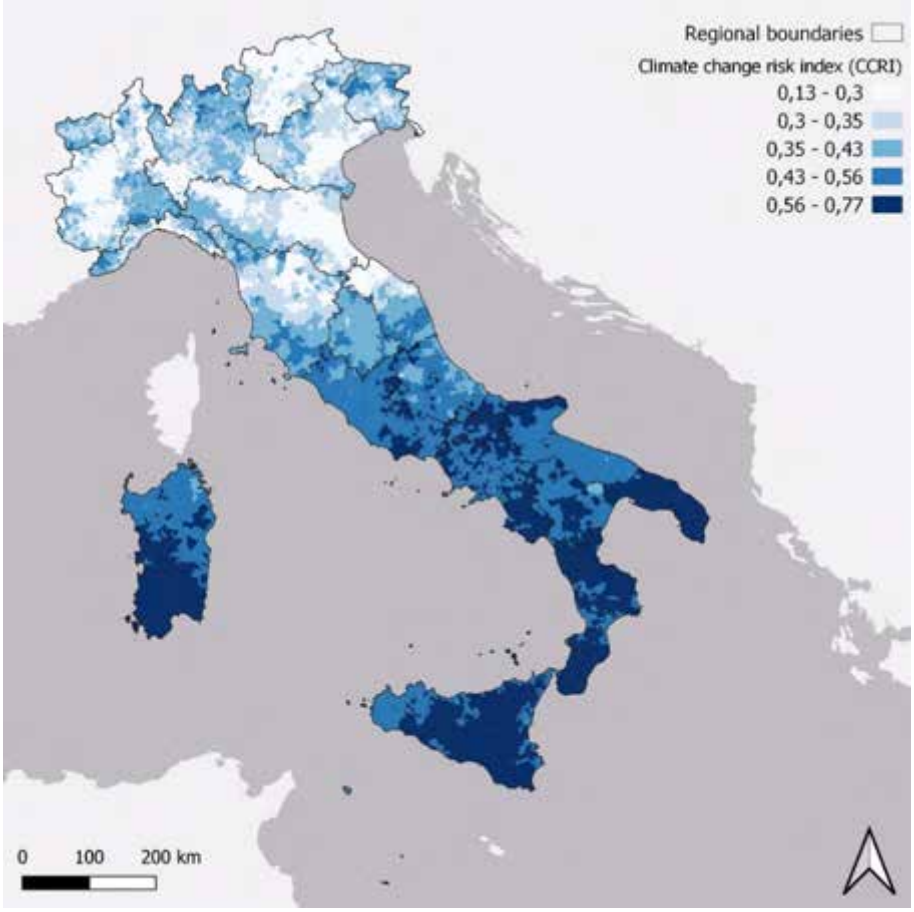

Figure 3. Climate Change Risk Index (CCRI) across Italy. Higher risk scores are concentrated in southern and rural regions, where climatic stressors coincide with fragile socio-economic conditions. Lower risk is observed in more resilient northern and metropolitan areas, though local hotspots remain due to uneven vulnerability patterns.

As Figure 3 shows, the southern regions, particularly Calabria, Sicily, and Apulia, exhibit the highest CCRI scores, exceeding 0.56. This pattern is primarily driven by prolonged exposure to extreme climatic events, such as extended consecutive days without rain (40.60 in inner areas) and duration of hot periods (22.40 days in certain areas). These regions also face socio-economic challenges, such as lower income levels and higher demographic pressures, which further amplify vulnerability. For example, inner remote areas show a SEVI of 0.54, exacerbating the region's inability to cope with climatic stressors. This pattern aligns with findings from another study (Mysiak *et al.*, 2018), which developed a Climate Risk Index for Italy to support national adaptation planning. While their approach relies on high-resolution gridded data and multi-model climate projections from EURO-CORDEX to simulate future scenarios (2021–2100), the present study focuses on recent observational data from open-access national sources to construct two present-day indices. A key methodological distinction lies in the composition of the indices: the Climate Risk Index incorporates a broader set of variables, including manufactured, natural, social, and economic capital, while the present study uses a more streamlined and spatially detailed set of indicators, emphasizing biophysical features (e.g., canopy cover, soil permeability) and socio-economic vulnerability.

Table 4. Average values of the Climate Change Risk Index (CCRI) and its component indicators (2.1 to 2.4) across different territorial typologies in Italy. Values are presented for each typology and sub-typology, including inner, intermediate, and metropolitan areas.

Territorial Typology	2.1	2.2	2.3	2.4	CCRI
1 INNER ITALY	28.97	16.48	2.2	0.52	0.5
1.1.1 – Inner, remote and sparsely populated area	28.27	15.56	2.2	0.54	0.49
1.1.2 – Inner and remote area with medium population density	28.65	19.27	2.34	0.45	0.49
1.2.1 – Sparsely populated inner area closest to a metropolitan area	31.21	18.74	2.1	0.49	0.52
1.2.2 – Inner area with medium population density closest to a metropolitan area	40.6	22.4	2.13	0.45	0.47
2 INTERMEDIATE ITALY	25.1	11.92	2.06	0.49	0.43
2.1.1.1 – Sparsely populated mountain/inland hill urban-rural continuum	25.94	14.29	2.06	0.49	0.43
2.1.1.2 – Mountain/inland hill urban-rural continuum with medium population density	22.54	10.89	2.03	0.38	0.37
2.1.2.1 – Sparsely populated coastal and/or lowland urban-rural continuum	25.29	7.82	1.94	0.34	0.38
2.1.2.2 – Coastal and/or plain urban-rural continuum with medium population density	25.17	12.86	2.15	0.35	0.43
2.2 – Medium-sized city or non-FUA capital	28.2	15.74	2.02	0.42	0.39
2.3 – De facto or de jure metropolitan fringe	25.38	12.1	2.01	0.39	0.36
3 METROPOLITAN ITALY	28.23	14.33	2.2	0.31	0.4
3.1.1 – De facto metropolitan centre	22.18	10.59	2.06	0.3	0.36
3.2.1 – De jure and de facto metropolitan area (not capital)	28.23	14.34	2.21	0.31	0.4
3.2.2 – Metropolitan capital	32.82	16.79	2.06	0.35	0.42

Table 4 summarizes the numerical findings separated by territorial typologies. In inner Italy, sparsely populated areas close to metropolitan regions demonstrate CCRI values of 0.52, driven by a combination of exposure indicators such as 31.21 consecutive dry days and moderate socio-economic vulnerabilities. These results emphasize that rural and remote areas remain disproportionately affected due to limited adaptive capacity, aging populations, and weaker economic conditions.

Conversely, northern and central Italy, particularly in metropolitan areas, show lower levels of climate change risk. Metropolitan regions like Lombardy and Veneto report CCRI scores as low as 0.36–0.40, reflecting favorable conditions, including shorter dry spells (22.18 consecutive days) and stronger economic resilience, evidenced by socio-economic index values as low as 0.31. However, even within metropolitan Italy, capital cities demonstrate slightly higher risk values (0.42), indicating localized challenges associated with urban heat and socio-economic disparities.

The results for intermediate Italy present a nuanced picture. Sparsely populated mountain and inland urban-rural areas report CCRI scores around 0.43, with lower exposure indicators but socio-economic vulnerabilities, such as aging populations and reduced employment rates. Areas with medium-sized cities demonstrate slightly better resilience, but exposure to warming trends still highlights the need for targeted adaptation measures.

Overall, the CCRI underscores the territorial patterns of climate risk across Italy. Southern and rural areas face the most significant challenges, where prolonged dry periods, rising temperatures, and economic fragility combine

to amplify vulnerability. In particular, Calabria region and some parts of Sicily score high both on climate exposure and socio-economic vulnerability with SEVI values exceeding 0.50. In contrast, northern and central metropolitan areas demonstrate lower hazard exposure and stronger socio-economic resilience. Intermediate Italy reflects a mixed picture: while some subtypes benefit from natural buffers, socio-economic fragilities in sparsely populated or mountainous areas contribute substantially to overall risk levels.

Addressing these disparities requires region-specific strategies that improve both adaptive capacity and socio-economic conditions, particularly in high-risk areas, through investments in green infrastructure, economic development, and climate-responsive policies.

Despite lower average CCRI values in several territorial typologies, approximately 27% of municipalities exhibit high climate risk due to socio-economic fragility as well. For example, many are located in urban-rural continuums or sparsely populated inner areas, demonstrate CCRI values above 0.50 and SEVI scores exceeding 0.50, placing them among the most vulnerable within otherwise more resilient typologies. These cases illustrate the importance of disaggregated assessments and reveal "outlier municipalities" (see Figure 4) that may be masked by broader territorial averages, as well as showing the impact of SEVI in CCRI. Recognizing such outliers is critical for ensuring that adaptation strategies are not only regionally targeted but also attentive to intra-regional inequalities.

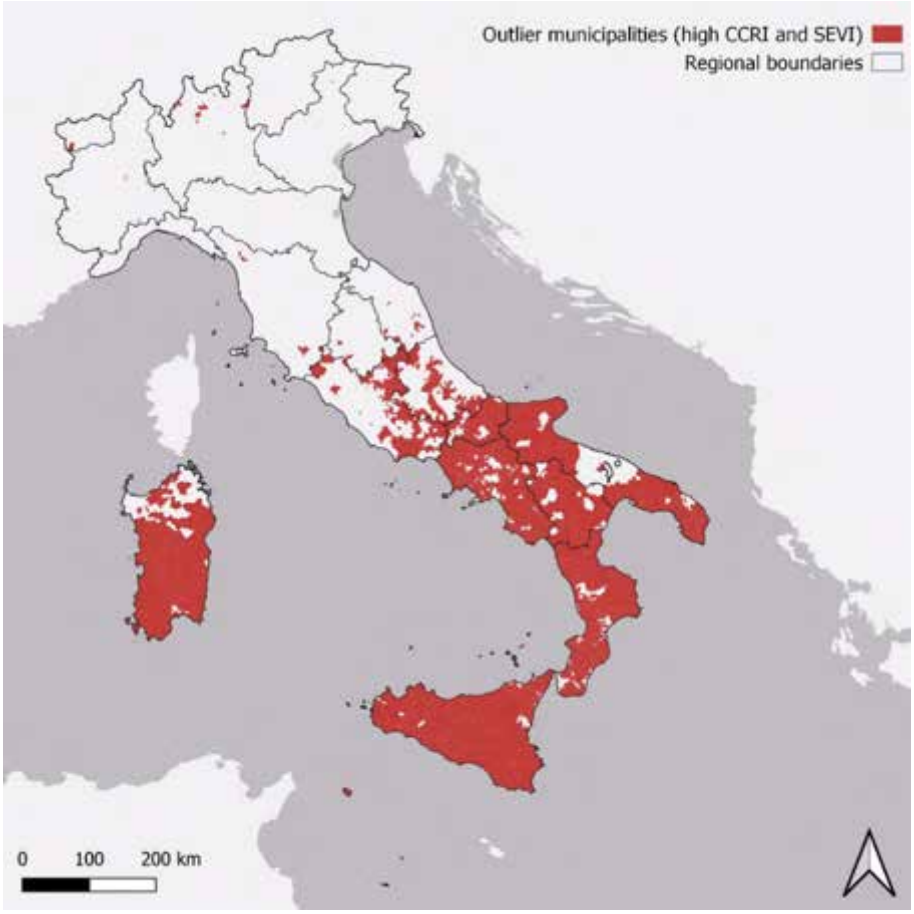

Figure 4. Municipalities with both CCRI and SEVI values above 0.50, identifying territorial climate resilience patterns.

3.3. **Cross-Index Analysis of Adaptability and Risk**

Bringing together the Climate Change Adaptability Index (CCAI) and the Climate Change Risk Index (CCRI) enables a more nuanced understanding of territorial resilience and fragility in Italy. While the CCAI reflects the capacity

of local systems to withstand climatic stress through natural and infrastructural buffers, the CCRI reveals where climate hazards overlap with socio-economic vulnerability. Viewing the indices together highlights critical intersections where resilience strategies are most urgently needed.

Both CCAI and CCRI are unitless composite indices derived from normalized data, which allows their spatial patterns to be jointly visualized.

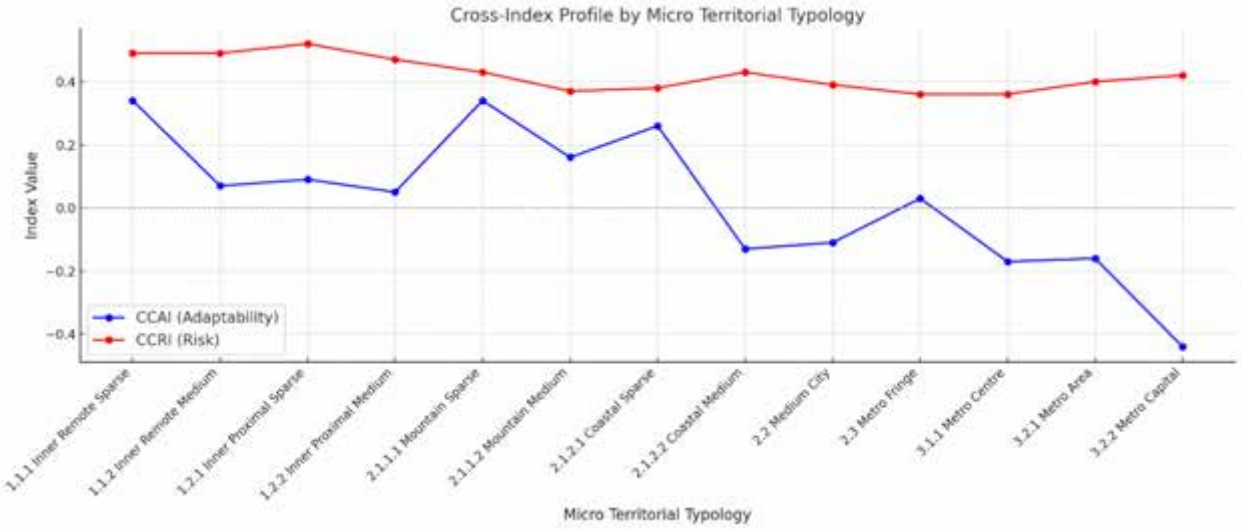

Figure 5. Climate Change Adaptability Index (CCAI) and Climate Change Risk Index (CCRI) across Italian micro territorial typologies. The figure highlights the inverse spatial relationship between adaptability and risk, with notable disparities across inner, intermediate, and metropolitan areas.

Figure 5 illustrates a cross-index plot showing the distribution of scores across micro territorial typologies. A striking feature of the plot is the consistent and steep drop in CCAI scores for metropolitan capitals (3.2.2), which contrasts with their moderate CCRI values—revealing a scenario where high exposure and environmental stress are somewhat offset by socio-economic robustness. Conversely, inner areas (e.g., 1.2.2) show moderate adaptability yet relatively high risk, illustrating the amplifying role of social vulnerability in rural or peri-urban contexts.

This combined perspective reinforces key findings from the previous sections: while natural conditions (e.g., canopy density, soil permeability) offer a degree of climate resilience, socio-economic disparities can override these advantages. At the same time, some urbanized areas with stronger institutions and services demonstrate the capacity to absorb risk, even when ecological adaptability is low.

The cross-index view supports the argument that place-based climate policies should not rely on environmental indicators alone. Instead, they must account for compounded vulnerabilities by aligning ecological investments (e.g., nature-based solutions) with social policy interventions (e.g., education, employment, and health infrastructure). In this way, the combined use of CCAI and CCRI offers a replicable framework for guiding adaptive strategies across diverse territorial contexts.

4. Conclusions

This contribution has presented a national-scale assessment of climate change adaptability and risk in Italy through the development of two open-data-based composite indices: the Climate Change Adaptability Index (CCAI) and the Climate Change Risk Index (CCRI). By integrating environmental and socio-economic indicators across a spatially detailed territorial taxonomy, the analysis reveals stark disparities in both adaptability and risk across Italian territories. The use of open data and a replicable methodological framework enhances the transparency, scalability, and policy relevance of the findings, offering a practical tool for spatialized climate

planning. Such technical foundations are crucial for developing robust composite indicators like the CCAI and CCRI introduced in this study, which depend on integrating open datasets from multiple institutions and spatial scales. Without clear standards and shared conventions, the operationalization of territorial climate assessments becomes fragile, limiting both their analytical reliability and policy relevance.

Despite the strengths mentioned above, the analysis also faces limitations linked to data availability, spatial resolution, and indicator harmonization, which may affect comparability across regions. Despite these constraints, the study demonstrates the potential of open-data-driven approaches for supporting place-based adaptation strategies and guiding informed territorial policy.

The analysis highlights specific regions (e.g., Calabria, Sicily, Apulia) and territorial typologies (particularly inner, remote, and sparsely populated areas) priority zones for climate adaptation. These areas consistently exhibit low adaptability and high climate risk due to limited ecological buffers and compounded socio-economic vulnerability. By contrast, some metropolitan and intermediate areas show greater resilience, yet still face localized pressures that warrant targeted planning. These findings support the need for differentiated place-based strategies tailored to the specific challenges and capacities of each territorial context.

Addressing climate risk and fostering adaptability in Italy requires tools that reflect territorial specificities and local-scale heterogeneity. National-level strategies must be grounded in spatialized assessments capable of identifying not only where risks are highest, but also where adaptive capacity is weakest. This highlights the importance of developing and applying robust, data-driven methodologies that integrate climatic and socio-ecological dimensions at appropriate scales. Such approaches are critical for informing place-based adaptation strategies and ensuring that policy responses are both equitable and effective across diverse territorial contexts.

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Special Session 18

Smart regions in an ageing society - new challenges for spatial planning in relation to healthcare

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Abstract
Healthcare has become increasingly relevant for spatial planning - not only due to the Covid-19 pandemic, but also because of growing shortages in skilled labour. Ensuring equal living conditions and basic outpatient care is gaining importance. This article presents a digital decision support system developed within the Carl-Zeiss-Stiftung-funded project Ageing Smart - designing spaces intelligently. The tool includes (1) a data-based analysis of population and healthcare structures, (2) dynamic, intermodal accessibility analyses, (3) a survey on healthcare needs among baby boomers in four municipalities, and (4) a catalogue of analogue and digital options for action. In the future, scenario-based impact visualisation will be added. The system supports evidence-based, participatory decision-making and strengthens spatial planning as a key actor in shaping future-proof healthcare infrastructures.

Keywords: smart region, spatial planning, decision support system, demographic change, public health care

1. Healthcare within the context of demographic change

1.1 Ageing as a key element of demographic change in Germany

In general terms, demographic change describes the change in population in terms of quantity and quality that in Germany has been observed for years. This development can be summarised with the keywords 'older', 'more diverse' and – regionally differentiated – 'fewer or more' (Gans, 2018, p.376). However, closer inspection reveals demographic change to be a multi-faceted process, characterised by the coexistence of shrinking and growing populations, as well as an ageing and increasingly heterogeneous society. Demographic change is therefore accompanied by far-reaching spatial implications, which are also significant in terms of the equivalence of living conditions and the safeguarding of services of general interest (ibid.).

Shrinkage and growth are a reflection of the quantitative aspect of demographic change, which results in a decline in the natural balance. This is due to the persistently low birth rates since the 1970s and the resulting steady reduction in the number of potential parent generations. This is in contrast to the overall positive migration balance (Federal Statistical Office, 2024). However, migration patterns are subject to a variety of influencing factors (e.g. political, economic), which is why they vary from region to region and are not constant. Internal migration within Germany is a key indicator of variations in quality and attractiveness, particularly with regard to the labour market and educational opportunities, as opposed to overall net migration. In contrast, external migration across national borders is influenced by external factors such as humanitarian crises and geopolitical conditions (Fürst & Mäding, 2011, p.29). The outcome of these reciprocal dynamics between natural population development and different migration movements is growth and shrinkage processes that take place side by side in different areas, with equally different spatial characteristics and effects.

Germany's ageing population is defined by an absolute and relative increase in older people. This issue has long been resolved for Germany (Federal Statistical Office, 2024). The population decline in birth rates and shrinking of potential parents generations (also known as 'ageing from below') is counteracted by the steady rise in life expectancy ('ageing from above') (Gans, 2018, p. 379f.). The ageing of the baby-boomer generation is driving this development, as about 25% of the German population was born between 1955-1969 (Federal Statistical Office, 2024;

Stefan et al., 2022: 1ff.). Specifically, the population is getting older as the average age is rising and age groups are shifting. The number of senior citizens and very old people is increasing. The 15th coordinated population projection assumes an increase in the 67-79 age group by 2037, followed by further increases from 2050, while the number of people in the 80+ age group will increase by 2050. The number of people of working age (20-66 years) will decline until the mid-2030s and stabilise from 2037 (depending on immigration).

1.2 Impacts for spatial planning and development

As outlined above, the spatial impacts of demographic change are diverse. They affect e.g. housing markets and settlement density, land use, public infrastructure (including capacity utilisation, costs and replacement needs), traffic flows, economic performance, labour markets, supply and demand structures, public finances, segregation, ethnic and social conflicts, and even public safety. The resulting effects vary in nature and intensity depending on the specific demographic processes and are influenced by various contextual factors. Most of these developments present challenges requiring active engagement from spatial planners and policymakers (Fürst & Mäding, 2011, p. 30).

In quantitative terms, demographic change is particularly evident in the decline of the population in structurally weak, peripheral and rural areas (Maretzke, 2018, p. 32). This is often associated with reduced economic attractiveness and demand for private goods, services, housing and infrastructure. Consequently, these areas face challenges such as vacant buildings, rising per capita costs, infrastructure capacity issues, closures of shops and medical practices, increasing catchment areas, a decline in qualified labour, and a general loss of attractiveness. This is coupled with underprovision of essential public services (Fürst & Mäding, 2011, p. 31; Fina et al., 2018, p. 14). These developments can intensify into self-reinforcing cycles of problems that place significant burdens on municipalities which are already facing declining tax revenues (Fina et al., 2018, p. 14). Internal migration exacerbates these disparities, with young people in particular relocating to economically prosperous metropolitan regions. This widens the gap between shrinking rural areas and growing urban centres (BiB, 2023

Qualitatively, ageing processes, which occur at varying intensities and paces across all German regions, represent the core challenge of demographic change. Those particularly affected include rural, peripheral areas with low population density, as well as urbanised regions and agglomerations with structural economic weaknesses (Gans, 2018, p. 382). While the increase in the old-age dependency ratio primarily challenges the pension system from a macroeconomic perspective, ageing from a regional and local perspective mainly stresses the social infrastructure, especially the provision of adequate healthcare and long-term care. The ongoing decline in the working-age population, combined with an increasing elderly population, exacerbates the imbalance between those in need of care and those able to provide it. The same applies to healthcare provision, where there is an increasing mismatch between the number of patients and the availability of service providers. As society ages, demands on infrastructure also change, affecting healthcare facilities, mobility infrastructure and cultural and recreational services. These needs were clearly identified in internal project workshops held in the seven model municipalities of the Ageing Smart project.

At the same time, an ageing society requires the built environment and public services to be adapted to meet the needs of older people. This involves promoting age-friendly housing and mobility solutions, providing access to healthcare and care services via alternative delivery models (e.g. mobile, digital, hybrid), and designing public spaces that cater to the social and physical requirements of older individuals (e.g. accessibility, seating; Körber Foundation & SRzG, 2020). In shrinking regions, it may also be necessary to reconsider existing infrastructure in light of demographic changes (BBSR, 2020).

1.3 Challenges for healthcare provision

General practitioners (GPs) are important because they're the first point of contact, have a close relationship with patients and coordinate further care and preventative measures. They're particularly important in rural regions, where distances to specialists and hospitals are greater (BBSR, 2025, p. 8). However, structural, demographic and economic conditions pose challenges to ensuring comprehensive, needs-based healthcare (BMWK, 2024, p. 202;

Cramer et al., 2022, p. 2). These areas have lower population density and a lower settlement and travel density (Ried, 2021). On the one hand, the steady ageing of the population is leading to an increasing need for medical care. This is leading to a rising number of elderly people, as well as an increase in multimorbidity and mobility restrictions. Changes in demand for age-specific infrastructure are therefore to be expected, particularly in outpatient, inpatient and nursing care facilities (Cramer et al., 2022, p. 2; Kuhn & Amelung, 2015, pp. 16–17). The effects of climate change on human health are also becoming increasingly noticeable (e.g. in the form of extreme heat events), and are exacerbating the situation (Birkmann & Blätgen, 2018, p. 1102).

This development is countered by declining treatment capacities due partly to population change and partly due to a declining willingness to set up a practice and a decline in full-time employment, alongside a drop in working hours (e.g. German Medical Association, 2023; Zwierlein et al., 2020). Here, too, the baby boomer cohort matters, since doctors aged 50 to 65 work long hours, which younger generations cannot easily cover (German Medical Association, 2023).

Alongside these quantitative challenges, there are also qualitative and spatial issues. There has been a maldistribution of specialists and a shortage of GPs willing to set up a practice. Spatially, there are disparities between affluent urban areas and rural communities where basic care is already at risk (Gerlach et al, 2014, p. 349 ff. and p. 377 ff.). It is hard to fill vacancies in these areas: in 2015-18, 50% of doctors were unwilling to work in rural areas (Zwierlein et al., 2020, p. 2; Jacob et al., 2015, p. 61 f).

Demographic change is putting increasing pressure on outpatient care, particularly in rural areas (Kuhn & Amelung, 2015, p. 18). Securing healthcare provision is therefore necessary, particularly with a view to achieving equality of living conditions (Stiewing & Mangels, 2022, pp. 410–411). Comprehensive measures are required in affected areas to counteract the aforementioned challenges and ensure comprehensive, needs-based healthcare. Local authorities are explicitly urged to establish integrated care and prevention structures, and to develop innovative, sustainable approaches (Böhm & Schönknecht, 2020, p. 1). However, control of the public healthcare system has largely been taken away from municipalities and transferred to statutory health insurance funds and medical service providers. Nevertheless, in the context of demographic change, the question of a stronger role for local authorities in this area arises. How can local authorities be actively involved in shaping local healthcare provision?

1.4 Research approach in the Carl Zeiss project 'Ageing Smart - Designing spaces intelligently'

The effects and challenges outlined in the context of demographic change clearly show that the baby boomer cohort in particular acts as a driver for some of these developments. The research project 'Ageing Smart - designing spaces intelligently', funded by the Carl Zeiss Foundation and the University of Kaiserslautern-Landau with 4.3 million euros over a period of five years, addresses these baby boomers, born between 1955 and 1969, and brings together spatial planning and supply-side approaches, baby boomer needs and local authority requirements and options for action in an integrated approach for the first time. The interdisciplinary research project, which is part of the university's "Region and City" research unit, is divided into ten sub-projects in the disciplines of spatial planning, urban sociology, climatology, computer science and mathematics and is coordinated by the Department of Urban Sociology under Prof Dr Annette Spellerberg.[1]

As the largest patient group, baby boomers are particularly relevant to the healthcare sector. The 'Healthcare' sub-project, coordinated by the Chair of Regional Development and Spatial Planning, focuses on general practitioner, specialist and dental care in four rural-suburban municipalities: Kusel-Altenglan, Nieder-Olm, Geisaer Land and Remshalden. As well as healthcare provision (supply and demand) and transport infrastructure to ensure individual mobility and accessibility to medical facilities, the project focuses on the current housing situation, prospective residential location behaviour, and healthcare behaviour of baby boomers, as well as their requirements in terms of accessibility and medical care design.

1 University of Kaiserslautern-Landau: "Ageing Smart - Designing spaces intelligently", https://www.ageing-smart.de/

The analysis of the preferences and needs of baby boomers serves to answer relevant questions and to derive needs and options for action in healthcare provision in rural-suburban communities. Later in the project, these will be used to feed into the planned decision support system, particularly in view of increasing demand with a simultaneous reduction in available supply. Of particular relevance here is the accessibility of the individual medical locations, which is why the development of a dynamic accessibility model to analyse time-dependent, intermodal accessibility and, in perspective, to optimise the location planning of different services represents an interdisciplinary cross-sectional approach from spatial planning and mathematics, with the aim of harmonising the needs of the ageing population, spatial development and local supply options (Stiewing et al., 2022, p. 132f.).

The objective of the joint project is the development of a data-driven, IT-based, and AI-driven decision support system (DSS) that can be utilised by public stakeholders in their planning and decision-making processes (municipalities ask, the DSS answers). Infrastructure, services and offerings should be developed in a manner that is demand-oriented, sustainable and future-oriented, with a view to ensuring and enhancing the quality of life of baby boomers and, in the long term, the entire population.

B With regard to the baby boomer cohort and the healthcare sector, questions arise concerning the supply of and demand for infrastructure and residential location behaviour, among other things: What are the current and future needs? Which infrastructures are increasingly in demand? How can the quality and accessibility of medical care in rural-suburban areas be improved by incorporating alternative services? What acceptance do digital, mobile and hybrid forms of healthcare provision have among the baby boomer generation? What relevance does the medical care infrastructure have for municipal development? What opportunities are there to influence the location of medical centres? What mobility services will be needed in the future? Where and how will baby boomers live in the future?

Taking demand and supply aspects into account, the role and potential influence of the municipal level in the area of healthcare was analysed and two rural and two suburban municipalities were examined with regard to the provision and accessibility of medical care. In addition, a survey on healthcare provision was conducted among baby boomers in these municipalities in order to generate data on the healthcare and residential location behaviour of baby boomers and the resulting challenges. The findings, e.g. on care structures, demand patterns and needs, residential location and mobility behaviour as well as the acceptance and relevance of digital-mobile forms of medical services, are used to identify specific requirements for action at
and to formulate options for action to ensure healthcare provision and its accessibility. These will also be supplemented by the assessment of experts from politics and administration in the model municipalities, outpatient demand planning and representatives of the leading medical associations.

2. Healthcare as a future task of general interest to municipalities

2.1 Equal living conditions as a guiding principle for services of general interest

Alongside the guiding principle of sustainable spatial development, the provision of equal living conditions is a key objective of German spatial planning policy, which is outlined in the Spatial Planning Act and the Basic Law of the Federal Republic of Germany. This demands comparable opportunities for the population, municipalities and companies in terms of starting, development and funding, as well as access to and accessibility of infrastructures of general interest (Troeger-Weiß, 2023, p. 305). It also means ensuring a comparable quality of life for the population, regardless of regional, social or economic circumstances (Priebs, 2021, pp. 12-13). The task of spatial planning is therefore to organise living conditions throughout Germany in such a way that the population perceives them as equal (Rosenfeld, 2018, p. 838). Ensuring equal living conditions means guaranteeing everyone the basic requirements for a good life. 'Equivalence' refers to fundamental services like education, mobility and healthcare. The guiding principle seeks to minimise disparities between urban centres, rural areas and between federal states (Rosenfeld, 2018, pp. 837-838). The concept of equal living conditions is closely linked to social justice. Regional disparities in infrastructure, education, the economy and healthcare require political intervention (Priebs, 2021, p. 16). However, the concept of equivalence does not imply complete equality. Instead, the desired

equivalence involves defining minimum standards adapted to the regional conditions of individual sub-regions (Rosenfeld, 2018, pp. 841-842).

Equivalent living conditions also include equivalent healthcare. Therefore, ensuring adequate healthcare is considered the responsibility of public services of general interest (Gerlinger, 2021, p. 71), which are embedded in spatial planning and municipal policy as a public mandate (Priebs, 2013, p. 142). This includes outpatient, inpatient and nursing care. However, in addition to providing appropriate healthcare infrastructure, the accessibility of facilities is also important. According to the Federal Government's Equivalence Report, health-related equivalence largely depends on the characteristics and interactions of the following factors:

- the status and development of regional old-age dependency ratios;
- life expectancy and premature mortality;
- the quality and accessibility of medical and nursing care facilities, e.g. the density of care in terms of GPs and access to medical care regardless of place of residence (BMWK, 2024, pp. 42-65).

Significant differences exist between urban and rural districts, particularly regarding accessibility to medical care (BMWK, 2024, pp. 62-64). The number of inhabitants per GP varies considerably, highlighting challenges in rural areas (BMWK, 2024, p. 65). A population survey revealed that 16% of respondents rated good healthcare and nursing care as important for their local area's quality of life (BMWK, 2024, p. 87). Despite efforts to achieve equivalence in healthcare, challenges persist due to spatial disparities and demographic trends. Against this backdrop, minimum standards (basic care) of services of general interest and new concepts in medical care are being discussed (Baumgart & Rüdiger, 2018, p. 831).

2.2 Organisation of healthcare in Germany

In Germany, responsibility for healthcare is not organised by the state, but rather through a self-governing system in which responsibilities are divided between the federal, state and local levels, in accordance with the federal structure of the state. The federal government defines the legal framework in the German Social Code (SGB), among other things, while the federal states and self-governing bodies — the health insurance funds and Associations of Statutory Health Insurance Physicians (KVen) — are responsible for the more precise organisation. The supreme body of this system is the Federal Joint Committee (G-BA), comprising the National Association of Statutory Health Insurance Physicians (KBV), the National Association of Statutory Health Insurance Dentists, the German Hospital Federation, and the National Association of Statutory Health Insurance Funds (G-BA, 2023).

With regard to outpatient healthcare, the responsibility for ensuring sufficient and comprehensive medical care within the framework of statutory health insurance, as set out in § 75 (1) SGB V, lies with the medical service providers (represented by the KVs) and the health insurance funds. The former, in agreement with the respective state associations of health insurance funds, draw up a requirements plan (§ 99 SGB V), which regulates the number and distribution of medical practices based on guidelines issued by the Federal Joint Committee, thereby guaranteeing the provision of care in accordance with this mandate. The demand planning guideline (BPL-RL) establishes nationwide specifications that are implemented at a regional level by the state committees. The BPL-RL describes a comprehensive functional planning system that formulates specifications for care levels, doctor groups and corresponding planning areas, while allowing room for regional deviations. Each group of doctors (e.g. orthopaedists) is assigned to one of four care levels, which are planned at different spatial resolutions: general practitioner care (middle areas), general specialist care (districts), specialised specialist care (regional planning regions), and separate specialist care (state level). The supply situation for each doctor group and region is assessed by comparing the population-physician ratio with the target level (KBV, 2025).

Inpatient care, on the other hand, is primarily the responsibility of the federal states, which must ensure that sufficient hospital services are provided locally. This is financed according to the principle of dual hospital financing by the federal states and health insurance funds. However, most federal states have transferred this responsibility to counties, which often act as hospital operators and are directly and indirectly involved in hospital financing

(Böhm & Schönknecht, 2020, p. 12).

2.3 Municipalities and their role within outpatient healthcare in Germany

Although municipalities are limited in their role within this system, they remain responsible for ensuring public health under constitutional law as part of the state administration (Gerlinger, 2021, p. 16). Effective municipal healthcare also aligns with an overarching health-promoting policy and the 'Health in All Policies' (HiAP) strategy. The latter is a multi-level approach that aims to integrate health into all policy areas and establish societal responsibility for health (Köckler & Geene, 2022). Figure 1 therefore illustrates the role of local authorities with regard to healthcare, health promotion and prevention.

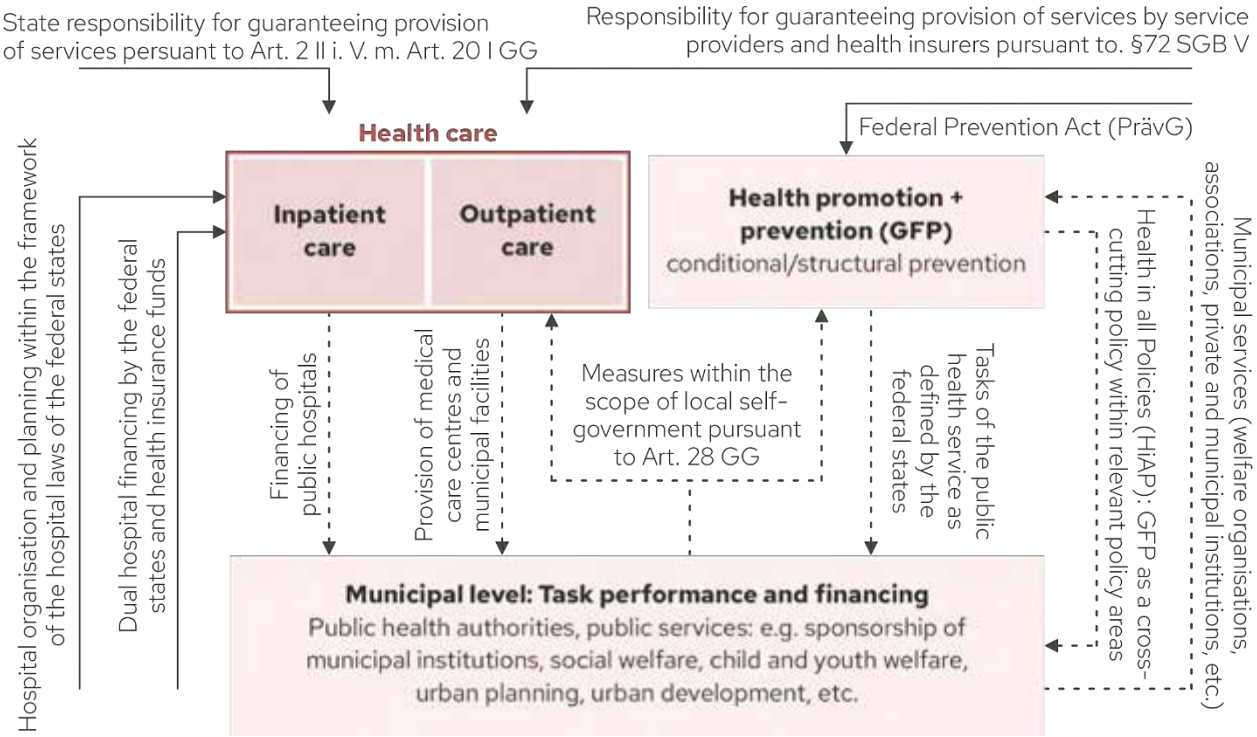

Fig. 1: The role of municipalities in the field of health (Stiewing & Mangels, forthcoming a).

Local authorities can explicitly act as service providers. The legal framework is defined by several acts, including SGB V and the Care Structure Act of 2012. Municipalities can operate their own facilities for direct medical care in justified exceptional cases (§ 105 (5) SGB V). Furthermore, § 95 (1a) SGB V permits the establishment of medical care centres (MVZ) under municipal or inter-municipal ownership, regardless of the approval of the KVs (Gerlinger, 2021, p.70). However, the implementation of this option remains challenging. Studies show that municipal officials are reluctant to establish MVZs, and concerns have been raised about their economic and organisational feasibility (Gerlinger, 2021, p.54; Barthen & Gerlinger, 2016; Kleinschmidt, 2019). The reasons cited include lack of financial resources and expertise. Consequently, the number of MVZs under municipal ownership has been low (Gerlinger, 2021, p.54). Most MVZs are initiated by small municipalities to minimise local supply bottlenecks (Müller, 2020, p.57).

In the context of demographic shifts, the German government passed the Act to Strengthen Healthcare Provision in March 2025. This act aims to enhance outpatient care, including through the simplification of municipal MVZs. While the GVSG is generally welcomed by municipal umbrella organisations, they also express criticism. In particular, they criticise the removal of previously planned opportunities for municipal stakeholders to influence healthcare provision. For instance, the following elements are no longer included: health regions; health kiosks; and primary care centres. Furthermore, the draft document focuses excessively on outpatient care, which means

that the GVSG contradicts the approach of cross-sectoral care. While the expansion of municipal healthcare is a key priority, it is vital to ensure that responsibilities are not significantly transferred to the municipalities, thereby limiting their capacity to deliver services.
Furthermore, municipalities have room for action thanks to the guarantee of municipal self-government enshrined in the German Basic Law (Art. 28 GG). Within this framework, local authorities can influence local healthcare provision through targeted measures such as counselling services, providing practice premises, and offering financial incentives to doctors (Kuhn & Amelung, 2015, p. 18). Furthermore, municipalities can utilise health conferences or inter-municipal and regional networks to encourage collaboration among local stakeholders, thereby addressing gaps in care and ensuring its provision (Böhm & Schönknecht, 2020, pp. 6–10). This is particularly relevant given that demographic change and a shortage of skilled labour are putting increasing pressure on outpatient care in rural and suburban areas (Kuhn & Amelung, 2015, p. 18).
As Böhm and Schönknecht state, municipalities are the lowest administrative unit and have the most direct access to local people. This enables them to align healthcare, health promotion and prevention directly with local needs. As the bodies responsible for the entire local public administration, municipalities have a special role to play in improving health equity and equal opportunities.

3. Decision support for municipalities on healthcare provision
One of the tasks of spatial planning is to record and visualise different developments and their spatial and temporal relationships in a way that is appropriate for the target group as part of spatial observation. Spatial planning thus creates a basis for work and discussion for both political decision-makers and the population, for example for the development of spatial strategies and concepts of various kinds.
In dialogue with municipal stakeholders, including in the context of internal project workshops, networking meetings and conferences, it became clear that there is a need for support, particularly in smaller municipalities with few resources. These tend to have a superficial overview of the local facilities and, from the perspective of the municipal decision-makers, show a rather diffuse awareness of the problem under the keyword "shortage of doctors". Feedback from the workshops held in the model municipalities as part of the project resulted in a multi-stage structure for concrete decision support, which is shown in Fig. 2.

Fig. 2: Components of the ageing smart decision support system in terms of healthcare

In addition to the generally understandable preparation of central trends and framework conditions, which also emphasise the relevance of the topic as a municipal task, the analysis of the current situation in the healthcare sector forms a necessary component for a fact-based decision-making basis. This includes

• general indicators of common spatial structural analyses alongside the requirements and needs of baby boomers surveyed in rural and suburban areas,
• analysis of the medical equipment on a municipal level and
• analysis of the intermodal accessibility of medical facilities.
The aim of this analysis is to describe the current situation of healthcare provision and to derive requirements for action at municipal level as a concrete contribution to decision-making support in municipalities

3.1 Perspective of the baby boomer generation on healthcare and mobility
Compared to previous generations, baby boomers are considered to remain fit and active for longer. However, as they age, this generation will also have greater need for medical care in the medium term. As the largest patient group in the future, baby boomers are therefore highly relevant for securing medical care and thus for municipal development. In this context, the subproject on healthcare conducted a partially standardised survey among baby boomers on healthcare in two rural (Geisaer Land and VG Kusel-Altenglan) and two suburban municipalities (Remshalden and VG Nieder-Olm) in Rhineland-Palatinate, Baden-Württemberg and Thuringia. (Stiewing & Mangels, forthcoming b). Based on e.g. statements on demand behaviour and needs for healthcare, (supra-local) residential location behaviour, mobility behaviour, the aim is to identify the need for action for both political decision-makers and healthcare providers and to formulate options for action to secure healthcare and mobility (Stiewing & Mangels, 2023, p. 403). Among other data, the following data is displayed in the DSS:

• subjective state of health as well as health restrictions, chronic illnesses, risk factors (multimorbidity) and social integration,
• Satisfaction with medical care and mobility at the place of residence,
• Acceptance of mobile and digital forms of healthcare provision,
• Importance of healthcare and mobility as location factors in the choice of residential location (past and anticipated),
• Requirements and wishes for living in old age.

For example, both mobile and digital services provide a flexible alternative to traditional healthcare. The survey therefore asked about acceptance of these types of service for medical consultations or treatments. Table 1 shows the corresponding approval ratings. Two-thirds of respondents can imagine using these services. From the perspective of baby boomers, mobile and digital services can therefore, at least in part, offer an alternative option for consultation or treatment and contribute to securing care, relieving the burden on doctors and improving quality in rural and suburban areas. A higher acceptance of mobile services and counselling is evident among respondents from the suburban model communities. The highest acceptance is among respondents for mobile and digital counselling (Stiewing & Mangels, forthcoming b).

Tab. 1: Acceptance of digital and mobile healthcare services: ('Can you imagine a. being advised/treated by a doctor in an a. online format (n = 279 / 505) / b. in a mobile doctor's office (n = 278 505)?'; percentages refer to the respective answer).

	digital counselling and treatment	digital counselling only	no digital counselling and treatment	mobile counselling and treatment	mobile counselling only	no mobile counselling and treatment
rural	23,3 %	43,4 %	33,3 %	53,8 %	14,7 %	32,1 %
suburban	31,4 %	45,8 %	22,7 %	59,2 %	12,1 %	28,7 %

3.2 Analysis of medical facilities in healthcare provision
In the area of healthcare, the following questions arise at the municipal level: What is the current situation of outpatient healthcare in the district / municipal association / municipality or in the municipal districts? What will the

healthcare situation probably be like in five to ten years' time? Where is there an acute and prospective need for action? A standard data-based inventory and analysis for a specific spatial area (e.g. a district, an association of municipalities) is usually part of a spatial structural analysis. This analysis usually comprises: "spatial structure and settlement development", "development and structure of the population" (including household structure), "development and structure of the economy and the labour market", "accessibility and infrastructure" and, depending on objectives, "trade" or "tourism". Relevant indicators are analysed and assessed using statistical data at municipal level and, where applicable, over time (usually development over the last ten years or so). Forecasts and comparative values can also be used to create a benchmark for assessing the current situation.
Healthcare provision is usually considered as part of the analysis of social infrastructure within the framework of traditional structural analyses. The analysis is usually limited to the location of healthcare facilities (e.g. GP practices and clinics), the number of doctors and the quantitative ratio of doctors to inhabitants in the analysed spatial unit. A more detailed analysis is being carried out as part of the DSS, whereby following data is used:

- Basic data for visualisation, i.e. administrative boundaries (e.g. at district, municipal association and municipal level) as well as settlement areas and buildings,
- Data on spatial structure, in particular spatial types and central locations
- Data on transport infrastructure, i.e. private and public transport, including routes, stops, frequency, distances and accessibility
- Socio-demographic data (e.g. census) to assess quantitative demand, in particular the status and development of the population over the last ten years, population density and population forecast, as well as data on the age structure, e.g. average age, proportion and development of the baby boomer cohort and the over 65/75/85 age groups, life expectancy
- Key data on outpatient demand planning to assess supply in quantitative and qualitative terms, i.e. in particular planning areas, level of care, open seats, ratio of residents per doctor (in the DSS focused on smallest planning areas of outpatient care, i.e. general practitioner, dentist and general specialist care)
- Data on medical facilities at municipal level to assess supply in spatial terms, i.e. in particular address-specific locations of outpatient (individual and group practices, medical care centres) and inpatient care (public and private hospitals) as well as pharmacies and, if applicable, existing mobile, digital and hybrid forms of supply.

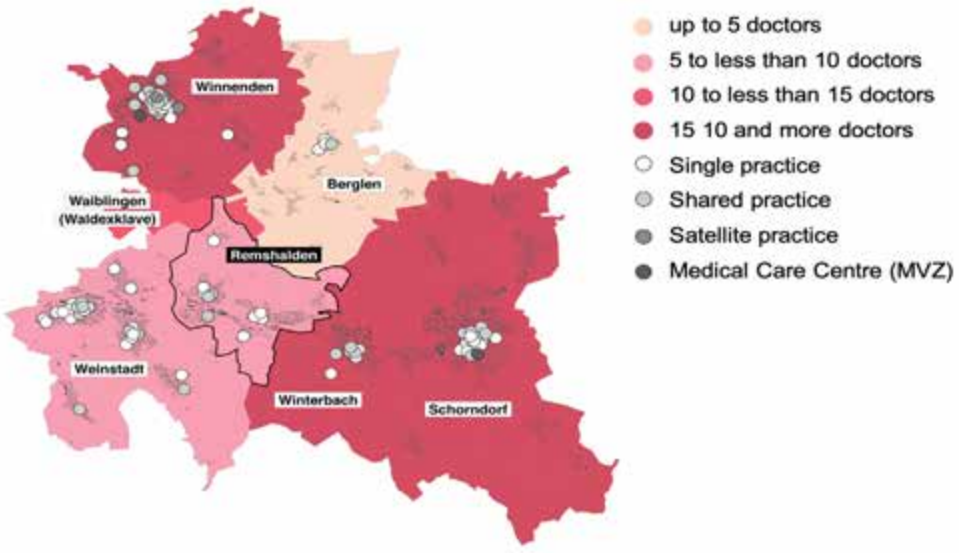

Fig. 3: Outpatient healthcare facilities and doctor-to-resident ratio in the pilote municipality of Remshalden, 2022

3.3 Analysis of intermodal, time-dependent accessibility in an algorithm-based accessibility model
In addition to the provision of medical facilities, accessibility is becoming increasingly important when assessing

medical services in terms of spatial quality, particularly against the backdrop of changing mobility in old age. In rural areas in particular, accessibility is a critical factor due to the sparser infrastructure network and longer distances. Standard structural analyses often depict accessibility by showing the existing transport infrastructure (usually motorised individual transport and public transport) and how long it takes to reach the nearest major or medium-sized centre by car. However, this assumes the availability of a private car, which gradually declines with age (BMVI, 2018, pp. 99–102). Additionally, the activity radius generally shrinks with age, making it more difficult to visit doctors in more distant locations (Stiewing & Mangels, forthcoming a). The analysis of healthcare provision is therefore supplemented by a mathematical accessibility analysis based on cross-sectional spatial planning and mathematical methods.

Accessibility analysis is no longer carried out purely statically in relation to the nearest major or medium-sized centre, or based on linear distance to the nearest infrastructural facility. Instead, it is time-dependent, intermodal and dynamic, in the sense of forward calculation. As part of an intermodal, thematically supported accessibility analysis, different means of transport and their interlinking can be considered, as well as individual mobility. As a component of the DSS, the model provides stakeholders in spatial planning administration (e.g. urban, transport and social planning), political decision-makers, and other stakeholders (e.g. from medical care, research, and demand planning) with an analysis tool. It considers different modes of transport and user profiles, enabling the identification of small-scale accessibility deficits and supply gaps within a planning area (Stiewing et al., 2022, pp. 131–141).

To analyse accessibility in the mathematical model, the locations of the facilities to be included (e.g. outpatient care) are first used as a basis. These locations are characterised by different structural features (e.g. type of practice). In addition, the age of the medical profession can be integrated into the DSS to provide insight into future supply, provided that the facilities remain unchanged. The calculation is also based on the underlying road network and real-time public transport timetable data. Previously defined parameters and ancillary conditions supported by transport planning also form the basis for the calculation (Stiewing et al., 2022, pp. 137–139). To reflect different types of mobility among users, three mobility profiles were configured in collaboration with the optimisation working group and the Chair of Urban Planning at the RPTU. These combine age-specific parameters relating to walking, cycling, public transport, and motorised private transport (MIT), enabling a differentiated analysis of the accessibility of medical services. The preconfigured, customisable 'limited mobility', 'average mobility' and 'above-average mobility' profiles are therefore used to analyse intermodal accessibility in the DSS.

The modelled accessibility is then assessed according to threshold values based on supply-side standards and recommendations for the accessibility of medical facilities. While 15 minutes is assumed for good or adequate general practitioner (GP) care, 30 minutes is used as the corresponding threshold for general specialist care. An exception to this is gynaecological care, which usually involves an annual consultation, so a threshold value of 20 minutes is set here (Stiewing & Mangels, forthcoming a). The same applies to dental care, as an annual consultation is also usually carried out here. Figure 4 shows a possible modelling result and depicts the healthcare situation for general practitioner care in the pilot municipality of Kusel-Altenglan from an accessibility perspective. This illustrates the impact of individual mobility on the quality of small-scale care provision. Analysing intermodal accessibility for the status quo and the anticipated temporal course can reveal areas where action is needed to secure healthcare provision. For example, underserved areas or areas where certain population groups are disadvantaged can be identified, even if the entire central or supply area has a sufficiently high level of supply (Stiewing et al., 2022, pp. 137–139).

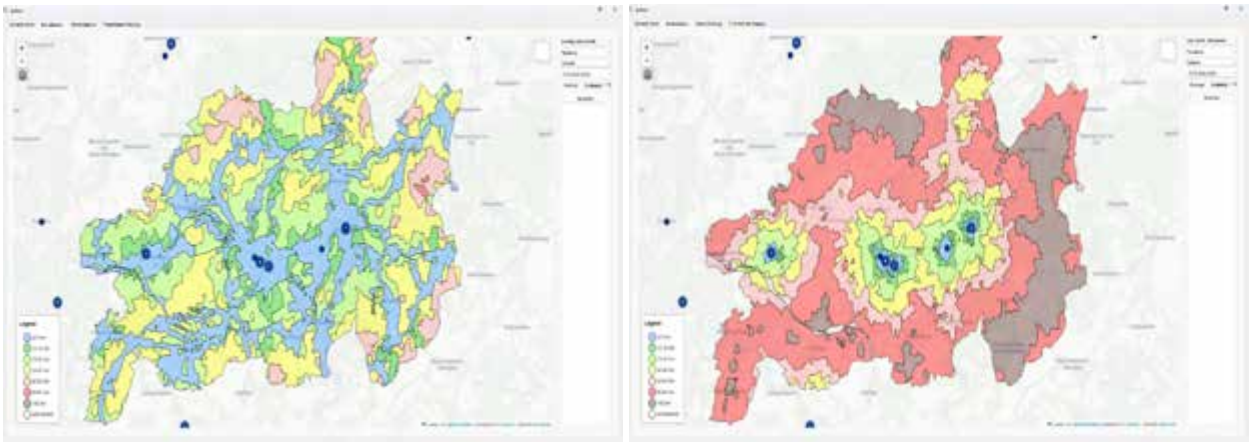

Fig. 4: Accessibility of the general practitioner care in the pilot municipality of Kusel-Altenglan with profile 'average mobility' (left) and 'limited mobility' (right), 2022

3.4 Municipal options for proactively shaping healthcare provision

Based on the described framework conditions and the structural analyses and surveys carried out for the rural and suburban model municipalities in the intermodal accessibility model, action is needed in the municipal provision of healthcare, including ensuring accessibility. Building on this analysis and problem definition, providing possible solutions in the DSS is the second step towards supporting decisions in the healthcare sector. This aims to safeguard the status quo and prevent a deterioration in accessibility, as well as the associated threat of an increase in scale of healthcare provision. The DSS options set out different 'interventions' with corresponding recommendations to support decision-making and, if necessary, alternative futures. They also serve to create scenarios in the decision-making process. As well as planning administrators and municipal decision-makers, the intended audience includes providers of medical services. The following questions take centre stage:

- How can the municipality improve healthcare in the community?
- What opportunities are there for doctors to set up in the community?
- What needs to be done step by step to realise a specific intervention?

As Fig. 5 shows, municipalities can become involved in healthcare to varying degrees. Initially, this commitment involves local authority representatives engaging with the topic and exchanging information with local medical service providers. This can lead to initial action plans, which can be summarised as "counselling", "support" and "mediation". One example is counselling in the context of the branch office. At the second stage, the municipality acts as a partner in searching for and, if necessary, establishing a location. This could include providing or leasing suitable practice premises, or selling real estate or building plots at favourable rates. At the third stage, the municipality becomes active as a moderator or driver by integrating health into its strategies and concepts. In this context, it also makes analysing the status quo and communicating about it the subject of municipal action. This can include inter-municipal strategies and networks. The highest level of municipal involvement is assuming an own care mandate, e.g. sponsoring or participating in a municipal medical care centre. These centres offer the option of employing doctors on a salaried basis, which is particularly popular with younger doctors (Dostal & Partner Management-Beratung GmbH, 2019; BMG, 2024). However, the individual stages do not necessarily build on each other; rather, they represent different organisational approaches that can be combined depending on local circumstances.

Fig. 5: Levels of municipal involvement in healthcare (Stiewing & Mangels, forthcoming b).

The options for action include measures to improve healthcare provision and accessibility in the short term, and health promotion and prevention in the long term. In the 'healthcare' field of action, measures in line with the 'service to people' approach are conceivable. For example, outpatient healthcare services could be provided independently of a location by creating additional services or through mobile and digital provision. In the 'mobility' field of action, the focus can instead be on improving accessibility to medical services through appropriate 'people to service' measures. Development concepts for healthcare or mobility can also be created for both strategies (Troeger-Weiß and Anslinger, 2015, p. 147). Opting for one approach represents an initial political preference decision. The options for action are divided into abstract approaches and measures as well as concrete best practice examples, and are presented in the form of standardised profiles. These profiles are stored in the DSS and contain information on the target group, implementation, challenges, timeframe, costs and the municipality's role.

The options for action can also serve as a basis for alternative scenarios to discuss various possible courses of action and their effects. One example of this is location planning, where the impact of different locations on accessibility can be visualised using the intermodal accessibility model outlined above (Stiewing et al., 2022, pp. 137–139). Examples include the inter-municipal establishment of a medical care centre, providing rooms and spaces for local doctors, and offering consulting services to doctors looking to set up a practice.

4. Outlook

Healthcare is a key aspect in the context of equal living conditions. Factors such as demographic ageing, population loss, the shortage of healthcare professionals and limited resources for the provision of infrastructure have a significant impact on the quality of care. These challenges not only jeopardise the idea of equal living conditions, but also make political and organisational interventions indispensable. Health must therefore be understood as a task for society as a whole, which makes both the active organisation of local authorities and an associated expanded understanding of their role, particularly in securing (outpatient) healthcare, appear sensible.

To date, healthcare has only been included in spatial structural analyses in spatial planning to a limited extent. Existing approaches often fall short, as they are usually limited to infrastructural facilities or the ratio of doctors to the population. These perspectives do not provide a sufficient basis for strategic decisions by planning administrations and politicians. The intermodal accessibility of healthcare facilities, taking individual mobility into account, is becoming increasingly important when analysing the municipal healthcare situation and should be brought into focus.

A data-based DSS can make a decisive contribution to planning and decision-making processes here. In the field of health, for example, it can be used to depict the current supply situation and derive key requirements for action and supplement and specify conventional spatial structural analyses in planning. For example, small- spatial disparities within a care area can be identified. Municipalities and other stakeholders (e.g. KVs, doctors willing to set up practices) in the area of healthcare are thus supported in developing infrastructural offers and services in a needs- and demand-orientated, sustainable and future-oriented manner.

In addition, the DSS enables local authorities to recognise and weigh up options for action in the areas of healthcare, mobility, health promotion and prevention and to implement them within the framework of various roles. Such a DSS can therefore not only be a tool for data exploration, but also an instrument for actively finding and shaping solutions to existing or foreseeable gaps in care. The DSS is initially focussing on the high-birth cohort of baby boomers and accordingly on age-specific infrastructures, offers and services in particular, including the area of healthcare. However, the use cases developed as part of the project are intended to be transferable to other facilities (e.g. local supply, retail, education). In the long term, the DSS can thus make an important contribution to intergenerational urban and spatial development in order to secure and promote the quality of life of both baby boomers and the population as a whole.

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